Objectives
Define an urban watershed for an area of interest in Maricopa County. Build an HEC-1 simulation and run this simulation based on both existing and proposed land use conditions to determine the impact of land use changes on the watershed hydrograph.

Prerequisite Tutorials
- Watershed Modeling – HEC-1 Interface
- Watershed Modeling – Advanced DEM Delineation Techniques

Required Components
- Data
- Drainage
- Map
- Hydrology

Time
- 30-60 minutes
2 Objectives

This exercise illustrates the use of a watershed model to predict possible hydrologic reactions based on planned land use developments. The following sections will show you how to use WMS to:

1. Define the watershed of interest
2. Build a Maricopa County HEC-1 simulation
3. Run HEC-1 based on existing land use and soil conditions
4. Run HEC-1 based on proposed conditions

3 Defining the Watershed

To create the basins to be used in our HEC-1 simulations, we will use a shapefile containing pre-delineated sub basins for the Maricopa County. Also, we will manually create drainage outlets and feature stream arcs for the basins of interest. Finally, we will use WMS to compute the hydrologic parameters for our watershed basins.

3.1 Converting the Shapefile to Feature Polygons

1. Close all instances of WMS
2. Open WMS
3. Switch to the GIS module
4. Select Data | Add Shapefile Data
5. Locate the *Maricopa\tut2* folder in your tutorial files. If you have used default installation settings in WMS, the tutorial files will be located in `\My documents\WMS 9.0\Tutorials\`.

6. Open “basins.shp”

7. Select File | Open 📚

8. Open “zoom_here.wms”. This file identifies the basins used in this exercise.

9. Select the Zoom tool 🕵️

10. Drag a box approximately around the rectangle shown in Figure 3-1

![Figure 3-1: Zoom in on the area bounded by the rectangle](image)

We will select two basins before converting the shapefile to feature polygons (when mapping shapefile data to feature objects, only the selected shapes are converted).

11. Choose the Select Shapes tool 🗺️

12. Multi-select the two polygons shown in Figure 3-2 by holding the SHIFT key while selecting each polygon
13. Select Mapping | Shapes -> Feature Objects
14. Select Next
15. Select Next
16. Select Finish

The feature polygons have now been created and we are ready to create the stream arcs. Before continuing, we will remove the basins shapefile from the Project Explorer:

17. Right-click “basins.shp” in the Project Explorer and select Delete

### 3.2 Getting a Background Image

To aid us in drawing the stream arcs, we will import a background map depicting some of the geographic features within the watershed.

1. Select File | Open
2. Open “maricopa.jpg, select Yes if prompted to create pyramids
3. Switch to the Map module
4. Select the Create Feature Arc tool
5. Select Feature Objects | Attributes
6. Change the Arc type to Stream
7. Select OK
8. Using Figure 3-3 as a guide, begin drawing an arc from the location labeled “Start Here.” Click along the outline of the stream shown on the topo map so that the arc represents the stream’s geometry. Double-click at the location labeled “End Here” to end the arc.
9. Draw a second stream arc as indicated in Figure 3-4.

Having created the stream arcs, we will define their shared node as an Outlet point:

10. Select the Select Feature Point tool.
11. Double-click on the node labeled “Start Here” in Figure 3-4.
12. Change the Point type to Drainage outlet.
13. Select OK.
3.3 Compute the Basin Data

You have completed the watershed construction and are ready to compute the basin parameters that will be used by HEC-1

1. Select Feature Objects | Compute Basin Data
2. Click the Current Projection... button
3. Change both the Horizontal and Vertical Units to U.S. Survey Feet
4. Select OK
5. Verify that the Parameter Units are Square miles for Basin Areas and Feet for Distances
6. Select OK

4 Building the HEC-1 Model

Having computed parameters such as basin area, slope, and length, we will proceed to set up a HEC-1 simulation.

4.1 Initialize Rainfall Data

1. Switch to the Hydrologic Modeling module
2. Select HEC-1 from the model drop-down box
3. Select HEC-1 | Job Control
4. Click the Initialize Maricopa County Precipitation Data button
5. Choose the Basin Average method and change the duration to 6 hour
6. Click on the Browse button to select a rainfall grid to read in and use to compute precipitation
7. Open “noaa50y6h”
8. Select OK to close the Compute Rainfall dialog
9. Select OK twice more to return to the WMS window

4.2 Define Unit Hydrograph Method

1. Double-click on the left basin icon
2. Click the Unit Hydrograph Method button
3. Click the Compute Parameters-Basin Data button
4. Set the Computation type to Compute Lag Time
5. Select Tulsa Rural Method from the Method drop-down box
6. Highlight the line containing S Maximum flow distance slope from the Variable list by clicking on it
7. Enter 2000 in the Variable value field
8. Highlight the line containing the variable S once again to update its value
9. Select OK
10. Choose the *Given unit hydrograph (UH)* option
11. Select the *Maricopa County S-Graph* button
12. Choose *Phoenix Valley* as the S-Graph type and select OK
13. Select OK to exit the XY Series Editor
14. Select OK to exit the Unit Hydrograph Method dialog
15. Click the *Next Hydrograph Station ->* button twice to edit the basin on the right
16. Repeat steps 2 thru 14 above to define the unit hydrograph for this basin. In this case, however, enter 2400 for the variable *S Max flow distance slope*.

### 4.3 Define Routing Method

1. Click the `<- Previous Hydrograph Station` button to select the outlet located between the two basins
2. Click the *Routing Data* button
3. Choose the *Muskingum (RM)* option
4. Click the *Compute NSTPS* button
5. Choose the *From Channel Velocity Estimate* option
6. Enter 6 for the velocity estimate and select OK
7. Select OK to exit the HEC-1 Routing Data dialog
8. Select Done to exit the Edit HEC-1 Parameters dialog

### 4.4 Import the Soil Type and Land Use Coverages

The last parameter we need to define before running HEC-1 is the Green-Ampt losses. To have WMS compute losses, we will create one soil-type coverage and three land-use coverages (one representing existing land-use conditions and two representing future land-use scenarios).

1. Switch to the Map module
2. Choose the *Select Drawing Objects* tool at the bottom of screen
3. Select the rectangle surrounding our two basins and press DELETE
4. Right-click on the Coverages folder in the Project Explorer and select *New Coverage*
5. Change the Coverage type to *Soil Type* (notice that the coverage name is automatically changed to “Soil Type”)
6. Select OK
7. Create another new coverage and change its type to *Land Use*
8. Set the coverage name as “LU existing”
9. Select OK
10. Create two more Land Use type coverages and name them “LU future 1” and “LU future 2”, respectively
11. Select the LU existing coverage in the Project Explorer to activate it
12. Switch to the GIS module
13. Select Data | Add Shapefile Data
14. Open “ExistingCondition.shp”
15. Select Mapping | Shapes -> Feature Objects
16. Select Yes when asked if you want to use all shapes
17. Select Next
18. Find the column labeled LDUSE_LID and change its Mapping field to Land use
19. Select Next
20. Select Finish
21. Select LU future 1 in the Project Explorer to activate it
22. Hide ExistingCondition.shp by un-checking its box in the Project Explorer
23. Switch to the GIS module
24. Select Data | Add Shapefile Data
25. Open “LU_future1.shp”
26. Choose the Select Shapes tool
27. Draw a selection box around the two basins (the extents of the watershed area)

By drawing a selection box around the extents of our watershed area, we select all land use polygons that overlap our watershed.

28. Select Mapping | Shapes -> Feature Objects
29. Select Next
30. Notice that in this case, the LU_CODE field was automatically mapped to the Land use attribute
31. Select Next
32. Select Finish
33. Activate the LU future 2 coverage in the Project Explorer
34. Hide LU_future1.shp by un-checking its box in the Project Explorer
35. Switch to the GIS module
36. Select Data | Add Shapefile Data
37. Open “LU_future2.shp”
38. Choose the Select Shapes tool.
39. Draw a selection box around the two basins (the extents of the watershed area).
40. Select Mapping | Shapes -> Feature Objects
41. Consecutively select Next, Next, and Finish
42. Activate the Soil Type coverage in the Project Explorer
43. Hide LU_future2.shp by un-checking its box in the Project Explorer
44. Switch to the GIS module.
45. Select Data | Add Shapefile Data
46. Open “soilwhitetanks.shp”
47. Choose the Select Shapes tool.
48. Draw a selection box around the two basins (the extents of the watershed area).
49. Select Mapping | Shapes -> Feature Objects
50. Select Next
51. Find the column labeled SLTYP_LID and change its Mapping field to SCS soil type.
52. Select Next
53. Select Finish
54. Hide soilwhitetanks.shp by un-checking its box in the Project Explorer.

4.5 Computing Losses

1. Switch to the Hydrologic Modeling module.
2. Select Calculators | Compute GIS Attributes
3. Change the Computation field to Green-Ampt parameters.
4. Select the Land use mapping option at the bottom
5. Click the Import button.
6. Open “landusemagtable.tbl”
7. Select the Soil type mapping option
8. Click the Import button.
9. Select OK if you receive a warning that any previous tables will be replaced.
10. Open “soiltable.tbl”
11. Set the land use coverage name field to LU Existing.
12. Select OK.
We have computed the losses for the existing land use conditions. Later, when we want to compute runoff values for the future scenarios, we will simply re-compute losses in the Compute GIS Attributes calculator.

## 5 Run HEC-1 for Existing Conditions

1. Select **HEC-1 | Run Simulation**
2. Click the browse button next to the Input File
3. For the file name enter “Mp_existing” 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** when the HEC-1 simulation finishes
7. Double-click on the most downstream hydrograph icon (farthest to the right)
8. The hydrograph shows that for the existing land use conditions, the peak runoff for a 50 year, 6 hour storm is approximately 1260 cfs.
9. Close the hydrograph plot window

## 6 Run HEC-1 for the Proposed Conditions

1. Select **Calculators | Compute GIS Attributes**
2. Change the land use coverage name to “LU future 1”
3. Change the Computation field to **Green-Ampt parameters**
4. Select **OK**
5. Select **HEC-1 | Run Simulation**
6. Click the browse button next to the Input File
7. For the file name enter “MP_future1” and click Save (this specifies the file name but does not actually save it)
8. Verify that the Save file before run is toggled on
9. Select **OK** to run HEC-1
10. Select **Close** when the HEC-1 simulation finishes
11. Double-click on the most downstream hydrograph icon
12. In the upper left-hand corner of the Plot Window, note that the peak runoff has increased to 1440 cfs. This new hydrograph is superimposed over the previous one. We can zoom in on a portion of the hydrographs and/or maximize the Plot Window to enlarge the graph(s).
13. Drag a box around the peaks of the hydrographs
14. Right-click anywhere within the Plot window and select **Maximize Plot**
15. Press the ESC key to return the Plot window to its original size.

16. To view the entire hydrographs once more, right-click anywhere within the Plot Window and select **Frame Plot**.

17. Close the plot window.

18. Select **Calculators | Compute GIS Attributes**.

19. Change the land use coverage name to “LU future 2”.

20. Select **OK**.

21. Select **HEC-1 | Run Simulation**.

22. Click the browse button next to the Input File.

23. For the file name enter “MP_future2” and click **Save** (this specifies the file name but does not actually save it).

24. Verify that the **Save file before run** is toggled on.

25. Select **OK** to run HEC-1.

26. Select **Close** when the HEC-1 simulation finishes.

27. Double-click on the most downstream hydrograph icon.

28. Notice that the peak runoff for LU future 2 (1460 cfs) is slightly higher than for LU future 1. The results we are viewing in the plot window can be exported as tabular data.

29. Right-click within the Plot window and select **Export/Print**.

30. Change the Export type to **Text / Data Only**.

31. Change the Export destination to **File**.

32. Click the **Browse** button.

33. Specify a path and filename.

34. Click the **Export** button.

35. Leave the options at the default settings and click the **Export** button.

The exported data can now be opened in a spreadsheet editor for further manipulation. Another effective way to view HEC-1 results is to browse the HEC-1 output file (*.out), which can be viewed with any text editor. Also, if HEC-1 had not terminated successfully, then checking the (*.out) file might reveal possible errors and/or warnings.