Delivery Tools for Combined Remedies

John Haselow
Redox Tech, LLC

1

Why Injection Isn't for Amateurs

2

BEFORE

3

AFTER

4

If you can set up your next shot, you are more likely to WIN!!!

5

ISCO vs ISCR

- Oxygen vs Hydrogen (and sometimes sulfide)
- For ISCO, persulfate, permanganate, peroxide, ozone, etc.
- Oxygen for biological processes
- For ISCR, zero valent iron (ZVI), polysulfide
- Carbon substrates (and maybe sulfate) fermenting to hydrogen

6

TOTAL OXIDANT DEMAND

No Matter How well the amendment is delivered, if the chemistry isn't correct, the treatment will fail

Total Oxidant Demand can vary between <0.1 to 155 g/Kg

Delivery Options

- Geoprobe Injection
- Fixed Wells
- Infiltration Galleries
- Hydraulic Fracturing
- Pneumatic Fracturing
- Dry Media Injection
- Mechanical Mixing

8

Geoprobe Injection

9

Geoprobe Advantages

- Lowest initial cost
- Flexibility to adapt injection strategy
- Can target multiple discrete intervals
- “Bottom-Up” or “Top Down” injection
- No well permits required in many States
- Widely available
- No precipitate fouling & can inject solids

10

Geoprobe Disadvantages

- Additional injections will require another geoprobe mobilization
- Greater potential for leaking along the casing vs. fixed wells
- Materials compatibility with Geoprobe rods
- Geoprobe injection points can be conduits for other injection points
- Clogging of geoprobe rods with flowing sands
- May get an operator not experienced with handling chemicals

11

Fixed Wells - Advantages

- Not paying for Geoprobe when not being used
- Can be used multiple times
- Wide variety of well materials available
- No problems with flowing sands (after installation)

12

Fixed Wells - Disadvantages

- If the well “fails”, you are “stuck”
- May have particulate fouling
- More difficult to isolate targeted interval – packers time-intensive
- Can’t perform fracturing through wells screens

13

Horizontal Wells

- Access difficult areas, under buildings, roads, etc.
- Long continuous screens perpendicular to flow
- Costs have steadily decreased over time
- Requires more careful consideration of fluid dynamics because injection pressure decreases over the length of the well

14

INFILTRATION GALLERIES

- Provide a linear discharge of amendments
- Difficult to control delivery rates because typically done under gravity
- Caution that amendments or changing geochemical conditions can lead to plugging

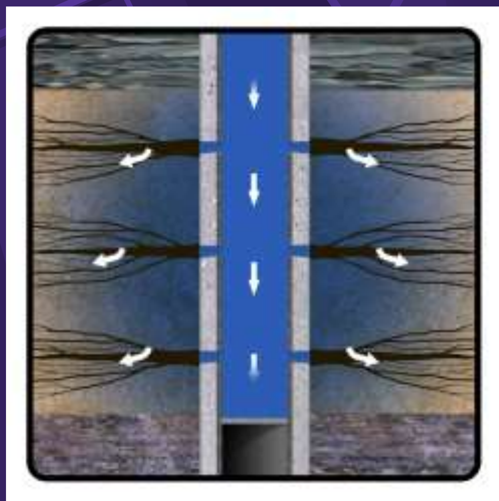
15

Hydraulic Fracturing

- Injection of water, solution or slurry at pressure that exceeds the lithostatic pressure and cohesive strength of the formation
- Results in short-term enhancement of soil permeability
- With proppant, long-term enhancement is achieved
- Increases radius-of-influence and injection rate

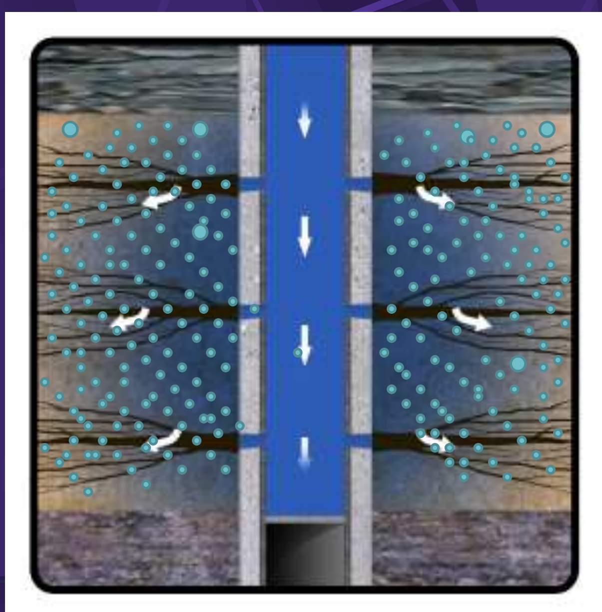
16

Hydraulic Fracturing



17

Secondary Delivery



- Carbon Substrate
- ZVI
- Hydrogen peroxide
- Calcium Peroxide

Pneumatic Fracturing

- Injection of gas at pressure that exceeds the lithostatic pressure and cohesive strength
- Results in short-term enhancement of soil permeability
- With proppant, long-term enhancement is achieved
- Increases radius-of-influence
- Larger volume of fluid than hydraulic

19

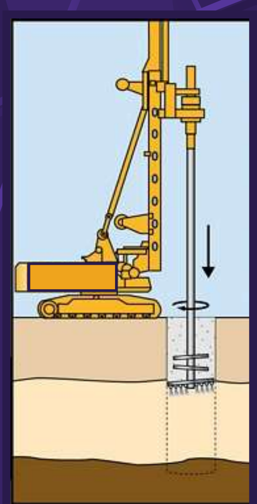
Soil Blending

- Efficient and uniform delivery of remediation amendments
- Production rates comparable to dig, haul and backfill
- No long term liability associated with disposal
- Costs can be 2 to 10 times less expensive than dig and haul, depending upon the extent of contamination
- No RCRA TSD permits are required
- Greener solution that results in treatment not transfer

When to Consider Using Soil Blending

- Cohesive or low permeable soils
- High volumes of amendment
- Timeframe for cleanup is short
- Shallow water table
- High disposal costs

Deep Soil Augers/Mixers



Source: www.haywardbaker.com

- Great for deep applications at well characterized sites
- Not as efficient for large areas.
- High Mobe/demobe costs

Excavator Style Soil Blenders

- **Soil Blenders** are limited in depth (~ 25’) without benching but:
  - Can efficiently blend large areas
  - Production rates 200 to 600 tons per day
  - Fit on standard size equipment so smaller equipment footprint
  - Lower mob/demob costs

Soil Blenders

ALLU

PMX-500
Working Depth: 16.4 feet
Constant Power: 90 HP
Dual Motors: Yes
Automatic Power Control: No
Reach Working Depth in Clay: No
Blend Weathered Rock: No

REDOX - LANG

Modified Lang
Working Depth: 25 feet
(with extension)
Constant Power: 200 HP
Dual Motors: No
Automatic Power Control: No
Reach Depth in Clay: Sometimes
Blend Weathered Rock: Maybe

REDOX TECH

Redox Tech Custom
Working Depth: 25 feet
Constant Power: 295 HP
Dual Motors: Yes
Automatic Power Control: Yes
Reach Working Depth in Clay: Yes
Blend Weathered Rock: Yes

Stabilization

- Commonly cited shortcoming is that soil blending lowers cohesive strength and loading rates
- However, Portland cement, lime, or fly ash can be blended to improve soil geotechnical properties
- Also, stabilization can be an effective method for in place treatment (activated carbon often added)
- Typical cost is about $5-10 per yard

REDOX TECH, LLC

Case Study

- Former manufacturing facility in NC
- Treated an area of ~2800 sq ft from 4 to 24 ft bgs
- Potassium permanganate applied at a loading rate of 5 g/kg (3,100 tons) to treat Vinyl Chloride concentrations of <100ppb in soil
- Post blending samples all Non-Detect (<5ppb in soil)
- Site required immediate stabilization to allow vehicle traffic
- Applied 60,000lbs of Portland cement to upper 5 feet of soils

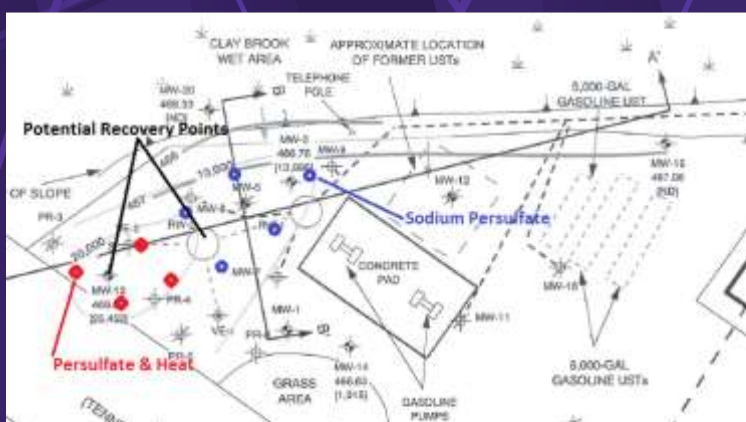
Adding 3 wt% Portland

Blending Portland

Case Study No. 1
Sodium Persulfate and Heat
Plymouth, New Hampshire

- Active convenience store and gas station.
- Three underground storage tanks (5,000 to 8,000 gallons) located approximately 40 feet northeast of treatment area.
- Gasoline release was detected in early 90’s and between 1994 and 1998 a pump and treat and SVE system was operating to remove product. System shut down in 1998.
- Passive recovery was conducted in the early 2000’s. Only recovered 4 gallons.
- MW-13 has product from sheen to 0.4 feet. Recovery wells are located near monitoring well.

Treatment Area (~ 2,500 SF)



31

Injection Plan

- 2,500 Square Feet.
- Four black iron injection points installed in area of MW-13 and RW-2. Five direct push points for dissolved plume.
- 8,500 pounds of sodium persulfate was injected into all 9 injection points. This was done first.
- Injection points received 450 gallons of a 25 wt% sodium persulfate solution.
- Two steamers injected heated water (low flow) to raise temperature to 40°C following persulfate injection.

32

Results

- MW-13: ND for product thickness; 4,000 ppb of total VOCs. Product not detected in surrounding wells.
- Dissolved plume: 84% reduction to no change.
- Second injection with Oxygen BioChem (OBC) and there was 50% to 90% reduction.
- Nine wells are below standards and seven have been decommissioned (2015 report to NH).
- Project was completed in 2010/2011.

33