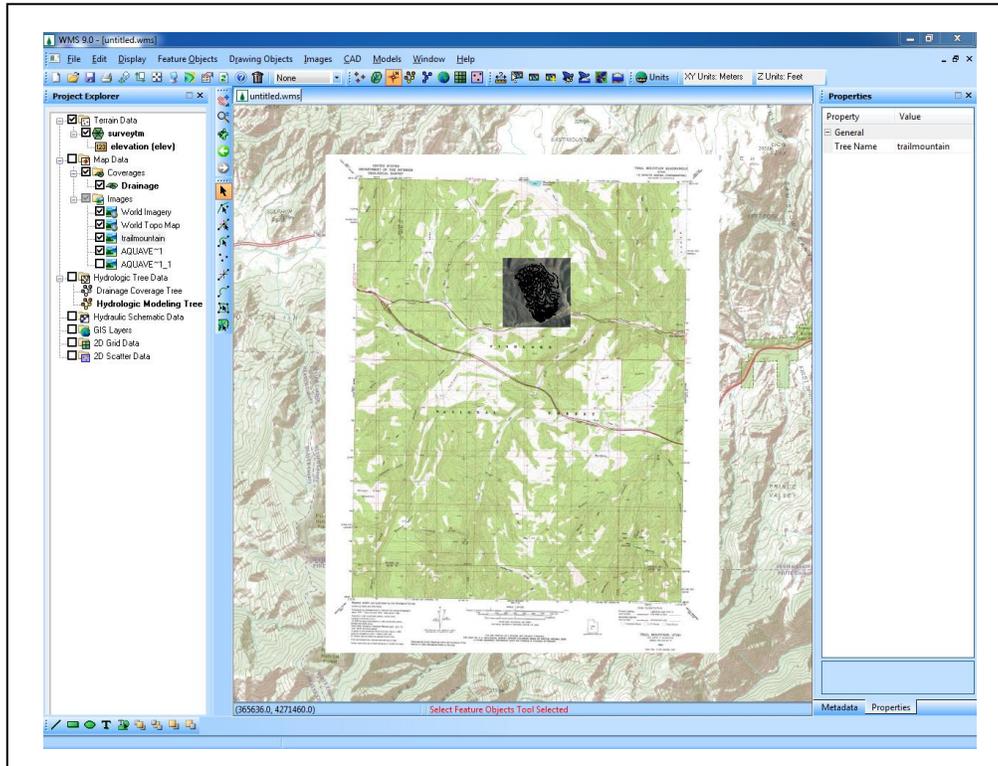*WMS 10.1 Tutorial*

Editing Elevations – Using TINs

Import, view, edit, convert, and digitize triangulated irregular networks

Objectives

Import survey data in an XYZ format. Digitize elevation points using contour imagery. Edit and merge TINs and convert between DEMs and TINs. Export TIN contours to a CAD file.

Prerequisite Tutorials

- None

Required Components

- Data
- Map

Time

- 30–60 minutes

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1   Introduction

Triangulated Irregular Networks (TINs) are constructed from a scattered set of *xyz*
vertices. They can be used for visualization, as background elevation maps for generating
new TINs or DEMs, or to obtain cross sections for hydraulic models. WMS has powerful
tools for importing and manipulating TIN data.

This tutorial will discuss and demonstrate importing survey data, digitizing data,
triangulation, automated and manual TIN editing, creating a TIN using a conceptual
model, converting a TIN to a DEM, and exporting data to CAD.

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   Importing Survey Data

1. Select *File | **Open*** 📂 to bring up the *Open* dialog.

2. Select "Text Files (*.txt)" from the *Files of type* drop-down.

3. Browse to the *tins\tins* folder and select "surveytm.txt".

This is a tab delimited file exported from Excel.

4. Click **Open** to exit the *Open* dialog and bring up the *Step 1 of 2* page of the *File Import Wizard* dialog.

5. Click **Next** to accept the defaults and go to the *Step 2 of 2* page of the *File Import Wizard* dialog.

6. Select "Survey Data" from the *WMS data type* drop-down.

7. In the spreadsheet in the *File preview* section, Select "X", "Y", and "Z" from the drop-downs in the *Type* row for the first, second, and third columns, respectively.

8. Click **Finish** to close the *File Import Wizard* dialog and finish importing the text file.

9. Right-click on " surveytm" under " Terrain Data" in the Project Explorer and select **Display Options…** to open the *Display Options* dialog.

10. Select "TIN Data" from the list on the left.

11. On the *TIN* tab, turn on *Unlocked Vertices*.

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

The points from the "surveytm.txt" file should now be visible (Figure 1).

Figure 1   Points in the imported TIN

13. Select *Display* / **Display Projection...** to bring up the *Display Projection* dialog.

14. In the *Horizontal* section, select *Global Projection*.

15. Click **Set Projection…** to bring up the *Select Projection* dialog.

16. Select "UTM" from the *Projection* drop-down.

17. Select "12 (114°W - 108°W – Northern Hemisphere)" from the *Zone* drop-down.

18. Select "NAD27" from the *Datum* drop-down.

19. Select "METERS" from the *Planar Units* drop-down.

20. Click **OK** to close the *Select Projection* dialog.

21. In the *Vertical* section, select "Feet (U.S. Survey)" from the *Units* drop-down.

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

23. Select **Yes** if a message appears saying that the horizontal and vertical units are inconsistent.

4   Getting a Background Image

The next two sections require an internet connection. If one is unavailable, please skip to section 4.3.

4.1   Getting a Background

Using an Internet connection, a background image (aerial photo or a topo map) can be loaded for the project site. WMS uses the built-in web services tool to load such images.

1. Click **Get Online Maps** to open the *Get Online Maps* dialog.

2. Select "World Imagery" and click **OK** to close the *Get Online Maps* dialog and import the image.

WMS will load the background image file. After a few moments, an aerial photo will be visible in the background (Figure 2).
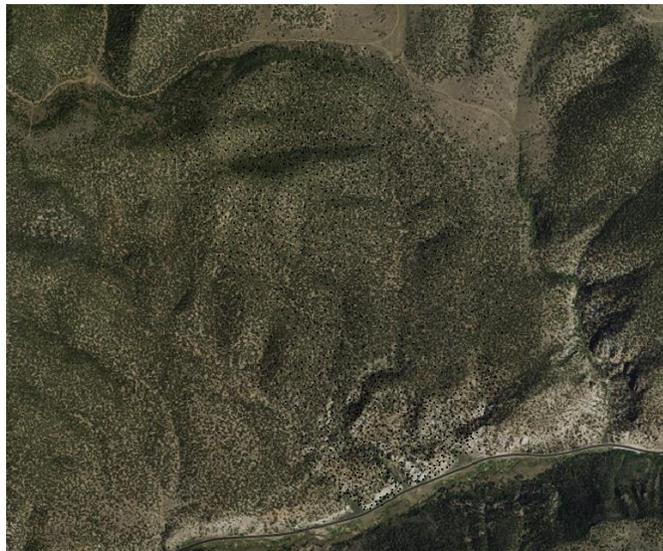

Figure 2   Aerial photo in the background

3. Click **Get Online Maps** to open the *Get Online Maps* dialog.

4. Scroll to the right and select "USA Topo Maps".

5. Click **OK** to close the *Get Online Maps* dialog and import the image.

A topographical map of the area will become visible after a few moments (Figure 3).
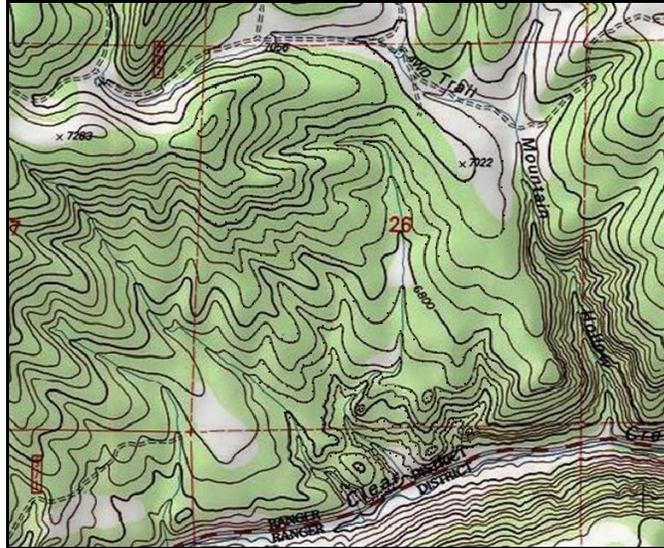
Figure 3   Topographical map of the area

4.2   Create a local copy of the images

The images just loaded are imported from a server and sometimes take a long time to zoom and pan around. A local copy of each image can be saved in order to expedite such navigation.

1. Right-click on " USA Topo Maps" under the " GIS Data" folder and select **Export** to bring up the *Resample and Export Raster* dialog.

2. Click **OK** to accept the suggested value of resample magnification and close the *Resample and Export Raster* dialog and bring up the *Save As* dialog.

A resample magnification factor of "1" means that the image will have exactly as many pixels as what is being displayed on the screen. Increase the factor if a higher resolution image is needed. Note that higher resolution images will take a longer time to download.

3. Select "Geo TIFF Files (*.tif)" from the *Save as type* drop-down.

4. Browse to the *tins\tins* directory.

5. Enter "TrailMount1.tif" as the *File name*.

WMS will display the download progress in a dialog.

6. Repeat steps 1–5 for " World Imagery", naming the file "TrailMount2.tif".

Once completed, " TrailMount1.tif" and " TrailMount2.tif" should be visible under the " GIS Data" folder in the Project Explorer.

7. Turn off " TrailMount1.tif" and " TrailMount2.tif" in the Project Explorer.

4.3   Open Background Image

1. Click **Open** to bring up the *Open* dialog.

2. Select "trailmountain.tif" and click **Open** to import the image and exit the *Open* dialog.

3. If asked to build image pyramids, select **No**.

4. **Zoom** in to the TIN vertices.

5. Turn off "trailmountain.tif" in the Project Explorer and **Frame** the project.

This zooms in on the TIN vertices.

6. Turn on "trailmountain.tif" after framing.

5   Digitizing Data

Digitize Mode allows maps to be quickly digitized or updated with additional vertices.

1. Select *Display* | *Toolbars* | **Digitize** to turn on the Digitize toolbar at the bottom of the WMS screen.

2. Click **Digitize Mode** to turn on digitize mode.

3. Enter "6800" in the white box to the right of the **Digitize Mode** button.

4. Switch to the **Terrain Data Module**.

5. Using the **Add Vertices** tool, digitize the 6800 foot contour (the darker line touching the large "26" near the middle of the screen) by using the background image to add vertices. Only digitize within the same area as the existing TIN vertices.

6. Click on **Digitize Mode** to turn off digitize mode.

7. Select *Display* | *Toolbars* | **Digitize** to turn off the *Digitize* toolbar.

6   Converting CAD Data to a TIN

Often terrain data is stored or processed in a CAD program in the form of contours or triangles. In either case the 3D data points (x,y,z) can be converted from the CAD data to TIN points and triangulated in WMS.

1. Click **New**.

2. Click **No** when asked to save changes.

3. Click **Open** to bring up the *Open* dialog.

4. Select "contours.dwg" and click **Open** to import the file and exit the *Open* dialog.

5. Right-click on "contours.dwg" under the "CAD Data" folder in the Project Explorer and select *CAD To* | **TIN…** to bring up the *CAD → TIN* dialog.

6. Click **OK** to accept the defaults and close the *CAD → TIN* dialog.

The points defining the contour lines contain x, y, and z coordinates. When the points are converted to TIN points and retriangulated, a 3D TIN surface is created (Figure 4). Zoom

in, rotate, and change the display or contour options as desired in order to better visualize the TIN. Other CAD files with 3D points can be imported and converted to a WMS TIN.
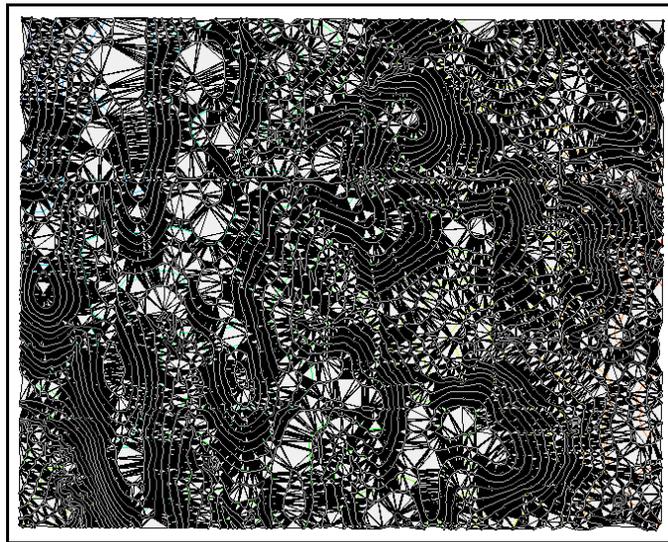

Figure 4   The 3D TIN surface resulting from conversion from CAD data

7   Merging TINs

It is sometimes desirable for elevation data from different sources to be merged together into a single TIN or DEM, especially when building a hydraulic model. For example, survey data representing the bathymetry of a stream channel may be stored as contours in a CAD program. That data can then be merged with DEM data from the USGS.

Merging data from several sources can be especially useful for hydraulic modeling applications. In some cases, it is necessary to cut cross sections that include both the channel geometry (obtained from a survey of the channel) and the floodplain (obtained from a USGS DEM).

Merging two or more elevation data sources into a single TIN is a 3-step process. First, make sure the coordinate systems of each set of elevation data match. All the elevation data needs to line up, and all the elevations should be in either US Customary or SI units. Second, convert each set of elevation data to a separate TIN. Third, merge all of the TINs into a single TIN using the merge TINs command. This section of the tutorial will show how these three steps are used to merge separate elevation sources in the WMS.

7.1   Importing a CAD File

1. Click **New** .
2. Click **No** if asked to save changes.
3. Select *File* / **Open** to bring up the *Open* dialog.
4. Select "tmcontours.dwg" and click **OK** to exit the *Open* dialog.

This file is from a CAD program and contains contours for a small area (Figure 5).
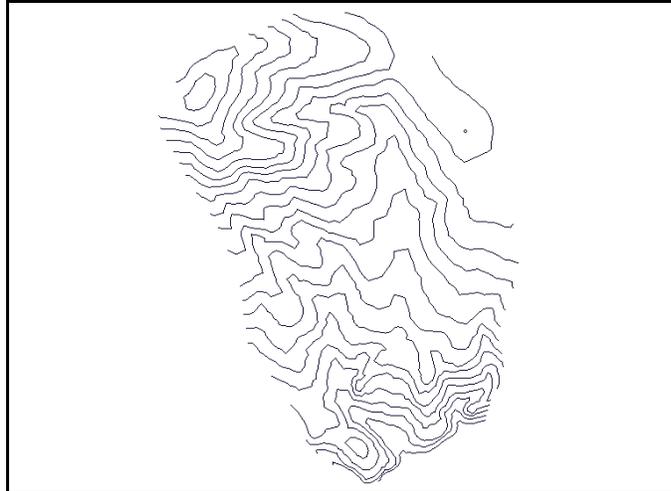
Figure 5   Imported CAD contour file

7.2   Converting the CAD Contours to Arcs

The elevation data in this file should be merged with data from a DEM. To convert the DWG file to a TIN, first convert the contour lines to arcs, redistribute vertices on the arcs, and convert the arcs with the redistributed vertices to a TIN. Normally, it is not recommended to convert contour lines directly to a TIN because the vertices along each contour line might be at a random or undesirable spacing to generate a quality TIN.

1. Right-click on "◻ tmcontours.dwg" under the "▤ CAD Data" folder and select *CAD To* | **Feature Objects…** to bring up the *CAD → Feature Objects* dialog.

2. Uncheck the check boxes on rows 1 and 2, leaving *CAD layers_arcs* turned on.

3. Click **OK** to close the *CAD → Feature Objects* dialog and bring up the *Clean Options* dialog.

4. Click **OK** to close the *Clean Options* dialog and open the *Coverage Properties* dialog.

5. Select "General" from the *Coverage type* drop-down.

6. Enter "CAD Layers" as the *Coverage name*.

7. Click **OK** to close the *Coverage Properties* dialog and create the *CAD layers* coverage.

8. Right-click on "▤ CAD Data" under the "🌐 GIS Data" folder and select **Remove**.

9. Switch to the **Map Module** ✛ and select the **Select Feature Arc** 🖈 tool.

10. Select *Edit* | **Select All** to select all feature arcs.

11. Select *Feature Objects* | **Redistribute…** to bring up the *Redistribute Vertices* dialog.

12. In the *Arc Redistribution* section, enter "20.00" as the *Average Spacing*.

13. Click **OK** to close the *Redistribute Vertices* dialog.

7.3   Converting the CAD File to a TIN

When redistributing the vertices, WMS interpolates elevations for any new vertices on the arc from existing arc vertices. Now that the vertices on the arcs have been redistributed to a more even spacing, convert the contours to a TIN.

1. Select *Feature Objects* | **Arcs → TIN Vertices**.

2. Right-click on the "🔷 New tin" and select *Triangles* | **Triangulate** on the pop-up menu.

WMS will create triangles throughout the TIN (Figure 6).
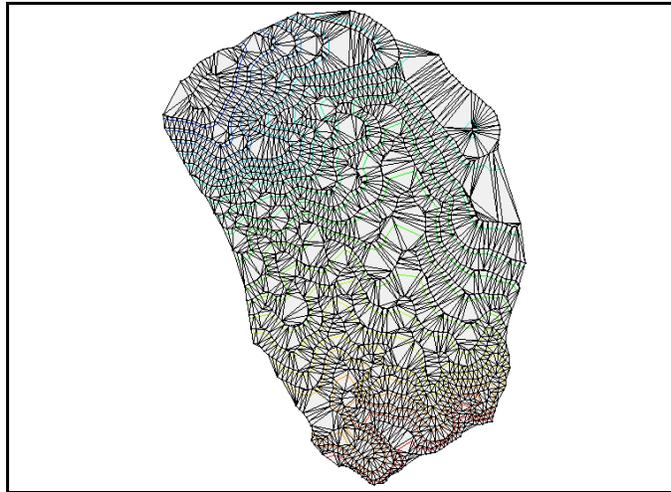

Figure 6   Triangulated TIN

3. Switch to the **Map Module** 🧭.

4. Select *Feature Objects* | **Delete** to bring up a confirmation dialog.

5. Click **OK** to delete all of the original contour data.

6. Right-click on "🔷 New tin" and select **Rename**.

7. Enter "CAD Contours" and press *Enter* to set the new name.

The TIN has now been created, but the projection has not yet been defined.

1. In the Project Explorer, right-click on "🔷 CAD Contours" and select *Projection* | **Projection**.

2. Select the *Global Projection* radio button in the *Projection* dialog and click **Set Projection** (if necessary) to bring up the *Select Projection* dialog.

3. Select "UTM" from the *Projection* drop-down.

4. Select "12 (114°W - 108° W – Northern Hemisphere)" from the *Zone* drop-down.

5. Select "NAD27" from the *Datum* drop-down.

6. Select "METERS" from the *Planar Units* drop-down.

7. Click **OK** to close the *Select Projection* dialog.

8. In the *Vertical* section; select "NGVD 29(US)" from the *Projection* drop-down.

9. Select "Feet (U.S. Survey)" from the *Units* drop-down.

10. Click **OK** to close the *Projection* dialog.

11. Click **Yes** when asked to continue with inconsistent horizontal and vertical units.

7.4   Importing the DEM File

1. Click **Open** to bring up the *Open* dialog.

2. Select "trailmountain.dem" and click **OK** to exit the *Open* dialog and open the *Importing USGS DEMs* dialog..

3. Click **OK** to close the *Importing USGS DEMs* dialog.

The USGS DEM file has now been imported, and the TIN is visible near the top of the DEM (Figure 7).
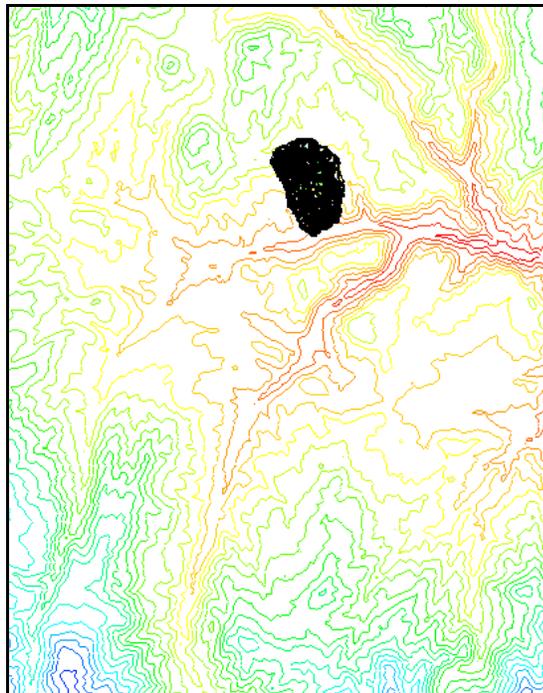

Figure 7   TIN (black) with imported DEM

7.5   Reprojecting the CAD TIN

To merge the imported DEM with the TIN created from the CAD contours, convert the DEM to a TIN and make sure all the TINs are in the same coordinate system. The XY projection of the DEM and TIN are currently in meters in the same UTM coordinate system, however, the elevations on the DEM are in meters while the elevations on the TIN are in feet. The vertical units for the "CAD Contours" TIN will need to be reprojected to "Meters" so that the units are consistent.

1. Right-click on " CAD Contours" and select *Projection* / **Reproject** to bring up the *Reproject Object* dialog.

2. In the *Project Projection* section, turn on *Set*.

3. In the *Horizontal* section, select *Global Projection*.

4. Click **Set Projection…** to bring up the *Select Projection* dialog.

5. Select "UTM" from the *Projection* drop-down.

6. Select "12 (114°W - 108° W – Northern Hemisphere)" from the *Zone* drop-down.

7. Select "NAD27" from the *Datum* drop-down.

8. Select "METERS" from the *Planar Units* drop-down.

9. Click **OK** to close the *Select Projection* dialog.

10. In the *Vertical* section, select "NGVD 29(US)" from the *Projection* drop-down

11. Select "Feet (U.S. Survey)" from the *Units* drop-down.

12. Click **OK** to close the *Reproject Object* dialog and reproject the data.

7.6   Converting the DEM to a TIN

The projections of the TIN and DEM are now consistent. But, before merging anything, the DEM must be converted to a TIN.

1. Right-click on "▦ trailmountain" and select *Convert | DEM → TIN | **All…*** to bring up the *DEM Conversion Options* dialog.

2. Turn on *Delete DEM*.

3. Click **OK** to accept the other settings and close the *DEM Conversion Options* dialog.

The DEM TIN may appear solid black. This is because the triangles for the DEM TIN are very small.

4. Right-click on "⬢ CAD Contours" and select **Merge…** to bring up the *Merge TINs* dialog.

5. Between the *Available TINs* and *TINs to Merge* lists, click **All →** to move both TINs in the *Available TINs* list to the *TINs to Merge* list.

To merge these TINs together and delete any regions of overlap between the TINs, order the TINs in the correct order in the list of TINs to merge. They should be ordered in the priority used for merging TINs. Put the least accurate TIN at the top, the most accurate at the bottom.

6. In the lower section, select *Delete overlapping regions*.

7. In the *TINs to Merge* list, select "CAD Contours" and click **Move down** so it is at the bottom of the list.

8. Click **OK** to close the Merge TINs dialog.

It may take a few moments for the merging to complete. Once complete, a new "⬡ Merged Tin" will appear in the Project Explorer.

9. In the Project Explorer, hold down the *Ctrl* key and select "⬡ CAD Contours" and "⬡ New tin".

10. Press **Delete** to remove these TINs.

A merged TIN has now been created that is a combination of the "⬡ CAD Contours" and the USGS DEM ("⬡ New tin"). This TIN can be used for hydraulic modeling or converted to a DEM so it can be used for hydrologic modeling.

8   Triangulation

Before proceeding with the tutorial, delete the existing data, import a TIN, and triangulate the data.

1. Select *File* / **New** 📄.
2. Click **No** if asked to save changes.
3. Select *File* / **Open** 📂 to bring up the *Open* dialog.
4. Select "digitizetm.tin" and click **Open** to import the TIN and exit the *Open* dialog.
5. Right-click on "⬡ New tin" and select *Triangles* / **Triangulate**.

The imported TIN should now have triangles connecting all the points (Figure 8).
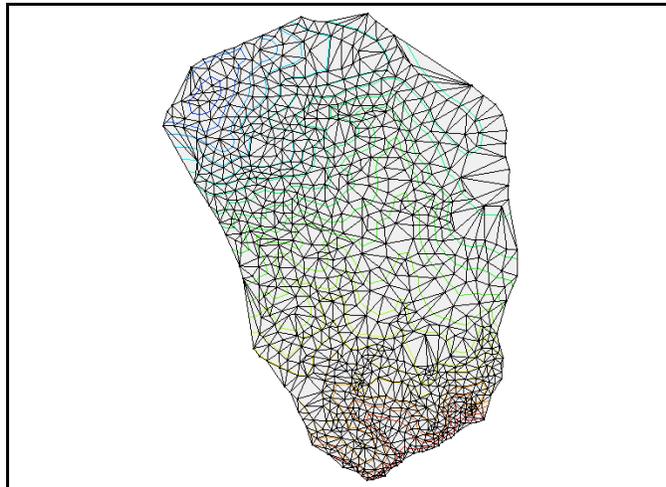

Figure 8   The TIN is now triangulated

9   Automated TIN Editing

WMS has automated methods of editing TINs to provide a representation of terrain that is useful for drainage analysis. These methods include data transformations and eliminating flat triangles and pits, but they are seldom needed since flat triangles and pits pose few problems when using the DEM-based watershed delineation tools in WMS. Data transformations may be useful for repositioning data if it is not originally located in the correct position because of survey errors or an unknown coordinate system. After transforming coordinates, always set the display projection system if it is known.

9.1   Transformations

Move the cursor over the TIN and notice that the *Z* values in the help strip at the bottom of the WMS window are in feet. Because the *XY* values on this particular TIN are in meters, the *X*, *Y*, and *Z* units should all be in meters so they match when delineating a watershed. In this section, the *Z* values are converted from feet to meters. This is normally done using the coordinate conversion tool, but the transform tool can be used to accomplish the same thing.

1. Select *TIN | Vertices | **Transform…*** to bring up the *Transform TIN* dialog.

2. In the first section, enter "0.3048" for the *Z* in the *Scale* column.

This changes the elevation units from feet to meters. Notice that there are several other options for transforming TIN vertices, including options to translate and rotate vertices on the entire TIN. These will not be used at this time.

3. In the lower section, turn on *Frame image after transformation*.

4. Click **OK** to close the *Transform TIN* dialog.

Move the cursor over the TIN and notice that the *Z* values in the help strip are now in meters. Elevation values should be in the 1900-2300 range.

9.2   Converting a TIN to a DEM

If delineating a watershed, convert the TIN to a DEM. This section demonstrates how to delineate a watershed from a TIN by converting the TIN to a DEM.

1. Right-click on "🔶 New tin" and select *Convert | **TIN → DEM*** to bring up the *Convert TIN to DEM* dialog.

2. Below the drop-down, enter "10.00" as both the *cell width* and *cell height*.

3. Click **OK** to close the *Convert TIN to DEM* dialog.

4. If asked to delete existing TIN data, click **Yes**.

Notice that the TIN disappeared, leaving only the contour lines.

5. Switch to the **Drainage** 🌊 module.

6. Select *DEM | **Compute Flow Direction/Accumulation…*** to bring up the *Flow Direction/Accumulation Run Options* dialog.

7. Click **OK** to accept the defaults and close the *Flow Direction/Accumulation Run Options* dialog and bring up the *Units* dialog.

8. Click **OK** to accept the defaults and close the *Units* dialog and bring up the *Model Wrapper* dialog.

9. When TOPAZ finishes, turn on *Read solution on exit* and click **Close** to close the *Model Wrapper* dialog.

10. Click **Display Options** 🖥 to bring up the *Display Options* dialog.

11. Select "DEM Data" from the list on the left.

12. On the DEM tab, enter "0.004" as the *Min. Accumulation For Display*.

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

14. Zoom in to the outlet area of the main stream system (Figure 9).

15. Using the **Create Outlet Point** ⬤ tool, create an outlet as shown in Figure 9.
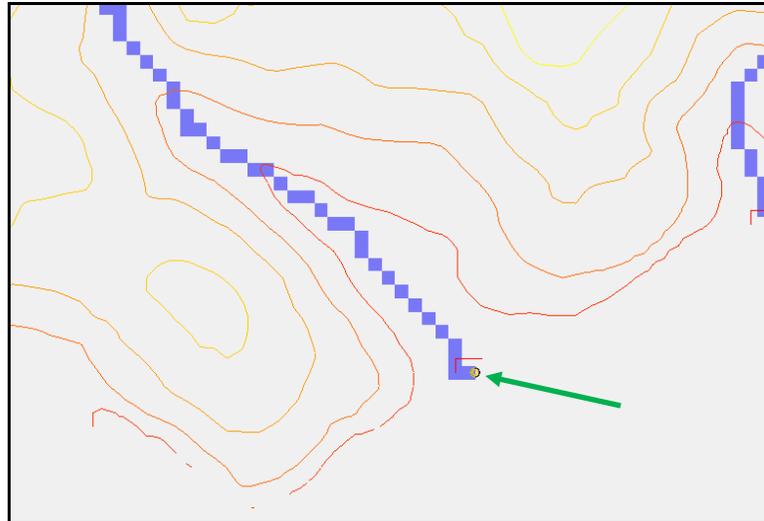

Figure 9   DEM outlet (green arrow)

16. Select *DEM* / **Delineate Basins Wizard** to bring up the *Stream Feature Arc Options* dialog.

17. Click **OK** to accept the defaults, close the *Stream Feature Arc Options* dialog, and open the *Units* dialog.

18. Click **OK** to accept the defaults, delineate the watershed, compute the basin data, and close the *Units* dialog.

19. **Frame** ⊡ the project.

20. Click **Display Options** 🖳 to bring up the *Display Options* dialog.

21. Select "Map Data" from the list on the left.

22. On the *Map* tab select "Drainage" from the *Coverage type* drop-down.

23. Below the *Legends* section, click **Set Polygon Transparency…** to bring up the *Set Feature Polygon Transparency* dialog.

24. Set *Transparency* to "75%" and click **OK** to close the *Set Feature Polygon Transparency* dialog.

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

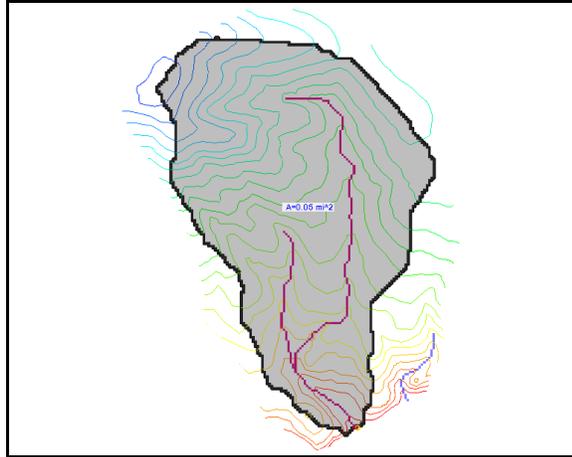A drainage boundary based on the DEM and drainage basin data is visible (Figure 10).

Figure 10   The drainage basin is now visible

10   Exporting Data to CAD

Visible data can be converted and saved as CAD data for use in CAD programs.

1. In the Project Explorer, right-click on " GIS Data" and select **Data → CAD**.

A " WMS Data" folder containing a set of layers should now be visible under the " CAD Data" folder in the Project Explorer. In order to view only the newly created CAD data, hide all other data in the Project Explorer.

2. Turn off the " Map Data" and " Terrain Data" folders in the Project Explorer.

3. Turn off the " 0" and " Drainage_arcs" layers under the " WMS Data" folder.

4. Select *File | Save As…* to bring up the *Save As* dialog.

5. Select "DWG Files (*.dwg)" from the *Save as type* drop-down.

6. Enter "UsingTINs.dwg" as the File name.

7. Click **Save** to export the DWG file and close the *Save As* dialog.

11   Conclusion

This concludes the "Editing Elevations – Using TINs" tutorial. The following topics were discussed and demonstrated:

- How to import survey data

- How to digitize data

- Triangulation

- Automated TIN editing

- Manual TIN editing

- How to create a TIN using a conceptual model

- How to convert a TIN to a DEM

- How to export data to CAD