ADVANCED RULE DEMO

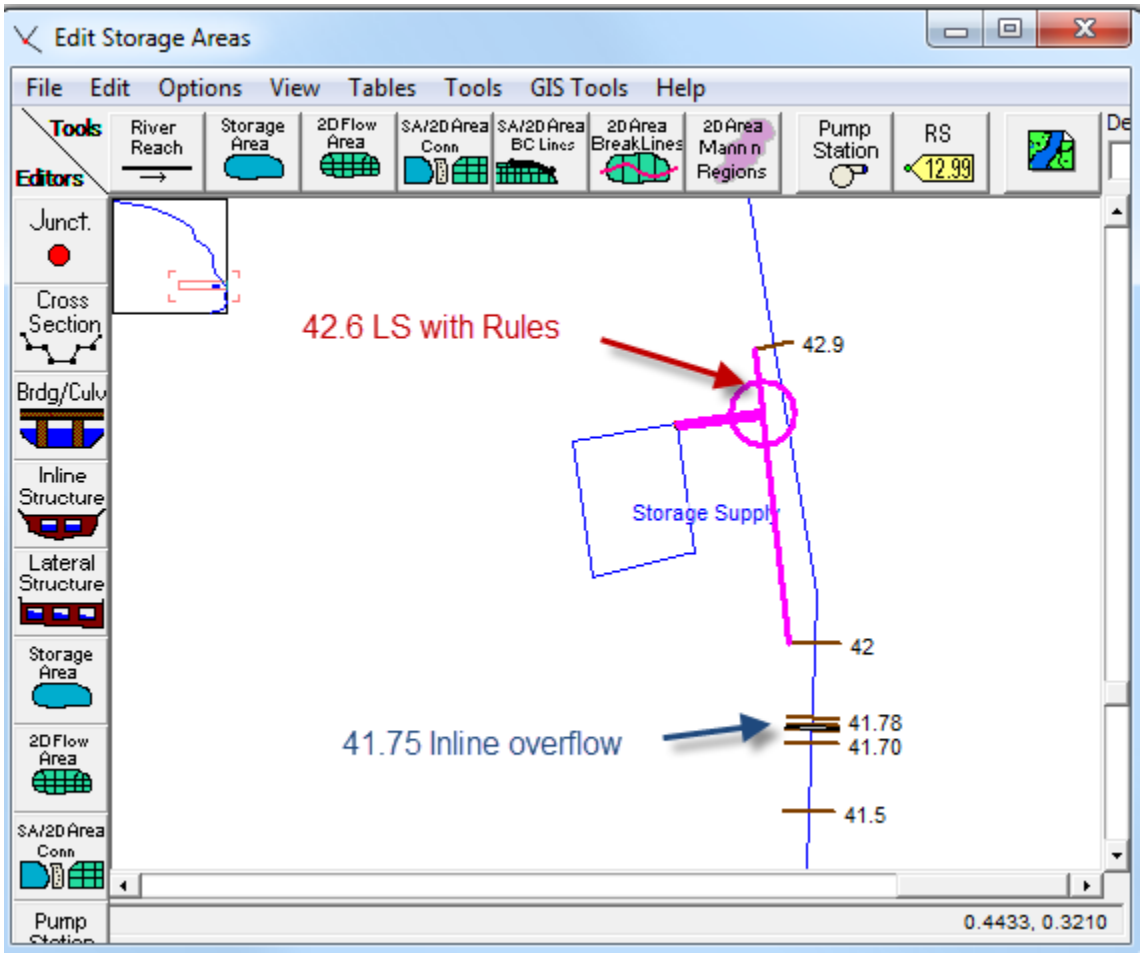
Introduction

This hands-on demonstration will help students learn how to use HEC-RAS to enter and edit advanced rules to control the gate operations at an inline structure.

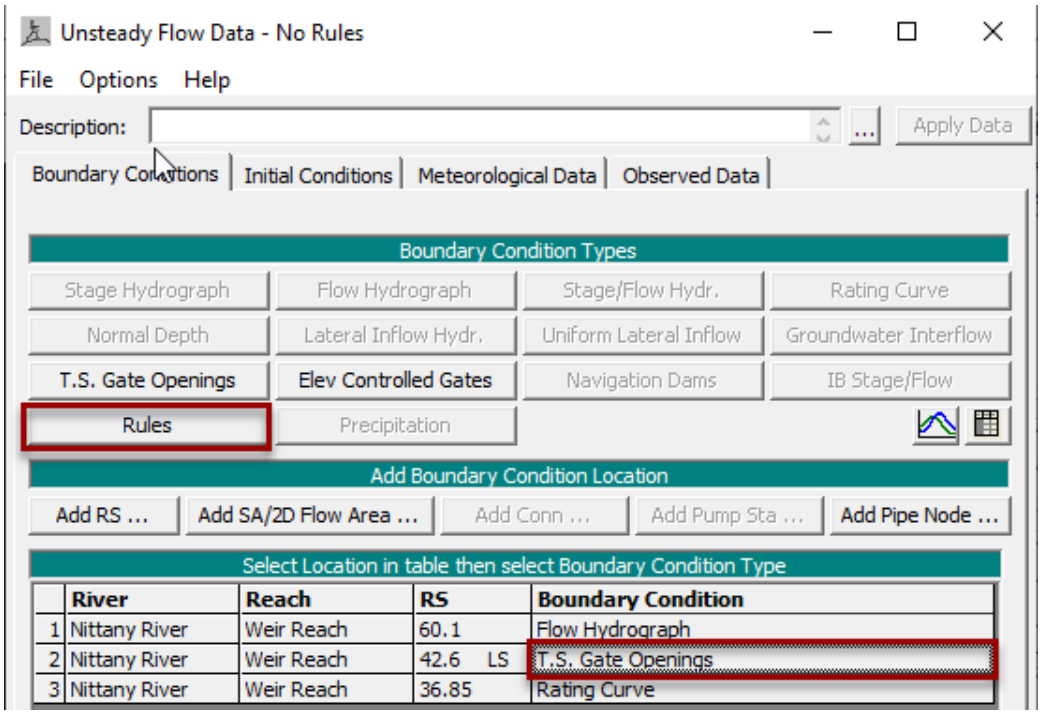
Problem

For this demonstration a project file (RuleDemo.prj) with the title "Advanced Rule Demonstration" has been loaded on your workshop computers. The initial gate information (opening rate, max opening, initial opening, etc.) has already been entered.

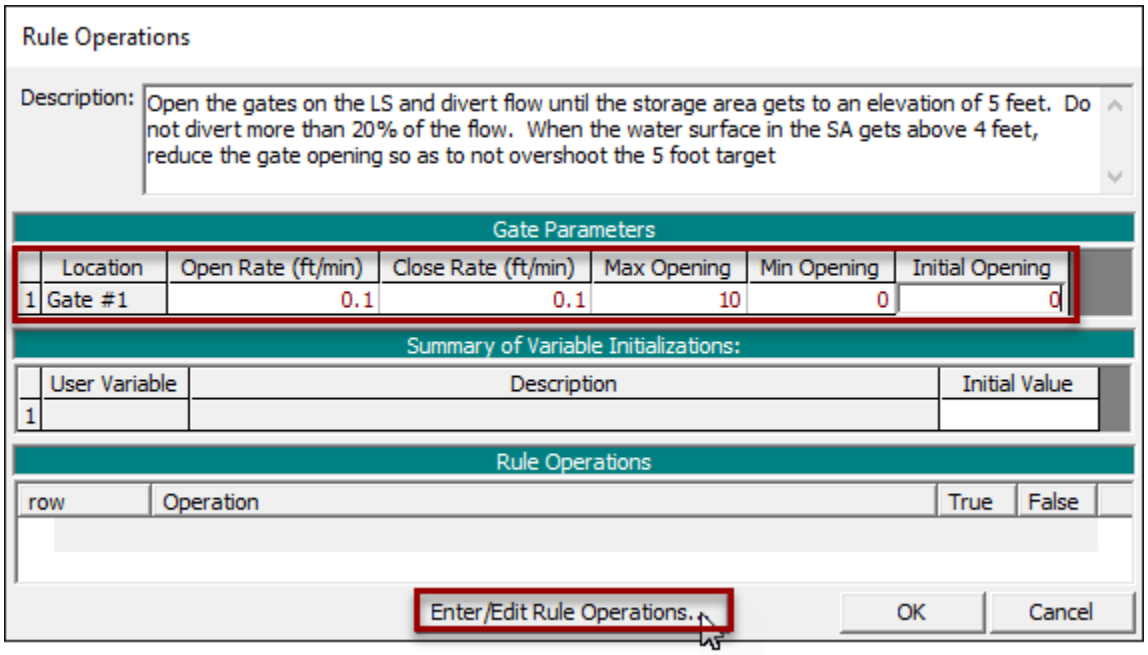
The rules will be used to open the gate on a lateral structure (RS 42.6) and fill a small storage area until the SA water surface reaches 5 feet. As class time permits, the flow being diverted will be limited to 20% of the flow going over the inline structure overflow weir (RS 41.75). Finally, additional logic will be added to keep the water surface in the SA from "overshooting" the 5 foot target.



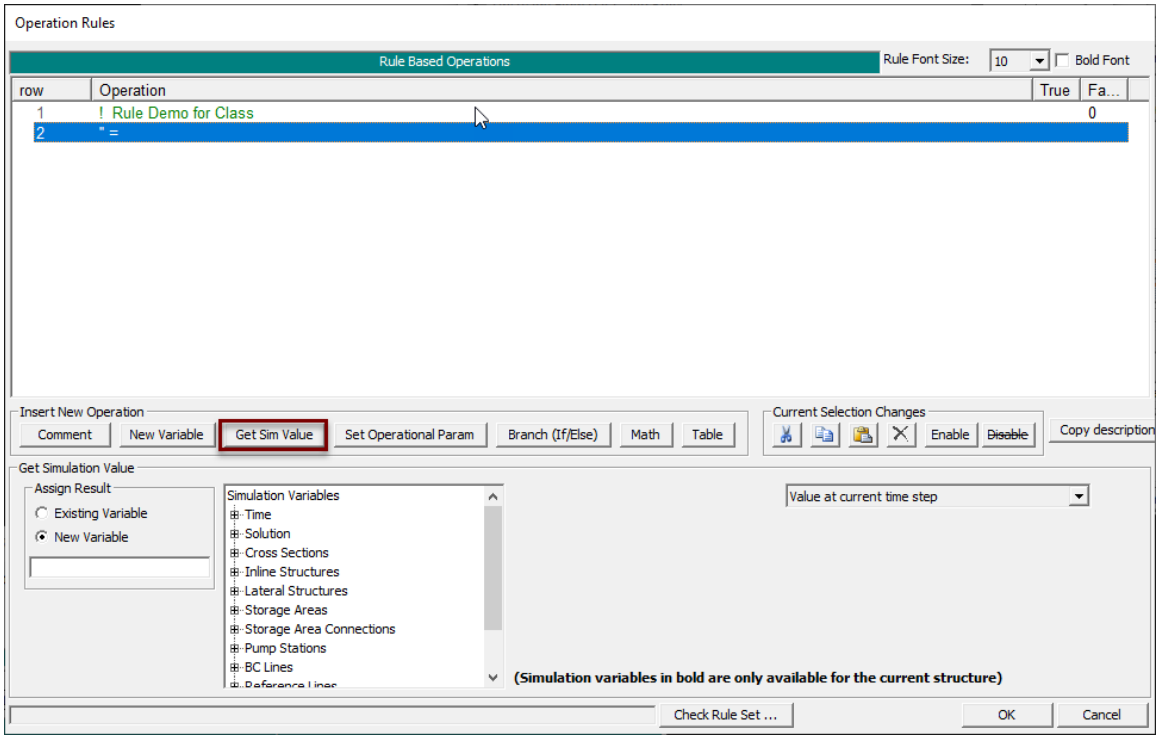
The default plan ("No Rules") models the lateral structure gates with 0-opening time series. To create rules, select this boundary condition and press the "Rules" button.



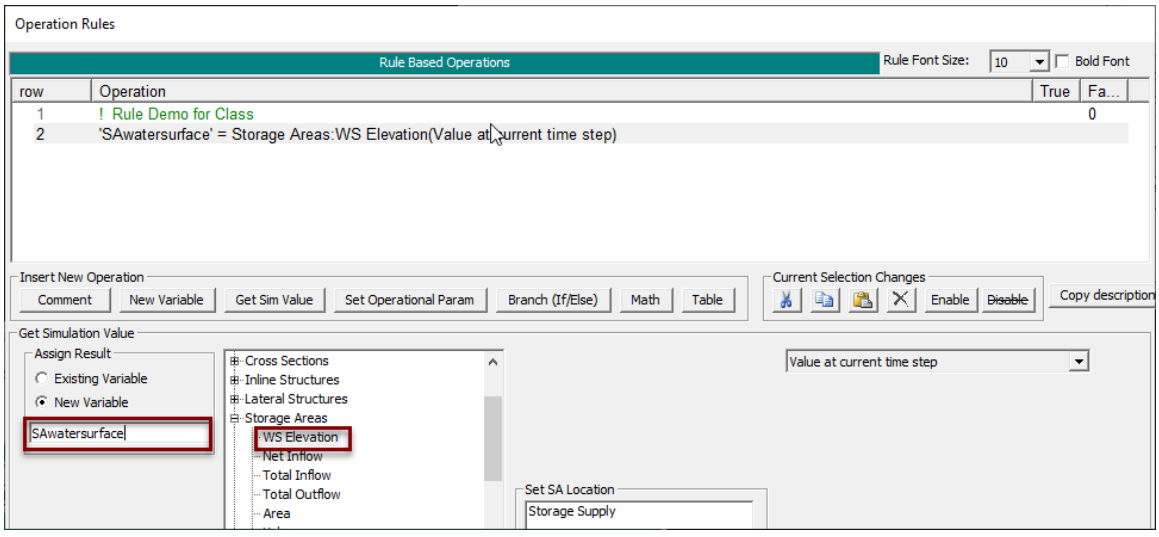
This will open the Rules Editor. The first step, before entering any rules, involves parameterizing the gate parameters. These five variables (open rate, close rate, max and min opening and initial opening) will provide critical gate information unless the rules override them. Then press **Enter/Edit Rules Operations…**



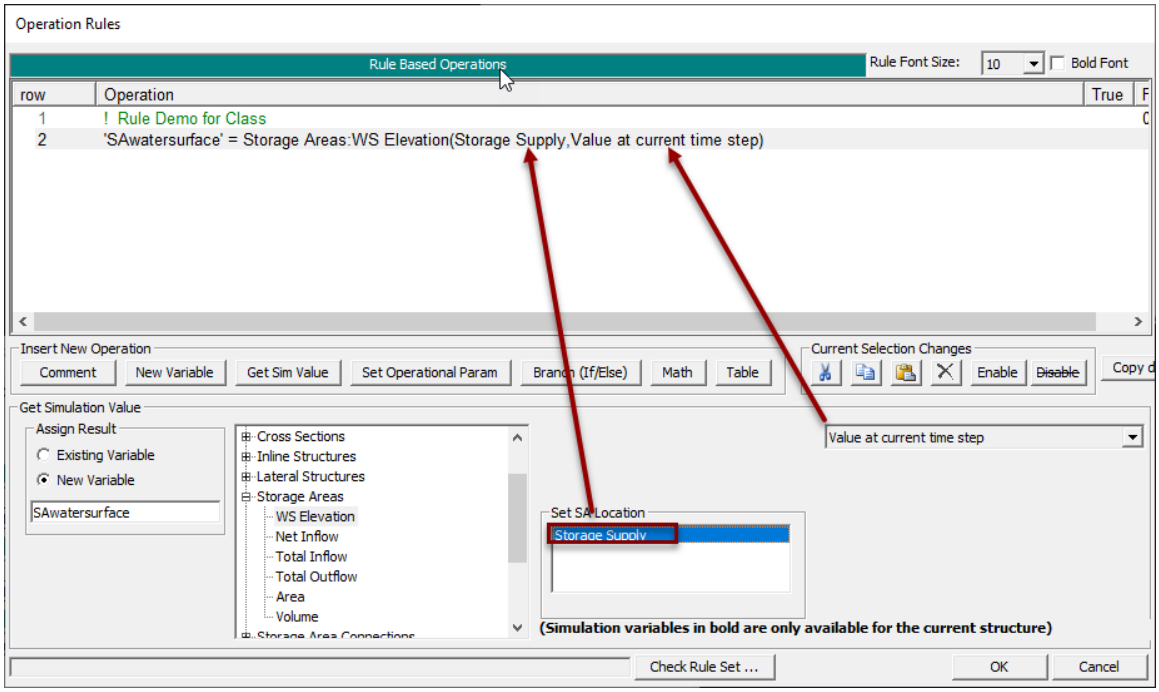
Press the Comment button to write a comment **! Rules Demo for Class**
Click on line number two to start the code there.
Click on the **Get Sim Value** Get Sim Value button to select a RAS result and name it as a Variable.



Select the storage area WS Elevation and assign the result to a new variable called SAwatersurface as shown in the green circle below.

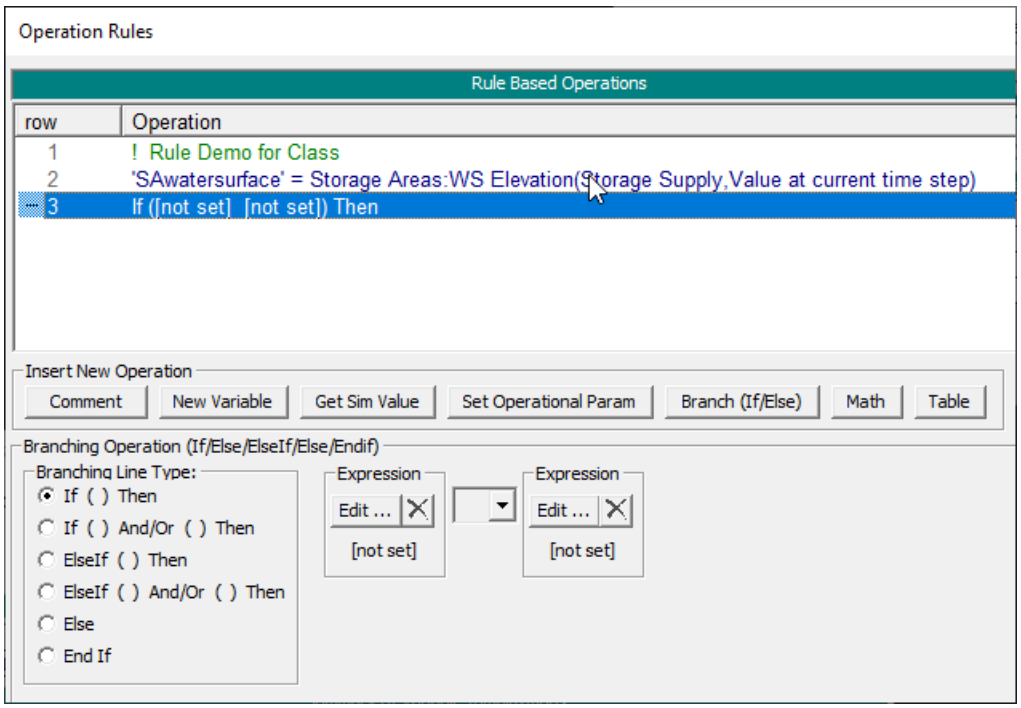


Even though there is only one storage area, the storage area must still be selected by clicking on it as shown below. The name of the SA should then show up in the rule (green circle).

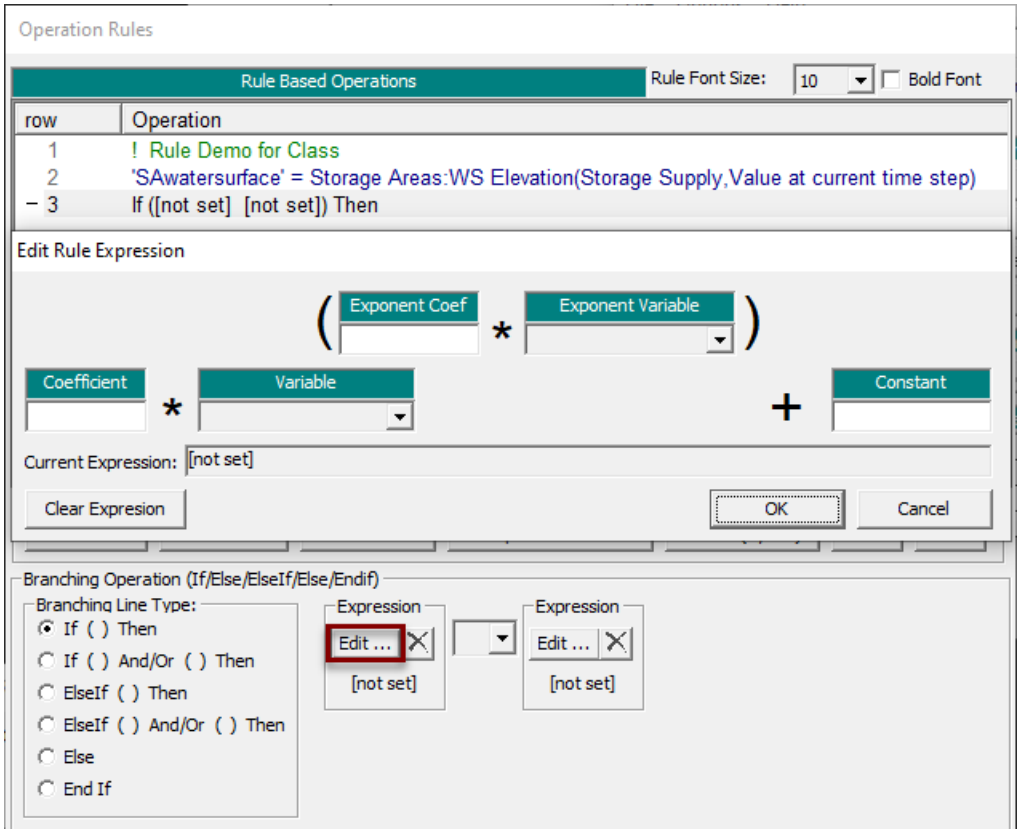


Click on line 3

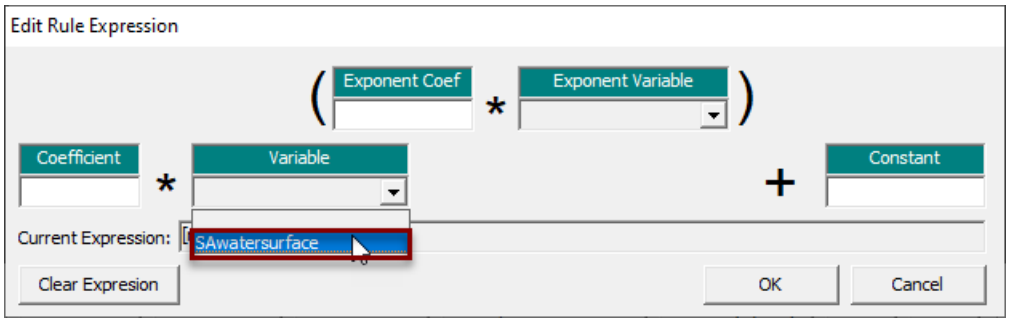
Create an If/Then rule by clicking on the **Branch** button Branch (If/Else).



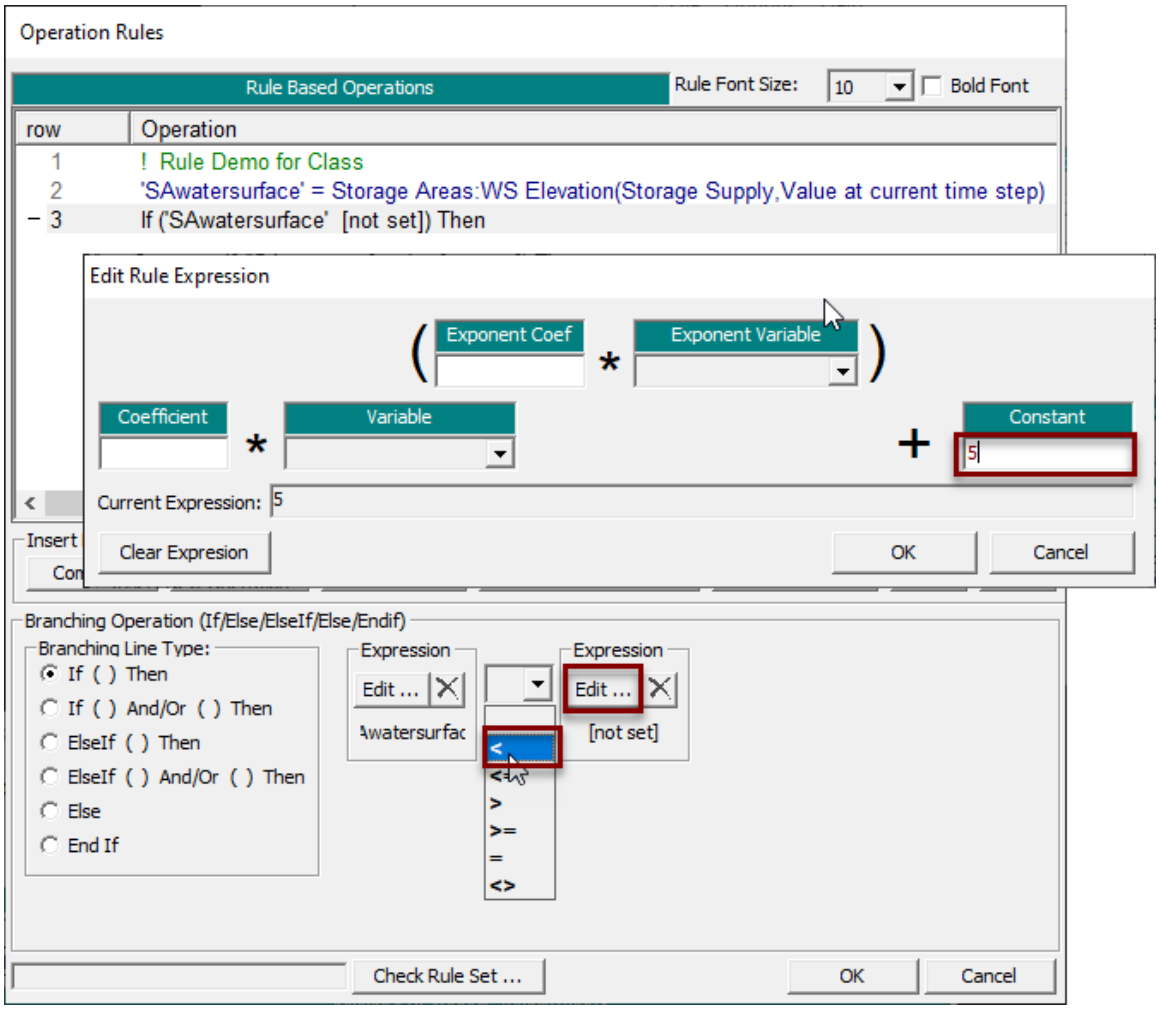
And then click on the left most **Edit** button to bring up the Expression editor.



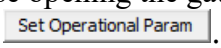
Click on the pull down menu under the **Variable** field and select the SAwatersurface variable and then click ok.



From the operator pull down, select “<” (less than).
Select the second Expression and enter “5” in the constant field.



The next step is to add a rule to open the gate.
Click on Line 4
The gate opening will be set to the maximum gate opening of 10 feet.
However, because the gate opening rate is limited to 0.1 feet/minute (as entered on the main Rule Operations Editor) and the time step is one minute duration, the gate opening will only increase by 0.1 feet per time step.

Because opening the gate is an "Operation" set it with the **Set Operational Param** button 

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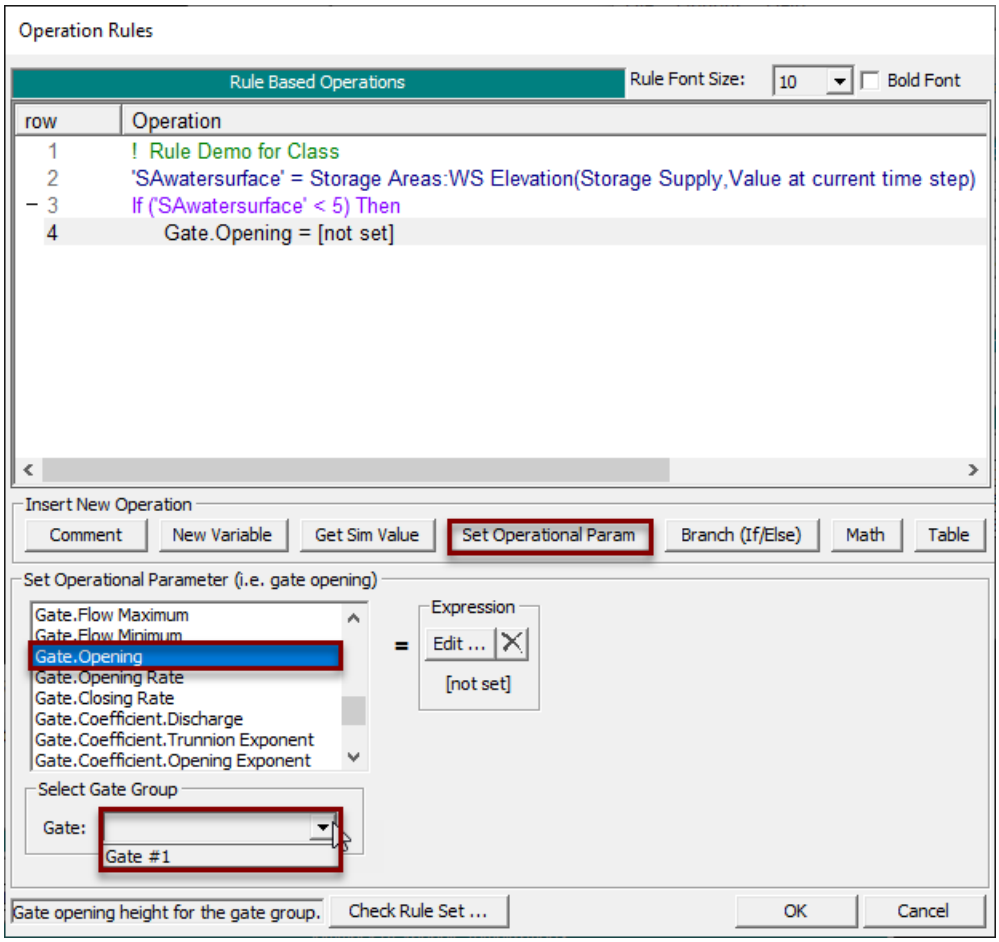
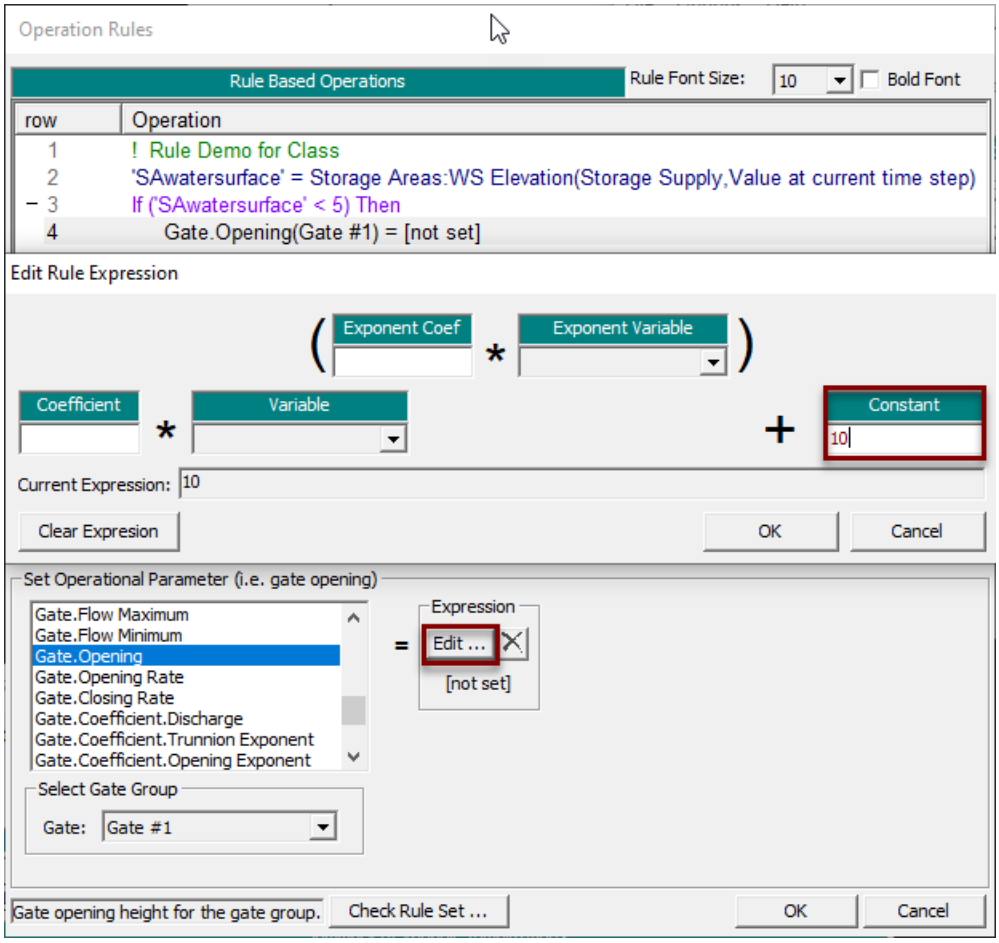
Then Scroll down and select "Gate.Opening". Even though there is only one gate group, it still needs to be selected (green circle).



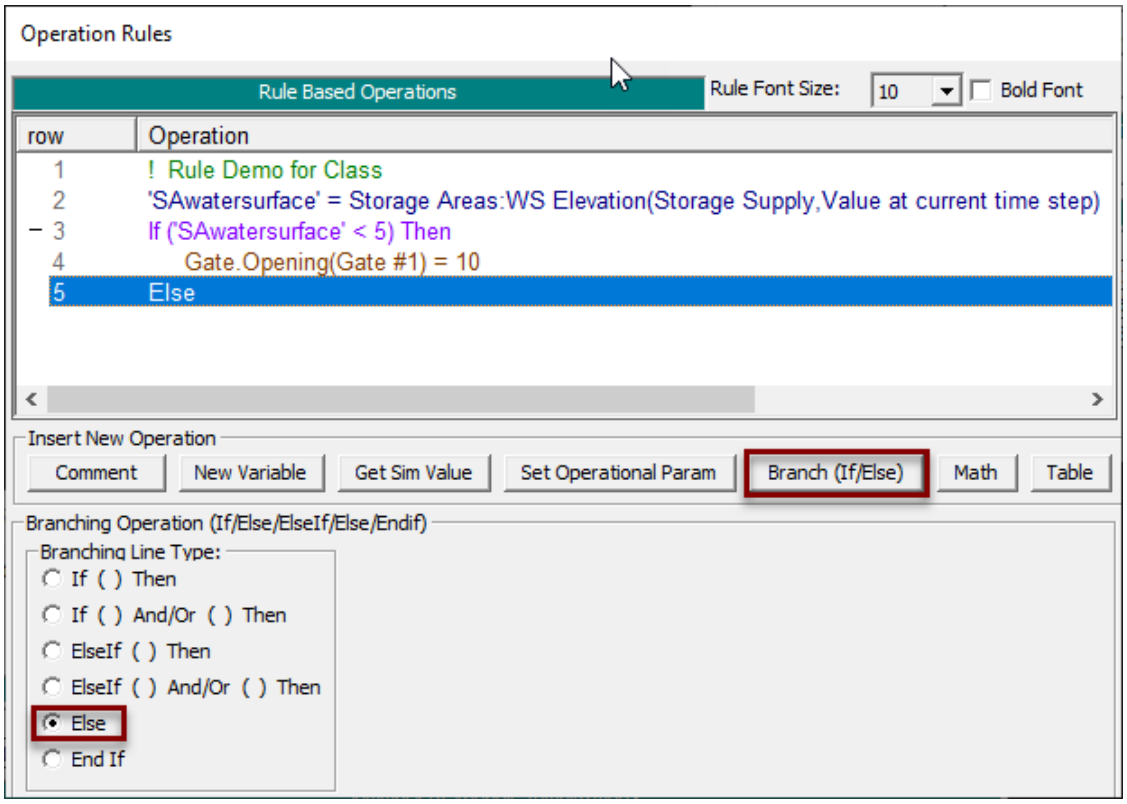
Select the gate group and Edit the Expression and set it to a constant of ten.



When the SA water surface gets to 5 feet, the gate needs to be closed. A new If/Then test could be created for this. However, it is simpler to just add an "Else" statement to the existing test.

Click on line 5.

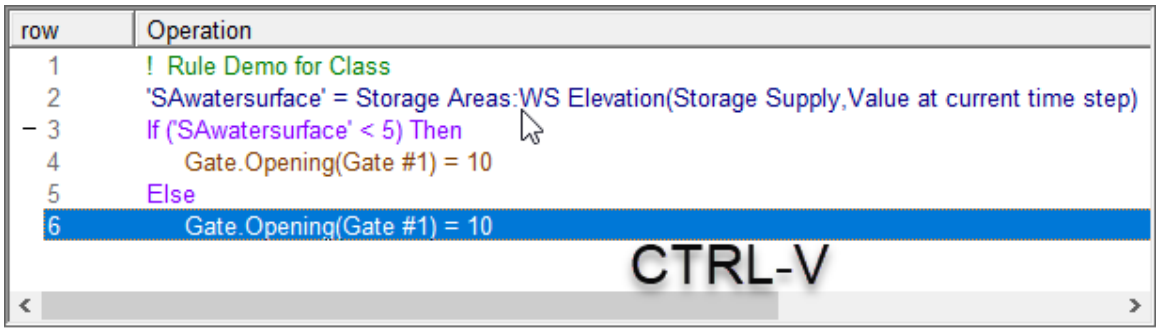
The "Else" is created by first clicking on the **Branch** button and then selecting the Else radial button.



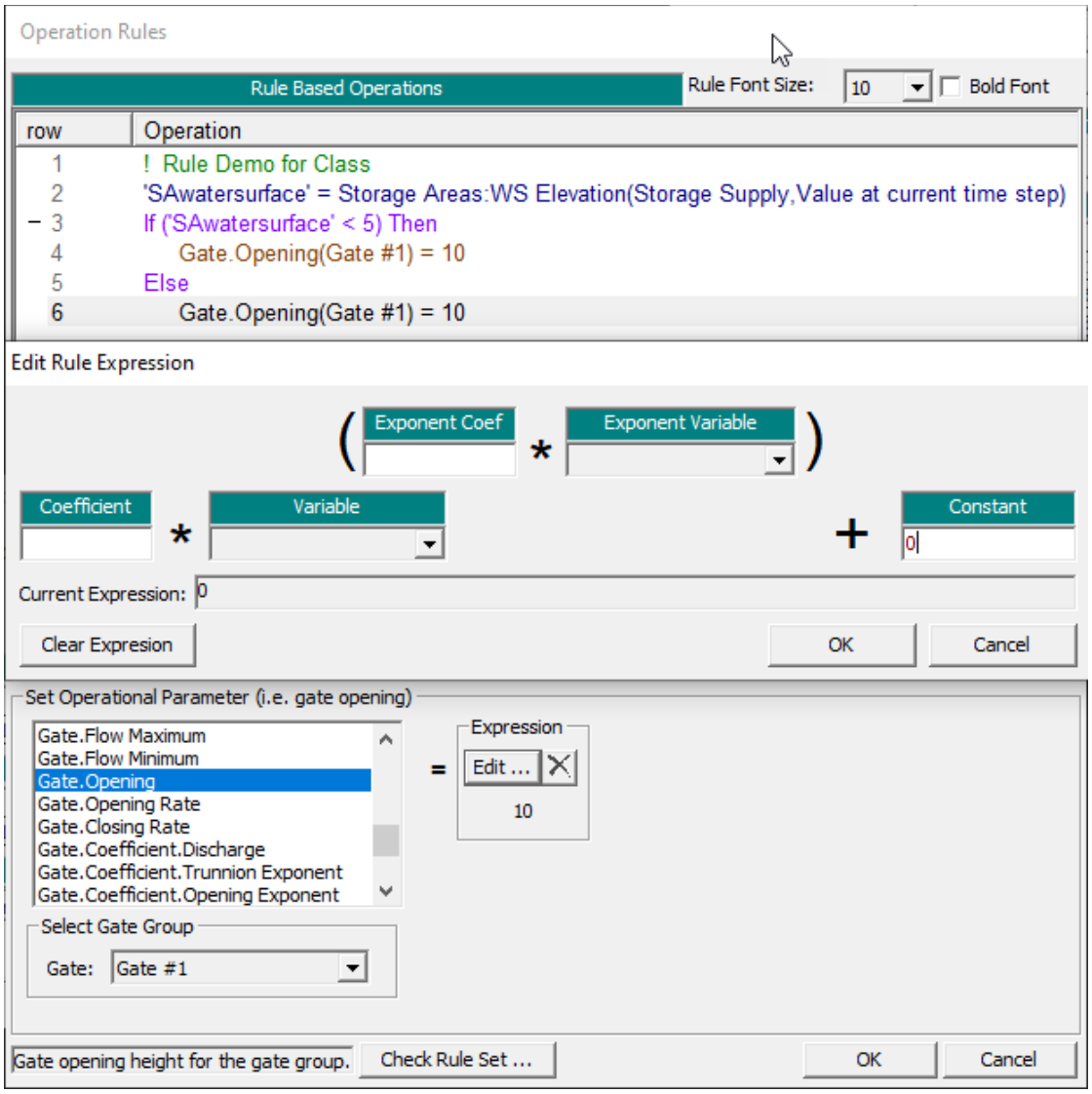
The next rule needs to close the gate by setting the opening to "0". A rule could be created from scratch just like the rule shown in row 4. However, it is much quicker to copy and paste rule 4 and then change the value of the expression.

Highlight row 4 by clicking on it and then click the **Copy** button (or use **Ctrl+C** on the keyboard).

Move the control below row 5, as would normally be done for a new rule, and click on the **Paste** button (or **Ctrl+V**).



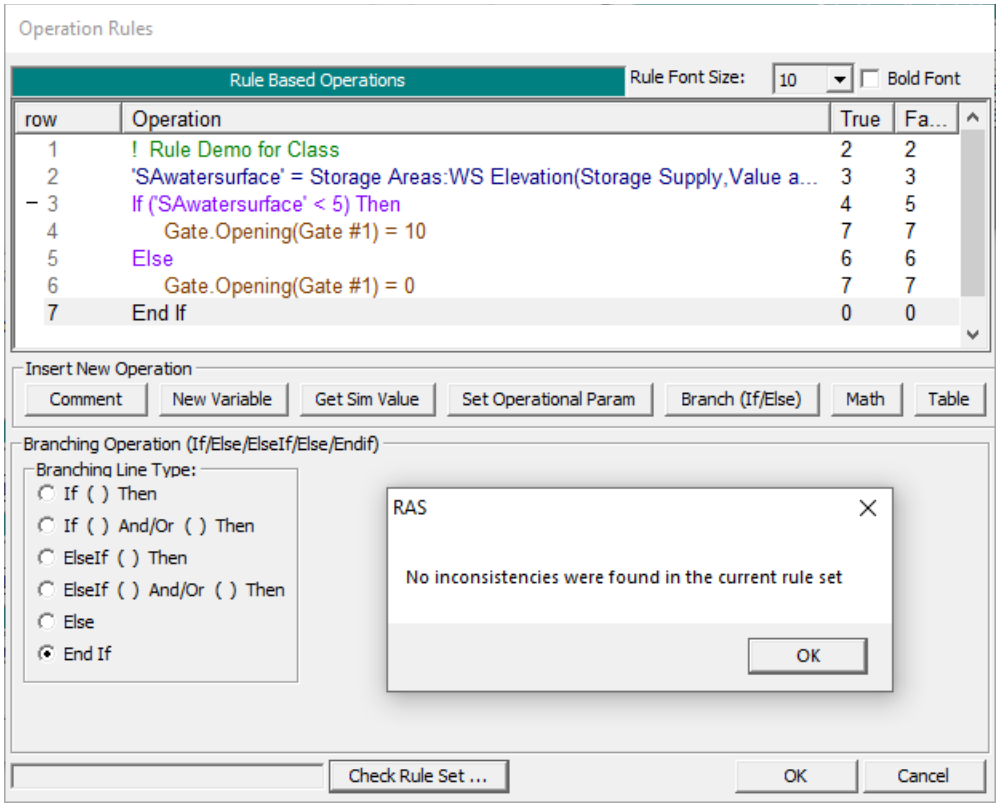
fter pasting the new rule, the row may look highlighted by the blue line but the bottom half of the Rule Editor is blank (as shown below). This can be fixed by moving the blue line up a row and then back down. (The highlighted blue line can be moved by using the up and down arrows on the keyboard.)



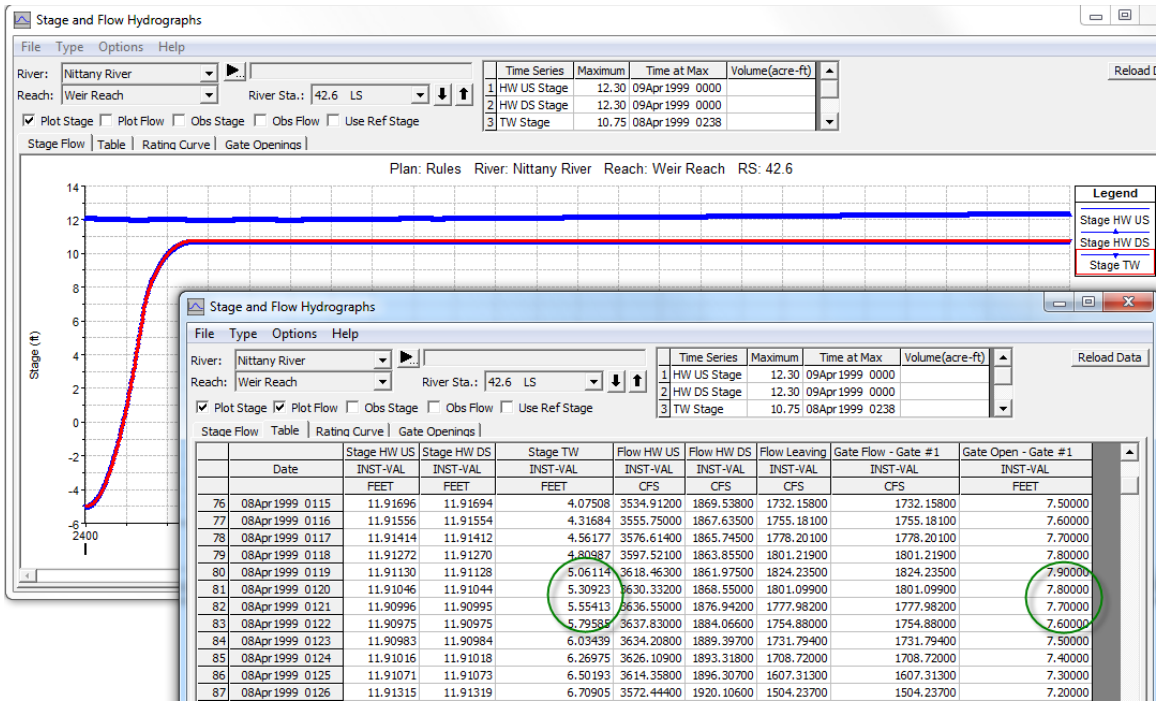
Click on the **Edit** button and change the constant from "10" to "0" to close the gate.

Every If/Then rule must have a corresponding End If.
Create a new Branch rule Branch (If/Else) and set it to End If.

At this point, the editor could be closed, the data saved, and the model run. However, it is useful to check the rules for bugs while the editor is still open. Click on the **Check Rule Set** button and RAS will pop up a window that will list the bugs, if any.

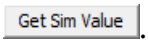


Fix any bugs, run the data set, and look at the lateral structure hydrographs.



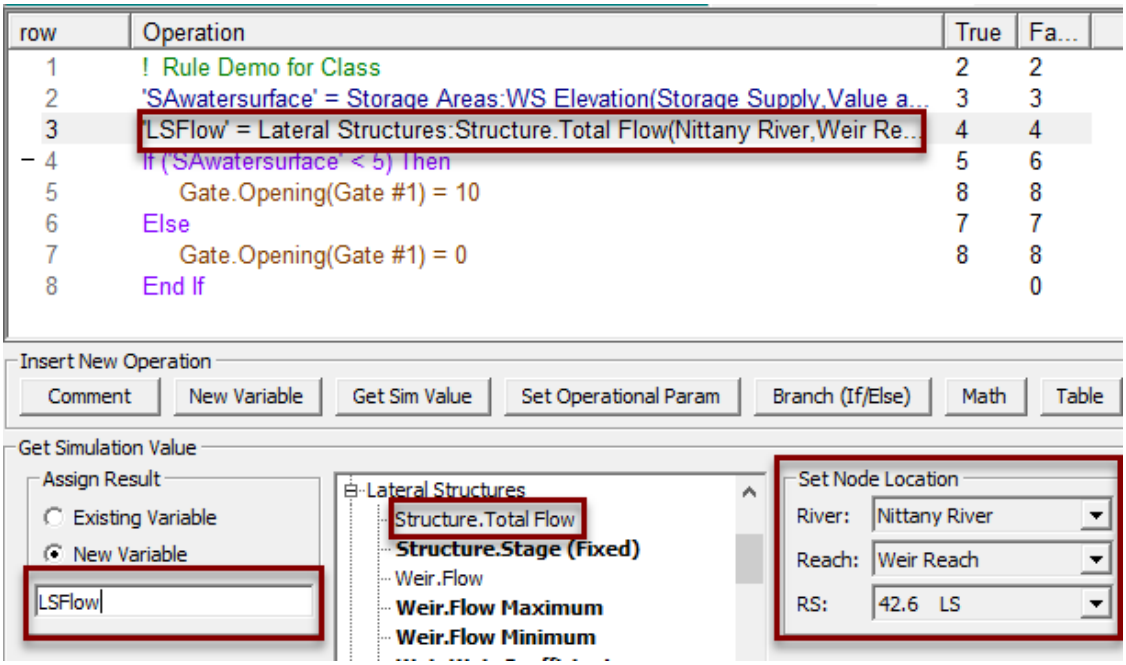
Since the lateral structure is connected to the storage area, the Stage TW of the lateral structure is the same as the water surface in the SA. The lateral structure is diverting flow into the SA and when the target water surface reaches 5 feet, the gate starts closing (although the target is dramatically exceeded by the time the gate gets fully closed).

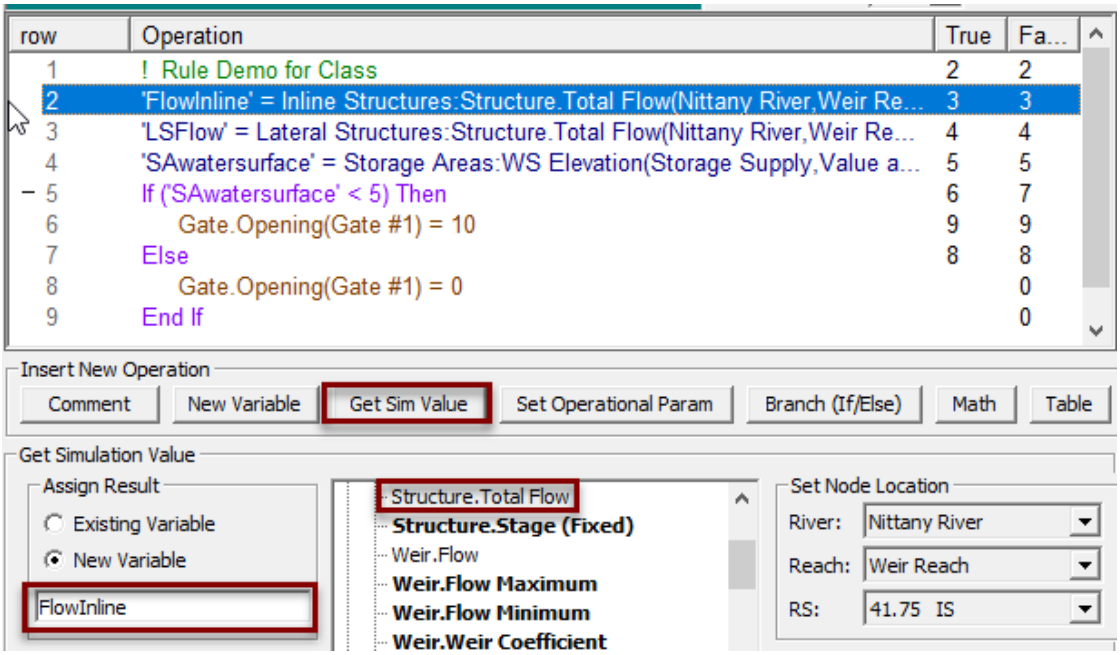
The next step is to limit the diversion to no more than 20% of flow that is going over the dam.

Add two more Get Sim Value rules 

. One that gets the total flow in the inline structure (there is only a single inline structure at 41.75) and a second that gets the total flow for the lateral structure. New variable names will have to be entered (green circle). Note also that these rules must come before the If/Then test rule.

Click on Line 3 to add.

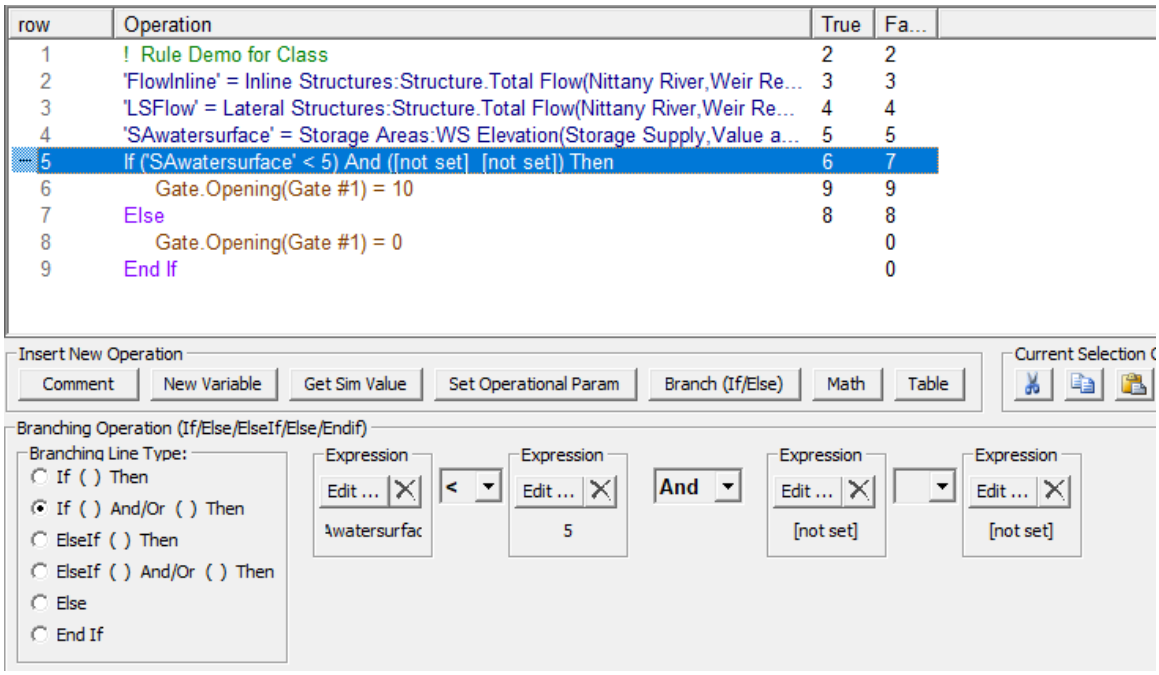




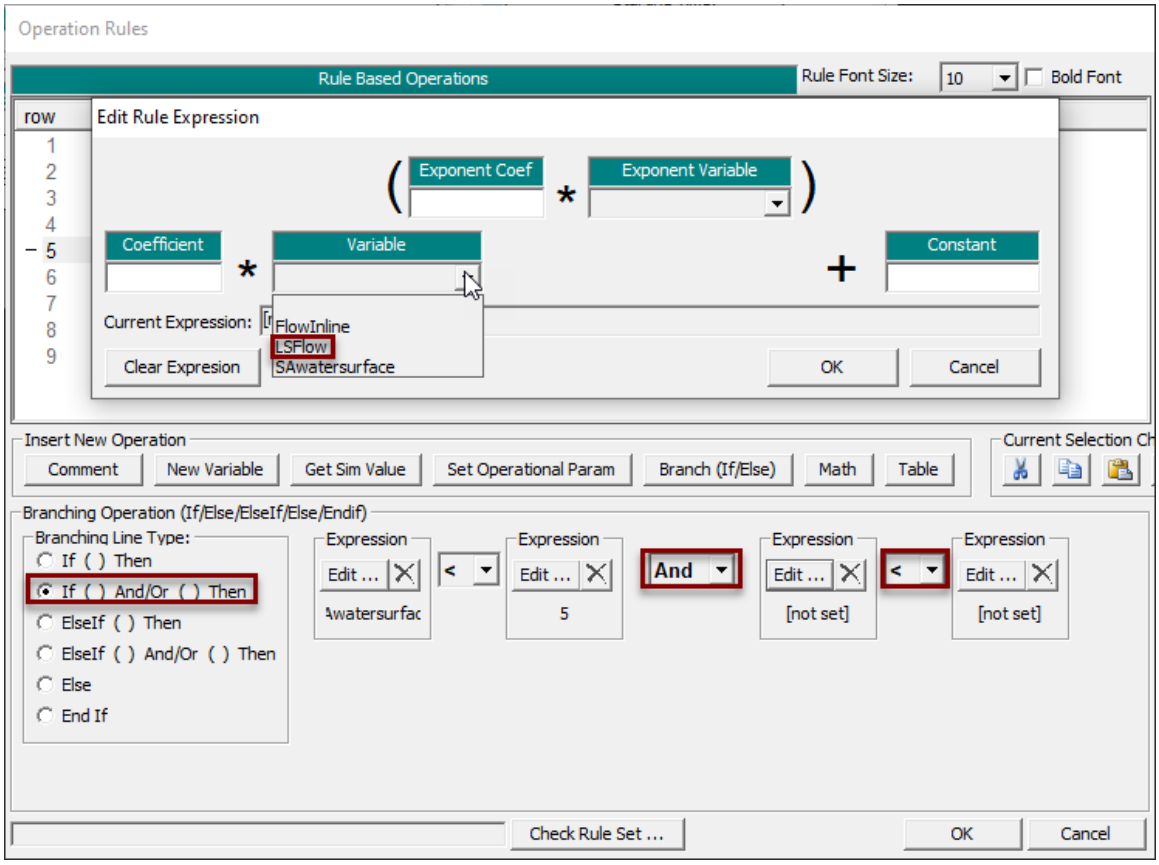
There are multiple options for how the 20% limit could be added. In this example, the If/Then test is going to be changed to a compound test that has the 20% built into the same row.

Highlight the If/Then test in row 5 and change the Branching Operation to a compound test. The rule for opening the gate is going to be changed so that it only opens if the SA water surface is less than 5 *and* the diverted flow is less than 20%. The "And" operator comes up by default (green circle). Since the check requires that both parts of the test

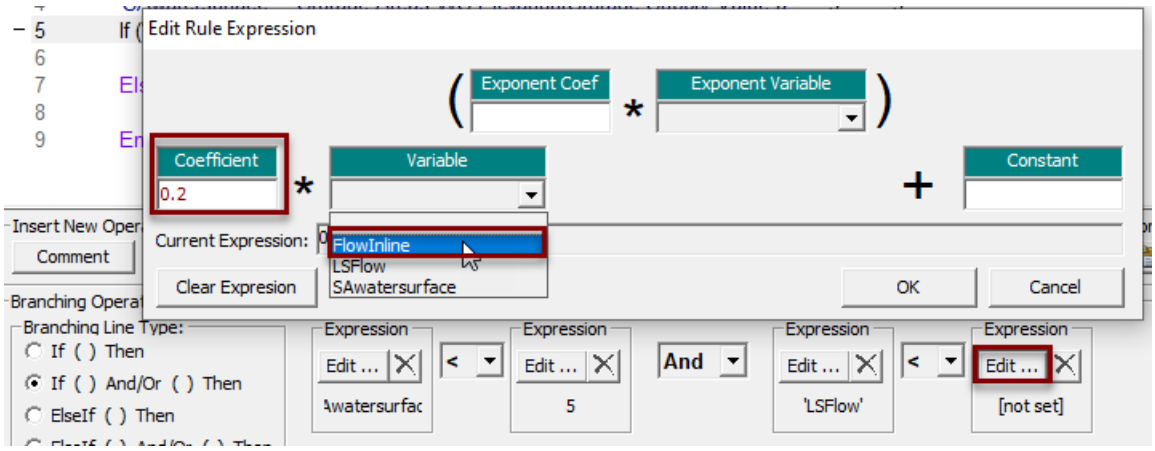
must be True in order to open the gate, the And is correct. (The other choice is an Or operator which would be used to check if either test is true.)



For the third expression select the lateral structure flow and set the second test to "<" (less than).



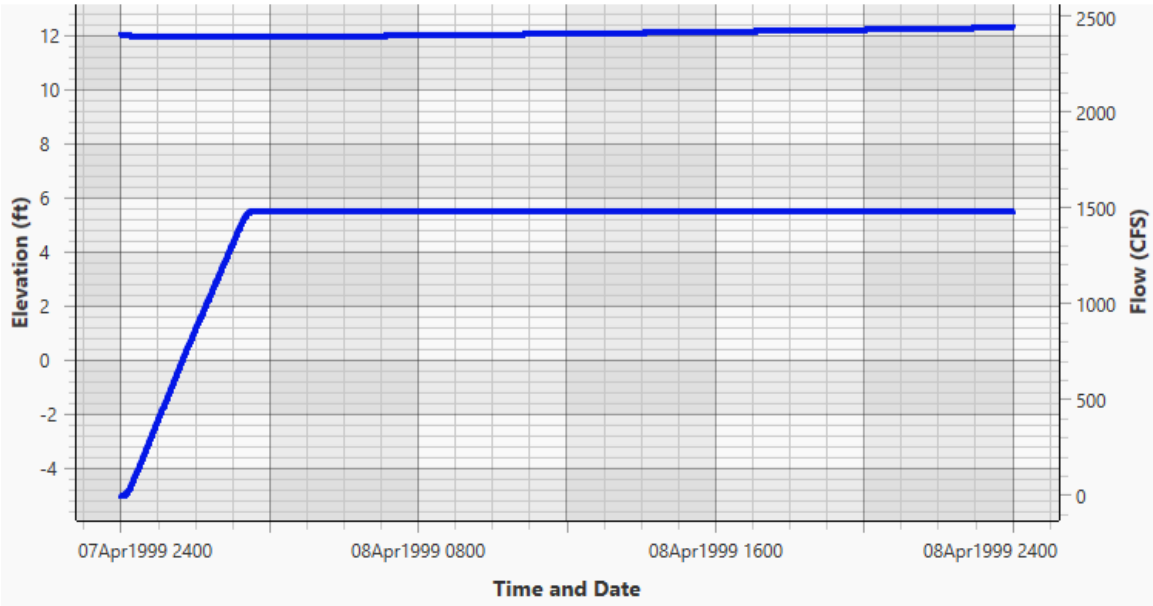
For the final Expression, select the variable for the flow over the inline structure. Since the test for the lateral structure flow is limited to 20% of the inline flow, a coefficient of 0.2 should be added.

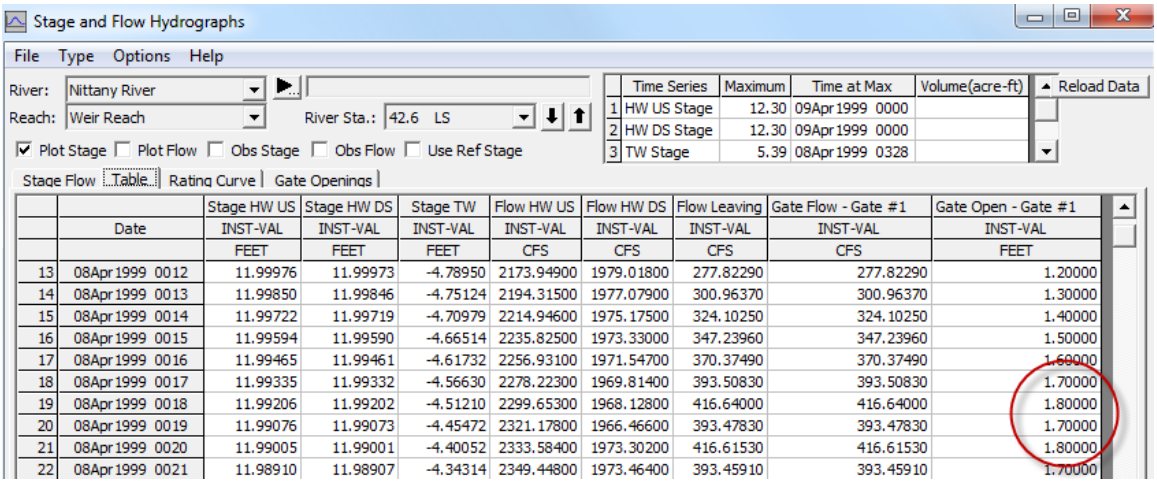


The final If/Then test is shown below.

```
1   ! Rule Demo for Class
2   'FlowInline' = Inline Structures:Structure.Total Flow(Nittany River,Weir Reach,41.75,Value at current time step)
3   'LSFlow' = Lateral Structures:Structure.Total Flow(Nittany River,Weir Reach,42.6,Value at current time step)
4   'SAwatersurface' = Storage Areas:WS Elevation(Storage Supply,Value at current time step)
5   If ('SAwatersurface' < 5) And ('LSFlow' < 0.2 * 'FlowInline') Then
6       Gate.Opening(Gate #1) = 10
7   Else
8       Gate.Opening(Gate #1) = 0
9   End If
```

With the additional test, the SA fills more slowly and the overshoot of the target is considerably reduced. Once the flow gets up to the 20% limit, the structure is oscillating between opening and closing the gate every other time step. Although this is not shown in this demo, more rules could be added to limit how frequently the gate is adjusted.





A final option is to start closing the gate before the SA reaches the 5 foot target. This is done by closing the gate to 0.3 feet once the water surface gets above 4 feet.

Additionally, comments can be used to document and explain the rule data set.