Module 4: The Virginia Runoff Reduction Method

Module 4 Objectives

After completing this module, you should be able to:

- Describe the hydrologic basis of the Virginia Runoff Reduction Method
- Explain the Virginia stormwater quality requirements and the site-based pollutant load limit
- Discuss the incentives to use Better Site Design and Runoff Reduction Best Management Practices (BMPs) to achieve compliance with the Virginia stormwater requirements
- Identify the basic architecture of the Virginia Runoff Reduction Spreadsheet

Module 4 Content

4a. Overview of the Virginia Runoff Reduction Method

4b. Land Cover and Volumetric Runoff Coefficients

4c. The Simple Method

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4a. Overview of the Virginia Runoff Reduction Method

The Virginia Runoff Reduction Method (VRRM) was developed in order to:

- Promote better stormwater design; and
- Provide an incentive for the use of Low Impact Development (LID) and Environmental Site Design (ESD) strategies in the design of land development projects.

LID and ESD are similar if not identical terms that describe the land development process as being focused on preserving the hydrologic function of the land by identifying existing natural features such as permeable soils, steep slopes, mature vegetation, streams and wetlands, etc., at the outset of a project, i.e., before the layout and design of the basic development pattern and infrastructure. The VRRM allows the designer to take credit for preserving those features, as well as other strategies such as reducing the amount of land disturbed during construction, reducing impervious cover, etc., which serves to reduce the overall stormwater impact of the project and provide a pathway for compliance with the Virginia Stormwater Management Regulations. (Additional information on ESD goals and objectives can be found in Module 6 of the Basic SWM Course).

The VRRM documents the hydrologic characteristics and reduced pollutant loading of ESD strategies.

Another feature of the VRRM is to provide credit for the **Total Performance** of structural and non-structural stormwater management practices. The total performance, or Total Mass Load Removal defined with the Virginia BMP Clearinghouse specifications, is a function of the practice's ability to achieve **Runoff Reduction (RR)** and **Pollutant Removal (PR)**. The latest research on stormwater practice performance indicates that some practices consistently perform better than others, and concludes that the RR component of certain practices provides the primary pollutant removal pathway, with the physical filtering, settling, or other physical process providing additional treatment.

The VRRM incorporates the latest research to properly credit the Total Performance (Total Mass Load Removal) of RR practices.

A third feature of the VRRM is to credit the conventional stormwater practices that achieve pollutant removal. This includes variations on filters, wet ponds, constructed wetlands and other practices that have demonstrated PR (capabilities, but are limited in overall performance based on the lack of volume reduction pathway. It is important to note that some development sites may be able to comply with the stormwater requirements solely by incorporating PR practices.

The VRRM includes the conventional PR practices for additional load reductions when necessary.

The VRRM incorporates these three features into an iterative step-wise procedure that is captured in the **VRRM Compliance Spreadsheet** and described as follows:

Step 1: Apply Site Design Practices to minimize disturbance of soils, impervious cover, grading, and loss of forest or other mature vegetative cover.

This step focuses on implementing Environmental Site Design (ESD) practices during the early phases of site layout. This process reduces the amount of rainfall that becomes runoff, thereby reducing the volume of runoff that must be managed and treated, and the corresponding required load pollutant load reduction.

Step 2: Apply Runoff Reduction (RR) Practices.

In this step, the designer selects the most appropriate RR practices or combination of RR practices for the site. The designer estimates the drainage area to be managed by each practice and the spreadsheet reduces the runoff volume based on the particular RR practice performance credit. The designer can use RR practices in series within individual drainage areas, e.g., a rooftop disconnection draining to a grass channel which in turn drains to a bioretention basin, in order to incrementally reduce the runoff volume further with each practice.

Step 3: Apply Pollutant Removal (PR) Practices

In this step, the designer applies PR practices to address any additional load reduction requirement needed in order to meet the water quality requirements.

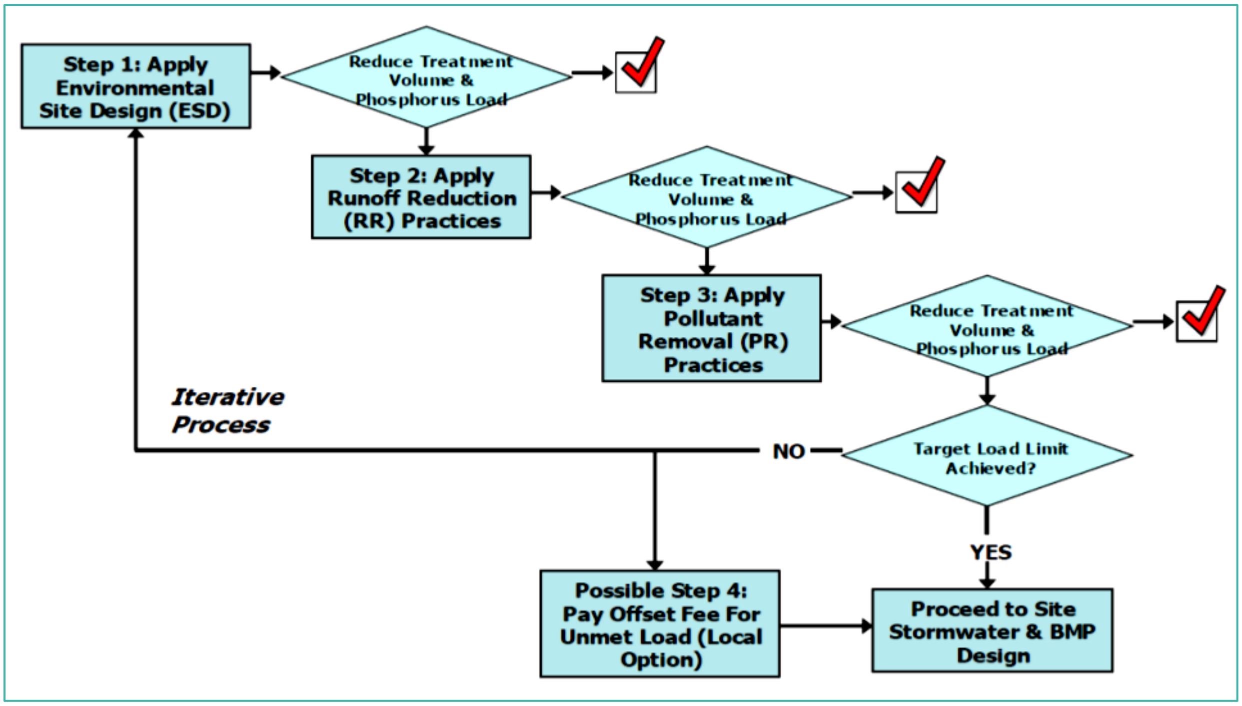


Figure 1: Virginia Runoff Reduction Method Step-Wise Process for Site Compliance

A fourth step is to determine if the strategy has met the required **Site Based Pollutant Load Limit** of the regulations. The VRRM Compliance Spreadsheet is a very convenient tool for quickly verifying the performance of the design and management practices, and fosters an iterative process to determine the most effective site design and stormwater practice strategy for the project.

The documentation for all the elements of the VRRM are found in the **Technical Memorandum: The Runoff Reduction Method, April 18, 2008**. Various sections of the Technical Memorandum will be repeated or referenced throughout this Module to help provide plan reviewers with the technical basis for designs.

Virginia Runoff Reduction Method Overview Terminology Review:

Runoff Reduction (RR)

Pollutant Removal (PR)

Total Performance

VRRM Compliance Spreadsheet

4b. Land Cover & Volumetric Runoff Coefficients

Minimization of Impacts: Impervious Cover and Beyond

The first step of minimizing impacts and implementing ESD is the process of identifying site features that can be preserved in order to provide a hydrologic benefit. This will also help to direct the design of the development layout such that the benefit of ESD strategies can be maximized. The following is excerpted from Module 6 of the Basic SWM Course:

Environmental Site Design Techniques and Practices
(Table 6-1 excerpt from SWM Basic Course Module 6)

Conserving natural features and resources	
Preserve undisturbed natural areas	Preserve or plant native trees
Preserve riparian buffers	Avoid floodplains
Avoid steep slopes	
Using low impact site design techniques	
Fit the design to the terrain	Locate development in less sensitive areas
Reduce the limits of clearing and grading	Use open space development
Consider creative development design	Reduce roadway lengths and widths
Reduce impervious footprints	Reduce the parking footprints
Reduce setbacks and frontages	Use fewer or alternative cul-de-sacs
Create parking lot stormwater "islands"	
Using natural features and runoff reduction to manage stormwater	
Use buffers and undisturbed filter areas	Use creative site grading, berming and terracing (terraforming)
Use natural drainageways and vegetated swales instead of storm sewers and curb and gutter	Drain runoff to pervious areas
Infiltrate site runoff or capture it for reuse	Restore or daylight streams at redevelopment projects

An important feature in the VRRM is the incentive to utilize ESD that is hard-wired into the method. The method includes a systematic approach to identifying the post-construction land cover and assigns a corresponding **Volumetric Runoff Coefficient (Rv)** with which to calculate the runoff volume and pollutant loads. Similar to the Rational Method runoff coefficient, the Rv is a unit-less coefficient that represents the fraction of rainfall that becomes runoff.

Table 4-1 provides the VRRM Rv values for Forest/Open Space, Managed Turf/Disturbed Soil, and Impervious Cover. There are many variations of runoff coefficients for similar land cover types referenced in other hydrologic models, including the Rational Method, however, the VRRM Rv values were derived through extensive research and are part of the VRRM.

Table 4-1. Land Cover Runoff Coefficients (Rv)				
Cover	**HSG A**	**HSG B**	**HSG C**	**HSG D**
Forest/Open Space	**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**

Pitt et al (2005), Lichter and Lindsey (1994), Schueler (2001a), Schueler, (2001b), Legg et al (1996), Pitt et al (1999), Schueler (1987) and Cappiella et al (2005).

Note:

Minimize the overall footprint of the construction, area of disturbance, and the compaction of native soil horizons during construction in order to consider using the low Rv values assigned to Forest/Open Space.

Land Cover

The definitions and application of specific land cover categories on the developed site are a fundamental part of documenting ESD and minimization of impacts. The plan reviewer must be familiar with the definitions of the VRRM Land Cover options, and be able to verify that they are accounted for on the design plans.

Forest/Open Space

The incentive for designers to reduce the overall footprint of land disturbance and incorporate ESD (as described in the Basic SWM Course Module 6) into the design of projects is derived from the relatively low Rv assigned to Forest/Open Space.

Forested/wooded areas, stream buffers, or areas designated as “conserved” open space should be:

- Designated on the plans as undisturbed;
- Be protected during construction with some form of barrier or fencing; and
- Be protected after construction with a protective covenant or easement, and signage where applicable.

Conservation areas, buffers, and designated open spaces must be designated on the plans and protected from disturbance during construction to be considered Forest/Open Space in VRRM Site Data calculations.

On-lot areas that are to remain undisturbed and/or serve as a BMP, e.g., impervious area disconnection or other on-lot micro-practice can also be considered open space in the VRRM Site. The primary performance goal is to designate these areas on the plan as undisturbed during construction, or is disturbance is unavoidable, to restore the soil in order to ensure the native soil horizons can absorb or retain runoff after construction is complete. These areas must be:

- Designated on the plan and
  - Protected During construction as noted above, or
  - Restored after construction with soil amendments if impacts are unavoidable.
- Include a long term maintenance agreement in accordance with the regulations if designated as a stormwater BMP.

Areas proposed for on-lot BMPs must be designated on the plans and protected from disturbance during construction, or restored after construction to be considered Forest/Open Space in VRRM Site Data calculations.

Virginia Runoff Reduction Method Guidance (March 24, 2011)

DEFINITION: FOREST & OPEN SPACE
Land that will remain undisturbed OR that will be restored to a hydrologically functional state: • Portions of residential lots that will NOT be disturbed during construction • Portions of roadway rights-of-way that, following construction, will be used as filter strips, grass channels, or stormwater treatment areas; MUST include soil restoration or placement of engineered soil mix as per the design specifications • Community open space areas that will not be mowed routinely, but left in a natural vegetated state (can include areas that will be bush hogged no more than four times per year) • Utility rights-of-way that will be left in a natural vegetated state (can include areas that will be bush hogged no more than four times per year) • Surface area of stormwater BMPs that are NOT wet ponds, have some type of vegetative cover, and that do not replace an otherwise impervious surface. BMPs in this category include bioretention, dry swale, grass channel, ED pond that is not mowed routinely. stormwater wetland, soil amended areas that are vegetated, and infiltration practices that have a vegetated cover. • Other areas of existing forest and/or open space that will be protected during construction and that will remain undisturbed. These include wetlands.

Management Conditions for Pervious Surfaces

The designation of pervious cover as Forest/Open Space is predicated on the application of general operational and management conditions shown below.

Virginia Runoff Reduction Method Guidance (March 28, 2011)

OPERATIONAL & MANAGEMENT CONDITIONS FOR LAND COVER IN FOREST & OPEN SPACE CATEGORY
• Undisturbed portions of yards, community open space, and other areas that will be considered as forest/open space must be shown outside the LOD on approved E&S plans AND demarcated in the field (e.g., fencing) prior to commencement of construction. • Portions of roadway rights-of-way that will count as forest/open space are assumed to be disturbed during construction, and must follow the most recent design specifications for soil restoration and, if applicable, site reforestation, as well as other relevant specifications if the area will be used as a filter strip, grass channel, bioretention, or other BMP • All areas that will be considered forest/open space for stormwater purposes must have documentation that prescribes that the area will remain in a natural, vegetated state. Appropriate documentation includes: subdivision covenants and restrictions, deeded operation and maintenance agreements and plans, parcel of common ownership with maintenance plan, third-party protective easement, within public right-of-way or easement with maintenance plan, or other documentation approved by the local program authority • While the goal is to have forest/open space areas remain undisturbed, some activities may be prescribed in the appropriate documentation, as approved by the local program authority: forest management, control of invasive species, replanting and revegetating, passive recreation (e.g., trails), limited bush hogging to maintain desired vegetative community, etc.

Managed Turf/Disturbed Soil

Numerous studies have documented the impact of grading and construction on the compaction of soils as (OCSCD et al, 2001; Pitt et al, 2002; Schueler and Holland, 2000):

- Increase in bulk density,
- Decline in soil permeability, and
- Increases in the runoff coefficient.

These areas of compacted soil, even when proposed to remain as pervious cover, e.g., lawn or managed open space, have a much greater hydrologic response to rainfall than undisturbed areas, e.g., forest, meadow, or pasture.

For pervious areas that are not necessarily disturbed during construction, but are proposed as open lawn areas of a residential lot are considered managed turf, and as such, can contribute to elevated nutrient loads. Typical turf management activities include (Robbins and Birkenholtz 2003):

- Mowing,
- Active recreational use, and
- Fertilizer and pesticide applications.

Analysis of Virginia-specific data from the National Stormwater Quality Database (Pitt et al. 2004) found that runoff from relatively low impervious cover residential land uses contained significantly higher nutrient concentrations than sites with higher impervious cover (CWP & VA DCR, 2007). The VRRM therefore considers these areas to be Managed Turf and assigns the corresponding Rv value.

Generally, all areas of the development that are not designated as impervious or Forest/Open Space are considered Managed Turf.

Virginia Runoff Reduction Method Guidance (March 24, 2011)

DEFINITION: MANAGED TURF
Land disturbed and/or graded for eventual use as managed turf: • Portions of residential yards that are graded or disturbed, including yard areas, septic fields, residential utility connections • Roadway rights-of-way that will be mowed and maintained as turf • Turf areas intended to be mowed and maintained as turf within residential, commercial, industrial, and institutional settings

Impervious Cover

Minimizing impervious cover is a self-crediting design feature. The less impervious cover, the lower the developed condition runoff Curve Number (CN) for all the hydrologic calculations. In the VRRM, the Rv values for Managed Turf are a factor of 5 to 7 times greater than Forest/Open Space (depending on soil type), and Impervious cover is 20 to 50 times greater.

Virginia Runoff Reduction Method Guidance (March 28, 2011)

IMPERVIOUS COVER
• Roadways, driveways, rooftops, parking lots, sidewalks, and other areas of impervious cover. • This category also includes the surface area of stormwater BMPs that: (1) are wet ponds, OR (2) replace an otherwise impervious surface (e.g., green roof, pervious parking).[1]
[1]Certain stormwater BMPs are considered impervious with regard to the land cover computations. These BMPs are still assigned Runoff Reduction and/or Pollutant Removal rates within the spreadsheet, so their "values" for stormwater management are still accounted for. The reason they are considered impervious is that they either do not reduce runoff volumes (e.g., wet ponds) OR their Runoff Reduction rates are based on comparison to a more conventional land cover type (e.g., green roofs, pervious parking).

4c. The Simple Method

Background

The Simple Method estimates the annual pollutant load exported in stormwater runoff from small urban catchments (Schueler, 1987). The Simple Method sacrifices some precision for the sake of simplicity and ease of use, but it is a reasonably accurate way to predict annual pollutant loads.

The Simple Method has been used in the Virginia Stormwater Program since the 1990's to establish the regulatory Total Phosphorus load limit:

$$L = P \times P_i \times Rv \times C \times A \times 2.72/12$$

Where:

L	= total post-development pollutant load (pounds/ year)
P	= average annual rainfall depth (inches) = 43 inches for Virginia
P_j	= fraction of rainfall events that produce runoff = 0.9
Rv	= volumetric runoff coefficient
C	= flow-weighted event mean concentration (EMC) of TP (mg/L) = 0.26 mg/L
A	= area of the development site (acres)
2.72	= unit conversion factor: L to ft^3, mg to lb, and acres to ft^2
12	= unit conversion factor: rainfall inches to feet

In the case of the old regulations (those referenced in Part II C), the load limit was based on theoretical threshold of 16% impervious cover as the sole water quality indicator for Total Phosphorus (TP). When using the Simple Method equation and a theoretical 16% impervious percentage to calculate Rv, the calculated annual site-based load limit (L) equals 0.41 lb/ac/yr.

The Simple Method has been used in the past to calculate the 'old' stormwater TP Annual Load Limit of 0.45 lb/ac/yr.

The new stormwater quality regulations have moved beyond impervious cover as the sole indicator for TP loads, and the Simple Method equation is revised to change the value of Rv to a **Composite Rv** representing Impervious, Managed Turf, and Forest/Open Space as follows:

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

Where: $Rv_{composite}$ =	Composite or weighted runoff coefficient
Rv_I =	Runoff coefficient for Impervious cover (Table 4-1)
Rv_T =	Runoff coefficient for Turf cover or disturbed soils (Table 4-1)
Rv_F =	Runoff coefficient for Forest/Open Space (Table 4-1)
$\% I$ =	Percent of site in Impervious cover (fraction)
$\%T$ =	Percent of site in Turf cover (fraction)
$\%F$ =	Percent of site in Forest/Open Space (fraction)

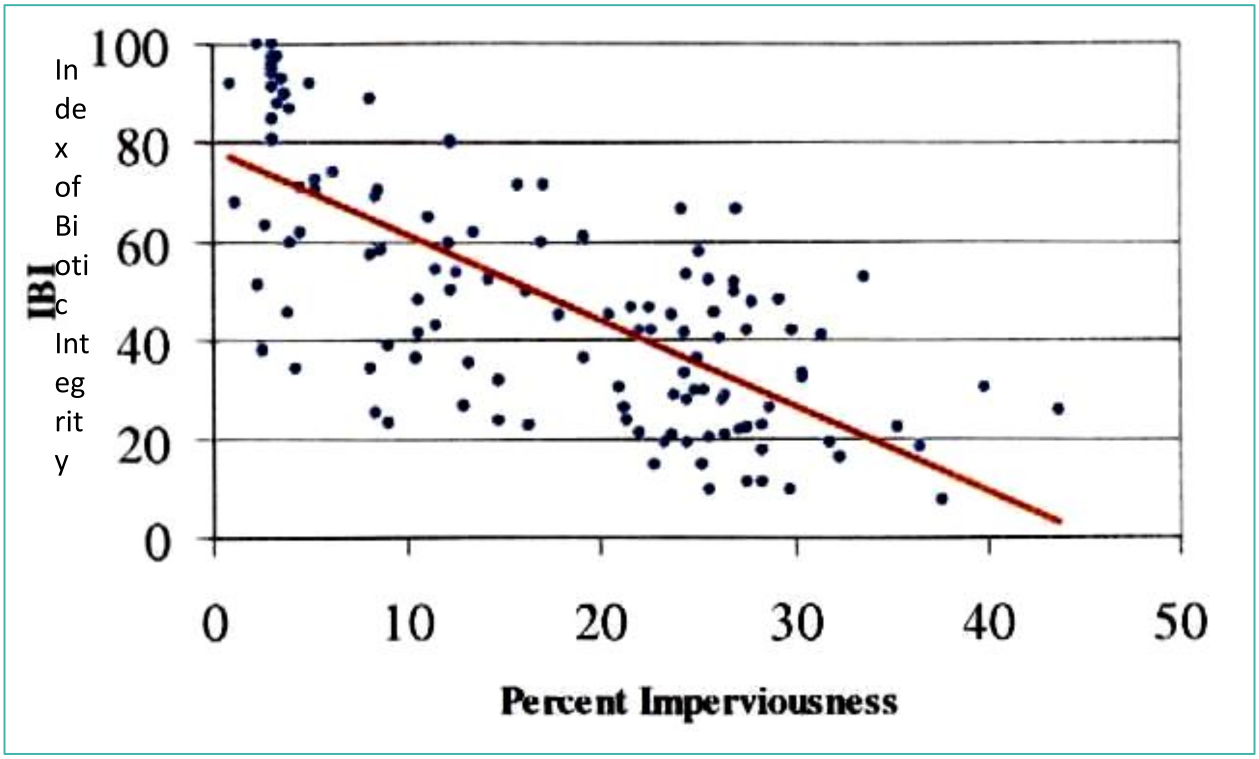
The other values in the Simple Method were not changed. Extensive research into the pollutant Event Mean Concentrations (EMCs) for TP and Total Nitrogen (TN) was performed to verify that the values utilized in the Simple Method are appropriate for regulatory compliance tools. Table 4-2 provides the results of that research, which verifies the continued use of EMC values of 0.26 mg/L for TP and 1.86 mg/L for TN.

Table 4-2. National vs Virginia Event Mean Concentrations

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

The Simple Method and the Virginia Stormwater Regulation Site Based Load Limit

The impact of impervious cover on stream health has been well documented. The result is often very obvious to the casual observer when the bed and banks of a stream are severely eroded with the channel cross section cutting deeper and eroding wider. The Impervious Cover Model (ICM) was first proposed in 1994 as a management tool for diagnosing impacts of future development patterns on streams in urbanizing watersheds. That research revealed that streams begin to exhibit impacts at as little as 10% impervious cover in a watershed. Over 200 studies linking impervious cover with 26 indicators of stream health referenced as Index of Biotic Integrity (IBI) support a general reference point of 10% impervious cover as the point of rapid decline in stream health. As impervious cover increases, the impacts become more severe.



This information serves as the basis of the **Virginia Stormwater Regulation Site Based Load Limit of 0.41 lb/ac/yr**. Similar to the development of the previous regulatory load limit of 0.45 lb/ac/yr, the new regulations established a standard theoretical land cover condition to represent the mutual program goals of:

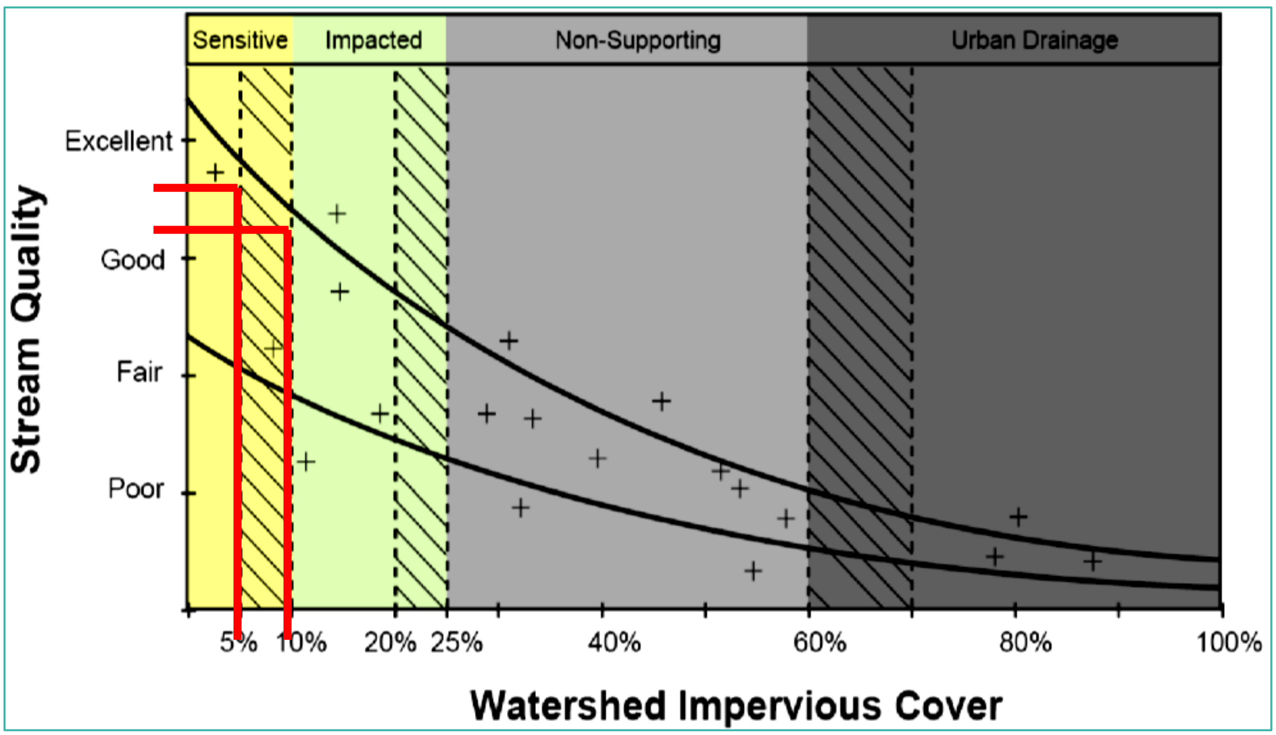
1. "No Net Increase" in pollutant loads; and
2. A regulatory threshold that is both practical (achievable) and can be scientifically defended as protective of healthy streams.

Evaluations of numerous development and land use scenarios were considered with The Virginia Chesapeake Bay TMDL Phase I WIP serving as the primary (but not the sole) driver:

- *Allocations for newly developed land set at levels that result in no increase above allowable 2025 average nutrient loads per acre from previous land uses*.
- *Tier 1 load-balancing approach of using allocation loads for forest, cropland, pasture, and hay land uses in the Chesapeake Bay Program's Phase 5.3 Watershed Model to calculate the average*

pollutant loads from a generic pre-development acre based on the mix of projected land to be developed for Virginia's Chesapeake Bay watershed.

This driving guidance was combined with statistical data regarding the type of land uses being converted to development, i.e., agriculture converted to development, versus forest converted to development. Several scenarios were considered based on the updated ICM which identifies a range of impervious cover values (rather than a single line) as indicators. The general message of this updated information is that all impervious cover is not bad: depending on specific hydrologic parameters, such as location within the watershed, direct connectedness to the drainage system, etc., the impacts of impervious cover can vary. The Updated ICM figure below provides a simple analysis of the recently compiled data, and the corresponding range in stream quality. The application of impervious cover in deriving a statewide site based load limit that is considered supportive of stream health therefore ranged from 5 to 10%.



Schueler, T., Fraley-McNeal, L., and Capiella, K.
"Is Impervious Cover Still Important? Review of Recent Research"
Journal of Hydrologic Engineering, April 2009

The basis of utilizing the upper end of the curve as shown was the inclusion of the VRRM and the inherent benefits associated with incentivizing ESD and retention storage to minimize the impacts of the impervious cover.

The analysis considered a theoretical breakdown of developed land cover between Impervious (ranging from 5 to 10%), and the balance of Managed Turf and Forest/Open Space as shown in Table 4-3. In addition, the analysis compared the load limits required by a "No Net Increase" policy were the load limit is determined by the assumed prior land uses (agriculture or forest). The resulting load limits from these scenarios provided in Table 4-3 shows that the compromise of 0.41 lb/ac/yr based on 10% impervious still achieves the "No Net Increase" goal of the Chesapeake Bay TMDL.

Table 4-3. Summary of Allowable Loading Rate Analysis

State-wide Requirement Based on Percentage of Impervious Cover and STATSGO average soil cover		Compromise	Chesapeake Bay Requirement Based on "No Increase" from previous land uses	
5% impervious, 65% forest, 30% turf	**0.30**	**0.41 lb/ac/yr**	**0.51**	36% forest, 64% agriculture
7.5% impervious, 62.5% forest, 30% turf	**0.36**		**0.56**	28% forest, 72% agriculture
10% impervious, 60% forest, 30% turf	**0.41**		**0.56**	29% forest, 71% agriculture

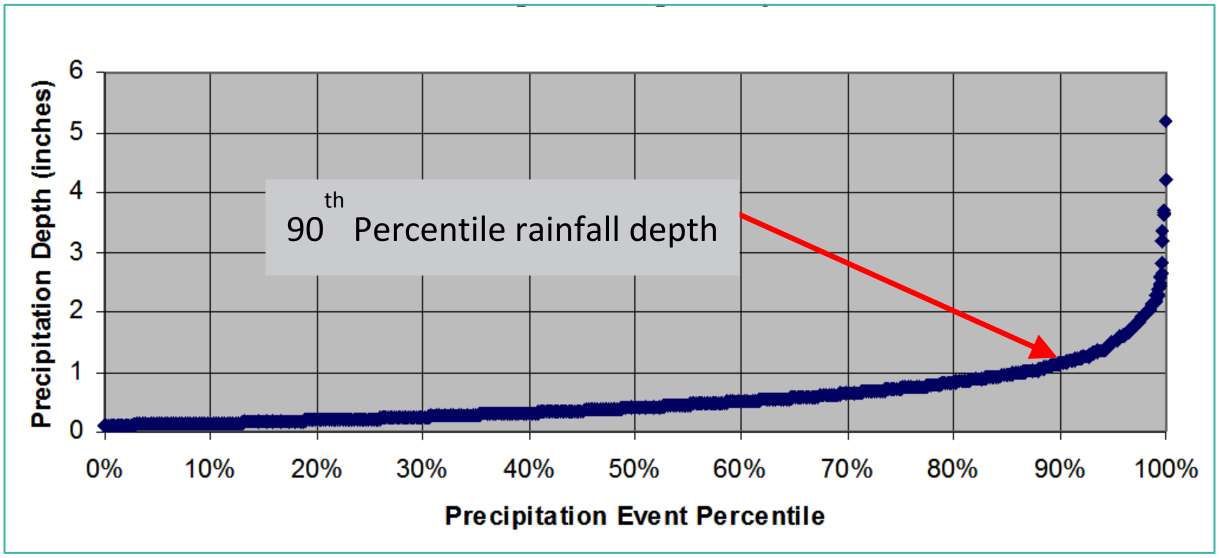
The final Site Based Load Limit for New- and Re-development in Virginia is 0.41 lb/ac/yr as calculated using the VRRM.

Treatment Volume and Stormwater Practice Sizing

The Treatment Volume (Tv) is the new regulatory equivalent of the water quality volume (WQv). The WQv is still considered the water quality design standard for grandfathered projects (Part IIC) and is defined as the *first 1/2 inch of runoff multiplied by the impervious surface of the land development project*. Like many of the standards upon which stormwater practices are based, the research on local rainfall distribution patterns, storm size, and the "first flush" phenomenon has resulted in a gradual change in the definition of the water quality storm and design treatment volume.

The definition of the Tv is the volume of runoff from the contributing drainage area generated by the rainfall from the 90th percentile storm event. The figure below represents the rainfall from the rain gauges at Regan Washington National Airport. The average rainfall from Regan Washington Airport, Richmond Airport, and the cities of Harrisonburg, Lynchburg, and Bristol provide an average 90th percentile rainfall depth of one inch.

90th Percentile Rainfall Depth at Reagan Washington National Airport



1" annual average: Reagan Washington National Airport,
Richmond International Airport, Harrisonburg, Lynchburg, Bristol

The Treatment Volume (Tv) is equal to the runoff volume from the contributing drainage area generated by a one-inch rainfall.

This 90th percentile rainfall depth is based on the performance goal of stormwater practices achieving an ***annual*** volume and ***annual*** load reduction. That is, 90% of all rainfall events are 1-inch or less in depth. So any stormwater practices designed to manage the runoff from this rainfall will be managing 90% of all storm events, and the first inch of those storms that exceed 1-inch. This corresponds to approximately 70% of the annual rainfall (meaning that a small number of larger storms contribute a disproportionate amount of rainfall ~ 30%).

The selection of 90th percentile corresponds nicely with the inflection point of the rainfall event curve; meaning that it represents an optimal target rainfall depth (selecting a larger storm event or a higher percentile would not greatly increase the annual volume captured, but would certainly increase the cost of implementation).

There are some important distinctions related to the new Tv standard:

- The management of the 1-inch rainfall event provides for an ***annual*** treatment, or better referred to as **Annual Volume Reduction** and **Annual Load Reduction**. The annual reduction represents an average over all storms and not individual single-event modeled storms. This means that oversizing a practice does not necessarily provide for an increase in performance (unless the entire Level 2 upgrade is included; to be discussed further in Module 7);

Stormwater practice sizing rules are based on the particular BMP. Some BMPs will include a storage volume component that must be sized to capture the Tv. These include Bioretention, Permeable Pavement, Wet Ponds, etc. Others BMPs are sized to manage this volume as a flow through practice and must be sized according to the sizing rules provided in the BMP Design Specifications. In either case, the contributing drainage area to the stormwater practice will have a composite Rv that will be used to design the BMP, referred to as Tv_{BMP} based on the following formula:

$$Tv_{BMP} = \frac{(P \times Rv_{composite} \times A)}{12}$$

Where:

Tv_{BMP} = Design Treatment Volume from the contributing drainage area to the stormwater practice (does not include remaining runoff from upstream practices)

P = 90^{th} Percentile rainfall depth = 1"

$Rv_{composite}$ = Composite runoff coefficient (equation shown below – discussed previously)

A = Contributing drainage area to the stormwater practice.

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

The volume of runoff is now the result of the runoff contribution from the entire drainage area based on the weighted Rv (Rvcomposite), and not just the impervious areas using a single Rv of 0.95.

The TvBMP is the primary sizing parameter for the stormwater practice. However, when using a treatment train, the designer should consult the spreadsheet to determine the total Tv: that contributed directly from the immediate contributing drainage area, and any additional remaining volume from the upstream BMP.

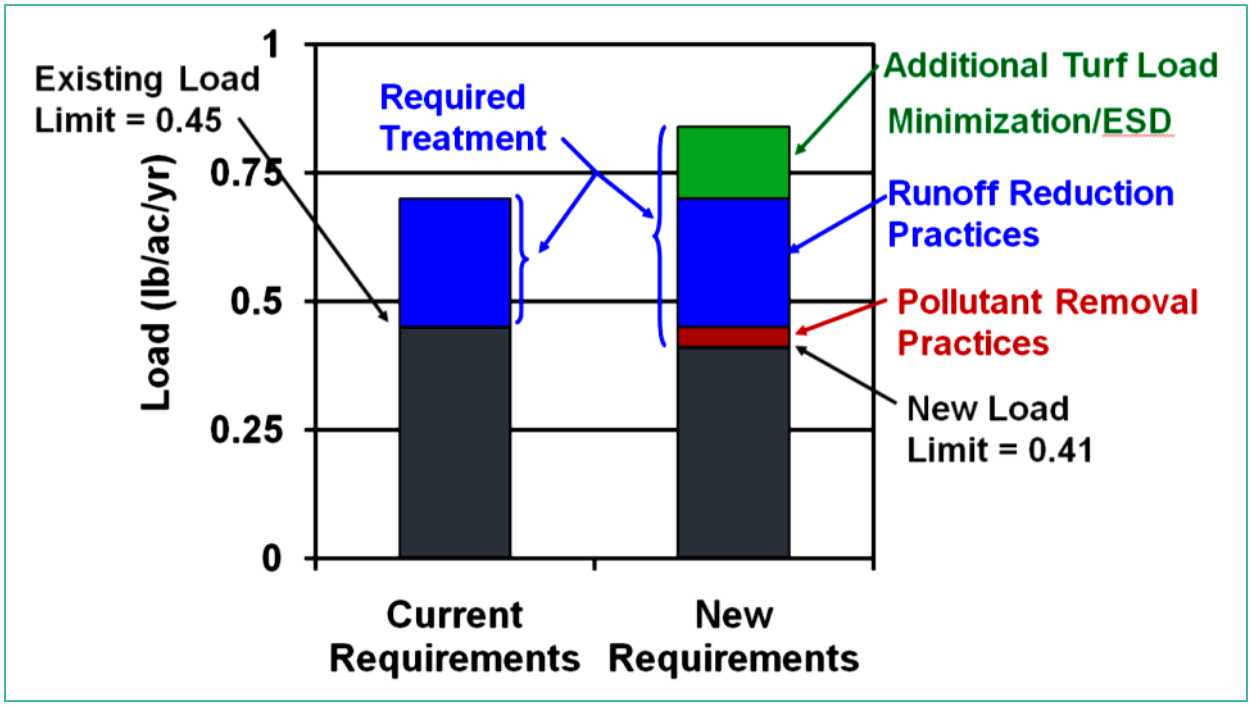
4d. VSMP Water Quality Requirements

9VAC25-870-55.A

A stormwater management plan for a land-disturbing activity shall apply the stormwater management technical criteria set forth in this part to the entire land-disturbing activity. Individual lots in new residential, commercial, or industrial developments shall not be considered separate land-disturbing activities.

9VAC25-870-63.A.1

New development: The total phosphorus load of new development projects shall not exceed 0.41 pounds per acre per year, as calculated using the VRRM (or an equivalent methodology approved by the Board).



Compliance Strategies and Application of ESD

Compliance with the Site Based Load Limit of 0.41 lb/ac/year can be achieved through multiple design strategies – either individually or combined.

The first step is to review the parcel and identify the environmental features as described in the SWM Basic Course Module 6.

The designer can then decide how to proceed with the site design by identifying the layout and the overall footprint of the development project in terms of disturbed areas, grading, and permanent infrastructure improvements such as buildings, houses, roads, parking lots, etc.

Wherever possible, the designer can designate land to be protected from disturbance. The designer must consider the ultimate use of the property and if possible, in concert with the Land Cover definitions and management conditions can further protect areas as conserved open space. Once the Land Cover is established as either Forest/Open Space, Managed Turf, or Impervious, the designer can readily evaluate the resulting pollutant load removal requirement using the VRRM Compliance Spreadsheet.

Introduction to the VRRM Compliance Spreadsheet

The VRRM Compliance Spreadsheet is designed to help designers and plan reviewers quickly evaluate the implementation of stormwater practices on a given site and verify compliance with the Virginia Stormwater requirements. The spreadsheets:

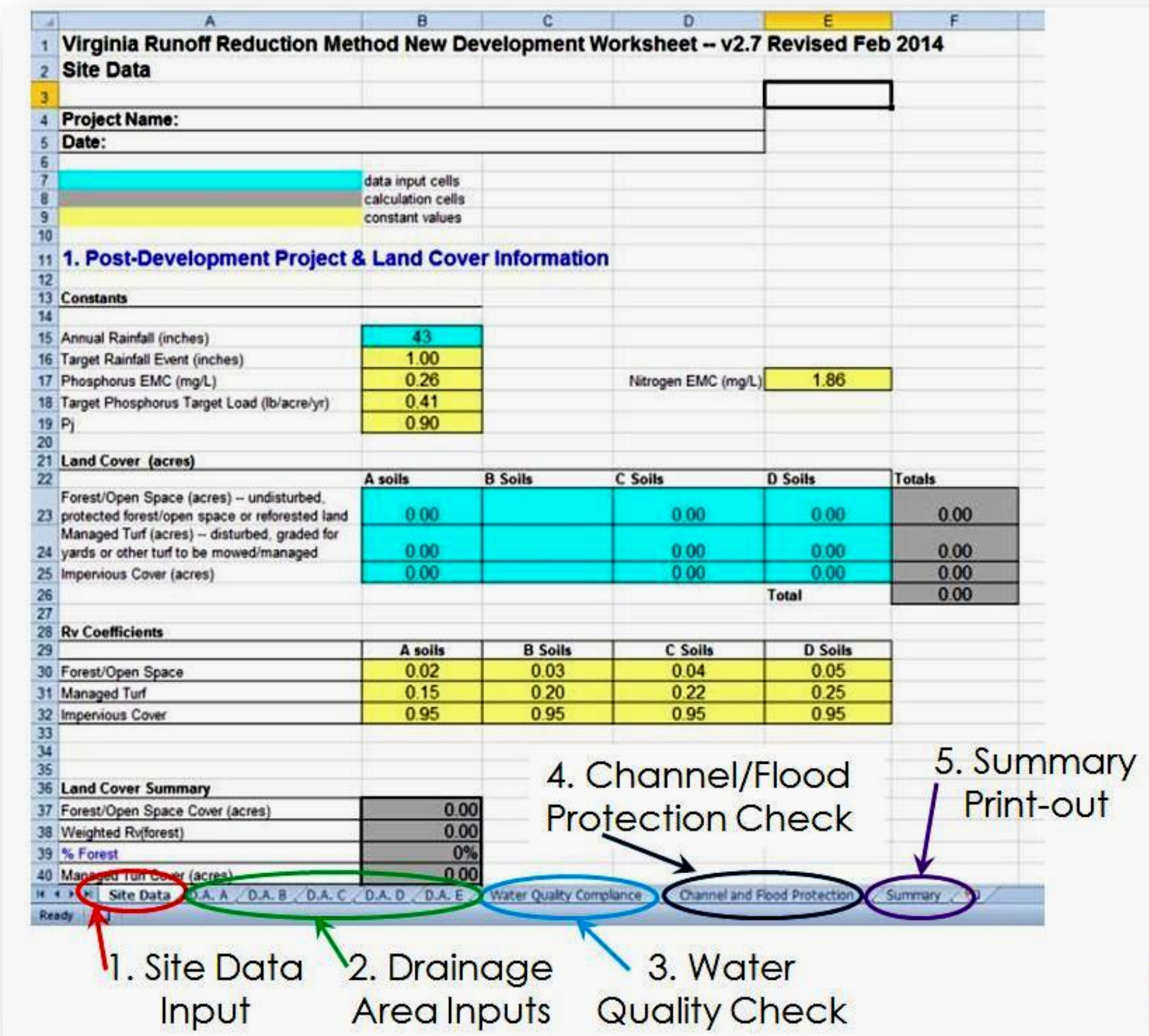
- Provide a summary of the total site developed condition **Land Cover, Pollutant Load** (Total Phosphorus and Total Nitrogen), and the corresponding design **Treatment Volume**.
- Allow the designer to quickly evaluate different combinations of ESD and the effectiveness of different BMPs and BMP combinations in up to five different drainage areas.
- Provide a summary for each drainage area that includes the land cover, runoff volume and pollutant load generated in the drainage area, the BMPs selected, and the runoff volume and pollutant load reduced by the selected BMPs.
- Calculate the volume reduction credited towards compliance with quantity control requirements in each drainage area (i.e., channel and flood protection requirements).
- Provides an overall compliance summary report that itemizes BMP implementation in each drainage area as well as overall site compliance.

Note:

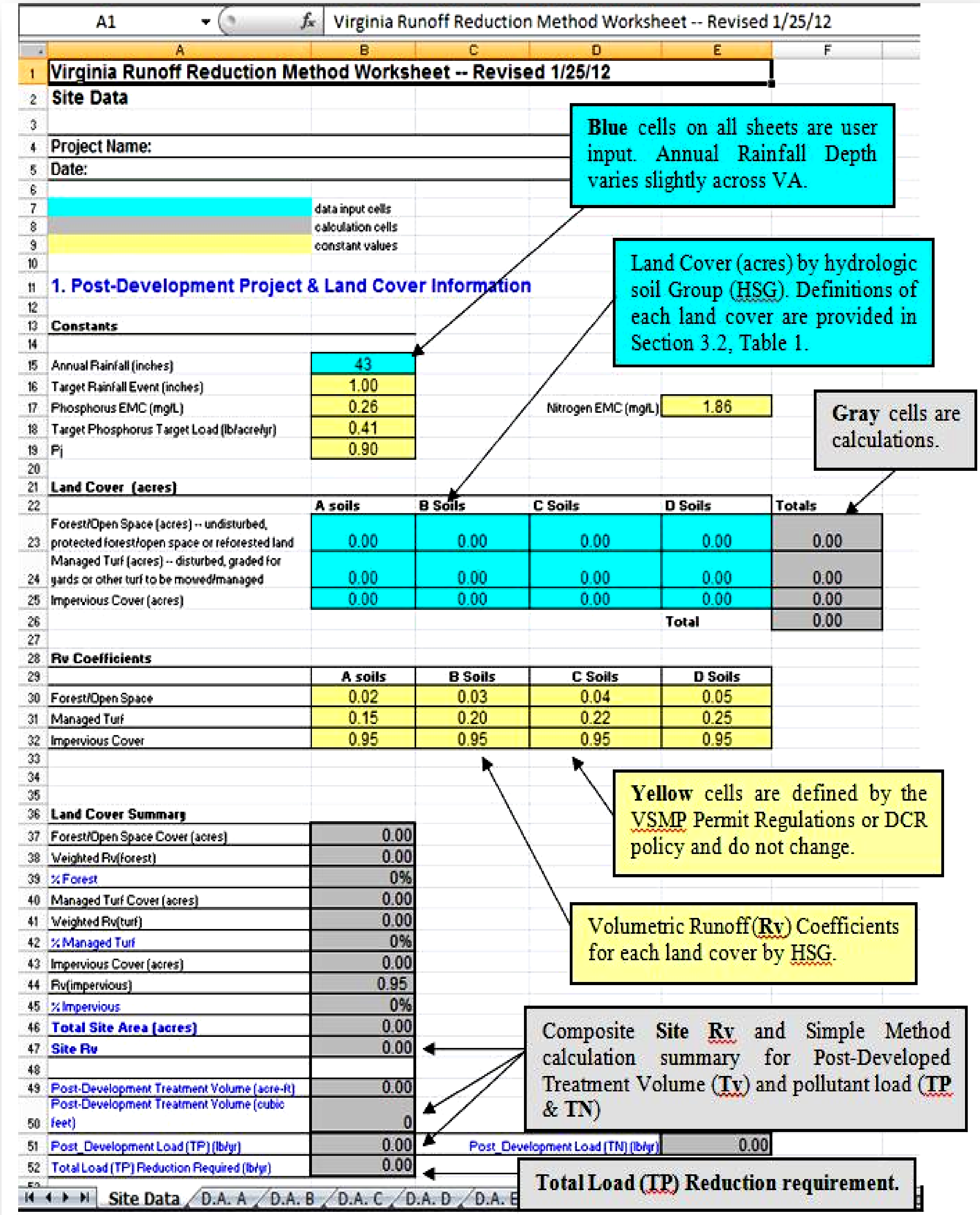
The VRRM compliance spreadsheet is not a BMP design tool. When a BMP is selected in the spreadsheet, it is assumed that the designer will locate and design the BMP according to the design criteria provided in the Virginia BMP

Overall Spreadsheet Structure:

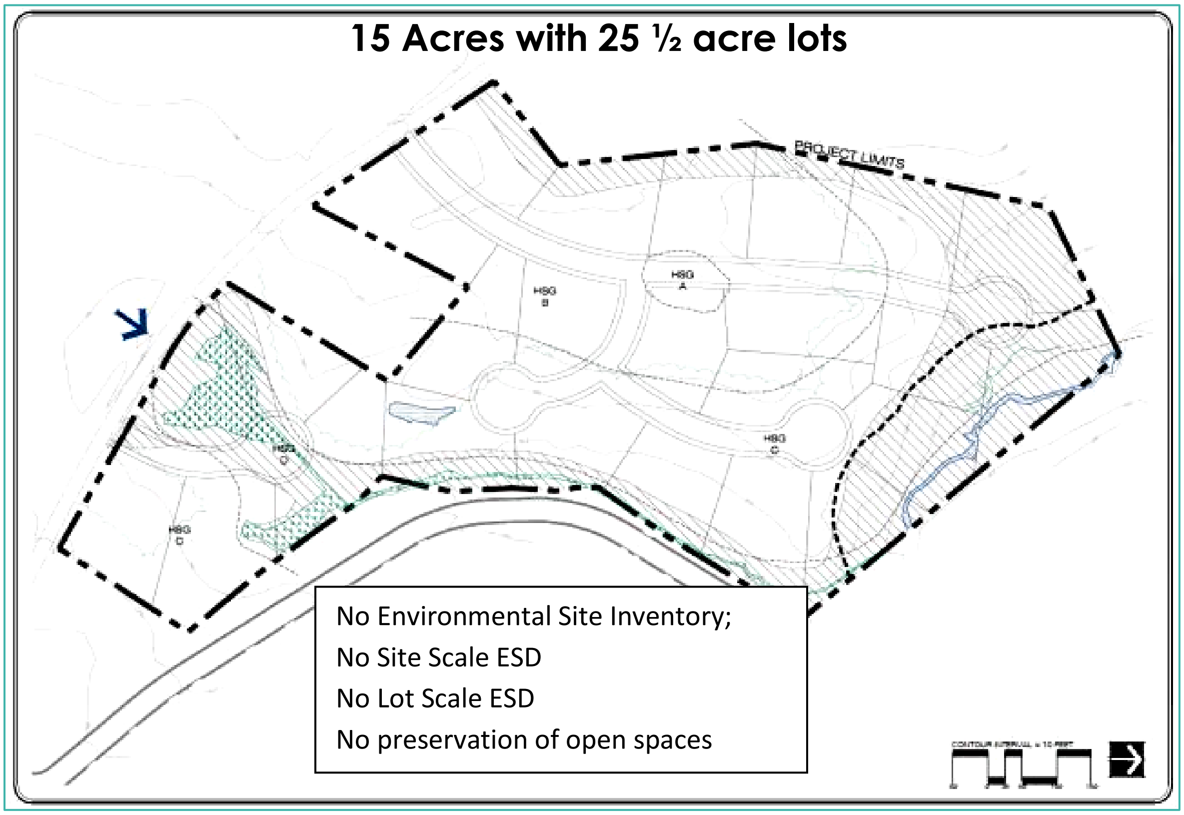
1. Site Data Tab;
2. Drainage Area Tabs (A thru E)
3. Water Quality Compliance Tab
4. Channel Flood Protection Tab
5. Summary Print-out Tab

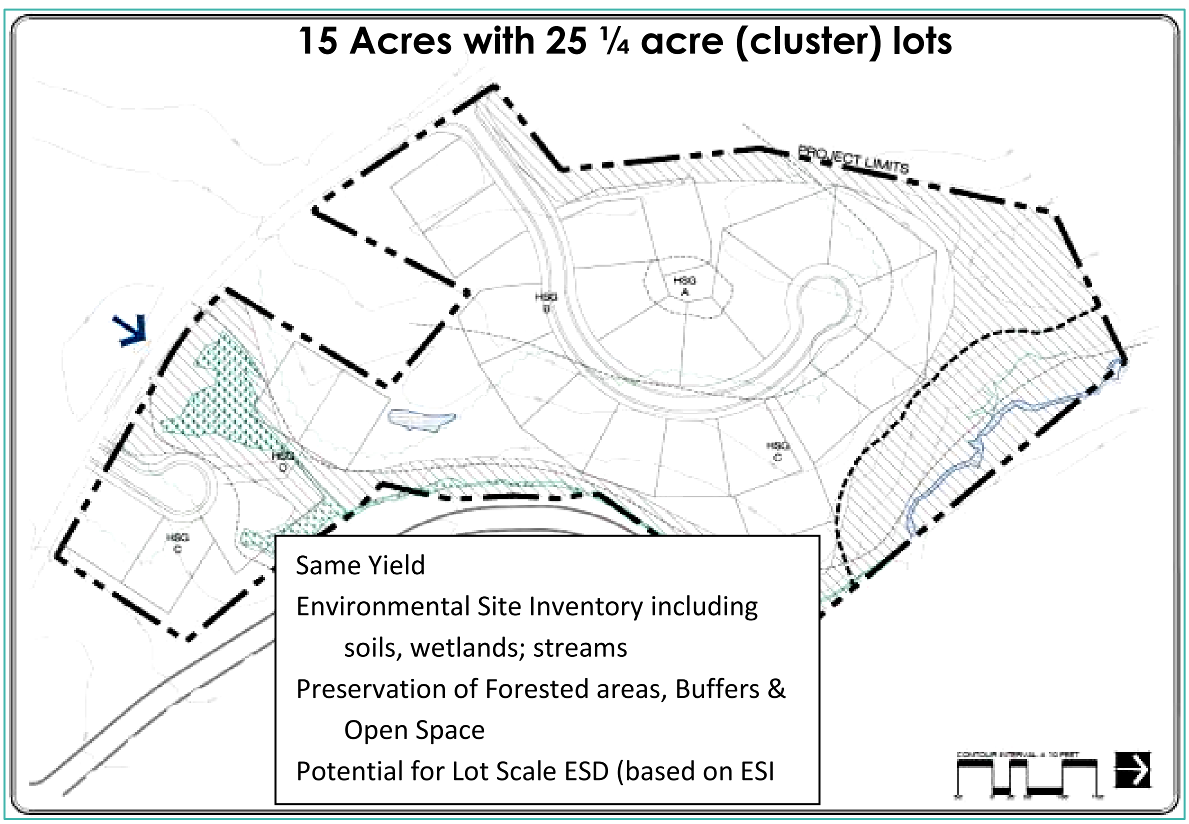


<u>Site Data Tab</u>:



Sample Project with and Without ESD





Site/Drainage Area Land Cover as Entered into the VRRM Compliance Spreadsheet **Site Data Tab**:

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**

Site/Drainage Area Summary as reported on the VRRM Compliance Spreadsheet **Site Data Tab**:

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 Reqd.	**4.39 lb/yr**	**2.34 lb/yr**

Note:

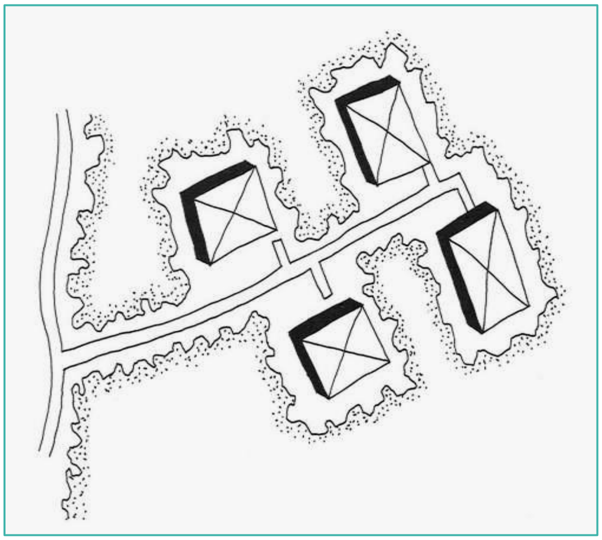
The reduced Tv for BMP sizing and the reduced Pollutant removal requirement based on site Scale ESD.

Types of ESD – Site Scale ESD

The different scales of ESD will require different levels of plan review. Clustering of lots that reduce the overall lot size and preserve open space can designate the open spaces as community open space.

- As lot sizes decrease, on-lot stormwater practices such as simple disconnection, micro-scale bioretention, etc., may be limited by available space.
- Alternatively, clustering allows for large conserved open space that:
    - Achieves significant and inexpensive RR based on ESD and, if applicable, treatment as the last practice in a treatment train;
    - Can be easily protected from impacts during construction and protected with restrictive covenants and signage after construction. These areas can also be used for stormwater treatment as the last practice in a treatment train.

Another form of Site Scale ESD is referred to as Site Finger-Printing where the area of disturbance and grading is limited to only those areas that are needed for construction of infrastructure. Areas that are protected can be considered Forest/Open Space.



Examples of Site Finger-Printing

Types of ESD – Lot Scale ESD

Lot Scale ESD refers to the application of on-lot stormwater practices. Many jurisdictions may establish specific limitations on the use of on-lot practices conditioned on:

- Local requirements for minimum lot size,
- On-lot stormwater practice maintenance agreements, or
- Other local VSMP Authority limitations approved by the Department.

Types of ESD – Soil Restoration

Ideally, the designer can designate the areas that are to be protected from impacts during construction for the eventual construction of stormwater practices such as on-lot impervious disconnection or vegetated filter strips, etc.

The following provides some simple examples of minimizing impacts during and after construction (derived from the requirements of **9VAC25-870-54. Stormwater Pollution Prevention Plans**):

- Minimize the disturbance and/or compaction of the native soils by directing construction traffic, material stockpiling, and other activities to only those areas of the site that are designated for proposed infrastructure (buildings, roads, parking areas, etc.);

- Avoid the disturbance of slopes 15% or steeper. When disturbance of steep slopes is unavoidable, or the resulting final grade of an area of exposed soil is 15% or greater, utilize terraces or other means to reduce the overall footprint of the new grade. Terraces can double as “bioretention walls” to manage the upstream contributing drainage area;
- Utilize natural buffers that may be required during construction as permanent features that can remain as conserved open space or a vegetated filter strip.

In the event that soils are impacted during construction, or if the existing soils were previously impacted or HSG D soils, the designer may elect to call for the remediation of the soils with a soil amendment in accordance with BMP Design Specification No. 4. Remediation of soils can occur after construction is complete or during construction if the area is to be protected from further impacts.

Design and Construction Documentation

The design and construction of on-lot stormwater practices will require careful coordination between the plan review, site-scale development, and individual residential lot construction in order to ensure that Land Cover is properly accounted between the VRRM Compliance Spreadsheet and the Construction Drawings.

4e. Introduction to Stormwater Runoff Reduction Practices

A key element of the VRRM is to provide credit for the **Total Performance** of structural and non-structural stormwater management Best Management Practices (BMPs). The total performance is a function of the practice's ability to achieve **Runoff Reduction** and **Pollutant Removal**.

Significant research into the capabilities of BMPs in order to determine how much of the performance was attributed to volume reduction and how much is attributed to pollutant removal.

Runoff Reduction Reported Performance:

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

Runoff Reduction (RR) is defined as:

The total annual runoff volume reduced through canopy interception, soil infiltration, evaporation, transpiration, rainfall harvesting, engineered infiltration, or extended filtration.

Pollutant Removal Reported Performance:

$$EMC_{IN}\ vs\ EMC_{OUT}$$

Pollutant Removal (PR) is defined as:

The change in EMC as runoff flows into and out of a BMP. Pollutant removal is accomplished via processes such as settling, filtering, adsorption, and biological uptake. This does not account for changes in the overall volume of runoff entering and leaving the BMP. EMC is defined as the average concentration of a pollutant in stormwater runoff for a monitored storm event.

Total Performance (reported as Load Reduction):

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

Total Performance is:

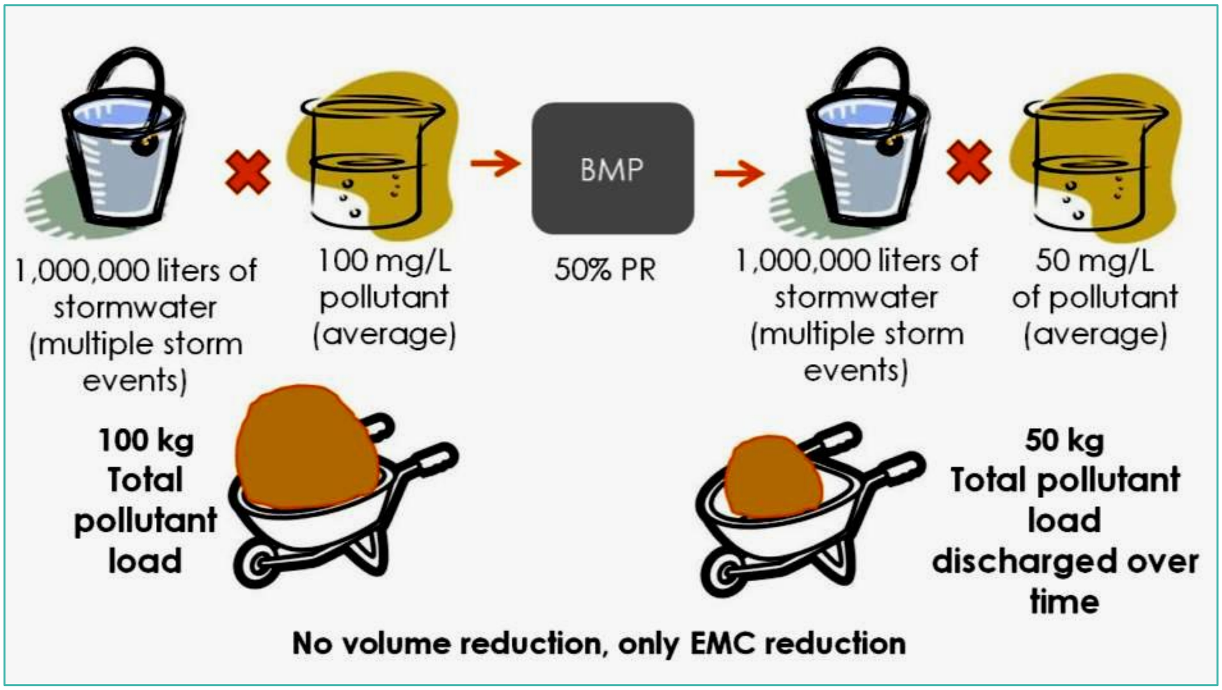
The pollutant mass reduction (or Total Mass Load Removal as defined within the Virginia BMP Clearinghouse specifications), which is the product of Runoff Reduction (RR) and Pollutant Removal (PR).

Identifying and crediting total BMP performance provides significant advantages:

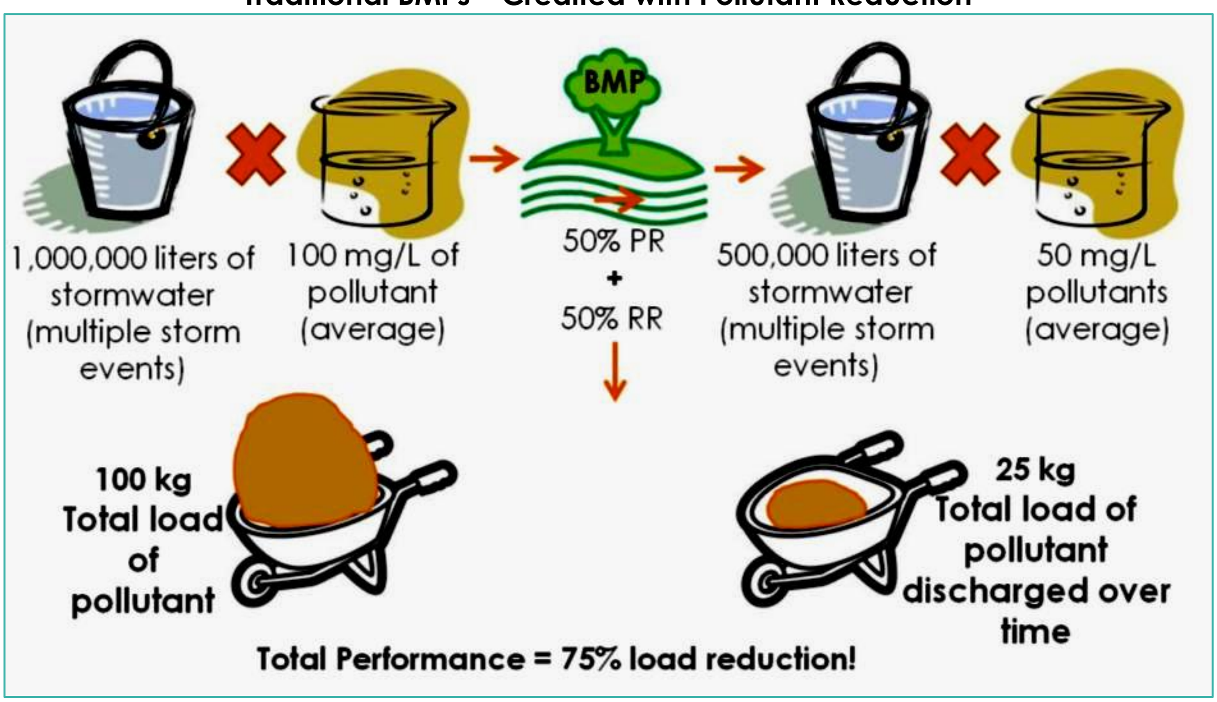
- Allows for reductions beyond irreducible concentrations by reducing the volume;
- Provides for maximum performance through a "Treatment Train" approach that utilizes different pollutant removal pathways:
    - Reduction of pollutants generated on the site using non-structural site design practices;

- Volume reduction using one or multiple RR practices;
- Pollutant removal achieved by runoff reduction practices and additional PR practices as needed.

Traditional BMPs – Credited with Pollutant Reduction



Traditional BMPs – Credited with Pollutant Reduction



The latest research, consisting of 166 studies (CWP, 2008) on stormwater practice performance indicates that some practices consistently perform better than others, and concludes that the RR component of certain practices provides the primary pollutant removal pathway, with the physical filtering, settling, or other physical process providing additional treatment. Key findings of the research include:

- The apparent RR capabilities of stormwater practices are much more consistent than PR performance.
- Nutrient PR in stormwater BMPs is notoriously inconsistent, whether it is due to seasonal influences or the fraction of the nutrient load in urban stormwater being in a dissolved state. Regardless, the consistent nature of the RR performance provides confidence in relatively consistent baseline performance.
- RR rates are an annual average based on the individual study site water balance. The rates (in percent) may not apply at full value during storm events larger than the typical "water quality storm," or approximately one-inch of rainfall (but it is likely that some reduction for larger events will occur).
- Given the limited number of runoff reduction performance studies available, the recommended rates were selected using conservative assumptions and best professional judgment;
- The RR rates provided in the stormwater regulations are dependent on meeting a Level 1 or Level 2 design criteria. The base pollutant removal and runoff reduction are the median values for Level 1 whereas Level 2 corresponds to the 75th percentile values;
- The studies helped identify the common BMP design components that become the basic design components for Level 1 and those components that can be expanded or enhanced to Level 2 performance.

Level 1 and Level 2 Stormwater Practices

Designating different levels of stormwater practices allows for designs that incorporate all the essential elements related to the long term performance, operation and maintenance, and community acceptance of the stormwater practice, and achieve compliance where the performance is met with the basic or Level 1 design standard performance credit. The benefit of the second level is to allow for the improved performance where necessary with recognized design enhancements.

Therefore, specifically identifying the design level, and providing documentation that all the required elements are incorporated into the design is a critical part of the plan review process.

Level 1 standard features included in all designs:

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

Level 2 design enhancements required for increased RR, PR, or both:

- Increased Tv sizing (by a factor of 1.1, 1.25 or 1.5 times the Tv);
- Enhanced design geometry;
- Vegetative condition;
- Multiple cells;
- Multiple treatment pathways; and Other bells and whistles, e.g., increased pretreatment, increased media depth, etc.

Planners, designers and reviewers must be must be familiar with the design specifications for Level 1 and Level 2. It is easy for the preliminary Plan or other planning level documentation to reference a Level 2 stormwater practice based on a quick check for compliance using the spreadsheet. However, it is important to ensure that the overall footprint available on the project can accommodate the Level 2 enhancements. Enhancements such as increased volume, geometry, flow path, pretreatment, multiple cells, etc., may increase the overall footprint such that a self-made hardship is created when it comes time to develop final design and construction drawings.

Treatment Trains

Treatment trains allow for compliance on high density sites that have high pollutant removal requirements. Treatment trains can also provide flexibility on tight sites by allowing multiple smaller BMPs to treat stormwater near the source with less overall impact on the site. The design benefit is that as the drainage area incrementally increases with each RR practice, the RR practices incrementally reduce the runoff volume and Tv_{BMP}, so each successive BMP is not necessarily being sized on the entire upstream drainage area. Rather, the practice is sized by the Tv_{BMP} from the directly contributing drainage area, and any remaining runoff from upstream RR practices.

An example of the Level 1 and Level 2 design sizing requirement and the relationship with upstream RR practices is excerpted from the Design Table for BMP Design Specification No. 9: Bioretention:

Level 1 Design (RR 40 TP: 25)	Level 2 Design (RR: 80 TP: 50)
Sizing (**Section 6.1**): Tv_{BMP} = [(1)(Rv)(A) / 12] + any remaining volume from upstream BMP	Sizing (**Section 6.1**): Tv_{BMP} = [(1.25)(Rv)(A) / 12] + any remaining volume from upstream BMP

Multi-Function Stormwater 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		✓	✓

Comparative Level 1 & Level 2

Runoff Reduction, Pollutant Removal, and Total 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

See footnotes on next page

Footnotes for Comparative Level 1 and Level 2 Performance Table

Notes [1] Lower rate is for HSG soils C and D, Higher rate is for HSG soils A and B.

[2] The removal can be increased to 50% for C and D soils by adding soil compost amendments, and may be higher yet if combined with secondary runoff reduction practices.

[3] Credit up to 90% is possible if all water from storms of 1-inch or less is used through demand, and the tank is sized such that no overflow occurs. The total credit may not exceed 90%.

[4] Lower nutrient removal in parentheses apply to wet ponds in coastal plain terrain.

[5] See BMP design specification for an explanation of how additional pollutant removal can be achieved.

[6] Total mass load removed is the product of annual runoff reduction rate and change in nutrient EMC.

4f. Virginia Runoff Reduction Method Compliance Spreadsheet Example

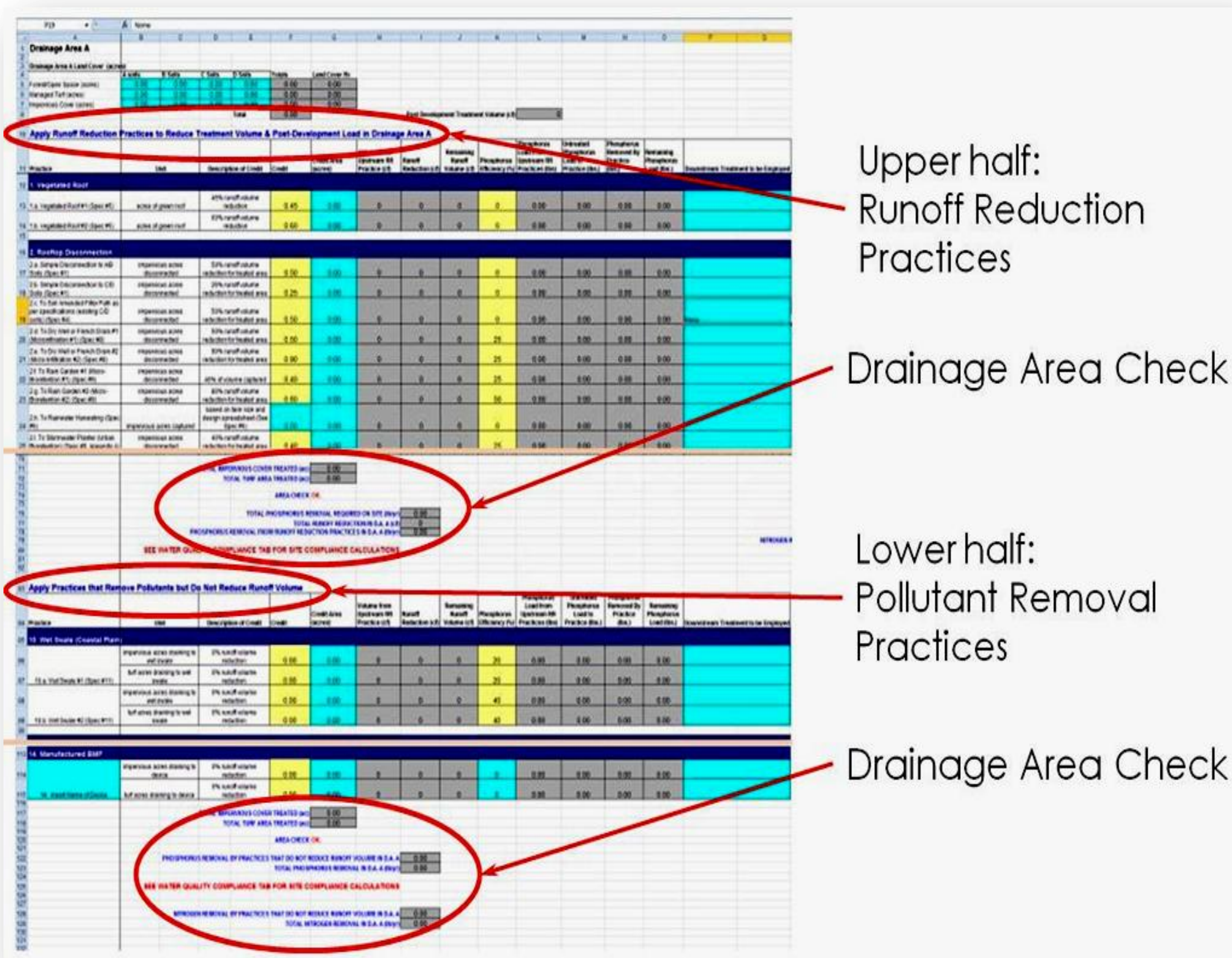
The following design example continues the previously referenced subdivision development. The figures below start by first providing the basic structure of the Drainage Area Tabs.

The upper half of the spreadsheet includes the Runoff Reduction practices and a Drainage Area Check. The Drainage Area Check ensures that there is no more acreage being treated by the selected BMPs than is available for treatment within the drainage area.

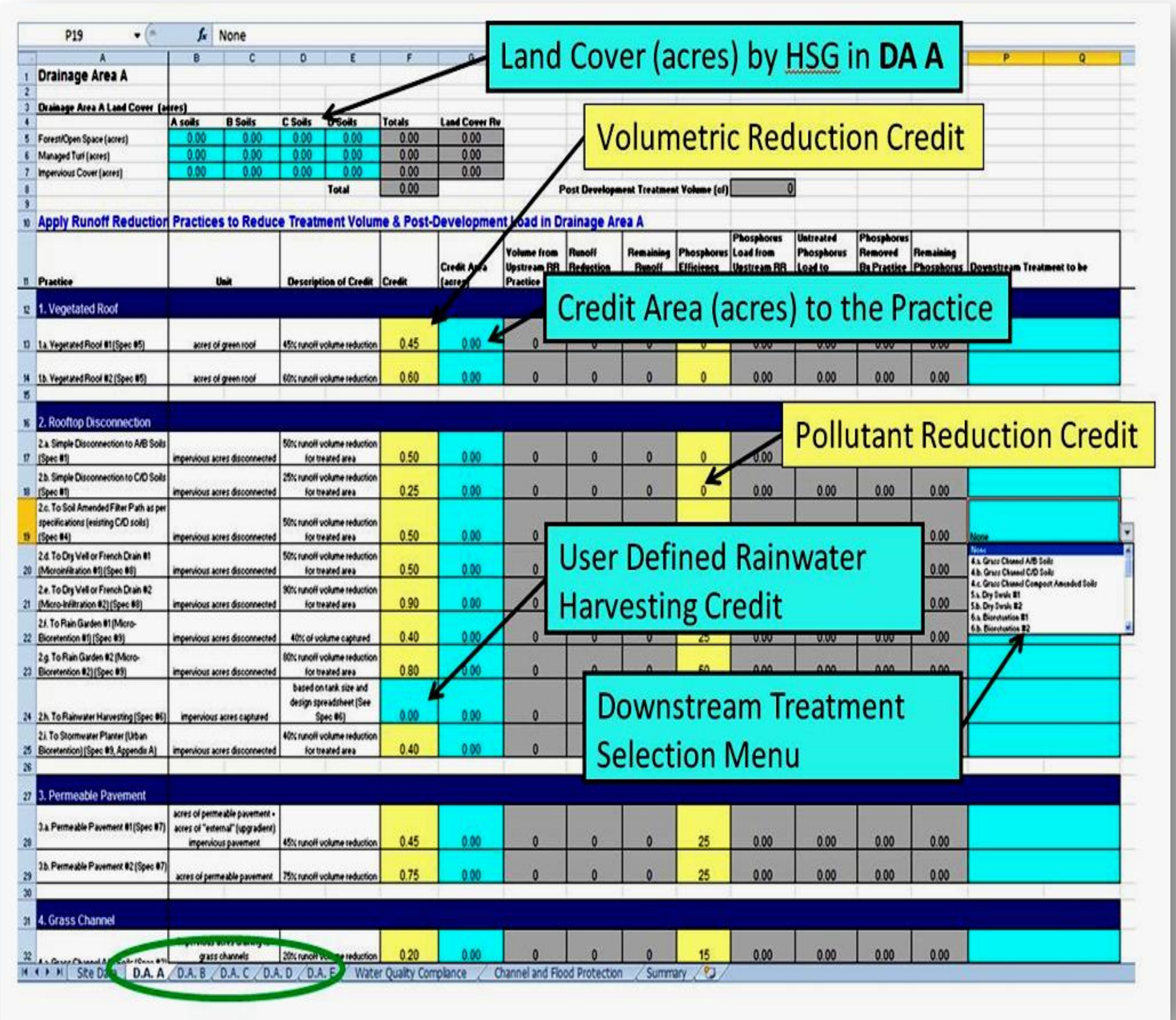
An additional Drainage Area Check is provided in the Water Quality Compliance Tab to ensure that the cumulative area being treated (Forest/Open Space, Managed Turf, and Impervious) does not exceed that which is on the site.

The easiest way to demonstrate compliance is to treat more land than that which is entered on the Site Data Tab!! Beware the Drainage Area Checks!!

Spreadsheet Drainage Area Tabs



The five Drainage Area tabs are identical. The designer enters the Land Cover for the drainage area according to HSG soil type. This spreadsheet computes a composite land cover Rv, and the Post Developed Treatment Volume (Tv) for the drainage area.



Design Example: Site Overview

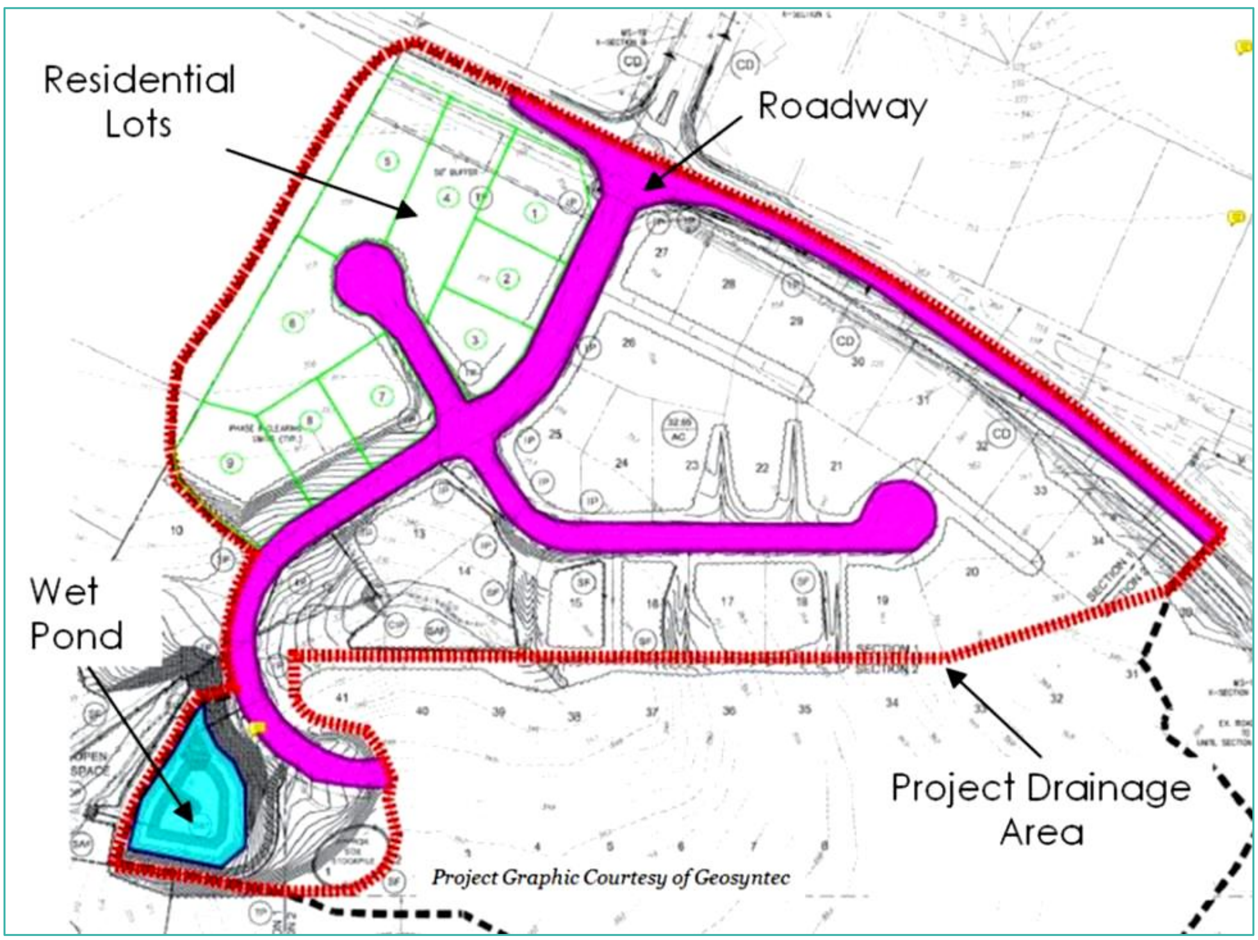
Typical subdivision development:

19.8 acre single Family Subdivision

2.2 acres of R.O.W.

34 lots (average lot size = 1/3 acre)

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

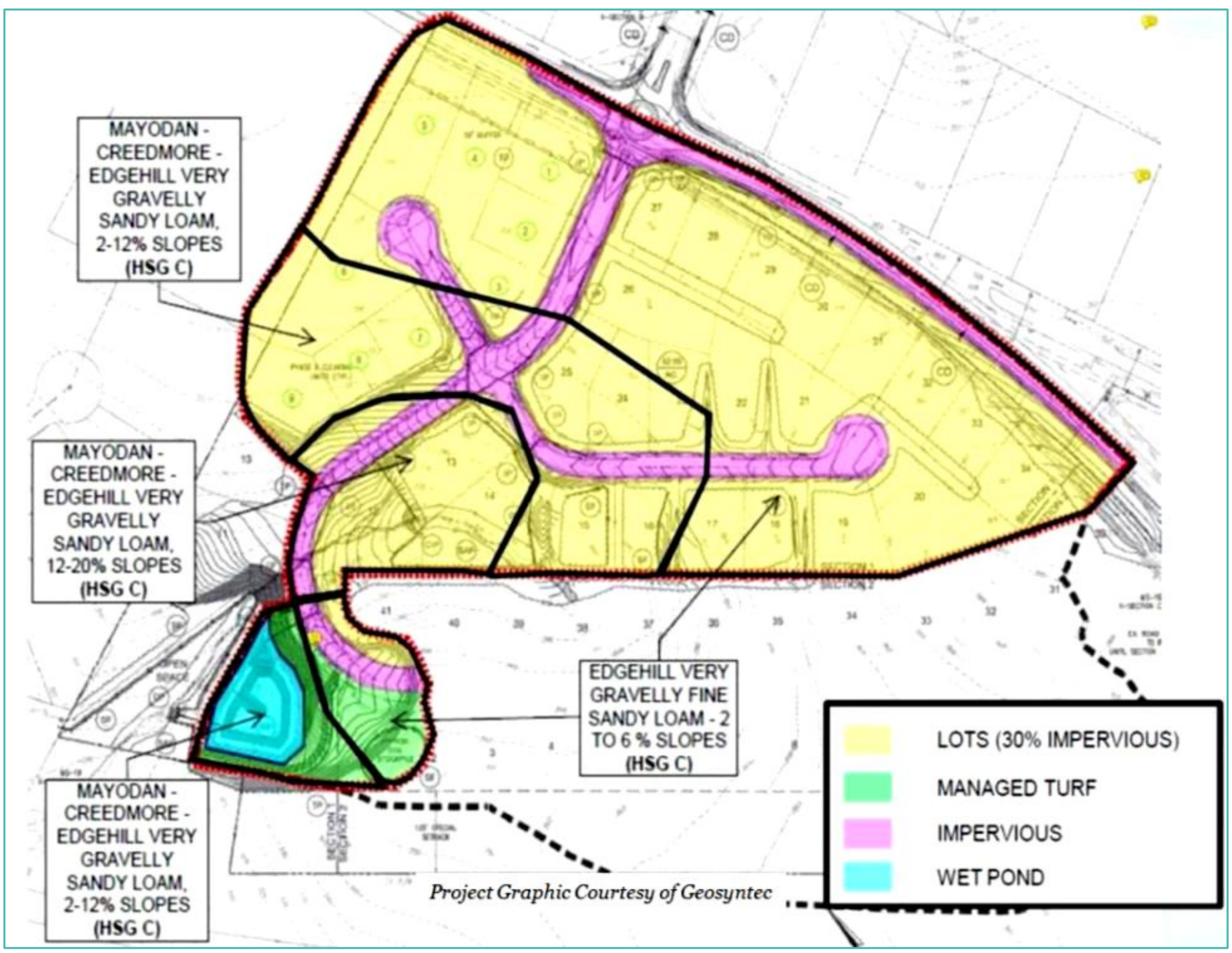


Design Example: Site Overview

Drainage Areas and Land Cover:

The typical or assumed impervious cover for each single family lot is determined to be 30%. The percent impervious cover assumptions within some hydrologic models may or may not include the assumed right of way associated with the development. For example, 30% impervious cover on one-third acre lots (average) is generally a high value and likely includes the assumed impervious cover of the right of way road frontage.

The reviewer may need to reference the assumed impervious cover and verify that the impervious cover represented on the eventual lot development grading plan or other required local building permit documentation is reasonably close.

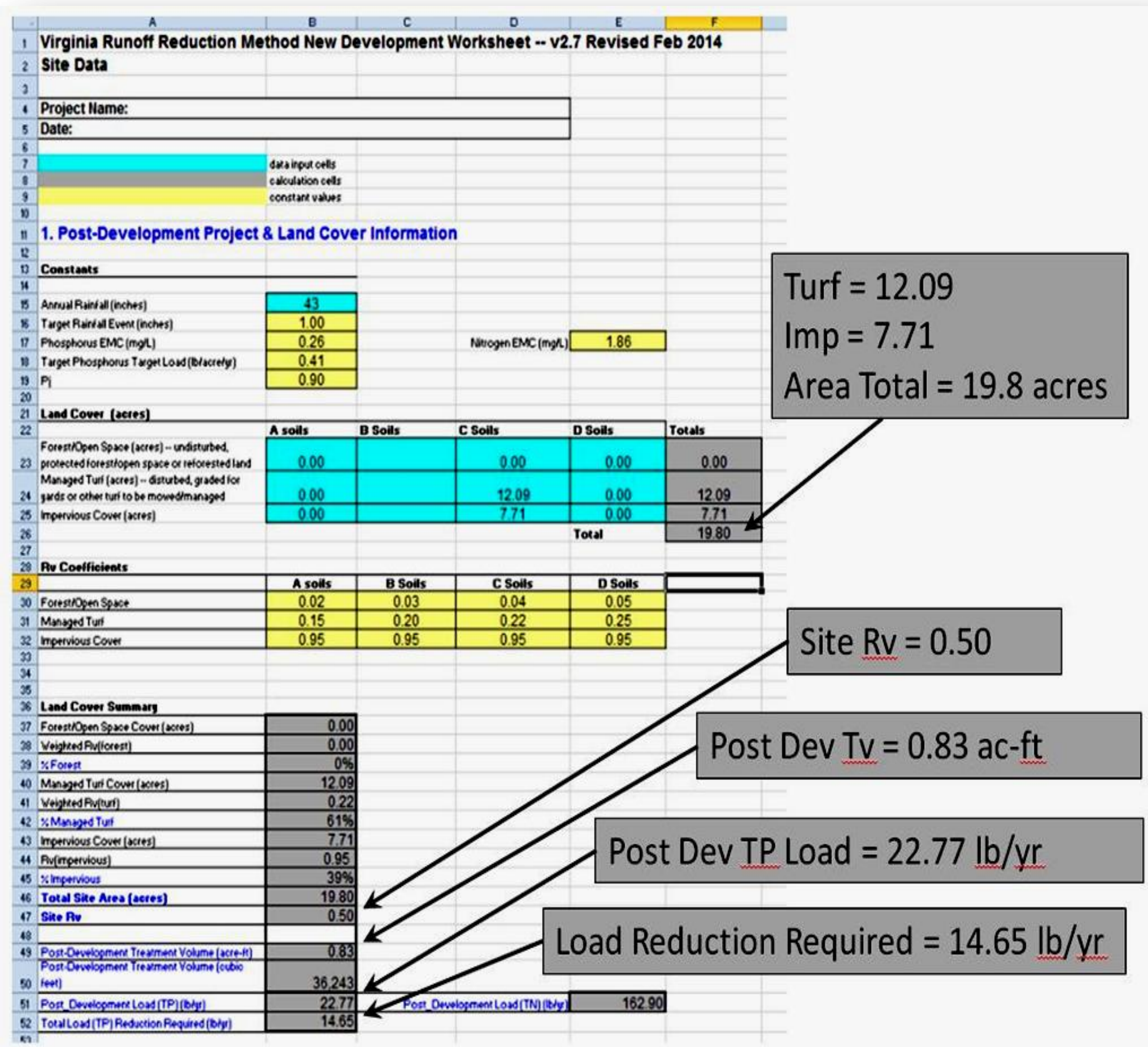


Site Data Tab

The project drainage is relatively simple for this initial design strategy and the entire site is captured in a single drainage area tab.

The specific Site Based Tv and Total Pollutant Load Reduction Requirement are calculated as shown.

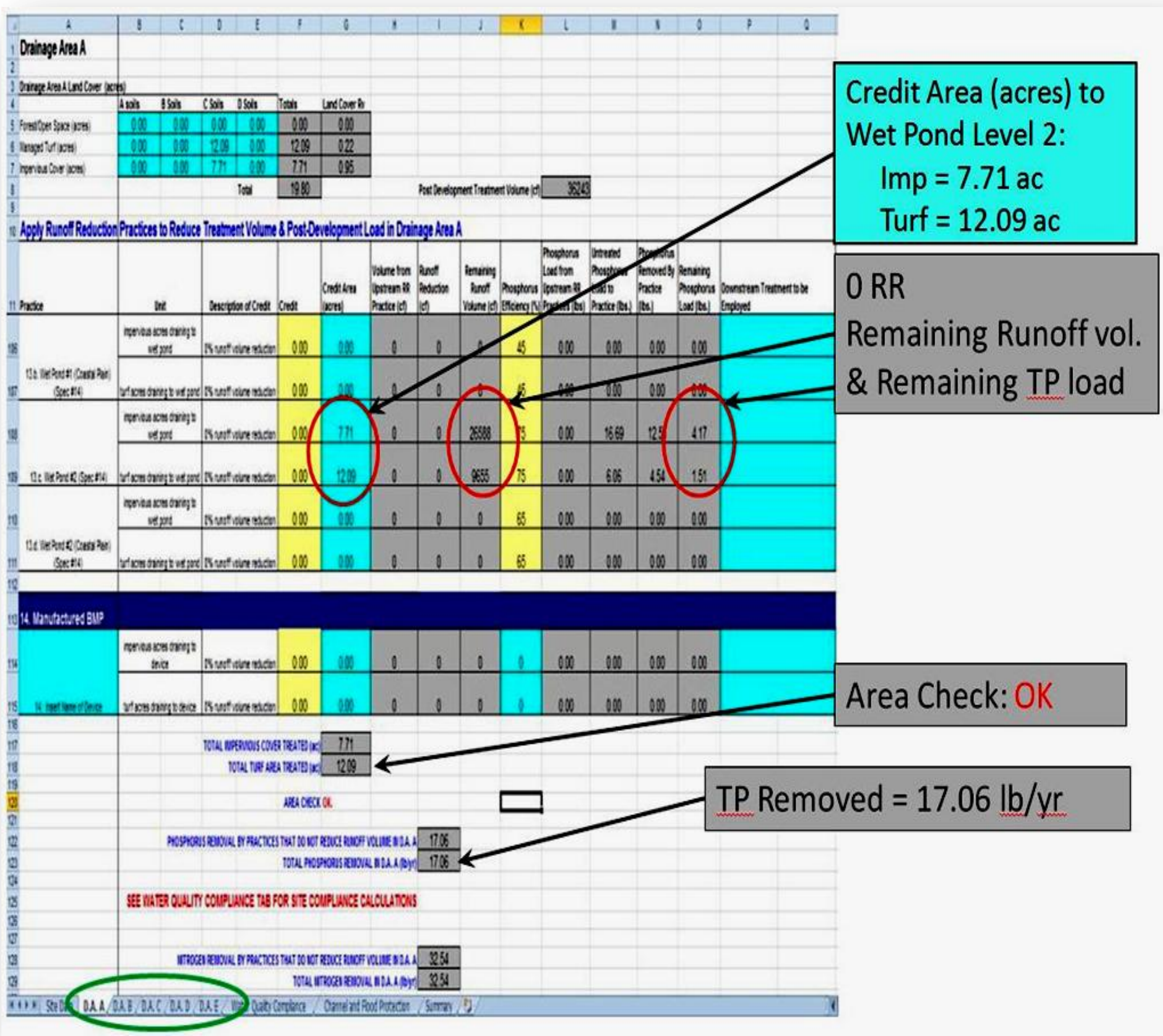
> **Note:**
>
> The Site Scale Tv is provided in units of **acre-feet** and **cubic feet** on the Site Data Tab. The remaining tabs reference the Tv and runoff reductions in **cubic feet**.



Drainage Area Tab

The entire site drains to a single proposed Wet Pond Level 2, therefore providing no runoff reduction credit. However, a Wet Pond Level 2 (not in the coastal Plain) provides a significant PR credit: 75%. As such, it's no easy design:

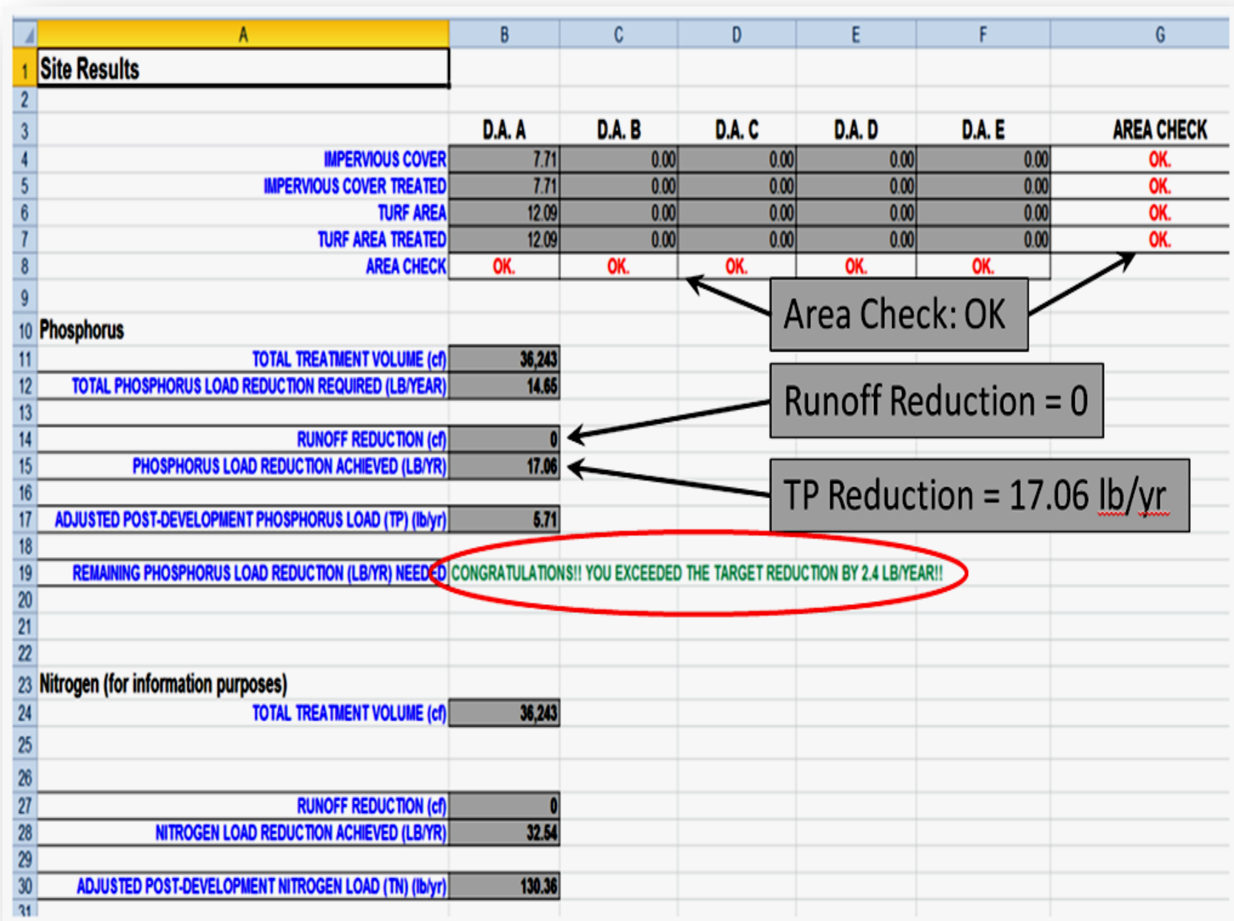
- The overall footprint is not necessarily larger than the old wet pond specifications, or even the Level 1 specification;
- Multiple criteria regarding the allowable water surface "bounce", multiple cells accommodating a wet pond/wetland combination, etc., make for a complex design that <u>may</u> increase the footprint depending on the topography.



Water Quality Compliance Tab

- The area Checks;
- 0 Runoff Reduction Credit; and
- Achieves compliance

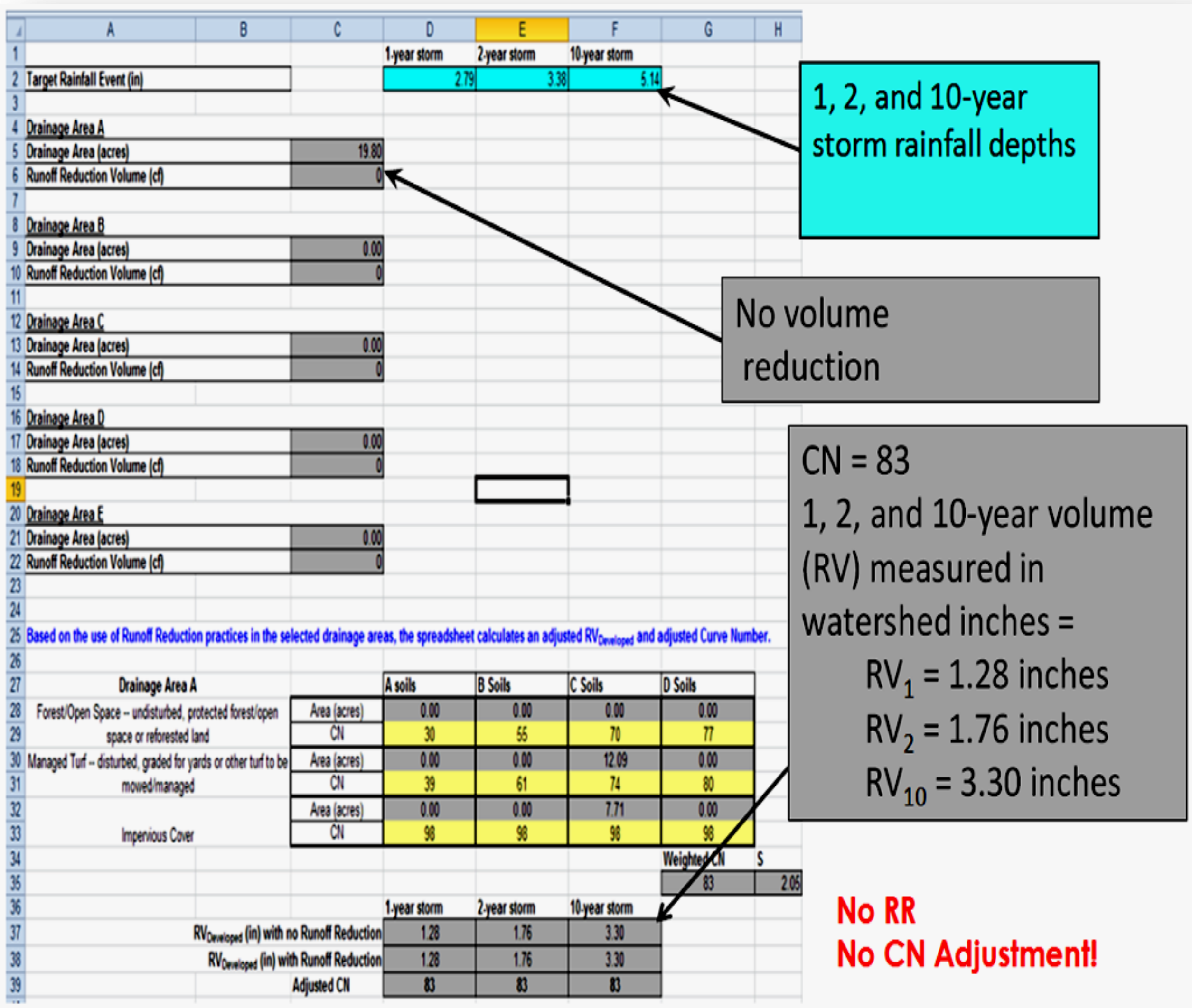
In terms of perspective: the load reduction required on a large lot subdivision to meet the 0.41 lb/ac/yr site based load limit is not overly difficult with RR or PR practices, especially with the PR credit of a Level 2 wet pond or constructed wetland



	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	AREA CHECK
Site Results						
IMPERVIOUS COVER	7.71	0.00	0.00	0.00	0.00	OK.
IMPERVIOUS COVER TREATED	7.71	0.00	0.00	0.00	0.00	OK.
TURF AREA	12.09	0.00	0.00	0.00	0.00	OK.
TURF AREA TREATED	12.09	0.00	0.00	0.00	0.00	OK.
AREA CHECK	OK.	OK.	OK.	OK.	OK.	
Phosphorus						
TOTAL TREATMENT VOLUME (cf)	36,243					
TOTAL PHOSPHORUS LOAD REDUCTION REQUIRED (LB/YEAR)	14.65					
RUNOFF REDUCTION (cf)	0					
PHOSPHORUS LOAD REDUCTION ACHIEVED (LB/YR)	17.06					
ADJUSTED POST-DEVELOPMENT PHOSPHORUS LOAD (TP) (lb/yr)	5.71					
REMAINING PHOSPHORUS LOAD REDUCTION (LB/YR) NEEDED	CONGRATULATIONS!! YOU EXCEEDED THE TARGET REDUCTION BY 2.4 LB/YEAR!!					
Nitrogen (for information purposes)						
TOTAL TREATMENT VOLUME (cf)	36,243					
RUNOFF REDUCTION (cf)	0					
NITROGEN LOAD REDUCTION ACHIEVED (LB/YR)	32.54					
ADJUSTED POST-DEVELOPMENT NITROGEN LOAD (TN) (lb/yr)	130.36					

Channel & Flood Protection Tab

The consequence of selecting a Wet Pond Level 2 (or any PR stormwater practice) is that there is no runoff reduction credit to be applied to the channel protection requirements. The RR credit is in the form of a Curve Number Adjustment, the derivation of which will be covered in Module 5.

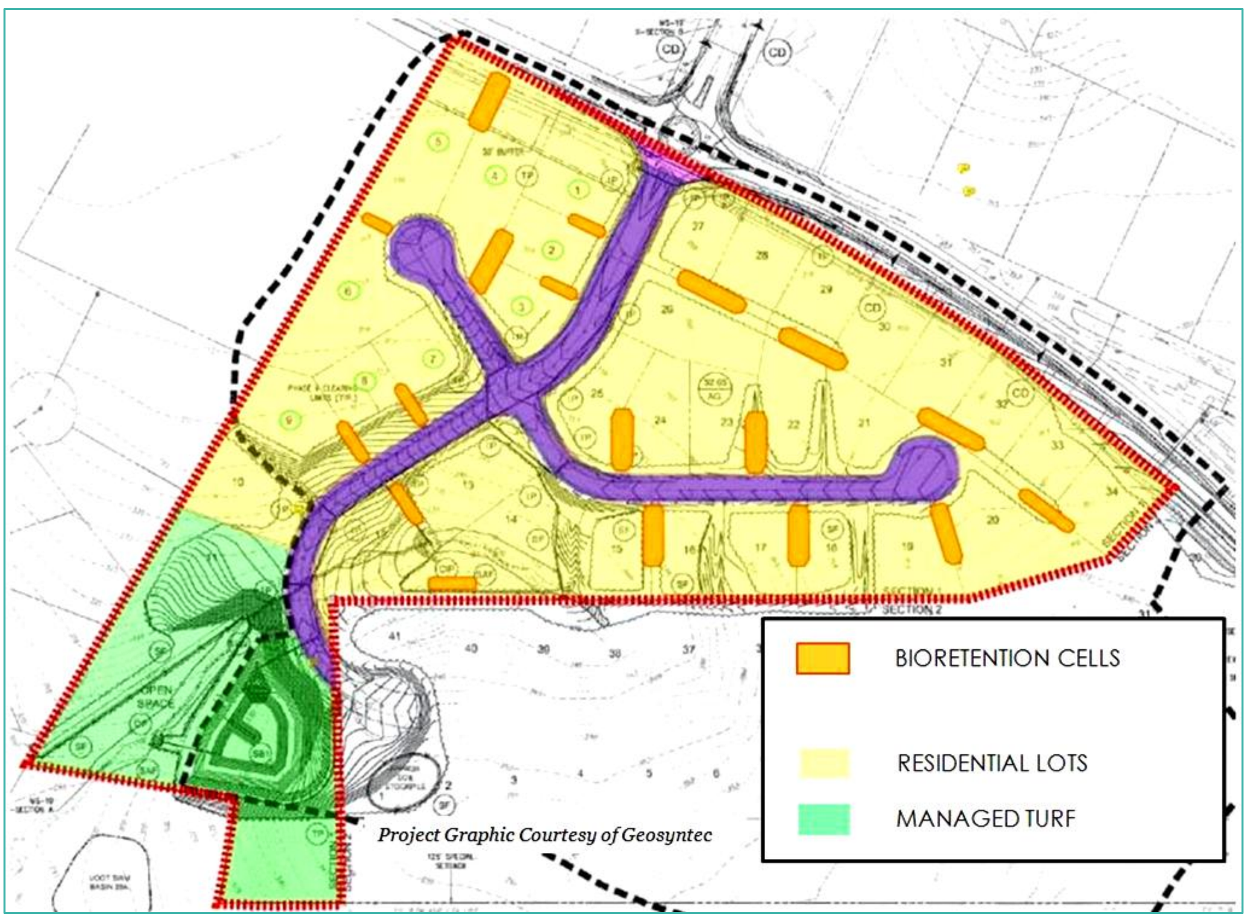


Alternative Design: RR Practices

To illustrate the runoff reduction capabilities of the RR practices and the documentation of the spreadsheet, consider the same development with a different stormwater approach. The goal is to address the water quality requirements to the extent practicable with upstream RR practices and eliminate the need for the wet pond. (It is expected that compliance with the channel protection criteria will still require a detention facility in that location.)

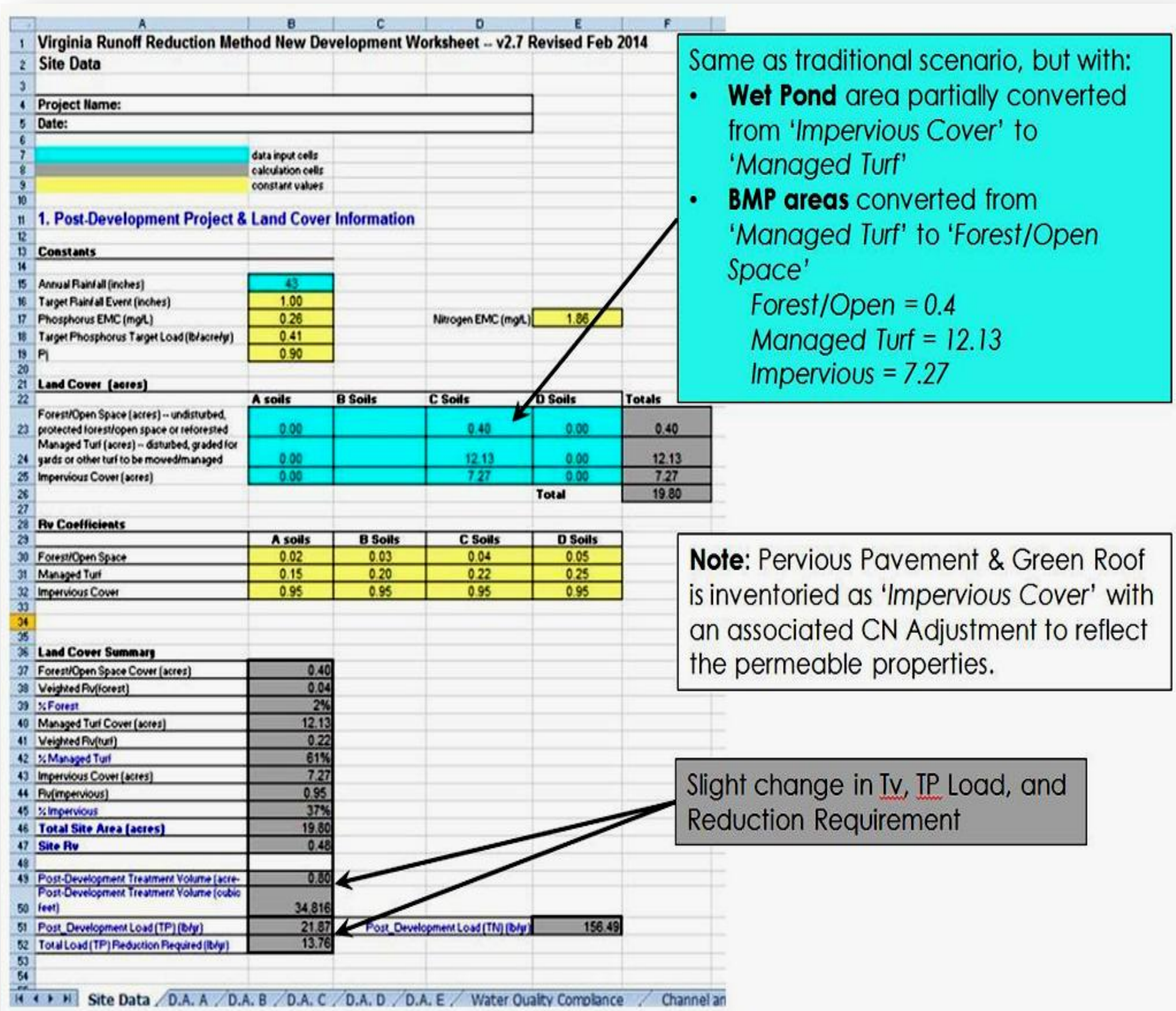
There is still no site-scale ESD, and instead RR practices will be placed along lot lines and contained with drainage easements. The design summary:

- ***Rooftop (simple) disconnection***, with downstream treatment: Bioretention;
- ***Bioretention*** to treat remaining runoff from the rooftop disconnection, plus
- Direct discharge from the remaining impervious areas on the site (roads, and any areas not captured by simple disconnection, plus
- Direct discharge from some of the pervious area on lots to ***Bioretention*** areas
- Additional Volume Reduction Treatment Train Options: Upstream Permeable Pavement on roads; and Downstream ***vegetated filter strip***



Site Data Tab: Revised

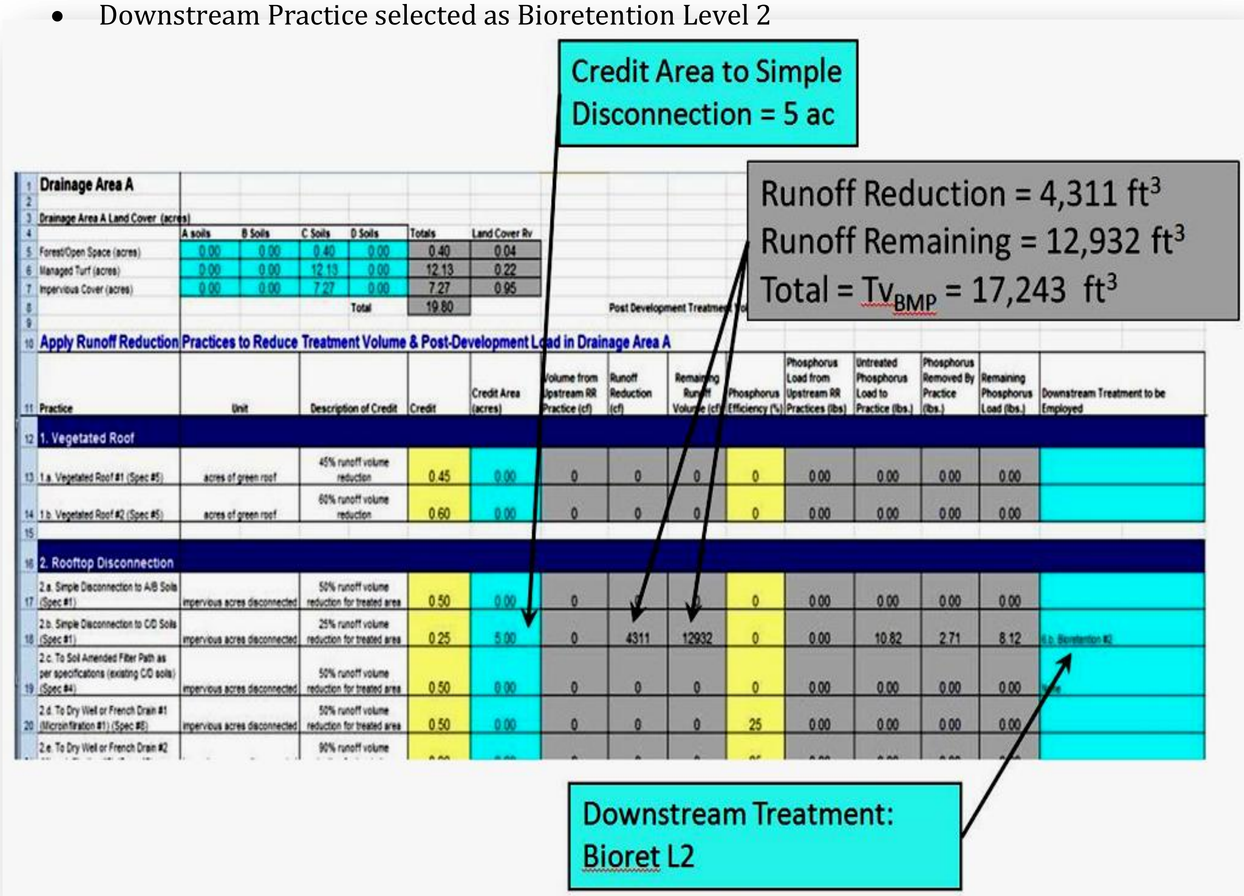
The implementation of RR practices and the subsequent reduction in the proposed wet pond requires an iterative process to determine the Land Cover area that can be converted from Impervious to Managed Turf and/or Managed Turf to Forest/Open Space (as shown). The aggregate area of proposed bioretention (surface area of planting bed, not the peripheral easement area or overflow drainage) is approximately 0.44 acres.



Drainage Area Tab

The aggregate area of rooftop, driveway and miscellaneous impervious cover on the designated lots are to be managed using Simple (or Alternative) Disconnection. Since these on-lot practices will be installed subsequent to the single family house construction, the SWM Design computations must identify the minimum amount of impervious cover that must be managed by disconnection on each lot, totaling 5 acres.

- Construction of the **Single Family residence as part of a Common Plan of Development** (CPD) with an **Agreement in Lieu of a Stormwater Management Plan** must demonstrate compliance with the RR goals associated with Impervious Disconnection as outlined in the CPD:
    - Reduction of 2.71 lb/yr TP (distributed among the lots as directed by the SWM Plan);
    - Reduction of 4,311 ft^3 of runoff (distributed among the lots as directed by the SWM Plan);
- Single Family construction may choose between the Simple or Alternate Practice Disconnection;
- Downstream Practice selected as Bioretention Level 2



Drainage Area A

Drainage Area A Land Cover (acres)

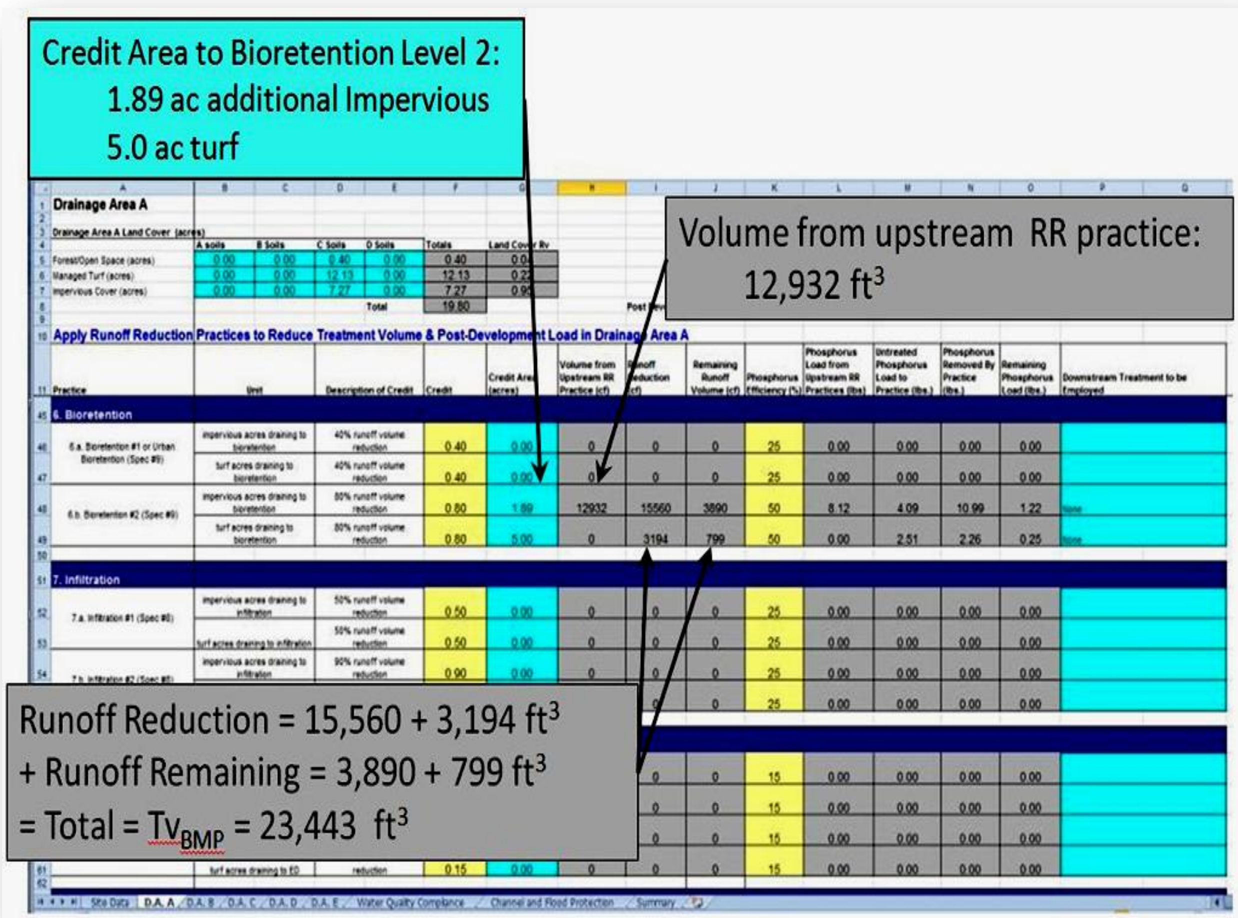
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	0.40	0.00	0.40	0.04
Managed Turf (acres)	0.00	0.00	12.13	0.00	12.13	0.22
Impervious Cover (acres)	0.00	0.00	7.27	0.00	7.27	0.95
				Total	19.80	

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
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 #8)	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											

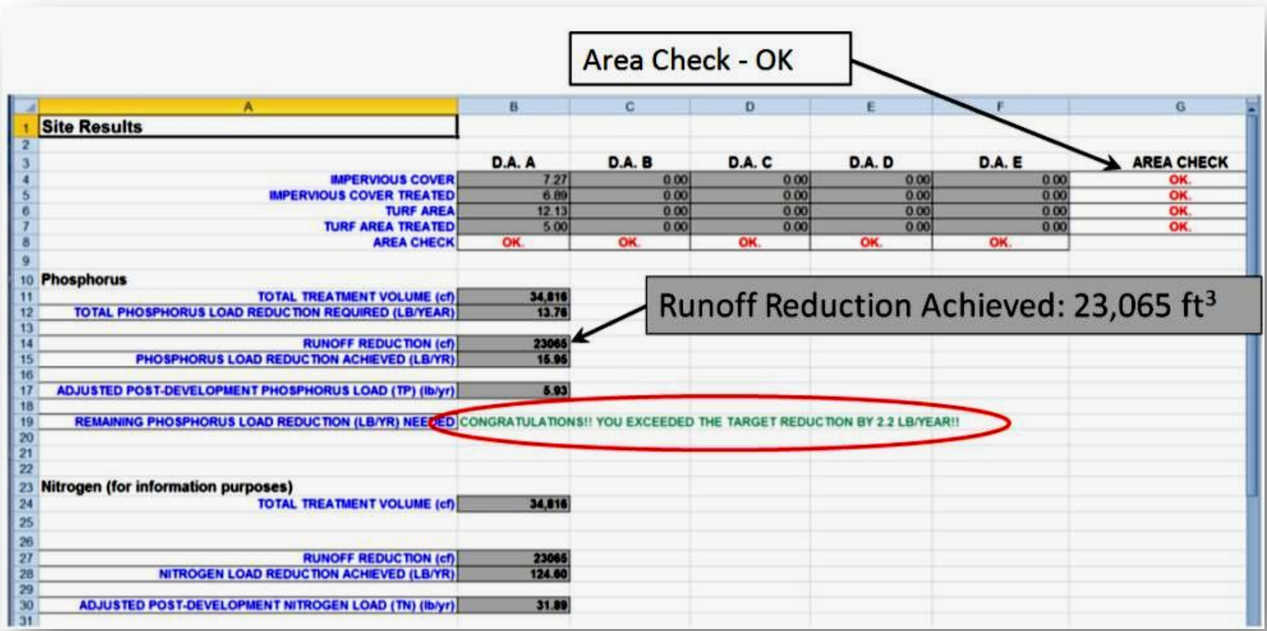
The selection of a single type of downstream practice for all the rooftop disconnection represents an aggregate application of a stormwater practice that simplifies the use of the compliance spreadsheet. This is similar to the strategy used for the impervious disconnection above: a predetermined number of lots were targeted for simple or alternate disconnection of and aggregated on the spreadsheet with the cumulative total of 5 acres. The same is done for the downstream bioretention:

- Remaining runoff from upstream RR practices = 12,932 ft^3
- Credit Area (direct runoff) of Impervious and Turf = 1.89 ac + 5.0 ac.
- Total TvBMP to be proportionately distributed among the Bioretention Areas = 23,443 ft^3
- **If all of the disconnected impervious area from does not drain to Bioretention, e.g., 2 acres of disconnected impervious drains to a grass channel instead, the designer would be required to use a second DA Tab to apply a parallel treatment train.**



Water Quality Compliance Tab

- The Water Quality Check Tab confirms that the area being treated across all the DA Tabs does not exceed the area of the site (if there were more than one DA Tab being used);
- The total volume of Runoff Reduction = 23,065 ft^3; and
- The BMP strategy complies with the site based load limit.

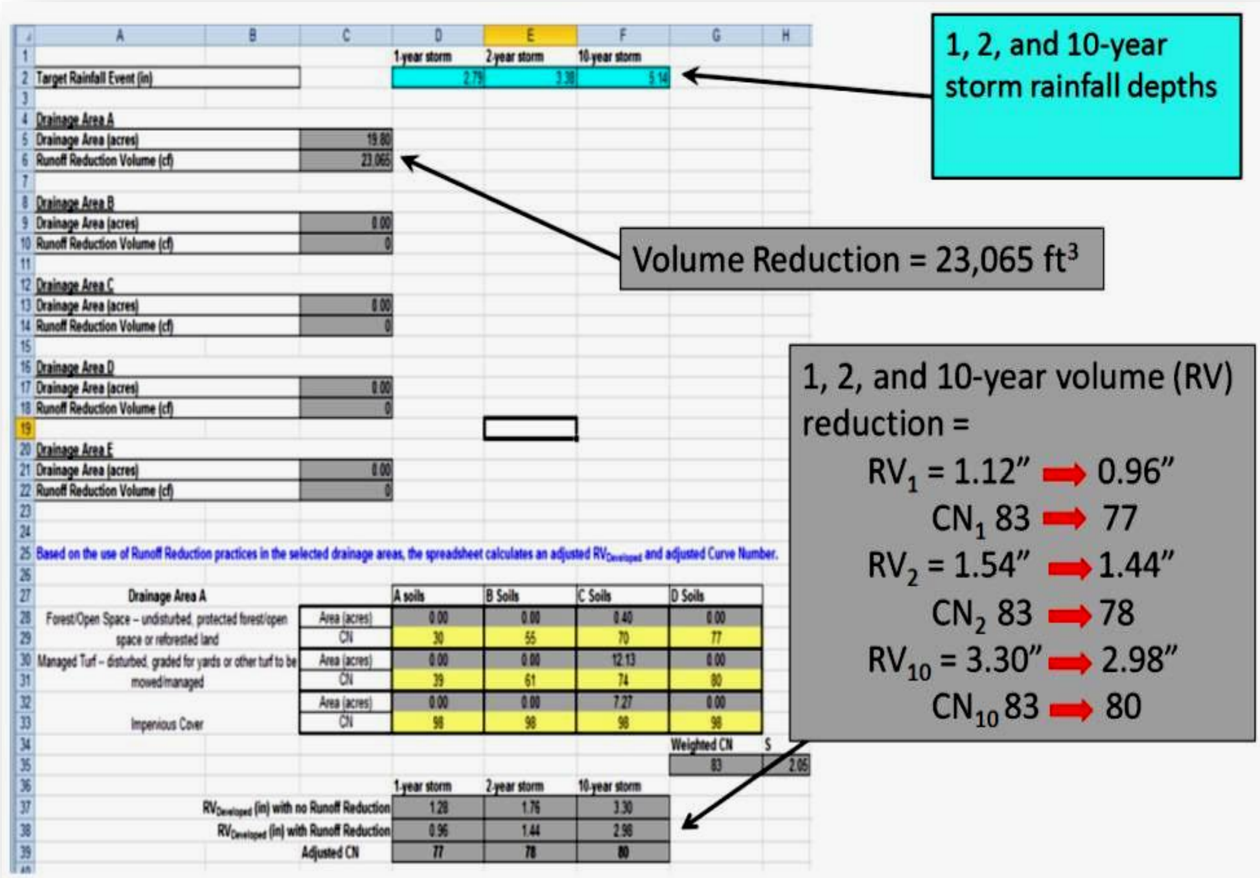


Channel & Flood Protection Tab

The stormwater quantity benefit of the RR design strategy is represented in two ways:

- The size of the stormwater pond required for Channel and Flood Protection is reduced by eliminating the required wet pond configuration that would have occupied the lower elevations of detention storage (normal pool); and
- The RR Curve Number Adjustment. For this example, the reduction of 23,065 ft^3 represents a Curve Number Adjustment for the 1-year design storm from a CN = 83 to a CN = 77. This adjustment:
  - Reduces the Vol_{pre}:Vol_{post} volume ratio in the energy balance equation, and
  - Reduces the post-condition peak discharge in the required s storage volume computation.

The Curve Number Adjustment will be discussed in more detail in Module 5



Design Comparison:

<u>The original design</u>:

- No Volume Reduction;
- Treats 100% of the site (19.8 ac) with Wet Pond Level 2 (Designer should review requirements for wet pond Level 2!)
- Compliance: exceed requirements by 2.4 lb/yr

<u>RR Design</u>:

- Treats 11.9 acres
- Compliance: exceed requirement by 2.2 lb/yr
- No wet pond required (for water quality)
- Reduce 23,065 ft^3 volume (from site Tv = 34,816 ft^3)
- Reduce 1-yr CN from 83 to 77

<u>Alternative RR Options</u>:

Permeable Pavement Level 1 on proposed roads (if allowed by VDOT):

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

Module 5 covers the Quantity Control requirements and the Energy Balance and VRRM Curve Number Adjustment. Refer to Module 5 for additional discussion on the capabilities and limitations of the VRRM.

4g. Part II C vs. II B Water Quality Comparison

Highlights of the changes to the water quality criteria contained in Part IIC versus Part IIB are listed below. Participants are encouraged to review information from Module 4 of the BASIC SWM training course and the previous sections for additional information.

	<u>Old</u> Technical Criteria/Method Part IIC	**<u>New</u>** Technical Criteria/Method Part IIB
Load Limitation (Total Phosphorus)	**0.45** lb/ac/yr	**0.41** lb/ac/yr
Uses EPA Simple Method	Yes	Yes (modified)
Addresses Runoff Coefficients for turf	No	Yes
Distinguishes between runoff reduction and pollutant removal facets of BMP treatment	No	Yes
Redevelopment Net Reduction Required	10%	10% < 1acre LDA 20% for larger projects