ARC HYDRO GROUNDWATER TUTORIALS

Subsurface Analyst – Creating rasters from cross sections

1   Introduction

Arc Hydro Groundwater (AHGW) is a geodatabase designed for representing groundwater datasets within ArcGIS. The data model helps to archive, display, and analyze multidimensional groundwater data, and includes several components to represent different types of datasets, including representations of aquifers and wells/boreholes, 3D hydrogeologic models, temporal information, and data from simulation models.

The *Arc Hydro Groundwater Tools* help to import, edit, and manage groundwater data stored in an AHGW geodatabase. *Subsurface Analyst* is a subset of the AHGW Tools used to manage 2D and 3D hydrogeologic data, and create subsurface models including generation of borehole representations, cross sections, surfaces, and volumes.

This tutorial demonstrates how 3D hydrogeologic models can be modified by including new data points derived from cross sections. The *GeoSections To Points* tool will be used, and the output points to interpolate new rasters will be included. The rasters are then loaded into a raster catalog and used to create volume and cross sections. The process of creating GeoSections from sketched 2D cross sections is illustrated in separate tutorials.

1.1   Background

Data used in this tutorial are based on data from a study conducted by the USGS in the city of Woburn, Massachusetts. The data were modified for the purposes of this tutorial. The site location is shown in Figure 1.
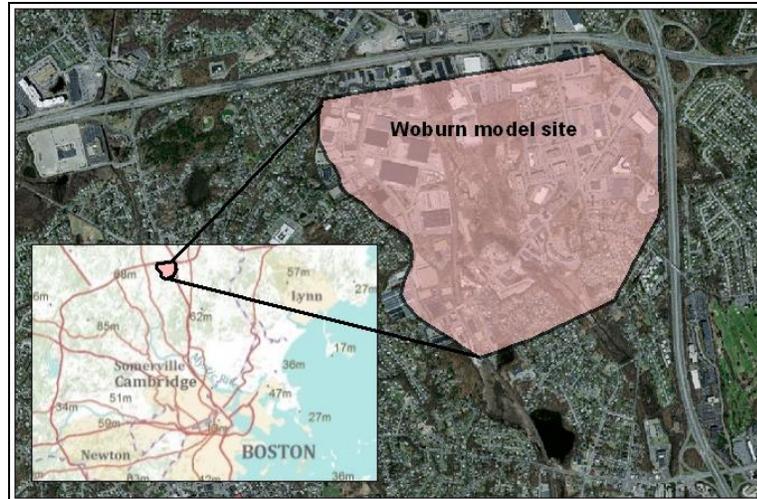
Figure 1   Location of the Roseville model

For the purpose of this tutorial, three primary hydrogeologic units were defined. The base of the model domain is deep gravel, the middle part is alluvium consisting of sand and silt, and the top unit is a peat layer that is limited to the river area. 1.1 shows the sequence of formations used in the model. Each of the units is indexed by a hydrogeologic unit identifier (HGUID), and the unit properties are defined in the HydrogeologicUnit table.

In addition, each of the units is indexed with a horizon ID. The term "horizon" refers to the top of each stratigraphic unit that will be represented in the subsurface model. Horizons are numbered consecutively in the order that the strata are "deposited" (from the bottom up). Each contact represented in the subsurface model must have a HorizonID.

Horizons can be represented as rasters, one for each horizon ID. The rasters will typically be created by interpolating contacts created from borehole and cross sections for each horizon. When organized in a raster catalog, the rasters can be used to create 3D GeoSection and GeoVolume features based on an attribute field containing the horizon ID.
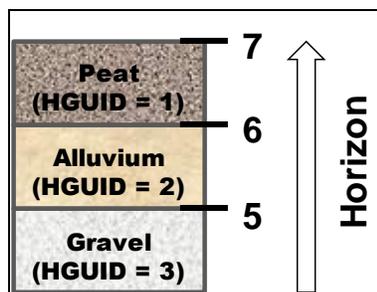

Figure 2   Hydrogeologic units indexed with HGUIDs and HorizonIDs

1.2   Outline

The objective of this tutorial is to introduce the basic workflow and tools for including data points derived from cross sections to interpolate 3D hydrogeologic models. The tutorial includes the following steps:

1. Transform GeoSections to points,

2. Select a set of points for a specific hydrogeologic unit (horizon),

3. Interpolate rasters,

4. Load and index rasters in a GeoRaster raster catalog, and

5. Create 3D GeoSection and GeoVolume features.

1.3   Required Modules and Interfaces

The following components are required in order to complete this tutorial:

•   ArcView license (or ArcEditor\ArcInfo)

•   3D Analyst

•   Arc Hydro Groundwater Tools

•   AHGW Tutorial Files

The AHGW Tools require a compatible ArcGIS service pack be installed. Check the AHGW Tools documentation to find the appropriate service pack for the version of the tools being used. The tutorial files should be downloaded to a local computer.

2   Getting Started

Before opening the tutorial scene, ensure that the AHGW Tools are correctly configured.

1. Launch *ArcScene*.

2. Click **ArcToolbox** to open the *ArcToolbox* window.

Make sure " Arc Hydro Groundwater Tools" is in the list of toolboxes. If it is, skip to step 7. If it is not, follow steps 3–6 to add it.

3. Add the toolbox by right-clicking anywhere in the *ArcToolbox* window and selecting **Add Toolbox…** to bring up the *Add Toolbox* dialog.

4. Select " Toolboxes" from the *Look in* drop-down.

5. Double-click on " System Toolboxes".

6. Select " Arc Hydro Groundwater Tools.tbx" and click **Open** to exit the *Add Toolbox* dialog.

7. Expand " Arc Hydro Groundwater Tools".

8. Expand " Subsurface Analyst".

The *Arc Hydro Groundwater Toolbar* will also be used. This toolbar contains additional user interface components not available in the toolbox. If the toolbar is not visible, do the following:

9. Right-click on a blank space on any visible toolbar and select **Arc Hydro Groundwater Toolbar** to make it appear.

When using geoprocessing tools, set the tools to overwrite outputs by default, and automatically add results to the map/scene. To set these options:

10. Select *Geoprocessing* / **Geoprocessing Options...** to bring up the *Geoprocessing Options* dialog.

11. In the *General* section, turn on *Overwrite the outputs of geoprocessing operations*.

12. In the *Background Processing* section, turn off *Enable*.

13. In the *Display / Temporary Data* section, turn on *Add results of geoprocessing operations to the display.*

14. Click **OK** to exit the *Geoprocessing Options* dialog.

3   Opening the Scene

Begin by opening a scene containing some background data for the project.

1. Select *File* / **Open…** to bring up the *Open* dialog.

2. Browse to the *Tutorials\subsurface analyst\GeoSection to Points* folder and select "Woburn_geosections_to_points.sxd".

3. Click **Open** to exit the *Open* dialog and import the SXD file.

The scene should appear similar to   Figure 3. It contains a set of 3D GeoSection features forming a fence diagram as well as BorePoint features that represent hydrostratigraphy along boreholes. The features are symbolized based on the HorizonID attribute.
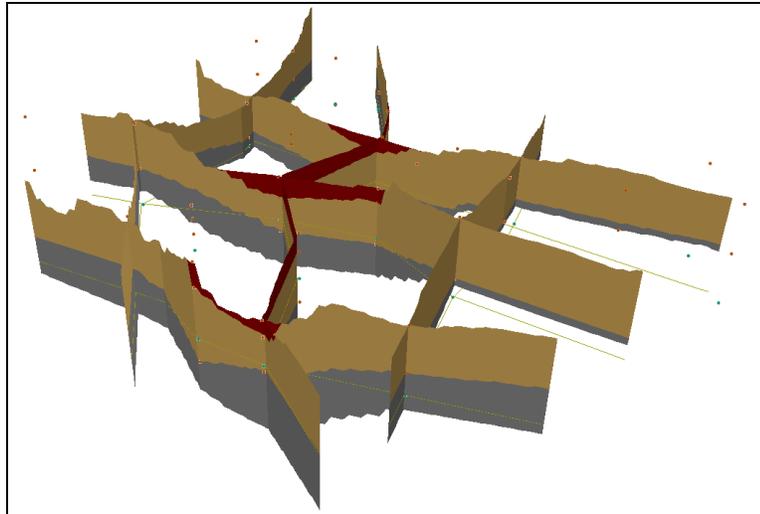
Figure 3   Scene showing GeoSections and BorePoints symbolized by the HorizonID

4   Transforming GeoSections to Points

Next, transform GeoSection features into points by sampling along the GeoSection and creating 3D points. Append the new points into the existing BorePoint feature class:

1. In the *ArcToolbox* window, expand " Features" under " Subsurface Analyst" under " Arc Hydro Groundwater Tools".

2. Double-click on " GeoSection to Points" to bring up the *GeoSection to Points* dialog.

3. Select "SectionLine" from the *Input SectionLine Features* drop-down.

4. Select "GeoSection" from the *Input GeoSection Features* drop-down.

5. Select "BorePoint" from the *Input BorePoint Features* drop-down.

6. Enter "200" as the *Sampling Distance*.

7. Turn off *Overwrite Existing BorePoint Features*.

8. Click **OK** to close the *GeoSection to Points* dialog and open the *GeoSection to Points* process wrapper dialog.

9. When the processing is complete, click **Close** to exit the *GeoSection to Points* process wrapper dialog.

A set of 3D points should appear (Figure 4), defining the boundary of the GeoSections features added to the BorePoint feature class.
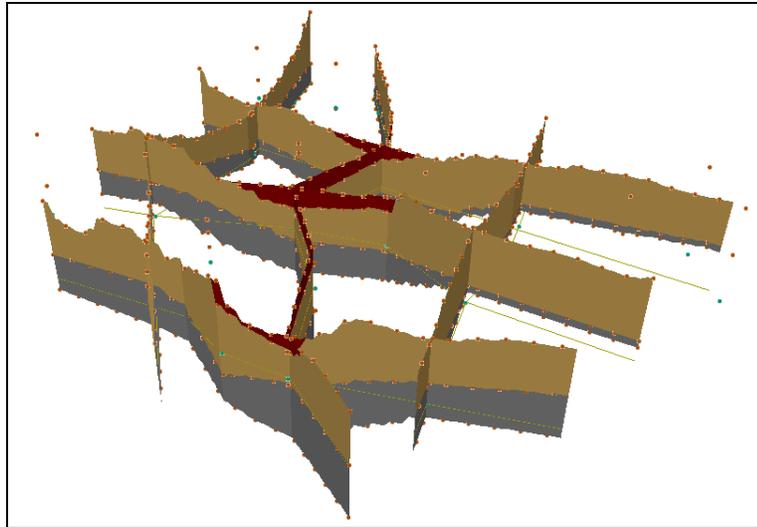
Figure 4   Points along GeoSection panels created using the GeoSection to Points tool

Once the tool has executed, do the following:

10. Under "⬚ Scene Layers" in the Table of Contents, right-click on "BorePoint" and select **Open Attribute Table** to bring up the *Table* dialog for BorePoints.

11. Scroll to the right in the spreadsheet to the *GeoSectionID* column, then scroll down until something other than "<Null>" appears in that column.

The *GeoSectionID* field was populated for each point with the *HydroID* of the associated GeoSection panel (the original BorePoint features will not have a GeoSectionID as they were created from borehole data). Notice that the *HGUID* field was also populated with the HGUID of the associated GeoSection panel. Finally, note that the *HorizonID* attribute of the *BorePoint* features match those of the GeoSection features they came from. A negative *HorizonID* indicates that the point came from the bottom of a GeoSection feature.

12. When done, close the *Table* dialog by clicking the **X** in its top right corner.

5   Interpolating Rasters

Next, interpolate rasters based upon the BorePoint features. This step requires the *Spatial Analyst* or *3D Analyst* extensions. If neither of these extensions is installed, this part of the tutorial cannot be completed (if desired, use the solution files to view the interpolated rasters). Use the *IDW* geoprocessing tool to perform the interpolation and set the *Environment* options such that the resulting raster is clipped to the *Boundary* feature class.

Before starting the interpolation, filter the points for a selected HorizonID using the Field Filter available in the AHGW toolbar.

1. Select the "BorePoint" layer in the Table of Contents.

2. In the Arc Hydro Groundwater toolbar, select "HorizonID" from the first *Field* drop-down and "-5" from the second drop-down (Figure 5).

This defines a definition query to show only points with HorizonID equal to "-5", which corresponds with the bottom of the gravel layer.

Field | HorizonID ▼ | -5 ▼

Figure 5   Field filter drop-downs

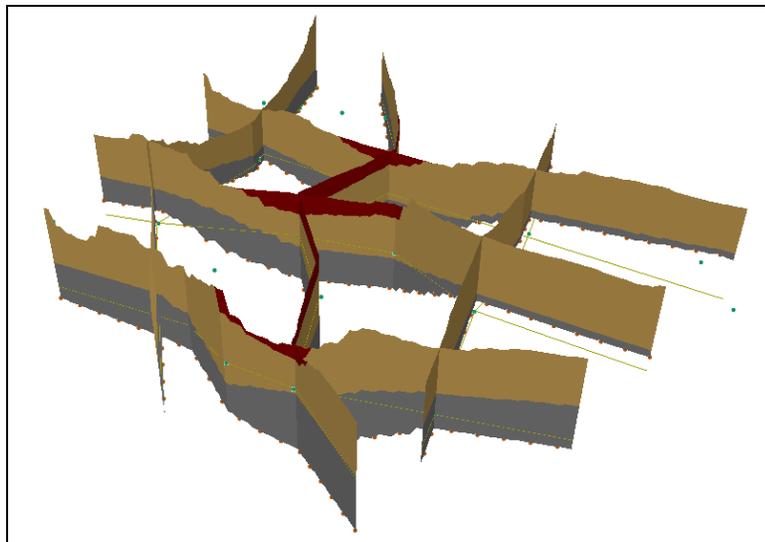At this point, the scene should appear similar to the one shown in Figure 6.

Figure 6   Points representing the bottom of the gravel layer (HorizonID = -5)

3. In the ArcToolbox, expand " Interpolation" under " Spatial Analyst Tools" and double-click on " IDW" to bring up the *IDW* dialog.

This dialog can also be accessed by expanding " Raster Interpolation" under " 3D Analyst Tools" and double-clicking on " IDW".

4. Select "BorePoint" from the *Input point features* drop-down.

5. Select "Shape.Z" from the *Z value field* drop-down.

Because the features are 3D features, the elevation can be read directly from the shape field. If using ArcGIS 9.3, use the *TopElev* field instead of the *Shape.Z* value.

6. Click to the right of the *Output raster* field to bring up the *Output raster* dialog.

7. Browse to the *GeoSection to Points\Tutorials\subsurface analyst\GeoSection to Points\rasters* folder and enter "horizon5b" as the *Name*.

8. Click **Save** to exit the *Output raster* dialog.

9. Enter "100" as the *Output cell size*.

10. Leave the other options at the default values and click **Environments…** to bring up the *Environment Settings* dialog.

11. Expand the *Processing Extent* (ArcGIS 10) or *General Settings* (ArcGIS 9.3) section and select "Same as layer Boundary" from the *Extent* drop-down.

This will cause the interpolation to extend out the rectangular limits of the *Boundary* feature class.

12. Scroll down and expand the *Raster Analysis* section.

13. Select "Boundary" from the *Mask* drop-down.

This will clip the raster to the actual boundary of the *Boundary* feature class.

14. Click **OK** to exit the *Environment Settings* dialog.

15. Click **OK** to exit the *IDW* dialog and execute the *IDW* tool.

16. When the tool completes its run, click **Close** to exit the *IDW* wrapper dialog.

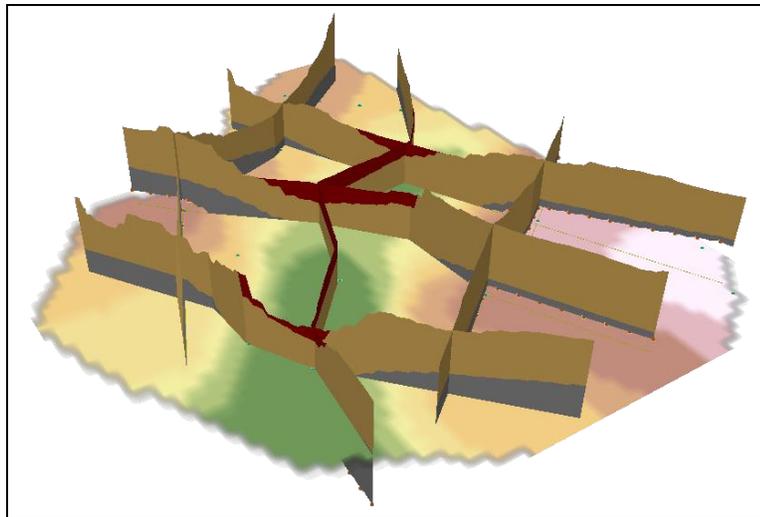Note the new raster is added to the display using zero as the display elevation (Figure 7).

Figure 7   The new raster using zero as the display elevation

To visualize the new raster based on its elevations, set the base height:

17. In the Table of Contents, select "horizon5b", right-click on it, and select **Properties…** to bring up the *Base Heights* tab in the *Layer Properties* dialog.

18. In the *Elevation from surfaces* section, select *Floating on a custom surface* (in ArcGIS 10) or *Obtain heights for layer from surface* (in ArcGIS 9.3).

19. Select the option from the drop-down that corresponds to the name of the raster (in this case, "horizon5b").

20. Click **Apply**, then **OK** to close the *Layer Properties* dialog.

The full path to the raster will be displayed as part of the name, and will use its own values for display in 3D. The new raster should now be rendered in 3D (Figure 8).
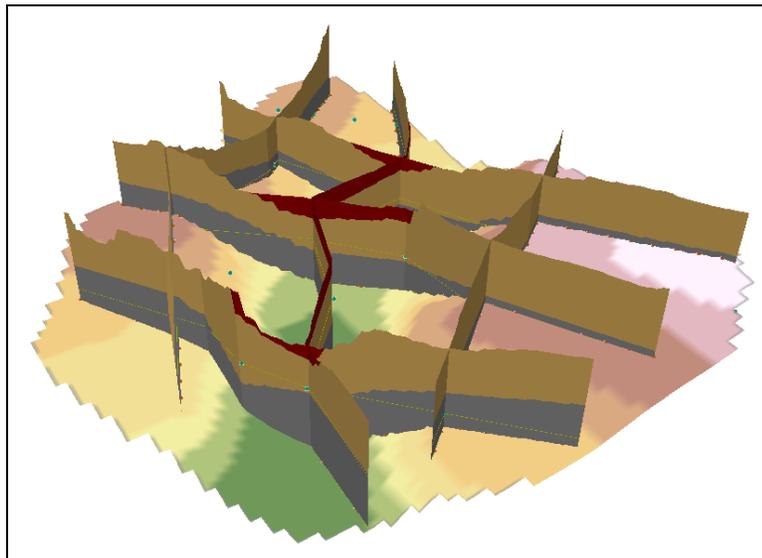

Figure 8   Visualizing the interpolated raster

21. Repeat steps 1–20 for Horizon 5, selecting "5" as the HorizonID in step 2 and entering or selecting "Horizon5" in steps 7, 17, and 19.

22. Repeat steps 1–20 for Horizon 6, selecting "6" as the HorizonID in step 2 and entering or selecting "Horizon6" in steps 7, 17, and 19.

23. Repeat steps 1–20 for Horizon 7, selecting "7" as the HorizonID in step 2 and entering or selecting "Horizon7" in steps 7, 17, and 19.

The scene should appear similar to Figure 9, showing a set of rasters representing the horizons within the model. The rasters are the base for creating 3D volume models. Coloring may be different, depending on the display settings being used.
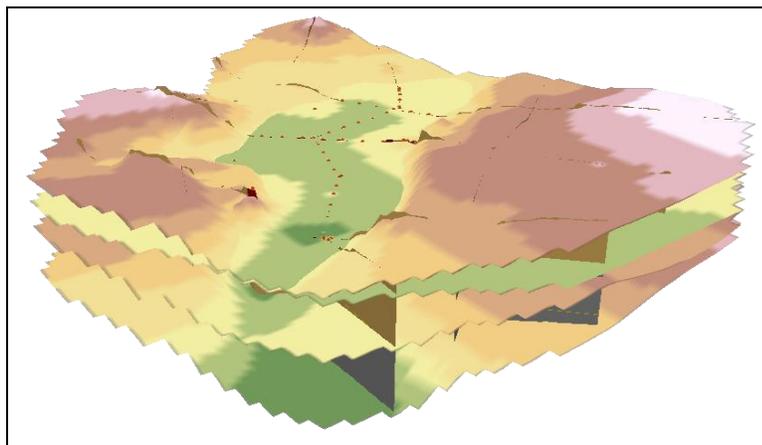

Figure 9   Interpolated rasters representing horizons in a 3D model

6   Loading Rasters to the GeoRasters Raster Catalog

In this step, load the rasters into a GeoRasters raster catalog and index them with attributes used later to create 3D GeoSection and GeoVolume features. A more detailed description of the process, including the creation of the raster catalog and an explanation of the different options, is available in the "Creating GeoRasters from Borehole Data" tutorial.

1. In the ArcToolbox, expand " To Geodatabase" under " Conversion Tools" and double-click on the " Raster to Geodatabase (multiple)" script to bring up the *Raster to Geodatabase (multiple)* dialog.

2. Click at the right of the *Input Rasters* field to bring up the *Input Rasters* dialog.

3. Browse to the *subsurface analyst\GeoSections to Points\rasters* folder for this tutorial and, while holding down the *Ctrl* key, select the horizons in the following order: "horizon5b", "horizon5", "horizon6", and "horizon7".

4. Click **Add** to close the *Input Rasters* dialog.

The four rasters should now be listed in the section below the *Input Rasters* field.

5. Click at the right of the *Output Geodatabase* field to bring up the *Output Geodatabase* dialog.

6. Browse to the *Tutorials\subsurface analyst\GeoSection to Points* folder and double-click on "woburn.gdb".

7. Select "GeoRasters" and click **Add** to exit the *Output Geodatabase* dialog.

8. Click **OK** to exit the *Rasters to Geodatabase (multiple)* dialog and bring up the *Rasters to Geodatabase (multiple)* wrapper dialog.

9. When the tool completes its run, click **Close** to exit the *Rasters to Geodatabase (multiple)* wrapper dialog.

Next, edit the attributes of the GeoRasters catalog.

10. Right-click on a blank spot in the toolbar area and turn on *3D Editor*.

11. From the *3D Editor* toolbar, select *3D Editor* | **Start Editing** to bring up the *Start Editing* dialog.

12. If a notice appears stating the spatial reference does not match the data frame, click **Continue** to close the *Start Editing* dialog.

13. Right-click on "GeoRasters" in the Table of Contents and select **Open Attribute Table** to bring up the *Table* dialog.

14. In the row with "horizon5b" in the *Name* column, enter "0", "1", and "-5" in the *Clip*, *Fill*, and *HorizonID* columns (respectively).

15. In the row with "horizon5" in the *Name* column, enter "0", "1", and "5" in the *Clip*, *Fill*, and *HorizonID* columns (respectively).

16. In the row with "horizon6" in the *Name* column, enter "0", "1", and "6" in the *Clip*, *Fill*, and *HorizonID* columns (respectively).

17. In the row with "horizon7" in the *Name* column, enter "0", "1", and "7" in the *Clip*, *Fill*, and *HorizonID* columns (respectively).

18. Select *3D Editor* | **Save Edits** to save the changes to the attribute table.

19. Select *3D Editor* | **Stop Editing** to exit editing mode.

20. Click the **X** in the top right corner of the *Table* dialog to close the GeoRasters attribute table.

7   Creating 3D GeoSection and GeoVolume Features

Now use the rasters indexed in the GeoRasters raster catalog to create 3D GeoSection and GeoVolume features.

7.1   Creating 3D GeoSections Features

1. Turn on and select "SectionLine" layer in the Table of Contents.

2. In the ArcToolbox " Arc Hydro Groundwater Tools", expand " Features" under " Subsurface Analyst" and double-click on " Rasters to GeoSections" to bring up the *Rasters to GeoSections* dialog.

3. Select "SectionLine" from the *Input SectionLine Features* drop-down.

4. Select "GeoRasters" from the *Input GeoRasters Catalog* drop-down.

5. Select "HorizonID" from the *Raster Catalog Horizon ID field* drop-down.

6. Select "Clip" from the *Raster Catalog Clip field* drop-down.

7. Select "Fill" from the *Raster Catalog Fill field* drop-down.

8. Select "HGUID" from the *Raster Catalog HGUID field* drop-down.

9. Enter "50" as the *Discretization Spacing*.

10. Select "GeoSection" from the *Input GeoSection Features* drop-down.

11. Make sure *Append to Existing GeoSection Features* is turned on.

12. Click **OK** to exit the *Rasters to GeoSections* dialog and open the *Rasters to GeoSections* wrapper dialog.

13. When the tool finishes running, click **Close** to exit the *Rasters to GeoSections* wrapper dialog.

Upon completion, a set of 3D GeoSection features should appear, as shown in Figure 10. Feel free to change the colors using the *Symbology* tab of the *Layer Properties* dialog. The four horizon layers have been turned off in the Table of Contents make the 3D GeoSection features more visible.
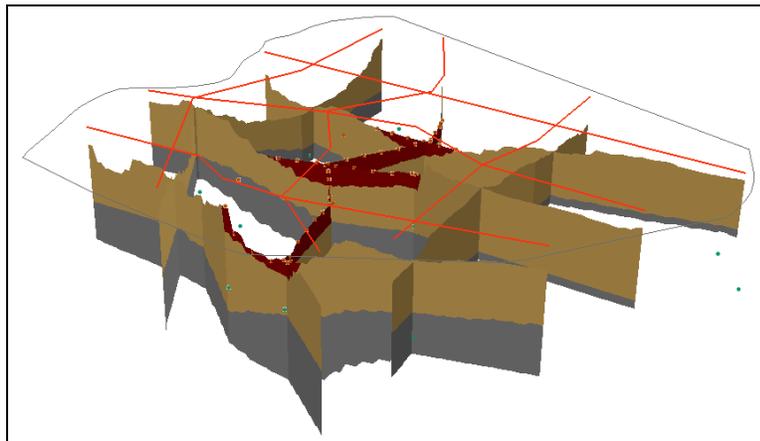

Figure 10   3D GeoSection features with boundary border visible

7.2 Creating 3D GeoVolume Features

Next, create 3D volume elements.

1. In the ArcToolbox " Arc Hydro Groundwater Tools", expand " Features" under " Subsurface Analyst" and double-click on " Rasters to GeoVolumes" to bring up the *Rasters to GeoVolumes* dialog.

2. Select "projtin300" from the *Input Projection TIN* drop-down.

3. Select "GeoRasters" from the *Input Raster Catalog* drop-down.

4. Select "HorizonID" from the *Raster Catalog Horizon ID field* drop-down.

5. Select "Clip" from the *Raster Catalog Clip field* drop-down.

6. Select "Fill" from the *Raster Catalog Fill field* drop-down.

7. Select "HGUID" from the *Raster Catalog HGUID field* drop-down.

8. Enter "1" as the *Minimum MultiPatch Thickness*.

9. Select "GeoVolume" from the *Input GeoVolume Features* drop-down.

10. Make sure *Append to Existing GeoVolume Features* is turned on.

11. Click **OK** to exit the *Rasters to GeoVolumes* dialog and bring up the *Rasters to GeoVolumes* wrapper dialog.

12. When it finishes, click **Close** to exit the *Rasters to GeoVolumes* wrapper dialog.

13. Right-click on "GeoVolumes" in the Table of Contents and select **Properties…** to bring up the *Symbology* tab of the *Layer Properties* dialog.

14. Under *Show* on the left, select "Categories", then "Unique values".

15. On the right, click **Add All Values** to add the three values for "5", "6", and "7" t the list.

16. Adjust the color for each layer as desired, then click **Apply**.

17. Click **OK** to close the *Layer Properties* dialog.

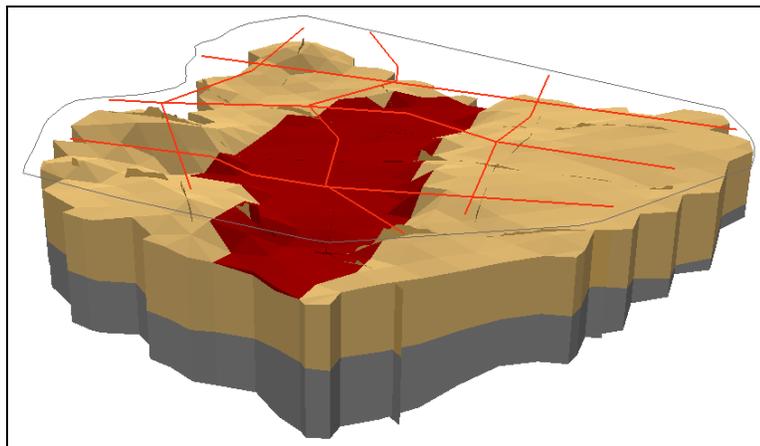The GeoVolumes should now be visible and appear similar to Figure 11.

Figure 11   GeoVolume features representing hydrogeologic units

8   Conclusion

This concludes the "Creating rasters from cross sections" tutorial. The following key concepts were discussed and demonstrated in this tutorial:

- Use the *GeoSection To Points* tool to create points along the panels of 3D GeoSections.

- The *HorizonID* attributes of new point features match those of the GeoSection feature from which they were created. A negative *HorizonID* indicates that the point came from the bottom of a GeoSection feature.

- GeoSection points can be combined with borehole points.

- A set of points can be filtered using the Field Filter in the AHGW toolbar.

- Rasters are interpolated using the standard ArcGIS interpolation tools.

- Raster catalogs, 3D fence diagrams, and volume models can be created or updated using the interpolated rasters.