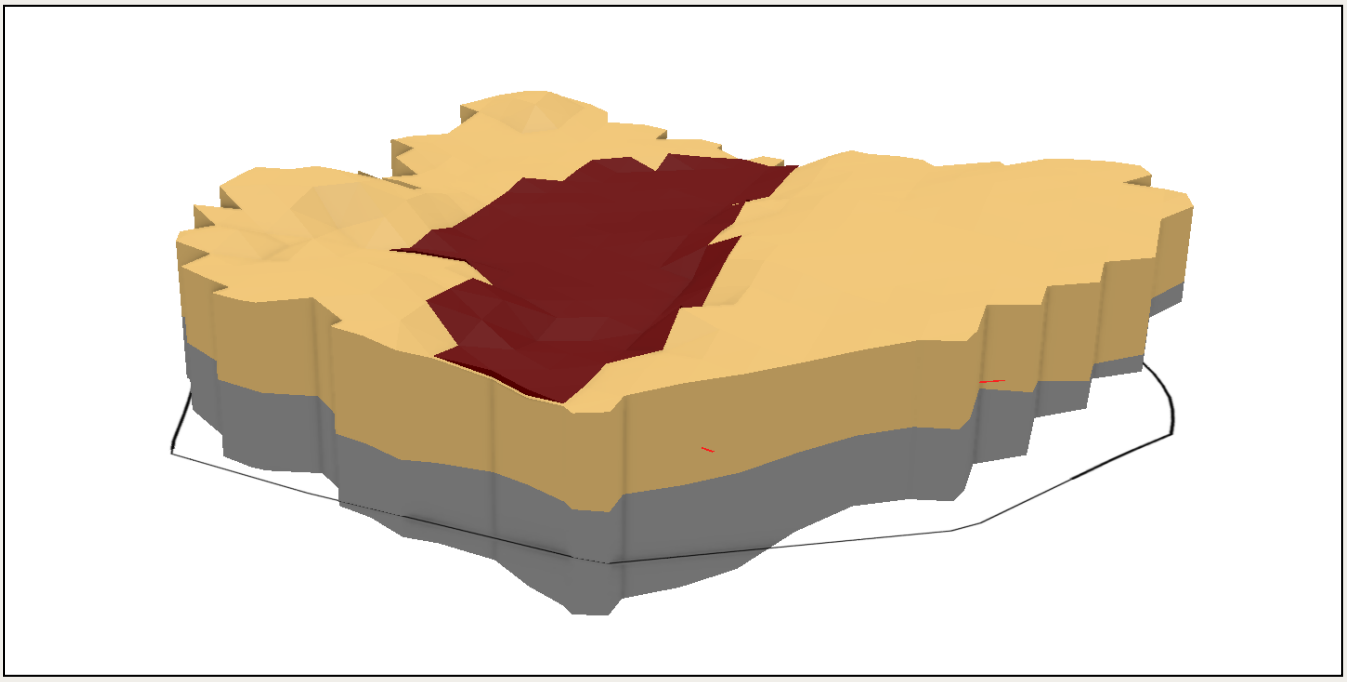
AHGW Pro 1.0 Tutorial

Creating Rasters from Cross Sections

Modifying 3D hydrogeologic models using Arc Hydro Groundwater tools



Objectives

Learn how to use the Arc Hydro Groundwater tools to create rasters from cross sections and load the rasters into a mosaic dataset; then, learn to create cross sections and GeoVolumes from rasters.

Prerequisite Tutorials

- Subsurface Analyst – Creating GeoRasters from Borehole Data

Required Components

- ArcGIS Pro
- 3D Analyst
- Subsurface Analyst

Time

- 20–35 minutes

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1 Introduction

Arc Hydro Groundwater Pro (AHGW Pro) is a geodatabase designed for representing groundwater datasets within ArcGIS Pro. 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 Pro 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 *GeoSection to Points* tool will be used to create the output points to interpolate new rasters. The rasters are then loaded into a mosaic dataset 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.

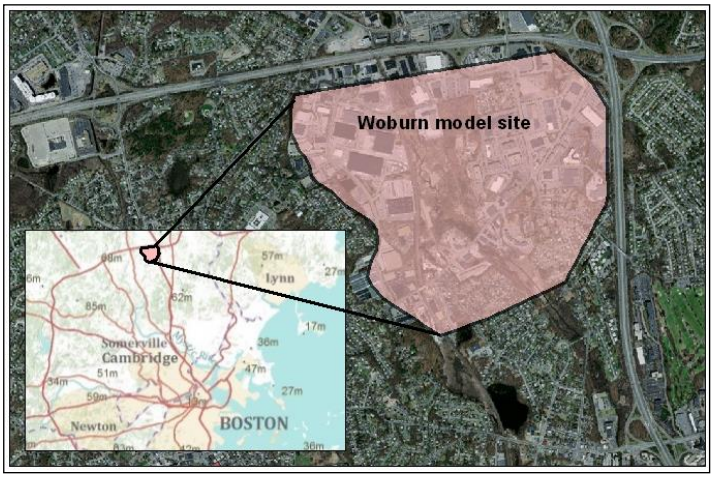

Figure 1 Location of the Roseville model

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. Figure 2 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 boreholes and cross sections for each horizon. When organized in a mosaic dataset, the rasters can be used to create 3D GeoSection and GeoVolume features based on an attribute field containing the horizon ID.

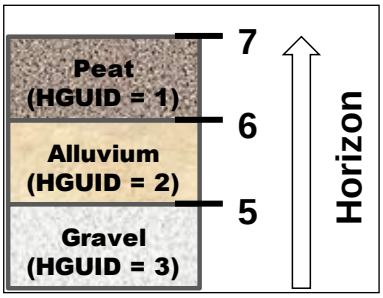

Figure 2 Hydrogeologic units indexed with HGUIDs and HorizonIDs

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 mosaic dataset, 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:

- ArcGIS Pro license
- 3D Analyst
- Arc Hydro Groundwater Pro Tools
- AHGW Pro Tutorial Files

The AHGW Pro Tools require a compatible ArcGIS Pro service pack be installed. Check the AHGW Pro Tools documentation to find the appropriate service pack for the version

of the tools being used. The tutorial files should be downloaded and saved to a local computer.

2 Getting Started

To start, open the project file for this tutorial.

1. If necessary, launch *ArcGIS Pro*.
2. If on the *ArcGIS Pro* start page, select **Open another project** in the bottom right corner of the window to open the *Open Project* dialog.
3. If already in the user interface, use the **Open** macro to open the *Open Project* dialog.
4. Browse to the location with tutorial files for this tutorial.
5. Select the file "GeoSection to Points.aprx" located in the *SubsurfaceAnalystPro\GeoSection to Points* folder.
6. Click **OK** to import the project.

A *Map* view and a *Scene* view appear. The *Scene* view 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.

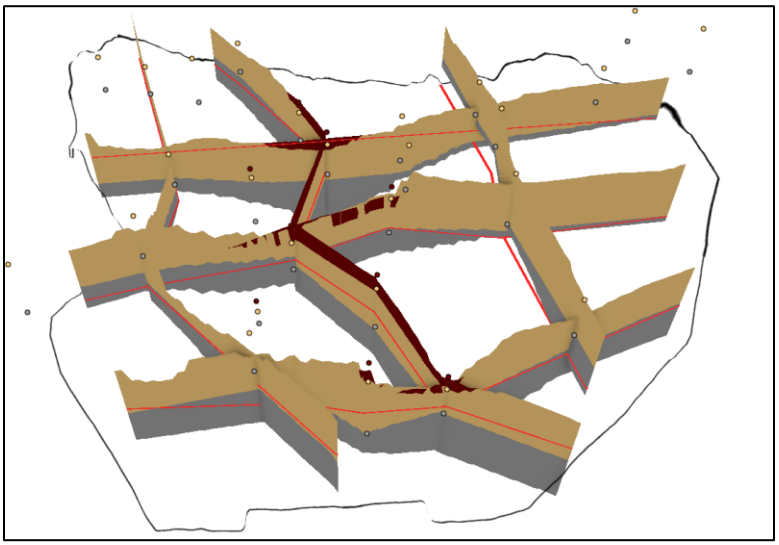

Figure 3 Scene showing GeoSection and BorePoints symbolized by the HorizonID

This entire tutorial is carried out in *Scene* view.

7. If necessary, click on the *Scene* tab to switch to the *Scene* view. Remain in this view for the entire tutorial.

It should appear similar to Figure 3.

Next, ensure that the AHGW Pro tools are correctly configured.

8. Expand the *Toolboxes* list in the *Catalog* pane. Check if "ArcHydroGroundwater.pyt" is there. If it is not there, follow steps 8-10.
9. In the *Catalog* pane, right-click on *Toolboxes* and use the **Add Toolbox** command.

10. In the *Add Toolbox* dialog, browse to the location where the Arc Hydro Groundwater Toolbox files were saved.
11. Select "ArcHydroGroundwater.pyt" and click **OK**.

"ArcHydroGroundwater.pyt" now appears in the *Toolboxes* list. When using geoprocessing tools, it's possible to set the tools to overwrite outputs by default, and automatically add results to the map/scene. To set these options:

12. On the ribbon, select the *Project* tab.
13. From the list on the left, select **Options** to open the *Options* dialog.
14. Select *Geoprocessing* from the list under *Application* on the left of the dialog.
15. Ensure that *Allow geoprocessing tools to overwrite existing datasets* and *Add output datasets to an open map* are turned on.

The options should appear similar to Figure 4.

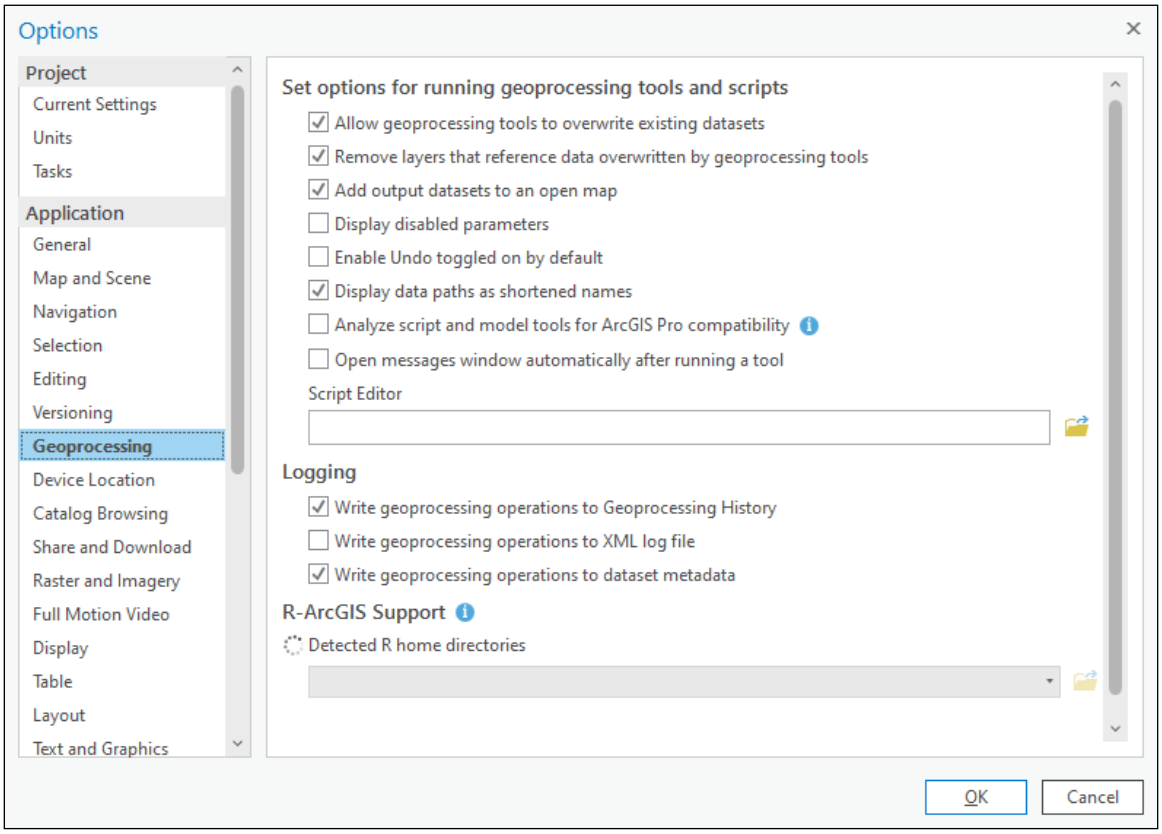

Figure 4 Setting Geoprocessing tools to overwrite outputs by default and to add results of geoprocessing tools to the display

16. Select **OK** to exit the *Options* dialog.
17. Using the arrow in the upper left corner, return to the main user interface.

3 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 *Catalog* pane, expand "ArcHydroGroundwater.pyt", then expand "Subsurface Analyst", then the "Features" toolset.
2. Double-click on "GeoSection to Points" to open the *GeoSection to Points* tool in the *Geoprocessing* pane.
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*.

When *Overwrite Existing Borepoint Features* is off, the tool appends the new BorePoints into the existing BorePoint feature class.

8. Click **Run** to run the *GeoSection to Points* tool.

A set of 3D points should appear (Figure 5), defining the boundary of the GeoSections features added to the BorePoint feature class.

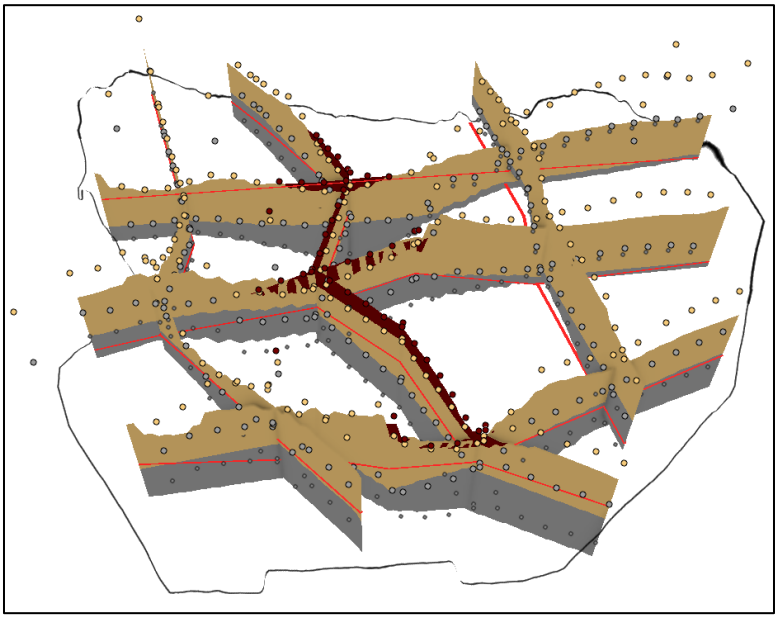

Figure 5 Points along GeoSection panels created using the GeoSection to Points tool

Once the tool has executed, do the following:

9. Under "3D Layers" in the *Contents* pane, right-click on "BorePoint" and select **Attribute Table** to bring up the *BorePoint* table view.
10. If necessary, 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.

11. When done, close the *BorePoint* table view.

4 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. First, make sure that “BorePoint” is selected using these steps:

1. On the ribbon, select the *Arc Hydro Groundwater* tab.
2. In the *Contents* pane, select “Well”.

It can be any item other than “BorePoint”.

3. Now select “BorePoint” again.

Using the *Filtering* section available in the *Arc Hydro Groundwater* ribbon tab, filter the points for a selected HorizonID.

4. On the ribbon, select the *Arc Hydro Groundwater* tab.
5. In the *Field* drop-down menu, select “HorizonID”.
6. In the *Value* drop-down menu, select “-5”

If nothing appears in the drop-down menu, repeat steps 2–3.

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

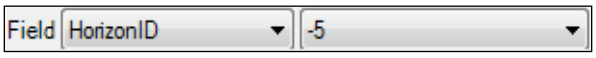

Figure 6 Field filter drop-downs

At this point, the scene should appear similar to the one shown in Figure 7.

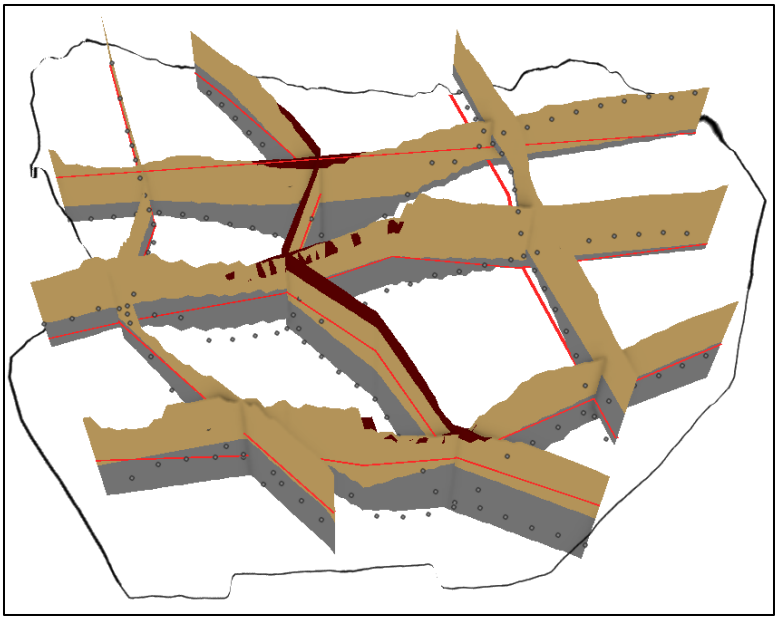

Figure 7 Points representing the bottom of the gravel layer (HorizonID = -5)

For this tutorial, use the IDW interpolation method to interpolate the points to create the rasters.

7. In the *Command Search* box above the ribbon tabs, enter “IDW”.
8. Select **IDW (Spatial Analyst Tools)** from the options that appear to open the *IDW* tool in the *Geoprocessing* pane.
9. Select “BorePoint” from the *Input point features* drop-down.
10. 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.

11. Click **Browse** to the right of the *Output raster* field to open the *Output raster* dialog.
12. Under the *Project* folder in the data tree, browse to the *Folders\GeoSection to Points\rasters* folder and enter “horizon5b” as the *Name*.
13. Click **Save** to save the output raster name and exit the *Output raster* dialog.
14. Enter “100” as the *Output cell size*.
15. Leave the other options at the default values and select the *Environments* tab.
16. Expand the *Processing Extent* section, and in the *Extent* drop-down under “Same As layer:” select “Boundary”.

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

17. Scroll down and if necessary, expand the *Raster Analysis* section.
18. Select “Boundary” from the *Mask* drop-down.

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

19. Click **Run** to run the *IDW* tool.
20. Leave the *Geoprocessing* pane open.

Note the new raster is added to the display using the “Ground” as the elevation surface (Figure 8).

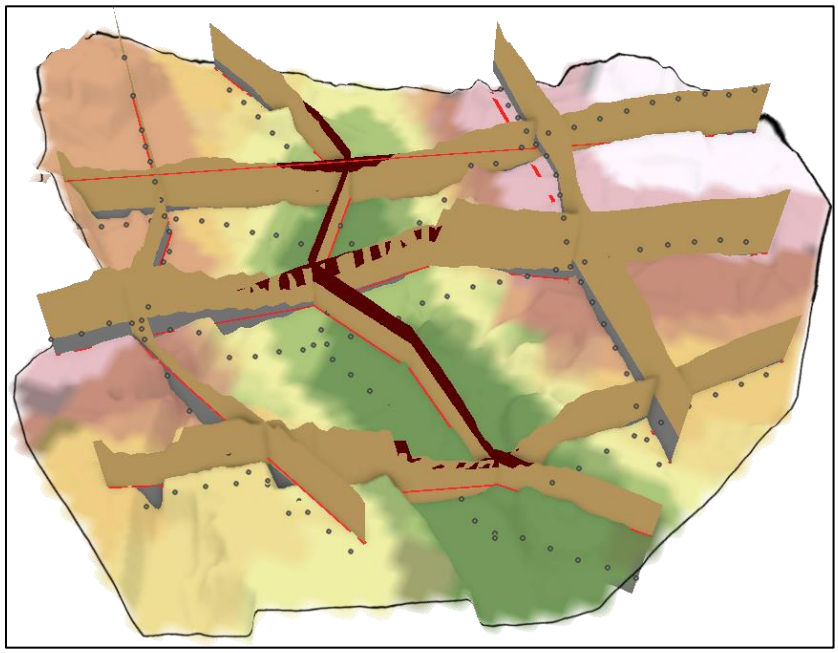

Figure 8 The new raster using the “Ground” as the elevation surface

In ArcGIS Pro, the most recently used geoprocessing tool remains open with all of the parameters intact. Since only small adjustments are needed to create each raster for this situation, there is no need to open a fresh *IDW* tool. To create the rest of the rasters, follow these steps:

21. For Horizon 5, repeat steps 1-6, but for step 6, select “5”.
22. In the *Geoprocessing* pane, for *Output raster*, enter “horizon5”.
23. Click **Run** to run the tool.
24. For Horizon 6, repeat steps 1-6, but for step 6, select “6”.
25. In the *Geoprocessing* pane, for *Output raster*, enter “horizon6”.
26. Click **Run** to run the tool.
27. For Horizon 7, repeat steps 1-6, but for step 6, select “7”.
28. In the *Geoprocessing* pane, for *Output raster*, enter “horizon7”.
29. Click **Run** to run the tool.

In this case, the rasters are each layered on top of each other, so they can only be visualized one at a time by turning them on or off in the *Contents* pane. The rasters are the base for creating 3D volume models. With the “horizon7” raster displayed, *Scene* view should appear similar to Figure 9. Coloring may be different, depending on the display settings being used.

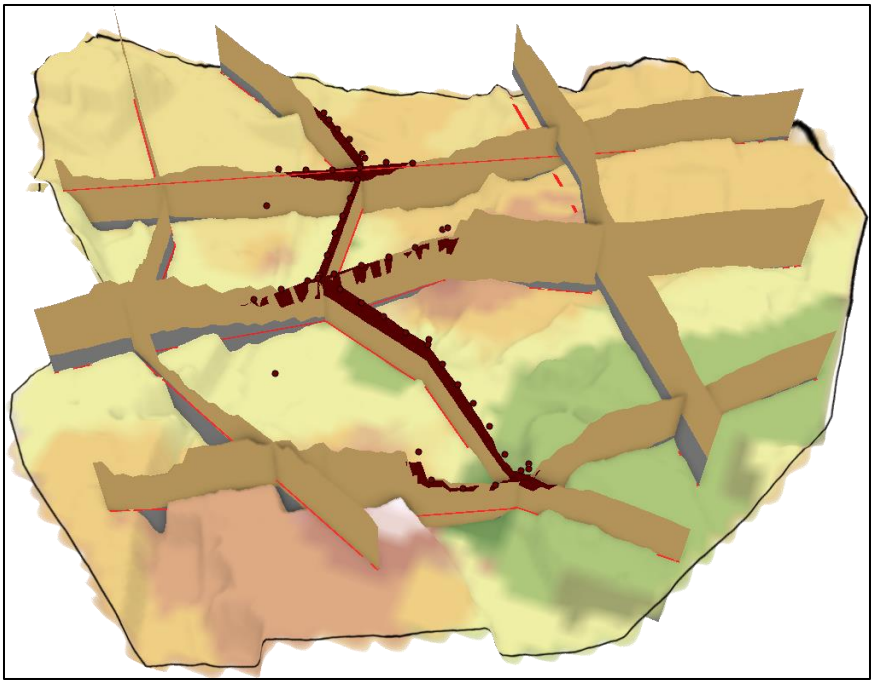

Figure 9 Scene view with the horizon7 raster visible

5 Loading Rasters to the GeoRaster Mosaic Dataset

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

1. In the *Command Search* box above the ribbon tabs, enter "Add Rasters to Mosaic Dataset".
2. Select **Add Rasters to Mosaic Dataset (Data Management Tools)** from the options that appear to open the *Add Rasters to Mosaic Dataset* tool in the *Geoprocessing* pane.
3. In the *Add Rasters to Mosaic Dataset* tool, for *Mosaic Dataset*, select "GeoRasters".
4. For *Raster Type*, select "Raster Dataset".
5. For *Input Data*, select "Dataset" from the drop-down menu.
6. Click the **Browse** button to open the *Input Data* dialog.
7. In the data tree on the left, under *Project*, browse to the *Folders\GeoSection to Points\rasters* folder for this tutorial.
8. While holding down the *Ctrl* key, select the horizons in the following order: "horizon5b", "horizon5", "horizon6", and "horizon7".
9. Click **OK** to close the *Input Data* dialog and to add the rasters to the *Input Data* list.

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

10. Click **Run** to run the *Add Rasters to Mosaic Dataset* tool.

Once the *Add Rasters To Mosaic Dataset* has finished running, edit the attributes of the *GeoRasters* attribute table.

11. If necessary, on the *Edit* ribbon tab, click **Edit** to enable editing.

The necessity of step 11 depends on the settings of ArcGIS Pro on the local machine.

12. Right-click on "GeoRasters" in the *Contents* pane and select *OpenTable* | **Attribute Table** to bring up the *GeoRasters: Footprint* table view.
13. In the *GeoRasters: Footprint* table view, right-click on the *Name* column and select the **Freeze/Unfreeze Field** command.

Now the *Name* column will always be visible. This is important in this case because the attributes to be edited are far to the right of the *Name* column.

14. Enter "0" in the *Clip* column for each row. It may be necessary to scroll to the right.
15. Enter "1" in the *Fill* column for each row.
16. Enter the appropriate HorizonIDs for the rasters according to the following table:

Raster Name	HorizonID
horizon5b	-5
horizon5	5
horizon6	6
horizon7	7

17. On the ribbon, go to the *Edit* tab.
18. Click **Save** to open the *Save Edits* dialog.
19. In the *Save Edits* dialog, click **Yes** to save the changes to the *GeoRasters*: *Footprint* table.
20. Close the *GeoRasters*: *Footprint* table view.

6 Creating 3D GeoSection and GeoVolume Features

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

6.1 Creating 3D GeoSections Features

1. Turn on and select "SectionLine" layer in the *Contents* pane.
2. In the *Catalog* pane in the "ArcHydroGroundwater.pyt" toolbox, expand "Features" under "Subsurface Analyst".
3. Double-click on "Rasters to GeoSections" to bring up the *Rasters to GeoSections* tool in the *Geoprocessing* pane.
4. Select "SectionLine" from the *Input SectionLine Features* drop-down.
5. Select "GeoRasters" from the *Input Raster Catalog* drop-down.

6. Select “HorizonID” from the *Raster Catalog Horizon ID field* drop-down.
7. Enter “50” as the *Discretization Spacing*.
8. Select “GeoSection” from the *Input GeoSection Features* drop-down.
9. Select “Clip” from the *Raster Catalog Clip field* drop-down.
10. Select “Fill” from the *Raster Catalog Fill field* drop-down.
11. Select “HGUID” from the *Raster Catalog HGUID field* drop-down.
12. Make sure *Append to Existing GeoSection Features* is turned on.
13. Click **Run** to run the *Rasters to GeoSections* tool.

Upon completion, a set of 3D GeoSection features have been created, as shown in Figure 10. Feel free to change the colors using the settings on the *Symbology* pane. In Figure 10, the four horizon layers have been turned off in the *Contents* pane to make the 3D GeoSection features more visible.

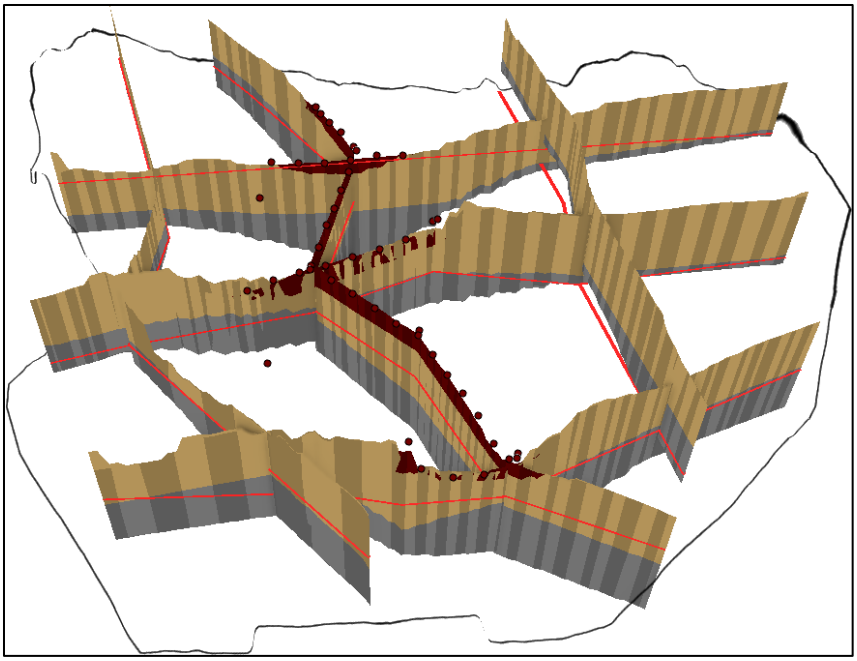

Figure 10 3D GeoSection features with boundary border visible

6.2 Creating 3D GeoVolume Features

Next, create 3D volume elements.

1. In the *Catalog* pane, expand “ ArcHydroGroundwater.pyt” then expand “ Features” under “ Subsurface Analyst”.
2. Double-click on “ Rasters to GeoVolumes” to bring up the *Rasters to GeoVolumes* tool in the *Geoprocessing* pane.
3. Select “projtin300” from the *Input Projection Tin* drop-down.
4. Select “GeoRasters” from the *Input Raster Catalog* drop-down.
5. Select “HorizonID” from the *Raster Catalog Horizon ID field* drop-down.
6. Enter “1” as the *Minimum MultiPatch Thickness*.

7. Select “GeoVolume” from the *Input GeoVolume Features* drop-down.
8. Select “Clip” from the *Raster Catalog Clip field* drop-down.
9. Select “Fill” from the *Raster Catalog Fill field* drop-down.
10. Select “HGUID” from the *Raster Catalog HGUID field* drop-down.
11. Make sure *Append to Existing GeoVolume Features* is turned on.
12. Click **Run** to run the *Rasters to GeoVolumes* tool.
13. Once the tool has finished running, right-click on “GeoVolume” in the *Contents* pane and select **Symbology** to open the *Symbology* pane.
14. Ensure that the first drop-down menu is set to “Unique Values”.
15. Under the tab that says *Classes*, click the **Add all values** button to add the three values for “5”, “6”, and “7” to the list.
16. Adjust the color for each layer as desired.

The GeoVolumes should now be visible. If the rasters are turned off the view will appear similar to Figure 11. Colors will vary according to the default colors assigned and the colors selected during step 16.

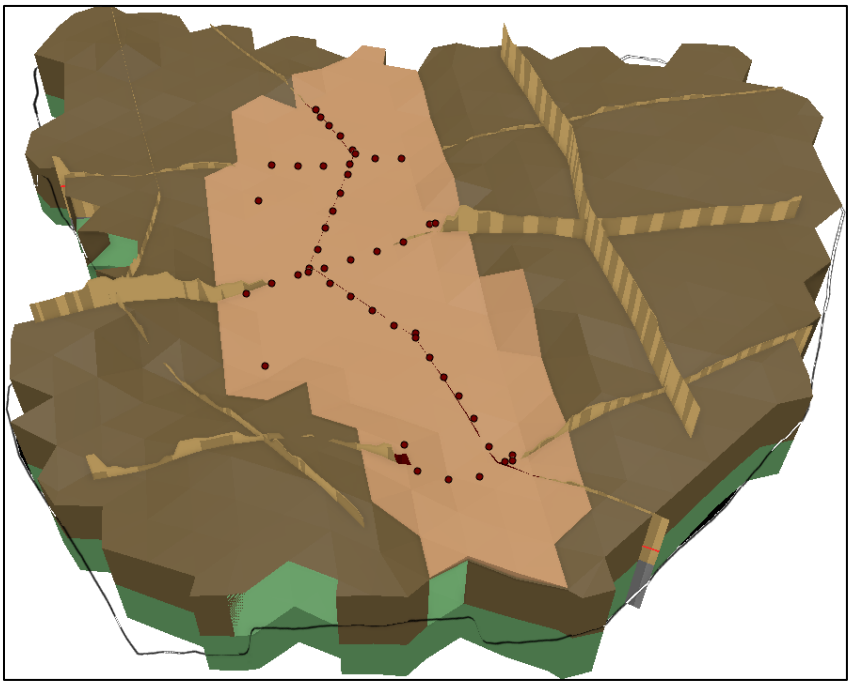

Figure 11 GeoVolume features representing hydrogeologic units

7 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 *Filtering* section in the *Arc Hydro Groundwater* ribbon tab.
- Rasters are interpolated using the standard ArcGIS Pro interpolation tools.
- Mosaic datasets, 3D cross sections, and volume models can be created or updated using the interpolated rasters.