

# Education evenings 2018

*Practical introduction  
to groundwater modelling*

Computer exercises  
01 04 Adding features to our model

# Purpose

In this exercise, we will

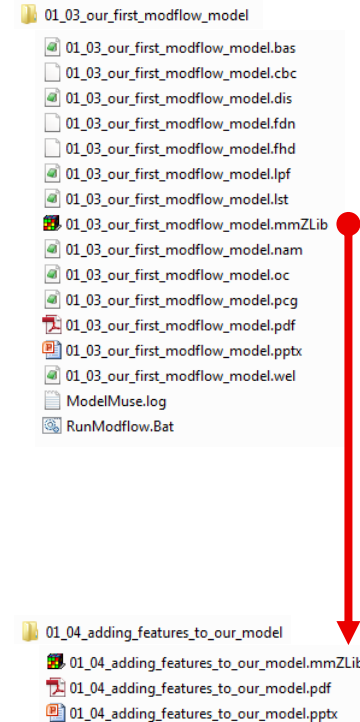
- ✓ add a river,
  - ✓ a drain,
  - ✓ and constant head boundaries
- to our model.

We will also

- ✓ visualize the fluxes from/to these model features.

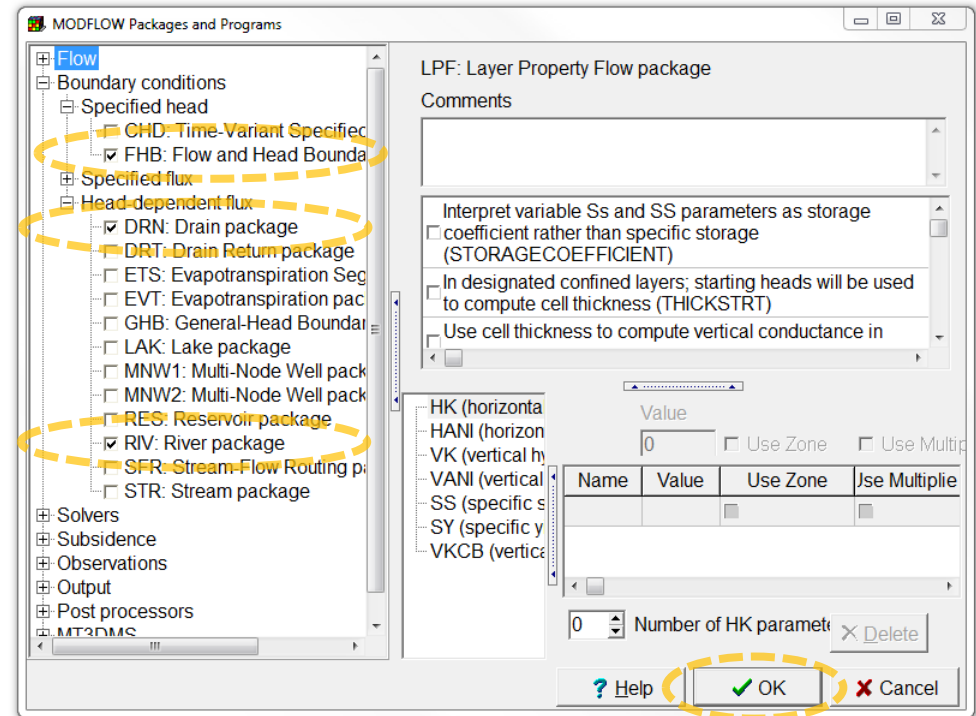
# Copy file previous exercise

- ✓ Copy file “/01-03\_our-first-modflow-model/01-03\_our-first-modflow-model.mmZLib” to folder “/01-04\_adding-features-to-our-model/”
- ✓ Change the file name to “01-04\_adding-features-to-our-model.mmZLib”,
- ✓ and open the file in ModelMuse.



# Enable MODFLOW packages

- ✓ Select **Model | MODFLOW Packages and Programs...**,
- ✓ and mark the checkboxes of the **Flow and Head Boundary, Drain, and River** packages.
- ✓ Then press **OK**.

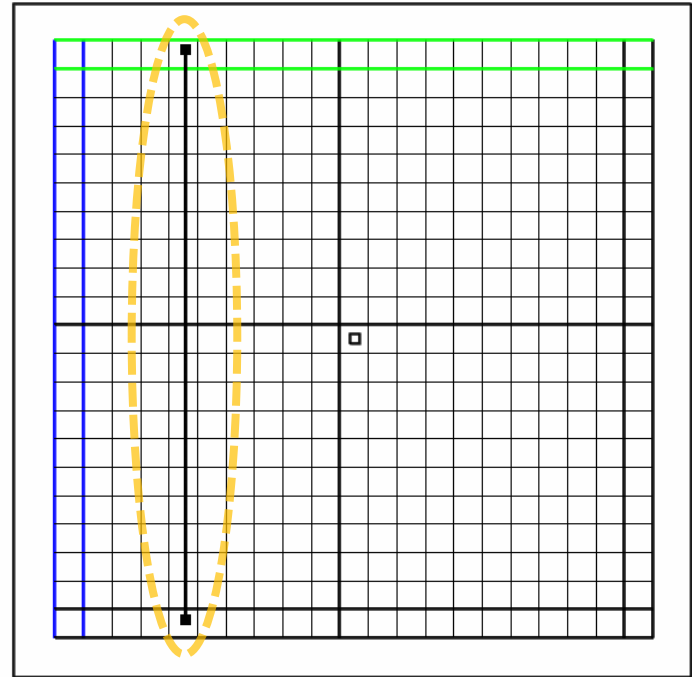


# Add a river (1/3)

- ✓ Select **Object | Create | Straight Line** or use the corresponding button,
- ✓ and draw a straight river in the fifth column, going from the first to the last row.

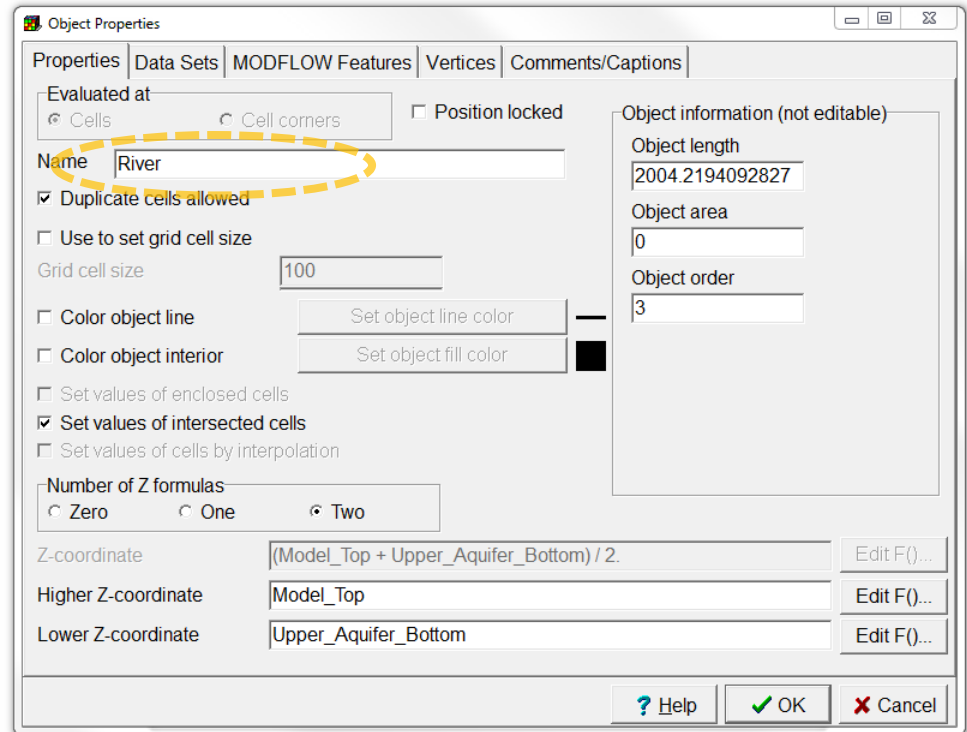


Create  
straight-line  
object



# Add a river (2/3)

- ✓ In the **Object Properties** dialog box, change the object name to “River”.



The screenshot shows the 'Object Properties' dialog box with the 'Name' field set to 'River'. A yellow dashed circle highlights the 'Name' field and the 'Duplicate cells allowed' checkbox. The dialog box has several tabs: 'Properties', 'Data Sets', 'MODFLOW Features', 'Vertices', and 'Comments/Captions'. The 'Properties' tab is active. It contains various settings for the object, including evaluation options, grid cell size, and color settings. On the right, there is a section for 'Object information (not editable)' showing 'Object length' as 2004.2194092827, 'Object area' as 0, and 'Object order' as 3. At the bottom, there are buttons for 'Help', 'OK', and 'Cancel'.

Object Properties	
<b>Properties</b>   Data Sets   MODFLOW Features   Vertices   Comments/Captions	
Evaluated at <input checked="" type="radio"/> Cells <input type="radio"/> Cell corners <input type="checkbox"/> Position locked	
Name: <u>River</u>	
<input checked="" type="checkbox"/> Duplicate cells allowed	
<input type="checkbox"/> Use to set grid cell size	
Grid cell size	100
<input type="checkbox"/> Color object line	Set object line color
<input type="checkbox"/> Color object interior	Set object fill color
<input type="checkbox"/> Set values of enclosed cells	
<input checked="" type="checkbox"/> Set values of intersected cells	
<input type="checkbox"/> Set values of cells by interpolation	
Number of Z formulas <input type="radio"/> Zero <input type="radio"/> One <input checked="" type="radio"/> Two	
Z-coordinate	(Model_Top + Upper_Aquifer_Bottom) / 2. <span>Edit F()...</span>
Higher Z-coordinate	Model_Top <span>Edit F()...</span>
Lower Z-coordinate	Upper_Aquifer_Bottom <span>Edit F()...</span>
<span>? Help</span> <span>✓ OK</span> <span>✗ Cancel</span>	

# Add a river (3/3)

- ✓ Switch to the **MODFLOW Features** tab, and
- ✓ check the **River package**.
- ✓ and fill in the **Starting time**, **Ending time**, **River stage**, **Conductance**, and **River bottom** with, respectively, -1, 1000, -0.1, 10, -0.5.
- ✓ Then press **OK**.

The screenshot shows the 'Object Properties' dialog box with the 'MODFLOW Features' tab selected. The 'RIV: River package' is checked in the list on the left. The 'Formula' table is populated with the following values:

Starting time	Ending time	River stage	Conductance per unit length or area	River bottom
-1	1000	-0.1	10	-0.5

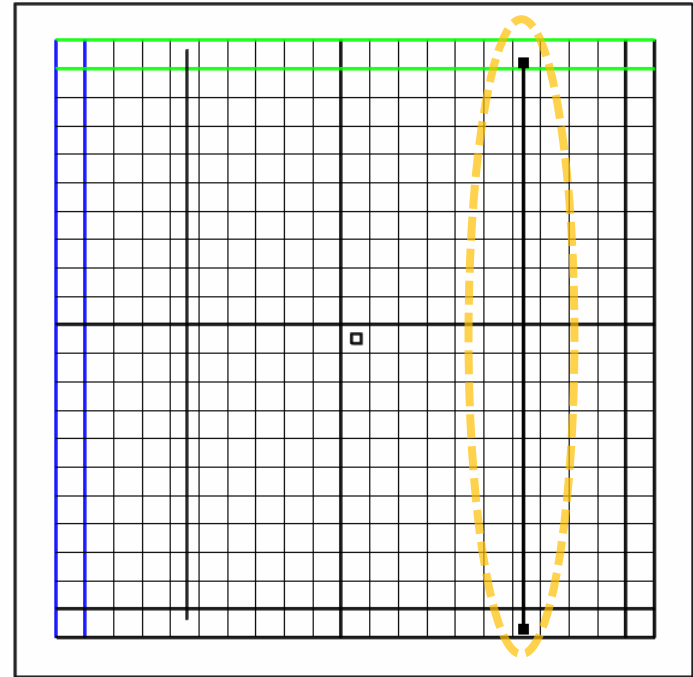
At the bottom of the dialog, the 'Number of times' is set to 1, 'Conductance interpretation' is set to 'Calculated', and the 'OK' button is highlighted.

# Add a drain (1/3)

- ✓ Select **Object | Create | Straight Line** or use the corresponding button,
- ✓ and draw a straight drain in the 17th column, going from the first to the last row.



Create  
straight-line  
object





# Add a drain (2/3)

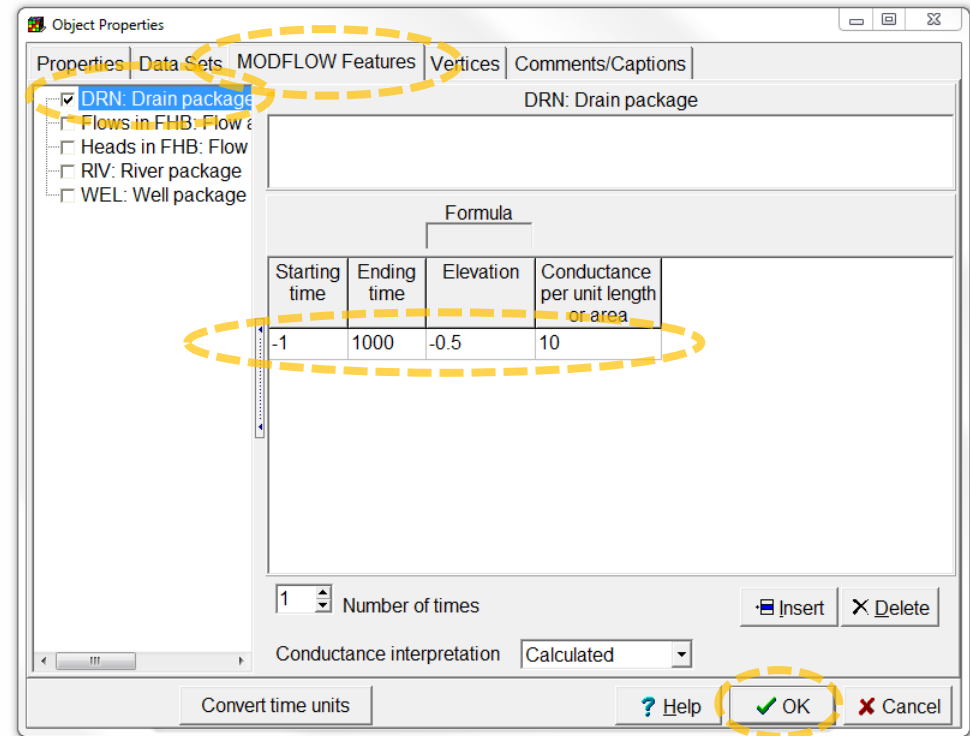
- ✓ In the **Object Properties** dialog box, change the object name to “Drain”.

The screenshot shows the 'Object Properties' dialog box with the 'Name' field highlighted by a yellow dashed circle. The 'Name' field contains the text 'Drain'. The 'Evaluated at' section has 'Cells' selected. The 'Duplicate cells allowed' checkbox is checked. The 'Grid cell size' is set to 100. The 'Number of Z formulas' section has 'Two' selected. The 'Z-coordinate' field contains the formula  $(Model\_Top + Upper\_Aquifer\_Bottom) / 2$ . The 'Higher Z-coordinate' field contains 'Model\_Top'. The 'Lower Z-coordinate' field contains 'Upper\_Aquifer\_Bottom'. The 'Object information (not editable)' section shows 'Object length' as 1991.5611814346, 'Object area' as 0, and 'Object order' as 4. The 'Convert time units' button is visible at the bottom left, and the 'Help', 'OK', and 'Cancel' buttons are at the bottom right.

Properties	Data Sets	MODFLOW Features	Vertices	Comments/Captions
<p>Evaluated at <input checked="" type="radio"/> Cells <input type="radio"/> Cell corners <input type="checkbox"/> Position locked</p> <p>Name <input type="text" value="Drain"/></p> <p><input checked="" type="checkbox"/> Duplicate cells allowed</p> <p><input type="checkbox"/> Use to set grid cell size Grid cell size <input type="text" value="100"/></p> <p><input type="checkbox"/> Color object line <input type="button" value="Set object line color"/></p> <p><input type="checkbox"/> Color object interior <input type="button" value="Set object fill color"/></p> <p><input type="checkbox"/> Set values of enclosed cells <input checked="" type="checkbox"/> Set values of intersected cells <input type="checkbox"/> Set values of cells by interpolation</p> <p>Number of Z formulas <input type="radio"/> Zero <input type="radio"/> One <input checked="" type="radio"/> Two</p> <p>Z-coordinate <input <input="" type="button" value="Edit F()..."/></p> <p>Higher Z-coordinate <input <input="" type="button" value="Edit F()..."/></p> <p>Lower Z-coordinate <input <input="" type="button" value="Edit F()..."/></p> <p><input type="button" value="Convert time units"/> <input type="button" value="? Help"/> <input type="button" value="OK"/> <input type="button" value="Cancel"/></p>				

# Add a drain (3/3)

- ✓ Switch to the **MODFLOW Features** tab, and
- ✓ check the **Drain package**.
- ✓ and fill in the **Starting time**, **Ending time**, **Elevation** and **Conductance** with, respectively, -1, 1000, -0.5 and 10.
- ✓ Then press **OK**.

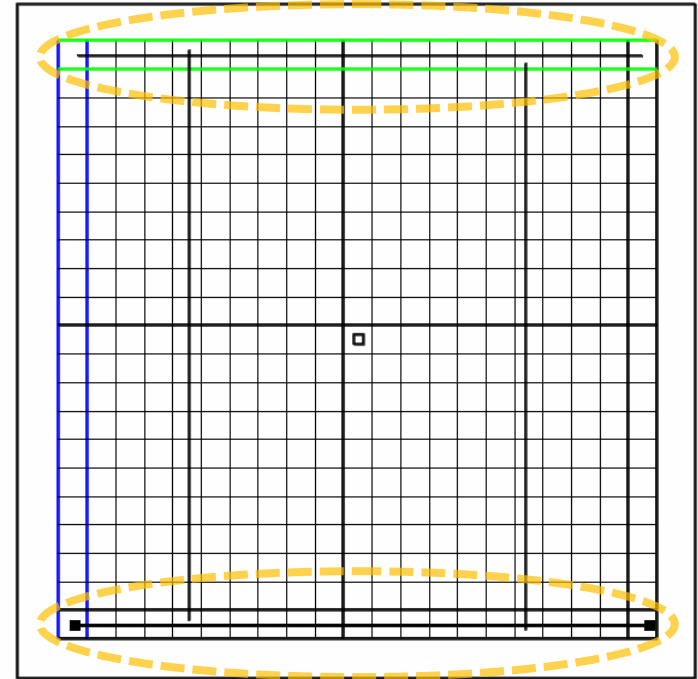


# Add constant head boundaries (1/3)

- ✓ Select **Object | Create | Straight Line** or use the corresponding button,
- ✓ and draw a straight line in the first row, going from the first to the last column.
- ✓ Go through the next 2 slides and then repeat the steps for the last row.

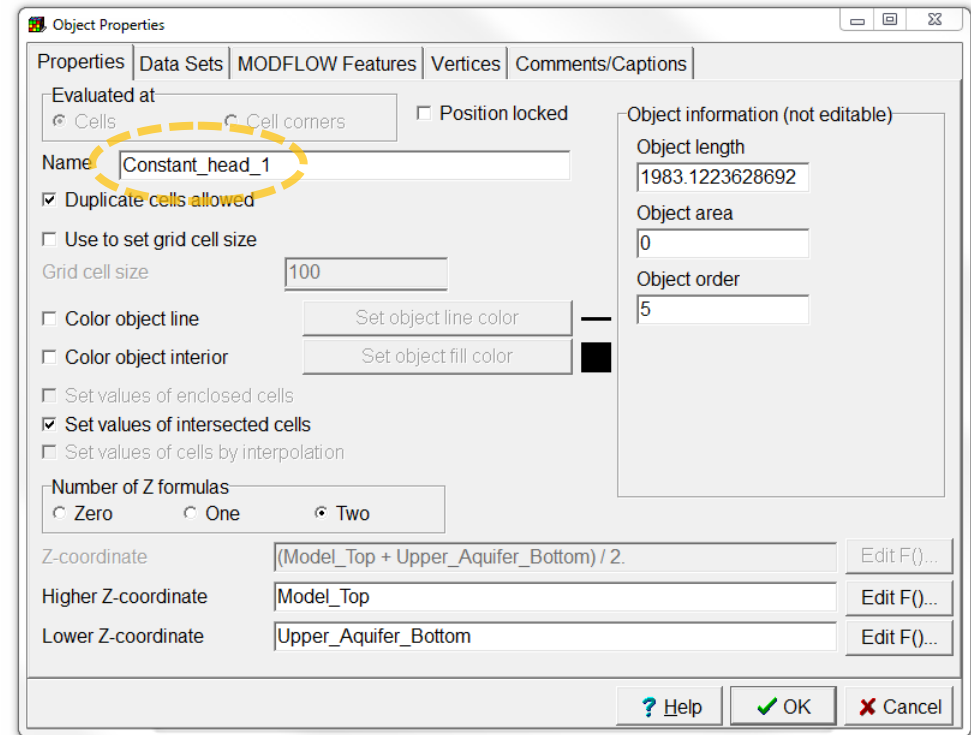


Create  
straight-line  
object



# Add constant head boundaries (2/3)

- ✓ In the **Object Properties** dialog box, change the object name to “**Constant\_head\_1**” or “**Constant\_head\_2**”.

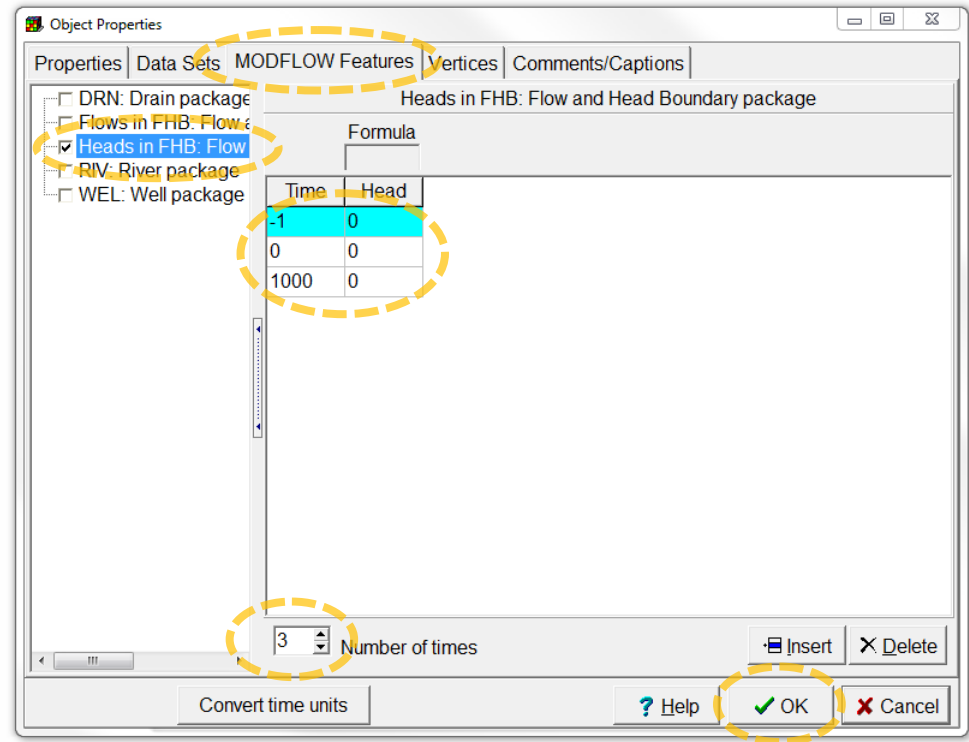


The screenshot shows the 'Object Properties' dialog box with the 'Properties' tab selected. A yellow dashed circle highlights the 'Name' field, which contains the text 'Constant\_head\_1'. The 'Evaluated at' section has 'Cells' selected. The 'Duplicate cells allowed' checkbox is checked. The 'Grid cell size' is set to 100. The 'Number of Z formulas' section has 'Two' selected. The 'Z-coordinate' field contains the formula  $(\text{Model\_Top} + \text{Upper\_Aquifer\_Bottom}) / 2$ . The 'Higher Z-coordinate' field contains 'Model\_Top'. The 'Lower Z-coordinate' field contains 'Upper\_Aquifer\_Bottom'. The 'Object information (not editable)' section shows 'Object length' as 1983.1223628692, 'Object area' as 0, and 'Object order' as 5. The 'OK' button is highlighted with a green checkmark.

Properties	Data Sets	MODFLOW Features	Vertices	Comments/Captions
<b>Evaluated at</b> <input checked="" type="radio"/> Cells <input type="radio"/> Cell corners <input type="checkbox"/> Position locked				
Name: <input type="text" value="Constant_head_1"/>				
<input checked="" type="checkbox"/> Duplicate cells allowed				
<input type="checkbox"/> Use to set grid cell size Grid cell size: <input type="text" value="100"/>				
<input type="checkbox"/> Color object line <input type="button" value="Set object line color"/>				
<input type="checkbox"/> Color object interior <input type="button" value="Set object fill color"/>				
<input type="checkbox"/> Set values of enclosed cells				
<input checked="" type="checkbox"/> Set values of intersected cells				
<input type="checkbox"/> Set values of cells by interpolation				
<b>Number of Z formulas</b> <input type="radio"/> Zero <input type="radio"/> One <input checked="" type="radio"/> Two				
Z-coordinate: <input type="text" value="(Model_Top + Upper_Aquifer_Bottom) / 2"/> <input <="" td="" type="button" value="Edit F()..."/>				
Higher Z-coordinate: <input type="text" value="Model_Top"/> <input <="" td="" type="button" value="Edit F()..."/>				
Lower Z-coordinate: <input type="text" value="Upper_Aquifer_Bottom"/> <input <="" td="" type="button" value="Edit F()..."/>				
<input type="button" value="Help"/> <input checked="" type="button" value="OK"/> <input type="button" value="Cancel"/>				

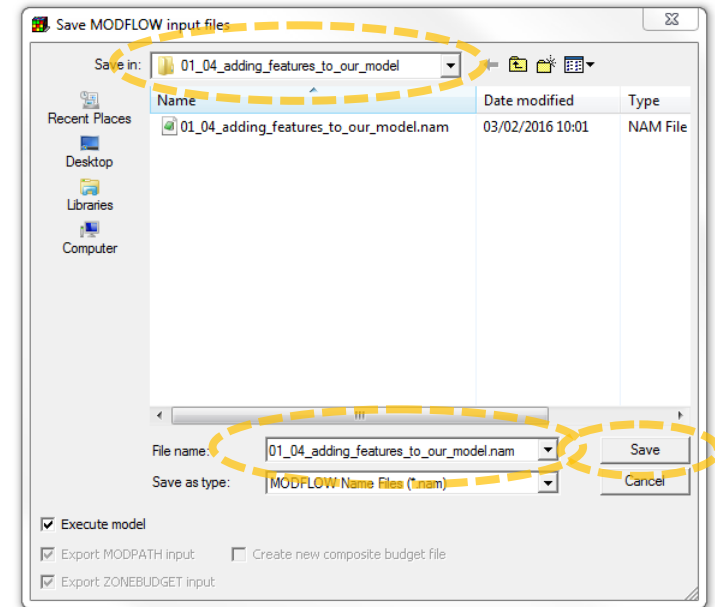
# Add constant head boundaries (3/3)

- ✓ Switch to the **MODFLOW Features** tab, and
- ✓ check the **Flow and Head Boundary package**.
- ✓ Change **Number of times** to 3,
- ✓ and fill in the **Time** column with -1, 0, 1000, and the **Head** column with 0, 0, 0.
- ✓ Then press **OK**.
- ✓ Make sure you defined two constant head boundaries!



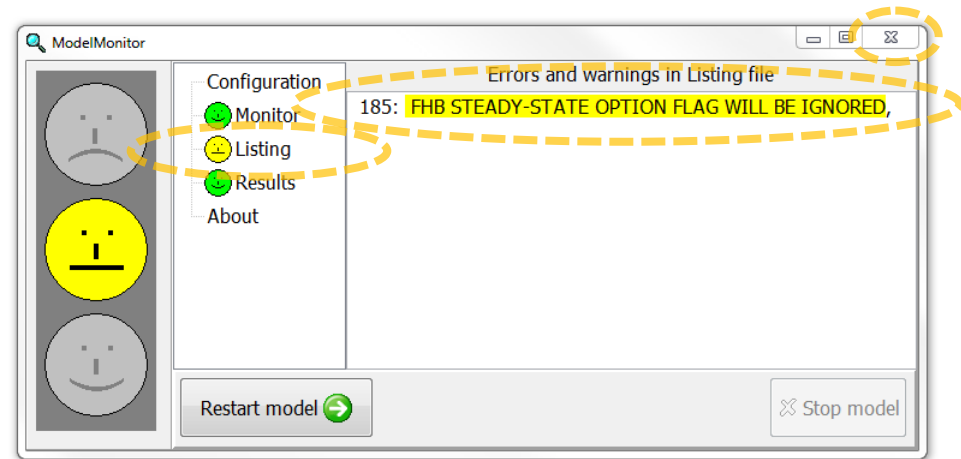
# Run model (1/2)

- ✓ Select **File | Export | MODFLOW Input Files**,
- ✓ specify the file name “/01-04\_adding-features-to-our-model/01-04\_adding-features-to-our-model.nam”, and
- ✓ click **Save**. ModelMuse will create the MODFLOW input files and start running MODFLOW.



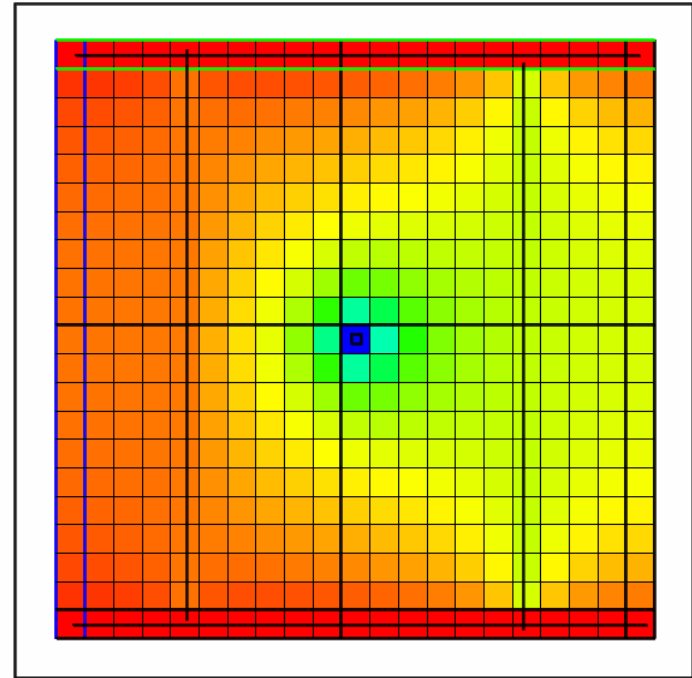
# Run model (2/2)

- ✓ ModelMonitor found a warning in the Listing file, but this is normal when using the **Flow and Head Boundary package** with transient stress periods.
- ✓ Close ModelMonitor,
- ✓ the listing file,
- ✓ and the command line window.



# Visualize simulated heads

- ✓ Color the grid with the simulated heads like we did during the previous exercise.



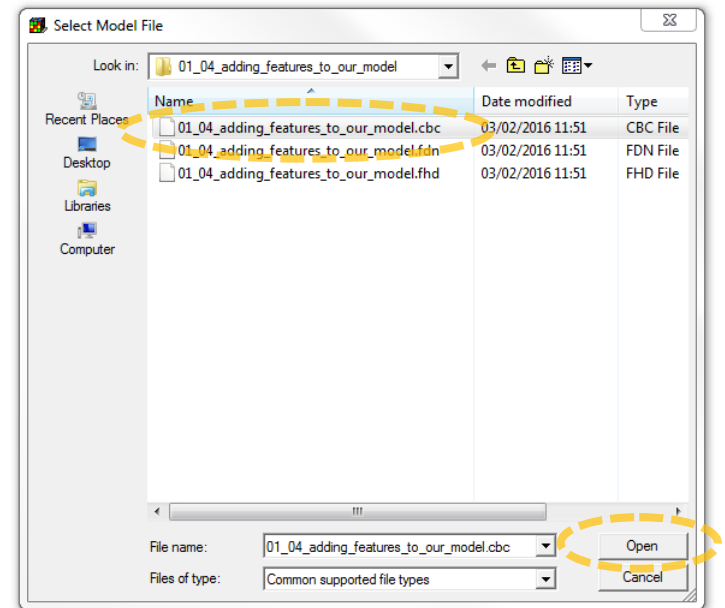


# Import flow data (1/2)

- ✓ Select **File | Import | Model Results...** or use the corresponding button,
- ✓ select the binary flow file “01-04\_adding-features-to-our-model.cbc”, and
- ✓ click **Open**.

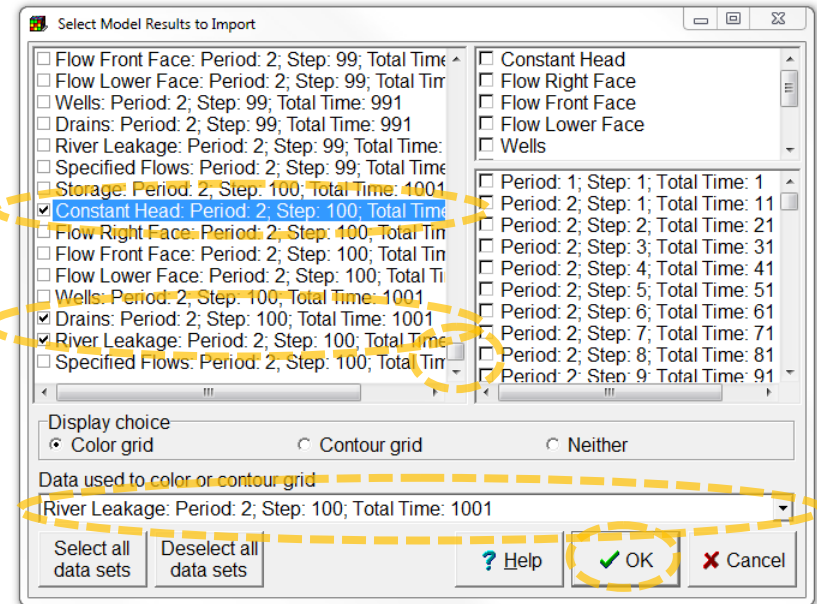


Import and  
display model  
results



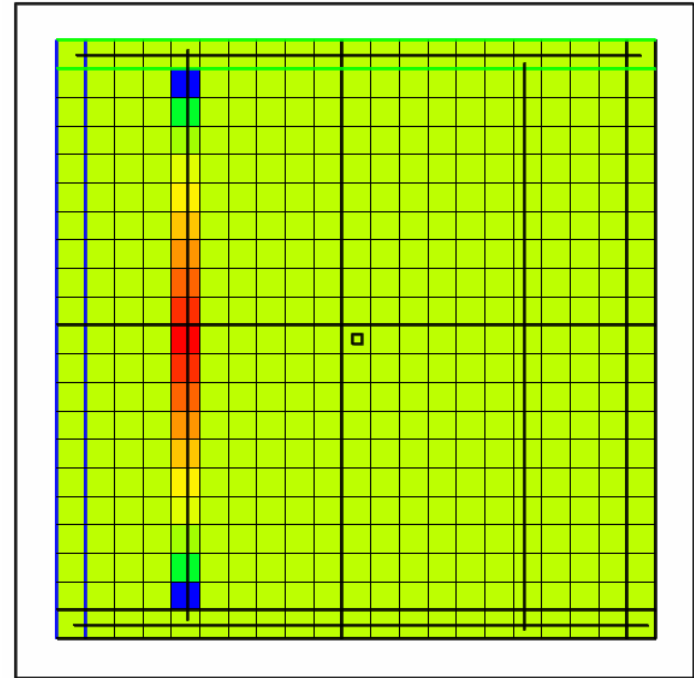
# Import flow data (2/2)

- ✓ In the **Select Model Results to Import** dialog box, scroll down to the bottom, and
- ✓ select **Constant Head, Drains, and River Leakage for Period: 2; Step: 100.**
- ✓ Also, choose to color the grid with the **River Leakage** flows.
- ✓ Then click **OK**.



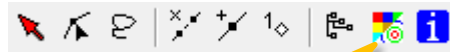
# Check fluxes from/to the river

- ✓ Check the values of the fluxes from/to the river using the status bar, or **Data | Show Grid or Mesh Values**.
- ✓ Is the river gaining water from, or losing water to the aquifer?

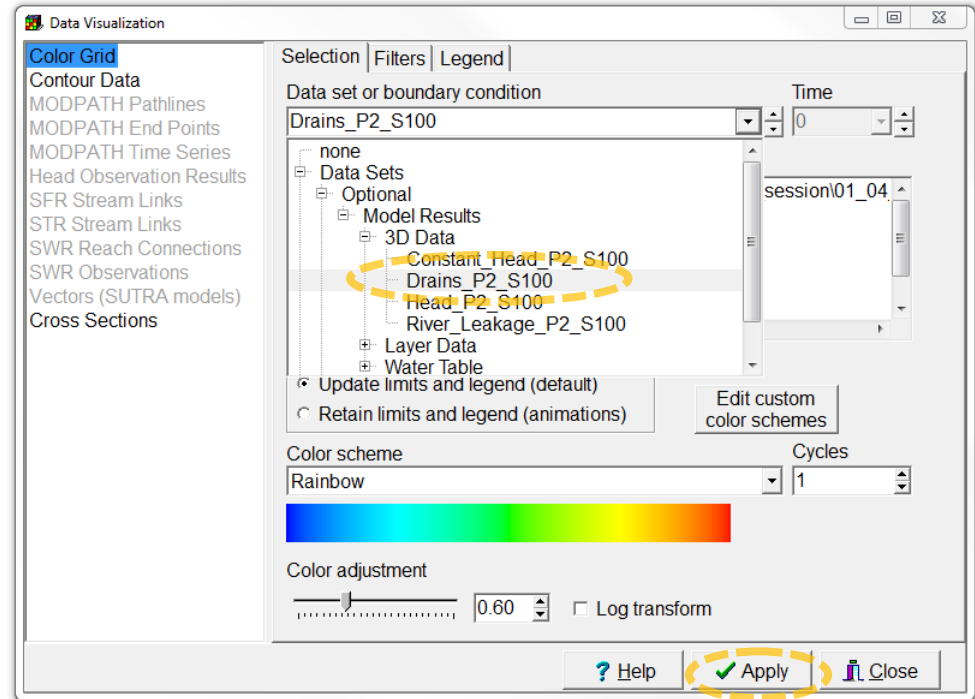


# Check fluxes to the drain (1/2)

- ✓ Now color the grid with the Drain flows, by selecting **Data | Data visualization**, or using the corresponding button,
- ✓ changing the data set to **Drains\_P2\_S100**,
- ✓ and pressing **Apply**.

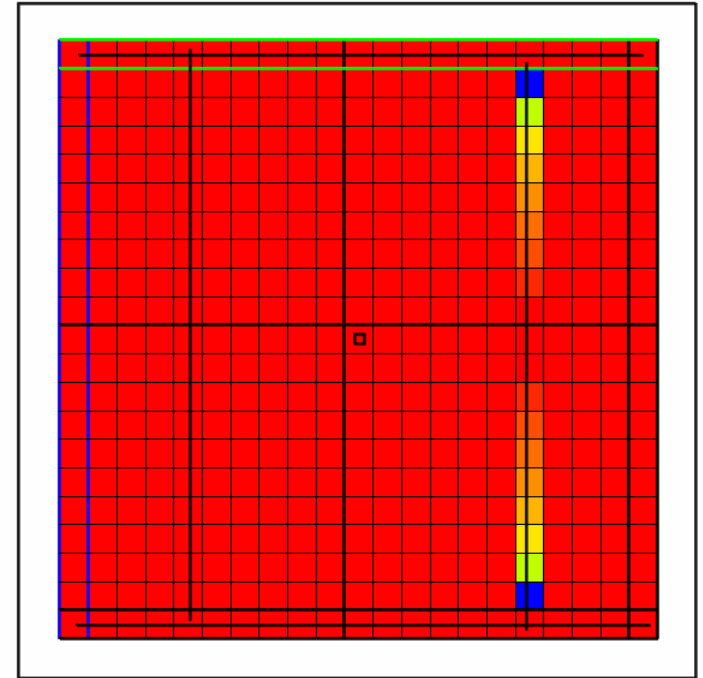


Data  
visualization



# Check fluxes to the drain (2/2)

- ✓ Check the values of the fluxes to the drain using the status bar, or **Data | Show Grid or Mesh Values.**
- ✓ Is the drain active over its entire length?

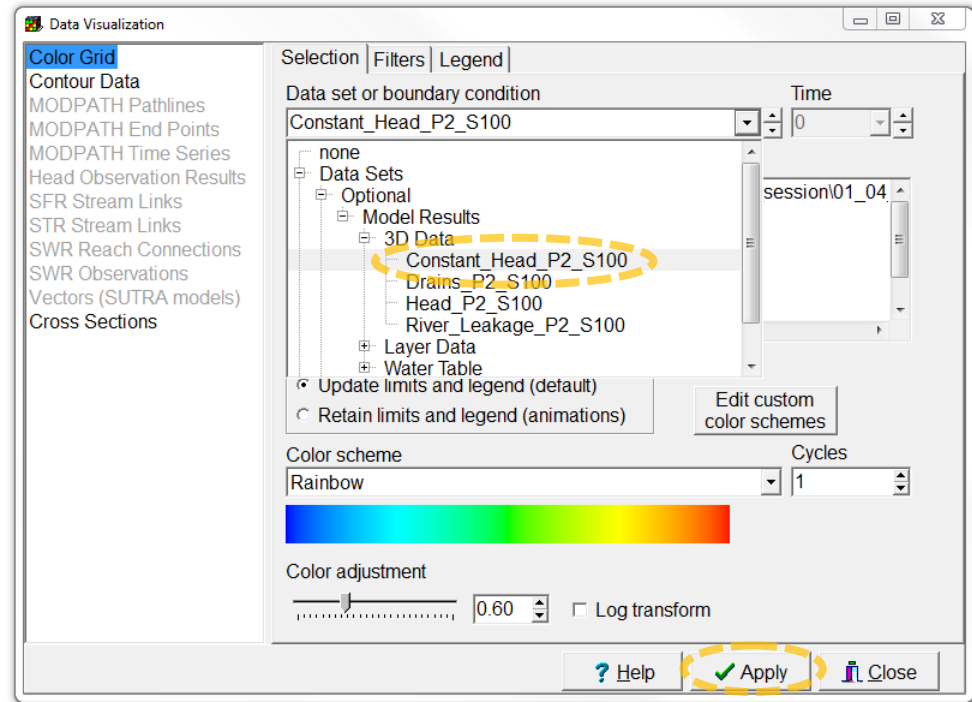


# Check fluxes from/to the constant head boundaries (1/2)

- ✓ Now color the grid with the Constant Head flows, by selecting **Data | Data visualization**, or using the corresponding button,
- ✓ changing the data set to **Constant\_Head\_P2\_S100**,
- ✓ and pressing **Apply**.

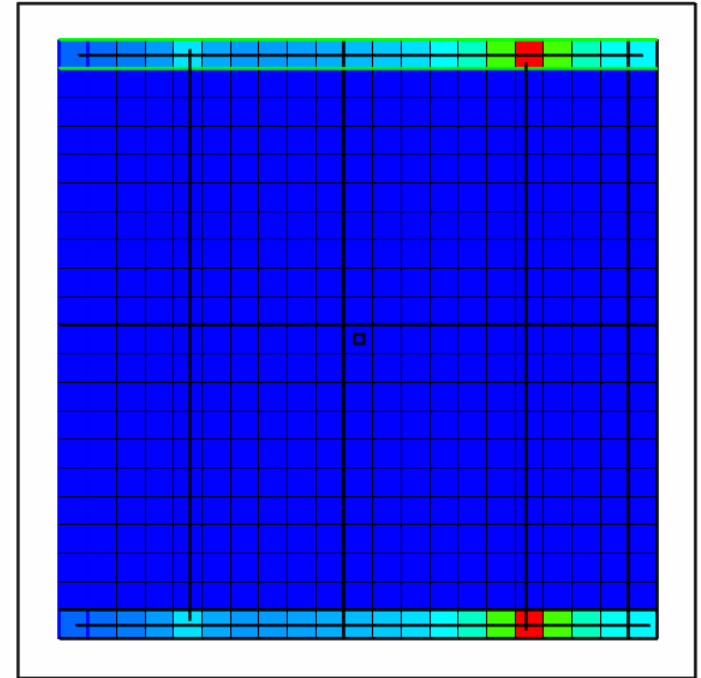


Data  
visualization



# Check fluxes from/to the constant head boundaries (2/2)

- ✓ Check the values of the fluxes to the Constant Head cells using the status bar, or **Data | Show Grid or Mesh Values**.
- ✓ Why are the largest values located at the drain?



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*Questions? Found an error?  
Please contact B. Rogiers at [brogiers@sckcen.be](mailto:brogiers@sckcen.be).*