

# Education evenings 2018

*Practical introduction  
to groundwater modelling*

Computer exercises  
03 01 RMA example model

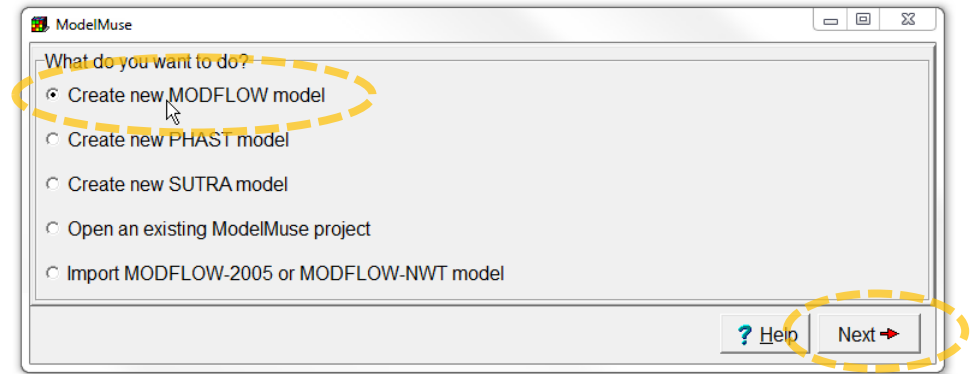
# Purpose

In this exercise, we will reconstruct the Rocky Mountain Arsenal model, which is one of the examples that come with ModelMuse. We will learn to

- ✓ import a map,
- ✓ import objects from a shapefile,
- ✓ generate the grid and
- ✓ use the CHD package.

# Create new model

- ✓ Start ModelMuse by double-clicking on its icon.
- ✓ Choose **Create new MODFLOW model** and click **Next**.
- ✓ Set the **Projection** to "NA" and click **Next**.



# Use a single layer

- ✓ Change the **Number of layers** to 1,
- ✓ set the **Layer group name** to “Aquifer”,
- ✓ and click the **No grid** button.

The screenshot shows the 'Initial Grid' dialog box with the following settings:

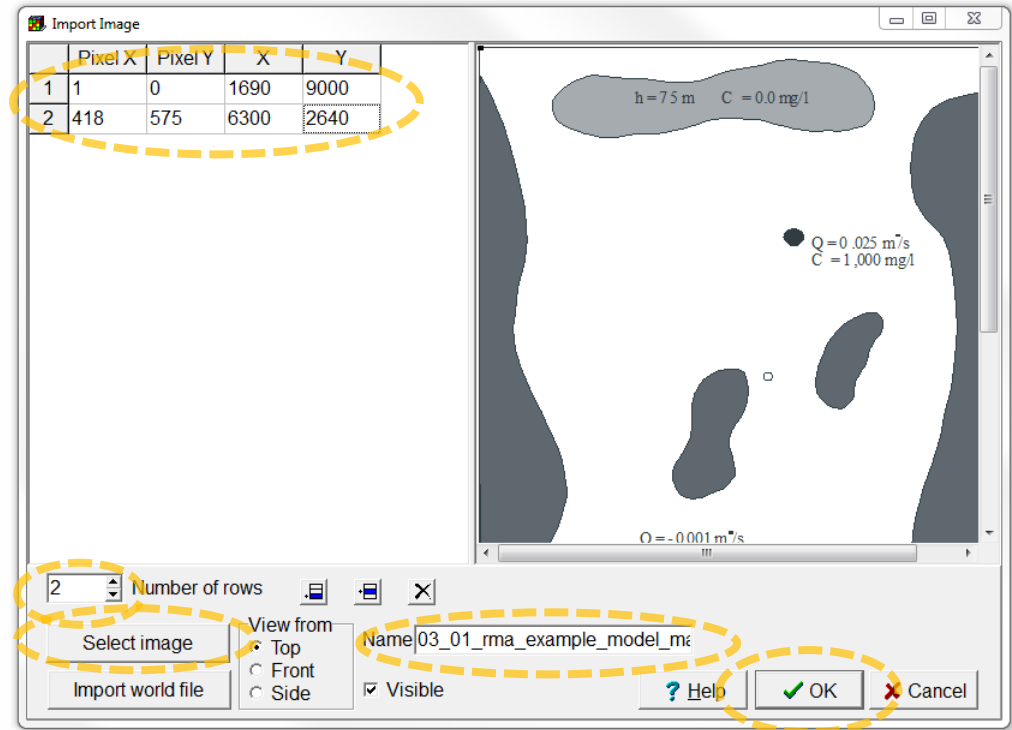
- Number of columns: 10
- Column width: 100
- Number of rows: 10
- Row width: 100
- Number of layers: 1 (circled in yellow)
- Grid origin: X=0, Y=0, Z=0
- Grid angle (degrees): 0
- Vertical exaggeration: (empty)
- Layer group name: Aquifer (circled in yellow)
- Bottom elevation: -10

At the bottom, the 'No grid' button (marked with a red X) is circled in yellow, along with the 'Help' and 'Finish' buttons.

Layer group name	Bottom elevation
Model Top	0
Aquifer	-10

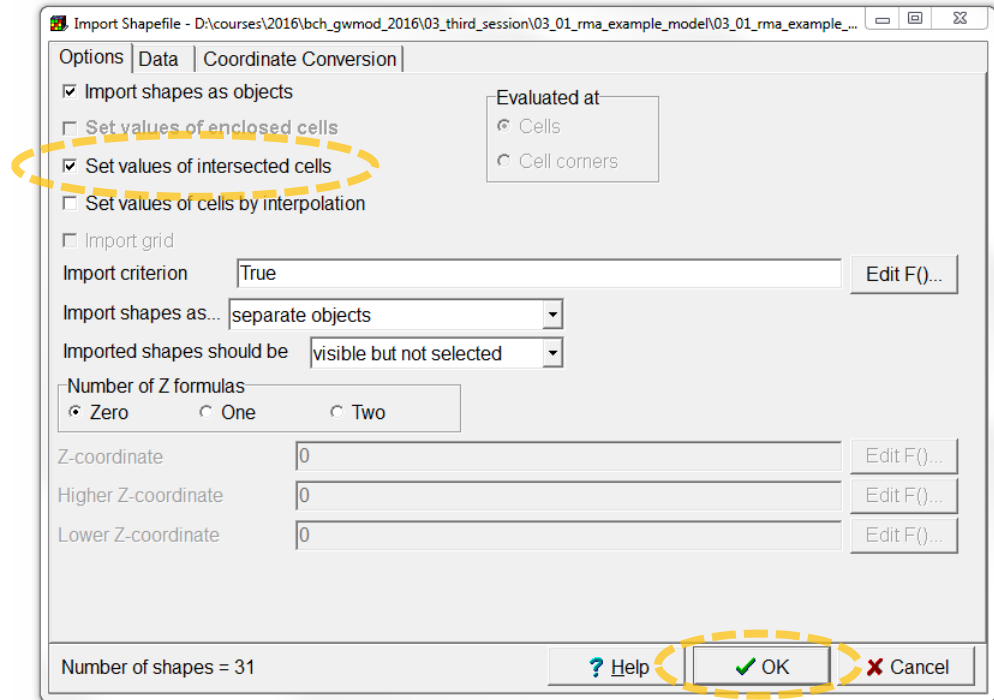
# Import image

- ✓ Select **File | Import | Image...**,
- ✓ and use the **Select image** button to choose “03-01\_rma-example-model-map.emf”.
- ✓ Then increase the **Number of rows** to 2, and
- ✓ fill in the table as shown on the right to correctly georeference the image.
- ✓ Click **OK**.



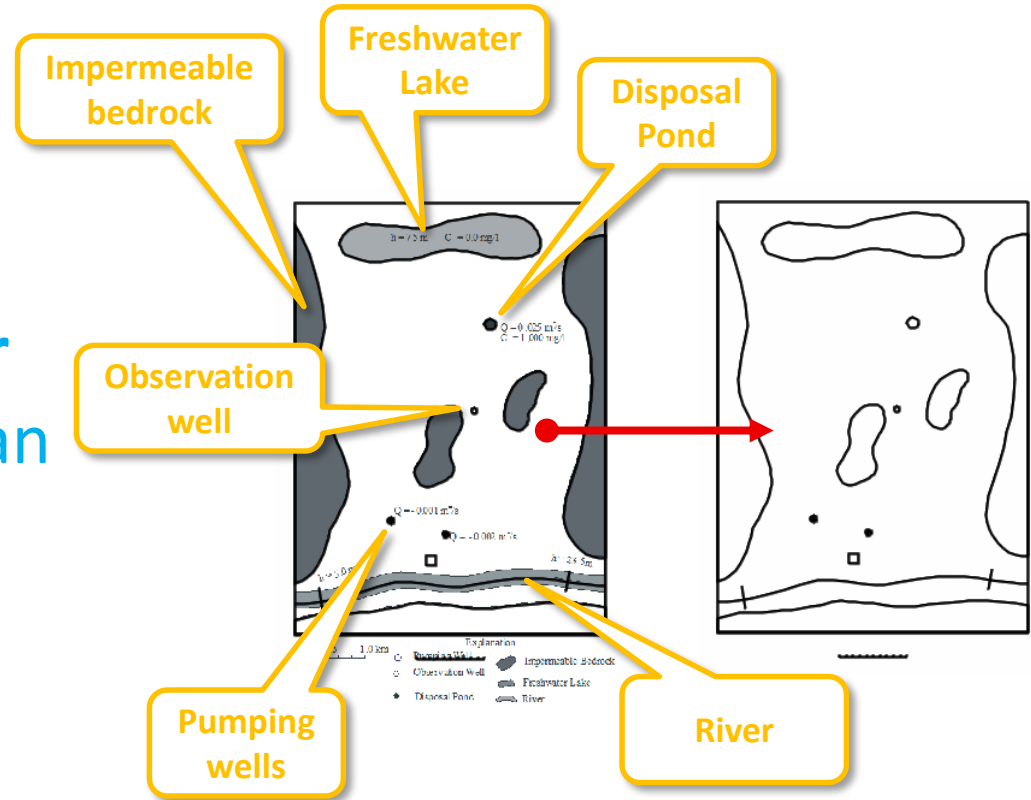
# Import objects (1/2)

- ✓ Select **File | Import | Shapefile...**,
- ✓ and choose “03-01\_rma-example-model-objects.SHP” in the **Open a Shapefile** dialog box.
- ✓ In the **Import Shapefile** dialog box, check the check box for **Set values of intersected cells**.
- ✓ We will only use the geometry of the shapes, so click **OK**.



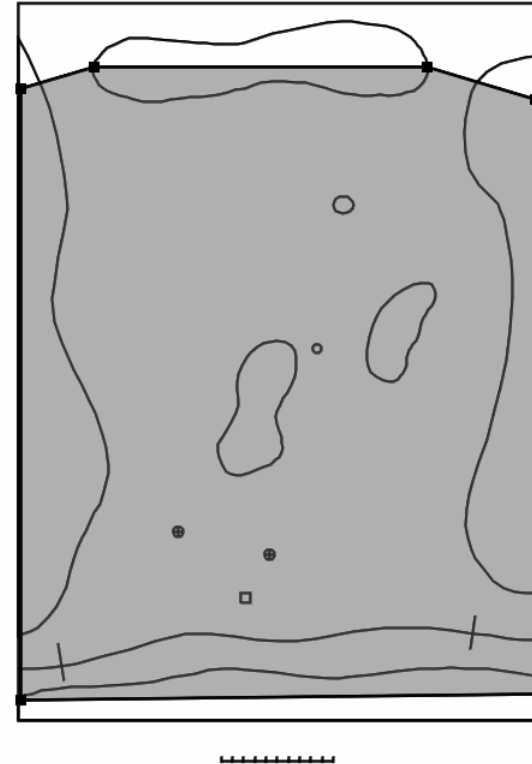
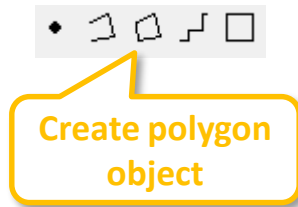
# Import objects (2/2)

- ✓ Take a moment to inspect the different items on the image.
- ✓ Select **Edit | Show or Hide Image**, so we can focus on the objects.



# Define model limits (1/2)

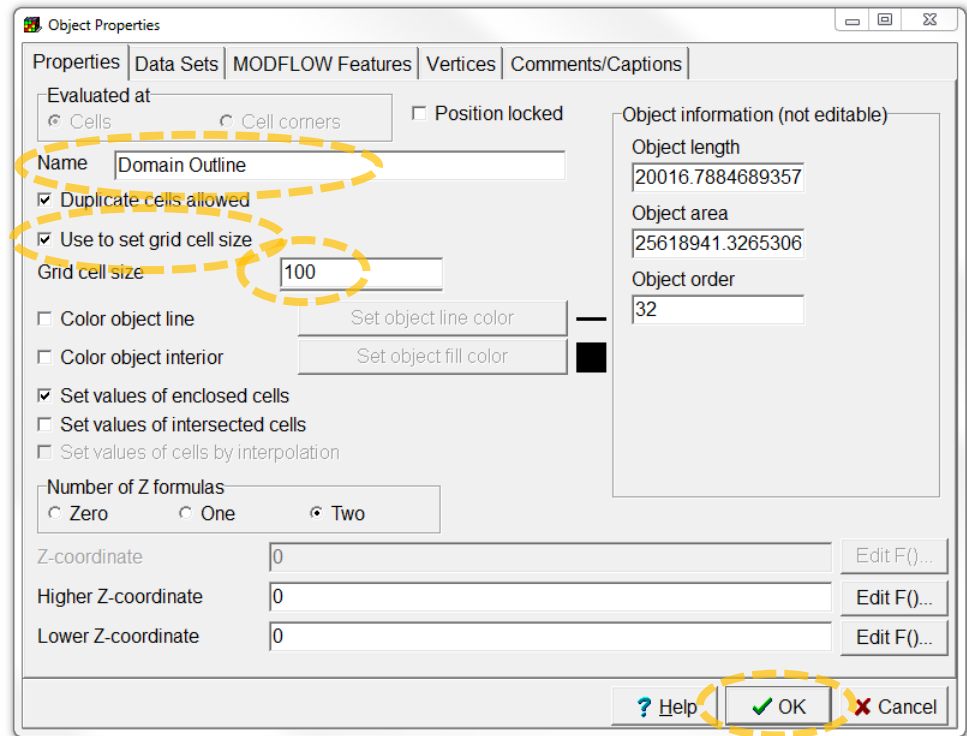
- ✓ Select **Object | Create | Polygon**, or use the corresponding button,
- ✓ and draw a polygon as shown on the right.
- ✓ Double click at the final point, to open the **Object Properties** dialog box.





# Define model limits (2/2)

- ✓ Change the object **Name** to “Domain Outline”,
- ✓ check the check box for **Use to set grid cell size**, and
- ✓ set the **Grid cell size** to 100.
- ✓ Then press **OK**.

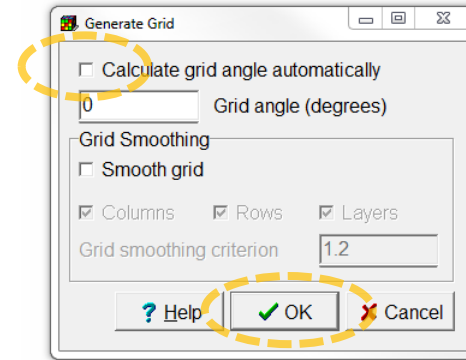


# Generate the grid

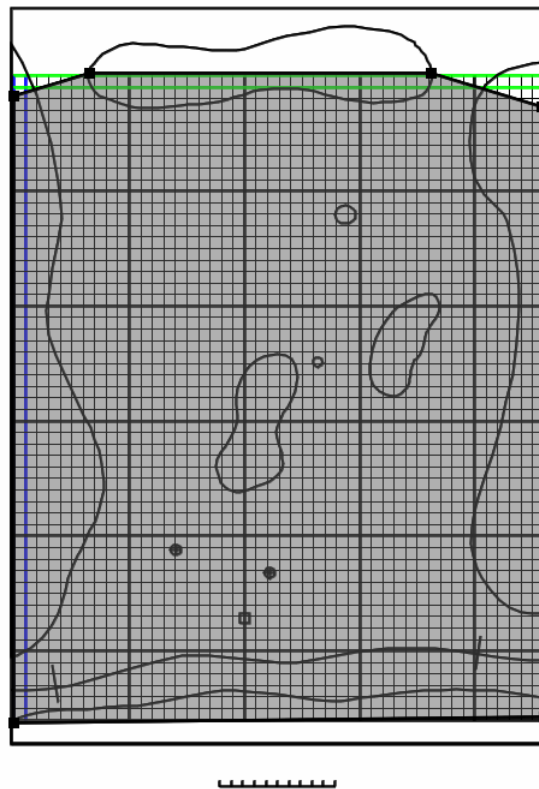
- ✓ Select **Grid | Generate Grid...** or use the corresponding button.
- ✓ Uncheck the **Calculate grid angle automatically** check box, and
- ✓ click **OK**.



Generate grid

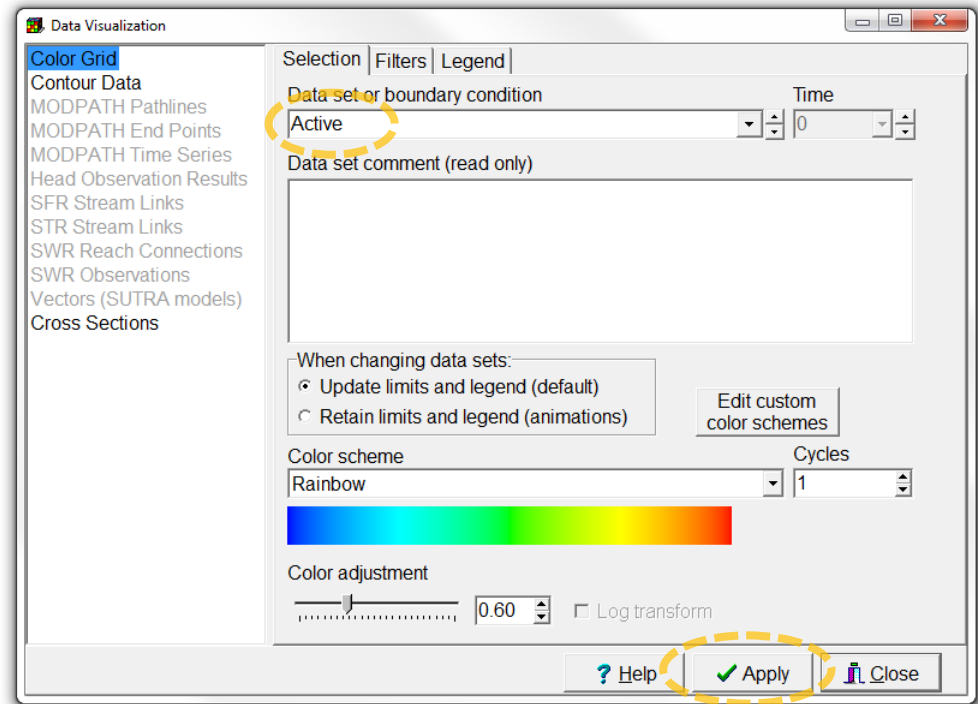


# This is what you should get



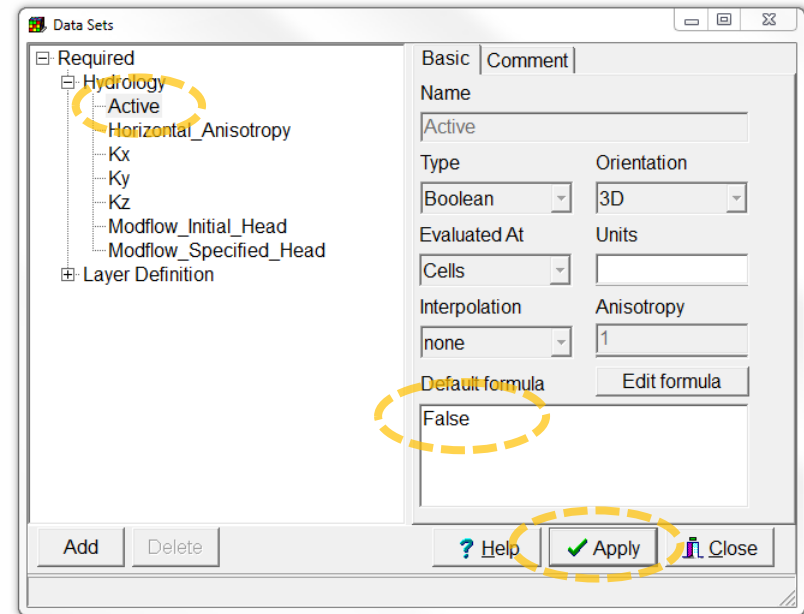
# Set active part of the grid (1/6)

- ✓ First visualize the **Active** data set by selecting **Data | Data Visualization...** or using the corresponding button,
- ✓ expanding **Data Sets | Required | Hydrology,**
- ✓ and selecting **Active**.
- ✓ Then press **Apply**.



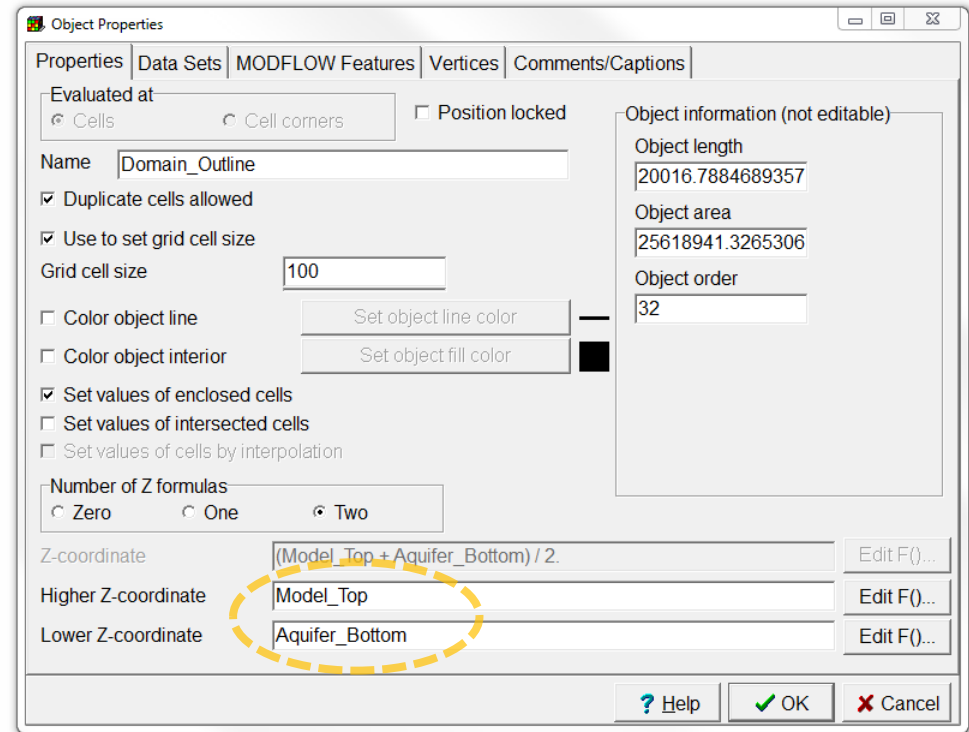
# Set active part of the grid (2/6)

- ✓ Select **Data | Edit Data Sets...**,
- ✓ and choose the **Active** data set.
- ✓ Change its **Default Formula** to “False”,
- ✓ and click **Apply**.



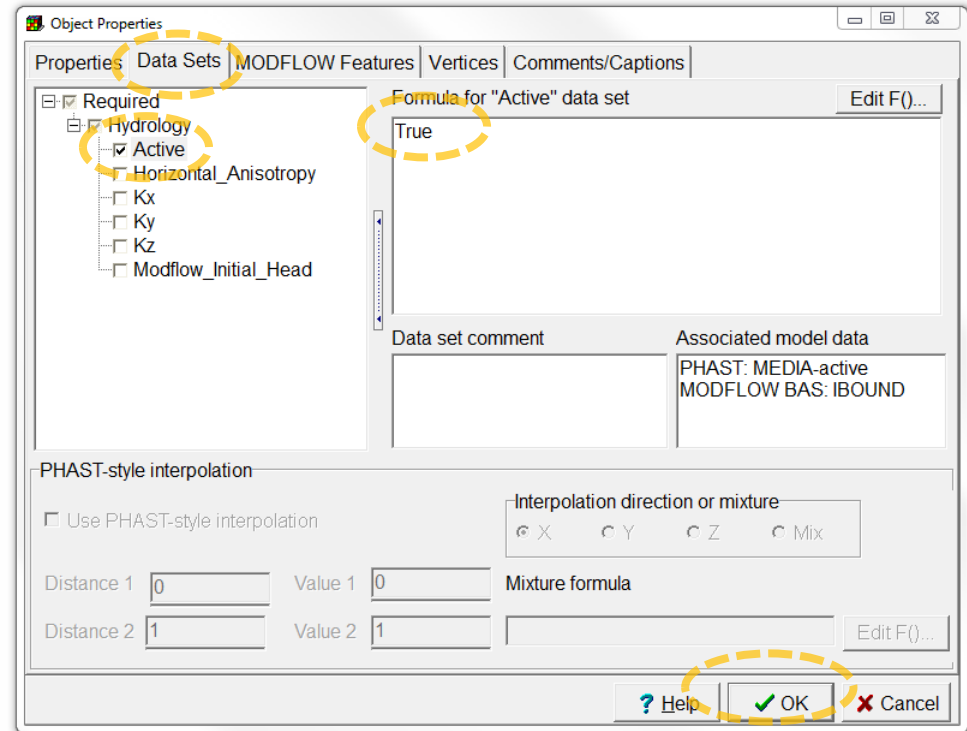
# Set active part of the grid (3/6)

- ✓ Select the object that was used to define the domain outline, and double-click to open the **Object Properties** dialog box.
- ✓ Change the **Higher Z-coordinate** and **Lower Z-coordinate** to “Model\_Top” and “Aquifer\_Bottom” respectively.



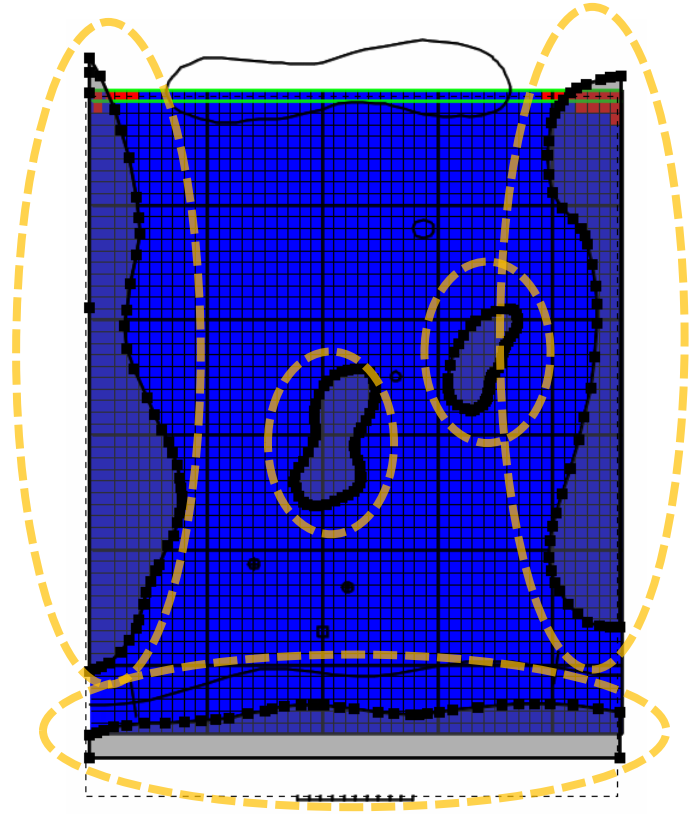
# Set active part of the grid (4/6)

- ✓ Switch to the **Data Sets** tab,
- ✓ expand **Required | Hydrology**,
- ✓ and select **Active**.
- ✓ Change the formula to “True”.
- ✓ Then press **OK**.



# Set active part of the grid (5/6)

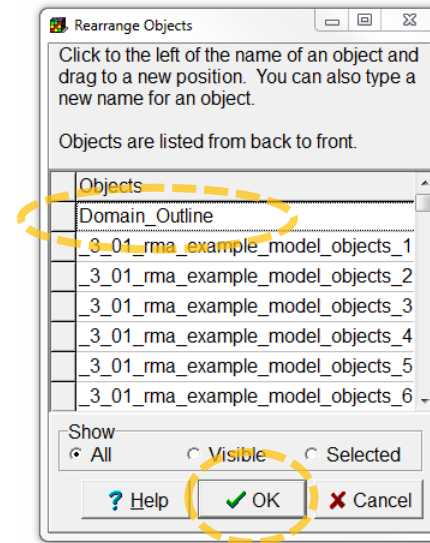
- ✓ Now repeat the procedure in the last two slides for the objects that are selected in the figure on the right, but set the **Active** data set to “False”.



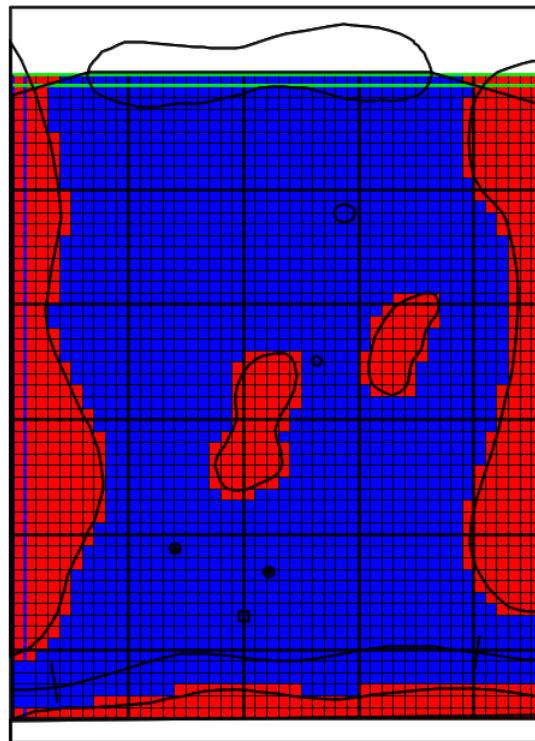


# Set active part of the grid (6/6)

- ✓ Finally, select **Object | Edit | Rearrange Objects...**, and
- ✓ move the **Domain\_Outline** object located at the bottom of the list to the top of the list.
- ✓ Then press **OK**.



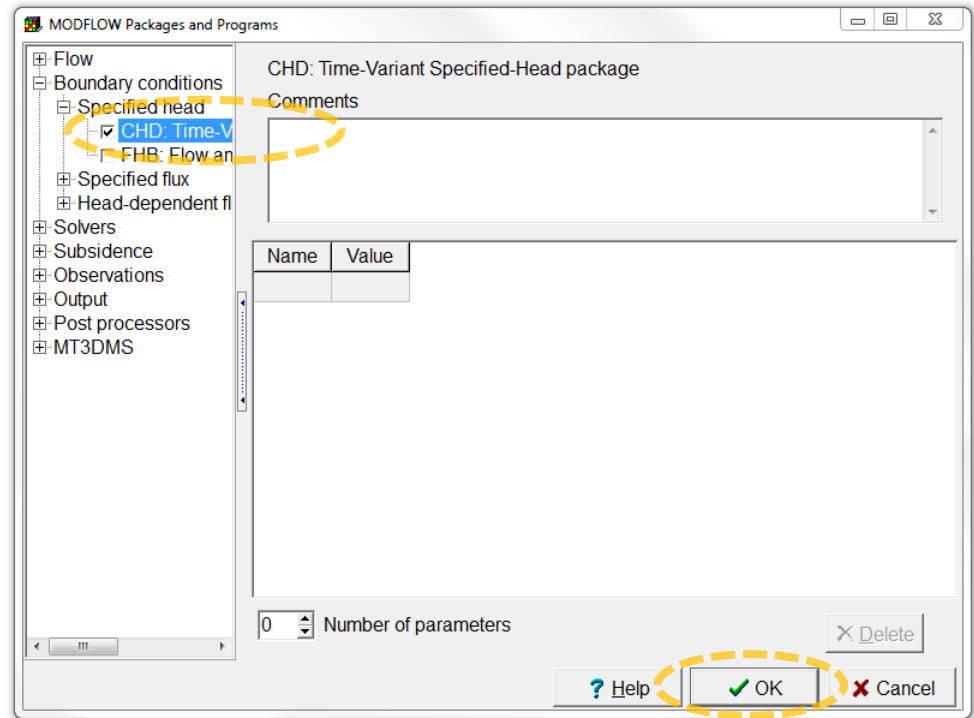
# This is what you should get



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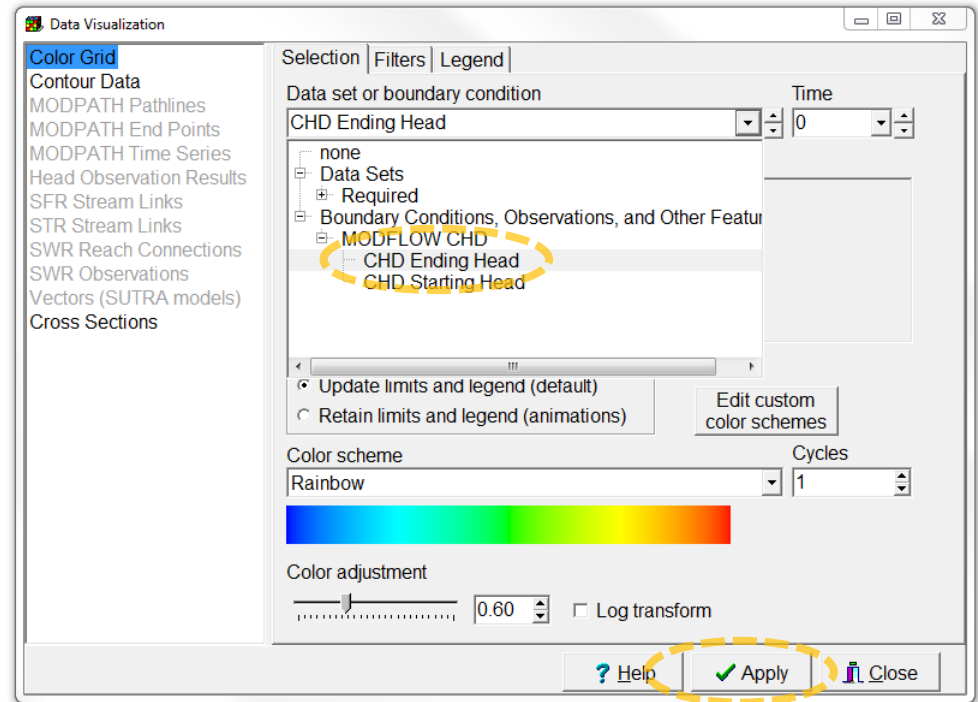
# Enable the CHD package

- ✓ Select **Model | MODFLOW Packages and Programs...**,
- ✓ expand **Boundary conditions | Specified head**,
- ✓ and select the **CHD** package.
- ✓ Then click **OK**.



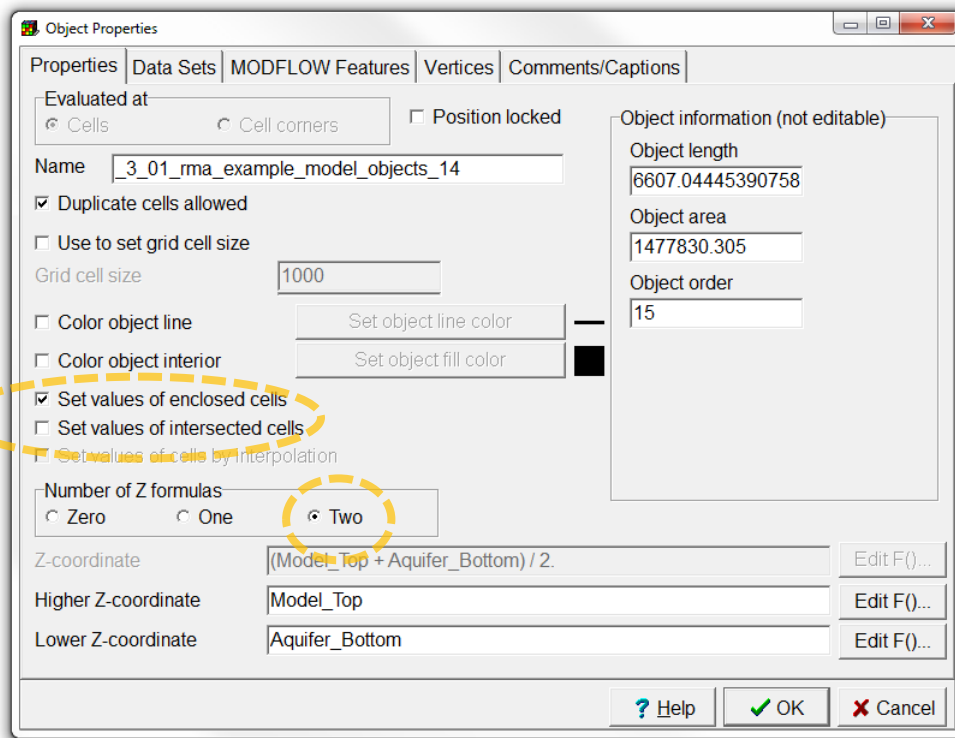
# Add specified head boundaries (1/6)

- ✓ We will model the lake and river as a specified head boundary.
- ✓ First select **Data | Data Visualization...** and select the **CHD Ending Head**.
- ✓ Then press **Apply**.
- ✓ You can ignore the warnings.



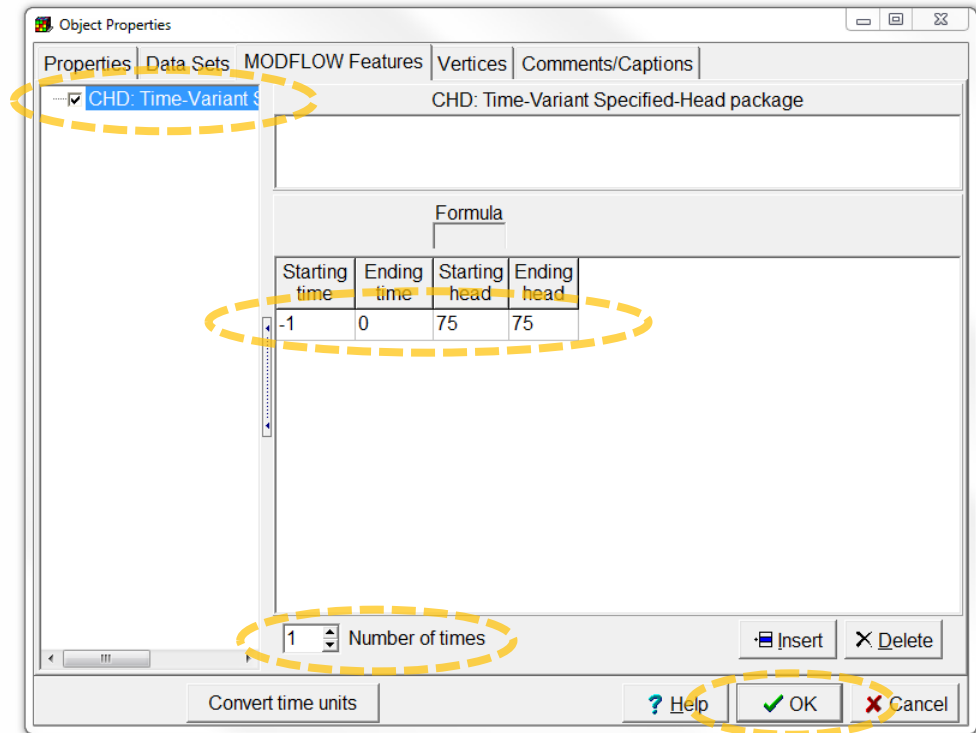
# Add specified head boundaries (2/6)

- ✓ Double-click the object that represents the lake.
- ✓ In the **Object Properties** dialog box, check **Set values of enclosed cells** and uncheck **Set values of intersected cells**.
- ✓ Change the **Number of Z formulas** to **Two**.



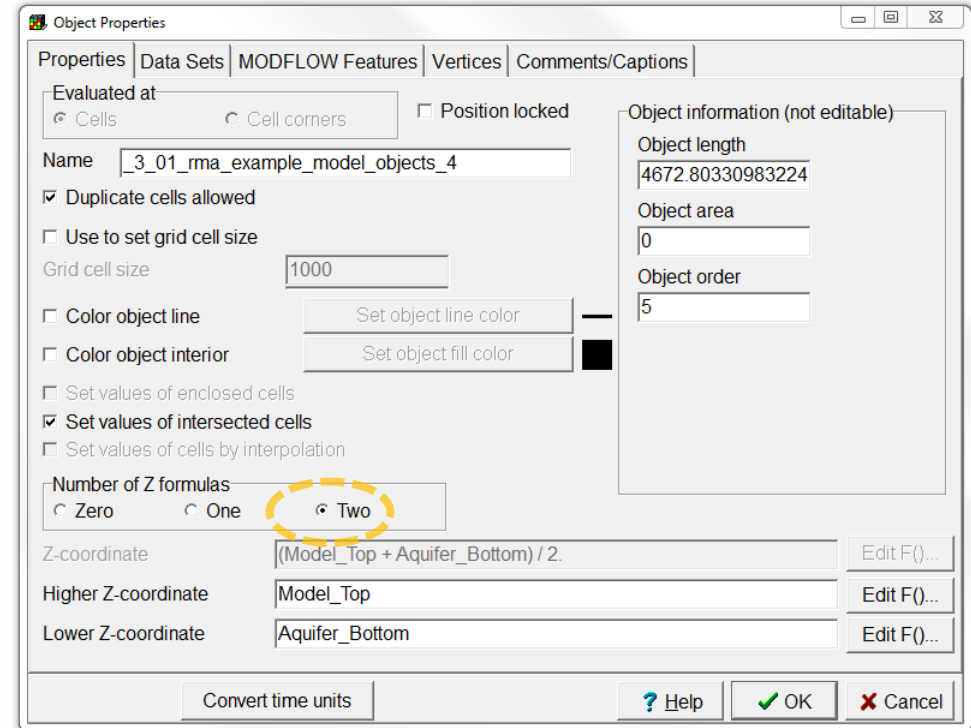
# Add specified head boundaries (3/6)

- ✓ Switch to the **MODFLOW** **Features** tab,
- ✓ select the **CHD** package,
- ✓ change the **Number of times** to 1,
- ✓ and set **Starting time**, **Ending time**, **Starting head**, and **Ending head** to -1, 0, 75 and 75.
- ✓ Then click **OK**.



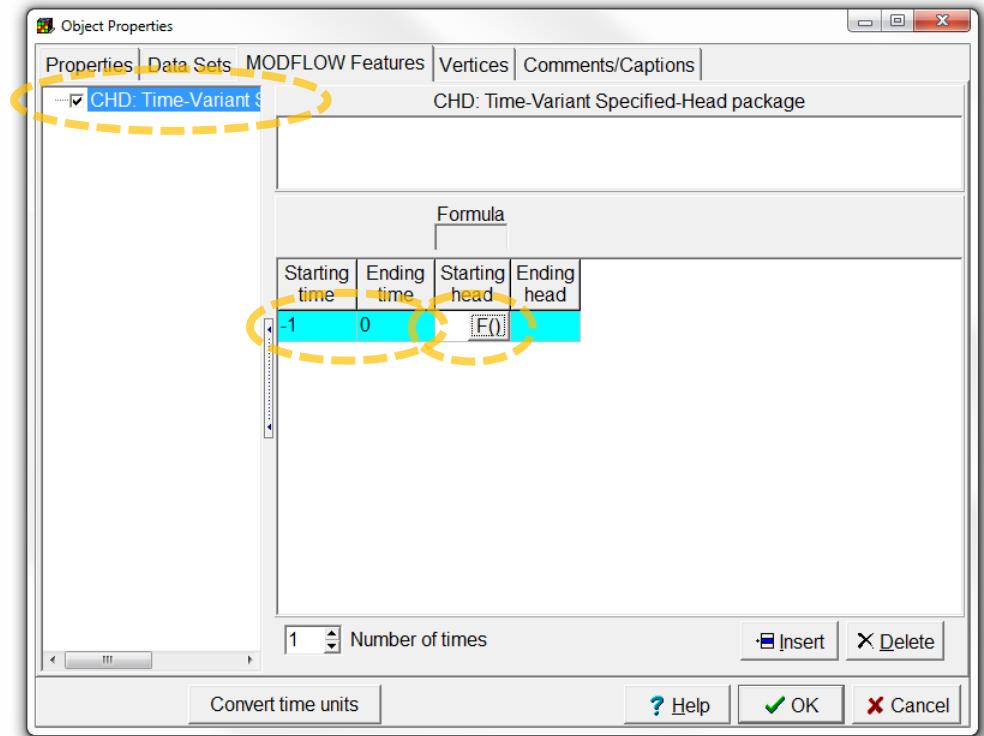
# Add specified head boundaries (4/6)

- ✓ Now double-click on the object that represents the river, to open the **Object Properties** dialog box.
- ✓ Change the **Number of Z formulas** to **Two**.



# Add specified head boundaries (5/6)

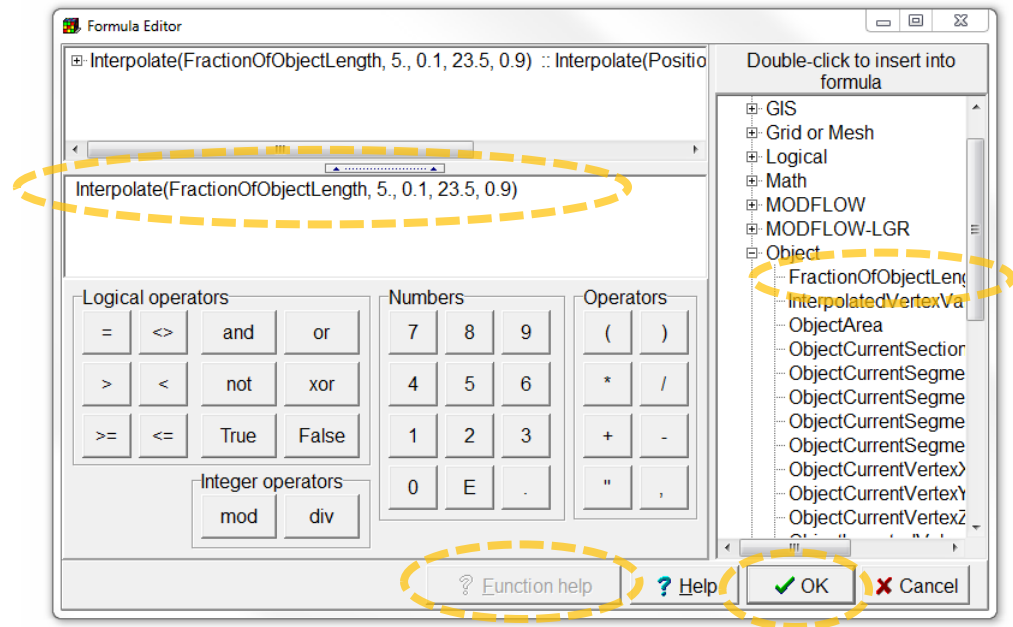
- ✓ Switch to the **MODFLOW** features tab,
- ✓ select the **CHD** package,
- ✓ set the **Starting time** and **Ending time** to -1 and 0,
- ✓ and click the button in the **Starting head** cell to open the **Formula Editor**.



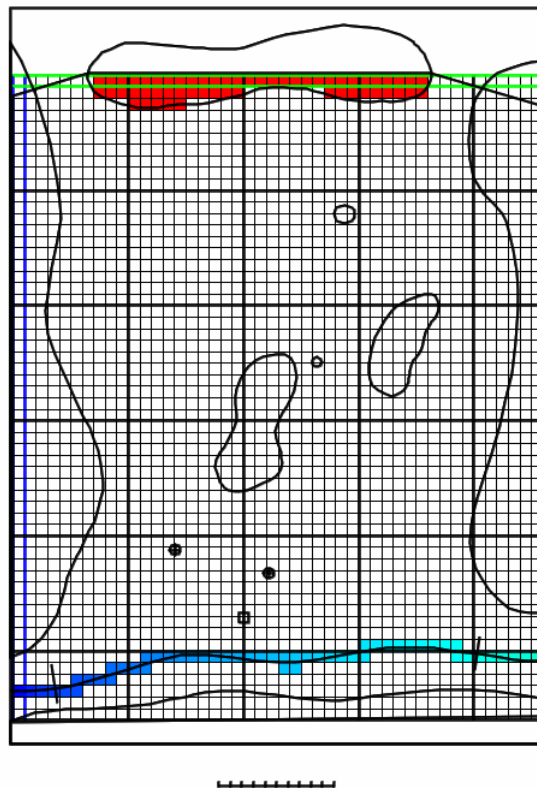


# Add specified head boundaries (6/6)

- ✓ The head in the stream varies from 5 near the cross mark near the left end of the stream to 23.5 near the cross mark at the right end of the stream. The cross marks are at 10% and 90% of the length of the object representing the stream. Enter the formula  
"Interpolate(FractionOfObjectLength, 5, 0.1, 23.5, 0.9)"
- ✓ Check the **Interpolate** and **FractionOfObjectLength** **help** to see what these functions do, and click **OK**.
- ✓ Copy the Starting head formula to the **Ending head** cell, and press **OK**.

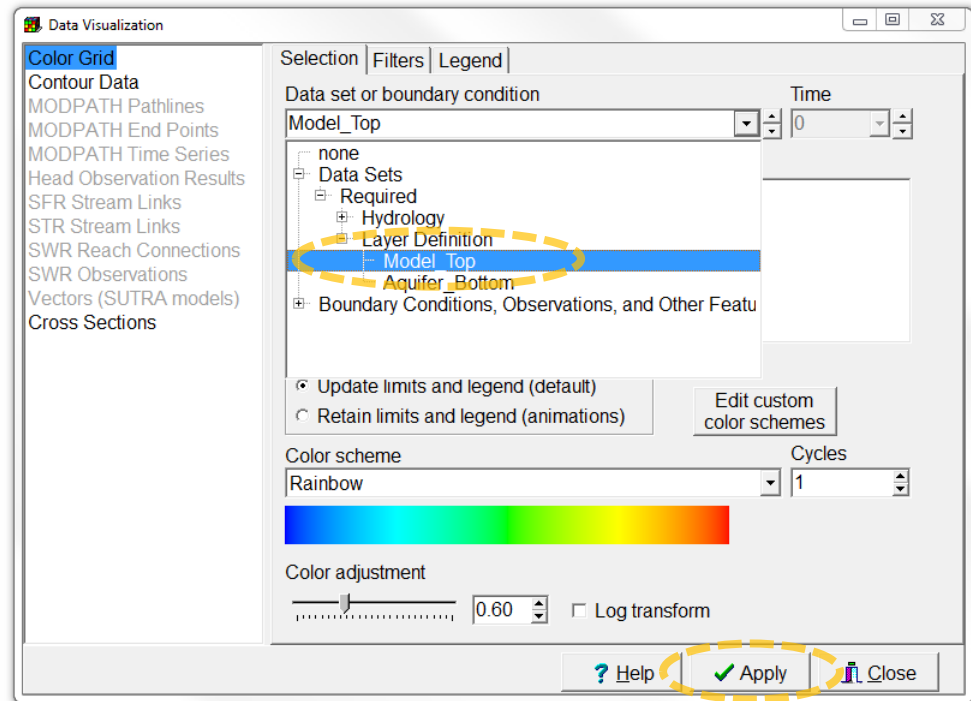


# This is what you should get



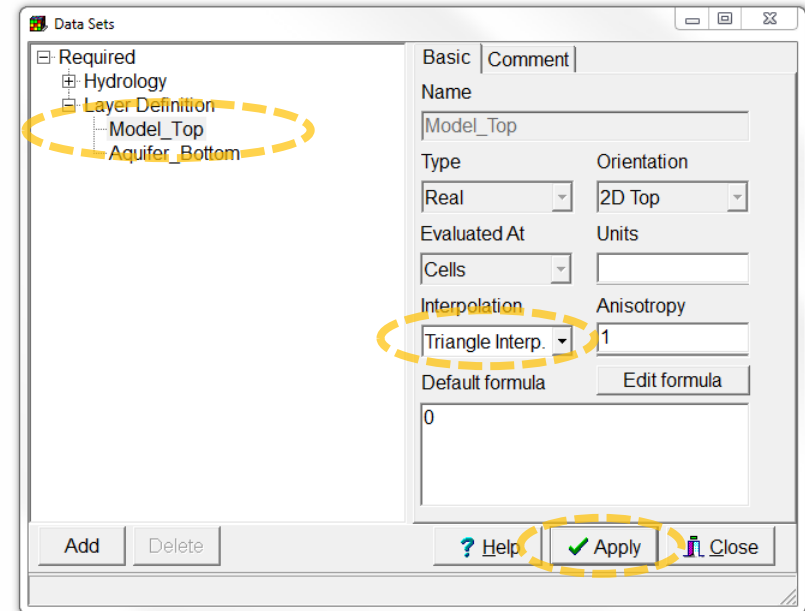
# Define aquifer geometry (1/9)

- ✓ The elevation of the top of the aquifer slopes gradually from approximately 71 at the north end of the model to 1 m above the stream at the south end of the model.
- ✓ First select **Data | Data Visualization...** and select the **Model\_Top**.
- ✓ Then press **Apply**.



# Define aquifer geometry (2/9)

- ✓ Select **Data | Edit Data Sets...**,
- ✓ select **Model\_Top**,
- ✓ for interpolation, select **Triangle Interp.**, and
- ✓ press **Apply**.

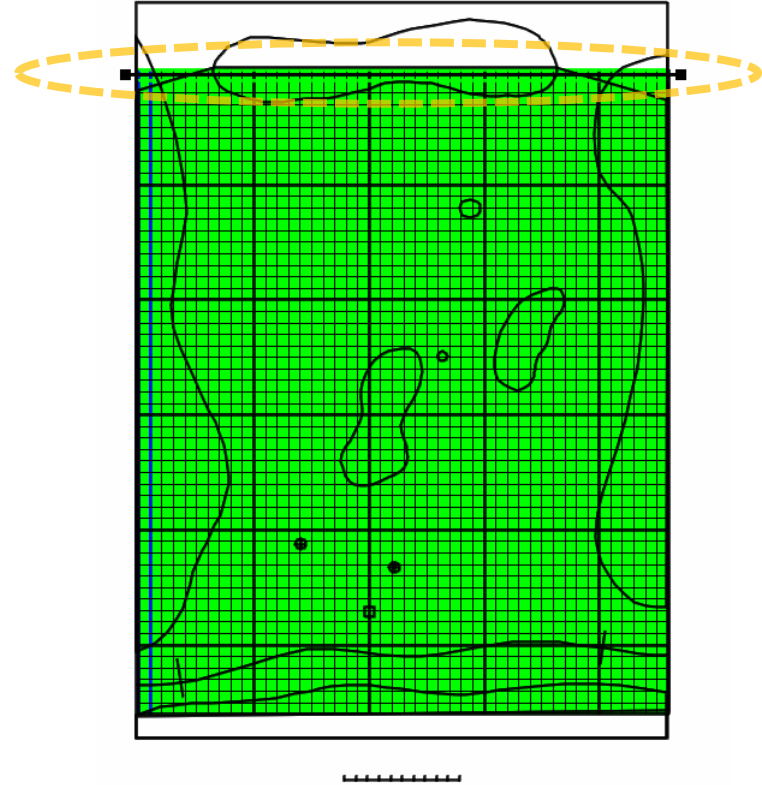


# Define aquifer geometry (3/9)

- ✓ Select **Object | Create | Straight Line**, or use the corresponding button, and
- ✓ draw a straight east-west line at the north end of the model.

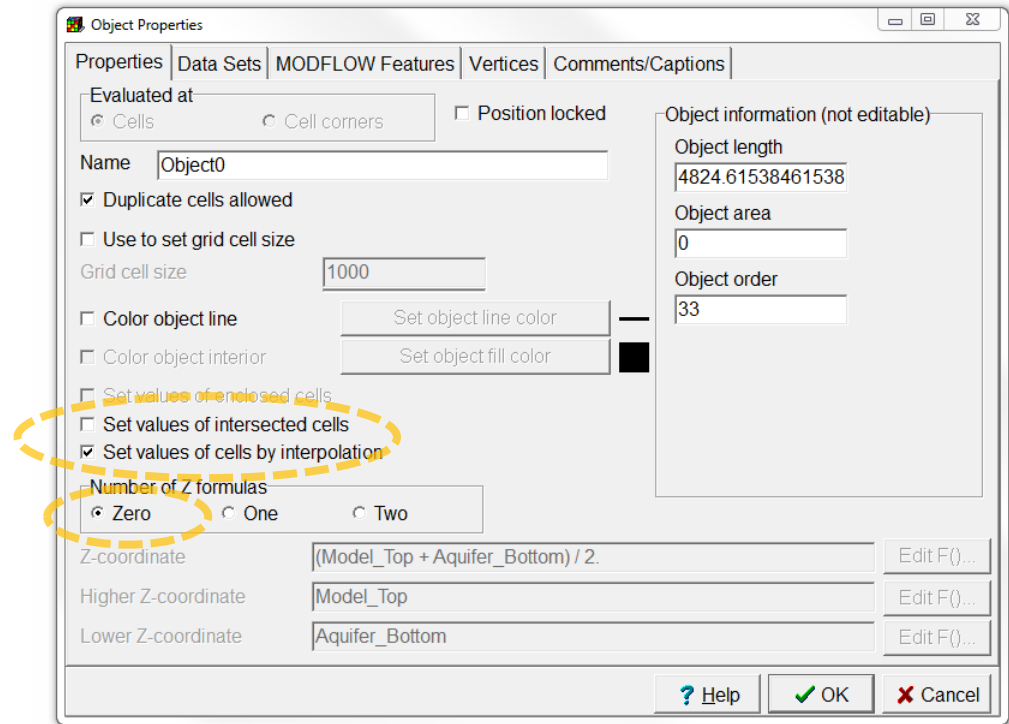


Create  
straight-line  
object



# Define aquifer geometry (4/9)

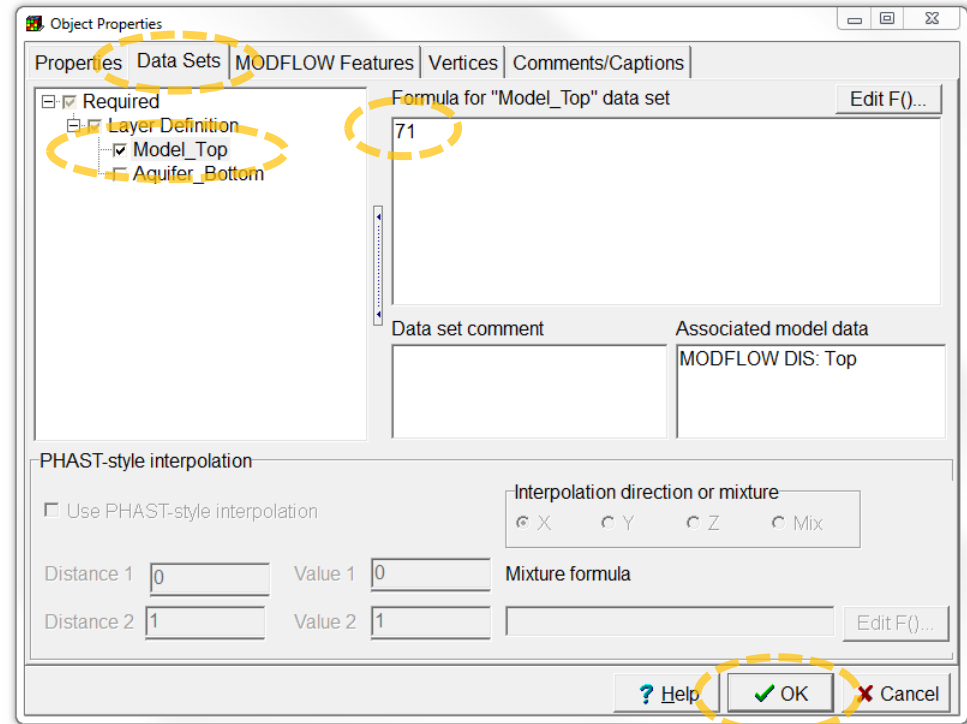
- ✓ In the **Object Properties** dialog box, change the **Number of Z formulas** to **Zero**,
- ✓ uncheck **Set values of intersected cells**, and
- ✓ check **Set values of cells by interpolation**.



# Define aquifer geometry (5/9)

- ✓ Switch to the **Data Sets** tab,
- ✓ select **Model\_Top**, and
- ✓ change its formula to 71.
- ✓ Then click **OK**.

Because there are only two points in this object, nothing will change yet. At least 3 non-collinear points must be present for **Triangle Interp.** to be used.

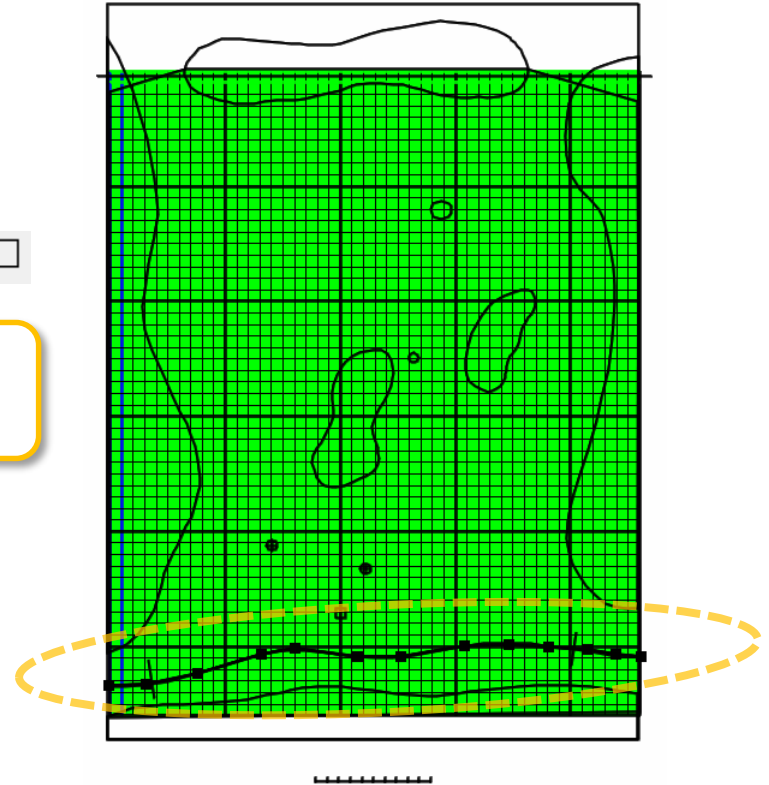


# Define aquifer geometry (6/9)

- ✓ Select **Object | Create | Polyline**, or use the corresponding button, and
- ✓ draw a polyline at the location of the stream.
- ✓ The previous stream object can not be used for this because it must have two Z formulas and this one will need to have zero Z formulas.



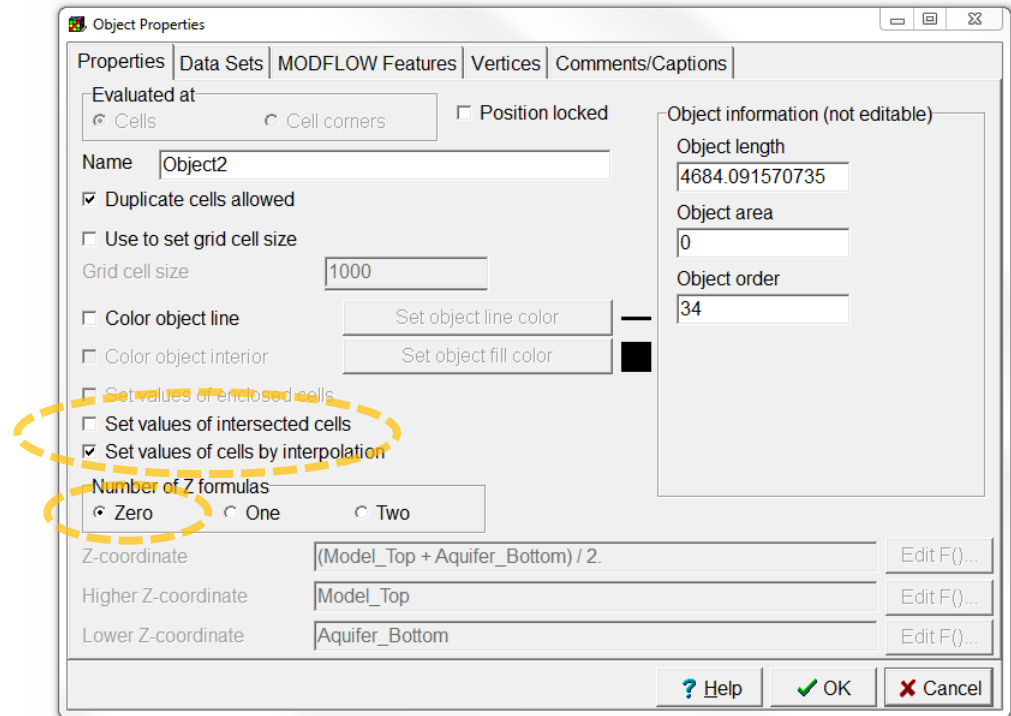
Create  
polyline  
object





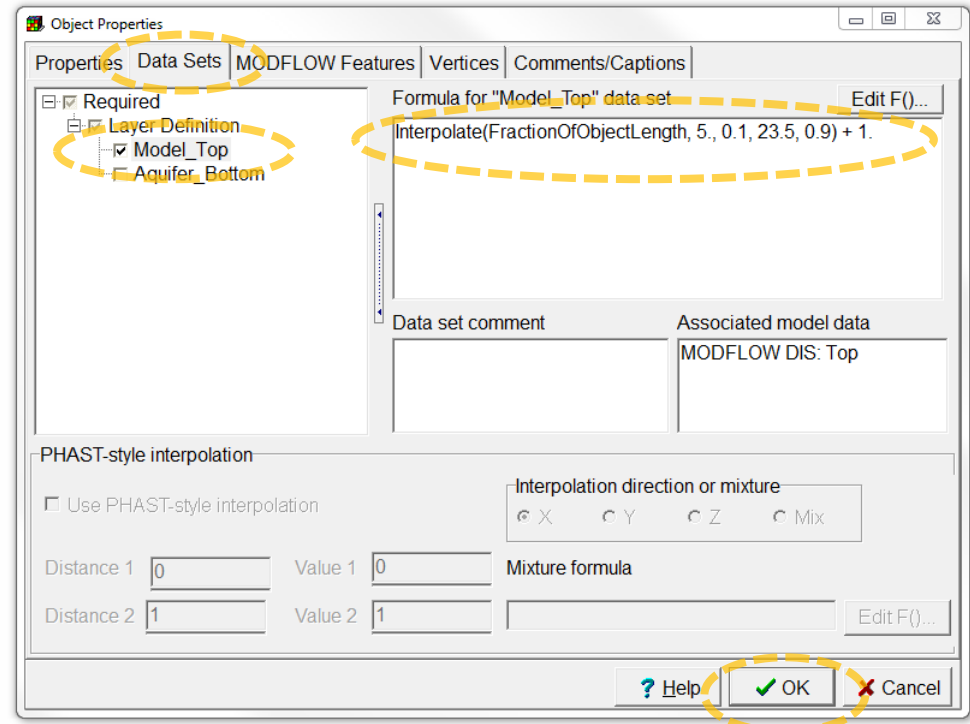
# Define aquifer geometry (7/9)

- ✓ In the **Object Properties** dialog box, change the **Number of Z formulas** to **Zero**,
- ✓ uncheck **Set values of intersected cells**, and
- ✓ check **Set values of cells by interpolation**.



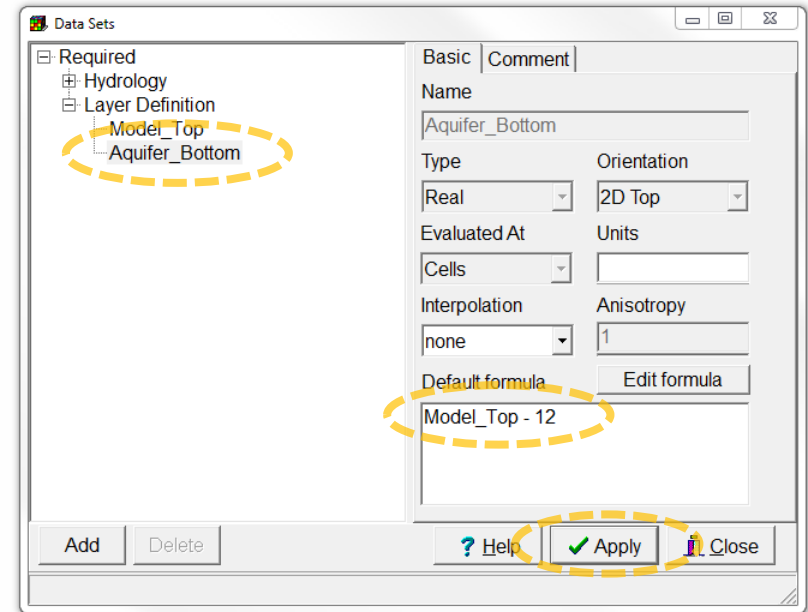
# Define aquifer geometry (8/9)

- ✓ Switch to the **Data Sets** tab,
- ✓ select **Model\_Top**, and
- ✓ change its formula to “Interpolate(FractionOfObject Length, 5., 0.1, 23.5, 0.9) + 1”.
- ✓ Then click **OK**.

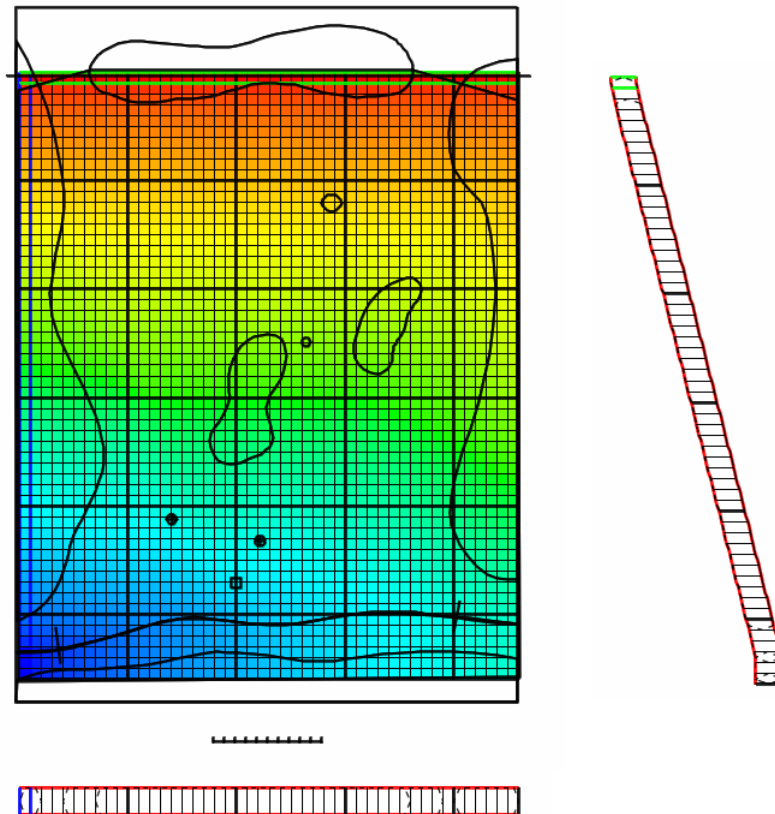


# Define aquifer geometry (9/9)

- ✓ Finally, change the aquifer bottom elevation by selecting **Data | Edit Data Sets...**,
- ✓ selecting **Aquifer\_Bottom**, and changing the **Default Formula** to “Model\_Top - 12”.
- ✓ Then click **Apply**.

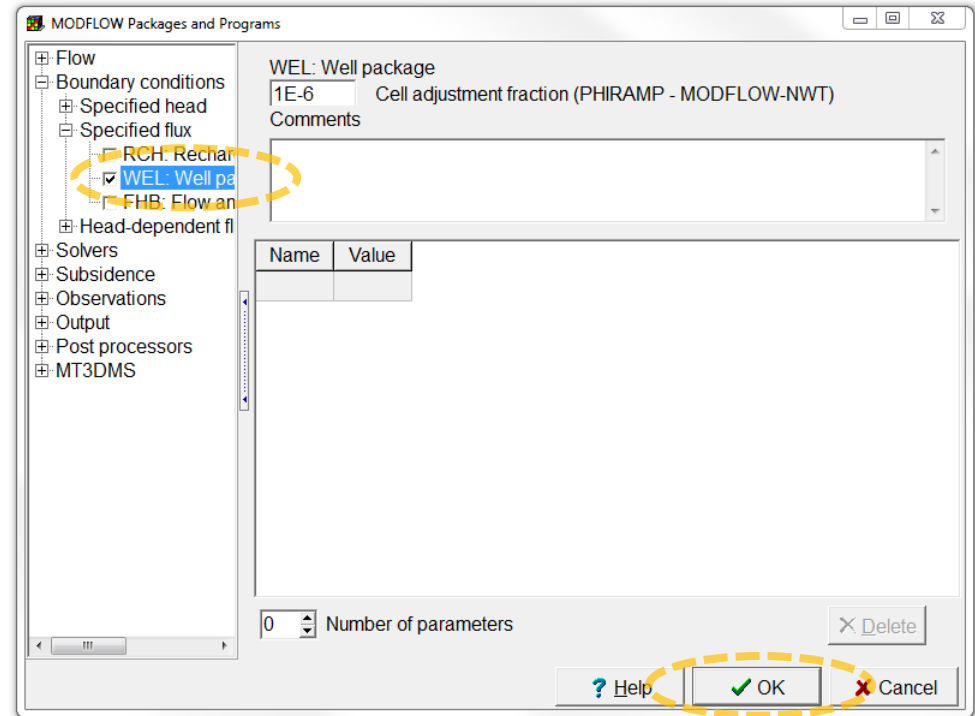


# This is what you should get



# Add wells (1/5)

- ✓ Select **Model | MODFLOW Packages and Programs...**,
- ✓ expand **Boundary conditions | Specified flux**, and
- ✓ check the **Well Package**.
- ✓ Then click **OK**.



# Add wells (2/5)

- ✓ Double click on the object that represents the disposal pond to open the **Object Properties** dialog box.
- ✓ Change the **Number of Z formulas** to **One** and make sure the formula is “ $(\text{Model\_Top} + \text{Aquifer\_Bottom}) / 2$ ”.

Object Properties

Properties | Data Sets | MODFLOW Features | Vertices | Comments/Captions

Evaluated at  
☒ Cells ☐ Cell corners ☐ Position locked

Name

☒ Duplicate cells allowed

☐ Use to set grid cell size

Grid cell size

☐ Color object line

☐ Color object interior

☐ Set values of enclosed cells

☒ Set values of intersected cells

☐ Set values of cells by interpolation

Number of Z formulas  
☐ Zero ☒ One ☐ Two

Z-coordinate

Higher Z-coordinate

Lower Z-coordinate

Object information (not editable)

Object length

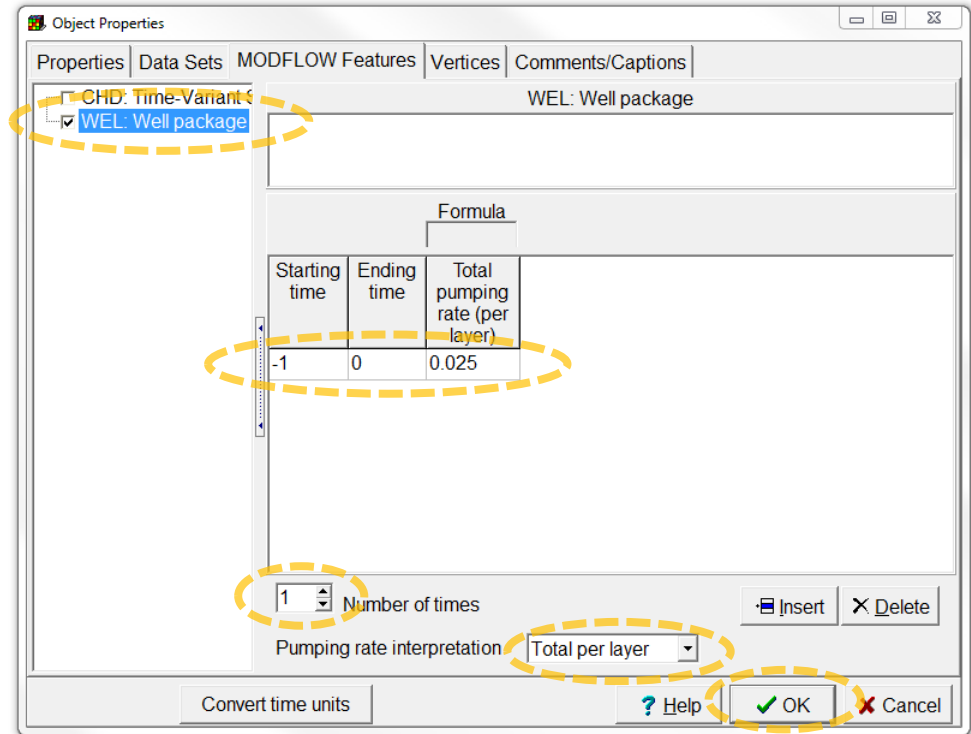
Object area

Object order

? Help

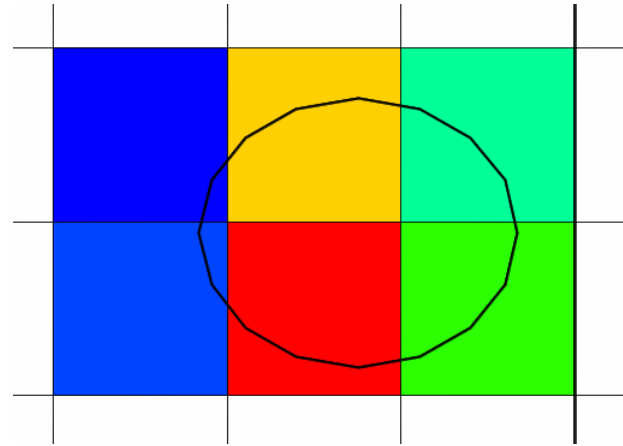
# Add wells (3/5)

- ✓ Switch to the **MODFLOW Features** tab,
- ✓ check the **WEL** package,
- ✓ change the **Number of times** to 1,
- ✓ the **Pumping rate interpretation** to **Total per layer**,
- ✓ and set **Starting time**, **Ending time** and **Total pumping rate** to -1, 0, and 0.025.
- ✓ Then click **OK**.



# Add wells (4/5)

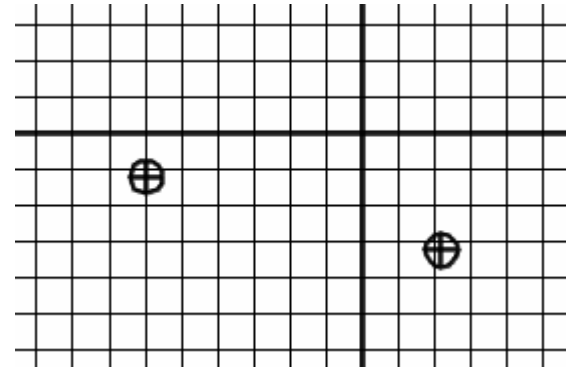
- ✓ Now colour the grid with the **Well pumping rate**,
- ✓ and check if the total is 0.025.





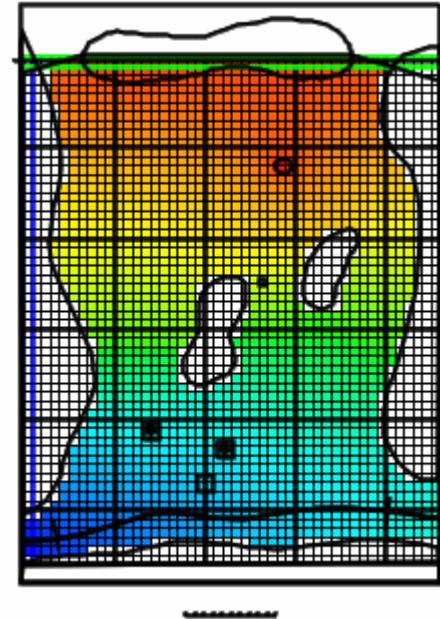
# Add wells (5/5)

- ✓ To add the two pumping wells, create point objects at the center of the well symbols,
- ✓ check the **WEL** package,
- ✓ set the **Number of times** to 1,
- ✓ the **Pumping rate interpretation** to **Direct**,
- ✓ the **Starting** and **Ending time** to -1 and 0,
- ✓ and finally the **Pumping rate** to -0.001 and -0.002 for the western and eastern well respectively.



# Run the model

- ✓ Now save the model as “03-01\_rma-example-model.mmZLib” in folder “03-01\_rma-example-model”,
- ✓ run MODFLOW, and
- ✓ import the head results.
- ✓ You should get something similar to the figure on the right.



# Education evenings 2018

*Practical introduction  
to groundwater modelling*

Computer exercises  
03 01 RMA example model

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