FLUTe liner technology - an innovative method of investigating fractured bedrock that has been impacted with chlorinated solvents

2024-03-21

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What are FLUTe Liners

- FLUTe liners are a simple but ingenious technique – delineates cVOC/BTEX at depth in BEDROCK (mainly)
  - Dry cleaners (PCE)
  - Metal surface treatment facilities (generally TCE/BTEX)
  - Pharmaceutical companies (TCE/DCA)
  - Plastics (TCE/vinyl chloride)
- FLUTe liners allow for detailed hydraulic conductivity and transmissivity studies
- Cased Hole Samplers and Waterflutes allow water to be extracted at predetermined levels
- FLUTe Liners can be installed to great depth (>200m) in bedrock

Knowing these results helps when assessing what remedial technique is a viable solution to target an impacted area.

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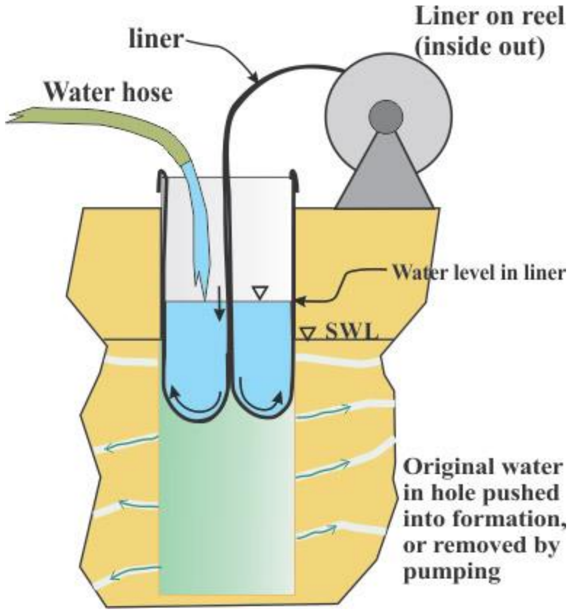
FLUTe™ Flexible Liner Underground Technologies

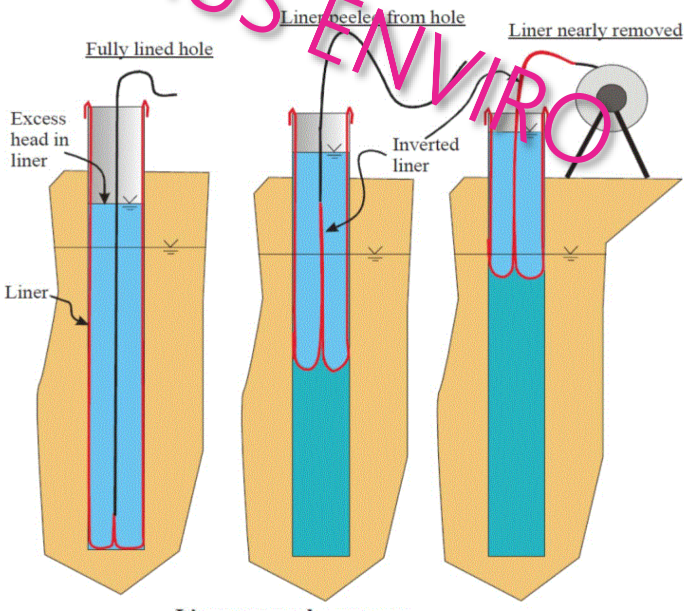
The FLUTe Liners

- Outer protective Carrier Liner - nylon or polyester fabric coated with urethane
- Inner NAPL FLUTe Liner - multi-coloured, striped, hydrophobic material that detects DNAPL in fractures
- FACT (FLUT Activated Carbon Technique) - continuous strip of felt fabric containing activated carbon

shipping reels with liners

Arrive inside out

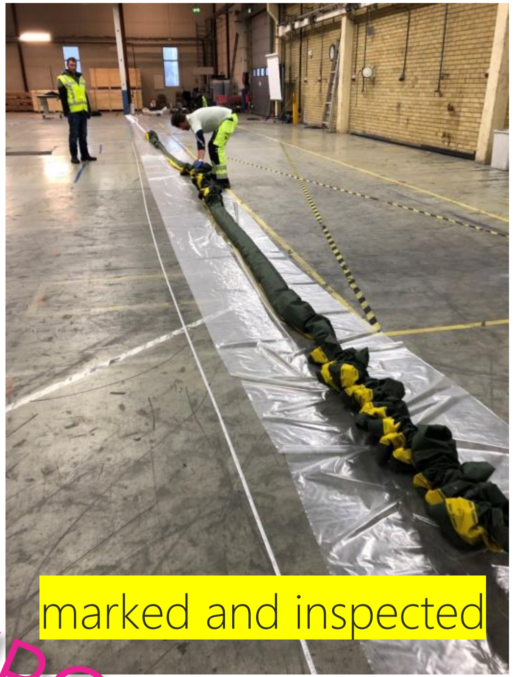


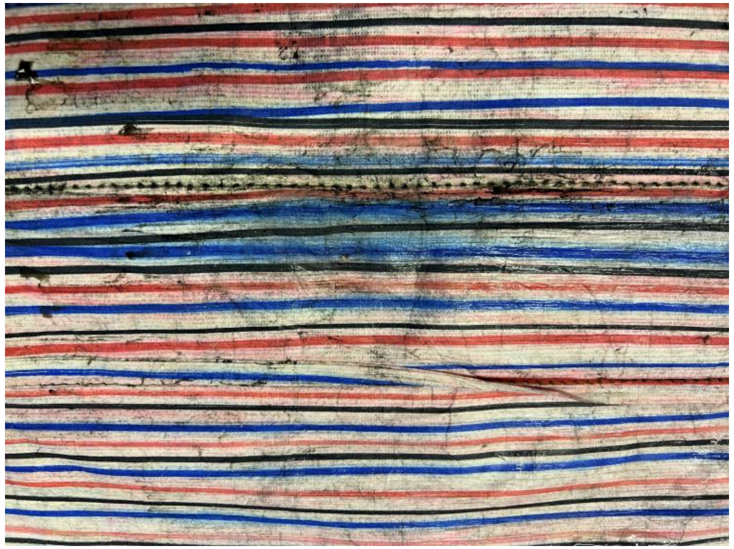


Advancing/everting a liner downhole by turning it right side-out and filling the annular space with water.

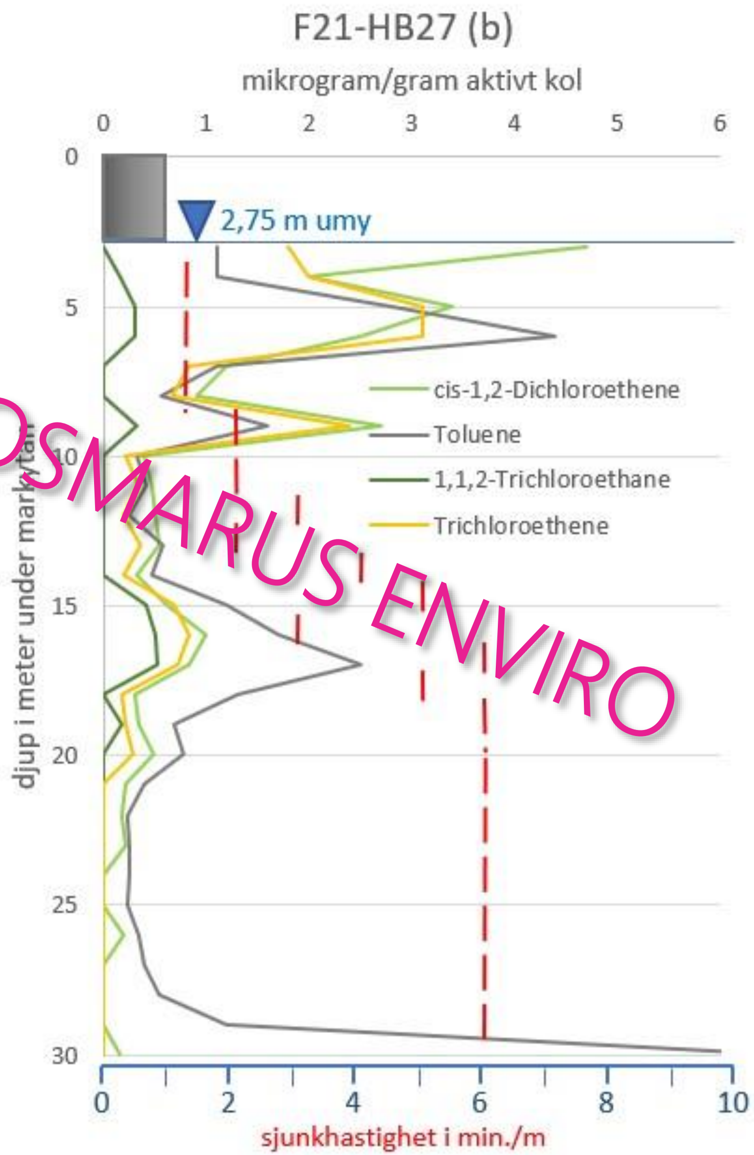

RB14
Whirlpool
After 2 weeks

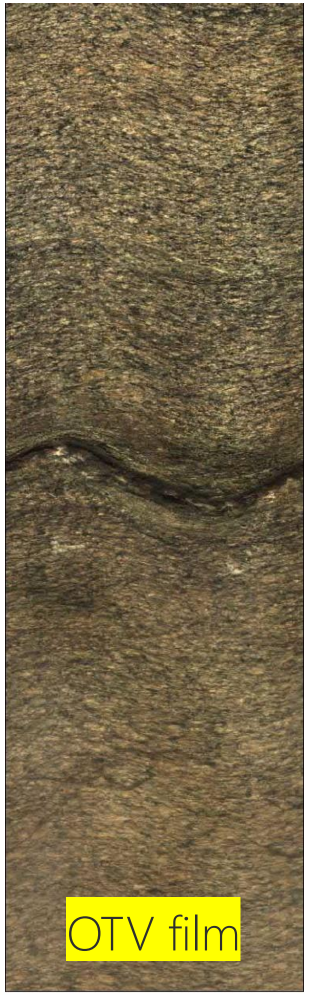

PCE DNAPL
@ 20,8 m bgs


marked and inspected




creosote/PAH/oil





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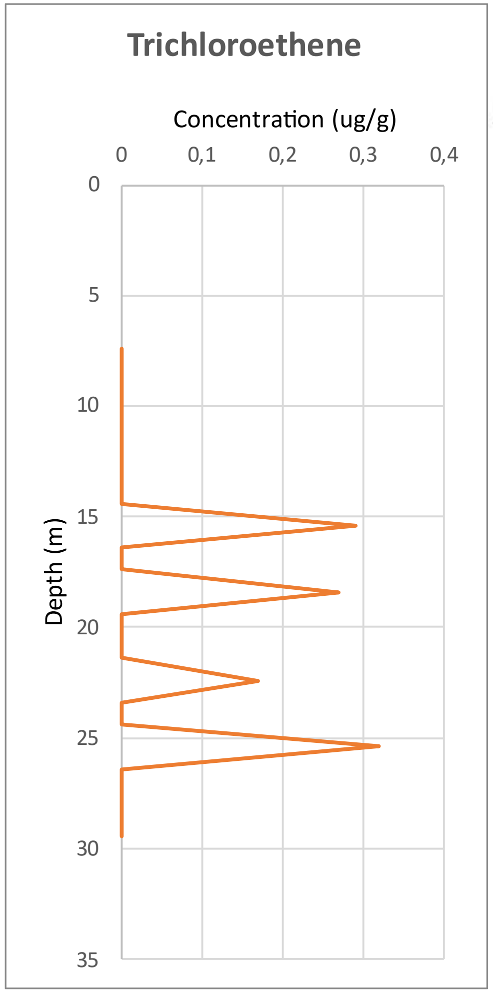
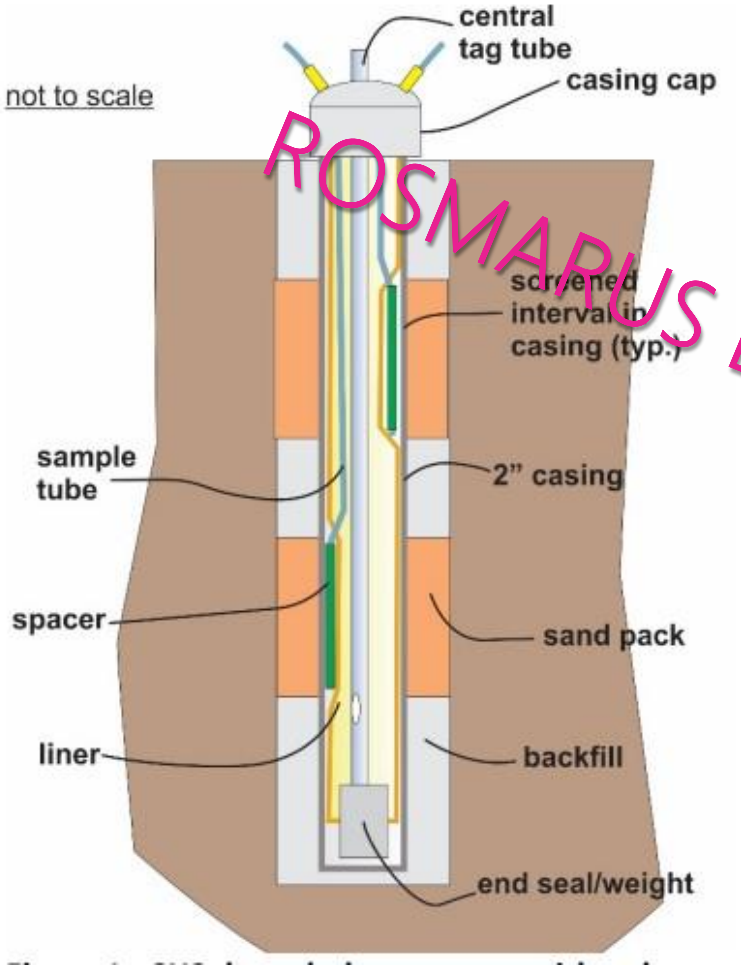
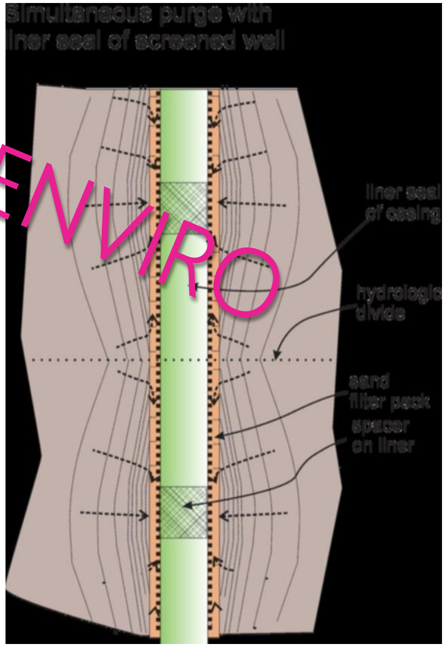
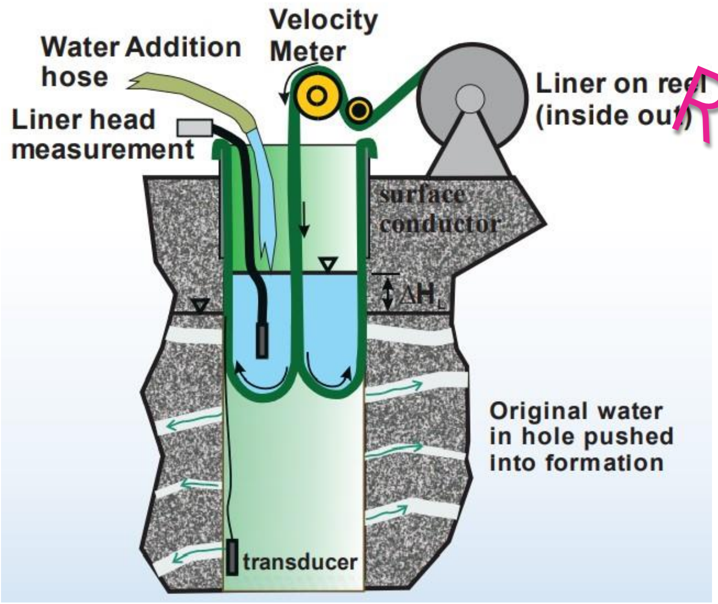
Cased Hole Samplers (CHS)

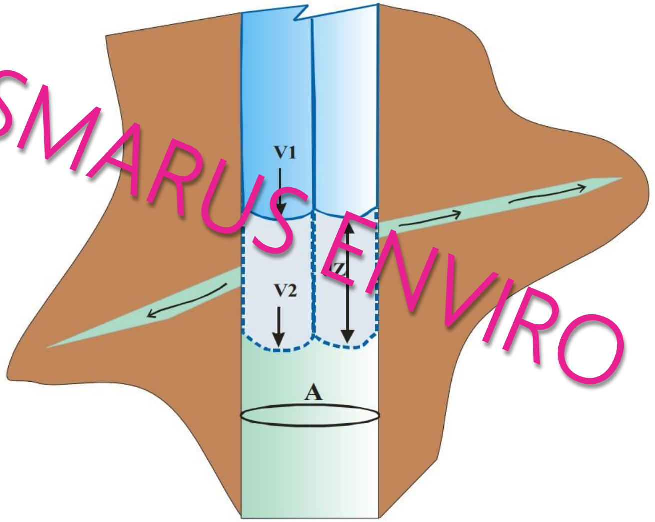


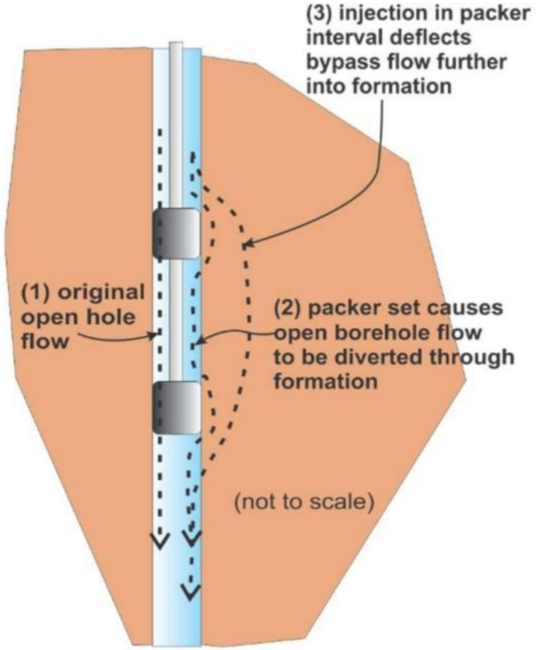


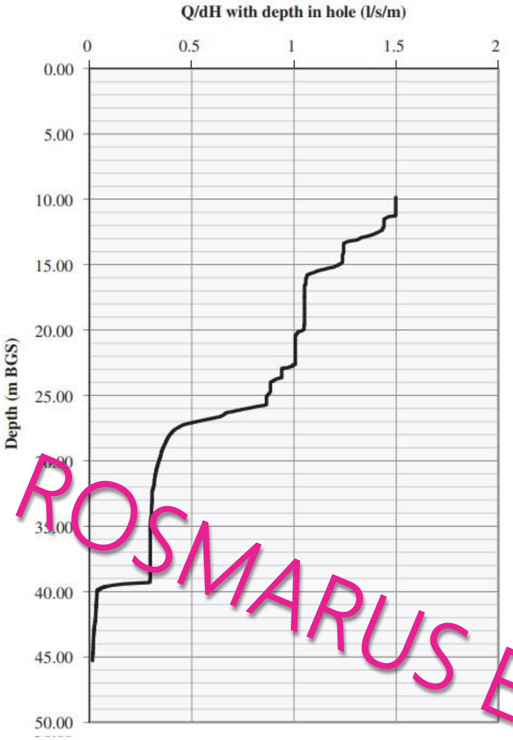


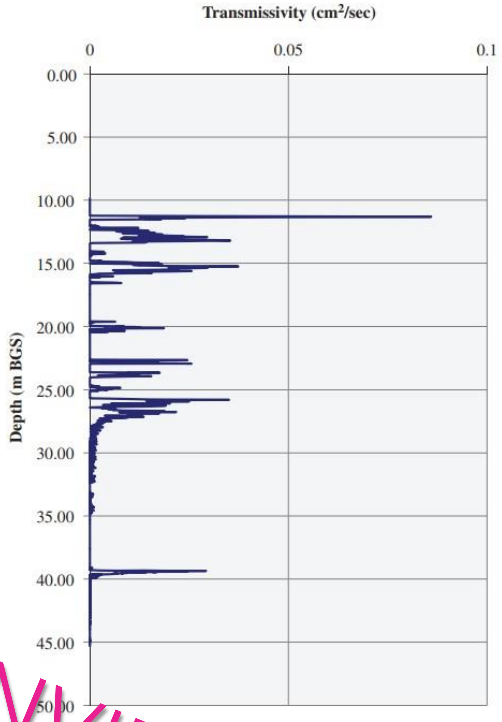
T-profiling : determining the transmissivity of a borehole



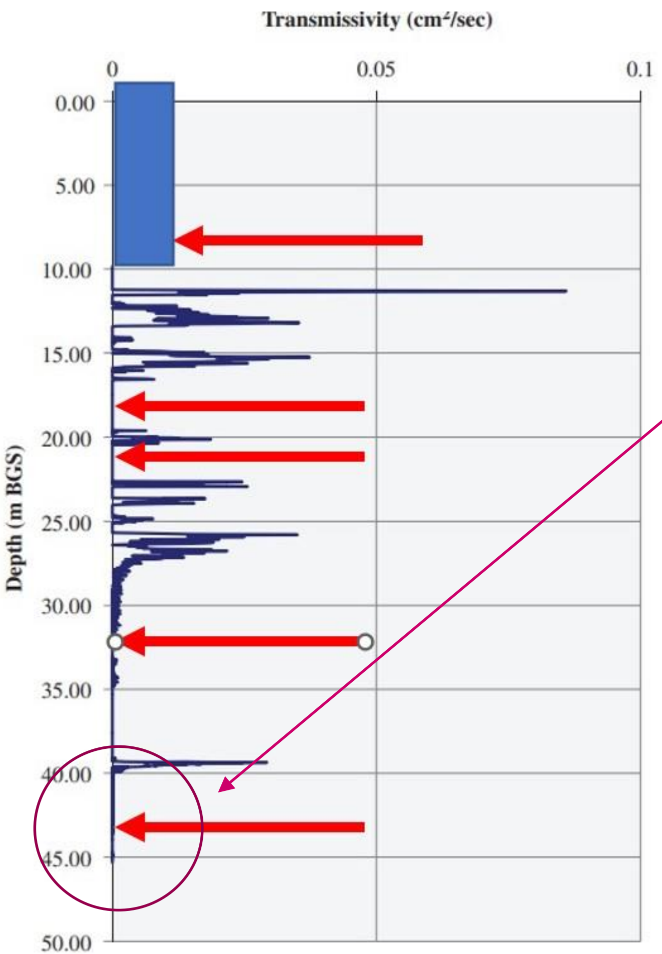


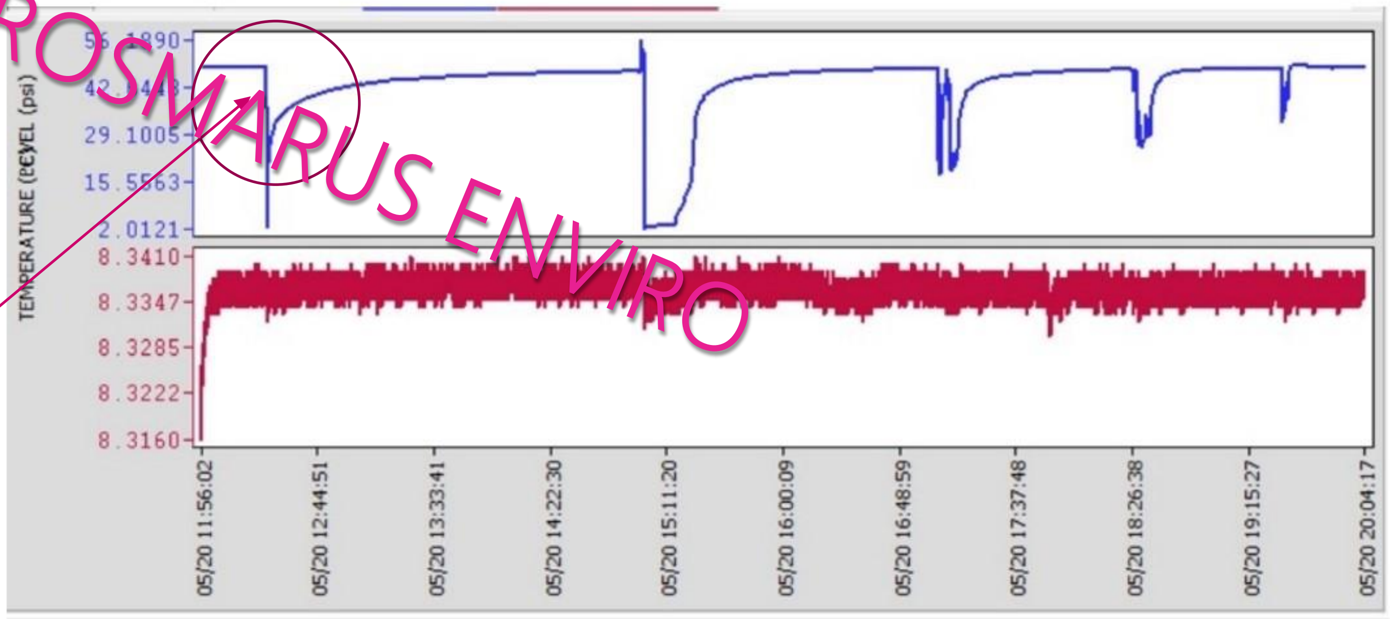



Q/dH with depth in hole (l/s/m)
0
0.5
1
1.5
2
Depth (m BGS)
0.00
5.00
10.00
15.00
20.00
25.00
40.00
45.00
50.00

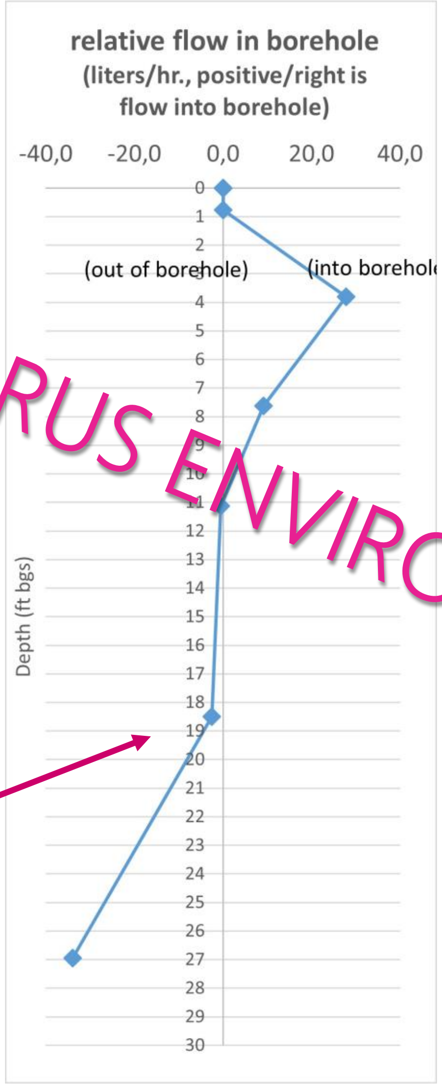

Transmissivity (cm^2/sec)
0
0.05
0.1
Depth (m BGS)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00

Reverse Head from transmissivity data





Know this when leaving bedrock boreholes open



DANGER!!

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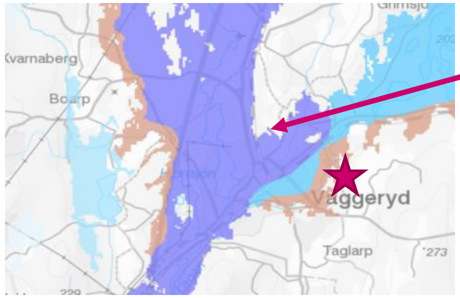
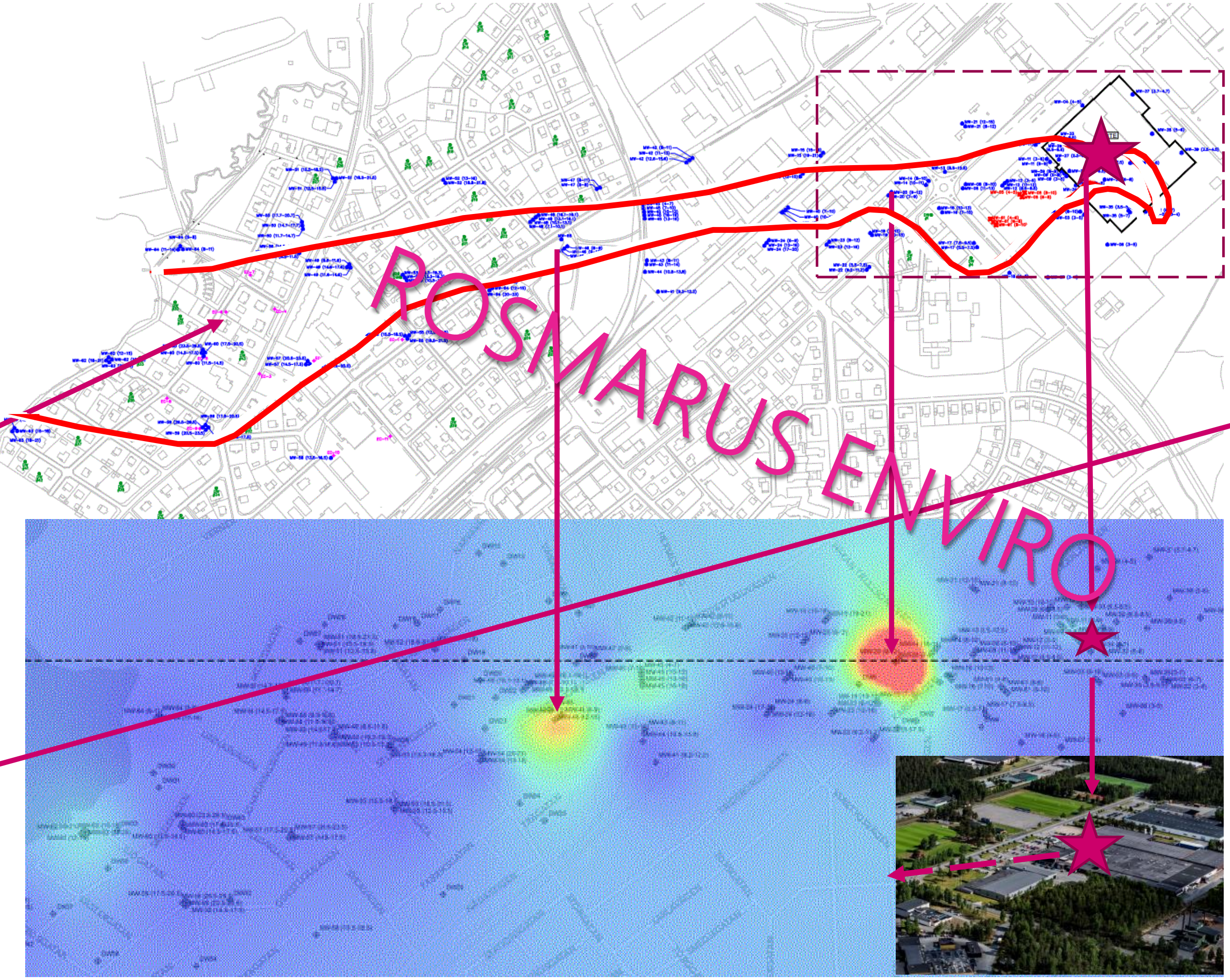
Case study 1





- Site source area
- 1.4 km long TCE plume
- Several down-gradient hotspots
- Important gw- reservoir

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Sustainable Soil Remediation

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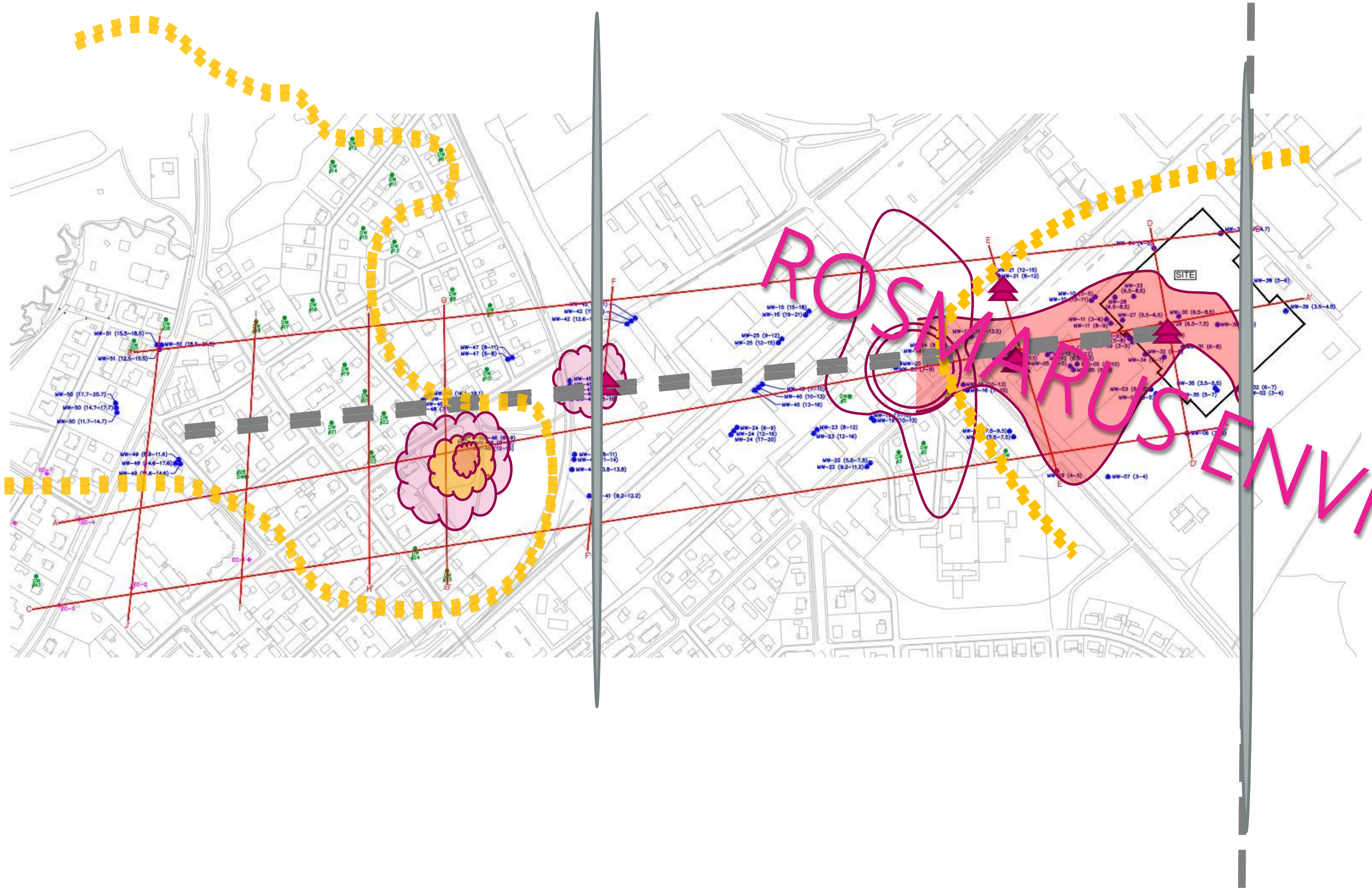
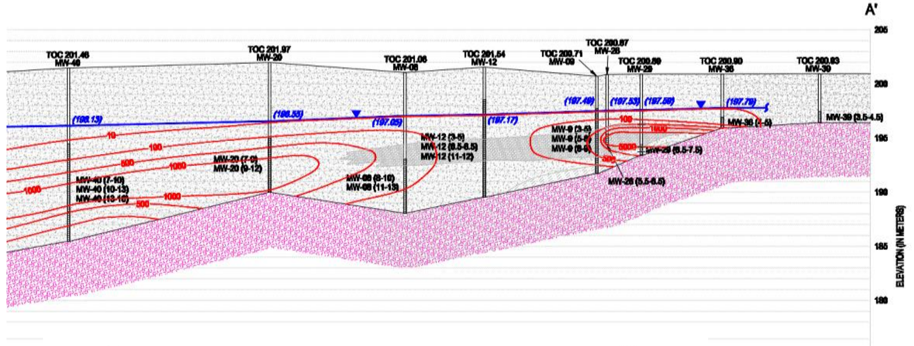
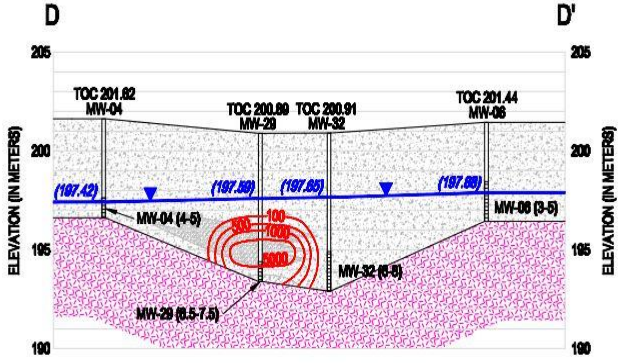
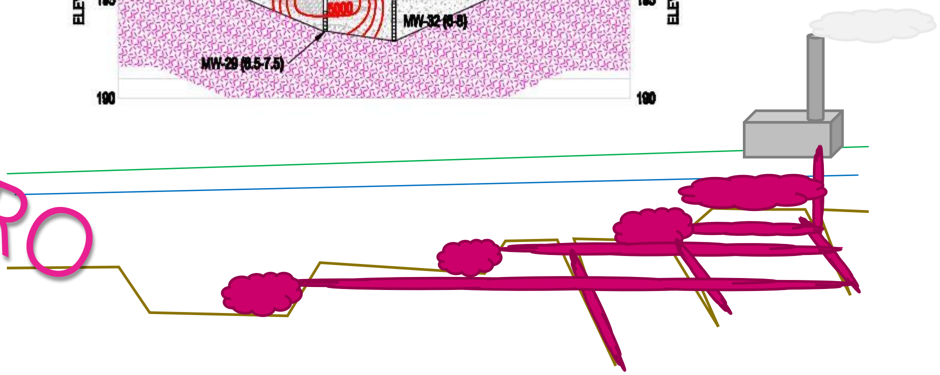
Case study 1









- Map scale structures coincide with hotspots
- ....but is it possible???

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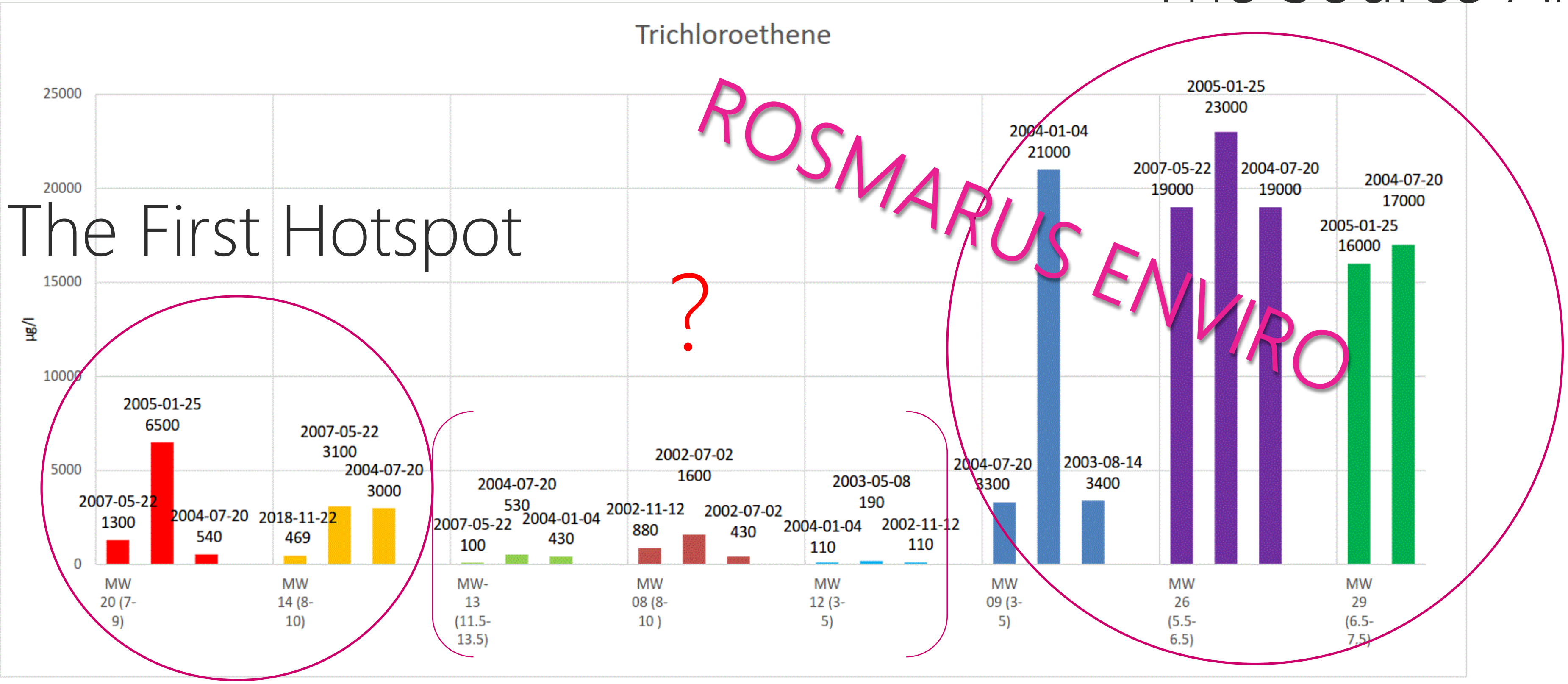
Challenging the previous CSM

The Intermediate Area

The Source Area



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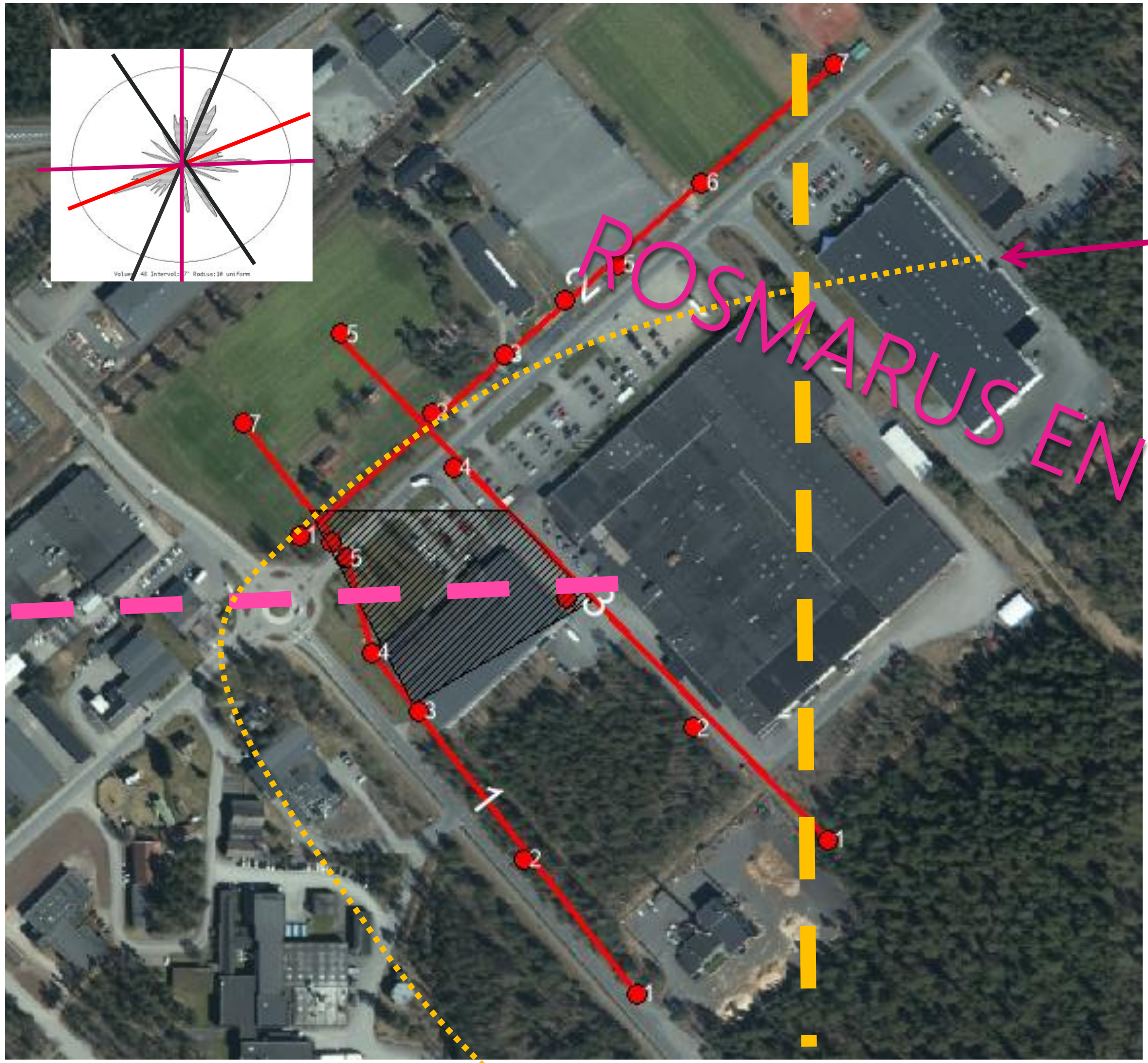
Continuing the Tiered Approach



Three 400 m long resistivity profiles placed utilising known geological data

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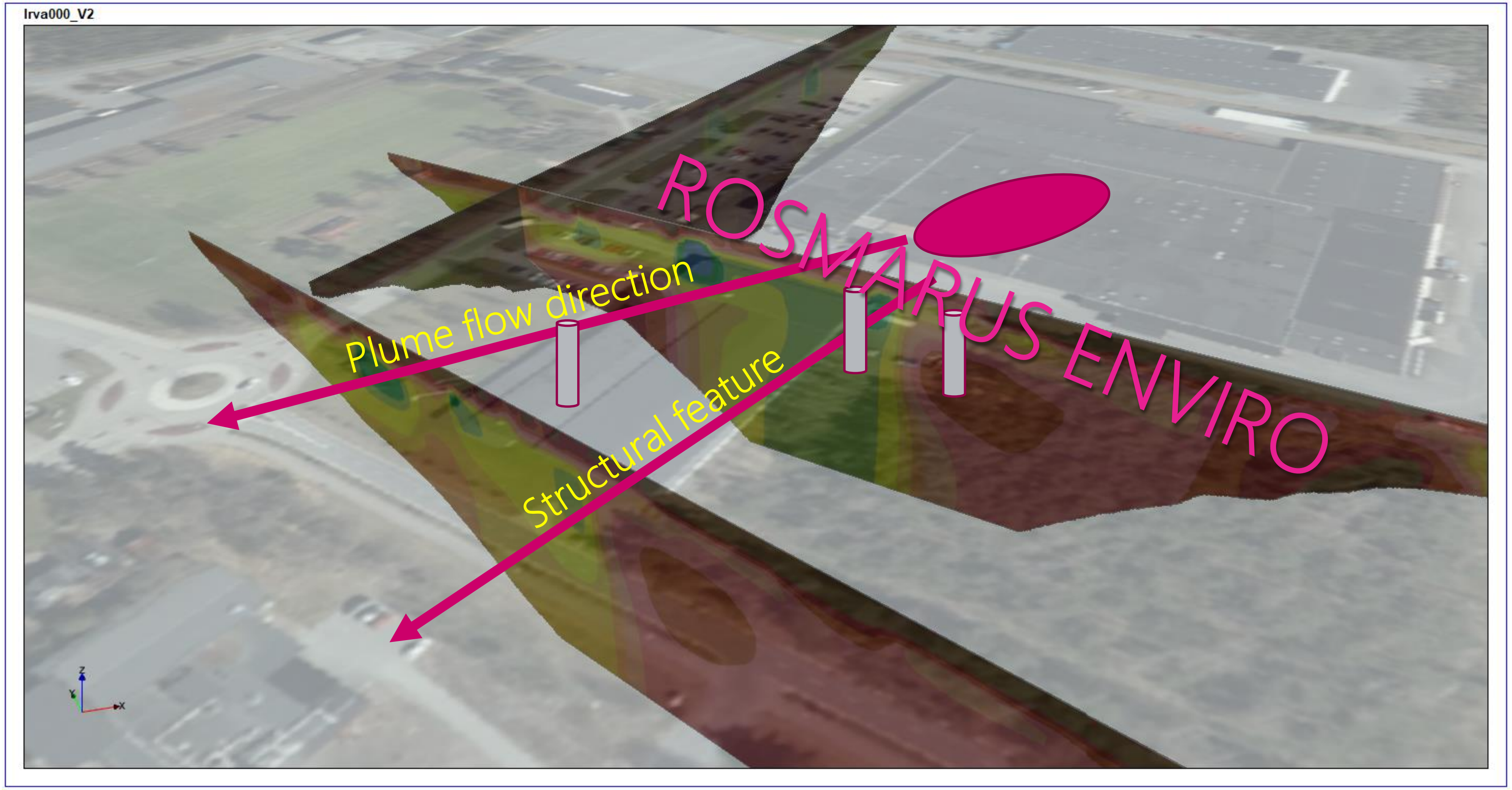
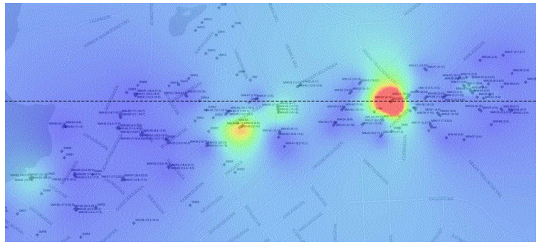
The Geological Substructures

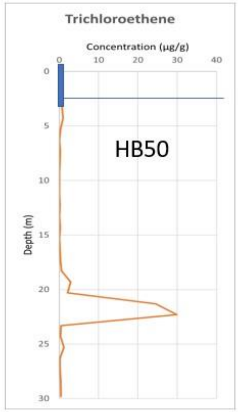


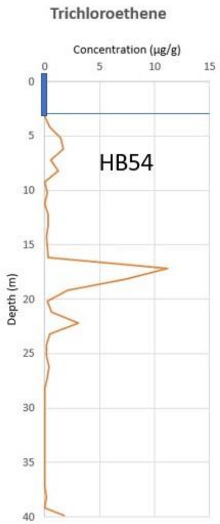
- The Plume
- The NEW structure
- Bedrock wells

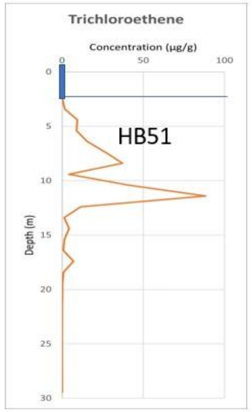


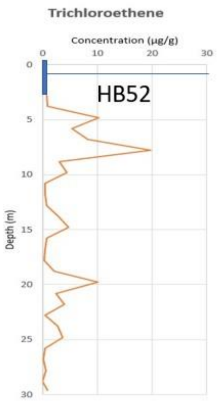
Case study 2

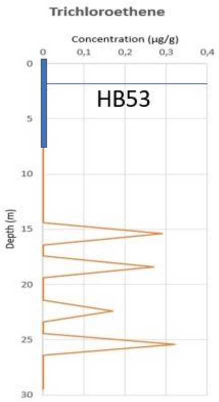
DNAPL PCE @
- 20,8 m bgs
- 29,7 m bgs











W E

SGU
Sveriges geologiska undersökning
Geological Survey of Sweden

SWECO

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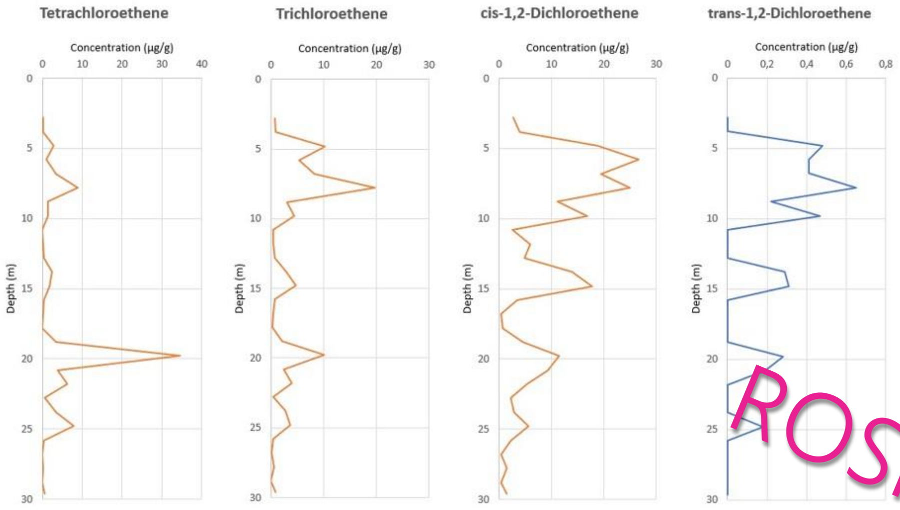
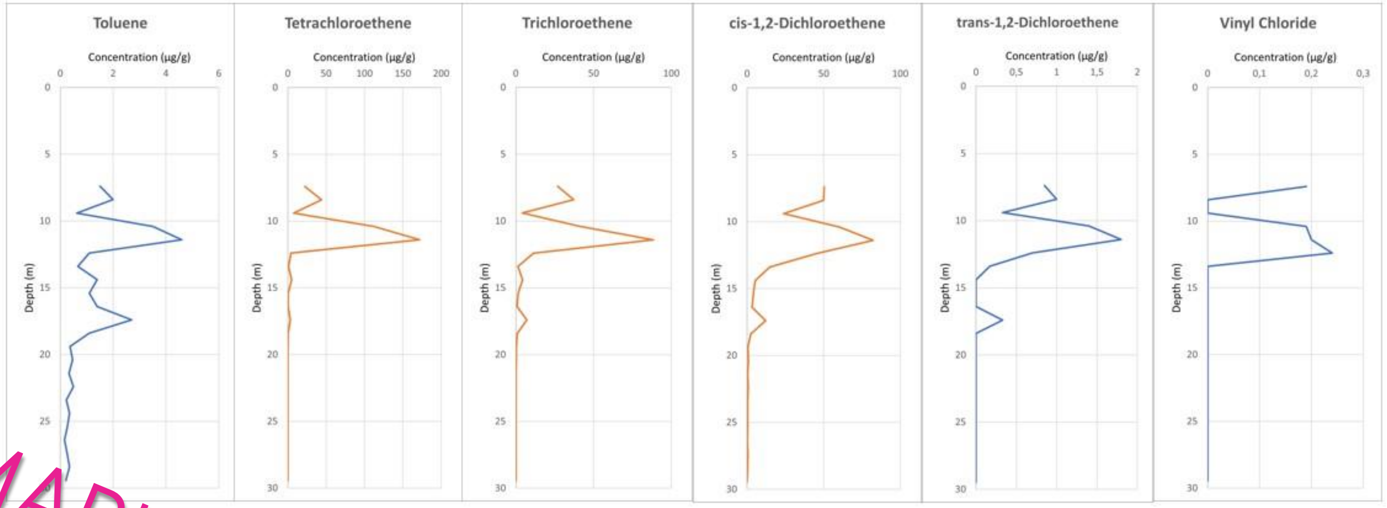
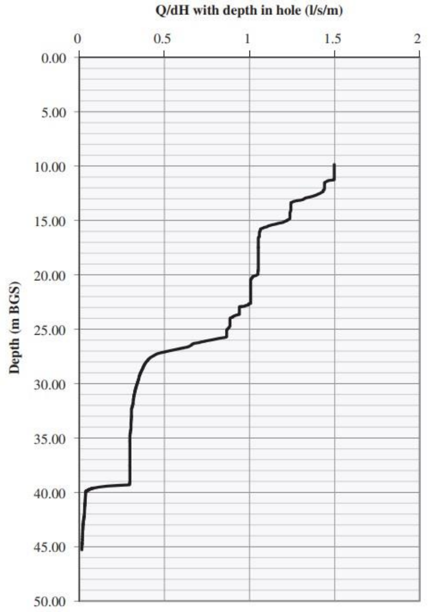
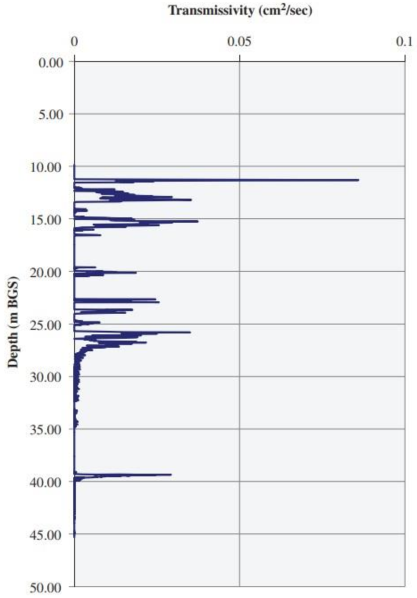
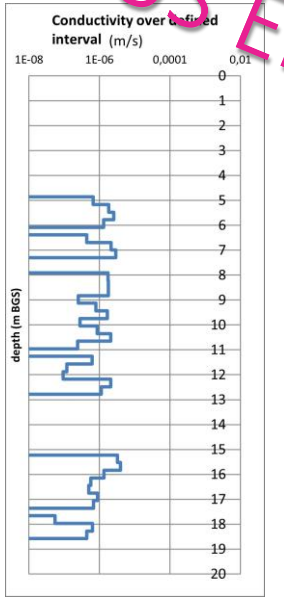

Tetrachloroethene
Concentration (µg/g)
Depth (m)
Trichloroethene
Concentration (µg/g)
Depth (m)
cis-1,2-Dichloroethene
Concentration (µg/g)
Depth (m)
trans-1,2-Dichloroethene
Concentration (µg/g)
Depth (m)


Toluene
Concentration (µg/g)
Depth (m)
Tetrachloroethene
Concentration (µg/g)
Depth (m)
Trichloroethene
Concentration (µg/g)
Depth (m)
cis-1,2-Dichloroethene
Concentration (µg/g)
Depth (m)
trans-1,2-Dichloroethene
Concentration (µg/g)
Depth (m)
Vinyl Chloride
Concentration (µg/g)
Depth (m)


Q/dH with depth in hole (l/s/m)
Depth (m BGS)


Transmissivity (cm²/sec)
Depth (m BGS)


Conductivity over defined interval (m/s)
1E-08
1E-06
0,0001
0,01
depth (m BGS)

When do we use liners?

- To confirm or reject the possibility of impacted bedrock below a source area.
- To delineate the extent of the impacted bedrock prior to remediation.
- To release areas that are currently restricted from drilling wells for geothermal heat exchange units
- Cased Hole Samplers and Waterflutes allow water to be extracted at predetermined fractues
- To inject solutions directly into impacted fracture systems at depth (DEIL system) or to recirculate treated water from bioremedial units

Rosmarus Enviro is the only European supplier of FLUT Technologies products and services.
Any questions, requests and orders for FLUT products should be directed to us.

- Rogier De Waele @ Greensoil Group, Belgium
- Sweco, Sweden
- Ramböll, Sweden
- WSP, Sweden
- The Swedish Geological Survey/SGU
- The Swedish EPA/Naturvårdsverket

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