# 1.0 Regenerative Stormwater Conveyance

## 1.1 Description

Regenerative Stormwater Conveyances (RSCs) are a type of Best Management Practice (BMP) intended to simultaneously convey and treat stormwater runoff, often down a naturally occurring slope. The practice, also known as a Step Pool Storm Conveyance (SPSC) System, consists of bioretention-like cells proceeding in series down a slope that convey and treat stormwater runoff. RSCs are essentially a way to combine stream restoration and site development stormwater treatment techniques to maximize treatment and minimize erosive channel flow. The BMP consists of level pools, connected by sloped cobble sections, and all underlain with a sand/wood chip layer that runs the length of the BMP and acts like an underdrain (United States Patent No. Pub. US 2009/0290936 A1, 2009). The outlet of each pool is a grade control structure typically constructed of cobble and anchored by boulders. Each pool discharges to a cobbled riffle section that slopes downward to the next pool. As runoff enters the practice, it is subject to infiltration into the subgrade, enters the sand/wood chip layer and eventually discharges from the bottom of the practice after filtering through the sand/wood chip layer, or is conveyed over the cobble riffles through successive pools, giving pollutants opportunity to settle out before being discharged from the last pool. The runoff left in each pool at the end of the storm seeps into the sand/wood chip layer and either infiltrates into the subgrade or is discharged through the downstream end of the practice.

## 1.2 Applicability

RSCs may be used at any point in a treatment train. Because they do not include the use of a riser structure with multi-stage outlet control, they are not well-suited for achieving water quantity control objectives for multiple design storms. RSCs are constructed on a slope and have small pools, therefore their detention capacity is low even when utilizing more complex outlet structures. However, when combined with a dry detention pond or other BMP better suited for quantity control, they can be a valuable part of the treatment train and significantly reduce the necessary size of quantity control BMPs. Similar to a bioretention practice, RSCs perform better if pretreatment is provided to remove some of the sediment load from the runoff before entering the RSC. Therefore, one of the most effective uses of an RSC is as a treatment measure downstream of a quantity control BMP to stabilize the outfall and site discharge while providing water quality treatment.

To install RSCs on a site, two characteristics must be present: a slope and sufficient area. When slopes are less than 10%, the practice can perform both conveyance and water quality treatment functions, but when applied to steeper slopes, the water quality treatment capability is reduced to accommodate the increased need for channel protection against higher flow velocities. However, depending on the nature of the planting plan and type of channel protection materials used, even an RSC on a steep slope may be a more aesthetic, and therefore better, choice for a particular site than more traditional methods of conveyance.

## 1.3 Design

The mechanisms employed for pollutant removal are settling, infiltration, filtration, and plant uptake, with filtration and infiltration providing the most removal. Design RSCs to fit the natural topography and complement the surrounding landscape. RSCs can be used to replace other forms of stormwater conveyance, and may be used as outfall protection or further upstream in a treatment train. It is unlikely that a designer will be able to meet the water quantity requirements for multiple design storms with an RSC alone, so the designer should consider ways to use it in conjunction with quantity control BMPs.

A summary of the design characteristics for RSCs is shown in Table 1.

Overall Longitudinal Slope	Not specified, but typically up to 10%	
System Configuration	Typically pools followed by riffle weir grade control structures that are half the length of the pool. Cascades may be utilized where the slope exceeds 5%.	
Depth of Pools	1.5 – 3 feet	
Width of Pools and Grade Control Structures	8 – 20 feet; pools and grade control structures must have equal widths.	
Thickness of Sand/Wood Chip Bed	1.5-foot minimum under pools (deeper elsewhere)	
Drainage Time	Design pools to draw down in no more than 24 hours and sand/wood chip filter bed to drain within 72 hours.	
Maintenance	Primarily vegetation management and replacing stones if needed.	

Table 1: General Design	Characteristics	for	RSCs
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## 1.3.1 Site Layout

RSC design consists of two main priorities: effectively conveying flow from the 10-year, 24-hour storm and providing the desired level of pollutant reduction through infiltration, filtration, and settling. After laying out the pools, grade control structures, and cascades, ensure the design safely conveys the 10-year storm, and then design the RSC to meet water quality requirements.

- 1. First, map the proposed path of the RSC on a topographic map. Whenever possible, RSCs follow the natural drainage of the site. Minimize impacts to existing natural features and vegetation. Avoid placing RSCs in entrenched channels; instead, fill and elevate the channel bed to produce a gentler slope and connection to the floodplain. Maximize the length of the system for maximum water quality benefit.
- 2. Measure the length of the RSC and the change in elevation. Figures 1 and 2 show example profiles of RSC designs, respectively without and with a cascade structure.



Figure 1: Typical Profile – Alternating Pools and Riffles



Figure 2: Cascade Profile- Three Pools Following Cascade

- 3. If the slope is less than 5%, then determine the number of control structures and pools: there is one pool for every foot of elevation drop across the length of the system (see Figure 1). If the overall slope exceeds 5%, one or more boulder cascades are needed for traversing the grade (see Figure 2). Use the following to determine the required number of boulder cascades:
  - Multiple cascades may be required along the length of the project to traverse steeper grades.
  - Place boulder cascades at a maximum of 50% slope (2H:1V).
  - A maximum 5 feet of vertical drop from the top of the cascade to the lowest point in the downstream pool is permitted for cascades with a 50% slope. Longer cascades at a flatter slope may be used in accordance with the cascade design chart (Table 2).
  - Use three consecutive pools separated by boulder weir grade control structures at the same elevation following a cascade. Each pool is at least 10 feet long.

Cascade Elevation Drop (ft)	Maximum Allowable Cascade Slope (ft/ft)	Minimum Required Cascade length (ft)
4	0.5	8
5	0.5	10
6	0.4	15
7	0.3	23
8	0.2	40
9	0.1	90
> 10	0.1	> 100

Table 2: Cascade Dimension Requirements	Table 2:	Cascade	Dimension	Requirements
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4. After determining the number and length of boulder cascades necessary, re-draw the RSC system on the topographic map indicating where the cascades and pools will be placed. Then check to see if the rest of the system has a slope of 5% or less. If not, then more cascades are necessary.

### 1.3.2 Sizing Criteria

1. If the slope(s) of the remaining section(s) of RSC are 5% or less, use the following equation to determine the length of each of the pools,  $L_{pool}$ , and length of the grade control structures,  $L_{GCS}$ . These lengths are based on the length of the RSC system,  $L_{system}$  (excluding any cascades and their associated pools), and the change in elevation,  $\Delta E_{system}$ . Pools are twice the length of the grade control structures, and each pool is followed by a single grade control structure.

$$L_{pool} = \frac{\binom{L_{system}}{\Delta E_{system}}}{1.5}$$
$$L_{GCS} = \frac{\binom{L_{system}}{\Delta E_{system}}}{3} = 2 * L_{pool}$$

- 2. Once the system is fully located, the grade control structures are sized. Determine the peak flow that is generated by the 10-year storm event. This flow corresponds with the maximum flow expected at any point in the system in the case of lateral inflow or multiple inflow points. The following instructions are for a typical grade control structure. If the designer wishes to create smaller control structures for some of the upper pools because of lower peak inflow during the 10-year storm, each structure must be designed with the following process. No infiltration or other losses within the RSC are considered.
- 3. Design the typical cross-section for the riffle/weir/cascade and pool channel segments. The grade control structures, which are parabolic in shape (see Figure 3), must convey the peak flow generated by the 10-year storm event in a stable manner. Using the iterative process below, determine the width and depth of the grade control structures and the required size of the material to construct them:
  - The riffle/weir/cascade and pool channels are parabolic in shape. See Figure 3.
  - Begin the design of the grade control structures using a cobble size  $(d_{50})$  of 6 inches. This cobble size should be generally available (e.g. Class A Riprap).
  - Set the depth of the cobble material to  $2 * d_{50}$ .
  - Determine a trial width ( $W_{GCS}$ ) and depth ( $D_{GCS}$ ) for the grade control structures. The width is the dimension perpendicular to the flow, and the depth is the maximum depth of the parabolic channel at that width (see Figure 3). The width of the grade control structures is: a) 10 times the depth of the grade control structures, and b) a minimum of 8 feet.



Figure 3: Typical Width, Depth, and Depth of Stone for Grade Control (Riffle) Sections

• Determine the allowable peak velocity of flow through the RSC System. This can be done using Manning's formula for the velocity of uniform flow. This is an iterative design process. Spreadsheets can be used to streamline the calculations.

$$V_{10-yr} = \frac{1.49}{n * (R_h)^{2/3} * (S)^{1/2}}$$

Where:

 $V_{10-yr}$  = velocity of flow associated with 10-yr storm (ft/s) n = Manning's roughness coefficient using equation below  $R_h$  = hydraulic radius of grade control structure (ft) using equation below S = slope in direction of flow over the riffle/cobble weir (ft/ft).

Use n = 0.05 for boulder cascades or the following equation for cobble riffle sections:

$$n = \frac{d_{10-yr}^{1/6}}{\left(21.6 * \log\left(\frac{d_{10-yr}}{d_{50}}\right) + 14\right)}$$

Where

 $d_{10-yr}$  = depth of flow in the riffle/weir channel associated with 10-year flow (ft)  $d_{50}$  = median cobble diameter (ft)

For a parabola:

$$R_{h} = \frac{2 * w_{10-yr}^{2} * d_{10-yr}}{\left(3 * w_{10-yr}^{2}\right) + \left(8 * d_{10-yr}^{2}\right)}$$

Where:

 $w_{10-yr}$  = top width of flow in the cross section associated with 10-year flow (ft)  $d_{10-yr}$  = depth of flow in the riffle channel associated with 10-year flow (ft)

• Ensure that the size of the stone cobble is capable to withstand the calculated allowable velocity. This is checked using the Isbash formula below (NRCS, 2007).

Max. Allowable Velocity = 
$$C * \left(2g * \frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{0.5} * d_{50}^{0.5}$$

Where:

C = 0.86 for prevailing supercritical flow and 1.2 for prevailing subcritical flow

- g = gravity = 32.2 (ft<sup>2</sup>/sec)
- $\gamma_s =$  stone density (lb/ft<sup>3</sup>)
- $\gamma_w =$  water density = 62.4 (lb/ft<sup>3</sup>)

 $d_{50}$  = median size of cobble stone diameter (ft)

If the calculated maximum allowable velocity is equal to or greater than the velocity determined using Manning's equation, then the designed riffle/weir structure width, depth, and cobble size are acceptable.

If this velocity is less than the velocity determined using Manning's equation, then adjust the riffle/weir structure width, depth, and/or cobble size is and re-check. The spreadsheet provided as a design aid has been populated with these formulas and makes the iterative process quicker. Table 3 provides stone size distribution specifications for typical median stone ( $d_{50}$ ) sizes.

Median Stone Size, d₅₀ (in)	Typical Stone Diameter (in)	% of Material Smaller than Typical Stone	Typical Stone Weight (Ibs)
	2	2-10	0.4
6	6	35-50	10
0	9	50-70	35
	12	70-100	85
	3	2-10	1.3
0	9	35-50	35
y	12	50-70	85
	15	70-100	160
12	4	2-10	3
	12	35-50	85
	18	50-70	275
	21	70-100	440
	6	2-10	10
18	18	35-50	275
	24	50-70	650
	30	70-100	1,280
	9	2-10	35
24	24	35-50	650
24	33	50-70	1,700
	42	70-100	3,500

**Table 3: Cobble Gradation Specifications** 

4. Using the following equation, check to ensure that the RSC System is adequate to convey the peak flow generated by the 10-year, 24-hour storm event:

$$Q = V_{10-yr} * A_{flow,10-yr}$$

Where

velocity of flow through the grade control structure during 10-year storm (ft/s)

 $A_{flow, 10-yr} =$  cross-sectional area of flow through the grade control structure during 10-year storm (ft<sup>2</sup>)

For a parabola:

 $V_{10-yr} =$ 

$$A_{flow,10-yr} = \frac{2}{3} * d_{10-yr} * w_{10-yr}$$

Where

 $w_{10-yr}$  = top width of flow in the riffle channel associated with 10-year flow (ft)  $d_{10-yr}$  = depth of flow in the riffle channel associated with 10-year flow (ft)

If the peak flow generated by the 10-year event exceeds the capacity of the system, increase the width and/or depth of the grade control structures and repeat Step 3 of this section.

- 5. Using the results of Steps 3 and 4 of this section, determine the remaining dimensions of the RSC: pool width and depth, and sand/wood chip bed width and depth. This can be accomplished by modeling the RSC in IDEAL iteratively until the desired trapping efficiency is attained. IDEAL modeling guidelines are in Section 1.6.
- 6. Several limits are placed on the design:
  - The pool width is equal to the width of the top of the grade control structures.

- The depth of the pool must be at least 1.5 feet and can be no more than 3 feet. The side slopes on the pool are 3H:1V or flatter.
- The sand/wood chip bed has a minimum depth of 1.5 feet below the pool bottom and a minimum width of 4 feet. The bed should be continuously-sloped on its bottom, such that the depth of this layer will vary depending on the location in the system.
  - The sand/wood chip bed consists of a mixture of 80% sand and 20% wood chips by volume, and is located beneath the entire length of the RSC System continuously.
  - Place a Class 2 nonwoven geotextile fabric beneath the sand/wood chip bed to stabilize the sand/wood chip bed.
- Ensure that the sand/wood chip bed (and pools) drain completely within 72 hours.

### 1.3.3 System Configuration

- 1. Using a topographic map with a maximum 1-foot contours, position the sand/wood chip bed, and bank run gravel layers along the path of the RSC System. Starting with the outlet pool, position each pool and grade control structure along the path of the RSC System.
- 2. Next, position the first grade control structure/cobble riffle immediately upstream of the outlet pool. The elevation of the bottom invert of the grade control structure is set to the elevation of the top of the outlet pool. The grade control structure rises 1-foot over its length, making its top invert elevation 1-foot higher than its bottom invert elevation.
- 3. Place a footer boulder at the downstream end of the grade control structure. Place the upstream face of the footer boulder to match the downstream face of the grade control structure. Place the top of the footer boulder at an elevation that is 6 inches below the top of the outlet pool (see Figure 4).
- 4. Place additional boulders to form the downstream end of the grade control structure. Place the downstream face of the boulders to match the position of the upstream face of the footer boulder (Figure 4). Extend the boulders, in a parabolic shape, across the width of the RSC System. The boulders should be placed at a depth of at least 6-inches into the existing soil, and underlain with a Class 2 non-woven geotextile fabric.



Figure 4: Typical Position of Weir Boulders in Relation to Riffles and Pools

5. Place cobble to form the remainder of the grade control structure. Extend the cobble across the width and remaining length of the grade control structure. Place the cobble to the depth of the grade control structures (in cross-section view) determined in Step 3 of Section 1.3.2 (Sizing Criteria), with a top invert elevation that is 1-foot greater than the bottom invert elevation. The cobble forms a parabolic shape when viewed in the cross section, to match the parabolic boulder weir and control flow as calculated in Section 1.3.2.

- 6. Below the grade control structure, position a cobble apron to provide a stable flow path from the bottom invert of the grade control structure to the bottom of the downstream pool when the pools are dry. The cobble apron is as wide as the grade control structure and extend to the bottom of the pool.
- 7. Position the second pool above the first grade control structure. Set the elevation of the top of the pool equal to the elevation of the top invert of the first grade control structure.
- 8. Repeat Steps 2-7 of this section, positioning grade control structures and pools until the starting point of the RSC System is reached. Set the elevation of the entry pool (and the elevation of the top invert of the upstreammost grade control structure) at an elevation causing slight backwater at the inlet pipe, culvert or swale. As noted in Step 3 of Section 1.3.1 (Site Layout), one or more cascades may be necessary to traverse steeper parts of the RSC flow path.

### 1.3.4 Material Requirements

- 1. Top dress the sides (outside the main flow path) of the RSC System with topsoil or compost and an appropriate temporary cover and permanent cover seed mix. Include stabilization, seeding, and top dressing notes on the design plans (see Section 1.3.4 for planting plan requirements).
- 2. Use materials meeting all specifications of Table 4.

Material/Use	Requirements	
Boulders for grade control structures	Sandstone or granite. Class 3 rip rap or larger. All boulders must be underlain with filter fabric.	
Cobble for grade control structures/riffles	Gradation according to Table 3.	
	AASHTO-M-6 or ASTM-C-33, 0.02 – 0.04 inches in size.	
Sand for sand/wood chip underlayer mix	Substitutions such as Diabase, Graystone (AASHTO) #10, calcium carbonate, dolomitic sand, and rock dust <u>are not acceptable</u> .	
	Target minimum coefficient of permeability is $K = 4.0$ feet/day (2 in/hr).	
	Native soil may be used instead of imported sand/wood chip mix if site tested infiltration rates of all soil used is greater than 2 inches/hour.	
Wood chips for sand/ wood chip layer	Double-ground hardwood chips	
Compost	Minimum 4-inch layer of compost throughout disturbed area (except in pools) with pH between 5 and 8.	

### Table 4: Material Specifications for RSC Systems

### 1.3.5 Plantings

Pool bottoms and side slopes should be permanently stabilized with either stone or permanent vegetation. Vegetation in the pool areas should be capable of withstanding periodic inundation and drought. All disturbed areas should be permanently stabilized with grass, native grass, perennials, shrubs, and/or other plants.

## 1.4 Construction Requirements

Do not construct RSC systems until all contributing drainage areas are stabilized as directed by the engineer. Do not use RSC systems as sediment control facilities for sediment control during construction. Do not operate heavy equipment within the perimeter of RSC areas during excavation, backfilling, planting, or mulching.

### 1.4.1 Site Preparation

Do not install RSCs on sites where the contributing area is not completely stabilized or is periodically being disturbed. If possible, providing pretreatment will reduce the maintenance needs of the RSC and should be installed before the RSC is brought online.

## 1.4.2 Excavation

Excavate the RSC to the dimensions, side slopes, and elevations shown on the Plans.

Ensure excavation minimizes the compaction of the bottom of the RSC. Operate excavators and backhoes on the ground adjacent to the RSC or use low ground-contact pressure equipment. Do not operate heavy equipment on the bottom of the RSC area. Remove excavated materials from the RSC and dispose of them properly.

### 1.4.3 Sand/Wood Chip Mixture Placement

Prior to placing the sand/wood chip mixture, alleviate compaction on the bottom of the RSC by using a primary tilling operation such as a chisel plow, ripper, or subsoiler to a depth of 12 inches. Substitute methods must be approved by the engineer. Rototillers typically do not till deep enough to reduce the effects of compaction from heavy equipment. Test the installed sand/wood chip media to determine the actual infiltration rate after placement.

The engineer must ensure the infiltration rate is greater than 2 inches per hour, or within the parameters of the infiltration rate modeled.

Install observation wells/cleanouts of 6-inch PVC vertically in the each pool. The PVC pipes are perforated at the bottom. Extend the wells/cleanouts from the subgrade to 6 inches above the pool bottom, and cap with a screw cap.

### 1.4.4 Plantings

Plant all RSC area grasses, native grasses, perennials, shrubs, trees, and other plant materials specified to applicable landscaping standards. Ensure all plant materials are kept moist during transport and on-site storage. Thoroughly water all plantings after installation. Brace trees using 2-inch by 2-inch stakes only as necessary. Ensure stakes are equally spaced on the outside of the tree ball.

### 1.4.5 Mulch

Immediately mulch the disturbed area surrounding the RSC to a uniform thickness of 3 inches after all plantings are in place. Do not place mulch in the pools or riffles of the RSC.

## 1.5 Inspection and Maintenance of RSC System

Regular inspection and maintenance is critical to the effective operation of RSC systems. Maintenance responsibility is vested with a responsible authority by means of a legally binding and enforceable maintenance agreement that is executed as a condition of plan approval. Typical maintenance tasks must be performed regularly as shown in Table 7.

Required Maintenance	Frequency
Pruning and weeding.	As needed
Remove trash and debris.	As needed
Inspect inflow points for clogging. Remove any sediment.	Semi-annual (every 6 months)
Repair eroded areas. Re-seed or sod as necessary.	Semi-annual (every 6 months)
Mulch void areas.	Semi-annual (every 6 months)

Required Maintenance	Frequency
Inspect trees and shrubs to evaluate their health.	Semi-annual (every 6 months)
Remove and replace dead or severely diseased vegetation.	Semi-annual (every 6 months)
Removal of evasive vegetation.	Semi-annual (every 6 months)
Nutrient and pesticide management.	Annual, or as needed
Water vegetation, shrubs and trees if necessary.	Semi-annual (every 6 months)
Test filter media for pH.	Annual
If poor vegetation and pH < 5.2, apply lime.	As needed
If poor vegetation and pH > 8.0, add iron sulfate + sulfur.	As needed

## 1.6 IDEAL Modeling

The County's preferred method of demonstrating compliance with its water quality standard is to use the IDEAL model. To facilitate use of this model, Table 8 below shows how to represent this BMP in the IDEAL model. It lists the parameters needed to successfully run the model and the parameters that affect the trapping efficiency of the BMP.

The RSC is different from many other BMPs in that there is not an RSC BMP available in IDEAL. Instead, the designer must model a series of bioretention cells to mimic the individual pools and sand/woodchip mix. For that reason, in addition to 8, use the following method:

- 1. Generally, an RSC system is modeled as a series of bioretention cells, with one bioretention cell used to model each pool. Neither the cobble riffle/grade control structures nor any cascades are modeled as separate BMPs.
- 2. Each bioretention cell has an underdrain that represents the flow through the sand/wood chip layer, media to represent the sand/wood chips mixture and an emergency spillway that acts as the parabolic grade control structure. IDEAL requires a riser input even when no riser will be present in the design, so select a riser height that is significantly higher than the emergency spillway (i.e., 99 feet). This ensures that no flow is allowed to enter the riser.
- 3. In the Cell Characteristics tab, select the size of the cell as the surface area at the bottom of the weir. In IDEAL, the BMP area receives rainfall, so the pervious watershed area surrounding the BMP should not include the area of the BMP itself. The total area of all watersheds and BMPs equals the disturbed area for the project (unless off-site runoff enters, in which case that area should be modeled as well).
- 4. Specify an underdrain, Subgrade Infiltration Parameters, and an Underdrain Flow Restriction Orifice.
  - The Degree of Saturation for the Subgrade is 0.7-0.9.
  - The underdrain is used to mimic the capability of the sand/wood chip mix to convey flow down the RSC system. Therefore, compute the Orifice Diameter to allow approximately the same flowrate as the sand/wood chip layer. To size this orifice diameter, follow the following procedure:

Use Darcy's Law to determine the flow rate through the sand/wood chip mix.

$$Q_{sand} = K * i * A$$

Where:

$Q_{sand} =$	flowrate through sand/wood chip mix (ft <sup>3</sup> /sec)
K =	hydraulic conductivity; use 4.6x10 <sup>-4</sup> (ft/sec) (approximately 2 in/hr)
	(or use actual sand/wood chip layer value if known)
i =	hydraulic gradient = change in elevation divided by length (ft/ft)
A =	cross sectional area of sand at smallest point (below pools) (ft <sup>2</sup> )

Using the equation above, the hydraulic gradient with an elevation drop of 1 ft for a typical profile and length from the upstream end of the pool to the upstream end of the next downstream pool, and the average cross sectional area of the sand/wood chip layer, find the flowrate,  $Q_{sand}$ , through the sand/wood chip media.

Then, use that flowrate, Q, to determine the Diameter of the Underdrain Flow Restricting Orifice,  $D_{underdrain}$ , using Bernoulli's equation. This equation compares elevation, pressure, and velocity heads at two points in the system. Point #1 in the equation below is the bottom of a pool and Point #2 is in the sand/wood chip layer where it passes below the next pool.

$$Z_1 + \frac{p_1}{\rho_1 g} + \frac{{v_1}^2}{2g} = Z_2 + \frac{p_2}{\rho_2 g} + \frac{{v_2}^2}{2g}$$

Where  $p_1$ ,  $v_1$ , and  $p_2 = 0$ , and

$$v_{2} = \frac{Q_{sand}}{A} = \frac{Q_{sand}}{\left(\left(\pi * D_{underdrain}^{2}\right)/4\right)}$$

Where

 $D_{underdrain} =$  underdrain diameter (ft)

Therefore,

$$D_{underdrain} = 0.398 * Q_{sand}^{0.5} * \Delta Z^{-0.25}$$

Or for a typical section with 1-foot elevation drop between pools,

$$D_{underdrain} = 0.398 * Q_{sand}^{0.5}$$

If performing these calculations for a typical section,  $\Delta Z$  will be equal to 1-foot, removing its term from the equation. If modeling a section of RSC that includes a cascade, the  $\Delta Z$  is necessary. This underdrain sizing method will convey approximately the same flowrate from pool to pool as the underlying sand layer in an RSC system.

- 5. Each bioretention cell's outlet is a broad-crested emergency spillway at the stage equal to the lowest stage of the pool's grade control structure (the bottom of the parabola).
- 6. The sand/wood chip mix is modeled in IDEAL as two separate layers of media. The total volume of the layers in the bioretention cell must equal those in the RSC below the pool being modeled *as well as* the cobble riffle/grade control structure.
  - Find the volume of the sand/wood chip mix from the design, making sure to include the volume below the pool and the subsequent riffle. After modeling all pools in IDEAL, all of the sand/wood chip mix should be included in IDEAL.
  - Divide the total volume of media by the area of the bioretention cell in IDEAL. This is the depth.
  - Use two layers, and make the first layer equal to 20% of the depth, selecting Cedar Chips as the media type. Then make the second layer 80% of the depth and select Sand Media. It does not matter which media type is on top, nor does it matter that they are in layers instead of mixed together. Convert the depths to inches before entering into IDEAL.
- 7. In the Riser/Barrel Inputs tab, IDEAL requires the user to create a riser; however, the riser is specified in such a way that it will not convey flow. It is also important to recognize that the barrel will convey flow from the underdrain, so ensure it is not undersized. Therefore, select a circular riser, 99 feet high, with a 24-inch diameter. Give the barrel a 24-inch diameter as well (or a diameter large enough to convey flow from the underdrain system specified), a length of 1-foot, and a Manning's n-value of 0.01. The short length and smooth Manning's n-value ensures that the barrel does not control flow.

- 8. In the Emergency Spillway tab, choose a Broad Crested, Trapezoidal Spillway, with a Height equal to the depth of the pool and a Width equal to the width of the grade control structure.
- 9. Repeat the above process for subsequent pools, connecting each with a non-routed connector.

RSC Modeling in IDEAL			
What to Model as in IDEAL	Series of Bioretention Cells		
Similar BMPs	Step Pool Storm Conveyance System		
Specifications Needed for IDEAL	Pool area and number of poo	Pool area and number of pools	
	Size of grade control structure		
	Volume of sand/wood chip media and equivalent underdrain		
	calculations		
	Shape and dimensions of the riser		
	Direct loading of bacteria that will be entering each cell, if any		
	Feature	How Value Affects Sediment Trapping	
		Efficiency (TE)	
	Underlying Soil Texture	Soils with higher infiltration capabilities	
Parameters that Drive Performance		increase TE	
	Size of pools	Increasing area increases TE	
	Volume of sand/wood chip media	More filtering media will increase TE	

#### Table 8: IDEAL Modeling Guide

## 1.7 References

- Flores, P. H., McMonigle, D., & Underwood, K. (2012, December). Step Pool Storm Conveyance Systems, Rev. 5a. Retrieved from Public Works- Anne Arundel County, MD: http://www.aacounty.org/departments/publicworks/wprp/watershed-assessment-and-planning/step-pool-conveyance-systems/
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