REGENESIS®

PROTE

Two new remediation technologies for treating high contaminant concentrations in groundwater

Gareth Leonard

REMEDy 2019

REGENESIS®

What is Zero Valent Iron (ZVI)?

- Strong 'engineered' reductant
- Iron typically exists as Fe^2 and Fe^3 oxides
- Fe^0 is manufactured to be reactive
- Provides In Situ Chemical Reduction (ISCR)

What are we trying to improve upon?

- ZVI has been used since the 1990's
- Address challenges of:
  - Reactivity
  - Persistence
  - Delivery
  - Ease of Use
- Resulting in a significant improvement in efficacy, utility and economy

REGENESIS

Sulfidated Micro-scale Colloidal Zero Valent Iron

Engineered Zero Valent Iron product:

- Colloidal – particle size <5µm
- Sulfidated particle coating
- Glycerol suspension

This combination results in:

- Abiotic degradation
- ISCR enhanced biological degradation
- Reduced daughter products
- Shorter treatment times

Targeting:

- Source treatment
- High concentrations
- Receptor protection
- Chlorinated solvents
- Pesticides

REGENESIS

Focus on Sulfidation

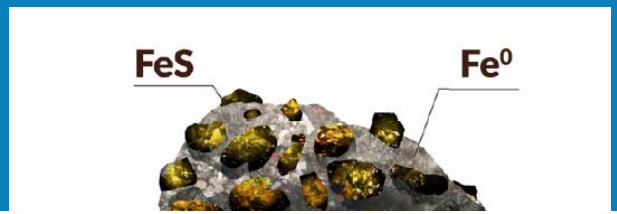
ZVI also reacts with water = H_2

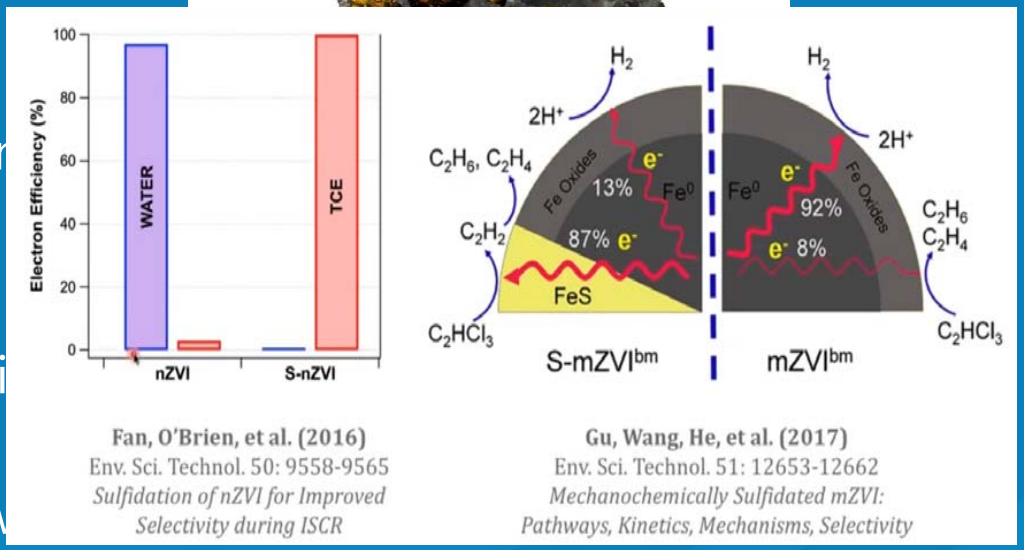
Results in:

- Passivation
- Decreased persistence
- Less treatment of the contaminar

Answer = Sulfidate the ZVI surface

- Coats the surface of the ZVI parti
- Results in an increase in Electron
  - Minimizes reaction rate with w
  - Maximizes reaction rate with contaminants
- Sulfidation enhances reaction rate with chlorinated ethenes





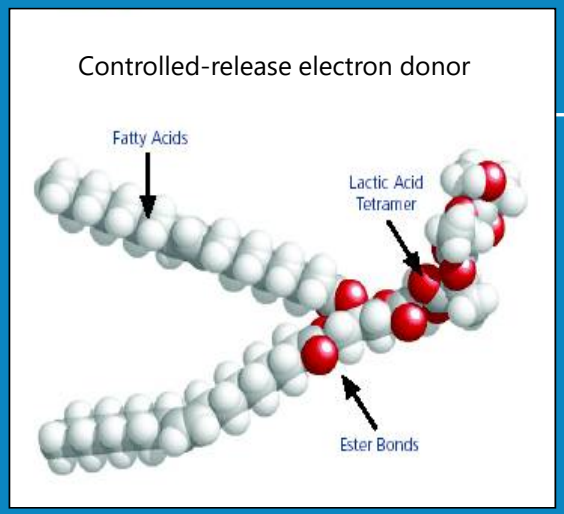
Fan, O'Brien, et al. (2016)
Env. Sci. Technol. 50: 9558-9565
Sulfidation of nZVI for Improved Selectivity during ISCR

Gu, Wang, He, et al. (2017)
Env. Sci. Technol. 51: 12653-12662
Mechanochemically Sulfidated mZVI: Pathways, Kinetics, Mechanisms, Selectivity

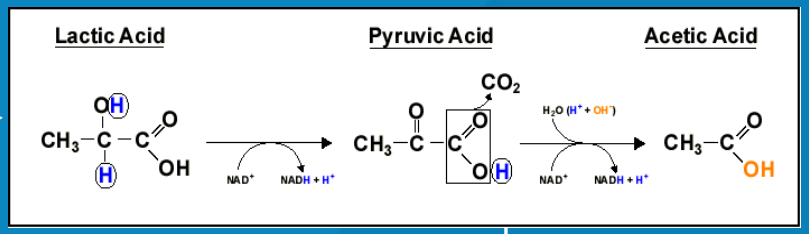
REGENESIS

S-Micro ZVI™
Sulfidated Zero-Valent Iron

ISCR-Assisted Bioremediation

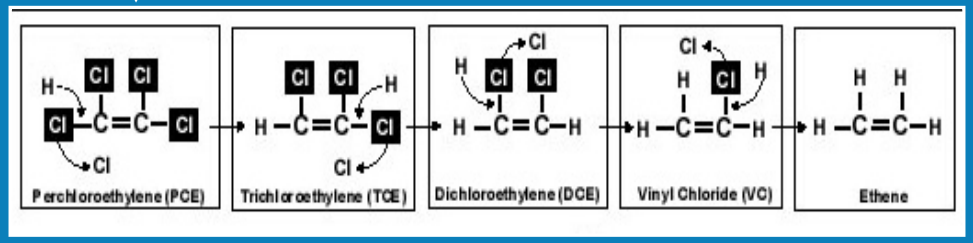


Dissolution

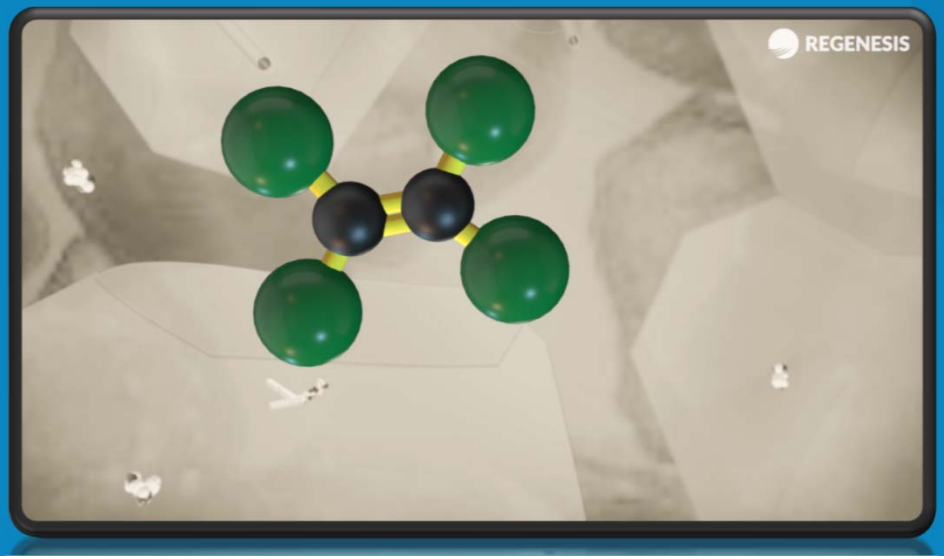


Fermentation

Hydrogenolysis



PCE ⟶ TCE ⟶ DCE ⟶ VC ⟶ Ethene

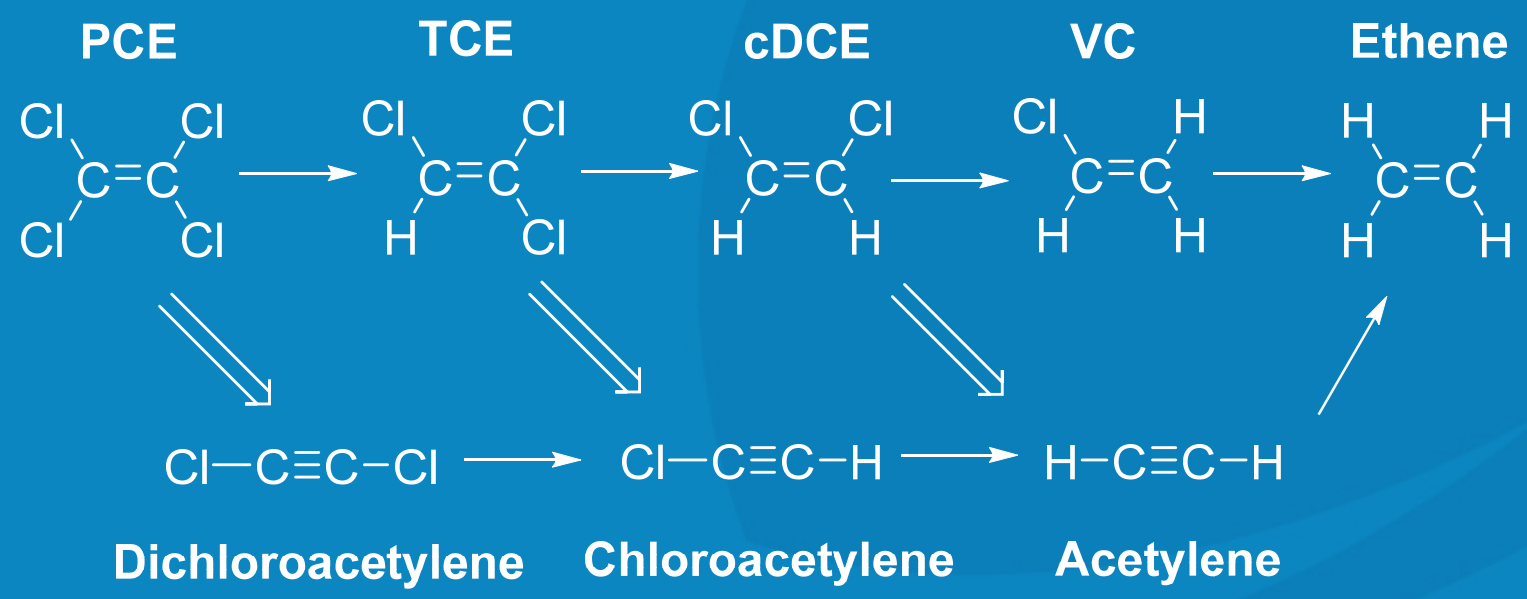


ISCR enhancement

- Rapidly create anaerobic conditions
- Remove dissolved oxygen
- Glycerol layer provides dissolved hydrogen
- Able to address greater mass – abiotic destruction of parent compounds

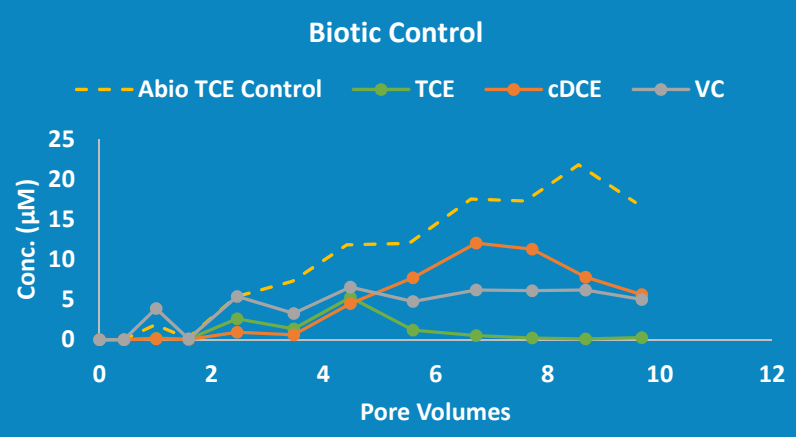
Chemical Reduction

Reaction pathway can bypass toxic daughter products



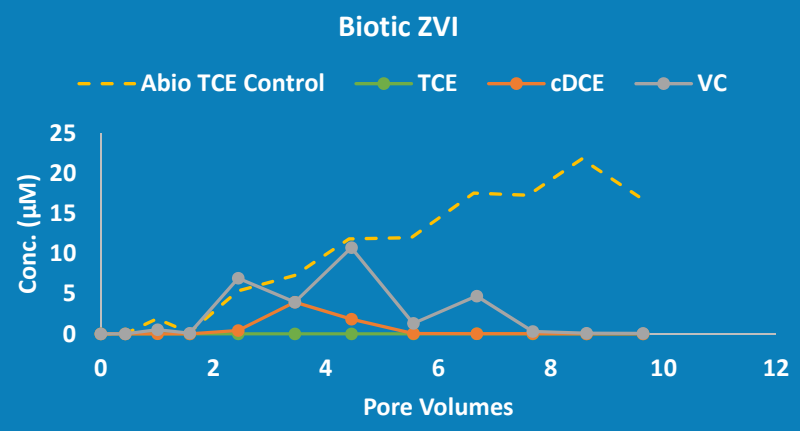
Laboratory Results

BIOTIC COLUMN



- TCE removed at week 7
- Maximum daughter product at week 7
- 10 µM daughter products at week 10

ISCR-ASSISTED COLUMN



- TCE removed immediately
- Maximum daughter products at week 5
- No contaminants at week 10

REGENESIS

Ease of use

- A fluid suspension is provided in 200L drums
- Pumped or poured into mix tank and diluted
- Simple mixing and pumping equipment
- Safe to use

- No need for powder handling equipment
- No dust or explosion hazard
- No thick slurries to fracture into the formation

REGENESIS

Distribution

characteristics of colloidal iron

S-MicroZVI suspension

Low pressure sandbox demo

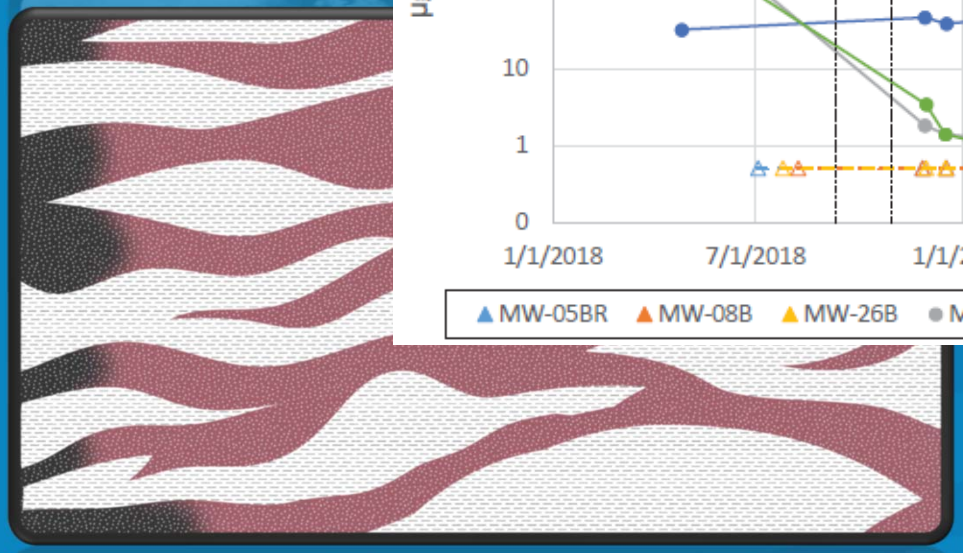
characteristics of microscale iron

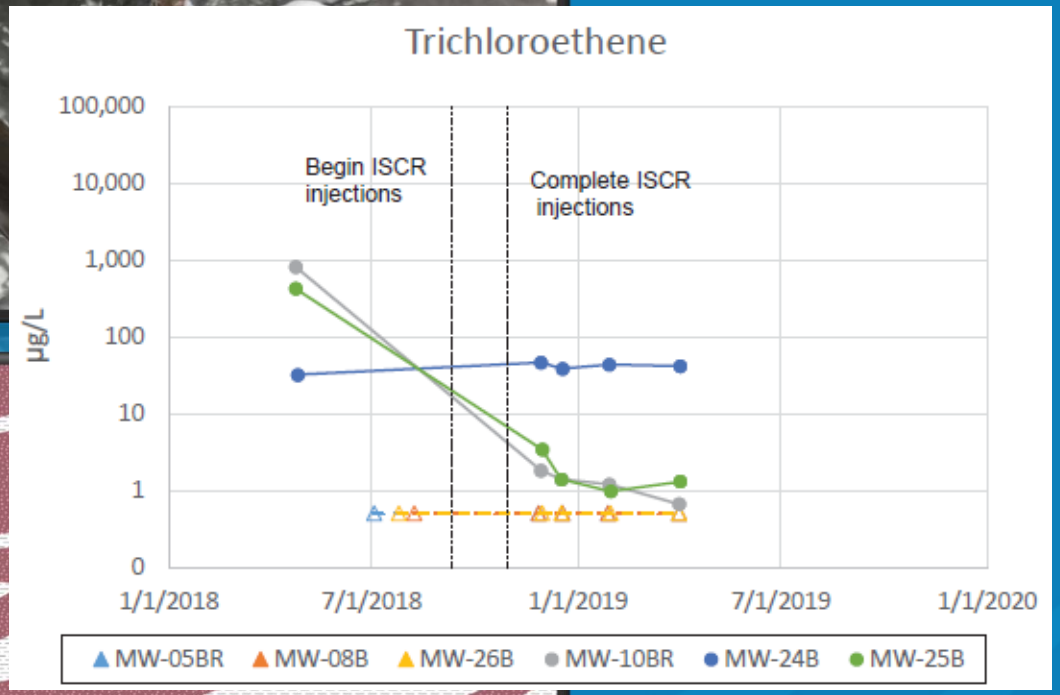
Microscale ZVI Slurry

Depiction of subsurface fractures

REGENESIS

Example Sites





REGENESIS


Dual Function, Activated Carbon Amendment
PetroFIX
Remediation Fluid

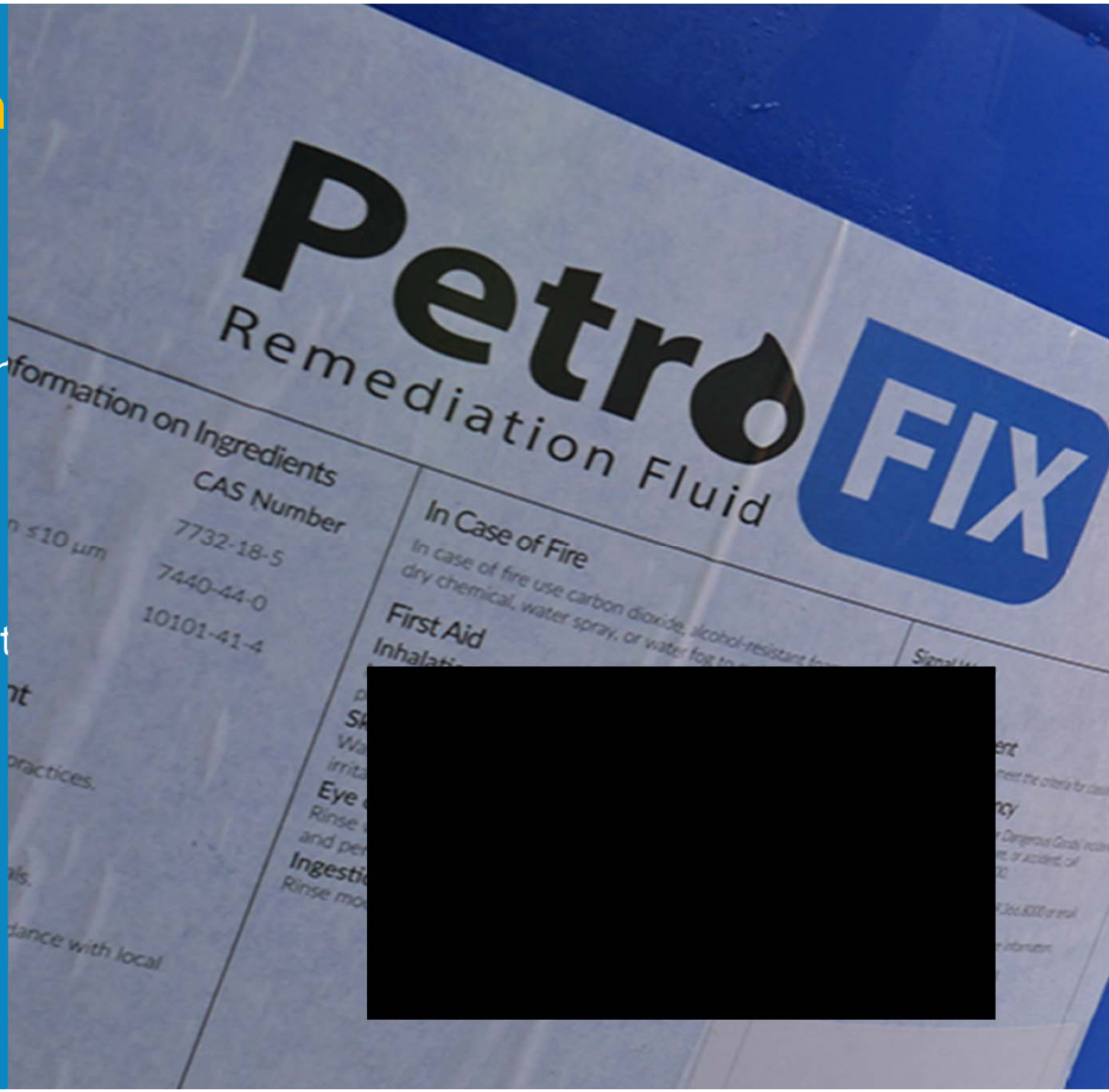
Dual Function Activated Ca

Consists of:

1. micro scale activated carbon
   electron acceptor
2. Nitrate and sulphate electror

Targets contaminants:

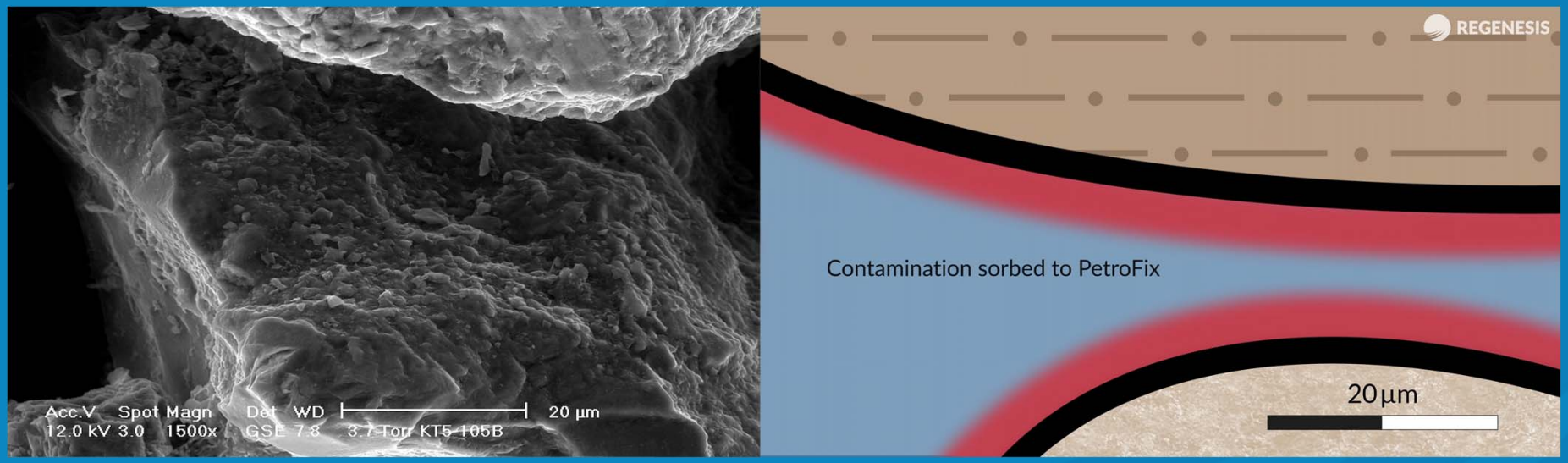
- Petroleum hydrocarbons
- BTEX, TPH-G, TPH-D, MTBE, napht



REGENESIS

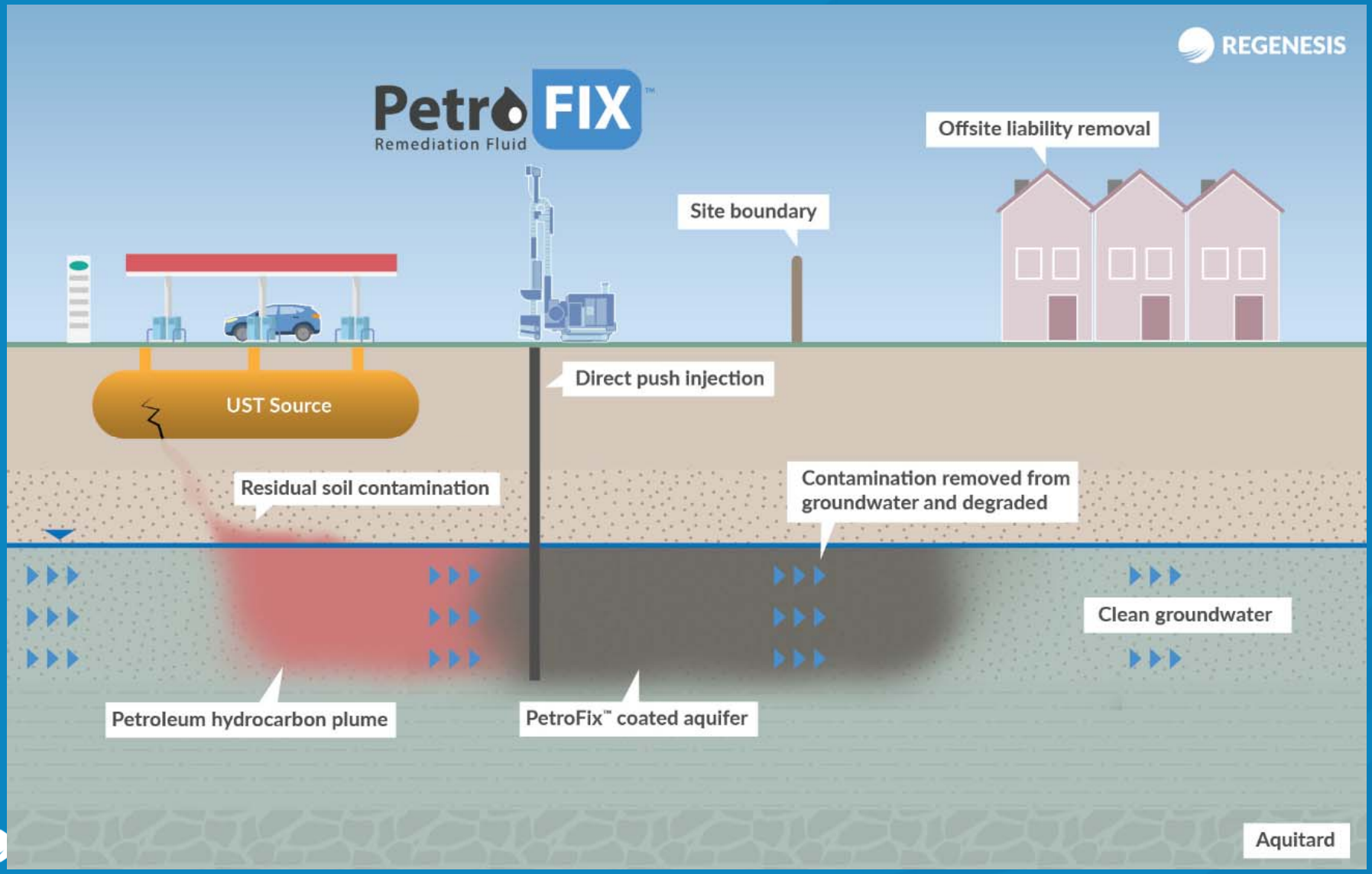
Remediation Process

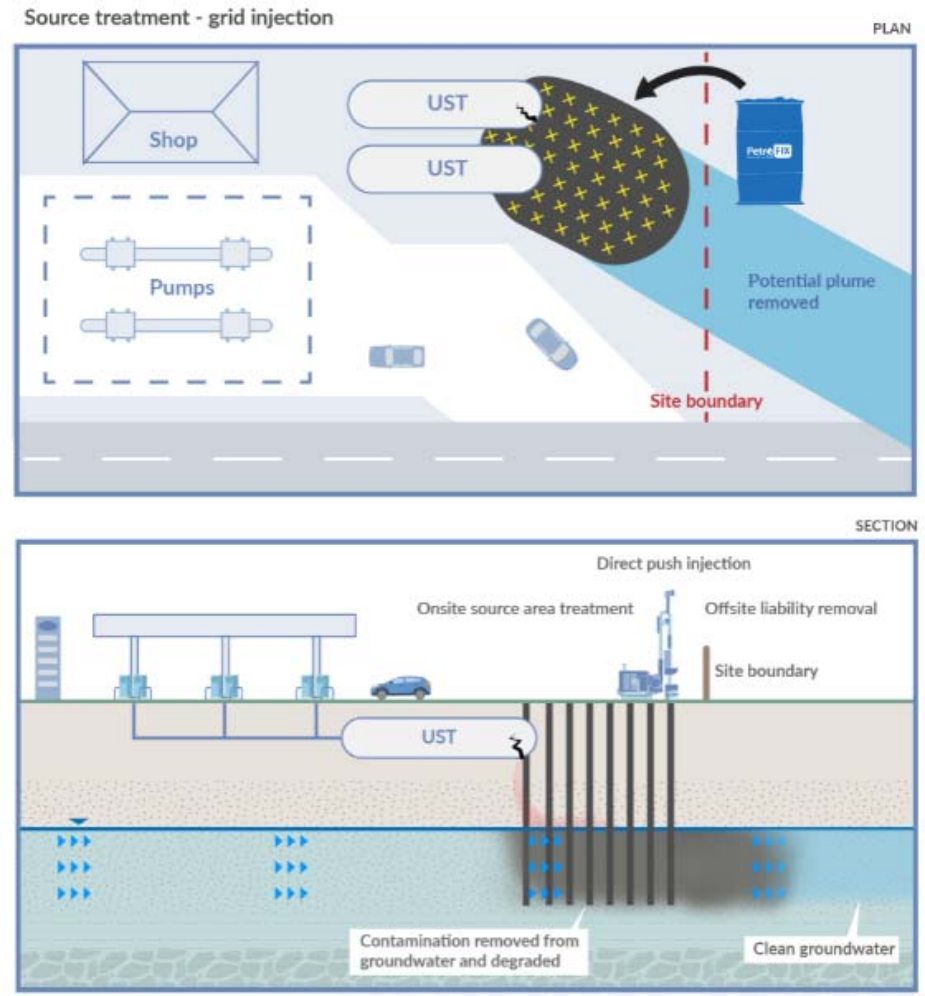
1) Adsorb contaminants onto activated carbon
2) Biologically degrade the sorbed contamination

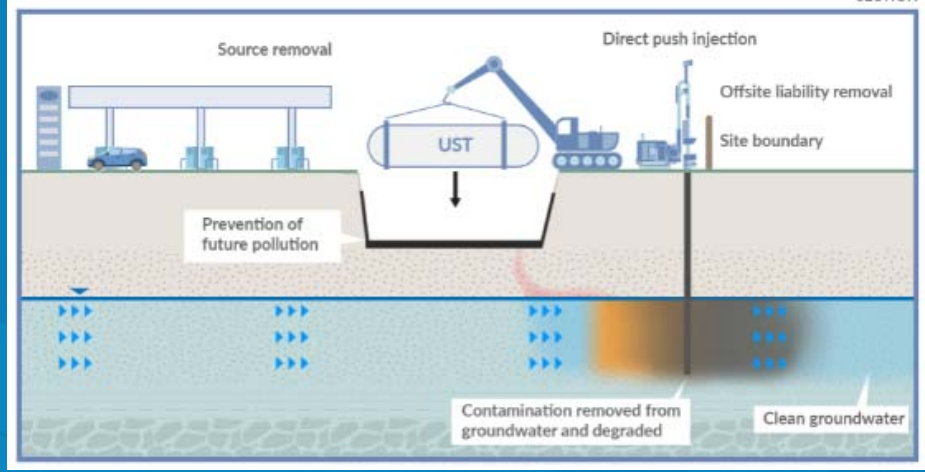


REGENESIS

PetroFIX Remediation Fluid


REGENESIS
PetroFIX™
Remediation Fluid
Offsite liability removal
Site boundary
Direct push injection
UST Source
Residual soil contamination
Contamination removed from groundwater and degraded
Clean groundwater
Petroleum hydrocarbon plume
PetroFix™ coated aquifer
Aquitard


Source treatment - grid injection
PLAN
Shop
UST
UST
Pumps
Potential plume removed
Site boundary
SECTION
Direct push injection
Onsite source area treatment
Offsite liability removal
Site boundary
UST
Contamination removed from groundwater and degraded
Clean groundwater


Source removal
Direct push injection
Offsite liability removal
Site boundary
UST
Prevention of future pollution
Contamination removed from groundwater and degraded
Clean groundwater

REGENESIS

Case Study: South Bend, USA

Site Background:

- Historical Bulk Petroleum Storage Facility
- Remedial activities initiated in 2006
    - LNAPL Recovery – 2006
    - AS/SVE – 2007-2009
- BTEX – 3,500 ug/l
- TPH-G –38,800 ug/l
- TPH-D –17,800 ug/l
- Remediation to prevent offsite migration

Application:

- 1000kgof PetroFix injected
- 12 direct push points
- Target treatment zone: 5-7mBGL
- In heterogeneous soils

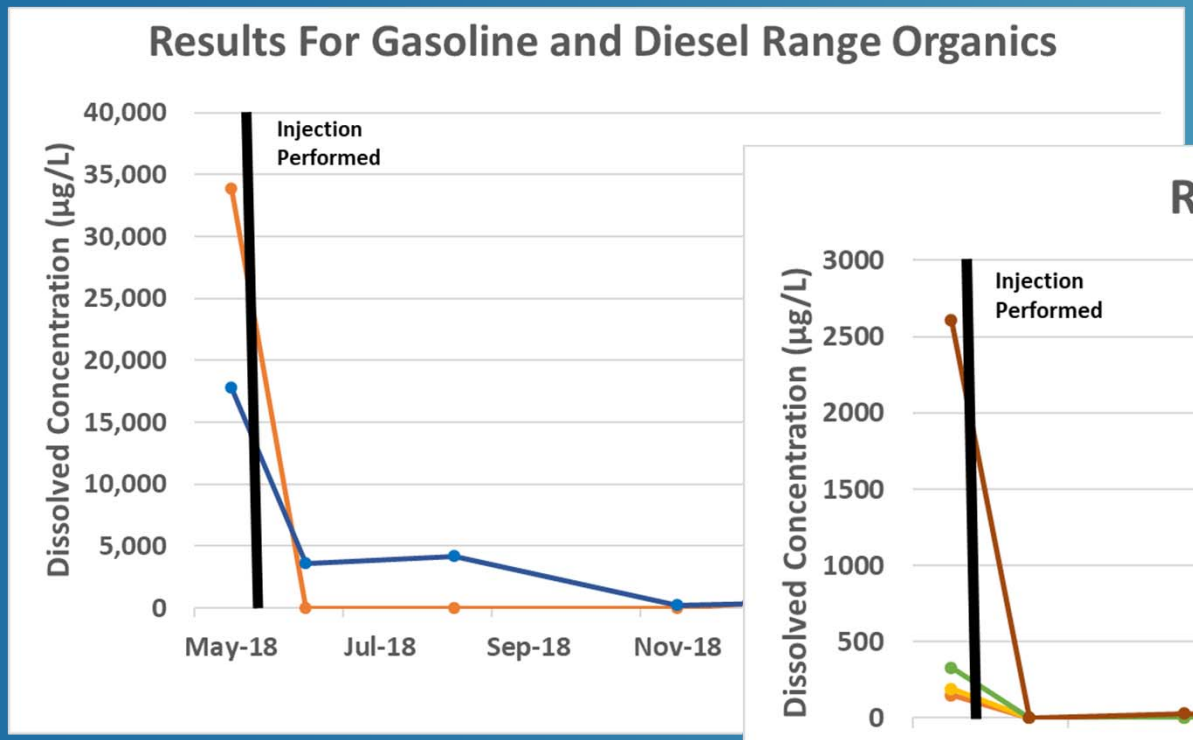
Distribution Confirmation:

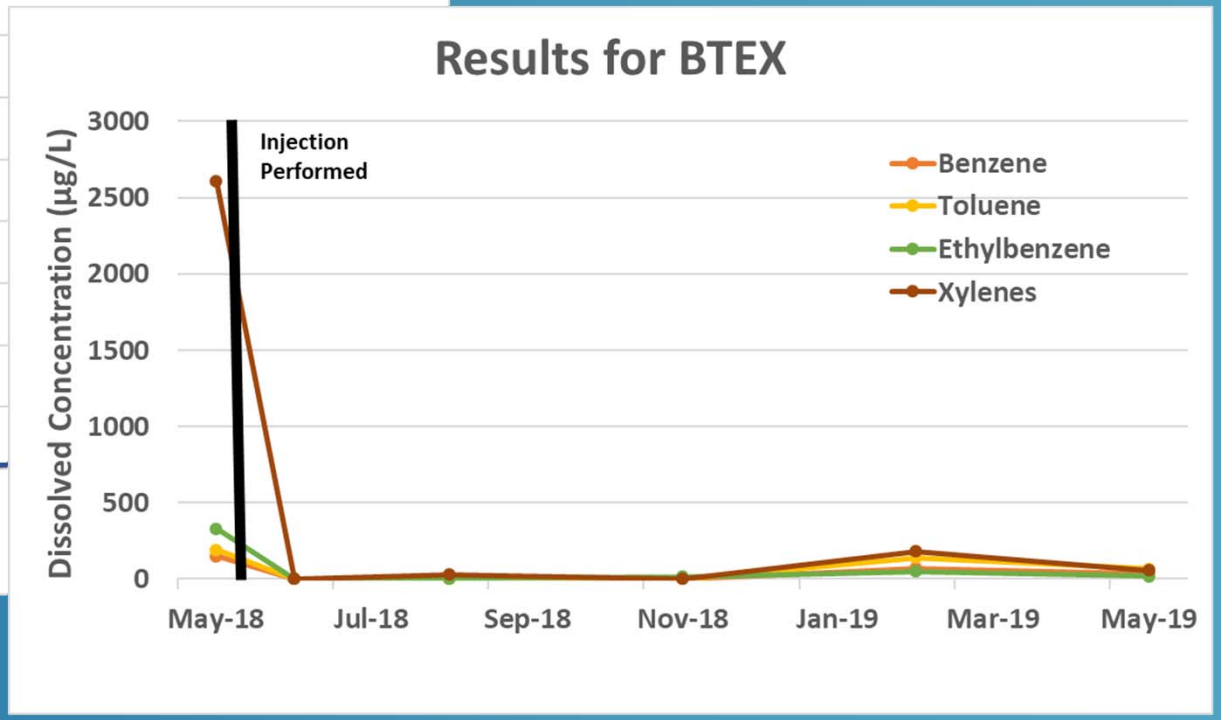
- 2-3.5m spacing was optimal for complete coverage

REGENESIS

Case Study: South Bend, USA

Results:

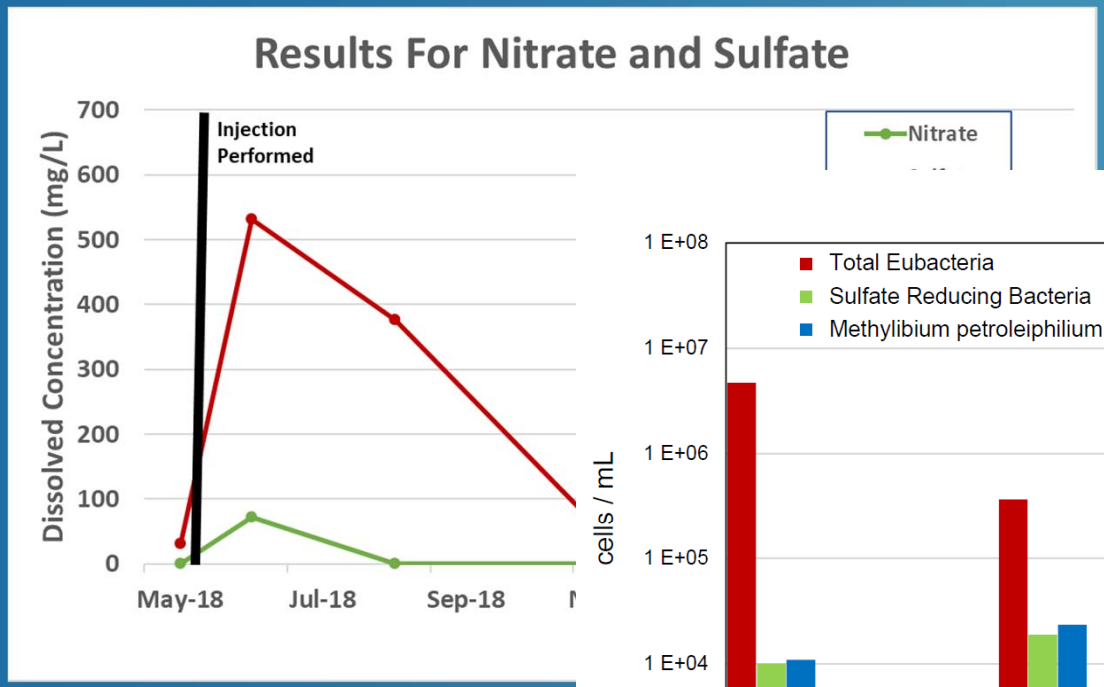


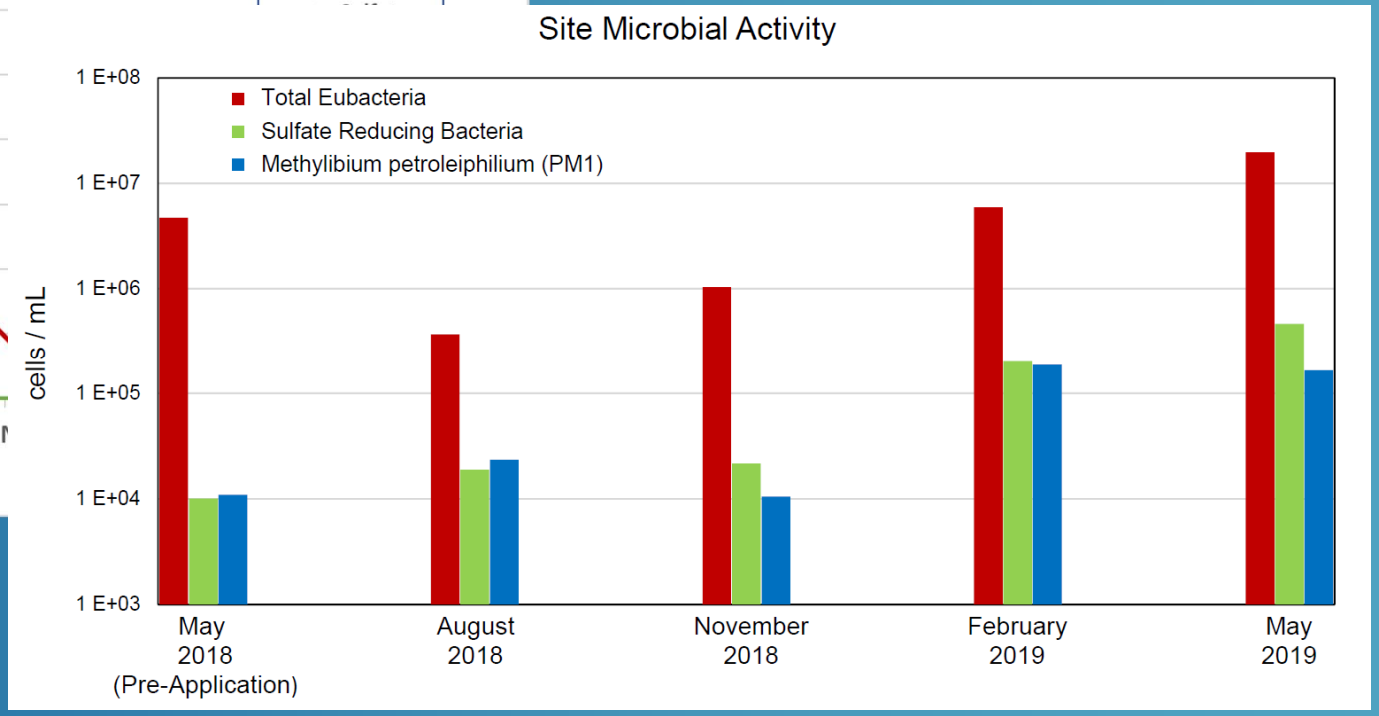


REGENESIS

Case Study: South Bend, USA

Results:





REGENESIS

Thank you

Any questions?

Gareth Leonard
Managing Director, Europe
REGENESIS
+44 1833 630 411
gleonard@regenesis.com

PROTE Technologie
dla Środowiska Sp. z o. o.

26 Firlika Str.
60-692 Poznan
Phone: +48 61 654 55 70