

# Riparian Zone Estimation Tool (RipZET) User's Manual

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## Introduction

The San Francisco Estuary Institute and Aquatic Science Center (SFEI-ASC) has developed the Riparian Zone Estimation Tool (RipZET) to help the California community of riparian interests visualize and characterize riparian areas as habitat unto themselves as well as their capacity to support the ecosystem services of the state's streams, lakes, and wetlands. RipZET is a tool used with a Geographic Information System (GIS) and spreadsheet software to estimate "functional riparian width." According to this concept, the kinds of functions that a riparian area can provide depend on its structure, which includes local physical site characteristics and vegetation characteristics, as well as its width and overall area. Essentially, larger riparian areas tend to support higher levels of more kinds of functions than smaller areas (Wenger 1999). The concept of functional riparian width is central to the riparian definition recommended by the National Research Council (NRC 2002) and is integral to many riparian design and management guidelines (e.g., Johnson and Buffler 2008).

RipZET produces estimates of functional riparian width along stream channels, lakes, and wetlands using three separate modules:

1. Hillslope Processes module (or Hillslope module)
  - Appropriate for steep, low order channels and upper watershed lakes and wetlands.
  - Targeted riparian functions include large woody debris (LWD) and coarse sediment supply.
  - Estimates functional riparian width for large watershed areas based on the hillslope angle adjacent to the channel. For every 1% increase above a threshold angle value, the module provides 1 m of functional riparian width.
2. Vegetation Processes module (or Vegetation module)
  - Appropriate for steep, low order channels to lower gradient, mid-watershed channels.
  - Targeted riparian functions include shading, bank stabilization, and runoff filtration.
  - Estimates functional riparian width for large watershed areas based on adjacent floodplain or hillslope angle and vegetation height. The module estimates functional riparian width using the equation:

$$w = Ah \times \cos(B)$$

where  $w$  is the functional width,  $h$  is the mature tree height,  $A$  is the tree height adjustment factor (greater than 1), and  $B$  is the floodplain or hillslope angle. Essentially, the functional riparian width for a flat floodplain is at least 1 tree height and the width decreases as the floodplain or hillslope angle becomes steeper.

3. Hydrologic Connectivity module (or HyCon module)
  - Appropriate for low gradient alluvial channels with established floodplains.
  - Targeted riparian functions include floodwater storage, fine sediment trapping, and groundwater recharge.
  - Estimates functional riparian width for discrete channel reaches based on an estimate of the inundation extent for large floods. The modules estimates functional riparian width using peak flood discharge estimates with a simple hydraulic equation (Manning's equation)



$$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$$

where  $Q$  is flow discharge,  $A$  is flow area within the channel,  $n$  is a surface roughness factor,  $R$  is hydraulic radius (similar to average flow depth), and  $S$  is local channel slope. The module uses this equation to determine flow stage for large floods, which is then used with channel-floodplain cross-section topography to estimate the maximum local flood elevation and the associated local inundation extent.

The output of each RipZET module is a unique visual display (GIS coverage) of the estimated functional riparian area. The displays are not regarded as riparian maps *per se* because they do not depict areas with definite boundaries based on field indicators. Instead, they depict areas where the riparian functions represented by the individual modules are likely to be supported. The modules can be run separately or together, and the outputs from different modules can be conflated to estimate the maximum likely riparian extent for all the functions represented by all the modules.

The purpose of this document is to provide RipZET users with the instruction needed to run the RipZET modules and troubleshoot simple issues that may arise while running the tool. Here, the user will find information about required hardware and software necessary for running RipZET, guidance regarding how to engage the tool, step-by-step instruction for running the three modules, and an overview of the outputs from the modules. The user is encouraged to refer to other related documents to find information regarding the science behind each of the RipZET modules (i.e., Collins et al. 2006, SFEI 2015a, SFEI 2015b).

## Hardware and Software Recommendations/Requirements

The following are required or recommended when using the RipZET Tools:

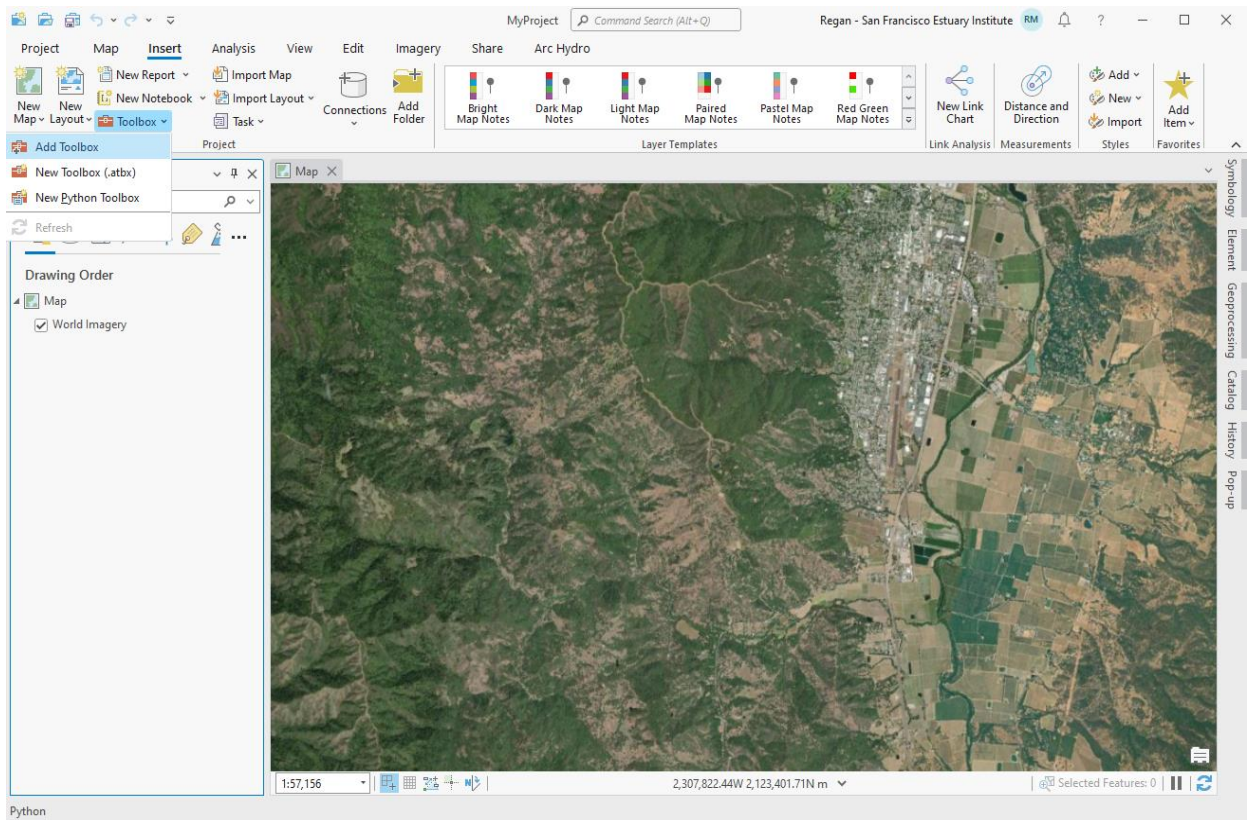
- (1) 4 GB RAM (*required*) - 8 GB RAM (*recommended*)
- (2) ArcGIS Pro 3.x
- (3) ArcPy 3.9
- (4) Spatial Analyst Extension
- (5) 3D Analyst Extension (*required for HyCon modules*)
- (6) Microsoft Excel (*required for HyCon modules*)

## Introduction to the RipZET Toolbox

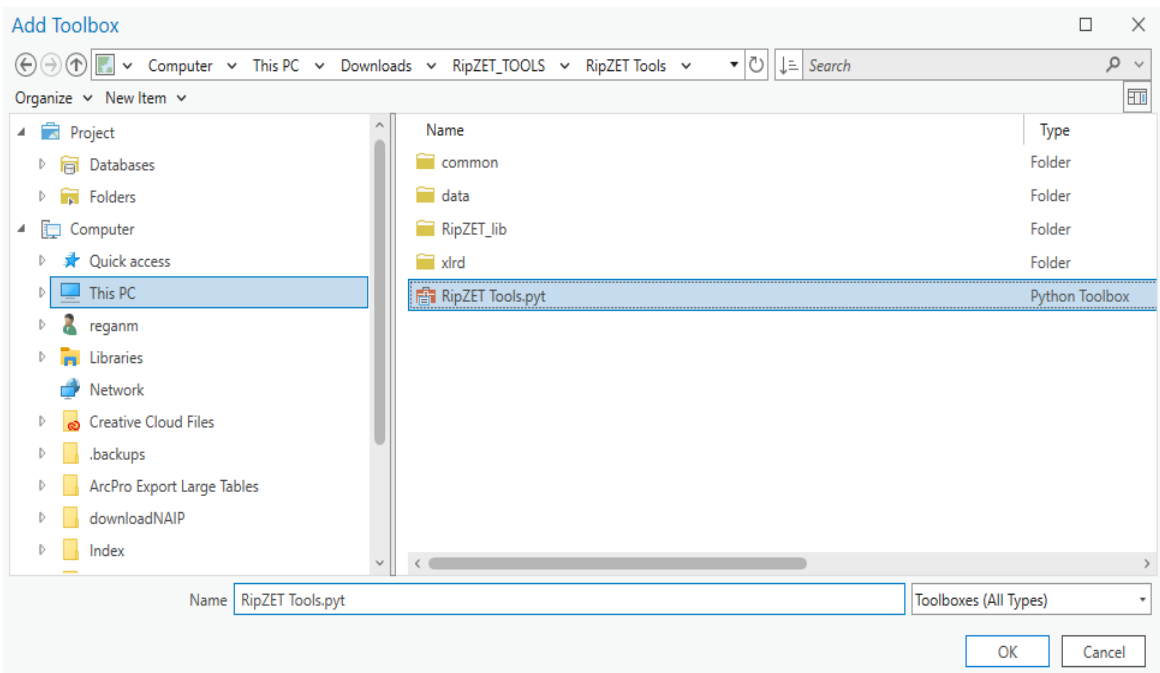
### Loading the RipZET Toolbox

- (1) Open a new map document in ArcGIS Pro.
- (2) Navigate to the **Insert** tab and click **Toolbox > Add Toolbox**.



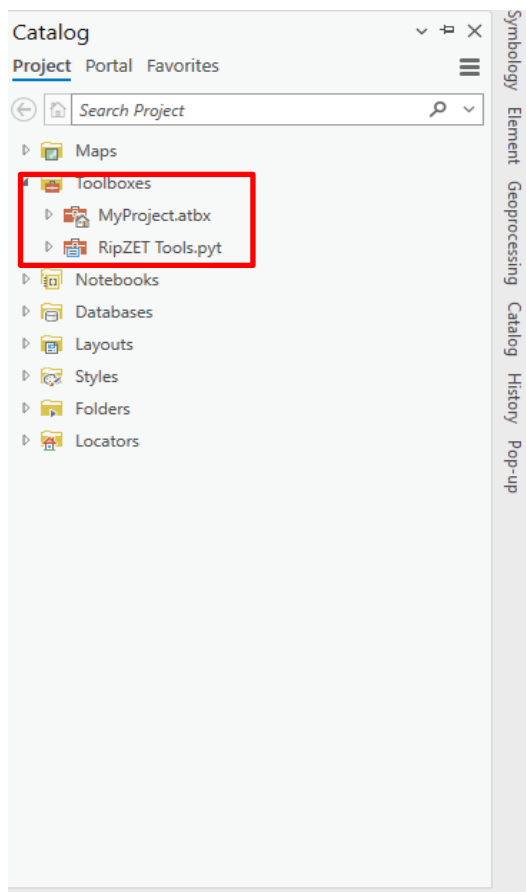


- (3) Browse to the location of the unzipped RipZET Tools folder and select the **RipZET Tools.pyt** toolbox file.



- (4) The RipZET Tools Toolbox has now been added to the **Toolboxes** section of the **Catalog** pane.





## The RipZET Toolbox

There are three primary RipZET modules that can be used to estimate functional riparian extent: **Hillslope**, **Vegetation**, and **Hydrologic Connectivity (HyCon)**. The Hillslope and Vegetation modules can be run together and used to determine functional riparian width for large watershed areas. Four tool components are required to run the Hillslope and Vegetation modules and generate width estimates:

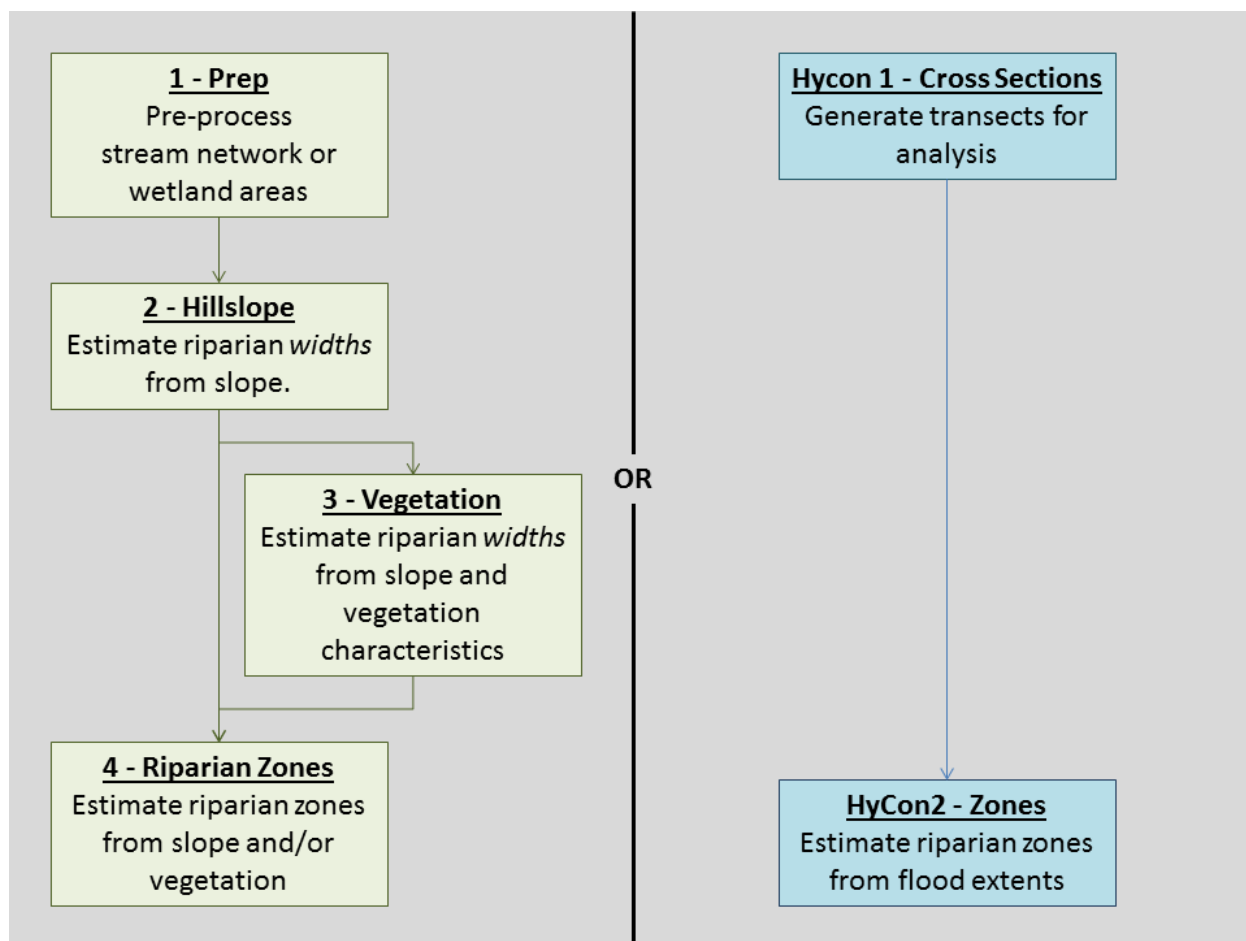
- 1 – Prep (prepares the input data)
- 2 – Hillslope
- 3 – Vegetation
- 4 – Riparian Zones (compiles the output data)

The HyCon module is used to determine the functional riparian zone width for discrete alluvial reaches. The module uses two tools to generate width estimates:

- HyCon 1 – Cross-Sections (generates channel-floodplain cross-sections)
- HyCon 2 – Zones (estimates functional riparian extent on the channel-floodplain cross-sections)

The diagram below outlines the **Riparian Zones** and **HyCon workflows**, or the order and combination of tools that must be run to estimate the riparian zone within a specified watershed area.





## Required Datasets and Tool Preparations

The Riparian Zones and HyCon workflows require a different set of input parameters. Some datasets used to generate input parameters may require pre-processing by the user. In general, all datasets should be saved with a consistent spatial reference in a file geodatabase.

### Riparian Zones (Hillslope and Vegetation)

- (1) Stream network (line feature class) and/or wetland areas (polygon feature class)
- (2) Topography (raster)
- (3) Vegetation layer (polygon feature class)

### Hydrologic Connectivity

- (1) Site point (point feature class)
- (2) Watershed boundary (polygon feature class)
- (3) Stream network (line feature class)
- (4) LiDAR Digital Elevation Model (DEM) (raster)



## Hillslope and Vegetation Module Data Requirements

### Stream Network

- (1) Required format: line feature class
- (2) Minimum field requirements:

Field Description	Field Type
Stream order (Strahler number)	Short integer
Stream type, with unique designations for "natural channels" and "unnatural channels"	Text

### Wetland Boundary

- (1) Required format: polygon feature class
- (2) Minimum field requirements:

Field Description	Field Type
Wetland type, with designation for "open water"	Text

### Topography

- (1) Required format: raster
- (2) Raster cells should have slope values in percent units.

### Vegetation

- (1) Required format: polygon feature class
- (2) Minimum field requirements:

Field Description	Field Type
Tree height (m)	Double
Standard Zone Distance (m)	Double
Vegetation Code	Text

### Preparing the Stream Lines

Some preprocessing of streamlines is required to assign Strahler stream orders to lines. RivEX (<http://www.rivex.co.uk/>) is recommended for this process, but other tools may be available to complete this step. The Prep tool requires that a stream order field exists and contains valid values.

Additional requirements:

- Stream features cannot be multipart: run the ArcGIS Multipart to Singlepart (Data Management) tool to explode multipart features
- Streams cannot contain Z or M values: run the ArcGIS Feature Class to Feature Class (Conversion) tool with Geodatabase Settings selected to ignore Z and M values

### Preparing the Vegetation Layer

The vegetation feature class must include tree height, standard zone distance, and vegetation code fields. The tree height field values are estimated vegetation heights by vegetation class or code; alternately, a standard zone distance field value can be assigned to indicate a default zone width that the tool will use instead of calculating zone width from tree height. Each feature should be assigned *either* a height or a standard distance value (a value of -1 signifies which field value should be ignored).



A minimum zone width of 1 m should be applied for barren classes, and open water should be assigned a zone width of 0.

Adding height and distance fields can be accomplished by first creating a table of heights and/or standard distances by tree species, class, or code, then joining the table to the vegetation feature class. A sample tree height table based on CALVEG classifications is provided in the RipZET download, but the same approach can be applied for any classification system as long as a unique code exists for joining the vegetation features. Alternatively, a normalized digital surface model (nDSM) of the project site can be used to statistically assign vegetation heights to a vegetation feature class as was done for the [DARI RipZet Pilot](#).

### ***HyCon Module Data Requirements***

All datasets should be saved with a consistent spatial reference in a file geodatabase.

#### **Site Point**

- (1) Required format: point feature class
- (2) This dataset should contain a single point, representing the along-stream midpoint of the reach.

#### **Watershed Area(s)**

- (1) Required format: polygon feature class

#### **Stream Network**

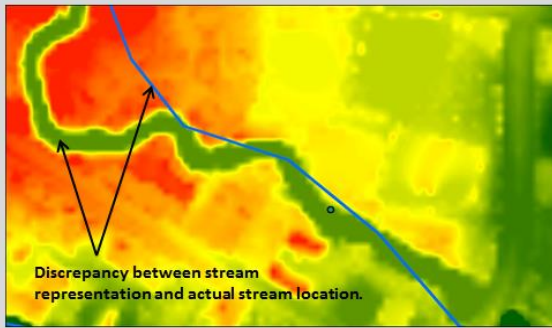
- (1) Required format: line feature class
- (2) Stream segment data in the area of interest may need to be edited to align approximately with the channel thalweg as indicated in the underlying LiDAR. Before editing, making a backup copy of the original stream data is recommended. Note that editing the stream segment may require reconnecting tributary streams to the final segment.

#### **LiDAR Digital Elevation Model**

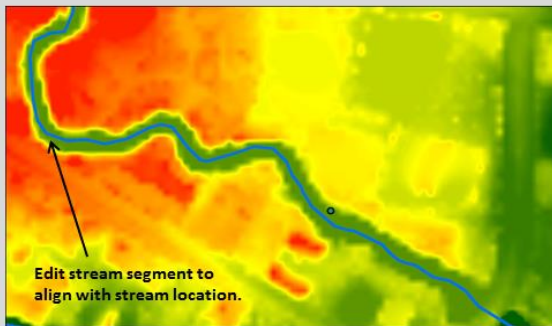
- (1) Required format: raster  
Minimum resolution requirement: we recommend using at least a 0.5-m resolution DEM.

### ***Preparing the Stream Line for HyCon***





If using a prefabricated stream dataset, a stream segment may only generally represent the stream topography. If so, edit the stream segment in the area of interest.



The HyCon module calculates the length of the stream reach based on local conditions, so the length of the segment needing adjustment will vary. Depending on the site, a total length of 400-600 m (200-300 m upstream and downstream) is suggested.

For the module to define the upper and lower bounds of the reach, the reach segment must be a single line feature. To create a single line feature, the following additional workflow may be required:

- Make a backup copy of the stream feature class
- In ArcMap, select the stream line features that compose the estimated reach segment
- Export the selected features to a new feature class
- Dissolve the exported features into a single line feature
- Delete the selected features from the original stream feature class
- Append the dissolved reach line to the stream feature class

## Suggested Stream and Wetland Data Sources

### Hydrography/wetlands:

[National Hydrography Dataset \(NHD\) - Streams](#)

[NHDplus - Streams](#)

[Bay Area Aquatic Resources Inventory \(BAARI\) - Streams and Wetlands](#)

### Hillslope:

[National Elevation Dataset](#)

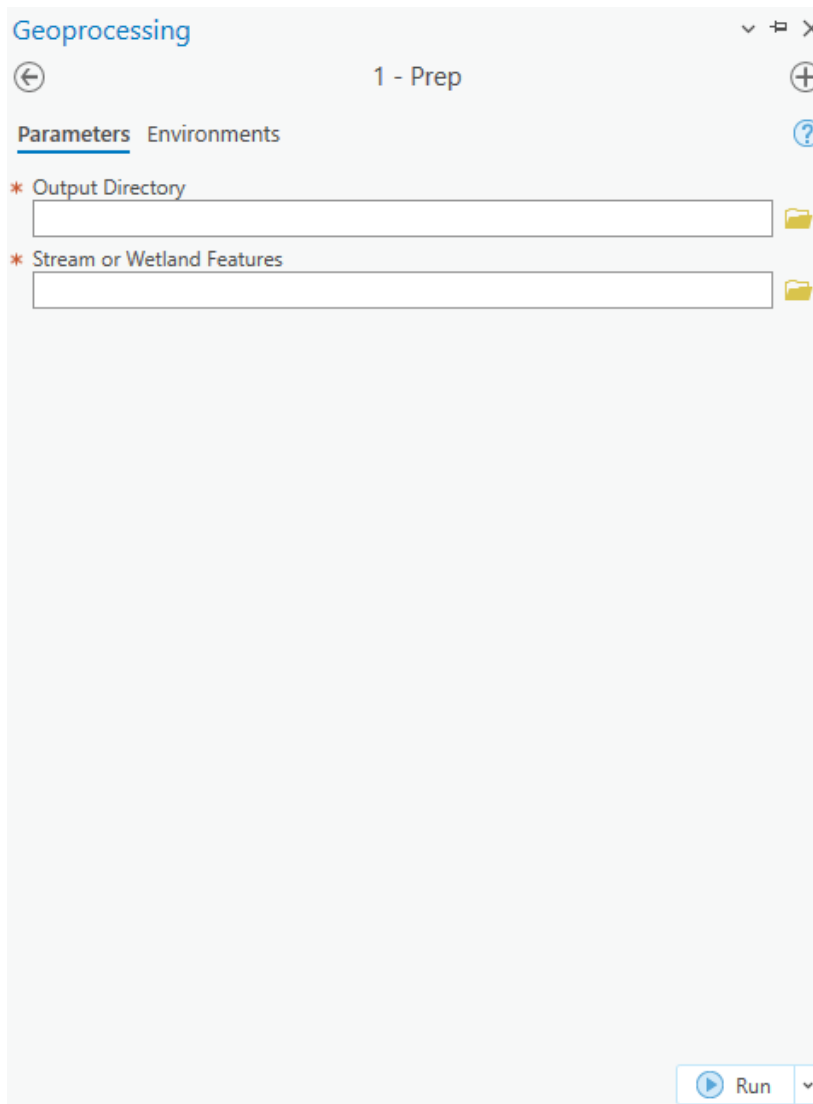
### Vegetation:



## Running the Riparian Zones Workflow (Hillslope and Vegetation Modules)

### 1 – Prep (*required*)

- (1) In the **RipZET Tools** toolbox, double-click on **1 – Prep**.
- (2) The tool will open to the following interface:



- **Output Directory:** Select the folder where you would like the tool outputs to save.
- **Streams or Wetland Features:** Select the line feature class (streams) or polygon feature class (wetland areas) for your desired area of interest.



Based on your **Stream or Wetlands** input (i.e. line or polygon feature class), the tool will determine which input parameters are required.

### **For Streams**

- (3) After a stream dataset is selected, the tool will present the following interface, highlighting the required input parameters:

The screenshot shows the 'Geoprocessing' window with the '1 - Prep' step selected. The 'Parameters' tab is active, and the 'Stream or Wetland Features' parameter is highlighted in red. The 'Type Field' parameter is also highlighted in red and marked with a red asterisk. The 'Stream Order Field' parameter is highlighted in red. The 'Standard Bank Distances (m)' parameter is highlighted in red. The 'Natural Channel Type' parameter is highlighted in red. The 'Unnatural Channel Type' parameter is highlighted in red. The 'Preserve Fields in Output' parameter is highlighted in red. The 'Run' button is at the bottom right.

Geoprocessing 1 - Prep

Parameters Environments

Output Directory  
RipZET\_User\_Manual\_Example

Stream or Wetland Features  
NHDFlowline\_CAalbers\_StreamOrder

\* Type Field

Stream Order Field

Standard Bank Distances (m)

Natural Channel Type

Unnatural Channel Type

Preserve Fields in Output

Run

- **Type Field:** Use the dropdown menu to select the attribute field for stream type.
- **Stream Order Field:** Use the dropdown menu to select the attribute field name for Strahler number.
- **Standard Bank Distances:** Distances to buffer streams by stream order. The default values begin with 1 m for stream order 1 and continue to the maximum stream order in the stream network. The final distance value is used for all unnatural channels.
- **Natural Channel Type:** Use the dropdown field to select the stream type attribute for natural stream channels.



- **Unnatural Channel Type:** Use the dropdown field to select the stream type attribute for unnatural stream channels/ditches.
  - **Preserve Fields in Output:** Select all fields that you wish to retain in the final tool outputs.
- (4) Enter or select the desired parameter values and click **OK**.
- (5) A warning may appear in the tool messages for first-order channels that are connected on both sides. This message is informational and does not indicate an error in processing or results.

### For Wetland Areas

- (6) After a wetland dataset is selected, the tool will present the following interface, highlighting the required input parameters:

The screenshot shows the 'Geoprocessing' window with the '1 - Prep' step selected. The 'Parameters' tab is active, displaying the following fields and options:

- Output Directory:** RipZET\_User\_Manual\_Example
- Stream or Wetland Features:** nwi\_wetlands
- Type Field:** RipZetType
- Open Water Type:** (empty field)
- Non-Riparian Types:** Select All (checkboxes for Open Water, Wetland)
- Inner Riparian Types:** Select All (checkboxes for Open Water, Wetland)
- Exclude Riparian Types:** Select All (checkboxes for Open Water, Wetland)
- Preserve Fields in Output:** (empty dropdown menu)

A 'Run' button is located at the bottom right of the interface.

- **Type Field:** Use the dropdown menu to select the attribute field for wetland type. *Polygons with an open water designation will receive a 1-m buffer when inside other wetland type areas and will be erased from the final slope and vegetation zones.*



- **Open Water Type:** Use the dropdown menu to select the wetland type attributes for open water.
- **Non-Riparian Types:** Select all wetland type attributes for non-riparian areas. *Polygons with any of the selected designations will receive no buffer when inside other wetland type areas.*
- **Inner Riparian Types:** Select all wetland type attributes for the inner riparian zone. *Polygons with any of the selected designations will receive a 1-m buffer when inside other wetland type areas and will be erased from the final slope and vegetation zones.*
- **Exclude Riparian Types:** Select any wetland type attributes that should be excluded from analysis.
- **Preserve Fields in Output:** Select all fields that you wish to retain in the final tool outputs. *(Recommended: use the Select All button to ensure your attribute data is retained.)*

(7) Enter or select the desired parameter values and click **OK**.

When the tool completes execution, a RipZET work geodatabase will be saved to your Output Directory. The file geodatabase will have a name of the format ripzet\_yyyy.mm.dd\_hh.mm.ss\_work.gdb and will be needed when running the subsequent Riparian Zone modules. The tool will also save a RipZET results geodatabase to the same directory, with the format ripzet\_yyyy.mm.dd\_hh.mm.ss\_results.gdb.

## 2 – Hillslope (required)

After running the Prep Tool, move on to the Hillslope module.

- (1) In the **RipZET Tools** toolbox, double-click on **2 – Hillslope**.  
The tool will open to the following interface:

The screenshot shows the '2 - Hillslope' tool interface within the Geoprocessing environment. The 'Parameters' tab is active, displaying several input fields and a 'Run' button. The 'RipZET Work Geodatabase' and 'Percent Slope Raster' fields are marked with a red asterisk, indicating they are required. The 'Percent Slope Threshold' is set to 20, 'Slope Segment Distance (m)' is set to 100, and 'Line Cluster Tolerance (m)' is set to 25. The 'Tool Mode' is a dropdown menu. A 'Run' button is located at the bottom right of the interface.



- **RipZET Work Geodatabase:** Navigate to and select the file geodatabase produced by the Prep Tool. (*Tip: this will be located in the output directory you specified in the Prep Tool.*)
- **Slope Raster:** Navigate to and select your slope raster (cell values should have percent units).
- **Slope Threshold:** Enter the slope limit (percent). Beyond this threshold, the buffer width will increase by 1 m for every percent increase in hillslope. Default value: 20%  
*Note:* Hillslope zones are not generated where average slope is less than the threshold value. Raising the slope threshold will increase overall hillslope zone width and area; lowering the slope threshold will decrease overall hillslope zone width and area.
- **Slope Segment Distance:** Enter the distance at which slope lines should be segmented. Default value: 100 m.
- **Line Cluster Tolerance:** Enter the line cluster tolerance—this is the minimum length for the line segments that are buffered to form riparian zones. Line segments shorter than this minimum distance will be appended to an adjacent line. Default value: 25 m.
- **Tool Mode:** Select Streams or Wetlands, based on the original Prep Tool input.

(2) Enter or select the desired parameter values and click **OK**.

After running the Hillslope module, the user may choose to also run the Vegetation module or to view the functional riparian zones widths generated by the Hillslope module.

### 3 – Vegetation (optional)

The Prep tool and Hillslope module must be executed prior to running the Vegetation module.

- (1) In the **RipZET Tools** toolbox, double-click on **3 – Vegetation**.  
The tool will open to the following interface:

The screenshot shows the '3 - Vegetation' tool interface. It has a title bar 'Geoprocessing' and a subtitle '3 - Vegetation'. Below the title bar are two tabs: 'Parameters' (selected) and 'Environments'. The 'Parameters' tab contains several input fields, each preceded by a red asterisk: 'RipZET Work Geodatabase', 'Vegetation Features', 'Line Cluster Tolerance (m)' (with a value of 25), 'Tree Height Field', 'Tree Height Factor' (with a value of 2), 'Standard Zone Distance Field', 'Vegetation Code Field', and 'Tool Mode'. At the bottom right, there is a 'Run' button with a play icon.



- **RipZET Work Geodatabase:** Navigate to and select the file geodatabase produced by the Prep Tool. (*Tip: this will be located in the output directory you specified in the Prep Tool.*)
- **Vegetation Features:** Navigate to and select the vegetation feature class.
- **Line Cluster Tolerance:** Enter the line cluster tolerance—this is the minimum length for the line segments that are buffered to form riparian zones. Line segments shorter than this minimum distance will be appended to an adjacent line. Default value: 25 m.
- **Tree Height Field:** Use the dropdown menu to select the vegetation feature class attribute field name for tree height.
- **Tree Height Factor:** Enter the number of mature tree heights to be used along with adjacent hillslope angle to determine functional width. Default value: 2.  
*Note:* Raising the tree height factor will increase overall vegetation zone width and area; lowering the tree height factor will decrease overall vegetation zone width and area.
- **Standard Zone Distance Field:** Use the dropdown menu to select the attribute field name for standard zone distance.
- **Vegetation Code Field:** Use the dropdown menu to select the attribute field name for vegetation code.
- **Tool Mode:** Select Streams or Wetlands, based on the original Prep Tool input.

(2) Enter or select the desired parameter values and click **OK**.

## 4 – Riparian Zones (required)

The user must run this tool to produce the final functional riparian zone estimates from the Hillslope and Vegetation modules.

- (1) In the **RipZET Tools** toolbox, double-click on **4 – Riparian Zones**.  
The tool will open to the following interface:

The screenshot shows the '4 - Riparian Zones' tool interface. It has a title bar with 'Geoprocessing' and '4 - Riparian Zones'. Below the title bar are tabs for 'Parameters' and 'Environments'. The 'Parameters' tab is active, showing several input fields:
 

- 'RipZET Work Geodatabase' with a folder icon.
- 'Riparian Zone Type' with a dropdown arrow.
- 'Tool Mode' with a dropdown arrow.
- 'Riparian Zone Bins (m)' with a text input field containing '0-10,10-30,30-50,50-100,100-'.
- 'Riparian Line Bins (m)' with a text input field containing '0-50,50-100,100-200,200-500,500-'.
- 'Inner Riparian Zone Distance (m)' with a text input field containing '1'.

 At the bottom right is a 'Run' button with a play icon.



- **RipZET Work Geodatabase:** Navigate to and select the file geodatabase produced by the Prep Tool. *(Tip: this will be located in the output directory you specified in the Prep Tool.)*
- **Riparian Zone Type:**
  - **Slope:** Select Slope to generate riparian zones based on hillslope.
  - **Vegetation:** Select Vegetation to generate riparian zones based on vegetation. This option requires that the Vegetation tool has been executed.
- **Tool Mode:** Select Streams or Wetlands, based on the original Prep Tool input.
- **Riparian Zone Bins:** The tool outputs include additional analysis by binned riparian zone widths. Default bins: 0-10, 10-30, 30-50, 50-100, 100-.
- **Riparian Line Bins:** The tool outputs include additional analysis by binned stream lengths. Default bins: 0-50, 50-100, 100-200, 200-500, 500-.
- **Inner Riparian Zone Distance:** Applies only to wetland zones. Default value: 1.

(2) Enter or select the desired parameter values and click **OK**.

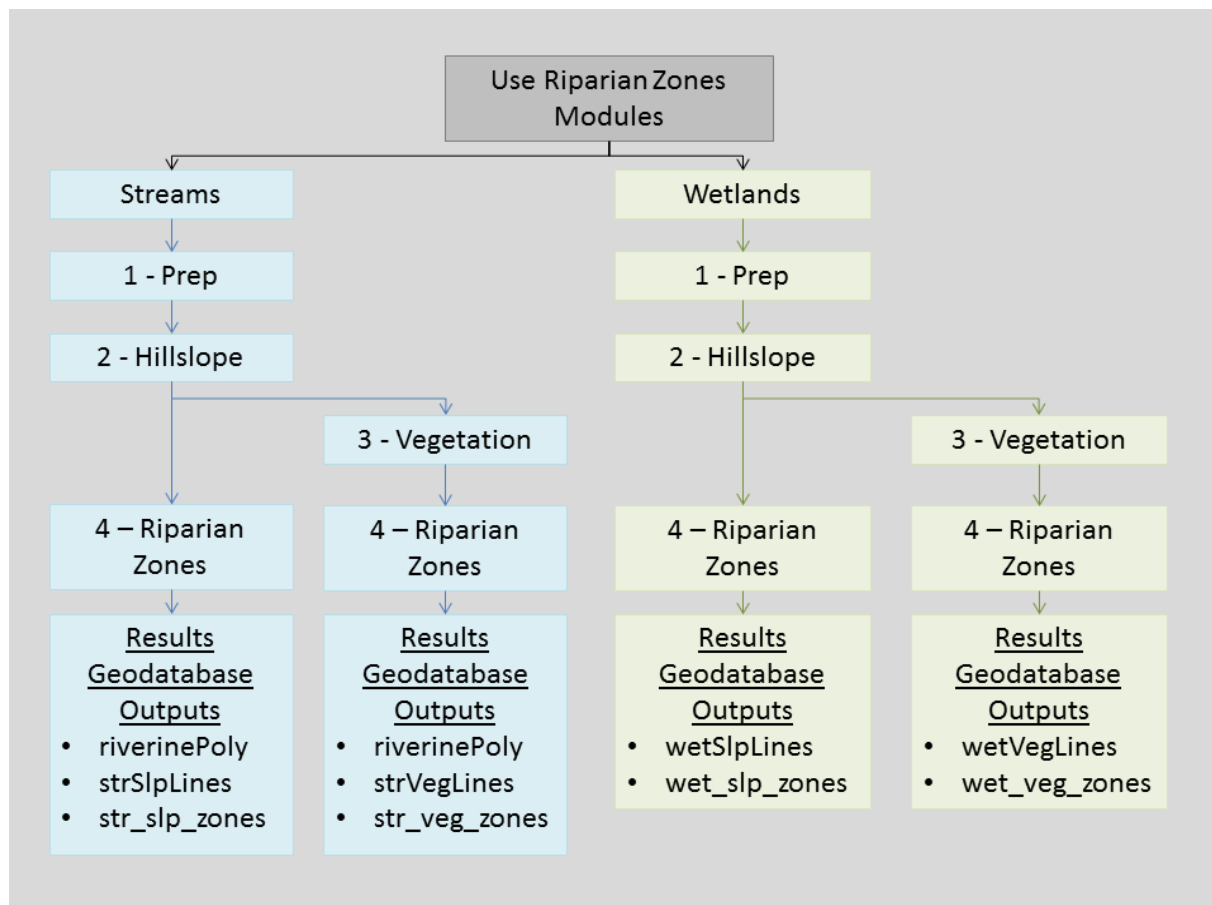
## Understanding the Riparian Zones Workflow Output

### Results Geodatabase

The primary final tool output will be a RipZET results geodatabase (a file geodatabase formatted as `ripzet_yyyy.mm.dd_hh.mm.ss_results.gdb`), which will contain the riparian zone estimates. The feature classes contained in the RipZET results geodatabase will depend on tool mode (i.e. streams or wetlands) and riparian zone type (i.e. based on Hillslope or Hillslope and Vegetation).

The diagram below describes the contents of your RipZET Results Geodatabase based on the modules and inputs used:





### **riverinePoly (polygon feature class)**

This polygon feature class is generated only when the initial input/tool mode is a stream dataset. This feature class contains polygon stream areas. The width of the buffered stream area is based on stream order and the standard bank distances provided as inputs to the Prep Tool.

### **strSlpLines, strVegLines, wetSlpLines, and wetVegLines (line feature classes)**

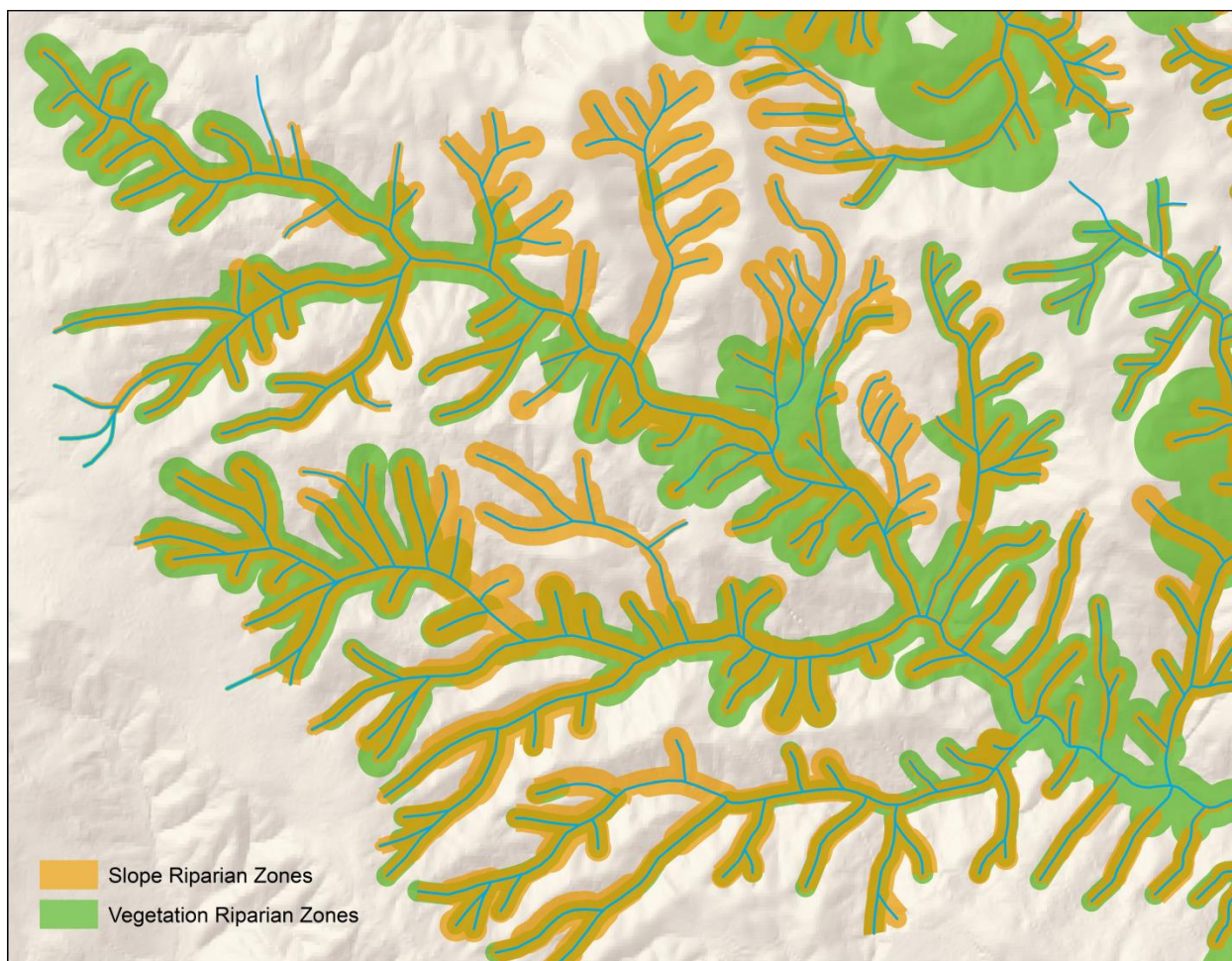
These feature classes contain line segments that represent the along-bank extent of the riparian zone estimated areas for the Hillslope and Vegetation modules along streams (strSlpLines and strVegLines) and along wetlands (wetSlpLines and wetVegLines).

### **str\_slp\_zones, str\_veg\_zones, wet\_slp\_zones, and wet\_veg\_zones (polygon feature classes)**

These feature classes contain the riparian zone estimated areas outside of the stream area polygon (riverinePoly).

The image below provides an example of the estimated riparian zone polygon for a channel network:





### **Map Document**

When the tool is completed a map document will be saved to the output folder specified while running the Prep Tool (formatted as ripzet\_yyyy.mm.dd\_hh.mm.ss\_map.mxd).

### **Ancillary Files**

<b>ripzet_yyyy.mm.dd_hh.mm.ss_messages.csv:</b>
If the RipZET tools are executed in an integrated development environment (IDE), this file will record all tool execution messages (similar to the Messages output in an ArcDesktop Results Window).
<b>ripzet_yyyy.mm.dd_hh.mm.ss_work_summary.csv:</b>
This file records the input parameters and process execution time for each of the Riparian Zone modules run.



**ripzet\_YYYY.MM.DD\_HH.MM.SS\_work\_mode\_riparianZoneType\_Charts.csv:**

This file provides tabular data for the following:

- Vegetation Riparian Functional Length by Buffer Width
- Vegetation Average Buffer Width by Stream Length
- Vegetation Riparian Functional Area by Stream Type
- Vegetation Riparian Functional Area by Buffer Width
- Vegetation Riparian Functional Area by Stream Order

**ripzet\_YYYY.MM.DD\_HH.MM.SS\_work\_mode\_riparianZoneType\_Charts.pdf:**

This pdf contains charts based on

ripzet\_YYYY.MM.DD\_HH.MM.SS\_work\_mode\_riparianZoneType\_Charts.csv.

## Running the Hydrologic Connectivity (HyCon) Modules

*Note: This tool has not been updated to Python 3 and is only usable in ArcMap. Additionally, these modules require the ArcGIS Spatial Analyst and 3D Analyst extensions and Microsoft Excel.*

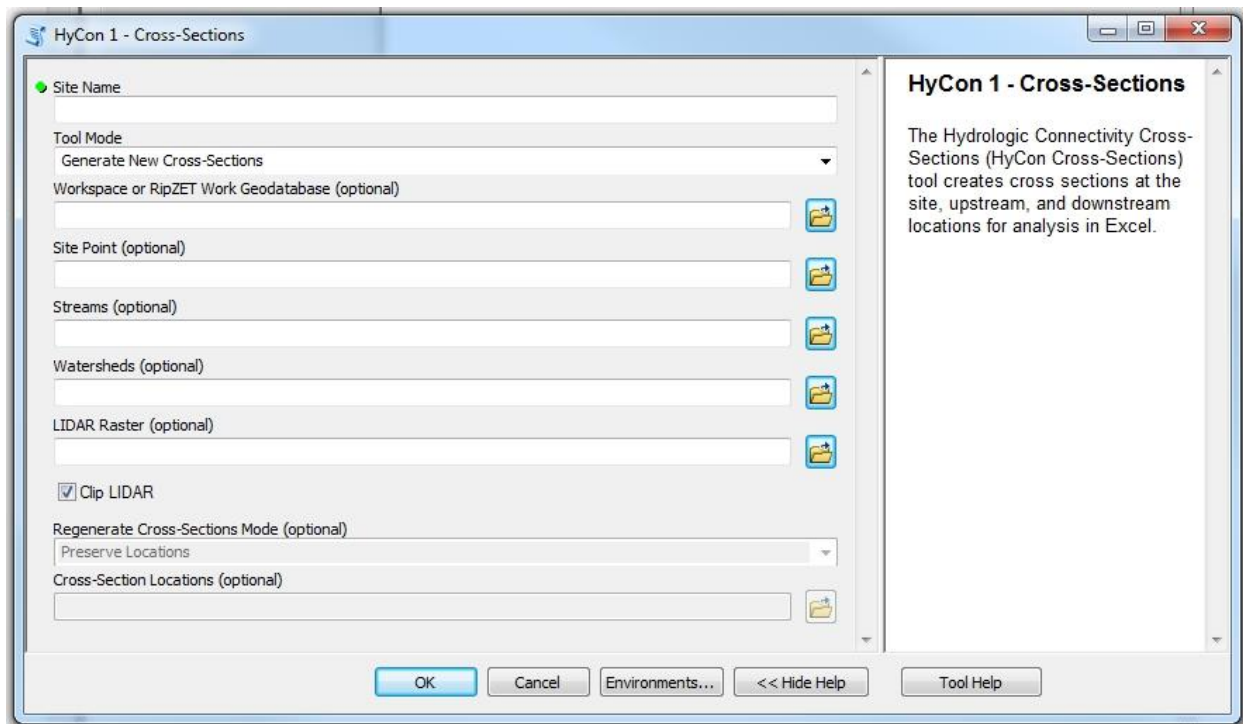
The HyCon modules are intended to be used in low gradient alluvial channels with established floodplains. Appropriate channel characteristics include an average channel gradient  $\leq 2.5\%$ , a width to depth ratio  $\geq 8$ , and adjacent floodplains that are currently or were historically inundated by frequent flood flows.

### HyCon 1 – Cross-Sections (required)

The Cross-Sections Tool is the first of the HyCon modules.

- (1) In the **RipZET Tools** toolbox, double-click on **HyCon 1 – Cross-Sections**.  
The tool will open to the following interface:



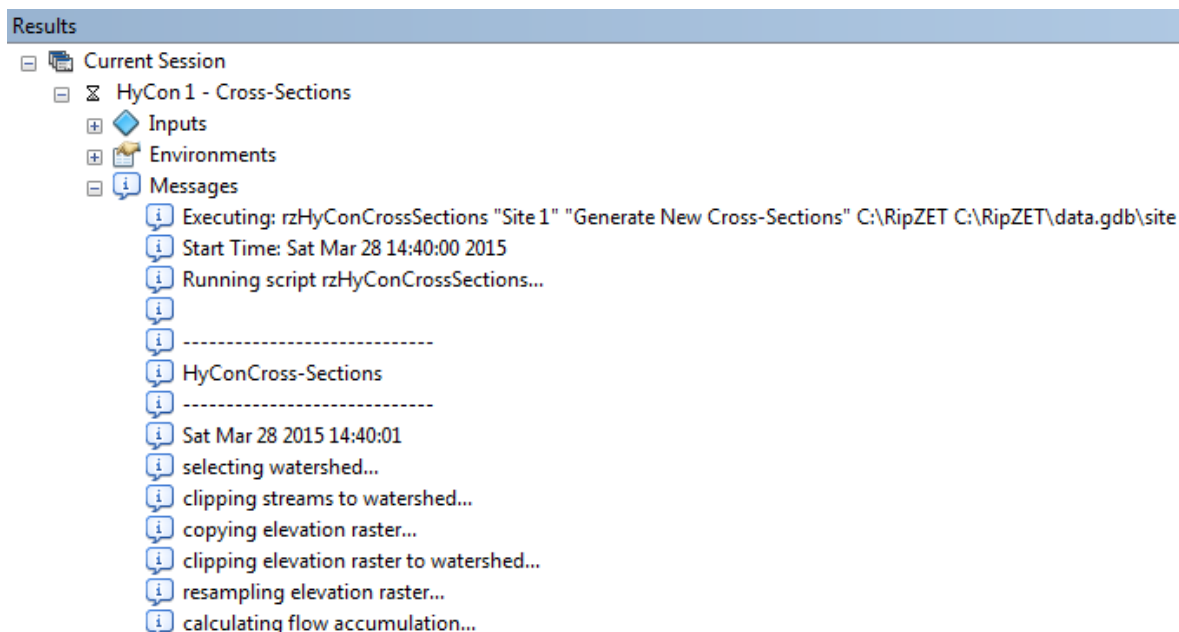


- **Site Name:** Create a name to identify the site in subsequent tool outputs.
- **Tool Mode:** Select Generate New Transects.
- **Workspace or RipZET Work Geodatabase:** Select the folder where you would like the tool outputs to save.
- **Site Point:** Navigate to and select the Site Point feature class, which should contain a point marking the center of the reach of interest.
- **Streams:** Navigate to and select the Streams feature class, which should contain the stream segment for the reach of interest. Remember that this should be edited to be consistent with the LiDAR topography, if necessary.
- **Watersheds:** Navigate to and select the Watershed feature class, which should contain the watershed boundary upstream of the reach of interest.
- **LiDAR Raster:** Navigate to and select the LiDAR raster for the reach of interest.
- **Clip LiDAR:** Check to clip the LiDAR raster to the site's watershed boundary. Clipping the LiDAR can reduce the processing time and output size. If the clipping has been done prior to executing the tool, uncheck this option.

(2) Enter or select the desired parameter values and click **OK**.

While the tool runs, it will provide the user with progress updates in the tool output window (if executing in the foreground) or the Messages section of the tool session in the Geoprocessing Results pane. (All output messages are also saved on tool completion to a text file in the specified output directory.)



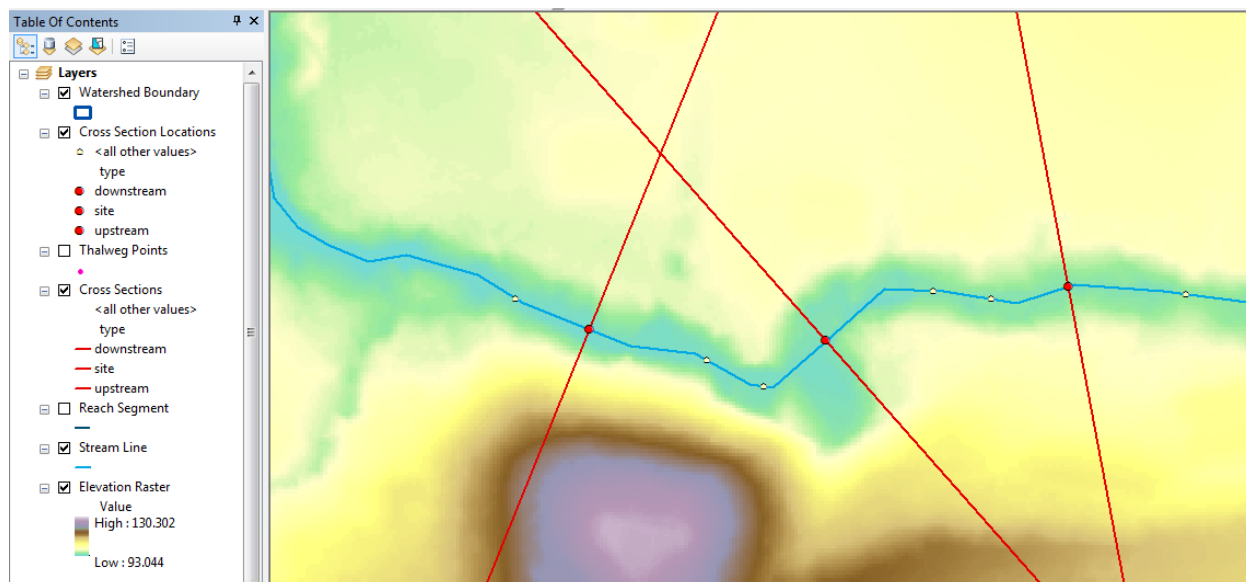


The tool will first let the user know if the selected reach is appropriate for running HyCon (average slope through the entire site reach is  $\leq 2.5\%$  and the width-to-depth ratio at the Site Point is  $\geq 8$ ). It will also let the user know if the local channel slope values through the cross-sections are zero or negative. Guidance for obtaining a positive channel gradient is given below.

- ⚠ WARNINGS:
- ⚠ Gradient is negative for cross-sections of type 'site', 'upstream'.
- ⚠
- ⚠ Gradient is zero for cross-sections of type 'downstream'.
- ⚠
- ⚠ consider moving the cross-section locations for more accurate elevation values:
- ⚠ 1. Adjust one or more points in C:\RipZET\ripzet\_2015.03.28\_14.40.01\_results.gdb\cross\_section\_locations.
- ⚠ 2. Rerun the tool using the updated feature class as the Cross-Section Locations input.

When the tool has run to completion, navigate to your Workspace. Open the map document (formatted as ripzet\_yyyy.mm.dd\_hh.mm.ss\_map.mxd):





The Cross-Sections Tool generates three cross-sections: one at the Site Point (type = site); one upstream of the Site Point at a distance of approximately 10 “bankfull widths” (based on a North Bay relationship between drainage area and bankfull flow width, type = upstream); and one downstream of the Site Point approximately 10 “bankfull widths” (type = downstream). The cross-sections extend out from the channel thalweg location approximately 20 “bankfull widths” into the right bank and left bank floodplains. Channel thalweg points are also identified approximately 3 “bankfull widths” upstream and downstream of each cross-section location (type = upstream\_up, upstream\_dn, site\_up, site\_dn, downstream\_up, downstream\_dn). The channel thalweg points are intended to be first approximation of appropriate locations for calculating local channel slope.

- (3) The user should inspect the generated cross-section locations (the points at which the cross-sections intersect the stream line, as well as the points upstream and downstream of each cross-section) to see if they are positioned appropriately and not on top of bridges or other channel-spanning features. Local channel slope is also an important factor in evaluating cross-section locations; zero or negative slope values can often be corrected by moving location points slightly upstream or downstream of the initially calculated positions (which are based on distance and do not consider channel topography) and rerunning the tool. If the slope through any cross-section location is zero, negative, or >2.5%, the tool will add a warning to the output messages. The existence of any of these slope conditions may indicate that the reach is not appropriate for the HyCon tool, but it may also be the result of either an upstream or downstream point falling in a pool instead of a riffle, for example—examining the point locations against the LiDAR can indicate to the user whether a slight adjustment to one or both points is reasonable. If it is, the user may edit the points in ArcMap and rerun the tool (see the next section below).
- (4) If the cross-sections locations are appropriate and no tool warnings were given for channel slope or width-to-depth ratio, the user should proceed to the Spreadsheet Model.

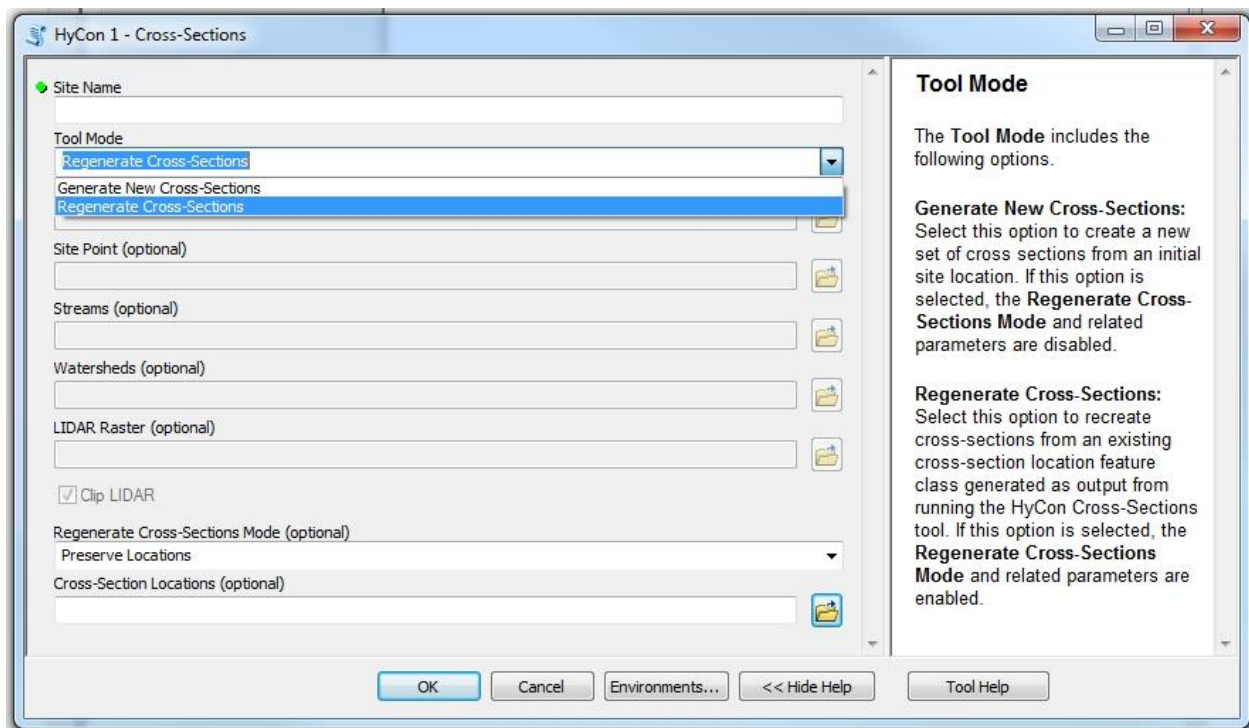
**If the cross-section locations need to be relocated or if the local reaches through the cross-sections need to be regenerated to produce a positive channel gradient**

- (1) Open the output map document in ArcMap and edit any of the point features in the Cross-Section Locations layer by dragging them upstream or downstream on the stream line. Ideally, both upstream and downstream points for each cross-section will be positioned on riffles and not pools



or banks. If the reach line does not correspond to the LiDAR channel, the line may need to be corrected before running the tool again (see **Preparing the Stream Line for HyCon** above). *Note:* The tool uses the locations as reference points for channel slope but performs the actual slope calculation based on the elevation value at the lowest channel point adjacent to each location point—for a visualization of these points, turn on the Thalweg Points layer in the output map document. When editing cross-section location points, be aware that the tool will first identify a thalweg point for each location on which to base the channel-slope calculation, so the LiDAR elevation value corresponding to the location point may not be the value used in the slope calculation.

- (2) Make sure the map document and spreadsheet are closed to prevent tool errors due to file locks.
- (3) In the **RipZET Tools** toolbox, double-click on **HyCon 1 – Cross-Sections**.
- (4) **Site Name:** Create a name to identify the site in subsequent tool outputs.
- (5) **Tool Mode:** Select Regenerate Cross-Sections.



- **Regenerate Cross-Sections Mode:**
  - **Preserve Locations:** Select Preserve Locations to preserve all locations; the local reach for each cross-section location (i.e., the distance between the thalweg location upstream and downstream of each cross-section) will not be recalculated and the upstream and downstream point locations will not be updated.
  - **Regenerate Reach:** Select Regenerate Reach to preserve only the upstream, site, and downstream locations; the local reach (upstream and downstream points) for each cross-section location will be recalculated.
- **Cross-Section Locations:** Navigate to and select the *cross\_section\_locations* feature class from a previous execution of the **HyCon 1 – Cross-Sections** module. (*Tip: this will be in the results geodatabase in the Workspace specified on the previous run.*)



- (6) Enter or select the desired parameter values and click **OK**.

### Spreadsheet Model (Excel Spreadsheet) (required)

The cross-section station and elevation data are transferred from ArcMap to an Excel spreadsheet. The user then works with the spreadsheet to generate location discharge-flow stage relationships (or rating curves) and the estimated flooding extent for the 2-, 10-, and 50-year floods. The spreadsheet has two tabs associated with each cross-section: one tab where the user enters and works with the appropriate data (e.g., *Site (Middle) XS*) and one tab with a plot of the cross-section elevation data (e.g., *Site (Middle) XS Profile*). The cross-section stationing increases going from the left bank to the right bank.

When the Cross-Sections Tool has run to completion, navigate to the Workspace you specified and open the xlsx file (formatted as ripzet\_YYYY.MM.DD\_HH.MM.SS\_HyCon.xlsx).

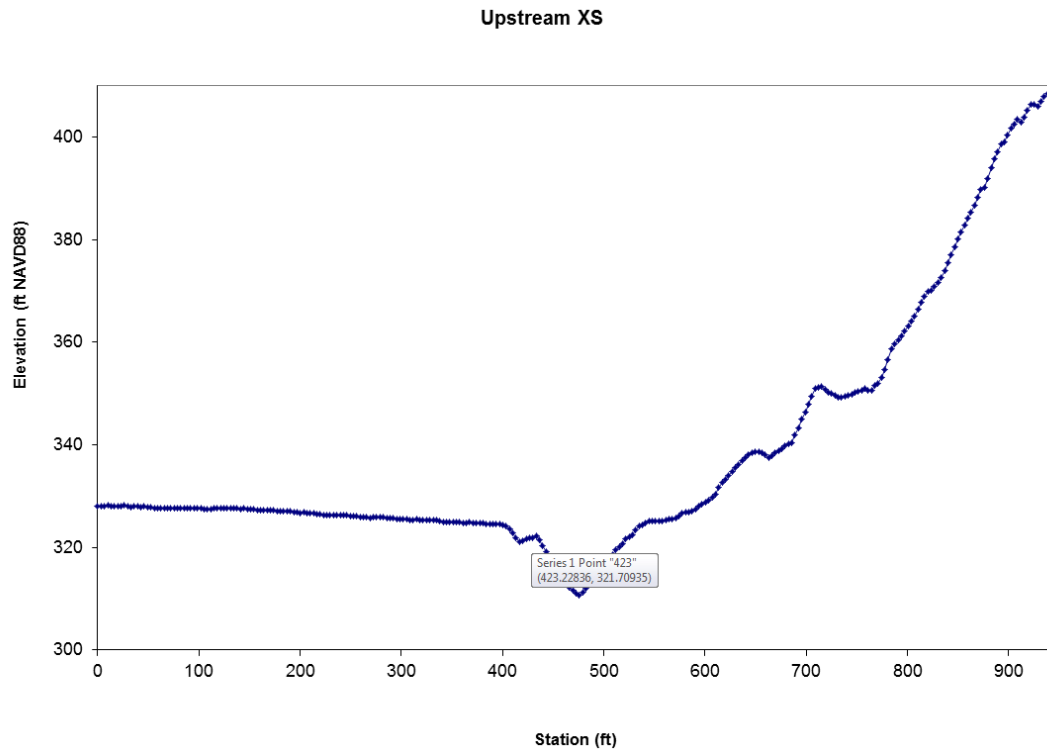
- (1) Click on the README tab to get an overview of the data needed to arrive at flooding extent at each cross-section and the sources for the necessary data.
- (2) Click on the Upstream XS tab. Start with **Step 1**, which entails reviewing the station and elevation data and the reach-average channel slope (i.e., the local slope through the cross-section using the upstream and downstream thalweg elevations).

11		
12	Reach-avg channel slope	0.0040
13		
14		
15	Station (ft)	Elevation (ft NAVD88)
16		
17		
18	0.00000	325.75003
19	3.28084	325.72963
20	6.56168	325.63070
21	9.84252	325.59626
22	13.12336	325.53473

If the cross-section topography appears problematic, the user can make modifications to the data within the spreadsheet

- (3) Move on to **Step 2**, which entails identifying the top of left bank and right bank location. The user should go to the Upstream XS Profile tab and hover the mouse over the apparent left bank edge (on the left of the plot) and right bank edge (on the right of the plot).





The user then needs to enter the station and elevation data for both tops of bank and click the “Click to Populate Top of Bank Location and Zone” button. Each station will then be identified as left floodplain, channel, or right floodplain in the “Zone” column (column E).

	Station (ft)	Elevation (ft NAVD88)
Top of left bank	423.23	319.78
Top of right bank	495.41	320.41
<div>Click to Populate Top of Bank Location and Zone</div>		
Top of Bank location	Zone	
	Left bank Floodplain	
	Left bank Floodplain	
	Left bank Floodplain	
	Left bank Floodplain	

- (4) Move on to **Step 3**, which entails assigning a roughness, or Manning’s n, value for each station.







average flow depth, and flow stage for the 2-year flood ( $Q_2$ ), 10-year flood ( $Q_{10}$ ), and the 50-year flood ( $Q_{50}$ ). The user can change the peak discharge values as needed, which will update the average flow depth and flow stage values. If the calculated  $Q_2$  average flow depth is less than the  $Q_2$  average flow depth derived from the regional curve and drainage area, the user will receive a warning message indicating that the Manning's  $n$  values in column I may need to be adjusted.

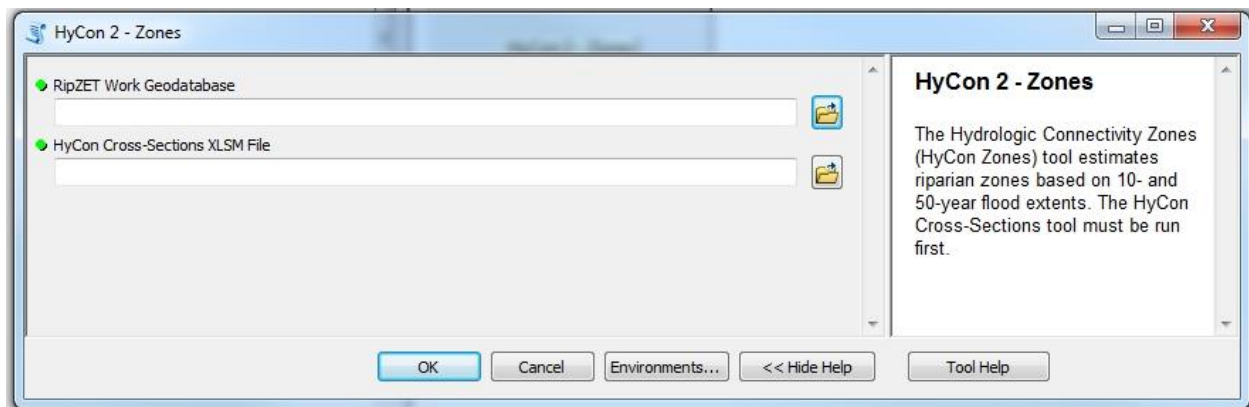
Click to Calculate Average Depth and Stage	
Mean annual ppt (in)	42.64569
Drainage area (sq. mi)	3.69528
Average bankfull depth (ft)	1.65074
Q2 discharge (cfs)	462.83488
Q2 average depth (ft)	3.07
Q2 stage (ft)	311.95
Q10 discharge (cfs)	974.71023
Q10 average depth (ft)	4.15
Q10 stage (ft)	313.97
Q50 discharge (cfs)	1341.8354
Q50 average depth (ft)	4.80
Q50 stage (ft)	314.94

- (7) The user then needs to repeat (1) through (6) above for the Middle and Lower cross-sections.
- (8) When all three cross-sections are complete, save the file and exit.

## HyCon 2 – Zones *(required)*

After completing the computations in the Spreadsheet Model, return to ArcMap or ArcCatalog to run the **HyCon 2 – Zones** module.

- (1) In the **RipZET Tools** toolbox, double-click on **HyCon 2 – Zones**.
- (2) The tool will open to the following interface:



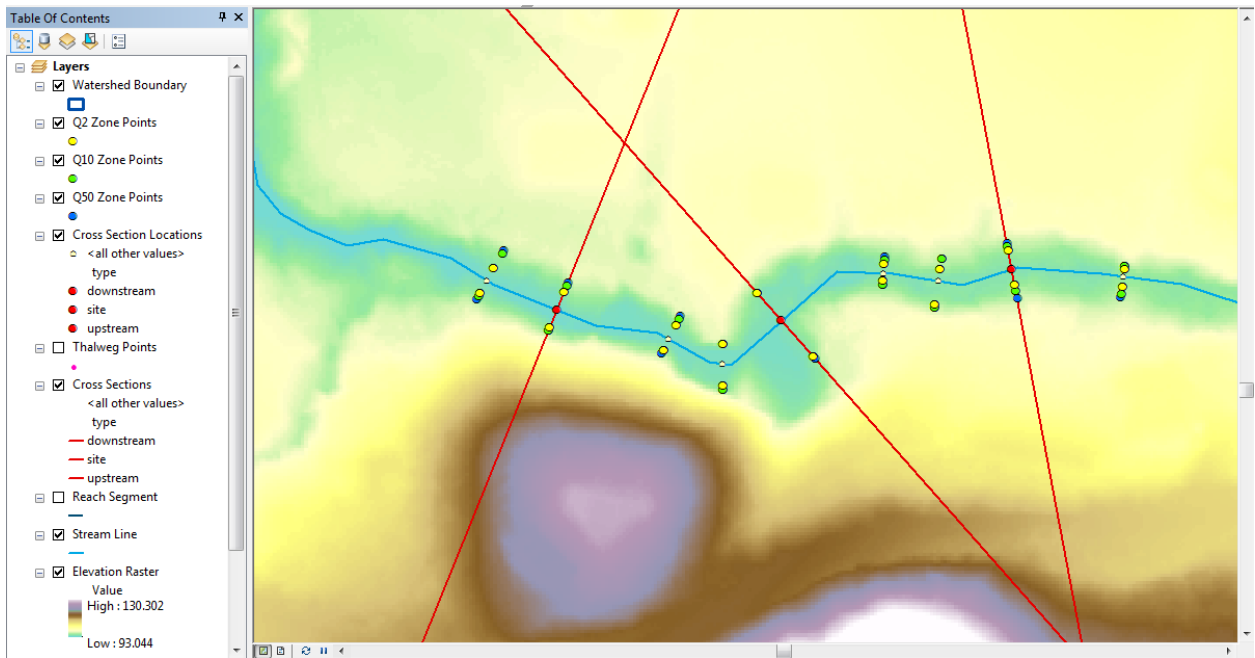
- **RipZET Work Geodatabase:** Navigate to the Workspace folder you specified in the Cross-Sections Tool; select your RipZET Work Geodatabase (formatted ripzet\_YYYY.MM.DD\_hh.mm.ss\_work.gdb).



- **HyCon Cross-Sections XLSM File:** In the same Workspace folder, navigate to and select the HyCon Cross-Sections Spreadsheet (formatted `ripzet_yyyy.mm.dd_hh.mm.ss_HyCon.xlsm`).

(3) Enter or select the desired parameter values and click **OK**.

When the tool has run to completion, navigate to your Workspace. Open the map document (formatted as `ripzet_yyyy.mm.dd_hh.mm.ss_map.mxd`):



- (4) Points representing the along-transect boundaries of the approximate  $Q_2$ ,  $Q_{10}$ , and  $Q_{50}$  flooding extents for the Upstream, Middle (Site), and Downstream cross-sections are shown. In addition, flood extent estimates are given at the thalweg locations between the cross-sections based on local channel-floodplain topography and the calculated rating curve from the closest cross-section.

## Understanding the Outputs

### Results Geodatabase

The primary final tool output will be a RipZET Results Geodatabase (a file geodatabase formatted as `ripzet_yyyy.mm.dd_hh.mm.ss_results.gdb`). See below for a description of the geodatabase contents:

**watershed:**

A polygon feature class containing the site watershed.

**hyCon\_lines:**

A copy of the streams feature class input in the Cross-Sections Tool.

**hyCon\_elevation:**

A copy of the LiDAR raster input in the Cross-Sections Tool.



**cross\_section\_locations:**

A point feature class containing the following points: site, site\_up, site\_dn, upstream, upstream\_up, upstream\_dn.

**cross\_sections:**

A line feature class showing the cross-sections at the site, upstream, and downstream locations.

**cross\_section\_pts\_site, cross\_section\_pts\_upstream, cross\_section\_pts\_downstream:**

Point feature classes of cross-section points along the site, upstream, and downstream cross-sections. Points are generated at 0.5-m intervals along cross-section lines.

**zone\_pts\_Q2, zone\_pts\_Q10, zone\_pts\_Q50:**

Point feature classes of the respective Q2, Q10, and Q50 extents along the site, upstream, and downstream cross-sections.

### **Map Document**

The final tool outputs, from the RipZET Results Geodatabase, will be saved in a map document (formatted as ripzet\_YYYY.MM.DD\_HH.MM.SS\_map.mxd) in the Workspace folder.

### **Spreadsheet/XLSM**

The Spreadsheet Model will be saved as an Excel XLSM file (ripzet\_YYYY.MM.DD\_HH.MM.SS\_HyCon.xls) in the Workspace folder.

### **Ancillary Files**

**ripzet\_YYYY.MM.DD\_HH.MM.SS\_messages.csv:**

If the RipZET tools are executed in an integrated development environment (IDE), this file will record all tool execution messages (similar to the Messages output in an ArcDesktop Results Window).

**ripzet\_YYYY.MM.DD\_HH.MM.SS\_summary.csv:**

This file records the input parameters and process execution time for each of the HyCon modules run.



# Troubleshooting

## RipZET Bugs

- The tool can fail if you have spaces in your input data file paths. Remove all spaces in the input data file paths. Example: “veg data” > “veg\_data”
- The tool does not recognize joined fields. If you are assigning attributes such as tree height via a join, you will instead need to make sure the original data has a field with the desired attributes written in.
- Occasionally, the tool can fail during “1 – Prep” if the input data is open in the current map document. Remove all input layers from the current map document and use the absolute file path as input when running the tool.

## Out-of-memory errors:

- Disable 64-bit background geoprocessing
- Increase system RAM

## File locks:

- Close all ArcGIS applications
- Close all inputs and outputs that may be open in other applications

## Excessively large outputs or long processing times:

- Clip all inputs to the area of interest
- Reduce the size of the area of interest or divide it into smaller parts that can be processed separately

## Unknown ArcGIS errors:

- Check/repair geometry of all inputs
- Check file/folder permissions of output directory

## Spreadsheet:

- Make sure that macros and editing are enabled in the spreadsheet
- Make sure to close the spreadsheet before running the HyCon Zones tool

## Other:

- See the text file of output messages created in the output directory for warnings and information on tool inputs and progress
- See the *ripzet\_log.txt* file in the tool directory for details on unhandled exceptions



## References

- Collins, J.N., M. Sutula, E.D. Stein, M. Odaya, E. Zhang, K. Larned. 2006. Comparison of Methods to Map California Riparian Areas. Final Report Prepared for the California Riparian Habitat Joint Venture. 85 pp.
- Johnson, C.W. and S. Buffler. 2008. Riparian buffer design guidelines for water quality and wildlife habitat functions on agricultural landscapes in the Intermountain West. Gen. Tech. Rep. RMRS-GTR-203. U.S. Forest Service, Fort Collins CO.
- NRC. 2002. Riparian areas: functions and strategies for management. National Academy of Science. Washington, DC.
- SFEI. 2015a. RipZET: The Riparian Zone Estimation Tool. Prepared by the San Francisco Estuary Institute – Wetlands Focus Area. Funded by Proposition 50 Watershed Protection Program Grant. Agreement Number: #10-429-550. Contribution #746. Richmond, CA 94804.
- SFEI. 2015b. Riparian Zone Estimation Tool. Hydrologic Connectivity Module. Documentation and Validation of Selected Methodology. Prepared by the San Francisco Estuary Institute - Wetlands Focus Area. Funded by Proposition 50 Watershed Protection Program Grant. Agreement Number: #10-429-550. Contribution #745. Richmond, CA 94804.
- Wenger, S. 1999. A review of the scientific literature on riparian buffer width, extent, and vegetation. Office of Publication Service and Outreach, Institute of Ecology, University of Georgia, Athens GA.