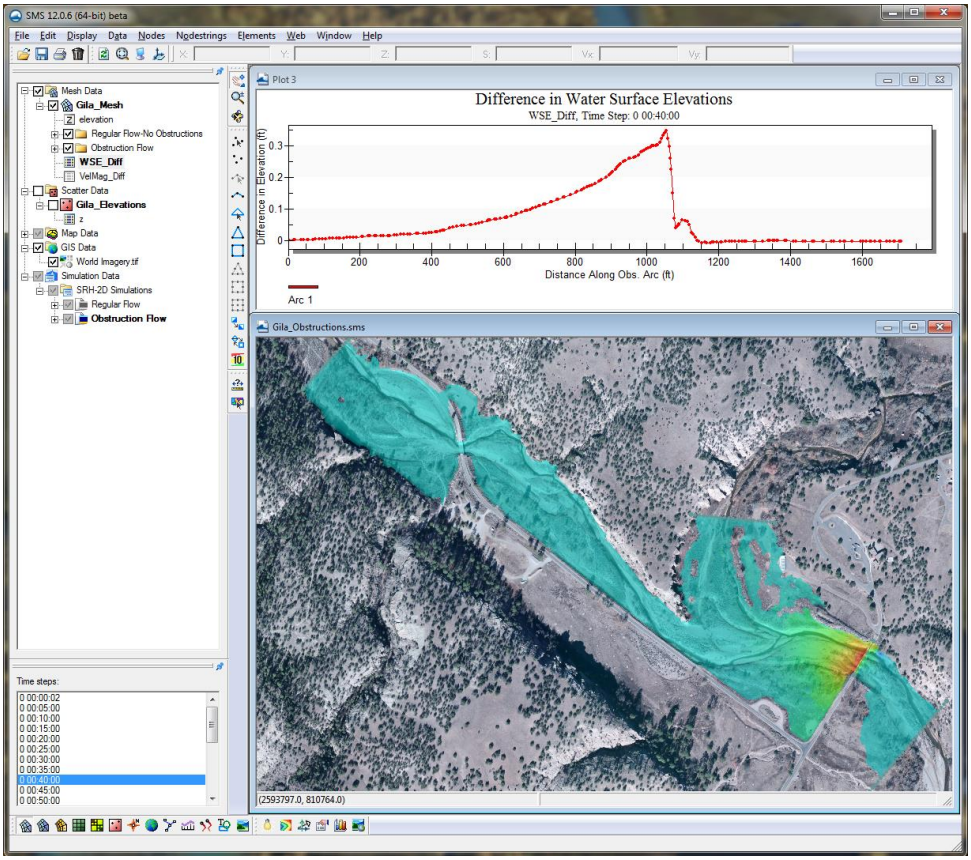
SRH-2D Tutorials

Obstructions



Objectives

This tutorial demonstrates the process of creating and defining in-stream obstructions within an SRH-2D model. The SRH-2D "Simulations" tutorial should have been completed before attempting this tutorial. All files referenced in the instructions are found in the "Data Files" folder within the "SRH-2D Obstructions" folder.

Prerequisites

- SRH-2D Simulations

Requirements

- SRH-2D
- Mesh Module
- Scatter Module
- Map Module

Time

- 25–30 minutes

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1 Model Overview

An existing SRH-2D model will be used to facilitate the setup for this tutorial. The area being modeled is located at the confluence of the West and Middle forks of the Gila River, located in New Mexico.

In this tutorial, an existing bridge just downstream of the confluence will be analyzed. Obstructions will be created that represent the piers and deck of the bridge. After creating the obstructions and running the model, the solution will be compared with a solution created without obstructions. Doing so will allow evaluation of the effects of the bridge on the stream during high flows.

2 Getting Started

To begin, do the following:

1. Open a new instance of SMS.
2. Select *File* | **Open**. The *Open* dialog will appear.
3. In the *Open* dialog, navigate to the *SRH2D_Obstruction/Data_Files* folder and select the "Gila_Structure.sms" project. Click **Open**.
4. The existing project will open and appear as displayed in Figure 1.

In the Project Explorer, notice that the "Regular Flow" simulation has been duplicated and renamed as "Obstruction Flow". Notice that the two simulations are currently using the same coverages.

The process of duplicating and linking these items to a simulation was demonstrated in the "SRH-2D Simulations" tutorial. Creating duplicates of simulations or coverages allows making modifications to a model while still preserving the original simulation or coverages. This also enables creating several modeling scenarios in the same project and comparing the solutions.

If desired, review the "SRH-2D Simulations" tutorial before continuing.

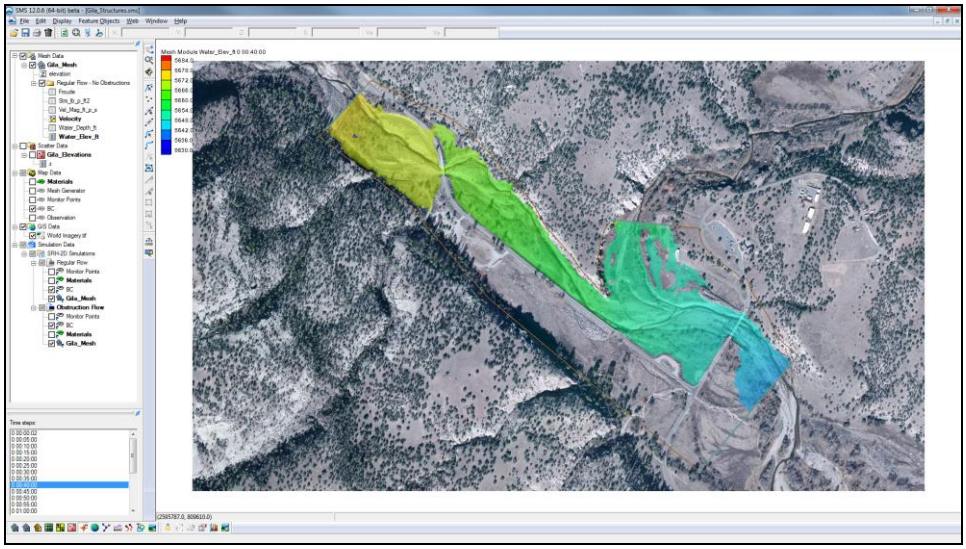

Figure 1 "Gila_Structure.sms" project

The mesh datasets, located under the "Regular Flow – No Obstructions" folder in the Project Explorer, are from an SRH-2D solution created without obstructions. They will be used to make comparisons and visualize the effects that the bridge pier and bridge deck obstructions will have on the model.

3 Creating the Obstructions

The obstructions will be created at the bridge location just downstream of the confluence (location displayed in Figure 2). Two different obstruction types can be defined, rectangular and circular. Rectangular obstructions are created with arcs while circular obstructions are created with points. After the obstruction features are created, parameters are assigned to define them.

3.1 Using Shapefiles to Create the Obstruction Features

The first step in creating an obstruction is to create the arc(s) or point(s) that will represent the obstruction(s). In this tutorial, several obstructions will be created. One rectangular obstruction will represent the bridge deck and five circular obstructions will represent the bridge piers. Two shapefiles have been previously created containing the arc and point features. The features found in the shapefiles will be converted to obstructions.

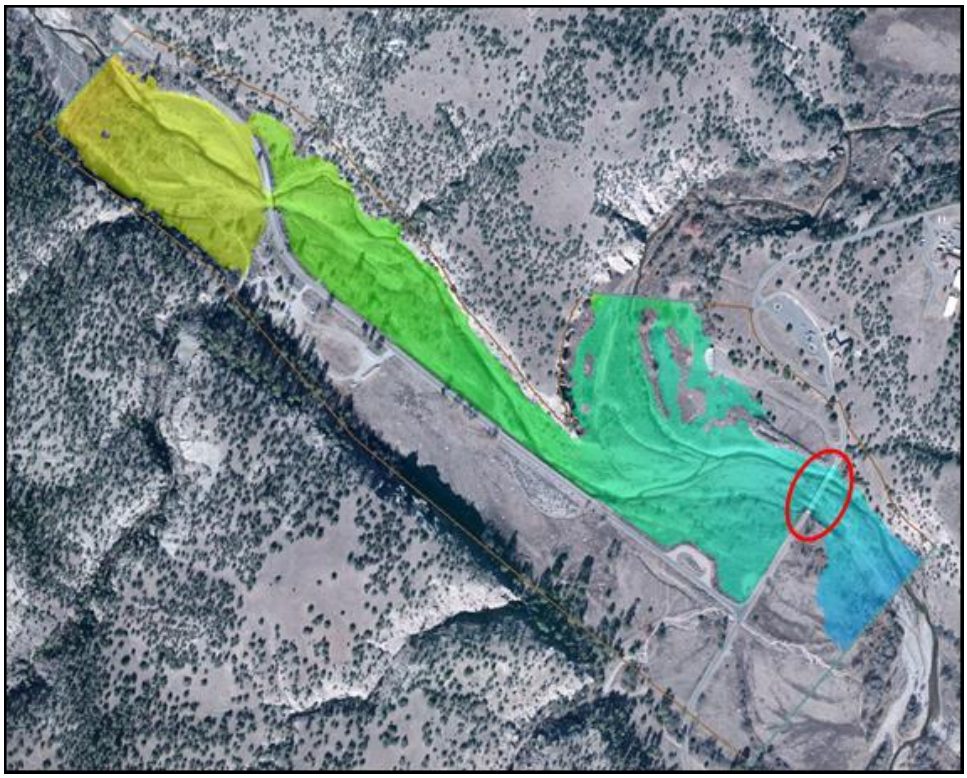

Figure 2 Bridge location circled near bottom right

1. Select the **Zoom** tool and zoom into the bridge location as shown in Figure 2.
2. Select *File* | **Open** to bring up the *Open* dialog.
3. In the dialog, browse to the *SRH2D_Obstruction/Data Files* directory. Select the "Gila_Bridge_Deck_Obstruction.shp" shapefile and click **Open**.
4. Select *File* | **Open**, again to bring up the *Open* dialog.
5. In the *Open* dialog, select the "Gila_Bridge_Pier_Obstructions.shp" shapefile and click **Open**.
6. In the Project Explorer. uncheck the box next to "World Imagery.tif" under "GIS Data" to turn off the display of the image.
7. Right-click "Map Data" and select **New Coverage…** to bring up the *New Coverage* dialog.
8. Select "Obstructions" under "SRH-2D" as the *Coverage type*.
9. Enter "Bridge Obstructions" as the *Coverage Name* and click **OK** to close the *New Coverage* dialog.

Notice the new "Bridge Obstructions" coverage in the Project Explorer.

10. Select the **GIS** module.

11. Using the **Select** tool, drag a box around all of the arcs and points representing the bridge obstructions. The selected objects should appear similar to Figure 3.

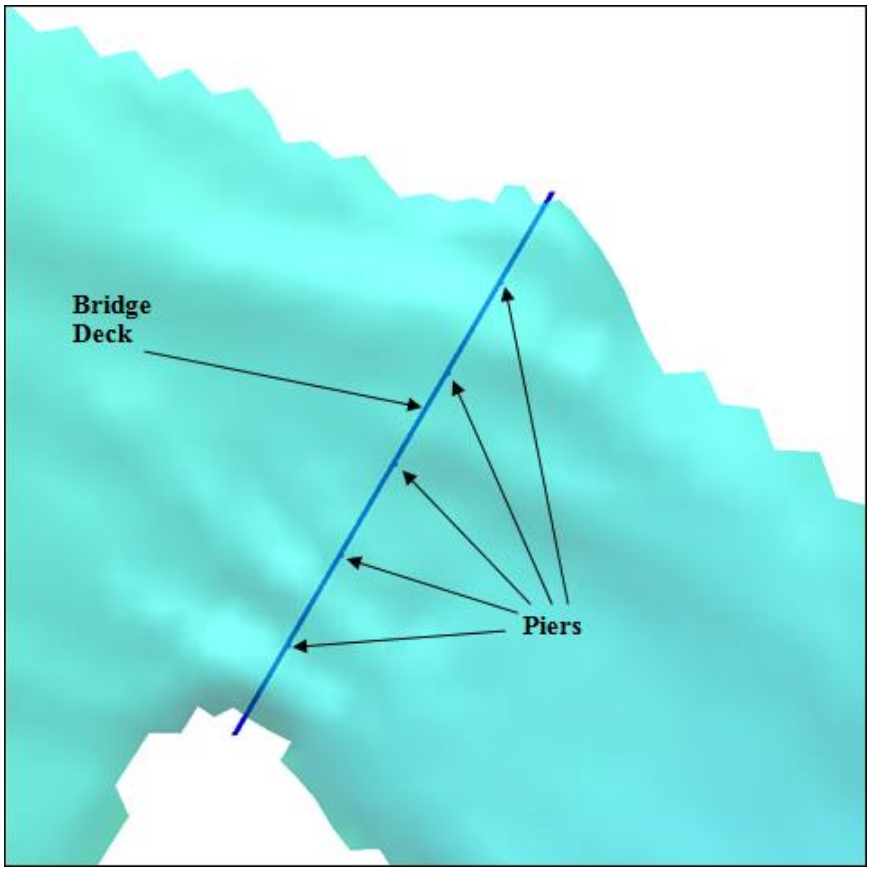

Figure 3 Selected shapefile features

12. Select *Mapping*| **Shapes → Feature Objects**. The *GIS to Feature Objects Wizard* will appear.
13. In the wizard dialog, select "Bridge Obstructions" from the *Select a coverage for mapping* drop-down and click on **Next**.
14. Leave the default options on *Step 1 of 2* in the wizard and click **Next**
15. On *Step 2 of 2* in the wizard, click **Finish**.
16. Uncheck the boxes next to " Gila_Bridge_Deck_Obstruction.shp" and " Gila_Bridge_Pier_Obstructions.shp" to turn off the display of the shapefiles and check the box next to " World Imagery.tif" to turn on the display of the background image.

4 Assigning the BC Attributes

The next step in creating an obstruction in SRH-2D is to set the elevation of the obstruction and define it by assigning parameters to the features representing the obstructions.

4.1 Defining Obstruction Elevations

An elevation must be assigned to the obstruction features. The elevation specified will represent the elevation of the bottom of the obstruction.

1. Select the "Bridge Obstructions" coverage in the Project Explorer to make it active.
2. Using the **Select Feature Arc** tool, select the arc that represents the bridge deck.
3. In the *Z* box found at the top of the SMS window, enter an elevation of "5642.0" ft. This elevation will represent the bottom of the bridge deck, or the low chord.
4. Using the **Select Feature Point** tool, multi-select all five of the points representing the piers by holding down the *Shift* key and clicking on each of them. (The points at the ends of the bridge deck arc do not need to be selected.)
5. In the *Z* box found at the top of the SMS window, enter an elevation of "5635.0" ft. This elevation, although below the elevation of the mesh, will represent the elevation of the bottom of the piers. A thickness will be defined later that will define how much the piers will extrude through the mesh giving them a specific height from the ground.

4.2 Defining Obstruction Parameters

With the obstruction feature created, and the elevation defined, parameters describing the obstruction can now be defined.

1. Using the **Select Feature Arc** tool, select the arc that represents the bridge deck.
2. Right-click on the arc and choose **Assign Obstruction…**. This will bring up the *Obstructions* dialog.
3. In the dialog, specify the *Obstruction Width/Diameter* as "25" ft. This represents the horizontal width of the bridge crossing.
4. Specify the *Obstruction Thickness (Z-dir)* as "4" ft. This represents the vertical thickness of the bridge measured upwards from the specified arc elevation.
5. Specify the *Drag Coefficient* as "1.98". This is a dimensionless coefficient used to describe the surface upon which the water will be flowing around. For more

guidance on this and how it is applied to the numerical computation, please see the wiki page on SRH-2D drag coefficients at www.xmswiki.com.

6. The *Units* can be left as "ft", and the *Porosity* can be left as "0". The porosity represents the ability for water to flow through the obstruction object. A porosity of 0 represents a solid surface with no pores allowing for water to pass through the object and 1 represents a surface comparable to a wire mesh with many holes allowing water to pass through it.
7. Click **OK** to close the *Obstructions* definition dialog.
8. Using the **Select Feature Point** tool, select one of the points representing the bridge pier.
9. Right-click on the selected point and select **Assign Obstructions…** to bring up the *Obstructions* dialog again.
10. Specify the *Obstruction Width/Diameter* as "6"ft. This represents the diameter of the pier obstruction.
11. Specify the *Obstruction Thickness (Z-dir)* as "7" ft. This represents the vertical thickness (height) of the pier measured upwards from the specified bottom elevation.
12. Specify the *Drag Coefficient* as "1.2".
13. The *Units* can be left as *ft* and the *Porosity* can be left as 0.
14. Select **OK** to close the *Obstructions* definition window.
15. Repeat steps 8–14 for the remaining four bridge piers.
16. Now would be a good time to save the project. Select *File* | **Save as…** to bring up the *Save As* dialog.
17. In the dialog, enter "Gila_Obstructions.sms" as the *File Name* and click **Save**.

5 Linking the Obstruction Coverage to the Simulation

To include the obstruction coverage in a simulation, it must be linked to one of the existing simulations.

1. Right-click on the *Bridge Obstructions* coverage and choose *Link to* | **SRH-2D Simulations→Obstruction Flow**.

The coverage has now been linked to the correct simulation and the obstructions will now be included when SRH-2D runs.

6 Running the Simulation

Now that the bridge deck and pier obstructions have been created and parameters for each obstruction have been defined, the model is ready to run.

1. Right-click on the "Obstruction Flow" simulation and choose **Model Control** to bring up the *Model Control* dialog for this simulation.
2. In the dialog, change the *Case Name* to "Obstruction_Flow" and select **OK** to close the *Model Control* window.
3. Right-click on the "Obstruction Flow" simulation and choose **Save, Export, and Launch SRH-2D**.
4. Select **OK** if a warning is displayed stating that the "Bridge Obstructions" coverage will be renumbered before exporting.

When saving, exporting and launching SRH-2D, SMS will initialize and run pre-SRH, the SRH-2D preprocessor. When pre-SRH has finished running, SRH-2D will begin to run. The progress of the run can be viewed in the SRH-2D window.

5. Select **Yes** when SRH-2D terminates.
6. Make sure *Load Solution* is checked in the SMS model wrapper and click **Exit**. The solution datasets will now be listed in the Project Explorer under *Gila_Mesh*.
7. Select the **Frame** tool to frame the model domain extents.
8. Toggle through the datasets and time steps to see the results. The effect of the obstructions may be difficult to see. In section 7 the results will be compared with a simulation run without obstructions to visualize the effect.

6.1 Organizing the Solution Datasets

For better dataset organization, a folder will be created in which the obstruction solution datasets may be stored.

1. Right-click on "Gila_Mesh" and select **New Folder**.
2. Rename the new folder as "Obstruction Flow".
3. Select the 6 mesh datasets that correspond to the obstruction solution by holding down the *Shift* key and selecting the datasets. The datasets are: "Froude," "Strs_lb_p_ft2", "Vel_Mag_ft_p_s", "Water_Elev_ft", and "Velocity".
4. Drag the selected datasets below the "Obstruction Flow" folder that was created in step 2. The datasets should be organized as shown in Figure 4.

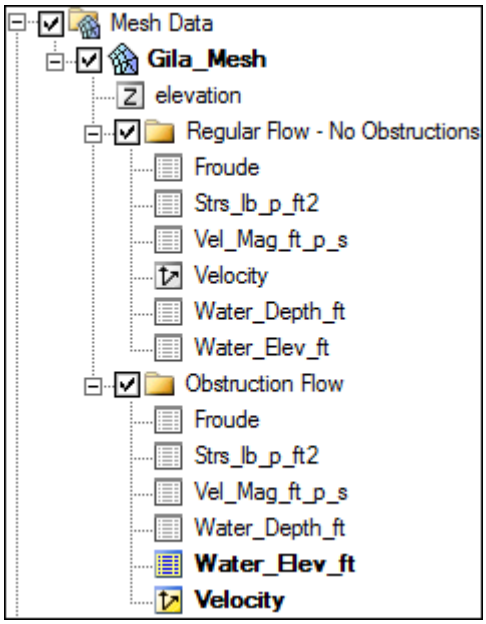

Figure 4 Mesh dataset organization

7 Visualizing Results

With the solution datasets imported into the SMS project, the data calculator will be used to calculate the difference in the water surface elevations with and without the obstructions. A 2D plot of the difference in water surface elevations will then be created to compare the solution with and without obstructions.

7.1 Creating a Difference Dataset with the Data Calculator

Using the dataset calculator, a difference dataset will be created subtracting the solution without obstructions from the solution with obstructions.

1. In the Project Explorer, select "Gila_Mesh" to activate the **Mesh** module.
2. Select *Data* | **Dataset Toolbox** to bring up the *Dataset Toolbox* window.
3. Select "Data Calculator" item under the *Tools* section.
4. Under the *Datasets* section of the dialog, select the "d11.Water_Elev_ft" dataset under the "Obstructions Flow" folder by clicking on it.
5. Turn on the box to *Use all time steps*.
6. Select the **Add to Expression** button.
7. Select the subtract button.
8. Select the "d6.Water_Elev_ft" dataset under the "Regular Flow – No Obstructions" folder by clicking on it.

9. Select the **Add to Expression** button.
10. Next to *Output dataset name* specify the name of the dataset as "WSE_Diff". The data calculator window should appear as shown in Figure 5.

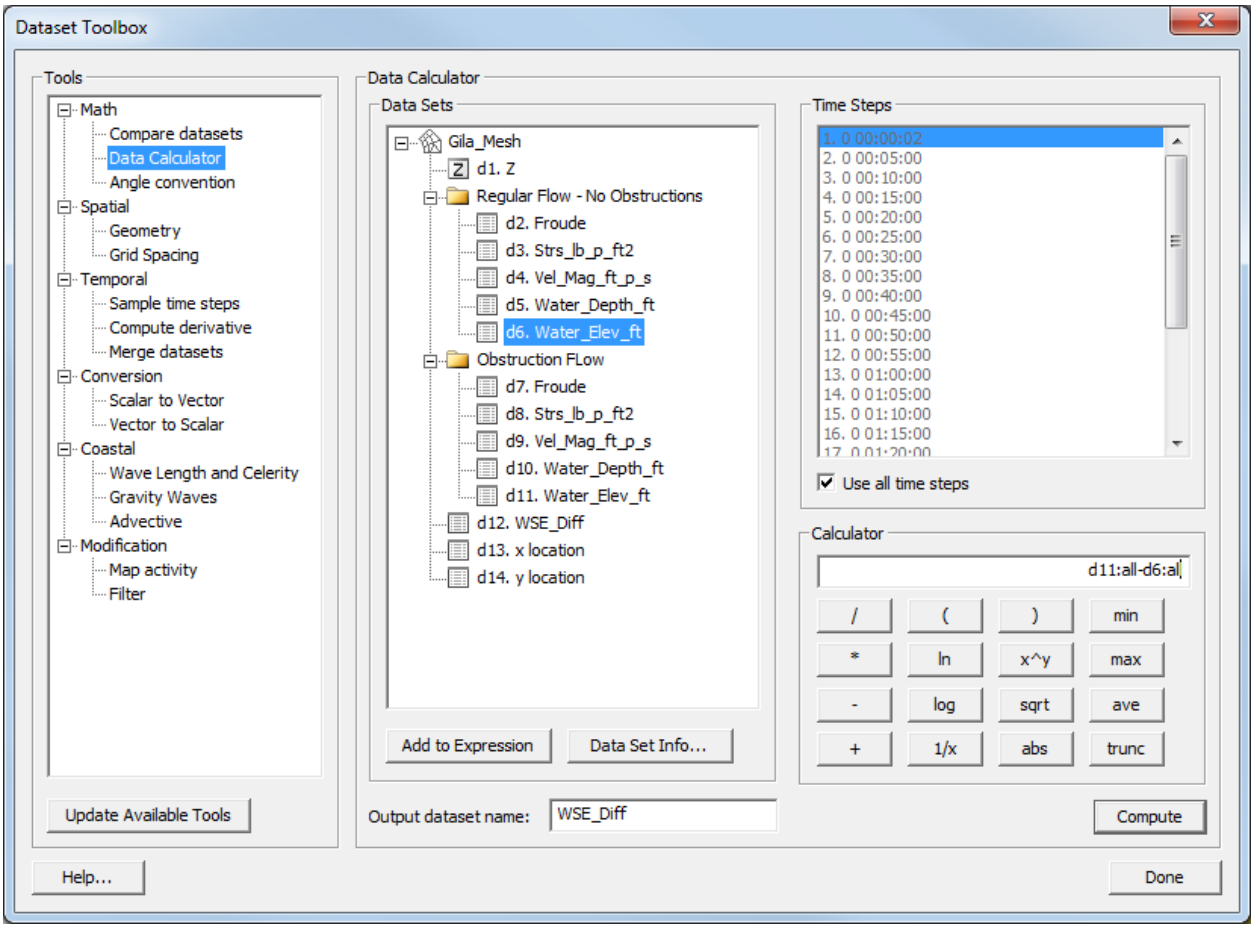

Figure 5 Data Calculator showing an equation for Water Surface Elevation Difference

11. Select **Compute** to create the dataset.
12. Select **Done** to close the *Dataset Toolbox* window. The new dataset can now be seen in the Project Explorer under "Gila_Mesh".
13. Select the "WSE_Diff" dataset and zoom into the bridge location.
14. Toggle through the time steps.

Red contours represent a rise in water surface elevation due to the obstructions and turquoise contours represent no, or little, change in the water surface elevation. The bridge obstructions raised the water surface by nearly 0.5 ft in areas immediately upstream of the bridge.

7.2 Creating an Observation Arc

To create the 2D plot, an observation coverage with an observation arc will need to be created.

1. In the Project Explorer, right-click on Map Data and choose **New Coverage** to bring up the *New Coverage* dialog.
2. Under *Coverage Type* choose "Observation" and select **OK.**
3. Click the "Observation" coverage to make it active.
4. Using the **Create Feature Arc** tool, draw an arc running through the channel and under the bridge. This will be used to create the water surface elevation profile on the 2D plot. The arc may look something like Figure 6.

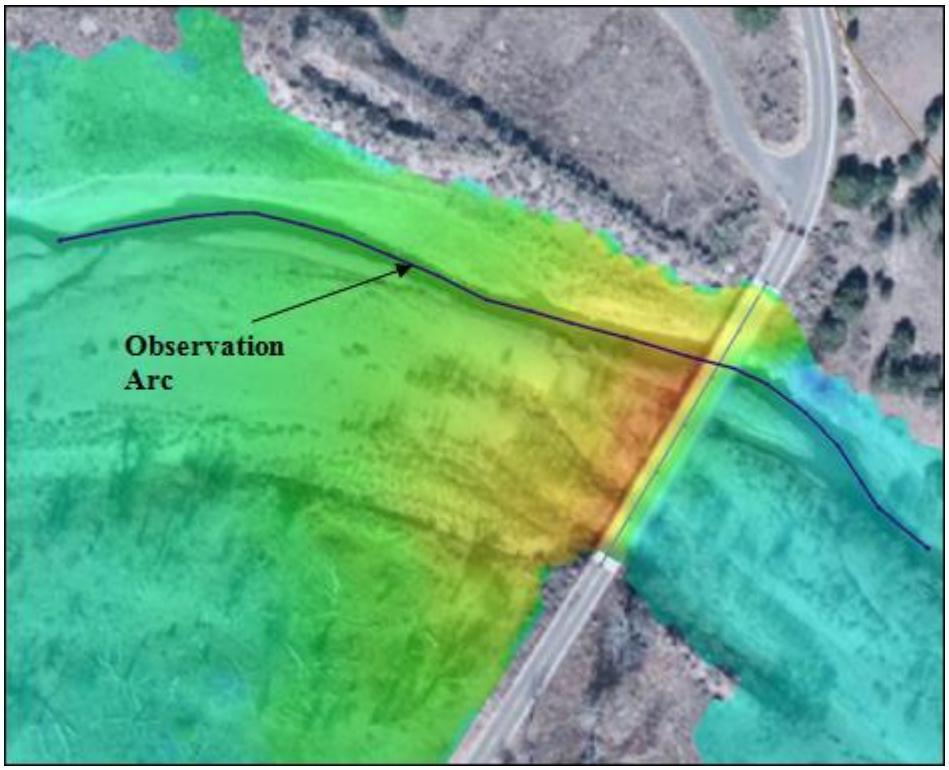

Figure 6 Observation arc

7.3 Setting Up the Plot Wizard

With the observation arc created, the 2D plot of the difference dataset can be created.

1. Select *Display* | **Plot Wizard…** to bring up the *Plot Wizard*.
2. In *Step 1 of 2* in the *Plot Wizard* dialog, select *Observation Profile* then **Next**.
3. In *Step 2 of 2* under *Dataset(s)* select the radio button next to *Specified*.
4. Check the box next to the "WSE_Diff" dataset.

Step 2 of the plot wizard should appear as Figure 7.

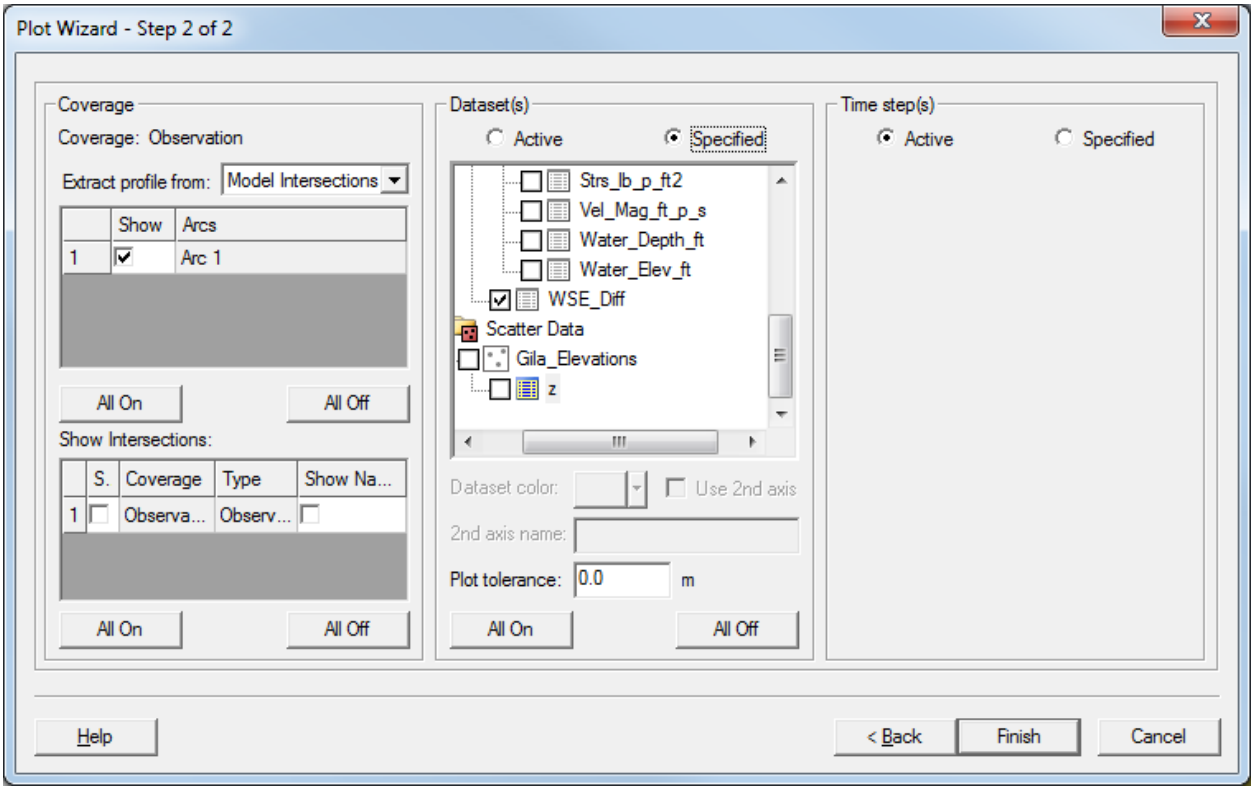

Figure 7 Plot Wizard setup

5. Select **Finish** to create the 2D observation plot.
6. Toggle through the time steps to observe how the plot changes over time. The obstructions in the simulation had a larger effect on the water surface elevations between times 0 00:20:00-0 01:20:00 with the largest change being nearly 0.5 ft.

The plot should appear similar to Figure 8.

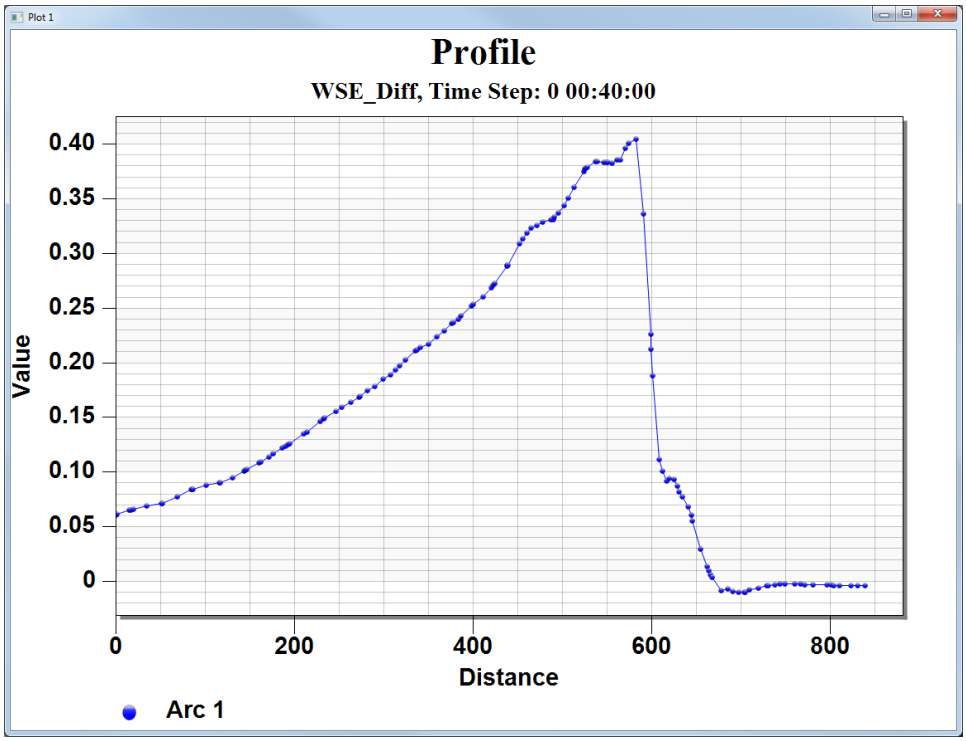

Figure 8 Observation profile plot

A similar approach could be used to compare the change in velocity by creating a difference dataset of the "Vel_Mag_ft_p_s" datasets.

8 Conclusion

This will conclude the "SRH-2D Obstructions"[1] tutorial. The topics demonstrated in this tutorial include:

- Opening an existing SRH-2D project.
- Creating obstruction features at a bridge location.
- Defining obstruction parameters.
- Saving and running SRH-2D.
- Using the data calculator to calculate the difference in water surface elevation.
- Creating an observation arc.
- Using an observation arc to create a profile plot to visualize results.

As desired, continue to experiment with the SMS interface or quit the program.

[1] This tutorial was developed by Aquaveo, LLC under contract with the Federal Highway Administration.