Use of Membrane Interface Probe and Passive Flux Meters for High Resolution Site Characterization and Measurement of Mass Flux/Discharge

Kenneth J. Cottrell, CPG, PG
HydroGeoLogic, Inc.
Presentation Overview

- Introduction
- Key Concepts re. Plume Evolution
- Brandywine Case Study
  - ERD, Pump and Treat (as interim) Remedies
  - High Resolution Site Characterization Techniques
  - Applications to Remedy
- Discussion
A smart person once said...

- Remediation is the final stage of site characterization
- Sources begin to reveal themselves as the remedy progresses.
Case Study – Brandywine DRMO
Plume Change 2007 - 2012
Plume Response to Treatment

- Dissolved plume remediated – 92% reduction in TCE plume size to 1.5 acres
- Diminishing returns in pump and treat system
- Contaminant rebound observed
High Resolution Site Characterization

- **HRSC techniques to identify nature and extent of source zone**
  - Membrane Interface Probe
  - Passive Flux Metes
MP Sampling Locations
Results: MP Profiles, Core of Plume

E0, E100, E200, E300, E375, along N150 line (through core of the plume)
MIP Results: ECD Detector Results
(>4.0X10^-5, ~1-5 mg/kg TCE)
MP Conductivity and ECD Responses

Conductivity

ECD Response
MP Conductivity and ECD Responses
Passive Flux Meter Results

Note differences in scales for contaminant flux
Results: PFM Data vs. MIP Profile N100 E150
Results

- **MIP:**
  - Contamination in release area predominantly in the silt and clayey sand underlying the Brandywine Formation
  - Moving northwest, contamination remains in the silt and clayey sand, and contamination in the Brandywine groundwater increases
  - Further downgradient, contamination is predominantly in the groundwater above the silt

- **PFMs:**
  - The highest mass flux of TCE was observed in well FW-3 along the plume centerline in the center of the suspected back-diffusion zone at a depth of 22.1 feet
    - MIP profile for well FW-3 indicates a distinct mass source from about 22 to 35 feet that may provide mass flux to the overlying aquifer
  - Well FW-5, located farthest down gradient after the groundwater extraction trench, shows lower mass flux than well FW-3 and a shift from TCE to DCE
    - MIP profile suggests low mass stored in the aquitard in this region
    - Suggest the potential for mass loading to the aquitard in this zone
  - The two wells on either side of the plume axis both showed lower magnitudes of mass flux
    - MIP ECD profiles did show mass storage
HRSC Conclusions

- Combination of tools supported CSM that back diffusion to the Brandywine Formation from the Calvert Formation is the primary source.

- MIP investigation successful in defining nature and extent of contamination.

- PFM data revealed “classic” back diffusion signature, with peak contaminant levels approximately one meter below interface.

- PFM data, used in combination with MIP data, showed areas of mass storage/back diffusion and potential mass loading area further downgradient of source.
Application of HRSC to Interim Remedy

- Pump and Treat System turned off May 2013
- Phase III Injections – late 2013/14
- Path to final remedy - VOC mass evaluation
  - How much mass is there?
  - How quickly is the mass coming out of the low permeability formation?
  - Is it accessible to treatment?
MP ECD Response “Slices”
Application of HRSC to Final Remedy

- **Mass Estimate and Flux**
  - Estimated mass of TCE in low permeability layer: 135,000 grams
  - TCE flux rate measured during study: 14 grams/day
  - Assuming linear flux rate, 9,643 days - over 25 years - to deplete TCE source!

- **Mass Location**
  - Results of HRSC provided how wide/thick/deep the contamination is
  - Bulk of mass present in low permeability layer
  - In-situ treatment such as ERD, ISCO requires contact

- **Final remedy selection**
  - Thermal remediation (Electrical Resistance Heating) is not limited by soil heterogeneity and contact