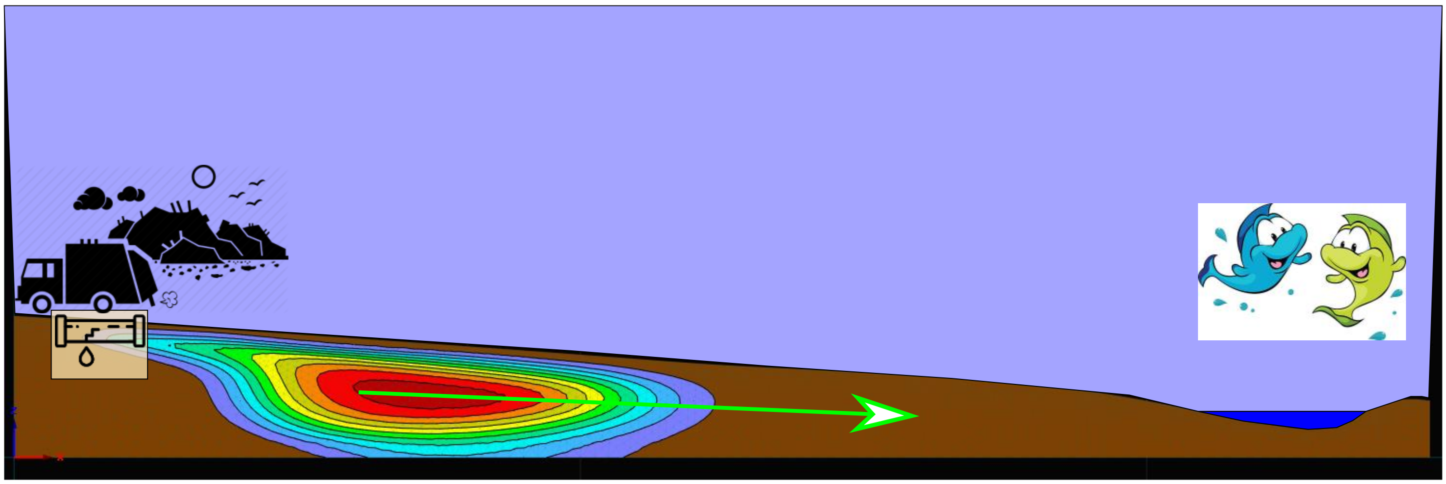
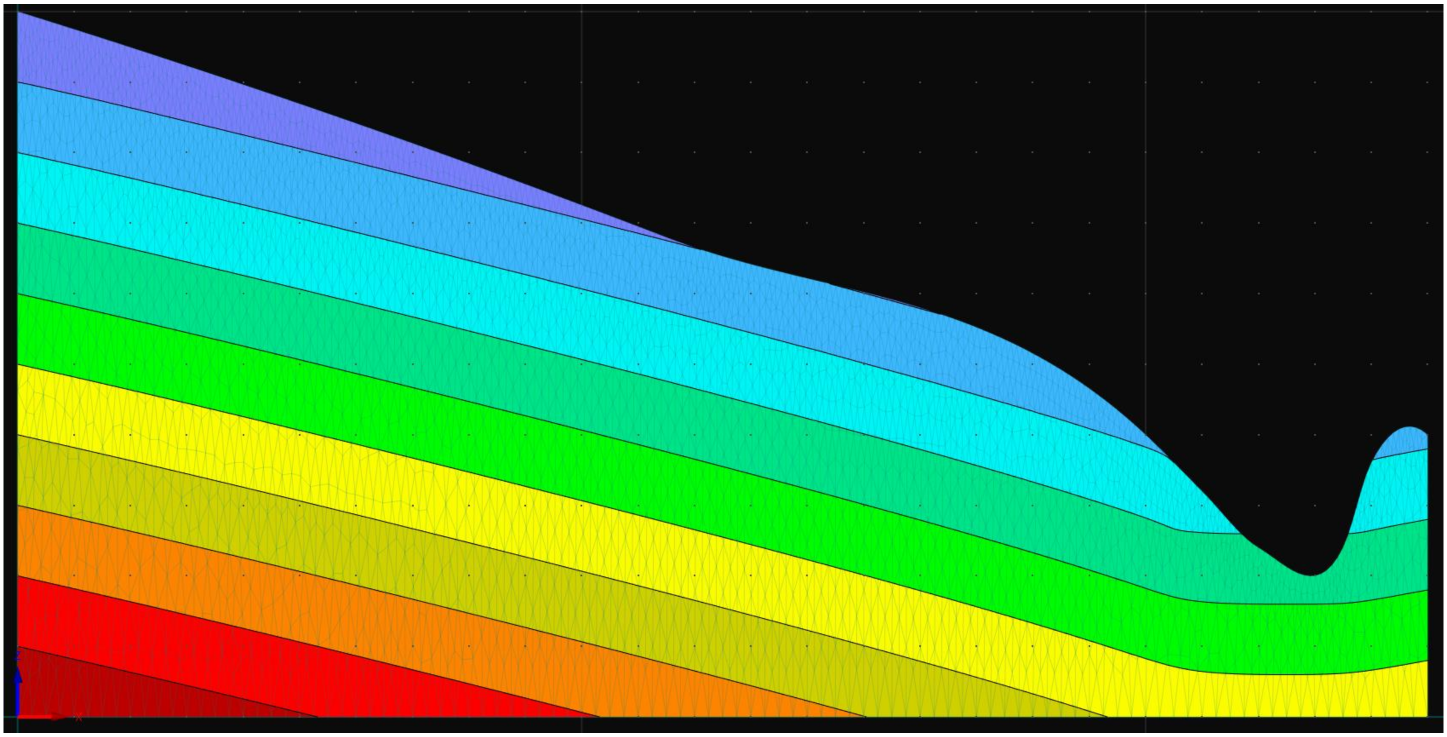
Transport of the leaked contaminant from the landfill to the river

Simulate the transport of the contaminant into the adjacent river. A contaminant with a concentration of 1 mg/cm2 was spread into the soil for 100 days due to a defect in a drainage pipe. The defect was repaired after 100 days. However, the contaminant remained in the soil even after the defect was removed. Your task is to determine how the contaminant spreads in the soil, when it begins to enter the river, and when the maximum concentration reaches the river. Determine when the contaminant reaches the river at different dispersion values. Highlighted text is what you need to put to report.
Send the report as docx or pdf to: jakub.jerabek@fsv.cvut.cz.



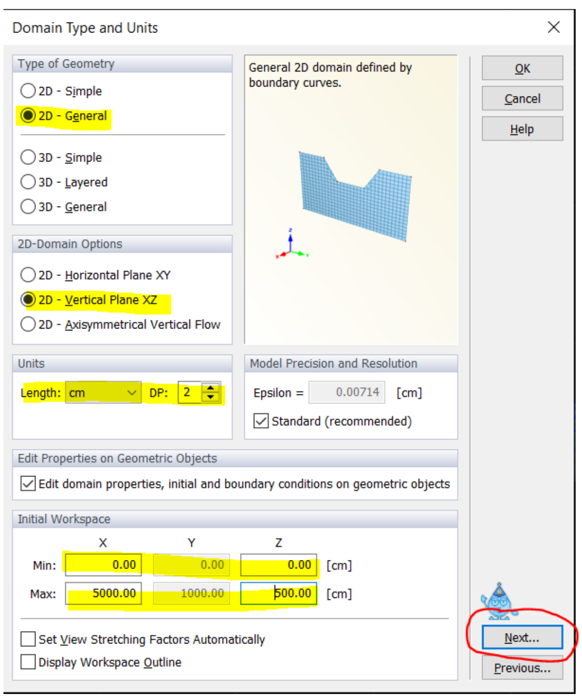
Approach

Building the model and creating the suction pressure initial condition

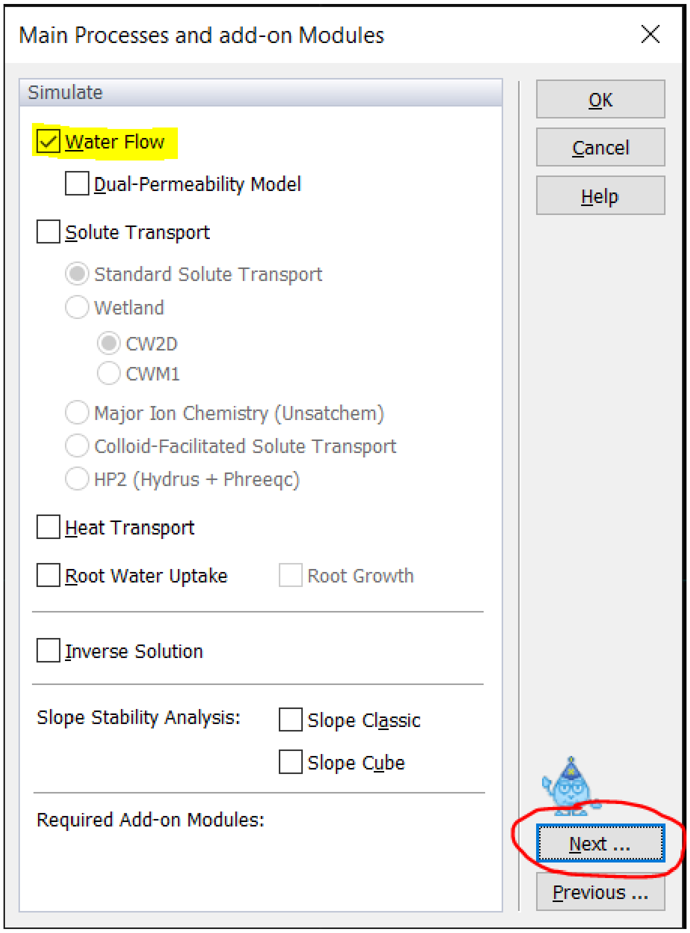


1) New project: Create a new project.

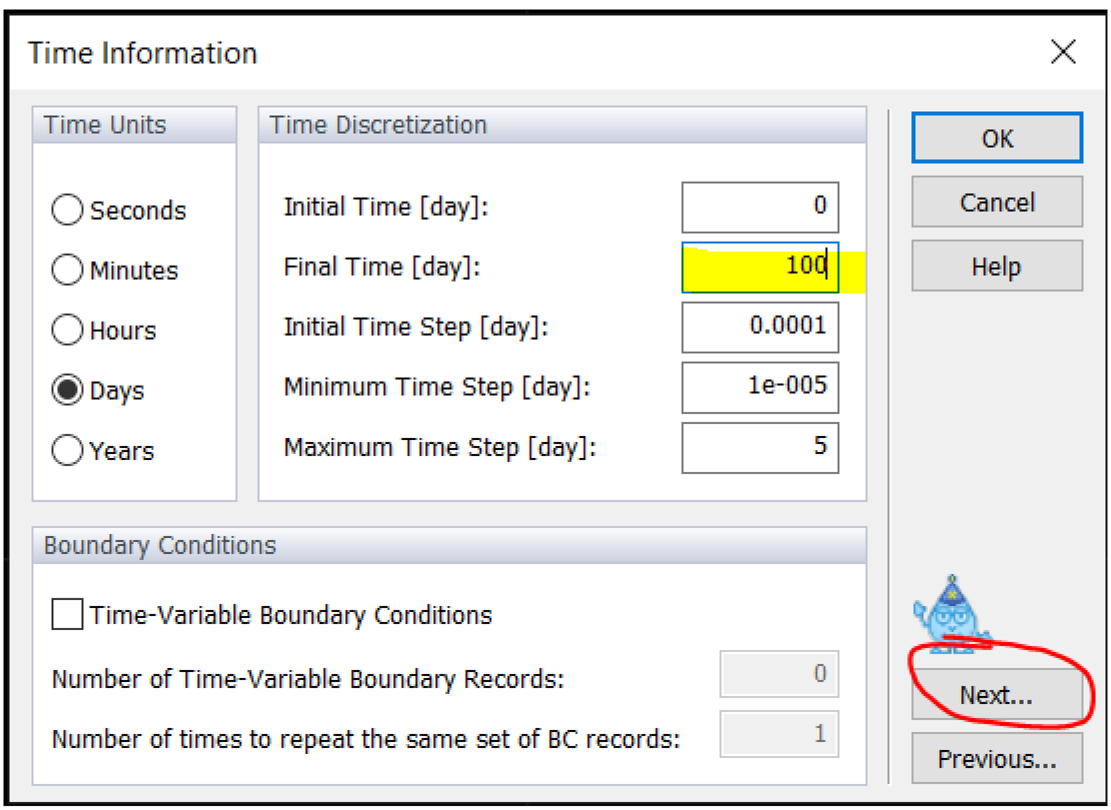
2) Domain Type and Units



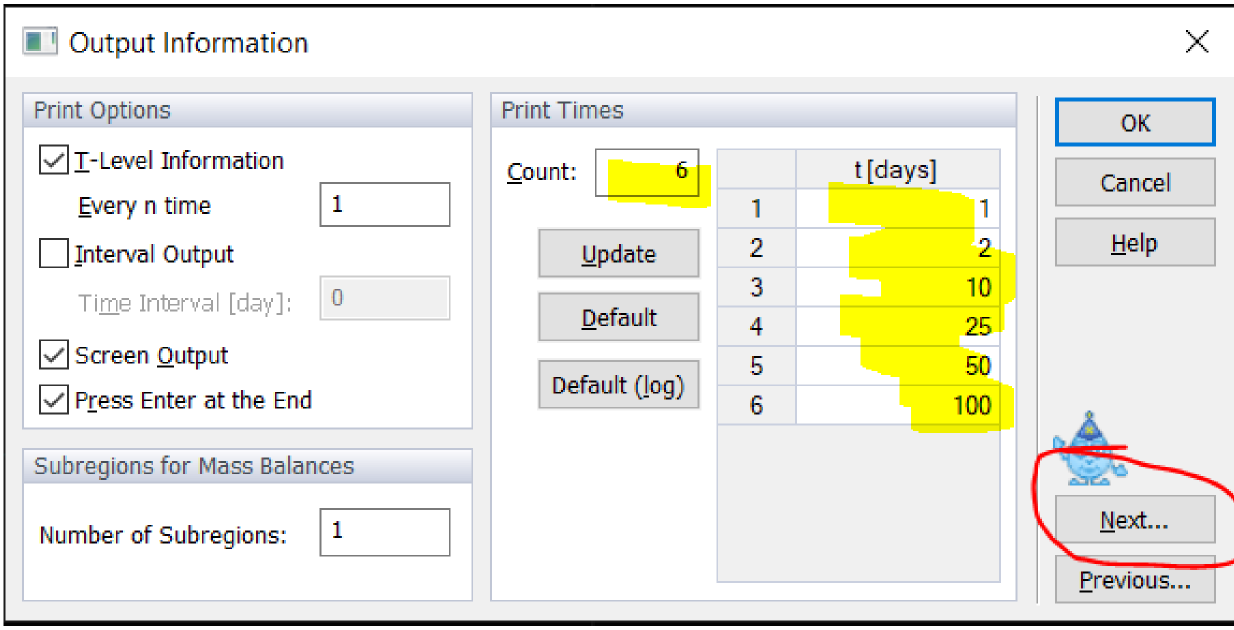
3) Main processes



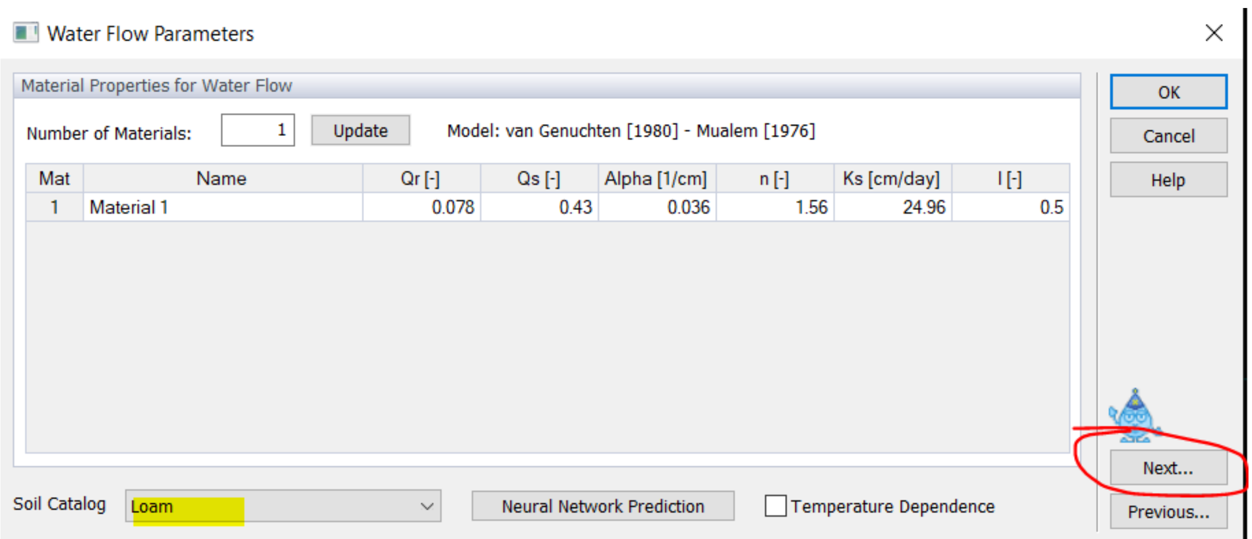
4) Time information



5) Output Infrmation

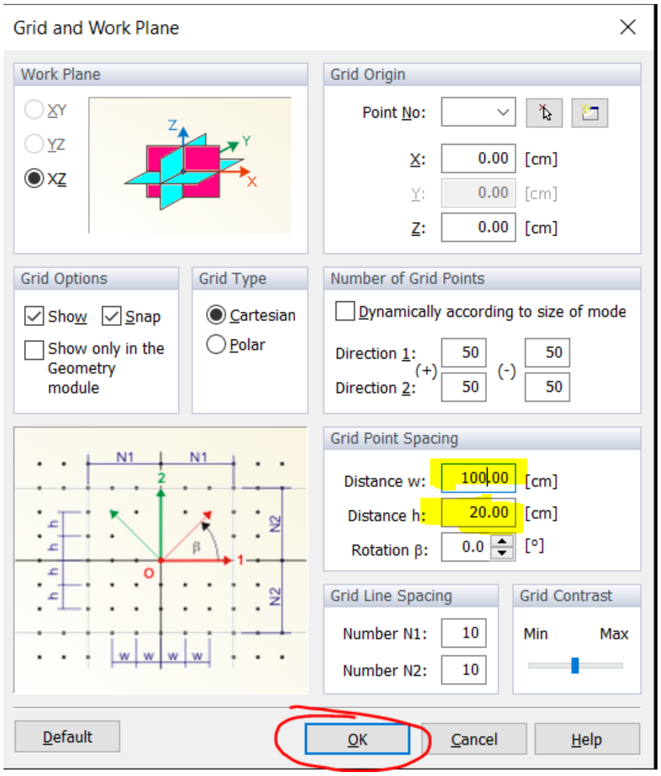


6) Flow parameters



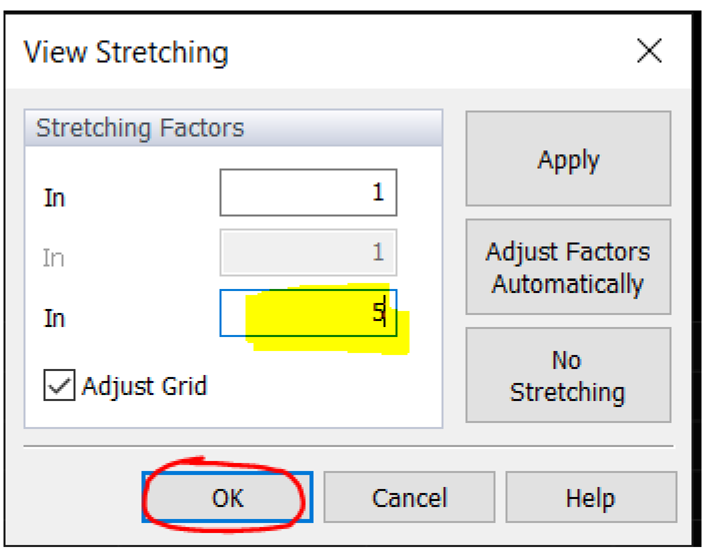
7) Prepare Grid point Spacing

Tools -> Grid and Work Plane



8) Stretch the view in the x-axis direction by a factor of 5.

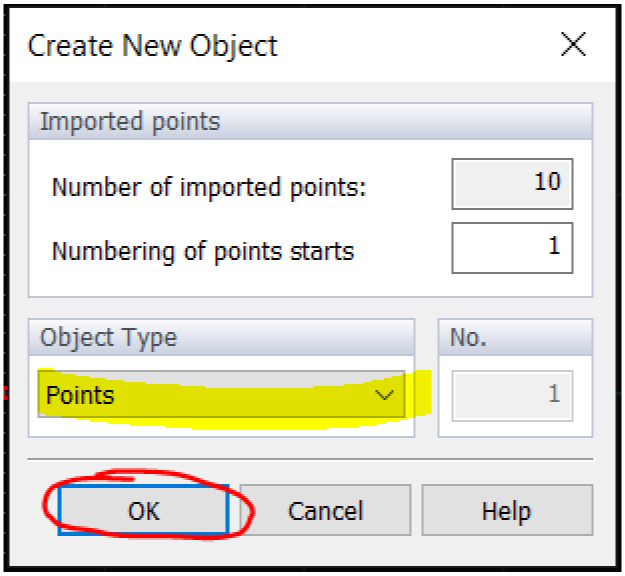
View -> View Stretching…



9) Geometry

Import and prepare geometry

File -> Import -> Import Points from Text File

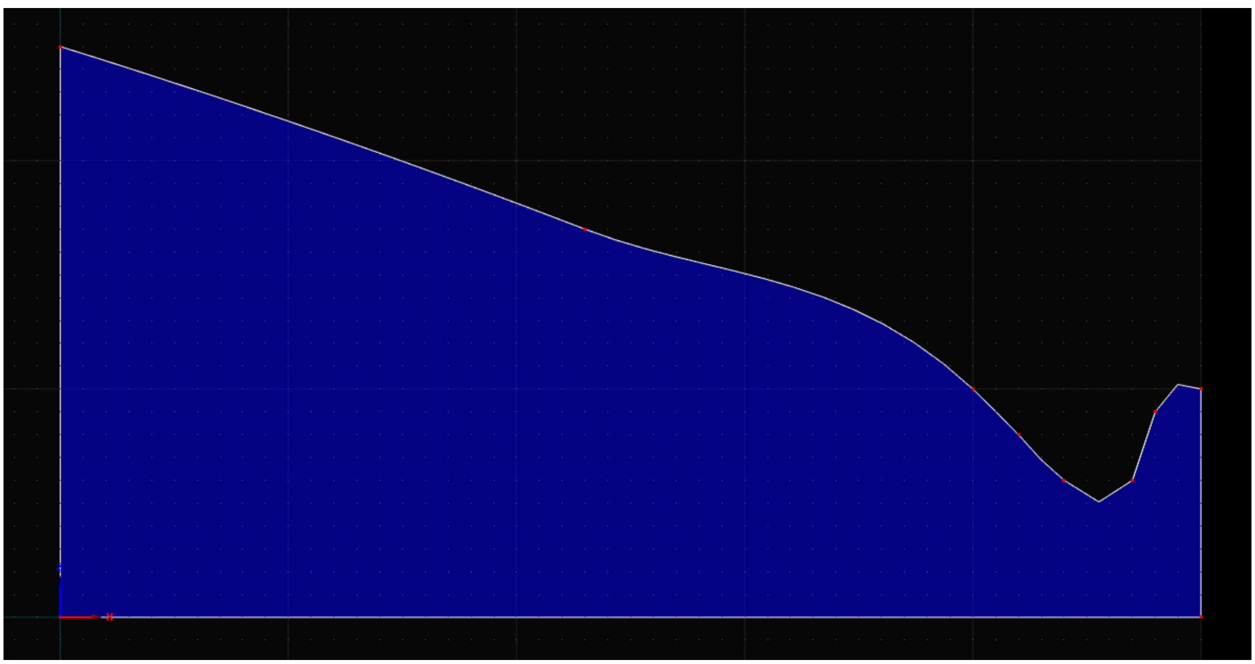


The points file can be found on the course website10) Geometry

Use Line-Polyline to connect points 1,2,3,4

Use Spline to join points 4, 5, 6, 7, 8, 9, 10, 1

Use Planar Surface via Boundary to create a surface



11) Mesh

FE-Mesh Parameters: Target element size: 50 cm

Insert mesh refinement: Finite element size: 20 cm

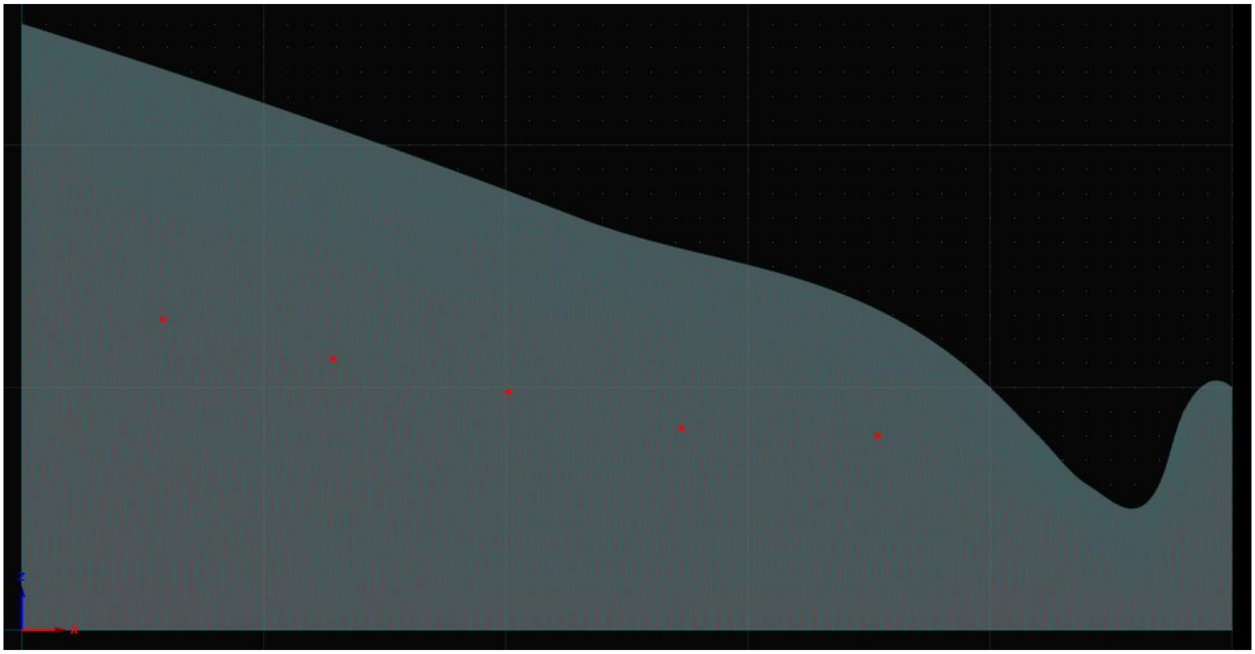
Apply to points with z > 0.

Generate Mesh: Generate FE-Mesh

12) Domain Properties

Hydraulic properties of Loam.

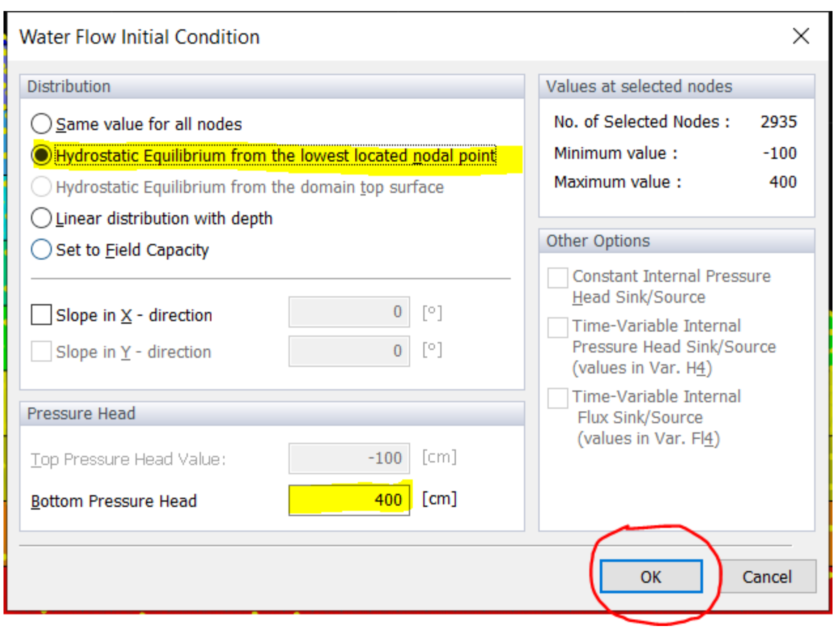
Insert 5 points (You need to edit FE-Mesh not Geo Objects)



13) Initial conditions

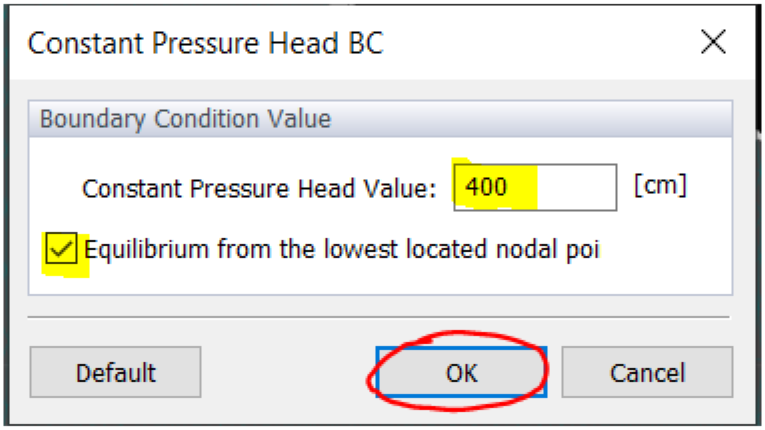
Mark the entire grid and create an initial condition such that the pressure at the bottom edge is 400 cm and the rest of the domain is in equilibrium with the pressure at the lowest point.

Set Pressure Head IC



14) Boundary conditions

Left boundary – Constant head – pressure 400 cm v n equilibrium with the lowest node.



Right boundary – Constant head - pressure 190 cm in balance with the lowest node.
River – Constant head – zoom to river, mark nodes with z < 175, set pressure 80 cm in equilibrium with the lowest node.

Seepage face – highlight points at boundary between river and z coordinate 300 cm (left from river) and set Seepage Face boundary conditions.

15) RUN THE CALCULATION

View pressures, soil water content, and velocity vectors as an animation. Copy the pressures, water content, and velocity vectors in the last calculation time to Word. Comment with one or two sentences what you see in the results.

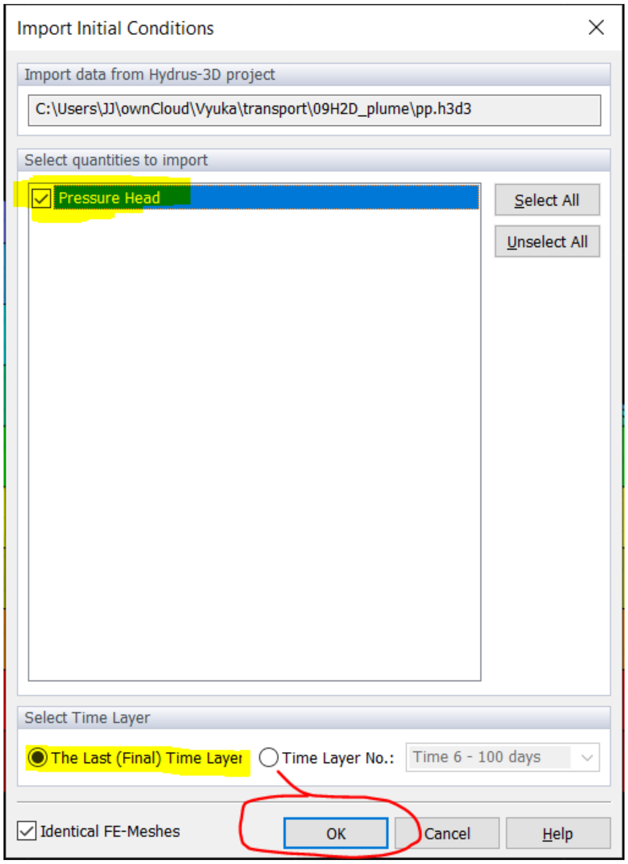
Creating of pressure field with the contaminant leakage.

Save the project as [your name]-2

1) Import the initial conditions from the project of the previous step.

Edit -> Initial conditions -> Import..

Open a previous project



2) Boundary conditions

Create a pressure boundary condition h = 0 at several nodes that represent the contaminant entry point (see the initial figure).

3) RUN THE CALCULATION

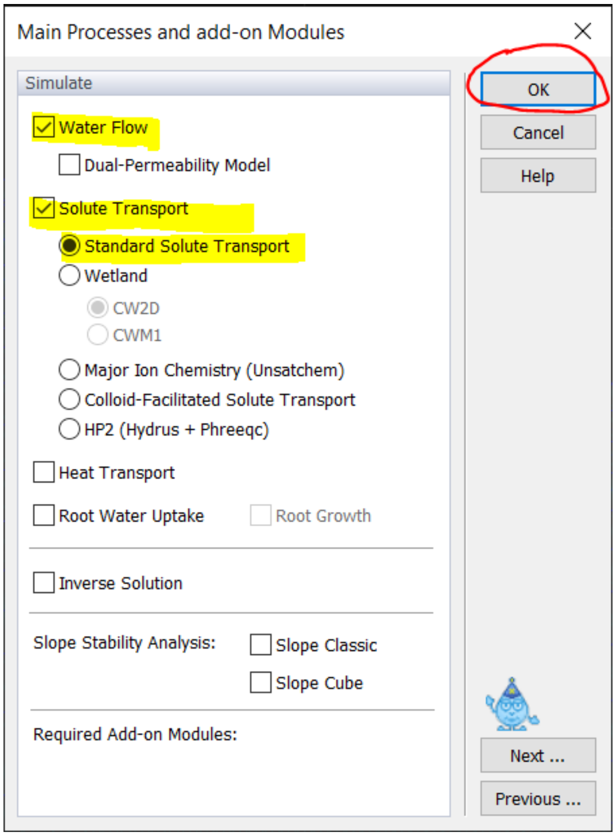
See the pressures as an animation. Copy the pressures in the last calculation time to Word and comment the picture with one or two sentences.

Creating a contaminated area

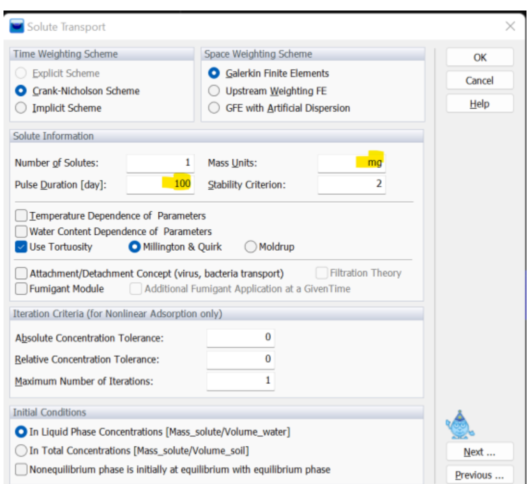
Save the project as [your name]-3.

1) Add the transport equation calculation module.

Flow and Transport Properties -> Main Processes and Modules



2) Set solute general information



3) Set the transport parameters

Flow and Transport Properties -> Solute transport -> Transport parameters

Diffusion Coefficient = 3
Disp.L = 10
Disp.T = 1

4) Set the concentration on the boundaries

Flow and Transport Properties -> Solute transport -> Reaction parameters

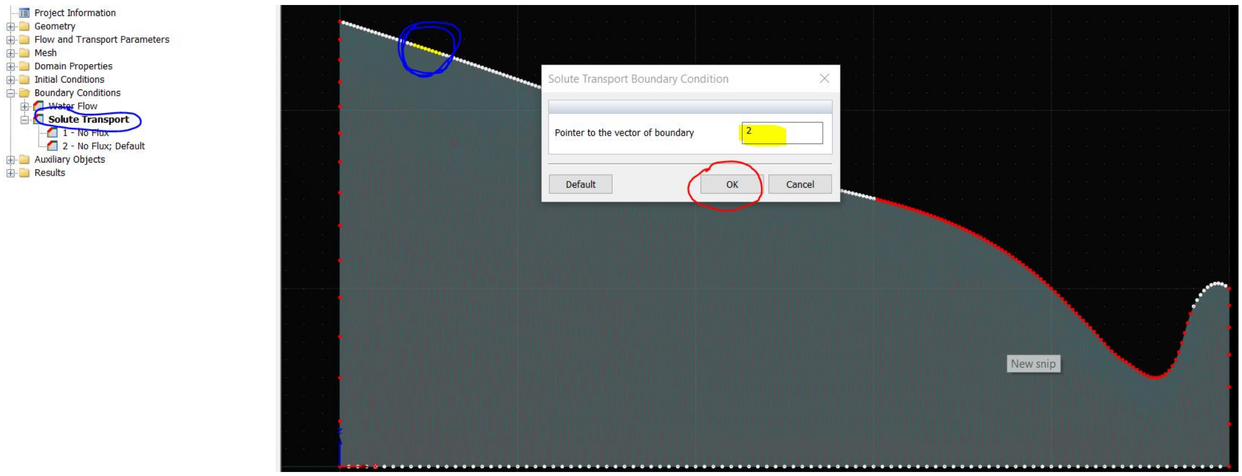
cBnd2 = 1

This represents a concentration of 1 mg/cm3.

5) Set the transport boundary conditions

Boundary conditions -> Solute transport

At the point of contaminant entry, set the concentration of cBnd2 using the Third-type boundary condition.



6) RUN THE CALCULATION

View pressures, water content, and concentration as an animation. Copy concentration in the last calculation time to Word. Comment with one or two sentences what you see on picture. Write in Word how much contaminant entered the calculation domain at the end of the calculation (Results -> Other Information -> Mass balance information -> ConcVol [VM/L3] at the last time).

Model the transport of the contaminant towards the flow

Save the project as [your name]-4.

1) Model a period of 100 - 2100 days

Flow and Transport Properties -> Time Information

Initial time: 100
Final time: 2100
Initial Time Step: 0.001
Minimum Time Step: 0.00001
Maximum Time Step: 50

Flow and Transport Properties -> Output Information

Print Times: 20

Update - creates 20 rows in the table for entering the time

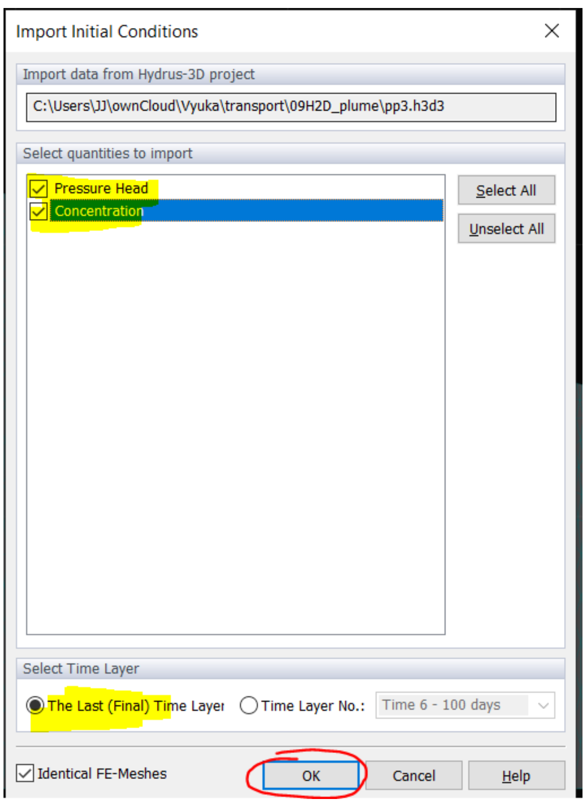
Default - Table fills

2) Initial conditions

Import the initial conditions from the project of the previous step.

Edit -> Initial conditions -> Import..

Import project xxx-3



3) Boundary conditions

Create a flux boundary condition of q = 0.05 cm/day at the surface nodes besides the seepage face area and river. This will remove the boundary condition at the contaminant inlet.

3) RUN THE CALCULATION

Check the concentration as an animation. Copy the concentration at time 1000 days and the last time of calculation to Word. Write in Word how much contaminant remained in the computational domain at the end of the calculation (Results -> Other Information -> Mass balance information -> ConcVol [VM/L3] at the last time). Copy the trend of concentrations at the observation points (Results - other information: Observation Points). Copy the concentration fluxes over the edges (Results - other information: Solute Fluxes -> All solute fluxes.

Analysis of transport parameter variables – sensitivity analysis

The calculation of the current model is the null scenario S0.

Model scenario S1, where the longitudinal dispersivity is 10 larger than in scenario S0.

Check the concentration as an animation. Copy the concentration at time 1000 days and the last time of calculation to Word. Write in Word how much contaminant remained in the computational domain at the end of the calculation (Results -> Other Information -> Mass balance information -> ConcVol [VM/L3] at the last time). Copy the trend of concentrations at the observation points (Results - other information: Observation Points). Copy the concentration fluxes over the edges (Results - other information: Solute Fluxes -> All solute fluxes.

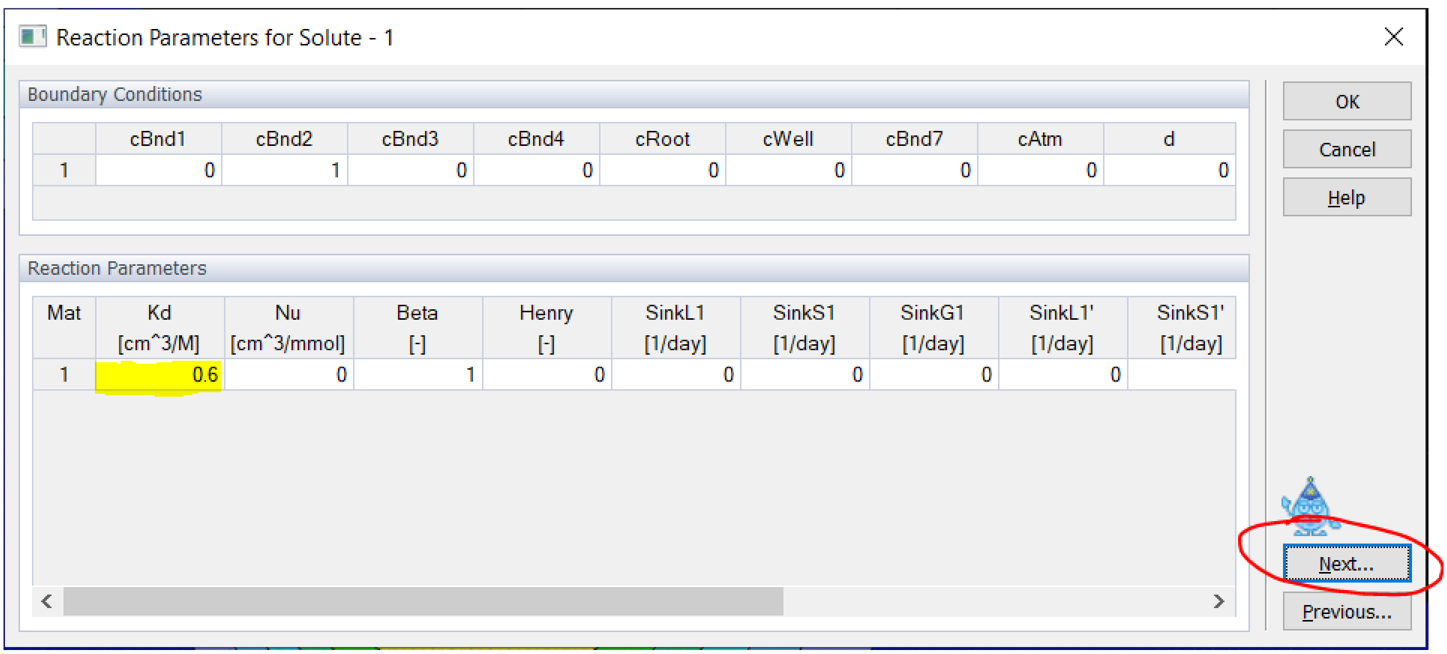
Model the S2 scenario where the coefficient of longitudinal and transversal dispersivity is equal to 10 cm (Unrealistic).

Check the concentration as an animation. Copy the concentration at time 1000 days and the last time of calculation to Word. Write in Word how much contaminant remained in the computational domain at the end of the calculation (Results -> Other Information -> Mass balance information -> ConcVol [VM/L3] at the last time). Copy the trend of concentrations at the observation points (Results - other information: Observation Points). Copy the concentration fluxes over the edges (Results - other information: Solute Fluxes -> All solute fluxes.

Model scenario S3, where the longitudinal and transverse dispersivity coefficient is the same as in S0, but the contaminant sorbs to the soil according to a linear adsorption isotherm.

Set Adsorption isotherm coefficient Kd as 0.6 cm3/g

Flow and Transport Properties -> Solute transport -> Reaction parameters



Check the concentration as an animation. Copy the concentration at time 1000 days and the last time of calculation to Word. Write in Word how much contaminant remained in the computational domain at the end of the calculation (Results -> Other Information -> Mass balance information -> ConcVol [VM/L3] at the last time). Copy the trend of concentrations at the observation points (Results - other information: Observation Points). Copy the concentration fluxes over the edges (Results - other information: Solute Fluxes -> All solute fluxes.

To report

How much contaminant remained in the soil at the end of calculation in scenario S0 in kg? How much contaminant left the soil in scenario S0 in kg? In which scenario was the most and second most residual contamination? Why?

Comment on the concentration in the soil. In which scenario is the concentration the highest at observation point closest to the river? Compare to other scenarios. When this peak concentration appeared.

Comment on the solute boundary fluxes. When the contaminant flows the most in the river in scenario S0? Is it via the overland flow or through the river bed? Which scenario has the highest solute boundary flux to the river?