Section 8a is a perquisite to this tutorial. Before starting, designers should complete and understand the Infiltration Pond tutorial in section 8a.

In this example you will learn:

- The design criteria for bioinfiltration ponds.
- The design procedure for drywells.
- An introduction to the UIC guidelines in the HRM and how they apply to drywells.
- How to use StormSHED output to verify the design criteria's is met.

## **Biofiltration Swale Sample Problem Description**

This tutorial will use the sample problem and StormSHED files from Section 8a.

## **Introduction to Bioinfiltration Swales**

Bioinfiltration ponds aka bioinfiltration swales or grass percolation areas, are a combination of grasses and soils used to remove stromwater pollutants by percolation into the ground. These ponds are designed to contain the runoff treatment volume (6 month storm) below the first 6" in the pond. The remaining volume from the pond (25 year storm) will overflow into a higher permeability (flow control) infiltration BMP such as a drywell. *Pretreament should be considered in the design process, to prevent the bioinfiltration pond treatment soil from clogging.* 

Bioinfiltration ponds can be utilized for runoff treatment and flow control. For runoff treatment BMP's, bioinfiltration ponds meet the requirements for basic and enhanced runoff treatment objectives as well as oil control for <u>high-use roads</u>. In order for the flow control criteria to be met, there must be a large area with a shallow water depth otherwise flow control must be implemented using a different BMP.

## **Bioinfiltration Sizing Criteria**

Bioinfiltration pond sizing is the same as for infiltration ponds including the design storm and precipitation values (see Section 8a of this tutorial) with the following exceptions:

- The pond should be designed to hold the <u>volume of stormwater from the 6 month</u> <u>long duration or Type 1A storm in the first 6" of the pond</u>. The remaining volume from the 25 year storm will overflow into a drywell or other infiltration or overflow facility.
- The swale bottom should be flat with a longitudinal slope of less than 1%.
- Bioinfiltration swales should be excavated to a minimum depth 6" below the bottom of the pond until after construction. Post construction the soil should be replaced with top soil that meets the minimum requirements:
  - 1. Contain sufficient organics and texture to ensure good vegetation growth. Also, SSC – 7 requirements for soil characteristics should be followed.
  - 2. For 6" of top soil, infiltration rates shall not exceed 1"/hr. A maximum infiltration rate of 2.4"/hr is allowed, however 18" of top soil must be provided at the bottom of the pond that meets the requirements of the SSC.
  - 3. If the infiltration rate of the native soil is less than that of the top soil, the native soil infiltration rate must be used for the design of the bioinfiltration pond.
- Grasses should drought tolerant or irrigation should be provided.
- Pretreatment should be considered to prevent clogging of the treatment soil and vegetation by debris, TSS, and oil and grease.
- When curb openings are used at the inlet, a concrete or riprap apron should be provided to prevent vegetation from blocking the inlet.



INFILTRATION SWALE

## **Introduction to Drywells**

Drywells are perforated pre-cast concrete manhole structures that are surrounded by drain rock. The primary purpose of a drywell is to discharge stormwater directly into the ground. Drywells can be used alone for flow control where runoff treatment is not required or in combination with a runoff treatment BMP. This tutorial will focus on the use of a drywell as an overflow structure in a bioinfiltration pond.



Standard Plan B-20.20.01 Drywell Type 1 (for Swales)

Drywells are considered a means of subsurface infiltrations and are designed based on the capacity of the subsurface soil conditions. Drywells are practical only in areas where groundwater tables are sufficiently below the bottom of the facility and in highly permeable soil conditions. The design of drywells is regulated by the Underground Injection Control (UIC) Rule, which is intended to protect drinking water. Infiltration systems regulated by the UIC include: drywells, pipe or french drains, drain fields, and other similar devices that are designed to discharge stormwater directly into the ground.

# Design Criteria for Drywells

Drywells should be designed with the following considerations:

- Drywells must meet the UIC requirements outlined in the HRM and be registered with the department of Ecology, see section 4-5.3 of the HRM for further guidance.
- The bottom of the drywell should be a minimum of 5' above the seasonal high ground water level or impervious soil layers.
- Typically drywells are 48" in diameter and approximately 5' (single barrel) to 10' (double barrel) deep.
- A geotextile should be placed on top of the drain rock before the drywell is backfilled to prevent migration of fines into the drain rock.
- When more than one drywell is installed, spacing should be no closer than 30' center-to-center.
- Drywells should not be built on slopes greater than 25% or above landslide hazards. For placement on slopes between 15%-25%, evaluation by a PE with geotechnical expertise is required.

## **Design Procedure for Drywells**

The design procedure for drywells has recently (2004 HRM) changed based on research conducted by Massmann for eastern Washington. In the past, WSDOT followed the Spokane County design methods, which were based on soil types in Spokane County. Through Massman's research, a more accurate design method was found that is based on soil types throughout eastern Washington. The design procedures for drywells are outlined in section 4-5.4.2 of the HRM and summarized below:

1. Estimate the volume of stormwater,  $V_{design}$ .

This step was performed in Tutorial 8a on approximately page 7. The pond volume was determined from the **developed** basin condition and the release rates from the **existing** basin.

2. Follow steps 4 through 5 in the Detailed Approach.

Both steps 4 and 5 involve conducting a geological investigation and collecting the soils data found in Tutorial 8a.

3. Determine the saturated hydraulic conductivity.

This was calculated to be **42in/hr** on approximately page 22 of Tutorial 8a.

4. Estimate the uncorrected steady-state infiltration rate for drywells.

Two equations were developed to estimate the steady-state infiltration rates, one double barrel drywells and the other is for single barrel drywells. The flow rates are based on the saturated hydraulic conductivity and the depth to ground water as shown below:

Double-barrel wells:

$$Q = K [3.5 \ln(D_{wt}) + 12.32]$$

Single-barrel wells:

$$Q = K [1.34 \ln(D_{wt}) + 8.81]$$

Where:

Q = the infiltration rate in cfs

K = the average saturated conductivity in fpm

 $D_{wt}$  = the depth from the bottom of the drywell to groundwater in feet

From Tutorial 8a, the ground elevation is 205' and the depth of groundwater is 191'. Given the 5' required separation between the groundwater depth and the bottom of the drywell, the maximum elevation of the bottom of the drywell is 196'. From that the drywell will need 5' for the single barrel (elevation 201) and 2'4" for the cone and adjustment section (elevation 203.33'). The top of the drywell will be set at elevation 203.33' and the bottom of the pond will be 6" below that or elevation 202.83'. Given the separation requirements, a Single-barrel well is the only option.

$$Q = K[1.34\ln(D_{wt}) + 8.81]$$

$$Q = 42\frac{in}{hr}x\frac{1hr}{60\min}x\frac{1ft}{12in}[1.34\ln(5') + 8.81]$$

$$Q = 0.6394cfs$$

5. Estimate the uncorrected, steady-state infiltration rate for drywells.

If a pretreatment facility is used, then no correction factor is needed. If not, the long term effects of siltation and should be considered by reducing the infiltration rates by a factor of 0.5.

Q = 0.6394 cfsx 0.5 = 0.32 cfs

6. Size the facility.

We now have all the information we need to size the biofiltration swale.

- Using the same StormSHED file from Tutorial 8a, open infiltration 8a and 8b.
- Create a new node called **bioinfiltration** and then select **OK**.

😸 AutoLabel	
Next Auto ID:	
bioir	filtration
,	
Cancel	ок

• Input the description and the elevations as shown below

	Nodes					
bi	oinfiltration	Contrib Draina	ge Areas   Trap			
	Node Type	e B type	Node ID	bioinfiltration	▼.	New Node
	⊂ Vault ⊙ Trap P	ond	Start EL(ft)	202.83	Max EL(ft):	205.00
	C Under	ground Pipe orage	Contrib Area Contrib Hyd	:		•
	C Level	Pool ny Node ound	North (ft) Increment f	or rating curves:	East (ft): 0.10 Void Ratio	0.00 (%) 100

• Select the <u>**Trap**</u> tab and guess the pond dimensions to be <u>**300'x16'**</u> as shown below:



• Select the **OK** button to close the dialog box.

### Create a Discharge Structure for the first 6"

Next we need to size the pond to contain the 6 month storm in pond at a depth of 6", without the dry well.

💀 Control Structures			
bioinfil size Infiltration			
Select Control Type	Control ID:		
Infiltration	bioinfil size	New Control	
	Description:		
	size pond		
	Start El:	Max WS EI over Ctrl	
	202.83	205.00	
	Increment:		
	0.10	Update Control Elevs	

• Input the Control Structures data as shown on the last and next dialog box.

🗄 Control Structures
bioinfil size Infiltration
Infiltration rate to be applied to wetted     surface area of storage structure (in/hr):
C Based on Soil Log/TP Based on Average Saturated Hydraulic Conductivity of:
0 (cm/sec)
Infiltration Rate Reduction Factors
High Potential for Biofouling
□ Avg to High Degree of Long Term Maintenance/Performance Monitoring
Enter groundwater elevation (ft):

• <u>Close</u> the dialog box.

The lab tested the soil in the area where the bioinfiltration swale will be installed and calculated the infiltration to be 3.0 in/hr. However, per the bioinfiltration design criteria the maximum discharge is 2.4in/hr and this requires the bottom of the pond replace 18" of native soil with 18" of topsoil that meet the requirements in the SSC. Therefore in the Control Structures dialog box, 2.4in/hr overrides the calculated 3.0 in/hr. If only 6" of top soil were installed, the corresponding maximum infiltration rate would be 1.0 in/hr.

Create a Level Pool to define the trap pond and discharge structure.

bioinfiltration and drywell       Contrib Drainage Areas       Detention         Node Type       Node ID:       bioinfiltration and drywell       New Node         MH/CB type       Vault       Description:       bioinfiltration pond and drywell       New Node         Trap Pond       Underground Pipe       Start EL(ft):       202.83       Max EL(ft):       205         Stg-Storage       Contrib Hyd:       Image Areas       Image Areas       Image Areas       Image Areas         Output       Noth (ft):       0.00       East (ft):       0.00       Increment for rating curves:       0.10       Void Ratio (%)       100	Hodes	
Node Type       Node ID:       bioinfiltration and drywell       New Node         C       MH/CB type       Description:       bioinfiltration pond and drywell       New Node         C       Vault       Description:       bioinfiltration pond and drywell       202.83       Max EL(ft):       205         C       Underground Pipe       Contrib Area:       Contrib Hyd:       Image: Cont	bioinfiltration and drywell (	Contrib Drainage Areas Detention
Image: Clevel Pool     North (ft):     0.00     East (ft):     0.00       Image: Clevel Pool     Increment for rating curves:     0.10     Void Ratio (%)     100	Node Type MH/CB type Vault Trap Pond Underground Pipe Stg-Storage	Node ID:       bioinfiltration and drywell       New Node         Description:       bioinfiltration pond and drywell         Start EL(ft):       202.83       Max EL(ft):       205         Contrib Area:
	C Dummy Node	North (ft):     0.00     East (ft):     0.00       Increment for rating curves:     0.10     Void Ratio (%)     100

• Input the data as shown on the dialog boxes as shown above and below.

🖷 Nodes				
bioinfiltration and drywell	Contrib Drainage Areas	Detention		
The metphor of a stage-storage and node from which the bioinfiltration	detention pond is used to d a stage discharge rating c he storage rating curve sho	lenote a sing urve can be ould be derive	le entity from which a derived. Select the ed:	
Select the contro derived: bioinfil size	ol structure from which the o	discharge rat	iing cuve can be	
bioinfiltration Select the contro derived: bioinfil size	I structure from which the o	discharge rat	ting cuve can be	

							L.A.
Design Event:	Matching Run	off Hyd:		% of F	Rate		Add
100 year	<ul> <li>existing</li> </ul>			▼ 100.0	0 ±		Delete
	Inflow Hyd/Ba	isin:		Out H	yd:		Stm Dur (h
	new basin			▼ 100 ye	ear out		- 24
Computatio	onal Instructions:						
Design Ev	Matching Hyd/B	%	Inflow Hyd/Basin		Outhyd		Compute
6 month	existing	100.00	new basin		6 month out		-
25 year	existing	100.00	new basin		25 year out		Routing
100 year	existing	100.00	new basin		100 year out		
							Size Out
<							>
Results:							Save Cha
Design Ev	Match Flow (cfs)	Peak	Max Depth (ft)	Detention Vol (cf)	Hrs to Empty (hr)	% Vol	Report
6 month	0.839186	0.322	0.496267	2617.37105	0.50	99.79	
25 year	2.152299	0.492	1.961987	13159.792119	7.333	99.93	☐ Display
100 year	2.659044	0.553	2.46618	17785.758879	10.167	99.93	Large V

### Verify the Pond Design meets the BMP requirements.

- Select the *Pond Design* tab and input the data as shown above.
- Click the <u>**Compute</u>** button and review the data to verify the design criteria is met.</u>

Since the 6 month stormwater elevation is less than 6", the pond size of 300'x12' is sufficient. Now we will repeat the process adding the drywell to the infiltration rate to see if the pond meets the requirements for the 25 and 100 year storms.

• Next create a discharge structure called drywell.

💀 AutoLabel	
Next Auto ID:	
drywell	
Cancel C	к //

• Next input the drywell details as shown below, StormSHED will automatically input the elevations after the stage-discharge table is input.

E Control Structures			
drywell Stage-Discharge Table			
Select Control Type	Control ID:		
Stage-Discharge	drywell	New Control	
	Description:		
	drywell and pond i	nfiltration	
	Start El:	Max WS El over Ctrl	
	202.83	203.34	
	Increment:		
	0.10	Update Control Elevs	

• Select the **<u>Stage-Discharge Table</u>** tab and input the data as shown below.

🔜 Cor	ntrol Structure	S	
drywe	ell Stage-Discl	harge Table	
	Stage	YVal	
	202.83	0	Stage/Discharge Rating Curve
	203.33	0	
	203.34	0.32	Note: Program expects active
*			lowest stage should have zero

These values are only for the drywell. At the bottom of the pond, elevation 202.83 the discharge through the drywell is zero. At elevation 203.33, the top of the drywell there is still no runoff discharging into the drywell. However, once the runoff elevation just tops the drywell or elevation 203.34 runoff will begin to discharge through the drywell.

## **Create a Combo Discharge Structure**

Next we need to create a combination discharge structure that will consider both the infiltration rate of the soil and discharge rate of the drywell.

• Create a *Control Structure* named <u>infildrywell</u> and select the <u>OK</u> button.

AutoLabel	
Next Auto ID:	
infildrywell	
Cancel OK	

• Create a *Control Structure* named <u>infildrywell</u> and select the <u>OK</u> button.

🔡 Control Structures		
infildrywell Combination		
Select Control Type	Control ID:	
Combination 🗨	infildrywell   New Control	
	Description:	
	infiltration and drywell	
	Start El: Max WS El over Ctrl	
	202.83 205	
	Increment:	
	0.10 Update Control Elevs	

- For the <u>Control Type</u> select <u>Combination</u>.
- Input a <u>description</u> and <u>Start El</u> as shown above. The Max elevation will automatically update after the discharge structures are selected.

E Control Structures			
infildrywell Combination			
All Control Structures: bioinfil size drywell infildrywell InfilStgDisc infiltration PROTOTYPE	Add Remove Refresh	Structure to Include: drywell bioinfil size	
🗖 Split total outflow hy	d into control struct	ure components.	

• Select the *Combination* tab and <u>add</u> both the <u>drywell</u> discharge structure and <u>bioinfil size</u> (infiltration rate). Both should appear in the right box titled <u>'Structure to include</u>'.

## **Define the RLPool**

🔜 Nodes	
bioinfiltration and drywell Co	ntrib Drainage Areas Detention
Node Type C MH/CB type C Vault C Trap Pond C Underground Pipe C Stg-Storage C Level Pool	Node ID:       bioinfiltration and drywell       New Node         Description:       bioinfiltration pond and drywell         Start EL(ft):       202.83       Max EL(ft):       205.00         Contrib Area:
C Dummy Node C Compound	Increment for rating curves: 0.10 Void Ratio (%) 100

• Open the existing node called 'bioinfiltration and drywell' as shown above.

- Select the <u>Level Pool</u> for <u>Node Type</u> and input the <u>description</u> and <u>Start El</u> as shown above.
- Select the *Detention* tab and change the discharge structure to **infildrywell**.

🔜 Nodes				
bioinfiltration and drywell	Contrib Drainage Areas	Detention		
The metphor of a c stage-storage and node from which th bioinfiltration Select the contro derived: infildrywell	detention pond is used to d a stage discharge rating c ne storage rating curve sho v I structure from which the o	enote a sing urve can be uld be derive discharge rat	le entity from which a derived. Select the ed: ting cuve can be	

• **Close** the dialog box.

#### Size the Biofiltration Pond

• Open the *Pond Design* tab and select the <u>Compute</u> button. The results should match the dialog box below.

					-		
Design Event	: Matching Run	Matching Runoff Hyd:			Rate		Add
100 year	<ul> <li>existing</li> </ul>			▼ 100.0	0 🛨		Delete
	Inflow Hyd/Ba	isin:		Out H	yd:	Stm Dur (hrs):	
	new basin 💌			▼ 100 ye	ear out	24 🕂	
Computatio	onal Instructions	R.					
Design Ev	Matching Hyd/B	%	Inflow Hyd/Basin		Outhyd		Compute
6 month	existing	100.00	new basin		6 month out		
25 year	existing	100.00	new basin		25 year out		Routing Table
100 year	existing	100.00	new basin		100 year out		Size Outlet
<	×						
							Save Chart
Results:	and the second se	Peak	Max Depth (ft)	Detention Vol (cf)	Hrs to Empty (hr)	% Vol	Report
Results: Design Ev	Match Flow (cfs)	i oure		2617 27105	0.50	99.79	
Results: Design Ev 6 month	Match Flow (cfs) 0.839186	0.322	0.496267	2017.07100		00.00	Display Peak El
Results: Design Ev 6 month 25 year	Match Flow (cfs) 0.839186 2.152299	0.322	0.496267 0.574737	3075.990405	2.333	33.33	
Results: Design Ev 6 month 25 year 100 year	Match Flow (cfs) 0.839186 2.152299 2.659044	0.322 2.872 3.4722	0.496267 0.574737 0.592324	3075.990405 3178.940445	2.333 2.333	99.93	Large Volume
Results: Design Ev 6 month 25 year 100 year	Match Flow (cfs) 0.839186 2.152299 2.659044	0.322 2.872 3.4722	0.496267 0.574737 0.592324	3075.990405 3178.940445	2.333 2.333	99.93	Large Volume Maximum Plot Time:

## **Results**

The bioinfiltration pond is required to have a 1' of freeboard above the 25 year storm and with only a max depth of 0.57' or approximately elevation 203.4, there is 1.6' of freeboard. Checking the 100 year storm, the elevation is nearly identical. Therefore this pond size meets the requirement.