1.1 Introduction: Overview

Purpose and New Features

The new outlet analysis excel tool leverages excel macros and streamlines the process of performing an outlet/outfall analysis for a NCDOT project.

With the rollout of the outlet analysis tool comes new guidance. This guidance is to utilize the outlet analysis excel tool and its printing macros for every outlet analysis going forward in order to provide a consistent deliverable as a separate PDF. Previous guidance on providing outlet analysis information (drainage area, Q2, Q5, Q10, etc.) directly on the redline drainage plan sheets is optional.

The following guide shows a new user the basics of using the tool, how to pick and choose outlet analysis points as well as how to label them on the redline drainage plan sheets.

1.2 Introduction: General Notes/Warnings

In the same manner that the Geopak Drainage Summary Sheet uses macros, this spreadsheet contains similar warnings. All the custom tools in the file are macro driven. Consequently, any changes that one of these tools makes to the file **cannot be undone by using the Edit Undo feature of Excel**. If you plan to use a custom tool that will make a big change to your file, consider making a backup copy of the file before using the tool. Make backup copies at various milestones throughout the outlet analysis process.

If you are running alternative analyses of an outlet location, create a copy of that specific outlet analysis tab and use that to run theoretical scenarios so that the work is not lost. Do not rely on Edit Undo for any major changes.

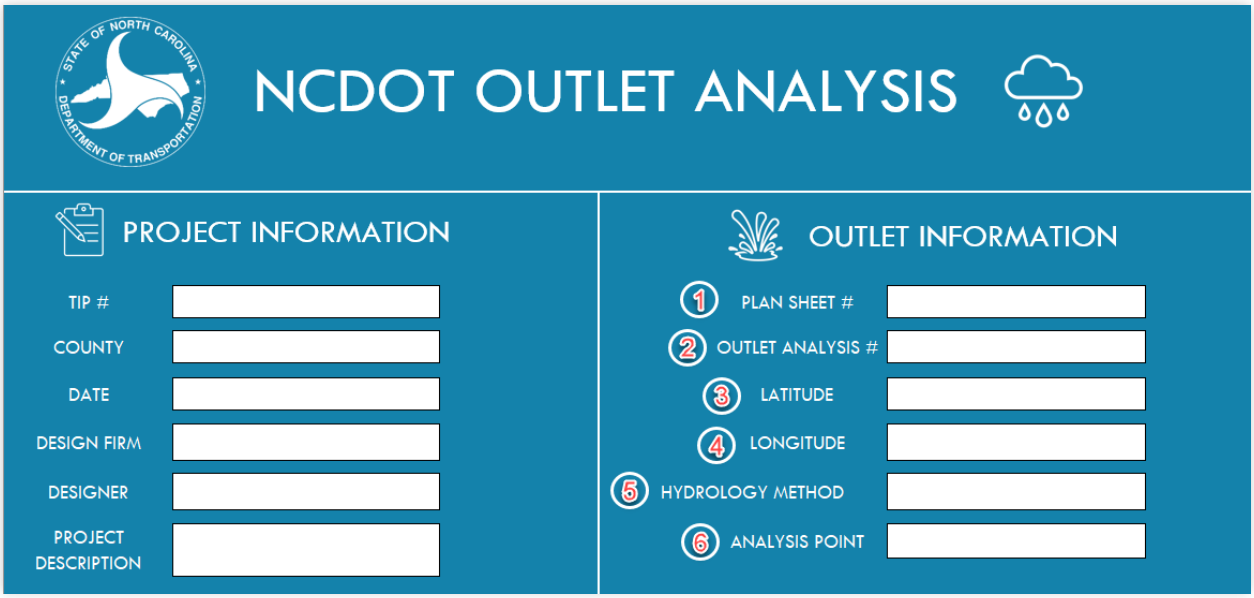
Due to the protection of the workbook, excel disables spell check. If spell check is desired to be used for the summary write up, the user will have to copy and paste the text to another document where spell check is enabled then copy it back.

Throughout the spreadsheet ⓘ symbols or ⓘ symbols are present. Wherever theses are present, they can be clicked and will open a pop-up dialog box with further guidance or information on that topic. Please read all the pop-ups in detail and follow the instructions to avoid unnecessary comments during NCDOT review.

1.3 Introduction: MAIN Tab

Creating An Analysis Tab For An Outlet

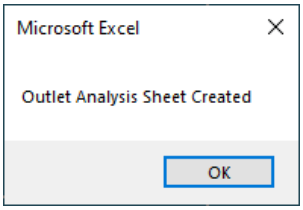
Upon opening the spreadsheet there will be only one tab at first called "MAIN". The "MAIN" tab of the NCDOT Outlet Analysis tool is shown below. The purpose of the MAIN tab is to create individual tabs for each outlet analysis point. Please see the next page for guidance on how to fill out each numbered section



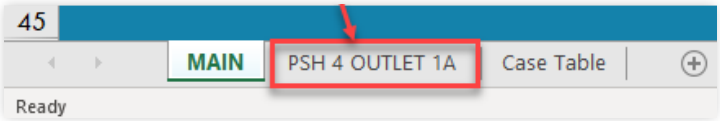
Note: Any information that is entered on the "MAIN" tab can be changed later after the sheet is generated except for the hydrology method.

1. **Plan Sheet Number:** Enter the plan sheet number that the outlet analysis point is located on. Standard format is to enter just the number (no leading zeros or leading "PSH-"). For example, if the plan sheet is plan sheet 4, simply enter "4".
2. **Outlet analysis Number:** Enter what number the analysis is on that plan sheet, starting with the number "1" and increasing in number from left to right along the alignment. The analysis number will reset back to "1" on each subsequent plan sheet.
    - Note: If there are multiple analysis points for the same outlet (for example: one at the outlet and another one 50 ft. downstream), then add a letter after the number (1A, 1B, 1C, etc.)
    - Do not name the analysis number something such as "OA-1" or "0401".
3. **Latitude:** Use the tool in Microstation or OpenRoads called "Open Location in Google Maps" to click on the exact spot the analysis is to be taken from. This is the fastest way to get latitude and longitude striaght from CADD. Note that latitude and longitude can be left blank if they are not known yet and filled out on the inidivudal analysis tab later on.
4. **Longitude:** See above.
5. **Hydrology Method:** Select appropriate hydrology method. Note that this must be known or an analysis cannot be created. If the hydrology method changes for an analysis, the user must come back to the "MAIN" tab to create the analysis again with the new hydrology method.
6. **Analysis Point:** Select Within, At or Downstream of Right of Way. Typically, the first analysis point for an outlet is recommended to be taken at the right of way. If subsequent analysis points are needed further downstream, create another analysis point (i.e "1B") and select "Downstream Past R/W"
    - Note: If "Downstream Past R/W" is selected a field will appear to enter how many feet downstream past the right of way the point is located.

- Once all the required fields are filled out, press the button labeled "CLICK TO GENERATE SHEET FOR THIS OUTLET"
- A message box will appear as shown below. Click OK.

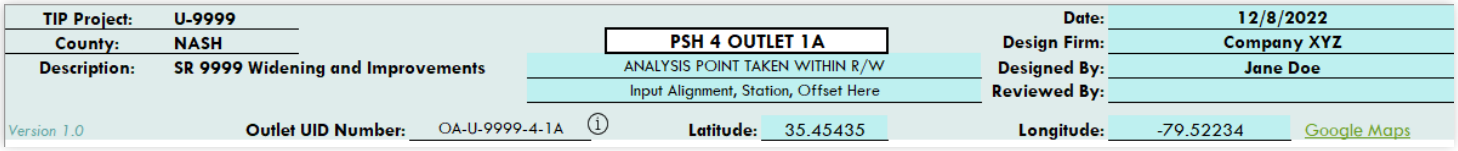


- The individual outlet analysis worksheed tab will be generated and appear as shown below. Select the indiviudal tab and follow the steps in the next section. Additionally, a second tab titled "Case Table" will appear. Case table information can be found in Section 2.4 of this document.



2.1 Individual Analysis Tab: Header

Upon opening the indivual analysis tab the first thing the user will see is the header with the anlaysis points information (see screenshot below)

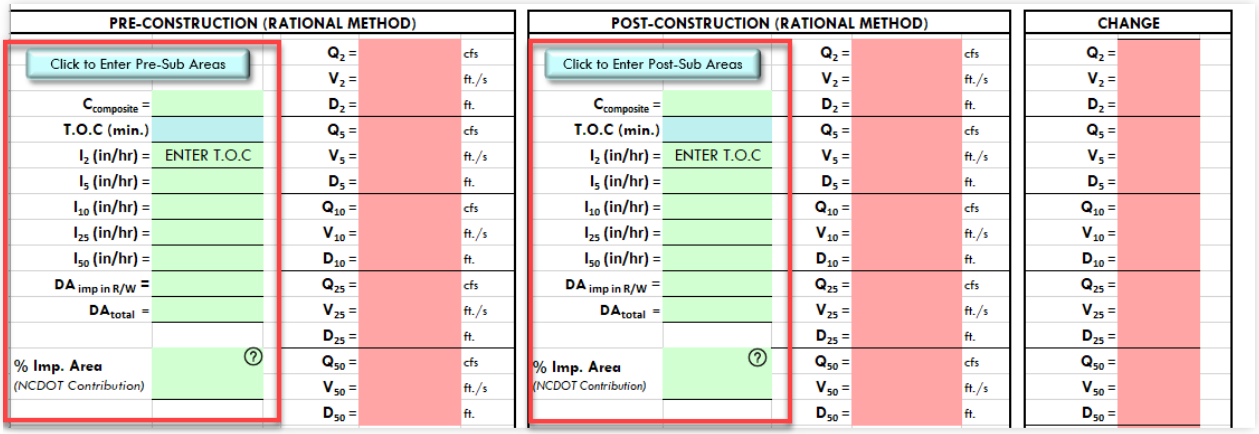


General Note: Each sheet is protected. Some cells are locked and cannot be edited.

- Most cells in the header are auto populated from the information in the MAIN tab however, they are unlocked so that the user can change them if necessary later on.
  - For example, if the analysis point changes lat/long, name or location relative to the right of way, all these fields are unlocked so that they may be edited later on.
- If a project is located in two or more counties, change the county on the indivudal tab (not the MAIN tab) corresponding to which county the outlet analysis point is located in (the county drop down is unique to each analysis tab.)
- The "Reviewed By:" field is unique to each analysis tab and initally blank. This is by deisgn so that it can be filled out by the reviewer(s) as they check each tab or if there are two or more reviewers reviewing different tabs.

2.2 Individual Analysis Tab: Hydrology Inputs

Once the header information is verified, the next step is to enter the hydrology inputs. Hydrology inputs include the drainage area, breakdown of landuse/impervious area, time of concentration, and rainfall intensities. The hydrology input section for the rational method is shown boxed in red below.

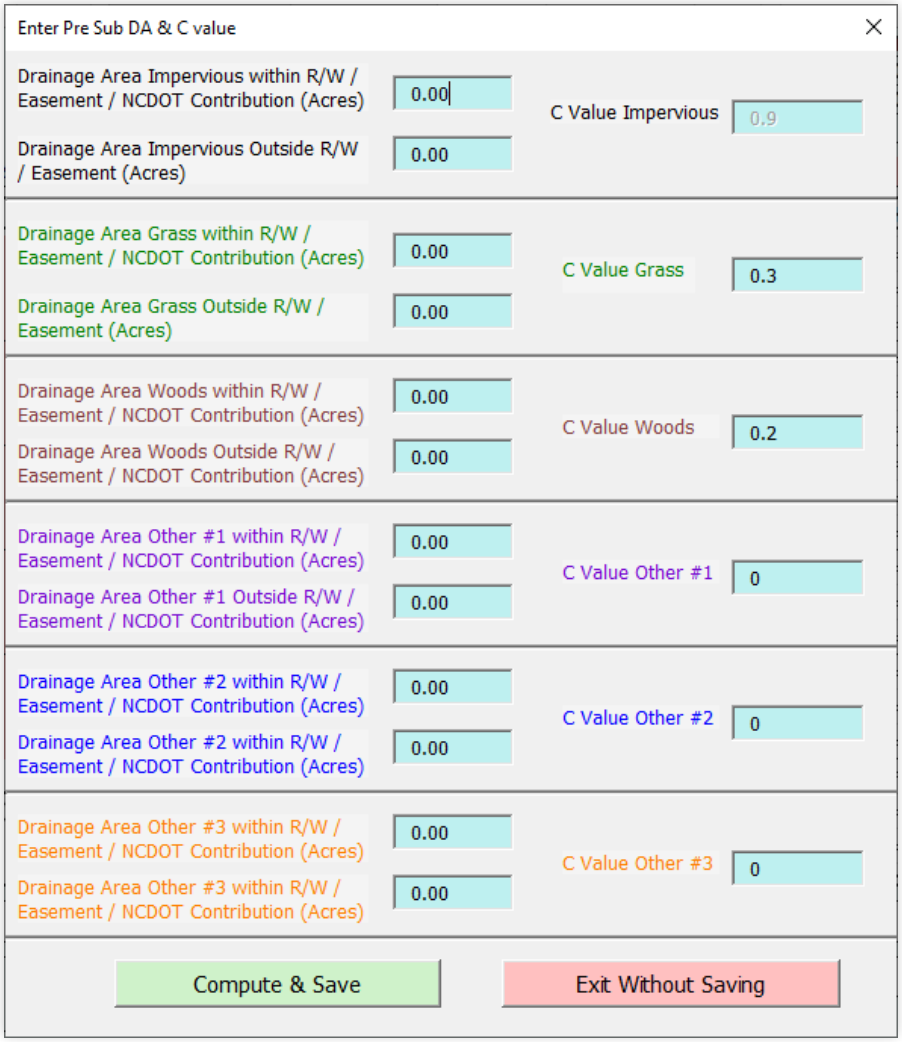


Note regarding other hydrology methods: This worksheet does not calculate flows from TR-55 and USGS methods. External software or spreadsheets such as WinTR-55 or the USGS spreadsheets should be used, and results are to be input manually.

- The legend for the color coding of the cells is located on the right side (outside of the print area) and shown below.

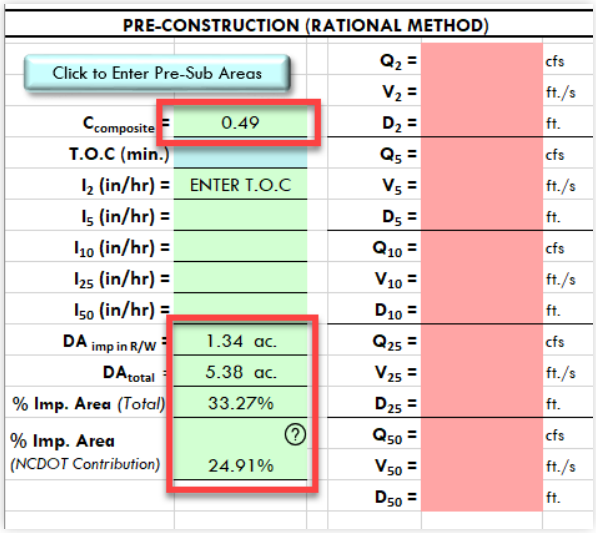
Green = Calculated / good / up to date
Red = Calculated, incorrect, or not up to date
light blue = user iput (cells unlocked)
Yellow = Warning / Caution ①

- Select the light blue button labeled "Enter Pre-Sub Areas" and the data input window will open as shown below
- Enter the pre-hydrology sub areas and C-values then select Compute & Save. **Note:** The new guidance is to breakup the land uses based on what is within NCDOT right of way / permanent easements and what is outside. **The user must break up the areas for all land uses, not just the impervious area.**



  - Note: A number must be entered in all fields. If there is no data for that field enter a zero ("0") or else you will receive an error.

- The cells shown boxed below will automatically be populated.



PRE-CONSTRUCTION (RATIONAL METHOD)				
Click to Enter Pre-Sub Areas			Q_2 =	cfs
			V_2 =	ft./s
$C_{composite}$ =	0.49		D_2 =	ft.
T.O.C (min.)			Q_5 =	cfs
I_2 (in/hr) =	ENTER T.O.C		V_5 =	ft./s
I_5 (in/hr) =			D_5 =	ft.
I_{10} (in/hr) =			Q_{10} =	cfs
I_{25} (in/hr) =			V_{10} =	ft./s
I_{50} (in/hr) =			D_{10} =	ft.
$DA_{imp\ in\ R/W}$ =	1.34 ac.		Q_{25} =	cfs
DA_{total} =	5.38 ac.		V_{25} =	ft./s
% Imp. Area *(Total)*	33.27%		D_{25} =	ft.
% Imp. Area *(NCDOT Contribution)*	24.91%	ⓘ	Q_{50} =	cfs
			V_{50} =	ft./s
			D_{50} =	ft.

- Enter time of concentration (10 minute minimum for NCDOT projects) and the intensities will automatically populate based on the county as shown below or based on custom IDF data entered on the "MAIN" tab. Peak flow values will be calculated.

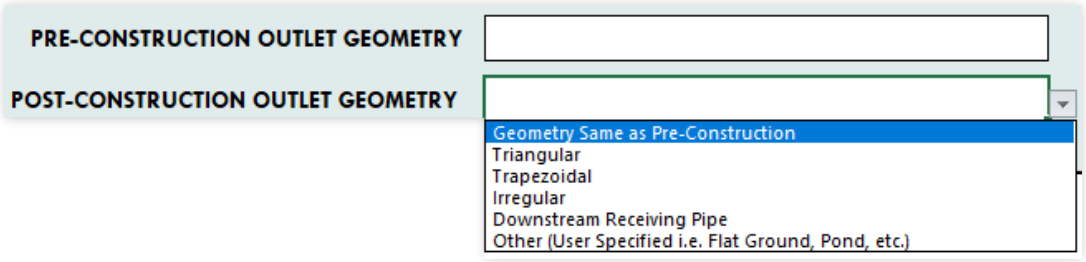
PRE-CONSTRUCTION (RATIONAL METHOD)					
Click to Enter Pre-Sub Areas			Q_2 =	11.0	cfs
			V_2 =		ft./s
$C_{composite}$ =	0.49		D_2 =		ft.
T.O.C (min.)	10.0		Q_5 =	12.0	cfs
I_2 (in/hr) =	4.13		V_5 =		ft./s
I_5 (in/hr) =	4.49		D_5 =		ft.
I_{10} (in/hr) =	5.30		Q_{10} =	14.1	cfs
I_{25} (in/hr) =	5.93		V_{10} =		ft./s
I_{50} (in/hr) =	6.62		D_{10} =		ft.
$DA_{imp\ in\ R/W}$ =	1.34 ac.		Q_{25} =	15.8	cfs
DA_{total} =	5.38 ac.		V_{25} =		ft./s
% Imp. Area *(Total)*	33.27%		D_{25} =		ft.
% Imp. Area *(NCDOT Contribution)*	24.91%	ⓘ	Q_{50} =	17.6	cfs
			V_{50} =		ft./s
			D_{50} =		ft.

Note: County intensity values are reproduced from the latest OpenRoads NCDOT workspace. They may differ slightly than the previous Geopak workspace.

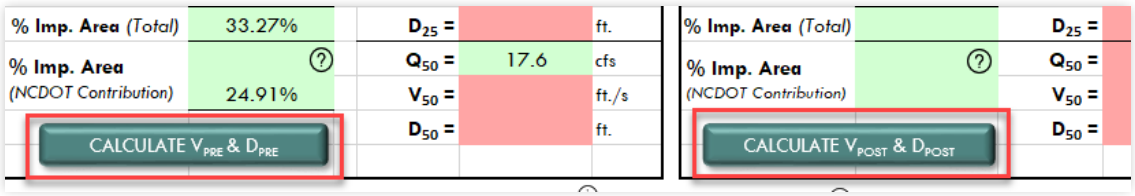
- Repeat this process for the post-construction hydrology inputs

2.3 Individual Analysis Tab: Velocity & Depth Calculations

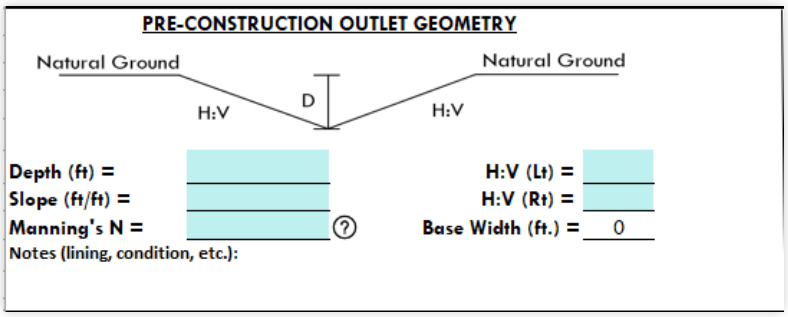
The spreadsheet has the functionality of calculating velocity and normal depth using the Manning's equation for simple channel geometries (triangular and trapezoidal). To access this feature, triangular/trapezoidal channel geometry must be selected using the drop downs shown below.



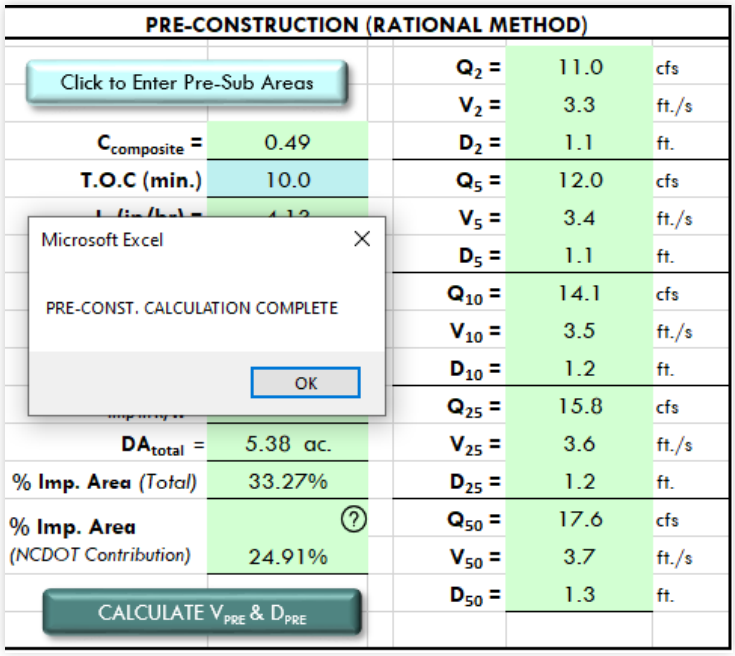
- Once triangular or trapezoidal geometry has been selected for both options, the "Calculate Vpre & Dpre" and "Calculate Vpost and Dpost" buttons will appear as shown boxed in red below. (Note: If these buttons disappear for the triangular or trapezoidal choices, simply reselect the drop down for that geometry choice as shown in the picture above)



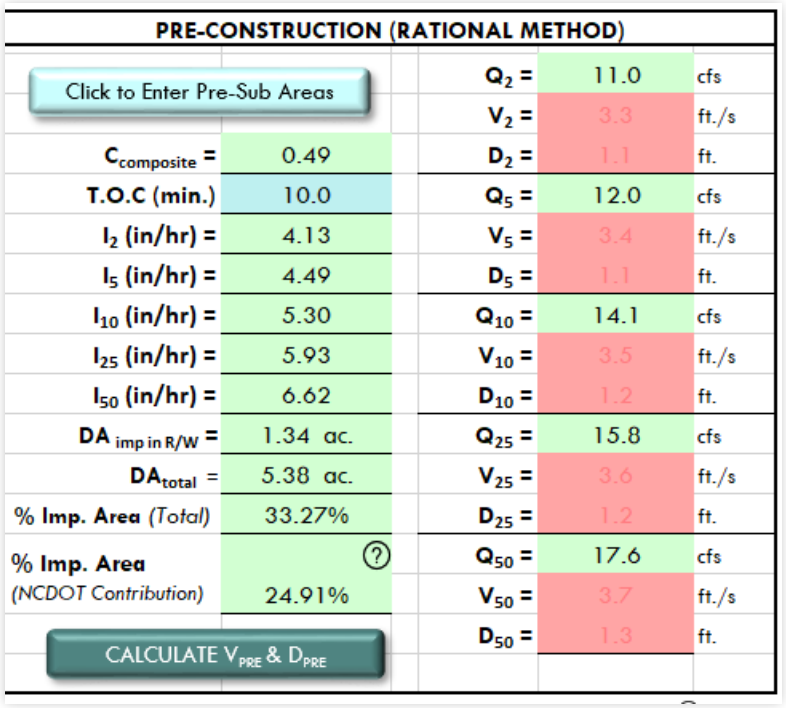
- Before the calculations can be run, the geometry information must be filled out in the slope, n-value, side slopes and base width fields shown below.



- Click the dark green calculate button and the V and D values will be populated and the cells will turn green signifying an up-to-date calculation. A message box will pop up stating the calculations are complete as shown below.



- Repeat this process for the post-construction and anytime that there is a change in variables.
- If a variable is changed that the calculations are dependent on, the V and D cells will be filled with red and the text will turn red signifying that the calculations are not up-to-date (see next page).



PRE-CONSTRUCTION (RATIONAL METHOD)				
Click to Enter Pre-Sub Areas		Q_2 =	11.0	cfs
		V_2 =	3.3	ft./s
$C_{composite}$ =	0.49	D_2 =	1.1	ft.
T.O.C (min.)	10.0	Q_5 =	12.0	cfs
I_2 (in/hr) =	4.13	V_5 =	3.4	ft./s
I_5 (in/hr) =	4.49	D_5 =	1.1	ft.
I_{10} (in/hr) =	5.30	Q_{10} =	14.1	cfs
I_{25} (in/hr) =	5.93	V_{10} =	3.5	ft./s
I_{50} (in/hr) =	6.62	D_{10} =	1.2	ft.
$DA_{imp\ in\ R/W}$ =	1.34 ac.	Q_{25} =	15.8	cfs
DA_{total} =	5.38 ac.	V_{25} =	3.6	ft./s
% Imp. Area *(Total)*	33.27%	D_{25} =	1.2	ft.
% Imp. Area *(NCDOT Contribution)*	24.91%	Q_{50} =	17.6	cfs
		V_{50} =	3.7	ft./s
CALCULATE V_{PRE} & D_{PRE}		D_{50} =	1.3	ft.

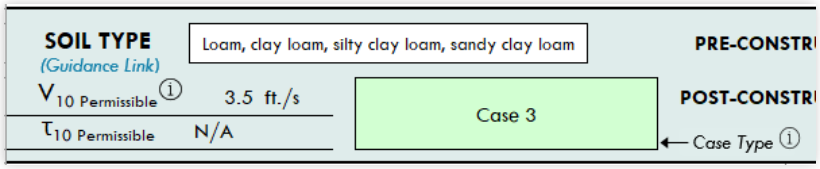
- The user must re-calculate V and D by pressing the dark green calculate button again to remove the red highlighted background and text. Prior to submittal, the user should do a QC to ensure no red backgrounds are present in the V and D cells.

Other Outlet Geometry Conditions (Non-Triangular/Trapezoidal)

- If a geometry selection other than triangular or trapezoidal is chosen, the velocity and depth cells will turn light blue and become unlocked. The user must then use a third-party software to calculate the velocity and depth and input them manually into the spreadsheet.
- If the outlet analysis point is where proposed drainage is tying to an existing closed drainage system, it may be sufficient to input "N/A" for the velocity and depth cells
    - If there are increases in flow, modeling the design storm HGL increases with third-party software may be required or requested by the NCDOT reviewer.

2.4 Case Type

Once all the variables have been calculated and proper drop-down selections chosen, the spreadsheet will calculate a "case type" for that outlet analysis as shown below.



The case table legend can be accessed by clicking the case type ⓘ button or in the separate case type tab that is generated automatically from the steps in Section 1.3

The case types are determined from the possible scenarios outlined in Rule 15A NCAC 04B .0109 (a screenshot of the case table legend is shown below).

Outlet Analysis Case	Existing Erosion	Pre vs Post Velocity	Post Velocity vs. Permissible Soil Velocity	Velocity Increase 10% Threshold	Rule 15A NCAC 04B .0109 Satisfied?	Additional Requirements / Description
Case 1	Not Present	Decrease or No Change	$V_{10\ Post}$ < Permissible for that Soil	Does not Apply. Compliance Already Met	YES	Mark "None" in the "Existing / Potential Erosion?" Cell drop down
Case 1A	Same as Case 1 except with existing erosion present				YES	Even though there is a decresae in velocity and it is not erosive, for unknown reasons there is existing erosion present. Mark "Existing" in the "Existing / Potential Erosion" Cell drop down.
Case 2	Not Present	Decrease or No Change	$V_{10\ Post}$ > Permissible for that Soil	N/A Velocity Decreased	YES	Even though there is a decrease in velocity the flows are still erosive, Mark "Potential" in the "Existing / Potential Erosion" Cell drop down
Case 2A	Same as Case 2 except with existing erosion present				YES	Even though there is a decrease in velocity the flows are still erosive and there is existing erosion present, Mark "Both" in the "Existing / Potential Erosion" Cell drop down
Case 3	Not Present	Increase	$V_{10\ Post}$ < Permissible for that Soil	Does not Apply. Compliance Already Met	YES	Even though there is an increase in velocity, the velocity it is not erosive. Mark "None" in the "Existing / Potential Erosion" Cell drop down
Case 3A	Same as Case 3 except with existing erosion present				YES	Even though there is an increase in velocity, the velocity is not erosive, however, there is existing erosion present for unknown reason. Mark "Both" in the "Existing / Potential Erosion" Cell drop down
Case 4	Not Present	Increase	$V_{10\ Post}$ > Permissible for that Soil	Vincrease < 10%	YES	Even though velocity increases are less than 10%, $V_{10\ Post}$ still creates potential for erosion - Mark "Potential" in "Existing / Potential Erosion" Cell drop down
Case 4A	Same as Case 4 except with existing erosion present				YES	Even though velocity increases are less than 10%, Existing Erosion and $V_{10\ Post}$ still creates potential for erosion - Mark "Both" in "Existing / Potential Erosion" Cell drop down
Case 5	Not Present	Increase	$V_{10\ Post}$ > Permissible for that Soil	Vincrease > 10%	NO	Design receiving channel to withstand Vpost anywhere it exceeds Vpre by 10%. Create another outlet analysis tab at that point downstream to show Vincrease < 10%. Coordination with NCDOT may be needed for potential design solutions or design exceptions in this case due to easement constraints or environmental permitting constraints.
Case 5A	Same as Case 5 except with existing erosion present				NO	

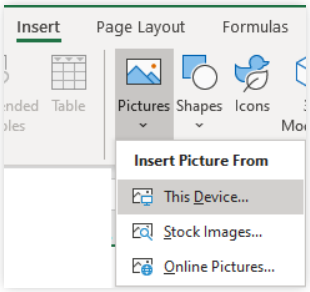
Note 1 In the case of a PROPOSED non-soil liner to absolve a Case 5 or 5A, Rule15A NCAC 04B .0109 is considered satisifed at this location. Mark only "Existing" or "None" in the "Existing / Potential Erosion Cell drop down". Other analysis points further downstream for where Vincrease becomes < 10% are still necessary.

Note 2 In the case of an EXISTING non-soil liner to remain post-construction, Rule 15A NCAC 04B .0109 does not provide guidance. Therefore, engineering judgement on the existing/potential erosion issues shall be used and discussed in the summary section of the outlet analysis. A combination of the 10% velocity increase threshold, the suggested max velocities, and suggested max shear stresses shall applied to make a design decision in these situations.

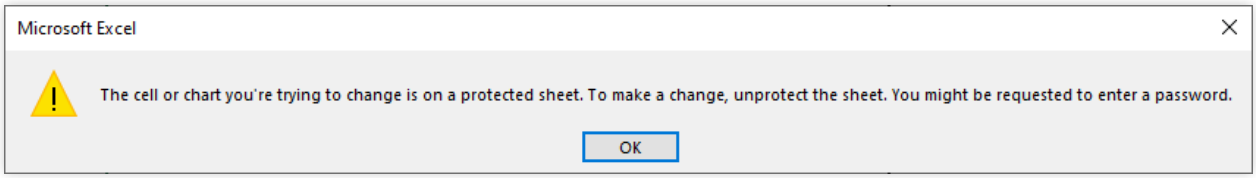
2.5 Individual Analysis Tab: Photos

- Outlet photos should be added to the quadrants as shown below.

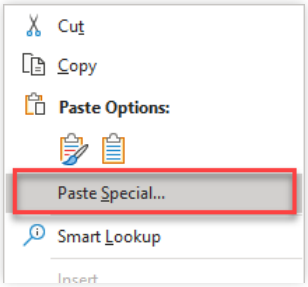
- Photos can either be copied and pasted into the cells or inserted via insert>picture>from this device as shown below



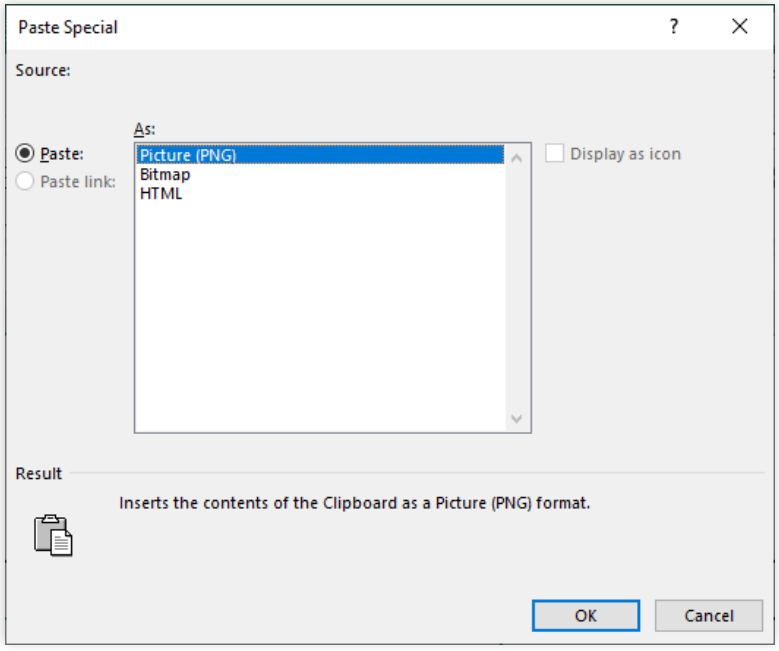
- If the copy/paste shows the error below follow these steps:



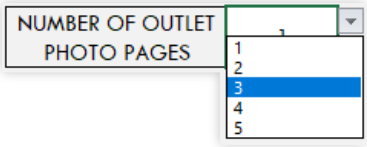
- Right click to paste, but select "Paste Special"



- Select one of the options shown below and click OK

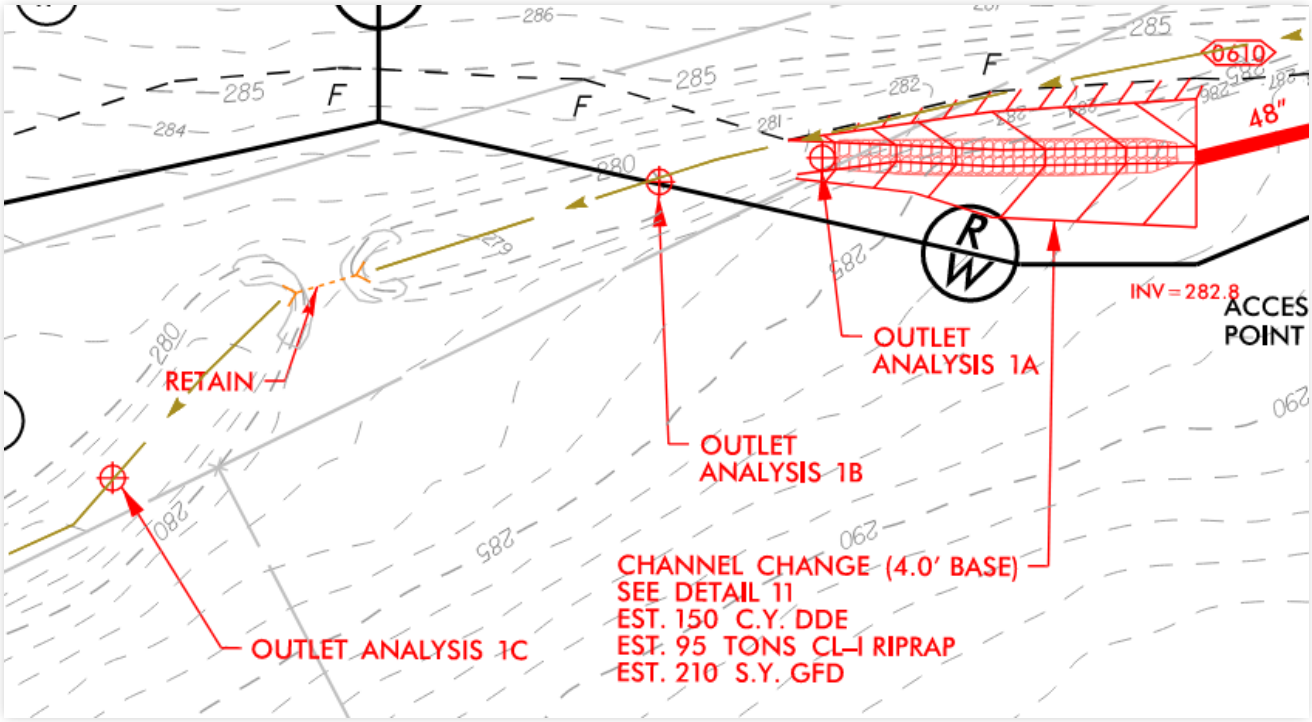


- If this still does not work, insert the pictures via insert>picture>from this device as discussed previously.
- To add additional photo pages use the drop down on the right as shown below



3.1 Redline Plan Sheet: Labeling

- Outlet analysis points should be labeled on the redline plan sheets in a method similar to what is shown below.



- A symbol (such as crosshairs or a star) should be placed at the exact location the analysis point is located and plotted in red.
- Note: the screenshot above shows the three standard location choices for outlet analysis (within right-of-way, at right-of-way, and downstream past right-of-way)