The below is a cell by cell reference guide for the Delaware Urban Runoff Management Model (DURMM) Version 2 Excel program, as prepared and issued by the Delaware Department of Natural Resources and Environmental Control Sediment and Stormwater Program. The Quick Start Guide for DURMM v2 can also be referenced for additional information.

C.A. RCN Worksheet (Contributing Area Runoff Curve Number):	
Project Information	
Project (cell C1)	Enter the project name or description.
Drainage Subarea ID (cell C2)	Enter the subarea number or description.
Location (County) (cell C3)	Select "New Castle", "Kent", or "Sussex" from the drop down list (or the information can be typed as listed above). No calculations can be performed if the County cell is left blank. This field determines the storm event rainfall amounts used for the 10-year and 100-year storms. Rainfall amounts for each County are shown in the reference table starting at cell N5 on the OLOD worksheet.
Unit Hydrograph (cell C4)	Select "DMV" to use the Delmarva Unit Hydrograph or "STD" to use the standard dimensionless unit hydrograph from the drop down list (or the information can be typed as listed above). The Delmarva Unit Hydrograph shall be used for all projects south of the Chesapeake and Delaware (C&D) Canal.
Note: The above information will replicate on the subsequent worksheets, and is not repeated below.	
Contributing Area Information	
Landcover Area in A soil (cells E9→84)	Enter the area, in acres, for the corresponding cover type, treatment, and hydrologic condition listed in Columns A, B and C that are within the Hydrologic Soil group A for the current subarea's contributing area (excluding any area accounted for in an upstream subarea). Any pre-development conditions shall be selected as good hydrologic condition.
Landcover Area in B soil (cells H9→84)	Enter the area, in acres, for the corresponding cover type, treatment, and hydrologic condition listed in Columns A, B and C that are within the Hydrologic Soil group B for the current subarea's contributing area (excluding any area accounted for in an upstream subarea). Any pre-development conditions shall be selected as good hydrologic condition.
Landcover Area in C soil (cells K9→84)	Enter the area, in acres, for the corresponding cover type, treatment, and hydrologic condition listed in Columns A, B and C that are within the Hydrologic Soil group C for the current subarea's contributing area (excluding any area accounted for in an upstream subarea). Any pre-development conditions shall be selected as good hydrologic condition.

Landcover Area in D soil (cells N9→84)	Enter the area, in acres, for the corresponding cover type, treatment, and hydrologic condition listed in Columns A, B and C that are within the Hydrologic Soil group D for the current subarea's contributing area (excluding any area accounted for in an upstream subarea). Any pre-development conditions shall be selected as good hydrologic condition.
User Defined Cells (cells B87 → O88)	Enter the cover type and condition, and the corresponding acreage and RCN per Hydrologic Soil Group for any special circumstances that require a unique curve number. If an acreage is entered, the corresponding RCN value must be entered, or else the RCN will be misinterpreted as "0" and skew the results.
Subarea Contributing Area per Soil Type (ac) (cells E90, H90, K90, N90)	Calculates the subarea's contributing area, in acres, per soil type, by summing the individual landcover areas. Example cell E90: ∑E9→88.
Subarea Contributing Area (ac) (cell C91)	Calculates the total subarea contributing area by summing the subarea contributing area per soil type; ∑E→N90
Upstream Contributing Areas (cells C93 → F96)	Enter the subarea ID, total contributing area (in acres) and the contributing area RCN for any upstream areas in columns C, E and F, respectively. If there are no upstream subareas, than the cells in this section should be left blank. If there is a series of LOD areas that contribute to the current subarea in a treatment train, than only the subarea nearest upstream to the current area should be entered, as the other areas upstream will be accounted for in this nearest upstream subarea. The upstream subarea contributing acreage and corresponding RCN can be taken directly from the DURMM report, cells B55 and B56, respectively, for each upstream subarea.
Total Contributing Area (ac) (cell K98)	Calculates the total contributing area, in acres, by summing the total acres per soil type, plus the acreage from each upstream contributing area; ∑E→N90+∑E93→96.
Weighted Runoff Curve Number (RCN): (cell K100)	Calculates the composite curve number for the contributing area, by summing the product of each landcover area times the respective RCN for each soil type, then all divided by the total acres; ∑(E9→88*F9→88+H9→88*I9→88+ K9→88*L9→88+ N9→88*O9→88+E93*F93+E94*F94+E95*F95+E96*F96)/K98. Note: some calculations are performed within hidden cells.
Note: The clear table icon (cell S9 and S89) will clear all entries within the worksheet, and reset any altered cells.	
<u>LOD Worksheet (Limit of Disturbance Calculations):</u>	
<u>Step1 – Subarea LOD Data</u>	

1.1 HSG Area Within LOD (ac) (cells B→E7)	Enter the total land area *within the limit of disturbance*, in acres, per the corresponding hydrologic soil group. If all of the contributing area lies within the LOD than this number should equal the total contributing area per soil type from the C.A. RCN worksheet, cells E90, H90, K90 and N90.
1.2 Pre-Developed Woods/Meadow within LOD (ac) (cell B→E8)	Enter the total *existing* woods or meadow area, in acres, from the pre-development state that is contained within the limit of disturbance, per the corresponding hydrologic soil group, even if the woods/meadow is disturbed in the post developed condition.
1.3 Pre-Developed Impervious within LOD (ac) (cell B→E9)	Enter the total *existing* impervious, in acres, from the pre-development state that is contained within the limit of disturbance, per the hydrologic soil group, even if the impervious area is disturbed in the post developed condition. Gravel areas should be considered impervious.
1.4.a Post Developed Imperviousness within LOD, Option #1 (ac) (cell B→E10)	Enter the total impervious area, in acres, from the post development state that is contained within the limit of disturbance, per the corresponding hydrologic soil group. Gravel areas and permeable pavement should be considered impervious.
1.4.b Post Developed Imperviousness within LOD, Option #2 (%) (cell B→E11)	Enter the total impervious area, in percent of the total limit of disturbance area, from the post development state that is contained within the limit of disturbance, per the corresponding hydrologic soil group. Note: This cell will automatically calculate if Option #1 is entered (B→E10 / B→E7); If Option #2 is manually entered, click the reset icon to regenerate the original equation, if desired.
Step 2 – Subarea LOD Runoff Calcs.	
2.1 RCN per HSG (cell B→E14)	Calculates the composite runoff curve number per hydrologic soil group within the LOD based on the percent of imperviousness times a runoff coefficient of 98, plus the percent of perviousness (total LOD area minus the impervious area) times a runoff coefficient corresponding to "grass cover, good" per the respective soil class (A = 39, B = 61, C = 74, D = 80). Example cell B14: B11*98+(1-B11)*39, where 39 represents the curve number for grass cover, good within the A soil group.
2.2 RPv per HSG (in.) (cell B→E15)	Calculates the Resource Protection runoff volume, in inches, per hydrologic soil group, using the previously calculated RCN per HSG within the event based runoff equation. Reference the LOD worksheet explanation for further details. Example cell B15: $0.000466*B14^2-0.023230*B14+0.263672$.

2.3 Target Runoff per HSG (in.) (cell B→E16)	Calculates the target runoff volume, in inches, based on the pre-developed woods and/or meadow area and the percent pre-developed impervious area, per hydrologic soil group. The first step multiplies the pre-developed woods and/or meadow area by the pre-determined RPv target runoff factor for a woods condition to establish the runoff from the woods and/or meadow. The second step calculates the runoff from the non-wood and/or non-meadow area by multiplying this area (the difference of the total LOD area minus the woods/meadow area) by the runoff generated based on the percent impervious within the LOD. Reference the LOD worksheet explanation for further details on the equation to derive this target runoff for the non-woods/non-meadow area. The result from the two steps are added together, and then divided by the total LOD area to produce the total target runoff per acre. Note that the pre-developed impervious area is multiplied by 30% since for redevelopment purposes, only 30% of the existing impervious needs to be accounted for. Example cell B16: ((B8*N15)+((B7-B8)*(1.4687*((B9/B7*0.3)^2)+0.9813*(B9/B7*0.3)+0.0125)))/B7, where N15 is the RPv target runoff factor for woods (0.00 for HSG A), and $1.4687x^2+0.9813x+0.0125$ is the RPv target factor for non-woods/non-meadow in HSG A based on the percent of effective impervious, x.
2.4 Cv Weighted Unit Discharge (cfs/ac) (cell B→E17)	Calculates the target runoff discharge for the Conveyance event, in cfs/ac, based on established unit discharges for wood/meadow and non-woods/meadow conditions per hydrologic soil group, similar to the target runoff above. This is done by summing the pre-developed woods/meadow area multiplied by the respective discharge rate plus the pre-developed non-woods/meadow area (the total HSG area minus the pre woods/meadow area) multiplied by the respective discharge rate, all divided by the total HSG area. Reference the LOD worksheet explanation for further details. Example cell B17: (B8*0+(B7-B8)*0.75)/B7, where 0 and 0.75 are the established Cv unit discharges for the A soil group for woods/meadow and non-woods/meadow, respectively.
2.5 Fv Weighted Unit Discharge (cfs/ac) (cell B→E18)	Calculates the target runoff discharge for the Flooding event, in cfs/ac, based on established unit discharges for wood/meadow and non-woods/meadow conditions per hydrologic soil group, similar to the target runoff above. This is done by summing the pre-developed woods/meadow area multiplied by the respective discharge rate plus the pre-developed non-woods/meadow area (the total HSG area minus the pre woods/meadow area) multiplied by the respective discharge rate, all divided by the total HSG area. Reference the LOD worksheet explanation for further details. Example cell B18: (B8*0.25+(B7-B8)*2.25)/B7, where 0.25 and 2.25 are the established Fv unit discharges for the A soil group for woods/meadow and non-woods/ meadow, respectively.

2.6 Subarea LOD (ac) (cell B20)	Adds the LOD area per hydrologic soil group for a combined subarea LOD, in acres. ∑B→E7.
2.7 Subarea Weighted RCN (cell B21)	Calculates the composite runoff curve number for the subarea LOD by adding the sum of each LOD area per HSG times its respective HSG RCN, and then dividing by the total subarea LOD. ∑(B7*B14+C7*C14+D7*D14+E7*E14)/B20.
2.8 Subarea Weighted RPv (in.) (cell B22)	Calculates the composite runoff for the subarea LOD during the RPv event, by adding the sum of each LOD area per HSG times its respective RPv per HSG, and then dividing by the total subarea LOD. ∑(B7*B15+C7*C15+D7*D15+E7*E15)/B20.
2.9 Subarea Weighted Target Runoff (in.) (cell B23)	Calculates the composite target runoff for the subarea LOD by adding the sum of each LOD area per HSG times its respective target runoff per HSG, and then dividing by the total subarea LOD. ∑(B7*B16+C7*C16+D7*D16+E7*E16)/B20.
Step 3 – Upstream LOD Areas *(from previous DURMM Report as applicable)*	
3.1 Upstream Subarea ID (cells B→E26)	Enter the ID name for each upstream LOD area that contributes to the current subarea (will auto-generate from the C.A. RCN worksheet if entered in cells C93→97). If there are no upstream LOD subareas, than the cells in the Step 3 section should be left blank. If there is a series of LOD areas that contribute to the current subarea in a treatment train, than only the subarea nearest upstream to the current area should be entered, as the other LOD areas upstream will be accounted for in this nearest upstream area. The upstream subarea ID name, and all subsequent upstream subarea information can be taken directly from the DURMM report for the corresponding subarea.
3.2 Upstream LOD Area (ac) (cells B→E27)	Enter the acreage of the contributing upstream LOD area, in acres, as stated in the corresponding DURMM Report, cell B58.
3.3 Target Runoff for Upstream Area (in.) (cells B→E28)	Enter the weighted target runoff for the upstream area, in inches, as stated in the corresponding DURMM Report, cell B59.
3.4 Adjusted CN after all Reduction (cells B→E29)	Enter the final curve number for the upstream area after all runoff and retention reductions are accounted for, as stated in the corresponding DURMM Report, cell B60.
3.5 Adjusted RPv (in.) (cells B→E30)	Enter the final runoff volume for the RPv event, in inches, for the upstream area after all runoff and retention reductions are accounted for, as stated in the corresponding DURMM Report, cell B61.
3.6 Adjusted Cv (in.) (cells B→E31)	Enter the final runoff volume for the Cv event, in inches, for the upstream area after all runoff and retention reductions are accounted for, as stated in the corresponding DURMM Report, cell B62.
3.6 Adjusted Fv (in.) (cells B→E32)	Enter the final runoff volume for the Fv event, in inches, for the upstream area after all runoff and retention reductions are accounted for, as stated in the corresponding DURMM Report, cell B63.

Step 4 - RPv Calculations for Combined LOD	
4.1 Combined LOD area (ac) (cell B35)	Calculates the total contributing LOD area, in acres, by adding the total subarea LOD to each of the upstream LOD areas. B20+B27+C27+D27+E27.
4.2 Weighted RCN (cell B36)	Calculates the weighted runoff curve number for the combined LOD area by summing the product of the subarea LOD times the subarea RCN and each upstream LOD area times its respective RCN, and then dividing by the total combined LOD area. ∑(B21*B20+B29*B27+C29*C27+D29*D27+E29*E27)/B35
4.3 Weighted RPv (in.) (cell B37)	Calculates the composite runoff volume for the LOD, in inches, by summing the product of the subarea LOD times the subarea RPv and each upstream LOD area times its respective adjusted RPv, and then dividing by the total combined LOD area. ∑(B22*B20+B30*B27+C30*C27+D30*D27+E30*E27)/B35
4.4 Weighted Target Runoff (in.) (cell B38)	Calculates the total weighted runoff volume for the LOD, in inches, by summing the product of the subarea LOD times the subarea target and each upstream LOD area times its respective target, and then dividing by the total combined LOD area. ∑(B23*B20+B28*B27+C28*C27+D28*D27+E28*E27)/B35
4.5 Estimated Annual Runoff (in.) (cell B39)	Calculates the amount of runoff generated throughout the course of the year, in inches, based on the weighted RCN for the combined LOD, $0.000004*B36^{3.5}$. Reference the LOD worksheet explanation for further details.
4.6 Required Runoff Reduction within LOD (in.) (cell B40)	Calculates the required reduction volume in runoff, in inches, by subtracting the combined target runoff from the total RPv runoff, B37-B38.
4.7 Required Runoff Reduction within LOD (%) (cell B41)	Calculates the percent of runoff reduction required for the RPv event by dividing the Required Runoff Reduction by the Weighted RPv, B40/B37.
Step 5 - Cv Unit Discharge	
5. LOD Allowable Unit Discharge (cfs/ac) (cell B44)	Calculates the maximum Cv unit discharge for the combined LOD, in cfs/acre, by summing each LOD area per hydrologic soil group times its respective Cv unit discharge and each upstream LOD area times its respective adjusted Cv, and then dividing by the total combined LOD area. ∑(B7*B17+C7*C17+D7*D17+E7*E17+B27*B31+C27*C31+D27*D31+E27*E31)/B35.

Step 6 - Fv Unit Discharge	
6. LOD Allowable Unit Discharge (cfs/ac) (cell B47)	Calculates the maximum Fv unit discharge for the combined LOD, in cfs/acre, by summing each LOD area per hydrologic soil group times its respective Fv unit discharge and each upstream LOD area times its respective adjusted Fv, and then dividing by the total combined LOD area. ∑(B7*B18+C7*C18+D7*D18+E7*E18+B27*B32+C27*C32+D27*D32+E27*E32)/B35.
Note: The Reset icon (cell G6) will clear all entries within the worksheet, and reset any altered cells.	
OLOD Worksheet (Outside the Limit of Disturbance Calculations):	
Step 1 - Site Data	
1.1 Total Contributing Area (ac) (cell B8)	Returns the total contributing area from the C.A. RCN worksheet, cell K98.
1.2 C.A. RCN (cell B9)	Returns the weighted runoff curve number for the contributing area from the C.A. RCN worksheet, cell K100.
1.3 LOD Area (ac) (cell B10)	Returns the limit of disturbance area for the current subarea from the LOD worksheet, cell B20.
1.4 LOD RCN (cell B11)	Returns the weighted runoff curve number for the current subarea's limit of disturbance from the LOD worksheet, cell B21.
1.5 Outside LOD Area (ac) (cell B12)	Calculates the area, in acres, outside of the limit of disturbance by subtracting the LOD area from the total contributing area. B8-B10.
1.6 Outside LOD RCN (cell B13)	Calculates the weighted runoff curve number for the outside limit of disturbance by subtracting the product of the LOD area times the LOD RCN from the product of the C.A. times the C.A. RCN, then dividing by the outside LOD area. ((B8*B9)-(B10*B11))/B12.
Step 2 - Time of Concentration	
2.1 Length (ft) (cells B19→29)	Enter the length, in feet, for each type of flow within the time of concentration (Tc) path. Three entries of sheet flow and shallow concentrated flow can be entered, and five entries of open channel flow can be entered. The maximum combined sheet flow length should be 100 feet.
2.2 Slope (ft/ft) (cells C19→29)	Enter the slope for each section of the Tc path given a defined length. The slope should be entered as foot per foot. The average slope should be entered; however, any major changes in slope should result in a separate entry.

2.3 Surface Code (cells D19→D24)	Enter the code corresponding to the type of surface cover for each entered segment of sheet and shallow concentrated flow. Surface codes do not need to be entered for open channel segments. The surface codes can be found starting at cell B34, and are as below. Sheet Flow Surface Codes: a, smooth surface; b, fallow (no residue); c, cultivated <20% residue; d, cultivated >20% residue; e, grass – range, short; f, grass, dense; g, grass, bermuda; h, woods, light; i, woods, dense; j, range, natural Shallow Concentrated Surface Codes: u, unpaved surface; p, paved surface
2.4.a Manning's n, sheet flow (cells E19→21)	Returns the corresponding Manning's n value for the entered type of surface per section of sheet flow. Reference the OLOD worksheet explanation for the Manning's n values used for each surface code.
2.4.b Manning's n, open channel flow (cells E25→29)	Enter the corresponding Manning's n value for the type of surface per section of open channel flow, i.e., 0.012 for plastic pipe, 0.013 for concrete, 0.022 for clean excavated channels, etc. The values used shall be per standard literature regarding open channel flow.
2.5.a Velocity, shallow concentrated flow (ft/sec) (cells F22→24)	Calculates the velocity, in ft/sec, for each section of shallow concentrated flow, using TR-55 average velocity equations based on the slope of the Tc path. Reference Figure 3-1 and Appendix F in the TR-55 manual. Example cell F22, Unpaved: $16.1345*C22^{0.5}$; Paved: $20.3282*C22^{0.5}$.
2.5.b Velocity, open channel flow (ft/sec) (cells F25→29)	Enter the velocity, in ft/sec, for each section of open channel flow, using Manning's equation, $v=1.49/n*R^{2/}3*S^{1/2}$.
2.6.a Travel Time, sheet flow (hrs) (cells G19→21)	Calculates the time of travel for each section of sheet flow, in hours, using TR-55 methodology. Example cell G19: $(0.007*(E19*B19)^{0.8})/(O31^{0.5}*C19^{0.4})$. Note: the 2-year, 24-hour rainfall used is 3.3" as defined in cell O31.
2.6.b Travel Time, shallow concentrated flow and open channel flow (hrs) (cells G22→29)	Calculates the time of travel for each section of shallow concentrated flow and/or each section of open channel flow, in hours, using TR-55 methodology. Example cell G22: B22/(3600*F22).
2.7 Time of Concentration (Tc) (hrs) (cell G31)	Calculates the total travel time, in hours, by adding the time for each section of flow, ∑G19→29. Note: If Step 2 is left blank than the minimum time of 0.10 hour is defaulted.
Step 3 - Peak Discharge	
3.1 Unit Hydrograph Type (cell B44)	Returns the Unit Hydrograph Type from the Project Information, cell B4.
3.2 Frequency (yr) (cells B→C 45)	Headers for the 10 year and 100 year storm events, whose data will be calculated below.
3.3 24-Hour Rainfall, P (in) (cells B→C46)	Returns the 24-hour rainfall amount, in inches, for the respective storm frequency and per which county the project is located within. Values are stored within cells O8→10 for the Cv and P8→10 for the Fv. Reference the OLOD worksheet explanation for the values used.

3.4 Initial Abstraction, Ia (in) (cells B→C47)	Returns the initial abstraction value, in inches, per the OLOD RCN (the same Ia value is used for both the 10 and 100 year storms). Ia lookup values are stored within cells V45→113. Reference the OLOD worksheet explanation for the values used.
3.5 Ia/P Ratio (cells B→C48)	Calculates the ratio of the Initial Abstraction divided by the rainfall amount. Example cell B48: B47/B46.
3.6 Unit Peak Discharge, q_u (csm/in) (cells B→C49)	Calculates the peak unit discharge, in csm/in, for the 10 and 100 year storm event depending on whether the Standard or Delmarva Unit Hydrograph is being used. Reference the OLOD worksheet explanation for further details. Example cell B49, STD: 10^{R52}; DMV: 10^{R64}.
3.7 Runoff (in.) (cells B→C50)	Calculates the volume of runoff, in inches, for the OLOD area by employing the SCS equations for runoff and the potential maximum retention, combined into one equation. Reference the OLOD worksheet explanation for further details. Example cell B50: $(B46-0.2*(1000/B13-10))^2/(B46+0.8*(1000/B13-10))$.
3.8 Peak Discharge, q_p (cfs) (cells B→C51)	Calculates the peak discharge for the OLOD, in cubic feet per second, by multiplying the outside LOD area, converted to square miles, times the unit peak discharge and times the runoff. Example cell B51: (B12/640)*B49*B50.
3.9 Equivalent Unit Peak Discharge (cfs/ac) (cells B→C52)	Calculates the per acre peak discharge for the OLOD area, in cubic feet per second per acre, by dividing the peak discharge by the outside LOD area. Example cell B52: B51/B12.
Note: The Clear Tc icon (cell I19) will clear all entries within the worksheet, and reset any altered cells.	
RPv Worksheet (1-Year, Resource Protection Event Modeling):	
BMP Type (cells C6, E6, G6, I6, K6)	Select the type of Best Management Practice from the drop down list of defined practices. Reference the Data and Documentation worksheet for a complete listing of the BMPs and their corresponding design parameters. The initial, furthest upstream practice shall be BMP 1, with each subsequent BMP being the next downstream. If a BMP is not needed for a specified column, than "--" must be chosen from the drop down list. If a desired BMP is not listed or additional BMP computation areas are needed, contact the DNREC Sediment and Stormwater Program for assistance.
Step 1 – Calculate Initial RPv	
1.1 Total contributing area to BMP (ac) (cells B8, D8, F8, H8, J8)	Returns the contributing area, in acres, from the C.A. RCN worksheet, cell K98.
1.2 Reserved	
1.3 Initial RCN (cell B10)	Returns the Runoff Curve Number previously calculated for either the contributing area or the combined LOD area; if the two area values are equal then the combined LOD RCN is returned; if the contributing area is greater, than the C.A. RCN is returned. Returns either cell K100 on the C.A. RCN worksheet, or B36 on the LOD worksheet based on the above logic.

1.4 RPv for Contributing Area (in.) (cell B11)	Returns the combined RPv runoff calculated in the LOD worksheet, cell B37, if the contributing area is equal to the combined LOD area. If the contributing area is greater than the combined LOD area, calculates the runoff generated for the RPv event for the entire contributing area, in inches, using the same methodology as used in the LOD worksheet to calculate the RPv, but uses the initial RCN, rather than the LOD RCN (the initial RCN will be the C.A. RCN if the equation is being utilized); $0.000466*B10^2-0.02323*B10+0.263672$. However, if the contributing area times this value, is less than the combined LOD area times the combined LOD runoff, then the RPv for the contributing area is calculated by taking the weighted average from the LOD, by multiplying the combined LOD area times the LOD runoff, divided by the contributing area; (LOD!B35*LOD!B37)/B8. This clause prevents any offsite contributions from creating a runoff that is less than the runoff calculated on the LOD worksheet.
1.5 Required RPv Reduction for Contributing Area (in.) (cell B12)	Calculates the required reduction in runoff for the RPv event, in inches, for the contributing area based on the required reduction for the combined LOD area. This is done by multiplying the required reduction for the LOD RPv by the total LOD area, and then dividing by the contributing area; LOD!B40*LOD!B35/B8.
1.6 Required RPv Reduction for Contributing Area (%) (cell B13)	Calculates the required reduction in runoff for the RPv event, in percent form, for the contributing area by dividing the required RPv reduction in inches by the total RPv for the contributing area, also in inches; B12/B11.
1.7 RPv Allowable Discharge Rate (cfs) (cell B14)	Calculates the allowable discharge rate, in cubic feet per second, for the contributing area, by multiplying the total LOD area times the runoff volume for the RPv event, and by applying the appropriate conversion factors to get cubic feet per second; LOD!B35*LOD!B37*43560/12/86400.
Step 2 – Adjust for Retention Reduction	
2.1 Storage Volume (cu. ft.) (cell B17, D17, F17, H17, J17)	Enter the volume of retention, in cubic feet, for retention practices only (cell will be green if entry is needed). Note that if a volume is entered for a BMP that does not have any retention capabilities, i.e., a vegetated open channel, the entered volume will not be utilized and will not affect any calculations. Reference the BMP Suite table, on the Data and Documentation Worksheet, column J – Retention Allowable, to determine if retention occurs within the BMP. Also note that the storage volume for a BMP may need to be split amongst several subareas based on the percent contribution (i.e., the total storage volume cannot be entered for multiple sub-areas; a percent of the total storage volume would need to be entered).
2.2 Retention Reduction Allowance (%) (cell B18, D18, F18, H18, J18)	Returns the percent of retention reduction that is allowable per the chosen BMP by comparing the BMP Type from cell C6, E6, G6, I6, K6 to the BMP Suite table on the Data and Documentation worksheet, column J – Retention Allowable.

2.3 Retention Reduction Volume (ac-ft) (cells B19, D19, F19, H19, J19)	Calculates the actual retention volume for the chosen BMP by multiplying the storage volume by the percentage of retention that is allowable, and then converting to acre-feet; Example cell B19: B17*B18/43560.
2.4 Retention Reduction Volume (in.) (cells B20, D20, F20, H20, J20)	Calculates the retention volume in inches on a per contributing area basis, by dividing the retention reduction volume in acre-feet, by the contributing area, and converting the units to achieve a volume in inches; Example cell B20: B19/B8*12.
2.5 Runoff Volume after Retention Reduction (in.) (cells B21, D21, F21, H21, J21)	Calculates the total runoff volume, in inches, for the contributing area after the retention reduction is accounted for, by subtracting the retention reduction volume from the contributing area runoff for BMP 1, or for the higher order BMPs, from the runoff volume after all reductions from the previous BMP. Example cell B21: B11-B20; Example cell D21: B34-D20.
2.6 Adjusted CN* (cells B22, D22, F22, H22, J22)	Calculates the revised runoff curve number for the contributing area based off of the runoff volume after retention reduction, using the Annual Curve Number equation. Reference the RPv worksheet explanation for further details. Example cell B22: 46.3241*√(B21+0.025831)+0.538054.
Step 3 - Adjust for Annual Runoff Reduction	
3.1 Annual CN (ACN) (cells B25, D25, F25, H25, J25)	Calculates the annual runoff curve number for the contributing area based of the runoff volume after reductions have been accounted for from the previous BMP. Reference the RPv worksheet explanation for further details about the annual curve number equation. Example cell D25: 46.3241*√(B34+0.025831)+0.538054. Note: for BMP 1, the annual CN is equal to the initial RCN, cell B10, since no previous BMP reductions have taken place.
3.2 Annual Runoff (in.) (cells B26, D26, F26, H26, J26)	Calculates the annual runoff volume, in inches, for the contributing area by using the annual CN value in the Annual Runoff Equation. Reference the LOD worksheet explanation for further details on the Annual Runoff Equation. Example cell B26: $0.000004*B25^{3.5}$.
3.3 Proportion A/B soils in BMP footprint (%) (cells B27, D27, F27, H27, J27)	Enter the combined percent of A and B soils within the footprint of the BMP (not the entire contributing area) for any BMPs that receive annual runoff reduction credit (cell will be green if entry is needed). Note that if a percentage is entered for a BMP that does not have any annual runoff reduction capabilities, i.e., a bioretention system, the entered percentage will not be utilized and will not affect any calculations. Reference the BMP Suite table, on the Data and Documentation Worksheet, column K and M – Annual RR, to determine if annual runoff reduction occurs within the BMP depending on the soil type. Note that vegetated roofs are always used on A/B soils to represent the growing media, not the native soil beneath the structure.

3.4 Annual runoff reduction allowance (%) (cells B28, D28, F28, H28, J28)	Returns the percent of annual runoff reduction allowed per the BMP type and per the amount of the BMP area in A and B soils versus C and D soils, by utilizing the specified reduction percent in the BMP Suite table in the Data and Documentation worksheet, columns K and M – Annual RR.
3.5 Annual runoff after reduction (in.) (cells B29, D29, F29, H29, J29)	Calculates the annual runoff volume, in inches, for the contributing area after the annual runoff reduction is accounted for, by multiplying the annual runoff by the difference of one minus the percent reduction allowed for the BMP. Example cell B29: B26*(1-B28).
3.6 Adjusted ACN (cells B30, D30, F30, J30, J30)	Calculates the revised runoff curve number based off of the amount of annual runoff once the reduction from the BMP is taken into account. This is done by solving for the ACN in the Annual Runoff equation, and using the resulting equation, ACN = 34.8553*Annual Runoff$^{0.285714}$. Example cell B30: 34.8553*B29$^{0.285714}$.
3.7 Annual Runoff Reduction Allowance for RPv (in.) (cells B31, D31, F31, H31, J31)	Calculates the amount of reduction created for the annual runoff, in inches, by using the RPv runoff equation with the adjusted ACN to determine the amount of runoff generated and then subtracting that value from the initial RPv runoff in order to determine the amount of reduction. B11-(0.000466*B30^2-0.02323*B30+0.263672).
Step 4 – Calculate RPv with BMP Reductions	
4.1 RPv runoff volume after all reductions (in.) (cells B34, D34, F34, H34, J34)	Calculates the final RPv runoff, in inches, after all adjustments are made for each BMP, by subtracting the retention reduction volume and the annual runoff reduction allowance from the initial RPv for the contributing area. Example cell B34: B11-B20-B31.
4.2 Total RPv runoff reduction (in.) (cells B35, D35, F35, H35, J35)	Calculates the total amount of runoff reduction, in inches, by subtracting the runoff volume after all reductions are accounted for from the original RPv runoff amount (equivalent to summing the retention reduction value and the annual runoff reduction value) for each BMP. Example cell B35: B11-B34.
4.3 Total RPv runoff reduction (%) (cells B36, D36, F36, H36, J36)	Calculates the percent of total runoff reduction for the Resource Protection Event, by dividing the total runoff reduction for each BMP by the original runoff amount. Example cell B36: B35/B11.
4.4 Adjusted CN after all reductions (cells B37, D37, F37, H37, J37)	Returns the lesser of the adjusted curve number after retention reduction and the adjusted curve number after annual runoff reduction for each BMP. Example cell B37: If B22<B30, than B22, if not B30.
4.5 Adjusted equivalent annual runoff (in.) (cells B38, D38, F38, H38, J38)	Calculates the annual runoff volume, in inches, for each BMP by using the adjusted CN after all reductions value in the Annual Runoff Equation. Reference the LOD worksheet explanation for further details on the Annual Runoff Equation. Example cell B38: 0.000004*B37$^{3.5}$.

4.6 Equivalent TR-5 RCN for H&H modeling (cells B39, D39, F39, H39, J39)	Calculates the comparative runoff curve number from an event-based approach to the derived annual runoff curve number, by using McCuen's change in curve number method. Reference the RPV worksheet explanation for further details. Example cell B39: 200/((2.7+2*B34+2)-√(5*2.7*B34+4*B34^2)).
4.7 Required reduction met? (cells B40, D40, F40, H40, J40)	Determines if the amount of reduction in runoff for the RPv event meets the required reduction amount needed for the contributing area by comparing the two values and returning "NO" if the reduction amount is not met, and "YES" if the reduction is met. If the reduction is not met, than additional BMP's should be employed until the reduction is met, or the corresponding offset fee is paid if BMP's have been utilized to the maximum extent practicable and the reduction is still not met. Example cell B40: If B35 ≥ B12, than YES, if not NO.
4.8 If required reduction met, reduction credit (cu.ft.) (cells B41, D41, F41, H41, J41)	If the required reduction has been met as determined in step 4.7, than the amount of over reduction, or reduction credit, is calculated in cubic feet. Note this value will always be negative. The credit can then be applied to downstream subareas or site point of discharge comparisons. Example cell B41: If B40 = YES, than (B12-B35)*43560/12*B8, if not N/A.
Step 5 – Determine Runoff Reduction Offset	
5.1 Runoff Reduction Shortfall (in.) (cells B44, D44, F44, H44, J44)	Calculates the difference in the required reduction compared to the total provided reduction for the RPv event, in inches, if the required reduction has not been met. If the required reduction has been met, then no shortfall will be calculated. Example cell B44: B12-B35.
5.2 Runoff Reduction Shortfall (cu.ft./ac) (cells B45, D45, F45, H45, J45)	Calculates the reduction shortfall in cubic feet per acre by applying the appropriate conversion. Example cell B45: B44*43560/12.
5.3 Total Offset Volume (cu.ft.) (cells B46, D46, F46, H46, J46)	Calculates the required offset volume, in cubic feet, by multiplying the contributing area times the reduction shortfall. Example cell D46: D8*D45. The initial shortfall, cell B46, uses the required reduction in cell B12 to calculate the shortfall, B12*43560/12*B8.
Note: The Reset icon (cell A5) will clear all entries within the worksheet, and reset any altered cells.	
TMDL Worksheet (Total Maximum Daily Load Modeling):	
Landuse Type (cell B3)	Select "Urban Open Space", "Residential", "Commercial", "Institutional", "Industrial", "Rural Road", or "Urban Road/Highway" from the drop down list, for the landuse that bests describes the contributing LOD area (or the information can be typed as listed above). If more than one description is applicable, the more conservative option shall be selected (i.e., the landuse type that has higher EMC values, see step 2.1 below).

TMDL Watershed (cell B4)	Select the watershed that the project site is within from the drop down list so that the appropriate total maximum daily load values can be applied per pollutant type. The water shed names are categorized per drainage basin, i.e., Piedmont, Delaware Bay, Chesapeake Bay and the Inland Bays/Atlantic Ocean.
BMP Type (cells C7, G7, K7, O7, S7)	Returns the type of Best Management Practice that was chosen on the RPv worksheet.
Step 1 – Calculate Annual Runoff Volume	
1.1 Total contributing area to BMP (ac) (cells B9)	Returns the contributing area, in acres, from the RPv worksheet, cell B8.
1.2 Initial RCN (cell B9)	Returns the initial Runoff Curve Number from the RPv worksheet, cell B10.
1.3 Annual runoff volume (in.) (cell B11)	Returns the annual runoff volume, in inches, as calculated in the RPv worksheet, cell B26.
1.4 Annual runoff volume (liters) (cell B12)	Converts the annual runoff volume to liters by applying the necessary unit conversions and then calculates the total volume for the subarea by multiplying by the total contributing area; B9*B11*102790.
Step 2 –Calculate Annual Pollutant Load	
2.1 EMC (mg/L) (cells C→E15, G→I15, K→M15, O→Q15, S→U15)	Returns the event mean concentration (EMC), in milligrams per liter, for each pollutant: Total Nitrogen (TN), Total Phosphorus (TP), and Total Suspended Solids (TSS). For BMP 1 looks up the value per defined Landuse Type from the EMC chart starting at cell Z1. Reference the TMDL worksheet explanation for additional information. For the subsequent BMPs, the effluent concentration from the previous BMP is returned as the initial EMC. Example cell G15 = C25.
2.2 Load (mg/yr) (cells C16, D16, E16)	Calculates the pollutant load in milligrams per year, by multiplying the EMC by the total annual runoff volume in liters for BMP 1, and by the Adjusted annual runoff volume for subsequent BMPs. Example cell C16: B12*C15; example cell G16: B22*G15.
2.3 Stormwater Load (lb/ac/yr) (cells C→E17, G→I17, K→M17, O→Q17, S→U17)	Calculates the pollutant load in pounds per acre per year, by multiplying the load calculated in step 2.2 by conversion factors and dividing by the total contributing area, for BMP 1. Example cell C17: C16*0.000002205/B9. Note: any latter BMPs use the adjusted load calculated in Step 3.7 from the previous BMP; Example cell G17: C26.
Step 3 – Adjust for Runoff Reduction	
3.1 BMP Annual Runoff Reduction (%) (cells B20, F20, J20, N20, R20)	Calculates the percent of runoff reduction on an annual basis per BMP based on the RPv worksheet results by subtracting the adjusted annual runoff from the initial annual runoff and then dividing by the initial annual runoff to determine the percent of reduction. Example cell B20: (RPv!B26–RPvB38)/RPv!B26.
3.2 Adjusted annual runoff volume (in.) (cells B21, F21, J21, N21, R21)	Returns the adjusted annual runoff volume, in inches, from the RPv worksheet for the corresponding BMP. Example cell B21: RPv!B38.

3.3 Adjusted annual runoff volume (liters) (cells B22, F22, J22, N22, R22)	Converts the annual runoff volume to liters per BMP by applying the necessary unit conversions and then calculates the total volume for the subarea by multiplying by the total contributing area. Example cell B22: B9*B21*102790.
3.4 Adjusted load from annual reductions (lb/ac/yr) (cells C→E23, G→I23, K→M23, O→Q23, S→U23)	Calculates the adjusted stormwater load due to annual runoff reductions, in pounds per acre per year, for each BMP and pollutant by multiplying the initial event mean concentration times the adjusted annual runoff volume times a conversion factor and dividing by the total contributing area. If the annual runoff reduction is 0%, then the initial stormwater load from step 2.3 is returned. Example cell C23: If B20=0 then C17, if not C15*B22*0.000002205/B9.
3.5 BMP Removal Efficiency (%) (cells C→E24, G→I24, K→M24, O→Q24, S→U24)	Returns the efficiency of the BMP to remove the specified pollutant, in percent form from the Data & Documentation worksheet, column D for TN, F for TP and H for TSS. If the pollutant removal is based on the annualized load reduction then "N/A" is returned, as this was accounted for in the previous calculations.
3.6 Treatment Train Removal Efficiency (%) (cells C→E25, G→I25, K→M25, O→Q25, S→U25)	Accounts for the reduction in efficiency for subsequent BMPs by multiply the BMP removal efficiency by 75% for all BMPs after the first (i.e., BMP 1's treatment train removal efficiency is still equal to the original amount).
3.7 BMP effluent concentration (mg/L) (cells C→E26, G→I26, K→M26, O→Q26, S→U26)	Calculates the revised pollutant concentration in milligrams per liter within the effluent of each BMP due to the BMP's reduction efficiency by multiplying the EMC of the influent by one minus the treatment train removal efficiency. If the BMP does not have any pollutant removal efficiency, the EMC of the influent is returned. Example cell C26: If C25="N/A" then C15, if not, C15*(1-C25).
3.8 Final Adjusted Load (lb/ac/yr) (cells C→E27, G→I27, K→M27, O→Q27, S→U27)	Calculates the final adjusted load, in pounds per acre per year, by multiplying the adjusted stormwater load due to annualized reductions by one minus the treatment train removal efficiency. If the BMP does not have any pollutant removal capabilities, then the adjusted stormwater load due to annualized reductions is returned. Example cell C27: If C25="N/A" then C23, if not, C23*(1-C25).
3.9 Final Adjusted Load (lb/yr) (cells C→E28, G→I28, K→M28, O→Q28, S→U28)	Calculates the final adjusted load in pounds per year by multiplying the result from step 3.8 by the total contributing area. Example cell C28: C27*B9.
Step 4 – Calculate Pollutant Reduction (for informational purposes)	
4.1 TMDL (lb/ac/yr) (cells C→E31)	Returns the allowable TMDL requirement, in pounds per acre per year, per the type of pollutant and per the selected watershed, by searching these parameters within the TMDL Reduction Requirements table, column AA for TN, AB for TP and AC for TSS.

4.2 Reduction met? (cells C→E32, G→I32, K→M32, O→Q32, S→U32)	Determines if the final adjusted pollutant load calculated in step 3.8 is less than or equal to the prescribed TMDL requirement for the watershed (or if the initial pollutant load calculated in step 2.3 is less than or equal to the TMDL) for each pollutant. If the adjusted load is less than the required TMDL than "YES" is returned; if not, "NO" is returned.
4.3 Removed Load (lb/yr) (cells C→E33, G→I33, K→M33, O→Q33, S→U33)	Calculates the total pollutant load removed by the BMP in pounds per year by subtracting the final adjusted load from the stormwater load and multiplying by the total contributing area. Example cell C33: (C17-C27)*B9.

Cv Worksheet (10-Year, Conveyance Event Modeling):	
BMP Type (cells C6, E6, G6, I6, K6)	Returns the type of Best Management Practice that was chosen on the RPv worksheet.
Step 1 – Calculate Initial Cv	
1.1 Total contributing area to BMP (ac) (cells B8, D8, F8, H8, J8)	Returns the contributing area, in acres, from the RPv worksheet, cell RPv!B8.
1.2 Initial RCN (cell B9)	Returns the initial Runoff Curve Number from the RPv worksheet, cell RPv!B10.
1.3 10-Year Rainfall (in.)(cell B10)	Returns the 24-hour rainfall amount, in inches, for the 10-year storm depending on which county the project is located within. For the values used, reference the OLOD worksheet explanation, step 3.3, for the 24-Hour Rainfall Table.
1.4 Cv runoff volume (in.) (cell B11)	Calculates the runoff volume for the Cv event, in inches, using the event-based runoff equation, explained within the OLOD worksheet explanation. $(B10-0.2*((1000/B9)-10))^2/(B10+0.8*((1000/B9)-10)))$.
1.5 LOD allowable unit discharge (cfs/ac) (cell B12)	Returns the allowable unit peak discharge, in cubic feet per second per acre, for the LOD area calculated for the Cv event in the LOD worksheet, cell LOD!B44.
1.6 Equivalent unit discharge outside LOD (cfs/ac) (cell B13)	Returns the equivalent allowable unit peak discharge, in cubic feet per second per acre, for the outside LOD area calculated for the Cv event in the OLOD worksheet, cell OLOD!B52.
1.7 Cv Allowable Discharge Rate (cfs) (cell B14)	Calculates the allowable discharge rate, in cubic feet per second, by adding the product of the LOD allowable unit discharge times the LOD area to the product of the OLOD allowable unit discharge times the OLOD area. B12*LOD!B35+B13*OLOD!B12. However, if the equivalent unit discharge rate is 0, the product of the total contributing area times the LOD allowable discharge rate is returned, B8*B12.
Step 2 – Adjust for Retention Reduction	
2.1 Storage volume (cu.ft.) (cells B17, D17, F17, H17, J17)	Returns the storage volume entered for the respective BMP on the RPv worksheet, row 17.
2.2 Storage volume (ac-ft) (cells B18, D18, F18, H18, J18)	Calculates the storage volume for the respective BMP, in acre-feet, by converting the previously defined storage volume. Example cell B18: B17/43560.
2.3 Storage volume (in.) (cells B19, D19, F19, H19, J19)	Calculates the storage volume for the respective BMP, in inches, by multiplying the previously defined storage volume by the total contributing area and applying the appropriate conversion factors. Example cell B19: B18*12/B8.
2.4 Runoff volume after reduction (in.) (cells B20, D20, F20, H20, J20)	Calculates the total runoff volume, in inches, after the retention reduction is accounted for, by subtracting the BMP storage volume from the Cv runoff volume for BMP 1; or for the higher order BMPs, from the runoff volume after all reductions are accounted for from the previous BMP. Example cell B20: B11-B19; Example cell D20: B30-D19.

2.5 CN* (cells B21, D21, F21, H21, J21)	Calculates the revised runoff curve number based off of the runoff volume after retention reduction, using the McCuen's change in curve number method. Reference the RPv worksheet explanation for further details. Example cell B21: 200/((B10+2*B20+2)-√((5*B10*B20)+4*B20^2)).
Step 3 – Adjust for Annual Runoff Reduction	
3.1 Runoff reduction allowance (%) (cells B24, D24, F24, H24, J24)	Returns the percent of runoff reduction allowed per the BMP type for the Cv event, by utilizing the specified reduction percent in the BMP Suite table in the Data and Documentation worksheet, column O.
3.2 Annual runoff after reduction (in.) (cells B25, D25, F25, H25, J25)	Calculates the annual runoff, in inches, after the runoff reduction for the respective BMP is accounted for, by multiplying the initial Cv runoff volume by one minus the percent of reduction allowed for the specified BMP. Example cell B25: B11*(1-B24). For the latter BMPs, the initial Cv runoff volume is replaced by the previous BMP's Cv runoff volume after all reductions were accounted for. Example cell D25: B30*(1-D24).
3.3 Adjusted ACN (cells B26, D26, F26, H26, J26)	Calculates the revised runoff curve number based off of the runoff volume after retention reduction, using the McCuen's change in curve number method. Reference the RPv worksheet explanation for further details. Example cell B26: 200/((B10+2*B25+2)-√((5*B10*B25)+4*B25^2)).
3.4 Event-based runoff reduction (in.) (cells B27, D27, F27, H27, J27)	Calculates the amount of reduction created for the Cv runoff, in inches, by using the event-based runoff equation with the adjusted ACN to determine the amount of runoff generated and then subtracting that value from the initial Cv runoff in order to determine the amount of reduction. Example cell B27: B11-(B10-0.2*(1000/B26-10))^2/(B10+0.8*(1000/B26-10)).
Step 4 – Calculate Cv with BMP Reductions	
4.1 Cv runoff volume after all reductions (in.) (cells B30, D30, F30, H30, J30)	Calculates the final runoff volume for the Cv event, in inches, by subtracting the retention reduction volume and the event based runoff reduction from the initial Cv runoff volume. Example cell B30: B11-B19-B27.
4.2 Total Cv runoff reduction (%) (cells B31, D31, F31, H31, J31)	Calculates the percent of reduction by subtracting the final runoff volume from the initial runoff volume and then dividing by the initial runoff volume. Example cell B31: (B11-B30)/B11.
4.3 Adjusted RCN for H&H modeling (cells B32, D32, F32, H32, J32)	Calculates the revised runoff curve number based off of the final runoff volume after all reductions, by using the McCuen's change in curve number method. Reference the RPv worksheet explanation for further details. Example cell B32: 200/((B10+2*B30+2)-√((5*B10*B30)+4*B30^2)).

Fv Worksheet (100-Year, Flooding Event Modeling):	
BMP Type (cells C6, E6, G6, I6, K6)	Returns the type of Best Management Practice that was chosen on the RPv worksheet.
Step 1 – Calculate Initial Fv	
1.1 Total contributing area to BMP (ac) (cells B8, D8, F8, H8, J8)	Returns the contributing area, in acres, from the RPv worksheet, cell RPv!B8.
1.2 Initial RCN (cell B9)	Returns the initial Runoff Curve Number from the RPv worksheet, cell RPv!B10.
1.3 100-Year Rainfall (in.)(cell B10)	Returns the 24-hour rainfall amount, in inches, for the 100-year storm depending on which county the project is located within. For the values used, reference the OLOD worksheet explanation, step 3.3, for the 24-Hour Rainfall Table.
1.4 Fv runoff volume (in.) (cell B11)	Calculates the runoff volume for the Fv event, in inches, using the event-based runoff equation, explained within the OLOD worksheet explanation. $(B10-0.2*((1000/B9)-10))^2/(B10+0.8*((1000/B9)-10)))$.
1.5 LOD allowable unit discharge (cfs/ac) (cell B12)	Returns the allowable unit peak discharge, in cubic feet per second per acre, for the LOD area calculated for the Fv event in the LOD worksheet, cell LOD!B47.
1.6 Equivalent unit discharge outside LOD (cfs/ac) (cell B13)	Returns the equivalent allowable unit peak discharge, in cubic feet per second per acre, for the outside LOD area calculated for the Fv event in the OLOD worksheet, cell OLOD!C52.
1.7 Fv Allowable Discharge Rate (cfs) (cell B14)	Calculates the allowable discharge rate, in cubic feet per second, by adding the product of the LOD allowable unit discharge times the LOD area to the product of the OLOD allowable unit discharge times the OLOD area. B12*LOD!B35+B13*OLOD!B12. However, if the equivalent unit discharge rate is 0, the product of the total contributing area times the LOD allowable discharge rate is returned, B8*B12.
Step 2 – Adjust for Retention Reduction	
2.1 Storage volume (cu.ft.) (cells B17, D17, F17, H17, J17)	Returns the storage volume entered for the respective BMP on the RPv worksheet, row 17.
2.2 Storage volume (ac-ft) (cells B18, D18, F18, H18, J18)	Calculates the storage volume for the respective BMP, in acre-feet, by converting the previously defined storage volume. Example cell B18: B17/43560.
2.3 Storage volume (in.) (cells B19, D19, F19, H19, J19)	Calculates the storage volume for the respective BMP, in inches, by multiplying the previously defined storage volume by the total contributing area and applying the appropriate conversion factors. Example cell B19: B18*12/B8.

2.4 Runoff volume after reduction (in.) (cells B20, D20, F20, H20, J20)	Calculates the total volume of storage, in inches, after accounting for the retention reduction volume, by subtracting the BMP storage volume from the Fv runoff volume for BMP 1; or for the higher order BMPs, from the runoff volume after all reductions are accounted for from the previous BMP. Example cell B20: B11-B19; Example cell D20: B30-D19.
2.5 CN* (cells B21, D21, F21, H21, J21)	Calculates the revised runoff curve number based off of the runoff volume after retention reduction, using the McCuen's change in curve number method. Reference the RPv worksheet explanation for further details. Example cell B21: 200/((B10+2*B20+2)-√((5*B10*B20)+4*B20^2)).
Step 3 – Adjust for Annual Runoff Reduction	
3.1 Runoff reduction allowance (%) (cells B24, D24, F24, H24, J24)	Returns the percent of annual runoff reduction allowed per the BMP type for the Fv event, by utilizing the specified reduction percent in the BMP Suite table in the Data and Documentation worksheet, column Q.
3.2 Annual runoff after reduction (in.) (cells B25, D25, F25, H25, J25)	Calculates the annual runoff, in inches, after the runoff reduction for the respective BMP is accounted for, by multiplying the initial Fv runoff volume by one minus the percent of reduction allowed for the specified BMP. Example cell B25: B11*(1-B24). For the latter BMPs, the initial Fv runoff volume is replaced by the previous BMP's Fv runoff volume after all reductions were accounted for. Example cell D25: B30*(1-D24).
3.3 Adjusted ACN (cells B26, D26, F26, H26, J26)	Calculates the revised runoff curve number based off of the runoff volume after retention reduction, using the McCuen's change in curve number method. Reference the RPv worksheet explanation for further details. Example cell B26: 200/((B10+2*B25+2)-√((5*B10*B25)+4*B25^2)).
3.4 Event-based runoff reduction (in.) (cells B27, D27, F27, H27, J27)	Calculates the amount of reduction created for the Fv runoff, in inches, by using the event-based runoff equation with the adjusted ACN to determine the amount of runoff generated and then subtracting that value from the initial Fv runoff in order to determine the amount of reduction. Example cell B27: B11-(B10-0.2*(1000/B26-10))^2/(B10+0.8*(1000/B26-10)).
Step 4 – Calculate Fv with BMP Reductions	
4.1 Fv runoff volume after all reductions (in.) (cells B30, D30, F30, H30, J30)	Calculates the final runoff volume for the Fv event, in inches, by subtracting the retention reduction volume and the event based runoff reduction from the initial Fv runoff volume. Example cell B30: B11-B19-B27.
4.2 Total Fv runoff reduction (%) (cells B31, D31, F31, H31, J31)	Calculates the percent of reduction by subtracting the final runoff volume from the initial runoff volume and then dividing by the initial runoff volume. Example cell B31: (B11-B30)/B11.

4.3 Adjusted RCN for H&H modeling (cells B32, D32, F32, H32, J32)	Calculates the revised runoff curve number based off of the final runoff volume after all reductions, by using the McCuen's change in curve number method. Reference the RPv worksheet explanation for further details. Example cell B32: 200/((B10+2*B30+2)-√((5*B10*B30)+4*B30^2)).

Notes:

1. If an entry is defined by a group of cells (i.e., one merged cell), then only the first represented cell number is listed in the above definitions.
2. If a step has more than one input or output cell associated with it (i.e., for the multiple BMPs), then only one respective cell is shown as an example.
3. The runoff volume is expressed in terms of inches as it is on a per acre unit basis.
4. Many of the defined cells include logic testing in order to eliminate negative numbers, provide a comparison between different values, or indicate "N/A" if a BMP is not selected. Any of this logic testing is not included in the example equations included within the definition.
5. The DURMM Report worksheet is not explained within the User Guide since all of the cells return previously defined information and it serves merely as a summary sheet. The only calculations performed are to return the minimum of a series of values, or to return the average of a series of values.
6. The Data and Documentation worksheet is not explained within the User Guide. This page references all of the Stormwater BMPs and their associated variants and lists the following information per column:
   - A. Class: Retention Practice, Annual Runoff Reduction Practice or Stormwater Treatment Practice are the three classes listed.
   - B. BMP Category: Lists the name and number of the practice as it appears on the corresponding Standard and Specification.
   - C. DURMM Variant: Lists the name and number of any variants for the BMP.
   - D. & E. TN Reduction: Lists the total nitrogen removal efficiency of the BMP as a percentage, or for Annual Runoff Reduction and Retention practices, that 100% of the total nitrogen within the adjusted load is reduced.
   - F. & G. TP Reduction: Lists the total phosphorus removal efficiency of the BMP as a percentage, or for Annual Runoff Reduction and Retention practices, that 100% of the total phosphorus within the adjusted load is reduced.
   - H. & I. TSS Reduction: Lists the total suspended solids removal efficiency of the BMP as a percentage, or for Annual Runoff Reduction and Retention practices, that 100% of the total suspended solids within the adjusted load is reduced.
   - J. Retention Allowable: Lists the allowable amount of retention in percent form for applicable BMPs.
   - K. & L. Annual RR, RPv, A/B Soil: Lists the allowable amount of annual runoff reduction for the Resource Protection Event in percent form for the applicable BMPs that are on HSG A or B.
   - M. & N. Annual RR, RPv, C/D Soil: Lists the allowable amount of annual runoff reduction for the Resource Protection Event in percent form for the applicable BMPs that are on HSG C or D.
   - O. & P. RR, Cv: Lists the allowable amount of runoff reduction for the Conveyance Event in percent form for the applicable BMPs.
   - Q. & R. RR, Fv: Lists the allowable amount of runoff reduction for the Flooding Event in percent form for the applicable BMPs.
7. The Summary Table for Sub-Areas Draining to a Common Point of Interest is not explained within the User Guide, but should be used to determine the net inputs to a common Point of Interest (POI) or global watershed. The inputs can be found on the DURMM Report worksheet. For a series of sub-areas

that drain into each other, only the furthest downstream sub-area should be entered as the upstream areas will already be accounted for in the downstream node.

Abbreviations:

Abbreviation	Definition	Abbreviation	Definition
ac	Acres	Fv	Flooding Event (100-Year)
ac-ft	Acre-ft	Ia	Initial Abstraction
ACN	Annual Curve Number	in.	Inch
Avg	Average	lbs	Pounds
BMP	Best Management Practice	lb/ac/yr	Pound per Acre per Year
C	Contoured	LOD	Limit of Disturbance
C&D	Chesapeake and Delaware Canal	mg/L	Milligram per Liter
C&T	Contoured and Terraced	mg/yr	Milligram per Year
C.A.	Contributing Area	OLOD	Outside the Limit of Disturbance
cfs	Cubic Feet per Second	P	Precipitation
cfs/ac	Cubic Feet per Second, per Acre	q_p	Peak Discharge
CN	Curve Number	q_u	Unit Peak Discharge
CR	Crop Residue	RCN	Runoff Curve Number
cu. ft.	Cubic Feet	RPv	Resource Protection Event (1-Year)
cu. ft./ac	Cubic Feet per Acre	RR	Runoff Reduction
Cv	Conveyance Event (10-Year)	SR	Straight Row
DMV	Delmarva Unit Hydrograph	STD	Standard Unit Hydrograph
DURMM	Delaware Urban Runoff Management Model	TMDL	Total Maximum Daily Load
		TN	Total Nitrogen
EMC	Event Mean Concentration	TP	Total Phosphorus
ft/ft	Foot per Foot	TR-55	Technical Release 55
ft/sec	Foot per Second	TSS	Total Suspended Solids
H&H	Hydraulic and Hydrology	WS	Watershed
HSG	Hydrologic Soil Group	yr	Year
hr (hrs)	Hour (Hours)		

Contributing Area Runoff Curve Number (C.A. RCN) Worksheet Explanation:

The calculations to determine the runoff curve number for the contributing area are derived through standard TR-55 methodologies. For additional information regarding the content and processes, reference the *Urban Hydrology for Small Watersheds Technical Release 55 (TR-55) Manual*, prepared by the United States Department of Agriculture, Natural Resources Conservation Service, last revised June 1986.

Limit of Disturbance (LOD) Worksheet Explanation:

The Resource Protection Runoff was derived by utilizing a Composite CN per the four hydrologic soil groups (based on the percent pervious versus the percent impervious), and plotting those values versus their respective runoff generated for a 1 year storm event using the original DURMM v.1 runoff equations. The original DURMM analyzed the runoff by calculating the amount generated in the pervious section, and adding to the amount generated in the impervious section. The combined amount was the total runoff for a 1 year storm. To simplify,

DURMM v.2 has used a polynomial regression equation to best fit the relationship between the Composite CN and the 1 year runoff. This produces, the RPv runoff equation of:

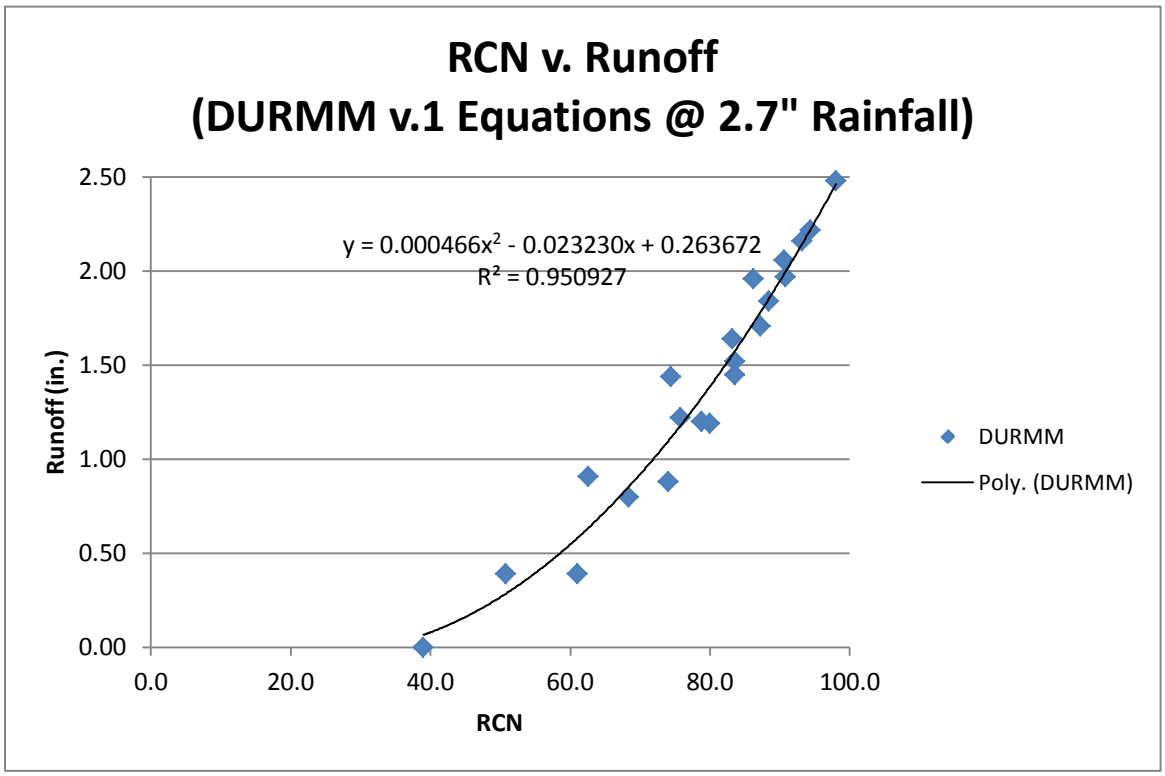
$$y = 0.000466x^2 - 0.023230x + 0.263672,$$

where y is the runoff in inches, and x is the composite CN. The R^2 value is equal to 0.950927 for the regression equation. See the below input data for the derivation of the RPv equation.

Input data:

	Pervious		Impervious		Composite	DURMM v.1 Runoff
Soil HSG	%	CN	%	CN	CN	(2.7" Rainfall) (in.)
HSG A	100%	39	0%	98	39.0	0.00
	80%	39	20%	98	50.8	0.39
	60%	39	40%	98	62.6	0.91
	40%	39	60%	98	74.4	1.44
	20%	39	80%	98	86.2	1.96
HSG B	100%	61	0%	98	61.0	0.39
	80%	61	20%	98	68.4	0.80
	60%	61	40%	98	75.8	1.22
	40%	61	60%	98	83.2	1.64
	20%	61	80%	98	90.6	2.06
HSG C	100%	74	0%	98	74.0	0.88
	80%	74	20%	98	78.8	1.20
	60%	74	40%	98	83.6	1.52
	40%	74	60%	98	88.4	1.84
	20%	74	80%	98	93.2	2.16
HSG D	100%	80	0%	98	80.0	1.19
	80%	80	20%	98	83.6	1.45
	60%	80	40%	98	87.2	1.71
	40%	80	60%	98	90.8	1.97
	20%	80	80%	98	94.4	2.22
N/A	0%	N/A	100%	98	98.0	2.48

Plot of the Composite CN versus DURMM v.1 for 1-Year Runoff:



The 1 year runoff generated within the LOD using the RPv equation, is then compared to the Target runoff that was generated in the pre-developed condition. RPv target runoff values for each of the four hydrologic soil groups in a woods state were established based on historical data. These values, shown below, are multiplied by the respective amount of pre-developed woods and/or meadow per soil group to establish the pre-developed runoff generated from the existing woods and/or meadow area.

Pre-Developed Woods/Meadow Factors				
	HSG A	HSG B	HSG C	HSG D
RPv Target Runoff (in)	0.00	0.12	0.55	0.87

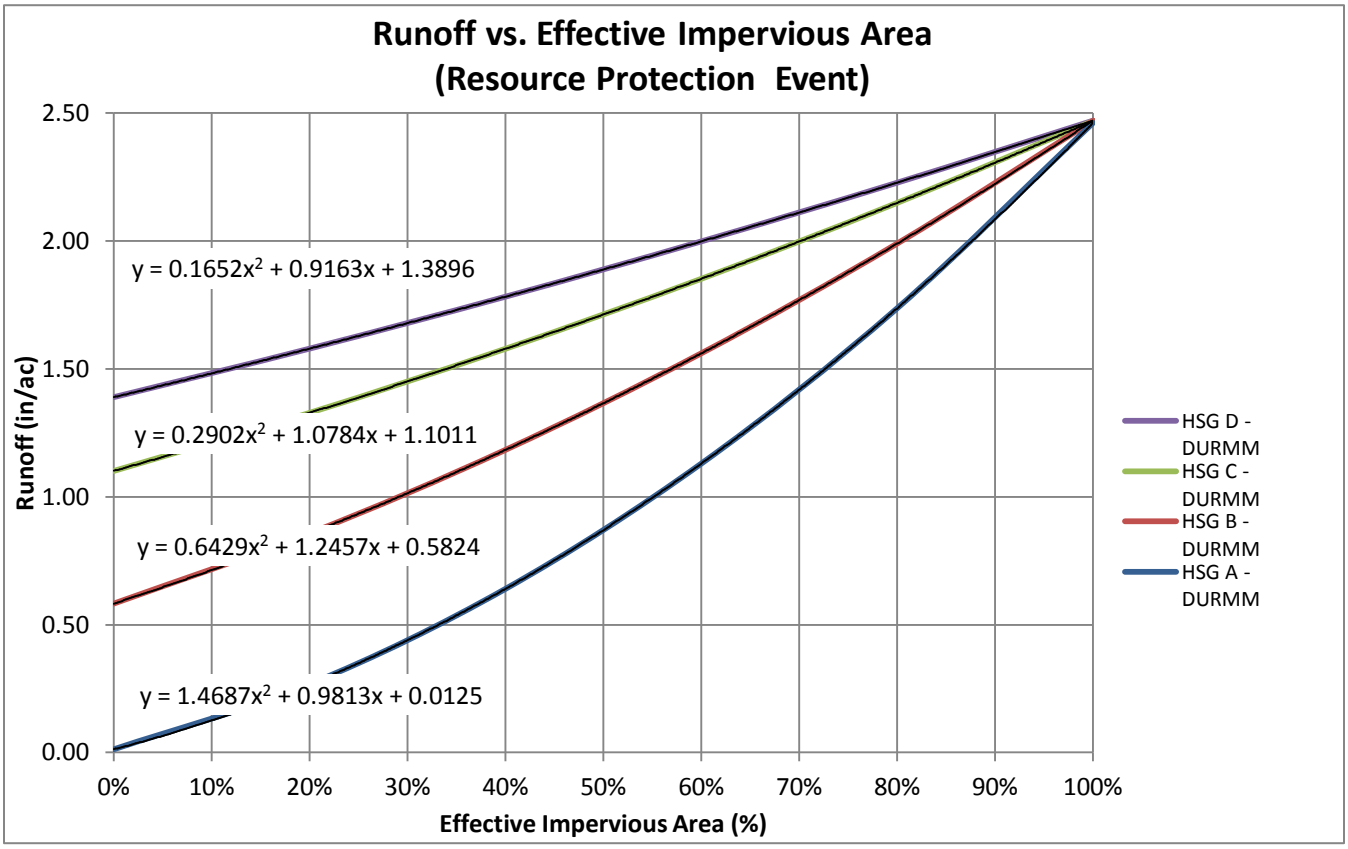
The amount of runoff produced from the non-woods and/or non-meadow area is also evaluated by multiplying the respective area per hydrologic soil group times the runoff generated based on the percent of impervious (only 50% of the impervious area is utilized for redevelopment purposes). This impervious percent, the impervious area within the HSG times 50% and divided by the total HSG area, is inputted into the equation of best fit per HSG for the amount of runoff generated by using the composite CN in the runoff equation described above. The sum of the woods/meadow and non-woods/non-meadow runoff values are added together and divided by the total LOD area for that soil group, to determine the target runoff amount for the RPv event per site acre.

Pre-developed Non-Woods/Non-Meadow Factors								
	HSG A		HSG B		HSG C		HSG D	
% Effective Impervious	Composite RCN	Runoff (in.)	Composite RCN	Runoff (in.)	Composite RCN	Runoff (in.)	Composite RCN	Runoff (in.)
0%	39	0	61	0.58	74	1.10	80	1.39
20%	50.8	0.29	68.4	0.86	78.8	1.33	83.6	1.58
40%	62.6	0.64	75.8	1.18	83.6	1.58	87.2	1.78
60%	74.4	1.12	83.2	1.56	88.4	1.85	90.8	2.00
80%	86.2	1.73	90.6	1.99	93.2	2.15	94.4	2.23
100%	98	2.47	98	2.47	98	2.47	98	2.47

Notes:

1. The curve numbers noted in the above table correspond to the Composite CN values described previously in the LOD explanation.
2. The runoff is generated by inserting the RCN values into the runoff equation: $y = 0.000466x^2 - 0.023230x + 0.263672$, where y is the runoff in inches, and x is the composite CN.

The effective impervious equations are generated by plotting the percent effective impervious versus the runoff and applying the line of best fit:



The Cv and Fv weighted unit discharges, indicate the discharge rate per LOD acre that would be generated per hydrologic soil group in the pre-developed condition. These values are determined by multiplying the respective amount of pre-developed woods/meadow and non-woods/meadow per soil group by set unit discharge amounts, and then dividing the sum by total LOD area for that soil type. The factor values were established by using historic data for the amount of discharge per soil and cover type in a per acre basis, and the values can be seen below:

Cv/Fv Unit Discharge
Woodland/Meadow (HSG A)
10-YR: 0 cfs/ac
100-YR: 0.25 cfs/ac
Woodland/Meadow (HSG B,C,D)
10-YR: 0.375 cfs/ac
100-YR: 1.25 cfs/ac
Non-Woodland/Non-Meadow (HSG A, B, C, D)
10-YR: 0.75 cfs/ac
100-YR: 2.25 cfs/ac

The estimated annual runoff within the LOD area is determined by using a power equation derived from the log-log plot of the Weighted LOD RCN versus the annual runoff calculated using WinSLAMM. The line of best fit results in the following equation:

$$y = 0.000004x^{3.5},$$

where y equals the Annual Runoff in inches, and x is the Weighted LOD RCN.

OLOD Worksheet Explanation:

The below table shows the Manning's n values used in step 2.3 on the OLOD worksheet to calculate the time of concentration. For each possible surface cover under sheet flow conditions a corresponding Manning's n value is given. The surface code used in step 2.2 is also referenced.

	Sheet Flow Surface Code & Type	Manning's "n"
a	Smooth Surface	0.01
b	fallow (no residue)	0.05
c	cultivated < 20% Res.	0.06
d	cultivated > 20% Res.	0.17
e	grass - range, short	0.15
f	grass, dense	0.24

g	grass, bermuda	0.41
h	woods, light	0.40
i	woods, dense	0.80
j	range, natural	0.13

The table below shows the 24-hour rainfall amounts per County used to determine the Cv and Fv peak discharge rates as referenced in step 3.3 on the OLOD worksheet.

24-Hour Rainfall per County (in.)

County	10-YR	100-YR
Kent	5.2	8.9
New Castle	4.8	8.0
Sussex	5.3	9.2

The lookup table used to determine the initial abstraction value (Ia) based upon the curve number for the OLOD area is shown below. This value is referenced in step 3.4 on the OLOD worksheet.

Curve Number	Ia (in)	Curve Number	Ia (in)
30	4.667	65	1.077
31	4.452	66	1.030
32	4.250	67	0.985
33	4.061	68	0.941
34	3.882	69	0.899
35	3.714	70	0.857
36	3.556	71	0.817
37	3.405	72	0.778
38	3.263	73	0.740
39	3.128	74	0.703
40	3.000	75	0.667
41	2.878	76	0.632
42	2.762	77	0.597
43	2.651	78	0.564
44	2.545	79	0.532
45	2.444	80	0.500
46	2.348	81	0.469
47	2.255	82	0.439
48	2.167	83	0.410
49	2.082	84	0.381
50	2.000	85	0.353
51	1.922	86	0.326

52	1.846	87	0.299
53	1.774	88	0.273
54	1.704	89	0.247
55	1.636	90	0.222
56	1.571	91	0.198
57	1.509	92	0.174
58	1.448	93	0.151
59	1.390	94	0.128
60	1.333	95	0.105
61	1.279	96	0.083
62	1.226	97	0.062
63	1.175	98	0.041
64	1.125		

The Unit Peak Discharge is calculated for the 10 and 100 year storm events for the OLOD area, by developing coefficient tables that represent the Type II storm data for the Standard SCS (STD) and the Delmarva (DMV) Unit Peak Discharge models. The coefficients, C_0, C_1, and C_2, that create the line of best fit for six Ia/P values are given for both the STD and DMV peak discharge curves, using the equation:

$$\log(q_u) = C_0 + C_1\log(Tc) + C_2,\log(Tc)^2$$

where q_u = unit peak discharge and Tc = time of concentration in hours . The actual Ia/P value for the site is then interpolated between these established values, so that the site specific coefficients can be determined, and then used in the line of best fit equation. This results in obtaining the log of the peak unit discharge, which is used in the output cells, B49 and C49, to determine the peak unit discharge by raising the log to the 10th power in step 3.6. The coefficient tables, which start at cell M43, can be seen below with example Ia/P site specific values being entered for the 10 and 100 year storms of 0.21 and 0.12, respectively:

STD Unit Peak Discharge Coefficient Table - Type II Storm

		Ia/P	C0	C1	C2	
	1	0.10	2.55323	-0.61512	-0.16403	
	2	0.30	2.46532	-0.62257	-0.11657	
	3	0.35	2.41896	-0.61594	-0.08820	
	4	0.40	2.36409	-0.59857	-0.05621	
	5	0.45	2.29238	-0.57005	-0.02281	
	6	0.50	2.20282	-0.51599	-0.01259	$\log(q_u)$
10-YR		0.21	2.52762	-0.62747	-0.13961	2.532455668
100-YR		0.12	2.55208	-0.62068	-0.16172	2.556857013

DMV Unit Peak Discharge Coefficient Table - Type II Storm

	Ia/P	C0	C1	C2	
1	0.10	2.33733	-0.68709	-0.10847	
2	0.30	2.22599	-0.68545	-0.03220	
3	0.35	2.17707	-0.66476	-0.00830	
4	0.40	2.12341	-0.63854	0.01624	
5	0.45	2.06447	-0.59720	0.02867	
6	0.50	1.99673	-0.53417	0.03114	$\log(q_u)$
10-YR	0.21	2.288136	-0.69299	-0.07442	2.293480471
100-YR	0.12	2.330644	-0.68859	-0.10391	2.335952591

The amount of runoff generated for both the 10 and 100 year storms is determined by using the SCS equation for runoff, $Q = (P-0.2S)^2/(P+0.8S)$, where P equals the precipitation in inches, and S is the potential maximum retention after runoff begins, and is defined by $S = 1000/CN - 10$, where CN equals the runoff curve number. These two equations are combined together to make one event-based runoff equation that is used within DURMM v.2:

$$y = (P - 0.2*(1000/RCN - 10))^2 / (P + 0.8*(1000/RCN - 10)),$$

where y equals the runoff volume in inches, and the other variables are as defined above.

RPv worksheet

In order to determine a comparative runoff curve number for the sub-area in question after all runoff reductions have been incorporated, the McCuen's Change in Curve Number Method is employed, as developed by Dr. Richard McCuen for the Maryland Standards and Specifications for Stormwater Management Infiltration Practices, 1984. The equation uses the 24-hour design storm precipitation value along with the final runoff volume after all reductions have been incorporated to calculate an adjusted curve number. The resulting curve number will be higher than the original curve number derived for the contributing area in order to account for the higher runoff values that are calculated using the WinSLAMM method compared to TR-55 methods. The McCuen's equation for the adjusted curve number, $CN_{adjusted}$, is:

$$CN_{adjusted} = 200 / ((P + 2*Q + 2) - \sqrt{(5*P*Q+4*Q^2)}),$$

where P equals the 24-hour design storm precipitation value, in inches (2.7" for the 1-year storm is used for the RPv event), and Q is the runoff volume after all reductions have been accounted for, in inches.

TMDL worksheet

The event mean concentration for each pollutant, TN, TP and TSS is listed in the below table per specified landuse type. The values are referenced in cells C15, D15 and E15 respectively per pollutant type in step 2.1 on the TMDL worksheet.

	EMC (mg/L)		
Landuse Type	TN	TP	TSS
Urban Open Space	2.0	0.27	50
Residential	2.0	0.27	60
Commercial	2.0	0.27	60
Institutional	2.0	0.27	60
Industrial	2.0	0.27	80
Rural Road	2.0	0.27	80
Urban Road/Highway	2.0	0.27	100

The established TMDL limits for each watershed are listed below for TN, TP and TSS:

TMDL Requirements (lb/ac/year)

Drainage Basin	TMDL Watershed	WS Code	TN TMDL	TP TMDL	TSS TMDL
Piedmont	Naamans Creek	1	10.40	0.72	N/A
	Shellpot Creek, above Rt. 13	2	6.30	0.43	N/A
	Shellpot Creek, below Rt. 13	2			
	Brandywine Creek	3	10.10	0.67	N/A
	Red Clay Creek	4	5.30	0.49	N/A
	White Clay Creek	5	8.00	0.46	N/A
	Christina River	6	5.70	0.35	N/A
Delaware Bay	Delaware River	7			
	Army Creek	8	2.10	0.18	N/A
	Mispillion River, King's Causeway Br.	20	5.70	0.10	N/A
	Mispillion River, Remaining WS	20	5.70	0.10	N/A
	Cedar Creek	21	6.40	0.25	N/A
	Broadkill River	22	11.90	0.50	N/A
Chesapeake Bay	Elk Creek	23	6.58	0.58	129
	Perch Creek	24	6.58	0.58	129
	C&D Canal West	25	6.58	0.58	129
	Bohemia Creek	26	6.58	0.58	129
	Sassafras River	27	6.58	0.58	129
	Chester River	28	6.58	0.58	129
	Choptank River	29	6.58	0.58	129
	Marshyhope Creek	30	6.58	0.58	129
	Nanticoke River	31	6.58	0.58	129
	Gum Branch	32	6.58	0.58	129
	Gravelly Branch	33	6.58	0.58	129
	Deep Creek	34	6.58	0.58	129
	Broad Creek	35	6.58	0.58	129

	Wicomico River	36	6.58	0.58	129
	Pocomoke River	37	6.58	0.58	129
Inland Bays/ Atlantic Ocean	Lewes-Rehoboth Canal	38	5.70	0.23	N/A
	Rehoboth Bay	39	5.70	0.23	N/A
	Indian River, Upper	40	3.30	0.18	N/A
	Indian River, Lower	40	5.70	0.23	N/A
	Iron Branch	41	3.30	0.18	N/A
	Indian River Bay	42	5.70	0.23	N/A
	Buntings Branch	43	11.90	0.39	N/A
	Assawoman Bay	44			
	Little Assawoman Bay	45	5.70	0.23	N/A