

## HEC-RAS Workshop: Hydraulic and Morphological Analysis for Stream Restoration

HEC-RAS includes several hydraulic and morphologic tools that can support river restoration analyses. This workshop will provide exposure to HEC-RAS and several of its capabilities that are useful for river restoration studies.



The lower Truckee River flows west from Lake Tahoe and is a historically productive fishery. The Nature Conservancy and the Corps analyzed a degraded reach for potential restoration alternatives to improve habitat and encourage biodiversity. In this workshop you will use some tools and perform some analyses to evaluate the hydraulic and morphologically feasibility of the design.

**Note: \*\*The models in this workshop have been modified and the alternative arbitrarily designed for the purposes of instruction\*\***


### 1. Analysis of Existing Conditions

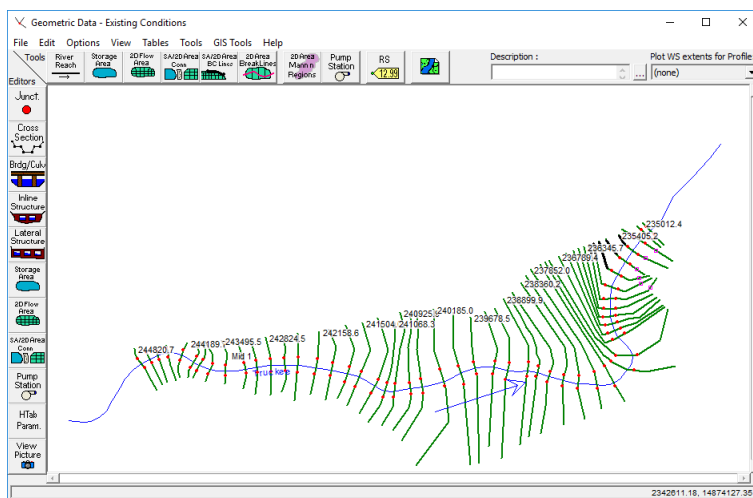
#### A. Open and View Project




Open HEC-RAS by selecting the desktop icon:



Open the 25RestRASwksp.prj file in the student directory using the **File→Open** menu

The “Existing Conditions” plan will be active. A complete HEC-RAS model has been constructed for the existing conditions. View the aerial photo and the model schematic by selecting the **Geometric Data** icon  or the **Edit→Geometric Data** Menu.



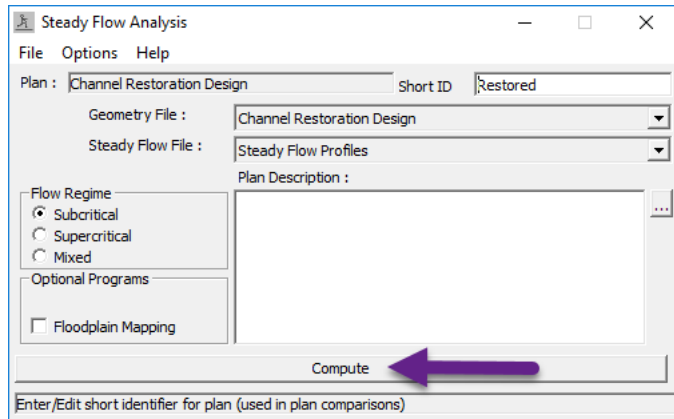
*B. Run Simulation and Estimate Bankfull Discharge*

Perform a steady flow run of the model. Select the **Perform Steady Flow Analysis** button  or the **Run→Steady Flow Analysis** menu. Press the **Compute** button on the dialog that appears.

View the results using the **View Cross Sections**  and the **View Profiles**  buttons or the first two items on the **View** menu. Profiles for 14 flows will plot.

Use the model runs to estimate a bank full flow: \_\_\_\_\_ cfs

(Note: Profiles have been named with the flow associated with them. You can scroll through the cross section plots and click on the profile closest to bank full to find the corresponding flow. Additionally, the profile plot includes right and left bank elevations.)



A frequency curve developed for this reach is included in Figure 1.

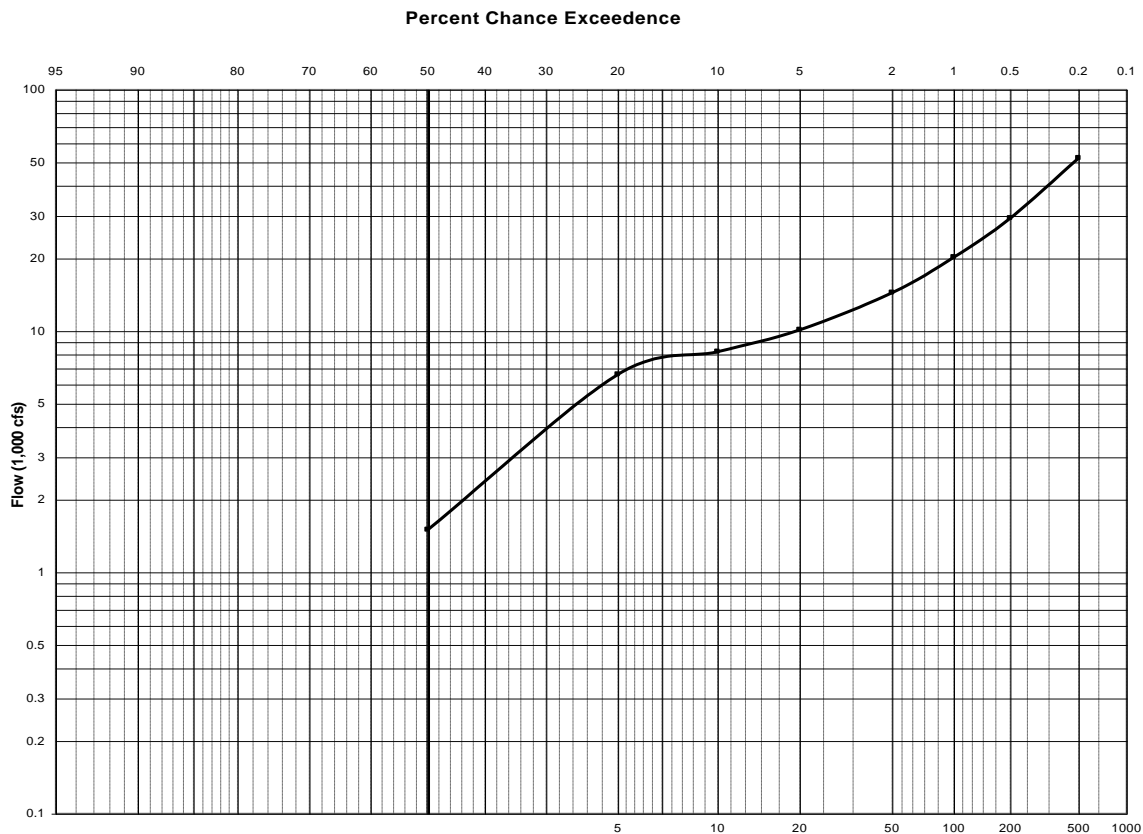


Figure 1: Flow-frequency relationship for this reach.

Based on this relationship, what is the 50% exceedance probability flow (e.g. 2-year flow)?  
\_\_\_\_\_ cfs

What is the exceedance probability associated with the “bankfull” flow determined from the water surface profile analysis? \_\_\_\_\_%

What is a possible explanation for the discrepancy between the 2-year flow and the “bankfull” discharge?

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### *C. Evaluate Restoration Alternative: Overbank Flows*

A second HEC-RAS model has been built to simulate the hydraulic conditions of a restoration alternative that includes a drop structure (at the downstream end) to reduce the channel slope and reintroduced meanders. The restored reach includes cross sections between 236200 and 243199 (approximately river stations 1000 ft to 9000 ft). To access this model open the “Restored Channel Conditions” plan by opening the **Steady Flow Analysis** dialog (with the **Perform Steady Flow Analysis** button  or the **Run→Steady Flow Analysis** menu) and selecting **File→Open Plan**. Run the new plan and view the channel geometry, cross sections and profile.


What flow floods the overbanks appreciably along most of the restored reach? \_\_\_\_\_ cfs

If the intention of the restoration is to flood the overbanks approximately every other year how effective is this design?

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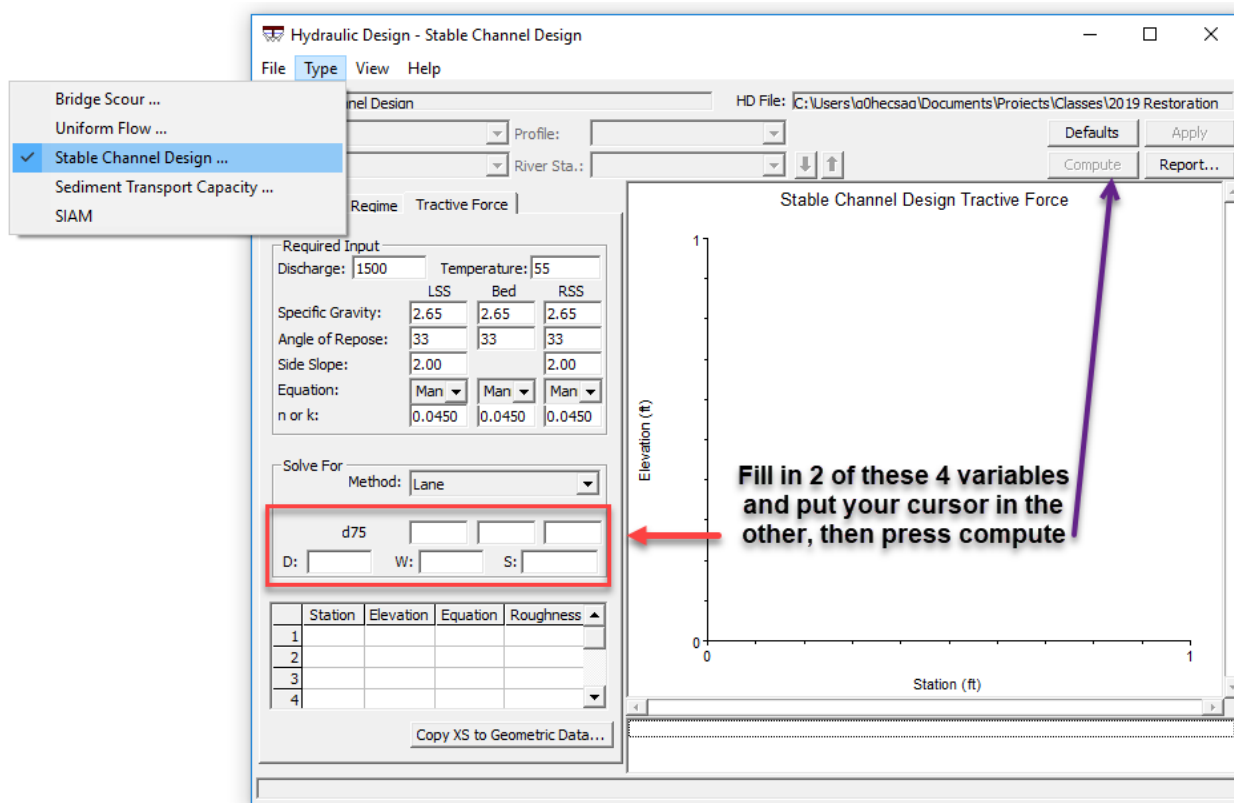
### *D. Evaluate Restoration Alternative: Channel Stability*

HEC-RAS includes functionalities to investigate channel stability and sediment transport behavior of existing or designed channels. These tools will be used to evaluate the restored channel design.

Begin by selecting the **Hydraulic Design** dialog (depicted in Figure 1) by pressing the **Hydraulic Design** button  or selecting the **Run→Hydraulic Design Functions** menu. Make sure that the **Stable Channel Design** function is selected from the **Type** menu and the **Tractive Force** method (tab) is activated.

This function will be used to evaluate the stability of the designed channel. A number of parameters are already specified.

Use the cross section and profile displays to fill in the fields for flow depth (**D**) *or* channel *bottom* width (**W**). The slope in the restored reach (**S**) is 0.001. Leave the three **D75** fields and one of the channel dimensions (**W** or **D**) open and press the **Calculate** button. This tool uses Lane’s Method to calculate the minimum sediment size for which the channel configuration will be stable. D75 is the grain size that is coarser than 75% of the material.



What are the minimum stable D75's for a channel like the one proposed:

Left Bank      Channel Bed      Right Bank  
 \_\_\_\_\_mm      \_\_\_\_\_mm      \_\_\_\_\_mm

A grain size distribution for this channel is included in Figure 2.

What is the D75 of this channel? \_\_\_\_\_mm

Is the channel likely to degrade?\_\_\_\_\_ Why or why not? \_\_\_\_\_

What other geomorphic issues should be considered? \_\_\_\_\_

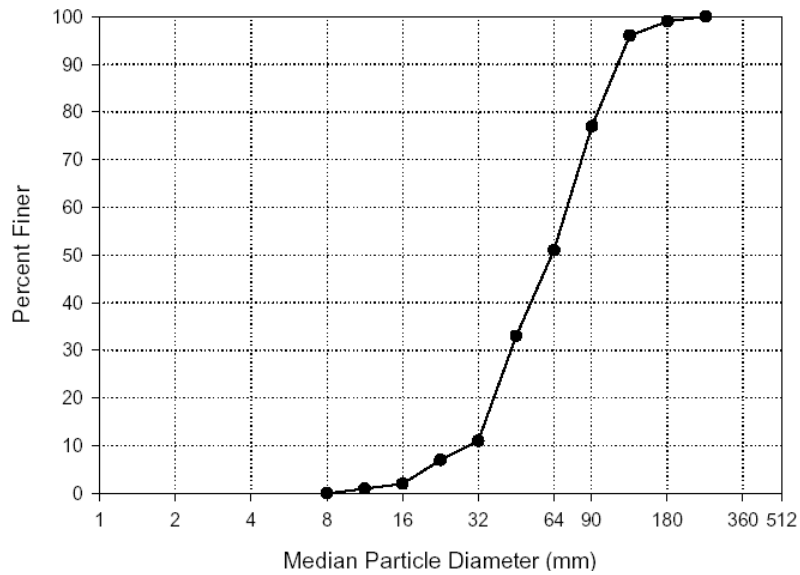
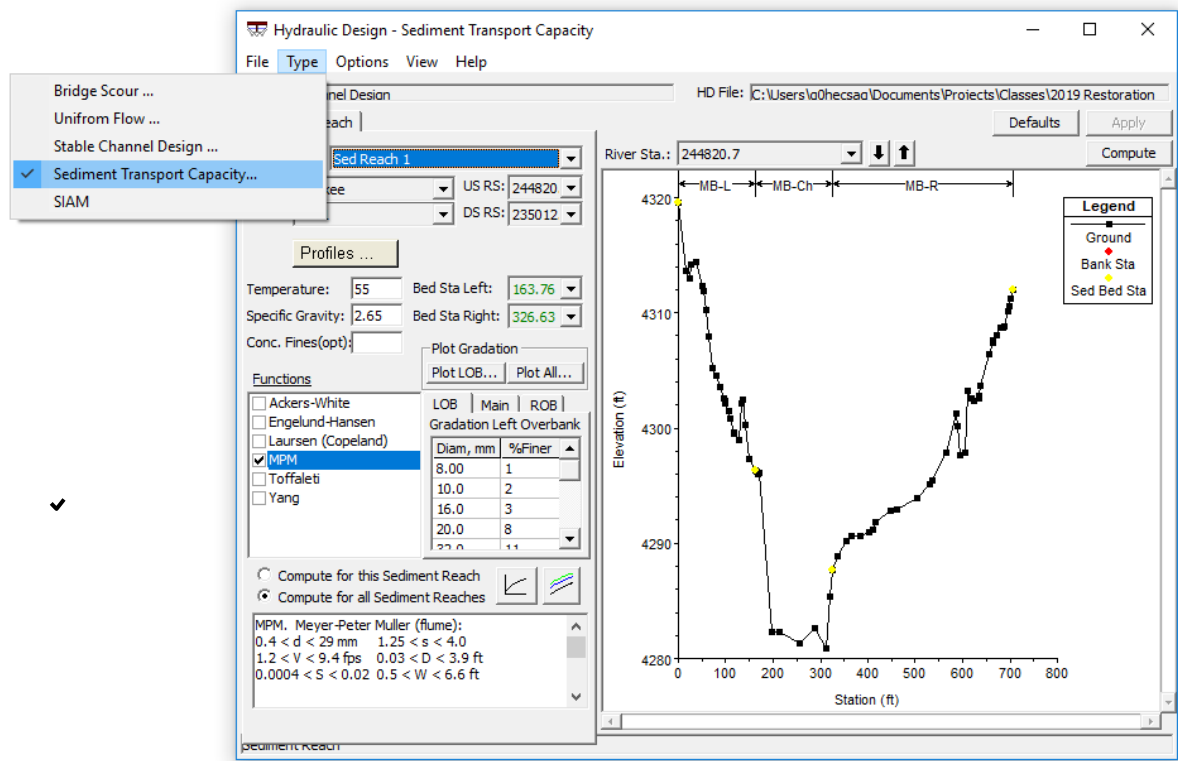



Figure 2: Particle size distribution for this reach.

*E. Evaluate Restoration Alternative: Sediment Transport Potential*

Evaluating the sediment transport potential of a restored channel is another helpful analysis HEC-RAS facilitates. To start this analysis open the **Hydraulic Design** dialog and select the **Type**→**Sediment Transport Capacity** menu. Since the riverbed is mostly gravel select the Meyer-Peter Muller (MPM) sediment transport function which was developed for gravel bed applications.



Since there is uncertainty about the effective discharge (the flow that transports the most sediment over time) in this reach, we will evaluate the transport potential for both the 2-year event and the previous “bank full” discharge. To do this click the **Profiles** button and choose **1500 cfs** and **7000 cfs** from the list of profiles. Calculate the sediment transport potential from this reach by pressing the **Compute** button.

Plot and view the channel sediment capacity of the reach by pressing the **Plot Sediment Profiles**  button.

At what station is the transport suspiciously high? \_\_\_\_\_

Why? \_\_\_\_\_

(Note: You can click on the profile nodes to find out what station they correspond to.)

Rescale the plot by zooming in on the rest of the data using the **View→Zoom In** menu (or right click to get the **Zoom In** feature).

What is the range of channel transport capacities along the restored reach for the 2-yr flow? \_\_\_\_\_

For the higher flow where is the most likely region(s) of scour? \_\_\_\_\_  
Deposition? \_\_\_\_\_

Look at some of the cross sections with high and low transport capacity for the 7000 cfs flow. What is causing the transport capacity to be higher in some than others?

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


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*If you have extra time:*

Plot the channel velocity and channel area profiles for the reach. From the main program dialog select the **View General Profile Plots** button  or the **View→General Profile Plots** menu. Choose which variables to plot under the **Standard Plots** menu. You can choose specific profiles by selecting the **Options→Profiles** menu?

How do velocity and area trends correspond to sediment capacity along the reach?

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Try other sediment transport functions for the sediment capacity calculation. How sensitive are the calculations to the selected function?

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## Advanced Exercise: Using the Copland Stable Channel Method to Evaluate Channel Restoration

If you get stuck, or when you finish, move on to the detailed analysis below. Over 100 years ago, farmers ditched a mildly meandering, sand bed river. Over the last century, the 10-mile channel has adjusted to the new alignment. But suburbs have grown around it and the community wants to restore a 1-mile reach as the centerpieces of a green-belt bike path and a riparian bird hotspot.

The current reach has the following average dimensions and properties:

Bank Full Discharge	3,000 cfs		d <sub>85</sub>	0.5 mm
Bottom Width	350 ft		d <sub>50</sub>	0.3 mm
Bank Roughness	0.03		d <sub>85</sub>	0.1 mm
Slope	0.000008*			
Bank full depth	8 ft			
Side Slopes	3			

\*The channel slope is about half of the valley slope

The landscape architect in charge of the project is proposing a meander channel pattern that will double the length of the channel, with the same channel dimensions.

**How do you expect this design to respond, morphologically?**

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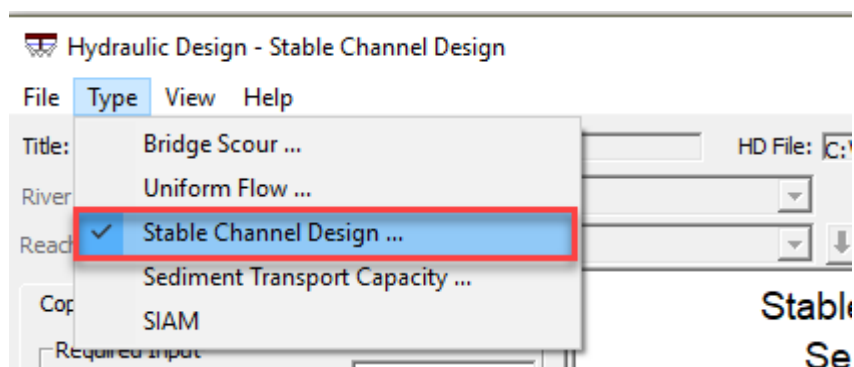
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Follow the steps below to apply the Copland Method in the HEC-RAS Hydraulic Design editor to evaluate the design and make recommendations.

## Step 1: Open HEC-RAS and the HD Editor

You do not need an HEC-RAS model to run the HD Calculators. So in this workshop, there are no starting files. Just open HEC-RAS, save a new project and give it a name. Then open the Hydraulic Design editor, save the new file and give it a name.

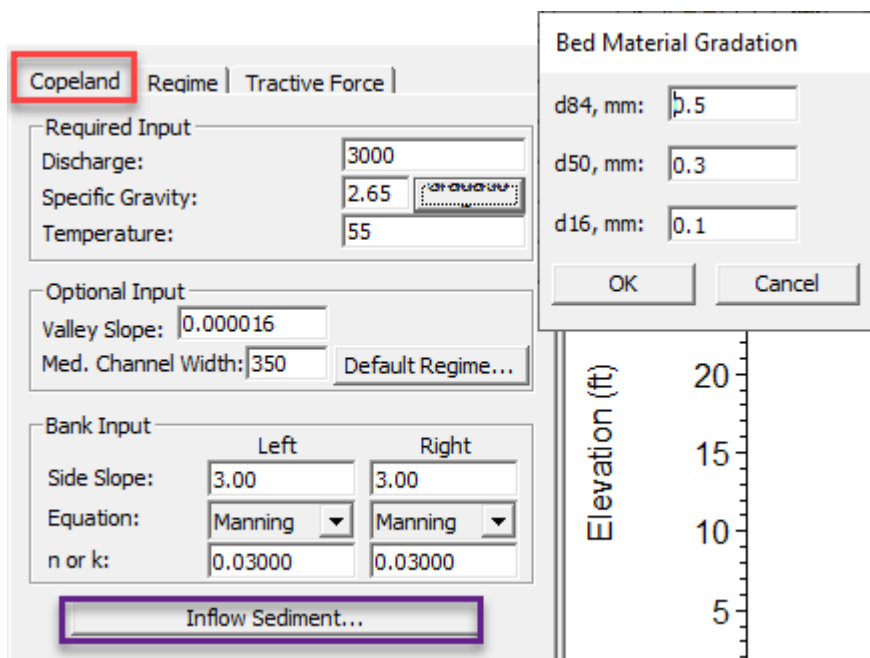
Select **Options**→**Stable Channel Design...** from the menu, and click on the **Copeland** tab in this editor.



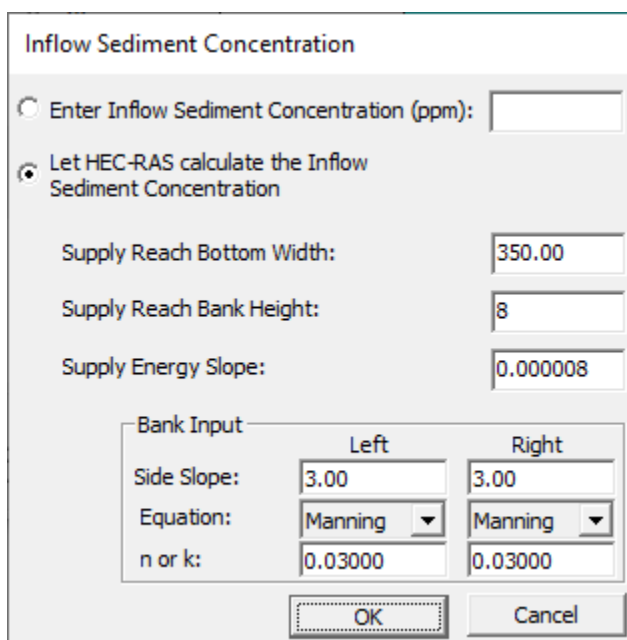
Then Populate the data in the main Copeland Tab. You will have to press the **Gradation** button  to complete this information.

The Copeland Method is ideal for this sort of analysis, because we believe the upstream reach is in equilibrium with the project reach, so we expect it will compute equilibrium for the existing conditions and give us a portfolio of equilibrium conditions for the alternatives.





To compute the equilibrium condition for the upstream reach, press the **Inflowing Sediment** Button.  We do not have sediment load information, so we are going to define the regional channel characteristic and the Copeland method will use the Brownlie transport function to estimate the equilibrium flux.



Press  and .

HEC-RAS will generate a suite of equilibrium Slope-Width pairs (and a set of hydrodynamics associated with each). Select the width you want to plot and press OK.

Press the **Stability Curve 1** button to display the results graphically.

Stable Channel Design, Copeland Method

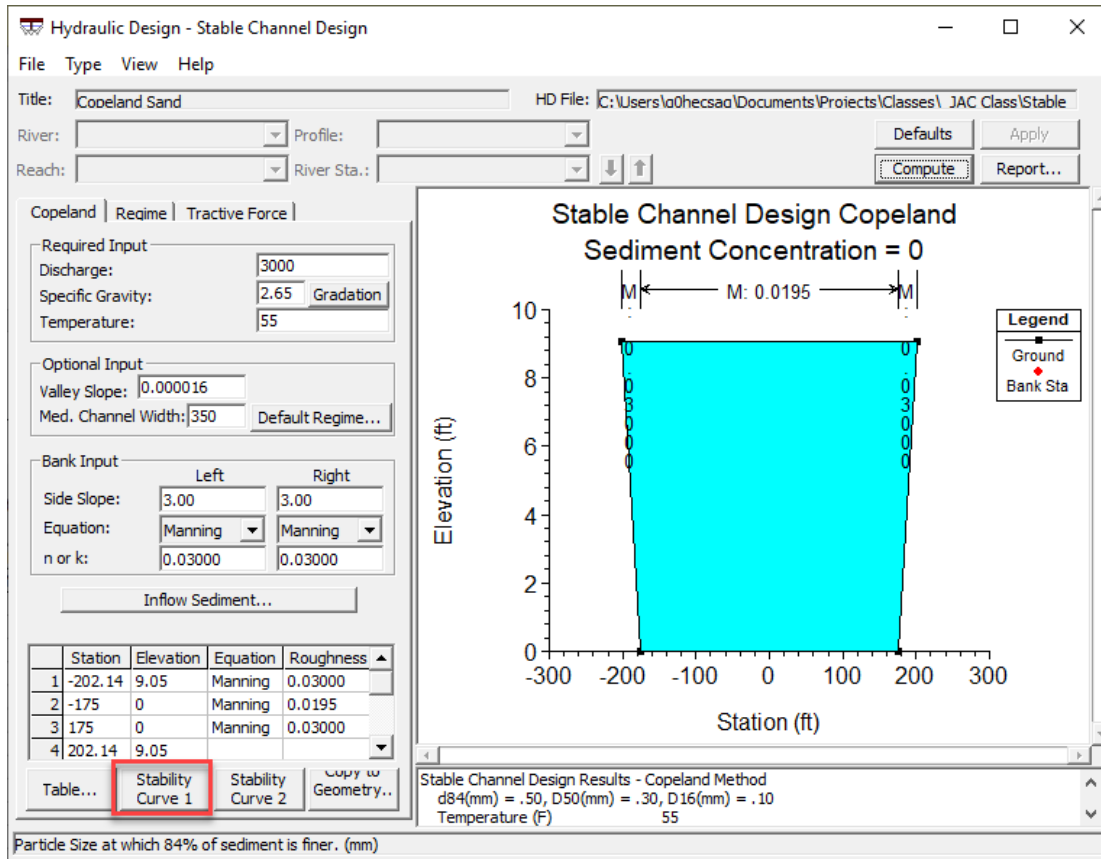
Select a stable channel dimension to display. Sediment Concentration, ppm 0

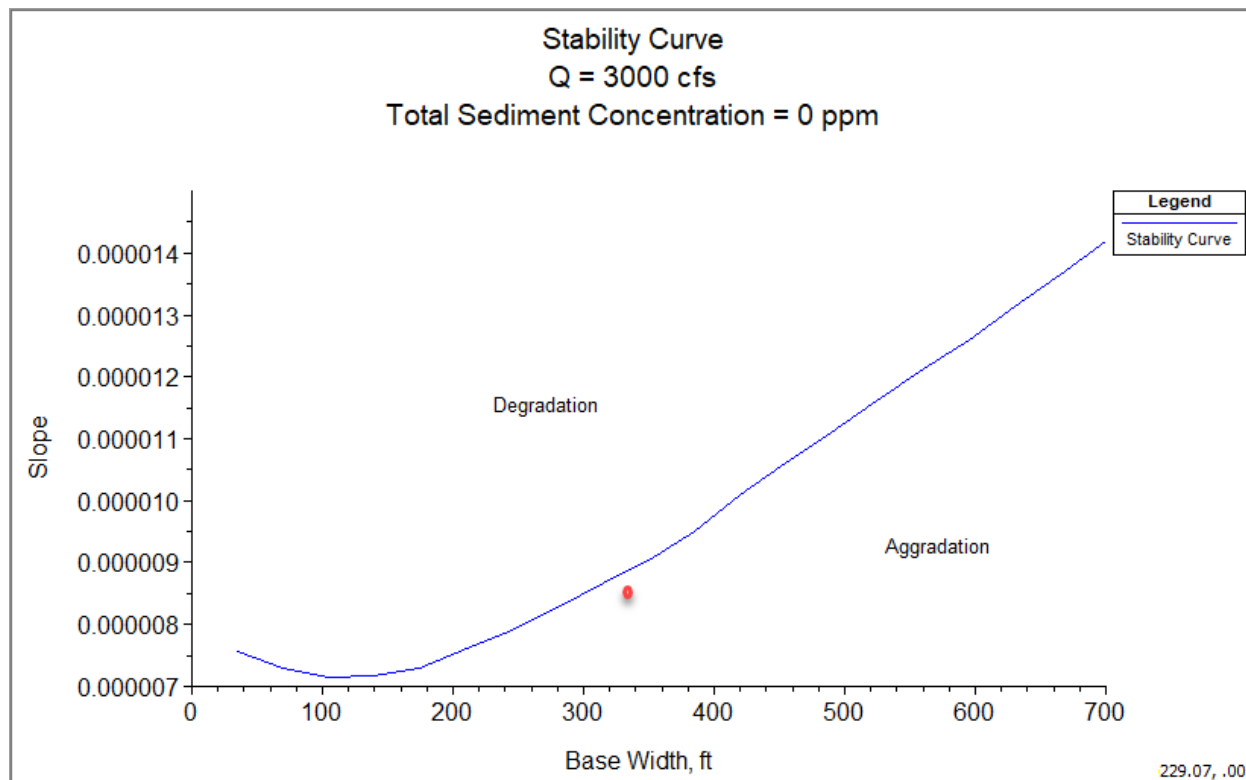
Bottom Width	Depth	Energy Slope	Composite n-value	Hyd Radius	Velocity	Froude Number	Shear Stress	Bed Regime
35	27.97	0.000008	0.0286	15.76	0.9	0.03	0.01	Lower
70	23.49	0.000007	0.0270	15.10	0.91	0.03	0.01	Lower
105	19.99	0.000007	0.0257	14.26	0.91	0.04	0.01	Lower
140	17.2	0.000007	0.0243	13.20	0.91	0.04	0.01	Lower
175	15.02	0.000007	0.0234	12.23	0.91	0.04	0.01	Lower
210	13.3	0.000008	0.0226	11.20	0.9	0.04	0.01	Lower
245	11.91	0.000008	0.0222	10.41	0.9	0.05	0.01	Lower
280	10.77	0.000008	0.0217	9.65	0.89	0.05	0.01	Lower
315	9.83	0.000009	0.0214	8.98	0.89	0.05	0.01	Lower
350	9.05	0.000009	0.0213	8.45	0.88	0.05	0.01	Lower
385	8.38	0.00001	0.0210	7.90	0.87	0.05	0	Lower
420	7.8	0.00001	0.0205	7.34	0.87	0.05	0	Lower
455	7.31	0.000011	0.0205	6.96	0.86	0.06	0	Lower
490	6.87	0.000011	0.0203	6.58	0.86	0.06	0	Lower
525	6.48	0.000012	0.0202	6.24	0.85	0.06	0	Lower
560	6.14	0.000012	0.0201	5.93	0.84	0.06	0	Lower
595	5.83	0.000013	0.0201	5.68	0.84	0.06	0	Lower
630	5.56	0.000013	0.0200	5.43	0.84	0.06	0	Lower
665	5.31	0.000014	0.0199	5.19	0.83	0.06	0	Lower
700	5.08	0.000014	0.0198	4.98	0.83	0.06	0	Lower
*****	Minimum	Stream	Power	*****				
121.46	18.56	0.000007	0.02493	13.77	0.91	0.04	0.01	Lower

Red text indicates that the computed slope is greater than the user-entered valley slope, indicating a potential sediment

\* indicates transitional regime. The default regime was used for the computations.

OK Cancel





The existing conditions plot close to the equilibrium line (slightly aggradational). Because we know this reach is roughly in equilibrium, that deviation is probably noise from the transport function.

The design doubles the local length which will halve the local slope of half the existing slope (0.000004).

### **How do you expect this design to respond, morphologically?**

There is no stable width at a slope of 0.000004. That is deep in the aggradation zone, particularly at the current width. This is a potentially problematic design, and the analysis suggests it will deposit, maybe aggressively.

### **Can you propose an alternate design?**

It is not the nice meandering reach the community is hoping for, but with a narrower channel (100 ft) the community could add some sinuosity, dropping the slope to 0.000007 (or even 0.0000065 given the offset of the stable, current, condition) without inducing dramatic deposition.