HWRS 505: Vadose Zone Hydrology

Lecture 17

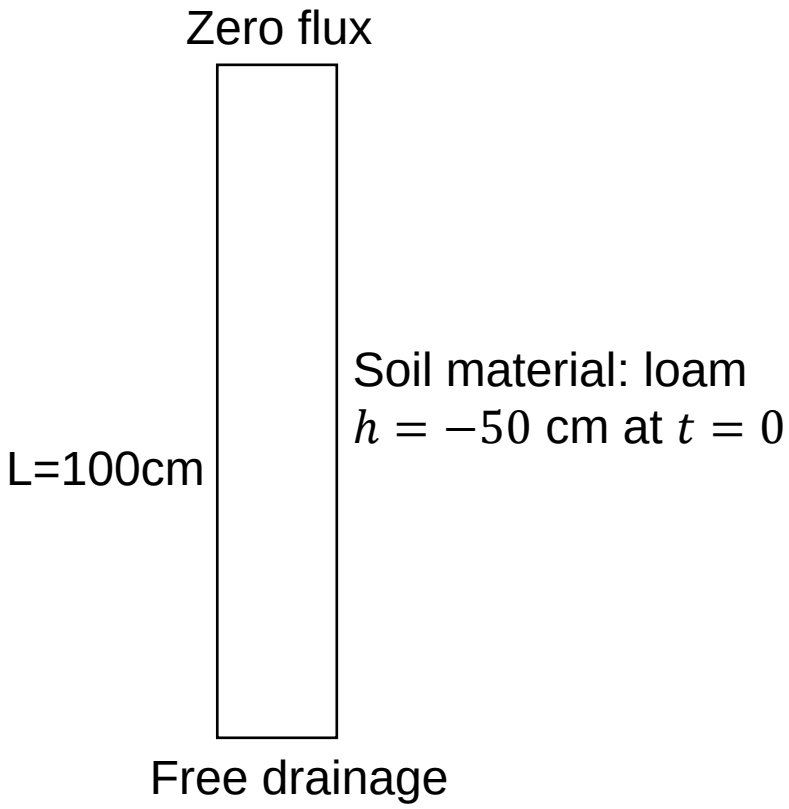
10/19/2023

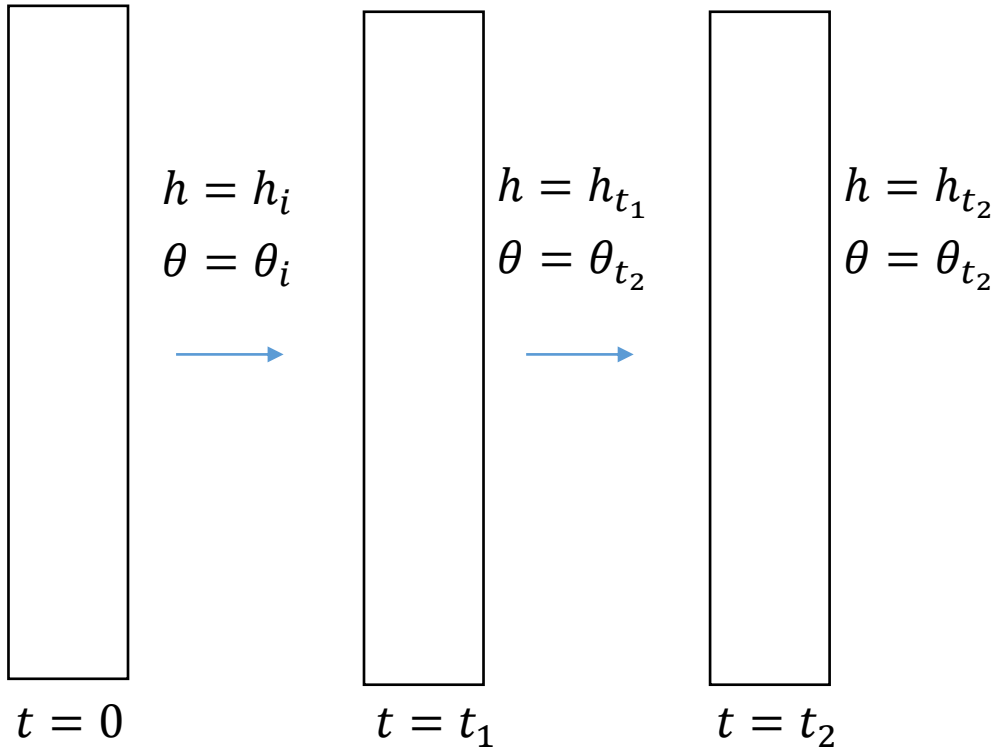
Today:

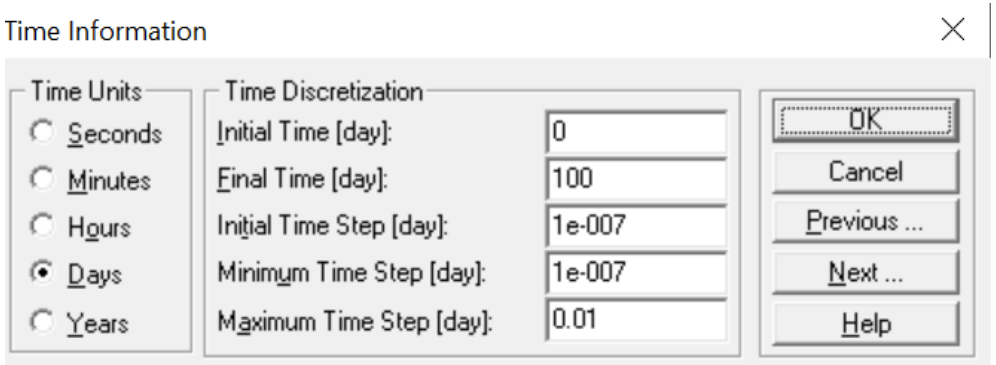
1. 2D Transient unsaturated flow

Another HYDRUS-1D exercise (will be in HW4)

Question: Is the "unit gradient" a reasonable assumption during drainage?



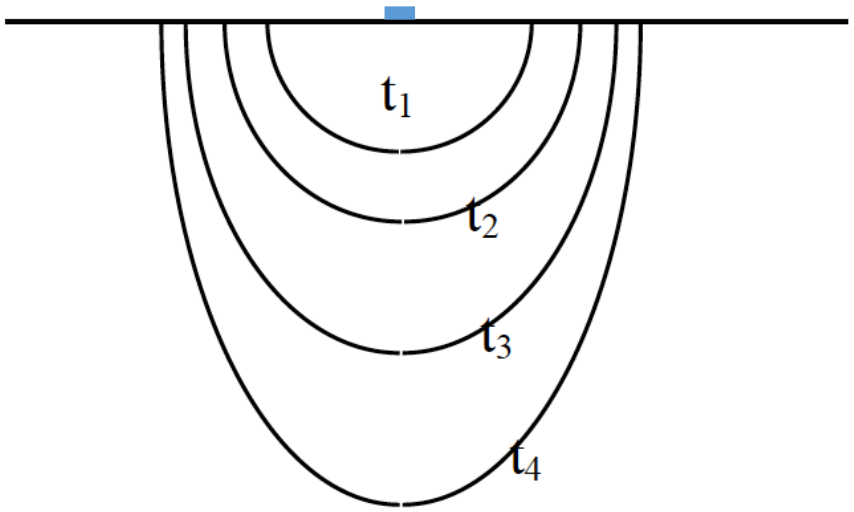




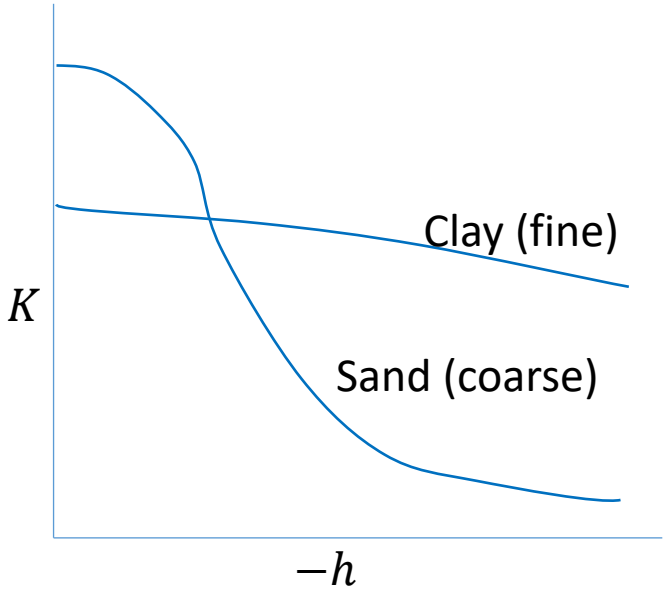
Note: "unit gradient" means flow is only driven by gravity

$$q = -K\left(\frac{\partial h}{\partial z}^{0} + 1\right) = -K$$

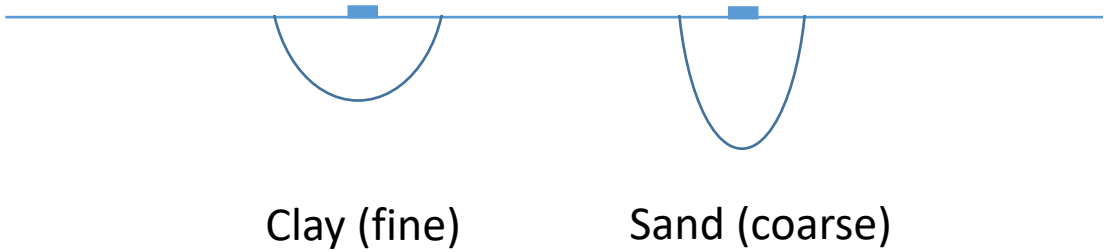
Infiltration from a Point Source



Horizontal flow: driven by capillary pressure
Vertical flow: driven by capillary pressure and gravity

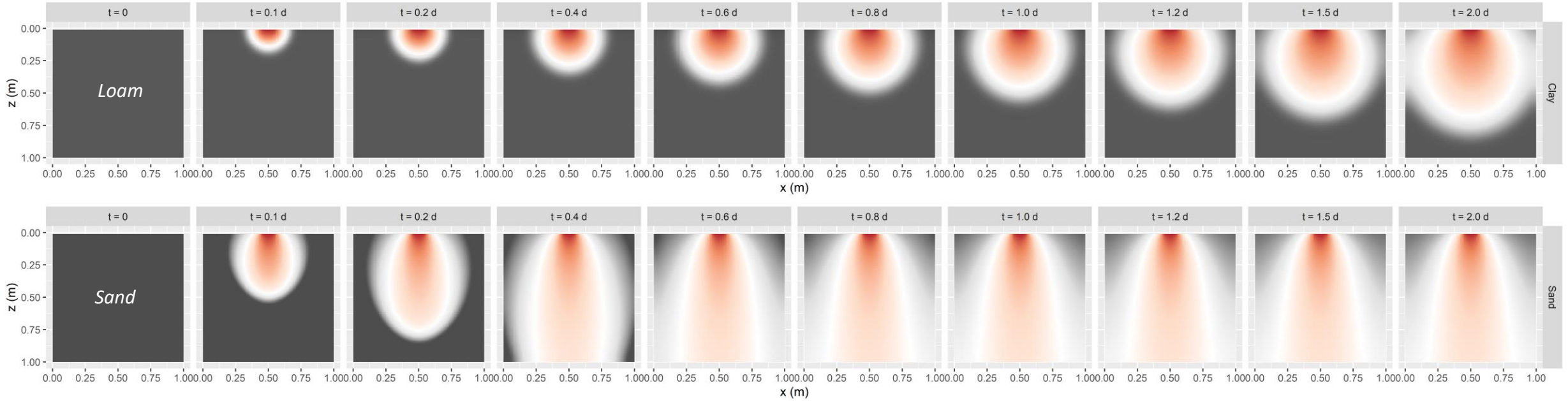


***Question**:* How will the wetted "bulb" be different for sand and clay?

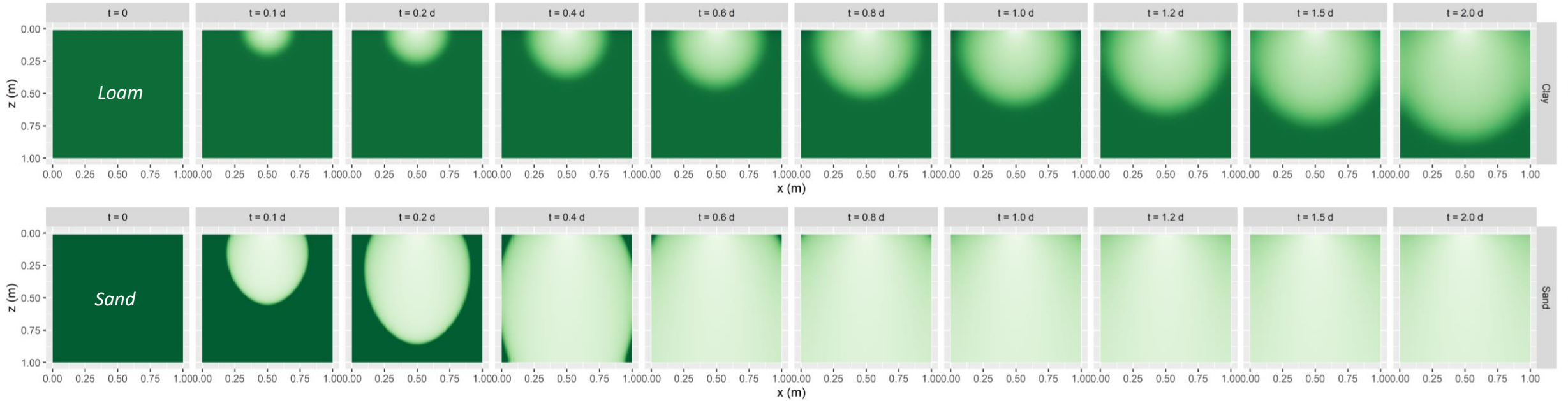


- Capillary pressure driven flow is stronger in clay

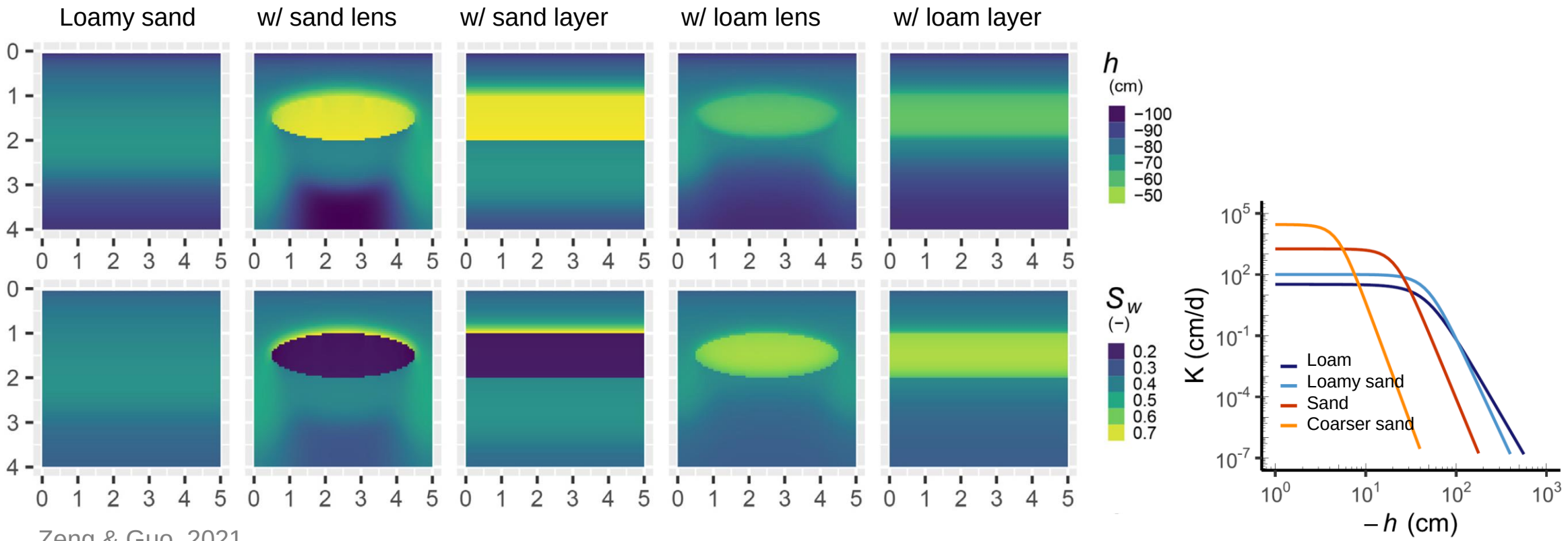
S_w


t = 0
t = 0.1 d
t = 0.2 d
t = 0.4 d
t = 0.6 d
t = 0.8 d
t = 1.0 d
t = 1.2 d
t = 1.5 d
t = 2.0 d
Loam
Sand
z (m)
x (m)
Clay
Sand
S_w (-)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2

h


t = 0
t = 0.1 d
t = 0.2 d
t = 0.4 d
t = 0.6 d
t = 0.8 d
t = 1.0 d
t = 1.2 d
t = 1.5 d
t = 2.0 d
Loam
Sand
z (m)
x (m)
Clay
Sand
h (cm)
-40
-60
-80
-100

Uniform infiltration in the presence of heterogeneity

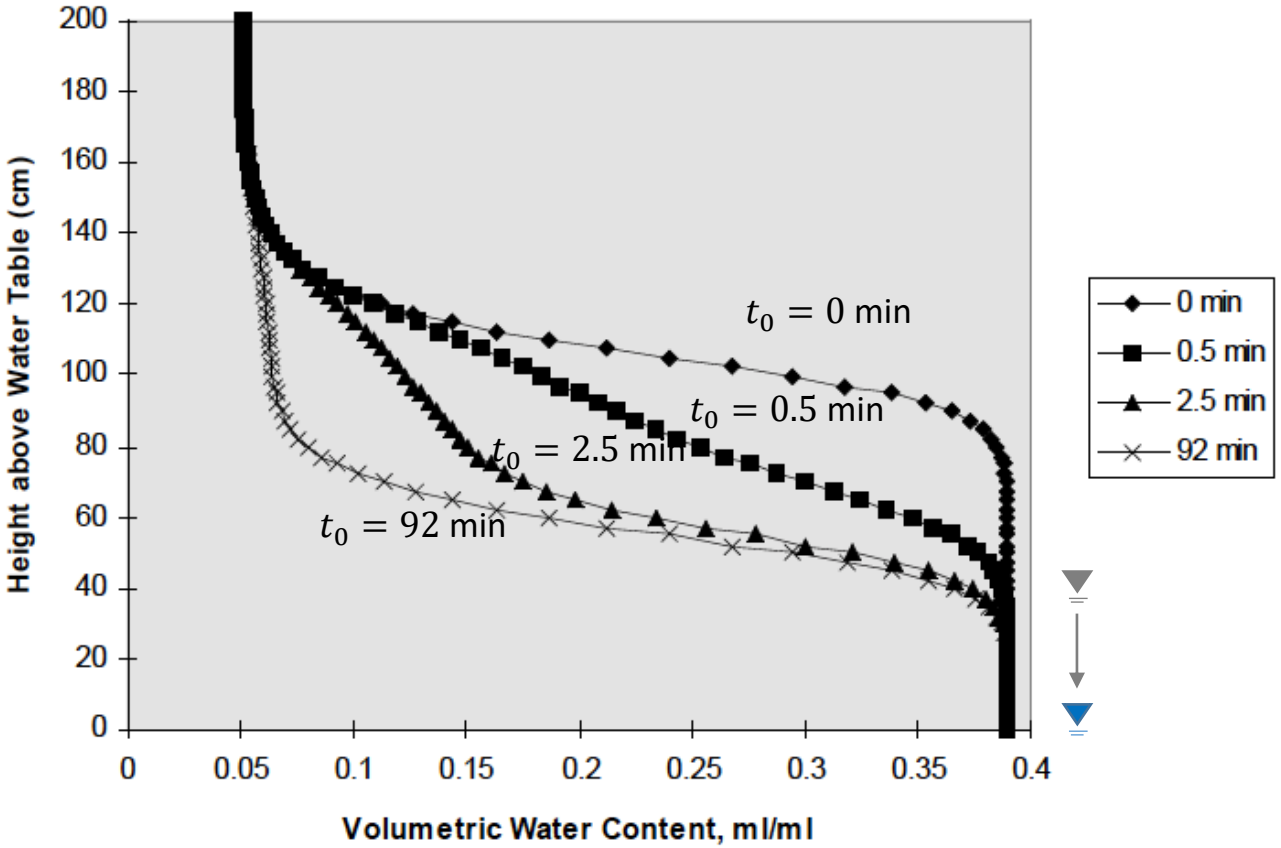


Zeng & Guo, 2021

- Both sand and loam act as a barrier for water flow in loamy sand, but the mechanisms are different.
- Sand acting as a barrier generates preferential flow on the side (the so-called “funnel flow”). See Chapter 4 of Jury & Horton.

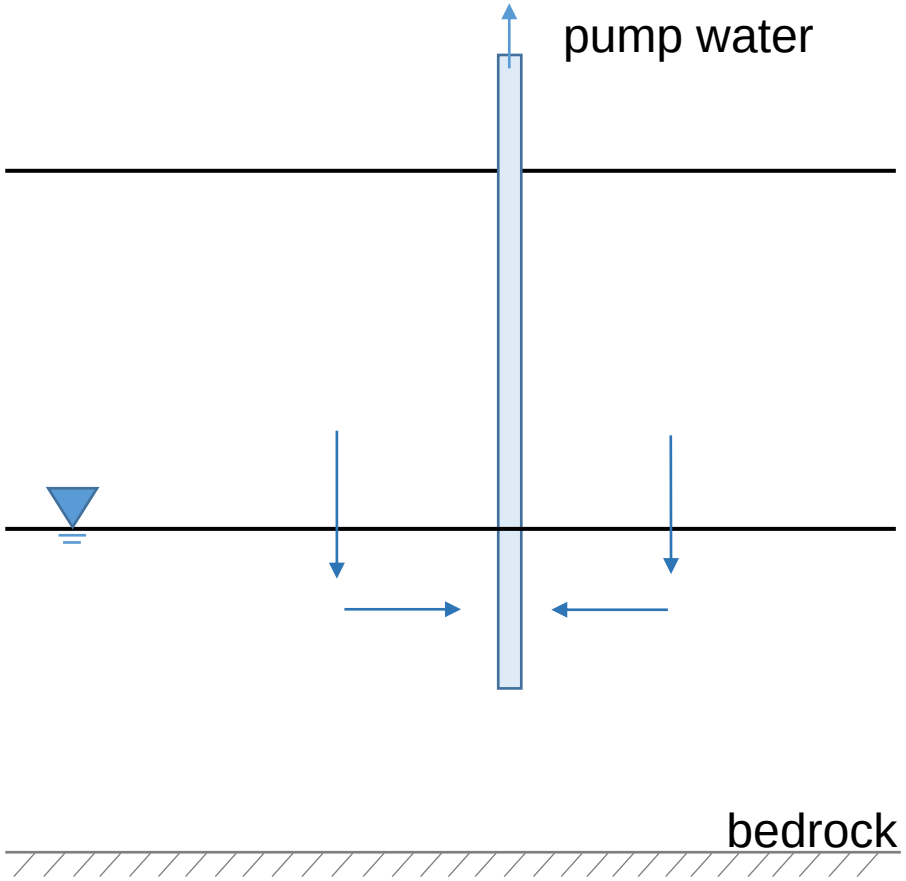
Delayed Drainage

1-D delayed drainage modeling for Borden aquifer parameters

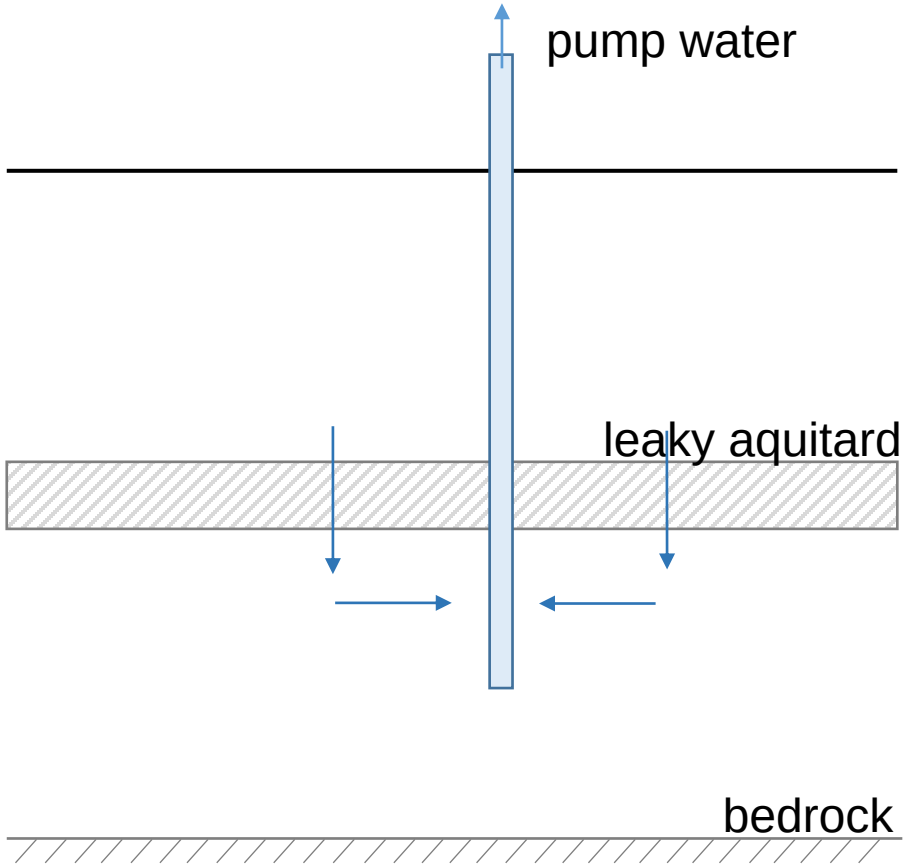


There is a time scale involved for unsaturated water to respond to change in water table

Pumping Tests: Unconfined Aquifers



Unconfined aquifer



Confined aquifer w/ leaky aquitard

Pumping Tests: Unconfined Aquifers