

# **Module 7: Evaluating Water Quality Compliance**

## 7a: Evaluating On-site Compliance

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### Objectives

- Identify Volume and Load Tracking in the Runoff Reduction Method
- Identify Total Removal of Clearinghouse BMP Practices
- Review Redevelopment Calculations
- Review Offline Facilities and Flow Bypass Approaches
- Calculate the water quality flow rate
- Recall Off-site Compliance materials presented in the Basic SWM course

## 7a. Evaluating On-site Compliance

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### 7a1. Introduction

On site water quality compliance for standard New Development activities was addressed previously in Module 4. This module is intended to provide practical information about the complexities of plan review, volume and load tracking, and redevelopment scenarios and requirements. For basic instructional material, refer to the Module 4 participant guide.

### 7a2. Complex Treatment Trains

Plan reviewers are likely to encounter many instances where there are limitations on the spreadsheets capabilities. Specifically, the spreadsheet will be useful for evaluating compliance on simple sites with very linear treatment processes, but will be of more limited use when complex treatment trains and drainage networks are employed.

1. The presentation introduces some scenarios and shows the user where the individual components of the spreadsheet track volume and load.
2. For complex scenarios, one spreadsheet may not be enough, so reviewers may have to check tabulated information that is derived from multiple spreadsheets.
3. Specifically, it is important for reviewers to understand some basic things about the methodology:
  - a. How is the treatment volume tracked in the spreadsheet?
  - b. How is runoff reduction tracked in the spreadsheet?
  - c. How is pollutant load tracked in the spreadsheet?
  - d. Variables to account for:
    - i. Hydrologic Parameters
      1. Land Cover: Forest/Turf/Impervious
      2. Hydrologic Soil Group: A/B/C/D
    - ii. Volume and Load
      1. Tracked for **each sub-area** and for **each practice**
      2. Volume to next practice includes **residual volume** from upstream BMP **plus direct volume**

3. Load includes **residual load** and **direct load**

4. Remember to include **bypass loads**

4. The illustrations are intended to give the reviewer a better feel for where the numbers derive.

The Runoff Reduction Technical Memorandum and the Spreadsheet Users Instructions should serve as the primary references for reviewers to understand how the method works and track volume and load, when the spreadsheet is insufficient for a given application.

**Treatment Volume Note:** Reviewers should understand that for a given BMP, the spreadsheet tabulates both the **“Runoff Reduction”**, and the **“Remaining Runoff Volume”**:

Volume from Upstream RR Practice (cf)	Runoff Reduction (cf)	Remaining Runoff Volume (cf)	Phosphorus Efficiency (%)
0	0	0	25
0	0	0	25
0	3104	345	25
0	719	80	25

The **Treatment Volume** for a given BMP is the **sum** of these two volumes (the spreadsheet does not tabulate the total Tv for each BMP on the drainage area tabs).

Residual volume from upstream BMP contributes to next BMP in treatment train for sizing:

Practice	Spec of Credit	Credit	Credit Area (acres)	Volume from Upstream RR Practice (cf)	Runoff Reduction (cf)	Remaining Runoff Volume (cf)	Phosphorus Efficiency (%)	Phosphorus Load from Upstream RR Practices (lbs)	Untreated Phosphorus Load to Practice (lbs)	Phosphorus Removed by Practice (lbs)	Remaining Phosphorus Load (lbs)	Downstream Treatment to be Employed
	Volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7. b. Infiltration #2 (Spec #8)	Volume reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	8. b. ED #2
	Volume reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	
<b>8. Extended Detention Pond</b>												
8. a. ED #1 (Spec #15)	Volume reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	Volume reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
8. b. ED #2 (Spec #15)	Volume reduction	0.15	1.00	345	569	3224	15	0.00	1.6	0.65	1.68	
	Volume reduction	0.15	0.00	80	12	68	15	0.00	0.01	0.03	0.03	

Total Mass Load Efficiency Note: The total removal efficiency of a practice is the sum of the Runoff Reduction efficiency and the Pollutant Removal efficiency applied to the balance of runoff:

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	50%	90%
Total Phosphorus (TP) EMC Reduction <sup>1</sup> by BMP Treatment Process	25%	+ 25% <del>x</del> Balance of Tv
Total Phosphorus (TP) Mass Load Removal	63%	= 93%
Total Nitrogen (TN) EMC Reduction <sup>1</sup> by BMP Treatment Process	15%	15%
Total Nitrogen (TN) Mass Load Removal	57%	92%

7.a. Infiltration #1 (Spec #8)	Runoff reduction	0.50	0.90	0	0	0	25	0.00	0.00	0.00	0.00	
	Volume reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	
7.b. Infiltration #2 (Spec #8)	Runoff reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	
	Volume reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	

**{TR: Total Mass Load Efficiency}**  
**= {RR Eff. } + {PR Eff x (1 - Rreff)}**

$$\{90\% \} + \{25\% \times (1 - 0.90)\} = \{90 + (25 \times 0.1)\} = 92.5\%$$

## Load Tracking:

**Apply Runoff Reduction Volume & Post-Development Load in Drainage Area B**

Practice	Percent of Credit	Credit	Credit Area (acres)	Volume from Upstream RR Practice (cf)	Runoff Reduction (cf)	Remaining Runoff Volume (cf)	Phosphorus Efficiency (%)	Phosphorus Load from Upstream RR Practices (lbs)	Untreated Phosphorus Load to Practice (lbs)	Phosphorus Removed By Practice (lbs)	Remaining Phosphorus Load (lbs)	Downstream Treatment to be Employed
<b>7. Infiltration</b>												
7.a. Infiltration #1 (Spec #8)	Some reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
	Some reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	Some reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	
	Some reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	

$\{ \text{Load Delivered to BMP} \} - \{ \text{Load Removed by BMP} \} = \{ \text{Remaining P Load (to next BMP or outlet)} \}$

Loading to the next BMP will include the residual load from the upstream BMPs and the additional (direct) untreated load to that BMP:

Practice	Percent of Credit	Credit	Credit Area (acres)	Volume from Upstream RR Practice (cf)	Runoff Reduction (cf)	Remaining Runoff Volume (cf)	Phosphorus Efficiency (%)	Phosphorus Load from Upstream RR Practices (lbs)	Untreated Phosphorus Load to Practice (lbs)	Phosphorus Removed By Practice (lbs)	Remaining Phosphorus Load (lbs)	Downstream Treatment to be Employed
<b>7. Infiltration</b>												
7.a. Infiltration #1 (Spec #8)	Some reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
	Some reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	Some reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	8.a. ED #2
	Some reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	8.a. ED #2
<b>8. Extended Detention Pond</b>												
8.a. ED #1 (Spec #15)	Some reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	Some reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
8.b. ED #2 (Spec #15)	Some reduction	0.15	1.00	345	569	3224	15	0.16	2.16	0.65	1.68	
	Some reduction	0.15	0.00	80	12	66	15	0.04	0.00	0.01	0.03	

### 7a3. Redevelopment

Redevelopment requirements for pollutant load reductions were addressed in the Basic SWM Course. Please refer to the Act, Regulations and the Basic SWM Participants Guide for additional information about redevelopment requirements.

#### Spreadsheet Demonstration

It is important for reviewers to understand several things about how the redevelopment requirements are implemented in the Runoff Reduction Method. Specifically:

1. Redevelopment reductions may vary dependent on the total disturbed area for the site
  - a. 10% net reduction required for <1 Acre of disturbance
  - b. 20% net reduction required for 1 Acre or more of disturbance
2. For sites which results in increases in impervious cover, the requirements for redevelopment and the requirements for the new development portion of the site are tabulated separately.
3. It is important for reviewers to understand to which area the redevelopment requirements will apply.
  - a. The redevelopment requirements of the Virginia Stormwater Management Regulations apply only to the land disturbing activity, but some authorities may implement more stringent requirements for redevelopment which apply to undisturbed portions of the redevelopment site.

**Predevelopment** refers to conditions that exist:

- at time plans are submitted for land development of a tract of land
- For multi-phase projects:
  - o at time of original submission for first phase of project

## Redevelopment Examples:

Post-ReDevelopment Project & Land Cover Information					Total Disturbed Acreage
<b>Constants</b>					
Annual Rainfall (inches)	43				
Target Rainfall Event (inches)	1.00				
Phosphorus EMC (mg/L)	0.26			Nitrogen EMC (mg/L)	1.86
Target Phosphorus Target Load (lb/acre/yr) Pj	0.41				
	0.90				
<b>Pre-ReDevelopment Land Cover (acres)</b>	<b>A soils</b>	<b>B Soils</b>	<b>C Soils</b>	<b>D Soils</b>	<b>Totals</b>
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.00	0.00
Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00
	<b>Total</b>				0.00
<b>Post-ReDevelopment Land Cover (acres)</b>	<b>A soils</b>	<b>B Soils</b>	<b>C Soils</b>	<b>D Soils</b>	<b>Totals</b>
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.00	0.00
Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00
	<b>Total</b>				0.00
<b>Area Check</b>	Okay	Okay	Okay	Okay	

### Example 1 (Project disturbs 1 acre or greater but has no increase in impervious cover):

**Site Data:** Managed Turf = 2 acres; Impervious Cover = 2 acres

Post-ReDevelopment Project & Land Cover Information					Total Disturbed Acreage
<b>Constants</b>					
Annual Rainfall (inches)	43				
Target Rainfall Event (inches)	1.00				
Phosphorus EMC (mg/L)	0.26			Nitrogen EMC (mg/L)	1.86
Target Phosphorus Target Load (lb/acre/yr) Pj	0.41				
	0.90				
<b>Total Site Area (acres)</b>	4.00	4.00	<b>Total ReDev. Site Area (acres)</b>	4.00	<b>Total New Dev. Site Area (acres)</b>
Site Rv	0.59	0.59	ReDev. Site Rv	0.59	New Dev. Site Rv
Pre-Development Treatment Volume (acre-ft)	0.1950	0.1950	Post-ReDevelopment Treatment Volume (acre-ft)	0.1950	Post-Development Treatment Volume (acre-ft)
Pre-Development Treatment Volume (cubic feet)	8,494	8,494	Post-Development Treatment Volume (cubic feet)	8,494	Post-Development Treatment Volume (cubic feet)
Pre-Development Load (TP) (lb/yr)	5.34	5.34	Post-ReDevelopment Load (TP) (lb/yr)	5.34	Post-Development Load (TP) (lb/yr)
<sup>1</sup> Adjusted Land Cover Summary reflects the pre redevelopment land cover minus the previous land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in Column I.			Maximum % Reduction Required Below Pre-ReDevelopment Load	20%	TP Load Reduction Required for New Impervious Area (lb/yr)
			TP Load Reduction Required for Redeveloped Area (lb/yr)	1.07	
			<b>Total Load Reduction Required (lb/yr)</b>	<b>1.07</b>	
Pre-Development Load (TN) (lb/yr)	38.18		Post-Development Load (TN) (lb/yr)	38.18	

**Example 2 (Project disturbs less than 1 acre but has no increase in impervious cover):**

Post-ReDevelopment Project & Land Cover Information			Total Disturbed Acreage	0.50
<b>Constants</b>				
Annual Rainfall (inches)	43			
Target Rainfall Event (inches)	1.00			
Phosphorus EMC (mg/L)	0.26		Nitrogen EMC (mg/L)	1.86
Target Phosphorus Target Load (lb/acre/yr)	0.41			
Pj	0.90			

**Site Data:** Managed Turf = 2 acres; Impervious Cover = 2 acres

Pre-Development Treatment Volume (acre-ft)	0.1950	0.1950	Post-ReDevelopment Treatment Volume (acre-ft)	0.1950	Post-Development Treatment Volume (acre-ft)	0.0000
Pre-Development Treatment Volume (cubic feet)	8,494	8,494	Post-ReDevelopment Treatment Volume (cubic feet)	8,494	Post-Development Treatment Volume (cubic feet)	0
Pre-Development Load (TP) (lb/yr)	5.34	5.34	Post-ReDevelopment Load (TP) (lb/yr)	5.34	Post-Development Load (TP) (lb/yr)	0.00
<i>Adjusted Land Cover Summary</i> reflects the pre redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in <b>Column I</b> .			Maximum % Reduction Required Below Pre-ReDevelopment Load	10%		
			TP Load Reduction Required for Redeveloped Area (lb/yr)	0.53	TP Load Reduction Required for New Impervious Area (lb/yr)	0.00
			Total Load Reduction Required (lb/yr)	0.53		
Pre-Development Load (TN) (lb/yr)	38.18		Post-Development Load (TN) (lb/yr)	38.18		

**Example 3 (Project disturbs more than 1 acre and has an increase in impervious cover):**

Site Data		
	Managed Turf	Impervious Cover
Pre-Development:	2 acres	2 acres
Post-Development:	1 acres	3 acres

Post-ReDevelopment Project & Land Cover Information					Total Disturbed Acreage
					1.50
<b>Constants</b>					
Annual Rainfall (inches)	43				
Target Rainfall Event (inches)	1.00				
Phosphorus EMC (mg/L)	0.26	Nitrogen EMC (mg/L) 1.86			
Target Phosphorus Target Load (lb/acre/yr)	0.41				
Pj	0.90				
<b>Pre-ReDevelopment Land Cover (acres)</b>					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) – undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) – disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	2.00	0.00	2.00
Impervious Cover (acres)	0.00	0.00	2.00	0.00	2.00
	Total				4.00
<b>Post-ReDevelopment Land Cover (acres)</b>					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) – undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) – disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	1.00	0.00	1.00
Impervious Cover (acres)	0.00	0.00	3.00	0.00	3.00
	Total				4.00

Post-ReDevelopment Project & Land Cover Information					Total Disturbed Acreage	
					1.50	
<b>Constants</b>						
<p><small>Adjusted Land Cover Summary reflects the pre redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in Column I.</small></p>						
Total Site Area (acres)	4.00	3.00	Total ReDev. Site Area (acres)	3.00	Total New Dev. Site Area (acres)	1.00
Site Rv	0.59	0.71	ReDev. Site Rv	0.71	New Dev. Site Rv	0.95
Pre-Development Treatment Volume (acre-ft)	0.1950	0.1767	Post-Development Treatment Volume (acre-ft)	0.1767	Post-Development Treatment Volume (acre-ft)	0.0790
Pre-Development Treatment Volume (cubic feet)	8,494	7,696	Post-Development Treatment Volume (cubic feet)	7,696	Post-Development Treatment Volume (cubic feet)	3,449
Pre-Development Load (TP) (lb/yr)	5.34	4.84	Post-Development Load (TP) (lb/yr)	4.84	Post-Development Load (TP) (lb/yr)	2.17
			Maximum % Reduction Required Below Pre-Development Load	20%		
			TP Load Reduction Required for Redeveloped Area (lb/yr)	0.97	TP Load Reduction Required for New Impervious Area (lb/yr)	1.76
			Total Load Reduction Required (lb/yr)	2.72		

**Example 4 (Redevelopment project equals the land disturbance area):**

Site Data		
	Managed Turf	Impervious Cover
Pre-Development:	1 acres	0.5 acres
Post-Development:	0 acres	1.5 acres

Post-ReDevelopment Project & Land Cover Information		Total Disturbed Acreage			
		1.50			
<b>Constants</b>					
Annual Rainfall (inches)	43				
Target Rainfall Event (inches)	1.00				
Phosphorus EMC (mg/L)	0.26	Nitrogen EMC (mg/L)	1.86		
Target Phosphorus Target Load (lb/acre/yr)	0.41				
P)	0.90				
<b>Pre-ReDevelopment Land Cover (acres)</b>					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	1.00	0.00	1.00
Impervious Cover (acres)	0.00	0.00	0.50	0.00	0.50
				Total	1.50
<b>Post-ReDevelopment Land Cover (acres)</b>					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.00	0.00
Impervious Cover (acres)	0.00	0.00	1.50	0.00	1.50
				Total	1.50

Post-ReDevelopment Project & Land Cover Information		Total Disturbed Acreage		
		1.50		
<b>Constants</b>				
Total Site Area (acres)	1.50	0.50	Total New Dev. Site Area (acres)	1.00
Site Rv	0.46	0.95	New Dev. Site Rv	0.95
Pre-Development Treatment Volume (acre-ft)	0.0579	0.0396	Post-Development Treatment Volume (acre-ft)	0.0790
Pre-Development Treatment Volume (cubic feet)	2,523	1,724	Post-Development Treatment Volume (cubic feet)	3,449
Pre-Development Load (TP) (lb/yr)	1.59	1.08	Post-Development Load (TP) (lb/yr)	2.17
<sup>1</sup> Adjusted Land Cover Summary reflects the pre redevelopment land cover minus the previous land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in Column I.				
Maximum % Reduction Required Below Pre-Development Load		20%		
TP Load Reduction Required for Redeveloped Area (lb/yr)		0.22		
Total Load Reduction Required (lb/yr)		1.97		
TP Load Reduction Required for New Impervious Area (lb/yr)		1.75		
Pre-Development Load (TN) (lb/yr)	11.34	Post-Development Load (TN) (lb/yr)	23.25	

## 7b. BMP Variations

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### 7b1. Introduction

We covered the BMP standards and specifications in Module 6. Some of the practices will require placement in an offline manner in order to reduce potential for hydraulic overloading, or due to site constraints. Additionally, some of the practices (including offline practices) will require verification that the “water quality flows” representing the treatment volume area directed to the practice satisfy certain hydraulic criteria required by the Specifications. This module briefly discusses those two issues and goes on to discuss the future pathway for updates and improvements to the BMP technology specifications on the Virginia BMP Clearinghouse web site.

### 7b2. Online vs. Offline Practices and Flow Bypass

Runoff Reduction BMPs are typically sized and designed to manage the design treatment volume from the 1-inch rainfall event. In some cases designers may choose to manage or detain a larger storm event in order to partially or fully meet the quantity control requirements. In all cases, the designer must account for the conveyance of these larger storms *through* the BMP (the BMP is said to be **On-Line**) or *around* the BMP (making the BMP **Off-Line**).

Using the water quality design  $T_v$  peak flow rate (described later in this Module), the designer can size a bypass control for an **On-Line** BMP, such that flows that exceed the design capacity exit via an internal riser structure or weir overflow. This means that the BMP accepts all the runoff from the contributing drainage area and the overflow is within the BMP (or main treatment area). On-line BMPs must be carefully designed to accommodate the large storm design peak flow rate in terms of inflow velocity and energy, as well as an adequately sized overflow to allow the runoff to safely exit the BMP.

On-line systems in these cases will require careful design and construction to ensure adequate conveyance of the large storm inflow.

On-line systems should include the following:

- Inflow points should be protected from erosive velocity
- An overflow structure must be provided within the practice to pass storms greater than the design storm storage to a stabilized conveyance or storm sewer system

- Discharge from the overflow structure should be controlled so that velocities are non-erosive at the outlet point

The overflow structure type and design should be scaled to the application – this may be a landscape grate or yard inlet for small practices or a commercial-type structure for larger installations.

Alternately, an **Off-Line** BMP design uses an external diversion structure to manage the large storm flow so the runoff in excess of the 1-inch rain event will not damage the BMP (excessive velocity or ponding depth) or re-suspend and export previously trapped pollutants. This can be accomplished through a low-flow diversion structure that channels the smaller storm flow volume into the BMP, while forcing the larger flows to bypass the BMP. These types of low-flow diversion or large storm bypass structures are external – thereby diverting the flow before it gets to the BMP – or they can be part of the BMP inlet structure, such as a forebay or level spreader. In some cases, off-line BMPs with a storage volume can be located so that once the storage volume is full, additional runoff simply diverts past or around the BMP. **Figure 7-1** below illustrates a simple off-line BMP.

Off-line designs require that the designer determine the runoff peak flow rates for the range of design storms: 1-inch rainfall depth, and 1-year, 2-year, and 10-year 24-hour storms, as needed.

Off-line designs are usually the preferred option for volume reduction BMPs, especially where larger drainage areas (e.g., greater than 0.5 to 1 acre) are conveyed by a pipe or armored drainage system.

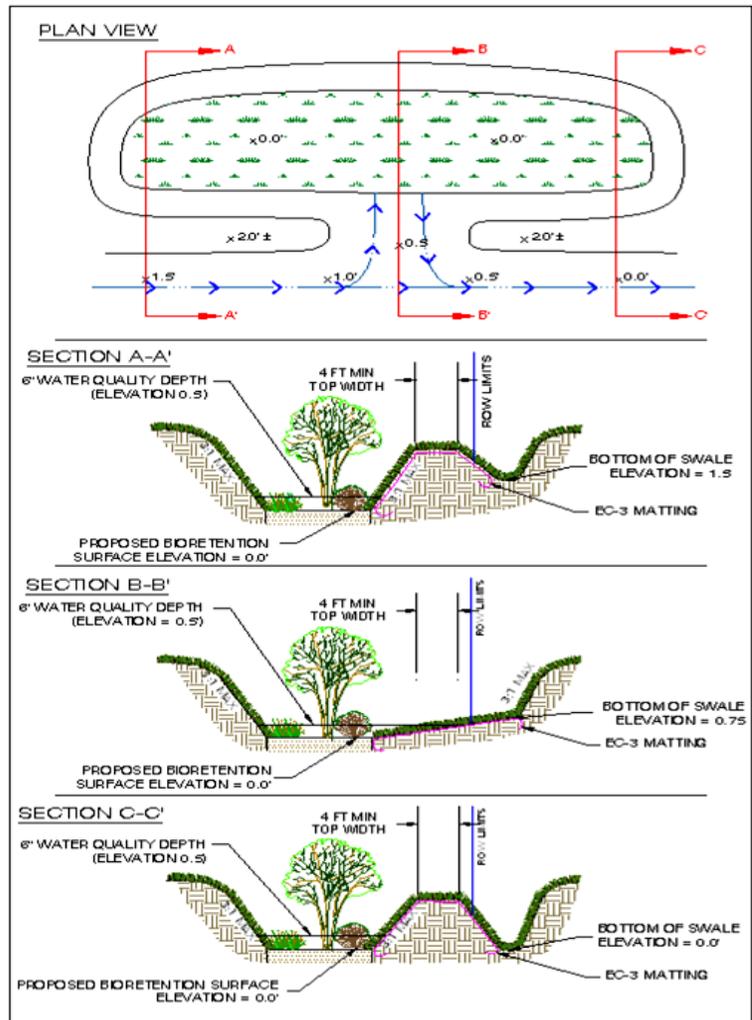
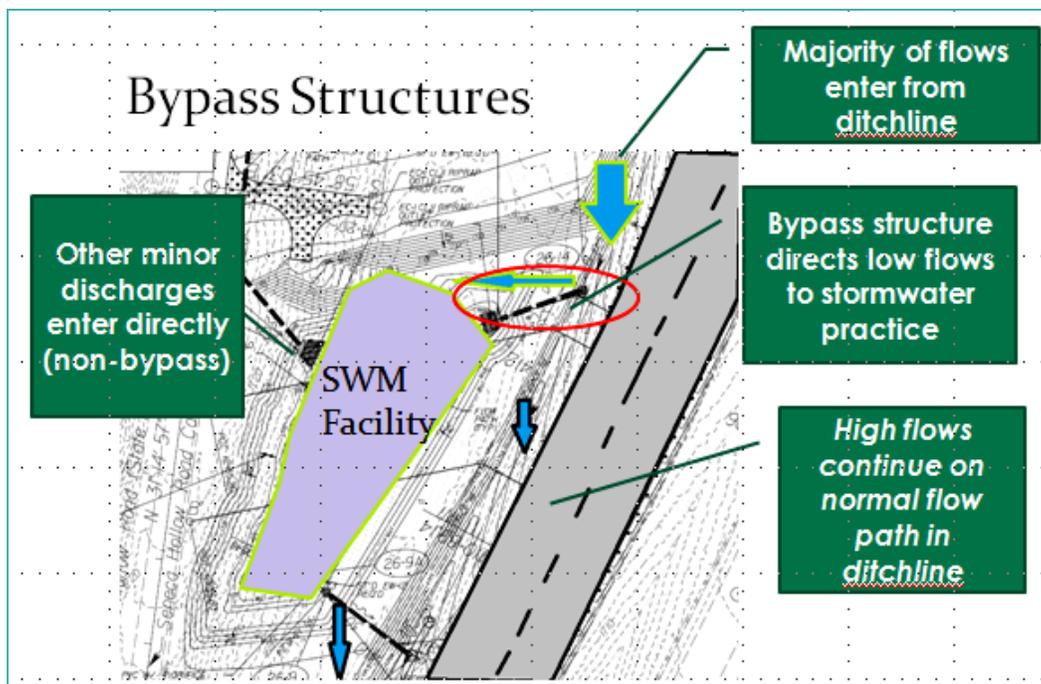


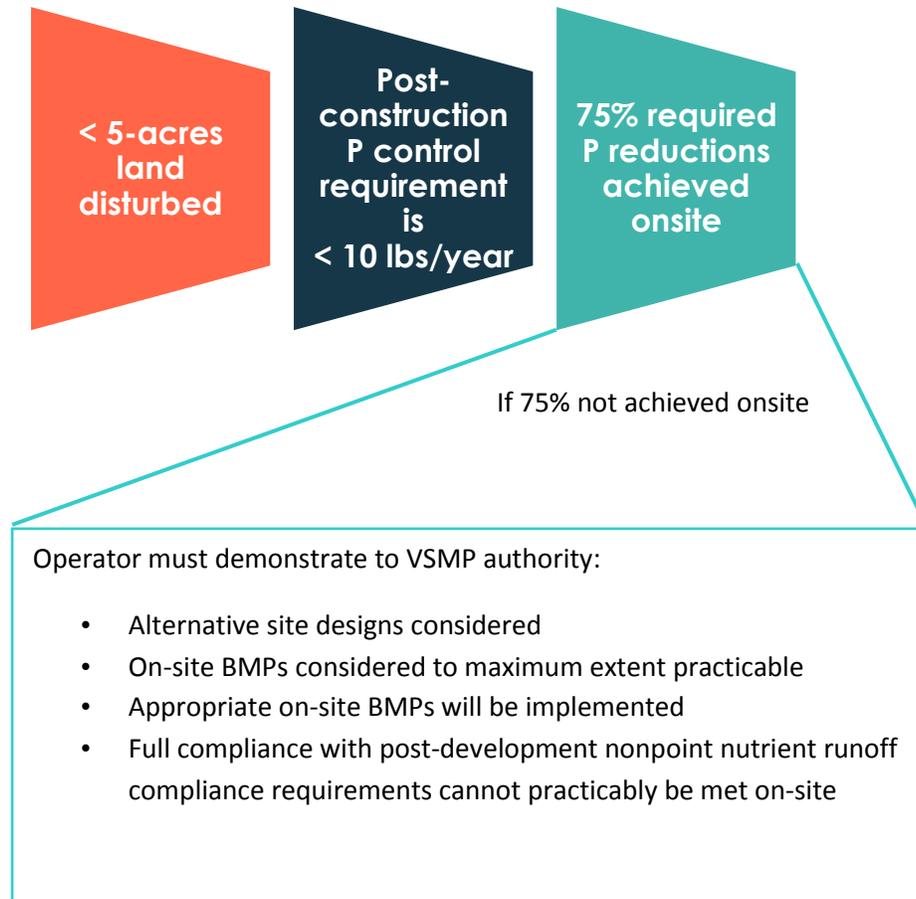
Figure 7-1: 1 Simple Off-Line BMP Plan and Cross-section



## 7c. Off-site Compliance Options

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Can be used under any of the following conditions:



See Module 2 for additional information.