LNAPL Transmissivity characterization and follow-up along a remediation project

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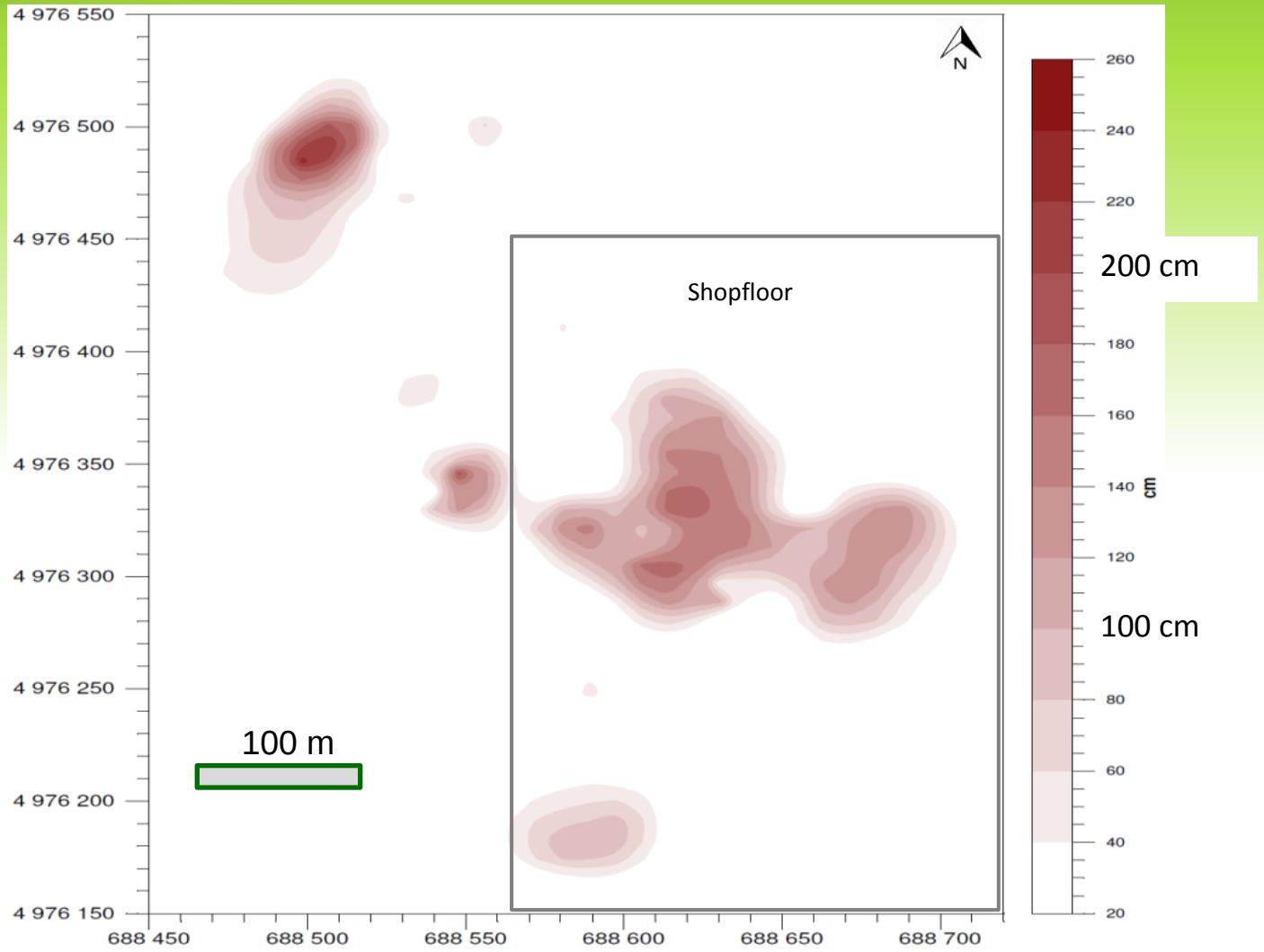
Site

- Old automotive industry with 4 main LNAPL lenses of cutting and hydraulic oil
- Floating phase surface is approximately 15 000 m²
- Oil thickness ranging from few centimetres to 2,5 m
- Sandy/gravel aquifer around 15 m thick
- Water level seasonal : -2 and -3,5 m below ground level
- water permeability Kw ≈ 2,88.10-4 m/s
- 300 wells , 100 are located in the oil phases

Oil thickness



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Objectives

- Which technique ?
- How many wells ?
- How long time ?

(Indeed, how much money ?)

Here a focus on skimming

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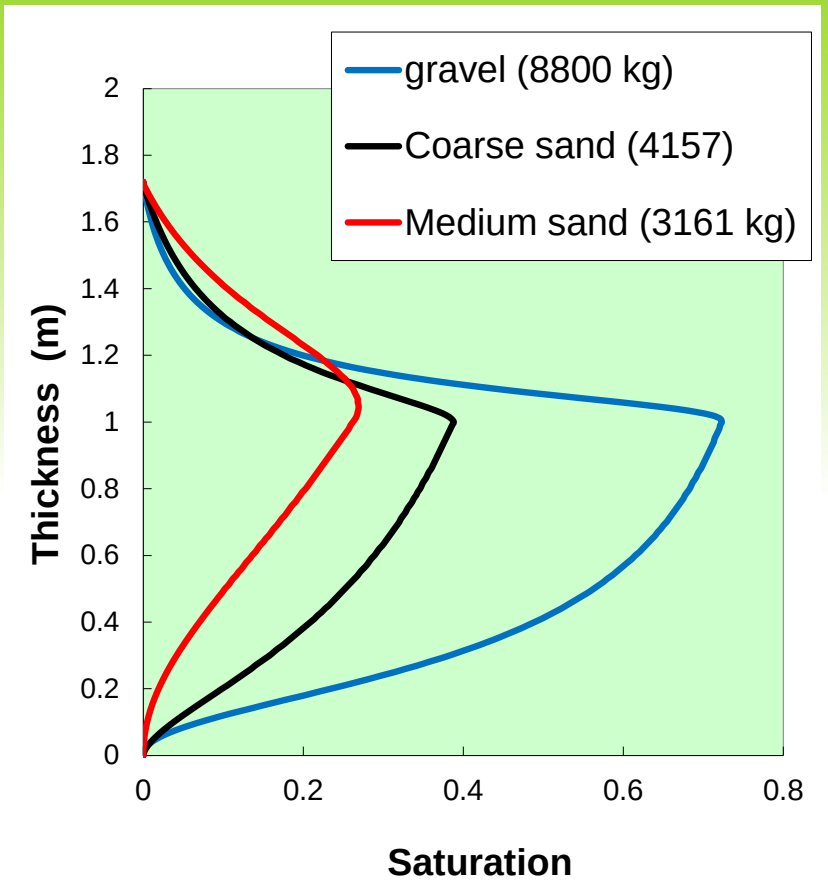
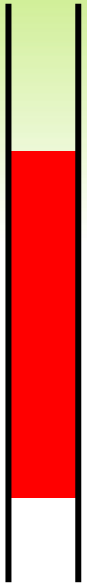
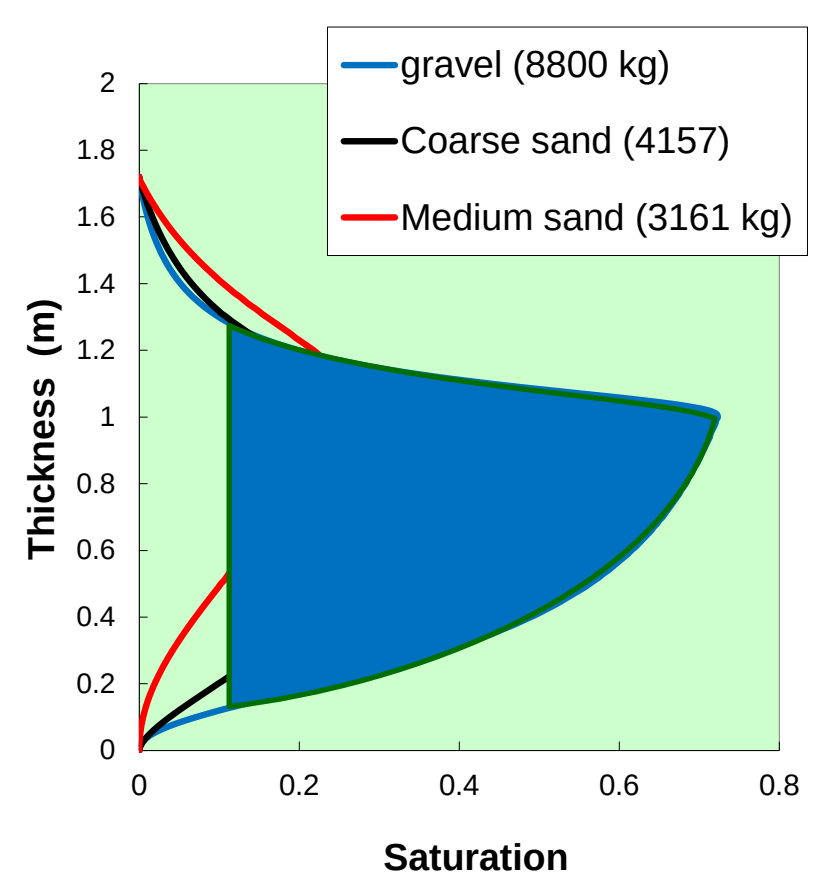
Saturation, mobility vs height



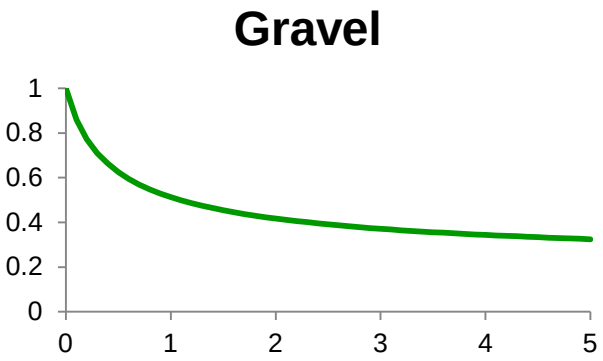


API-LNAPL

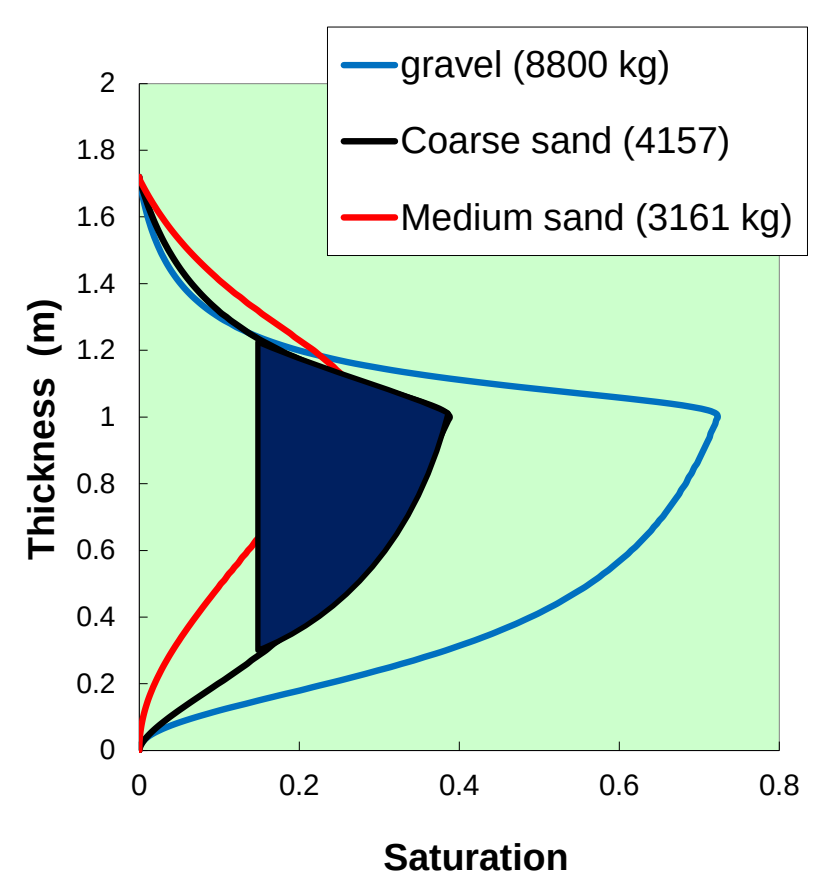
Saturation, mobility vs height



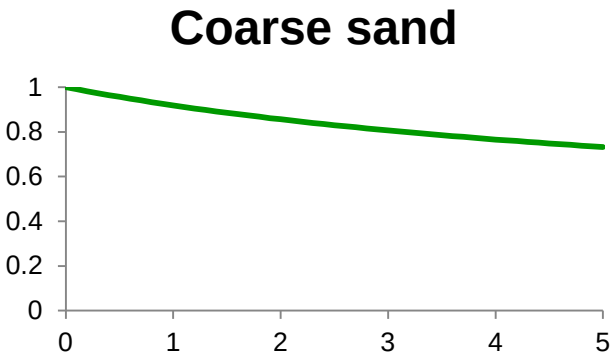
77 % volume extractible
Kw : 100 m/d
Ko : 0.28 m/d



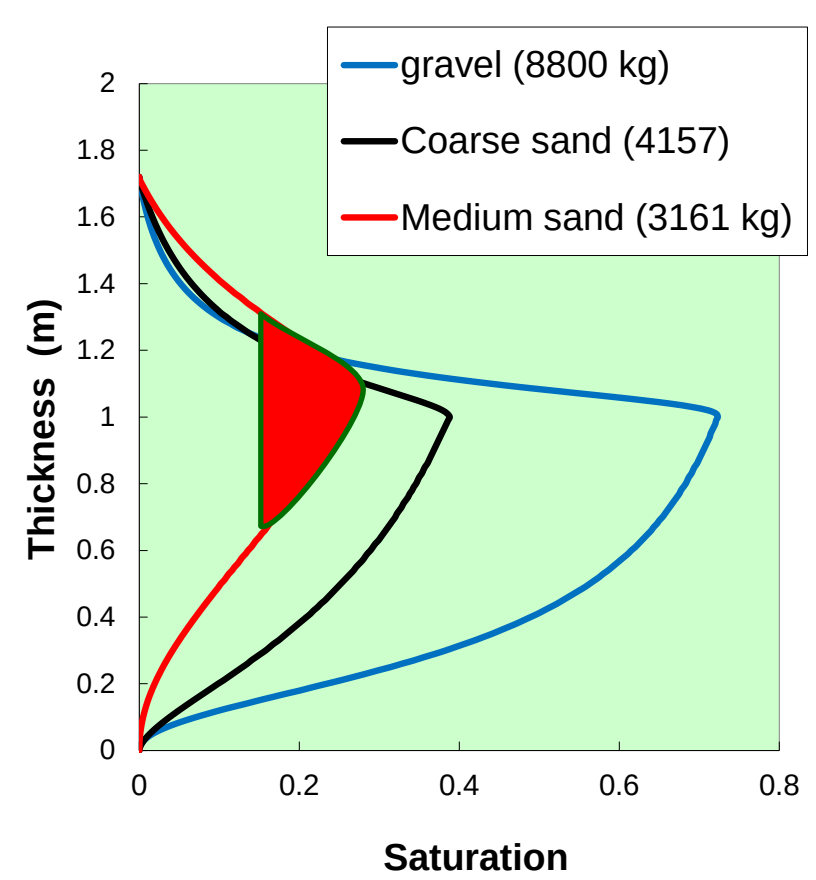
Saturation, mobility vs height



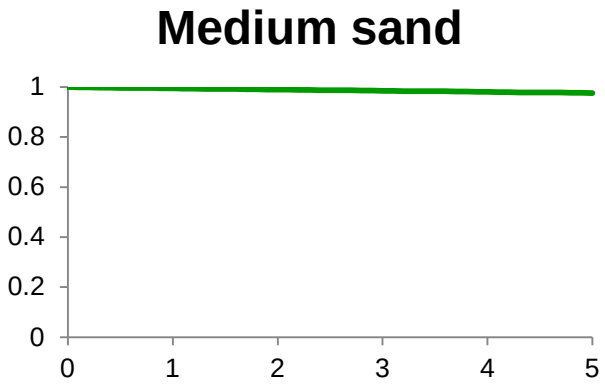
41 % volume extractible
Kw : 11.6 m/d
Ko : 0.09 m/d



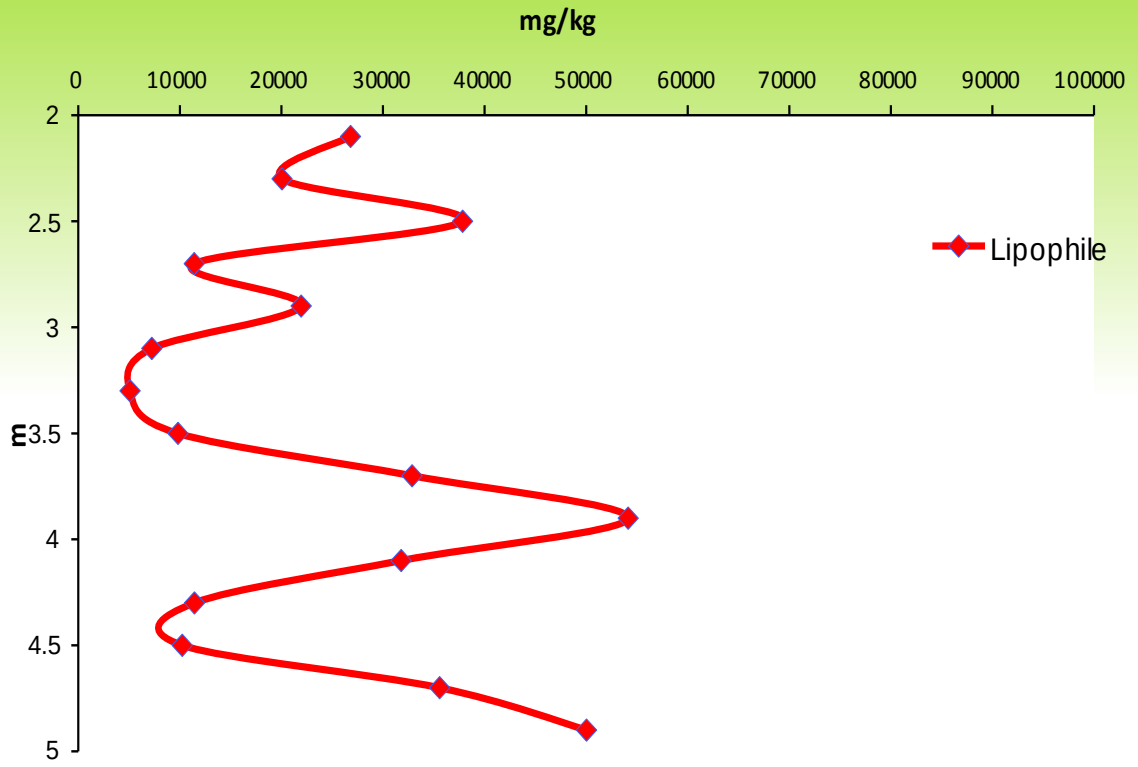
Saturation, mobility vs height



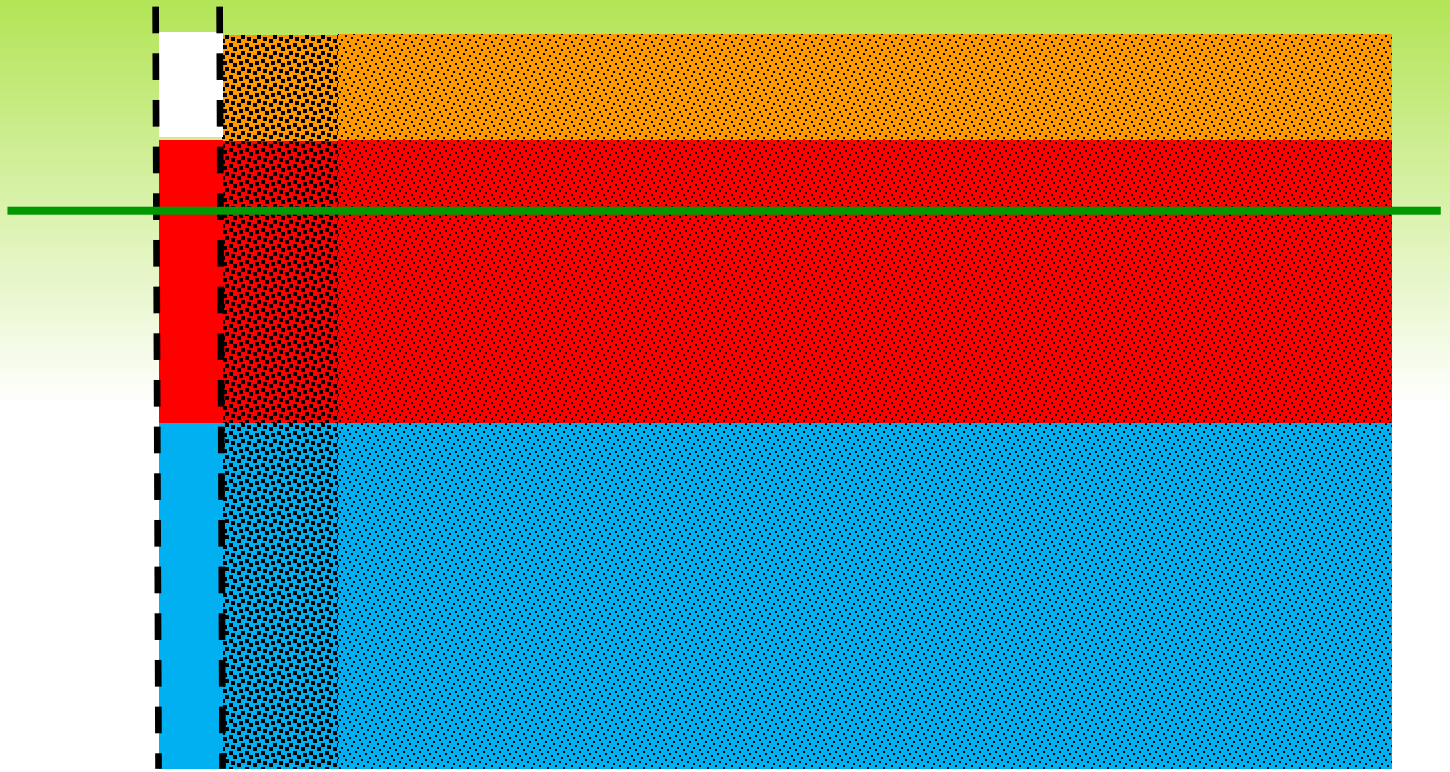
22 % volume extractible
Kw : 7.3 m/d
Ko : 0.05 m/d



Measured saturation profile…



Mobility : Bail-down test



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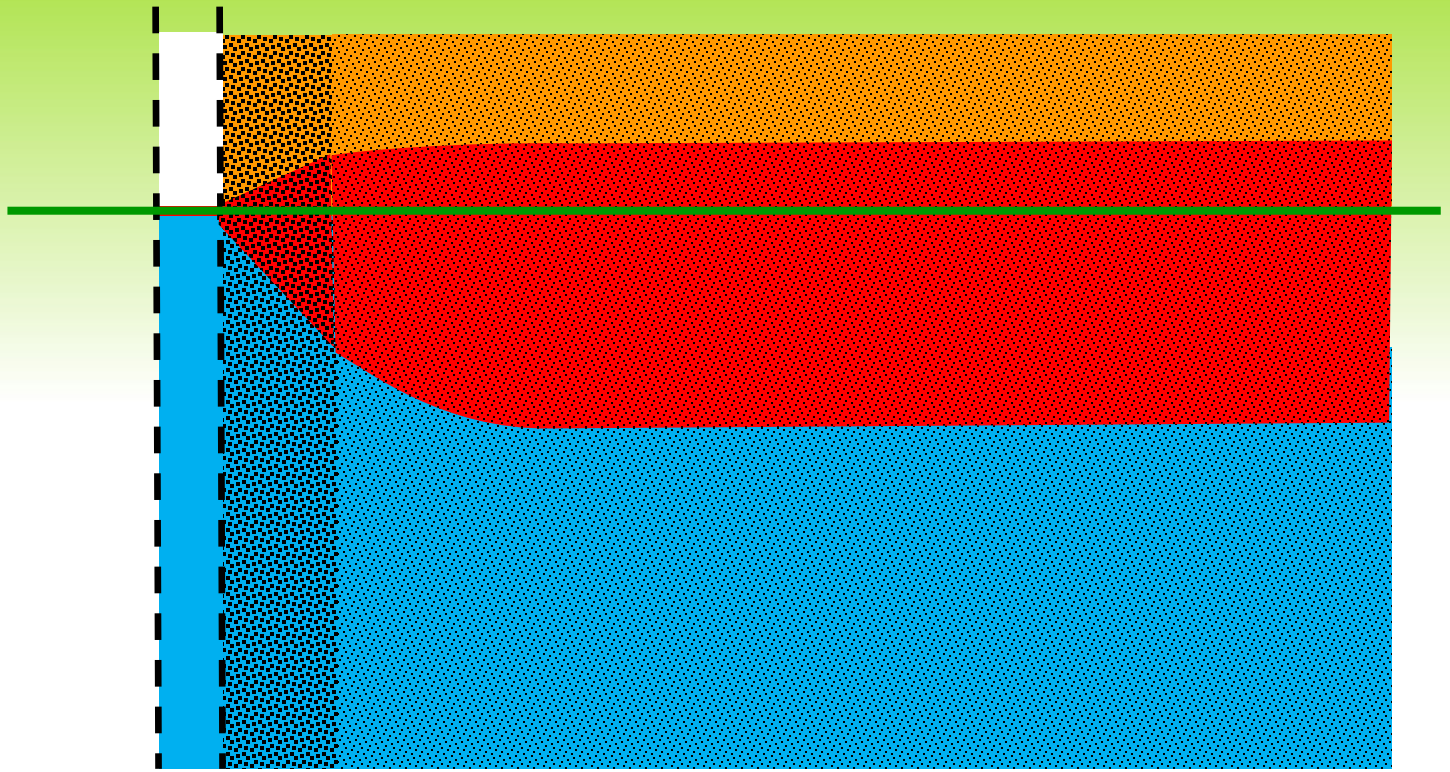
Mobility : Bail-down test



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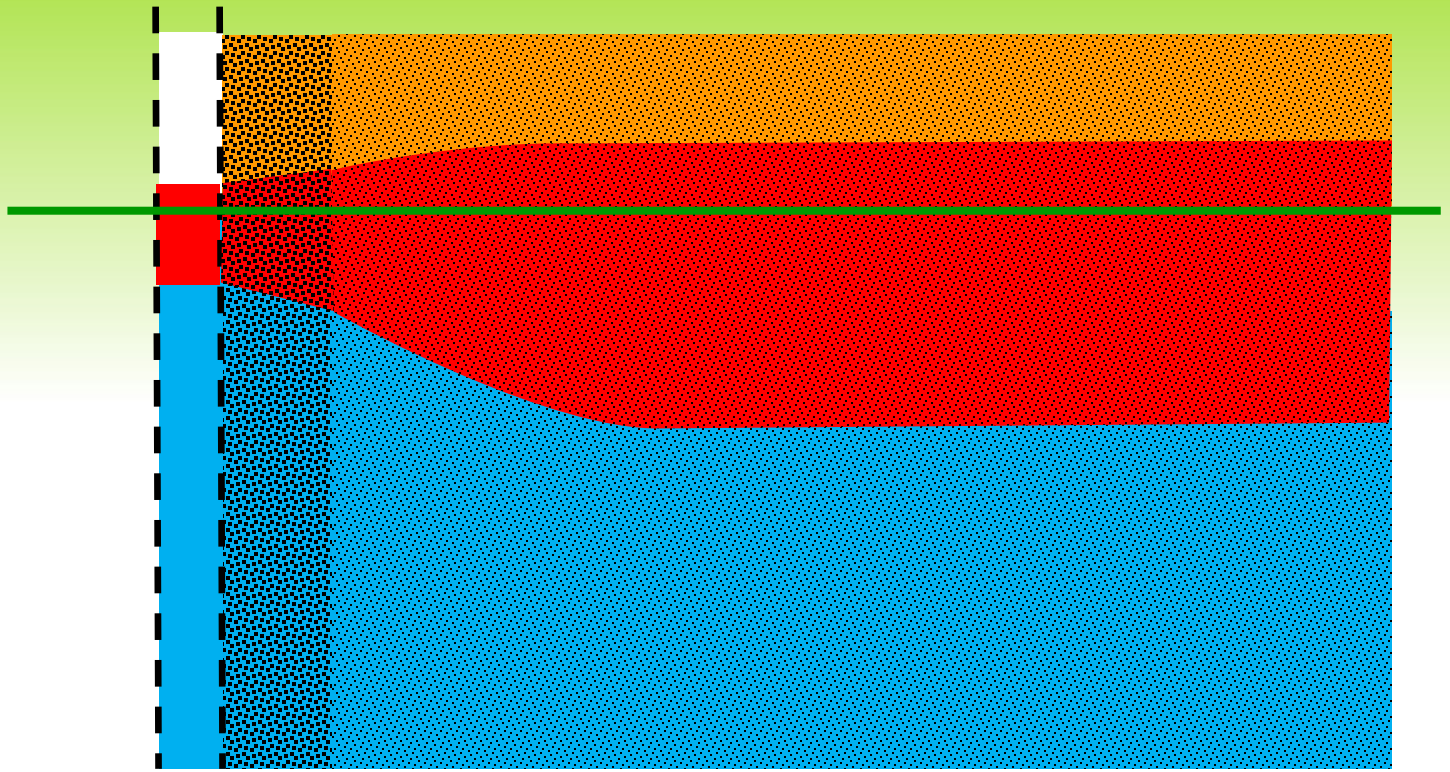
Mobility : Bail-down test



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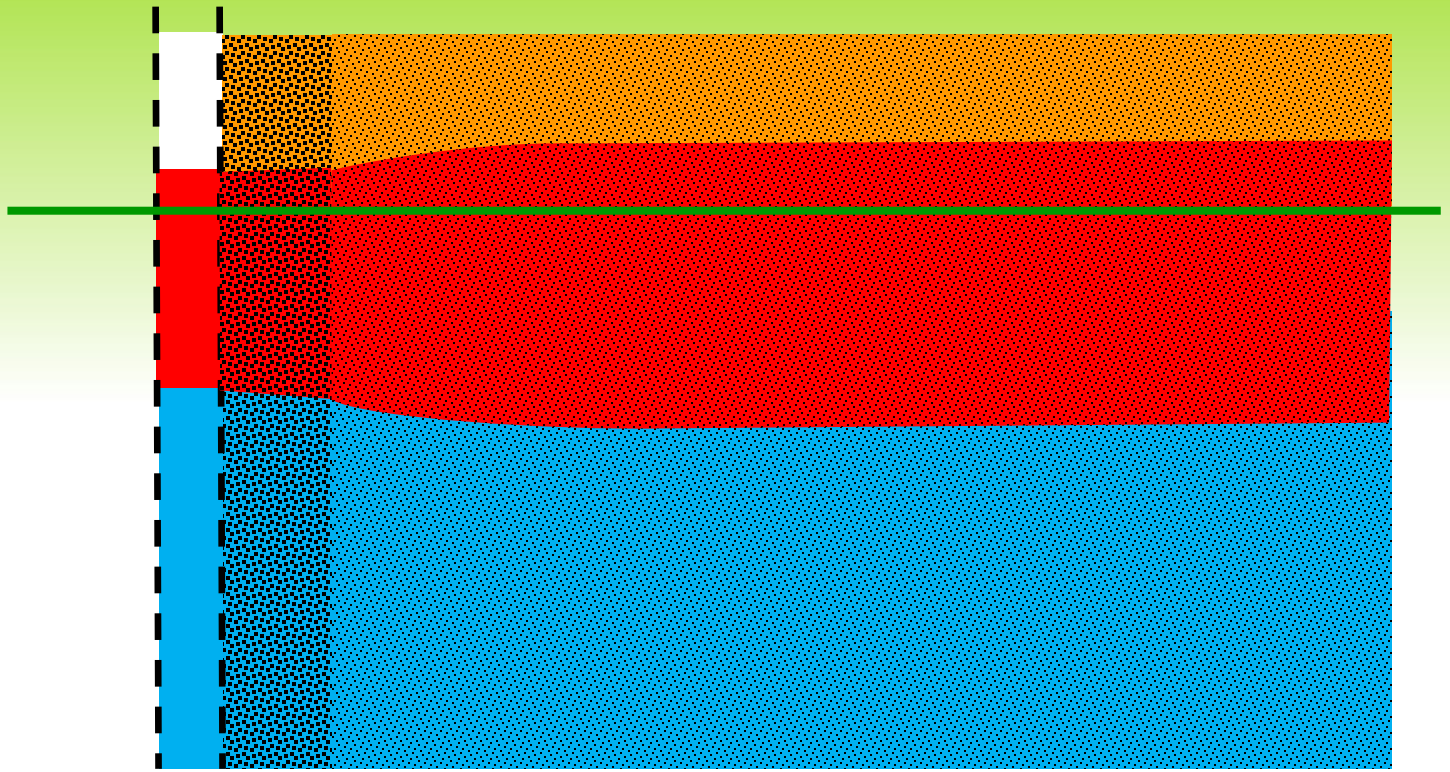

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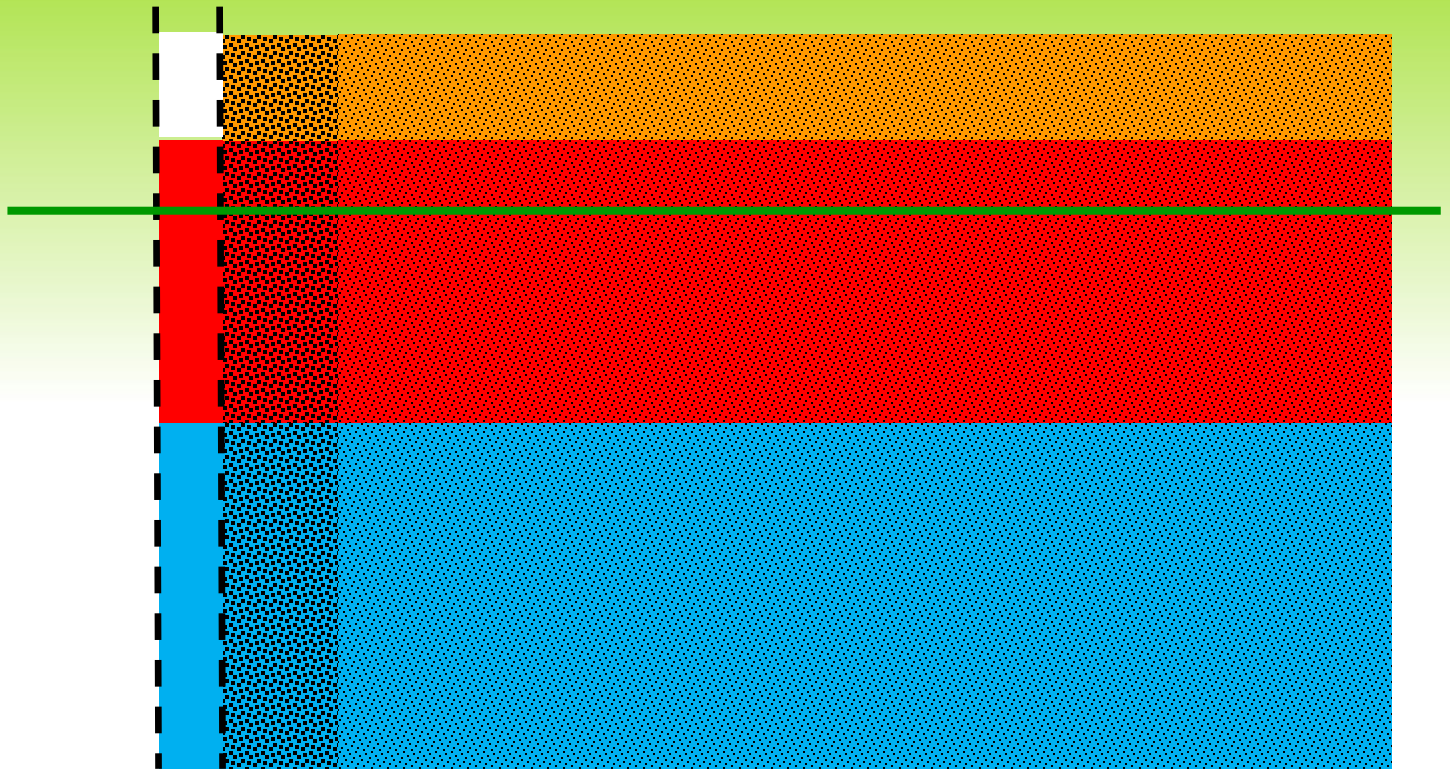
Mobility : Bail-down test



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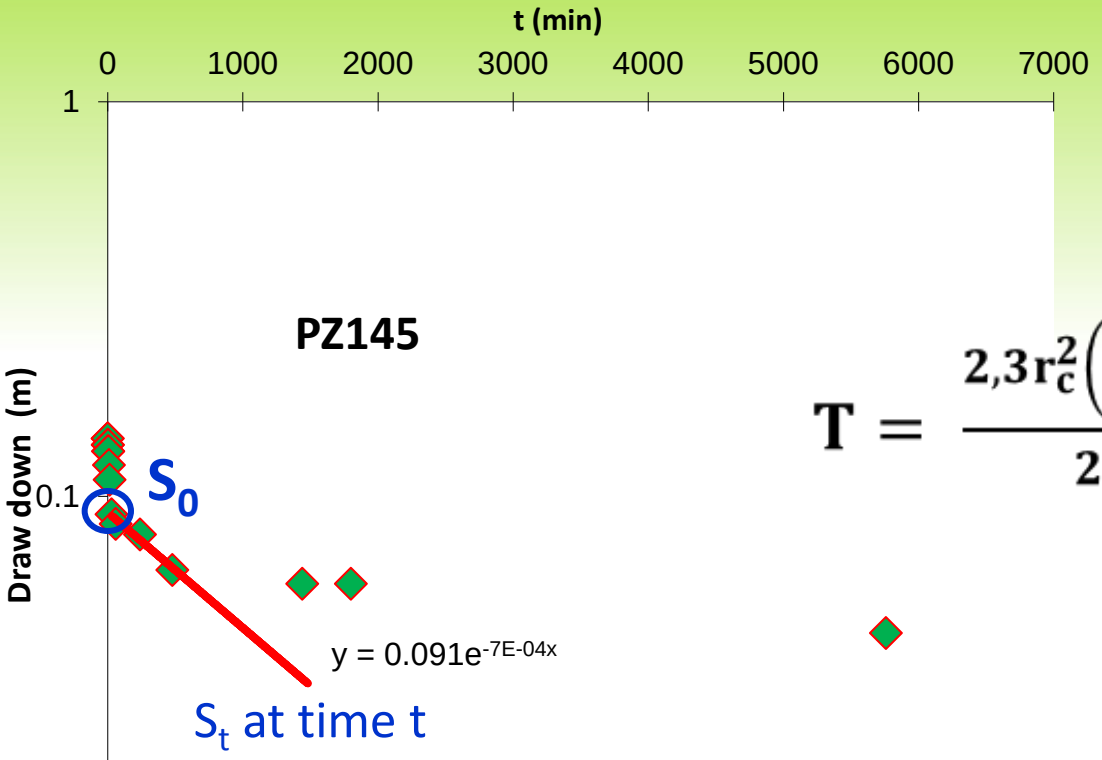
Bail-down test interpretation

- Bouwer & Rice (modified by Huntley 2000)
- Cooper
- Jacob-Lohman (modified by Huntley 2000)

Only 30% of the well could be interpreted :
- Emulsion
- Hp not constant

Modified B&R method

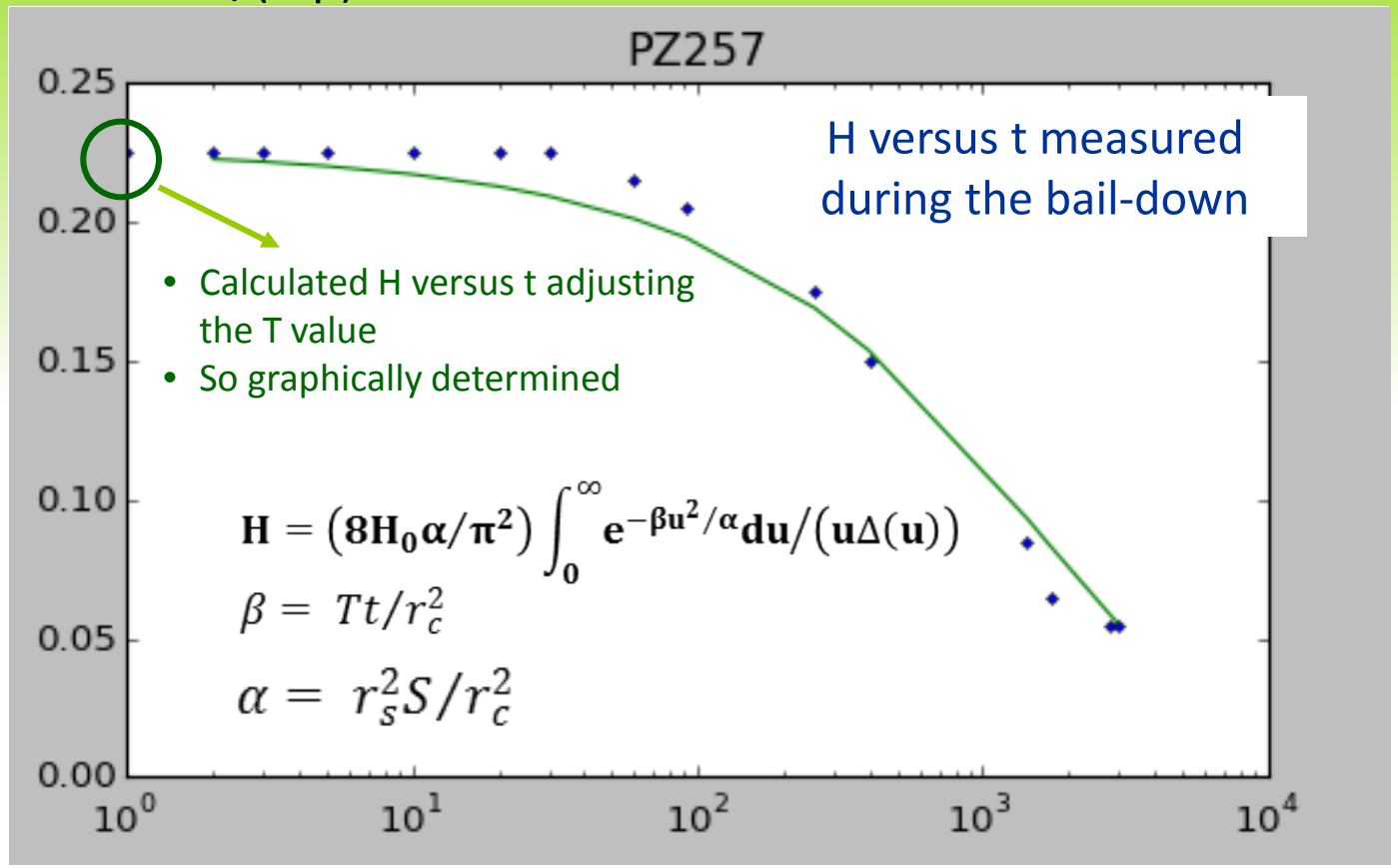
- water bail-down in **confined/unconfined** aquifers
- Only when Ko<<Kw so Hp relatively constant during the test



$$T = \frac{2{,}3r_c^2\left(\frac{1}{1-\rho_r}\right)}{2t}\ln\left(\frac{r_0}{r_w}\right)\log\left(\frac{s_0}{s}\right)$$

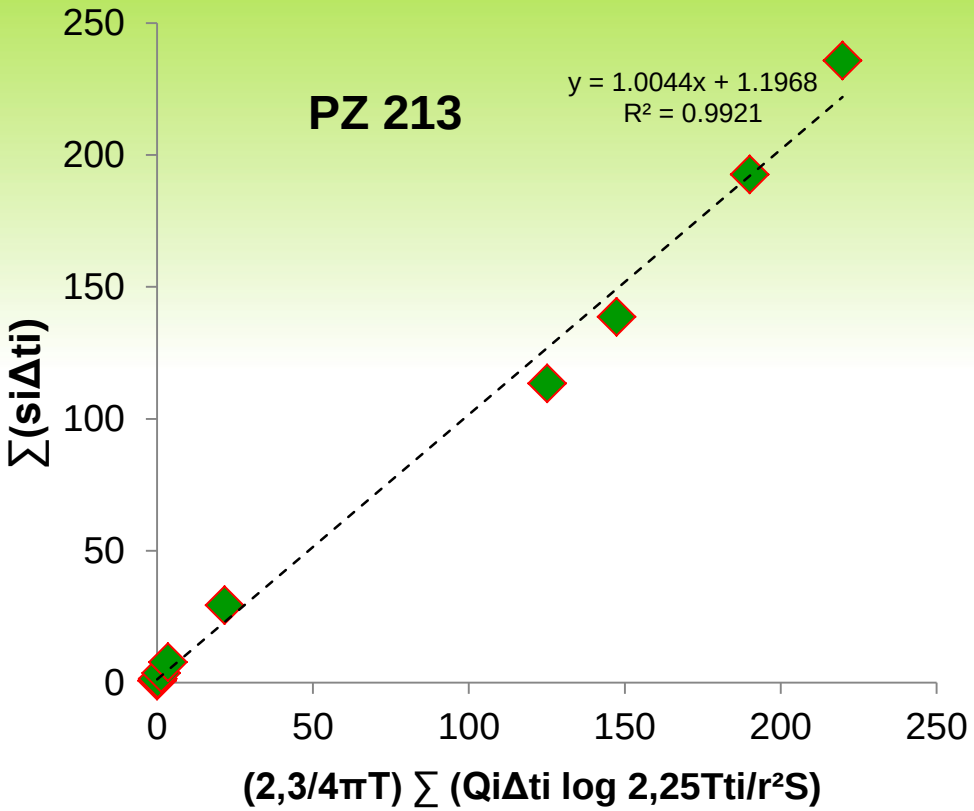
Modified Cooper method

- water bail-down in **confined** aquifers
- Correction factor 1/(1-ρ)



Modified Jacob & Lohman method

- water bail-down in **confined** aquifers
- Hp constant or not



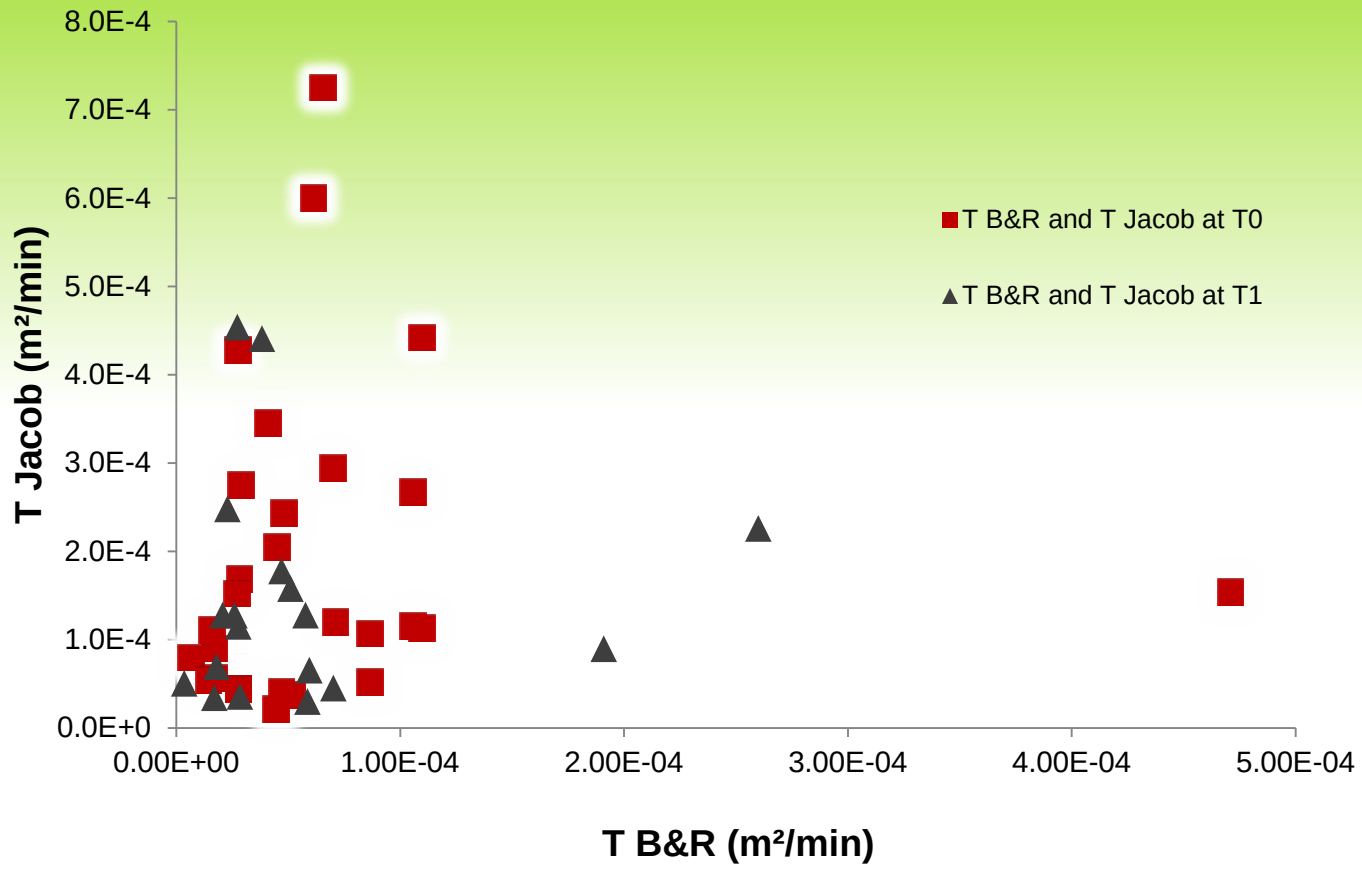
$$\frac{s}{Q} = \frac{2,3}{4\pi T} \log \frac{2,25Tt}{r^2 S}$$

$$(s\Delta t) = \frac{2,3(Q\Delta t)}{4\pi T} \log \frac{2,25\ Tt}{r^2 S}$$

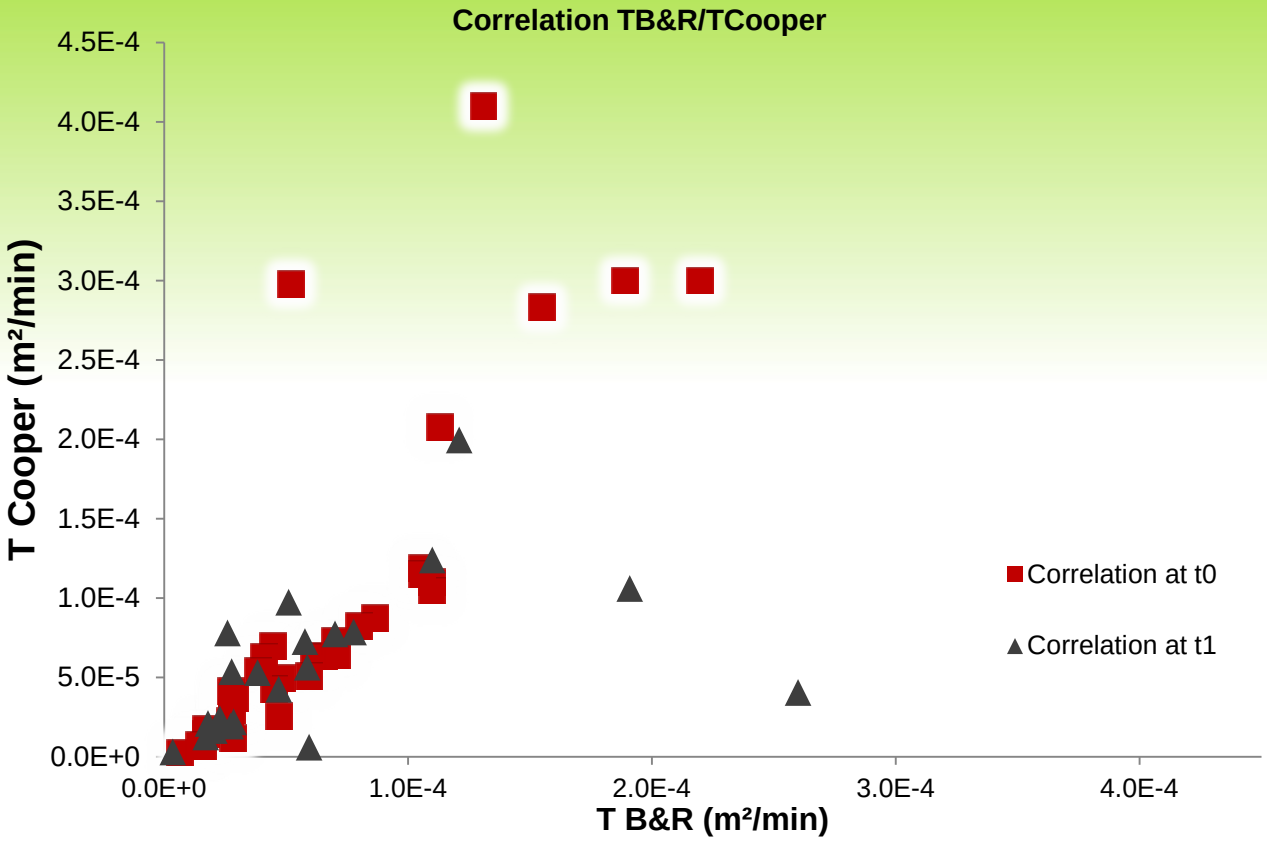
$$\sum_{i=1}^{n} (s_i \Delta t_i) = \frac{2,3}{4\pi T} \sum_{i=1}^{n} \left(Q_i \Delta t_i \log \frac{2,25Tt_i}{r^2 S} \right)$$

Solution determined iteratively

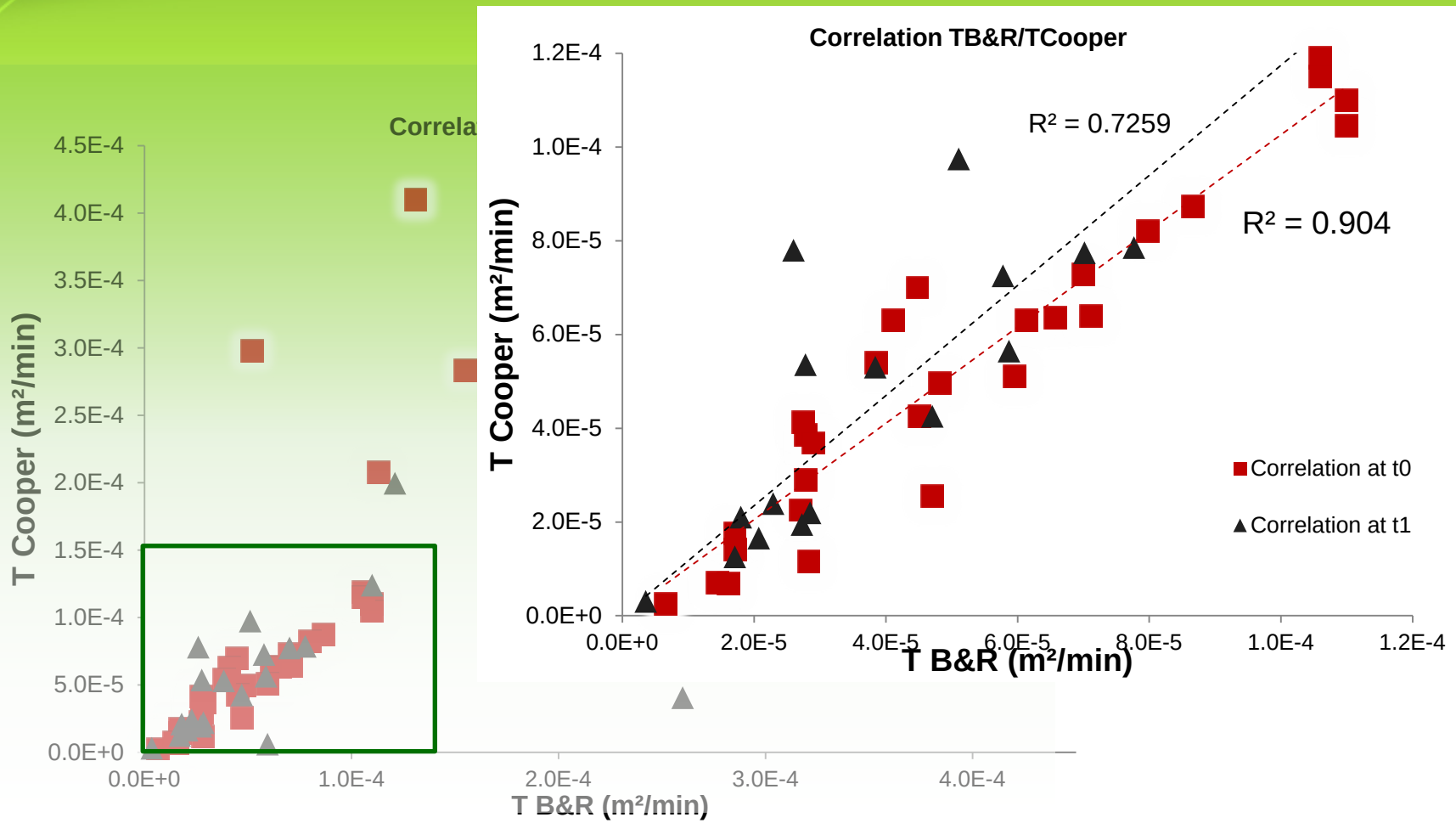
Comparison T B&R T Jacob



Comparison T B&R T Cooper



Comparison T B&R T Cooper



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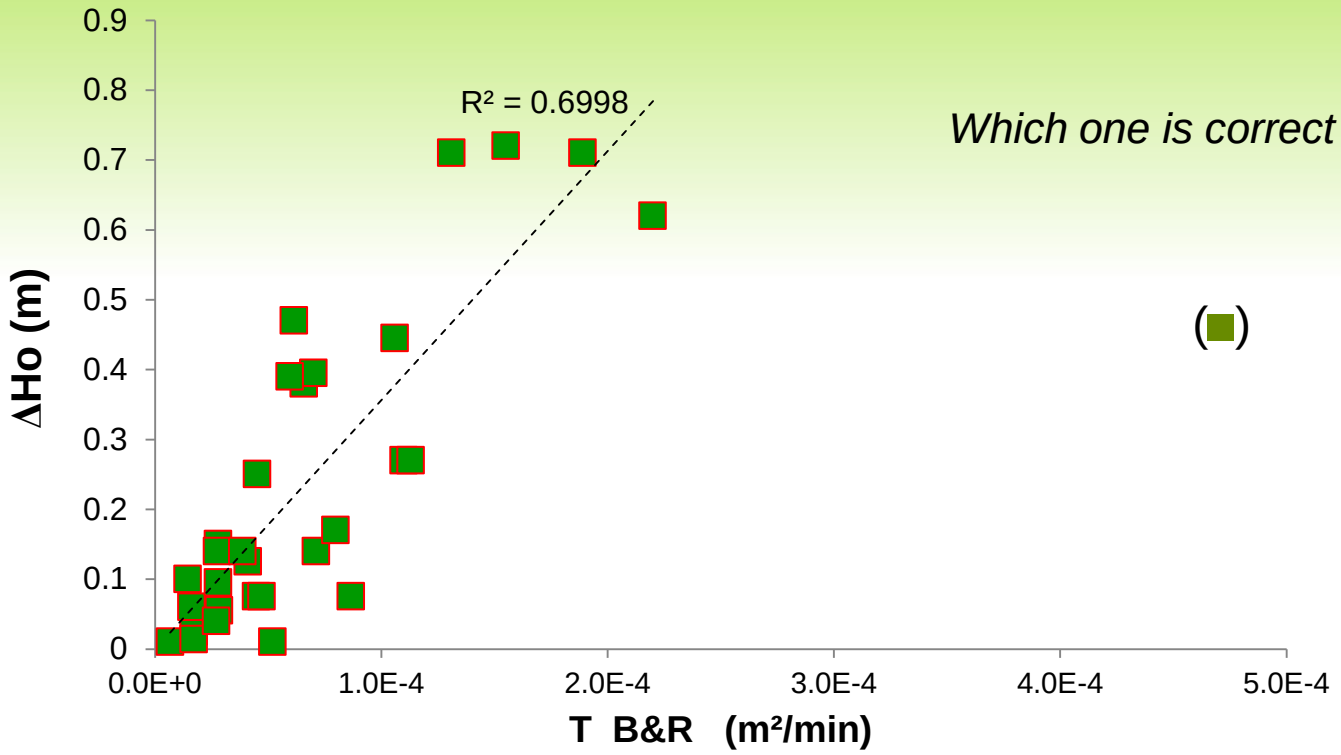
Comparison with discharge

The variation of drawdown (or volume) between 1 and 4 h can also be a measure of mobility



Which one is correct ?

(■)

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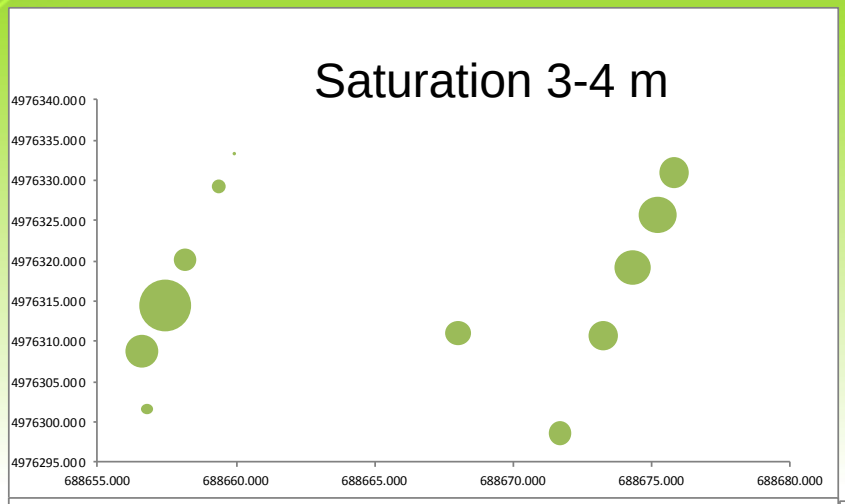
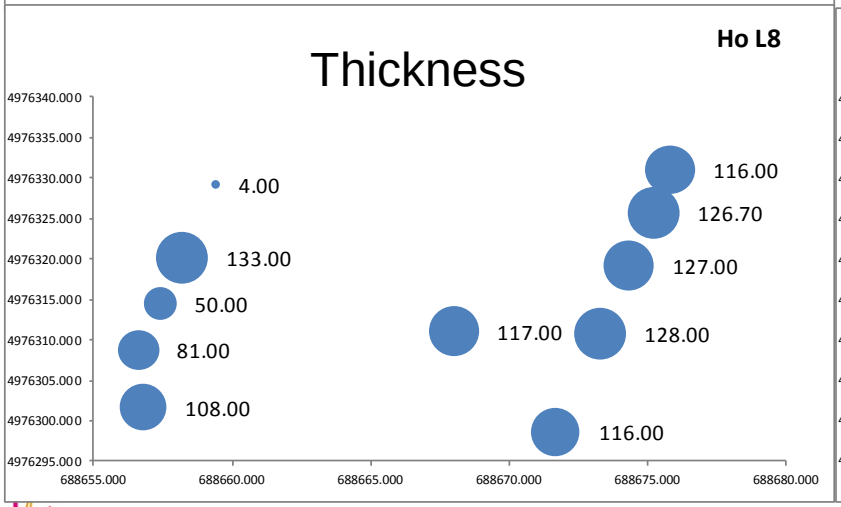
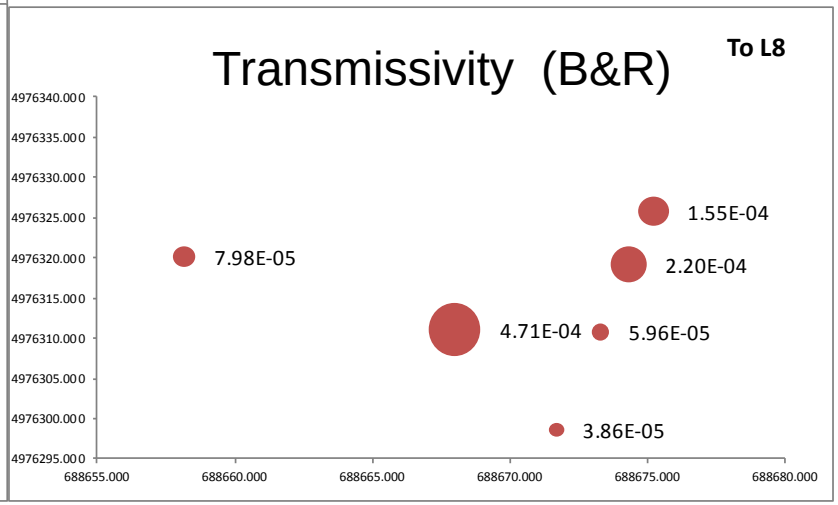
No link between H and T



Not even in
« homogeneous » region

Measurement required





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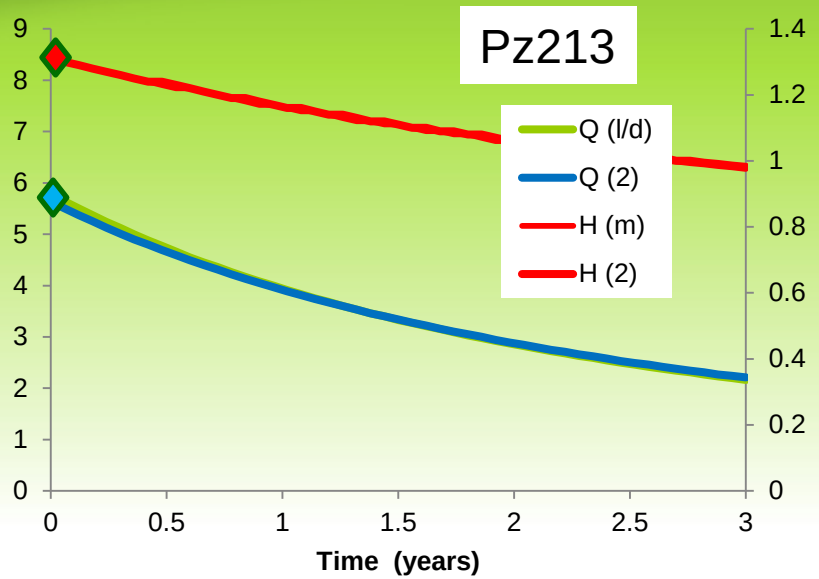
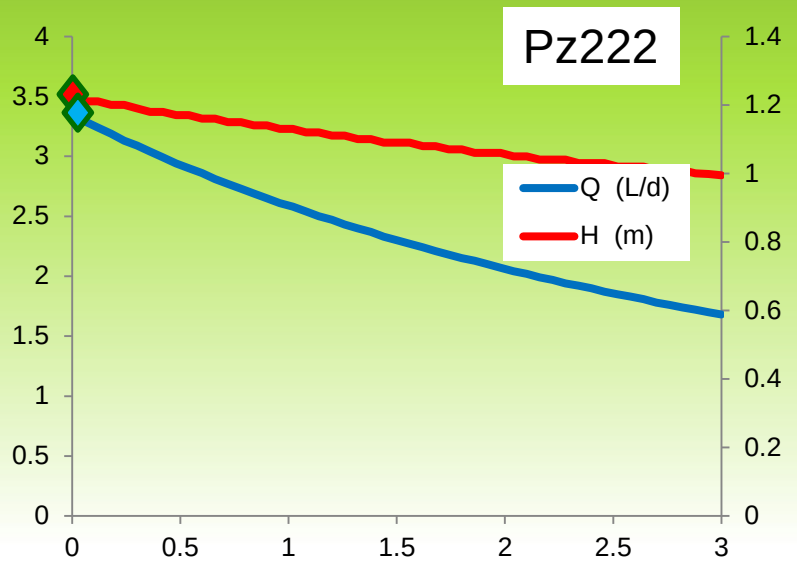
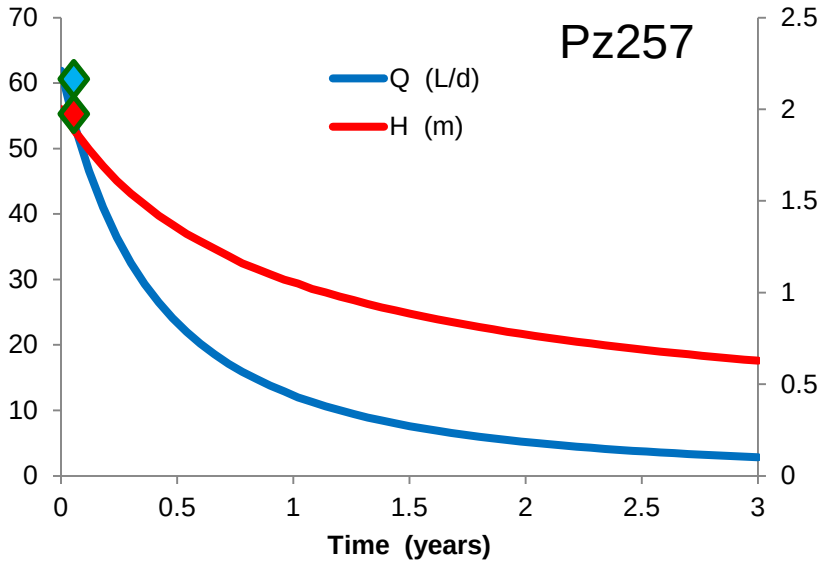
Temporal evolution : specific wells







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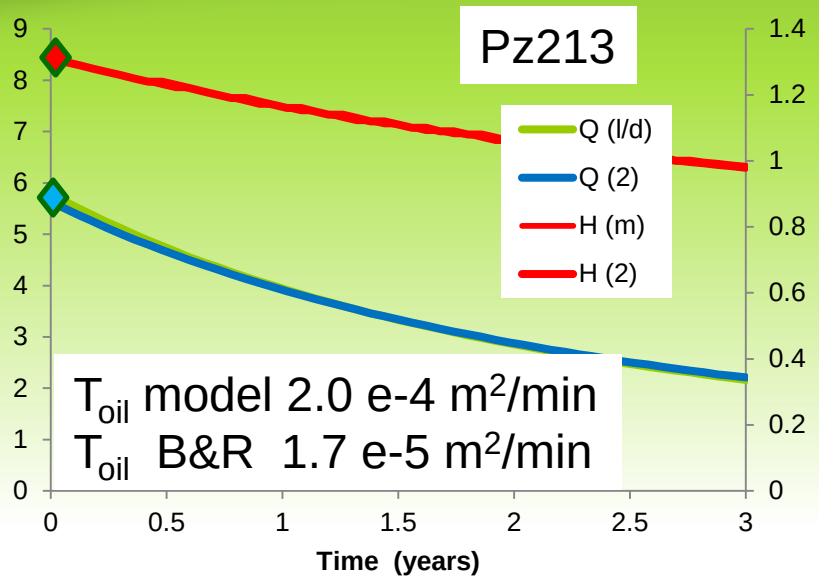
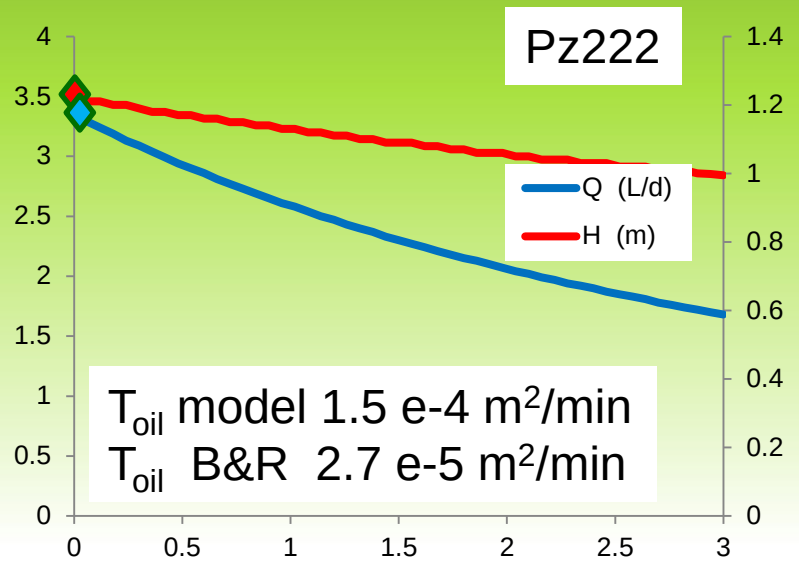
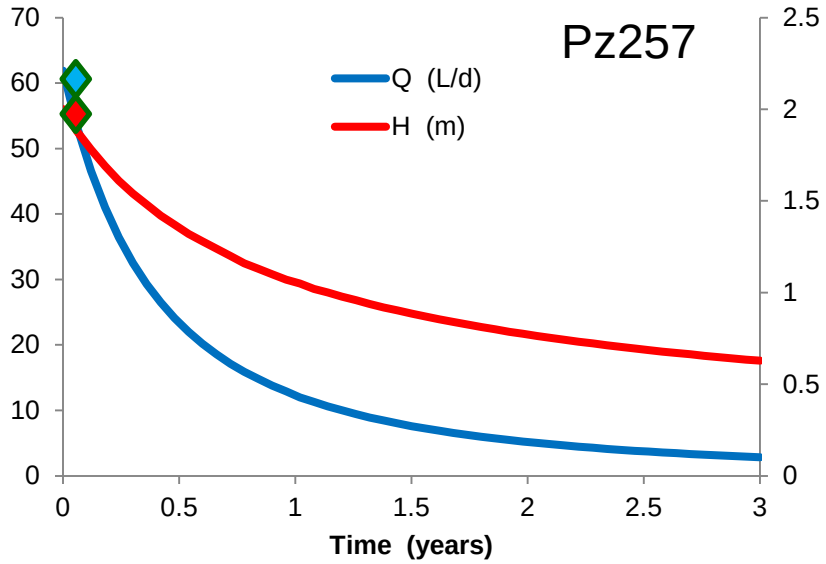
Temporal evolution : specific wells







T_{oil} model 8.0 e-4 m²/min
T_{oil} B&R 1.9 e-4 m²/min

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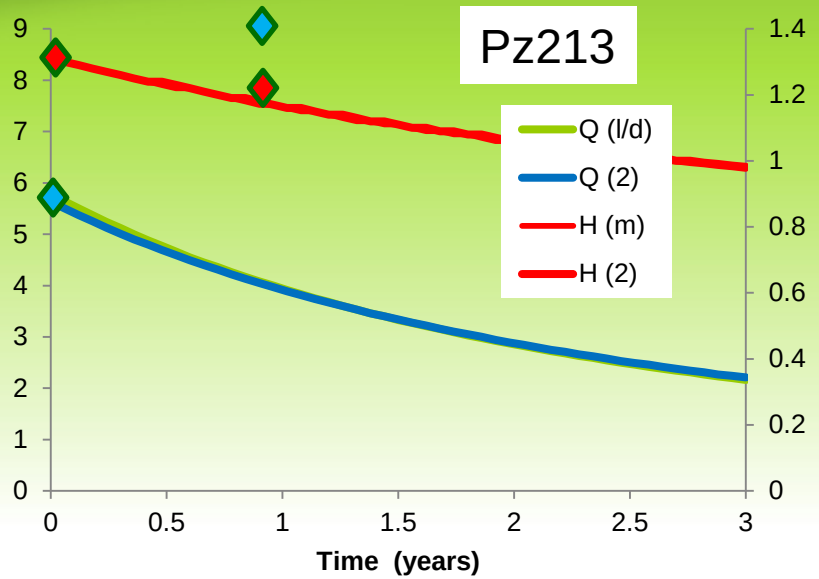
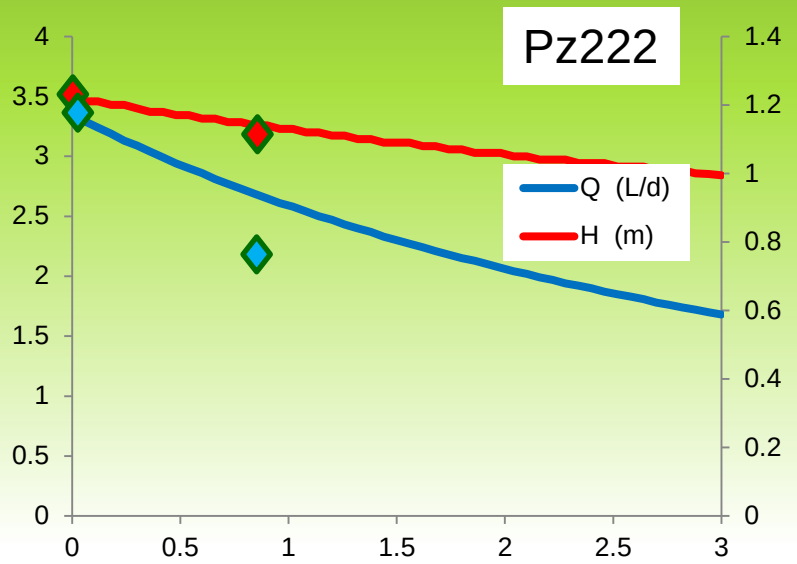
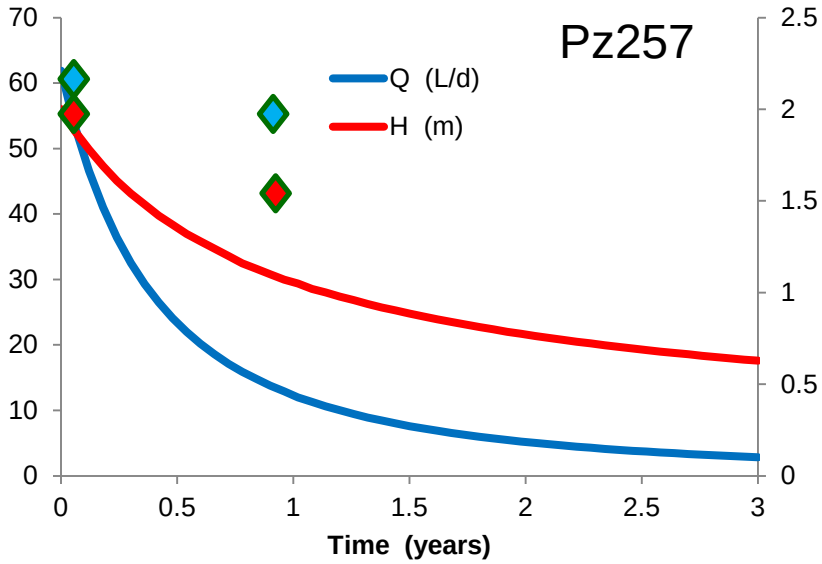
Temporal evolution : specific wells







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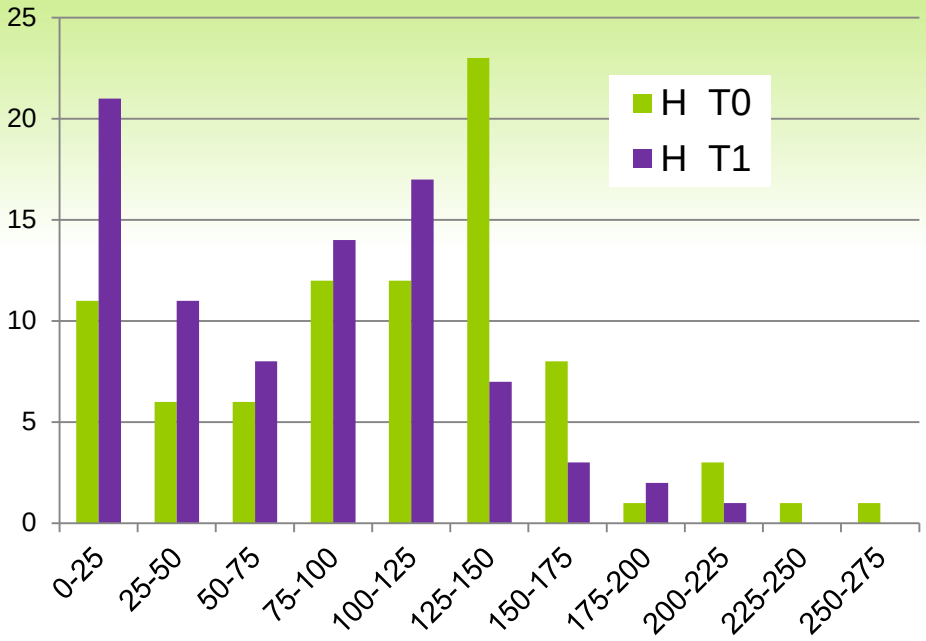
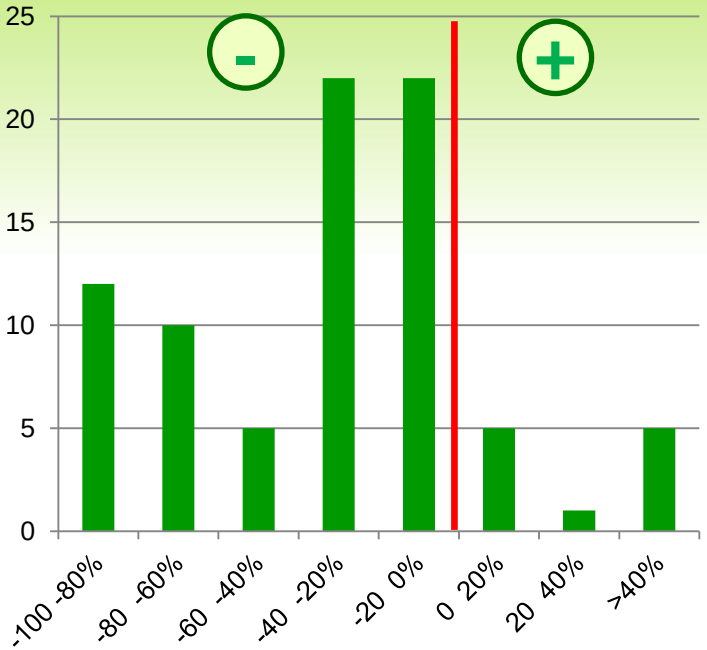
Temporal evolution : global

Not enough data on T, ~ same water level at t_0 and t_1

Oil thickness evolution : average decrease 20%





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Conclusion

- Oil thickness **alone** cannot be used for predictions
  - Heterogeneity : not possible to use the same parameters for several wells
- Bail-down tests in oil : low reproductibility
  - calculated Toil ↔ Q_{oil} 1-4h
- Well by well analysis needs lot of data
  - For the 1st year overall Ho decrease ~ model
  - Effect of transient effects ? (→ x campaigns)

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