Errata Sheet for VOLUME 3 – PROJECT STORMWATER CONTROL

This document contains errata for the 2016 City of Seattle Stormwater Manual Final Draft, Volume 3. The 2016 City of Seattle Stormwater Manual Final Draft documents are available on the following website:
http://www.seattle.gov/dpd/codesrules/changestocode/stormwatercode/projectdocuments/default.htm

Errata as of October 2, 2015:

1. Volume 3, Section 4.1.3.2. Flow Control, Page 4-5. Revise the second paragraph as follows:

Under the Modeling Approach, flow control BMPs are designed to achieve flow control standards using a continuous rainfall-runoff model refer to (refer to *Volume 1*, *Section 5.2)*. Specific modeling requirements are presented in the *BMP Sizing* or ~~*Flow*~~ *BMP* ~~*Control*~~ *Credits* section for each BMP in *Chapter 5*. For detention BMPs the minimum bottom orifice diameter will be too large to meet standard release rates in some scenarios, even with minimal head. Designers should iteratively increase detention area and decrease live storage depth until the performance criteria are met. However, live storage depth need not be reduced to less than 3 feet in an attempt to meet the flow control standards. As a rule of thumb, flow control standards can be achieved using a 0.5-inch diameter bottom orifice with a 3-foot live storage depth in the following scenarios:

- Pre-developed Forested Standard can be achieved when the contributing impervious area is greater than approximately 45,000 square feet~~TBD~~.
- Pre-developed Pasture Standard can be achieved when the contributing impervious area is greater than approximately ~~TBD~~19,000 square feet.
- Peak Control Standard can be achieved when the contributing impervious area is greater than approximately ~~TBD~~2,000 square feet.

~~When there is less~~For smaller contributing impervious area~~ (as noted above)~~s, the following design/modeling approach is recommended:

2. Volume 3, Section 5.3.3.3. Applicability. Add a footnote "a" to Peak Flow Control standard in table as follows:

BMP	On-site		Flow Control			Water Quality				Conveyance
	List	Standard	Forest	Pasture	Peak	Basic	Enhanced	Oil Control	Phosphorus	
Splashblock downspout dispersion	✓	✓[a]	✓[a]	✓[a]	✓[a]	✓[b]				

[a] Standard may be partially or completely achieved depending upon underlying soil type.

[b] Must meet additional design requirements for basic filter strips (refer to *Section 5.8.4*).

3. Volume 3, Section 5.3.3.6. BMP Credits, Pre-Sized Approach for Flow Control. Revise this section and Table 5.4 as follows:

The Pre-sized Approach may be used for projects with new and replaced hard surface areas up to 10,000 square feet. Under the Pre-sized Approach (refer to *Section 4.1.2*), flow control credits may be achieved by using downspout dispersion. Credits are provided in Table 5.4, organized by flow control standard. These credits can be applied to reduce the hard surface area requiring flow control. Since the credits for dispersion are less than ~~A~~ 100 percent, ~~credit means that the flow control goal is achieved and no further control is required for the area from which runoff is dispersed. If partial credit is received,~~ the standard is not achieved and additional flow control measures ~~may~~ will be required. As an example, for a site subject to the Pre-developed Pasture Standard, a dispersed hard surface area would receive a ~~90~~91 percent credit. Therefore, ~~90~~ 91 percent of the hard surface area dispersed can be excluded from flow control calculations. The hard surface area (area used to size a downstream flow control BMP) would be calculated as ~~10~~ 9 percent of the hard surface area dispersed.

Table 5.4. Flow Control Credits for Splashblock Downspout Dispersion.

Dispersion Type	Credit (%)	
	Pre-developed Pasture Standard	Peak Control Standard
Splashblock Downspout Dispersion	~~TBD~~91%	~~TBD~~94%

Hard Surface Area Managed = Hard Surface Area Dispersed x Credit (%)/100.

~~Pre-sized Approach may be used to meet water quality treatment if soil suitability criteria are met (refer to *Section 4.5.2*).~~

4. Volume 3, Section 5.3.4.3. Applicability. Add a footnote "a" to Peak Flow Control standard in table as follows:

BMP	On-site		Flow Control			Water Quality				Conveyance
	List	Standard	Forest	Pasture	Peak	Basic	Enhanced	Oil Control	Phosphorus	
Trench downspout dispersion	✓	✓[a]	✓[a]	✓[a]	✓[a]	✓[b]				

[a] Standard may be partially or completely achieved depending upon underlying soil type.

[b] Must meet additional design requirements for basic filter strips (refer to *Section 5.8.4*).

5. Volume 3, Section 5.3.4.6. BMP Credits, Pre-Sized Approach for Flow Control. Revise Table 5.6 as follows:

Table 5.6. Flow Control Credits for Trench Downspout Dispersion.

Dispersion Type	Credit (%)	
	Pre-developed Pasture Standard	Peak Control Standard
Trench Downspout Dispersion	~~TBD~~91%	~~TBD~~94%

Hard Surface Area Managed = Hard Surface Area Dispersed x Credit (%)/100.

6. Volume 3, Section 5.3.5.3. Applicability. Add a footnote "a" to Peak Flow Control standard in table as follows:

BMP	On-site		Flow Control			Water Quality				Conveyance
	List	Standard	Forest	Pasture	Peak	Basic	Enhanced	Oil Control	Phosphorus	
Sheet flow dispersion	✓	✓[a]	✓[a]	✓[a]	✓[a]	✓[b]				

[a] Standard may be partially or completely achieved depending upon underlying soil type.

[b] Must meet additional design requirements for basic filter strips (refer to *Section 5.8.4*).

7. Volume 3, Section 5.3.5.6. BMP Credits, Pre-Sized Approach for Flow Control. Revise Table 5.7 as follows:

Table 5.7. Flow Control Credits for Sheet Flow Dispersion.

Dispersion Type	Credit (%)	
	Pre-developed Pasture Standard	Peak Control Standard
Sheet flow	~~TBD~~91%	~~TBD~~94%

Hard Surface Area Managed = Hard Surface Area Dispersed x Credit (%)/100.

~~Pre-sized Approach may be used to meet water quality treatment if soil suitability criteria are met (refer to *Section 4.5.2*).~~

8. Volume 3, Section 5.3.6.3. Applicability. Add a footnote "a" to Peak Flow Control standard in table as follows:

BMP	On-site		Flow Control			Water Quality				Conveyance
	List	Standard	Forest	Pasture	Peak	Basic	Enhanced	Oil Control	Phosphorus	
Concentrated Flow Dispersion	✓	✓[a]	✓[a]	✓[a]	✓[a]	✓[b]				

[a] Standard may be partially or completely achieved depending upon underlying soil type.

[b] Must meet additional design requirements for basic filter strips (refer to *Section 5.8.4*).

9. Volume 3, Section 5.3.6.6. BMP Credits, Pre-Sized Approach for Flow Control. Revise Table 5.9 as follows:

Table 5.9. Flow Control Credits for Concentrated Flow Dispersion.

Dispersion Type	Credit (%)	
	Pre-developed Pasture Standard	Peak Control Standard
Concentrated Flow Dispersion	~~TBD~~91%	~~TBD~~94%

Hard Surface Area Managed = Hard Surface Area Dispersed x Credit (%)/100

~~Pre-sized Approach may be used to meet water quality treatment if soil suitability criteria are met (refer to *Section 4.5.2*).~~

10. Volume 3, Section 5.4.2.6. BMP Credits, Pre-sized Approach for Flow Control and Water Quality Treatment. Revise this subsection and Table 5.12 as follows:

The Pre-sized Approach may be used for projects with new and replaced hard surface areas up to 10,000 square feet. Under the Pre-sized Approach (refer to *Section 4.1.2*), pre-sized infiltration trenches may be used to achieve Pre-developed Pasture, Peak Control and Water Quality Treatment Standards. Sizing factors and equations for infiltration trenches receiving runoff from a hard surface are provided in Table 5.12. Factors are organized by flow control standard, trench depth, ~~and~~ subgrade soil design infiltration rate, and contributing area. A 1.5-foot or 3-foot aggregate storage reservoir depth may be selected. The aggregate storage reservoir is the subsurface aggregate layer below the overflow invert elevation that stores water for infiltration into the underlying subgrade soils (refer to Figures 5.7 and 5.8). The design rate for the subgrade soils shall be rounded down to the nearest infiltration rate in the pre-sized table (i.e., 0.15, 0.3, 0.6, 1.0, or 2.5 inch per hour).

To use these sizing factors or equations to meet flow control standards, the facility shall meet the general requirements for infiltration trenches outlined in this section, plus the following specific requirements:

- The trench area shall be sized using the applicable sizing factor or equation.
- The average aggregate storage reservoir depth across the trench shall be set at the designated height (1.5 or 3 feet). For intermediate ponding depths (between 1.5 and 3.0 feet), the sizing factor may be linearly interpolated.

- To use these pre-sized infiltration trenches to meet water quality treatment, the underlying soil shall meet soil requirements specified in *Section 4.5.2*.
- The aggregate storage reservoir shall be composed of Mineral Aggregate Type 4 or approved equal.
- Invert of overflow shall be set at top of the storage reservoir to provide the required aggregate storage reservoir depth (e.g., pipe invert set at 1.5 or 3 feet if the bottom of the trench is flat).

Table 5.12. Sizing Factors and Equations for Infiltration Trenches.

Trench Depth	Subgrade Soil Design Infiltration Rate	~~Sizing Factor for Infiltration Trench Area~~ Contributing Area (sf)	Sizing Factor/Equation for Infiltration Trench Area		
			Pre-developed Pasture Standard	Peak Control Standard	Water Quality Treatment Standard[a]
1.5 feet	0.15 inch/hour	< 2,000	29.5%	33.5%	12.1%
		2,000 – 10,000	[0.1813 x A] +233.6		
	0.3 inch/hour	< 2,000	21.7%	28.4%	10.0%
		2,000 – 10,000	[0.1583 x A] +79.7		
	0.6 inch/hour	< 2,000	13.8%	18.1%	5.7%
		2,000 – 10,000	[0.0863 x A] +106.2		
	1.0 inch/hour	< 2,000	12.0%	16.1%	5.0%
		2,000 – 10,000	[0.0677 x A] +83.8		
	2.5 inch/hour	< 2,000	5.4%	8.3%	2.2%
		2,000 – 10,000	[0.0311 x A] +47.2		
3.0 feet	0.15 inch/hour	< 2,000	19.2%	20.7%	8.3%
		2,000 – 10,000	[0.1248 x A] +137.9		
	0.3 inch/hour	< 2,000	16.0%	17.9%	6.8%
		2,000 – 10,000	[0.0398 x A] +317.7		
	0.6 inch/hour	< 2,000	9.7%	12.3%	4.0%
		2,000 – 10,000	[0.0622 x A] +70.4		
	1.0 inch/hour	< 2,000	8.4%	11.0%	3.5%
		2,000 – 10,000	[0.0482 x A] +80.4		
	2.5 inch/hour	< 2,000	3.8%	6.0%	1.6%
		2,000 – 10,000	[0.0241 x A] +27.7		

A – contributing hard surface area; sf – square feet.

For Sizing Factors: Infiltration Trench Area = Contributing Hard Surface Area x Factor (%)/100.

Hard Surface Area Managed = Trench Area ÷ Factor (%)/100.

For Sizing Equations: Infiltration Trench Area (sf) = [Factor x A (sf)] + Integer.

Hard Surface Area Managed (sf) = [Trench Area (sf) - Integer]÷ Factor.

[a] Pre-sized Approach may be used to meet basic water quality treatment. Enhanced water quality treatment may be achieved if soil suitability criteria are met (refer to *Section 4.5.2*).

The infiltration trench facility area is calculated as a function of the area contributing runoff to the trench. As an example, to meet the Pre-developed Pasture Standard for a contributing area between 2,000 and 10, 000 square feet where the design subgrade infiltration rate is between 0.3 and 0.6 inches per hour and the trench depth is

1.5 feet, the trench area would be ~~equal to 27.3 percent~~calculated as: 0.1583 x ~~of the~~ contributing hard surface area +79.7 ~~when the subgrade infiltration rate is between 0.25 and 0.5 inches per hour and the trench depth is 1.5 feet~~. All area values shall be in square feet.

Alternatively, infiltration trench facilities can be sized using a continuous hydrologic simulation model as described in the subsequent section.

11. Volume 3, Section 5.4.3.6. BMP Sizing. Revise footnotes to Table 5.14 as follows:

Drywell ~~Aggregate Volume~~Area (sf) = ~~(~~Contributing Hard Surface Area x Factor (%)/100.
Hard Surface Area Managed = Drywell Area ÷ Factor (%)/100.
~~(sf)/1,000) x V.~~
Drywell shall be a minimum of 48 inches in diameter.

12. Volume 3, Section 5.4.3.6. BMP Sizing, Pre-sized Approach for Flow Control. Revise this subsection and Table 5.15 as follows:

The Pre-sized Approach may be used for projects with new and replaced hard surface areas up to 10,000 square feet. Under the Pre-sized Approach (refer to *Section 4.1.2*), pre-sized drywells may be used to achieve Pre-developed Pasture and Peak Control Standards. Sizing factors and equations for drywells receiving runoff from a hard surface are provided in Table 5.15. Factors are organized by flow control standard, drywell depth, ~~and~~ subgrade soil design infiltration rates and contributing area. A 4-foot or 6-foot aggregate storage reservoir depth may be selected. The aggregate storage reservoir is the subsurface aggregate layer below the overflow invert elevation that stores water for infiltration into the underlying subgrade soils. The design rate for the subgrade soils shall be rounded down to the nearest infiltration rate in the pre-sized table (i.e., 0.25, 0.5, or 1.0 inch per hour).

To use these sizing factors or equations to meet flow control standards, the facility shall meet the general requirements for drywells outlined in this section plus the following specific requirements:

- The drywell area shall be sized using the applicable sizing factor or equation.
- The average aggregate storage reservoir depth in the drywell shall be set at the designated height (e.g., 4 feet). For intermediate ponding depths (between 4 and 6 feet), the sizing factor may be linearly interpolated.
- The aggregate storage reservoir shall be composed of Mineral Aggregate Type 4 or approved equal.
- The invert of the overflow shall be set at top of the storage reservoir to provide the required aggregate storage reservoir depth (e.g., pipe invert set at 4 feet if the bottom of the well is flat).

Table 5.15. Sizing Factors and Equations for Drywells.

Drywell Depth	Subgrade Soil Design Infiltration Rate	Contributing Area (sf)	Sizing Factor/Equation for Drywell Area	
			Pre-developed Pasture Standard	Peak Control Standard
4.0 feet	0.15 inch/hour	< 2,000	16.0%	16.8%
		2,000 – 10,000	[0.106 x A] +108.6	
	0.3 inch/hour	< 2,000	13.4%	14.6%
		2,000 – 10,000	[0.088 x A] +91.4	
	0.6 inch/hour	< 2,000	8.1%	10.3%
		2,000 – 10,000	[0.053 x A] +56.8	
	1.0 inch/hour	< 2,000	7.0%	9.2%
		2,000 – 10,000	[0.046 x A] +49.1	
	2.5 inch/hour	< 2,000	3.1%	5.1%
		2,000 – 10,000	[0.021 x A] +20.2	
6.0 feet	0.15 inch/hour	< 2,000	12.0%	13.2%
		2,000 – 10,000	[0.084 x A] +72.6	
	0.3 inch/hour	< 2,000	8.5%	10.0%
		2,000 – 10,000	[0.059 x A] +53	
	0.6 inch/hour	< 2,000	5.9%	7.9%
		2,000 – 10,000	[0.042 x A] +36	
	1.0 inch/hour	< 2,000	4.3%	6.4%
		2,000 – 10,000	[0.032 x A] +22.5	
	2.5 inch/hour	< 2,000	2.2%	3.9%
		2,000 – 10,000	[0.017 x A] +10.4	

A – contributing hard surface area; sf – square feet.

Drywell shall be a minimum of 48 inches in diameter.

For Sizing Factors: Drywell Area = Contributing Hard Surface Area x Factor (%)/100.

Hard Surface Area Managed = Drywell Area ÷ Factor (%)/100.

For Sizing Equations: Drywell Area (sf) = [Factor x A (sf)] + Integer.

Hard Surface Area Managed (sf) = [Drywell Area (sf) - Integer]÷ Factor.

The drywell facility area is calculated as a function of the area contributing runoff to the drywell. As an example, to meet the Pre-developed Pasture Standard for a contributing area less than 2,000 square feet, the well area would be equal to ~~X.X~~5.9 percent of the contributing area when the subgrade infiltration rate is between 0.~~5~~ 6 and 1.0 inches per hour and the well depth is 6.0 feet.

Alternatively, drywell facilities can be sized using a continuous hydrologic simulation model as described in the subsequent section.

13. Volume 3, Section 5.4.4.3. Applicability. Add a footnote "a" to Peak Flow Control standard in table as follows:

BMP	On-site		Flow Control			Water Quality				Conveyance
	List	Standard	Forest	Pasture	Peak	Basic	Enhanced	Oil Control	Phosphorus	
Infiltrating bioretention without underdrain	✓	✓	✓	✓	✓	✓	✓		✓[b]	✓[c]
Infiltrating bioretention with underdrain	✓	✓[a]	✓[a]	✓[a]	✓[a]	✓	✓		✓[b]	✓[c]

[a] Standard may be partially achieved.

[b] Refer to treatment train options for infiltration BMPs included in Section 4.4.3.2.

[c] Infiltrating bioretention facilities may be connected in series, with the overflows from upstream cells directed to downstream cells to provide conveyance.

14. Volume 3, Section 5.4.4.6. BMP Sizing, Pre-Sized Approach for Flow Control and Water Quality Treatment. Revise this subsection and Table 5.19 and 5.20 as follows:

The Pre-sized Approach may be used for projects with new and replaced hard surface areas up to 10,000 square feet. Under the Pre-sized Approach (refer to *Section 4.1.2*), simple equations are used to calculate the size of "pre-designed" bioretention facilities subject to specific design requirements (e.g., side slope, ponding depth). Sizing factors and equations for infiltrating bioretention without underdrains and with underdrains are provided in Tables 5.19 and 5.20, respectively. Note that the modeling conducted to develop sizing factors and equations for bioretention with underdrains did not include infiltration to underlying soil due to modeling constraints at the time of publication.

Pre-sized infiltrating bioretention facilities without underdrains may be used to achieve the Pre-developed Pasture, Peak Control, and Water Quality Treatment Standards. Pre-sized infiltrating bioretention facilities with underdrains may be used to achieve the Peak Control and Water Quality Treatment Standards. Sizing factors are organized by side slopes (i.e., sloped sides or vertical sides), performance standard, facility ponding depth, ~~and~~ subgrade soil design infiltration rate (for facilities without underdrains), and contributing area. To select the appropriate sizing factor or equation:

- The design ponding depth shall be rounded down to the nearest depth in the sizing table, or sizing factors may be linearly interpolated for intermediate ponding depths (e.g., between 6 and 12 inches ponding).
- For facilities without underdrains, round the design infiltration rate for the subgrade soils down to the nearest infiltration rate in the pre-sized table (i.e., 0.15, 0.3, 0.6, 1.0, or 2.5 inches per hour).

Table 5.19. Sizing Factors and Equations for Infiltrating Bioretention without Underdrains.

Bioretention Configuration	Ponding Depth	Subgrade Soil Design Infiltration Rate	Contributing Area (sf)	Sizing Factor/Equation for Facility Bottom Area		
				Pre-developed Pasture Standard	Peak Control Standard	Water Quality Treatment Standard[a]
Sloped sides	2-inches	0.15 inch/hour	< 2,000	37.8%	NP	10.3%
			2,000 – 10,000	[0.213 x A] +325.2		
		0.3 inch/hour	< 2,000	29.7%	NP	8.4%
			2,000 – 10,000	[0.173 x A] +246.6		
		0.6 inch/hour	< 2,000	13.6%	NP	4.4%
			2,000 – 10,000	[0.092 x A] +89.3		
		1.0 inch/hour	< 2,000	11.7%	NP	3.8%
			2,000 – 10,000	[0.079 x A] +76.1		
		2.5 inch/hour	< 2,000	4.3%	NP	1.5%
			2,000 – 10,000	[0.030 x A] +26.2		
	6-inches	0.15 inch/hour	< 2,000	NA[b]	NA[b]	NA[b]
			2,000 – 10,000			
		0.3 inch/hour	< 2,000	13.9%	17.7%	4.7%
			2,000 – 10,000	[0.098 x A] +80		
		0.6 inch/hour	< 2,000	8.5%	12.2%	3.0%
			2,000 – 10,000	[0.065 x A] +38.2		
		1.0 inch/hour	< 2,000	7.3%	10.7%	2.6%
			2,000 – 10,000	[0.056 x A] +32.7		
		2.5 inch/hour	< 2,000	2.9%	5.3%	1.0%
			2,000 – 10,000	[0.021 x A] +12		
	12-inches	0.15 inch/hour	< 2,000	NA[b]	NA[b]	NA[b]
			2,000 – 10,000			
		0.3 inch/hour	< 2,000	NA[b]	NA[b]	NA[b]
			2,000 – 10,000			
		0.6 inch/hour	< 2,000	4.3%	8.2%	1.7%
			2,000 – 10,000	[0.044 x A] -3.6		
		1.0 inch/hour	< 2,000	3.7%	7.2%	1.5%
			2,000 – 10,000	[0.038 x A] -4		
		2.5 inch/hour	< 2,000	1.2%	3.3%	0.6%
			2,000 – 10,000	[0.014 x A] -5.5		
Vertical sides	6-inches	0.15 inch/hour	< 2,000	NA[b]	NA[b]	NA[b]
			2,000 – 10,000			
		0.3 inch/hour	< 2,000	20.2%	20.8%	6.6%
			2,000 – 10,000	[0.111 x A] +182.2		
		0.6 inch/hour	< 2,000	13.6%	15.4%	4.5%
			2,000 – 10,000	[0.075 x A] +124.7		
		1.0 inch/hour	< 2,000	11.9%	13.7%	4.0%

Bioretention Configuration	Ponding Depth	Subgrade Soil Design Infiltration Rate	Contributing Area (sf)	Sizing Factor/Equation for Facility Bottom Area		
				Pre-developed Pasture Standard	Peak Control Standard	Water Quality Treatment Standard[a]
			2,000 – 10,000	[0.066 x A] +108.8		
		2.5 inch/hour	< 2,000	5.4%	7.3%	1.9%
			2,000 – 10,000	[0.030 x A] +49.4		
	12-inches	0.15 inch/hour	< 2,000	NA[b]	NA[b]	NA[b]
			2,000 – 10,000			
		0.3 inch/hour	< 2,000	NA[b]	NA[b]	NA[b]
			2,000 – 10,000			
		0.6 inch/hour	< 2,000	10.2%	11.2%	3.6%
			2,000 – 10,000	[0.058 x A] +90.1		
		1.0 inch/hour	< 2,000	9.0%	10.1%	3.2%
			2,000 – 10,000	[0.051 x A] +79.1		
		2.5 inch/hour	< 2,000	4.4%	5.7%	1.6%
			2,000 – 10,000	[0.026 x A] +38		

NP – sizing factors not provided; NA – not applicable; A – contributing hard surface area; sf – square feet.

For Sizing Factors: Bioretention Facility Bottom Area = Contributing Hard Surface Area x Factor (%)/100.

Hard Surface Area Managed = Bioretention Facility Bottom Area ÷ Factor (%)/100.

For Sizing Equations: Bioretention Facility Bottom Area (sf) = [Factor x A (sf)] + Integer.

Hard Surface Area Managed (sf) = [Bioretention Bottom Area (sf) - Integer]÷ Factor.

[a] Pre-sized Approach may be used to meet basic water quality treatment. Enhanced water quality treatment may be achieved if soil suitability criteria are met (refer to *Section 4.5.2*).

[b] Ponding depth and infiltration rate combination do not achieve drawdown requirements.

Table 5.20. Sizing Factors and Equations for Infiltrating Bioretention with Underdrains.

Bioretention Configuration	Ponding Depth	Contributing Area (sf)	Sizing Factor/Equation for Facility Bottom Area		
			Pre-developed Pasture Standard	Peak Control Standard	Water Quality Treatment
Sloped sides	2 inches	0 – 10,000	NA[a]	NA[a]	1.3%
	6 inches	< 2,000	NA[a]	NA[a]	[0.0059 x A] - 3.2
		2,000 – 10,000			[0.0097x A] - 11.3
	12 inches	< 2,700	NA[a]	3% to 4.5%[b]	2.0%
		2,700 – 10,000			]0.0052 x A] - 12.1
Vertical sides	6 inches	0 – 10,000	NA[a]	NA[a]	1.3%
	12 inches	0 – 10,000	NA[a]	4.5%[b]	1.1%

~~NP – sizing factors not provided;~~ NA- not applicable

For Sizing Factors: Bioretention Facility Bottom Area = Contributing Hard Surface Area x Factor (%)/100

Hard Surface Area Managed = Bioretention Facility Bottom Area ÷ Factor (%)/100

For Sizing Equations: Bioretention Facility Bottom Area (sf) = [Factor x A (sf)] + Integer.

Hard Surface Area Managed (sf) = [Bioretention Bottom Area (sf) - Integer]÷ Factor.

[a] ~~Pre-sized Approach may be used to meet water quality treatment if soil suitability criteria are met (refer to *Section 4.5.2*).~~Bioretention facilities with underdrains are not capable of achieving the standard unless orifice controls are used. The Modeling Approach may be used to more accurately represent additional performance due to infiltration, which is neglected in the Pre-Sized approach.

[b] When used to meet the Peak Control Standard, the facility size shall not be larger than prescribed by the sizing factor (or sizing factor range) because flow control performance may be diminished for larger facilities (larger facilities will not pond water sufficiently to slow flows).

To use these pre-sized facilities to meet performance standards, the bioretention facility shall meet the general requirements outlined in this section plus the following specific requirements:

- The bottom area shall be sized using the applicable sizing factor or equation.
- It is preferred that the bottom area is flat, but up to 3 percent slope is permitted.
- For facilities with sloped sides, the side slopes within the ponded area shall be no steeper than 2.5H:1V.
- For facilities without underdrains, the bioretention soil depth shall be a minimum of 12 inches for flow control and 18 inches for water quality treatment. For facilities with underdrains, the amended soil shall have a minimum depth of 18 inches.
- The average ponding depth for the cell shall be no less than the selected ponding depth.

The *bottom area* for the cell is calculated as a function of the hard surface area routed to it. As an example, to meet the Pre-developed Pasture Standard using a bioretention facility without an underdrain and with sloped sides and a ponding depth of 6 inches for a contributing area between 2,000 and 10, 000 square feet where the design subgrade infiltration rate is between 1 and 2.5 inches per hour, the bioretention bottom area would be calculated as: 0.0561 x contributing hard surface area +32.7. All area values shall be in square feet. The bottom area of the same facility sized for a contributing area less than 2,000 square feet would be equal to ~~, the bottom area of the bioretention cell with slopes sides and without an underdrain would be equal to 6.0~~7.3 percent of the hard surface area routed to it ~~when the ponding depth is 6 inches and the subgrade infiltration rate is equal to or greater than 1.0 inch per hour~~.

For facilities with sloped sides, the top area is calculated as a function of the cell bottom area and the side slopes up to the total facility depth (i.e., ponding and freeboard depth).

Alternatively, infiltrating bioretention facilities can be sized using a continuous simulation hydrologic model as described in the subsequent section.

15. Volume 3, Section 5.4.6.6. BMP Sizing, Sizing for On-site List Approach. Revise this subsection as follows and delete Table 5.24:

Permeable pavement facilities without underdrains may be selected to meet the On-site List Requirement (refer to *Section 3.3.1* and *Appendix C* for infeasibility criteria). The area of the permeable pavement facility meets the requirement. In addition, hard surface area contributing run-on to a permeable pavement facility also meets the requirement if it does not exceed the ~~areas allowed by the sizing factors in Table 5.24~~thresholds listed below:

- For pollution-generating impervious surfaces (e.g., roadways, parking lots) the run-on ratio shall be no more than 2:1 (sizing factor 50 percent or greater)
- For non-pollution generating hard surfaces (e.g., roofs, sidewalks) and stabilized pervious surfaces the run-on ratio shall be no more than 5:1 (sizing factor 20 percent of greater)
- For a mix of surface areas, the maximum run-on ratio shall be area-weighted (e.g., a contributing area comprised of half parking lot and half roof would be subject to a maximum run-on ratio of 3.5:1).

~~.~~

For permeable pavement facilities receiving run-on, t~~T~~he minimum required permeable pavement facility area is calculated as ~~a function of the hard surface area routed to it. As an example, the minimum permeable pavement area would be equal to X~~ 50 and 20 percent of the hard surface area routed to it for pollution-generating and non-pollution generating surfaces, respectively ~~when the average water depth in the storage reservoir is 6 inches and the subgrade infiltration rate is between 0.3 and 0.6 inches per hour~~.

16. Volume 3, Section 5.4.6.6. BMP Sizing, Pre-sized Approach for Flow Control and Water Quality Treatment. Revise this subsection as follows:

The Pre-sized Approach may be used for projects with new and replaced hard surface areas up to 10,000 square feet. Under the Pre-sized Approach (refer to *Section 4.1.2*), pre-sized permeable pavement facilities without underdrains may be used to achieve Pre-developed Pasture, Peak Control and Water Quality Treatment Standards. Sizing factors and equations for permeable pavement facilities receiving runoff from a hard surface are provided in Table 5.25. Factors are organized by performance standard, ~~and~~ subgrade soil design infiltration rate, and contributing area. The design rate for the subgrade soil shall be rounded down to the nearest infiltration rate in the pre-sized table (i.e., 0.15, 0.3, 0.6, 1.0 or 2.5 inches per hour).

To use these sizing factors or equations to meet performance standards, the facility shall meet the general requirements for permeable pavement facilities outlined in this section plus the following specific requirements:

- The permeable pavement area shall be sized using the applicable sizing factor or equation.
- The selected subsurface ponding depth (i.e., 6 or 12 inches) shall be provided in the storage reservoir. For intermediate ponding depths (between 6 and 12 inches), the sizing factor may be linearly interpolated. For subgrade slopes

of 0.5 percent or greater, check dams are required to provide this subsurface ponding depth, on average, across the facility.

- To meet water quality treatment, the underlying soil shall meet the soil requirements outlined in *Section 4.5.2* or a water quality treatment course shall be used.
- No underdrain or impermeable liner may be used.

Table 5.25. Sizing Factors and Equations for Permeable Pavement Facilities without Underdrains.

Ponding Depth in Storage Reservoir	Subgrade Soil Design Infiltration Rate	Contributing Area (sf)	Sizing Factor/Equation for Permeable Pavement Facility Area[a]		
			Pre-developed Pasture Standard	Peak Control Standard	Water Quality Treatment Standard[b]
6 inches	0.15 inch/hour	< 2,000	132.6%	256.8%	26.9%
		2,000 – 10,000	[0.484 x A] +1651.1		
	0.3 inch/hour	< 2,000	99.8%	190.2%	21.4%
		2,000 – 10,000	[0.375 x A] +1223.9		
	0.6 inch/hour	< 2,000	34.1%	56.9%	20.0%[c]
		2,000 – 10,000	[0.157 x A] +369.4		
	1.0 inch/hour	< 2,000	29.2%	49.6%	20.0%[c]
		2,000 – 10,000	[0.135 x A] +314.9		
	2.5 inch/hour	< 2,000	20.0%[c]	22.4%	20.0%[c]
		2,000 – 10,000	[0.053 x A] +110.7		
12 inches	0.15 inch/hour	< 2,000	71.4%	100.8%	20.0%[c]
		2,000 – 10,000	[0.324 x A] +785.9		
	0.3 inch/hour	< 2,000	55.5%	79.3%	20.0%[c]
		2,000 – 10,000	[0.257 x A] +600.3		
	0.6 inch/hour	< 2,000	23.8%	36.1%	20.0%[c]
		2,000 – 10,000	[0.125 x A] +229.2		
	1.0 inch/hour	< 2,000	20.5%	31.5%	20.0%[c]
		2,000 – 10,000	[0.108 x A] +198.2		
	2.5 inch/hour	< 2,000	20.0%[c]	20.0%[c]	20.0%[c]
		2,000 – 10,000	[0.044 x A] +81.7		

A – contributing hard surface area; sf – square feet.

For Sizing Factors: Permeable Pavement Facility Area = Contributing Hard Surface Area x Factor (%)/100.

Hard Surface Area Managed = Permeable Pavement Area ÷ Factor (%)/100.

For Sizing Equations: Permeable Pavement Area (sf) = [Factor x A (sf)] + Integer.

Hard Surface Area Managed (sf) = [Permeable Pavement Area (sf) - Integer]÷ Factor.

[a] Maximum run-on ratios apply which may require larger permeable pavement facilities than those sized using the Pre-sized Approach.

[b] Pre-sized Approach may be used to meet basic water quality treatment. Enhanced water quality treatment may be achieved if soil suitability criteria are met (refer to *Section 4.5.2*).

[c] The minimum sizing factor is ~~33.3~~20 percent because the contributing area to a facility is limited to 5~~3~~ times the permeable pavement facility area.

~~[b] Pre-sized Approach may be used to meet basic water quality treatment. Enhanced water quality treatment may be achieved if soil suitability criteria are met (refer to *Section 4.5.2*).~~

~~Permeable Pavement Facility Area = Contributing Hard Surface Area x Factor (%)/100.~~
~~Hard Surface Area Managed = Permeable Pavement Facility Area ÷ Factor (%)/100.~~

The required permeable pavement facility area is calculated as a function of the hard surface area routed to it. As an example, to meet the Pre-developed Pasture Standard for a contributing area less than 2,000 square feet, the permeable pavement area would be equal to ~~X~~ 34.1 percent of the hard surface area routed to it when the average water depth in the storage reservoir is 6 inches and the subgrade infiltration rate is between 0.~~25~~ 6 and ~~0.5~~1.0 inches per hour (Table 5.25). If the contributing area is a non-pollution generating surface (e.g., roof, sidewalk), a sizing factor of 34.1 percent is acceptable because it is greater than 20 percent (corresponding to a run-on ratio less than 5:1). However, if the contributing area is pollution generating (e.g., driveway, parking lot), a minimum sizing factor of 50 percent is required (corresponding to a run-on ratio less than 2:1). If the contributing area is a mix of surface types, the minimum sizing factor and maximum run-on ratio must be calculated as a weighted average:

> Minimum Sizing Factor = (% area non-pollution generating x 20% + % area pollution generating x 50%)/100%
>
> Maximum Run-on Ratio (X:1) = (% area non-pollution generating x 5 + % area pollution generating x 2)/100%

For example, a site with 70 percent roof and 30 percent driveway would have a minimum sizing factor of 29% [(30% x 50% + 70% x 20%0/100] and a maximum run-on ratio of 4:1 [(70% x 5 + 30% x 2)/100%].

~~The sizing factors for permeable pavement facilities are conservative. For infiltration rates of 0.5 and 1.0 inches per hour, modeling would likely yield ponding depth requirements less than 6 inches. Note that the minimum sizing factor is 33.3 percent because the area contributing runoff to a facility is limited to 3 times the permeable pavement facility area.~~

Alternatively, permeable pavement facilities can be sized using a continuous simulation hydrologic model as described below.

17. Volume 3, Section 5.4.9.5. Design Criteria. Add the following as the third sentence of the first paragraph, and add a new Figure X. Typical Infiltration Chamber after the last bullet:

Refer to Figure X for a schematic of a typical infiltration chamber.

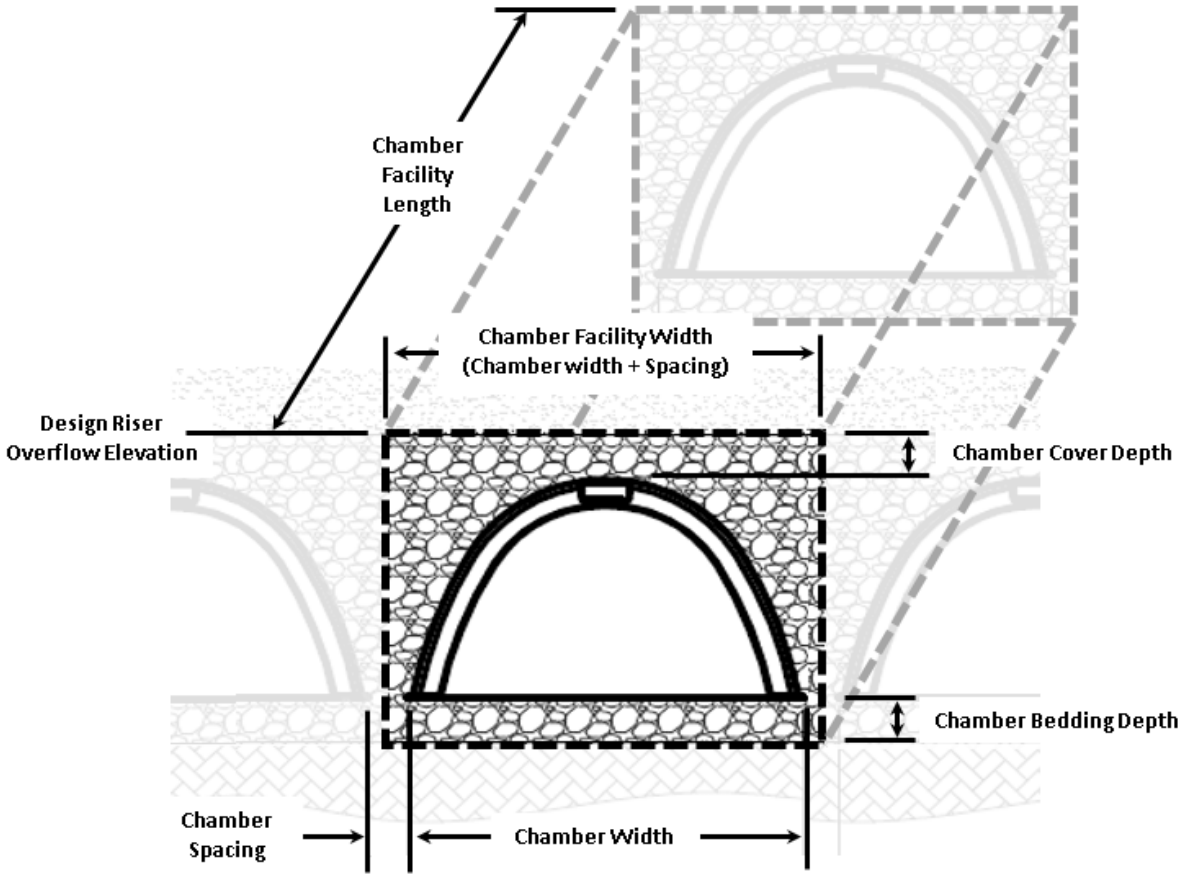

Figure X.X. Typical Infiltration Chamber.

18. Volume 3, Section 5.4.9.5. Design Criteria, Chamber Bedding. Replace the last sentence of this subsection with the following:

Chambers shall be filled with uniformly-graded, washed gravel with a nominal size from 3/4- to 1-1/2-inch diameter. The minimum void volume shall be 30 percent. These requirements can be met with City of Seattle Mineral Aggregate Type 4.

~~Bedding material shall be per City of Seattle Mineral Aggregate Type 4.~~

19. Volume 3, Section 5.4.9.6. BMP Sizing, Pre-Sized Approach for Flow Control and Water Quality Treatment. Revise this subsection as follows and add a new Table X.X Sizing Factors for Infiltration Chambers:

The Pre-sized Approach may be used for projects with new and replaced hard surface areas up to 10,000 square feet. Under the ~~The~~ Pre-sized Approach (refer to *Section 4.1.2*), ~~can be used for sizing~~ pre-sized arched infiltration chambers may be used to achieve Pre-developed Pasture, Peak Control and Water Quality Treatment Standards~~to meet storage or flow control requirements~~. Sizing factors and equations

for infiltration chambers receiving runoff from a hard surface are provided in Table X.X. Factors are organized by flow control standard, subgrade soil design infiltration rate, and contributing area. The design rate for the subgrade soils shall be rounded down to the nearest infiltration rate in the pre-sized table (i.e., 0.15, 0.3, 0.6, 1.0, or 2.5 inch per hour).

To use these sizing factors or equations to meet flow control standards, the facility shall meet the general requirements for infiltration chambers outlined in this section, plus the following specific requirements:

- The chamber area shall be sized using the applicable sizing factor or equation.
- The aggregate storage reservoir shall be composed of Mineral Aggregate Type 4 or approved equal.
- The effective chamber storage depth (as calculated in the Modeling Approach below) shall be at least 2 feet.
- To use these pre-sized infiltration chamber facility to meet water quality treatment, the underlying soil shall meet soil requirements specified in *Section 4.5.2*.
- Invert of overflow shall be set at top of the storage reservoir to provide the required storage reservoir depth used in the manufacturer's calculation of chamber facility storage volume.

Chambers that do not meet the above requirements shall use the Modeling Approach.

Table X.X. Sizing Factors for Infiltration Chambers.

Subgrade Soil Design Infiltration Rate	Contributing Area (sf)	Sizing Factor/Equation for Infiltration Chamber Area		
		Pre-developed Pasture Standard	Peak Control Standard	Water Quality Treatment Standard[a]
0.15 inch/hour	< 2,000	13.1%	12.6%	6.2%
	2,000 – 10,000	[0.0879 x A] +91.4		
0.3 inch/hour	< 2,000	11.1%	11.1%	5.1%
	2,000 – 10,000	[0.0733 x A[+79.9		
0.6 inch/hour	< 2,000	7.2%	8.0%	3.0%
	2,000 – 10,000	[0.0441 x A] +56.8		
1.0 inch/hour	< 2,000	6.4%	7.2%	2.6%
	2,000 – 10,000	[0.0392 x A] +50.7		
2.5 inch/hour	< 2,000	3.4%	4.3%	1.4%
	2,000 – 10,000	[0.021 x A] +28		

A – contributing hard surface area; sf – square feet.

For Sizing Factors: Infiltration Chamber Area (sf) = Contributing Hard Surface Area (sf) x Factor (%)/100.

Hard Surface Area Managed (sf) = Chamber Area (sf) ÷ Factor (%)/100.

For Sizing Equations: Infiltration Chamber Area (sf) = [Factor x A (sf)] + Integer.

Hard Surface Area Managed (sf) = [Chamber Area (sf) - Integer]÷ Factor.

[a] Pre-sized Approach may be used to meet basic water quality treatment. Enhanced water quality treatment may be achieved if soil suitability criteria are met (refer to *Section 4.5.2*).

The infiltration chamber facility area is calculated as a function of the area contributing runoff to the chamber facility. As an example, to meet the Pre-developed Pasture Standard for a contributing area between 2,000 and 10, 000 square feet where the subgrade infiltration rate is between 0.3 and 0.6 inches per hour, the chamber facility area would be calculated as: 0.0733 x contributing hard surface area +79.9. All area values shall be in square feet.

Alternatively, infiltration chamber facilities can be sized using a continuous hydrologic simulation model as described in the subsequent section.~~Different materials and shapes shall use the Modeling Approach.~~

20. Volume 3, Section 5.4.9.6., BMP Sizing, Modeling Approach for On-site Performance Standard, Flow Control, and Water Quality Treatment

When using continuous hydrologic modeling to size infiltration chambers, the assumptions listed in Table 5.27 shall be applied. It is recommended that infiltration chambers be modeled as a pond with vertical side walls and a depth (controlled in the model by the height of the outlet structure) set equal to the effective depth of the chamber facility. For a given chamber type and size, the effective depth (i.e., the equivalent chamber facility storage depth assuming 100 percent voids) can be estimated based on the chamber facility storage volume (chamber plus aggregate storage - typically obtained from the chamber manufacturer) and chamber facility footprint area (including aggregate spacing between chambers). Storage volume provided by the manufacturer should assume 30 percent aggregate porosity unless test showing higher porosity is provided. For example, for a 4 foot wide by 7 foot long chamber with 6 inch chamber spacing and a manufacturer provided storage volume of 70 cubic feet (assuming 30 percent aggregate porosity), the effective depth would be calculated as follows:

Effective Storage Depth = Storage Volume (70 cubic feet – per manufacturer) ÷ Chamber Facility Area where,

Chamber Area = Chamber Width including Spacing (4 feet + 3 inches + 3 inches) x Chamber Length (7 feet).

Once the effective depth for a given chamber system is established, the ~~gravel trench beds with infiltration. The contributing area,~~ chamber area or length~~, and depth~~ should be iteratively sized until the Minimum Requirements for Flow Control are met (refer to *Volume 1, Section 5.3*). General sizing procedures for infiltration facilities are presented in *Section 4.5.1*.

Table 5.27. Continuous Modeling Assumptions for Infiltration Chambers.

Variable	Assumption
Precipitation Series	Seattle 158-year, 5-minute series.
Computational Time Step	5 minutes.
Inflows to Facility	Surface flow and interflow from total drainage area (including impervious and pervious contributing areas) routed to facility.
Precipitation and Evaporation Applied to Facility	~~Yes~~No~~, if sited under pervious surface. If model does not apply precipitation and evaporation to facility, include the facility area as~~

	additional impervious area in the post-developed basin area that contributes runoff to the facility.
Total DepthAggregate Storage Reservoir Depth	Effective storage depth plus freeboard. TBD
Aggregate Storage Reservoir Porosity	TBD
Subgrade Soil Design Infiltration Rate	Design infiltration rate (*Section 4.5.2*, *Appendix D*)
Infiltration Across Wetted Surface Area	No (bottom area only).
Outlet Structure	Specify riser diameter and riser height (set equal to the effective storage depth).Overflow elevation set at average maximum subsurface ponding depth. May be modeled as weir flow over riser edge. Note that freeboard shall be sufficient to allow water surface elevation to rise above the overflow elevation to provide head for discharge.

21. Volume 3, Section 5.5.1.6. BMP Sizing, Modeling Approach for On-site Performance Standard and Flow Control. Revise last sentence of Step 1 as follows:

> The rainwater demand is then reduced by a factor of 150 percent (multiplied by a factor of 0.859) to account for lower than anticipated water use (e.g., periods of vacancy).

22. Volume 3, Section 5.5.2.6. BMP Sizing, Sizing for On-site List Approach. Revise this subsection and Table 5.31 as follows:

> SFR cisterns may be selected to meet the On-site List Requirement (refer to *Section 3.3.1* and *Appendix C* for infeasibility criteria). The area draining to a properly sized cistern meets the requirement. The cistern shall have three feet of live storage between the low flow orifice and the overflow, and have a 0.25 inch diameter low flow orifice. The minimum cistern bottom area sizing factors and minimum live storage depths is are provided in Table 5.31. The cistern shall have tThree to five -feet of live storage between the low flow orifice and the overflow must be provided, and havethe low flow orifice shall have a diameter of -a 0.25 inches diameter low flow orifice. For contributing areas up to 400 square feet, the minimum cistern bottom is 6.7 square feet. For larger contributing areas, the minimum cistern bottom areas shall be calculated using the sizing factor or sizing equation provided.

Table 5.31. On-site List Sizing for SFR Cisterns.

Contributing Area (sf)	Minimum Sizing Factor Cistern Bottom Area On-site Performance Standard	Minimum Live Storage Depth [a] (ft)
400-799	3.6%	3
800-899	2.8%	4
900-999	2.4%	
1,000-1,099	2.0%	
1,100-1,199	1.7%	
1,200-1,299	1.4%	

1,300-1,399	1.4%	5
1,400-1,899	1.3%	
1,900-1,999	1.2%	
2,000-2,999	1.6%	
3,000-4,200	1.9%	

sf – square feet.

Cistern Area = Contributing Hard Surface Area x Factor (%)/100.

Hard Surface Area Managed = Cistern Area ÷ Factor (%)/100.

[a] Detention depth refers to live storage depth (i.e., does not include freeboard or sediment storage requirements).

23. Volume 3, Section 5.6.1.6. BMP Credits, Pre-sized Approach for Flow Control. Revise this subsection and Table 5.32 as follows:

The Pre-sized Approach may be used for projects with new and replaced hard surface areas up to 10,000 square feet. Under the Pre-sized Approach (refer to *Section 4.1.2*), flow control credits towards meeting the Pre-developed Pasture and Peak Control Standards may be partially achieved by vegetated roof systems. Credits for vegetated roofs are provided in Table 5.32, organized by performance standard and growth media depth. These credits can be applied to reduce the hard surface area requiring flow control. Since the credits for vegetated roofs are less than 100 percent, the standard ~~cannot~~ is not~~be~~ completely achieved and additional flow control measures will be required. As an example, for a site subject to the Peak Control Standard, a ~~multi-course~~ vegetated roof ~~with 4 inches of growth media~~ would receive an ~~71~~ 86 percent credit. Therefore, ~~71~~ 86 percent of the impervious area covered by the vegetated roof can be excluded from drainage calculations. The impervious area used to size the downstream flow control facility would be calculated as ~~29~~ 16 percent of the impervious area covered by the vegetated roof.

Table 5.32. Flow Control Credits for Vegetated Roofs.

~~Course / Media Depth~~Vegetated Roof Type	Credit (%)	
	Pre-developed Pasture Standard	Peak Control Standard
Single or Mulit-Course / 4 inch minimum media depth~~es~~	~~TBD~~21%	~~TBD~~86%
~~Multi-Course / 4 inches~~	~~TBD~~	~~TBD~~
~~Multi-Course / 8 inches~~	~~TBD~~	~~TBD~~

Impervious Area Managed = Vegetated roof Area x Credit (%)/100.

The flow control credits outlined above are applicable only if the vegetated roof meets the minimum design requirements outlined in this section and the minimum media depth specified in Table 5.32.

Alternatively, vegetated roofs can be sized using a continuous model as described below.

24. Volume 3, Section 5.6.2.6. BMP Sizing, Pre-Sized Approach for Flow Control. Revise this subsection and Table 5.34 as follows.

The Pre-sized Approach may be used for projects with new and replaced hard surface areas up to 10,000 square feet. Under the Pre-sized Approach (refer to *Section 4.1.2*), pre-sized permeable pavement surfaces receive credits toward meeting the Pre-developed Pasture and Peak Control Standards. Credits for permeable pavement surfaces are provided in Table 5.34, organized by performance standard and subgrade slope. These credits can be applied to reduce the hard surface area requiring flow control. If partial credit (less than 100 percent) is received, the standard is not completely achieved and additional measures will be required. As an example, for a site subject to the Peak Control~~re-developed Pasture~~ Standard, a permeable pavement surface on subgrade with a slope ~~between~~ exceeding 2- ~~and 6~~ percent would receive a ~~XX~~ 71 percent credit. Therefore, ~~XX~~ 71 percent of the permeable pavement surface can be excluded from drainage calculations. The impervious area (the area used to size the downstream flow control facility) would be calculated as ~~XX~~ 29 percent of the permeable pavement surface area.

Table 5.34. Credits for Permeable Pavement Surfaces without Check Dams.

Subgrade Slope	Credit (%)		
	Pre-developed Pasture Standard	Peak Control Standard	Water Quality Treatment Standard[a]
Up to 2%	~~TBD~~100%	~~TBD~~96%[b]	~~TBD~~100%
>2~~ to 6~~%	~~TBD~~99%	~~TBD~~71%	~~TBD~~100%

Impervious Area Managed = Permeable Pavement Surface Area x Credit (%)/100.

[a] Pre-sized Approach may be used to meet basic water quality treatment. Enhanced water quality treatment may be achieved if soil suitability criteria are met (refer to *Section 4.5.2*).

[b] Permeable pavement surface meets the peak flow standard (i.e., achieves a 100% credit) if the aggregate subbase depth is increased to 3.5 inches.

To use these flow control credits to meet flow control standards, the BMP shall meet the general requirements for permeable pavement surfaces outlined in this section plus the following specific requirements:

- The aggregate subbase shall be at least 3 inches in depth.
- Subgrade slope shall be as specified in the table.
- To meet water quality treatment, the underlying soil shall meet the treatment soil requirements outlined in *Section 4.5.2* or a water quality treatment course shall be used.
- No underdrain or impermeable liner may be used.

For subgrade slopes ~~between~~ exceeding 2 ~~and 6~~ percent flow control performance is lower. For improved performance, the surface may be designed as a permeable pavement facility with subsurface ponding and/or increased aggregate subbase depth. In this case, the surface shall be evaluated as a permeable pavement facility (refer to *Section 5.4.6*).

Alternatively, the performance of permeable pavement surfaces can be evaluated using a continuous simulation hydrologic model as described below.

25. Volume 3, Section 5.7.2.6. BMP Sizing, Pre-Sized Approach for Flow Control. Revise the last paragraph of this subsection and Table 5.39 as follows:

The pipe length is calculated as a function of the hard surface area routed to it. As an example, for the Pre-developed Pasture Standard, the pipe length for a 24-inch diameter pipe receiving runoff from between ~~5~~2,000 to 10,000 square feet of hard surface would be calculated as: 0.~~120~~ 0571 x contributing hard surface area (square feet) ~~-~~+ ~~235~~ 49.5 feet. All area values shall be in square feet and length values shall be in feet.

Alternatively, detention pipes for small sites can be sized using a continuous model as described in the subsequent section.

Table 5.39. Sizing Equations for Detention Pipe.

Detention Pipe Diameter[a]	Contributing Area	Sizing Equation for Pipe Length	
		Pre-developed Pasture Standard	Peak Control Standard
24 inches	2,000 - 10,000 sf	[0.0571 x A] + 49.5	0.00014 x [A^1.69]
36 inches	2,000 - 10,000 sf	[0.0257 x A] + 21.8	0.000196 x [A^1.55]

A – contributing hard surface area; ft – feet; sf – square feet.

For ~~A < 5,000 sf~~Peak Control Standard: Pipe Length (ft) = Factor x [A (sf)^Integer].

Hard Surface Area Managed (sf) = [Pipe Length (ft) ÷ Factor]^(1 ÷ Integer).

For ~~A 5,000 to 10,000 sf~~Pre-developed Pasture Standard: Pipe Length (ft) = [Factor x A (sf)] ~~-~~+ Integer.

Hard Surface Area Managed (sf) = [Pipe Length (ft) ~~+~~- Integer]÷ Factor.

[a] Detention pipe diameter refers to live storage depth (i.e., does not include freeboard or sediment storage requirements).

26. Volume 3, Section 5.7.3.6. BMP Sizing, Pre-sized Approach for Flow Control. Revise the second paragraph of this subsection and Table 5.41 and as follows:

Table 5.41. Sizing Equations for Detention Vaults.

Detention Depth[a]	Contributing Area	Sizing Equation for Vault Area	
		Pre-developed Pasture Standard	Peak Control Standard
3 feet	2,000 – ~~5~~3,000 sf	[0.0662 x A]+38.9	64 sf
	~~5~~3,000 – 10,000 sf		0.00025 x [A^1.62]
4 feet	2,000 – ~~5~~3,000 sf	NA[b]	62 sf
	~~5~~3,000 – 10,000 sf		0.0011 x [A^1.41]

A – contributing hard surface area; NA- not applicable; sf- square feet.

For Peak Control Standard~~A < 5,000 sf~~: Vault Area (sf) = Factor x [A (sf)^Integer].

Hard Surface Area Managed (sf) = [Vault Area (sf) ÷ Factor]^(1 ÷ Integer).

For Pre-developed Pasture Standard~~A 5,000 to 10,000 sf~~: Vault Area (sf) = [Factor x A (sf)] ~~-~~+ Integer.

Hard Surface Area Managed (sf) = [Vault Area (sf)~~+~~ - Integer] ÷ Factor.

[a] Detention depth refers to live storage depth (i.e., does not include freeboard or sediment storage requirements).

[b] A vault with 4 feet of head above the low flow orifice is not applicable for sites subject to the Pre-developed Pasture Standard because the designer is required to reduce the head to at least 3 feet in an attempt to meet this standard (see Section 4.1.3.2).

The vault area is calculated as a function of the hard area routed to it. As an example, for the Peak Control Standard, the area for a vault with an overflow invert set at 4.0 feet above the low flow orifice and receiving runoff from ~~less than 5~~between 3,000 and 10,000 square feet of hard surface would be calculated as: 0.00~~0004~~41 x hard surface area (square feet) ^~~2.0~~1.4. All area units shall be square feet.

27. Volume 3, Section 5.7.4.6. BMP Sizing, Pre-sized Approach for Flow Control. Revise this subsection and Table 5.43 as follows:

The Pre-sized Approach may be used for projects with new and replaced hard surface areas up to 10,000 square feet. Under the Pre-sized Approach (refer to *Section 4.1.2*), pre-sized detention cisterns may be used to achieve Pre-developed Pasture and Peak Control Standards. Sizing factors and equations for aboveground cisterns receiving runoff from a hard surface are provided in Table 5.43. Factors are organized by flow control standard, cistern overflow depth and contributing area. To use these sizing factors to meet flow control standards, the facility shall meet the general requirements for cisterns outlined in this section plus the following specific requirements:

- The cistern area shall be sized using the applicable sizing factor or equation.
- The flow control orifice diameter shall be 0.25 inches.
- The invert of the overflow shall be set at the designated detention (i.e., live storage) depth (3 or 4 feet) above the invert of the flow control orifice. For intermediate depths (between 3 and 4 feet), the cistern area may be linearly interpolated.
- The cistern shall have vertical walls to the designated overflow height.

Table 5.43. Sizing Equations for Aboveground Detention Cisterns.

Detention Depth[a]	Contributing Area (sf)	Sizing Factor/Equation for Cistern Area	
		Pre-developed Pasture Standard	Peak Control Standard
3 feet	< 2,000	10.6%	5.9%
	2,000 - 3,500		0.00036 x A^1.68
	3,500 - 5,000	408 sf	
	5,000 – 10,000	0.00015 x [A^1.74]	
4 feet	< 2,000	6.4%	4.11%
	2,000 - 5,000		0.00038 x [A^1.63]
	5,000 - 6,000	322 sf	
	6,000 – 10,000	0.0001 x [A^1.73]	

A – contributing hard surface area; ~~NA – not applicable;~~ sf – square feet.

For Sizing Factors: Cistern Area = Contributing Hard Surface Area x Factor (%)/100.

Hard Surface Area Managed = Cistern Area ÷ Factor (%)/100.

For Linear Equations: Cistern Area (sf) = [Factor x A (sf)] + Integer or Factor x [A (sf)^Integer].

Hard Surface Area Managed (sf) = [Cistern Area (sf) - + Integer] ÷ Factor or [Cistern Area (sf) ÷ Factor]^(1 ÷ Integer).

For Power Equations: Cistern Area (sf) = Factor x [A (sf)^Integer].

Hard Surface Area Managed (sf) = [Cistern Area (sf) ÷ Factor]^(1 ÷ Integer).

[a] Detention depth refers to live storage depth (i.e., does not include freeboard or sediment storage requirements).

The cistern bottom area is calculated as a function of the hard surface area routed to it. As an example, to meet the Pre-developed Pasture Standard, the area of a cistern with an overflow invert set at 3 feet above the flow control orifice and receiving runoff from between 5,000 and 10,000 less than 6,140 square feet would be calculated as: TBD 0.000147 x contributing hard surface area (square feet) ^TBD1.74. All areas values shall be in units of square feet. For the same cistern receiving runoff from between 3,5000 and 5,000 between 6,140 and 8,000 square feet, the cistern area would be TBD 408 square feet.

A cistern with 4 feet of head above the flow control orifice is not applicable for sites subject to the Pre-developed Pasture Standard because the head is too large to meet this standard. To meet the Pre-developed Pasture Standard and use the Pre-sized Approach, a cistern with 3 feet of detention depth shall be used(refer to *Section 4.1.2*).

Alternatively, cisterns can be sized using a continuous model as described in the next section.

28. Volume 3, Section 5.8.2.6. BMP Sizing, Pre-sized Approach for Flow Control and Water Quality Treatment. Revise this subsection and replace Table 5.46 as follows:

The Pre-sized Approach may be used for projects with new and replaced hard surface areas up to 10,000 square feet. Under the Pre-sized Approach (refer to *Section 4.1.2*), pre-sized non-infiltrating bioretention facilities may be used to achieve the Peak Control and Water Quality Treatment Standards. Sizing factors and equations for non-infiltrating bioretention facilities with underdrains are provided in Table 5.46. Factors are organized by side slopes (i.e., sloped sides or vertical sides), performance standard, and facility ponding depth, and contributing area. To select the appropriate sizing factor the design ponding depth shall be rounded down to the nearest depth in the sizing table, or sizing factors may be linearly interpolated for intermediate ponding depths (e.g., between 6 and 12 inches ponding).

To use these pre-sized facilities to meet performance standards, the bioretention facility shall meet the general requirements outlined in this section plus the following specific requirements:

- The bottom area shall be sized using the applicable sizing factor or equation. When used to meet the Peak Control Standard, the facility size shall not be larger than prescribed by the sizing factor because flow control performance may be diminished for larger facilities.

- It is preferred that the bottom area is flat, but up to a 3 percent slope is permitted.
- For facilities with sloped sides, the side slopes within the ponded area shall be no steeper than 2.5H:1V.
- The bioretention soil depth shall be a minimum of 18 inches.
- The average ponding depth for the cell shall be no less than the selected ponding depth.

Table 5.46. Sizing Factors/Equations for Non-infiltrating Bioretention.

Bioretention Configuration	Ponding Depth	Contributing Area (sf)	Sizing Factor/Equation for Facility Bottom Area		
			Pre-developed Pasture Standard	Peak Control Standard	Water Quality Treatment
Sloped sides	2 inches	0 – 10,000	NA[a]	NA[a]	1.3%
	6 inches	< 2,000	NA[a]	NA[a]	[0.0059 x A] - 3.2
		2,000 – 10,000			[0.0097x A] - 11.3
	12 inches	< 2,700	NA[a]	3% to 4.5%[b]	2.0%
		2,700 – 10,000			]0.0052 x A] - 12.1
Vertical sides	6 inches	0 – 10,000	NA[a]	NA[a]	1.3%
	12 inches	0 – 10,000	NA[a]	4.5%[b]	1.1%

NA- not applicable

For Sizing Factors: Bioretention Facility Bottom Area = Contributing Hard Surface Area x Factor (%)/100

Hard Surface Area Managed = Bioretention Facility Bottom Area ÷ Factor (%)/100

For Sizing Equations: Bioretention Facility Bottom Area (sf) = [Factor x A (sf)] + Integer.

Hard Surface Area Managed (sf) = [Bioretention Bottom Area (sf) - Integer]÷ Factor.

[a] Bioretention facilities with underdrains are not capable of achieving the standard unless orifice controls are used.

[b] When used to meet the Peak Control Standard, the facility size shall not be larger than prescribed by the sizing factor (or sizing factor range) because flow control performance may be diminished for larger facilities (larger facilities will not pond water sufficiently to slow flows).

The *bottom area* for the bioretention facility area is calculated as a function of the hard surface area routed to it. As an example, to meet the Water Quality Treatment Standard, the bottom area of the bioretention facility with vertical sides and 12 inches of ponding would be equal to 1.1 percent of the hard surface area routed to it ~~when the ponding depth is 12 inches~~. The bottom area of same facility with slopes sides would be calculated as: 0.0052 x contributing hard surface area – 12.1. All area values shall be in square feet. For facilities with sloped sides, the top area is calculated as a function of the cell bottom area and the side slopes up to the total facility depth (i.e., ponding and freeboard depth).

Instead of using the Pre-sized Approach, non-infiltrating bioretention facilities can be sized using a continuous simulation hydrologic model as described in the subsequent section.