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Numerical flow and transport modeling using the INOWAS platform

Tutorial 2: Transient groundwater flow model and scenario analysis

Introduction

This tutorial gives an overview of the “Numerical groundwater modelling and optimization” tool of the INOWAS platform and guides users to create a simple **transient groundwater flow model**. Furthermore, a **scenario analysis** presenting tool “MODFLOW model scenario manager” will be conducted. More information about the tools can be found on the respective documentation pages:

https://inowas.com/tools/t03-modflow-model-setup-and-editor/

https://inowas.com/tools/t07-application-specific-scenarios-analyzer/

A prerequisite to start Tutorial 2 is that you have finished Tutorial 1 on the INOWAS platform. The tutorial takes about 45 min to complete.

Background

This spatial discretization is the same as for Tutorial 1. However, the model has 3 stress periods (one steady state and two transient periods). The aquifer is unconfined in this case. As boundaries two GHBs (General Head Boundaries) are defined on each side. In the center of the study area, there is a pumping well which only pumps water in the third stress period:

Period 1 (1 day):

- steady state with left and right GHB stage = 60 m

Period 2 (100 days):

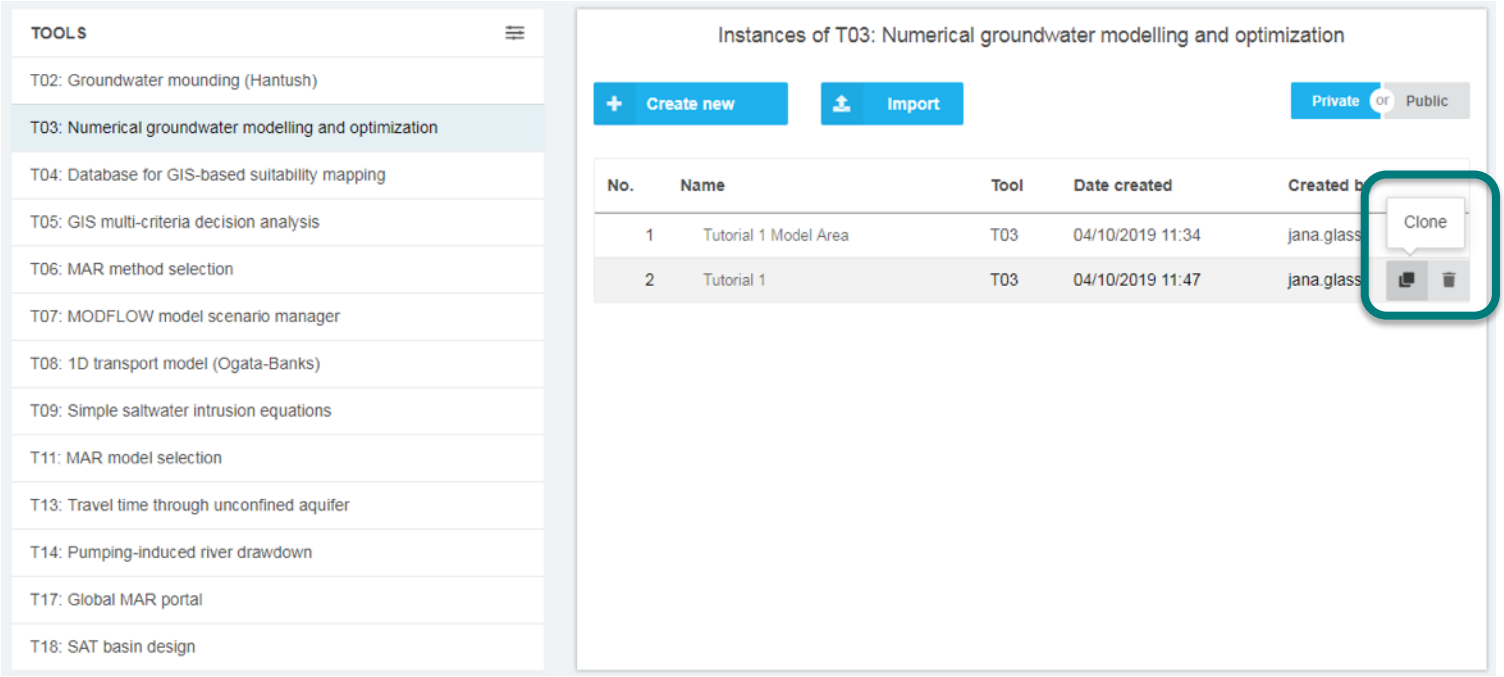
- left GHB with stage = 60 m, right GHB with stage set to 50 m.

Period 3 (100 days):

- pumping well at model centre with rate = -100 m^3/d
- left GHB with stage = 60 m, right GHB with stage set to 50 m.

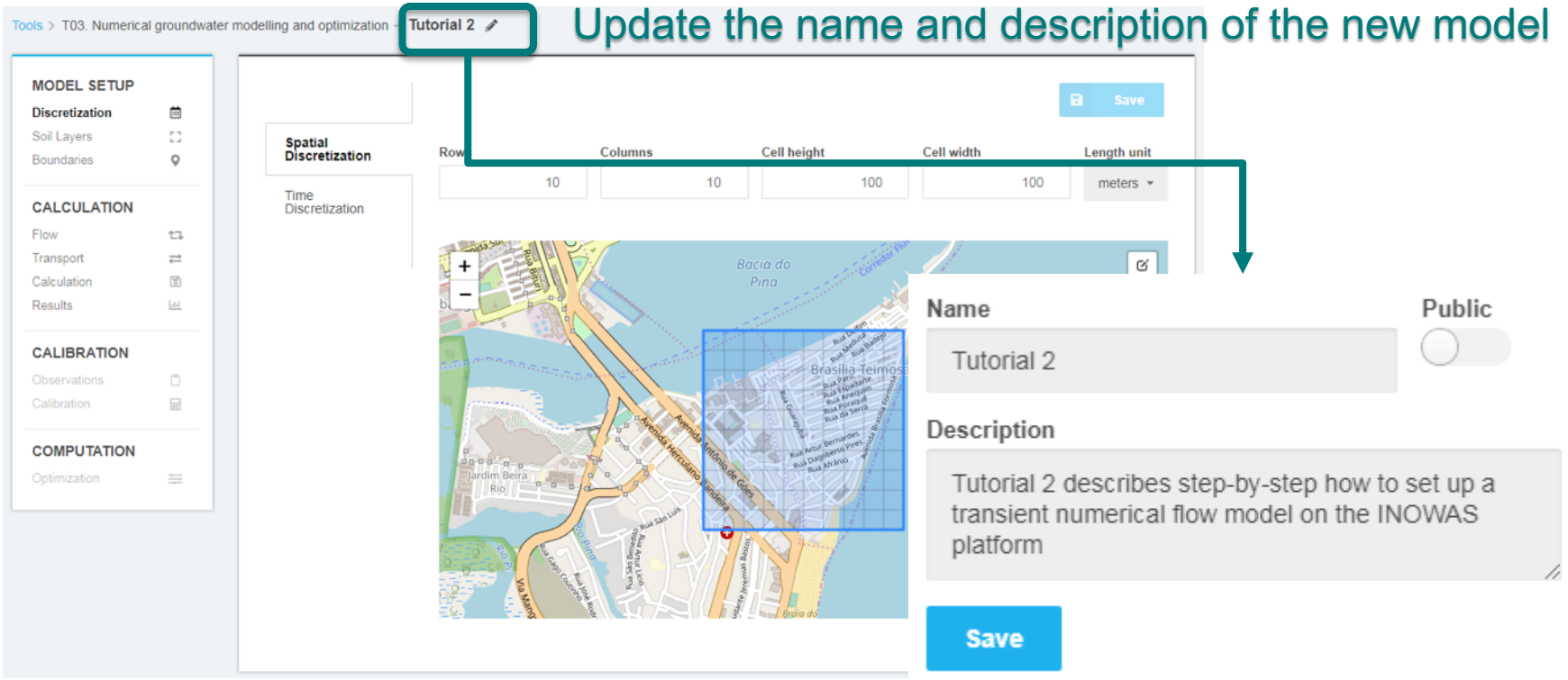
Create new model /clone tutorial 1

As the model in Tutorial 2 has the same discretization as the model in Tutorial 1, the model can be cloned. For cloning, go to the dashboard, click on tool “T03: Numerical groundwater modeling and optimization” and search for your model from Tutorial 1. If you cannot find it, you can also clone “Tutorial 1” which was created by inowas.



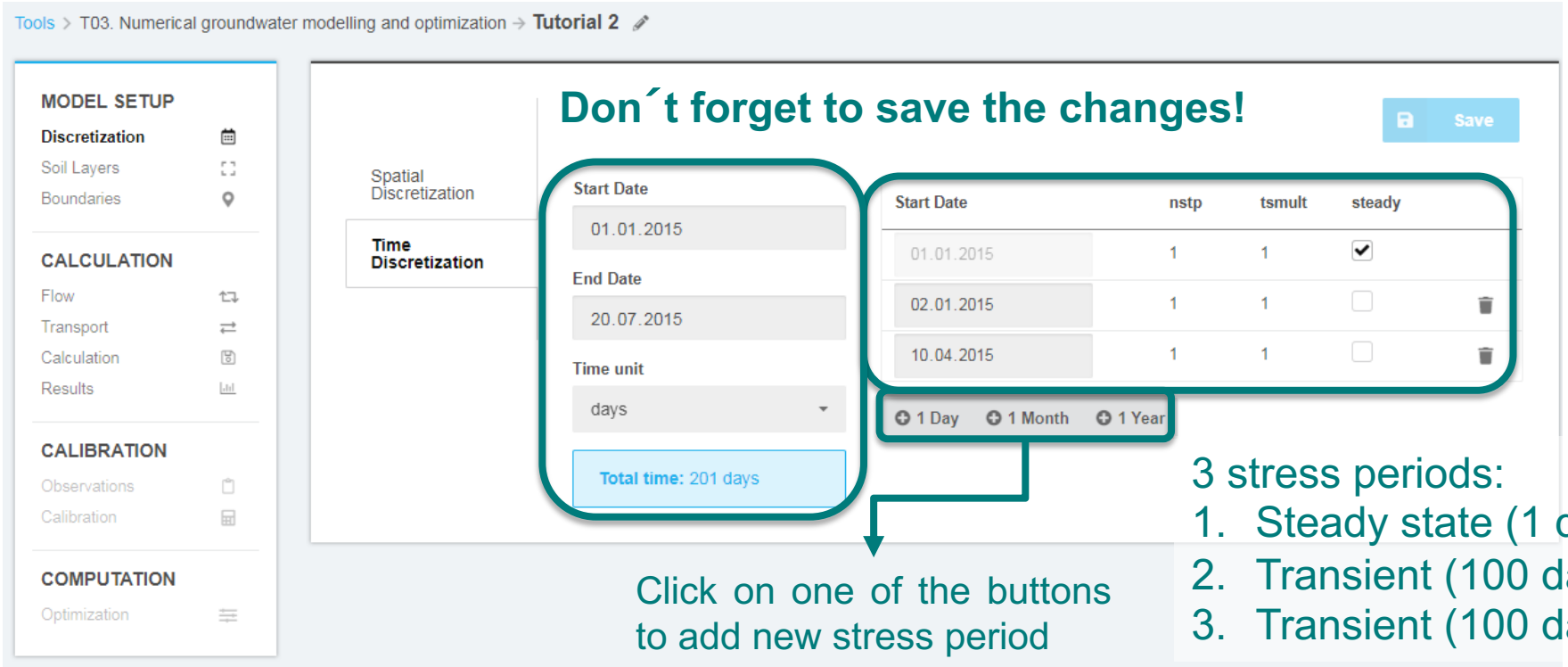
Update name and description

You should now have two models with the same name in your **private dashboard**. Click on the model title to start editing. As a first step, update the general information of the new model. It is also possible to switch between private and public.



Time discretization

The spatial discretization is kept the same as in Tutorial 1. The time discretization needs to be changed: create two new stress periods with starting date 02.01.2015 and 10.04.2015, respectively. The end date should be set to 20.07.2015, the total simulation time is 201 days.

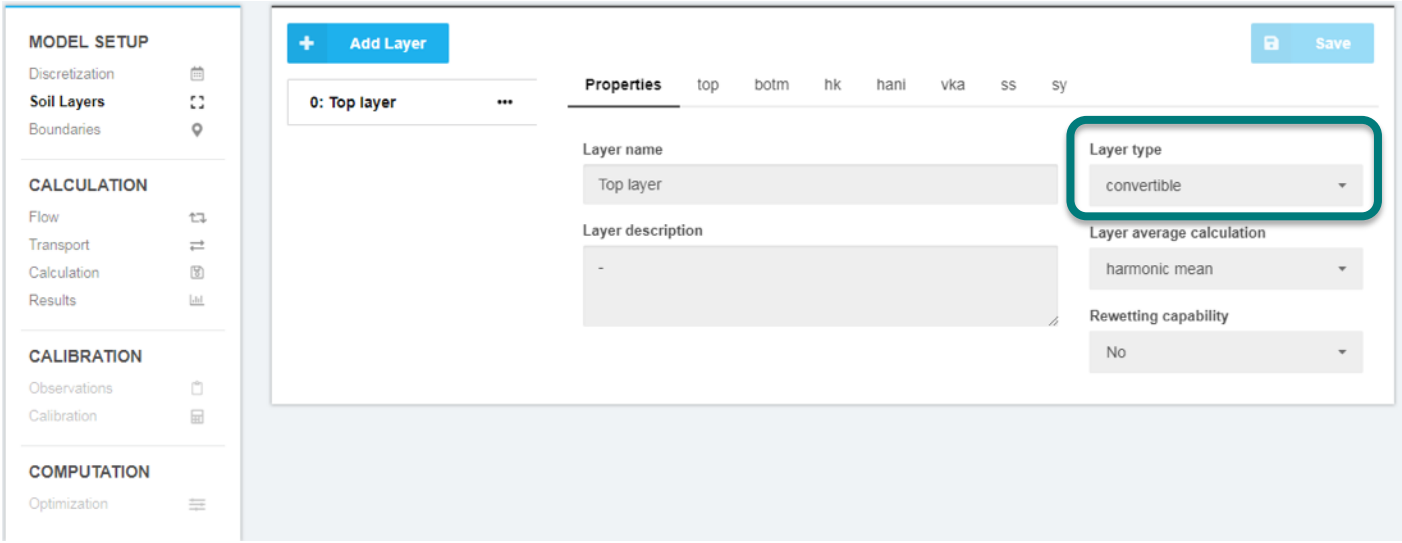


Update soil properties

The layer type needs to be changed to convertible. The following soil parameters also need to be changed:

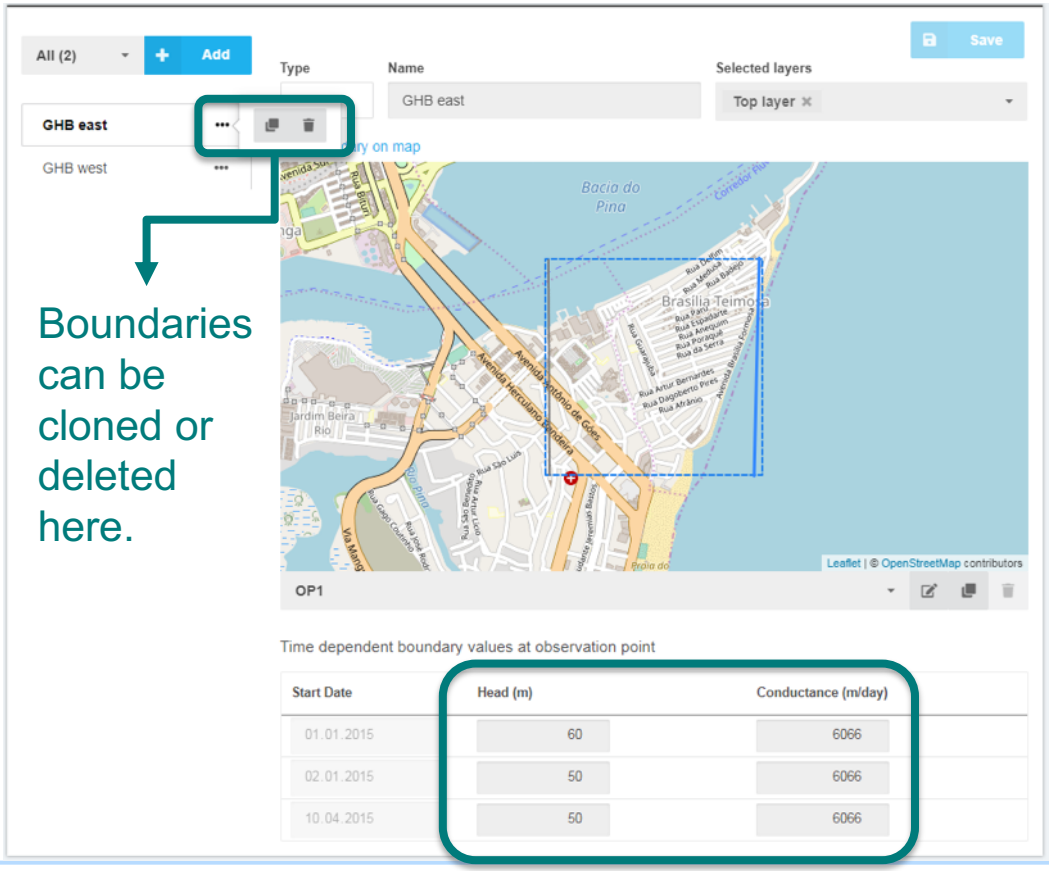
- Top of model layer: **top: 60**
- Horizontal hydraulic conductivity **Hk: 1**
- Vertical hydraulic conductivity **Vka: 1**
- Specific storage **Ss: 0.0001**
- Specific yield **Sy: 0.1**

Don´t forget to save the changes!



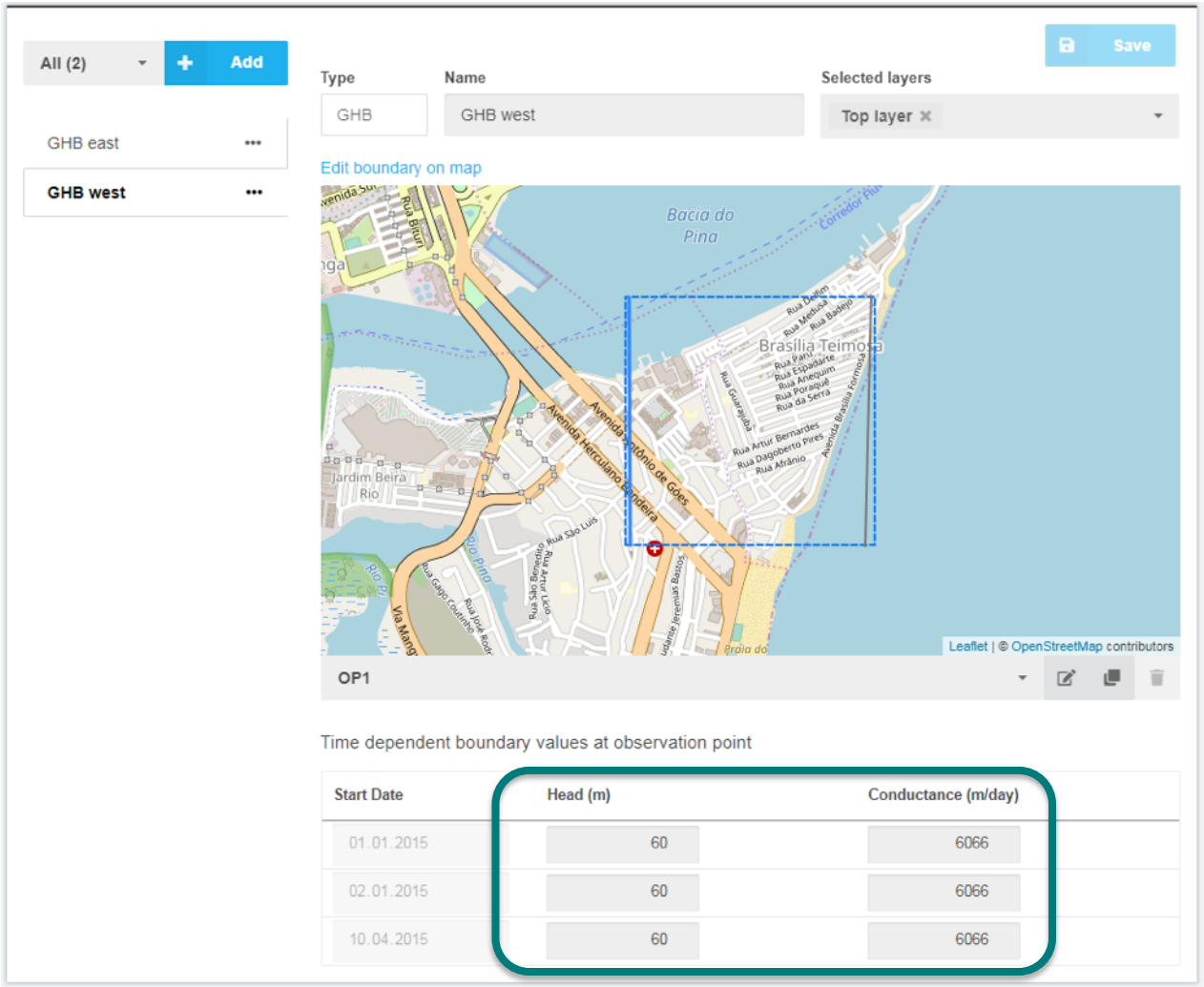
Update boundaries

Delete the two constant head (CHD) boundaries and create two general head (GHB) boundaries at the eastern and western boundary of the model domain.



GHB east:
Conductance: 6066 m/d
Head Stress Period 1: 60 m
Head Stress Period 2: 50 m
Head Stress Period 3: 50 m

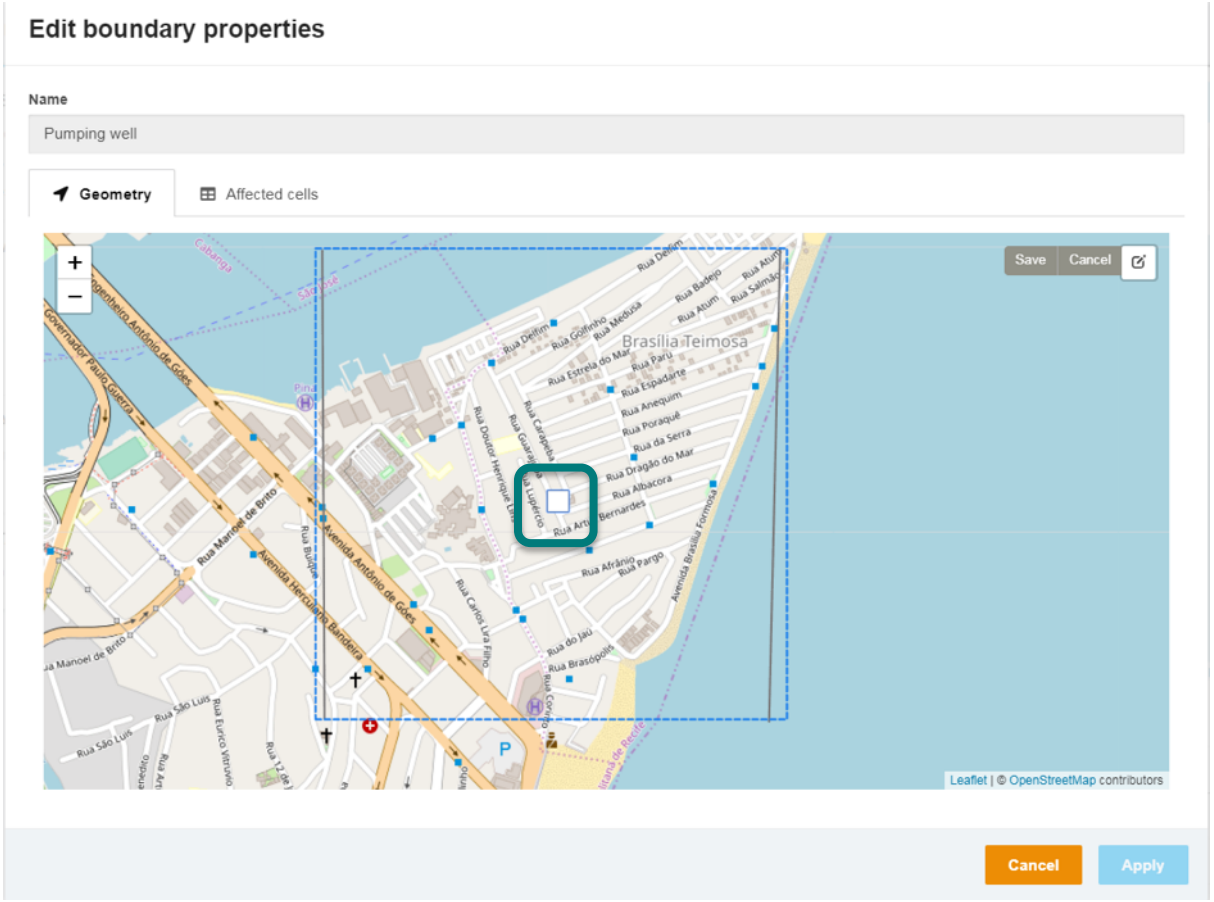
Update boundaries (2)



GHB west:
Conductance: 6066 m/d
Head Stress Period 1: 60 m
Head Stress Period 2: 60 m
Head Stress Period 3: 60 m

Add pumping well

Add a pumping well boundary (WEL) in the central part of the model domain.

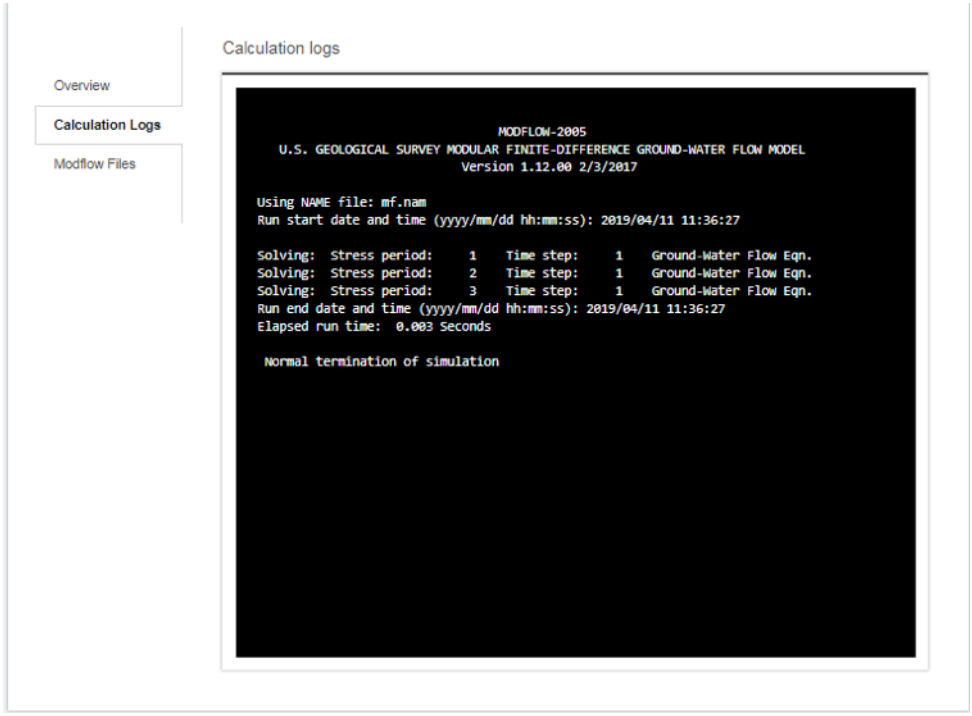


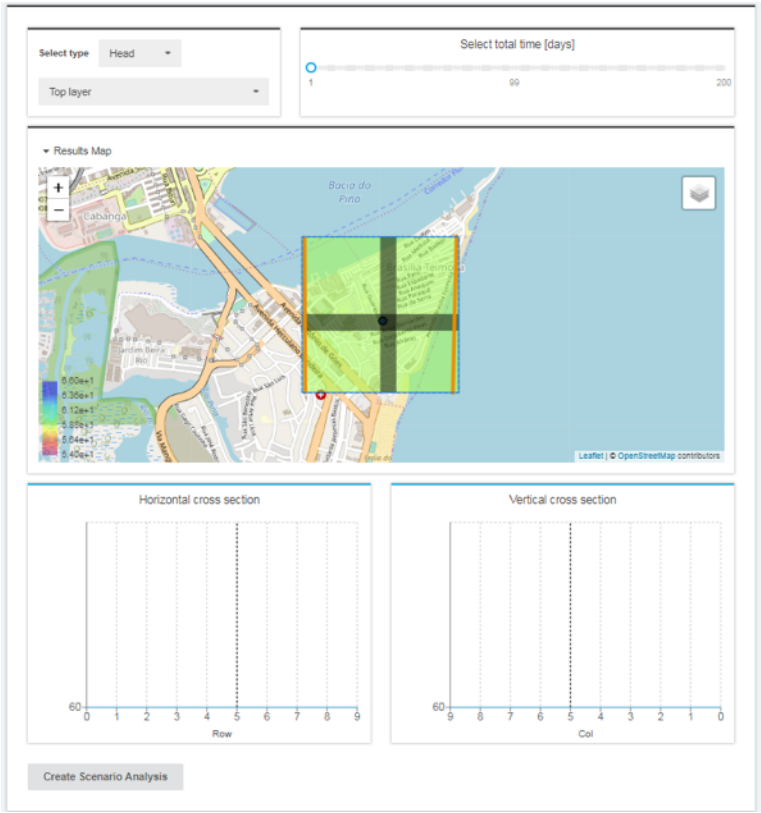
Pumping rate:
Stress Period 1: 0 m³/d
Stress Period 2: 0 m³/d
Stress Period 3:
-100 m³/d

Run the model

In the calculation section, run the model and view the results. First have a look, if the simulation terminated normally. Then, you can have a look at the head results for the three stress periods.

Normal termination of simulation?

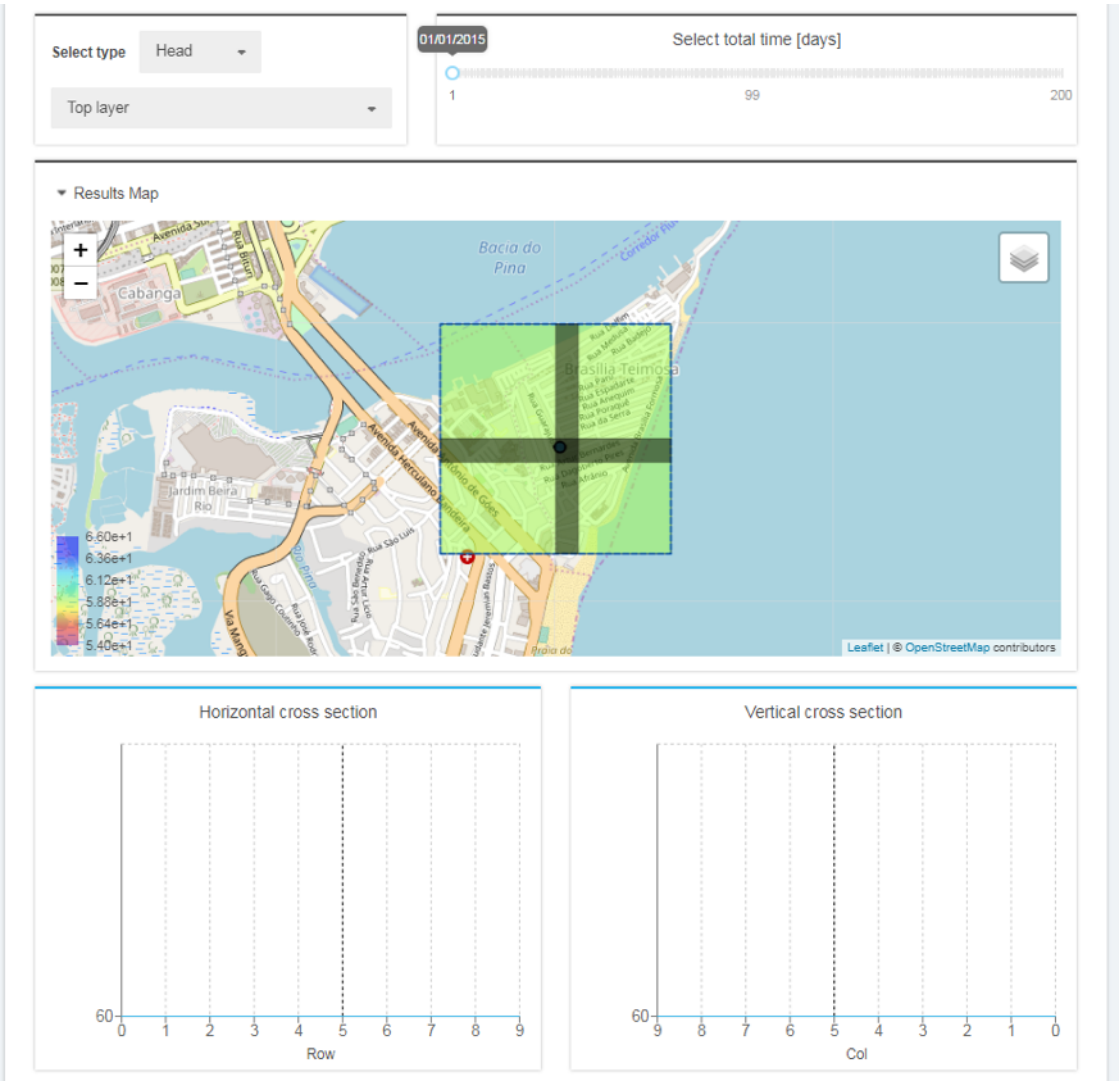




Results

Stress period 1:

the head are constant throughout the model area.

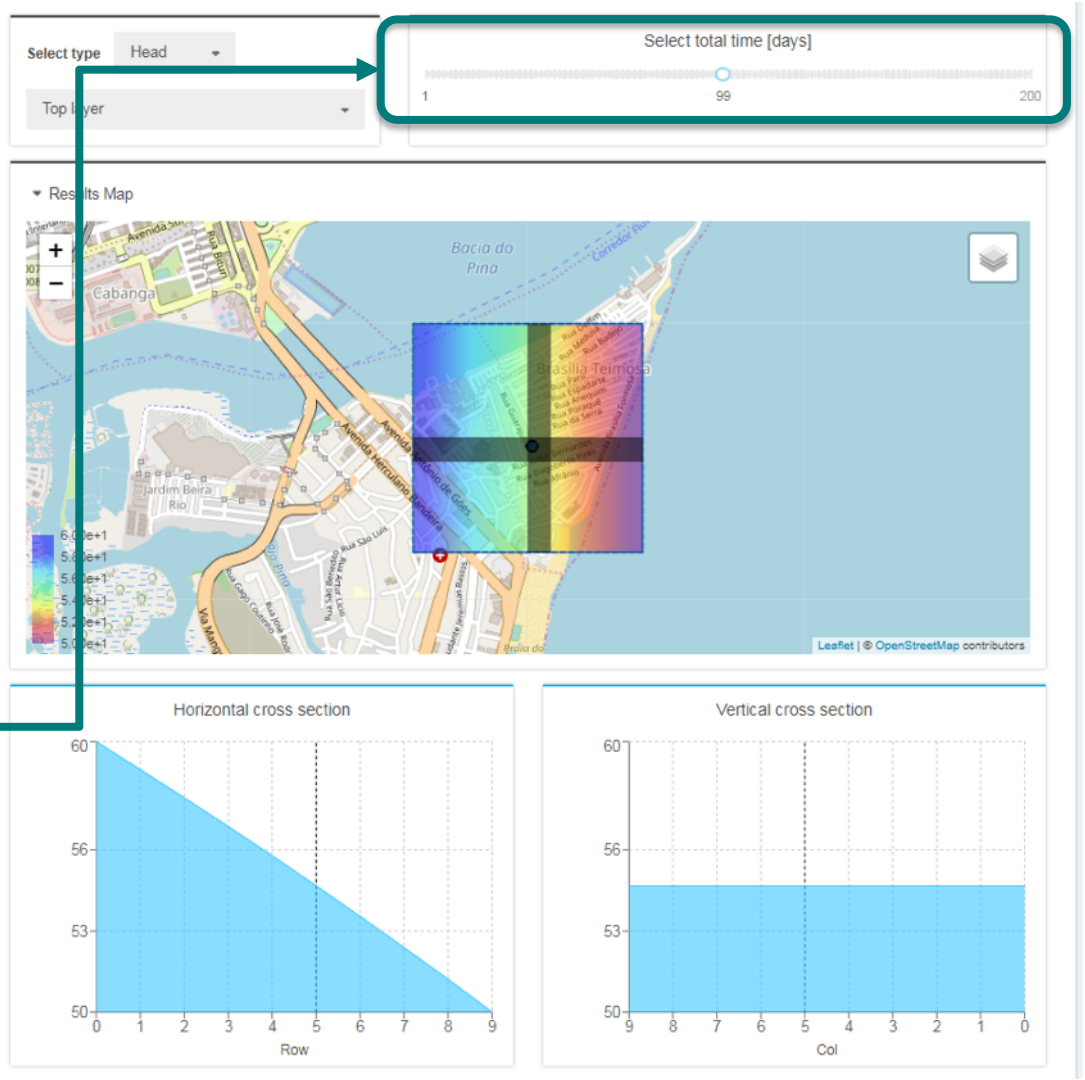


Results

Stress period 2:

Water is flowing from left to right due to the GHB gradient.

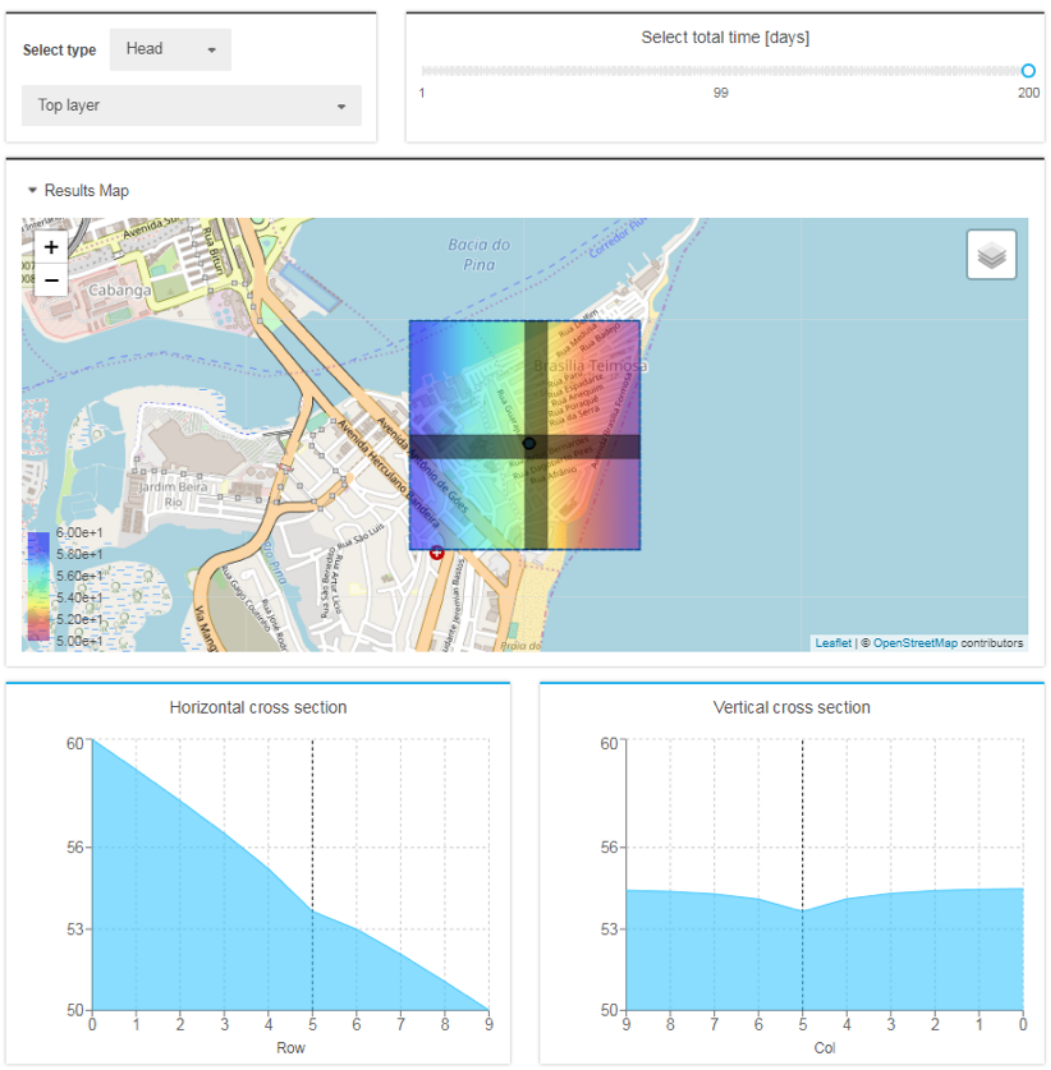
Change stress period, time steps



Results

Stress period 3:

The pumping from the well causes a small depression cone.

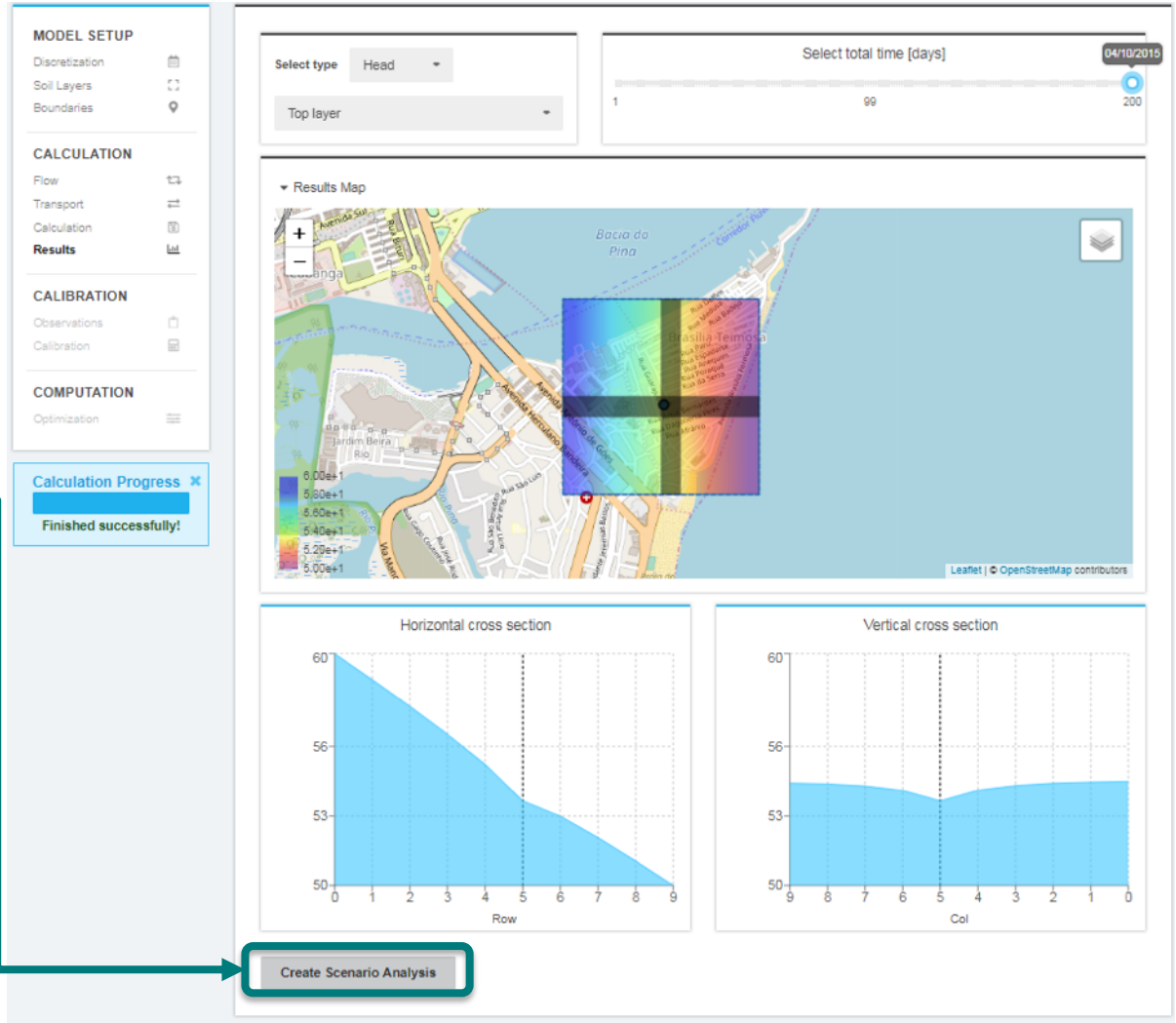


Scenario Analysis

In the scenario analysis, we want to examine what happens if the pumping rate is further increased.

For that create a scenario analysis in the results section.

The present model will be taken as the base model.

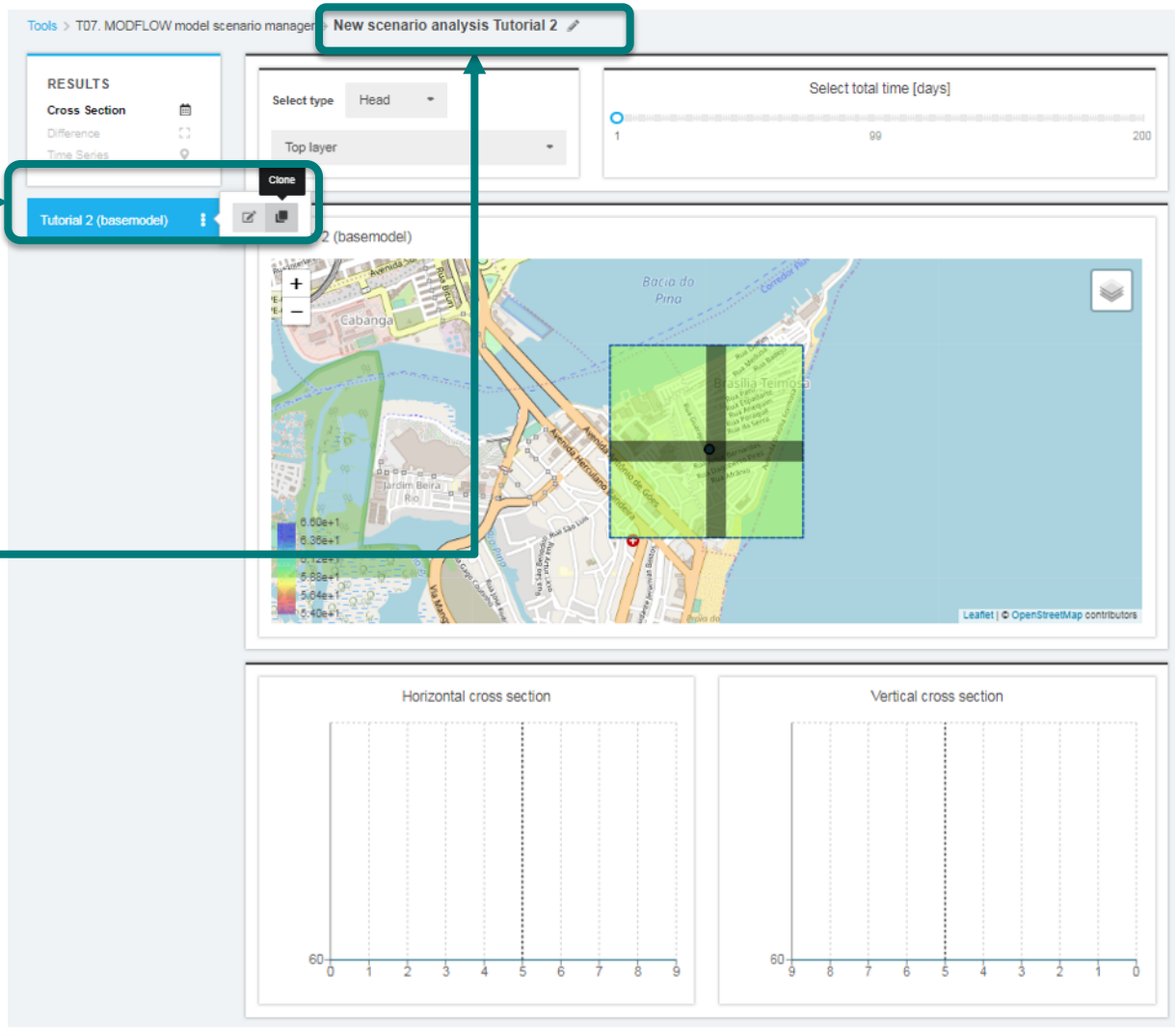


Scenario Analysis

Be aware, that you are now in Tool „T07. MODFLOW model scenario manager“.

Change the name, description and public/private status.

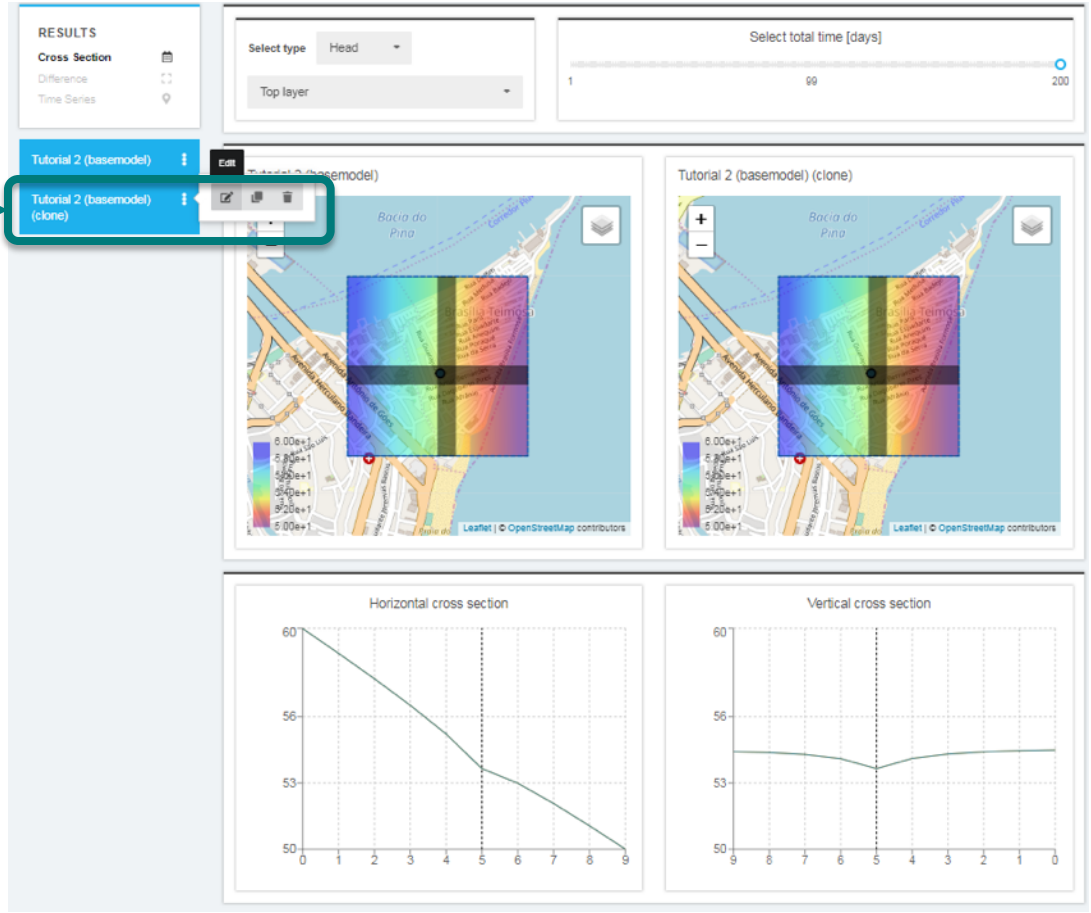
Clone the base model to create a scenario.



Scenario Analysis

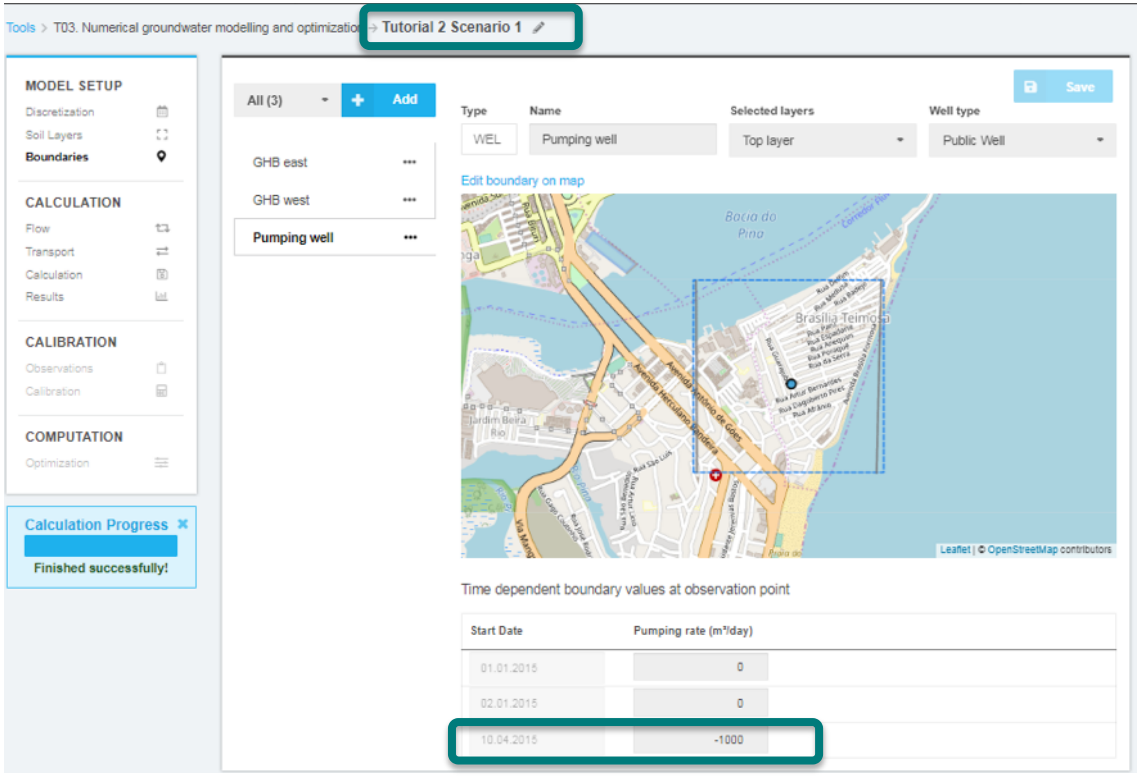
There should be now two models in the slider: Tutorial 2 (basemodel) and Tutorial 2 (basemodel) clone.

Edit the clone to change the pumping rate.



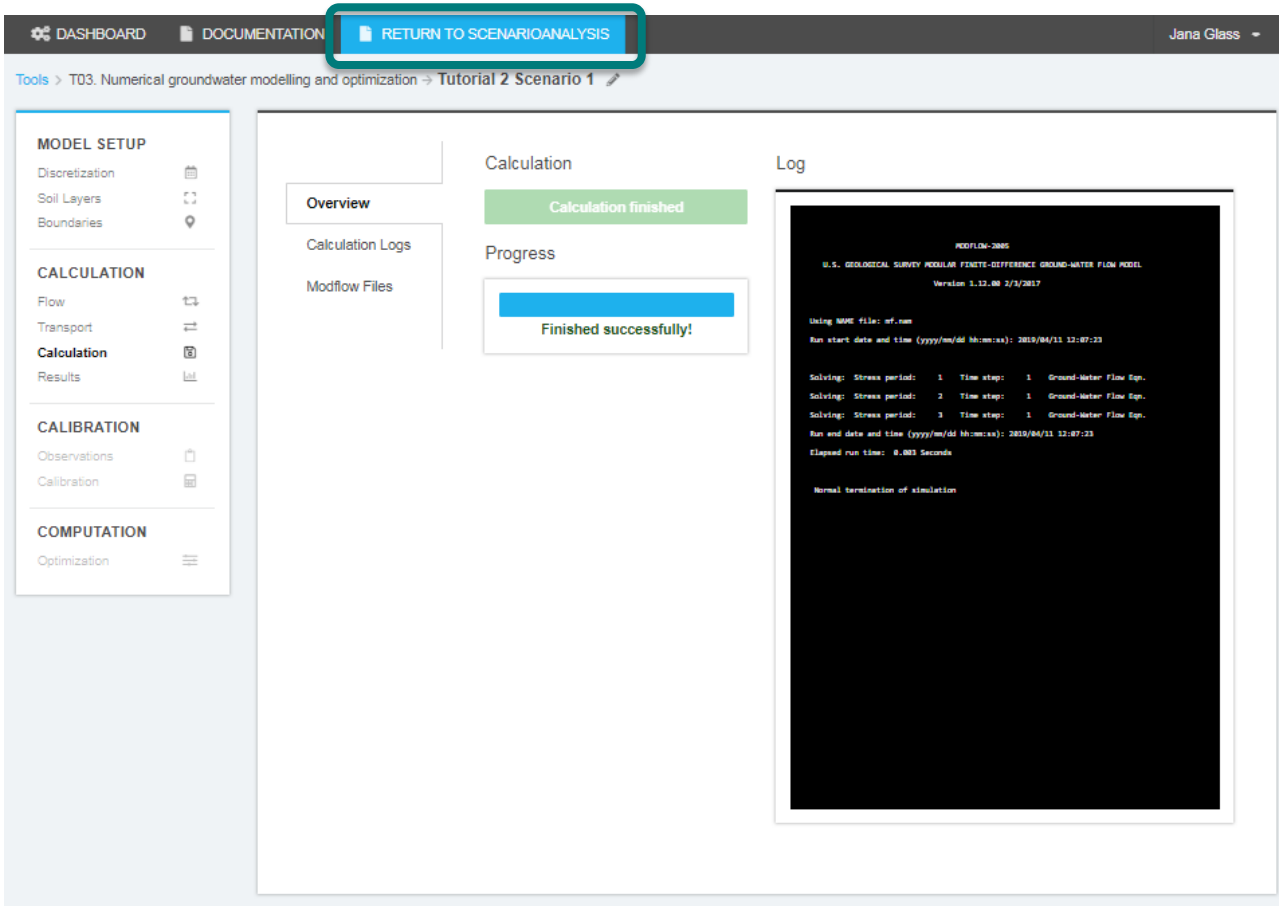
Scenario Analysis

Be aware that you are now back in the Model Editor (Tool T03). Rename the Scenario to e.g. Tutorial 2 Scenario 1 and change the pumping rate to -1000 m³/d.



Scenario Analysis

Run the model and make sure the simulation terminated normally. Then return to the scenario analysis.

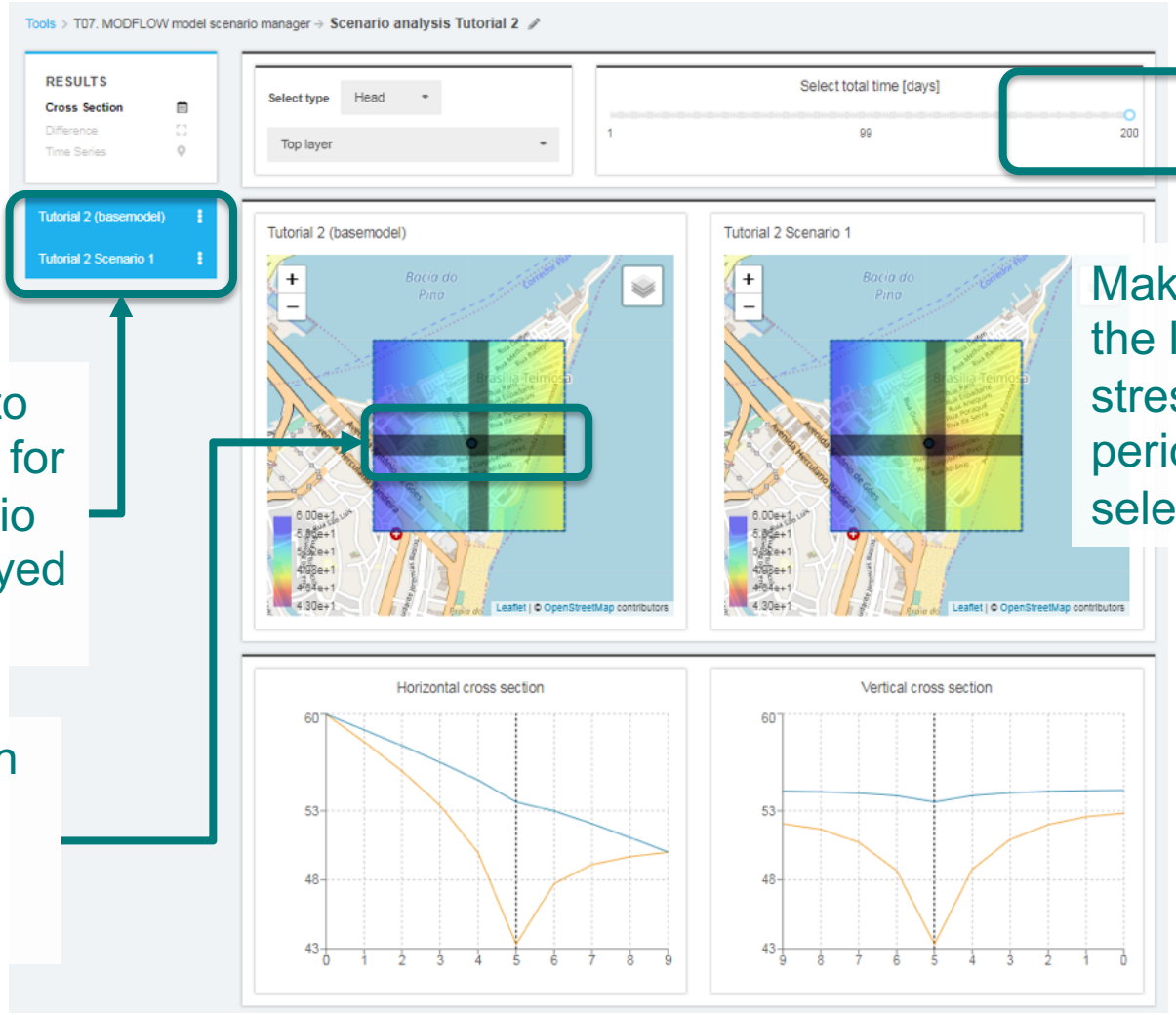


Scenario Analysis

In the scenario manager, the head of the Base model and scenario 1 can be compared.

Both scenarios have to be switched on (blue) for comparison. A scenario is currently not displayed if the button is white.

Select the row/column where the pumping well is located to visualize its influence



Make sure the last stress period is selected.

Additional Task

The water authority decided that the groundwater head is not allowed to drop below 50 m in the whole model area due to land subsidence issues.

How much water can be pumped from the pumping well so that the water level stays above 50 m?

Create an additional scenario and try to find out.

Contact

Thank you for going through Tutorial 2. If you have any comments or questions, please contact us (also if you want to find out if your answer of the additional task is correct) !

Further Tutorials about the INOWAS platform:

Tutorial 1- Set up of steady state groundwater flow model

Tutorial 3- Set up of solute transport model