

## WinSLAMM v 10.3 Biofiltration

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## We will cover . . .

- **Biofilter Design Concepts and Issues**
- **Biofilter Model Algorithms**
- **Entering Biofilter Data into the Model**



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## Modeling Notes

- **Control practice used to model:**
  - **Biofilters**
  - **Rain Gardens**
  - **Infiltration Fields**
  - **Infiltration Trenches**



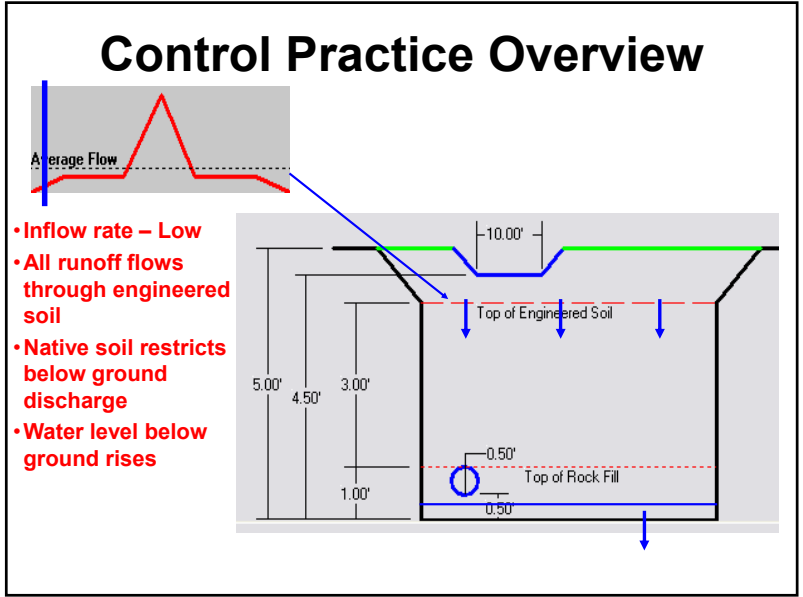
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## Modeling Notes

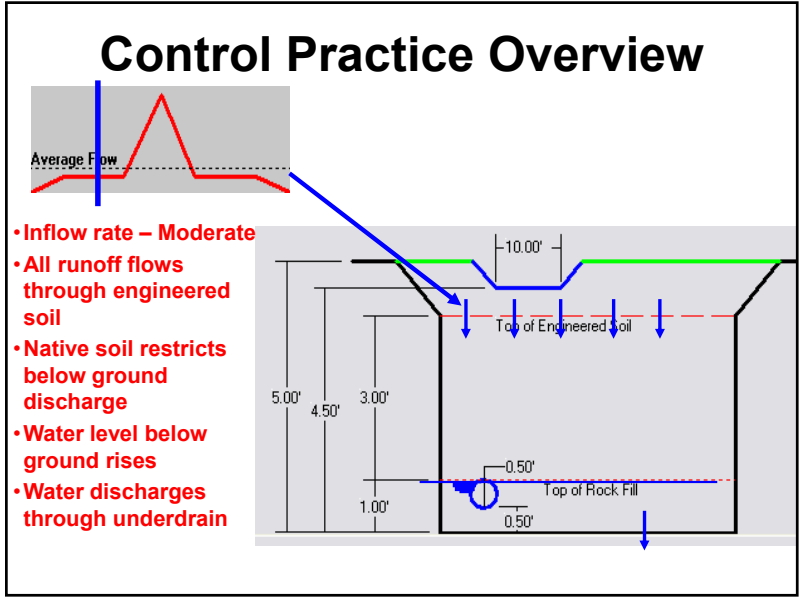
- **Biofilter routing is performed using the Modified Puls Storage – Indication Method.**
- **Time increments are established by the user – default = 6 minutes**
- **Yield reductions due to runoff volume reduction through infiltration and filtering through engineered soil**



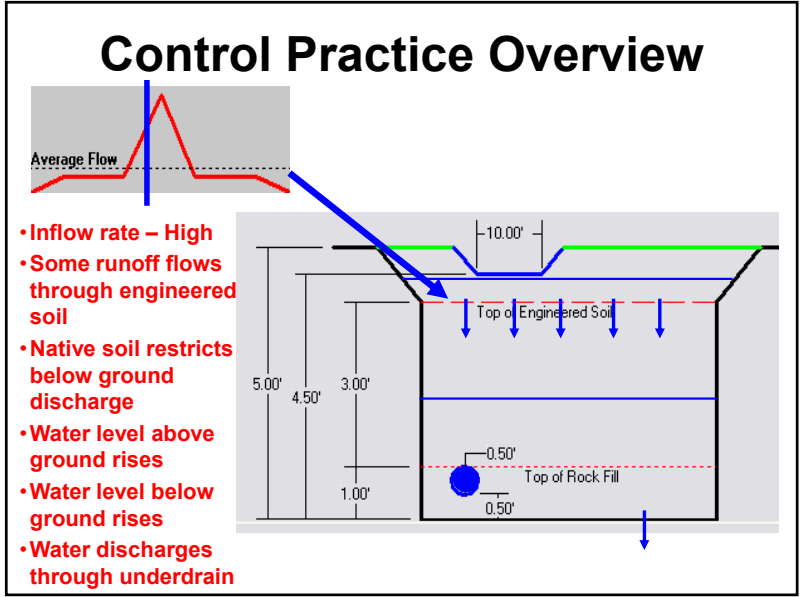
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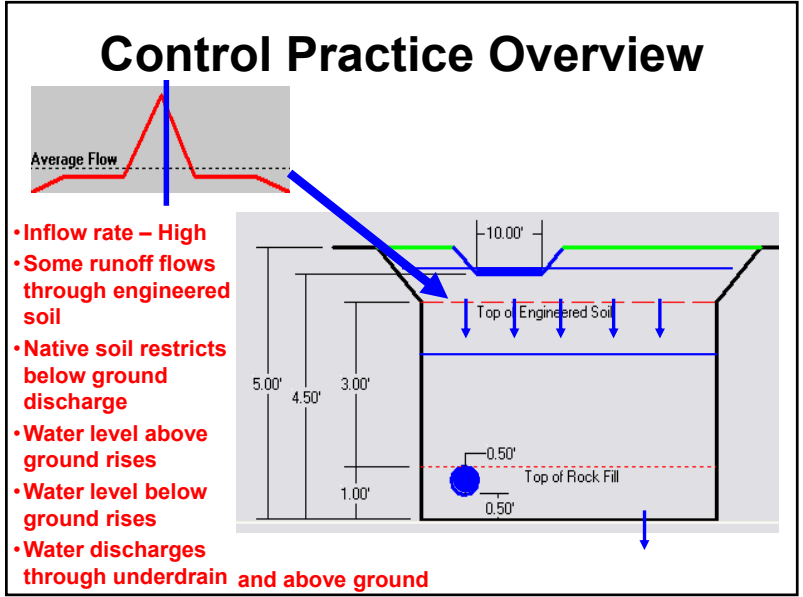
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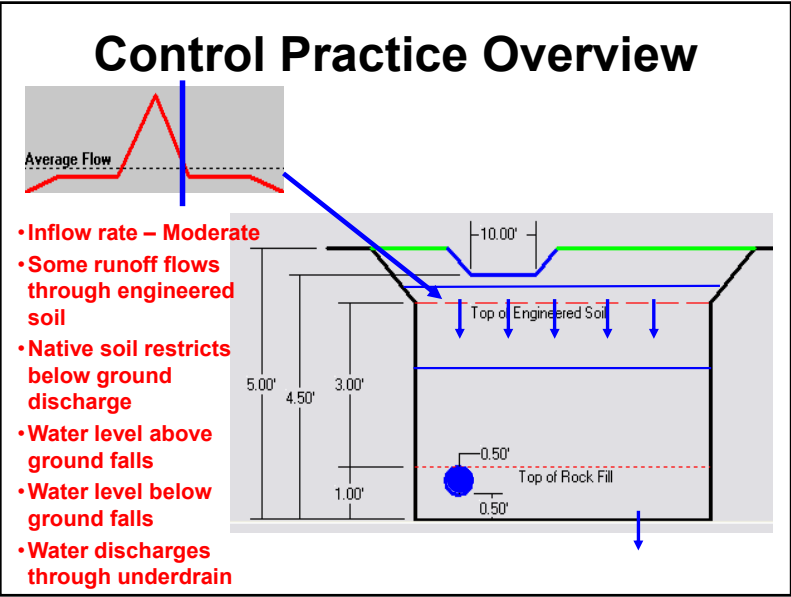
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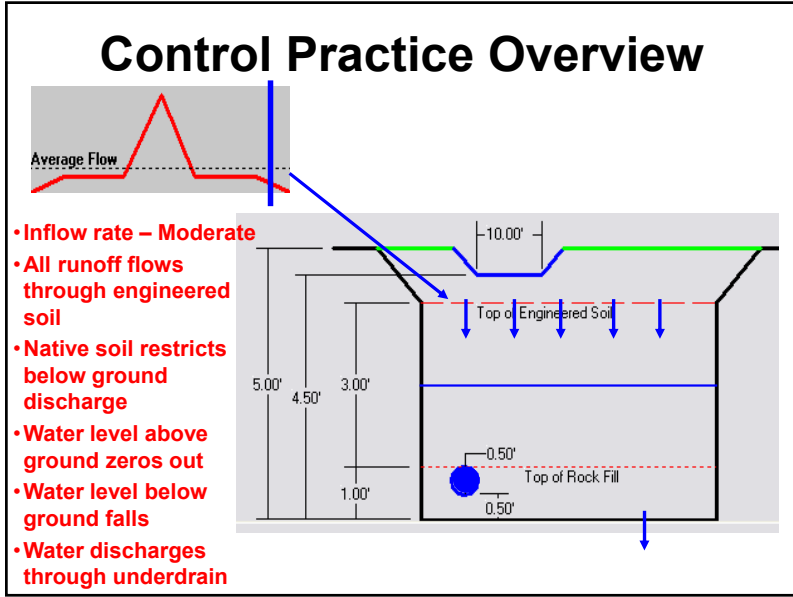
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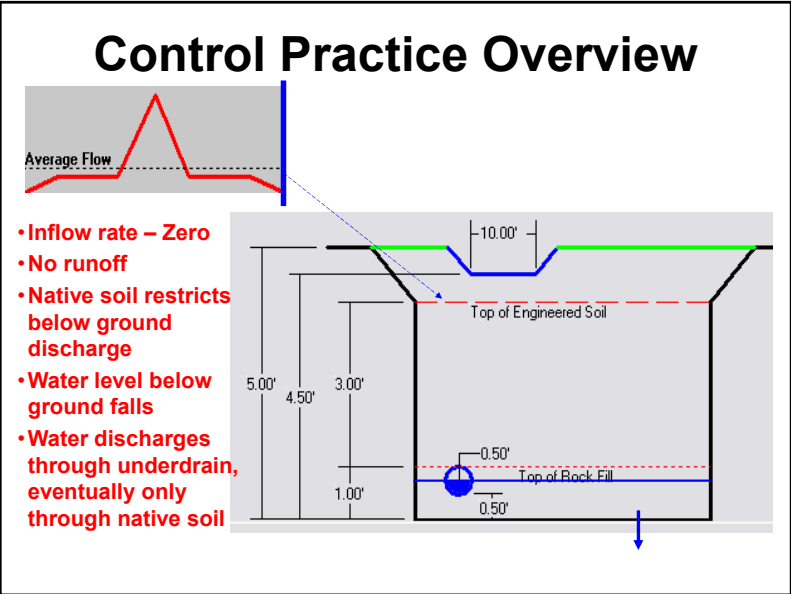
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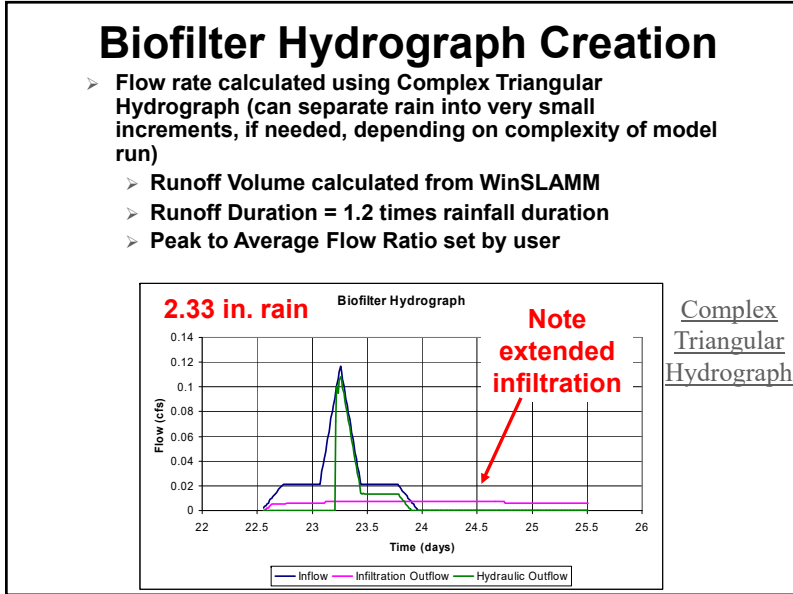
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**Stormwater Constituents that may Adversely Affect Infiltration Device Life and Performance**

- Sediment (suspended solids) will clog device
- Major cations ( $K^+$ ,  $Mg^{+2}$ ,  $Na^+$ ,  $Ca^{+2}$ , plus various heavy metals in high abundance, such as Al and Fe) will consume soil CEC (cation exchange capacity) in competition with stormwater pollutants.
- An excess of sodium, in relation to calcium and magnesium (such as in snowmelt), can increase the soil's SAR (sodium adsorption ratio), which decreases the soil's infiltration rate and hydraulic conductivity.

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**Sodium Adsorption Ratio (SAR)**

The sodium adsorption ratio can radically affect the performance of an infiltration device. Soils with an excess of sodium ions, compared to calcium and magnesium ions, remain in a dispersed condition, almost impermeable to rain or applied water. 20 lb/ft<sup>2</sup> gypsum top-dressing as a soil amendment may help reduce SAR problems (used on agricultural fields, but not really shown to be useful at urban sites).

SAR value of 15, or greater, indicates that an excess of sodium will be adsorbed by the soil clay particles. This can cause the soil to:

- be hard and cloddy when dry
- crust badly
- take water very slowly

SAR values near 5 can also cause problems, depending on the type of clay present.

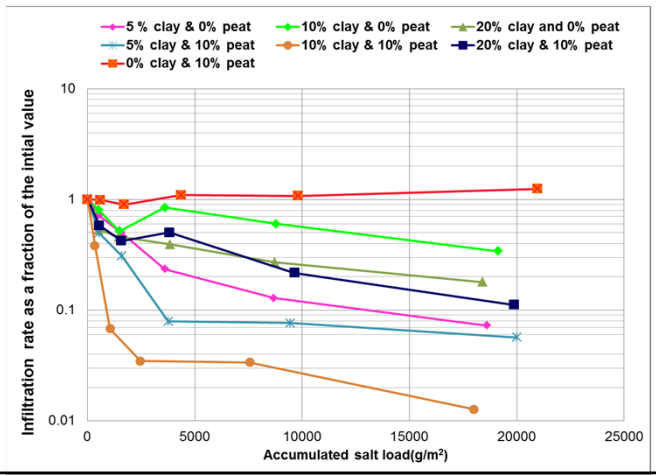
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A new infiltration pond after first winter; receives snowmelt from adjacent salted parking areas (plus sediment from area construction); lost almost all of the infiltration capacity and is rapidly becoming a (poorly designed) wet pond.



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**UA Student's Salt Addition Tests of Biofilter Media in Columns: Lost Infiltration Rates with Clay (above 5%) and with Organic Supplements (peat in this example)**



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### Ground Water Mounding "Rules of Thumb"

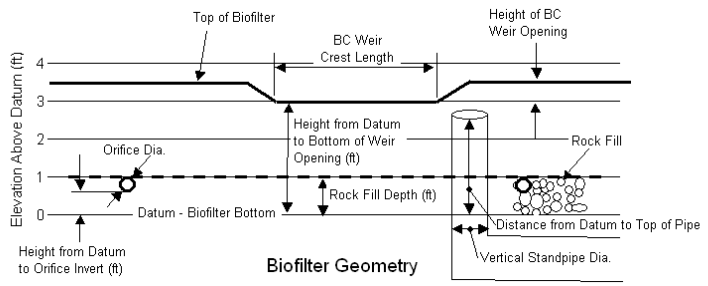
- Mounding reduces infiltration rate to saturated permeability of soil, often 2 to 3 orders of magnitude (100 to 1,000X reductions) lower than dry soil infiltration rate.
- Long narrow system (i.e. trenches) don't mound as much as broad, square/round systems

### Five Components to Modeling Biofilters

1. Structure Geometry
2. Outlet Information
3. Infiltration Data
4. Hydrograph and Flow Routing Information
5. Particle Size Distribution



### Biofilter Geometry



**Biofilter Datum is always zero ft.**

### Biofilter Data Entry Form

Device Properties	Biofilter Number 1	Add   Sharp Created Weir	Add   Other Outlet	Evaporation
Top Area (sf)	120	Set Length (ft)	Stage Number	Month
Bottom Area (sf)	100	Height from datum to top of weir opening (ft)	Stage (ft)	Other Outflow Rate (cfs)
Total Depth (ft)	4.00	Remove   Broad Crested Weir	1	Jan
Typical Width (ft) (Cost est. only)	10.00	Ver crest length (ft)	2	Feb
Native Soil Infiltration Rate (in/yr)	0.1	Ver crest width (ft)	3	Mar
Native Soil Infiltration Rate (in/yr)	N/A	Right from datum to bottom of weir opening (ft)	4	Apr
Infil. Rate Fraction-Bottom (0-1)	1.00	Right from datum to bottom of weir opening (ft)	5	May
Infil. Rate Fraction-Sides (0-1)	1.00	Add   Vertical Stand Pipe		Jun
Rock Filled Depth (ft)	1.00	Set diameter (ft)		Jul
Rock Fill Porosity (0-1)	0.40	Invert elevation above datum (ft)		Aug
Engineered Soil Type	Soil Data 1	Remove   Surface Discharge Pipe		Sep
Engineered Soil Infiltration Rate (in/yr)	3.40	Set diameter (ft)		Oct
Engineered Soil Infiltration Rate COV	N/A	Invert elevation above datum (ft)		Nov
Engineered Soil Depth (ft)	2	Number of orifices in set		Dec
Engineered Soil Porosity (0-1)	0.35	Remove   Drain Tile/Underdrain		
Percent solids reduction due to biofilter (0-1)	N/A	Set diameter (ft)		
Inflow Hydrograph Peak to Average Flow Ratio	3.80	Invert elevation above datum (ft)		
Number of Devices in Source Area or Land Use	1	Number of orifices in set		

**Biofilter Geometry**

**Outflow Structure Information**

### Biofilter Data Entry Form

The screenshot shows the 'Biofilter Control Device' software interface. Key sections include:

- Device Properties:** Biofilter Number 1, Top Area (sf) 120, Bottom Area (sf) 100, Total Depth (ft) 4.00, Typical Width (ft) 10.00, Native Soil Infiltration Rate (in/hr) 0.1.
- ET Plant Type Variables:** A table for selecting plant types with columns for Plant Type, Root Depth (ft), and ET Crop Adjustment Factor.
- Plant Types:** A table with columns for Plant Types 1, 2, 3, and 4, including Fraction of available capacity when irrigation stops (D-1) and Plant type.
- ET Plant Types Information:** A schematic diagram showing the biofilter layout with dimensions and elevation markers.

### Biofilter Data Entry Form

The screenshot shows the 'Biofilter Control Device' software interface with the 'Detailed Media Characteristics' dialog box open. Key sections include:

- Soil Data:** A table for defining soil types with columns for Soil Type, Saturation Water Content (%), Field Capacity (Percent), Permanent Wilting Point (Percent), Infiltration Rate (in/hr), and Fraction of Soil Type Texture in Engineered Soil (D-1).
- User Defined Soil Type:** A section where a user-defined soil type is selected, showing its characteristics.
- Soil Data Table:** A table listing various soil types like 'Gravel', 'Loamy Sand', 'Sandy Loams', etc., with their respective characteristics.

User Defined Type Activates User Defined Percent Solids Reduction due to Engineered Media

### Biofilter Data Entry Form

The screenshot shows the 'Biofilter Control Device' software interface with the 'Modify Biofilter Geometry' dialog box open. Key sections include:

- Modify Biofilter Geometry:** A dialog box for adjusting device dimensions, including Top Area, Bottom Area, Depth, and Side Slope.
- Change Geometry:** A section for copying or pasting biofilter data.
- Select Native Soil Infiltration Rate:** A list of soil types and their infiltration rates.

### Biofilter Data Entry Form

The screenshot shows the 'Biofilter Control Device' software interface with the 'Detailed Media Characteristics' dialog box open. Key sections include:

- Activate Pipe or Box Storage:** A section for configuring storage options, including Diameter and Length.
- Change Geometry:** A section for copying or pasting biofilter data.
- Select Native Soil Infiltration Rate:** A list of soil types and their infiltration rates.



# Tab 4-G: Biofilter Control Practice

## Biofilter Input/Output Example

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## WinSLAMM Model Output - Output Summary

File Name: C:\Files\SLAMM\Training\Presentation\UV\ EPD\2015 Madison March\UV drafts\Examples Used In Presentations\BF Example.mdb

### Outfall Output Summary

	Runoff Volume (cu. ft.)	Percent Runoff Reduction	Runoff Coefficient (Rv)	Particulate Solids Conc. (mg/L)	Particulate Solids Yield (lbs)	Percent Particulate Solids Reduction
Total of All Land Uses without Controls	332693		0.47	163.3	3392	
Outfall Total with Controls	114198	65.67 %	0.16	125.6	895.5	73.60 %

Current File Output: Annualized Total After Outfall Controls: 125543    Years in Model Run: 0.91    984.5

Pollutant	Concentration - No Controls	Concentration - With Controls	Concentration Units	Pollutant Yield - No Controls	Pollutant Yield - With Controls	Pollutant Yield Units	Percent Yield Reduction
Particulate Solids	163.3	125.6 mg/L		3392	895.5 lbs		73.60 %
Total Phosphorus	0.3073	0.2614 mg/L		6.382	1.864 lbs		70.80 %

### Total Control Practice Costs

Capital Cost	\$ 935763
Land Cost	\$ 45913
Annual Maintenance Cost	\$ 55173
Present Value of All Costs	\$ 1802522
Annualized Value of All Costs	\$ 121157

Total Area Modeled (ac): 12.130

### Receiving Water Impacts Due To Stormwater Runoff (CWP Impervious Cover Model)

	Calculated Rv	Approximate Urban Stream Classification
Without Controls	0.47	Poor
With Controls	0.16	Fair

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## WinSLAMM Model Output - Control Practices

Data File: C:\Files\SLAMM\Training\ Madison March\UV drafts\Examples Used In Presentations\BF Example.mdb  
 Rain File: CO Denver Stapleton.F  
 Date: 03-02-15 Time: 7:05:53 PM  
 Site Description: Calgary, AB LID Ion Pond

Control Practice No.	Control Practice Type	Total Inflow Volume (cf)	Total Outflow Volume (cf)	Percent Volume Reduction	Total Influent Load (lbs)	Total Effluent Load (lbs)	Percent Load Reduction	Flow Weighted Influent Conc (mg/L)	Flow Weighted Effluent Conc (mg/L)	Percent Conc. Reduction
1	Biofilter	332693	114198	65.67	3392	895.5	73.60	163.3	125.6	23.098

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# Control Practice Summary Table

Data File: C:\Files\SLAMM\Training\Presentations\LUV EPD\2015 Madison March\JV drafts\Examples Used In Presentations\BF Example.mdb  
 Rain File: CO Denver Stapleton AP 4899.RAN  
 Date: 03-02-15 Time: 7:05:53 PM  
 Site Description: Calgary, AB LID Example, with Biofilters and Wet Detention Pond

Control Practice No.	Control Practice Type	Control Practice Name or Location	Total Inflow Volume (cf)	Total Outflow Volume (cf)	Percent Volume Reduction	Total Influent Load (lbs)	Total Effluent Load (lbs)	Percent Load Reduction	Flow Weighted Influent Conc (mg/L)	Flow Weighted Effluent Conc (mg/L)
1	Biofilter	DS Biofilters #1	332693	114198	65.67	3392	895.5	73.60	163.3	125.6

Data File: C:\Files\SLAMM\Training\Presentations\LUV EPD\2015 Madison March\JV drafts\Examples Used In Presentations\BF Example.mdb  
 Rain File: CO Denver Stapleton AP 4899.RAN  
 Date: 03-02-15 Time: 7:05:53 PM  
 Site Description: Calgary, AB LID

Control Practice No.	Control Practice Type	Percent Conc. Reduction	Influent Median Part. Size (microns)	Effluent Median Part. Size (microns)	Notes	Maximum Stage (ft)	Hydraulic Volume Out (cf)	% of Clogging Factor	Maximum Surface Ponding Time (hrs)	Maximum Subsurface Ponding Time (hrs)	Volume Infiltrated (cf)	Ur Di V
1	Biofilter	23.098	7.90	5.55	No Biofilter Overflows	4.01	110421		0.0	24.66	134066.30	

Data File: C:\Files\SLAMM\Training\Presentations\LUV EPD\2015 Madison March\JV drafts\Examples Used In Presentations\BF Example.mdb  
 Rain File: CO Denver Stapleton AP 4899.RAN  
 Date: 03-02-15 Time: 7:05:53 PM  
 Site Description: Calgary, AB LID

Control Practice No.	Control Practice Type	Maximum Subsurface Ponding Time (hrs)	Volume Infiltrated (cf)	Underdrain Discharge Vol. (cf)	Evapo-Transpir. Vol. (cf)	Minimum Soil Moist (frac)	Surface Discharge Bypass Vol. (cf)	Evap. Vol. (cf)	Volume Supplement. (cf)	Surface Ponding Events > 72 hrs (Count)	Runoff Producing Events/ Tot. Rains
1	Biofilter	24.66	134066.30	107362	119531.50		0.00			0	9.55

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# Control Practice Detail Tables

Data File: C:\Files\SLAMM\Training\Presentations\LUV EPD\2015 Madison March\JV drafts\Examples Used In Presentations\BF Example.mdb  
 Rain File: CO Denver Stapleton AP 4899.RAN  
 Date: 03-02-15 Time: 7:05:53 PM  
 Site Description: Calgary, AB LID Example, with Biofilters and Wet Detention Pond

Runoff Volume				Part. Solids Yield (lbs)			
Control Practice Type ==>	Control Practice Name/Location ==>	Rain Number	Start Date	Rain Total (in)	Influent Runoff Vol (cf)	Effluent Runoff Vol (cf)	Runoff Vol. Percent Reduction
DS Biofilters #1		484	03/30/55	-	0	0	0
		485	04/11/55	0.48	11059	0	100.00
		486	05/08/55	0.02	83.39	0	100.00
		487	05/09/55	0.11	1626	0	100.00
		488	05/16/55	0.12	1881	0	100.00
		489	05/18/55	1.75	5245	25066	52.94
		490	05/22/55	0.07	763.9	0	100.00
		491	05/25/55	0.40	8965	1,337	99.99
		492	06/04/55	0.43	9738	0	100.00
		493	06/05/55	0.14	2316	0.04611	100.00
		494	06/08/55	0.03	187.6	1.789E-04	100.00
		495	06/08/55	0.01	20.85	2.112E-05	100.00
		496	06/13/55	0.19	3657	0	100.00
		497	06/14/55	0.13	2094	0.06578	100.00
		498	06/16/55	0.11	1626	0.001842	100.00
		499	06/16/55	0.23	4504	0.05530	100.00
		500	06/18/55	0.07	763.9	0.02714	100.00
		501	06/20/55	0.02	83.39	2.932E-04	100.00
		502	06/25/55	0.03	187.6	0	100.00
		503	07/04/55	0.02	83.39	0	100.00
		504	07/10/55	0.01	20.85	0	100.00
		505	07/12/55	0.02	83.39	0	100.00
		506	07/20/55	0.16	2786	0.1940	99.99

Data File: C:\Files\SLAMM\Training\Presentations\LUV EPD\2015 Madison March\JV drafts\Examples Used In Presentations\BF Example.mdb  
 Rain File: CO Denver Stapleton AP 4899.RAN  
 Date: 03-02-15 Time: 7:05:53 PM  
 Site Description: Calgary, AB LID Example, with Biofilters and Wet Detention Pond

Runoff Volume				Part. Solids Yield (lbs)			
Control Practice Type ==>	Control Practice Name/Location ==>	Rain Number	Start Date	Rain Total (in)	Influent Part. Sol. Yield (lbs)	Effluent Part. Sol. Yield (lbs)	Part. Yield Percent Reduction
DS Biofilters #1		484	03/30/55	-	0	0	0
		485	04/11/55	0.48	109.2	0	100.00
		486	05/08/55	0.02	1.125	0	100.00
		487	05/09/55	0.11	17.42	0	100.00
		488	05/16/55	0.12	19.59	0	100.00
		489	05/18/55	1.75	552.3	199.6	63.86
		490	05/22/55	0.07	3.438	0	100.00
		491	05/25/55	0.40	88.02	0.01313	99.99
		492	06/04/55	0.43	95.83	0	100.00
		493	06/05/55	0.14	23.77	4.732E-04	100.00
		494	06/08/55	0.03	2.531	2.413E-06	100.00
		495	06/08/55	0.01	0.2812	2.849E-07	100.00
		496	06/13/55	0.19	35.36	0	100.00
		497	06/14/55	0.13	21.85	6.800E-04	100.00
		498	06/16/55	0.11	17.42	1.973E-05	100.00
		499	06/16/55	0.23	44.52	5.466E-04	100.00
		500	06/18/55	0.07	9.439	3.353E-04	100.00
		501	06/20/55	0.02	1.125	3.955E-06	100.00
		502	06/25/55	0.03	2.531	0	100.00
		503	07/04/55	0.02	1.125	0	100.00
		504	07/10/55	0.01	0.2812	0	100.00
		505	07/12/55	0.02	1.125	0	100.00
		506	07/20/55	0.16	28.21	0.001964	99.99

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# Additional Output Biofilter Event by Event Output

Biofilter Water Balance Performance Summary, by Event

BioF Source Area Number	Rain Number	Rain Depth (in)	Time (Julian Date)	Maximum BioF Stage (ft)	Minimum BioF Stage (ft)	Event Inflow Volume (ac-ft)	Event Hydr. Outflow (ac-ft)	Event Infil. Outflow (ac-ft)	Event Evap. Outflow (ac-ft)	Event Cistern Outflow (ac-ft)	Event Office Outflow (ac-ft)	Event Total Outflow (ac-ft)	Event Flow Balance (ac-ft)	Volume Reduction Fraction	Solids Reduction Fraction
7	1	0.01	0	0.12	0	0	0	0	0	0	0	0	0	1	0
7	2	0.05	31	0.57	0	0.007	0	0.001	0	0	0.006	0.007	0	0.183	0
7	3	0.1	59	0.71	0	0.015	0	0.002	0	0	0.013	0.015	0	0.995	0
7	4	0.25	90	1.2	0	0.042	0	0.002	0	0	0.041	0.042	0	0.043	0
7	5	0.5	120	2.03	0	0.084	0	0.002	0	0	0.082	0.084	0	0.024	0
7	6	0.75	151	2.46	0	0.125	0	0.002	0	0	0.122	0.125	0	0.018	0
7	7	1	181	2.5	0	0.165	0.007	0.002	0	0	0.156	0.165	0	0.014	0
7	8	1.5	212	2.52	0	0.249	0.034	0.003	0	0	0.213	0.249	0	0.011	0
7	9	2	243	2.52	0	0.335	0.066	0.003	0	0	0.266	0.335	0	0.008	0
7	10	2.5	273	2.53	0	0.416	0.087	0.003	0	0	0.326	0.416	0	0.008	0
7	11	3	304	2.52	0	0.497	0.097	0.004	0	0	0.396	0.497	0	0.008	0
7	12	4	334	2.53	0	0.661	0.149	0.004	0	0	0.507	0.661	0	0.007	0

## Other Output Options

- Time step detail
- Irreducible concentration
- Particulate reduction
- Stage outflow
- Stochastic seepage rates
- Water Balance
- Evapotranspiration

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