

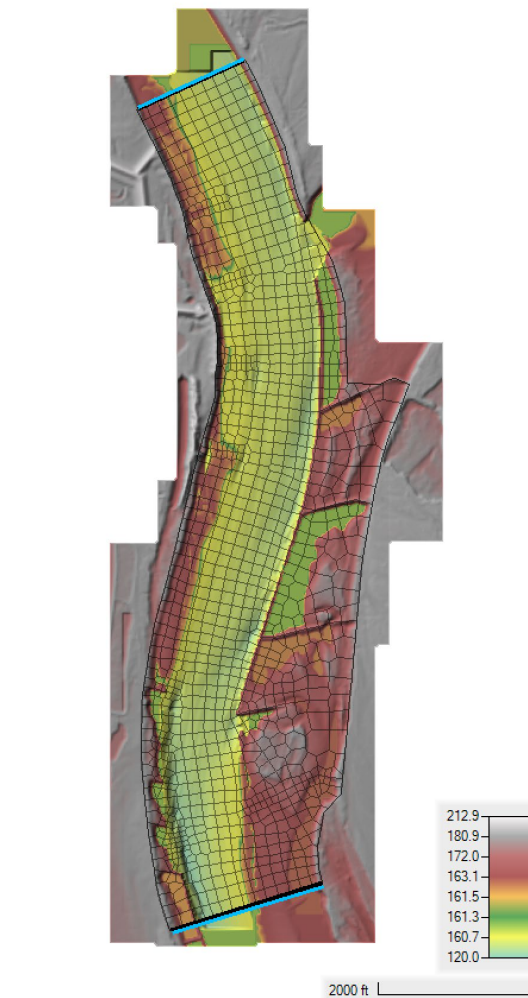
Advection-Diffusion Parameters Workshop

1 Objective

The goal of this workshop is to understand the effects of the advection-diffusion parameters on sediment transport results. Specifically, the workshop covers the load correction factor, diffusion coefficient, and numerical options and advection scheme.

2 Introduction



The model is based on a small reach of the Arkansas River. For the purposes of the workshop, the model is setup is relatively simple and fast. The model extent is relatively small model, and the mesh has a coarse resolution. The computational mesh, boundary condition lines, and terrain are shown in the figure below.

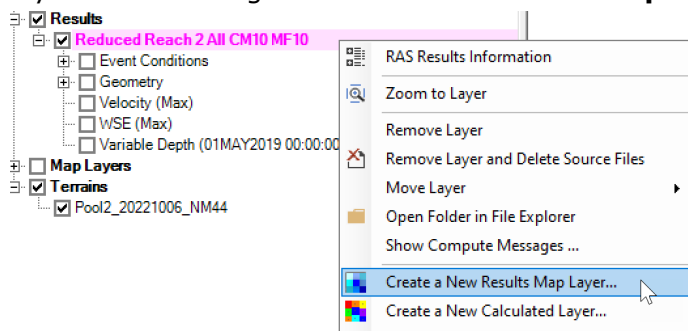


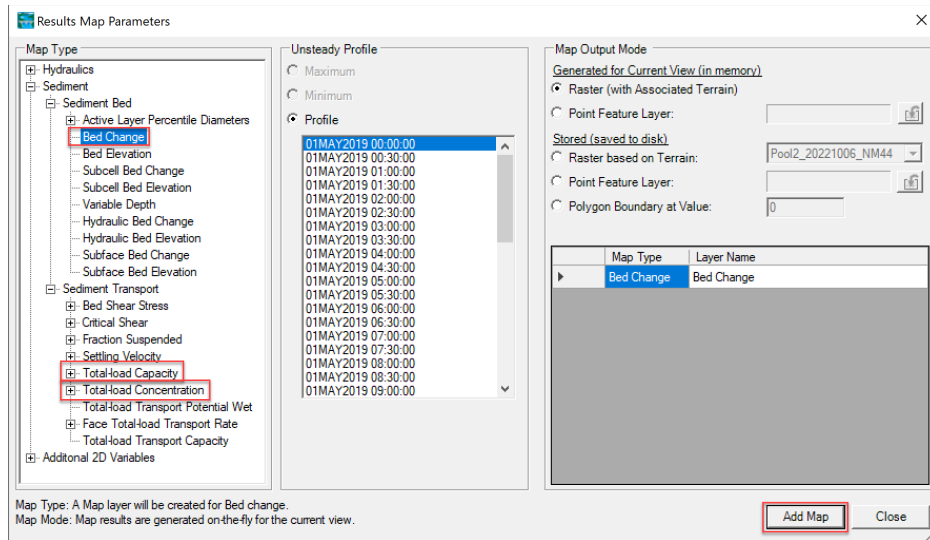
The base model has a constant flow upstream of 70,000 cfs, and a constant stage downstream of 172.936 ft. A morphologic acceleration factor of 10 is utilized to simulate 10 days of bed change over one day of simulation time. With this model setup, each run takes about 5-8 seconds to run which good for sensitivity analysis. It is important to note, that though the current model setup may not be good for final production runs of a project, the sensitivity analysis as applied here with a fast model setup is useful and recommended for projects.

3 No Advection or Diffusion

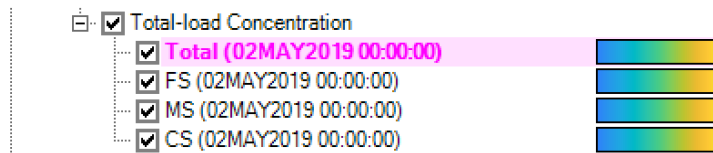
In this section, a base run is setup to model sediment transport with no advection or diffusion. In reality, sediment cannot be transported horizontally without advection and diffusion. However, this refers to the advective process as simulated in non-equilibrium sediment transport models. Firstly, advection is ignored in the hydraulics. This is accomplished by utilizing the Diffusive Wave solver. The Diffusive Wave solver ignores advection and diffusion of momentum. Secondly, by forcing the actual concentrations to be equal to the equilibrium concentrations, the sediment model effectively simulates an Exner type Equilibrium sediment transport model which does not simulate advection or diffusion as in a non-equilibrium model.

1. **Start HEC-RAS.**
2. **Open** the HEC-RAS project names "ArkansasPool2.prj" in the "Advection-Diffusion" Workshop folder.
3. **Open** the **Unsteady Flow Analysis**  editor, and **Run** the plan called "No Adv Diff Eq".
4. After the simulation is complete, open **RAS Mapper** .
5. Begin inspecting the results by looking at the hydraulics.
6. **Add** the following variables to **Ras Mapper** by clicking on the Plan Results layer and selecting **Create a New Results Map Layer...** as shown below

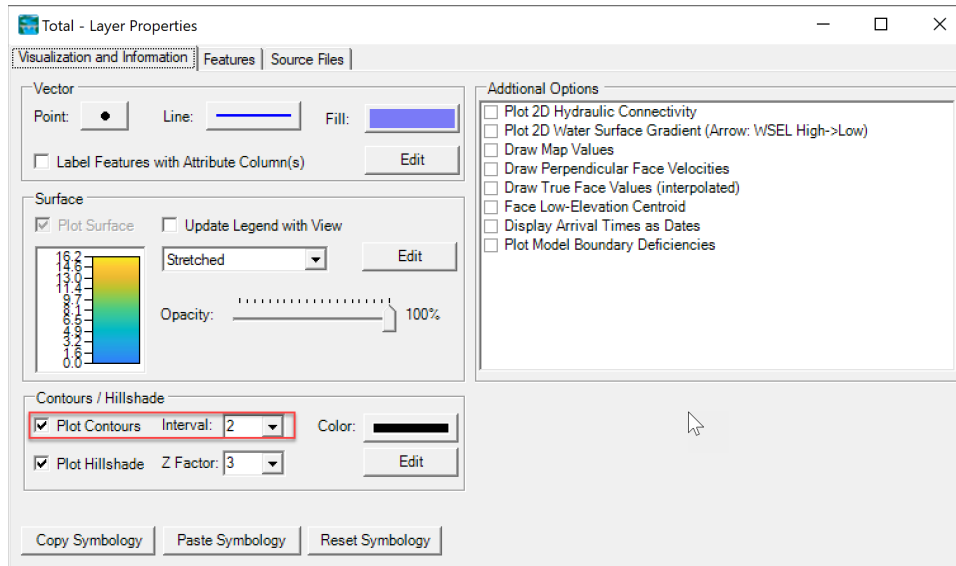




7. **Double-click** on the **Total Total-load Concentration** color ramp and





8. Adds Contour lines at a 1-2 mg/L interval.

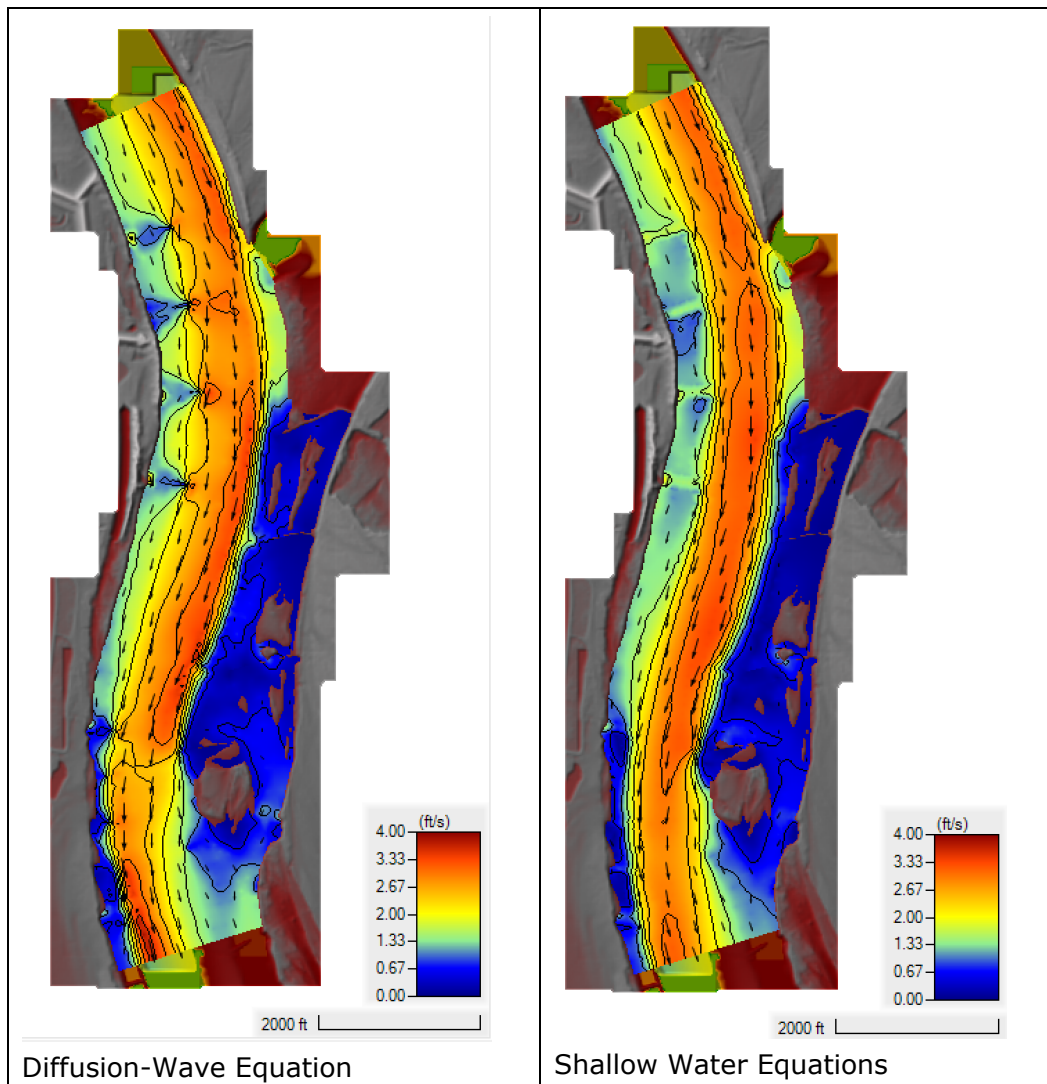


9. Inspect the sediment capacities, concentrations, and bed change.

4 Advection Only

In this section a run is setup to simulate non-equilibrium sediment transport with advection but no diffusion. The model is setup with the Shallow Water Equations (SWE) and non-equilibrium sediment transport. By default, all 2D simulation are run with only advection.

10. **Open** the HEC-RAS project names "WhiteRiverPool2.prj" in the "Advection-Diffusion" Workshop folder.
11. **Open** the **Unsteady Flow Analysis**  editor, and **Run** the plan called "Adv Only".
12. **Open RAS Mapper**  when the simulation is complete.
13. **Open RAS Mapper** and **add** the same sediment variables as described in Section 3.
14. **Compare** the hydraulics for the existing two plans. The figure below shows an example of the current velocities at the end of the simulation.



Question: Based on the hydraulics alone, do expect the sediment transport results to be similar between Diffusion-Wave (DW) and Shallow Water Equations?

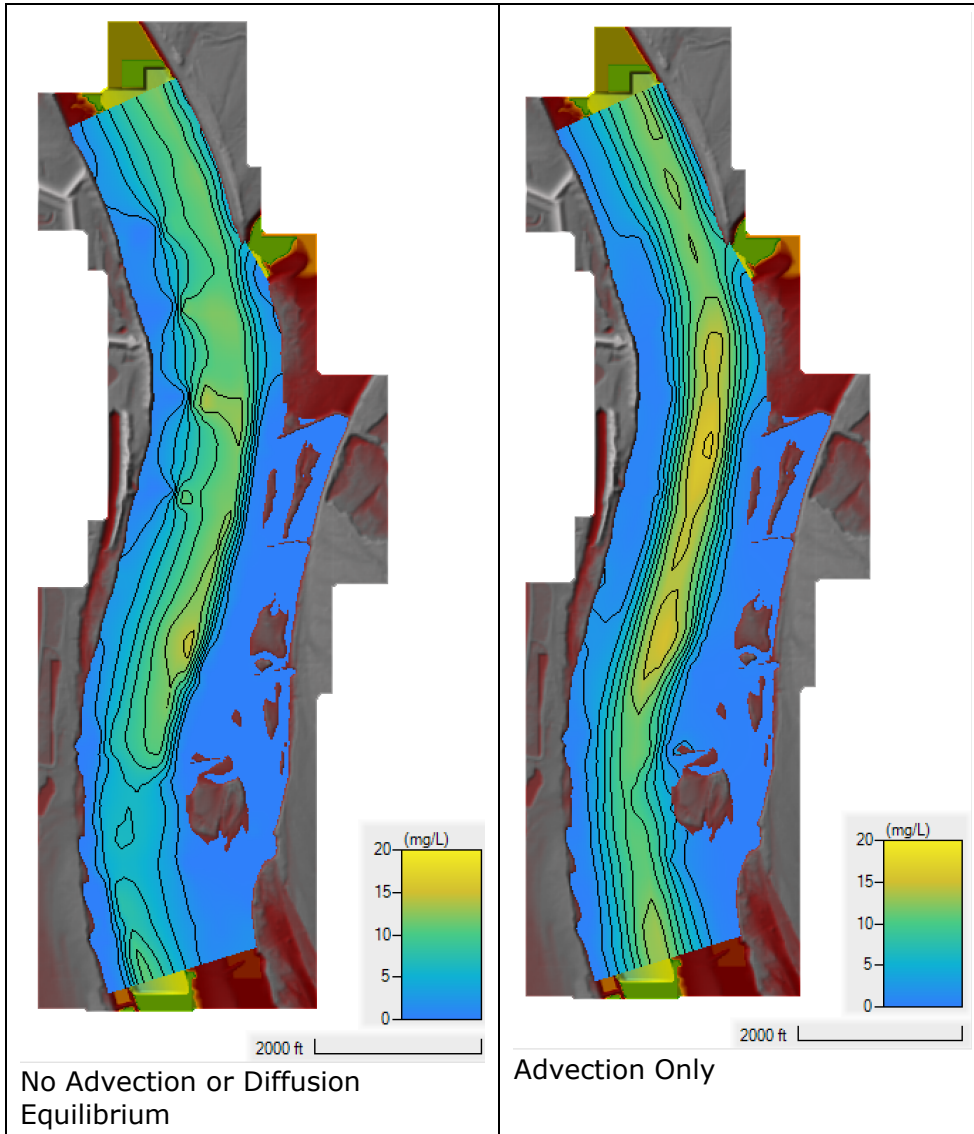
Question: What is the difference in water surface elevations at the upstream end of the model and that different significant?

Question: Do you think it is appropriate to utilize the DW model for river hydraulics?

Question: Why are the DW model water surfaces generally lower than the shallow water equations?

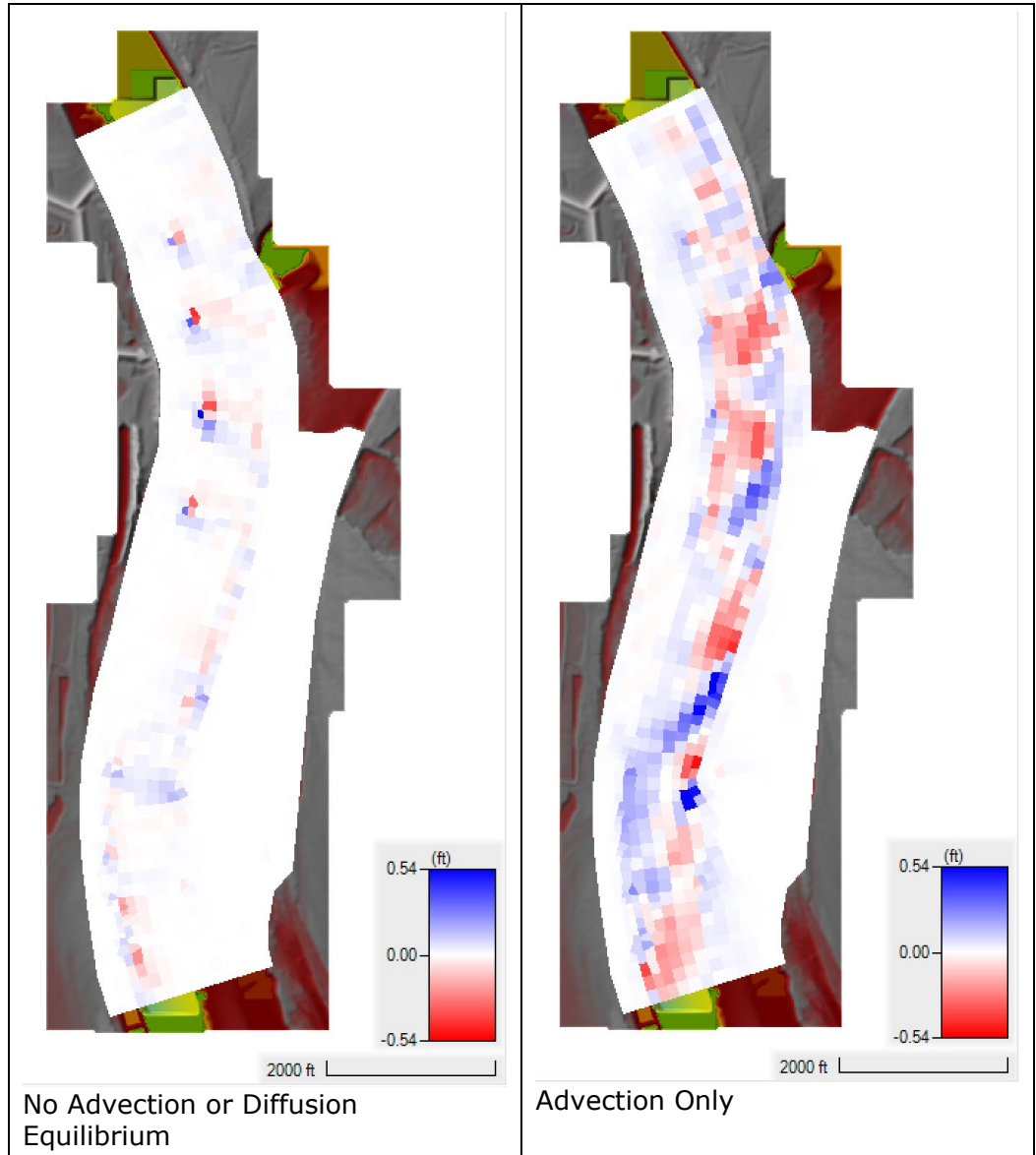
Question: Based on the SWE results, is the location of the upstream boundary condition well positioned if the goal is to study the effect of the dikes on the flow and sediment transport?

15. **Compare** the sediment concentrations between this plan and the previous plans. The results should look something like figure below. Remember copy-paste the color ramp symbology between results in order to compare them effectively. Below is an example of the sediment concentrations at the end of the simulation for the two plans.



Question: Based on the sediment concentrations, do you expect the bed change results to be similar between Diffusion-Wave (DW) and Shallow Water Equations?

16. **Compare** the bed change between this plan and the previous plans. The results should look something like figure below. Remember copy-paste the color ramp symbology between results to compare them effectively. Below is an example of the bed change at the end of the simulation for the two plans.



Question: Why does the SWE model generally produce more bed change compared the previous model.

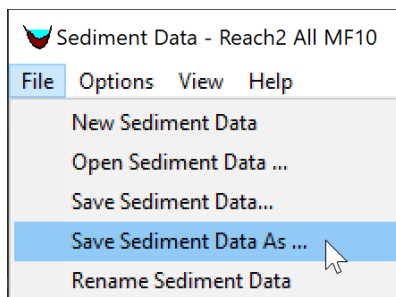
5 Advection and Diffusion

In this section, several new plans are created and compared with the previous plan with only advection. In total, three plans are created in section with different settings for the diffusion coefficient calculation method.

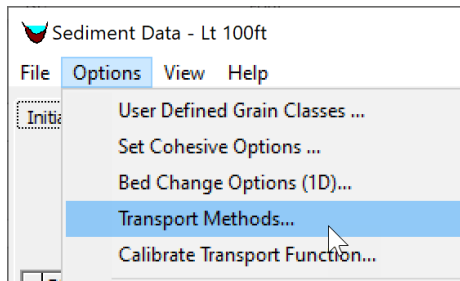
5.1 Constant Diffusion Coefficient

The simplest method for the diffusion coefficient is a constant value. In this section, diffusion is introduced by specifying a constant diffusion coefficient.

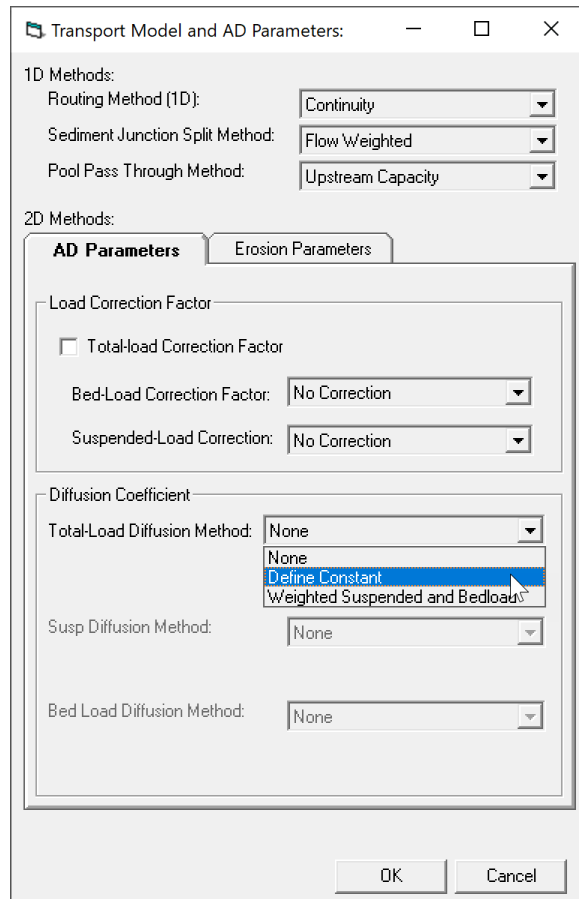
17. **Open** the **Sediment Data** editor .
18. **Click** on **File | Save Sediment Data As...** and save the data as "Adv Diff K 10"



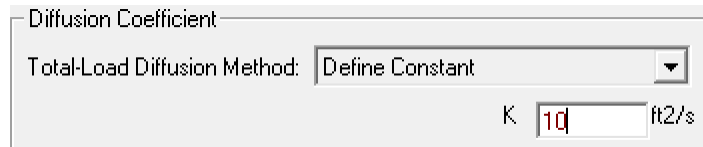
19. **Click** on the menu **Options | Transport Methods** as shown below



20. In the **Transport Model and AD Parameters** editor, under the **Diffusion Coefficient** section, select the drop-down menu for the **Total-load Diffusion Method** and select the **Define Constant** option as shown in the figure below.



21. **Enter** a constant diffusion coefficient of **10 ft²/s**.

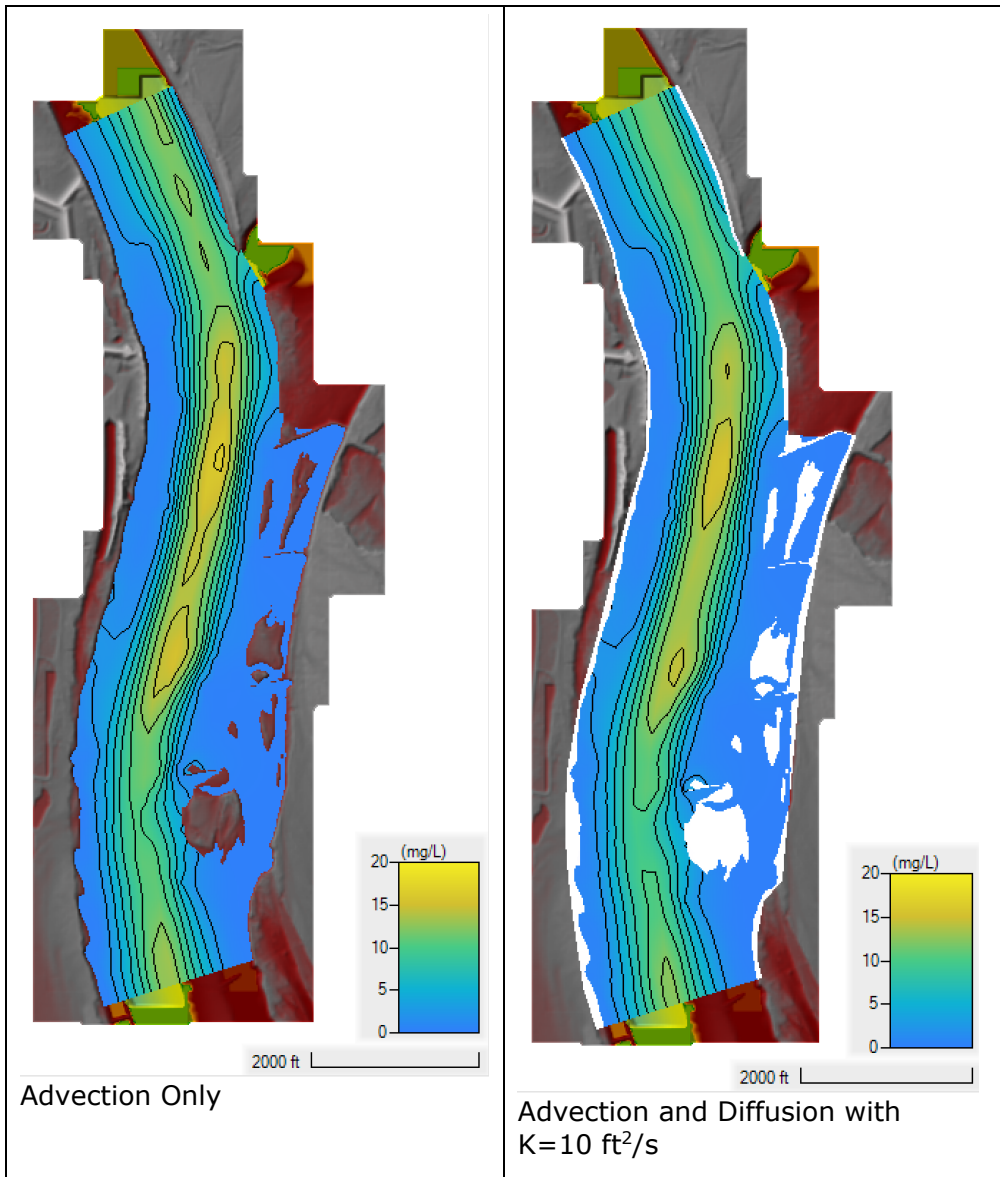


22. **Save** the **Sediment Data**.

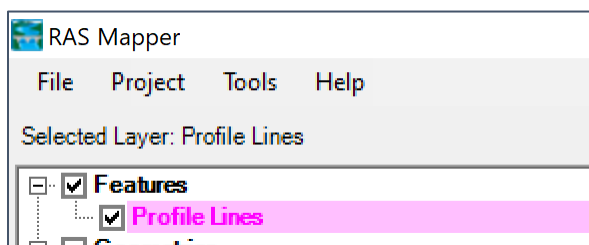
23. **Save** a new plan with the Title and Short ID "Adv Diff K 10".

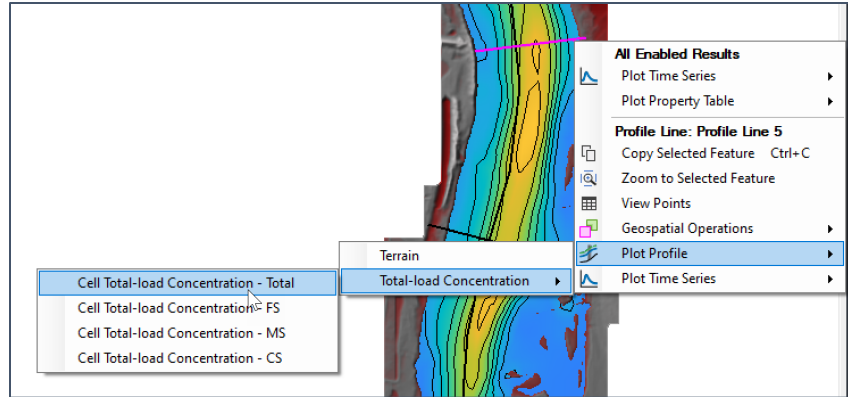
24. **Run** the plan

25. **Open RAS Mapper** and **add** the same sediment variables as described in Section 3. The figure below shows a comparison of the runs without advection and with a constant diffusion coefficient of 10 ft²/s.

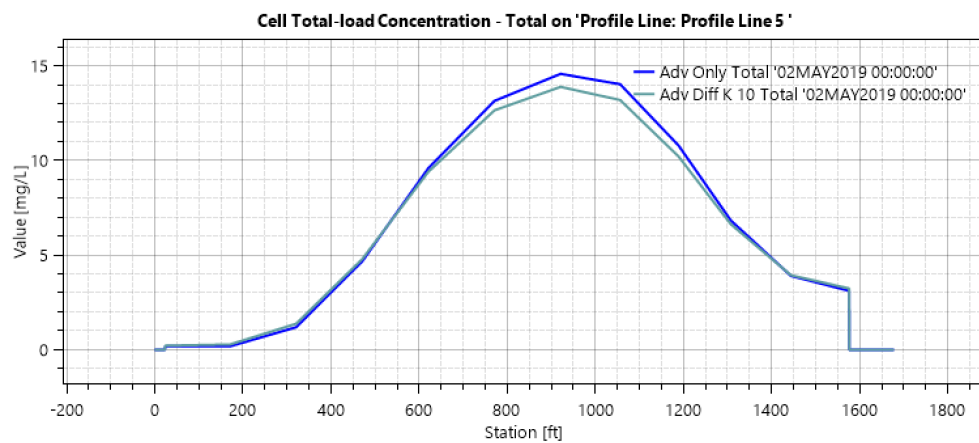


26. **Plot** the total-load concentration for both plans along one of the profiles to compare how diffusion affects the sediment concentrations. Do this by turning on the **Profile Lines** layer in the **Features** node. And then **right-click** on one of the profile lines, and select **Plot Profile | Total-load Concentration | Cell Total-load Concentration – Total** as shown in the figures below.






An example profile looks like this

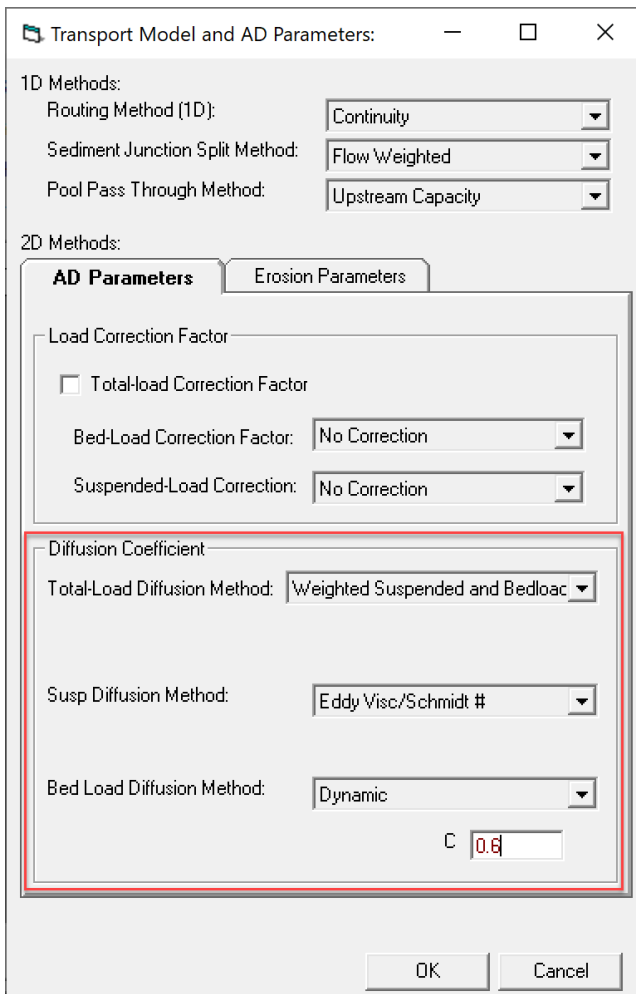


Question: Why does the plan with diffusion show a lower peak concentration in the transverse profile plot?

5.2 Weighted Bed- and Suspended-load Diffusion Coefficient

A constant diffusion is not recommended for most field applications because the mixing/diffusion coefficient varies significantly both in space and time as a function of hydraulics and grain size. In this section a new plan will be created with a spatially variable diffusion coefficient computed from a weighted average of the bed- and suspended-load diffusion coefficients.

27. **Open** the **Sediment Data** editor .
28. **Click** on **File | Save Sediment Data As...** and save the data as "Adv Diff Wght"
29. **Click** on the menu **Options | Transport Methods** as shown below
30. In the **Transport Model and AD Parameters** editor, under the **Diffusion Coefficient** section, select the drop down menu for the **Total-load Diffusion Method** and select the **Weighted Suspended and Bedload** option as shown in the figure below. Then set the suspended-load diffusion coefficient method to **Eddy Visc/Schmidt #**, and the bedload diffusion method to **Dynamic** as shown in the figure below. Use a coefficient C for dynamic bedload diffusion coefficient of **C = 0.6** as shown below.



Transport Model and AD Parameters: - □ ×

1D Methods:

Routing Method (1D): Continuity

Sediment Junction Split Method: Flow Weighted

Pool Pass Through Method: Upstream Capacity

2D Methods:

AD Parameters Erosion Parameters

Load Correction Factor

Total-Load Correction Factor

Bed-Load Correction Factor: No Correction

Suspended-Load Correction: No Correction

Diffusion Coefficient

Total-Load Diffusion Method: Weighted Suspended and Bedload

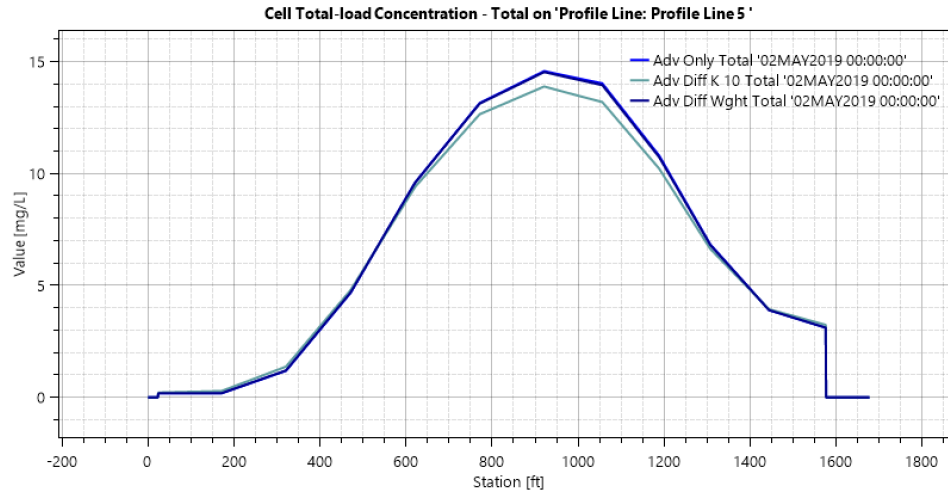
Susp Diffusion Method: Eddy Visc/Schmidt #

Bed Load Diffusion Method: Dynamic

C 0.6

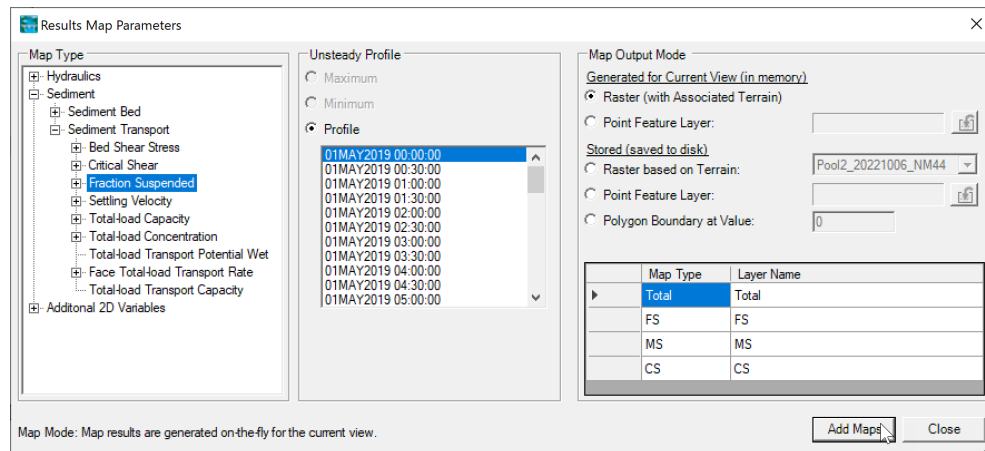
OK Cancel

31. **Save** the **Sediment Data**.
32. **Save** a new plan with the Title and Short ID "Adv Diff Wght".
33. **Run** the plan
34. **Open RAS Mapper** and **add** the same sediment variables as described in the previous section.
35. **Compare** new results with previous two plans. Below is an example profile plot of sediment concentrations at Profile Line 5.

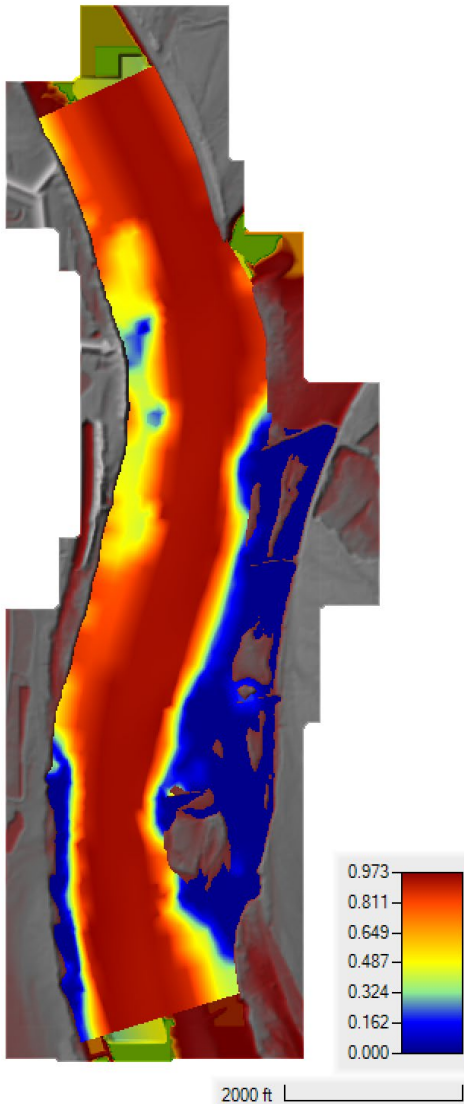


Question: From looking at the concentration fields, did the plan with the weighted diffusion coefficient produce diffusion coefficients larger or smaller than the plan with a constant value of 10 ft²/s?

36. **Add** the fraction of suspended sediments called **Fraction Suspended**.




The fraction of suspended sediments should look something like the figure below.

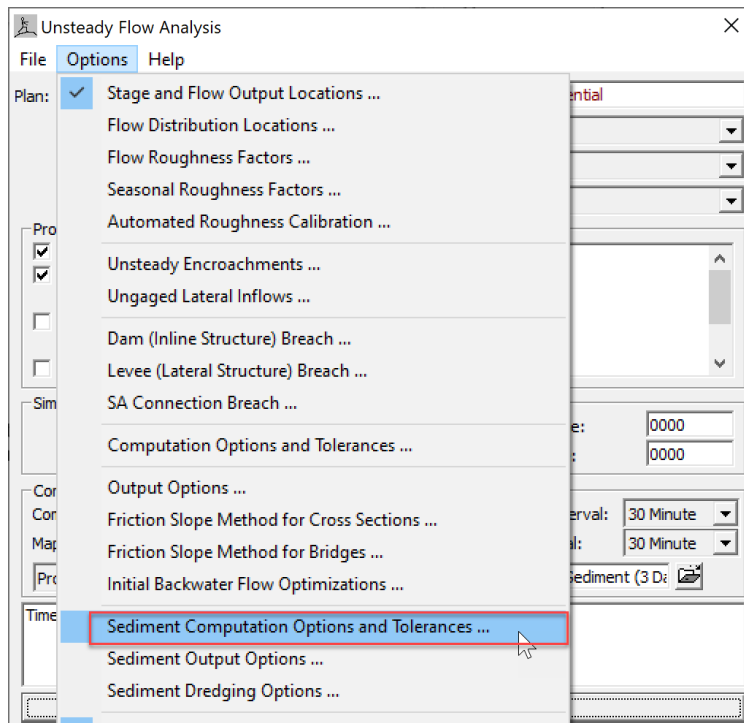


Question: For this model, would the results be sensitive to changes in the bedload diffusion coefficient and why?

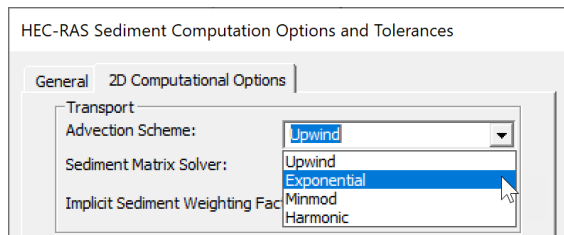
5.3 Exponential Scheme

The **Exponential Scheme** is linear scheme based on an analytical solution of the 1D steady-state advection diffusion. If you look at how this scheme is implemented, it is basically the upwind scheme with a reduction of the diffusion term to account for “excess” diffusion from the upwind scheme. The scheme also has the benefit of being inexpensive and linear which means it does not require significant additional computations or iterations to solve. In this section, a plan is setup and run with the **Exponential Scheme**.

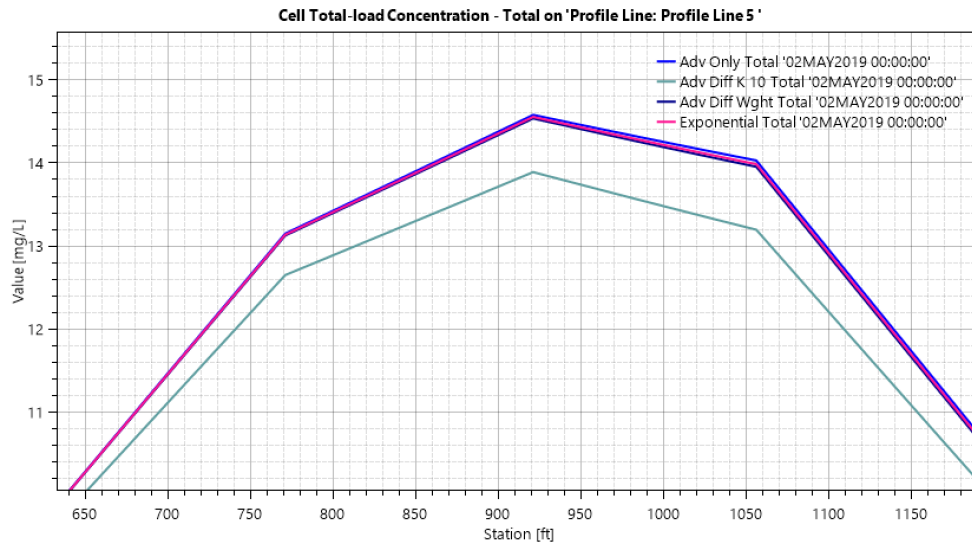
37. **Open** the **Unsteady Flow Analysis** window .
38. **Click on File | Save Plan As** and create a new plan with the Title and Short ID “Exponential”.
39. **Click on the menu Options | Sediment Computation Options and Tolerances** as shown in the figure below.



40. **Click on the 2D Computational Options** tab and within the section called **Transport** select the **Advection Scheme** to **Exponential** as shown in the figure below.



41. **Click OK** and **close** the **Sediment Computation Options and Tolerances** editor.
42. **Run** the plan.
43. **Open RAS Mapper** and **Add** the same sediment variables as described in Section 3.
44. **Compare** new results with previous two plans. Below is an example close-up of sediment concentrations along Profile Line 5.




Question: How does the Exponential Scheme compare to the other plans?

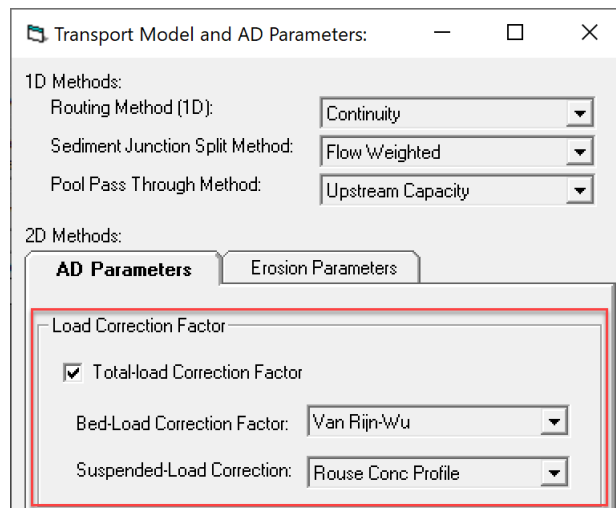
Question: Considering the level of uncertainty in sediment transport, are the differences between the different concentration fields with different diffusion settings significant?

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6 Load Correction Factor

The 2D sediment transport model in HEC-RAS uses a velocity-weighted concentration. This means that the model does not have advection coefficients and instead has a load-correction factor in the temporal term. The load-correction factor is more important for dynamic datasets with rapid changes in hydraulics.

45. **Open** the **Sediment Data** editor .
46. **Click** on **File | Save Sediment Data As...** and save the data as "Correction Factor"
47. **Click** on the menu **Options | Transport Methods** as shown below
48. In the **Transport Model and AD Parameters** editor, under the **Load Correction Factor** section, check the box next to **Total-load Correction Factor**, and set the bed- and suspended-load correction factor methods as shown below.



49. **Save** the **Sediment Data**.
50. **Save** a new plan with the Title and Short ID "Correction Factor".
51. **Run** the plan
52. **Open RAS Mapper** and **add** the same sediment variables as described in the previous section.