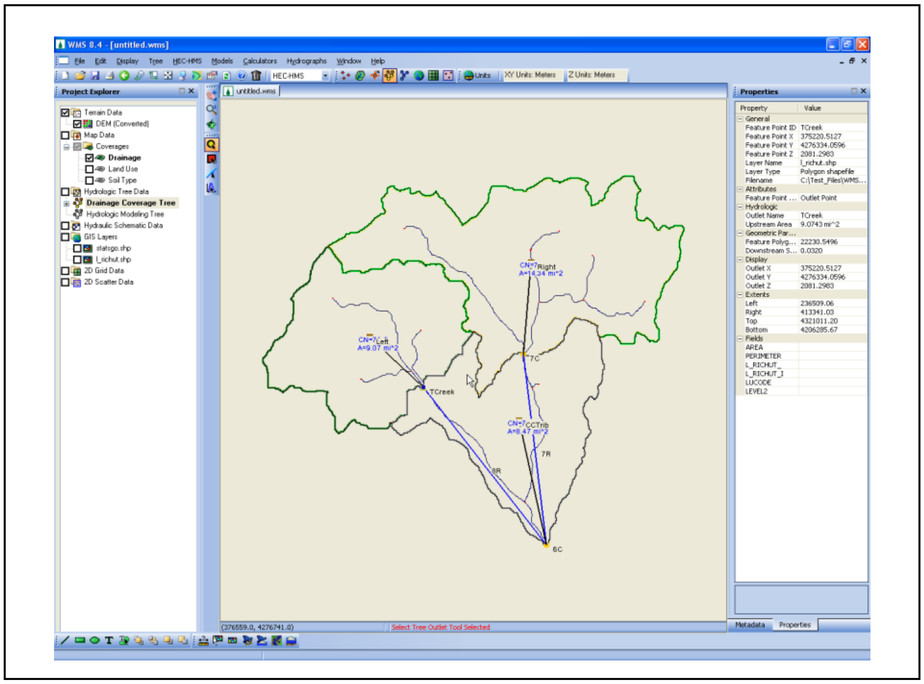
v. 10.1

WMS 10.1 Tutorial

Watershed Modeling – HEC-HMS Interface

Learn how to set up a basic HEC-HMS model using WMS



Objectives

Build a basic HEC-HMS model from scratch using a DEM, land use, and soil data. Compute the geometric and hydrologic parameters required to run the HEC-HMS model. Divide a single watershed into multiple sub-basins, and define reach and reservoir routing between sub-basins.

Prerequisite Tutorials

- Watershed Modeling – DEM Delineation

Required Components

- Data
- Drainage
- Map
- Hydrology
- Hydrologic Models

Time

- 30–60 minutes

1 Introduction

WMS includes a graphical interface to HEC-HMS. This tutorial is similar to the “Watershed Modeling - HEC-1 Interface” tutorial. Geometric attributes such as areas, lengths, and slopes are computed automatically from the digital watershed. Parameters such as loss rates, base flow, unit hydrograph method, and routing data are entered through a series of interactive dialog boxes. Once the parameters needed to define an HMS model have been entered, an input file with the proper format for HMS can be created automatically.

Since only parts of the HMS input file are defined in this tutorial, feel free to explore the different available options of each dialog, being sure to select the given method and values before exiting the dialog. Unlike HEC-1, it is necessary to export the HMS files from WMS and then run the HMS graphical user interface to view the results. In order to do this, have the most recent version of HMS installed.[1]

Open a file with a watershed delineated from a DEM. Then develop a simple, single basin model using the delineated watershed to derive many of the parameters. Land use and soil shapefiles (downloaded from the Internet) will be used to develop a SCS curve number (CN) value. After establishing the initial HMS model, other variations will be developed, including defining multiple basins with reach routing and including a reservoir with storage routing.

[1] The most recent version of HEC-HMS is available on the U.S. Army Corps of Engineers Hydrologic Engineering Center website: http://www.hec.usace.army.mil/software/hec-hms/downloads.aspx.

2 Getting Started

Starting WMS new at the beginning of each tutorial is recommended. This resets the data, display options, and other WMS settings to their defaults. To do this:

1. If necessary, launch WMS.
2. If WMS is already running, press *Ctrl-N* or select *File* | **New…** to ensure that the program settings are restored to their default state.
3. A dialog may appear asking to save changes. Click **No** to clear all data.

The graphics window of WMS should refresh to show an empty space.

3 Single Basin Analysis

The first simulation will be defined for a single basin. It's necessary to enter the global—or Job Control—parameters, as well as basin and meteorological data.

3.1 Setting up the Job Control

Most of the parameters required for a HEC-HMS model are defined for basins, outlets, and reaches. However, there are some "global" parameters that control the overall simulation and are not specific to any basin or reach in the model. These parameters are defined in the WMS interface using the Job Control dialog.

1. Select *File* **| Open…** to bring up the *Open* dialog.
2. Select "WMS XMDF Project File (*.wms)" from the *Files of type* drop-down.
3. Browse to the *hec-1\hec-1* directory and select "hec-1_SingleWatershed.wms".
4. Click **Open** to import the project file and close the *Open* dialog.

The project in the Main Graphics Window should appear similar to Figure 1.

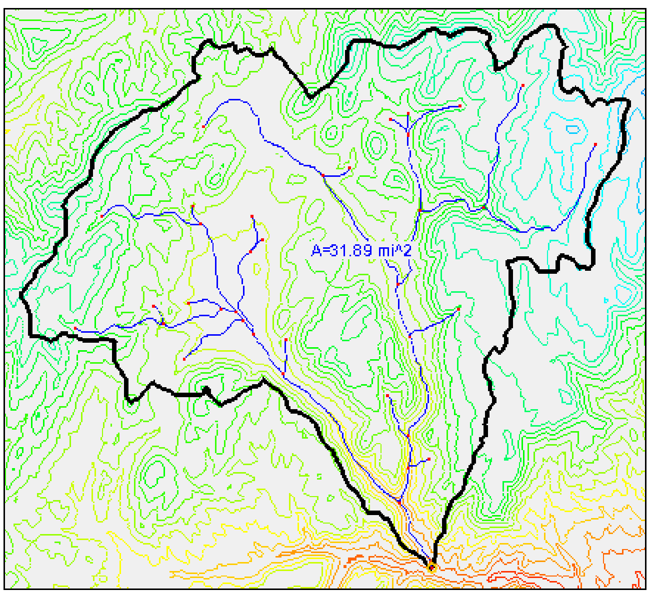


Figure 1 The drainage basin used in this tutorial

5. Turn off "GIS Data" in the Project Explorer.
6. Switch to the **Hydrologic Modeling** module.
7. Select "HEC-HMS" from the Model selection drop-down (Figure 2).

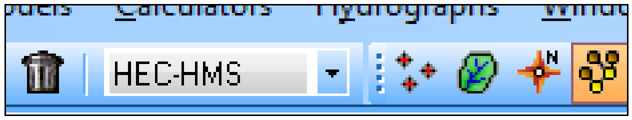


Figure 2 HEC-HMS selected in Model drop-down

8. Select *HEC-HMS* | **Job Control…** to bring up the *HMS Job Control* dialog.
9. In the *Control Specifications* section of the *Control Options* tab, enter "Clear Creek Tributary" as the *Name*.
10. In the *Description* field, enter "job1".

By default the simulation is set to run for 24 hours starting from today's date at 15 minute intervals. For this simulation, the settings need to be changed to run it for 25 hours at five minute intervals.

11. Add one hour to the *Ending time* by clicking the small up arrow located just to the right of the field, or by manually changing the hours part of the field.
12. Select "5 Minutes" from the *Time interval* drop-down.
13. In the *Basin Model Options* section of the *Basin Options* tab, enter "Clear Creek Tributary" in the *Name* field.
14. In the *Basin Model Units* section, select *US customary (English)*.

Setting the computation units does not cause any unit conversion to take place. This tells HEC-1 that input units will be provided in English units (sq. miles for area, inches for rain, feet/miles for length) and expect results of computation to be in English units (cfs). If specifying Metric, then ensure that input units are metric (sq. kilometers, mm for rain, meters/kilometers for length) and results will be in metric (cms).

15. In the *Meteorological Model Options* section of the *Meteorological Options* tab, enter "Clear Creek Tributary" in the *Name* field.
16. Click **OK** to close the *HMS Job Control* dialog.

Note that HEC-HMS includes advanced options for long term simulation and local inflows at junctions, but these will not be explored in this tutorial.

3.2 Setting up the Meteorological Data

In HEC-1, precipitation is handled as a Basin Data attribute. HEC-HMS instead defines precipitation separately in the Meteorological Data. This is because of the ability of HEC-HMS to model long term simulations that require additional information and often a lot more input.

1. Select *HEC-HMS* | **Meteorologic Parameters…** to bring up the *HMS Meteorological Model* dialog.
2. Select "SCS Hypothetical Storm" from the *Precipitation Method* drop-down.

3. In the *Precipitation Data* section, select “Type II” from the *Storm Selection* drop-down.
4. Enter “1.8” as the *Storm Depth*.
5. Click **OK** to close the *HMS Meteorological Model* dialog.

3.3 Setting up the Basin Data Parameters

In the first simulation, treat the entire watershed as a single basin.

1. Using the **Select Basin** tool, double-click on the brown basin icon to bring up the *HMS Properties* dialog. The icon may be partially obscured by another label (Figure 3).

Double-clicking on a basin or outlet icon always brings up the parameter editor dialog for the current model (in this case, HEC-HMS). Notice that the area has been calculated—in this case, in square miles—because calculations are performed in English units.

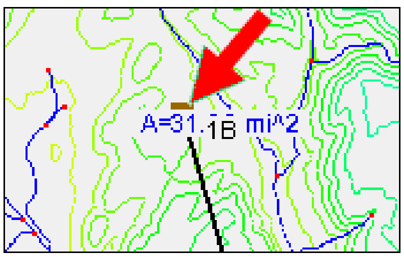


Figure 3 Basin icon 1B behind label, with top just visible

2. In the *Display options* section, turn on *Loss Rate Method* in the *Display* column. A new column will appear in the *Properties* section.
3. Turn on *SCS Curve Number* in the *Show* column. Several new columns will appear in the *Properties* section.
4. Scroll down and turn on *Transform* in the *Display* column. Several new columns will appear in the *Properties* section.
5. Turn on *SCS* in the *Show* column. Two new columns will appear in the *Properties* section.
6. In the *Properties* section, click the “1B” in the *Name* column to highlight it.
7. Enter “CCTrib” and press the *Tab* key twice to move to the *Description* field.
8. Enter “Main Branch” and press *Tab* four times to go to the *SCS Curve No.* column.
9. Enter “70.0” in the *SCS Curve No.* column. This computes a curve number (CN) value from actual land use and soil files later.

For the SCS CN method, initial losses are estimated as 20% of the maximum storage value computed from the CN when the initial loss is zero. To override this computation, enter a value other than zero. For now, assume there is no impervious area.

10. Scroll to the right and click **Compute…** in the *Basin Data* column to bring up the *Basin Time Computation* dialog.
11. Select “Compute Lag Time” from the *Computation type* drop-down.

12. Select “SCS Method” from the *Method* drop-down.
13. Click **OK** to update the computed lag time and close the *Basin Time Computation* dialog.
14. Click **OK** to close the *HMS Properties* dialog.

The brown basin icon formerly named “1B” is now named “CCTrib”. All of the parameters set to run a single basin analysis are now entered.

3.4 Running HEC-HMS

Whenever running an HEC-HMS simulation, the information created in WMS must be saved to HEC-HMS files and then loaded as a project in HEC-HMS. This tutorial is not a comprehensive review of HEC-HMS but should give an idea of how to open a project created by WMS, run an analysis and view some basic results.

1. Select *HEC-HMS* | **Save HMS File…** to bring up the *Save HMS File* dialog.
2. Select “HMS file (*.hms)” from the *Save as type* drop-down.
3. Enter “CCTribNew.hms” in the *File name* field.

Use only alphanumeric characters in the file name, and do not use any characters with diacritics (i.e., umlaut, accent, circumflex). HEC-HMS will not process the files correctly if special characters are in the file name.

4. Click **Save** to save the HMS file and close the *Save HMS File* dialog.

Now launch HEC-HMS on the computer.

5. Locate and launch “HEC-HMS.exe” on the computer being used.
6. Once in HEC-HMS, select *File* **| Open…** to bring up the *Open an Existing Project* dialog.
7. If needed, click **Browse** to bring up the *Select Project File* dialog.
8. Browse to where the HMS project from WMS was just saved (the default location is the *hec-1\hec-1* tutorial directory) and select “CCTribNew.hms”.
9. Click **Select** to open the file and close the *Select Project File* dialog.
10. Click **Convert Project** if asked to convert from an older version of HEC-HMS to a new version.
11. The *Open File Format* dialog may appear. If so, in the *Open file as* section, select “HMS Basin Files” from the drop-down and click **OK** to close the *Open File Format* dialog.
12. In the HEC-HMS Project Explorer (called the Watershed Explorer in HEC-HMS), expand the “ Basin Models”, “ Meteorologic Models”, and “ Control Specifications” folders.
13. Expand the “ Clear Creek Tributary” basin model by selecting it.
14. Expand “ CCTrib”. The HEC-HMS Project Explorer should appear similar to Figure 4.

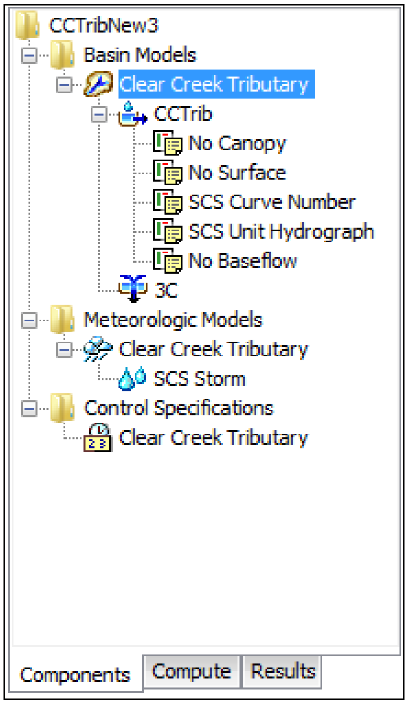


Figure 4 HEC-HMS Project Explorer

To run the simulation, do the following in HEC-HMS:

15. Switch to the *Compute* tab in the HEC-HMS Project Explorer.
16. Select " Run 1" under the " Simulation Runs" folder under " CCTribNew".
17. Select *Compute* | **Compute Run [Run 1]** to bring up a progress dialog.
18. Click **Close** when HEC-HMS finishes computing to close the progress dialog.
19. Click on the *Results* tab in the HEC-HMS Project Explorer.
20. Expand the " Simulation Runs" folder and select " Run 1" to expand the results.
21. Select " Global Summary" to bring up the *Global Summary Results for Run "Run 1"* dialog. This dialog displays the peak discharge flow.
22. Select " CCTrib" in the HEC-HMS Project Explorer to expand the basin results.
23. Select " Graph" to view the outflow hydrograph and rainfall plot.
24. Select " Summary Table" to review the computed results.
25. Select " Time-Series Table" to explore the computed time series data.
26. Review the remaining plots (" Outflow", " Precipitation", " Cumulative Precipitation", and so on) by selecting each in turn to make them appear in the *Preview* tab in the section below the HEC-HMS Project Explorer.

There is now a completed HEC-HMS simulation for a single basin. The resulting hydrograph for the CCTrib sub-basin element should look similar to Figure 5.

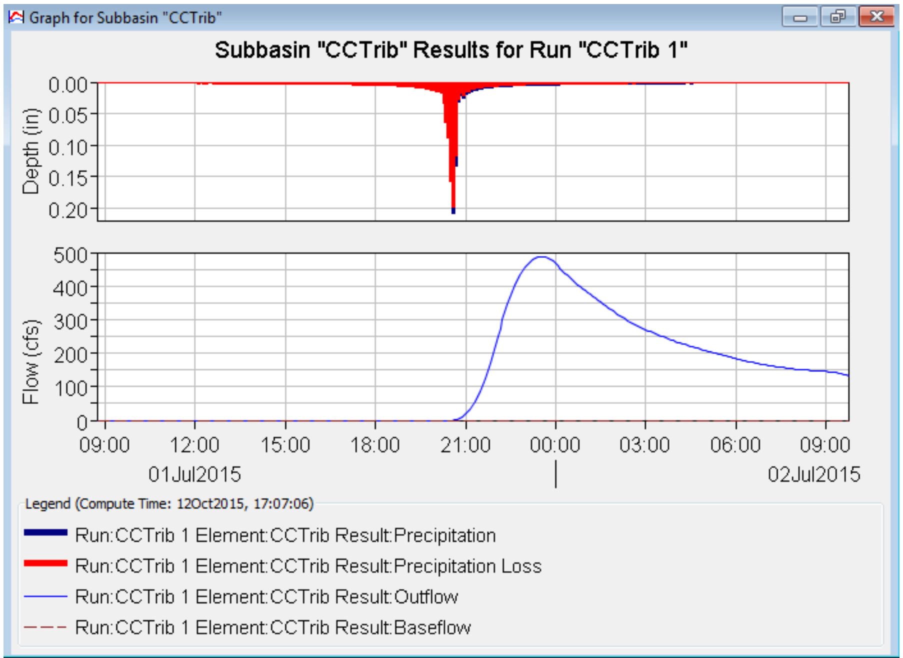


Figure 5 Solution hydrograph for HEC-HMS simulation

Feel free to explore the HEC-HMS input parameters passed from WMS, computed results, or any other options in HEC-HMS.

27. When finished, select *File* | **Exit** to close the project and exit HEC-HMS.
28. Click **Yes** if prompted to save the project.

4 Computing the CN Using Land Use and Soils Data

In the initial simulation, a CN was estimated, but with access to the internet it is simple to compute a composite CN based on digital land use and soils files. This was demonstrated in more detail in the *Advanced Feature Objects* tutorial, but the steps are here as a review.

4.1 Computing a Composite CN

At the beginning of this tutorial, digital land use and soils files were loaded for the purpose of calculating a CN. In addition to this data, a table must be defined that relates CN values for each of the four different hydrologic soil groups (A, B, C, D) for each land use. To do this, import an existing file and compute the CN numbers.

1. Turn on " Land Use" and " Soil Type" in the Project Explorer.

While it is not necessary to have the Land Use and Soil Type coverages displayed for the computations to work, they can provide useful information.

2. Select " Drainage" to make it active.
3. Switch to the **Hydrologic Modeling** module.
4. Select *Calculators* | **Compute GIS Attributes…** to bring up the *Compute GIS Attributes* dialog.

5. Click **Import** to bring up the *Open* dialog.
6. Click **OK** when advised the new table will overwrite the current table.
7. Select "Land/Soil Table File (*.txt)" from the *Files of type* drop-down.
8. Select "scsland.txt" and click **Open** to import the table and close the *Open* dialog.
9. Click **OK** to compute the CN from the land use and soils layers, close the *Compute GIS Attributes* dialog, and bring up the *View Data File* dialog. If the *Never ask this again* option was previously turned on, this dialog will not appear. If this is the case, skip to step 11.
10. Select the desired text editor from the *Open With* drop-down and click **OK** to close the *View Data File* dialog and open the "cn_report.txt" file in the selected text editor.

Notice the computed CN displayed in the Runoff Curve Number Report and above the area label in the WMS graphics window.

11. When done reviewing the Runoff Curve Number Report, click to close the text editor and return to WMS.

4.2 Running HEC-HMS

Next, run another simulation to compare the results with the modified CN value.

1. Right click on " Drainage Coverage Tree" in the Project Explorer and select **Save HMS File…** to bring up the *Save HMS File* dialog.
2. Select "HMS File (*.hms)" from the *Save as type* drop-down.
3. Enter "CCTribCN.hms" as the *File name*.
4. Click **Save** to save the HMS file and close the *Save HMS File* dialog.

The external program HEC-HMS will be used to do additional calculations:

5. Locate and launch "HEC-HMS.exe" on the computer being used.
6. Once in HEC-HMS, select *File* | **Open…** to bring up the *Open an Existing Project* dialog.
7. Click **Browse** to bring up the *Select Project File* dialog.
8. Browse to the *hec-1\hec-1* directory and select "CCTribCN.hms".
9. Click **Select** to open the file and close the *Select Project File* dialog.
10. If asked to convert the file to the current version of HEC-HMS, click **Convert Project**.
11. The *Open File Format* dialog may appear. If so, in the *Open file as* section, select "HMS Basin Files" from the drop-down and click **OK** to close the *Open File Format* dialog.
12. In the HEC-HMS Project Explorer, expand " Basin Models", " Meteorologic Models", and "Control Specifications".
13. Select " Clear Creek Tributary", then expand " CCTrib".

14. Select " SCS Curve Number" and view the computed curve number from WMS on the *Loss* tab in the lower left of the HMS window.

To run the simulation, do the following in HEC-HMS:

15. Switch to the *Compute* tab in the HEC-HMS Project Explorer.
16. Select " Run 1" under the " Simulation Runs" folder under " CCTribCN".
17. Select *Compute* | **Compute Run [Run 1]** to bring up a progress dialog.
18. Click **Close** when HEC-HMS finishes computing to close the progress dialog.
19. Switch to the *Results* tab in the HEC-HMS Project Explorer.
20. Expand the " Simulation Runs" folder and select " Run 1" to expand the results.
21. Select " Global Summary" to review the peak flow data.
22. Select " CCTrib" to expand the basin results, then select " Graph" to view the outflow hydrograph and rainfall plot.
23. Select " Summary Table" to view the computed results of the simulation run.
24. Select " Time-Series Table" and explore the computed time series results.
25. Review the remaining plots (" Outflow", " Precipitation", " Cumulative Precipitation", and so on) by selecting each in turn to make them appear in the *Preview* tab in the section below the HEC-HMS Project Explorer.

Feel free to explore the HEC-HMS input parameters passed from WMS, computed results, or any other options in HEC-HMS.

26. When finished, select *File* | **Exit** to close the project and exit HEC-HMS and return to WMS.
27. Click **Yes** if prompted to save the project.

5 Adding Sub-basins and Routing

Now to subdivide the watershed into two upper basins and one lower basin and define routing for the reaches that connect the upper basins to the watershed outlet.

5.1 Delineating the Sub-basin

1. Turn off " Land Use" and " Soil Type" in the Project Explorer.
2. Click **Display Options** to bring up the *Display Options* dialog.
3. Select "Map Data" from the list on the left.
4. On the *Map* tab, turn on *Vertices* and click on the button to bring up the *Point Properties* dialog.
5. Enter "3" as the *Radius* and click **OK** to close the *Point Properties* dialog.
6. Click **OK** to close the *Display Options* dialog.

7. **Zoom** in to the area shown in Figure 6.

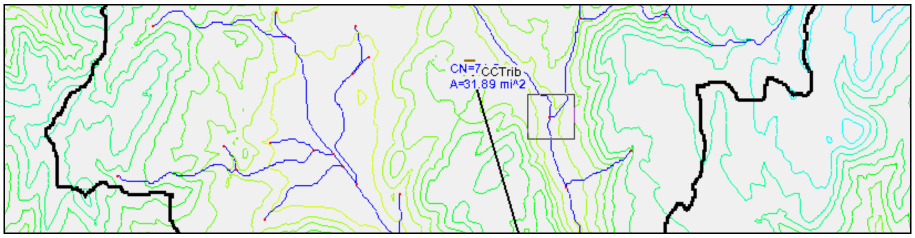


Figure 6 Zoom to the area indicated by the box near the center of the basin

8. Switch to the **Drainage Module** module.
9. Using the **Select Feature Vertex** tool, select the vertex just below the main branching point (Figure 7).
10. Select *DEM* **| Node ↔ Outlet**.

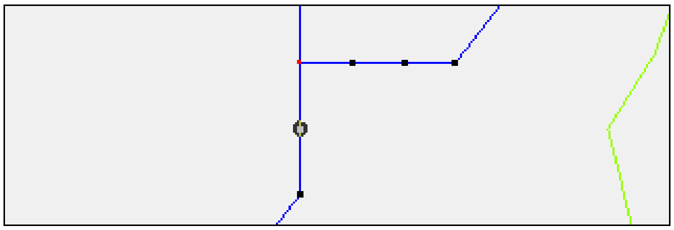


Figure 7 Select the vertex just below the junction point

This creates an outlet point just below the branch in order to have a single upstream basin (Figure 8). To create a separate basin for each upstream branch, define the branching node as an outlet.

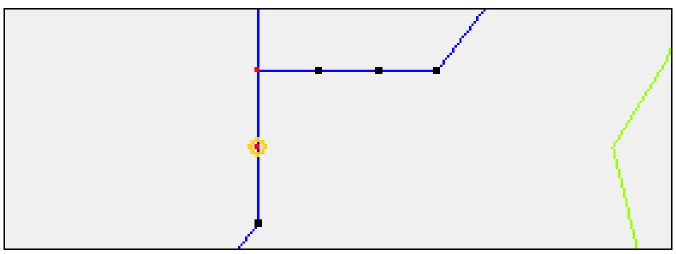


Figure 8 The select vertex is now an outlet

11. **Frame** the project.
12. **Zoom** in to the area shown in Figure 9.

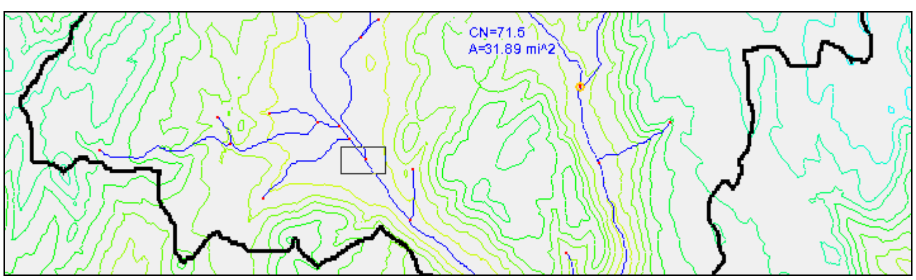


Figure 9 Zoom to the area indicated by the box on the right side

13. Using the **Select Feature Vertex** tool, select the vertex just below the main branching point (Figure 10).

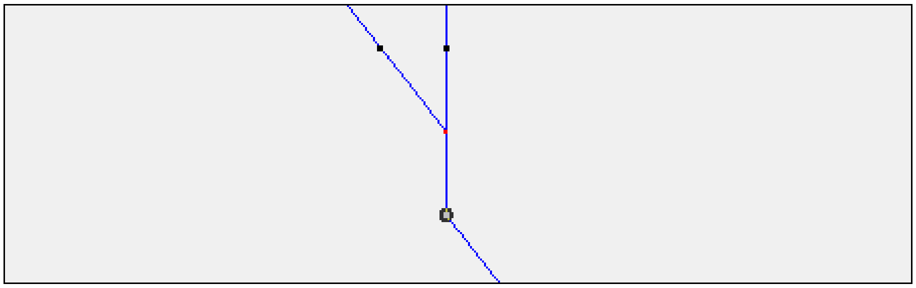


Figure 10 Select the vertex just below the junction

14. Select *DEM* | **Node ↔ Outlet** to create the outlet point.
15. **Frame** the project.
16. Select *DEM* | **Delineate Basins Wizard** to bring up the *Stream Feature Arc Options* dialog.
17. If advised that all existing feature data will be deleted and recreated, click **OK**.
18. Click **OK** to accept the defaults, close the *Stream Feature Arc Options* dialog, and open the *Units* dialog.
19. Click **OK** to accept the defaults and close the *Units* dialog.

The drainage basin should now be divided into three sub-basins (Figure 11).

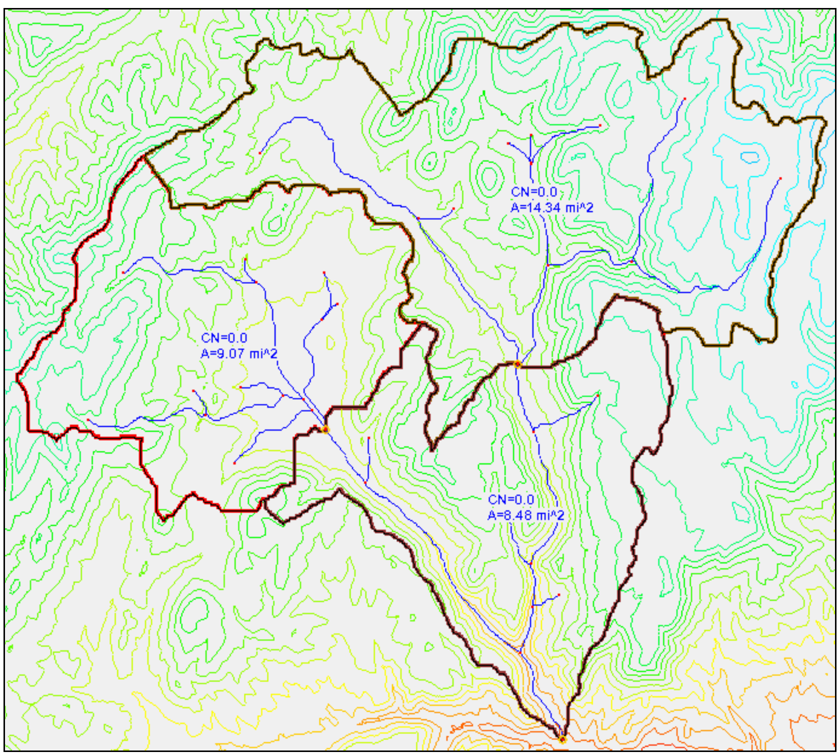


Figure 11 The three sub-basins after delineation

5.2 Updating the Basin Parameters

Because the single basin has been divided into multiple basins, it is necessary to recompute the CN values and define precipitation and lag time for the basins.

1. Switch to the **Hydrologic Modeling** module.
2. Select *Calculators* | **Compute GIS Attributes…** to bring up the *Compute GIS Attributes* dialog.
3. Click **OK** to accept the defaults and close the *Compute GIS Attributes* dialog and bring up the *View Data File* dialog. If the *Never ask this again* option has previously been turned on, this dialog will not appear. In this case, skip to step 5.
4. Select the desired text editor from the *Open With* drop-down, then click **OK** to close the *View Data File* dialog and open the "cn_report.txt" file in the selected text editor.

Notice the computed CN displayed in the Runoff Curve Number Report and above the area label in the WMS graphics window. The recomputed CN values for all three basins are very similar because there is one dominant soil polygon that covers the entire watershed.

5. When done viewing the Runoff Curve Number Report, click and return to WMS.
6. Make note of the label names for the three basins, noting which number belongs to the top right, top left, and bottom basins.

The names of the basins should follow the pattern "1B", "2B", "3B", though the names may be slightly different. This information will be used the steps below.

7. Using the **Select Basin** tool, double-click on the upper right brown basin icon to bring up the *HMS Properties* dialog.
8. Select "All" from the *Show* drop-down.
9. In the *Display options* section, turn on *Loss Rate Method* in the *Display* column and *SCS Curve Number* in the *Show* column.
10. Turn on *Transform* in the *Display* column and *SCS* in the *Show* column.
11. In the *Properties* section in the *Name* column, change the top right basin name to "Right".
12. Change the top left basin name to "Left".
13. Change the bottom basin name to "CCTrib".
14. Click **Compute…** in the *Basin Data* column of the "Right" row to bring up the *Basin Time Computation* dialog.
15. Select "Compute Lag Time" from the *Computation type* drop-down.
16. Select "SCS Method" from the *Method* drop-down.
17. Click **OK** to close the *Basin Time Computation* dialog.
18. Repeat steps 13–16 for the "Left" and "CCTrib" rows.

There is now a computed lag time for each basin (each about 1 hour). Because the CN values have been computed automatically, they do not need to be changed here.

19. Click **OK** to close the *HMS Properties* dialog.

5.3 Setting up the Routing Parameters

If HEC-HMS were run right now, the hydrographs from the upper basins would be combined with the lower basin hydrograph at the watershed outlet without any lag or attenuation because the routing parameters are not yet set. A routing method needs to be defined to instruct HEC-HMS to compute lag and attenuation on the upper basin hydrographs before adding them to the lower hydrograph.

Routing for a reach is always defined at the upstream outlet of the reach in WMS.

1. Using the **Select Outlet** tool, double-click on the upper right basin outlet to bring up the *HMS Properties* dialog.
2. Select "Reaches" from the *Type* drop-down.
3. Select "Selected" from the *Show* drop-down.
4. In the *Display options* section, turn on *Method* in the *Display* column and *Muskingum Cunge Std* in the *Show* column.
5. In the *Properties* section, select "Muskingum Cunge" from the *Routing Method* drop-down.
6. Scroll to the right and enter "5.0" in the *Bottom Width/Diameter (ft)* column.
7. Enter "1.0" in the *Side Slope (xH:1V)* column.
8. Enter "0.05" in the *Mannings n* column. This is fairly rough, giving an exaggerated routing effect for the purposes of this tutorial.
9. Click **OK** to close the *HMS Properties* dialog.
10. Using the **Select Outlet** tool, double-click on the upper left basin outlet to bring up the *HMS Properties* dialog.
11. Repeat steps 2–9.

The project will appear similar to Figure 12.

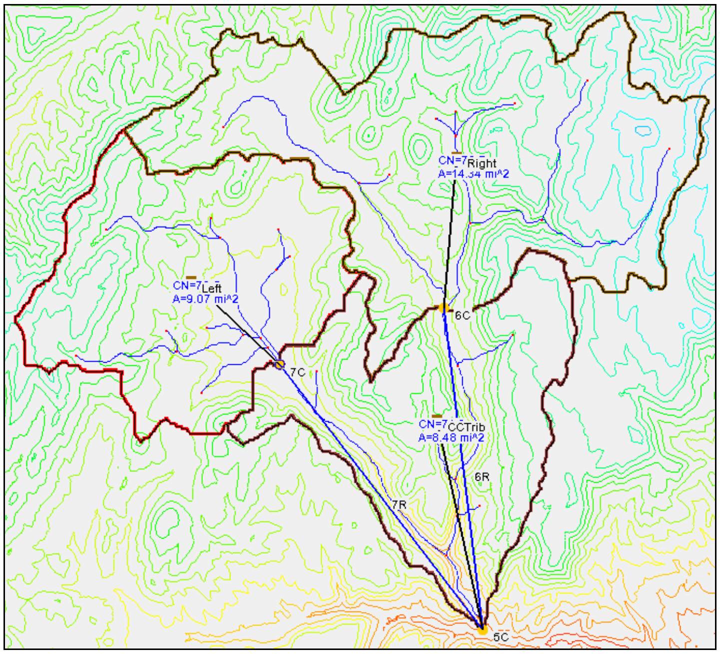


Figure 12 Three sub-basins after upper basins' output defined

5.4 Running HEC-HMS

Everything is now defined to run a three basin HEC-HMS analysis that includes routing the upper basins through the reaches connecting them to the watershed outlet.

1. Right click on " Drainage Coverage Tree" in the Project Explorer and select **Save HMS File…** to bring up the *Save HMS File* dialog.
2. Select "HMS File (*.hms)" from the *Save as type* drop-down.
3. Enter "CCTribRoute.hms" as the *File name*.
4. Click **Save** to save the HMS file and close the *Save HMS File* dialog.

HEC-HMS will be used to do additional calculations:

5. Locate and launch "HEC-HMS.exe" on the computer being used.
6. Once in HEC-HMS, select *File* **| Open…** to bring up the *Open an Existing Project* dialog.
7. Click **Browse** to bring up the *Select Project File* dialog.
8. Browse to *hec-1\hec-1* and select "CCTribRoute.hms".
9. Click **Select** to open the file and close the *Select Project File* dialog.
10. If asked to convert the file to the current version of HEC-HMS, click **Convert Project**.
11. The *Open File Format* dialog may appear. If so, in the *Open file as* section, select "HMS Basin Files" from the drop-down and click **OK** to close the *Open File Format* dialog.

12. In the HEC-HMS Project Explorer, expand " Basin Models", " Meteorologic Models", and "Control Specifications".
13. Select " Clear Creek Tributary" to expand it and make it active.

To create the simulation, do the following in HEC-HMS:

14. Switch to the *Compute* tab in the HEC-HMS Project Explorer.
15. Select " Run 1" under the " Simulation Runs" folder under " CCTribRoute".
16. Select *Compute* | **Compute Run [Run 1]** to bring up a progress dialog.
17. Click **Close** when HEC-HMS finishes computing to close the progress dialog.
18. Switch to the *Results* tab in the HEC-HMS Project Explorer.
19. Expand the " Simulation Runs" folder and select " Run 1" to expand the results.
20. Select " Global Summary" to review the peak flows.
21. Select " Graph" below the entry for the junction for the entire basin to view the hydrograph for the entire basin.

Notice that there are four hydrograph curves in the plot (Figure 13). One represents the discharge from the CCTrib basin, one represents routed flow from the right basin, one represents routed flow from the left basin, and the curve with the largest peak represents the superimposed composite of the other three curves.

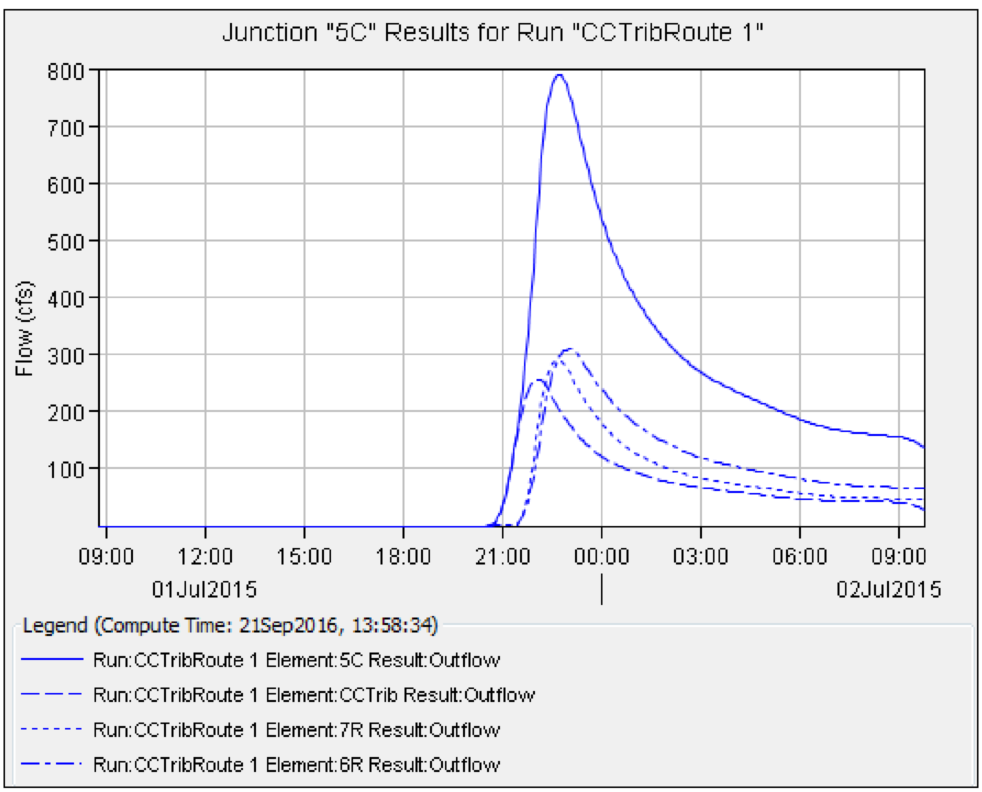


Figure 13 Hydrograph for entire basin, including all three sub-basins

Feel free to explore and review the graphs and charts in each entry below the " Global Summary". Selecting each will cause the results to appear.

22. When finished, close and exit HEC-HMS by selecting *File* | **Exit.**
23. Click **Yes** if prompted to save the project.
24. Return to WMS.

6 Modeling a Reservoir in HEC-HMS

A small reservoir exists at the outlet of the upper left basin. It has a storage capacity of 1000 ac-ft at the spillway level and 1540 ac-ft at the dam crest.

6.1 Defining a Reservoir in Combination with Routing

One of the routing methods available in HEC-HMS is storage routing, which can be used to define reservoir routing. In this case, Muskingum-Cunge routing is already being used to move the hydrograph through the reach connecting the upper left basin to the watershed outlet. The outlet must be defined as a reservoir in order to route the hydrograph through the reservoir before routing it downstream.

1. Using the **Select Outlet** tool, select the outlet of the upper left basin.
2. Right-click on the outlet and select *Add* | **Reservoir**.

The icon will change color and become a triangle.

6.2 Setting up the Reservoir Routing Parameters

In order to define reservoir routing with HEC-HMS, elevation vs. storage (storage capacity curve) and elevation vs. discharge rating curves must be defined. Values can be entered directly or computed based on hydraulic structures. In this tutorial, values will be entered directly, using the same elevation values for both curves.

In this case, there should be no outflow until the elevation in the reservoir reaches the spillway. Since HEC-HMS linearly interpolates between consecutive points on the elevation-discharge and elevation-volume curves, two points on the curves at almost the same elevation (6821.99 ft and 6822 ft) will be entered. The first will have no outflow and the second will have the discharge over the spillway (640 cfs) as defined for the dam.

The initial conditions of the reservoir need to be entered to define the reservoir routing. These can be defined as an elevation, a discharge, or a volume. For this tutorial, the initial condition is set to an elevation four feet below the top of the spillway (the spillway corresponds to an elevation of 6822).

1. Using the **Select Outlet** tool, double-click on the reservoir outlet point to bring up the *HMS Properties* dialog.
2. In the *Properties* section, change the value in the *Name* column to "Tcreek".
3. On the *Tcreek* row, select "Elevation-Storage-Discharge" from the *Method* drop-down.
4. Select "Elevation (ft)" from the *Initial* drop-down.

5. Enter “6818.0” in the *Initial Value* column.
6. Click **Define…** in the *Elevation-Storage* column to bring up the *XY Series Editor* dialog.
7. Click **New** and enter “Elevation-Storage” as the *Curve Name*.
8. In an external spreadsheet program, open the “reservoir-hms.xls” file found in the *hec1\hec1* directory.
9. Copy the numbered contents in the “Elevation” column.
10. In WMS in the *XY Series Editor* dialog, right-click in the empty cell on row *1* in the *Elevation (ft)* column and select **Paste**.
11. In the external spreadsheet program, copy the numbered contents in the “Storage” column.
12. In WMS in the *XY Series Editor* dialog, right-click in the empty cell on row *1* in the *Storage (ac-ft)* column and select **Paste**.
13. Click **OK** to close the *XY Series Editor* dialog.
14. Click the **Define…** button in the *Storage-Discharge* column to bring up the *XY Series Editor* dialog.
15. Click **New** and enter “Storage-Discharge” in the *Curve Name* field.
16. In the external spreadsheet program, copy the numbered contents in the “Storage” column.
17. In WMS in the *XY Series Editor* dialog, right-click in the empty cell on row *1* in the *Volume (ac-ft)* column and select **Paste**.
18. In the external spreadsheet program, copy the numbered contents in the “Discharge” column.
19. In WMS in the *XY Series Editor* dialog, right-click in the empty cell on row *1* in the *Discharge (cfs)* column and select **Paste**.
20. Click **OK** to close the *XY Series Editor* dialog.
21. Click **OK** to close the *HMS Properties* dialog.

6.3 Running HEC-HMS

Everything is now defined to run a three-basin HEC-HMS analysis that includes routing the upper basins through the reaches connecting them to the watershed outlet.

1. Right click on “ Drainage Coverage Tree” in the Project Explorer and select **Save HMS File…** to bring up the *Save HMS File* dialog.
2. Select “HMS File (*.hms)” from the *Save as type* drop-down.
3. Enter “CCTribReservoir.hms” as the *File name*.
4. Click **Save** to save the HMS file and close the *Save HMS File* dialog.

HEC-HMS will be used to do additional calculations:

5. Locate and launch “HEC-HMS.exe” on the computer being used.

6. Once in HEC-HMS, select *File* | **Open…** to bring up the *Open an Existing Project* dialog.
7. Click **Browse** to bring up the *Select Project File* dialog.
8. Browse to the *hec-1\hec-1* directory and select "CCTribReservoir.hms".
9. Click **Select** to open the file and close the *Select Project File* dialog.
10. If asked to convert the file to the current version of HEC-HMS, click **Convert Project**.
11. The *Open File Format* dialog may appear. If so, in the *Open file as* section, select "HMS Basin Files" from the drop-down and click **OK** to close the *Open File Format* dialog.
12. In the HEC-HMS Project Explorer, expand the " Basin Models", " Meteorologic Models", " Control Specifications", and " Paired Data" folders.
13. Select " Clear Creek Tributary" to expand it.

To run the simulation, do the following in HEC-HMS:

1. Switch to the *Compute* tab in the HEC-HMS Project Explorer.
2. Select " Run 1" under the " Simulation Runs" folder under " CCTribReservoir".
3. Select *Compute* | **Compute Run [Run 1]** to bring up a progress dialog.
4. Click **Close** when HEC-HMS finishes computing to close the progress dialog.
5. At the bottom of the HEC-HMS Project Explorer, select the *Results* tab.
6. Expand the " Simulation Runs" folder and select " Run 1" to expand the results.
7. Select " Global Summary" to review the peak flows.
8. Select " Graph" below the entry for the junction for the entire basin to view the hydrograph for the entire basin.

Notice that there are four hydrograph curves in the plot (Figure 14). One represents the discharge from the CCTrib basin, one represents routed flow from the right basin, one represents routed flow from the left basin, and the curve with the largest peak represents the superimposed composite of the other three curves.

Feel free to explore and review the graphs and charts in each entry below the " Global Summary". Selecting each will cause the results to appear.

13. When finished, close and exit HEC-HMS by selecting *File* | **Exit.**
14. Click **Yes** if prompted to save the project.
15. Return to WMS.

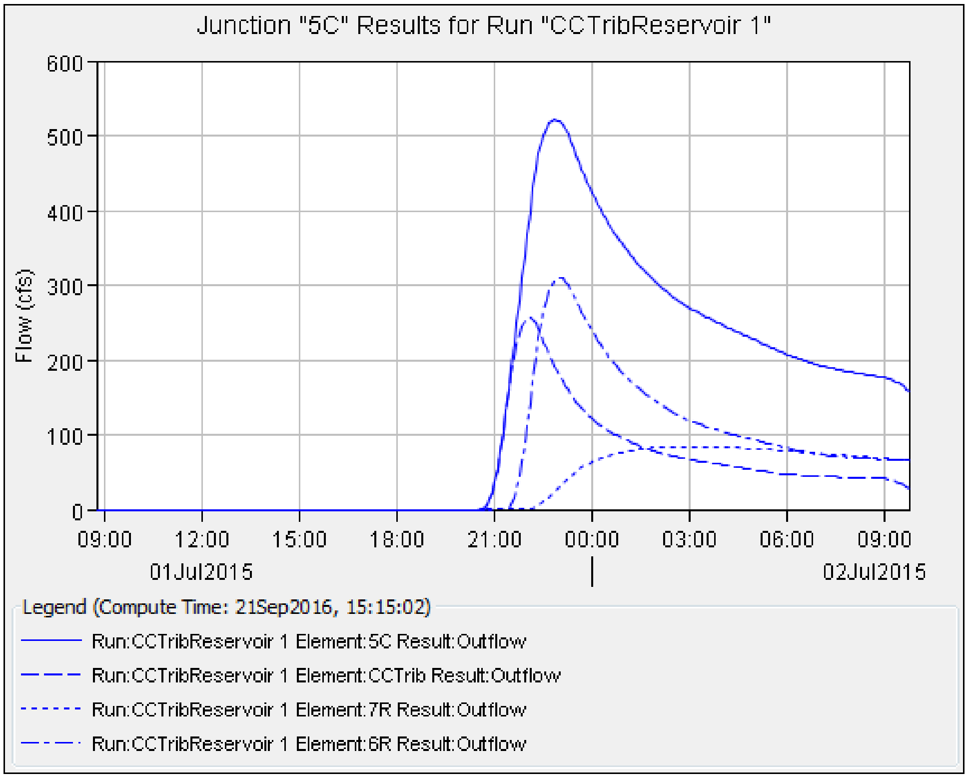


Figure 14 Hydrograph for entire basin with reservoir, including all three sub-basins

7 Conclusion

This concludes the "Watershed Modeling – HEC-HMS Interface" tutorial. The key concepts discussed and demonstrated include:

- Entering job control parameters
- Defining basin parameters such as loss rates, precipitation, and hydrograph methodology
- Performing a watershed analysis
- Defining routing parameters
- Routing a hydrograph through a reservoir
- Saving and running HEC-HMS simulations