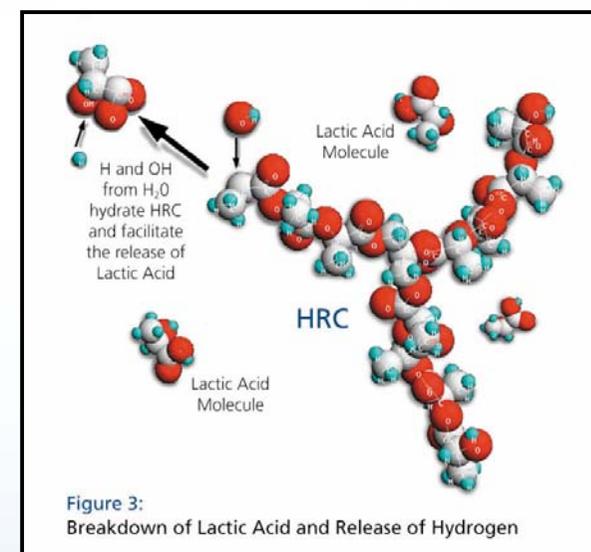


A decade of large-scale enhanced reductive dechlorination;
the evolution in the usage of a high-volume controlled-
release electron donor substrate

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Managing Director
REGENESIS

Introduction

- Enhanced Reductive Dechlorination used for remediation of CHC's for over 2 decades
- Started with the use of soluble substrates
- Late 1990's controlled/slow release substrates came on the market
 - Overcome vinyl chloride stall
 - Avoid multiple applications
 - Low volume
 - = good for low permeability
- But chlorinated solvent plumes can be BIG!
- Wanted to create a version for large plumes



Large Scale Enhanced Reductive Dechlorination

FIGURE 1:
THE HRC ADVANCED™ MOLECULAR STRUCTURE

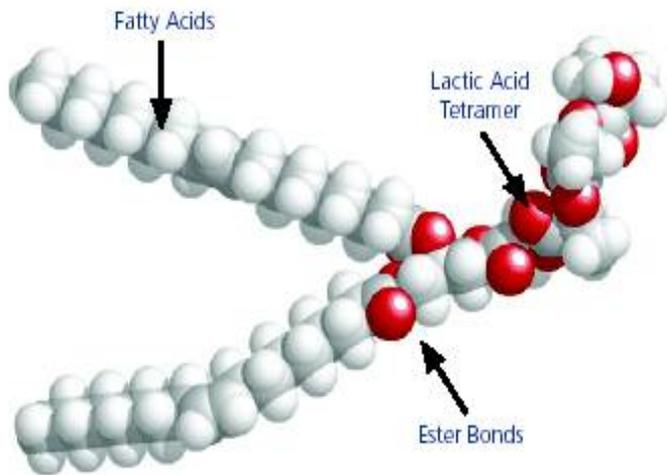
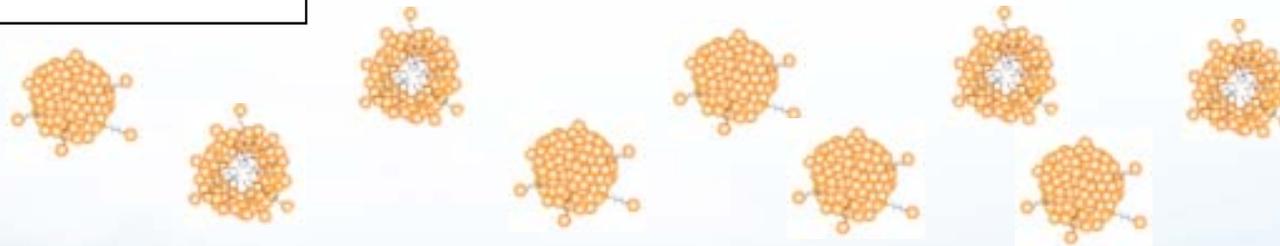
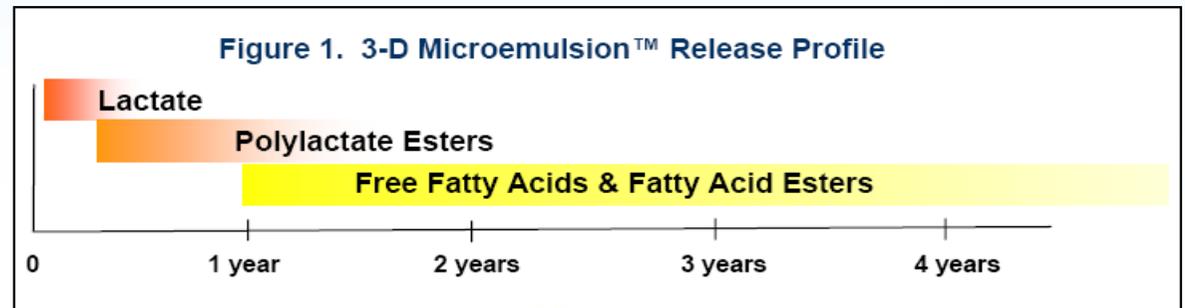
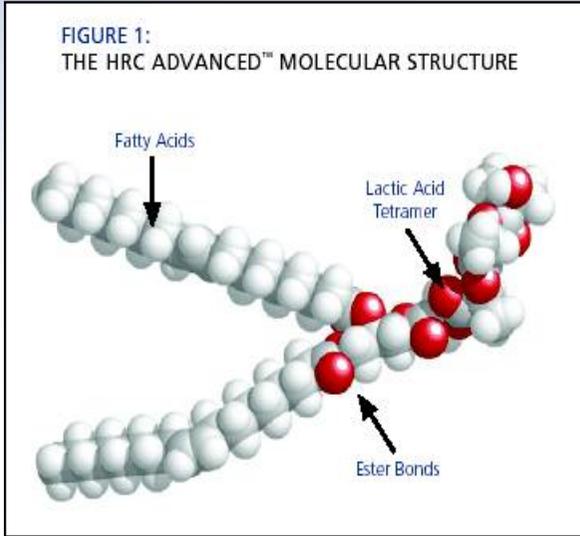


Figure 1. 3-D Microemulsion™ Release Profile

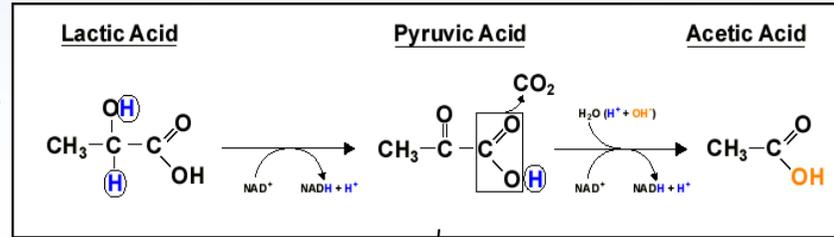


Enhanced Reductive Dechlorination

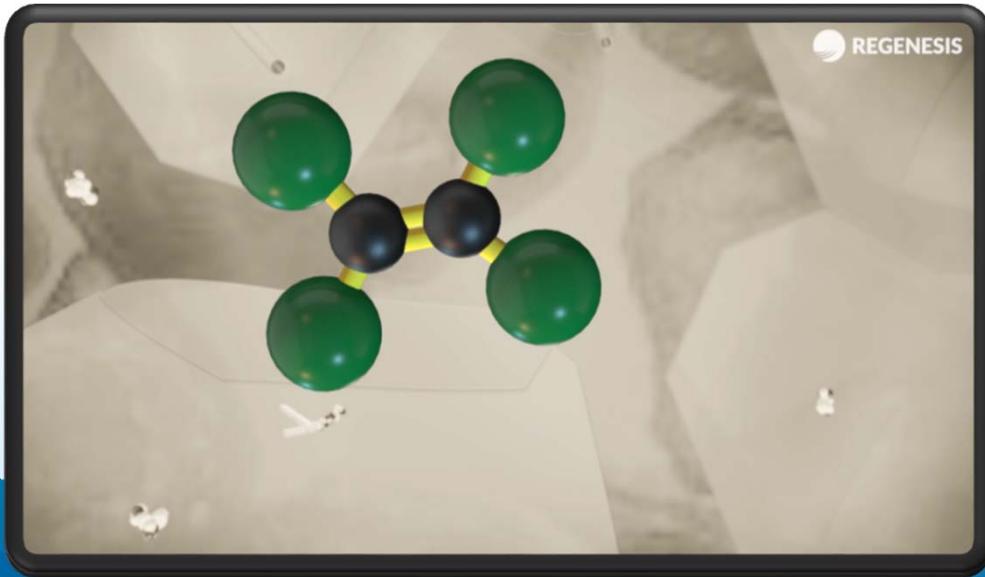
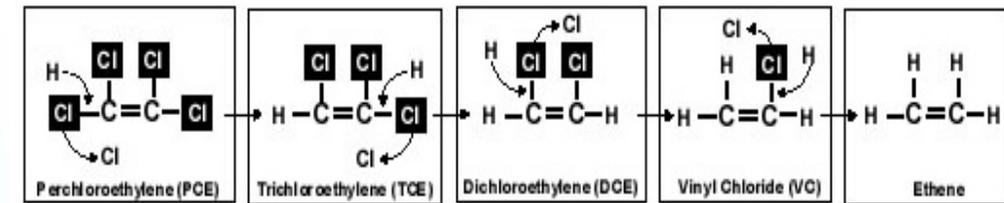


Dissolution

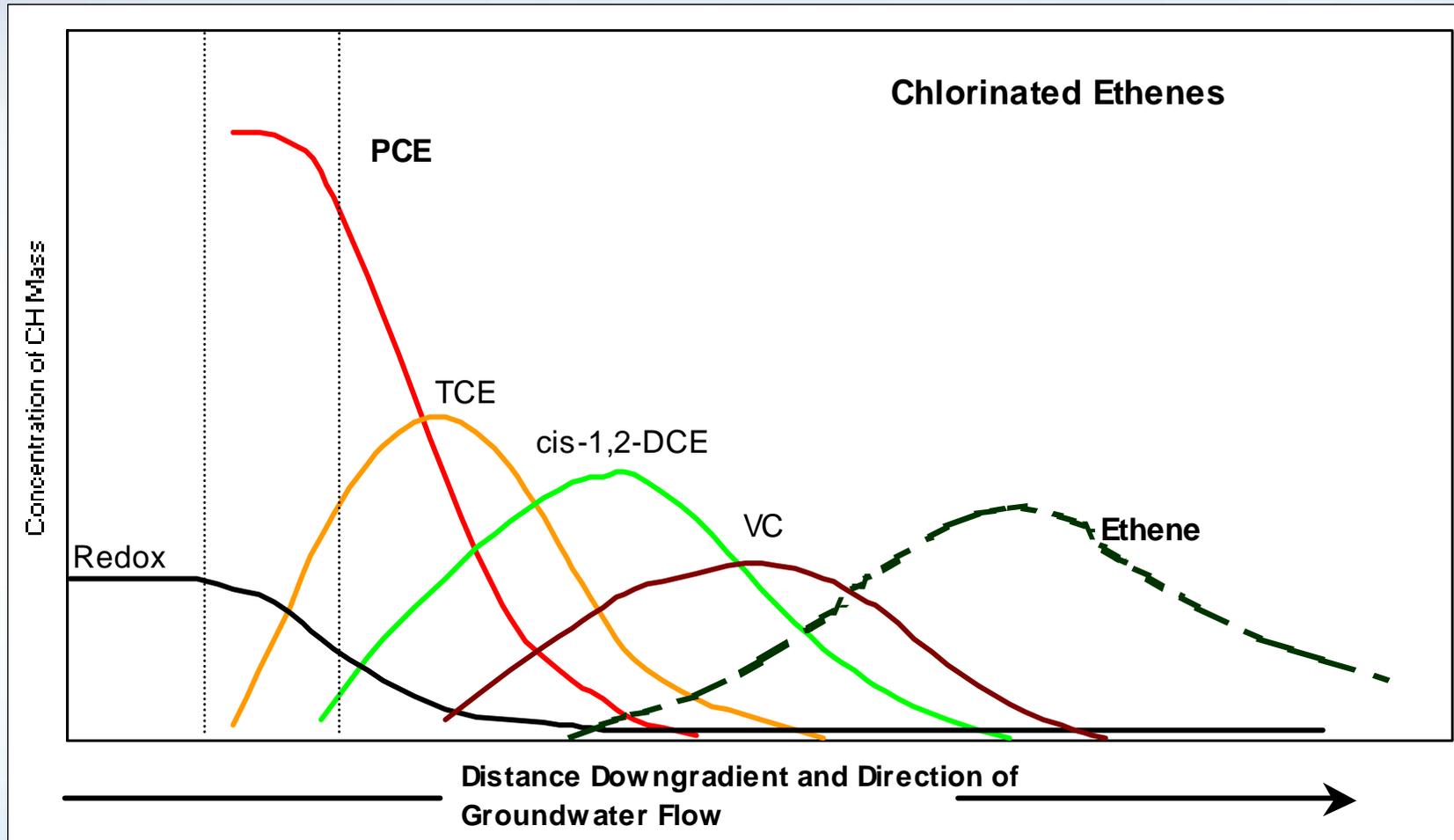
Fermentation



Enhanced Reductive Dechlorination

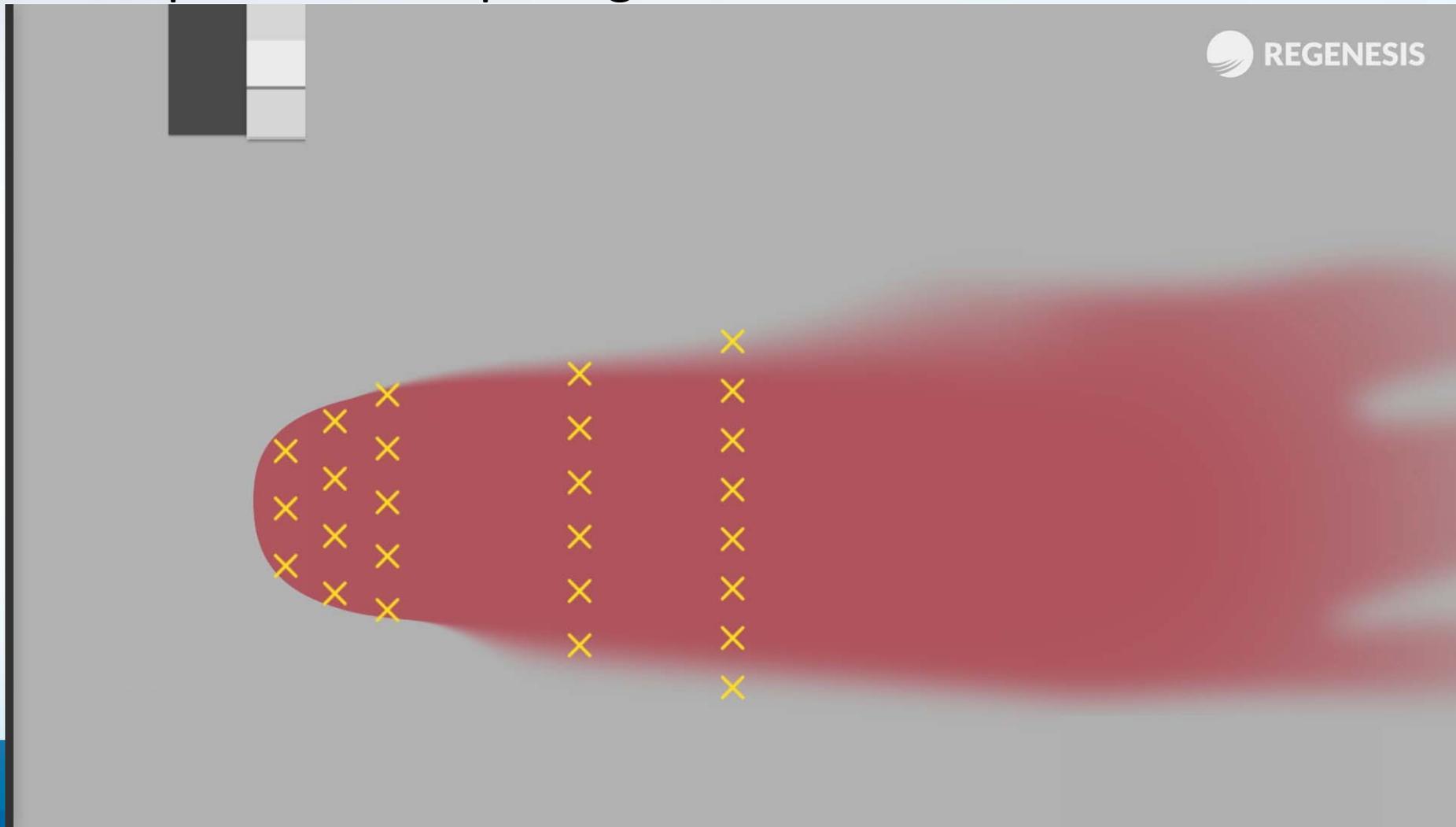


Expected Results



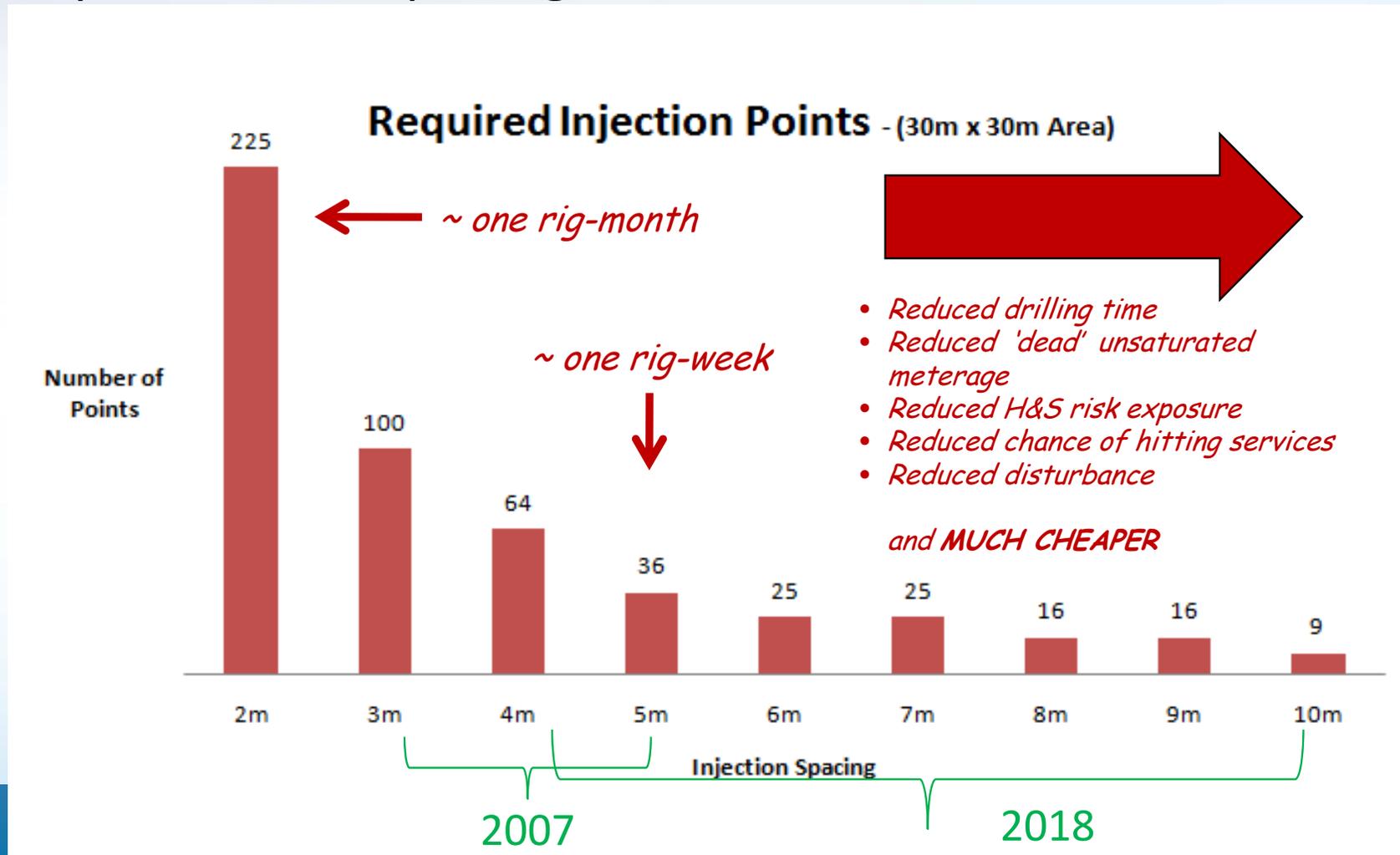
Lessons Learned: Application Development

- The importance of spacing

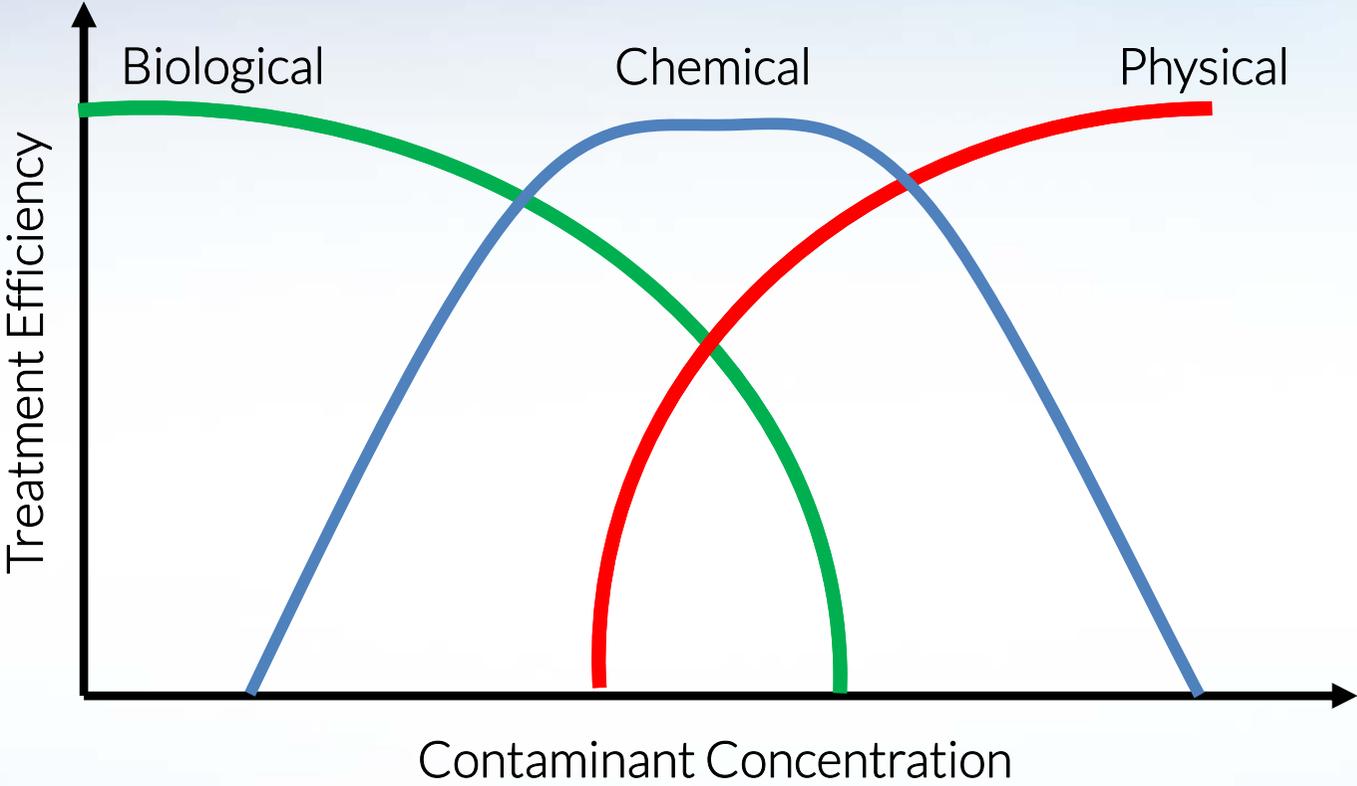


Lessons Learned: Application Development

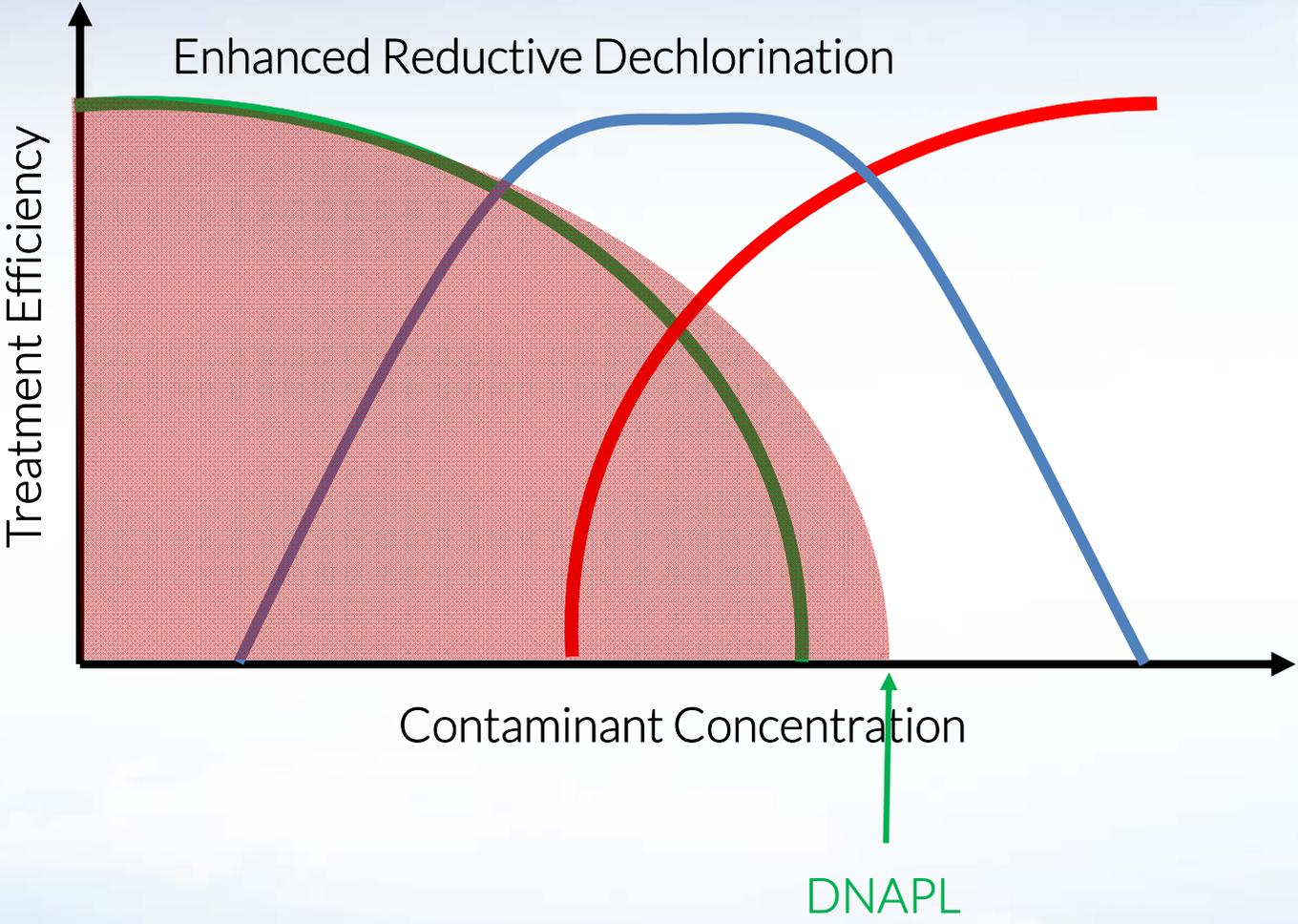
- The importance of spacing



Lessons Learned: Treatment Envelope

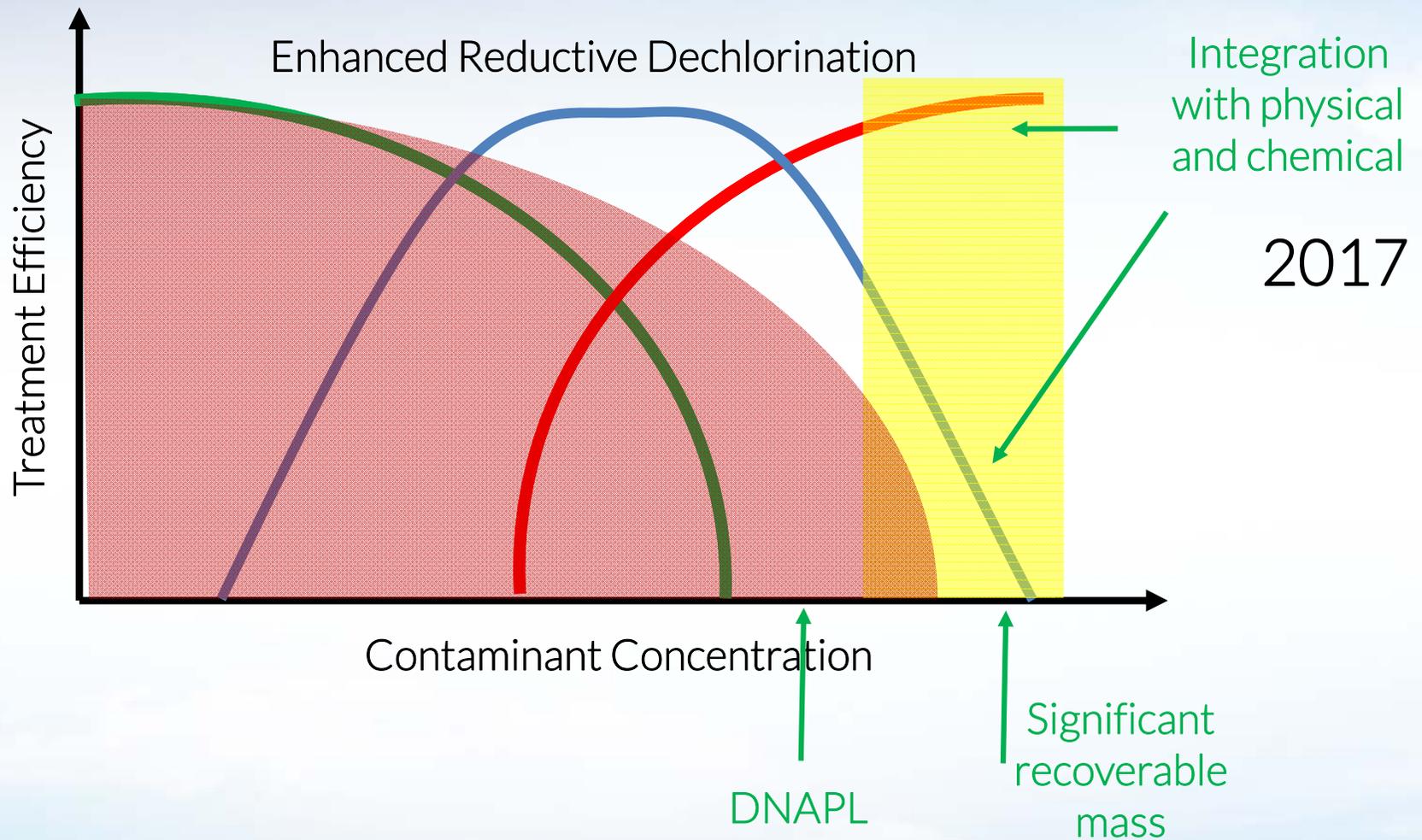


Lessons Learned: Treatment Envelope



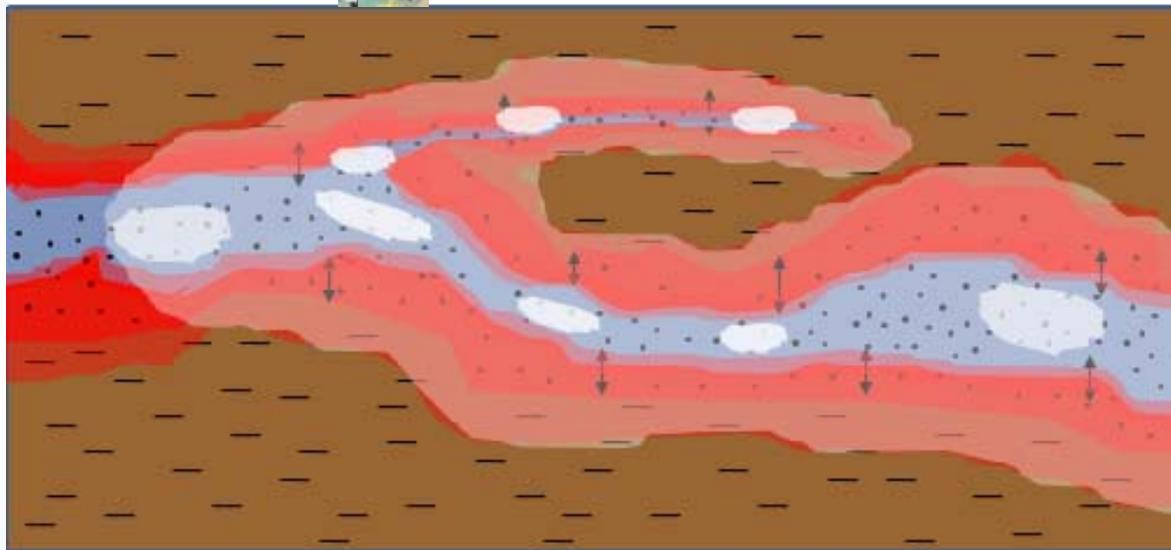
2007

Lessons Learned: Integration Envelope



Lessons Learned: Heterogeneous Formations

- High volume product designed to target permeable formations
- ...and that's what we use it for
- ...also able to address mass in immobile porosity
 - Crucial to avoid rebound from back diffusion



Lessons Learned: Bedrock Treatment



Lessons Learned: Performance

- 2017: Review of data completed on 24 sites (100 wells) in US
- Intention was to create a simple benchmark for projects
- Work in progress
 - Presently adding European data to this (6 sites, 19 wells)
 - Some sites used are still live
- Useful information emerging



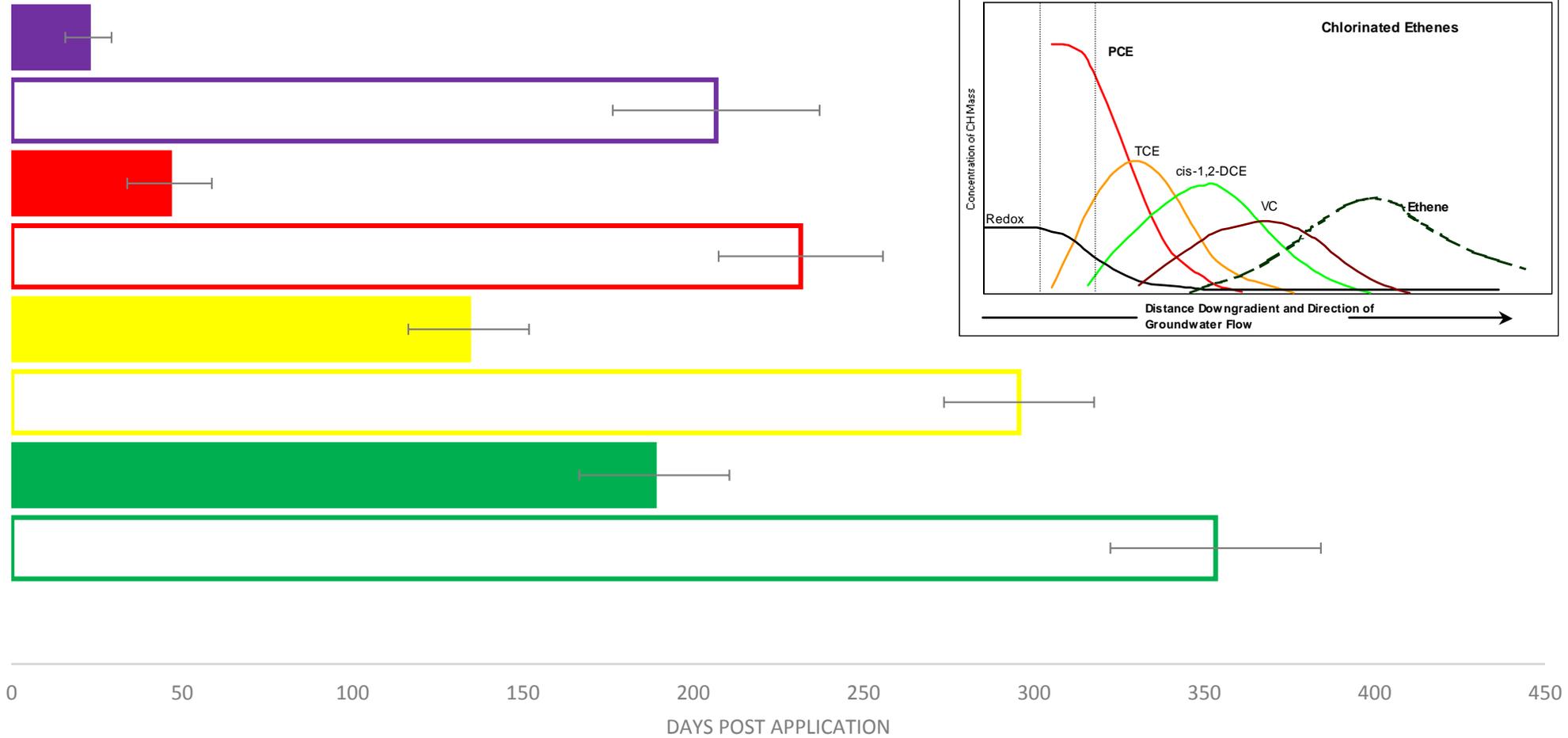
ERD Event Analysis - Chlorinated VOCs

Average Days to Reach Peak Concentration and 90% Reduction

■ Max PCE Reached □ PCE - 90% reduced ■ Max TCE Reached □ TCE - 90% reduced ■ Max cisDCE Reached □ cisDCE - 90% reduced ■ Max VC reached □ VC - 90% reduced

100 Wells

MW Averages



Lessons Learned

- Dechlorination Rates

Event	PCE	TCE	cis-DCE	VC
Days to reach max. conc.	22	46	134	189
Days to reach 90% reduction	207	232	296	353
Days between events	184	185	162	165

- Similar for each constituent
- Slight faster for daughter CVOC's
- Daughter products do not build excessively
- DNAPL slows reductions
- ..but high starting concentrations may assist reaching low targets
- Geology appears to be no barrier to performance

...and so to the Present Day

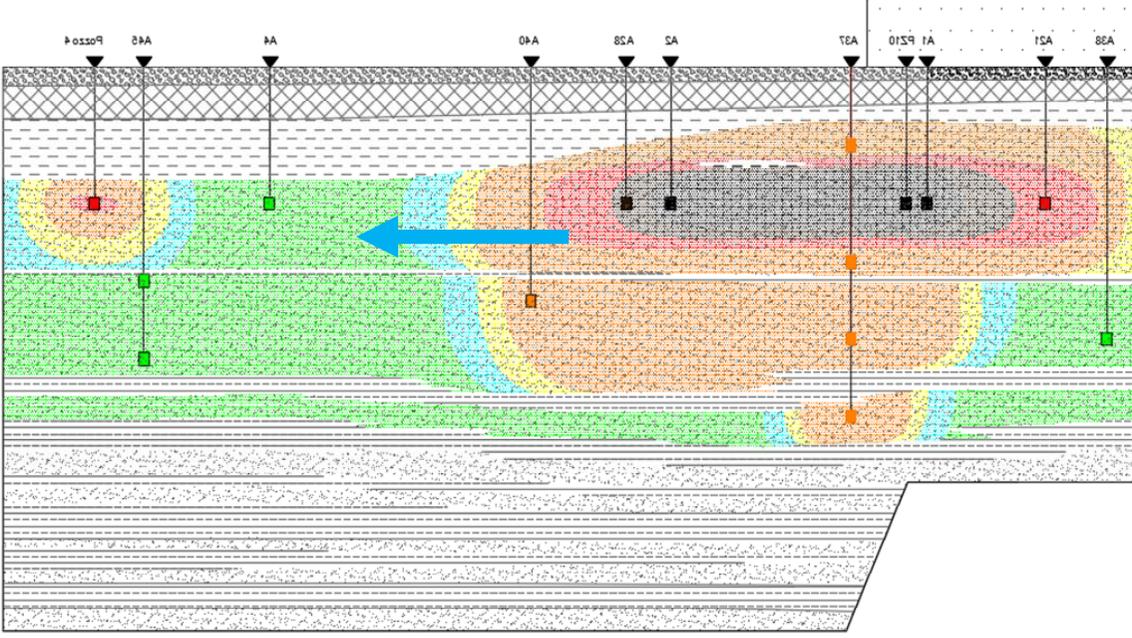


TRICLOROETILENE

Concentrazione ($\mu\text{g/l}$)

- da 0 a 1,5
- da 1,5 a 7,5
- da 7,5 a 15
- da 15 a 150
- da 150 a 1500
- da 1500 a 15000
- da 15000 a 150000

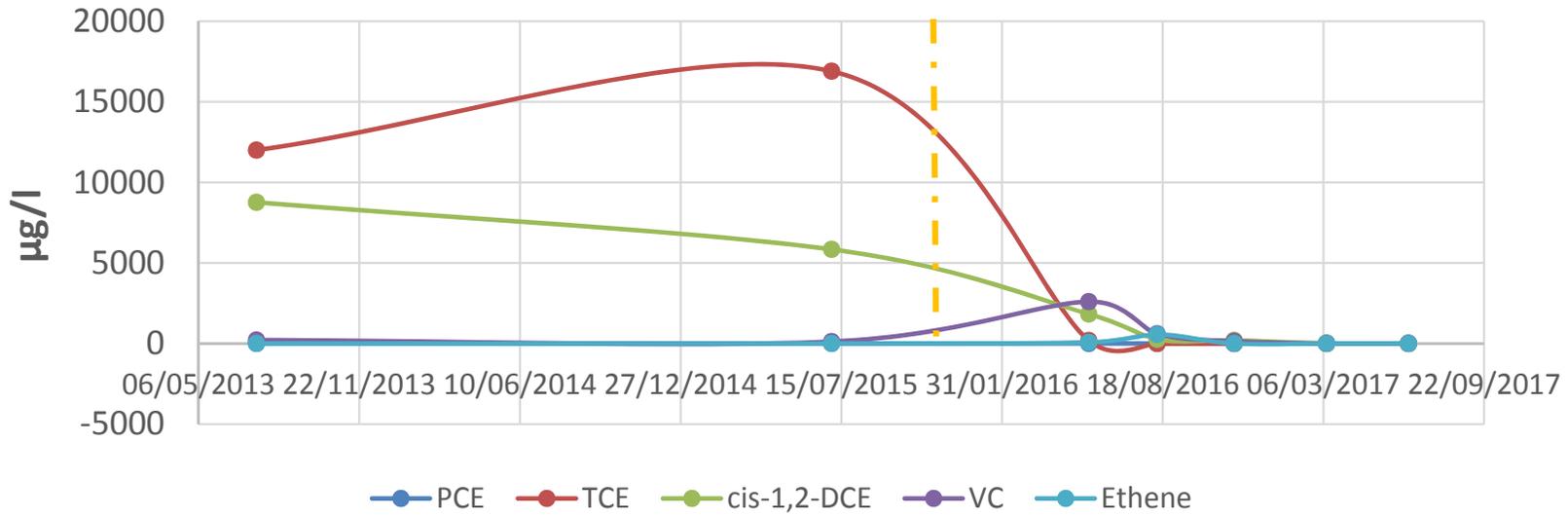
Concentrazione limite D.Lgs. 152/06 pari a 1,5 $\mu\text{g/l}$



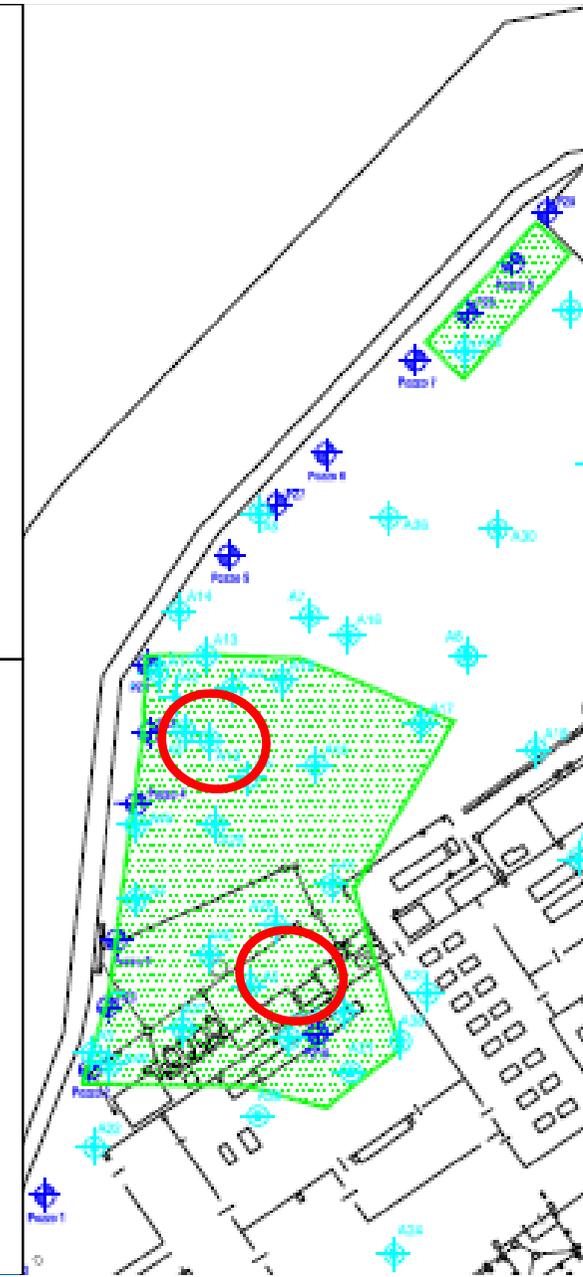
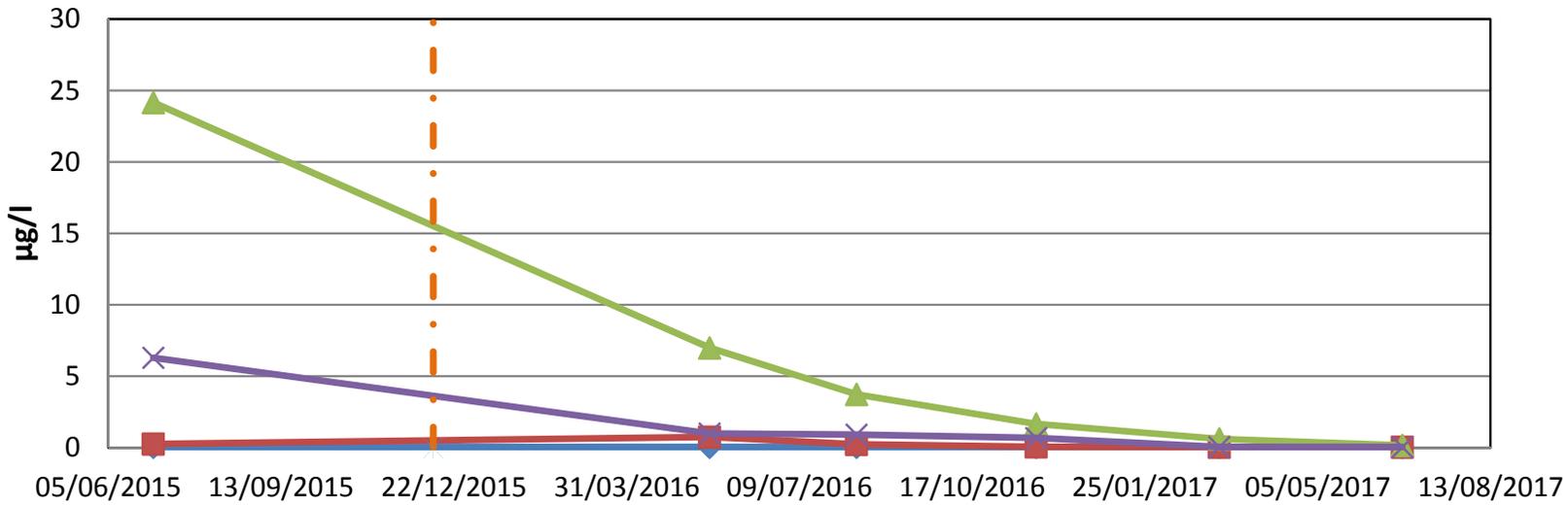
Application



Source



Plume



Merci!

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