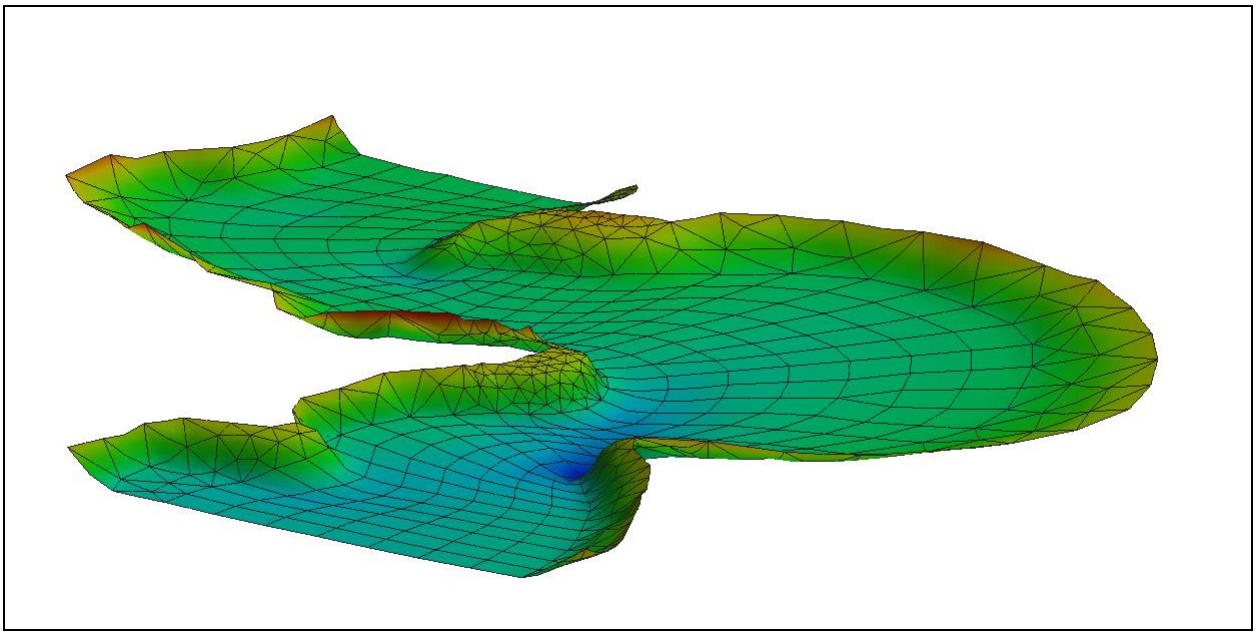
SMS

v. 12.2

*SMS 12.2 Tutorial*

# *FESWMS Sensitivity Analysis*



## Objectives

This tutorial 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.

## Prerequisites

- Basic FESWMS Analysis

## Requirements

- FESWMS
- Mesh Module
- Map Module

## Time

- 45–60 minutes

AQUAVEO™

# 1 Simple Channel with Single Material

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

To open the file that contains the necessary mesh:

1. Select *File* | **Open…** to bring up the *Open* dialog.
2. Select "Project Files (*.sms)" from the *Files of type* drop-down.
3. Browse to the *data files* folder for this tutorial and select "flumea1.sms".
4. Click **Open** to import the project file and exit the *Open* dialog.
5. If geometry is still open from a previous tutorial, SMS will ask if it should delete existing data. Click **Yes**.

The graphics window should appear similar to Figure 1.

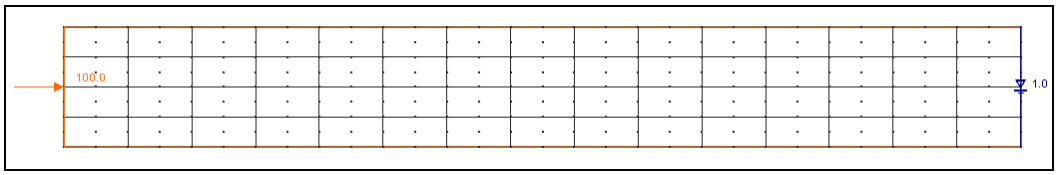



*Figure 1 The mesh for "flumea1.sms"*

## 1.1 Running the Model

The correct material properties have been set for the initial run. It's necessary to run the model with the current settings. For instructions on how to run FESWMS, see the "Basic FESWMS Analysis" tutorial.

1. Select *FESWMS* | **Run FSTDH** to bring up the *FESWMS* model wrapper dialog.
2. When the model finishes its run, turn on *Load solution* and click **Exit** to close the *FESWMS* model wrapper dialog.

## 1.2 Creating Profile Plots

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

1. Select "Area Property" in the Project Explorer to make it active.
2. Right-click "Area Property" and select *Type* | *Generic* | **Observation**.
3. Right-click "Area Property" and select **Rename**.
4. Enter "Observation" and press *Enter* to set the new coverage name.
5. Using the **Create Feature Arc** tool, create a horizontal arc just above the center of the flume.

The project should appear similar to Figure 2.

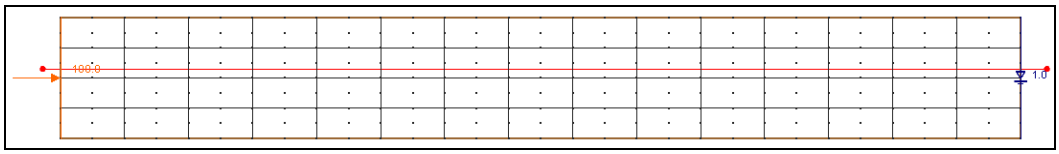


*Figure 2 Mesh with observation arc*

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

1. Select *Display* | **Plot Wizard…** to bring up the *Step 1 of 2* page of the *Plot Wizard* dialog.
2. Select "Observation Profile" from the list on the left.
3. Click **Next** to go to the *Step 2 of 2* page of the *Plot Wizard* dialog.
4. In the *Dataset(s)* section, select *Specified*.
5. Select " water depth" from the list of datasets that appears.
6. Click **Finish** to close the *Plot Wizard* dialog.

A plot dialog showing the water depth profile should appear (Figure 3). When done reviewing it, minimize the plot window or move it out of the way so the main SMS window is visible.

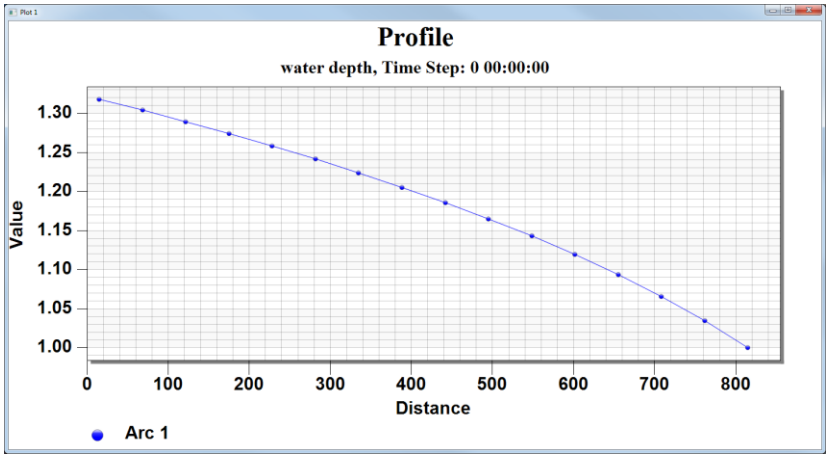



*Figure 3 Water depth profile*

## 1.3 Varying Manning's Roughness

For this step, create a second set of observations by changing the material properties and rerun the model in order to compare the results.

1. Select "flumea1" to make it active.
2. Select *FESWMS* | **Material Properties…** to bring up the *FESWMS Material Properties* dialog.
3. Select "material_01" from the list on the left.
4. On the *Roughness Parameters* tab, enter "0.045" as both *n1* and *n2*.
5. Click **OK** to close the *FESWMS Material Properties* dialog.

Next, save the project with a new name, run FESWMS, and create a new plot.

6. Select *File* | **Save As…** to bring up the *Save As* dialog.
7. Select "Project Files (*.sms)" from the *Save as type* drop-down.
8. Enter "flumea2.sms" as the *File name*.
9. Click **Save** to save the project under the new name and close the *Save As* dialog.
10. Select *FESWMS* | **Run FSTDH** to bring up the *FESWMS* model wrapper dialog.
11. When the model finishes its run, turn on *Load solution* and click **Exit** to close the *FESWMS* model wrapper dialog.
12. Go to the plot window, right-click in it, and select **Plot Data…** to bring up the *Data Options* dialog.
13. In the *Dataset(s)* section, select *Specified*.
14. Select "water depth (2)" from the list of datasets below that.
15. Select "Red" as the *Dataset color*.
16. Click **OK** to close the *Data Options* dialog.

The plot should appear similar to Figure 4.

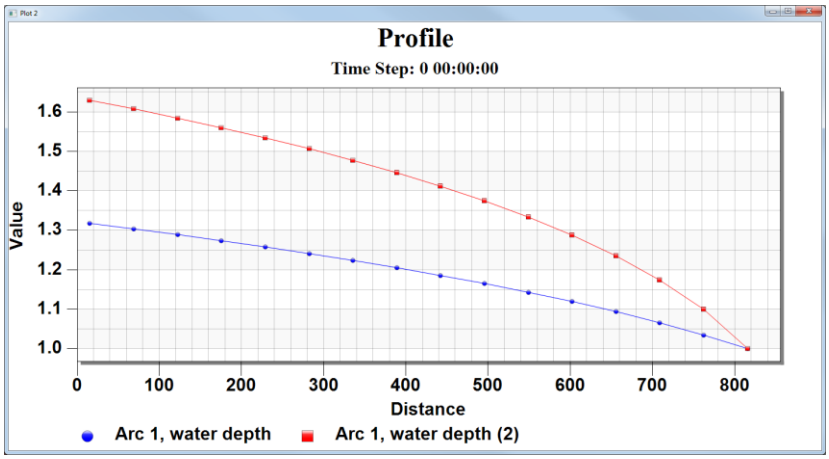



*Figure 4 Plot showing the second set of observations*

Now create a third set of observations to plot:

17. Minimize the plot window when done comparing the two observation datasets.
18. Repeat steps 1-16, changing the following:
    - Enter "0.065" in step 4 for *n1* and *n2*.
    - Enter "flumea3.sms" as the *File name* in step 8.
    - Select "  water depth (3)" from the list of datasets in step 14.
    - Select "Green" as the *Dataset color* in step 15.

The plot should now appear similar to Figure 5.

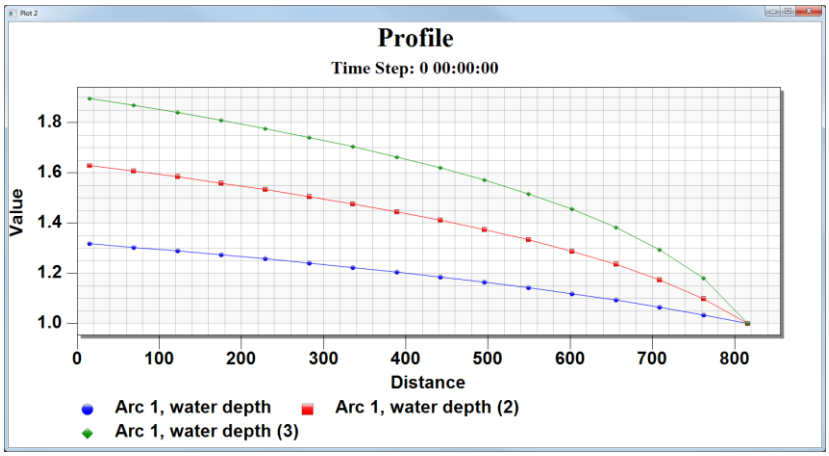



*Figure 5 Plot showing the third set of observations*

19. Minimize (do not close) the plot window when done comparing the three observation datasets.

The plot demonstrates the fact that as the roughness increases, the upstream water surface elevation increases.

## 1.4 Changing Eddy Viscosities

Eddy viscosity is another parameter that can be modified to alter the model solution. This section demonstrates how to analyze the effects of various eddy viscosities while keeping Manning's coefficient constant.

Adjust the model by doing the following:

1. Right-click on "flumea1.flo (FESWMS)" and select **Delete**.
2. Click **Yes** when asked to confirm the deletion.
3. Select *FESWMS* | **Material Properties…** to bring up the *FESWMS Material Properties* dialog.
4. Select "material_01" from the list on the left.
5. On the *Roughness Parameters* tab, enter "0.035" for both *n1* and *n2*.
6. On the *Turbulence Parameters* tab, enter "1.0" for *Vo* and click **OK** to close the *FESWMS Material Properties* dialog.
7. Click *File* | **Save As…** to bring up the *Save As* dialog.
8. Select "Project Files (*.sms)" from the *Save as type* drop-down.
9. Enter "flumeb1.sms" as the *File name*.
10. Click **Save** to save the project under the new name and close the *Save As* dialog.
11. Select *FESWMS* | **Run FSTDH** to bring up the *FESWMS* model wrapper dialog.
12. When the model finishes its run, turn on *Load solution* and click **Exit** to close the *FESWMS* model wrapper dialog.
13. Repeat steps 3-12, changing the following:
    - Enter "10.0" in step 6 for *Vo*.
    - Enter "flumeb2.sms" as the *File name* in step 9.
14. Repeat steps 3-12, changing the following:
    - Enter "100.0" in step 6 for *Vo*.
    - Enter "flumeb3.sms" as the *File name* in step 9.
15. Go to the plot window, right-click in it, and select **Plot Data…** to bring up the *Data Options* dialog.
16. In the *Dataset(s)* section, select *Specified*.
17. Select "water depth" , "water depth (2)", and "water depth (3)" from the list of datasets below that.
18. Feel free to select a different *Dataset color* for each dataset. This makes it easier to distinguish between the plot lines.
19. Click **OK** to close the *Data Options* dialog.

The plot window should appear similar to Figure 6. The FESWMS results have little difference even for viscosity values as high as 100 $m^2/s$.

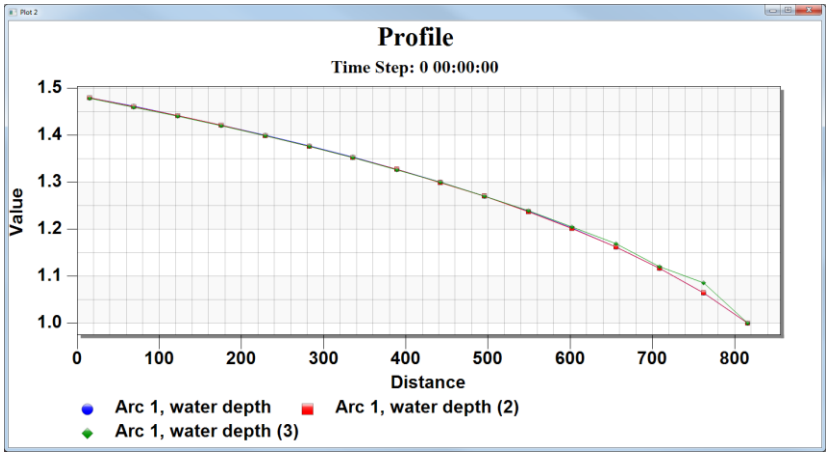



*Figure 6 Eddy viscosities of 1, 10, and 100 $m^2/s$ with n=0.035*

# 2 Constrained Flume with a Single Material

The second example 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 the first flume, but it is constricted to 20 meter wide through the middle. The channel has gradual contractions and expansions above and below the constricted section. The flowrate will remain 100 m3/s. The downstream water surface elevation will remain 1 meter.

To open the new mesh, do the following:

1. Select *File* | **Delete All** or press *Ctrl-N*.
2. Click **Yes** when asked to confirm deletion of all existing data.
3. Select *File* | **Open…** to bring up the *Open* dialog.
4. Select "Project Files (*.sms)" from the *Files of type* drop-down.
5. Browse to the *data files* folder for this tutorial and select "flumec1.sms".
6. Click **Open** to import the project and exit the *Open* dialog.
7. Select "  flumec1" to make it active.

The graphics window should appear similar to Figure 7.

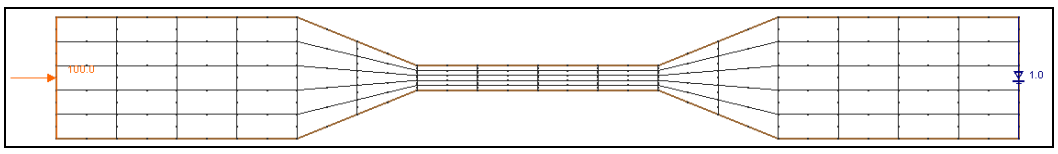



*Figure 7 Constrained flume test channel*

## 2.1 Renumbering Nodestrings and Running the Model

The correct material properties have been set for the initial run. It's necessary to run the model with the current settings. First, renumber the nodestrings by doing the following:

1. Using the **Select Nodestring** tool, select the left boundary nodestring.
2. Select *Nodestrings* | **Renumber**.
3. Select *FESWMS* | **Run FSTDH** to bring up the *FESWMS* model wrapper dialog.
4. When the model finishes its run, turn on *Load solution* and click **Exit** to close the *FESWMS* model wrapper dialog.

## 2.2 Creating Profile Plots

Now change the existing coverage into an observation coverage with a profile arc:

1. Select "Area Property" in the Project Explorer to make it active.
2. Right-click "Area Property" and select *Type* | *Generic* | **Observation**.
3. Right-click "Area Property" and select **Rename**.
4. Enter "Observation" and press *Enter* to set the new coverage name.
5. Using the **Create Feature Arc** tool, create a horizontal arc just above the center of the flume.

The project should appear similar to Figure 8.

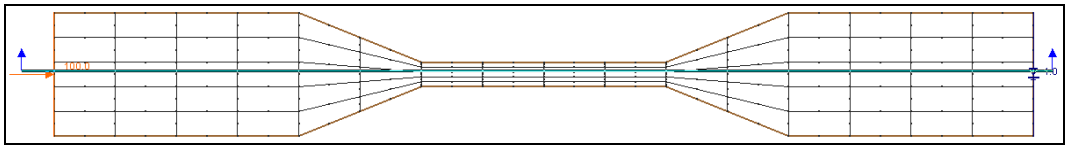


*Figure 8 Observation ark through the constrained flume*

Next, create a profile plot by doing the following:

1. Select *Display* | **Plot Wizard…** to bring up the *Step 1 of 2* page of the *Plot Wizard* dialog.
2. Select "Observation Profile" from the list on the left.
3. Click **Next** to go to the *Step 2 of 2* page of the *Plot Wizard* dialog.
4. In the *Dataset(s)* section, select *Specified*.
5. Select " water depth" from the list of datasets that appears.
6. Click **Finish** to close the *Plot Wizard* dialog.

A plot dialog showing the water depth profile should appear (Figure 9). When done reviewing it, minimize the plot window or move it out of the way so the main SMS window is visible.

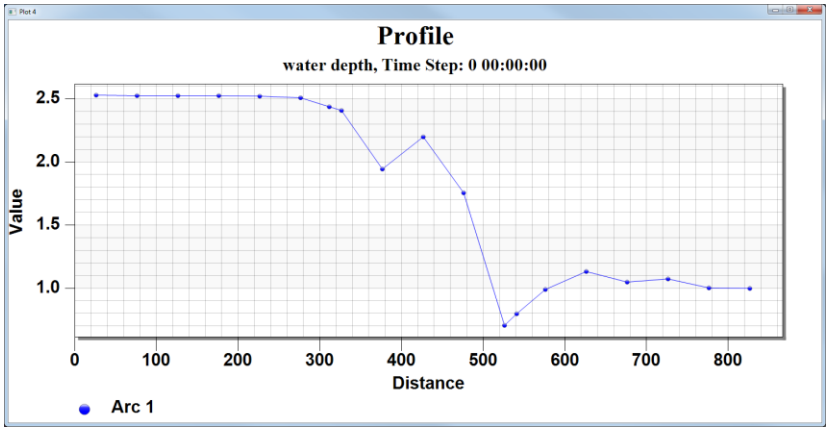



*Figure 9 Single water depth profile for constrained flume*

## 2.3 Varying Manning's Coefficient

For this step, create a second set of observations by changing the material properties and rerun the model in order to compare the results.

1. Select "flumec1" to make it active.
2. Select *FESWMS* | **Material Properties…** to bring up the *FESWMS Material Properties* dialog.
3. Select "material_01" from the list on the left.
4. On the *Roughness Parameters* tab, enter "0.045" as both *n1* and *n2*.
5. Click **OK** to close the *FESWMS Material Properties* dialog.

Next, save the project with a new name, run FESWMS, and create a new plot.

6. Select *File* | **Save As…** to bring up the *Save As* dialog.
7. Select "Project Files (*.sms)" from the *Save as type* drop-down.
8. Enter "flumec2.sms" as the *File name*.
9. Click **Save** to save the project under the new name and close the *Save As* dialog.
10. Select *FESWMS* | **Run FSTDH** to bring up the *FESWMS* model wrapper dialog.
11. When the model finishes its run, turn on *Load solution* and click **Exit** to close the *FESWMS* model wrapper dialog.
12. Repeat steps 1-11, changing the following:
    - Enter "0.065" in step 4 for *n1* and *n2*.
    - Enter "flumec3.sms" as the *File name* in step 8.
13. Go to the plot window, right-click in it, and select **Plot Data…** to bring up the *Data Options* dialog.
14. In the *Dataset(s)* section, select *Specified*.

15. Select "water depth", "water depth (2)", and "water depth (3)" from the list of datasets below that.
16. Feel free to select a different *Dataset color* for each dataset. This makes it easier to distinguish between the plot lines.
17. Click **OK** to close the *Data Options* dialog.

The plot should appear similar to Figure 10.

18. Minimize the plot window when done comparing the observation datasets.

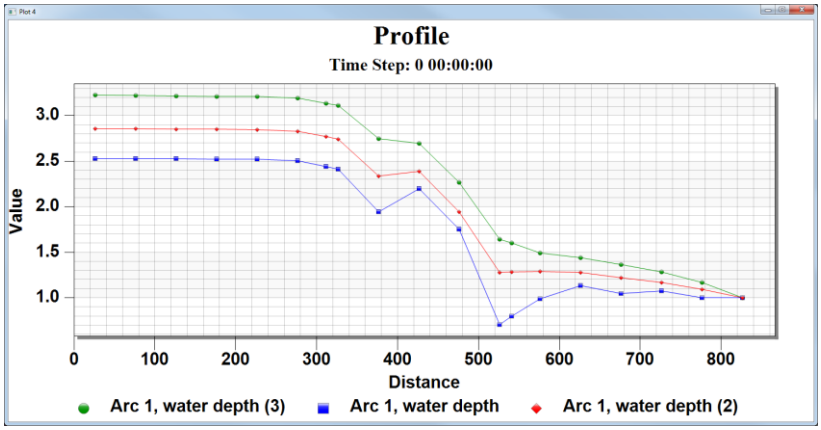



*Figure 10 Constructed flume water depths with various roughness factors*

## 2.4 Varying Eddy Viscosities

Now analyze the effects of changing eddy viscosities by doing the following:

1. Right-click on "flumec1.flo (FESWMS)" in the Project Explorer and select **Delete**.
2. Select *FESWMS* | **Material Properties…** to bring up the *FESWMS Material Properties* dialog.
3. Select "material_01" from the list on the left.
4. On the *Roughness Parameters* tab, enter "0.035" for both *n1* and *n2*.
5. On the *Turbulence Parameters* tab, enter "1.0" as the *Vo*.
6. Click **OK** to close the *FESWMS Material Properties* tab.
7. Select *File* | **Save As…** to bring up the *Save As* dialog.
8. Select "Project Files (*.sms)" from the *Save as type* drop-down.
9. Enter "flumed1.sms" as the *File name*.
10. Click **Save** to save the project under the new name and close the *Save As* dialog.
11. Select *FESWMS* | **Run FSTDH** to bring up the *FESWMS* model wrapper dialog.
12. When the model finishes its run, turn on *Load solution* and click **Exit** to close the *FESWMS* model wrapper dialog.

13. Repeat steps 2-12, changing the following:
    - Enter "10.0" in step 5 for *Vo*.
    - Enter "flumed2.sms" as the *File name* in step 9.
14. Repeat steps 2-12, changing the following:
    - Enter "100.0" in step 5 for *Vo*.
    - Enter "flumed3.sms" as the *File name* in step 9.
15. Select *Display* | **Plot Wizard…** to bring up the *Step 1 of 2* page of the *Plot Wizard* dialog.
16. Select "Observation Profile" from the list on the left.
17. Click **Next** to go to the *Step 2 of 2* page of the *Plot Wizard* dialog.
18. In the *Dataset(s)* section, select *Specified*.
19. Select "water depth", "water depth (2)", and "water depth (3)" from the list of datasets below that.
20. Feel free to select a different *Dataset color* for each dataset. This makes it easier to distinguish between the plot lines.
21. Click **OK** to close the *Data Options* dialog.

The plot should appear similar to Figure 11. Notice that 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.

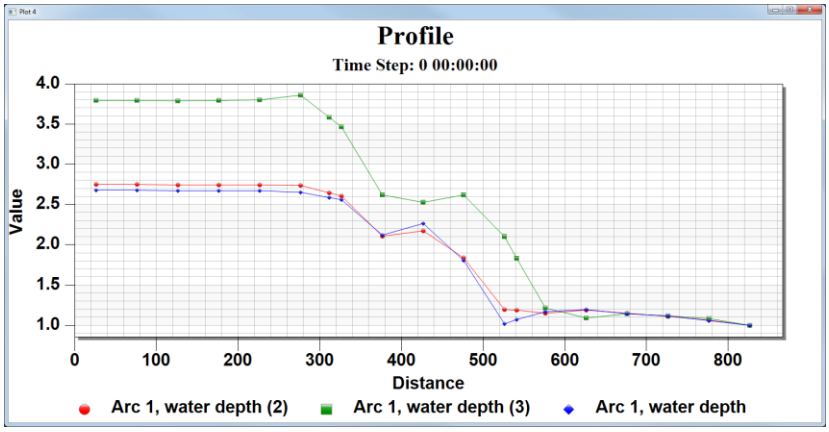



*Figure 11 Constricted flume depths with various eddy viscosities*

# 3 Simple Channel with Two Materials

This example 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. This section will examine the effects the lateral roughness variation has on velocity.

1. Select *File* | **Delete All** or press *Ctrl-N*.

2. Click **Yes** when asked to confirm deletion of all existing data.
3. Select *File* | **Open…** to bring up the *Open* dialog.
4. Select "Project Files (*.sms)" from the *Files of type* drop-down.
5. Browse to the *data files* folder for this tutorial and select "flumee1.sms".
6. Click **Open** to import the project and exit the *Open* dialog.
7. Select "  flumee1" to make it active.

The graphics window should appear similar to Figure 12.

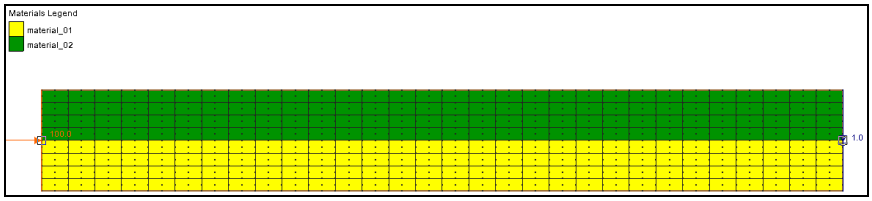



*Figure 12 Simple channel with two materials*

1. Select *FESWMS* | **Run FSTDH** to bring up the *FESWMS* model wrapper dialog.
2. When the model finishes its run, turn on *Load solution* and click **Exit** to close the *FESWMS* model wrapper dialog.
3. Select *FESWMS* | **Material Properties…** to bring up the *FESWMS Material Properties* dialog.
4. Select "material_01" from the list on the left.
5. On the *Turbulence Parameters* tab, enter "5.0" as the *Vo*.
6. Repeat steps 4-5 for "material_02".
7. Click **OK** to close the *FESWMS Material Properties* dialog.
8. Select *File* | **Save As…** to bring up the *Save As* dialog.
9. Select "Project Files (*.sms)" from the *Save as type* drop-down.
10. Enter "flumee2.sms" as the *File name*.
11. Click **Save** to save the project under the new name and close the *Save As* dialog.
12. Select *FESWMS* | **Run FSTDH** to bring up the *FESWMS* model wrapper dialog.
13. When the model finishes its run, turn on *Load solution* and click **Exit** to close the *FESWMS* model wrapper dialog.
14. Repeat steps 3-13, changing the following:
    - Enter "50.0" in steps 4-6 for *Vo*.
    - Enter "flumee3.sms" as the *File name* in step 10.
15. Repeat steps 3-13, changing the following:
    - Enter "100.0" in steps 4-6 for *Vo*.
    - Enter "flumee4.sms" as the *File name* in step 10.

Now create an observation coverage and a plot by doing the following:

1. Select "Area Property" in the Project Explorer to make it active.
2. Right-click "Area Property" and select *Type* | *Generic* | **Observation**.
3. Right-click "Area Property" and select **Rename**.
4. Enter "Observation" and press *Enter* to set the new coverage name.
5. Using the **Create Feature Arc** tool, create a vertical arc about 200 meters from the downstream boundary of the flume (Figure 13).

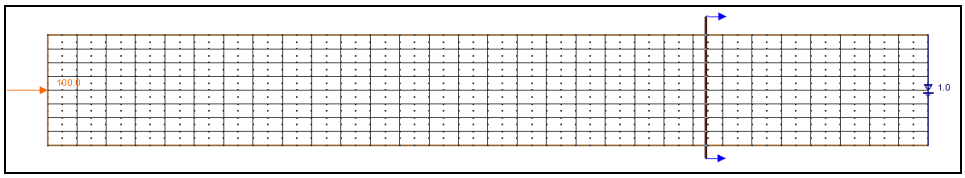


*Figure 13 Placement of observation arc*

6. Select *Display* | **Plot Wizard…** to bring up the *Step 1 of 2* page of the *Plot Wizard* dialog.
7. Select "Observation Profile" from the list on the left.
8. Click **Next** to go to the *Step 2 of 2* page of the *Plot Wizard* dialog.
9. In the *Coverage* section, select "Model Intersections" from the *Extract profile from* drop-down.
10. In the *Dataset(s)* section, select *Specified*.
11. Select "velocity mag", "velocity mag (2)", "velocity mag (3)", and "velocity mag (4)" from the list of datasets that appears.
12. Feel free to select a different *Dataset color* for each dataset. This makes it easier to distinguish between the plot lines.
13. Click **Finish** to close the *Plot Wizard* dialog.
14. The plot should appear similar to Figure 14. Notice how smaller eddy viscosities allow larger transverse velocity gradients to appear in the solution.

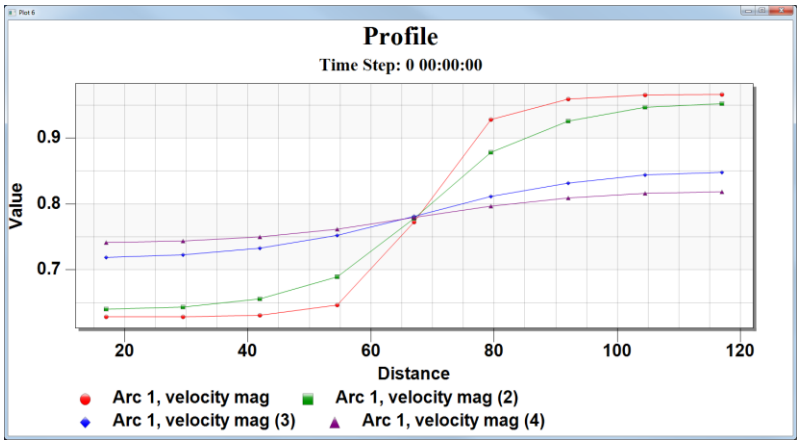



*Figure 14 Solution plots for various eddy viscosities*

# 4 Conclusion

This concludes the "FESWMS Sensitivity Analysis" tutorial. If desired, experiment further with different channel arrangements and watch the effects of changing roughness and viscosity values. When done exit the program.