

INSTALLATION OF A SUCCESSFUL ACTIVATED CARBON BASED PERMEABLE REACTIVE BARRIER FOR PETROLEUM HYDROCARBONS AND 1,2-DCA

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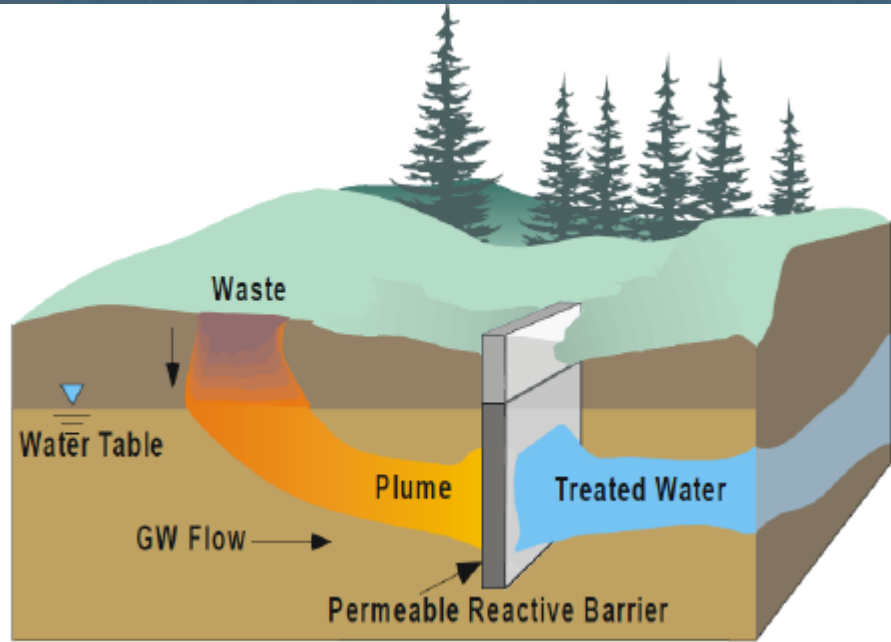
**2024 Chlorinated
Conference**

June 2-6, 2024 | Denver, Colorado

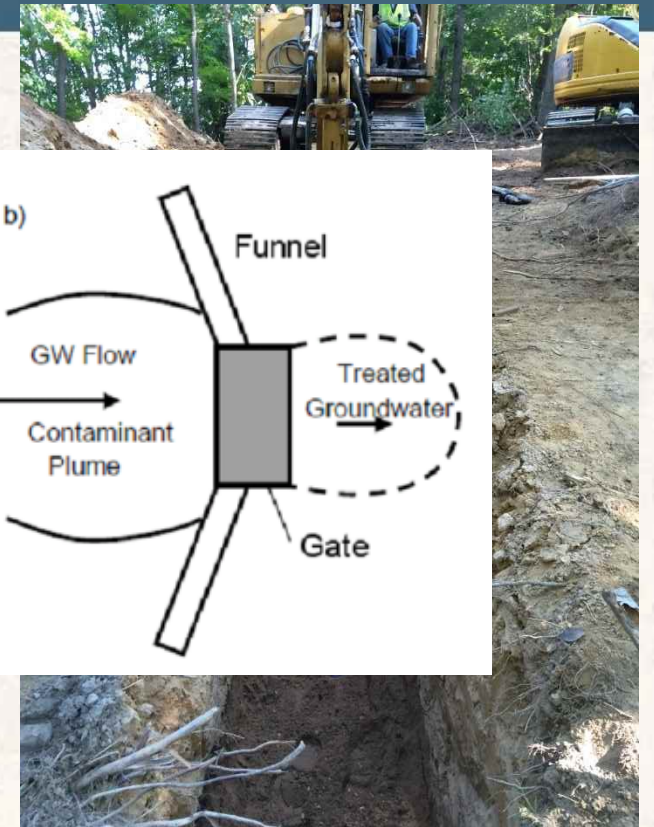
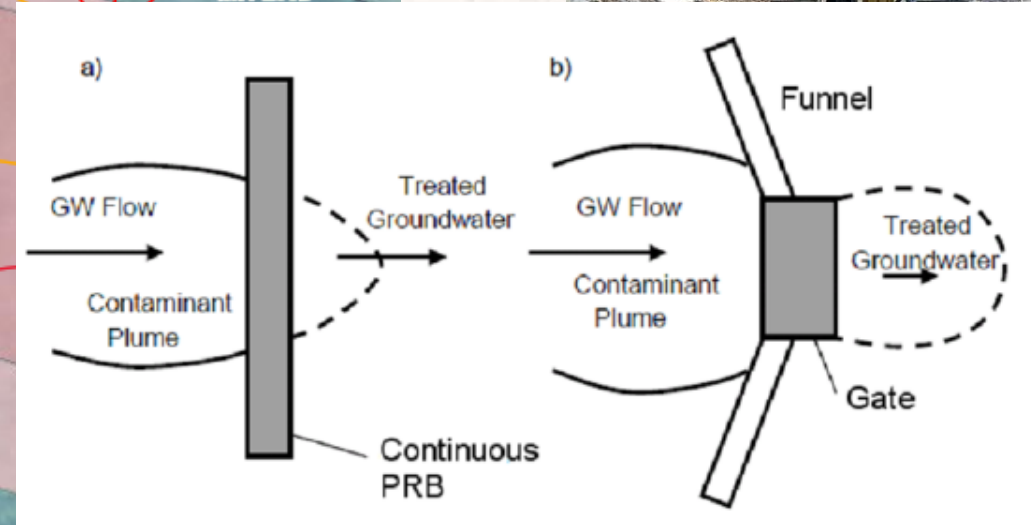
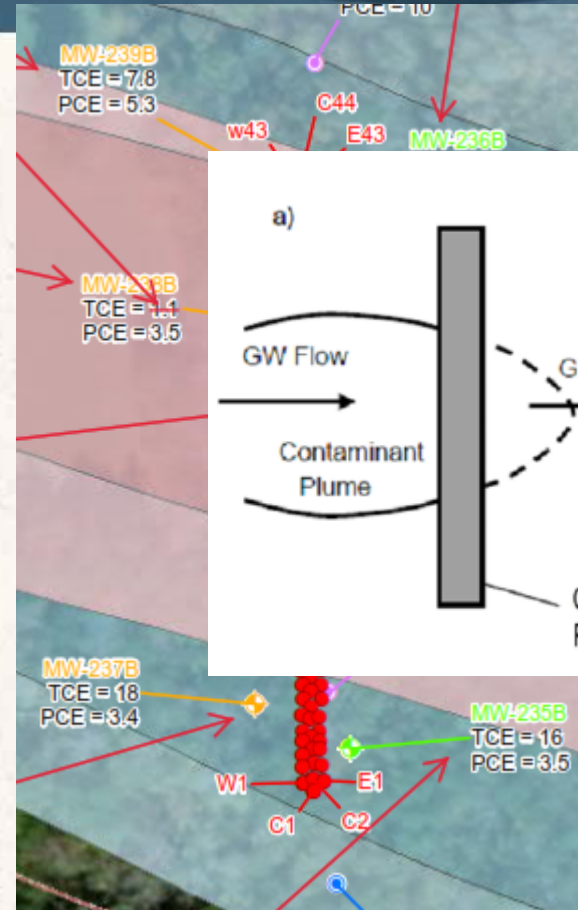
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Permeable Reactive Barriers (PRBs)

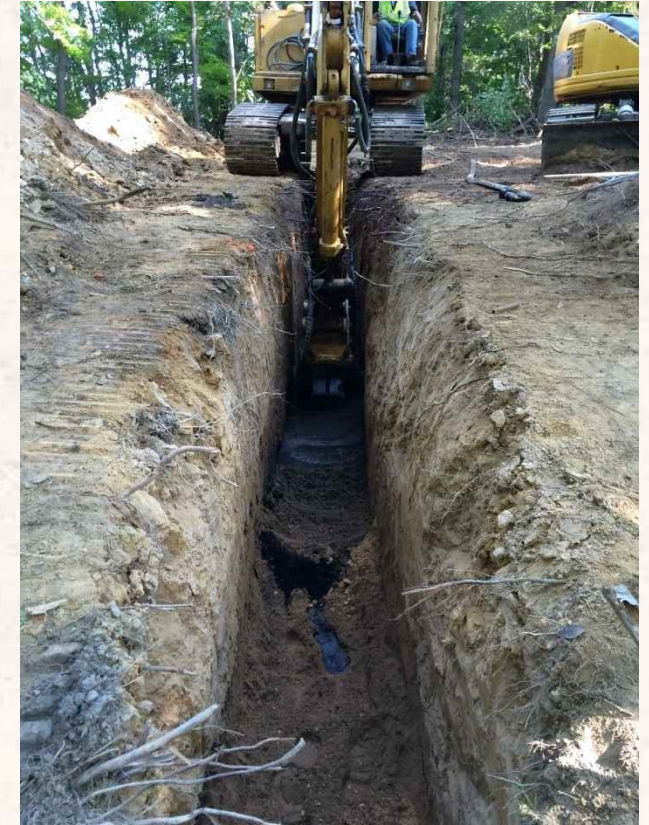
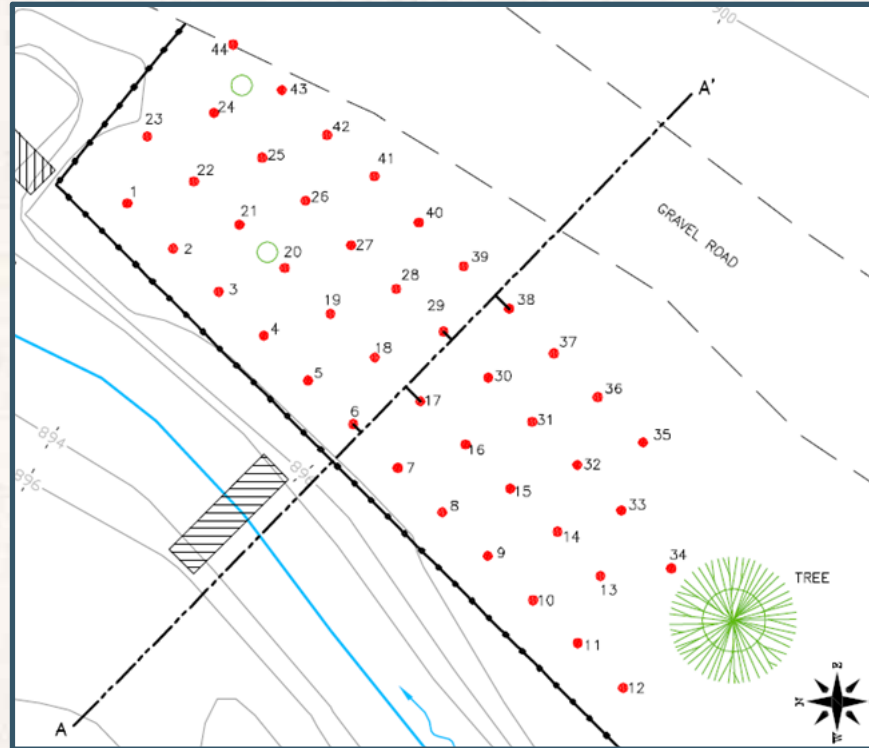


- PRB is an in situ, permeable treatment zone designed to intercept and remediate a contaminant plume. (ITRC, 2011)



Permeable Reactive Barrier Installation

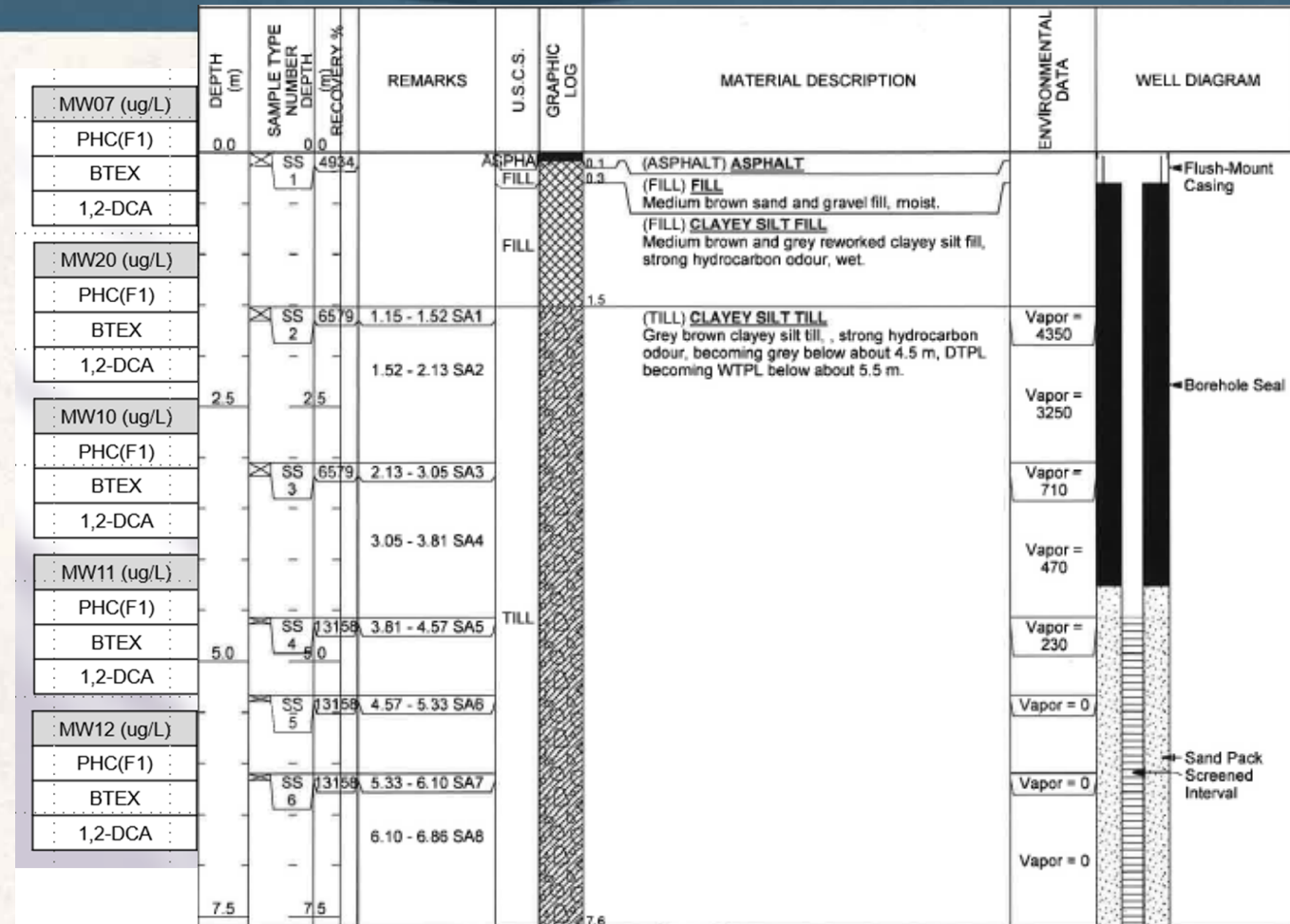
- DPT injection approach
 - Multiple tightly spaced rows (3-4+)
 - Injection wells may need to be installed for future injection events
- Trench approach
 - Simple applications < 15 ft
 - > 15 ft?



Site Background

- Confidential Site
- Large REIT (real estate investment trust) purchasing portions of a block in large Canadian city. This Site was the key corner lot.
- Former gas station:
 - Operating 50+ years (1930s to 1980s)
 - At least 3 former USTs noted on Fire Insurance Plans
 - Late 1960s due to road widening, USTs and pump island relocated on Site
- Petroleum Hydrocarbon (PHC) contamination
- Full remediation in future (redevelopment of whole block)
- Short term:
 - Coffee chain set to lease existing building
 - Lease contract detailed no contamination to migrate off-site during lease timeframe

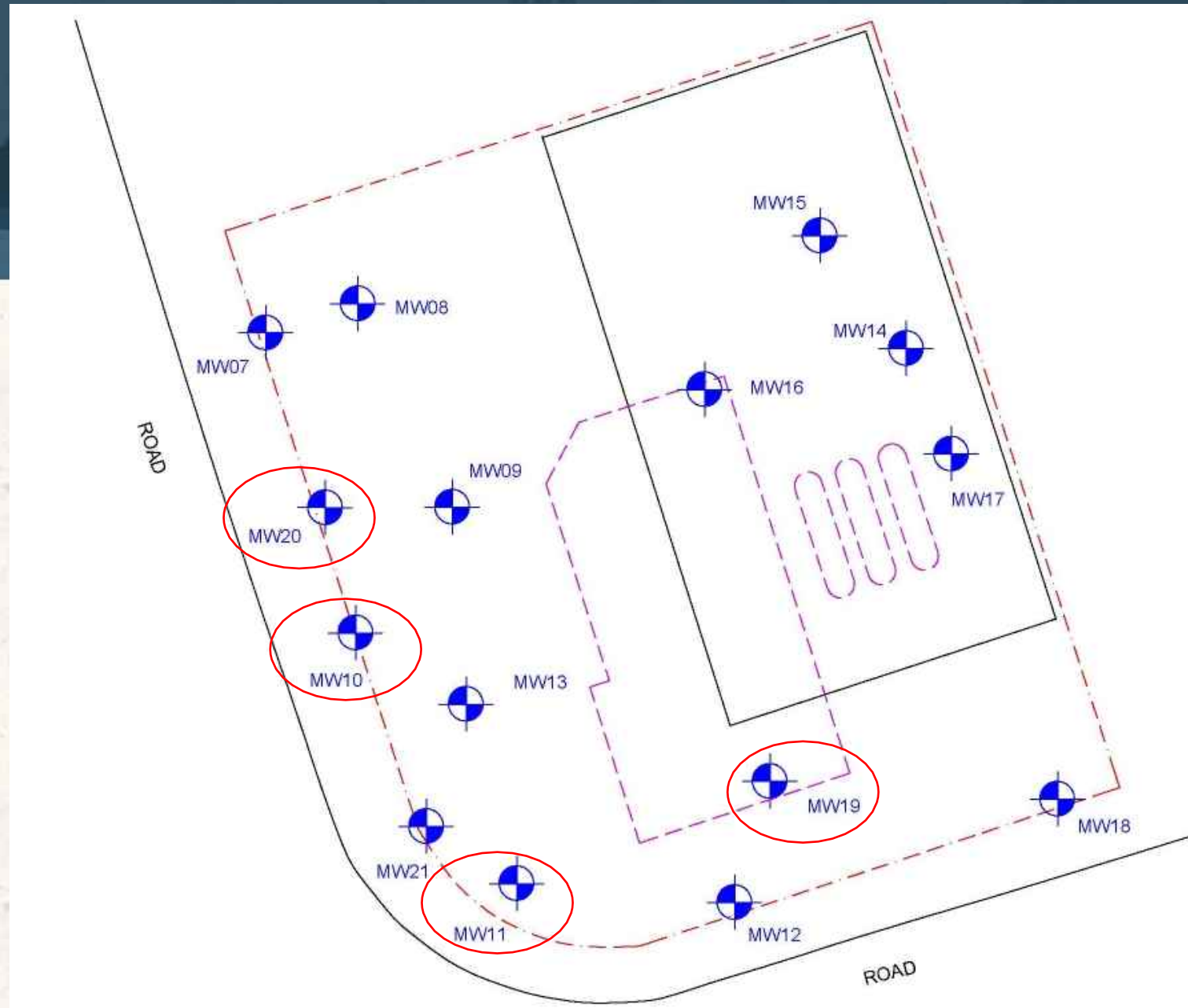
- Soil profile: Fill over hard silty-clay till
- Groundwater: 17-19 ft below grade
- Contamination: BTEX, GRO, and 1,2-DCA



Conc.	Standard
30,000	750
8,700	-
<0.5	12

Background – LNAPL?

- Comment in Phase II ESA (2017)
- “There was no measureable non-aqueous phase liquid detected in any of the groundwater monitoring wells, however, evidence of liquid phase gasoline was observed during the drilling in boreholes MW10, MW11, MW19 and MW20.”
- “It should be noted that during the purging of location MW19, **hydrocarbon product** was observed in the **purge water** and on the sample tubing.”



Background – Analytical (2017 Phase II ESA)

Soil

(mg/kg)	Maximum Concentration	Standard
PHC(F1)	3,900	65
PHC(F2)	770	250
Benzene	150	0.4
Toluene	970	78
Ethylbenzene	250	19
Xylenes	1,100	30
1,2-DCA	0.50	0.05

Dec 2016 Data

Groundwater

(ug/L)	Maximum Concentration	Standard
PHC(F1)	130,000	750
PHC(F2)	18,000	150
Benzene	6,500	430
Toluene	12,000	18,000
Ethylbenzene	5,500	2,300
Xylenes	25,000	4,200
1,2-DCA	15	12

Dec 2016 Data

Remediation Approach (Phases 1-3)

The first 3 phases of work were performed by others and included the injection of colloidal activated carbon (CAC) and a chemical oxidant.

- Injection #1: CAC and Oxygen Releasing Material (ORM) injected along 80 ft length in 24 injection points in 3 discrete intervals.
- Injection #2: CAC and ORM injected along 80 ft length in 17 injection points in 1-2 discrete intervals.
- Injection #3: Chemical oxidant injected in 8 injection points in 2 discrete intervals

Remediation Approach (Phases 1-3)

Phase 1:

- Colloidal AC PRB Injection #1
- 80 ft long by 10 ft wide
- 24 Injection Points
 - Single line
 - 3 ft spacing
 - 3 discrete vertical intervals
- 4 days of work (January 2017)
- Colloidal AC Product
 - 2,900 gal of solution was injected
 - 10% of dilute colloidal AC product used
 - 240 lb of ORM was added to solution

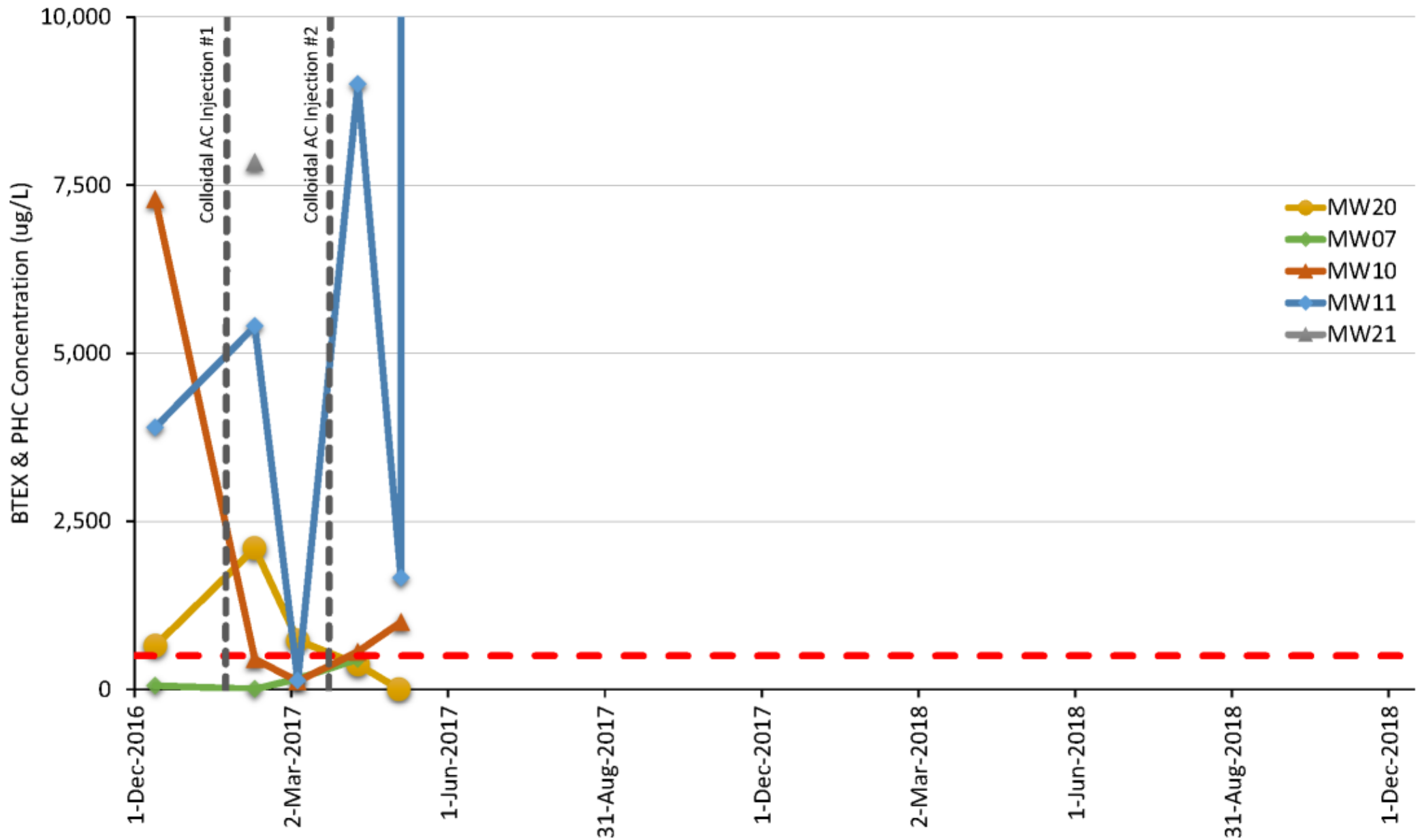
Phase 2:

- Colloidal AC PRB Injection #2
- 80 ft long by 10 ft wide
- 17 Injection Points
 - Single line
 - 15 ft spacing
 - 1 to 2 discrete vertical intervals
- 2 days of work (March 2017)
- Colloidal AC Product
 - 1,200 gal of solution was injected
 - 15% of dilute colloidal AC product used
 - 165 lb of ORM was added to solution

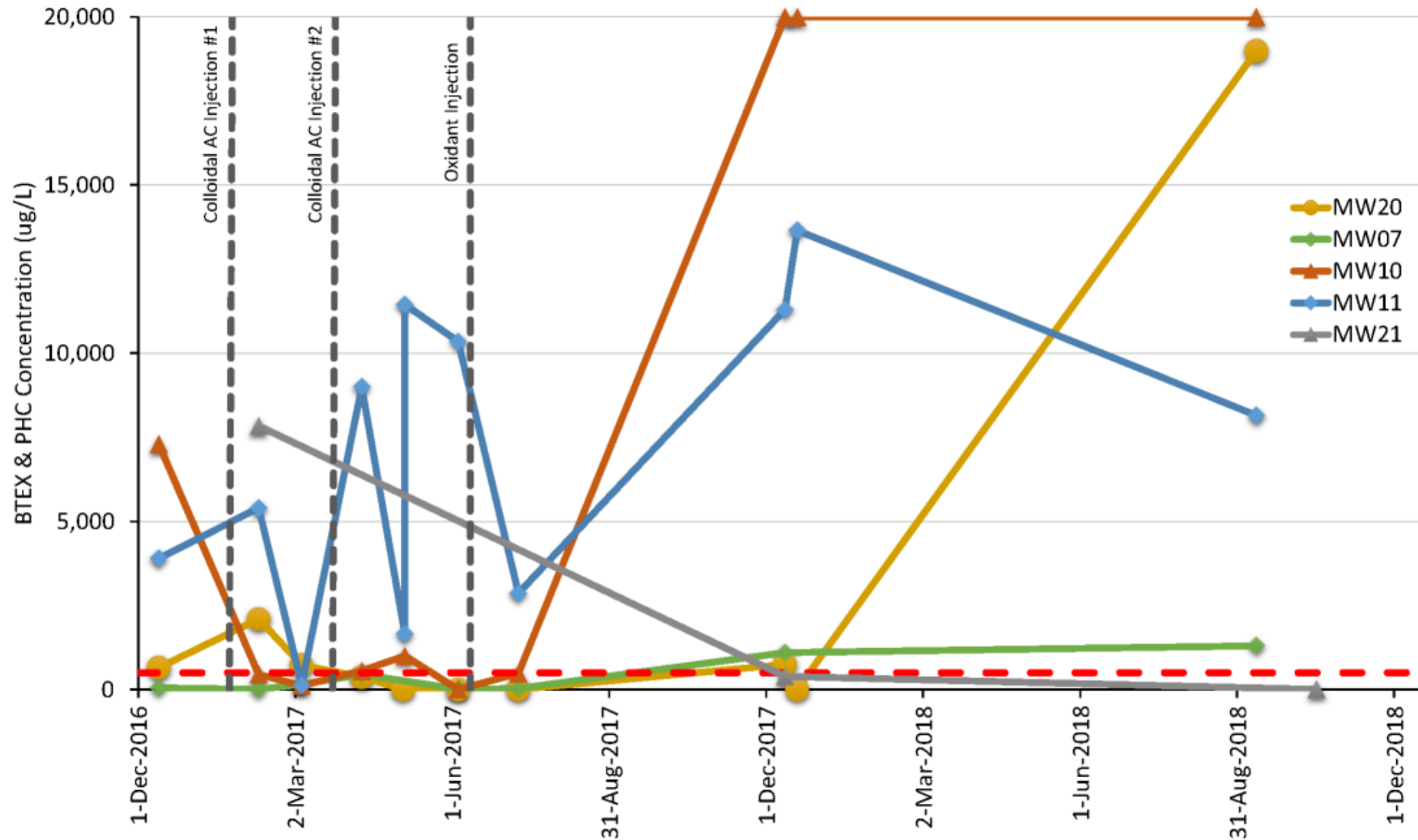
Phase 3:

- Oxidant Injection
- Targeted (MW10, MW11)
- 8 Injection Points
 - Single line
 - random spacing
 - 2 discrete vertical intervals
- 1 day of work (June 2017)
- Sodium persulfate product
 - 370 gal of solution was injected
 - 20% of oxidant (660 lb)
 - 165 lb of ORM was added to solution

Total PHCs in Groundwater



Total PHCs in Groundwater



Remediation Approach (Phases 4-5)

Phase 4 preceded by Remedial Design Characterization (RDC) to better define plume and saturated soil mass

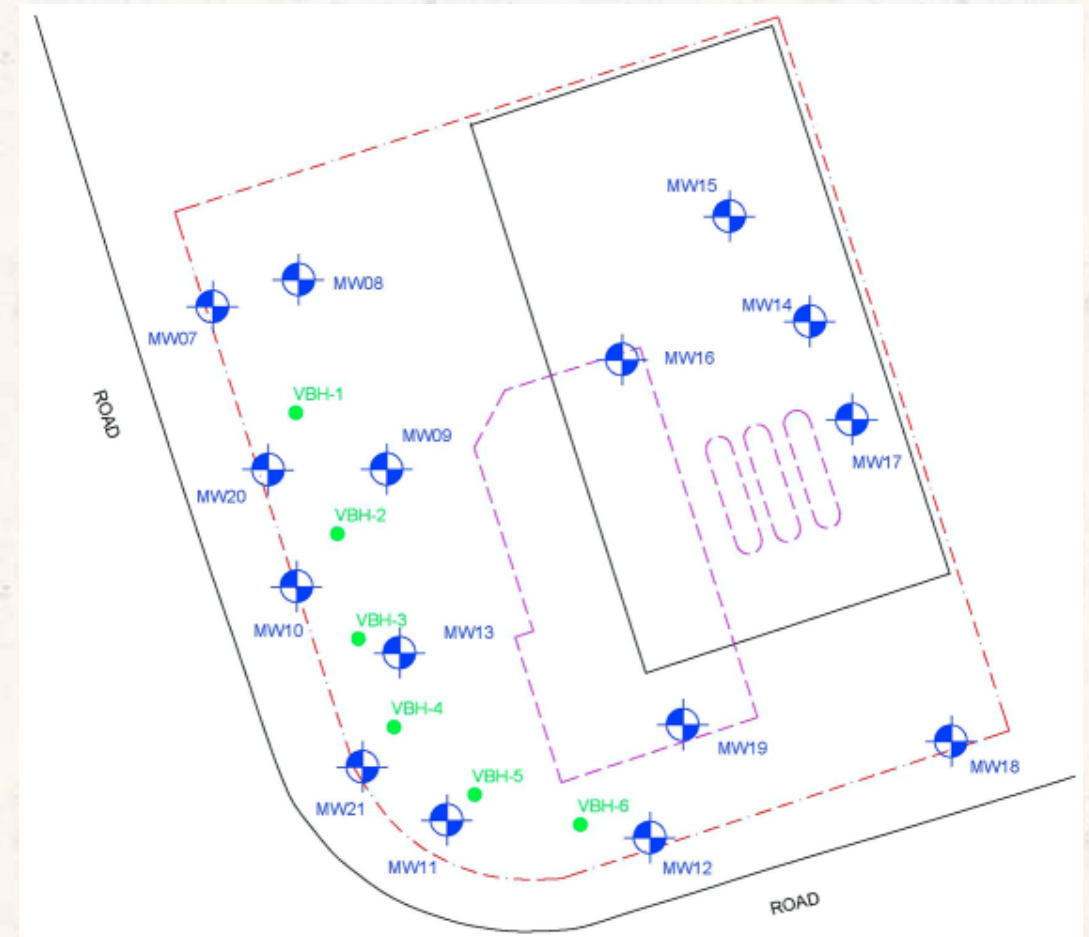
- Application of Powder Activated Carbon, terminal electron acceptors, and hydrocarbon degrading bacteria
- 81 injection locations with 9 discrete intervals

Phase 5 included the addition of a dechlorinating culture that is capable of degrading 1,2-DCA



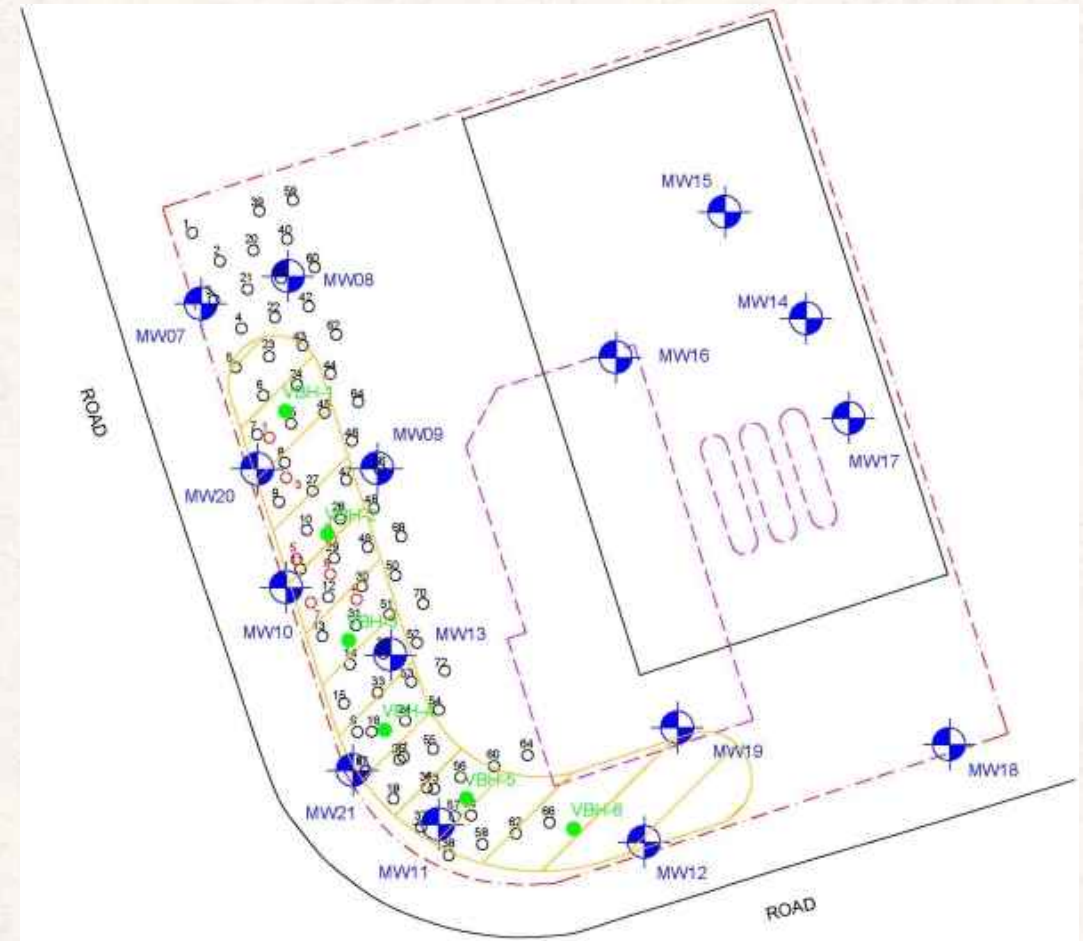
Remedial Design Characterization

- Six (6) boreholes
- 1 day of work
- Sept 2018
- 27 soil samples (4-5/borehole)
- Detailed analysis of PHCs with depth
- 12 groundwater samples
- Allowed for detailed understanding of PHC contaminated zones



Remediation – Phase 4

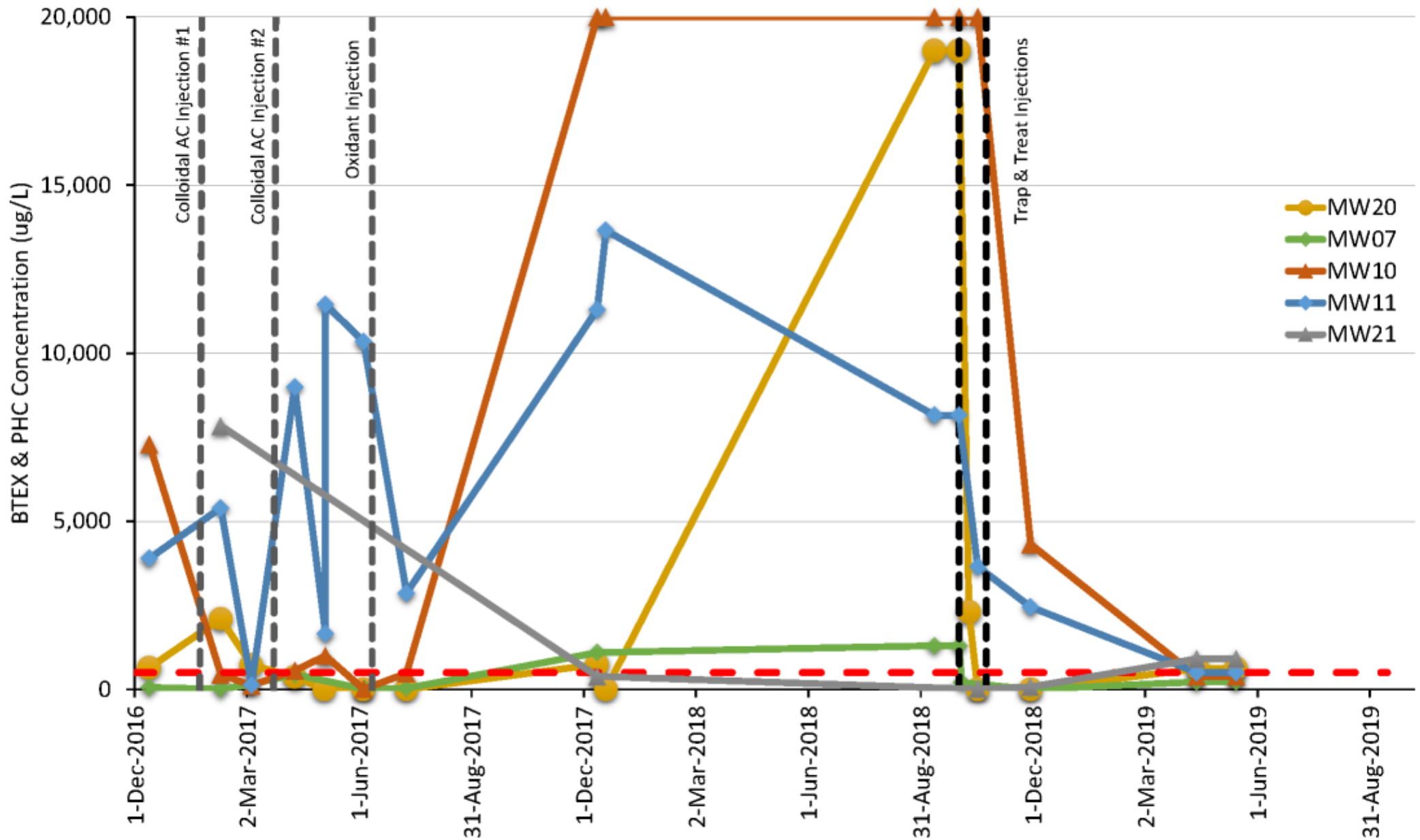
- Powdered AC Injection
- 80 ft long by 10 ft wide
- 81 Injection Points
 - 3 Rows forming Triangular Grid
 - 3 ft spacing
 - 9 discrete vertical intervals
- 9 days of work (Oct 2018)
- Powdered carbon
 - 3,900 gal of solution was injected
 - 28% of pure powdered AC product used
 - About 8,600 lb of activated carbon
 - 3,600 lb sulfate added (for anaerobic bio)



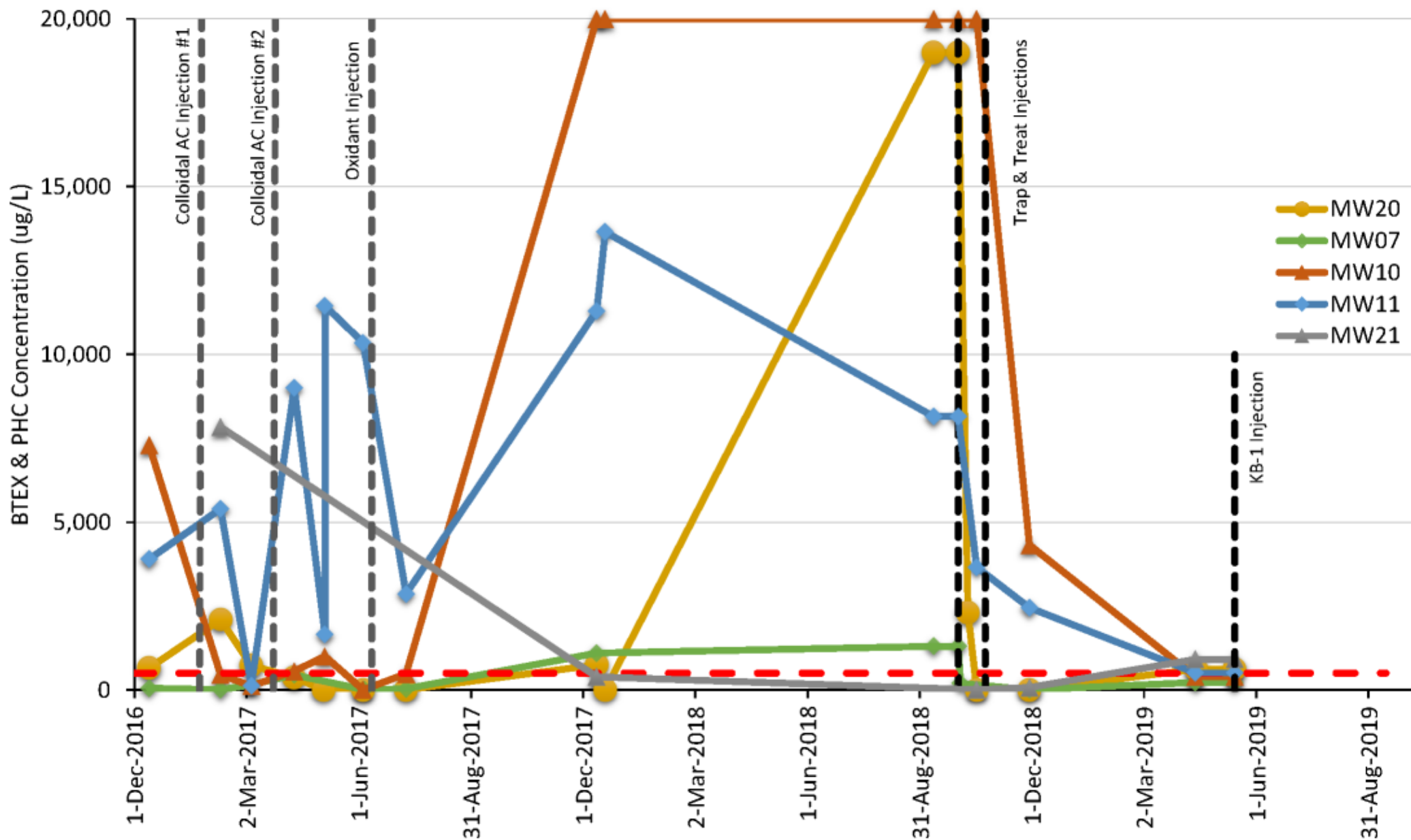
Remediation Approach – Updated

- Colloidal AC Injection
 - 80 ft long by 10 ft wide
 - 24 Injection Points
 - Single line
 - 3 ft spacing
 - 3 discrete vertical intervals
 - 4 days of work (January 2017)
 - Colloidal AC Product
 - 2,900 gal of solution was injected
 - 10% of dilute colloidal AC product used
 - 240 lb of ORM was added to solution
- Powdered AC Injection
 - 80 ft long by 10 ft wide
 - **81 Injection Points**
 - **3 Rows**
 - 3 ft spacing
 - **9 discrete vertical intervals**
 - 9 days of work (Oct 2018)
 - Powdered carbon
 - 3,900 gal of solution was injected
 - 28% of pure powdered AC product used
 - About 8,600 lb of activated carbon
 - 3,600 lb sulfate added

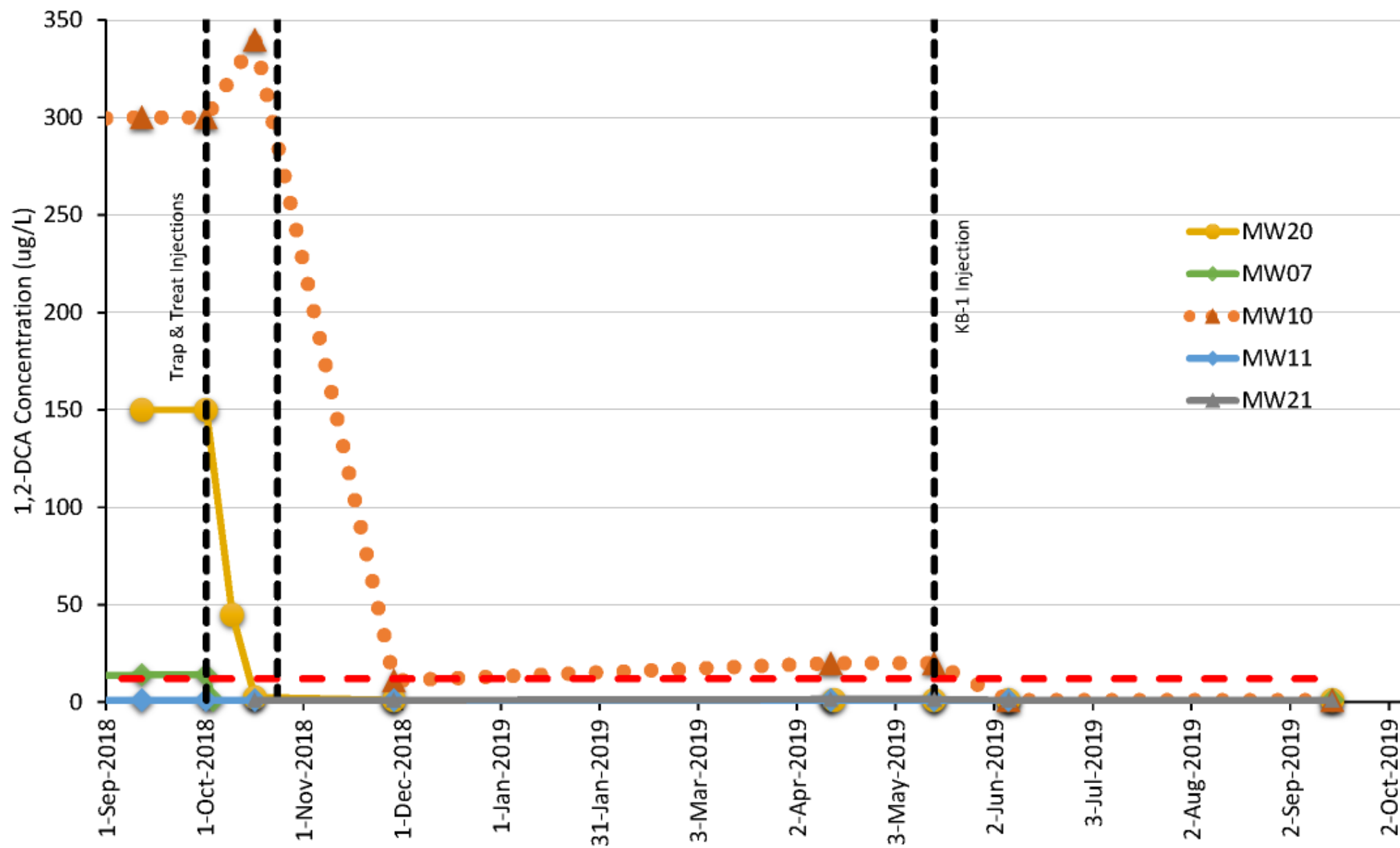
Total PHCs in Groundwater



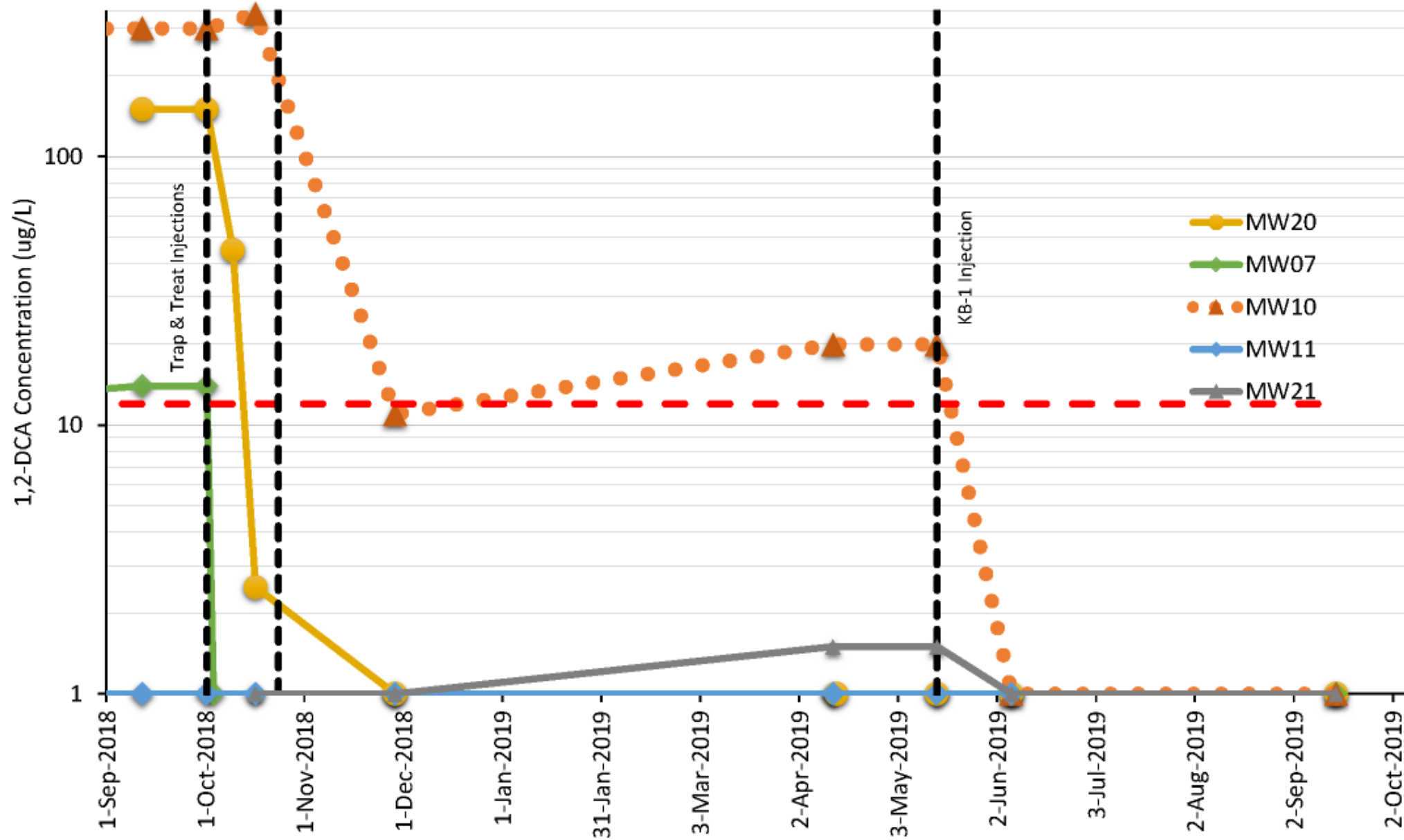
Total PHCs in Groundwater

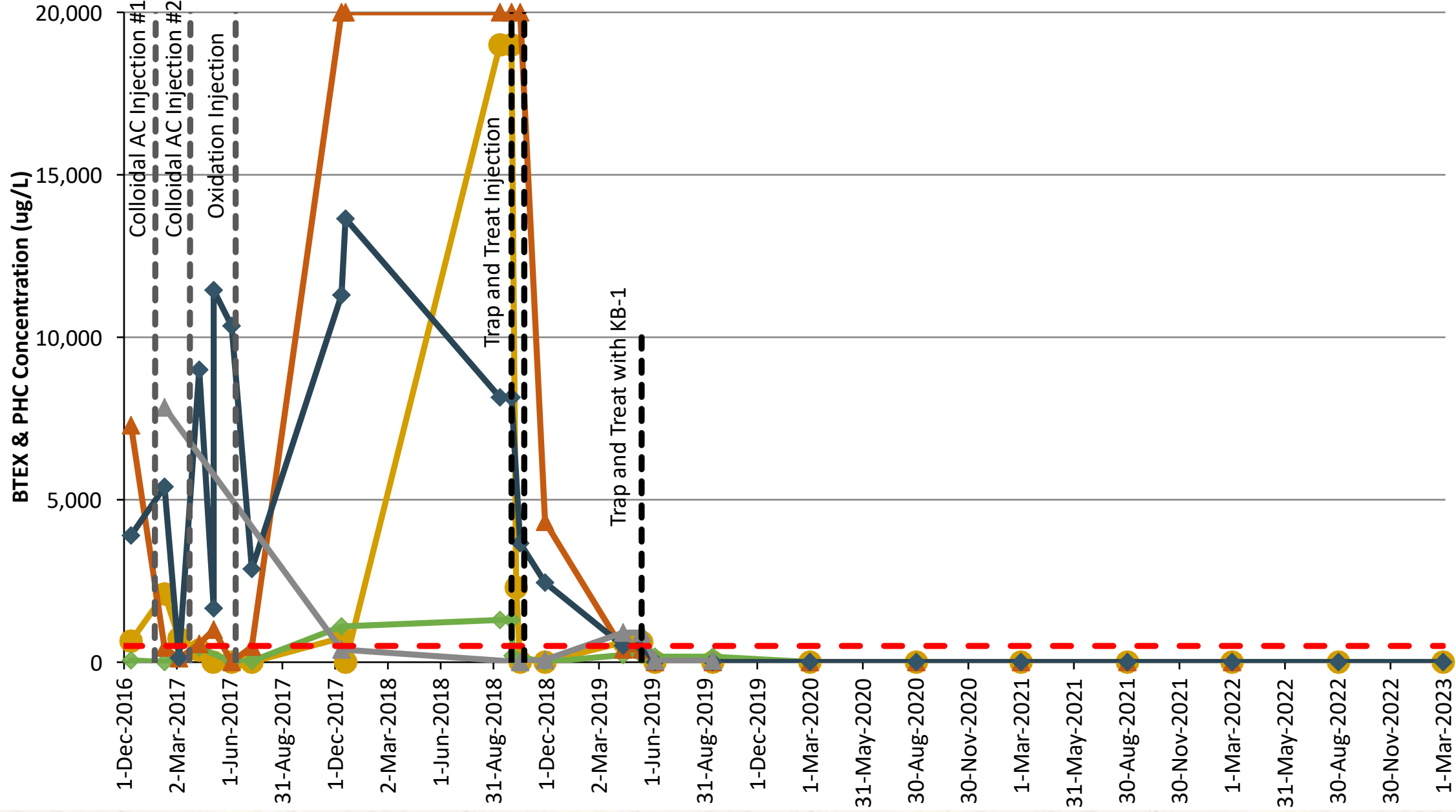


1,2-DCA in Groundwater



1,2-DCA in Groundwater





Lessons Learned

- Contaminant Concentration / Distribution (LNAPL, etc.)
 - Evidence of LNAPL possibly not taken into account during initial design
- Wrong Technology / Order of Application
 - ISCO completed after AC injection
- Under-Dosing the Amendment
 - Apparent low mass of AC and ORM injected relative to contaminant mass present
- Poor Contact / Distribution in the Subsurface
 - Insufficient number of IPs and vertical intervals for an injected PRB
- Baseline Geochemistry
 - Hard to try to maintain aerobic conditions over the long term



Thank you for your time! Questions?

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