Cross Sections & Dimensions 1.0

(User Manual)

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Cross Sections & Dimensions 1.0 (User Manual)

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Contents

1 Introduction

This user manual is for a GIS tool that was developed as part of Melbourne Waterway Research-Practice Partnership for automated extraction of channel metrics. The tool runs using ArcGIS Pro functions as a backend. Thus, it requires ArcGIS Pro to be installed and licenced.

This document covers the following:

- User Interface, and
- Software Installation

2 User Interface

Figure 1 below shows the Graphic User Interface (GUI) of the Cross Sections and Dimensions tool. The tool requires only two key datasets as input. They are 1) the stream centreline and, 2) the digital elevation model (DEM). Users of this tool are expected to understand and interpret the DEM-based slope data to identify thresholds that form the toe and top of bank in their study area. At present this tool is limited to work with GDA_1994_MGA_Zone_55 projection. Below sections describe input and output options and the parameters of the tool.

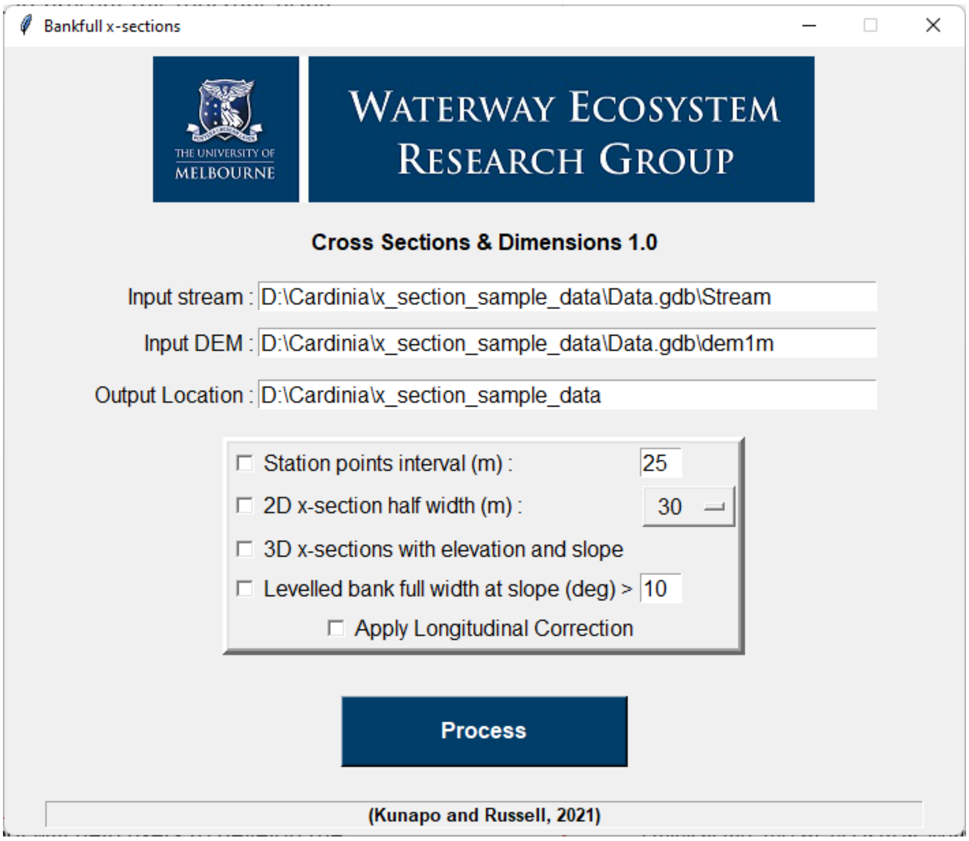


Figure 1 Graphic User Interface (GUI) of the tool.

2.1 Inputs

Parameters	Values	File format	Description
Input stream	Path to the stream centreline feature class.	ESRI feature geodatabase	• The tool starts at the centreline location to build various outputs. This stream centreline is crucial for this tool. The centreline must be within 5 metres of the lowest elevation point (i.e., thalweg) of the stream. • Users may use DEM, hillshade and/or slope data to generate and/or correct the centreline before using it with this tool. • The tool will correct the exact lowest point of cross-sections if the centreline is within 5 meters of the thalweg.
Input DEM	Path to the DEM raster.	ESRI grid, ESRI ASCII grid, TIFF or ESRI feature geodatabase	• This tool was developed to work with a 1m resolution DEM.
Output Location	Output folder location.	Directory path	• Please avoid long paths and paths with spaces. GIS functions often fail with such situations, and it varies from function to function. • Directory must exist – it may need to be created in the file system before running the tool.

2.2 Outputs

All outputs are stored in a geodatabase at <**Output location>\x_sec_outputs.gdb**

IMPORTANT: Once generated, outputs will be re-used at each rerun of the tool (with same parameters and output location) to save time. Please delete manually any outputs you need to recreate.

Station points interval (m):

This option will place station points (Figure 2) along the stream centreline at a defined interval in metres.

- Points are added in the direction of the line for each branch of the stream network.
- First, the stream centreline segments are defined, and a line feature class is created named **mwstr_segments**. Separate segments are defined between confluences (junctions of more than two stream centrelines). Otherwise, centrelines which join end to end are merged together. A field is added named **"seg_id"** which gives each segment a unique ID. This field will be carried across all cross-sectional outputs.
- The process then creates a point feature class named **station_points_<interval>m.**
- The process adds a field named "**x_sec_id**" with unique values for each station point. This field will be carried across all cross-sectional outputs.

Parameters	Values (m)	Default	Description
Station points interval (m)	5 to 1000	25	Spacing of station points (where cross-sections will be placed) along centreline

Figure 2 Typical station points generated along the input stream centreline.

2D x-section half width (m):

This option generates cross-sections at station points (Figure 4).

- The process creates a line feature class named **x_sec_i< interval >_w< half width>.**
- Users need to define the half width of the cross sections which will be used as the maximum buffer distance from the stream centreline (see Figure 3) in constructing the cross sections.
- The output cross-sections are not fully perpendicular to the stream network, rather they follow a buffer distance from the centreline (Figure 3). This method avoids intersecting cross sections.
- The cross sections are generated from left to right in the direction of stream. Figure 3 and 4 show typical cross sections developed for 40m half-width (80m total width).
- **Tip**: Estimate maximum width of the top of bank of your study area and provide half width accordingly to get better results rather than leaving the defaults. Providing a larger width than required may cause overlap issues at meandering areas and errors in levelling the cross sections.

Parameters	Values (m)	Default	Output name
2D x-section half width (m)	20 to 100	30	x_sec_i< interval >_w< half width>

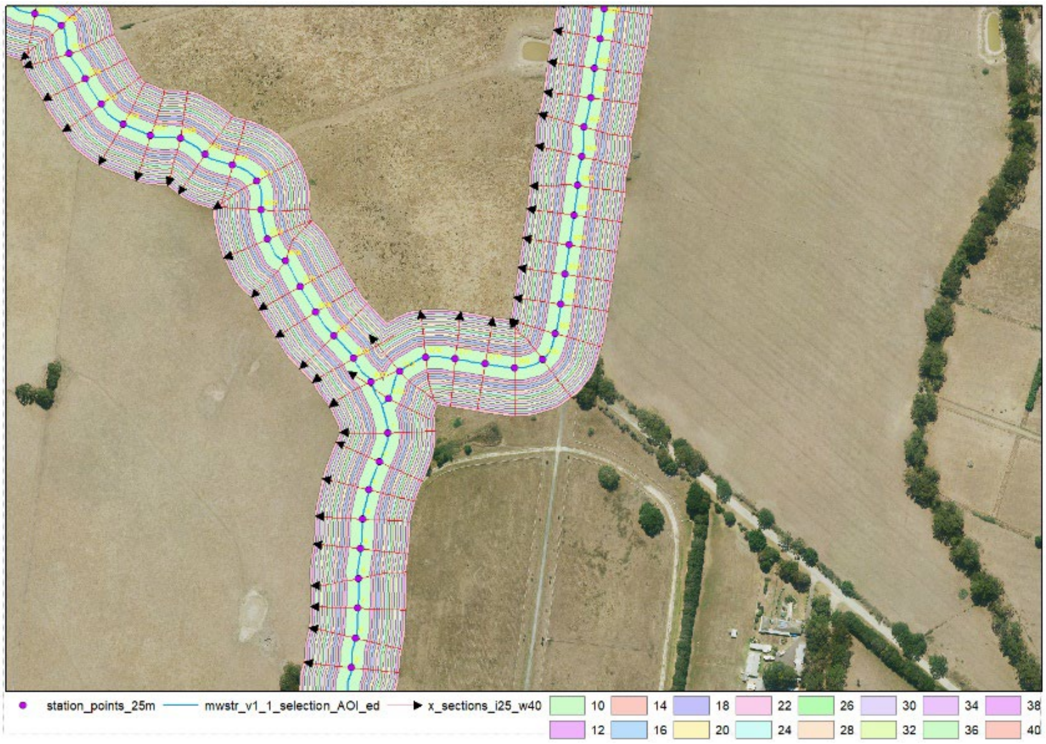


Figure 3: Figure showing how buffer rings are used in constructing cross sections.

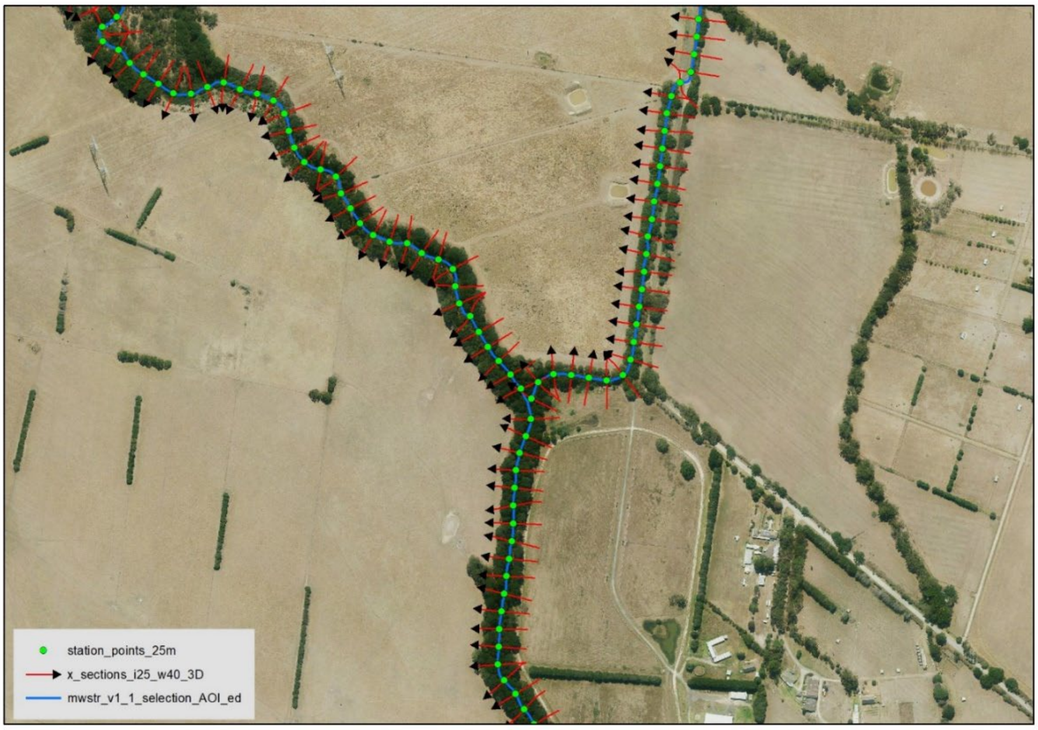
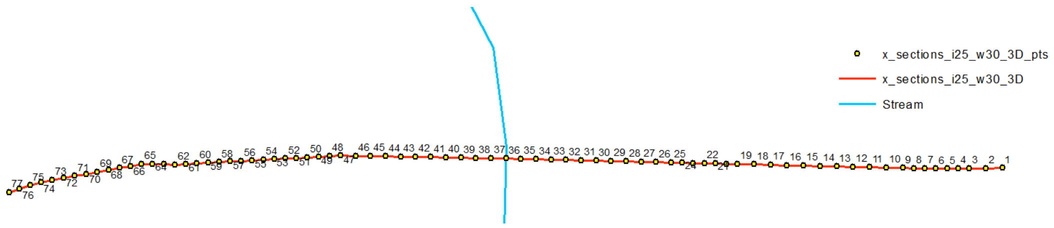


Figure 4: Typical cross-sections generated by the tool.

3D x-sections with elevation and slope:

This option will first use the input DEM to develop a slope raster in degrees named **slope_deg**.
 	
It will then use the above cross sections, the input DEM and the slope raster to develop two outputs (Figure 5):
 	
• 3D cross-section lines – **x_sec_i<interval>_w<half width>_3D.** Lines with Z values extracted from the input DEM.
• 3D cross-section points - **x_sec_i<interval>_w< half width>_3D_pts:** Points along each 3D cross-section line. This points output is used to develop levelled bankfull cross sections and levelled bank-full width polygons. The following fields are added:
    • **POINT_X**: X-coordinate of the point.
    • **POINT_Y**: Y-coordinate of the point.
    • **POINT_Z**: Z-coordinate of the point.
    • **Sort_Value**: Point sort order by position along cross-section, starting from left to right to the direction of stream.
 	

 	
    • **slope_deg**: Slope in degrees for each point.
    • **CurCentre**: Point at the centre of the cross-section (= station point location)
    • **NewCentre**: The lowest elevation point in the cross-section (within 5m of CurCentre).

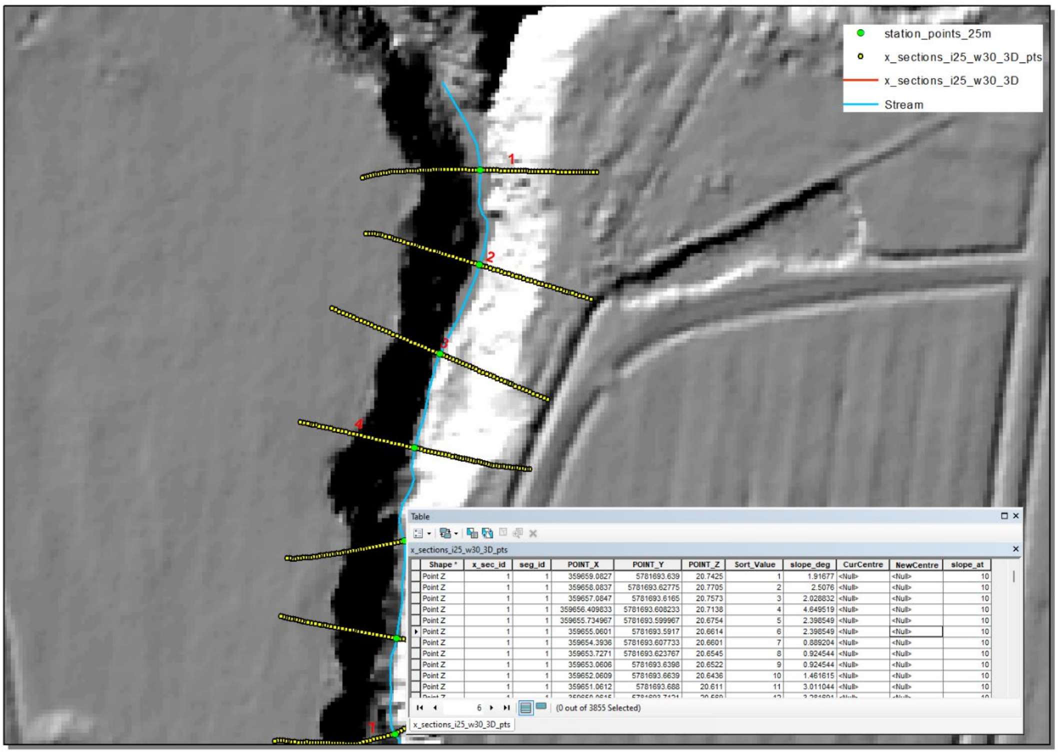
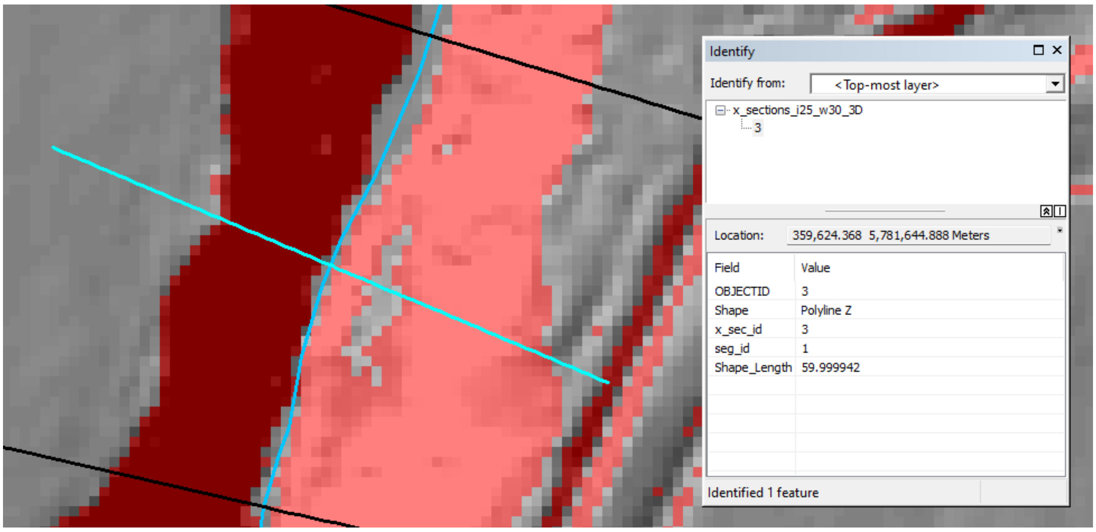


Figure 5: Typical 3D cross-sectional information generated by the tool

Levelled bank full width at slope (deg) >:
This option creates levelled bankfull cross-sections and points, and levelled bankfull extent polygon, where the bankfull elevation is based on the top of the lower of the two banks as defined by a slope threshold. While all the previous steps can be automated without any human interaction, this step requires the user's judgment and may require rerunning the tool until desired results are achieved. Users of the tool may use a slope raster to identify a threshold of slope (in degrees) where top of bank can be identified. **The tool performs the following steps using 3D x-section points and their attributes:** **Step 1:** Get high slope points (>= defined slope threshold). **Step 2**: For each cross-section, use NewCentre, minimum and maximum of sort values (Sort_Value) to separate left and right points. **Step 3:** Get max (POINT_Z) for each side to get initial estimate of levelled Z (minimum of left and right max (POINT_Z)). Remove points which are above this levelled Z.

Step 4: For the above refined collection of points, identify any slope gaps. For examples, below selected cross-section (x_sec_id = 3) has a slope gap (flat areas) along the cross-section due to stepped elevations banks. The first gap is acceptable, but not the second gap which is at the top of bank.



- Thus, logic has been built to accept only the first gap along the cross-section and the gap can't exceed more than 2 sort values.
- If the gap is larger than 2 points it will stop searching further and it recalculates levelled Z.

Step 5: Re-construct levelled cross-section lines and points (Figure 6) using the new bounds and constructs the bank full width polygon.

The flowing layers are created:

- Levelled cross-section points – **x_sec_i<interval>_w<half width>_3D_s<slope>_levelled_pts**
  The following fields are added:
  - **Slope_at** – slope threshold used to identify top of bank
  - **Lvl_z** – bankfull elevation
- Levelled cross-section lines – **x_sec_i<interval>_w<half width>_3D_s<slope>_levelled_lines**
  The following fields are added:
  - **lvl_d** – bankfull depth
  - **lvl_w** – bankfull width
- Levelled cross-section polygons - **x_sec_i<interval>_w<half width>_3D_s<slope>_levelled_poly**

Parameters	Values (m)	Default	Description
Levelled bank full width at slope (deg)	5 to 15	10	Slope threshold for identification of top of bank

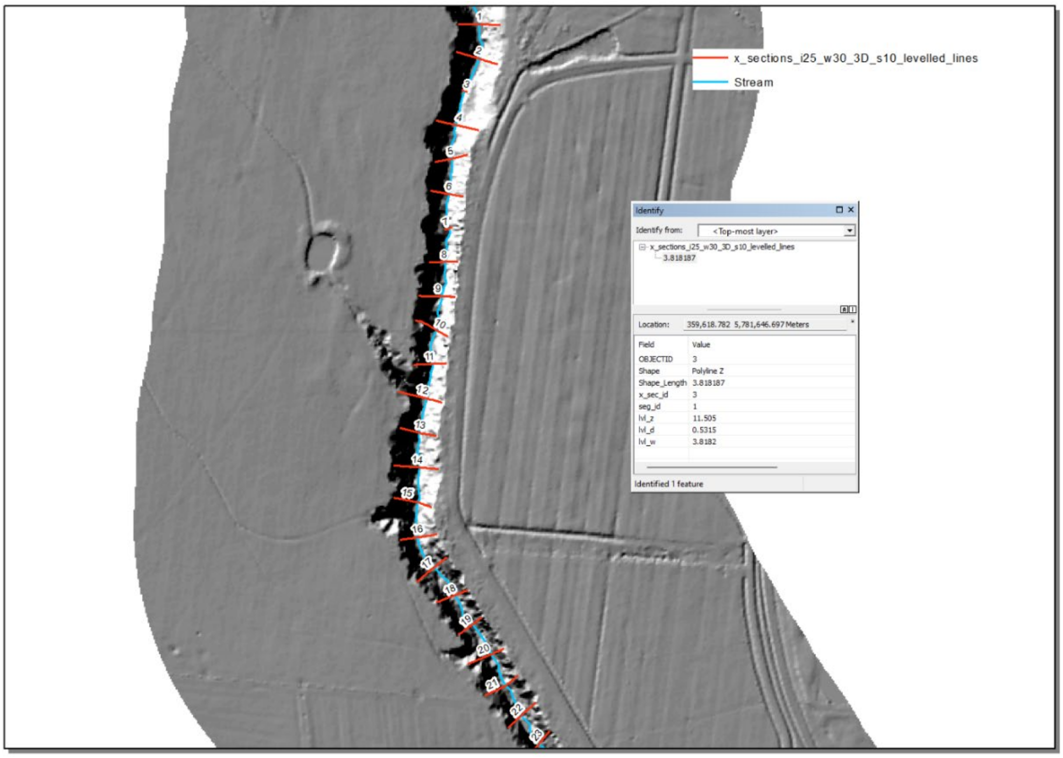


Figure 6: Typical levelled 3D cross-sections with their elevation, depth, and width. Please note 3rd cross-section shows slope-gap threshold application affect.

Apply Longitudinal Correction

This option will enable longitudinal correction to the above levelled cross-sections to smooth irregularities in bankfull width between neighbouring cross-sections. For example, cross-section 3 in figure 6 is unusual when compared to its upstream downstream cross-sections.

- The following logic is applied to correct such irregularities considering 10 cross-sections at a time to look upstream/downstream widths and their coherence:
  - **Step 1**: Remove severe outliers. For each point look at its previous and next bankfull elevations. If its elevation is a sudden change (+/- 3m) from its neighbours, it will be flagged and ignored.
  - **Step 2**: run a Linear Regression (LR) model between bankfull elevation and cross-section ID, for ten cross-sections at a time (ignoring any severe outliers already flagged). Get predicted regression values for each cross-section. If the difference between original and predicted bankfull elevation is more than 1 m, flag as an outlier and use the predicted bankfull elevation.

- **Step 3:** Re-construct levelled cross-section lines and points (Figure 7) using the new bankfull elevation (lvl_z) applied to original cross-sections and also construct the bank full width polygon (Figure 8).

Cross-section 3 in figure 7 below is an example of the effect of longitudinal correction. Longitudinal correction of outliers may or may not be desirable depending on the application. The user's judgment is required here.

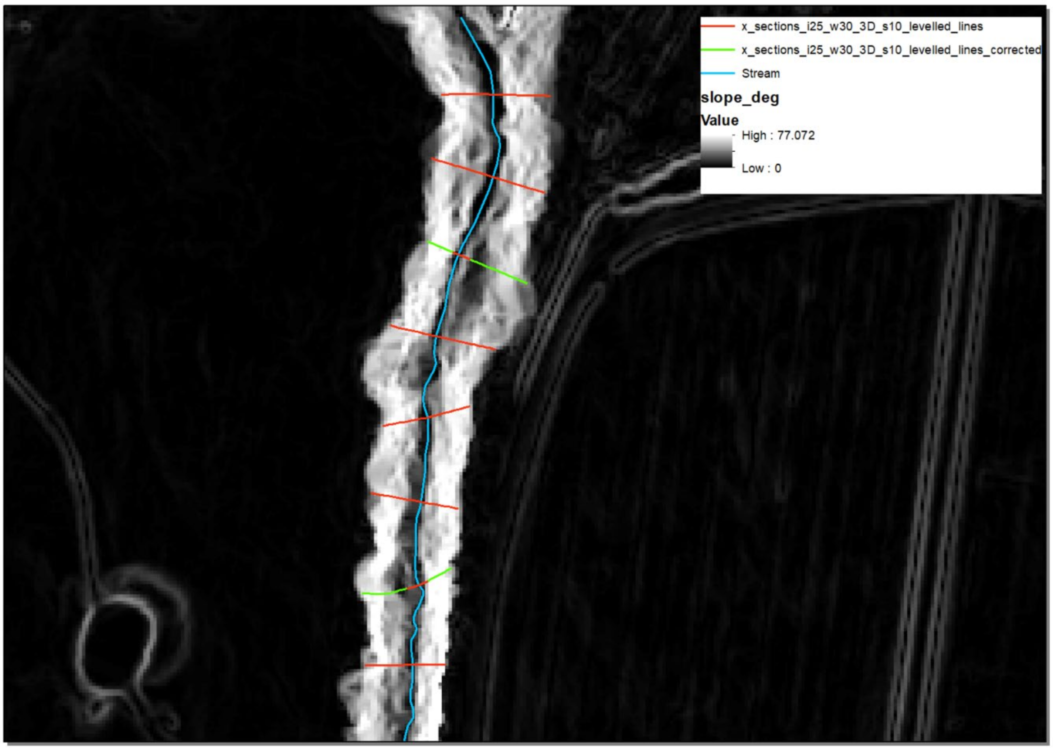


Figure 7: Typical levelled 3D cross-sections with longitudinal correction applied.

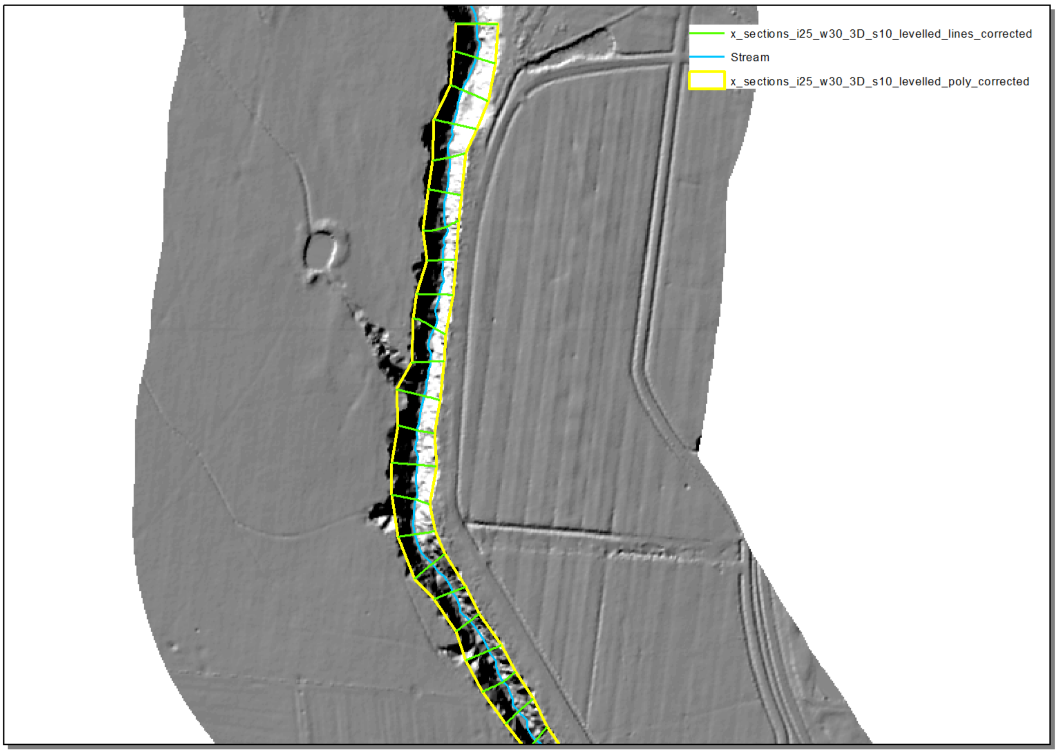


Figure 8: Typical bankfull width polygon constructed using levelled cross-sections.

3 Software installation

3.1 System Requirements:

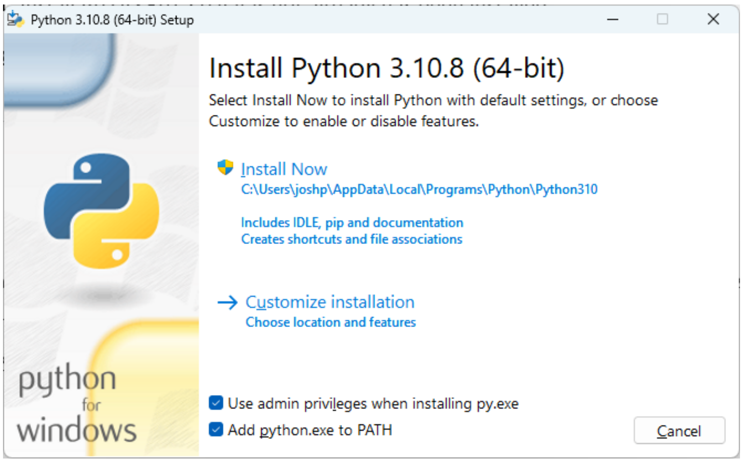
ArcGIS Pro must be installed prior to the installation of this Tool.

3.2 Installation:

Step 1: Install ArcGIS Pro 3.0 if it is not already has been installed.

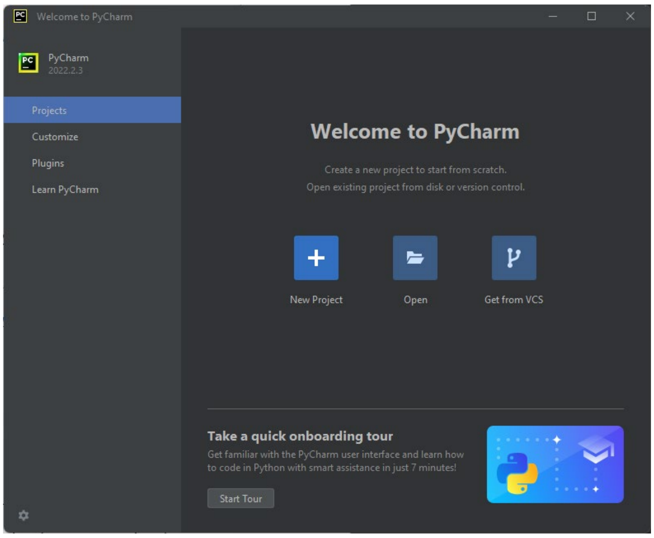
Step 2: Install Python 3.10 or greater.

https://www.python.org/ftp/python/3.10.8/python-3.10.8-amd64.exe



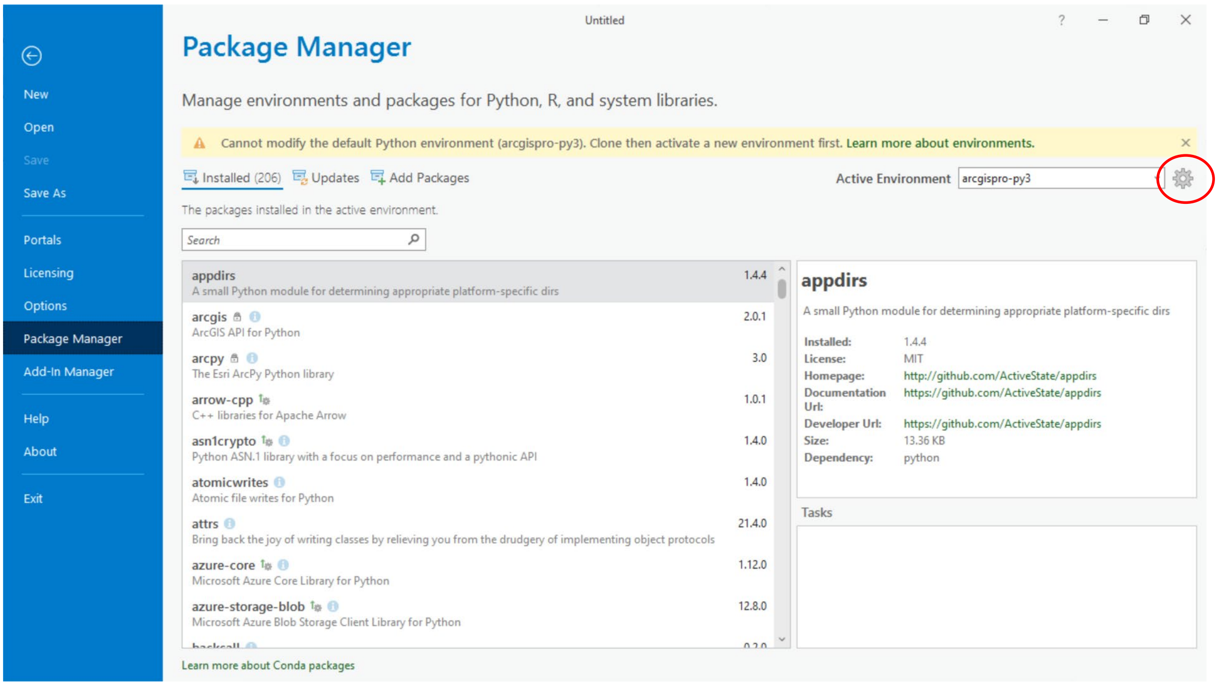
Step 3: Install latest Pycharm Community Edition from https://www.jetbrains.com/pycharm/

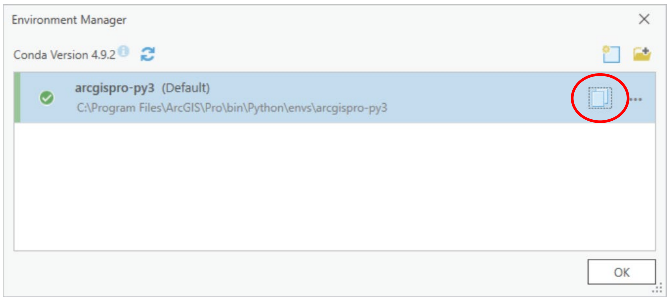
https://www.jetbrains.com/pycharm/download/download-thanks.html?platform=windows&code=PCC

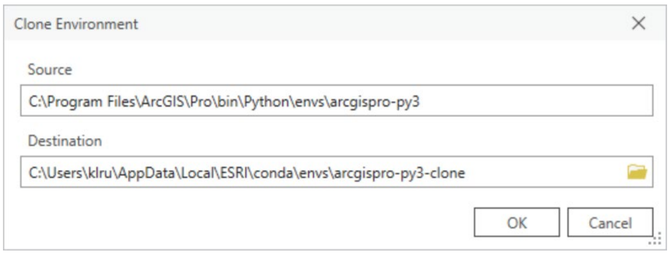


Step 4: In ArcGIS Pro, Clone arcgispro-py3 environment, install Scikit-learn package in clone environment.

Go to Project -> Package Manager, then next to Active Environment click the settings gear wheel.

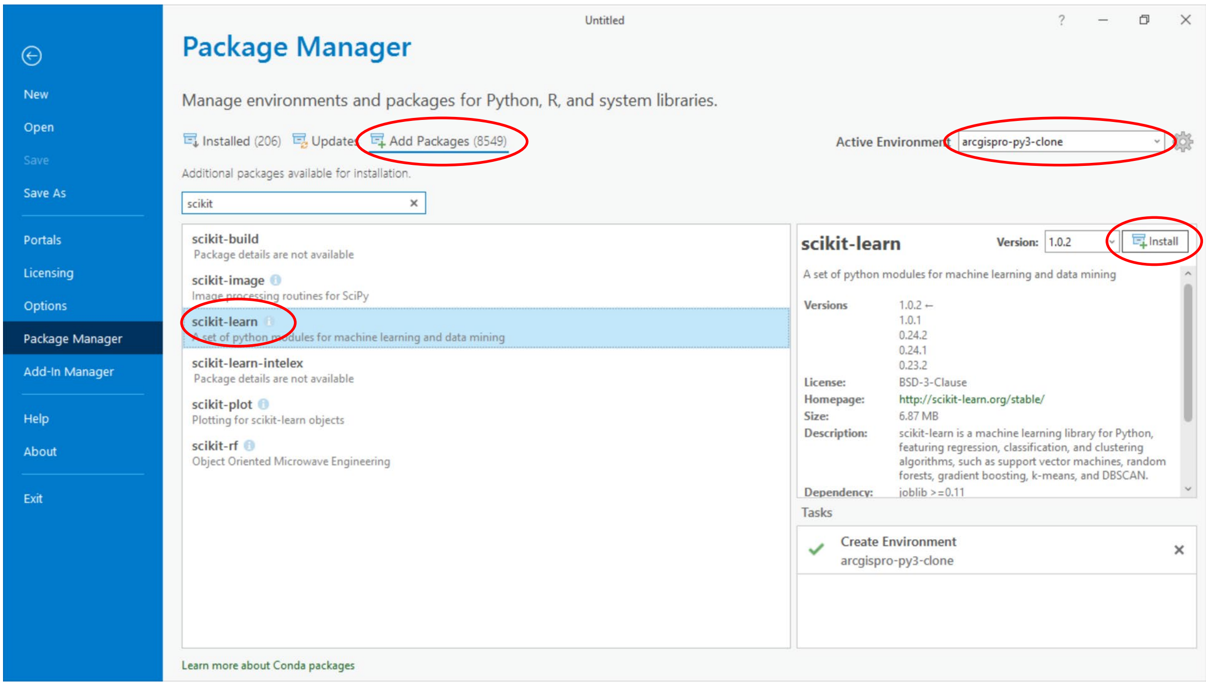






Cloning can take a few minutes.

Change Active Environment to the cloned environment, then go to Add Packages and search for scikit-learn and click install.



You can now exit ArcGIS Pro.

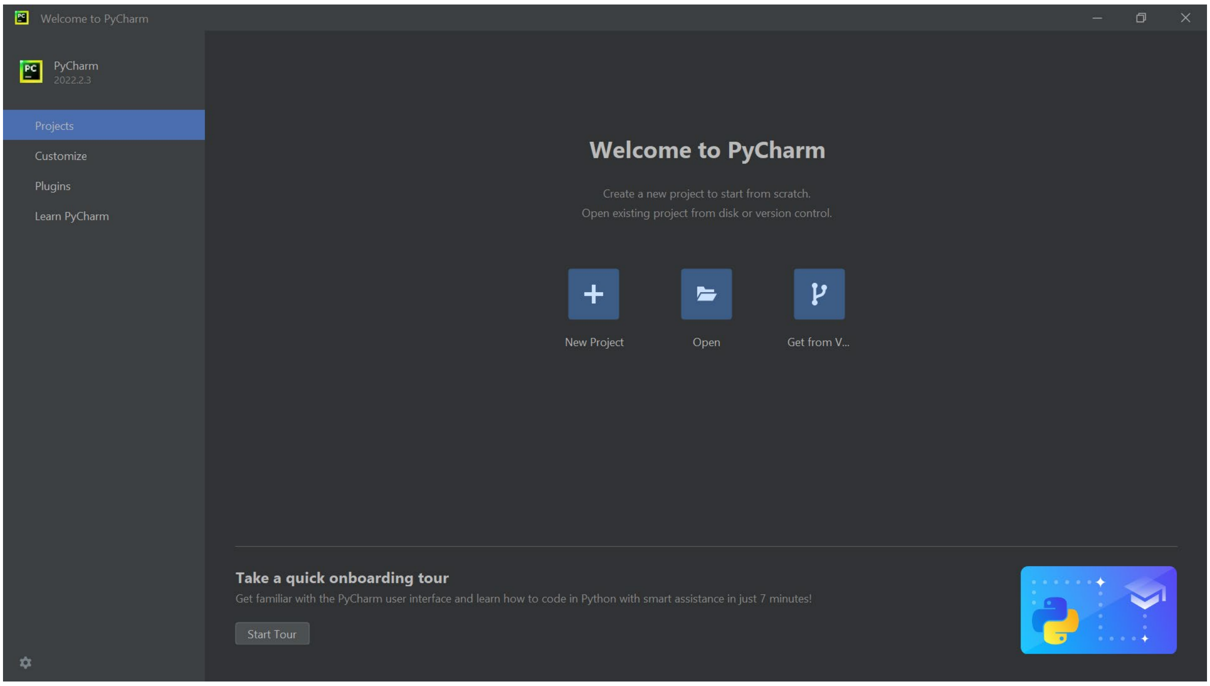
Step 5: In PyCharm, Configure Python interpreter for ArcGIS Pro (arcgispro-py3-clone)

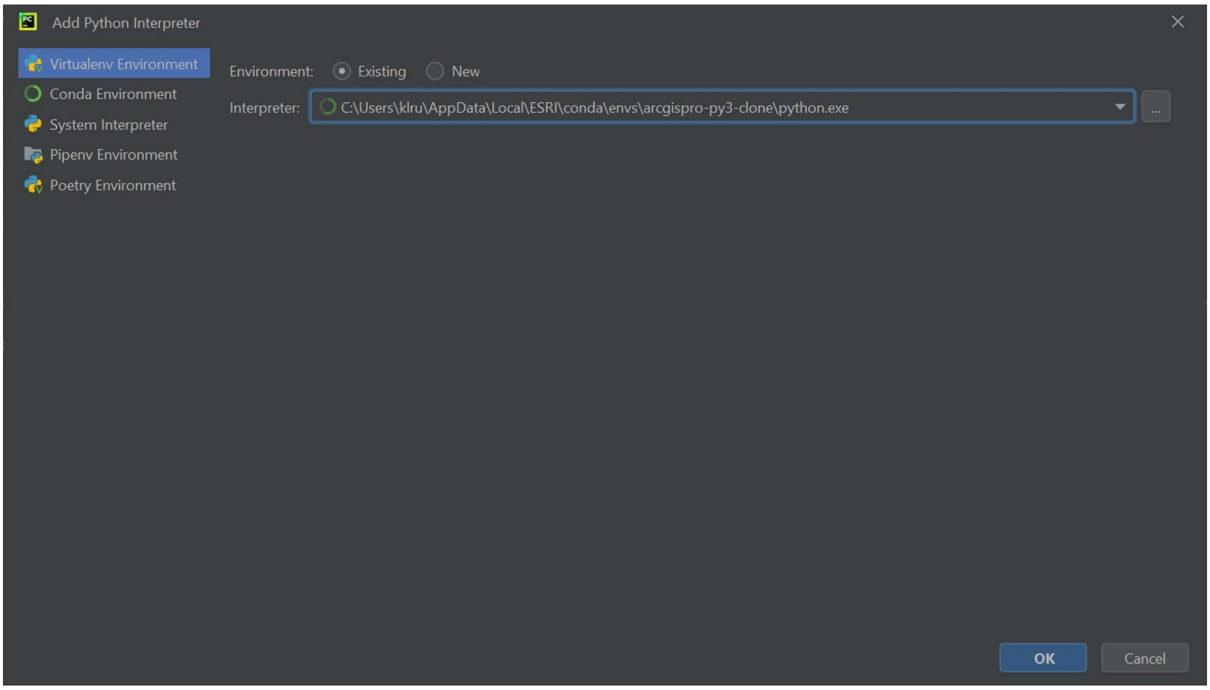
When you first launch PyCharm, click New Project.

Create a new project in whatever location you like.

Under Python Interpreter, select "Previously configured interpreter" then select Environment: "Existing" and navigate to the python.exe file in the cloned environment. The path in our example is:

C:\Users\klru\AppData\Local\ESRI\conda\envs\arcgispro-py3-clone\python.exe

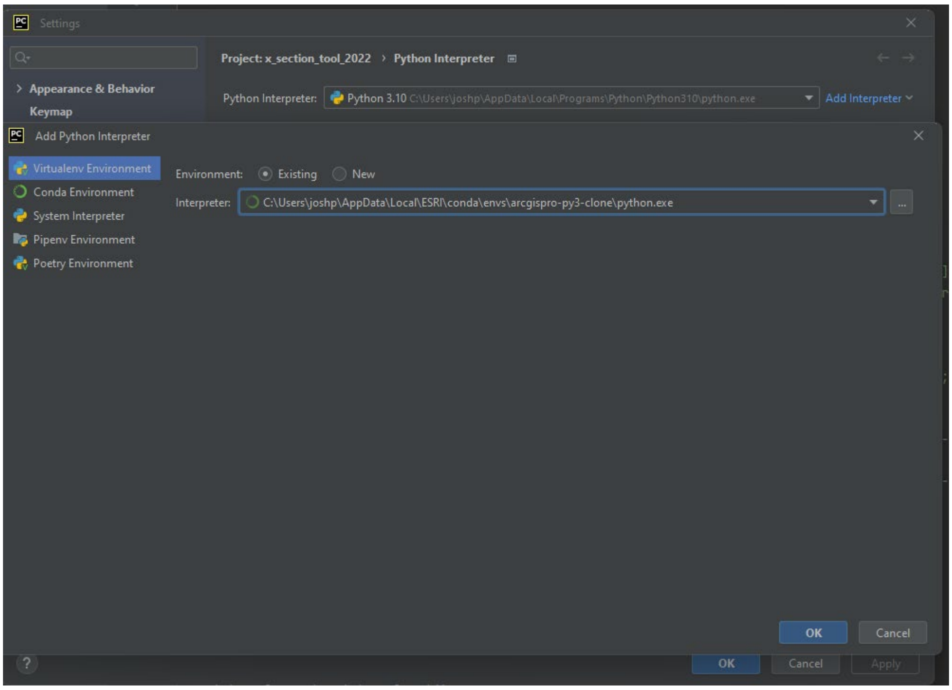




If you have previously configured PyCharm, change the Python interpreter as follows.

After PyCharm launches, click the gear at the upper right corner of the screen (or press Ctrl-Alt-S) to open the settings dialog. You can set up PyCharm with multiple Python interpreters, and we want to make the default setup for ArcGIS Pro (you can choose others though, which is handy!)

1. *Select Project: (project name) and then Python Interpreter at left*
2. *Click Add Interpreter at upper right and select Add Local Interpreter*
3. *Select the Existing environment radio button*
4. *For Interpreter: click the ... icon at right and navigate to and select the python.exe for Pro: C:\Users\klru\AppData\Local\ESRI\conda\envs\arcgispro-py3-clone\python.exe*
5. *Click OK.*

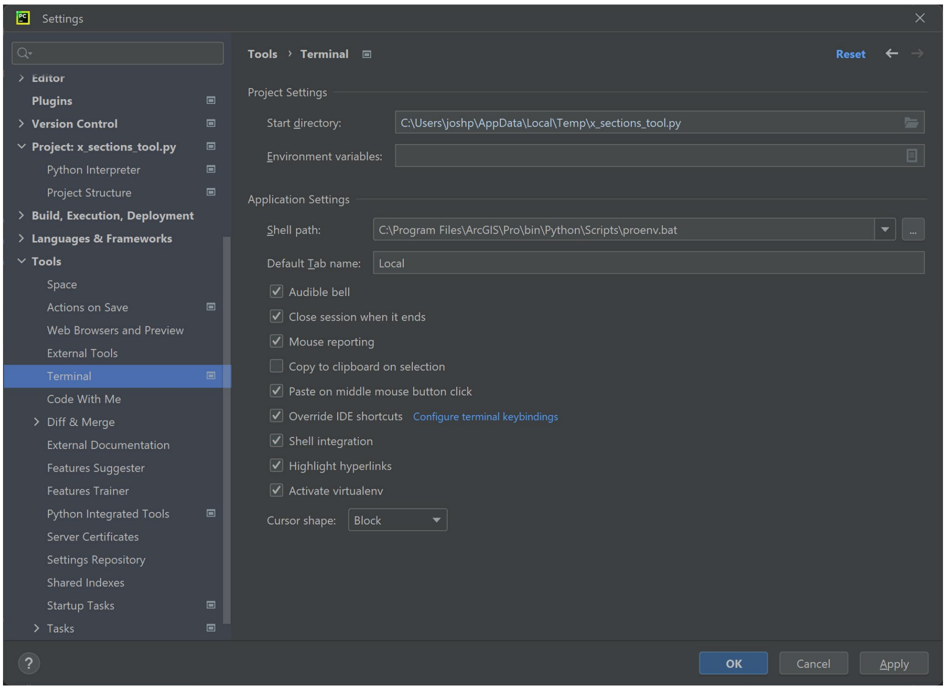


Configure PyCharm Terminal for ArcGIS Pro

PyCharm supports a terminal window for use in manipulating the conda environment, running shell tools, editors, or whatever else. The standard shell environment for ArcGIS Pro is the one you launch by with the Windows shortcut Python Command Prompt - which launches a shell with the proenv.bat script.

Bring up to the same settings dialog used above to set the Python interpreters

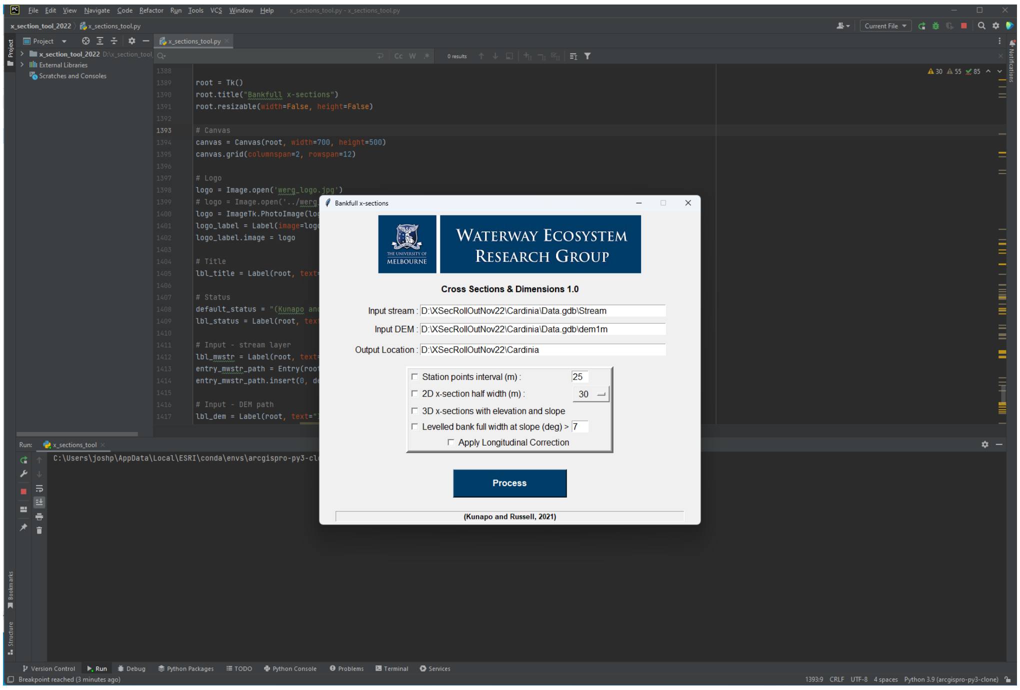
Still in Settings, at left, find Tools > Terminal



For Shell Path: click the ... icon at right and navigate to and select

C:\Program Files\ArcGIS\Pro\bin\Python\Scripts\proenv.bat

Step 6: Open "D:\x_section_tool_2022\x_sections_tool.py" in Pycharm code editor and run.



3.3 Tutorial Dataset:

A sample dataset (<Drive>:\x_section_tool_2022\x_sec_sample_data) has been provided to test this tool. Run the tool using this sample data at least once before using your own data.