



CASE STUDY:

Using Recirculation Injection Methodology to Improve Efficacy of In Situ Chemical Oxidation Remediation

BATTELLE CHLORINATED CONFERENCE 2024
DENVER, COLORADO

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Introduction

Site Background and Geology

Approach

Pilot Study 1 and 2

Pilot Study 3 - Recirculation Implementation

Results

Field Observations

Analytical Results

Lessons Learned

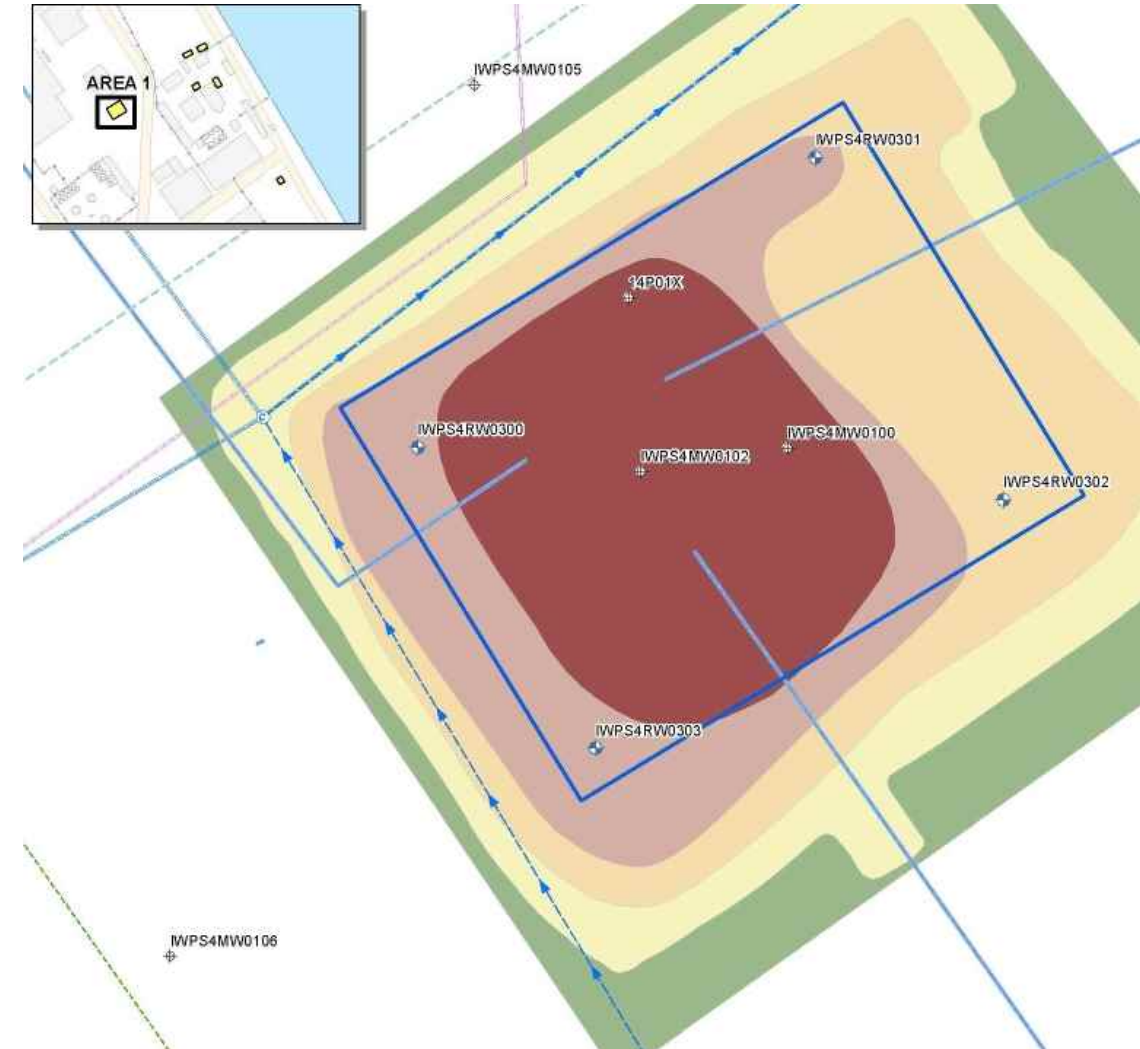
Conclusion

Introduction



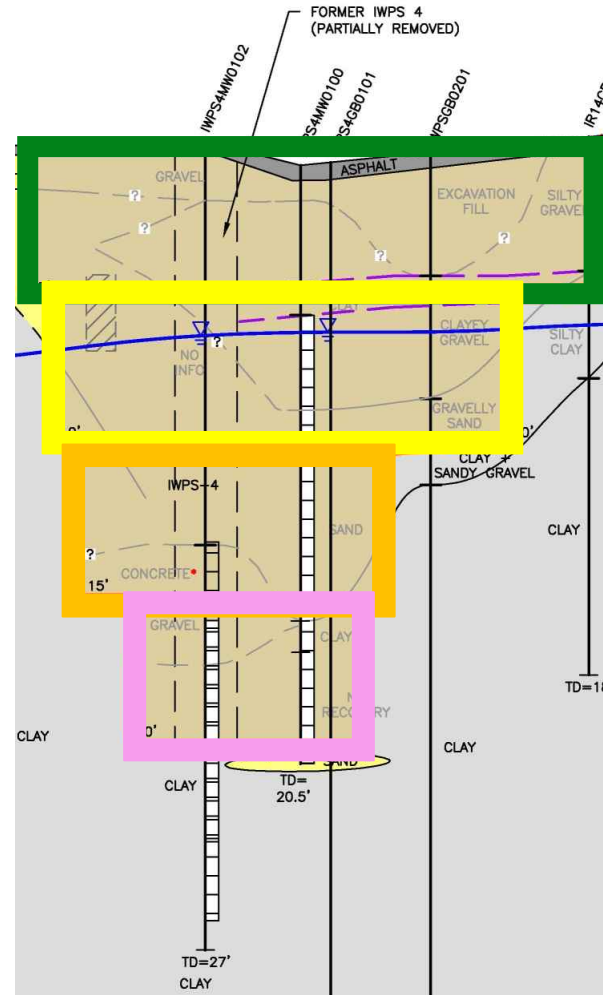
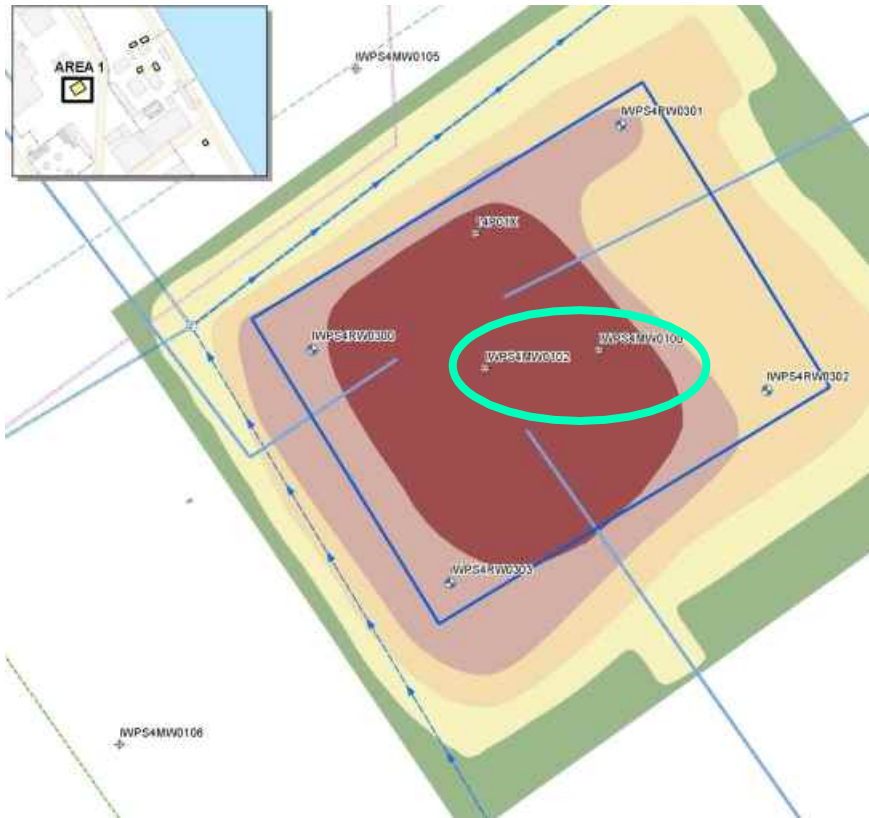
Site Background

- Constituents of concern:
 - TPH-d (640 µg/L cleanup goal)
 - cis-1,2-DCE (22,400 µg/L cleanup goal)
 - TCE (200 µg/L cleanup goal)
 - VC (13 µg/L cleanup goal)
- Site consists of four treatment areas
 - No distinct plume but rather limited areas of residual impacts
- Area 1 - location of former industrial wastewater pump station
 - Pump station installed ~20 ft bgs was removed in 2005 and backfilled with material generally more permeable than native materials



Introduction

Geology



Area 1 Composition

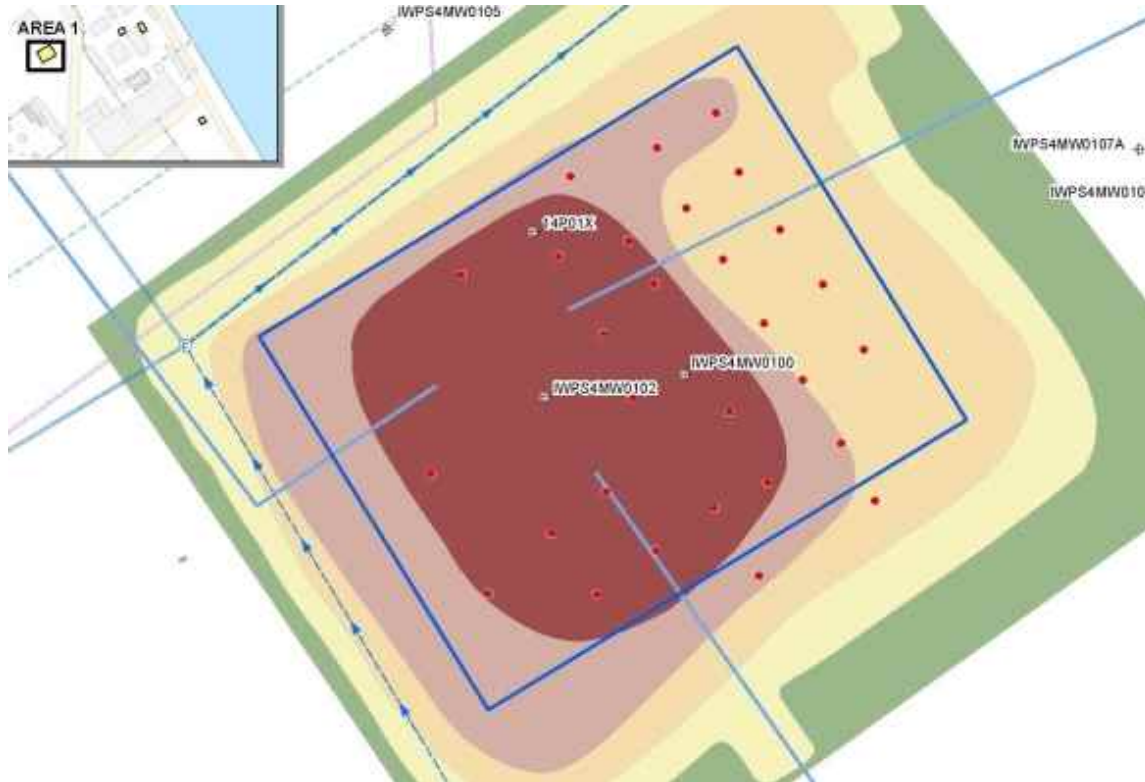
- Geology consists of three primary geologic units:
 - Heterogeneous layer due to extensive land reclamation activities performed historically.
 - Unconsolidated natural deposits primarily silty clays
 - Bedrock

Approach



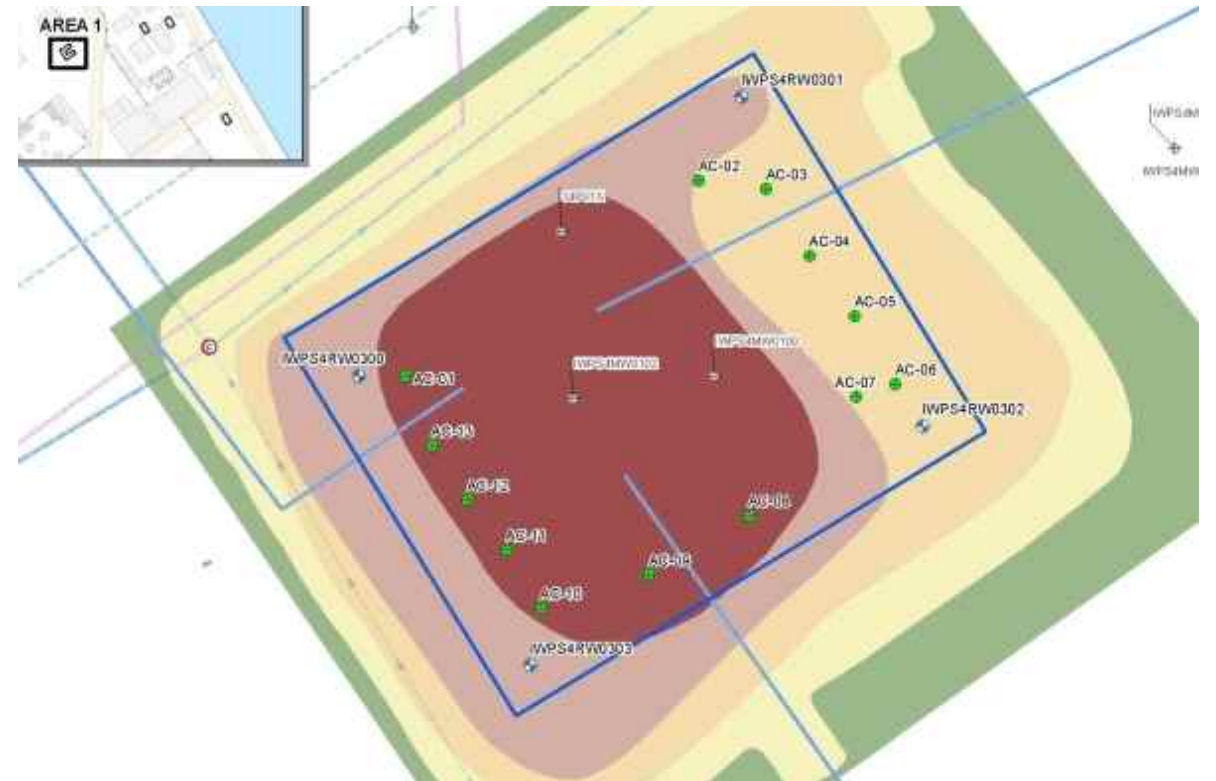
Pilot Study 1 (2014)

- 30 ISCO direct push injection points across two injection events eight weeks apart
- 5,900 gallons of 12% activated sodium persulfate (ASP) (PersulfOx®) solution injected

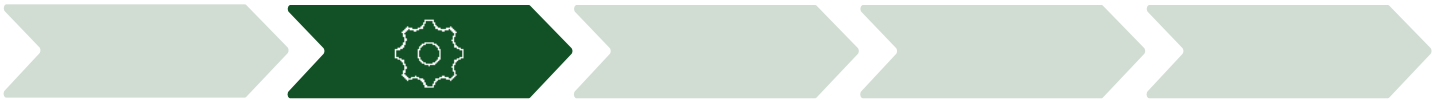


Pilot Study 2 (2019)

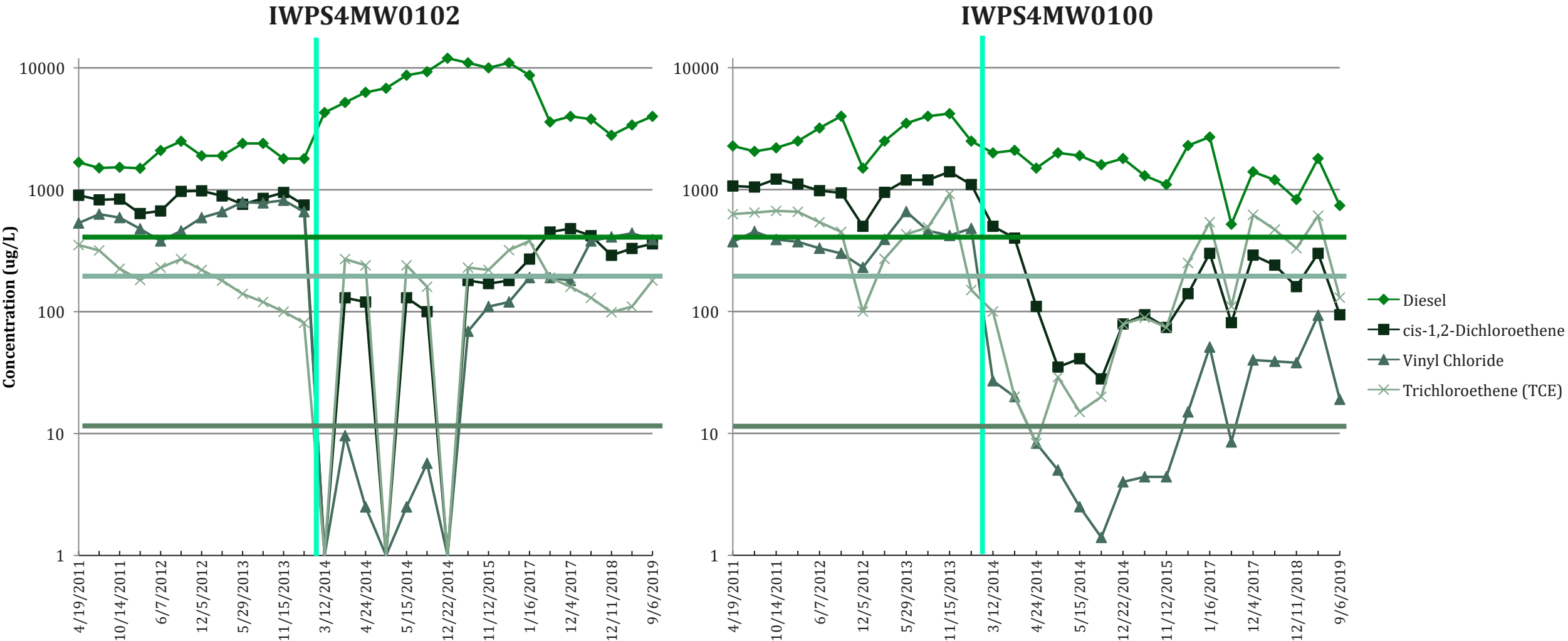
- Injected 7,100 gallons of 8 - 14% ASP (PersulfOx®) into 4 permanent wells (screened from 5 to 25 ft bgs) across two injection events six weeks apart
- Injected 1,564 pounds of activated carbon (BOS200®) to 13 direct push injection points following ASP injections



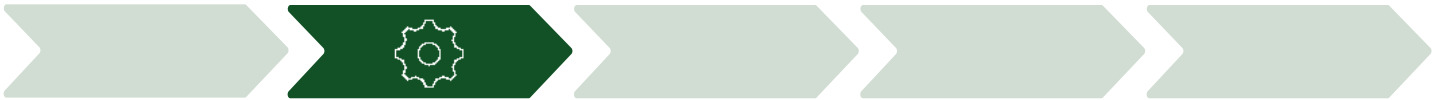
Approach



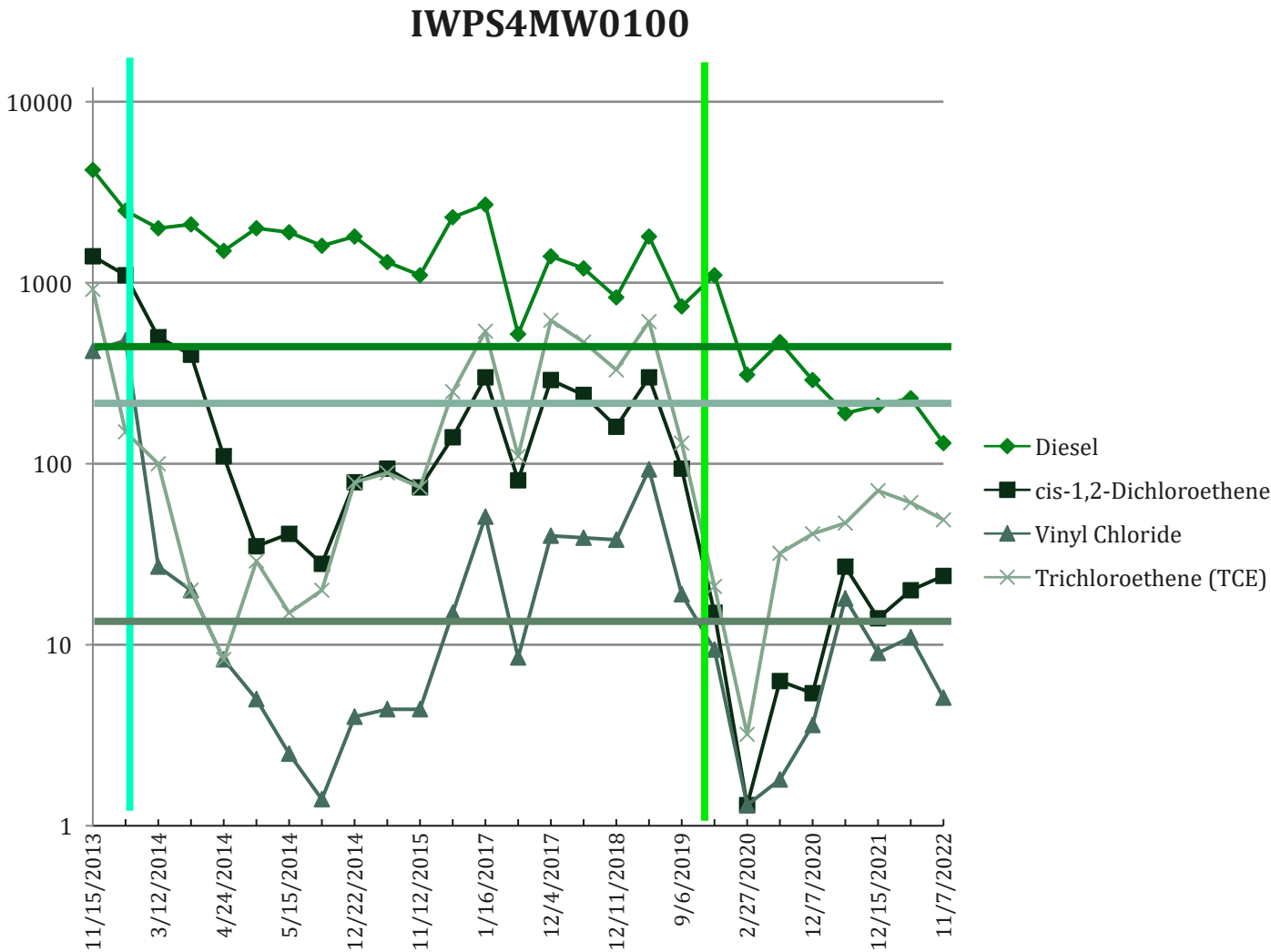
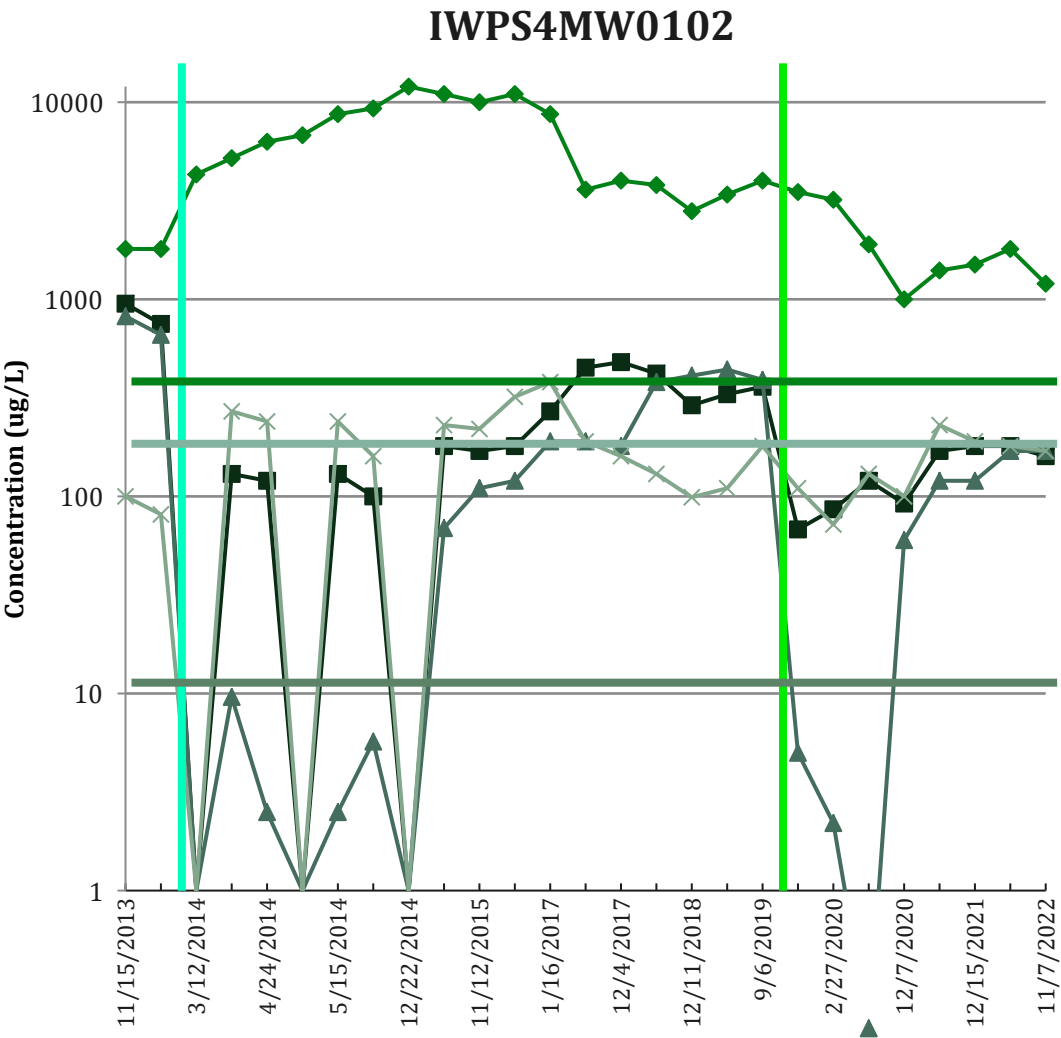
Pilot Study 1 Results



Approach



Pilot Study 2 Results



Approach

Lessons Learned From Pilot Studies 1 and 2

Successes

- ASP was effective in reducing chlorinated volatile organic compound concentrations and creating conditions suitable for longer-term degradation of TPH
- Observed greater longevity of oxidant and oxidative conditions injecting in permanent wells vs direct push points

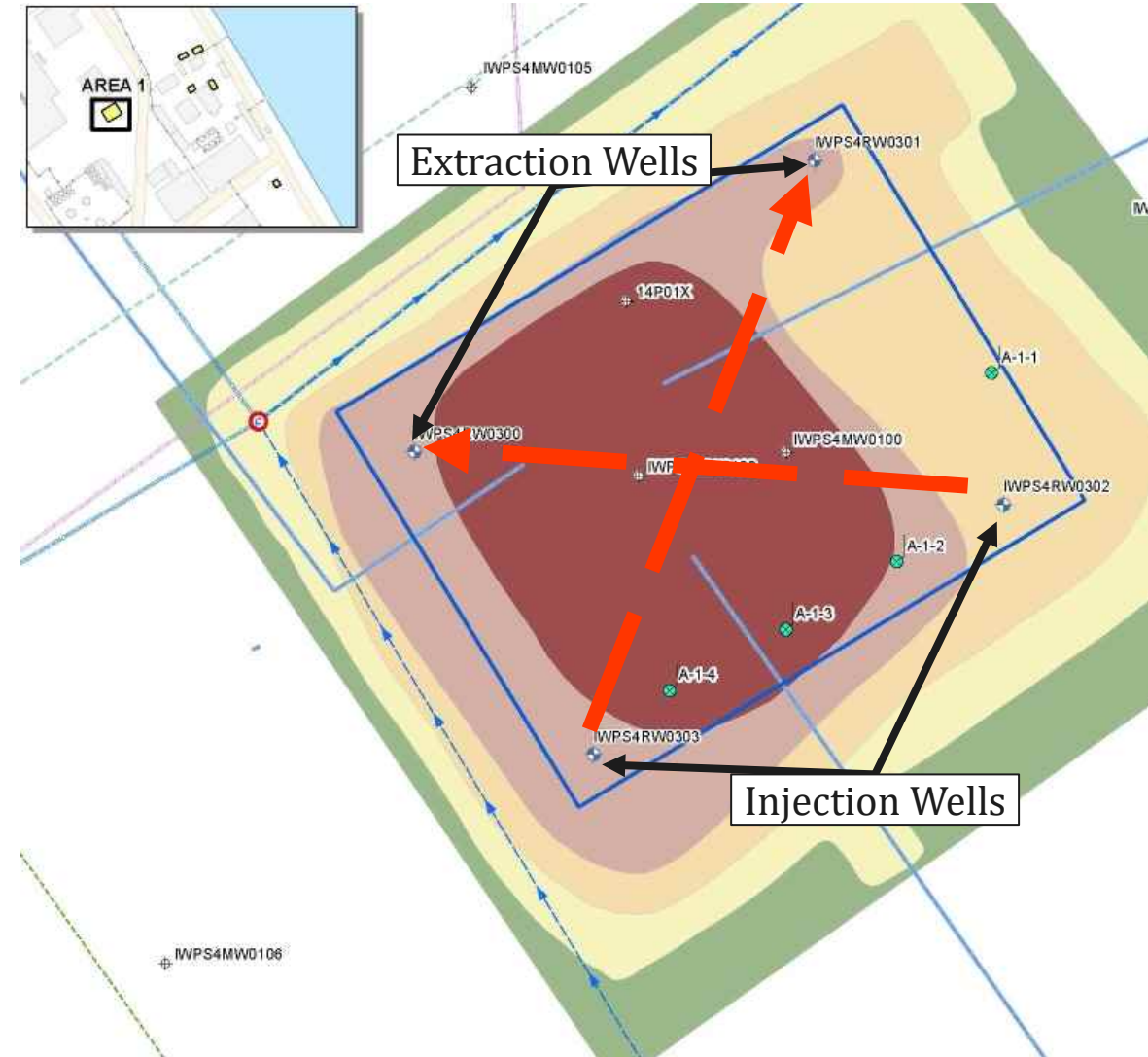
Limitations

- Abundance of utilities likely present preferential pathways and make adequate distribution of direct push injection points difficult
- Heterogeneity of soil limits consistent distribution of reagent
- Low groundwater flow rates limit the degree to which reagent is dispersed

Approach

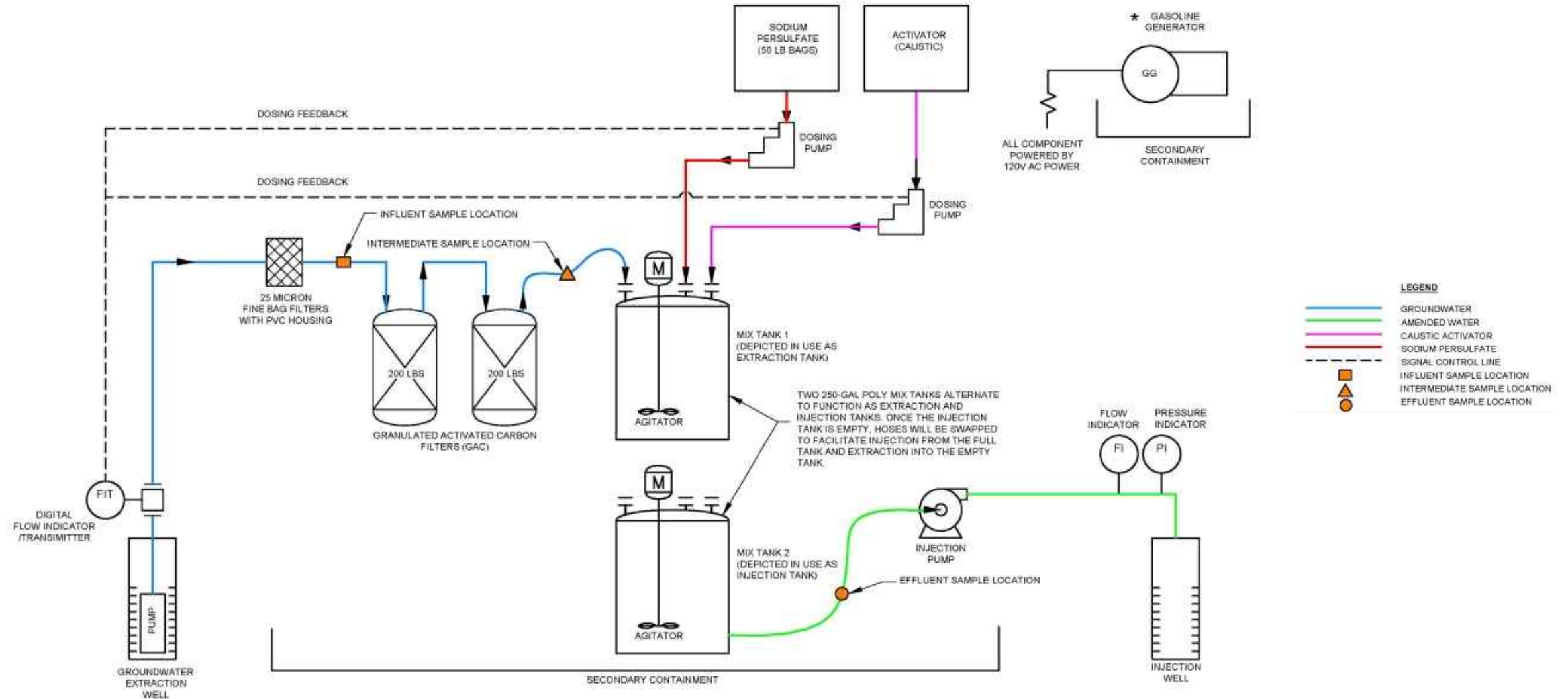
Pilot Study 3 Methodology

- Reagent solution would be injected concurrently with continued groundwater extraction in well pairs to facilitate distribution via “convection cell”
- Developed treatment criteria to determine in the field when distribution objectives had been achieved:
 - Detection of persulfate at 3,000 milligrams per liter (mg/L; 10 percent of the estimated target concentration in groundwater) at a minimum; and
 - Exchanging at least 60 percent of the total treatment area estimated effective porosity.
- Develop groundwater extraction treatment process and sampling protocol to avoid mixing and reinjecting impacted groundwater



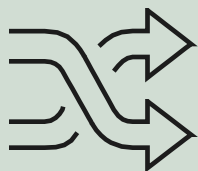
Approach

Pilot Study 3 Methodology



Approach

Pilot Study 3 Methodology



Recirculation Injections

In total, **8,156 gallons** of 7.5 to 15% Klozur SP™ solution was recirculated between two well pairs.



Direct Push Injections

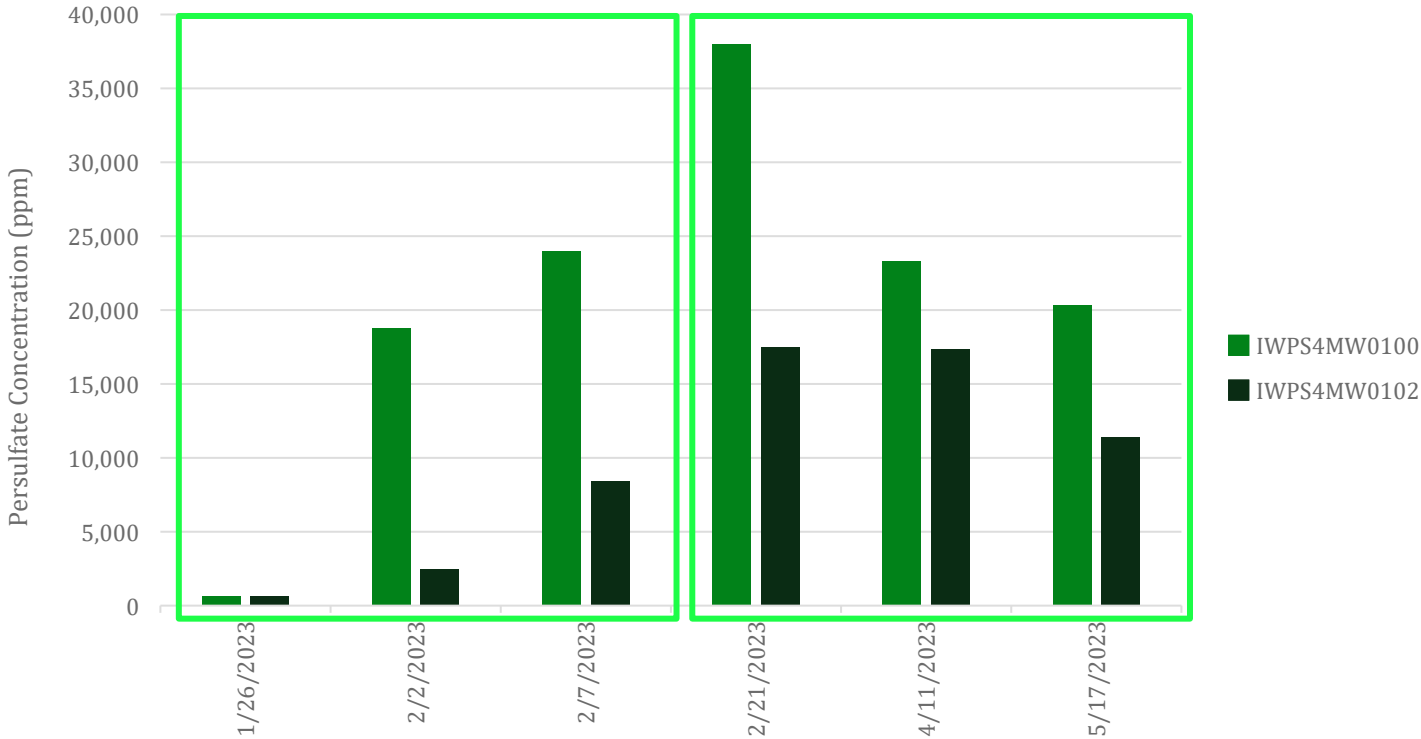
In total, **5,504 gallons** of 7.5 to 15% Klozur SP™ solution was in four direct push injection points.

Results



Field Observations and Challenges

- Field test kit was used to monitor reagent concentration at monitoring and extraction wells
 - Monitoring Well Max Persulfate concentration: 23,280 ppm
 - Extraction Well Max Persulfate concentration: 8,419 ppm (above target concentration of 3,000 ppm)



Results



Field Observations and Challenges

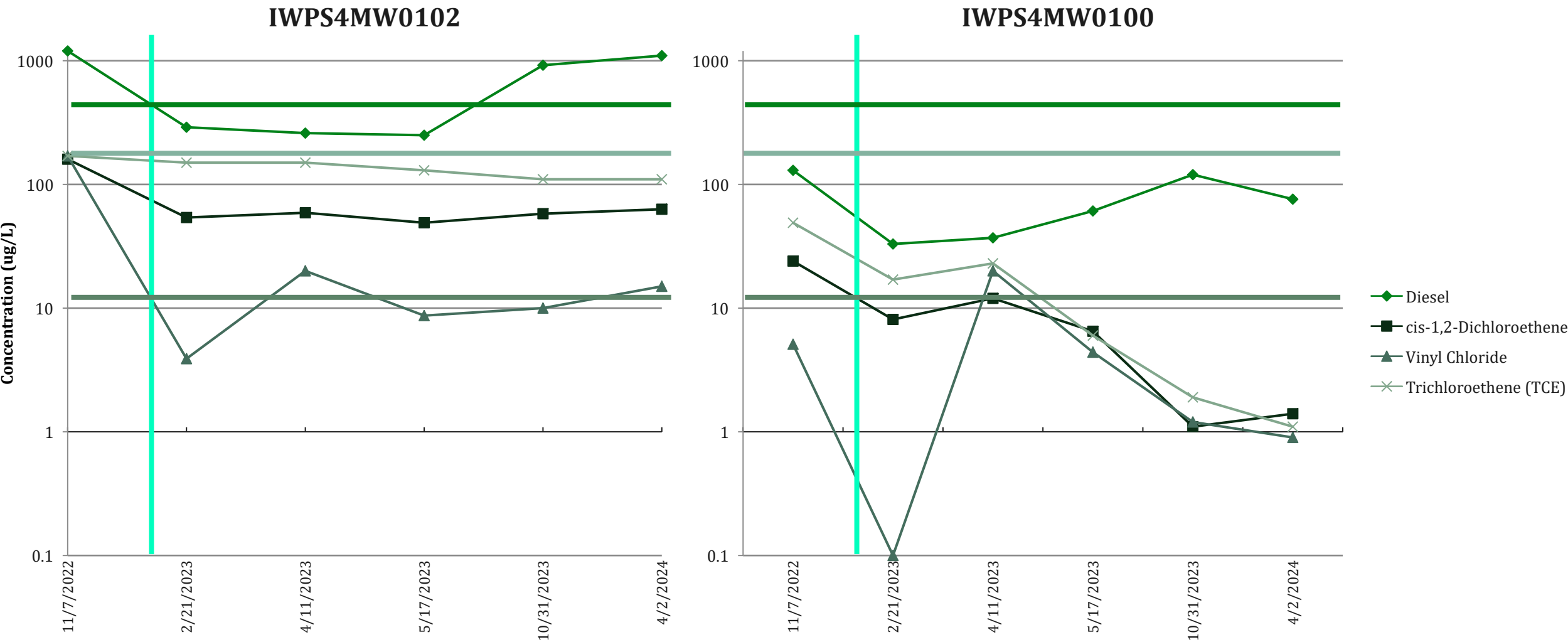
- Poor extraction volume yield from second well pair
 - Reagent volume was repurposed injected into the four direct push points along injection well side of treatment area
 - Recirculation through the first well pair was restarted



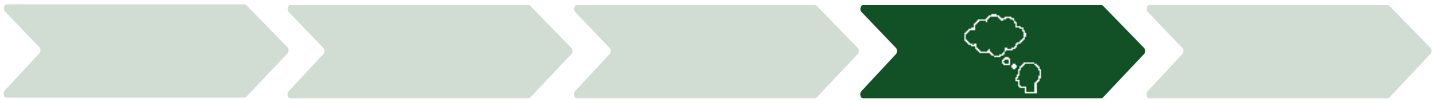
Results



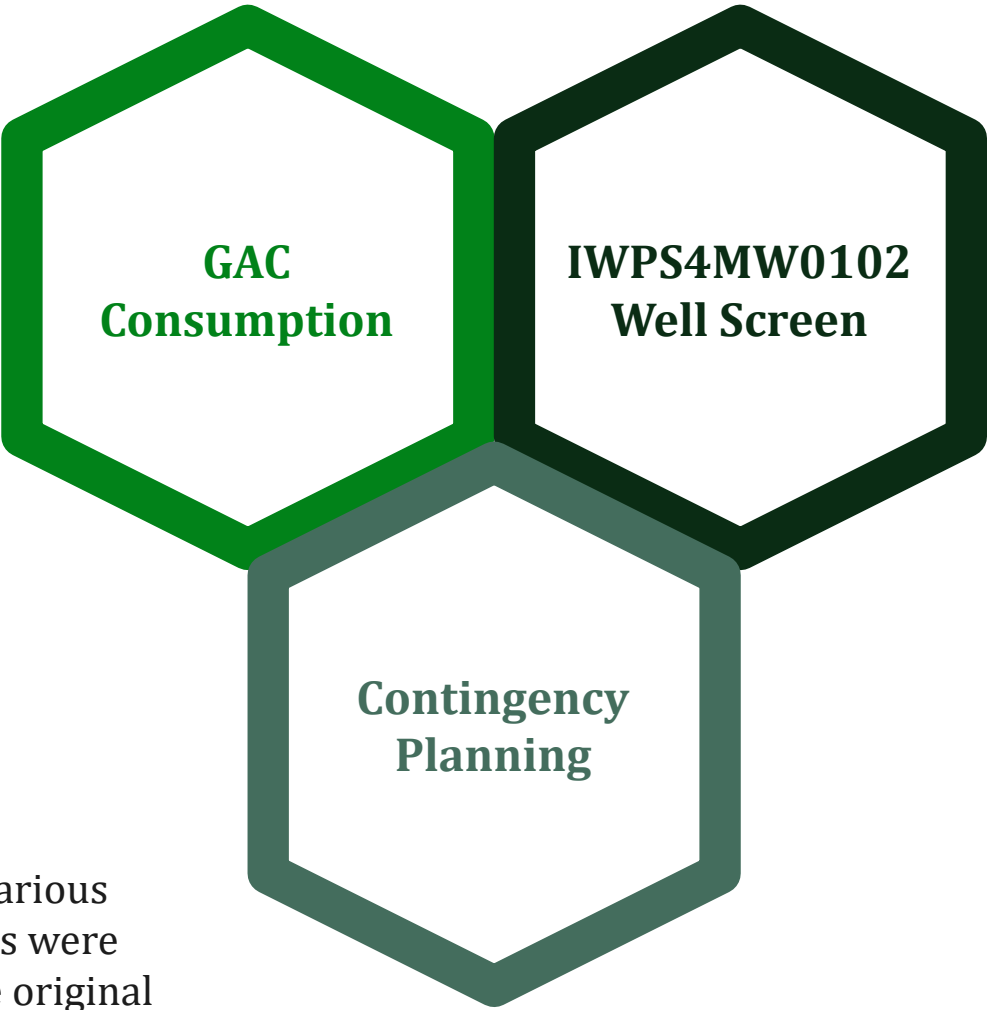
Pilot Study 3 Results



Lessons Learned



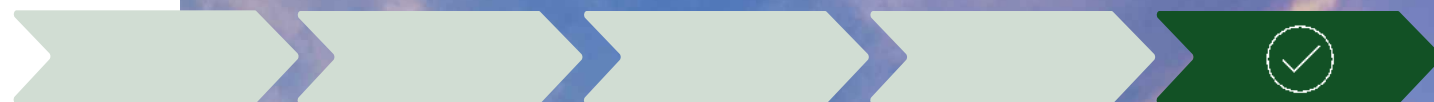
Groundwater being extracted contained higher concentrations of persulfate going into the treatment system, causing increased GAC consumption.



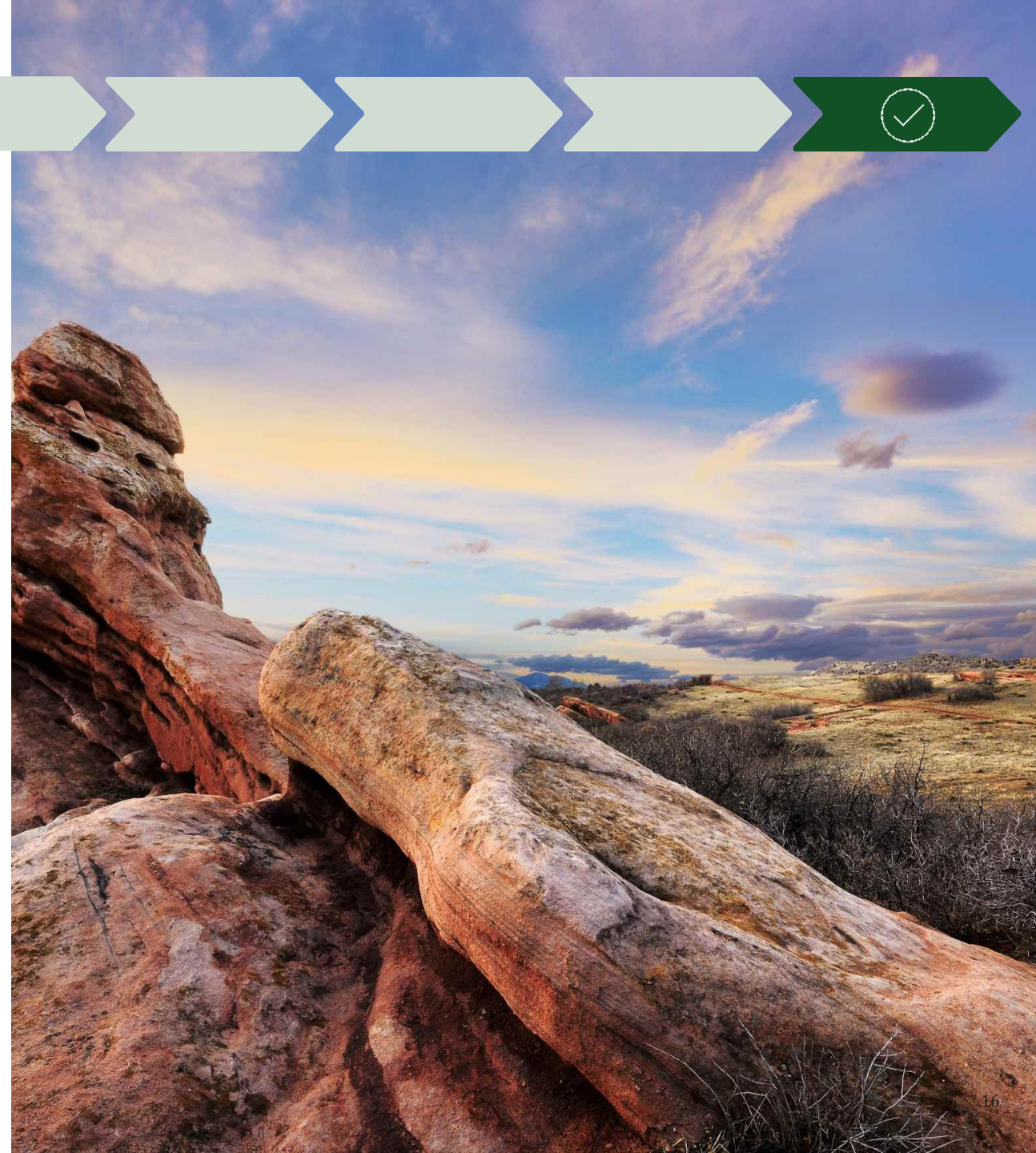
Well screen of IWPS4MW0102 installed in the silty clay layer, potentially accounting for the unclear remedial results at this well.

Workplan specified various contingencies if issues were encountered with the original plan.

Conclusion



- Elevated persulfate concentrations (>10,000 ppm) were observed in both monitoring wells for 3 months following injections
- Oxidative reductive potential was increased and maintained following injections
- Able to meet most clean up goals for contaminants of concern, on the path to receiving approval for no further remedial action within treatment area



Thank you

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