BMT Designers & Planners

PASSIVE GROUNDWATER SAMPLING METHODS

Applications and Experience

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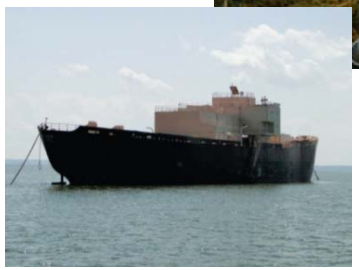
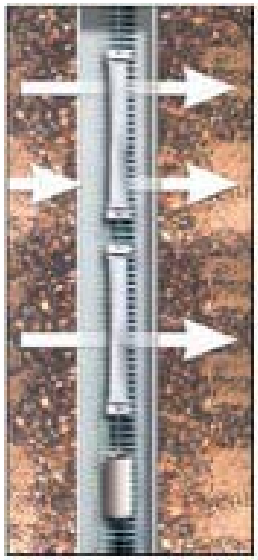
BMT Designers & Planners
Applied Environmental Services

- Environmental Site Assessment
- Compliance Assessment and Management
- Human and Ecological Risk Assessment
- Data Management/ Quality Assurance
- Remedial Technology Assessment
- Remedial Action and Cleanup
- Decontamination & Decommissioning
- NEPA Environmental Assessment
- Regulatory and Permitting Support



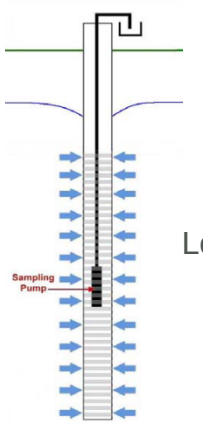
Groundwater Sampling

- Collecting “Representative” Samples
- Goal to ensure that the result accurately portrays reality
- Factors Affecting Results
  - Chemical Properties
  - Variations in Sample Collection Methods
  - Variations in the Geologic Formation
  - Variations in Sample Handling, Packaging and Shipment (SOPs)
    - Decontamination
    - Preservation
    - Containers; Trip and Field Blanks
  - Laboratory



Groundwater Sampling

- Data Quality Objectives (DQOs)
- Quality Assurance Plan (QAP)
- Evolution of Sample Collection Methods
  - Need for Purging
    - Bailer
    - Low-Flow Sampling
      - Representative – Consistent/ Reproducible/ Comparable
      - Purge until pH, temperature, specific conductance, oxidation reduction potential (ORP), dissolved oxygen and turbidity stable
      - Minimize pumping disturbance and drawdown



Low-Flow Sampling Schematic

Advantages

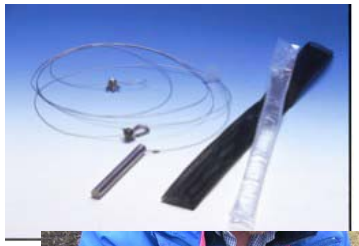
- **Minimal disturbance of water column yields samples representative of the formation (dissolved and colloid-associated)**
- **Smaller purging volume; reduces waste disposal costs and sampling time**
- Reduced operator variability, greater operator control
- Reduced mixing of potentially stagnant casing water with formation water
- Stabilization of parameters more readily achieved
- Approved ASTM Standard Practice (D 6771) assures regulatory acceptance

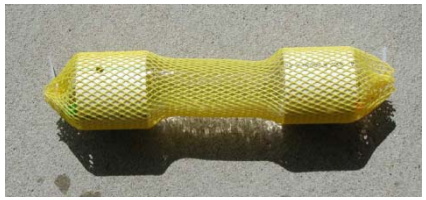
Disadvantages

- **Increased initial capital costs (pumps, equipment)**
- **Purge water still needs to be managed and disposed**
- Increased set-up time
- Transporting additional equipment to and from sampling locations (i.e., time)
- Need to train technicians

Passive, No Purge Sampling Devices

- 3 Major Types; over a dozen vendors
  - Passive Diffusion Bag (PDB) Samplers – polyethylene, cellulose dialysis
  - Grab – “Snap” and Hydrasleeve
  - Sorptive – AGI





Passive Groundwater Sampling Devices

- All have been extensively tested; many validated
  - DOD
    - Army Corps
    - SERDP/ESTCP and US Geological Survey (USGS)
    - Air Force, NAVFAC
  - Quasi-Government and Non-Profit Collaborators
    - National Groundwater Association
    - Interstate Technology Regulatory Council (ITRC)
  - ASTM Standard Guide for Passive Sampling, D7929 -14

Applications

- Repeated sampling over time is needed (e.g., monthly, quarterly, annual) to demonstrate trends/patterns over time
- Large areal extent
- Terrain or access issues
- Large number of monitoring wells
- Sample needed from specific depth interval(s) to identify stratification and concentration gradients

Advantages and Limitations

- **Advantages**
  - Significant cost reduction over low flow
    - No purge needed
      - Reduce field labor to collect samples
      - No (or little) IDW generated
      - Reduce need for hauling pumps, generators and equipment
  - Minimal training needed
  - Good for sampling multiple elevations in water column
  - Unrestricted depth
  - Data typically reproducible (chlorinated VOCs)
    - Different systems expanding analytes
      - Regenerated Cellulose Dialysis Membrane (RCDM) – (dioxanes)
      - Rigid Porous Polyethylene Samplers (RPPS) – MTBE, some hydrophilic inorganics

Advantages and Limitations

- **Cautions/ Limitations**
  - Assumes wells are properly constructed and developed when deployed
  - Sample volume requirements
    - A 2-inch diameter well provides only 250 ml sample volume per foot of screen
  - Require deployment followed by equilibration
  - Some analytes (e.g., acetone)
    - Turbidity – metals
  - In contrast, passive-grab samplers collect whole water samples and can be used for most analytes.

Advantages and Limitations

Cautions/ Limitations (continued)

Passive Diffusion

Analytical
VOCs (some exceptions [e.g., acetone, MTBE])
Cl VOCs
Explosives
Inorganics (some)
Perchlorate
MNA parameters

- Particulates do not penetrate polyethylene; no turbidity interference
- May require additional equilibrium time for less-water-soluble VOCs and SVOCs
- Not suitable for all analytes
- May collect insufficient sample volume for multiple analyses and/or QC
- Requires special extraction for SVOC analysis

Grab (SNAP, Hydrasleeve)

Analytical
VOC
Cl VOCs
Inorganics
Explosives
Perchlorate
MNA parameters
MTBE

- Collects a discrete grab sample; does not rely on diffusion
- Small sample volume limits sample available for field parameters or inorganics
- Requires dedicated “trigger” lines
- Potential turbidity interferences

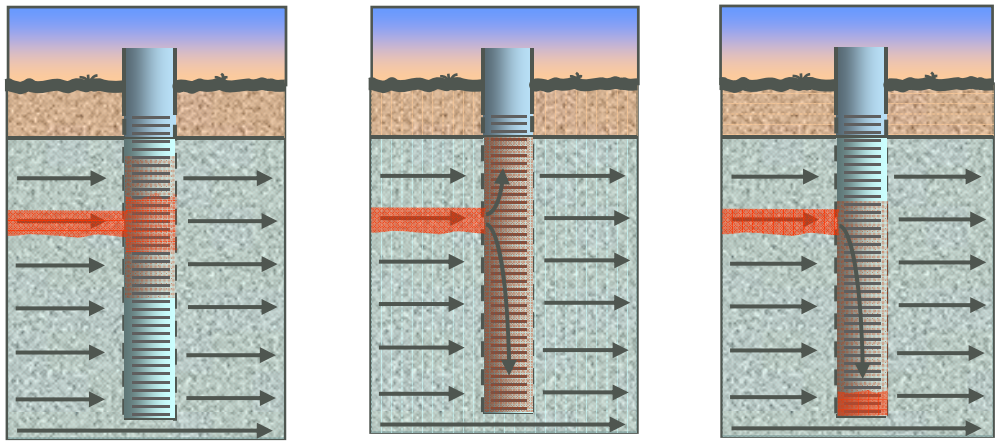
Sorptive

Analytical
Cl VOCs
BTEX
Alkyl benzenes
PAHs

- Limited suppliers
- No sample volume limits ability to sample for field parameters or inorganics
- Requires algorithm to convert to concentration.

Advantages and Limitations

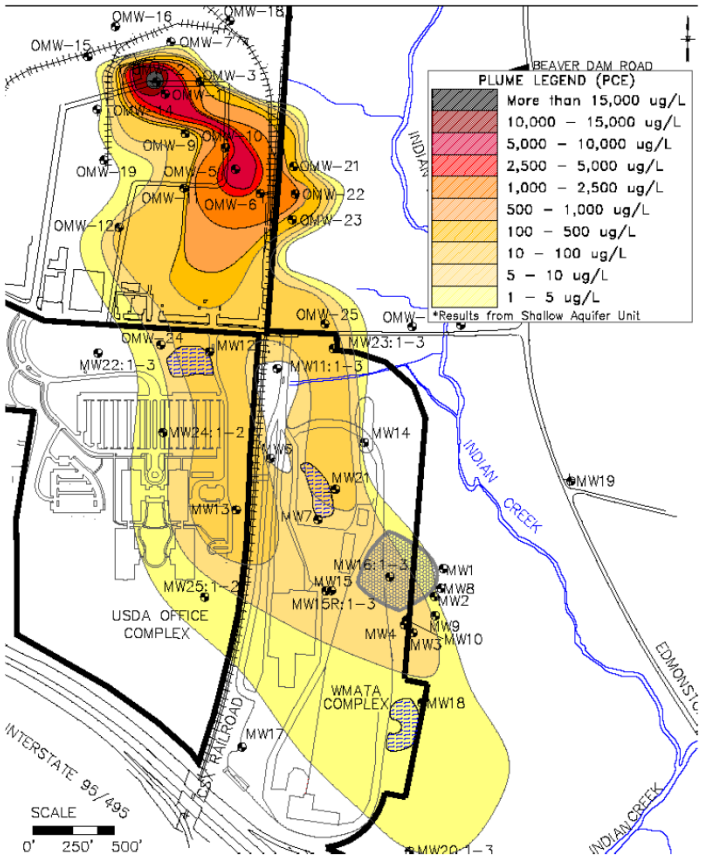
- **Cautions/ Limitations (continued)**
  - Cost differences/ disposable vs purchase
  - Varying densities/mixing within screened interval of interest



Britt, S.L., 2005, Testing the In-Well Horizontal Laminar Flow Assumption with a Sand-Tank Well Model, GWMR, v.23, no. 3, p. 73-81.

Side-by-Side Demonstration

- **“Biodegradable Site” at USDA facility in Beltsville, Maryland**
  - Large plume extending almost 2 miles downgradient from the source
  - VOCs (from PCE spill) are the only contaminants of concern (PCE, TCE, DCE, chloroform)
  - 25 monitoring wells; some nested to evaluate VOC levels at multiple elevations to 70 feet below grade
  - EPA required demonstration before allowing use of PDBs



Side-by-Side Pilot Evaluation

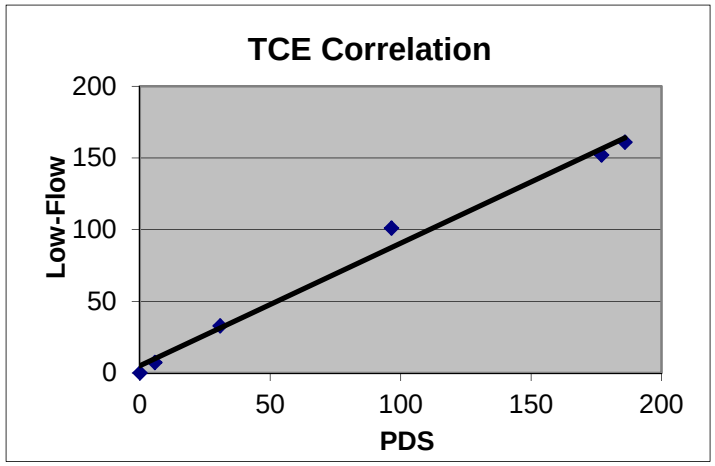
- 6 wells selected for comparison
- PDBs set at midpoint of the screen to mimic low flow sampling
- Chlorinated VOCs only
- Full range of observed concentrations to provide confidence that results were representative
  - Non-Detect (ND) to 190 ug/L for trichloroethylene (TCE)
- Duplicates
- Trip blanks

Side-by Side Pilot Evaluation

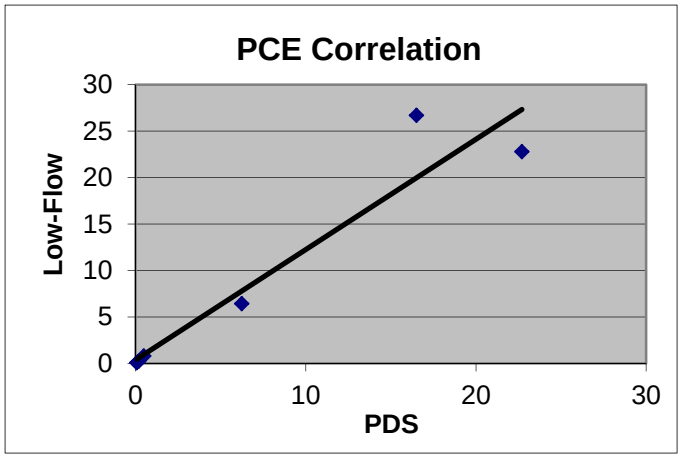
Results (ug/L)

Sample ID	1,1-DCA	1,1-DCE	1,1,1-TCA	c-1,2-DCE	Chloroform	PCE	TCE
MW-1-PDS	5.94	18.9	11.6	10.1	0.124J	0.483J	30.8
MW1-LF	7.58	19.9	14.7	10.8	0.168J	0.801J	32.9
MW-12-PDS	3.69J	105	128	7.94	1.81J	16.5	186
MW-12-LF	3.35J	86.1	122	6.72	1.77J	26.7	161
MW-13-PDS	2.15J	91.9	185	6.03	1.80J	22.7	177
MW-13-LF	2.26J	80.8	176	5.53	1.88J	22.8	152
MW-13-LF DUP	2.13J	80.9	175	5.57	1.80J	22.4	151
MW-14-PDS	0.059 (ND)	0.69 (ND)	0.62 (ND)	0.049 (ND)	0.053J	0.08 (ND)	0.07 (ND)
MW-14-LF	0.059 (ND)	0.69 (ND)	0.62 (ND)	0.049 (ND)	0.082J	0.08 (ND)	0.07 (ND)
MW-15-PDS	1.51J	47.9	61.8	2.85	0.607J	6.24	96.5
MW-15-LF	1.78J	48.6	64.7	3.14	0.730J	6.43	101
MW-17-PDS	0.059 (ND)	2.75	3.19	0.124J	0.847J	0.189J	5.82
MW-17-LF	0.140J	3.09	3.93	0.146J	0.625J	0.236J	7.26
Linear Regression Analysis, Correlation Coefficient	**0.98**	**0.96**	**0.99**	**0.98**	**0.98**	**0.95**	**0.99**
Trip Blank	ND	ND	ND	ND	ND	ND	ND

Side-by-Side Pilot Evaluation



R = 0.99



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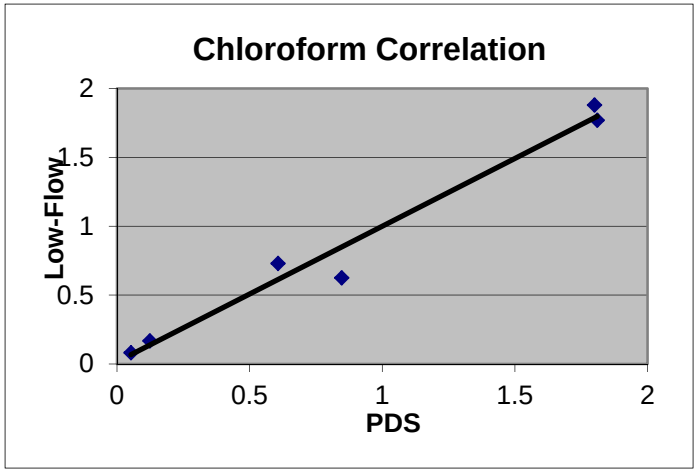

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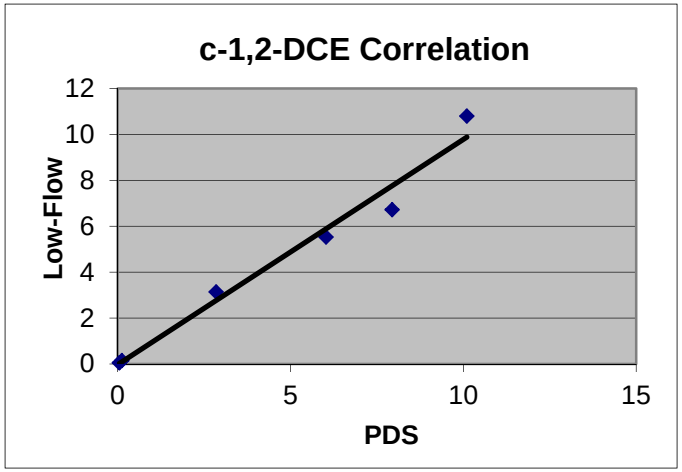

R = 0.98

Findings and Conclusions

- PDB has High Correlation to Low Flow Method
- No issues deploying equipment
- Significant (~50%) field time reduction
- Low equipment cost
- Simple statistical tools used to compare
  - All VOC analytes exhibited correlation coefficient of 0.95 or above (results were consistent with previous results)
  - No sampling issues observed with trip blanks or duplicates
- Report issued and accepted by EPA
- Studies repeated at a second site at Beltsville with similar results
  - Continued use of PDB technology

Findings and Conclusions

- Many opportunities to fall short of collecting the truly representative sample!
- Potential time and cost savings demand evaluating passive methods
  - Need to pay attention to:
    - Sampling Goals and DQOs
    - Subsurface conditions
    - Sampling and lab error
    - Passive Sampler selection
    - Statistics to evaluate
  - PDBs demonstrated to be well suited for:
    - Chlorinated VOCs (and others)
    - Large areas; large number of wells or depth intervals

References

- Strategic Environmental Research and Development Program / Environmental Security Technology Certification Program (SERDP/ESTCP)
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  - https://serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/Monitoring/ER-200313/ER-200313
- Interstate Technology Regulatory Council (ITRC)
  - http://www.itrcweb.org/GuidanceDocuments/DSP-5.pdf
  - http://www.itrcweb.org/documents/mcclellan%20rpt_oct2005.pdf
- National Groundwater Association (NGWA)
  - http://community.ngwa.org/communities/viewdiscussions/viewthread/?GroupId=151&MID=1419
- U.S. Geological Survey (USGS)
  - http://pubs.usgs.gov/fs/fs-088-00/
  - http://pubs.usgs.gov/wri/wri034157/
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