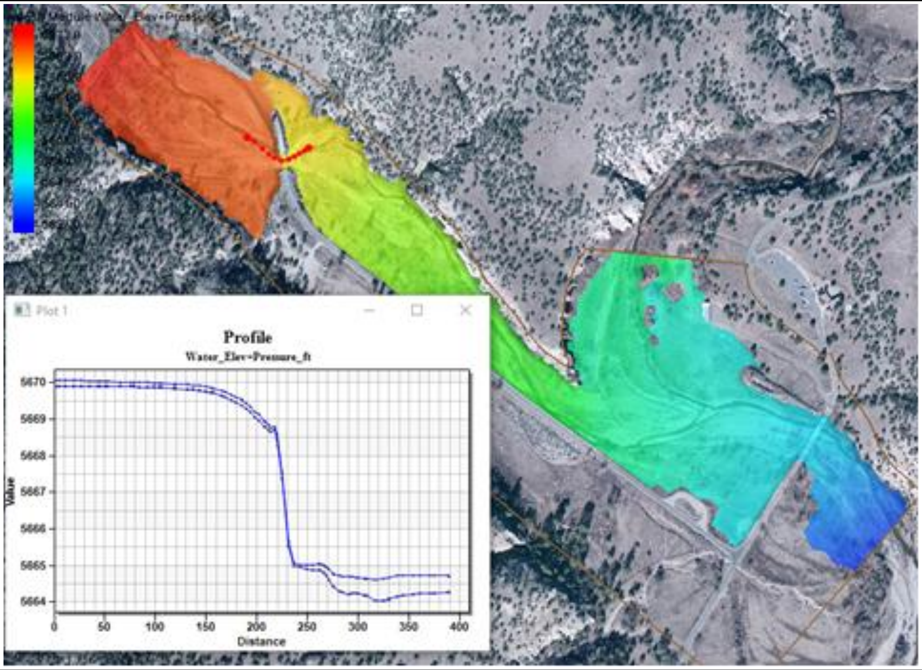
SMS 14.0 Tutorial

SRH-2D Manning’s N Calibration

Calibration tool for SRH-2D



Objectives

This tutorial demonstrates how to use the SRH-2D calibration feature to calibrate the hydraulic model by adjusting Manning’s N values.

Prerequisite Tutorials

- Overview
- SRH-2D

Required Components

- SMS Core
- SRH-2D Model & Interface

Time

- 10–20 minutes

1 Introduction

This tutorial demonstrates how to use the calibration feature for SRH-2D in SMS. Calibration automates the process of finding the parameters for a simulation to match observed data (such as an historic flood event). This tutorial uses calibration to determine the Manning's N (material roughness) that would match observed water elevations.

The area being modeled is located at the confluence of the west and middle forks of the Gila River, located in New Mexico. For more background information about the model area see the "SRH-2D Bridge Pressure Flow" tutorial.

2 Getting Started

Start by importing a project file containing an existing SRH-2D simulation:

1. In SMS, select *File* | **Open…** to bring up the *Open* dialog.
2. Browse to the *data_files* folder for this tutorial and select "Gila_calibration.sms".
3. Click **Open** to import the project and exit the *Open* dialog.

Before continuing, it is best to save the project under a new name in order to preserve the starting project for future use.

4. Select *File* | **Save As…** to bring up a *Save As* dialog.
5. Enter the *File name* "Gila_AdvSim_Calibration.sms" and click **Save** to close the *Save As* dialog.

The project should appear similar to Figure 1. The project contains an SRH-2D simulation named " Structure Flow". The simulation includes a 2D mesh, an SRH-2D materials coverage, an SRH-2D monitor coverage, and an SRH-2D boundary conditions coverage. The simulation solution is also loaded.

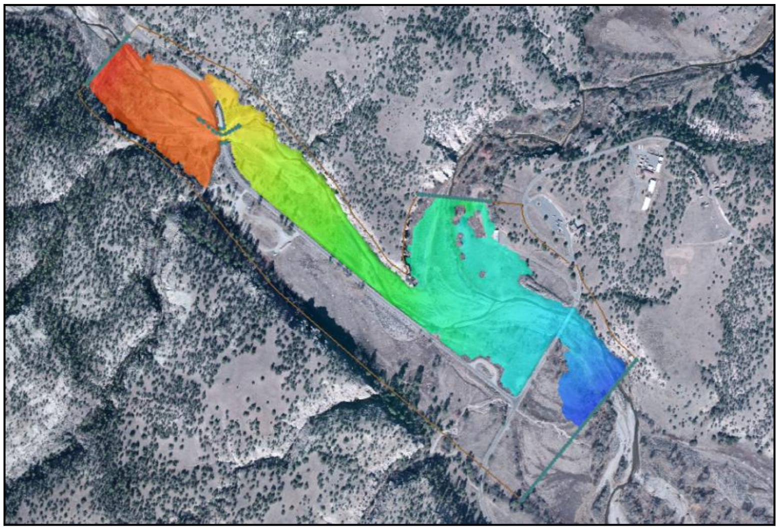


Figure 1 Initial project

3 Monitor Points

In order to calibrate a model, measured water surface elevations must be associated with monitor points. For this example, do the following:

1. Select the " Monitor" coverage to make it active.
2. **Zoom** in on the area around the pressure bridge (Figure 2).
3. Using the **Create Feature Point** tool, create a point upstream of the roadway in the middle of the overtopping area (Figure 2).
4. Using the **Select Feature Point** tool, double-click on the monitor point that was just created to open the *SRH-2D Assign Monitor Point Properties* dialog.
5. Turn on *Measured value*.
6. For the *Water surface elevation* field, enter "5669.1".
7. Select **OK** to close the *SRH-2D Assign Monitor Point Properties* dialog.
8. Repeat steps 2–7 for the location in Figure 3 and entering a *Water surface elevation* of "5644.7".

This water surface elevation value represents the desired value at the end of the SRH-2D run.

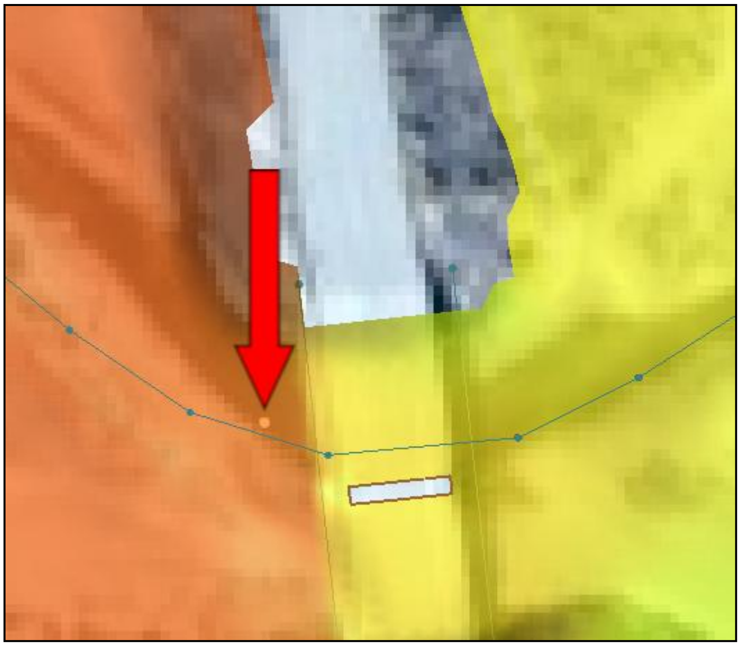


Figure 2 Observation point location upstream

Figure 3 Observation point location downstream

4 Calibrating Manning's n Values

SMS will use the PEST (Parameter ESTimation) program to run SRH-2D multiple times to calibrate the model to the desired water surface elevation. The SRH-2D input parameters that can be adjusted by PEST to calibrate a model include inlet-Q and Manning's N.

To activate the simulation calibration options, do the following:

1. Right-click on the " Structure Flow" simulation and select *Tools* | **Advanced Simulation (Beta)…** to bring up the *Advanced Simulation* dialog.
2. Turn on the *Use Parameters* option.
3. Changed the *Run type* to be "Calibration".

The *Advanced Simulation* dialog allows setting the calibration parameters. After selecting the "Calibration" option, there are options to set the maximum number of iterations and maximum number of iterations with no improvement. The maximum number of iterations determines the maximum number of optimization iterations that PEST is permitted to undertake on a particular parameter estimation run. The maximum number of iterations with no improvement will terminate execution of successive iterations if PEST has failed to lower the objective function.

4. Set *Max number of calibration iterations* to "1".

To allow PEST to compute the Manning's N values, do the following:

5. Change the *Show type* to "Mannings N".
6. In the *Available parameters* section, in the *Use* column, check on the boxes for the rows containing the *Description:* "Channel", "Dry Bed", "Trees" and "Light Veg".
7. For the materials listed in step 6, for min, enter "0.01".
8. For the materials listed in step 6, for max, enter "0.1".
9. Leave all the entries under the *Value* column at their previously specified values.
10. Click **OK** to close the *Advanced Simulation* dialog.

The calibration parameters have now been set.

5 Running SRH-2D

The model runs are now ready to be executed. Using PEST, multiple model runs will be started. To do this:

1. Right-click on the " Structure Flow" simulation and select **Save Project, Simulation and Run** to bring up the *Simulation Run Queue* dialog.

All necessary input files for all of the model runs will be exported.

2. Click **OK** to close the notification that the existing solution will be deleted.

The *Simulation Run Queue* appears, but it does not include the standard entries that you may expect for an SRH-2D simulation. That is because it is running a PEST simulation that is running multiple SRH-2D simulations. The run of PEST includes two tabs. The first contains command line output of the PEST analysis. The second contains a plot of the error through analysis.

3. When the simulation is complete, review the *Command Line* tab of the *Simulation Run Queue* dialog for the PEST SH-2D (running) process.

The total number of model runs is reported. Scroll through the data and note the iterations. Any iteration run starts with an initial "phi" value. This value represents the error between a model run and the specified target values.

If running up to four iterations, users may note how the "phi" value decreases for the first two iterations but not for iterations three and four.

If this had been run with five iterations, for iterations one through three, the iteration would start by performing four model runs. This is because there are four different n values being adjusted and PEST is computing a Jacobian matrix to evaluate the impact of the variable. For iterations four and five, PEST would perform eight model runs to compute a derivative for each of the four variables. This analysis should run the model around 40 times in total (each run takes between one and three minutes depending on the processor speed).

4. Click **Load Solution** to import the solutions into SMS.
5. Click **Close** to exit the *Simulation Run Queue* dialog.

Solution sets from the calibration run will appear in the Project Explorer. The calibration process only computes the last time step of the simulation.

6 Viewing SRH-2D Output

With the model run finished, the results can be examined.

1. Right-click on the " Structure Flow" simulation and select *Tools* | **Advanced Simulation (Beta)…** to bring up the *Advanced Simulation* dialog.

Note the *Optimized Value* has now been entered for the "Channel", "Light Veg", "Trees" and "Dry Bed" materials. If desired, these values can be copied and pasted into the material table in the " Materials" coverage. Review these values and determine if they are appropriate for the material conditions. One or two may be surprising. These will be discussed more in the next sections of this tutorial.

Note the table at the bottom of the dialog. This table shows the measured and computed values for each of the monitor points along with the difference.

2. Click **OK** to close the *Advanced Simulation* dialog.

Use the visualization tools in SMS as described in the "Data Visualization" tutorial or other tutorials to evaluate the solution datasets created by the SRH-2D model.

7 General PEST Comments

It should be noted that ideally, there would be at least one monitor point for each variable PEST is asked to determine. In this case, the number of variables was 4, and the number of points was 2. This means that this problem is potentially a poorly posed problem. However, this could be a common situation due to the lack of real world calibration data. If this is the case, PEST may reach different solutions depending on the initial conditions provided for the analysis. For this reason, use care to specify reasonable roughness values for the materials to begin with.

There is also the possibility that no parameters in the specified allowable range will result in a match for the specified monitor point water surface elevations. In this case, PEST will generally push the optimized value to one edge of the range or the other and the phi value will be larger.

8 The PEST Record File

PEST reports all model runs with their associated parameter values and errors in a record file. To evaluate the output from PEST, remember that the materials are passed to SRH-2D by index, rather than name, so the following applies:

- Channel = "mat_1"
- Light Veg = "mat_2"
- Trees = "mat_4"
- Dry Bed = "mat_5"

To review the PEST record file:

1. In a file browser, go to the "Gila_Calibration_models\SRH-2D\Structure Flow" directory.
2. Using a text editor, open the file "gila_calibration.rec".

This file consists of three main parts.

- Part 1 – The top section of this file reports on the analysis that was performed including the parameters and PEST options.
- Part 2 – Search for the line "OPTIMISATION RECORD" in this file (it should be around line 142). This section contains a record of each iteration performed including the parameters values used for each of the four materials and the error (phi) for each simulation run. During each iteration, PEST starts by computing a Jacobian or baseline for the model sensitivity to each variable. This requires either one (1) or two (2) simulation runs for each variable. In each iteration, if the error is reduced by more than 50%, PEST will terminate the iteration and compute a new Jacobian baseline for the next iteration.
- Part 3 – Search for the line "OPTIMISATION RESULTS" in this file (it should be around line 270). This section contains the results of the calibration. This is the information that was displayed in the calibration dialog.

9 The PEST Sensitivity File

PEST also reports which parameters the model results are most sensitive to.

The sensitivity can be seen by:

1. In a file browser, go to the "Gila_Calibration_models\SRH-2D\Structure Flow" directory.
2. Using a text editor, open the file "gila_calibration.sen" and browse to the bottom of the file.

The values in the last table in this file represent the composite sensitivity of the simulation to each variable. These are relative values, so the magnitude should not be considered as much as the relative magnitude. The table shows that the values for "mat_1" and "mat_2" (Channel and Light Veg) are much higher than the other two. This makes sense when the percentage of the wet area covered by each material type is considered. It also could explain why the *n* value for Trees or Dry Bed may not be quite what you expected. PEST could move these values more with a smaller impact, so they may not be the most reasonable.

10 Conclusion

This concludes the "SRH-2D Manning's N Calibration" tutorial. It has demonstrated:

- How to set observed values for water elevation at monitor point locations.
- How to specify that PEST can change the *n* value associated with a material zone and specify the allowable range of *n* values.
- How to run the calibration tool to interpret the results.

If desired, experiment with the SMS SRH-2D calibration tool. Possible suggestions include:

- Try to run the PEST analysis only allowing Channel and Light Veg roughness to be modified.
- Try starting the PEST analysis with different initial roughness values.
- Try modifying the allowable range of *n* values and/or the observed water levels.