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Module 4

Runoff Reduction and Water Quality

Module 4 Content

4a: Overview of the Runoff Reduction Method

4b: Land Cover & Volumetric Runoff Coefficients

4c: The Simple Method

4d: Virginia Water Quality Requirements

4e: Introduction to Stormwater Runoff Reduction Practices

4f: VRRM Compliance Spreadsheet Example

Virginia Runoff Reduction Method Spreadsheet

	A	B	C	D	E	F
1	Virginia Runoff Reduction Method New Development Worksheet -- v2.7 Revised Feb 2014					
2	Site Data					
3						
4	Project Name:					
5	Date:					
7	data input cells					
8	calculation cells					
9	constant values					
11	1. Post-Development Project & Land Cover Information					
13	Constants					
15	Annual Rainfall (inches)	43				
16	Target Rainfall Event (inches)	1.00				
17	Phosphorus EMC (mg/L)	0.26	Nitrogen EMC (mg/L)	1.86		
18	Target Phosphorus Target Load (lb/acre/yr)	0.41				
19	Pj	0.90				
21	Land Cover (acres)					
22		A soils	B Soils	C Soils	D Soils	Totals
23	Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00		0.00	0.00	0.00
24	Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00		0.00	0.00	0.00
25	Impervious Cover (acres)	0.00		0.00	0.00	0.00
26		Total				0.00
28	Rv Coefficients					
29		A soils	B Soils	C Soils	D Soils	
30	Forest/Open Space	0.02	0.03	0.04	0.05	
31	Managed Turf	0.15	0.20	0.22	0.25	
32	Impervious Cover	0.95	0.95	0.95	0.95	
36	Land Cover Summary					
37	Forest/Open Space Cover (acres)	0.00				
38	Weighted Rv(forest)	0.00				
39	% Forest	0%				
40	Managed Turf Cover (acres)	0.00				

Site Data Input

Summary Print-out

Drainage Area Inputs

Water Quality Check

Channel/Flood Protection Info

Virginia Runoff Reduction Method Spreadsheet

Virginia Runoff Reduction Method New Development Worksheet -- v2.7 Revised Feb 2014

Site Data

Project Name:

Date:

1. Post-Development Project & Land Cover Information

Constants

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Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals
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Impervious Cover (acres)	0.00		0.00	0.00	0.00
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Rv Coefficients

	A soils	B Soils	C Soils	D Soils
Forest/Open Space	0.02	0.03	0.04	0.05
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Land Cover Summary

Forest/Open Space Cover (acres)	0.00
Weighted Rv(forest)	0.00
% Forest	0%
Managed Turf Cover (acres)	0.00

Land Cover (acres) by HSG

Constants & Volumetric Runoff Coefficients

Calculated Results:
 Composite Rv
 Pollutant Load
 Load Reduction
 Treatment Volume

Site Data Input

4a. Overview of the Virginia Runoff Reduction Method (VRRM)

- **Environmental Site Design**
- **Land cover type** in pollutant and hydrologic loading factors
- New treatment options with performance credit breakouts
(RR and EMC → Mass Load)
- Step-wise (iterative) compliance process

4a. Overview of the VRRM

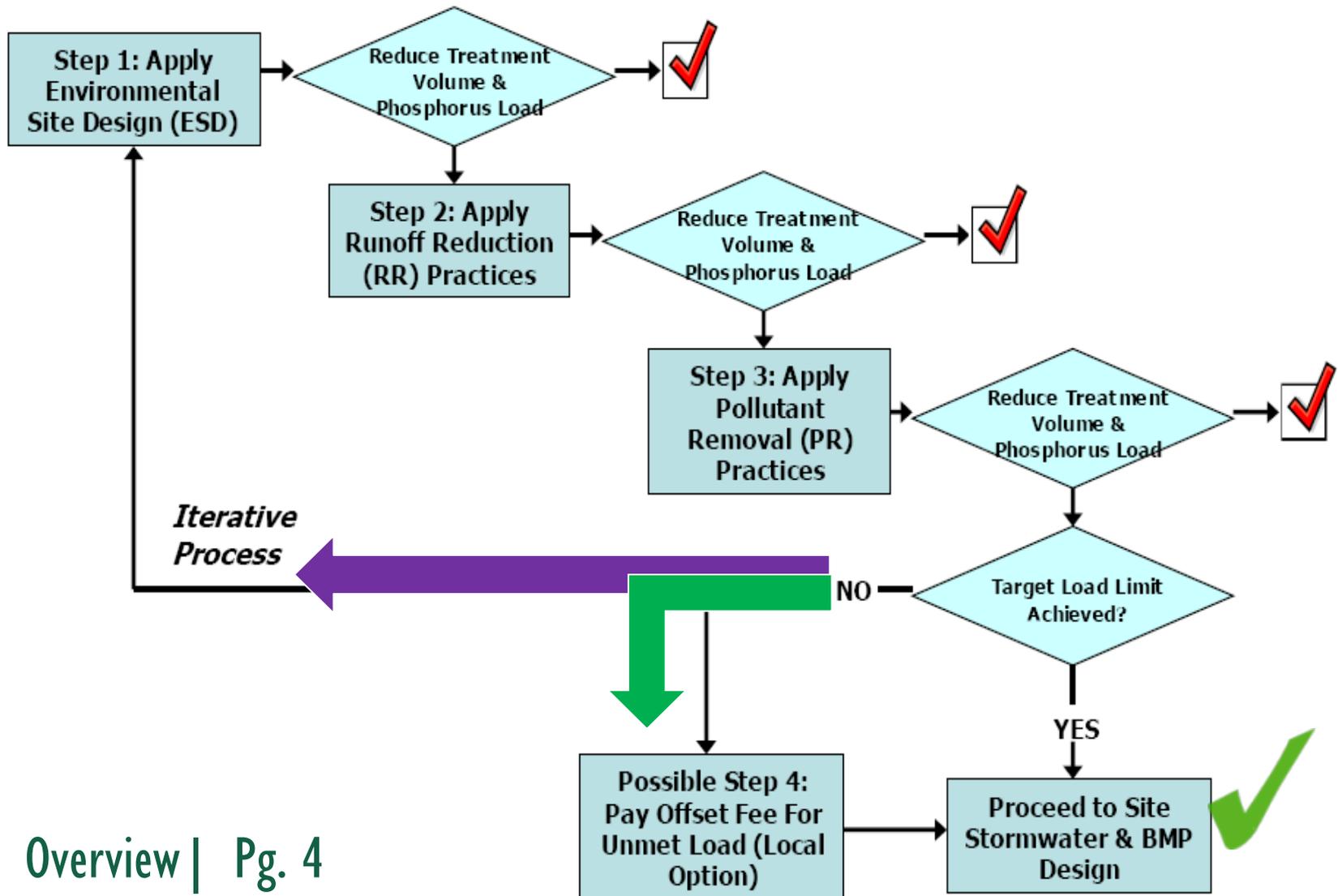
- CWP Technical Memorandum: Runoff Reduction Method (April, 2008)
- VRRM Instructions & Documentation (March, 2011)

www.deq.virginia.gov/Programs/Water/Laws,Regulations,Guidance/Guidance/StormwaterManagementGuidance.aspx

4a. Overview of the VRRM

- Key Terminology Review
 - Runoff Reduction (RR)
 - Pollutant Removal (PR)
 - Total Performance
 - VRRM Compliance Spreadsheet

4a. Overview of the VRRM



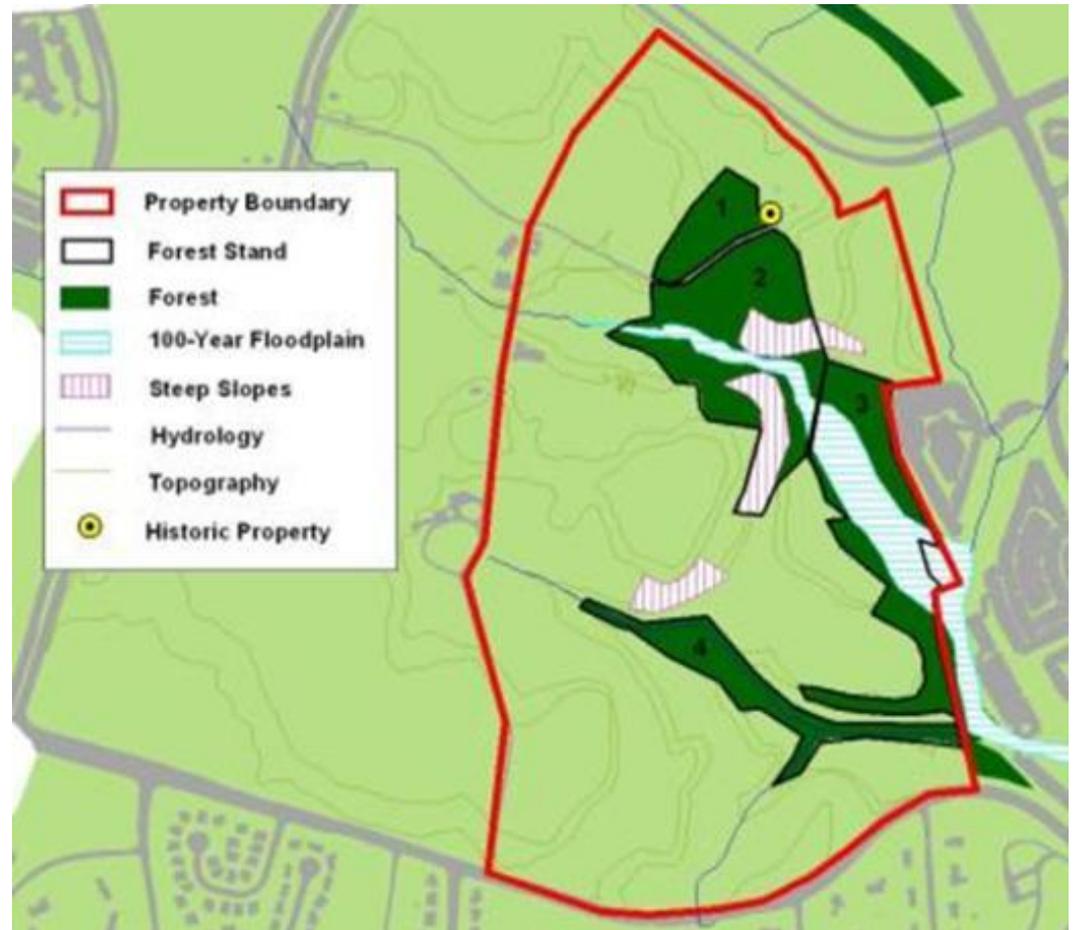
4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- **Codifies & incentivizes minimization and avoidance**
- Beyond impervious cover
- Latest BMP research (Total Mass Load Removal)
- Credits total BMP performance

4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- Environmental Site Design

site inventory & assessment



4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

Impacts from soil grading/ compaction



Volumetric Runoff Coefficients in VRRM



Undisturbed
pervious
areas



Impacted soils
& managed turf

4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

Impacts from turf management activities



4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- Treatment Volume:
Site Runoff Coefficients (Rv)

Cover	HSG A	HSG B	HSG C	HSG D
Forest/Open	0.02	0.03	0.04	0.05
Managed Turf / Disturbed Soil	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

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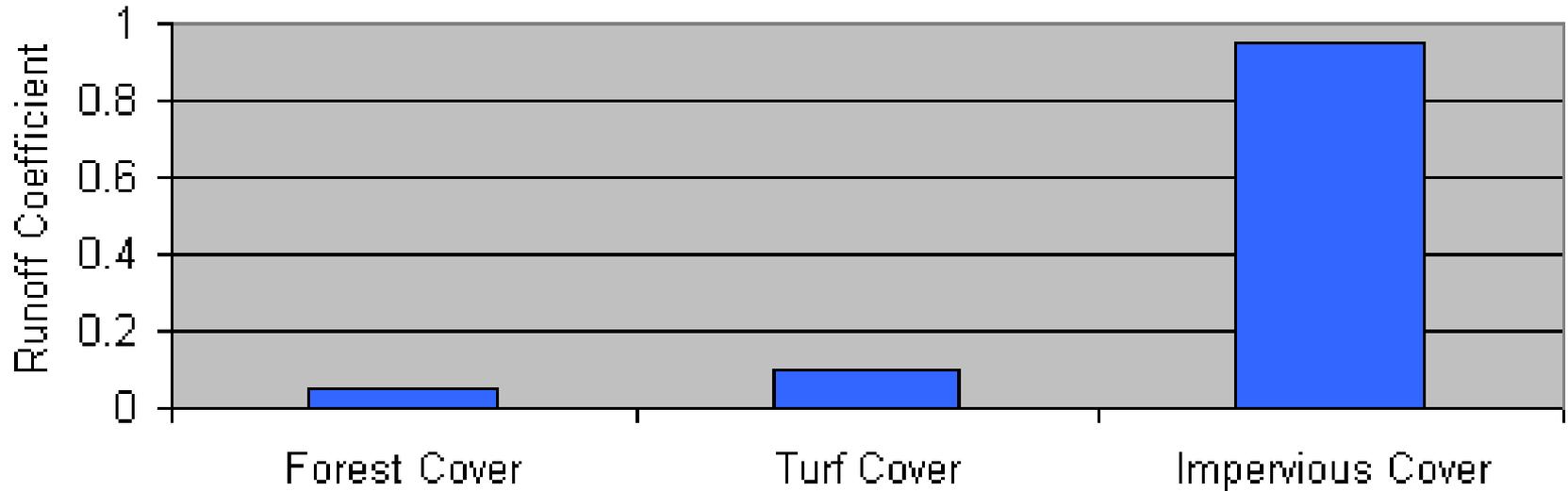
Volumetric Runoff Coefficients



Site Data Input

4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- Land Cover Runoff Coefficients



4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- Land Cover Definitions

Forest and Open Space

Portions of residential lots **not** disturbed during construction

Portions of road rights-of-way used as:
filter strips, grass channels, stormwater treatment areas

Community open space areas **not** mowed routinely

4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- Land Cover Definitions

Forest and Open Space

Utility rights-of-way left in natural vegetated state

4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- Land Cover Definitions

Forest and Open Space

Surface area of stormwater BMPs:

NOT wet ponds

Some type of vegetative cover

Do NOT replace otherwise impervious surface

4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- Land Cover Definitions

Forest and Open Space

Other areas of existing forest/open space:

Protected during construction

Remain undisturbed

Includes wetlands

4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- Land Cover Definitions

Forest and Open Space Op & Management

Undisturbed portions of yards, community open space, and other areas:

Must show outside **LOD** on approved ESC plans

Demarcated in field (e.g., fencing) prior to commencement of construction

4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- Land Cover Definitions

Forest and Open Space Op & Management

Roadway rights-of-way that will count as forest/open space:

Assumed to be disturbed during construction

Current soil restoration/site reforestation design specs

Other relevant specs if area will be **used as BMP**

4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- Land Cover Definitions

Forest and Open Space Op & Management

Documentation for area remaining in natural, vegetated state*

**only approved management activities*

4b. Land Cover and Volumetric Runoff Coefficients in the VRRM

- Land Cover Definitions

Managed Turf

Areas intended to be mowed and maintained as turf within:

Residential

Industrial

Commercial

Institutional
settings

Virginia Runoff Reduction Spreadsheet

Virginia Runoff Reduction Method New Development Worksheet -- v2.7 Revised Feb 2014

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7 data input cells
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9 constant values

1. Post-Development Project & Land Cover Information

Constants

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Target Rainfall Event (inches) 1.00

Phosphorus EMC (mg/L) 0.26

Target Phosphorus Target Load (lb/acre/yr) 0.41

Pj 0.00

Nitrogen EMC (mg/L) 1.86

Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals
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Impervious Cover (acres)	0.00		0.00	0.00	0.00
	Total				0.00

Rv Coefficients	A soils	B Soils	C Soils	D Soils
Forest/Open Space	0.02	0.03	0.04	0.05
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Land Cover Summary

Forest/Open Space Cover (acres) 0.00

Weighted Rv(forest) 0.00

% Forest 0%

Managed Turf Cover (acres) 0.00

Ready

Areas by:
Land Cover Type
and
HSG

Site Data Input

4c. The Simple Method

$$L = P \times Pj \times Rv \times C \times A \times \frac{2.72}{12}$$

- Estimates annual pollutant load exported in stormwater runoff from small urban catchments

4c. The Simple Method

$$\underline{L} = \underline{P} \times \underline{P_j} \times Rv \times C \times A \times \frac{2.72}{12}$$

L (lbs/yr) = total post-dev. pollutant load

P (in) = average annual rainfall depth
= 43 in. (VA)

P_j = fraction of rainfall producing runoff
= 0.9

4c. The Simple Method

$$L = P \times Pj \times \underline{Rv} \times \underline{C} \times \underline{A} \times \frac{2.72}{12}$$

Rv = volumetric runoff coefficient

C (mg/L) = flow-weighted event mean concentration (EMC) of TP

= 0.26

A (acres) = area of development site

4c. The Simple Method

$$L = P \times Pj \times Rv \times C \times A \times \frac{2.72}{12}$$

2.72 = unit conversion factor:

(L to ft³, mg to lb, acres to ft²)

12 = unit conversion factor
(rainfall in. to ft.)

$$L = P \times P_j \times R_v \times C \times A \times \frac{2.72}{12}$$

Virginia Runoff Reduction Method New Development Worksheet -- v2.7 Revised Feb 2014

Site Data

Project Name:

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1. Post-Development Project & Land Cover Information

Constants

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P _j	0.90

Nitrogen EMC (mg/L) 1.86

Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals
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Impervious Cover (acres)	0.00		0.00	0.00	0.00
				Total	0.00

Rv Coefficients	A soils	B Soils	C Soils	D Soils
Forest/Open Space	0.02	0.03	0.04	0.05
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Land Cover Summary

Forest/Open Space Cover (acres)	0.00
Weighted Rv(forest)	0.00
% Forest	0%
Managed Turf Cover (acres)	0.00

Constants:

$C_{(\text{phosphorus})} = 0.26 \text{ mg/L}$
 $P_{(\text{VA annual})} = 43 \text{ in}$
 $P_j = 0.9$

$R_{v(\text{SITE})}$

Calculated Results:
Pollutant Loads (L)

Site Data Input

4c. The Simple Method **Old Rules** (Part IIC)

$$L = P \times Pj \times \underline{Rv} \times C \times A \times \frac{2.72}{12}$$

Rv based on 16% impervious cover

C = 0.26 mg/L

Load Limit (L) = 0.45 lb/ac/yr

4c. The Simple Method

$$L = P \times P_j \times R_{Vcomposite} \times C \times A \times \frac{2.72}{12}$$

- C = 0.26 mg/l

*New Rules
(Part IIB)*

*Runoff Reduction
Method Technical
Memorandum, April
2008*

Parameter	Median EMC (mg/L)
Total Nitrogen	
National	1.9
Virginia	1.86
<i>Residential</i>	2.67
<i>Non-Residential</i>	1.12
Virginia Coastal Plain	2.13
<i>Residential</i>	2.96
<i>Non-Residential</i>	1.08
Virginia Piedmont	1.70
<i>Residential</i>	1.87
<i>Non-Residential</i>	1.30
Total Phosphorus	
National	0.27
Virginia	0.26
<i>Residential</i>	0.28
<i>Non-Residential</i>	0.23
Virginia Coastal Plain	0.27
Virginia Piedmont	0.22
Total Suspended Solids	
National	62
Virginia	40

4c. The Simple Method

$$L = P \times Pj \times Rv_{composite} \times C \times A \times \frac{2.72}{12}$$

New Rules:

$Rv_{composite}$ = Composite or weighted runoff coefficient

$$Rv_{composite} = (Rv_I \times \%I) + (Rv_T \times \%T) + (Rv_F \times \%F)$$

Where:

Rv_I = Runoff coefficient for Impervious cover (0.95)

Rv_T = for Managed Turf/Disturbed soils (Table 4-1)

Rv_F = for Forest/Open Space (Table 4-1)

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41	Weighted Rv(turf)	0.00				
42	% Managed Turf	0%				
43	Impervious Cover (acres)	0.00				
44	Rv(impervious)	0.95				
45	% Impervious	0%				
46	Total Site Area (acres)	0.00				
47	Site Rv	0.00				
48						
49	Post-Development Treatment Volume (acre-ft)	0.00				
50	Post-Development Treatment Volume (cubic feet)	0				
51	Post-Development Load (TP) (lb/yr)	0.00	Post-Development Load (TN) (lb/yr)			0.00
52	Total Load (TP) Reduction Required (lb/yr)	0.00				

What about site load limit?
0.41 lb/acre/yr

Weighted (by HSG) Rv for Forest, Turf, & Imp
Composite Site Rv

4c. The Simple Method

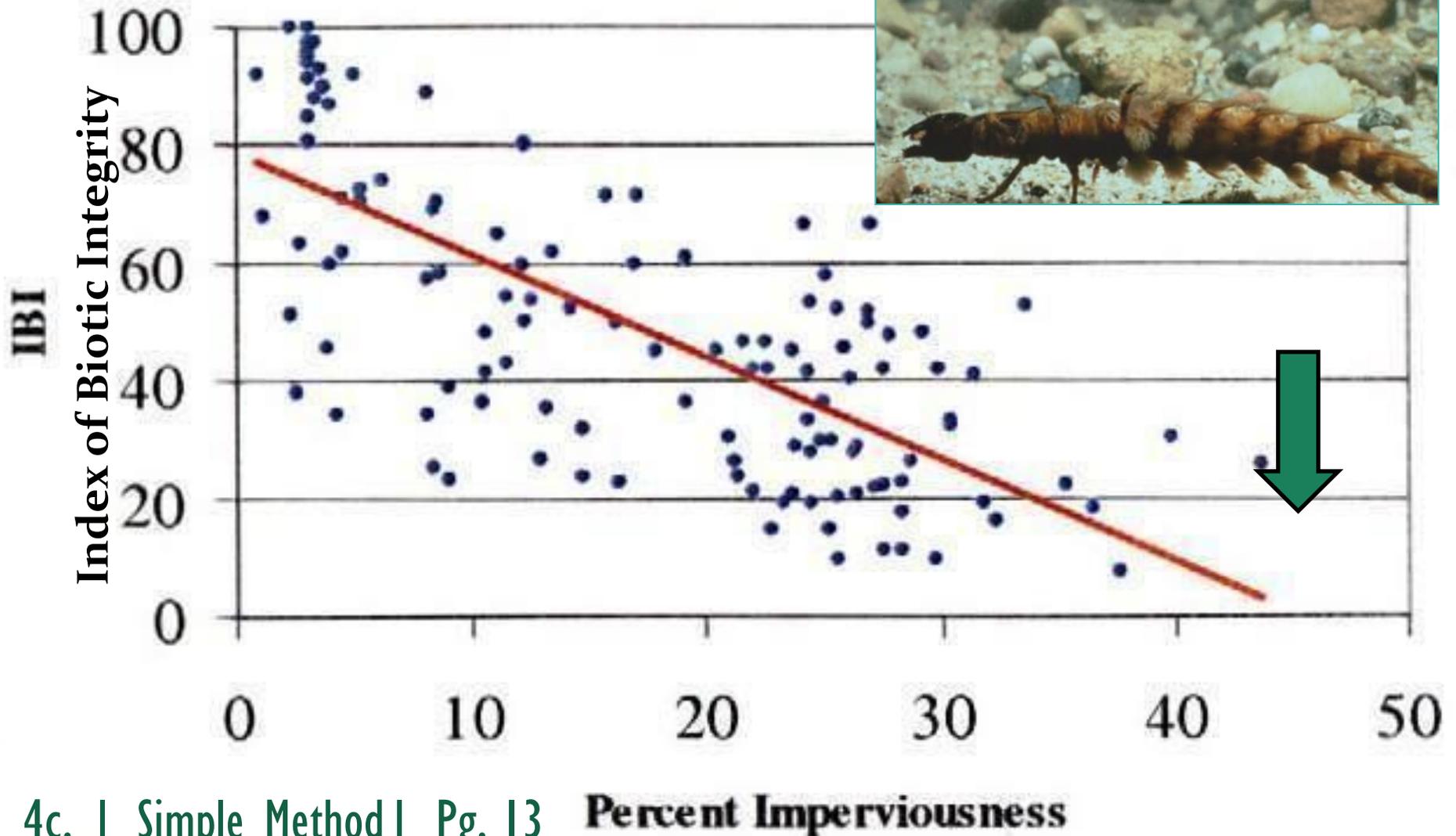
$$Rv_{composite} = (Rv_I \times \%I) + (Rv_T \times \%T) + (Rv_F \times \%F)$$

New Development Water Quality Requirements:

- **Old Requirement:** 0.45 lb/ac/yr TP
- **New Proposal:** 0.28 lb/ac/yr TP
- **Final Adopted:** **0.41 lb/ac/yr TP**
(annual load limit)

Where did I get that number?

Impervious Cover Model (ICM)

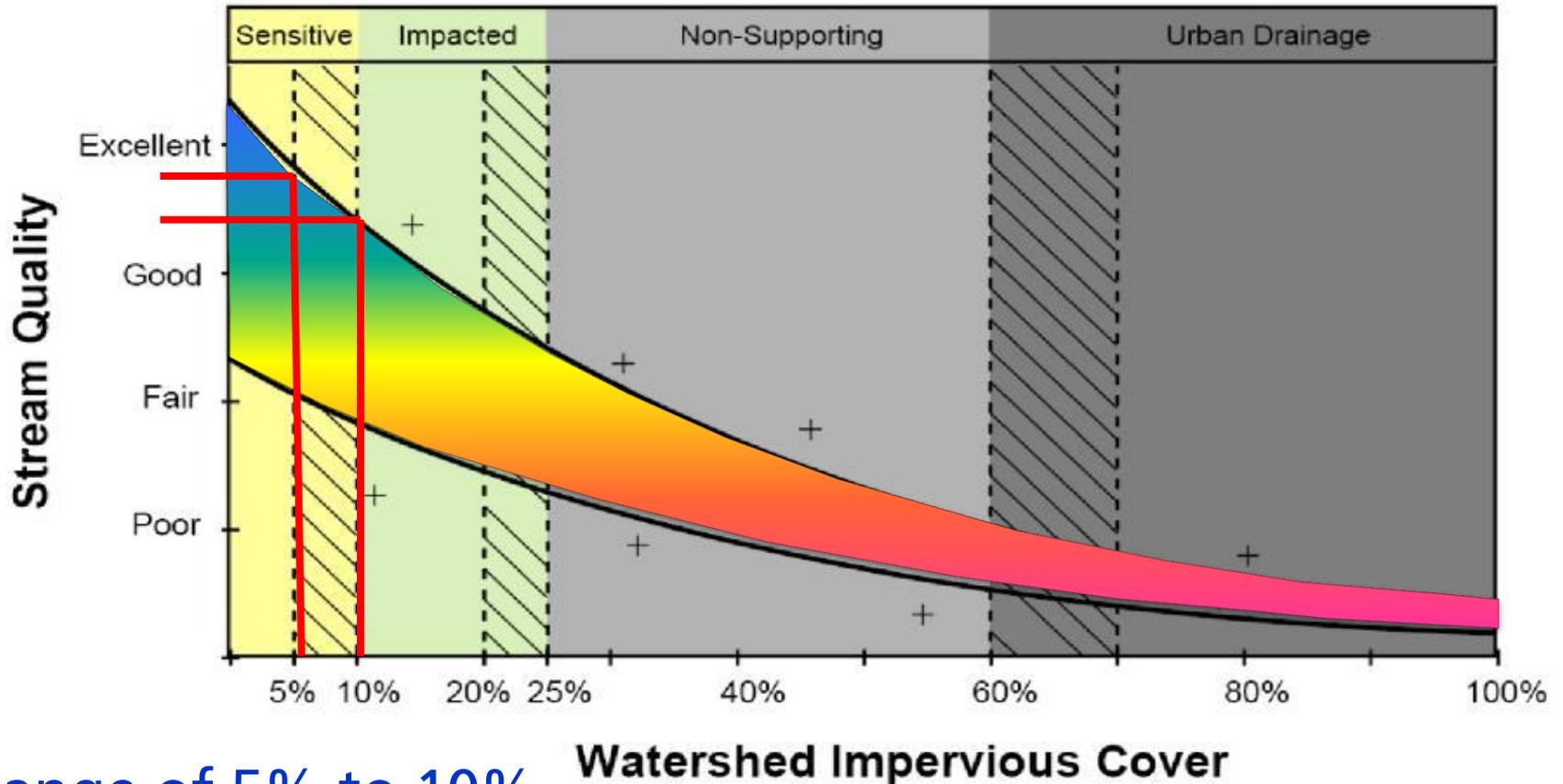


Over 10%
impervious cover:

- Streams visibly impacted
- Stream channel widened and/or deepened
- Tree roots exposed
- Pool and riffle structure compromised



Impervious Cover Model Revisited



Range of 5% to 10%
Impervious Cover

Watershed-Based Site Load Limit

$$L = P \times P_j \times R_v \times C \times A \times 2.72/12$$
$$= 0.41 \text{ lb/acre/yr}$$

Composite R_v^2 calculated using:

10% impervious cover

60% forest

30% managed turf

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Weighted (by HSG) Rv for Forest, Turf, & Imp

Composite Site Rv

Post-Dev Tv

Pollutant Load (TP & TN)

Total Load Reduction Req'd.

4d. Water Quality Requirements

- **New Development:**

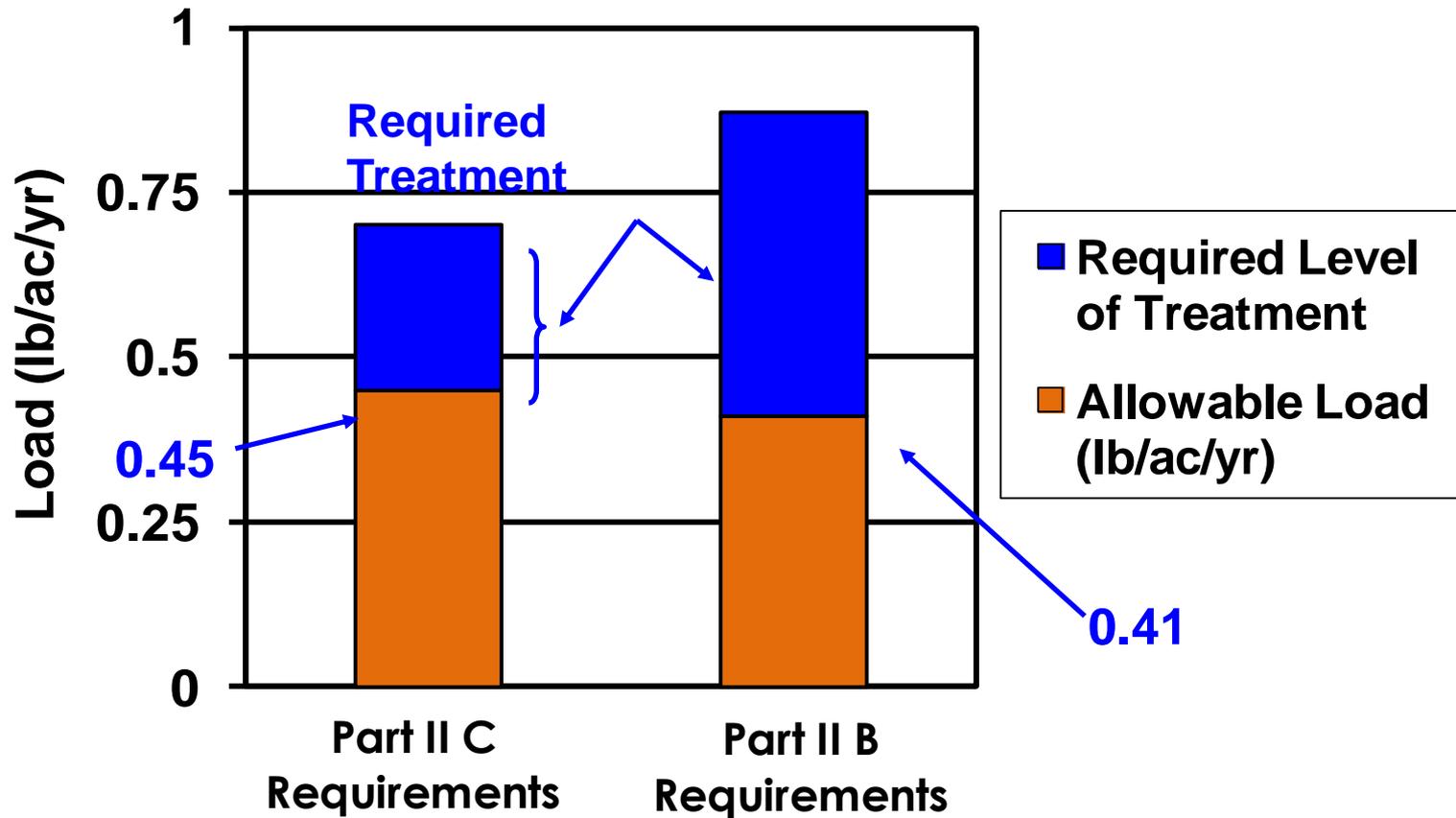
- 0.41 lb/ac/yr TP

- **Re-Development:**

- LDA \geq 1 acre: 20% reduction in exist annual TP load

- LDA $<$ 1 acre: 10% reduction in exist annual TP load

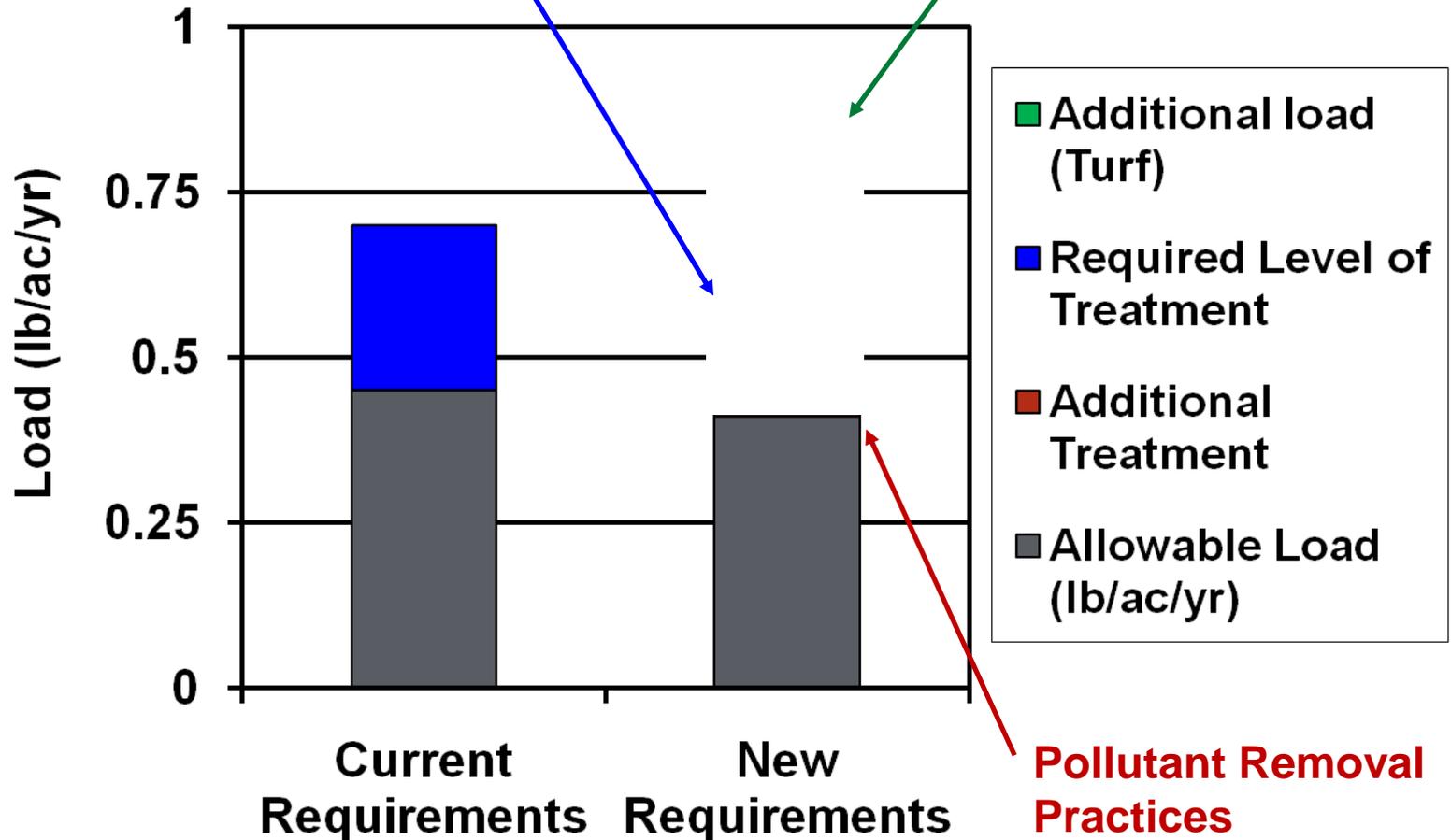
Water Quality Requirements



Treatment Options Made Simple

Runoff Reduction Practices

Minimization/ESD



Question:

A project entails the conversion of a managed grass field to a sport field with impervious cover areas.

Can VSMP water quality compliance be demonstrated using the VRRM Re-Development spreadsheet?

Re-Development

9VAC25-870-10:

Prior developed lands: land previously utilized with associated ***impervious areas altered*** during a land-disturbing activity

Re-Development

9VAC25-870-63.A.2:

d. Linear developments TP load must be reduced by **20%** on prior developed lands.

e. Site's TP load cannot be required to be less than 0.41 lb TP/acre/year*

**9VAC25-870-63.D. A locality's VSMP authority can establish a more stringent water quality design criteria in accordance with § 62.1-44.15:33*

Water Quality Compliance

9VAC25-870-65 A: VRRM or Board-approved

9VAC25-870-65 B: 15 non-proprietary BMPs listed and those on VA SW BMP Clearinghouse website

9VAC25-870-65 C: BMPs not listed on VA SW BMP Clearinghouse website must be reviewed and approved by DEQ

9VAC25-870-65 D: A VSMP authority may limit use of specific BMPs in accordance with § 62.1-

44.15:33

Other Water Quality Requirements

9VAC25-870-65 E: Site drainage \geq HUC, must meet TP load reduction requirements within each HUC unless comprehensive stormwater management plan used per 9VAC25-870-92.

9VAC25-870-65 F: Offsite alternatives may be used to meet water quality requirements where allowed per 9VAC25-870-69.

How can ESD apply?



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Land Cover (acres)	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
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00		0.00	0.00	0.00
Impervious Cover (acres)	0.00		0.00	0.00	0.00
	Total				0.00

Rv Coefficients

	A soils	B Soils	C Soils	D Soils
Forest/Open Space	0.02	0.03	0.04	0.05
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Land Cover Summary

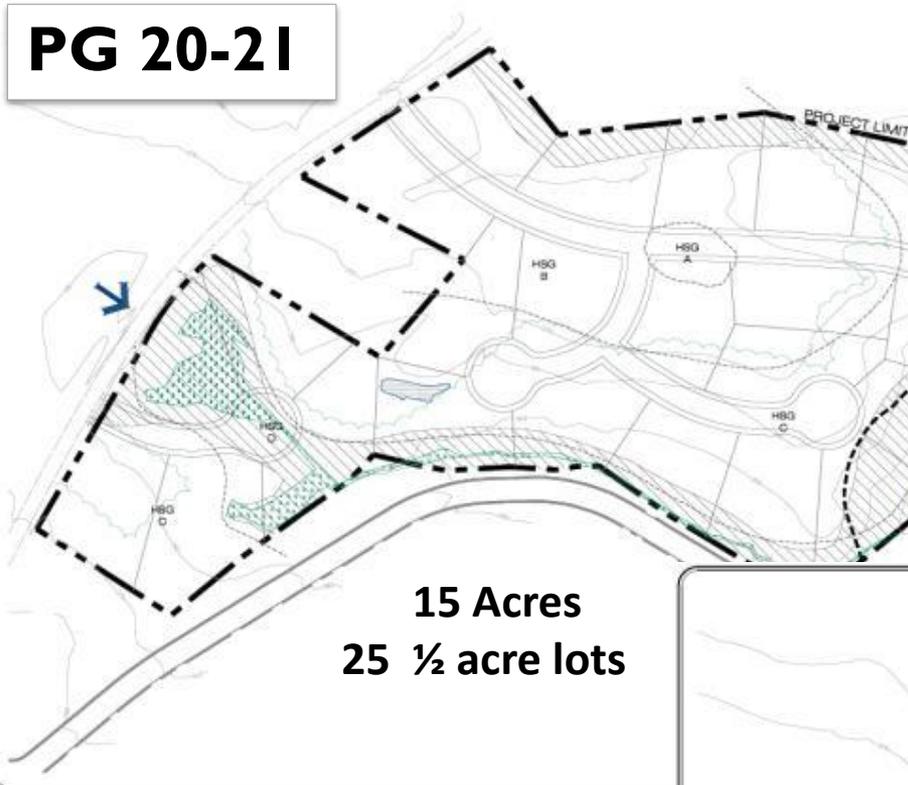
Forest/Open Space Cover (acres) 0.00
 Weighted Rv(forest) 0.00
 % Forest 0%
 Managed Turf Cover (acres) 0.00

Site Data | D.A. A | D.A. B | D.A. C | D.A. D | D.A. E | Water Quality Compliance | Channel and Flood Protection | Summary

Areas by:
 Land Cover Type
 and
 HSG

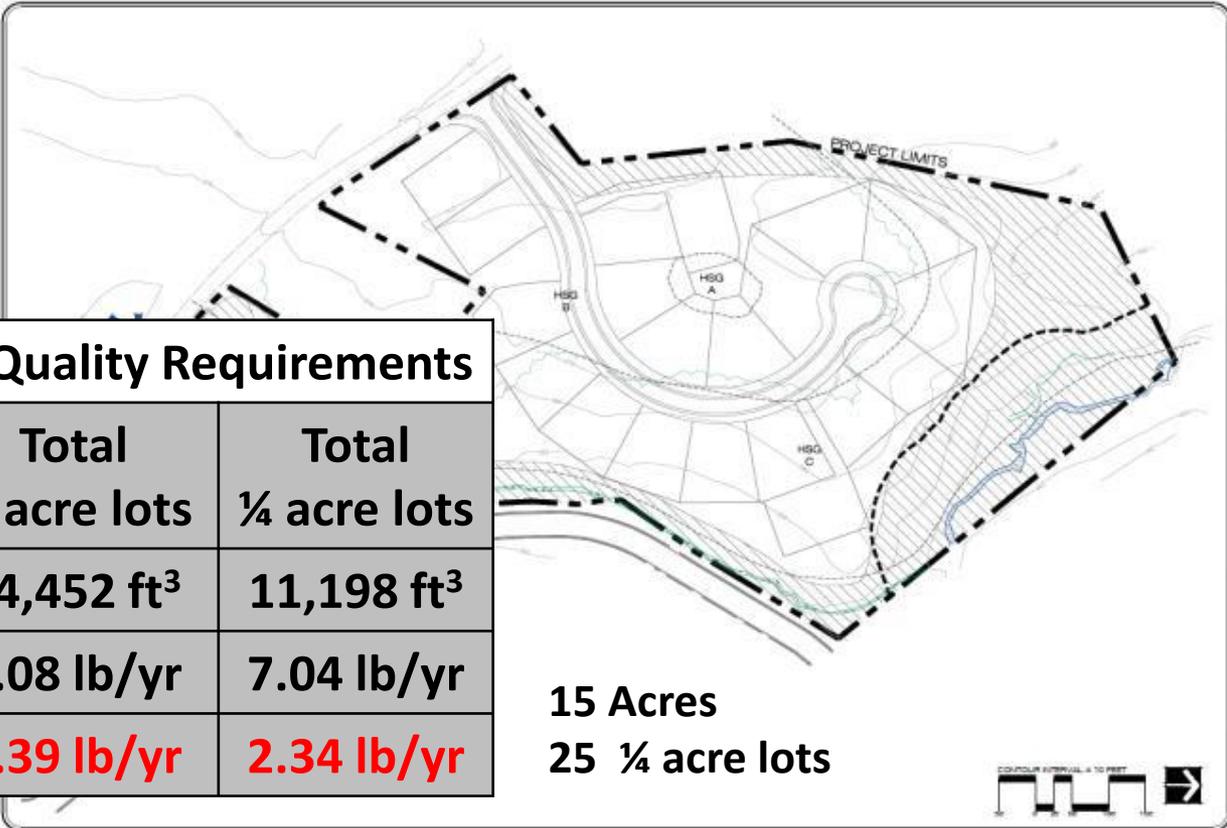
Site Data Input

PG 20-21



15 Acres
25 ½ acre lots

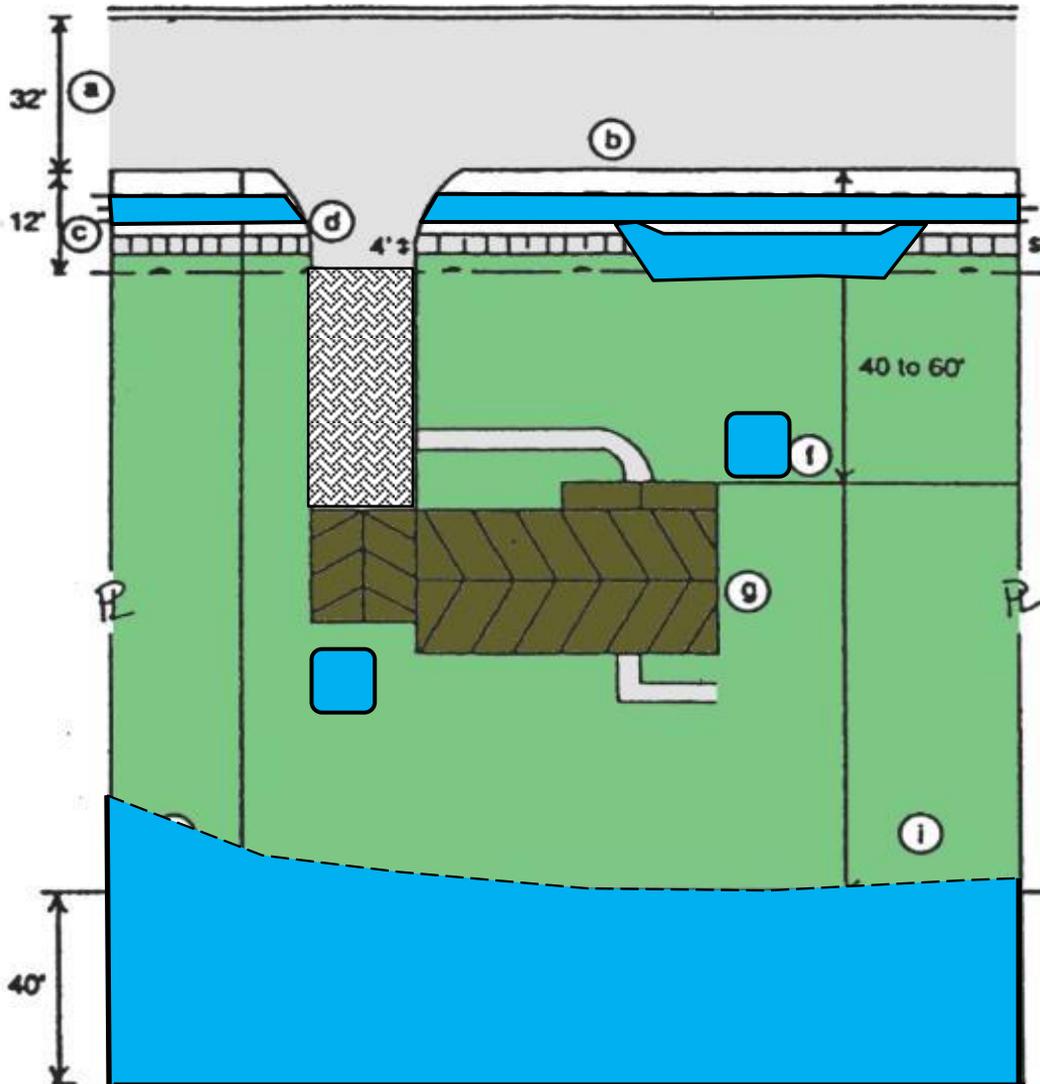
Drainage Area Land Cover (Acres)		
Land Cover	Total ½ acre lots	Total ¼ acre lots
Forest	0.87	4.31
Turf	8.32	5.26
Impervious	2.26	1.88



15 Acres
25 ¼ acre lots

Drainage Area Water Quality Requirements		
	Total ½ acre lots	Total ¼ acre lots
Post-Dev Treatment Vol	14,452 ft ³	11,198 ft ³
Post-Dev TP Load	9.08 lb/yr	7.04 lb/yr
Pollutant Removal Req'd.	4.39 lb/yr	2.34 lb/yr

Site Design: Decentralized Treatment



Right-of-way

Treatment

Grass Channels

Bioretention

On-Lot Treatment

Simple Disconnection

Alternative Practice

Disconnection

- Raingardens

- Drywells

- Cisterns

Permeable Pavement

Driveways

Soil Restoration

When soil disturbance
unavoidable:



BMP Design Specification No. 4

Soil Restoration

*Photo Credit: Richard McLaughlin, Ph.D.,
North Carolina State University*

Soil Testing



Recognized non-
structural RR
stormwater practice

4e. Introduction to Stormwater Runoff Reduction BMPs

- Codifies & incentivizes minimization and avoidance
- Goes beyond impervious cover as a water quality indicator
- **Utilizes latest BMP research for Total Performance**
- **Credits total BMP performance**

(New Specifications with Level 1 and Level 2)

Latest Science and Research

Total BMP Performance:

Runoff Reduction Reported Performance

$Runoff\ Vol_{IN}$ vs $Runoff\ Vol_{OUT}$



Pollutant Removal Reported Performance:

EMC_{IN} vs EMC_{OUT}



Total BMP Performance (Reported as Load Reduction):

$(Vol_{IN}) \times (EMC_{IN})$ vs $(Vol_{OUT})(EMC_{OUT})$

Total BMP Performance

Runoff Reduction (RR) and pollutant removal (PR):

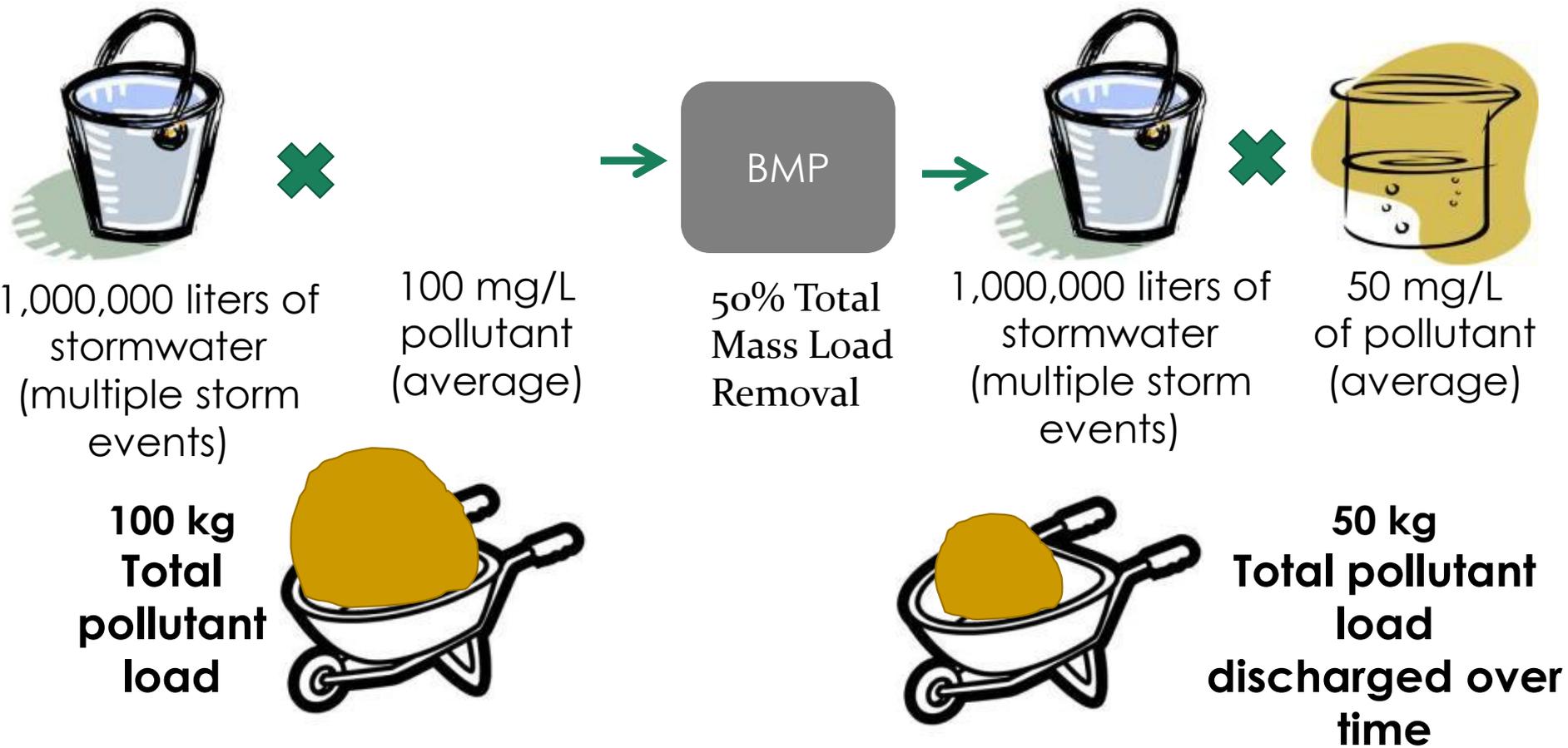
- Reductions by reducing volume
- Beyond irreducible concentrations

Total BMP Performance

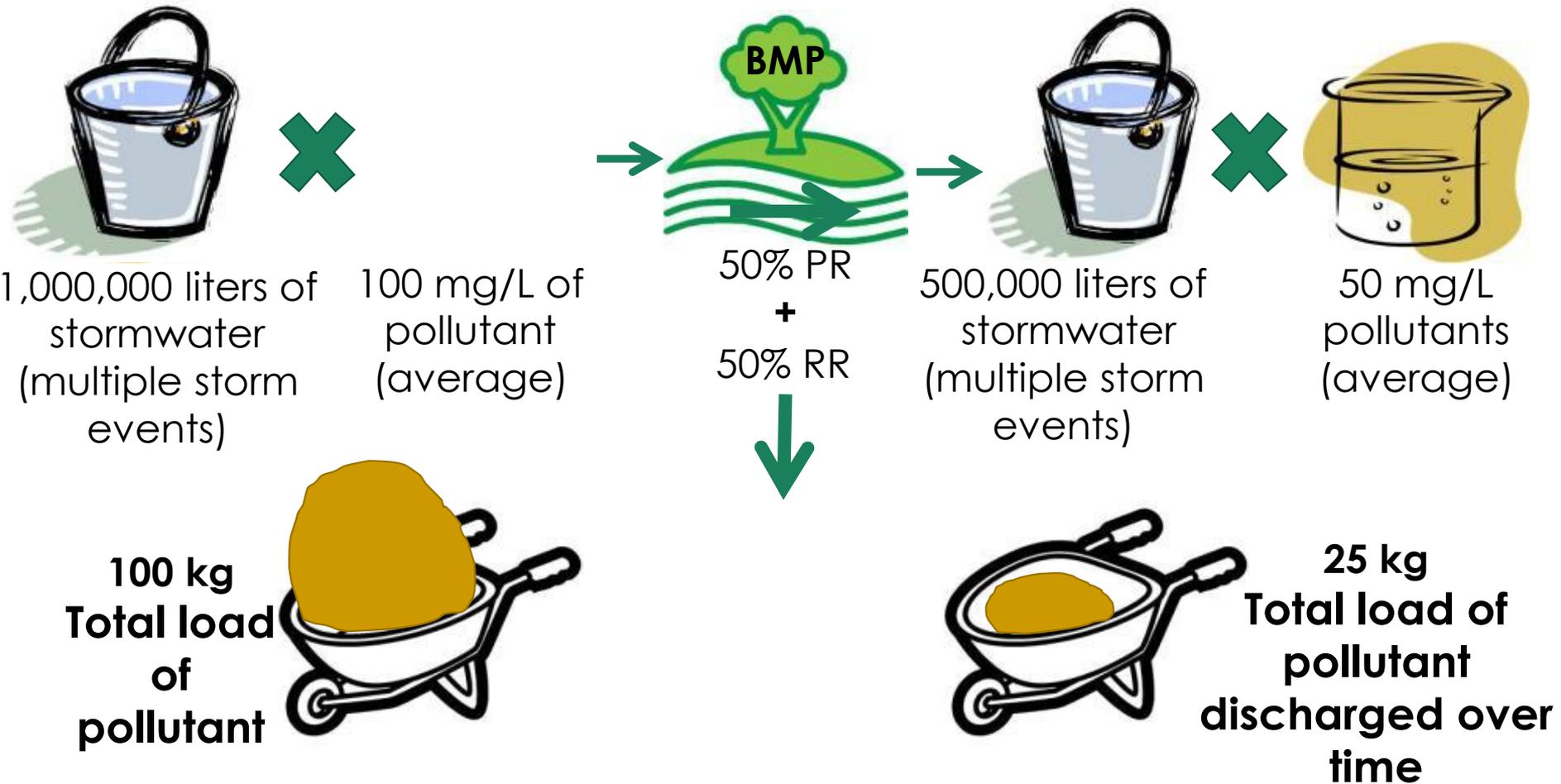
Runoff Reduction (RR) and pollutant removal (PR):

- Maximum performance through “Treatment Train” approach:
 - Pollutant Reduction (site-generated) using non-structural site design practices
 - Volume reduction using one or multiple **runoff reduction (RR) practices**
 - Pollutant removal by runoff reduction practices and additional **pollutant removal (PR) practices** as needed

Traditional BMPs



RRM, "New" BMPs



Total Performance = 75% load reduction!

Multi-Function Practices

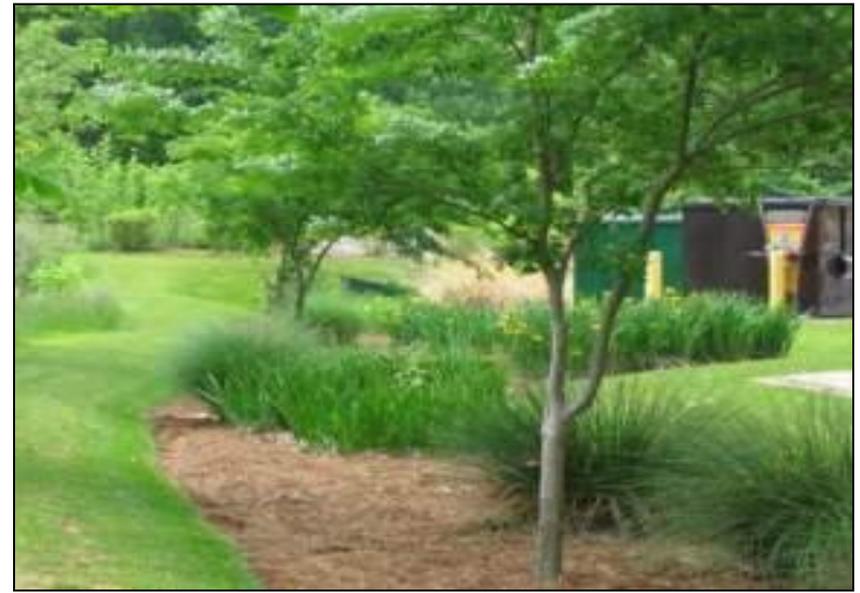
	Site Design	Runoff Reduction	Pollutant Removal
1. Rooftop Disconnection	✓	✓	
2. Filter Strip	✓	✓	
3. Grass Channel		✓	✓
4. Soil Amendments	✓*	✓	
5. Green Roof		✓	
6. Rain Tanks & Cisterns		✓	
7. Permeable Pavement		✓	✓
8. Infiltration		✓	✓
9. Bioretention		✓	✓
10. Dry Swales		✓	✓
12. Filtering Practices			✓
13. Constructed Wetlands			✓
14. Wet Ponds			✓
15. ED Ponds		✓	✓

Stormwater Practices Differ Sharply in Ability to Reduce Runoff Volume



Wet Ponds, ED Ponds,
Constructed Wetlands, Filters:

**= 0 to 10% Runoff Volume
Reduction**



Bioretention, Infiltration, Dry
Swales, Soil Amendments,
disconnection, Related Practices
Reduce:

**= 50 to 90% Runoff Volume
Reduction**

VRRM Spreadsheet DA Tabs

Drainage Area A													
Drainage Area & Land Cover (acres)													
	A Soils	B Soils	C Soils	D Soils	Total	Level	Cover %						
1	Forest/Space (acres)	0.00	0.00	0.00	0.00	0.00	0.00						
2	Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0.00						
3	Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00	0.00						
Total					0.00			First Development Treatment Volume (cft)					
13 Apply Runoff Reduction Practices to Reduce Treatment Volume & Post-Development Load in Drainage Area A													
Practice	Unit	Description of Credit	Credit	Credit Area (acres)	Upstream RR Practice (c)	Runoff Reduction (cft)	Remaining Runoff Volume (cft)	Phosphorus Efficiency (%)	Phosphorus Load from Upstream RR Practices (lbs)	Phosphorus Load from Upstream RR Practices (lbs)	Phosphorus Removed by Practice (lbs)	Remaining Phosphorus Load (lbs)	Downstream Treatment to be Employed
1. vegetated Roof													
13.1	13.1.a. vegetated Roof #1 (Spec #5)	area of green roof	40% runoff volume reduction	0.45	0.00	0	0	0	0.00	0.00	0.00	0.00	
13.2	13.1.b. vegetated Roof #2 (Spec #6)	area of green roof	60% runoff volume reduction	0.60	0.00	0	0	0	0.00	0.00	0.00	0.00	
14. Rooftop Disconnection													
14.1	14.1.a. Simple Disconnection to AD (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.00	0.00	0	0	0	0.00	0.00	0.00	0.00	
14.2	14.1.b. Simple Disconnection to CD (Spec #1)	impervious acres disconnected	20% runoff volume reduction for treated area	0.25	0.00	0	0	0	0.00	0.00	0.00	0.00	
14.3	14.1.c. To the Nearest Flow Path as per specifications (existing C/O) (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.00	0.00	0	0	0	0.00	0.00	0.00	0.00	None
14.4	14.1.d. To Dry Well or French Drain #1 (Microfiltration #1) (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.00	0.00	0	0	25	0.00	0.00	0.00	0.00	
14.5	14.1.e. To Dry Well or French Drain #2 (Microfiltration #2) (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.00	0.00	0	0	25	0.00	0.00	0.00	0.00	
14.6	14.1.f. To Rain Garden #1 (Microfiltration #1) (Spec #1)	impervious acres disconnected	40% if volume captured	0.40	0.00	0	0	25	0.00	0.00	0.00	0.00	
14.7	14.1.g. To Rain Garden #2 (Microfiltration #2) (Spec #1)	impervious acres disconnected	40% if volume captured	0.60	0.00	0	0	50	0.00	0.00	0.00	0.00	
14.8	14.1.h. To Rainwater Harvesting (Spec #1)	impervious acres captured	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00	
14.9	14.1.i. To Stormwater Ponds (Urban Stormwater Pond #1) (Spec #1)	impervious acres captured	40% if volume captured	0.40	0.00	0	0	25	0.00	0.00	0.00	0.00	
TOTAL IMPERVIOUS COVER TREATED (ac)				0.00									
TOTAL TRAP AREA TREATED (ac)				0.00									
AREA CHECK				OK									
TOTAL PHOSPHORUS REMOVAL REQUIRED OR SITE (lbs/c)				0.00									
TOTAL RUNOFF REDUCTION IN D.A. A (cft)				0									
PHOSPHORUS REMOVAL FROM RUNOFF REDUCTION PRACTICES IN D.A. A (lbs/c)				0.00									
SEE WATER QUALITY COMPLIANCE TAB FOR SITE COMPLIANCE CALCULATIONS													
14 Apply Practices that Remove Pollutants but Do Not Reduce Runoff Volume													
Practice	Unit	Description of Credit	Credit	Credit Area (acres)	Volume from Upstream RR Practices (cft)	Runoff Reduction (cft)	Remaining Runoff Volume (cft)	Phosphorus Efficiency (%)	Phosphorus Load from Upstream RR Practices (lbs)	Phosphorus Load from Upstream RR Practices (lbs)	Phosphorus Removed by Practice (lbs)	Remaining Phosphorus Load (lbs)	Downstream Treatment to be Employed
15. Wet Swale (Coastal Plain)													
15.1	15.1.a. Wet Swale #1 (Spec #1)	impervious acres draining to wet swale	5% runoff volume reduction	0.00	0.00	0	0	20	0.00	0.00	0.00	0.00	
15.2	15.1.b. Wet Swale #2 (Spec #1)	turf areas draining to wet swale	5% runoff volume reduction	0.00	0.00	0	0	20	0.00	0.00	0.00	0.00	
15.3	15.1.c. Wet Swale #3 (Spec #1)	impervious acres draining to wet swale	5% runoff volume reduction	0.00	0.00	0	0	40	0.00	0.00	0.00	0.00	
15.4	15.1.d. Wet Swale #4 (Spec #1)	turf areas draining to wet swale	5% runoff volume reduction	0.00	0.00	0	0	40	0.00	0.00	0.00	0.00	
16. Manufactured BMP													
16.1	16.1.a. Manufactured BMP #1	impervious acres draining to device	5% runoff volume reduction	0.00	0.00	0	0	0	0.00	0.00	0.00	0.00	
16.2	16.1.b. Manufactured BMP #2	turf areas draining to device	5% runoff volume reduction	0.00	0.00	0	0	0	0.00	0.00	0.00	0.00	
TOTAL IMPERVIOUS COVER TREATED (ac)				0.00									
TOTAL TRAP AREA TREATED (ac)				0.00									
AREA CHECK				OK									
PHOSPHORUS REMOVAL BY PRACTICES THAT DO NOT REDUCE RUNOFF VOLUME IN D.A. A				0.00									
TOTAL PHOSPHORUS REMOVAL IN D.A. A (lbs/c)				0.00									
SEE WATER QUALITY COMPLIANCE TAB FOR SITE COMPLIANCE CALCULATIONS													
NITROGEN REMOVAL BY PRACTICES THAT DO NOT REDUCE RUNOFF VOLUME IN D.A. A				0.00									
TOTAL NITROGEN REMOVAL IN D.A. A (lbs/c)				0.00									

Upper half:
Runoff Reduction
Practices

Lower half:
Pollutant Removal
Practices

BMP Performance - Level 1 and Level 2

Level 1 standard features:

- Function
- Safety
- Appearance
- Safe conveyance
- Performance longevity
- Maintenance



BMP Performance - Level 1 and Level 2

Level 2 design enhancements

Increased RR, PR or both:

- Increased Tv sizing (x 1.1, 1.25 or 1.5 times Tv)
- Enhanced design geometry
- Vegetative condition
- Multiple cells
- Multiple treatment pathways
- Other bells and whistles

(increased pretreatment/media depth, etc.)

VRRM Spreadsheet DA Tabs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1	Drainage Area A															
3	Drainage Area A Land Cover (acres)															
4		A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv									
5	Forest/Open Space (acres)	0.00	0.00	0.00	0.00	0.00	0.00									
6	Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0.00									
7	Impervious Acres (acres)	0.00	0.00	0.00	0.00	0.00	0.00									
8		0.00													Post Development Treatment Volume (cf)	0

Volumetric Reduction Credit

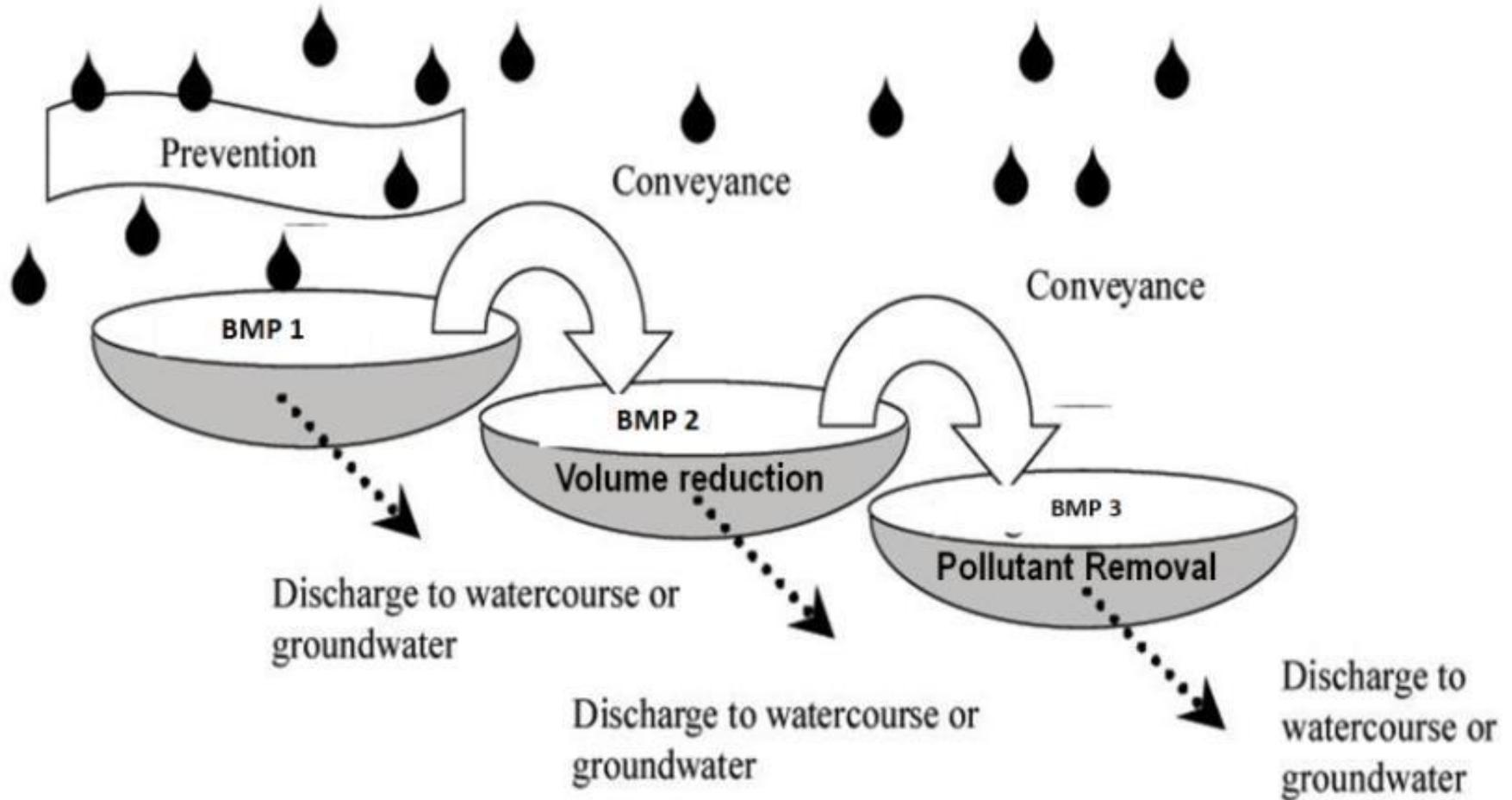
Credit Area (acres) to the Practice

Pollutant Reduction Credit

Apply Runoff Reduction Practices to Reduce Treatment Volume & Post-Development Load in Drainage Area A

Practice	Unit	Description 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.)
6. Bioretention												
6.a. Bioretention #1 or Urban Bioretention (Spec #9)	L1	impervious acres draining to bioretention	40% runoff volume reduction	0.40	0.00	0	0	25	0.00	0.00	0.00	0.00
		turf acres draining to bioretention	40% runoff volume reduction	0.40	0.00	0	0	25	0.00	0.00	0.00	0.00
6.b. Bioretention #2 (Spec #9)	L2	impervious acres draining to bioretention	60% runoff volume reduction	0.80	0.00	0	0	50	0.00	0.00	0.00	0.00
		turf acres draining to bioretention	80% runoff volume reduction	0.80	0.00	0	0	50	0.00	0.00	0.00	0.00
7. Infiltration												
7.a. Infiltration #1 (Spec #8)		impervious acres draining to infiltration	50% runoff volume reduction	0.50	0.00	0	0	25	0.00	0.00	0.00	0.00
		turf acres draining to infiltration	50% runoff volume reduction	0.50	0.00	0	0	25	0.00	0.00	0.00	0.00
		impervious acres draining to infiltration	90% runoff volume reduction	0.90	0.00	0	0	25	0.00	0.00	0.00	0.00

BMP Treatment Train



BMP Treatment Trains

- High density sites (*high removal requirements*)
- Flexibility on tight sites - multiple smaller BMPs treat stormwater near source
- Runoff reduction and TV_{BMP} :
 - Incrementally **increases**
(with each RR practice)

Level 1 and Level 2 & BMP Treatment Trains

Tv_{BMP} - direct contributing drainage area + any remaining runoff from upstream RR practices

Design Summary Table BMP Design Spec.

No. 9: Bioretention

Level 1 (RR 40 TP: 25)	Level 2 (RR: 80 TP: 50)
<p><u>Sizing (Section 6.1):</u> $Tv_{BMP} = [(1)(Rv)(A) / 12] + \text{any remaining volume from upstream BMP}$</p>	<p><u>Sizing (Section 6.1):</u> $Tv_{BMP} = [(1.25)(Rv)(A) / 12] + \text{any remaining volume from upstream BMP}$</p>

BMP Treatment Train

VRRM_NewDev_Compliance Spreadsheet_v2.8_2011.xlsm - Microsoft Excel

File Home Insert Page Layout Formulas Data Review View Developer Nuance PDF

Clipboard Font Alignment Number Styles Cells Editing

P46

Drainage Area A	Drainage Area A Land Cover (acres)						Post Development Treatment Volume (cf)	
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv		
Forest/Open Space (acres)	0.00	0.00	0.00	0.00	0.00	0.00		
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0.00		
Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00	0.00		
	Total				0.00		0	

Apply Runoff Reduction Practices to Reduce Treatment Volume & Post-Development Load in Drainage Area A

Practice	Unit	Description 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	Untreated Phosphorus Load to Practice	Phosphorus Removed By Practice	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed
6. Bioretention													
6.a. Bioretention #1 or Urban Bioretention (Spec #9)	impervious acres draining to bioretention	40% runoff volume reduction	0.40	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
	turf acres draining to bioretention	40% runoff volume reduction	0.40	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
6.b. Bioretention #2 (Spec #9)	impervious acres draining to bioretention	80% runoff volume reduction	0.80	0.00	0	0	0	50	0.00	0.00	0.00	0.00	
	turf acres draining to bioretention	80% runoff volume reduction	0.80	0.00	0	0	0	50	0.00	0.00	0.00	0.00	
7. Infiltration													
7.a. Infiltration #1 (Spec #8)	impervious acres draining to infiltration	50% runoff volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
	turf acres draining to infiltration	50% runoff volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	impervious acres draining to infiltration	90% runoff volume reduction	0.90	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
	turf acres draining to infiltration	90% runoff volume reduction	0.90	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
8. Extended Detention Pond													

Site Data D.A. A D.A. B D.A. C D.A. D D.A. E Water Quality Compliance Channel and Flood Protection Summary Notes

Downstream practice(s)

Scroll to the right to enter downstream practice(s)

BMP Treatment Train

P46		fx		8.b. ED #2	
A		N	O	P	Q
1	Drainage Area A				
2					
3	Drainage Area A Land Cover (acres)				
4					
5	Forest/Open Space (acres)				
6	Managed Turf (acres)				
7	Impervious Cover (acres)				
8					
9					
10	Apply Runoff Reduction Prac				
11	Practice	Phosphorus Removed By Practice (lbs.)	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed	
46	6.a. Bioretention #1 or Urban Bioretention (Spec #9)	0.00	0.00	8.b. ED #2	
47		0.00	0.00	8.b. ED #2 9.a. Sheetflow to Conservation Area with A/B Soils 9.b. Sheetflow to Conservation Area with C/D Soils 9.c. Sheetflow to Vegetated Filter Strip 10.a. Wet Swale #1 10.b. Wet Swale #2 11.a. Filtering Practice #1 11.b. Filtering Practice #2	
48	6.b. Bioretention #2 (Spec #9)	0.00	0.00		
49		0.00	0.00		
50					
51	7. Infiltration				
E2		0.00	0.00		

Downstream Treatment Dropdown Selection Menu



Comparative BMP Level 1 & Level 2 Performance

Practice	Design Level	Runoff Reduction	TN EMC Removal ³	TN Mass Load Removal	TP EMC Removal	TP Mass Load Removal ⁶
Rooftop Disconnect	1 ²	25 to 50 ¹	0	25 to 50 ¹	0	25 to 50 ¹
	No Level 2 Design					
Sheet Flow to Veg. Filter or Conserv. Open Space	1	50	0	50	0	50
	2 ⁵	50 to 75 ¹	0	50 to 75 ¹	0	50 to 75 ¹
Grass Channels	1	10 to 20 ¹	20	28 to 44 ¹	15	24 to 41 ¹
	No Level 2 Design					
Soil Compost Amendment	Can be used to Decrease Runoff Coefficient for Turf Cover at Site. See the design specs for Rooftop Disconnection, Sheet Flow to Vegetated Filter or Conserved Open Space, and Grass Channel					
Vegetated Roof	1	45	0	45	0	45
	2	60	0	60	0	60
Rainwater Harvesting	1	Up to 90 ^{3, 5}	0	Up to 90 ^{3, 5}	0	Up to 90 ^{3, 5}
	No Level 2 Design					
Permeable Pavement	1	45	25	59	25	59
	2	75	25	81	25	81
Infiltration Practices	1	50	15	57	25	63
	2	90	15	92	25	93
Bioretention Practices	1	40	40	64	25	55
	2	80	60	90	50	90
Urban Bioretention	1	40	40	64	25	55
	No Level 2 Design					
Dry Swales	1	40	25	55	20	52
	2	60	35	74	40	76
Wet Swales	1	0	25	25	20	20
	2	0	35	35	40	40
Filtering Practices	1	0	30	30	60	60
	2	0	45	45	65	65
Constructed Wetlands	1	0	25	25	50	50
	2	0	55	55	75	75
Wet Ponds	1	0	30 (20) ⁴	30 (20) ⁴	50 (45) ⁴	50 (45) ⁴
	2	0	40 (30) ⁴	40 (30) ⁴	75 (65) ⁴	75 (65) ⁴
Ext. Det. Ponds	1	0	10	10	15	15
	2	15	10	24	15	31

4f. VRRM Compliance Spreadsheet Example

VRRM Spreadsheet DA Tabs

Drainage Area A													
Drainage Area & Land Cover (acres)													
	A Soils	B Soils	C Soils	D Soils	Total	Level	Cover %						
1	Forest/Space (Spec #)	0.00	0.00	0.00	0.00	0.00	0.00						
2	Managed Turf (Spec #)	0.00	0.00	0.00	0.00	0.00	0.00						
3	Impervious Cover (Spec #)	0.00	0.00	0.00	0.00	0.00	0.00						
					Total	0.00	0.00						
11 Apply Runoff Reduction Practices to Reduce Treatment Volume & Post-Development Load in Drainage Area A													
Practice	Unit	Description of Credit	Credit	Credit Area (Acres)	Upstream RR Practice (C)	Runoff Reduction (C)	Remaining Runoff Volume (C)	Phosphorus Removal Efficiency (E)	Phosphorus Load from Upstream RR Practices (E)	Phosphorus Load to Practice (E)	Phosphorus Removed by Practice (E)	Remaining Phosphorus Load (E)	Downstream Treatment to be Employed
1. vegetated Roof													
11.1.a	11.1.a. vegetated Roof #1 (Spec #5)	area of green roof	40% runoff volume reduction	0.45	0.00	0	0	0	0.00	0.00	0.00	0.00	
11.1.b	11.1.b. vegetated Roof #2 (Spec #6)	area of green roof	60% runoff volume reduction	0.60	0.00	0	0	0	0.00	0.00	0.00	0.00	
11.2. Rooftop Disconnection													
11.2.a	11.2.a. Simple Disconnection to AD (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.00	0.00	0	0	0	0.00	0.00	0.00	0.00	
11.2.b	11.2.b. Simple Disconnection to CED (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.25	0.00	0	0	0	0.00	0.00	0.00	0.00	
11.2.c	11.2.c. To the Street (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.00	0.00	0	0	0	0.00	0.00	0.00	0.00	
11.2.d	11.2.d. To Dry Well or French Drain #1 (Microfiltration #1) (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.00	0.00	0	0	25	0.00	0.00	0.00	0.00	
11.2.e	11.2.e. To Dry Well or French Drain #2 (Microfiltration #2) (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.00	0.00	0	0	25	0.00	0.00	0.00	0.00	
11.2.f	11.2.f. To Rain Garden #1 (Spec #1)	impervious acres disconnected	40% if volume captured	0.40	0.00	0	0	25	0.00	0.00	0.00	0.00	
11.2.g	11.2.g. To Rain Garden #2 (Microfiltration #2) (Spec #1)	impervious acres disconnected	40% runoff volume reduction for treated area based on base size and design spreadsheet (See Spec #1)	0.00	0.00	0	0	50	0.00	0.00	0.00	0.00	
11.2.h	11.2.h. To Rainwater Harvesting (Spec #1)	impervious acres captured	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00	
11.2.i	11.2.i. To Stormwater Ponds (Spec #1)	impervious acres disconnected	40% runoff volume reduction for treated area	0.40	0.00	0	0	25	0.00	0.00	0.00	0.00	
				TOTAL IMPERVIOUS COVER TREATED (ac)	0.00								
				TOTAL TRAP AREA TREATED (ac)	0.00								
AREA CHECK OK													
				TOTAL PHOSPHORUS REMOVAL REQUIRED OR SITE (lbs/yr)	0.00								
				TOTAL RUNOFF REDUCTION IN D.A. A (C)	0								
				PHOSPHORUS REMOVAL FROM RUNOFF REDUCTION PRACTICES IN D.A. A (lbs/yr)	0.00								
SEE WATER QUALITY COMPLIANCE TAB FOR SITE COMPLIANCE CALCULATIONS													
NITROGEN													
11 Apply Practice that Remove Pollutants but Do Not Reduce Runoff Volume													
Practice	Unit	Description of Credit	Credit	Credit Area (Acres)	Volume from Upstream RR Practice (C)	Runoff Reduction (C)	Remaining Runoff Volume (C)	Phosphorus Removal Efficiency (E)	Phosphorus Load from Upstream RR Practices (E)	Phosphorus Load to Practice (E)	Phosphorus Removed by Practice (E)	Remaining Phosphorus Load (E)	Downstream Treatment to be Employed
11.3. Wet Swale (Coastal Plain)													
11.3.a	11.3.a. Wet Swale #1 (Spec #11)	impervious acres draining to wet swale	5% runoff volume reduction	0.00	0.00	0	0	20	0.00	0.00	0.00	0.00	
11.3.b	11.3.b. Wet Swale #2 (Spec #11)	turf areas draining to wet swale	5% runoff volume reduction	0.00	0.00	0	0	20	0.00	0.00	0.00	0.00	
11.3.c	11.3.c. Wet Swale #3 (Spec #11)	impervious acres draining to wet swale	5% runoff volume reduction	0.00	0.00	0	0	40	0.00	0.00	0.00	0.00	
11.3.d	11.3.d. Wet Swale #4 (Spec #11)	turf areas draining to wet swale	5% runoff volume reduction	0.00	0.00	0	0	40	0.00	0.00	0.00	0.00	
11.4. Manufactured BMP													
11.4.a	11.4.a. Manufactured BMP #1 (Spec #1)	impervious acres draining to device	5% runoff volume reduction	0.00	0.00	0	0	0	0.00	0.00	0.00	0.00	
11.4.b	11.4.b. Manufactured BMP #2 (Spec #1)	turf areas draining to device	5% runoff volume reduction	0.00	0.00	0	0	0	0.00	0.00	0.00	0.00	
				TOTAL IMPERVIOUS COVER TREATED (ac)	0.00								
				TOTAL TRAP AREA TREATED (ac)	0.00								
AREA CHECK OK													
				PHOSPHORUS REMOVAL BY PRACTICES THAT DO NOT REDUCE RUNOFF VOLUME IN D.A. A	0.00								
				TOTAL PHOSPHORUS REMOVAL IN D.A. A (lbs/yr)	0.00								
SEE WATER QUALITY COMPLIANCE TAB FOR SITE COMPLIANCE CALCULATIONS													
NITROGEN REMOVAL BY PRACTICES THAT DO NOT REDUCE RUNOFF VOLUME IN D.A. A													
				TOTAL NITROGEN REMOVAL IN D.A. A (lbs/yr)	0.00								

Upper half:
Runoff Reduction
Practices

Lower half:
Pollutant Removal
Practices

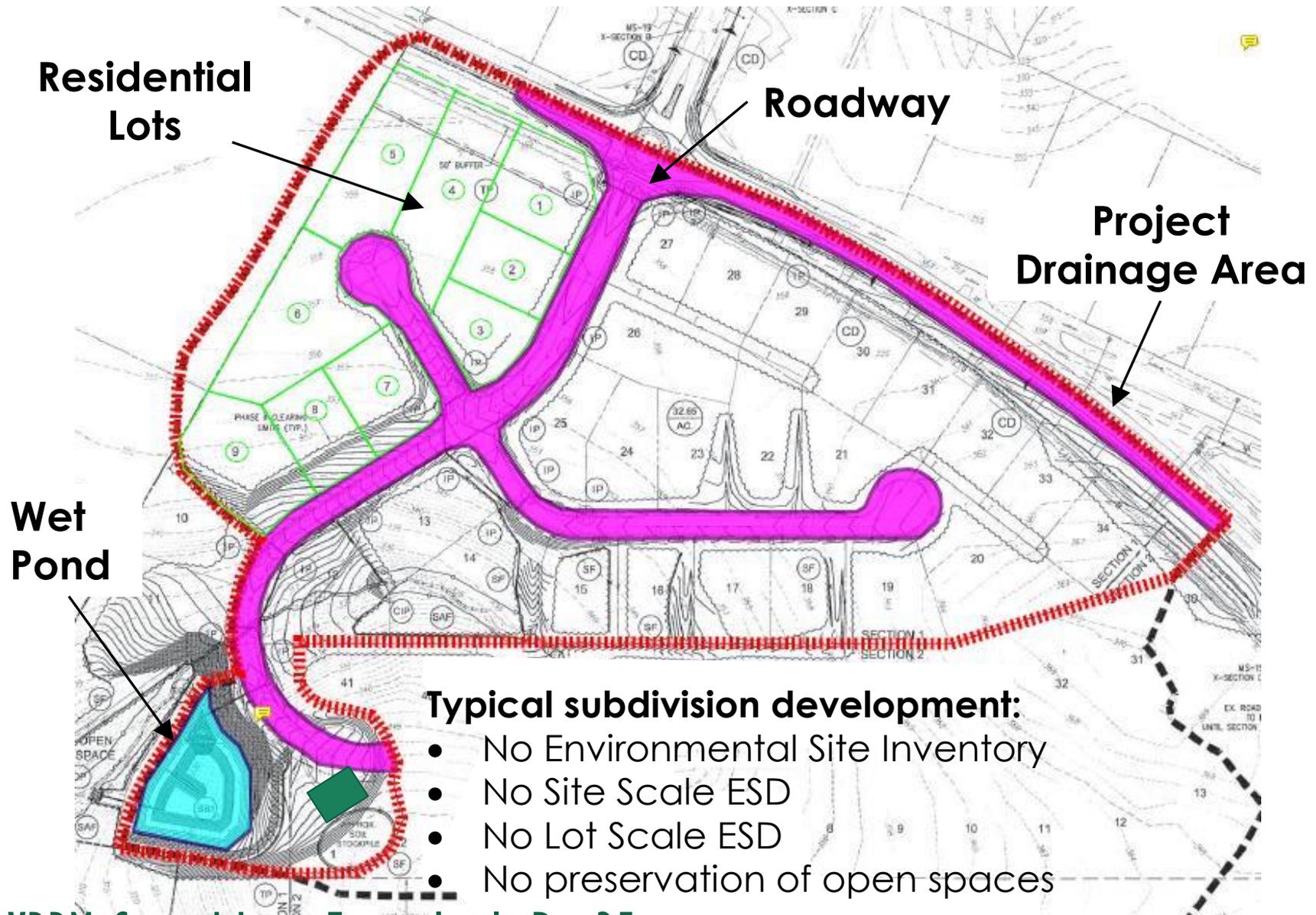
VRRM Spreadsheet DA Tabs

P19															None	
Drainage Area A															P	Q
Drainage Area A Land Cover (acres)																
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv										
5	Forest/Open Space (acres)	0.00	0.00	0.00	0.00	0.00	0.00									
6	Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0.00									
7	Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00	0.00									
8		Total				0.00			Post Development Treatment Volume (cf)				0			
Apply Runoff Reduction Practices to Reduce Treatment Volume & Post-Development Load in Drainage Area A																
Practice	Unit	Description 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			
1. Vegetated Roof																
13	1.a. Vegetated Roof #1 (Spec #5)	acres of green roof	45% runoff volume reduction	0.45	0.00	0	0	0	0.00	0.00	0.00	0.00				
14	1.b. Vegetated Roof #2 (Spec #5)	acres of green roof	60% runoff volume reduction	0.60	0.00	0	0	0	0.00	0.00	0.00	0.00				
2. Rooftop Disconnection																
17	2.a. Simple Disconnection to A/B Soils (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.50	0.00	0	0	0	0.00	0.00	0.00	0.00				
18	2.b. Simple Disconnection to C/D Soils (Spec #1)	impervious acres disconnected	25% runoff volume reduction for treated area	0.25	0.00	0	0	0	0.00	0.00	0.00	0.00				
19	2.c. To Soil Amended Filter Path as per specifications (existing C/D soils) (Spec #4)	impervious acres disconnected	50% runoff volume reduction for treated area	0.50								0.00	None			
20	2.d. To Dry Well or French Drain #1 (Microinfiltration #1) (Spec #8)	impervious acres disconnected	50% runoff volume reduction for treated area	0.50								0.00	None			
21	2.e. To Dry Well or French Drain #2 (Micro-Infiltration #2) (Spec #8)	impervious acres disconnected	90% runoff volume reduction for treated area	0.90								0.00	None			
22	2.f. To Rain Garden #1 (Micro-Bioretenion #1) (Spec #9)	impervious acres disconnected	40% of volume captured	0.40	0.00	0	0	0	25	0.00	0.00	0.00	None			
23	2.g. To Rain Garden #2 (Micro-Bioretenion #2) (Spec #9)	impervious acres disconnected	80% runoff volume reduction for treated area	0.80	0.00	0	0	0	50	0.00	0.00	0.00	None			
24	2.h. To Rainwater Harvesting (Spec #6)	impervious acres captured	based on tank size and design spreadsheet (See Spec #6)	0.00	0.00	0	0	0	0	0.00	0.00	0.00	None			
25	2.i. To Stormwater Planter (Urban Bioretention) (Spec #9, Appendix A)	impervious acres disconnected	40% runoff volume reduction for treated area	0.40	0.00	0	0	0	25	0.00	0.00	0.00	None			
3. Permeable Pavement																
28	3.a. Permeable Pavement #1 (Spec #7)	acres of permeable pavement + acres of "external" (upgradient) impervious pavement	45% runoff volume reduction	0.45	0.00	0	0	0	25	0.00	0.00	0.00	None			
29	3.b. Permeable Pavement #2 (Spec #7)	acres of permeable pavement	75% runoff volume reduction	0.75	0.00	0	0	0	25	0.00	0.00	0.00	None			
4. Grass Channel																
32	4.a. Grass Channel A/B Soils (Spec #1)	impervious acres draining to grass channels	20% runoff volume reduction	0.20	0.00	0	0	0	15	0.00	0.00	0.00	None			

User Defined Rainwater Harvesting Credit

- None
- 4.a. Grass Channel A/B Soils
- 4.b. Grass Channel C/D Soils
- 4.c. Grass Channel Compost Amended Soils
- 5.a. Dry Swale #1
- 5.b. Dry Swale #2
- 6.a. Bioretention #1
- 6.b. Bioretention #2

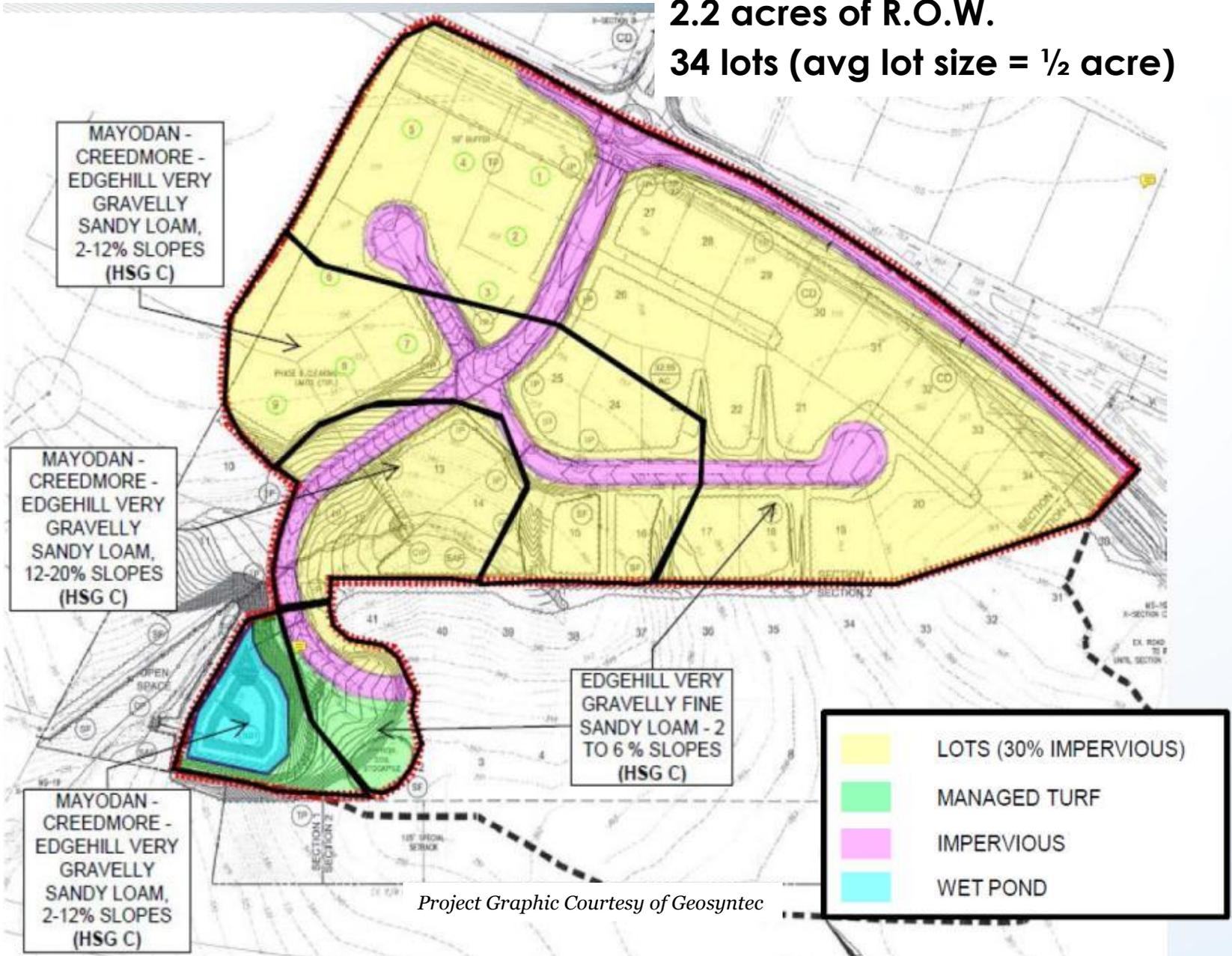
Design Example



Typical subdivision development:

- No Environmental Site Inventory
- No Site Scale ESD
- No Lot Scale ESD
- No preservation of open spaces

19.8 acre single Family Subdivision
2.2 acres of R.O.W.
34 lots (avg lot size = 1/2 acre)



Project Graphic Courtesy of Geosyntec

Site Data Tab

	A	B				
1	Virginia Runoff Reduction Method Nev					
2	Site Data					
3						
4	Project Name:					
5	Date:					
6						
7			data input cells			
8			calculation cells			
9			constant values			
10						
11	1. Post-Development Project & Land Cover Information					
12						
13	Constants					
14						
15	Annual Rainfall (Inches)	43				
16	Target Rainfall Event (Inches)	1.00				
17	Phosphorus EMC (mg/L)	0.26	Nitrogen EMC (mg/L) 1.86			
18	Target Phosphorus Target Load (lb/acre/yr)	0.41				
19	Pj	0.90				
20						
21	Land Cover (acres)					
22		A soils	B Soils	C Soils	D Soils	Totals
23	Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00		0.00	0.00	0.00
24	Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00		12.09	0.00	12.09
25	Impervious Cover (acres)	0.00		7.71	0.00	7.71
26						Total 19.80
27						
28	Rv Coefficients					
29		A soils	B Soils	C Soils	D Soils	
30	Forest/Open Space	0.02	0.03	0.04	0.05	
31	Managed Turf	0.15	0.20	0.22	0.25	
32	Impervious Cover	0.95	0.95	0.95	0.95	
33						
34						
35						
36	Land Cover Summary					
37	Forest/Open Space Cover (acres)	0.00				
38	Weighted Rv(forest)	0.00				
39	% Forest	0%				
40	Managed Turf Cover (acres)	12.09				
41	Weighted Rv(turf)	0.22				
42	% Managed Turf	61%				
43	Impervious Cover (acres)	7.71				
44	Rv(impervious)	0.95				
45	% Impervious	39%				
46	Total Site Area (acres)	19.80				
47	Site Rv	0.50				
48						
49	Post-Development Treatment Volume (acre-ft)	0.83				
50	Post-Development Treatment Volume (cubic feet)	36,243				
51	Post-Development Load (TP) (lb/yr)	22.77				
52	Total Load (TP) Reduction Required (lb/yr)	14.65				

Turf = 12.09
 Imp = 7.71
 Area Total = 19.8 acres

Site Rv = 0.50

Post Dev Tv = 0.83 ac-ft

Post Dev TP Load = 22.77 lb/yr

Load Reduction Required = 14.65 lb/yr

Drainage Area Tab

	A	B	C											
1	Drainage Area A													
2														
3	Drainage Area A Land Cover (acres)													
4	A Soils	B Soils	C Soils	D Soils	Totals	Land Cover Rr								
5	Forest/Open Space (acres)	0.00	0.00	0.00	0.00	0.00								
6	Managed Turf (acres)	0.00	0.00	12.09	12.09	0.22								
7	Impervious Cover (acres)	0.00	0.00	7.71	7.71	0.95								
8				Total	19.80									
9					Post Development Treatment Volume (cf)	36243								
10	Apply Runoff Reduction Practices to Reduce Treatment Volume & Post-Development Load in Drainage Area A													
11	Practice	Unit	Description 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
106	13.b. Wet Pond #1 (Coastal Plain) (Spec #14)	impervious acres draining to wet pond	0% runoff volume reduction	0.00	0.00	0	0	0	45	0.00	0.00	0.00	0.00	
107		turf acres draining to wet pond	0% runoff volume reduction	0.00	0.00	0	0	0	75	0.00	0.00	0.00	0.00	
108	13.c. Wet Pond #2 (Spec #14)	impervious acres draining to wet pond	0% runoff volume reduction	0.00	7.71	0	0	26588	75	0.00	16.69	12.8	4.17	
109		turf acres draining to wet pond	0% runoff volume reduction	0.00	12.09	0	0	9655	75	0.00	6.06	4.54	1.51	
110	13.d. Wet Pond #2 (Coastal Plain) (Spec #14)	impervious acres draining to wet pond	0% runoff volume reduction	0.00	0.00	0	0	0	65	0.00	0.00	0.00	0.00	
111		turf acres draining to wet pond	0% runoff volume reduction	0.00	0.00	0	0	0	65	0.00	0.00	0.00	0.00	
112														
113	14. Manufactured BMP													
114	14. Insert Name of Device	impervious acres draining to device	0% runoff volume reduction	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00	
115		turf acres draining to device	0% runoff volume reduction	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00	
116														
117	TOTAL IMPERVIOUS COVER TREATED (ac)				7.71									
118	TOTAL TURF AREA TREATED (ac)				12.09									
119														
120	AREA CHECK OK													
121														
122	PHOSPHORUS REMOVAL BY PRACTICES THAT DO NOT REDUCE RUNOFF VOLUME IN D.A. A						17.06							
123	TOTAL PHOSPHORUS REMOVAL IN D.A. A (lb/yr)						17.06							
124														
125	SEE WATER QUALITY COMPLIANCE TAB FOR SITE COMPLIANCE CALCULATIONS													
126														
127														
128	NITROGEN REMOVAL BY PRACTICES THAT DO NOT REDUCE RUNOFF VOLUME IN D.A. A						32.54							
129	TOTAL NITROGEN REMOVAL IN D.A. A (lb/yr)						32.54							

Credit Area (acres) to Wet Pond Level 2:
 Imp = 7.71 ac
 Turf = 12.09 ac

0 RR
 Remaining Runoff vol.
 & Remaining TP load

Area Check: **OK**

TP Removed = 17.06 lb/yr

D.A. A

Water Quality Compliance Tab

	A	B	C	D	E	F	G
1	Site Results						
2							
3		D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	AREA CHECK
4	IMPERVIOUS COVER	7.71	0.00	0.00	0.00	0.00	OK.
5	IMPERVIOUS COVER TREATED	7.71	0.00	0.00	0.00	0.00	OK.
6	TURF AREA	12.09	0.00	0.00	0.00	0.00	OK.
7	TURF AREA TREATED	12.09	0.00	0.00	0.00	0.00	OK.
8	AREA CHECK	OK.	OK.	OK.	OK.	OK.	
9							
10	Phosphorus						
11	TOTAL TREATMENT VOLUME (cf)	36,243					
12	TOTAL PHOSPHORUS LOAD REDUCTION REQUIRED (LB/YEAR)	14.65					
13							
14	RUNOFF REDUCTION (cf)	0					
15	PHOSPHORUS LOAD REDUCTION ACHIEVED (LB/YR)	17.06					
16							
17	ADJUSTED POST-DEVELOPMENT PHOSPHORUS LOAD (TP) (lb/yr)	5.71					
18							
19	REMAINING PHOSPHORUS LOAD REDUCTION (LB/YR) NEEDED	CONGRATULATIONS!! YOU EXCEEDED THE TARGET REDUCTION BY 2.4 LB/YEAR!!					
20							
21							
22							
23	Nitrogen (for information purposes)						
24	TOTAL TREATMENT VOLUME (cf)	36,243					
25							
26							
27	RUNOFF REDUCTION (cf)	0					
28	NITROGEN LOAD REDUCTION ACHIEVED (LB/YR)	32.54					
29							
30	ADJUSTED POST-DEVELOPMENT NITROGEN LOAD (TN) (lb/yr)	130.36					
31							

Area Check: OK

Runoff Reduction = 0

TP Reduction = 17.06 lb/yr

CONGRATULATIONS!! YOU EXCEEDED THE TARGET REDUCTION BY 2.4 LB/YEAR!!

Channel & Flood Protection Tab

	A	B	C	D	E	F	G	H
1				1-year storm	2-year storm	10-year storm		
2	Target Rainfall Event (in)			2.79	3.38	5.14		
4	Drainage Area A							
5	Drainage Area (acres)		19.80					
6	Runoff Reduction Volume (cf)		0					
8	Drainage Area B							
9	Drainage Area (acres)		0.00					
10	Runoff Reduction Volume (cf)		0					
12	Drainage Area C							
13	Drainage Area (acres)		0.00					
14	Runoff Reduction Volume (cf)		0					
16	Drainage Area D							
17	Drainage Area (acres)		0.00					
18	Runoff Reduction Volume (cf)		0					
20	Drainage Area E							
21	Drainage Area (acres)		0.00					
22	Runoff Reduction Volume (cf)		0					
25	Based on the use of Runoff Reduction practices in the selected drainage areas, the spreadsheet calculates an adjusted $RV_{Developed}$ and adjusted Curve Number.							
27	Drainage Area A			A soils	B Soils	C Soils	D Soils	
28	Forest/Open Space -- undisturbed, protected forest/open space or reforested land	Area (acres)	0.00	0.00	0.00	0.00	0.00	
29		CN	30	55	70	77		
30	Managed Turf -- disturbed, graded for yards or other turf to be mowed/managed	Area (acres)	0.00	0.00	12.09	0.00		
31		CN	39	61	74	80		
32		Area (acres)	0.00	0.00	7.71	0.00		
33	Impervious Cover	CN	98	98	98	98		
34							Weighted CN	S
35							83	2.05
36				1-year storm	2-year storm	10-year storm		
37		$RV_{Developed}$ (in) with no Runoff Reduction		1.28	1.76	3.30		
38		$RV_{Developed}$ (in) with Runoff Reduction		1.28	1.76	3.30		
39		Adjusted CN		83	83	83		

1, 2, and 10-year storm rainfall depths

No volume reduction

CN = 83
 1, 2, and 10-year volume (RV) measured in watershed inches =
 $RV_1 = 1.28$ inches
 $RV_2 = 1.76$ inches
 $RV_{10} = 3.30$ inches

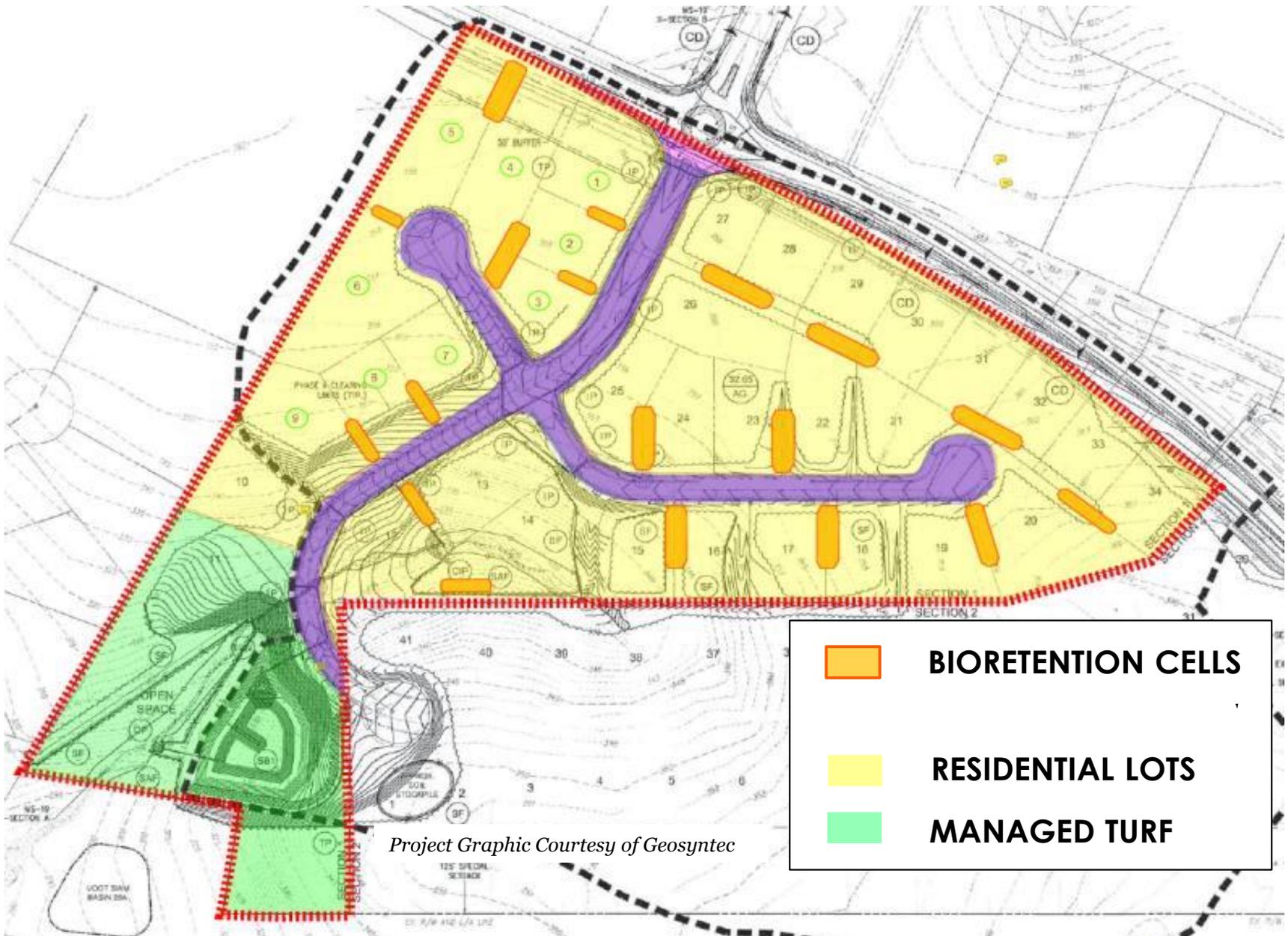
No RR
No CN Adjustment!

Alternative Design

Goal: Replace wet pond with BMPs that will reduce runoff volume (and remove pollutants):

- ***Rooftop disconnection***, downstream treatment to ***Bioretention*** to treat all impervious area on residential lots
- Remaining impervious (roads) and some pervious area on lots to ***Bioretention*** areas
- Conveyance to ***vegetated filter strip*** for downstream treatment

Additional Volume Reduction options: Permeable Pavement on roads; downstream Vegetated Filter Strips (or Conserved Open Space)



Project Graphic Courtesy of Geosyntec

-  **BIORETENTION CELLS**
-  **RESIDENTIAL LOTS**
-  **MANAGED TURF**

	A	B	C	D	E	F
1	Virginia Runoff Reduction Method New Development Worksheet -- v2.7 Revised Feb 2014					
2	Site Data					
3						
4	Project Name:					
5	Date:					
6						
7	data input cells					
8	calculation cells					
9	constant values					
10						
11	1. Post-Development Project & Land Cover Information					
12						
13	Constants					
14						
15	Annual Rainfall (inches)	43				
16	Target Rainfall Event (inches)	1.00				
17	Phosphorus EMC (mg/L)	0.26	Nitrogen EMC (mg/L)	1.86		
18	Target Phosphorus Target Load (lb/acre/yr)	0.41				
19	P _i	0.90				
20						
21	Land Cover (acres)					
22		A soils	B Soils	C Soils	D Soils	Totals
23	Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested	0.00		0.40	0.00	0.40
24	Managed Turf (acres) -- disturbed, graded for yards or other turf to be moved/managed	0.00		12.13	0.00	12.13
25	Impervious Cover (acres)	0.00		7.27	0.00	7.27
26						
27				Total		19.80
28	Rv Coefficients					
29		A soils	B Soils	C Soils	D Soils	
30	Forest/Open Space	0.02	0.03	0.04	0.05	
31	Managed Turf	0.15	0.20	0.22	0.25	
32	Impervious Cover	0.95	0.95	0.95	0.95	
33						
34						
35						
36	Land Cover Summary					
37	Forest/Open Space Cover (acres)	0.40				
38	Weighted Rv(forest)	0.04				
39	% Forest	2%				
40	Managed Turf Cover (acres)	12.13				
41	Weighted Rv(turf)	0.22				
42	% Managed Turf	61%				
43	Impervious Cover (acres)	7.27				
44	Rv(impervious)	0.95				
45	% Impervious	37%				
46	Total Site Area (acres)	19.80				
47	Site Rv	0.48				
48						
49	Post-Development Treatment Volume (acre-feet)	0.80				
50	Post-Development Treatment Volume (cubic feet)	34,816				
51	Post-Development Load (TP) (lb/yr)	21.87	Post-Development Load (TN) (lb/yr)	156.49		
52	Total Load (TP) Reduction Required (lb/yr)	13.76				
53						
54						

Same as traditional scenario, but:

- **Wet Pond** area partially converted from 'Impervious Cover' to 'Managed Turf'
 - **BMP areas** converted from 'Managed Turf' to 'Forest/Open Space'
- Forest/Open = 0.4
 Managed Turf = 12.13
 Impervious = 7.27

Slight change in Tv, TP Load, and Reduction Requirement

Note: Pervious Pavement & Green Roof is inventoried as 'Impervious Cover' with an associated CN Adjustment to reflect the permeable properties.

Runoff Reduction Design

Credit Area to Simple Disconnection = 5 ac

**Runoff Reduction = 4,311 ft³
 Runoff Remaining = 12,932 ft³
 Total = Tv_{BMP} = 17,243 ft³**

Drainage Area A Land Cover (acres)							Totals		Land Cover Rv	
	A soils	B Soils	C Soils	D Soils						
Forest/Open Space (acres)	0.00	0.00	0.40	0.00	0.40	0.04				
Managed Turf (acres)	0.00	0.00	12.13	0.00	12.13	0.22				
Impervious Cover (acres)	0.00	0.00	7.27	0.00	7.27	0.95				
Total					19.80					

Practice	Unit	Description 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 Practices (lbs)	Untreated Phosphorus Load to Practice (lbs.)	Phosphorus Removed By Practice (lbs.)	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed
1. Vegetated Roof													
1.a. Vegetated Roof #1 (Spec #5)	acres of green roof	45% runoff volume reduction	0.45	0.00	0	0	0	0	0.00	0.00	0.00	0.00	
1.b. Vegetated Roof #2 (Spec #5)	acres of green roof	60% runoff volume reduction	0.60	0.00	0	0	0	0	0.00	0.00	0.00	0.00	
2. Rooftop Disconnection													
2.a. Simple Disconnection to A/B Soils (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.50	0.00	0	0	0	0	0.00	0.00	0.00	0.00	
2.b. Simple Disconnection to C/D Soils (Spec #1)	impervious acres disconnected	25% runoff volume reduction for treated area	0.25	5.00	0	4311	12932	0	0.00	10.82	2.71	8.12	6.b. Bioretention #2
2.c. To Soil Amended Filter Path as per specifications (existing C/D soils) (Spec #4)	impervious acres disconnected	50% runoff volume reduction for treated area	0.50	0.00	0	0	0	0	0.00	0.00	0.00	0.00	None
2.d. To Dry Well or French Drain #1 (Microinfiltration #1) (Spec #5)	impervious acres disconnected	50% runoff volume reduction for treated area	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
2.e. To Dry Well or French Drain #2		90% runoff volume	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00	

Downstream Treatment: Bioretention L2

Runoff Reduction Design

Credit Area to Bioretention Level 2:
1.89 ac additional Impervious
5.0 ac turf

Volume from upstream RR practice:
12,932 ft³

Drainage Area A													
Drainage Area A Land Cover (acres)													
	A Soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv							
Forest/Open Space (acres)	0.00	0.00	0.40	0.00	0.40	0.04							
Managed Turf (acres)	0.00	0.00	12.13	0.00	12.13	0.22							
Impervious Cover (acres)	0.00	0.00	7.27	0.00	7.27	0.95							
	Total				19.80								
Apply Runoff Reduction Practices to Reduce Treatment Volume & Post-Development Load in Drainage Area A													
Practice	Unit	Description 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
6. Bioretention													
6.a. Bioretention #1 or Urban Bioretention (Spec #9)	impervious acres draining to bioretention	40% runoff volume reduction	0.40	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
	turf acres draining to bioretention	40% runoff volume reduction	0.40	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
6.b. Bioretention #2 (Spec #9)	impervious acres draining to bioretention	80% runoff volume reduction	0.80	1.89	12932	15560	3890	50	8.12	4.09	10.99	1.22	None
	turf acres draining to bioretention	80% runoff volume reduction	0.80	5.00	0	3194	799	50	0.00	2.51	2.26	0.25	None
7. Infiltration													
7.a. Infiltration #1 (Spec #8)	impervious acres draining to infiltration	50% runoff volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
	turf acres draining to infiltration	50% runoff volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	impervious acres draining to infiltration	90% runoff volume reduction	0.90	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
	turf acres draining to infiltration	90% runoff volume reduction	0.15	0.00	0	0	0	15	0.00	0.00	0.00	0.00	

Runoff Reduction = 15,560 + 3,194 ft³
+ Runoff Remaining = 3,890 + 799 ft³
= Total = Tv_{BMP} = 23,443 ft³

Water Quality Compliance Tab

Area Check - OK

A	B	C	D	E	F	G	
1	Site Results						
2							
3		D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	AREA CHECK
4	IMPERVIOUS COVER	7.27	0.00	0.00	0.00	0.00	OK.
5	IMPERVIOUS COVER TREATED	6.89	0.00	0.00	0.00	0.00	OK.
6	TURF AREA	12.13	0.00	0.00	0.00	0.00	OK.
7	TURF AREA TREATED	5.00	0.00	0.00	0.00	0.00	OK.
8	AREA CHECK	OK.	OK.	OK.	OK.	OK.	
9							
10	Phosphorus						
11	TOTAL TREATMENT VOLUME (cf)	34,816					
12	TOTAL PHOSPHORUS LOAD REDUCTION REQUIRED (LB/YEAR)	13.76					
13							
14	RUNOFF REDUCTION (cf)	23065					
15	PHOSPHORUS LOAD REDUCTION ACHIEVED (LB/YR)	15.95					
16							
17	ADJUSTED POST-DEVELOPMENT PHOSPHORUS LOAD (TP) (lb/yr)	5.93					
18							
19	REMAINING PHOSPHORUS LOAD REDUCTION (LB/YR) NEEDED	CONGRATULATIONS!! YOU EXCEEDED THE TARGET REDUCTION BY 2.2 LB/YEAR!!					
20							
21							
22							
23	Nitrogen (for information purposes)						
24	TOTAL TREATMENT VOLUME (cf)	34,816					
25							
26							
27	RUNOFF REDUCTION (cf)	23065					
28	NITROGEN LOAD REDUCTION ACHIEVED (LB/YR)	124.60					
29							
30	ADJUSTED POST-DEVELOPMENT NITROGEN LOAD (TN) (lb/yr)	31.89					
31							

**Runoff Reduction Achieved:
23,065 ft³**

CONGRATULATIONS!! YOU EXCEEDED THE TARGET REDUCTION BY 2.2 LB/YEAR!!

Congratulations! You exceeded target reduction by 2.2 lbs/yr

Channel & Flood Protection Tab

	A	B	C	D	E	F	G	H
1				1-year storm	2-year storm	10-year storm		
2	Target Rainfall Event (in)			2.79	3.38	5.14		
3								
4	<u>Drainage Area A</u>							
5	Drainage Area (acres)		19.80					
6	Runoff Reduction Volume (cf)		23,065					
7								
8	<u>Drainage Area B</u>							
9	Drainage Area (acres)		0.00					
10	Runoff Reduction Volume (cf)		0					
11								
12	<u>Drainage Area C</u>							
13	Drainage Area (acres)		0.00					
14	Runoff Reduction Volume (cf)		0					
15								
16	<u>Drainage Area D</u>							
17	Drainage Area (acres)		0.00					
18	Runoff Reduction Volume (cf)		0					
19								
20	<u>Drainage Area E</u>							
21	Drainage Area (acres)		0.00					
22	Runoff Reduction Volume (cf)		0					
23								
24								
25	Based on the use of Runoff Reduction practices in the selected drainage areas, the spreadsheet calculates an adjusted $RV_{Developed}$ and adjusted CN							
26								
27	Drainage Area A			A soils	B Soils	C Soils	D Soils	
28	Forest/Open Space – undisturbed, protected forest/open space or reforested land	Area (acres)	0.00	0.00	0.40	0.00		
29		CN	30	55	70	77		
30	Managed Turf – disturbed, graded for yards or other turf to be mowed/managed	Area (acres)	0.00	0.00	12.13	0.00		
31		CN	39	61	74	80		
32	Impervious Cover	Area (acres)	0.00	0.00	7.27	0.00		
33		CN	98	98	98	98		
34								
35						Weighted CN	83	2.05
36								
37				1-year storm	2-year storm	10-year storm		
38		$RV_{Developed}$ (in) with no Runoff Reduction		1.28	1.76	3.30		
39		$RV_{Developed}$ (in) with Runoff Reduction		0.96	1.44	2.98		
40		Adjusted CN		77	78	80		

1, 2, and 10-year storm rainfall depths

Volume Reduction = 23,065 ft³

1, 2, and 10-year volume (RV) reduction =

$RV_1 = 1.28'' \rightarrow 0.96''$
 $CN_1 \ 83 \rightarrow 77$

$RV_2 = 1.76'' \rightarrow 1.44''$
 $CN_2 \ 83 \rightarrow 78$

$RV_{10} = 3.30'' \rightarrow 2.98''$
 $CN_{10} \ 83 \rightarrow 80$

Design Comparison

Original design:

- No Volume Reduction
- Treat 100% of site (19.8 ac) with Wet Pond Level 2
- Compliance: exceed reqmt. by 2.4 lb/yr

RR Design:

- Treat 11.9 acres
- Compliance: exceed reqmt. by 2.2 lb/yr
- No wet pond Req'd (for water quality)
- Reduce 23,065 ft³ volume (from site Tv = 34,816 ft³)
- Reduce 1-yr CN from 83 to 77

Alternative Design

Additional Volume Reduction:

Option of adding permeable pavement:

- Increases load reduction 1 pound/yr:
2.2 to 3.2 lb/yr;
- Increases volume reduction approx 8%
- Increases CN Reduction for 1-yr storm:
from 83 to 76 (versus 83 to 77)

Cost-Benefit analysis of incremental increase in performance?

Runoff Reduction Method

- Not difficult!
- Spreadsheet tracks runoff volume and pollutant load reductions by DA (Summary Tab)
- Additional tracking tools (spreadsheets or other tools can be utilized)
- Better site design, improved BMP performance, and practices designed for long term functioning

- Additional discussion on VRRM and Compliance Spreadsheet
 - Capabilities
 - Limitations



(Modules 5-7)

Questions & Discussion