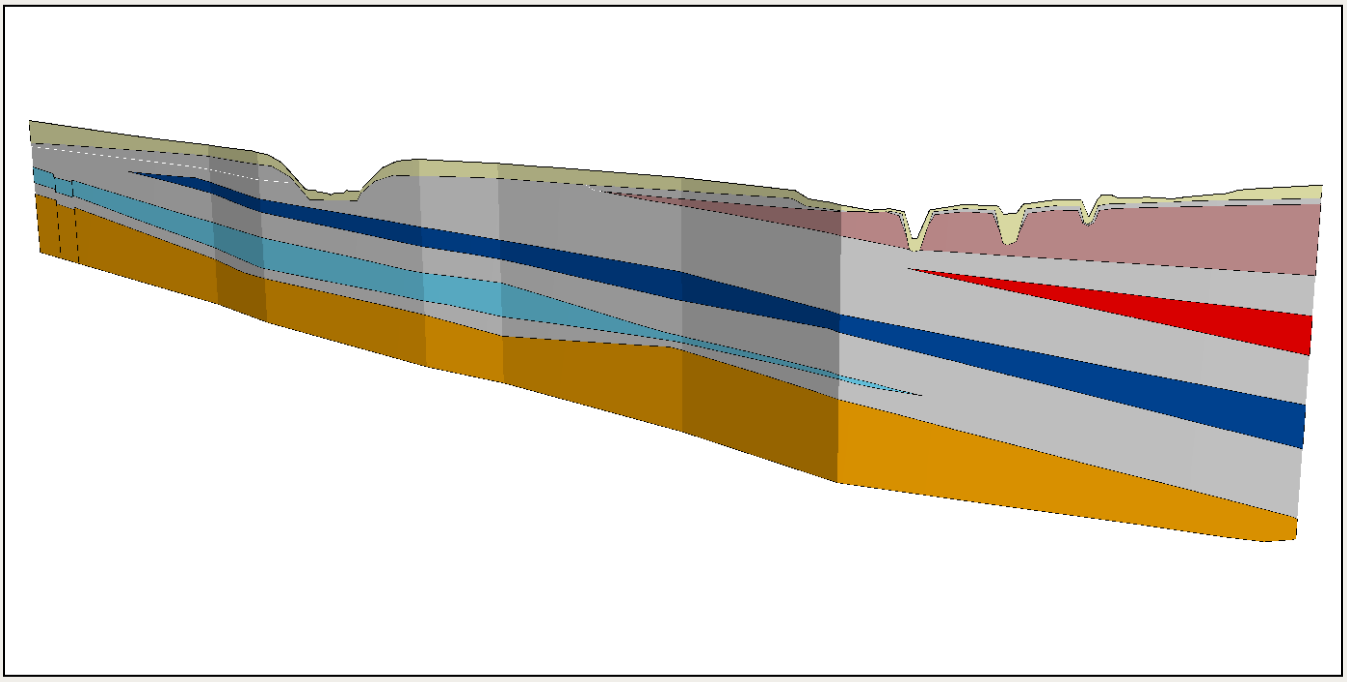
AHGW Pro 1.0 Tutorial

Subsurface Analyst – Creating ArcGIS Pro Cross Sections from Existing Cross Section Images

Add images and update cross sections using images in ArcGIS Pro



Objectives

Learn how to use Arc Hydro Groundwater Pro tools to add images to cross sections.

Prerequisite Tutorials

- Subsurface Analyst – Creating 2D Cross Sections

Required Components

- ArcGIS Pro
- 3D Analyst
- Subsurface Analyst

Time

- 25–45 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. It includes several components to represent different types of datasets such as 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. *Subsurface Analyst* is a subset of the AHGW Pro 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.

This tutorial will demonstrate how to add images to cross sections. Adding cross sections from reports may be useful for a number of purposes:

- Adding “legacy” knowledge to cross sections. Existing cross sections from reports/papers/map books with new information (boreholes, rasters, faults, etc.) can be combined to create new cross sections or update the old ones.
- Inclusion of data in existing cross sections from papers/reports/map books in the development of 3D hydrogeologic models.
- Archiving cross sections in a systematic way inside a geodatabase.

Subsurface Analyst includes tools for creating 2D cross sections by adding data to a new XS2D data frame and “sketching” cross sections based on borehole stratigraphy, outcrops, faults, etc. In addition Subsurface Analyst supports the creation of 3D cross sections and volumes from a set of surfaces. The 2D and 3D features can be viewed in ArcGIS Pro. The workflow and tools for creating 2D cross sections and 3D features are described in separate tutorial.

1.1 Background

Data used in this tutorial are part of a USGS report describing the hydrogeologic units of the Coastal Plain in Virginia (http://pubs.usgs.gov/pp/2006/1731/). The cross sections shown in Figure 1 were digitized from the report.

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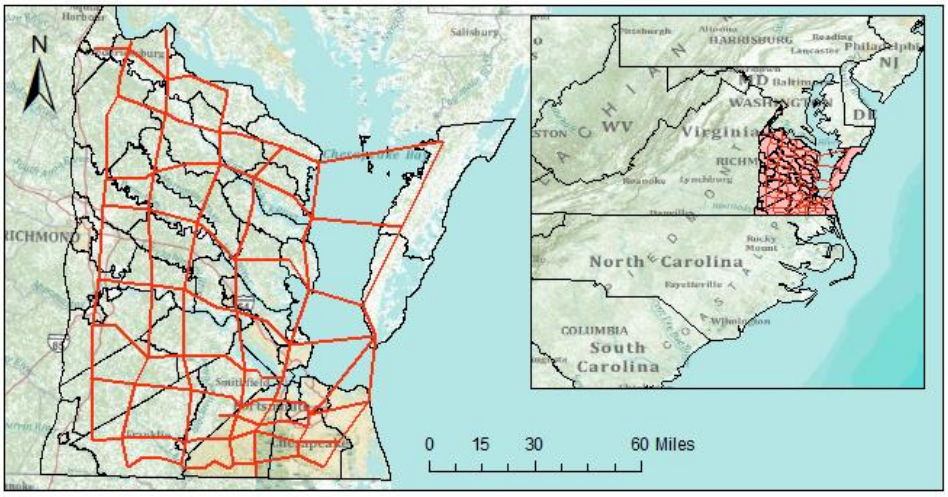

Figure 1 Location of the cross sections covering the Coastal Plain in Virginia

The cross section lines shown in the map are related with a vertical cross section describing hydrogeologic units in the Coastal Plain Aquifer system. The vertical cross sections are detailed in a set of PDF files. Figure 2 shows an example of such a cross section. The solid colors represent aquifers and the white colors in between represent confining units.

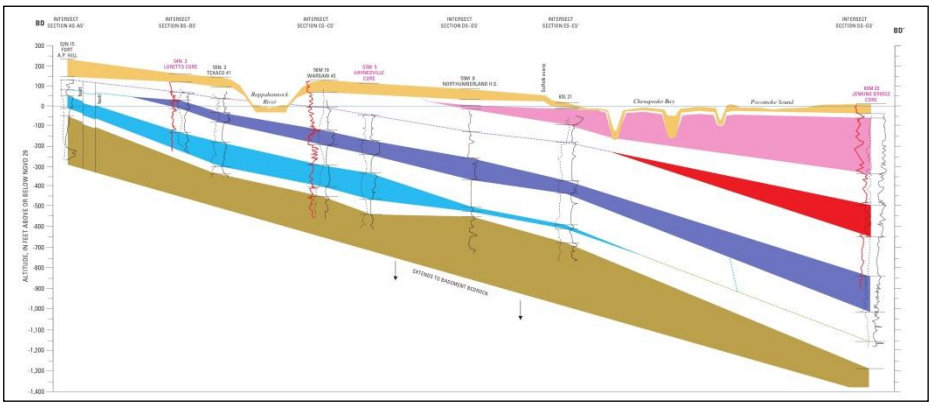

Figure 2 Example cross section showing hydrogeologic units along a cross section

1.2 Outline

The objective of this tutorial is to introduce the basic workflow and tools for adding existing 2D cross sections (in the form of images) to a XS2D data frame in ArcGIS Pro. The tutorial includes the following steps:

1. Running the Import XS2D Image Wizard to create a new XS2D data frame and corresponding feature classes and georeference the cross section image in the XS2D data frame.
2. Digitizing XS2D panels based on the image.
3. Building 3D GeoSections from the panels and visualize in ArcScene.

1.3 Required Modules/Interfaces

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

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

The AHGW Pro Tools require that you have a compatible ArcGIS Pro service pack installed. If needed, check the AHGW Pro Tools documentation to find the appropriate service pack for the version of the tools. *3D Analyst* is required for the last section of the tutorial for visualizing 3D features. If *3D Analyst* is not available, skip these parts of the tutorial. The tutorial files should be downloaded to the computer.

2 Getting Started

Begin by opening a project containing some background data.

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 “xs2d_image.aprx” located in the *SubsurfaceAnalystPro/XS2D_Image* folder.
6. Click **OK** to import the project.

Once the file has loaded, there should appear a map of Virginia with digitized cross section lines covering the Coastal Plain region (Figure 3). In a separate “images” folder there is a PDF document taken from the USGS report. There also are two JPG images representing cross sections AD-AD’ and BD-BD’ that were cropped from the PDF document. View these files to get familiar with the cross section images. Locate these cross sections on the map.

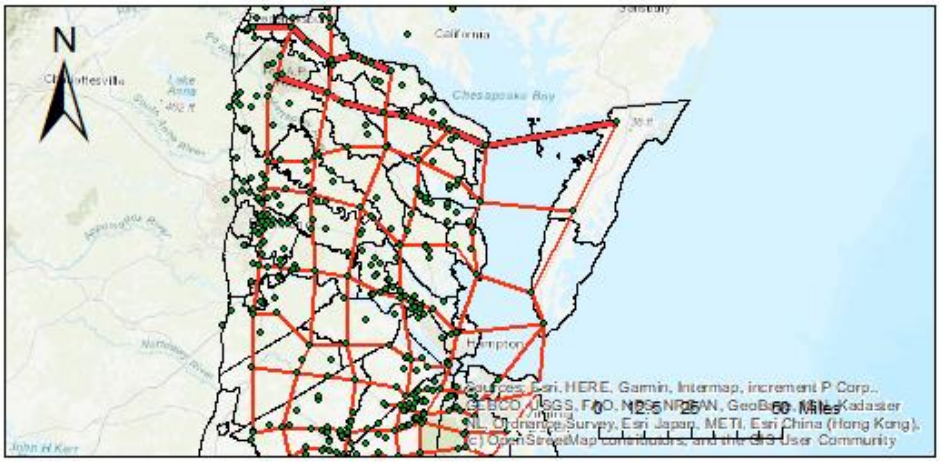

Figure 3 Starting project

The following section describes the concepts and datasets used to build a XS2D data frame. The same concepts are presented in other XS2D tutorials; if familiar with this material skip section 3.

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Before continuing, ensure that the AHGW Pro tools are correctly configured.

1. In the *Catalog* pane, expand the *Toolboxes* folder.

The *ArcHydroGroundwater.pyt* toolbox should appear under the list of toolboxes. If toolbox is not visible, complete the following:

2. In the *Catalog* pane, right-click on *Toolboxes* and use the **Add Toolbox** command to open the *Add Toolbox* dialog.
3. Browse to the location of *C:\Program Files\Aquaveo\ AHGW_ArcGIS_Pro_Python_Toolbox* directory and select and open the *ArcHydroGroundwater.pyt* file.
4. Click **OK** to close the *Add Toolbox* dialog.

With the *ArcHydroGroundwater.pyt* toolbox available, access the Groundwater Analyst tool.

5. Expand "ArcHydroGroundwater.pyt".
6. Expand "Groundwater Analyst".

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:

7. At the top of the *ArcGIS Pro* window, select the *Project* tab. From the list on the left, select **Options** to open the *Options* dialog.
8. Select *Geoprocessing* from the list under *Application* on the left of the dialog.
9. Ensure that *Allow geoprocessing tools to overwrite existing datasets* and *Add output datasets to an open map* are turned on.
10. Select **OK** to exit the *Options* dialog.
11. Using the arrow in the upper left corner, return to the main screen.

3 Representing 2D Cross Sections in the AHGW Pro Data Model

Before starting to create cross sections, it is helpful to review the component of the AHGW Pro Data Model. The AHGW Pro Data Model includes a number of components used for different purposes. The hydrostratigraphy component includes data structures for representing 2D and 3D hydrostratigraphy, including the creation of 2D cross sections (Figure 4).

SectionLine is the central feature class used to manage cross sections. Each SectionLine represents a cross section in map view. SectionLine features are indexed with a HydroID, which uniquely identifies them within the geodatabase. To create a vertical (profile) view of the cross section along the SectionLine, each SectionLine feature is associated with multiple feature classes representing the two-dimensional cross section, and these are given the "XS2D" prefix.

Common XS2D feature classes are:

- XS2D_Panel – polygon features representing cross section "panels".
- XS2D_BoreLine – vertical lines representing hydrostratigraphy along selected boreholes adjacent to the SectionLine.
- XS2D_PanelDivider – vertical guides showing the location where a SectionLine changes direction.

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- XS2D_MajorGrid and XS2D_MinorGrid – grid lines showing the vertical and horizontal scales in an XS2D data frame.

Additional feature classes can be added to represent items such as land surface elevation, water table, faults, etc.

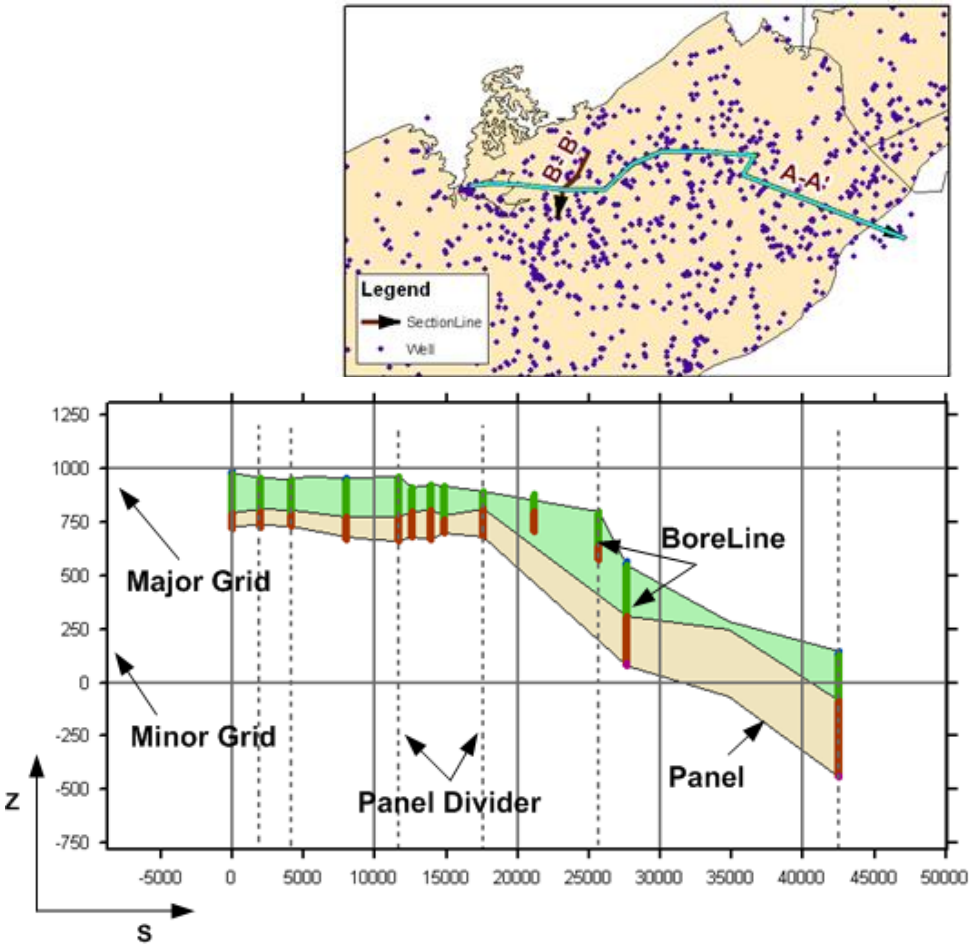

Figure 4 Datasets used for creating 2D cross sections

Each of the 2D cross sections is generated in a separate data frame in ArcGIS Pro. The XS2D feature classes are created in an {S, Z} coordinate system that is unique for each cross section. The S coordinate represents the length along the SectionLine (equivalent to the x-direction in the XS2D data frame) and the Z coordinate represents the vertical dimension (the y-direction in the XS2D data frame). In addition, XS2D features can be scaled (exaggerated) in the Z dimension for better visualization. *Subsurface Analyst* includes a number of tools for transforming features between a "real" coordinate system (X, Y, and Z) and a 2D coordinate system (S, Z), and for scaling features.

The XS2D_Catalog table is used for managing XS2D feature classes. The Catalog lists the XS2D feature classes related with each SectionLine feature. The SectionID field in the XS2D_Catalog references a HydroID of a SectionLine feature, thus creating a relationship between SectionLines (defined in real world coordinates) and XS2D feature classes. An example of a typical XS2D_Catalog table is shown in Figure 5.

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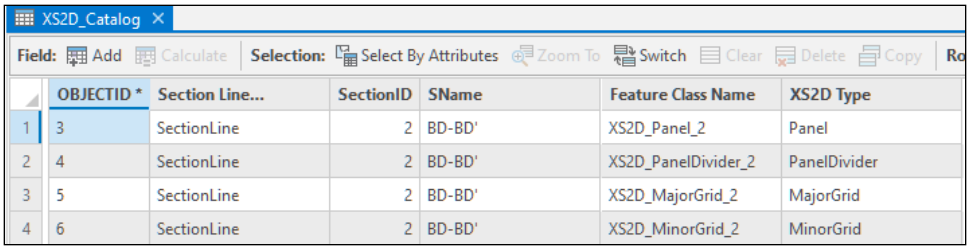

	OBJECTID *	Section Line...	SectionID	SName	Feature Class Name	XS2D Type
1	3	SectionLine	2	BD-BD'	XS2D_Panel_2	Panel
2	4	SectionLine	2	BD-BD'	XS2D_PanelDivider_2	PanelDivider
3	5	SectionLine	2	BD-BD'	XS2D_MajorGrid_2	MajorGrid
4	6	SectionLine	2	BD-BD'	XS2D_MinorGrid_2	MinorGrid

Figure 5 Example XS2D_Catalog used for managing XS2D feature classes and establishing a relationship between the XS2D features and a SectionLine feature

4 Adding Borehole Images to Cross Sections

The *XS2D Cross Section Image tool* creates a new set of feature classes for representing a 2D cross section based on a specific SectionLine feature. The tool creates a new data frame to which the XS2D feature classes (XS2D_Panel, XS2D_PanelDivider, XS2D_MajorGrid, and XS2D_MinorGrid) are added. In addition, the tool georeferences a selected image so it can be displayed in the XS2D data frame.

The tool is based on a selected section line (run the tool one cross section at a time). In this tutorial, a SectionLine feature class is already provided. To use the *XS2D Cross Section Image* tool:

1. On the ribbon, select the *Arc Hydro Groundwater Toolbar* tab.
2. Select **2D Cross Section Image** tool to open the *XS2D Cross Section Image* pane.
3. Using the **Select** tool located in the *SelectLine* section, click on BD-BD' SectionLine feature (topmost horizontal section line that crosses the bay).
4. For the *XS2D Catalog Table* option, make sure "XS2D_Catalog" is selected.
5. Make sure the *Default output workspace* is selecting "xs2d_image.gdb\Data" directory.
6. In the *Image File* section, select the browse button to open the *Choose XS2D Image* dialog.
7. Locate and select the field "BD-BD'.jpg" in the *Images* folder for this tutorial.
8. Select **OK** to close the *Choose XS2D Image* dialog and open the *XS2D Image* dialog.

The *XS2D Image* dialog is used to reference the imported image. If needed, resize the window to make it easier to view the cross section.

9. Use the sliders on the top, bottom, left, and right to move the referencing lines (in green and red) to the referencing locations on the image:
   - *XLeft* and *XRight* referencing lines should be located on the edge of the cross section features.
   - *ZTop* and *ZBottom* lines can be referenced to the vertical scale and tick marks on the left and right sides of the cross section.
   - Specify the *ZTop* as "300" and *ZBottom* as "-1300" in the boxes at the bottom of the form.

At this point the inputs should be similar to the ones shown in Figure 6.

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Figure 6 Settings for Step 2 in the Import XS2D Image Wizard

10. When done click **Finish** to exit the *XS2D Image* dialog.

The *XS2D Cross Section Image* pane is used to create panels and panel dividers. The minimum and maximum elevations for drawing panel dividers can be modified manually.

11. In the *Panel Divider Elevation* section, specify the maximum and minimum elevations to draw panel dividers:
    - *Minimum* set to “-2000”.
    - *Maximum* set to “600”.

The XS2D Cross Section Image pane is also used to setup the construction of the grid lines. The grid extent and spacing can be automatically specified based on the length of the selected SectionLine and elevations, or they can be set manually. Default values are set for the left, right, minimum and maximum elevations, and spacing of the grid features.

12. In the *Grid Extent* section, specify the following for the grid extent:
    - *Top* set to “600”.
    - *Bottom* set to “-2,000”.
    - *Left* set to “-100,000”.
    - *Right* set to “2,000,000”.

13. In the *Grid Spacing* section, specify the following for the grid spacing:

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- *Distance between major grid lines Horizontal* set to “200,000”.
- *Distance between major grid line Vertical* to “200”.
- *Number of minor grid lines Vertical* to “3”.
- *Number of minor grid lines Horizontal* to “1”.

14. Select **Create XS2D Data** to run the tool.

A new “ Section BD-BD’” data frame should be added to the map (make sure to be in layout view to be able to view data frames). The grid lines, the panel dividers, and the referenced cross section image should all be visible.

Next to resize the BD-BD’ data frame and move it within the map layout such that both data frames are visible. To better view the XS2D features created:

15. Using the **Explore** tool, move the BD-BD’ data frame within the map layout and resize it.
16. Use the zoom tools ( ) to focus on the data within the cross section.

At the end of this process there should be a cross section data frame that is similar to the one shown in Figure 7.

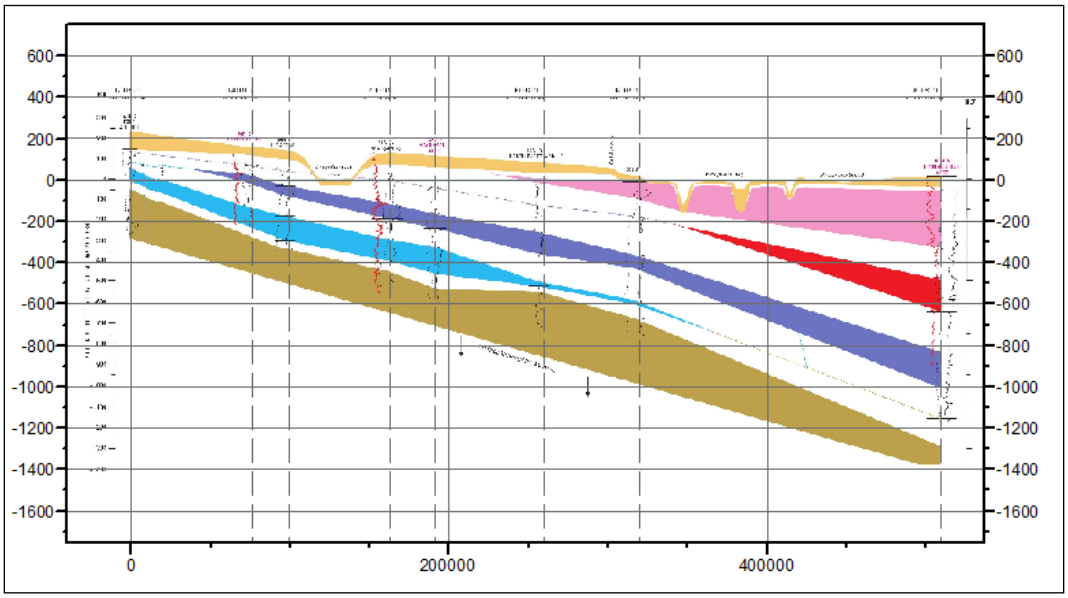

Figure 7 Initial XS2D data frame with the referenced cross section image

This is a good starting point for digitizing cross section panels by tracing over the image. Additional data such as faults, borehole stratigraphy, outcrops, land surface, and water levels could also be added using the XS2D tools (the process of adding data to a XS2D data frame is explained in separate tutorials). The following legend in Figure 8 shows the major units described in the cross section.

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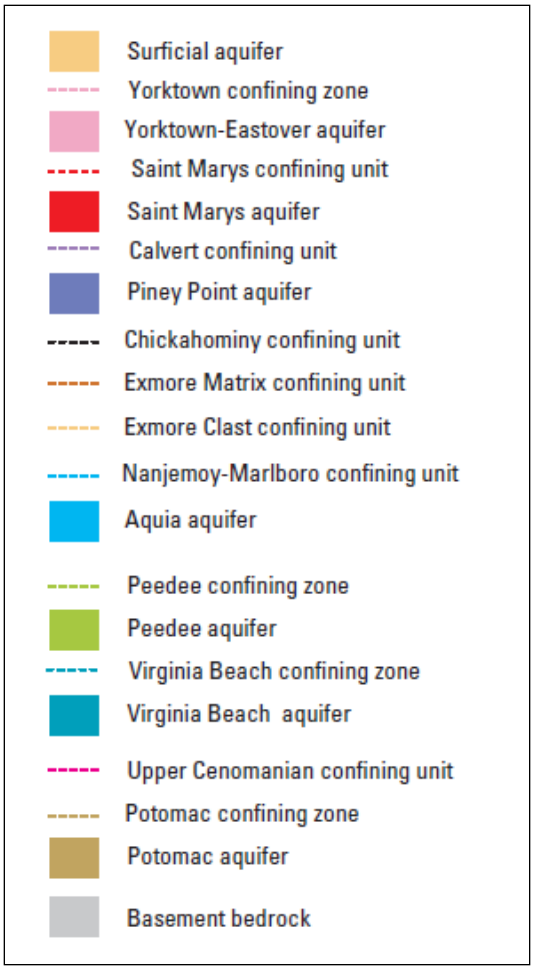

Figure 8 Aquifer units and confining layers in the Coastal Plain Aquifer system. Confining units are symbolized in cross sections as white panels and their boundary is defined by a dashed line.

5 Sketching Cross Section Panels

In this section, new cross section panels will be sketch. It will use the referenced image and utilize the advanced editing capabilities available in ArcGIS Pro.

5.1 Creating a New Template for Editing XS2D Panel Features

The first steps will be to set the editing environment:

1. In the *Contents* pane, right-click on "XS2D_Panel_2" and select **Symbology** to open the *Symbology* pane.
2. Click the menu button ☰ and select **Import Symbology…** to open the *Apply Symbology From Layer* pane.
3. For the *Symbology Layer*, select the browser button to open *Symbology Layer* dialog.

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4. Browse to the *Symbology* folder for this project and select the "XS2D_Panel.lyr" file.
5. Click **OK** to close *Symbology Layer* dialog.
6. Click **Run** to execute the tool.

The symbology for the XS2D_Panel_2 feature class should now appear in the *Contents* pane, as shown in Figure 9.

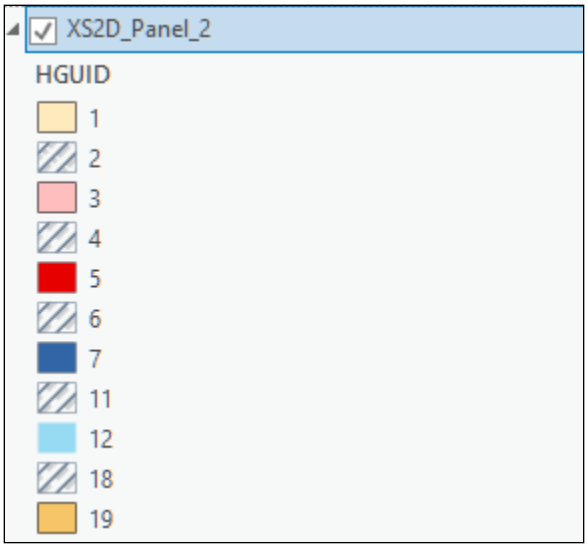

Figure 9 The Create Feature window with a template for XS2D Panel features

In the next section, set the snapping environment.

5.2 Setting the Snapping Environment Options

1. On the ribbon, select the *Edit* tab again.
2. In the *Snapping* section of the *Edit* tab on the ribbon, select the down arrow under **Snapping** to open up a menu.
3. Select the **Snapping** icon to turn snapping on.

5.3 Sketching Panels

First, sketch the upper surficial aquifer unit:

1. Zoom to the right end of the cross section and zoom in on the outcrop representing HGUID = 1 (Alluvium).
2. Select *Edit* tab in the ribbon.
3. In the *Features* group, click the **Create** button to open the *Create Features* pane.
4. In the *Create Features* pane, under "XS2D_Panel_2" template, select the feature symbology for HGUID = 1.

Notice that in the *Construction Tools* window, a list of the available tools appears for use in creating new panels (Figure 10).

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Figure 10 Construction tools available for sketching XS2D Panels

5. Make sure the **Polygon** tool is selected.

   Tip: while digitizing, use the zoom and pan tools to focus on certain elements of the cross section. Use the mouse wheel scrolling to zoom (or the *Z* and *X* keys) or hold down the mouse wheel (or *C* key) for panning.

6. Using the **Line** tool, start tracing the panel of HGUID = 1. Make sure to snap to the panel dividers on the right and left sides of the cross section.
7. Double-click on the starting point to close the panel.

The sketch should be similar to the one shown in Figure 11.

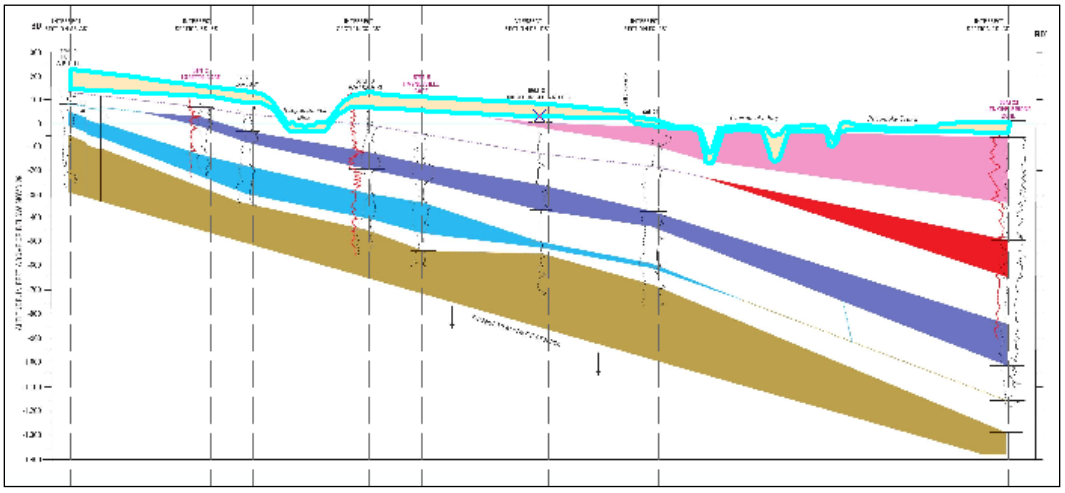

Figure 11 Sketch of the surficial aquifer (HGUID = 1.

After digitizing panels, edit attributes. The HGUID values should be automatically assigned from the feature template created earlier. The HGUID values are based on a HydrogeologicUnit table.

8. Using the **Select** tool, select the feature which was just created.
9. Right-click and select **Attributes** to open the *Attributes* pane.
10. In the *Attributes* window make sure a value of "1" is in the *HGUID* field. This value should be created automatically as you are using a template for editing.
11. In the *Edit* tab of the ribbon, select **Save Edits**.

Next, digitize the panel for the Yorktown confining unit (HGUID = 2):

12. Zoom to the right side of the cross section.
13. In the *Create Features* window, under "XS2D_Panel_2" template, select the feature symbology for HGUID = 2

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14. Select the **Autocomplete Polygon** tool, as shown in Figure 12.

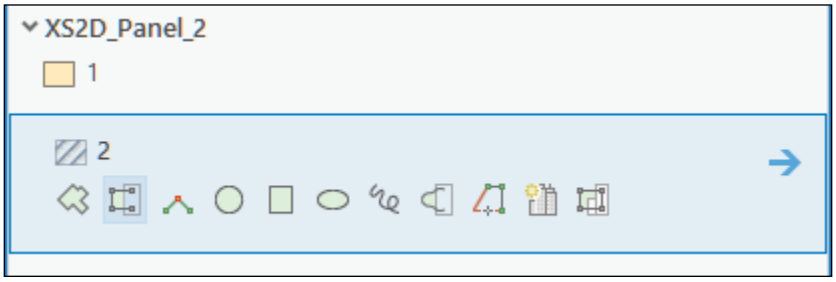

Figure 12 Selecting the Autocomplete Polygon Task in the Construction Tools window

Now to begin sketching the Yorktown confining unit (symbolized as the white area between the yellow and pink units in the cross section image) by sketching from the bottom right corner of the surficial aquifer panel.

15. Using the **Line** tool, sketch the panel of HGUID = 2. Start at the bottom right corner of the surficial aquifer panel and make sure the sketch snapped to the panel corner. Sketch along the upper boundary of the Yorktown aquifer unit (symbolized in pink in the cross section image) until the point where the confining unit interests the surficial aquifer panel, as shown in Figure 13. Make sure to snap to the surficial aquifer panel edge.

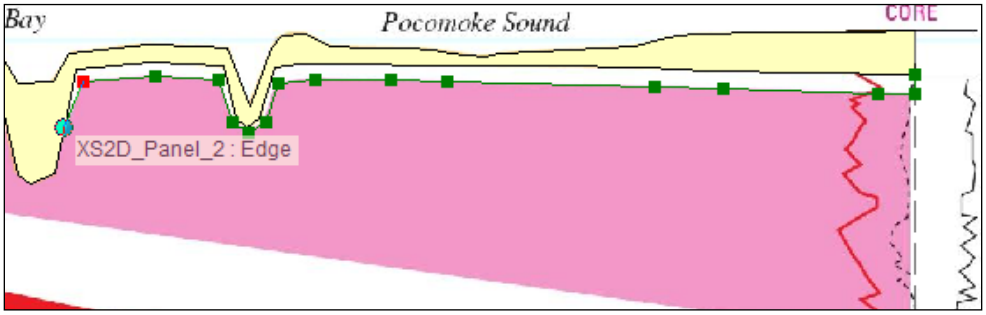

Figure 13 Sketching the Yorktown confining unit

16. Double-click on the starting point to close the panel.

A new polygon representing HGUID = 2 should be created. The polygon's upper boundary should match the boundary of the polygon representing HGUID = 1.

The sketch should be similar to the one shown in Figure 14.

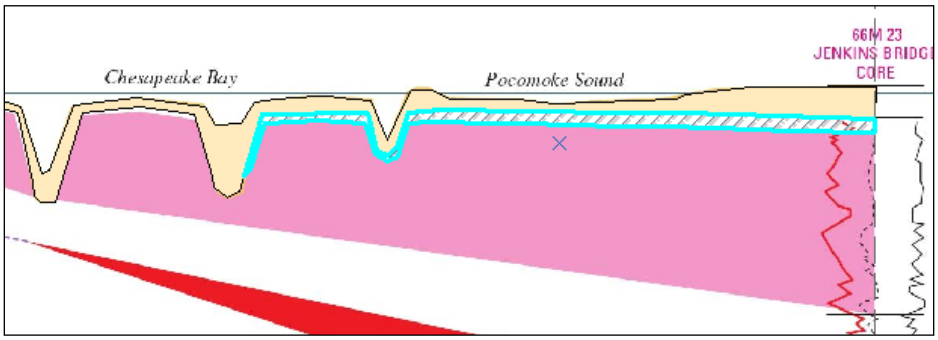

Figure 14 Cross section panel of the Yorktown confining unit (HGUID = 2) created using the Autocomplete Polygon task

17. Using the **Select** tool, select the feature which was just created.

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18. Right-click and select **Attributes** to open the *Attributes* pane.
19. In the *Attributes* pane, make sure a value of "2" is in the HGUID field. This value should be created automatically as you are using a template for editing.
20. In the *Edit* tab of the ribbon, select **Save Edits** .

Notice that the Yorktown confining unit (HGUID = 2) is composed of a number of polygons.

21. Repeat steps 12–20 to create more panels representing the Yorktown confining unit.

At the end of this process, the cross section should have panel representations for units 1 and 2 as shown in Figure 15.

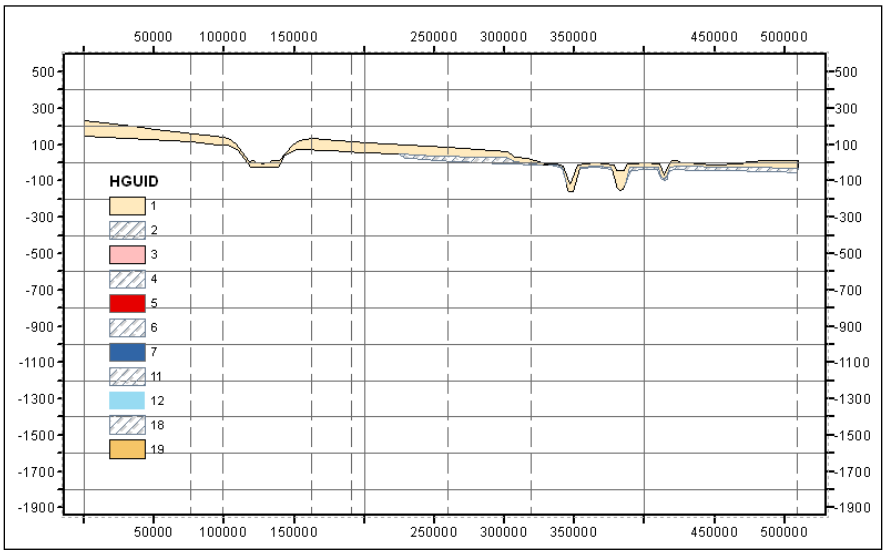

Figure 15 Panel features representing units 1 and 2

If desired, repeat this process to digitize the rest of the hydrogeologic units, or, to save time, use a set of predefined panels.

1. Select **Add Data** to open the *Add Data* dialog.
2. Locate and select the "XS2D_Panel_2_solution" file in the *xs2d_image.gdb\data* directory.
3. Click **OK** to close the *Add Dialog* and import the solution.
4. Follow the steps in Section 5.1 to adjust the symbology of the layer.

At the end of this process you will have a set of panels representing the units from the referenced image, as shown in Figure 16.

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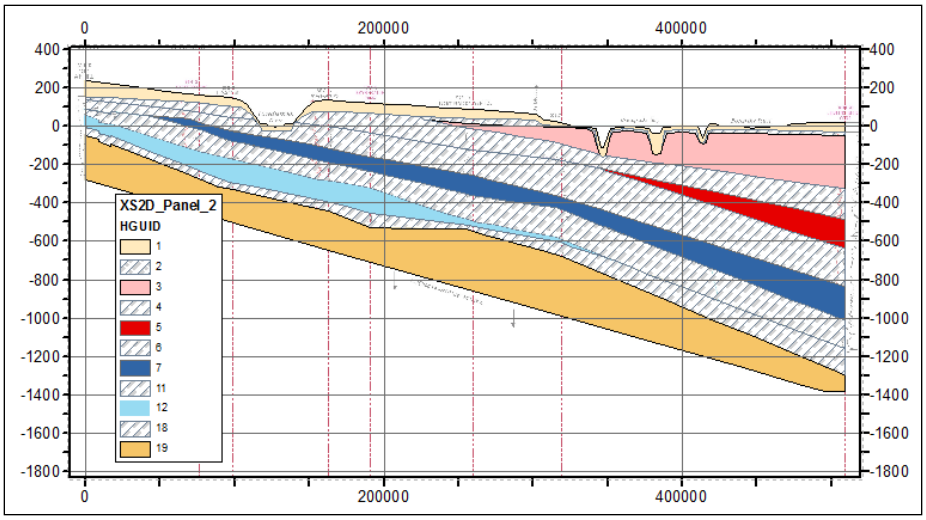

Figure 16 XS2D panel features representing units in a cross section

6 Transforming 2D Cross Section to 3D GeoSections

Once the 2D cross sections are created, it is possible to transform them to 3D features (GeoSections) and visualize them in ArcGIS Pro. This part of the tutorial requires 3D Analyst.

First, create the GeoSection feature class:

1. Switch to the "Map" view
2. In the *Catalog* pane, expand the "Subsurface Analyst/Features" toolset, double-click on "Create GeoSection Feature Class" tool to open the *Create GeoSection Feature Class* pane.
3. In the *Output GeoSection Features* field, click the browse button to open the *Output GeoSection Features* dialog.
4. Browse to the *xs2d_image.mdb\Data* directory and enter "GeoSection" as the feature class name.
5. Click **Save** to close the *Output GeoSection Features* dialog.
6. Select **Run** to execute the tool.

Next, create the GeoSection features by transforming 2D panels to 3D GeoSections:

7. In the *Catalog* pane, expand the "Subsurface Analyst/XS2D Editor" toolset then double-click on "Transform XS2D Panel to GeoSection" tool to open the *Transform XS2D Panel to GeoSection* pane
8. For *Input Section Line Features* select "SectionLine".
9. For *Input XS2D_Catalog Table* select "XS2D_Catalog".
10. For *Input GeoSection Features* select "GeoSection".
11. Select **Run** to execute the tool.

Do the following to visualize the 3D GeoSections just created.

12. Switch to the "Scene" map view.

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13. Select **Add Data** to open the *Add Data* dialog.
14. Browse to and open the "xs2d_image.gdb" geodatabase and open the "Data" directory.
15. Select the "GeoSection" file and click **OK** to import the table and close the *Add Data* dialog.
16. If desired, symbolize the GeoSection layer using the HGU Color Manager.

The scene should be similar to the one shown in Figure 17.

Figure 17 Scene including the GeoSection features transformed from the 2D cross section

If desired, the complete set of GeoSection features that were created for the BD-BD' cross section can be added. The features are in the "GeoSection_Solution" feature class located in the *xs2d_image.mdb\Data* feature dataset.

7 Conclusion

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

- The Arc Hydro Groundwater data model includes XS2D feature classes that provide the framework for working with 2D cross sections in ArcGIS Pro.
- The Import XS2D Image Wizard is used to reference an existing cross section image, set up a new data frame, and create the basic XS2D feature classes.
- ArcGIS Pro editing tools are used to help digitize cross sections based on the referenced image.
- 2D cross section panels can be transformed to 3D features and visualized in ArcGIS Pro.

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