Michigan Geological Survey

ArcGIS Pro Custom Tools Training

Mapping Projects

Basic Requirements:

ArcGIS Pro with all extensions
Access to Cross-Section Toolset

Quick Note for Data and Layers:

From preface: It is important to consider data quality before data collection. For example, much of the Wellogic well log data that is available for use can be incomplete or incorrect. We don't want to use this data in our calculations because the accuracy of the data will be in question and may not yield the correct interpretation. We will want to make sure we clean up the data before we use it (more to discuss further in the document). The same goes for the DEM data and any other data that we download.

The processing time for all tools is directly tied to the size of the input datasets. Very large datasets (state-wide or larger) can take days to finish processing. For the quickest results clip your data down to only what you need.

Final note: Each project is unique and should be treated as such. There is a standard workflow for each project but should be noted that each project will have its own data needs that should be addressed from project to project that may not follow the standard workflow.

OPTION 1: Cross-Section Only (Wellogic Data)

Step 1: Prepare the DEM and Project Area

1. Begin by opening a new map in ArcGIS Pro.
2. Obtain the appropriate elevation data and place it into the map (1-meter-resolution DEMs are recommended for areas less than 10 mi^2 in size). Merge DEMs as necessary to make a single raster file. **Make sure the elevation unit for the DEM is in feet for the next step.**
3. Next, ensure you have a proper polygon to encase your project area. Existing township or county boundaries work well, or you can make a custom polygon to suit the project's needs.
4. Acquire the Wellogic water well data for the project. Download all the counties that are needed for the extent of the project area. If there are multiple counties in the project area, merge the water well points together into one shapefile as well as the lithology tables.
    a. Note: The tools are designed to only work with well data in this specific format.

Step 2: Data Formatting

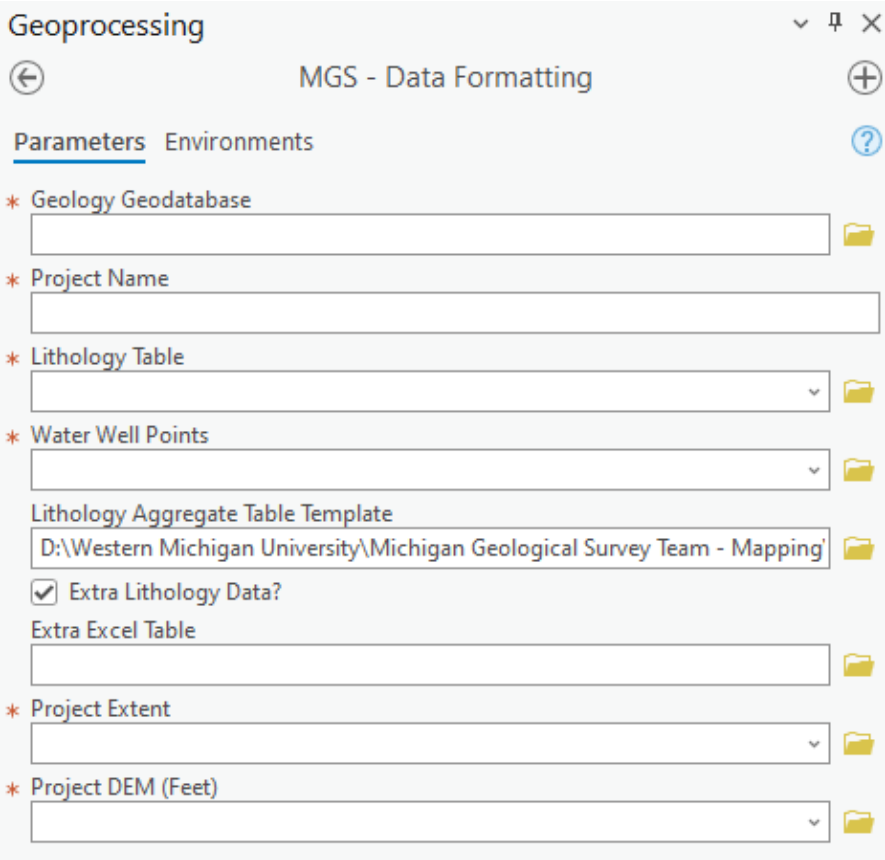


Figure 1: *Screenshot of MGS – Data Formatting custom Python script in the ArcGIS Pro software.*

1. Open the Data Formatting Tools inside the MGS toolbox and select the "MGS – Data Formatting" tool. See in **Figure 1.**
2. Create/Select a geology geodatabase for the project. ****IMPORTANT NOTE: This should be separate from your default geodatabase.****
3. Provide the name of the project. *No special characters or spaces except for underscores and cannot begin with a number.*
4. Select the Wellogic lithology table and water well points.
5. Provide the lithology aggregate Excel spreadsheet.
    a. Provided in the cross-section tools package.
6. Select the polygon used for the project's extent.
    a. Note: Projects larger than one county will take significantly longer to process.
7. Select the project DEM.

Step 3: Groundwater Level Raster Creation (Optional)

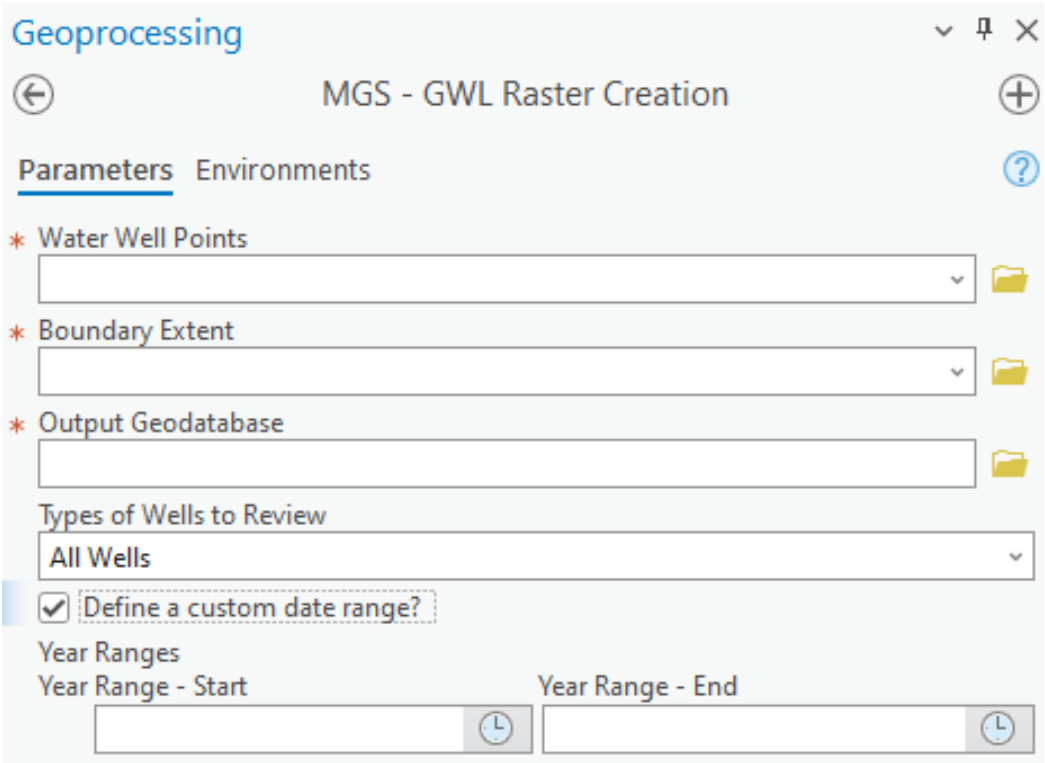


***Figure 2**: Screenshot of MGS - GWL Raster Creation custom Python script in the ArcGIS Pro software.*

This tool is used to generate groundwater rasters across several year increments to see how it changes over time. This can also be used to delineate between bedrock and drift aquifer systems if the need arises. These are later used in the cross-section tool to predict water levels along the cross-section.

1. Select "MGS – Raster Creation" tool below the Data Formatting tool seen in **Figure 2.**
2. Once the tool is open, define the wells to be used in the analysis. These features must have gone through the Project Creation tool or the Data Formatting tool (see discussion of Data Formatting tool).
3. Define the desired boundary of the rasters. You can use the previously defined project extent or choose a new one.
4. Select the geodatabase where you would like to store the output rasters.
5. Select the types of wells to review.
    a. All Wells = Every well in the feature class.
    b. Bedrock Wells = All the wells designated as "Bedrock Aquifers"
    c. Drift Wells = All the wells designated as "Glacial Drift Aquifers"
6. Define a custom date range if needed.
    a. Note: The standard format will be a groundwater surface encompassing all wells drilled in the area, all wells drilled before 2000, and 5-year increments after 2000 to the current year.

Step 4: Drawing Cross-Section Lines

1. Before using the cross-section tool, you must create cross-section lines on your map. Start by creating a new Polyline feature class in your default geodatabase.
2. Create two text string fields within the feature class called “XSEC” and “DIRECTION” (case sensitive).
3. Use the “XSEC” to name the cross-section(s).
4. In the “DIRECTION” field, you must specify the quadrant you would like the cross-section to start analyzing (or drawing) from. You must use one of the following codes below in order to define the drawing direction:
    a. If the direction is labeled as W-E, NW-SE, or E-W, the script will be reading the cross-section from the **Northwest quadrant.**
    b. If the direction is labeled SW-NE, S-N, or N-S, the script will be reading the cross-section from the **Southwest quadrant.**
    c. If the direction is labeled as NE-SW, the script will be reading the cross-section from the **Northeast quadrant.**
    d. If the direction is labeled as SE-NW, the script will be reading the cross-section from the **Southeast quadrant.**
5. Draw all necessary cross-section lines and fill out the required information in the attribute table.
6. ***DISCLAIMER*** The number of wells will determine the length of time needed to process the cross-section lines. The length of the line will also increase the processing time.

Step 5: Cross-Section Tool (All Steps)

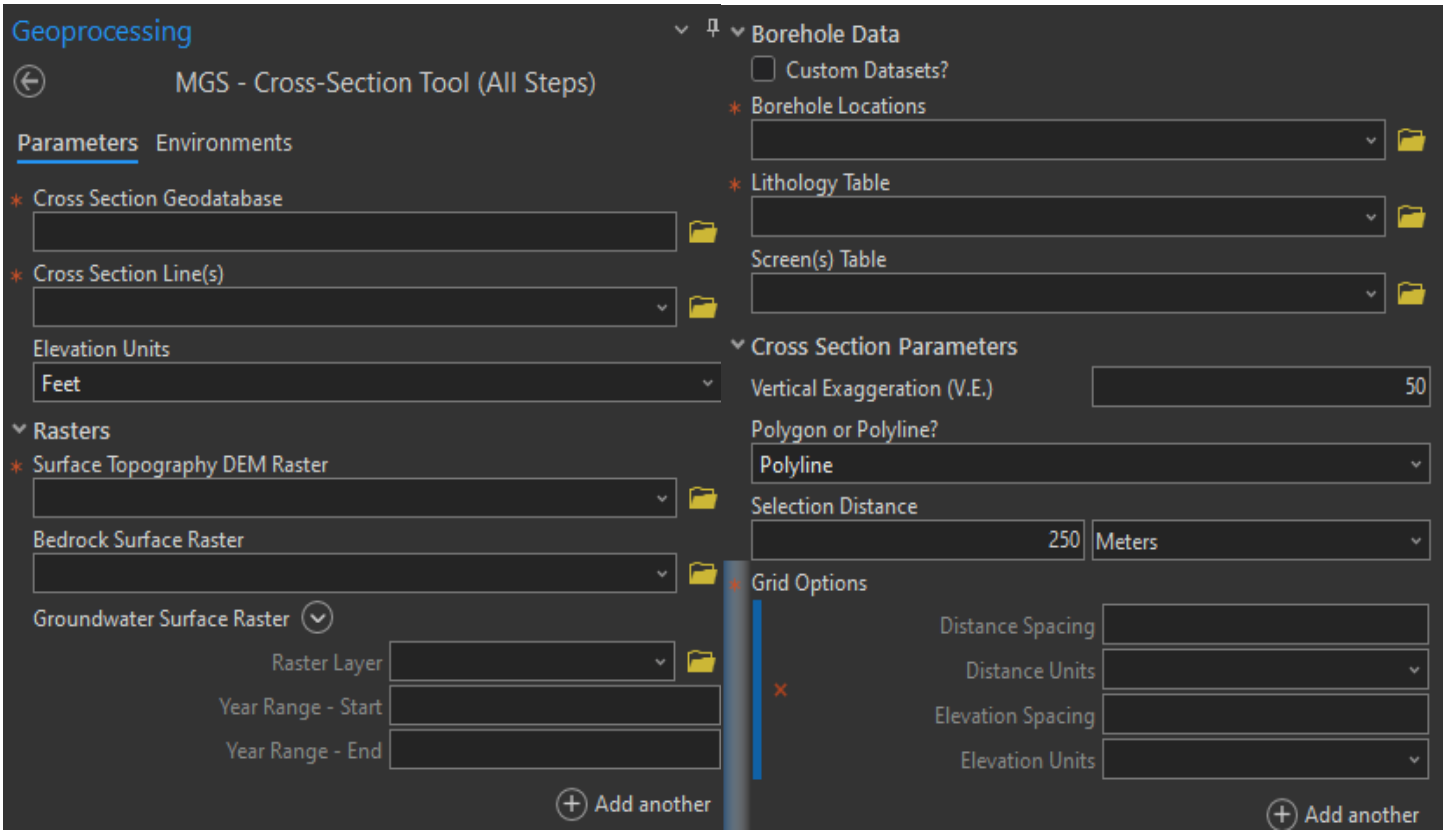


Figure 3: *Screenshot of MGS - Cross-Section Tool (All Steps) custom Python script in the ArcGIS Pro software for Wellogic input.*

1. Create a cross-section geodatabase for the cross-section files.
    a. Warning: Files may be erased if the files are placed in an existing geodatabase or if the tool is run again in the same geodatabase.
    b. ****IMPORTANT NOTE: This geodatabase must be separate from your default geodatabase or the tool may fail.****
2. Open the "MGS – Cross-Section Tool (All Steps) under the Cross Section Tools Toolset
    a. Several of the steps have been separated out of the "All Steps" script to be repeated upon changes made to other datasets. These include "Borehole Only", "Segment Profiles Only", and "Grid Line Creation Only". Remember, default names will be overwritten when running these tools. If you wish to keep any of your original outputs then you must rename them.
3. Select the newly created cross-section geodatabase.
4. Select the cross-section feature class.
5. Select the elevation units for **all your features.** The default is set to feet units.
6. Select the surface DEM used for the project.
7. Select the bedrock surface raster and the groundwater surface raster(s) (Optional)
    a. Note for Cross-Sections: These surfaces are generated in sections of confidence (solid line) and inferred (dashed lines). Anomalies in the groundwater levels often come from areas where there are no wells drilled within the selected time interval to support the predicted groundwater level.

   b. For groundwater levels, input the years you would like included in the analysis for the confidence of the surface. These years should match the years of the wells that were selected to create the groundwater raster. If left blank this will include all years.
8. Select the reformatted water well points.
9. Select the reformatted Wellogic lithology table.
10. Select the screen table created by the data formatting tool (Optional)
11. Choose your vertical exaggeration (V.E.).
    a. 50 – 100x Recommended. Default is 50.
12. Choose whether you would like the borehole lithologies to be represented by polylines or polygons.
    a. Note: Polylines are easier to read on dense cross-sections.
13. Choose how far away wells should be selected to be included in the cross-section.
    a. 250 Meters is recommended and is the default.
14. Choose your grid spacing for the cross-section frame.
    a. Recommendation if Elevation Units are in Feet = Distance: 2000 feet and Elevation: 50 feet.
15. Run the tool.
16. Complete your layout. For tips on how to put this together, watch the introductory video on creating a cross-section layout. See completed cross-section in **Figure 4**.

OPTION 2: Cross-Section Only (Custom Datasets)

The following instructions are for creating cross-sections from custom datasets that were not output from either the project creation tool or the data formatting tool.

Step 1: Prepare the workspace

1. Begin by opening a new map in ArcGIS Pro.
2. Obtain the appropriate elevation data (1-meter-resolution DEMs are recommended for areas less than 10 mi^2 in size). Merge DEMs, if necessary, to make a single raster file.
3. Create a geodatabase specifically for storing the cross-section files. ****IMPORTANT NOTE: This must be separate from your default geodatabase or the tool may fail.****

Step 2: Prepare inputs

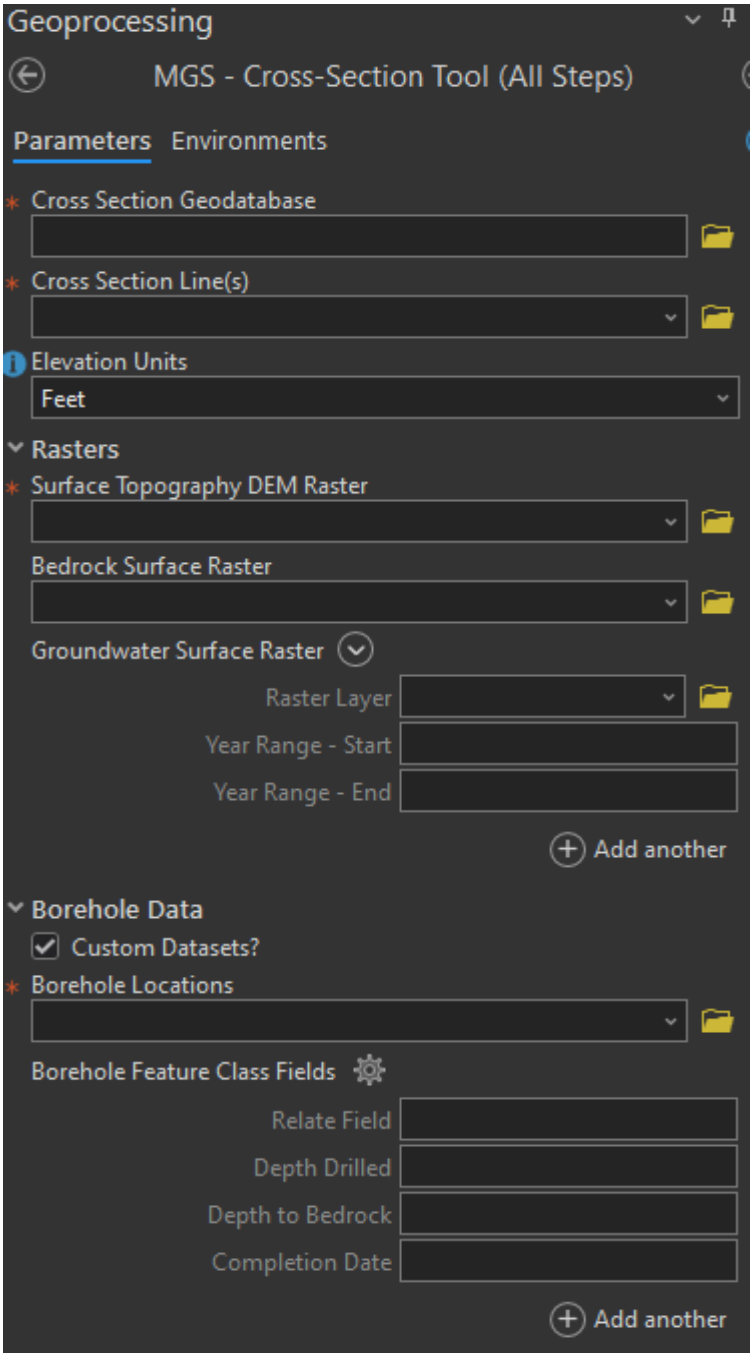
****IMPORTANT NOTE: All files used for tool inputs (other than rasters) must be in geodatabases****

1. Borehole Data
   ****IMPORTANT NOTE: Locations, lithology, and screens must all be separate files or the tool will fail. If the information for one or more of these inputs is in a single file, copy it to use as additional input****
   a. Borehole Locations
      i. This must be a point feature layer in a geodatabase.
      ii. Fields
         1. Relate Field (ID shared between all the tables with well information)
         2. Depth Drilled (Data Type-Double)
         3. Depth to Bedrock (Data Type-Double) **(Optional)**
         4. Completion Date (Data Type-Date) **(Optional)**
   b. Lithology Table

        i. Fields
            1. Relate Field
            2. Depth: Top (Data Type-Double)
            3. Depth: Bottom (Data Type-Double)
    c. Screens Table **(Optional)**
        i. Fields
            1. Relate Field
            2. Depth: Top (Data Type-Double)
            3. Depth: Bottom (Data Type-Double)
2. Surface Rasters **(Optional)**
    a. Bedrock Surface
    b. Groundwater Surface(s)

Step 3: Drawing Cross-Section Lines

1. Before using the cross-section tool, you must create cross-section lines on your map. Start by creating a new Polyline feature class in your default geodatabase.
2. Create two text string fields within the feature class called “XSEC” and “DIRECTION” (case sensitive).
3. Use the “XSEC” to name the cross-section(s).
4. In the “DIRECTION” field, you must specify the quadrant you would like the cross-section to start analyzing (or drawing) from. You must use one of the following codes below in order to define the drawing direction:
    a. If the direction is labeled as W-E, NW-SE, or E-W, the script will be reading the cross-section from the **Northwest quadrant.**
    b. If the direction is labeled SW-NE, S-N, or N-S, the script will be reading the cross-section from the **Southwest quadrant.**
    c. If the direction is labeled as NE-SW, the script will be reading the cross-section from the **Northeast quadrant.**
    d. If the direction is labeled as SE-NW, the script will be reading the cross-section from the **Southeast quadrant.**
5. Draw all necessary cross-section lines and fill out the required information in the attribute table.
6. ***DISCLAIMER*** The number of wells will determine the length of time needed to process the cross-section lines. The length of the line will also increase the processing time.



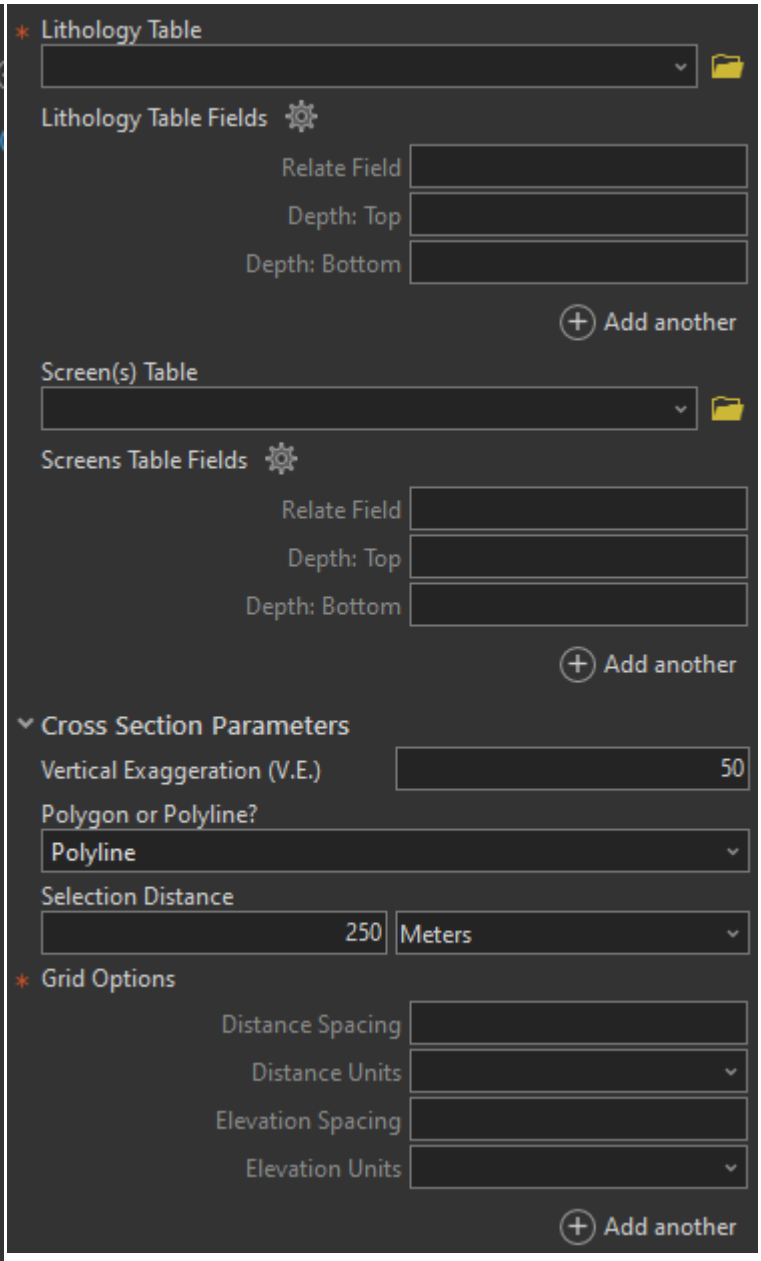


Figure 4: *Screenshot of MGS - Cross-Section Tool (All Steps) custom Python script in the ArcGIS Pro software.*

Step 5: Cross-Section Tool (All Steps)

1. Open the "MGS – Cross-Section Tool (All Steps) under the Cross Section Tools Toolset
    a. Several of the steps have been separated out of the "All Steps" script to be repeated upon changes made to other datasets. These include "Borehole Only", "Segment Profiles Only", and "Grid Line Creation Only". These can be useful for making adjustments to be specific pieces of your cross-sections without having to run the All Steps tool. Remember, default names will be overwritten when running these tools. If you wish to keep any of your initial outputs then you must rename them.
2. Select the newly created cross-section geodatabase.
3. Select the cross-section feature class.
4. Select the elevation units for **all your features.** The default is set to feet units.
5. Select the surface DEM used for the project.
6. Select the bedrock surface raster and the groundwater surface raster(s) **(Optional)**
    a. Note for Cross-Sections: These surfaces are generated in sections of confidence (solid line) and inferred (dashed lines). Anomalies in the groundwater levels often come from areas where there are no wells drilled within the selected time interval to support the predicted groundwater level.
    b. For groundwater levels, input the years you would like included in the analysis for the confidence of the surface. These years should match the years of the wells that were selected to create the groundwater raster. If left blank this will include all years.
7. Select the "Custom Datasets" check box.
8. Borehole Data
   ****IMPORTANT NOTE: Borehole Locations, Lithology**
    a. Provide the Borehole Locations for your map area.
        i. Fields
            1. Relate Field (ID shared between all the tables with well information)
            2. Depth Drilled (Data Type-Double)
            3. Depth to Bedrock (Data Type-Double) **(Optional)**
            4. Completion Date (Data Type-Date) **(Optional)**
    b. Select the lithology table.
        i. Fields
            1. Relate Field
            2. Depth: Top (Data Type-Double)
            3. Depth: Bottom (Data Type-Double)
    c. Select the screen table created by the data formatting tool **(Optional)**
        i. Fields
            1. Relate Field
            2. Depth: Top (Data Type-Double)
            3. Depth: Bottom (Data Type-Double)
9. Cross Section Parameters
    a. Choose your vertical exaggeration (V.E.).

    i. 50 – 100x Recommended. Default is 50.
b. Choose whether you would like the borehole lithologies to be represented by polylines or polygons.
    i. Note: Polylines are easier to read on dense cross-sections.
c. Choose how far away wells should be selected to be included in the cross-section.
    i. 250 Meters is recommended and is the default.
d. Choose your grid spacing for the cross-section frame.
    i. Recommendation if Elevation Units are in Feet = Distance: 2000 feet and Elevation: 50 feet.
e. Run the tool.
f. Complete your layout. See completed cross-section in **Figure 4**

Figure 5: Example cross-section for the sample project. (Credit: Garrett Ringle)