VIRGINIA RUNOFF REDUCTION METHOD
Compliance Spreadsheet User's Guide & Documentation
(Version 3.0, *April* 2016)

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1.0 INTRODUCTION

The Virginia Stormwater Management Program (VSMP) regulations utilize the Virginia Runoff Reduction Method (VRRM) for compliance with the water quality criteria (*9VAC25-870-65*). The VRRM is supported by stormwater research for runoff reduction and pollutant removal capabilities of various stormwater best management practices (BMPs). Information and documentation concerning the development of the VRRM can be obtained from *Technical Memorandum: The Runoff Reduction Method* prepared by the Center for Watershed Protection (CWP) (*www.cwp.org*) and the Chesapeake Stormwater Network (CWP, 2008).

DEQ has developed two Excel spreadsheets to assist in determining compliance with the VRRM; one spreadsheet is for new development and the other is for redevelopment. The spreadsheets are designed to help users see the benefits of environmental site design (ESD) and experiment with various stormwater BMPs on a particular site. Selected stormwater BMPs can also be evaluated in series (e.g., treatment trains) to meet the water quality standards in the regulations.

Each VRRM compliance spreadsheet is meant to serve as a tool for determining compliance and does not limit the use of other tools or methods consistent with the water quality requirements. It is important to note that compliance determination is only the first step in the design process. The suitability of environmental site design features and design BMP specifications to a project site are not determined by the spreadsheets. 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 Stormwater BMP Standards and Specifications.

Key Features of New Development and ReDevelopment VRRM *Spreadsheets:*

- Provide a summary of land cover statistics that includes the composite runoff coefficient for the entire site in its developed condition, the pollutant load (total phosphorus [TP] and total nitrogen [TN]), and the corresponding treatment volume (Tv).
- Allow the designer to evaluate the effectiveness of different BMPs and BMP combinations with respect to water quality compliance using up to five different drainage area tabs within a site.
- Provide a summary for each drainage area tab that includes the land cover, runoff volume and pollutant load generated, the BMPs selected, and the runoff volume and pollutant load reduced by the selected BMPs.
- Track the volume reduction that can be counted towards compliance with water quantity control requirements in each drainage area tab.
- Provide an overall compliance summary report that itemizes BMP implementation in each drainage area tab as well as overall site compliance.

2.0 BASICS FOR USING SPREADSHEET AND GUIDANCE

2.1. SPREADSHEET BASICS

The VRRM New Development and VRRM ReDevelopment Compliance Spreadsheets are each composed of six different types of tabs. The **Site tab** calculates a nutrient load for the site and runoff treatment volume based on the proposed land cover characteristics. The five **Drainage Area tabs (A to E)**, which are identical, can represent different drainage areas discharging to different outfalls located within the site, or BMPs can be grouped together on a single **Drainage Area tab** for more complex designs. BMPs applied to the site within user defined drainage areas for water quality compliance are selected within the **Drainage Area tabs**. The **Water Quality Compliance tab** provides information on site and drainage area nutrient loads and runoff volumes. This tab's primary function is to indicate whether or not compliance with phosphorus load limitations has been achieved, and if not, where there may be further opportunity for phosphorus reductions. The **Runoff Volume and CN tab** provides the user with volume tracking information, runoff depth, and curve number (CN) adjustments associated with runoff volume-reducing BMPs. The **Summary tab** organizes and displays the information entered and calculated on the other tabs. The **Summary tab** information can easily be printed as a report for submittal or review purposes. The final tab, the **Notes tab**, is a running list of the changes associated with the different released versions of the spreadsheet including changes and corrections made in Version 3.0.

The ReDevelopment Spreadsheet and the New Development Spreadsheet are essentially the same with a few exceptions reflected in two of the spreadsheet tabs. The **Site tab** has a different look between the two spreadsheets due to differences in data inputs and compliance requirements. Similarly, the **Summary tab** differs given the respective reporting of each spreadsheet's data inputs and calculated results. The **Site tab** for the ReDevelopment Spreadsheet requires data input on the existing site and proposed site conditions and incorporates different compliance computations in accordance with the regulations, *9VAC25-870-63 A 2*. The nutrient loads and volumes are calculated for both the existing site and the proposed site, and the regulatory phosphorus load reduction requirement for the site is comprised of both a reduction to the existing nutrient load and meeting the new development compliance phosphorus limitation for any new net impervious areas. Once the load reduction requirements are determined, the procedures for selecting the BMPs and verifying compliance are the same as those for new development. Instructions on using the **Site tab** for redevelopment (including site area versus disturbed area) are included in Section 4.

Both spreadsheets can incorporate use of either the 2011 BMP Standards and Specifications included in the VSMP regulations (*9VAC25-870-65 B*) or the Draft 2013 BMP Standards and Specifications. The user's selection is made through a two-option button included at the top of

the **Site tab**. There is only one difference between the two specifications that is applicable to the spreadsheets: the revised runoff reduction credit for compost amended grass channels (BMP No. 4) in the Draft 2013 BMP Standards and Specifications.

Using the VRRM spreadsheet

Functional spreadsheet **cells** are color-coded as follows:

Green Cells ***(unlocked)*** are for user data entries

Yellow cells ***(locked)*** are fixed constant values.

Grey cells ***(locked)*** are calculated values.

Indigo Cells ***(locked)*** are final results (Total Phosphorus reduction requirement).

2.2. SOFTWARE SPECIFICATIONS

The spreadsheet files (Version 3.0) are Excel documents and were developed using Microsoft Excel 2007 in a macro-enabled workbook format (.xlsm). Users must enable macros in order for the spreadsheets to function properly (Fig. 1).

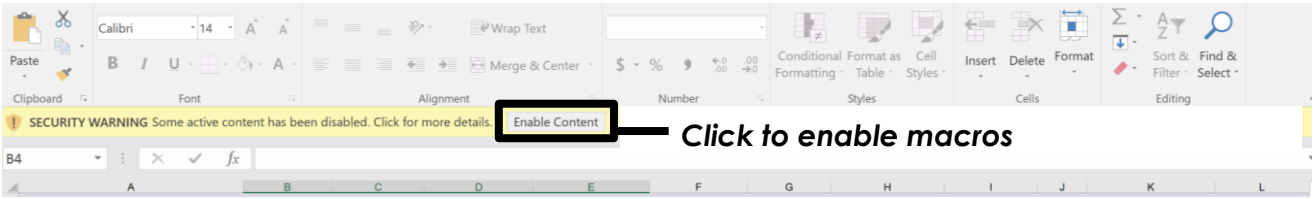


Figure 1. Enabling macros

2.3. GUIDANCE BASICS

The basic components and terms of the VRRM compliance spreadsheets are discussed in the sections below and presented along with step-by-step user instructions. This guidance applies to Version 3.0 of the spreadsheets. **This guidance can be used for older versions of the spreadsheets but cell references may differ.** Version 3.0 provides corrections for several errors found in the earlier spreadsheet versions and adds ease-of-use features.

3.0 SITE TAB (NEW DEVELOPMENT)

The **Site tab** requires site data inputs and provides overall site information. The main purpose of this tab is to compute the required reduction of TP for the site based on the proposed site land cover characteristics. Using the land cover data entered by the user and the fixed constant values the site TP loading is calculated using the Simple Method equation (Eq. 4). The required load reduction is based on the difference between the post-development site load and the load limit of 0.41 pounds TP per acre per year. The tab also shows the calculated values used to derive the required site load reduction. The data input cells and constants used in the Simple Method load calculations are described below and shown on the **Site tab** screen shot in Fig. 2.

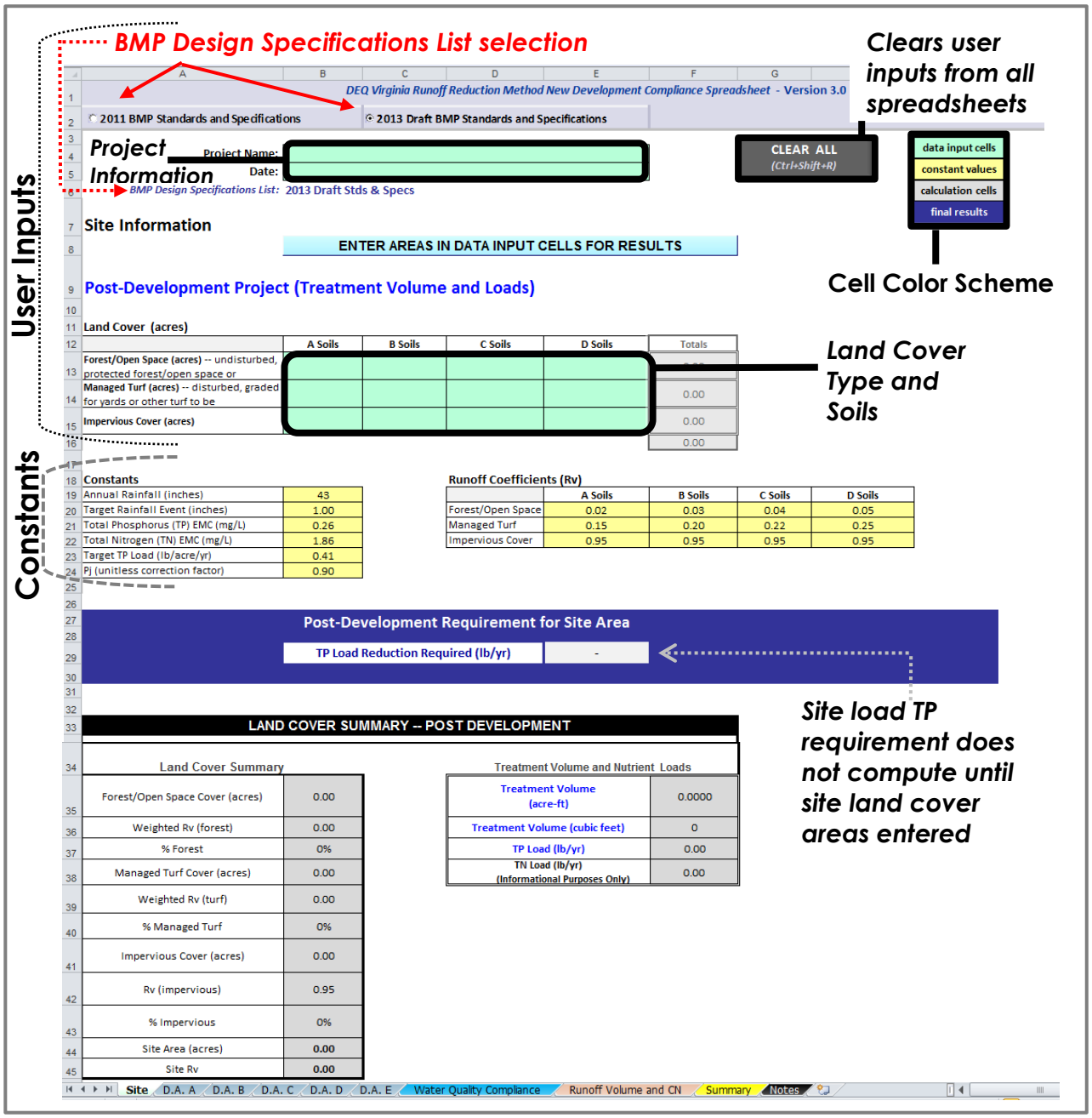
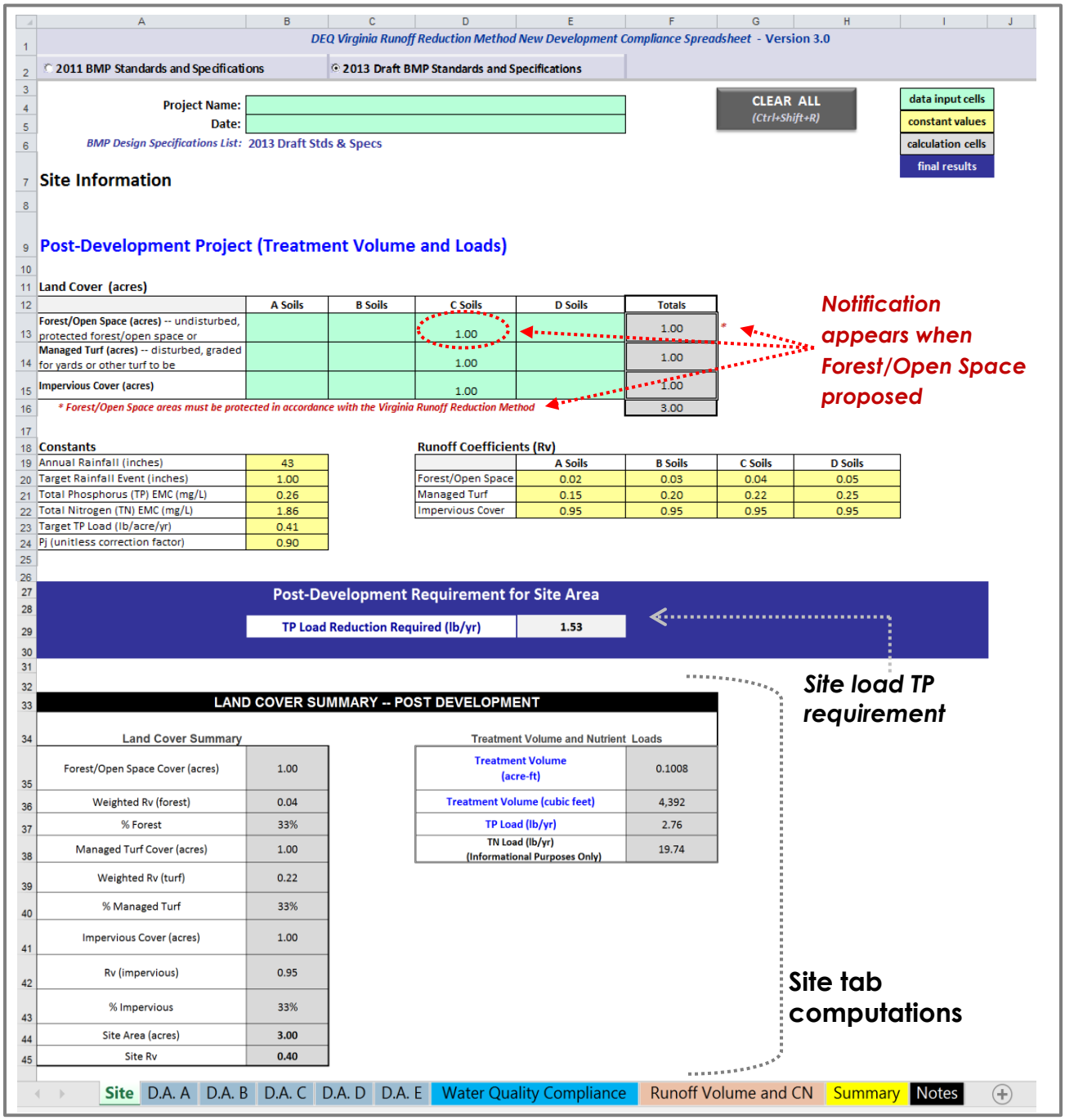


Figure 2. VRRM New Development Compliance Spreadsheet – Site Tab with No User Inputs

Figure 2 shows a screenshot of the **Site tab** when land cover data has been entered.



DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 3.0

2011 BMP Standards and Specifications | 2013 Draft BMP Standards and Specifications

Project Name:
Date:
BMP Design Specifications List: 2013 Draft Stds & Specs

CLEAR ALL (Ctrl+Shift+R)

data input cells
constant values
calculation cells
final results

Site Information

Post-Development Project (Treatment Volume and Loads)

Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or			1.00		1.00 *
Managed Turf (acres) -- disturbed, graded for yards or other turf to be			1.00		1.00
Impervious Cover (acres)			1.00		1.00
					3.00

* Forest/Open Space areas must be protected in accordance with the Virginia Runoff Reduction Method

Notification appears when Forest/Open Space proposed

Constants

Annual Rainfall (inches)	43
Target Rainfall Event (inches)	1.00
Total Phosphorus (TP) EMC (mg/L)	0.26
Total Nitrogen (TN) EMC (mg/L)	1.86
Target TP Load (lb/acre/yr)	0.41
Pj (unitless correction factor)	0.90

Runoff Coefficients (Rv)

	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

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	1.53

Site load TP requirement

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary

Forest/Open Space Cover (acres)	1.00
Weighted Rv (forest)	0.04
% Forest	33%
Managed Turf Cover (acres)	1.00
Weighted Rv (turf)	0.22
% Managed Turf	33%
Impervious Cover (acres)	1.00
Rv (impervious)	0.95
% Impervious	33%
Site Area (acres)	3.00
Site Rv	0.40

Treatment Volume and Nutrient Loads

Treatment Volume (acre-ft)	0.1008
Treatment Volume (cubic feet)	4,392
TP Load (lb/yr)	2.76
TN Load (lb/yr) (Informational Purposes Only)	19.74

Site tab computations

Site | D.A. A | D.A. B | D.A. C | D.A. D | D.A. E | Water Quality Compliance | Runoff Volume and CN | Summary | Notes

Figure 3. VRRM New Development Compliance Spreadsheet – Site Tab with User Land Cover Inputs

Using the VRRM spreadsheet *(Site tab)*

1. Enable macros to allow access between worksheets (tabs).
2. Use the **CLEAR ALL** button to delete all prior user data inputs from entire spreadsheet.
3. Select either the 2011 or the Draft 2013 BMP Specifications list from the top of the worksheet (**row 2**). *This triggers the appropriate runoff reduction credit associated with 4.c. Grass Channel with Compost Amended Soils (Specification #4) listed on the drainage area tabs.*
4. Enter project name (**cell B4**) and date (**cell B5**) in the provided spaces.

3.1. SITE TAB – LAND COVER

The **green cells** in the land cover section of the **Site tab** are where the user enters the land cover type by hydrologic soil group (HSG) for the entire site area (in acres) for the post-developed condition. There are three categories of developed land: *Forest/Open Space (F/O)*, *Managed Turf (MT)*, and *Impervious Cover (IC).* Definitions of the three categories of land cover and the basic qualifications for each are provided in Table 1. Hydrologic soil group determinations can be made using the National Resources Conservation Service (NRCS) web soil surveys. Runoff coefficients (Rv) by land cover and hydrologic soil groups are included in the **Site tab** as fixed constants in **yellow cells**. A composite runoff coefficient for the site is then computed from the user acreage inputs and the fixed runoff coefficients.

Table 1. Land Cover Guidance for VRRM Compliance Spreadsheets

FOREST & OPEN SPACE

Land that will remain undisturbed OR restored to a hydrologically functional state[1]:
• 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 design specifications
• Community open space areas that will not be mowed routinely, but left in a natural vegetated state (can include areas 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 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[2]
  o BMPs in this category include bioretention, dry swale, grass channel, extended detention (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, including wetlands, that will be protected during construction and that will remain undisturbed
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 limits of disturbance (LOD) on approved erosion and sediment control 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
  o 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
• Although 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:
  o 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
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
• Roadways, driveways, rooftops, parking lots, sidewalks, and other impervious areas 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]Pre-redevelopment areas that are undisturbed and naturally vegetated are considered forest/open space in the redevelopment spreadsheet. [2]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).

Whenever Forest/Open Space acreages are entered as post-development land cover, a notification will appear below the land cover inputs in row 16 reminding the user that Forest/Open Space areas must be protected in accordance with the Virginia Runoff Reduction Method (see Fig. 3). Users should review the Forest/Open Space definition and be familiar with protection and maintenance requirements if this land cover type is proposed (see Table 1).

Using the VRRM spreadsheet *(Site tab)*

5. Enter the post-development acreages of each land cover type by soil group (**cells B13 to E15**).

   Emphasis should be placed on environmental design principles during the early phases of project development. If Forest/Open space is used, take note of pop-up message in **cell A16**.

3.2. SITE TAB – CONSTANTS

The **Site tab** constants, **yellow cells**, described in Table 2 are the fixed values used in the Simple Method computation of the site's nutrient loads and treatment volume.

Table 2. Site Tab Constants (New Development)

Site Tab Constants	Value & Cell Reference
Annual Rainfall (inches) The average annual rainfall depth for Virginia. The defined value is used across Virginia to derive the total phosphorous and nitrogen loadings.	43" **Cell B19**
Target Rainfall Event (inches) The 90th percentile rainfall depth is used to calculate the treatment volume for the site. This value is equal to one-inch of rainfall. In other words, 90% of all storm events have a rainfall depth equal to or less than 1 inch.	1 inch **Cell B20**
EMCs (mg/L) for **Total Phosphorus (TP)** and **Total Nitrogen (TN)** The urban runoff Event Mean Concentrations (EMCs) for TP and TN used to calculate site TP and TN loads, respectively. These values are based on an extensive review of monitoring data in Virginia (CWP 2008).	TP (0.26 mg/L) TN (1.86 mg/L) **Cell B21** **Cell B22**
Target TP Load (lb/ac/yr) The total phosphorus load limit established by the VSMP regulations (*9VAC25-870-63 A*) and is used to compute the required load reduction for the site.	0.41 lb/ac/yr **Cell B23**
Pj The unitless correction factor that represents the fraction of rainfall producing runoff for the pollutant load calculations.	0.9 **Cell B24**
Runoff Coefficients (Rv) The unitless volumetric runoff coefficients that represent the runoff potential from the different land covers by Hydrologic Soil Groups (HSG) A, B, C, and D. These values are based on literature reviews as described in the Virginia Runoff Reduction Method (CWP 2008)	*See Fig. 2* **Cells E20 - H22** (F/O) **Cells E21 - H21** (MT) **Cells E22 - H2** (IC)

3.3. SITE TAB – COMPUTATIONS

This section addresses the intermediate and final calculated results, **grey cells** and **indigo cells**, related to the site nutrient loads. These include post-development site land cover summary, site treatment volume, site TP and TN loads, and the site TP load reduction requirement (Table 3)

Table 3. Site Tab Computations (New Development)

Site Tab Computations	Cell Reference
Land Cover Summary Totals of user inputs for each land cover type	**Grey Cells**
Totals: Forest/Open Space, Managed Turf, Impervious Cover (acres) Sums of each land cover type area across hydrologic soil groups	**F13 & B35** (F/O) **F14 & B38** (MT) **F15 & B41** (IC)
Weighted Rv for Forest/Open, Managed Turf, Impervious Cover* Runoff coefficient weighted across land cover types and HSGs **Runoff coefficient for impervious cover is independent of HSGs* *Equation 1.1a, 1.2a, 1.3a*	**B36** (F/O) **B39** (MT) **B42** (IC)
%Forest/Open, %Managed Turf, %Impervious Cover Percentage coverage for each land cover type across HSGs *Equation 1.1b,1.2b,1.3b*	**B37** (F/O) **B40** (MT) **B43** (IC)
Total Site Area (acres) Area summed across land cover types and HSGs	**F16 & B44**
Site Rv Composite runoff coefficient across land cover types and HSGs *Equation 2*	**B45**
Treatment Volume Post-development treatment volumes in acre-feet and cubic feet calculated using the target rainfall event, site Rv, and site area *Equation 3*	**F35** (acre-ft) **F36** (cf)
Site Loads (lb/yr) Site post-development TP load and TN load (informational only). Loads are computed using the Simple Method with annual rainfall (43") and nutrient EMC value (0.26 mg/L TP, 1.86 mg/L TN). *Equation 4*	**F37** (TP load) **F38** (TN load)
Post-development requirement for Total Site Area (lb/yr) The total TP load reduction required for compliance for the total site. This is the difference between the post-development TP load and the site-based load limit of 0.41 lb TP/ac/yr established by the VSMP regulations (*9VAC25-870-63*). *Equation 5*	**Indigo Cells** **E29** *Land cover data must be entered for result to calculate*

Using the VRRM spreadsheet *(Site tab)*

6. Take note of the post-development TP reduction requirement in **cell E29**.

a. This requirement is a site-based water quality requirement and unlike water quantity control requirements, which must be met at each of the site's stormwater discharge points (per *9VAC25-870-66*), the TP load reduction requirement may be met using various **Drainage Area tab** load reduction combinations, unless restricted as per *9VAC25-870-65.E*.

b. Depending on the post-development land cover type and HSGs, the site may or may not require further TP load reduction to meet the water quality compliance requirements.

If the computed TP load reduction requirement (**cell E29)** is:

i. Less than or equal to zero (site is at or below the 0.41 lb/ac/yr load limit), the site's TP load meets water quality compliance requirements. A message will appear in **cell G29**:

TP load reduction is not required;

ii. Greater than zero (site is above the 0.41 lb/ac/yr load limit), **cell E29** will reflect the TP load reduction required for site compliance.

7. If **cell E29** is greater than zero, proceed to **Drainage Area tab**.

4.0 SITE TAB (RE-DEVELOPMENT)

The VSMP regulations refer to redevelopment as development on prior developed lands. In accordance with *9VAC25-870-10*:

> "Prior developed lands" means land that has been previously utilized for residential, commercial, industrial, institutional, recreation, transportation or utility facilities or structures, and that will have the impervious areas associated with those uses altered during a land-disturbing activity."

The water quality requirements for redevelopment (*9VAC25-870-63 A 2*) apply to those projects where impervious areas, as part of the existing conditions, are altered during the course of construction, as applicable to regulated land-disturbing activities.

The basic structure of the ***VRRM ReDevelopment Compliance Spreadsheet*** and the VRRM New Development Compliance Spreadsheet are similar. One of the main differences between the two spreadsheets is the computation of the site TP load reduction requirement on the **Site tab**, which for redevelopment projects, other than linear projects, is influenced by whether or not there is an increase in net impervious cover.

- When there is no net increase in impervious cover from the predevelopment condition, the post-development TP load must simply be reduced to below the predevelopment TP load by either 10 or 20% depending on the total area of land disturbance in accordance with *9VAC25-870-63 A 2 a* and *A 2 b.*
- When there is a net increase in impervious cover from the predevelopment condition: the new net impervious area must meet the TP new development load limitation of 0.41 lb/ac/yr in accordance with *9VAC25-870-63 A 2 c*, and the post-development TP load for the remaining area of the site must be reduced to below the predevelopment TP load of the same area by either 10 or 20% depending on the total area of land disturbance (per *9VAC25-870-63 A 2 a* and *A 2 b*).
- When the redevelopment project is a linear project, the post-development TP load must be reduced to 20% below the predevelopment TP load irrespective of whether or not there has been an increase in impervious cover as per *9VAC25-870-63 A 2 d.*

  It should be noted that impervious areas included within the site of a linear redevelopment project must be undergoing alteration during the land disturbing activity as per the definition of "*prior developed lands*" in (*9VAC25-870-10*) listed above.

  Users should also note the definition of routine maintenance, which is not considered redevelopment in *§ 62.1-44.15:34.C.7:*

  "Routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original construction of the project. The paving of an existing road with a compacted or impervious surface and reestablishment of existing associated ditches and shoulders shall be deemed routine maintenance if performed in accordance with this subsection;…"

Summary

- Any new net impervious areas must meet 0.41 lb TP/acre/year
- Total disturbed area < 1 acre, 10% TP load reduction required for remainder of site
- Total disturbed area ≥ 1 acre, 20% TP load reduction required for remainder of site
- Linear projects, 20% TP load reduction required for site

Compared to the New Development Site tab, the TP load computations for the ReDevelopment **Site tab** require additional user inputs and result in a more complex look for the tab. The ReDevelopment **Site tab** also has different cell references (locations of cells or cell ranges within sheet tabs) for similar elements. This section highlights and describes the similarities and differences for the two spreadsheets.

Once the load reduction requirement for the redevelopment site has been determined, the procedures for using the spreadsheet (**Drainage Area tabs**, **Water Quality Compliance tab**, **Runoff Volume and CN tab**, and **Summary tab**) are the same as those of for the New Development Compliance Spreadsheet described in this document. Any **Summary tab** dissimilarities reflect the distinct regulatory requirements and computations between new development and redevelopment.

4.1. WHAT'S SIMILAR?

The land cover categories of *Forest/Open Space*, *Managed Turf*, and *Impervious Cover* and the corresponding definitions are the same as those for the new development computations (see Table 1 in Section 3.1).

The constants, **yellow cells**, are similarly used and defined in both spreadsheets. The constants on the **Site tab** of the ReDevelopment Spreadsheet are listed below with their cell references (Table 4, Fig. 4).

Table 4. ReDevelopment Spreadsheet Site Tab Constants

ReDevelopment Site Tab Constants	Site Tab Cell References **Yellow cells**
Annual Rainfall	**B31**
Target Rainfall Event	**B32**
EMCs Total Phosphorus (TP) and **Total Nitrogen (TN)**	**B33 (TP)** **B34 (TN)**
Target TP Load	**B35**
Pj	**B36**
Runoff Coefficients (Rv)	**E32 - H32** (F/O) **E33 - H33** (MT) **E34 - H34** (IC)

4.2. WHAT'S DIFFERENT?

4.2.1. SITE TAB (REDEVELOPMENT) – LAND COVER AREA INPUTS

Whereas the New Development Spreadsheet requires the user to input post-development land cover areas, the ReDevelopment Spreadsheet requires the user to input existing (*prior to redevelopment*) and post-development (*following redevelopment*) land cover areas as well as the total disturbed area (Table 5). Consequently, area checks are included in the **Site tab** along with an error notification summary in cells H10-K13 for **Site tab** user inputs that are missing or in error. Furthermore, spreadsheet calculated results will not populate until all user errors are reconciled (See Figs. 4 to 7).

As noted in Section 4.0, the redevelopment water quality criteria include a percent reduction requirement (for existing site areas not replaced by new net impervious cover), which is dependent on the total land disturbance acreage being either (i) less than, or (ii) greater than or equal to one acre.

It is important for the user to understand that both spreadsheets (ReDevelopment and New Development) use the site area for load calculations. In the case of redevelopment, the site area may or may not be the same as the total disturbed area. For example, if post-development areas are being preserved as Forest/Open Space, then the site area will necessarily be greater than the disturbed acreage. The user should check with the VSMP authority for any applicable restrictions that could limit available options.

A new feature included in the ReDevelopment Spreadsheet is the option to indicate a linear development project by selecting "Yes" from the dropdown menu in row 6 of the **Site tab**. This will set the TP percent load reduction requirement at 20% (final TP load must be at least 20% below the pre-redevelopment TP load). (See Figs. 8 and **Error! Reference source not found.**). A separate section for linear project water quality compliance results will appear in both the **Water Quality Compliance tab** and the **Summary tab** when a linear project is indicated on the **Site tab** (See related figures in Sections 6 and 8).

Table 5. ReDevelopment Spreadsheet – Site Tab, Land Cover Areas

ReDevelopment Land Cover Areas	Cell Reference
Total Disturbed Acreage User input for the redevelopment percent reduction standard (< 1 acre requires 10%, ≥1 acre requires 20% reduction). *Acreage entered can be limited to land disturbance or extended to a larger site area.* Results will not calculate (**rows 42-68**) and message prompts appear in **cell E60** and **row 10** if disturbed acreage not entered (Fig. 7).	**Green Cells** **F10**
Final results/compliance information per *9VAC25-870-63 A 2*. **Maximum reduction required** (10 or 20%) **Site's net increase in impervious cover (acres)** **Post-Development TP Load Reduction for Site (lb/yr)**	**Indigo Cells** **F12** **F13** **F14**
Pre-ReDevelopment Land Cover (acres) User inputs for existing conditions (prior developed lands): **Forest/Open Space, Managed Turf, Impervious Cover (acres)** Entries of each existing land cover type area across HSGs	**Green Cells** **B17 - E17** (F/O) **B18 - E18** (MT) **B19 - E19** (IC)
Pre-ReDevelopment Land Cover Totals (acres) Sums of each land cover type area across HSGs	**Grey Cells** **F17** (F/O) **F18** (MT) **F19** (IC) **F20** (All)
Post-Development Land Cover (acres) User inputs for post-development conditions: **Forest/Open Space, Managed Turf, Impervious Cover (acres)** Entries of each proposed land cover type area across HSGs	**Green Cells** **B24 - E24** (F/O) **B25 - E25** (MT) **B26 - E26** (IC)
Post-Development Land Cover Totals (acres) Sums of each land cover type area across HSGs	**Grey Cells** **F24** (F/O) **F25** (MT), **F26** (IC) **F27** (All)
AREA CHECK Pre-ReDevelopment and Post-Development land cover areas must equal for each HSG (soil type does not change). **OK.** message when area totals are equal. **Check Areas!** message when area totals are not equal. Results (**rows 42 to 68**) will not appear until all area errors resolved. **Cells H10-K13** provide summary of user input errors	**Grey Cells** **B27** (A Soils) **C27** (B Soils) **D27** (C Soils) **E27** (D Soils)

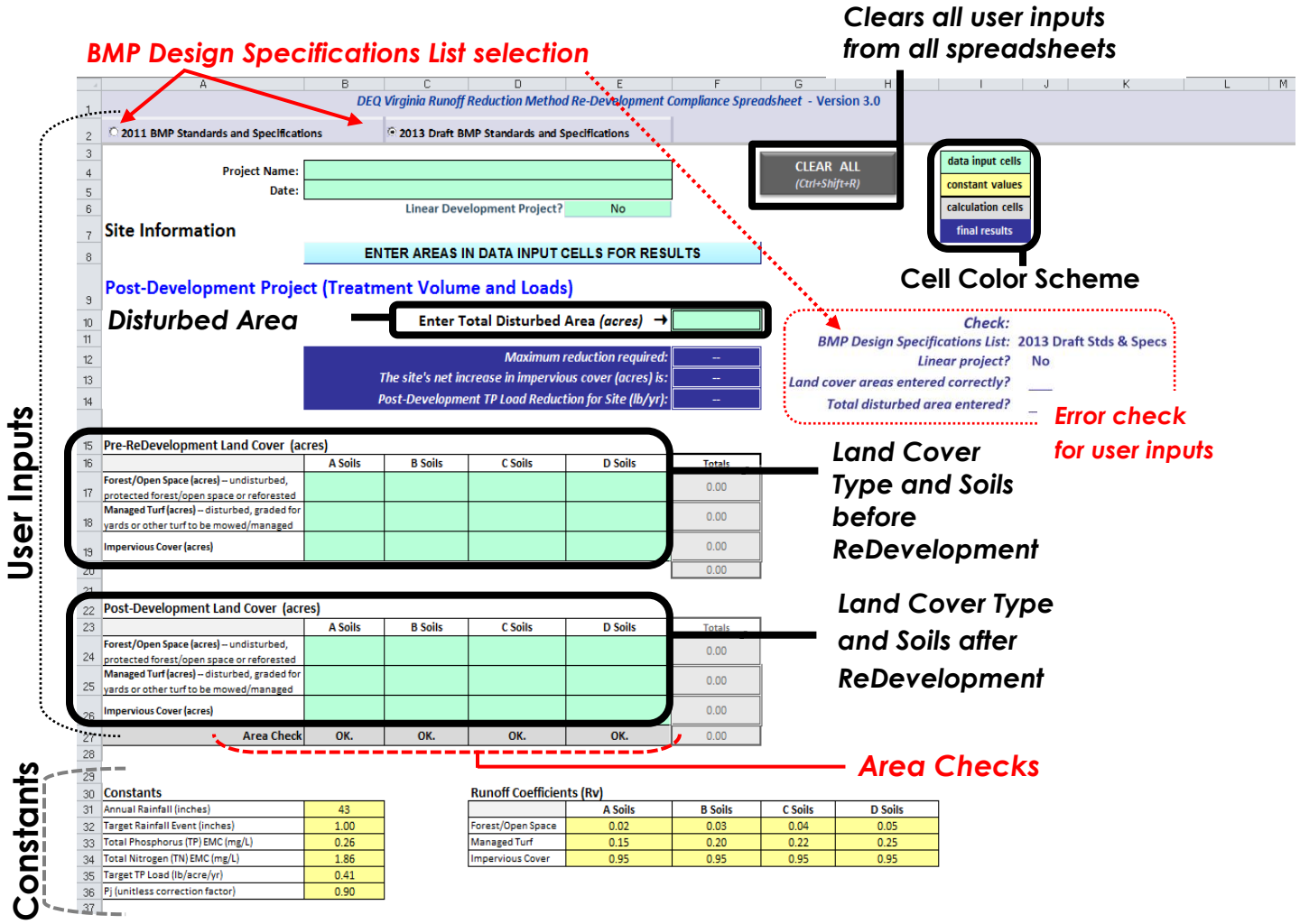
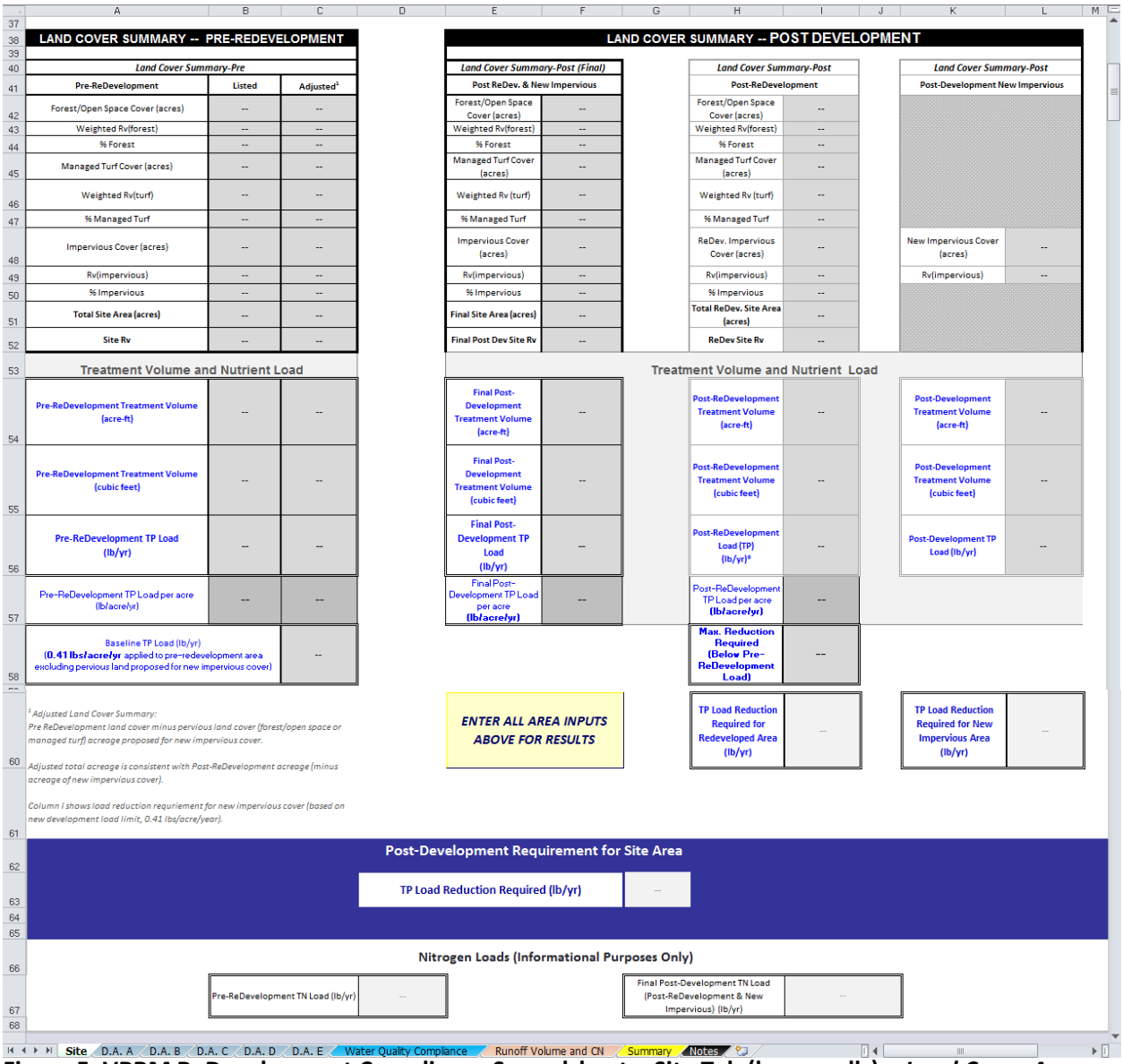


Figure 4. VRRM ReDevelopment Compliance Spreadsheet – Site Tab (upper cells)



LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre		
Pre-ReDevelopment	Listed	Adjusted[1]
Forest/Open Space Cover (acres)	--	--
Weighted Rv(forest)	--	--
% Forest	--	--
Managed Turf Cover (acres)	--	--
Weighted Rv(turf)	--	--
% Managed Turf	--	--
Impervious Cover (acres)	--	--
Rv(impervious)	--	--
% Impervious	--	--
Total Site Area (acres)	--	--
Site Rv	--	--

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)		*Land Cover Summary-Post*		*Land Cover Summary-Post*	
Post ReDev. & New Impervious		Post-ReDevelopment		Post-Development New Impervious	
Forest/Open Space Cover (acres)	--	Forest/Open Space Cover (acres)	--		
Weighted Rv(forest)	--	Weighted Rv(forest)	--		
% Forest	--	% Forest	--		
Managed Turf Cover (acres)	--	Managed Turf Cover (acres)	--		
Weighted Rv (turf)	--	Weighted Rv (turf)	--		
% Managed Turf	--	% Managed Turf	--		
Impervious Cover (acres)	--	ReDev. Impervious Cover (acres)	--	New Impervious Cover (acres)	--
Rv(impervious)	--	Rv(impervious)	--	Rv(impervious)	--
% Impervious	--	% Impervious	--		
Final Site Area (acres)	--	**Total ReDev. Site Area (acres)**	--		
Final Post Dev Site Rv	--	**ReDev Site Rv**	--		

Treatment Volume and Nutrient Load

Pre-ReDevelopment Treatment Volume (acre-ft)	--	--	Final Post-Development Treatment Volume (acre-ft)	--	Post-ReDevelopment Treatment Volume (acre-ft)	--	Post-Development Treatment Volume (acre-ft)	--
Pre-ReDevelopment Treatment Volume (cubic feet)	--	--	Final Post-Development Treatment Volume (cubic feet)	--	Post-ReDevelopment Treatment Volume (cubic feet)	--	Post-Development Treatment Volume (cubic feet)	--
Pre-ReDevelopment TP Load (lb/yr)	--	--	Final Post-Development TP Load (lb/yr)	--	Post-ReDevelopment Load (TP) (lb/yr)[8]	--	Post-Development TP Load (lb/yr)	--
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	--	--	Final Post-Development TP Load per acre (lb/acre/yr)	--	Post-ReDevelopment TP Load per acre (lb/acre/yr)	--		
Baseline TP Load (lb/yr) (0.41 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		--			Max. Reduction Required (Below Pre-ReDevelopment Load)	--		

[1] *Adjusted Land Cover Summary:*
Pre ReDevelopment land cover minus pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.41 lbs/acre/year).

ENTER ALL AREA INPUTS ABOVE FOR RESULTS

TP Load Reduction Required for Redeveloped Area (lb/yr)	--	TP Load Reduction Required for New Impervious Area (lb/yr)	--

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	--

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	--	Final Post-Development TN Load (Post-ReDevelopment & New Impervious) (lb/yr)	--

Site | D.A. A | D.A. B | D.A. C | D.A. D | D.A. E | Water Quality Compliance | Runoff Volume and CN | Summary | Notes

Figure 5. VRRM ReDevelopment Compliance Spreadsheet – Site Tab (lower cells) – *Land Cover Areas and Total Disturbed Acreage not entered*

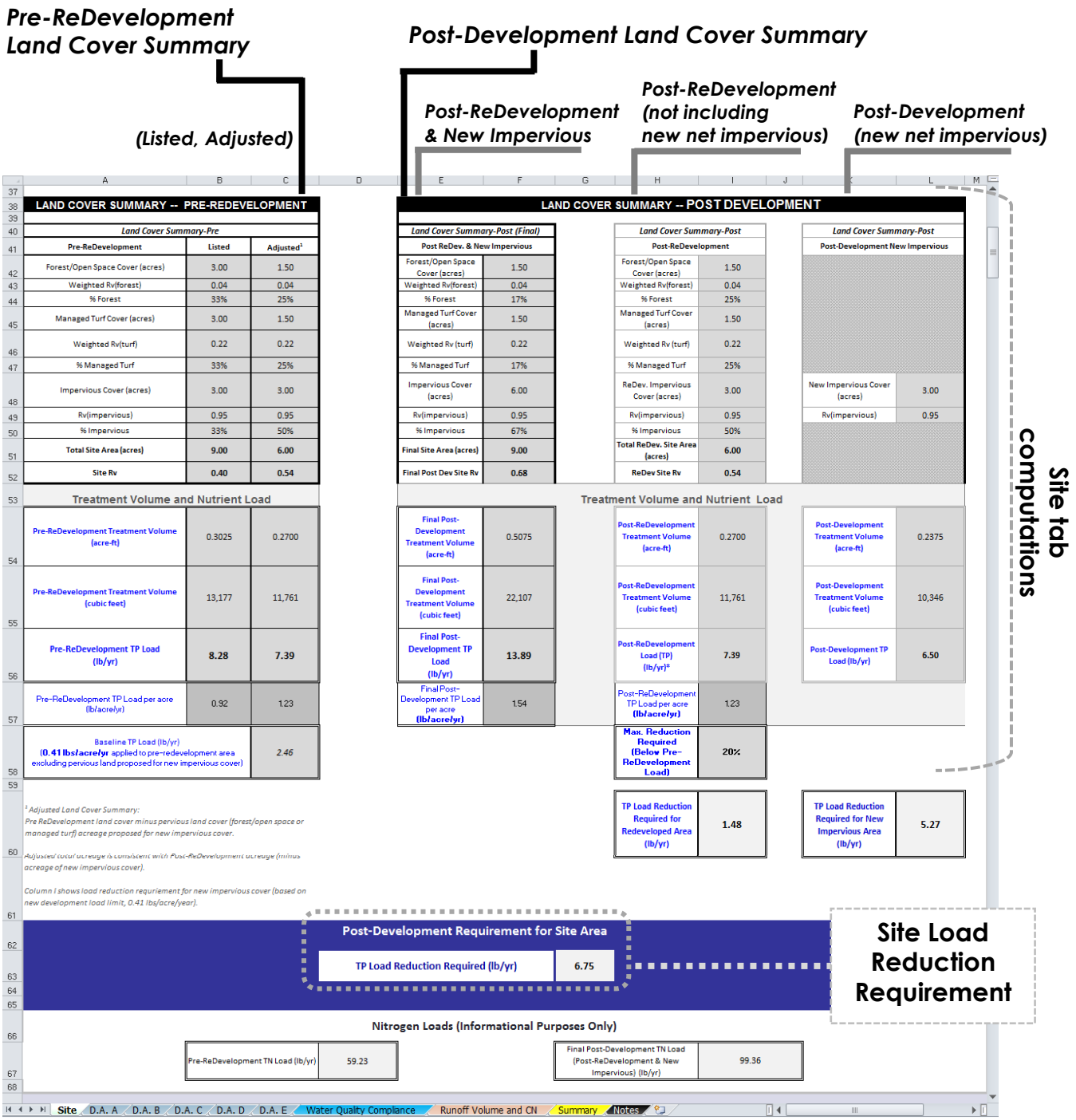


Figure 6. VRRM ReDevelopment Site Tab (lower cells) – ***Land Cover Areas and Total Disturbed Acreage entered***

DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet - Version 3.0

◉ 2011 BMP Standards and Specifications ○ 2013 Draft BMP Standards and Specifications

Project Name:
Date:
Linear Development Project? No

CLEAR ALL (Ctrl+Shift+R)

data input cells
constant values
calculation cells
final results

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* →

Maximum reduction required:	--
The site's net increase in impervious cover (acres) is:	--
Post-Development TP Load Reduction for Site (lb/yr):	--

Check:
BMP Design Specifications List: 2011 Stds & Specs
Linear project? No
Land cover areas entered correctly? ✔
Total disturbed area entered? x *Total disturbed area missing!*

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested			3.00		3.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be			3.00		3.00
Impervious Cover (acres)			3.00		3.00
					9.00

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested			1.50		1.50 *
Managed Turf (acres) -- disturbed, graded for yards or other turf to be			1.50		1.50
Impervious Cover (acres)			6.00		6.00
Area Check	OK.	OK.	OK.	OK.	9.00

** Forest/Open Space areas must be protected in accordance with the Virginia Runoff Reduction Method*

Constants

Annual Rainfall (inches)	43
Target Rainfall Event (inches)	1.00
Total Phosphorus (TP) EMC (mg/L)	0.26
Total Nitrogen (TN) EMC (mg/L)	1.86
Target TP Load (lb/acre/yr)	0.41
Pj (unitless correction factor)	0.90

Runoff Coefficients (Rv)

	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 -- PRE-REDEVELOPMENT

Land Cover Summary-Pre		
Pre-ReDevelopment	**Listed**	**Adjusted[1]**
Forest/Open Space Cover (acres)	--	--
Weighted Rv(forest)	--	--
% Forest	--	--
Managed Turf Cover (acres)	--	--
Weighted Rv(turf)	--	--
% Managed Turf	--	--
Impervious Cover (acres)	--	--
Rv(impervious)	--	--
% Impervious	--	--
Total Site Area (acres)	--	--
Site Rv	--	--

Treatment Volume and Nutrient Load

Pre-ReDevelopment Treatment Volume (acre-ft)	--	--
Pre-ReDevelopment Treatment Volume (cubic feet)	--	--
Pre-ReDevelopment TP Load (lb/yr)	--	--
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	--	--
Baseline TP Load (lb/yr) (**0.41 lbs/acre/yr** applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		--

[1] *Adjusted Land Cover Summary:*
Pre ReDevelopment land cover minus pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.41 lbs/acre/year).

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)	
Post ReDev. & New Impervious	
Forest/Open Space Cover (acres)	--
Weighted Rv(forest)	--
% Forest	--
Managed Turf Cover (acres)	--
Weighted Rv (turf)	--
% Managed Turf	--
Impervious Cover (acres)	--
Rv(impervious)	--
% Impervious	--
Final Site Area (acres)	--
Final Post Dev Site Rv	--

Land Cover Summary-Post	
Post-ReDevelopment	
Forest/Open Space Cover (acres)	--
Weighted Rv(forest)	--
% Forest	--
Managed Turf Cover (acres)	--
Weighted Rv (turf)	--
% Managed Turf	--
ReDev. Impervious Cover (acres)	--
Rv(impervious)	--
% Impervious	--
Total ReDev. Site Area (acres)	--
ReDev Site Rv	--

Land Cover Summary-Post	
Post-Development New Impervious	
New Impervious Cover (acres)	--
Rv(impervious)	--

Treatment Volume and Nutrient Load

Final Post-Development Treatment Volume (acre-ft)	--	Post-ReDevelopment Treatment Volume (acre-ft)	--	Post-Development Treatment Volume (acre-ft)	--
Final Post-Development Treatment Volume (cubic feet)	--	Post-ReDevelopment Treatment Volume (cubic feet)	--	Post-Development Treatment Volume (cubic feet)	--
Final Post-Development TP Load (lb/yr)	--	Post-ReDevelopment Load (TP) (lb/yr)#	--	Post-Development TP Load (lb/yr)	--
Final Post-Development TP Load per acre (lb/acre/yr)	--	Post-ReDevelopment TP Load per acre (lb/acre/yr)	--		
		Max. Reduction Required (Below Pre-ReDevelopment Load)	--		

ENTER TOTAL DISTURBED AREA ABOVE!

TP Load Reduction Required for Redeveloped Area (lb/yr)	--	**TP Load Reduction Required for New Impervious Area (lb/yr)**	--

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	--

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	--	Final Post-Development TN Load (Post-ReDevelopment & New Impervious) (lb/yr)	--

Site | D.A. A | D.A. B | D.A. C | D.A. D | D.A. E | Water Quality Compliance | Runoff Volume and CN | Summary | Notes

Figure 7. VRRM ReDevelopment Site Tab (lower cells) – ***Land Cover Areas entered, Total Disturbed Acreage not entered***

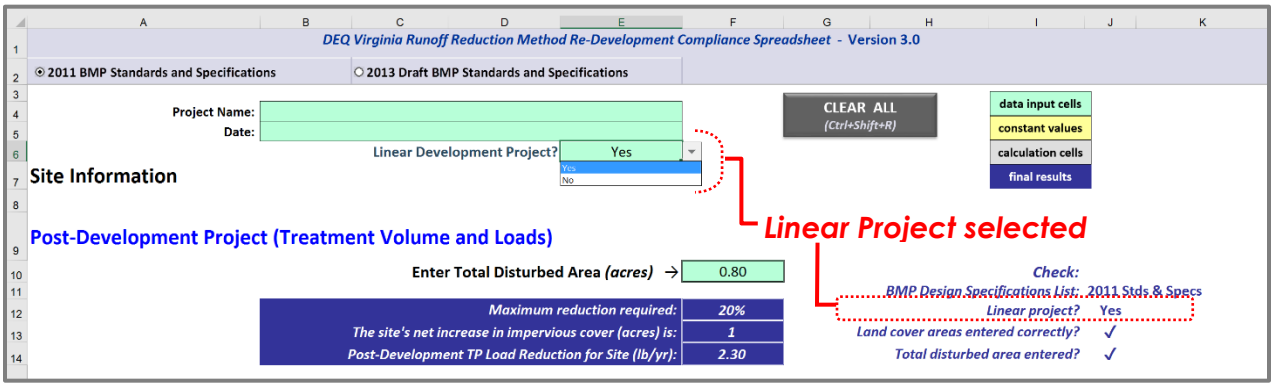


Figure 8. VRRM ReDevelopment Site Tab (upper cells) – *Linear Development Project selected*

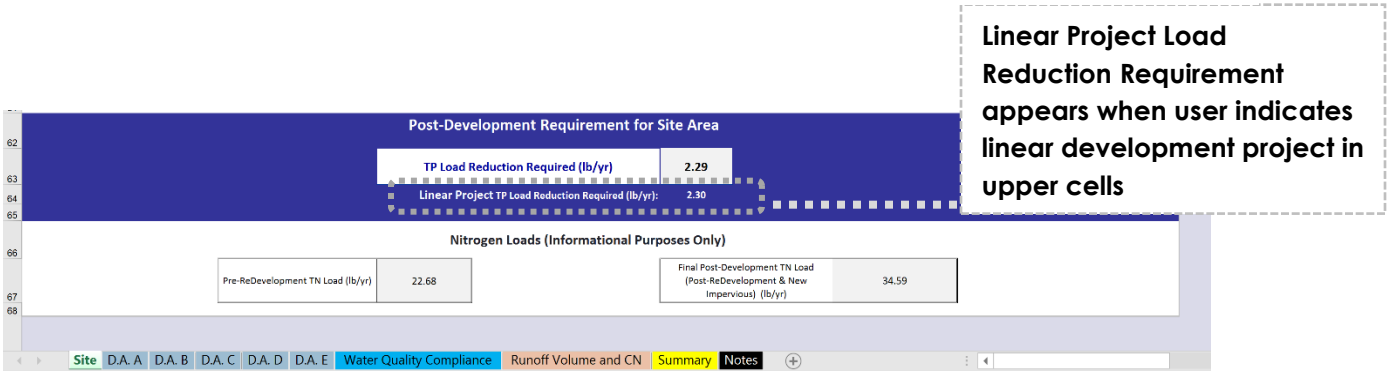


Figure 9. VRRM ReDevelopment Site Tab (lower cells) – Linear Development Project selected

4.2.2. SITE TAB (REDEVELOPMENT) – LAND COVER SUMMARIES

The ***ReDevelopment Spreadsheet*** differs from the New Development Spreadsheet in that the Land Cover Summaries (rows 38-58) are organized into land cover summary information for the pre-redevelopment condition (***Land Cover Summary-Pre***) and the post-redevelopment condition (***Land Cover Summary-Post***) (Figs. 6 and 7). In addition, both pre-redevelopment and post-development are further subdivided as follows:

Land Cover Summary-Pre

- ***Pre-ReDevelopment – Listed:*** Cells B42-B52 represent information derived directly from the pre-redevelopment land cover areas entered in rows 17-19 (Table 6).
- ***Pre-ReDevelopment – Adjusted:*** Cells C42-C52 reflect the pre-redevelopment land cover areas entered in rows 17-19 after excluding pervious areas (Forest/Open Space and/or Managed Turf) that will be converted to new net impervious cover (Table 7). If there is no post-development increase in net impervious cover, then there is no adjustment to the land cover areas entered by the user for pre-redevelopment, and the adjusted cells are the same as the listed cells.

  The Adjusted Pre-ReDevelopment data are needed to compute the site's baseline TP load (cell C58, based on 0.41 lb/acre/year applied to the pre-redevelopment area excluding pervious land proposed for new impervious cover).

Land Cover Summary-Post

- ***(Final) Post-ReDevelopment & New Impervious:*** Cells F42-F52 represent the entire post-development site, which is the combination of the post-redevelopment land cover areas and any new net impervious cover area (Table 8).
- ***Post-ReDevelopment:*** Cells I42-I52 represent the post-development land cover areas entered in rows 24-26 excluding any new net impervious cover area (Table 9).
- ***Post-Development New Impervious:*** Cells L48-L49 represent the post-development new net impervious cover (Table 10).

The ***Listed*** and ***Adjusted Pre-ReDevelopment*** computed site data in the ***Land Cover Summary-Pre*** section of the **Site tab** is needed to facilitate the computation of distinct water quality criteria applicable to different portions of the site in a single spreadsheet, without overlap.

Tables 6 to 10 list the computational areas of the ***ReDevelopment*** **Site tab** with cell references. Brief descriptions are included where differences exist with the ***New Development*** **Site tab**.

Table 6. Site Tab Computations for Land Cover Summary (Pre-ReDevelopment, Listed)

Site Tab Computations **Land Cover Summary – Pre ReDevelopment (Listed)**	Cell Reference Column B
The land cover summary for the existing conditions (prior developed lands):	
Totals: Forest/Open Space, Managed Turf, Impervious Cover (acres)	**B42** (F/O) **B45** (MT) **B48** (IC)
Weighted Rv for Forest/Open, Managed Turf, Impervious Cover	**B43** (F/O) **B46** (MT) **B49** (IC)
%Forest/Open, %Managed Turf, %Impervious Cover	**B44** (F/O) **B47** (MT) **B50** (IC)
Total Site Area (acres)	**B51**
Site Rv	**B52**
Treatment Volume	**B54** (acre-ft) **B55** (cf)
Pre-ReDevelopment TP Load Site pre-redevelopment TP load computed using the Simple Method based on the annual rainfall, and the TP EMC value (0.26 mg/L TP).	**B56** (lb/yr)
The lb/acre/yr TP loading rate is also included for comparison purposes.	**B57** (lb/acre/yr)

Table 7. Site Tab Computations for Land Cover Summary (Pre-ReDevelopment, Adjusted)

Site Tab Computations **Land Cover Summary – Pre ReDevelopment (Adjusted)**	Cell Reference **Column C**
Where redevelopment results in a net increase in impervious cover, the existing land cover data is adjusted by subtracting out any pervious acreage proposed for new net impervious cover, if applicable. For redevelopment that does *not* result in a net increase in impervious cover, the Adjusted and Listed Land Cover Summaries are the same.	
Totals: Forest/Open Space, Managed Turf, Impervious Cover (acres)	**C42** (F/O) **C45** (MT) **C48** (IC)
Weighted Rv for Forest/Open, Managed Turf, Impervious Cover	**C43** (F/O) **C46** (MT) **C49** (IC)
%Forest/Open, %Managed Turf, %Impervious Cover	**C44** (F/O) **C47** (MT) **C50** (IC)
Total Site Area (acres)	**C51**
Site Rv	**C52**
Treatment Volume	**C54** (acre-ft) **C55** (cf)
Pre-Re-Development TP Load Adjusted site pre-redevelopment TP load using the adjusted land cover areas.	**C56** (lb/yr)
The lb/acre/yr TP loading rate is also included for comparison purposes.	**C57** (lb/acre/yr)
Baseline TP Load (lb/yr) The new development TP standard of 0.41 lb/acre/yr is applied to the adjusted pre-redevelopment total site area (existing area excluding pervious areas proposed as new net impervious cover). This is also the baseline TP load for the post-redevelopment area excluding new net impervious cover.	**C58**

Table 8. Site Tab Computations for Land Cover Summary (Final Post-Development)

Site Tab Computations **Land Cover Summary – Post *(Final)***	Cell Reference **Column F**
The final post development land cover summary represents the total site area (all land cover areas including new net impervious cover).	
Totals: Forest/Open Space, Managed Turf, Impervious Cover (acres)	**F42** (F/O) **F45** (MT) **F48** (IC)
Weighted Rv for Forest/Open, Managed Turf, Impervious Cover	**F43** (F/O) **F46** (MT) **F49** (IC)
%Forest/Open, %Managed Turf, %Impervious Cover	**F44** (F/O) **F47** (MT) **F50** (IC)
Final Site Area (acres)	**F51**
Final Post Dev Site Rv	**F52**
Final Post-Development Treatment Volume	**F54** (acre-ft) **F55** (cf)
Final Post-Development TP Load Site post-redevelopment TP load (excluding new net impervious cover). The TP loading rate (lb/acre/yr) is also included for comparison purposes.	**F56** (lb/yr) **F57** (lb/acre/yr)

Table 9. Site Tab Computations for Land Cover Summary (Post-ReDevelopment)

Site Tab Computations **Land Cover Summary – Post ReDevelopment**	Cell Reference **Column I**
The post-redevelopment land cover summary represents the land cover area entered by the user as post-redevelopment, not including new net impervious cover.	
Totals: Forest/Open Space, Managed Turf, Impervious Cover (acres)	**I42** (F/O) **I45** (MT) **I48** (IC)
Weighted Rv for Forest/Open, Managed Turf, Impervious Cover	**I43** (F/O) **I46** (MT) **I49** (IC)
%Forest/Open, %Managed Turf, %Impervious Cover	**I44** (F/O) **I47** (MT) **I50** (IC)
Total ReDev Site Area (acres)	**I51**
ReDev Site Rv	**I52**
Post-ReDevelopment Treatment Volume	**I54** (acre-ft) **I55** (cf)
Post-ReDevelopment TP Load Site post-redevelopment TP load (excluding new net impervious cover). The lb/acre/yr TP loading rate is also included for comparison purposes.	**I56** (lb/yr) **I57** (lb/acre/yr)
Max. Reduction Required (Below Pre-ReDevelopment Load) The applicable percent reduction standard (based on the Total Disturbed Acreage **(cell F10)** entered by the user).	**I58** (10 or 20%)
TP Load Reduction Required for Redeveloped Area (lb/yr) The TP load reduction requirement for the redeveloped area (proposed site not including new net impervious cover) If the adjusted pre-redevelopment TP load after application of the required percent reduction is below the baseline load for the adjusted pre-redevelopment area, then: - The required post-development load cannot be less than the baseline load unless a more stringent standard has been established by a local VSMP authority. - A notification just below **cell I60** will appear: ***Reduction below baseline TP Load (0.41 lb/acres) not required**	**I60** *Equations 22a & 22b*

Table 10. Site Tab Computations for Land Cover Summary (Post-ReDevelopment, New Impervious)

Site Tab Computations **Land Cover Summary – Post ReDevelopment** **New Impervious**	**Cell Reference** **Column L**
The post-redevelopment land cover summary for any new net impervious cover (populates only when there is an increase in net impervious cover).	
Totals: New Impervious Cover (acres)	**L48**
Rv for Impervious Cover	**L49**
Post-Development Treatment Volume	**L54** (acre-ft) **L55** (cf)
Post-Development TP Load Post-development TP load for new net impervious cover.	**L56** (lb/yr)
TP Load Reduction for New Impervious Area (lb/yr) The required TP load reduction for new net impervious area based on the new development TP load limit of 0.41 lb/acre/yr (*9VAC25-870-63 A 2 c*). *Equations 19 and 20*	**L60**

4.2.3. SITE TAB (REDEVELOPMENT) – WATER QUALITY REQUIREMENTS

There are two water quality criteria for redevelopment projects under the VSMP regulations (*9VAC25-870-63 A 2 a to c*). Compliance is achieved as follows:

- For new net impervious cover (cell L60), the total phosphorus load must be reduced to meet the new development criteria of 0.41 lb TP/acre/yr, and
- For the remaining site area (not including any new net impervious cover), the total phosphorus load must be reduced to either 10 or 20% below the pre-redevelopment total phosphorus load, depending on the project's total disturbed acreage (cell I60). The reduction requirement is either:
  - 10% if the total disturbed acreage is less than 1 acre, or
  - 20% if the total disturbed acreage is greater than or equal to 1 acre.
  - *Both of these reduction requirements are limited in that a reduction to below the applicable standard for new development (0.41 lb TP/acre/yr cannot be required unless a more stringent standard is established by a local VSMP authority) (9VAC25-870-63 A 2 e).*

The ***ReDevelopment spreadsheet*** automatically calculates the required reductions as soon as the total disturbed area and land cover areas are entered with no errors (See Table 11).

The rest of this section further explains and highlights the logic used for the redevelopment load computations. The area and load equations (Eq. 19-23) and a decision flowchart for the spreadsheet computations (Fig. 28) are provided in Section 9.4.

Table 11. Site Tab Computations for Total Site Area Post-Development

Site Tab Computations **Post-Development Requirement for Total Site Area**	Cell Reference Indigo Cells
TP Load Reduction Required (lb/yr) The total phosphorus load reduction that must be met to comply with the water quality requirements for redevelopment: The post-development load reduction requirement equals the reduction required for the redeveloped area (excluding pervious area conversions to net impervious cover) listed in **cell I60** plus the reduction required to meet the new development standard for any new net impervious cover listed in **cell L60**. The required post-development load cannot be less than the post-development baseline load (0.41 lb TP/acre/yr) unless a more stringent standard has been established by a local VSMP authority. - A notification in **cells H63-I63** or or for linear projects, **H64-I64** will appear when: ***** TP LOAD REDUCTION NOT REQUIRED*** *Equation 23*	**G63** **G64 (linear)**
Nitrogen Summary (Informational Purposes) (lb/yr) TN loads provided for informational purposes only: Pre-ReDevelopment TN load Post-ReDevelopment + Post Development (New Impervious) TN Load	 **D67** **I67**

In order to calculate the TP load requirement for the redevelopment project, it is necessary to establish:

1) The increase in net impervious cover proposed (if applicable),
2) The pervious land cover areas (Forest/Open Space and/or Managed Turf) that will be converted to new net impervious cover (if any), and as applicable,
3) The minimum regulatory (or baseline) TP load for the adjusted total site area (pre-redevelopment site area not including pervious areas converted to impervious cover).
4) The least stringent TP load requirement for the post-redevelopment site area (not including any new net impervious area, if applicable).

These three necessary steps for the computation of the TP load requirement are explained in detail below:

1) ***The increase in net impervious cover proposed (if applicable)*** (cell L48) is determined in order to apply the new development 0.41 lb/acre/yr TP load limitation to any new net increases in impervious cover as per *9VAC25-870-63 A 2 c*. (see also Eq. 19 in Section 9.4),

2) ***The pervious land cover areas (Forest/Open Space and/or Managed Turf) that will be converted to new net impervious cover (if applicable)*** are determined for exclusion from the pre-redevelopment TP load calculation (adjusted pre-redevelopment) to ensure that both water quality criteria are not simultaneously applied to new net impervious cover areas.

   The net decrease in pervious land cover areas occurs as a result of the net increase in impervious cover (Fig. 10). *The total pre-redevelopment and post-development site acreages (*cell F20 *and* F27*), which sum the user input pre- and post-redevelopment land cover areas (*rows 17-19 *and* 24-26*, respectively), must be equal in order to enable the spreadsheet computation of the appropriate load requirements.*

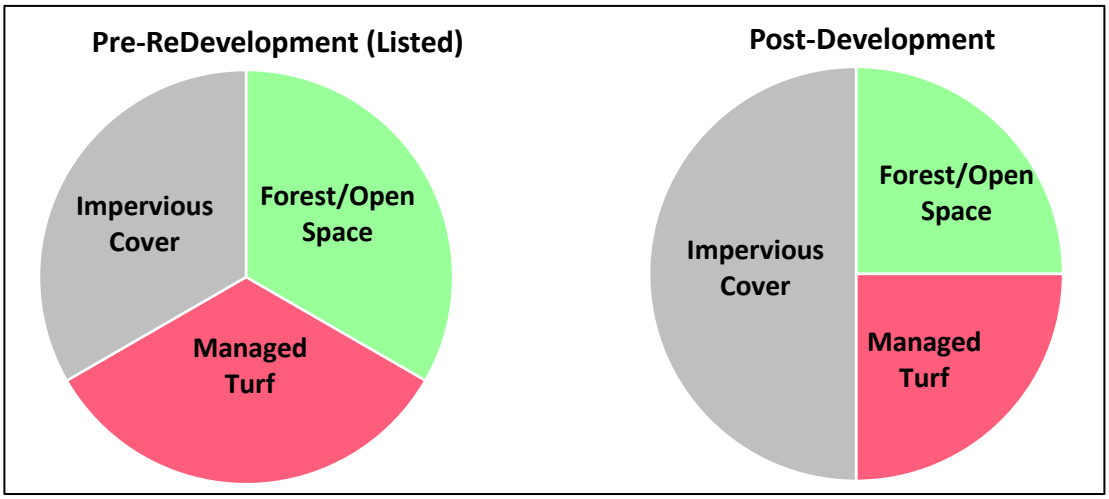


Figure 10. User listed pre-redevelopment and post-development land cover areas.

The pervious areas that are converted to impervious cover are excluded from the adjusted pre-redevelopment areas (cells C42 and C45) and the pre-redevelopment TP load (Fig. 11). The equation used to determine the net decrease in pervious areas (Eq. 21) and decision flowchart (Fig. 28) for the spreadsheet computation are presented in Section 9.4.1.

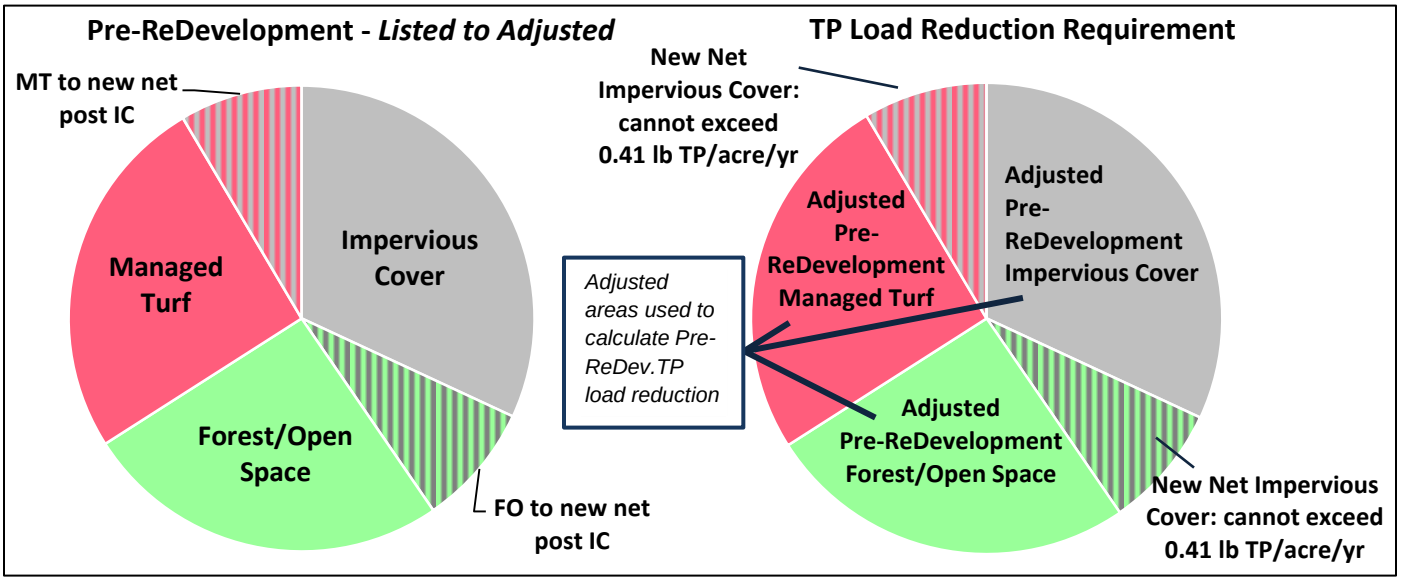


Figure 11. Pre-redevelopment land cover areas showing changes from *Listed* to *Adjusted* spreadsheet land cover areas and applicable TP load reduction requirements

3) ***The minimum regulatory (or baseline) TP load for the adjusted pre-redevelopment area*** is the new development standard of 0.41 lb TP/acre/yr multiplied by the adjusted total site acreage, cell C58. The adjusted pre-redevelopment area equals the post-redevelopment area minus any new net impervious area, if applicable. This baseline TP load is the most stringent load that can be required for water quality compliance of the post-redevelopment area (not including any new net impervious area, if applicable).

4) The target TP load of the pre-redevelopment adjusted area (*the TP load after 10 or 20% reduction, i.e., 80 or 90% of the TP load for the pre-redevelopment adjusted area, respectively*), is compared to the baseline TP load, and the least stringent becomes the required compliance load for the post-redevelopment area, not including any new net impervious area, if applicable.

The regulations do not require a post-development TP load below the new development standard of 0.41 lb TP/acre/yr for any part of the site, unless a more stringent standard has been established by the VSMP authority.

Two examples are graphically represented in Fig. 12 to illustrate when each of the two different load reduction requirements apply. Both examples show TP loads for re-development sites with more than one acre of disturbance. Example 1 in Fig. 12 shows a site where the adjusted pre-redevelopment TP load reduced by 20% (orange, short-dashed line) is the required post-development compliance load (with no net increases in impervious cover). Example 2 in Fig. 12 shows a site where the new development criteria of 0.41 lb TP/acre/yr (black, long-dashed line) applied to the pre-redevelopment adjusted site area is the required post-development compliance load (with no net increases in impervious cover). See also Eqns. 22a and 22b in Section 9.4.1.

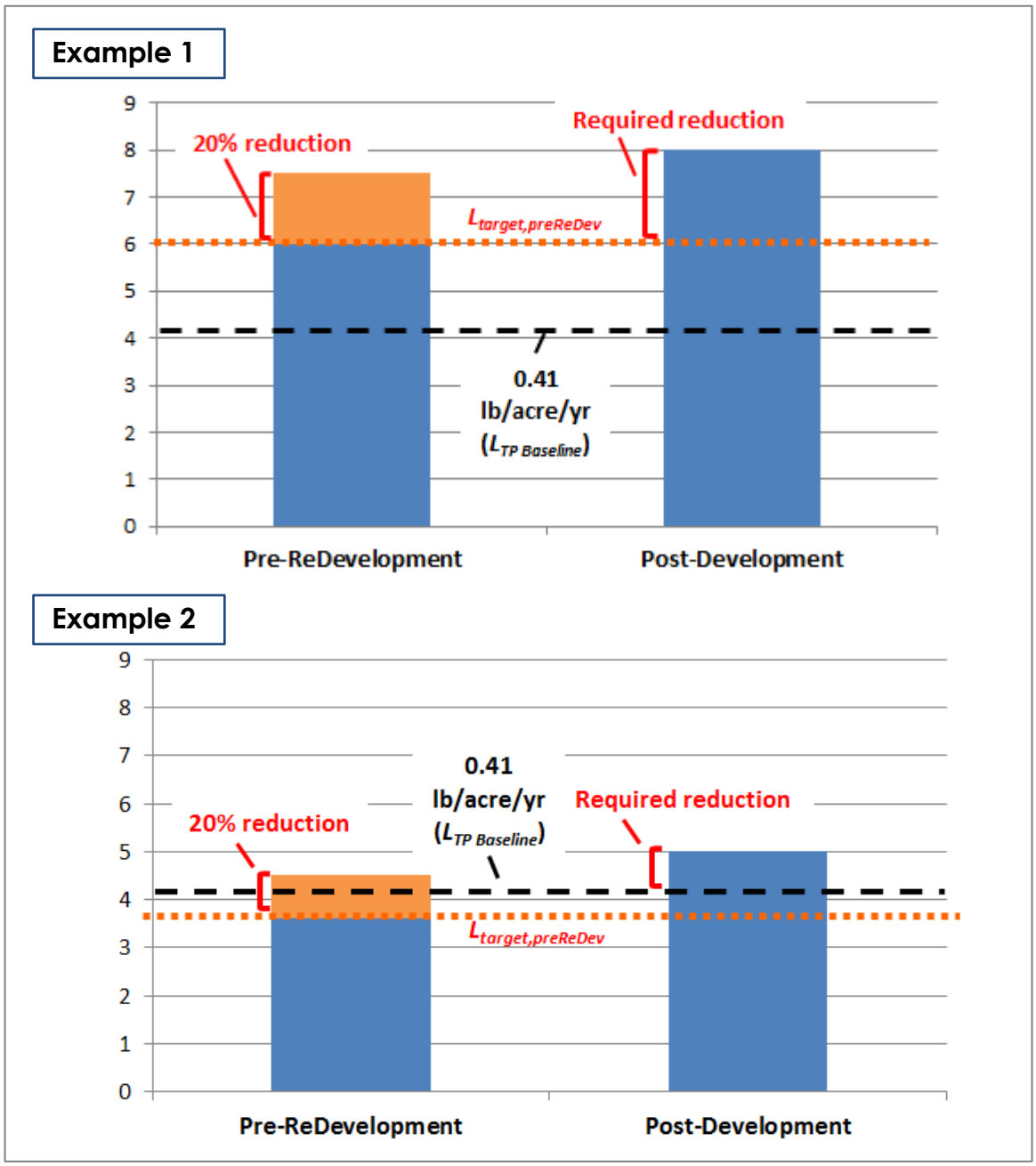


Figure 12. Reduction requirements for redevelopment projects (no new net impervious cover)

Using the VRRM spreadsheet *(Re-Development Site tab)*

RD1. Select either the 2011 or the Draft 2013 BMP Stds and Specs (**row 2**)

RD2. Enter Total Disturbed Acreage (**cell F10**)

RD3. Enter Pre-ReDevelopment land cover based on existing conditions (conditions at time application submitted).

RD4. Enter Post-ReDevelopment Land Cover based on proposed conditions.

RD5. Any error notifications (**cells H10-K13**) or Check Areas! messages (**row 27**) must be resolved before proceeding.

RD6. Take note of the **Indigo Cells** indicating maximum reduction required (**cell F12**), the site's net increase in impervious cover (**cell F13**), the post-development TP reduction requirement in **cell F14** and also **G63** within the indigo results section (**rows 62-65**).

a. As noted in Step 6 for New Development, the post-development TP reduction requirement is a site-based water quality requirement and can be met using various **Drainage Area tab** load reduction combinations.

b. Depending on the post-development and pre-redevelopment land cover areas, TP load reduction within the **Drainage Area tabs** may or may not be needed to meet water quality compliance requirements.

If the post-redevelopment TP load, **cell I56**, (which excludes new net impervious cover) is less than the target pre-redevelopment TP load or the TP baseline (see Equations 22a and 22b), then no further TP load reduction is required for the redevelopment portion of the site, and:

i. A TP load credit will appear as a negative value in **cell I60**

(see Section 9.4 for more information)

ii. If sufficient, such load credit will be applied to offset TP reduction requirements for any new net impervious cover (**cell L60**) which will reduce the TP load reduction requirement for the total site (**cell G63**).

5.0 DRAINAGE AREA (D.A.) TABS

The VRRM spreadsheet contains five **Drainage Area tabs** (**D.A. A to E**) that allow the user to enter land cover data (land cover type by HSGs) for separate **Drainage Area tabs (D.A. tabs)** and to select stormwater BMPs for water quality compliance via runoff volume reduction, pollutant removal, or both (Fig. 13). The **D.A. tabs** do not reference each other, but the information and computations within each **Drainage Area tab** are combined in the **Water Quality Compliance tab**, the **Runoff Volume and CN tab**, and the **Summary tab**.

Using the VRRM spreadsheet *(Drainage Area tab)*

8. Determine how many **Drainage Area tabs** are to be used to evaluate site water quality compliance. Site compliance may be achieved within one drainage area, a portion of a drainage area, or in multiple drainage areas (limited by the TP load available per drainage area):

a. Each **Drainage Area tab** can reflect a site drainage area with a distinct discharge point from the site, or

b. Similar BMP credit areas for the same type of practice(s) (areas of the site draining to specific BMPs or BMP treatment trains) can be grouped together on one **Drainage Area tab** even if they exist within different site drainage areas as long as:

   i. Treatment volumes for each individual BMP (TV_{BMP}) are calculated separately; and

   ii. Any managed turf areas draining to separate BMPs within a grouping must have the same runoff coefficient, i.e., different managed turf areas must all have the same HSG configurations (total areas per HSG*)* in order to be grouped together.

   (only applied when managed turf areas are draining to more than one practice in the grouping).

c. Nutrient removal within each **Drainage Area tab** is limited by the nutrient available for removal within that **Drainage Area tab** (varies with load generated for that **Drainage Area tab**, which is based on user inputs for **D.A. tab** land cover types by HSGs). TP available for removal is computed in **cell M7** within each **Drainage Area tab**.

d. Discretion should be exercised if drainage areas or sub-drainage areas with different flow path times of concentration (Tc) are grouped together in a single **D.A. tab.**

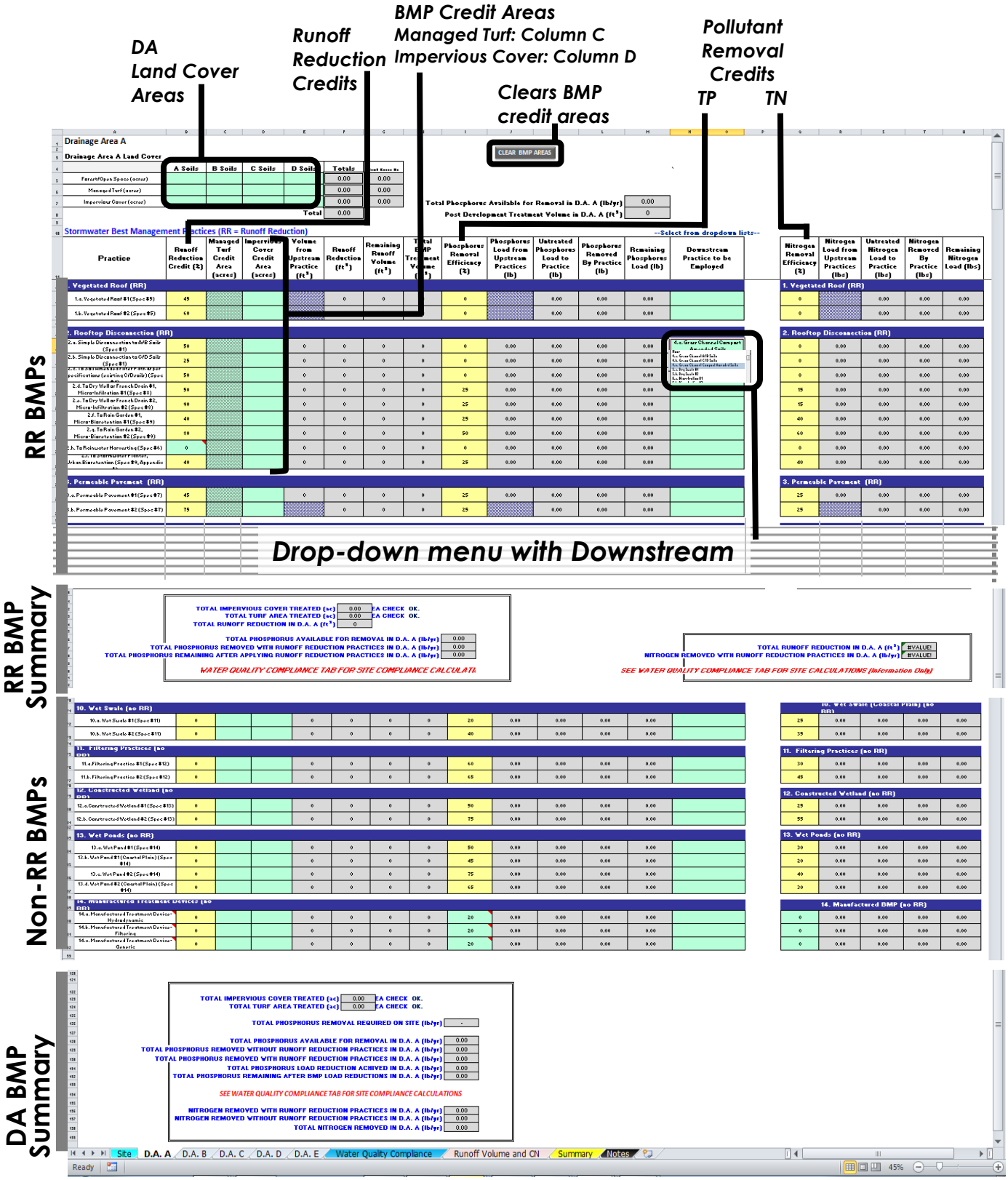


Figure 13. Drainage Area Tab (sections)

5.1. DRAINAGE AREA TAB LAND COVER AREAS

The land cover data at the top of the **Drainage Area tab** is similar to that on the **Site tab** in that acreages are entered for each land cover type by HSGs (Fig. 14). If only one **Drainage Area tab** is used to evaluate water quality compliance for the entire site, then the land cover data on the **Drainage Area tab** should match the land cover data on the **Site tab**. Alternatively, the sum of land cover data entered on multiple **Drainage Area tabs** should equal the land cover data entered on the **Site tab**. For the ReDevelopment Spreadsheet, the total land cover inputs **on all Drainage Area tabs** used should equal the post-development land cover data entered on the **Site tab**.

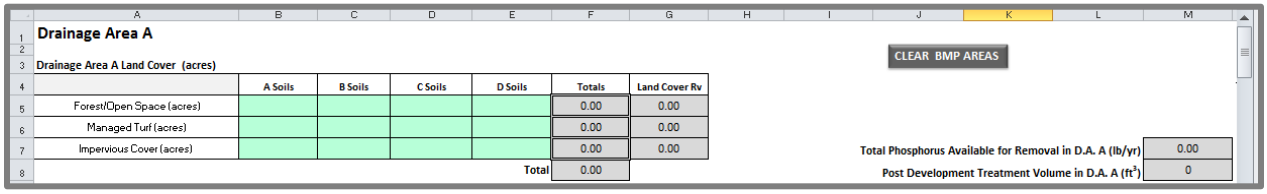


Figure 14. Drainage Area Tab, Land Cover Areas

Using the VRRM spreadsheet *(Drainage Area tab – Land Cover Areas)*

9. Click on the **CLEAR BMP AREAS** button to reset all BMP credit areas to zero.
10. Enter land cover data in **cells B5 to E7** at the top of the **Drainage Area tab** (acreages entered for each land cover type by HSGs). The land cover data must be entered on the **Drainage Area tab** in order to allow all of the **grey cells** to auto-calculate in this tab and within other tabs (e.g., **Water Quality Compliance tab, Runoff Volume and CN tab**).

    Note that the **CLEAR BMP AREAS** *button does not clear land cover data (***B5 to E7***), which may only change slightly if users are trying different BMP configurations within the* **Drainage Area tab***.*

5.2. DRAINAGE AREA LAND COVER SUMMARY

The computations at the top of the **Drainage Area tab** (Fig. 14 and Table 12) provide land cover summary information, treatment volume, and total phosphorus loading for the overall **Drainage Area tab**.

Table 12. Drainage Area Tab Computations for Land Cover Summary

Drainage Area Tab Computations – Land Cover Summary	Cell Reference Grey Cells
Forest/Open Space, Managed Turf, Impervious Cover (acres) Sums of each land cover type area across hydrologic soil groups.	**F5** (F/O) **F6** (MT) **F7** (IC)
Total Land Cover Area (acres) Area summed across land cover types and HSGs	**F8**
Weighted Rv for Forest/Open, Managed Turf, Impervious Cover* Runoff coefficient for each land cover type weighted across HSGs **Runoff coefficient for impervious cover is independent of HSGs*	**G5** (F/O) **G6** (MT) **G7** (IC)
Total Phosphorus Available for Removal in DA (lb/yr) The post-development TP load generated from MT and IC areas and thus available for removal from the Drainage Area tab. Similar to loads calculated on the Site tab, D.A. loads are computed using the Simple Method and based on annual rainfall, and nutrient EMC values (0.26 mg/L TP, 1.86 mg/L TN). This D.A. TP load available for removal does not include loads generated from F/O areas. *Equation 7* *(Note: TP releases from F/O areas unlikely in form that can be practically removed via current BMP technology; Computed TP loads from F/O areas are approximately 0.01 lb TP/acre/yr and far below the new development load limit of 0.41 lb TP/acre/yr)*	**M7**
Post-Development Treatment Volume from DA (ft^3) Post-development treatment volume available for runoff reduction within the D.A. tab land cover area (MT and IC areas only**). *Equation 6* ***F/O areas used for curve number calculations computed on the Runoff Vol CN tab.*	**M8** (cf)

5.3. DRAINAGE AREA TAB STORMWATER BMPS

Whereas environmental site design principles can be applied to a site, in terms of proposed land cover types (i.e., maximizing forest/open space and permeable soils and minimizing managed turf and impervious cover over impacted soils), often additional measures are required to meet water quality site compliance. All or a portion of a site or site's drainage area can be treated using non-proprietary or proprietary stormwater management facilities approved by DEQ for use in Virginia. Stormwater management facilities are also referred to as stormwater best management practices (BMPs) and are listed along with their approved runoff removal credits, treatment efficiencies and design specifications in the 2011 or Draft 2013 BMP Standards and Specifications (see Section 1.0).

The approved BMPs are listed in two groups: I) Stormwater BMPs with Runoff Reduction (see 5.3.2, Table 13), and II) Stormwater BMPs with No Runoff Reduction (see 5.3.3, Table 14). Group I practices are able to reduce the pollutant load through volume reduction of the site's runoff or site's treatment volume and possibly also through a reduction of the runoff pollutant concentration via non-volumetric pollutant removal treatment (e.g., settling or filtration). Group II practices are limited to non-volumetric pollutant removal treatment for pollutant load reductions. The BMPs are thus grouped to highlight those practices that provide runoff volume reduction (first half) and those that do not. This grouping is used in the BMP list provided in Tables 13 and 14, reflected in both VRRM spreadsheets.

5.3.1. BMP DESIGN LEVELS

Several of the BMPs can be constructed to two different design level standards, typically with differing runoff removal credits and/or treatment removal efficiencies. The Level 1 and Level 2 design standards are included in the BMP design specifications and are individually indicated after the BMP name where they apply as #1 (Level 1) and #2 (Level 2) in column A of the **Drainage Area tab**. Each BMP's approved runoff removal credit is listed in column B. The approved treatment removal efficiencies are listed in column I (Total Phosphorus) and column Q (Total Nitrogen).

It is important to review and understand the design criteria associated with the Level 1 and Level 2 designations. Whereas the Level 2 practices will generally provide greater load reductions, they may also require a larger footprint, specific soil conditions, greater engineering effort, and other factors for correct implementation. BMP selection and design guidance, including designated Level 1 and Level 2 criteria, can be found in the BMP Standards and Specifications.

5.3.2. RUNOFF REDUCTION BMPS

Table 13. Stormwater Best Management Practices – with Runoff Reduction

I. Stormwater BMPs with Runoff Reduction (Pollutant removal via runoff reduction w/wo non-volumetric treatment)	**BMP Design Spec. (DA Tab Cell Ref.)**
1. Vegetated Roof a. Vegetated Roof #1 b. Vegetated Roof #2	Spec. No. 5 **(rows 13-14)**
2. Rooftop Disconnection a. Simple Disconnection to A/B Soils b. Simple Disconnection to C/D Soils c. Alternative Practice Disconnection to C/D soils with Soil Amended Filter Path d. Alternative Practice Disconnection to Dry Well/French Drain #1 e. Alternative Practice Disconnection to Dry Well/French Drain #2 f. Alternative Practice Disconnection to Rain Garden #1 g. Alternative Practice Disconnection to Rain Garden #2 h. Alternative Practice Disconnection to Rainwater Harvesting* i. Alternative Practice Disconnection to Stormwater Planter	Spec. No. 1 **(rows 17-25)**
3. Permeable pavement a. Permeable pavement #1 b. Permeable pavement #2	Spec. No. 7 **(rows 28-29)**
4. Grass channel a. Grass Channel A/B Soils b. Grass Channel C/D Soils c. Grass Channel with Compost Amended Soils	Spec. No. 3 **(rows 32-34)**
5. Dry swale a. Dry swale #1 b. Dry swale #2	Spec. No. 10 **(rows 37-38)**
6. Bioretention a. Bioretention #1 or Micro-Bioretention #1 or Urban Bioretention b. Bioretention #2 or Micro-Bioretention #2	Spec. No. 9 **(rows 41-42)**
7. Infiltration a. Infiltration #1 b. Infiltration #2	Spec. No. 8 **(rows 45-46)**
8. Extended detention pond a. ED #1 b. ED #2	Spec. No. 15 **(rows 49-50)**
9. Sheetflow to Filter/Open Space a. Sheetflow to Conservation Area with A/B Soils b. Sheetflow to Conservation Area with C/D Soils c. Sheetflow to Vegetated Filter Strip in A Soils or Compost Amended B/C/D Soils (and Spec. No. 4)	Spec. No. 2 **(rows 53-55)**

**** Rainwater Harvesting BMP (Spec.6) restricted to rooftop disconnection option (see 2h above & VRRM spreadsheets).***

5.3.3. NON-RUNOFF REDUCTION BMPS

Table 14. Stormwater Best Management Practices – No Runoff Reduction

II. Stormwater BMPs with No Runoff Reduction (Pollutant removal through non-volumetric treatment)	**BMP Design Specification (DA Tab Cell Reference)**
10. Wet Swale a. Wet Swale #1 b. Wet Swale #2	Spec. No. 11 **(rows 72-73)**
11. Filtering Practices a. Filtering Practice #1 b. Filtering Practice #2	Spec. No. 12 **(rows 76-77)**
12. Constructed Wetland a. Constructed Wetland #1 b. Constructed Wetland #2	Spec. No. 13 **(rows 80-81)**
13. Wet Ponds a. Wet Pond #1 b. Wet Pond #1 (Coastal Plain) c. Wet Pond #2 d. Wet Pond #2 (Coastal Plain)	Spec. No. 14 **(rows 84-87)**
14. Manufactured Treatment Devices (MTDs) a. Manufactured Treatment Device-Hydrodynamic b. Manufactured Treatment Device-Filtering c. Manufactured Treatment Device-Generic	Links to individual MTD specifications available on: VA SWM BMP Clearinghouse **(rows 90-92)**

Using the VRRM spreadsheet *(Drainage Area tab – BMP selection)*

11. Select runoff reduction BMPs (top half of **Drainage Area tab**) and then, if necessary, non-runoff reduction pollutant removal BMPs (bottom half of **Drainage Area tab**), which can include proprietary BMPs listed as Manufactured Treatment Devices.

Starting the BMP selection process with runoff reducing BMPs followed by non-runoff reducing pollutant removal BMPs (and then utilizing a stepwise iterative process back to ESD principles) is consistent with the VRRM.

12. Find the appropriate **rows** for the selected BMP(s) and enter the contributing drainage areas in acres to each of the selected BMP(s) in the Credit Area **cells** (**column C** for Managed Turf and **column D** for Impervious Cover). Impervious Cover and Managed Turf areas must be entered separately for each BMP:

a. Forest/Open Space is not treated by BMPs in accordance with the VRRM, but surface areas of certain BMPs can qualify as Forest/Open Space as per the VRRM land cover type definitions (Table 1) and should be entered accordingly in the Land Cover Area sections within both the **Drainage Area tab** and the **Site tab**.

   i. Natural undisturbed vegetated areas can be preserved and protected for certain BMP installations in accordance with design specifications (e.g., sheetflow to Forest/Open Space, BMP Design Spec. 2); or

   ii. Land cover conversions can be performed to transform areas to one of the non-proprietary BMPs (e.g., buffer areas can be reforested as conservation areas or vegetated filter strips, managed turf can be transitioned to forest/open space via soil amendments and natural vegetation; see VRRM Land Cover Definitions and BMP Specifications for additional details).

   iii. Increasing Forest/Open Space results in a reduction of generated runoff volume and consequently nutrient load for the individual **Drainage Area tab(s)** and **Site tab.**

   Vegetated Roof, Rooftop Disconnection, and Permeable Pavement allow credit area entries for only impervious areas.

b. Rooftop Disconnection to Rainwater Harvesting (2.h., Spec. No. 1) requires the user to enter a runoff volume reduction credit (**cell B24**), which is determined separately using the Cistern Design Spreadsheet (see

Virginia Stormwater BMP Clearinghouse) or a similar method that configures cistern sizing with water budget development.

c. Manufactured Treatment Devices (MTDs) (**rows 90-92**) require user entries for phosphorus removal efficiencies. The efficiencies entered for specific MTD(s) planned for use should match the DEQ approved efficiencies published on the Virginia Stormwater BMP Clearinghouse website (under Proprietary BMPs section):

13. If BMP's are to be used in series (e.g., treatment trains):

a. The credit area draining directly to a BMP should be entered only once. The next BMP in the treatment train is selected in the same **row** as the previous receiving practice from the pull down menu of the Downstream Practice (**columns N-O**).

A down arrow will appear at the bottom right of the **cell** *Downstream Practice to be Employed once that* **cell** *is selected. Clicking the arrow will allow the user to scroll and select from the menu of practice options applicable to the upstream BMP.*

b. The previous step can be repeated if additional BMPs are used in the treatment train.

5.3.4. DRAINAGE AREA TAB BMP COMPUTATIONS

As the user inputs BMP Credit Areas (columns C and D), volume and loading information for the selected BMP auto-populate in the **grey cells** of the same worksheet row (Table 15-17). Runoff/treatment volumes and pollutant loads generated by contributing drainage area to each practice are calculated using weighted land cover coefficients for Managed Turf and Impervious Cover only. Under VRRM, BMPs do not receive credit for treating Forest/Open Space areas.

Table 15. Drainage Area Tab Volume Computations per BMP

Drainage Area *Volume* Computations for each selected BMP	**Cell References** **Grey Cells**
Volume from Upstream RR Practice (ft^3) The runoff volume entering the selected BMP from an upstream practice (provided only when BMPs used in series). *If upstream practice used: Equals remaining runoff volume (**column G**) from applicable upstream practice (auto-populates).* *If **no** upstream practice used: Equals zero.*	**Column E**
Runoff Reduction (ft^3) The runoff volume reduction achieved by the selected BMP. *Equals the volume entering the practice multiplied by the runoff reduction credit.* *Equation 9*	**Column F**
Remaining Runoff Volume (ft^3) The runoff volume exiting the selected BMP (for non-RR BMPS, this is the same as the runoff volume entering practice). *Equals the volume entering the practice multiplied by the proportion of runoff not being reduced (1 – runoff reduction credit).* *Equation 10*	**Column G**
Total BMP Treatment Volume (ft^3) The total runoff volume entering the practice (runoff generated by the contributing drainage area [turf and impervious areas only] to the selected BMP plus the runoff volume being received by an upstream practice [if any]. *Reflects the minimum volume that the BMP must be sized for water quality treatment. Water quantity considerations will also need to be considered.*** *Equation 11*	**Column H**

*****Rainwater Harvesting cistern sizing is in accordance with the Cistern Design Spreadsheet or a similar methodology rather than based on BMP Treatment Volume.***

Table 16. Drainage Area Tab TP Load Computations per BMP

Drainage Area *TP Load* Computations for each selected BMP	**Cell Reference**
Phosphorus load from upstream practice(s) (lb) The total phosphorus load entering the selected BMP from an upstream practice (if BMPs used in series). *If upstream practice used: Equals remaining phosphorus load* (**column M**) *from applicable upstream practice (auto-populates).* *If **no** upstream practice used: Equals zero.*	**Column J**
Untreated phosphorus load to practice (lb) The total phosphorus load generated by the contributing drainage area (or BMP credit area). *The load calculated using the Simple Method.* *Equation 12*	**Column K**
Phosphorus Removed By Practice (lb) The total phosphorus load removed by the practice through any combination of runoff reduction and pollutant (treatment) reduction applicable to the selected BMP. *The TP removal treatment efficiency* (**column I**) *is used to compute the proportion of phosphorus removed from the total phosphorus entering the practice.* *The TP entering the practice is the sum of both the phosphorus load generated directly by the contributing drainage area (or BMP credit area) to the practice* (**column K**) *and TP contributions (or remaining phosphorus load) from any upstream practice(s)* (**column J**). *Equation 13*	**Column L**
Remaining Phosphorus Load (lb) The total phosphorus load that exits the practice. *The total phosphorus load entering the practice (from* **column J** *and* **column K***) minus the total phosphorus load removed by the practice (from* **column L***).* *Equation 14*	**Column M**

Table 17. Drainage Area Tab TN Load Computations per BMP

Drainage Area *TN Load* Computations for each selected BMP	**Cell Reference**
Nitrogen load from upstream practice(s) (lb) The total nitrogen load entering the selected BMP from an upstream practice (if BMPs used in series). *If upstream practice used: Equals remaining nitrogen load* (**column U**) *from applicable upstream practice (auto-populates).* *If **no** upstream practice used: Equals zero.*	**Column R**
Untreated nitrogen load to practice (lb) The total nitrogen load generated by the contributing drainage area (or BMP credit area). *The load is calculated using the Simple Method.* *Equation 12*	**Column S**
Nitrogen Removed By Practice (lb) The total nitrogen load removed by the practice through any combination of runoff reduction and pollutant (treatment) reduction applicable to the selected BMP. *The TN removal treatment efficiency* (**column Q**) *is used to compute the proportion of nitrogen removed from the total nitrogen entering the practice.* *The TN entering the practice is the sum of both the nitrogen load generated directly by the contributing drainage area (or BMP credit area) to the practice* (**column S**) *and TN contributions (or remaining nitrogen load) from any upstream practice(s)* (**column R**). *Equation 13*	**Column T**
Remaining Nitrogen Load (lb) The total nitrogen load that exits the practice. *The total nitrogen load entering the practice (from* **column R** *and* **column S***) minus the total nitrogen load removed by the practice (from* **column T***).* *Equation 14*	**Column U**

5.3.5. DRAINAGE AREA TAB COMPUTATION SUMMARIES (RUNOFF REDUCTION BMPS AND ALL BMPS)

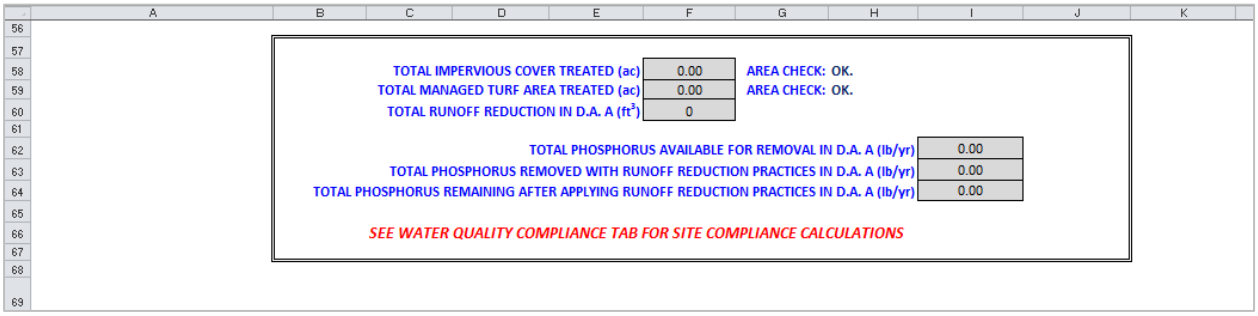
There are two locations within each **Drainage Area tab** where summary information on treated areas and nutrient loads is provided: one summary for the Runoff Reduction (RR) BMPs only (rows 57-67); and one general summary for all BMPs (rows 95-112). These summaries are described in Tables 18 and 19 and shown in Figs. 15 and 16.

Table 18. Drainage Area Tab Runoff Reduction BMP Summary

Drainage Area Tab – *Runoff Reduction (RR)* BMP Summary	**Cell Reference**
Total Impervious Cover Treated (acres) The total impervious areas in the D.A. tab included within all selected Runoff Reduction (RR) BMP contributing areas (or BMP credit areas) ***Area Check*** *indicates (***OK.** *or* **AREA EXCEEDED!***) to notify if sum of all RR-BMP impervious credit areas* (**F58**) *exceeds D.A. tab land cover inputs* (**F7**)	**F58** **H58**
Total Managed Turf Area Treated (acres) The total managed turf areas in the D.A. tab included within all selected RR BMP contributing areas (or BMP credit areas) ***Area Check*** *indicates (***OK.** *or* **AREA EXCEEDED!***) to notify if sum of all RR-BMP turf credit areas* (**F59**) *exceeds D.A. tab land cover inputs* (**F6**)	**F59** **H59**
Total Runoff Reduction (ft^3) The total runoff reduction volume achieved within D.A. tab by all selected RR-BMPs.	**F60**
Total Phosphorus Available for Removal (lb/yr) The post-development total phosphorus load generated from MT and IC areas and available for removal within D.A. tab. *Repeated from* **cell M7** *and explained in more detail in Section 5.2.*	**I62**
Total Phosphorus Removed With Runoff Reduction Practices (lb/yr) The total phosphorus load removed through RR BMPs within D.A. tab.	**I63**
Total Phosphorus Remaining After Applying Runoff Reduction Practices (lb/yr) The total phosphorus load that still remains after user selection and application of RR BMPs in D.A. tab.	**I64**
Nitrogen Summary for Runoff Reduction in D.A. Tab **Total Runoff Reduction in D.A. (ft^3)** *(from* **F60***)* **Nitrogen Removed With Runoff Reduction Practices (lb/yr)** *(similar to TP removed with RR-BMPs above)*	**V63** **V64**

Table 19. Drainage Area Tab Total BMP Summary

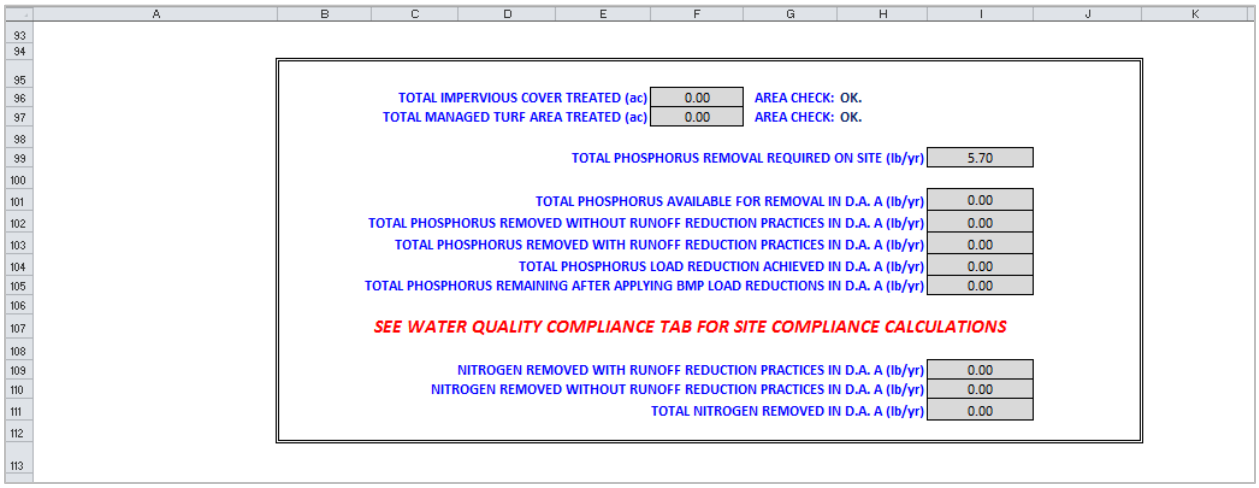
Drainage Area Tab – *Total* BMP Summary	**Cell Reference**
Total Impervious Cover Treated (acres) The total impervious areas in the D.A. tab included within all selected (RR and non-RR) BMP contributing areas (or BMP credit areas) ***Area Check*** *indicates (***OK.** *or* **AREA EXCEEDED!***) to notify if sum of all (RR and non-RR) BMP impervious credit areas* (**F96**) *exceeds D.A. tab land cover inputs* (**F7**)	**F96** **H96**
Total Managed Turf Area Treated (acres) The total turf areas in the D.A. tab included within all selected (RR and non-RR) BMP contributing areas (or BMP credit areas) ***Area Check*** *indicates (***OK.** *or* **AREA EXCEEDED!***) to notify if sum of all* (RR and non-RR) BMP *turf credit areas* (**F97**) *exceeds D.A. tab land cover inputs* (**F6**)	**F97** **H97**
Total Phosphorus Removal Required on Site (lb/yr) The total phosphorus removal requirement for entire site (from **Site tab G63**).	**I99**
Total Phosphorus Available for Removal in D.A. Tab (lb/yr) The post-development total phosphorus load generated from MT and IC areas and available for removal within D.A. tab. *Repeated from* **cell M7** *(and* **cell I62***) and explained in more detail in Section 5.2.*	**I101**
Total Phosphorus Removed Without Runoff Reduction Practices (lb/yr) The total phosphorus load removed through non-RR BMPs within D.A. tab.	**I102**
Total Phosphorus Removed With Runoff Reduction Practices (lb/yr) The total phosphorus load removed through RR BMPs within D.A. tab.*(***I63***)*	**I103**
Total Phosphorus Load Reduction Achieved (lb/yr) The total phosphorus load removed through all BMPs (RR and non-RR) within the D.A. tab. *(Sum of RR and non-RR BMP TP load reductions,* **I102+I103***)*	**I104**
Total Phosphorus Remaining After Applying BMP Load Reductions (lb/yr) The total phosphorus load remaining after application of all selected BMPs in D.A. tab.	**I105**
Nitrogen Removal Summary for Runoff Reduction in D.A. Tab (lb/yr): **Nitrogen Removed With Runoff Reduction Practices** *(from* **cell V64***)* **Nitrogen Removed Without Runoff Reduction Practices** **Total Nitrogen Removed**	 **I109** **I110** **I111**



TOTAL IMPERVIOUS COVER TREATED (ac)	0.00	AREA CHECK: OK.
TOTAL MANAGED TURF AREA TREATED (ac)	0.00	AREA CHECK: OK.
TOTAL RUNOFF REDUCTION IN D.A. A (ft^3)	0	
TOTAL PHOSPHORUS AVAILABLE FOR REMOVAL IN D.A. A (lb/yr)	0.00	
TOTAL PHOSPHORUS REMOVED WITH RUNOFF REDUCTION PRACTICES IN D.A. A (lb/yr)	0.00	
TOTAL PHOSPHORUS REMAINING AFTER APPLYING RUNOFF REDUCTION PRACTICES IN D.A. A (lb/yr)	0.00	

SEE WATER QUALITY COMPLIANCE TAB FOR SITE COMPLIANCE CALCULATIONS

Figure 15. Drainage Area Tab, RR BMP Summary



TOTAL IMPERVIOUS COVER TREATED (ac)	0.00	AREA CHECK: OK.
TOTAL MANAGED TURF AREA TREATED (ac)	0.00	AREA CHECK: OK.
TOTAL PHOSPHORUS REMOVAL REQUIRED ON SITE (lb/yr)	5.70	
TOTAL PHOSPHORUS AVAILABLE FOR REMOVAL IN D.A. A (lb/yr)	0.00	
TOTAL PHOSPHORUS REMOVED WITHOUT RUNOFF REDUCTION PRACTICES IN D.A. A (lb/yr)	0.00	
TOTAL PHOSPHORUS REMOVED WITH RUNOFF REDUCTION PRACTICES IN D.A. A (lb/yr)	0.00	
TOTAL PHOSPHORUS LOAD REDUCTION ACHIEVED IN D.A. A (lb/yr)	0.00	
TOTAL PHOSPHORUS REMAINING AFTER APPLYING BMP LOAD REDUCTIONS IN D.A. A (lb/yr)	0.00	
NITROGEN REMOVED WITH RUNOFF REDUCTION PRACTICES IN D.A. A (lb/yr)	0.00	
NITROGEN REMOVED WITHOUT RUNOFF REDUCTION PRACTICES IN D.A. A (lb/yr)	0.00	
TOTAL NITROGEN REMOVED IN D.A. A (lb/yr)	0.00	

SEE WATER QUALITY COMPLIANCE TAB FOR SITE COMPLIANCE CALCULATIONS

Figure 16. Drainage Area Tab, BMP Summary (All BMPs)

Using the VRRM spreadsheet *(Drainage Area tab – Summary sections)*

1. Check the **Drainage Area tab** summaries for performance of Runoff Reduction BMPs (**rows 57-67**), and for performance of all BMPs combined (non-RR BMPs and RR BMPS), (**rows 95-105**). Summary information here includes runoff volume reductions achieved, TP load reductions achieved and TP remaining. **Drainage Area tab** area checks should also be reviewed in both summary locations to ensure BMP credit areas do not exceed **Drainage Area tab** land cover type totals (**cells F6 and F7**). See summary tables above for additional details.

   Similar summaries are also provided for Total Nitrogen loading (**cells V63-V64** for RR-BMPs and **cells I109-I111** for all BMPs).

2. If other **Drainage Area tabs** are used, repeat steps 9 through 14 for each **Drainage Area tab**.

3. Proceed to the **Water Quality Compliance tab** for additional area checks and to verify compliance with water quality requirements for entire site.

6.0 WATER QUALITY COMPLIANCE TAB

The **Water Quality Compliance tab** provides the user with water quality site results and area checks drawn from user inputs on the **Site tab** and **Drainage Area tabs**. The information is presented in four sections: Area Checks (rows 3-8), Runoff Reduction Volume and TP *(and TN)* by Drainage Area (rows 10-19), Total Phosphorus (rows 22-26), and Total Nitrogen (rows 25-28). These main sections are described along with the related user instructions in the following tables (Tables 29-31).

Table 20. Water Quality Compliance Tab Site Results (Areas and Checks)

Site Results (Water Quality Compliance), Area Checks	Cell Reference
Forest/Open Space (acres) *Forest/Open spaceareas totaled across HSGs for each Drainage Area tab*	**C3-G3** **D.A. Tab F5**
Impervious Cover (acres) *Impervious cover areas totaled across HSGs for each Drainage Area tab*	**C4-G4** **D.A. Tab F7**
Impervious Cover Treated (acres) *Total treated impervious cover (BMP Credit Areas) for each Drainage Area tab*	**C5-G5** **D.A. Tab F96**
Managed Turf Area (acres) *Turf cover areas totaled across HSGs for each Drainage Area tab*	**C6-G6** **D.A. Tab F6**
Managed Turf Area Treated (acres) *Total treated turf cover (BMP Credit Areas) for each Drainage Area tab*	**C7-G7** **D.A. Tab F97**
Area Check per D.A. Tabs *Checks to ensure treated impervious cover and managed turf areas do not exceed available impervious cover and managed turf areas, respectively, within each Drainage Area tab.* *Indicates (***OK.** *or* **AREA EXCEEDED!***)*	**C8-G8**
Area Check for Impervious Cover and Managed Turf *Checks to ensure impervious cover and managed turf areas totaled across Drainage Area tabs do not exceed impervious cover and managed turf areas entered on* ***Site tab****.* *Indicates (***OK.** *or* **AREA EXCEEDED!***)*	**H3** (FO) **H4** (IC) **H6** (MT)
Area Check for Treated Impervious Cover and Treated Managed Turf *Checks to ensure treated impervious cover and treated managed turf areas totaled across Drainage Area tabs do not exceed available impervious cover and managed turf areas totaled across Drainage Area tabs.* *Indicates (***OK.** *or* **AREA EXCEEDED!***)*	**H5** (IC) **H7** (MT)
Site Treatment Volume (ft^3) *Total Treatment Volume for the post-development site area*	**C10**

Using the VRRM spreadsheet *(Water Quality Compliance Site Results) – Area Checks*

4. Check the Water Quality Compliance Area Checks (**C8-G8** and **H3-H7**) to ensure:
   a. Treated land cover areas do not exceed land cover areas available within each **Drainage Area tab**, and
   b. Areas entered on **Drainage Area tabs** do not exceed areas entered on **Site tab**.
5. If **AREA EXCEEDED!** messages appear, check information entered on **Drainage Area tabs** (land cover information and BMP Credit Areas) and **Site tab**. Error messages on these tabs will help direct the user to problem entries.

Table 21. Water Quality Compliance Tab Site Results (Volume, TP, and TN* by DA Tabs)

Site Results (Water Quality Compliance), Runoff Reduction Volume and TP By Drainage Area	**Cell Reference**
Runoff Reduction Volume Achieved (ft^3) *Runoff Reduction Volumes summed within each Drainage Area tab* **Total** *Across Drainage Area Tabs*	**C14-G14** **D.A. Tab F60** **H14**
TP Load Available For Removal (lb/yr) *Total phosphorus load available for removal within each Drainage Area tab* **Total** *Across Drainage Area Tabs*	**C15-G15** **D.A. Tab M7** **H15**
TP Load Reduction Achieved (lb/yr) *Total phosphorus load reduction achieved within each Drainage Area tab* **Total** *Across Drainage Area Tabs*	**C16-G16** **D.A. Tab I104** **H16**
TP Load Remaining (lb/yr) *Total phosphorus load remaining within each Drainage Area tab (difference between TP Load Available and TP Load Reduced)* **Total** *Across Drainage Area Tabs*	**C17-G17** **H17**
Nitrogen Load Reduction Achieved (lb/yr)* *Total nitrogen load reduction achieved within each Drainage Area tab* **Total** *Across Drainage Area Tabs*	**C19-G19** **D.A. Tab I111** **H19**

**For informational purposes only.*

Table 22. Water Quality Compliance Tab Site Results (Total Phosphorus, Total Nitrogen)

Site Results (Water Quality Compliance), Total Phosphorus	**Cell Reference**
Final Post-Development TP Load (lb/yr) *Total phosphorus load reduction achieved across all Drainage Area tabs*	**C22**
TP Load Reduction Required (lb/yr) *Total phosphorus load reduction required for site compliance (based on 0.41 lb TP/acre/yr new development load limitation)*	**C23**
TP Load Reduction Achieved (lb/yr) *Total phosphorus load reduction achieved across all Drainage Area tabs*	**C24**
TP Load Remaining (lb/yr) *Total phosphorus load reduction achieved across all Drainage Area tabs*	**C25**
Remaining TP Load Reduction Required (lb/yr) *Phosphorus load reduction that is still required for site compliance (difference between TP required and TP achieved).* **C27** *Indicates:* ****No further TP load reduction required** *if TP load reduction achieved on site equals compliance requirements* *or* **TARGET TP REDUCTION EXCEEDED BY __ LB/YEAR**** *if TP load reduction achieved on site exceeds compliance requirements.*	**C26**
Total Nitrogen (lb/yr)* *Total nitrogen summary for entire site includes:* *Post-Development Load* *Nitrogen Load Reduction Achieved* *Remaining Post-Development Nitrogen Load*	 **C29** **C30** **C31**

**For informational purposes only*

Using the VRRM spreadsheet *(Site Results Water Quality Compliance)*

– Runoff Reduction Volume and TP By Drainage Area

6. Check to see if water quality compliance has been achieved on the site by going to the Remaining TP Load Reduction Required result in **cell C26**:

a. If the result indicates anything greater than zero lb/yr, then the user must continue to reduce the TP load by the amount indicated in **cell C26** (which is the difference between the site based TP load reduction required in **C23** and the reduction which is so far achieved in **cell C24**):

i. Check the runoff reduction volumes and total phosphorus loadings (**cells C14-H17**) for where additional opportunities to reduce the TP load may be found and optimized.

ii. Return to **Site tab** and **Drainage Area tabs** to possibly reconfigure the site layout and/or revise the on-site BMP strategy (change BMP credit areas and/or BMP selections).

b. If the result indicates that either:

No further TP reduction required

OR

TARGET TP REQUIRED EXCEED BY __ LB/YR,

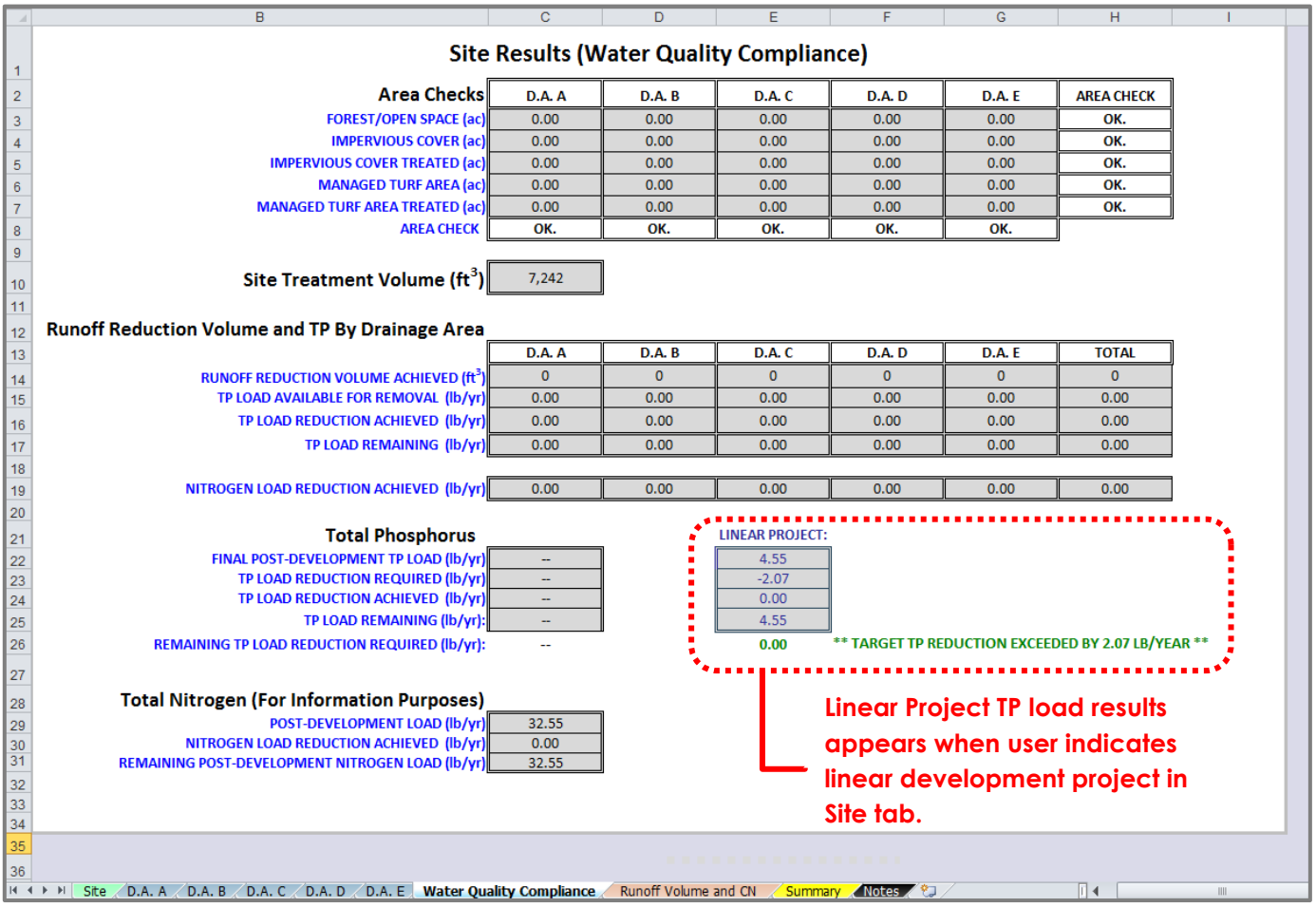
then the user can proceed with the proposed site layout and selected BMPs per **Drainage Area tab** to begin the site design.

7. If information on nitrogen loads is desired, check the Total Nitrogen sections (**cells C19-H19 and C29-C31**).

8. Proceed to the **Runoff Volume and CN tab** if the spreadsheet results for runoff (watershed-inches) and/or curve number adjustments will be used in subsequent water quantity calculations.

9. Proceed to the **Summary tab** to view and print a VRRM Spreadsheet Compliance Report.

The layout of the **Water Quality Compliance tab** for the ReDevelopment spreadsheet differs from New Development spreadsheet only with respect to the inclusion of a TP load results section for linear projects in **cells E21-I27** as shown in Figure 17 below.



Site Results (Water Quality Compliance)

Area Checks	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	AREA CHECK
FOREST/OPEN SPACE (ac)	0.00	0.00	0.00	0.00	0.00	OK.
IMPERVIOUS COVER (ac)	0.00	0.00	0.00	0.00	0.00	OK.
IMPERVIOUS COVER TREATED (ac)	0.00	0.00	0.00	0.00	0.00	OK.
MANAGED TURF AREA (ac)	0.00	0.00	0.00	0.00	0.00	OK.
MANAGED TURF AREA TREATED (ac)	0.00	0.00	0.00	0.00	0.00	OK.
AREA CHECK	OK.	OK.	OK.	OK.	OK.	

Site Treatment Volume (ft^3): 7,242

Runoff Reduction Volume and TP By Drainage Area

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	TOTAL
RUNOFF REDUCTION VOLUME ACHIEVED (ft^3)	0	0	0	0	0	0
TP LOAD AVAILABLE FOR REMOVAL (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00
TP LOAD REDUCTION ACHIEVED (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00
TP LOAD REMAINING (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00
NITROGEN LOAD REDUCTION ACHIEVED (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00

Total Phosphorus

		LINEAR PROJECT:
FINAL POST-DEVELOPMENT TP LOAD (lb/yr)	--	4.55
TP LOAD REDUCTION REQUIRED (lb/yr)	--	-2.07
TP LOAD REDUCTION ACHIEVED (lb/yr)	--	0.00
TP LOAD REMAINING (lb/yr):	--	4.55
REMAINING TP LOAD REDUCTION REQUIRED (lb/yr):	--	0.00

** TARGET TP REDUCTION EXCEEDED BY 2.07 LB/YEAR **

Total Nitrogen (For Information Purposes)

POST-DEVELOPMENT LOAD (lb/yr)	32.55
NITROGEN LOAD REDUCTION ACHIEVED (lb/yr)	0.00
REMAINING POST-DEVELOPMENT NITROGEN LOAD (lb/yr)	32.55

Linear Project TP load results appears when user indicates linear development project in Site tab.

Site | D.A. A | D.A. B | D.A. C | D.A. D | D.A. E | Water Quality Compliance | Runoff Volume and CN | Summary | Notes

Figure 17. Water Quality Compliance Tab, ReDevelopment spreadsheet with linear project results section

7.0 RUNOFF VOLUME AND CN TAB

The **Runoff Volume and CN tab** calculates the runoff volume reduction benefit in terms that can be applied to the water quantity control requirements of the VSMP regulations (Channel protection and Flood protection, *9VAC25-870-66*).

When designed to manage the water quality target rainfall event (one-inch of rainfall), the volume reduction achieved by the runoff reduction practices will provide some degree of benefit or credit when complying with any of these water quantity control requirements. This volume credit is applied in the form of a curve number reduction based on the Natural Resource Conservation Service (NRCS) runoff equations provided in *Urban Hydrology for Small Watersheds: TR-55* (NRCS 1986).

It is important to understand that the **Runoff Volume and CN tab** results do not indicate whether or not water quantity compliance has been achieved. Further computations and/or analyses are required for this determination. The user should carefully review the water quantity control regulations (*9VAC25-870-66*) to ensure understanding of compliance requirements.

It is also important to note that the spreadsheet calculates the volume reduction credit assuming that each BMP is designed and sized according to the minimum requirements of the BMP Design Specifications. If the user has oversized a practice, the spreadsheet will not reflect additional volume reduction credit for channel and flood protection (see Section 7.3). Routing of BMPs can be a complex task given all the hydrologic and hydraulic variables associated with volume storage and reduction, and would need to be performed outside of the spreadsheet.

7.1. RUNOFF VOLUME AND CN TAB USER INPUTS AND LIMITATIONS

There are a maximum of three entries on the Runoff Volume and CN Tab for design storm rainfall depths in inches (cells F6 to H6):

Using the VRRM spreadsheet *(Runoff Volume and CN) – User inputs*

10. Enter the 24-hour rainfall depth for the Target Rainfall Event (inches) which can be the 1-year, 2-year and/or 10-year frequency storm events:

a. The rainfall depths can be found using NOAA Atlas 14 (*http://hdsc.nws.noaa.gov/hdsc/pfds/*)

b. Remember that **Drainage Area tab** land cover data must be entered before calculations can be performed on this tab.

Just below the user input cells is a list of three notes (dark red font) which provide the user with some of the limitations of the spreadsheet and the **Runoff Volume and CN tab** computations (Fig. 18, Table 23).

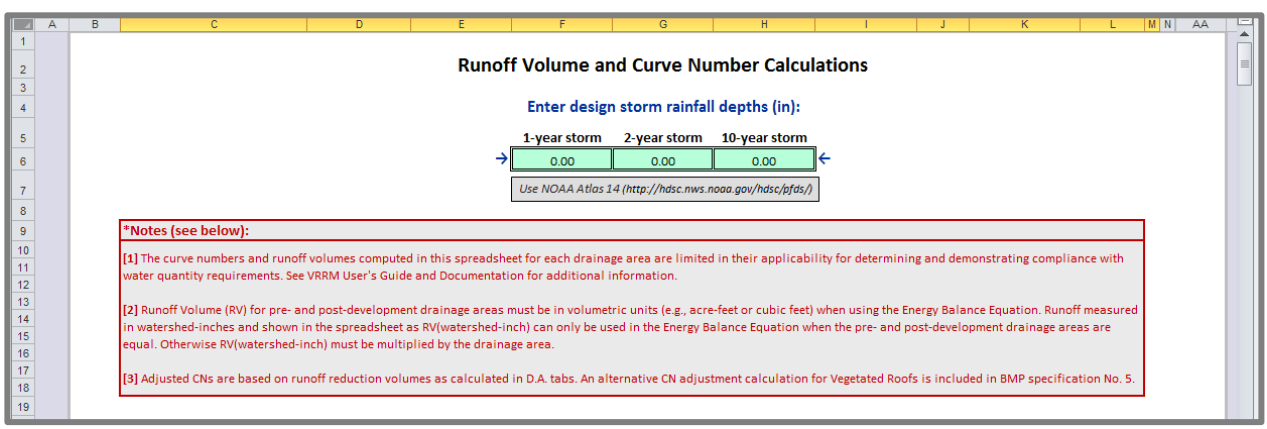


Figure 18. Runoff and CN Tab, Limitations

Table 23. Runoff Volume and CN Tab Limitations

Runoff Volume and CN (Limitations)	Cell Reference
[1] The curve numbers and runoff volumes computed in this spreadsheet for each drainage area are limited in their applicability for determining and demonstrating compliance with water quantity requirements. See VRRM User's Guide and Documentation for additional information. *This note is to inform the user that sites that have more than one drainage area converging to a common point of analysis is too complex of a drainage network for this tab to calculate CN values and runoff depths correctly. Hydrologic modeling is recommended for these and other types of complex configurations.*	**C10-L12**
[2] Runoff Volume (RV) for pre- and post-development drainage areas must be in volumetric units (e.g., acre-feet or cubic feet) when using the Energy Balance Equation. Runoff measured in watershed-inches and shown in the spreadsheet as RV (watershed-inch) can only be used in the Energy Balance Equation when the pre- and post-development drainage areas are equal. Otherwise RV (watershed-inch) must be multiplied by the drainage area. *The Runoff Volume (RV) provided in watershed inches is actually a depth measurement and not volume. When comparing forested, pre-, and post-development drainage area volumes for energy balance calculations, the volume units must be in acre-feet or cubic feet unless the drainage areas are the same.*	**C13-L16**
[3] Adjusted CNs are based on runoff reduction volumes as calculated in D.A. tabs. An alternative CN adjustment calculation for Vegetated Roofs is included in BMP specification No. 5. *The runoff reduction volumes calculated in the D.A. tabs are used for CN adjustments. The vegetated roof practice allows a pre-determined curve number adjustment that is listed in Table 5.1 of Specification No. 5.*	**C17-L18**

7.2. RUNOFF VOLUME AND CN TAB RESULTS

The **Runoff Volume and CN tab** results primarily show (for each **Drainage Area tab**) the volume reduction achieved and the **Drainage Area tab** composite curve number ($CN_{(D.A.)}$) before and after accounting for achieved volume reduction (Adjusted CN, Fig. 19, Table 24). Each of the **Drainage Area tabs** is represented in a separate table of results (for a total of five results tables).

Each **D.A. tab** results table includes constants, namely assigned CNs for each land cover type by HSGs, computations carried over from **Drainage Area tabs** (acreages and volumes), and CN calculations as represented in Fig. 19.

The user should consult the VA SWM Handbook for additional information and details on computational procedures.

Drainage Area Curve Numbers and Runoff Depths*

Curve numbers (CN, CNadj) and runoff depths ($RV_{Developed}$) are computed with and without reduction practices.

Drainage Area A		A Soils	B Soils	C Soils	D Soils
Forest/Open Space -- undisturbed, protected forest/open space or reforested land	Area (acres)	0.00	0.00	0.00	0.00
	CN	30	55	70	77
Managed Turf -- disturbed, graded for yards or other turf to be mowed/managed	Area (acres)	0.00	0.00	0.00	0.00
	CN	39	61	74	80
Impervious Cover	Area (acres)	0.00	0.00	0.00	0.00
	CN	98	98	98	98

Total Area (acres):	0.00
Runoff Reduction Volume (ft^3):	0

$CN_{(D.A. A)}$
0

	1-year storm	2-year storm	10-year storm
$RV_{Developed}$ *(watershed-inch)* with no Runoff Reduction*	0.00	0.00	0.00
$RV_{Developed}$ *(watershed-inch)* with Runoff Reduction*	0.00	0.00	0.00
Adjusted CN*	0	0	0

**See Notes above*

Figure 19. Runoff and CN Tab, Drainage Area A Summary

Table 24. Runoff Volume and CN Tab Results

Runoff Volume and CN (Results for D.A. A Tab)	Cell Reference
Land Cover Areas by HSGs *Areas of land cover type by hydrologic soil groups is carried over from the Drainage Area tab.*	**F24-I24** (F/O) **D.A. Tab B5-E5** **F26-I26** (MT) **D.A. Tab B6-E6** **F28-I28** (IC) **D.A. Tab B7-E7**
Total Area (acres) *The sum of all areas within the Drainage Area tab (across land cover type and HSGs)*	**L23** **D.A. Tab F8**
Runoff Reduction Volume (ft^3) *The total runoff reduction volume for the Drainage Area tab via runoff reduction BMPs.*	**L25** **D.A. Tab F60**
CN *Assigned curve numbers for each land cover type by hydrologic soil groups within the Drainage Area tab.*	**F25-I25** (F/O) **F27-I27** (MT) **F29-I29** (IC)
$CN_{(D.A. A)}$ *The composite curve number for the Drainage Area tab (across land cover types and hydrologic soil groups).* *Equation 15*	**I31**
$RV_{Developed}$ *(watershed-inch)* with no Runoff Reduction **(1-year storm, 2-year storm, 10-year storm)** *The post-development runoff volume in watershed-inches for the Drainage Area tab without applying any RR-BMPs. This value is calculated for each target rainfall event entered by the user (1-yr, 2-yr, 10-yr storms) using the D.A. tab composite curve number ($CN_{(D.A.)}$).* *Equation 16*	**F33 - H33**
$RV_{Developed}$ *(watershed-inch)* with Runoff Reduction **(1-year storm, 2-year storm, 10-year storm)** *The post-development runoff volume in watershed-inches for the Drainage Area tab after applying runoff volume reduction from any utilized RR-BMPs. The runoff volume reduction is subtracted from the post-development runoff volume above ($RV_{Developed}$ no RR) for each target rainfall event and converted to watershed-inches.* *Equation 17*	**F34-H34**
Adjusted CN **(1-year storm, 2-year storm, 10-year storm)** *The adjusted curve number for each target rainfall event obtained using a look-up table of curve numbers and corresponding runoff depths (watershed-in). Adjusted CN can also be determined using Fig. 2-1 of TR-55.* *Equation 18*	**F35-H35**

7.3. INTEGRATING WATER QUALITY TREATMENT WITH CONTROL OF LARGER STORMS

Compliance with Part IIB of the VSMP regulations means that stormwater management must include provisions for channel protection and flood control. The Part IIB water quality regulations require management of the 1-inch storm event (approximately equivalent to a 3-month 24-hour storm). The stormwater BMP Design Specifications allow for additional storage features that go beyond the required BMP treatment volumes and beyond the assigned runoff reduction credits. If a BMP is designed with increased storage volume to manage the volume from a 1-, 2-, or 10-year storm event, the VRRM spreadsheet will not recognize this additional volume stored. The designer will need to perform additional computations outside of the VRRM spreadsheet.

Stormwater BMPs that provide a runoff reduction (RR) credit do so by providing a storage component and/or slowing the release of discharge to the nearby receiving stream. These processes attenuate the runoff by encouraging abstraction and infiltration, resulting in a decrease in the computed release volume. The effectiveness of a practice's volume reduction (or ability to reduce the curve number) during larger storms is dependent on the relative volume of storage provided versus the volume of runoff generated. As the runoff depth increases, say from a 1-year frequency rainfall to a 10-year frequency rainfall, the practice's reduction volume remains the same but relative to the increased runoff generated, the practice's proportional runoff reduction decreases.

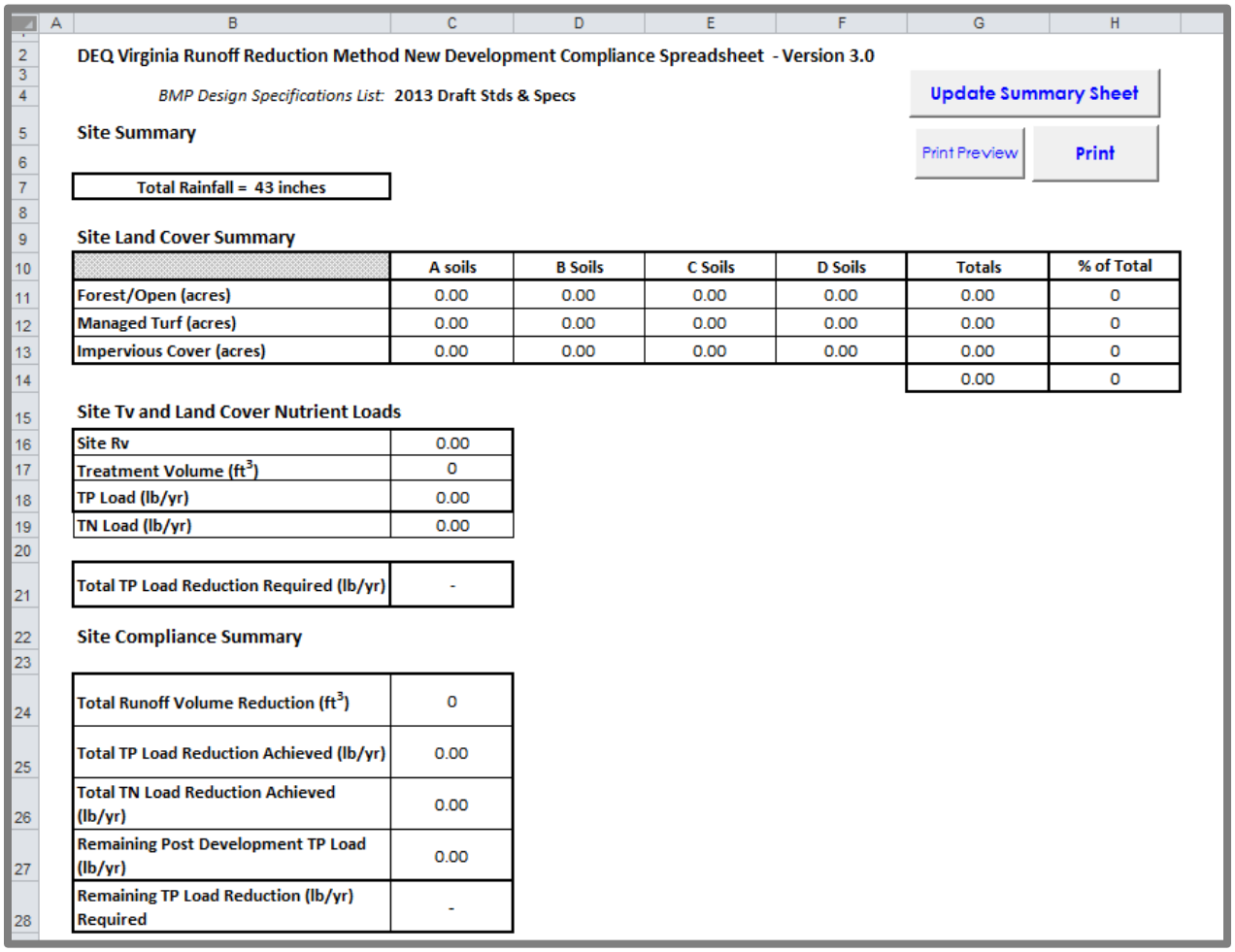
BMP practices that can be expanded to provide a greater volume of storage for larger storm events may be utilized in accordance with guidance provided in the specifications. The designer may than choose to utilize the total storage volume provided rather than the values used in the VRRM spreadsheet and compute an adjusted curve number directly from TR-55 for the desired storm events. A curve number must be computed for each storm event due to the diminishing effect of storage as rainfall depth increases. It is important to note that the RR credit assigned in the spreadsheet, and not the actual storage, must be used for the water quality calculations. In most cases, use of upland runoff reduction practices will reduce the storage volumes needed to manage the larger storm events associated with channel protection and/or flood control.

8.0 SUMMARY TAB (COMPLIANCE SUMMARY)

The user must enable macros for full functionality of the Summary tab.

The **Summary tab** compiles a report style summary of the spreadsheet results and water quality compliance information. All but one section of the **Summary tab** will auto-populate as user entries are made on the **Site tab**, **Drainage Area tabs**, and **Runoff and CN tab**. The individual **Drainage Area tab** summaries, including BMP selection summaries, will only populate and/or update once the user clicks the **Update Summary Sheet** button. The **Print Preview** button was included to remind the user that the printout can be customized to accommodate user needs (e.g., specify 1 page wide by X pages long), and the **Print** button opens the Excel Print Function (see user steps 28-29 below).

The upper section of the **Summary tab** includes site information and water quality compliance information carried forward from the **Site tab** and **Water Quality Compliance tab**, respectively (rows 5-28 for New Development, Fig.20; rows 5-46 for ReDevelopment, Fig. 20)



DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: 2013 Draft Stds & Specs

Update Summary Sheet | Print Preview | Print

Site Summary

Total Rainfall = 43 inches

Site Land Cover Summary

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	0.00	0.00	0.00	0.00	0
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00	0
					0.00	0

Site Tv and Land Cover Nutrient Loads

Site Rv	0.00
Treatment Volume (ft^3)	0
TP Load (lb/yr)	0.00
TN Load (lb/yr)	0.00

Total TP Load Reduction Required (lb/yr)	-

Site Compliance Summary

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	0.00
Total TN Load Reduction Achieved (lb/yr)	0.00
Remaining Post Development TP Load (lb/yr)	0.00
Remaining TP Load Reduction (lb/yr) Required	-

Figure 20. New Development Summary Tab – Water Quality Compliance, Site Summary Sections

DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: **2013 Draft Stds & Specs**

Update Summary Sheet

Print Preview | Print

Site Summary

Total Rainfall (in):	43
Total Disturbed Acreage:	0.00

Site Land Cover Summary

Pre-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	0.00	0.00	0.00	0.00	0
Managed Turf (acres)	0.00	0.00	1.00	0.00	1.00	50
Impervious Cover (acres)	0.00	0.00	1.00	0.00	1.00	50
					2.00	100

Post-Development Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	0.00	0.00	0.00	0.00	0
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.00	1.80	0.00	1.80	90
					1.80	90

Site Tv and Land Cover Nutrient Loads

	Final Post-Development (Post-ReDevelopment & New Impervious)	Post-ReDevelopment	Post-Development (New Impervious)	Adjusted Pre-ReDevelopment
Site Rv	--	--	0.00	--
Treatment Volume (ft^3)	--	--	--	--
TP Load (lb/yr)	--	--	--	--

Pre-ReDevelopment TP Load per acre (lb/acre/yr)	Final Post-Development TP Load per acre (lb/acre/yr)	Post-ReDevelopment TP Load per acre (lb/acre/yr)
--	--	--

Total TP Load Reduction Required (lb/yr)	--	--	--

	Final Post-Development Load (Post-ReDevelopment & New Impervious)	Pre-ReDevelopment
TN Load (lb/yr)	--	--

Site Compliance Summary

Maximum % Reduction Required Below Pre-ReDevelopment Load	--

Total Runoff Volume Reduction (ft^3)	931
Total TP Load Reduction Achieved (lb/yr)	1.11
Total TN Load Reduction Achieved (lb/yr)	6.70
Remaining Post Development TP Load (lb/yr)	0.00
Remaining TP Load Reduction (lb/yr) Required	-

Error Summary:

Errors on Site tab

Errors on D.A. tab(s)

Areas on D.A. tab(s) exceed Site tab areas

Figure 21. ReDevelopment Summary Tab – Water Quality Compliance, Site Summary showing errors

The next section of the **Summary tab** includes land cover and nutrient loading reductions for all of the **Drainage Area tabs** carried forward from the **Drainage Area tabs** (rows 30-42 for New Development, Fig. 22; rows 48-60 for ReDevelopment).

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest/Open (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 Area (acres)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Reduced (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00
TN Load Reduced (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00

Figure 22. New Development Summary Tab – Drainage Area Summary and Drainage Area Compliance Summary

The individual **Drainage Area tab** summaries (Fig.23) populate just below the overall **Drainage Area tab** summary (rows 45+ for New Development Spreadsheet and rows 63+ for ReDevelopment Spreadsheet). The **Drainage Area tab** summaries include land cover information and a BMP summary for each **Drainage Area tab** where user inputs have been made (i.e., only utilized **Drainage Area tabs** and selected BMPs will populate in this section of the **Summary tab**).

Drainage Area A Summary

Land Cover Summary

Drainage area is greater than site area!

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest/Open (acres)	0.00	0.00	0.50	0.00	0.50	22
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.00	1.80	0.00	1.80	78
					2.30	

BMP Selections

Practice	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	BMP Treatment Volume (ft^3)	TP Load from Upstream Practices (lbs)	Untreated TP Load to Practice (lbs)	TP Removed (lb/yr)	TP Remaining (lb/yr)	Downstream Treatment to be Employed
2.i. To Stormwater Planter, Urban Bioretention (Spec #9, Appendix A)		2	6,897.00	0.00	4.33	2.38	1.95	

Total Impervious Cover Treated (acres)	2.00
Total Turf Area Treated (acres)	0.00
Total TP Load Reduction Achieved in D.A. (lb/yr)	2.38
Total TN Load Reduction Achieved in D.A. (lb/yr)	19.82

Site | D.A. A | D.A. B | D.A. C | D.A. D | D.A. E | Water Quality Compliance | Runoff Volume and CN | Summary | Notes

Figure 23. Summary Tab – Drainage Area A Land Cover Summary, BMP Selections, and Water Quality Compliance.

The bottom section of the Summary tab includes a table of composite curve numbers, runoff reductions and adjusted curve numbers from the Runoff Volume and CN tab for each drainage area (Fig. 24). The exact location of this section on the tab will depend on the quantity of information compiled for the preceding section of individual Drainage Area tab summaries.

Runoff Volume and CN Calculations

	1-year storm	2-year storm	10-year storm
Target Rainfall Event (in)	0.00	0.00	0.00

Drainage Areas	RV & CN	Draiange Area A	Draiange Area B	Draiange Area C	Draiange Area D	Draiange Area E
CN		92	0	0	0	0
RR (ft^3)		2,759	0	0	0	0
1-year return period	RV wo RR (ws-in)	0.00	0.00	0.00	0.00	0.00
	RV w RR (ws-in)	0.00	0.00	0.00	0.00	0.00
	CN adjusted	100	0	0	0	0
2-year return period	RV wo RR (ws-in)	0.00	0.00	0.00	0.00	0.00
	RV w RR (ws-in)	0.00	0.00	0.00	0.00	0.00
	CN adjusted	100	0	0	0	0
10-year return period	RV wo RR (ws-in)	0.00	0.00	0.00	0.00	0.00
	RV w RR (ws-in)	0.00	0.00	0.00	0.00	0.00
	CN adjusted	100	0	0	0	0

Figure 24. Summary Tab – Water Quality Compliance, Runoff Volume and CN Calculations

Using the VRRM spreadsheet *(Summary Tab)*

11. **Remember**: Macros must be enabled for full functionality of the **Summary tab.** Return to **Site tab** and Step 1 in this document.
12. Ensure that the correct BMP Design Specifications list appears in **cell C4.** If not, revise the selection in **row 2** of the **Site tab.**
13. Click the **Update Summary Sheet** button in order to populate the individual **Drainage Area tabs** with BMP summaries.

    Each time changes are made to individual Drainage Area tabs, the **Summary tab** must be updated by selecting this button.
14. Review the summary sheet:
    a. If errors are noted, return to the tabs identified in the error notification table (Fig. 25)
    b. If there are no errors, proceed to the next step.

Site Compliance Summary

New Development Spreadsheet

Total Runoff Volume Reduction (ft^3)	1,035
Total TP Load Reduction Achieved (lb/yr)	0.65
Total TN Load Reduction Achieved (lb/yr)	4.64
Remaining Post Development TP Load (lb/yr)	1.52
Remaining TP Load Reduction (lb/yr) Required	**1.11**

Error Summary:

Areas on D.A. tab(s) exceed Site tab areas
Errors on D.A. tab(s)

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total	
Forest/Open (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)	1.10	0.00	0.00	0.00	0.00	1.10	X
Total Area (acres)	**1.10**	**0.00**	**0.00**	**0.00**	**0.00**	**1.10**	

D.A. A Errors!

Pre-ReDevelopment Load	

Re-Development Spreadsheet

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	0.97
Total TN Load Reduction Achieved (lb/yr)	4.64
Remaining Post Development TP Load (lb/yr)	0.00
Remaining TP Load Reduction (lb/yr) Required	-

Error Summary:

Errors on Site tab

Errors on D.A. tab(s)

Areas on D.A. tab(s) exceed Site tab areas

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total	
Forest/Open (acres)	0.50	0.00	0.00	0.00	0.00	0.50	X
Managed Turf (acres)	0.50	0.00	0.00	0.00	0.00	0.50	X
Impervious Cover (acres)	2.10	0.00	0.00	0.00	0.00	2.10	
Total Area (acres)	**3.10**	**0.00**	**0.00**	**0.00**	**0.00**	**3.10**	

D.A. A Errors!

Figure 25. Summary Tab Error Notifications for New Development (upper) and ReDevelopment (lower) Spreadsheets.

Using the VRRM spreadsheet *(Summary Tab)* ***.....continued***

15. Click the **Print Preview** button. This will open the Excel Print Preview Screen (Fig. 26) and allow the user to:

a. View the report prior to printing, and/or

b. Select the Excel Page Setup function (top bar menu option) in order to customize the report printout.

16. At this point, the user can click the **Print** button, select a connected printer or print to pdf (Fig. 27).

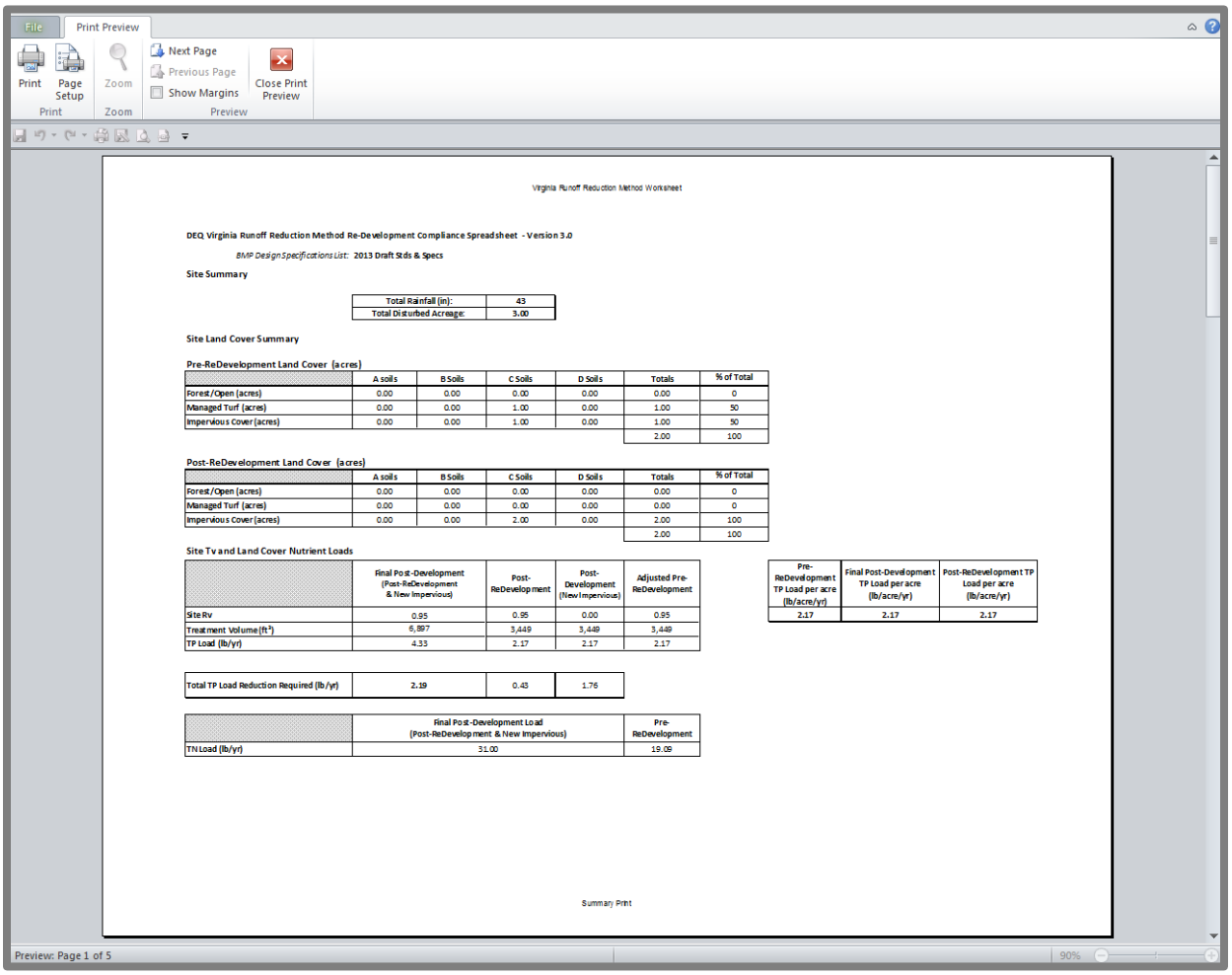
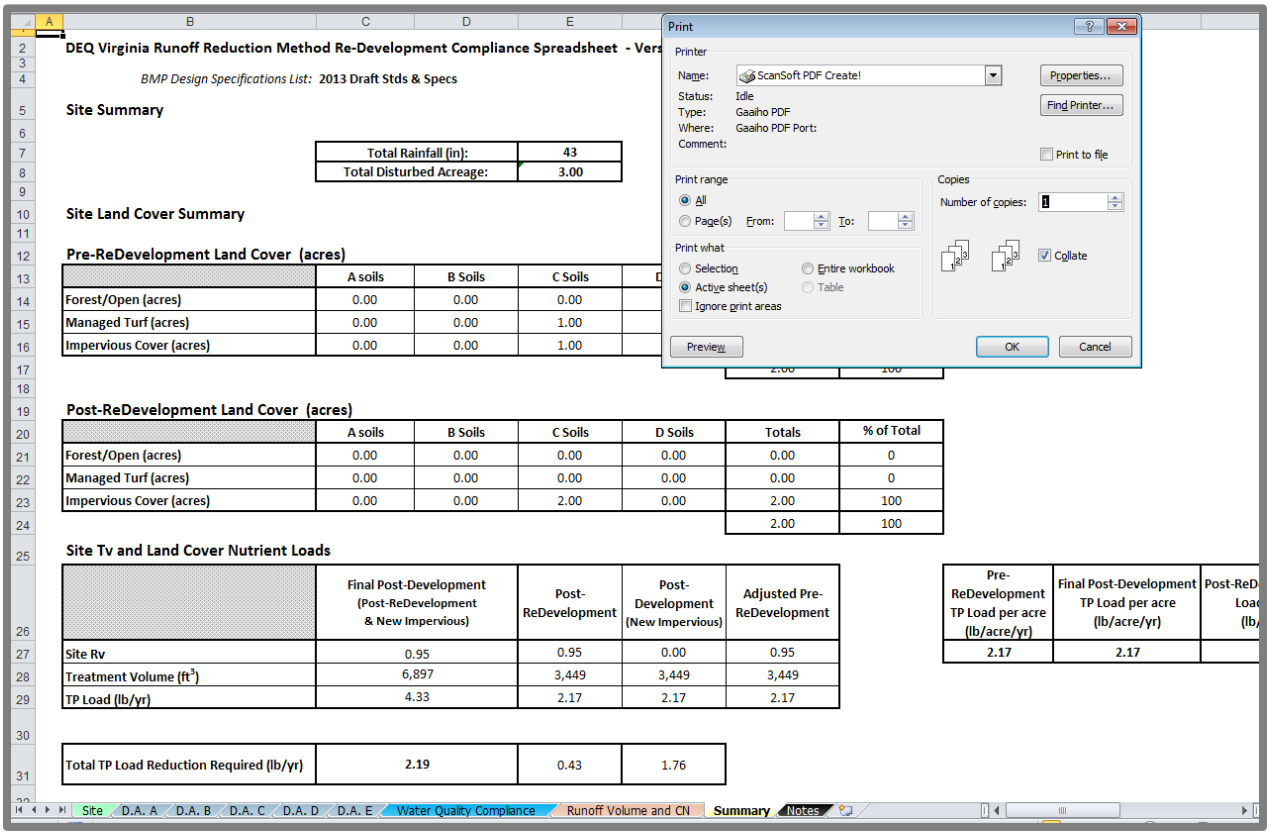


Figure 26. Summary Tab – Water Quality Compliance Report – Print Preview Screen



DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet - Vers

BMP Design Specifications List: 2013 Draft Stds & Specs

Site Summary

Total Rainfall (in):	43
Total Disturbed Acreage:	3.00

Site Land Cover Summary

Pre-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D
Forest/Open (acres)	0.00	0.00	0.00	
Managed Turf (acres)	0.00	0.00	1.00	
Impervious Cover (acres)	0.00	0.00	1.00	

Post-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	0.00	0.00	0.00	0.00	0
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.00	2.00	0.00	2.00	100
					2.00	100

Site Tv and Land Cover Nutrient Loads

	Final Post-Development (Post-ReDevelopment & New Impervious)	Post-ReDevelopment	Post-Development (New Impervious)	Adjusted Pre-ReDevelopment
Site Rv	0.95	0.95	0.00	0.95
Treatment Volume (ft^3)	6,897	3,449	3,449	3,449
TP Load (lb/yr)	4.33	2.17	2.17	2.17

Total TP Load Reduction Required (lb/yr)	2.19	0.43	1.76

Pre-ReDevelopment TP Load per acre (lb/acre/yr)	Final Post-Development TP Load per acre (lb/acre/yr)	Post-ReD Loa (lb/
2.17	2.17	

Print

Printer
Name: ScanSoft PDF Create!
Status: Idle
Type: Gaaiho PDF
Where: Gaaiho PDF Port:
Comment:
Properties... Find Printer... Print to file

Print range: All; Page(s) From: To:
Copies: Number of copies: 1; Collate
Print what: Selection; Entire workbook; Active sheet(s); Table; Ignore print areas
Preview OK Cancel

Site | D.A. A | D.A. B | D.A. C | D.A. D | D.A. E | Water Quality Compliance | Runoff Volume and CN | Summary | Notes

Figure 27. Site Summary Tab (Print Button Activated)

9.0 VRRM SPREADSHEET EQUATIONS

9.1. SITE TAB

Equation 1.1a. Forest/Open Space Runoff Coefficient (Weighted for Soil Groups):

$$Rv_{FO} = \frac{[(A_{FO_A} \times 0.02) + (A_{FO_B} \times 0.03) + (A_{FO_C} \times 0.04) + (A_{FO_D} \times 0.05)]}{A_{FO}}$$

Equation 1.1b. Percentage Forest/Open Space Area:

$$\%FO = \frac{A_{FO_A} + A_{FO_B} + A_{FO_C} + A_{FO_D}}{A_{site}} \times 100$$

Equation 1.2a. Managed Turf Runoff Coefficient (Weighted for Soil Groups):

$$Rv_{MT} = \frac{[(A_{MT_A} \times 0.15) + (A_{MT_B} \times 0.20) + (A_{MT_C} \times 0.22) + (A_{MT_D} \times 0.25)]}{A_{MT}}$$

Equation 1.2b. Percentage Managed Turf Area:

$$\%MT = \frac{A_{MT_A} + A_{MT_B} + A_{MT_C} + A_{MT_D}}{A_{site}} \times 100$$

Equation 1.3a. Impervious Cover Runoff Coefficient:

$$Rv_{IC} = 0.95$$

Equation 1.3b. Percentage Impervious Cover Area:

$$\%IC = \frac{A_{IC_A} + A_{IC_B} + A_{IC_C} + A_{IC_D}}{A_{site}} \times 100$$

Where:

Rv_{FO} = *weighted forest/open space runoff coefficient across hydrologic soil groups*
$\%FO$ = *percentage of total forest area for the site*
A_{FO_A} = *area of post-development forest/open space with A soils (acres)*
A_{FO_B} = *area of post-development forest/open space in B soils (acres)*
A_{FO_C} = *area of post-development forest/open space in C soils (acres)*
A_{FO_D} = *area of post-development forest/open space in D soils (acres)*

Rv_{MT} = *weighted managed turf runoff coefficient across hydrologic soil groups*
$\%MT$ = *percentage of total managed turf area for the site*
A_{MT_A} = *area of post-development managed turf in A soils (acres)*
A_{MT_B} = *area of post-development managed turf in B soils (acres)*
A_{MT_C} = *area of post-development managed turf in C soils (acres)*
A_{MT_D} = *area of post-development managed turf in D soils (acres)*

Rv_{IC} = *impervious cover runoff coefficient across hydrologic soil groups*
$\%IC$ = *percentage of total impervious cover area for the site*
A_{IC_A} = *area of post-development impervious cover in A soils (acres)*
A_{IC_B} = *area of post-development impervious cover in B soils (acres)*
A_{IC_C} = *area of post-development impervious cover in C soils (acres)*
A_{IC_D} = *area of post-development impervious cover in D soils (acres)*
A_{site} = *total site area (acres)*

Equation 2. Site Composite Runoff Coefficient

$$Rv_{site} = [(Rv_{FO} \times \%FO) + (Rv_{MT} \times \%MT) + (Rv_{IC} \times \%IC)]/100$$

Where:

Rv_{site} = *unitless composite volumetric runoff coefficient for the site*
Rv_{FO} = *weighted forest/open space runoff coefficient across hydrologic soil groups (Eq. 1.1a)*
Rv_{MT} = *weighted managed turf runoff coefficient across hydrologic soil groups (Eq. 1.2a)*
Rv_{IC} = *impervious cover runoff coefficient across hydrologic soil groups (Eq. 1.3a)*
$\%FO$ = *percentage of total forest area for the site (Eq. 1.1b)*
$\%MT$ = *percentage of total managed turf area for the site (Eq. 1.2b)*
$\%IC$ = *percentage of total impervious cover area for the site (Eq. 1.3b)*

Equation 3. Post-Development Site Treatment Volume

$$Tv_{site} = Rd \times Rv_{site} \times {}^{A_{site}}/_{12} \quad (acre\text{-}ft)$$

$$= Rd \times Rv_{site} \times {}^{A_{site}}/_{12} \times 43{,}560 \quad (ft^3)$$

Where:

Tv_{site} = *post-development treatment volume for site (acre-ft)*
Rd = *target rainfall event depth (1 inch for water quality storm)*
Rv_{site} = *runoff coefficient for the site (Eq. 2)*
A_{site} = *total site area (acres)*
12 = *unit adjustment factor, converting inches to feet*
$43{,}560$ = *unit adjustment factor, converting acres to square feet*

Equation 4. Post-Development Site TP Load

$$L = P \times P_j \times \left({}^{Tv_{site}}/_{Rd}\right) \times C \times 2.72$$

Where:

L = *post-development pollutant load for site (pounds/year)*
P = *average annual rainfall depth (inches) = 43 inches for Virginia*
P_j = *fraction of total rainfall that produces runoff = 0.9*
Tv_{site} = *post-development treatment volume for site (acre-ft) (Eq. 3)*
Rd = *rainfall depth for target event (1 inch for water quality storm)*
C = *flow-weighted mean concentration of pollutant in urban runoff (mg/L)*
= *0.26 mg/L for total phosphorus*
2.72 = *unit adjustment factor, converting milligrams to pounds and liters to acre-feet*

Equation 5. Required Site TP Load Reduction

$$L_{reduction} = L_{TP} - TP_{target} \times A_{site}$$

Where:

$L_{reduction}$ = *required TP Load Reduction (pounds/year)*
L_{TP} = *post-development TP load for site (pounds/year), calculated as in Eq. 4*
TP_{target} = *target phosphorous load (pounds/acre/year) = 0.41 lb/ac/yr*
A_{site} = *total site area (acres)*

9.2. D.A. TABS

Equation 6. Runoff Volume from Entire Drainage Area (Cell M8)

$$Tv_{DA_} = Rd \times Rv_{DA_MT,IC} \times DA_{MT,IC} \times 3{,}630$$

Where:

$Tv_{DA_}$ = *runoff or treatment volume for entire drainage area (DA__)*
(turf and impervious areas only, cubic feet)

Rd = *rainfall depth for target event (1 inch for water quality storm)*

$Rv_{DA_MT,IC}$ = *composite runoff coefficient for turf and impervious areas in DA__*

$$= \frac{(Rv_{DA_MT} \times DA_{MT}) + (Rv_{DA_IC} \times DA_{IC})}{DA_{MT} + DA_{IC}}$$

$DA_{MT,IC}$ = *turf and impervious areas in DA__ (acres)*

$3{,}630$ = *unit adjustment factor, converting acre-inches to cubic feet*

Equation 7. Total Phosphorus Available for Removal From Entire Drainage Area (Cell M7)

$$L_{(TP,DA_)} = P \times P_j \times \left({Tv_{DA_}}/{Rd} \right) \times C \times \frac{2.72}{43{,}560}$$

Where:

$L_{(TP,DA_)}$ = *post-development TP load for DA__ (pounds/year)*

P = *average annual rainfall depth (inches) = 43 inches for Virginia*

P_j = *fraction of total rainfall that produces runoff = 0.9*

$Tv_{DA_}$ = *treatment volume for DA__*
(turf and impervious areas only, cubic feet, Eq. 6)

Rd = *rainfall depth for target event (1 inch for water quality storm)*

C = *flow-weighted mean concentration of pollutant in urban runoff (mg/L)*
= *0.26 mg/L for total phosphorus*

2.72 = *unit adjustment factor, converting milligrams to pounds and liters to acre-feet*

$43{,}560$ = *unit adjustment factor, converting acres to square feet*

Equation 8. Runoff Volume from Contributing Drainage Area

$$Tv_{CA} = Rd \times Rv_{CA} \times CA \times 3{,}630$$

Where:

Tv_{CA} = *treatment volume for contributing drainage area, or Credit Area to practice (cubic feet)*

Rd = *rainfall depth for target event (1 inch for water quality storm)*

Rv_{CA} = *composite runoff coefficient for credit area (CA) being treated by credit practice (only MT and IC areas considered)*

$= \frac{(Rv_{MT} \times CA_{MT}) + (Rv_{IC} \times CA_{IC})}{CA_{MT} + CA_{IC}}$

CA = *credit area applied to practice (acres, columns C and D)*

$3{,}630$ = *unit adjustment factor, converting acre-inches to cubic feet*

Equation 9. Runoff Reduction Achieved by Practice (Column F)

$$\begin{aligned} V_{reduction} &= Tv_{BMP} \times RR_{CR} \\ &= \left(Tv_{CA} + V_{upstream}\right) \times RR_{CR} \\ &= \left[(Rd \times Rv_{CA} \times CA \times 3{,}630) + V_{upstream}\right] \times RR_{CR} \ * \end{aligned}$$

**formula used in spreadsheet, substituting in Eqs. 8 and 11*

Where:

$V_{reduction}$ = *runoff reduction achieved by practice (cubic feet)*

Tv_{BMP} = *total volume of runoff to practice (cubic feet, Eq. 11, column K)*

RR_{CR} = *runoff reduction performance credit for the practice (column B)*

Tv_{CA} = *treatment volume for credit area (cubic feet, Eq. 8)*

$V_{upstream}$ = *volume from upstream runoff reduction practice (cubic feet, column E)*

Rd = *rainfall depth for target event (1 inch for water quality storm)*

Rv_{CA} = *composite runoff coefficient for credit area (CA) being treated by credit practice (only MT and IC areas considered)*

CA = *credit area applied to practice (acres, columns C and D)*

$3{,}630$ = *unit adjustment factor, converting acre-inches to cubic feet*

Equation 10. Remaining Runoff Volume Leaving the Practice (Column G)

$$V_{remaining} = Tv_{BMP} \times (1 - RR_{CR})$$
$$= \left(Tv_{CA} + V_{upstream}\right) \times (1 - RR_{CR})$$
$$= \left[(Rd \times Rv_{CA} \times CA \times 3{,}630) + V_{upstream}\right] \times (1 - RR_{CR})\ *$$

**formula used in spreadsheet, substituting in Eqs. 8 and 11*

Where:

$V_{remaining}$ = *volume of runoff remaining or discharged from practice after applying practice's runoff reduction credit (cubic feet)*
Tv_{BMP} = *total volume of runoff to practice (cubic feet, Eq. 11, column H)*
RR_{CR} = *runoff reduction performance credit for the practice (column B)*

Tv_{CA} = *treatment volume for credit area (cubic feet, Eq. 8)*
$V_{upstream}$ = *volume from upstream runoff reduction practice (cubic feet, column E)*

Rd = *rainfall depth for target event (1 inch for water quality storm)*
Rv_{CA} = *composite runoff coefficient for credit area (CA) being treated by credit practice (only MT and IC areas considered)*
CA = *credit area applied to practice (acres, columns C and D)*
3,630 = *unit adjustment factor, converting acre-inches to cubic feet*

OR

$$V_{remaining} = Tv_{BMP} - V_{reduction}$$

Where:

$V_{remaining}$ = *volume of runoff remaining or discharged from practice after applying practice's runoff reduction credit (cubic feet)*
Tv_{BMP} = *total volume of runoff to practice (cubic feet, Eq. 11, column H)*
$V_{reduction}$ = *runoff reduction achieved by practice (cubic feet, Eq. 9, column F)*

Equation 11. BMP Treatment Volume (Total Runoff Volume to Practice, Column H)

$$
\begin{aligned}
Tv_{BMP} &= Tv_{CA} + V_{upstream} \\
&= \left(Tv_{CA} + V_{upstream}\right)(RR_{CR}) + \left(Tv_{CA} + V_{upstream}\right)(1 - RR_{CR}) \\
&= V_{reduction} + V_{remaining}\ *
\end{aligned}
$$

**formula used in spreadsheet, rearranging and substituting in Eq. 9 and 10*

Where:

Tv_{BMP} = *total volume of runoff to practice (cubic feet)*
= *minimum BMP volume capacity for water quality purposes*

Tv_{CA} = *treatment volume for credit area to practice (cubic feet, Eq. 8)*

$V_{upstream}$ = *volume of runoff from upstream runoff reduction practice (cubic feet, column E)*

$V_{reduction}$ = *runoff reduction achieved by practice (cubic feet)*

$V_{remaining}$ = *volume of runoff remaining or discharged from practice after applying practice's runoff reduction credit (cubic feet)*

Equation 12. Untreated Pollutant Load to Practice (Phosphorus, Column K; Nitrogen, Column S)

$$L_{untreated} = P \times P_j \times \left({Tv_{CA}}/{Rd}\right) \times C \times 2.72$$

Where:

$L_{untreated}$ = *untreated pollutant load to practice (pounds/year of pollutant)*

P = *average annual rainfall depth (inches) = 43 inches/year for Virginia*

P_j = *fraction of total rainfall that produces runoff = 0.9*

Tv_{CA} = *treatment volume for credit area to practice (cubic feet, Eq. 8,)*
$= Rd \times Rv_{CA} \times {CA}/{12}$

Where:

Rd = *target rainfall event depth (1 inch for water quality storm)*

Rv_{CA} = *composite runoff coefficient for credit area (CA) being treated by credit practice (only MT and IC areas considered)*

CA = *credit area applied to practice (acres, columns C and D)*

Rd = *rainfall depth for target event (1 inch for water quality storm)*

C = *flow-weighted mean concentration of pollutant in urban runoff (mg/L)*
= *0.26 mg/L for total phosphorus, 1.86 mg/l for total nitrogen*

2.72 = *unit adjustment factor, converting milligrams to pounds and acre-feet to liters*

Equation 13. Total Load Removal by Practice (Phosphorus, Column L; Nitrogen, Column T)

$$L_{removed} = \left(L_{upstream} + L_{untreated}\right) \times \left(Tv_{BMP} \times {}^{PR_{CR}}/_{100}\right) \Big/ Tv_{BMP}$$

Derivation:

$$\left[\left(L_{upstream} + L_{untreated}\right) \times \frac{V_{reduction}}{Tv_{BMP}}\right] + \left[\left(L_{upstream} + L_{untreated}\right) \times \frac{V_{remaining}}{Tv_{BMP}} \times \left({}^{PR_{CR}}/_{100}\right)\right]$$

$$= \left(L_{upstream} + L_{untreated}\right) \times \left[\frac{V_{reduction} + V_{remaining} \times \left({}^{PR_{CR}}/_{100}\right)}{Tv_{BMP}}\right]$$

Where:

$L_{removed}$ = *total pollutant load removed by practice (pounds/year)*

$L_{upstream}$ = *pollutant load from upstream treatment practice (pounds/year, TP-column J, TN-column R)*

$L_{untreated}$ = *untreated pollutant load to practice (pounds/year, Eq. 12, TP-column K, TN-column S)*

Tv_{BMP} = *total runoff volume to practice (cubic feet, Eq. 11, column H)*

PR_{CR} = *pollutant removal performance credit (TP-column I, TN-column Q)*

100 = *% conversion factor*

$V_{reduction}$ = *runoff reduction achieved by practice (cubic feet, column F)*

$V_{remaining}$ = *volume of runoff remaining or discharged from practice after applying practice's runoff reduction credit (cubic feet, column G)*

Equation 14. Remaining Load (Phosphorus, Column M; Nitrogen, Column U)

$$L_{remaining} = L_{upstream} + L_{untreated} - L_{removed}$$

Where:

$L_{remaining}$ = *pollutant load leaving practice or remaining after treatment (pounds/year, TP-Column M, TN-Column U)*

$L_{upstream}$ = *pollutant load from upstream treatment practice (pounds/year, TP-column J, TN-column R)*

$L_{untreated}$ = *untreated pollutant load to practice (pounds/year, Eq. 12, TP-column K, TN-column S)*

$L_{removed}$ = *total pollutant load removed by practice (pounds/year, Eq. 13, TP-Column L, TN-Column T)*

9.3. RUNOFF VOLUME AND CN TAB

Equation 15. Composite Curve Number (CN)

$$CN_{D.A.} = \left[\left(A_{FO_A} \times 30\right) + \left(A_{FO_B} \times 55\right) + \left(A_{FO_C} \times 70\right) + \left(A_{FO_D} \times 77\right)\right]$$
$$+\left[\left(A_{MT_A} \times 39\right) + \left(A_{MT_B} \times 61\right) + \left(A_{MT_C} \times 74\right) + \left(A_{MT_D} \times 80\right)\right.$$
$$\left.+\left[\left(A_{IC_A} + A_{IC_B} + A_{IC_C} + A_{IC_D}\right) \times 98\right]\right]/DA$$

Where:

$CN_{D.A.}$ = *composite curve number for Drainage Area*
A_{FO_A} = *area of post-development forest/open space with A soils (acres)*
A_{FO_B} = *area of post-development forest/open space in B soils (acres)*
A_{FO_C} = *area of post-development forest/open space in C soils (acres)*
A_{FO_D} = *area of post-development forest/open space in D soils (acres)*

A_{MT_A} = *area of post-development managed turf in A soils (acres)*
A_{MT_B} = *area of post-development managed turf in B soils (acres)*
A_{MT_C} = *area of post-development managed turf in C soils (acres)*
A_{MT_D} = *area of post-development managed turf in D soils (acres)*

A_{IC_A} = *area of post-development impervious cover in A soils (acres)*
A_{IC_B} = *area of post-development impervious cover in B soils (acres)*
A_{IC_C} = *area of post-development impervious cover in C soils (acres)*
A_{IC_D} = *area of post-development impervious cover in D soils (acres)*

30, 55, 70, 77 = assigned curve numbers for forest/open space A, B, C, D soils, respectively
39, 61, 74, 80 = assigned curve numbers for managed turf A, B, C, D soils, respectively
98 = assigned curve number for impervious cover irrespective of underlying soil groups

DA = *Drainage Area (acres)*

Equation 16. Runoff Volume with no Runoff Reduction, Row 33

$$RV_{no-RR} = (P - 0.2 \times S)^2/(P + 0.8 \times S)$$

Where:

RV_{no-RR} = *post-development runoff volume without runoff reduction practices in drainage area (watershed-inches)*

P = Rd, *rainfall depth for target rainfall event (24-hour storm depth, inches)*

S = *potential maximum retention after runoff begins (inches), based on composite curve number for drainage area,* $CN_{D.A.}$ *(Eq. 15)*

$$= \frac{1000}{CN_{D.A.}} - 10$$

Equation 17. Runoff Volume with Runoff Reduction, Row 34

$$RV_{RR} = RV_{no-RR} - \left(V_{total_red}/3{,}630\right)/DA$$

Where:

RV_{RR} = *post-development runoff volume in drainage area with runoff reduction practices, if applicable (watershed-inches)*

RV_{no-RR} = *post-development runoff volume in drainage area without runoff reduction practices (watershed-inches, Eq. 16)*

V_{total_red} = *runoff reduction volume achieved by runoff reduction practices in drainage area (cubic feet, cell L25)*

3,630 = *unit adjustment factor, cubic feet to acre-inches*

DA = *drainage area (acres)*

Equation 18. Adjusted Curve Number

Note: *The adjusted curve number ($CN_{adjusted}$) is determined using a lookup table of curve number and runoff volumes so that:*

$CN_{adjusted}$ *corresponds to Runoff Volume with runoff reduction,* RV_{RR} *(watershed-in, Eq. 17)*

such that

$$RV_{RR} = \left(P - 0.2 \times S_{adjusted}\right)^2 / \left(P + 0.8 \times S_{adjusted}\right)$$

and

$$S_{adjusted} = \frac{1000}{CN_{adjusted}} - 10$$

Where:

$CN_{adjusted}$ = *adjusted curve number generating a runoff volume (watershed-inches) equal to the drainage area runoff volume with runoff reduction practices (RV_{RR}, Eq. 17)*

RV_{RR} = *Runoff reduction volume in drainage area with runoff reduction practices (watershed-inches)*

P = Rd, *rainfall depth for target rainfall event (24-hour storm depth, inches)*

$S_{adjusted}$ = *potential maximum retention after runoff begins (inches) based upon adjusted curve number*

9.4. REDEVELOPMENT SITE TAB – COMPUTATIONS

This section provides the equations (including logical derivations) for the determination of redevelopment water quality compliance. A graphical representation is given in Section 4.2.3.

Equation 19. Net Change in Impervious Cover

$$A_{IC,post} - A_{IC,pre} = X_{IC}$$

Where:
$A_{IC,post}$ *= area of post-development impervious cover (acres)*
$A_{IC,pre}$ *= area of pre-redevelopment impervious cover (acres)*
X_{IC} *= the change in pre-redevelopment to post-development impervious acreage*

9.4.1. REDEVELOPMENT WITH IMPERVIOUS COVER INCREASE, $(A_{IC,post} - A_{IC,pre}) > 0$

Equation 20. TP Load Reduction Requirement for New Net Impervious Cover

$$L_{reduction_IC,new.post} = L_{IC,new.post} - TP_{target} \times A_{IC,new.post}$$

Where:
$L_{reduction_IC,new.post}$ *= required TP load reduction for post-development new net impervious cover (pounds/year)*
$L_{IC,new.post}$ *= post-development TP load for new net impervious cover (pounds/year), calculated as in Eq. 4*
TP_{target} *= target phosphorous load (pounds/acre/year) = 0.41 lb/ac/yr*
$A_{IC,new.post}$ *= impervious cover net increase from pre-redevelopment to post-development, equal to X_{IC} from Eq. 19 when the impervious cover change is a net increase (acres)*

Equation 21. Net Decrease in Pervious Areas

The net decrease in pervious acreages (forest/open space and/or managed turf) is equivalent to the post-development increase in impervious cover.

$$X_{IC} = -(X_{FO} + X_{MT})$$

Where:

$$X_{FO} = A_{FO,post} - A_{FO,pre}$$
$$X_{MT} = A_{MT,post} - A_{MT,pre}$$

Given that the pre-redevelopment site acreage equals the post-development site acreage:

$$A_{site,pre} = A_{site,post} \quad \textit{Where:} \quad A_{site,pre} = A_{FO,pre} + A_{MT,pre} + A_{IC,pre}$$
$$\textit{And:} \quad A_{site,post} = A_{FO,post} + A_{MT,post} + A_{IC,post}$$

Therefore:

$$A_{FO,pre} + A_{MT,pre} + A_{IC,pre} = A_{FO,post} + A_{MT,post} + A_{IC,post}$$

We can rearrange to:

$$A_{IC,post} - A_{IC,pre} = \left(A_{FO,pre} - A_{FO,post}\right) + \left(A_{MT,pre} - A_{MT,post}\right)$$

And, by substitution:

$$X_{IC} = -(X_{FO} + X_{MT}) \qquad \textbf{(Eq. 21)}$$

Where:

$A_{site,pre}$ *= pre-redevelopment site area (acres)*
$A_{site,post}$ *= post-development site area (acres)*
$A_{FO,pre}$ *= area of pre-redevelopment forest/open space (acres)*
$A_{MT,pre}$ *= area of pre-redevelopment managed turf (acres)*
$A_{IC,pre}$ *= area of pre-redevelopment impervious cover (acres)*
$A_{FO,post}$ *= area of post-development forest/open space (acres)*
$A_{MT,post}$ *= area of post-development managed turf (acres)*
$A_{IC,post}$ *= area of post-development impervious cover (acres)*

X_{IC} *= difference in pre-redevelopment to post-development impervious acreage*
X_{FO} *= difference in pre-redevelopment to post-development forest/open space acreage*
X_{MT} *= difference in pre-redevelopment to post-development managed turf acreage*

When the net impervious cover (IC) increases following redevelopment, there must be a simultaneous decrease in forest/open space (F/O) and/or managed turf (MT). Through a comparison process, the net decrease for the specific pervious land cover type areas must be quantified (F/O and/or MT) in order to exclude those acreages from the pre-redevelopment F/O and MT areas and establish the pre-redevelopment adjusted areas. This computation is performed in the ***ReDevelopment spreadsheet*** **Site tab** ***(hidden columns N through S)*** as follows in Fig. 28:

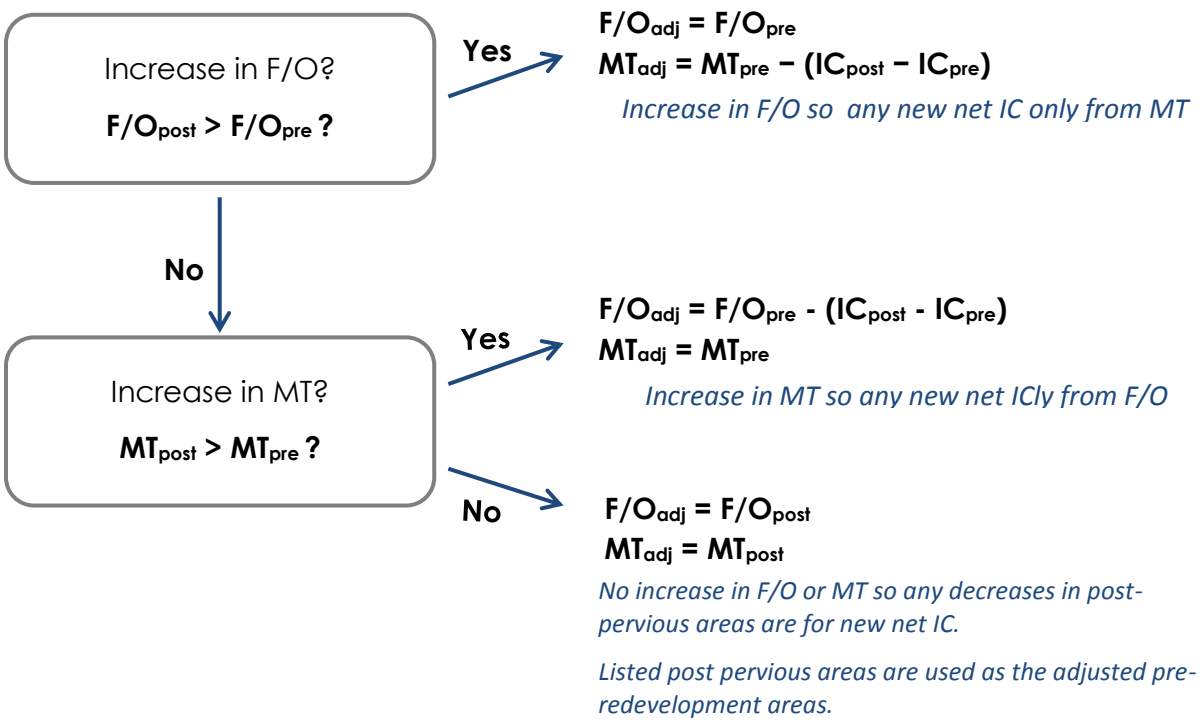


Figure 28. Decision flowchart for determination of pervious area converted to new net impervious cover in redevelopment spreadsheet.

The required reduction for the pre-redevelopment area is the post-redevelopment load for the site (excluding new net impervious cover) minus [the pre-redevelopment load for the adjusted site areas (excluding pervious areas proposed for new net impervious cover) after reduction by the maximum percentage reduction requirement] or [the TP baseline load], whichever is greatest. The required TP reduction is limited to the TP baseline load of 0.41 lb TP/acre/year applied to the adjusted pre-redevelopment site areas) as explained in Section 4.2.3.

Equation 22a. TP Load Reduction Requirement for Post-ReDevelopment Area (when target TP baseline less than or equal to target TP load, $L_{TP\ Baseline} \leq L_{target,preReDev}$)

$$\begin{aligned} L_{reduction_postReDev} &= L_{postReDev} - L_{target,preReDev} \\ &= \left(L_{FO,post} + L_{MT,post} + L_{IC,post.ReD}\right) \\ &\quad -(1 - \%MaxR) \times \left(L_{FO,pre_adj} + L_{MT,pre_adj} + L_{IC,pre_adj}\right) \end{aligned}$$

Where:

$L_{TP\ Baseline} = 0.41\ lb/acre/yr \times A_{site,pre_adj}$ *= baseline TP load (lb/yr)*

$L_{target,preReDev}$ *= the target pre-redevelopment TP load (lb/yr)*

$$= (1 - \%MaxR) \times \left(L_{FO,pre_adj} + L_{MT,pre_adj} + L_{IC,pre_adj}\right)$$

$L_{reduction_postReDev}$ *= required TP load reduction for the post-development area not including any new net impervious cover (pounds/year)*

$L_{postReDev}$ *= the post-redevelopment TP load (excluding new net impervious cover)*

$$= \left(L_{FO,post} + L_{MT,post} + L_{IC,post.ReD}\right)$$

A_{site,pre_adj} *= adjusted pre-redevelopment total site area that excludes pervious areas proposed for new net impervious cover (acres)*

$L_{FO,post}$ *= TP load calculated for post-development forest/open space areas (pounds/year)*

$L_{MT,post}$ *= TP load calculated for post-development managed turf areas (pounds/year)*

$L_{IC,post.ReD}$ *= TP load calculated for post-development impervious cover areas that do not include any new net impervious cover (pounds/year)*

$\%MaxR$ = *the maximum percentage reduction required below the pre-redevelopment load (10 or 20% expressed as 0.1 or 0.2, respectively)*

L_{FO,pre_adj} = *TP Load calculated for pre-redevelopment forest/open space areas that do not include forest/open space areas converted to post-development new net impervious cover (pounds/year)*

L_{MT,pre_adj} = *TP Load calculated for pre-redevelopment managed turf areas that do not include managed turf areas converted to post-development new net impervious cover (pounds/year)*

L_{IC,pre_adj} = *TP Load calculated for pre-redevelopment impervious cover areas (pounds/year)*

Equation 22b. TP Load Reduction Requirement for Post-ReDevelopment Area (when target TP load less than TP baseline, $L_{target,preReDev} < L_{TP\ Baseline}$)

$$L_{reduction_{postReDev}} = L_{postReDev} - L_{TP\ Baseline}$$
$$= \left(L_{FO,post} + L_{MT,post} + L_{IC,post.ReD}\right)$$
$$-0.41\ lb/acre/yr\ \times A_{site,pre_adj}$$

Where:

$L_{target,preReDev}$ = *the target pre-redevelopment TP load (pounds/year)*

$$= (1 - \%MaxR) \times \left(L_{FO,pre_adj} + L_{MT,pre_adj} + L_{IC,pre_adj}\right)$$

$L_{TP\ Baseline} = 0.41\ lb/acre/yr\ \times A_{site,pre_adj}$ = *baseline TP load*

$L_{reduction_postReDev}$ = *required TP load reduction for the post-development area excluding any new net impervious cover (pounds/year)*

$L_{postReDev}$ = *the post-redevelopment TP load (excludes new net impervious cover)*

$$= \left(L_{FO,post} + L_{MT,post} + L_{IC,post.ReD}\right)$$

$\%MaxR$ = *the maximum percentage reduction required below the pre-redevelopment load (10 or 20%, expressed as 0.1 or 0.2, respectively)*

L_{FO,pre_adj} = *TP Load calculated for pre-redevelopment forest/open space areas that do not include forest/open space areas converted to post-development new net impervious cover (pounds/year)*

L_{MT,pre_adj} = *TP Load calculated for pre-redevelopment managed turf areas that do not include managed turf areas converted to post-development new net impervious cover (pounds/year)*

L_{IC,pre_adj} = *TP Load calculated for pre-redevelopment impervious cover areas (pounds/year)*

A_{site,pre_adj} = *adjusted pre-redevelopment total site area that excludes pervious areas proposed for new net impervious cover (acres)*

$L_{FO,post}$ = *TP load calculated for post-development forest/open space areas (pounds/year)*

$L_{MT,post}$ = *TP load calculated for post-development managed turf areas (pounds/year)*

$L_{IC,post.ReD}$ = *TP load calculated for post-development impervious cover areas that do not include any new net impervious cover (pounds/year)*

9.4.2. REDEVELOPMENT WITH NO IMPERVIOUS COVER INCREASE, $(A_{IC,post} - A_{IC,pre}) \leq 0$

In the situations where a redevelopment project does not include a net change in impervious cover acreage (i.e., no new net impervious cover), the post-development site total phosphorus load must meet the pre-redevelopment total phosphorus load after the 10 or 20% reduction, depending on the project's total disturbed acreage, up to the pre-redevelopment project's baseline load at 0.41 lb TP/acre/yr. This situation is illustrated above in Section 4.2.3.

Using Equations 19 and 20:

$A_{IC,new.post} = 0$

And

$L_{reduction_IC,new.post} = 0$

9.4.3. FINAL POST-DEVELOPMENT SITE REQUIREMENT

Equation 23. Final TP Load Reduction Requirement for ReDevelopment

$$L_{reduction_FinalPost} = L_{reduction_IC,new.post} + L_{reduction_postReDev}$$

Where:

$L_{reduction_FinalPost}$ = *required TP load reduction for the post-development site consisting of all land cover areas (pounds/year)*

$L_{reduction_IC,new.post}$ = *required TP load reduction for post-development new net impervious cover (pounds/year)*

$L_{reduction_postReDev}$ = *required TP load reduction for the post-development area not including any new net impervious cover (pounds/year)*

10.0 REFERENCES

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Volume I - Introductions & Chapters 1-3:
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Volume II – Chapters 4-6 & Glossary:
http://www.deq.virginia.gov/Portals/0/DEQ/Water/StormwaterManagement/SWMHandbookVolume%20II.pdf

Virginia Stormwater Management Handbook, Second Edition (*2013 Draft*):
http://www.deq.virginia.gov/fileshare/wps/2013_SWM_Handbook/

11.0 ACRONYMS AND DEFINITIONS

BMP: Best Management Practice

BMP Clearinghouse: Virginia Stormwater BMP Clearinhouse, vwrrc.vt.edu/swc/

CN: Curve Number

DA: Drainage Area

DEQ: Virginia Department of Environmental Quality

F/O: Forest or open space

LOD: Limits of disturbance

NRCS: Natural Resources Conservation Service

HSG: Hydrologic Soil Group

IC: Impervious Cover

MT: Managed Turf

MTD: Manufactured Treatment Device

Permanent BMP: Permanent best management practice or stormwater management facilities as defined in (9VAC25-870-10)

Regulated LDA: Land-disturbing activity of one acre or more, 2,500 square feet in all areas of jurisdictions designated as subject to the Chesapeake Bay Preservation Act, part of a larger common plan of development or sale that is one acre or more, or a more stringent area as established in local ordinance, that must follow the provisions of the VSMP Regulations and obtain state permit coverage, where applicable, and VSMP authority permit coverage.

RRM: Runoff Reduction Method

RR: Runoff Reduction

RV: Runoff Volume

SWM: Stormwater management

TN: Total Nitrogen

TP: Total Phosphorus

TV: Treatment Volume

VRRM: Virginia Runoff Reduction Method

VSMP: Virginia Stormwater Management Program