Parameters for groundwater modelling

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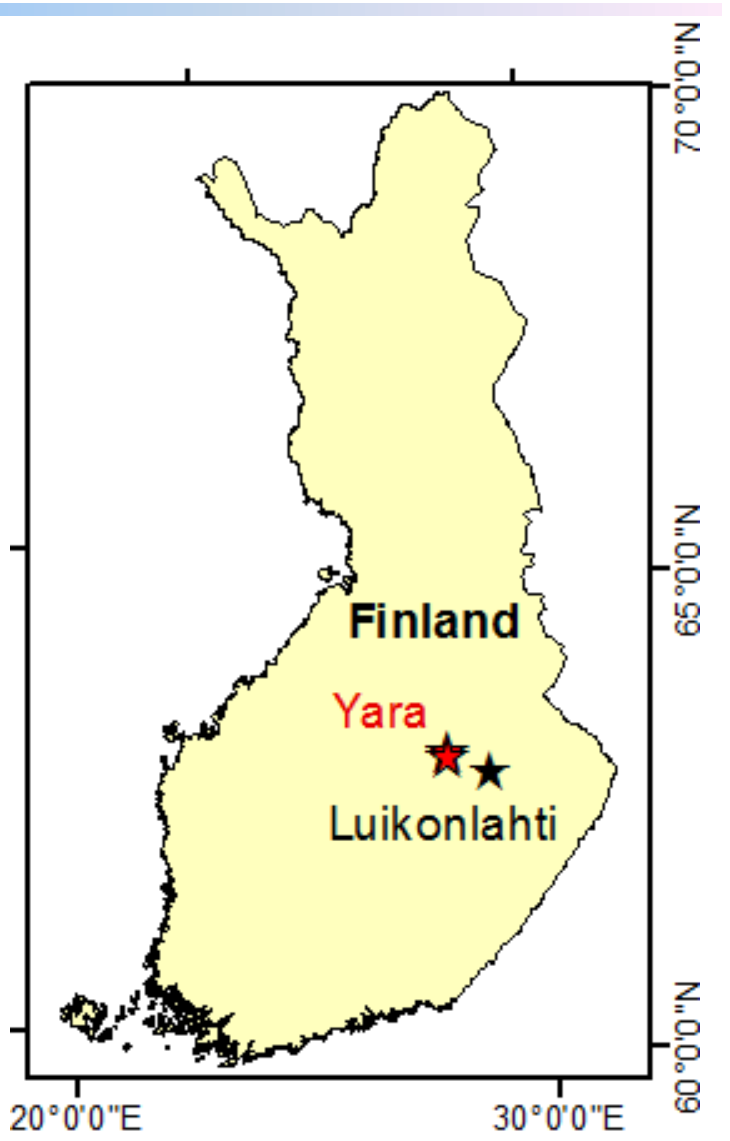
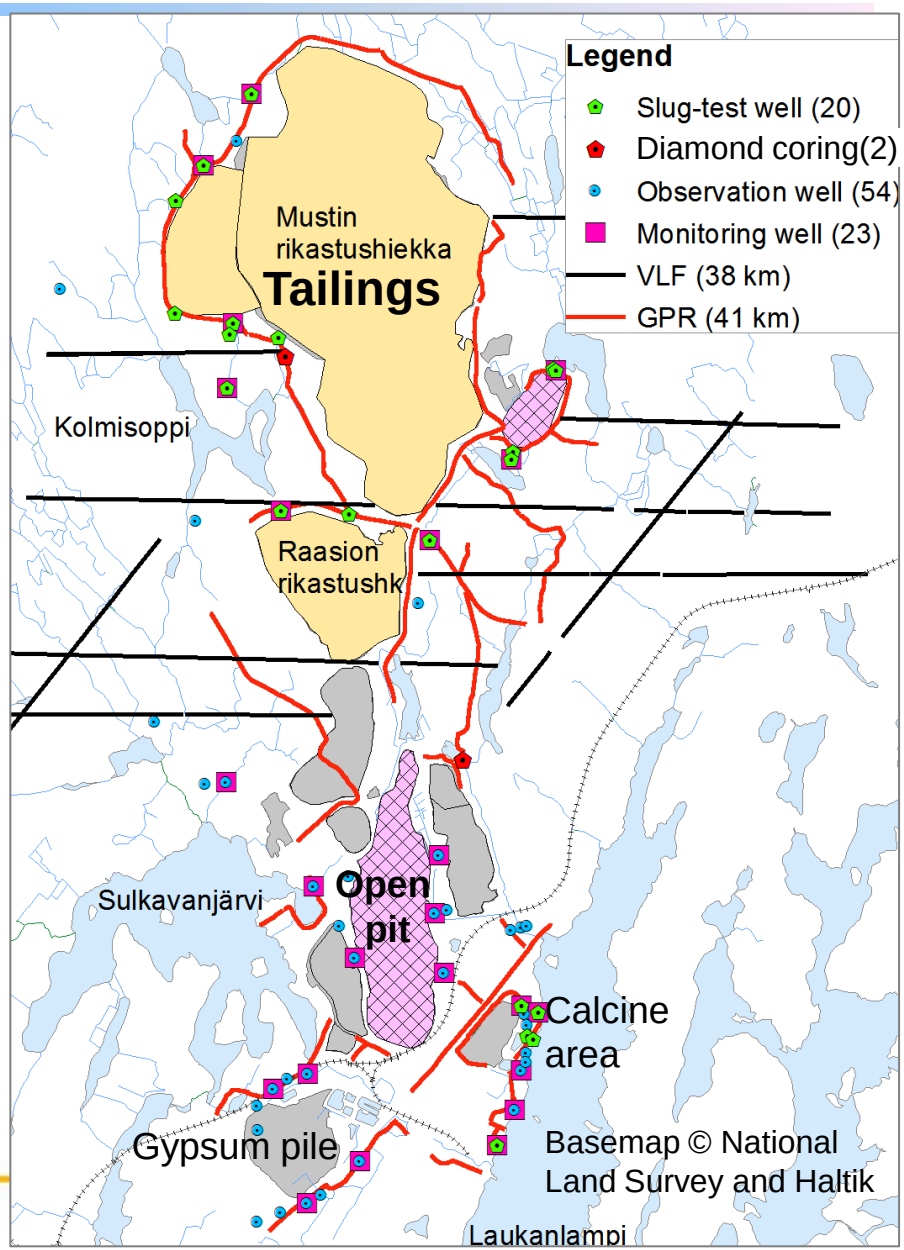
Introduction

- WaterSmart Project – GTK's main task is in WP2: Data collection and monitoring in two study areas:
  - Yara Suomi Oy – Siilinjärvi Mine
  - Altona Mining Oy - Luikonlahti Site



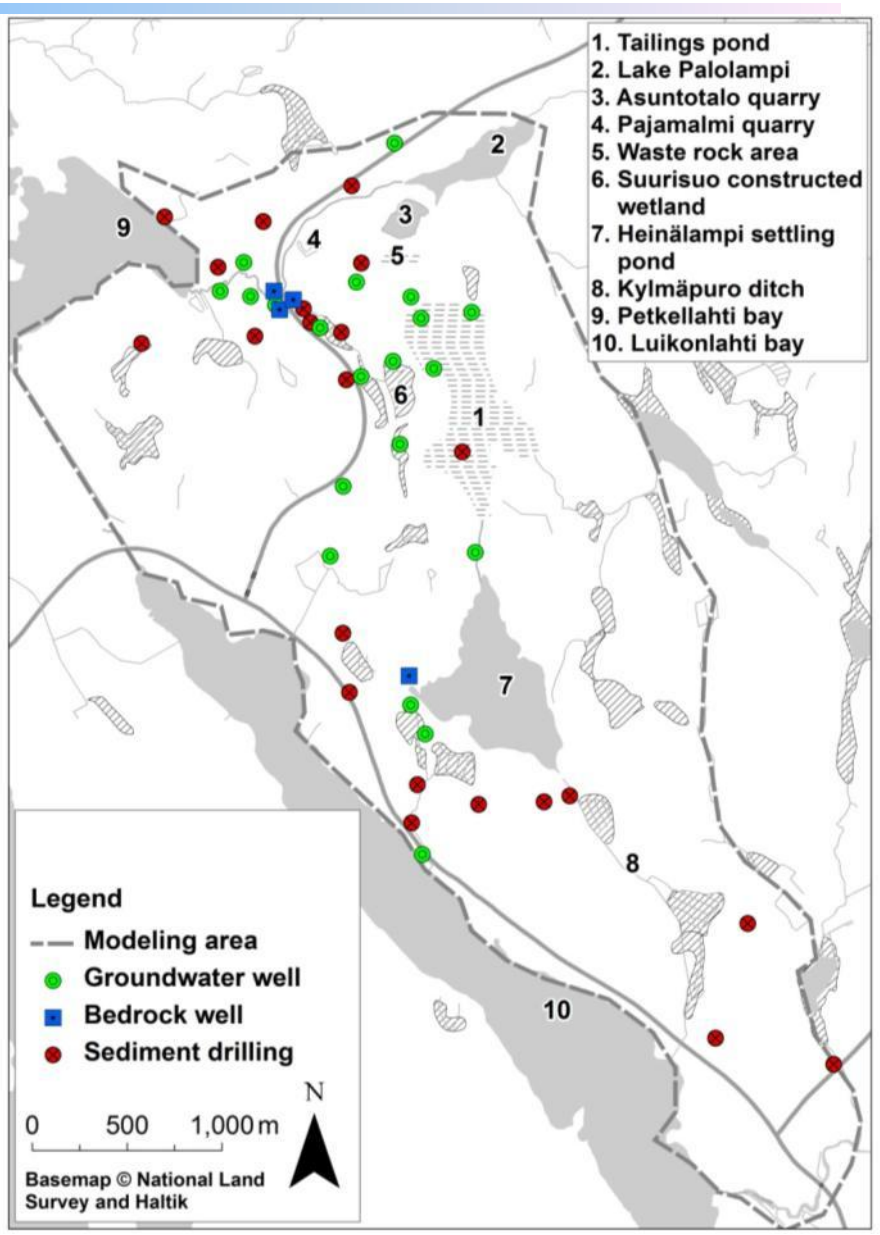
Field investigations

- Geophysical and geological studies in **Yara** during 2014-2015:
  - 41 km **GPR** survey for bedrock surface, sediment properties and thickness
  - 38 km **VLF-R and magnetic** survey to identify the bedrock fracture zones
  - **Diamond coring** in fracture zones and installation of 2 observation wells
  - **Groundwater monitoring** with HOBO diver (pressure, (depth), temperature at freq. 30 mins) for 23 wells



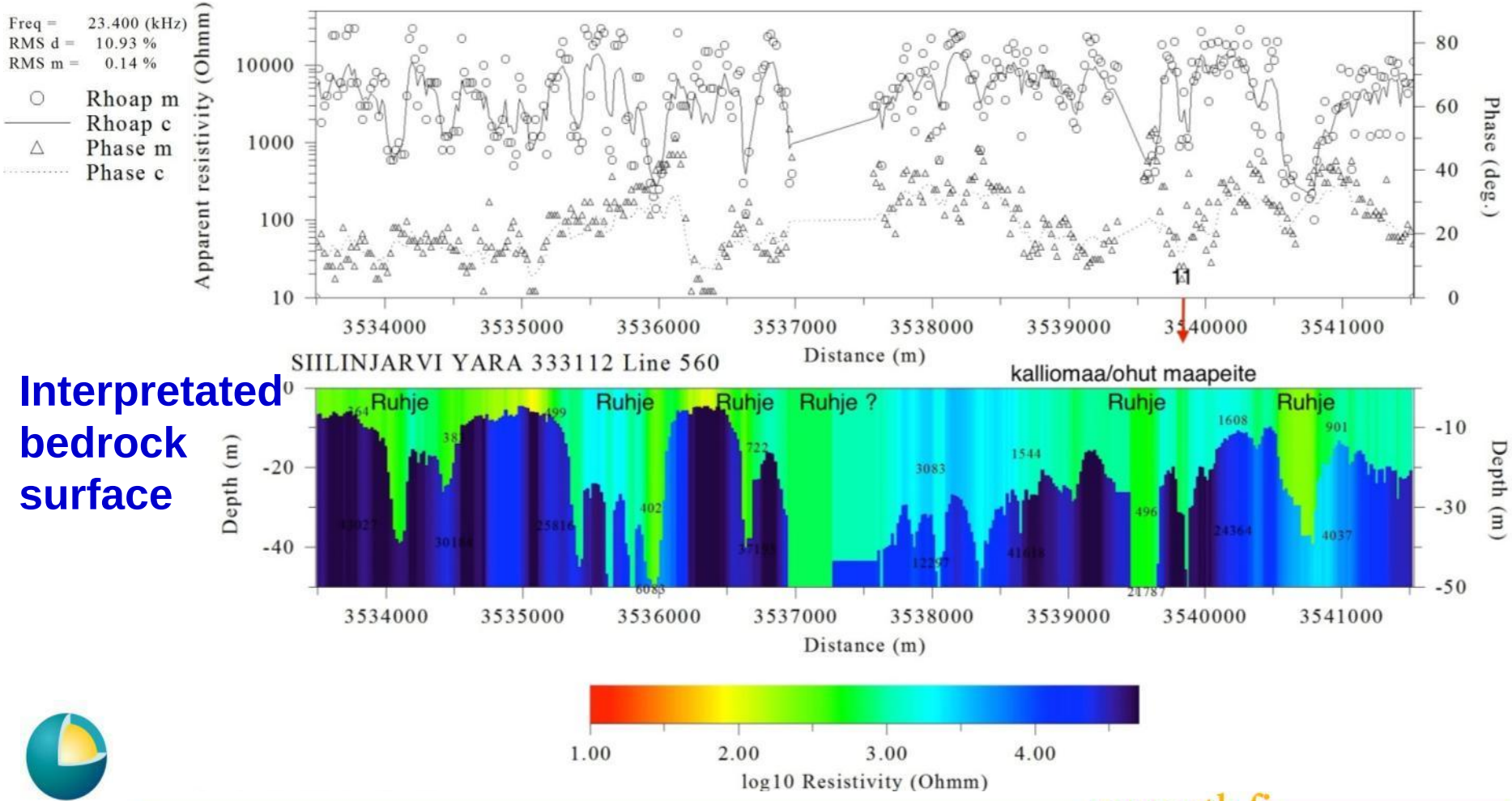
Field investigations

- In both Yara and Luikonlahti sites during 2014-2015:
  - **Slug tests** on sediment and bedrock groundwater observation wells
  - **LiDAR** (2m grid size) was used to identify the watershed and modelling area
  - 3D geological modelling and groundwater flow modelling



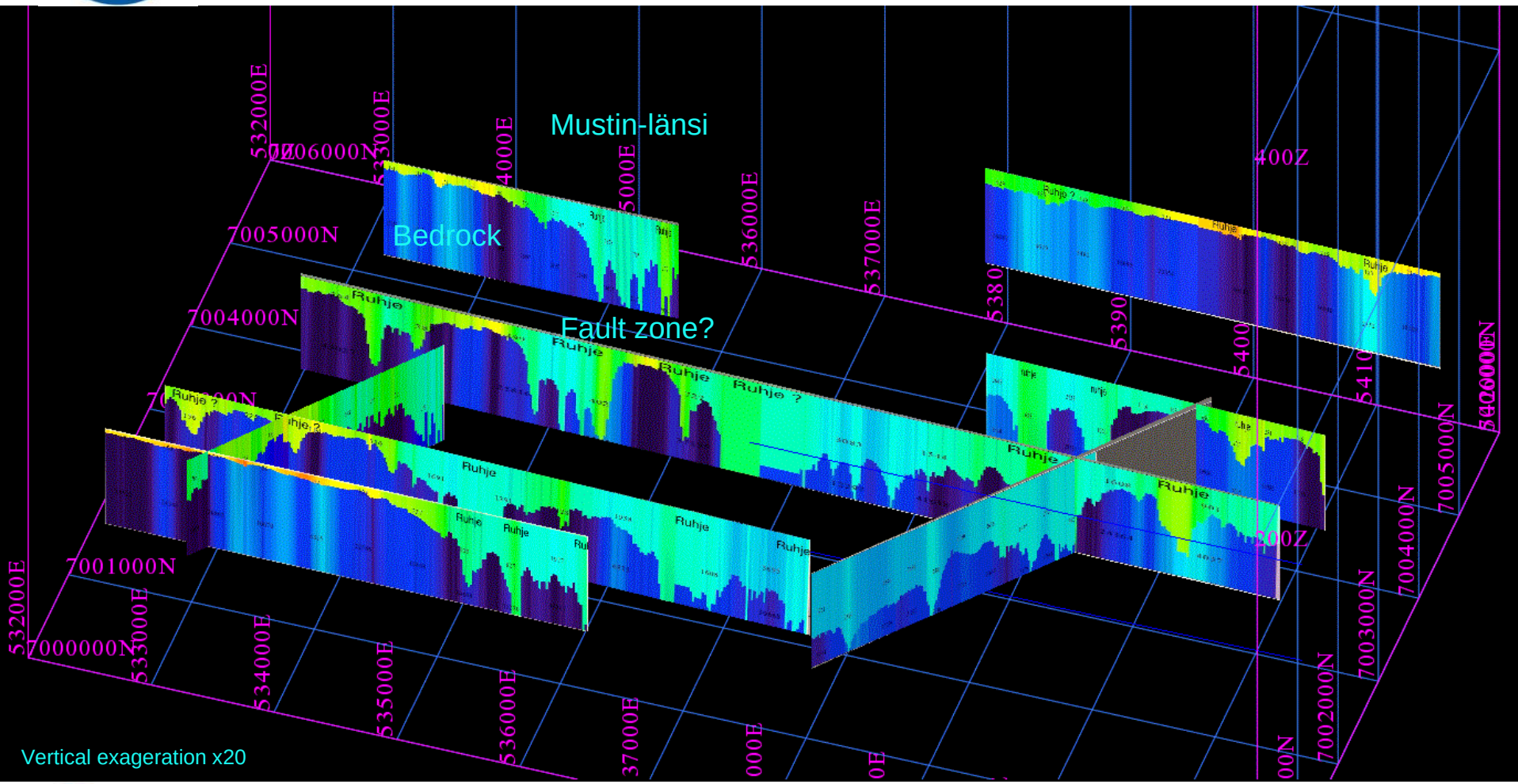
VLF-R Profile

- VLF-R and magnetic survey to identify the bedrock fracture zones



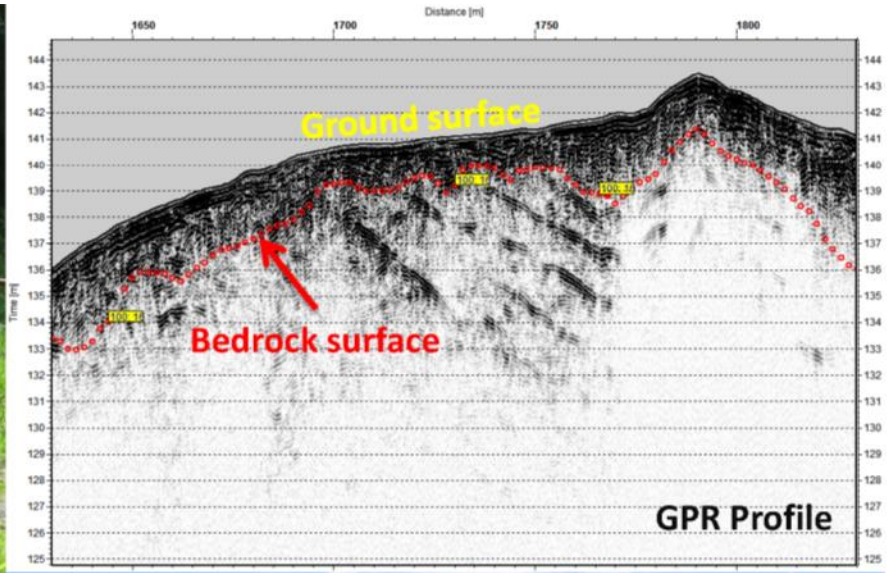
Interpretated bedrock surface

VLF-R Profiles in 3D view

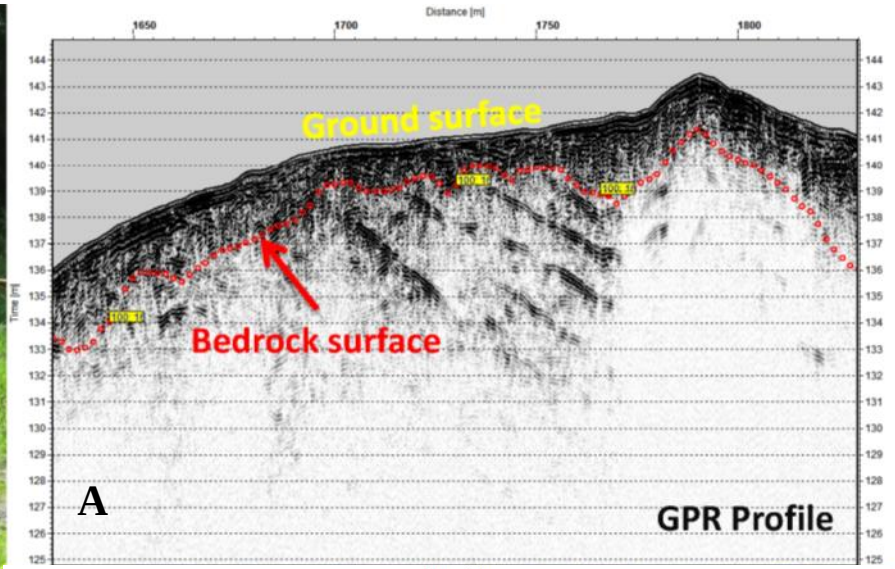


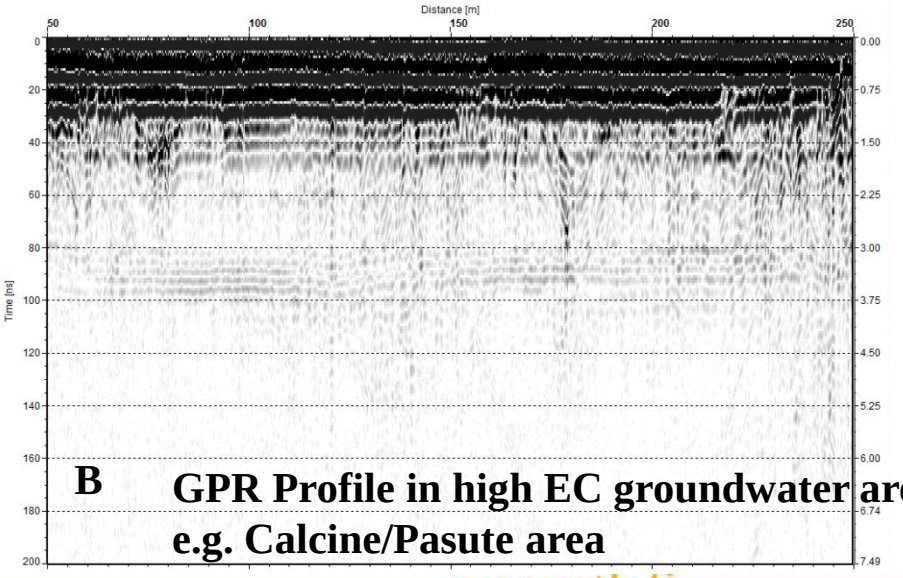
Interpreted bedrock surface

GPR Survey and GW monitoring



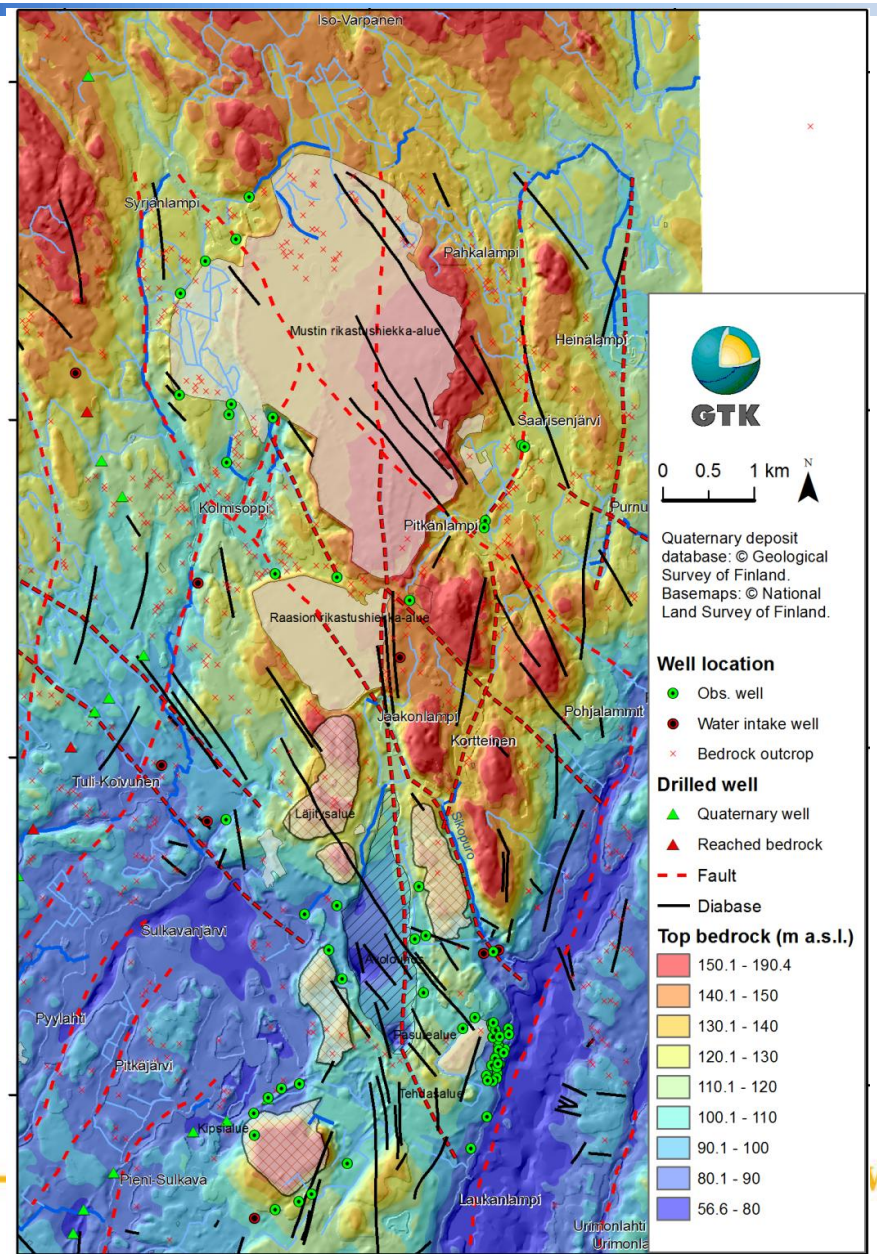
GPR Survey



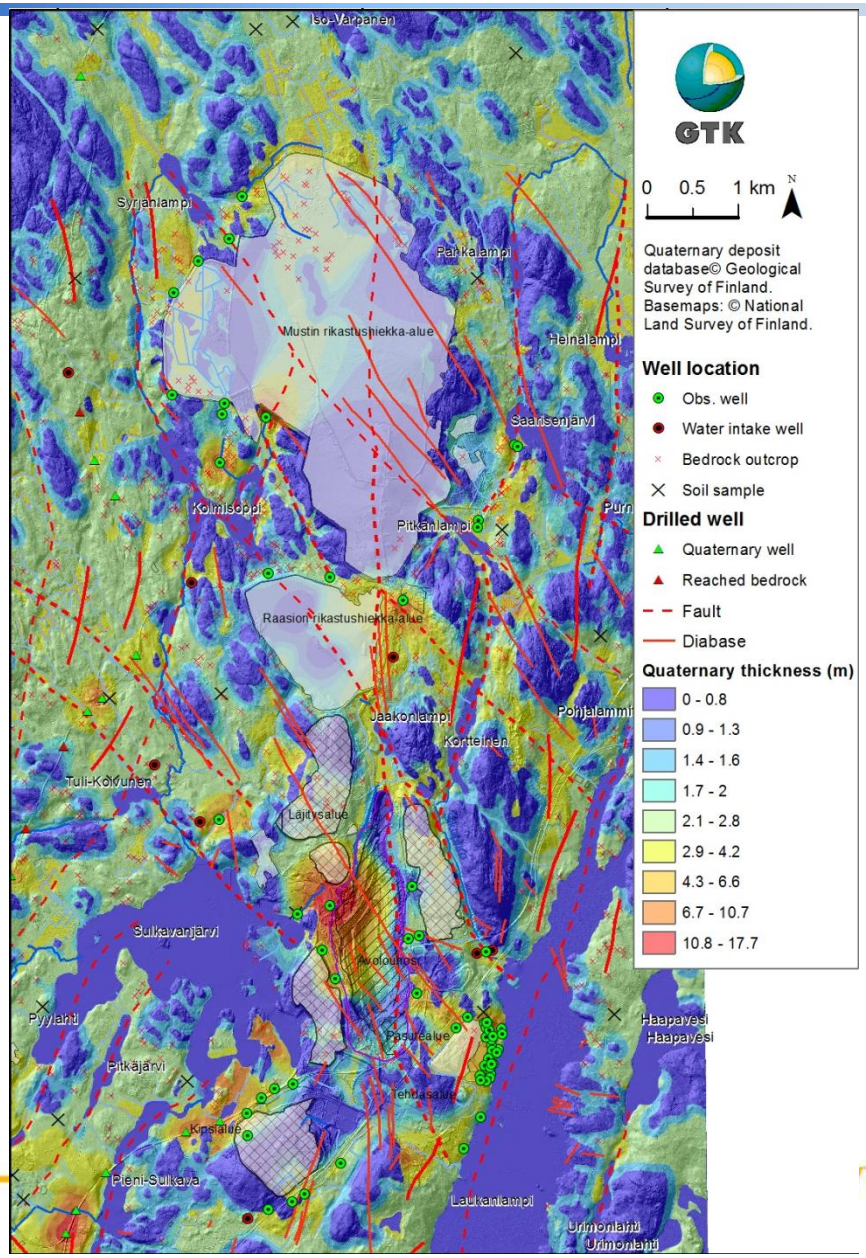


GPR Profile in high EC groundwater area e.g. Calcine/Pasute area

Interpolated bedrock surface

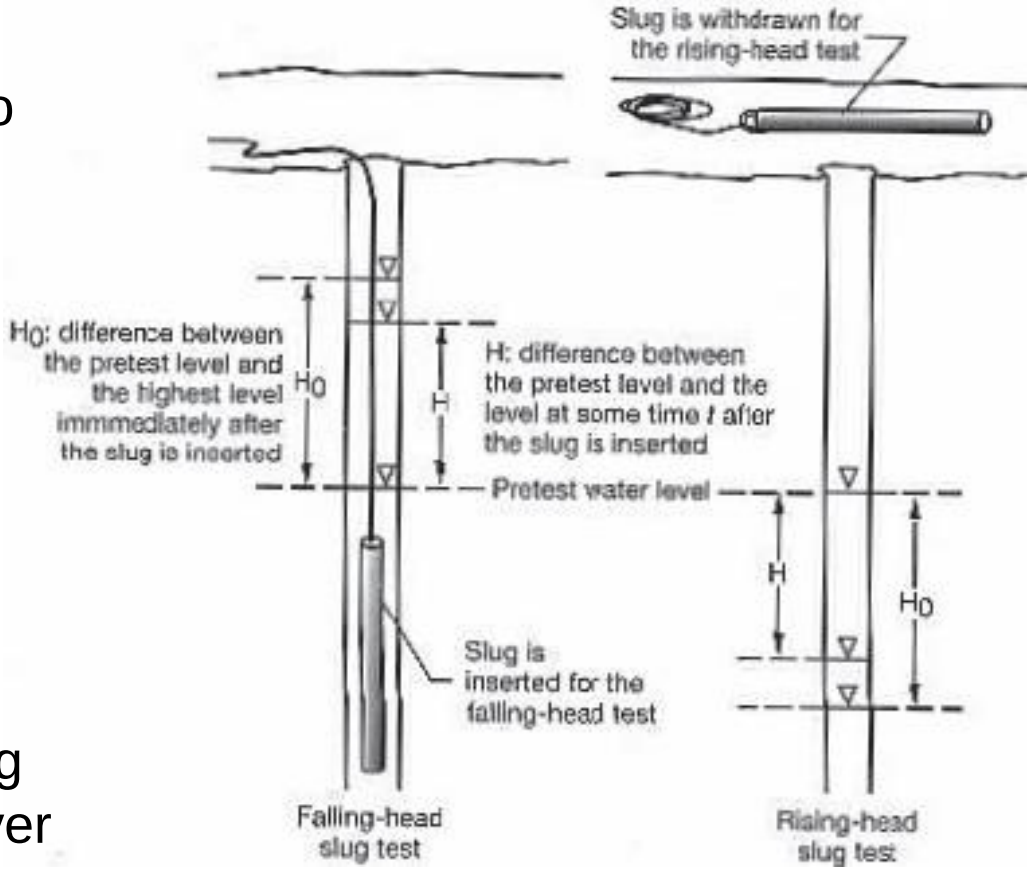


Interpolated Quaternary thickness



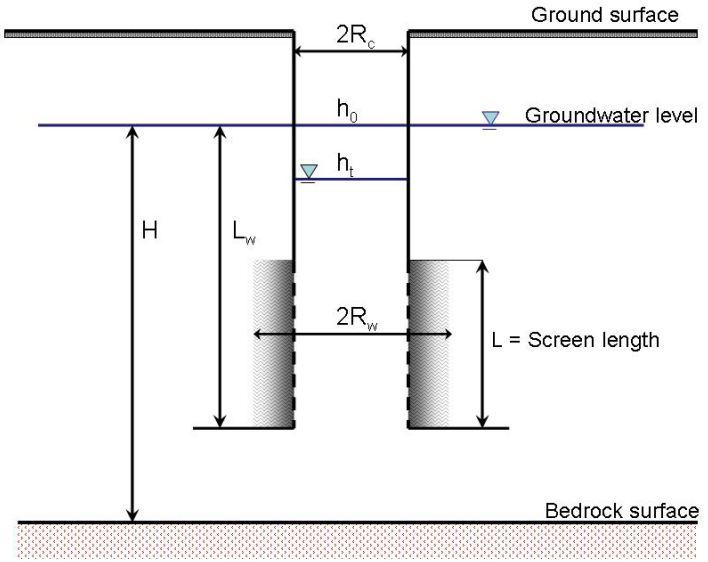
Slug-test

- The slug test is a fast and inexpensive field technique to determine the localized hydraulic conductivity (K) values.
- The method involves the instantaneous injection or withdrawal of a volume beneath the groundwater surface into a well. The K-values around the well can then be obtained by analyzing the change of water levels over time



(Fabbri et al., 2012)

Slug-test



$$K = \frac{R_c^2 \, ln\,(R_e/R_w)}{2L} \times \frac{1}{t} \times ln\,(h_0/h_t)$$

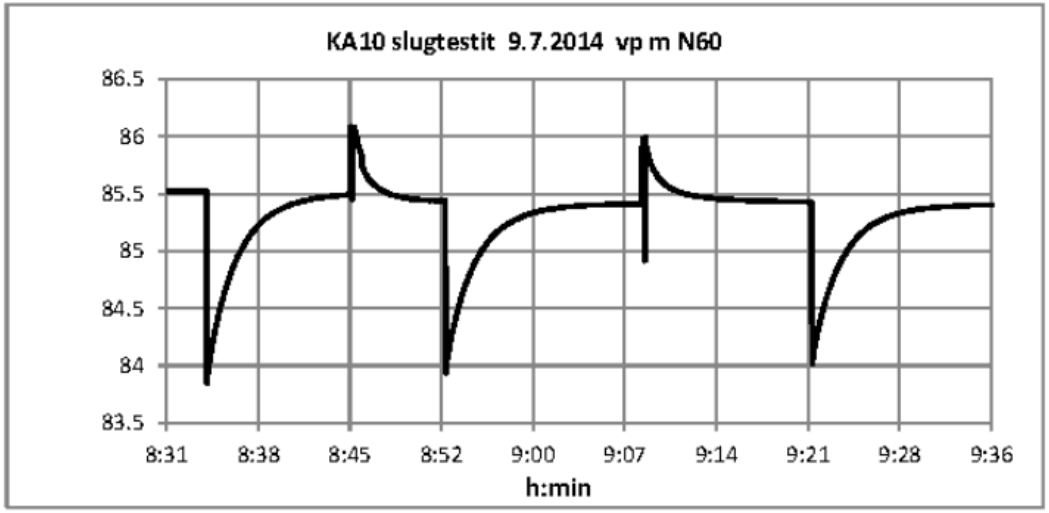
Where

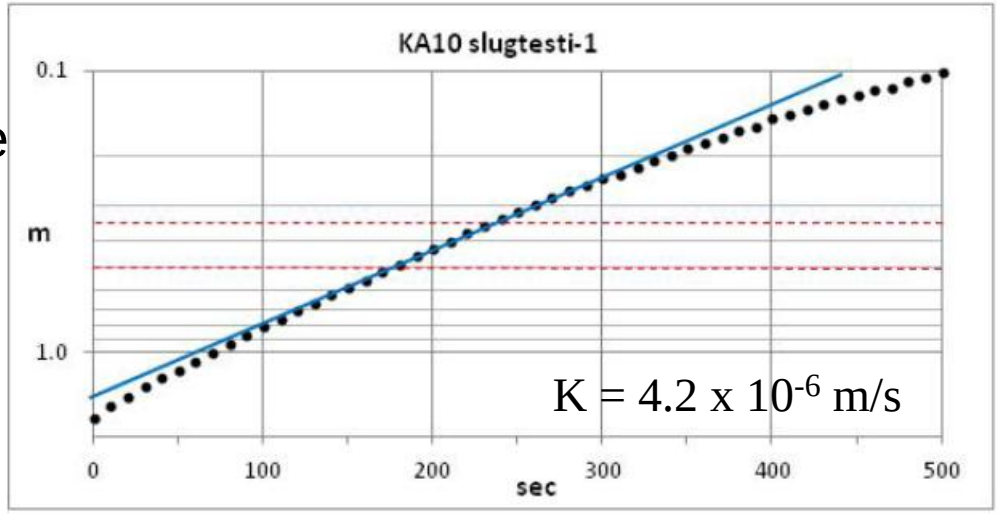
K	=	hydraulic conductivity [L/T]
R_c	=	radius of well casing [L]
R_w	=	effective radial distance between well centre and undisturbed aquifer [L]
R_e	=	effective radial distance over which the head difference is dissipated [L]
L	=	screened interval [L]
t	=	time [T]
h_0	=	static (undisturbed pre-test) water level at time 0 [L]
h_t	=	slug-displaced water levels at time t [L]
L_w	=	length from screen bottom to water level [L]
H	=	saturated thickness, length from top bedrock to water table [L]

A dimensionless ratio of $ln\,(R_e/R_w)$ is evaluated from analogue curves and it depends on the well geometry (Bouwer & Rice, 1976):

Slug-test in sediment section

- Slug test was done using the rising-head test by removed slug (a solid cylindrical PVC) quickly from the well
- GW level and the recovery time was recorded
- The K-value was calculated by using the AqTestSolver program and Bouwer & Rice method

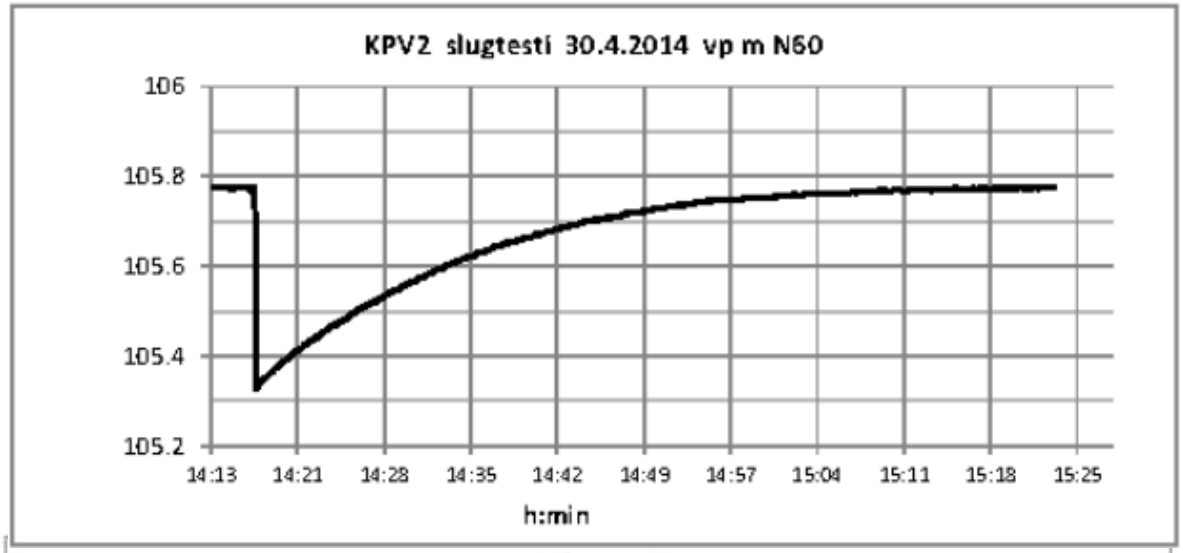


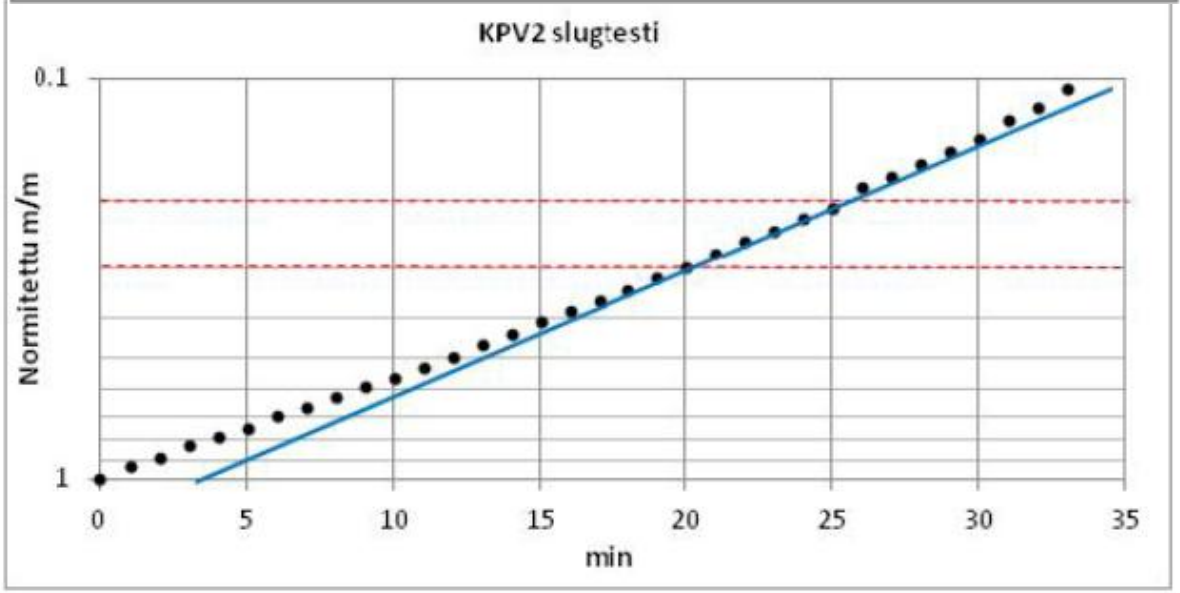


Slug-test in bedrock section

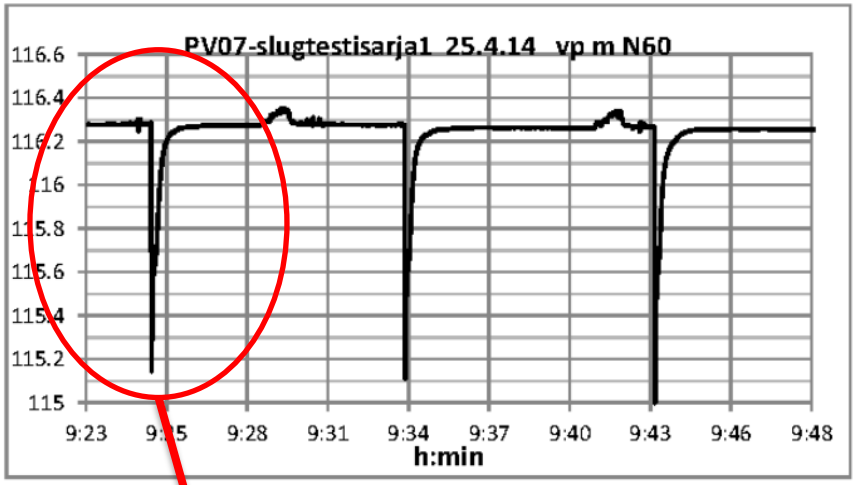
- Example of slug test in the bedrock well
- GW recovery time = 75 minutes

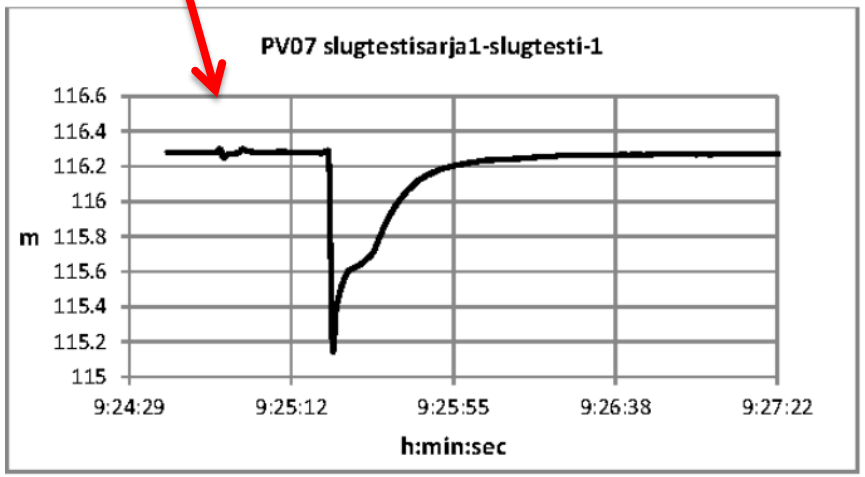
K = 2.3E-7 m/s

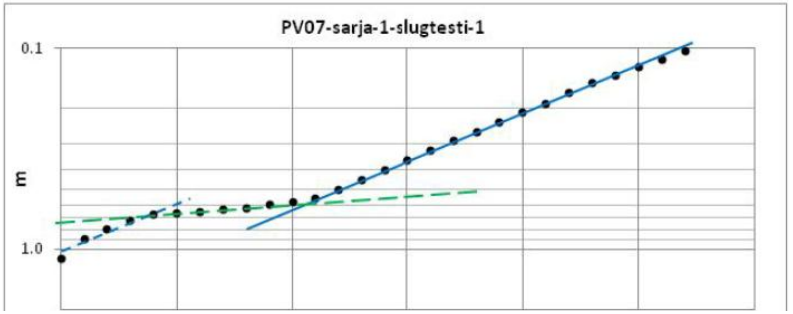


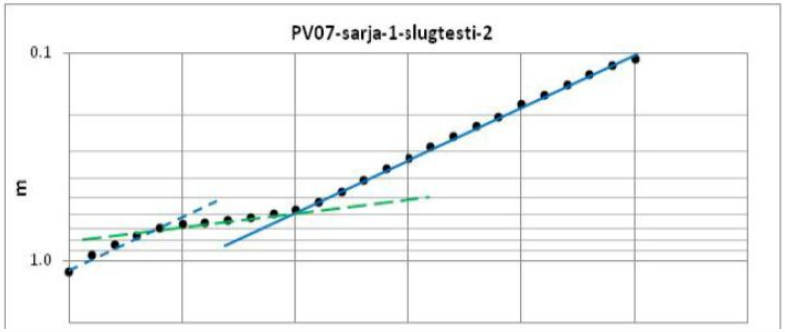


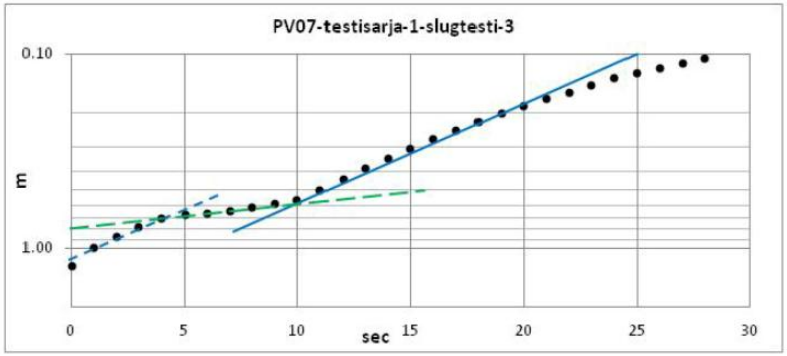
Slug-test indicates stratigraphic heterogeneity





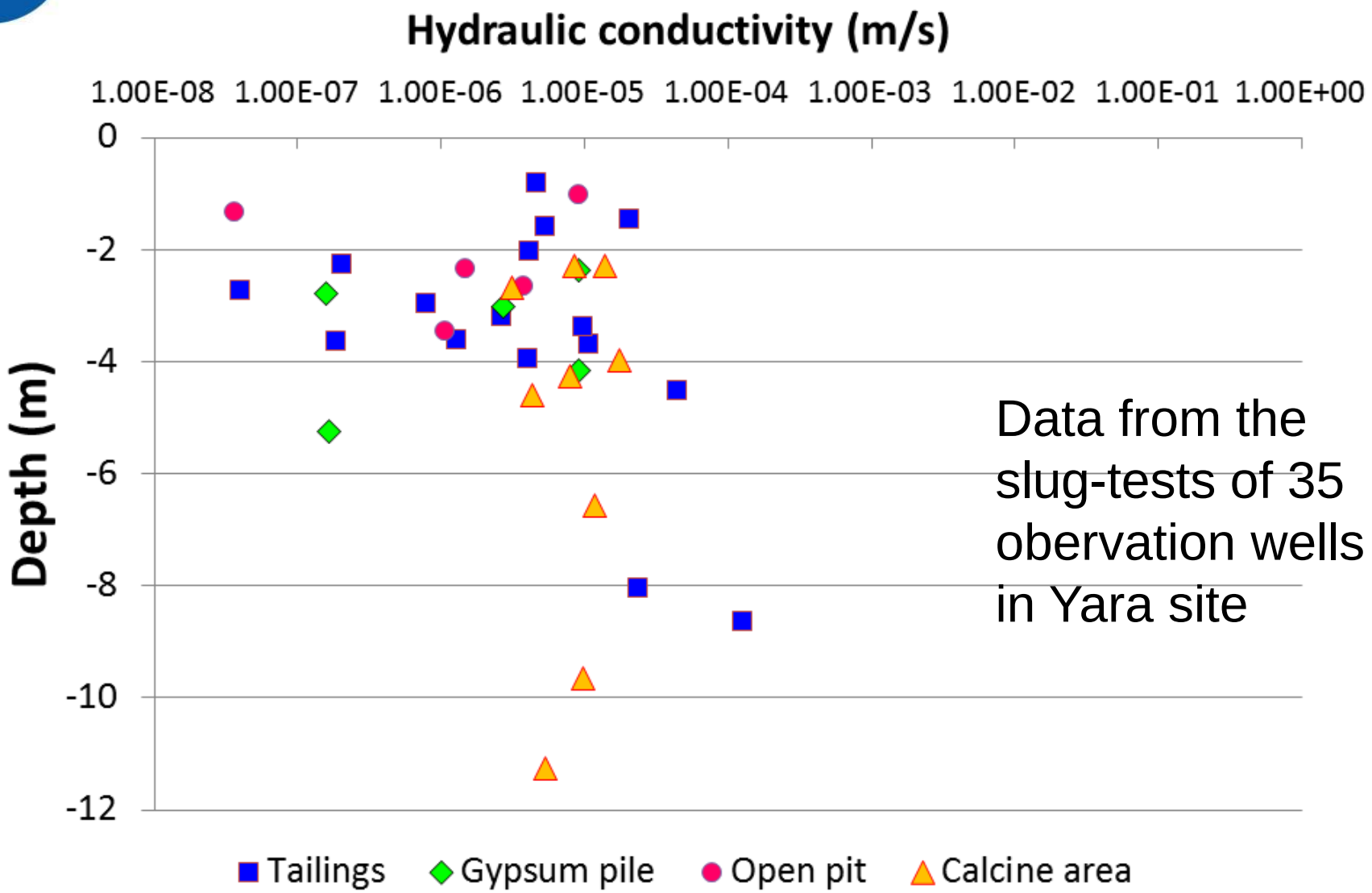






Slug-test	slug-1-1	slug-1-2	slug-1-3	slug-2-1	slug-2-2
kerros-1 m/s	4.20E-05	4.10E-05	4.70E-05	6.20E-05	6.00E-05
kerros-2 m/s	9.90E-06	1.00E-05	1.10E-05	1.50E-05	1.50E-05
kerros-3 m/s	4.10E-05	4.60E-05	4.30E-05	5.40E-05	4.80E-05

Depth profile distribution of K-value



Data from the slug-tests of 35 obervation wells in Yara site

Slug-test

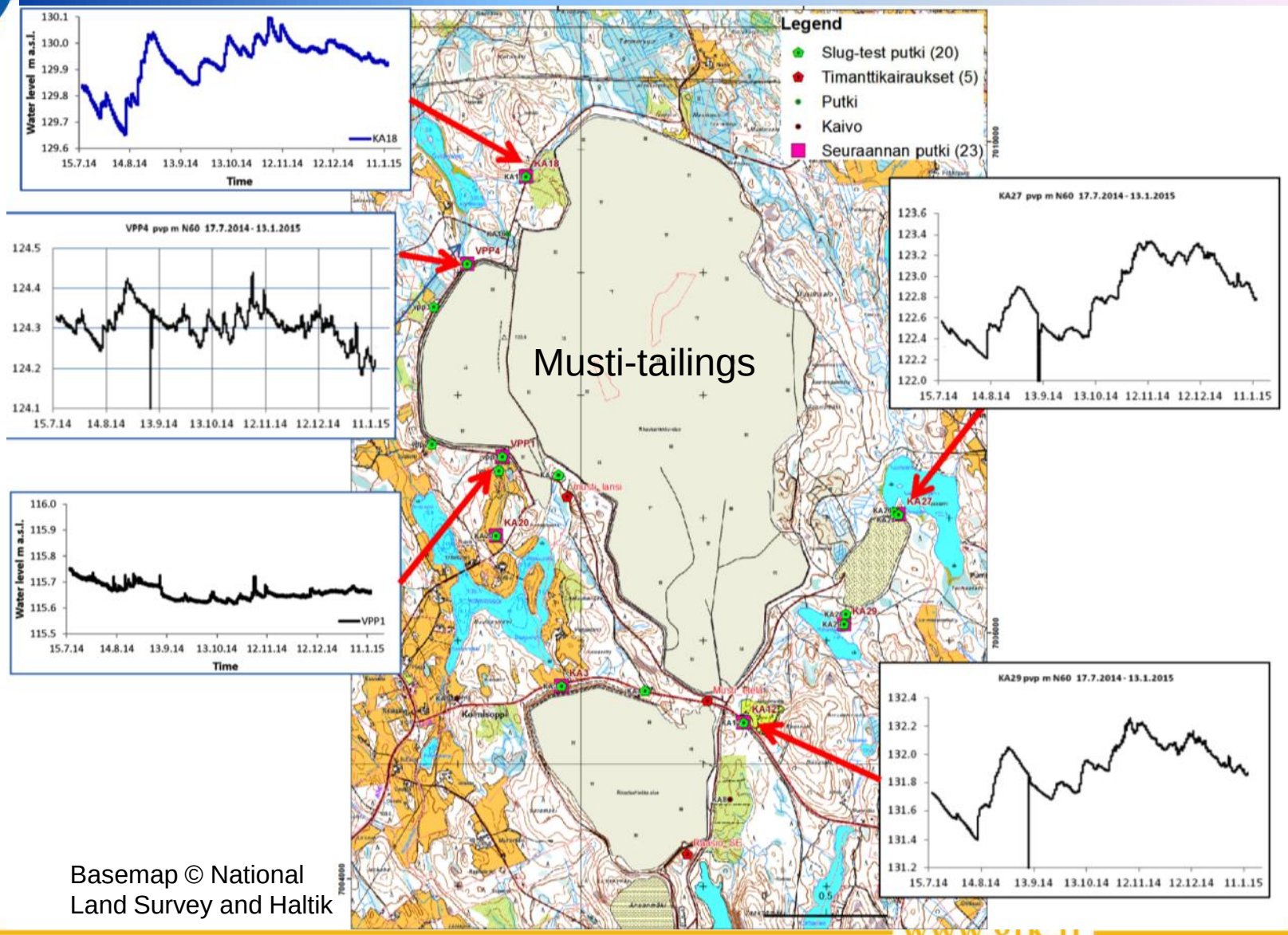
PROS:

- Simple, fast, inexpensive and does not require pumps or complex equipment
- The test indicates the K-values of the localized area near the testing site.
- The analysis of the data is often simple, and many software programs for data analysis are available
- The slug test is also useful in the case of polluted aquifers because the extraction of water is not necessary

CONS:

- The reliability of a slug test is less than a pumping test
- Only the permeability near the borehole can be evaluated, and this value cannot be representative of all aquifer
- Slug tests are sensitive to near-well conditions, and low-K skins produce slug-test estimates lower than the K-values of the formation near the well screen

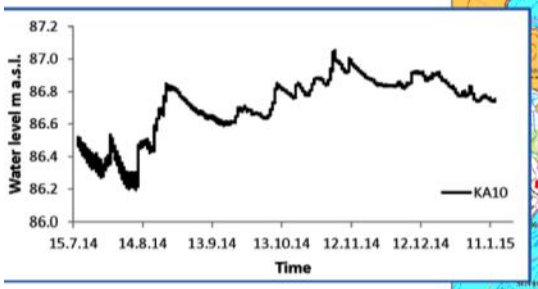
Groundwater monitoring data

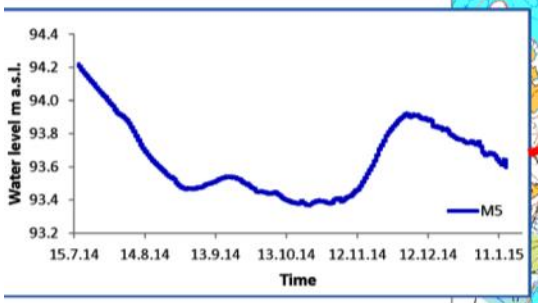


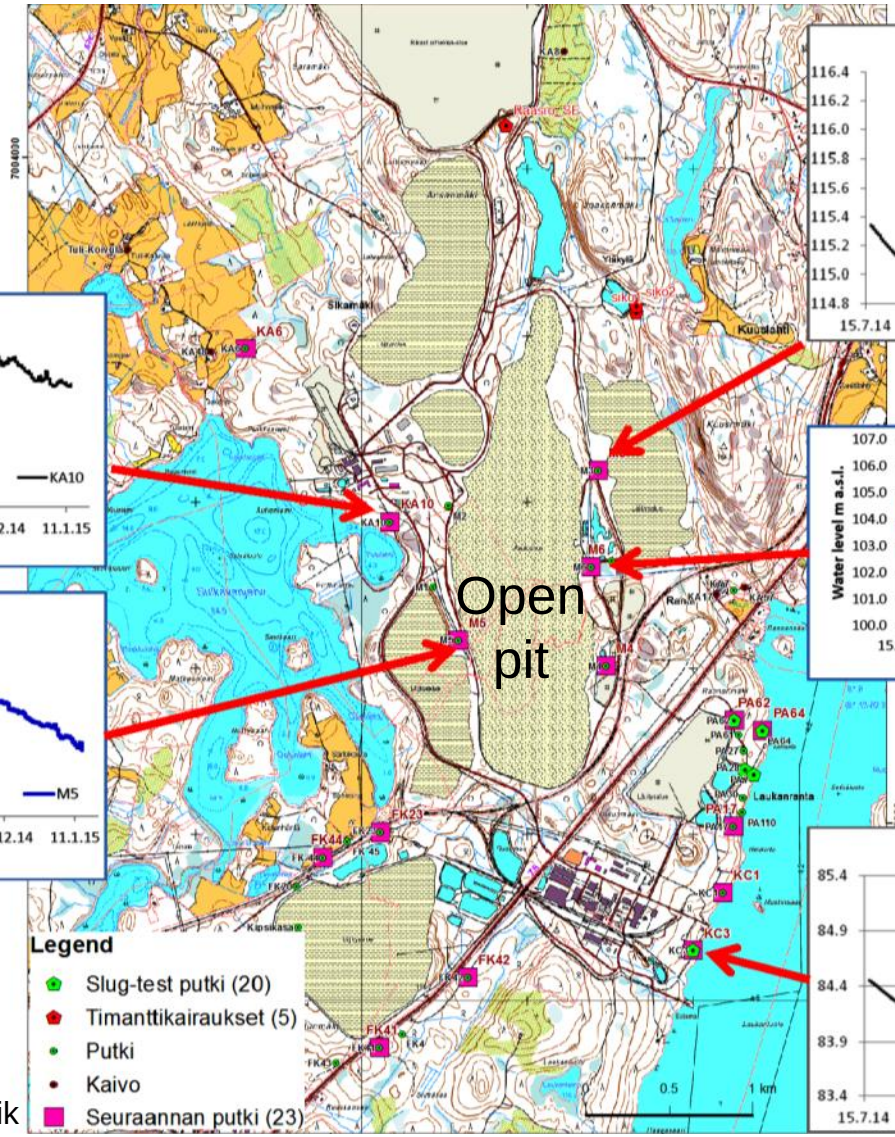
Basemap © National Land Survey and Haltik

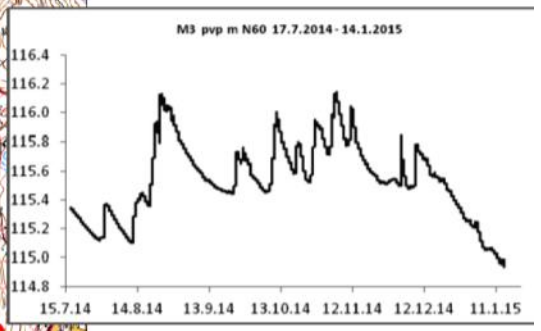
Data during 7.7.2014-15.1.2015

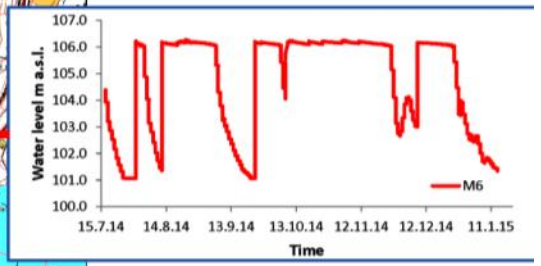
Groundwater monitoring data

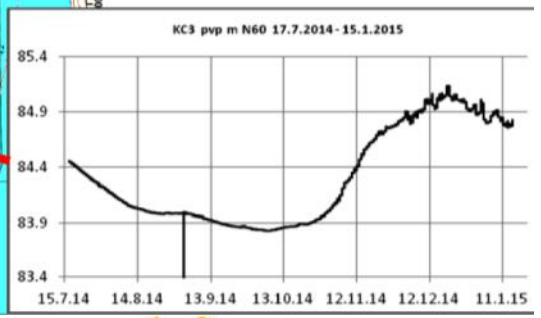












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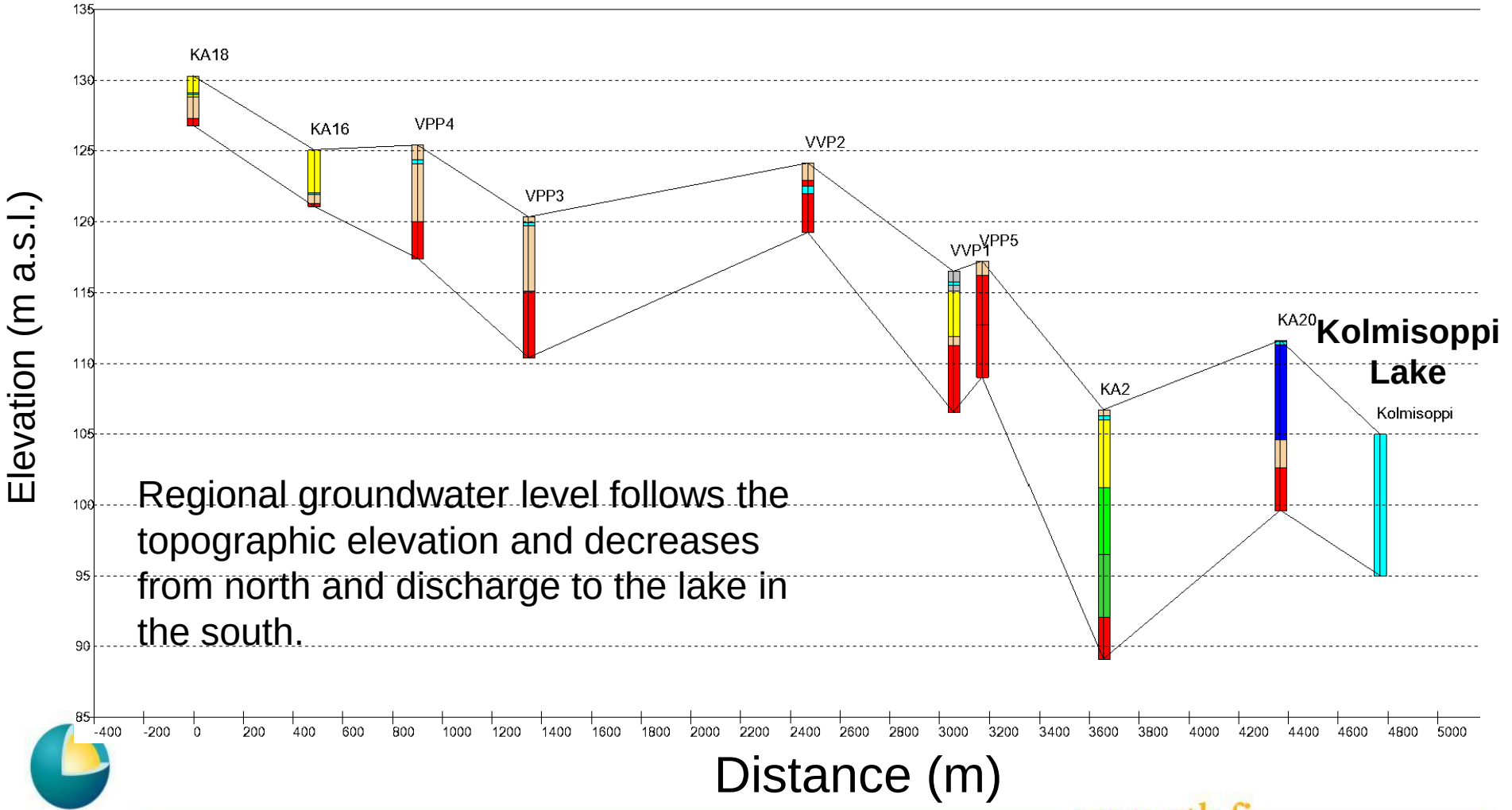
Data during 7.7.2014-15.1.2015

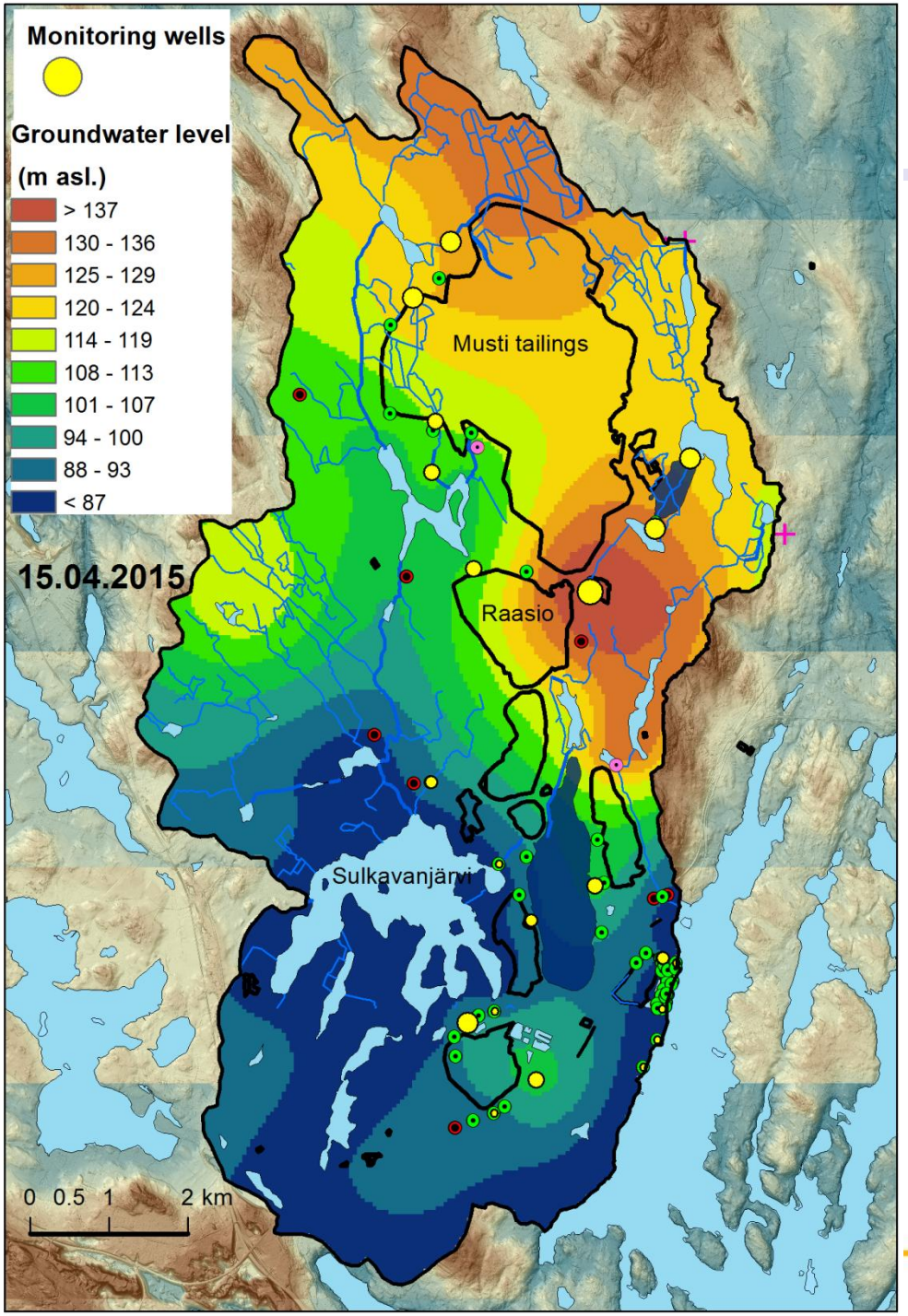
Groundwater monitoring data

North **South**



Regional groundwater level follows the topographic elevation and decreases from north and discharge to the lake in the south.

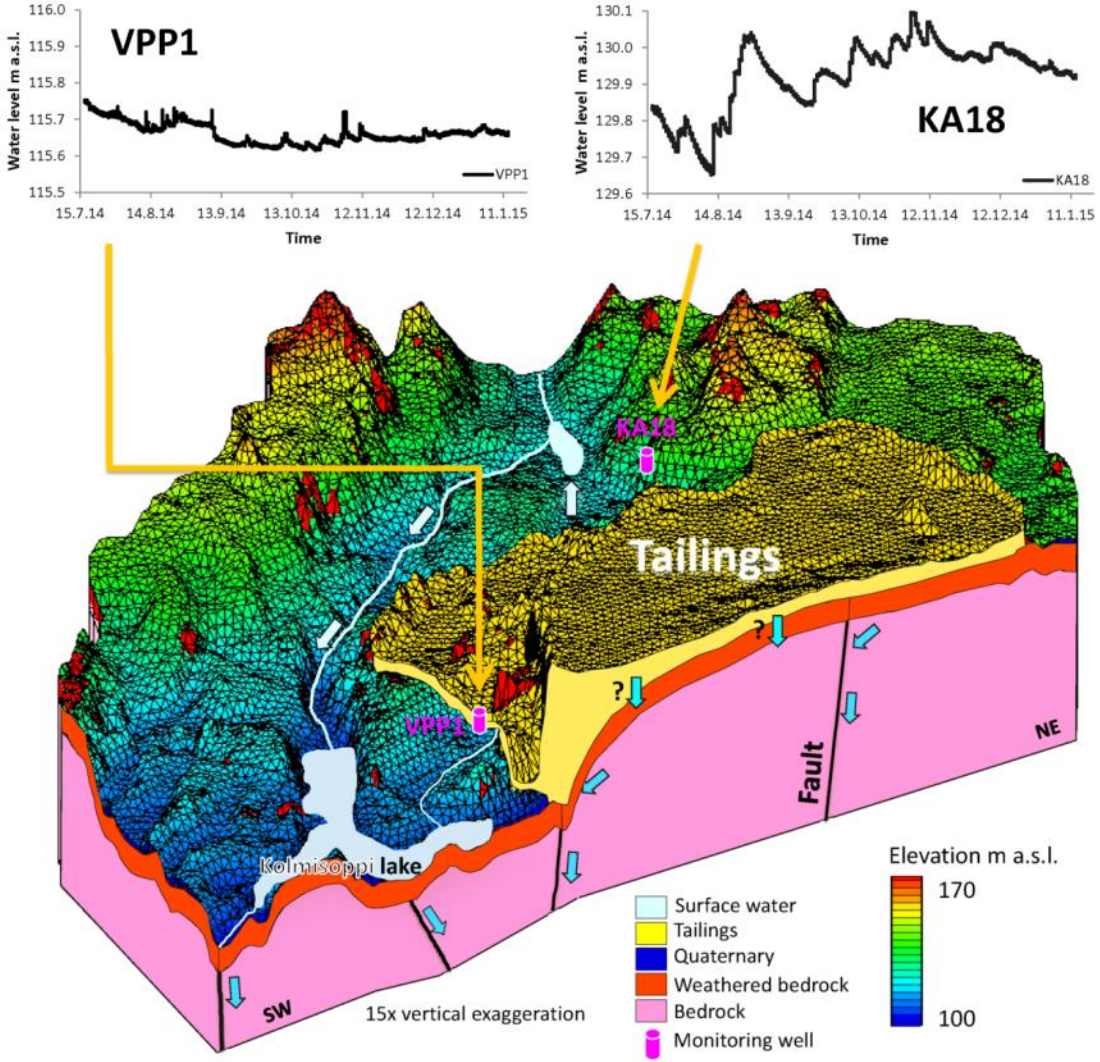
Interpolated groundwater level map based on monitoring data on 15.4.2015



Conceptual modelling

Tekes

Groundwater level monitoring during 7.7.2014 – 15.1.2015



Conceptual modelling

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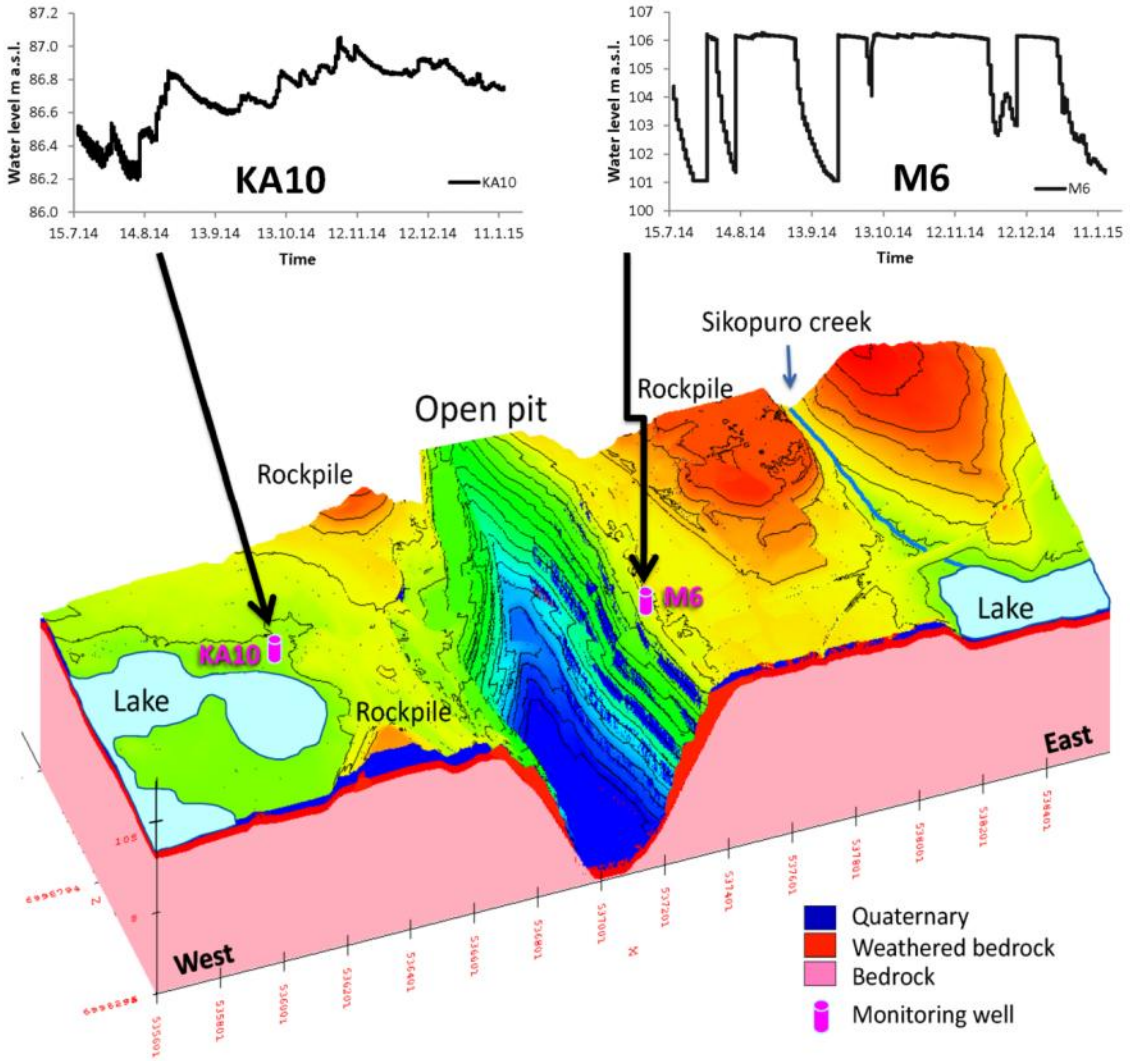
Groundwater level monitoring during 7.7.2014 – 15.1.2015



Thank you!

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