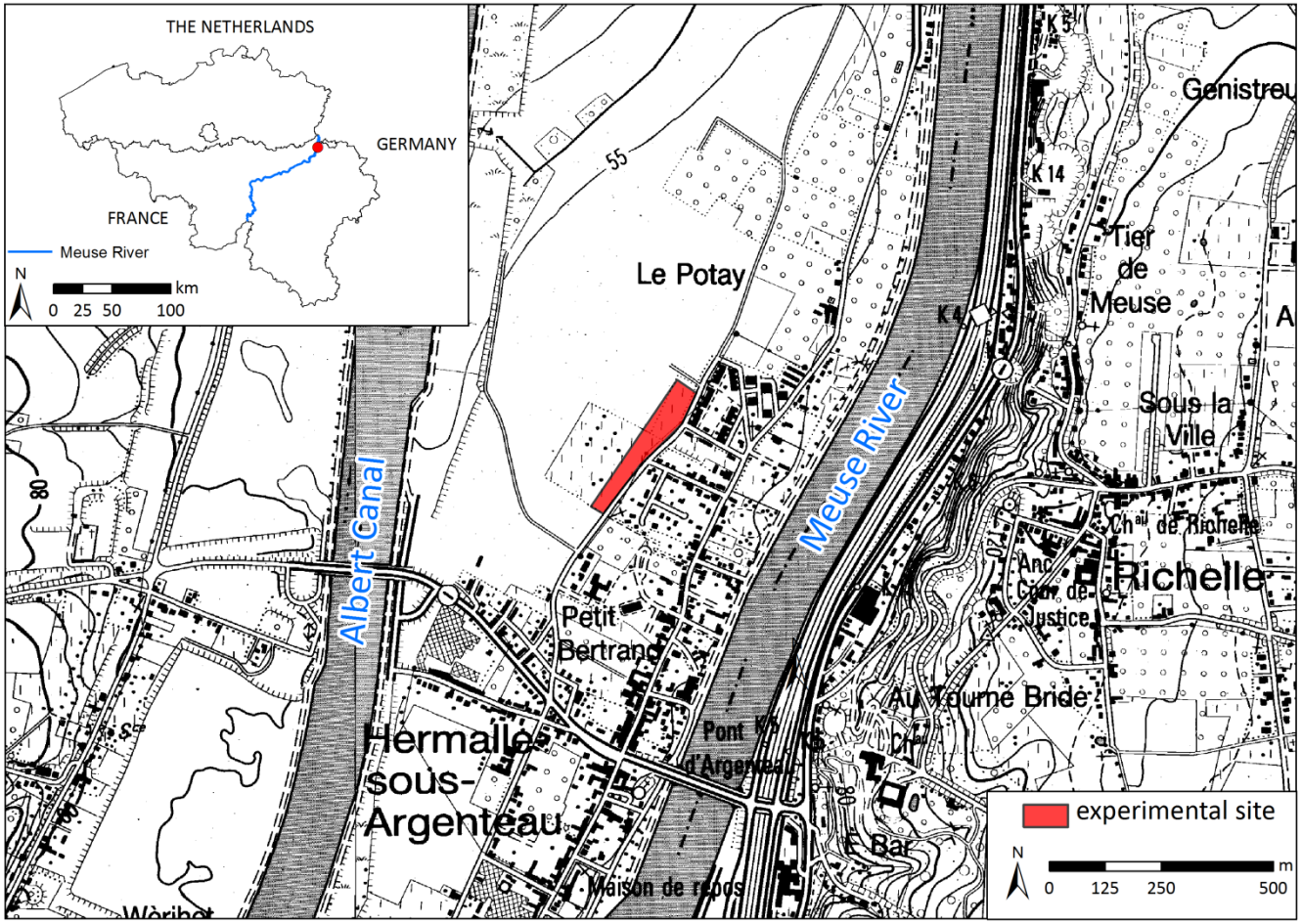
Introduction to HssA test site

Pierre JAMIN

12/10/2017

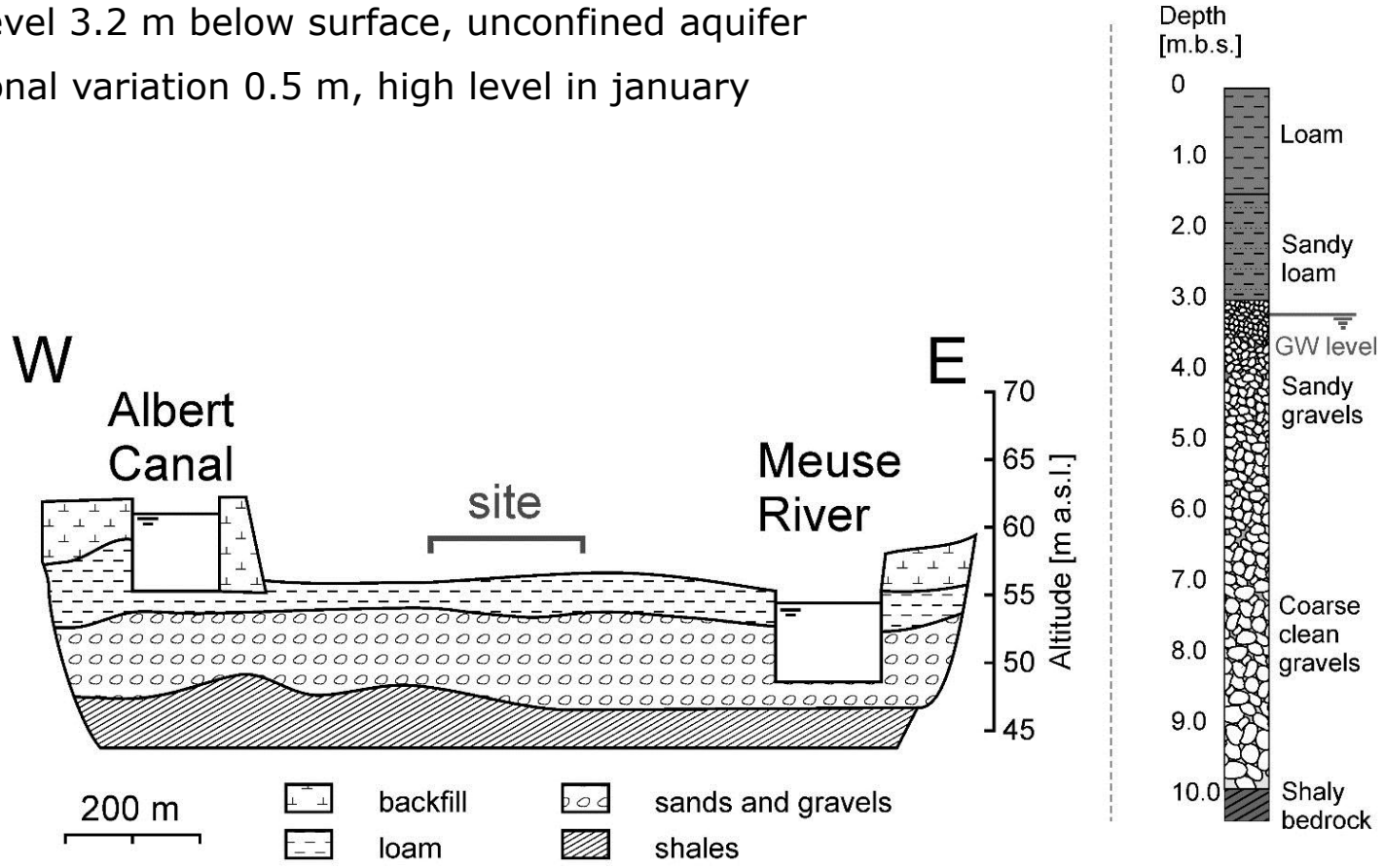
Location : Alluvial plain of the Meuse

- Rue Joseph Bonhomme, Hermalle-sous-Argenteau ($X_{Lambert}$=242670 m, $Y_{Lambert}$=157150 m)
- Between the Albert Canal and the Meuse River



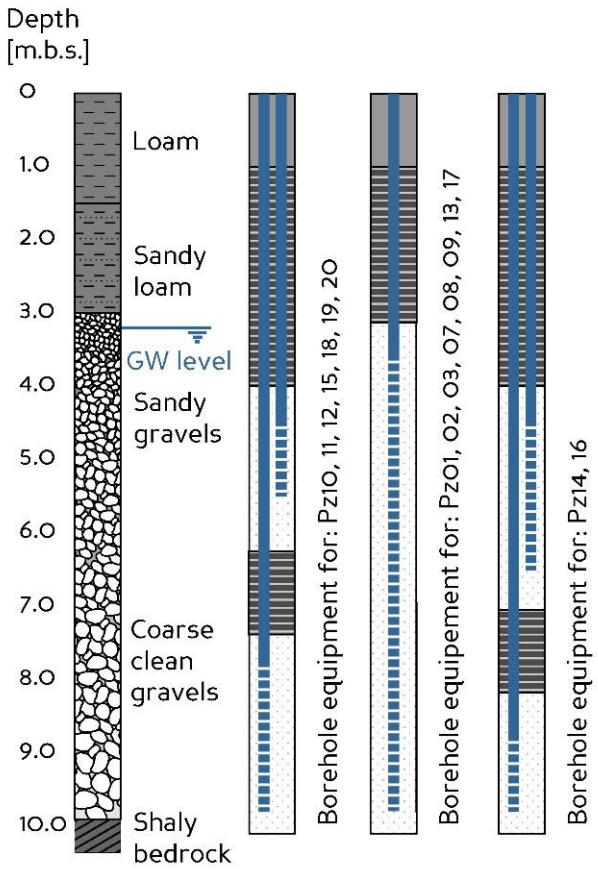
Geology : Alluvial plain sediments

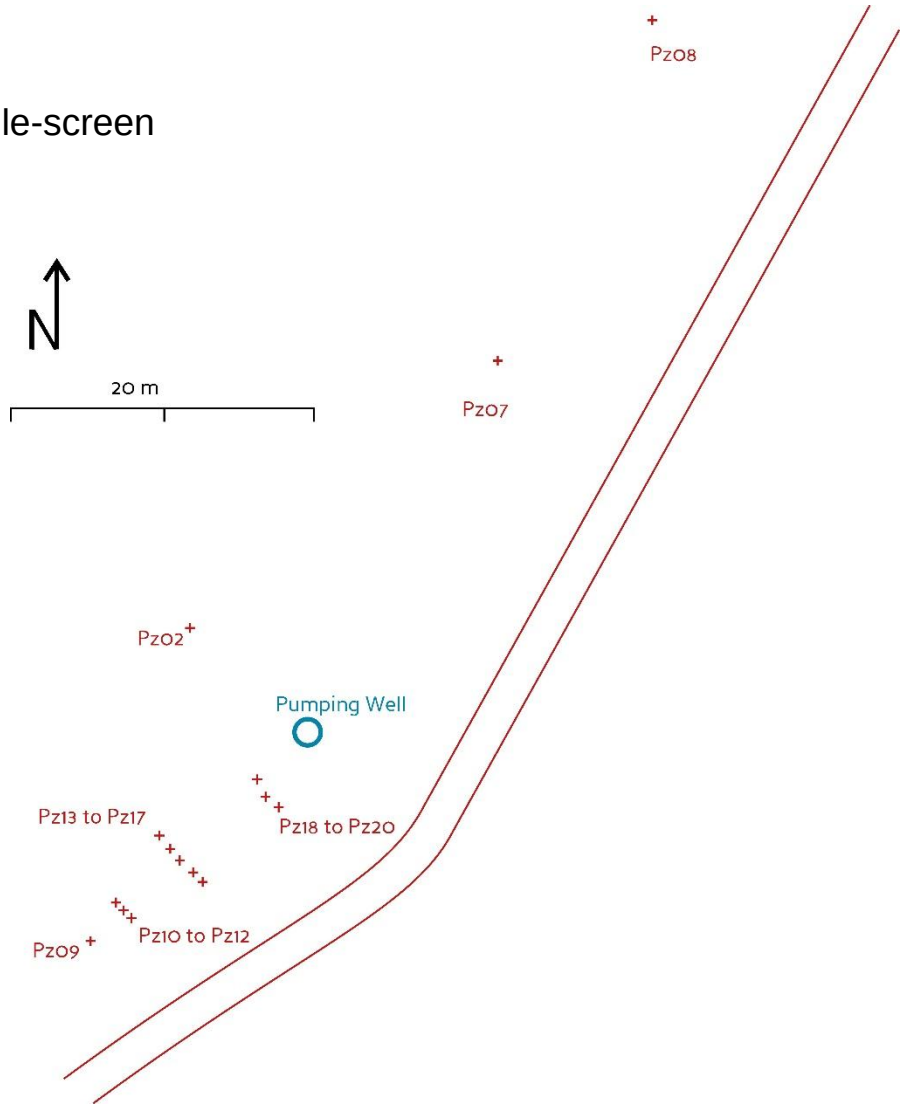
- 3 m of loam
- 7 m of sandy gravels than becomes coarser and cleaner with depth
- Shaly bedrock at 10 m below surface = base of the aquifer
- GW level 3.2 m below surface, unconfined aquifer
- Seasonal variation 0.5 m, high level in january



Equipment : 1 Pumping well, 15 piezometers, electricity

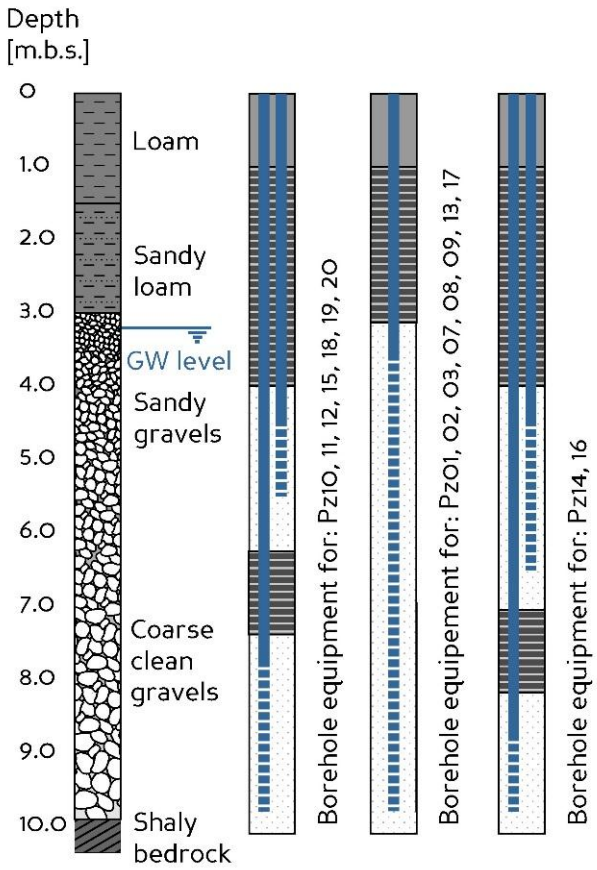
- 6″ pumping well fully screened
- 3 « old » 2″ piezometers fully screened
- 12 « new » 2″ piezometers, 3 fully screened, 9 double-screen
- Electricity available on site (3x400V)

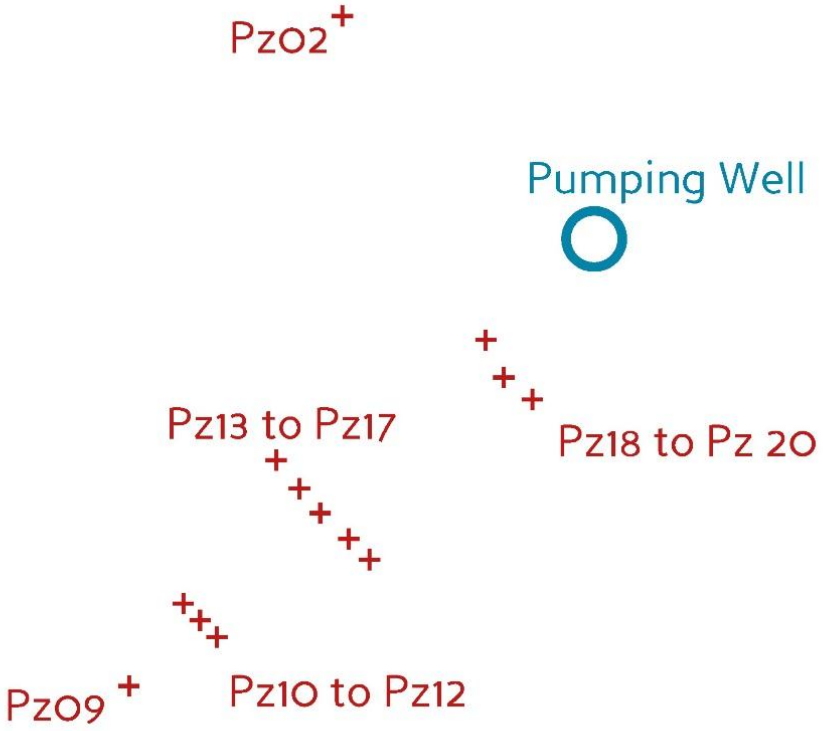




Equipment : 1 Pumping well, 15 piezometers, electricity

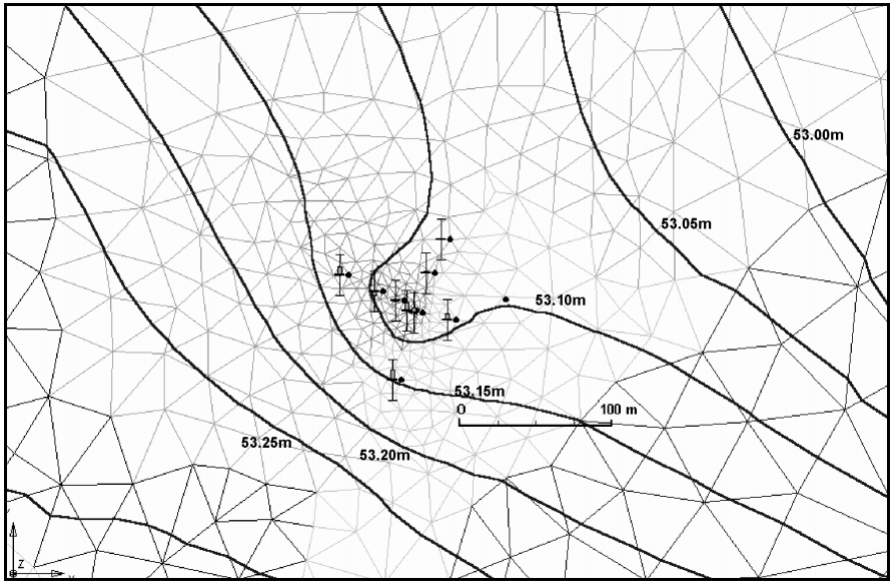
- 6″ pumping well fully screened
- 3 « old » 2″ piezometers fully screened
- 12 « new » 2″ piezometers, 3 fully screened, 9 double-screen
- Electricity available on site (3x400V)





First site characterization: 2001 PhD of Brouyère S.

- Pumping tests determining K = 1,8 to 7,6 $.10^{-2}$m/s
- Hydraulic gradient 0.5 % NE
- Effective porosity 0.04 to 0.08
- Immobile porosity 0.1 to 0.4
- Longitudinal dispersivity 0.5 to 4.5 m



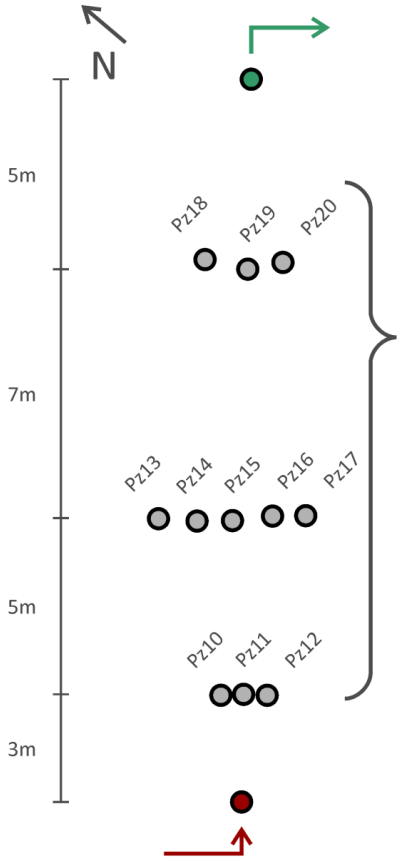
- Tracer behavior on site :
  - I, NO3, Cl, Br conservative
  - Li, K, Sr, Fluoresceine, Rhodamine can be adsorbed
  - Napthionate degrades with 1st order coef 1,5 $.10^{-5}$ s^{-1}
- Modeling

http://bictel.ulg.ac.be/ETD-db/collection/available/ULgetd-08222007-101855/

2012 Thermal tracer test: Heat + Naphtionate

- Simultaneous injection of Heat and Fluorescent Dye
- Allowing to study different processes in the aquifer

- Injection in Pz9
- Monitoring in control panels
- Recovery at pumping well



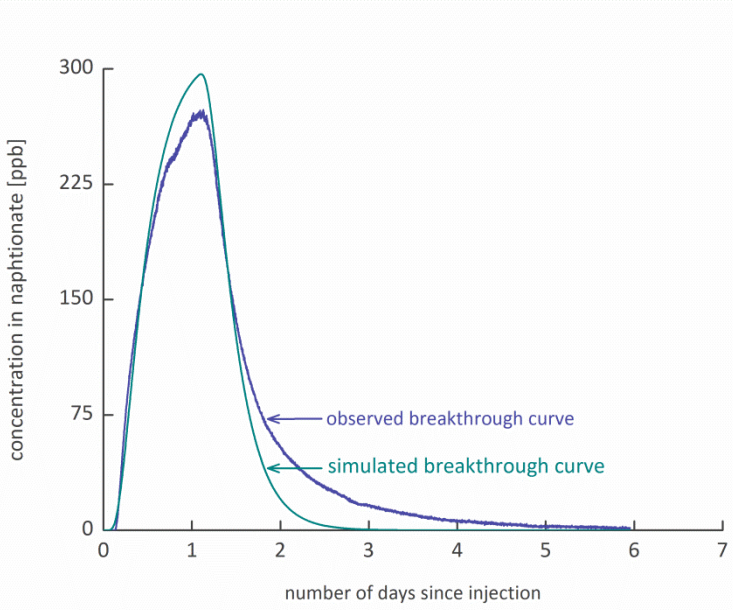
Pumping well at 30 m³/h
T° monitoring
Field fluorimeter

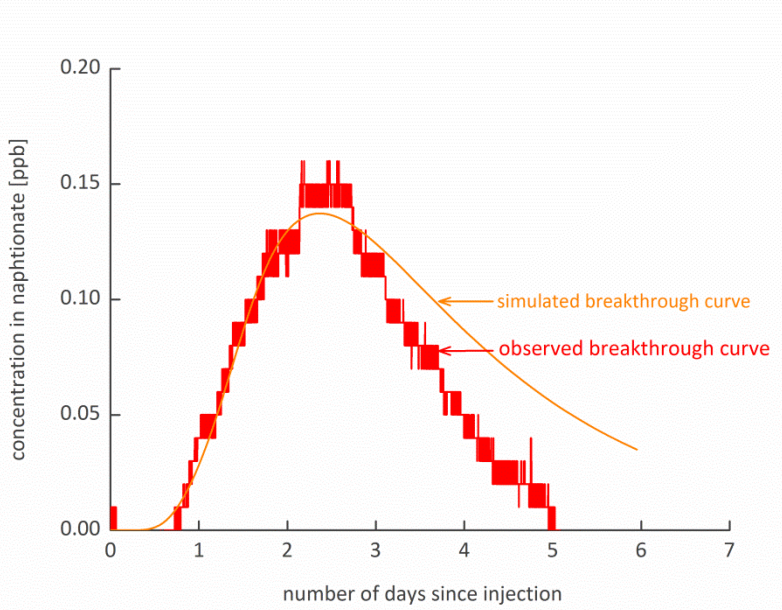
Dual screen monitoring wells
GW depth and T°

Pz9 : injection well
3 m³/h at 40 °C during 24 h
0.06 L/min at 4 g/L of Napthionate
T° well logging

2012 Thermal tracer test: Breakthrough curve at PP

- Radial converging flow





	Naphtionate	Temperature
Longitudinal dispersion (α_L) [m]	3	
Porosity (n) [-]	0.04	
1st order degradation coefficient λ [s^{-1}]	1.5×10^{-5}	0
Retardation factor R [-]	1	5

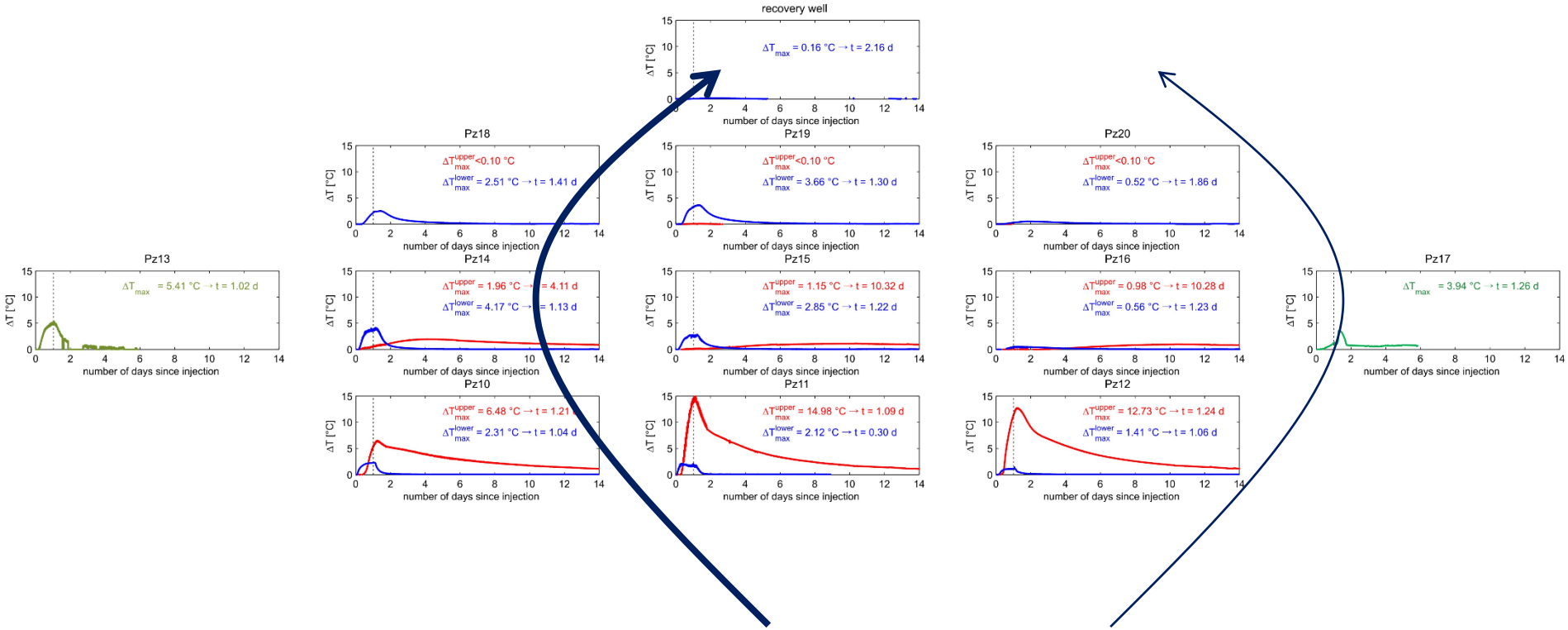
(Hecht-Méndez et al. 2010)

$R = C_m/nC_w$

$C_m = 2.3\ MJ/m^3/K$

2012 Thermal tracer test: control panels T° curves

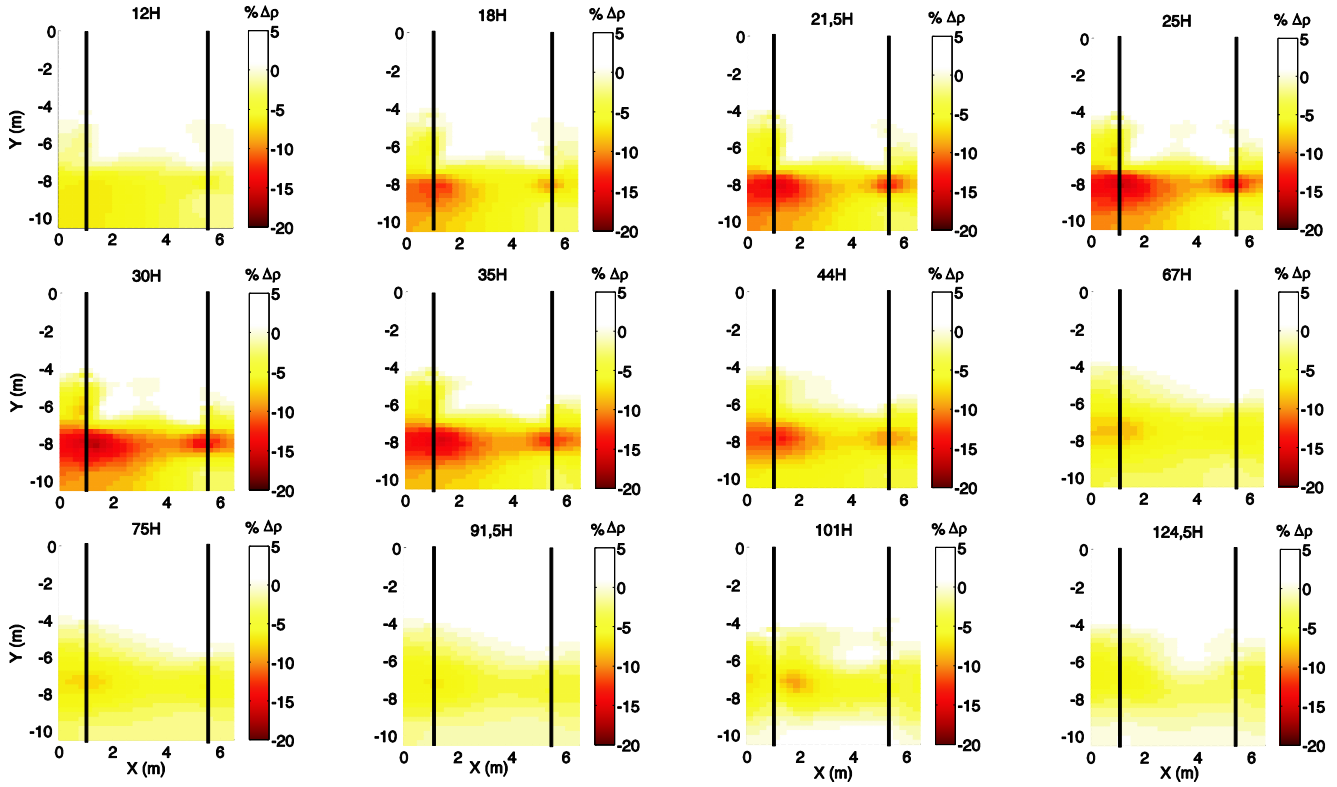
- Heterogeneity of the aquifer



Wildemeersch et al. 2014, J. Contam. Hydrol.
http://hdl.handle.net/2268/171944

Crosshole ERT: Spatial and temporal imaging of resistivity

- Lateral variations related to heterogeneity in the deposits
- Changes seem stronger around first borehole
- Spatially, temperatures increase only in the bottom part of the aquifer (clean gravel)
- Detection limit -3%



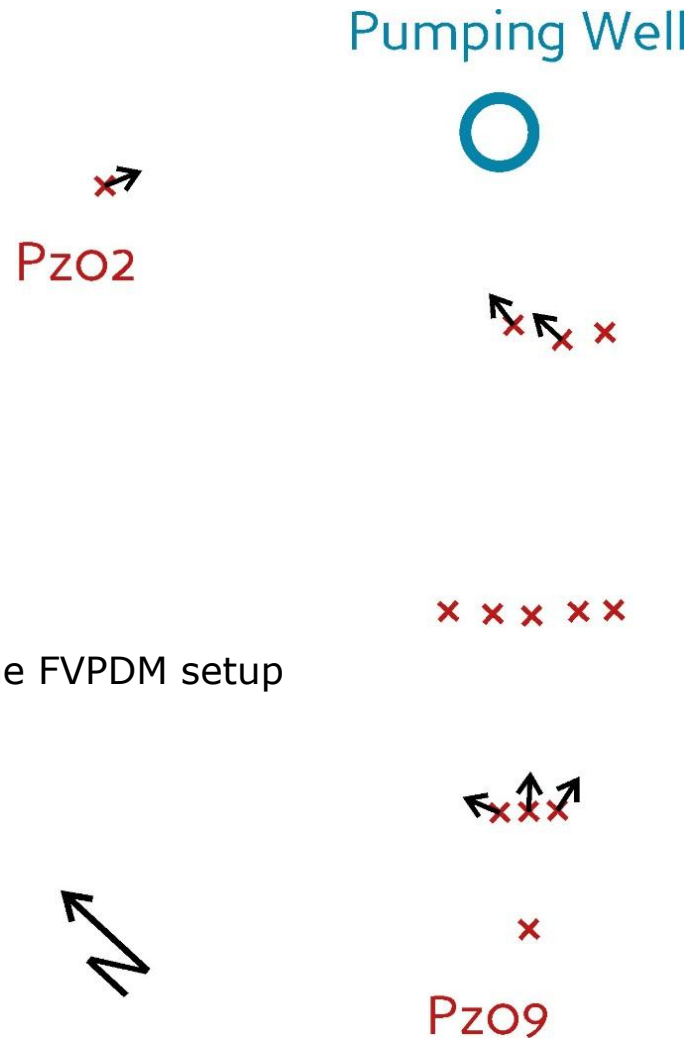
- Hermans, T. et al. (2015). Geothermics http://hdl.handle.net/2268/164949

Measurement of GW flux and flow direction: FVPDM

Finite Volume Point Dilution Method

Generalisation of single well dilution techniques

Brouyère *et al.* 2008, J. Contam. Hydrol.



- Darcy's flux in the
  - upper part of the aquifer 10 m/d
  - lower part of the aquifer 200 m/d

-> **10 x times higher in the lower part**

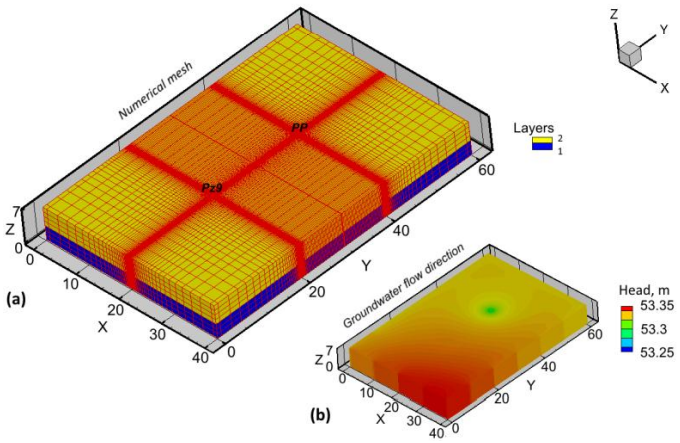
- Measuring GW flow direction using an evolution of the FVPDM setup
- Diverging flow direction on the first control panel

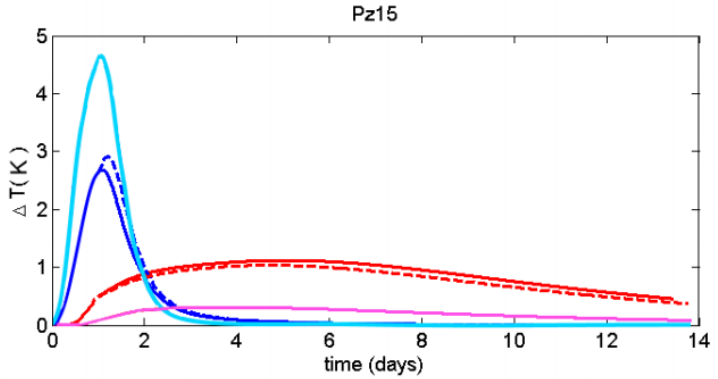
2015 Modeling of the 2012 thermal tracer test

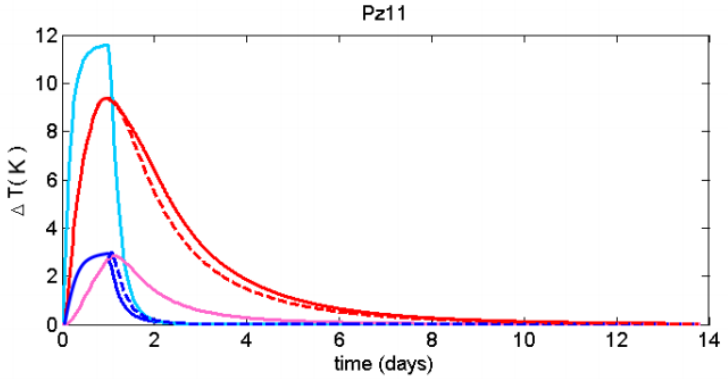
- Modeling to study 3D shape of the heat plume (HGS)
- Calibration using T° bkth. curves and pilot points

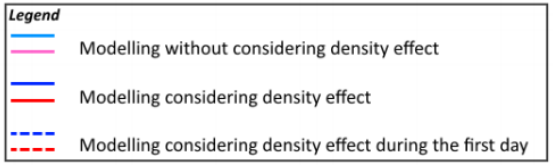
- Complex behavior of the heat plume explained by high lateral and vertical heterogeneity of the hydraulic conductivity field

- Temperature-induced water density effect









Klepikova et al. 2015 J. Hydrol.
http://hdl.handle.net/2268/199598

Reference list

- Hermans, T., & Irving, J. (2017). Facies discrimination with electrical resistivity tomography using a probabilistic methodology: Effect of sensitivity and regularization. Near Surface Geophysics, 15, 13-25. http://hdl.handle.net/2268/202474

- Hermans T. et al. (2016). Covariance-constrained difference inversion of time-lapse electrical resistivity tomography data. Geophysics, 81(5), 311-E322. http://hdl.handle.net/2268/197112

- Klepikova M. et al. (2016). Heat tracer test in an alluvial aquifer: field experiment and inverse modelling. Journal of hydrology, 540, 812-823. http://hdl.handle.net/2268/199598

- Hermans, T. et al. (2016). Direct prediction of spatially and temporally varying physical properties from time-lapse electrical resistance data. Water Resources Research, 52, 7262-7283. http://hdl.handle.net/2268/201489

- Hermans, T. et al. (2015). Uncertainty in training image-based inversion of hydraulic head data constrained to ERT data: workflow and case study. Water Resources Research, 51, 5332-5352. http://hdl.handle.net/2268/184023

- Hermans, T. et al. (2015). Quantitative temperature monitoring of a heat tracing experiment using cross-borehole ERT. Geothermics, 53, 14-26. http://hdl.handle.net/2268/164949

- Hermans, T. (2014). Integration of near-surface geophysical, geological and hydrogeological data with multiple-point geostatistics in alluvial aquifers. PhD thesis, University of Liège. http://hdl.handle.net/2268/163547

- Wildemeersch S. et al. (2014). Coupling heat and chemical tracer experiments for estimating heat transfer parameters in shallow alluvial aquifers. Journal of Contaminant Hydrology, 169, 90-99. http://hdl.handle.net/2268/171944

- Brouyère S. (2001). Etude et modélisation du transport et du piégeage des solutés en milieu souterrain variablement saturé, PhD thesis, University of Liège. http://bictel.ulg.ac.be/ETD-db/collection/available/ULgetd-08222007-101855/