

# ARC HYDRO GROUNDWATER TUTORIALS

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## ***Subsurface Analyst – Advanced Cross Section Editing***

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. This includes 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. This includes generation of borehole representations, cross sections, surfaces, and volumes. This tutorial will demonstrate how to create cross sections by combining data from different sources including geologic maps, surfaces, and borehole stratigraphy.

*Subsurface Analyst* includes tools for creating 3D cross sections and volumes from a set of surfaces. The 3D features can be viewed in ArcScene or can be transformed to 2D so they can be displayed in ArcMap. The workflow and tools for creating 3D features are described in a separate tutorial.

### **1.1 Background**

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Data used in this tutorial are part of a project for developing a groundwater simulation model: The Western Placer Groundwater Management Plan Model, which encompasses an area of approximately 1,360 square miles (871,000 acres) near the city of Roseville in the Sacramento valley, California. The model is bounded by the Bear River and Feather River to the north, the Mokelumne River to the south, the Sacramento River to the west and by bedrock of the Sierra Nevada to the east (Figure 1).



Figure 1 Location of the Roseville Model.

Six primary stratigraphic units were defined for modeling purposes. The base of the model domain represents the marine sediments consisting of sandstone and shale that were deposited about a hundred million years ago when an ancient sea formerly covered what is now the Sacramento and San Joaquin Valley. The depositional environment consisted of a progression of sands, silts, and clay that have accumulated over a history of erosional sequences and volcanic eruptions. 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.

### Hydrogeologic units

	<b>Alluvium (HGUID = 8)</b>
	<b>Riverbank (HGUID = 1)</b>
	<b>Turlock Lake Laguna (HGUID = 2)</b>
	<b>Mehrten (HGUID = 4)</b>
	<b>Valley Springs (HGUID = 6)</b>
	<b>Ione (HGUID = 7)</b>

Figure 2 Hydrostratigraphic units in the model area.

## 1.2 Outline

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The objective of this tutorial is to introduce the basic workflow and tools for creating 2D cross sections. This tutorial will cover the following tasks:

1. Review the structure of the data model classes needed for working with 2D cross sections.
2. Run the XS2D Wizard to set up a new XS2D data frame and corresponding feature classes.
3. Create XS2D Lines representing the intersection of the ground surface DEM with a set of outcrop polygons from a geologic map.
4. Sketch cross section panels in the XS2D data frame in ArcMap.
5. Add an XS2D Line representing the salt water interface to the cross section.
6. Build 3D GeoSections from the sketched cross section, and visualize the new GeoSection features in ArcScene.

## 1.3 Required Modules/Interfaces

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Following components should be enabled in order to complete this tutorial:

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

The AHGW Tools require that a compatible ArcGIS service pack is installed. Check the AHGW 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

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Before opening our map, ensure that the AHGW Tools are correctly configured.

1. If necessary, launch *ArcMap*.
2. Open the ArcToolbox window by clicking **ArcToolbox** .
3. If “ Arc Hydro Groundwater Tools” is not in the list of available toolboxes, follow steps 4–6. If it is already listed, skip to step 7.
4. Right-click anywhere in the *ArcToolbox* window and select **Add Toolbox...** to bring up the *Add Toolbox* dialog.
5. Browse to the *Toolboxes\System Toolboxes* folder and select “Arc Hydro Groundwater Tools.tbx”.
6. Click **Open** to exit the *Add Toolbox* dialog.
7. Expand “ Arc Hydro Groundwater Tools”.
8. Expand “ Subsurface Analyst”.

The *Arc Hydro Groundwater Toolbar* is needed as well. The toolbar contains additional user interface components not available in the toolbox. If the toolbar is not visible, do the following:

9. 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:

10. Select *Geoprocessing / Geoprocessing Options...* to bring up the *Geoprocessing Options* dialog.
11. In the *General* section, turn on *Overwrite the outputs of geoprocessing operations*.
12. In the *Display / Temporary Data* section, turn on *Add results of geoprocessing operations to the display*”.
13. Click **OK** to exit the *Geoprocessing Options* dialog.

### 3 Opening the Map

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

1. Select *File* | **Open...** to bring up the *Open* dialog.
2. Browse to the *Tutorials\subsurface analyst\XS2D advanced editing* folder.
3. Select “Roseville.mxd” and click **Open** to exit the *Open* dialog and import the model file.

Once the file has loaded, a map will appear of the model area in the California Central Valley (Figure 3). The map includes a boundary of the model domain, a polygon of the city of Roseville, layers representing streams, lakes, surface geology, wells, and section lines, a Digital Elevation Model (DEM) raster representing the land surface elevation over the model domain, and a raster representing the salt water interface over the model domain.

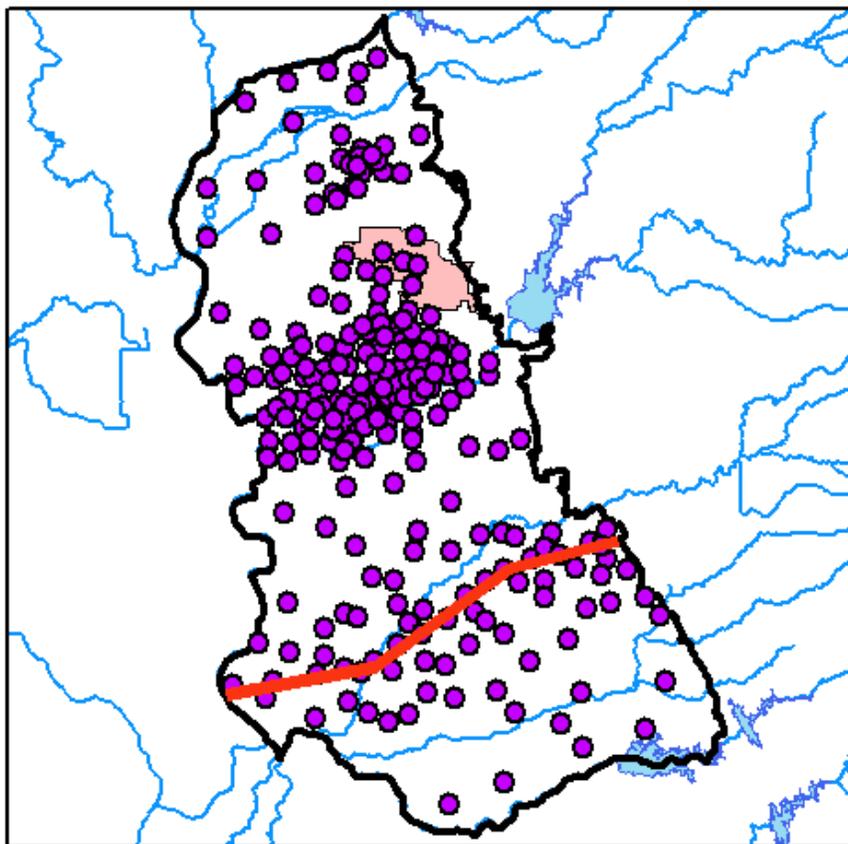


Figure 3 Model area in the California Central Valley

## 4 Representing 2D Cross Sections in the AHGW Data Model

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Before starting to create cross sections, it is helpful to review the components of the AHGW Data Model. The AHGW 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.
- 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.

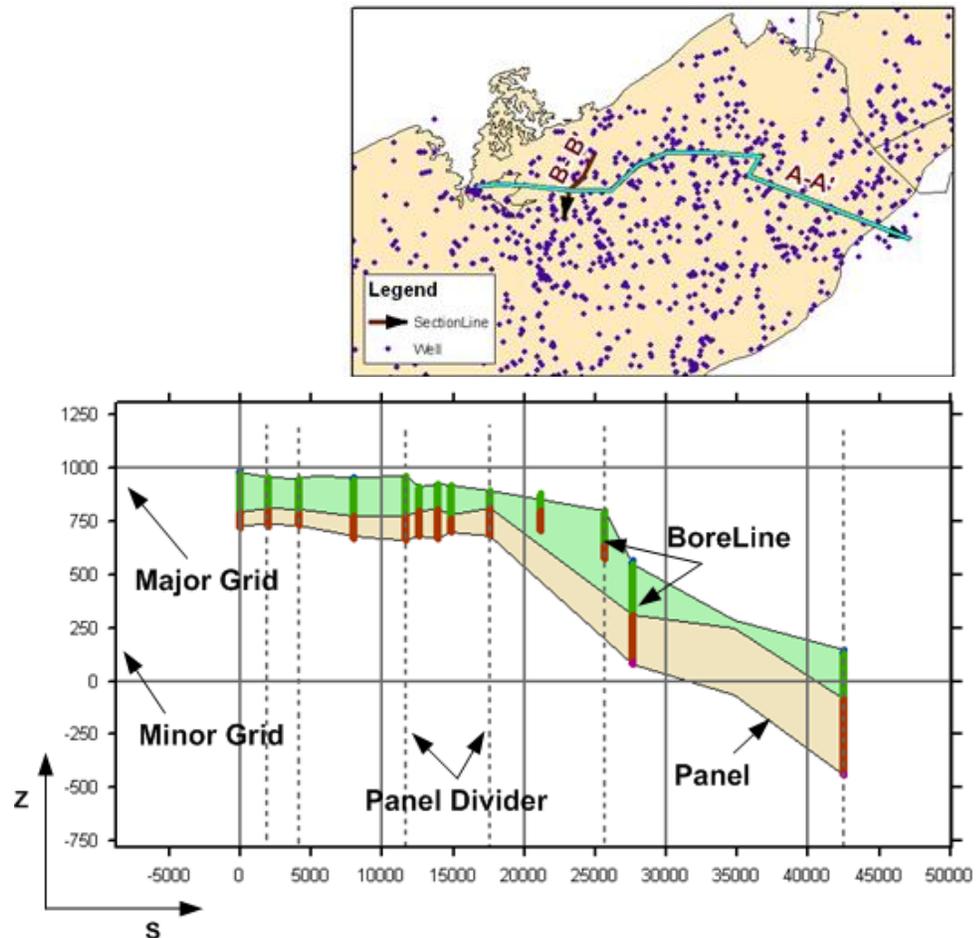
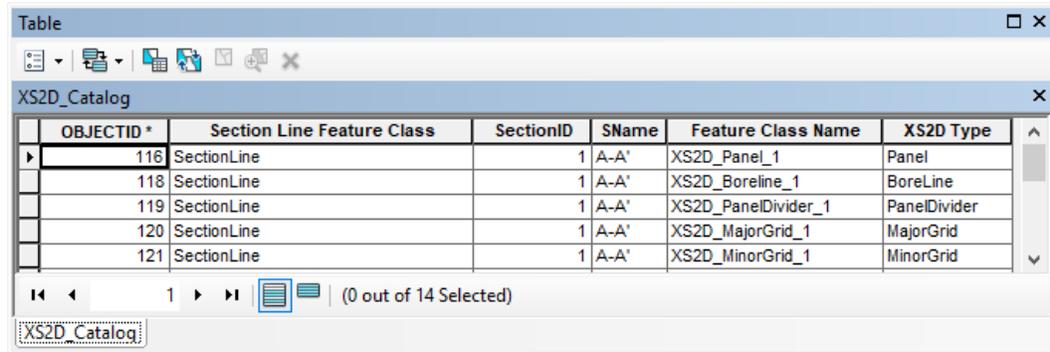


Figure 4 Datasets used for creating 2D cross sections.

Each of the 2D cross sections is generated in a separate data frame in ArcMap. 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. Notice that all feature classes in the catalog end with a number (in this example 6475) that references the HydroID of the related section line.



OBJECTID *	Section Line Feature Class	SectionID	SName	Feature Class Name	XS2D Type
116	SectionLine	1	A-A'	XS2D_Panel_1	Panel
118	SectionLine	1	A-A'	XS2D_Boreline_1	BoreLine
119	SectionLine	1	A-A'	XS2D_PanelDivider_1	PanelDivider
120	SectionLine	1	A-A'	XS2D_MajorGrid_1	MajorGrid
121	SectionLine	1	A-A'	XS2D_MinorGrid_1	MinorGrid

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

## 5 Running the XS2D Wizard

The *XS2D Wizard* creates a new set of feature classes for representing a 2D cross section based on a specific SectionLine feature. The wizard creates a new data frame to which the XS2D feature classes (XS2D\_Panel, XS2D\_BoreLine, XS2D\_PanelDivider, XS2D\_MajorGrid, and XS2D\_MinorGrid) are added. Using a separate data frame for each 2D cross section allows us to visualize the features from each cross section independently.

Before actually running the *XS2D Wizard*, select a set of wells to be included in the process of creating a 2D cross section. Borehole data related to these wells will help guide the cross section dimensions and borehole stratigraphy can then be added to the cross section.

1. Select the SectionLine using the **Select Features**  tool.
2. Select *Selection* | **Select By Location** to open the *Select By Location* dialog.
3. In the *Selection Method:* section, select the “Select features from” option.
4. In the *Target layer(s):* section, turn on the “Well” item.
5. In the *Source layer:* section, select the “SectionLine” item.
6. Enable the *Use Selected Features* option.
7. In the *Spatial selection method for target layer feature(s):* section, select the “are within a distance of the Source layer feature” option.
8. Turn on *Apply a search distance* and enter a buffer distance of “1500’ feet
9. Click **OK** to close the *Select by Location* dialog and create the selection.

After applying the selection there should be 11 wells selected in the map as shown in Figure 6.

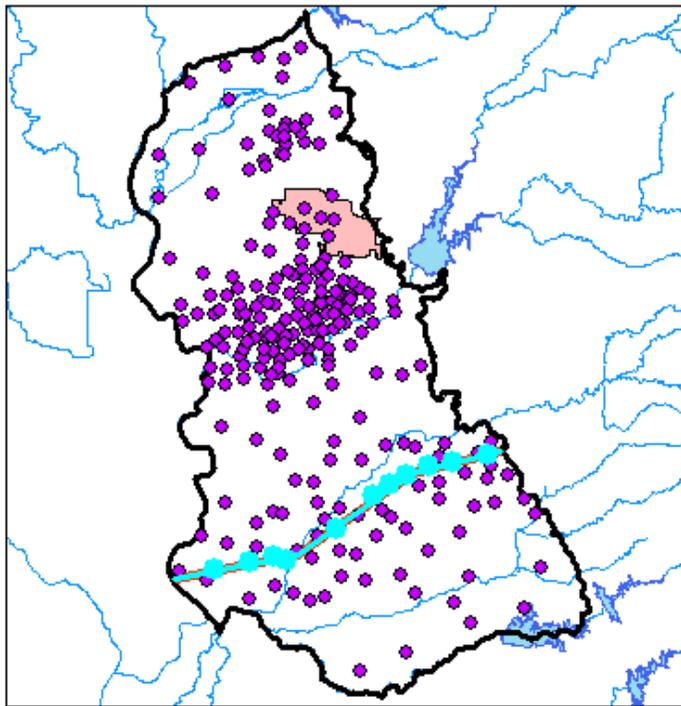


Figure 6 Selected features after applying the Select By Location with a buffer of 1,500 feet.

Next, run the *XS2D Wizard* to create a new cross section. The *XS2D Wizard* is based on a selected section line (run the wizard one cross section at a time). In this tutorial a *SectionLine* feature class is already provided and a cross section digitized across the model domain. To start the *XS2D Wizard*:

10. Select the **XS2D Wizard**  icon in the *Arc Hydro Groundwater Toolbar*.
11. With the tool activated, click on a *SectionLine* feature (it is fine if the section line is already selected) to launch the *2D Cross Section Wizard*.

The *2D Cross Section Wizard* will create a set of feature classes and a new data frame for the selected *SectionLine*. *Step 1* of the wizard shows the *SectionLine* properties (HydroID, Name, and Length). In addition you can specify the well feature class and borehole log table and specify if you wish to use well and borehole log data. You can also specify a vertical exaggeration (default is the vertical exaggeration value read from the *SectionLine* feature), select the *XS2D\_Catalog* table used to manage the *XS2D* feature classes, and set the default output workspace.

At this point your inputs should be similar to the ones shown in Figure 7.

12. Make sure the *Default output workspace* points to the *Roseville.mdb\Data* feature dataset.
13. Select **Next** to move to the next step in the wizard.

The screenshot shows the '2D Cross Section Wizard' dialog box. The title bar reads '2D Cross Section Wizard'. The main heading is '2D Cross Section Wizard'. Below the heading is a descriptive sentence: 'This wizard will help you create a new data frame to display a 2D cross section for the selected section line.' The dialog is divided into three main sections: 'Section Line Properties', 'Wells and Borehole Log', and 'Cross Section Setup'.  
1. 'Section Line Properties': A table-like structure with two columns. The first column contains 'Layer: SectionLine' and 'ID: 6475'. The second column contains 'Length: 171492 (Foot\_US)' and 'Name: A-A''.  
2. 'Wells and Borehole Log': This section has a radio button for 'Use well and borehole log data:' set to 'Yes'. Below are four dropdown menus: 'Well layer:' (set to 'Well'), 'Borehole log table:' (set to 'BoreholeLog'), 'Well unique ID field:' (set to 'HydroID'), and 'WellID field:' (set to 'WellID'). At the bottom of this section, it says 'Number of wells selected: 11'.  
3. 'Cross Section Setup': This section has a text input for 'Vertical exaggeration:' with the value '20'. Below it is a dropdown for 'XS2D Catalog Table:' set to 'XS2D\_Catalog'. At the bottom of this section is a text input for 'Default output workspace:' containing the path 's:\AHGW\XS2D\_Advanced\_Editing\Tutorials\subsurface analyst\XS2D advanced editing\Roseville.mdb\Data' and a browse button (...).  
At the bottom right of the dialog are two buttons: 'Next >' and 'Cancel'.

Figure 7 Settings for step 1 in the XS2D Wizard.

Step 2 in the wizard is used to set up the appropriate panel, boreline, and panel divider feature classes. It can also specify the elevations for drawing panel dividers. Notice that by default the created XS2D feature classes are located in the default output workspace, and the HydroID of the section line for this cross section is appended as a suffix to the feature class names. This naming convention is not mandatory, but it helps in identifying the feature classes when multiple cross sections are created.

Default values, based on the borehole data, are set for the minimum and maximum elevations of the panel dividers. You can keep the default values or modify them.

14. Leave the default minimum and maximum elevations for drawing panel dividers

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

15. Select **Next** to move to the next step in the wizard.

Figure 8 Settings for step 2 in the XS2D Wizard.

Step 3 in the wizard is used to create major and minor grid lines. The grid extent and spacing can be automatically specified based on the length of the selected SectionLine and borehole data, or they can be set manually.

Default values are set for the left, right, minimum and maximum elevations, and spacing of the grid features. The default values can be kept or modified.

16. Leave the default values for the grid extent:

17. Specify the following for the grid spacing:

- *Horizontal distance between vertical major grid lines* set to “40,000”
- *Vertical distance between horizontal major grid lines* set to “1,000”
- *Number of minor grid lines between major vertical grid lines* to “3”
- *Number of minor grid lines between major horizontal grid lines* to “3”

At this point the inputs should be similar to the ones shown in Figure 9.

18. Select **Finish** to run the wizard.

**2D Cross Section Wizard**

**Step 3: Grid Lines**

Output major grid feature class (optional)  
 ...

Output minor grid feature class (optional)  
 ...

**Grid Extent**

Maximum elevation:

Left:  Right:

Minimum elevation:

**Grid Spacing**

Horizontal distance between vertical major grid lines:

Vertical distance between horizontal major grid lines:

Number of minor grid lines between major vertical grid lines:

Number of minor grid lines between major horizontal grid lines:

Figure 9 Settings for step 3 in the XS2D Wizard.

A new Data Frame (Section A-A') should be added to the map (make sure you are in layout view to be able to view data frames). Notice the grid lines, the panel dividers, and the boreline features. Boreline features are automatically symbolized by the *HGUID* to differentiate between the hydrogeologic units. In addition, the borelines are symbolized by the *Offset* field such that borelines from wells closer to the cross section are wider. Also, notice that grid lines showing the vertical and horizontal dimensions were added to the data frame.

Resize the AA' data frame and move it within the map layout in order to see both data frames. To better view the XS2D feature created:

- Using the **Select Elements**  tool, move the Section A-A' data frame within the map layout and resize it.
- Use the zoom tools (  ) to focus on the data within the cross section.

- Control the grid properties (text size, color, etc.) by right-clicking on the data frame and selecting **Properties** to open the *Data Frame Properties* dialog. In the dialog, select the *Grids* tab, and specify which grid lines you want to display and modify the labels, ticks, color, etc.

A layer file containing the symbology for the XS2D\_Boreline feature class has been prepared. To apply the predefined symbology:

19. In the *Table of Contents*, right-click on “ Section A-A” and select **Activate**.
20. Right-click on the “XS2D\_Boreline\_6475” layer and select **Properties** to open the *Layer Properties* dialog.
21. On the *Symbology* tab, select the **Import** button on the top right to bring up the *Import Symbology* dialog.
22. Click the browser  button to open the *Import Symbology from Layer* dialog.
23. Browse to the *Symbology* folder for this tutorial and select the “XS2D\_Boreline.lyr” file.
24. Select **Add** to close the *Import Symbology from Layer* dialog.
25. In the *What do you want to import?* section select the *Complete symbology definition* option.
26. Select **OK** to close the *Import Symbology* dialog and open the *Import Symbology Matching Dialog*.
27. Specify the “HGUID” field in the first *Value Field* section.
28. Select **OK** to close the *Import Symbology Matching Dialog*.
29. Select **OK** to close the *Layer Properties* dialog.

At the end of this process the XS2D data frame should appear similar to the one shown in Figure 10

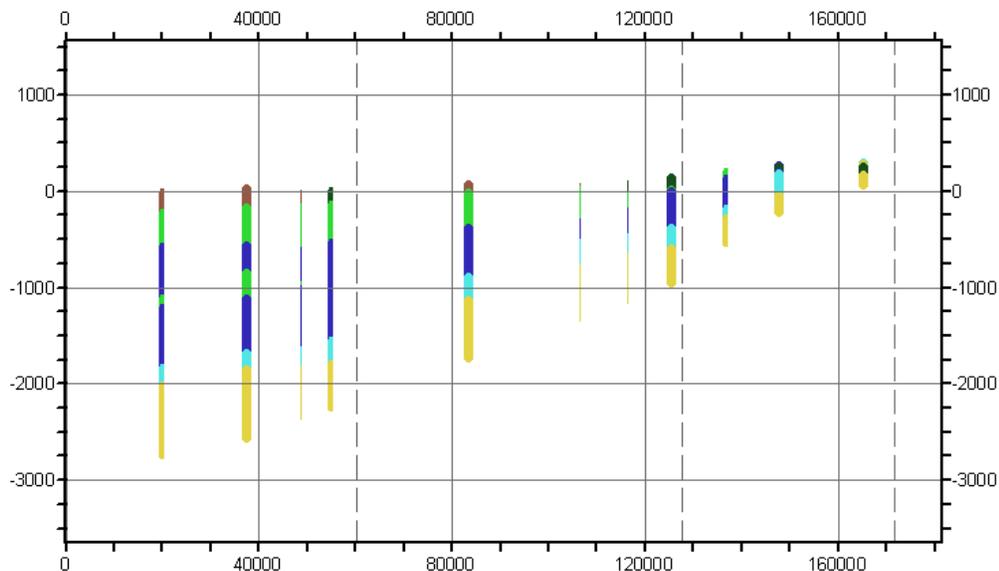


Figure 10 Initial XS2D data frame with XS2D features created by the XS2D Wizard.

This is a good starting point for digitizing cross sections by connecting borehole data. But before sketching cross sections, add additional data that will guide the process for creating cross sections.

## 6 Adding Data from Geologic Maps

An important source of data to use as a guide sketching cross sections is outcrop information from geologic maps. Geologic maps describe the outcropping of rock units (the coverage of a rock unit over the land surface). When combined with a digital elevation model, the geologic map data provides additional information to include in a cross section.

The map includes a set of polygon features that represent outcrops of the formations defined within the model. The oldest formations outcrop at the eastern edge of the model (Figure 11).

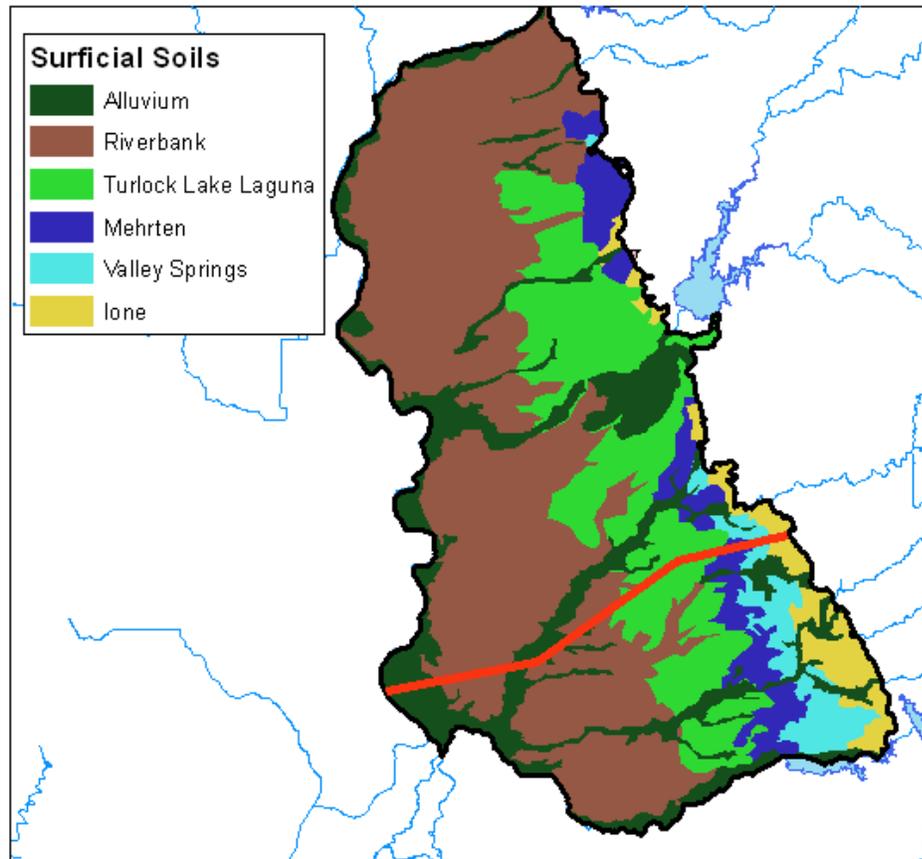


Figure 11 Geologic map showing outcrops of formations within the model area. Features are symbolized based on the hydrogeologic units.

Before continuing, create a new line feature class to which the output XS2D Lines will be written.

1. In the *Table of Contents*, right-click on “ Layers” and select **Activate**.

This is important as the section lines and additional datasets such as the DEM and outcrops are only loaded in the Layers data frame.

2. Expand the “ XS2D Editor” toolset under the “ Subsurface Analyst” toolset.
3. Double-click on the “ Create XS2D Line Feature Class” tool to open the *Create XS2D Line Feature Class* dialog.

This tool will create a new XS2DLine feature class for each of the selected SectionLine features. If no section line is selected it will create feature classes for all section lines in the SectionLine feature class.

4. For *Input Section Line Features* select “SectionLine”.
5. For *XS2D\_Catalog Table* select “XS2S\_Catalog”.

6. For *XS2DType value* enter “Outcrop”.
7. For *Feature Class Name Prefix* enter “Outcrop”.

The feature classes created will include the prefix specified and the HydroID of the section line feature (e.g. Outcrop\_6475).

8. Click **OK** exit the *Create XS2D Line Feature Class* dialog and run the tool.

A new feature class named Outcrop\_6475 should be added to the map.

9. In the *Table of Contents*, right-click on “ Section A-A” and select **Activate**.
10. Select **Add Data**  to open the *Add Data* dialog.
11. Browse to and open the “Roseville.mdb” geodatabase and open the “Data” directory.
12. Select the “Outcrop\_6475” file and click **Add** to import the table and close the *Add Data* dialog.

Next, add XS2DLine features to the feature class just created. Each line in the feature class represents the intersection of the section line with a surface (raster). The values from the raster are usually scaled in the Z dimension, so they can be better visualized.

To add geologic map data along the cross section, apply the *Transform Polygons to XS2D Lines* tool by doing the following:

13. In the *Table of Contents*, right-click on “ Layers” and select **Activate**
14. In the “ XS2D Editor” toolset, double-click on “ Transform Polygons to XS2D Lines” tool to open the *Transform Polygons to XS2D Lines* dialog.
15. For *Input Polygon Features* select “Surficial Soils”.
16. For *Input Section Line Features* select “SectionLine”.
17. For *Input XS2D\_Catalog Table* select “XS2D\_Catelog”.
18. For *XS2DType* select “Outcrop”.
19. For *Ground Surface DEM* select “dem30m”..

The *Discretization Spacing* should be automatically populated when you select the raster. The default spacing is equal to the raster cell size.

20. Specify a *Discretization Spacing* of “1000”.
21. For *FType* enter “Outcrop”. This is an optional value that enables classifying the XS2DLine feature created.

The *Overwrite* parameter should be enabled automatically, such that before writing new features, the tool clears the target feature class. If it is disabled, then new features will be appended to the feature class.

22. Click **OK** to close the *Transform Polygons to XS2D Lines* dialog and launch the tool.

When the tool is done, a new set of lines should appear in the cross section. If the lines do not appear, refresh the map and make sure to drag the outcrop layer to the A-A' data frame. It is possible to symbolize the lines to show the different formations. A layer file containing the symbology for the outcrop feature class has been prepared so it is easy to match the symbology of the outcrops with that of the borelines.

23. In the “ Section A-A'” data frame, right-click on the “Outcrop\_6475” layer and select **Properties** to open the *Layer Properties* dialog.
24. On the *Symbology* tab, select the **Import** button on the top right to bring up the *Import Symbology* dialog.
25. Click the browser  button to open the *Import Symbology from Layer* dialog.
26. Browse to the *Symbology* folder for this tutorial and select the “XS2DLine.lyr” file.
27. Select **Add** to close the *Import Symbology from Layer* dialog.
28. In the *What do you want to import?* section select the *Complete symbology definition* option.
29. Select **OK** to close the *Import Symbology* dialog and open the *Import Symbology Matching Dialog*.
30. Specify the “HGUID” field in the first *Value Field* section.
31. Select **OK** to close the *Import Symbology Matching Dialog*.

At this point the XS2D data frame (Section A-A') should be similar to the one shown in Figure 12.

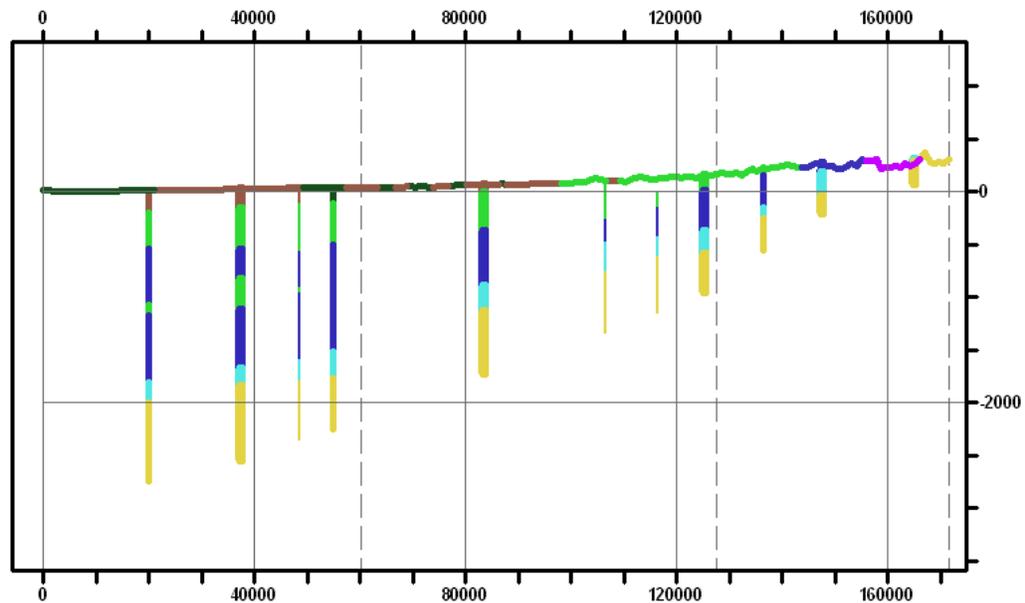


Figure 12 Cross section with borelines and outcrops.

The borelines and outcrops will be used as guides while digitizing new cross sections.

## 7 Sketching Cross Section Panels

This section will demonstrate sketching new cross section panels using the boreline data and outcrops as guides. It will make use of the advanced editing capabilities available in ArcMap.

### 7.1 Creating a New Template for Editing XS2D Panel Features

In ArcGIS 10 the concept of feature templates is introduced. Templates allow predefining different types of features with symbology and default attributes that are automatically updated while editing. To create a template for the XS2D Panel feature class:

1. In the *Table of Contents*, right-click on “ Section A-A” and select **Activate**.
2. In the “ Section A-A” data frame, right-click on the “XS2D\_Panel\_6475” layer and select **Properties** to open the *Layer Properties* dialog.
3. On the *Symbology* tab, select the **Import** button on the top right to bring up the *Import Symbology* dialog.
4. Click the browser  button to open the *Import Symbology from Layer* dialog.
5. Browse to the *Symbology* folder for this tutorial and select the “XS2D\_Panel.lyr” file.

6. Select **Add** to close the *Import Symbolology from Layer* dialog.
7. In the *What do you want to import?* section select the *Complete symbolology definition* option.
8. Select **OK** to close the *Import Symbolology* dialog and open the *Import Symbolology Matching Dialog*.
9. Specify the “HGUID” field in the first *Value Field* section.
10. Select **OK** to close the *Import Symbolology Matching Dialog*.

The XS2D Panel should have 4 classes (2, 4, 6 and 7) based on the HGUID field.

Next, define a new feature template:

11. If the *Editor Toolbar* is not already visible, click the **Editor Toolbar**  icon.
12. Select **Start Editing** in the *Editor* menu of the *Editor Toolbar*.

Notice that the *Create Features* editing window opens.

The *Create Features* window should include a template for the XS2D\_Panel\_6475 feature class, as shown in Figure 13.

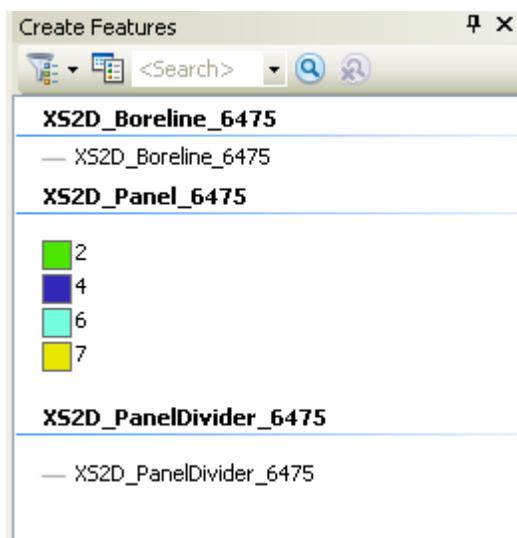


Figure 13 The *Create Feature* window after adding a template for XS2D Panel features.

13. If the template does not appear as shown in Figure 13 then proceed with steps 144 through 19. If the template does appear skip to Section 7.2.
14. Select **Organize Templates**  located at the top of the *Create Features* window to open the *Organize Feature Templates* dialog.

15. In the *Layers* section, select “XS2D\_Panel\_6475”. Notice that no template is associated with this layer.
16. Select **New Template** to open the *Create New Template Wizard*.
17. Make sure “XS2D\_Panel\_6475” is the only layer selected.
18. Select **Next** to view the symbology of the features in the template.
19. Select **Finish** to create the template

The *Create Features* window should include a template for the XS2D\_Panel\_6475 feature class. Next set the snapping environment.

## 7.2 Setting the Snapping Environment Options

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1. In the *Table of Contents*, right-click on “ Section A-A” and select **Activate**.
2. Make sure the *Snapping* toolbar is loaded in the map by right-clicking on any toolbar and selecting the **Snapping** toolbar.

For this tutorial, activate the classic snapping option. To enable this option:

3. Select *Editor* | **Options** to bring up the *Editing Option* dialog.
4. In the *General* tab, turn on *Use Classic Snapping*. This allows controlling settings of the snapping environment, such as how our edits will be snapped (vertex, edge, end) and the priority of snapping between the layers.
5. Click **OK** to close the *Editing Options* dialog.
6. Select *Editor* | *Snapping* | **Snapping Window** to open the *Snapping Environment* window.
7. Move the layers by selecting them and moving them up or down so that they are in the following order:
  - Outcrop\_6475
  - XS2D\_Boreline\_6475
  - XS2D\_Panel\_6475
  - XS2D\_PanelDivider\_6475
  - XS2D\_MajorGrid\_6475
  - XS2D\_MinorGrid\_6475

The order of the layers within the snapping environment interface determines the snapping priority.

8. For “Outcrop\_6475” turn on *End*.
9. For “XS2D\_Boreline\_6475” turn on *End*.
10. For “XS2D\_Panel\_6475” turn on *Vertex*.
11. For “XS2D\_PanelDivider\_6475” turn on *Edge*.

While editing, enable Snap Tips to show the features to which the new features are being snapped.

1. Select *Editor /Snapping / Options* to open the *Classic Snapping Options* dialog.
2. Turn on *Snap Tips*.
3. Change the *Snapping tolerance* to “7”.
4. Click **OK** to close the *Classic Snapping Options* dialog.

### 7.3 Sketching Panels

1. Select *View | Data View*. It is generally easier to sketch in Data View.
2. **Zoom**  to the right end of the cross section and zoom in on the outcrop representing HGUID = 7.
3. In the *Create Features* window, under “XS2D\_Panel\_6475” template”, select the feature symbology for HGUID = 7

Notice the Construction Tools window shows a list of the available tools for creating new panels (Figure 14).



Figure 14 Construction tools available for sketching XS2D Panels.

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

The **Trace Editing** tool will be used to trace the outcrop as part of the cross section creation. To better visualize a single outcrop, use the filter tool in the AHGW Toolbar.

Tip: while digitizing, use the zoom and pan tools to focus on certain elements of the cross section.

5. In the *Editor* menu, select the **Trace**  tool.
6. Start tracing the outcrop defining HGUID = 7. Start tracing from the right side by clicking on the edge of the line then drag the mouse over the outcrop line. A new line should appear while moving the mouse to the left side of the outcrop. When the end of the outcrop line is reached click on the edge to create a vertex.

The sketch should be similar to the one shown in Step 1 of Figure 15.

7. Using the **Straight Segment**  tool, continue sketching a cross section panel. Use the boreline edges as guide points. The sketch tool should automatically snap to the end of the boreline features. Make sure to snap also to the panel dividers defining the start and end of the cross section.

The sketch should be similar to the one shown in Step 2 of Figure 15.

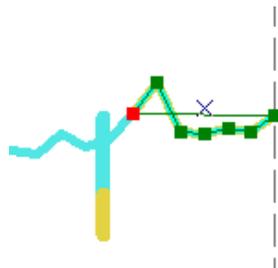
8. Make sure to reach the right side panel divider as shown in Step 3 of Figure 15.
9. Double-click on the starting point to close the panel.

The sketch should be similar to the one shown in Step 4 of Figure 15.

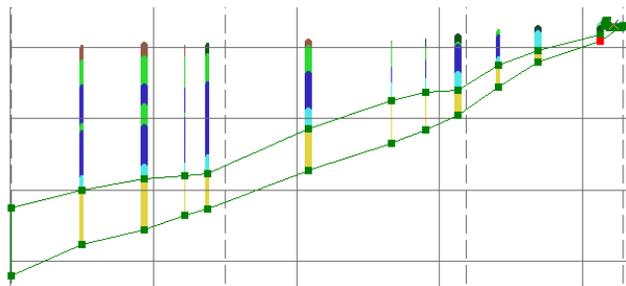
Tip: To better visualize the borelines on top of the panels, set a transparency of 50% on the panel features (select the layer, right-click, and select Display tab to set the transparency for the layer).

Next, assign some basic attributes to the panel.

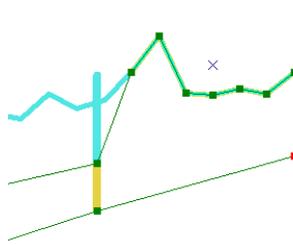
**Step 1: use the trace tool to trace the outcrop line**



**Step 2: Sketch a cross section panel guided by borelines**



**Step 3: Make sure to reach the panel divider**



**Step 4: Finish the sketch**

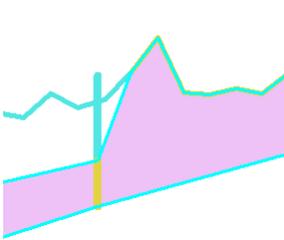


Figure 15 Steps in sketching a cross section panel.

10. Using the **Edit**  tool in the *Editor* toolbar, select the feature which was just created.
11. Right-click and select **Attributes** to open the *Attributes* window.
12. In the *Attributes* window edit the following attributes:
  - Make sure a value of “7” is in the *HGUID* field so it matches the HGUID of the borelines and outcrops used in the sketching process. This value should be created automatically.
  - Set the *SectionID* attribute to be equal to the HydroID of the section line (*SectionID* = “6475”).
13. When done editing the attributes, close the *Attributes* window.
14. In the *Editor* menu, select **Save Edits**.

Next, digitize the panel for HGUID = 6:

15. **Zoom**  in to the outcrop line representing HGUID = 6.
16. In the *Create Features* window, under “XS2D\_Panel”, select the feature symbology for HGUID = 6.

17. In the *Construction Tools* window, select *Auto Complete Polygon*.
18. Use the **Trace**  tool to sketch a line following the outcrop representing HGUID = 6.
19. After sketching the outcrop portion, use the **Straight Segment**  tool to continue sketching. Use the borelines as guides for sketching.
20. Make sure that the line snaps to the intersection point of the panel divider and the cross section feature, as shown in Figure 16.

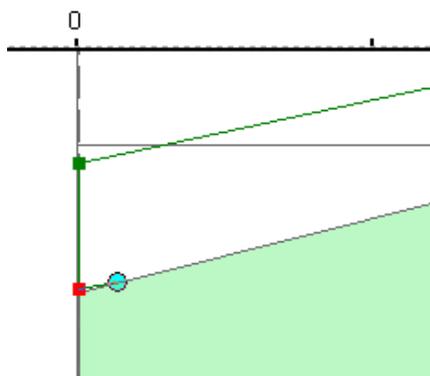


Figure 16 The new polygon should snap to the vertex located at the intersection of the cross section feature and the panel divider.

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

A new polygon representing HGUID = 6 should be created. The polygon's boundary should match the boundary of the polygon representing HGUID = 7.

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

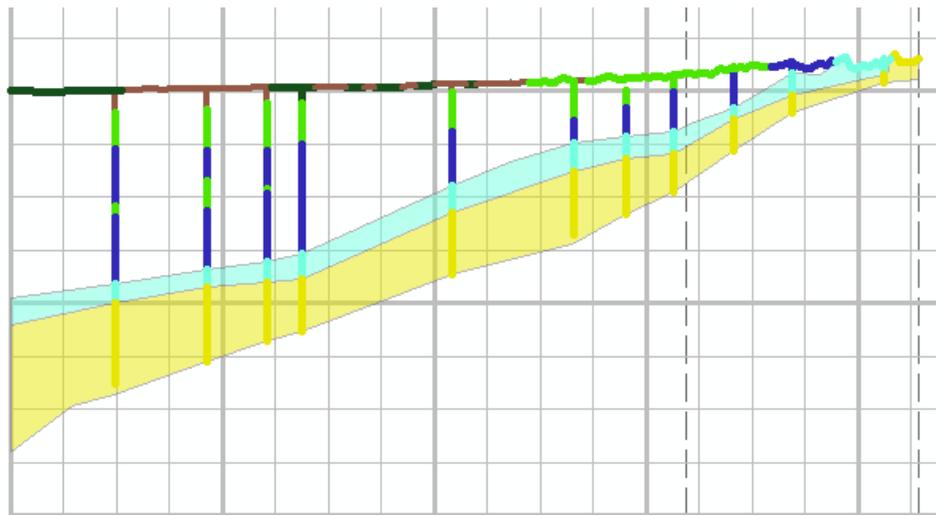


Figure 17 Cross section panel created using the Auto Complete Polygon task.

22. Using the **Edit**  tool in the *Editor* toolbar, select the feature which was just created.
23. Right-click and select **Attributes** to open the *Attributes* window.
24. In the *Attributes* window edit the following attributes:
  - Make sure the *HGUID* attribute contains a value of “6”, so it matches the HGUID of the borelines and outcrops used in the sketching process.
  - Set the *SectionID* attribute to be equal to the HydroID of the section line (*SectionID* = “6475”).
25. In the *Editor* menu, select **Save Edits**.
26. Repeat steps 15 to 25 for HGUID = 4. The sketch should be similar to the one shown in Figure 18.

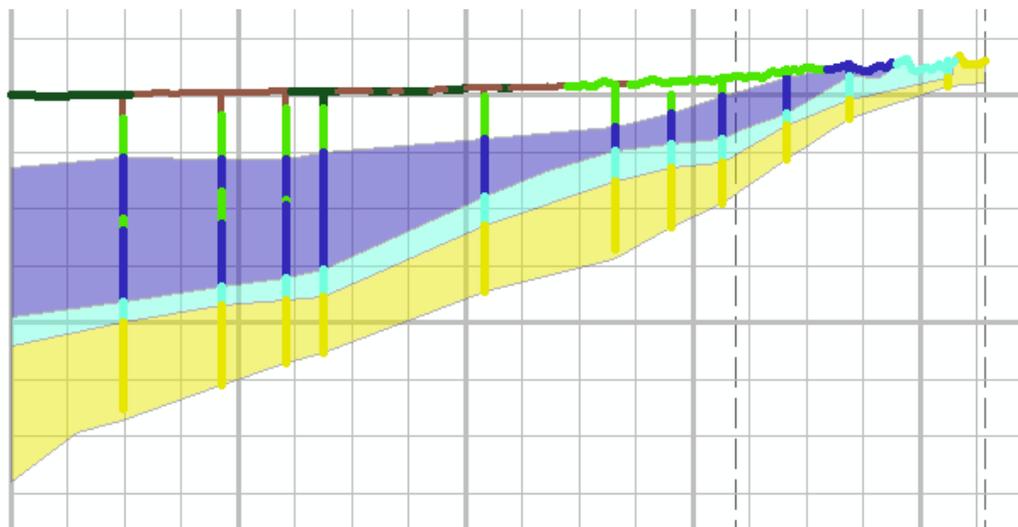


Figure 18 Cross section panel for unit HGUID = 4.

Next, sketch the panel for HGUID = 2. Notice that there are multiple outcrop lines for units 2 and 1. Either trace across multiple outcrops or sketch smaller un-connected units. It is also possible to alternate between the trace and sketch tools to make the cross section as detailed as needed. In some cases the outcrop lines and borehole data do not agree. This is a common issue which needs to resolve based on the best understanding of the system and the accuracy of the data.

Notice the seam of this formation (HGUID = 2) within the underlying formation. This seam will be added as well.

27. Repeat steps 15 to 25 for HGUID = 2. The sketch should be similar to the one shown in Figure 19.

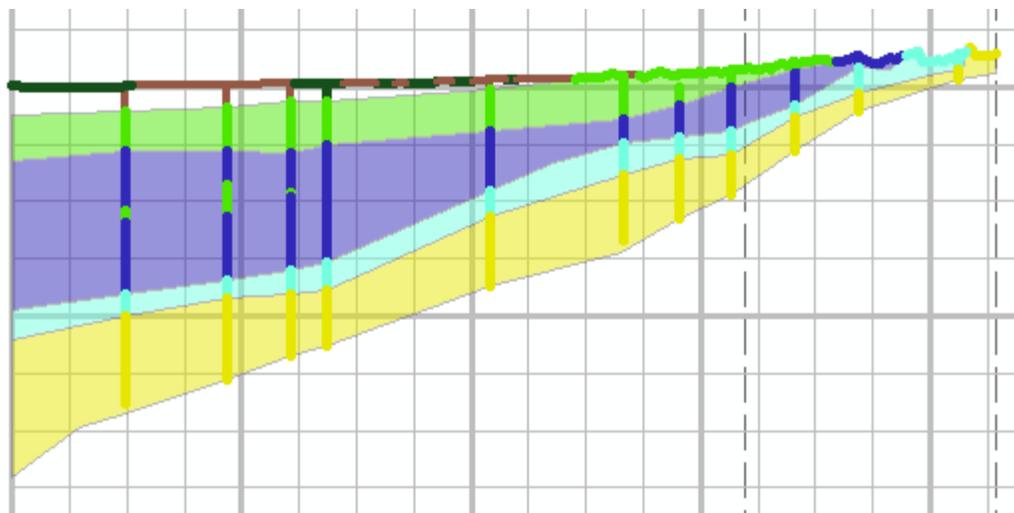


Figure 19 Cross section panel for unit HGUID = 2.

## 7.4 Adding a Seam

Next, add a seam of unit 2 in the middle of unit 4.

1. **Zoom**  in to the left side of the cross section to the area where the seam in unit 2 is located.
2. In the *Create Features* window, under “XS2D\_Panel”, select the feature symbology for HGUID = 2.
3. In the *Construction Tools* window, select *Freehand*.
4. Sketch a seam using following the boreline edges and pinching out beyond the borelines. The seam should be similar to the one shown in Figure 20.

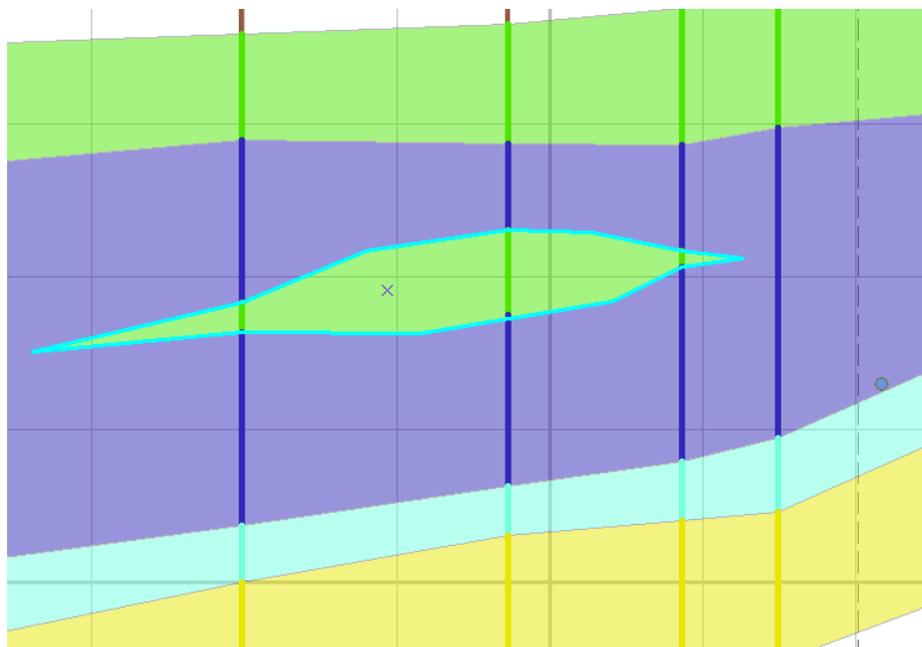


Figure 20 Sketched seam of hydrogeologic unit 2 within hydrogeologic unit 4.

5. Using the **Edit** tool in the *Editor* toolbar, select the feature which was just created.
6. Right-click and select **Attributes** to open the *Attributes* window.
7. In the *Attributes* window edit the following attributes:
  - Make sure the *HGUID* attribute contains a value of “2”, so it matches the HGUID of the borelines and outcrops used in the sketching process.
  - Set the *SectionID* attribute to be equal to the HydroID of the section line (*SectionID* = “6475”).
8. In the *Editor* menu, select **Save Edits**.

Next, clip the area of the seam from the larger polygon containing the seam.

9. In the *Editor* menu, select **Clip** to open the *Clip* dialog.
10. Set a *Buffer Distance* of “0”, and select the *Discard the area that intersects* option.
11. Select **OK** to close the *Clip* dialog and run the tool.

If the filter in the AHGW Toolbar is used to filter the panel features for only HGUID = 4, the seam is shown clipped out of the polygon representing unit 4, as in Figure 21.

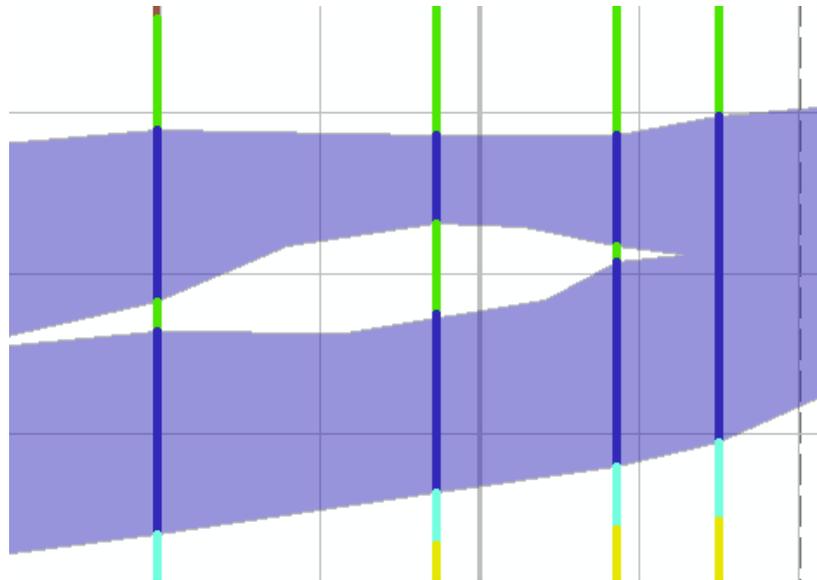


Figure 21 Seam clipped out of the polygon representing unit 4.

Repeat the process of creating cross section panels for the upper units of the cross section (units 1 and 8).

12. When done, in the *Editor* menu, select **Save Edits**.
13. In the *Editor* menu, select **Stop Editing**.

## 8 Adding Additional Data to the Cross Section

In this section, add a line representing a salt water interface to the cross section. The line is derived from a raster representing the elevation of the salt water interface, values from the raster are transformed into the XS2D coordinate system and a new line is created in the cross section.

1. In the *Table of Contents*, right-click on “Layers” and select **Activate**.
2. In the “XS2D Editor” toolset, double-click on “Create XS2D Line Feature Class” tool to open the *Create XS2D Line Feature Class* dialog.
3. For *Input Section Line Features* select “SectionLine”.
4. For *Input XS2D\_Catalog Table* select “XS2D\_Catalog”.
5. For *XS2DType Value* enter “Salt Water Surface”.
6. For *Feature Class Name Prefix* enter “SaltWater”.
7. Select **OK** to exit the *Create XS2D Line Feature Class* dialog and run the tool.

A new line feature class should be added. Now create a new line feature representing the salt water interface along the section line.

8. In the “ XS2D Editor” toolset, double-click on “ Transform Raster to XS2D Line” tool to open the *Transform Raster to XS2D Line* dialog.
9. For *Input Section Line Features* select “SectionLine”.
10. For *Input Raster* select “swinterface”.
11. For *Input XS2D\_Catalog Table* select “XS2D\_Catelog”.
12. For *XS2DType value* select “Salt Water Interface”.
13. The *Discretization Spacing* should be automatically updated to “881.24”.
14. For *FType* enter “Salt Water Interface”.
15. The *Append to Existing XS2D\_Line Features* option should be enabled to append the new feature to existing features.
16. Select **OK** to exit the *Transform Raster to XS2D Line* dialog and run the tool.
17. To view the salt water interface line on the cross section, drag the “SaltWater\_6475” layer to the “ Section A-A” data frame.

At the end of this process, a line representing the salt water interface should be added to the cross section, similar to the red line shown in Figure 22. If necessary, refresh the map in order to make the line appear.

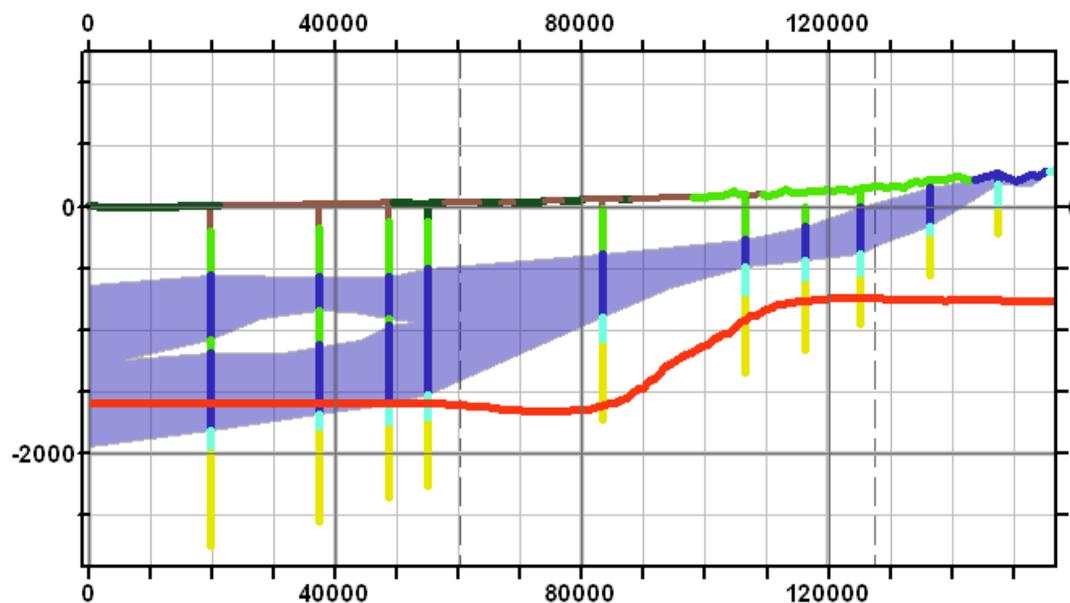


Figure 22 Line representing the salt water interface

## 9 Transforming 2D Cross Section to 3D GeoSections

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

First, create the GeoSection feature class:

1. In the *Table of Contents*, right-click on “ Section A-A” and select **Activate**.
2. In the “ Features” toolset, double-click on “ Create GeoSection Feature Class” tool to open the *Create GeoSection Feature Class* dialog.
3. In the *Output GeoSection Features* field, click the **Browse** button to open the *Output GeoSection Features* dialog.
4. Browse to the *Roseville.mdb\Data* directory and enter “GeoSection” as the feature class name.
5. Click **Save** to close the *Output GeoSection Features* dialog.
6. Select **OK** to exit the *Create GeoSection Feature Class* dialog and run the tool.
7. Add the GeoSection feature class to the map (if it was not added automatically).

Next, create the GeoSection features by transforming 2D cross section polygons to 3D GeoSections:

8. Select the SectionLine using the **Select Features**  tool.
9. In the “ XS2D Editor” toolset, double-click on “ Transform XS2D Panel to GeoSection” tool to open the *Transform XS2D Panel to GeoSection* dialog.
10. For *Input Section Line Features* select “SectionLine”.
11. For *Input XS2D\_Catalog Table* select “XS2D\_Catelog”.
12. For *Input GeoSection Features* select “GeoSection”.
13. Select **OK** to exit the *Transform XS2D Panel to GeoSection* dialog and run the tool.

Use ArcScene to visualize the 3D GeoSections just created.

14. If necessary, launch *ArcScene*.
15. Select *File | Open...* to bring up the *Open* dialog.
16. Browse to the *Tutorials\subsurface analyst\XS2D advanced editing* folder.

17. Select “Roseville.sxd” and click **Open** to exit the *Open* dialog and import the model file.

A 3D scene should appear that includes the DEM and salt water interface rasters rendered as 3D surfaces.

18. Select **Add Data**  to open the *Add Data* dialog.
19. Browse to and open the “Roseville.mdb” geodatabase and open the “Data” directory.
20. Select the “GeoSection” file and click **Add** to import the table and close the *Add Data* dialog.
21. If desired, symbolize the GeoSection layer using the HGU Color Manager.

The scene should be similar to the one shown in Figure 23.

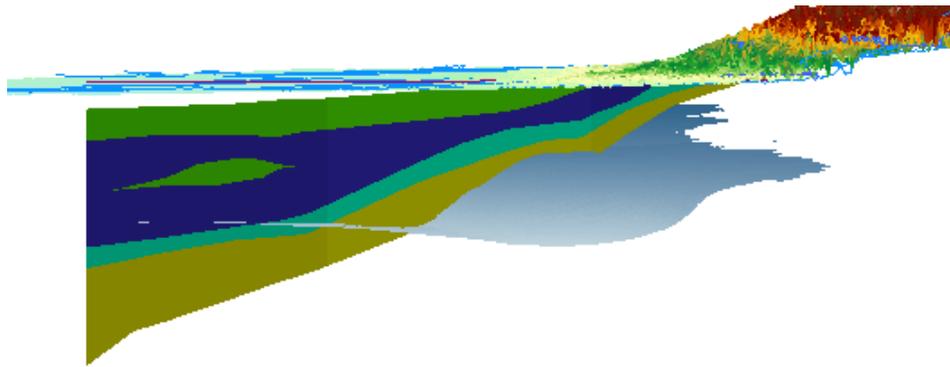


Figure 23 Scene including the GeoSection features transformed from the 2D cross section.

## 10 Conclusion

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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 ArcMap.
- The XS2D Wizard is used to set up a new data frame and create the basic XS2D feature classes.
- Data from geologic maps in combination with digital elevation models can be transformed to the XS2D data frame, and are used as guides for “sketching” cross sections.

- ArcGIS editing tools are used to help digitize cross sections based on guiding features (e.g. borelines, outcrop lines).
- Additional data can be transformed to the XS2D data frame and added to the cross section.
- 2D cross sections can be transformed to 3D features and visualized in ArcScene.