# *ARC HYDRO GROUNDWATER TUTORIALS*

## ***Subsurface Analyst – Creating rasters from cross sections***

Arc Hydro Groundwater (AHGW) is a geodatabase design 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 that is used to manage 2D and 3D hydrogeologic data, and create subsurface models including generation of borehole representations, cross sections, surfaces, and volumes.

In this tutorial we will demonstrate how 3D hydrogeologic models can be modified by including new data points derived from cross sections. We will use the *GeoSections To Points* tool and include the output points to interpolate a new raster. 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 in the city of Woburn conducted by the USGS. The data were modified for the purposes of the tutorial. The site location is shown in Figure 1.

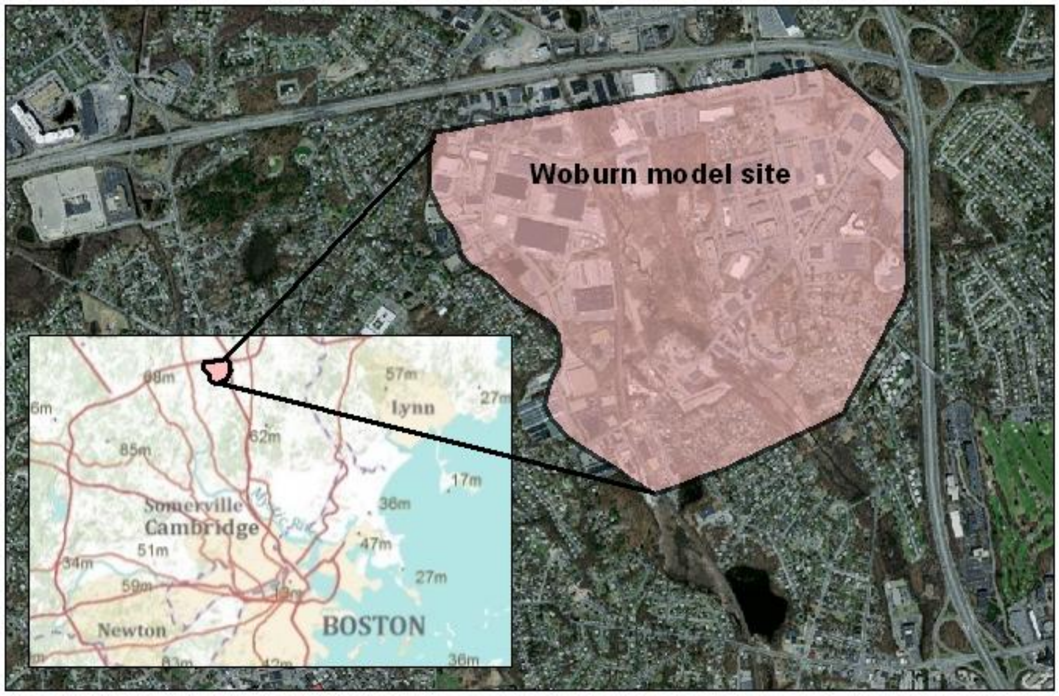


*Figure 1 Location of the Roseville Model.*

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 that you wish to represent 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.

 

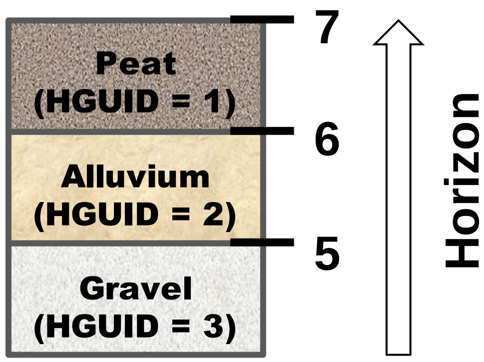


*Figure 2 Hydrogeologic units indexed with a HGUID and a HorizonID.*

### 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.

### 1.3 Required Modules/Interfaces

You will need the following components enabled in order to complete this tutorial:

- Arc View license (or ArcEditor\ArcInfo)
- 3D Analyst
- Arc Hydro Groundwater Tools
- AHGW Tutorial Files

The AHGW Tools require that you have a compatible ArcGIS service pack installed. You may wish to check the AHGW Tools documentation to find the appropriate service pack for your version of the tools. The tutorial files should be downloaded to your computer and saved on a local drive.

## 2 Getting Started

Before opening the tutorial map, let's ensure that the AHGW Tools are correctly configured.

 

1. If necessary, launch *ArcScene*.

2. If necessary, open the *ArcToolbox* window by clicking on the *ArcToolbox* icon .

3. Make sure the Arc Hydro Groundwater Toolbox is loaded. If it is not, add the toolbox by right-clicking anywhere in the *ArcToolbox* window and selecting the *Add Toolbox…* command. Browse to the top level of the *Catalog* and then browse down to the *Toolboxes* | *System Toolboxes* directory. Select the toolbox and select the *Open* button.

4. Expand the *Arc Hydro Groundwater Tools* item and then expand the *Subsurface Analyst* toolset to expose the tools we will be using in this tutorial.

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

5. Right-click on any visible toolbar and select the *Arc Hydro Groundwater Toolbar* item.

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

6. Select the *Geoprocessing* | *Options...* command.

7. Activate the option: "*Overwrite the outputs of geoprocessing operations*" as shown in Figure 3.

8. Enable the option to "*Add results of geoprocessing operations to the display*" as shown in Figure 3.

9. Select *OK* to exit the setup.

 

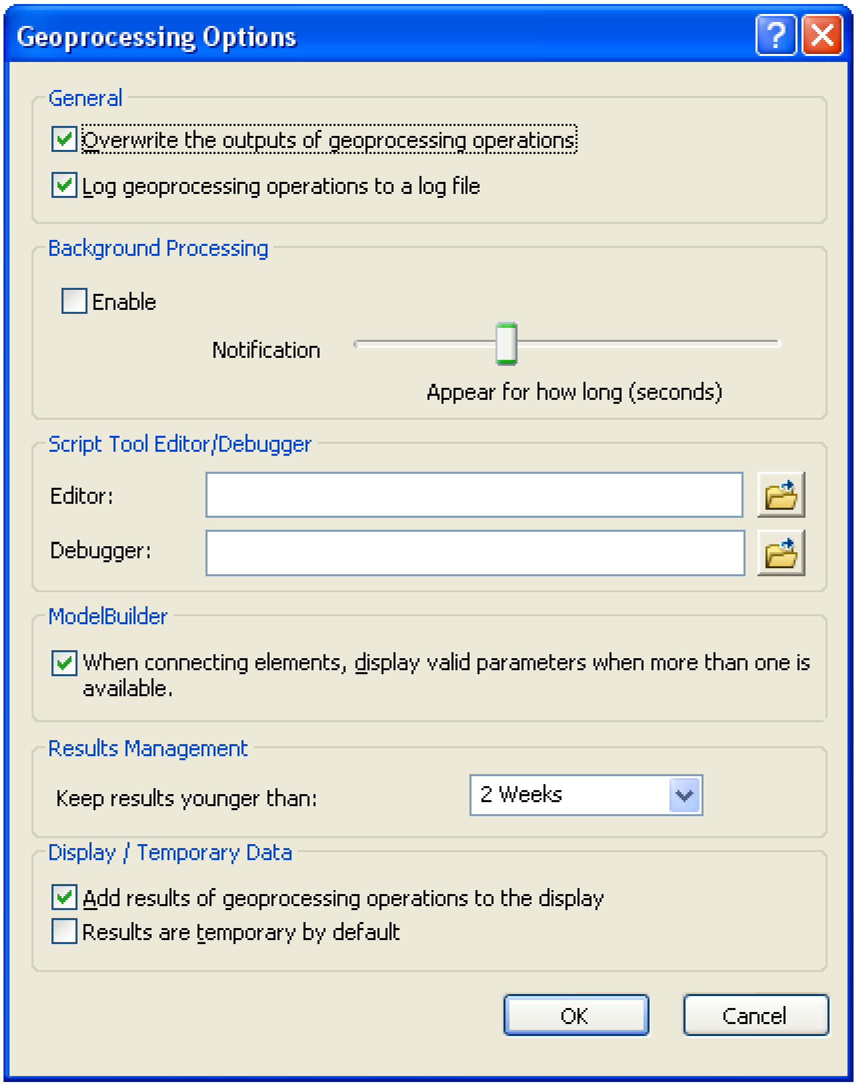


*Figure 3 Setting Geoprocessing tools to overwrite outputs by default, and to add results of geoproceesing tools to the display.*

# 3 Opening the Scene

We will begin by opening a scene containing some background data for the project.

1. Select the *File*| *Open* command and browse to the location on your local drive where you have saved the AHGW tutorials. Browse to the ***GeoSection to Points*** folder and open the file entitled ***Woburn_geosections_to_points.sxd***.

Once the file has loaded you will see a scene that contains a set of 3D GeoSection features forming a fence diagram. The scene also contains BorePoint features that represent hydrostratigraphy along boreholes. The features are symbolized based on the HorizonID attribute as shown in Figure 4.

 

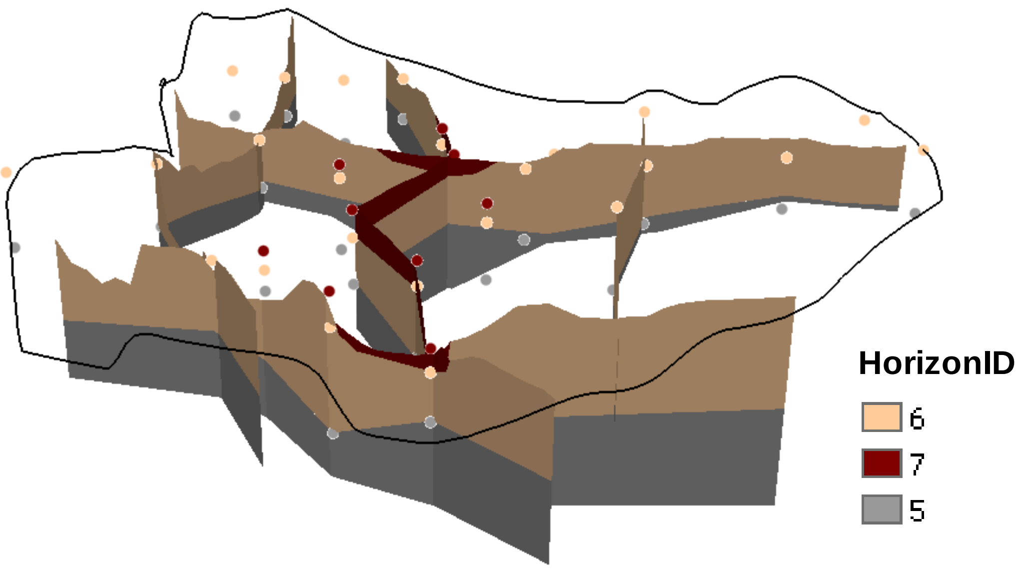


*Figure 4 Scene showing GeoSections and BorePoints symbolized by the HorizonID.*

## 4 Transforming GeoSections to points

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

1. Open the ***GeoSection To Points*** tool located in the *Subsurface Analyst | Features* toolset.
2. Select the **SectionLine** feature class as *the Input SectionLine Features*.
3. Select the **GeoSection** feature class as *the Input GeoSection Features*.
4. Select the **BorePoint** feature class as *the Input BorePoint Features*.
5. Enter a *Sampling Distance* of **200**.
6. Make sure to **disable** the *Overwrite Existing BorePoint Features* option.

At this point your inputs should be similar to the ones shown in Figure 5.

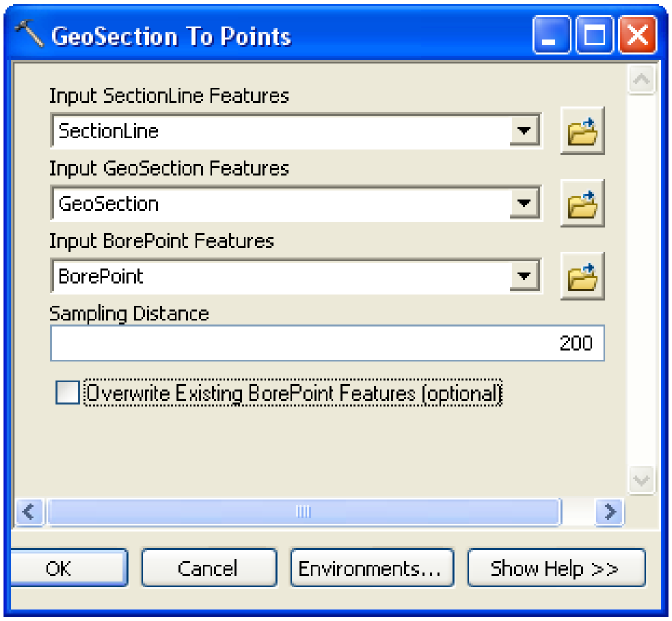


*Figure 5 Inputs for the GeoSection Table To Points tool.*

7. Select *OK* to run the tool.

At the end of this process you should have a set of 3D points, defining the boundary of the GeoSections features added to the BorePoint feature class (see Figure 6).

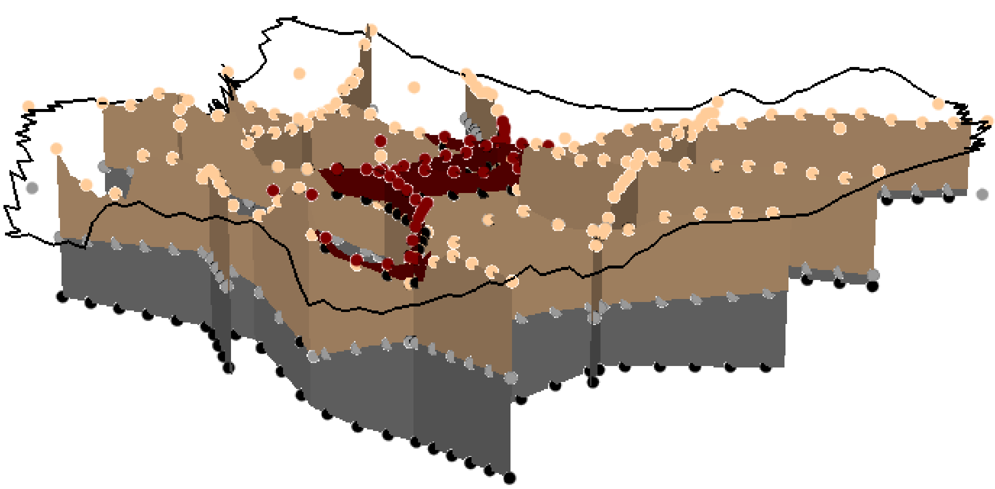

*Figure 6 Points along the GeoSection panels created using the GeoSection to Points tool.*

Once the tool has executed, you can open the *BorePoint* feature class attribute table and see that 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, you will 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.

# 5 Interpolating rasters

We are now ready to interpolate rasters based upon the BorePoint features. This step requires *Spatial Analyst* or *3D Analyst* extensions. If you do not have either of these extensions installed, you will not be able to complete this part of the tutorial (you can use the solution files to view the interpolated rasters). We will use the *IDW* geoprocessing tool to perform the interpolation and we will set the *Environment* options such that the resulting raster is clipped to the *Boundary* feature class.

Before we start the interpolation we will 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 Field Filter select the HorizonID filed and select the -5 value. This defines a Definition Query to show only points with HorizonID = -5, which correspond with the bottom of the gravel layer.


At this point your scene should be similar to the one shown in Figure 7.

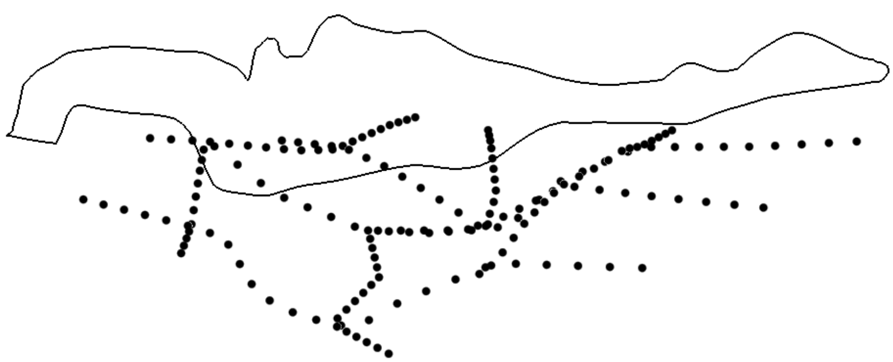

*Figure 7 Points representing the bottom of the gravel layer (HorizonID = -5).*

3. Open the *IDW* tool located in the *Spatial Analyst Tools | Interpolation* or the *3D Analyst Tools | Raster Interpolation* toolset.

4. For the *Input point* features select the **BorePoint** layer.

5. For the *Z value field* select **Shape.Z** (because the features are 3D features we are able to read the elevation directly from the shape field).

 

6. For the *Output raster* browse to the ***GeoSection to Points\rasters* folder** and name the new raster **horizon5b**.

7. Select an *Output cell size* of **100**.

At this point your inputs should be similar to the ones shown in Figure 8.

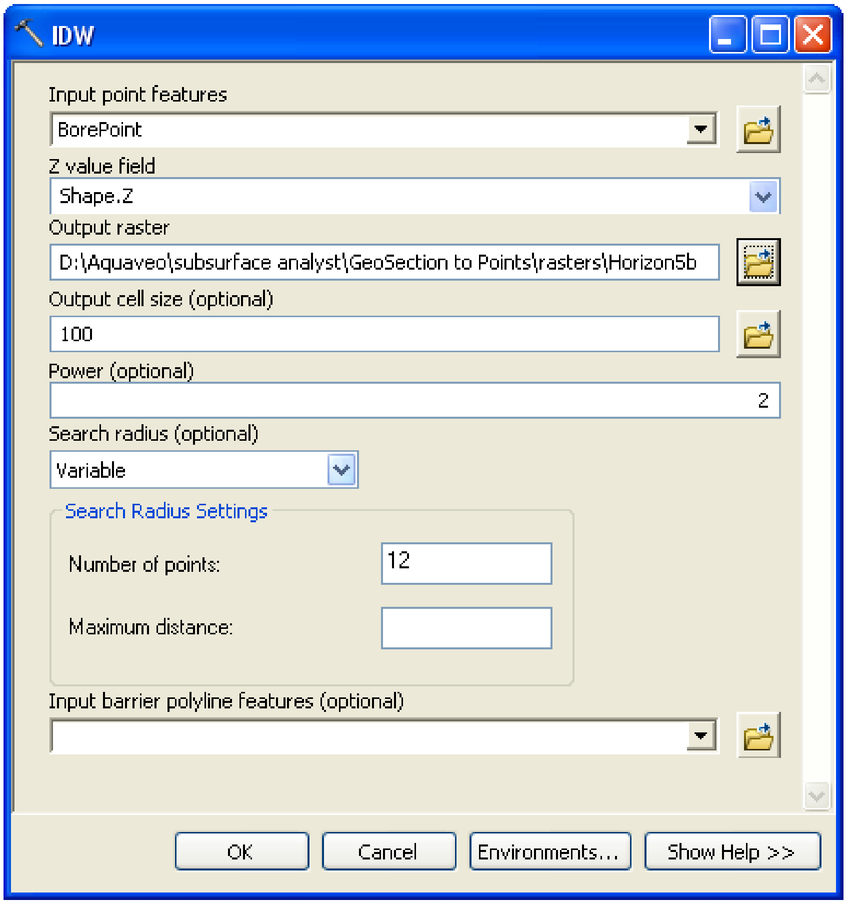


*Figure 8 Inputs for the IDW tool.*

8. Click the *Environments…* button.

9. Expand the *Processing Extent* (ArcGIS 10) or *General Settings* (ArcGIS 9.3) section and change the *Extent* option to *Same as layer Boundary*. This will cause the interpolation to extend out the rectangular limits of the *Boundary* feature class.

10. Scroll down and expand the *Raster Analysis Settings* section and change the Mask to *Boundary*. This will clip the raster to the actual boundary of the *Boundary* feature class.

11. Select the **OK** button to exit the *Environment Settings* dialog.

12. Select the **OK** button to execute the *IDW* tool.

Note the new raster is added to the display using zero as the display elevation. To visualize the new raster based on its elevations, we will need to set the Base Height:

13. Select the *horizon5b* raster in the Table of Contents, right-click and select *Properties*.

14. In the *Base Heights* tab, for ArcGIS 10, select the option: *Floating on a custom surface.* In ArcGIS 9.3, select the option: *Obtain heights for layer from surface*. Then specify the appropriate raster (for each raster layer the custom surface is the raster itself, such that the raster will display in 3D using its values) as shown in Figure 9.

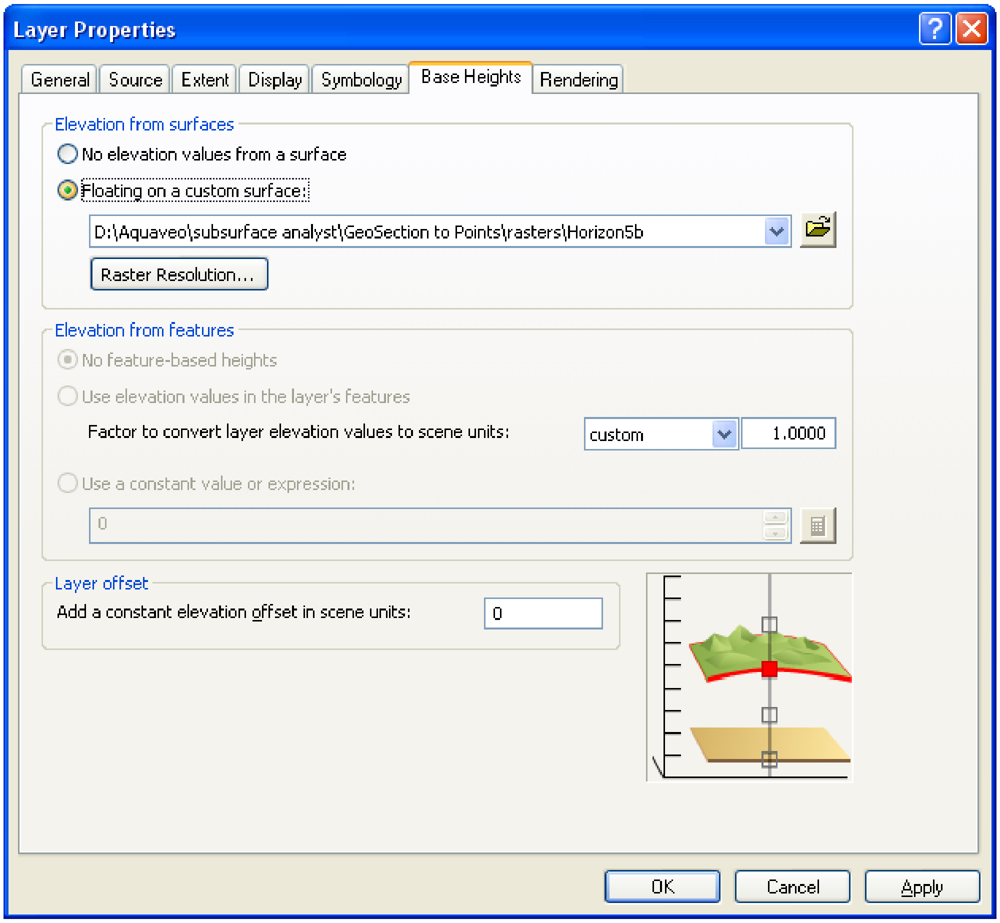


*Figure 9 Setting the base heights for rasters in ArcScene.*

You can now see the new raster rendered in 3D.

 

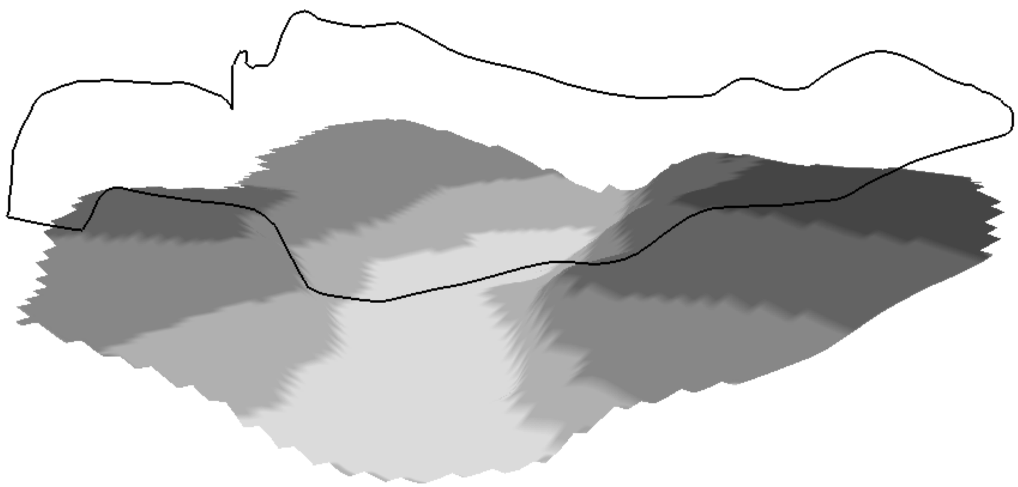

*Figure 10 Visualizing the interpolated raster in ArcScene.*

15. Repeat steps 1-14 for Horizons 5, 6, and 7. For the peat layer (Horizon 7) use the Peat_Boundary polygon as the interpolation extent and mask (steps 9 and 10). Name the rasters Horizon5, Horizon6, and Horizon7.

Note - another option to create the top surface is to use a DEM as the top horizon. For simplification purposes we used the BorePoints with HorizonID = 7 to interpolate the top surface.

At the end of this process you should have a set of rasters representing the horizons within the model. The rasters are the base for creating 3D volume models.

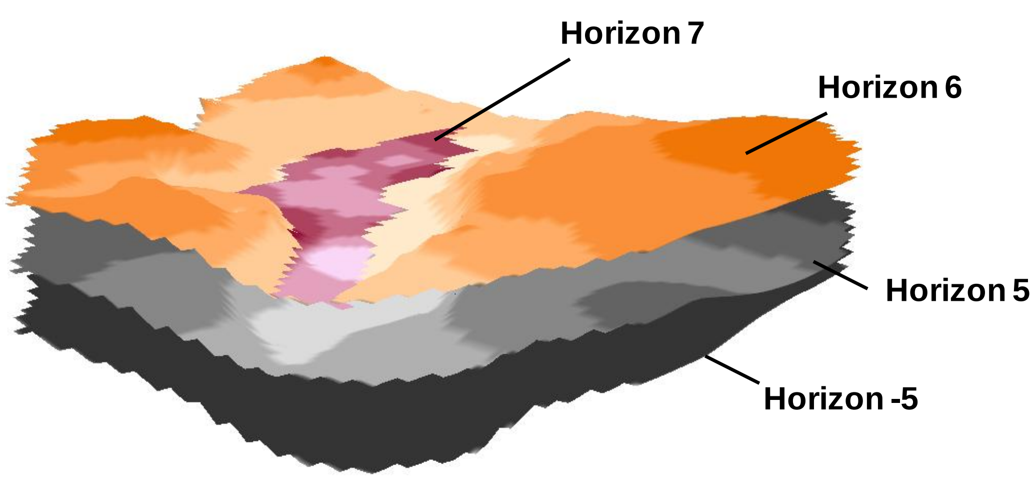


*Figure 11 Interpolated rasters representing horizons in a 3D model.*

# 6 Conclusion

This concludes the tutorial. Here are some of the key concepts in this tutorial:

- Points along the panels of 3D GeoSections can be created using the *GeoSection To Points* tool.
- The *HorizonID* attributes of the new point features matches that of the GeoSection feature they came from. 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.