HEC-HMS Tutorial

CE 531 2009 winter

Table of Contents

1.0 General - Using SCS Method

As we have discussed earlier, HEC-HMS is a stand alone program with its own graphical user interface (GUI). All the input files that we created in WMS can be created in HMS itself. But it cannot handle the DEM things for which purpose HEC has developed HEC-GeoHMS. But in this tutorial, we will use some of the data from WMS but enter everything in HMS itself.

We will work again on Clear Creek Tributary data and try to compare the results that we obtained using the WMS interface.

1.1 Project Definition

1. Open HEC-HMS 3.1.0
2. Select File | New, type 'Clear Creek' for the name, add some description if you want to, select the directory to save the project and choose U.S. Customary for units. The click Create.

This will create an empty project and you have to define Basin Model, Meteorologic Model and Control specifications to the Watershed.

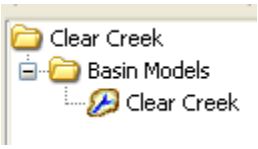
3. Select Tools | Project Options and set the following.
    - Unit system: English customary.
    - Loss: SCS Curve Number
    - Transform: SCS Unit Hydrograph
    - Baseflow: None
    - Routing: Lag
    - Gain Loss: None
    - Precipitation: SCS storm
    - Evapotranspiration: None
    - Snowmelt; None

Select OK.

1.2 Defining Basin Model

When you export HMS file from WMS, you have seen that there is a background map which is represents the watershed and it also shows the location of river. It is in fact just the graphical representation and has nothing to do in HMS computation. You cannot directly have that sketch here in HMS rather you have to import a file that has the coordinates of each of the points of that sketch. Such file is stored as *.map file and WMS exports this file together with HMS file. In this tutorial we will not use the background map. If you are interested you can see the map file in the folder where you have saved your hms file while working with WMS interface.

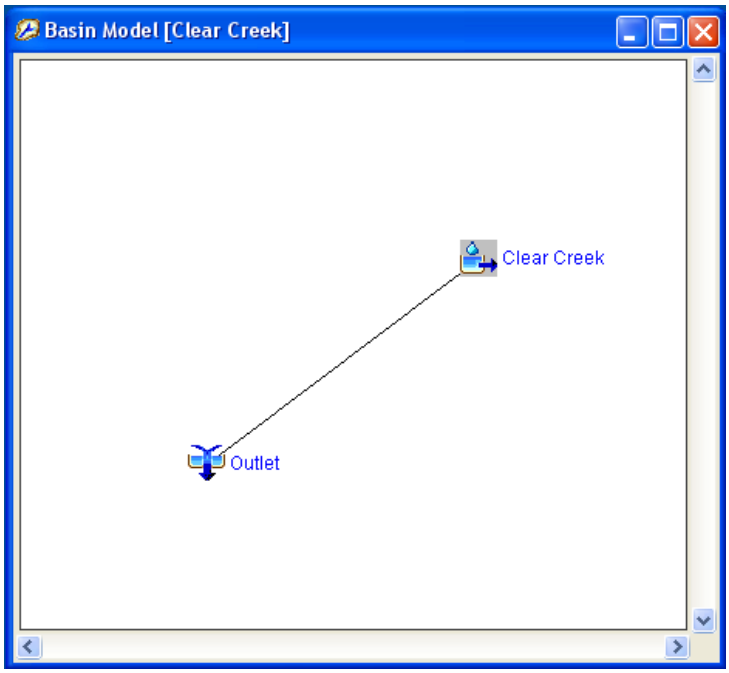
1. Select Components | Basin Model Manager. Click on New and enter 'Clear Creek' for Name. Click on Create and close the Basin Model Manager dialog.



2. Expand Basin Models in the watershed explorer and click on Clear Creek this will open the basin schematic window.

3. Click on Subbasin Creation Tool  and click on the desktop which will prompt you to name. Type Clear Creek for the name and click Create. Similarly click on Junction creation tool  and click on the desktop which will again prompt for the name. Enter Outlet as name and click create. This will add a sub basin and an outlet to the watershed.

The basin and outlet are created but they are not yet associated with each other. So, you need to define that the basin will drain out to the outlet. For this, select Arrow Tool  , right click on the Clear Creek sub basin icon and select Connect Downstream. Then the cursor will change to cross hair (+ sign). Click the Outlet icon which will connect the basin with the outlet and you can see a line connecting the two.



You have created the basin model and now need to enter some of the parameters.

4. Click on Clear Creek Basin icon in the project explorer and on the Component Editor Window, select Subbasin tab. Fill in the following data.
    - Write description if you want.
    - Downstream: Outlet

    It confirms that the component downstream of the sub basin (Clear Creek) is junction (Outlet)

    - Area(MI2): 31.89 sq miles
    - Loss method: SCS Curve Number (should be default as you already defined in the project options).
    - Transform method: SCS Unit Hydrograph (should be default as you already defined in the project options).
    - Baseflow Method: None

5. Now switch to Loss tab and enter the following values:
    - Initial abstraction: 0.00
    - Curve Number: 70
    - Impervious (%): 0.0

6. Switch to Transform Tab and enter 124.104 mins for Lag Time. This value is actually determined in WMS using the SCS Lag time equation. You can compute this value manually too.
7. Leave everything default for Options tab.

1.3 Defining Meteorologic Model

Now you have finished entering all the data for basin Model. Next we will create Meteorologic Model.

1. Select Components | Meteorologic Model Manager. Select New and type Clear Creek for the name and click Create. Close the Meteorologic Model Manager dialog.

You can see Meteorologic Models added to the Watershed Explorer window. Expand Meteorologic Models and click on Clear Creek. The contents on Component Editor will now change.

2. Next click on SCS storm just below Meteorologic Model under Clear Creek in the watershed explorer.
3. In component editor, select Type II for method and enter 1.8 in. for depth.
4. Click on Clear Creek under Meteorologic Models to select it. Then in the object explorer, leave everything the default on Meteorology Model tab. Switch to Basins tab and select YES from the drop down box for 'Include Subbasin" option.
5.  Save your project.

1.4 Defining Control Specification

So far, you have defined your Basin Model and Meteorologic Model. Now, we will be defining control specification for the model.

1. Select Components | Control Specification Manager. Select New, type Clear Creek for the name and click Create. Close the control Specification Manger.
2. Expand Control Specifications from the watershed explorer and click on Clear Creek.
3. Under Control Specifications enter the following data:
    - Description: Type description if you want.
    - Start Date: 23Aug2001 (This should be the format of date).

- Start Time: 00:00
- End Date: 25Aug2001
- End time: 00:00
- Time Interval: 5 mins

Save your project again. The project is now ready to execute. You have defined all the basic components and the parameters associated to them.

1.5 Run the Model

1. Select Compute | Create Simulation Runs. Change the name if you want and click Next. Select Next again to confirm the basin Model, Next again to confirm Meteorologic Model and finally to confirm control specification. Then hit Finish.

In some simulations, you might work with several precipitation events and different control specification for different basins in the same project. This might be the case when you have sub basins and you have different basin, Meteorologic and control models for each sub basin. In that situation, you have to be careful while clicking Next and be sure that proper models are being used.

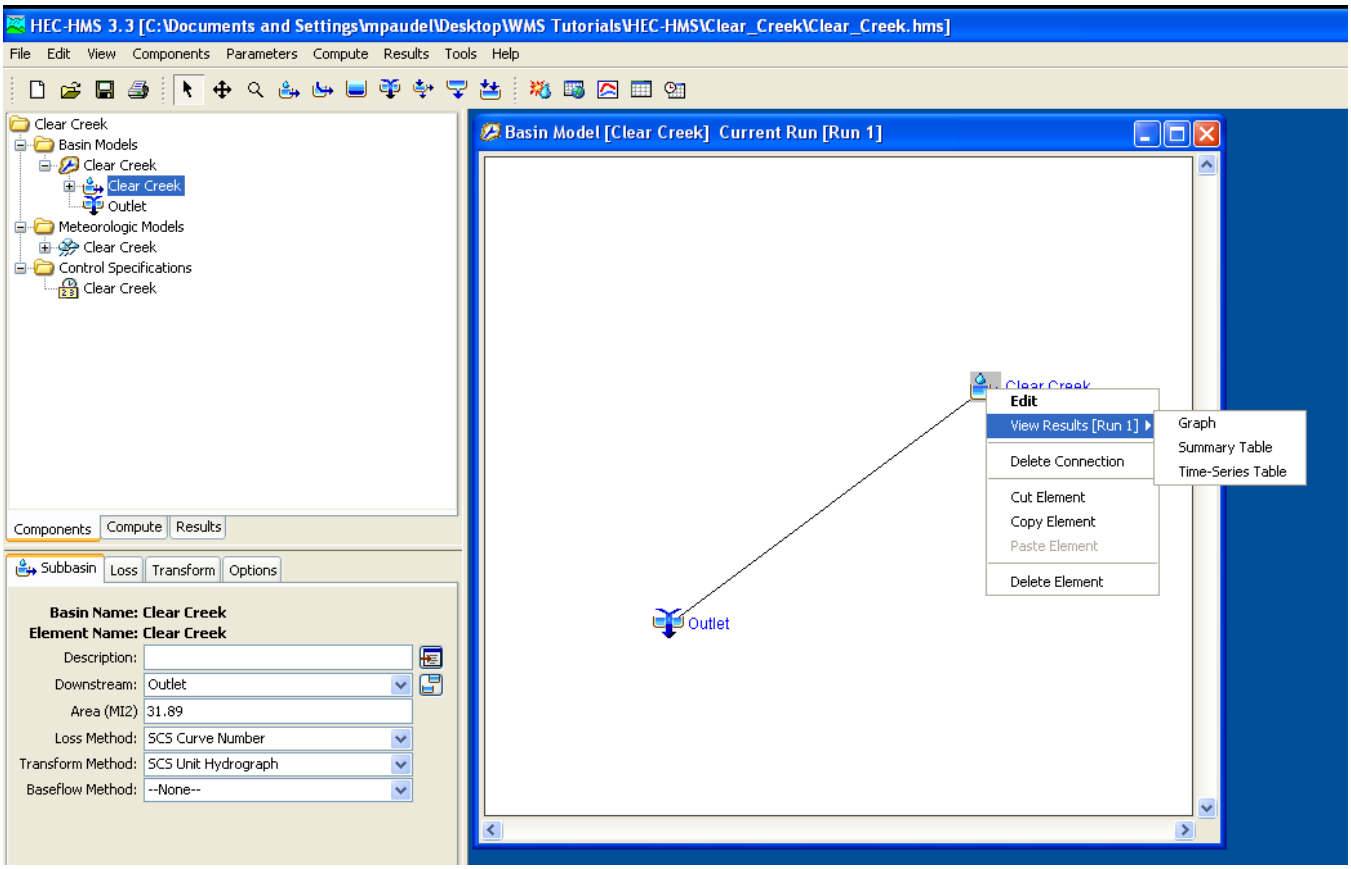
2. Now switch to Compute Tab and expand Clear Creek and Simulation Runs. There you can see Run1 macro 

. Right click Run1 and select Compute. Close the progress indicator window when computation is 100%.

1.6 View the Results

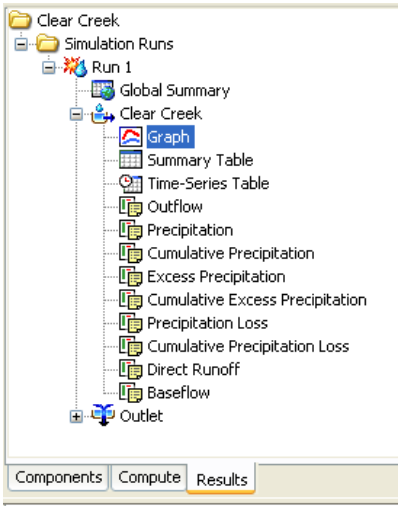
Option 1:

1. Go to Basin schematic by clicking Clear Creek Sub-basin icon under Basin Models in the watershed explorer.
2. Right click respective element and select View Results [Run1]. There you have options to see graph, summary table or time series table. Select desired mode of display. See the following figure.



The View Results option will be faded out when the computation is not done.

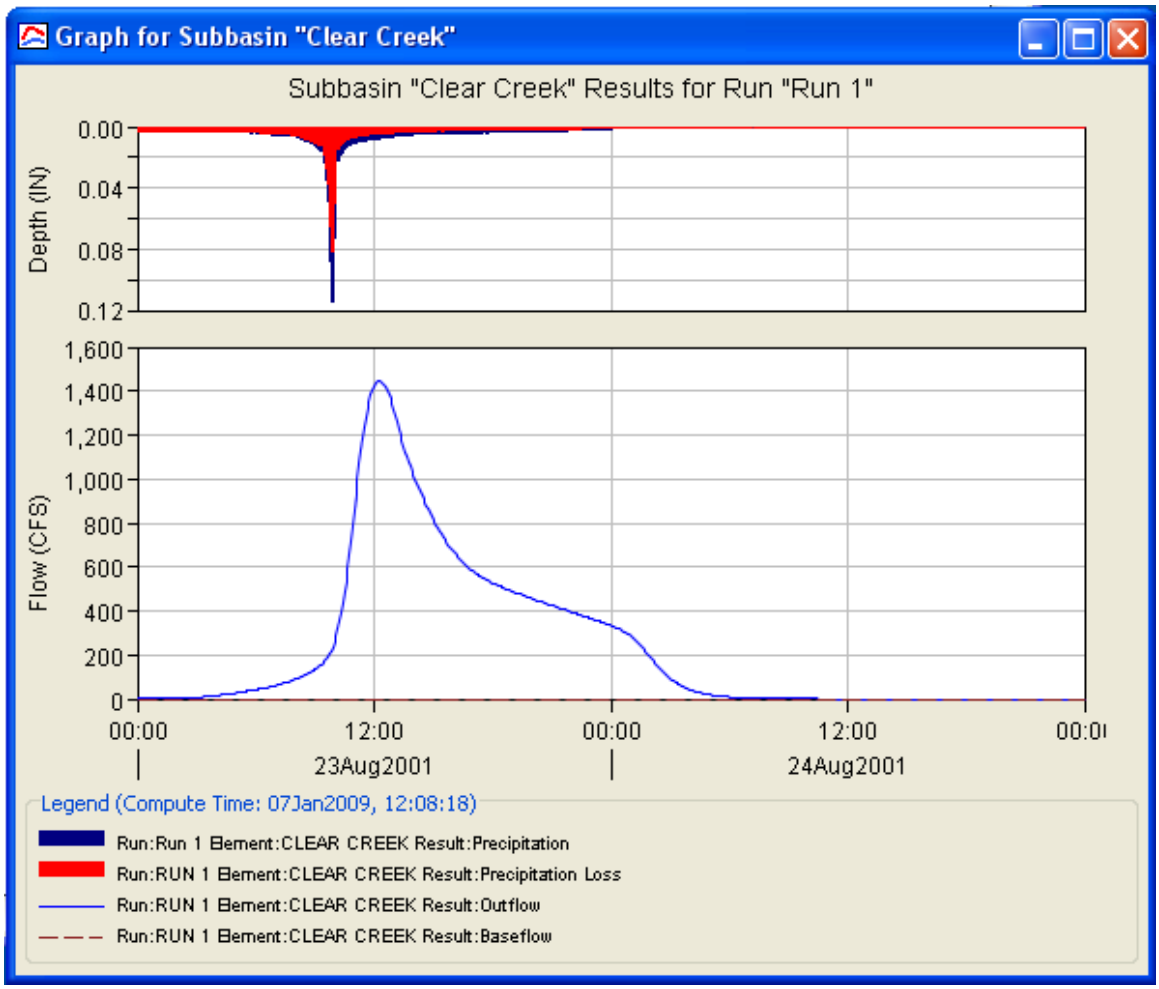
Option 2:



1. Switch to results tab in the watershed explorer window and expand Simulation Runs under Clear Creek. Click on Run1 macro which will expand as shown:

2. Click on the Outlet and you can see different options for displaying the results. To view the time series data, you can click on View Time Series button  at the right side of menu bar.

At this stage, compare the results you got from this simulation with the results you got while using WMS interface.


Graph for Subbasin "Clear Creek"
Subbasin "Clear Creek" Results for Run "Run 1"
Depth (IN)
0.00
0.04
0.08
0.12
Flow (CFS)
1,600
1,400
1,200
1,000
800
600
400
200
0
00:00
12:00
00:00
12:00
00:0
23Aug2001
24Aug2001
Legend (Compute Time: 07Jan2009, 12:08:18)
Run:Run 1 Element:CLEAR CREEK Result:Precipitation
Run:RUN 1 Element:CLEAR CREEK Result:Precipitation Loss
Run:RUN 1 Element:CLEAR CREEK Result:Outflow
Run:RUN 1 Element:CLEAR CREEK Result:Baseflow

2.0 Analyzing Sub-basins and Routing

In this tutorial you will create two sub basins and define routing parameters. We will not use WMS interface but might use some of the values computed in WMS just to avoid hand calculation.

2.1 Project Definition

1. Open HEC-HMS 3.1.0
2. Select File | New, type CCRTribRoute for the name, add some description if you want to, select the directory to save the project and choose U.S. Customary for units. The click Create.

This will create an empty project and you have to define Basin Model, Meteorologic Model and Control specifications to the Watershed.

3. Select Tools | Project Options and set the following.
    - Unit system: English customary.
    - Loss: SCS Curve Number
    - Transform: SCS Unit Hydrograph
    - Baseflow: None
    - Routing: Muskingum Cunge
    - Gain Loss: None
    - Precipitation: SCS storm
    - Evapotranspiration: None
    - Snowmelt; None

Select OK.

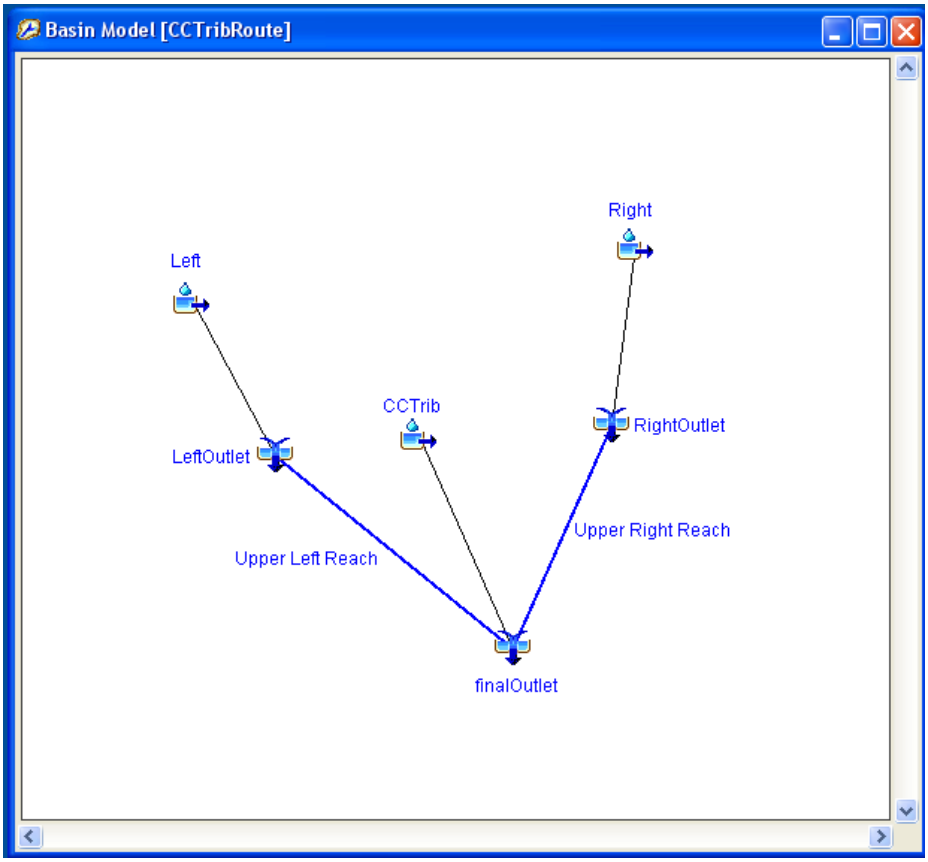
2.2 Defining Basin Model

When you export HMS file from WMS, you have seen that there is a background map which is representing the watershed and it also shows the location of river. It is in fact just the graphical representation and has nothing to do in HMS computation. You cannot directly have that sketch here in HMS rather you have to import a file that has the coordinates of each of the points of that sketch. Such file is stored as *.map file

and WMS exports this file together with HMS file. In this tutorial we will not use the background map. If you are interested you can see the map file in the folder where you have saved your hms file while working with WMS interface.

1. Select Components | Basin Model Manager. Click on New and enter CCTribRoute for Name. Close the Basin Model Manager dialog.
2. Expand Basin Models in the watershed explorer and click on CCTribRoute which will open the basin schematic window.
3. Click on Subbasin Creation Tool  and click on the desktop towards left which will prompt you to name. Type Left for the name and click Create. Click on the desktop towards the right to create another sub basin, enter Right as its name. Similarly, click again on the desktop little below both the sub basins. Enter the name CCTRib for another sub basin.
4. Click on Junction creation tool  and create junction at the most downstream end and enter FinalOutlet for the name, create one on the downstream of Left sub basin and name it LeftOutlet and finally create one on the downstream of Right sub basin and name it RightOutlet.
5. Select Arrow Tool  , right click on each of the sub basins and select Connect Downstream to connect them with the respective outlets. The flow from LeftOutlet and RightOutlet will be routed to FinalOutlet. So, they should be connected by a Routing reach. For this:
6. Select Reach Creation Tool.  and click on the desktop in between RightOutlet and FinalOutlet. Enter Upper Right Reach for the name and click create. This will add a blue colored line with the name you entered just before.
7. Select Arrow Tool, right click the reach and select connect downstream. Then select FinalOutlet as downstream end of the reach. Now click on the right edge of the blue line which will show a blue dot at the tip showing that it is selected. Then drag the right end (end with light blue dot) and drop over RoghtOutlet. This will connect the reach to RightOutlet.

8. Similarly, create another reach for the LeftOutlet and name it Upper Left Reach. Connect its one end to the FinalOutlet and other to the LeftOutlet.
9. Your complete schematic should look some what like this:



You have created the basin model and now need to enter some of the parameters.

2.2.1 Parameters for Left Sub Basin

1. Click on Left Subbasin icon in the project explorer and on Component Editor Window, select Subbasin tab. Fill in the following data.
    - Write description if you want.
    - Downstream: LeftOutlet
    - Area(MI2): 9.13 sq miles
    - Loss method: SCS Curve Number (should be default as you already defined in the project options).
    - Transform method: SCS Unit Hydrograph (should be default as you already defined in the project options).
    - Baseflow Method: None

2. Now switch to Loss tab and enter the following values:
    - Initial abstraction: 0.00
    - Curve Number: 72.48
    - Impervious (%): 0.0
3. Switch to Transform Tab and enter 69.306 mins for Lag Time.
4. Leave everything default for Options tab.

2.2.2 Parameters for Upper Left Reach

1. Click on Upper Left Reach icon on the watershed explorer window and on component editor, switch to Reach tab. Enter the following:
    - Downstream: FinalOutlet
    - Routing Method: Muskingum Cunge (It should be default)
    - Loss/Gain Method: None
2. Switch to routing Tab and enter the following:
    - Length : 22279.706 ft (Determined in WMS)
    - Slope : 0.031970 ft/ft (Determined in WMS)
    - Manning's n: 0.05
    - Shape: Trapezoid
    - Bottom Width: 5 ft
    - Side slope: 1

Leave rest of all the default.

3. Do not change anything on the Options tab

2.2.3 Parameters for Right Sub Basin

1. Click on Right Subbasin icon in the project explorer and on Component Editor Window, select Subbasin tab. Fill in the following data.
    - Write description if you want.
    - Downstream: RightOutlet

    It confirms that the component downstream of Right subbasin is OutletRight.
    - Area(MI2): 14.336 sq miles

- Loss method: SCS Curve Number (should be default as you already defined in the project options).
- Transform method: SCS Unit Hydrograph (should be default as you already defined in the project options).
- Baseflow Method: None

2. Now switch to Loss tab and enter the following values:
    - Initial abstraction: 0.00
    - Curve Number: 70.76
    - Impervious (%): 0.0
3. Switch to Transform Tab and enter 81.3840 mins for Lag Time.
4. Leave everything default for Options tab.

2.2.4 Parameters for Upper Right Reach

4. Click on Upper Right Reach Icon on the watershed explorer window and on component editor switch to Reach tab. Enter the following:
    - Downstream: FinalOutlet
    - Routing Method: Muskingum Cunge (It should be default)
    - Loss/Gain Method: None
5. Switch to Routing Tab and enter the following:
    - Length : 22656.966 ft (Determined in WMS)
    - Slope : 0.038980 ft/ft (Determined in WMS)
    - Manning's n: 0.05
    - Shape: Trapezoid
    - Bottom Width: 5 ft
    - Side slope: 1

Leave rest of all the default.

6. Do not change anything on the Options tab

2.2.5 Parameters for CCTrib Sub Basin

1. Click on CCTrib sub basin icon in the project explorer and on Component Editor Window, select Subbasin tab. Fill in the following data.

- Write description if you want.
- Downstream: FinalOutlet
- Area(MI2): 8.4257 sq miles
- Loss method: SCS Curve Number (should be default as you already defined in the project options).
- Transform method: SCS Unit Hydrograph (should be default as you already defined in the project options).
- Baseflow Method: None

2. Now switch to Loss tab and enter the following values:
    - Initial abstraction: 0.00
    - Curve Number: 71.93
    - Impervious (%): 0.0
3. Switch to Transform Tab and enter 64.1580 mins for Lag Time.
4. Leave everything default for Options tab.
5. Save your project.

You have now defined the basin model. Save your model.

2.3 Defining Meteorologic Model

Now you have finished entering all the data for basin Model. Next we will create Meteorologic Model.

1. Select Components | Meteorologic Model Manager. Select New and type CCTrib for the name and click Create. Close the Meteorologic Model Manager dialog.

You can see Meteorologic Models added to the Watershed Explorer window. Expand Meteorologic Models and click on CCTrib. The contents on Component Editor will now change.

2. Leave everything the default on meteorology Model tab. Switch to Basins tab and select YES from the drop down box for 'Include Subbasin" option.
3. Next click on SCS storm just below Meteorologic Model under CCTrib in the watershed explorer.

4. In component editor, select Type I for method and enter 1.8 in for depth.
5. Save your project.

2.4 Defining Control Specification

So far you have defined your Basin Model and Meteorologic Model. Now, we will be defining control specification for the model.

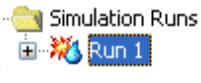
4. Select Components | Control Specification Manager. Select New, type CCTrib for the name and click Create. Close the control Specification Manger.
5. Expand Control Specifications from the watershed explorer and click on CCTrib.
6. Under Control Specifications enter the following data:
    - Description: Type description if you want.
    - Start Date: 23Aug2001 (This should be the format of date).
    - Start Time: 00:00
    - End Date: 24Aug2001
    - End time: 08:00
    - Time Interval: 5 mins

Save your project again. The project is now ready for run. You have defined all the basic components and the parameters associated to them.

2.5 Run the Model

1. Select compute | Create Simulation Runs. Change the name if you want and click Next. Select Next again to confirm the basin Model, Next again to confirm Meteorologic Model and finally to confirm control specification. Then hit Finish.

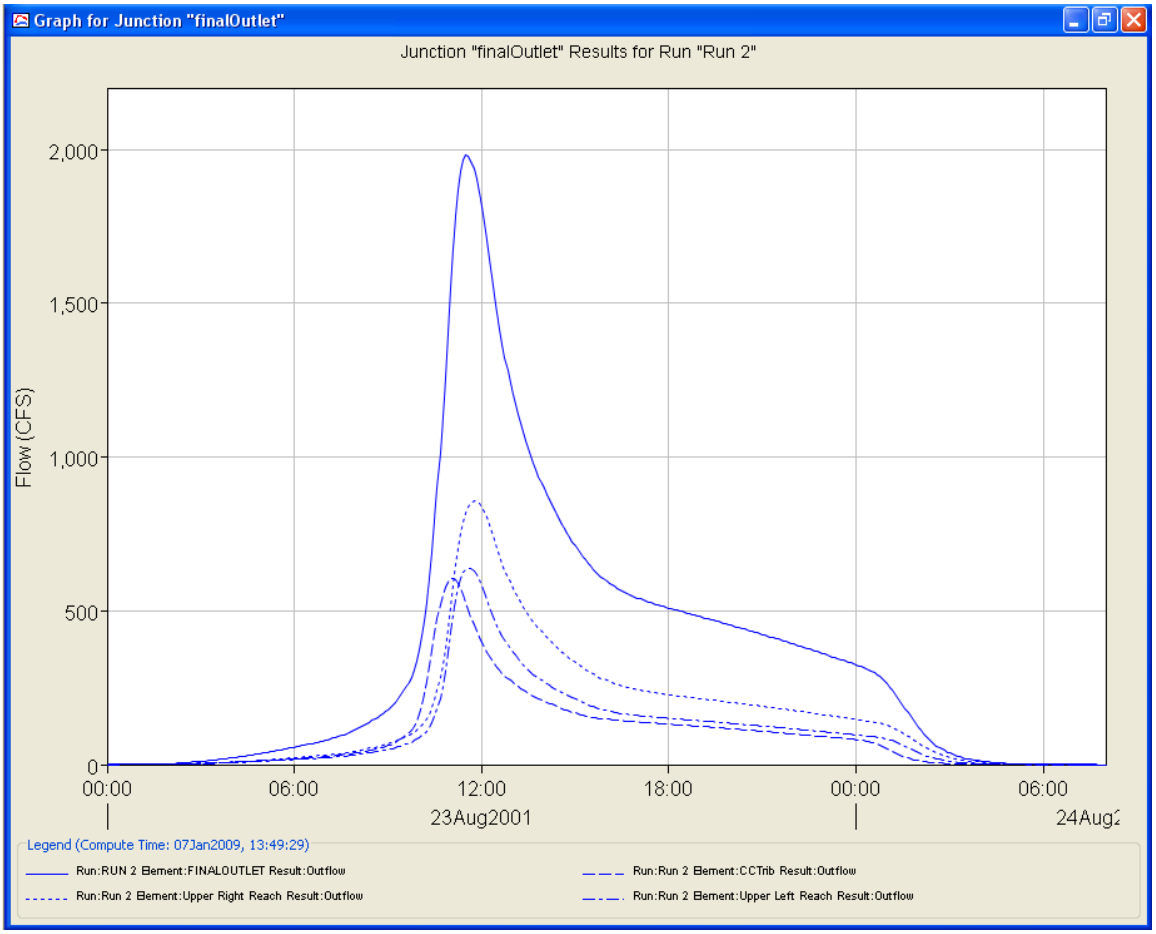
In some simulations, you might work with several precipitation events and different control specification for different basins in the same project. This might be the case when you have sub basins and you have different basin, Meteorologic and control models for each sub basin. In that situation, you have to be careful while clicking Next and be sure that proper models are being used.

2. Now switch to Compute Tab and expand CCTrib and Simulation Runs. There you can see Run1 macro 

. Right click Run1 and select Compute. Close the progress indicator window when computation is 100%.

2.6 View the Results

Repeat the process discussed in section 1.6 to view the results. The final hydrograph will look something like this:

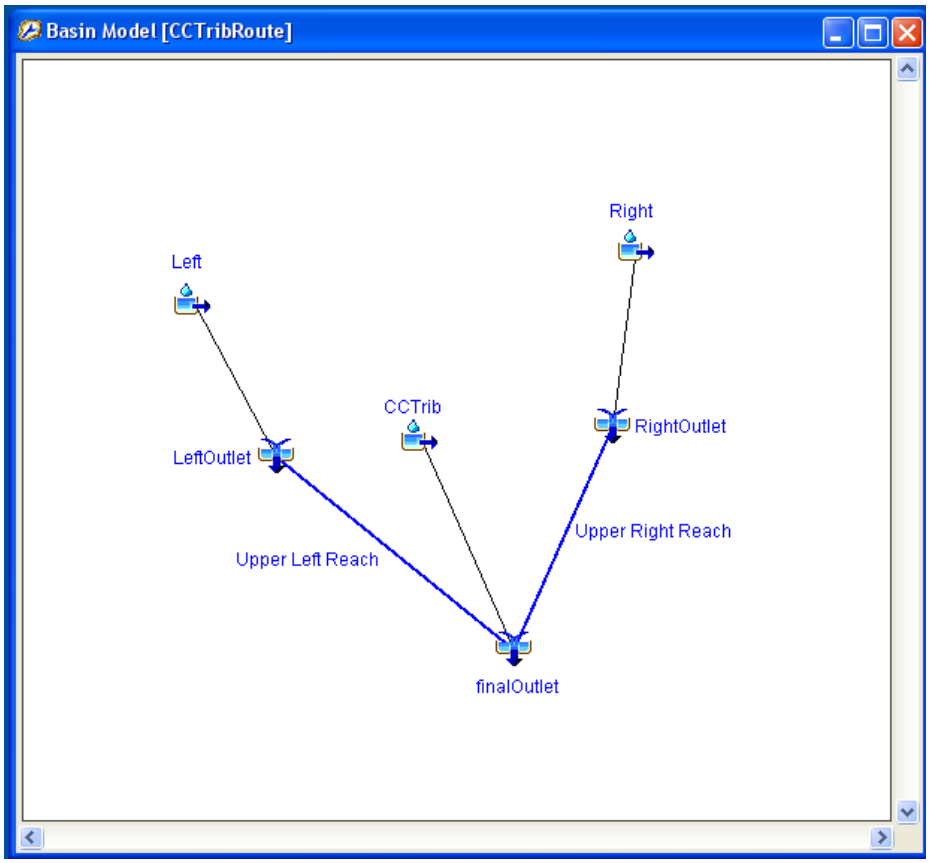


3.0 Reservoir Routing

In this tutorial we are going to add a reservoir at the location where we had LeftOutlet junction (Refer to tutorial chapter 2.0). We will open the project developed in previous exercise, create a copy of it and edit it to add a reservoir.

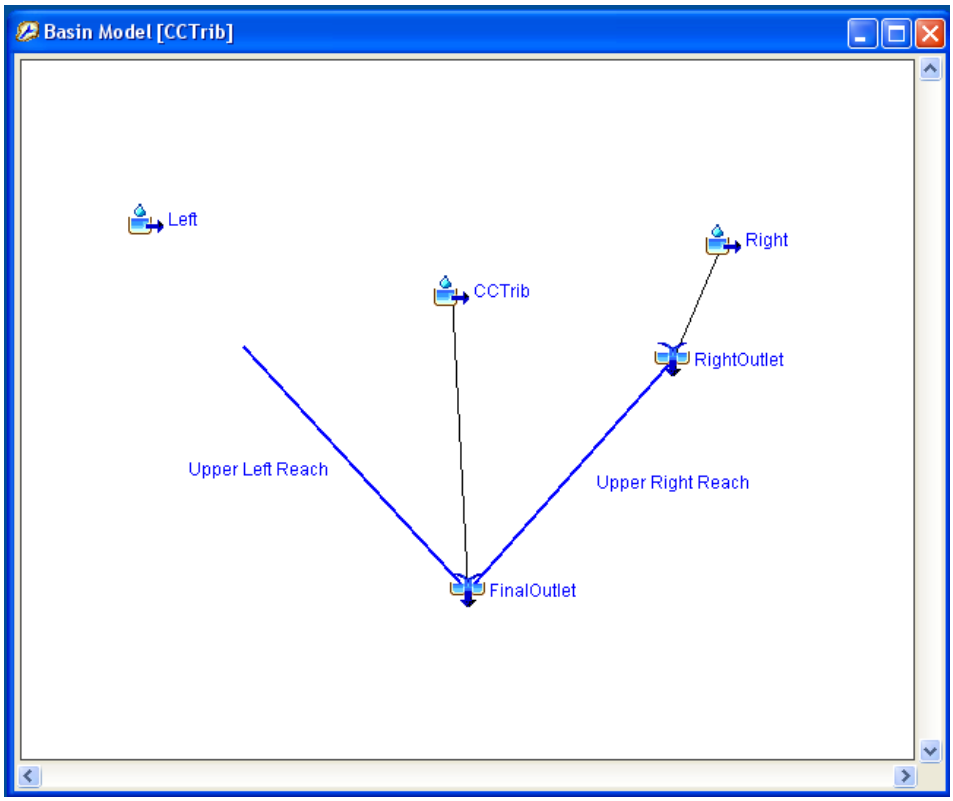
3.1 Project Definition

1. Copy your previous project in a new location using windows explorer.
2. Open HEC-HMS 3.1.0
3. Select File | Open. Browse and open the project saved in the previous exercise (CCRTribRoute) which should have a schematic like this:

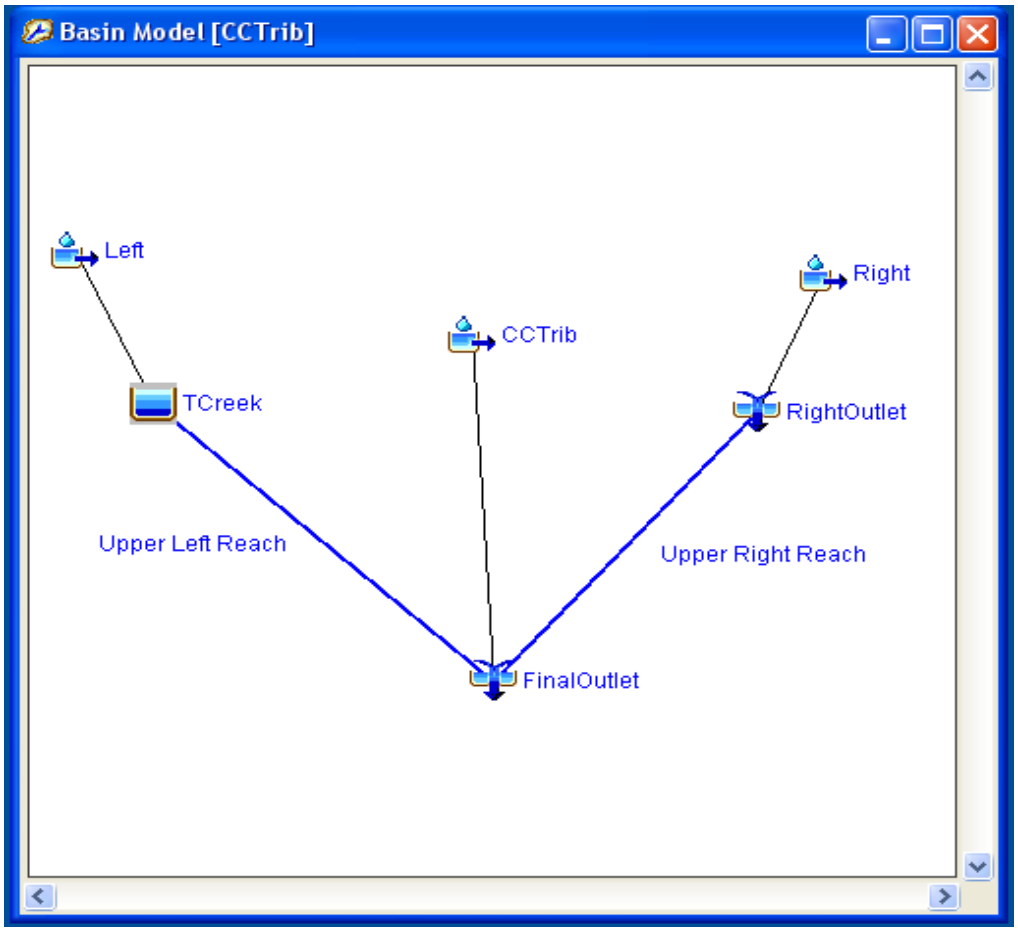


Here, you will be replacing the LeftOutlet with a reservoir.

4. Right click the LeftOutlet icon and select Cut Element. Select Yes to confirm deletion. The basin schematic will look like this:



5. Click on Reservoir Creation Tool  and click on the desktop, downstream of Left sub basin and enter TCreek as the name and click Create.
6. Select Arrow Tool  , right click on the Left sub basin icon and select Connect Downstream. Then the cursor will change to cross hair (+ sign). Click the Reservoir icon which will connect the Left sub basin with the reservoir.
7. Select Arrow Tool  , click on Upper Left Reach to select it. Again click on the upper tip of the reach (blue line) which will show a blue dot at the tip. Click on that end (end with light blue dot) and drop over the reservoir (TCreek). This will connect the reach to the reservoir.
8. The basin schematic will be as shown below:



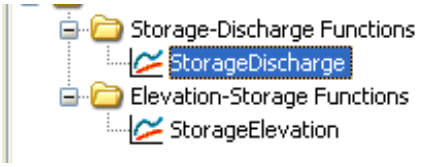
Next step is to define the parameters for the reservoir

3.2 Parameters for Reservoir

1. Click the Reservoir icon on Watershed explorer. Then on component editor window, select Reservoir tab and fill in the following values:
    - Downstream: Upper Left Reach
    - Method: Outflow Curve
    - Storage Method: Elevation-Storage-Discharge
    - Primary: Storage-Discharge
    - Initial Condition: Elevation
    - Initial elevation: 6818 ft

3.3 Defining Storage-Elevation-Discharge data for the reservoir

1. Select Components | Paired Data Manager and select Storage-Discharge Functions for Data Type.
2. Click New and type StorageDischarge for the name and click Create.
3. Change the data type to Elevation-Storage Functions and click on New. Enter StorageElevation for name and click Create. Close the Paired Data Manager dialog.
4. Now on the Watershed Explorer window expand Paired Data where you can see Storage-Discharge functions and Storage-Elevation functions. Expand both of them.
5. Click on StorageDischarge as shown in the figure which will show bring the edit option for Storage-Discharge curve.

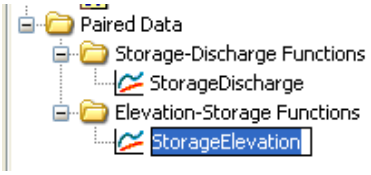


6. In paired Data Tab, change Data source to Manual Entry and Units to AC-FT: CFS (should be default).
7. In Table tab, fill in the following values. The table will expand itself while you enter the data.

Storage (AC-FT)	Discharge (CFS)
0	0
200	0
410	0
650	0
999.99	639.99
1000	640
1540	7000

You can see this data plotted on the Graph tab.

8. Click on StorageElevation on watershed explorer. In Paired Data tab, select Manual Entry for Data source and FT: AC-FT for Units (should be default).



9. Switch to Table tab and fill the following values.

Elevation (FT)	Storage (AC-FT)
6803	0
6808	200
6813	410
6818	650
6821.99	999.99
6822	1000
6825	1540

You entered the storage-elevation-discharge function for the reservoir but it is not yet defined to be used for the reservoir routing. To do this, follow these steps.

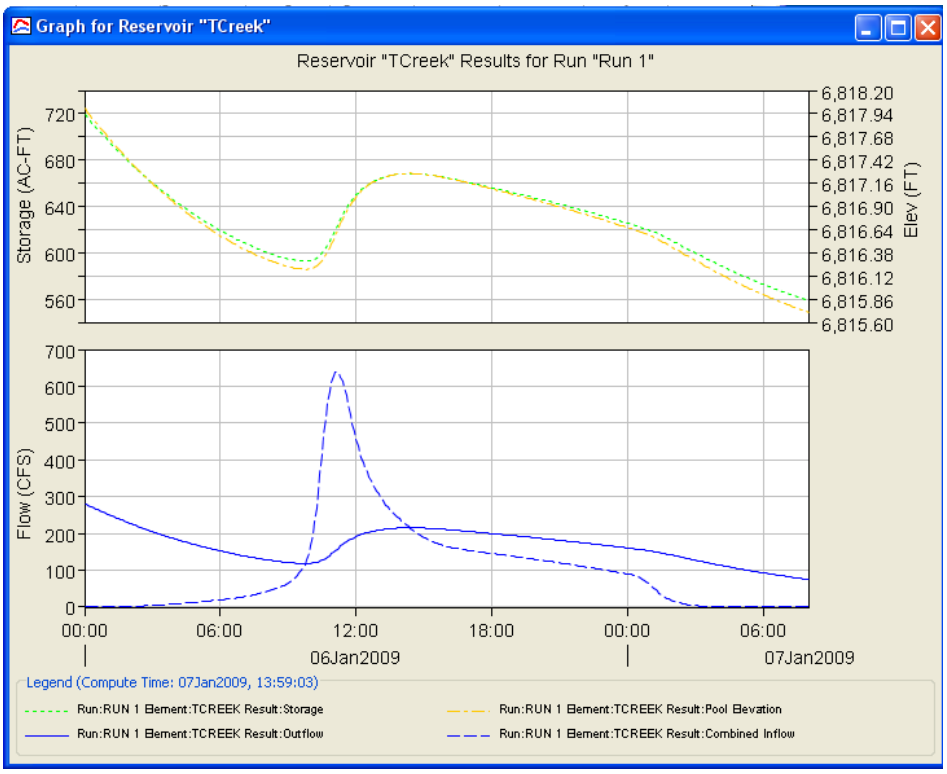
10. Click the reservoir icon on the Watershed explorer. Under Reservoir tab, select the following:
    - Stor-Dis function: StorageDischarge
    - Elev-Stor Function: StorageElevation

All other values were already defined; just make sure that all the values are entered right.

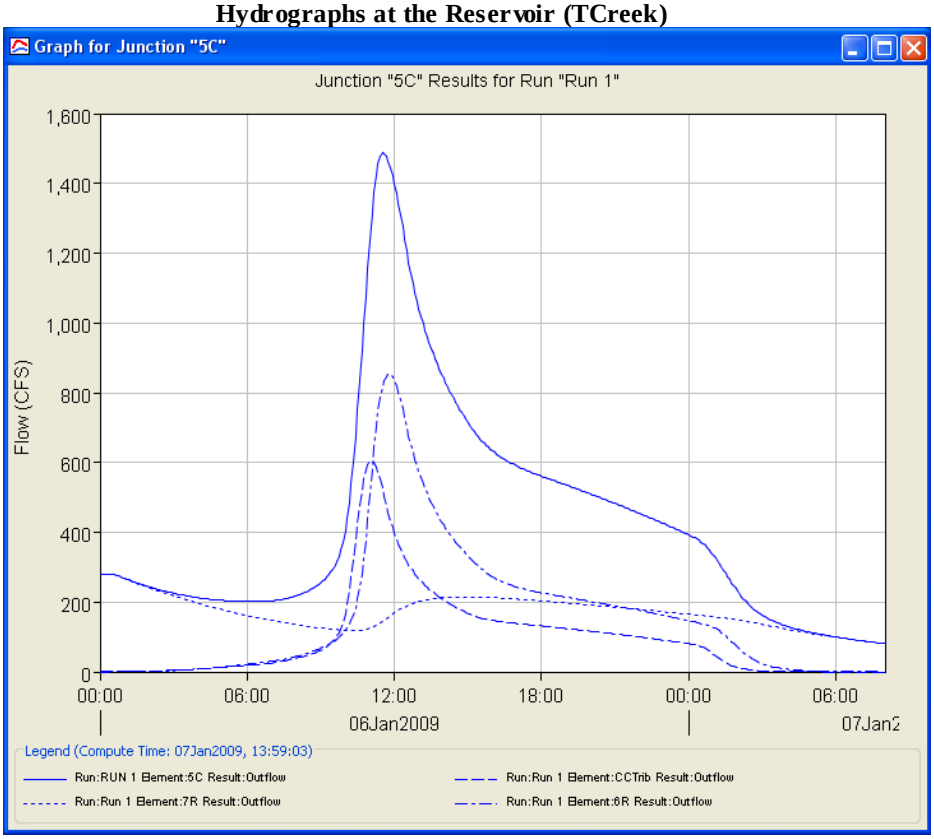
Save your project again. The project is now ready for run. You have defined all the basic components and the parameters associated to them.

3.4 Run the Model

1. Select compute | Create Simulation Runs. Change the name if you want and click Next. Select Next again to confirm the basin Model, Next again to confirm Meteorologic Model and finally to confirm control specification. Then hit Finish.
2. Run the model and view results.



Hydrographs at the Reservoir (TCreek)



Hydrograph at the FinalOutlet