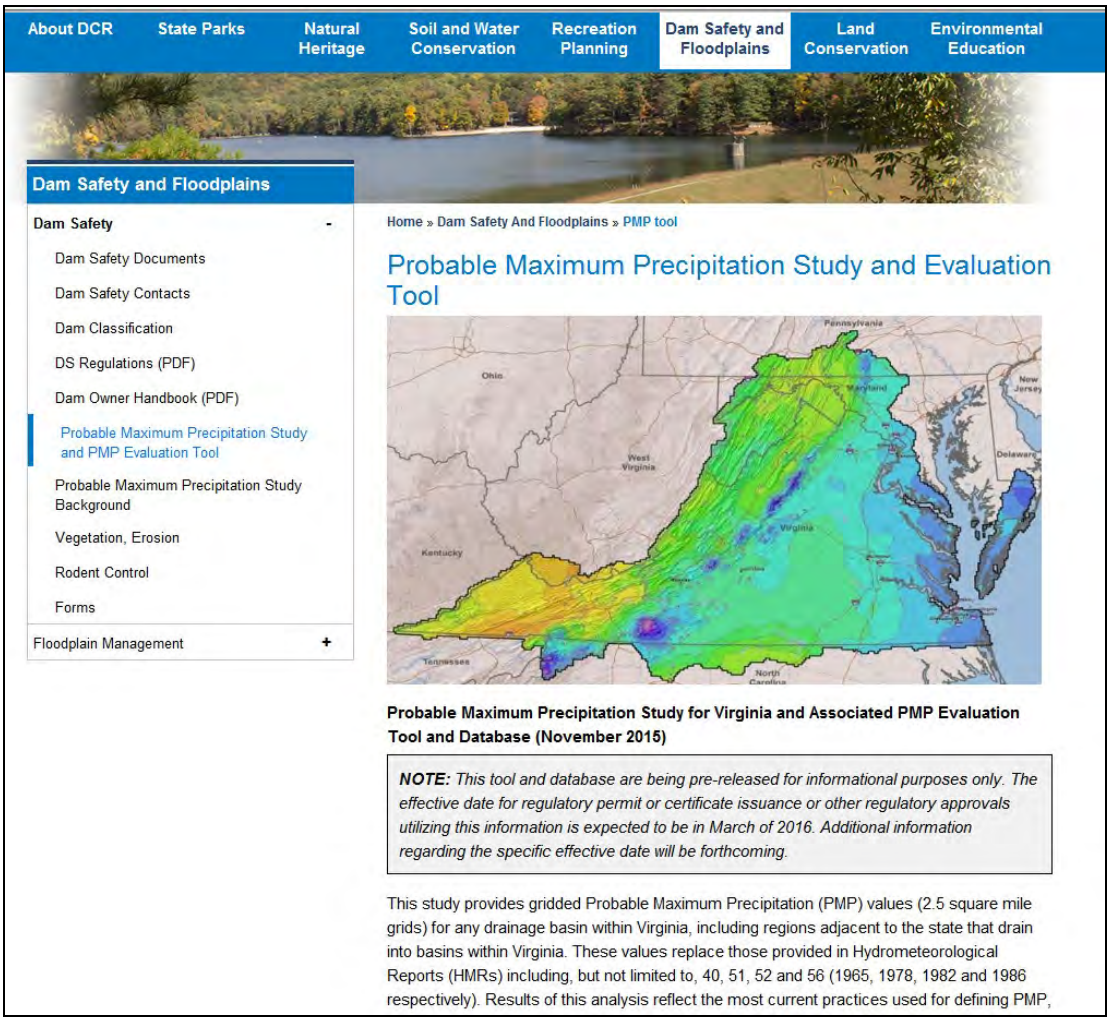
PMP Evaluation Tool Training Document February 2016

Virginia DCR Dam Safety

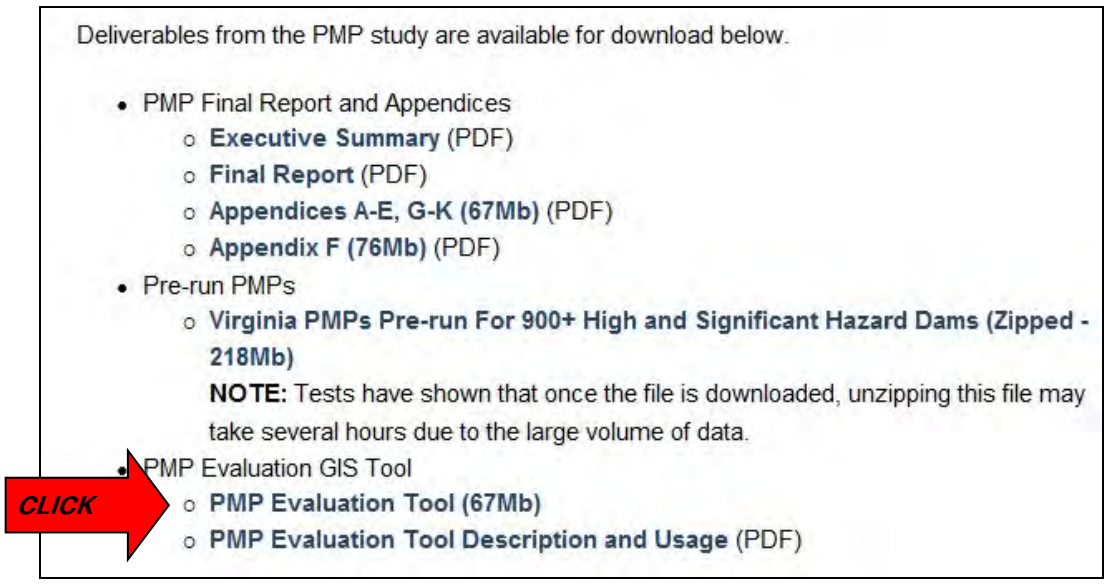
This document has been produced by the Virginia Department of Conservation and Recreation, Division of Dam Safety and Floodplain Management (VA DCR Dam Safety) to provide guidance to Dam Owners and the Engineering community when utilizing the new Probable Maximum Precipitation (PMP) Evaluation Tool located on VA DCR's Dam Safety website (see website link in step 1). This document shall provide users with a step by step guide and briefly discuss how to interpret results from the tool. All example information utilized in this training document is fictional and is for training purposes only.

In conjunction with the developer's "PMP Evaluation Tool Description and Usage" PDF and Virginia PMP 2015 Watershed Calculation Spreadsheet (Excel) located on our website, VA DCR Dam Safety offers the following PMP Evaluation Tool Training Document:

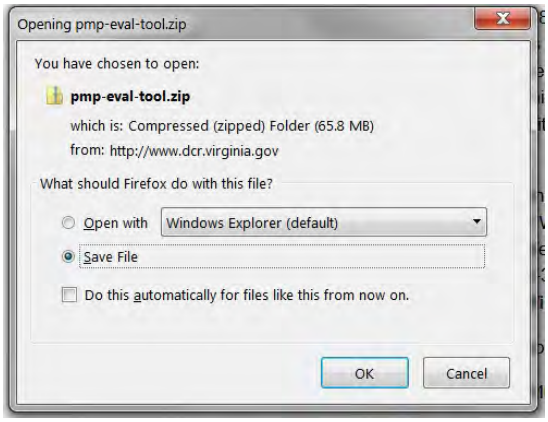
1. Open your Internet browser and Go to http://www.dcr.virginia.gov/dam-safety-and-floodplains/pmp-tool. This will open a sub-webpage of the VA DCR Dam Safety main webpage named **Probable Maximum Precipitation Study and Evaluation Tool**. Please see graphic below.

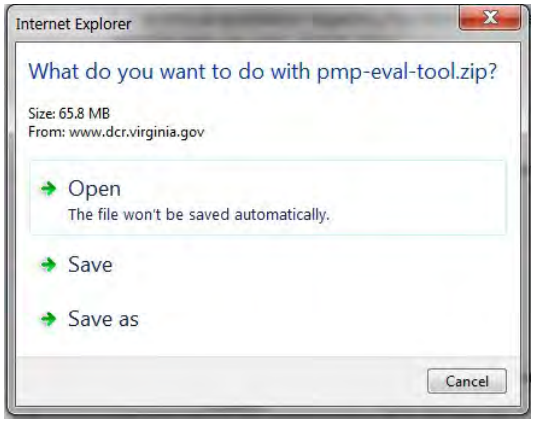


2. Scroll half way down the webpage and look for **PMP Evaluation GIS tool** under the section named **Deliverables from the PMP study are available for download below**.
3. Click on the **PMP Evaluation Tool (67 Mb)** link. Please see graphic below

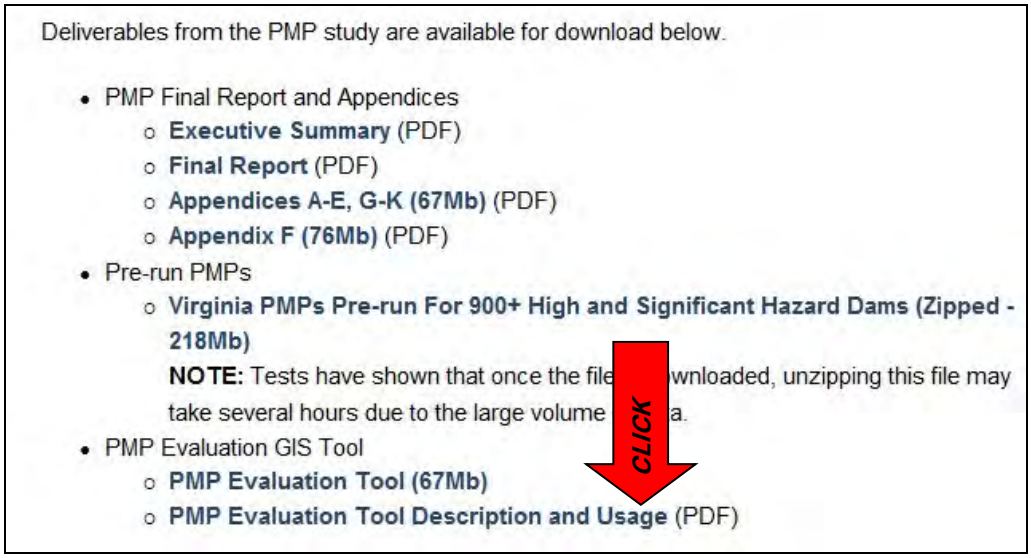


4. A **file save pop-up box** will open once the user has clicked on the link (see graphics below). Save the **pmp-eval-tool.zip** file to your computer and move the zip file to the desktop or a location of your choosing. For the purposes of this training document, the zip file was saved to the desktop.



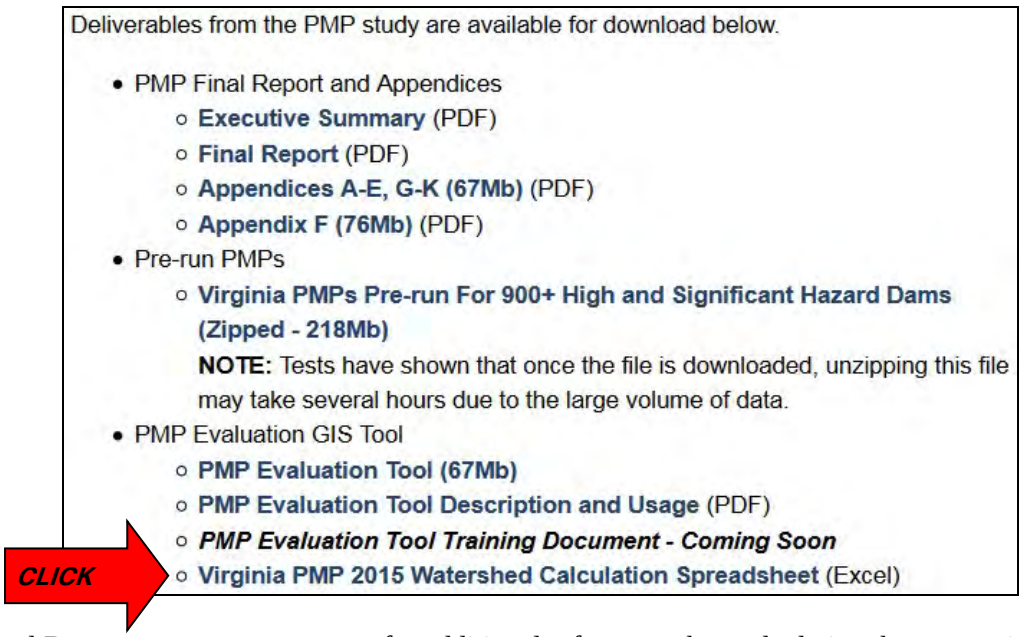


5. Please note that the saving of this file could take up to 10 minutes (or longer) based on the user's internet connection.
6. Once the file has finished downloading, return to the **Probable Maximum Precipitation Study and Evaluation Tool** website (see **Step 1**) and click on the **PMP Evaluation Tool Description and Usage (PDF**) link under **PMP Evaluation GIS tool** section of the webpage. Please see graphic below:



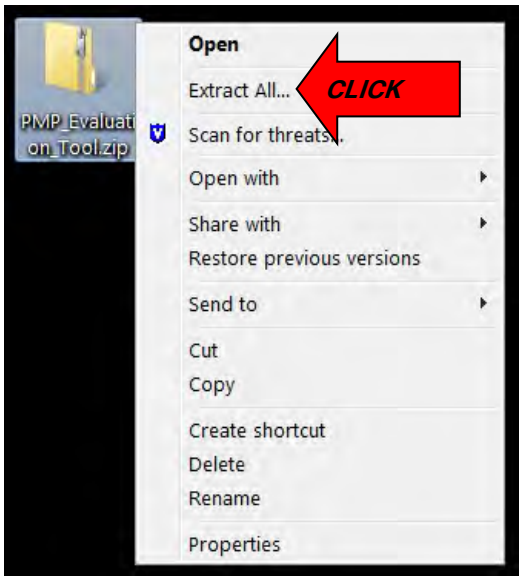
7. Save the Document to your computer for additional reference when using the PMP Tool.

8. Once the PDF file has been saved to your computer, return to the **Probable Maximum Precipitation Study and Evaluation Tool** website (see **Step 1**) and click on the **Virginia PMP 2015 Watershed Calculation Spreadsheet (Excel)** link under **PMP Evaluation GIS tool** section of the webpage. Please see graphic below:

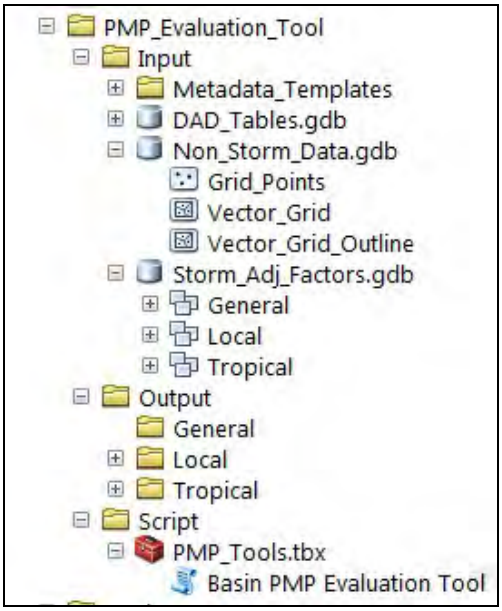


9. Save the Excel Document to your computer for additional reference when calculating the appropriate 6-hour, 12-hour and 24-hour rainfall values for the watershed in question. For the purposes of this training document, the **Virginia PMP 2015 Watershed Calculation Spreadsheet (Excel)** was saved to the desktop and will be referenced / utilized later in this document.

10. Locate the **pmp-eval-tool.zip** on your desktop (or saved location of your choice). Right click on the zip file and choose the **extract all** option. Extract file onto the desktop with the name **PMP_Evaluation_Tool**. See Graphic Below.



11. A new folder should now be on your computer's desktop (or location of your choice) called **PMP_Evaluation_Tool.**
12. Double click on the **PMP_Evaluation_Tool** folder to expose three additional folders called **Input**, **Output**, and **Script**. See graphic below.

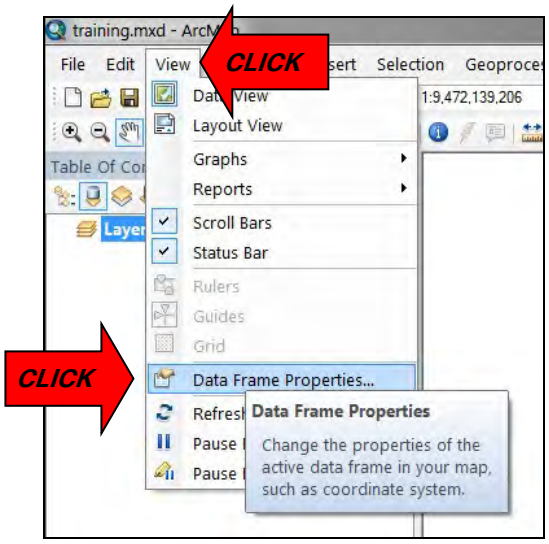


13. The **Input** folder contains all of the meteorological / PMP data for the State of Virginia required for the PMP Evaluation Tool to function properly. For additional information on the State of Virginia meteorological / PMP data utilized in this tool, please reference the Applied Weather Associates' November 2015 Probable Maximum Precipitation Study for Virginia (**Final Report (PDF)** link) on the http://www.dcr.virginia.gov/dam-safety-and-floodplains/pmp-tool sub-webpage under the **PMP Final Report & Appendices** section.
14. The **Output** folder contains the geodatabases where the PMP output information will be housed once the tool has been run by the user.
15. The **Script** folder contains a copy of the python script utilized to create the PMP Evaluation Tool and an ArcGIS toolbox containing the actual **Basin PMP Evaluation Tool**.
16. Close / minimize the folder window which opened when you previously double-clicked on the folder called **PMP_Evaluation_Tool** located on your desktop.
17. Open your Esri ArcMap program (Esri ArcMap 10.0 or better)

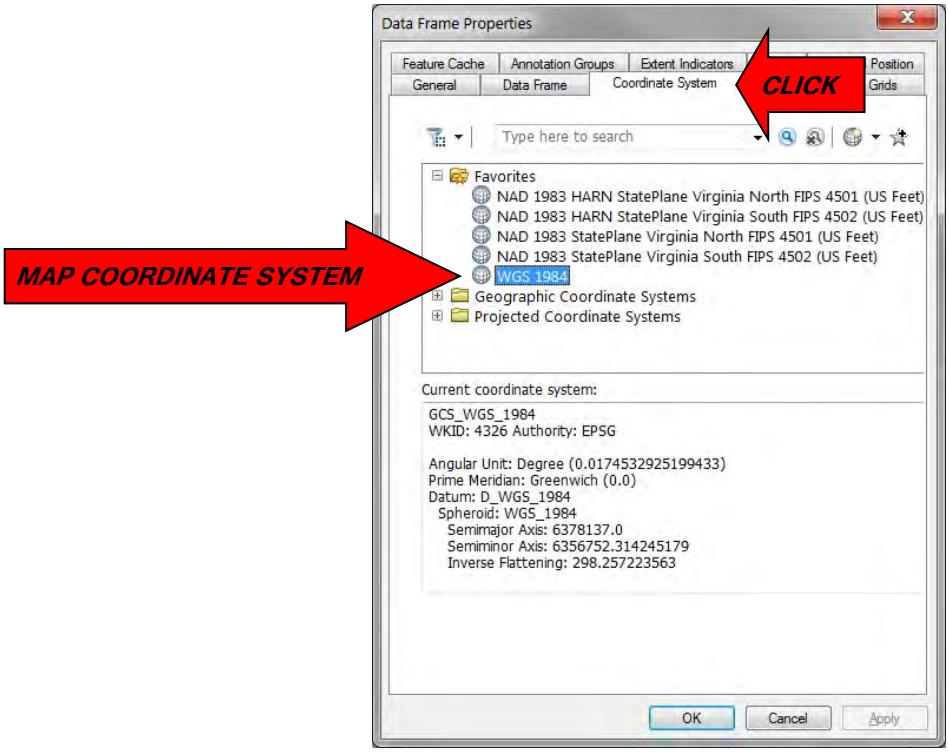
18. Save the ArcGIS work map (work map) to your Desktop (or a location of your choosing) with a filename of your choosing. For the purposes of this training document, we will be working in ArcMap 10.1 Service Pack 1 with an ArcGIS work map named **training.**

19. Moving forward, it is recommended that the work map be saved often as the user works through this training document.

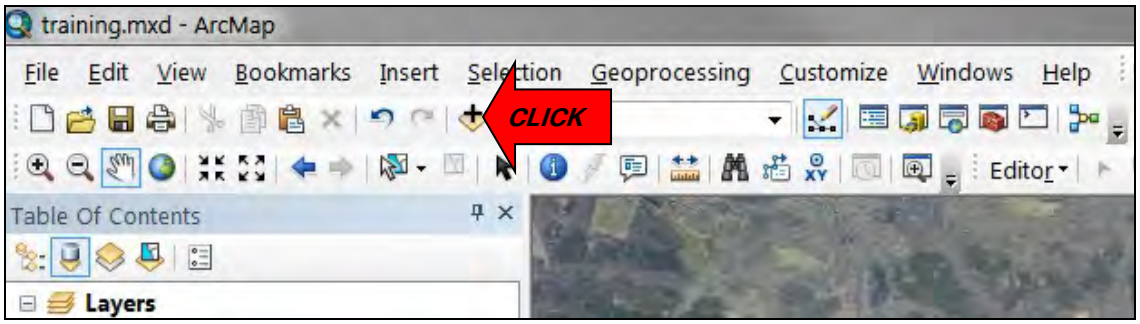
20. The default coordinate system for the **PMP_Evaluation_Tool** is **GCS_WGS_1984**. To check your current work map's coordinate system, navigate to the **View** pull down and select **Data Frame Properties**. Please see graphic below.

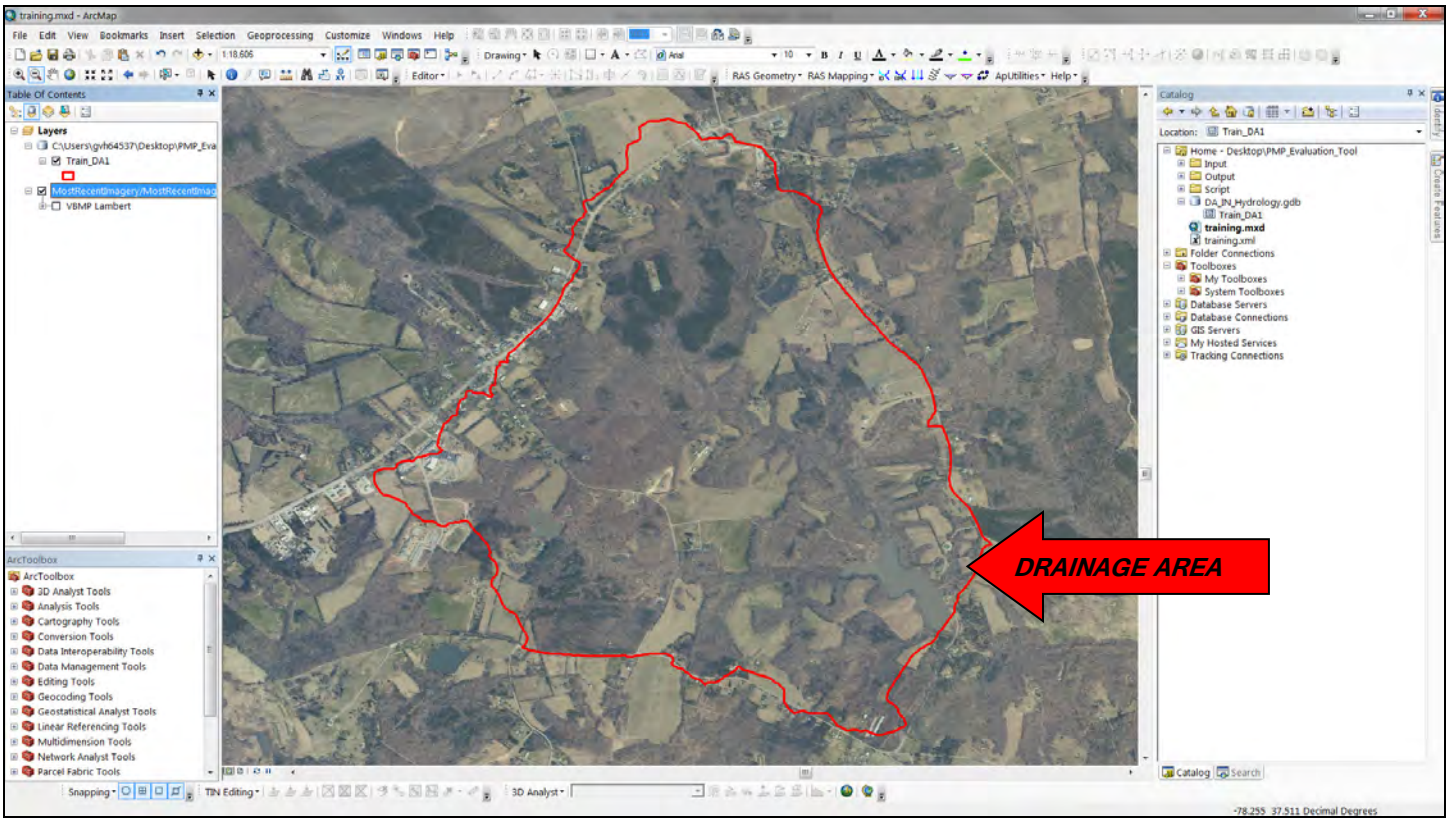


21. Choose the **Coordinate System** tab and determine the coordinate system for your current work map. Once finished, click **Ok** which will close the **Data Frame Properties** window. See graphic below. For the purposes of this training document, the coordinate system for the **training** work map will be in **GCS_WGS_1984**. If you decide to utilize a different coordinate system in your work map other than the PMP tool's default system, coordinate system transformations may be required to ensure accurate location of the PMP tool's output grids. You will receive a warning message from ArcMap if you attempt to add data from a coordinate system different than the one selected in the Data Frame Properties. If you should need help with GIS coordinate system transformations, VA DCR Dam Safety suggests referencing ArcGIS help through ArcMap or talking with your internal ArcGIS helpdesk support.

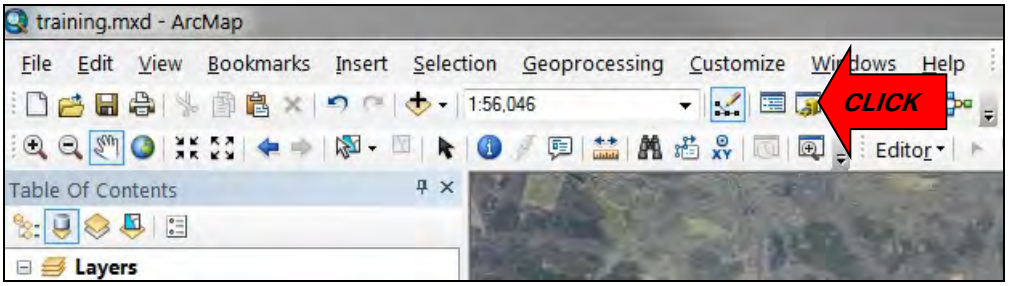


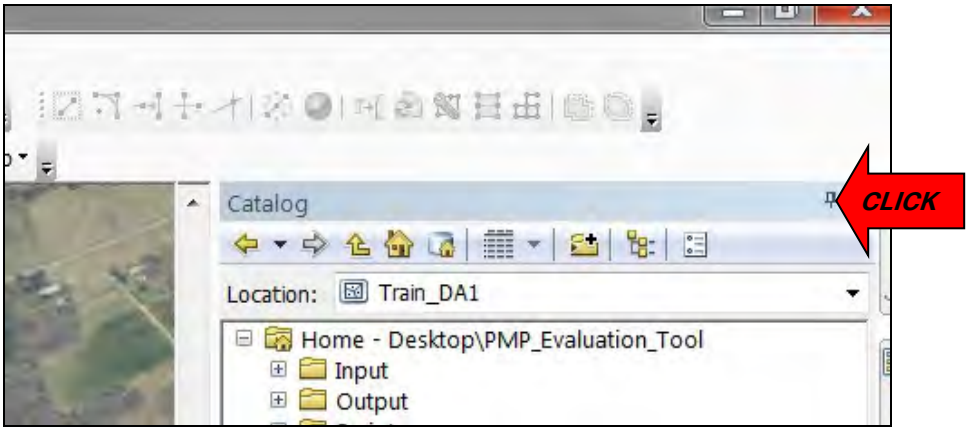
22. Navigate to the **add data** symbol in your work map (yellow diamond symbol with a plus sign, see graphic below), browse to your drainage area, and add the drainage area for the Dam in question into your work map. Please note the drainage area must be either a **Shapefile** or **geo-database (GDB) feature class** and must be **CLOSED**. The user must supply the drainage area in order for the **PMP_Evaluation_Tool** to work properly. For the purposes of this training document, a closed drainage area from a file geo-database (GDB) for a dam located in the piedmont region of Virginia (Transposition Zone 6 – see page 53 of the Applied Weather Associates' November 2015 Probable Maximum Precipitation Study for Virginia) will be utilized.



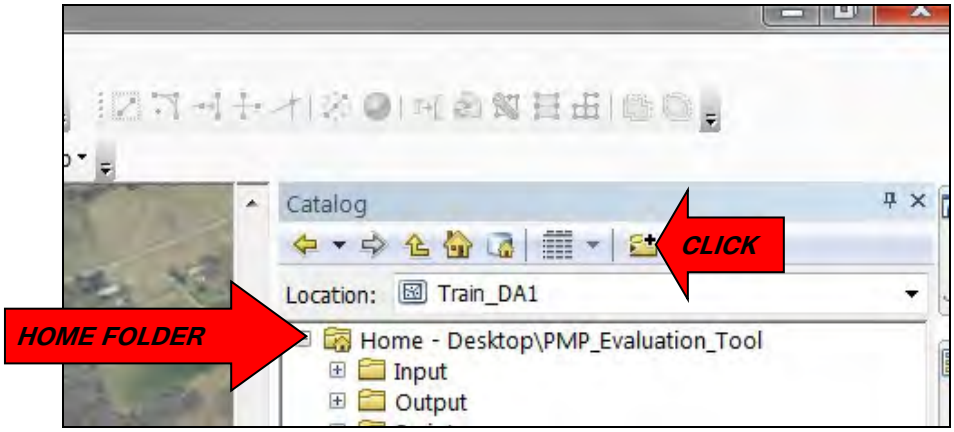


23. Open **ArcCatalog** (symbol looks like a yellow filing cabinet, see graphic below) in your work map. **Pin ArcCatalog** to the right in your work map and turn off the auto hide option (looks like a thumbtack in top right of ArcCatalog window). See graphic below.

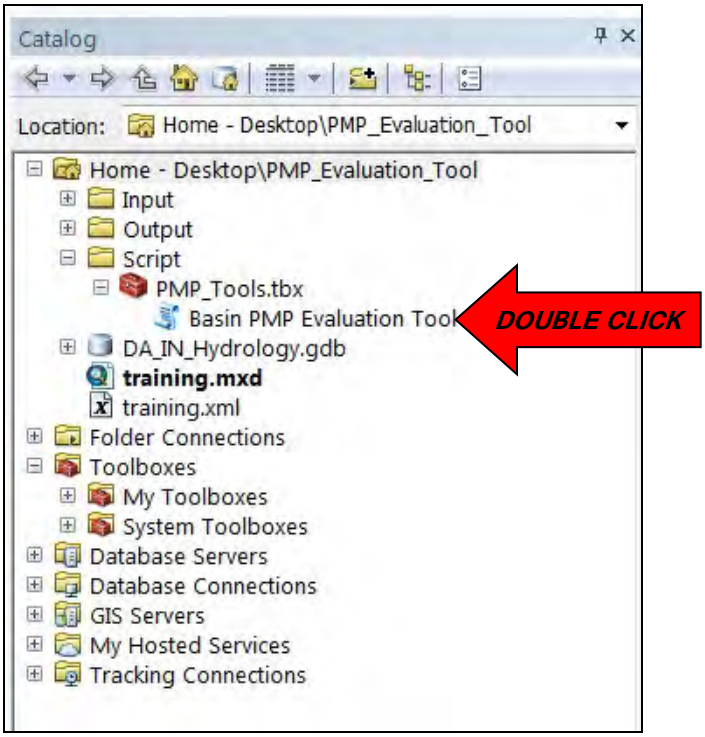




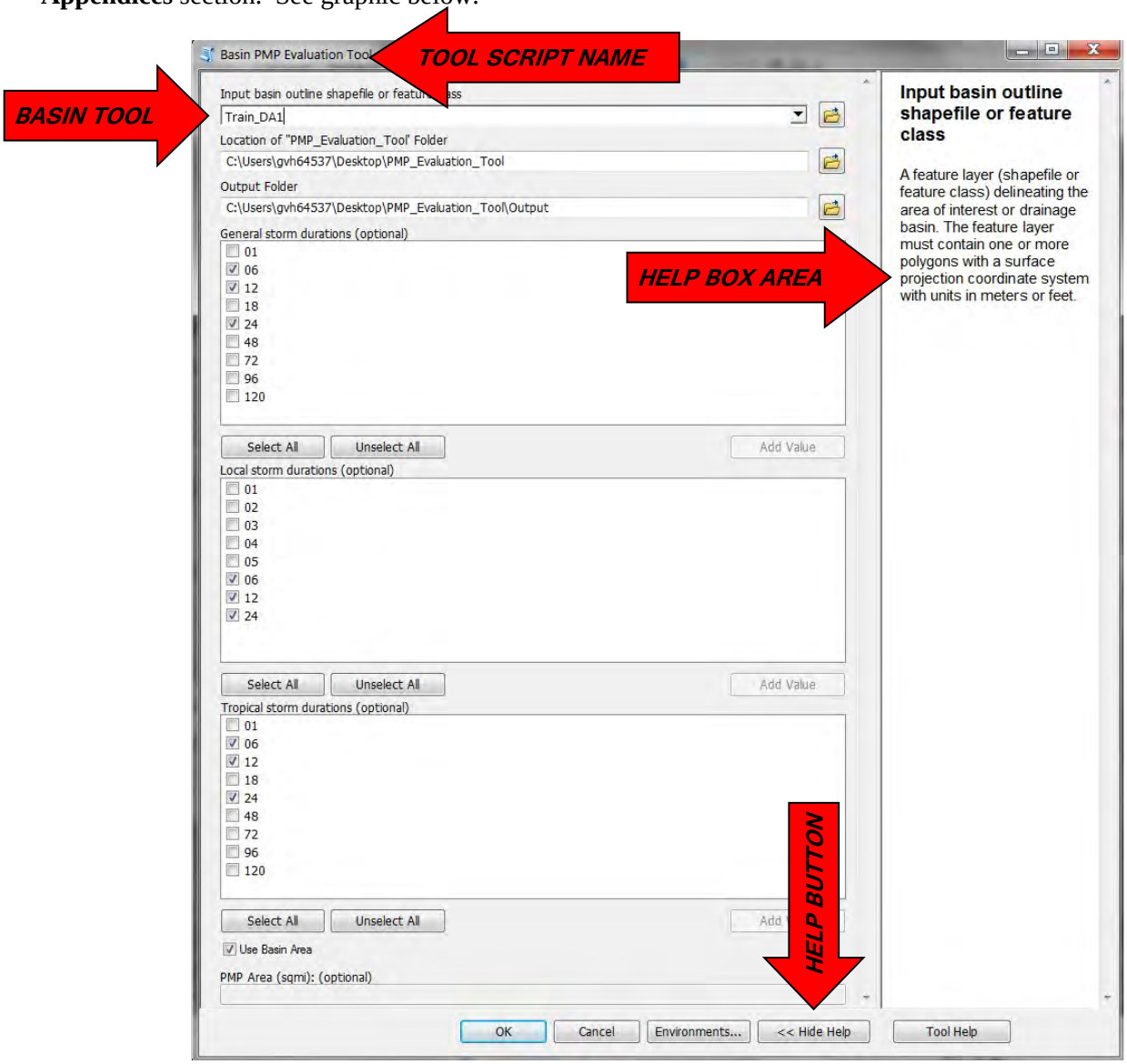
24. Utilizing ArcCatalog, click on the **Connect to Folder symbol** (see graphic below) to connect to your **PMP_Evaluation_Tool** folder to your work map. Navigate to the **PMP_Evaluation_Tool** folder on your desktop (or other location where folder is saved) and click **Ok** to connect to said folder. The **home folder** in ArcCatalog should now be linked to the **PMP_Evaluation_Tool** folder (see graphic below).



25. **Expand** the **PMP_Evaluation_Tool** folder (if not already expanded) and locate the **Script** folder. **Expand** the **Script** folder and then **expand** the **PMP_Tools.tbx** ArcGIS toolbox. **Double click** on the **Basin PMP Evaluation Tool** script to open the **PMP_Evaluation_Tool** in your work map. See graphic below.

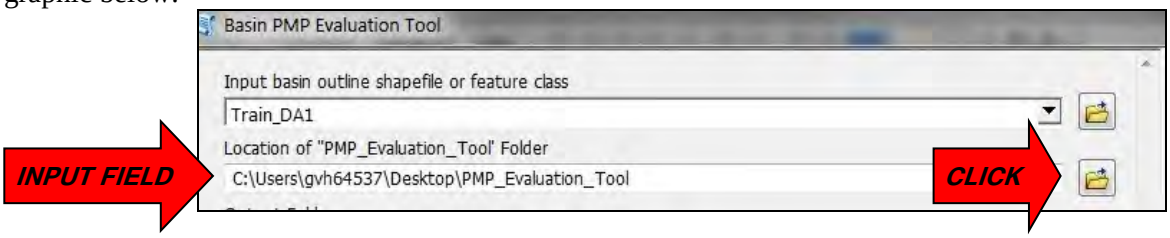


26. The **PMP_Evaluation_Tool** will open in your ArcGIS work map and require inputs by the user in six different categories. The script name of the actual toolbox is **Basin PMP Evaluation Tool**. On the bottom of the tool window, ensure the **show help / hide help button** has been clicked to show help on right side of tool. When the user clicks on each category / section, a help box with a description of what information / data is required for said category / section will be shown the right of tool (if available). The designated **General**, **Local**, and **Tropical** fields within the tool represent three distinct storm types utilized to develop the new PMP values within the State of Virginia. Each storm type includes multiple storm duration options to aid the user in modeling the Dam in question. For more information on the **General**, **Local**, and **Tropical** storm event types, please reference Applied Weather Associates' November 2015 Probable Maximum Precipitation Study for Virginia (**Final Report (PDF)** link) on the http://www.dcr.virginia.gov/dam-safety-and-floodplains/pmp-tool sub-webpage under the **PMP Final Report & Appendices** section. See graphic below.

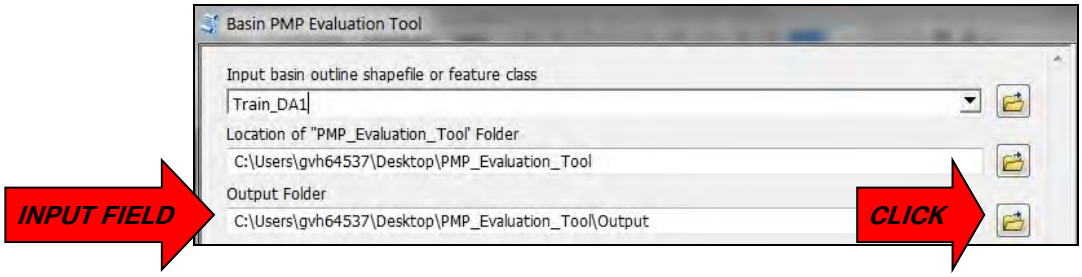


27. Input basin outline Shapefile or feature class Input Field – **Click** the **drop down arrow** on the right side of the input field and choose the **drainage area feature class / shapefile** previously added to the work map in previous steps (**Step 19**). If the drainage area feature class / Shapefile has not already been added to the work map, click on the **open folder** symbol to the right of input field to navigate to their required drainage area file. See graphic below.

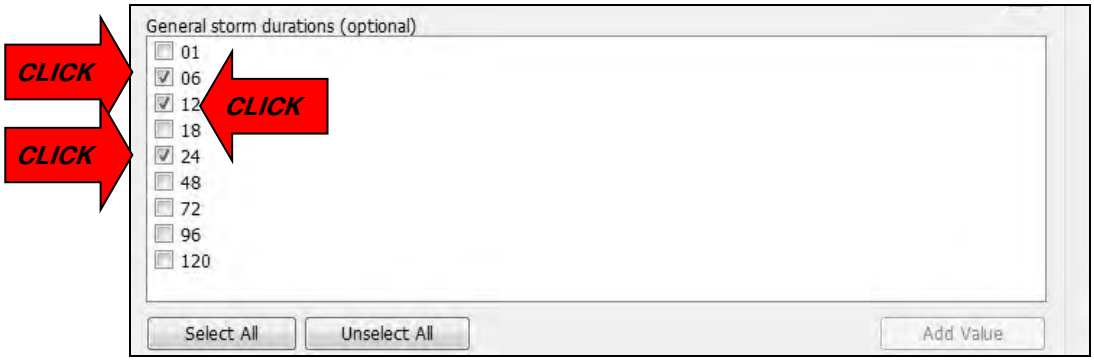
28. Location of PMP_Evaluation_Tool Folder Input Field – **Click** on the **Open Folder** symbol to the right of the input field. Browse to the **PMP_Evaluation_Tool folder** and hit **ok**. For the purposes of this training document, the PMP_Evaluation_Tool folder is located on the desktop. This field may **default** to the PMP_Evaluation_Tool folder when the tool is opened if said folder has been marked as the **home folder** in **ArcCatalog** for your work map. See graphic below.



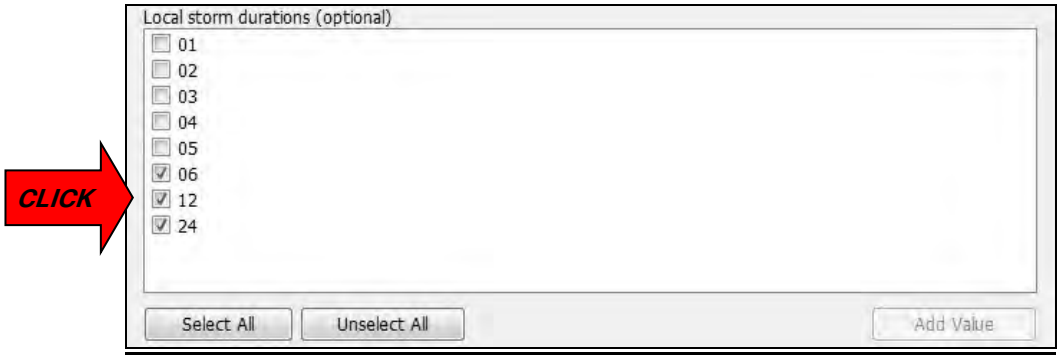
29. Output Folder Input Field – **Click** on the **Open Folder** symbol to the right of the input field and **browse** to a location on your computer where you would like the tool's output data to be located. Choose **Ok**. The **default location** for the output data is in the **Output** folder of the **PMP_Evaluation_Tool** folder. Please note that if the output location for this input field always remains the same when using the tool, the output data will automatically overwrite itself each time the tool is utilized. For the purposes of this training document, the default **Output** folder will be utilized for the output data. See graphic below.



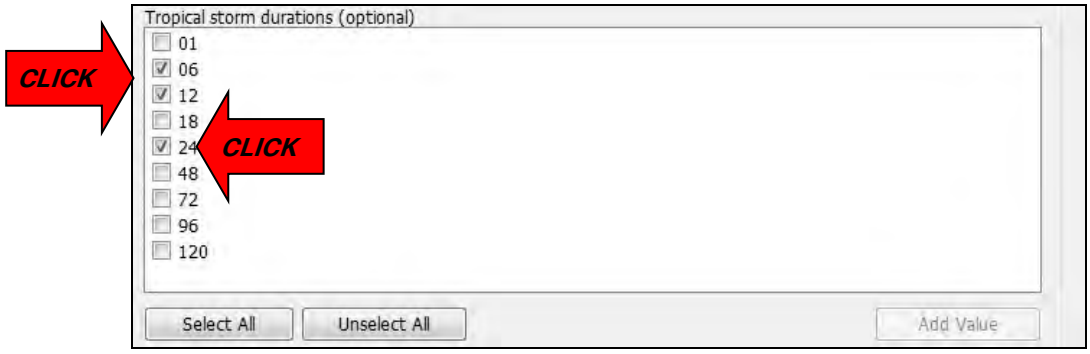
30. General Storm Durations (optional) Input Field – **Select (checkbox)** a **storm duration** from the list of storm durations in the **General Storm** input field. Per current DCR Dam Safety Regulations; it is required that at a minimum the 6-hour, 12-hour, and 24-hour storm events be selected from the **General Storm** input field for the Dam in question. All provided storm durations may be selected for the **General Storm** input field if desired, but may impact tool computation times. For the purposes of this training document; the 6-hour, 12-hour, and 24-hour storm durations have been selected and will be analyzed. See graphic below.



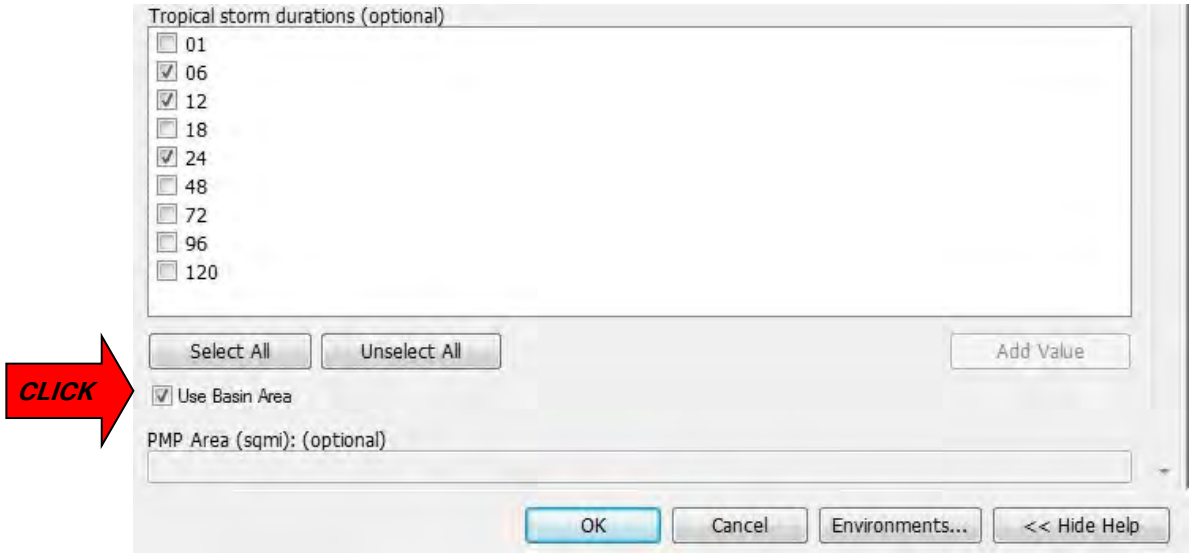
31. Local Storm Durations (optional) Input Field – **Select (checkbox)** a **storm duration** from the list of storm durations in the **Local Storm** input field. Per current DCR Dam Safety Regulations; it is required that at a minimum the 6-hour, 12-hour, and 24-hour storm events be selected from the **Local Storm** input field for the Dam in question. All provided storm durations may be selected for the **Local Storm input** field if desired, but may impact tool computation times. For the purposes of this training document; the 6-hour, 12-hour, and 24-hour storm durations have been selected and will be analyzed. See graphic below.



32. Tropical storm durations (optional) Input Field – **Select (checkbox)** a **storm duration** from the list of storm durations in the **Tropical Storm** input field. Per current DCR Dam Safety Regulations; it is required that at a minimum the 6-hour, 12-hour, and 24-hour storm events be selected from the **Tropical Storm input** field for the Dam in question. All provided storm durations may be selected for the **Tropical Storm** input field if desired, but may impact tool computation times. For the purposes of this training document; the 6-hour, 12-hour, and 24-hour storm durations have been selected and will be analyzed. See graphic below.

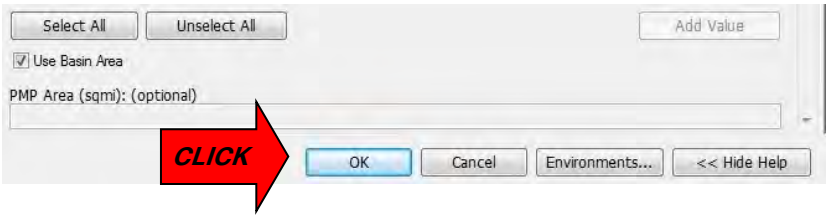


33. Use Basin Area Check Box – Ensure the **Use Basin Area** option box located below the **Tropical storm durations (optional) Input Field** is **selected**. By selecting this box, the Basin PMP Evaluation tool will utilize the basin area from the drainage area chosen in the **Input basin outline Shapefile or feature class Input Field** (**Step 24**). If the **Use Basin Area** box is unchecked, the user then has the ability to input a PMP Area (sqmi): (optional) in the input field below the checkbox. This new PMP area number would override the basin area from the drainage area selected in the **Input basin outline Shapefile or feature class Input Field** (**Step 24**). For the purposes of this training document, the **Use Basin Area** checkbox will be selected. See graphic below.

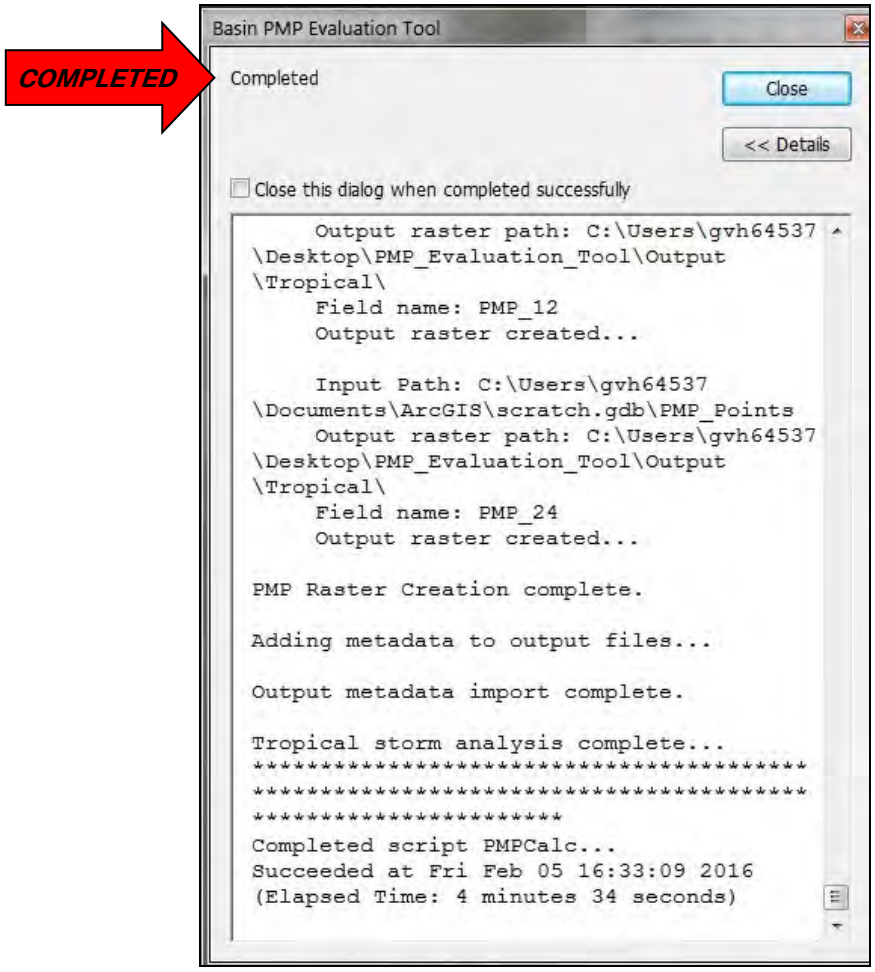


34. Review the tool's inputs and change any **Environments** settings deemed necessary for your project. For the purposes of this training document, no adjustments to any of the **Environments** settings were made. Once reviewed, click the **OK** button to run the Basin PMP Evaluation tool. Depending on the size of the inputted drainage area, the

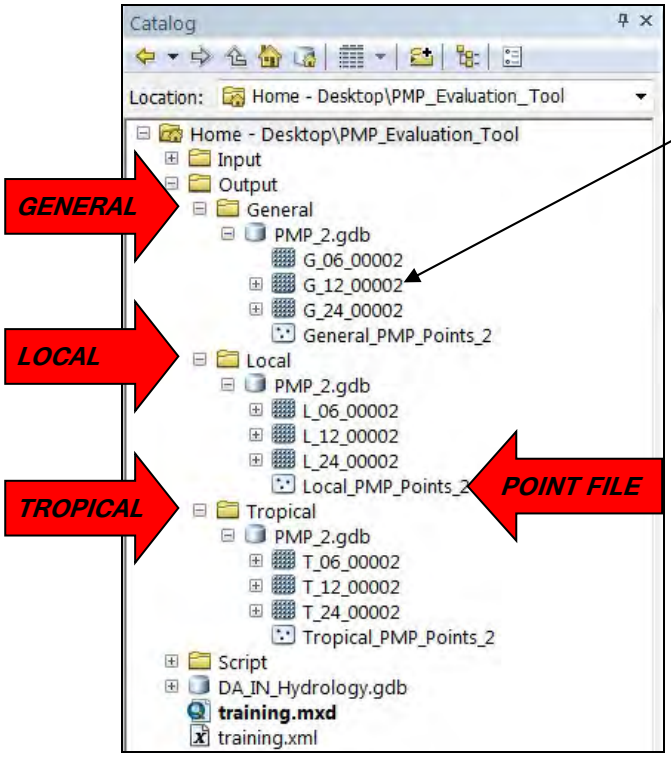
computation time for the Basin PMP Evaluation Tool will average from 5 minutes to multiple hours to complete. See graphic below.



35. Ensure before moving forward the tool has completed. The tool should state **completed** once finished and the user should have the ability to close out of the tool. See graphic below.

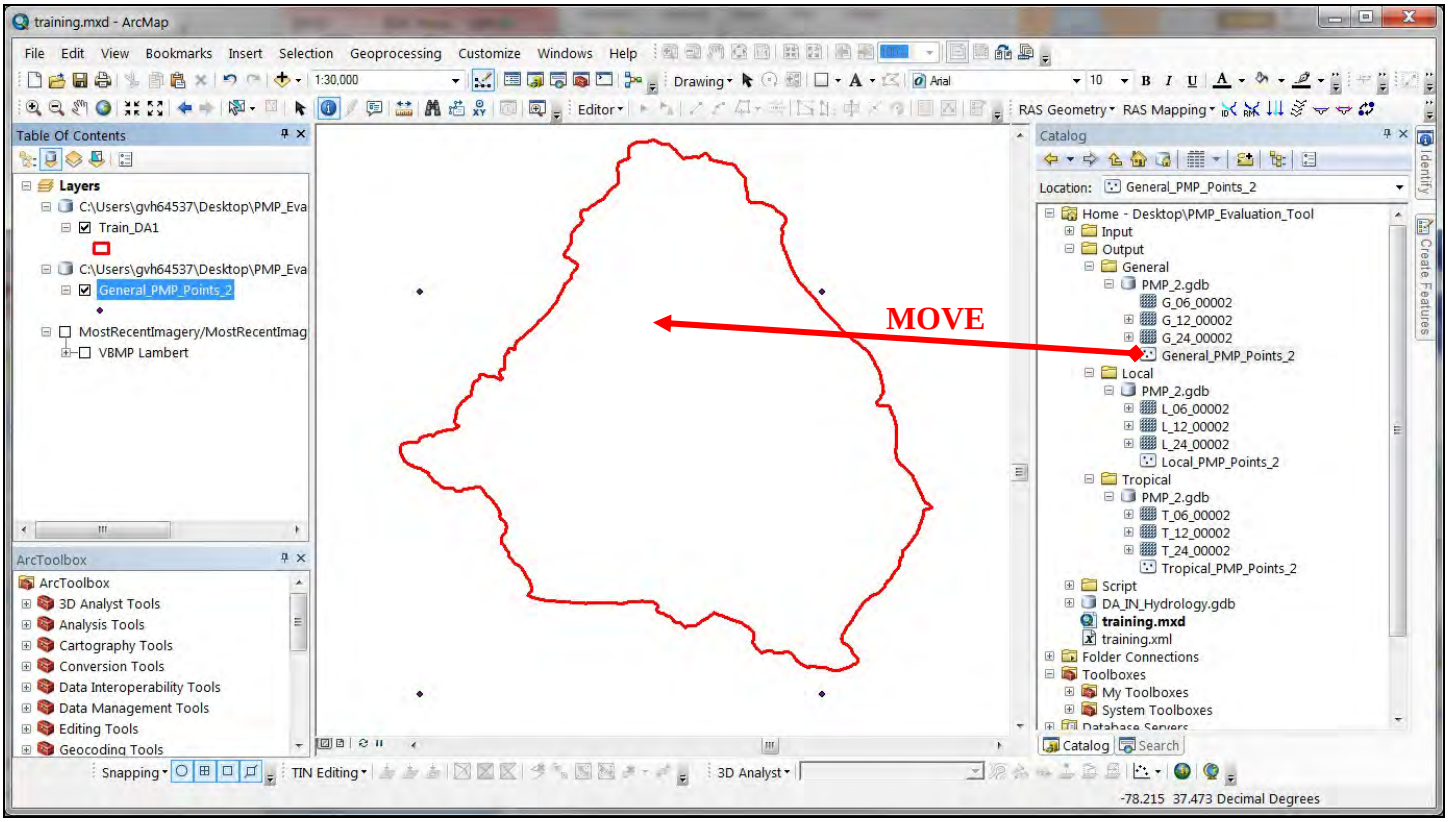


36. Once the **Basin PMP Evaluation Tool** has completed, navigate to the **Output** folder in ArcCatalog under the **PMP_Evaluation_Tool** main folder. Expand the **Output** folder. The **Output** folder should have three sub-folders under it named **General**, **Local**, and **Tropical**. Upon further **expanding** each of the **subfolders**, each sub-folder should have a **geodatabase** with tables and a **Point file**. See graphic below.

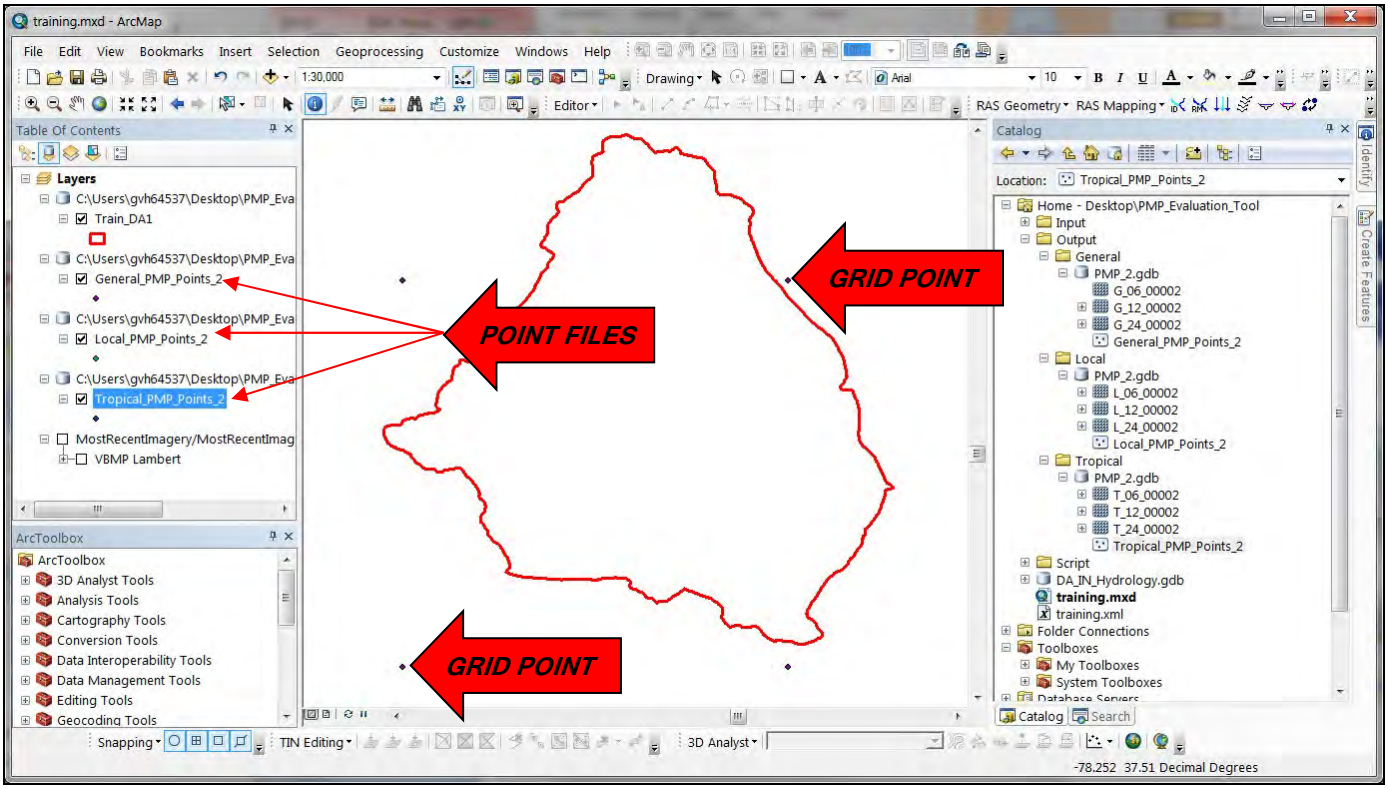


Note: The file naming convention utilized in the Basin PMP Evaluation Tool's **Output** files (geodatabase, table files, point files, etc.) will be based on the storm events selected and storm event type (general, local, & tropical). The number portion of the file name is based on the size of your **Input Basin**. For the purposes of this training document, the input basin utilized was approximately 2.27 mi^2. As a result, there is a 2 at the end of each **Output** file's name to represent the 2.27 mi^2 basin.

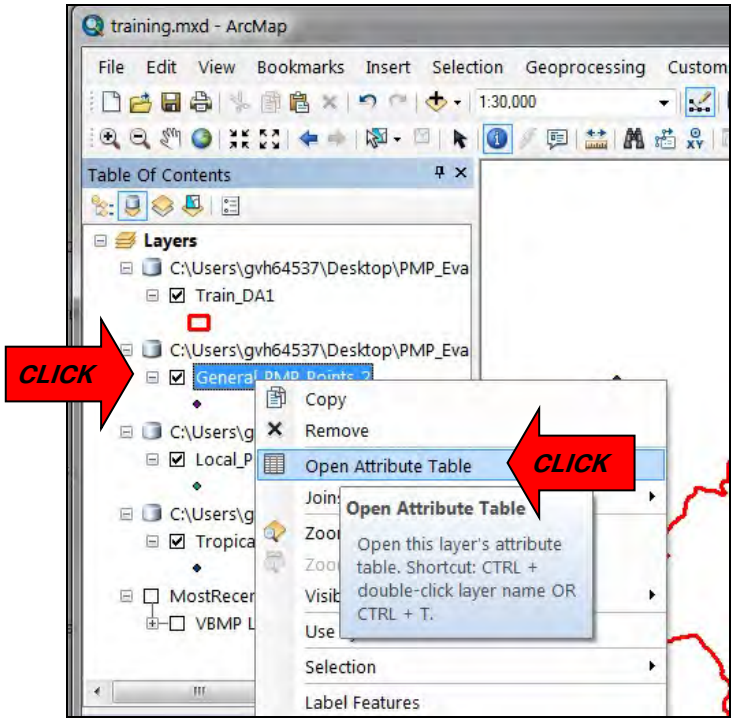
37. Select the **General_PMP_Points_2** point file feature class under the **Output → General → PMP_2.gdb** in ArcCatalog and move (drag and drop) the **General_PMP_Points_2** point file feature class into the work map (this action will add the point file feature class to the work map). The user may also add the **General_PMP_Points_2** point file feature to the work map utilizing the **Add Data** option as discussed in **Step 21** of this training document**.** At this time a point feature class named **General_PMP_Points_2** should be in the work map. See graphic below.



38. Return to the **Output** folder and complete the same process as dictated in **Step 36** for the **Local** and **Tropical** point file feature classes. Once completed, there should be three point feature classes in the work map. See graphic below.



39. **Select** the **General_PMP_Points_2** point file feature class in the work map's table of contents section and **right click**. Navigate to **Open Attribute Table** and **click** to open the file's table. See graphic below.



40. The **Attribute Table** for the **General_PMP_Points_2** point file feature class should now be open in the work map. In this particular example, four distinct **grid points** are located within the drainage area in question (see graphic in **Step 38**). Each grid point represents a data point full of storm based data information (**Input** portion of **PMP_Evaluation_Tool**) for multiple storm durations which is utilized by the **Basin PMP Evaluation Tool** to analyze the watershed in question. An explanation of each of the Attribute Table's columns as well as a graphic can be found below.

    a. Object ID – This column represents each point located within the points feature class

    b. Shape – This column defines the type of shape for the grid point in question

c. Id – default column

d. Point X – X coordinate for grid point in question

e. Point Y – Y coordinate for grid point in question

f. Zone – Transposition Zone for grid point in question

g. PMP_06 – Controlling 6 Hr PMP value for grid point in question

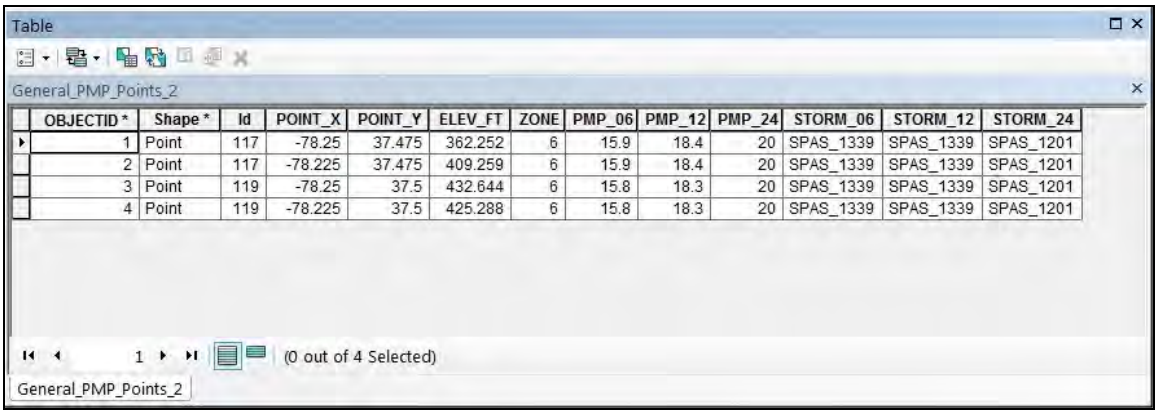
h. PMP_12 – Controlling 12 Hr PMP value for grid point in question

i. PMP_24 – Controlling 24 Hr PMP value for grid point in question

j. Storm_06 - Controlling storm event for the 6 Hr PMP event for grid point in question

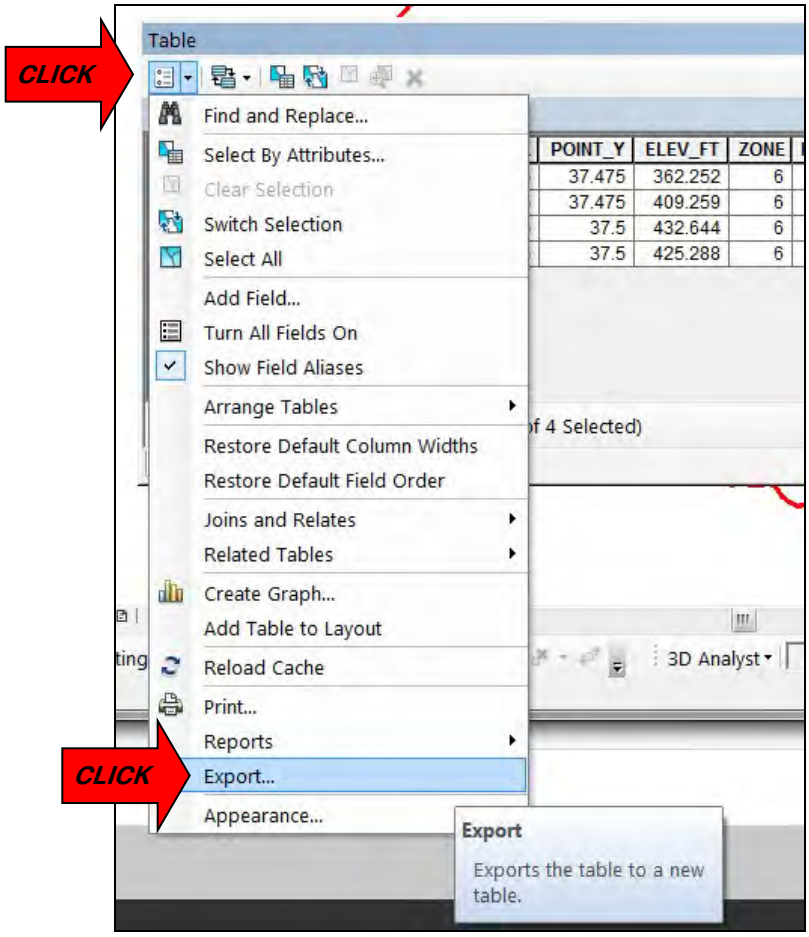
k. Storm_12 - Controlling storm event for the 12 Hr PMP event for grid point in question

l. Storm_24 - Controlling storm event for the 24 Hr PMP event for grid point in question

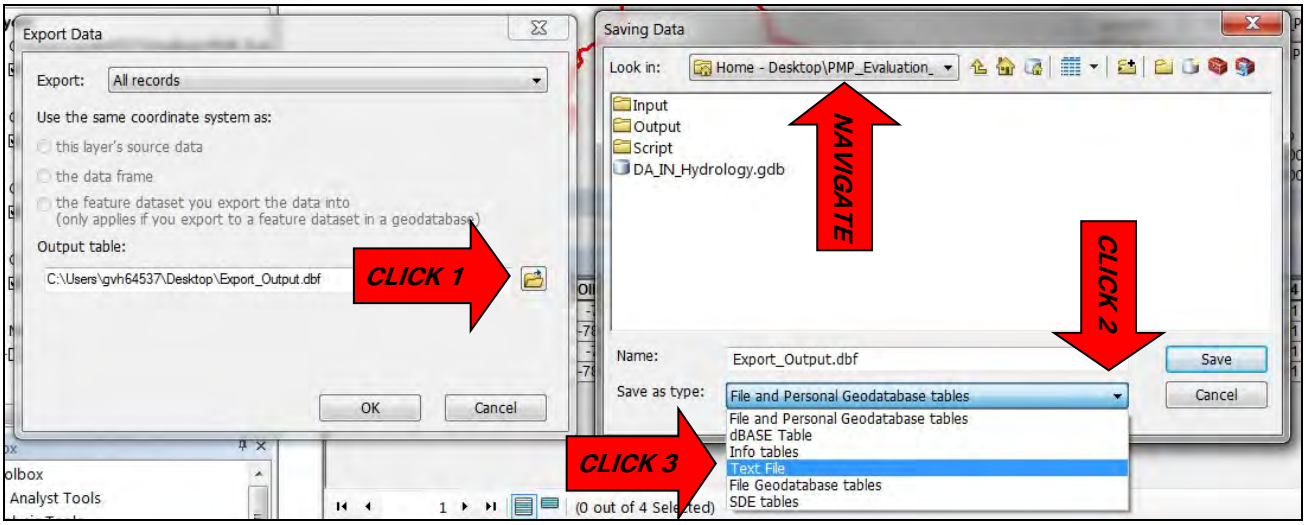


OBJECTID *	Shape *	Id	POINT_X	POINT_Y	ELEV_FT	ZONE	PMP_06	PMP_12	PMP_24	STORM_06	STORM_12	STORM_24
1	Point	117	-78.25	37.475	362.252	6	15.9	18.4	20	SPAS_1339	SPAS_1339	SPAS_1201
2	Point	117	-78.225	37.475	409.259	6	15.9	18.4	20	SPAS_1339	SPAS_1339	SPAS_1201
3	Point	119	-78.25	37.5	432.644	6	15.8	18.3	20	SPAS_1339	SPAS_1339	SPAS_1201
4	Point	119	-78.225	37.5	425.288	6	15.8	18.3	20	SPAS_1339	SPAS_1339	SPAS_1201

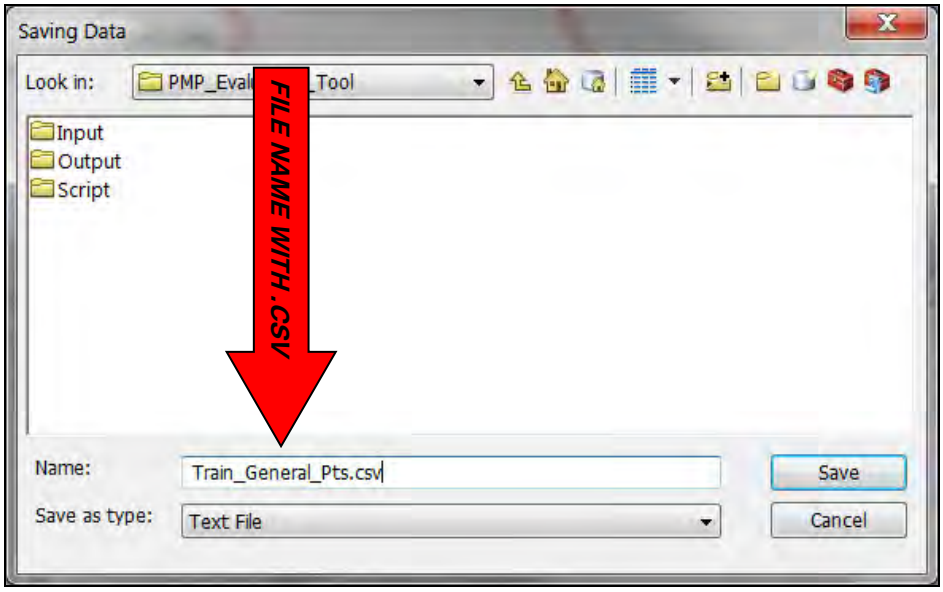
41. We will now export the data out of the Attribute Table into Excel file format for use with the previously saved **Virginia PMP 2015 Watershed Calculation Spreadsheet (Excel)** (see **Step 8**). In the open **Attribute Table**, **Click** on the **Attribute Table Icon** (pull down icon on left of table directly below the Table label) and navigate to the **Export** option (second from the bottom of the pull down menu). **Click** on the Export option. See graphic below.



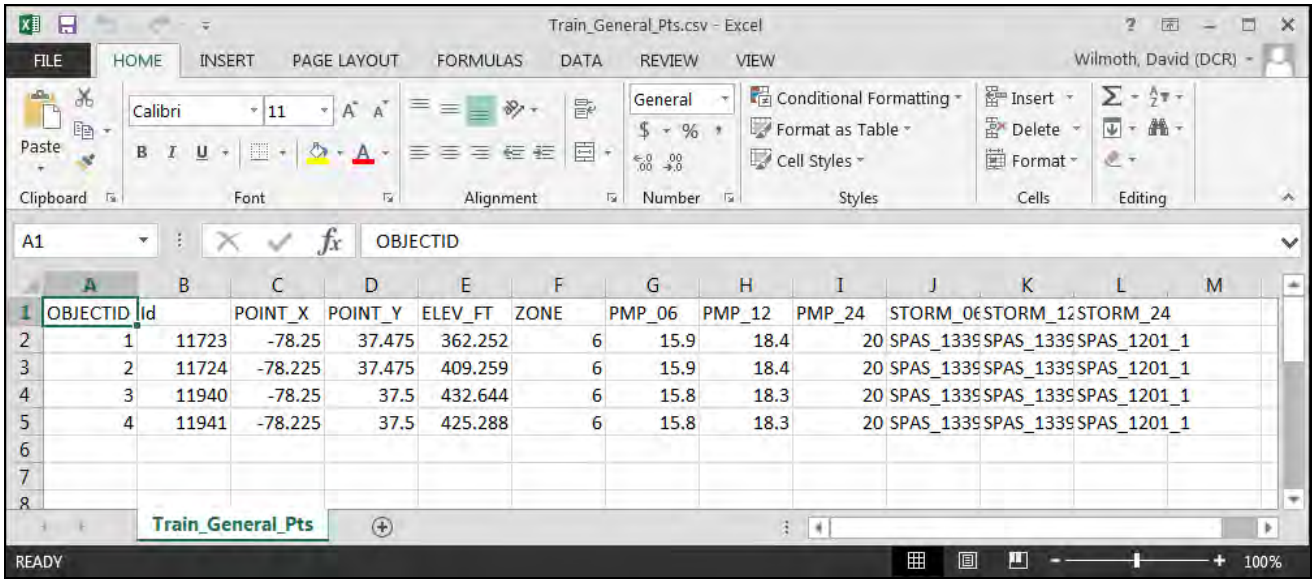
42. Once selected, an **Export Data** pop-up box will open allowing the user to save the exported data from the Attribute Table to a chosen location. **Click** on the **open folder** icon in the **Export Data** pop-up box. An additional pop-up box should open named **Saving Data** which will allow the user to navigate to a location to save said data. The data can be saved in multiple file formats in the **Save as type** field. **Click** the pull down arrow on the field and **choose Text File** as the file type. See graphic below.



43. After selecting the **Text File** as the file type for the exported data, **rename** the export file to a name of your choice with an extension of **.csv** (excel file format). Note that the dot at the beginning of the **.csv** is very important. For the purposes of this training document, we will be naming the file **Train_General_Pts.csv** and saving the file within the PMP_Evaluation_Tool folder on the desktop. See graphic below.



44. Once you navigated to the save location of your choice and have renamed your file with the **.csv** file extension, **click save**. **Ensure** the **file address** in the **Export Data** pop-up box is correct with the **.csv** extension. Once checked, **click Ok**. An ArcMap **caution box** will open after selecting Ok asking the user if they want to add the new table to the current work map. **Click No**. **Navigate** to the saved location for the exported data and **open** the excel file. The excel file should look like the graphic below.



OBJECTID	Id	POINT_X	POINT_Y	ELEV_FT	ZONE	PMP_06	PMP_12	PMP_24	STORM_06	STORM_12	STORM_24
1	11723	-78.25	37.475	362.252	6	15.9	18.4	20	SPAS_1339	SPAS_1339	SPAS_1201_1
2	11724	-78.225	37.475	409.259	6	15.9	18.4	20	SPAS_1339	SPAS_1339	SPAS_1201_1
3	11940	-78.25	37.5	432.644	6	15.8	18.3	20	SPAS_1339	SPAS_1339	SPAS_1201_1
4	11941	-78.225	37.5	425.288	6	15.8	18.3	20	SPAS_1339	SPAS_1339	SPAS_1201_1

45. Now we will repeat the same excel table export processes for the **Local** and **Tropical** file point feature classes added into the work map in **Step 38**. **Repeat Steps 39 through 44** for the **Local** file point feature class and for the **Tropical** file point feature class. For the purposes of this training document, the **Local** export table will be renamed to **Train_Local_Pts.csv** and the **Tropical** export table will be renamed to **Train_Tropical_Pts.csv** with both files being saved under the **PMP_Evaluation_Tool** folder located on the desktop. At this time you should have exported data in excel file format for the **General, Local,** and **Tropical** storm event types (three files).

46. Now we will analyze the exported work map Attribute Table data (General, Local, & Tropical) utilizing Excel to determine the controlling 6-hour, 12-hour, and 24-hour rainfall values for the durations chosen for the drainage area in question. **Locate** and **Open** the previously saved **Virginia PMP 2015 Watershed Calculation Spreadsheet (Excel)** as discussed in **Step 8**. The excel file should look like the graphic below.

Virginia 2015 PMP Calculation Worksheet

Project: X Dam Failure Analysis — Date:

Agency

Engineer:

Drainage Area to Dam — User Defined Variable

Information obtained from GIS Shapefile / Watershed Boundary Analysis

Drainage Area	1454.16 Acres	2.271 Sq. Miles

DRAINAGE AREA UTILIZED

General Storm Events

GENERAL STORM EVENT

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-78.25	37.475	6	15.9	18.4	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
2	-78.225	37.475	6	15.9	18.4	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
3	-78.25	37.5	6	15.8	18.3	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
4	-78.225	37.5	6	15.8	18.3	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
		Average PMP Values:		15.9	18.3	20.0			

Local Storm Events

LOCAL STORM EVENT

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-78.25	37.475	6	27.6	31.5	31.5	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
2	-78.225	37.475	6	27.6	31.5	31.5	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
3	-78.25	37.5	6	27.6	31.4	31.4	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
4	-78.225	37.5	6	27.6	31.4	31.4	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
		Average PMP Values:		27.6	31.4	31.4			

Tropical Storm Events

TROPICAL STORM EVENT

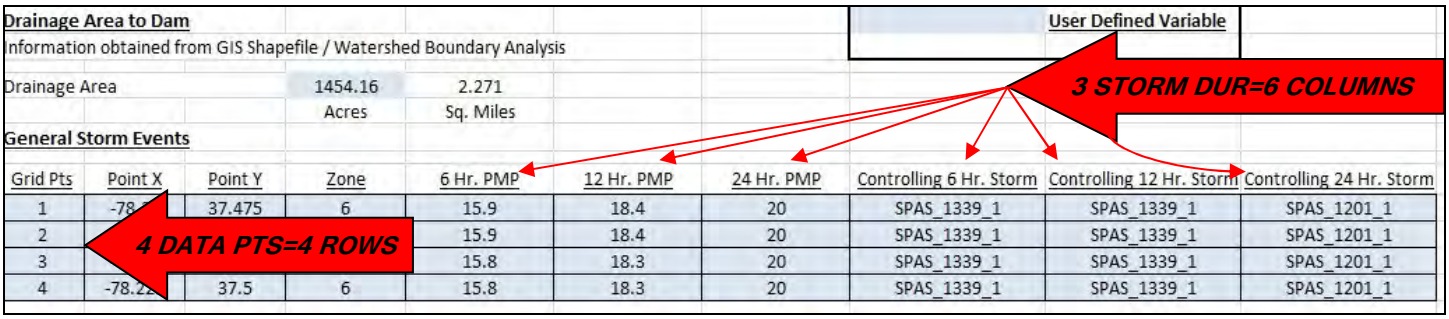
Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-78.25	37.475	6	19.3	29.5	29.5	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
2	-78.225	37.475	6	19.3	29.5	29.5	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
3	-78.25	37.5	6	19.2	29.4	29.4	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
4	-78.225	37.5	6	19.2	29.4	29.4	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
		Average PMP Values:		19.3	29.4	29.4			

Controlling PMP Values from Storm Events

	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP
Controlling PMP Values for Watershed	**27.6**	**31.4**	**31.4**

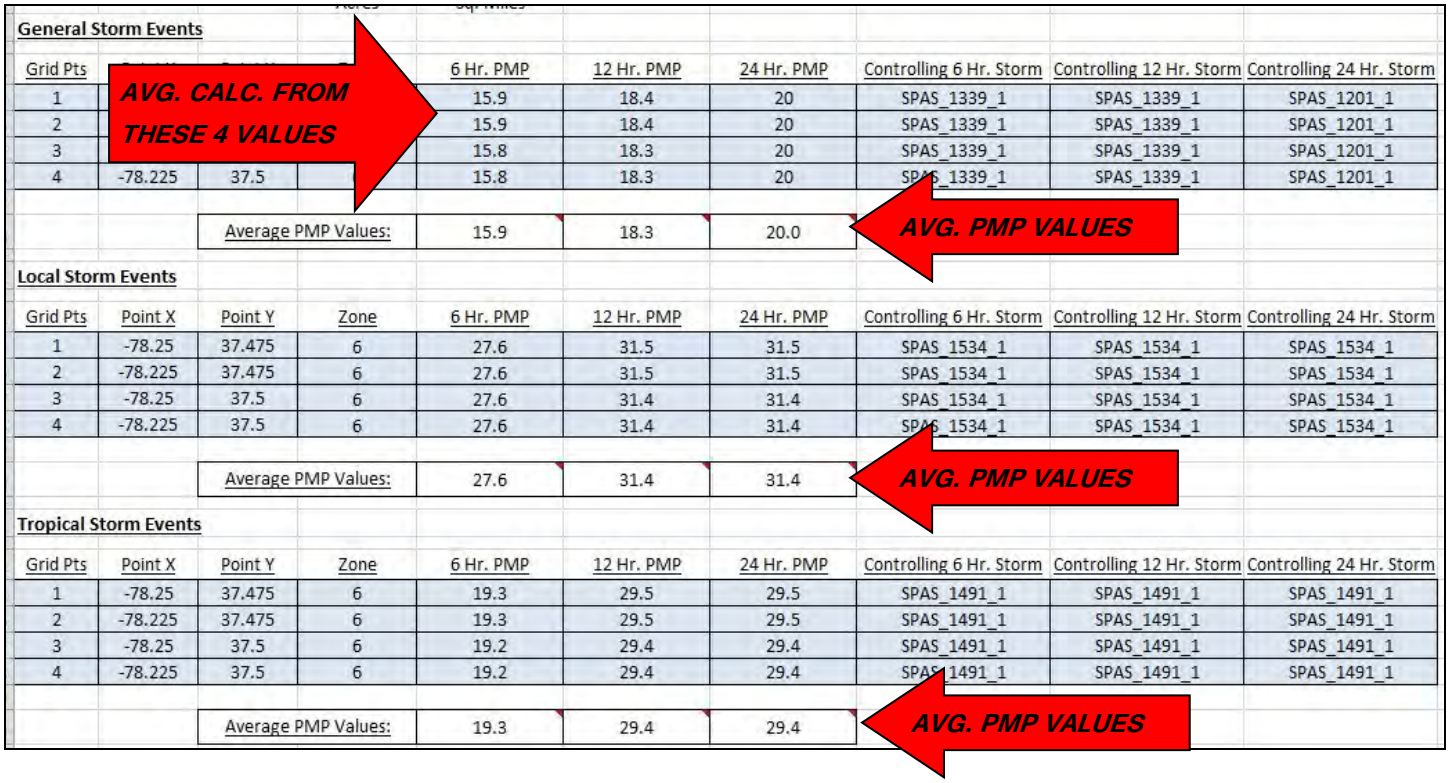
CONTROLLING PMP VALUES

47. Utilizing the three excel files from **Step 45**, copy and paste the appropriate data into the appropriate locations in the **Virginia PMP 2015 Watershed Calculation Spreadsheet (Excel) (**VA PMP Worksheet). As stated in the VA PMP worksheet, the cells shaded with light blue define areas where the user must populate the fields. The VA PMP Worksheet is provided with default data already in the required user defined cells by default. The user will need to adjust said values and the number of rows / columns to adhere to the number of points in the drainage area in question (rows) and the number of storm durations chosen from the **Basin PMP Evaluation Tool** (columns). For the purpose of this training document, the drainage area in question utilized four data points (four rows under each storm event type) and three storm durations (6-hour, 12-hour, and 24-hour rainfall / controlling storm data (six columns under each storm event type). In addition for the purposes of this training document, the default information presented in VA PMP Worksheet matches the information from the three excel files generated in **Step 45**. See graphic below.



48. Utilizing the VA PMP Worksheet we will determine the controlling 6-hour, 12-hour, and 24-hour rainfall values for the watershed in question. After adding the appropriate data into the appropriate locations as discussed in **Step 47**, the VA PMP Worksheet has been set up to aide in the calculation of the controlling rainfall values. The VA PMP Worksheet follows the following calculation procedures:

    a. Average PMP Values – Utilizing the **General Storm Events** section of the completed VA PMP Worksheet as an example, we have four data points in the analyzed drainage area resulting in four rows of storm data (larger drainage area would result in more data points which would ultimately result in more rows). Each data point provides a storm rainfall for the durations chosen as well as the controlling storm event from which the data was extracted. In order to determine the overall average PMP rainfall value across the drainage area for each storm duration for the General Storm Type, an **average rainfall** for each storm duration is obtained. For example looking at the **6 Hr. PMP column** in the **General Storm Type** section, there are four rainfall values with the average of those four rainfall values being 15.9 inches. The same average calculation is completed for the 12 Hr. (average 18.3 inches) and 24 Hr. (average 20.0 inches) PMP Values within the General Storm Events section. The same process is then completed for the **Local Storm Events** and **Tropical Storm Events** sections. See graphic below.



General Storm Events

Grid Pts				6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1				15.9	18.4	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
2				15.9	18.4	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
3				15.8	18.3	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
4	-78.225	37.5		15.8	18.3	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
		Average PMP Values:		15.9	18.3	20.0			

Local Storm Events

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-78.25	37.475	6	27.6	31.5	31.5	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
2	-78.225	37.475	6	27.6	31.5	31.5	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
3	-78.25	37.5	6	27.6	31.4	31.4	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
4	-78.225	37.5	6	27.6	31.4	31.4	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
		Average PMP Values:		27.6	31.4	31.4			

Tropical Storm Events

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-78.25	37.475	6	19.3	29.5	29.5	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
2	-78.225	37.475	6	19.3	29.5	29.5	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
3	-78.25	37.5	6	19.2	29.4	29.4	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
4	-78.225	37.5	6	19.2	29.4	29.4	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
		Average PMP Values:		19.3	29.4	29.4			

    b. Controlling Storm Events – As shown in the graphic above, the defined controlling storm event is provided by the **Basin PMP Evaluation Tool** for each data point (row) in each storm event type (General, Local, and Tropical). Additional information for these storms (name, storm type, location, rainfall specifics, etc.) can be found in the Appendices of the Applied Weather Associates' November 2015 Probable Maximum Precipitation Study for Virginia (**Final Report (PDF)** link) on the http://www.dcr.virginia.gov/dam-safety-and-floodplains/pmp-tool sub-webpage under the **PMP Final Report & Appendices** section.

    c. Controlling PMP Values from Storm Events – After determining the average rainfall values per duration for each of the three storm types (General, Local, and Tropical), the user should have three 6-hour rainfall values (one for General, one for Local, and one for Tropical). Analyzing these three values for the 6-hour rainfall, the controlling 6-hour rainfall PMP value would be the **maximum** of these three values. Utilizing information from training document's example, the three 6-hour average rainfall values calculated in the VA PMP Worksheet are 15.9 inches (General), 27.6 inches (Local), and 19.3 inches (Tropical). After evaluating these three values, the **maximum** 6-hour average rainfall value is 27.6 inches which in turn becomes your controlling 6-hour rainfall value. This same process is applied to the three 12-hour and 24-hour values (General, Local, and Tropical). The controlling 12-hour rainfall value should be 31.4 inches and the controlling 24-hour rainfall value should be 31.4 inches. See graphic below.

General Storm Events

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-78.25	37.475	6	15.9	18.4	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
2	-78.225	37.475	6	15.9	18.4	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
3	-78.25	37.5	6	15.8	18.3	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
4	-78.225	37.5	6	15.8	18.3	20	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
		Average PMP Values:		15.9	18.3	20.0			

AVG. PMP VALUES

Local Storm Events

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-78.25	37.475	6	27.6	31.5	31.5	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
2	-78.225	37.475	6	27.6	31.5	31.5	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
3	-78.25	37.5	6	27.6	31.4	31.4	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
4	-78.225	37.5	6	27.6	31.4	31.4	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
		Average PMP Values:		27.6	31.4	31.4			

AVG. PMP VALUES

Tropical Storm Events

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-78.25	37.475	6	19.3	29.5	29.5	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
2	-78.225	37.475	6	19.3	29.5	29.5	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
3	-78.25	37.5	6	19.2	29.4	29.4	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
4	-78.225	37.5	6	19.2	29.4	29.4	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
		Average PMP Values:		19.3	29.4	29.4			

AVG. PMP VALUES

Controlling PMP Values from Storm Events

	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP
Controlling PMP Values for Watershed	**27.6**	**31.4**	**31.4**

CONTROLLING PMP VALUES (MAXIMUM)

d. Why are the rainfall values for 12-Hr. PMP & 24-Hr. PMP the same? - The Virginia Applied Weather Associates' November 2015 Probable Maximum Precipitation Study for Virginia (**Final Report (PDF)** link) was developed utilizing real world data from actual storm events. For this particular case where the 12-hour and 24-hour rainfall values are the same, the controlling PMP storm (producing the largest PMP values which in this case is the SPAS_1534_1 storm (see Local Storm Type Section above)) is no longer accumulating rainfall beyond the given timeframe and no other analyzed storm events produced a greater depth of rainfall. Looking at our example above, the 12-hour event provided a maximum rainfall value of 31.4 inches (Local storm type section) within a 12-hour period. When the program evaluated the 24-hour event utilizing Local storm type within the limits of the analyzed drainage area, there were no other storm events which produced more than 31.4 inches of rainfall over a 24-hour period. In some cases another storm may eventually produce more rainfall as the duration continues to increase, but not within the chosen durations in the example above (24-hour storm was the longest chosen storm duration). There are two options moving forward when a user has a situation where two of the controlling PMP values are the same:

i. Use the data as it is provided. This is the most accurate option based on how the data was developed by Applied Weather Associates.

ii. Add a very minor incremental accumulation if the model requires it. For example, add 0.01 inches per subsequent duration. If you have 30 inches at 12 hours, it would be 30.01 inches at 24 hours, 30.02 inches at 48 hours, and 30.03 inches at 72 hours, etc. As stated earlier this should only be used when the hydrologic model requires it.

e. Values to utilize in the hydrologic modeling moving forward – Moving forward, the user would use the following values from our example to in their hydrologic modeling for the dam failure analysis in question:

i. Controlling 6-Hr. PMP Rainfall Value – 27.6 inches

ii. Controlling 12-Hr. PMP Rainfall Value – 31.4 inches

iii. Controlling 24-Hr. PMP Rainfall Value – 31.4 inches.

49. This concludes our training document. If you have any questions or concerns, please contact:

Regional Dam Safety Engineer
(https://www.dcr.virginia.gov/dam-safety-and-floodplains/dsfpmcontx)
Division of Dam Safety & Floodplain Management
Virginia Department of Conservation & Recreation
600 East Main Street
Richmond, VA 23219

The Division of Dam Safety and Floodplain Management (VA Dam Safety) has provided this training document as a reference tool when utilizing the Virginia Basin PMP Evaluation Tool and should be treated as such. It is the responsibility of the Professional Engineer to understand and utilize the VA Basin PMP Evaluation Tool correctly when completing required calculations. VA Dam Safety takes no legal responsibility or liability for any of the information provided above or additional guidance documents / spreadsheets provided (see Disclaimer at http://www.dcr.virginia.gov/dam-safety-and-floodplains/pmp-tool).