Remediation of Low Concentration Perchloroethylene Impacts at Former Dry Cleaning Facility Using In-Situ Chemical Oxidation

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- Environmental engineering consulting services: site assessments, remediation, risk assessments

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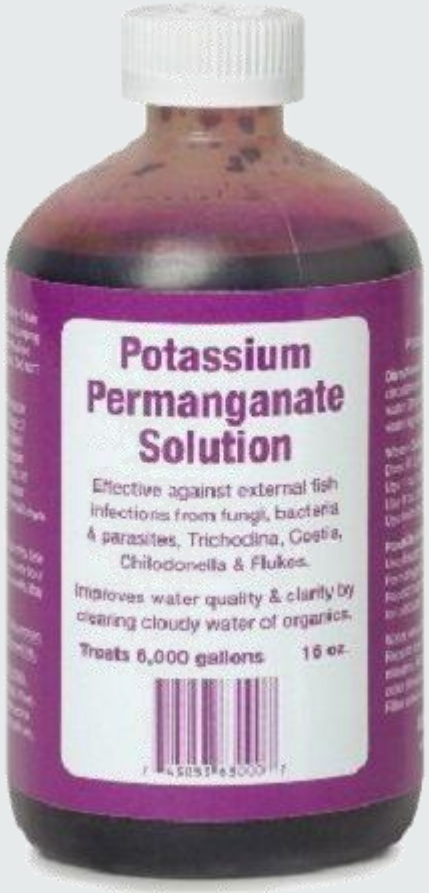
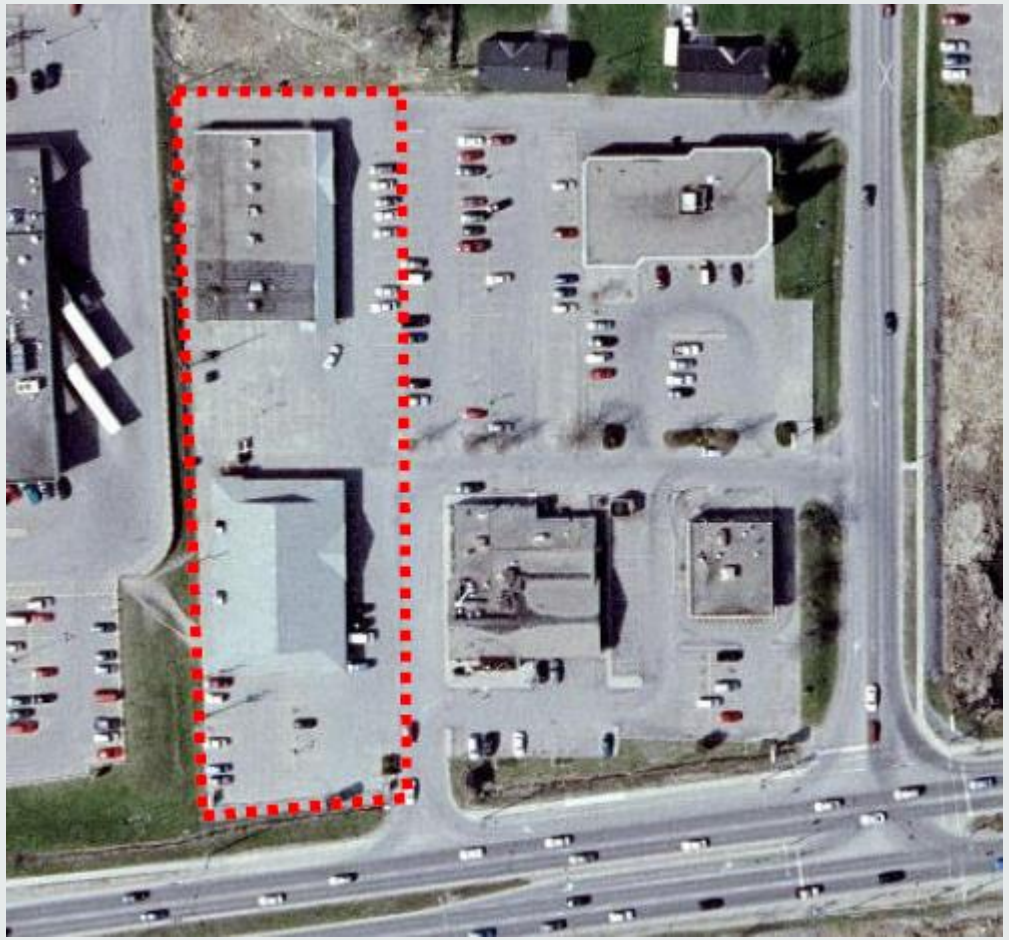
In-situ Chemical Oxidation (ISCO)

- ISCO is effective at reducing PCE and other VOC concentrations from thousands of ppb to tens of ppb
- Achieving and sustaining concentrations in the order of 1 ppb is challenging



Case Study



- Commercial Plaza, Kingston, Ontario

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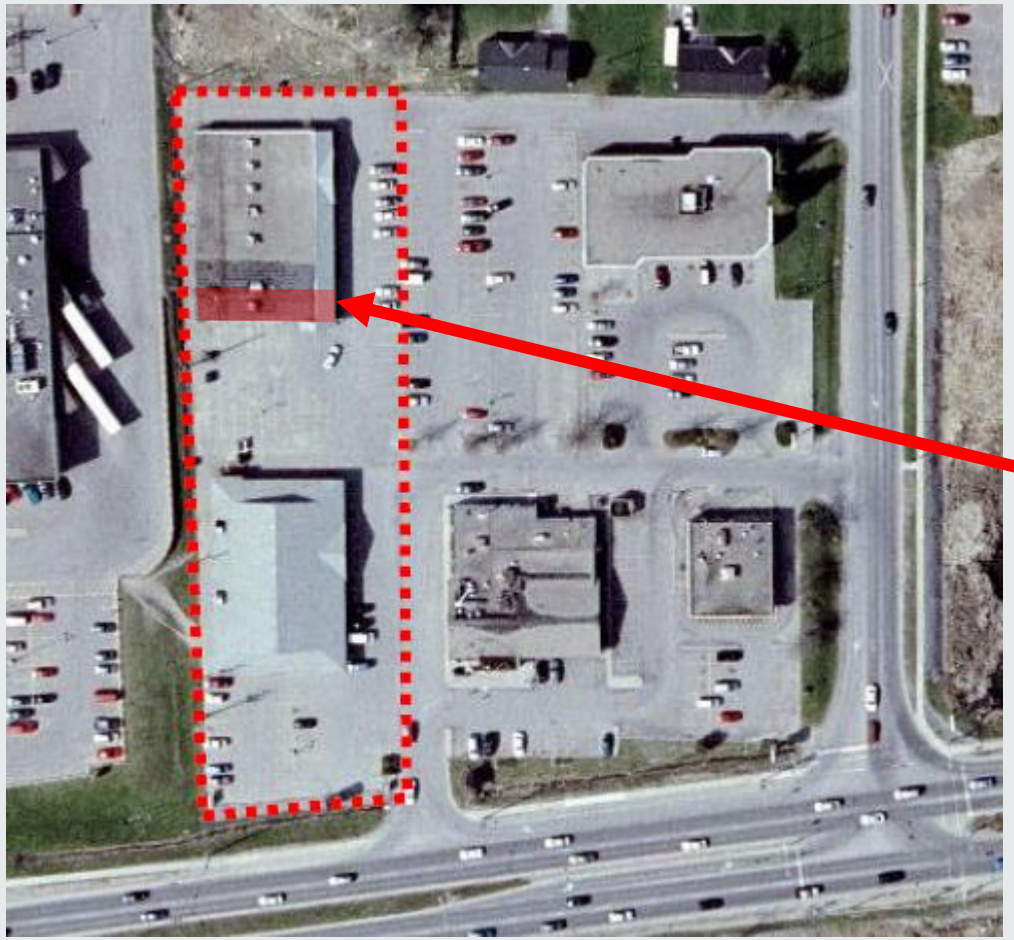


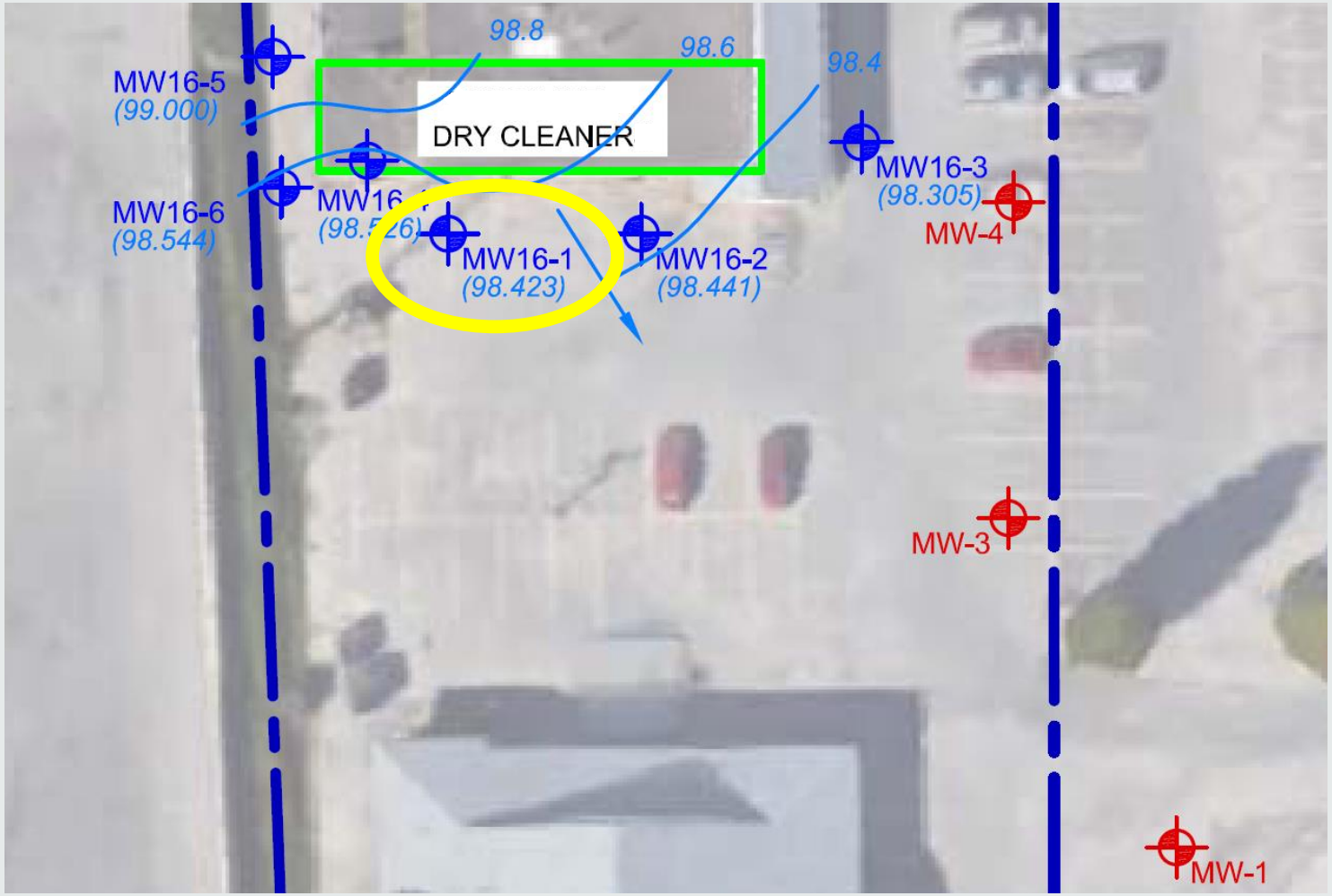
- Commercial Plaza, Kingston, Ontario
- Former dry cleaner operated on-site for 33 years

Phase One and Two ESAs

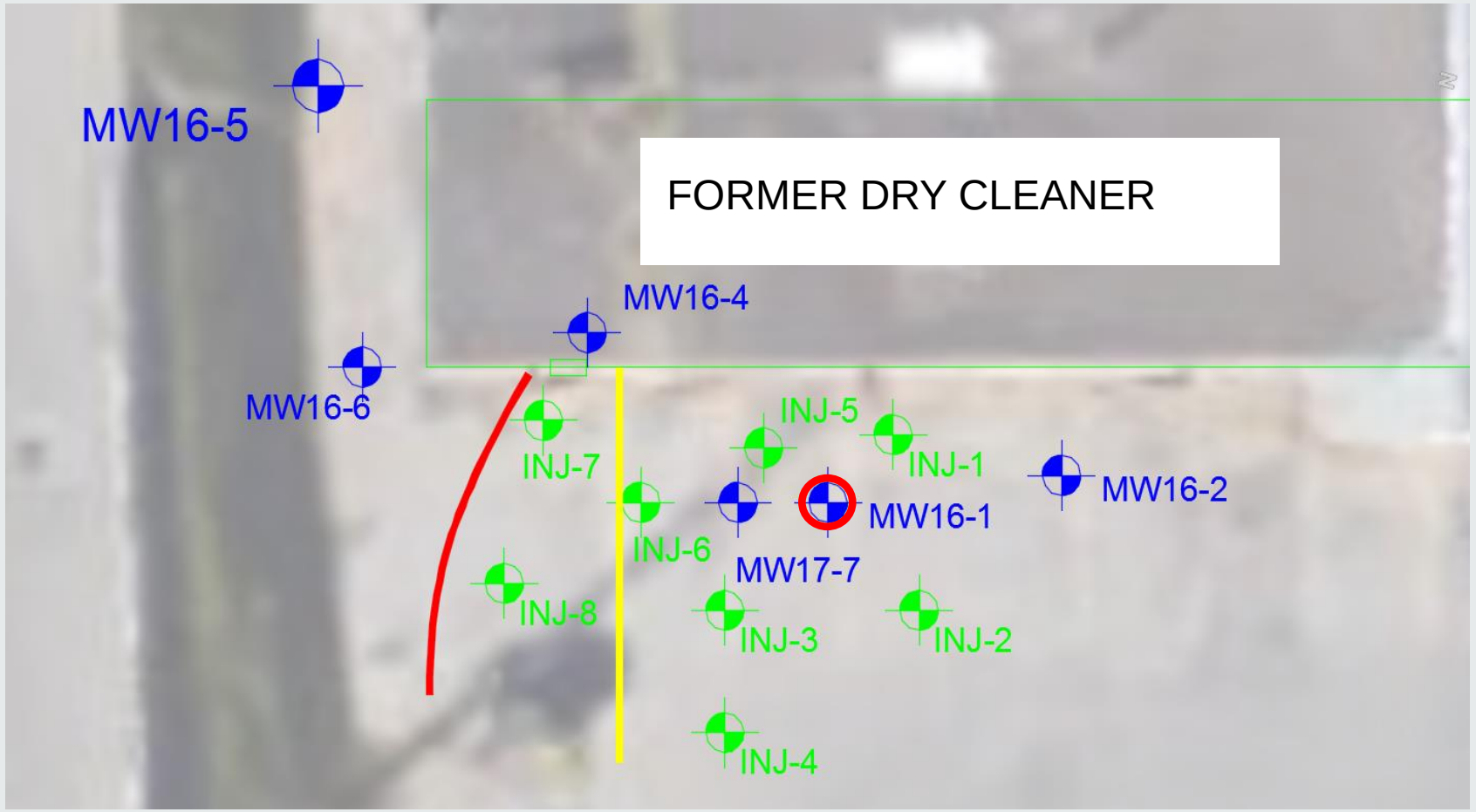
- Phase One and Two ESAs completed in 2016
- Dry cleaner was identified as primary Area of Potential Environmental Concern (APEC)
- Dry cleaning operation was still active at time of Phase One ESA

Phase One and Two ESAs

- Phase Two ESA found perchloroethylene (PCE) at 1.7 µg/L and 1.8 µg/L in one monitoring well
- Table 3 Site Condition Standard in Ontario is 1.6 µg/L



Delineation and Injection Well Installation



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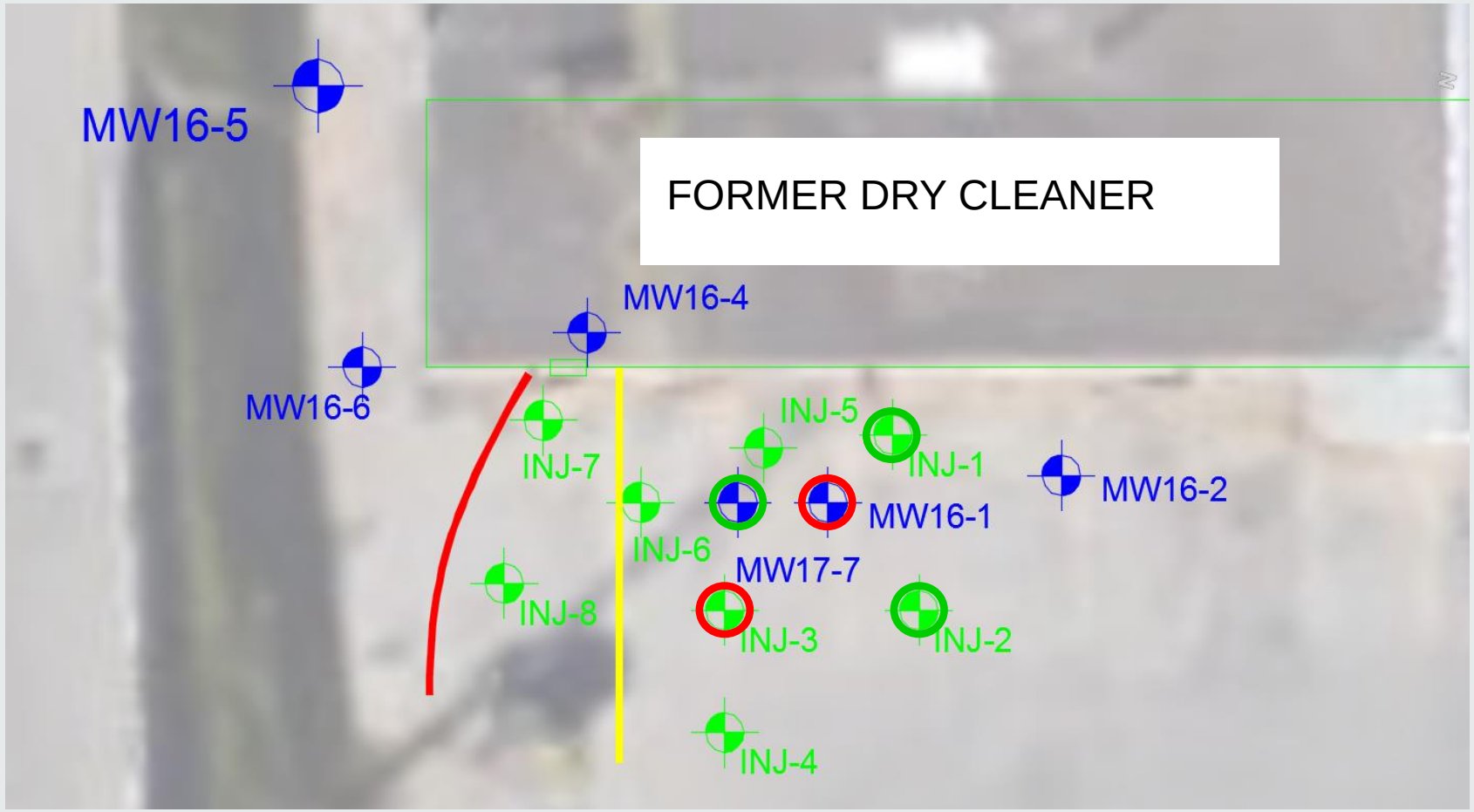
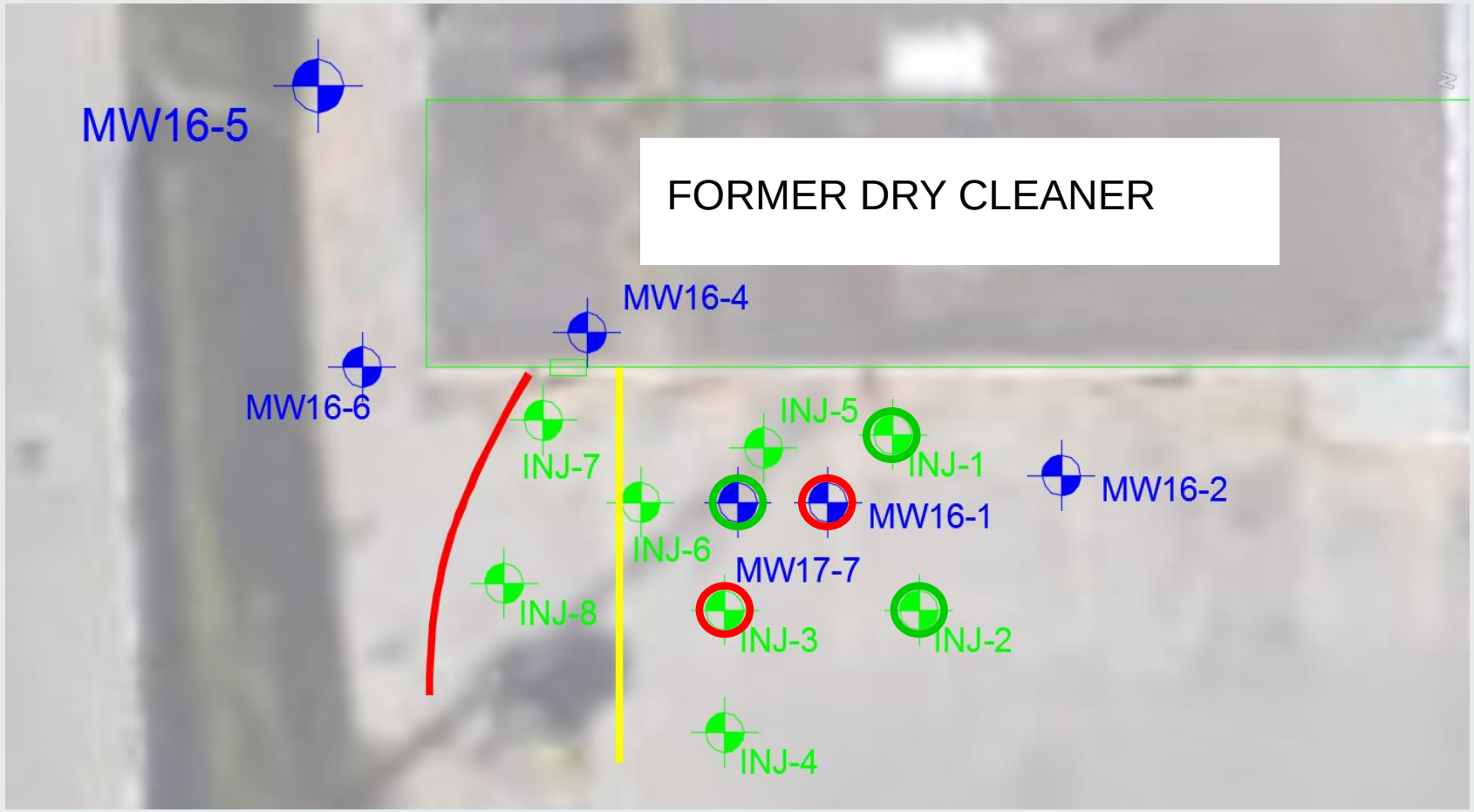


Stage 1

- Injection wells INJ-1, INJ-2 and INJ-3
- Bedrock well MW17-7
- INJ-3 had PCE at 2.0 µg/L
- PCE was ND in INJ-1, INJ-2 and MW17-7

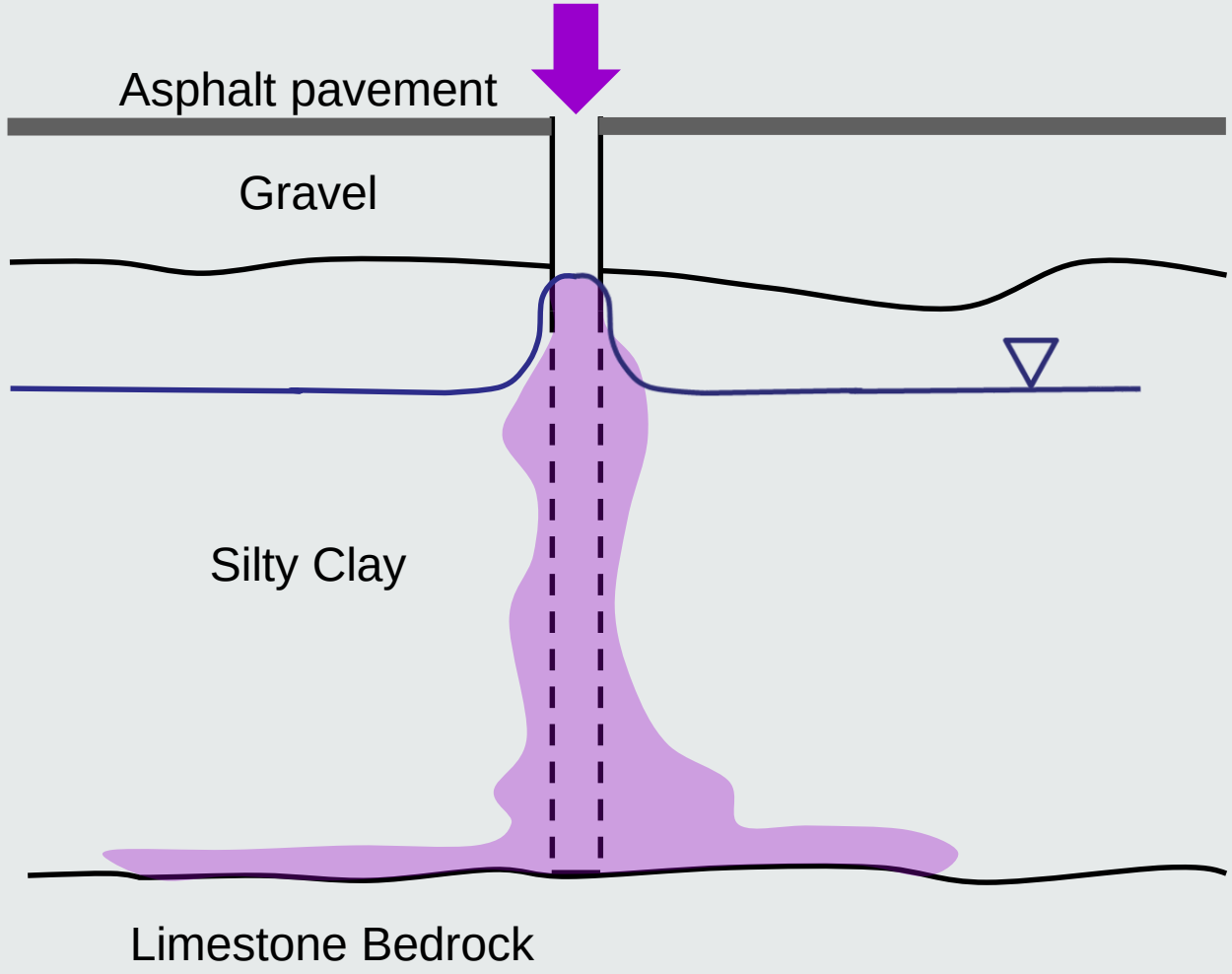
Delineation and Injection Well Installation



Stage 1

- Hydraulic conductivity in INJ-1, INJ-2 and INJ-3 was tested
- 4.4×10^{-3} cm/s was the average k
- Seepage rate of 60 to 100 metres per year

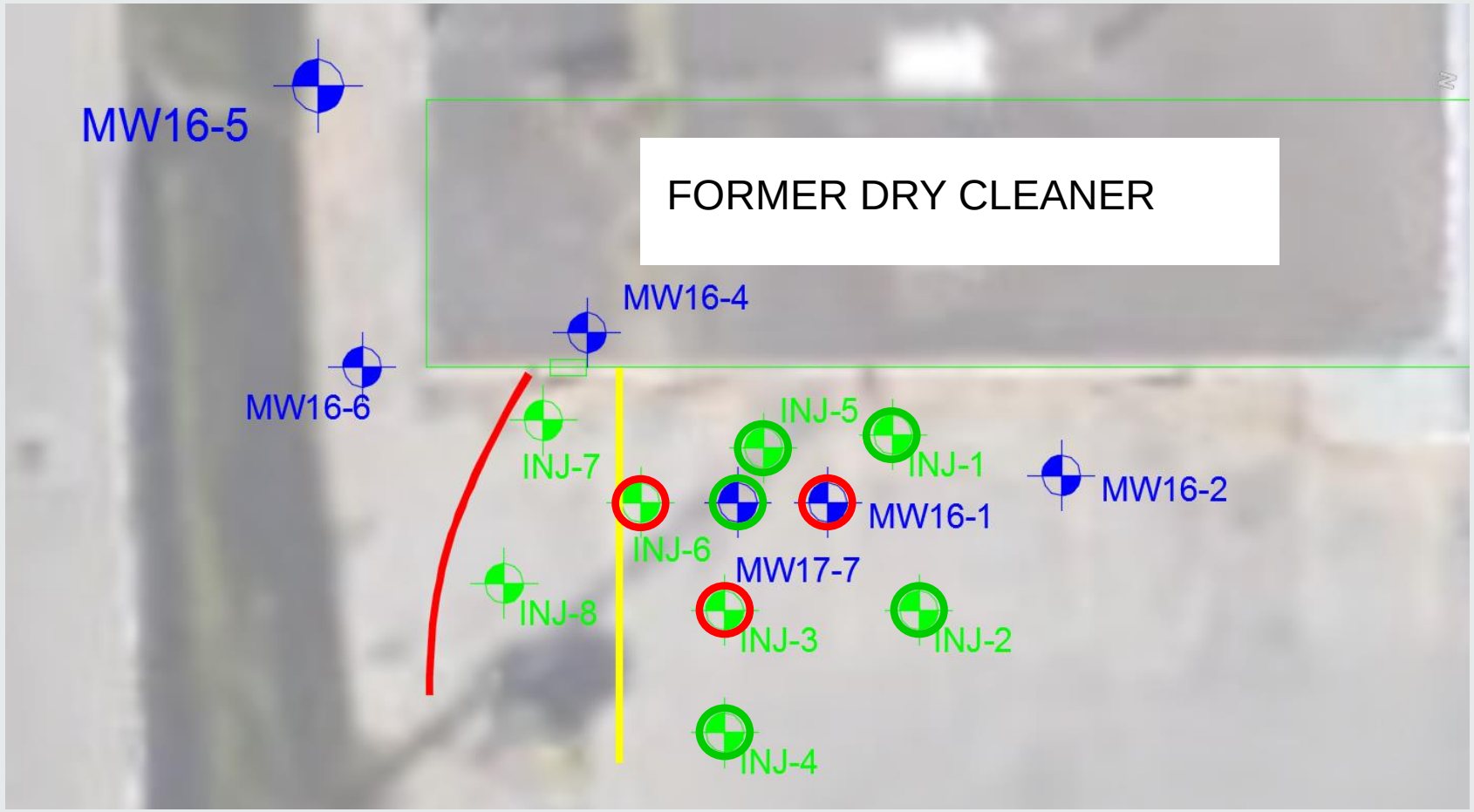
Delineation and Injection Well Installation



Preferential Pathways

- Even distribution of the injected solution is highly unlikely

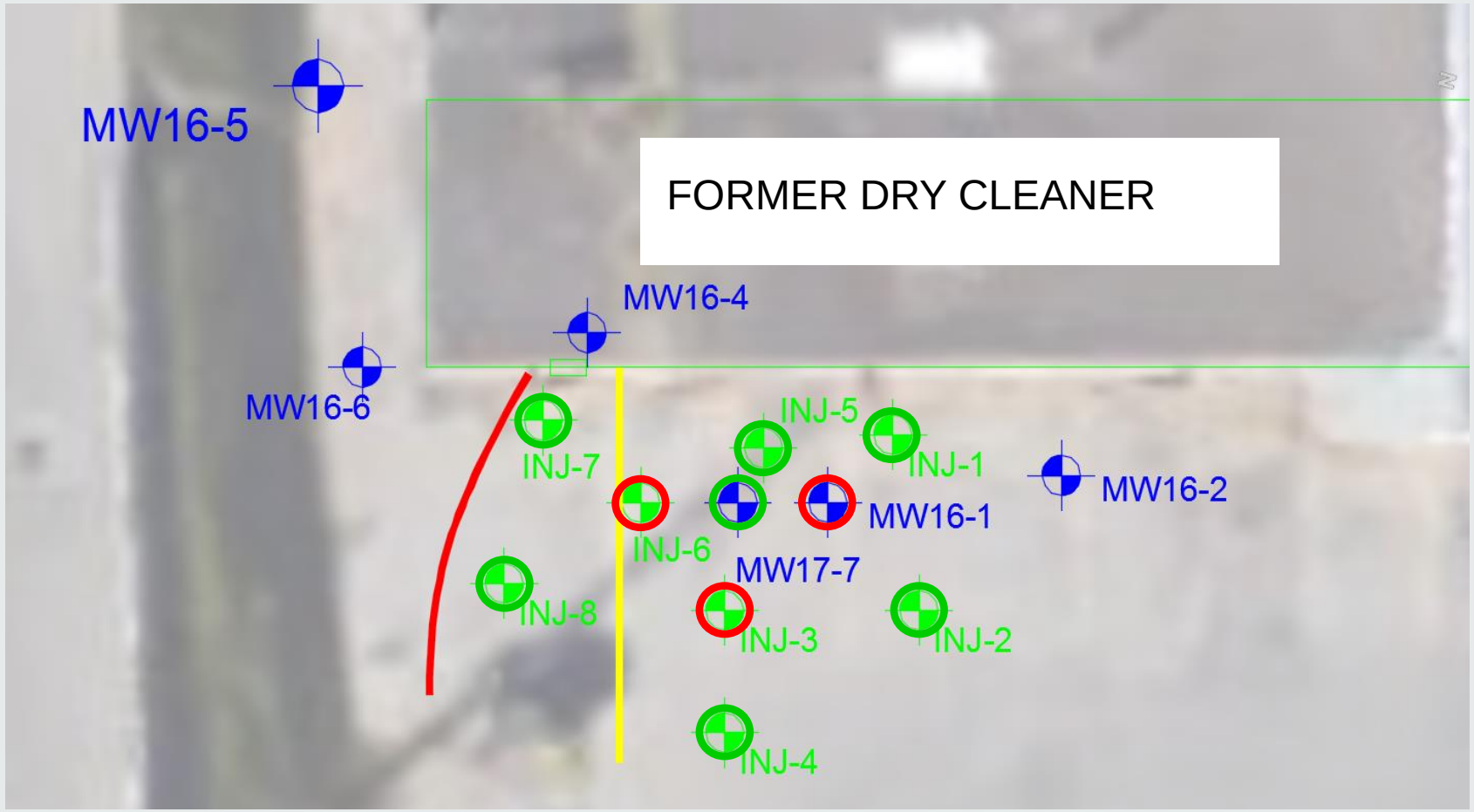
Delineation and Injection Well Installation



Stage 2

- Injection wells INJ-4, INJ-5 and INJ-6
- INJ-6 had PCE at 2.3 µg/L
- PCE was ND in INJ-4 and 1.1 µg/L in INJ-5

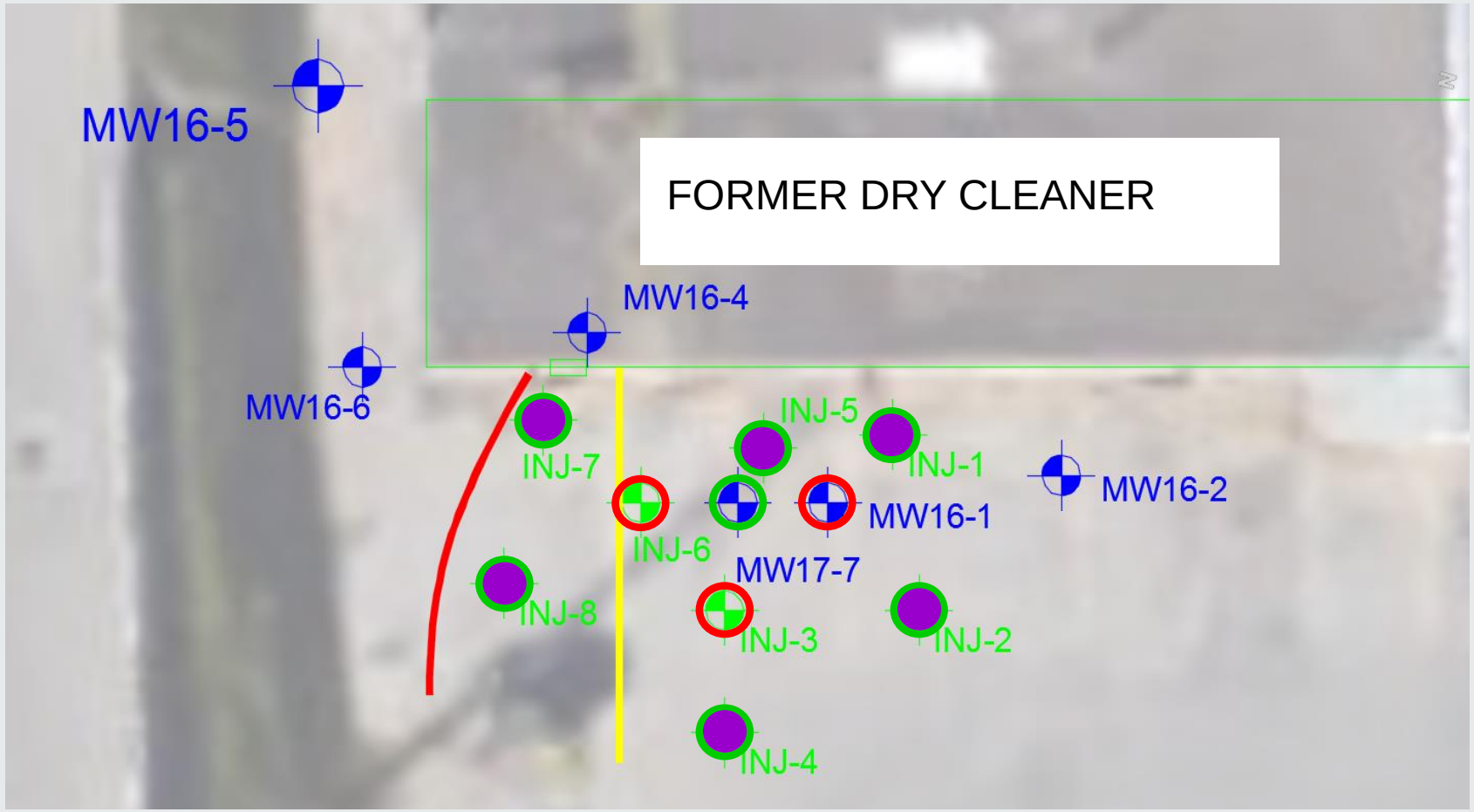
Delineation and Injection Well Installation



Stage 3

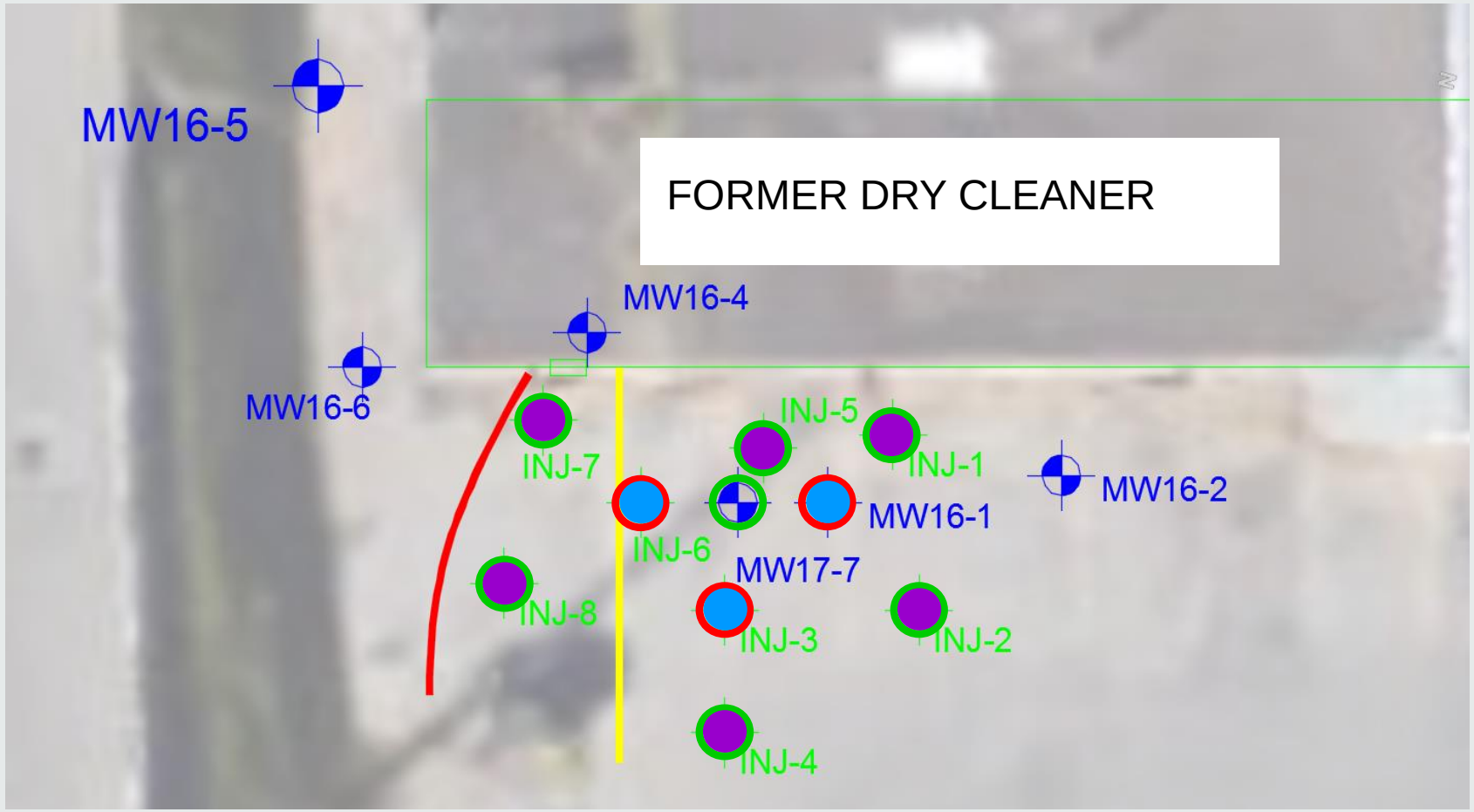
- Injection wells INJ-7 and INJ-8
- PCE was ND in both INJ-7 and INJ-8

Delineation and Injection Well Installation



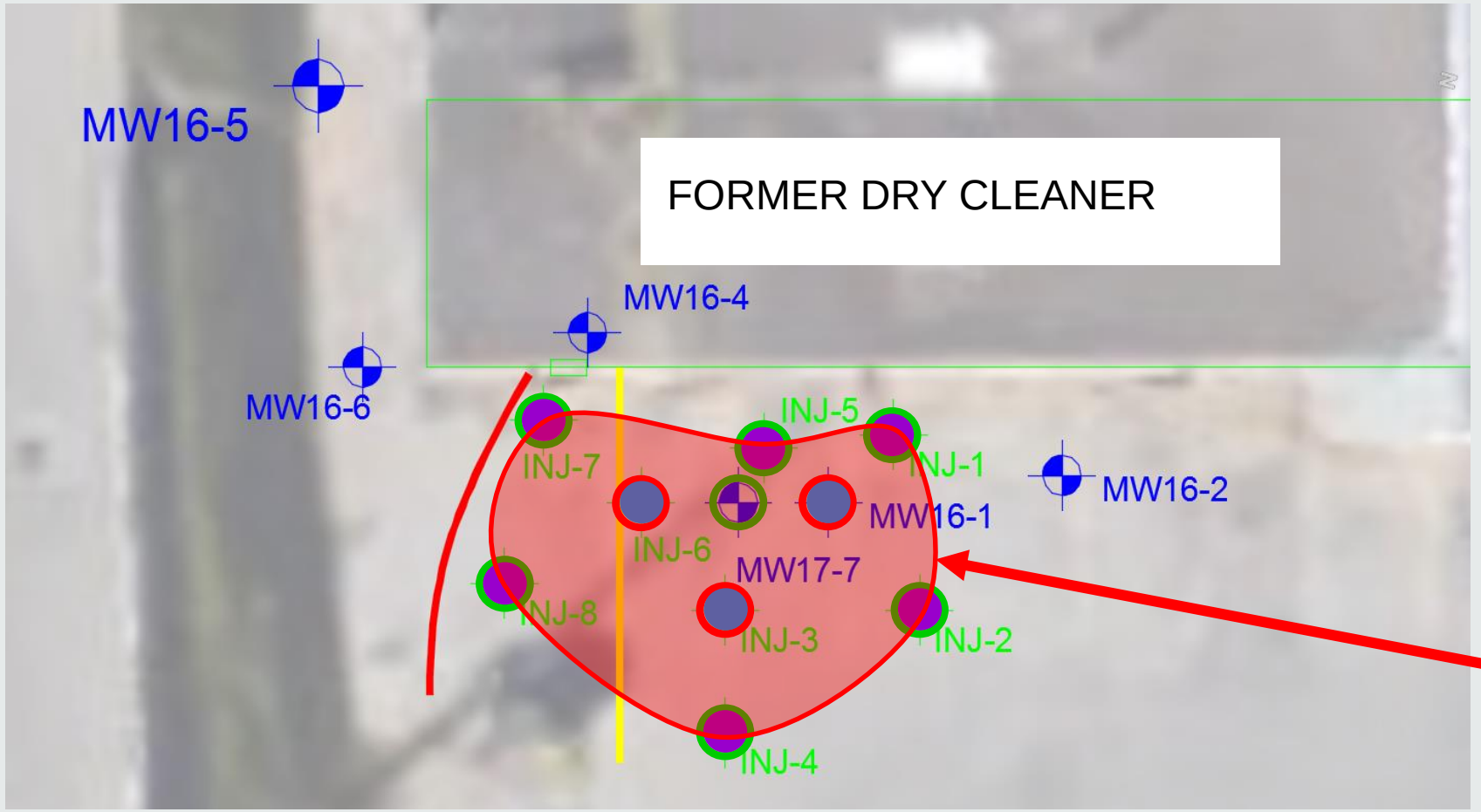
- Injection wells = ●

Delineation and Injection Well Installation



- Injection wells =
- Monitoring wells =

How much PCE is there?



Depth of PCE-impacted groundwater = 3 m

Assumed soil porosity = 0.3

Average PCE concentration = 2 µg/L

Area of PCE-impacted groundwater = 60 m^2

How much PCE is there?

60 m^2 x 3 m x 0.3 = 54 m^3 = 54,000 litres

54,000 litres x 2 µg/L = 108,000 µg = 0.108 grams

This is equal to about 0.07 mL of PCE.

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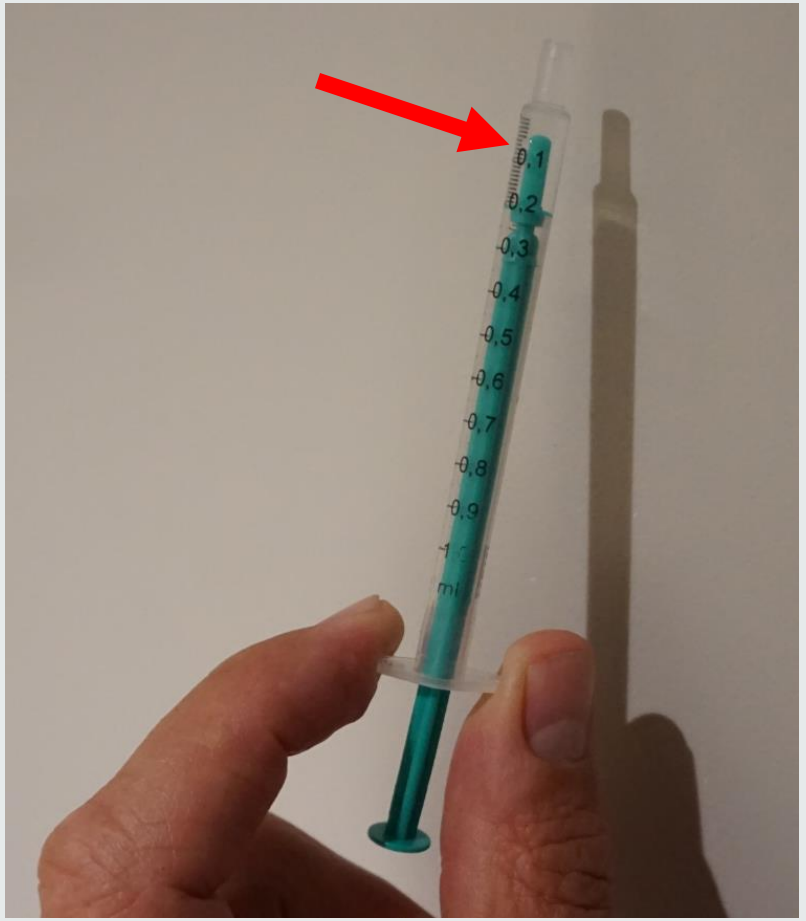

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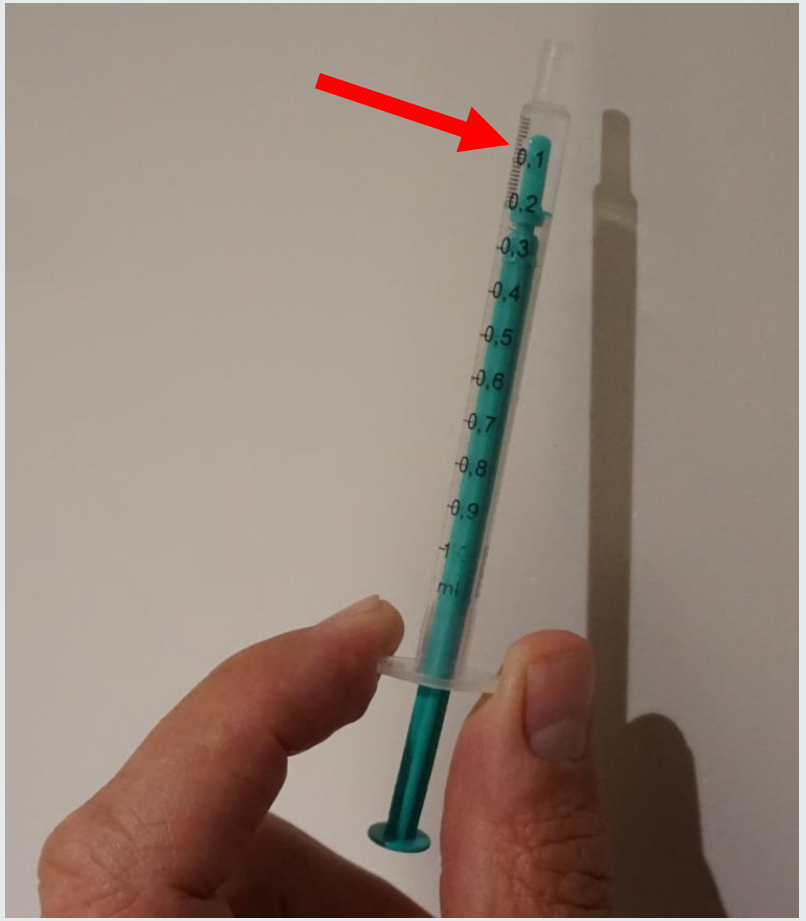
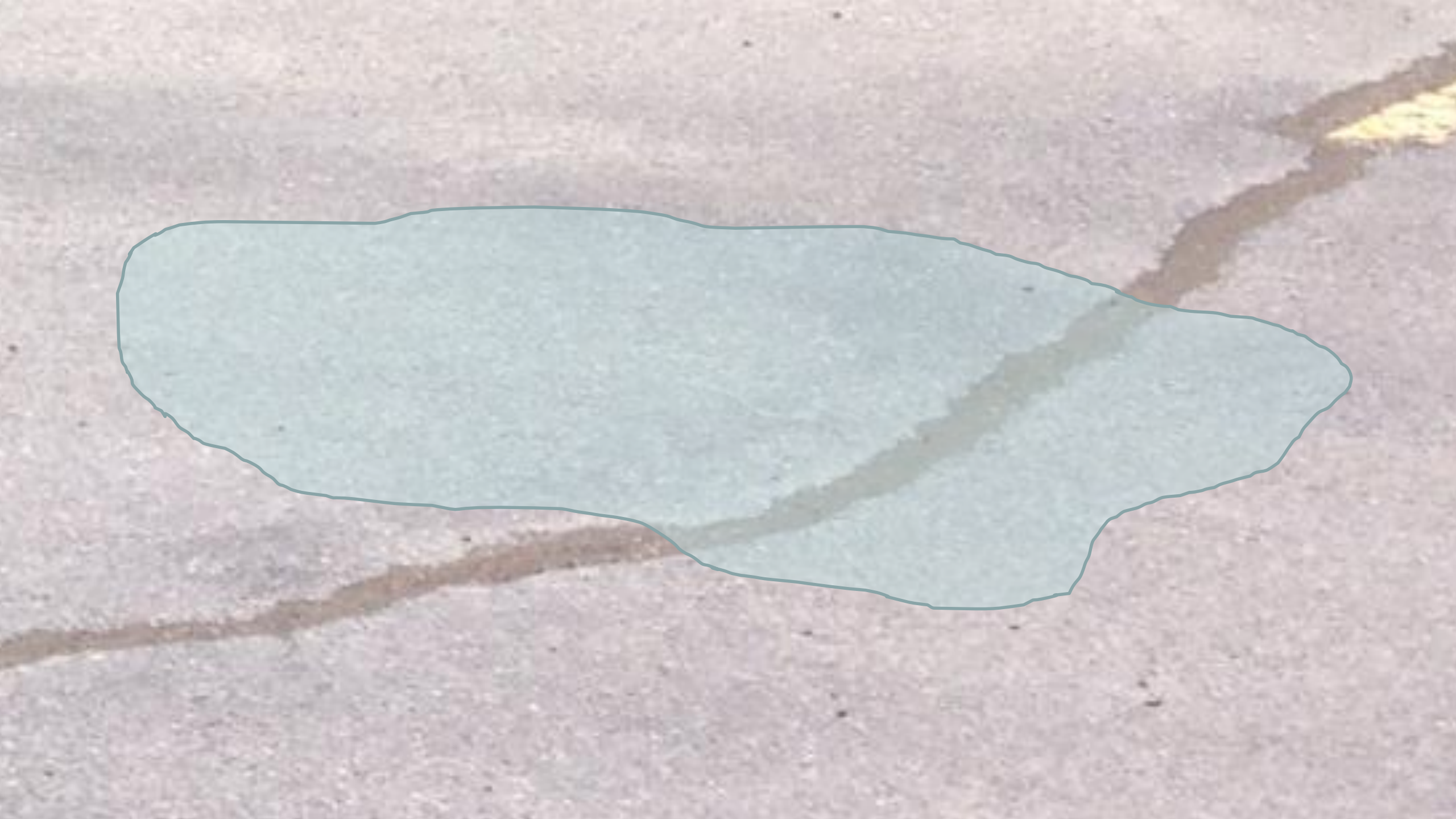
54,000 litres x 2 µg/L = 108,000 µg = 0.108 grams

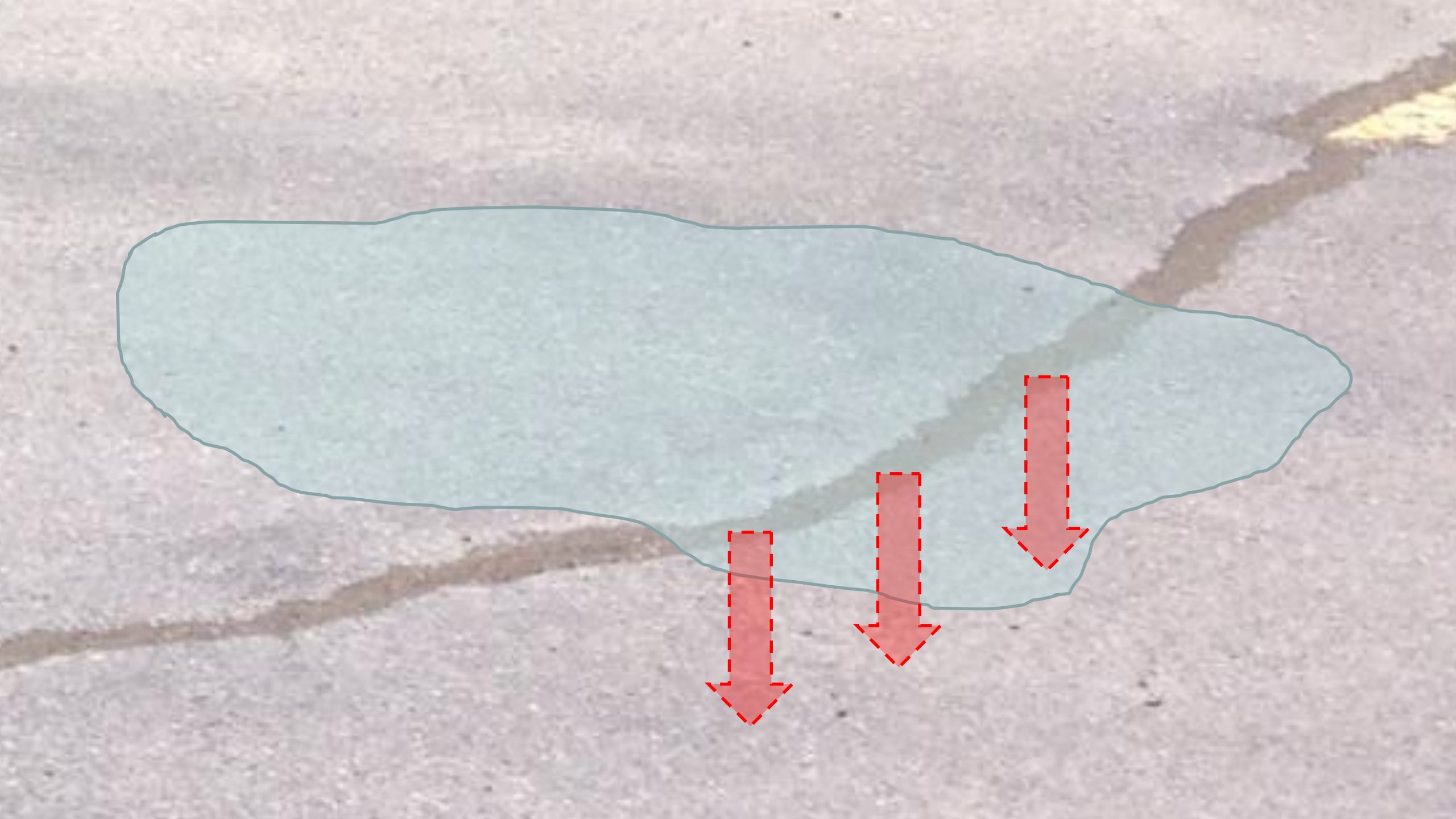
This is equal to about 0.07 mL of PCE.

There is no way that this is the entire mass of PCE we are dealing with at this site!

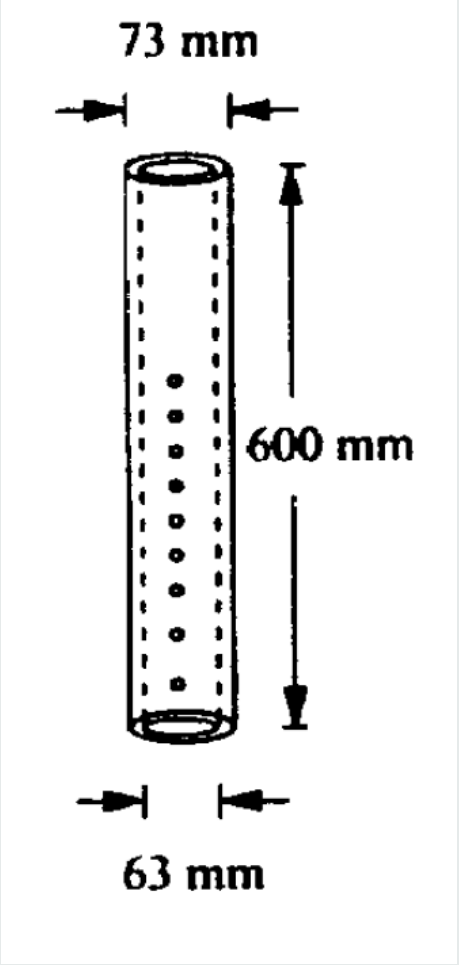


A more realistic scenario:





Guigard, Stiver & Zytner (1996)



- Column filled with soil
- 135 mL of PCE applied to soil surface
- Infiltration times and liquid front movement measured for different soil types
- Cross-sectional area of column = 0.0031 m^2

Guigard, Stiver & Zytner (1996)

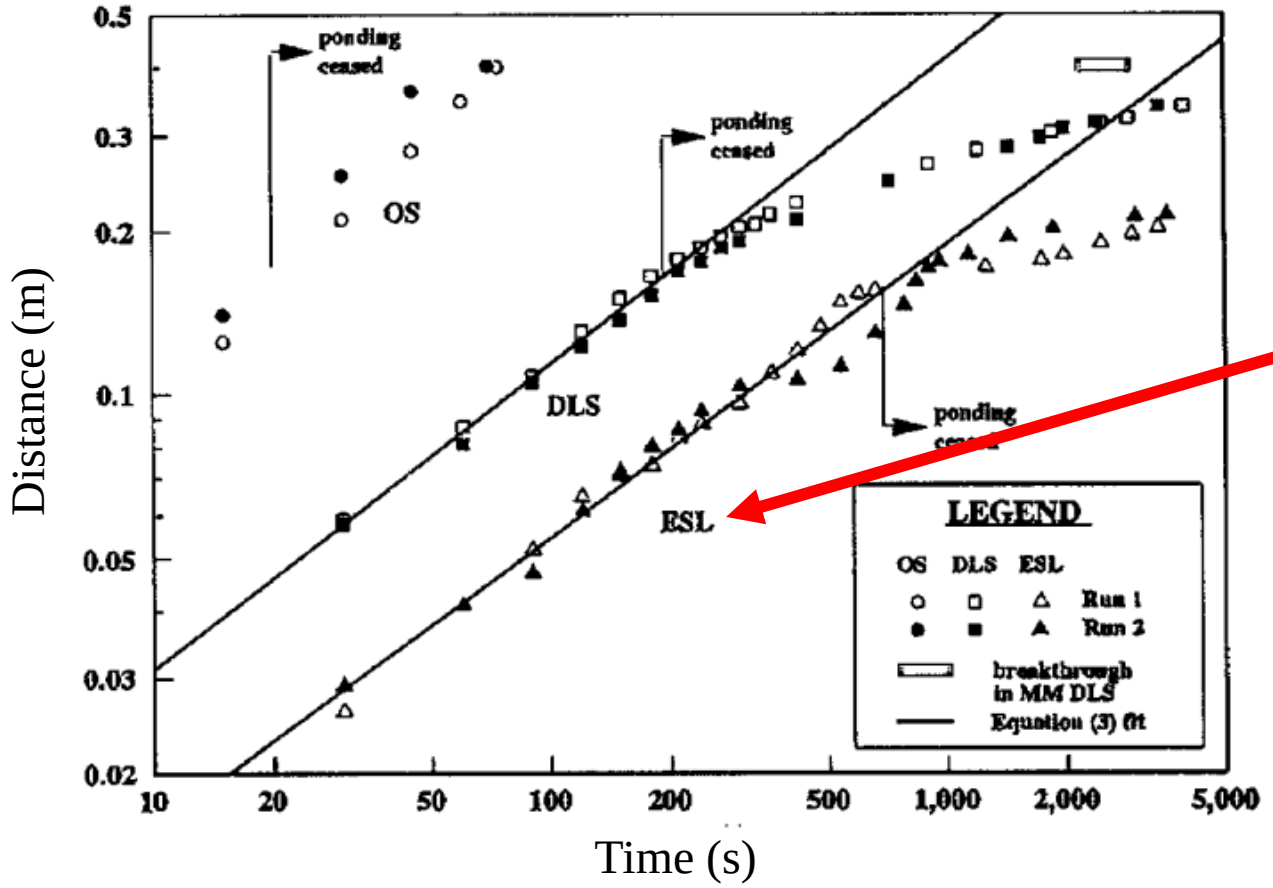
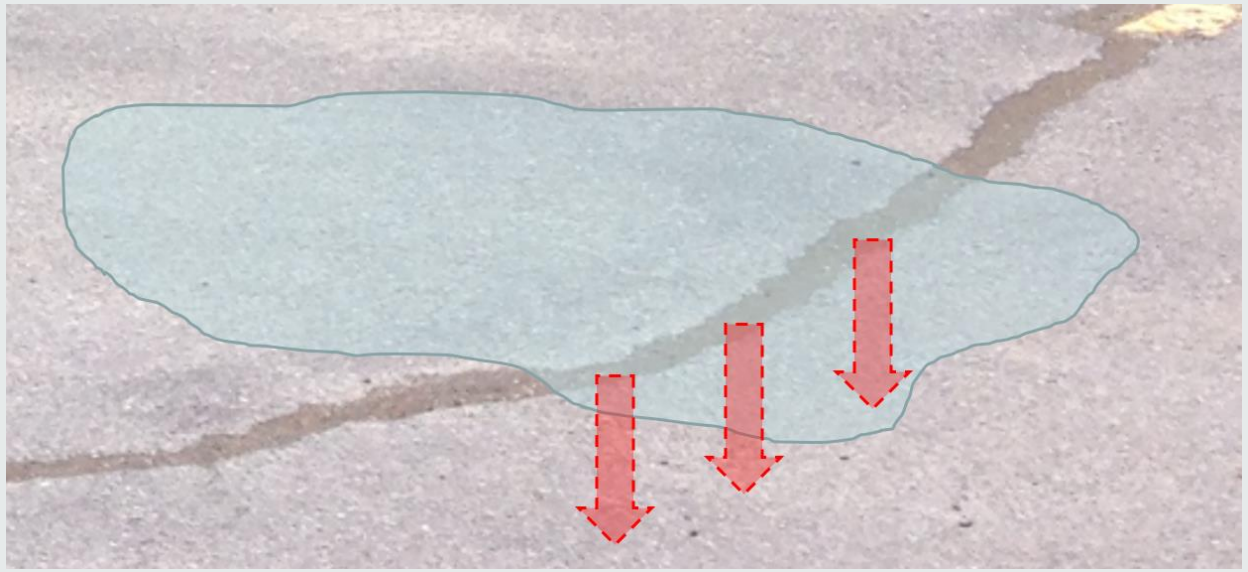


Figure 3. PCE liquid front movement in air dry soils: Green and Ampt Model.

Sandy clayey silt

S. Guigard , W. H. Stiver & R. G. Zytner (1996) The Infiltration and Movement of Immiscible Chemicals in Unsaturated Soil, Environmental Technology, 17:10, 1123-1130, DOI: 10.1080/09593331708616481

Guigard, Stiver & Zytner (1996)



- Water table is 1.5 m below surface
- Assume crack 1 m long and 3 mm wide (area = 0.003 m^2)
- Approximately 1 litre of PCE would need to penetrate the crack to reach the water table

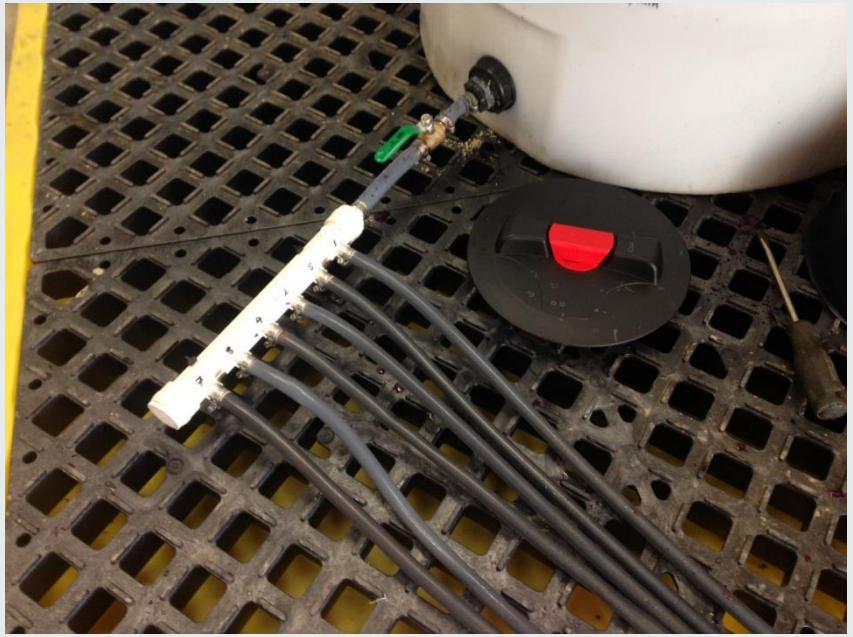
- This is enough PCE to fill the saturated void space in the impacted zone with 2 µg/L of PCE over 14,000 times

Injections

Potassium Permanganate Health and Safety

Injections

Injections

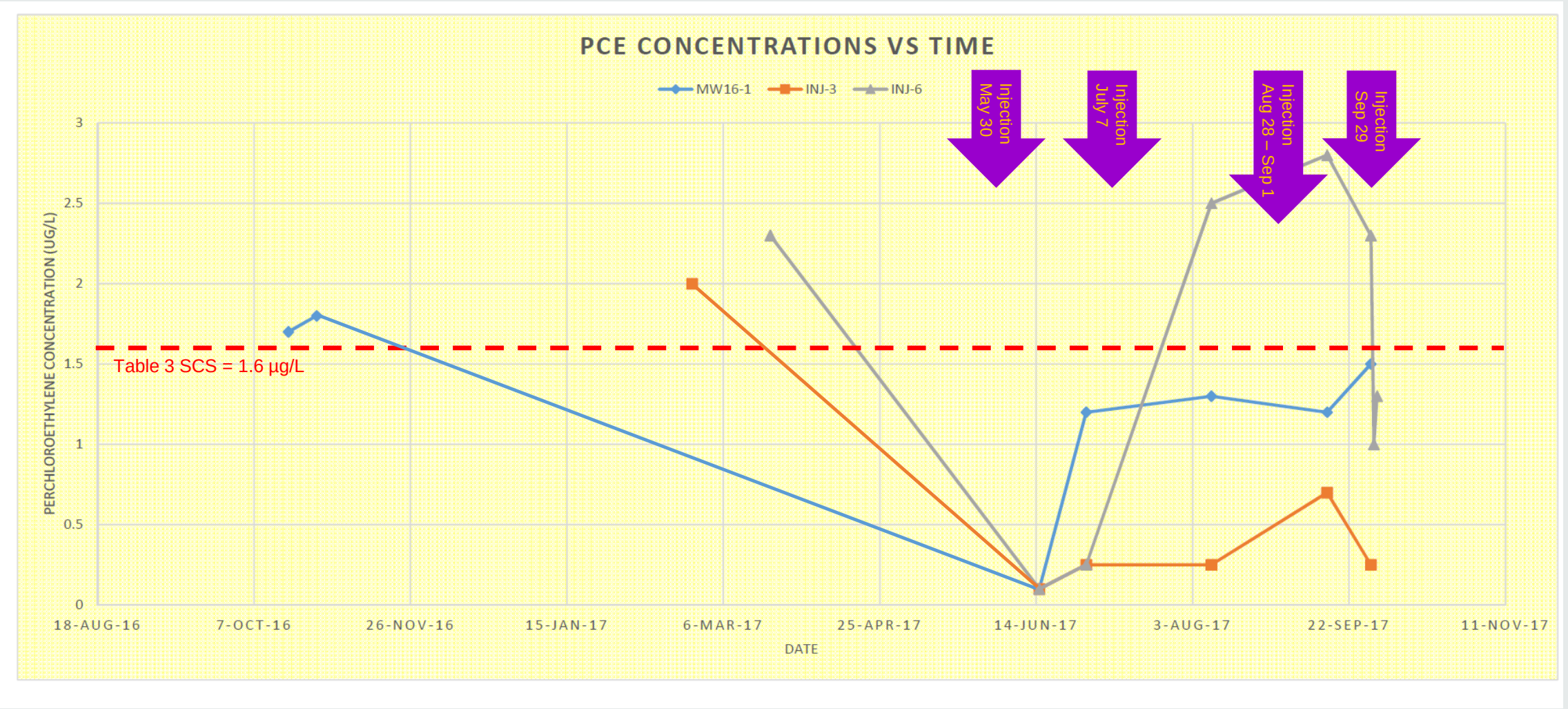


- One 380-litre polyethylene tank used for mixing
- Injections by gravity


Injections

- Checking for presence of potassium permanganate in a monitoring well

Results


PCE CONCENTRATIONS VS TIME
MW16-1
INJ-3
INJ-6
Injection May 30
Injection July 7
Injection Aug 28 – Sep 1
Injection Sep 29
Table 3 SCS = 1.6 µg/L
PERCHLOROETHYLENE CONCENTRATION (UG/L)
3
2.5
2
1.5
1
0.5
0
18-AUG-16
7-OCT-16
26-NOV-16
15-JAN-17
6-MAR-17
25-APR-17
14-JUN-17
3-AUG-17
22-SEP-17
11-NOV-17
DATE

Conclusions

- Some progress towards reduced concentrations has been made
- An elusive PCE source zone is contributing to rebound of the PCE concentrations
- Additional site characterization and targeting of the source zone may be needed
- Risk assessment may be a more appropriate approach for this site

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Questions?