The NanoRem Experience: Large Scale and Case Study Testing

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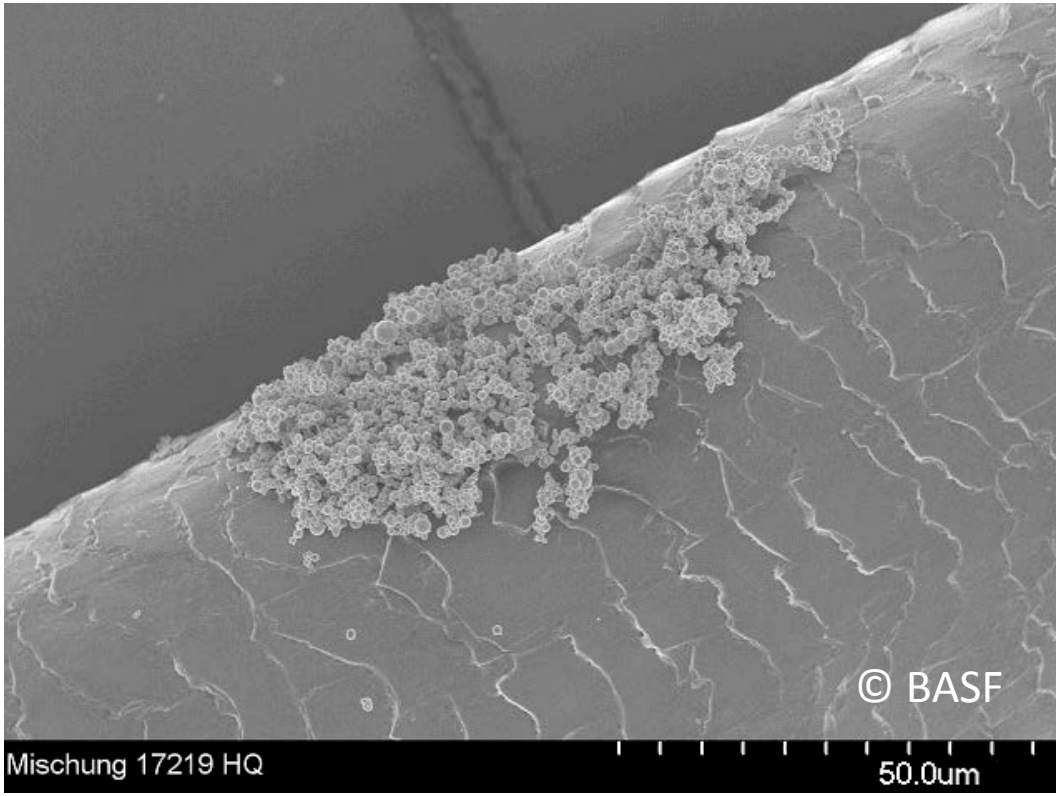
Challenge

Transport (migration) of nanoparticles is a function of

- Density of particles
- Rheology of injected suspension
- Particle concentration
- Surface charge
- Contaminant saturation
- Flow velocity
- Heterogeneity



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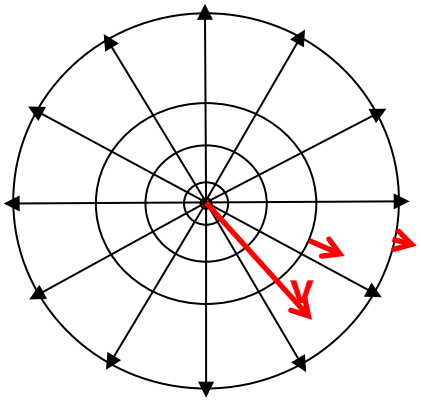
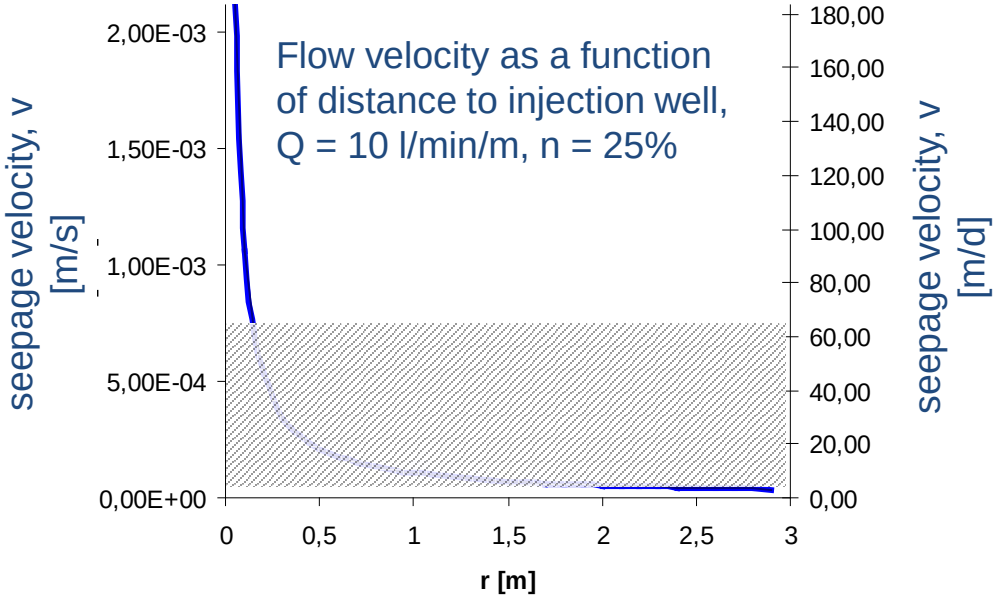
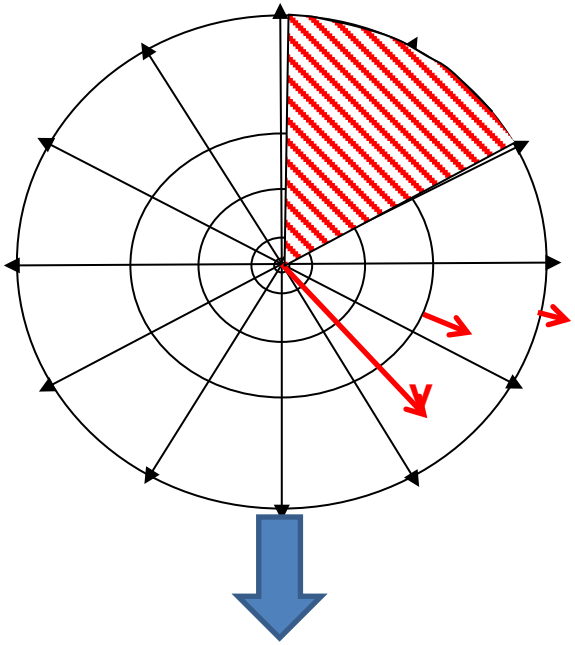
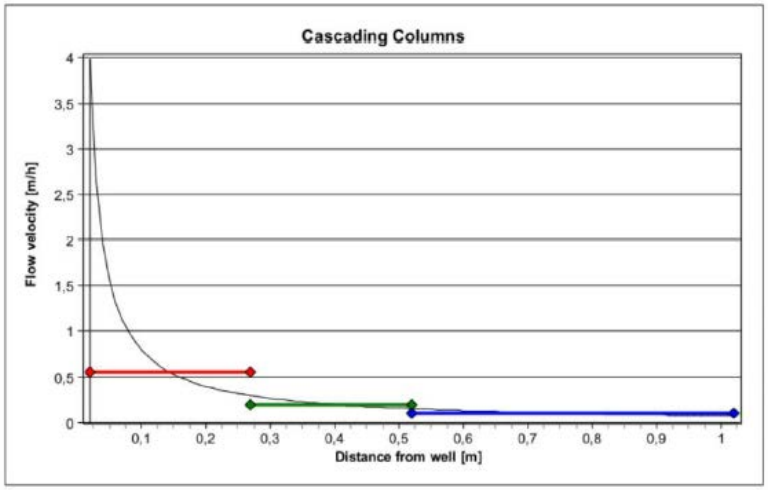


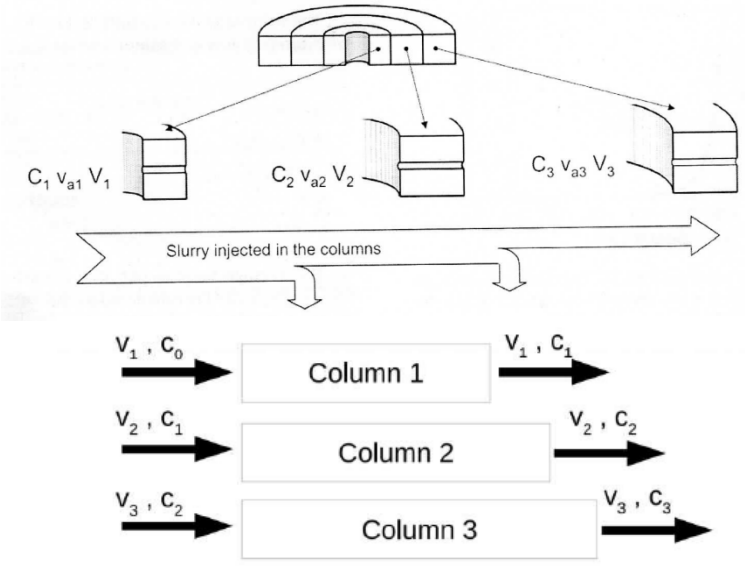


→ **2D and 3D experiments necessary**

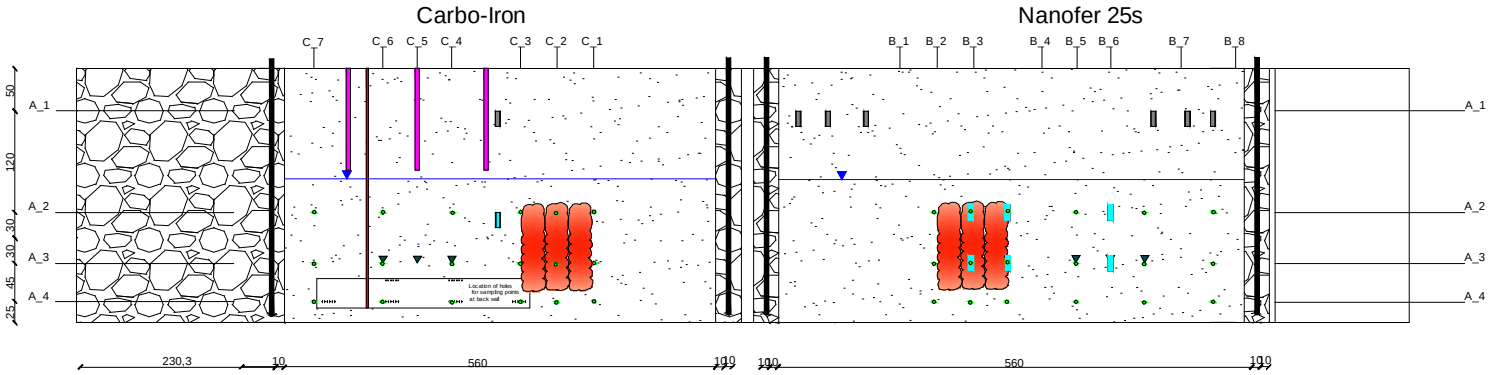
2D, homogeneous, confined







3D homogeneous unconfined Large Scale Flume



- Stainless steel walls
- Glass front
- Size (L/W/H): 6.0/1.0/3.0m
- Division into two compartments, 9m x 1m x 3m each
- 32 sampling and measurement ports in each compartment

Soil: Homogeneous medium sand ($K = 4*10^{-4}$)

BC in: constant flux @ q = 0.2 m/d,
BC out: constant head @ 1.7 m

Emplacement PCE Source and Injection of NP (Nanofer 25s)

Volume Source Zone V_S = 0.8 m³

Mass of PCE: 2kg

(injected in 60 increments/locations),

→ $S_{PCE} \approx 3.4\%$

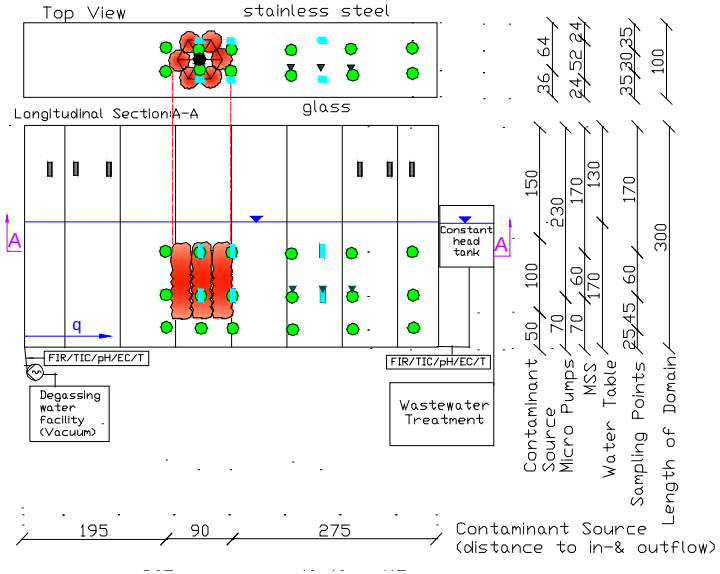
→ $S_{PCE} < S_{PCE,res}$ → Stable source zone

NP Injection via Direct Push

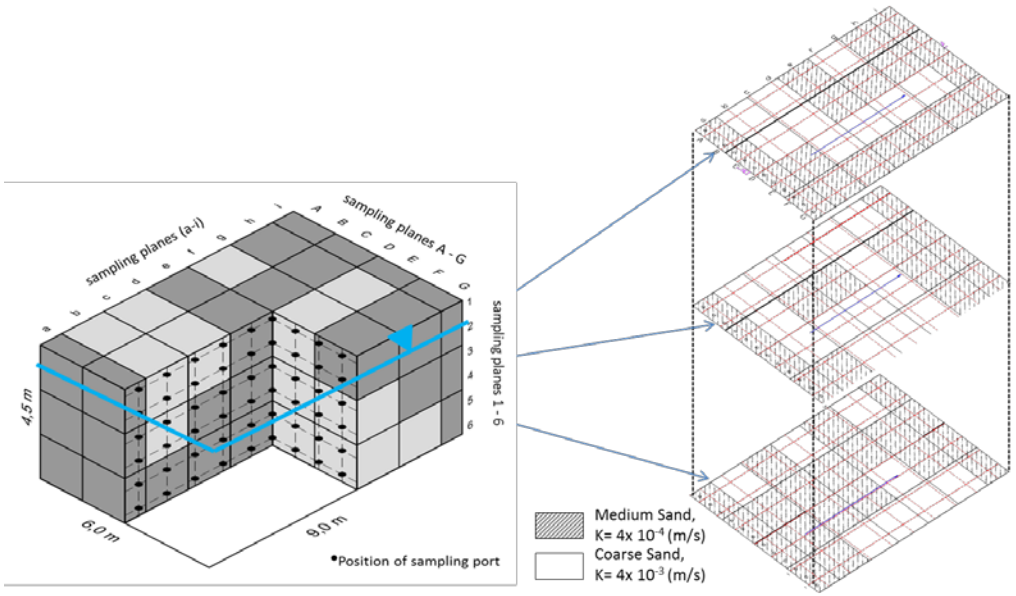
into source zone

Pressure limitation to avoid blow-out

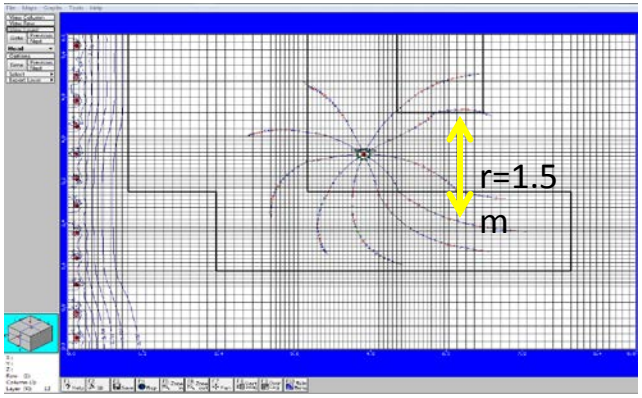
→ Limited transport distances



3D, heterogeneous, unconfined - setup

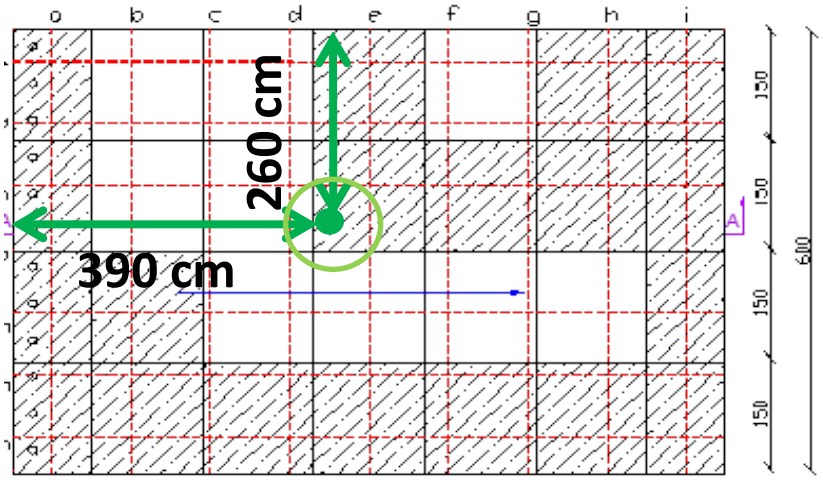


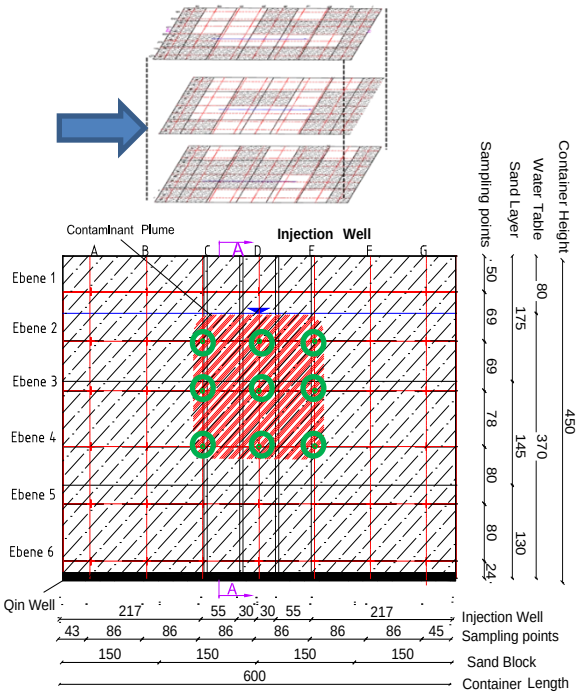
- Stainless steel walls
- Division into 3 compartments (L/W/H = 9/ 6/ 4.5 m
- 378 sampling and measurement ports in each compartment



3D – Plume Emplacement and Goethite NP Injection

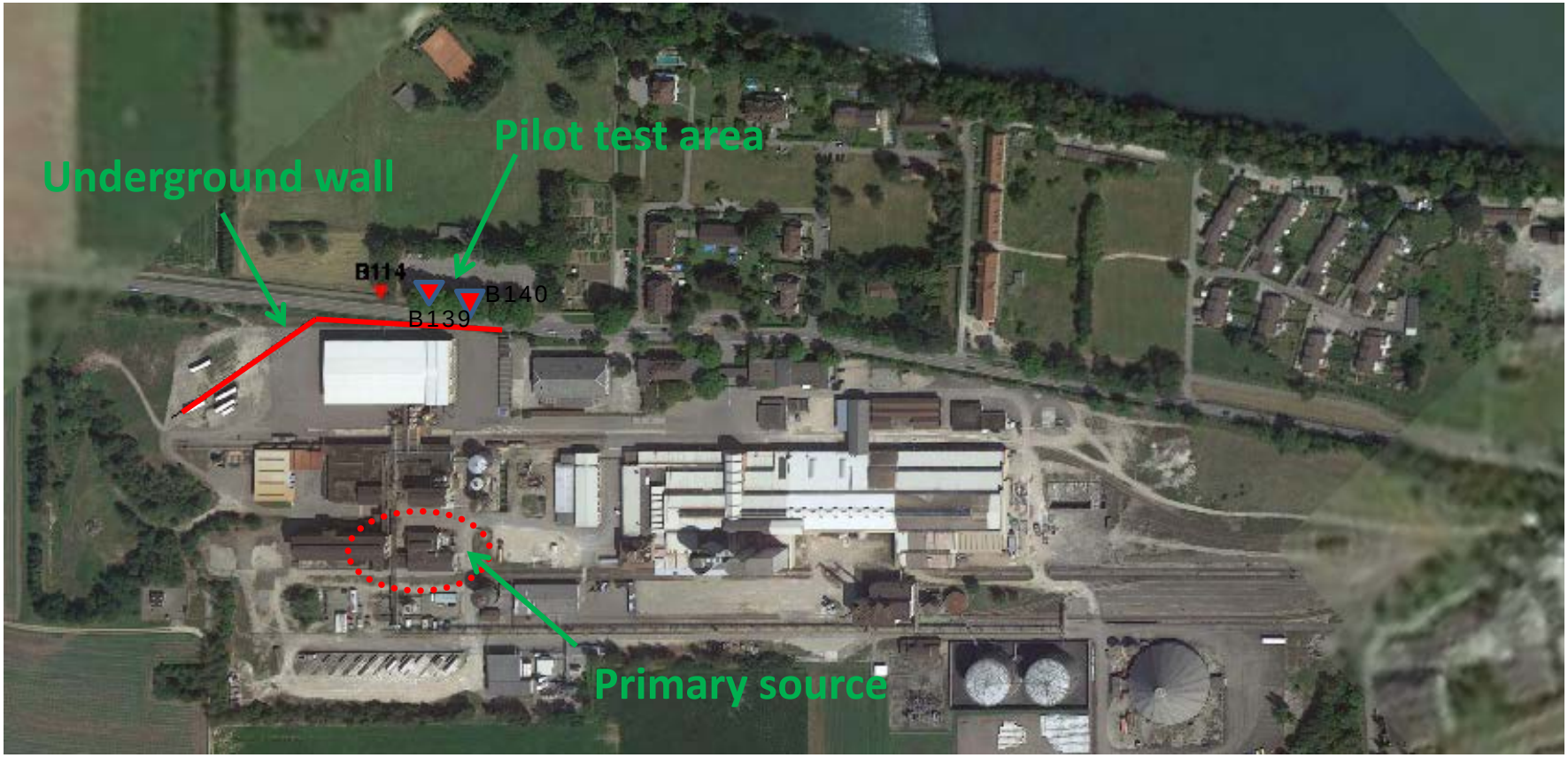
- Toluene plume
- Cross-section 2m x 2m = 4m²
- to be intercepted by 9 sampling ports on each vertical sampling plane





- → Transport with sufficient concentration of NP was achieved
- → Remediation of Toluene successful
- → Exact delineation of processes participating in remediation pending

3D field - Zurzach, Switzerland



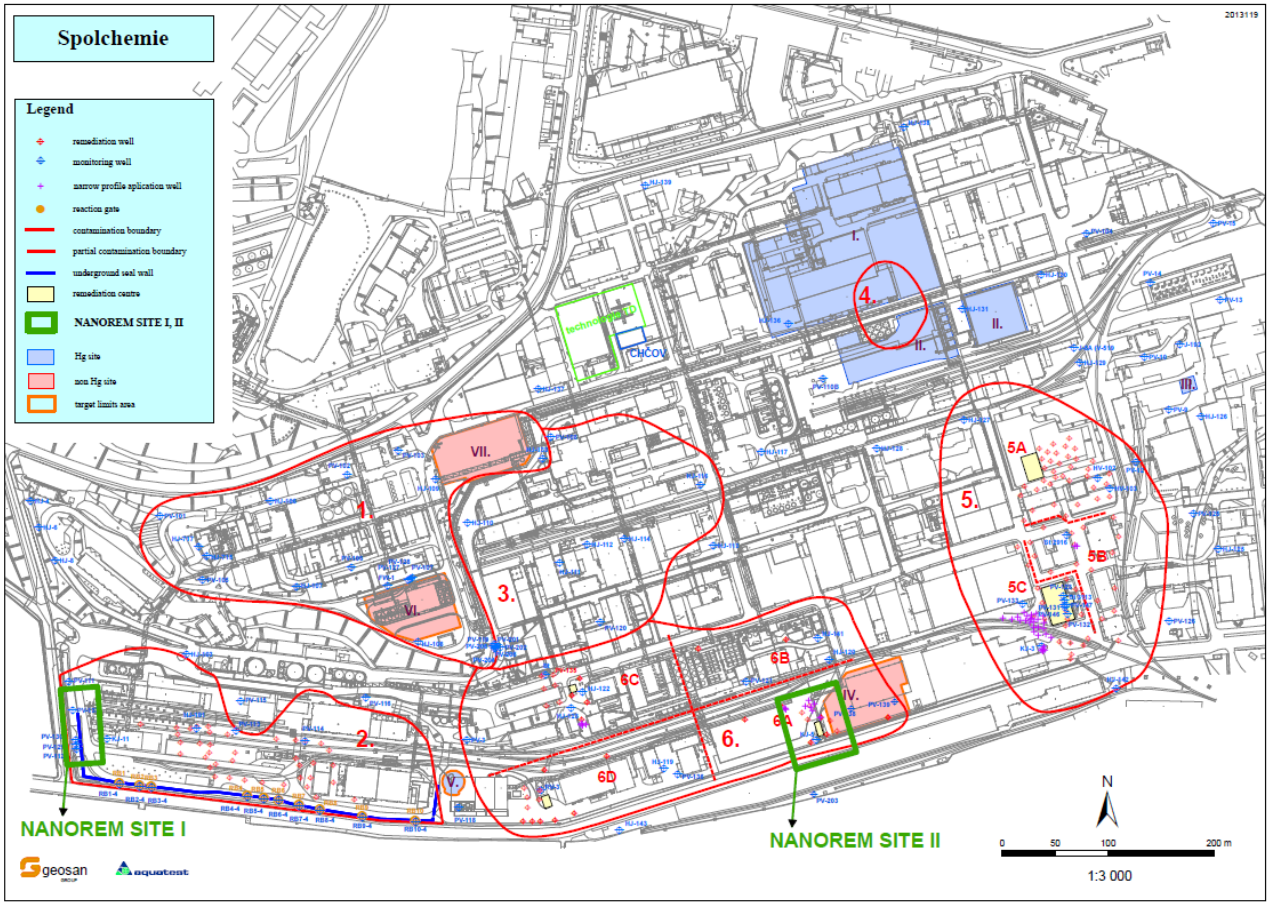
Alluvial aquifer, moderate climate, CHC contamination, high groundwater flow velocity
→ Injection of milled nZVI (UVR-FIA)

Spolchemie DNAPL, CZ

Quaternary sand gravel aquifer, continental climate, CHC contamination, small groundwater flow velocity

→ Injection of Nanofer 25s + Nanofer STAR? (NANO IRON)

Spolchemie LNAPL, CZ



Quaternary sand gravel aquifer, continental climate, BTEX contamination, small groundwater flow velocity

→ Injection of Goethite NP (UDE)

Barreiro, Portugal

Semi confined aquifer, sand, silts, warm, moderate climate, low pH, heavy metals, sulphates, nitrates, high groundwater velocities

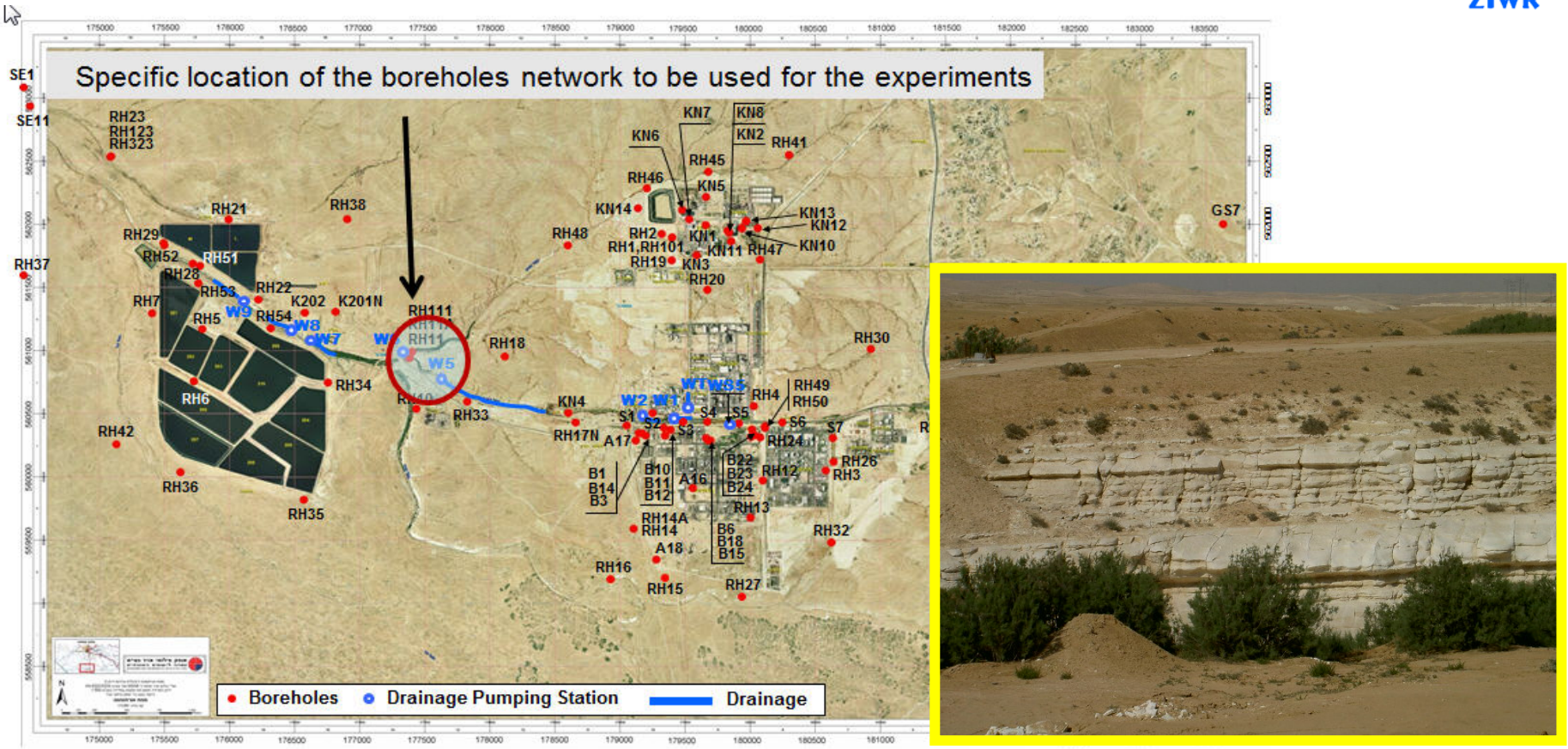
→ inject Nanofer STAR (NANO IRON)? tbd

Nitrastur, Spain

Alluvial aquifer with artificial backfilling, warm, moderate climate, heavy metals, moderate groundwater velocities

→ inject Goethite (UDE) or Nanofer STAR (NANO IRON)? tbd

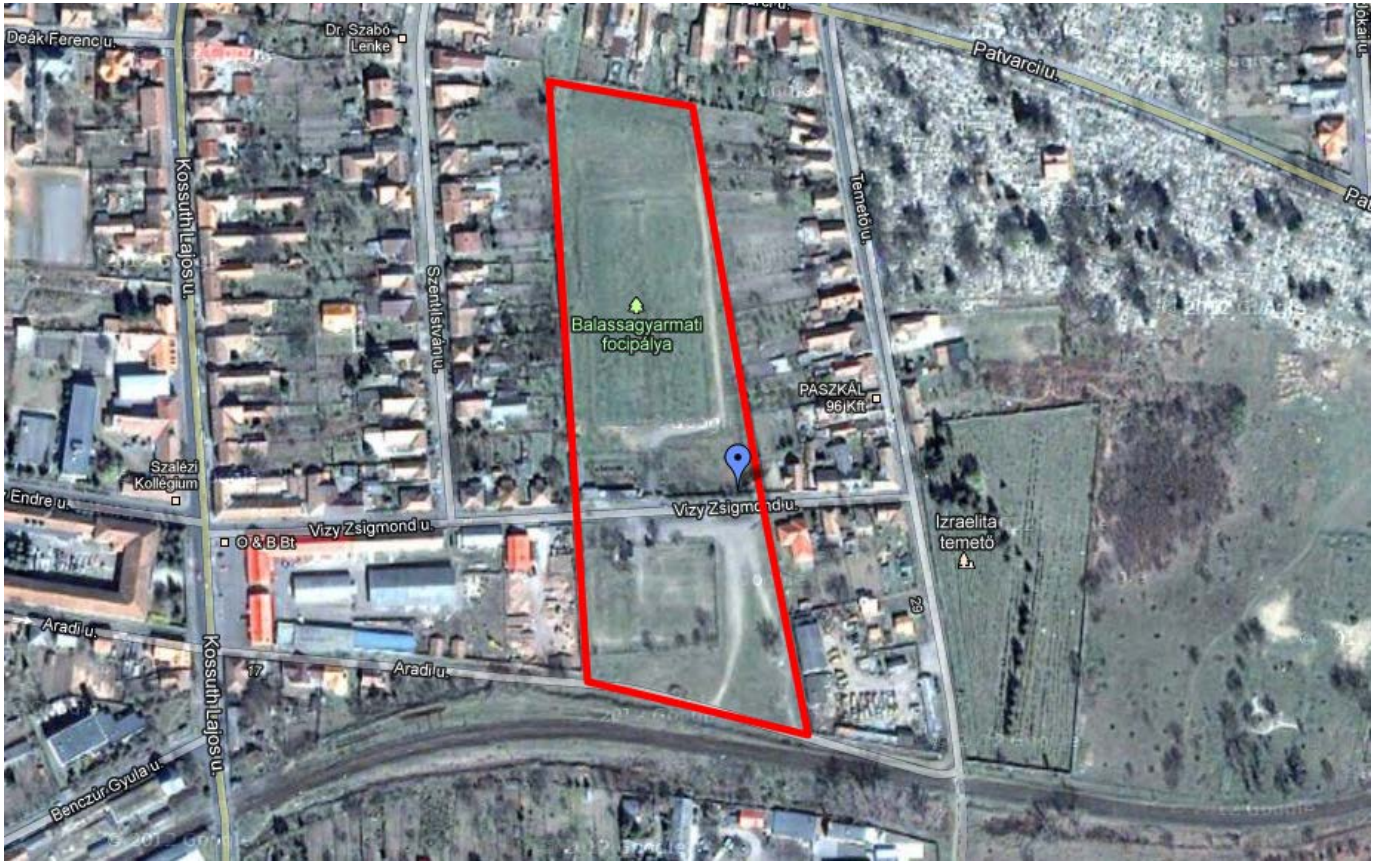
Besor-Secher, Israel



Fractured Aquifer, hot, arid climate, moderate groundwater velocities

→ inject Nanofer STAR and Carbo-Iron to investigate migration in fractures.

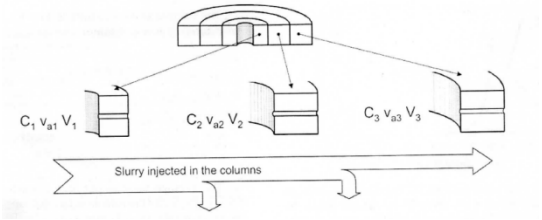
Balassagyarmat, Hungary

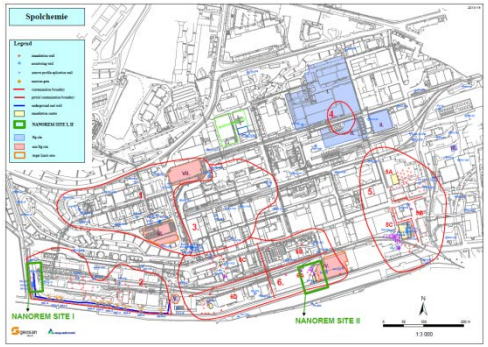


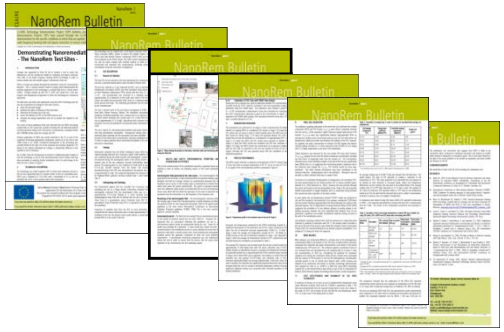
Alluvial aquifer, continental climate, CHC contamination, small groundwater flow velocity

→ Injection of Carbo-Iron® (UFZ, SciDre)

Cl:aire – NanoRem Bulletins







Thank you for your attention!

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