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   USDA NRCS Custom Soil Resource Report for District of Columbia, Rock Creek Park Tennis Center

   Rock Creek Park

APPENDIX B TREATMENT CALCULATIONS

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1 INTRODUCTION

The thirty (30)-acre Project Area is located in northern Washington, D.C. adjacent to the 16th Street Heights neighborhood. The Rock Creek Park Tennis Center sits at the headwaters of the Blagden Run watershed, a subwatershed of Rock Creek (Figure 1).

The Project Area was identified as a priority restoration area by FWS and NPS due to its impact on a portion of the three (3)-mile area where the known endemic population of *Stygobromus hayi* ("Hay's Spring amphipods") is found. During rain events, stormwater swiftly leaves the Project Area from five outfalls and is believed to compromise the endangered Hay's Spring amphipod population by washing the amphipod from its habitat, eroding the headwater spring areas where the amphipod is endemic, and lowering the groundwater table, which reduces habitat available for the species.

Four distinct gullies have been created by stormwater from outfalls draining the Project Area. Stormwater also leaves the Project Area through overland flow and a storm sewer that drains directly to Blagden Run. The targeted eleven (11)-acre impervious area has no stormwater controls because it was developed prior to the promulgation of the District’s stormwater regulations.

The goal of the Project is to fully retrofit the targeted eleven (11)-acre impervious area with green infrastructure to restore natural hydrology, prevent erosion, reduce stormwater pollution and protect natural habitat for the federally listed endangered Hay's Spring amphipod.

Figure 1: Project study area
2 EXISTING CONDITIONS AND DATA COLLECTION

Biohabitats assessed the existing conditions at the Rock Creek Tennis Center through a desktop review of available GIS data record drawings and multiple site visits. An existing conditions survey is currently in progress and will be completed prior to submission of a 60% design submittal.

2.1 GIS Data
Biohabitats compiled a base map of the existing conditions from available GIS data (LiDAR, Property Lines, impervious surface layers, etc.) to inform the 30% design submittals. Until a topographic survey is complete, a combination of GIS data and record drawings provides the best available data for design purposes. As needed for design purposes, specific components have been visually verified to ensure consistency of information (i.e., wet weather flow patterns across the parking lot).

2.2 Record Drawings
NPS provided Biohabitats with as-built plans for the parking lot and event layout drawings for the Citi Open Professional Tennis Tournament for review and consideration in developing the proposed 30% design submission. The record as-built plans identified for the project are listed below.

- Rock Creek Park Plans for Proposed Project PRA-ROCR 18(1): Reconstruction and Resurfacing of Parking Areas and Roadways serving the Carter Barron Amphitheater and the Tennis Pavilion and Stadium, Washington D.C. NPS No. 821/41918/

2.3 Topographic and Tree Survey
A topographic and tree survey of the project area is currently in progress and will be completed prior to the 60% submittal.

2.4 Soils
Biohabitats utilized the United States Department of Agriculture’s (USDA) Natural Resources Conservation Service’s (NRCS) Web Soil Survey to perform a preliminary analysis of the existing on-site soils. Pending additional soil testing and the topographic survey, Biohabitats will also utilize the Web Soil Survey results to inform a more detailed hydrologic assessment. Table 1 below provides a list of the soils present at the site. A full printout of the Web Soil Survey has been attached in Appendix A.

Soil borings and Infiltration testing will be performed following the 30% design submittal.
## Table 1: USDA NRCS Web Soil Survey Results

<table>
<thead>
<tr>
<th>Map Unit Symbol</th>
<th>Map Unit Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>BdB</td>
<td>Beltsville silt loam, 0 to 8 percent slopes</td>
</tr>
<tr>
<td>CcB</td>
<td>Chillum silt loam, 0 to 8 percent slopes</td>
</tr>
<tr>
<td>CcC</td>
<td>Chillum silt loam, 8 to 15 percent slopes</td>
</tr>
<tr>
<td>CdB</td>
<td>Chillum-Urban land complex, 0 to 8 percent slopes</td>
</tr>
<tr>
<td>GgB</td>
<td>Glenelg loam, 0 to 8 percent slopes</td>
</tr>
<tr>
<td>GgC</td>
<td>Glenelg loam, 8 to 15 percent slopes</td>
</tr>
<tr>
<td>GgD</td>
<td>Glenelg loam, 15 to 25 percent slopes</td>
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<tr>
<td>KmB</td>
<td>Keyport-Urban land complex, 0 to 8 percent slopes</td>
</tr>
<tr>
<td>MbD</td>
<td>Manor loam, 15 to 40 percent slopes</td>
</tr>
<tr>
<td>ScC</td>
<td>Sassafras gravelly sandy loam, 8 to 15 percent slopes</td>
</tr>
<tr>
<td>Ub</td>
<td>Urban land</td>
</tr>
</tbody>
</table>

### 2.5 Site Visits

#### 2.5.1 Project Kick-off (4/10/2017)

Staff from the District of Columbia’s Department of Energy and Environment (DOEE), U.S. National Park Service (NPS), and Biohabitats (Bio) met on April 10th, 2017 at the project site to kick-off the design-build contract for the Carter Barron LID Retrofits project. The attendees walked the site, discussing the original concept drawing produced by Biohabitats, design concerns, and possible alternatives.

#### 2.5.2 DOEE Wet Weather Site Visit (5/11/2017)

On May 11th, 2017 staff from DOEE (Steve Saari) conducted a site visit during a rain event in order to review the existing drainage patterns at the site. During the site visit, Mr. Saari captured numerous site photos (See Appendix C, photos C-5 to C-8 for sample photos) and took detailed field notes on the existing drainage patterns (See Appendix A).

### 3 HYDROLOGY and SWRv Computations

During the design process, Biohabitats delineated the drainage areas to each proposed BMP to calculate the required Stormwater Retention Volume (SWRv). Following the 30% submittal, Biohabitats will conduct a detailed Hydrologic Analysis of these drainage areas including the peak flow rates for the 15-year rainfall event ($Q_{15}$) as necessary to determine adequate sizing of BMP inlet and outlet structures.

#### 3.1 SWRv

The required stormwater retention volumes (SWRv) for the project site were calculated following the methodology described in the DOEE Stormwater Management Guidebook (July 2013). Based on the project location, the proposed retrofit project has targeted a 1.2-inch rainfall event when calculating the SWRv for the site using Equation 2.1 from the guidebook.

The project site was split into thirteen contributing drainage areas (CDA) based on the possible locations of proposed BMPs. Table 2 below presents the breakout of drainage area characteristics and the Targeted SWRv for each CDA. Detailed calculations for the targeted SWRvs have been provided within Appendix B.
Table 2: SWRv Calculations

<table>
<thead>
<tr>
<th>CDA ID</th>
<th>Paved SF</th>
<th>Compacted SF</th>
<th>Natural SF</th>
<th>Total SF</th>
<th>P IN</th>
<th>Stormwater Retention Volume (SWRv)</th>
</tr>
</thead>
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</tr>
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<td>4,780</td>
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<td>1.2</td>
<td>470</td>
</tr>
</tbody>
</table>

4 PROPOSED DESIGN

The proposed design aims to meet the project goals through the installation of bioretention basins, sand seepage berms, riffle grade control structures and post and wattle structures. Additionally, the proposed design recommends utilizing a subsoiler to reduce soil compaction and improve infiltration within existing fields.

4.1 Bioretention

Bioretention Basins were located within numerous site locations based on their stormwater treatment and aesthetic values, versatility, and adaptability to site constraints. Due to the lack of infiltration testing results, Biohabitats has assumed that all bioretention features are considered to be “enhanced with an underdrain” design, as defined within the DOEE Stormwater Management Guidebook.

In addition to the standard bioretention design, Biohabitats has incorporated a shallow ponding shelf within multiple Bioretention areas. The intent of the ponding shelf is to allow a smaller footprint for the bioretention media by providing a large, shallow area that will be accessed by ponding during larger storm events. Because the ponding shelf is not intended to take credit for infiltration that may occur within its area, it can be sodded and receive heavy foot traffic. This has the added benefit of allowing park visitors and activities to utilize the ponding shelf area, outside of larger storm events.

4.2 Sand Seepage Berms

In the design plans, berms are graded perpendicular to concentrated flows to hold diverted storm flows in the adjacent floodplain. The berms are constructed of clean sand and wood chips to act as a filter bed. Berm dimensions are typically 1 foot in height with variable top widths, gradual side slopes (i.e. 10:1) and 6-inch sand lift of variable length. The wide top widths and gradual side slopes make the berms conducive to pedestrian traffic, where applicable. Following the topographic and tree surveys, placement of berms will be determined based on minimizing impacts to trees and pedestrian areas.

The berms are able to pond storm flows directed from the parking lots and to hold these diverted waters. This forces the water to take a longer flowpath, as well as create temporary ponding, infiltration,
transpiration, and seepage. In this manner, the berms will attenuate storm flows, increase time of concentration, and increase subsurface flows of the site by restoring the shallow groundwater table.

### 4.3 Riffle Grade Control Structures

Riffle Grade Controls consist of a series of riffles and/or cascades and shallow aquatic pools and native vegetation that safely attenuates and conveys storm flow, and converts stormwater to groundwater through infiltration and shallow groundwater seepage. The riffle grade controls may be constructed of logs and/or cobbles and may include a sand seepage layer to increase stormwater treatment. Selection of construction materials and inclusion of a sand seepage layer will be determined following topographic and tree surveys.

#### Sand Seepage Layer

Starting at a location of concentrated stormwater, the structures set water surface elevations at each pool and establish the hydraulic head necessary to drive the sand seepage system and support the vegetation. If utilized, the sand seepage bed is constructed by filling the existing eroded stream channel with clean sand and hardwood chips to function as a filtering bed. Structures (riffles or boulder cascades) provide grade control for the stable conveyance of storm flows.

These systems are effective at flow attenuation and can be designed to reduce runoff to mimic predevelopment, wooded condition in some situations, converting all surface flow inputs into shallow groundwater flows that discharge as seeps to the receiving stream or wetland. A full range of typical stormwater management criteria, including: groundwater recharge, volume reduction, water quality, channel protection, and flood control can be achieved by the systems, yet are also designed to be stable enough to convey flows associated with events up to and including the extreme floods (i.e. 100-year storm) in a non-erosive manner, which results in reduced channel erosion impacts commonly associated with stormwater practice outfalls and receiving waters. Because of the integration of vegetation and rock structures, the system is mostly self-maintaining. The expected benefits would include storm water quality and quantity control over a range of storm flows, enhanced habitat, and enhanced aesthetic appeal.

As of this concept submission, stormwater treatment has not be determined for proposed riffle grade control structures.

### 4.4 Post and Wattle Structures

Within the forested areas west of the parking lot, eroded gully’s have begun to form due to concentrated flows originating at storm drain outfalls. The proposed restoration design calls for a low impact approach to minimize impacts to existing riparian forests and the groundwater seeps that are habitat for the federally endangered Hay’s Spring Amphipod. Within these gullies a series of post and wattle structures will be placed to slow concentrated flows and spread the flow out of the eroded channels, promoting additional shallow subsurface interactions to benefit the Hay’s Spring Amphipod habitat. The post and wattle structures consist of 2 rows of a series of approximately 7-foot-long 3” diameter wooden posts that are driven into the stream bed. Branches are woven in-between the posts to provide a matrix of material for trapping sediment and debris. In between the two rows of posts, branches will be placed. The specific locations of the post and wattle structures will determined when field topographic survey is completed.

### 4.5 Subsoiler

Soils in green spaces with heavy pedestrian and/or traffic, such as ball fields and overflow parking areas, can become deeply compacted over time. This compaction of green spaces results in reduced rainwater absorption and infiltration capacities and reduced the health of surrounding vegetation (eg. grass, shrubs, trees, etc.). Typical aeration practices intended to reduce compaction and restore the soil's hydraulic
characteristics only penetrate a few inches into the topsoil and do not address the compaction of soil layers that typically develop 12-22 inches below the surface.

The proposed application of a subsoiler to "fracture" these compacted layers that develop within the 12-22 inches below the surface have been found to dramatically increase the hydraulic characteristics (soil moisture, infiltration capacity, etc.) of the open green spaces. A recent study on the benefits of subsoiler application (Schwartz, 2016) estimated that the use of subsoiling reduced the Effective Curve Number (ECN) and Runoff Coefficient (Rv) of an urban athletic field from 87.4 and 0.52 to 43.7 and 0.016 respectively. A conversion of this magnitude in ECN and Rv values was determined to relate closest to the forested condition for pollutant loading rates, as identified in the Chesapeake Bay Watershed Model (v5.3.0), and therefore used as the post subsoiling rates.

Additionally, under the DOEE Stormwater Management Guidebook, these green spaces area considered “compacted” drainage areas. Based on this categorization, the total area of each athletic field is given a runoff coefficient of 0.25 and thus an equivalent required SWRv of 8,145 gallons per acre of athletic field. The runoff coefficient of 0.25 accounts for the compaction levels within these areas that greatly reduce the initial abstraction and infiltration of rainfall prior to developing runoff from the site. In comparison, “natural” areas are given a runoff coefficient value of 0.00 when calculating the required SWRv. Based on these definitions, conversion of athletic fields to a “natural” soil and rainfall capture capacity could yield an equivalent SWRv treated of 8,145 gallons per acre.

Pollutant Removals for the subsoiler are calculated by comparing the existing conditions nutrient loading rates for the athletic fields with the post-subsoiler application nutrient loading rates, assumed to have the hydrologic characteristics of a forested condition.

4.6 Stormwater Treatment
Biohabitats has calculated stormwater treatment (Retention Value and Pollutant Removals) for the bioretention basins, sand seepage berms, and subsoiler applications. Pending the topographic survey, Biohabitats may also present treatment credits for the riffle grade control structures. Table 3 below provides a summary of the treatment calculations, while Appendix B includes full calculations for the proposed BMPs. Table 3 presents of summary of the treatment credits.

4.6.1 Retention Value
Biohabitats calculated retention values for the bioretention basins and sand seepage berms based on the storage volumes provided within the ponding areas and media for each structure. Bioretention Basins were assumed to be “enhanced with an underdrain” until soil testing can be completed. For the storage calculations, Bioretention and Sand Seepage Media were given a porosity of 0.25 while stone within the bioretention reservoir was given a porosity of 0.4.

4.6.2 Pollutant Removals
Pollutant removal rates were calculated using the retrofit removal adjuster curves as defined in the "Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects" (Chesapeake Stormwater Network, 2015). In this methodology, the removal rates for Total Phosphorus (TP), Total Nitrogen (TN), and Total Suspended Solids (TSS) are calculated from a series of predefined "retrofit removal curves" for each BMP. For the District of Columbia, Biohabitats has calculated the runoff depth treated from the Stormwater Retention Volume (SWRv) and the BMPs Storage Volume using the following equation. The precipitation (P) used to calculate the SWRv throughout the project site equals 1.2 inches.

\[
\text{Runoff Treated (in)} = \frac{\text{SWRv(cf)} \times P \text{ (in)}}{Sv \text{ (cf)}}
\]
<table>
<thead>
<tr>
<th>BMP</th>
<th>BMP Type</th>
<th>Type</th>
<th>SWRv</th>
<th>Sv</th>
<th>Runoff Treated</th>
<th>TP Load Reduction</th>
<th>TN Load Reduction</th>
<th>TSS Load Reduction</th>
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<td>1-1</td>
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<td>2,347</td>
<td>2,381</td>
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<td>3.22</td>
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<td>1.51</td>
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</table>
APPENDIX A  EXISTING CONDITIONS DATA

USDA NRCS Custom Soil Resource Report for District of Columbia, Rock Creek Park Tennis Center

Rock Creek Park Flow Patterns Redlines (Courtesy of Steve Saari of DOEE)
The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)
Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.
Soil Survey Area: District of Columbia
Survey Area Data: Version 10, Sep 19, 2016
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.
Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.
## Hydrologic Soil Group

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<th>Map unit symbol</th>
<th>Map unit name</th>
<th>Rating</th>
<th>Acres in AOI</th>
<th>Percent of AOI</th>
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<td>BdB</td>
<td>Beltsville silt loam, 0 to 8 percent slopes</td>
<td>C</td>
<td>4.2</td>
<td>1.7%</td>
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<tr>
<td>BtB</td>
<td>Brandywine-Urban land complex, 0 to 8 percent slopes</td>
<td>A</td>
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<td>2.3%</td>
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<td>6.0%</td>
</tr>
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<td>CcC</td>
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<td>8.0</td>
<td>3.3%</td>
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<tr>
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<td>B</td>
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<td>0.4%</td>
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<tr>
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<td>B</td>
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<td>6.9%</td>
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<td>B</td>
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<td>7.0%</td>
</tr>
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</table>
Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition
Component Percent Cutoff: None Specified
Tie-break Rule: Higher
Assumed Boundaries of the Limit of Disturbed Area

Legend
- Limit of disturbance
- Water
- Rock Creek Boundary

Produce by Rock Creek Park
October 2014
APPENDIX B    TREATMENT CALCULATIONS

- Stormwater Retention Volume Calculations
- Bioretention Basin Design Calculations
- Sand Seepage Berms Design Calculations
- Pollutant Removal Calculations
**Stormwater Retention Volume (SWRv)**

"Regulated sites that undergo a major land-disturbing activity or a major substantial improvement activity must employ BMPs and post-development land cover necessary to achieve the stormwater retention volume (SWRv) equal to the post-development runoff from the applicable rainfall event, as measured for a 24-hour storm with a 72-hour antecedent dry period. For a major substantial improvement activity located in the AWDZ, governed by the Anacostia Waterfront Environmental Standards Amendment Act of 2012, the applicable rainfall event is the 85th percentile rainfall event (1.0 inches). For all other major substantial improvement activities throughout the District, the applicable rainfall event is the 80th percentile rainfall event (0.8 inches)." (DDOE Stormwater Management Guidebook. July, 2013)

The SWRv is calculated as follows for the entire site and for each drainage area:

\[
SWRv = P \times \left[ (RvI \times AI) + (RvC \times AC) + (RvN \times AN) \right] / AT
\]

where:
- \( P \) = variable percentile rainfall event for the District dependent on regulatory trigger (1.2 inches)
- \( RvI = 0.95 \) (runoff coefficient for impervious cover)
- \( RvC = 0.25 \) (runoff coefficient for compacted cover)
- \( RvN = 0.00 \) (runoff coefficient for natural cover)
- \( AI \) = Area of site in impervious cover (square feet)
- \( AC \) = Area of site in compacted cover (square feet)
- \( AN \) = Area of site in natural cover (square feet)
- \( AT \) = Total area of site (square feet)
- 12 = conversion factor, converting inches to feet

**SUMMARY TABLE**

<table>
<thead>
<tr>
<th>CDA ID</th>
<th>Paved SF</th>
<th>Compacted SF</th>
<th>Natural SF</th>
<th>Total SF</th>
<th>P</th>
<th>SWRv Volume (SWRv) CF</th>
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<td>150,146</td>
<td>1.2</td>
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</tbody>
</table>
### DA 1-1

**Step 1:** Calculate SWRv

\[ SWRv = P \times \left( Rv_I \times A_I + (Rv_C \times A_p) + (Rv_N \times A_N) \right) / A_I / 12 \]

\[ SWRv = 1.2 \times \left( 24700 \times 0.95 \right) + (0 \times 0.25) + (0 \times 0) / 24700 \]

\[ SWRv = 2,347 \text{ cubic feet} \]

### DA 1-2

**Step 1:** Calculate SWRv

\[ SWRv = P \times \left( Rv_I \times A_I + (Rv_C \times A_p) + (Rv_N \times A_N) \right) / A_I / 12 \]

\[ SWRv = 1.2 \times \left( 13160 \times 0.95 \right) + (7025 \times 0.25) + (0 \times 0) / 20185 \]

\[ SWRv = 1,426 \text{ cubic feet} \]

### DA 1-3

**Step 1:** Calculate SWRv

\[ SWRv = P \times \left( Rv_I \times A_I + (Rv_C \times A_p) + (Rv_N \times A_N) \right) / A_I / 12 \]

\[ SWRv = 1.2 \times \left( 59560 \times 0.95 \right) + (0 \times 0.25) + (0 \times 0) / 59560 \]

\[ SWRv = 5,658 \text{ cubic feet} \]

### DA 1-4

**Step 1:** Calculate SWRv

\[ SWRv = P \times \left( Rv_I \times A_I + (Rv_C \times A_p) + (Rv_N \times A_N) \right) / A_I / 12 \]

\[ SWRv = 1.2 \times \left( 78520 \times 0.95 \right) + (0 \times 0.25) + (0 \times 0) / 78520 \]

\[ SWRv = 7,459 \text{ cubic feet} \]

### DA 1-5

**Step 1:** Calculate SWRv

\[ SWRv = P \times \left( Rv_I \times A_I + (Rv_C \times A_p) + (Rv_N \times A_N) \right) / A_I / 12 \]

\[ SWRv = 1.2 \times \left( 55500 \times 0.95 \right) + (20275 \times 0.25) + (88450 \times 0) / 164225 \]

\[ SWRv = 5,779 \text{ cubic feet} \]

### DA 1-6

**Step 1:** Calculate SWRv

\[ SWRv = P \times \left( Rv_I \times A_I + (Rv_C \times A_p) + (Rv_N \times A_N) \right) / A_I / 12 \]

\[ SWRv = 1.2 \times \left( 18380 \times 0.95 \right) + (0 \times 0.25) + (0 \times 0) / 18380 \]

\[ SWRv = 1,746 \text{ cubic feet} \]

### DA 1-7

**Step 1:** Calculate SWRv

\[ SWRv = P \times \left( Rv_I \times A_I + (Rv_C \times A_p) + (Rv_N \times A_N) \right) / A_I / 12 \]

\[ SWRv = 1.2 \times \left( 16970 \times 0.95 \right) + (0 \times 0.25) + (13490 \times 0) / 30460 \]

\[ SWRv = 1,612 \text{ cubic feet} \]

### DA 2-1

**Step 1:** Calculate SWRv

\[ SWRv = P \times \left( Rv_I \times A_I + (Rv_C \times A_p) + (Rv_N \times A_N) \right) / A_I / 12 \]

\[ SWRv = 1.2 \times \left( 22780 \times 0.95 \right) + (0 \times 0.25) + (35200 \times 0) / 57980 \]

\[ SWRv = 2,164 \text{ cubic feet} \]

### DA 3-1

**Step 1:** Calculate SWRv
\[ SWR_v = P \times \frac{[(Rv_i \times A_i) + (Rv_c \times A_p) + (Rv_n \times A_n)]}{A_t} / 12 \]

### DA 4-1

**Step 1: Calculate \( SWR_v \)**

\[ SWR_v = 1.2 \times \frac{[(10360 \times 0.95) + (0 \times 0.25) + (32840 \times 0)]}{43200} \]

\[ SWR_v = 984 \text{ cubic feet} \]

### DA 5-1

**Step 1: Calculate \( SWR_v \)**

\[ SWR_v = 1.2 \times \frac{[(6060 \times 0.95) + (0 \times 0.25) + (5560 \times 0)]}{11620} \]

\[ SWR_v = 576 \text{ cubic feet} \]

### DA 6-1

**Step 1: Calculate \( SWR_v \)**

\[ SWR_v = 1.2 \times \frac{[(4310 \times 0.95) + (2420 \times 0.25) + (0 \times 0)]}{6730} \]

\[ SWR_v = 470 \text{ cubic feet} \]

### DA 7-1

**Step 1: Calculate \( SWR_v \)**

\[ SWR_v = 1.2 \times \frac{[(17380 \times 0.95) + (61880 \times 0.25) + (0 \times 0)]}{79260} \]

\[ SWR_v = 3,198 \text{ cubic feet} \]

### DA 7-2ss

**Step 1: Calculate \( SWR_v \)**

\[ SWR_v = 1.2 \times \frac{[(0 \times 0.95) + (239650 \times 0.25) + (0 \times 0)]}{239650} \]

\[ SWR_v = 5,991 \text{ cubic feet} \]
**Bioretention Basins**

Bioretention Basins capture and store stormwater runoff and pass it through a filter bed of engineered soil media composed of sand, soil, and organic matter. Filtered runoff may be collected and returned to the conveyance system, or allowed to infiltrate into the soil. There are two different types of bioretention design configurations:

- **Standard Designs.** Practices with a standard underdrain design and less than 24 inches of filter media depth. If trees are planted using this design, the filter media depth must be at least 24 inches to support the trees.
- **Enhanced Designs.** Practices with underdrains that contain at least 24 inches of filter media depth and an infiltration sump/storage layer or practices that can infiltrate the design storm volume in 72 hours.

Storage Volumes within a Bioretention Basin have been calculated using the following equation from the DDOE Stormwater Management Guidebook (July, 2013):

![Equation]

\[
S_{\text{tank}} = \frac{V_{\text{surf}} \cdot \eta_{\text{surf}} + V_{\text{grv}} \cdot \eta_{\text{grv}} + \left( \frac{V_{\text{insmp}} \cdot \eta_{\text{insmp}}}{2} \right)}{\eta_{\text{maxp}}}
\]

Where:
- \( S_{\text{tank}} \): total storage volume of bioretention (ft³)
- \( V_{\text{surf}} \): bottom surface area of bioretention (ft²)
- \( \eta_{\text{surf}} \): effective porosity of the filter media (typically 0.25)
- \( V_{\text{grv}} \): depth of the underdrain and underlying storage gravel layer (ft)
- \( \eta_{\text{grv}} \): effective porosity of the gravel layer (typically 0.4)
- \( V_{\text{insmp}} \): storage surface area of bioretention (ft²)
- \( \eta_{\text{insmp}} \): typically, where \( S_{\text{insmp}} \) is the top surface area of the bioretention basin.
- \( \eta_{\text{maxp}} \): maximum ponding depth of bioretention (ft)

**SUMMARY TABLE**

<table>
<thead>
<tr>
<th>BMP</th>
<th>Bioretention Version</th>
<th>Contributing Drainage Area ID</th>
<th>SWRv (1.2&quot;)</th>
<th>Infiltration Rate</th>
<th>Ponded Shelf Area</th>
<th>Bioretention Area</th>
<th>Ponding (Over Shelf)</th>
<th>Ponding (Over Bio)</th>
<th>Bioretention Soil Media + Stone Sump</th>
<th>Storage Volume</th>
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### Bioretention Calculations

**BMP 1-1**  
**Step 1:** Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)  
**Step 4:** Check Sv vs SWRv of Drainage Area  

\[
\begin{align*}
SA::CDA & = 1095.24700 \\
SA::CDA & = 4.4% \\
R_v CDA & = \text{Value from DDOT Summary Data Spreadsheet} \\
R_v CDA & = 0.95
\end{align*}
\]

*From DDOT Table 3.21 for SA::CDA & RvCDA Above*  
**Max. Filter Media Depth** = 36 inches

**Step 2:** Select Ponding & Media Depths+ based on Site Constraints  
- \(d_{ponding} = 12.0\) inches  
- \(d_{media} = 18.0\) inches  
- \(d_{store} = 24.0\) inches

**Step 3:** Calculate Storage Volume  
\[
S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{store} \times \eta_{store})] + (SA_{bottom} \times d_{ponding-hel} + SA_{store} \times d_{ponding-hel})
\]

\[
S_v = 1095 \times [(1.5 \times 0.25) + (2 \times 0.4)] + (1095 \times 1 + 0 \times 0)
\]

\[
S_v = 2,881 \text{ cubic feet}
\]

**BMP 1-2**  
**Step 1:** Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)  
**Step 4:** Check Sv vs SWRv of Drainage Area  

\[
\begin{align*}
SA::CDA & = 1061.20185 \\
SA::CDA & = 5.3% \\
R_v CDA & = \text{Value from DDOT Summary Data Spreadsheet} \\
R_v CDA & = 0.71
\end{align*}
\]

*From DDOT Table 3.21 for SA::CDA & RvCDA Above*  
**Max. Filter Media Depth** = 36 inches

**Step 2:** Select Ponding & Media Depths+ based on Site Constraints  
- \(d_{ponding} = 12.0\) inches  
- \(d_{media} = 18.0\) inches  
- \(d_{store} = 24.0\) inches

**Step 3:** Calculate Storage Volume  
\[
S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{store} \times \eta_{store})] + (SA_{bottom} \times d_{ponding-hel} + SA_{store} \times d_{ponding-hel})
\]

\[
S_v = 1061 \times [(1.5 \times 0.25) + (2 \times 0.4)] + (1061 \times 1 + 1430 \times 0.25)
\]

\[
S_v = 2,665 \text{ cubic feet}
\]

**BMP 1-4**  
**Step 1:** Determine Max. Filter Depth from SA::CDA & RvCDA (Table 3.21)  
**Step 4:** Check Sv vs SWRv of Drainage Area  

\[
\begin{align*}
SA::CDA & = 4892.78520 \\
SA::CDA & = 6.2% \\
R_v CDA & = \text{Value from DDOT Summary Data Spreadsheet} \\
R_v CDA & = 0.95
\end{align*}
\]

*From DDOT Table 3.21 for SA::CDA & RvCDA Above*  
**Max. Filter Media Depth** = 42 inches

**Step 2:** Select Ponding & Media Depths+ based on Site Constraints  
- \(d_{ponding} = 12.0\) inches  
- \(d_{media} = 18.0\) inches  
- \(d_{store} = 24.0\) inches

**Step 3:** Calculate Storage Volume  
\[
S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{store} \times \eta_{store})] + (SA_{bottom} \times d_{ponding-hel} + SA_{store} \times d_{ponding-hel})
\]

\[
S_v = 4892 \times [(1.5 \times 0.25) + (2 \times 0.4)] + (4892 \times 1 + 0 \times 0)
\]

\[
S_v = 10,639 \text{ cubic feet}
\]
**BMP 1-5**

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)  
Step 4: Check Sv vs SWRv of Drainage Area

\[
\begin{align*}
SA: CDA &= 1164:164225 \\
SA: CDA &= 0.7% \\
R_v: CDA &= \text{Value from DDOT Summary Data Spreadsheet} \\
R_v: CDA &= 0.35
\end{align*}
\]

**From DDOT Table 3.21 for SA:CDA & RvCDA Above**

**Max. Filter Media Depth** = 72 inches

Step 2: Select Ponding & Media Depths+ based on Site Constraints

\[
\begin{align*}
d_{\text{ponding}} &= 12.0 \text{ inches} \\
d_{\text{media}} &= 18.0 \text{ inches} \\
d_{\text{snow}} &= 24.0 \text{ inches}
\end{align*}
\]

Step 3: Calculate Storage Volume

\[
\begin{align*}
S_v &= SA_{\text{bottom}} \times [(d_{\text{media}} \times \eta_{\text{media}}) + (d_{\text{snow}} \times \eta_{\text{snow}})] + (SA_{\text{bottom}} \times d_{\text{ponding}}} + SA_{\text{roof}} \times d_{\text{ponding}}} \\
S_v &= 1164 \times [(1.5 \times 0.25) + (2 \times 0.4)] + (1164 \times 1 + 4650 \times 0.25) \\
S_v &= 3694 \text{ cubic feet}
\end{align*}
\]

**BMP 1-6**

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)  
Step 4: Check Sv vs SWRv of Drainage Area

\[
\begin{align*}
SA: CDA &= 716:18380 \\
SA: CDA &= 3.9% \\
R_v: CDA &= \text{Value from DDOT Summary Data Spreadsheet} \\
R_v: CDA &= 0.95
\end{align*}
\]

**From DDOT Table 3.21 for SA:CDA & RvCDA Above**

**Max. Filter Media Depth** = 60 inches

Step 2: Select Ponding & Media Depths+ based on Site Constraints

\[
\begin{align*}
d_{\text{ponding}} &= 12.0 \text{ inches} \\
d_{\text{media}} &= 18.0 \text{ inches} \\
d_{\text{snow}} &= 36.0 \text{ inches}
\end{align*}
\]

Step 3: Calculate Storage Volume

\[
\begin{align*}
S_v &= SA_{\text{bottom}} \times [(d_{\text{media}} \times \eta_{\text{media}}) + (d_{\text{snow}} \times \eta_{\text{snow}})] + (SA_{\text{bottom}} \times d_{\text{ponding}}} + SA_{\text{roof}} \times d_{\text{ponding}}} \\
S_v &= 716 \times [(1.5 \times 0.25) + (3 \times 0.4)] + (716 \times 1 + 0 \times 0) \\
S_v &= 1844 \text{ cubic feet}
\end{align*}
\]

**BMP 1-7**

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)  
Step 4: Check Sv vs SWRv of Drainage Area

\[
\begin{align*}
SA: CDA &= 589:30460 \\
SA: CDA &= 1.9% \\
R_v: CDA &= \text{Value from DDOT Summary Data Spreadsheet} \\
R_v: CDA &= 0.53
\end{align*}
\]

**From DDOT Table 3.21 for SA:CDA & RvCDA Above**

**Max. Filter Media Depth** = 72 inches

Step 2: Select Ponding & Media Depths+ based on Site Constraints

\[
\begin{align*}
d_{\text{ponding}} &= 12.0 \text{ inches} \\
d_{\text{media}} &= 24.0 \text{ inches} \\
d_{\text{snow}} &= 24.0 \text{ inches}
\end{align*}
\]

Step 3: Calculate Storage Volume

\[
\begin{align*}
S_v &= SA_{\text{bottom}} \times [(d_{\text{media}} \times \eta_{\text{media}}) + (d_{\text{snow}} \times \eta_{\text{snow}})] + (SA_{\text{bottom}} \times d_{\text{ponding}}} + SA_{\text{roof}} \times d_{\text{ponding}}} \\
S_v &= 589 \times [(2 \times 0.25) + (2 \times 0.4)] + (589 \times 1 + 0 \times 0) \\
S_v &= 1355 \text{ cubic feet}
\end{align*}
\]

---

Bioretention Calculations - Page 6
BMP 2-1

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

<table>
<thead>
<tr>
<th>SA:CDA</th>
<th>1178.57980</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_v CDA</td>
<td>2.0%</td>
</tr>
</tbody>
</table>

\[ R_v CDA = \text{Value from DDOT Summary Data Spreadsheet} \]

From DDOT Table 3.21 for SA:CDA & RvCDA Above

Max. Filter Media Depth = 36 inches

Step 2: Select Ponding & Media Depths+ based on Site Constraints

\[ d_{ponding} = 12.0 \text{ inches} \]
\[ d_{media} = 18.0 \text{ inches} \]
\[ d_{Grow} = 24.0 \text{ inches} \]

Step 3: Calculate Storage Volume

\[ S_v = \left( \text{SA bottom} \times (\text{d}_{media} \times \eta_{media}) + (d_{Grow} \times \eta_{Grow}) \right) + \left( \text{SA bottom} \times d_{ponding} \times \eta_{ponding} \right) \]

\[ S_v = 1178 \times (1.5 \times 0.25) + (2 \times 0.4) + (1178 \times 1 + 0 \times 0) \]

\[ S_v = 2562 \text{ cubic feet} \]

BMP 3-1

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

<table>
<thead>
<tr>
<th>SA:CDA</th>
<th>287:43200</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_v CDA</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

\[ R_v CDA = \text{Value from DDOT Summary Data Spreadsheet} \]

From DDOT Table 3.21 for SA:CDA & RvCDA Above

Max. Filter Media Depth = #N/A inches

Step 2: Select Ponding & Media Depths+ based on Site Constraints

\[ d_{ponding} = 12.0 \text{ inches} \]
\[ d_{media} = 24.0 \text{ inches} \]
\[ d_{Grow} = 36.0 \text{ inches} \]

Step 3: Calculate Storage Volume

\[ S_v = \left( \text{SA bottom} \times (\text{d}_{media} \times \eta_{media}) + (d_{Grow} \times \eta_{Grow}) \right) + \left( \text{SA bottom} \times d_{ponding} \times \eta_{ponding} \right) \]

\[ S_v = 287 \times (2 \times 0.25) + (3 \times 0.4) + (287 \times 1 + 0 \times 0) \]

\[ S_v = 775 \text{ cubic feet} \]

BMP 4-1

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

<table>
<thead>
<tr>
<th>SA:CDA</th>
<th>235:11620</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_v CDA</td>
<td>2.0%</td>
</tr>
</tbody>
</table>

\[ R_v CDA = \text{Value from DDOT Summary Data Spreadsheet} \]

From DDOT Table 3.21 for SA:CDA & RvCDA Above

Max. Filter Media Depth = 48 inches

Step 2: Select Ponding & Media Depths+ based on Site Constraints

\[ d_{ponding} = 12.0 \text{ inches} \]
\[ d_{media} = 24.0 \text{ inches} \]
\[ d_{Grow} = 24.0 \text{ inches} \]

Step 3: Calculate Storage Volume

\[ S_v = \left( \text{SA bottom} \times (\text{d}_{media} \times \eta_{media}) + (d_{Grow} \times \eta_{Grow}) \right) + \left( \text{SA bottom} \times d_{ponding} \times \eta_{ponding} \right) \]

\[ S_v = 235 \times (2 \times 0.25) + (2 \times 0.4) + (235 \times 1 + 0 \times 0) \]

\[ S_v = 541 \text{ cubic feet} \]
### BMP 5-1

**Step 1:** Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

\[
SA: CDA = 411:32970
\]

\[
SA: CDA = \frac{1.2}{100}\%
\]

\[
R_{v,CDA} = \text{Value from DDOT Summary Data Spreadsheet}
\]

\[
R_{v,CDA} = 0.31
\]

**Step 4:** Check Sv vs SWRv of Drainage Area

\[
S_v: SWRv = 1274:1037
\]

\[
S_v: SWRv = 123\%
\]

**From DDOT Table 3.21 for SA:CDA & RvCDA Above**

**Max. Filter Media Depth** = 66 inches

**Step 2:** Select Ponding & Media Depths+ based on Site Constraints

\[
d_{p,\text{ponding}} = 12.0\text{ inches}
\]

\[
d_{\text{media}} = 24.0\text{ inches}
\]

\[
d_{\text{snow}} = 48.0\text{ inches}
\]

**Step 3:** Calculate Storage Volume

\[
S_v = \left[ SA_{bottom} \times \left[ \left( d_{\text{media}} \times \eta_{\text{media}} \right) + \left( d_{\text{snow}} \times \eta_{\text{snow}} \right) \right] + \left( SA_{bottom} \times d_{\text{ponding-hw}} \times SA_{\text{depth}} \times d_{\text{ponding-hw}} \right) \right]
\]

\[
S_v = 411 \times [(2 \times 0.25)+(4 \times 0.4)] + (411 \times 1 + 0 \times 0)
\]

\[
S_v = 1,274 \text{ cubic feet}
\]

### BMP 6-1

**Step 1:** Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

\[
SA: CDA = 226:6730
\]

\[
SA: CDA = \frac{3.4}{100}\%
\]

\[
R_{v,CDA} = \text{Value from DDOT Summary Data Spreadsheet}
\]

\[
R_{v,CDA} = 0.7\%
\]

**Step 4:** Check Sv vs SWRv of Drainage Area

\[
S_v: SWRv = 705:470
\]

\[
S_v: SWRv = 150\%
\]

**From DDOT Table 3.21 for SA:CDA & RvCDA Above**

**Max. Filter Media Depth** = 48 inches

**Step 2:** Select Ponding & Media Depths+ based on Site Constraints

\[
d_{p,\text{ponding}} = 12.0\text{ inches}
\]

\[
d_{\text{media}} = 24.0\text{ inches}
\]

\[
d_{\text{snow}} = 24.0\text{ inches}
\]

**Step 3:** Calculate Storage Volume

\[
S_v = \left[ SA_{bottom} \times \left[ \left( d_{\text{media}} \times \eta_{\text{media}} \right) + \left( d_{\text{snow}} \times \eta_{\text{snow}} \right) \right] + \left( SA_{bottom} \times d_{\text{ponding-hw}} \times SA_{\text{depth}} \times d_{\text{ponding-hw}} \right) \right]
\]

\[
S_v = 226 \times [(2 \times 0.25)+(2 \times 0.4)] + (226 \times 1 + 744 \times 0.25)
\]

\[
S_v = 705 \text{ cubic feet}
\]

### BMP 7-1

**Step 1:** Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

\[
SA: CDA = 1217:79260
\]

\[
SA: CDA = \frac{1.5}{100}\%
\]

\[
R_{v,CDA} = \text{Value from DDOT Summary Data Spreadsheet}
\]

\[
R_{v,CDA} = 0.4\%
\]

**Step 4:** Check Sv vs SWRv of Drainage Area

\[
S_v: SWRv = 3491:3198
\]

\[
S_v: SWRv = 109\%
\]

**From DDOT Table 3.21 for SA:CDA & RvCDA Above**

**Max. Filter Media Depth** = 60 inches

**Step 2:** Select Ponding & Media Depths+ based on Site Constraints

\[
d_{p,\text{ponding}} = 12.0\text{ inches}
\]

\[
d_{\text{media}} = 18.0\text{ inches}
\]

\[
d_{\text{snow}} = 24.0\text{ inches}
\]

**Step 3:** Calculate Storage Volume

\[
S_v = \left[ SA_{bottom} \times \left[ \left( d_{\text{media}} \times \eta_{\text{media}} \right) + \left( d_{\text{snow}} \times \eta_{\text{snow}} \right) \right] + \left( SA_{bottom} \times d_{\text{ponding-hw}} \times SA_{\text{depth}} \times d_{\text{ponding-hw}} \right) \right]
\]

\[
S_v = 1217 \times [(1.5 \times 0.25)+(2 \times 0.4)] + (1217 \times 1 + 3378 \times 0.25)
\]

\[
S_v = \text{3,491 cubic feet}
\]
Sand Seepage Berms
Sand seepage berms are constructed of clean sand and wood chips to act as a filter bed. Berm dimensions are typically 1 foot in height with variable top widths, gradual side slopes (i.e. 10:1) and 6-inch sand lift of variable length. The wide top widths and gradual side slopes make the berms conducive to pedestrian traffic, where applicable. The berms will provide microtopography throughout the landscape. Grading in the vicinity of the berms will be roughened to provide additional microtopography variations. Following the topographic and tree surveys, placement of berms will be determined based on minimizing impacts to trees and pedestrian areas.

The berms are able to pond storm flows directed from the parking lots and to hold these diverted waters. This forces the water to take a longer flow path, as well as create temporary ponding, infiltration, transpiration, and seepage. In this manner, the berms will attenuate storm flows, increase time of concentration, and increase subsurface flows of the site by restoring the shallow groundwater table.

Storage volumes for stormwater treatment are calculated by assuming a 0.25 porosity of the filter media.

### SUMMARY TABLE

<table>
<thead>
<tr>
<th>BMP</th>
<th>Drainage Area ID</th>
<th>SWRv (1.2&quot;)</th>
<th>Infiltration Rate</th>
<th>Areas</th>
<th>Depths</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CF</td>
<td>CF</td>
<td>Ponding SF</td>
<td>Berms SF</td>
</tr>
<tr>
<td>1-3</td>
<td>1-3</td>
<td>5,685</td>
<td>0.200</td>
<td>3,000</td>
<td>20,000</td>
</tr>
</tbody>
</table>

### Calculations

**Step 1:** Select Ponding & Media Depths based on Site Constraints

\[
\begin{align*}
\text{d}_{\text{ponding}} &= 12.0 \text{ inches} \\
\text{d}_{\text{media}} &= 6.0 \text{ inches}
\end{align*}
\]

**Step 2:** Calculate Storage Volume

\[
\begin{align*}
S_v &= (SA_{\text{media}} \times d_{\text{media}} \times n_{\text{media}}) + (SA_{\text{ponding}} \times d_{\text{ponding}}) \\
S_v &= \frac{(20000 \times 6 \times 0.25) + (3000 \times 12)}{12} \\
S_v &= 5,500 \text{ cubic feet}
\end{align*}
\]
Pollutant Removals - Bioretention, Sand Seepage

Pollutant removal rates are calculated using the retrofit removal adjuster curves as defined in the “Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects” (Chesapeake Stormwater Network, 2015). In this methodology, the removal rates for Total Phosphorus (TP), Total Nitrogen (TN), and Total Suspended Solids (TSS) are calculated from a series of predefined “retrofit removal” within each BMP. For the District of Columbia, Biohabitats has calculated the runoff depth treated from the Stormwater Retention Volume (SWRv) and the BMPs Storage Volume using the following equation. The precipitation (P) used to calculate the SWRv throughout the project site equals 1.2 inches.

\[
Runoff\ Treated\ (in) = \frac{SWRv (cf) \times P (in)}{Sv (cf)}
\]

Pollutant Removals - Subsoiler

Pollutant Removals for the subsoiler are calculated by comparing the existing conditions nutrient loading rates for the athletic fields with the post-subsoiler application nutrient loading rates, assumed to have the hydrologic characteristics of a forested condition. A recent study on the benefits of subsoiler application (Schwartz, 2016) estimated that the use of subsoiling reduced the Effective Curve Number (ECN) and Runoff Coefficient (Rv) of an urban athletic field from 87.4 and 0.52 to 43.7 and 0.016 respectively. A conversion of this magnitude in ECN and Rv values was determined to relate closest to the forested condition for pollutant loading rates, as identified in the Chesapeake Bay Watershed Model (v5.3.0), and therefore used as the post subsoiling rates.

<table>
<thead>
<tr>
<th>Pollutant Loading Rates</th>
<th>Urban (Impervious) lbs/ac/yr</th>
<th>Previous Urban (Impervious) lbs/ac/yr</th>
<th>Forested lbs/ac/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>TN</td>
<td>10.85</td>
<td>9.41</td>
<td>3.16</td>
</tr>
<tr>
<td>TP</td>
<td>2.04</td>
<td>0.57</td>
<td>0.19</td>
</tr>
<tr>
<td>TSS</td>
<td>0.44</td>
<td>0.07</td>
<td>0.02</td>
</tr>
</tbody>
</table>

SUMMARY TABLE

<table>
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<tr>
<th>BMP</th>
<th>BMP Type</th>
<th>TOP</th>
<th>CDA ID</th>
<th>SWRv CF</th>
<th>Sv CF</th>
<th>Runoff Treated IN</th>
<th>TP Load lbs/yr</th>
<th>TN Load lbs/yr</th>
<th>TSS Load tons/yr</th>
<th>TP Removal %</th>
<th>TN Removal %</th>
<th>TSS Removal %</th>
<th>TP Load Reduction lbs/yr</th>
<th>TN Load Reduction lbs/yr</th>
<th>TSS Load Reduction tons/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>Bioretention</td>
<td>RR</td>
<td>1-1</td>
<td>2,347</td>
<td>2,381</td>
<td>1.22</td>
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<td>63</td>
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<td>59</td>
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<td>Subsoiler</td>
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<td>NA</td>
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<td>57</td>
<td>1.51</td>
<td>21.45</td>
<td>0.14</td>
</tr>
</tbody>
</table>
APPENDIX C  PHOTO LOG

Image C-1: Eroding Gully (4/10/2017)

Image C-2: Location of BMP 1-2 (4/10/2017)

Image C-3: Location of BMP 1-3 (4/10/2017)

Image C-4: Location of BMP 7-1 (4/10/2017)
Image C-5: BMP 7-1 Flow Patterns
(5/11/2017, Courtesy of DOEE)

Image C-6: BMP 1-2 Flow Patterns
(5/11/2017, Courtesy of DOEE)

Image C-7: BMP 1-1 Flow Patterns
(5/11/2017, Courtesy of DOEE)

Image C-8: BMP 1-3 Flow Patterns
(4/15/2017, Courtesy of DOEE)