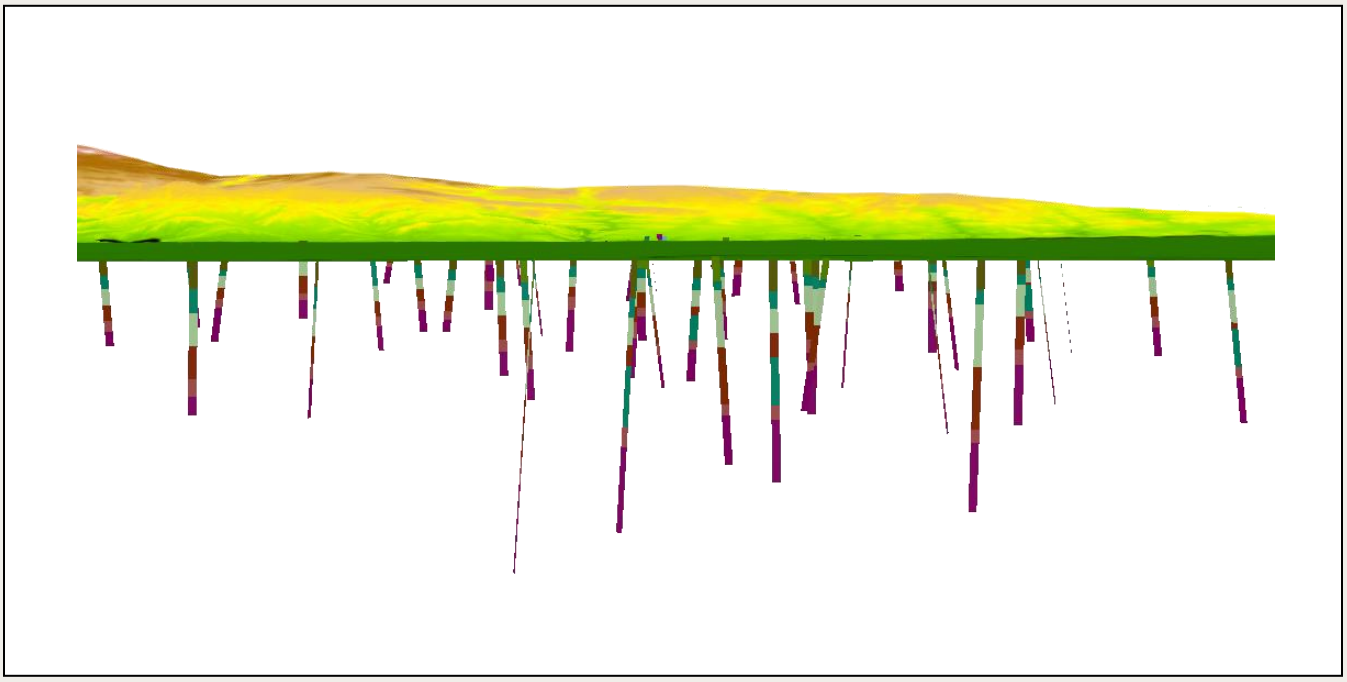
AHGW Pro 1.0 Tutorial

Working with Non-Vertical Borehole Data

Managing and representing non-vertical boreholes with Arc Hydro Groundwater



Objectives

Learn how to use Arc Hydro Groundwater Pro tools to manage non-vertical borehole data and create 3D representations of hydrostratigraphy in non-vertical boreholes.

Prerequisite Tutorials

- Working with Borehole Data

Required Components

- ArcGIS Pro
- 3D Analyst
- Subsurface Analyst

Time

- 15–35 minutes

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1 Introduction

Arc Hydro Groundwater Pro (AHGW Pro) is a geodatabase design 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 Pro Tools* help to import, edit, and manage groundwater data stored in an AHGW Pro 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 Pro data model is suggested, but not required, prior to beginning this tutorial.

1.1 Outline

This tutorial 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. The tutorial covers how to:

1. Import a set of non-vertical borehole data into an AHGW Pro 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

The following components must be enabled in order to complete this tutorial:

- ArcGIS Pro license
- 3D Analyst.
- AHGW pro Tutorial Files.

The *AHGW Pro Tools* require that you have a compatible ArcGIS Pro service pack installed. You may wish to check the *AHGW Pro 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

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 "non vertical boreholes.aprx" located in the *SubsurfaceAnalystPro\non vertical boreholes* folder.
6. Click **OK** to import the project.

A *Map* view and a *Scene* view should appear containing a DEM of the model domain and a set of well features (Figure 1).

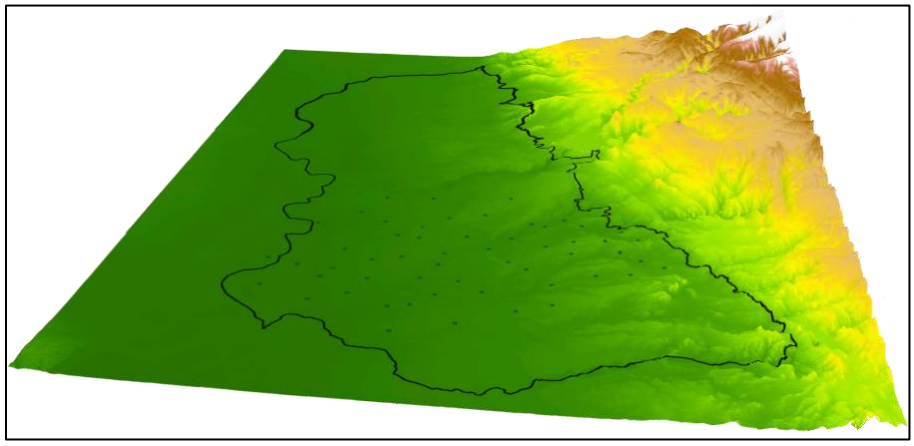

Figure 1 Scene of the Roseville model domain with well features shown on top of a DEM

This tutorial works best in *Scene* view.

7. Select the *Scene* view.

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

3 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. Dip defines the vertical angle of the borehole and can be measured as an angle from a horizontal or vertical plane (Figure 2). 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.

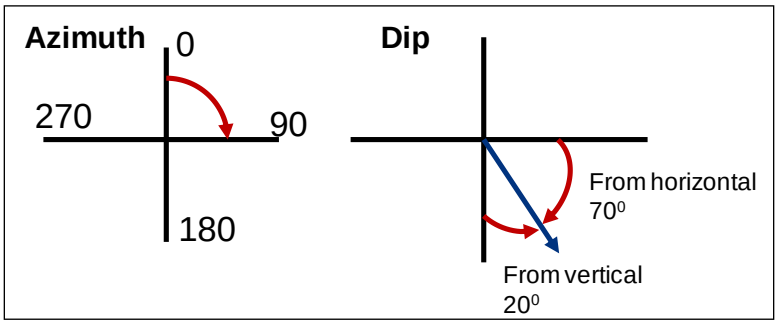

Figure 2 Azimuth and Dip define the orientation of the borehole in 3D space

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 3).

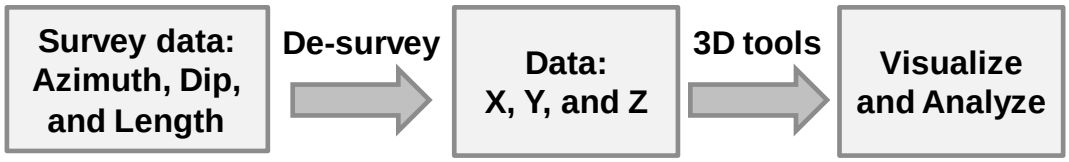

Figure 3 Process of creating 3D features from survey data

4 Importing Borehole Data

The nv_wells feature class consists of points defining the XY locations of wells in the model domain. In this step, a text file containing data from borehole logs associated with the non-vertical wells will be imported. 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.

To import a text file:

1. On the ribbon, select the *Map* tab.
2. Select **Add Data** to open the *Add Data* dialog.

3. In the data tree on the left, under *Project*, browse to *Folders\non vertical boreholes*.
4. In the *non vertical boreholes* folder, select "Survey.txt".
5. Click **OK** to close the *Add Data* dialog and import "Survey.txt".

The "Survey.txt" file should now appear in the *Contents* pane under the heading *Standalone Tables*. Now the data just imported will be appended into the existing "Survey" table:

6. In the *Command Search* box in the upper left corner of the main user interface, enter "Append".
7. Select "**Append (Data Management Tools)**" from the drop-down that appears to open the *Append* tool in the *Geoprocessing* pane.
8. In the *Append* tool, enter the following values:
   - For *Input Dataset*, select "Survey.txt" from the drop-down.
   - For *Target Dataset*, select "Survey" from the drop-down.
   - For *Field Matching Type,* select "Use the field map to reconcile field differences" from the drop-down.

If the fields did not match the text file exactly, this feature would be used to match the correct fields. To be sure the fields match:

9. Under the *Field Map* section, ensure that the fields are mapped correctly by clicking on each item and checking that they match as described in the table below.

The fields should match automatically because the field names already match the output fields.

Output Fields	*Source*
WellID	WellID
Azimuth	Azimuth
Dip	Dip
DH_Length	DH_Length
HGUID	HGUID

10. Click **Run** to run the *Append* tool.

The "Survey" table is now populated. To view the new records in the "Survey" table:

11. Select the **List By Data Source** tab in the *Contents* pane.
12. Right-click on "Survey" and select **Open** to bring up the *Survey* table view.

The second 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 Pro 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:

13. Close the *Survey* table view.

14. Right-click on “HydrogeologicUnit” and select **Open** to bring up the *HydrogeologicUnit* table view.

In this table, view the indexing 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.

15. Close the *HydrogeologicUnit* table view.
16. Select the **List By Drawing Order** tab in the *Contents* pane.

5 De-Surveying Borehole Data

1. In the *Catalog* pane, under “ArcHydroGroundwater.pyt” expand the “Subsurface Analyst” toolset then the “Features” toolset.
2. Double-click on the “Desurvey Borelog” tool to open the *Desurvey Borelog* tool in the *Geoprocessing* pane.
3. Specify the input parameters as follows:
   - *Input Well Features* to “nv_wells”.
   - *Input Log Table* to “Survey”.
   - *Log Table WellID Field* to “WellID”.
   - *Log Table Azimuth Field* to “Azimuth”.
   - *Log Table Dip Field* to “Dip”.
   - *Log Table Distance (Measurement) Field* to “DH_Length”.
   - *Log Table HGUID Field* to “HGUID”.
   - *Well Ground Elevation (if not Z enabled)* to “LandElev”
4. Next to *Output Desurvey Table*, click **Browse** to open the *Output Desurvey Table* dialog.
5. In the data tree on the left, under *Project*, open *Databases* then double-click on *nv_boreholes.gdb* to open it.
6. In the *nv_boreholes.gdb* database, enter “Desurvey” in the *Name* field.
7. Click **Save** to close the *Output Desurvey Table* dialog and save the output desurvey table name.
8. In the *Log Table Fields of Interest* section, click to expand a list with checkboxes.
9. In the lower left corner, select **Toggle All Checkboxes** to check all the checkboxes.
10. Click **Add** to select all the options as log table fields of interest.
11. Click on **Run** to run the *Desurvey Borelog* tool.

A new “Desurvey” table should be created and added to the scene. If desired, open the Desurvey table to 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.

6 Creating 3D BoreLines

Next, 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 the scene view of ArcGIS Pro.

1. In the *Catalog* pane, make sure that the " Features" toolset under " Subsurface Analyst" is expanded.
2. Double-click on the " Create Non-Vertical Borelines" tool to open the *Create Non-Vertical Borelines* tool in the *Geoprocessing* pane.
3. In the pane, enter the following:
   - *Input Well Features* to "nv_wells".
   - *Input Desurvey Table* to "Desurvey".
   - *Input BoreLine Features* to "nv_BoreLine".
4. Click **Run** to run the *Create Non-Vertical Borelines* tool.

A set of 3D lines should appear below the well points. (If they do not, click the **Refresh** button in the bottom-right corner of the view. If that doesn't work, right-click on " nv_boreholes.gdb" under "Databases" in the *Catalog* pane and select **Refresh**. Now, adjustments should be made so that the lines are more visible. First, make the lines wider by doing the following:

5. In the *Contents* pane, right-click on the "nv_BoreLine" layer and select **Symbology…** to open the *Symbology - nv_BoreLine* pane.
6. In the drop-down below *Primary symbology*, select "Unique Values".
7. Change *Field 1* to "HGUID".
8. If desired, change the color scheme using the drop-down next to *Color Scheme*.

The colors may also be changed individually by selecting the line icon in the first column of the table. Now, make some adjustments to increase visibility. Start by increasing the width of the lines.

9. On the Symbology pane, in the top right corner of the *Classes* tab, click *More* | **Format all symbols** to go to the *Format Multiple Line Symbols* page.
10. At the top, select the *Properties* tab.
11. Next to *Line width*, enter a value of "8 pt".
12. Click outside the *Line Width* box.
13. At the bottom of the pane, click **Apply** to apply the line width change to all of the lines.
14. Using the **Return** button, return to the main *Symbology* pane.

Now, the vertical exaggeration will be adjusted:

15. In the *Contents* pane, right-click on the "nv_BoreLine" layer and select **Properties** to open the *Layer Properties: nv_BoreLine* dialog.
16. Select *Elevation* from the list on the left.

17. Set the *Features are* drop-down to “Relative to the ground”.
18. For *Vertical Exaggeration*, enter “10.00”.
19. Click **OK** to save the settings and close the *Layer Properties: nv_BoreLine* dialog.

Now, viewing beneath the surface using the **Explore** tool or the navigator should reveal clearly drawn BoreLines.

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

20. Right-click on the “nv_BoreLine” layer in the *Contents* pane and select **Attribute Table** to bring up the *nv_BoreLine* table view.

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.

21. When done, close the *nv_BoreLine* table view.

7 Using the HGU Color Manager

Use the *HGU Color Manager* to control the colors of the BoreLine features so they match the colors previously defined.

1. On the ribbon, select the *Arc Hydro Groundwater* tab.
2. Select the **HGU Color Manager** to open the *HGU Color Manager* pane.
3. Change the settings to the following:
   - *HGU Table* to “HydrogeologicUnit”.
   - *HGU ID Field* to “HydroID”.
   - *HGU Name Field* to “Description”.
4. If desired, select the color scheme for the different units.
5. In the *Apply* table at the bottom, only check nv_BoreLine. If necessary, uncheck everything else.
6. Click **Apply Symbology** to apply the changes.

Note that the selected color scheme has been applied to the BoreLine layer. Note that clicking **Apply Symbology** not only adjusted the colors of the BoreLine layer, but it changed the line width back to 1 pt. If desired, adjust the line width back to 8 pt in the *Symbology* pane using steps 9-14 of Section 6 in this tutorial.

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

8 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 x, 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.