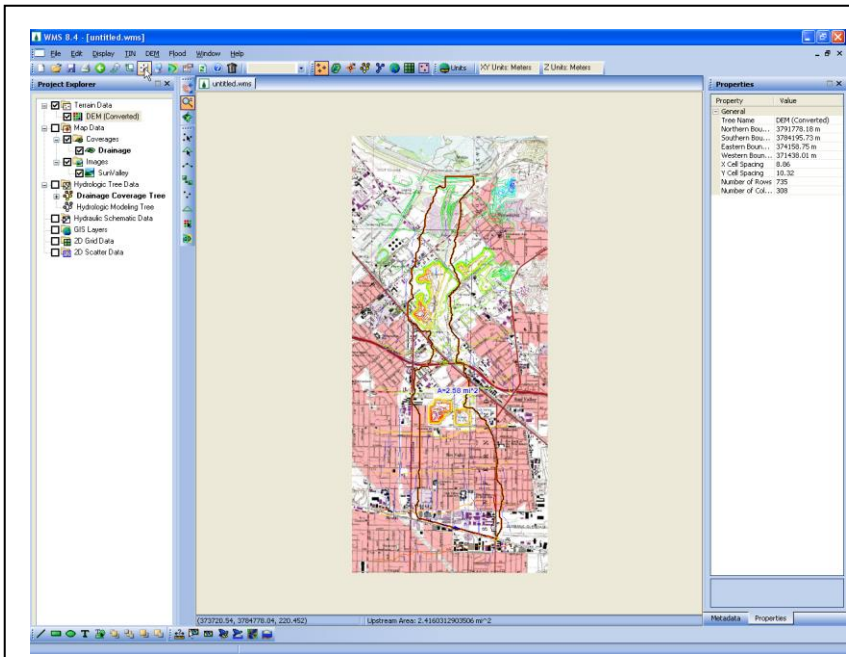
WMS

v. 10.1

WMS 10.1 Tutorial

Watershed Modeling – Advanced DEM Delineation Techniques

Model manmade and natural drainage features



Objectives

Learn to 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 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.

This exercise teaches how to manipulate DEM data for more accurate drainage analysis by discussing and demonstrating how to use stream arcs to manipulate basin delineation, how to handle depressions, how to develop time of concentration according to the longest flow path, how to map polygons representing drainage basins to the DEMs, and how to smooth results for reporting and presentations.

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 Use Stream Arcs to Manipulate Basin Delineation

Sometimes it is necessary to add stream arcs to a 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.

3.1 Open DEM Data

1. Click **Open** to bring up the *Open* dialog.
2. Select "NED GRIDFLOAT header (*.hdr)" from the *Files of type* drop-down.
3. Browse to the *demedit\demedit\86666671* directory and select "86666671.hdr".
4. Click **OK** to exit the *Open* dialog and bring up the *Importing NED GRIDFLOAT File* dialog.
5. Click **OK** to close the *Importing NED GRIDFLOAT File* dialog.
6. Click **Yes** when prompted to change the projection and open the *Reproject Object* dialog.
7. In the *Project projection* section, turn on *Set*.
8. In the *Horizontal* section of the *Project projection* section, select *Global Projection*.
9. Click **Set Projection…** to bring up the *Select Projection* dialog.
10. Select "UTM" from the *Projection* drop-down.
11. Select "11 (120°W – 114°W – Northern Hemisphere)" from the *Zone* drop-down.
12. Select "NAD83" from the *Datum* drop-down.
13. Select "METERS" from the *Planar Units* drop-down.
14. Click **OK** to close the *Select Projection* dialog.
15. In the *Vertical* section of the *Project projection* section, select "Local" from the *Projection* drop-down and "Meters" from the *Units* drop-down.

These should match the same options in the *Vertical* section in the *Object projection* section.

16. Click **OK** to close the *Reproject Object* dialog.

Now change the display options so make sure the project is visible.

17. Click **Display Options** to bring up the *Display Options* dialog.
18. Select "DEM Data" from the list on the left.
19. On the *DEM* tab, turn on *Stream*, *Flow Accumulation*, *Color Fill Drainage Basins*, *Fill Basin Boundary Only*, and *DEM Contours*.
20. Select "Map Data" from the list on the left.
21. On the *Map* tab, turn off *Color Fill Polygons*.

22. Click **OK** to close the *Display Options* dialog.

The Graphics Window should appear similar to Figure 1.

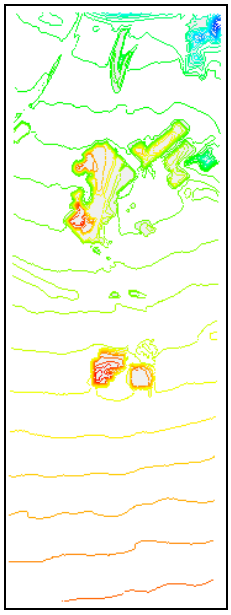

Figure 1 Initial project appearance

3.2 Open Background Topographic Map Image

1. Select *File* | **Open…** to bring up the *Open* dialog.
2. Select "All Files (*.*)" from the *Files of type* drop-down.
3. Browse to the *demedit\demedit* directory and select "SunValley.jpg".
4. Click **Open** to exit the *Open* dialog and import the image.
5. Click **Yes** if asked to generate image pyramids.

The Graphics Window should appear similar to Figure 2.

Figure 2 With topo map background

3.3 Run TOPAZ

1. Switch to the **Drainage** module.
2. Select *DEM* | **Compute Flow Direction/Accumulation…** to bring up the *Flow Direction/Accumulation Run Options* dialog.
3. Click **OK** to close the *Flow Direction/Accumulation Run Options* dialog and open the *Units* dialog.
4. Click **OK** to close the *Units* dialog and open the *Model Wrapper* dialog.
5. Once TOPAZ finishes running, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog.
6. Right-click on "86666671 (Converted)" in the Project Explorer and select **Display Options…** to bring up the *Display Options* dialog.
7. Select "DEM Data" from the list on the left.
8. On the *DEM* tab, enter "0.04" as the *Minimum Accumulation For Display*.
9. Click **OK** to close the *Display Options* dialog**.**

3.4 Basin Delineation

1. **Zoom** in to the area near the bottom of the project as indicated in Figure 3.

Figure 3 Zoom Area

2. Switch to the **Drainage** module.
3. Using the **Create Outlet Point** tool, click anywhere on the DEM to create an outlet.
4. Click **OK** if a message appears stating that the outlet is not located in a flow accumulation cell.
5. In the Properties window on the right side of the WMS display, enter"373777.7" as the *Feature Point X* and "3784742.5" as the *Feature Point Y*.

This moves the outlet location to the new coordinates near the lower right of the area selected in step 1.

6. Select *DEM* | **Delineate Basins Wizard** to bring up the *Stream Feature Arc Options* dialog.
7. Click **OK** to close the *Stream Feature Arc Options* dialog and bring up the *Units* dialog.

This runs the WMS menu commands **DEM → Stream Arcs…**, **Define Basins**, **Basins → Polygons**, and **Compute Basin Data**.

8. Click **OK** to close the *Units* dialog.
9. Click **Display Options** to bring up the *Display Options* dialog.
10. Select "DEM Data from the list on the left.
11. On the *DEM* tab, turn off *Fill Basin Boundary Only*.
12. Select "Map Data" from the list on the left.
13. On the *Map* tab, turn on *Color Fill Polygons* and click **Drainage Basin Display Options** to bring up the *Drainage Basin Display Options* dialog.
14. Click the button under *Pattern* on the left, select "Lime" from the list of colors, and click **OK** to close the *Drainage Basin Display Options* dialog.
15. Select "Drainage Data" from the list on the left.
16. On the *Drainage Data* tab, turn on *Basin Names*, *Show Units*, *Basin Areas*, *Basin Slopes*, and *Max Flow Distance*.
17. Click **OK** to close the *Display Options* dialog.

The DEM cells assigned to the delineated drainage basin are now color-filled and should appear similar to Figure 4.

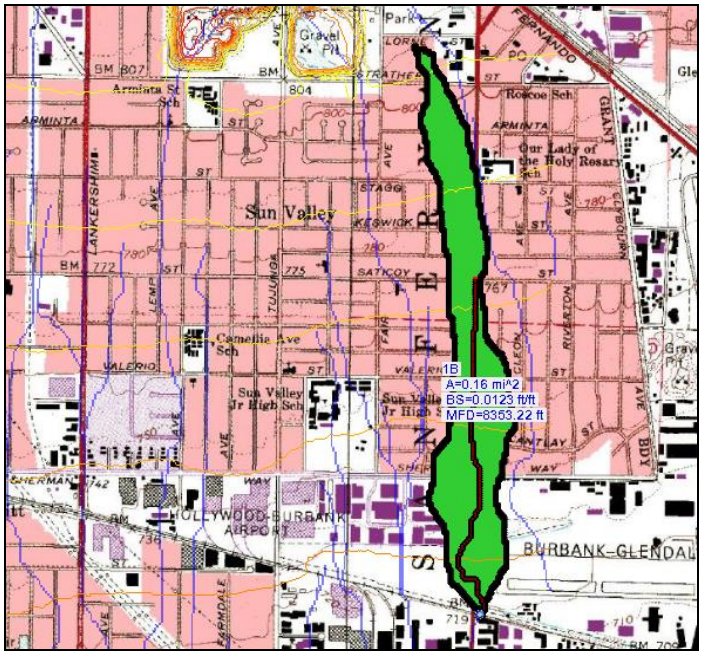

Figure 4 Initial delineation results

The results do not quite look like what might be expected 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 diagonally across the lower portion of Figure 4 along which the outlet point is located.

3.5 Display Flow Directions

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

1. Click **Display Options** to bring up the *Display Options* dialog.
2. Select "DEM Data" from the list on the left.
3. On the *DEM* tab, enter "5" as the *Point Display Step*.
4. Turn on *Flow Direction* and *Points*.
5. Click **OK** to close the *Display Options* dialog.

Notice that flow direction arrows for DEM points are visible. Because the display of flow directions is adaptive, not every DEM point has a flow direction arrow visible. More flow directions are displayed when zooming in and fewer flow directions are visible when zooming out.

6. **Zoom** in along the railroad tracks until the DEM flow directions for each DEM point are visible.

Notice that flow goes right over the railroad tracks.

7. Select *Display* | **Display Options…** to bring up the *Display Options* dialog.
8. Select "DEM Data" from the list on the left.
9. On the *DEM* tab, turn off *Flow Direction* and *Points*.
10. Click **OK** to close the *Display Options* dialog.
11. Right-click on " Drainage" in the Project Explorer and select **Zoom to Layer**.

3.6 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. Switch to the **Map** module.
3. Select the **Create Feature Arc** tool.
4. Select *Feature Objects* | **Attributes…** to bring up the *Feature Arc Type* dialog.
5. In the *Type* section, select *Stream* and click **OK** to close the *Feature Arc Type* dialog.
6. Using Figure 5 as a guide, begin a new stream arc attached to the existing stream arc by clicking on the vertex just upstream of the outlet point.

Click far enough away from the outlet point that WMS does not snap to the outlet point.

Figure 5 Start point for the railroad stream arc

7. Using Figure 6 as a guide, create the arc along the railroad, double-clicking to end the arc at the location shown by the blue arrow (the orange arrow indicates where the arc started, just to the right of the outlet point).

Use the scroll wheel button on the mouse to zoom and pan while creating the arc.

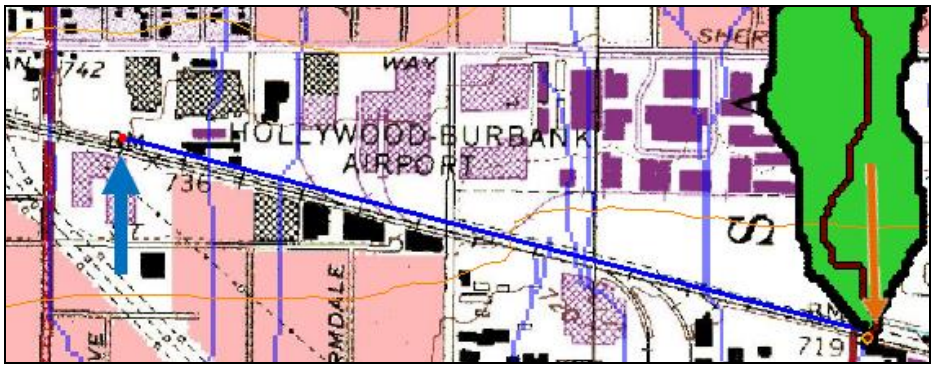

Figure 6 Start (orange) and end (blue) points of the railroad stream

3.7 Basin Delineation with the New Stream

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, use the **Define Basins** and **Basins → Polygons** commands to update the delineation.

1. Switch to the **Drainage** module.
2. Select *DEM* | **Define Basins**.

Notice that the basin area has expanded significantly.

3. Select *DEM* | **Basins → Polygons**.

Notice that the polygon boundary has shifted to encompass the expanded area of the drainage basin (Figure 7).

4. Select *DEM* | **Compute Basin Data** to bring up the *Units* dialog.
5. Click **OK** to close the *Units* dialog.
6. Right-click on "Drainage" in the Project Explorer and select **Zoom to Layer**.

The drainage basin data has been recalculated (Figure 7).

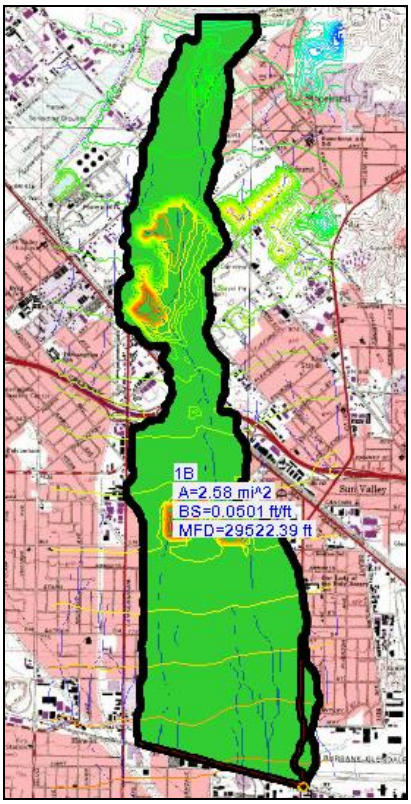

Figure 7 New drainage basin area with basin data

7. Right-click on "86666671 (Converted)" in the Project Explorer and select **Display Options…** to bring up the *Display Options* dialog.
8. Select "DEM Data" from the list on the left.
9. On the *DEM* tab, turn on *Flow Direction* and *Points* and turn off *Stream*, *Flow Accumulation*, and *Color Fill Drainage Basins*.
10. Click **OK** to close the *Display Options* dialog.
11. **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.

12. Right-click on "86666671 (Converted)" and select **Display Options…** to bring up the *Display Options* dialog.
13. Select "DEM Data" from the list on the left.

14. On the *DEM* tab, turn off *Flow Direction* and turn on *Stream*, *Flow Accumulation*, *Color Fill Drainage Basins*, and *Fill Basin Boundary Only*.
15. Click **OK** to close the *Display Options* dialog.
16. Right-click on "Drainage" in the Project Explorer and select **Zoom to Layer**.

The Graphic Window should appear similar to Figure 8.

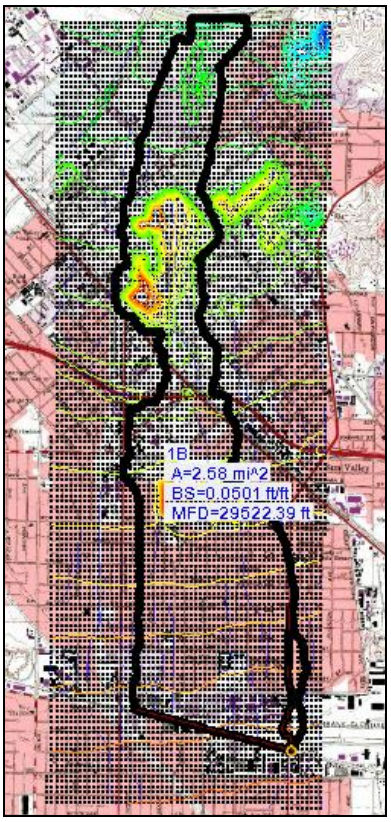

Figure 8 The drainage basin delineated with the railroad stream

3.8 Save the Project

Save the project before continuing with the tutorial.

1. Select *File* | **Save As…** to bring up the *Save As* dialog.
2. Select "Project Files (*.wms)" from the *Save as type* drop-down.
3. Enter "advDEMdt1.wms" as the File name.
4. Click **Save** to save the project with the new name and close the *Save As* dialog.
5. Click **Yes** if asked to save image files in the project directory.

It is recommended to **Save** projects frequently while working on them.

4 Depression Points

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

4.1 Depression Attribute

1. Turn off "SunValley.jpg" in the Project Explorer.
2. Click **Display Options** to bring up the *Display Options* dialog.
3. Select "Drainage Data" from the list on the left.
4. Turn off all options on the *Drainage Data* tab.
5. Select "DEM Data" from the list on the left.
6. Turn off *Points* and *Stream* and turn on *Depression Cells*.
7. Enter "1" as the *Point Display Step*.
8. Select "Map Data" from the list on the left.
9. On the *Map* tab, turn off *Color Fill Polygons*.
10. Click **OK** to close the *Display Options* dialog.
11. **Zoom** in to the area indicated by the blue box in Figure 9.

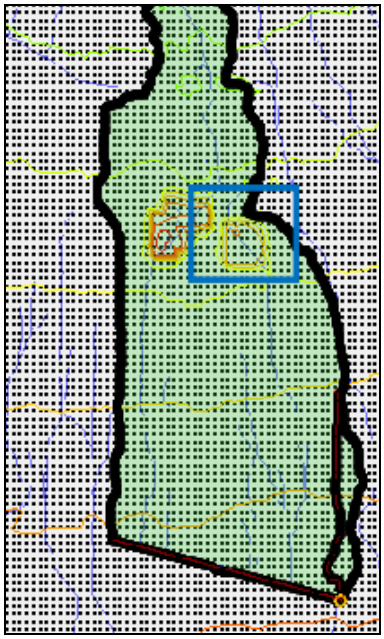

Figure 9 Zoom to depression

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.

12. **Zoom** in to the area with the lowest elevation contour line, as indicated by the orange box in Figure 10.

Note that contours may not appear exactly as in the image.

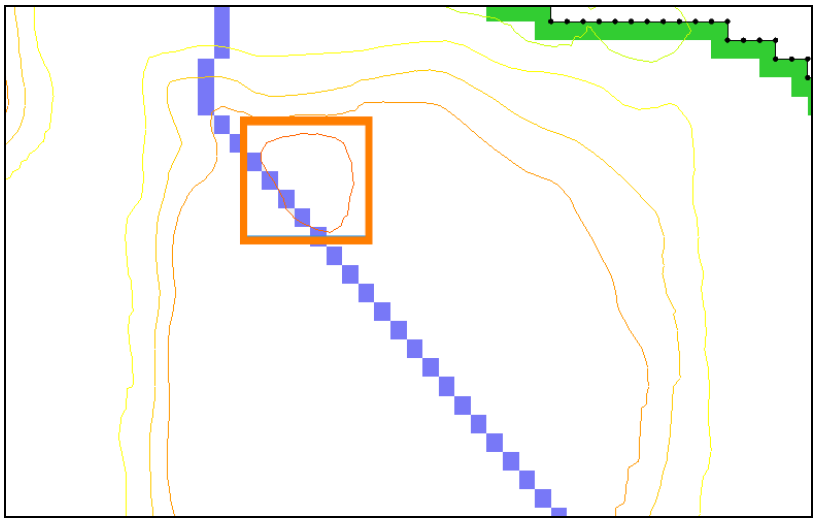

Figure 10 Zoom to depression pit

Within this contour lies the lowest elevation DEM point representing the bottom of the gravel pit. The DEM point with the lowest elevation must be identified so that it can be defined as a depression point in the DEM point attributes. Use the **Set Contour Min/Max** tool to help indicate the lowest elevation point within this area by changing the contour range minimum and maximum values for viewing in this area.

13. Switch to the **Terrain Data** module.
14. Using the **Set Contour Min/Max** tool, click and drag a box around the orange/red contour range as shown in Figure 11.

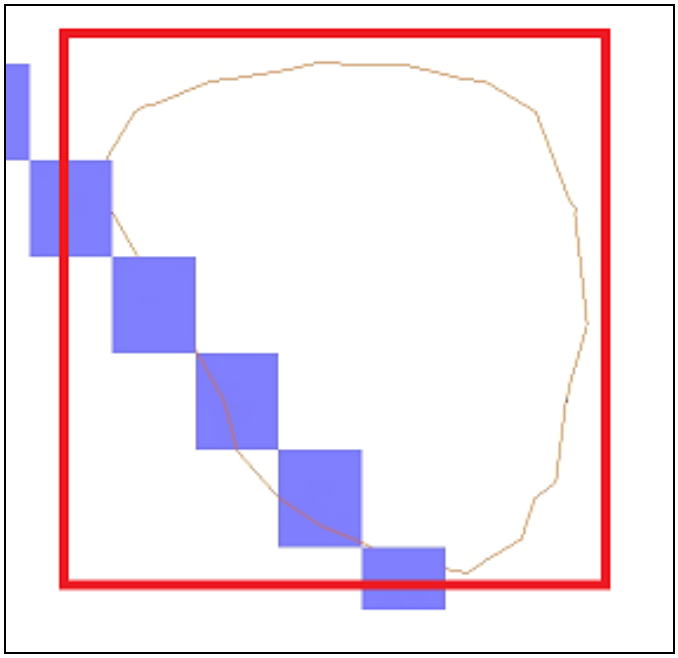

Figure 11 Selection Box for Set Contour Min/Max Tool

15. Using the **Select DEM Points** tool, drag a box around the red contour in the center area to highlight the DEM points in that area.

Notice the now-visible DEM point near the center of the red contour area (Figure 12).

16. Select the highlighted point as shown in Figure 12.

This DEM point has an elevation of "212.5064" (*IJ* coordinates of 185,292). This is visible in the Properties section of the WMS screen.

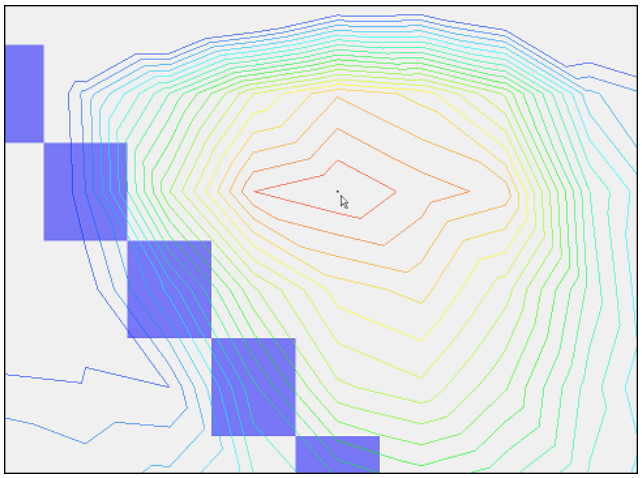

Figure 12 Select DEM Point

17. Select *DEM* | **Point Attributes** to bring up the *DEM Point Attributes* dialog.
18. In the *Attributes* section, turn on *Depression point* and click **OK** to close the *DEM Point Attributes* dialog.
19. Using the *Set Contour Min/Max* tool, right-click anywhere in the Graphics Window and select *Clear Min/Max Contour Ranges*.

4.2 Run TOPAZ

1. Switch to the **Drainage** module.
2. Select *DEM* | **Compute Flow Direction/Accumulation…** to bring up the *Flow Direction/Accumulation Run Options* dialog.
3. Click **OK** to close the *Flow Direction/Accumulation Run Options* dialog and bring up the *Units* dialog.
4. Click **OK** to close the *Units* dialog and bring up the *Model Wrapper* dialog.
5. Once TOPAZ finishes running, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog.
6. **Zoom** to the extents of the depression, if necessary.

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

4.3 Create Outlet Point

1. Using the **Create Outlet Point** tool, create an outlet point in the flow accumulation cell containing the lowest DEM point (as selected in step 4.1, see Figure 13).

This is the cell with the DEM point elevation of "212.5064".

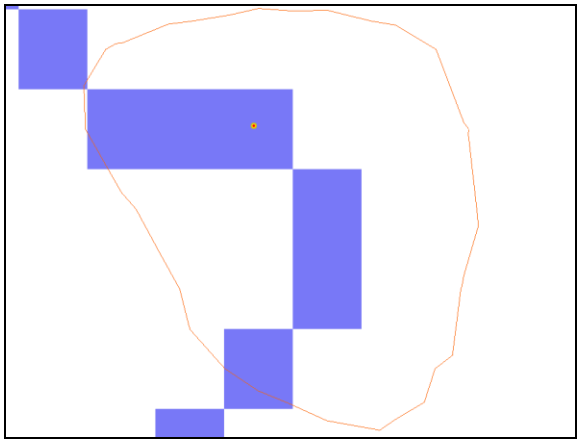

Figure 13 Location of the outlet point

4.4 Create Stream Arc

1. Switch to the **Map** module.
2. Select the **Create Feature Arc** tool.
3. Select *Feature Objects* | **Attributes…** to bring up the *Feature Arc Type* dialog.
4. In the *Type* section, select *Stream* and click **OK** to close the *Feature Arc Type* dialog.
5. Create the arc shown in Figure 14, clicking on the outlet point to begin the arc and double-clicking to end it in the lower flow accumulation cell.

The arc may not be visible after ending the arc if it is hidden behind the display of DEM flow accumulations.

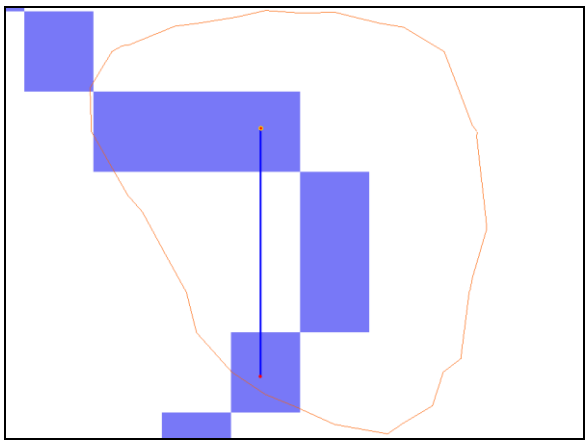

Figure 14 Depression arc

4.5 Basin Delineation for the Depression Point

1. Switch to the **Drainage** module.
2. Select *DEM* | **Define Basins**.
3. Select *DEM* | **Basins** → **Polygons**.
4. Select *DEM* | **Compute Basin Data** to bring up the *Units* dialog**.**
5. Click **OK** to close the *Units* dialog.

Notice that the flow accumulation cells adjusted to the path of the new stream (Figure 15).

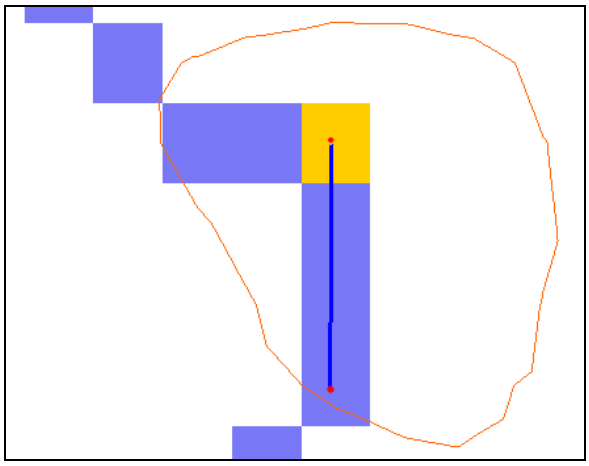

Figure 15 Flow accumulation cells adjusted to location of stream

4.6 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. Using the **Select Outlet** tool, select the outlet at the depression.
3. Select *Calculators* | **Detention Basins…** to bring up the *Detention Basin Hydrograph Routing* dialog.
4. Click **Define…** to bring up the *Storage Capacity Input* dialog.
5. Enter "803.00" in the field below *Use DEM*.
6. Click **OK** to close the *Storage Capacity Input* dialog and bring up the *Detention Basin Analysis* dialog.

This dialog lists elevation values from the base elevation up to 803 ft of elevation. Along with the elevation values, the computed storage values should also be listed.

7. Click **OK** to close the *Detention Basin Analysis* dialog.

The curve displayed in the *Detention Basin Hydrograph Routing* window is the computed storage-elevation curve for the depression pit (Figure 16).

8. Click **OK** in the *Detention Basin Hydrograph Routing* dialog.

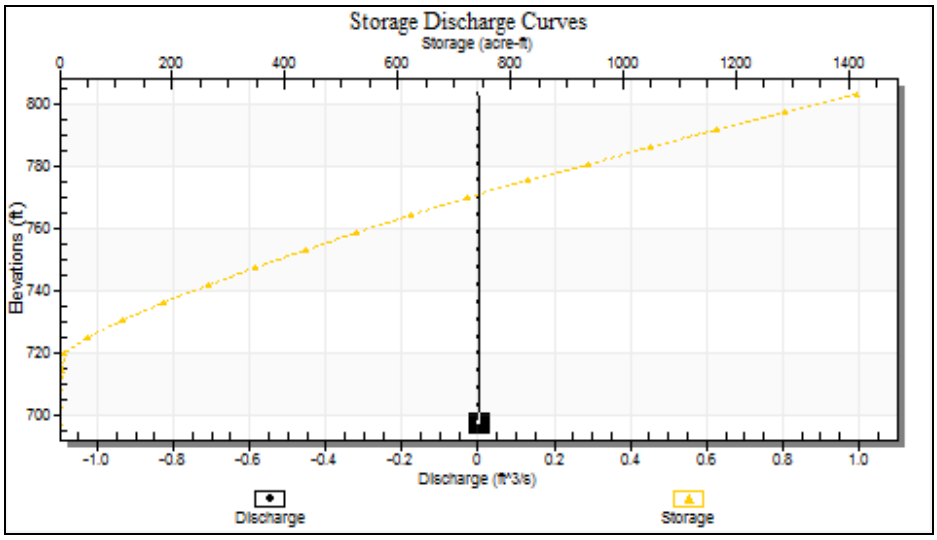

Figure 16 Storage Discharge Curve

5 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. **Frame** the project.
2. Switch to the **Drainage** module.
3. Select *DEM* | **Compute Basin Data** to bring up the *Units* dialog.
4. Click **Drain Data Compute Opts...** to bring up the *Drainage Data Computation Options* dialog.
5. Below the list, turn on *Create Tc Coverage* and click **OK** to close the *Drainage Data Computation Options* dialog.
6. Click **OK** to close the *Units* dialog.
7. Turn off "86666671 (Converted)" in the Project Explorer.
8. Select the new "Time Computation" coverage in the Project Explorer to make it active.

The Tc arcs generated for each one of the drainage basins should be visible.

6 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. Select "Drainage" in the Project Explorer to make it active.
2. Right-click on "GIS Data" in the Project Explorer and select **Add Shapefile Data…** to bring up the *Select shapefile* dialog.

3. Select "basin_ poly.shp" and click **Open** to import the shapefile and exit the *Select shapefile* dialog.
4. Turn on "86666671 (Converted)" in the Project Explorer.
5. **Zoom** in to the area indicated by the blue box in Figure 17.

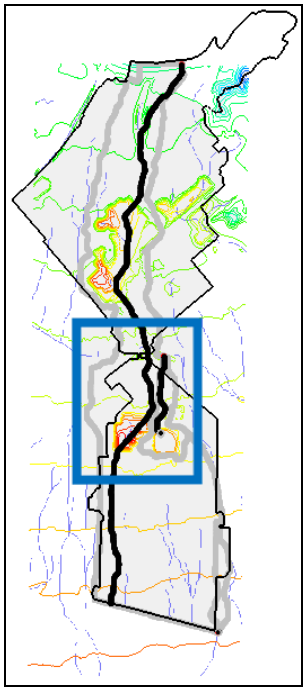

Figure 17 Zoom to Basin Boundary

This shapefile contains a more accurate representation of the drainage basin boundaries that exist in this urban area. Notice that the delineation does not exactly match the actual basin boundaries shown in the shapefile (Figure 18). The data from the shapefile can be used to manually update the basin boundaries.

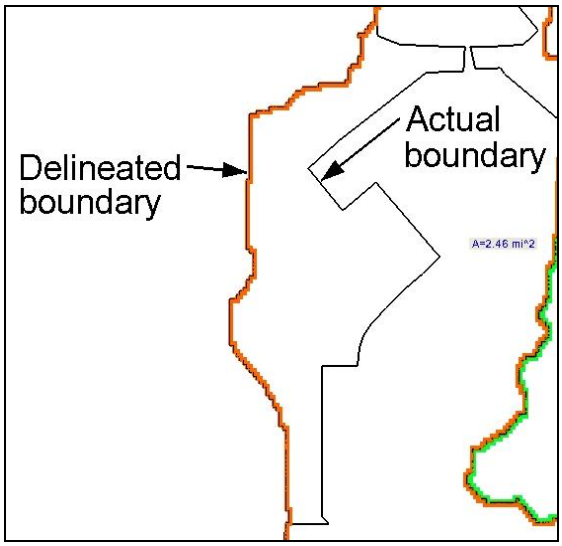

Figure 18 Discrepancy in basin boundaries

6. Switch to the **Map** module.

7. Select the **Create Feature Arc** tool.
8. Select *Feature Objects* | **Attributes…** to bring up the *Feature Arc Type* dialog.
9. In the *Type* section, select *Generic* and click **OK** to close the *Feature Arc Type* dialog.
10. Begin an arc by clicking on the vertex shown in Figure 19 (WMS will automatically snap to the existing arc).

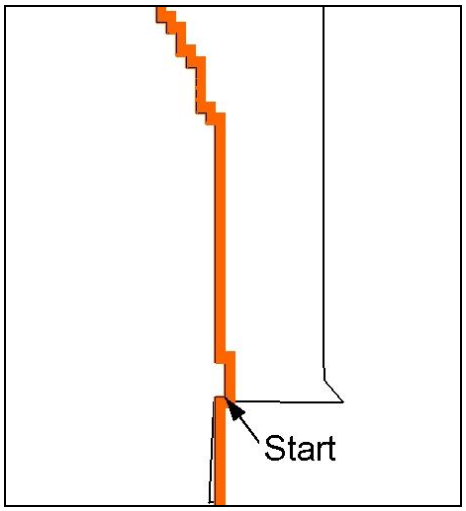

Figure 19 Start the boundary arc here

11. Digitize an arc along the actual boundary arc, ending the arc by double-clicking when the actual boundary arc intersects the delineated boundary arc again (Figure 20).

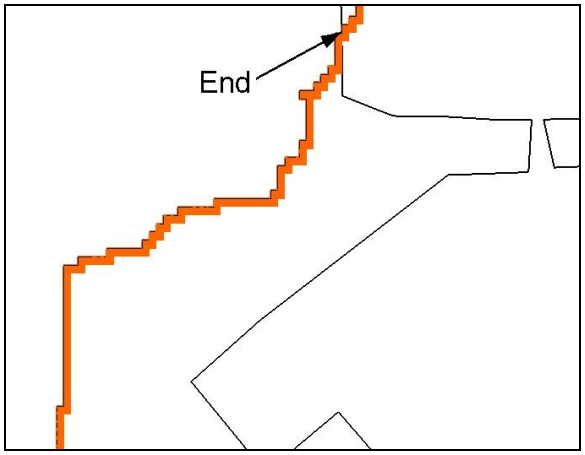

Figure 20 End the boundary arc here

12. Turn off "GIS Data" in the Project Explorer.
13. Using the **Select Feature Arc** tool, select and delete the arc segment representing the original delineated boundary.
14. Right-click on "Drainage" and select **Zoom to Layer.**
15. Right-click on "Drainage" and select **Build Polygon.**

16. Click **OK** to use all arcs.
17. Right-click on "86666671 (Converted)" and select **Display Options…** to bring up the *Display Options* dialog.
18. Select "DEM Data" from the list on the left.
19. On the *DEM* tab, turn off *Fill Basin Boundary Only* and click **OK** to close the *Display Options* dialog.

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 corrected in order to properly compute geometric properties of the drainage basin based on the DEM data by using the **Compute Basin Data** command.

20. Switch to the **Drainage** module.
21. Select *DEM* | **Polygon Basin IDs → DEM.**
22. Select *DEM* | **Compute Basin Data** to bring up the *Units* dialog.
23. Click **Drain Data Compute Opts…** to bring up the *Drainage Data Computation Options* dialog.
24. Below the list, turn off *Create TC coverage* and click **OK** to close the *Drain Data Computation Options* window.
25. Click **OK** to close the *Units* window and compute the basin data.
26. Click **OK** if notice(s) appear regarding basin edges being encountered.

In this case, the messages do not indicate an actual problem because the drainage basin boundary was manually manipulated.

7 Smoothing Boundaries

1. Select "Drainage" to make it active.
2. **Zoom** in to any section of the basin boundary.

Notice that the boundary arcs are not smooth because they are formed by tracing the square DEM cells. WMS allows redistribution of vertices to smooth these boundaries for reporting and presentation purposes.

3. Select the **Select Feature Arc** tool.
4. Select *Edit* | **Select All**.
5. Select *Feature Objects* | **Redistribute…** to bring up the *Redistribute Vertices* dialog.
6. In the *Arc Redistribution* section, enter "30.0" as the *Average Spacing*.
7. Click **OK** to close the *Redistribute Vertices* dialog.

Notice that the basin boundaries are now much smoother (Figure 21).

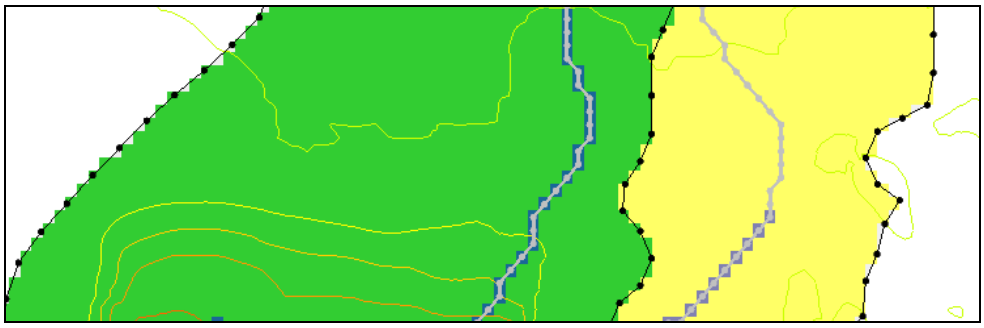

Figure 21 The basin boundaries are smoother

8 Conclusion

This concludes the "Watershed Modeling – Advanced DEM Delineation Techniques" tutorial. A few of the many advanced basin delineation features were demonstrated that set WMS apart from other GIS-based automated delineation techniques. The tools can be used for many different scenarios where the automated delineation does not yield the expected results. Key topics discussed and demonstrated include:

- Using stream arcs to manipulate basin delineation
- Manipulating depressions
- Developing time of concentration according to the longest flow path
- Mapping polygons representing drainage basins to the DEMs
- Smoothing results for reporting and presentations