A Field Study Comparing the Insitu Treatment of PHCs Using Activated and Catalyzed Persulphate

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2013 Remediation Technologies Symposium

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Background

- Base-Activated Persulphate
  - Effective oxidizer of PHCs
  - Formation of free radicals, sulphate and hydroxyl
  - pH > 10
  - M. Miraglio (2009) showed that hydroxyl radical formation still occurred at pH < 10 but slower rates

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Site Overview

- Hydrogeology
  - Unconfined
  - Water Table ~2 mbgs
  - K 10^{-4} To 10^{-6} m/sec
- Geochemistry
  - Anaerobic
  - Sulphate Reducing
- CoCs
  - BTEX
  - F1 (C_6-C_{10})
  - F2 ($C_{>10}$-C_{16})
  - Total PHC ~ 30 mg/L
- Geology
  - Silty Sand
  - Interlayered
  - $CaCO_3$ ~ 2 to 3 wt. %
  - SOD/NOD ~ 1.8 g/kg

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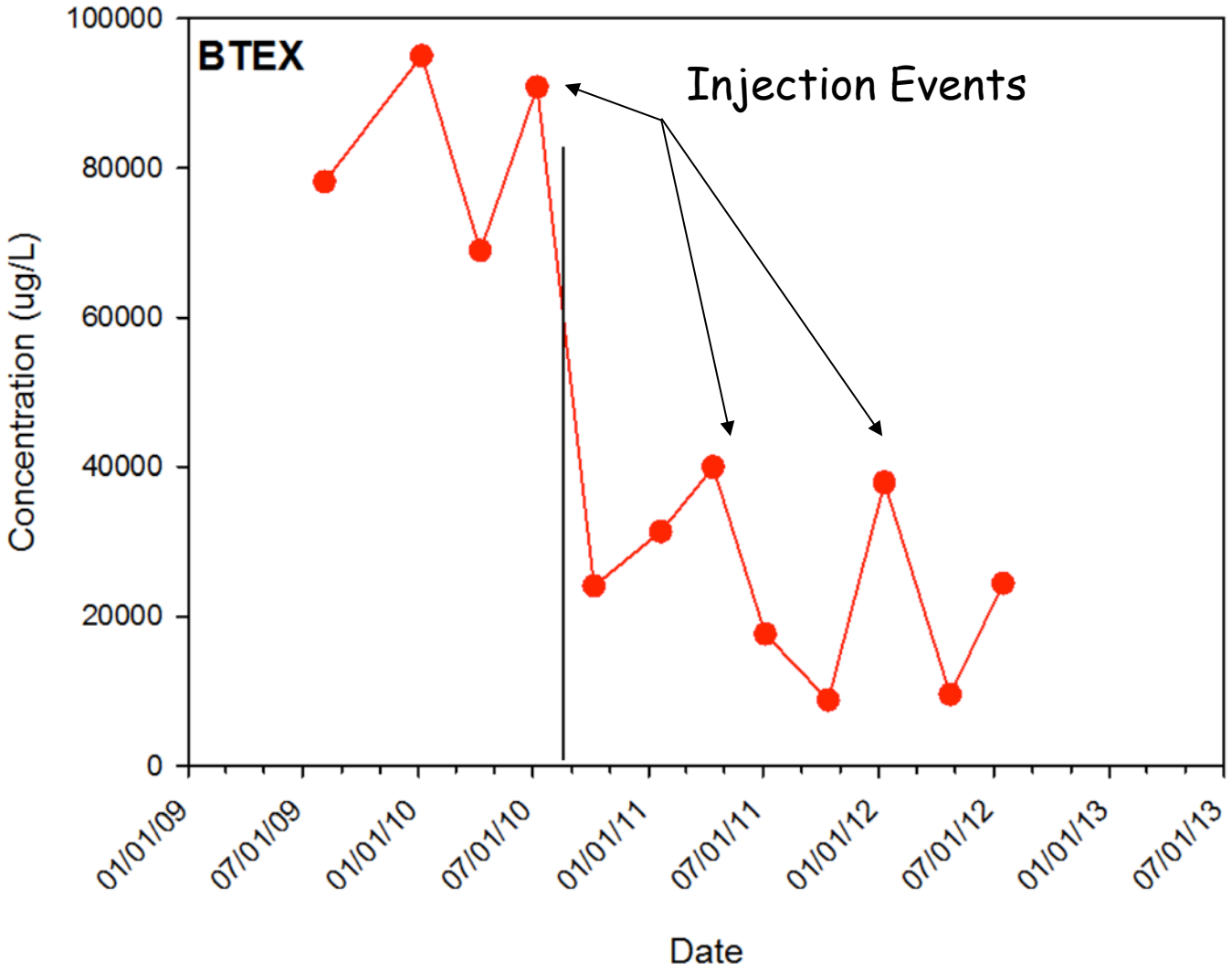
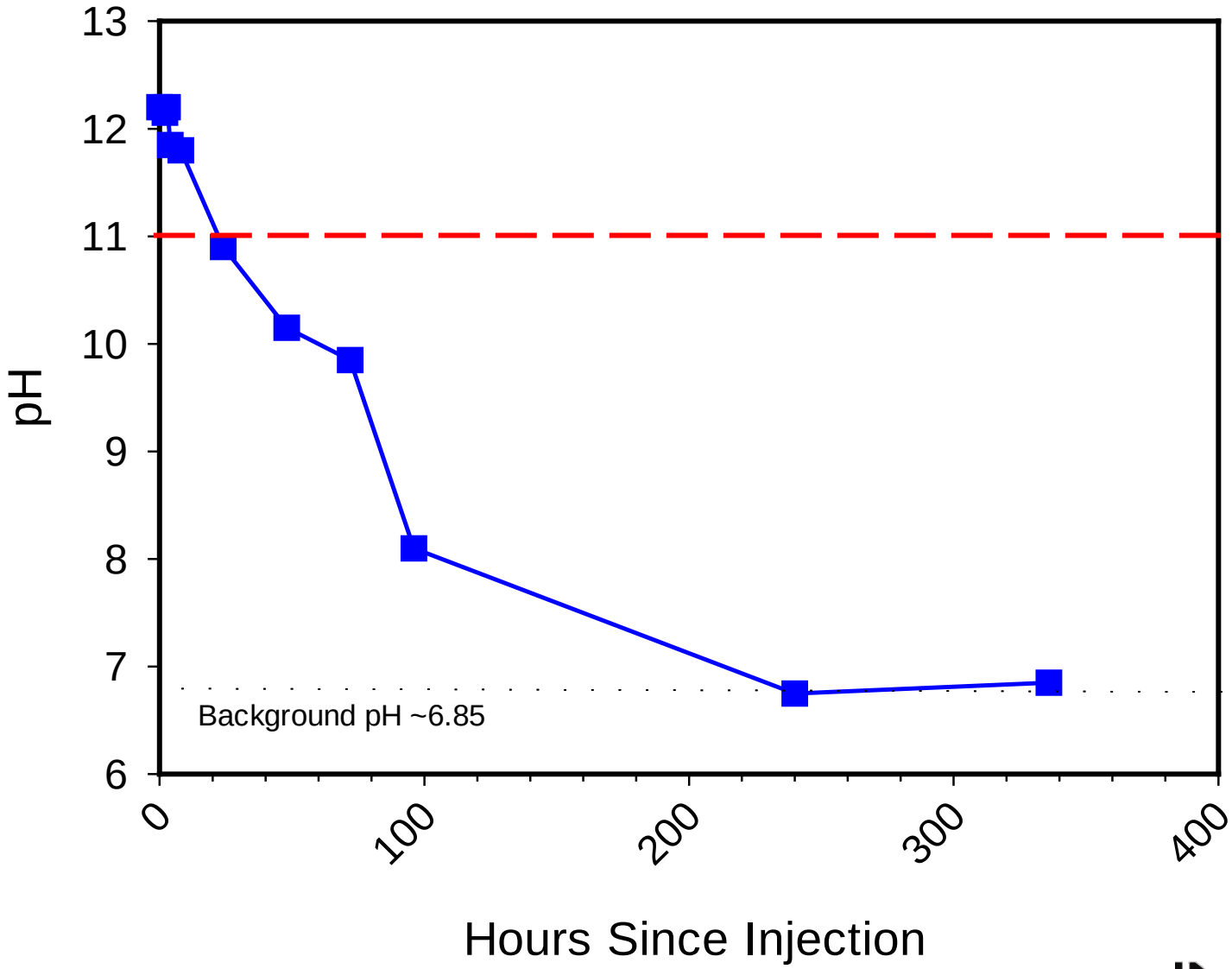
BTEX Treatment



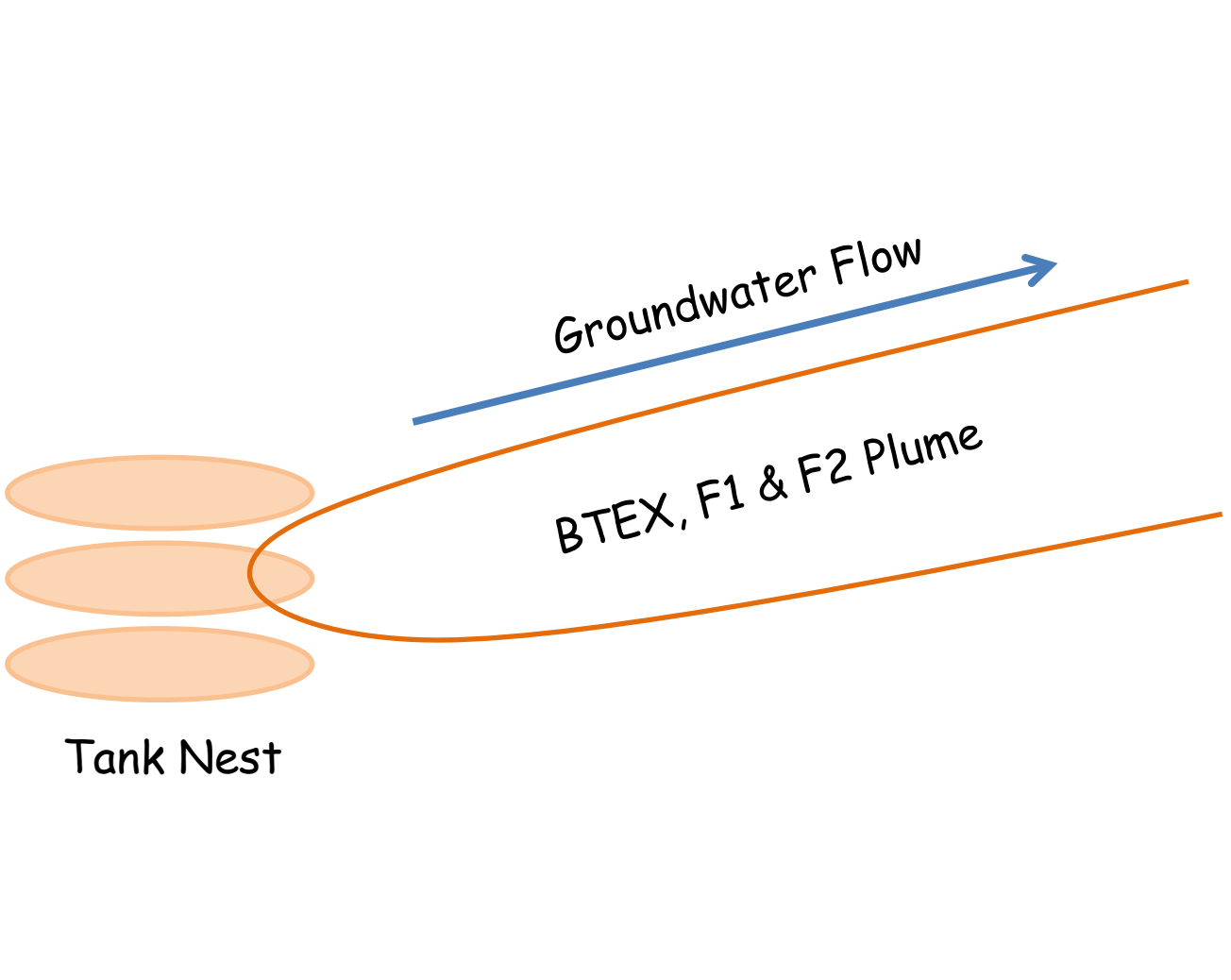
pH Persistence



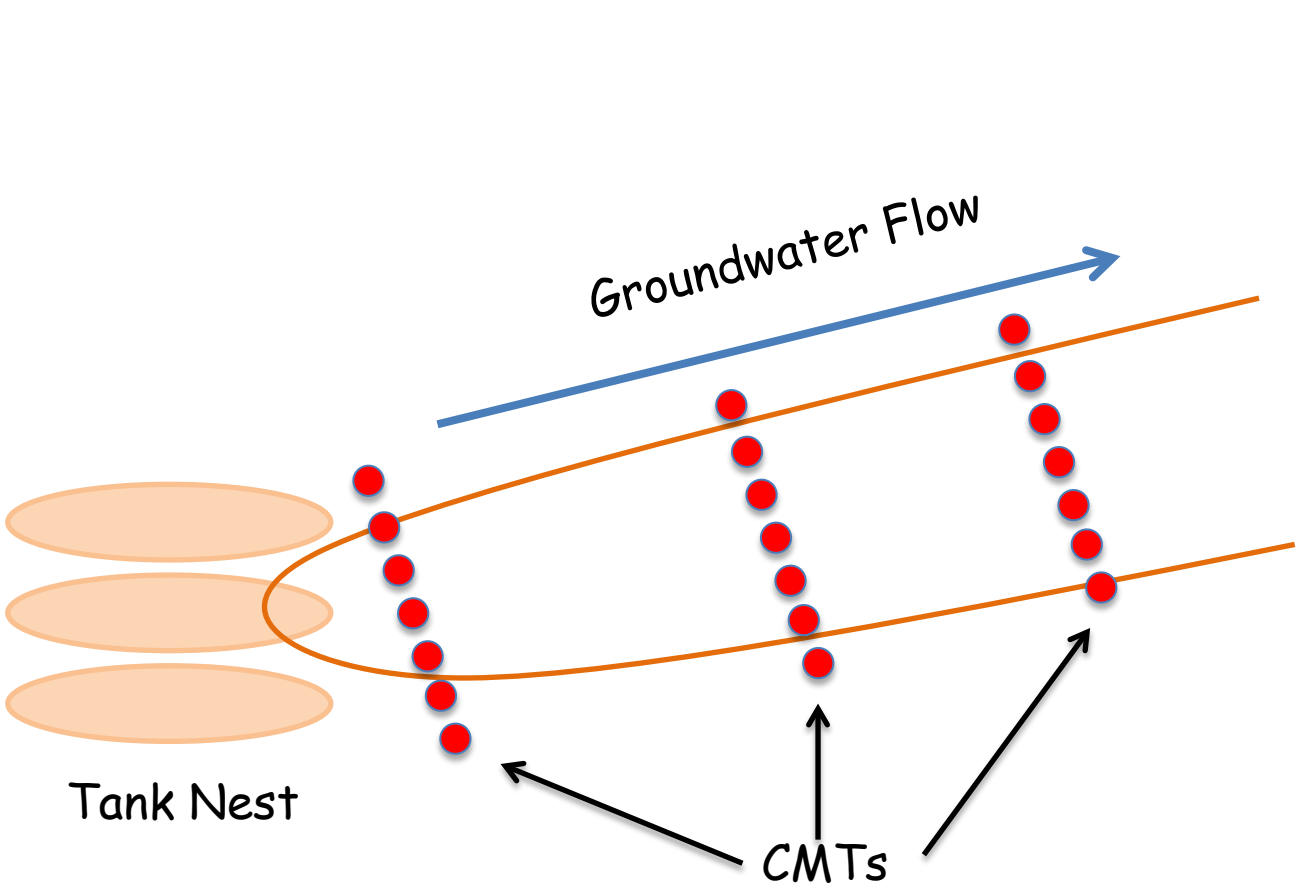
Purpose of Study

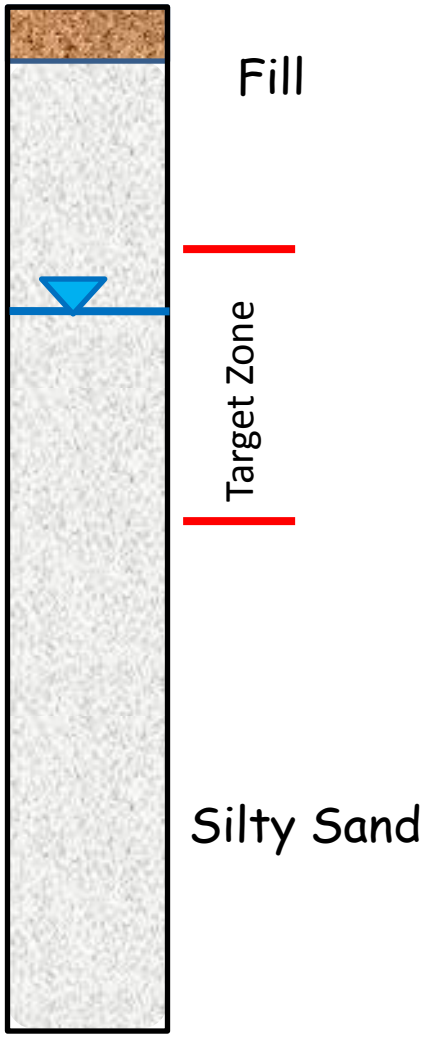
- Initial treatment using base-activated persulphate
  - Plateauing of concentrations
  - Maintaining high pH issue
- Study methodology
  - Direct comparison
  - Distribution evaluation
  - Delivery issues
  - Persistence evaluation
  - Rebound evaluation

Site Overview

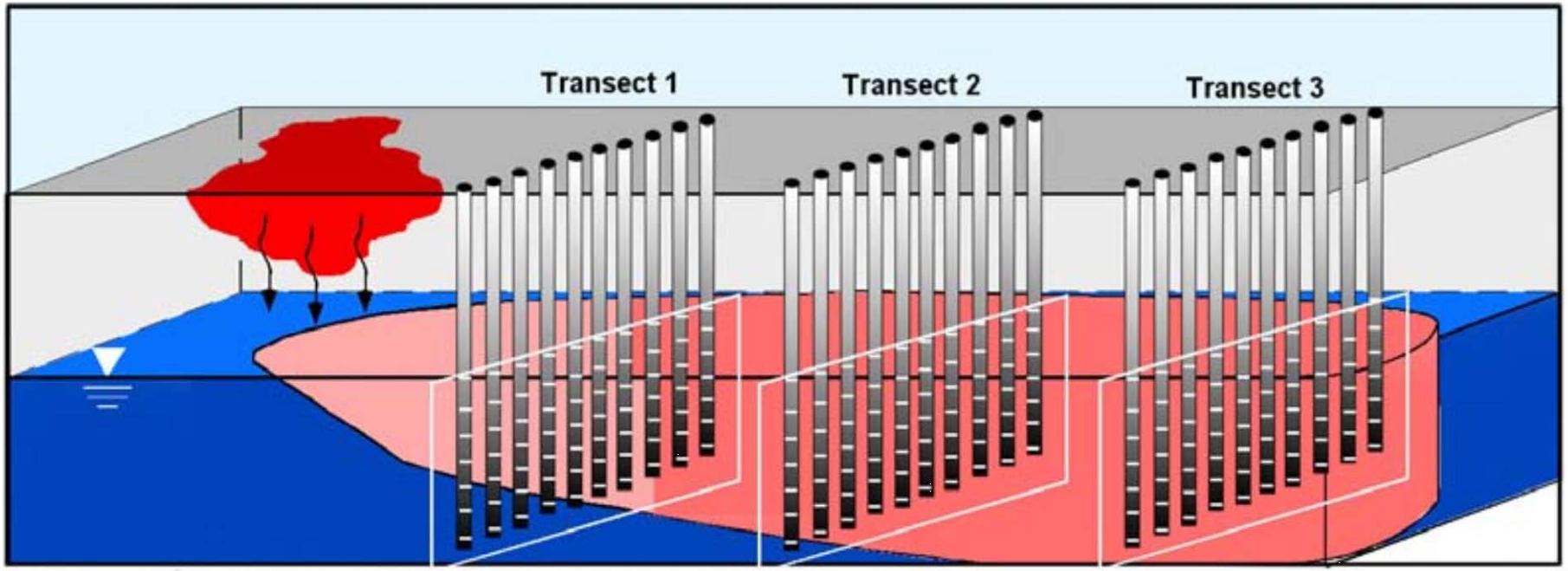


Site Overview





Site Overview



Source API

Injection Methodology

- Based on Pore Volume
  - > 0.5 PV
  - One event
- Direct Push
- Geology Specific Tools
- Multiple Locations
- Multiple Intervals
- Low Pressure
  - <25 psi
- Low Volume
  - ~200 litres/location

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Monitoring Methodology

- Pore Water
  - 25 Cores
    - 24, 96 & 1,000 hours
  - ~1,500 Pore Water Samples
    - Persulphate
    - pH
    - Catalyze
- Groundwater
  - 21 CMTs (3 & 7 channel)
    - pH, persulphate and catalyze
    - 24, 96 & 1,000 hours
  - CSIA

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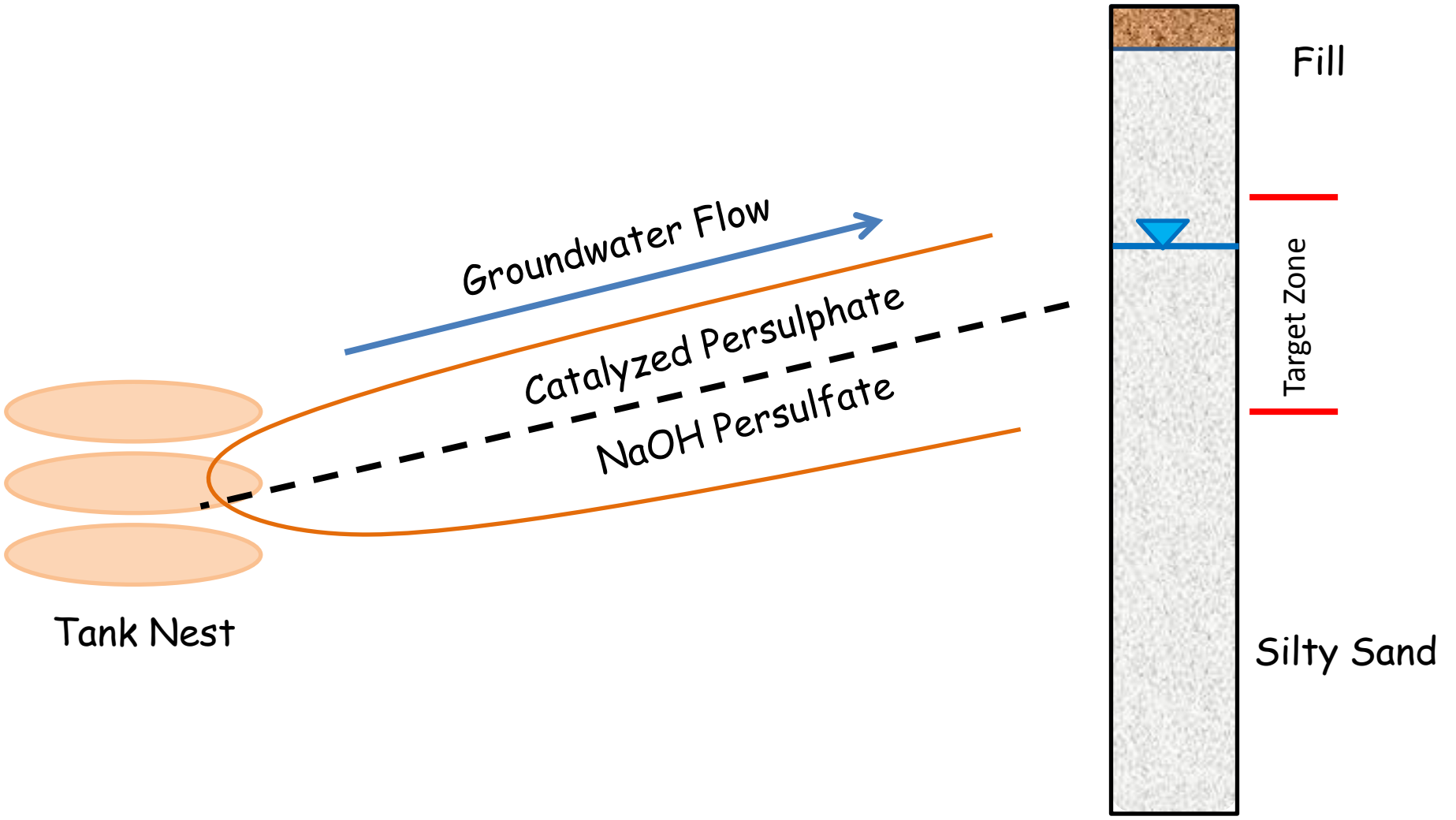
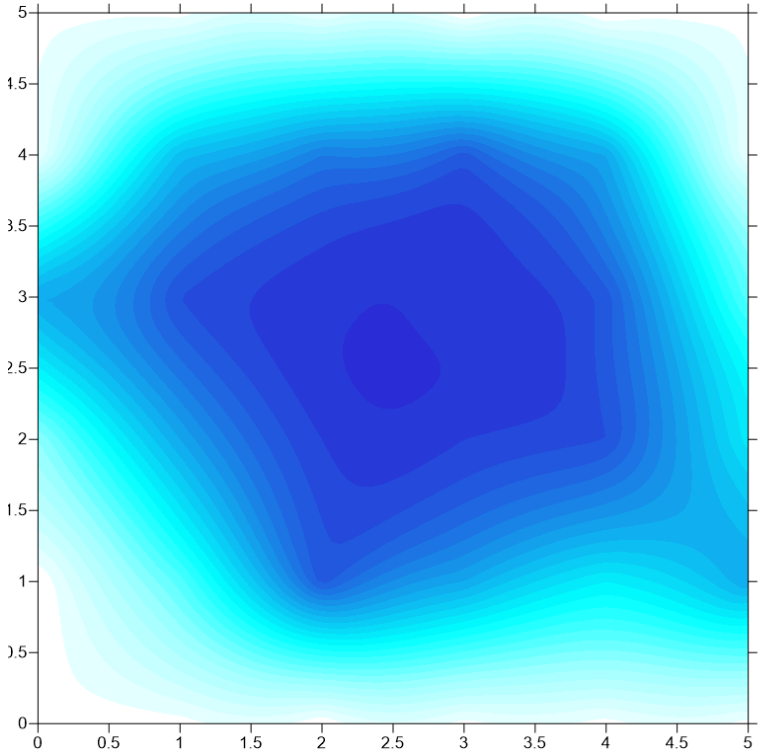
Site Overview



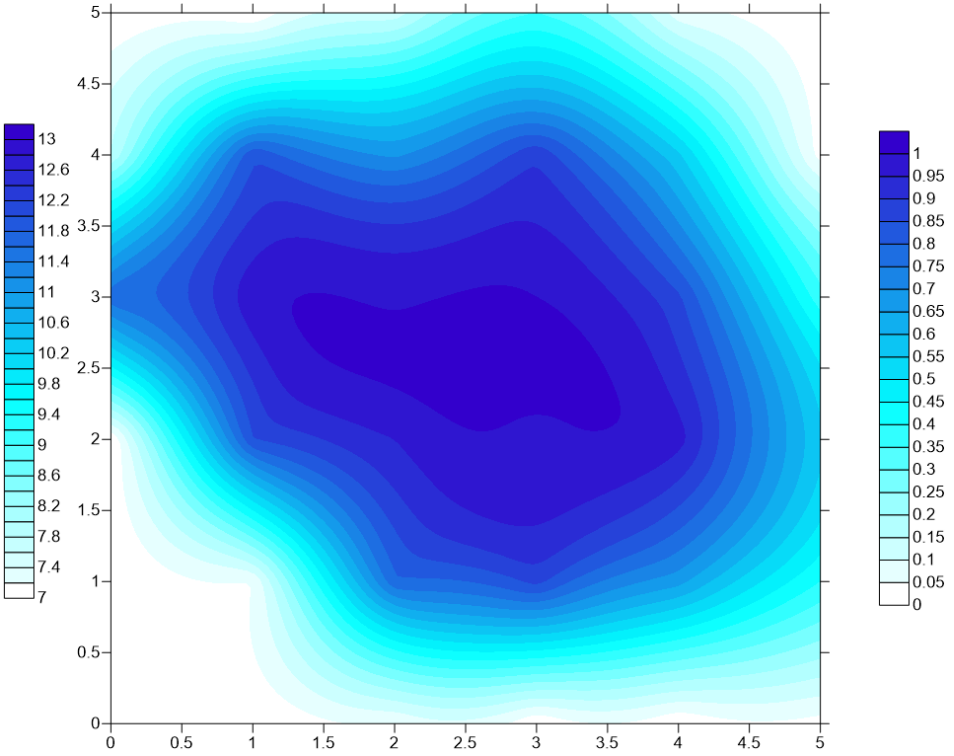
Distribution

Distribution Comparison

NaOH Activated Persulphate



Catalyzed Persulphate



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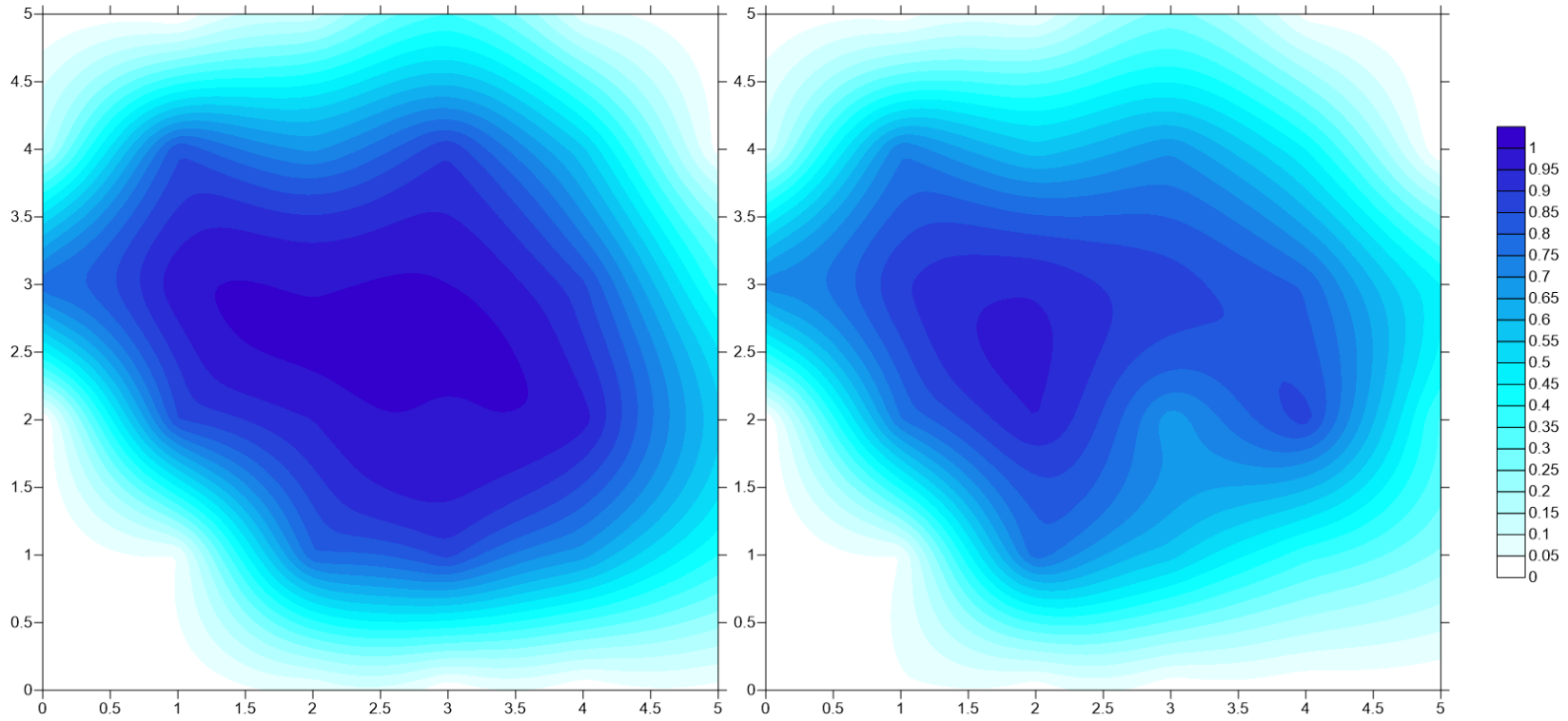
Persistence

Catalyze Persistence - Catalyzed Persulphate

24 Hours

96 Hours



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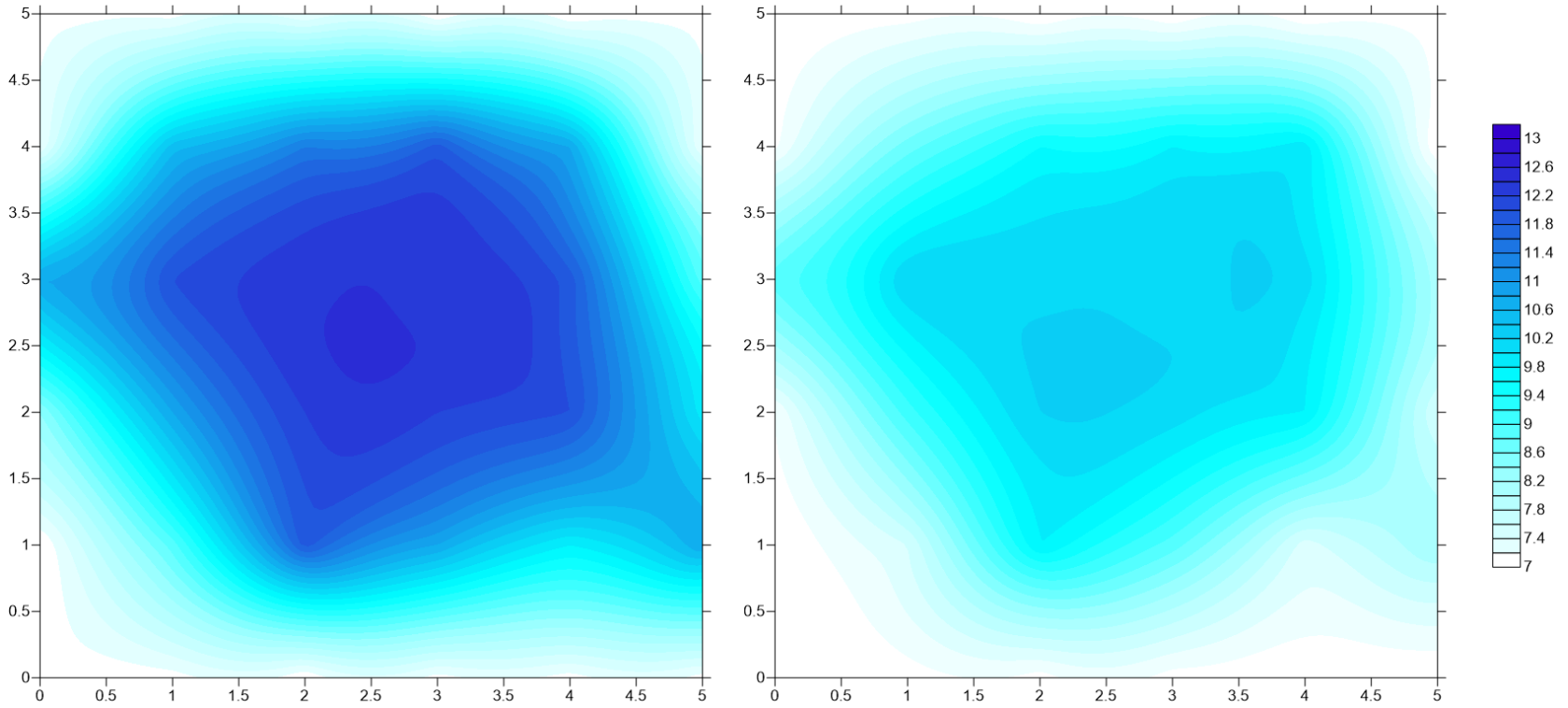
Persistence

pH Persistence – Base Activated Persulfate

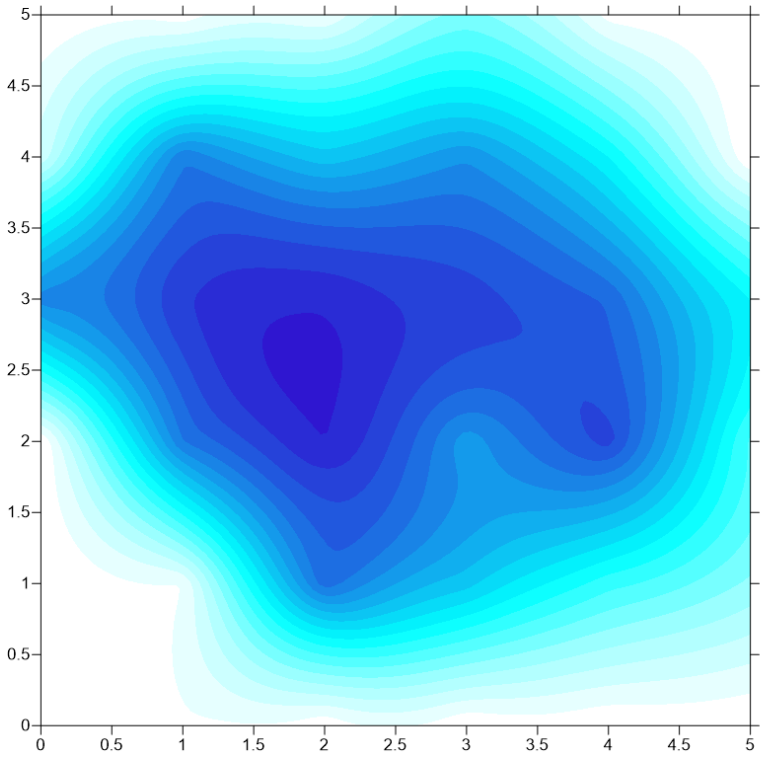
24 Hours

96 Hours

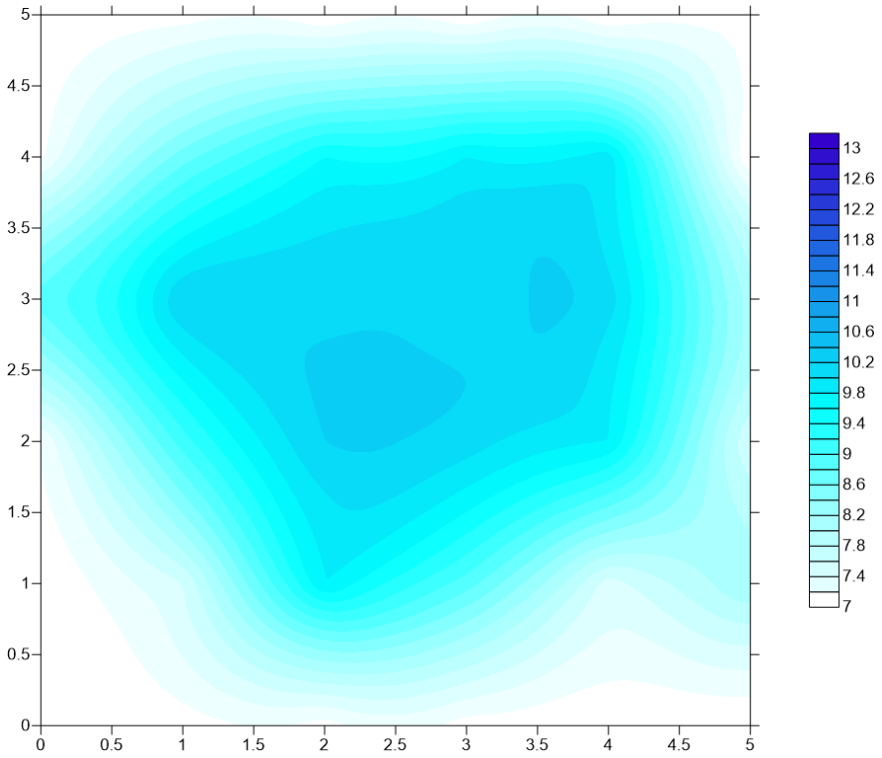


Persistence

Catalyzed Persulphate



NaOH Activated Persulfate



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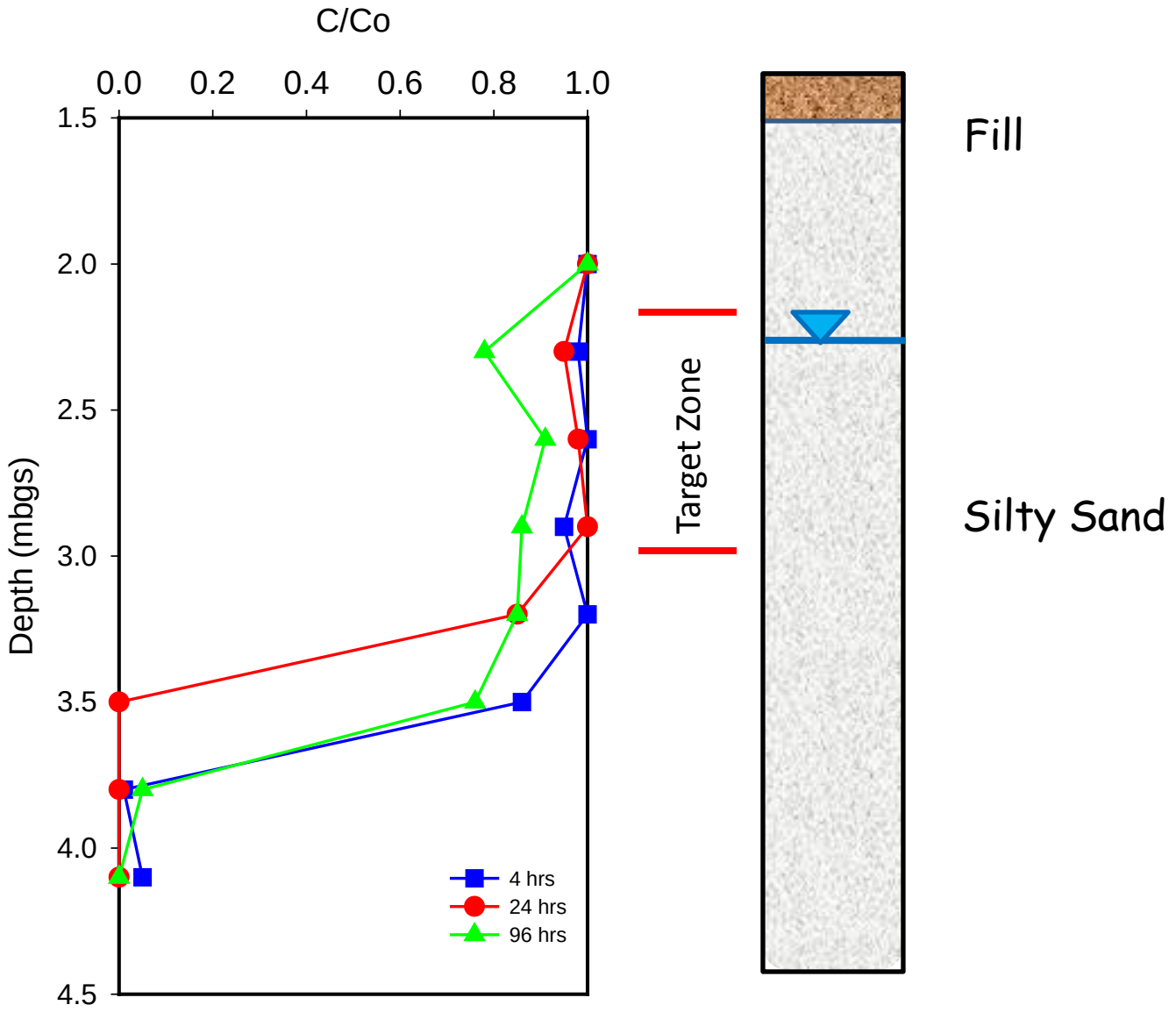
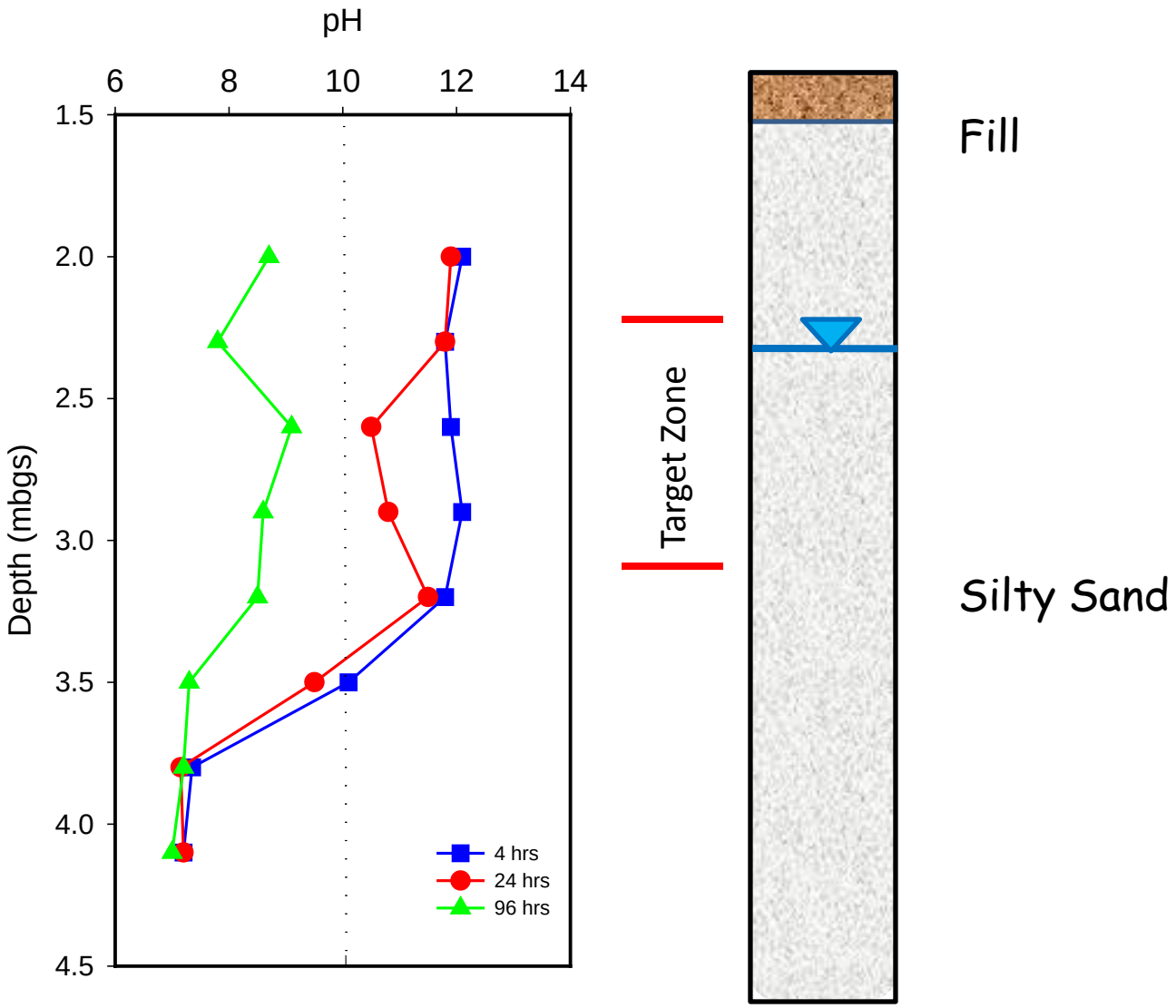
Catalyze Persistence- Catalyzed Persulphate



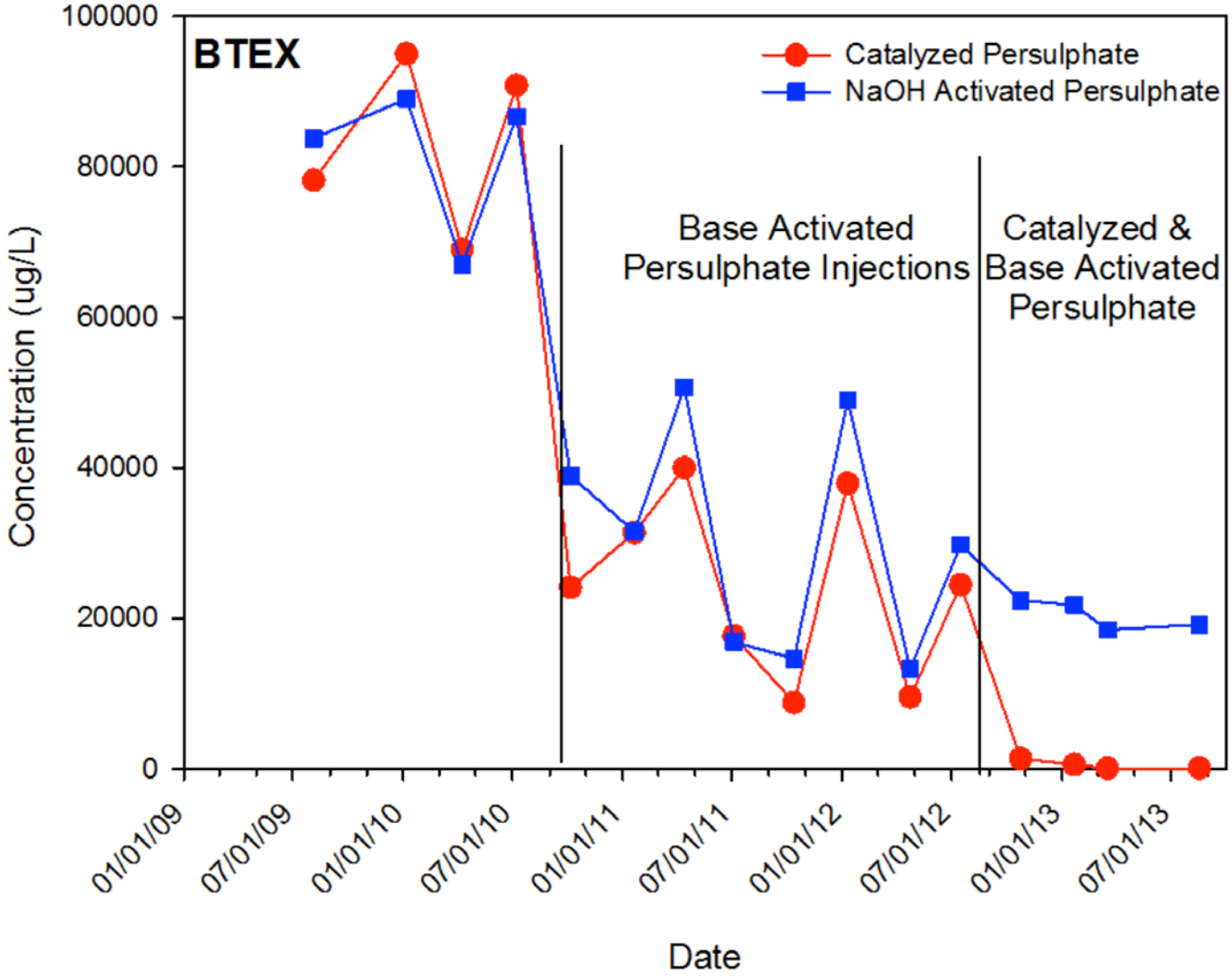
pH Persistence – NaOH Persulphate



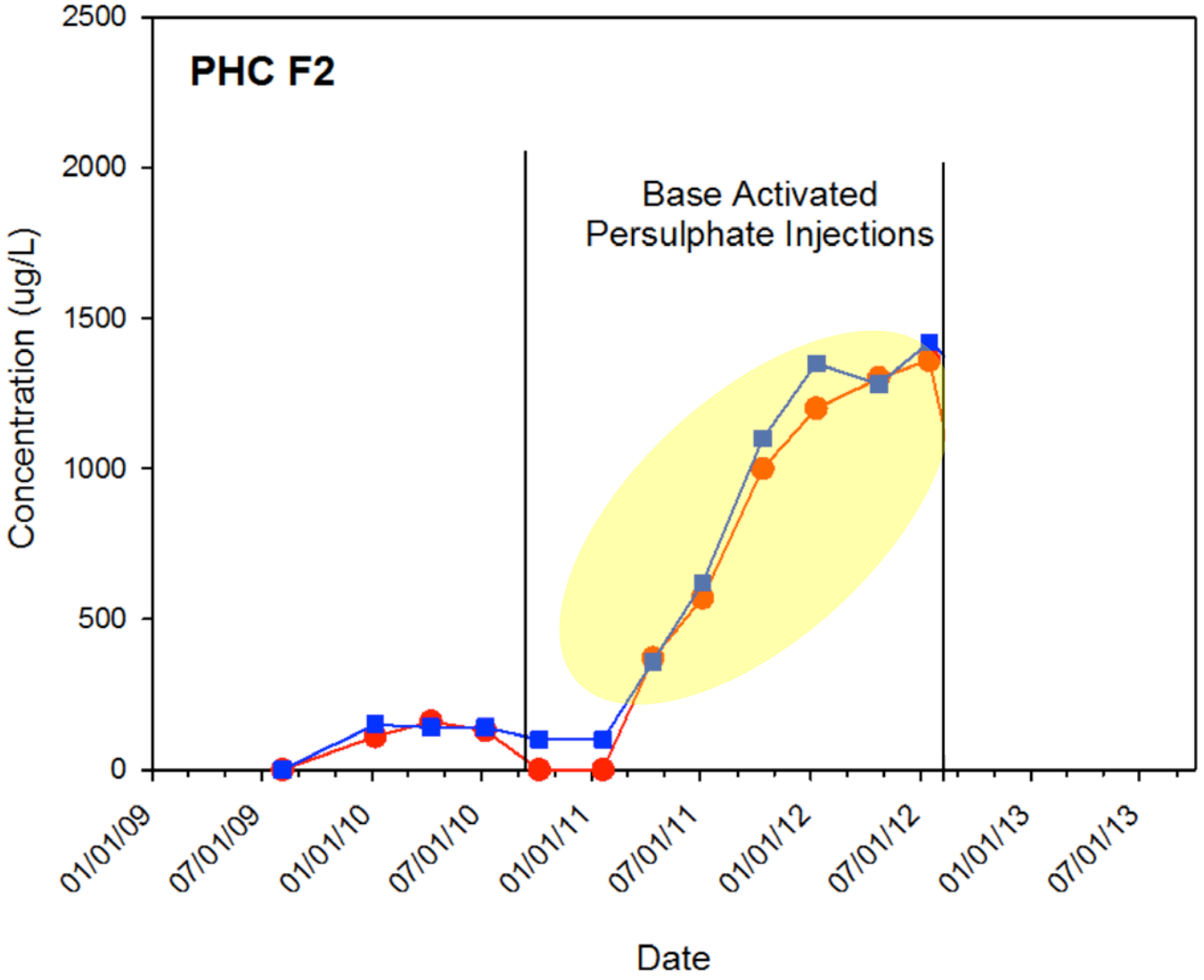
Persistence/Distribution Observations

- Similar lateral and vertical distributions
  - Effective distribution over target zone
  - ~ 2.5 m radius of influence
  - ~ uniform
- Persistence of activator/catalyze varied
  - Catalyze present for grater than 6 weeks
  - pH greater than 10 for less than 3 days

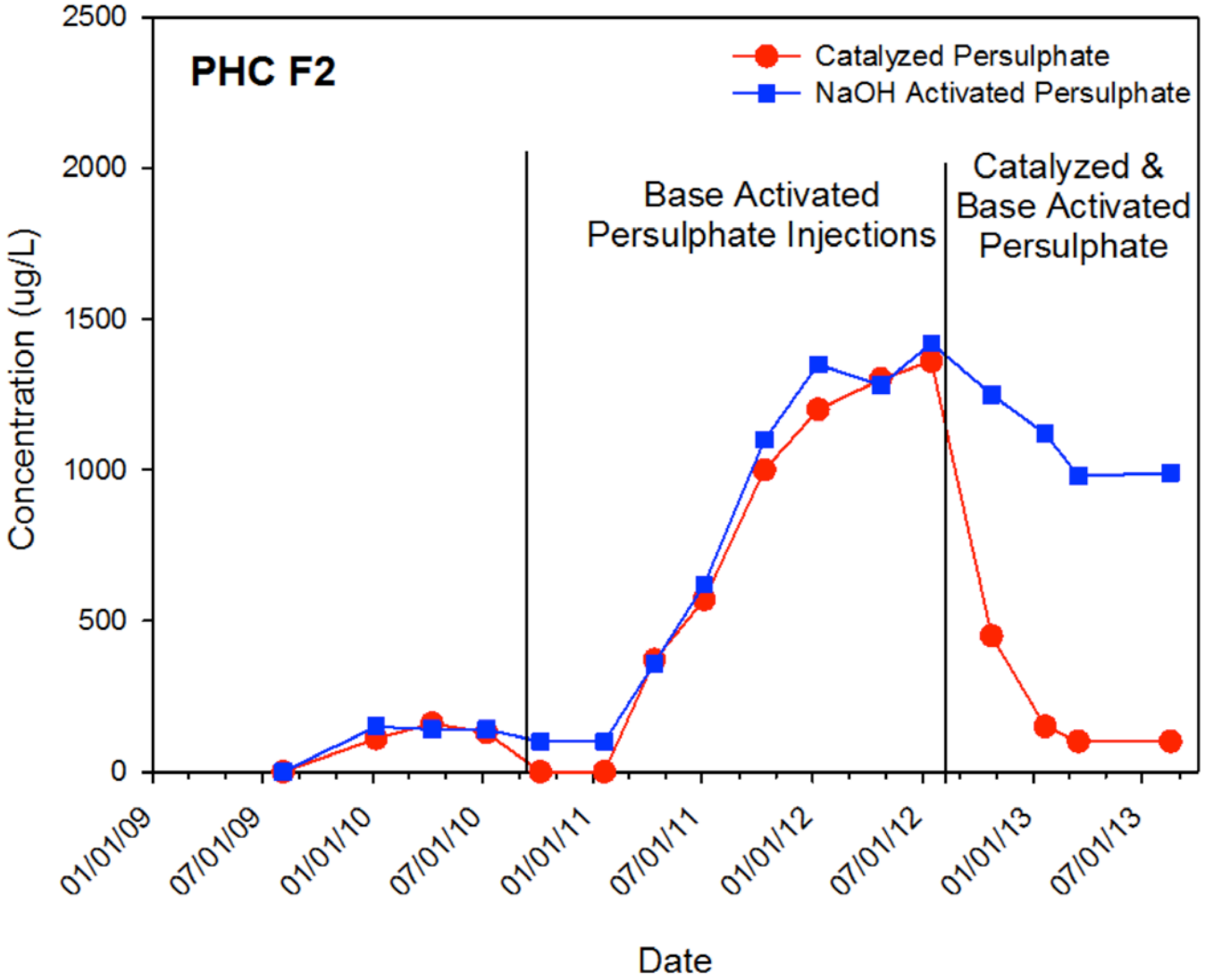
BTEX Treatment



F2 Treatment



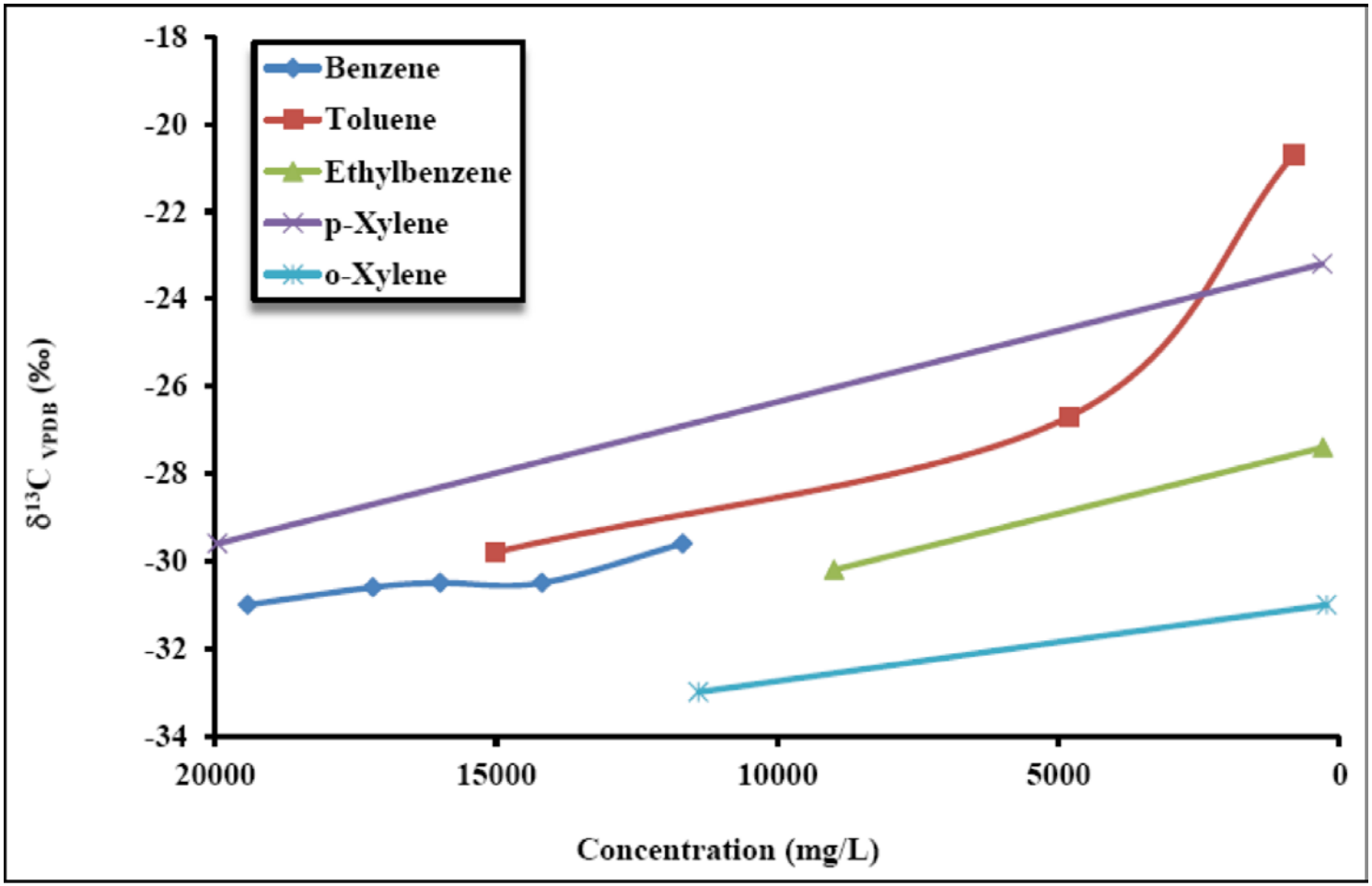
F2 Treatment



Mass Flux

NaOH Persulphate	Catalyzed Persulphate
Pre Comparison Injection	
1540 grams/year	1456 grams/year
Post Comparison Injection	
1136 grams/year 26.2% Reduction	6.6 grams/year 99.55% Reduction

CSIA


Benzene
Toluene
Ethylbenzene
p-Xylene
o-Xylene
-18
-20
-22
-24
-26
-28
-30
-32
-34
δ13C VPDB (‰)
20000
15000
10000
5000
0
Concentration (mg/L)

Conclusions

- NaOH-activated and catalyzed persulfate both showed good treatment of PHCs including:
  - BTEX,
  - F1, F2 and F3 fractions
- Similar lateral and vertical distributions
- Catalyzed persulphate persistence was good
- NaOH-activated persulphate had issues with maintaining pH greater than 10

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Ending

- Questions and Thank you