



REGENESIS[®]

Sulfidated Colloidal Zero-Valent Iron
For Groundwater Treatment

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Europe



What is In Situ Chemical Reduction (ISCR)?

- Term used since the 1990's
- Category of in situ groundwater remediation technologies where treatment occurs primarily by chemical reduction of contaminants
- Emphasis on abiotic reduction:
 - Reductant supplies electrons
 - Contaminant accepts electrons: TCE loses Cl, gains H
- Can occur naturally, when stimulating anaerobic biological degradation or by addition of strong chemical reductants

What is Zero Valent Iron (ZVI)?

- Strong 'engineered' reductant
- Iron typically exists as Fe² and Fe³ oxides
- Fe⁰ is manufactured to be reactive

What are we trying to improve upon?

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

New ZVI Substrate

Engineered Zero Valent Iron product:

- Colloidal – particle size $<5\mu\text{m}$
- Sulfidated particle coating
- Glycerol suspension

This combination results in:

- Abiotic degradation
- ISCR enhanced biological degradation

S-Micro ZVI
Sulfidated Zero-Valent Iron



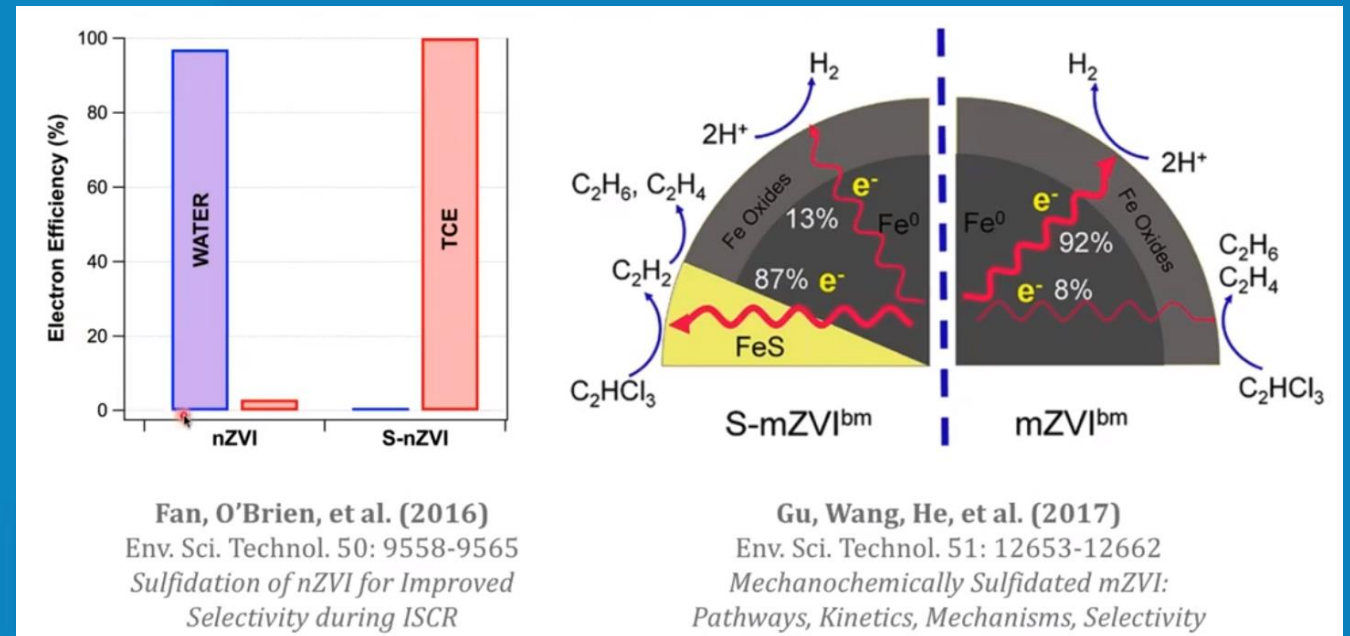
1) Reactivity: Focus on Sulfidation

ZVI also reacts with water = H_2

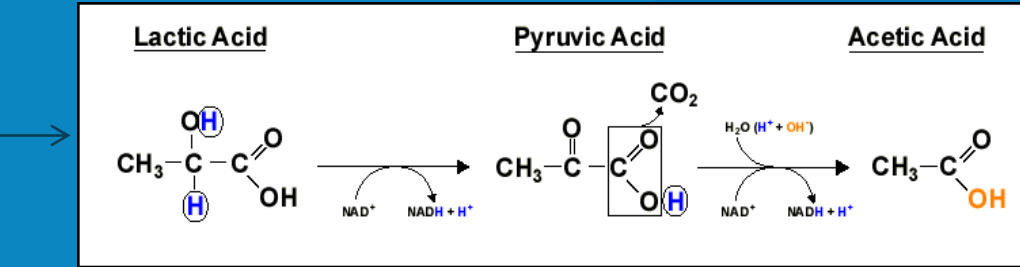
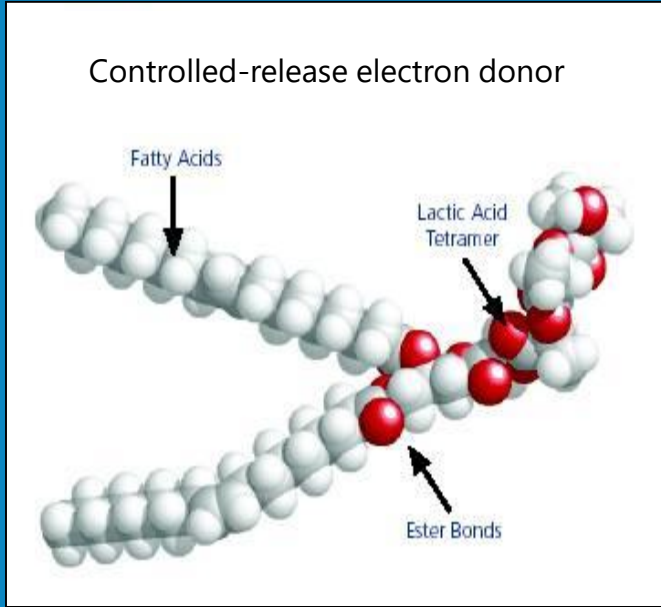
- Results in:
 - passivation
 - decreased persistence
 - Less treatment of the contaminant

Answer = sulfidate the ZVI surface

- Coats the surface of the ZVI particle with iron sulfide
- Results in an increase in Electron Efficiency (EE):
 - Minimizes reaction rate with water
 - Maximizes reaction rate with contaminants
- Sulfidation enhances reaction rate with chlorinated ethenes



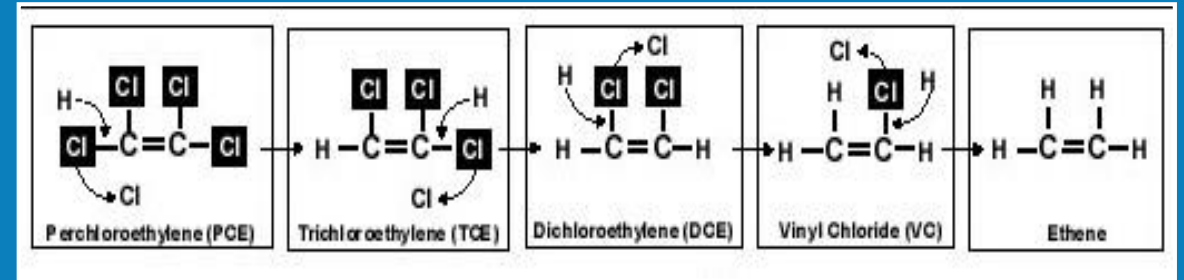
ISCR-Assisted Bioremediation



Fermentation

Dissolution

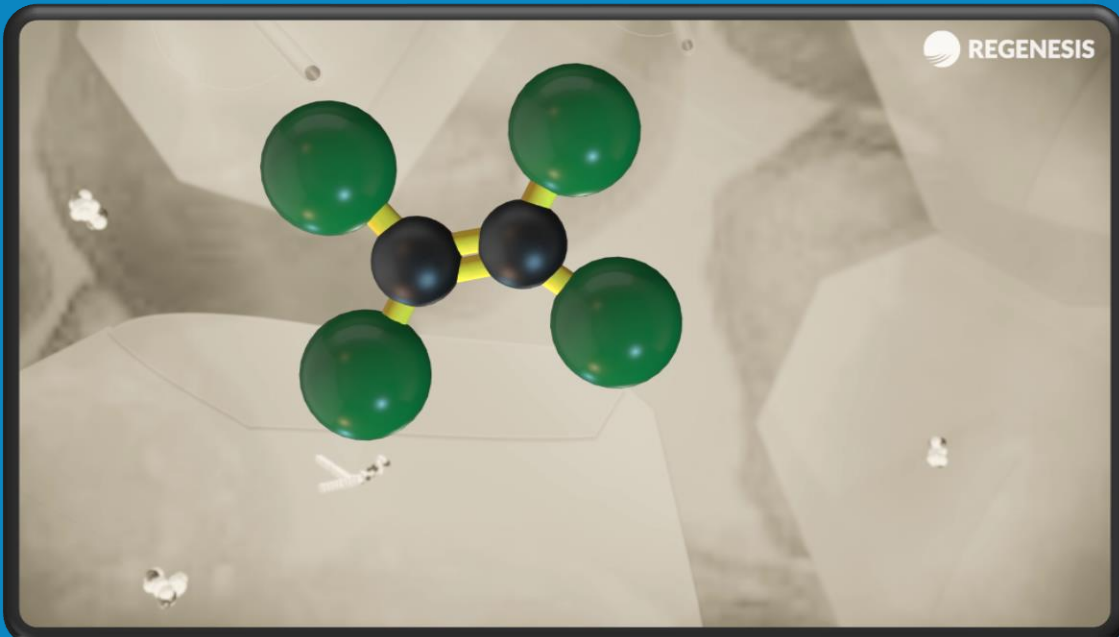
Hydrogenolysis



PCE → TCE → DCE → VC → Ethene

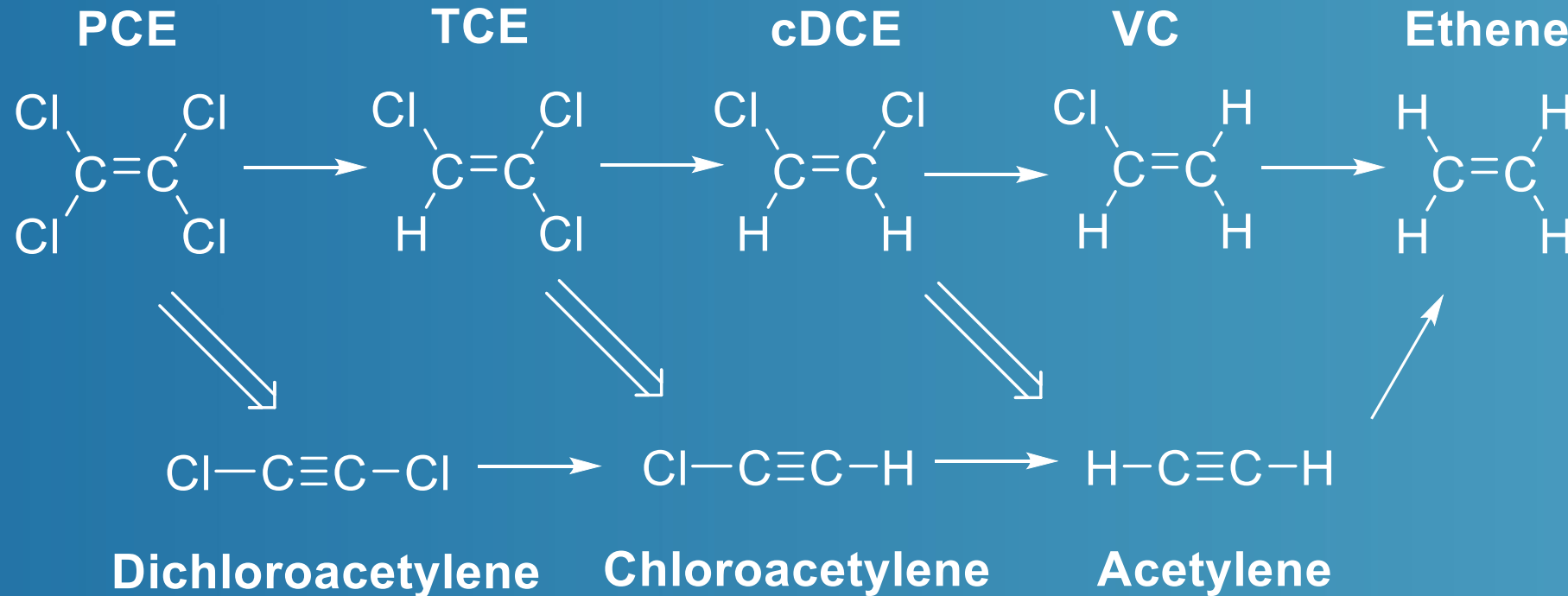
ISCR enhancement

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



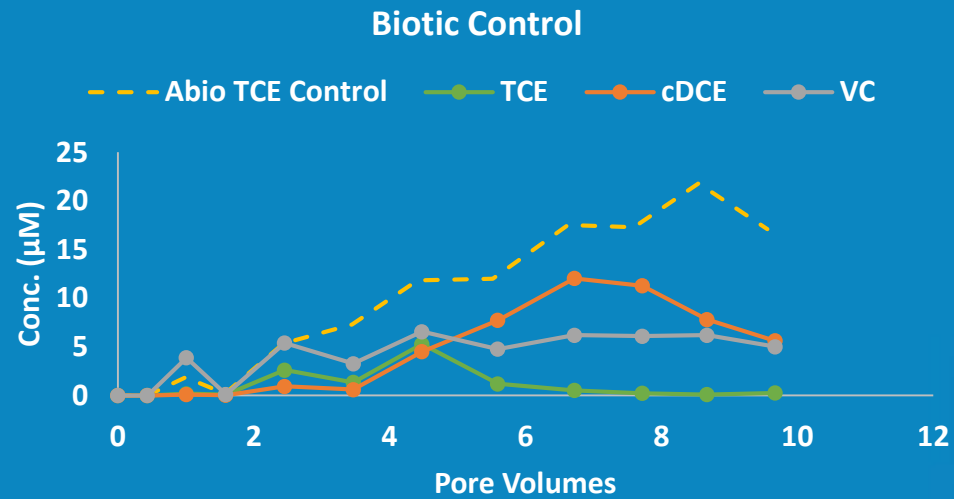
CHEMICAL (ABIOTIC) REDUCTION:

Reaction pathway can bypass toxic daughter products



ISCR-ASSISTED BIOREMEDIATION

BIOTIC COLUMN

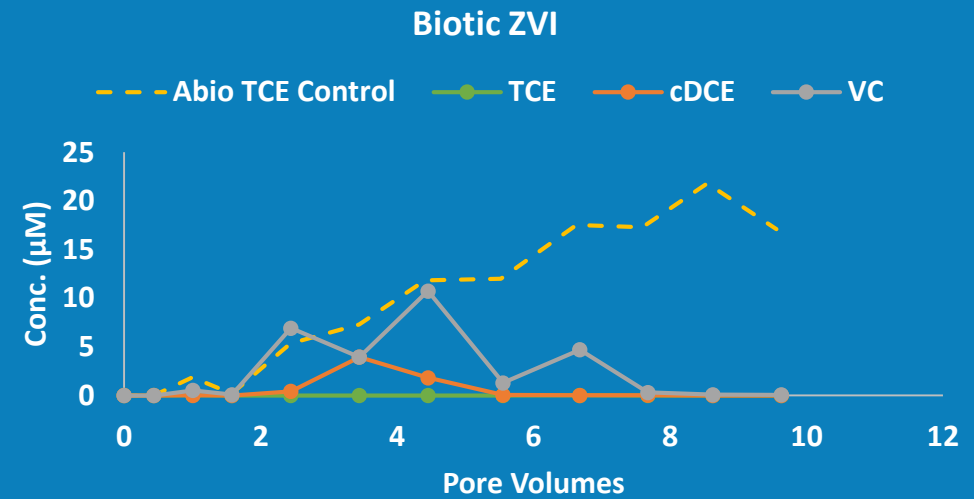


TCE removed at week 7

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

2) DISTRIBUTION: **Mixing and Injection**

Characteristics of
colloidal iron



Characteristics of
microscale iron



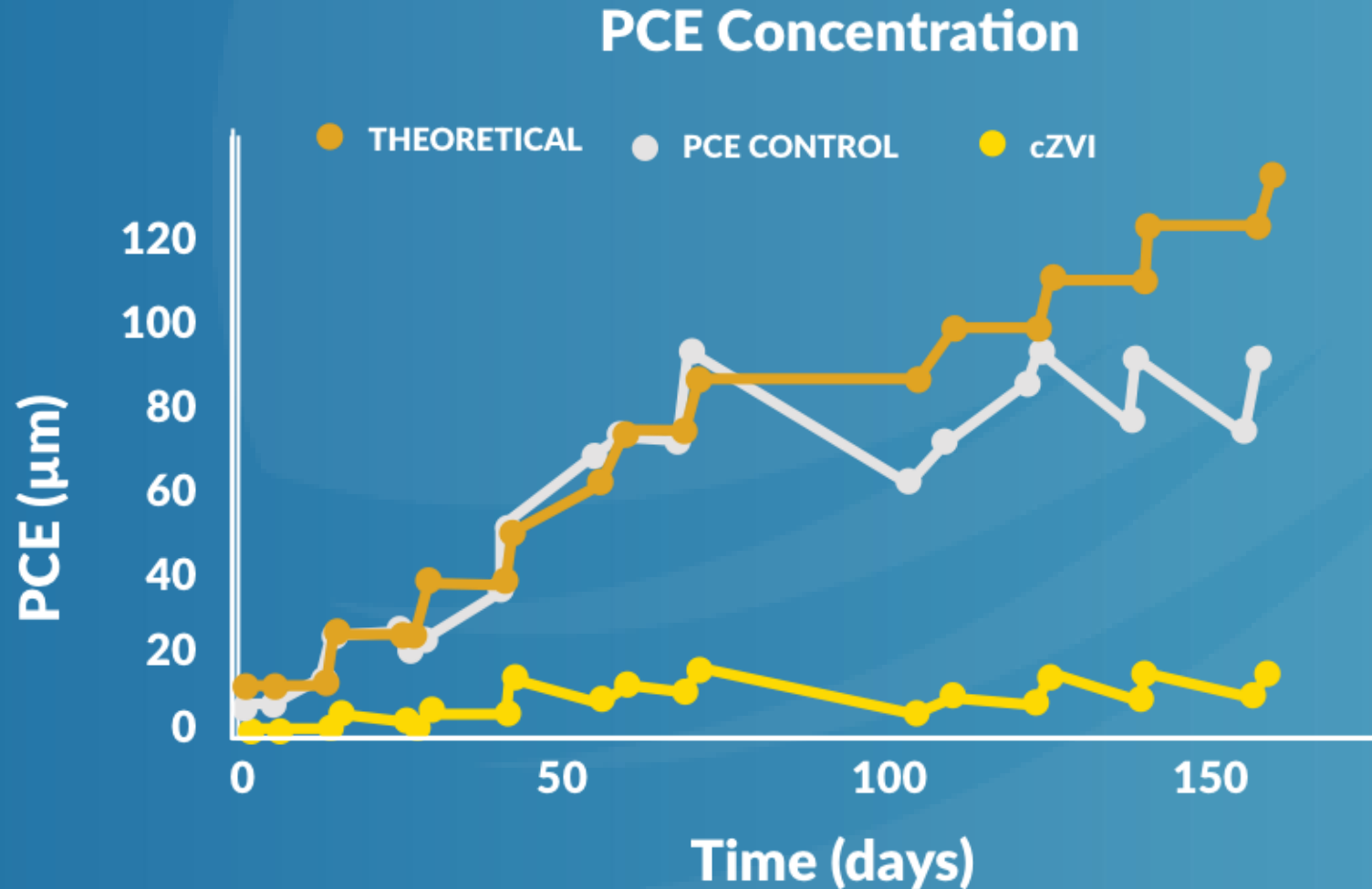
3) EASE OF USE

- 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



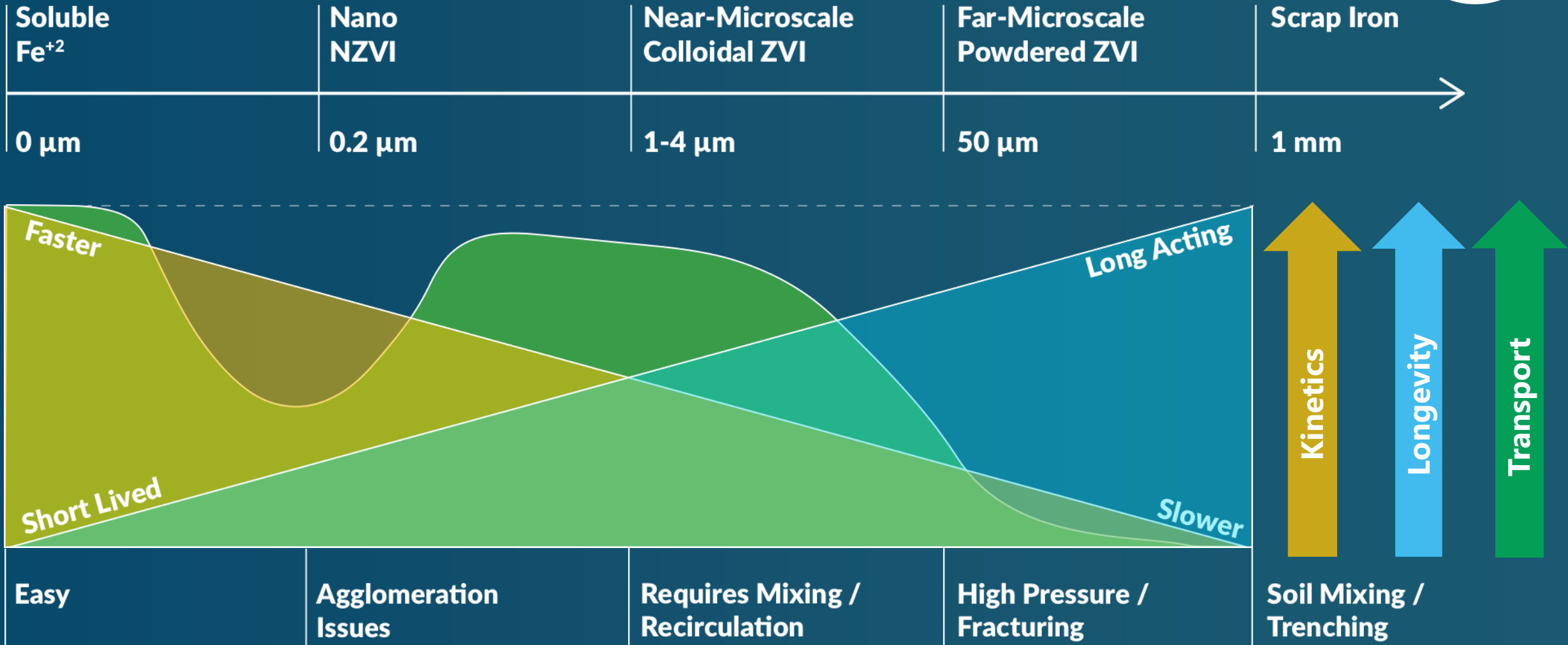
4) Persistence

- Improved EE from sulfidation
- Reduction in passivation

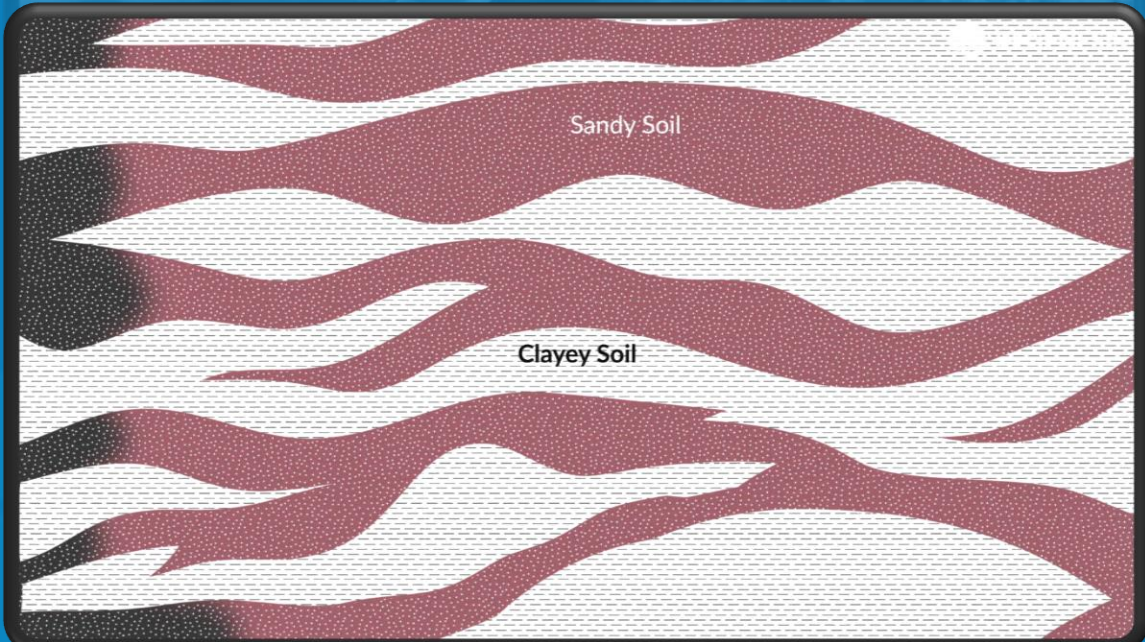




FEATUES OF DIFFERENT PARTICLE SIZE ZVI



Application



Case Study: Southern California Site



Case Study: Results

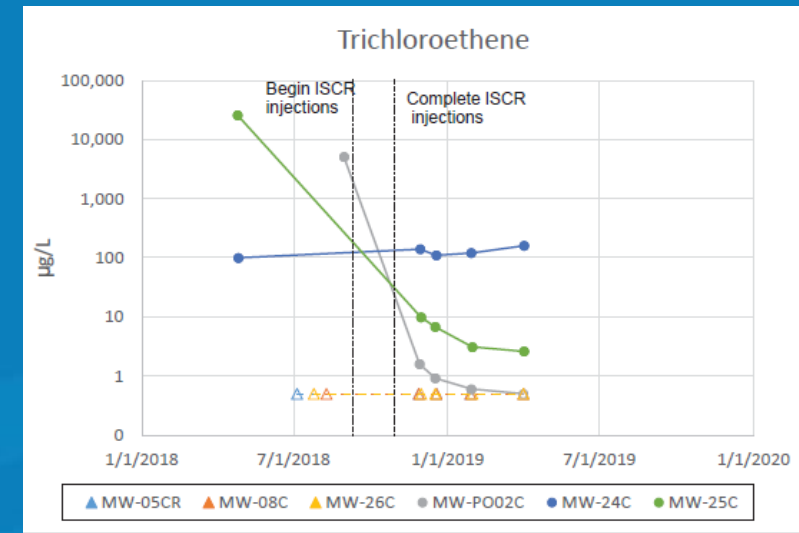
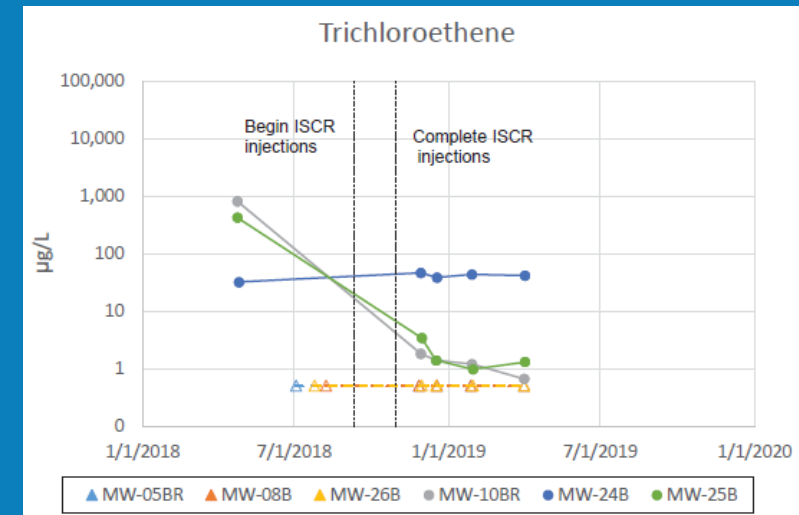
MW-25

Injection depth (mBGL)	Baseline TCE (µg/L)	6 months (µg/L)	% Reduction
3-11	20,000	7.3	99.96%
11-16	420	1.3	99.71%
16-23	26,000	2.6	99.99%
23-30	2300	51	97.78%

MW-10

Injection depth (mBGL)	Baseline TCE (µg/L)	6 months (µg/L)	% Reduction
3-11	320	82	74.38%
11-16	810	0.7	99.91%
16-23	5100	ND	100%
23-30	0.73	ND	100%

- Site sold
- Validation will continue for a further 18 months



Conclusions

- S-MicroZVI effective for a wide range of contaminants, particularly chlorinated solvents
- Unsurpassed combination of:
 - Reactivity
 - Persistence
 - Distribution
 - Ease of Use
- Can target high concentrations of contaminants
- Integrates with electron donor substrates and colloidal activated carbon treatment

Thank you

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