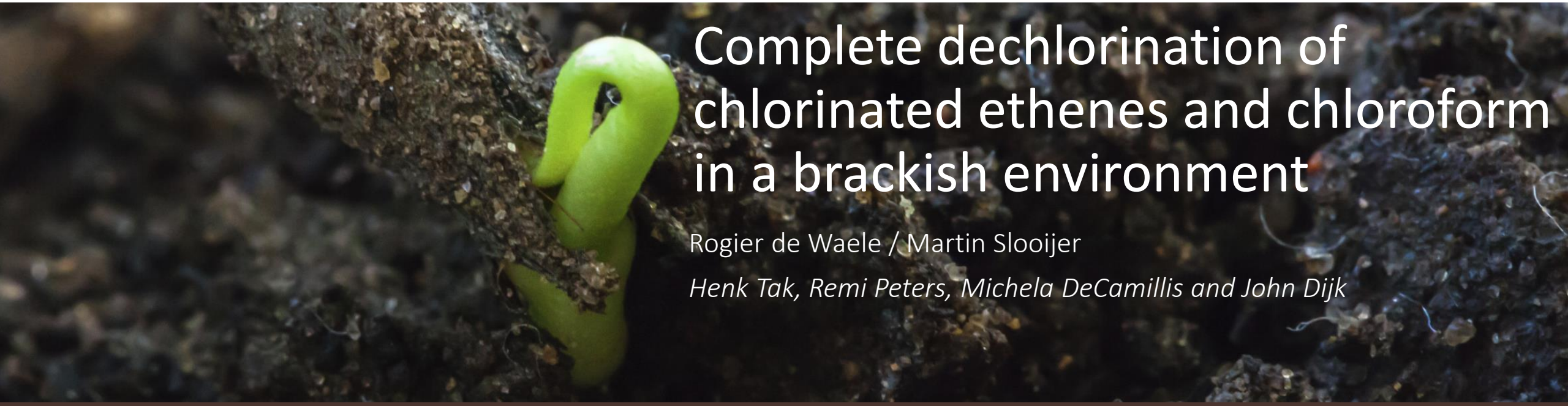

# Complete dechlorination of chlorinated ethenes and chloroform in a brackish environment

Rogier de Waele / Martin Slooijer

*Henk Tak, Remi Peters, Michela DeCamillis and John Dijk*

# GreenSoil - International

- Specialized, innovative and international general (bio)remediation contractor

**The Netherlands**
Office: Papendrecht

**Belgium**
Office: Genk / Ghent

**Brazil**
Office: Sao Paulo

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# Site background

- Industrial site in a port in Spain
- Contaminated with mainly chlorinated ethenes and chloroform
- DNAPL present
- Brackish-salt

# Site background - concentrations

| Compound | Max. concentration (µg/l) | Max. concentration (mg/kg) |
|---|---|---|
| PCE | 100,000 | 570 |
| VC | 41,000 | |
| Chloroform | 340,000 | |

- $SO_4^{2-}$ up to 1,500 mg/l, EC up to 25,000 µS/cm

Chloroform > 5,000 µg/l ->
inhibit growth of *Dehalococcoides*[1]

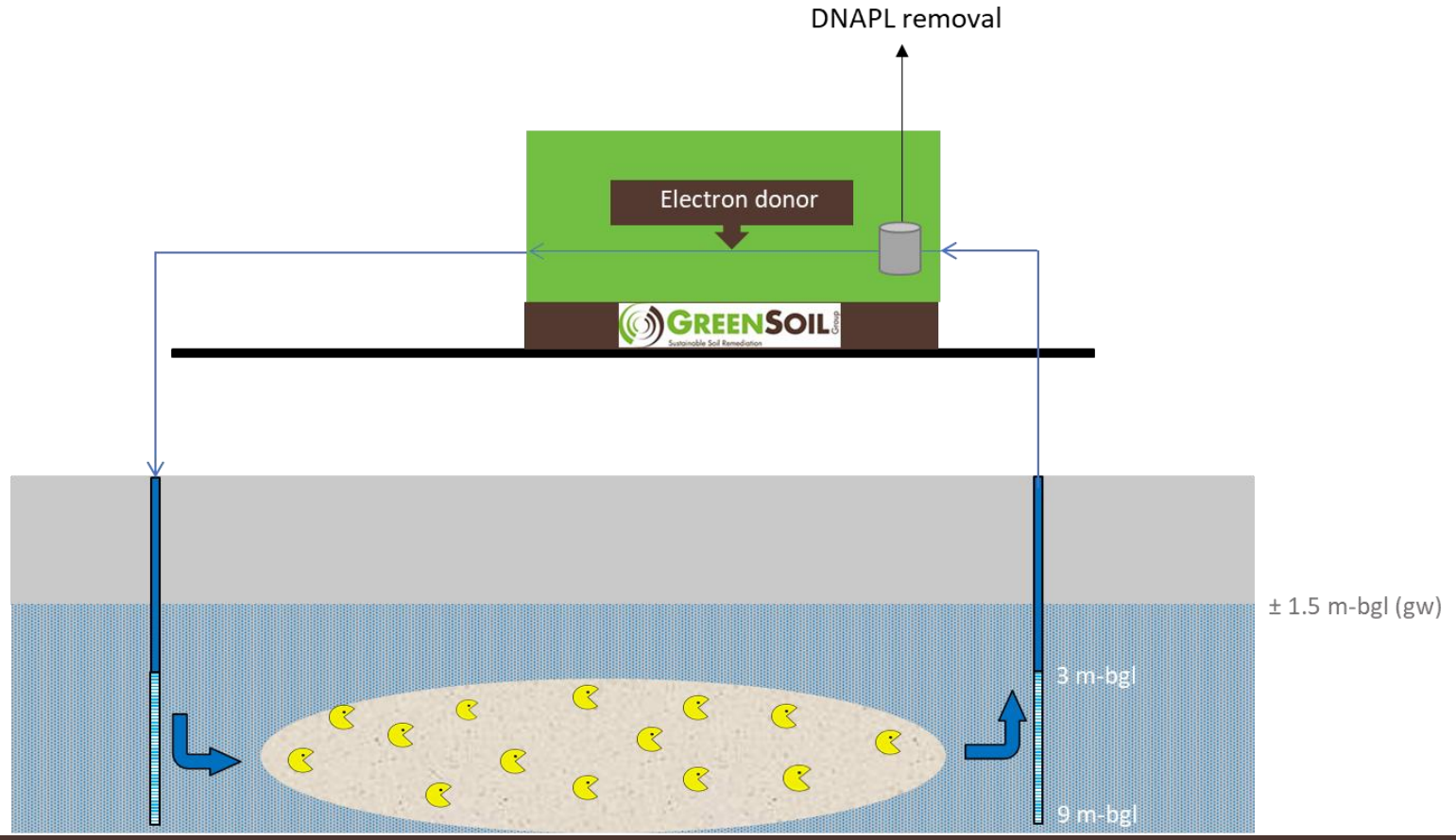
[1]*Baldwin, B.R. et al (2017) Bioremediation Management Reduces Mass Discharge at a Chlorinated DNAPL site. Groundwater Monitoring&Remediation*

# Enhanced reductive dechlorination (ERD)

- Laboratory and pilot tests conducted in the past
- Continuous circulation of groundwater
- Semi-continuous dosage of electron donor
- In-situ bioreactor
- DNAPL extraction/removal

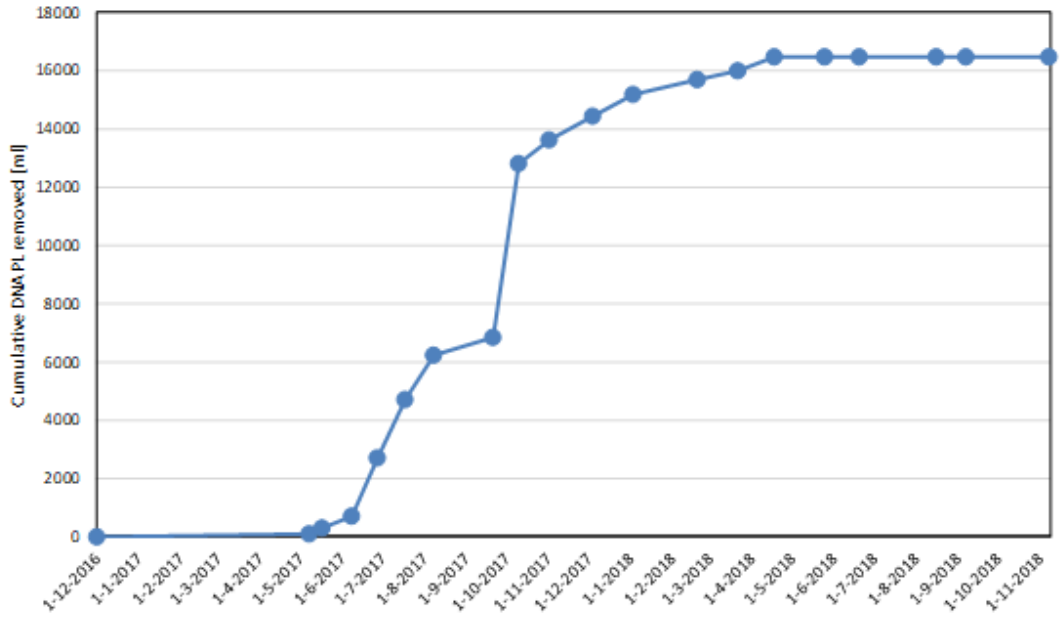
# Enhanced reductive dechlorination (ERD)

**In-situ bioreactor**



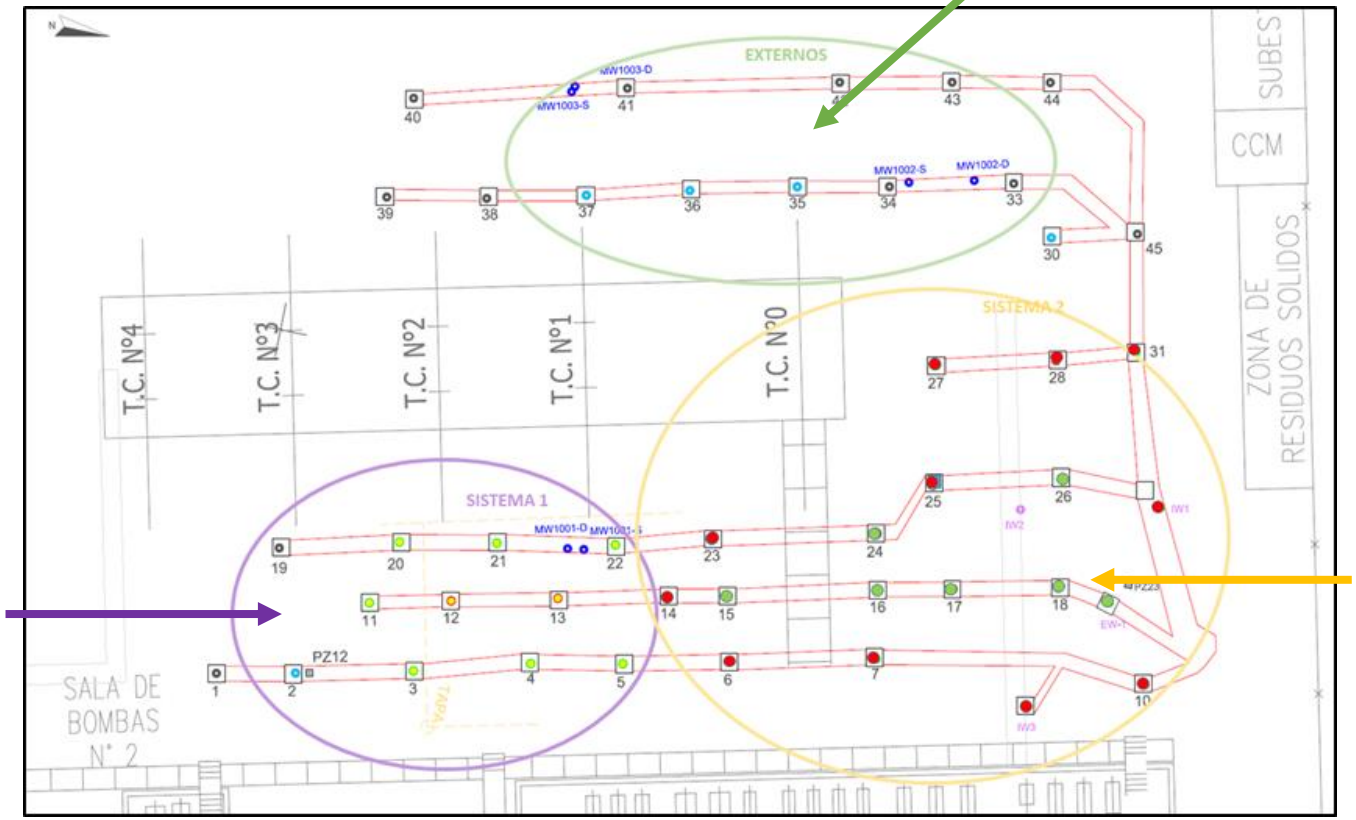
# DNAPL removal

- 16,5 l DNAPL extracted in 1 year



# Bioremediation

Outer area




Outside source area

Source area



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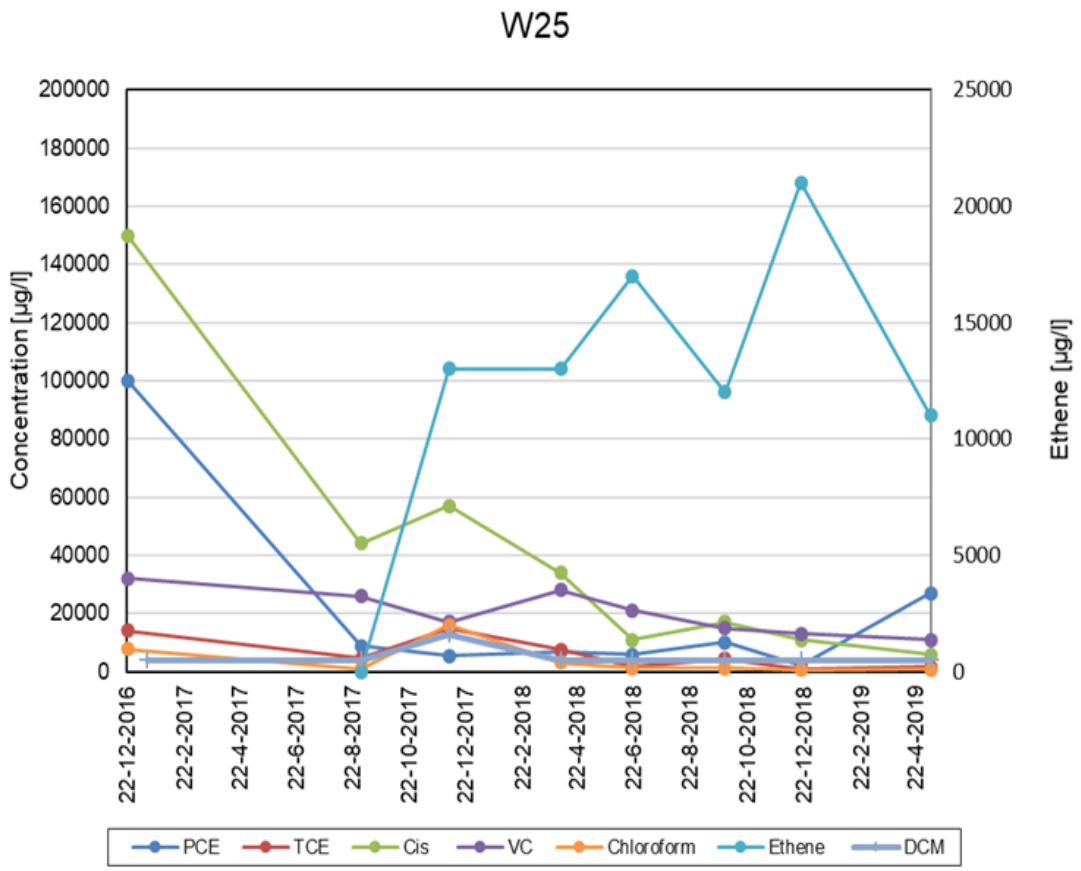
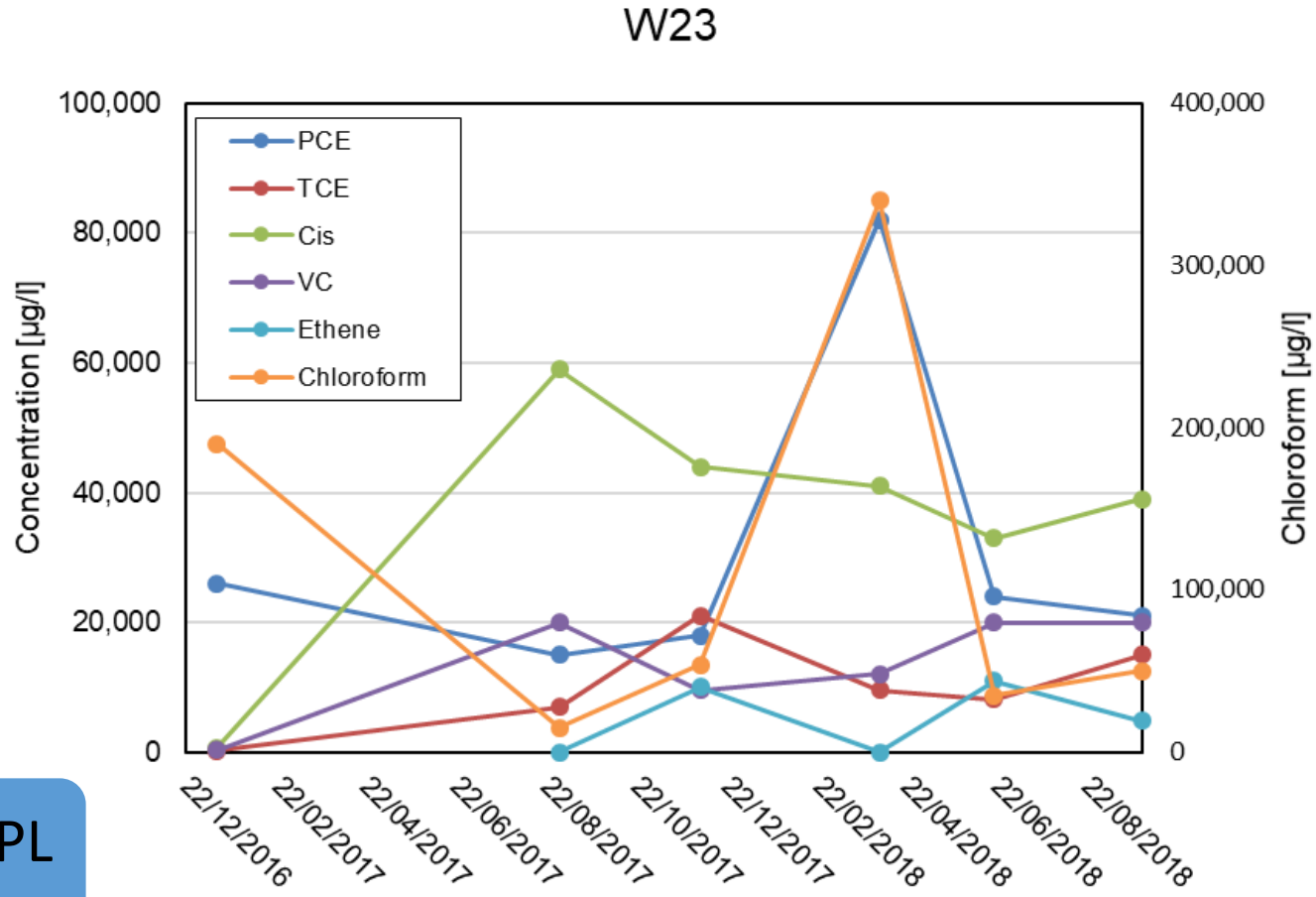
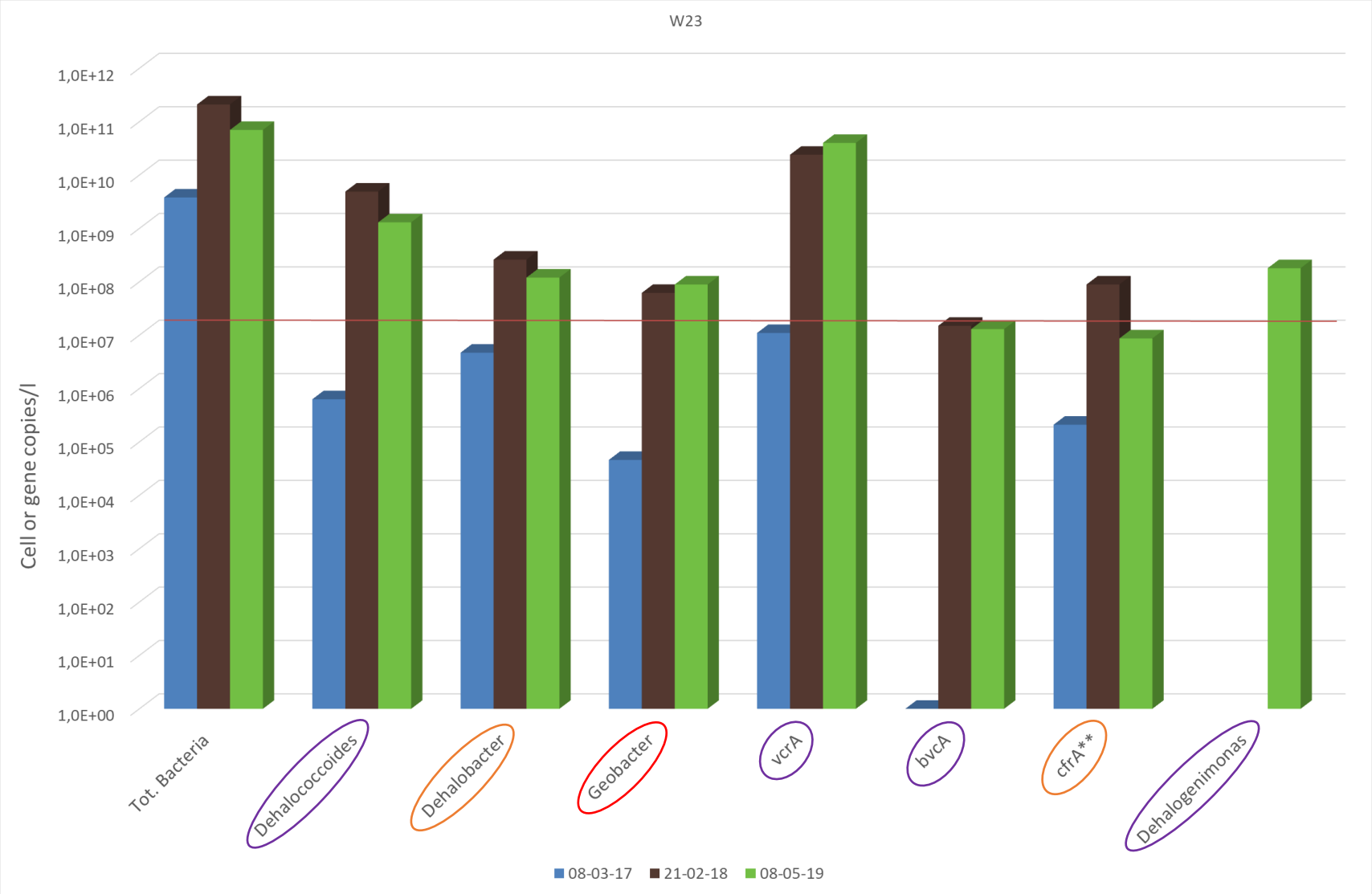
# Bioremediation – source zone




Residual DNAPL

# Bioremediation – source zone




PCE -> cDCE

cDCE/VC ->

Chloroform -> DCM
( -> acetate)



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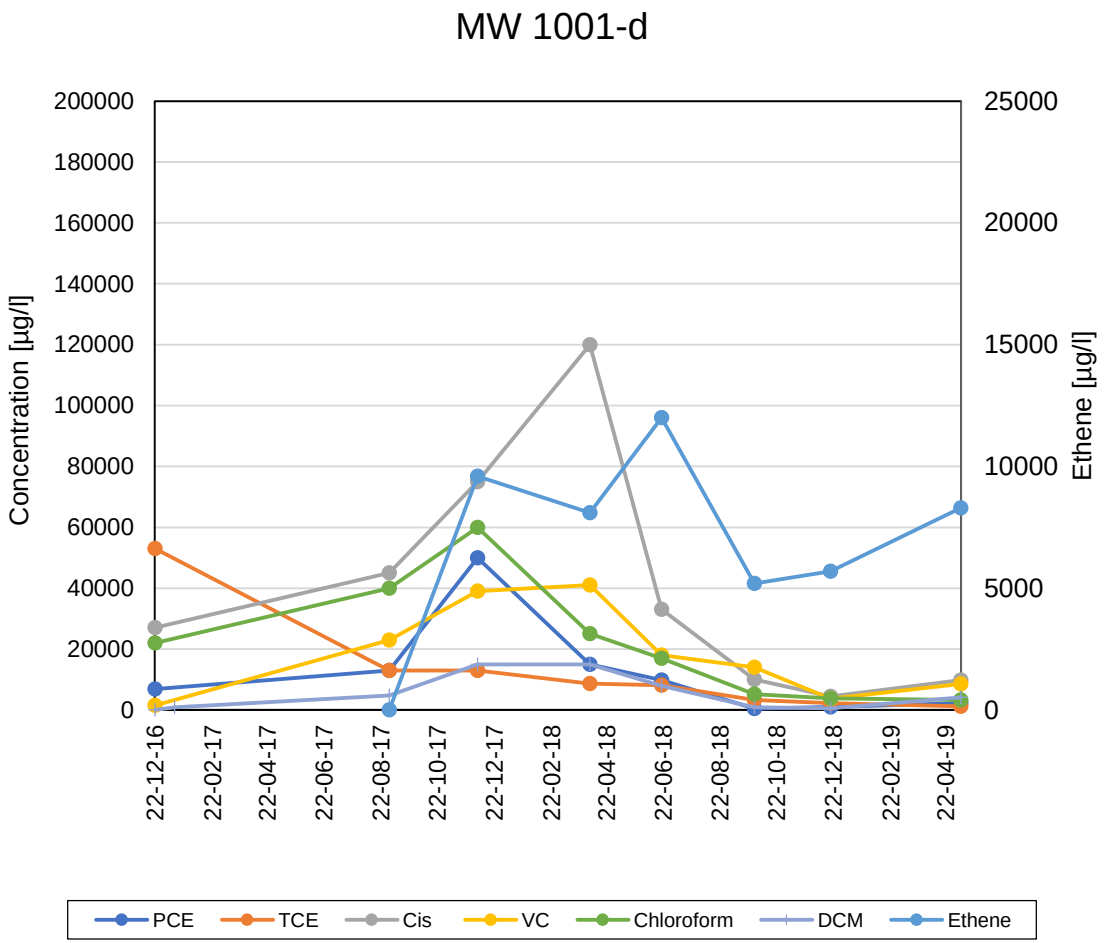
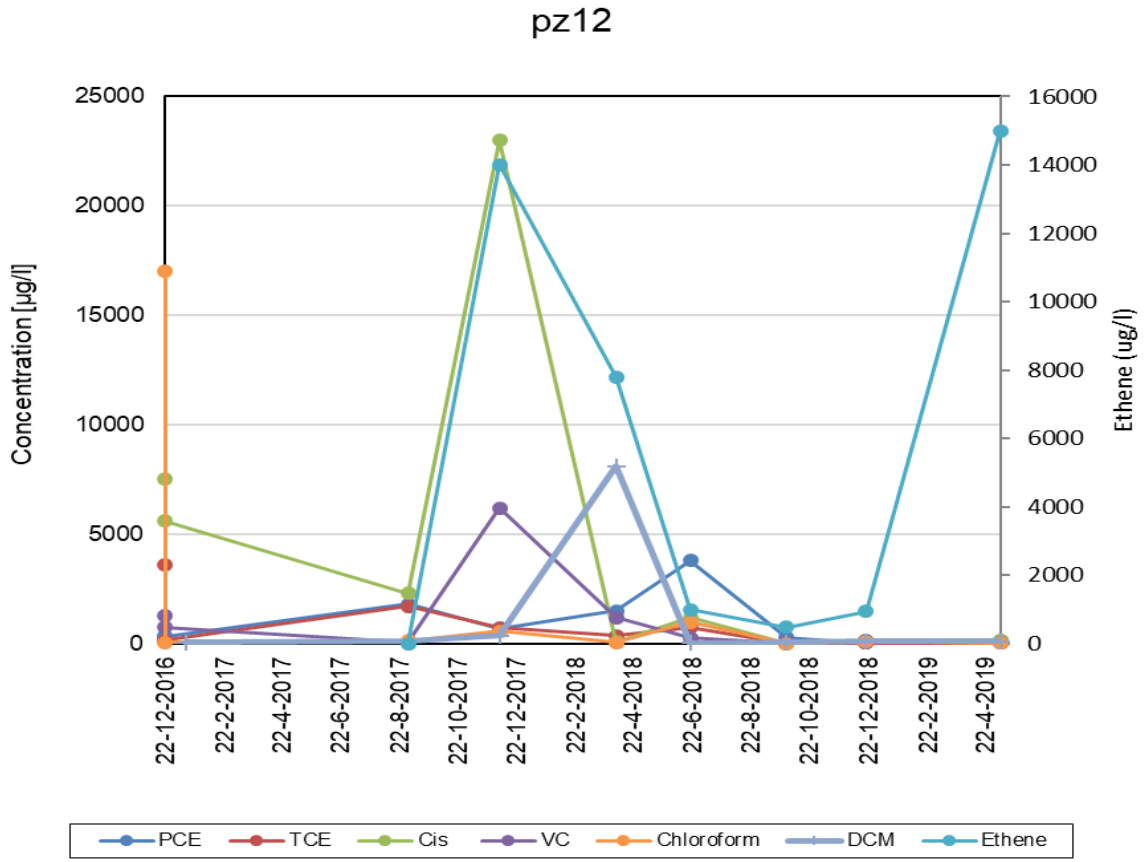
# Bioremediation – outside source

From active to passive



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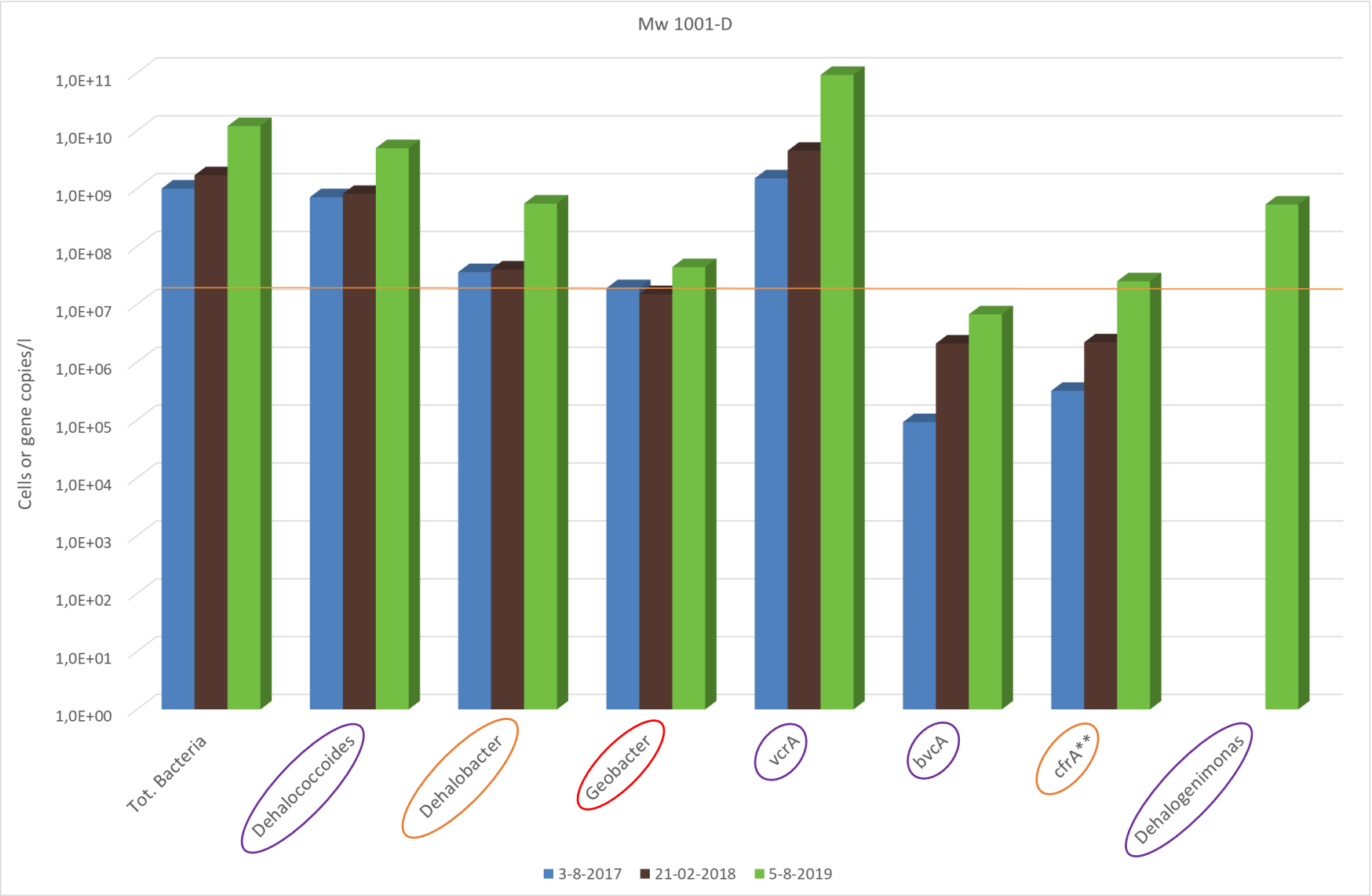
# Bioremediation – outside source




PCE -> cDCE (DNAPL)

cDCE/VC -> ethene

Chloroform -> DCM ( -> acetate)



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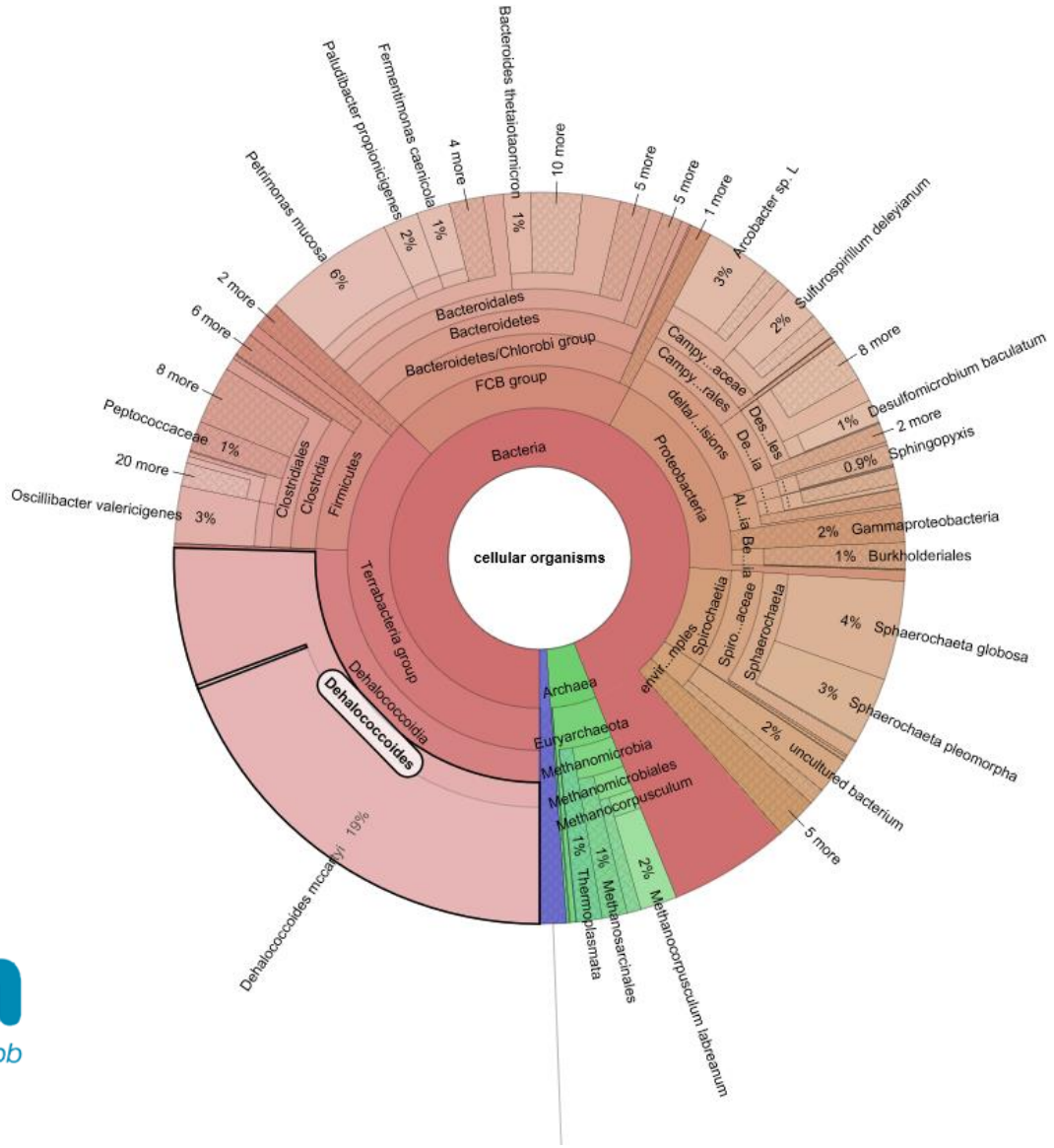
# Bioremediation-NGS

- *Dehalococcoides* dominance
  - *Dehalococcoides*: 27% of all bacteria
  - *Dehalococcoides mccartyi*: 19%



# Biological degradation rates

Biological degradation rates (PCE) were estimated based upon:

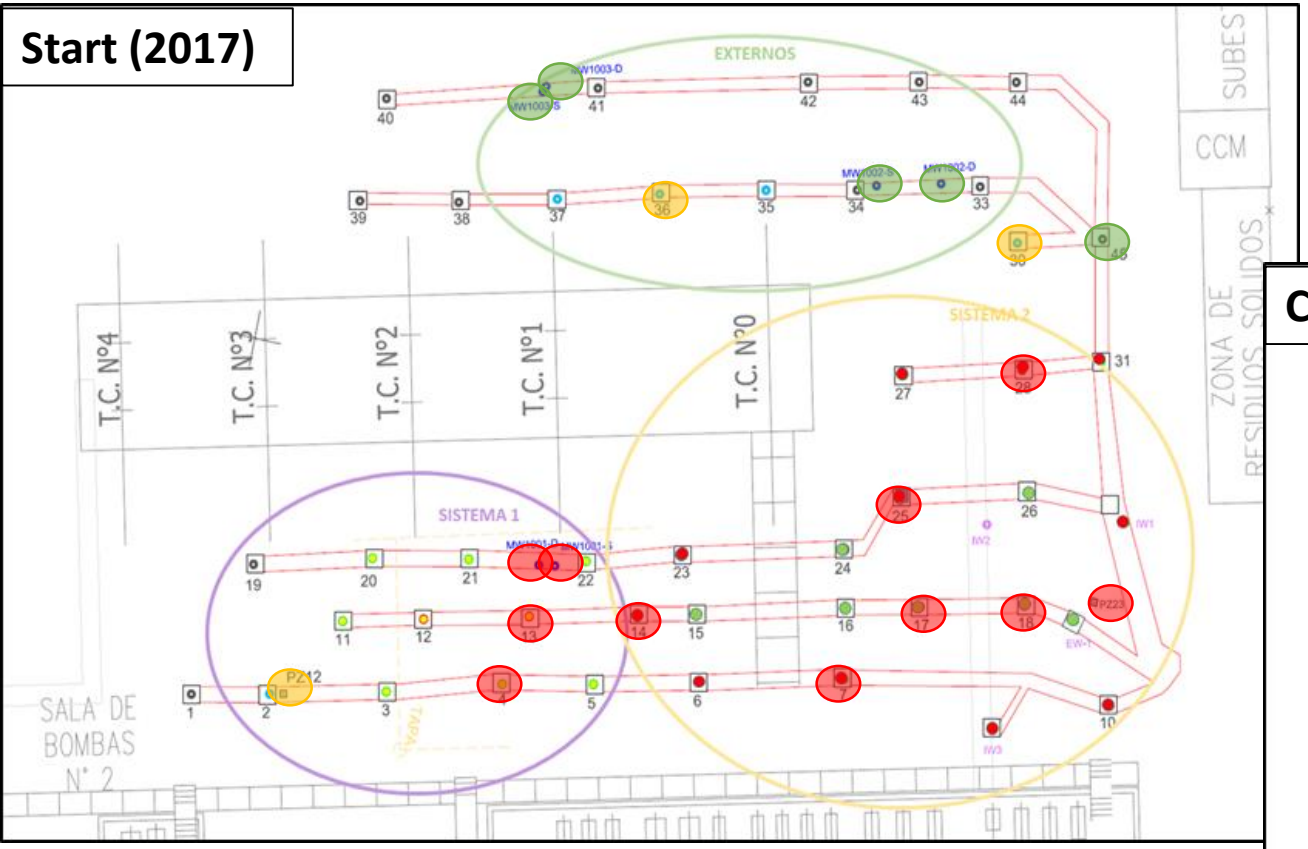
- Literature and bacteria numbers
- Degradation (site/lab) test with groundwater from different wells

**Results PCE removal:**

| | | | |
|---|---|---|---|
| Minimal: | 1,50 g/m$^3$.day | => since start: | 2,000 kg |
| Maximal: | 1,97 g/m$^3$.day | => since start: | 3,580 kg |
| | | | (640 days) |

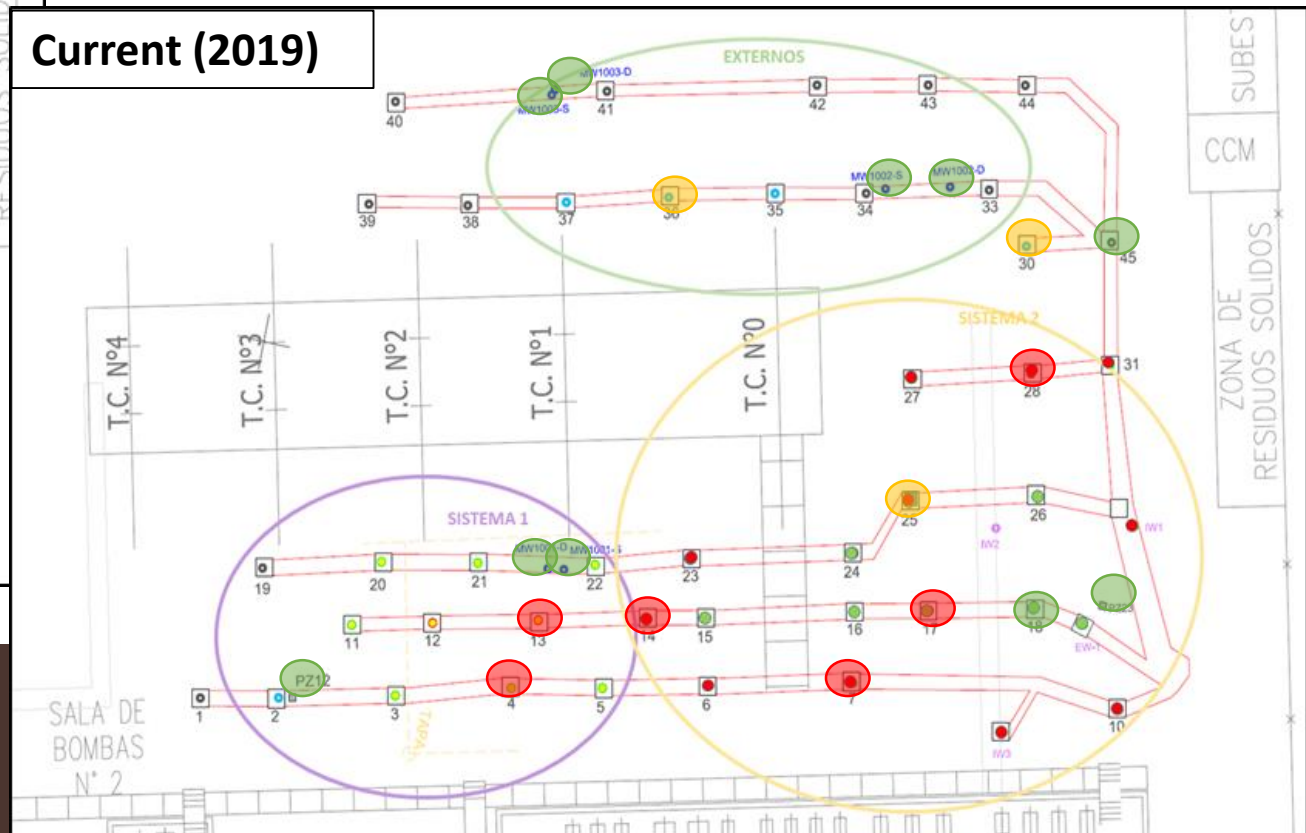
# Progress

**Start (2017)**




- < 1% solubility PCE
- < 10% solubility PCE
- > 10% solubility PCE

**Current (2019)**



# Conclusions

- Complete dechlorination in brackish environment ($SO_4$ presence)
- Complete dechlorination despite high chloroform concentrations
- *Dehalococcoides* dominance
- Outside source area: active -> passive
- Source area: is shrinking but still residual DNAPL present
- Combination of different monitoring techniques helps explain degradation processes

# Contact and Questions

For soil related questions, Greensoil can always be contacted