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The art of environmental innovations



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In situ remediation case examples from Finland

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Webinar: Soil contamination problems and biological methods for soil remediation

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Doranova Oy

AGENDA

1. Company introduction
2. CASE EXAMPLES of Biological in situ treatment
 - I. Chlorinated solvent contaminated groundwater remediation at a factory site (2009-2016)
 - II. Sawmill area contaminated with chlorophenols (2016-)
 - III. Large industrial area groundwater remediation with direct push application (2019)





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25 YEARS

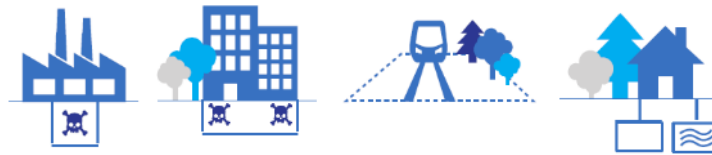
Finnish environmental
engineering company



Innovation, design, project
management

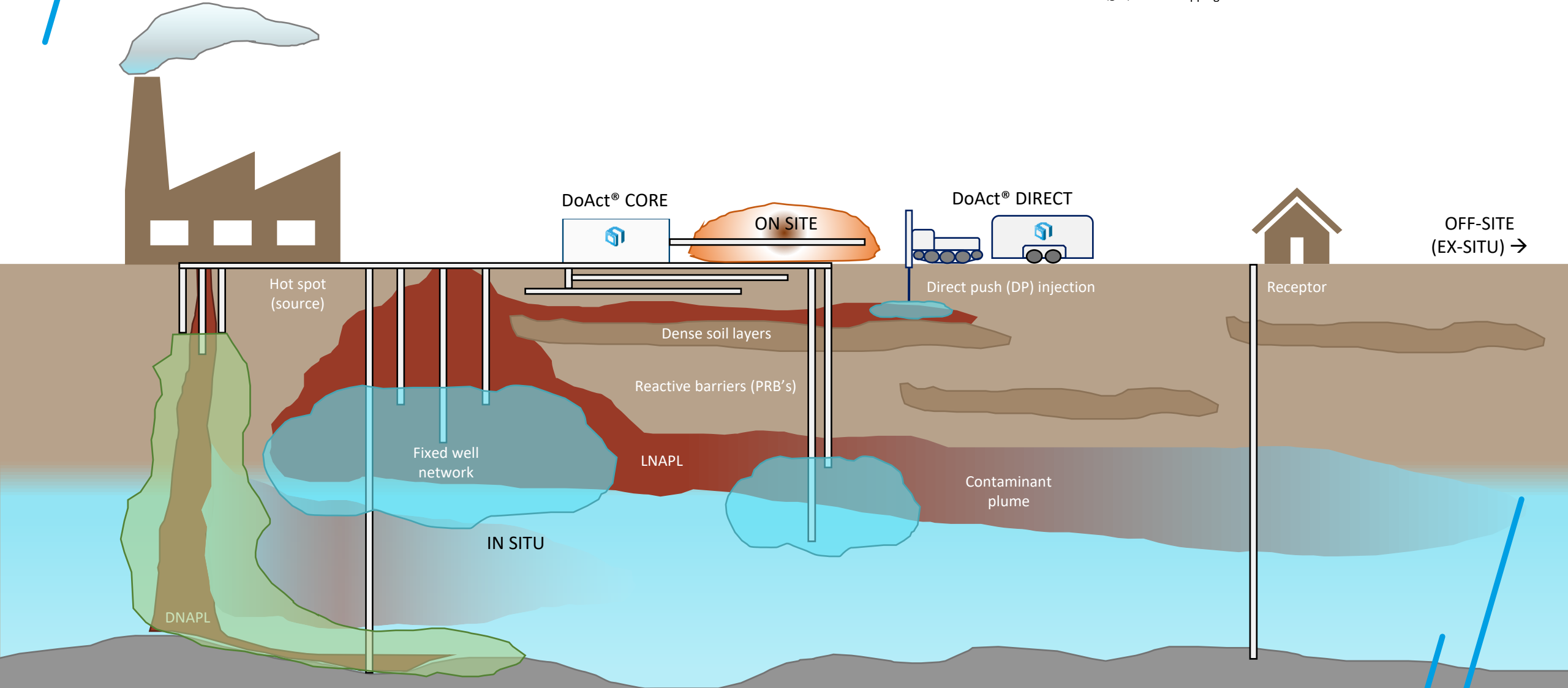
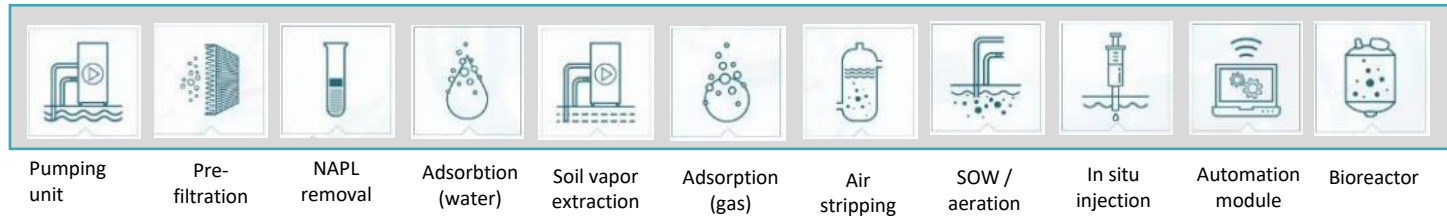


Leading in situ contractor in
Finland



International projects

DoAct[®] CORE DoAct[®] DIRECT



CASE I

Chlorinated solvent contaminated groundwater remediation project



CASE I



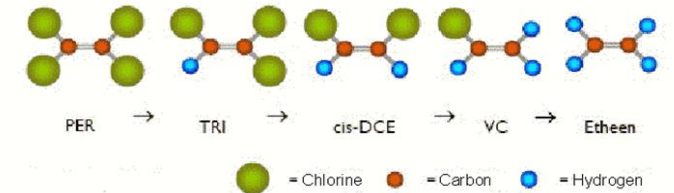
- Industrial site, client was multinational electronics manufacturer
- Factory established in 1960's
 - Solvents for degreasing (TCE, trichloroethylene) used in two factories on the area between 1960-1984
 - Contamination identified in drinking water first time in 1994.
 - 2006 survey indicated increased concentrations;
 - Measured levels up to 230 000 µg/l, accepted level in drinking water 10 µg/l
 - Groundwater contaminated in over 2 km² area
- Doranova conducted in situ groundwater remediation project in two phases, 2009-2012 and 2013-2016



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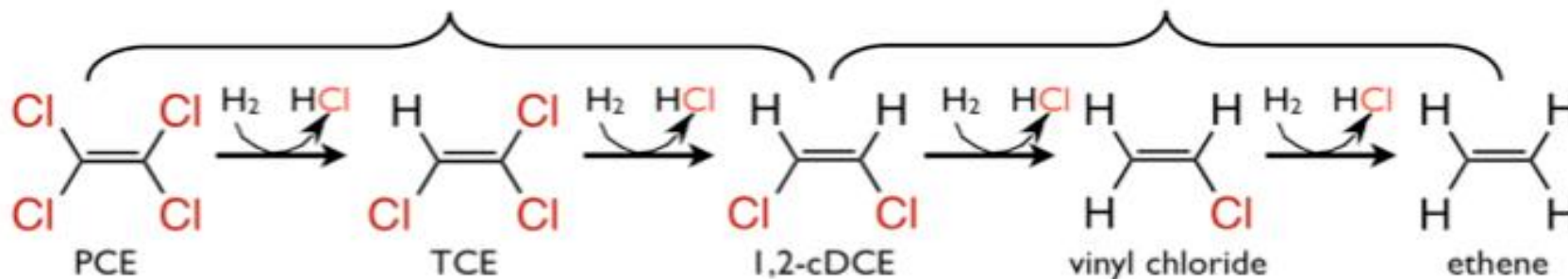
CASE I – REMEDIAL DESIGN

- Remediation using naturally occurring bacteria for biodegradation of chlorinated solvents (ARD, anaerobic dechlorination)
 - TCE will degrade eventually to ethene gas.

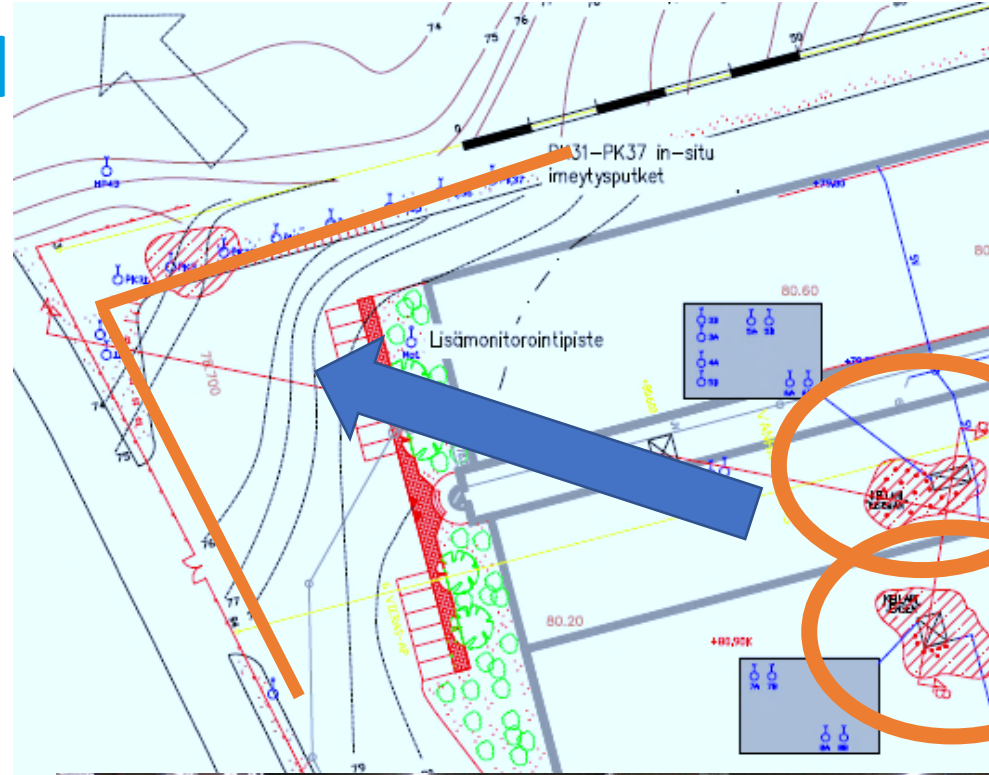


Dehalobacter spp., *Dehalospirillum* spp., *Desulfitobacterium* spp.
Desulfomonile spp., *Dehalococcoides* spp.

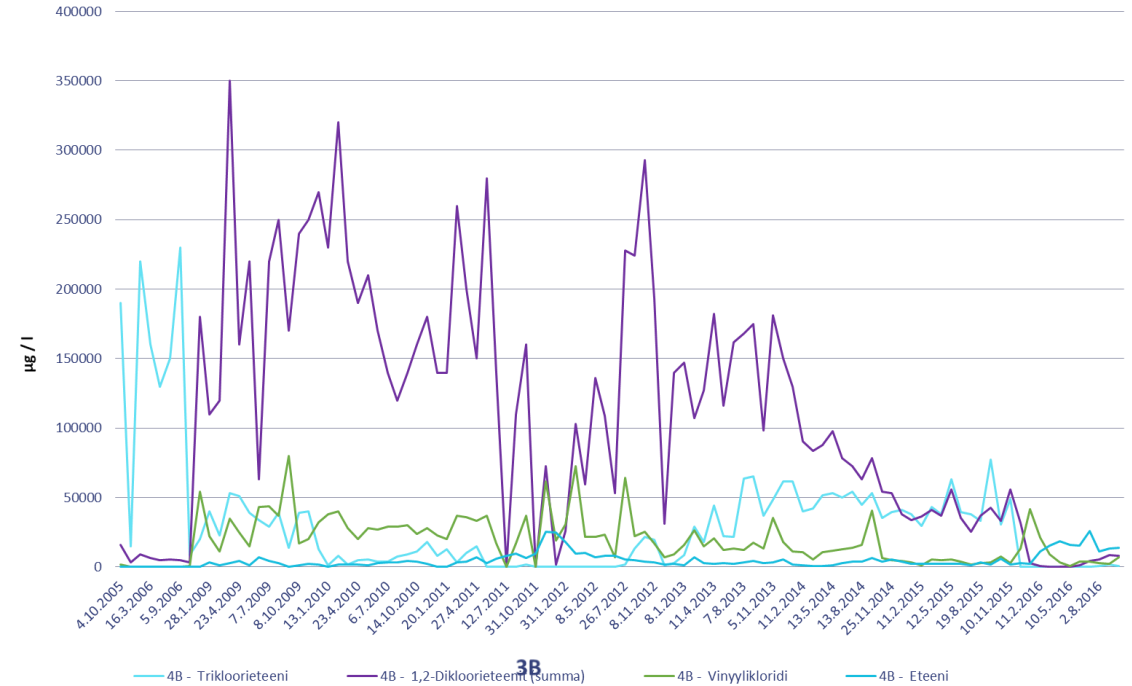
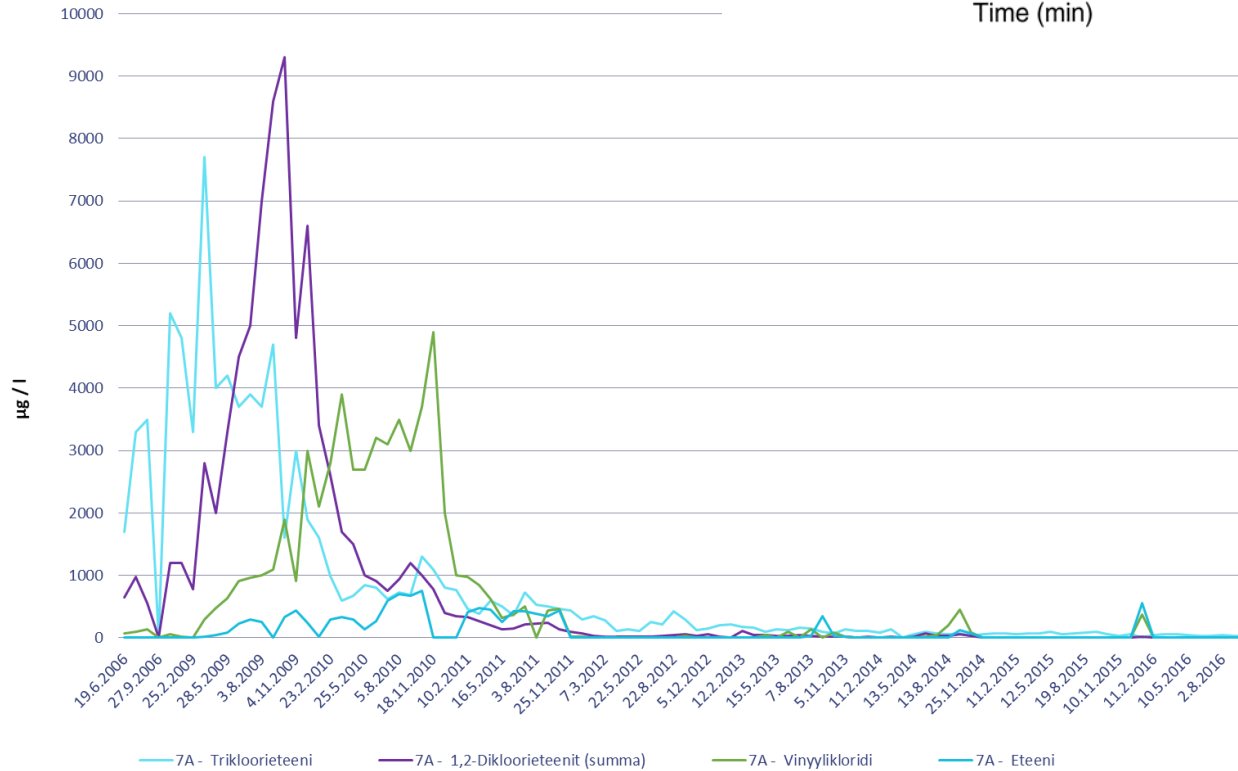
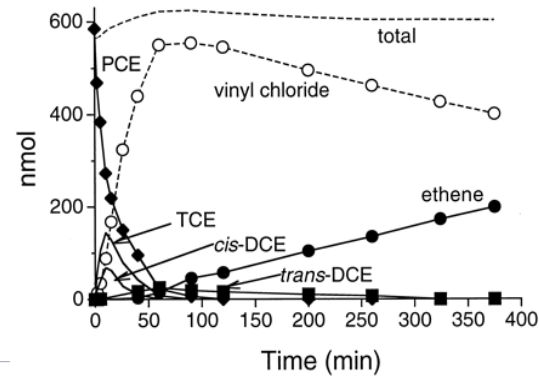
Dehalococcoides



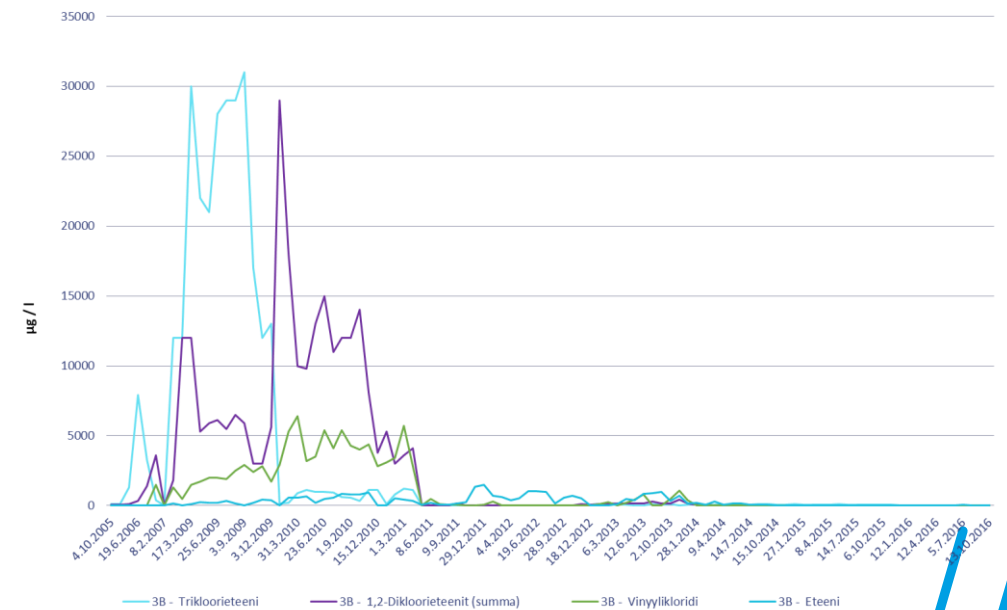
CASE I APPROACH



CASE I RESULTS



4B - Trikloorieteeni 4B - 1,2-Dikloorieteenit (summa) 4B - Vinyylkloridi 4B - Eteeni



3B - Trikloorieteeni 3B - 1,2-Dikloorieteenit (summa) 3B - Vinyylkloridi 3B - Eteeni



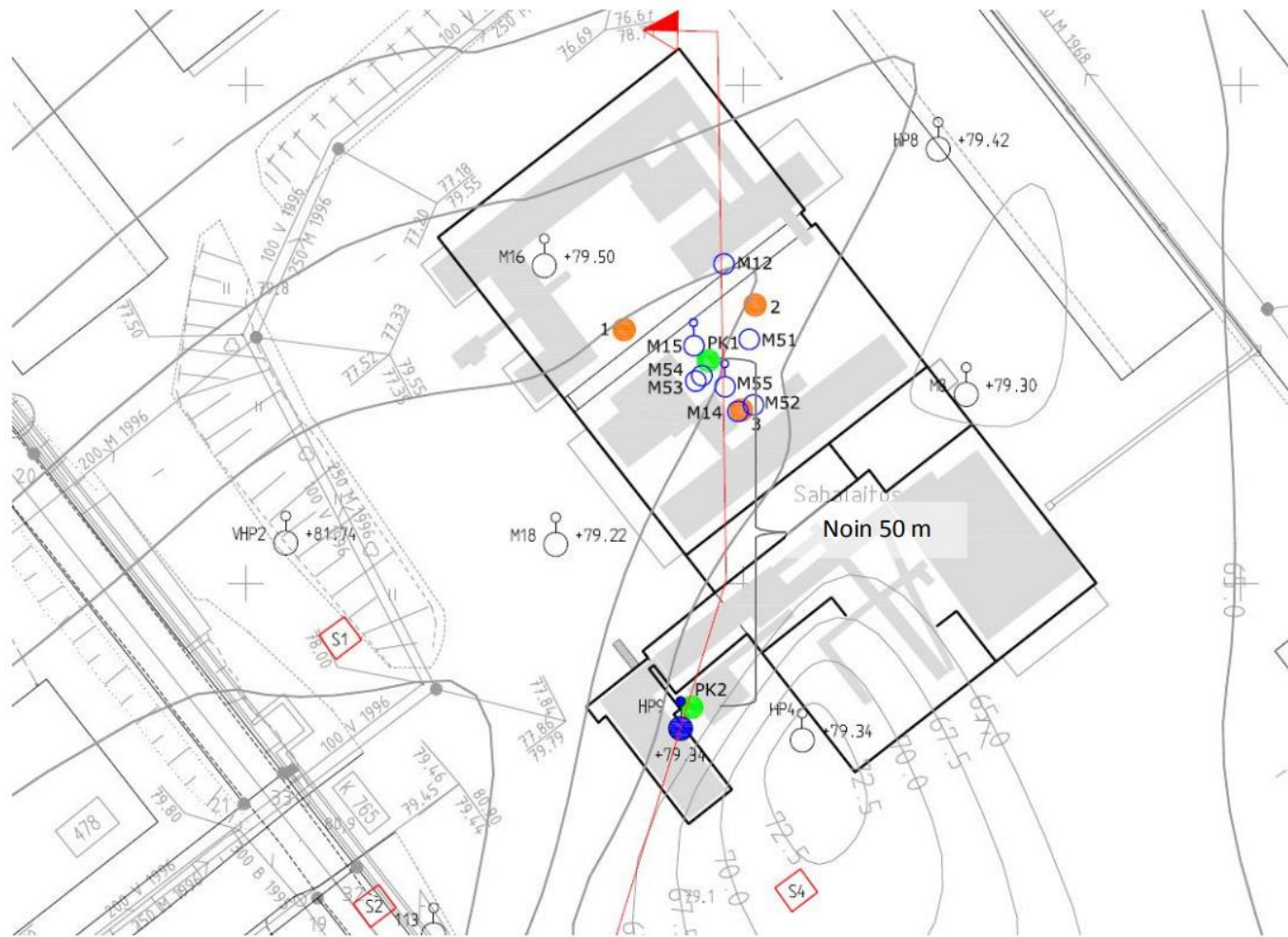
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CASE II

Sawmill area contaminated with chlorophenols



CASE II – Sawmill area contaminated with chlorophenols



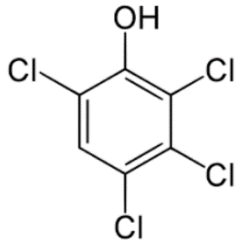
© Sitowise / Itkonen



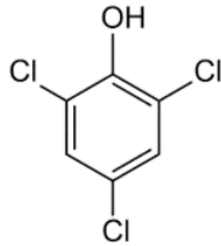
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Contaminants

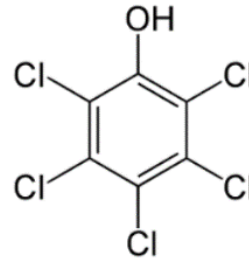
- Target contaminants are the main components of KY-5 anti-blooming agent; tetrachlorophenol, pentachlorophenol and 2,4,6-trichlorophenol



2,3,4,6-tetrachlorophenol (TeCP)



Kuva 4. 2,4,6-trichlorophenol (TCP)

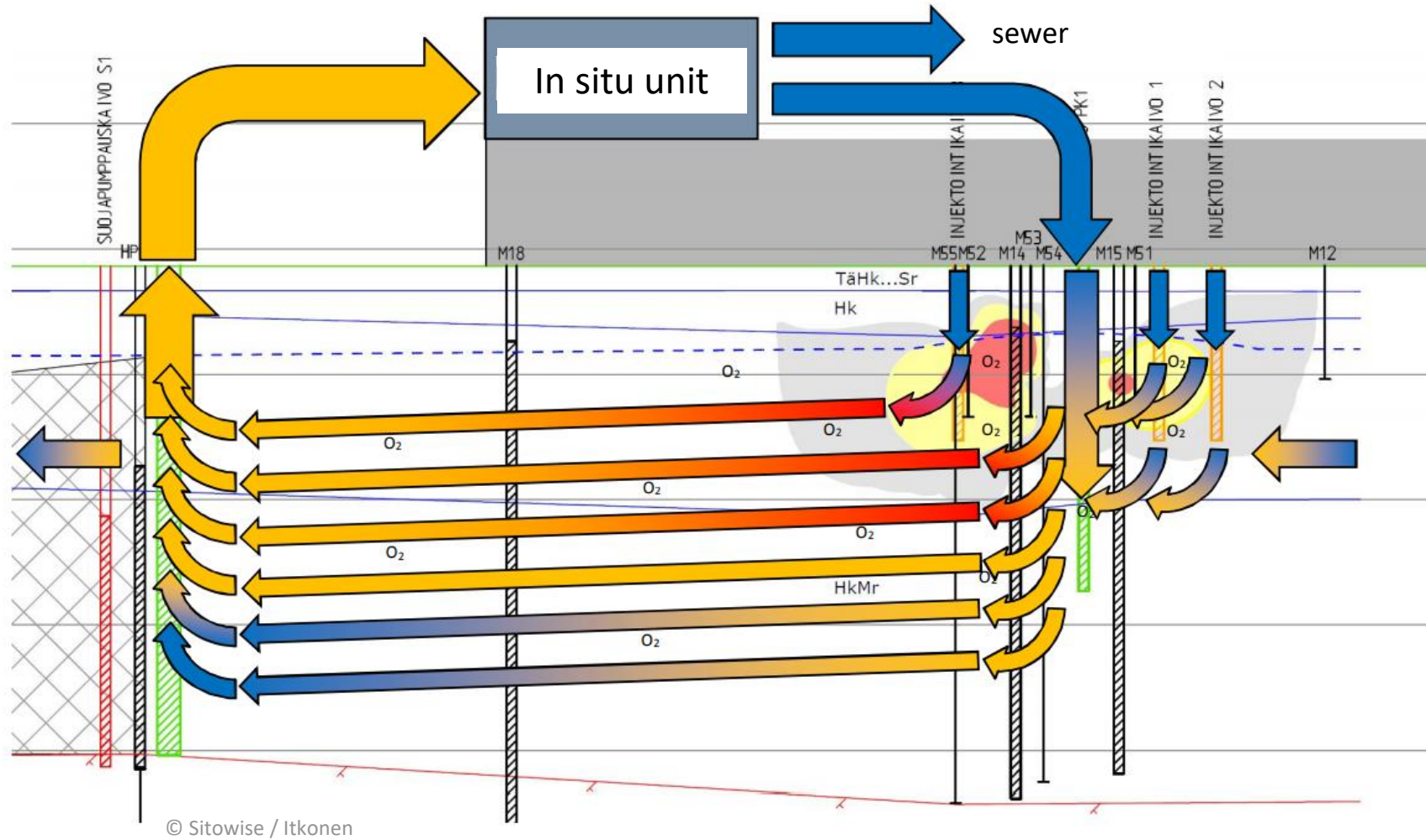


Kuva 5. Pentachlorophenol(PCP)

- TeCP is the major contaminant, concentration around 10 times more than pentachlorophenol.

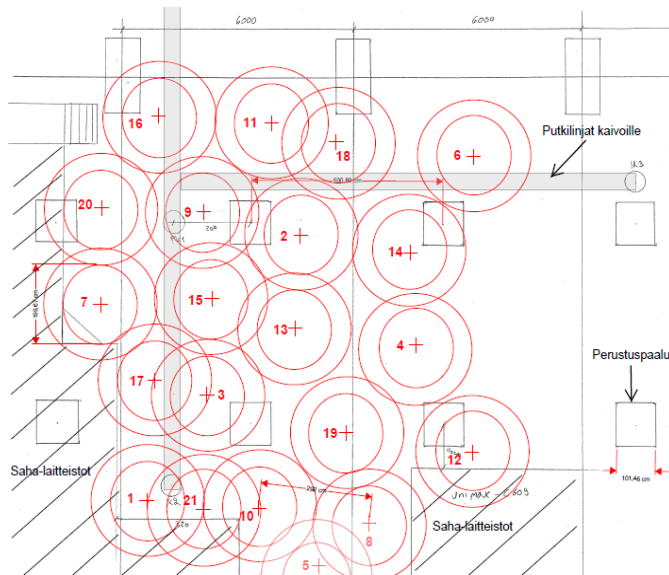


In situ treatment process

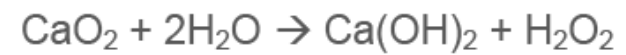


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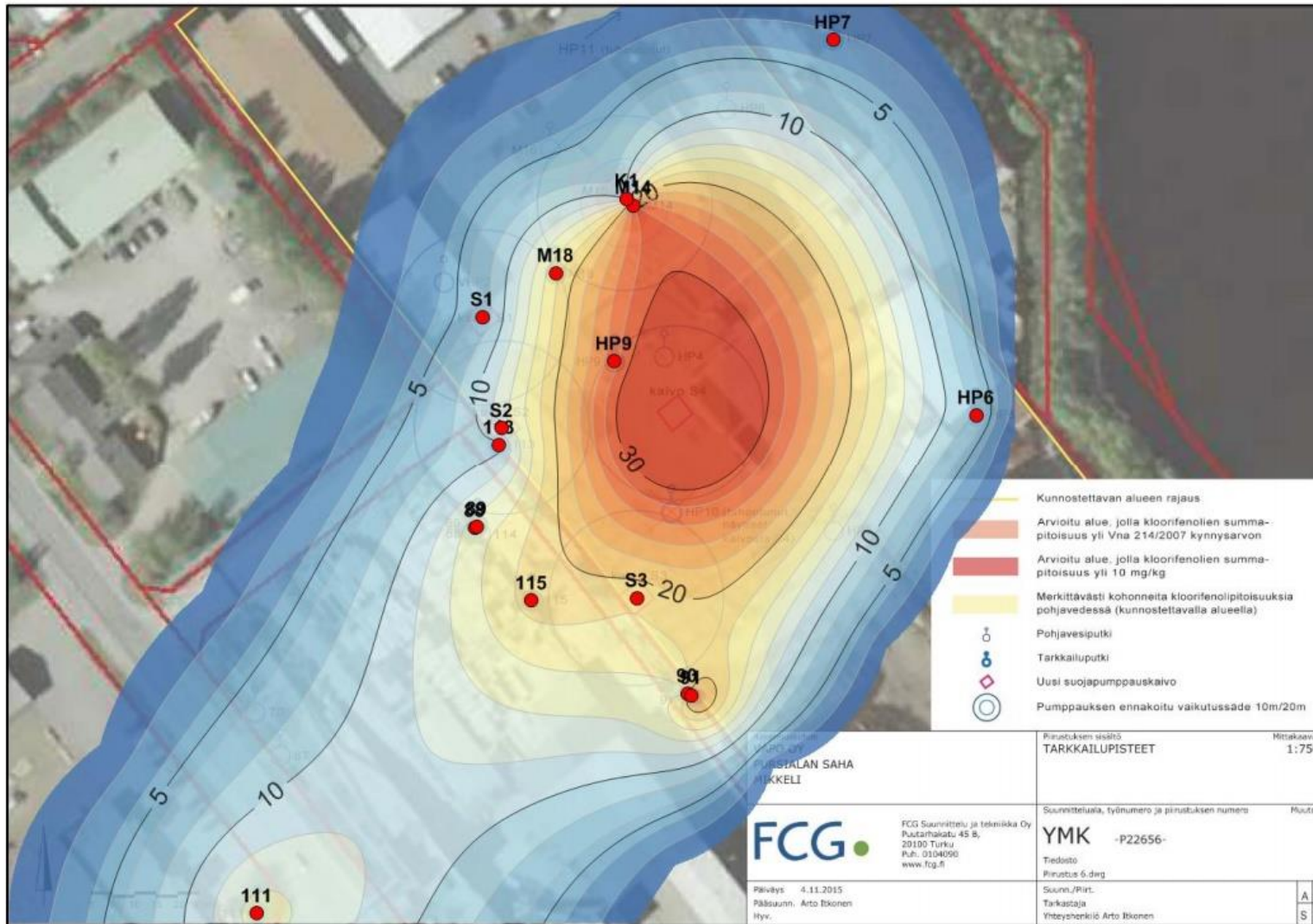
Direct push injections at the source area



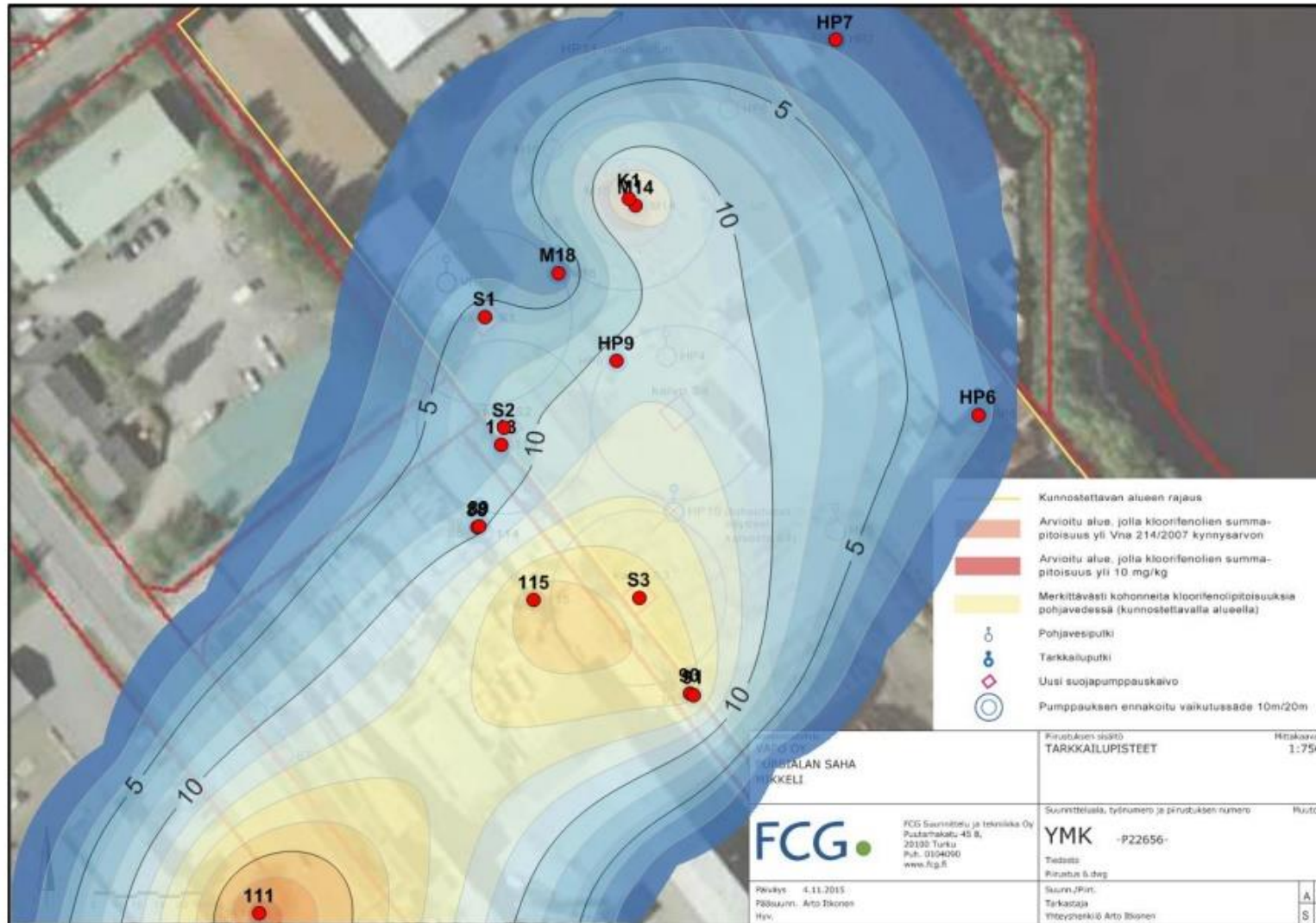
Calcium peroxide based product to increase the oxygen level of the ground water



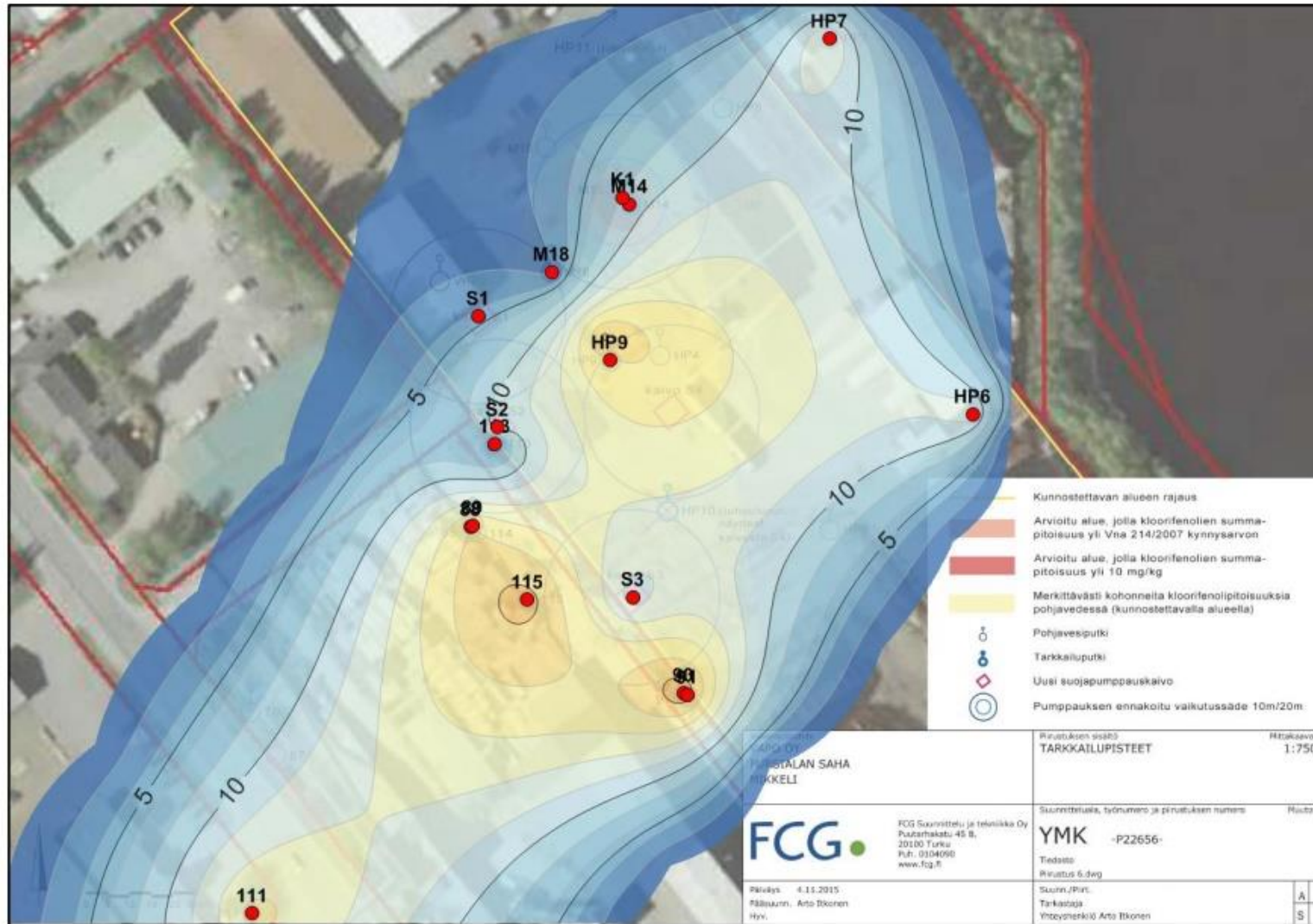
TeCP/PCP ratio before the in situ remediation



TeCP/PCP ratio during the in situ remediation (2016-17)



TeCP/PCP ratio during the in situ remediation (2017-18)



CASE III

Large industrial area groundwater remediation with direct push application



CASE III

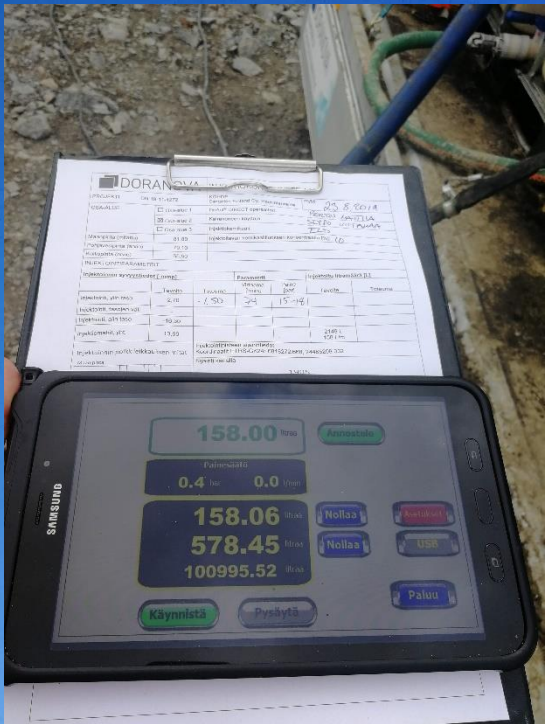
- Large brownfield area; former industrial park with 100 years of operation. Area is being converted into residential area.
- Soil and groundwater contaminated with multiple contaminants
 - Several remediation projects during the years (dig&dump, in situ)
 - Groundwater still contaminated with **chlorinated solvents**, area over 9 hectares.

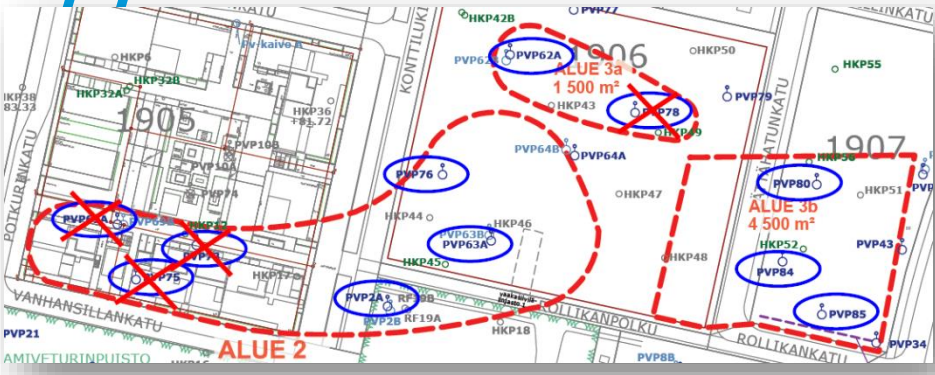


Remedial design

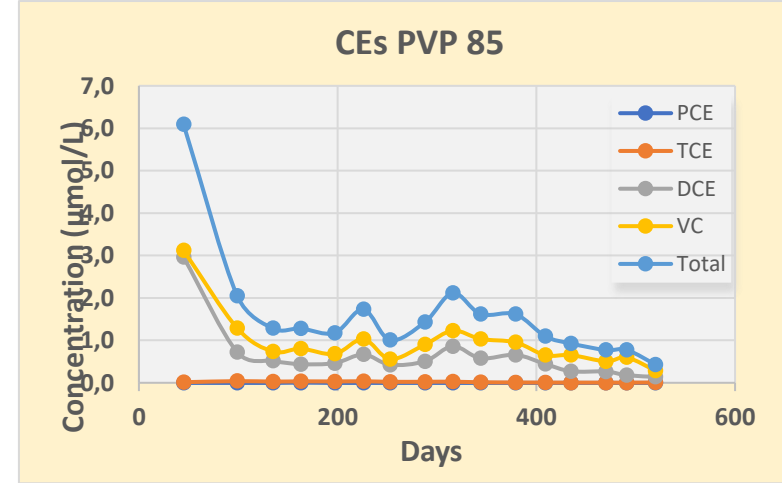
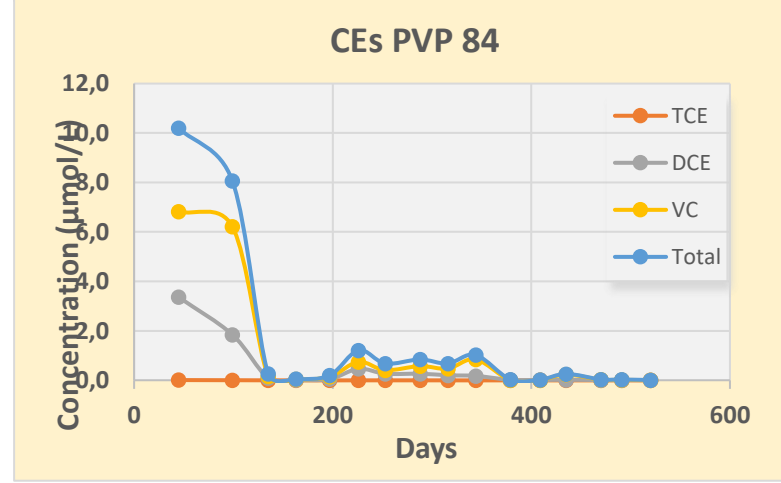
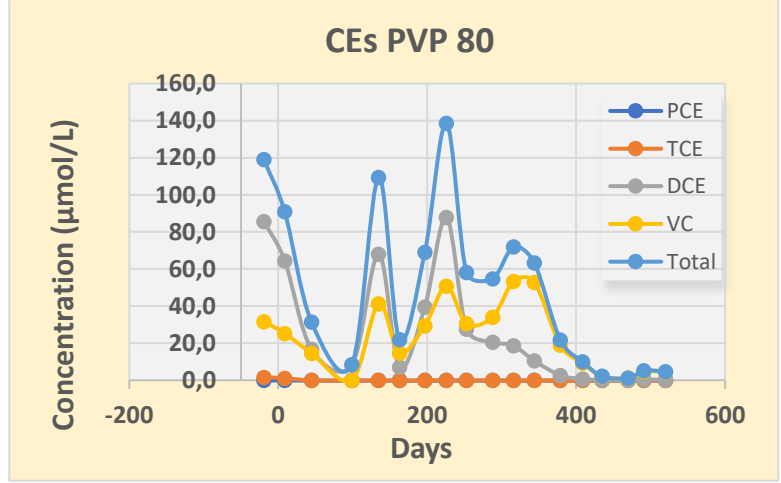
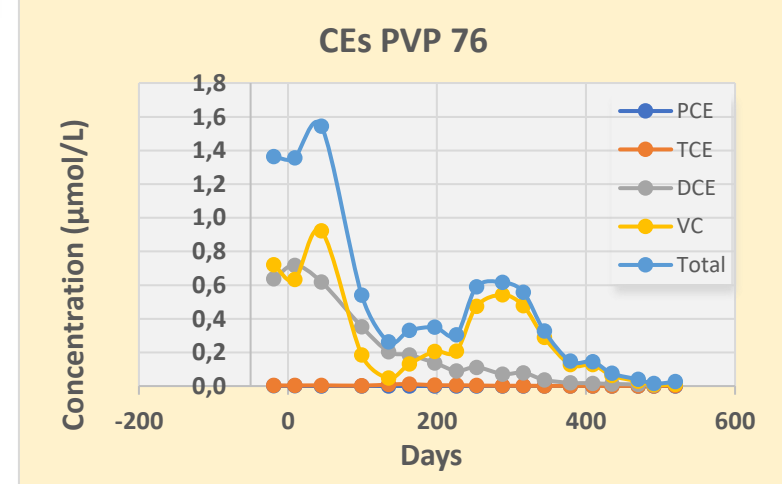
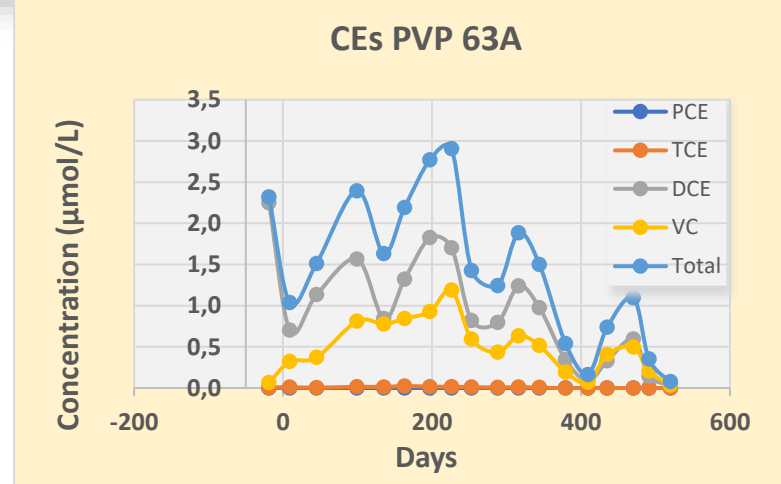
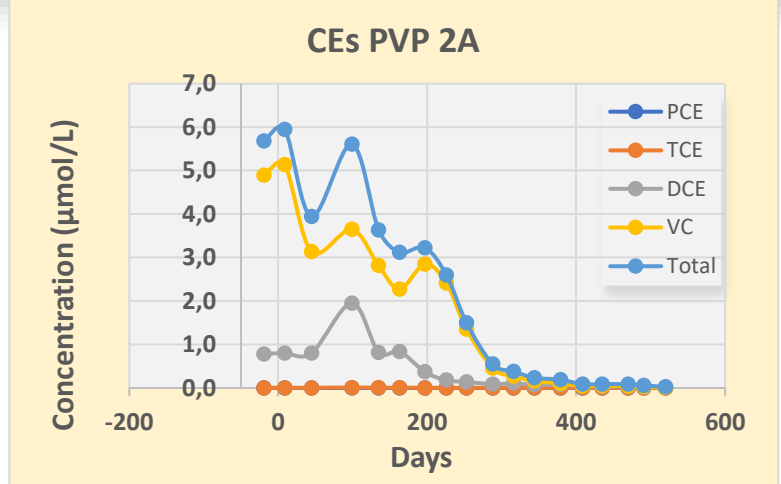
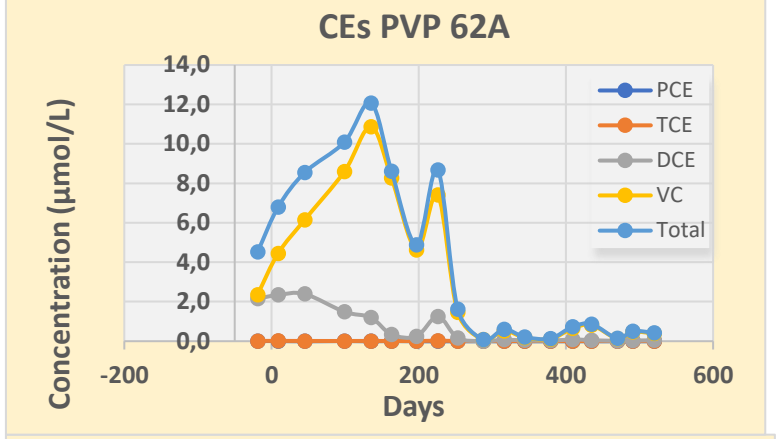
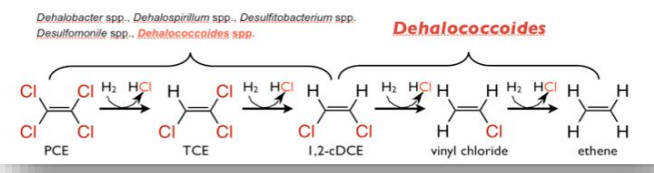
- Contaminants: mainly chlorinated solvents (DCE, VC)
 - Groundwater conditions suitable for ARD (low oxygen, low Redox)
1. Injection of ARD substrate into the groundwater layer
 2. Separate reactive wall with activated carbon
 - Injections performed in 6-10/2019
 - Area covering over 14 000 m²
 - Total of 405 injection points







1 mol PCE → 1 mol TCE
 1 mol TCE → 1 mol DCE
 1 mol DCE → 1 mol VC
 1 mol VC → 1 mol eteeni C₂H₄



LESSONS LEARNED IN FINLAND

1. Increasing interest towards sustainable risk management tools and technologies
 - Sustainability (economic, social, environment)
 - Utilization of know-how from key experts / "in situ clusters"
2. *In situ* remediation requires more detailed understanding of the potential risks and exposure pathways
 - Target the right actions at the right place (at the right time)
 - Lab pilot > field pilot > full scale approach
3. Most often hybrid remediation model is the key to success
 - Several technologies / approaches at one site to meet the target
 - Importance of pre-investigation / studies
 - In situ remediation is dynamic and complex process
 - prepare for re-evaluation of the remedial design / approach
 - adjust the process
 - re-evaluate the targets



THANK YOU!



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