Enhancing Bioremediation through In Situ Sorption of Extremely Low Chlorinated Solvent Concentrations at a High-Speed, Italian Railway Station

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REGENESIS

RFI
RETE FERROVIARIA ITALIANA
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Fourth International Symposium on Bioremediation and Sustainable Environmental Technologies

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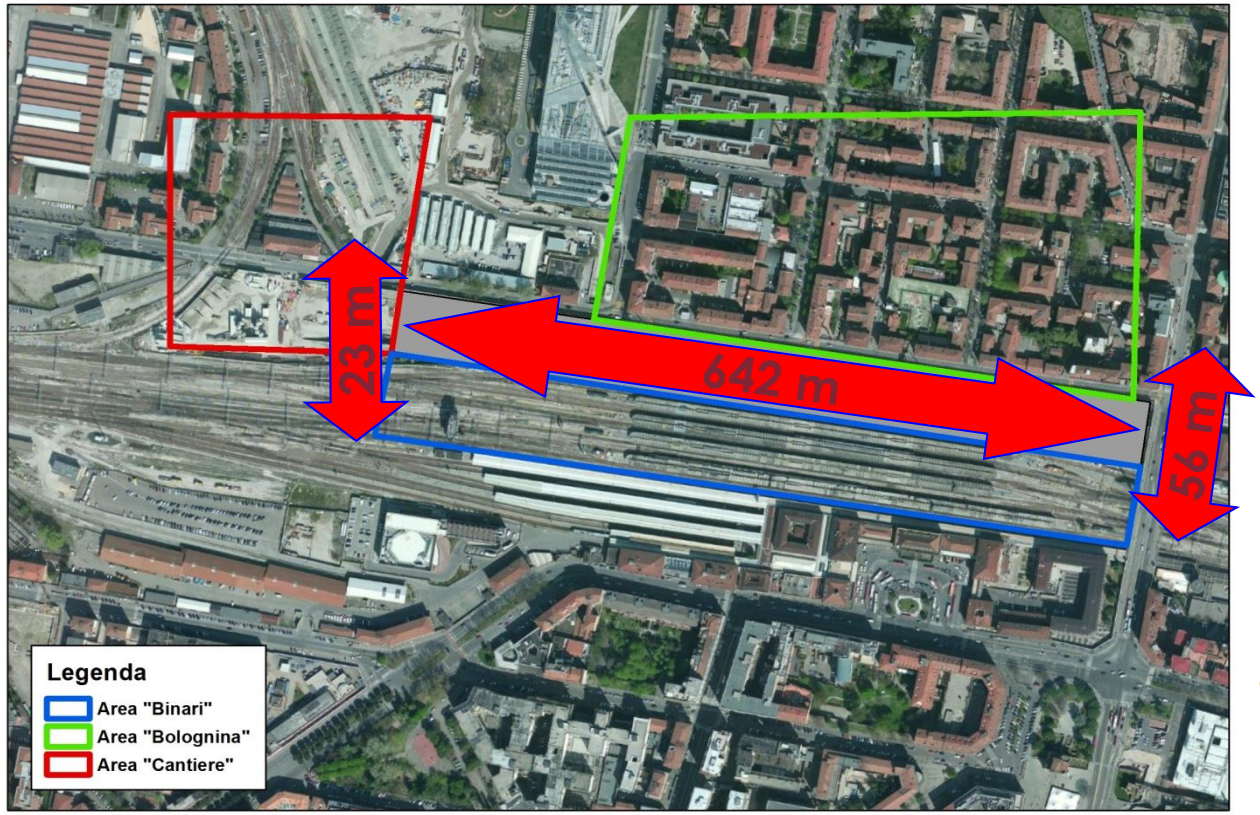
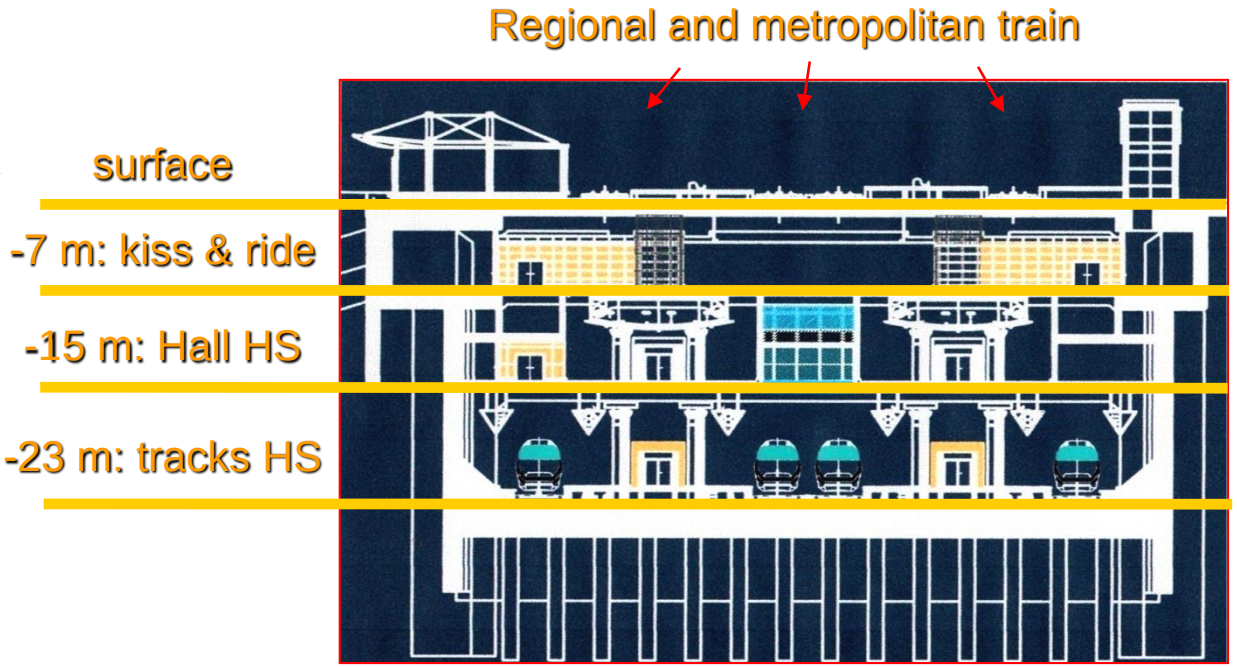
BATTELLE
It can be done

The site: Bologna High-Speed Railway Station



~ **1.000.000 m³** of soils (slightly contaminated) was excavated to give the floor to the new station



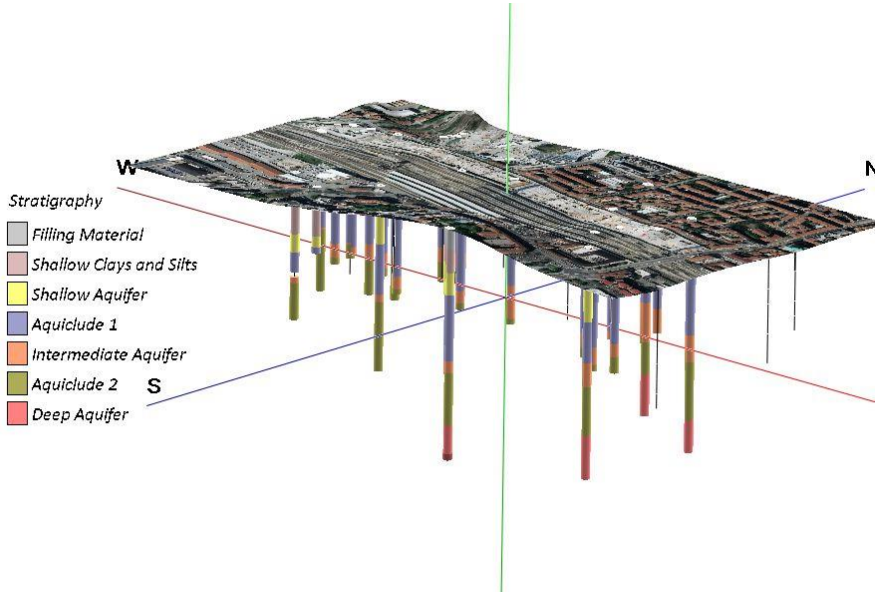
The site: Bologna High-Speed Railway Station

Stages of station construction

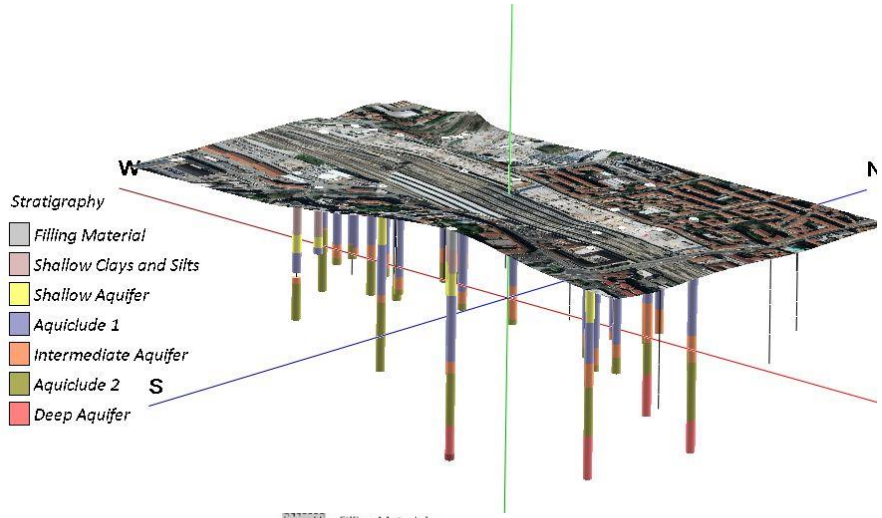
1. ***ante operam : october 2004 – may 2006.*** Beginning of the new AV station construction with archeological investigation
2. ***Preliminary escavation: may 2006 – october 2009.*** Excavation down to - 7 meters, realization of the containment bulkheads of the “camerone”
3. ***«camerone» escavation: october 2009 – august 2011.***
4. ***post escavation: august 2011 – january 2013.*** AV Station final arrangement
5. **post opera and monitoring: january 2013 -**

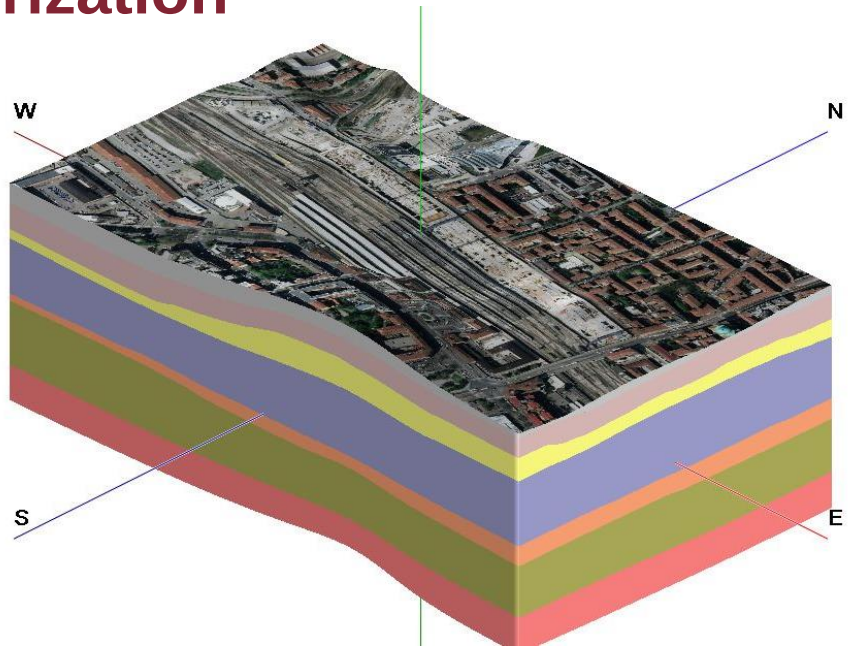
Hydrogeological characterization

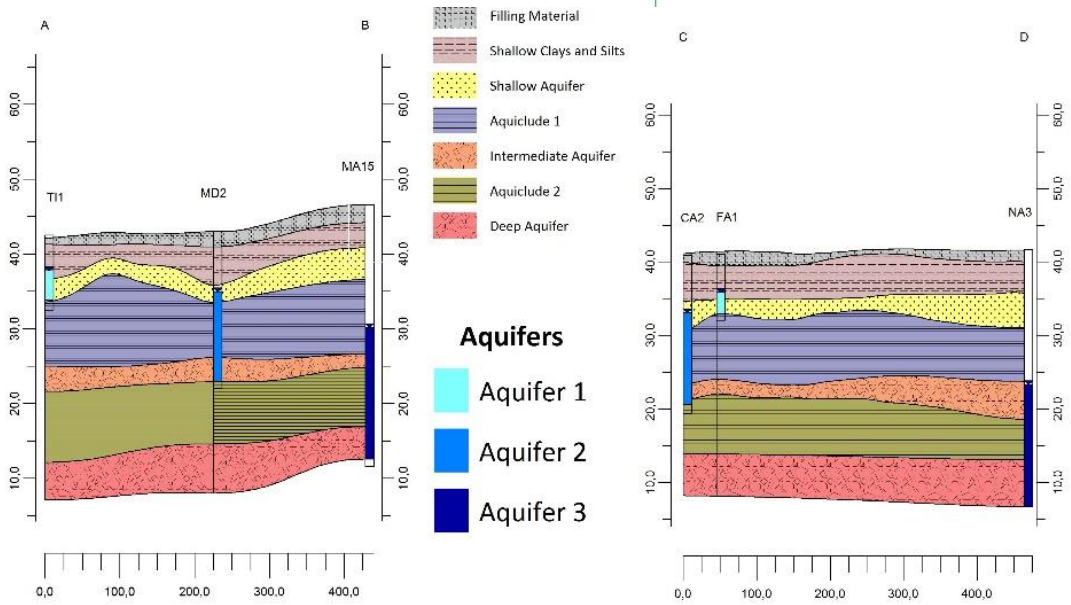
63 core samples



Hydrogeological characterization





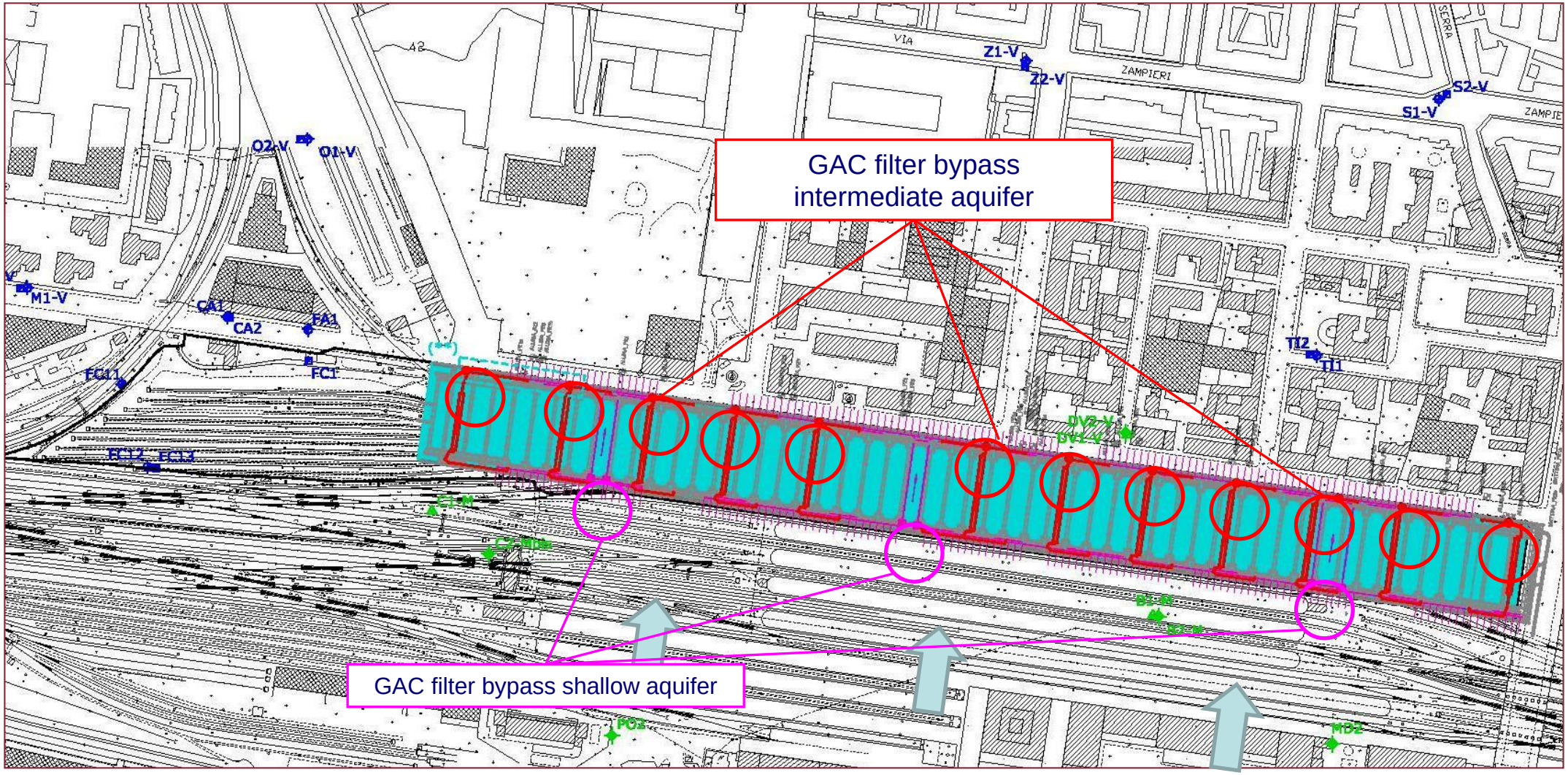


Shallow Aquifer:
unconfined, water table depth about 3-4 m bg, thickness 6-8 m, fine sands with the presence of silty fraction, K = $5*10^{-6}$ - $1*10^{-5}$ m/s, average groundwater flow velocity ~ 5 m/yr

Intermediate Aquifer:
confined, water table depth about 17-19 m bg, thickness 2-4 m, fine and medium sands, K = $5*10^{-5}$ - $1*10^{-4}$ m/s, average groundwater flow velocity 50 m/yr

Deep Aquifer (non contaminated)

Bypass for the hydraulic aquifer continuity equipped with GAC filters

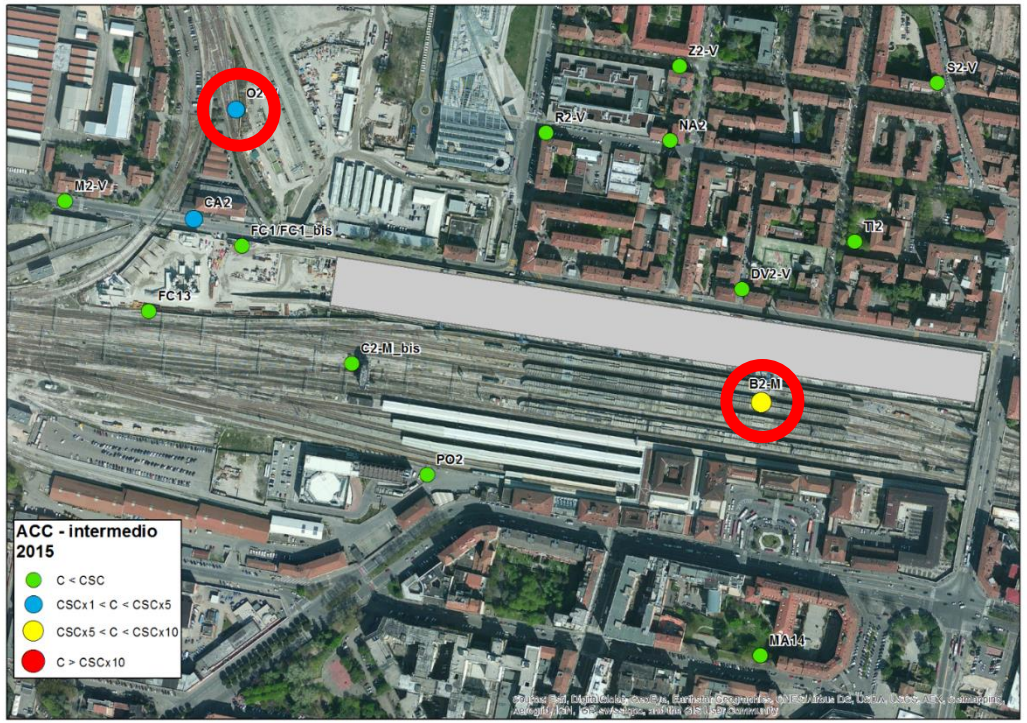


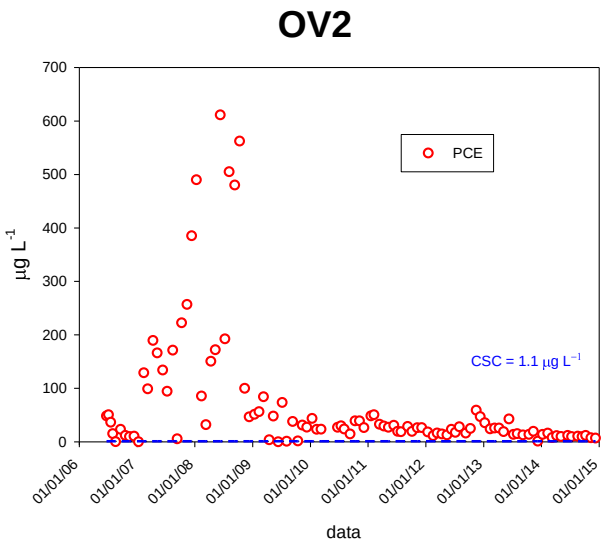
Hydrogeological characterization

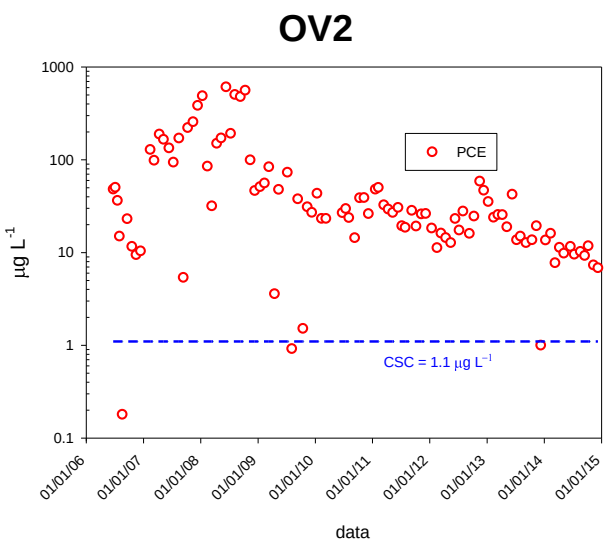
Shallow Aquifer ➔ ≈ 5 m yr^{-1}

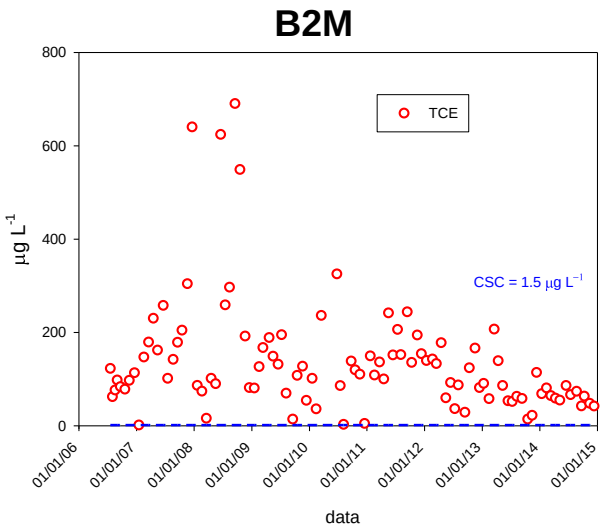
Intermediate Aquifer ➔ ≈ 50 m yr^{-1}

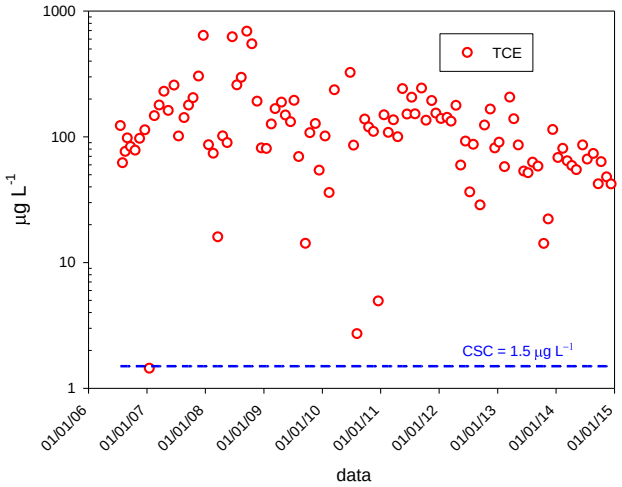
Groundwater contamination: long term monitoring



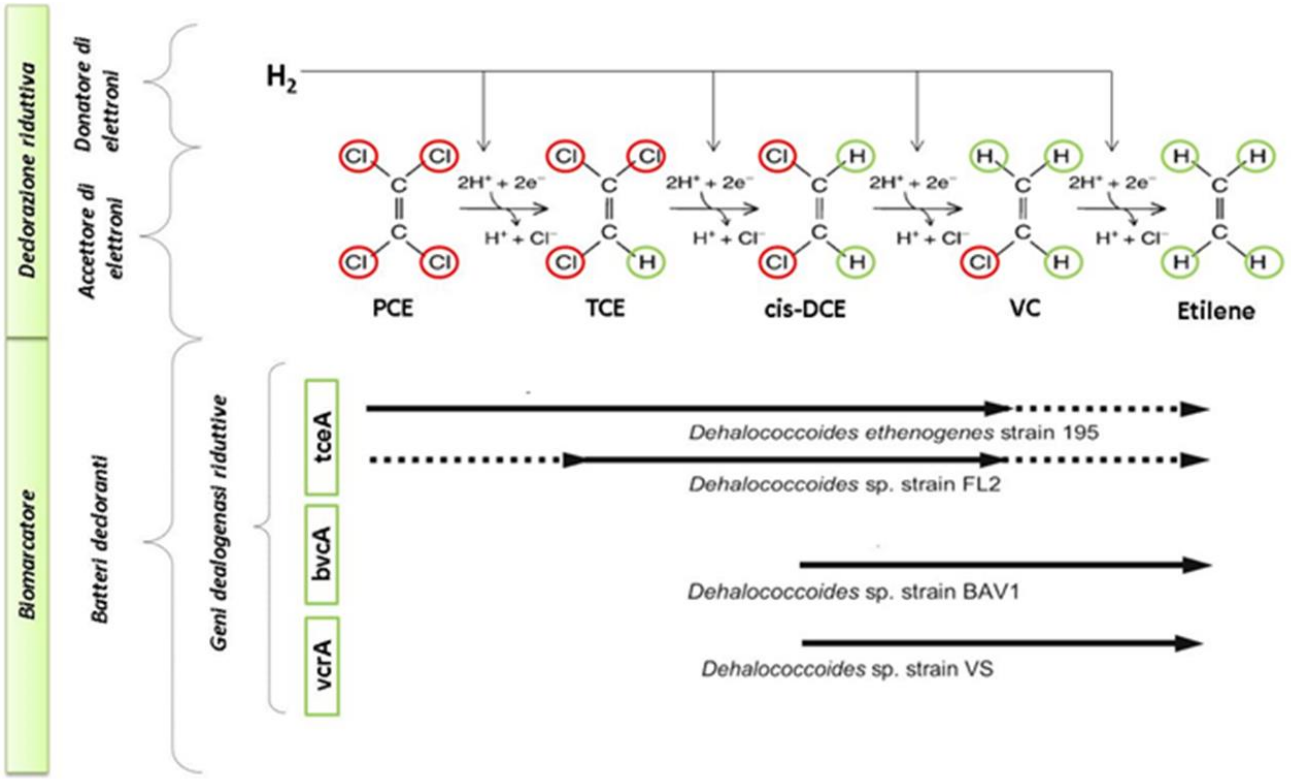








Microbiological characterization for the evaluation of the biological dechlorinating potential

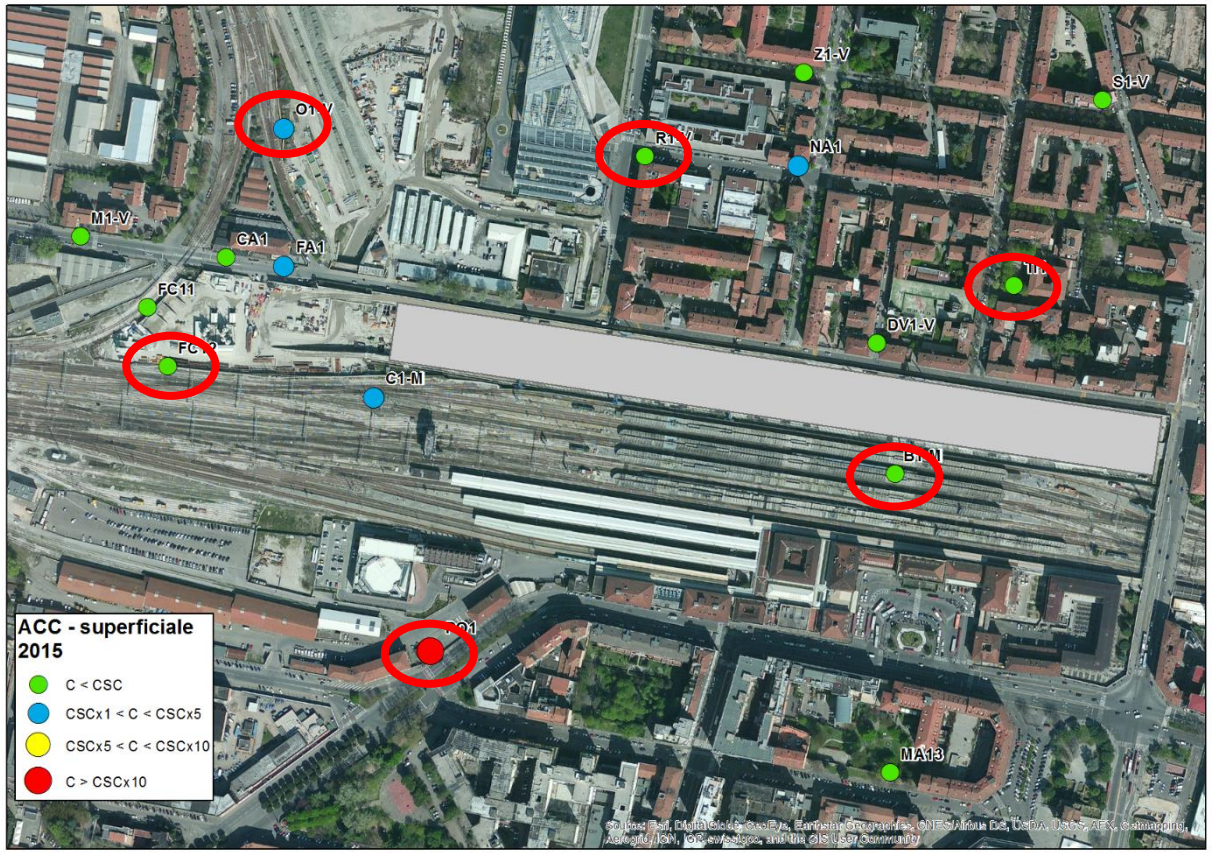


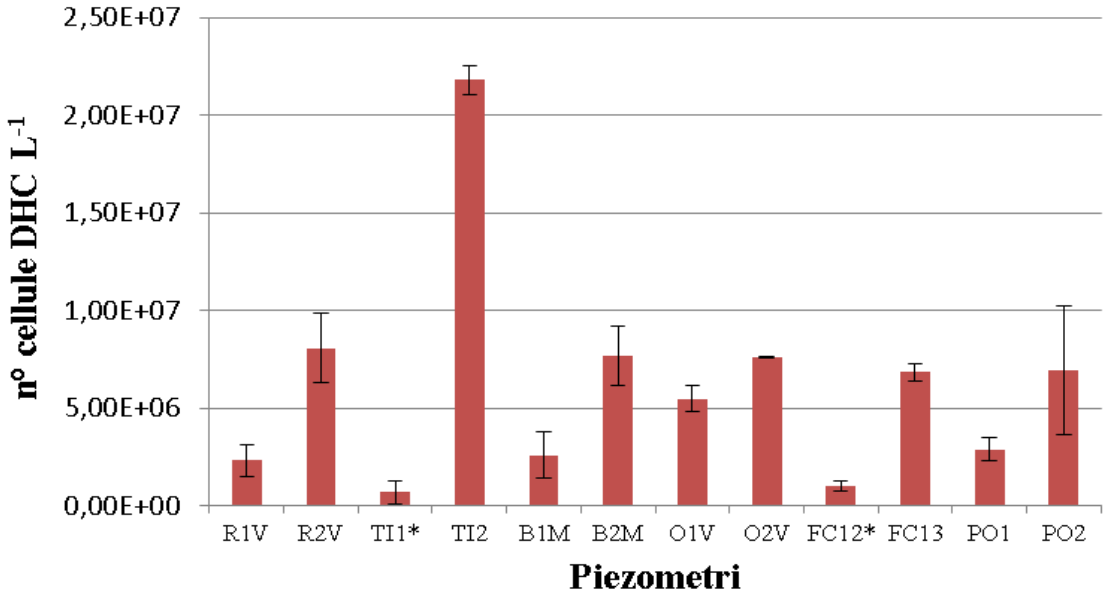
Water Research Institute (IRSA)
Italian National Research Council (CNR)

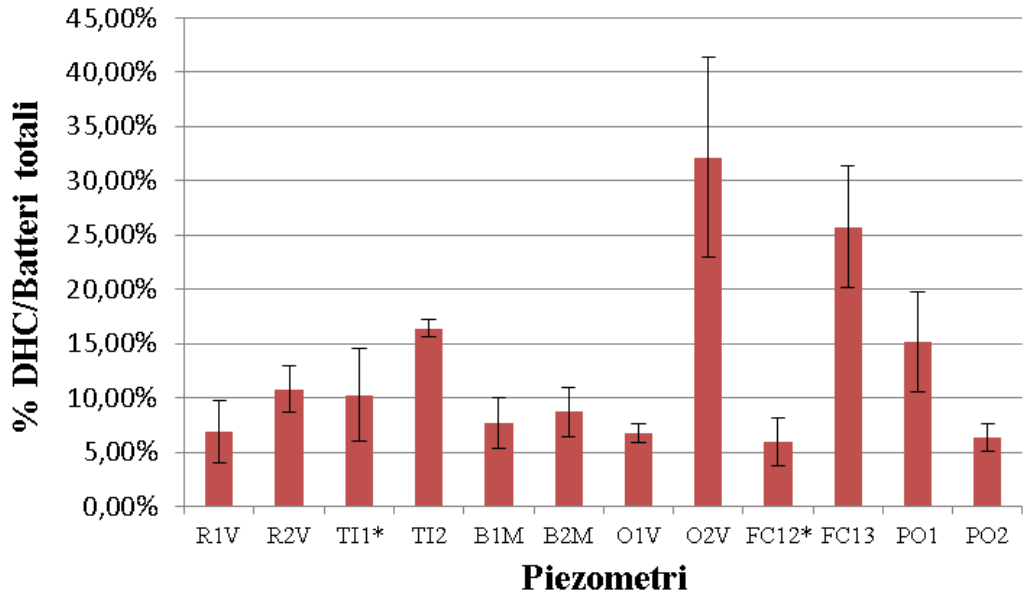
Dr. Simona Rossetti
Dr. Bruna Matturro

CARD-FISH
Real time qPCR

Microbiological characterization for the evaluation of the biological dechlorinating potential







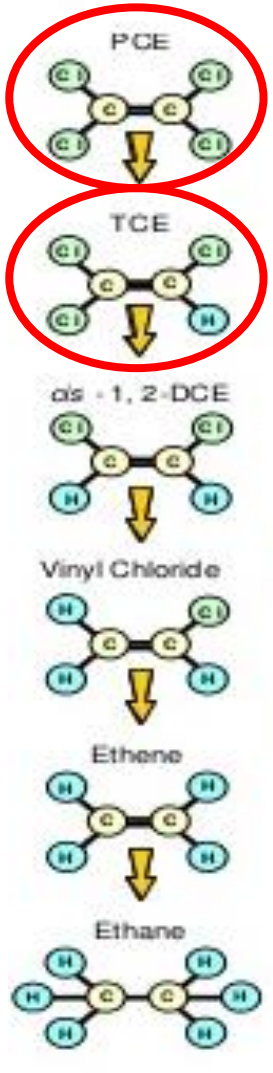
Sampling for the microcosm study: biological reductive dechlorination

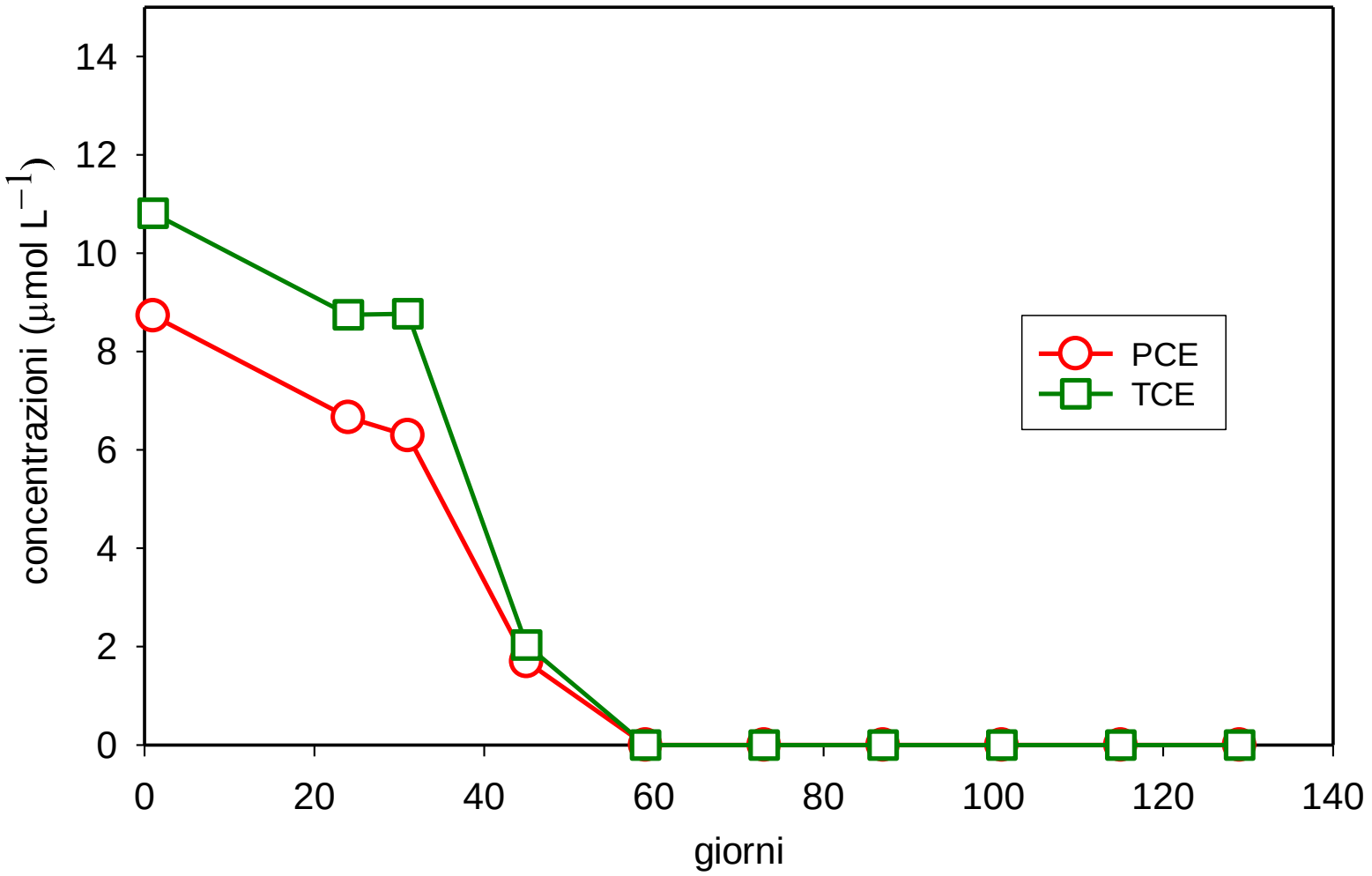
from the field

to the lab

A representative example of the microcosm results

(lactate amendment)





A representative example of the microcosm results

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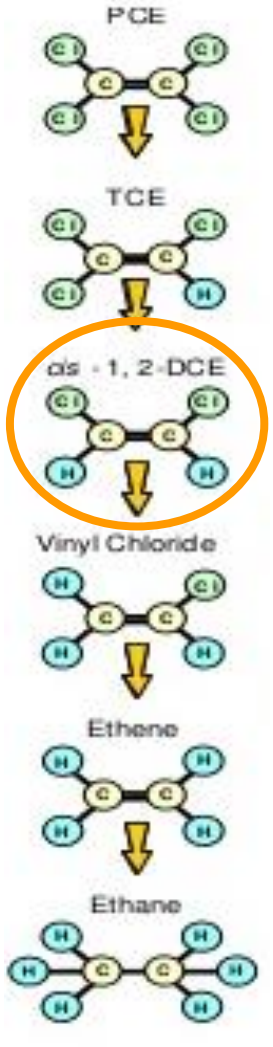

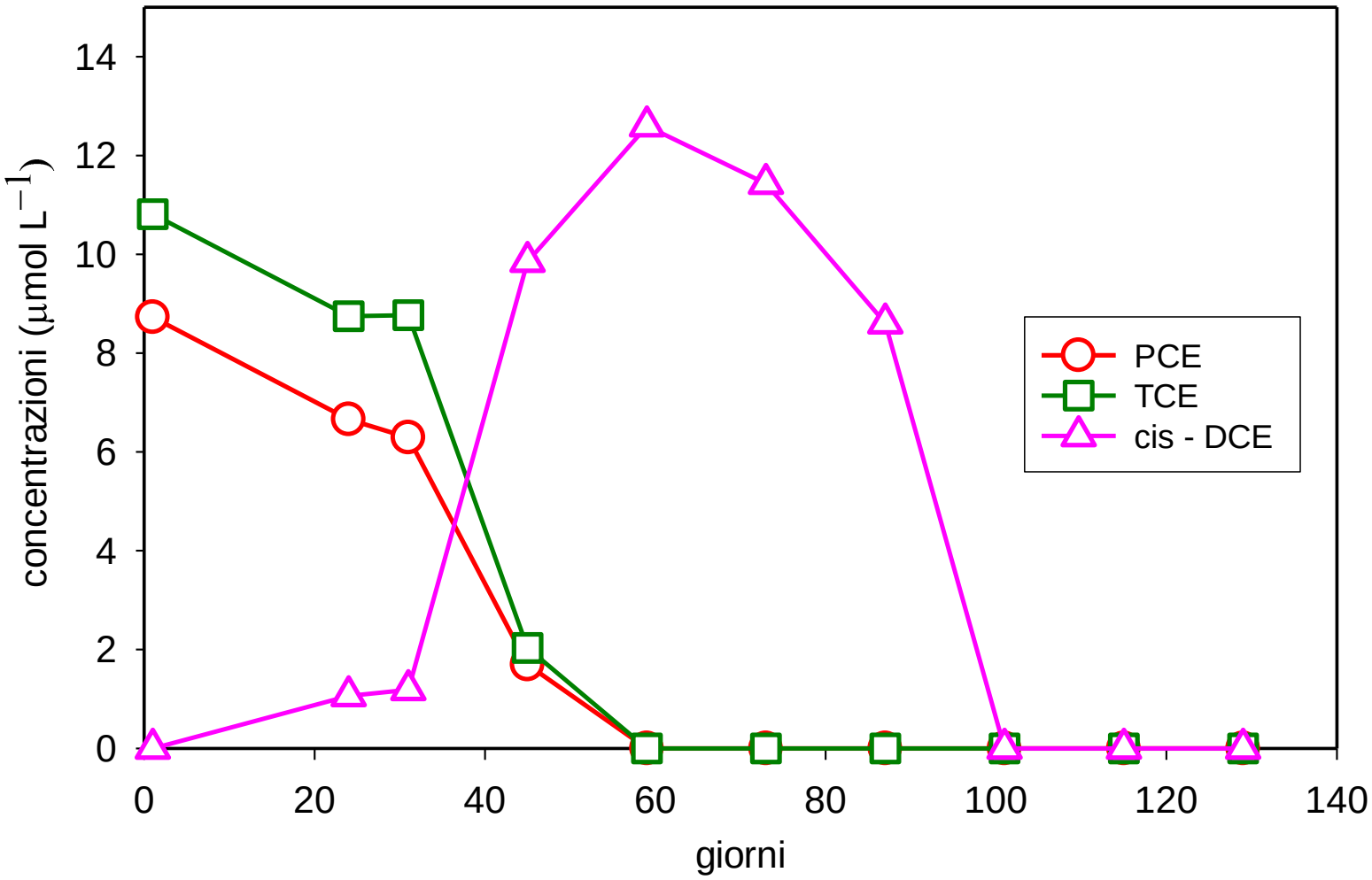

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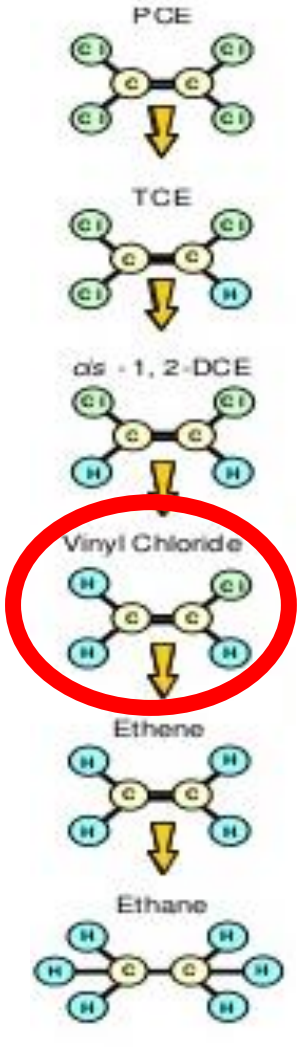
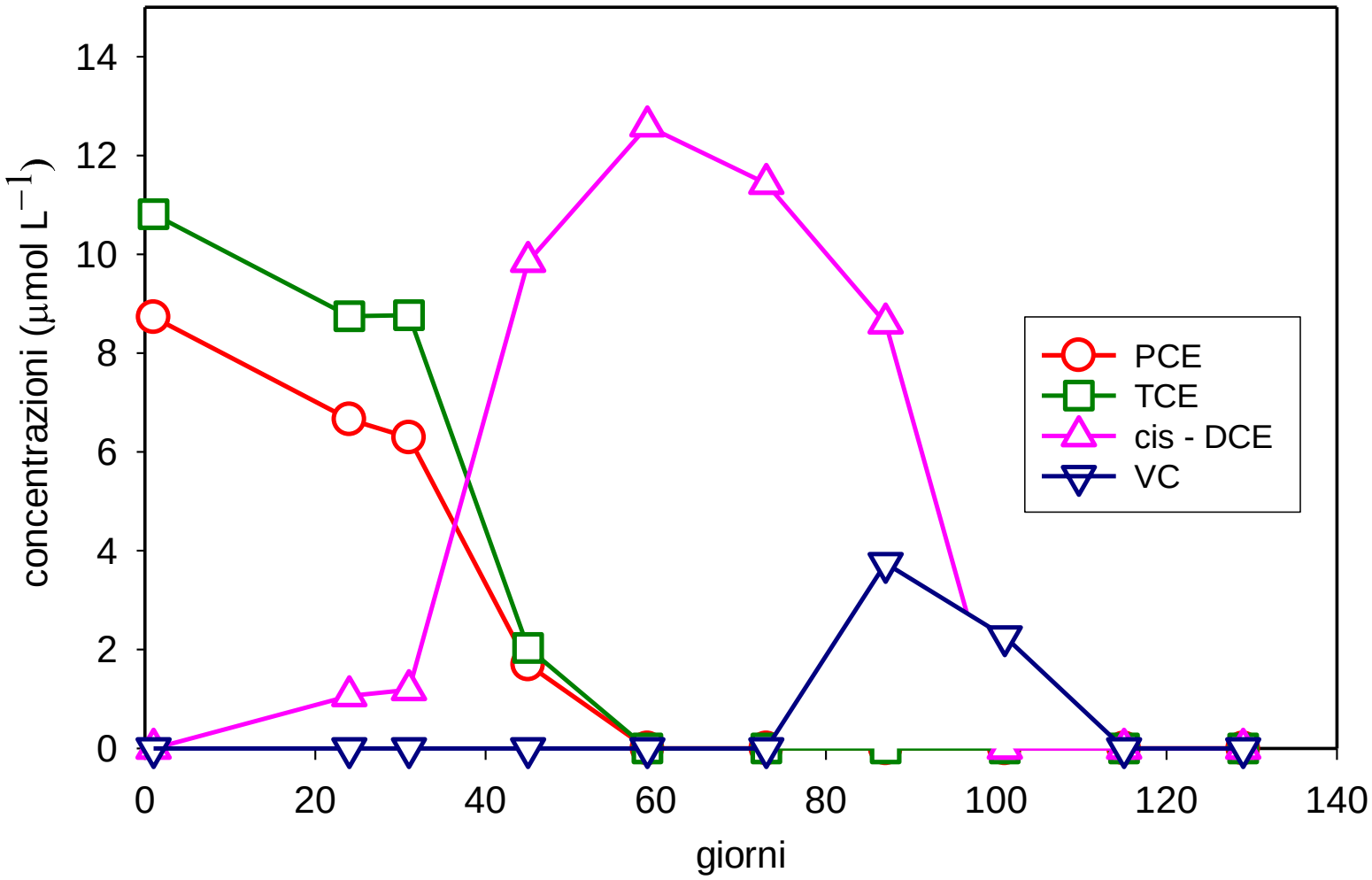
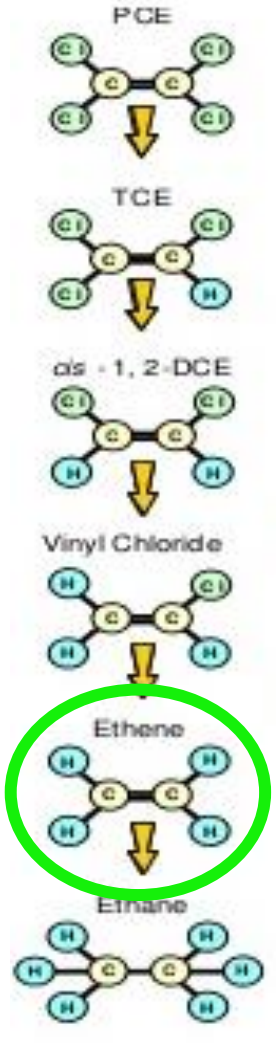
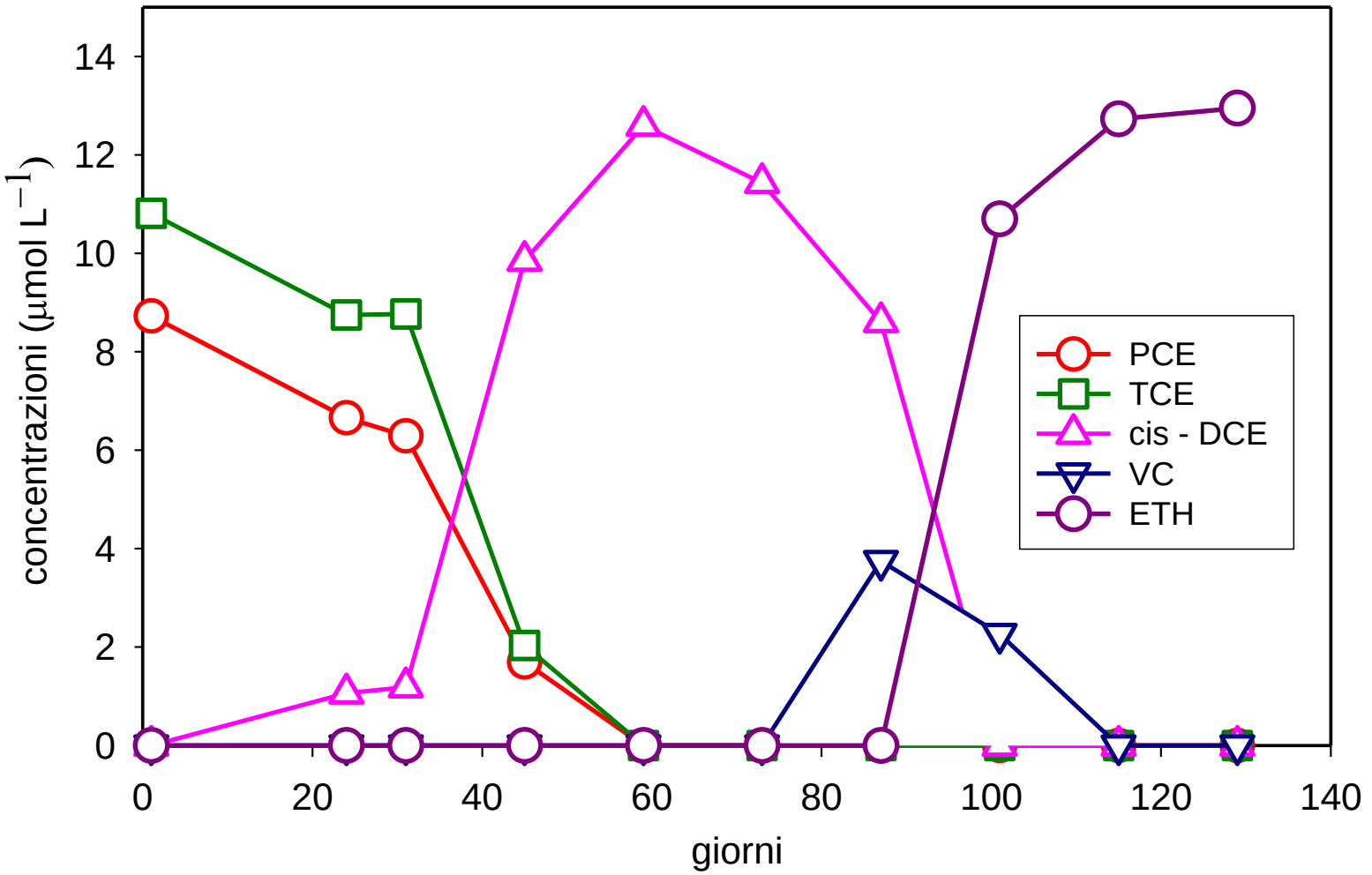




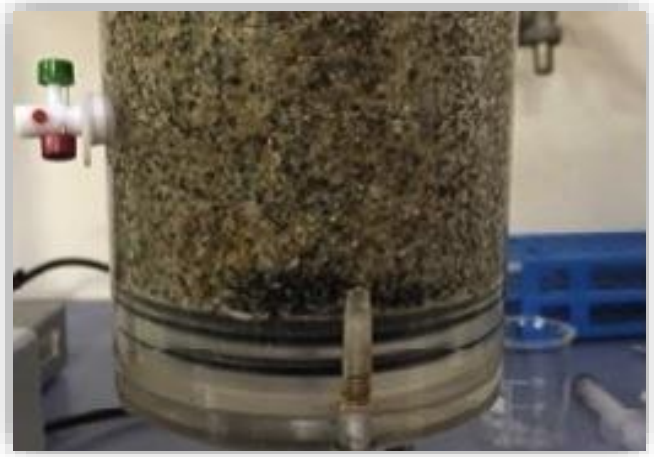
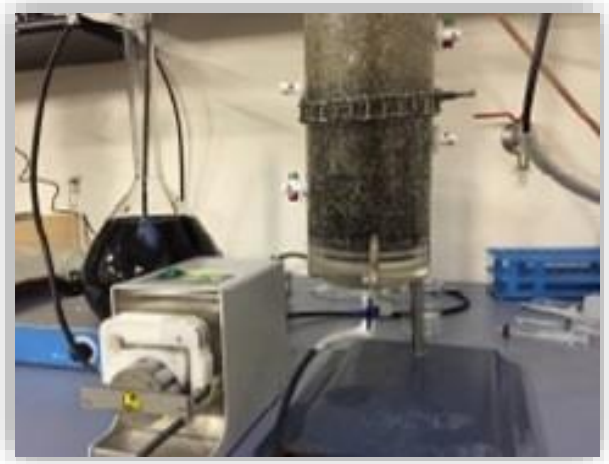
A representative example of the microcosm results

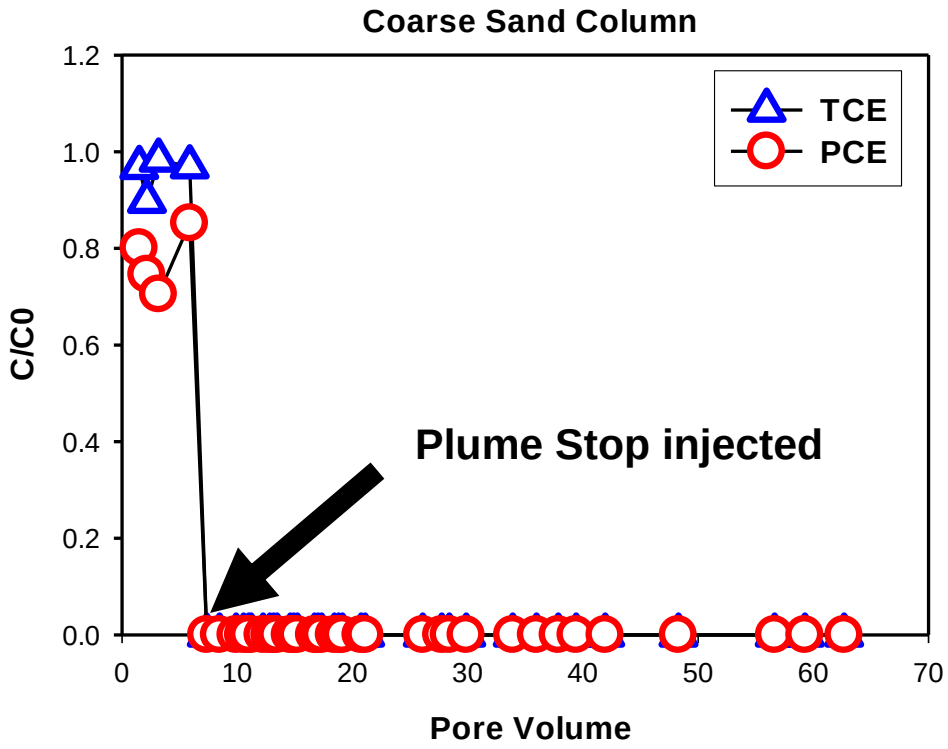
(lactate amendment)

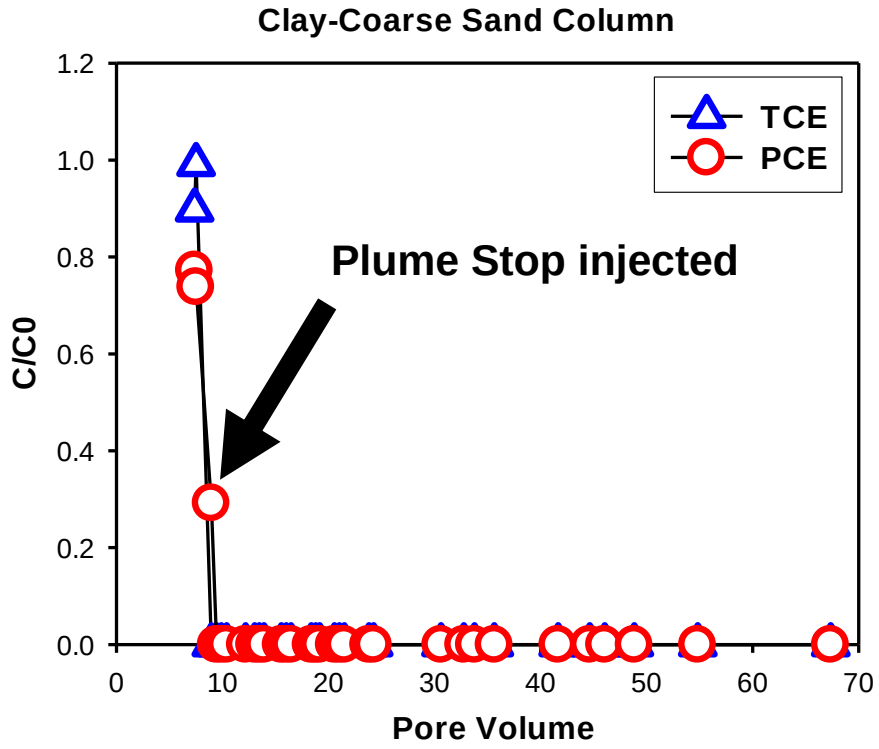




Testing PlumeStop by lab column experiments (injectability and sorption capacity)

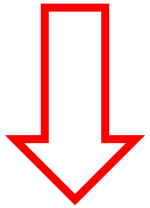




Coarse Sand Column
C/C0
Pore Volume
TCE
PCE
Plume Stop injected
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
10
20
30
40
50
60
70

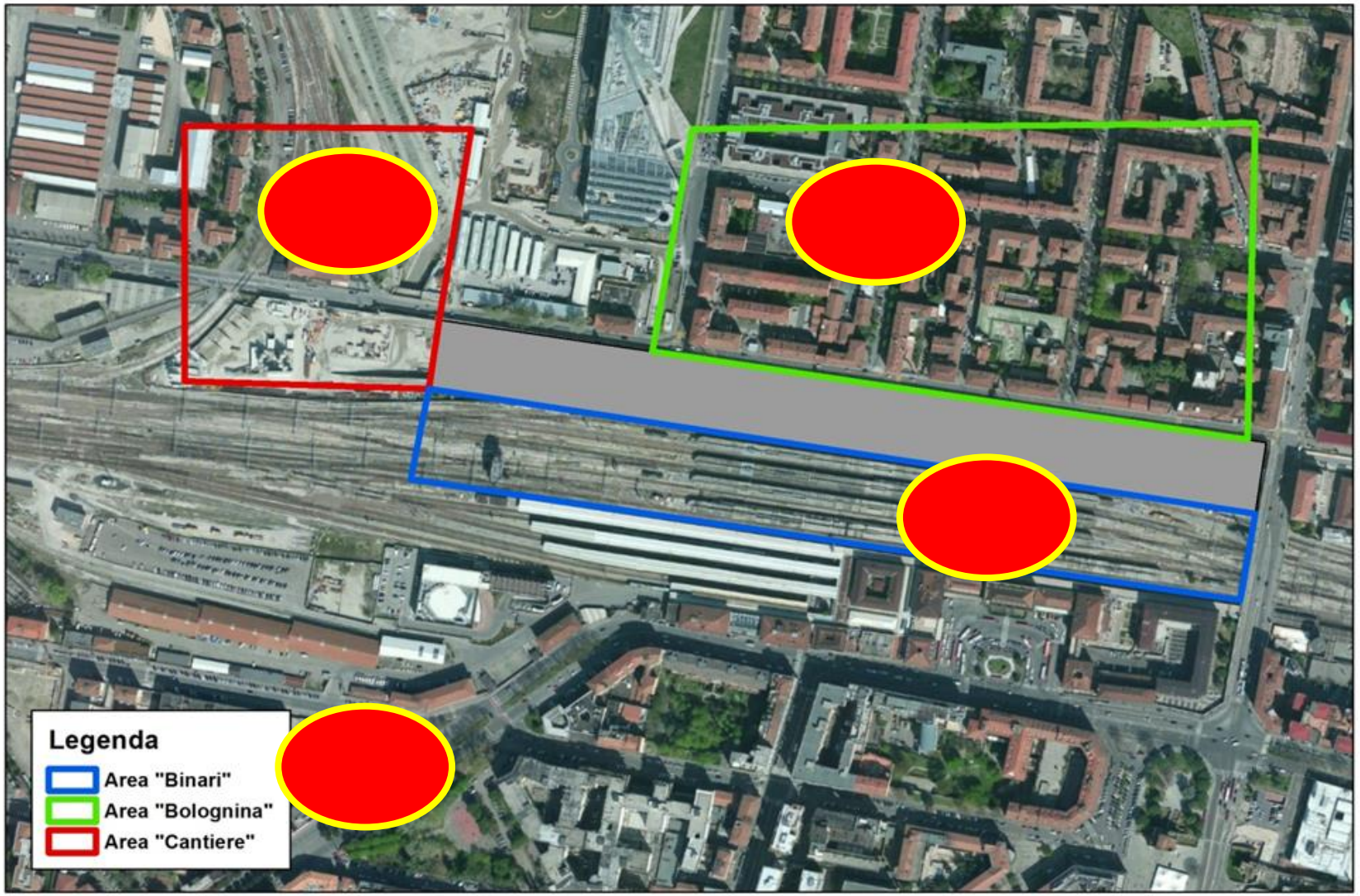

Clay-Coarse Sand Column
C/C0
Pore Volume
TCE
PCE
Plume Stop injected
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
10
20
30
40
50
60
70

The remediation strategy

- Persistent **low concentration** of chlorinated solvents in a large urban area
- Evident **potential** for the enhancement of **Biological Reductive Dechlorination**
- Limitation due to **lack of electron donor** and extremely **low concentration**
- Stringent **regulatory limits** (1.1 μg L^{-1} PCE, 1.5 μg L^{-1} TCE, 0.5 μg L^{-1} VC)
- Some «**spots**» of concentration with relatively higher concentration

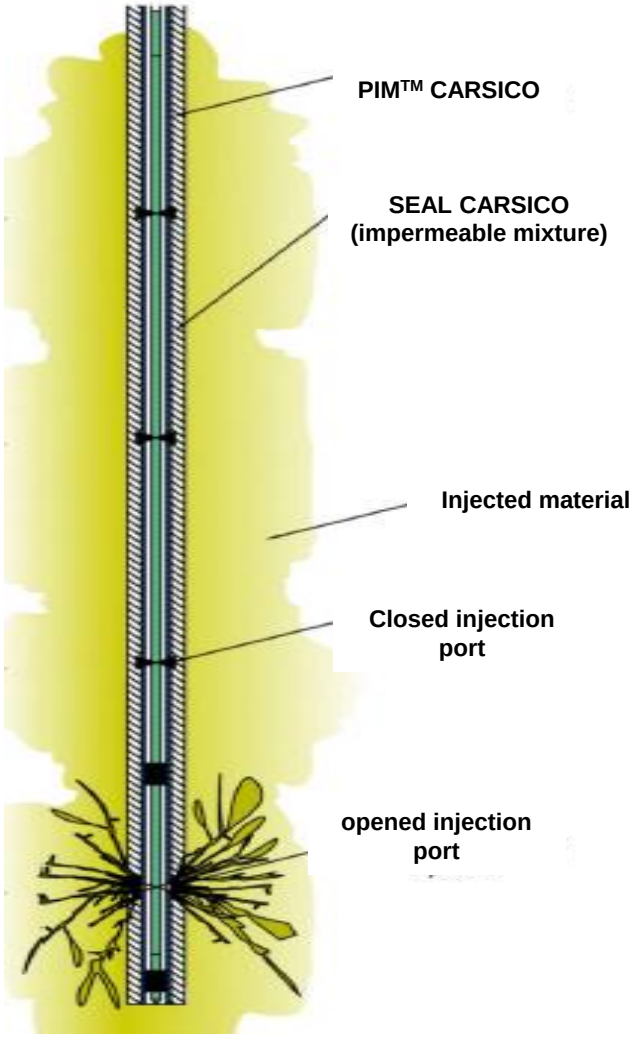


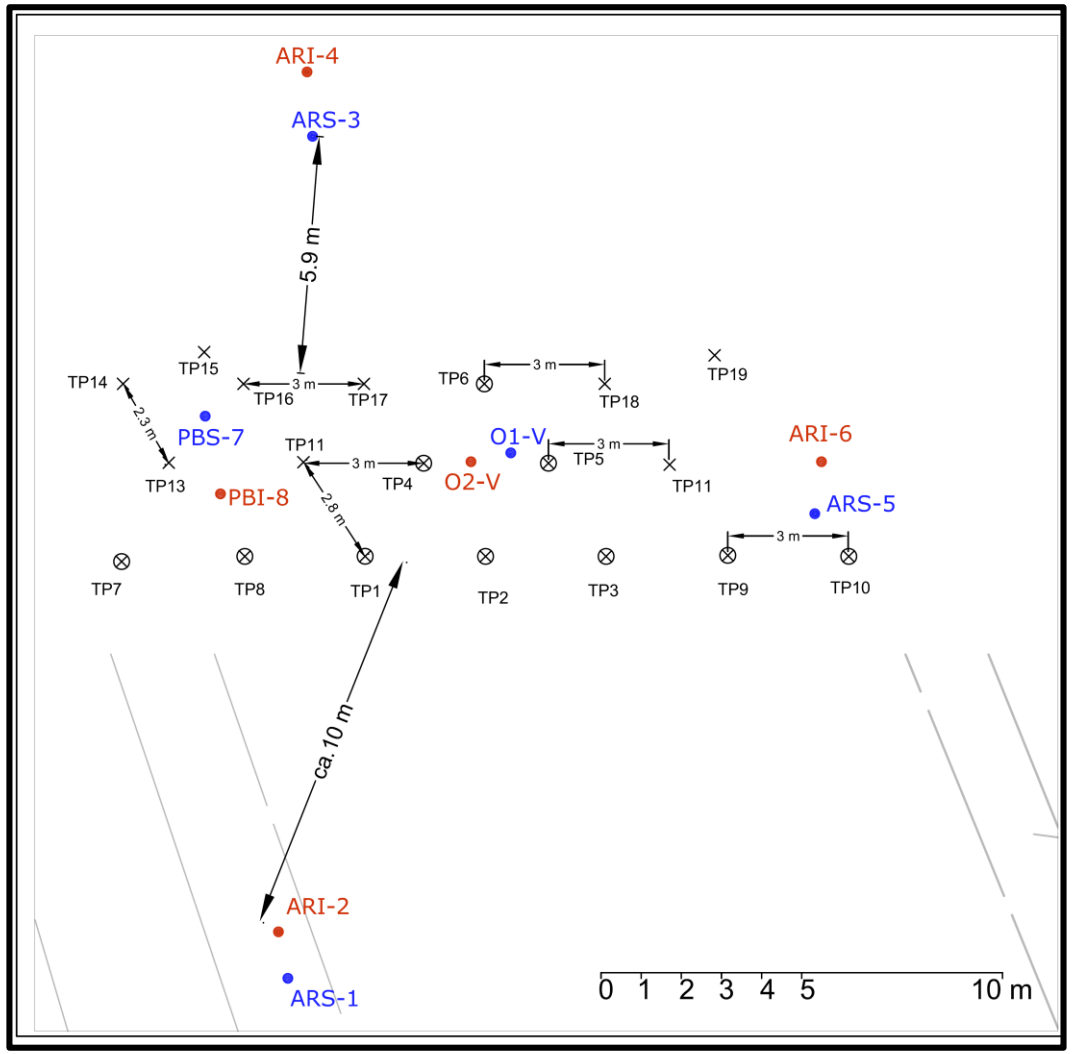
Realization of "**reactive zones**" by the **injection** of a **Colloidal Activated Carbon** (PlumeStop™ by Regenesis) together with an **electron donor** source (HRC by Regenesis) in order to **quickly reduce** the dissolved CAH concentration (**sorption**) and to obtain a **"reasonable" kinetic** for Biological Reductive Dechlorination onto sorbed CAHs

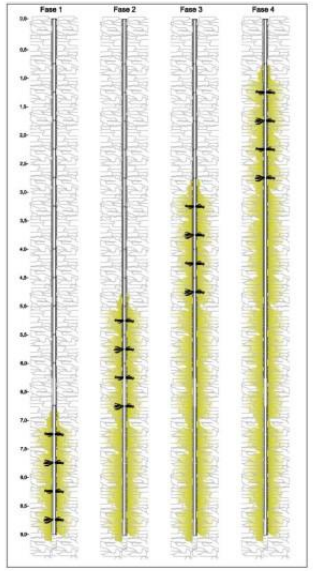

Legenda
Area "Binari"
Area "Bolognina"
Area "Cantiere"

Full scale application (July 2016)

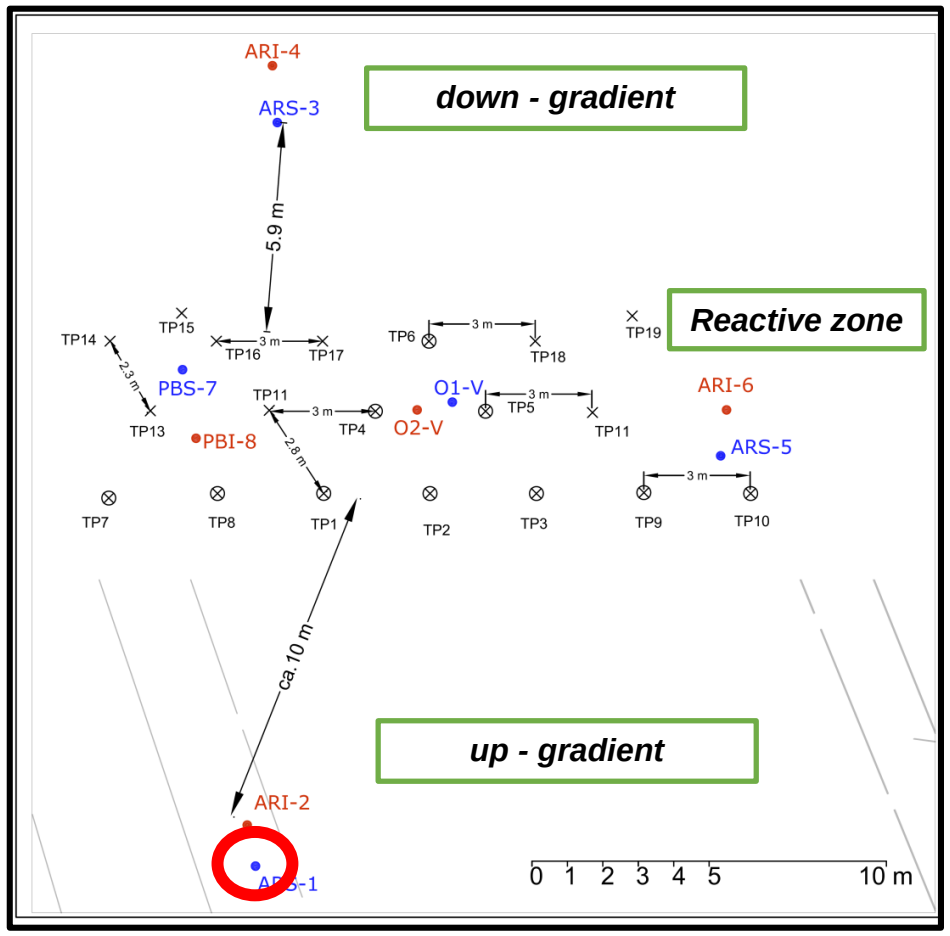
Fixed Multi – Injection Well

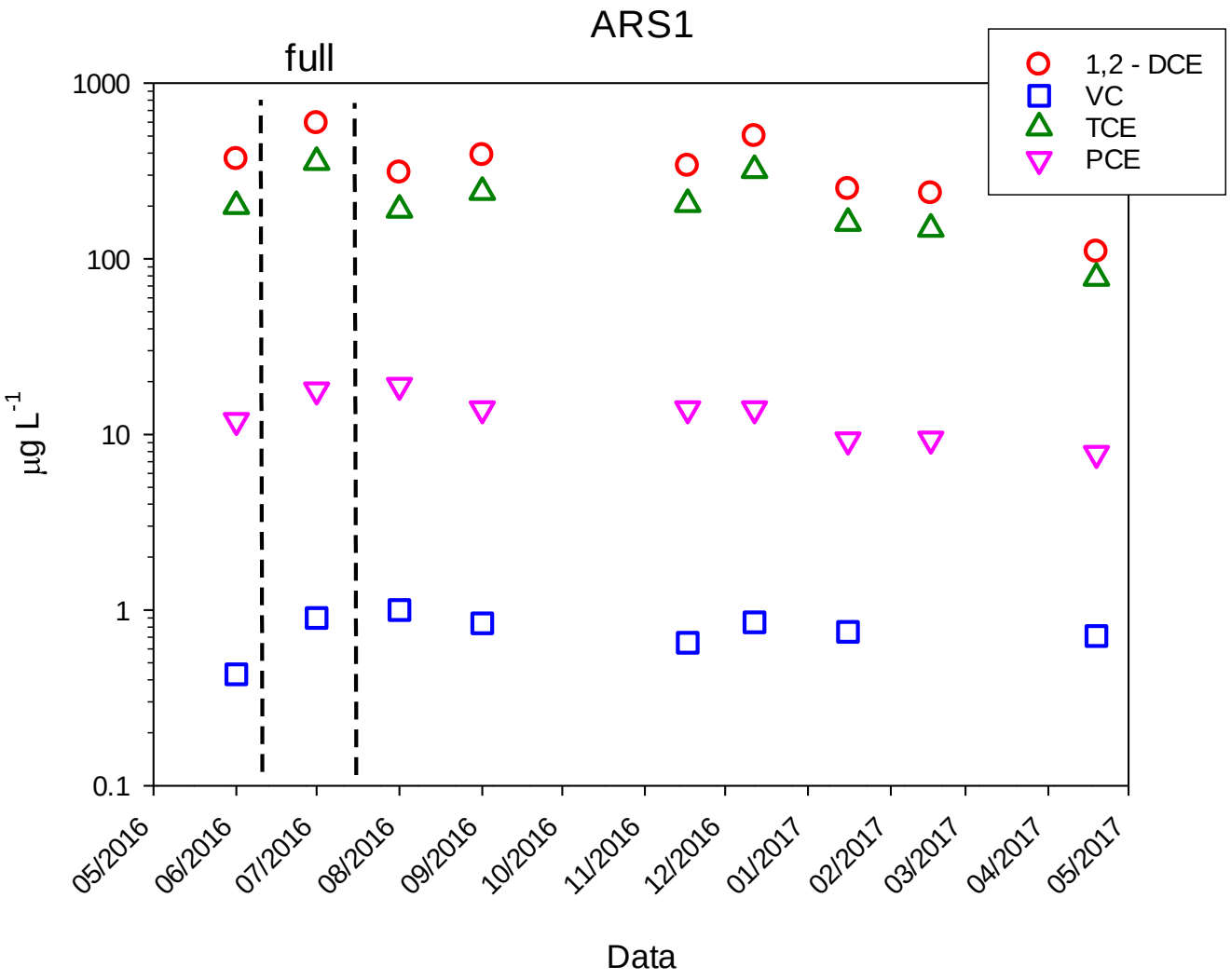






Results from the first 8 months after the full scale application





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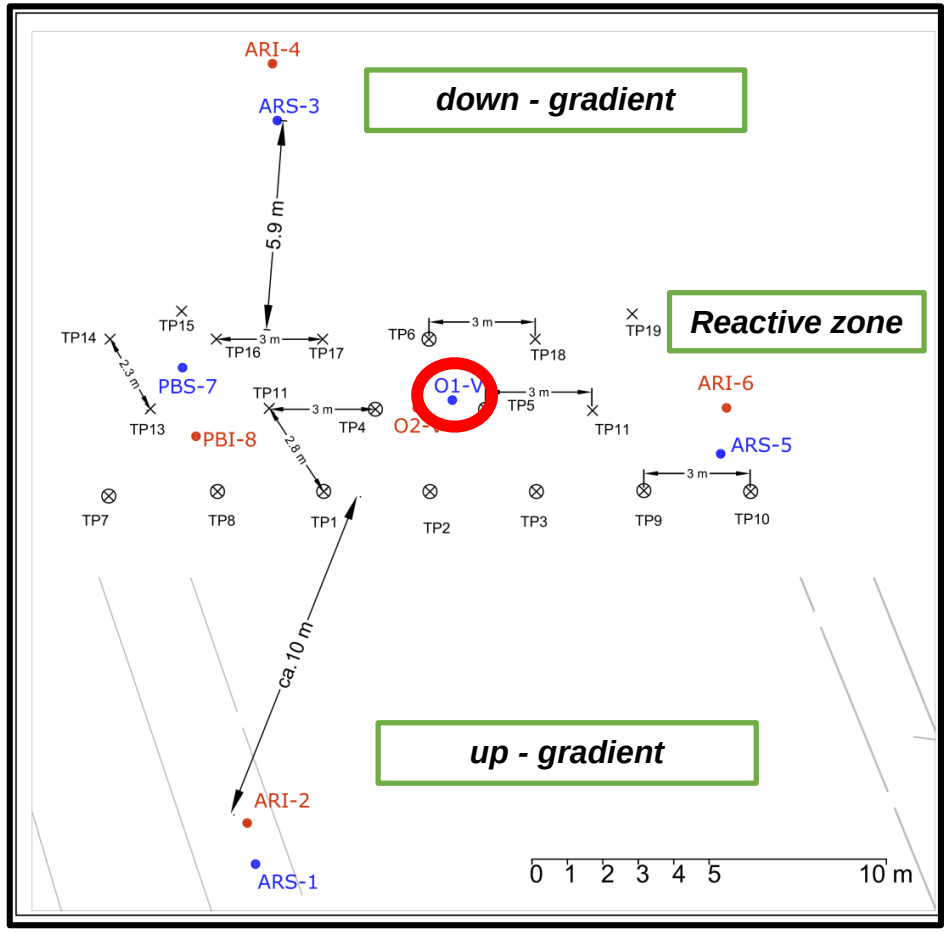

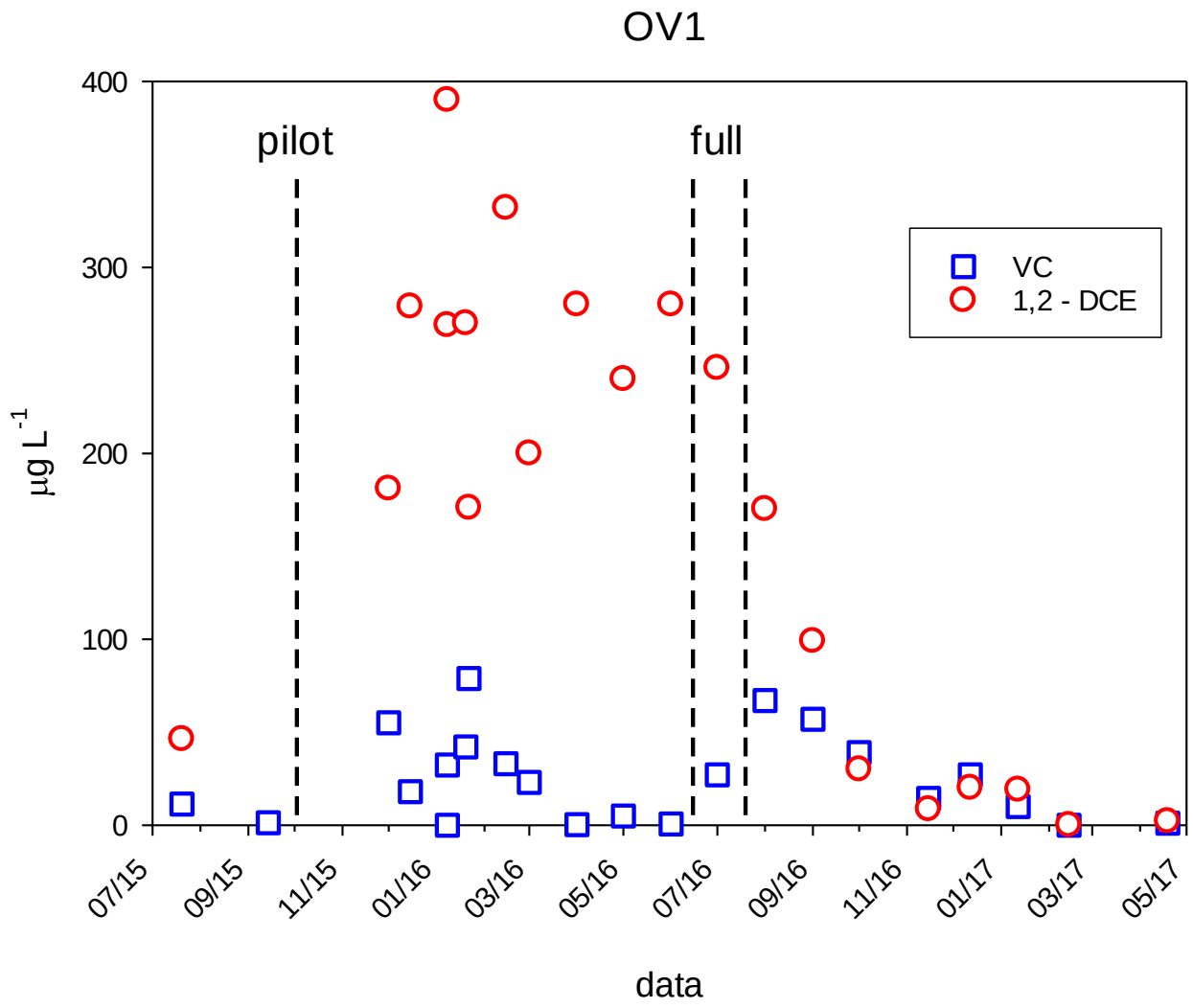

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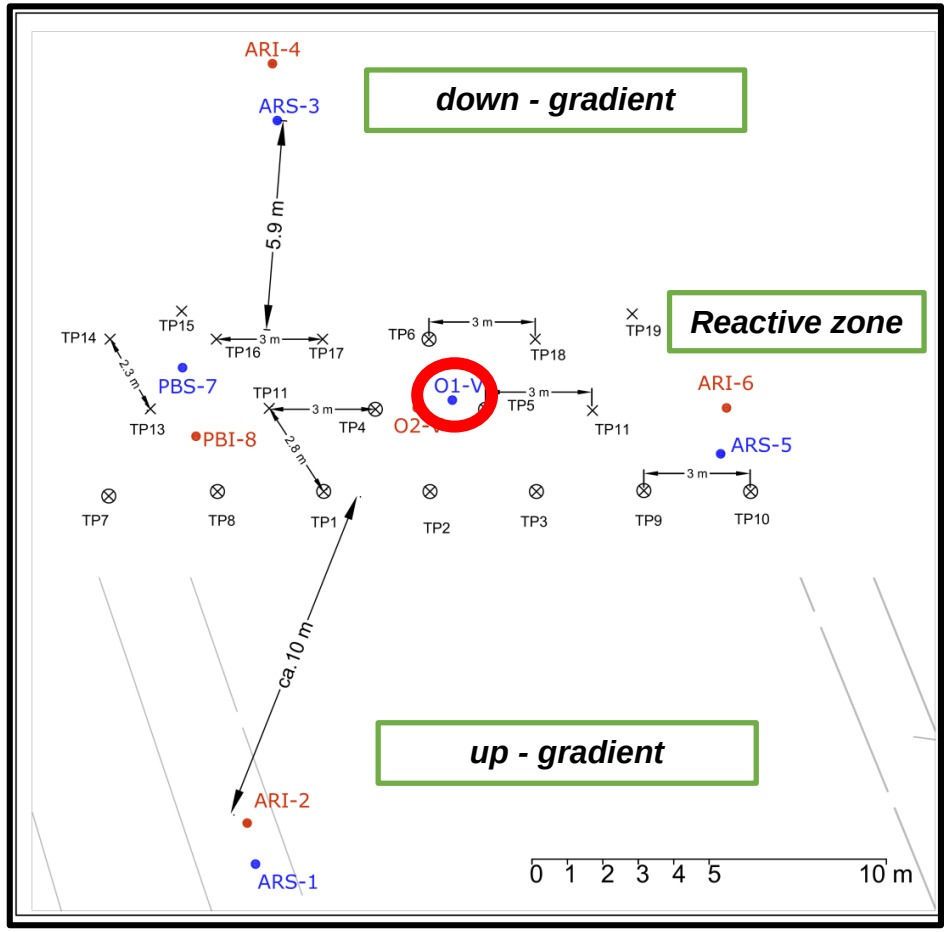

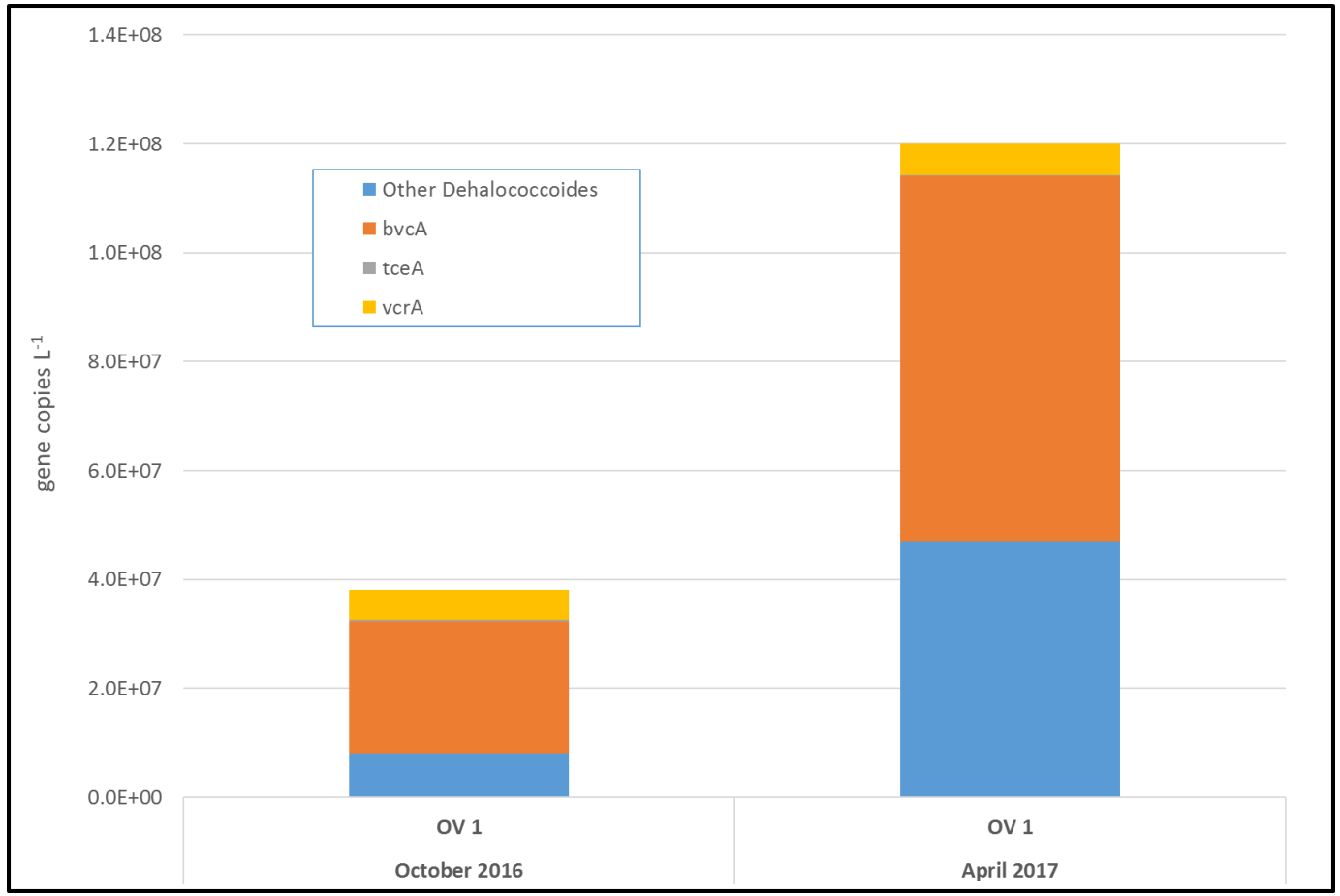

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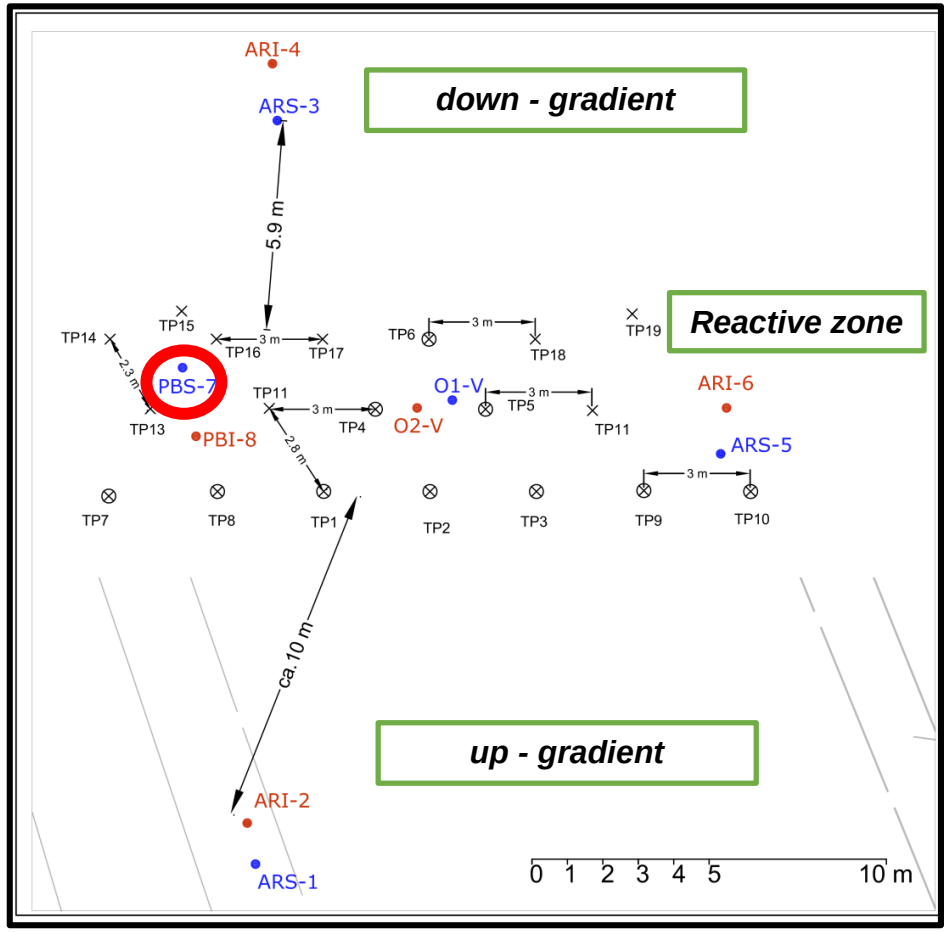

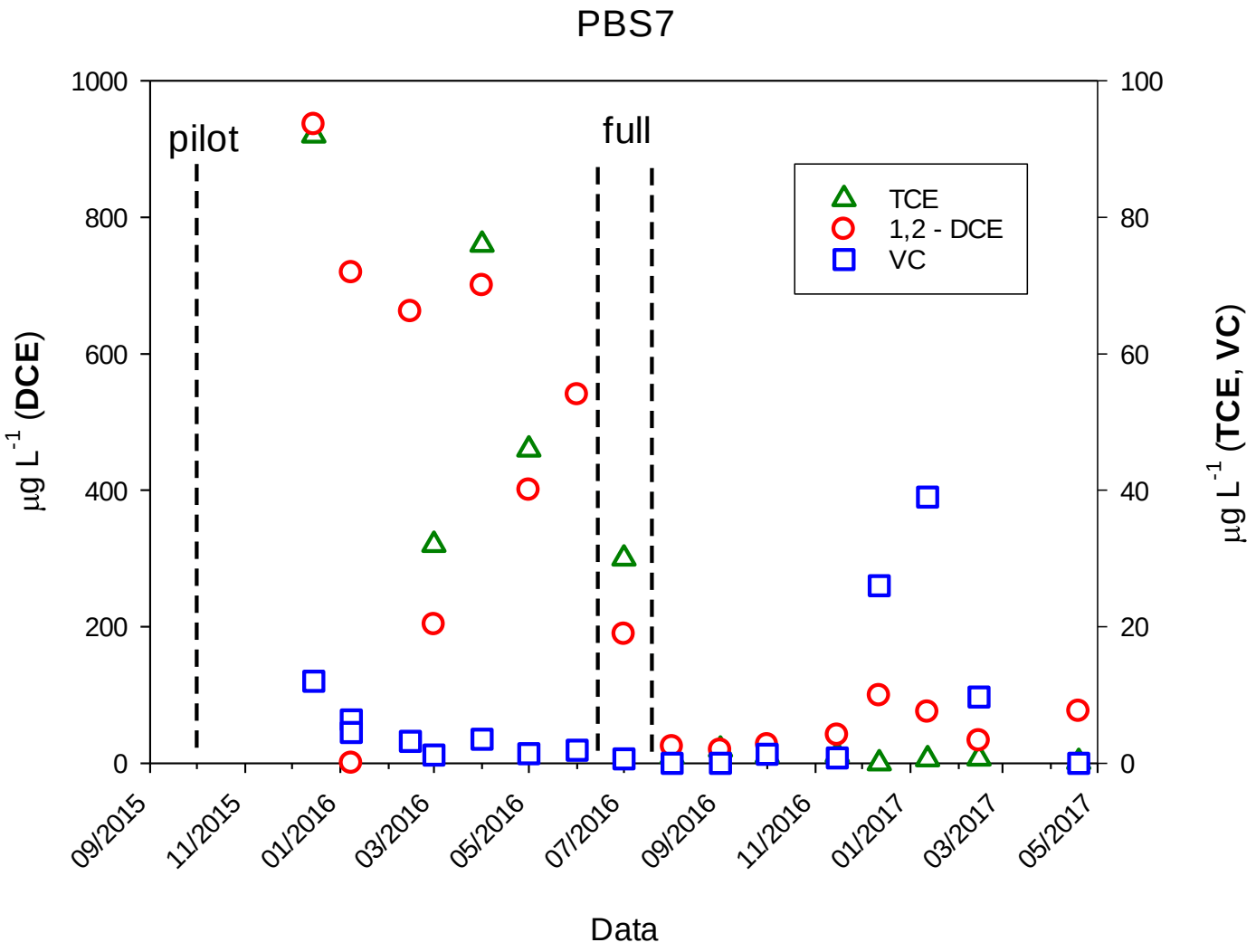

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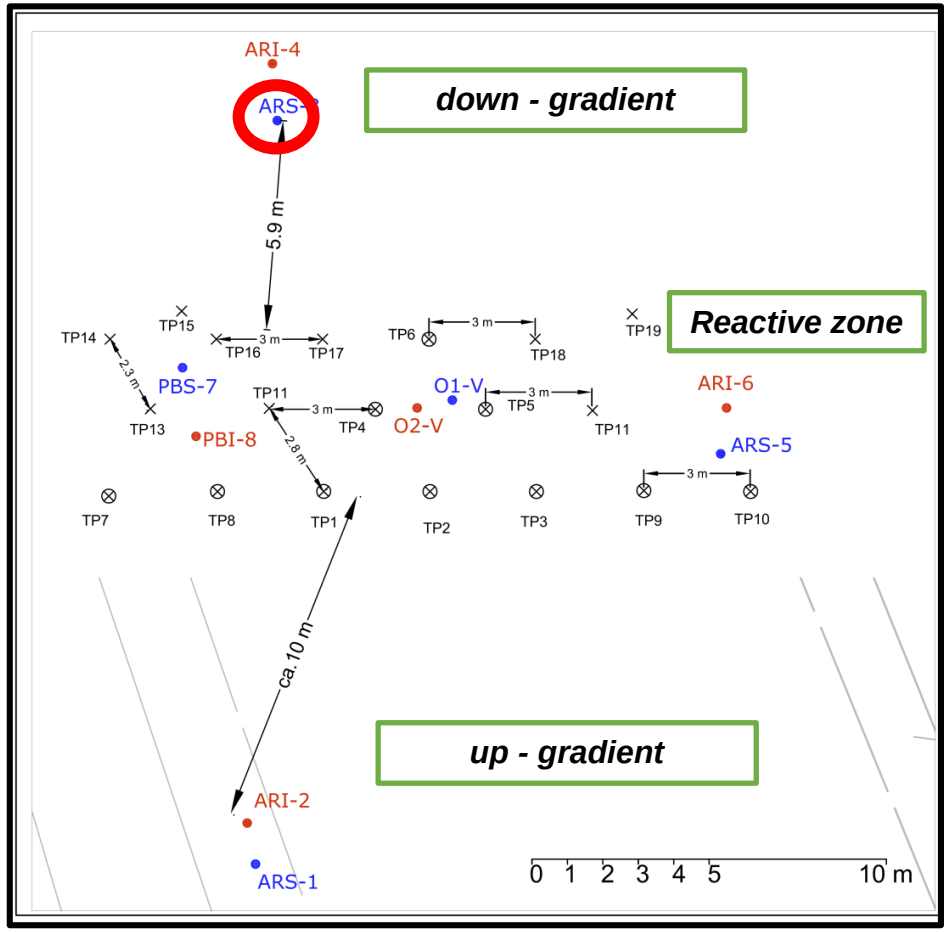

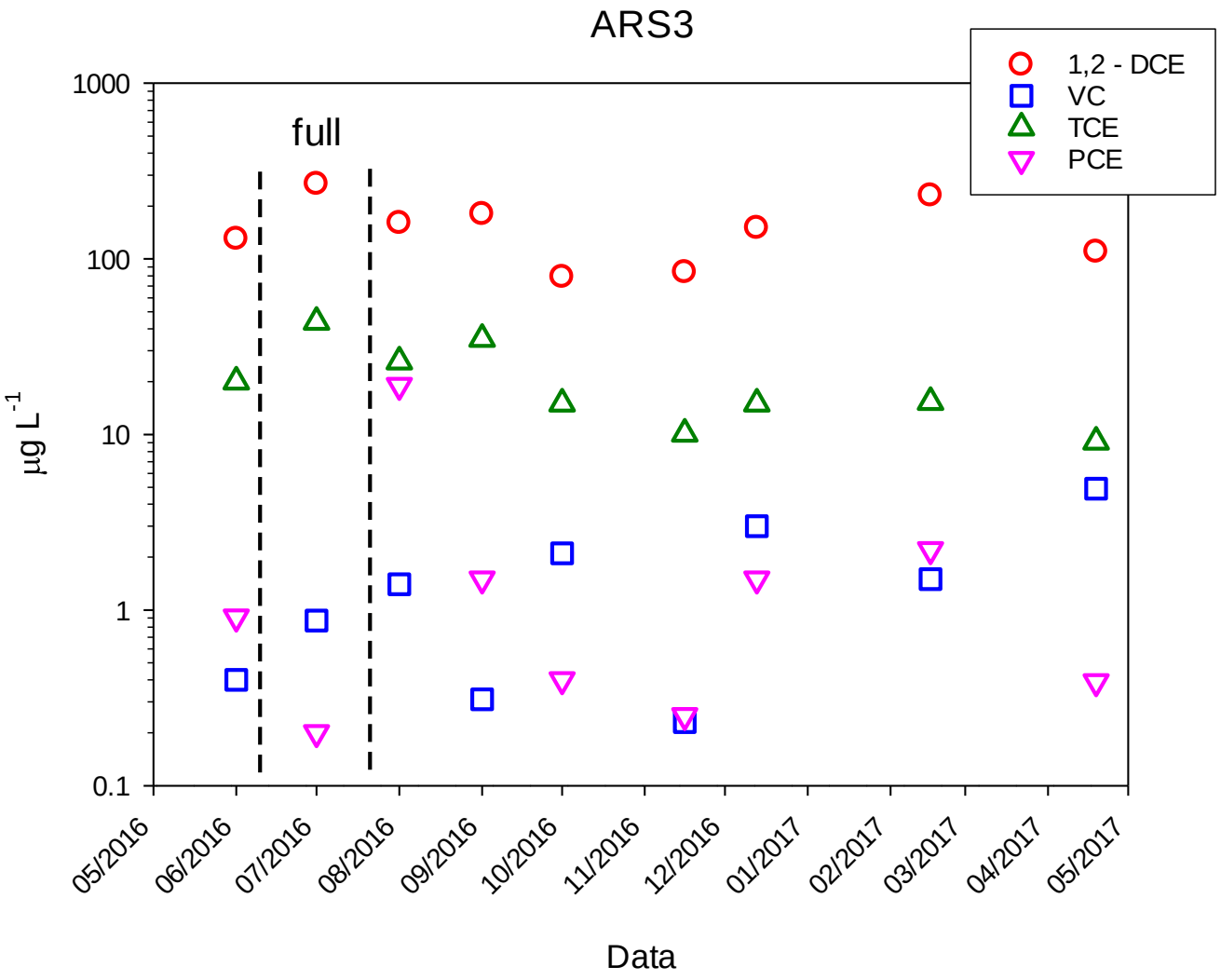

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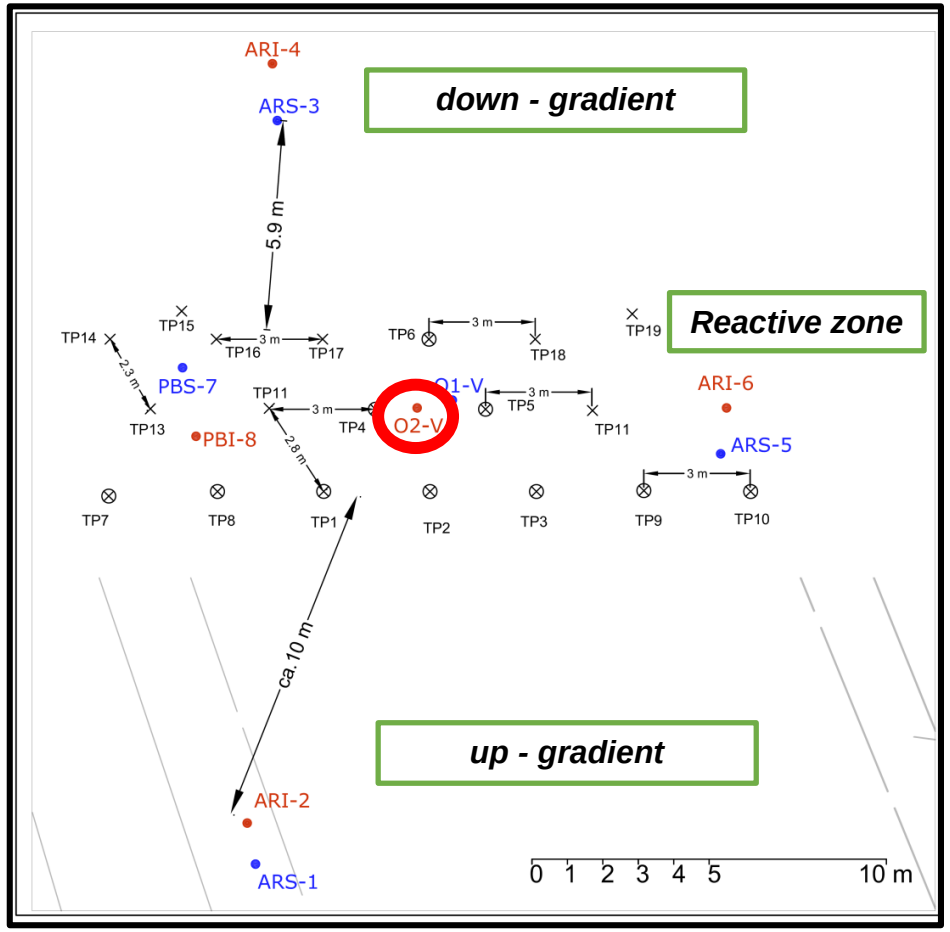

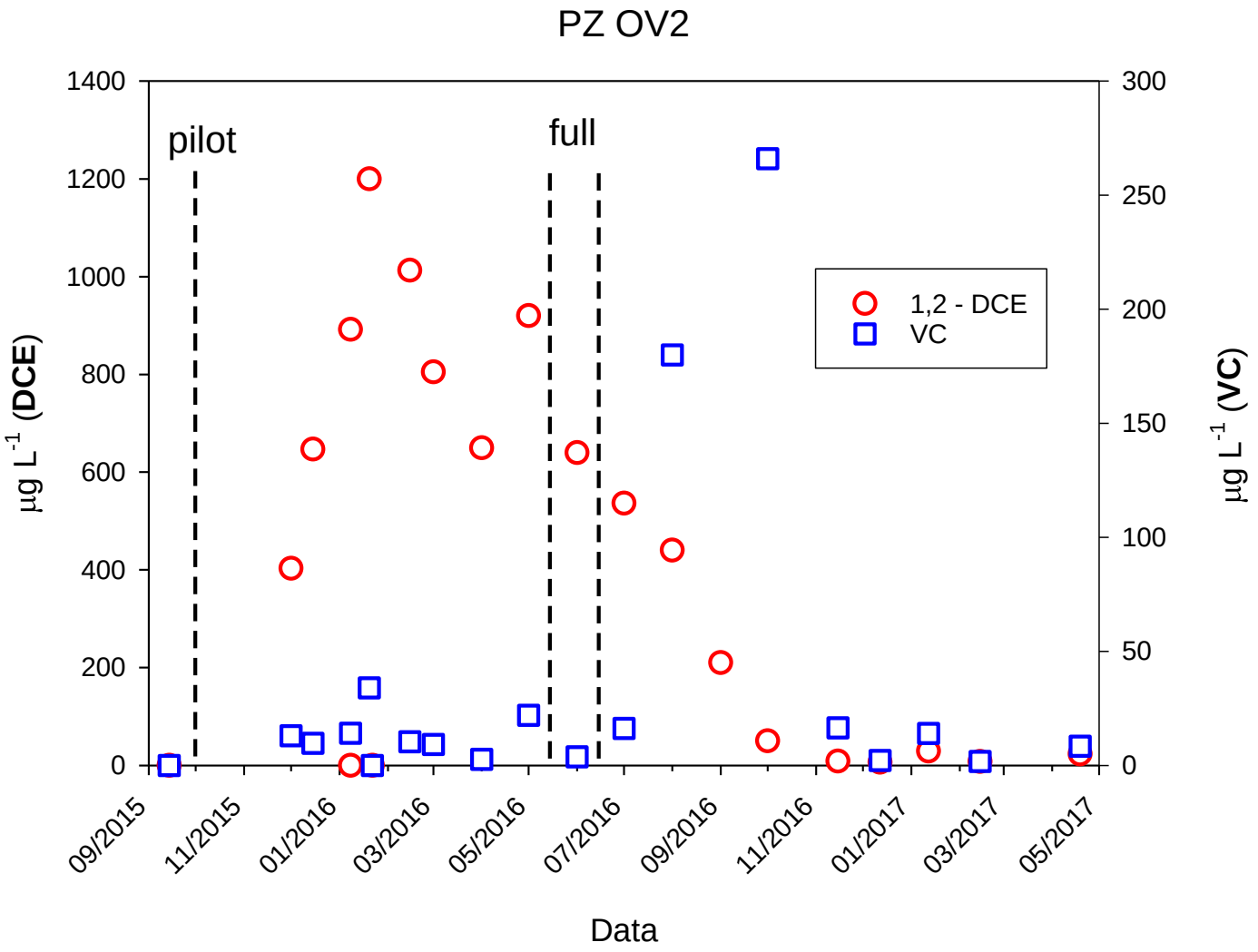

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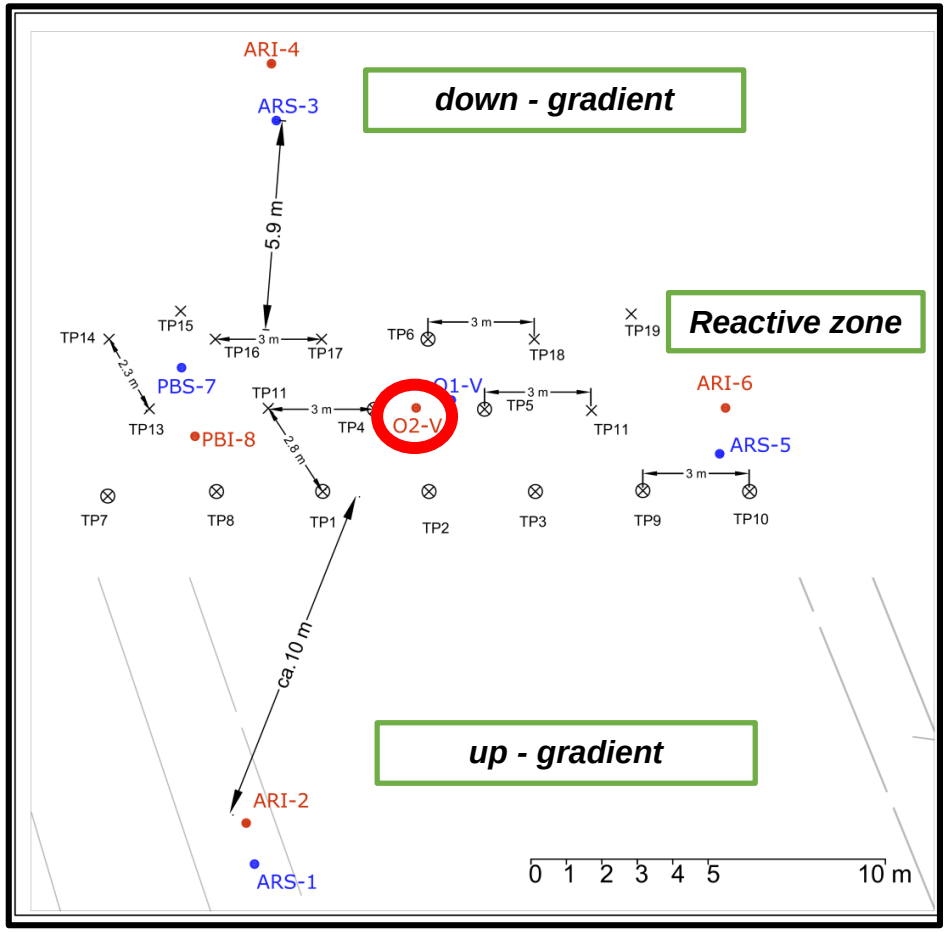

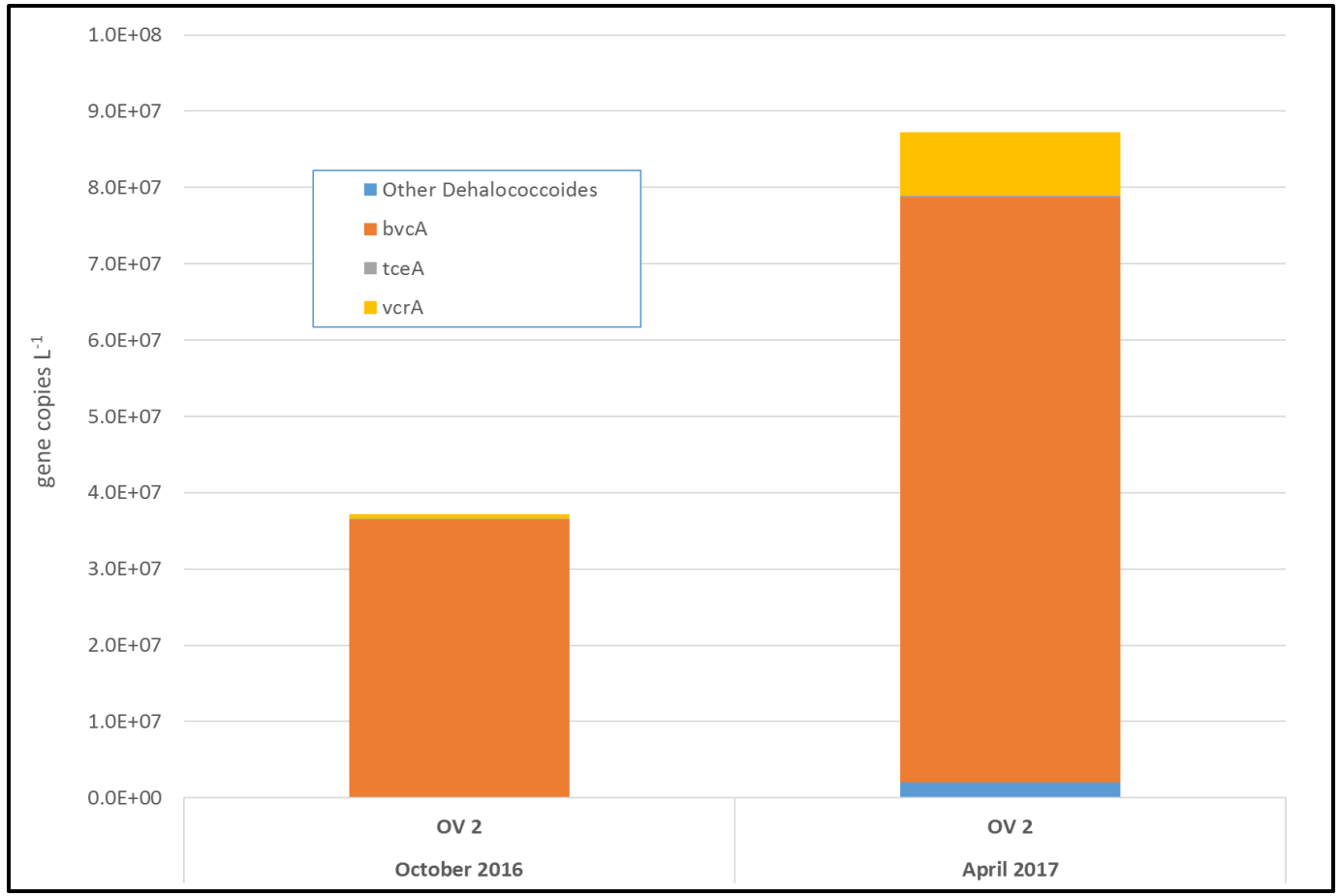

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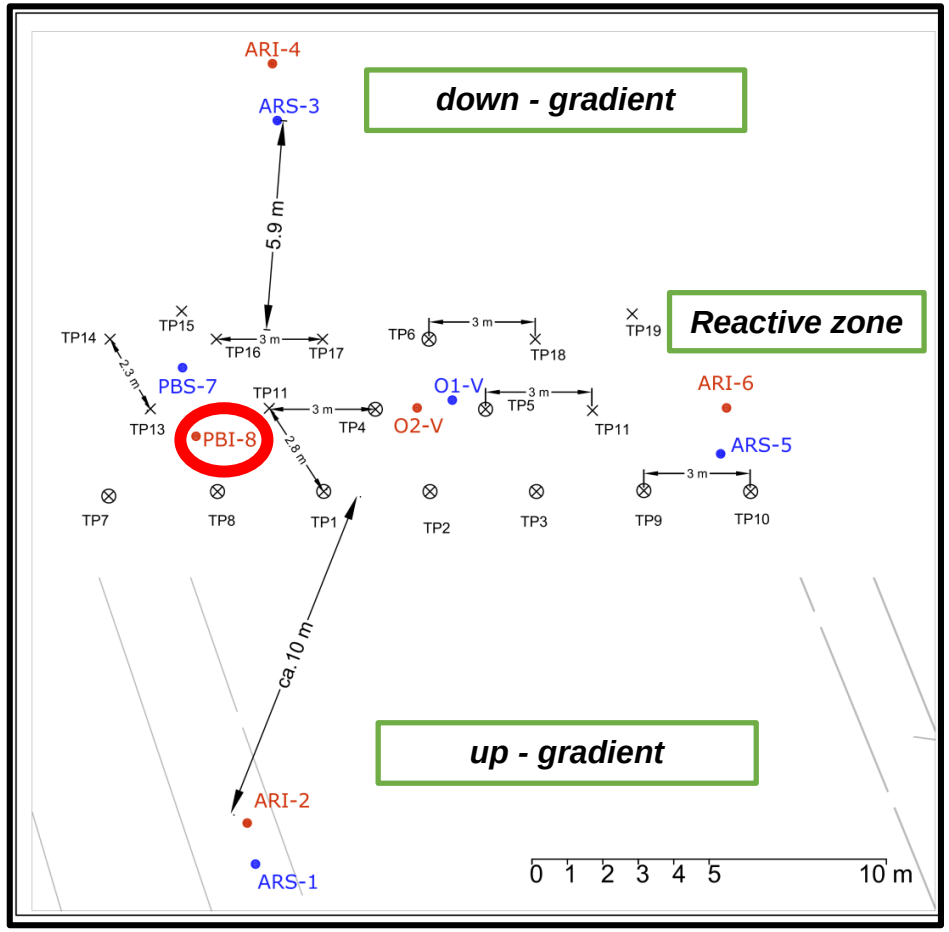

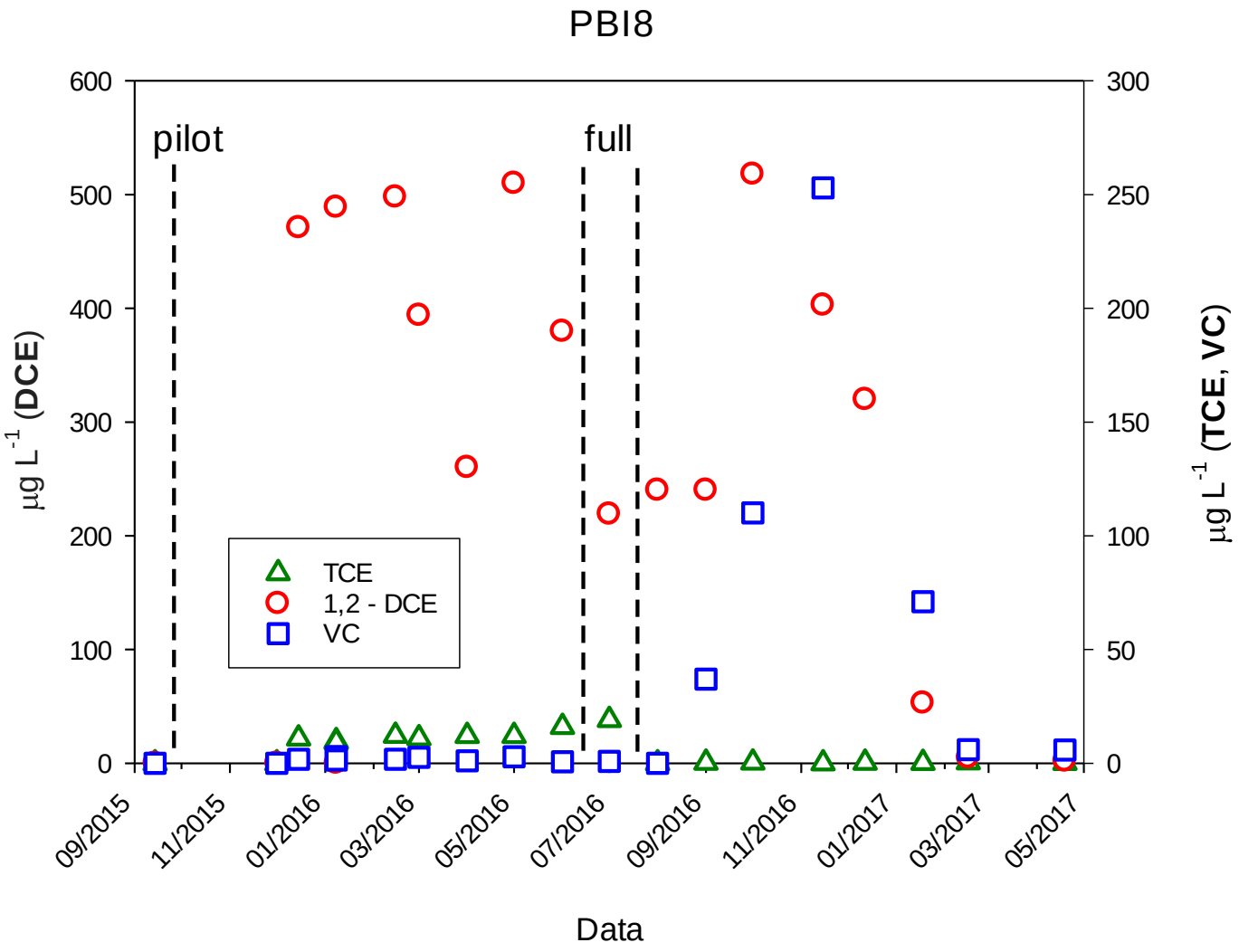

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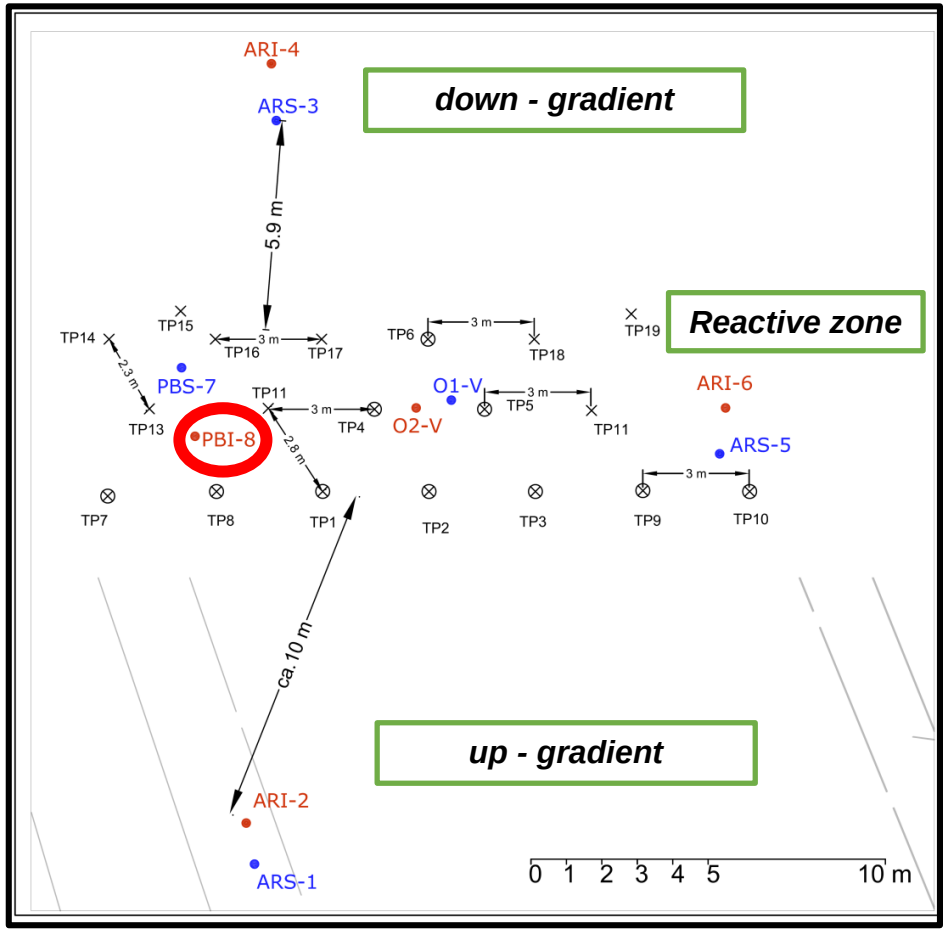

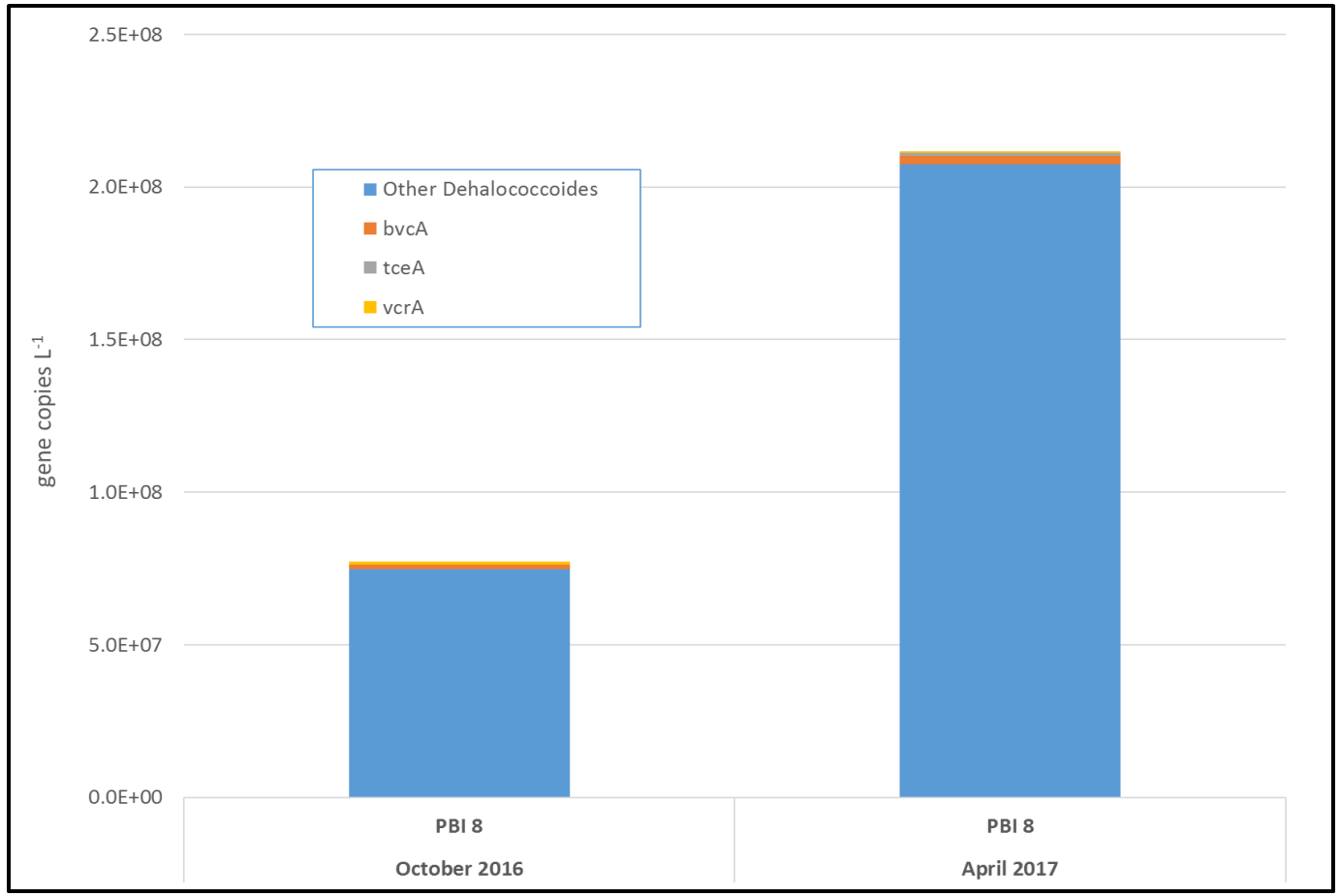

Some final remarks after 8 months of full scale application

- Fruitful **collaboration** between "**research**" (University and IRSA) and the **industrial actors** (RFI, Italfer, Regenesis and Carsico)
- Accurate characterization by **microbiological analysis** and **microcosm tests** was fundamental for the selection of the appropriate strategy
- Key aspect in the success of full scale intervention was certainly the ***in situ*** **distribution of reagents** in the aquifers
- By this regard, it was crucial to carry out a **pilot test** (as a full scale intervention module) for the process optimization
- **Combining** the **adsorption** on an injectable activated carbon matrix with the stimulation of **dechlorinating biological activity** is particularly advantageous for low CAH concentrations and low mass flows
- Positive effect resulting from the **significant rapid decrease** in observed concentrations

Thanks for your attention

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