HEC-HMS Lab 5 – Using Frequency Storms in HEC-HMS

Created by Venkatesh Merwade (vmerwade@purdue.edu)

Learning outcomes

The objective of this lab is to learn how HEC-HMS is used to determine "design flow" by using a design storm event. By the end of this exercise, you will:

1) Have some knowledge of terms used in hydrologic design, including return period and storm frequency.
2) How to use design storm data to create Meteorologic file in HEC-HMS

Student Time Required: 60 minutes

Design Rainfall

Most engineering projects are designed to withstand extreme hydrologic events. For example, a bridge is designed to withstand the maximum possible discharge that may happen in the next 50 – 100 years. Until now, you have learned how to get the streamflow hydrograph from HEC-HMS by using a rainfall hyetograph that was observed or recorded for a historic event, but hydrologic design requires the use of design storms. These storms are derived through statistical analysis by using historical data. In simplest terms, to know the maximum rainfall that may occur in the next 100 years, you need to know what happened in the last 100 years, but generally we do not have long data to look at historic events. Therefore, we have to perform some statistical analysis to come up with data needed for hydrologic design. We will look into the statistical analysis part of hydrology later in the semester, but for now lets assume that this statistical analysis has been done to develop design rainfall data for a given area. Most design storms contain information on rainfall intensity (or depth), duration (how long the event will last) and frequency (how often the event will occur). The frequency of a design event is presented by using "return period". If a storm has a return period of 100 years, it means that on average such an event will occur every 100 years over a long time. If we get a 100 year storm this year, it does not mean that we will not get it for next 100 years. Alternatively, a 100 year return period storm has an occurrence chance of 1% (= 1/return period = 1/100) every year. The table below gives design rainfall data for De Kalb County in Indiana. The rainfall duration ranges from five minutes to 24 hours (1440 mins) and the rainfall hyetographs (cumulative) are provided for different return periods. In this exercise, you will create a simple basin model to compute the discharge hydrograph for a 24 hour rainfall event with 10 year return period (event that has a 1/10 percent chance of occurring every year).

Table 1

Rainfall Depths for Various Return Periods						
Depth (inches)						
Duration (mins)	Return Period (years)					
	2	5	10	25	50	100
5	0.39	0.50	0.57	0.66	0.72	0.78
10	0.60	0.77	0.88	1.00	1.09	1.18
15	0.74	0.94	1.08	1.24	1.35	1.47
30	0.99	1.29	1.50	1.75	1.93	2.12
60	1.21	1.62	1.90	2.27	2.54	2.83
120	1.44	1.94	2.28	2.74	3.10	3.48
180	1.53	2.04	2.43	2.94	3.33	3.75
360	1.80	2.40	2.88	3.48	3.96	4.50
720	2.04	2.76	3.24	3.96	4.56	5.04
1440	2.40	3.12	3.84	4.56	5.04	5.76

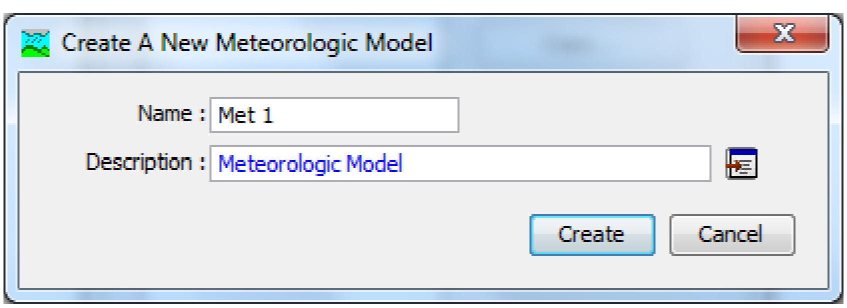
Steps:

1) Create new HEC-HMS project and name it as Lab5 or any other name you would like to give. Save it in a new folder. Use some logical name for this new folder so you do not mix files from multiple labs.
2) Create a basin model to include one sub-basin with the following characteristics:
   - Area = 700 km^2
   - Use SCS method for computing rainfall losses with the following parameters: CN = 70, impervious cover = 0, Initial abstraction = 0
   - Use SCS unit hydrograph for transformation with the lag time as 100 minutes.
   - Use None for all other methods. (No canopy, no surface and no baseflow)

Save you basin model.

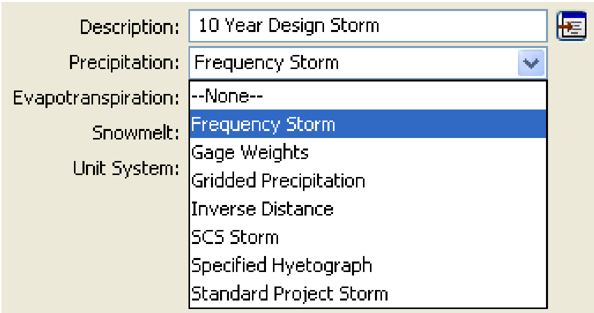
3) Create the Meteorologic Model

To create a Meteorologic model, go to Components→Meterologic Model Manager, and create New. Use the default name and provide some basis description and click Create.

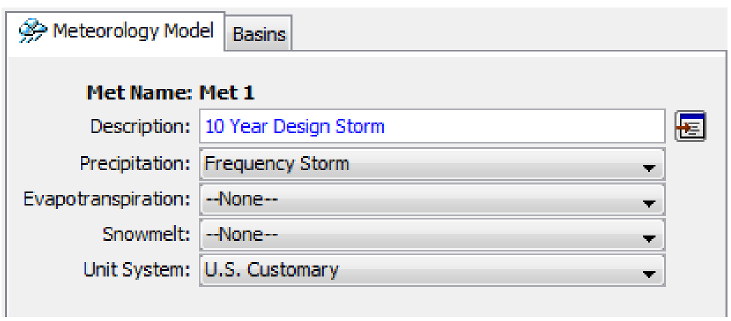


You will see a new folder called Meteorologic Models in the watershed explorer, and if you expand this folder, you will see the Met 1 file that you just created. Under Met 1 label, you will see Specified

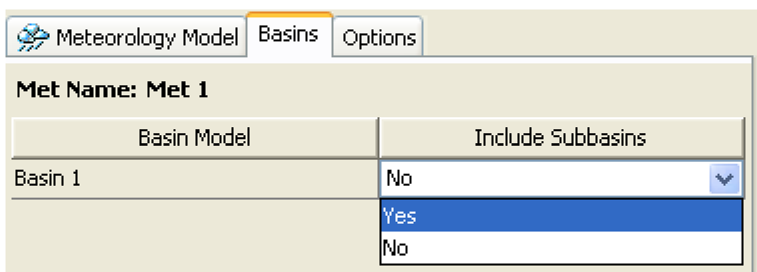
Hyetograph label. Click on Met 1 in the watershed explorer and then change the precipitation type from Specified Hyetograph to Frequency Storm as shown below.



Change the description as per your project needs. This is not that critical. Leave the Evapotranspiration and Snowmelt unchanged as "None**". If your design rainfall input is in mm, choose the Unit System as metric. If the rainfall data is in inches, then select US Customary for Unit System as shown below.** Also make sure Replace Missing is set to default. The data used in this lab is in inches so the Unit System is US customary as shown below.

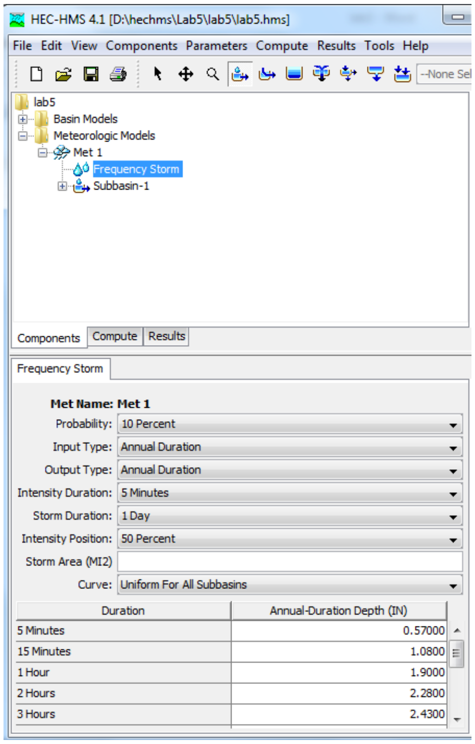


Next, select the Basins tab in the Component editor, and then click Yes on Include sub-basins. This will link rainfall data to your watershed (sub-basin 1).



Once you specify the precipitation type, the next step is to enter the data. To enter the data, you need to expand the *Met 1* model in the watershed explorer and then choose the precipitation type (Frequency Storm) as shown below:

This will prompt a precipitation tab in the component editor. **Fill** in the values **depending on your design storm data given in Table 1**. In this lab, a 10-year design storm is used so the probability is 10% (1/10). If your design rainfall is for 50-year return period, the probability is 2% (1/50) and for 100 year event, the probability is 1% (1/100). Next, the input type is (annual duration), duration of maximum intensity (5 mins), storm duration (one day), and percentage of storm that occurs before the peak intensity (50 %) as shown below:



Save the project. Now we have the watershed description and the input information.

4) Create Control Specification File.

Create a control specification file to run the simulation for three days. It does not matter what time or date you choose. For convenience, use today's date and start time of 00:00 hrs. End the simulation exactly after 36 hours. Use a time step of 10 mins.

5) Run the simulation.

Turn-in

- Hydrograph for the 10-year design storm. Report the peak discharge (in m3/s), time to peak (in hrs) and the base time (in hrs).
- For the area you just modeled using the 10-year storm, the current storm water system is designed to handle 50 year return period design storm. The city council is interested in designing a flow diversion system should the area receive a 100-year return period storm. As an engineer, you are asked to find out what will be the increase in peak flow that needs to be diverted if the area receives a 100 year return period storm. Write a brief report (less than two pages) with your findings to be submitted to the city council. Your report must describe your approach and include simulation results and plots to show your work.