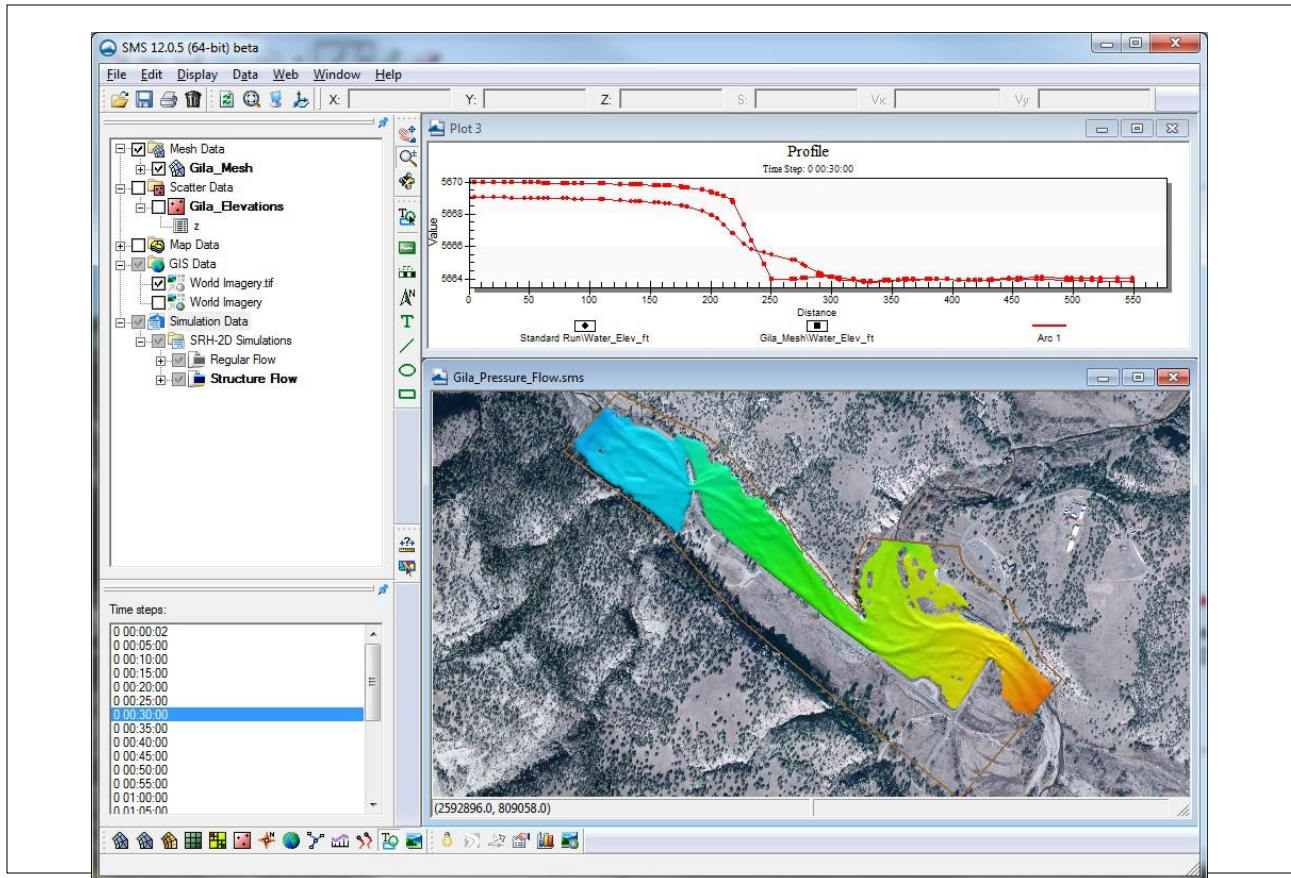*SRH-2D Tutorial*
Bridge Pressure Flow

Objectives

This tutorial demonstrates the process of creating a pressure flow structure within SRH-2D to model pressurized flow beneath a bridge. The SRH-2D "Simulations" tutorial should have been completed before attempting this tutorial. All files referenced in the instructions are found in the "Input" folder within the "SMS_SRH-2D_Pressure" folder.

Prerequisites

- SMS Overview
- SRH-2D
- SRH-2D – Simulations

Requirements

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

Time

- 15–20 minutes

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 upstream of the confluence will be analyzed. One concern with the design is that the elevation of the low chord will impede the flow of the river during high flows. The bridge deck will be represented as a pressure flow structure in SMS. After running the model with the pressure flow bridge, the solution will be compared with an existing condition solution provided to evaluate the effects.

2   Getting Started

To begin, do the following:

1. Open a new instance of SMS.

2. Select *File* | **Open**.

3. Navigate to the "Gila_Structure.sms" project found in the *Input* folder for this tutorial.

4. Click **Open** to import the project.

The project should appear similar to Figure 1.

In the Project Explorer, duplicates of the " Regular Flow" simulation and the " BC" coverage have been made to facilitate the model setup. The duplicates have been renamed as " Structure Flow" and " Structure BC" respectively.

The process of duplicating and linking these items to a simulation was demonstrated in the "Simulations" tutorial. Creating duplicates of simulations or coverages allows 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.

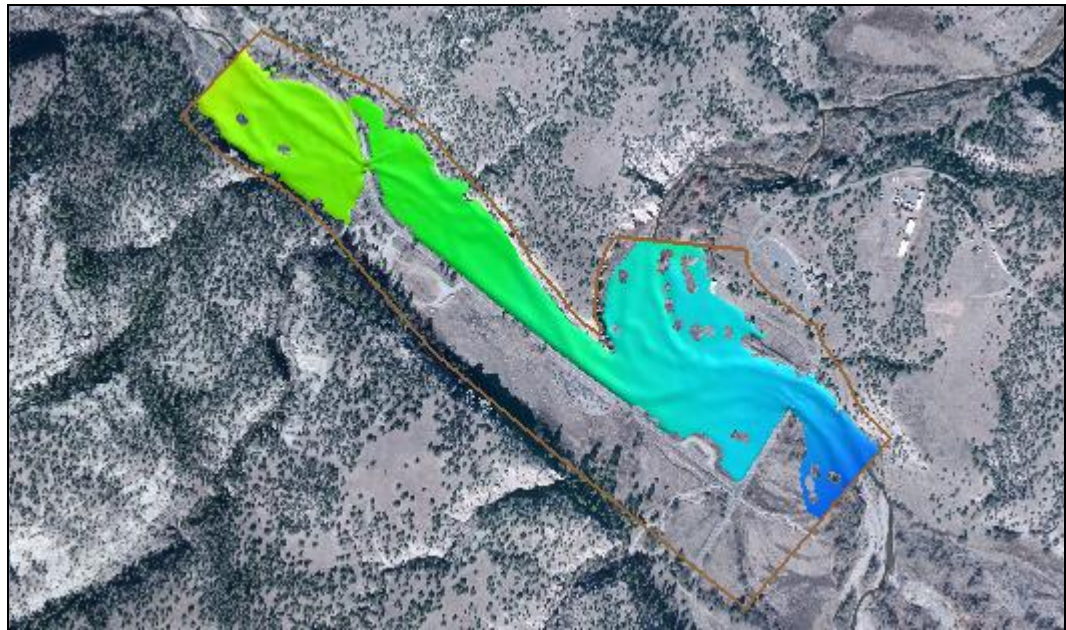If desired, review the "Simulations" tutorial before continuing.

Figure 1   Gila_Structure.sms project

The mesh datasets located under the "📁 Regular Flow" folder in the Project Explorer are from an SRH-2D solution of the existing flow conditions, without the pressure flow structure. These results will be used to make comparisons and visualize the effects that the pressure flow structure will have on the model.

3   Creating the Pressure Flow Structure

The pressure flow structure will be created at the bridge location just upstream of the confluence (location displayed in Figure 2). Pressure flow structures are defined by creating an arc at the upstream side of the bridge deck and an arc at the downstream side of the bridge deck representing the upstream and downstream extents of the bridge. The arc type for these arcs is defined as "Pressure" and attributes are assigned to them such as low chord elevations, a Manning's *n* value, and overtopping parameters.

3.1   Creating the Structure Arcs

To create a pressure flow structure, first create arcs representing the bridge deck.
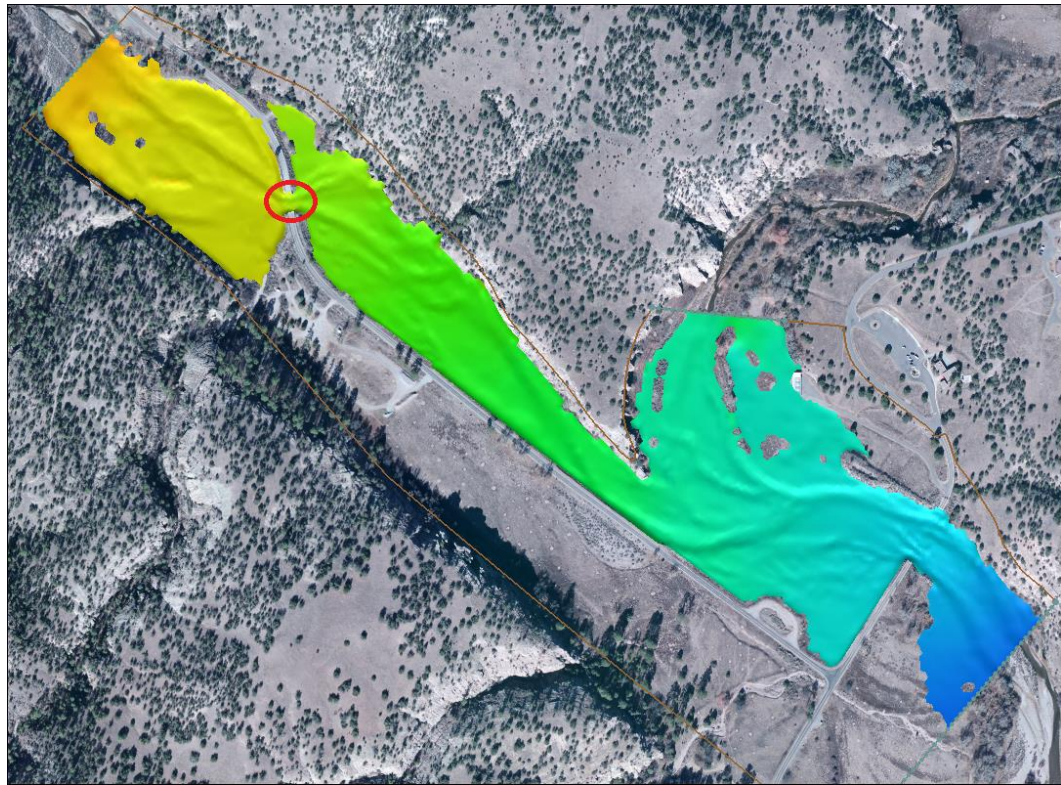
Figure 2   Bridge pressure flow location

1. Use the **Zoom** 🔍 tool to zoom into the bridge location (Figure 2).

2. Select the "Z Z" dataset under "🔺 Gila_Mesh" in the Project Explorer to display the mesh elevations.

3. Select *Display* | **Display Options…** to open the *Display Options* dialog.

4. In the *2D Mesh* section, check the box next to *Elements* and select **OK** to close the *Display Options* dialog.

5. In the Project Explorer select the "🔵 Structure BC" coverage to make it the active coverage. Make sure the checkbox is checked to display this coverage

6. Use the **Create Feature Arc** 𝒇 tool to create one arc on each side of the bridge to define the upstream and downstream faces of the bridge deck. The arcs should look similar to Figure 3.

It is recommended that the mesh be created to contain quadrilateral elements within the area between these two arcs which represent the bridge deck and that the structure arcs be aligned with a clean row of element edges. The arcs should also extend into the embankments.

Note: When drawing these arcs, they should be drawn in the same direction. After the first arc has been drawn, ensure that the second arc is drawn in the same direction (north

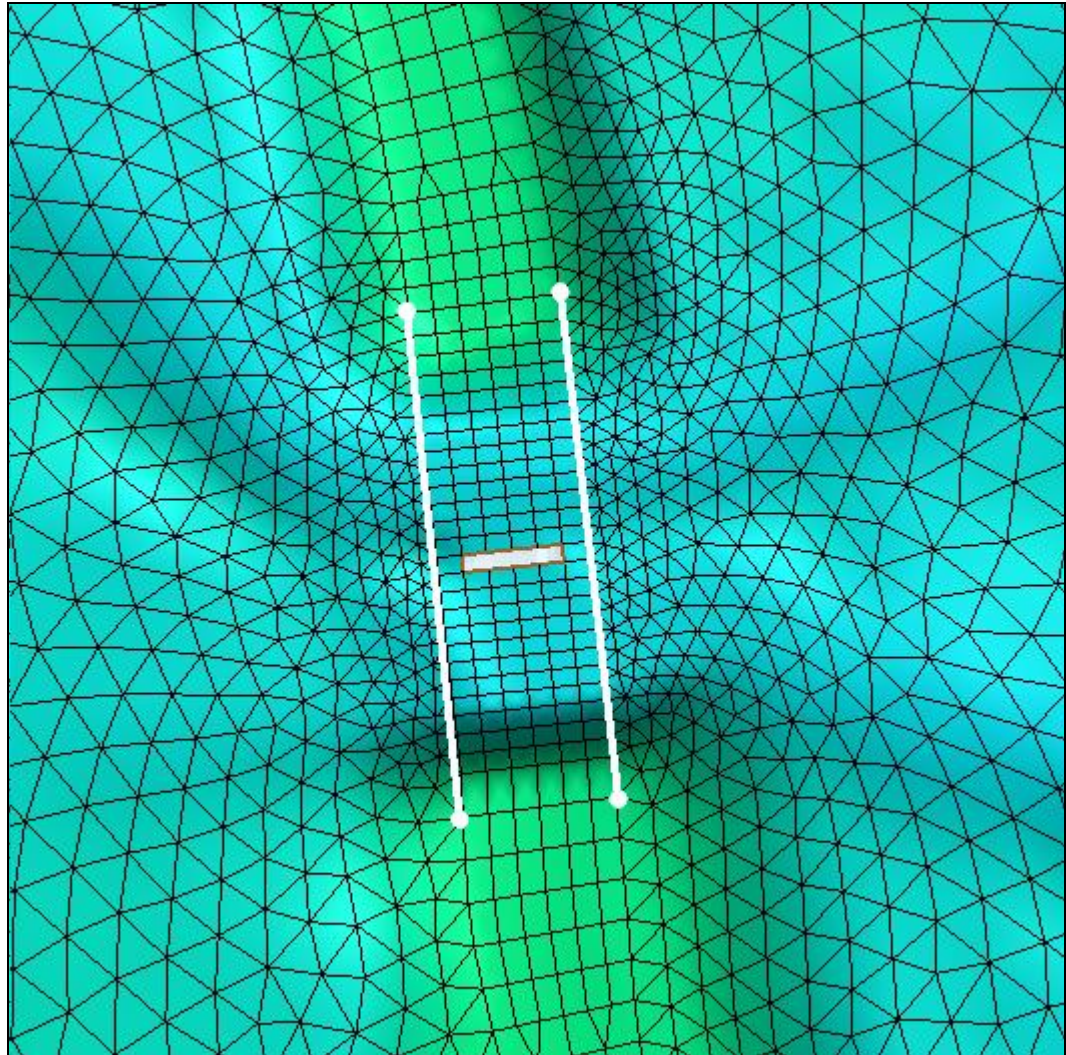to south or south to north). Drawing them in opposing directions may cause an error when running SRH-2D.

Figure 3   Pressure flow arc locations

3.2   Assigning the Structure Attributes

The next step is to specify the boundary condition type and assign attributes to the arcs.

1. Using the **Select Feature Arc** tool, select the upstream (leftmost) arc. Take note of the ID for this arc which is displayed in the help window below the SMS display window.

2. While pressing the *Shift* key, select the downstream arc so that both of the arcs are selected.

3. Right-click on either arc and then select **Assign Linear BC...** to bring up the *SRH-2D Linear BC* dialog.

4. In the *Type* combo box, select "Pressure".

5. Note the assignment of "Pressure Upstream" and "Pressure Downstream" to the two arcs, associated with their ID values. If the ID displayed for pressure upstream is not the same as noted above in step 1, switch the associations using the drop-down for *Role*.

6. The *Units* should be left as "ft".

7. Enter "5665" for both the *Ceiling elevation along upstream (flat) or edges (parabolic)* and *Ceiling elevation along downstream (flat) or midspan (parabolic)*. These ceiling elevations represent the low chord for the bridge, and can be different for the upstream and downstream faces of the bridge deck.

8. Enter "0.09" for the *Manning roughness coefficient between water and ceiling*.

9. Check the box next to *Overtopping*.

10. Enter "5672" as the *Crest Elevation* for overtopping. This corresponds to the road surface in this case.

11. Enter "130" as the *Length of Weir over pressure zone*. This is the lateral length of the portion of the bridge which will undergo weir flow if overtopped.

12. Select **OK** to exit the *SRH-2D Linear BC* dialog.

4   Saving and Running the Simulation

Now that the pressure flow structure has been created, the model is ready to run.

1. Right-click on the " Structure Flow" simulation and choose **Model Control…** The *SRH-2D Model Control* dialog will appear.

2. In the dialog, change the *Case Name* to "Pressure_Flow" and select **OK** to close the *SRH-2D Model Control* window.

3. Right-click on the " Structure Flow" simulation and choose **Save, Export, and Launch SRH-2D**.

4. Select **OK** if a warning is displayed stating that the "Structure BC" coverage will be renumbered before exporting.

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

5. Once it has finished running, a message should appear stating: "Program terminated with exit code 0 Exit Window?". Select **Yes** to return to the *SRH-2D: Structure Flow* dialog.

6. Make sure *Load Solution* is checked, as shown in Figure 4, in the SMS model wrapper and click **Exit** to close the *SRH-2D: Structure Flow* dialog.

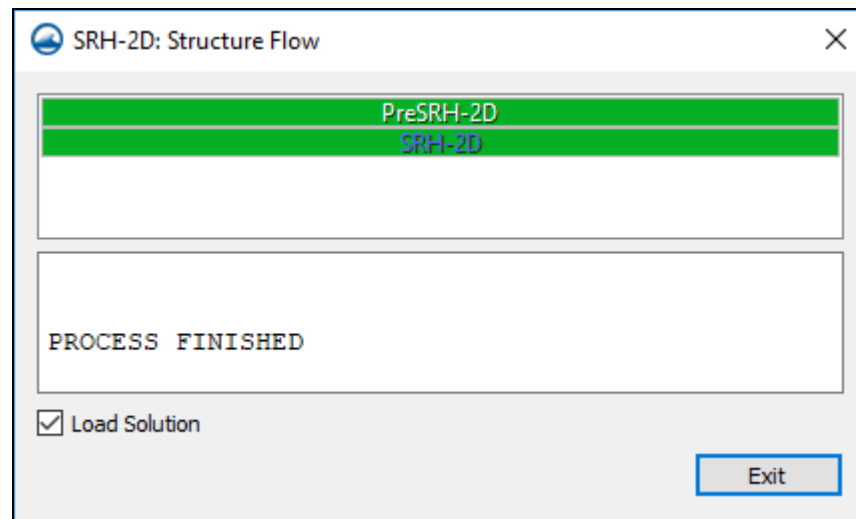The solution datasets will now be listed in the Project Explorer under " Gila_Mesh".

Figure 4   SMS Model Wrapper

7. Select the **Frame** ⊕ tool to frame the model domain extents.

8. Select *Display* | **Display Options…** to open the *Display Options* dialog.

9. In the *2D Mesh* section of the dialog, uncheck the box next to *Elements* to turn off the display of mesh elements.

10. Click **OK** to close the *Display Options* dialog.

11. Cycle through the datasets and time steps to see the results. Notice that it appears that more water is flowing over the roadway to the north of the bridge.

4.1   Organizing the Solution Datasets

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

1. Right-click on "🔷 Gila_Mesh" under "🔷 Mesh Data" and select **New Folder**.

2. Right-click on the new folder and select **Rename**.

3. Enter "Pressure Flow" as the new name.

4. Select the six new mesh datasets corresponding to the pressure flow simulation just completed by selecting the first one, holding down the *Shift* key, then selecting the last dataset.

5. Drag the selected datasets below the "📁 Pressure Flow" folder that was created in step 1. The datasets should be organized as shown in Figure 5.
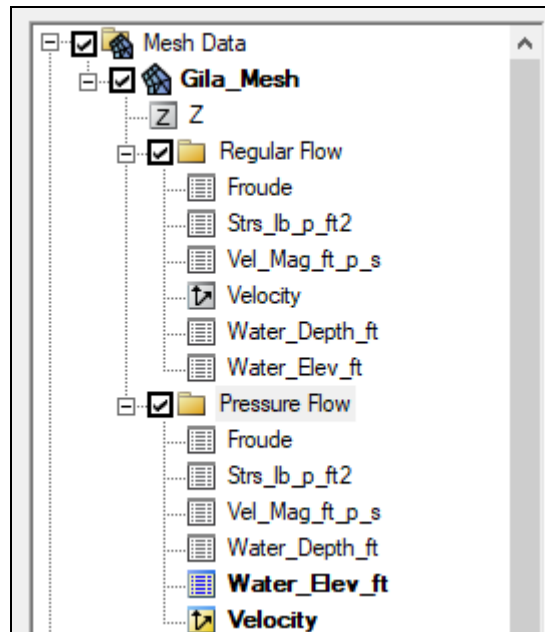
Figure 5   Mesh dataset organization

5   Visualizing Results

With the solution datasets read into the SMS project, create a 2D plot of the water surface elevations to compare the pressure flow solution with the original solution without pressure flow.

5.1   Creating an Observation Arc

To create the 2D plot, first create an observation coverage with an observation arc.

1. Use the **Zoom** tool to zoom into the bridge location.

2. In the Project Explorer, select the "Water_Elev_ft" dataset within the "Pressure Flow" folder to make it the active dataset.

3. In the Project Explorer, right-click on "Map Data" and choose **New Coverage** to bring up the *New Coverage* dialog.

4. In the dialog, under *Coverage Type* choose *Observation* and enter "Observation" as the *Coverage Name*.

5. Select **OK** to close the *New Coverage* dialog and create a new coverage in the Project Explorer called "Observation".

6. Select the "Observation" coverage to make it active.

7. Using the **Create Feature Arc** ∫ tool, draw an arc starting on the upstream side of the bridge, running through the channel and under the bridge, and ending on the downstream side of the bridge. This will be used to create the water surface elevation profile on the 2D plot. The arc should look similar to the one in Figure 6.

Figure 6   Observation Arc

5.2   Setting Up the Plot Wizard

With the observation arc created, the 2D plot of the water surface elevation profiles can be created.

1. Select *Display* | **Plot Wizard…** to bring up the *Plot Wizard* dialog.

2. In step 1 of 2 of the wizard, select *Observation Profile* then select **Next.**

3. In step 2 of 2of the wizard, choose *Specified* under *Dataset(s)*.

4. Check the boxes next to the "▦ Water_Elev_ft" datasets under both the "📁 Regular Flow" folder and under the "📁 Pressure Flow" folder.

5. Check the box next to the "☒ Z" dataset.

6. Choose *Specified* under *Time step(s)*.

7. Check the box next to time "0 02:30:00".

8. Select **Finish** to close the *Plot Wizard* dialog to generate the profile plot (Figure 7).

The effects of the bridge are apparent as the water is backed up and forced below the bridge deck.
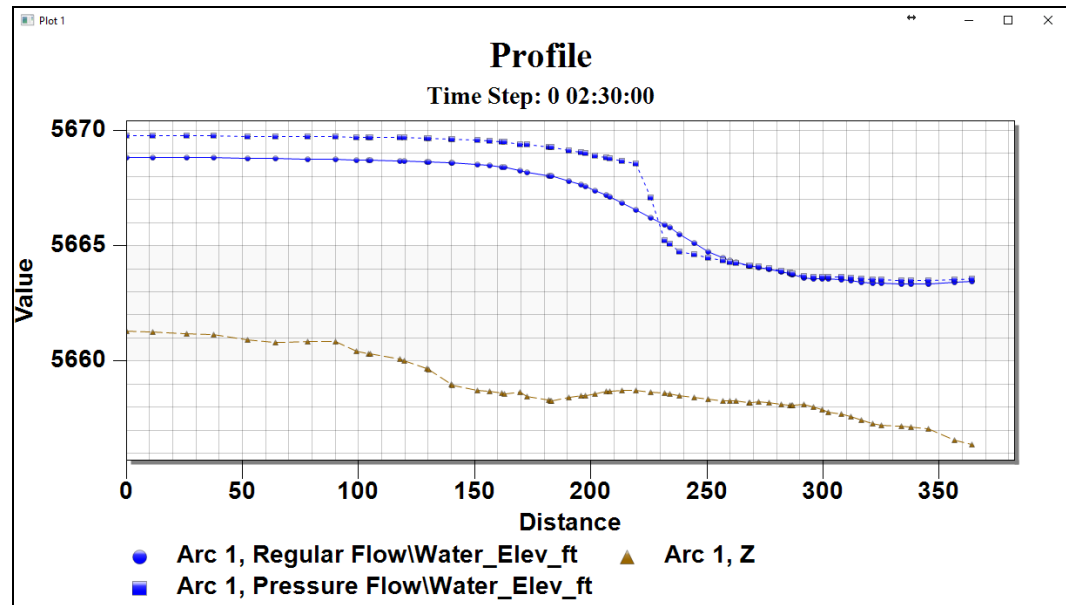

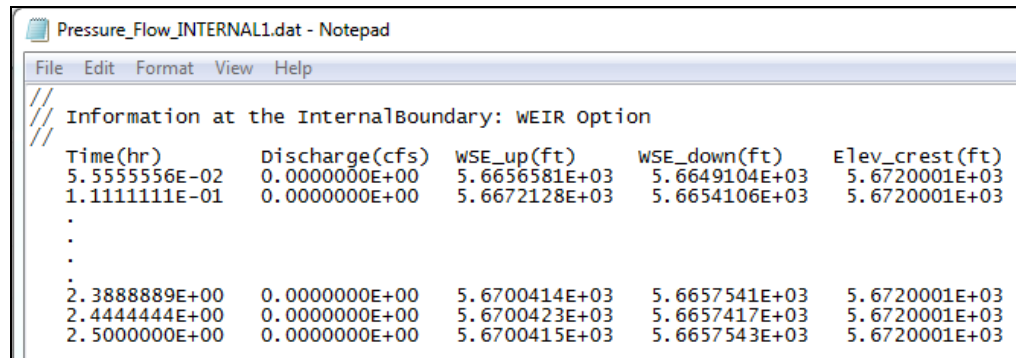*Figure 7   Water Surface Elevation Profile Plot*

5.3   Checking Overtopping

This case was run with overtopping allowed across the pressure flow structure. A crest elevation of 5672 feet was specified in section 3.2 corresponding to the elevation of top of the roadway. For pressure flow structures, only the flow going over the roadway in the area of the bridge deck is calculated. Overtopping of the roadway in other areas occurs over the terrain within the 2D model domain.

The overtopping flow is only reported in a separate output file in the simulation results directory. Now to review this file to see if any overtopping occurred.

1. Navigate to the simulation results directory. In this case this will be the *…/SMS_SRH-2D_Pressure /Input/Gila_Structure/SRH-2D/Structure Flow* directory which has the results for the current *Structure Flow* simulation.

2. The *Case Name* for our solution is 'Pressure_Flow". Open the file "Pressure_Flow_INTERNAL1.dat" in a text editor. The file will be formatted as shown in Figure 8.

This file shows the *Discharge* across the pressure flow structure due to overtopping at every time step. In this case there is no overtopping at the bridge, so the discharge is zero throughout the simulation period. The file also shows the upstream and downstream WSE values at each time step along with the overtopping crest elevation for reference.

Figure 8　　Output file containing overtopping discharge values

6　Conclusion

This concludes the "SRH-2D Bridge Pressure Flow"[1] tutorial. Further analysis could be performed on this solution to evaluate other effects of the bridge on the channel. The topics demonstrated in this tutorial include:

- Opening an existing SRH-2D project.
- Creating a pressure flow structure at a bridge location.
- Saving and running SRH-2D
- Creating an observation arc.
- Using an observation arc to create a water surface elevation profile plot to visualize results.
- Checking output files for overtopping at the bridge.

If desired, continue experimenting with the SMS interface or quit the program.

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