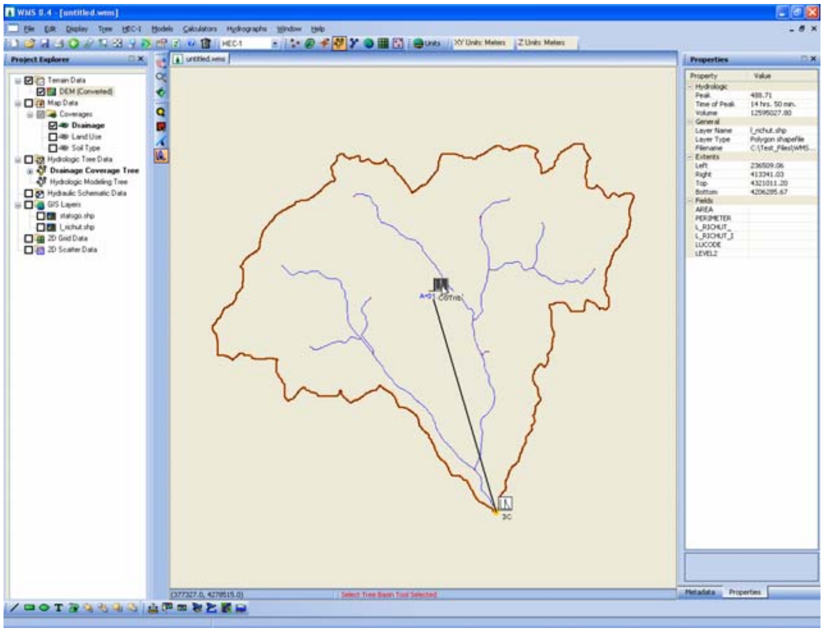
v. 8.4

WMS 8.4 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 your HEC-1 model. Divide your 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

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1 Contents

2 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, you are encouraged 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.

3 Objectives

As a review, you will delineate a watershed from a DEM. You will 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 HEC-1 model, other variations will be developed, including defining multiple basins with reach routing and including a reservoir with storage routing.

4 Delineating the Watershed

Since the land use, soil type, and DEM data for our watershed all originate in the Geographic coordinate system, we will begin by opening them together and converting them to UTM coordinates. The land use and soil type data were downloaded from the Environmental Protection Agency (EPA) website. The DEM data used for this watershed were previously downloaded from the National Elevation Dataset website as was demonstrated in the DEM Basics exercise (Volume 1, chapter 4).

1. Close all instances of WMS
2. Open WMS
3. Select ***File* | *Open***
4. Locate the folder ***C:\Program Files\WMS84\tutorial\hec-1***
5. Select *NED GRIDFLOAT Header (*.hdr)* from the Files of type list of file filters
6. Open *"67845267.hdr"*
7. Select *OK*
8. When prompted if you want to convert the current coordinates select *No*

4.1 Create Land Use and Soil Coverages

1. Right-click on the Coverages folder in the Project Explorer
2. Select ***New Coverage***
3. Change the coverage type to *Land Use*
4. Select *OK*
5. Create a new coverage once again and set its coverage type to *Soil Type*

4.2 Open the Soils Data

1. Make sure the *Soil Type* coverage is active in the Project Explorer
2. Right-click on *GIS layers* in the Project Explorer and select ***Add Shapefile Data***
3. Open *"statsgo.shp"*
4. If a dialog appears regarding coordinate conversion select ***No***

5. Right-click on *statsgo.shp* layer in the Project Explorer
6. Select ***Open Attribute Table***

Notice that the table has three fields named AREA, PERIMETER, and MUID

7. Select *OK*

4.3 Join Soils Database File Table to Shapefile Table

1. Right-click on *statsgo.shp* in the Project Explorer
2. Select ***Join Table to Layer***
3. Open *"statsgoc.dbf"*
4. Ensure that Shapefile Join Field and Table Join Field are both set to *MUID*
5. Change the Table Data Field to *HYDGRP*
6. Select *OK*
7. Right-click on *statsgo.shp* in the Project Explorer
8. Select ***Open Attribute Table***

Notice that the HYDGRP field is now a part of the shapefile.

9. Select *OK*

4.4 Convert Soil Shapefile Data to Feature Objects

1. Choose the *Select Shapes* tool 
2. Draw a selection box around the DEM extents
3. Select ***Mapping* | *Shapes -> Feature Objects***
4. Select *Next*

This window shows all of the attribute fields in the soils shape file. Because this file was derived from a standard NRCS statsgo file you will notice that the hydrologic soil groups field is named HYDGRP and so WMS will automatically map this to be the soil type. If the attribute field were named anything other than HYDGRP then you would have to manually map it using the drop down list in the spreadsheet.

5. Make sure the HYDGRP field is mapped to the SCS soil type attribute
6. Select *Next*
7. Select *Finish*
8. Clear the selected polygons by single-clicking somewhere beyond the extents of the shapefile polygons
9. Hide the *statsgo.shp* file by toggling off its check box in the Project Explorer

4.5 Open the Land Use Data

1. Select the *Land Use* coverage in the Project Explorer to designate it as the active coverage
2. Right-click on *GIS layers* in the Project Explorer and select ***Add Shapefile Data***
3. Open *"l_richut.shp"*
4. Choose the *Select Shapes* tool
5. Draw a selection box around the DEM extents
6. Select ***Mapping | Shapes -> Feature Objects***
7. Select *Next*
8. Make sure the LUCODE field is mapped to the Land use attribute
9. Select *Next*
10. Select *Finish*
11. Hide the *l_richut.shp* file by toggling off its check box in the Project Explorer

4.6 Convert/Set the Coordinate System of the Data

1. Right-click on *Terrain Data* in the Project Explorer and select ***Coordinate Conversion***
2. In the *Current Projection* section of the *Reproject Current* dialog, select *Specify*
3. Select *Global Projection* in the *Current Projection* Section.
4. Select *Set Projection* in the *Current Projection* Section
5. Set *Projection* to *Geographic*, and *Datum* to *NAD 83*
6. Select *OK*
7. Set the Vertical *Projection* to *NAVD 88(US)* and the vertical units to *Meters*
8. Select *Global Projection* in the *New Projection* Section.
9. Select *Set Projection*, in the *New Projection* section.
10. Set *Projection* to *UTM*, *Datum* to *NAD83*, *Planar Units* to *METERS*, and *Zone* to *12 (114°W - 108°W – Northern Hemisphere)*
11. Select *OK*
12. Set the Vertical *Projection* to *NAVD 88(US)* and the vertical units to *Meters*
13. Click OK
14. Since we will not be using them until later, hide the *Land Use* and *Soil Type* coverages by toggling off their check boxes in the Project Explorer

15. Select the *Drainage* coverage from the Project Explorer to make sure it is the active coverage

4.7 Delineate the Watershed

1. Select the *Drainage* module
2. Select the *Frame* macro
3. Select ***DEM* | *Compute Flow Direction/Accumulation***
4. Select *OK*
5. Select *OK* in the Units dialog
6. Select *Close* once TOPAZ finishes running (you may have to wait a few seconds to a minute or so)
7. Select the *Zoom* tool
8. Zoom in by dragging a box as illustrated in Figure 4-1

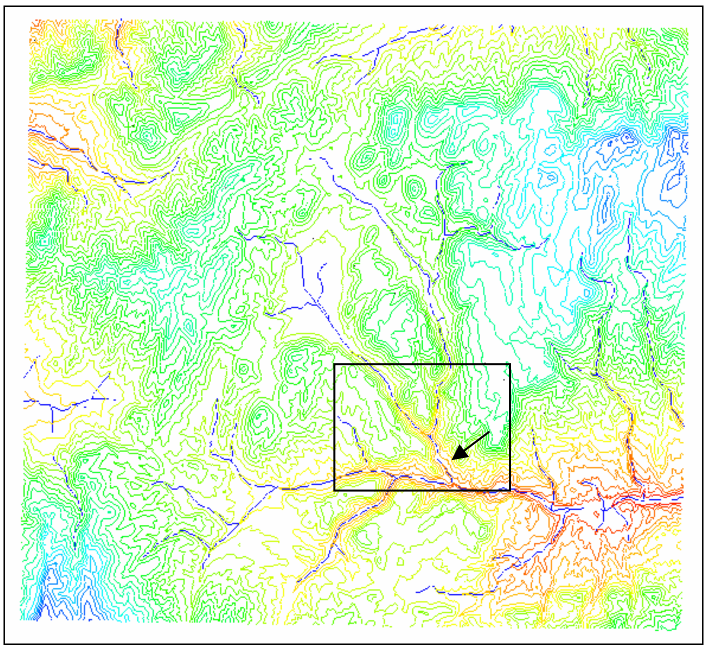


Figure 4-1: Zoom in on the area bounded by the rectangle above

9. Select the *Create Outlet Point* tool
10. Create a new outlet point where the tributary you just zoomed in on separates from the main stream as illustrated by the arrow in Figure 4-1. Make certain that the outlet point is on the tributary and not part of the main stream. Also, the outlet needs to be inside one of the flow accumulation (blue) cells. WMS will move the outlet to the nearest flow accumulation cell if you do not click right in one of the flow accumulations cells.
11. Select the *Frame* macro
12. Select ***DEM* | *Delineate Basins Wizard***

13. Select ***Delineate Watershed***
14. Select *Close*

You have now completed the delineation of a single watershed. In order to make the view clearer for defining the hydrologic model you can turn off many of the DEM and other display options.

15. Right-click on DEM in the Project Explorer and select ***Display Options***
16. On the DEM tab, toggle off the display for *Watershed*, *Stream*, *Flow Accumulation*, and *DEM Contours*
17. On the Map tab, toggle *Vertices* off
18. Select *OK*

5 Single Basin Analysis

The first simulation will be defined for a single basin. You will need to enter the global, or Job Control parameters as well as the rainfall event, loss method, and unit hydrograph method.

5.1 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. Switch to the *Hydrologic Modeling* module
2. HEC-1 should be the default model, but if it is not select it from the drop down list of models found in the Edit Window
3. Select ***HEC-1 | Job Control***
4. The first three lines are for comments/identification at the top of the HEC-1 input file. The first line already has information indicating that the input file is generated by WMS (you can change this if you want). Enter "*Clear Creek Tributary Watershed*" for the second ID line. Enter your name and current date in the third line.
5. Leave the Day, Month, and Year fields alone

HEC-1 allows you to enter a date, but almost always you are simulating some kind of hypothetical or design storm and not an actual storm. If you change the simulation date you will need to be careful to make sure the storm date is in synch, but if you leave it alone, there will not be a problem.

6. Enter **5** (minutes) for the Computation time interval, and **300** for the Number of hydrograph ordinates. Leave the Beginning time at **0**.

An HEC-1 simulation will run for a length of time equal to the time step multiplied by the number of ordinates. If you are simulating a 24-hr storm but only run the simulation for 12 hours you will not capture the full hydrograph. Conversely, if you run a 24-hr simulation for 96-hrs you are probably going to have a lot of runoff ordinates equal to 0 at the end. In this case we are running the simulation for 1500 minutes (slightly more than 24 hours) with an ordinate on the hydrograph being computed for every 5 minutes.

7. Set the computation units to *English units* (this should be the default)

Setting the computation units DOES NOT cause any units conversion to take place. You are simply telling HEC-1 that you will provide input units 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 you specify Metric then you must ensure that input units are metric (sq. kilometers, mm for rain, meters/kilometers for length) and results will be in metric (cms).

8. Select *OK*

For now we will leave the other Job Control settings at their default values.

5.2 Setting up the Basin Data Parameters

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

1. Select the *Select Basin* tool 
2. Double-click on the brown basin icon labeled 1B. Double-clicking on a basin or outlet icon always brings up the parameter editor dialog for the current model (in this case HEC-1)
3. Select the *Basin Data* button
4. Notice that the area has been calculated (in this case in sq. miles because we are performing calculations in English units)
5. Change the name to *CCTrib*. HEC-1 will only use the first SIX characters so do not use names longer than six characters for basins or outlets.
6. Select *OK*
7. Select the *Precipitation* button
8. Select the *Basin Average* option
9. Enter **1.8** (inches) for the Average precipitation depth
10. Select the *Define Series* button

In order to simulate a rainfall event you must enter both a rainfall depth and a temporal distribution. The SCS uses standard time distributions for different areas of the U.S. These are stored in WMS. You could also define your own series according to an actual storm, or a design storm from a regulating agency.

11. In the Selected Curve drop down list select the *typeII-24hour* curve
12. Select *OK*
13. Select *OK*
14. Select the *Loss Method* button
15. Enter a Curve Number (CRVNBR field) of **70**. We will compute a CN value from actual land use and soil files later.
16. Select *OK*

17. Select the *Unit Hydrograph Method* button
18. Make sure the *SCS dimensionless* option is chosen (it is the default)
19. Select the *Compute Parameters - Basin Data* button
20. Set the Computation Type to *Compute Lag Time* (the default)
21. Set the Method drop down list to *SCS Method* (near the bottom of the list)
22. Select *OK* to update the computed lag time for the SCS dimensionless method
23. Select *OK*
24. Select *Done*

You now have all of the parameters set to run a single basin analysis.

5.3 Running HEC-1

Whenever you run a HEC-1 simulation, WMS will first save a standard HEC-1 input file. You will also be prompted for the name of an output file and a solutions file. The output file is the standard text output file generated by HEC-1 and the solution file is a plot file that contains the hydrographs formatted in a way that makes it easy for WMS to read and plot (it is actually the HEC-1 TAPE22 file).

1. Select ***HEC-1 | Run Simulation***
2. Click the browse button next to the Input File
3. For the file name enter "*CCTrib*" and click *Save* (this specifies the file name but does not actually save it)
4. Verify that the *Save file before run* is toggled on
5. Select *OK*
6. Select *Close* once HEC-1 finishes running (you may have to wait a few seconds to a minute or so)

The solutions will automatically be read in and you should see a small hydrograph plot to the upper right of the Basin icon (now labeled as CCTrib).

7. Double-click on the hydrograph icon.

A plot window will appear with the hydrograph. You will see that the hydrograph suddenly stops at 1500 minutes (the duration of the simulation as established in the Job Control dialog), but the simulation obviously has not run to completion.

8. Close the plot window by selecting the X in the upper right corner of the window
9. Select ***Hydrographs | Delete All***
10. Select ***HEC-1 | Job Control***
11. Set the Number of hydrograph ordinates to be **400**
12. Select *OK*
13. Select ***HEC-1 | Run Simulation***

14. Select *OK* (you can let it overwrite the other files)
15. Select *Close* once HEC-1 finishes running (you may have to wait a few seconds to a minute or so)
16. Double-click on the hydrograph icon

You now have a completed HEC-1 simulation for a single basin and the resulting hydrograph should look something like the solution shown in Figure 5-1.

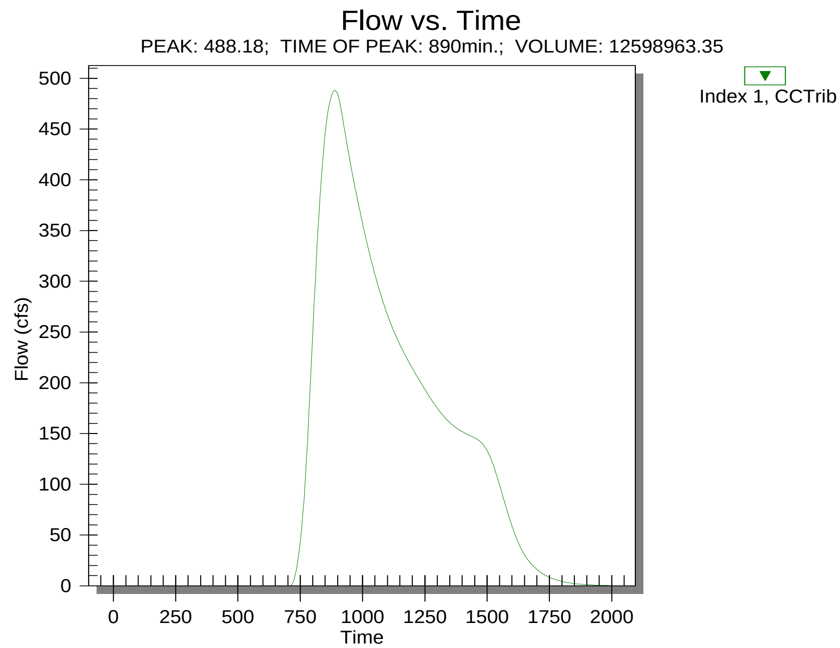


Figure 5-1: Solution hydrograph for HEC-1 simulation

17. Close the hydrograph window by selecting the X in the upper right of the window

6 Computing the CN Using Land Use and Soils Data

In the initial simulation you estimated a CN, 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 exercise (Volume 1, chapter 6), but you will go through the steps here as a review.

6.1 Computing a Composite CN

In addition to the digital land use and soils file that overlap the watershed, you must have a table defined that identifies CN values for each of the four different hydrologic soil groups (A, B, C, D). This is described in detail at the gsda website (http://www.xmswiki.com/wiki/GSDA:GSDA), and in the Advanced Feature Objects exercise (Volume 1, chapter 6). For this exercise you will read in an existing file (you can examine it in a text editor if you wish) and compute the CN numbers.

1. Select the *Hydrologic Modeling* module

2. Select ***Calculators | Compute GIS Attributes***
3. Select the *Import* button to load the mapping table
4. Select *OK* to overwrite the current definition
5. Find and open the file named *"scsland.tbl"*
6. Select *OK* to compute the CN from the land use and soils layers

You should find that CN computed from the land use and soils digital data is about 72 or 73. While there is still some "judgment" required in setting up the mapping table, there is a lot more justification for this value than the one previously estimated.

7. Close the Curve Number Report

6.2 Running HEC-1

You can now run another simulation to compare the results with the modified CN value.

1. Select ***HEC-1 | Run Simulation***
2. Select *OK* (it is fine to overwrite the existing files, but you can change the file names if you want)
3. Select *Close* once HEC-1 finishes running (you may have to wait a few seconds to a minute or so)
4. Double-click on the hydrograph icon to plot both the old and the new hydrograph in a plot window

With the increased CN value you should see that the resulting hydrograph peaks higher (more runoff). The peak should be about 600 cfs rather than the 500 cfs that was generated with a CN value of 70.

5. Close the hydrograph window by selecting the X in the upper right corner of the window.
6. Select ***Hydrographs | Delete All***

7 Adding Sub-basins and Routing

You will now 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.

7.1 Delineating the Sub-basin

1. Select the *Drainage* module 
2. Select the *Zoom* tool 
3. Create a zoom box around the region identified by a box in Figure 7-1

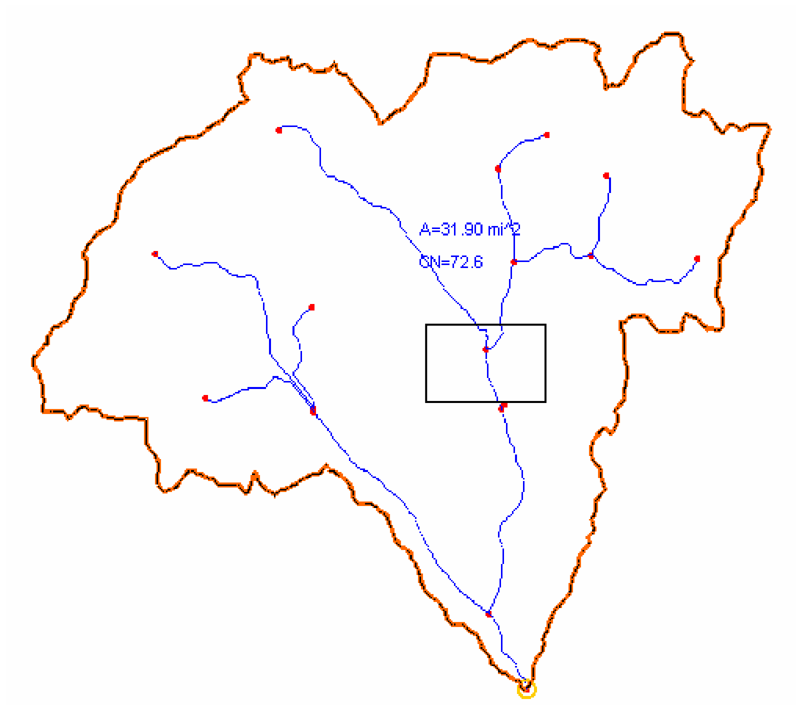
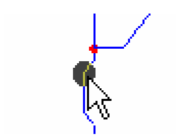


Figure 7-1: Zoom in on the area indicated by the rectangle.

4. Select ***Display* | *Display Options***
5. On the Map tab toggle on *Vertices*
6. Select *OK*
7. Select the *Select Feature Vertex* tool



8. Select the vertex that is just below the main branching point you just zoomed in around
9. Select ***DEM* | *Node* <-> *Outlet***

You created the outlet point just below the branch in order to have a single upstream basin. If you wanted a separate basin for each upstream branch you could define the branching node to be an outlet. Thus, WMS would automatically assume that you want separate basins for each branch, so we have created a node just downstream of the branch and defined it as the outlet for the upper basin.

10. Select the *Frame* macro
11. Select the *Zoom* tool
12. Create a zoom box around the region identified by a box in Figure 7-2

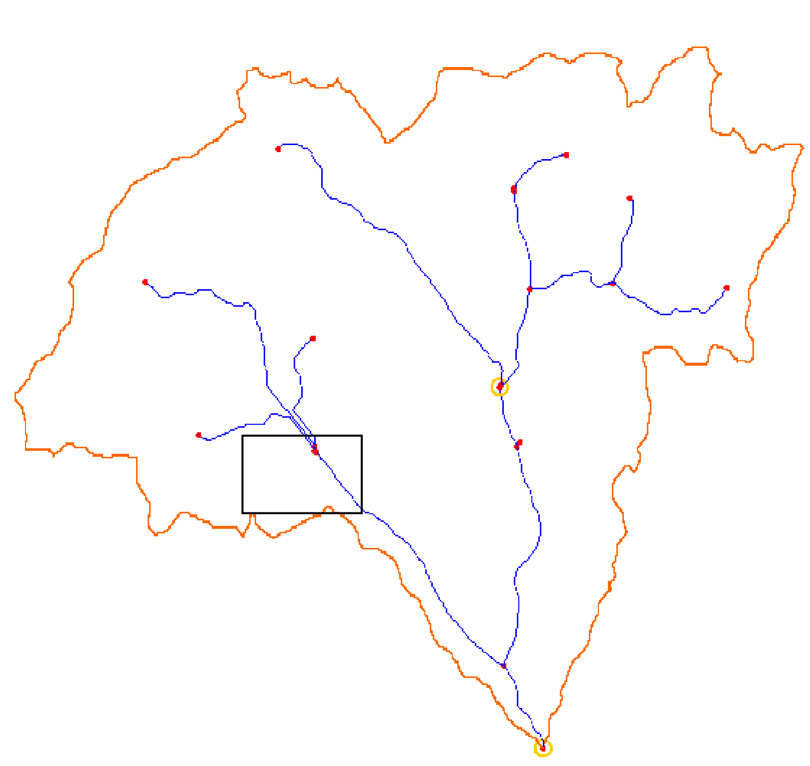
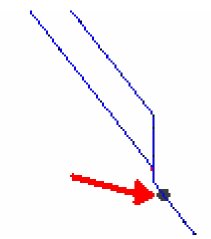


Figure 7-2: Zoom in on the area indicated by the rectangle

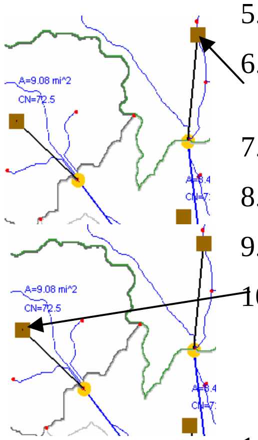


13. Select the *Select Feature Vertex* tool
14. Select the vertex that is just below the feature node where the streams branch
15. Select ***DEM* | *Node*** <-> ***Outlet***
16. Select the *Frame* macro
17. Select ***DEM* | *Delineate Basins Wizard***
18. Select *Delineate Watershed*
19. Select *OK*
20. Select *Close*

7.2 Updating the Basin Parameters

You will have to recompute the CN values and define precipitation and lag time for the basins.

1. Select the *Hydrologic Modeling* module
2. Select ***Calculators* | *Compute GIS Attributes***
3. Select *OK* and the CN values will be updated for all basins (they are actually very similar in this case because of the dominant soil polygon that covers the watershed)
4. Close the Curve Number Report



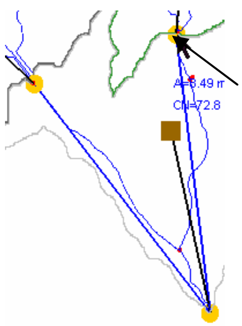
5. Select the *Select Basin* tool
6. Double-click on the upper right basin icon to bring up the Edit HEC-1 Parameters dialog
7. Select the *Basin Data* button
8. Change the name to *Right*
9. Select *OK*
10. Move the Edit HEC-1 Parameters dialog out of the way, if necessary, and click on the upper left basin icon to edit parameters for the upper left basin. Alternatively, you could select *Done* and then double-click on a basin to obtain the Edit HEC-1 Parameters dialog.
11. Select the *Basin Data* button
12. Change the name to *Left*
13. Select *OK*
14. Move the Edit HEC-1 Parameters dialog out of the way, if necessary, and click on the lower basin icon to edit parameters for the lower basin
15. Select the *Basin Data* button
16. Change the name to *CCTrib*
17. Select *OK*
18. Select *Done*
19. Select ***Edit | Select All*** to select all basins
20. Select ***HEC-1 | Edit Parameters*** to edit parameters for all basins at once
21. Select the *Precipitation* button
22. Select the *Basin Average* option
23. Set the Average Precipitation to be **1.8** in
24. Select the *Define Series* button
25. Choose the *typeII-24hour* curve in the Selected Curve drop down list
26. Select *OK*
27. Select *OK*
28. Select the *Unit Hydrograph Method* button
29. Make sure the *SCS dimensionless* option is chosen (it is the default)
30. Select the *Compute Parameters - Basin Data* button
31. Select *CCTrib* in the Basin window so that it is highlighted
32. Select the method to be *SCS Method* (near the bottom of the list)
33. Select *Right* in the Basin window so that it is highlighted
34. Select the Method to be *SCS Method* (near the bottom of the list)
35. Select *Left* in the Basin window so that it is highlighted

36. Select the method to be *SCS Method* (near the bottom of the list)
37. Select *OK*
38. Select *OK*
39. Select *Done*

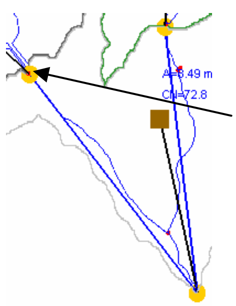
7.3 Setting up the Routing Parameters

If you were to run HEC-1 now (you can if you want), you would see that the hydrographs from the upper basins would be combined with the lower basin hydrograph at the watershed outlet without any lag or attenuation because you have not yet set the routing parameters. You will now define a routing method, which will instruct 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. Select the *Select Outlet* tool
2. Double-click on the outlet (the yellow circle icon) of the upper right basin
3. Select the *Routing Data* button
4. Select the *Muskingum-Cunge* method for routing
5. Set the width (WD) field to be **5** (five feet wide)
6. Set the side slope value (Z) to be **1** (1:1 side slope)
7. Set the Manning's roughness (N) to be **0.05** (this is fairly rough, but we want to exaggerate the routing effects for this exercise)



8. Select *OK*
9. Select *Done*
10. Double-click on the outlet of the upper left basin
11. Select the *Routing Data* button
12. Select the *Muskingum-Cunge* method for routing
13. Set the width (WD) field to be **5**
14. Set the side slope value (Z) to be **1**
15. Set the Manning's roughness (N) to be **0.05**
16. Select *OK*
17. Select *Done*

7.4 Running HEC-1

You now have everything 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***
2. Click the browse button next to the Input File

3. For the file name enter "*Routing*" and click *Save* (this specifies the file name but does not actually save it)
4. Verify that the *Save file before run* is toggled on
5. Select *OK*
6. Select *Close* once HEC-1 finishes running (you may have to wait a few seconds to a minute or so)
7. While holding the SHIFT key down, select all of the hydrograph icons, double-clicking on the last one so that all hydrographs are drawn in the same plot window
8. Close the plot window by selecting the X in the upper right corner

8 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.

8.1 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. However, in this case we are already using Muskingum-Cunge ng to move the hydrograph through the reach connecting the upper left basin to the rshed outlet so we must define the outlet as a reservoir so that we can route the ograph through the reservoir before routing it downstream.

1. Select the *Select Outlet* tool
2. Select the outlet of the upper left basin
3. Right-click on the outlet you have just selected and select ***Add | Reservoir***

8.2 Setting up the Reservoir Routing Parameters

In order to define reservoir routing with HEC-1 you must define elevation vs. storage (storage capacity curve) and elevation vs. discharge rating curves. You can enter values directly, or enter hydraulic structures and compute the values, but in this exercise you will enter the values directly. You will use the same elevation values for both curves (this is common, but not a requirement in HEC-1).

For this example we want to have no outflow 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 we will "trick" it by entering 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. Double-click on the reservoir outlet point (it is now represented as a triangle since you have defined a reservoir at this location)
2. Select the *Reservoir Data* button
3. Change the Reservoir name to *Tcreek*

4. Set the Type of storage routing to *Reservoir*
5. Select the *Define* button to the right of the reservoir option
6. On the right side of this dialog you will define the Volume or storage capacity data. Choose the *Known Volume* option.
7. Toggle on the check boxes for *SV* (Volumes) and *SE* (Elevations)
8. Select the *Define* button to the right of the SV option

You will define separate XY series for Volumes, Elevations, and Discharges using the XY Series editor.

9. Select *New*
10. Change the name of the new curve to *"Volume"*
11. In the first seven edit fields enter the values **0**, **200**, **410**, **650**, **1000**, **1000**, **1540** (acre-ft of volume), as shown in Figure 8-1
12. Select the 8th through 20th edit fields and select the DELETE key so that the values are blank rather than zero. You can select them all at once (the way you do in a spreadsheet since this dialog behaves like a spreadsheet) by clicking in the top and while holding the mouse button down dragging to the last, or you can select one at a time.

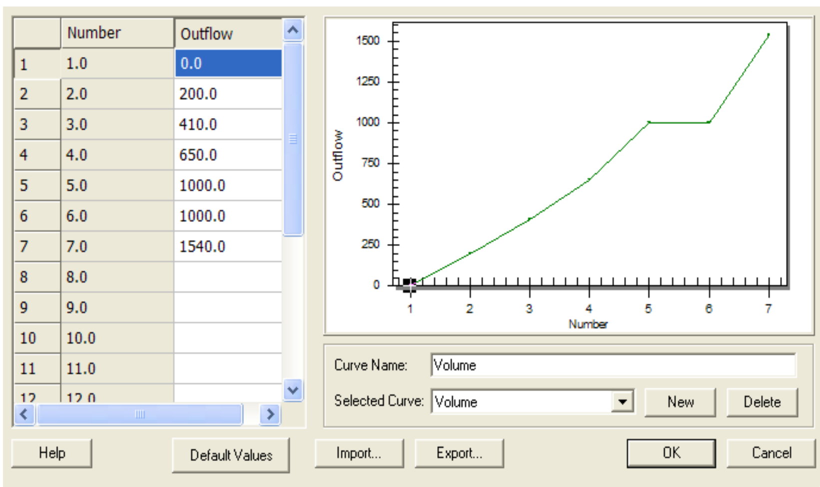


Figure 8-1: The XY Series editor for inputting volumes.

13. Select *OK*
14. Select the *Define* button to the right of the SE option
15. Select *New*
16. Change the name of the new curve to *"Elevation"*
17. In the first seven entry fields enter the following values: **6803**, **6808**, **6813**, **6818**, **6821.99**, **6822**, **6825** (feet of elevation)
18. Set the 8th through 20th fields blank instead of zero as with the volume series
19. Select *OK*

20. On the left side of this dialog you will define the Outflow or elevation - discharge data. Choose the *Known Outflow* option.
21. Toggle on the check boxes for *SQ* (Discharges) and *SE* (Elevations)
22. Select the *Define* button to the right of the SQ option
23. Select *New*
24. Change the name of the new curve to *"Discharge"*
25. In the first seven entry fields enter the following values: **0**, **0**, **0**, **0**, **640**, **640**, **7000** (cubic feet per second of flow). There is no outflow until the water reaches the spillway.
26. Set the 8^{th} through 20^{th} fields blank instead of zero as with the volume series
27. Select *OK*
28. Select the *Define* button to the right of the SE option

This time rather than creating a new curve you will select the elevation curve previously defined for the storage capacity curve.

29. Select the *Elevation* curve from the Selected Curve drop down list
30. Select *OK*

If you would like you may plot either the elevation-discharge or the elevation-volume curves by selecting the *Plot SQ-SE* or *Plot SV-SE* buttons. This will bring the curve into a plot window that you can export, print, or control the same way you can a hydrograph or any other plot in a plot window.

31. Select *OK*

The last thing you need to input to define reservoir routing is the initial conditions of the reservoir. The initial condition can be defined as an elevation, a discharge, or a volume (with the data you just entered HEC-1 can determine the initial condition of the other two based on the one you enter). For this example we will set the initial condition to an elevation four feet below the top of the spillway (the spillway corresponds to elevation 6822).

32. Under the Initial Condition Type select the *ELEV* option
33. Set the RSVRIC (reservoir initial condition) to be **6818**
34. Select *OK*
35. Select *Done*

8.3 Running HEC-1

You are now ready to save and run the HEC-1 file with the defined reservoir.

1. Select ***HEC-1 | Run Simulation***
2. Click the browse button next to the Input File
3. For the file name enter "Reservoir" and click *Save* (this specifies the file name but does not actually save it)

4. Verify that the *Save file before run* is toggled on
5. Select *OK*
6. Ensure that *Read solution on exit* is selected and select *Close* once HEC-1 finishes running (you may have to wait a few seconds to a minute or so)
7. After HEC-1 runs you can open any (or multiple within the same plot window by holding down the SHIFT key to multi-select) of the hydrographs by double-clicking on the corresponding icon.
8. Close all plot windows before moving on

9 Reviewing Output

It should be emphasized here that 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. You are encouraged to read the HEC-1 manual found in the documents directory distributed with WMS and other texts on hydrologic modeling. You are also encouraged to review the HEC-1 output file that is generated with each simulation in order to glean more understanding about how your model is working.

1. Select ***File | Edit File***
2. Find and open the file named *“reservoir.out”*
3. Select *OK* to open the file with Notepad
4. Scroll through this file and examine what information HEC-1 saves to the output file. If you have errors running HEC-1 simulations you may often find the answer to the problem within the *.out output file.

10 Conclusion

This concludes the exercise defining HEC-1 files and displaying hydrographs. The concepts learned include the following:

- 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