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The Evolution of Two Remediation Technologies: Combined In Situ Stabilization (ISS) and In Situ Chemical Oxidation (ISCO)

*Brant Smith, Evonik Active Oxygens LLC, Director of
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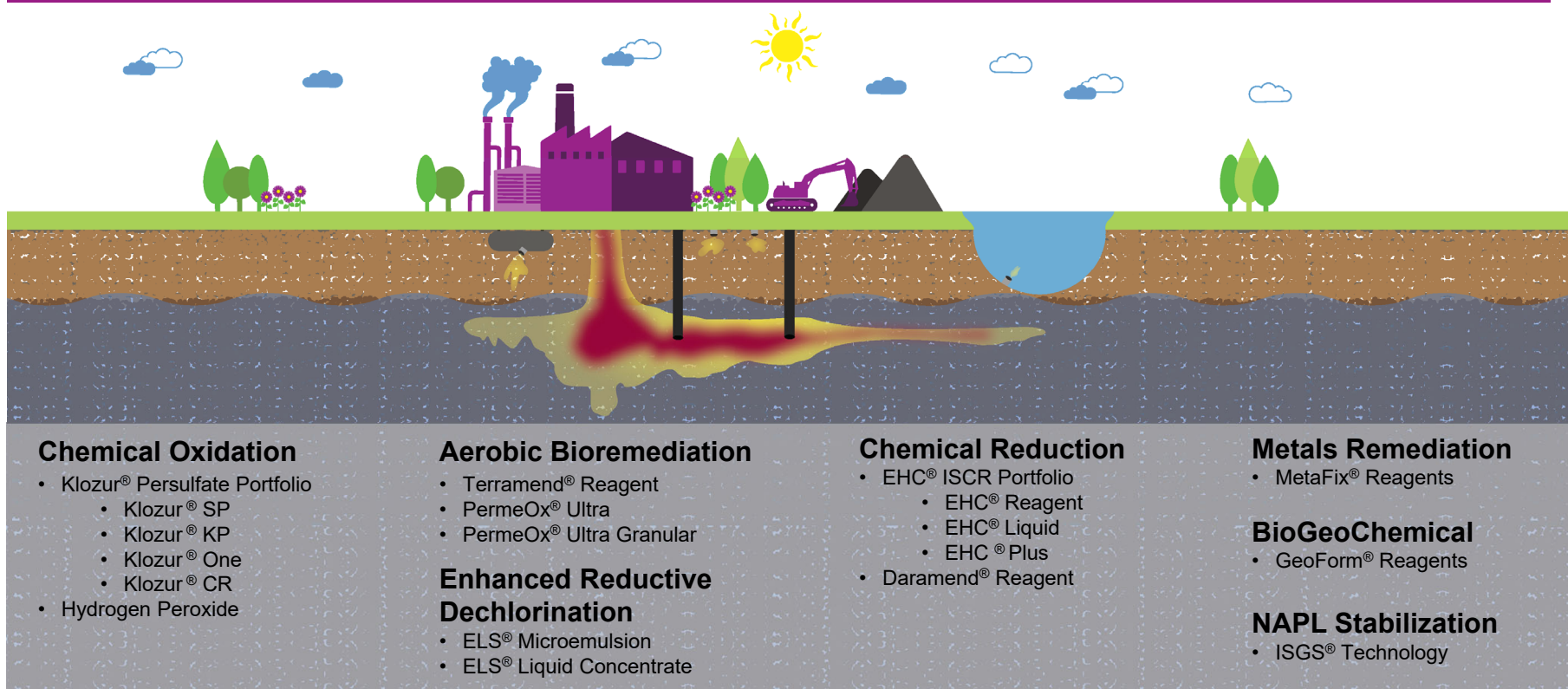
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Evonik Soil & Groundwater Remediation

Field-Proven Portfolio of Remediation Technologies



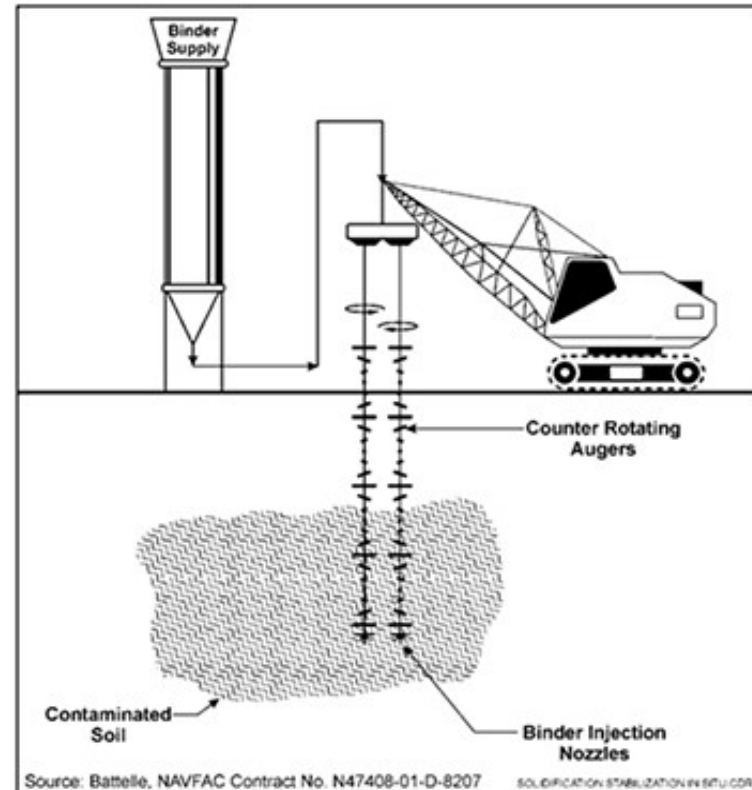
Presentation Outline

- Technology Overview
 - ISS
 - ISCO
 - Combined ISCO / ISS
- Why Combine?
 - Synergies
- Case Studies



In Situ Solidification and Stabilization

- Use of soil mixing to blend binding agent(s) with contaminated soils:
 - Portland Cement
 - Blast Furnace Slag
- Methods:
 - Stabilization:
 - Chemical processes that reduce leachability
 - Solidification:
 - Decreasing of surface area, hydraulic conductivity, effective porosity
 - Increasing compressive strength



Common Objectives of ISS

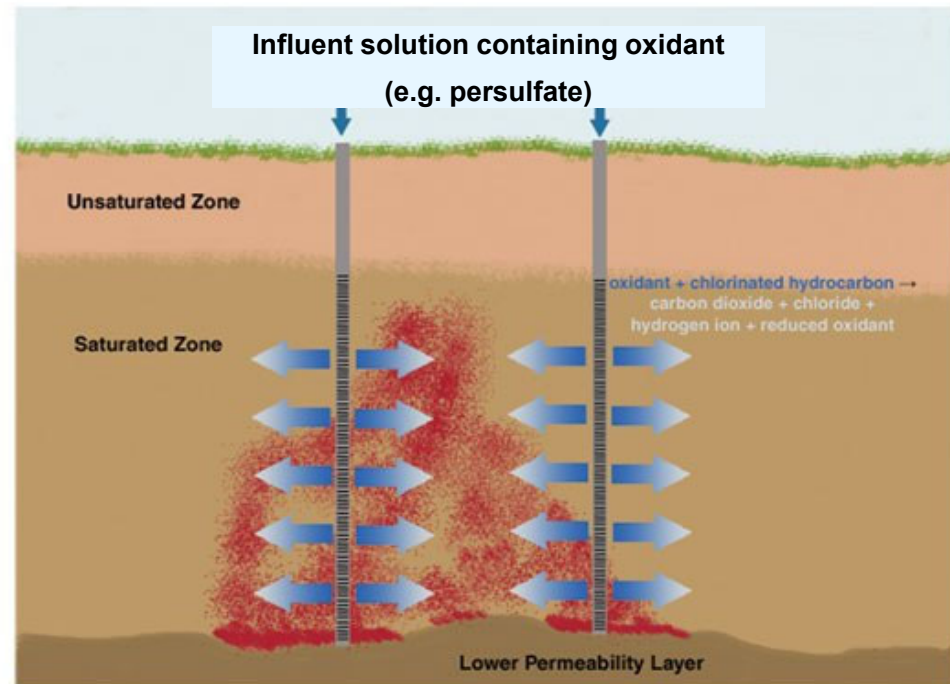
1. Reduced hydraulic conductivity
 - 2-3 orders of magnitude below native soils
 - 1×10^{-6} cm/sec
2. Unconfined Compressive Strength (UCS)
 - “Workable” ~20-60 psi
 - Hardened
 - ISS often targets 50 psi
3. Lower contaminant flux and leachate concentrations

General Relationship between Soil Consistency and Unconfined Compressive Strength				
Consistency	Unconfined Compressive Strength (UCS) Ranges			
	psi		kPa (KN/m ²)	
	Low	High	Low	High
Very soft	0	3	0	24
Soft	3	7	24	48
Medium	7	14	48	96
Stiff	14	28	96	192
Very Stiff	28	56	192	383
Hard	>56		>383	

Typical target range for “workable” soils ~20-60 psi

In Situ Chemical Oxidation

- What it is:
 - Oxidants are reagents that accept/take electrons from, or oxidize, contaminants of concern → CO₂
 - Typically applied via injection or soil mixing
- Objectives:
 - Contaminant destruction / mass reduction
 - Reduced concentrations in soil, groundwater, leachate and vapors



Examples (persulfate reactions):



Combined Remedy: Benefits

- Benefits:
 - Two remedies from single application
 - Ready for redevelopment/access shortly after application
 - Soil mixing
 - Homogenizes heterogenous contaminant
 - Ensures better contact with contamination
 - Can add more oxidant per application (if needed)



Courtesy of Stockholm Stadt



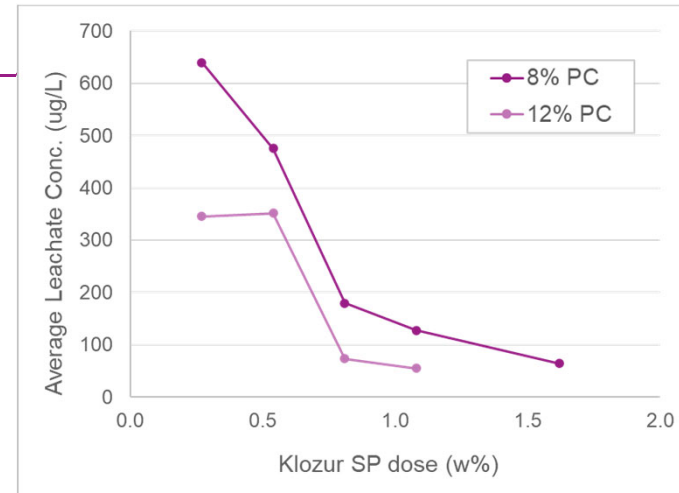
Courtesy of Bill Lang



Courtesy of Jacobs

Combined Remedy: Synergies

- Synergies
 - Alkalinity from ISS creates alkaline activated persulfate
 - ~2 parts PC to 1 part SP
 - Compounding effect:
 - Both technologies reduce leachate and soil vapors
 - Oxidizing organic results in stronger solidification
 - Lower hydraulic conductivity
 - Can result in less bulking/swell
 - Decrease handling/disposal costs



Klozur SP (% w/w soil)	8% PC		8% PC/BFS	
	Day 90 UCS (psi)	% of ISS only	Day 90 UCS (psi)	% of ISS only
0	90	100%	110	100%
1	105	117%	160	145%
2	110	122%	175	159%
4	75	83%	140	127%

ISCO-ISS Successfully Remediates PCE DNAPL at Former Dry Cleaner in Residential Neighborhood

Location: Former Kent Cleaners, Lansing, Michigan

Lead Consultant: Hamp Mathews & Associates

Contractor: Lang Tool

Regulator: EGLE

Contaminants: PCE (up to >1,000 mg/kg)

Goal: Reduce vapor intrusion risk

Treatment volume: 12,354 cy soil,

Reagent Dose (w/w soil):

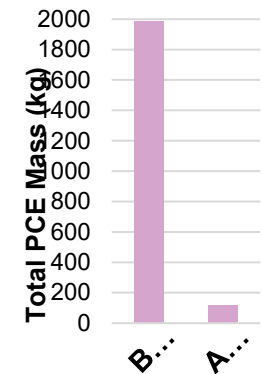
- Klozur SP: 1-2% (440K lbs)
- Portland Cement: 4% (1.6M lbs)



Results

- 94% reduction in PCE mass
- UCS of 25-50 psi (Day 60)
- Underlying GW conc. reduced by 90 to 99%

Saved client >\$2.5 Million compared to excavation estimate



ISCO-ISS Successfully Remediates Petroleum Contaminated Soils for Site Redevelopment

Location: Bolzano, Italy

Lead Consultant: Ladurner Bonifiche S.r.l.

Contaminants: Petroleum Hydrocarbons

Goals: Combination of contaminant reduction, soil stability targets, limit soil bulking

Treatment volume: 3,500 m³, from 3-8 m bgs

Dose (w/w soil):

- Klozur SP: 0.7-1%
- Portland Cement: 4-8%

Installation: 556 columns w. large diameter auger



ISCO Results & Goals:

- Benzene: 100% samples < 2 mg/Kg
- TPH (C4-C12): 100% samples <250 mg/Kg
- TPH (C13-C40): Over 50% samples <750 mg/Kg

ISS / Geotechnical Goals Achieved:

- UCS: 30 to 70 psi
- Permeability: 2.8 x 10⁻⁶ to 7.3 x 10⁻⁷ cm/sec

Less than 15% soil bulking

Summary

- ISCO-ISS is combined remedy of two established technologies
 - Single application
 - Treat/degrade significant portions of contaminant mass
 - Residual is solidified in a monolith
 - Several synergistic benefits:
 - Higher UCS, lower leachate, lower hydraulic conductivity
 - Target UCS range, soils can be reworked, if needed
 - Less soil bulking can decrease project costs
 - Site ready for redevelopment/access shortly after application

Thank you!

Questions?



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Thank you!

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