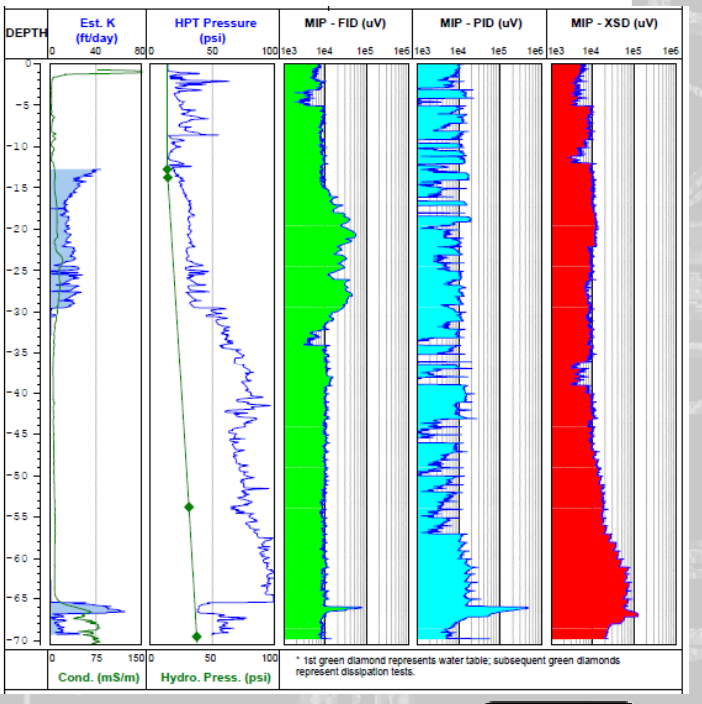
USE OF HIGH RESOLUTION CHARACTERIZATION DATA TO OPTIMIZE SOURCE AREA REMEDIATION AT AOC 50 AT FORMER BASE FORT DEVENS



FRTR Meeting November 2, 2016

Daniel Groher, USACE

US Army Corps of Engineers

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Presentation Outline

- Background for AOC 50 and Membrane Interface / Hydraulic Profiling Tool (MiHPT) Investigation
- Summary of Field Efforts and Procedures
- Results of MiHPT Investigation
- Interpretation of MiHPT Results
- Source Area Remediation Optimization

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AOC 50 Background

- Sources of groundwater impacts are two World War II fueling systems, a former drywell associated with the parachute shakeout tower and a tetrachloroethylene (PCE) drum storage area
- The impacted groundwater extends from the Source Area approximately 3,000 feet downgradient
- ROD and full scale remedy in 2004
  - All the sources were removed and primary GW primary remedy is enhanced reductive dechlorination (ERD)
  - ERD system consists of periodic injections of a organic carbon substrate into permanent wells to stimulate microbial activity
  - Injections into the Source Area (Area 1) and then 4 additional transects across the plume

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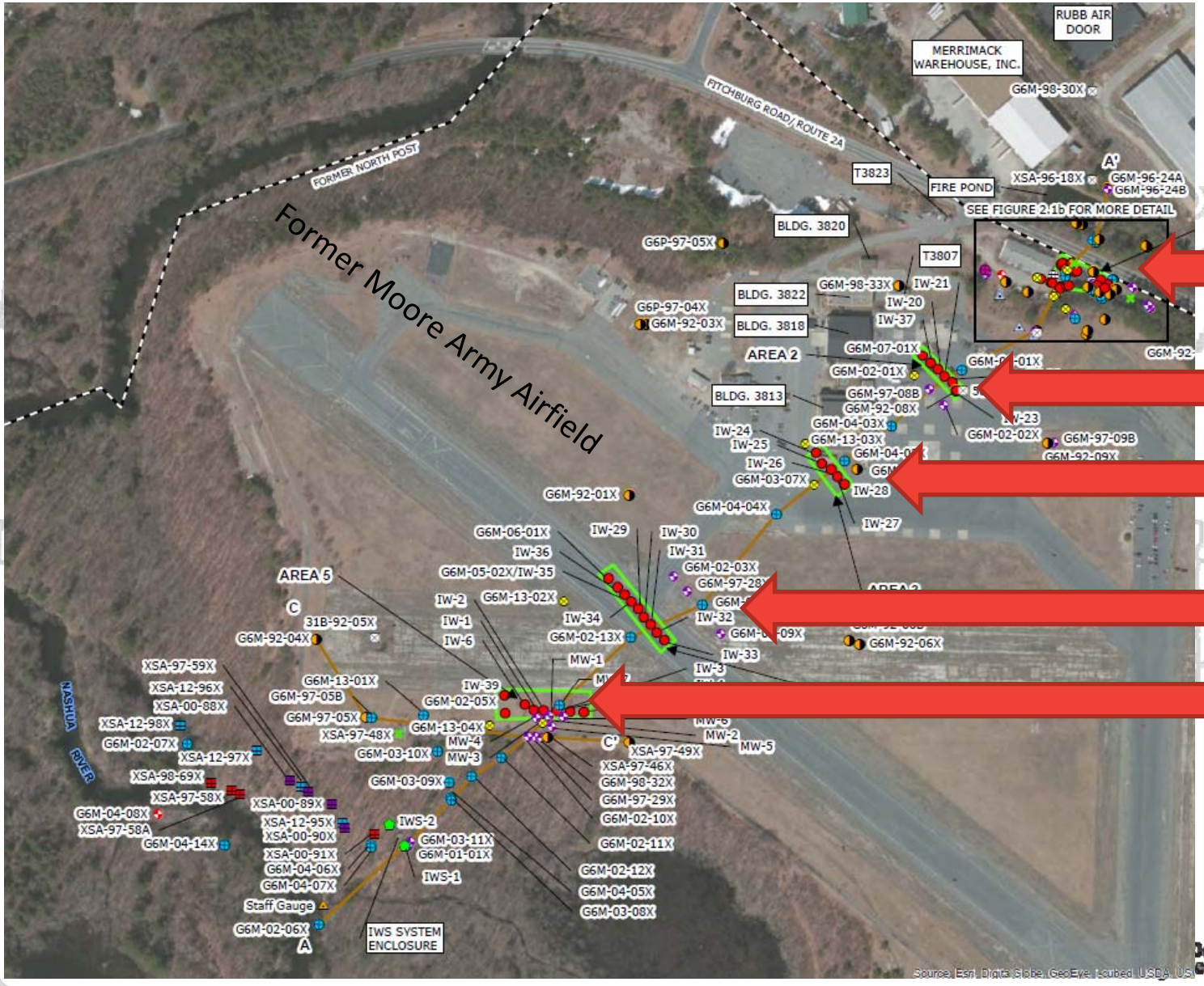
BACKGROUND – AOC 50



Source Area / Area 1

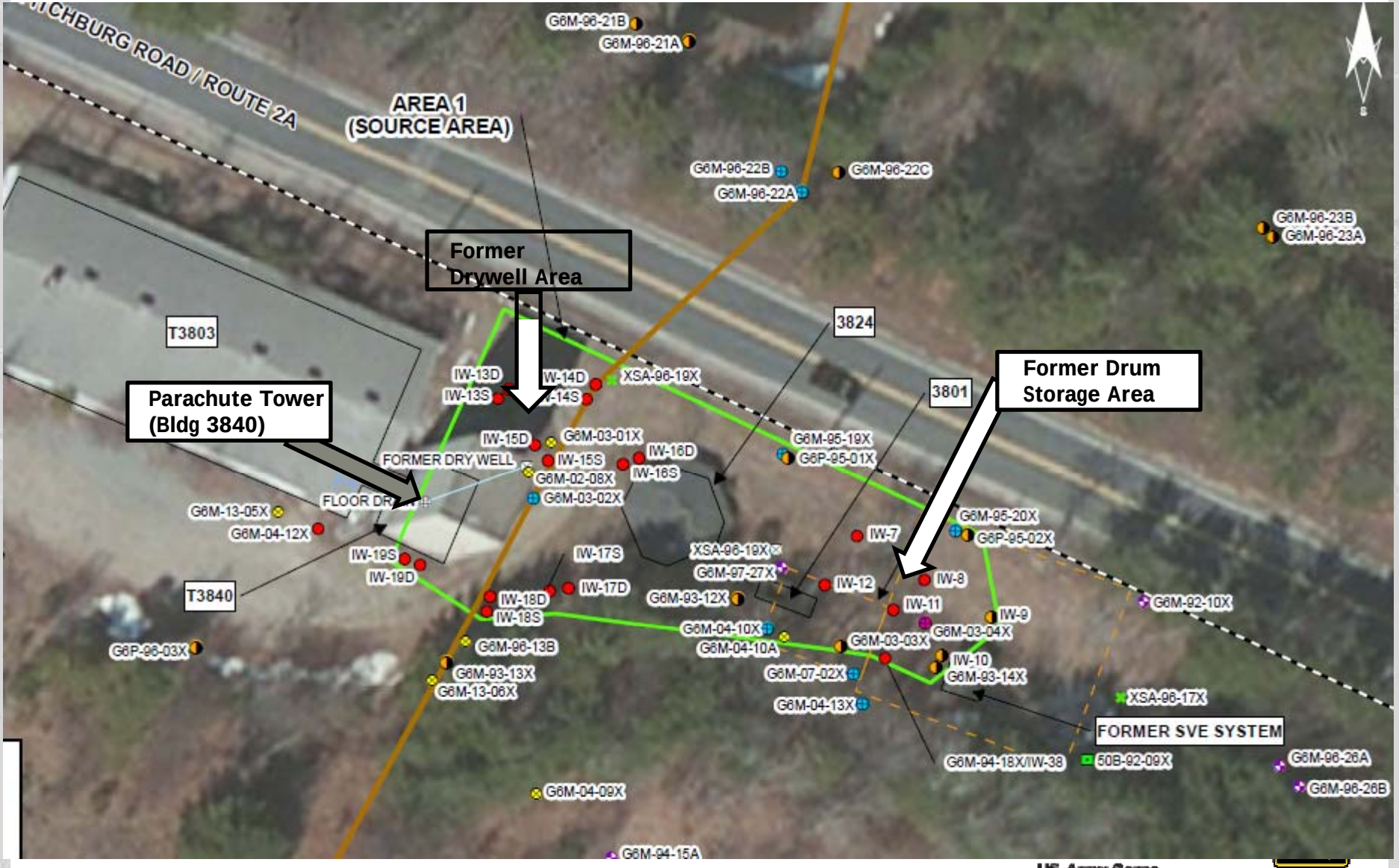
Area 2

Area 3

Area 4

Area 5

Detail of AOC 50 Source Area 1



2013 Groundwater Profiling Work

- Completed vertical profiling using direct push at each injection area
- Groundwater samples collected at 10’ depth intervals for Volatile Organic Carbon (VOC) analysis.
- 15 locations advanced in Area 1 (Source Area)
- Once lab data reviewed:
  - Higher than expected PCE results in the Source Area at several locations compared to permanent well samples
  - Concluded that field-based high resolution site characterization warranted

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2014 High Resolution Site Characterization

- Utilize MiHPT to determine where PCE hot spots exist and the relative permeability of these locations;
  - Investigate beneath Parachute Tower to determine if the floor drains in the building are an additional source
- 17 MiHPT locations in source area late September and early October 2014 (5 more than originally planned)
- Small number of confirmatory soil and groundwater samples (used to confirm and calibrate)
- Each boring was grouted upon completion

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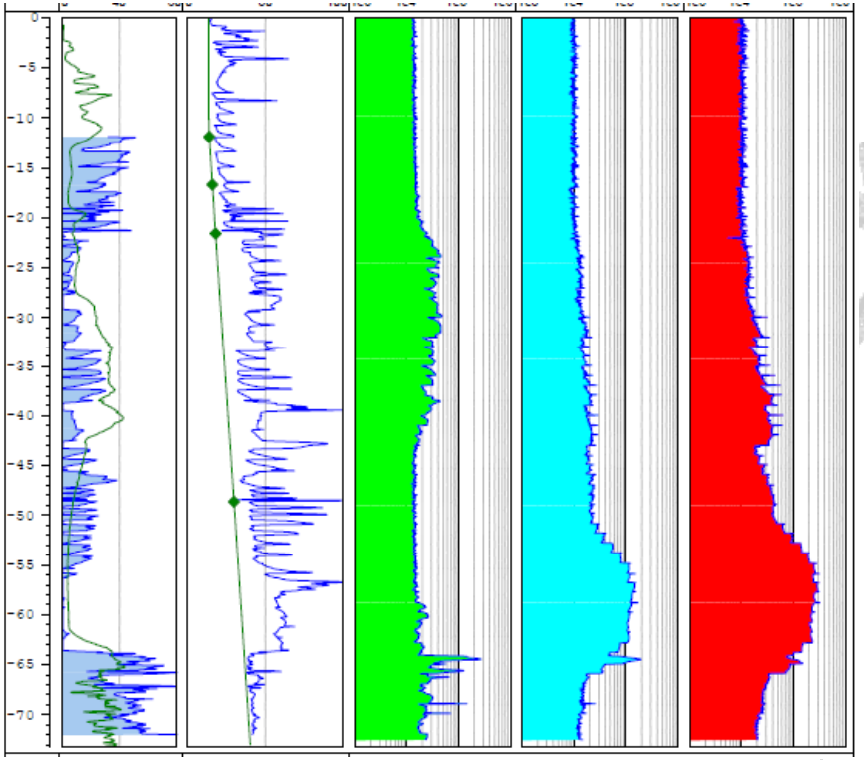
Background – How MiHPT Works

- MIP is a membrane located on the drill stem, connected to a carrier gas trunk line to the surface.
- Carrier gas pumped past the membrane collects VOCs from the subsurface at each discrete depth for field analysis (by FID, PID, and XSD).
- An electrical conductivity (EC) probe is also attached to the drill stem.
- Hydraulic profiling (HPT) via an hydrostatic pressure probe.

Field results for a Single Probe



- HPT operates by pumping clean water into the formation and recording the injection pressure.
- More information: http://geoprobe.com/mihpt

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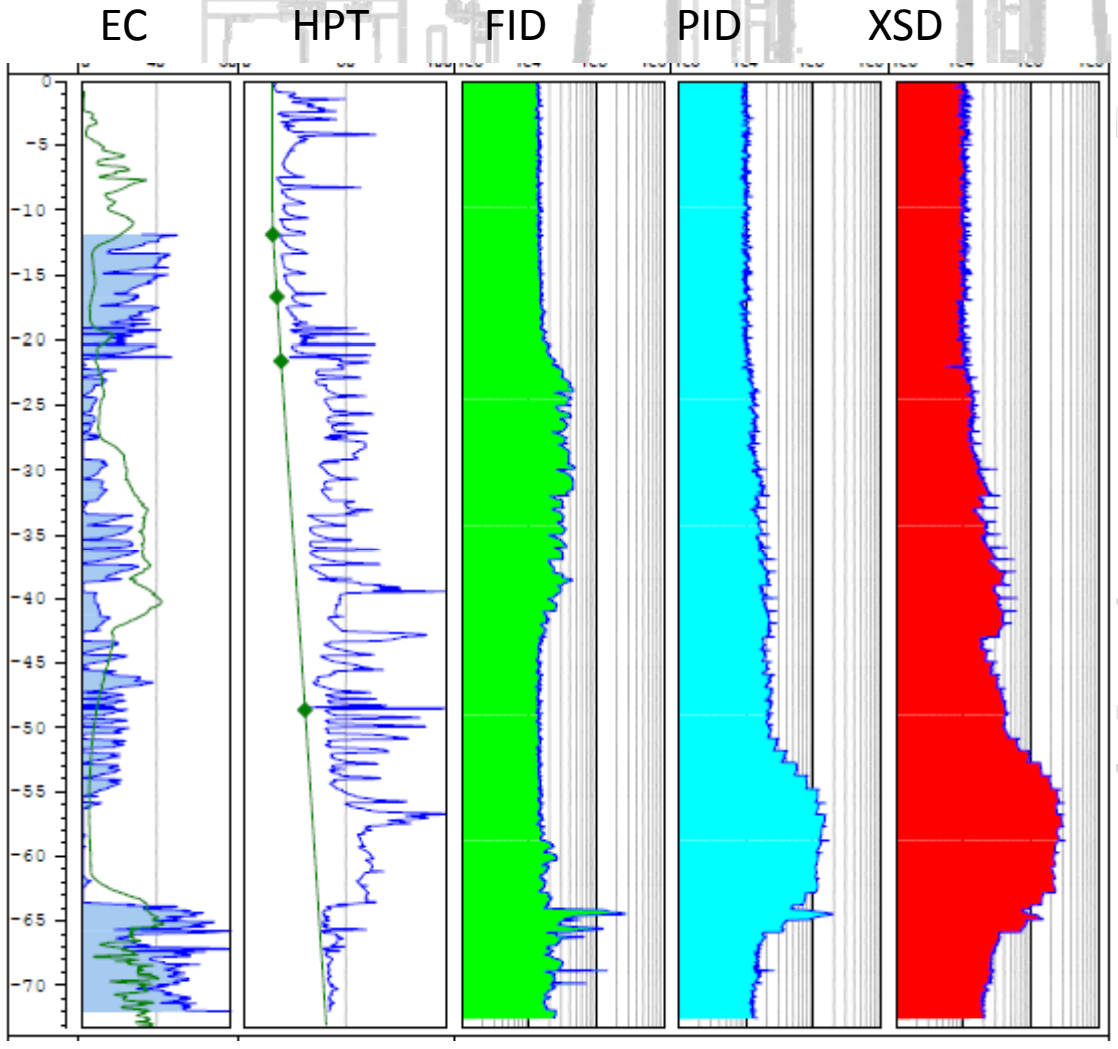
Interpreting MiHPT Output Graphs



- EC – Electrical Conductivity – translates to hydraulic conductivity
- HPT – Higher pressure signifies denser material
- FID – Flame ionization detector – measures gases such as methane, a byproduct of ERD
- PID – Photo ionization detector – measures VOC concentrations.
- XSD – Detector calibrated specifically to PCE.

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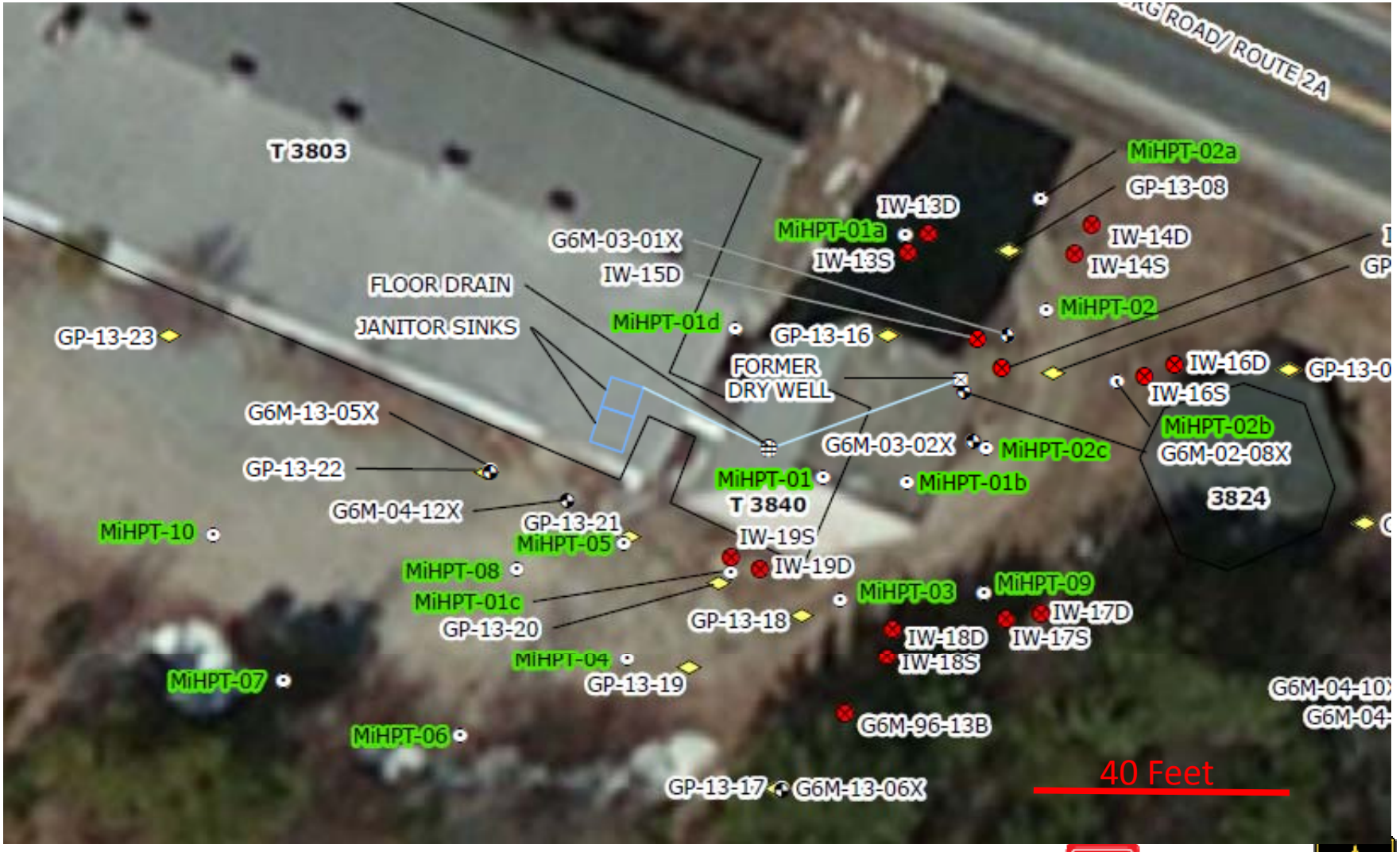
Completed Locations



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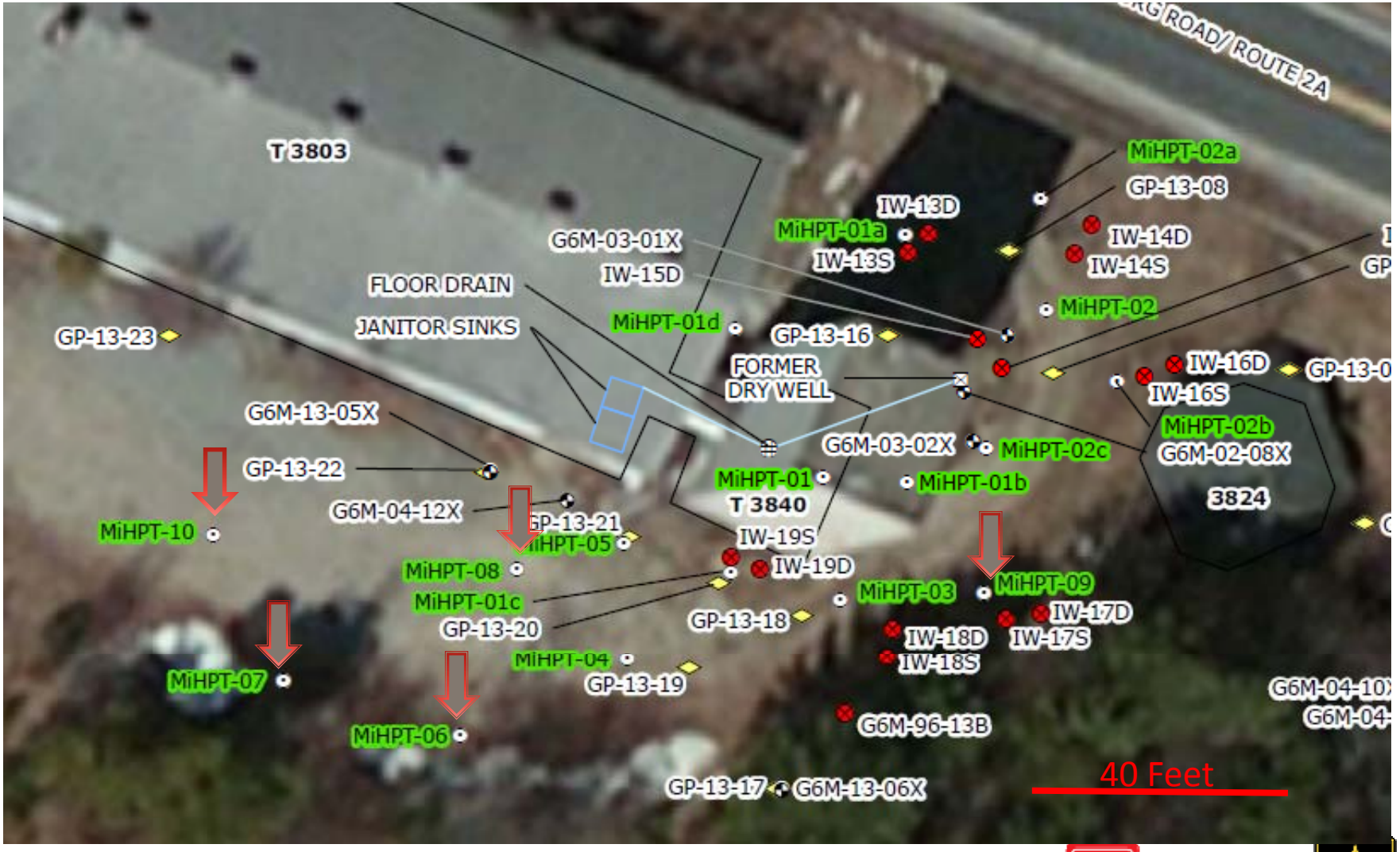
Completed Locations



Extra/unplanned location

Evaluation of Data

- MiHPT logs were developed for each location.
- Side-by-side logs for each detector.
- Allowed analysis of PCE concentrations related to subsurface features (stratigraphic changes/boundaries)
- Allowed evaluation of microbial activity through methane detection by FID.
- Grab groundwater samples collected for calibration/evaluation at select locations
- Soil geotechnical data collected to confirm hydraulic profiling tool (HPT) data

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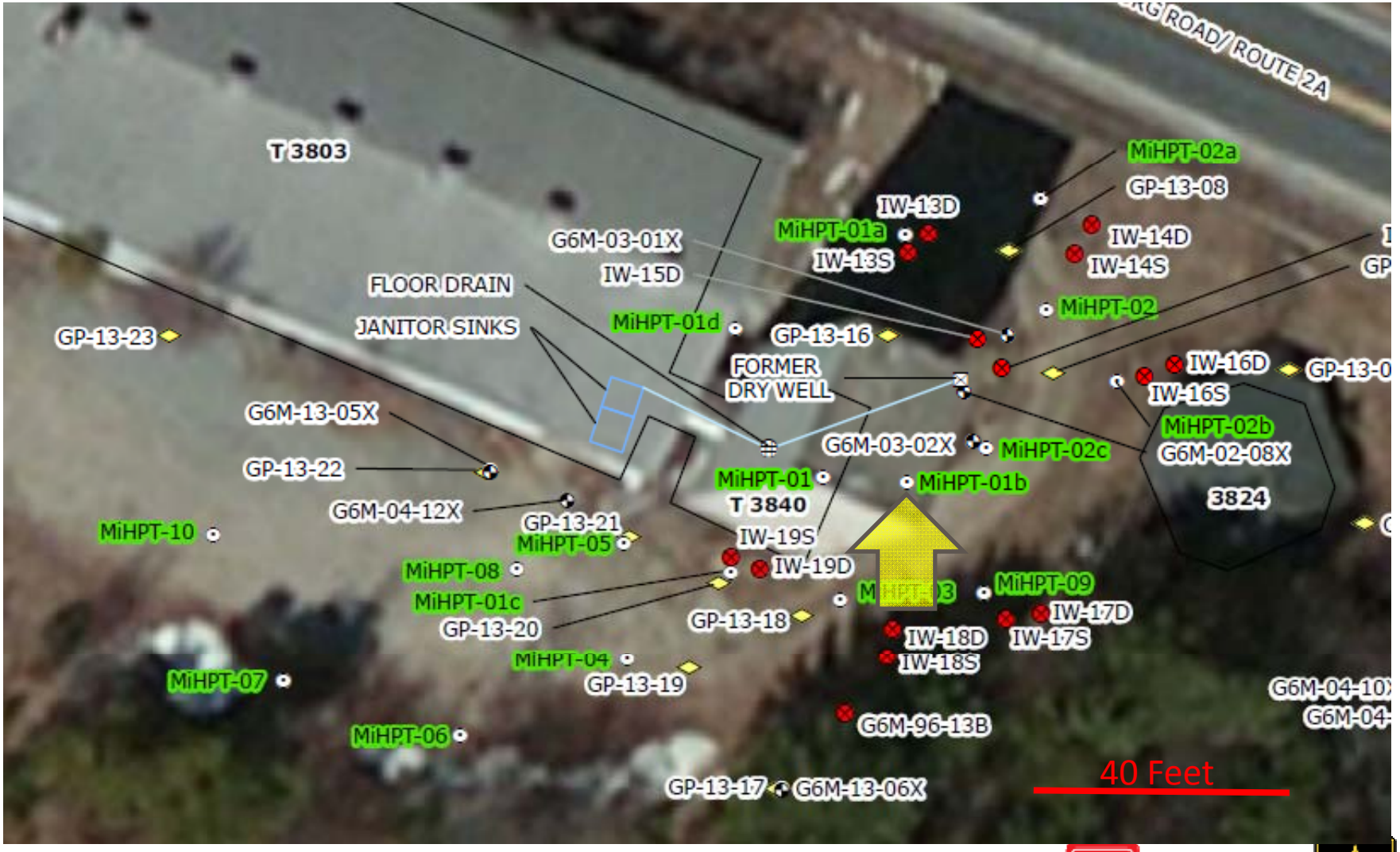
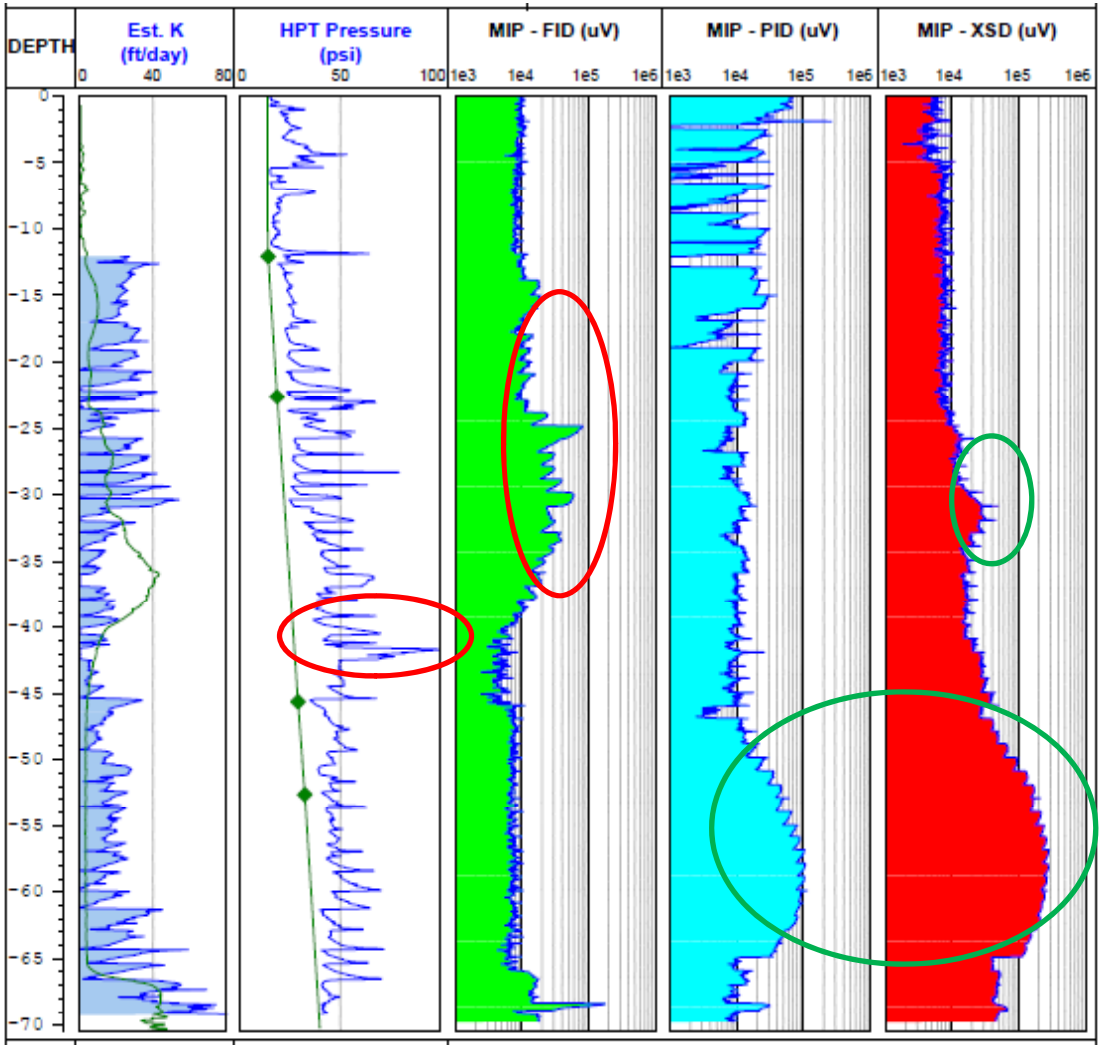
Highlight – MiHPT 1b



MiHPT Interpretation – MiHPT 1b



- HPT indicates dense zone at 40-42’ bgs.
- FID increases in shallow zone likely methane response from past ERD injections - concentrated shallower than 40’ bgs.
- Bulk of PCE mass is below 45’ bgs, with a smaller mass in the 25’ to 35’ zone, correlating with FID increased results.
- Nature and extent are consistent with CSM/dry well source.

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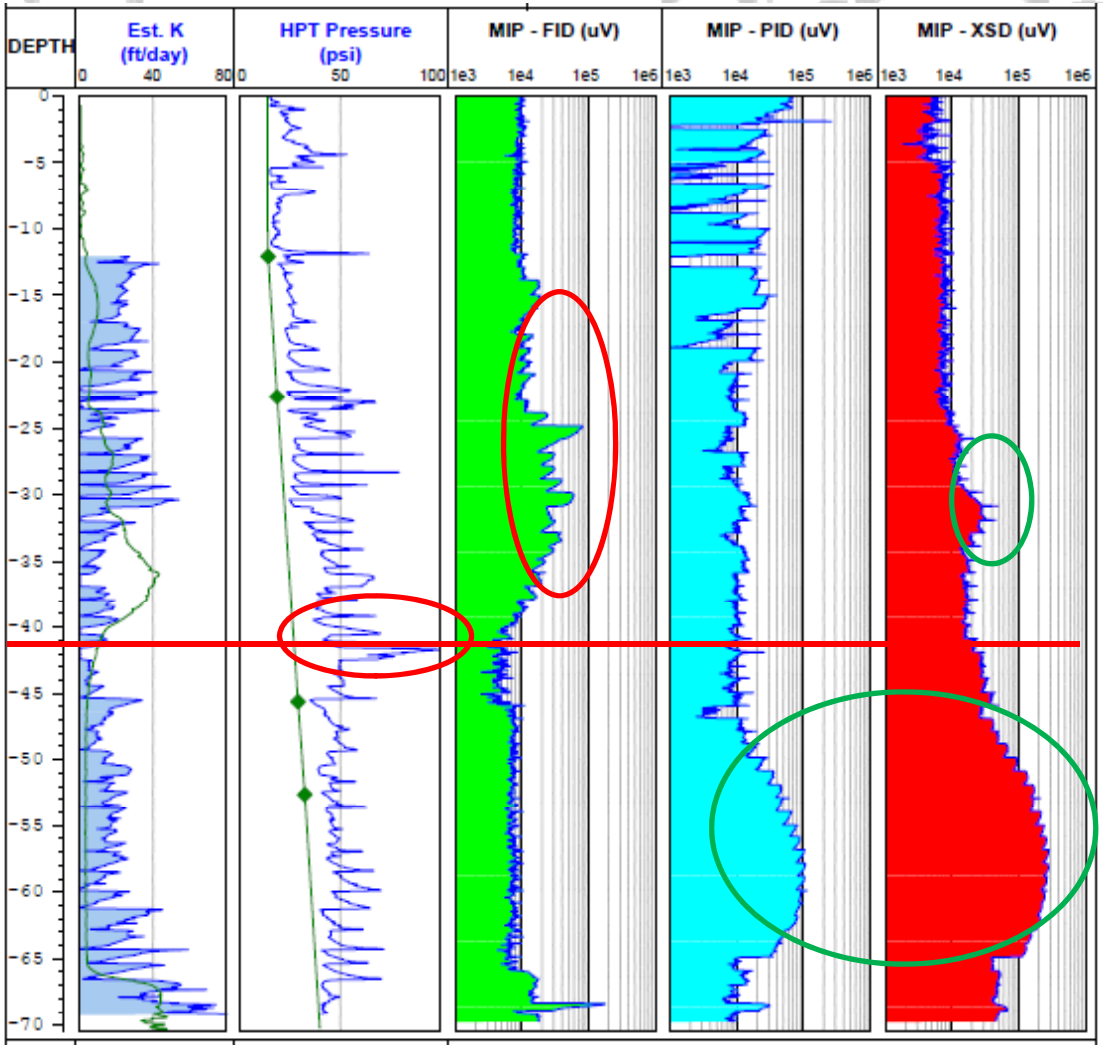
MiHPT Interpretation – MiHTP 1b (cont'd)



- Dense zone at 40-42 feet may represent a low permeability layer limiting ERD effect. This is supported by increased FID results at shallower depths coupled with residual mass at shallower depths.
- One conclusion is that remediation injections are concentrating in the aquifer above 40' and have more limited contact with bulk of mass deeper.

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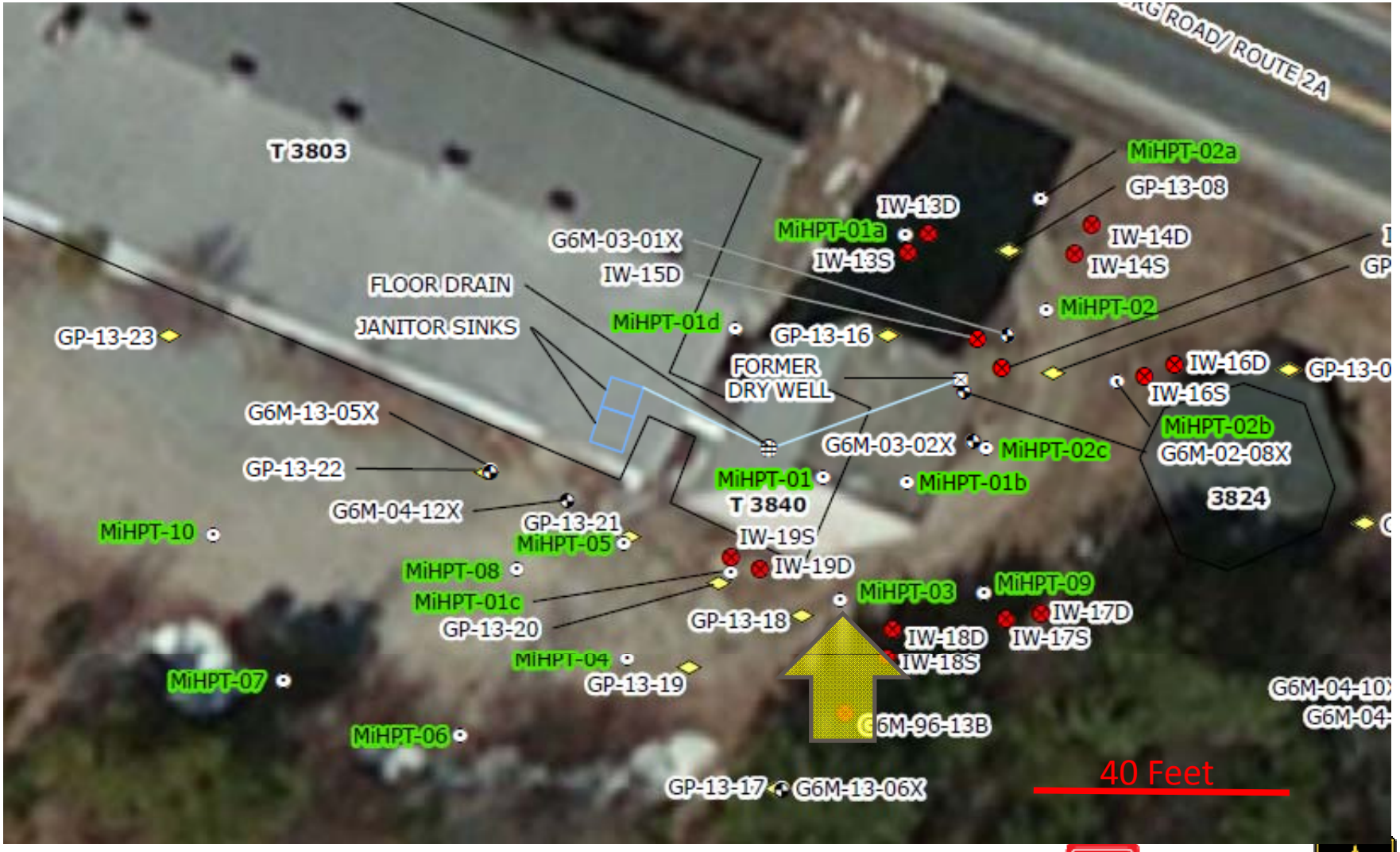
Highlight – MiHPT-03



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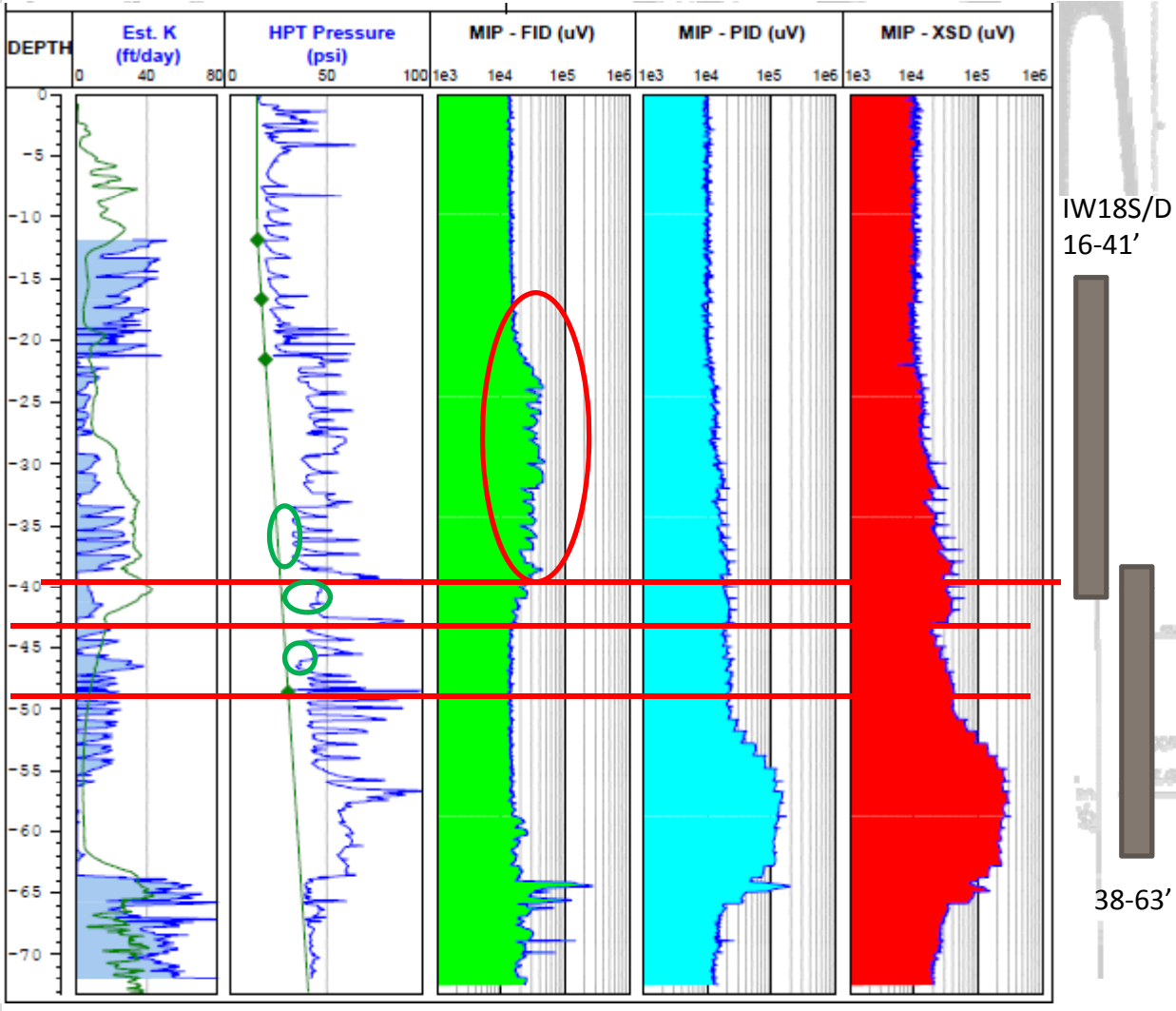
MiHPT Interpretation – MiHPT 03



- Dense zone at 40-50 feet may represent a ERD contact barrier. Note less dense zones (green circles).
- Blue rectangles represent well screens for IW-18S/D
- Suggests gravity ERD injections in IW-18S resulting in methane generation, injections in IW-18D may be biased in permeable areas shallower than zone of most impact.

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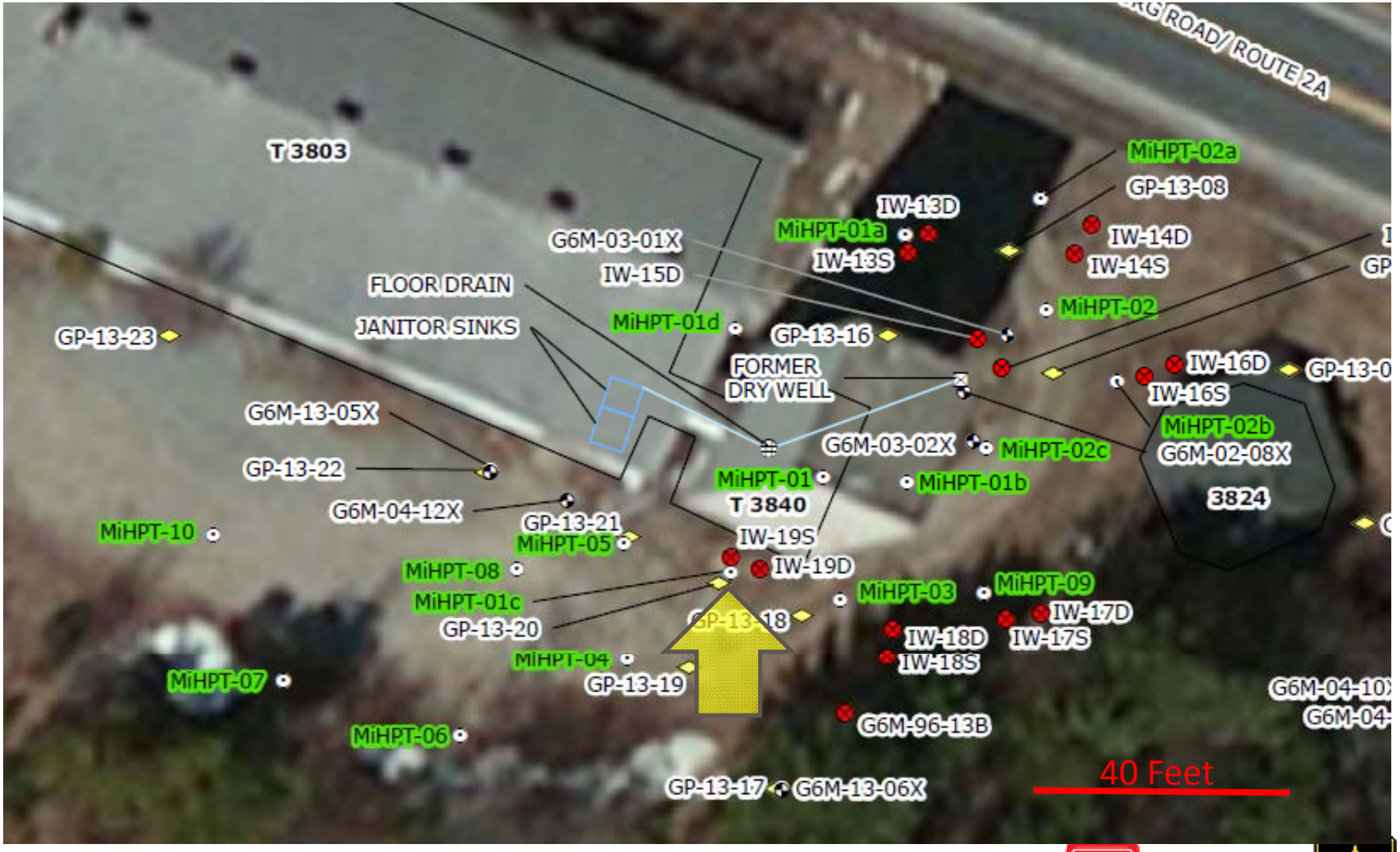
Highlight – MiHPT-01c



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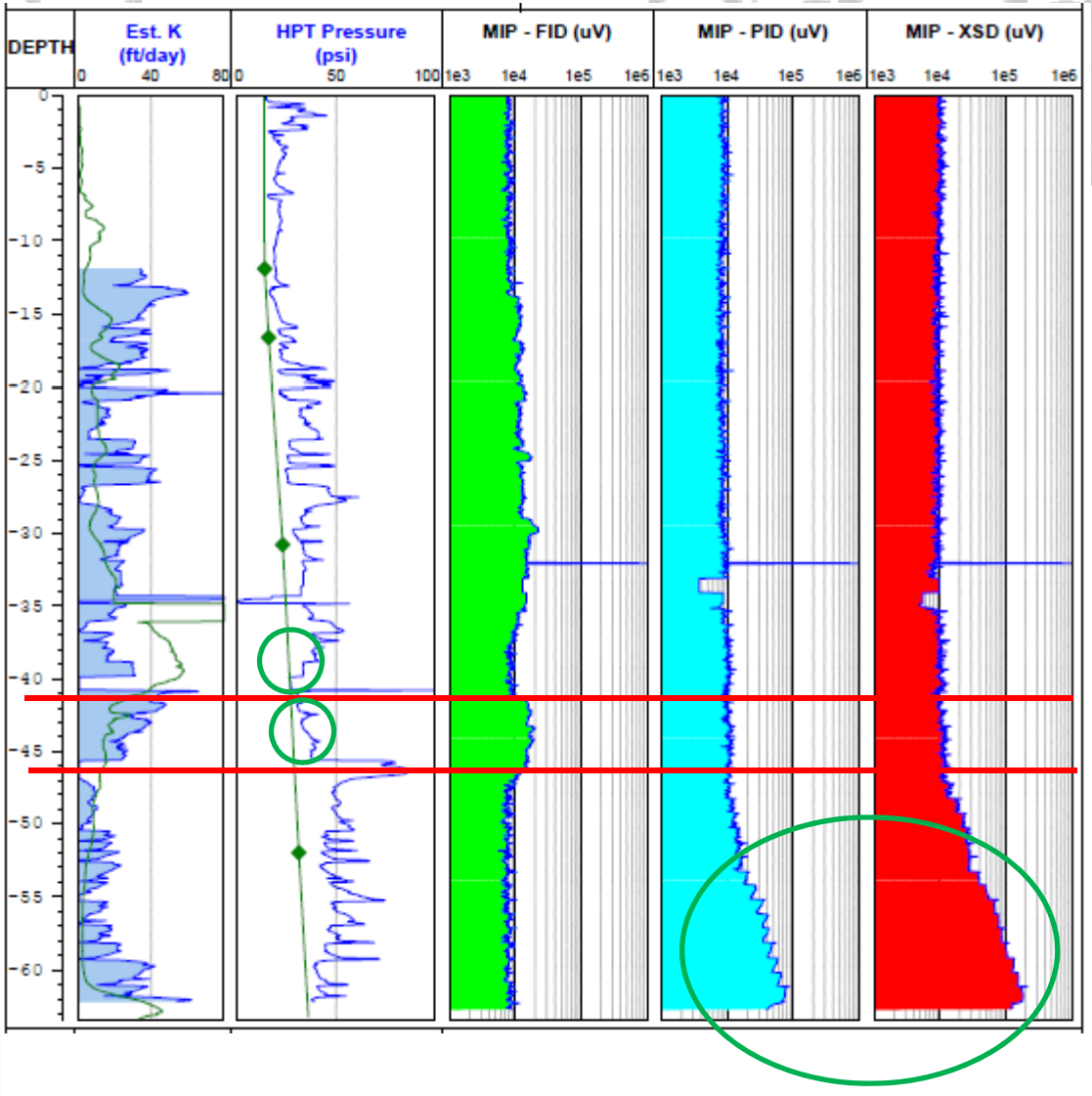
MiHPT Interpretation – MiHPT-01c



IW-19
S/D
16-41’

41-66’

- Dense layers at 40-42 feet and ~ 47 feet.
- Higher permeable aquifer material appears immediately above the dense layer and between.
- FID responses in shallower aquifer and in the zone between 42 and 47 feet.
- Data suggest ERD material affecting zone between 42 and 47 feet.

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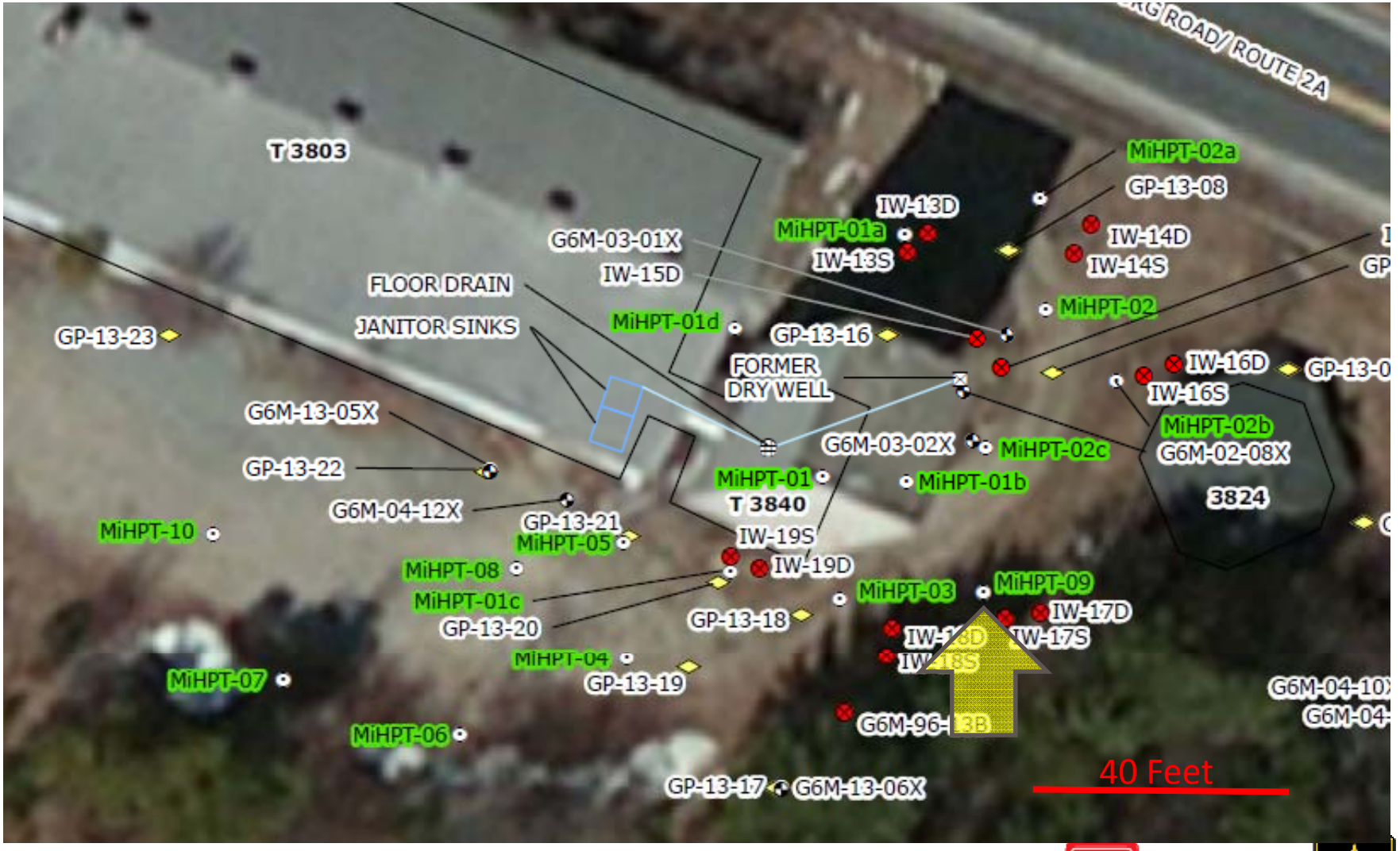
Highlight – MiHPT-09



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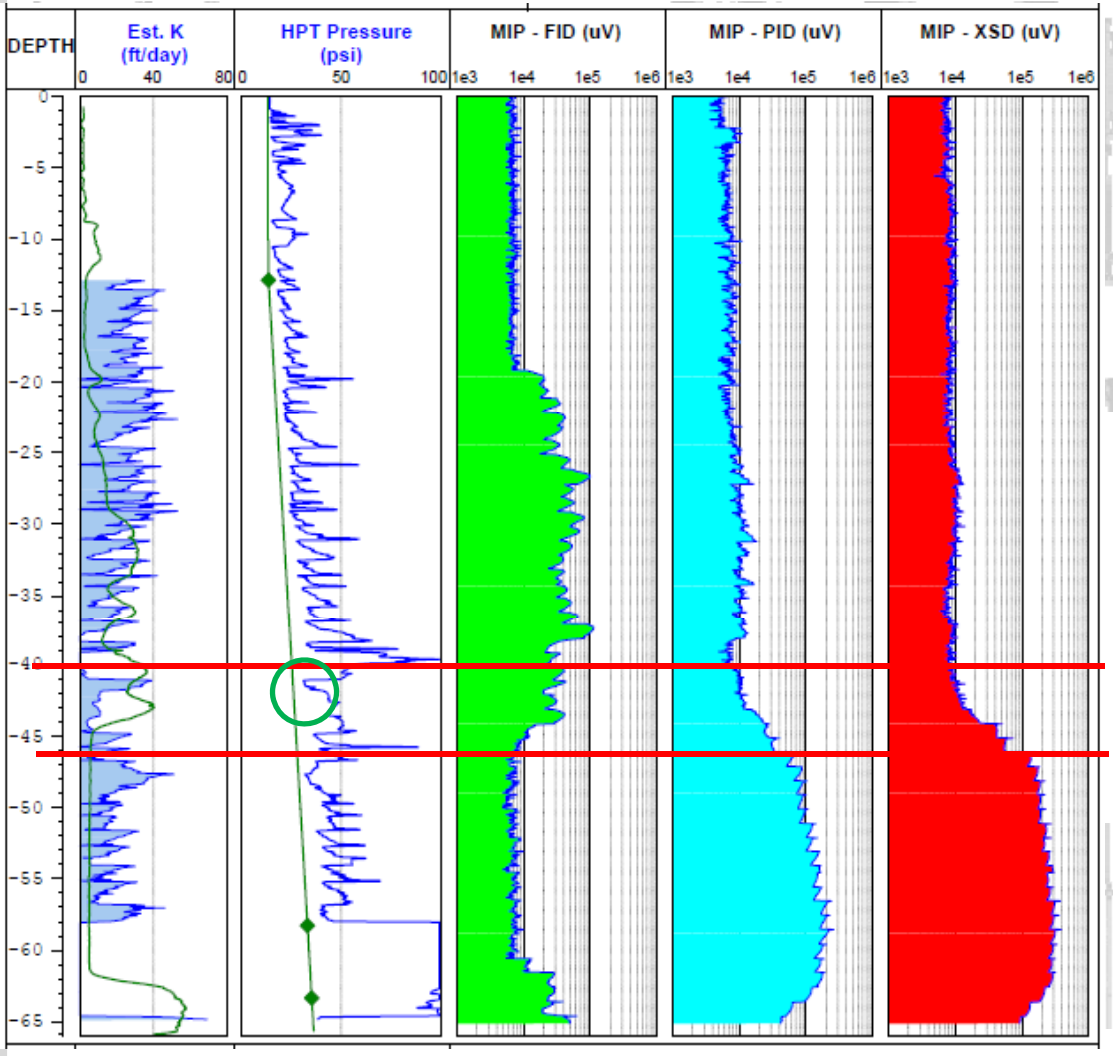
MiHPT Results and Interpretation – MiHPT-09



IW17S/D 17-42’

42-67’

- Dense layer at 40’ and again at 46’
- Higher permeable aquifer material appears above the dense layers and between.
- FID responses in shallower aquifer and in the zone between 40 and 46 feet.
- IW-17D screened 42-67’ bgs. Data suggest majority of ERD material affecting zone between 40 and 46 feet only.

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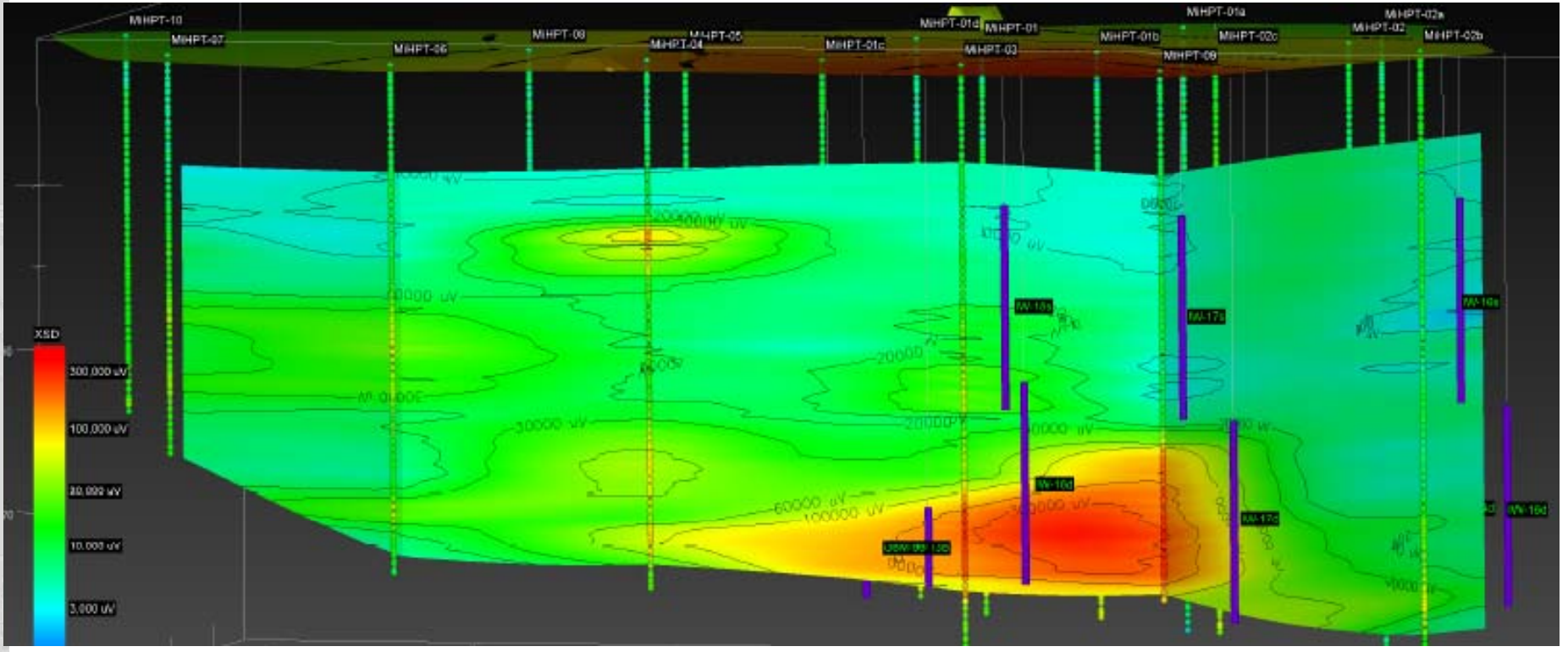
XSD Cross Section

View to the south/southwest - downgradient

Source Area



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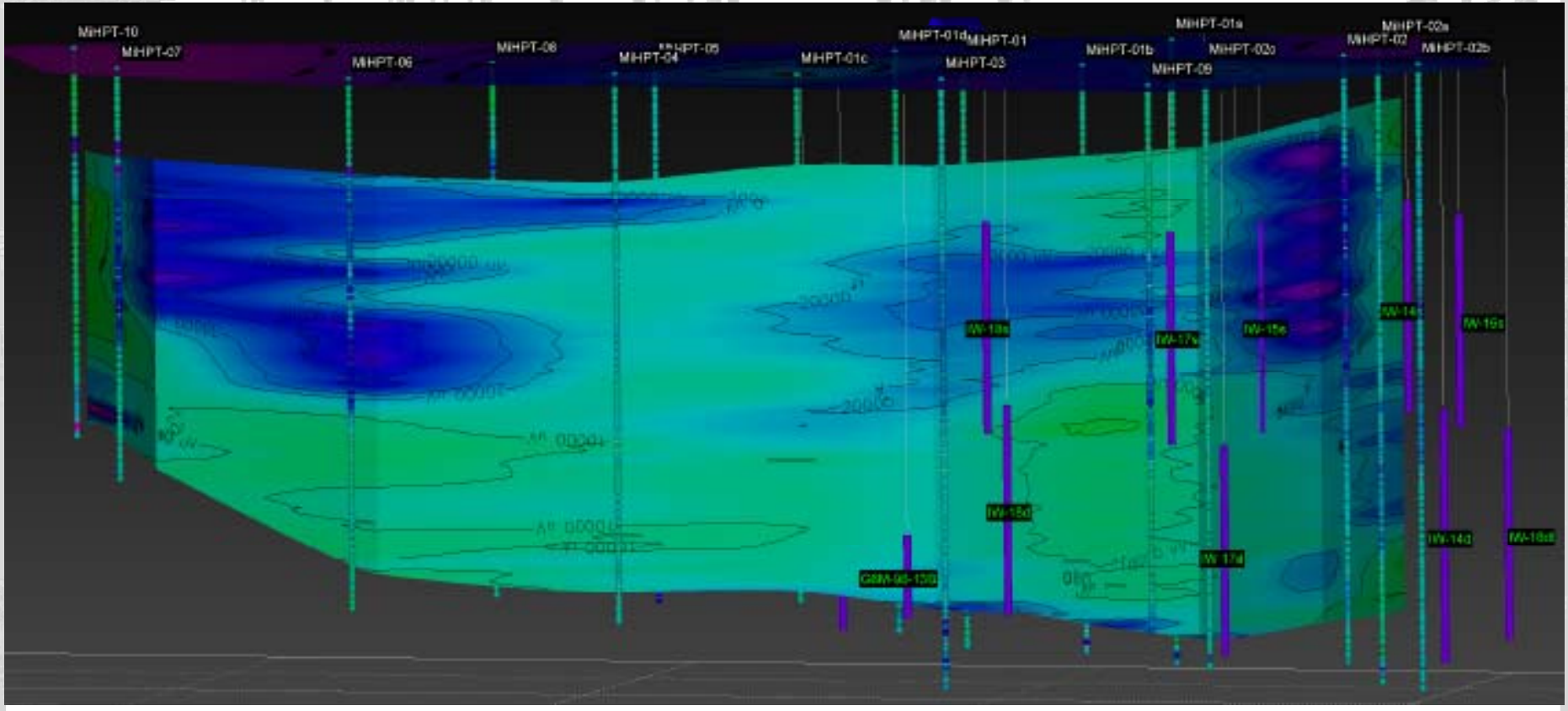
FID Cross Section

View to the south/southwest - downgradient

Source Area



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Summary of MiHPT Conclusions

1. The distribution of PCE is consistent with the known source areas and generalized site understanding/conceptual model.
2. The former dry well and drum storage areas remain the primary sources of PCE.
3. No significant source of PCE was found near the floor drains or beneath the floor drains.
4. There is continued evidence that ERD injections have been successful in the shallower aquifer (FID response coupled with XCD Data).
5. Residual PCE impact remains in the shallower aquifer downgradient of the source area.
6. PCE remain highest in the lower portion of the aquifer, generally from 45’ to 65’ bgs.

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Summary of MiHPT Conclusions (Cont'd)

7. Maximum relative concentrations by XSD were between 1 and 5 ppm. Confirmatory groundwater grab sample at MiHPT-09 was approximately 1 ppm.
8. HPT indicates a silty/clay layer approximately 40-45 feet depth with less dense material above.
9. Deep injection wells extend from 38 to 67' and intersect both the silty/clay layers at 40-45' as well as the less dense material.
10. ERD material may be only partially penetrating the deeper areas as material injected may be exiting at the very top of the screens above the silty clay layer.

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Optimization of AOC 50 Remedial Program

Injections of began in October 2004 and occurred twice a year – originally molasses and then switched to ABC-product (soluble lactates).

- The lactates which also contain lactate esters and alcohols function are a short-term component, its quickly consumed.

Changed source area *well* injections in July 2015 using substrate that contains lactates, C18 fatty acid and zero valent iron.

- The C18 fatty acid, also known as Oleic Acid – less soluble and longer lasting

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Optimization, continued

- Used direct-push technology (Geoprobe™) to supplement permanent wells
  - Lactates, Oleic Acid, and zero valent iron (ZVI)
  - ZVI assists with ERD aiding in the production of hydrogen which in turn feeds the anaerobic degradation process
- No obvious improvement in monitoring well data after first "optimized" injections
- Additional ERD injections planned: both wells and additional direct push injections

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