ARC HYDRO GROUNDWATER TUTORIALS

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, including representations of aquifers and wells/boreholes, 3D hydrogeologic models, temporal information, and data from simulation models. The *Arc Hydro Groundwater Tools* help to import, edit, and manage groundwater data stored in an AHGW geodatabase. *Subsurface Analyst* is a subset of the AHGW 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. In this tutorial we will learn 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

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).

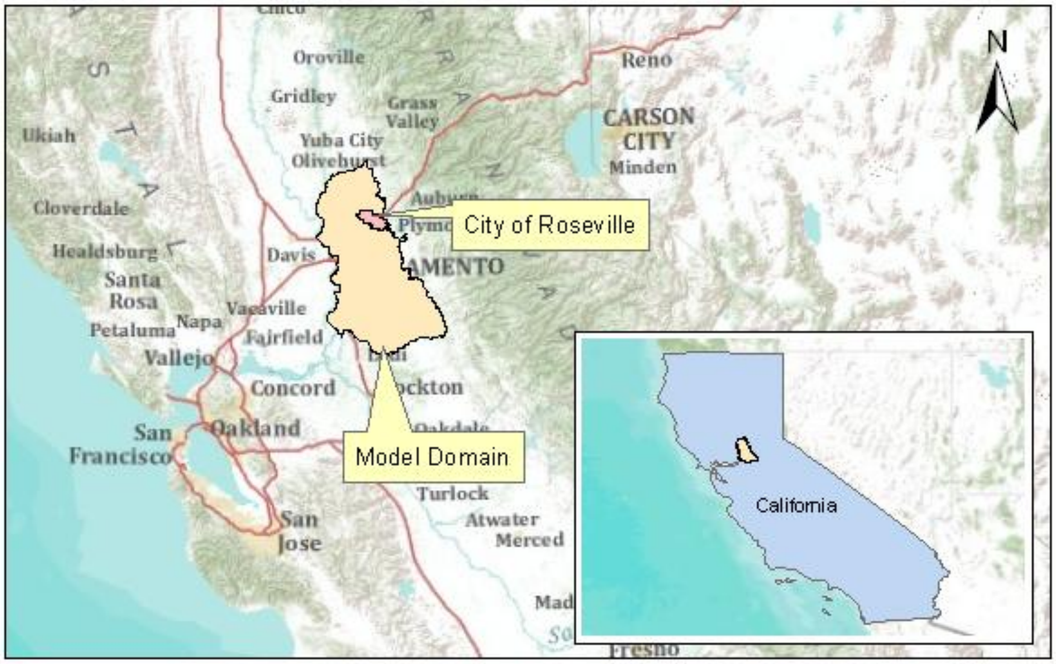


Figure 1 Location of the Roseville Model.

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.

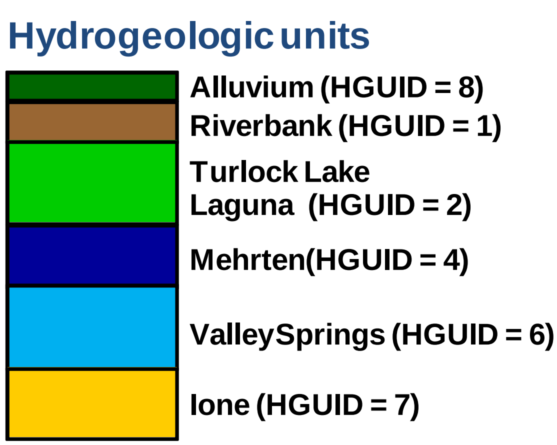


Figure 2 Hydrostratigraphic units in the model area.

1.2 Outline

The objective of this tutorial is to introduce the basic workflow and tools for creating 2D cross sections. We will complete 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

You will need the following components 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 you have a compatible ArcGIS service pack installed. You may wish to check the AHGW Tools documentation to find the appropriate service pack for your version of the tools. *3D Analyst* is required for the last section of the tutorial for visualizing 3D features. If you do not have *3D Analyst*, you can skip these parts of the tutorial. The tutorial files should be downloaded to your computer and saved on a local drive.

2 Getting Started

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

1. If necessary, launch *ArcMap*.

2. If necessary, open the *ArcToolbox* window by clicking on the *ArcToolbox* icon .

3. Make sure the Arc Hydro Groundwater Toolbox is loaded. If they are not, add the toolboxes by right-clicking anywhere in the *ArcToolbox* window and selecting the *Add Toolbox…* command. Browse to the top level of the *Catalog* and then browse down to the *Toolboxes|System Toolboxes* directory. Select the Arc Hydro Groundwater toolbox and select the *Open* button.

4. Expand the *Arc Hydro Groundwater Tools* item and then expand the *Subsurface Analyst* toolset to expose the tools we will be using in this tutorial.

We will also be using the *Arc Hydro Groundwater Toolbar.* The toolbar contains additional user interface components not available in the toolbox. If the toolbar is not visible, do the following:

5. Right-click on any visible toolbar and select the *Arc Hydro Groundwater Toolbar* item.

When using geoprocessing tools you can set the tools to overwrite outputs by default, and automatically add results to the map/scene. To set these options:

6. Select the *Geoprocessing | Geoprocessing Options...* command.

7. Activate the option: "*Overwrite the outputs of geoprocessing operations*" as shown in Figure 3.

8. Enable the option to "*Add results of geoprocessing operations to the display*" as shown in Figure 3.

9. Select *OK* to exit the setup.

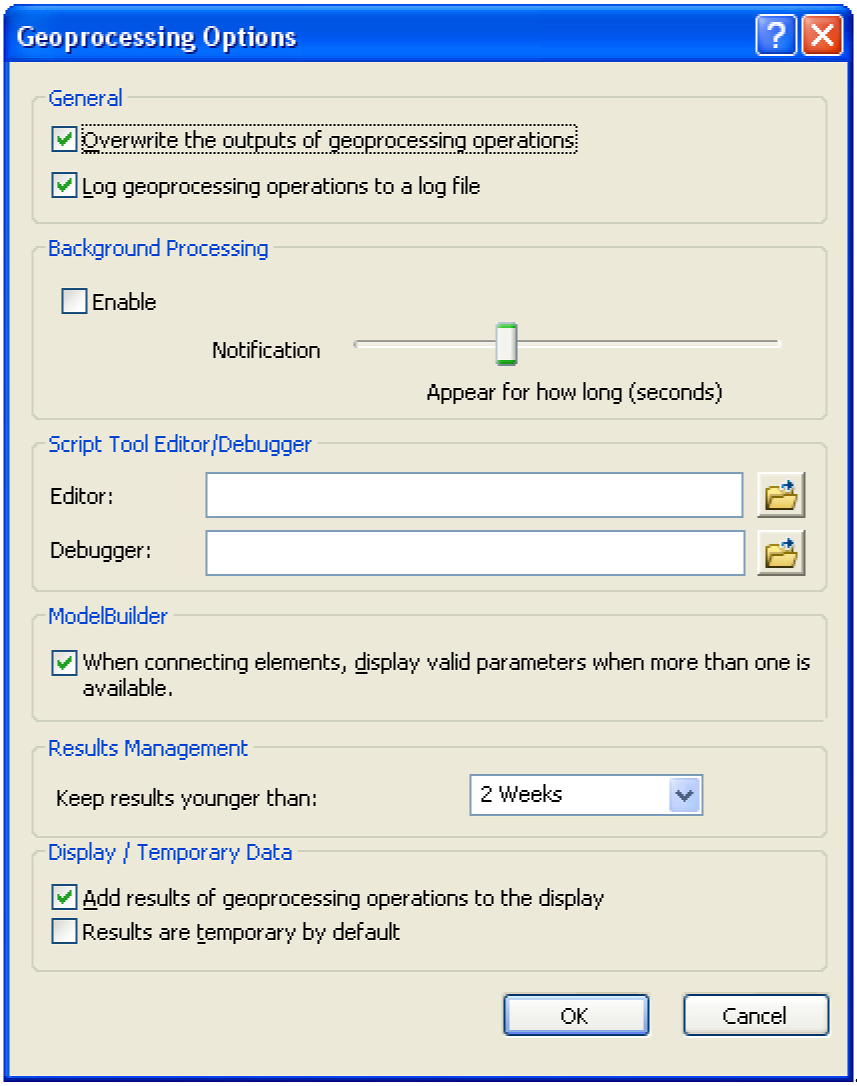


Figure 3 Setting Geoprocessing tools to overwrite outputs by default, and to add results of geoprocessing tools to the display.

3 Upgrading the geodatabase

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

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

Your tool should be similar to the one shown in Figure 4.

5. Select *OK* to upgrade the geodatabase.

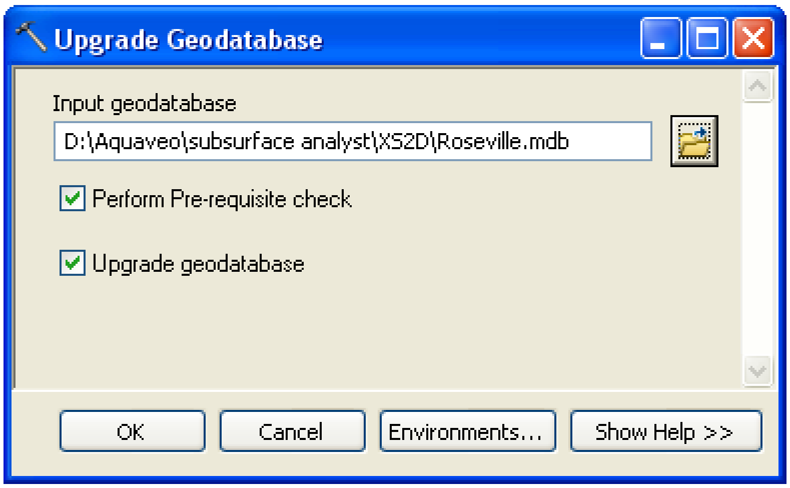


Figure 4 Settings of the Upgrade Geodatabase tool

4 Opening the Map

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

1. Select the *File| Open* command and browse to the location on your local drive where you have saved the AHGW tutorials. Browse to the *subsurface analyst/XS2D* folder and open the file entitled ***Roseville.mxd***.

Once the file has loaded you will see a map of the model area in the California Central Valley. 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.

5 Representing 2D cross sections in the AHGW Data Model

Before starting to create cross sections, it is helpful to review the component of the AHGW Data Model we will be using. 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 5).

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.

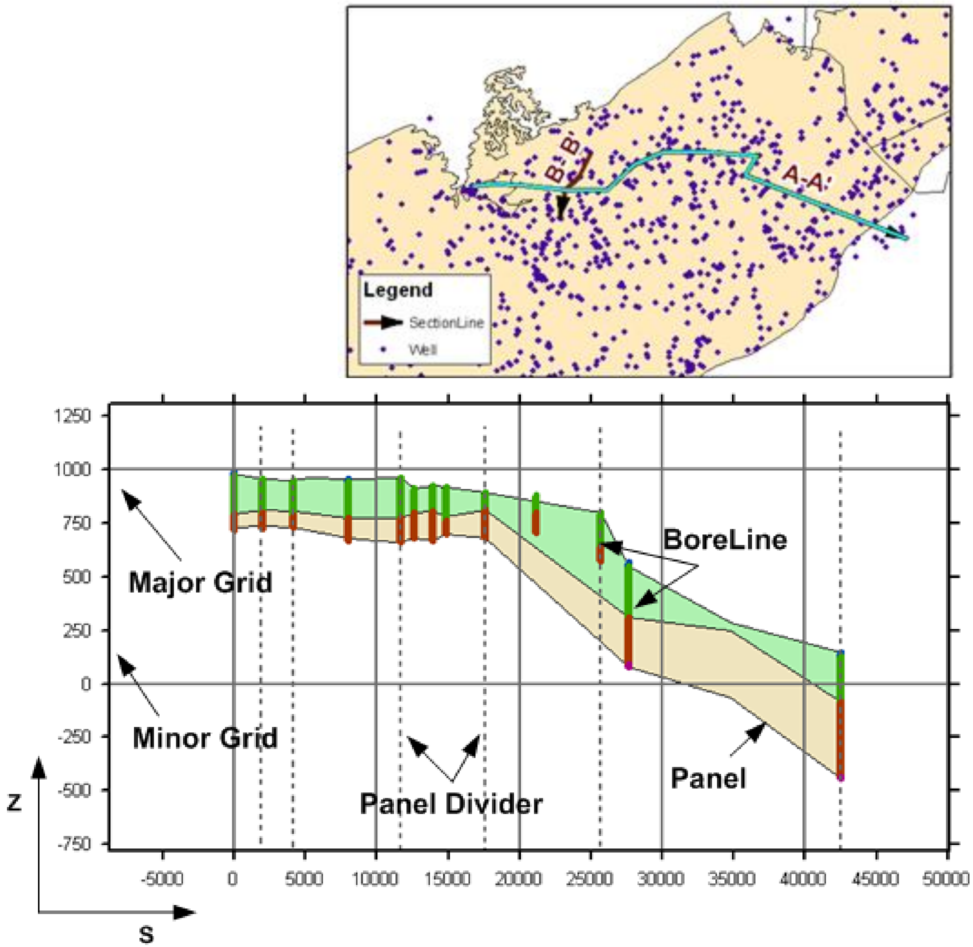
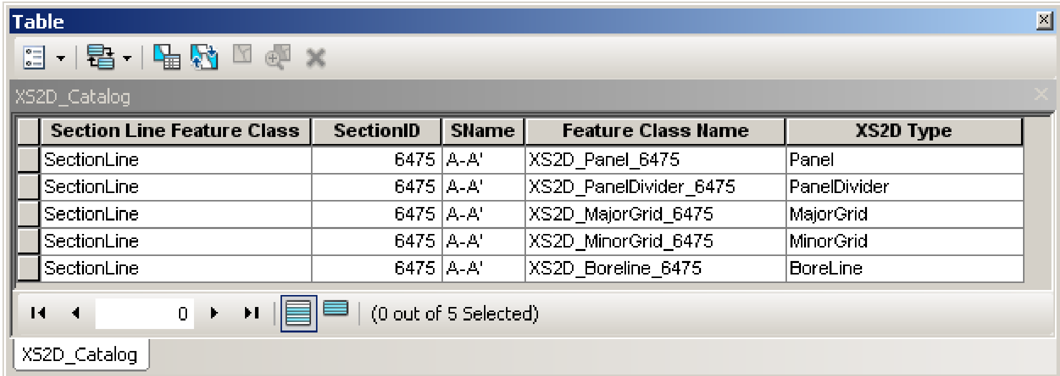


Figure 5 *Datasets used for creating 2D cross sections.*

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 6. 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.



Section Line Feature Class	SectionID	SName	Feature Class Name	XS2D Type
SectionLine	6475	A-A'	XS2D_Panel_6475	Panel
SectionLine	6475	A-A'	XS2D_PanelDivider_6475	PanelDivider
SectionLine	6475	A-A'	XS2D_MajorGrid_6475	MajorGrid
SectionLine	6475	A-A'	XS2D_MinorGrid_6475	MinorGrid
SectionLine	6475	A-A'	XS2D_Boreline_6475	BoreLine

Figure 6 Example XS2D_Catalog used for managing XS2D feature classes and establishing a relationship between the XS2D features and a SectionLine feature.

6 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 you need to 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 will be added to the cross section.

1. Select the SectionLine feature in the map using the select tool .
2. Open the *Select By Location* command in the *Selection* menu.
3. In the "*Selection Method:*" section, choose the **select features from** option.
4. In the *"Target layer(s):"* section, select the **Well** item.
5. In the "*Source layer:*" section, select the **SectionLine** item.
6. In the "*Spatial selection method:*" section, select the **Target layer(s) features are within a distance of the Source layer feature** option.
7. Turn on the "*Apply a search distance*" toggle and enter a buffer distance of **1,500** feet.

At this point, your selections should be similar to those shown in Figure 7.

8. Select the *OK* button to create the selection.

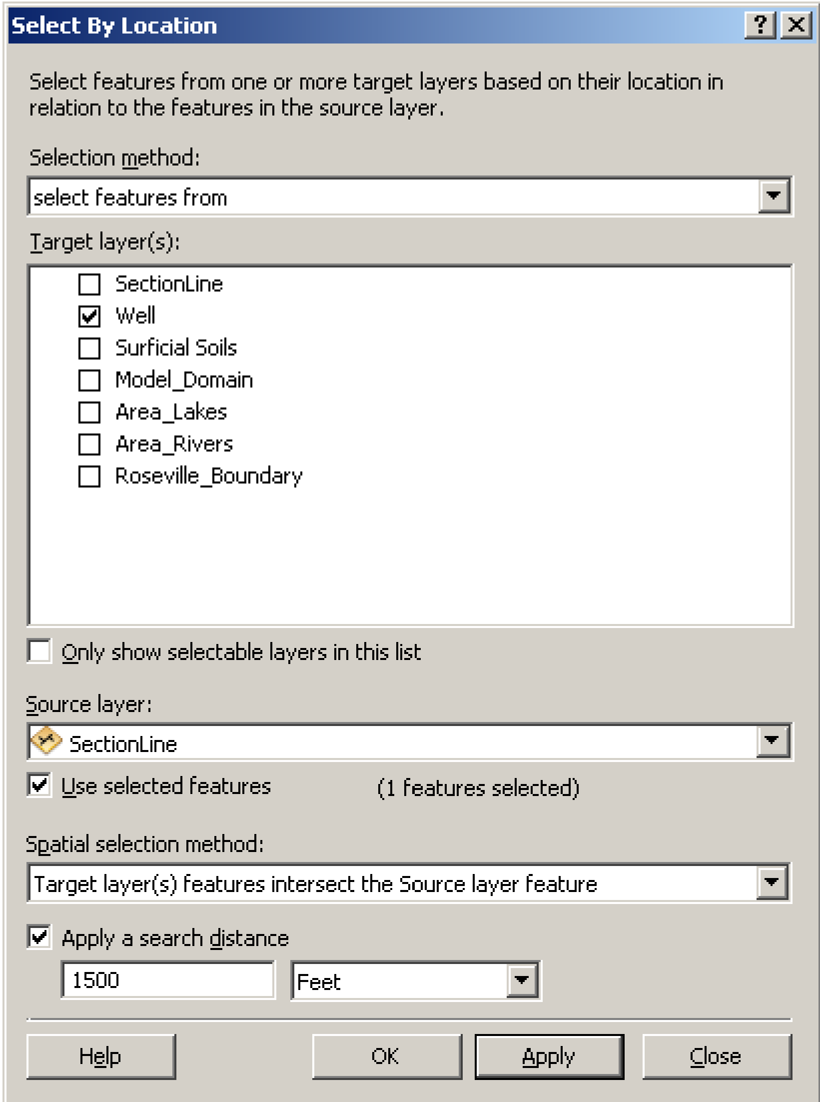


Figure 7 Settings for the Select By Location tool.

After applying the selection you should have 11 wells selected in your map as shown in Figure 8.

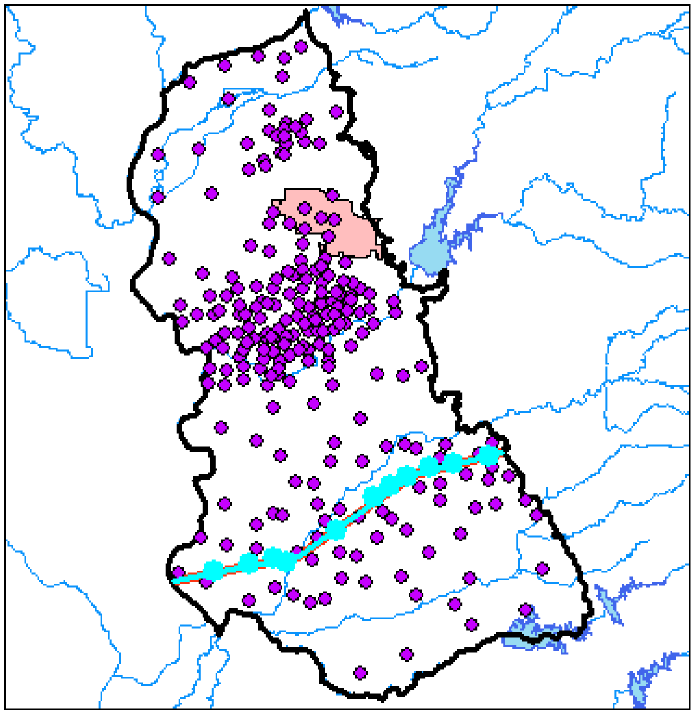


Figure 8 *Selected features after applying the Select By Location with a buffer of 1,500 feet.*

Next, we will run the XS2D Wizard to create a new cross section. The XS2D Wizard is based on a selected section line (you 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 create your own SectionLine feature class you can use the *Create SectionLine Feature Class* tool, in the *Subsurface Analyst | Features toolset*. You can then use the regular ArcMap editing tools to sketch your section lines. For this tutorial we recommend that you work with the existing section line feature. To start the XS2D Wizard:

9. Select the *XS2D Wizard* tool in the *Arc Hydro Groundwater Toolbar*.

10. With the tool activated, click on a SectionLine feature (it is fine if the section line is already selected) to start the creation of a new cross section.

The XS2D 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 9.

11. Make sure the Default output workspace points to the **Roseville.mdb\Data** feature dataset.

12. Select Next to move to the next step in the wizard.

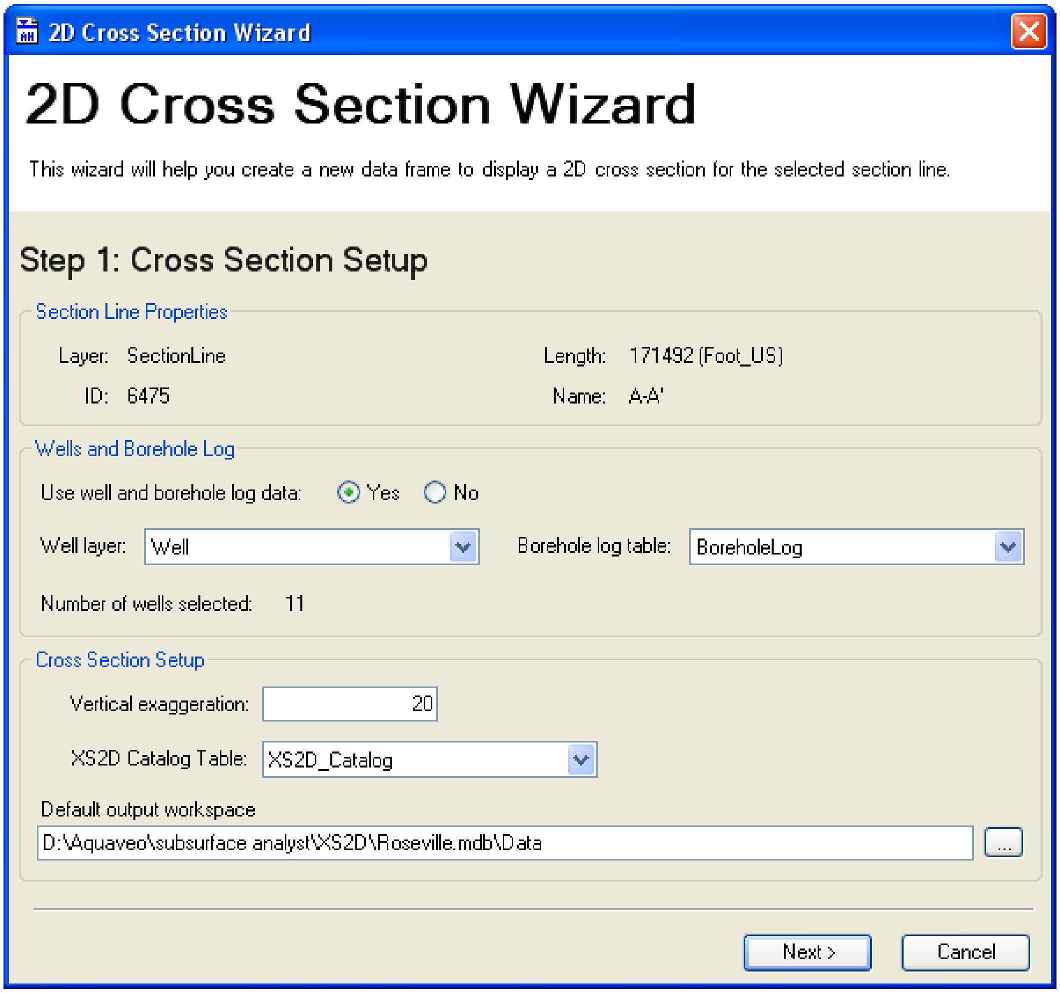


Figure 9 Settings for step 1 in the XS2D Wizard.

Step 2 in the wizard is used to set up the appropriate panel, boreline, and panel divider feature classes. You 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 prefix 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.

13. 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 10.

14. Select Next to move to the next step in the wizard.

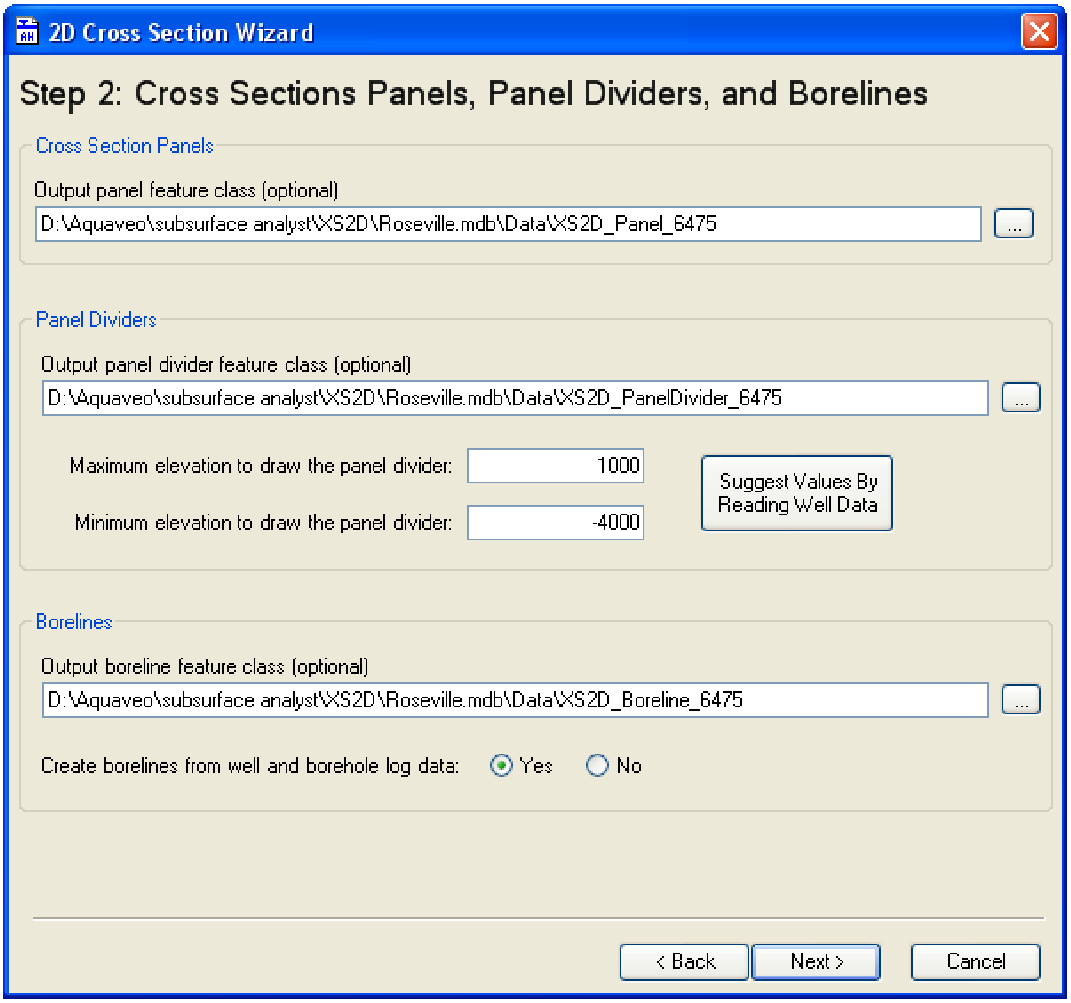


Figure 10 Settings for step 2 in the XS2D Wizard.

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. You can keep the default values or modify them.

15. Leave the default values for the grid extent:

16. Specify the following for the grid spacing:

   - Horizontal distance between vertical major grid lines: ***40,000***
   - Vertical distance between horizontal major grid lines***: 1,000***
   - Number of minor grid lines between major vertical grid lines: ***3***
   - Number of minor grid lines between major horizontal grid lines: ***3***

At this point your inputs should be similar to the ones shown in Figure 11.

17. Select Finish to run the wizard.

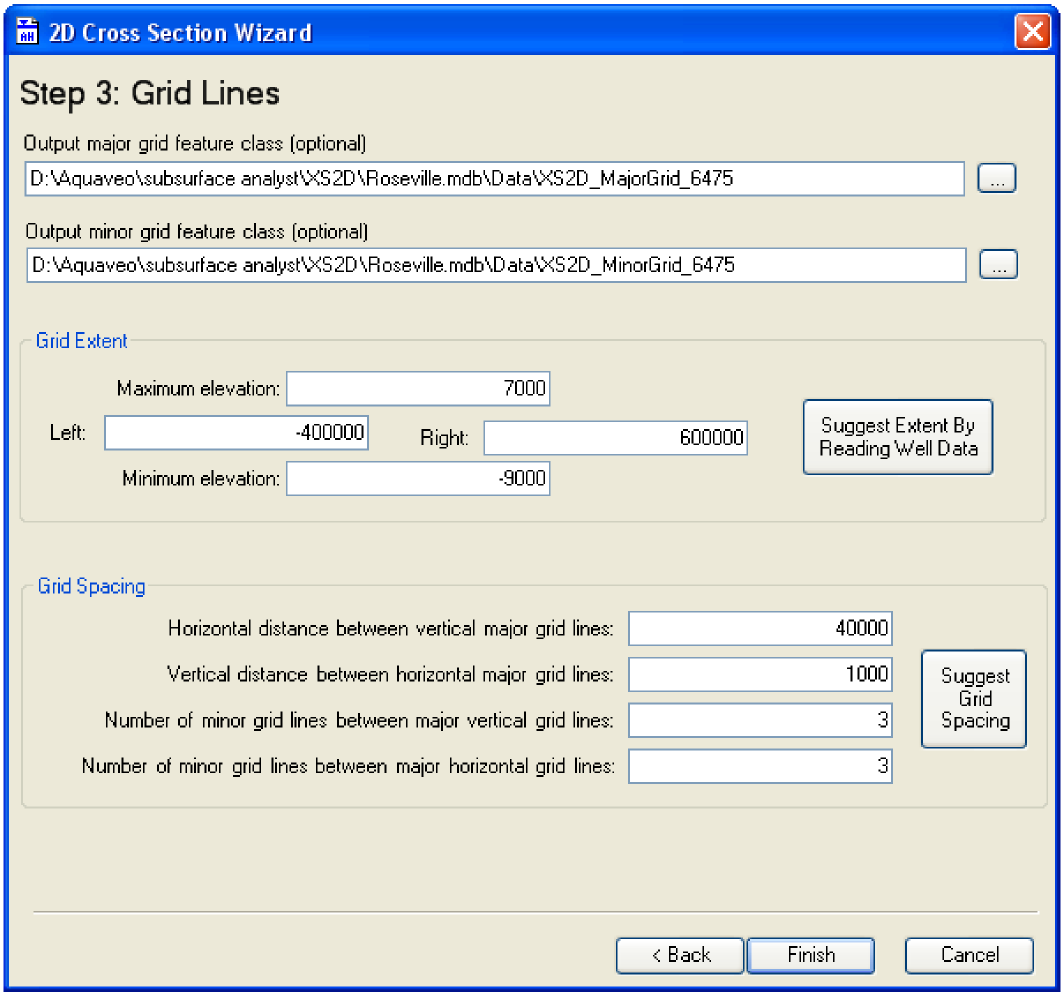


Figure 11 Settings for step 3 in the XS2D Wizard.

A new Data Frame (Section A-A') should be added to your map (make sure you are in layout view to be able to view data frames). You should see 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.

You can resize the AA' data frame and move it within the map layout such that you can see both data frames. To better view the XS2D feature created:

- Select 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.

- You can control the grid properties (text size, color, etc.) by selecting the data frame, right click and select *Properties*, 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.

18. To apply the predefined symbology:
    - Make sure the ***A-A' data frame*** is activated. And select the ***XS2D_Boreline_6475 layer***.
    - Open the layer **Properties** and select the **Symbology** tab.
    - Select the ***Import*** option on the top right 
.
    - In the *Import Symbology* dialog, browse to the ***XS2D_Boreline.lyr*** file located in the ***Symbology*** folder of the tutorial solution.
    - In the *What do you want to import?* section select the ***Complete symbology definition*** option.
    - Select ***OK***.
    - In the *Import Symbology Matching Dialog* specify the ***HGUID*** field in the *Value Field* section.
    - Select ***OK,*** and ***OK*** again to finish specifying the symbology.

At the end of this process you should have a XS2D data frame that is similar to the one shown in Figure 12

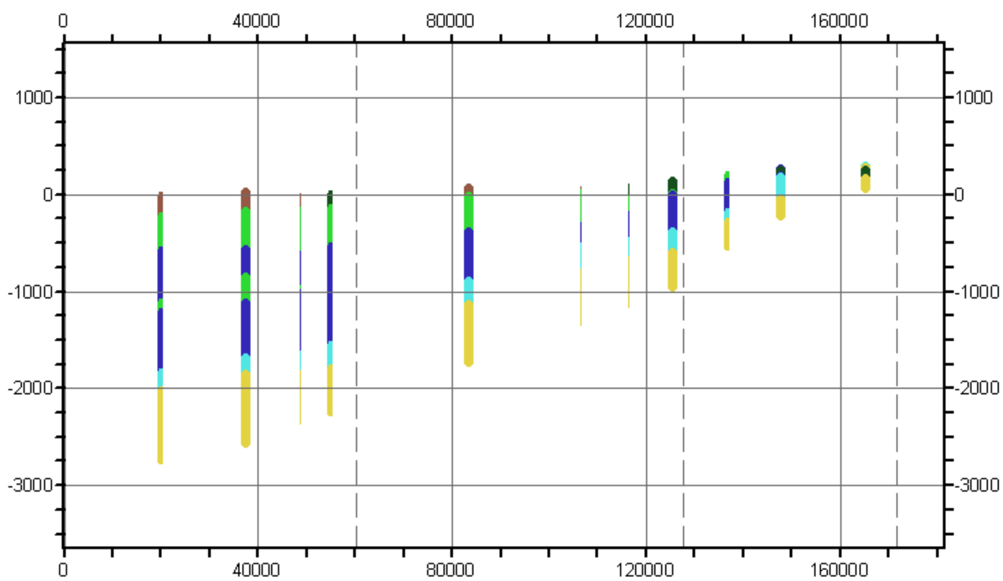


Figure 12 Initial XS2D data frame with XS2D features created by the XS2D Wizard.

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

7 Adding data from geologic maps

An important source of data that can guide you while 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.

Your 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 13).

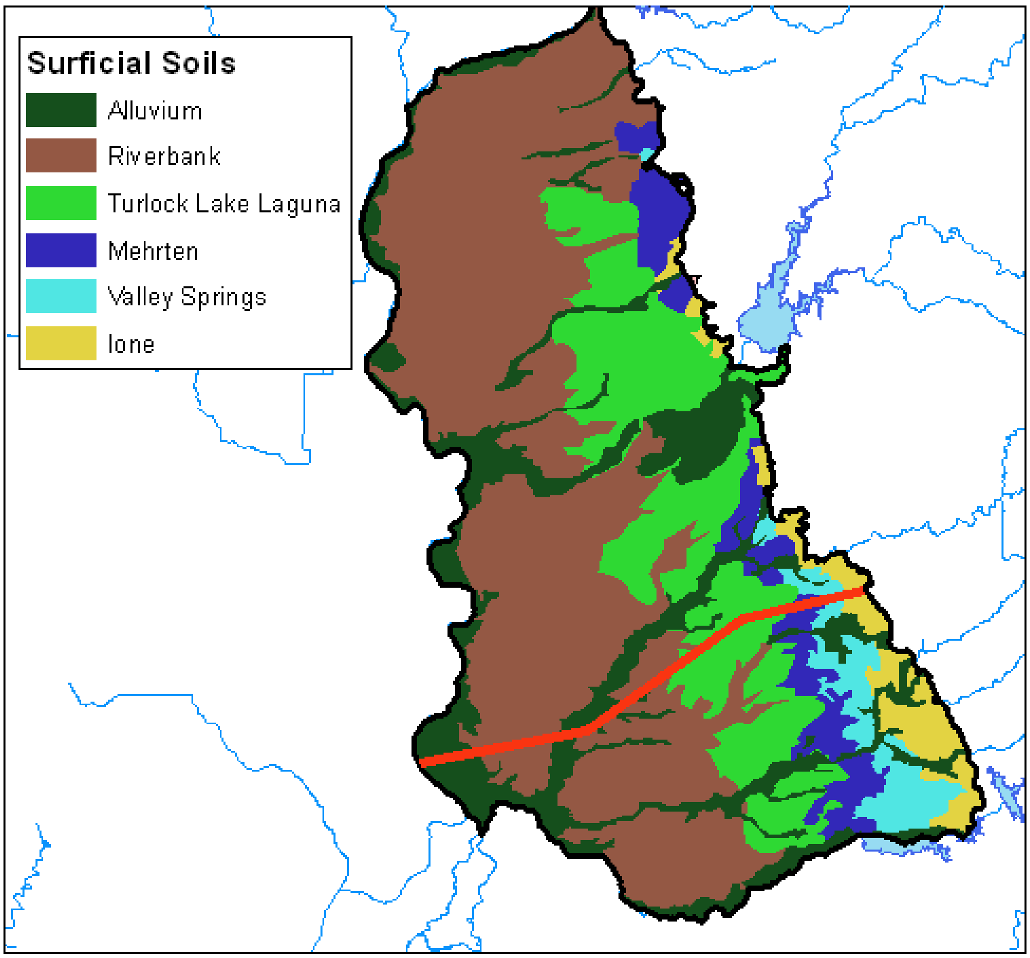


Figure 13 Geologic map showing outcrops of formations within the model area. Features are symbolized based on the hydrogeologic units.

Before we continue we will need to create a new line feature class to which the output XS2D Lines will be written.

1. Make sure the Layers data frame is the active data frame (you can activate the data frame by selecting it, right clicking, and selecting the *Activate* option). 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. Open the *Create XS2D Line Feature Class* tool in the *Subsurface Analyst/XS2D Editor* toolset.

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.

3. For the *Input Section Line Features* select the ***SectionLine*** feature class.

4. Specify ***XS2D_Catalog*** for the *XS2D_Catalog Table*.

5. Enter ***Outcrop*** as the *XS2DType value*.

6. Enter ***Outcrop*** as the *Feature Class Name Prefix*.

The feature classes created will include the prefix specified and the HydroID of the section line feature (e.g. Outcrop_6475).

At this point, your selections should be similar to those shown in Figure 14.

7. Select the *OK* button to execute the tool.

8. Select the *Close* button when the tool has finished.

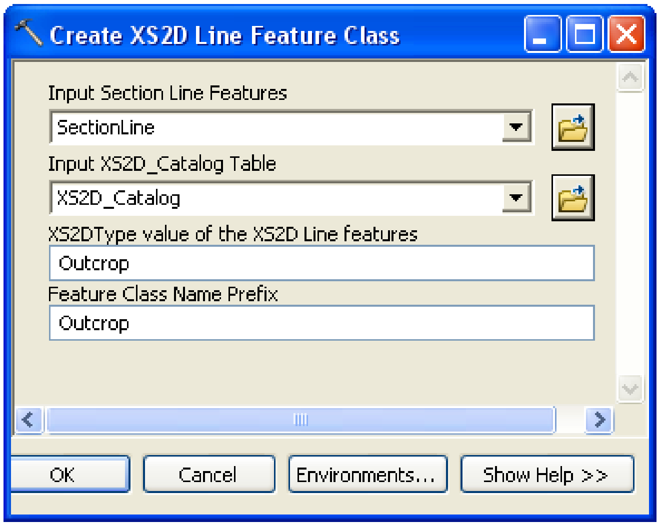


Figure 14 Settings for the Create XS2D Line Feature Class Tool.

A new feature class named Outcrop_6475 should be added to the map.

9. Add the *Outcrop_6475* feature class to the Section A-A' data frame (you can select the layer and drag it to the data frame, or use the Add Data tool).

Next, you will 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 we will apply the ***Transform Polygons To XS2D Lines tool:***

10. Double-click on the ***Transform Polygons to XS2D Lines*** tool in the *Subsurface Analyst|XS2D Editor* toolset.

11. Select the ***Surficial Soils*** layer as the input *Polygon Features*.

12. Select ***SectionLine*** as the *Input Section Line Features* tool.

13. Select ***XS2D_Catalog*** as the *Input XS2D_Catalog Table*.

14. Select ***Outcrop*** as the *XS2DType* value.

15. Select the ***dem30m*** raster as the *Ground Surface DEM*.

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

16. Specify a *Discretization Spacing* of ***1000***.

17. Enter ***Outcrop*** as the *FType* value. 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.

At this point, the settings for the tool should match those shown in Figure 15.

18. Click *OK* to launch the tool.

19. When the tool is finished, click the *Close* button.

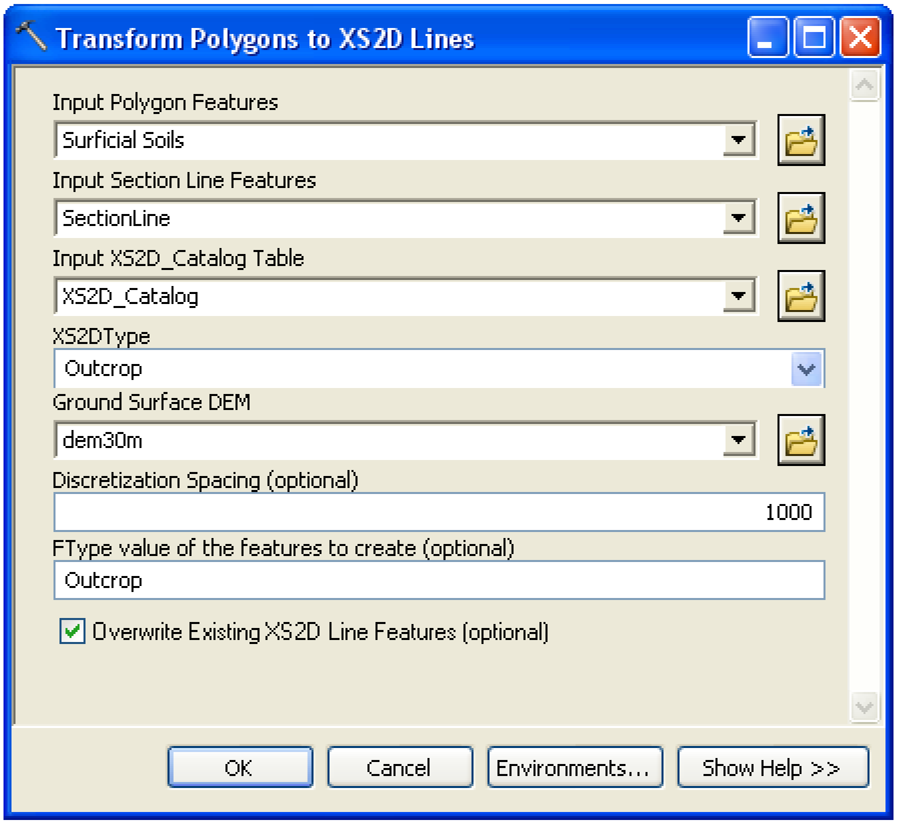


Figure 15 Settings for the Transform Polygons to XS2D Lines Tool.

When the tool is done you should see a new set of lines in your cross section. If the lines do not appear, refresh the map and make sure to drag the outcrop layer to your A-A' data frame. You can 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.

20. In the Section A-A' data frame, select the Outcrop_6475 layer, right click and select *Properties*. Select the *Symbology* tab to reach the symbology interface.

21. Select the Import option on the top right 

.

22. In the *Import Symbology* dialog, browse to the ***Outcrop.lyr*** file located in the ***Symbology*** folder of the tutorial solution.

23. In the *What do you want to import?* section select the ***Complete symbology definition*** option.

24. Select ***OK***.

25. In the *Import Symbology Matching Dialog* specify the ***HGUID*** field in the *Value Field* section.

26. Select ***OK,*** and ***OK*** again to finish specifying the symbology.

At this point your XS2D data frame (Section A-A') should be similar to the one shown in Figure 16.

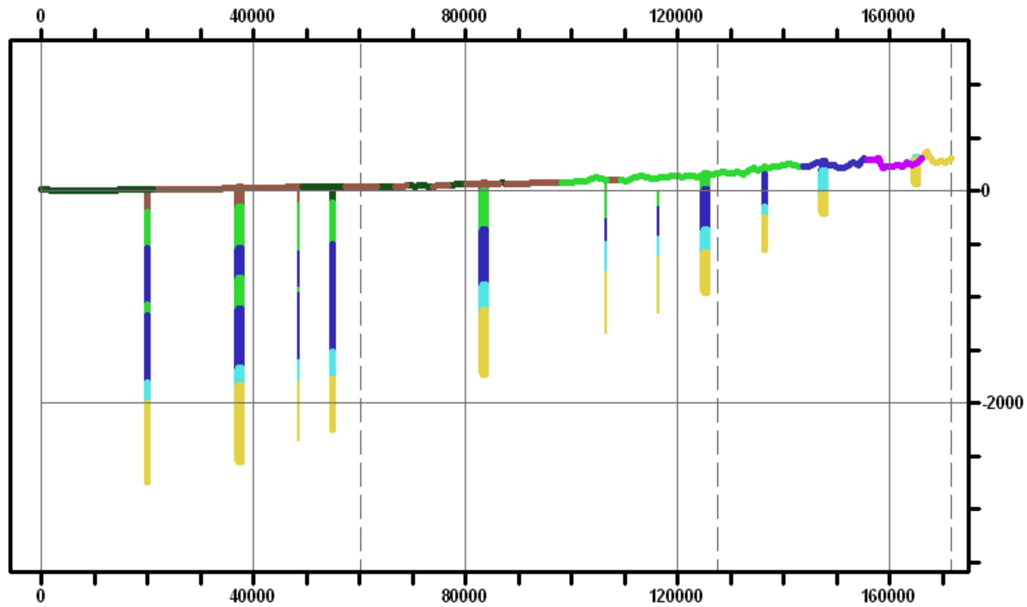


Figure 16 Cross section with borelines and outcrops.

The borelines and outcrops will guide you while digitizing new cross sections.

8 Sketching cross section panels

In this step you will sketch new cross section panels. We will use the boreline data and outcrops as guides. We will utilize the advanced editing capabilities available in ArcMap. The following steps (8.1 through 8.4) apply specifically to ArcGIS 10, if you are using ArcGIS 9.2 or 9.3 then browse to the *subsurface analyst\XS2D* folder and open the file entitled ***ArcGIS 9 Sketching.pdf*** and follow the steps outlined in that document. After you have completed all the steps return to Section 9 of this document and continue with the tutorial. If you are using ArcGIS 10 continue as outlined below.

8.1 Creating a new template for editing XS2D Panel features

In ArcGIS 10 the concept of feature templates is introduced. This allows us to predefine different types of features with symbology and default attributes that are automatically updated as we edit. We will first create a template for the XS2D Panel feature class:

1. Make sure the *Section A-A'* data frame is activated.

2. In the *Section A-A'* data frame, select the XS2D_Panel_6475 layer, right click and select *Properties*. Select the *Symbology* tab to reach the symbology interface.

3. Select the Import option on the top right 

.

4. In the *Import Symbology* dialog, browse to the ***XS2D_Panel.lyr*** file located in the ***Symbology*** folder of the tutorial folder.

5. In the *What do you want to import?* section select the ***Complete symbology definition*** option.

6. Select ***OK***.

7. In the *Import Symbology Matching Dialog* specify the ***HGUID*** field in the *Value Field* section.

Select ***OK,*** and ***OK*** again to finish specifying the symbology. Your XS2D Panel should have 4 classes (2, 4, 6 and 7) based on the HGUID field.

Next we will define a new feature template:

8. To start editing, select the *Editor* / *Start Editing* option 

.

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 17.

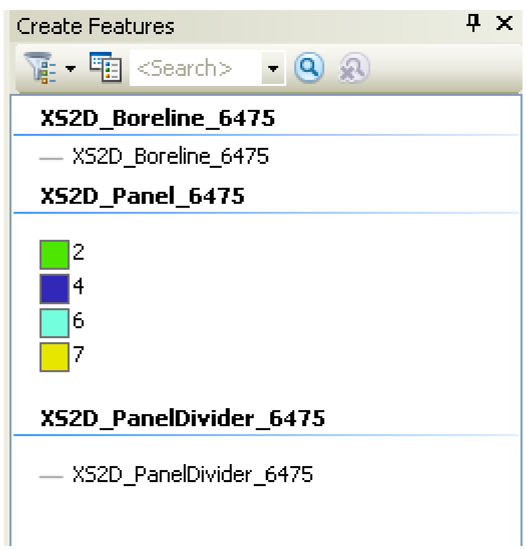


Figure 17 The Create Feature window after adding a template for XS2D Panel features.

9. If the template does not appear as shown in Figure 17 then proceed with steps 10 through 15. If the template does appear skip to Section 8.2.

10. Select the *Organize Templates* button  located at the top of the Create Features window.

11. In the *Organize Templates* window select the XS2D_Panel layer. You will notice that no template is associated with this layer.

12. Select the *New Template* button 

to open the *Create New Template Wizard.*

13. Make sure the XS2D_Panel layer is the only one selected as shown in Figure 18.

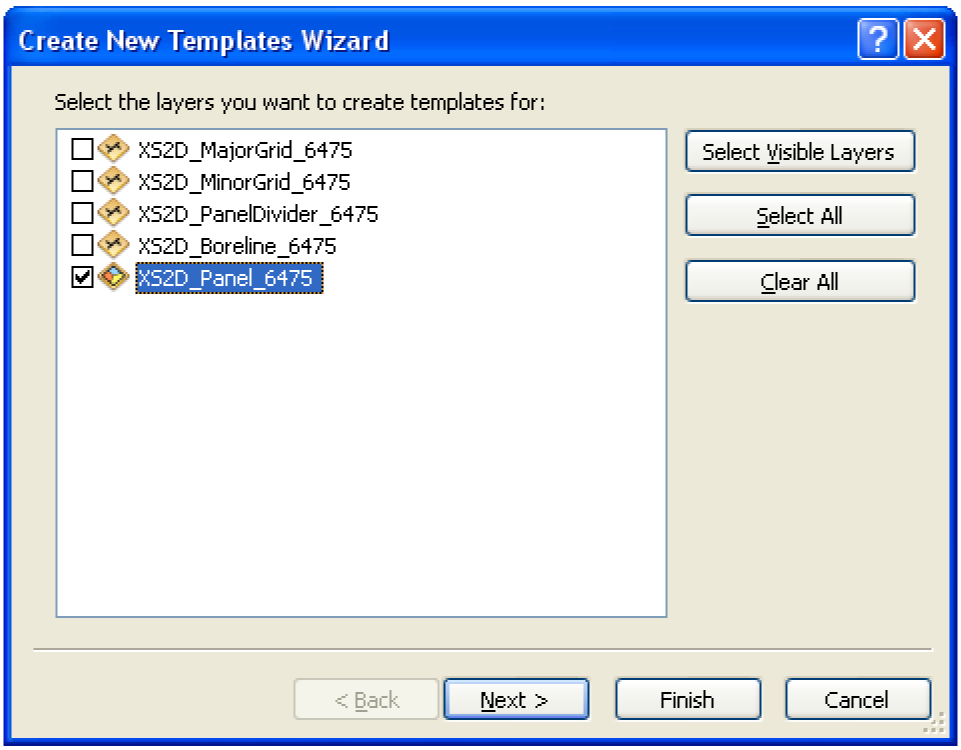


Figure 18 Creating a new template for the XS2D_Panel feature class

14. Select *Next* to view the symbology of the features in the template.

15. Select *Finish* to create the template

The Create Features window should include a template for the XS2D_Panel_6475 feature class, as shown above in Figure 17.

Next we will set the snapping environment.

8.2 Setting the snapping environment options

1. Make sure the Section A-A' data frame is activated.

2. Make sure the Snapping toolbar is loaded in the map. You can load it by right clicking on any toolbar and selecting the Snapping toolbar.

3. Make sure you are in an active edit session. If not, select the *Editor* / *Start Editing* option 

.

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

4. Enable the "***use classic snapping***" option under *Editor* | *Options.* This allows us to control 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. Open the snapping window by going to *Editor* |*Snapping* | *Snapping Window…*

6. Specify the snapping environments for the Outcrop_6475, XS2D_BoreLine_6475, XS2D_Panel_6475, and XS2D_PanelDivider_6475 layers, as shown in Figure 19.

The order of the layers within the snapping environment interface determines the snapping priority. You can move the layers by selecting them and moving them up or down.

7. Make sure that the layers are in the order shown in Figure 19.

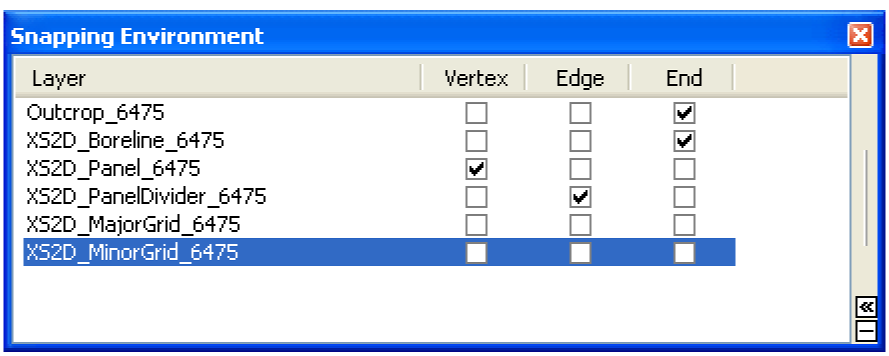


Figure 19 Snapping environment settings.

While editing you can enable Snap Tips that will show you the features to which your new features are being snapped.

8. In the editing toolbar select *Editor* | *Snapping* | *Options*. Enable the Snap Tips as shown in Figure 20.

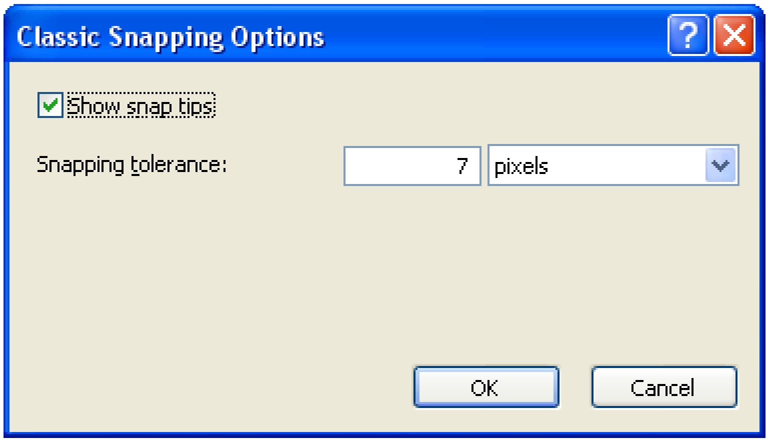


Figure 20 Snapping options settings.

8.3 Sketching panels

1. If necessary change from Layout to 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 | XS2D_Panel_6475 template, select the feature symbology for HGUID = 7.

Notice that in the Construction Tools window you get a list of the available tools you can use for creating new panels (Figure 21).

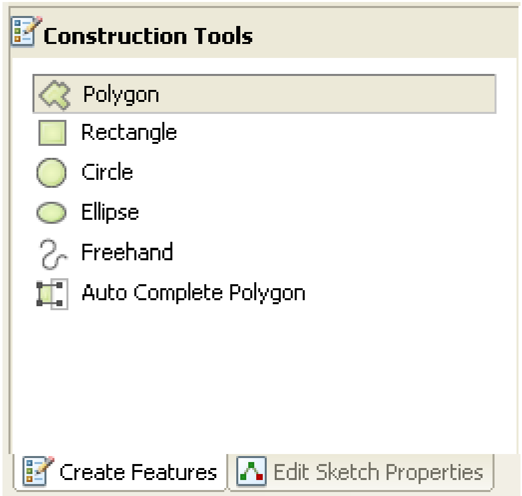


Figure 21 Construction tools available for sketching XS2D Panels.

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

We will use the *Trace* editing tool to trace the outcrop as part of the cross section creation. To better visualize a single outcrop we can use the filter tool in the AHGW Toolbar.

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

5. Select the trace editing tool in the Editor menu .

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, you should see the new line created as you move the mouse to the left side of the outcrop. When you reach the end of the outcrop line click on the edge to create a vertex.

Your sketch should be similar to the one shown in Step 1 of Figure 22.

7. Switch to the *Straight Segment* tool , and continue sketching a cross section panel. Your guiding points should be the boreline edges. The sketch tool should automatically snap to the end of the boreline features as you digitize. Make sure to snap also to the panel dividers defining the start and end of the cross section.

Your sketch should be similar to the one shown in Step 2 of Figure 22.

8. Make sure to reach the right side panel divider as shown in Step 3 of Figure 22.

9. Select *Finish Sketch* to close the panel you digitized.

Your sketch should be similar to the one shown in Step 4 of Figure 22.

Tip: To better visualize the borelines on top of the panels, you can 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 you will assign some basic attributes to the panel.

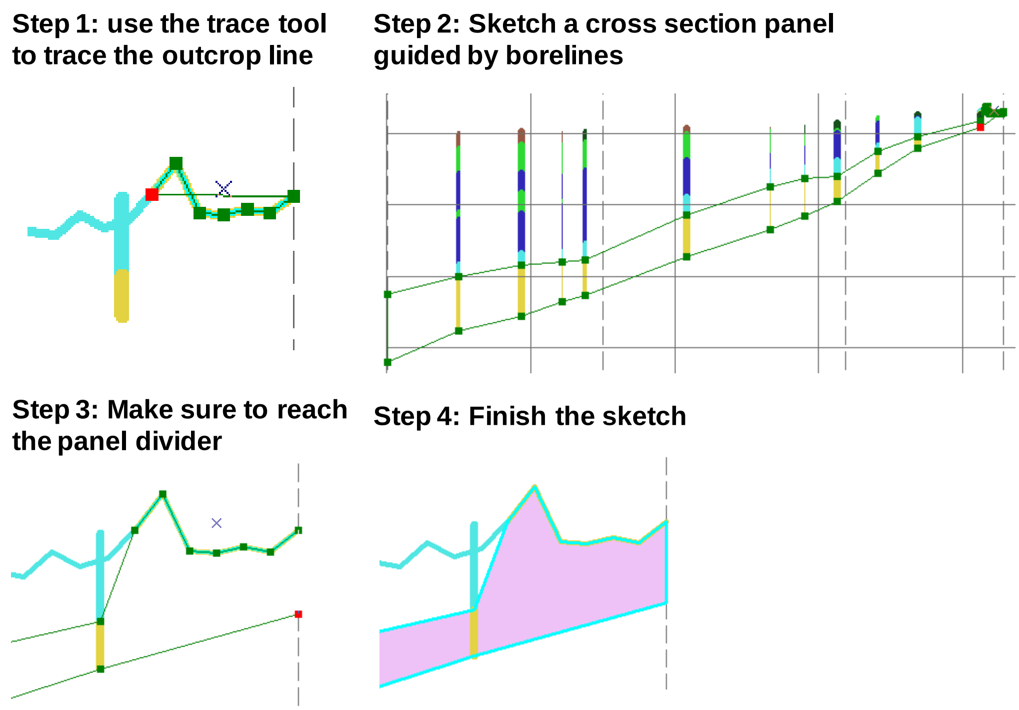


Figure 22 Steps in sketching a cross section panel.

10. Use the *Edit* tool in the editor toolbar to select the feature you just created.

11. Select the Attributes button to open the Attributes window (you can also right click with the feature selected and select the Attributes command).

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 as you are using a template for editing.

    - Set the SectionID attribute to be equal to the HydroID of the section line (***SectionID = 6475***).

13. After editing the attributes, close the attributes window, and save the edits by selecting the *Save Edits* option in the *Editor* menu .

Next, you will digitize the panel for HGUID = 6:

14. Zoom in to the outcrop line representing HGUID = 6.

15. Select the HGUID = 6 symbology in the XS2D_Panel template.

16. In the Construction Tools window select the *Auto Complete Polygon* task, as shown in Figure 23.

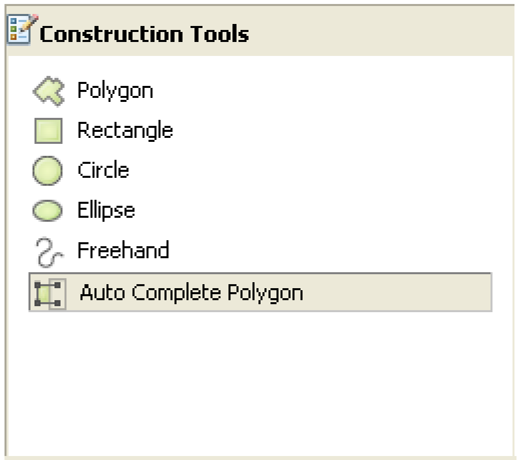
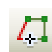


Figure 23 Selecting the Auto Complete Polygon Task in the Construction Tools window.

17. Use the *Trace* tool  to sketch a line following the outcrop representing HGUID = 6.

18. After sketching the outcrop portion, keep sketching using the *Straight Segment* tool , and use the borelines as guides for sketching.

19. Make sure that the line snaps to the intersection point of the panel divider and the cross section feature you digitized before, as shown in Figure 24.

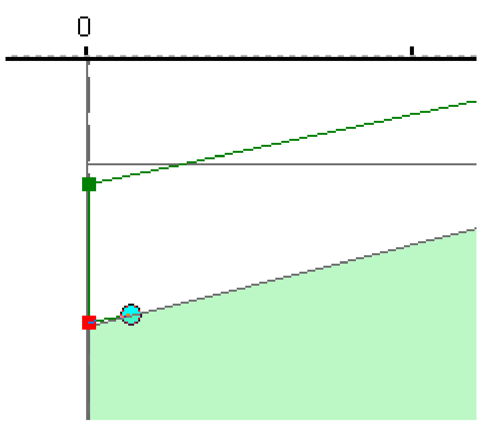


Figure 24 The new polygon should snap to the vertex located at the intersection of the cross section feature and the panel divider.

20. Select *Finish Sketch*  to close the panel you digitized. A new polygon representing HGUID = 6 should be created. The polygon's boundary should match the boundary of the polygon representing HGUID = 7.

Your sketch should be similar to the one shown in Figure 25.

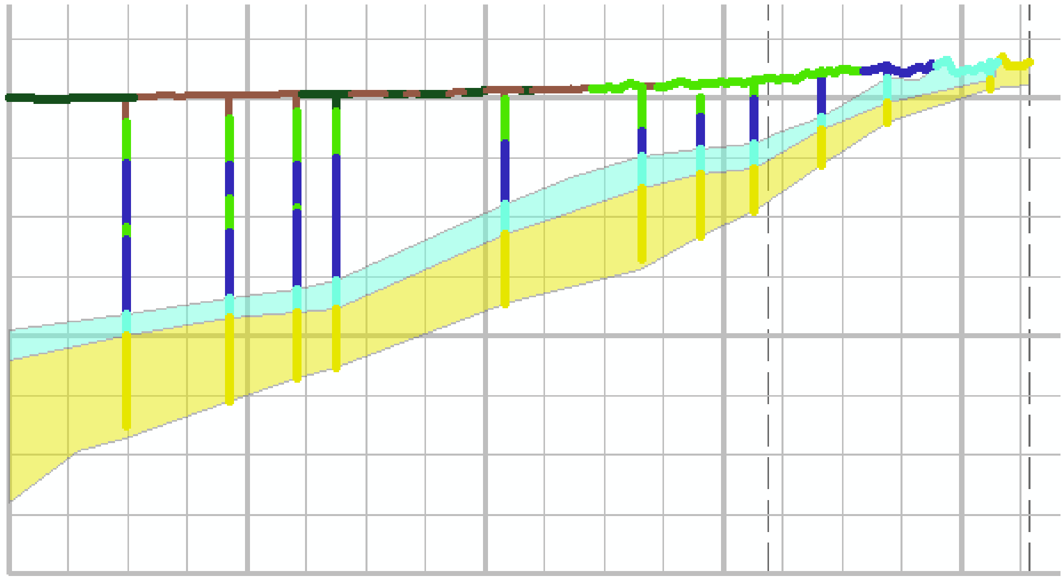
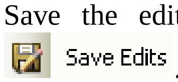


Figure 25 Cross section panel created using the Auto Complete Polygon task.

21. Use the *Edit* tool  in the editor toolbar to select the feature you just created. Select the Attributes button to open 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***).

22. Save the edits by selecting the *Save Edits* option in the *Editor* menu 

.

23. Repeat steps 14 to 22 for HGUID = 4. Your sketch should be similar to the one shown in Figure 26.

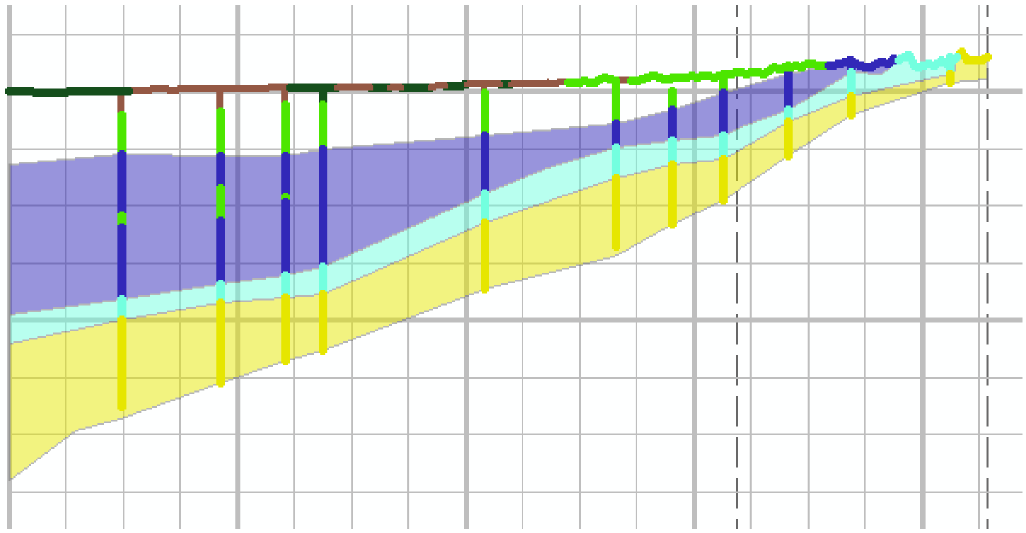


Figure 26 Cross section panel for unit HGUID = 4.

Next we will sketch the panel for HGUID = 2. You may notice that there are multiple outcrop lines for units 2 and 1. You can trace across multiple outcrops or sketch smaller un-connected units. You can also alternate between the trace and sketch tools to make your cross section as detailed as you need. In some cases the outcrop lines and borehole data do not agree. This is a common issue which you will need to resolve based on your best understanding of the system and the accuracy of the data.

Notice the seam of this formation (HGUID = 2) within the underlying formation. We will add this seam as well.

24. Repeat steps 14 to 22 for HGUID = 2. Your sketch should be similar to the one shown in Figure 27.

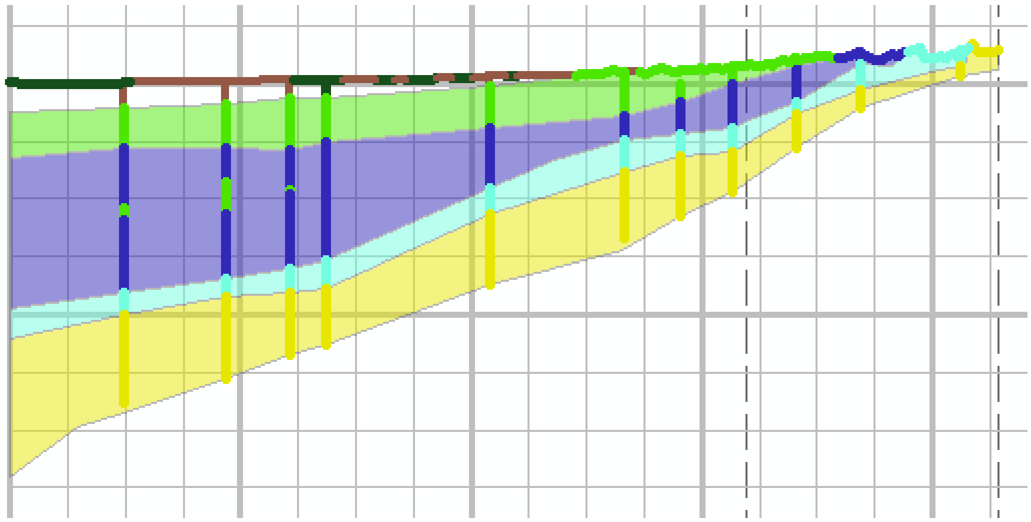


Figure 27 Cross section panel for unit HGUID = 2.

8.4 Adding a seam

Next we will 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. Select the symbology for HGUID = 2 in the XS2D_Panel template.

3. Select the *Freehand* tool in the Construction Tools window, as shown in Figure 28.

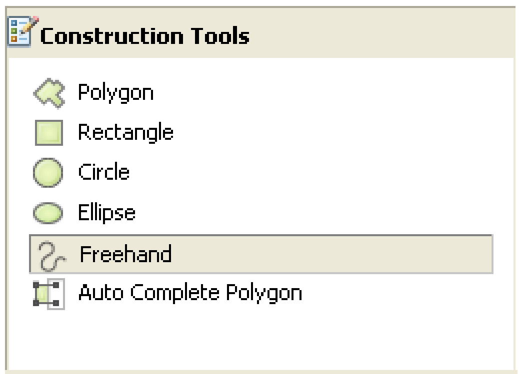


Figure 28 Create New Feature task.

4. Sketch a seam using following the boreline edges and pinching out beyond the borelines. Your seam should be similar to the one shown in Figure 29.

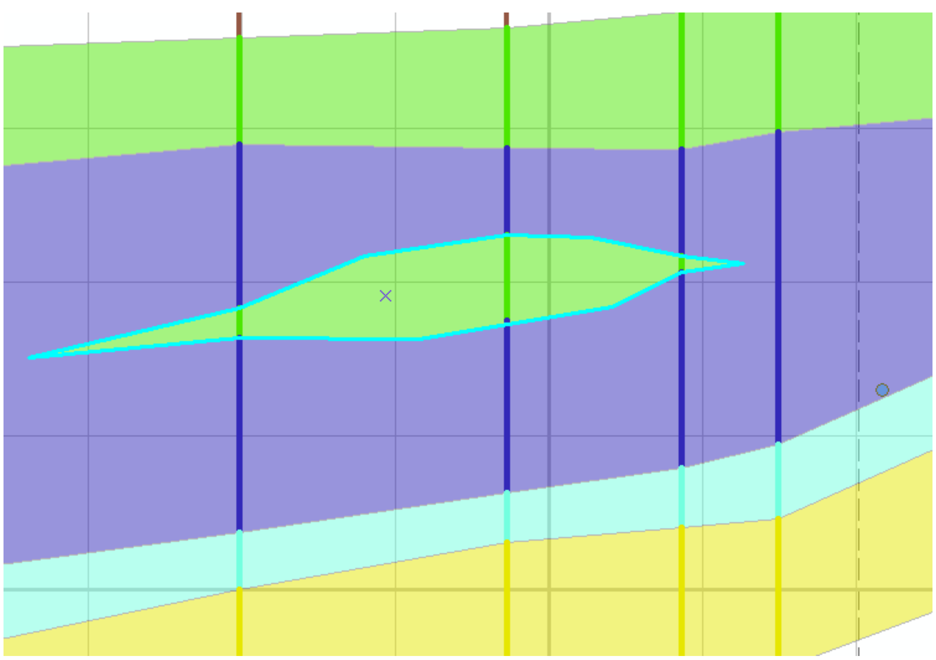


Figure 29 Sketched seam of hydrogeologic unit 2 within hydrogeologic unit 4.

5. Edit the attributes of the new polygon such that HGUID = 2 and SectionID = 6475.

6. Save the edits using the *Save Edits* option in the *Editor* menu.

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

7. In the *Editor* menu select the *Clip* tool.

8. Select a buffer distance of 0, and select the option to *Discard the area that intersects*, as shown in Figure 30.

9. Select *OK* to run the *Clip* tool.

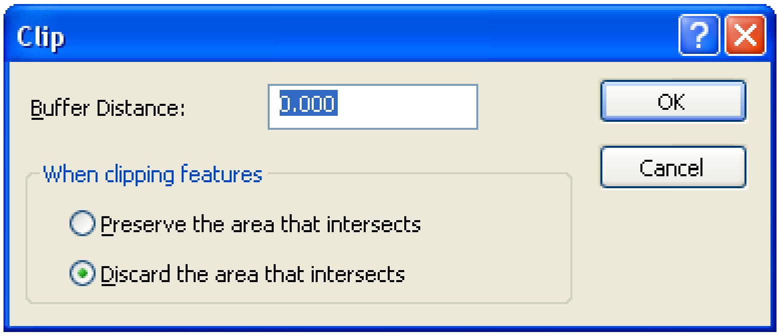


Figure 30 Settings for the Clip tool.

If you use the filter in the AHGW Toolbar to filter the panel features for only features with HGUID = 4, you should see the seam clipped out of the polygon representing unit 4, as shown in Figure 31.

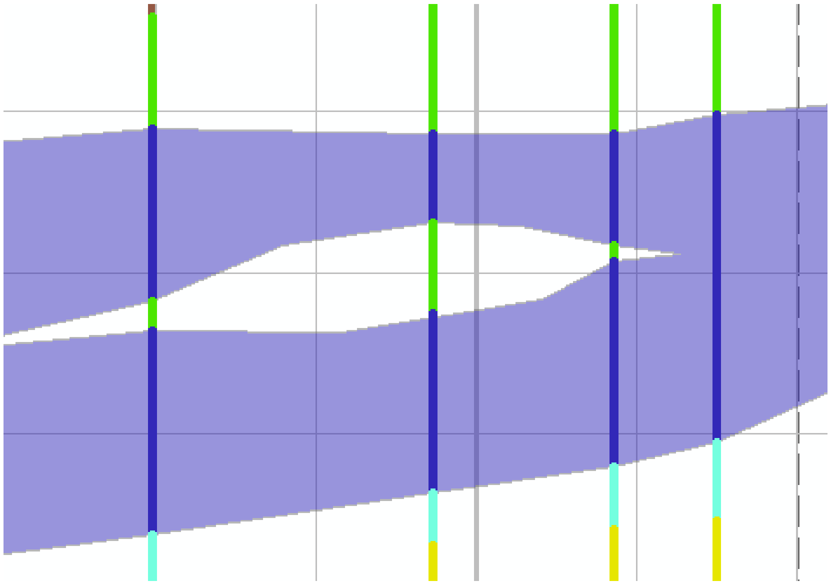


Figure 31 Seam clipped out of the polygon representing unit 4.

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

10. When you completed your cross section, save your edits using the ***Save Edits*** button on the Editor toolbar 

and close the edit session using the ***Stop Editing*** button 

.

9 Adding additional data to the cross section

In this section we will 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. Activate the *Layers* data frame (we will work in this data frame as the SectionLine, and raster datasets are in it).

2. Open the *Create XS2D Line Feature Class* tool located in the XS2D Editor toolset.

3. Specify the **SectionLine** and **XS2D_Catalog** inputs as shown in Figure 32.

4. For the *XS2DType value* enter **Salt Water Interface**.

5. For the *Feature Class Name Prefix* enter **SaltWater.**

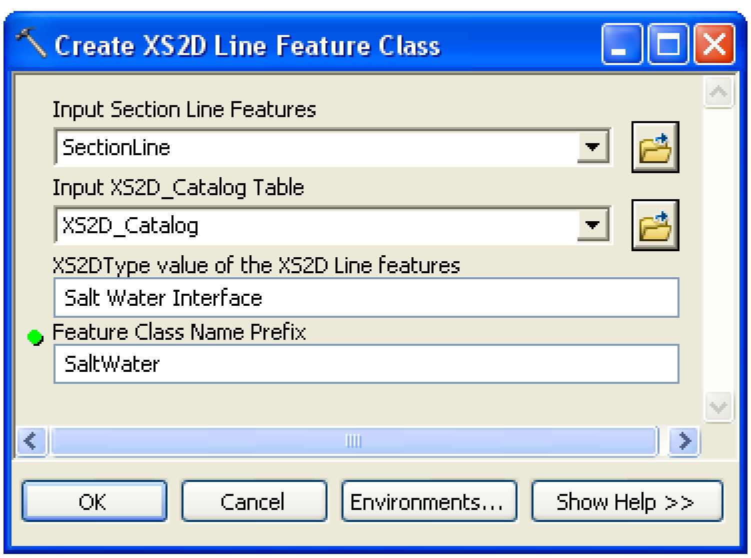


Figure 32 Settings for the Create XS2D Line Feature Class tool.

6. Select *OK* to run the tool.

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

7. Open the *Transform Raster to XS2D Line* tool located in the *XS2D Editor* toolset.

8. For the *Input Section Line Features* select the ***SectionLine*** feature class

9. For the *Input Raster* select the ***swinterface*** raster.

10. Specify the ***XS2D_Catalog*** table as the *Input XS2D_Catalog Table*.

11. Select ***Salt Water Interface*** as the *XS2DType value*.

12. The *Discretization Spacing* should be automatically updated, leave the default value of ***881.24***.

13. For the *FType* value, enter "***Salt Water Interface***".

14. The *Append* parameter should be enabled to append the new feature to existing features.

At this point your tool settings should look as shown in Figure 33.

15. Select *OK* to run the tool.

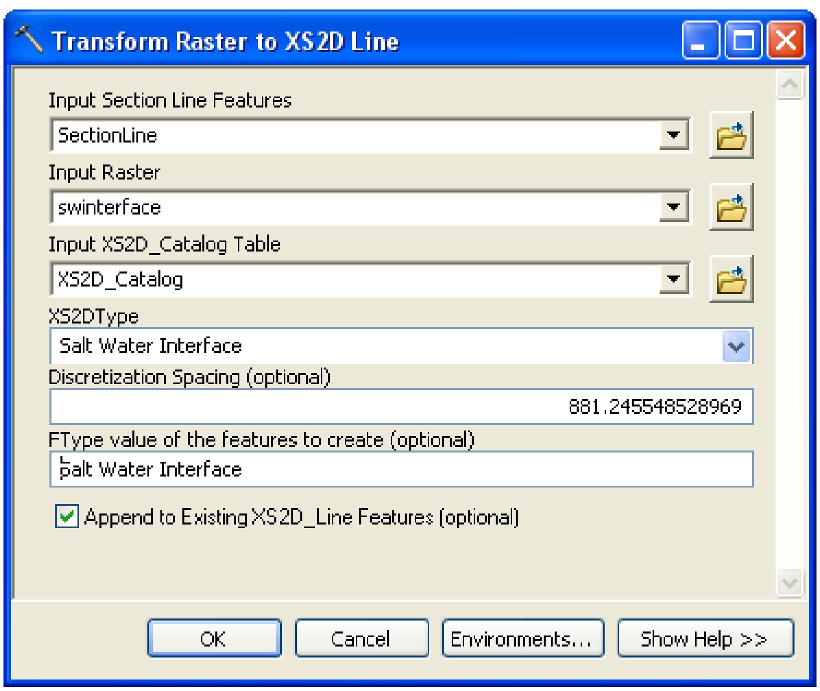


Figure 33 Settings for the Transform Raster to XS2D Line Tool

16. To view the salt water interface line on the cross section, drag the SaltWater_6475 layer to the A-A' data frame.

At the end of this process you should see a line representing the salt water interface added to your cross section, similar to the red line shown in Figure 34. You may need to refresh the map in order to make the line appear.

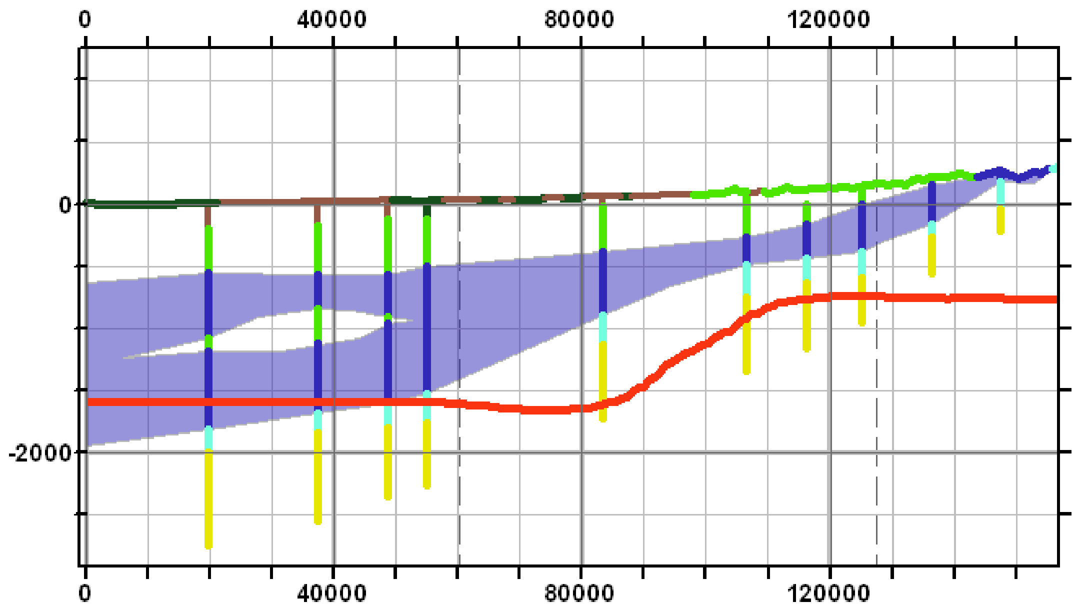


Figure 34 Line representing the salt water interface

10 Transforming 2D cross section to 3D GeoSections

Once the2D 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 we will create the GeoSection feature class:

1. Make sure the A-A' data frame is activated.
2. Open the *Create GeoSection Feature Class* tool, located in the *Subsurface Analyst | Features* toolset.
3. For the *Output GeoSection Features* browse to the ***Roseville.mdb\Data*** feature dataset and enter ***GeoSection*** as the feature class name (as shown in Figure 35).
4. Select *OK* to run the tool.

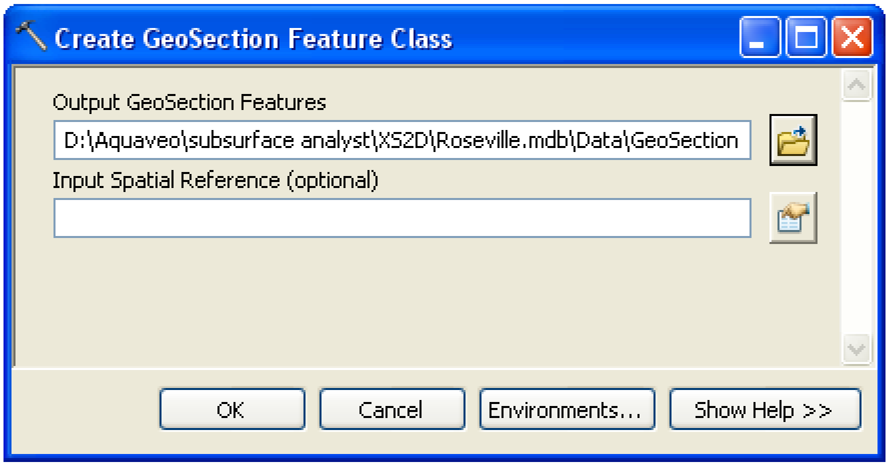


Figure 35 Settings for the Create GeoSection Feature Class tool

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

5. Select the ***SectionLine*** feature with a HydroID of 6475.

6. Open the ***Transform XS2D Panel To GeoSection*** tool located in the *XS2D Editor* toolset.

7. Specify the ***SectionLine*** layer for the *Input Section Line Features*.

8. Specify the ***XS2D_Catalog*** table for the *Input XS2D_Catalog Table*.

9. Select the ***GeoSection*** layer for the *Input GeoSection Features*.

At this point your tool settings should look as shown in Figure 36.

10. Select *OK* to run the tool.

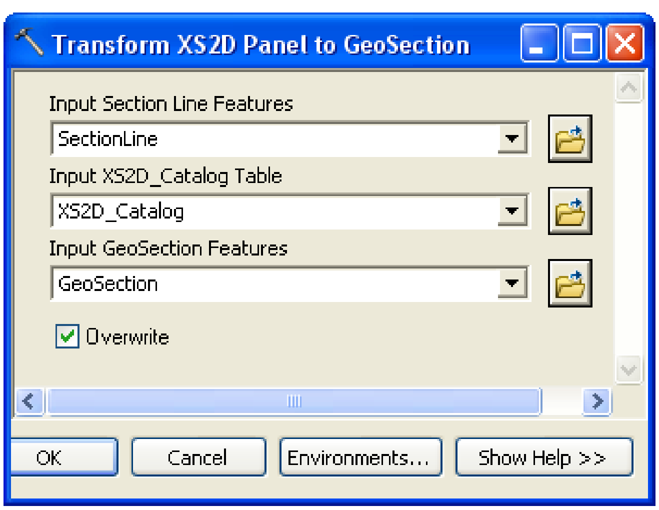


Figure 36 Settings for the XS2D_CrossSection To GeoSection tool

We will use ArcScene to visualize the 3D GeoSections just created.

11. Open the ***Roseville.sxd*** file.

12. You will see a 3D scene that includes the DEM and salt water interface rasters rendered as 3D surfaces.

13. Add the GeoSection feature class you created to the scene using the *Add Data* tool .

14. You can symbolize the GeoSection layer by importing a symbology layer. Use the ***GeoSection.lyr*** file located in the *Symbology* folder of the tutorial files.

Your scene should be similar to the one shown in Figure 37.

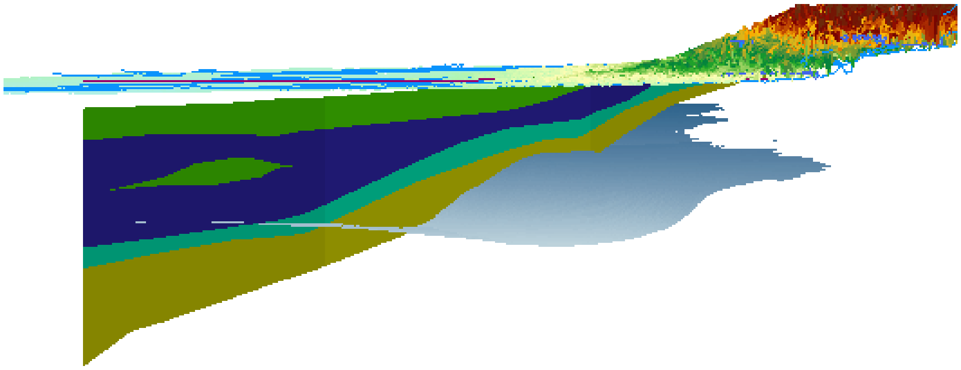


Figure 37 Scene including the GeoSection features transformed from the 2D cross section.

11 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 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.