HYDRUS 2D – úvod a ilustrativní úloha

Opakování teorie

Richards equation

$$\frac{\partial}{\partial x}\left(K_x(\theta)\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_y(\theta)\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_z(\theta)\frac{\partial h}{\partial z}\right)+\frac{\partial K_z}{\partial z}=\frac{\partial \theta}{\partial t} \quad \textbf{... in 3D}$$

$$\frac{\partial}{\partial z}\left(K(h)\frac{\partial h}{\partial z}+K(h)\right)-S=\frac{\partial \theta}{\partial t}$$

van Genuchten

$$\theta_e(h)=\begin{cases}\dfrac{1}{\left(1+(-\alpha h)^n\right)^m} & h<0\\ 1 & h\geq 0\end{cases}$$

Mualem

$$K_r(\theta_e)=\theta_e^{1/2}\left[1-(1-\theta_e^{1/m})^m\right]^2$$

Opakování teorie

$$\frac{\partial \theta}{\partial t} = -\frac{\partial q}{\partial z} - S = \frac{\partial}{\partial z}\left[K\left(\frac{\partial h}{\partial z} + 1\right)\right] - S$$

Advekčně disperzní rovnice (jak je zavedena v HYDRUSu 1D):

Sink (flow)

Reactions (decay/rozpad)

$$\frac{\partial \theta c}{\partial t} + \frac{\partial \rho s}{\partial t} = \frac{\partial}{\partial z}\left(\theta D \frac{\partial c}{\partial z}\right) - \frac{\partial qc}{\partial z} - Sc_r - \mu_w \theta c - \mu_s \rho s + \gamma_w \theta + \gamma_s \rho$$

c – solute concentration in liquid phase
s – solute concentration on solid phase

Molecular diffusion coef.

Long. dispersivity (*input*)

$$D = D_w \tau + \lambda |v|$$

Dispersion coefficient

Tortuosity factor

Mean pore velocity

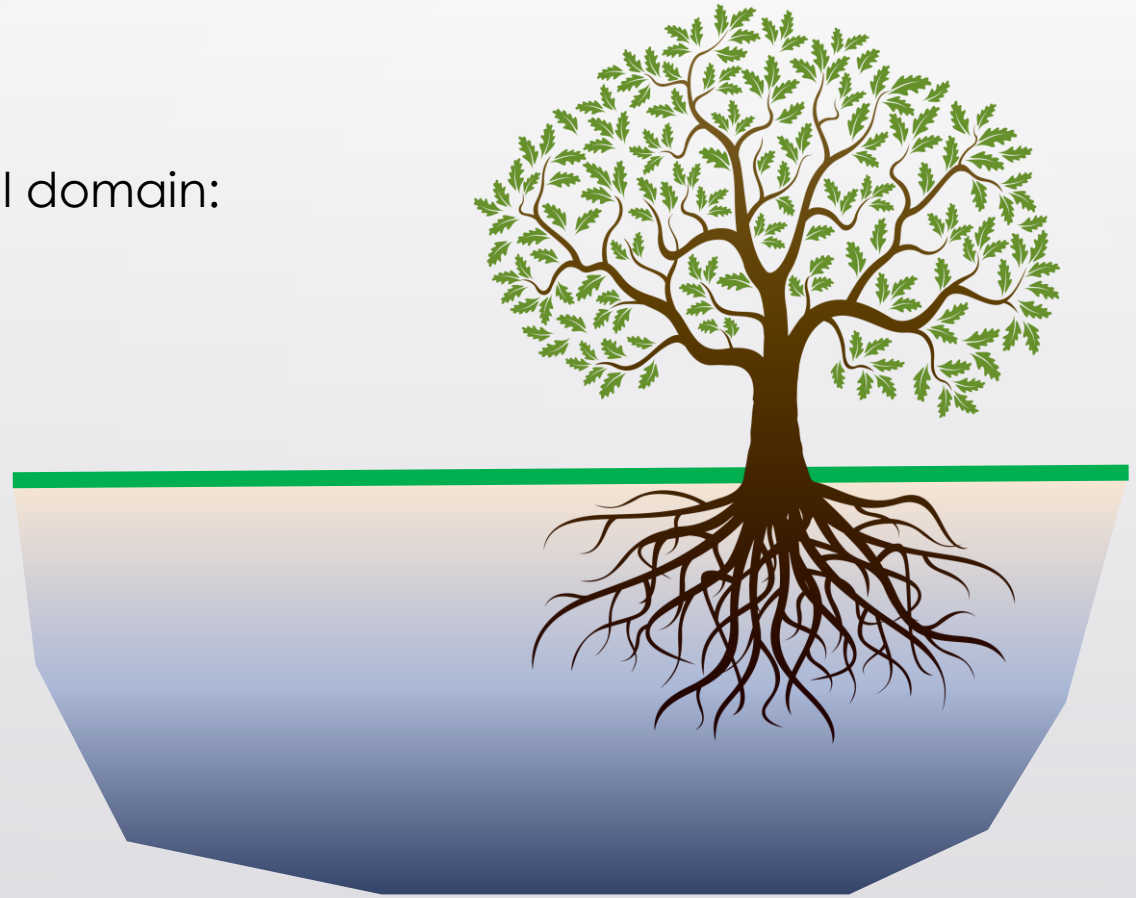
<u>Equilibrium adsorption:</u>

$$s = k_d c^\beta / (1 + \eta c^\beta)$$

Distribution coeff.

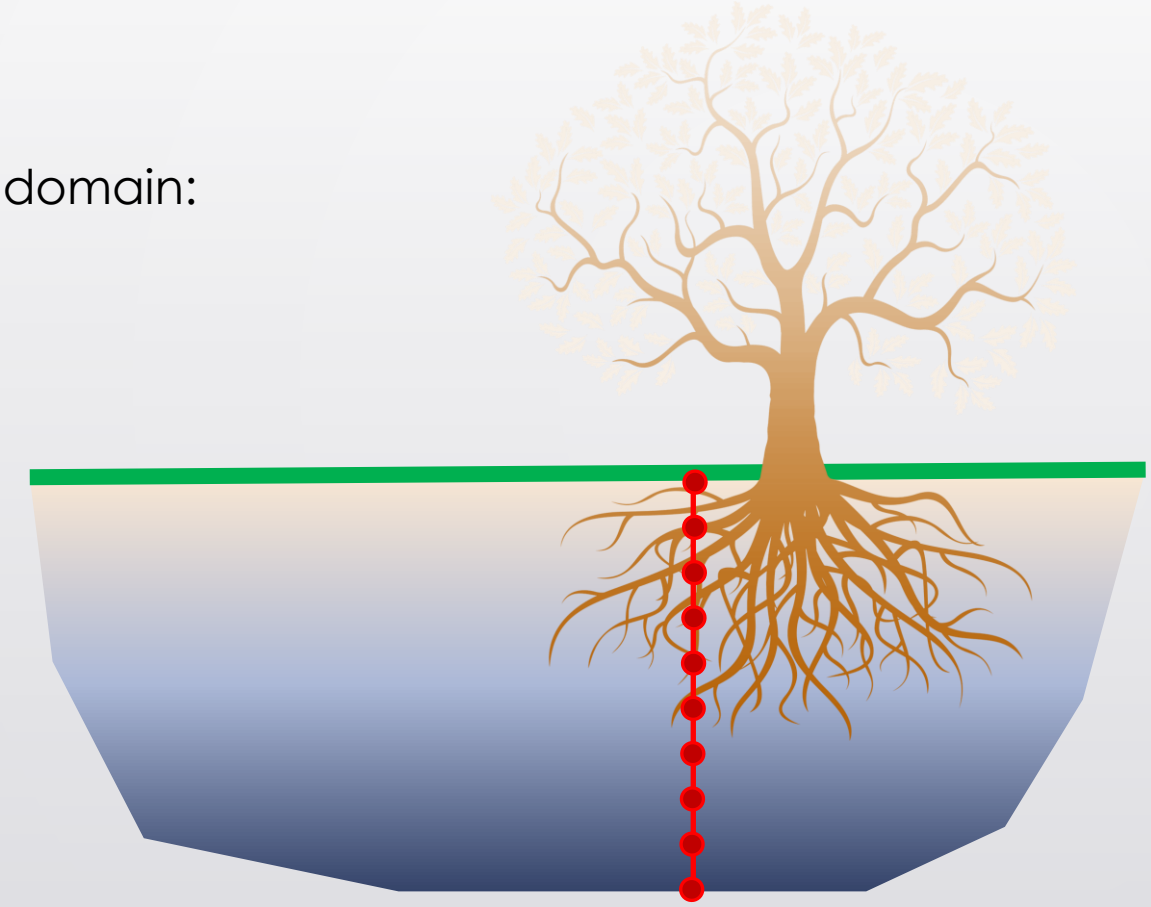
Diskretizace domény v 1D

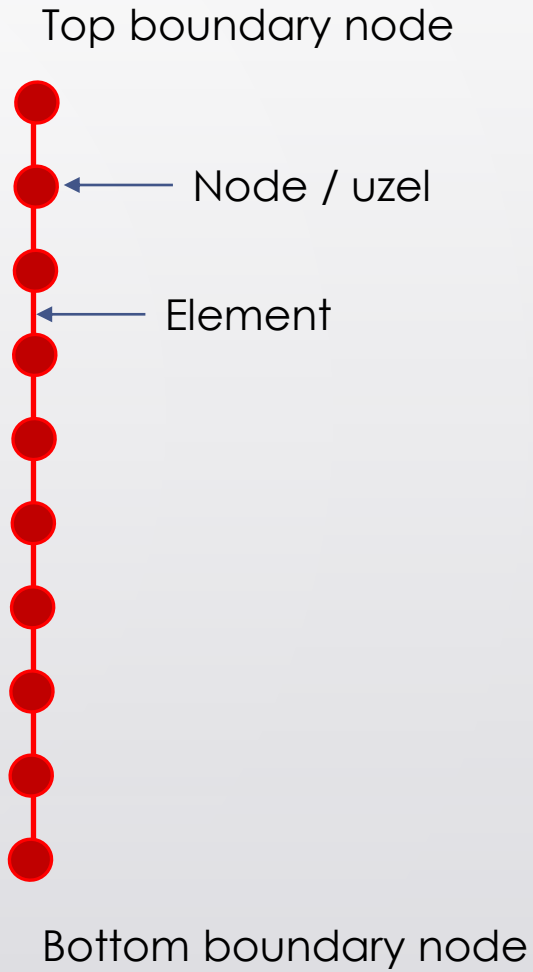
Real domain:



Diskretizace domény v 1D

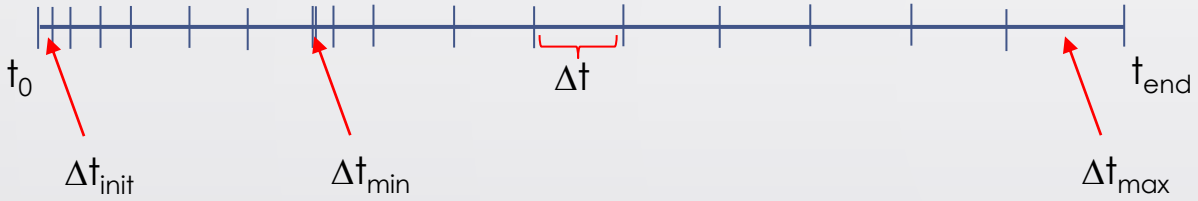
1D domain:



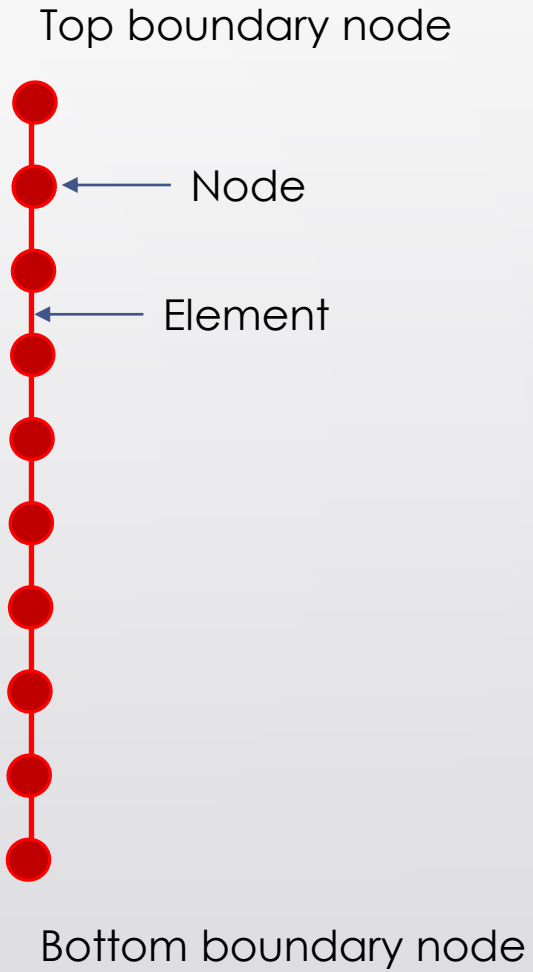


Diskretizace času

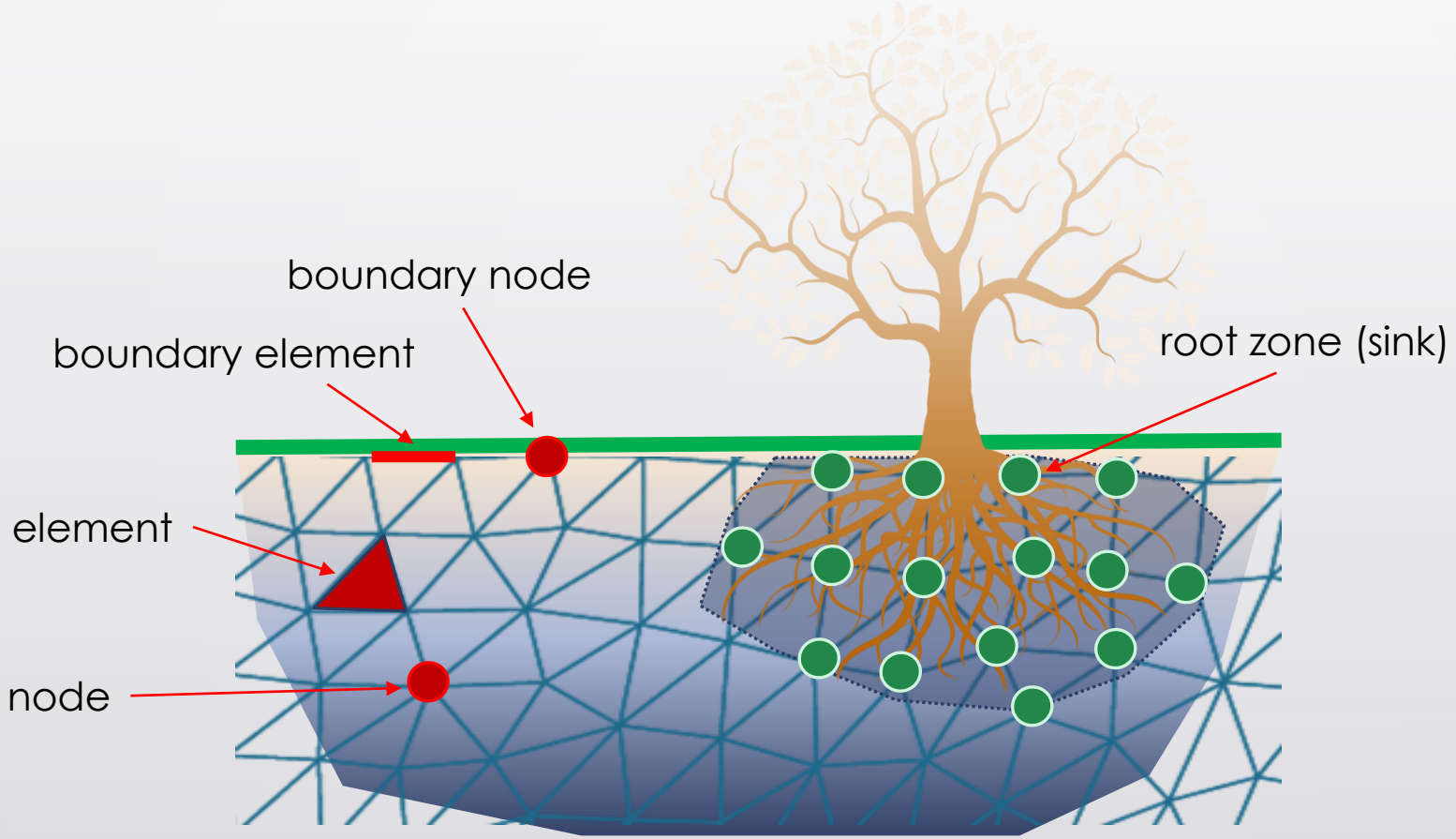
TIME:



SPACE:

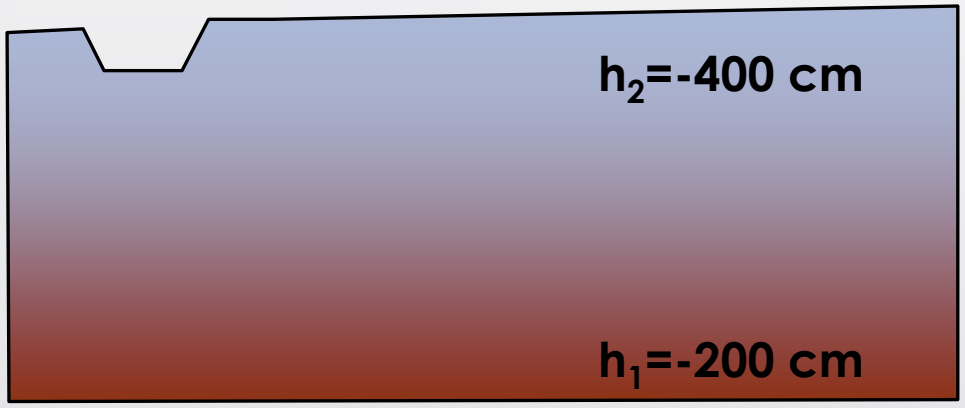


Diskretizace v 2D

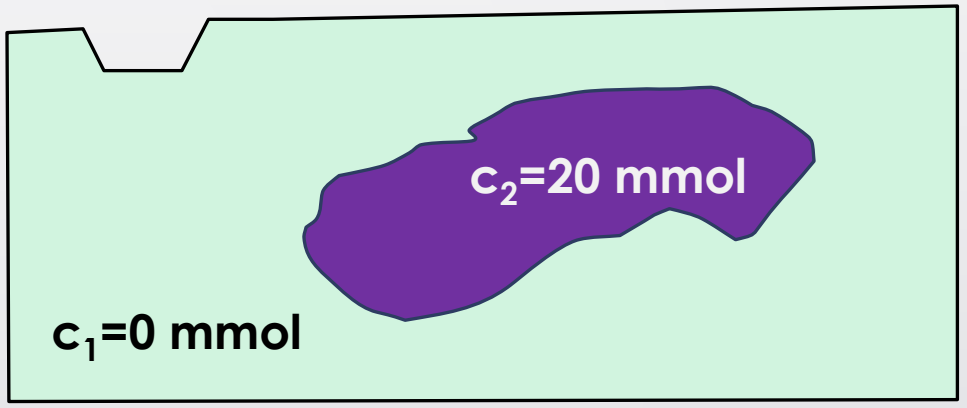


Počáteční podmínky

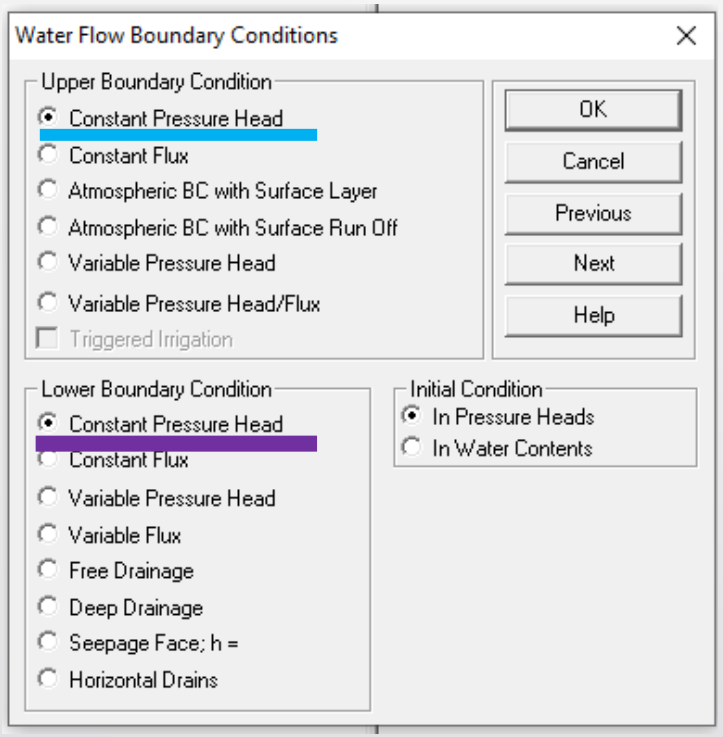
Richards eq.:
Rozložení sacího tlaku / vlhkosti

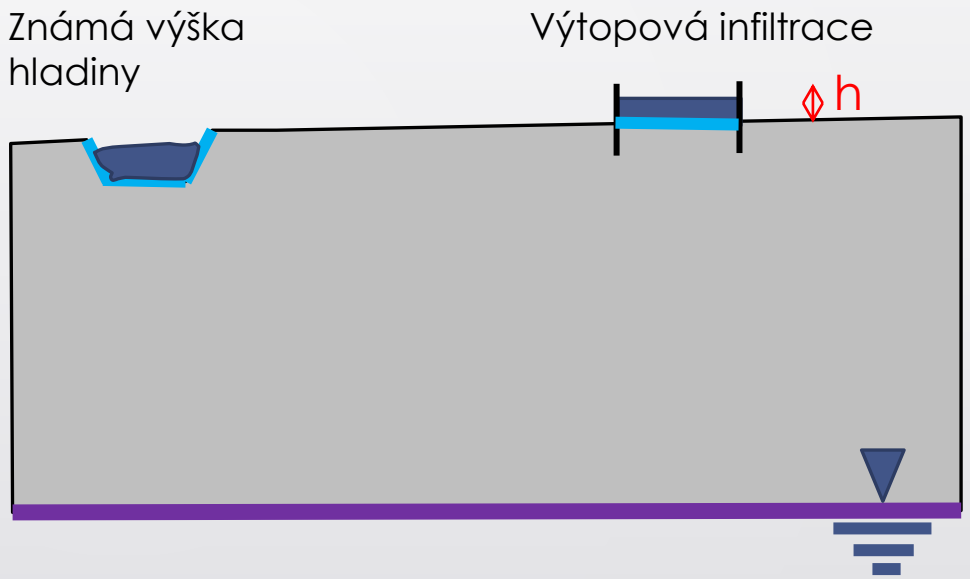


ADE:
Počáteční rozložení koncentrace

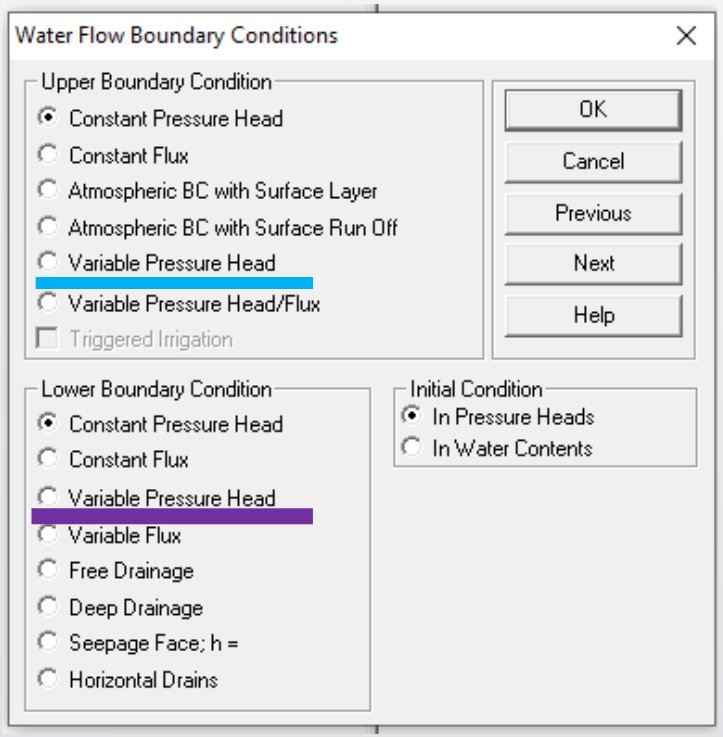


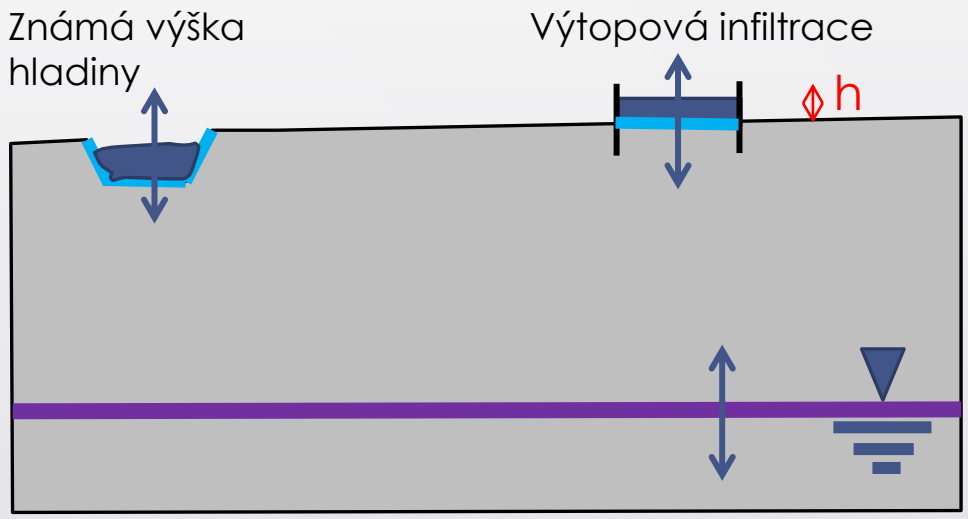
Okrajové podmínky - opakování





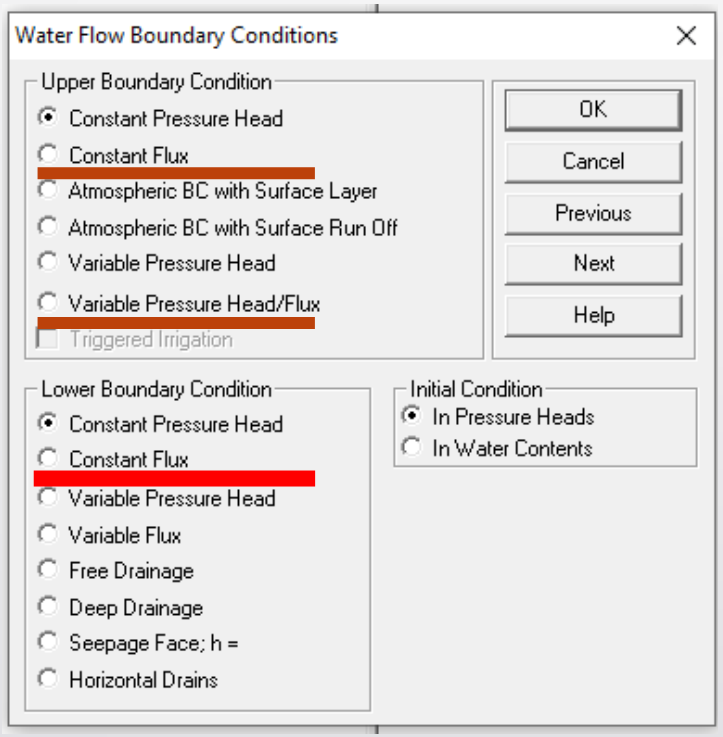
Boundary conditions

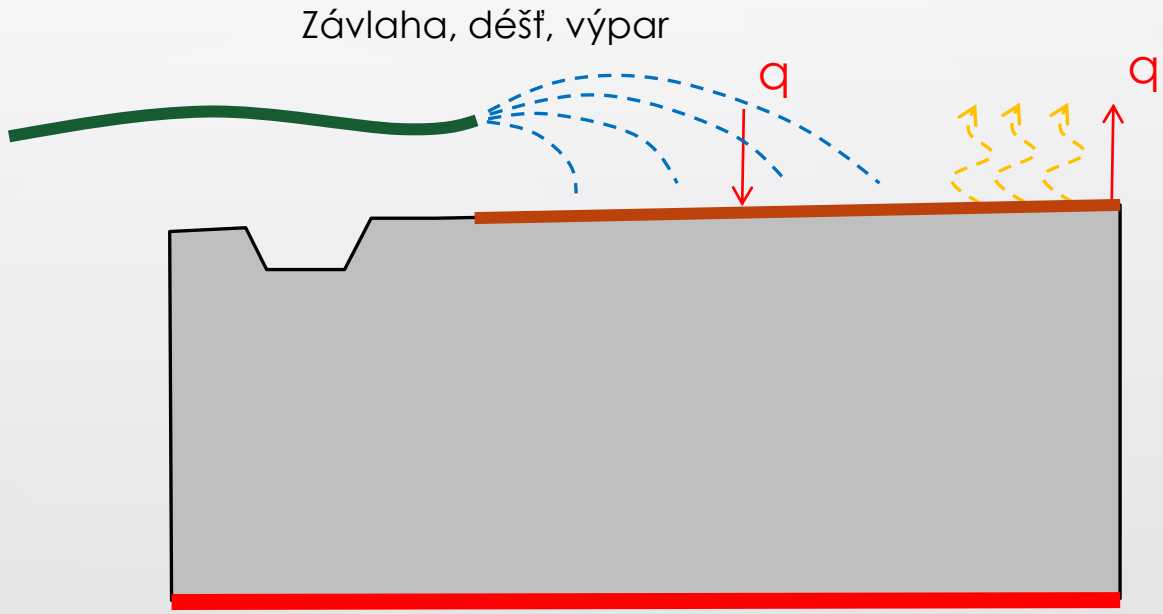




Hladina podzemní vody e.g. h = 0 cm

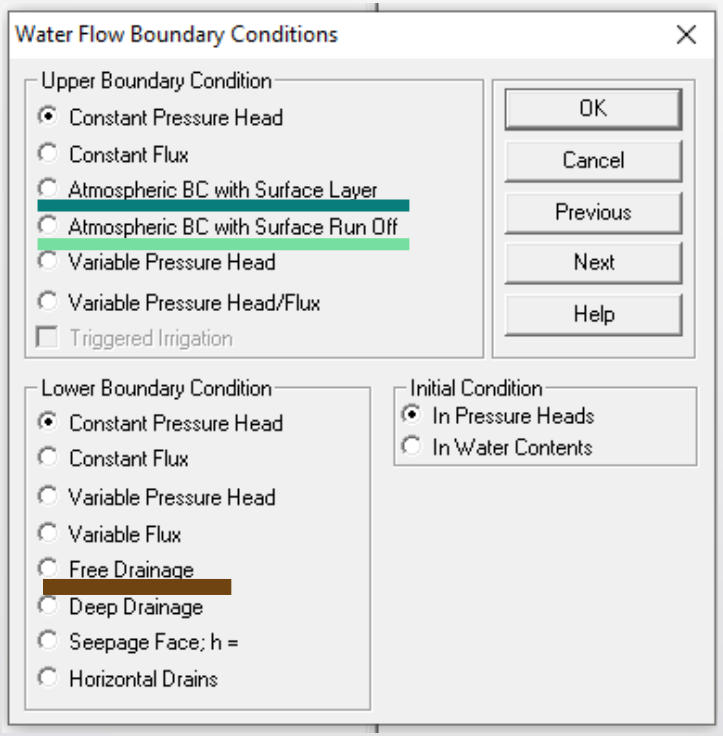
Boundary conditions

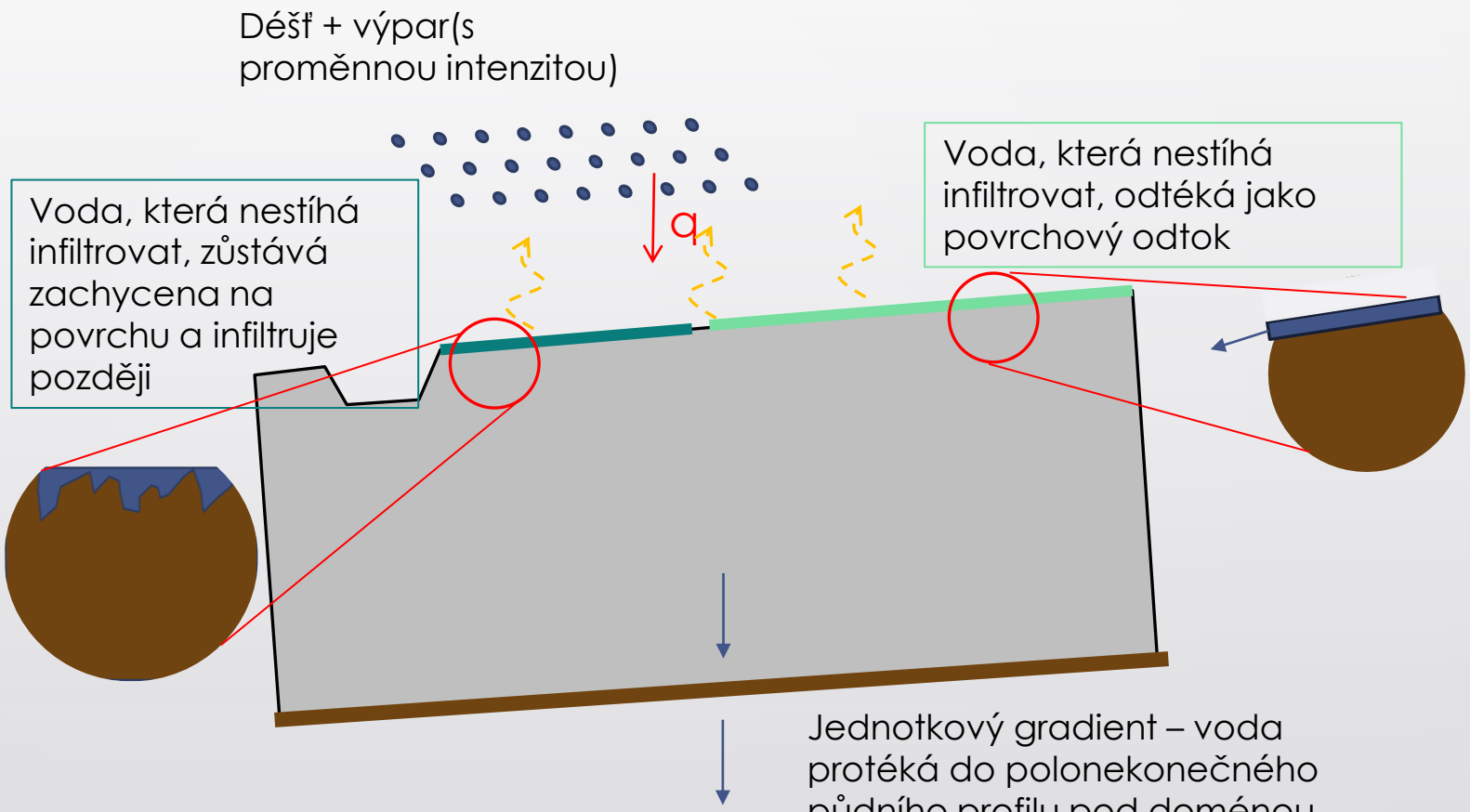




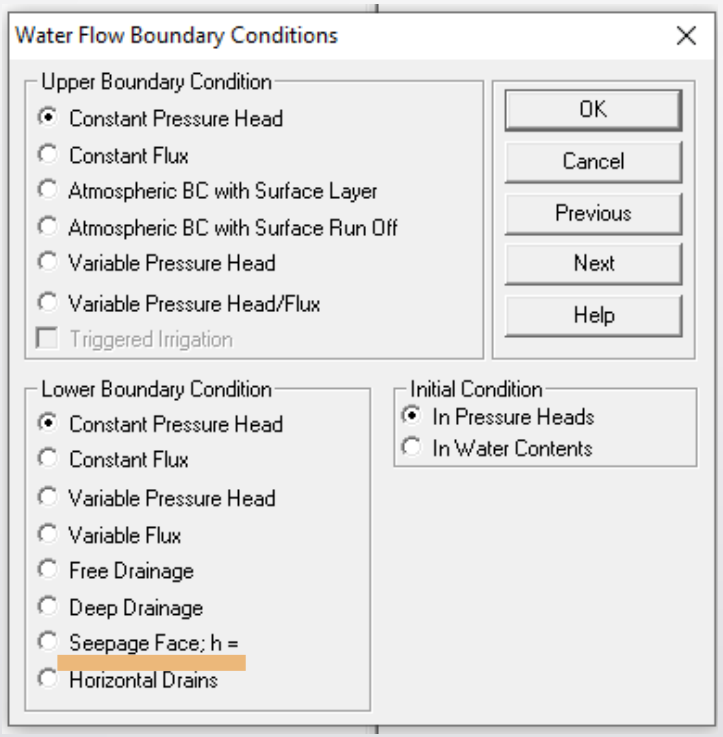
Nepropustná hranice (skála)
q = 0 cm/d

Boundary conditions

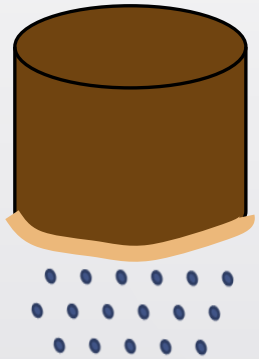




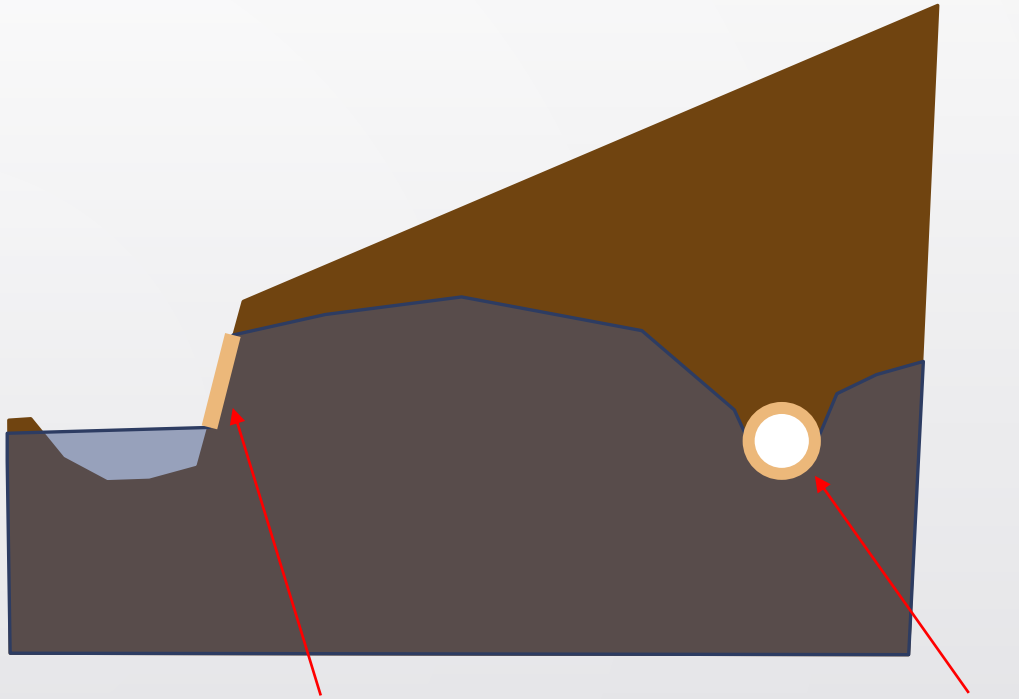
Boundary conditions



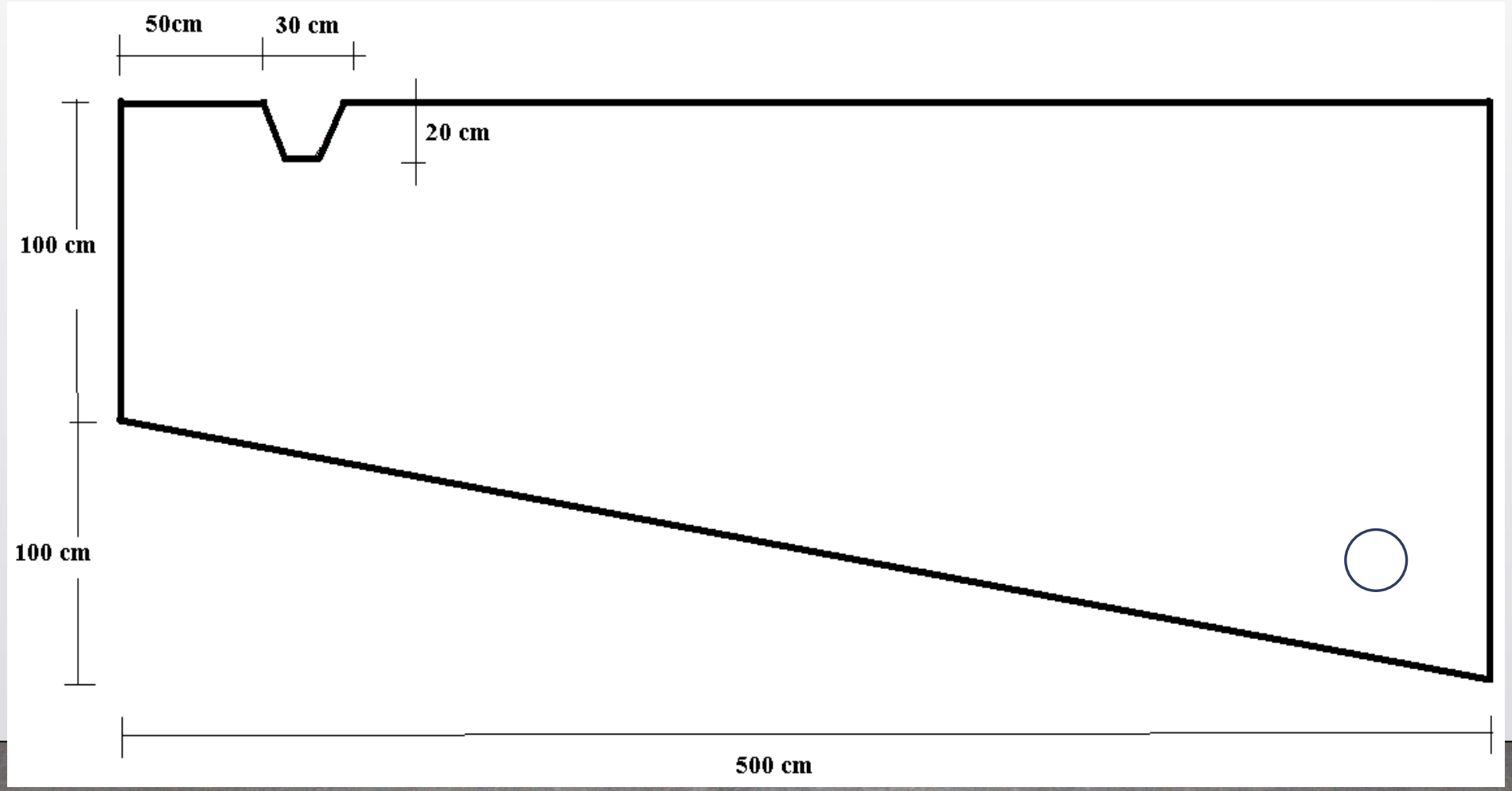
Rozhraní mezi půdou a atmosférou



Neporušený půdní vzorek



Infiltrace z příkopu do domény s nepropustným podožím

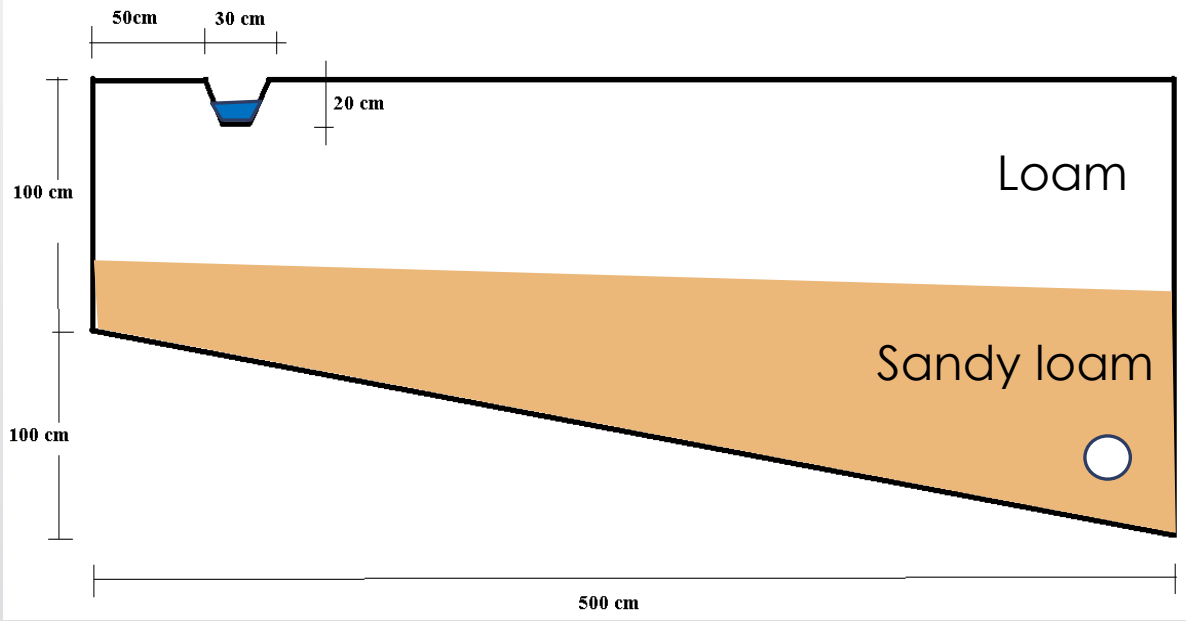


Infiltrace z příkopu do domény s nepropustným podožím

Příkop byl naplněn vodou do výšky 8 cm.
Initial conditions: pressure 0 cm at the lowest point of the domain, the rest in equilibrium
Boundary conditions: no flux – všude mimo příkop a drenáž

Duration: 50 days

Půda:
svrchní horizont: loam,
spodní vrstva: sandy loam



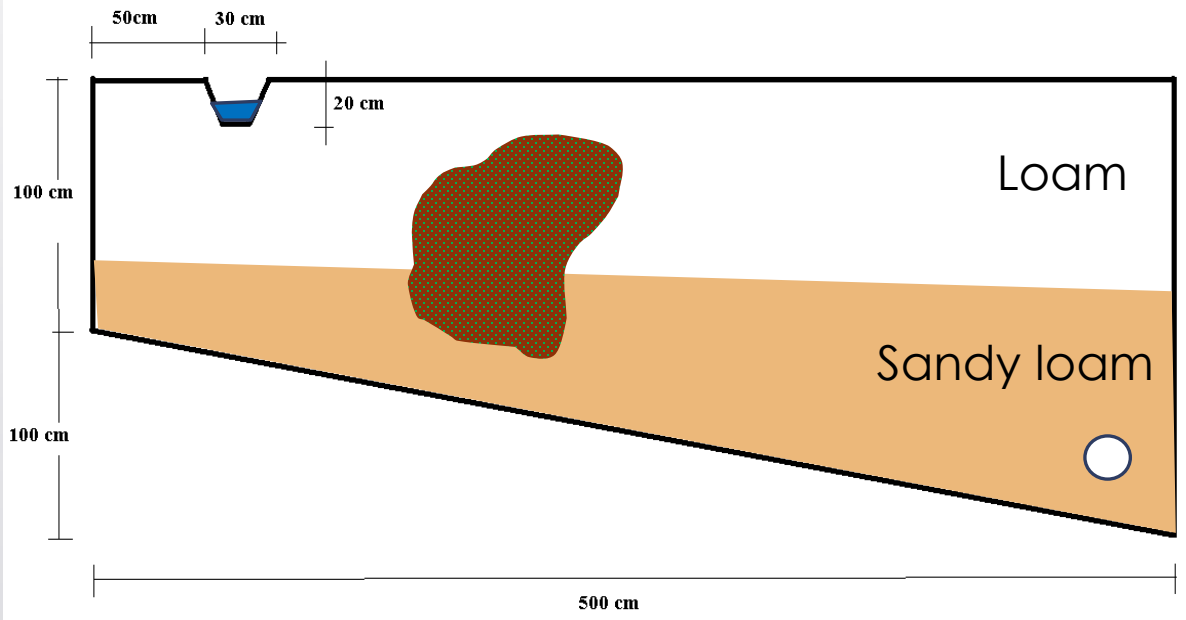
Transport:

1. Simulujte šíření konzervativního traceru, rozpuštěného ve vodě v příkopu po dobu 1 dne a koncentraci 5 mg/cm^2.
2. Uvažujte látku B, která se nacházela v doméně (umístěte kontaminant libovolně mezi příkop a drenáž). Kd = 1.1, conc. 10 mg/cm^2.

Dispersivity (v onou směrech): 40 cm
Topsoil bulk density: 1.28 g/cm^3, bottom 1.40 g/cm^3

Print information: vyberte 500 tiskových časů, s krokem 12 h

Flowing particles: vložte 5 – 15 částis(několik poblíž příkopu, zbytek libovolně)



Otázky

a/ Sledujte, jak probíhá plnění domény vodou a jak se pohybují obě znečišťující látky.

b/ Identifikujte místa s nejvyšší rychlostí proudění.

c/ Jaké množství vody a sledovaných látek se do domény infiltrovalo a doméno opustilo drénem po 10 a 50 dnech?

d/ Kolik kontaminantu zůstalo v doméně na konci simulace?