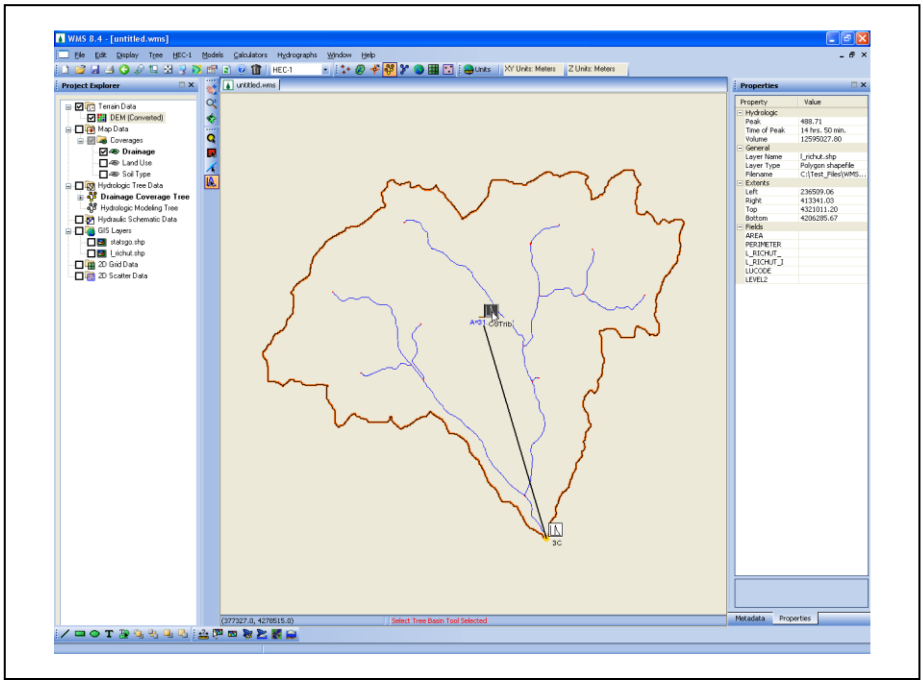
v. 10.1

WMS 10.1 Tutorial

Watershed Modeling – HEC-1 Interface

Learn how to setup a basic HEC-1 model using WMS



Objectives

Build a basic HEC-1 model from scratch using a DEM, land use, and soil data. Compute the geometric and hydrologic parameters required to run a HEC-1 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-1. 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 HEC-1 model have been entered, an input file with the proper format for HEC-1 can be written automatically. Since only parts of the HEC-1 input file are defined in this chapter, feel free to explore the different available options of each dialog, being sure to select the given method and values before exiting the dialog.

The US Army Corps of Engineers now supports HMS rather than HEC-1, but the hydrologic calculations for the options within HEC-1 have not changed. Results of the two models will be identical.

In this tutorial, a watershed will be delineated from a DEM. A simple, single basin model will be developed 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 HEC-1 model, other variations will be developed, including defining multiple basins with reach routing and including a reservoir with storage routing.

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 by entering the Job Control parameters as well as the rainfall event, loss method, and unit hydrograph method parameters.

3.1 Setting up the Job Control

Most of the parameters required for a HEC-1 model are defined for basins, outlets, and reaches. However, there are many "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 "Project Files (*.wms)" from the *Files of type* drop-down.
3. Browse to the *hec-1\hec-1* folder and select "hec-1_SingleWatershed.wms".
4. Click **Open** to import the project and exit the *Open* dialog.

A watershed model should appear (Figure 1).

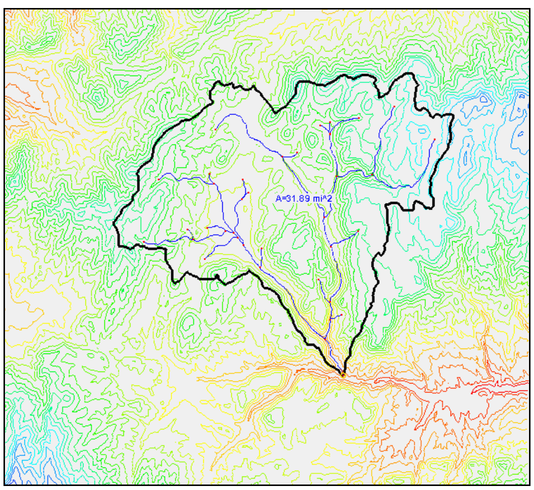


Figure 1 The watershed model

5. Switch to the **Hydrologic Modeling** module.
6. Select "HEC-1" from the Model list drop-down (Figure 2).

Figure 2 Model list drop-down

7. Select *HEC-1* **| Job Control…** to bring up the *HEC-1 Job Control* dialog.

The first three lines are displayed at the top of the HEC-1 input file that will be created. The first line already has information indicating that the input file is generated by WMS. The other two lines can contain any desired information to help identify the project when reviewing the HEC-1 input file. The **Add Row** and **Delete Row** buttons can be used to add and delete rows as needed for additional information to be displayed at the top of the input file.

For this tutorial, do the following:

8. Enter "Clear Creek Tributary Watershed" on the second ID line.
9. Enter your name and the current date on the third line.
10. In the second section, leave the default values in the *Day*, *Month*, and *Year* fields.

HEC-1 allows a date to be entered here. In this tutorial, a hypothetical storm (rather than an actual storm) will be simulated. If these values are changed, be sure these fields match the beginning storm date in the *XY Series Editor* dialog (discussed later in this tutorial).

11. Enter "5" as the *Computational time interval*.
12. Enter "300" as the *Number of hydrograph ordinates*.

HEC-1 simulations run for a length of time equal to the time step multiplied by the number of ordinates. If simulating a 24-hour storm, but the simulation is run for only 12 hours, the full hydrograph will not be captured. Conversely, running a 24-hour simulation for 96 hours will generally produce a lot of runoff ordinates equal to 0 at the end. In this case, the simulation is running for 1500 minutes (slightly more than 24 hours) with an ordinate on the hydrograph being computed for every 5 minutes.

13. In the fourth section, select *English units* as the *Computation units*.

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

For now, the other *HEC-1 Job Control* dialog settings will be left at their default values.

14. Click **OK** to close the *HEC-1 Job Control* dialog.

3.2 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 labeled 1B to bring up the *Edit HEC-1 Parameters* dialog.

The brown basin icon may be partially hidden behind the basin labels near the center of the basin. Double-clicking on a basin or outlet icon always brings up the parameter editor dialog for the current model (in this case HEC-1).

2. In the *Basin HEC-1 Cards* section, click **Basin Data…** to bring up the *HEC-1 Basin Data* dialog.

Notice that the *Area* has been calculated. If metric units were being used, the *Area* would show in square kilometers.

3. In the top section, enter "CCTrib" as the *Basin name*.

HEC-1 only uses the first six characters entered, so it is not recommended to use basin or outlet names longer than six characters.

4. Click **OK** to close the *HEC-1 Basin Data* dialog.
5. Click **Precipitation…** to bring up the *HEC-1 Precipitation* dialog.
6. Select *Basin Average (PB)* and enter "1.8" as the *Average precipitation*.
7. Click **Define Series** to bring up the *XY Series Editor* dialog.

In order to simulate a rainfall event, enter both a rainfall depth and a temporal distribution. The NRCS uses standard time distributions for different areas of the U.S. These are stored in WMS. Additionally, a series can be defined based on an actual storm or on a design from a regulating agency.

8. On the lower right, select "typeII-24hour" from the *Selected Curve* drop-down.
9. Click **OK** to close the *XY Series Editor* dialog.
10. Click **OK** to close the *HEC-1 Precipitation* dialog.
11. Click **Loss Method…** to bring up the *HEC-1 Loss Methods* dialog.
12. Enter "70.0" as the *CRVNBR* and click **OK** to close the *HEC-1 Loss Method* dialog.

A CN value will be computed later from actual land use and soil files.

13. Click **Unit Hydrograph Method…** to bring up the *HEC-1 Unit Hydrograph Methods* dialog.
14. Select *SCS dimensionless (UD)* and click **Compute Parameters - Basin Data** 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 and click **OK** to close the *Basin Time Computation* dialog.

Notice that the computed lag time for the *SCS dimensionless (UD)* has been updated (the number in the *TLAG* field).

17. Click **OK** to close the *HEC-1 Unit Hydrograph Methods* dialog.
18. Click **Done** to close the *Edit HEC-1 Parameters* dialog.

Now all of the parameters needed to run a single basin analysis have been entered.

3.3 Running HEC-1

Whenever running a HEC-1 simulation, WMS will first save a standard HEC-1 input file. An output file and a solutions file will need to have names specified. The output file is the standard text output file generated by HEC-1 and the solution file is an HEC-1 TAPE22 file (a plot file) containing the hydrographs formatted to make it easy for WMS to read and plot.

1. Select *HEC-1* | **Run Simulation…** to bring up the *HEC-1 Run Options* dialog.

2. Below *Input file*, click to bring up the *Select HEC-1 Input File* dialog.
3. Enter "CCTrib.hc1" as the *File name* and click **Save** to set the file name and close the *Select HEC-1 Input File* dialog.

Notice that the file name specified in step 3 now appears to the right of *Input file*. This specifies the file name but does not actually save it yet.

4. Turn on *Save file before run*.
5. Click **OK** to close the *HEC-1 Run Options* dialog and bring up the *Model Wrapper* dialog.
6. Once HEC-1 finished, turn on *Read solution on exit*.
7. Click **Close** to import the solutions and close the *Model Wrapper* dialog.

A small hydrograph plot icon will appear by the basin icon.

8. Using the **Select Hydrograph** tool, double-click on the hydrograph icon to open the *Hydrograph* dialog.

The dialog should display a hydrograph similar to Figure 3. Notice that the hydrograph suddenly stops at 1500 minutes (the duration of the simulation as established in the *Job Control* dialog), but the simulation has not run to completion. Run the simulation again with additional hydrograph ordinates to capture the entire storm.

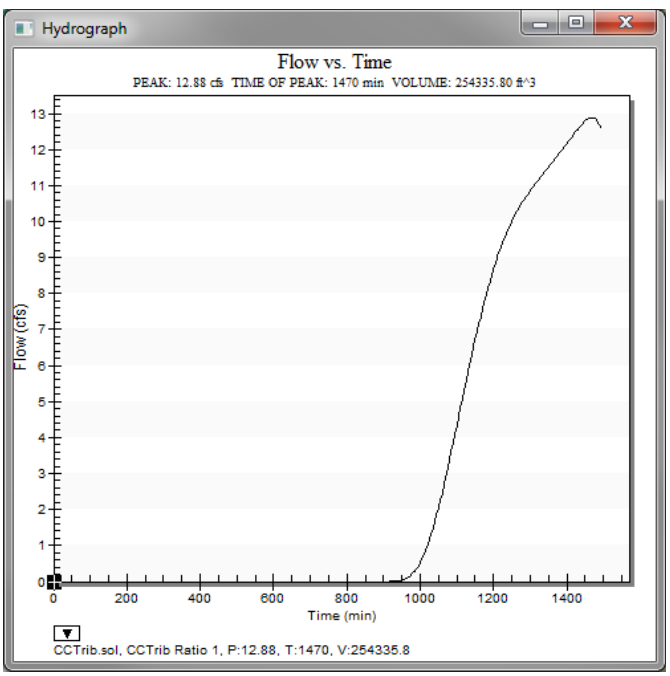


Figure 3 Hydrograph after first HEC-1 run

9. Close the *Hydrograph* dialog by clicking in the upper right corner of the window.
10. Select *Hydrographs* | **Delete All** to remove the hydrograph.
11. Select *HEC-1* | **Job Control…** to bring up the *HEC-1 Job Control* dialog.
12. Enter "400" as the *Number of hydrograph ordinates* and click **OK** to close the *HEC-1 Job Control* dialog.

13. Select *HEC-1* **| Run Simulation…** to bring up the *HEC-1 Run Options* dialog.
14. Click **OK** to close the *HEC-1 Run Options* dialog and bring up the *Model Wrapper* dialog.

This overwrites the previous files, which is acceptable because the hydrograph was incomplete.

15. Once HEC-1 finishes, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog.
16. Using the **Select Hydrograph** tool, double-click on the hydrograph icon next to the basin icon to bring up the *Hydrograph* dialog.

The HEC-1 simulation has now been completed for a single basin and the resulting hydrograph should appear similar to Figure 4.

17. Close the *Hydrograph* dialog by clicking in the upper right corner of the window.

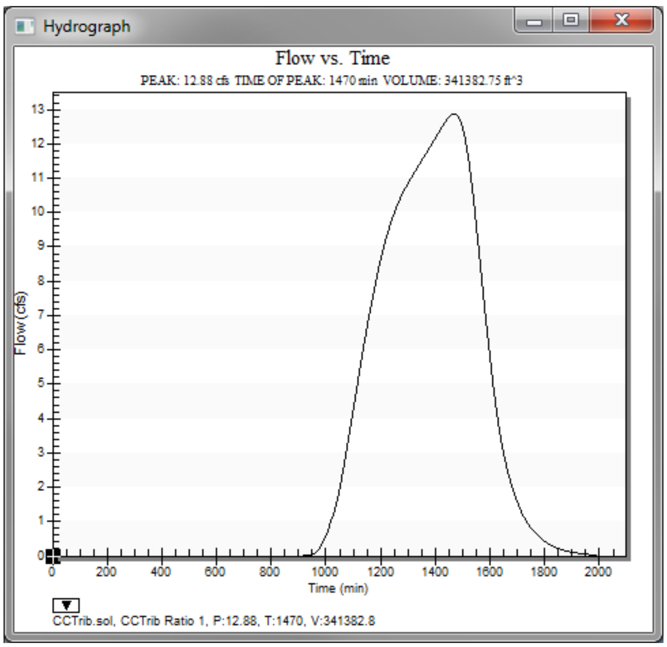


Figure 4 Solution hydrograph for HEC-1 Simulation

4 Computing the CN Using Land Use and Soils Data

In the initial simulation, a CN was estimated, but it is simple to acquire digital land use and soils files via the internet and compute a composite CN. The "Introduction – Advanced Feature Objects" tutorial covers this in more detail.

4.1 Computing a Composite CN

In addition to the digital land use and soils file that overlap the watershed, a table must be defined that identifies CN values for each of the four different hydrologic soil groups (A, B, C, and D) based on GSDA information.[1] For this tutorial, an existing file will be imported and used to compute the CN values. Feel free to examine the file in a text editor if desired.

1. Switch to the **Hydrologic Modeling** module.
2. Select *Calculators* **| Compute GIS Attributes…** to bring up the *Compute GIS Attributes* dialog.
3. Click **Import** and click **OK** to overwrite the current definition and bring up the *Open* dialog.
4. Select "Land/Soil Table File (*.txt)" from the *Files of type* drop-down.
5. Select "scsland.txt" and click **OK** to import the file into the *Mapping* section and exit the *Open* dialog.

This data will be used to compute the CN from the land use and soils layers.

6. Click **OK** to close the *Compute GIS Attributes* dialog and bring up the *View Data File* dialog. If the *Never ask this again* option has previously been selected, this dialog will not appear. If this is the case, skip to step 8.
7. Select the desired text editor from the *Open With* drop-down and click **OK** to close the *View Data File* dialog and open the file in the desired text editor.
8. Scroll to the bottom of the report to see the CN.

Notice that the CN computed from the land use and soils digital data is about "71.5". While there is still some judgment required in setting up the mapping table, this value is based on collected data rather than being an estimate. It will therefore provide more accurate results.

9. Close the text editor and return to WMS.

The computed curve number has now been automatically assigned to the HEC-1 basin data and the simulation can now be run.

4.2 Running HEC-1

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

1. Select *HEC-1* **| Run Simulation…** to bring up the *HEC-1 Run Options* dialog.
2. Click **OK** to close the *HEC-1 Run Options* dialog and bring up the *Model Wrapper* dialog.

As with the previous run, it is fine to overwrite the existing files. If desired, feel free to change the *Output file* and *Solution file* names.

3. Once HEC-1 finishes running, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog and import the solutions.
4. Using the **Select Hydrograph** tool, double-click on the hydrograph icon open the *Hydrograph* dialog.

[1] See the articles listed at http://www.xmswiki.com/wiki/GSDA:GSDA for more details.

Notice that both the old and new hydrographs are shown (Figure 5). Notice also that the increased CN value resulted in a higher peak in the hydrograph, indicating that there was more runoff.

5. Close the *Hydrograph* dialog by clicking in the upper right corner of the window.
6. Select *Hydrographs* | **Delete All** to remove all generated hydrographs.
7. Select *File* | **Save as…** to bring up the *Save As* dialog.
8. Select "WMS XMDF Project File (*.wms)" from the *Save as type* drop-down.
9. Enter "CCTribHEC1.wms" as the *File name* and click **Save** to export the file under the new name and close the *Save As* dialog.

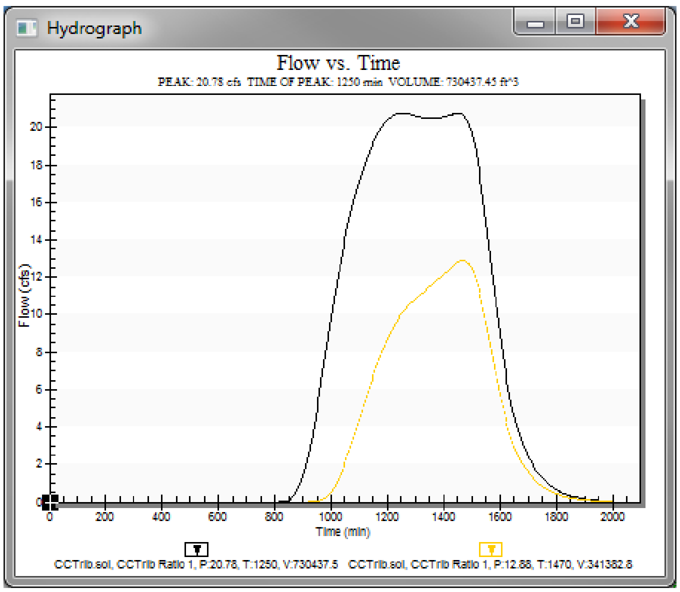


Figure 5 Both hydrographs are showing

5 Adding Sub-basins and Routing

The watershed will now be subdivided into two upper basins and one lower basin. Routing will also be defined for the reaches that connect the upper basins to the watershed outlet.

5.1 Delineating the Sub-basin

1. Switch to the **Drainage** module.
2. **Zoom** in to the location indicated by the box in Figure 6.
3. Click **Display Options** to open the *Display Options* dialog.
4. Select "Map Data" from the list on the left.
5. On the *Map* tab, turn on *Vertices* and click the to the right to bring up the *Point Properties* dialog.

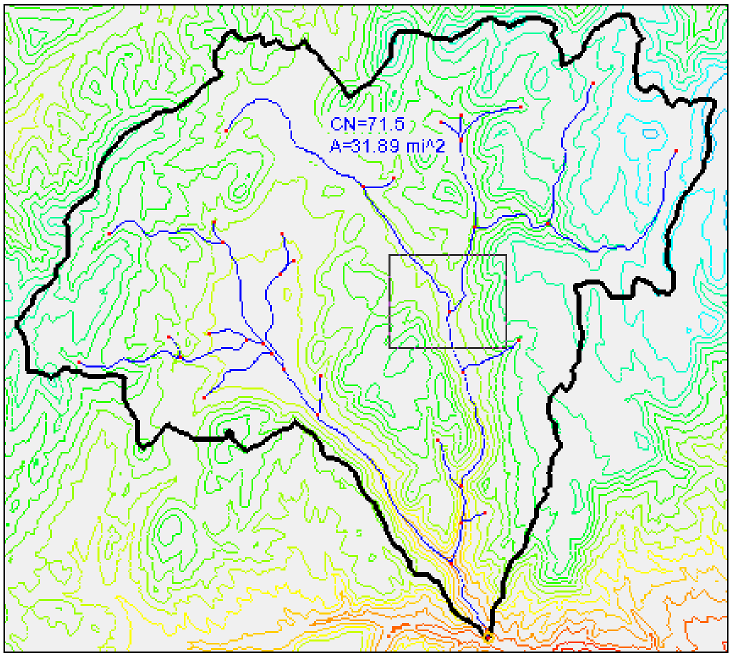


Figure 6 Zoom area for upper right sub-basin

6. Enter "3" as the *Radius* and click **OK** to close the *Point Properties* dialog.
7. Click **OK** to close the *Display Options* dialog.
8. Using the **Select Feature Vertex** tool, select the vertex that is just below the main branching point (Figure 7).

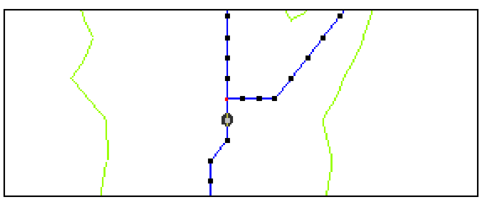


Figure 7 Vertex just below branch

9. Select *DEM* | **Node ↔ Outlet**.

The outlet point was created just below the branch so that only a single upstream basin was created (Figure 8). If a separate basin is desired for each upstream branch, the branching node (rather than the vertex below it) should be defined as an outlet. WMS always assumes one separate basin for each upstream branch connected to an outlet node.

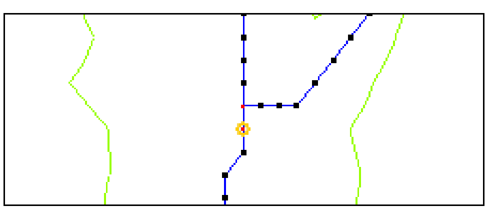


Figure 8 The new outlet point

10. **Frame** the project.
11. **Zoom** in to the location indicated by the box in Figure 9.

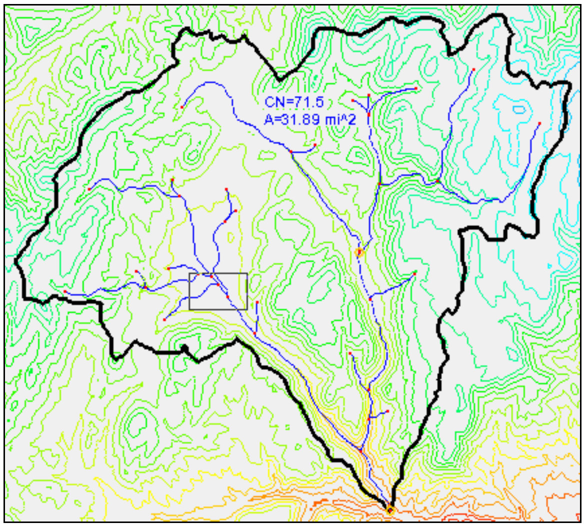


Figure 9 Zoom area for upper left sub-basin

12. Using the **Select Feature Vertex** tool, select the vertex just below the feature node where the streams branch (Figure 10).

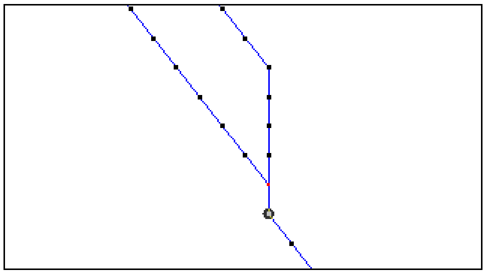


Figure 10 Select the vertex below the branch

13. Select *DEM* | **Node ↔ Outlet** to create the sub-basin outlet (Figure 11).

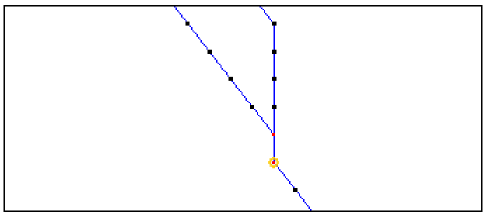


Figure 11 Outlet point for top left sub-basin

14. **Frame** the project.
15. Select *DEM* | **Delineate Basins Wizard** to bring up the *Stream Feature Arc Options* dialog.
16. Click **OK** when prompted to delete all existing feature data.
17. Click **OK** to close the *Stream Feature Arc Options* dialog and bring up the *Units* dialog.
18. Click **OK** to close the *Units* dialog, finish delineating the watershed, and compute the basin data.

The project should appear similar to Figure 12.

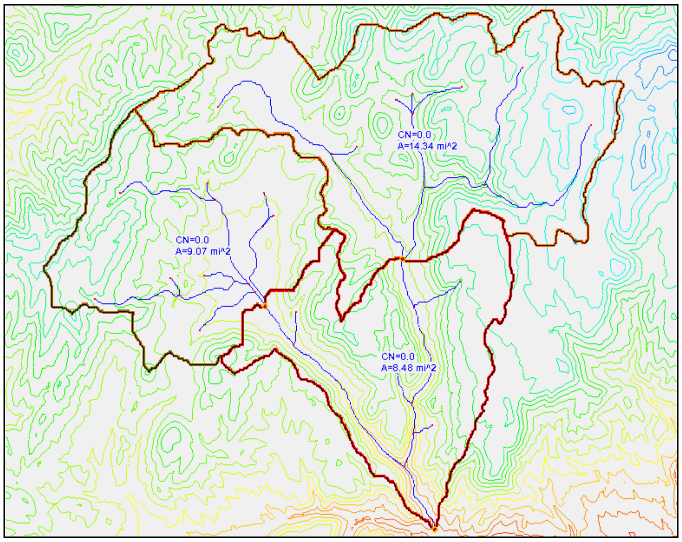


Figure 12 Three sub-basins

5.2 Updating the Basin Parameters

Now 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 update the CN values for all basins, close the *Compute GIS Attributes* dialog, and open the *View Data File* dialog. If the *Never ask this again* option was previously selected, this dialog may not appear. If this is the case, skip to step 5.
4. 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 in the desired text editor.

Notice that the CN for all three basins is similar. This is because of the dominant soil polygon that covers the watershed.

5. Once done reviewing the CN report, close the text editor and return to WMS.
6. Using the **Select Basin** tool, double-click on the upper right basin icon to bring up the *Edit HEC-1 Parameters* dialog.
7. In the *Basin HEC-1 Cards* section, click **Basin Data…** to bring up the *HEC-1 Basin Data* dialog.
8. Enter "Right" as the *Basin name* and click **OK** to close the *HEC-1 Basin Data* dialog.

The *Edit HEC-1 Parameters* dialog is non-modal (or modeless). This means it can be moved to the side so that actions can be taken in the main WMS window without closing the dialog.

9. Move the *Edit HEC-1 Parameters* dialog so all three basins are visible, then select the upper left basin icon.

Notice that the content in the *HEC-1 File Output – select to edit* section of the dialog changed when the new basin was selected. The parameters for the upper left basin can now be edited.

10. Repeat steps 7–8, entering "Left" as the *Basin name*.
11. In the main WMS window, select the lower basin icon.
12. Repeat steps 7–8, entering "CCTrib" as the *Basin name*.

Next, enter simultaneously parameters in common to all basins by selecting all the basins and applying parameters to them. This reduces the number of steps required to apply parameters to the basins.

13. In the main WMS window, select *Edit* **| Select All** to select all three basins.

Notice that the content in the *HEC-1 File Output – select to edit* section of the dialog now displays the parameters for all three basins. The parameters for the upper left basin can now be edited.

14. In the *Basin HEC-1 Cards* section of the *Edit HEC-1 Parameters* dialog, click **Precipitation…** to bring up the *HEC-1 Precipitation* dialog
15. Select *Basin Average* and enter "1.8" as the *Average precipitation*.
16. Click **Define Series** to open the *XY Series Editor* dialog.
17. On the lower right, select "typeII-24hour" from the *Selected Curve* drop-down.
18. Click **OK** to close the *XY Series Editor* dialog.
19. Click **OK** to close the *HEC-1 Precipitation* dialog.
20. Click **Unit Hydrograph Method…** to bring up the *HEC-1 Unit Hydrograph Methods* dialog.
21. Select *SCS dimensionless* and click **Compute Parameters - Basin Data** to bring up the *Basin Time Computation* dialog.
22. In the *Basin* section, select "CCTrib".
23. Select "SCS Method" from the *Method* drop-down.
24. Repeat steps 22–23 for both "Right" and "Left" in the *Basin* section.
25. Click **OK** to close the *Basin Time Computation* dialog.
26. Click **OK** to close the *HEC-1 Unit Hydrograph Methods* dialog.
27. Click **Done** to close the *Edit HEC-1 Parameters* dialog.

5.3 Setting up the Routing Parameters

If HEC-1 were to be run 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 have not yet been set. A routing method will now be defined instructing HEC-1 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 (Figure 13) to bring up the *Edit HEC-1 Parameters* dialog.

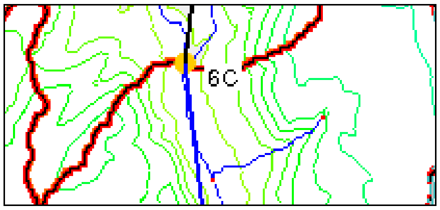


Figure 13 Upper right basin outlet 6C

2. In the *Routing HEC-1 Cards* section, click **Routing Data…** to bring up the *HEC-1 Routing Data* dialog.
3. Select "Muskingum-Cunge (RD)" from the *Routing type* drop-down.
4. In the *Normal Muskingum Cunge parameters* section, enter "5.0" as the *WD*.

The means it will be five feet wide.

5. Enter "1.0" as the *Z*.

This is the side slope, giving it a 1:1 side slope.

6. Enter "0.05" as the *N*.

This is the Manning's roughness. This indicates the surface is fairly rough in order to exaggerate the routing effects for this tutorial.

7. Click **OK** to close the *HEC-1 Routing Data* dialog.
8. In the main WMS window, select the upper left basin outlet (Figure 14).
9. In the *Edit HEC-1 Parameters* dialog, repeat steps 2–7.
10. Click **Done** to close the *Edit HEC-1 Parameters* dialog.

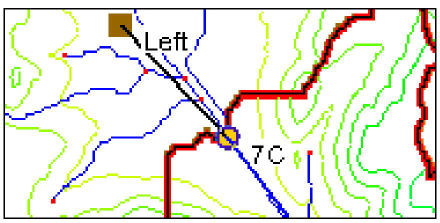


Figure 14 Upper left basin outlet 7C

5.4 Running HEC-1

Everything has now been defined to run a three basin HEC-1 analysis that includes routing the upper basins through the reaches connecting them to the watershed outlet.

1. Select *HEC-1* | **Run Simulation…** to bring up the *HEC-1 Run Options* dialog.
2. Below *Input file*, click to bring up the *Select HEC-1 Input File* dialog.
3. Select "HEC-1 Files (*.hc1)" from the *Save as type* drop-down.
4. Enter "Routing.hc1" as the *File name* and click **Save** to close the *Select HEC-1 Input File* dialog.

5. Turn on *Save file before run* and click **OK** to close the *HEC-1 Run Options* dialog and open the *Model Wrapper* dialog.
6. Once HEC-1 finishes running, turn on Read solution on exit.
7. Click **Close** to import the solution and close the *Model Wrapper* dialog.
8. Using the **Select Hydrograph** tool while holding down the *Shift* key, select all of the hydrograph icons, double-clicking on the last one to bring up the Hydrograph dialog.

All hydrographs should appear together in the Hydrograph dialog (Figure 15). Resize hydrograph window and review the hydrographs if desired.

9. Close the *Hydrograph* dialog by clicking in the upper right corner of the window.

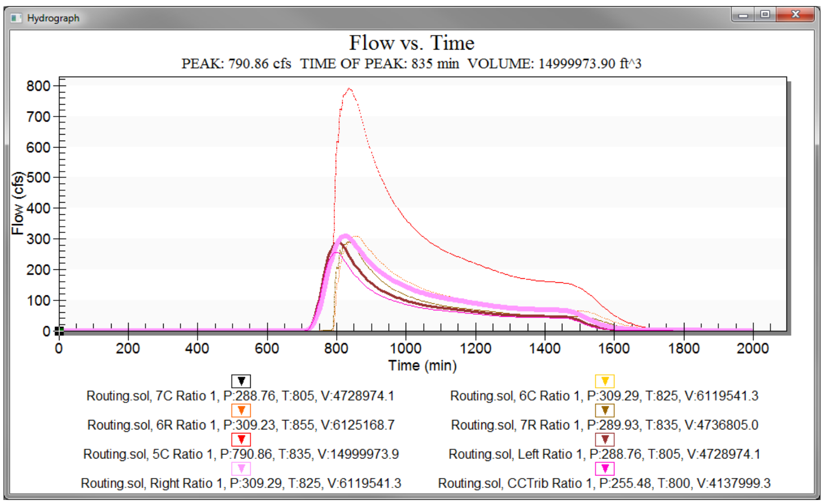


Figure 15 Hydrographs

6 Modeling a Reservoir in HEC-1

There is an existing small reservoir 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-1 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. Therefore, the outlet must be defined as a reservoir so that the hydrograph can be routed through the reservoir before routing it downstream.

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

Notice that the icon for the outlet changed to a blue triangle, indicating it is now a reservoir (Figure 16).

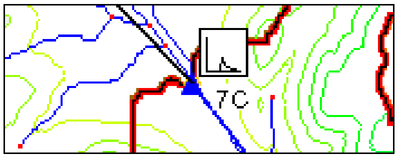


Figure 16 Reservoir indicated by a blue triangle

6.2 Setting up the Reservoir Routing Parameters

In order to define reservoir routing with HEC-1, elevation vs. storage (storage capacity curve) and elevation vs. discharge rating curves must be defined. Values can be entered directly, or hydraulic structures can be entered and the values computed. In this tutorial, enter the values directly. Use the same elevation values for both curves (this is common, but not a requirement in HEC-1).

For this tutorial, no outflow is desired until the elevation in the reservoir reaches the spillway. Since HEC-1 linearly interpolates between consecutive points on the elevation-discharge and elevation-volume curves, enter two points on the curves at essentially the same elevation (6821.99 ft and 6822 ft) with the first having no outflow and the second having the discharge over the spillway (640 cfs) as defined for this dam.

1. Using the **Select Outlet** tool, double-click on the reservoir outlet point to bring up the *Edit HEC-1 Parameters* dialog.
2. In the *Routing HEC-1 Cards* section, click **Reservoir Data…** to bring up the *Reservoir Routing Data* dialog.
3. Enter "Tcreek" as the *Reservoir name*.
4. Select *Reservoir* under *Type of storage routing*.
5. Click **Define** to bring up the *HEC-1 Reservoir Routing Options* dialog.
6. In the *Volume* section, select *Known volume* and turn on *SV* and *SE*.

This section allows defining of the reservoir storage capacity by entering elevations and their corresponding volumes.

7. Click **Define** the right of *SV* to bring up the *XY Series Editor* dialog.

Separate XY series for volumes, elevations, and discharges will now be defined using this dialog.

8. At the bottom right, click **New** to create a new curve.
9. Enter "Volume" as the *Curve Name*.
10. In an external spreadsheet program, open the "reservoir.xls" file found in the *hec1\hec1* directory.
11. Copy the numbered contents in the "Outflow".
12. 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**.

The copied numbers should now be on rows *1-7* in the *Volume (ac-ft)* column.

13. *Shift*-select rows *8* through *20* in the *Volume (ac-ft)* column and **Delete** them.

The values for those rows should change from "0.0" to blank.

14. Click **OK** to close the *XY Series Editor* dialog.
15. Click **Define** to the right of *SE* to bring up the *XY Series Editor* dialog.
16. Using the numbers in the “Elevation” column in the external “reservoir.xls” spreadsheet, repeat steps 8–14. Use “Elevation” as the *Curve Name* in step 9.
17. In the *Outflow* section, select *Known outflow* and turn on *SQ* and *SE*.
18. Click **Define** to the right of *SQ* to bring up the *XY Series Editor* dialog.
19. Using the numbers in the “Discharge” column in the external “reservoir.xls” spreadsheet, repeat steps 8–14. Use “Discharge” as the *Curve Name* in step 9.
20. In the *Outflow* section, click **Define** to the right of *SE* to bring up the *XY Series Editor* dialog.

Rather than creating a new curve, use the previously defined elevation curve.

21. Select “Elevation” from the *Selected Curve* drop-down.
22. Click **OK** to close the *XY Series Editor* dialog.

Clicking Plot SQ-SE or Plot SV-SE generates a elevation-discharge or elevation-volume curves (respectively) in a separate *HEC Plot* dialog. This curve can be exported, printed, or controlled in the same way as a hydrograph or any other plot in a plot window.

23. Click **OK** to close the *HEC-1 Reservoir Routing Options* window.

The last input needed to define reservoir routing is the initial condition type of the reservoir, defined as an elevation, a discharge, or a volume. Using the data just entered, HEC-1 can determine the initial condition of the other two. For this tutorial, set the initial condition as an elevation four feet below the top of the spillway (which has an elevation of “6822.0”).

24. Under *Initial condition type*, select *ELEV*.
25. Enter “6818.0” as the *RSVRIC* (reservoir initial condition).
26. Click **OK** to close the *Reservoir Routing Data* dialog.
27. Click **Done** to close the *Edit HEC-1 Parameters* dialog.

6.3 Running HEC-1

At this point, save and run the HEC-1 file with the defined reservoir.

1. Select *HEC-1* **| Run Simulation…** to bring up the *HEC-1 Run Options* dialog.
2. Under *Input file*, click to open the *Select HEC-1 Input File* dialog.
3. Select “HEC-1 Files (*.hc1)” from the *Save as type* drop-down.
4. Enter “Reservoir.hc1” as the *File name* and click **Save** to close the *Select HEC-1 Input File* dialog.
5. Turn on *Save file before run* and click **OK** to close the *HEC-1 Run Options* dialog and open the *Model Wrapper* dialog.
6. Once HEC-1 is finished, turn on *Read solution on exit* and click **Close** to import the solutions and close the *Model Wrapper* dialog.

7. Use the **Select Hydrograph**  while pressing the *Shift* key to select all of the hydrographs, double-clicking on the last one to open the *Hydrograph* dialog (Figure 17).
8. Close all *Hydrograph* dialogs once done reviewing them.

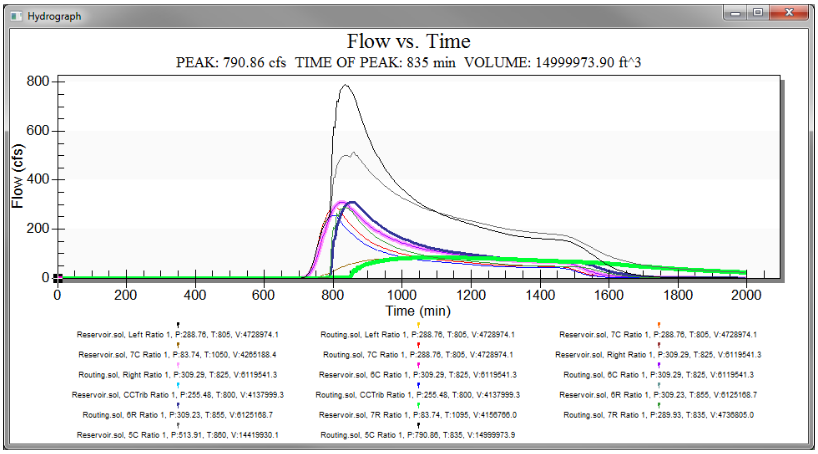


Figure 17 Hydrographs with reservoir

7 Reviewing Output

While WMS makes it easy to set up a HEC-1 model and compute a result, it is not a substitute for understanding the basic theory and equations used in HEC-1. For further detail and information, consult texts on hydrologic modeling and read the HEC-1 manual found in the documents directory distributed with WMS.

An HEC-1 output file is also generated with each simulation. Review it in order to better understand how the model works.

1. Select *File* | **Edit File…** to bring up the *Open* dialog.
2. Select “reservoir.out” and click **Open** to exit the *Open* dialog and open the *View Data File* dialog. If the *Never ask this again* option was previously checked, this dialog will not appear. If this is the case, skip to step 4.
3. Select the desired text editor from the *Open With* drop-down and click **OK** to close the *View Data File* dialog and open the output file in the desired text editor.
4. Review the file to understand what information HEC-1 saves to the output file.

If there are errors running HEC-1 simulations, the reasons for the errors are often recorded within the OUT file.

5. When finished reviewing the OUT file, close the text editor.

8 Conclusion

This concludes the “Watershed Modeling – HEC-1 Interface” tutorial. The key concepts discussed and demonstrated include:

- Entering job control parameters

- Defining basin parameters such as loss rates, precipitation, and hydrograph methodology a watershed analysis
- Defining routing parameters
- Routing a hydrograph through a reservoir
- Saving HEC-1 input files
- Reading hydrograph results

