Spatial and Temporal Application of Two Remedial Technologies at an Active Industrial Site Help Manage Environmental Risks

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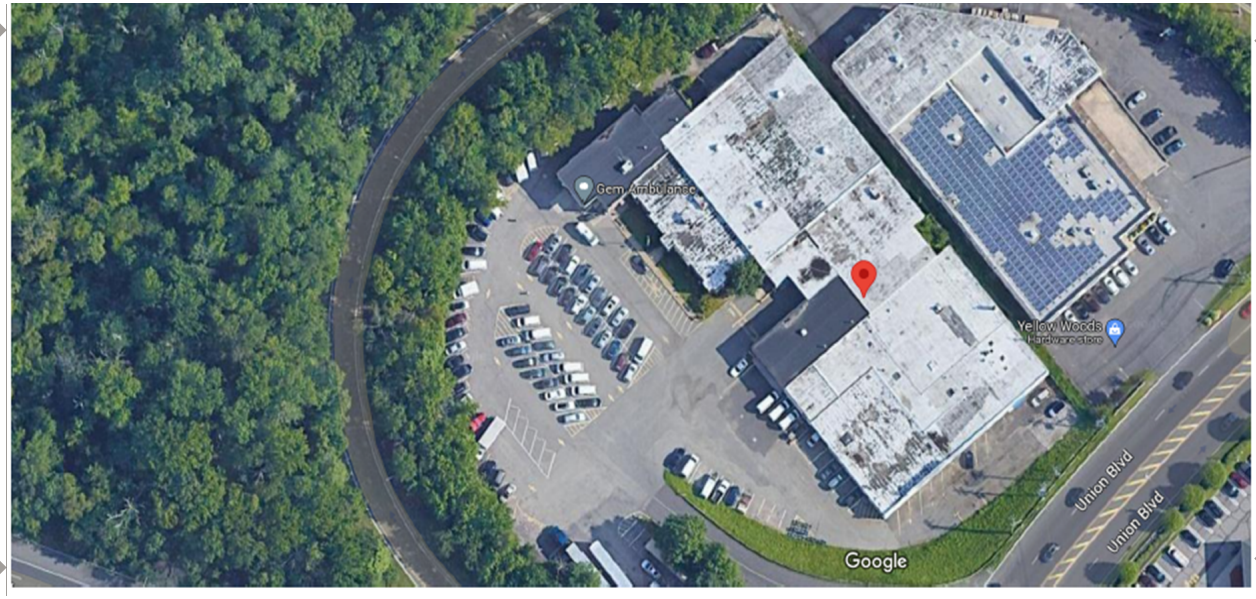
Presentation Outline

1. Site Background
2. Combined Remedies- Technical basis for Integration and Reagent Selection
3. ISCO- Design, Implementation and Results
4. Transition points between ISCO and Biogeochemical Reduction
5. Geochemical trends post ISCR implementation
6. Key Findings and Path Forward

Site Background

Former manufacturing Facility Northern NJ

Currently Light Manufacturing



P&T System, ZVI slurry wall (1990s)

Excavation (2019)

Source Area CVOC concentrations > 300 mg/L

Primary Contaminants are Chlorinated ethenes

Residual Chlorinated ethanes

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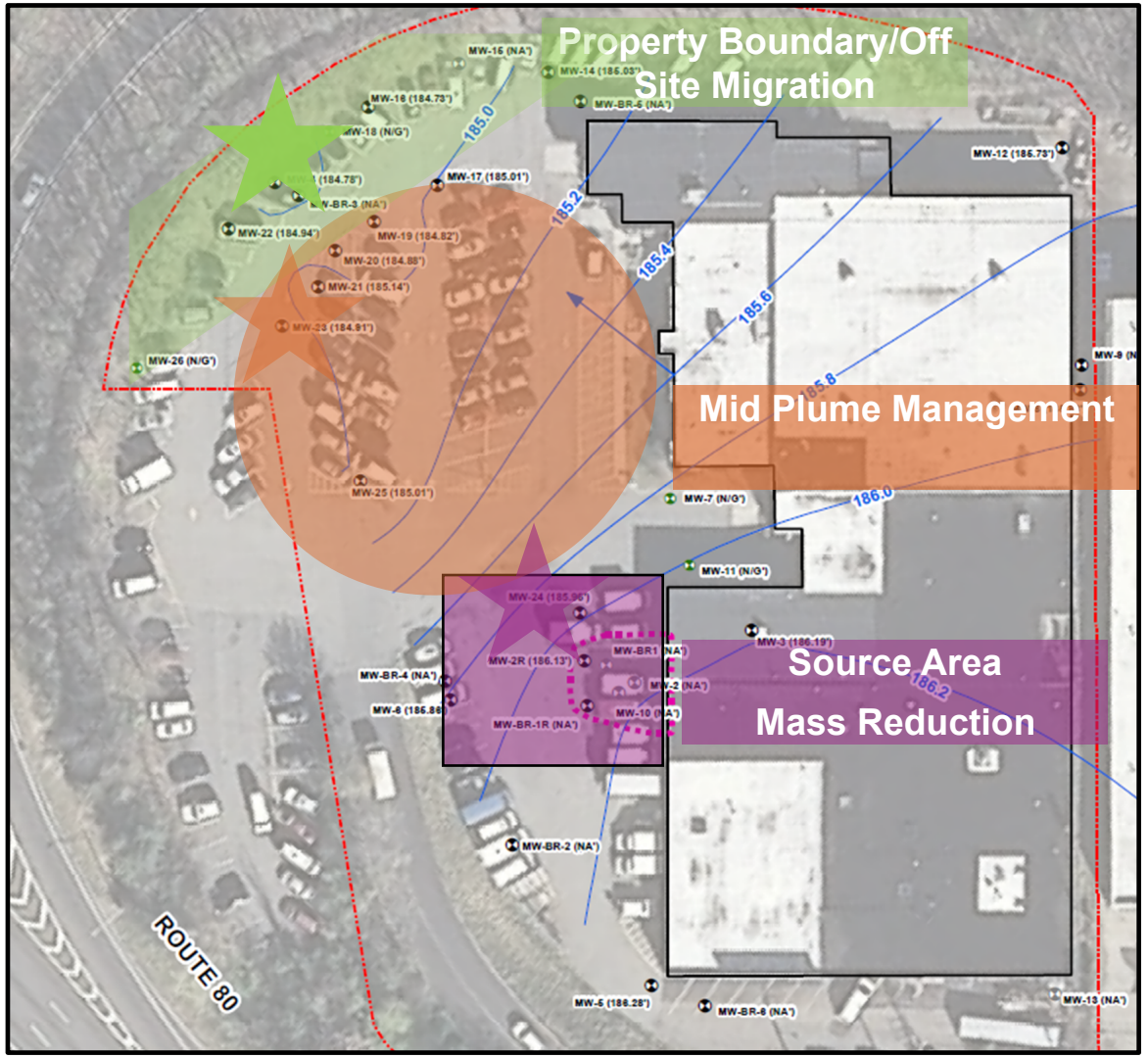
Site Background

MW-23	(5/13/20)	(11/11/20)	(5/25/21)
1,1,1-TCA:	ND	ND	ND
1,1-DCA:	30 J	ND	14 J
1,1-DCE:	93 J	12 J	43
Benzene:	ND	ND	ND
CIS-DCE:	13000	2600	7900
TRANS-DCE:	44 J	9.5 J	21
PCE:	ND	ND	7.9 J
TCE:	35000	4600	13000
Toluene:	ND	ND	ND
VC:	410	10	150
1,4-Dioxane:	6.8	ND*	ND*



MW-4	(5/13/20)	(8/11/20)	(11/10/20)	(5/25/21)
1,1,1-TCA:	ND	ND	ND	ND
1,1-DCA:	ND	1.4 J	2.7 J	ND
1,1-DCE:	30	9	18	11
CIS-DCE:	4900	1800	3100	1700
TRANS-DCE:	17 J	5.9	9.8 J	4.7 J
PCE:	ND	ND	ND	ND
TCE:	7200	1400	3400	2400
Toluene:	ND	ND	ND	ND
VC:	360	110	160	59
1,4-Dioxane:	8.2*	ND	11*	ND

MW-24	(5/12/20)	(8/11/20)	(11/11/20)
1,1,1-TCA:	ND	ND	ND
1,1-DCA:	ND	ND	ND
1,1-DCE:	400 J	430 J	410 J
CIS-DCE:	61000	74000	100000
TRANS-DCE:	300 J	300 J	300 J
PCE:	360 J	380 J	370 J
TCE:	330000	330000	320000
Toluene:	ND	ND	ND
VC:	640 J	650 J	750 J
1,4-Dioxane:	ND	ND	ND

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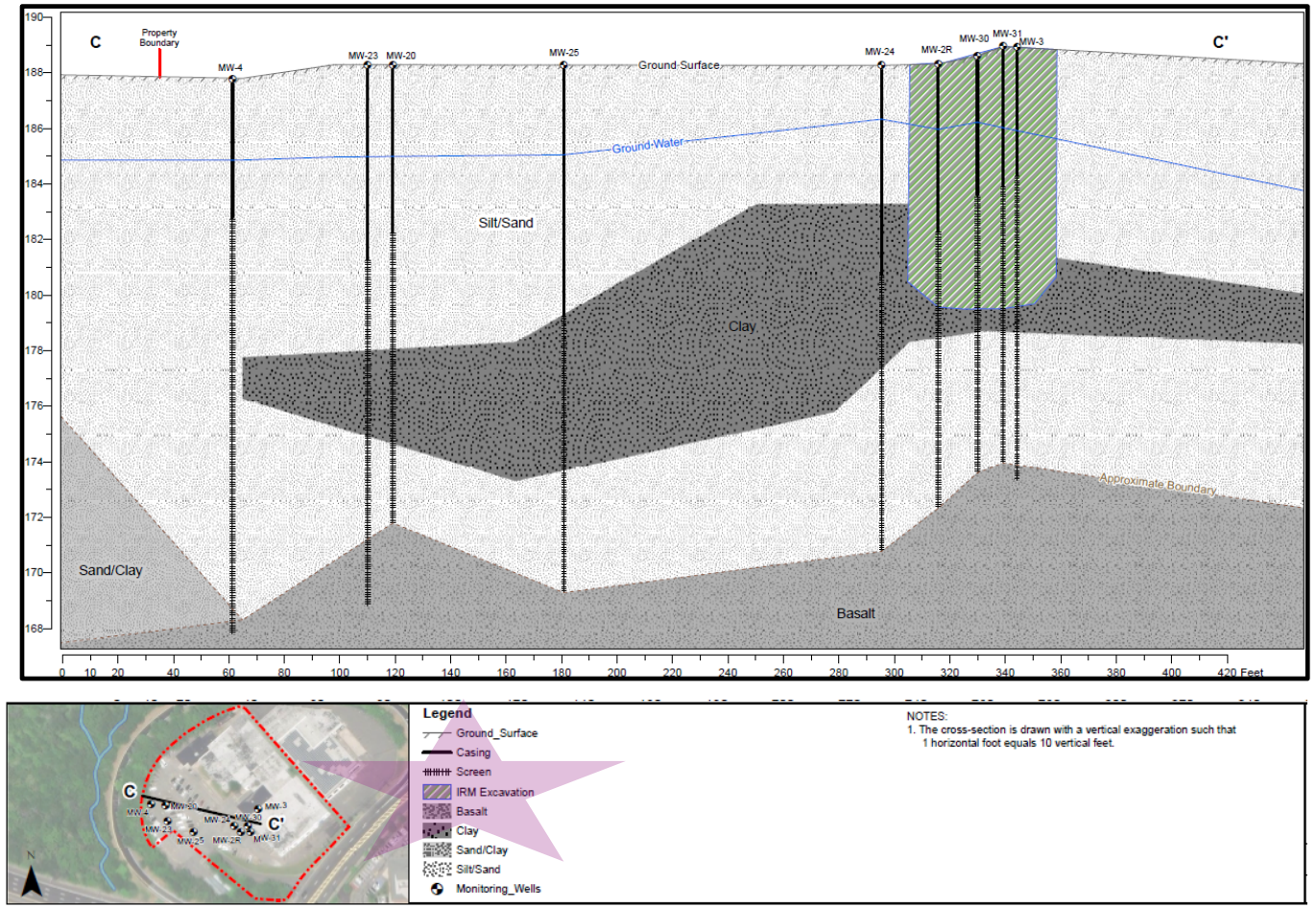
Site Background

Geology

- Overburden soils consist of glacial lake bottom sediments and till including silt, fine sands, and clay. Very low permeability due to prevalence of fine material.
- Groundwater in the overburden is encountered at approximately 2 ft – 5 ft bgs across the Site
- Bedrock in the area of the Site (~15 ft bgs) consists of dark gray basalt (volcanic rock) of the Preakness Formation.



Groundwater flow approximately 10-50 ft/yr.

Flows to the Northwest

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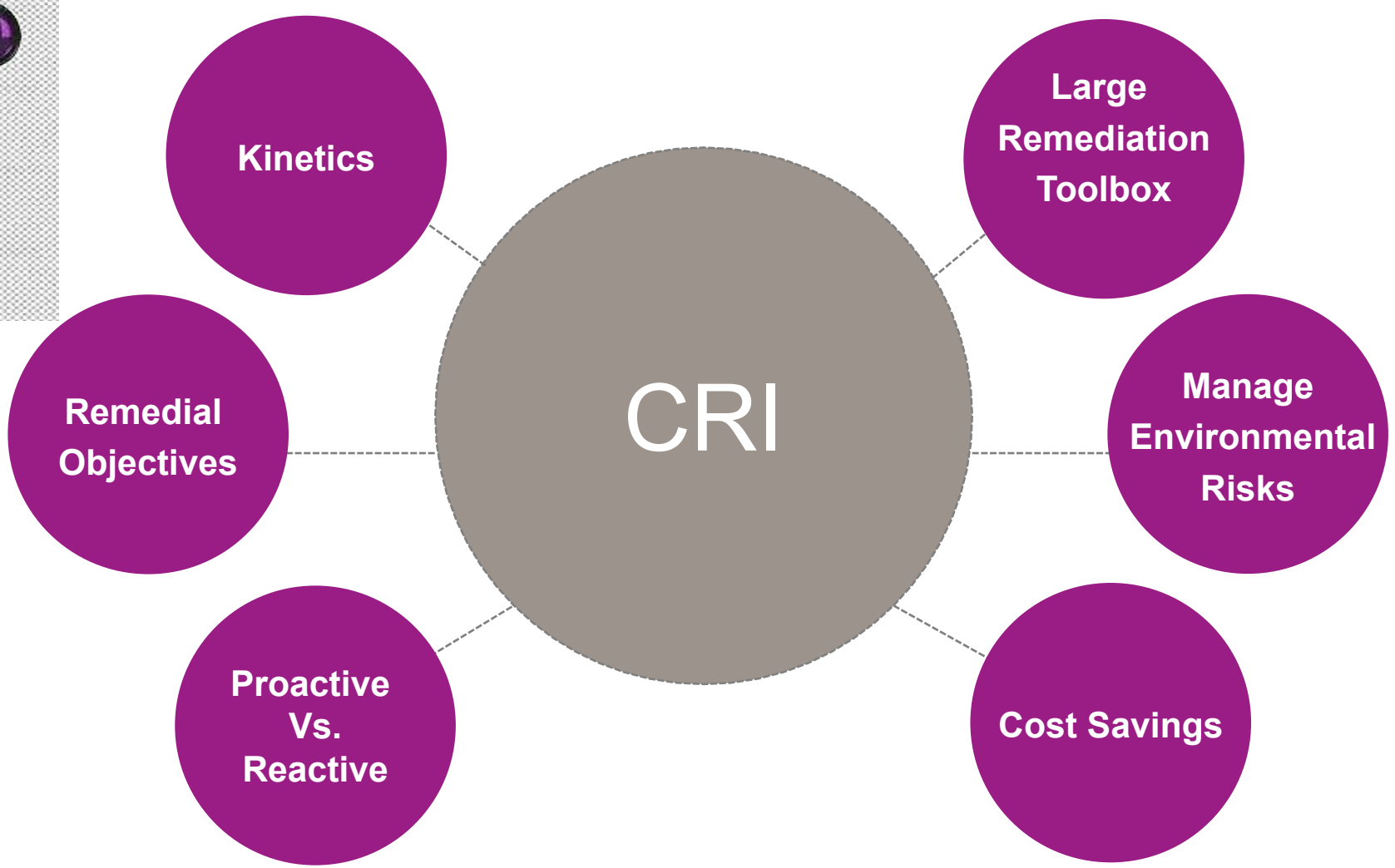
Combined Remedies Initiative (CRI)- Why?



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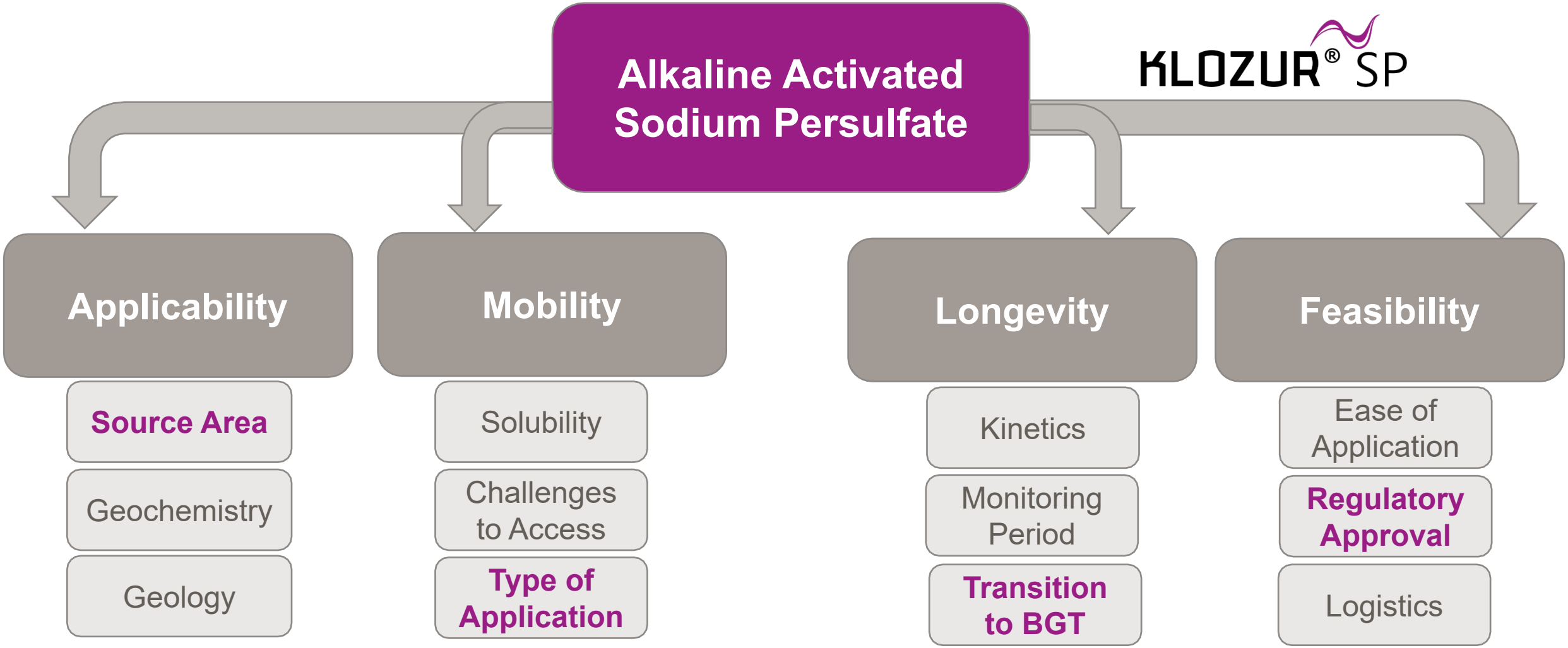
Technical Basis for Integration/Reagent Selection



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Timeline of Remediation

June-Aug 2019
Source Area Excavation

May 2020-Oct 2021
Pre-Injection Site Characterization

Nov/Dec 2021
ISCO 1st Application Source Area

Apr/May 2022
ISCO 2'nd Application Source Area

Oct/Nov 2022
Mid Plume ISCR/ISBGT

Jan-May 2023
Site Monitoring

Future Source Area / Plume Injections

MNA 2027?

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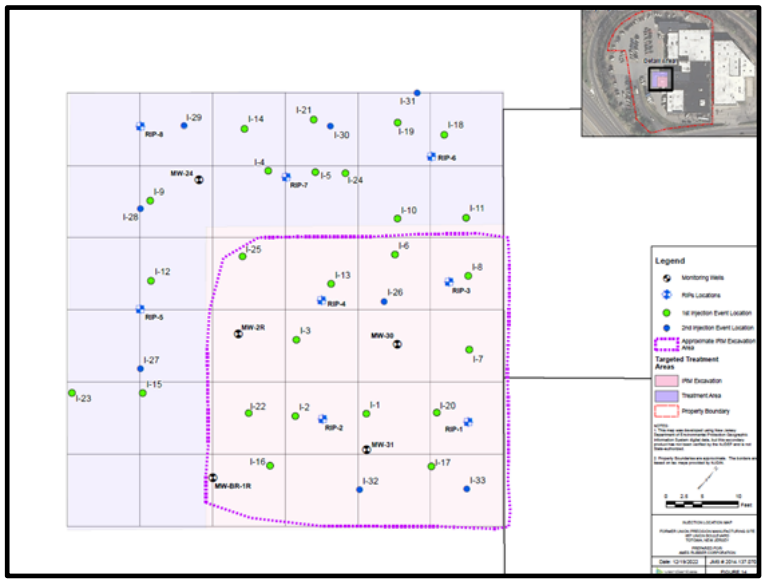
ISCO- Design and Implementation (Nov 2021- July 2022)

Design

- 3,600 sq. ft source area targeting 6ft vertical thickness (9-15 ft)
- 10,500 lbs of Klozur SP (20% solution) and 17,500 lbs of 25% NaOH (2 applications)

Injections:

- DPT (25 IP 1'st application)
- DPT/RIP 16 points (2'nd application)
- 15 days /application
- Surfacing mitigated by injection rate and solution concentration



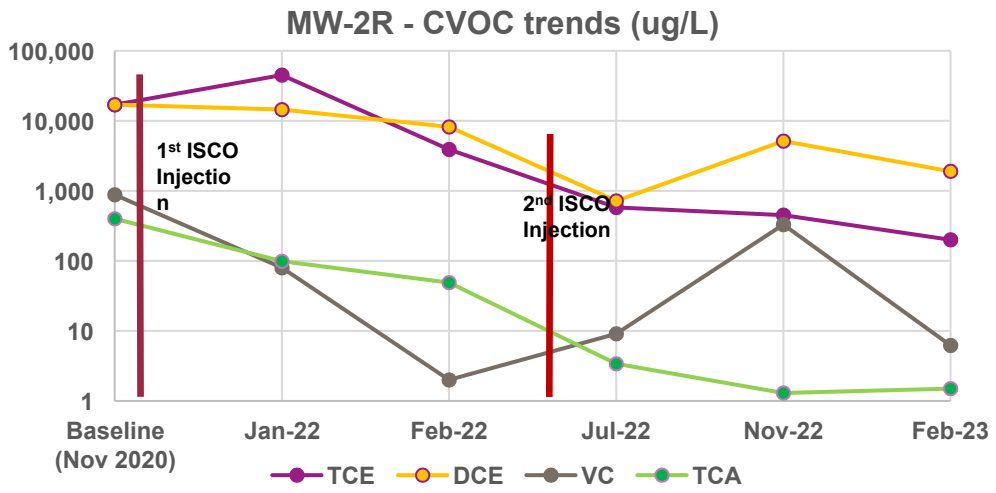
Dose (per application):

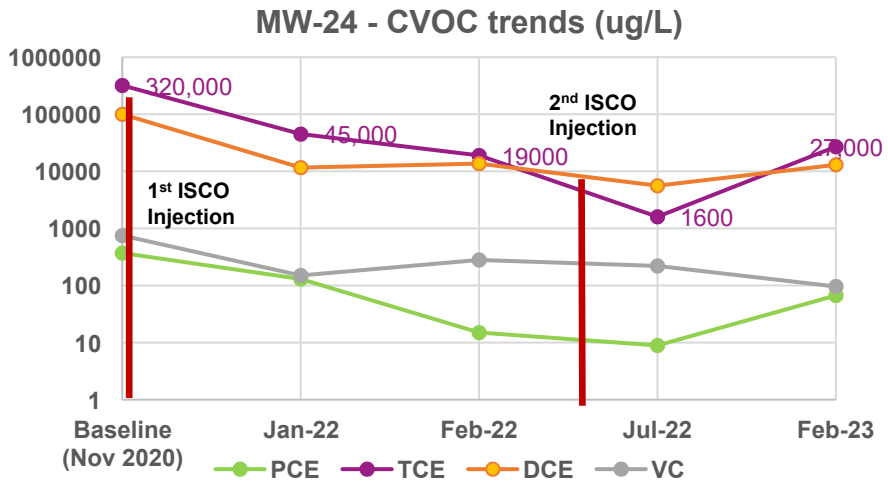
- Injection concentration 198-228 g/L
- Targeting ~ 24% of total pore volume (228*0.24 = 91.2 g/L)
- Sodium (19%) – 17,300 mg/L
- Sulfate (81%) – 73,800 mg/L

Monitoring Program:

- Monthly monitoring
- CVOCs in groundwater
- pH, ORP, Conductivity and persulfate
- Sulfate, sodium and alkalinity

ISCO-Post Monitoring Trends





Soil TCE (mg/kg)	Pre- ISCO	Post-ISCO
SB-1A	6,100	47
GP-18 (15)	4,510	660
S-9 (12.5)	8,720	0.8
S-9 (15)	5,690	4.8
S-3 (13.5)	6,900	400
S-4 (13)	1,100	18
S-5 (12) EMSL	16,000	50

>2-3 orders of magnitude reduction in soil concentrations

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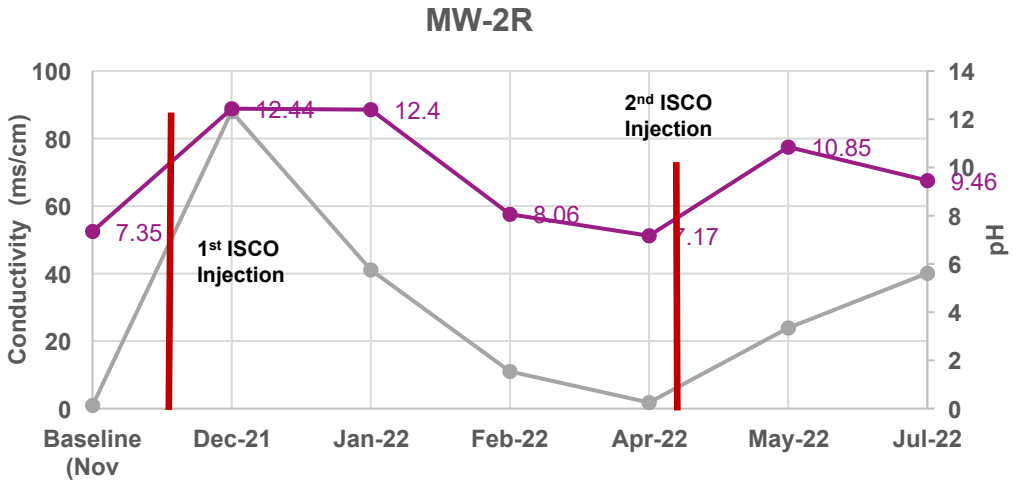
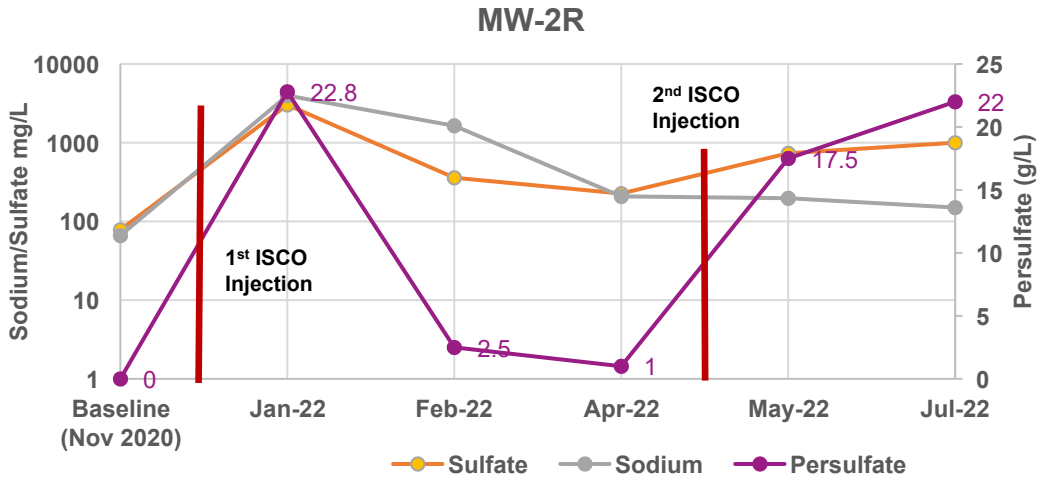
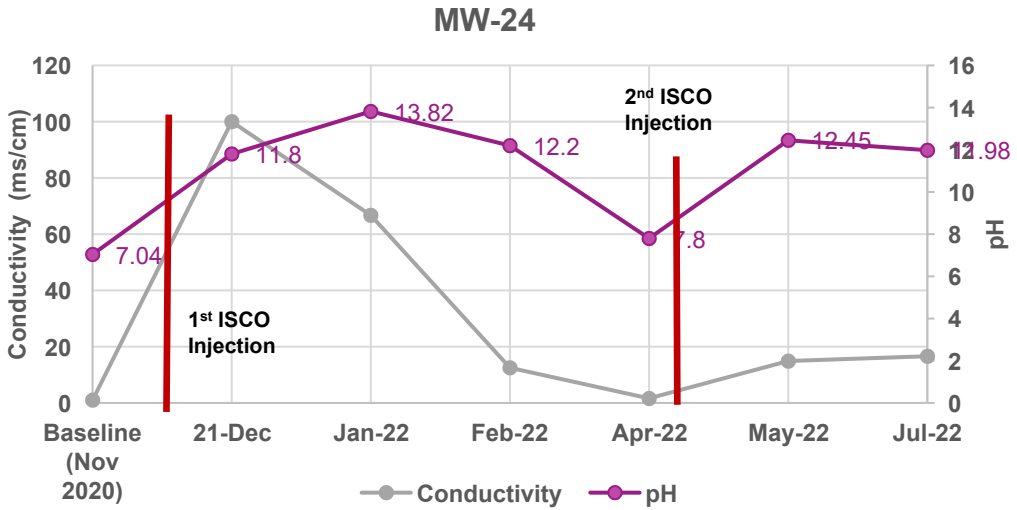
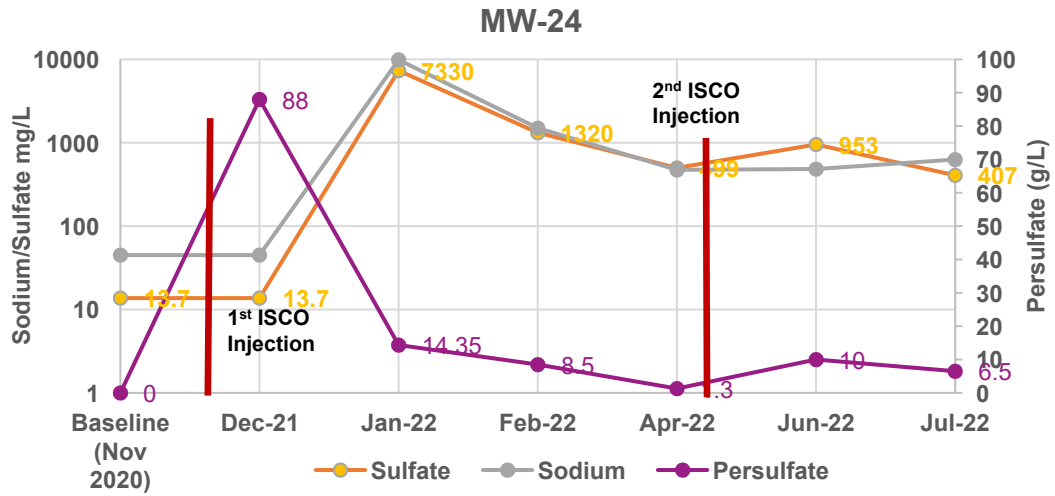
ISCO-Geochemical Signature









ISCO: Material + Injection costs 130K USD or 6$/ft^3

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Site Specific Transition Points

- Achieved orders of magnitude (OOMs) reduction in source area concentrations.

- Shift in geochemical conditions to support the next step in the treatment train
  - Source Area (high pH from ISCO)

  - Mid Plume (transition to reductive technologies)

- Downgradient area- Reactive barrier downgradient to prevent any migration of residual CVOCs (i.e., cis-1,2-DCE or VC)

Treatment Train Approach

The path from…….

ISCO

Using engineered products
Source area treatment
Mass reduction / Flux reduction
Alkaline Activated persulfate

Biogeochemical Transformation

ISCR Substrates (organic carbon + ZVI)
Residual sulfate from ISCO injections
Indirect chemical reaction (mackinawite, pyrite etc..)
Address back diffusion

Monitored Natural Attenuation (MNA)

Organic Substrate Fermentation
→ **Reduced Conditions**

Sulfate reduction by SRBs:

$$2CH_2O_{(s)} + SO_4^{2-} + 2H^+_{(aq)} \rightarrow H_2S + 2CO_{2(aq)} + H_2O$$

Precipitation of Ferrous Iron with Sulfide:

$$Fe^{2+}_{(aq)} + H_2S_{(aq)} \rightarrow FeS_{(s)} + 2H^+_{(aq)}$$

In Situ Biogeochemical Transformations

Pyrite FeS_2

Mackinawite FeS

EHC® Reagent
GeoForm® Biogeochemical
ELS® Microemulsion

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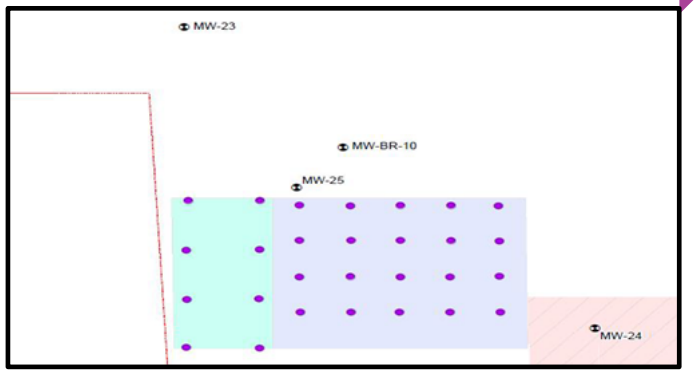
ISCR/ISBGT- Design and Implementation (Jul-Nov 2022)

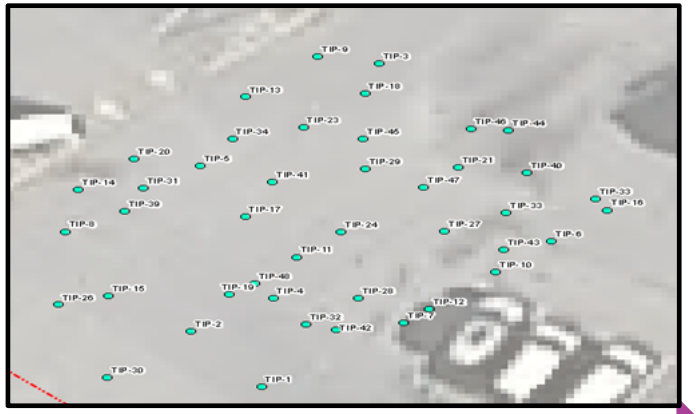
Primary Area

- 3,000 ft^2 targeting 6-13 ft bgs
- 15,200 lbs of EHC at 0.15% application rate
- 3,360 lbs of 25% ELS (2,000 mg/L)
- 9L DHC

Secondary Area

- 1,000 ft^2 targeting 6-13 ft bgs
- 3,360 lbs of 25% ELS (3,000 mg/L) and 265 lbs of Geoform Soluble Mix
- 3L DHC





Injections:

- DPT (48 Injection Points)
- Only 50% of EHC mass injected
- 22 Injection days
- Surfacing mitigated by injection rate and staggering IPs

Monitoring Program:

- Quarterly monitoring
- CVOCs in groundwater
- pH, ORP, Conductivity and Alkalinity
- TOC, Fe, Sulfate and Chloride

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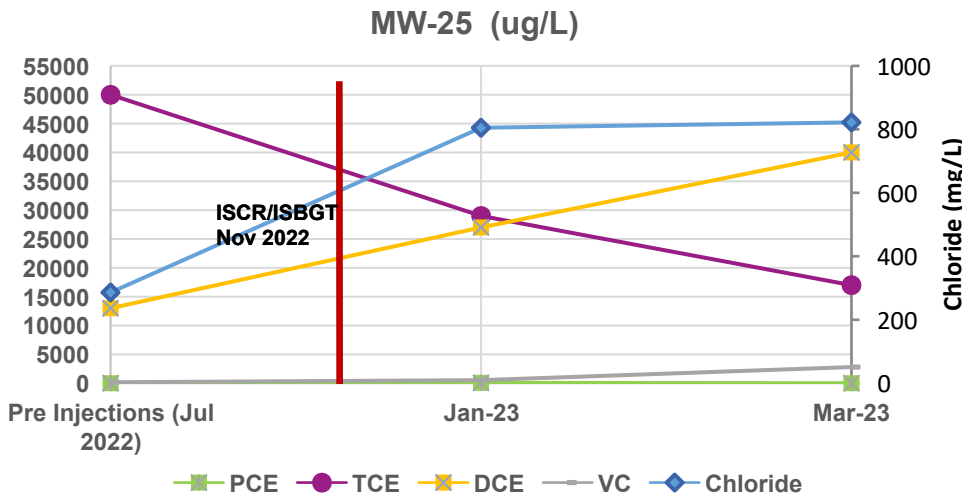
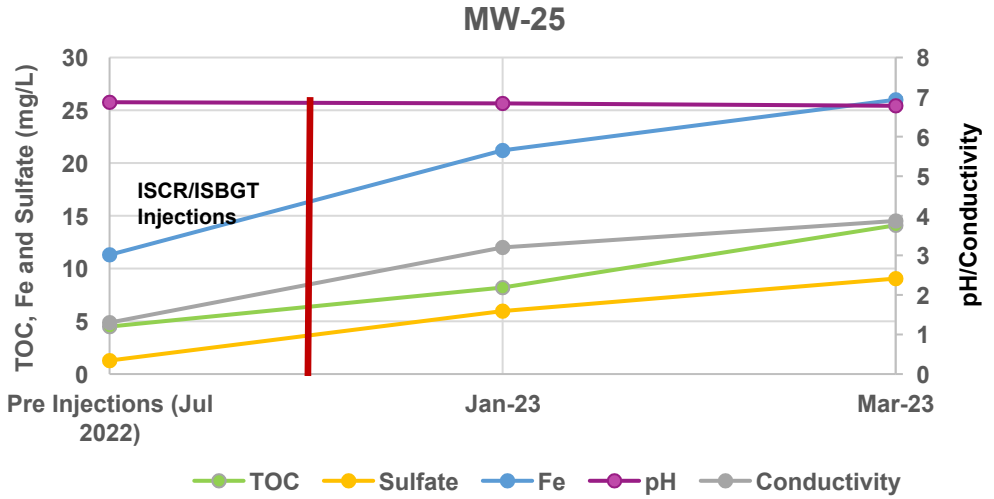
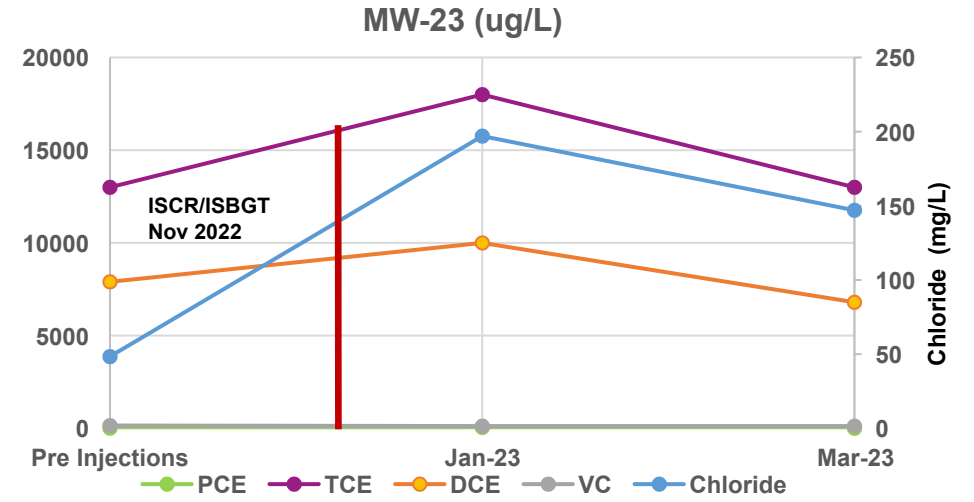
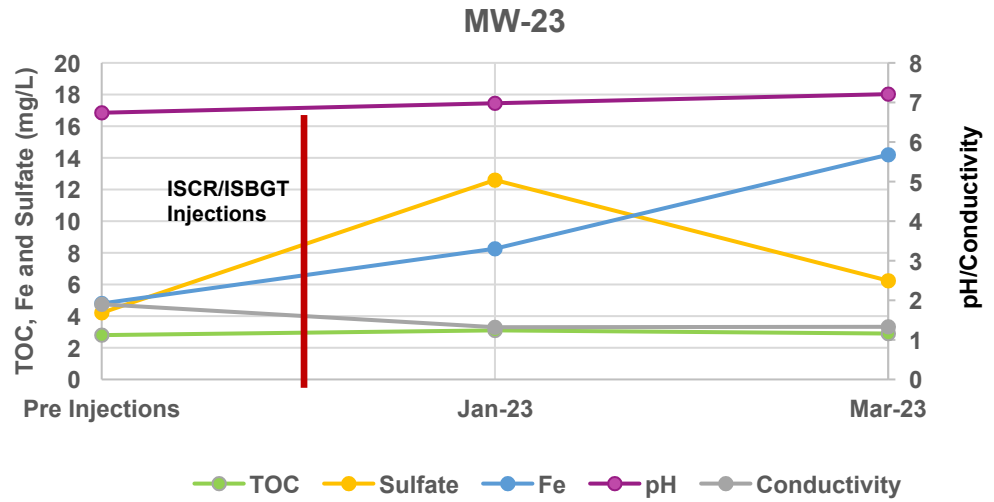
ISBGT –Results and Discussion









ISCR: Material + Injection costs 150K USD or 4.7$/ft³

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Key Findings and Path Forward

ISCO	ISBGT
• Very effective in reducing source concentrations by orders of magnitude • Focused Injection Application • pH above 12.5 s.u. persist in the source area within the sheeting from 2019 excavation • Will address 1,4-Dioxane • Residual sulfate paves way for transition to ISCR/ISBGT reagents. • Soluble reagents (Klozur® SP) pose fewer injection challenges	• Not 100% contact dependent (can be effective over a wider area) • Work in progress (transient). ISBGT mechanisms lasts for years . • Solid Reagents (slurry) increases injection time and pose challenges with surfacing in shallow aquifers. • CRI accelerates remediation timeframe

Additional Source Area injections Q3 2023/Q2 2024

Additional Mid-plume and PRB Injections Q3 2023/Q2 2024

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Injection Photos

ISCO

ISCR/ISBGT

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Questions?

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