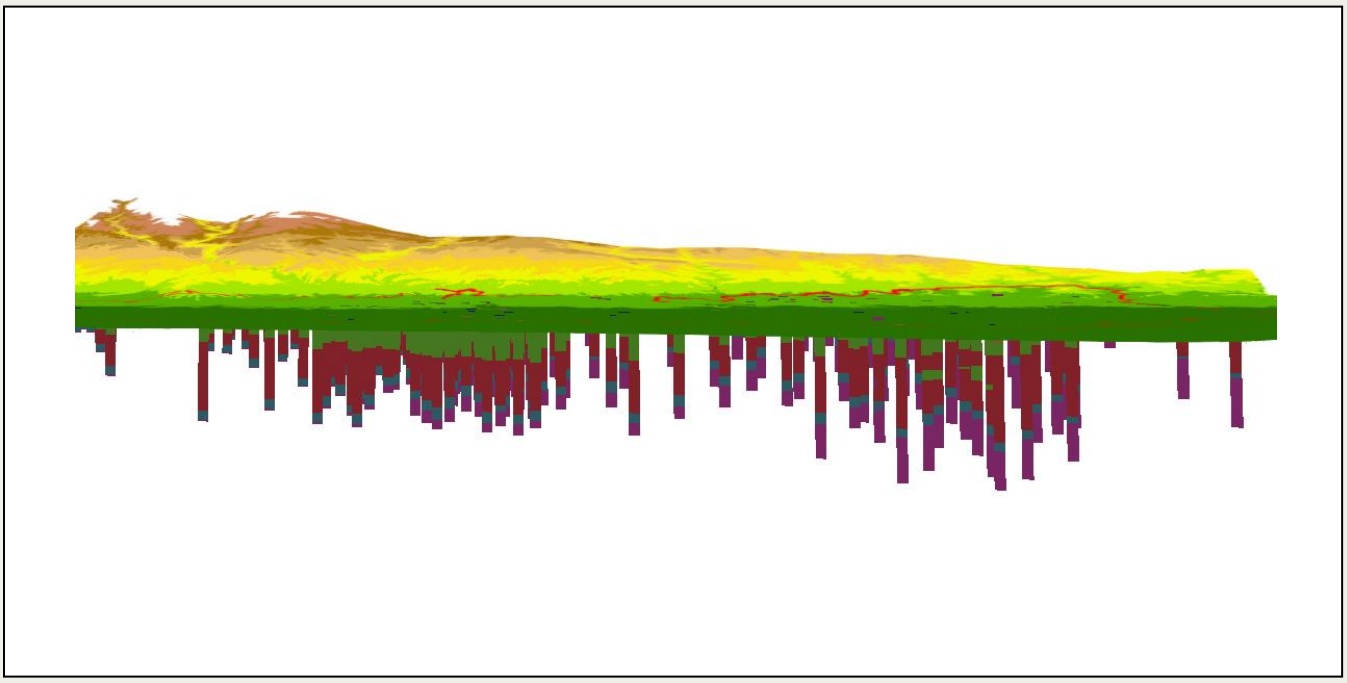
AHGW Pro 1.0 Tutorial

Working with Borehole Data

Managing borehole data and representing hydrostratigraphy



Objectives

Learn how to use the Arc Hydro Groundwater Pro tools to manage borehole data and create 3D representations of hydrostratigraphy.

Prerequisite Tutorials

- None

Required Components

- ArcGIS Pro
- 3D Analyst
- Groundwater Analyst
- Subsurface Analyst

Time

- 30–50 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 multi-dimensional groundwater data. It 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. This tutorial illustrates how to use the tools to manage borehole data and create 3D representations of hydrostratigraphy. 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 work with borehole data developed as part of a project for creating a groundwater simulation model near the city of Roseville in the Sacramento Valley, California. The tutorial will cover the following tasks:

1. Creating a geodatabase to store well and borehole information.
2. Importing a set of borehole data into an AHGW Pro geodatabase.
3. Exploring the borehole logs.
4. Generating and viewing 3D BoreLines derived from the 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 a compatible ArcGIS service pack installed. If needed, 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 "boreholes.aprx" located in the *SubsurfaceAnalystPro\boreholes* folder.
6. Click **OK** to import the project.

A *Map* view and a *Scene* view containing a DEM of the model domain (Figure 1) should appear. By default, the *Map* view is the first one to appear.

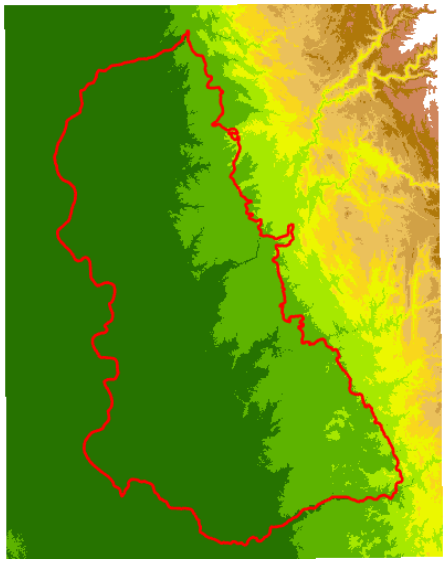

Figure 1 Map view of the Roseville model domain on top of a DEM of the region

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

7. Click on the *Scene* tab to switch to the *Scene* view. Remain in this view for the entire tutorial.

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, 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 Pro 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.

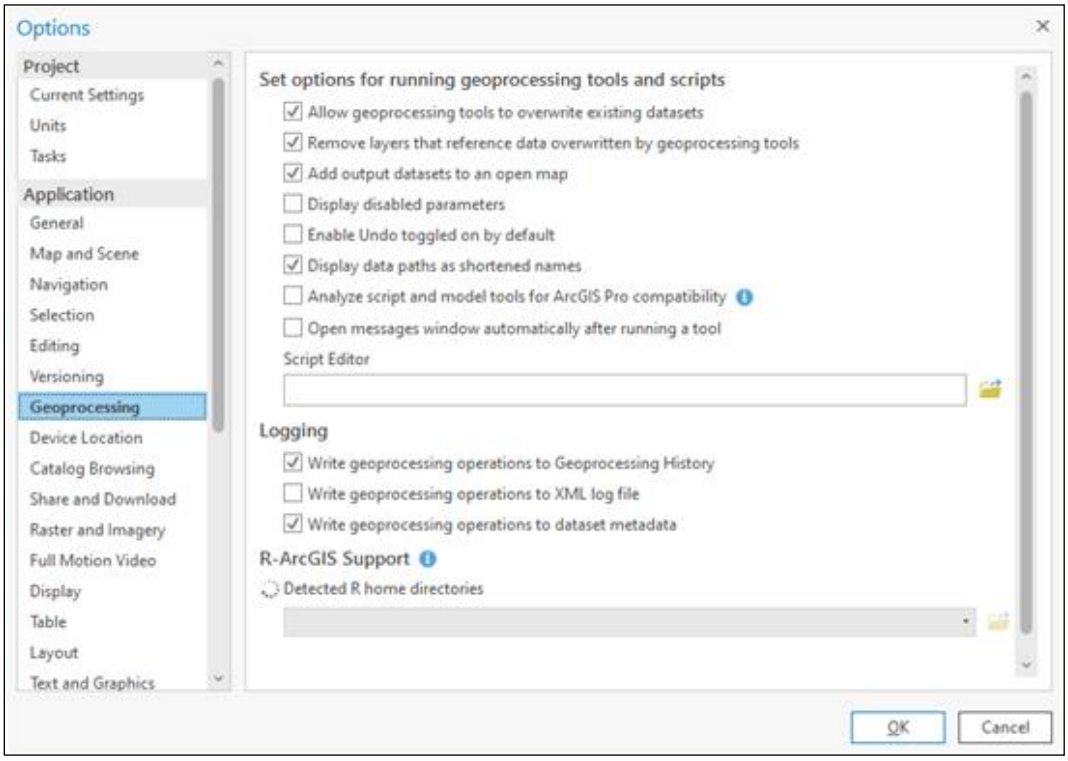

Figure 2 Setting Geoprocessing tools to overwrite outputs by default and to add results of geoprocessing tools to the display

3 Creating the Geodatabase

Now an empty geodatabase will be created with feature classes and tables to store the information necessary for the tutorial.

1. In the *Catalog* pane, expand *ArcHydroGroundwater.pyt,* then expand *Groundwater Analyst.*
2. In the *Groundwater Analyst* toolset, double-click on the **Create Blank AHGW Geodatabase** tool to open the *Create Blank AHGW Geodatabase* tool in the *Geoprocessing* pane.

3. For the *Geodatabase Location,* click the **Browse** button to open the *Geodatabase Location* dialog.
4. If necessary, click the **Up** button so that the *Project\Folders\boreholes* folder is visible in the dialog.
5. Select the *boreholes* folder and click **OK** to set it as the *Geodatabase Location*.
6. For the *Geodatabase Name* enter “Boreholes1”.
7. For the *Spatial Reference*, select the arrow to the right to open the drop-down menu and select “ModelBoundary”.

The program fills in “NAD_1983_StatePlane_California_11_FIPS_0402_Feet” for the *Spatial Reference*. Next, set the Z coordinate system.

8. Click the **Select coordinate system** button to open the *Coordinate System* dialog.
9. Select the box under *Current Z* that likely says “<None>”.
10. Under *Z coordinate Systems Available*, use the data tree to browse to *Vertical Coordinate System* | *Gravity-related* | *North America*.
11. Under *North America*, select *NAVD88 height (ftUS).*

The *Coordinate System* dialog should appear similar to the one shown in Figure 3. Note that it is important that the Z coordinate system is in the same units as the XY spatial reference, in this case both are in feet.

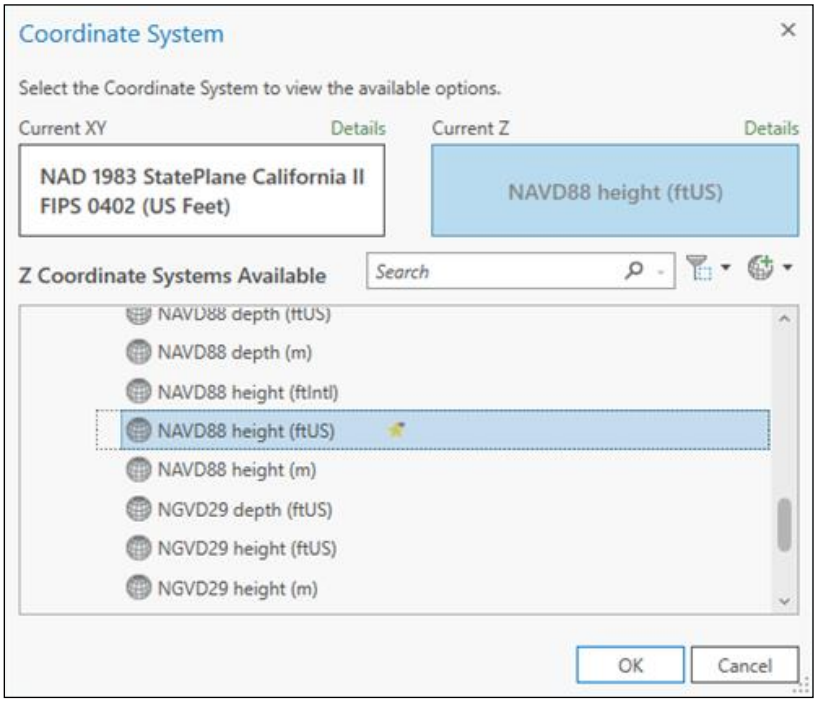

Figure 3 Coordinate System dialog with XY and Z coordinate systems selected.

12. Click **OK** to save the coordinate system settings and close the *Coordinate System* dialog.
13. In the *Framework Datasets* section, select the *Well* feature class.
14. In the *Subsurface Datasets* section, select the *BoreholeLog* and *HydrogeologicUnit* tables, and the *BoreLine* feature class.

The tool inputs should be similar to the ones shown in Figure 4

15. Select **Run** to run the tool.

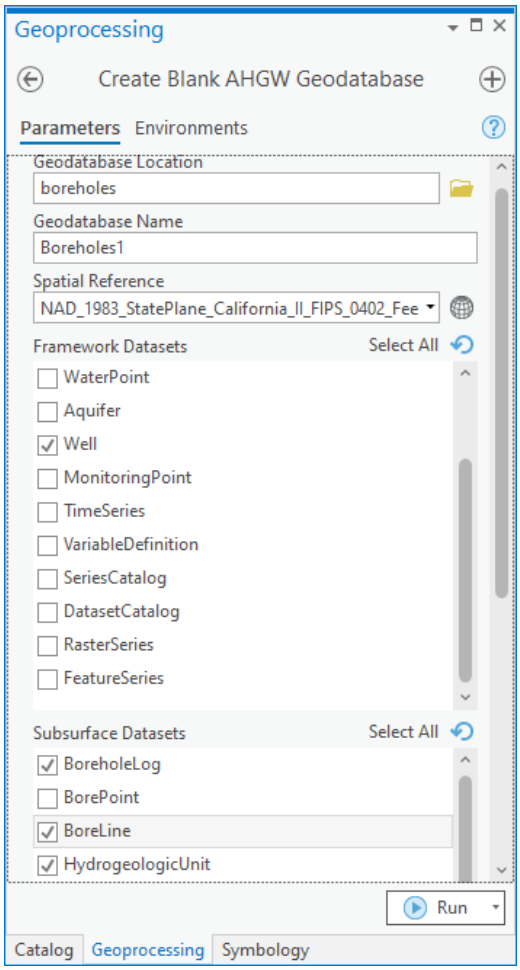

Figure 4 Inputs for the Create Blank AHGW Geodatabase tool

Once the run has successfully completed, a green banner will appear saying “Create Blank AHGW Geodatabase completed.”

16. In the *Catalog* pane, expand *Databases*.
17. Right-click on Databases and select **Add Database** to open the *Select Existing Geodatabase* dialog.
18. Browse to the *Project\Folders\boreholes* directory and select “Boreholes1.gdb”.
19. Click **OK** to add the geodatabase and close the *Select Existing Geodatabase* dialog.
20. In the *Catalog* pane, right-click on “Boreholes1.gdb” and select the **Make Default** command.

“Boreholes1.gdb” is now the default geodatabase. The icon should change to .

21. Expand “Boreholes1.gdb” and drag “Framework”, “Subsurface”, “BoreholeLog”, and “HydrogeologicUnit” into the view one at a time.

It's important to drag each of them because they will not automatically load into the view. There may not be a change in the display, but the *Contents* pane will update with each added item.

Next, data will be imported into the empty tables and features classes that were created.

4 Importing Well Features

To import well features, follow these steps:

1. On the ribbon, select the *Map* tab.
2. Click the **Add Data** button to open the *Add Data* dialog.
3. Browse to the data folder for this tutorial and select "wells.txt".
4. Click **OK** to import the dataset and exit the *Add Data* dialog.

A new "wells.txt" item will appear in the *Standalone Tables* section of the *Contents* pane. Now, the data will be set to display.

5. Right-click on the "wells.txt" standalone table and select **Display XY Data** to open the *Display XY Data* dialog.
6. Under *Output Feature Class*, click the **Browse** button to open the *Output Feature Class* dialog.

This determines the location of the output.

7. Browse to the data folder for this tutorial and open the "Boreholes1.gdb" file.
8. For the *Name*, enter "wells_imported".
9. Click **Save** to close the *Output Feature Class* dialog.
10. Under *Coordinate System*, click the arrow and select "Well" from the drop-down menu.

It will auto populate with "NAD_1983_StatePlane_California_11_FIPS_0402_Feet / VCS:NAVD88_height".

11. Click **OK** to close the *Display XY Data* dialog and run the tool.
12. Exit the warning that appears about empty Z values.

A new layer now appears in the map with points at the proper XY locations. Now, the Append tool will be used to input the data from "wells_imported" to the "Well" feature class.

13. On the ribbon, select the *View* tab.
14. Select **Geoprocessing** to open the *Geoprocessing* pane.
15. On the Geoprocessing pane, u*nder* the Toolboxes tab, click *Data Management Tools* to expand the list.
16. Click *General* | **Append** to open the *Append* tool in the *Geoprocessing* pane.
17. Under *Input Datasets*, select "wells_imported" from the drop-down menu.
18. Under *Target Dataset*, select "Well" from the drop-down menu.

This indicates that the empty Well feature class created earlier will have data from "wells_imported" imported into it. Now, set up the mapping using the following instructions.

19. Under *Field Matching Type*, select “Use the field map to reconcile field differences” from the drop-down menu.
20. In the *Field Map* section, in the *Output Fields* list, select *HydroID*.
21. To the right, under the *Source* tab, check that *Merge Rule* is set to “First” and the source, the second drop-down menu, is set to “HydroID”.
22. In the *Field Map* section, in the *Output Fields* list, select *FType*.
23. To the right, under the *Source* tab, check that the *Merge Rule* is set to “First” and the source, the second drop-down menu, is set to “FType”.
24. Select the **Run** command to run the **Append** tool.

The mapping occurs automatically. To visualize the newly created Well features, remove the “wells_imported” layer created previously:

25. Under the *Contents* pane, right-click on *wells_imported* and select the **Remove** command.

The well features should be visible in the scene as shown in Figure 5.

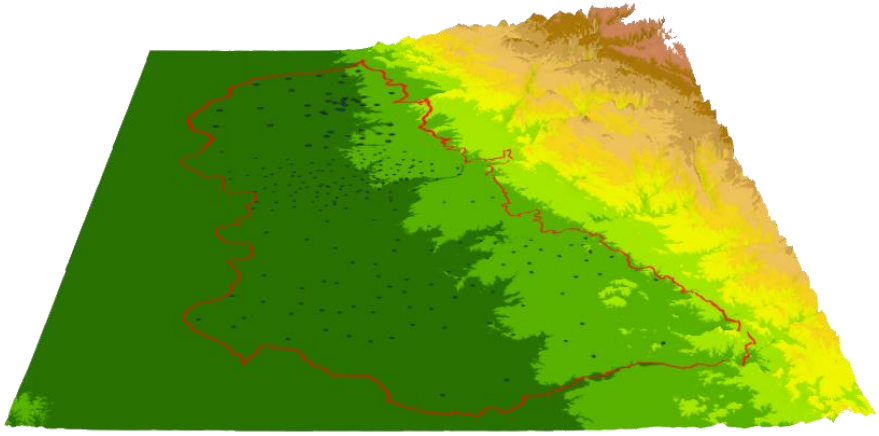

Figure 5 Well features shown in Scene view floating on top of a DEM

The HydroID of the well features is the key identifier for the features. Borehole information will be related to the well points by referencing the HydroID of the well.

In the next section, borehole data will be imported.

5 Importing Borehole Data

The Well feature class consists of points defining the XY locations of wells in the model domain. In this step, a text file will be imported containing data from borehole logs associated with the wells. The records in this file will be added to the *BoreholeLog* table. Each record in the table represents a contact or elevation in the borehole at which the soil type changes from one material to another. These records define the stratigraphy at the location the borehole is drilled. The records are imported through a process similar to the process used to import the well features.

1. On the ribbon, select the *Map* tab.
2. Click the **Add Data** button to open the *Add Data* dialog.
3. Browse to the data folder for this tutorial and select “Boreholes.txt”.
4. Click **OK** to import the dataset and exit the *Add Data* dialog.

A new "Boreholes.txt" standalone table appears in the *Standalone Tables* section of the *Contents* pane. Now, it's time run the **Append** command for the new dataset. To do so, follow these steps:

5. If necessary, close the *Geoprocessing* pane.

This ensures that the **Append** tool will return to default settings, so the tool can be run on the new dataset without any of information from the last dataset. To find the tool this time, use the *Command Search* box.

6. In the *Command Search* box to the left of the ribbon tabs, enter "Append".
7. Select **Append (Data Management Tools)** to open the *Append* tool in the *Geoprocessing* pane.
8. In the *Geoprocessing* pane, for the *Input Datasets*, enter "Boreholes.txt", the file imported in steps 1-4.
9. For the *Target Dataset*, select the "BoreholeLog" standalone table from the drop-down menu.
10. For *Field Matching Type*, select "Use the field map to reconcile field differences" from the drop-down menu.
11. 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
RefElev	RefElev
FromDepth	FromDepth
ToDepth	ToDepth
TopElev	TopElev
BottomElev	BottomElev
ElevUnits	ElevUnits
HGUID	HGUID
LogType	LogType

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

To view the new records in the BoreholeLog table:

13. Click on the *List By Data Source* tab in the *Contents* pane.
14. Right-click on the "BoreholeLog" table and select the **Open** command to bring up the *BoreholeLog* table view.

The second column in the table (*WellID*) relates to the *HydroID* of the corresponding well. *TopElev* and *BottomElev* define the top and bottom elevation of the borehole segment represented by each record. 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.

15. Close the *BoreholeLog* table view.
16. Click on the *List By Drawing Order* tab in the *Contents* pane.

Next, data will be imported into the HydrogeologicUnit table.

6 Importing Hydrogeologic Unit Data

The borehole logs imported in the previous steps include a reference to hydrogeologic units. The reference is based on a HGUID field that points to definitions of hydrogeologic units.

The data is imported through a process similar to the process used to import the well features and the borehole data.

1. On the ribbon, select the *Map* tab.
2. Click the **Add Data** button to open the *Add Data* dialog.
3. Browse to the data folder for this tutorial and select "HGUs.txt".
4. Click **OK** to import the new standalone table and exit the *Add Data* dialog.

A new "HGUs.txt" standalone table appears in the *Standalone Tables* section of the *Contents* pane. Now, it's time run the **Append** command for the new dataset. To do so, follow these steps:

5. If necessary, close the *Geoprocessing* pane.

This allows for opening a "clean" version of the **Append** command.To find the tool this time, use the *Command Search* box.

6. In the *Command Search* box to the left of the ribbon tabs, enter "Append".
7. Select **Append (Data Management Tools)** to open the *Append* tool in the *Geoprocessing* pane.
8. In the *Geoprocessing* pane, for the *Input Datasets*, enter "HGUs.txt", the file imported in steps 1-4.
9. For the *Target Dataset*, select the "HydrogeologicUnit" standalone table from the drop-down menu.
10. For *Field Matching Type*, select "Use the field map to reconcile field differences" from the drop-down menu.
11. 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
HydroID	HydroID
HGUCode	HGUCode

HGUName	HGUName

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

When the run has finished, to view the new records in the HydrogeologicUnit table:

13. Click on the *List By Data Source* tab in the *Contents* pane.
14. Right-click on the "HydrogeologicUnit" table and click **Open** to bring up the *HydrogeologicUnit* table view.

The second column in the table (*HydroID*) is the unique identifier of the unit. Data in the BoreholeLog table are classified using a HGUID identifier. The records relate to the HydrogeologicUnit table via the HydroID–HGUID association.

Review 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.

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

7 Using the Borehole Viewer

The *BoreholeLog* table is used to store vertical measurement records associated with a set of boreholes (i.e., wells). The set of records associated with a given well define a vertical profile of the hydrogeology of a site as shown in Figure 6. Later in the tutorial, 3D lines that can be viewed in the *Scene* view will be created from the BoreholeLog. However, first the *Borehole Viewer* provided in the AHGW Pro Subsurface Analyst will be used to view borehole log data for individual wells.

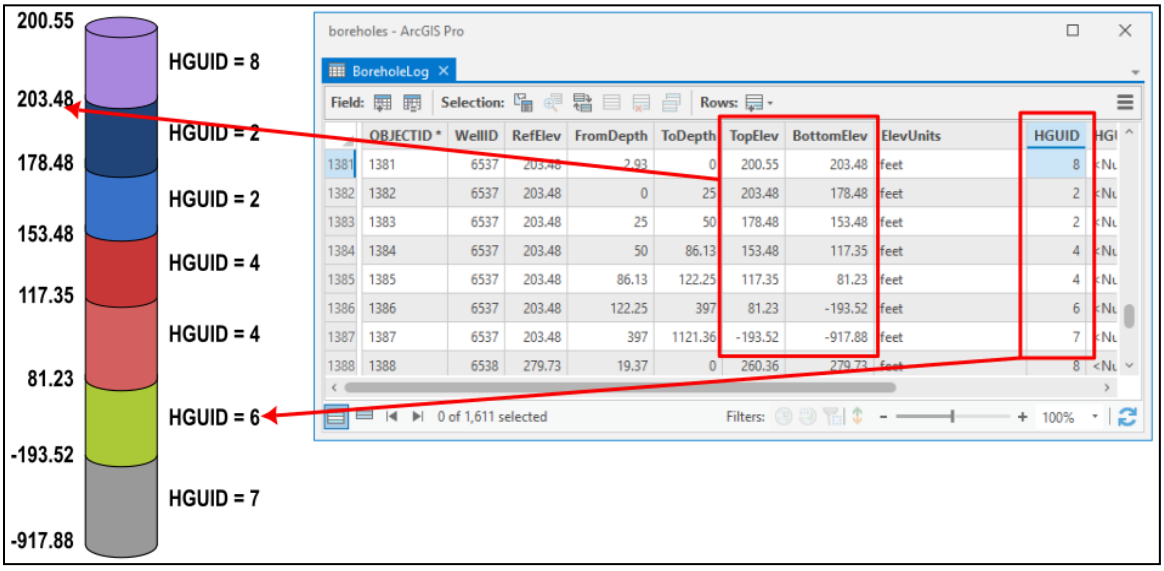

Figure 6 Borehole profile defined by data in the BoreholeLog table

1. On the ribbon, select the *Arc Hydro Groundwater* tab.
2. Select **Borehole Viewer** to open the *Borehole Viewer* pane.

The first step in using the *Borehole Viewer* is to select the appropriate Well feature class, BoreholeLog table, and fields that relate the two.

3. Set the options in the *Borehole Viewer* pane to be as follows:
    - *Well Layer* to “Well”.
    - *Well key field* to “HydroID”.
    - *BoreholeLog Table* to “BoreholeLog”.
    - *Log key field* to “WellID”.
    - *Log unit field* to “HGUID”.

The *Borehole Viewer* should appear similar to Figure 7.

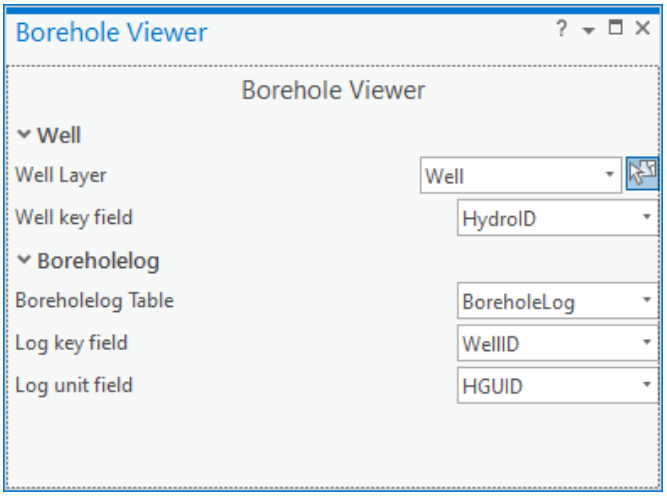

Figure 7 Settings for the Borehole Viewer

4. Click on the icon next to the *Well Layer* drop-down menu to activate the Borehole Viewer tool.
5. Click on some of the boreholes to view the stratigraphy along a number of boreholes.

The information will appear as a plot in a *Pop-up* pane. The plot in the *Pop-up* pane shows the selected unit for the chosen well based on information from the BoreholeLog table. Hovering over portions of the plot shows the actual information being plotted.

6. Hover over the plot with the mouse to see the actual values being plotted.

The plot will vary depending on the selected borehole, but it should look similar to Figure 8.

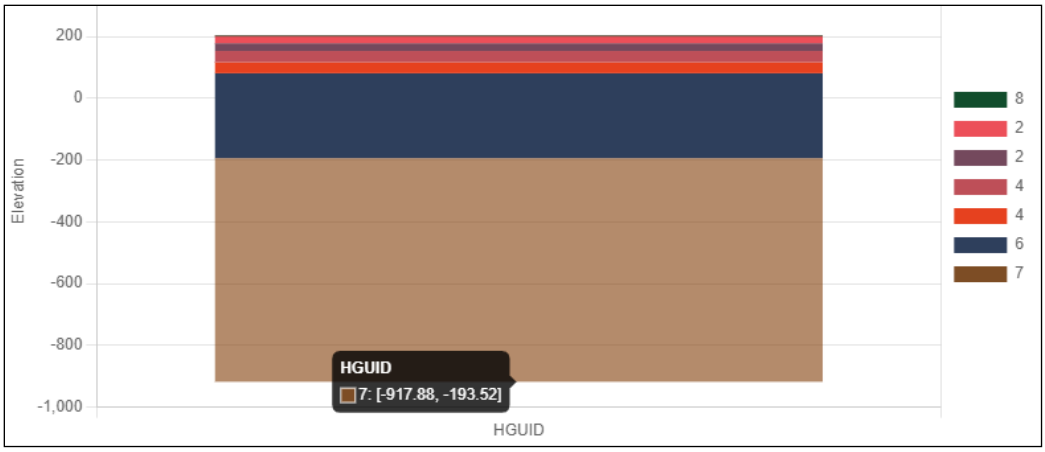

Figure 8 Borehole Viewer Plot for a Borehole selected using the Borehole Viewer tool

Note: In *ArcGIS Pro*, boreholes cannot be edited from the *Borehole Viewer*. All changes to boreholes must be made in the *BoreholeLog* table.

The color scheme of the borehole plot can be controlled via the *HGU Color Manager*. This color manager is based on the *HydrogeologicUnit* table which defines a set of Hydrogeologic units for the project. To enable the *HGU Color Manager*:

7. On the ribbon, select *Arc Hydro Groundwater*.
8. Select the **HGU Color Manager** tool to open the *HGU Color Manager* pane.

This pane allows for editing the colors associated with HGU. For example, it affects the display of the plots that appear when boreholes are selected. To edit the appropriate color fields, follow these steps:

9. Set the options in the *HGU Color Manager* to be as follows:
    - *HGU Table* select “Hydrogeologic Unit”.
    - *HGU ID Field* select “HydroID”.
    - *HGU Name Field* select “HGUName”.

Now the HGUIDs and the HGU names are visible in the table.

10. To edit the color corresponding to each, double-click in the box in the *Color* column.
11. Click in the box again to open up a palette of color options.
12. Select a color for each row.
13. At the bottom, uncheck every option except *BoreLine*.

The *HGU Color Manager* should look similar to Figure 9, but the particular colors chosen are unimportant.

14. Select **Apply Symbology**.

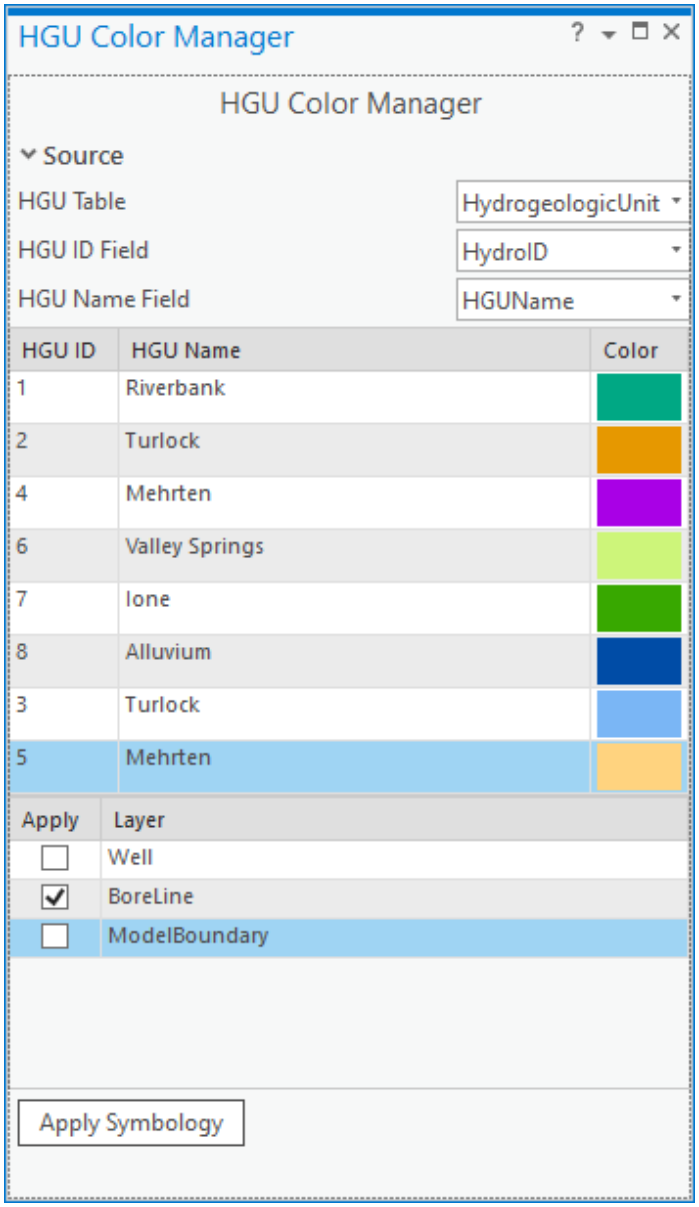

Figure 9 HGU Color Manager for controlling the symbology of Hydrogeologic units

After selecting **Apply Symbology**, the colors of the borehole plot should update to match the colors specified in the color manager.

15. Select various boreholes. Observe the change in the color of the plot display.

8 Creating 3D BoreLines

Next, a geoprocessing tool will be used to generate a 3D view of the borehole logs. This tool uses the Well features and the BoreholeLog table to build 3D “borelines” that can be rendered in the *Scene* pane.

1. In the Catalog pane, navigate to *ArcHydroGroundwater.pyt* | *Subsurface Analyst* | *Features*.

2. Under *Features*, double-click the **Create Borelines** tool to open the *Create Borelines* tool in the *Geoprocessing* pane.
3. Enter the settings as follows:
    - *Input Well Features* enter “Well”.
    - *Well Unique Feature Identifier Field* select “HydroID”.
    - *Input BoreLine Features* enter “BoreLine”.
    - *BoreLine Related Identifier Field* select “WellID”.
    - *BoreLine GroupID* select “HGUID”.
    - *Input Borehole Data Table* enter “BoreholeLog”.
    - *BoreholeLog Related Identifier Field* select “WellID”.
    - *BoreholeLog GroupID* select “HGUID”.
    - *BoreholeLog Top Elevation* select “TopElev”.
    - *BoreholeLog Bottom Elevation* select “BottomElev”.
4. When done, click **Run** to create the BoreLines.

A set of short 3D lines may appear below the well points. They may not be visible, depending on the view in the *Scene* pane. It’s possible they will not be visible until later steps are completed. The lines will be made more visible in a later step of the tutorial.

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

5. In the *Contents* pane, right-click on *BoreLine* under *3D Layers* and select **Attribute Table** to bring up a *BoreLine* table pane.

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

6. Close the *BoreLine* table pane.

9 Using the HGU Color Manager

The *HGU Color Manager* is used 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 **HGU Color Manager** to open the *HGU Color Manager* pane.
3. If necessary, enter the settings as follows:
    - *HGU Table* select “Hydrogeologic Unit”.
    - *HGU ID Field* select “HydroID”.
    - *HGU Name Field* select “HGUName”.

Note that the colors selected in the *HGU Color Manager* in previous steps were saved to the *HydrogeologicUnit* table and are now displayed in the *HGU Color Manager*. This same color scheme can be applied to the borelines or the color scheme can be modified.

4. Turn off the *Well* and *ModelBoundary* options in the *Apply* column at the bottom of the pane.

5. Click on the **Apply Symbology** button to apply the changes.

Note that the selected color scheme has been applied to the BoreLine layer and made the BoreLines visible if they were not before. Be advised that this also changes any settings adjusted in the *Symbology* pane for the BoreLine layer. It changes the line size to 1 pt in addition to making the prescribed color changes.

10 Visualizing the 3D BoreLines

A set of color-coded 3D lines are visible below the well points. The lines will now be adjusted to make them more visible. First, make the lines wider:

1. In the *Contents* pane, right-click on the *Boreline* layer and select **Symbology** to open the *Symbology - BoreLine* pane.
2. In the first drop-down menu, select “Unique Values”
3. In the *Field 1* drop-down menu, select “HGUID”.
4. In the table at the bottom of the pane, click the line symbol in the first column in the first row to open *Format Line Symbol - 1* in the *Symbology - Boreline* pane.
5. Click on the *Properties* tab.
6. In the *Line width* section, change the point value to “8 pt”.
7. Click **Apply** at the bottom of the pane to apply the changes.
8. Return to the main *Symbology - Boreline* pane by clicking the arrow in the upper left corner.
9. Repeat steps 4-8 for each row of the table.

Now that the lines are wider; their colors are more obvious when viewed in the *Scene* view. Next, the Z values will be exaggerated:

10. In the *Contents* pane, select *Ground* to activate the *Elevation Surface* ribbon.
11. Select the *Appearance* tab on the *Elevation Surface* ribbon.
12. Ensure that *Vertical Exaggeration* is set to “10.00”.
13. Ensure that *Navigate Underground* is turned on.
14. In the *Contents* pane, right-click on the *BoreLine* layer and select **Properties** to open the *Layer Properties: BoreLine* dialog.
15. Select *Elevation* from the list on the left to open the elevation property sheet.
16. Set the *Vertical Exaggeration* to “10.00” as above.
17. Click **OK** to close the *Layer Properties: BoreLine* dialog.

Now the borehole lines should be more visible, but they are beneath the DEM. To visualize the borehole lines, do the following:

18. Rotate the scene using the *Navigation* tool to visualize beneath the DEM. Observe the borehole lines.

Note that the borehole lines are thicker, but they are still flat. This means that from some angles, they are still very difficult to see.

19. Rotate the view until the full width of the borehole lines is visible

11 Conclusion

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

- Well features can be imported using the tools in ArcGIS Pro.
- Borehole log data can be imported and associated with well features.
- Hydrogeologic units can be imported and stored in the HydrogeologicUnit table.
- The *Borehole Viewer* is used to view data for individual boreholes.
- BoreLine features are created from the BoreholeLog table.
- The *HGU Color Manager* is used to apply a common color scheme to all features associated with a set of common hydrogeologic units.