

ARC HYDRO GROUNDWATER TUTORIALS

Working with Non-Vertical Borehole Data

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. This tutorial illustrates how to use the tools to manage non-vertical borehole data and create 3D representations of hydrostratigraphy in non-vertical boreholes. A basic familiarity with the AHGW data model is suggested, but not required, prior to beginning this tutorial.

1.1 Outline

In this tutorial, we will be working with non-vertical borehole data near the city of Roseville in the Sacramento Valley, California. Data used in this tutorial is mock data and is used for illustrative purposes only. We will complete the following tasks:

1. Import a set of non-vertical borehole data into an AHGW geodatabase.
2. Explore the borehole logs.
3. De-survey the borehole logs.
4. Generate and view 3D BoreLines derived from the non-vertical borehole data.

1.2 Required Modules/Interfaces


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

- Arc View license (or ArcEditor\ArcInfo)
- 3D Analyst.
- 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 our scene, 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. If you have not already done so, add the *AHGW Toolbox* by right-clicking anywhere in the *ArcToolbox* window and selecting the *Add Toolbox...* command. Browse to the *C:\Program Files\Aquaveo\Arc Hydro Groundwater Tools* directory and select and open the *Arc Hydro Groundwater Tools.tbx* file.
4. Expand the *Arc Hydro Groundwater Tools* item and then expand the *Subsurface Analyst* toolset to expose the *Subsurface Analyst* tools.

Note that many of the geoprocessing tools in the AHGW Toolbox can also be accessed from the *AHGW 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. Open ArcScene/ArcCatalog (if not already open).
7. Select the *Geoprocessing / Geoprocessing Options...* command.

8. Activate the option: “*Overwrite the outputs of geoprocessing operations*” as shown in Figure 1.
9. Enable the option to “*Add results of geoprocessing operations to the display*” as shown in Figure 1.
10. Select *OK* to exit the setup.

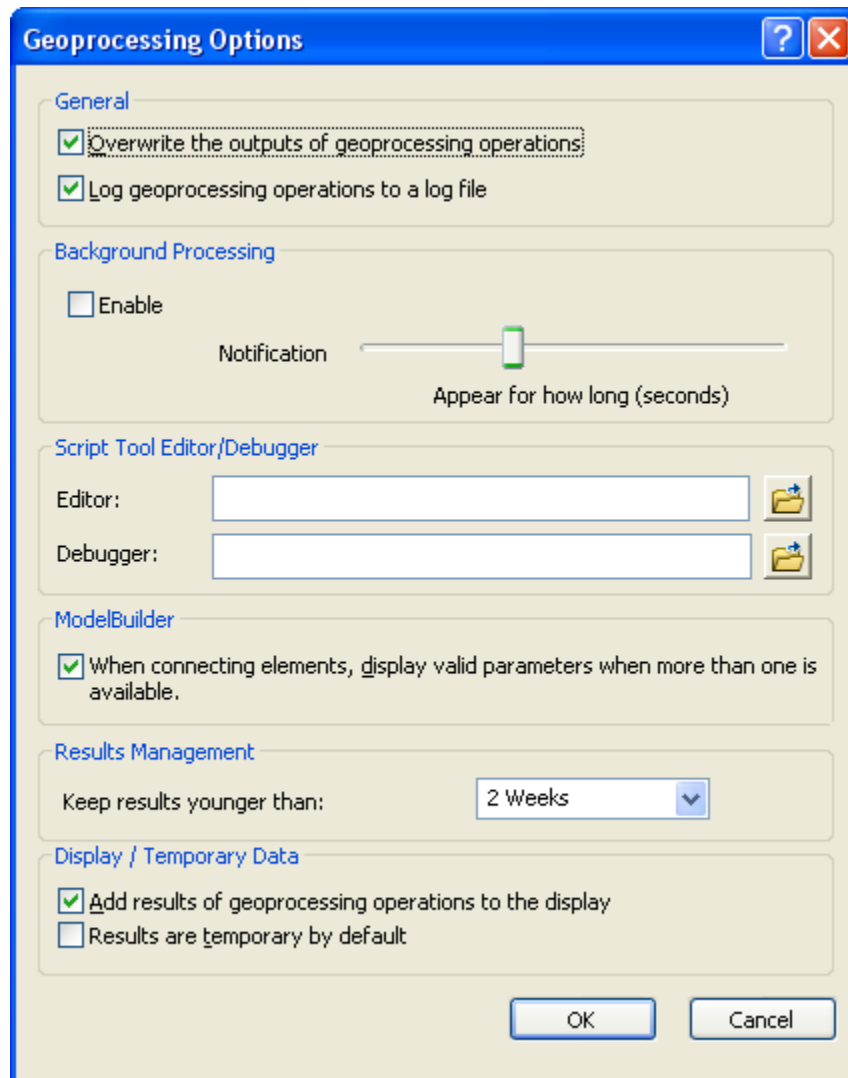


Figure 1 Setting Geoprocessing tools to overwrite outputs by default, and to add results of geoprocessing tools to the display.

3 Upgrading the Geodatabase

Due to changes in the geodatabase between ArcGIS 9.3 and ArcGIS 10, if you are using ArcGIS 10 you will need to upgrade your geodatabase to be able to create 3D vertical features. If you are using version 9.3 you can skip the following steps.

1. Open ArcScene/ArcCatalog (if not already open).
2. Open the *Upgrade Geodatabase* geoprocessing tool located in the *Data Management Tools / Database* toolset.
3. Select the **nv_boreholes.mdb** geodatabase as the *Input Geodatabase*.
4. Leave the defaults for the other parameters.

Your tool should be similar to the one shown in Figure 2.

5. Select *OK* to upgrade the geodatabase.

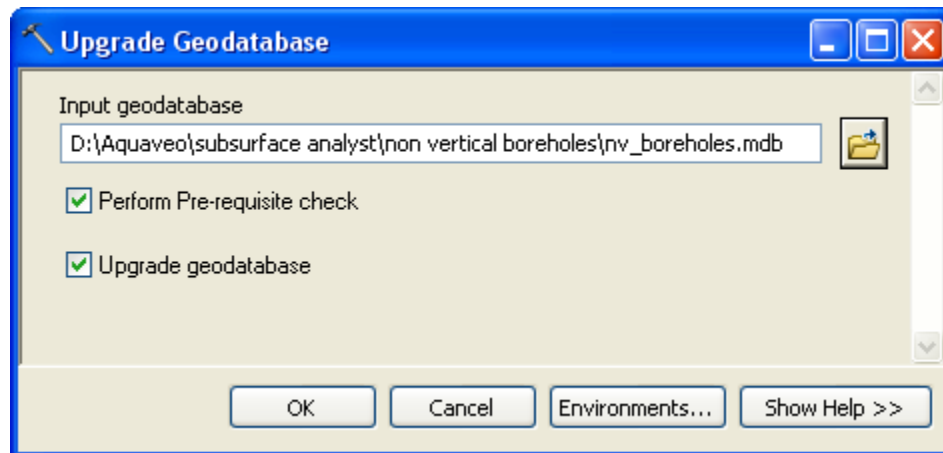


Figure 2 Settings of the Upgrade Geodatabase Tool

4 Opening the Scene

We will begin by opening a scene of the model area.

1. In ArcScene, select the *File / Open* command and browse to the location on your local drive where you have saved the AHGW tutorials. Browse to the *subsurface analyst/boreholes* folder and open the file titled **nv_boreholes.sxd**.

You should see a scene containing a DEM of the model domain and a set of Well features (Figure 3).

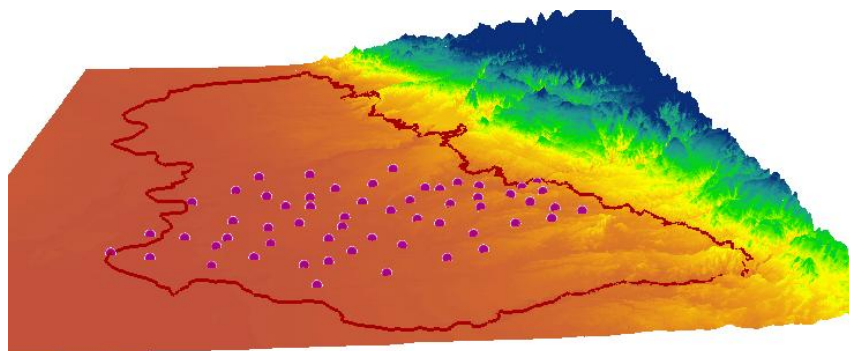


Figure 3 Scene of the Roseville model domain with Well features shown on top of a DEM.

5 Non-Vertical Borehole Data

Stratigraphy records in non-vertical boreholes are usually stored as survey data in the form of Azimuth, Dip, and Length. Azimuth describes the direction in which the borehole is drilled and is usually given as an angle measured from the north, and Dip defines the vertical angle of the borehole and can be measured as an angle from a horizontal or vertical plane (Figure 4). Length is the distance along the borehole and is usually measured from a reference point, either the land elevation at the borehole location or from the top of casing.

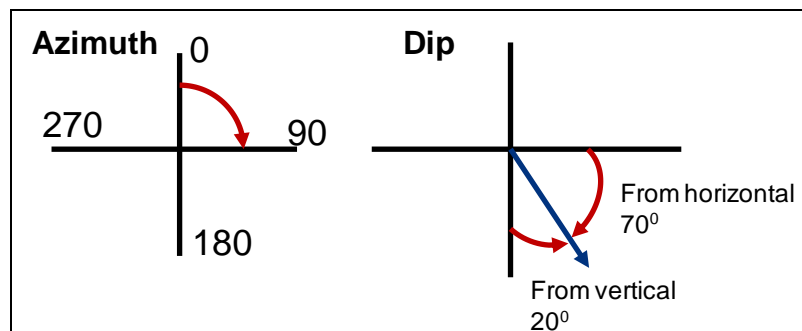


Figure 4 Azimuth and Dip define the orientation of the borehole in 3D space.

The survey data is later de-surveyed to X, Y and Z coordinates, and then 3D tools are applied to create 3D features for visualizing and analyzing the data in a GIS (Figure 5).

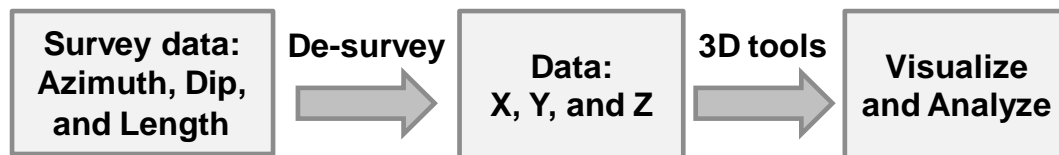


Figure 5 Process of creating 3D features from survey data.

6 Importing Borehole Data

The `nv_wells` feature class consists of points defining the XY locations of wells in the model domain. In this step, we will import a text file containing data from borehole logs associated with the non-vertical wells. The records in this file will be added to the *Survey* table. Each record in the table represents a contact or elevation along the borehole at which the stratigraphy changes from one unit to another.

We will import the records using the *Text Import* command in the AHGW Toolbar.

1. Select the *Arc Hydro GW / Text Import* command in the AHGW Toolbar.
2. Navigate to the *non vertical boreholes* folder where the tutorial files are stored on the local drive and open the *survey.txt* file.
3. For the first step of the *File Import Wizard*, enable the *Comma* delimiter only and the *Heading row* option, as shown in Figure 6.

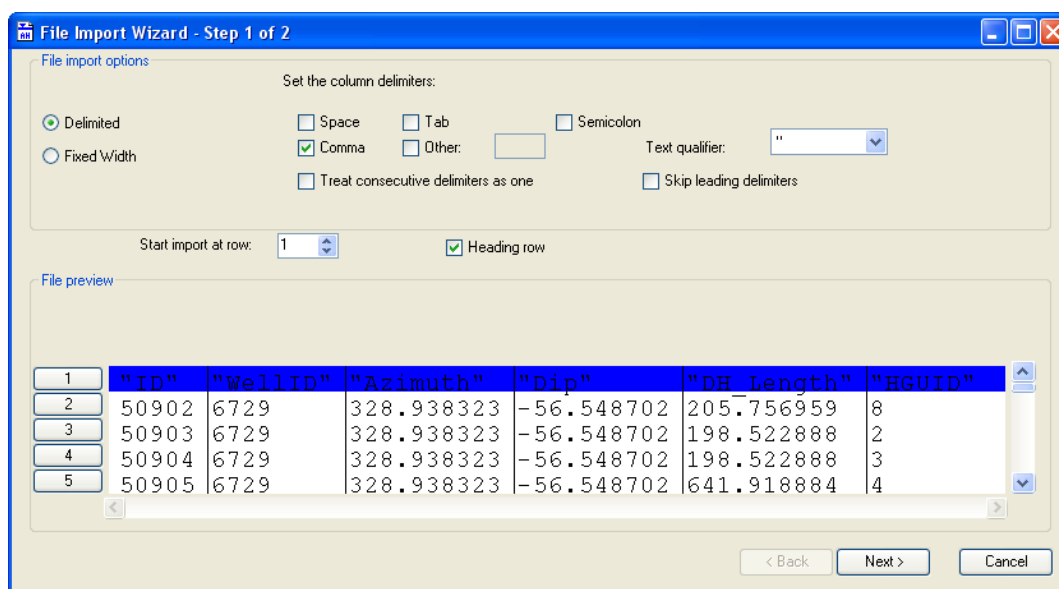


Figure 6 Settings for the First Step of the File Import Wizard.

4. Click on the *Next* button to go to the next step of the *File Import Wizard*.

In the next step of the wizard we indicate the type of data we are importing and specify how each of the columns in the file is linked to fields in the target feature class/table. The contents of the file are shown in the table at the bottom of the dialog. For each column that we wish to import, we will select the appropriate field name in the Type row. By default, <not mapped> is selected for some columns indicating that the columns will not be imported to a field in the target table.

5. Make sure that the **Survey** table is selected in the *Create Features/Rows in:* combo box.
6. Make sure that the fields are mapped correctly as shown in Figure 7 (the fields should be matched automatically).

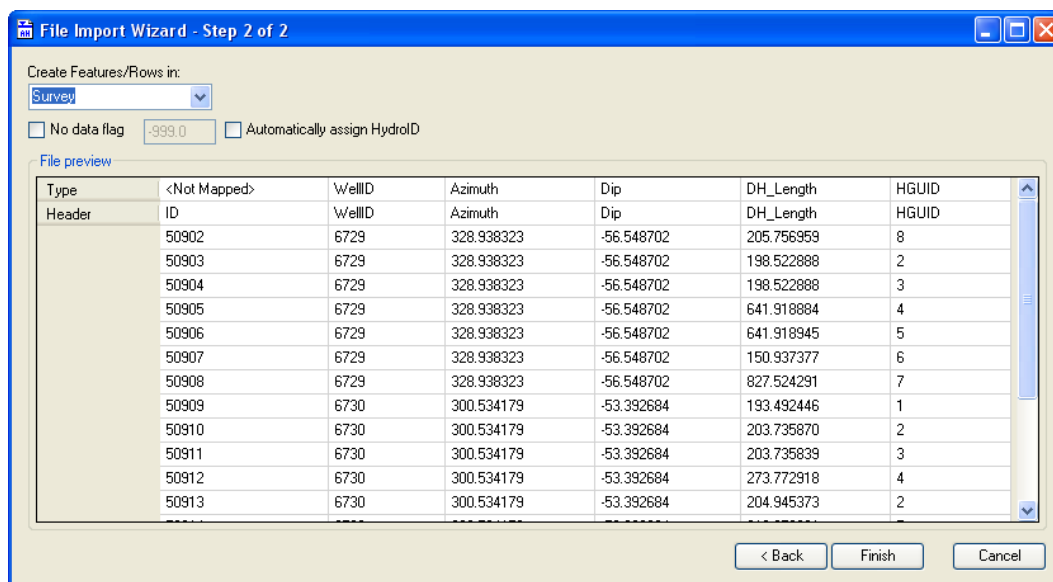


Figure 7 Settings for the Second Step of the File Import Wizard.

7. Click on the *Finish* button.
8. Click *OK* at the prompt to confirm the import.

To view the new records in the Survey table:

9. Click on the *List By Source* tab in the TOC window.
10. Right-click on the *Survey* table and select the *Open* command.

The first column in the table (*WellID*) relates to the *HydroID* of the corresponding well. The *HGUID* relates to the *HydroID* of a hydrogeologic unit defined in the *HydrogeologicUnit* table. Several of the features in the AHGW data model are used to model different representations of the same HGU's. For example, boreholes, GeoSections, and GeoVolumes, are different representations of the same formations. Thus, a common table is used to store summary information about HGU's and the various features are related using an HGUID field. To view the *HydrogeologicUnit* table:

11. Close the *Survey* table, right-click on the *HydrogeologicUnit* table and select the *Open* command.

You can view the indexing of the units in the table and the description of the units. Notice that there are two indexing systems. The HydroID is unique for every row in the table. HGUCode and HGUName fields can be used to describe grouping of units. For example the Turlock and Mehrten units can be divided into upper and lower sections, or grouped into single units.

12. Close the *HydrogeologicUnit* table.
13. Click on the *List By Drawing Order* tab in the TOC window.

7 De-Surveying Borehole Data

1. Open the *Desurvey Borelog* tool located in the *Subsurface Analyst/Features* toolset.
2. Specify the input parameters as shown in Figure 8.

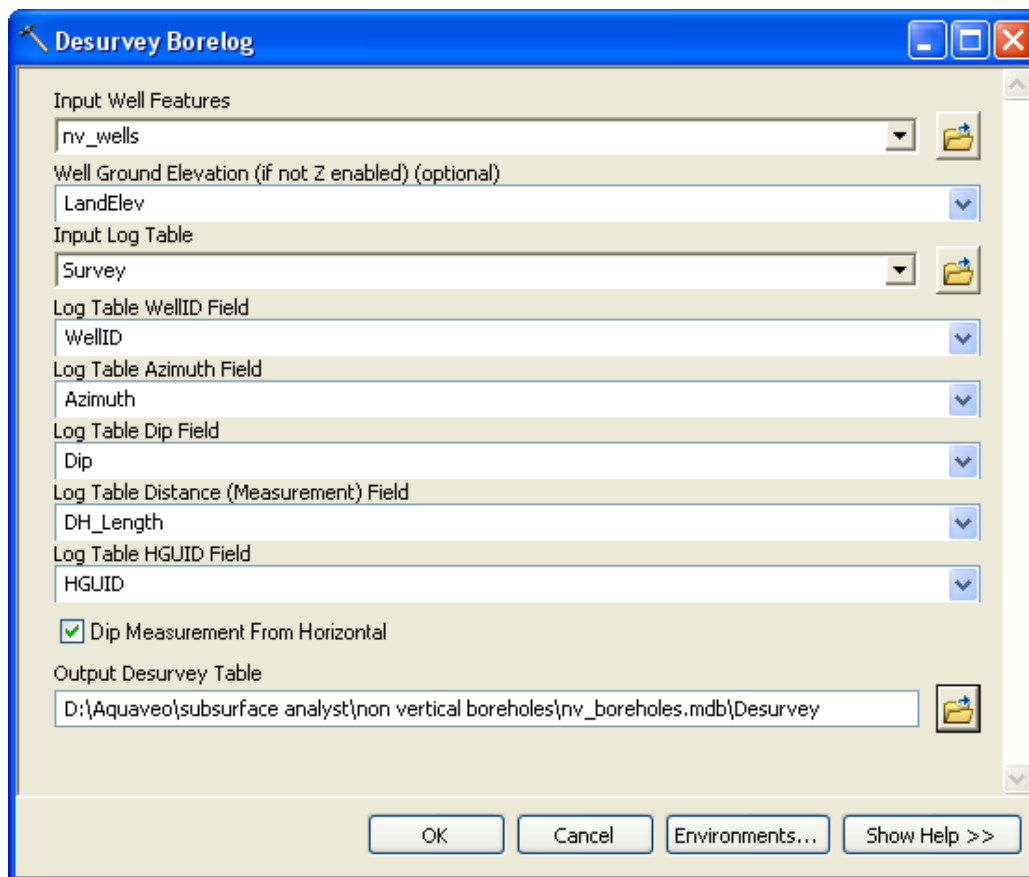


Figure 8 Settings for the *Desurvey Borelog* tool.

3. Click on *OK* to run the tool.

A new Desurvey table should be created and added to the map. If you open the Desurvey table you will see that the table contains X, Y, and Z coordinates, and an HGUID field. The table also contains a field named BoreOrder that defines the ordering of the contacts along the borehole.

8 Creating 3D BoreLines

Next, we will use a geoprocessing tool to generate a 3D view of the borehole logs. This tool uses the Well features and the Desurvey table to build 3D “borelines” that can be rendered in ArcScene.

1. Open the *Create Non-Vertical Borelines* tool in the *AHGW Tools | Subsurface Analyst | Features* toolset.
2. Enter the settings as shown in Figure 9.
3. Click on the *OK* button.
4. Click on the *Close* button when the tool has finished.

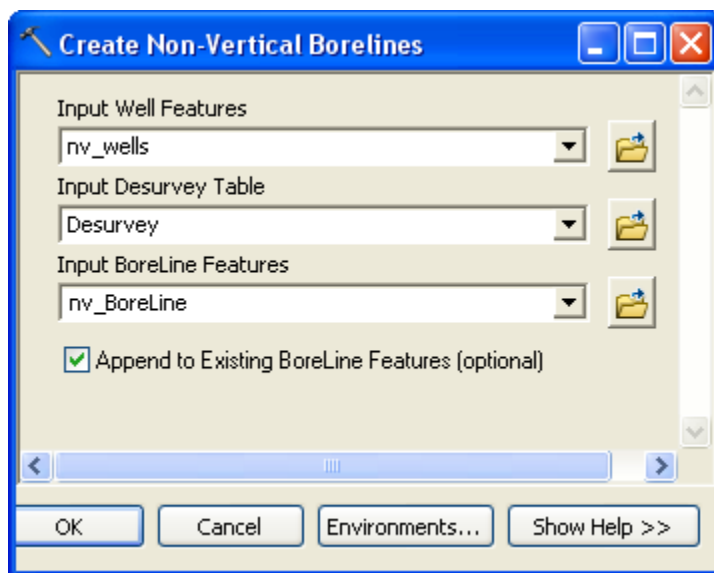


Figure 9 Settings for the *Create Non-Vertical Borelines* Tool.

You should now see a set of 3D lines below the well points (if they do not appear, right-click on the *nv_BoreLine* layer in the TOC and select *Refresh*). We will make some adjustments so that the lines are more visible. First, we will make the lines wider.

5. Right-click on the *nv_BoreLine* layer and select *Properties*.
6. Click on the *Symbology* tab.

7. In the *Show* section select the *Categories / Unique values* option and the *HGUID* field as the *Value Field* (as shown in Figure 10). Click *Add All Values* button.
8. Select a *Color Ramp* of your choice.
9. You can change the width for all lines at once by right-clicking the *Symbol* header above the line symbols and selecting *Properties for All Symbols...* from the resulting drop-down menu.
10. In the *Symbol Selector* dialog adjust the symbol widths to a value of **8.0**.
11. Click on the *OK* button to close the *Symbol Selector* dialog.
12. Click on the *OK* button to close the *Layer Properties* dialog.

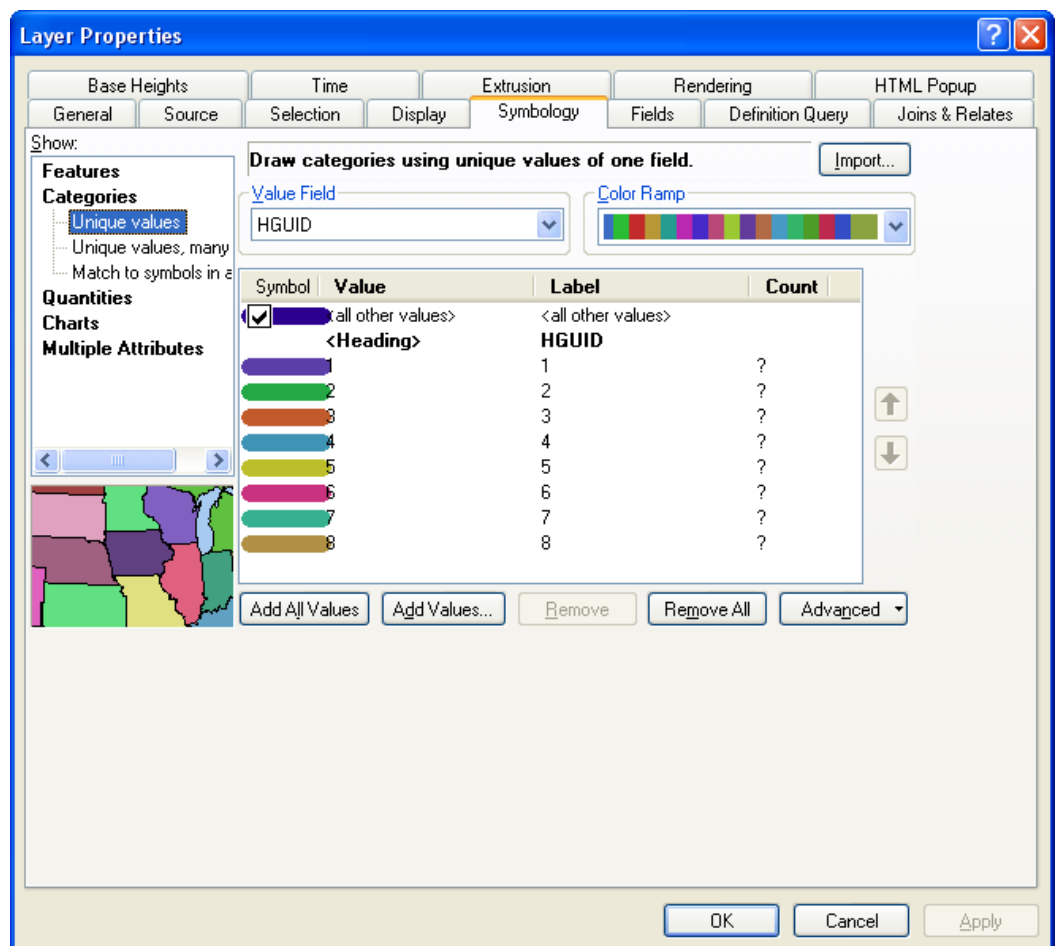


Figure 10 Boreline Symbology Settings.

The non-vertical BoreLines are stored in a 3D line (Polyline Z) feature class. To view the BoreLine feature attributes:

13. Right-click on the *nv_BoreLine* layer in the TOC window and select the *Open Attribute Table* command.

Note that the table includes many of the same fields as the Survey table. The values for the TopElev, BottomElev, WellID, and HGUID fields have all been extracted from the Survey table.

14. Close the attribute table.

9 Using the HGU Color Manager

You can use the HGU Color Manager to control the colors of the BoreLine features so they match the colors you previously defined.

1. Select the *HGU Color Manager* command in the *Subsurface* menu in the AHGW Toolbar.
2. Click on the *Setup* button.
3. Change the settings to match those shown in Figure 11.
4. Click on the *OK* button.

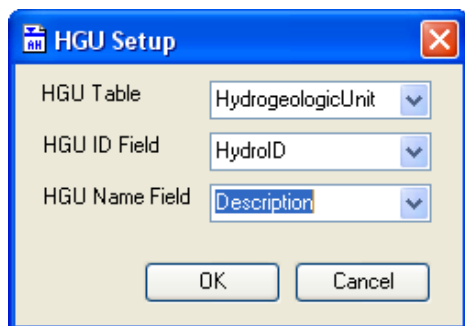


Figure 11 Settings for the HGU Setup Dialog.

5. Turn off the *nv_Well* option in the *Apply* column at the bottom, as shown in Figure 12.
6. Select the color scheme for the different units.

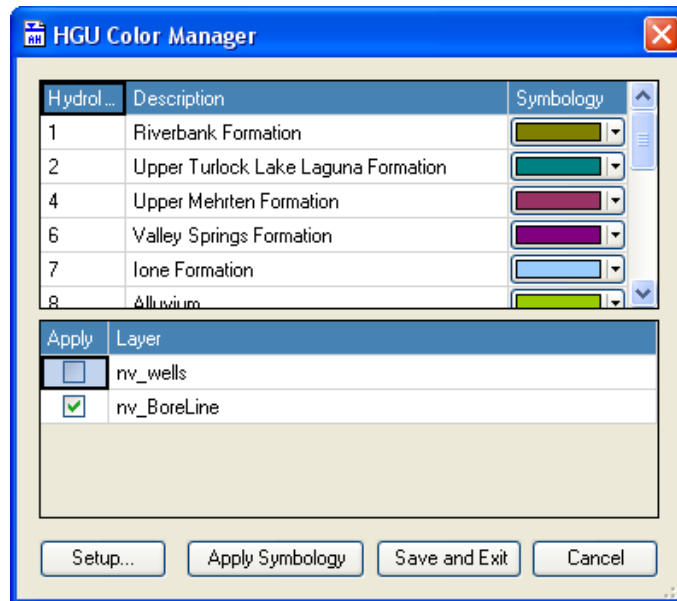


Figure 12 Settings for the HGU Color Manager.

7. Click on the *Apply Symbology* button to apply your changes.

Note that the selected color scheme has been applied to the BoreLine layer.

8. Click on the *Save and Exit* button to save the symbology and exit the color manager Symbology button to apply your changes.

The colors are stored in the HydrogeologicUnit table; this enables later use of the same color scheme and applying it to different feature classes.

10 Conclusion

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

- Non-vertical borehole log data can be imported and associated with well features.
- Non-vertical survey data is de-surveyed to transform azimuth, dip, and length values to z, y, and z coordinates.
- Non-vertical BoreLine features are created from the de-survey data.
- The HGU Color Manager is used to apply a common color scheme to all features associated with a set of common hydrogeologic units.