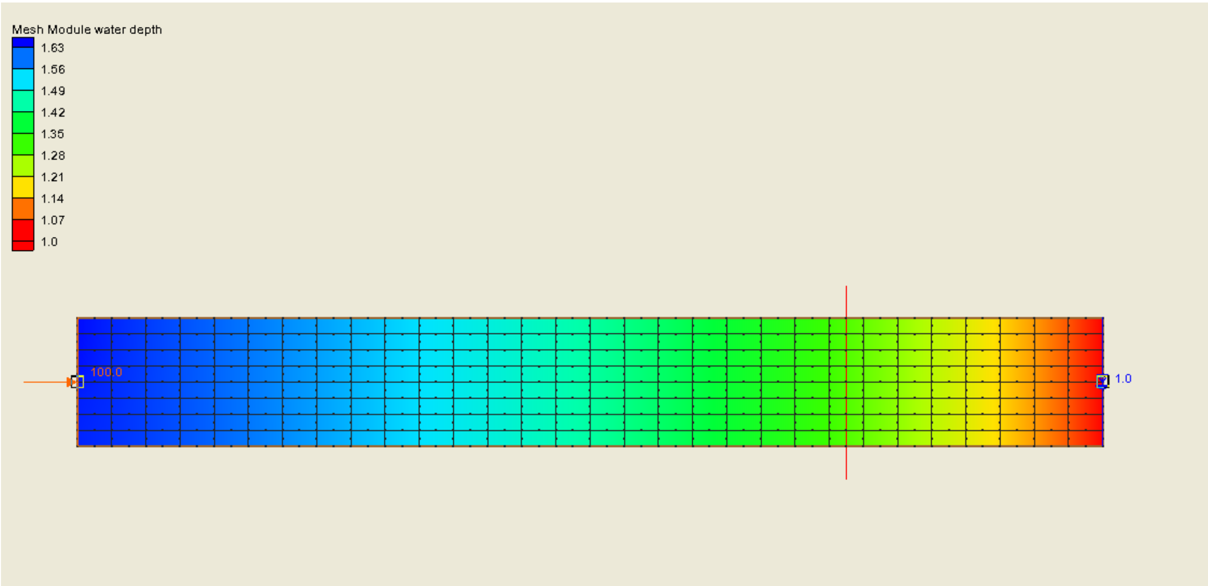
SMS

v. 11.1

SMS 11.1 Tutorial
Sensitivity Analysis



Objectives

This lesson analyzes the effects of changes in Manning's roughness coefficients and of kinematic eddy viscosity on various channel arrangements. Understanding the effects of Manning's roughness and eddy viscosity are useful in model calibration.

Either *RMA2* or *FESWMS* may be used for this lesson. Generic solutions to the models generated by *RMA2* or *FESWMS* have been provided for those without the *RMA2* or *FESWMS* interface enabled.

Prerequisites

- RMA2 Tutorial
- FESWMS Tutorial

Requirements

- RMA2/FESWMS
- Mesh Module
- Map Module

Time

- 45-60 minutes

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1 Before Getting Started

***Note: If the *FESWMS* or *RMA2* interface is disabled, generic mesh files can be found of the format (**.2dm*) with the solution to each model run (labeled **.h5*) in the directory for this tutorial. For each project file (**.sms*) referenced in this tutorial, it will be necessary to load both the mesh file and the corresponding solution from the *Generic* folder found in the directory for this tutorial. Likewise, any steps that reference running either *FESWMS* or *RMA2* models should be skipped and the generic solutions to each step should be loaded.

2 Simple Channel with Single Material

A flume 800 meters by 100 meters has been prepared for use in this lesson. The flowrate is set at 100 m^3/s. The downstream water surface elevation is 1 m. This flume has no slope and is comprised of a single material.

2.1 Open the Simulation

To open the file that contains the necessary mesh.

1. Select File | Open.
2. Open flumea1.sms (Use the RMA2 directory if you are using *RMA2*, the FESWMS directory for *FESWMS*, or the *Generic* directory for generic model files in the Data Files Folder.) If you still have geometry open from a previous tutorial, you will be asked if you want to delete existing data. If this happens, click the *Yes* button.

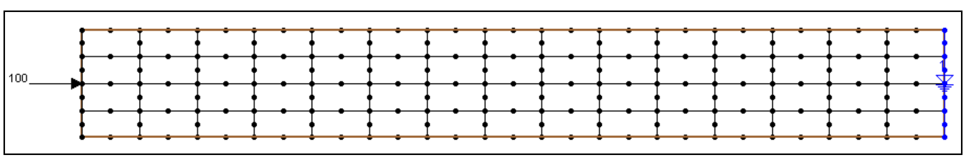

Figure 1 The mesh flumea1.

2.2 Running the Model

The correct material properties have been set for the initial run. You will need to run the model with the current settings. For instructions on running RMA2, see the RMA2 model tutorial. For instructions on how to run FESWMS, see the FESWMS model tutorial.

2.3 Creating Profile Plots

Before making a profile plot it is necessary to create an observation coverage, with an observation arc to define the profile to plot. To create an observation coverage and profile arc:

1. Select *default coverage* to activate it.
2. Right click on *default coverage*, go to *type*, and change the *coverage type* to *Observation*.
3. Select the Create Feature Arc *tool* from the toolbox.
4. Create an arc down the center of the flume as shown in Figure 2.

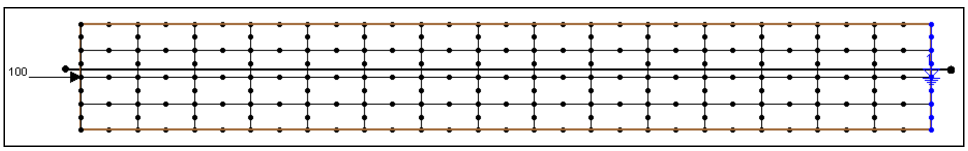

Figure 2 Mesh with Observation Arc.

In *SMS*, profile plots can be created to visualize the results of a model run. To create a profile plot:

1. Select Display | Plot Wizard.
2. Select the *Observation Profile* option and click *Next*.
3. In the "Dataset(s)" section choose "specified" to use specified datasets. Select "water depth". Click the *Finish* button. The plot should now appear on your screen.

2.4 Varying Manning's Roughness

The next step is to change the material properties and rerun the model in order to compare the results. To change the material properties:

1. Click on the Mesh Data object in the project explorer or click the Mesh Module macro below the project explorer to switch to the Mesh Module.

2. If using RMA2, select RMA2 | Material Properties. If using FESWMS, select FESWMS | Material Properties.
3. If using RMA2, in the Roughness tab change the roughness value to 0.045.
4. If using FESWMS, in the Roughness Parameters tab change the Manning's roughness (n1 and n2) to 0.045.
5. Click OK.
6. Select File | Save As.
7. Save the new project as flumea2.sms.
8. Rerun the model with the new roughness value. The new solution file should be read in automatically.
9. Right click on the plot and select Plot Data.
10. Select the newly computed water depth data set to add it to the plot.

Repeat steps 2-8 except change the n value to 0.065, and save the file as flumea3.sms. The plot should now look like Figure 3. The plot demonstrates the fact that as the roughness increases, the upstream water surface elevation increases.

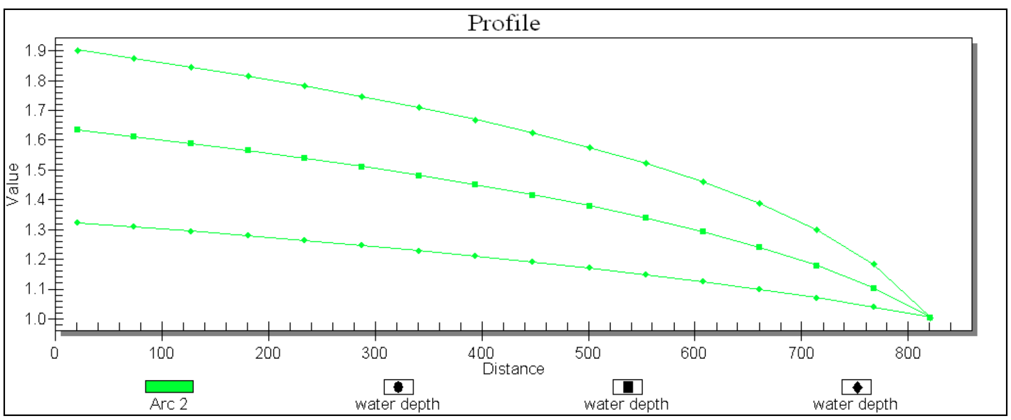

Figure 3 Water depth with varied roughness parameters.

2.5 Changes in Eddy Viscosity

Eddy Viscosity is another parameter that can be modified to alter the model's solution. This section will analyze the effects of various eddy viscosities while keeping Manning's coefficient constant. To setup the first run:

1. First erase the old solutions by right clicking on them and choosing Delete .
2. If using RMA2, select RMA2 | Material Properties.
3. If using FESWMS, select FESWMS | Material Properties.
4. Change the material_01 roughness value to 0.035.
5. If using RMA2, in the Turbulence tab change the Eddy Viscosity (Exx) to 5.0.
6. If using FESWMS, in the Turbulence Parameters tab change the Viscosity (Vo) to 1.0 m2/s.
7. Click OK.
8. Select File | Save As.
9. Save the project as flumeb1.sms.
10. Rerun the model with the new model parameters.

Now create two new solutions using steps 2-8. For RMA2 use viscosities of 100 and 500,000. For FESWMS use viscosities of 10 and 100 m^2/s. Name the files as flumeb2.sms and flumeb3.sms. Edit the plot data to show the water depths for these new runs instead of the previous runs. Your plots should look like Figure 4 for RMA2 and Figure 5 for FESWMS.

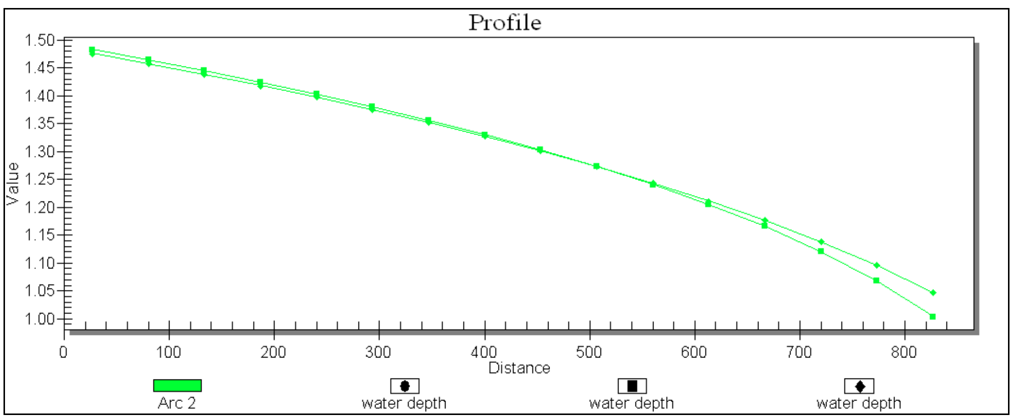

Figure 4 Eddy Viscosities of 5, 100, 500,000 with n = 0.035 using RMA2.

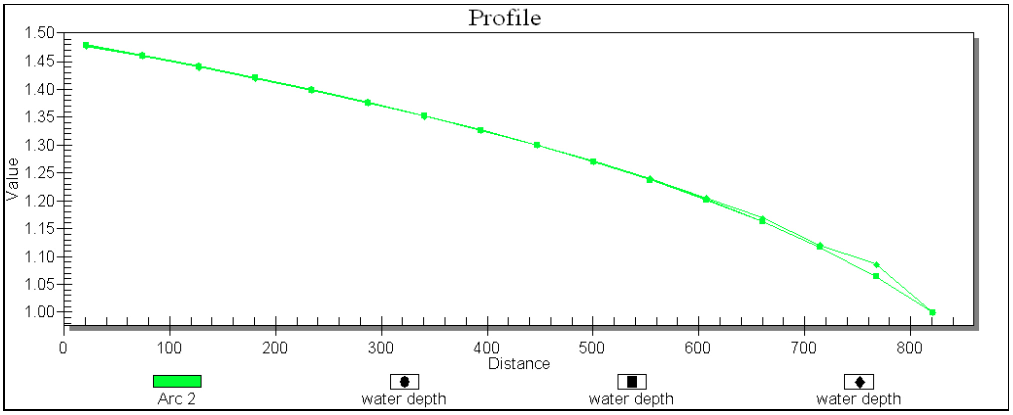

Figure 5 Eddy Viscosities of 1, 10, 100 m^2/s with n = 0.035 using FESWMS.

The results in *RMA2* changed little even for the unrealistic value of 500,000. *FESWMS* also had very little difference even for values as high as 100 m^2/s.

3 Constrained Flume with Single Material

The second channel was designed to show the effect of roughness coefficients and eddy viscosities when large velocity gradients occur in the longitudinal flow direction. This channel has the same dimensions as our first flume, but it is constricted to 20 m wide through the middle. The channel has gradual contractions and expansions above and below the constricted section. The flowrate will remain 100 m^3/s. The downstream water surface elevation will remain 1 m.

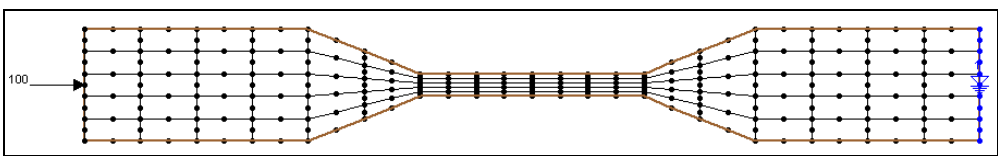

Figure 6 Test Channel #2.

3.1 Open the Simulation

To open the new mesh:

1. First Select *File* | *Delete All*. Click *Yes* to delete all existing data.
2. Select File | Open.
3. Select the file *flumec1.sms*.

3.2 Varying Manning's Coefficient

Select the left boundary nodestring and select *Nodestrings* | *Renumber*. Then repeat the same procedure as was outlined in sections 2.2 to 2.4. First, run the model as configured. Use n values of 0.045 and 0.065 *for the subsequent model runs*. Save the files as flumec2.sms and flumec3.*sms*. Make sure to add all three solutions into the profile plot. When finished, the plots should look like Figure 7 for *RMA2* and Figure 8 for *FESWMS*.

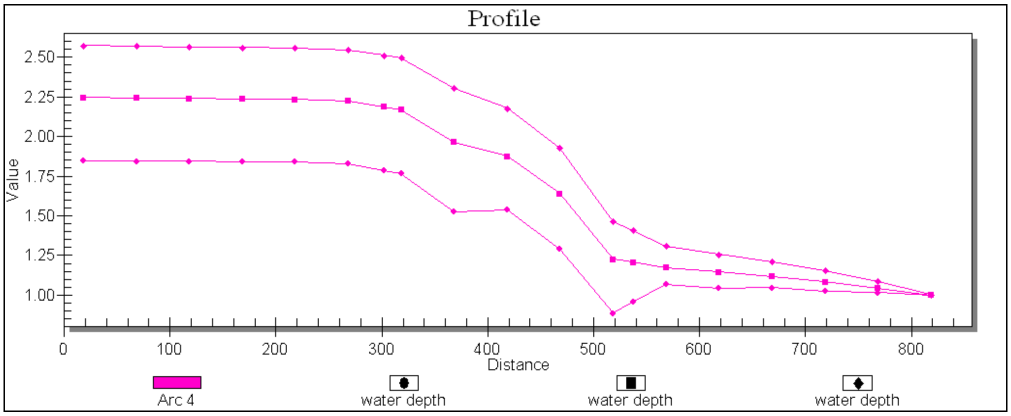

Figure 7 Constricted flume water depths with various roughness factors for RMA2.

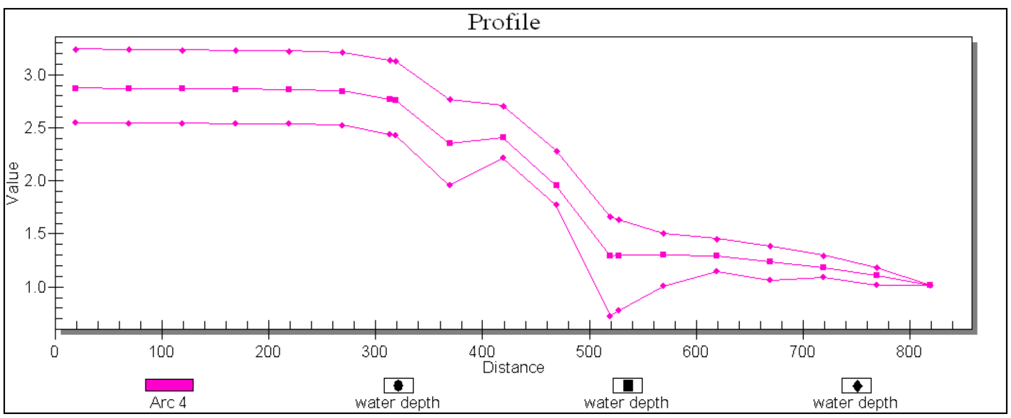

Figure 8 Constructed flume water depths with various roughness factors for FESWMS.

3.3 Varying Eddy Viscosities

To analyze the effect of changing eddy viscosities:

11. Erase the old solutions by right clicking on them and choosing Delete.
12. In the Material Properties dialog change the Manning's roughness value to 0.035.
13. If using RMA2, make sure the Eddy Viscosity (Exx) is 5.
14. If using FESWMS, make sure the Viscosity (Vo) is 1 m2/s.
15. Click OK.
16. Select File | Save As.
17. Save the file as flumed1.sms.
18. Run the model.

Now create two new solutions using steps outlined above. For RMA2 use viscosities of 100 and 2,000. For FESWMS use viscosities of 10 and 100 m^2/s. Name the files flumed2.sms and flumed3.sms respectively. Add the water depths for all three solutions into the profile plot.

As shown in Figure 9 and Figure 10 , eddy viscosities have a much larger effect when there are large longitudinal velocity gradients. For realistic values of eddy viscosity, differences in depth at the upstream end of the channel are small.

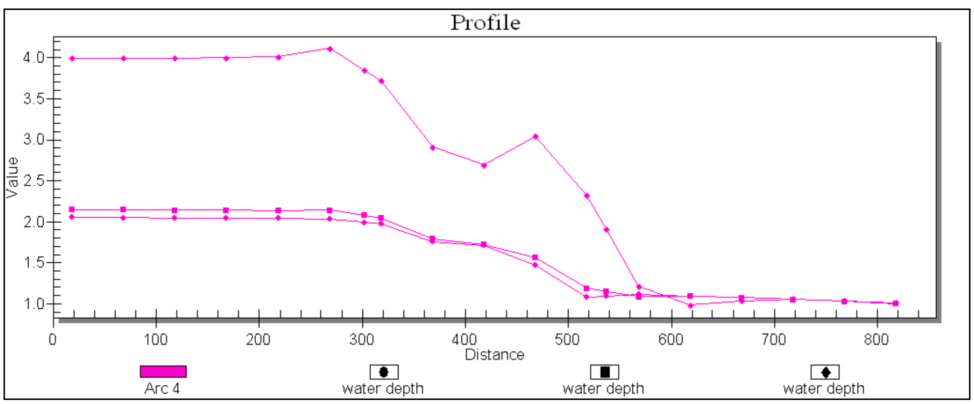

Figure 9 Constricted flume depths with various eddy viscosities for RMA2.

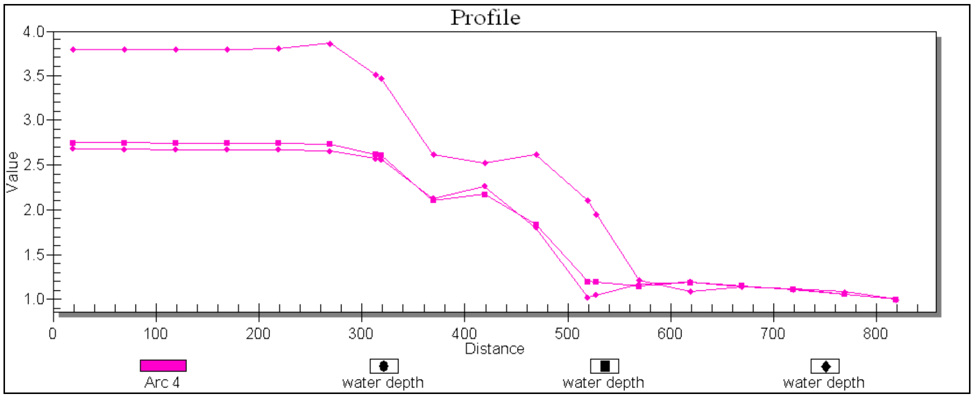

Figure 10 Constricted flume depths with various eddy viscosities for FESWMS.

4 Simple Channel with Two Materials

This channel has the same dimensions and boundary conditions as the first one. The elements are smaller and the channel has two material types rather than one. We will examine the effects the lateral roughness variation has on velocity.

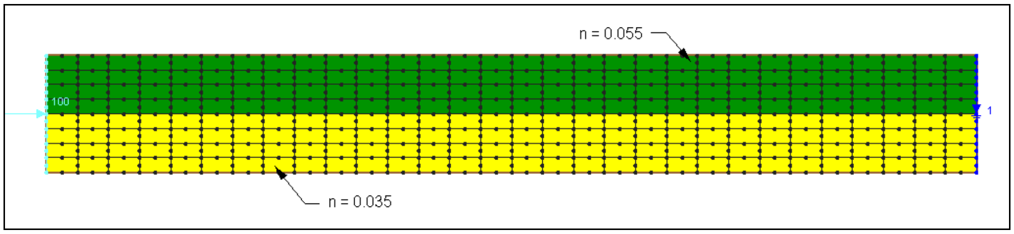

Figure 11 Channel #3 simple flume with two materials

This time specific instructions will not be given. If you don't remember how to do something, look back at the lesson for help.

19. Delete all the existing data by selecting File | Delete All and clicking Yes to continue deleting all data.
20. Open the file flumee1.sms.
21. Run the simulation with the current settings.
22. For RMA2 rerun the model with viscosities of 500, 5000, and 50,000 for both materials.
23. For FESWMS rerun the model with viscosities of 5, 50, and 100 for both materials.

24. Name the simulation files flumee2.sms, flumee3.sms, and flumee4.sms.
25. Create an observation coverage.
26. Create an observation arc across the flume from top to bottom at about 200 m from the downstream boundary as shown in Figure 12.
27. Create an observation profile plot turning on the velocity mag function for each solution. Make sure that in step 2 of the Plot wizard, that you set the *Extract profile from:* to *Model Intersections.*

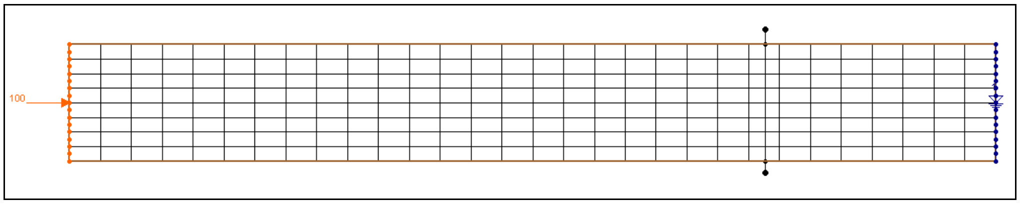

Figure 12 Channel #3 showing placement of observation arc.

The plot should look like Figure 13 for RMA2 or Figure 14 for FESWMS. As you can see in the graph, smaller eddy viscosities allow larger transverse velocity gradients to appear in the solution.

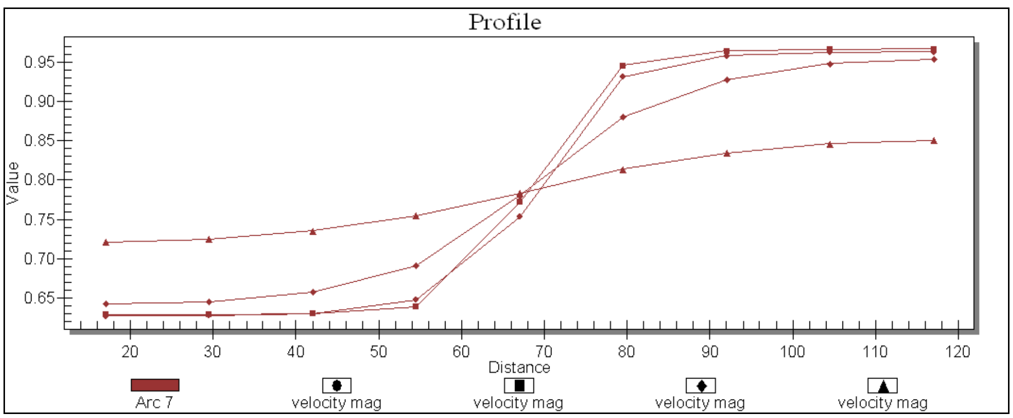

Figure 13 Plot of RMA2 solution for various eddy viscosities for channel #3.

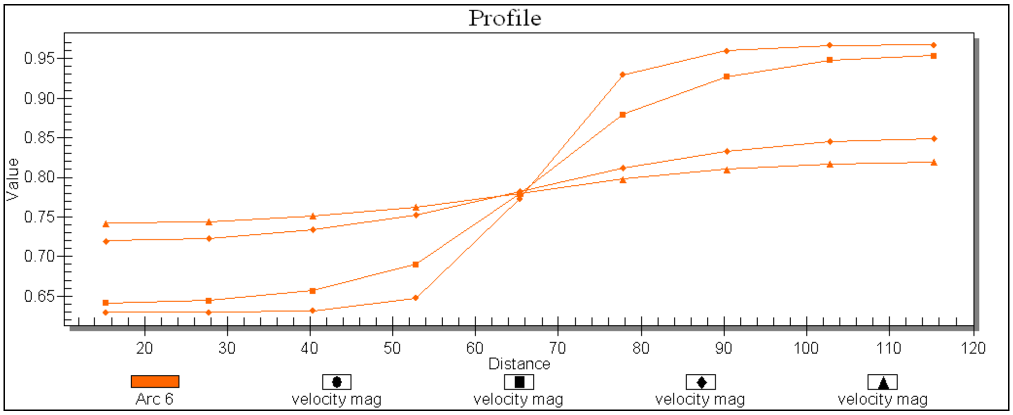

Figure 14 Plot of FESWMS solution for various eddy viscosities for channel #3.

5 Conclusion

This concludes the *Sensitivity Analysis* tutorial. You may wish to experiment further with different channel arrangements and watch the effects of changing roughness and viscosity values. This concludes the tutorial.