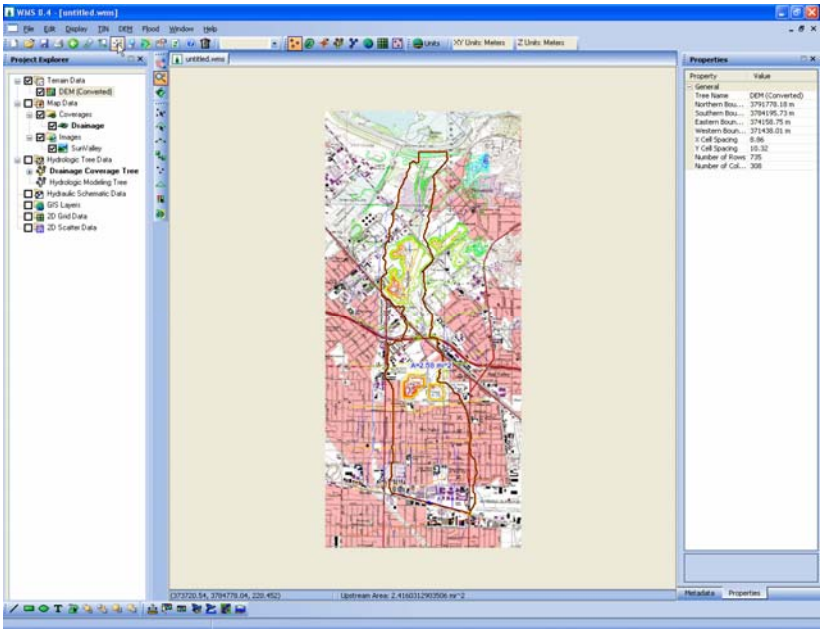
WMS

v. 9.0

WMS 9.0 Tutorial

Watershed Modeling – Advanced DEM Delineation Techniques

Learn how to model manmade and natural drainage features such as road embankments, depressions, and gutters



Objectives

Manipulate the default watershed boundaries by assigning map features such as road embankments, gutters, and known watershed boundaries to watershed delineations.

Prerequisite Tutorials

- Watershed Modeling – DEM Delineation

Required Components

- Data
- Drainage
- Map

Time

- 30-60 minutes

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1 Contents

2 Introduction

Some terrain features, including roads, canals, dams, dikes, or levees, are not well represented in DEMs, especially if the DEM resolution is coarse. This can lead to erroneous automated watershed delineation. In addition, it may be desirable to evaluate future alterations in terrain that result from development scenarios. WMS has tools for manipulating DEM delineation results in order to accurately represent the actual watershed drainage basins.

3 Objectives

In this exercise you will learn how to manipulate DEM data for more accurate drainage analysis by completing the following steps:

1. Use stream arcs to manipulate basin delineation
2. Handle depressions
3. Develop time of concentration according to the longest flow path
4. Map polygons representing drainage basins to the DEM s
5. Smooth results for reporting and presentations

4 Use Stream Arcs to Manipulate Basin Delineation

Sometimes it is necessary to add stream arcs to your basin to represent water that accumulates along man-made objects such as roads. Roads often disrupt the natural flow of watersheds, acting as a barrier that collects water creating something similar to a stream. The water collected along a road needs to be "added" into the watershed in order to properly model the hydrology. Stream arcs can be used to edit flow directions associated with the DEM routing water into the proper drainage basins.

4.1 Open DEM Data

1. Close all instances of WMS
2. Open WMS
3. Select ***File*** **|** ***Open*** 
4. Locate the ***demedit*** 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\.***
5. In the folder ***\86666671*** open *"86666671.hdr"*
6. Select *OK* on the Importing NED GRIDFLOAT File dialog
7. Select *Yes* when prompted to reproject.
8. Toggle on the *Set* option in the Project projection section of the dialog
9. Select the *Global Projection* option
10. Click on the *Set Projection* button
11. In the Select Projection dialog set:
    - Projection to *UTM*
    - Datum to *NAD83*
    - Planar Units to *METERS*
    - Zone to *11 (120°W - 114°W – Northern Hemisphere)*
12. Select *OK*
13. Make sure that the Vertical Projection and Units in the Project projection section of the dialog match the vertical projection and units in the Object projection part of the dialog
14. Select *OK*

4.2 Open Background Topographic Map Image

1. Select ***File*** **|** ***Open*** 
2. Open *"SunValley.jpg"*
3. Select *Yes* to generate pyramids

4.3 Run TOPAZ

1. Switch to the *Drainage* module
2. Select ***DEM | Compute Flow Direction/Accumulation…***
3. Select *OK*
4. Select *OK*
5. Select *Close* once TOPAZ finishes running (you may have to wait a few seconds to a minute or so)
6. Right-click on DEM (Converted) in the Project Explorer and select ***Display Options***
7. Change the Minimum Accumulation For Display to **0.04** mi^2
8. Select *OK*

4.4 Basin Delineation

1. Zoom in to the box shown in Figure 4-1

Figure 4-1: Zoom Area

2. Switch to the Drainage module
3. Select the *Create Outlet Point* tool
4. Click anywhere on the DEM to create an outlet
5. Select *OK* if you get a message telling you that the outlet is not located in a flow accumulation cell
6. Enter a Feature Point X-value of **373777.7** and a Feature Point Y-value of **3784742.5** in the Properties window on the right of the screen to edit the outlet location

7. Select ***DEM | Delineate Basins Wizard***
8. Click on the *Delineate Watershed* button

The Delineate Watershed step of the Hydrologic Modeling Wizard runs the WMS menu commands ***DEM -> Stream Arcs…***, ***Define Basins***, ***Basins -> Polygons***, and ***Compute Basin Data***.

9. Select *Close* to exit the Hydrologic Modeling Wizard
10. Select ***Display | Display Options*** 
11. On the DEM tab toggle OFF *Fill Basin Boundary Only*
12. Select *OK*

The DEM cells assigned to the delineated drainage basin are color-filled and displayed as shown in Figure 4-2. The results do not quite look like what we might expect in an urban area. Even though the drainage basin was delineated using ~10 m elevation data, there are still many features of the urban terrain that are not well represented in the DEM data. One example is the railroad running across the lower portion of Figure 4-2 that the outlet point is located along.

Figure 4-2: Initial Delineation Results

4.5 Display Flow Directions

The DEM flow directions will show water flowing right across the railroad tracks instead of collecting along the tracks.

1. Select ***Display | Display Options*** 
2. On the DEM tab, toggle ON *Flow Direction* and *Points*, and change the *Point Display Step* to 5
3. Select *OK*

Notice that flow direction arrows for DEM points are visible, but not necessarily for every DEM point because the display of flow directions is adaptive. More flow directions are displayed as you zoom in and fewer flow directions are visible as you zoom out.

4. Zoom in along the railroad until you can see the DEM flow directions for each DEM point, which show that flow goes right over the railroad tracks
5. Select ***Display | Display Options*** 
6. On the DEM tab, toggle OFF *Flow Direction* and *Points*
7. Select *OK*
8. Right-click on the Drainage coverage in the Project Explorer and select ***Zoom to Layer***

4.6 Add Stream Arcs Along Railroad

In WMS a stream arc can be used to conceptually model runoff collecting along the railroad tracks.

1. Zoom in to the outlet point for the delineated drainage basin 
2. Choose the *Create Feature Arc* tool 
3. Select ***Feature Objects | Attributes***
4. Choose the *Stream* option
5. Select *OK*
6. Using Figure 4-3 as a guide begin a new stream arc that is attached to the existing stream arc by clicking on a point just upstream of the outlet point (make sure that you click far enough away from the outlet point that WMS does not snap to the outlet point)

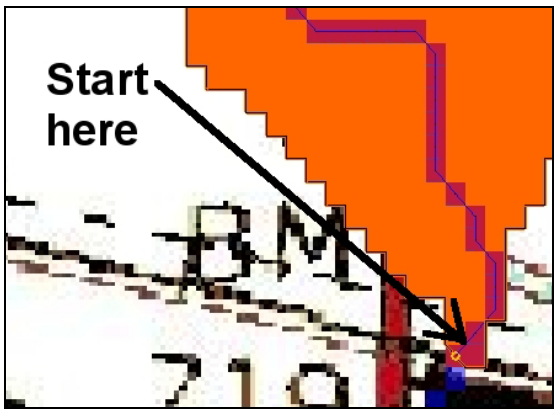

Figure 4-3: Start Point for the Stream Arc

7. Create the arc so that it follows along the railroad double-clicking to end the arc at the location show in Figure 4-4 (the scroll wheel/button on the mouse are helpful for zooming and panning while you create the arc)

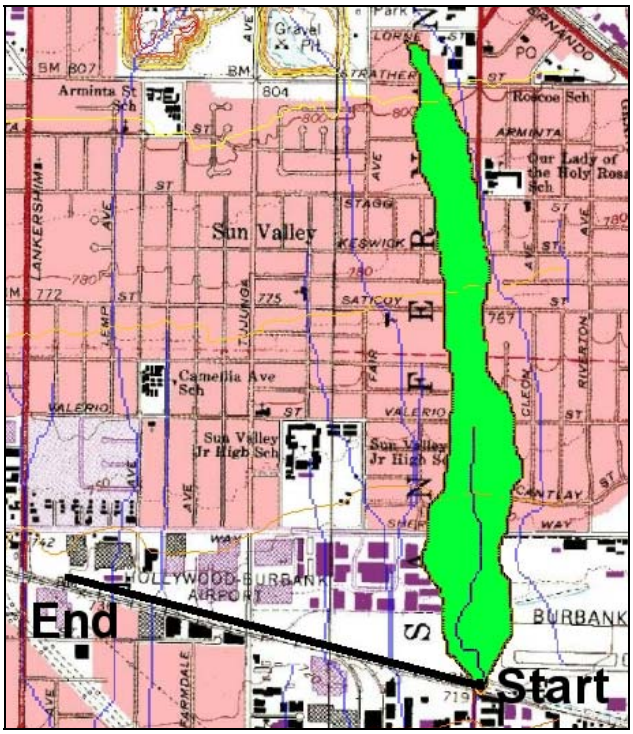

Figure 4-4: Add Stream Arc Along Railroad

4.7 Basin Delineation

When the basin is defined WMS will change flow directions for DEM cells under the stream arc so that they are aligned with the stream arc. The basin definition will then include all area which has flow paths intercepted by the stream arc.

The ***DEM -> Stream Arcs…*** and ***Delineate Basins Wizard*** menu commands for delineating drainage basins should not generally be used once the automated delineation results are manually manipulated, in this case by adding a stream arc to collect runoff along the railroad tracks. This is because WMS will delete all existing feature data except for outlet points when these tasks are performed, removing the stream arcs added for manual manipulation as well. Instead, we will use the ***Define Basins*** and ***Basins->Polygons*** commands to update the delineation.

1. Switch to the *Drainage* module
2. Select ***DEM | Define Basins***
3. Select ***DEM | Basins->Polygons***
4. Select ***DEM | Compute Basin Data***
5. Select *OK*
6. Right-click on the Drainage coverage in the Project Explorer and select ***Zoom to Layer***
7. Right-click on DEM (Converted) under Terrain Data in the Project Explorer and select ***Display Options***

8. On the DEM tab toggle ON *Flow Direction* and *Points*; toggle OFF *Stream*, *Flow Accumulation*, and *Color Fill Drainage Basins*
9. Select *OK*
10. Zoom in to the stream arc along the railroad track until flow directions for each DEM point are visible

Notice that the flow directions are now aligned with the stream arc so that flow no longer crosses the railroad tracks.

11. Right-click on the DEM (Converted) under Terrain Data in the Project Explorer and select ***Display Options***
12. On the DEM tab toggle OFF *Flow Direction* and *Points*; toggle ON *Stream*, *Flow Accumulation*, *Color Fill Drainage Basins*, and *Fill Basin Boundary Only*
13. Select *OK*

5 Depression Points

DEM delineation for depressions requires that the low point of the depression be identified as a depression point.

5.1 Depression Attribute

1. Select the *Frame* macro
2. Toggle OFF the display of the Images folder in the Project Explorer
3. *Zoom in to the box shown in* Figure 5-1

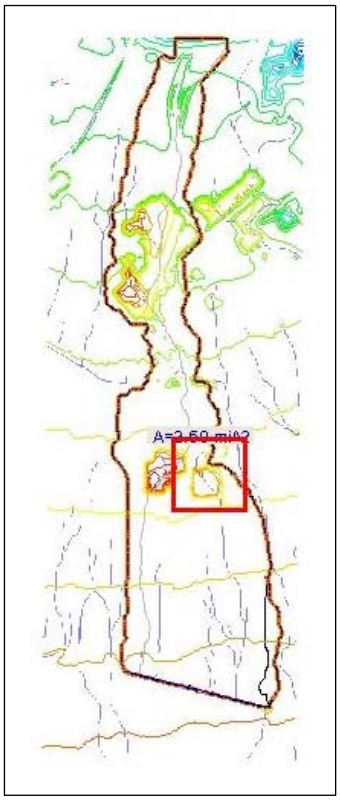

Figure 5-1: Zoom to Depression

The contours show that there is a depression here, but the flow accumulations indicate that flow comes in one side and exits the other side of the depression. This occurs because TOPAZ forces flow movement by filling all depressions when processing DEM elevations.

4. Zoom in to the box surrounding the lowest elevation point of the depression shown in Figure 5-2

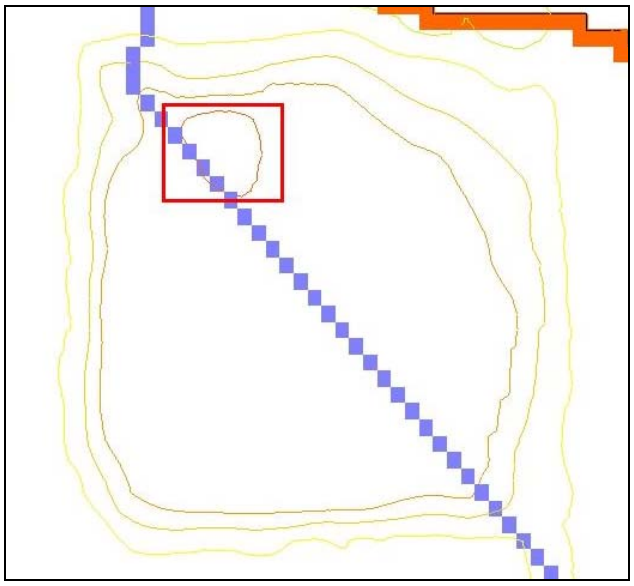

Figure 5-2: Zoom to Depression Pit

5. Right-click on the DEM (Converted) under Terrain Data in the Project Explorer and select ***Display Options***
6. On the DEM tab toggle ON *Points*
7. Select *OK*
8. Switch to the *Terrain Data* module
9. Choose the *Select DEM Points* tool
10. Select the DEM point indicated in Figure 5-3, which has an elevation of 212.5064

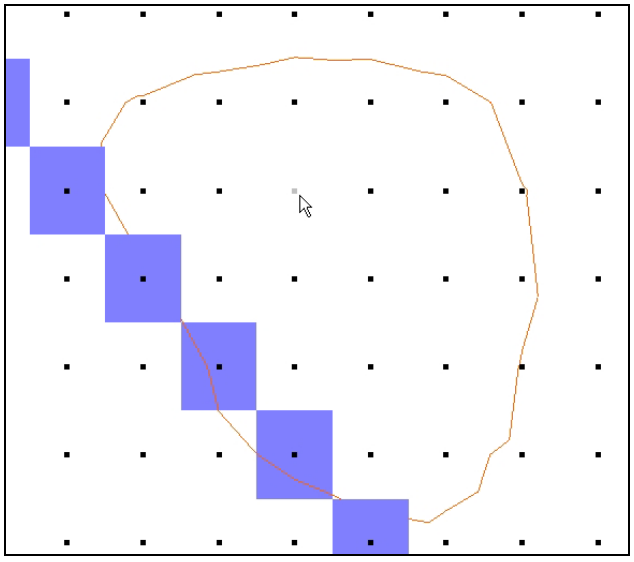

Figure 5-3: Select DEM Point

11. Select ***DEM | Point Attributes***

12. Toggle ON the *Depression point* option
13. Select *OK*
14. Right-click on the DEM (Converted) under Terrain Data in the Project Explorer and select ***Display Options***
15. On the DEM tab toggle OFF *Points*
16. Select *OK*

5.2 Run TOPAZ

1. Zoom out to the extents of the depression
2. Switch to the *Drainage* module
3. Select ***DEM | Compute Flow Direction/Accumulation…***
4. Select *OK*
5. Select *OK*
6. Select *Close* once TOPAZ finishes running (you may have to wait a few seconds to a minute or so)

TOPAZ allows flow from the depression to go to the low point rather than "filling" the depression once the depression point attribute is assigned.

5.3 Create Outlet Point

1. Choose the *Create Outlet Point* tool
2. Create an outlet point in the flow accumulation cell shown in Figure 5-4

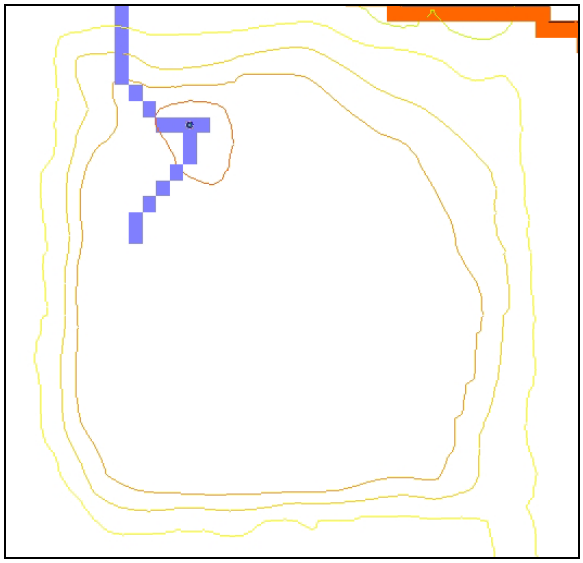

Figure 5-4: Depression Outlet Point Location

5.4 Create Stream Arc

1. Switch to the *Map* module
2. Choose the *Create Feature Arc* tool
3. Select ***Feature Objects* | *Attributes***
4. Choose the *Stream* option
5. Select *OK*
6. Create the arc shown in Figure 5-5, clicking at the outlet point to begin the arc (the arc will not be visible after double-clicking to end the arc because it is hidden behind the display of DEM flow accumulations)

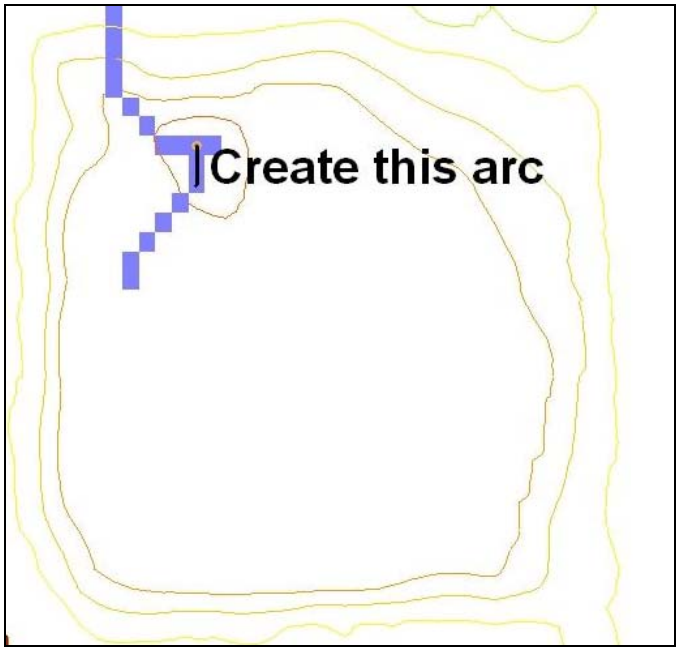

Figure 5-5: Depression Arc

5.5 Basin Delineation

1. Switch to the *Drainage* module
2. Select ***DEM* | *Define Basins***
3. Select ***DEM* | *Basins->Polygons***
4. Select ***DEM* | *Compute Basin Data***
5. Select *OK*

5.6 Compute Storage Capacity Curve

WMS will use the DEM cells that are part of a selected drainage basin to compute a storage capacity curve given a water surface elevation.

1. Switch to the *Hydrologic Modeling* module

2. Select the depression outlet
3. Select ***Calculators | Detention Basins…***
4. Click on the *Define…* button
5. Click on the *Define Storage…* button
6. Choose the *Digital terrain model (DTM)* option
7. For Water surface enter **803.00** ft
8. Select *OK*
9. Select *OK* in the Elevation – Storage Capacity – Discharge dialog
10. Select *OK* in the Detention Basin Hydrograph Routing dialog

6 Time of Concentration Arcs

Once DEM cells are assigned to drainage basins, WMS can use the DEM flow directions to automatically create an arc in each basin that represents the longest flow path. This is especially useful for developing times of concentration.

1. Select the *Frame* macro
2. Switch to the *Drainage* module
3. Select ***DEM | Compute Basin Data***
4. In the Units dialog, select the *Drain Data Compute Opts...* button. Toggle on the checkbox to *Create Tc Coverage.*
5. Select *OK*, and then *OK* again on the Units dialog.
6. Toggle OFF the display of the DEM (Converted) in the Terrain Data folder of the Project Explorer
7. Click on the newly created Time Computation coverage in the Project Explorer to view the Tc arcs generated for each one of the drainage basins

7 Polygon Basin IDs to DEM

In some situations it is more effective to delineate drainage basins by hand or to import basin boundaries from a GIS or CAD file.

1. Click on the Drainage coverage in the Project Explorer to make it the active coverage
2. Right-click on the GIS Layers folder in the Project Explorer and select ***Add Shapefile Data…***
3. Open *"basin_ poly.shp"*
4. Zoom in to the box shown in Figure 7-1

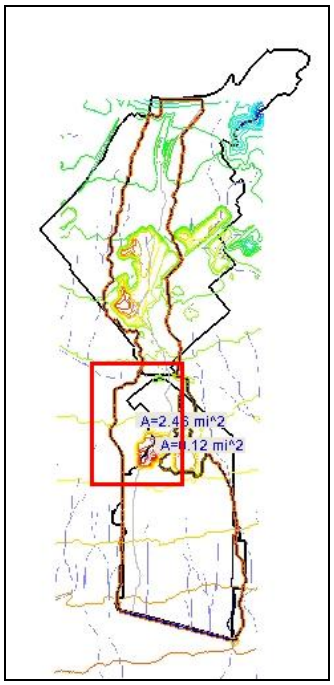

Figure 7-1: Zoom to Basin Boundary

This shapefile contains a more accurate representation of the drainage basin boundaries that exist in this urban area. Notice that our delineation does not exactly match the actual basin boundaries shown in the shapefile. The data from the shapefile can be used to manually update the basin boundaries.

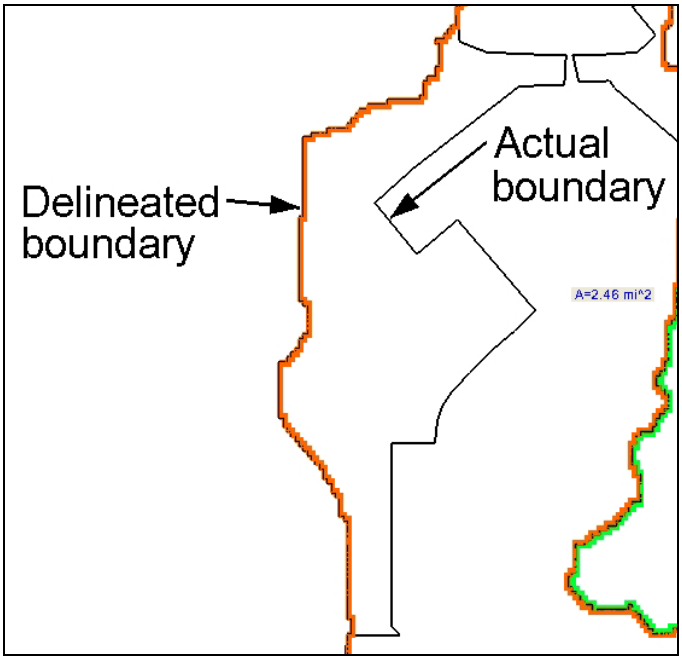

Figure 7-2: Discrepancy in Basin Boundaries

5. Switch to the *Map* module
6. Choose the *Create Feature Arc* tool

7. Select ***Feature Objects | Attributes***
8. Make sure that the *Generic* option is selected
9. Select *OK*
10. Begin an arc by clicking on the vertex shown in Figure 7-3 (WMS will automatically snap to the existing arc)

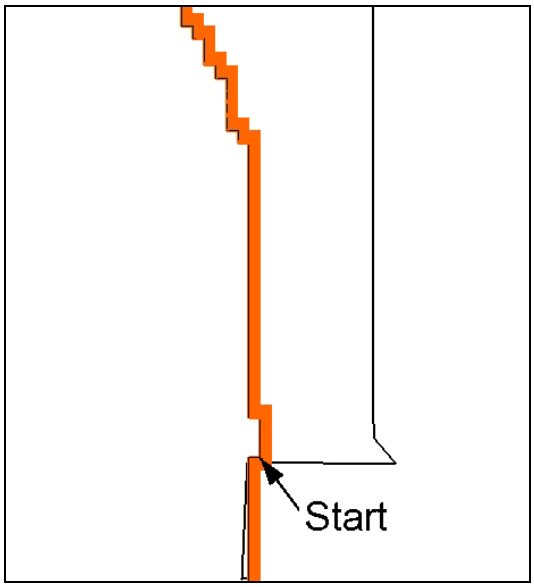

Figure 7-3: Start Boundary Arc

11. Digitize an arc along the actual arc, ending the arc when the actual arc intersects the delineated arc again, shown in Figure 7-4

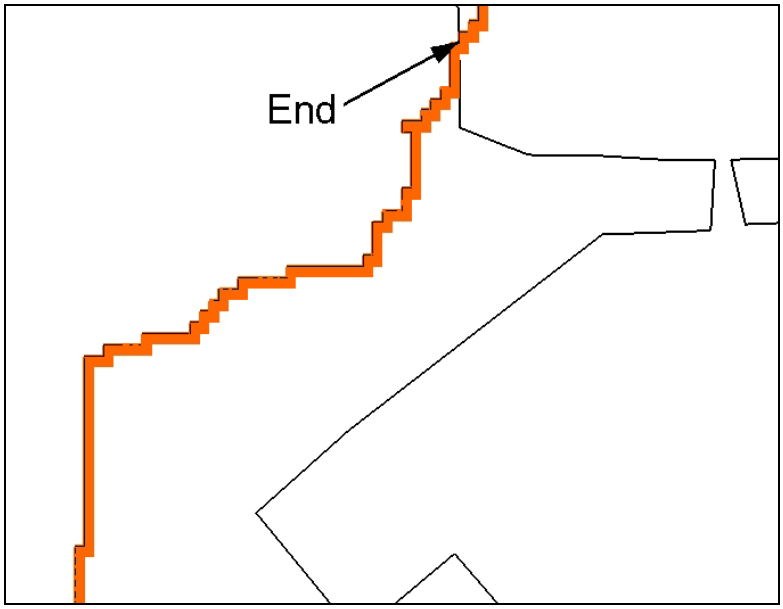

Figure 7-4: End Boundary Arc

12. Toggle OFF the display of the GIS Layers folder in the Project Explorer

13. Choose the *Select feature arc* tool
14. Select and delete the arc segment representing the original delineated boundary
15. Right-click on the Drainage coverage in the Project Explorer and select ***Zoom to Layer***
16. Right-click on the Drainage coverage in the Project Explorer and select ***Build Polygon***
17. Select *OK* to use all arcs
18. Right-click on DEM (Converted) under Terrain Data in the Project Explorer and select ***Display Options***
19. In the DEM tab toggle OFF the *Fill Basin Boundary Only* option
20. Select *OK*

Notice that the drainage basins assigned to DEM cells no longer match up with the new drainage basin boundary polygon that was created. This must be rectified in order to properly compute geometric properties of the drainage basin based on the DEM data using the ***Compute Basin Data*** command.

21. Switch to the *Drainage* module
22. Select ***DEM | Polygon Basin IDs -> DEM***
23. Select ***DEM | Compute Basin Data***
24. Select *OK*

Messages will appear indicating that basin edges were encountered while computing geometric parameters. Click *OK* on the messages to continue. In this case the messages are not a problem because the drainage basin boundary was manually manipulated.

8 Generate Time of Concentration Arcs from a Point

A new time computation coverage was also created when basin data was last computed.

1. Toggle OFF the display of the Time Computation coverage in the Project Explorer
2. In the Project Explorer click on the Time Computation (2) coverage to make it active

There is a Tc arc for the basin which drains to the depression on this coverage, but not for the larger basin. A Tc arc for the larger basin was not created because WMS encountered basin edges while computing basin data.

3. Select ***Display | Display Options***
4. In the Drainage Data tab toggle ON *Flow Distance Contours*
5. In the DEM tab toggle ON *Fill Basin Boundary Only*
6. Select *OK*

WMS traces the flow path from each DEM cell and then contours the flow distances from the DEM cells to their drainage basin outlet points.

7. Zoom in to the upper part of the watershed, where the flow distances are the greatest

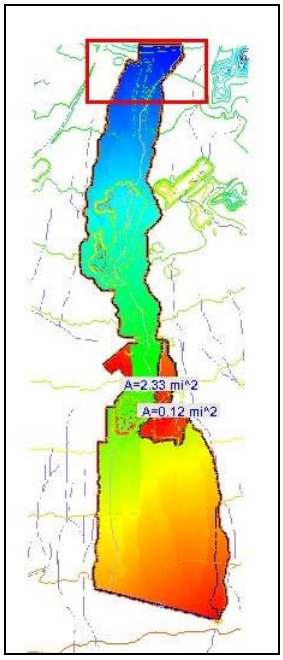

Figure 8-1: Zoom to Flow Distance Contours

8. Choose the *Create Feature Point* tool
9. Click in the upper right portion of the basin to create a feature point
10. Select ***Feature Objects | Node > Flow arcs***
11. Choose the *Create one continuous arc* option
12. Select *OK*
13. Select the *Frame* macro 

Now there is also a Tc arc in the larger basin. It is also possible to digitize Tc arcs by hand.

9 Smoothing Boundaries

1. In the Project Explorer click on the Drainage coverage to make it active
2. Zoom in near the boundary of one of the basins,

You will see that the boundary arcs are not smooth because they are formed by tracing the DEM cells. WMS allows you to redistribute vertices to smooth these boundaries for reporting and presentation purposes.

3. Choose the *Select Feature Arc* tool 
4. Select ***Edit | Select All***

5. Select ***Feature Objects* | *Redistribute***
6. Enter **30** in the Spacing edit box
7. Select *OK*

When you zoom in on the basin boundaries now, they should be much smoother.

10 Conclusion

In this exercise you have learned some of the advanced basin delineation features that set WMS apart from other GIS-based automated delineation techniques. While this exercise illustrated only a few ways these tools can be applied, proper understanding enables you to use the tools for many different scenarios where the automated delineation does not yield the results you expect.