Site Characterization for Fuel Oxygenates

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Site Assessment / Characterization

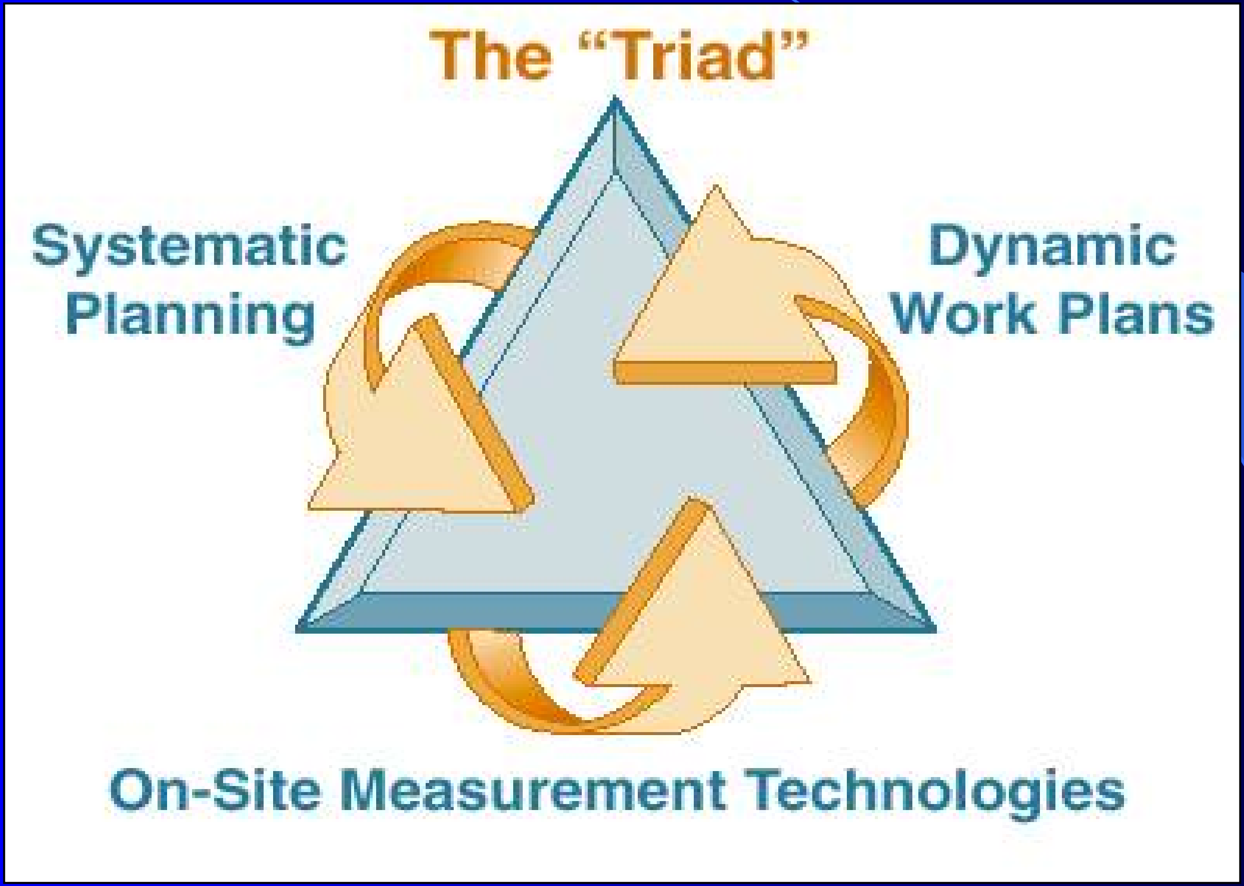
- Surface and subsurface definition is an iterative process and is data-dependent
  - Field analytics & dynamic work planning http://clu-in.com/tiopersp/issue.cfm
  - Hydrogeology controls the migration!
    - **Heterogeneity is the rule, not the exception**
    - **Denser sampling networks can reduce uncertainty but do not eliminate it**
- Tools / Strategies
  - Conventional vs Triad (ESA)
  - Emerging technologies

Conventional vs. Expedited Site Characterization

	Conventional	**Expedited**
Sample Points	Predetermined quantity and locations	Flexible quantity and locations
Work Plan	Rigid plan, multiple phases	Flexible plan, single phase
Field Management	Manager in office, junior staff in field	Manager in field with experienced staff
Interpretation and Evaluation	In office, post-field work (weeks later)	On-site, ongoing during field work
Monitoring	Hunt and peck well location, long screens	Targeted locations, targeted screens
Regulatory Review	Burden on regulators and PRPs	One comprehensive report
Cost	High cost	Cost effective

Small, 1998

Modern Site Characterization



http://www.epa.gov/tio/triad/

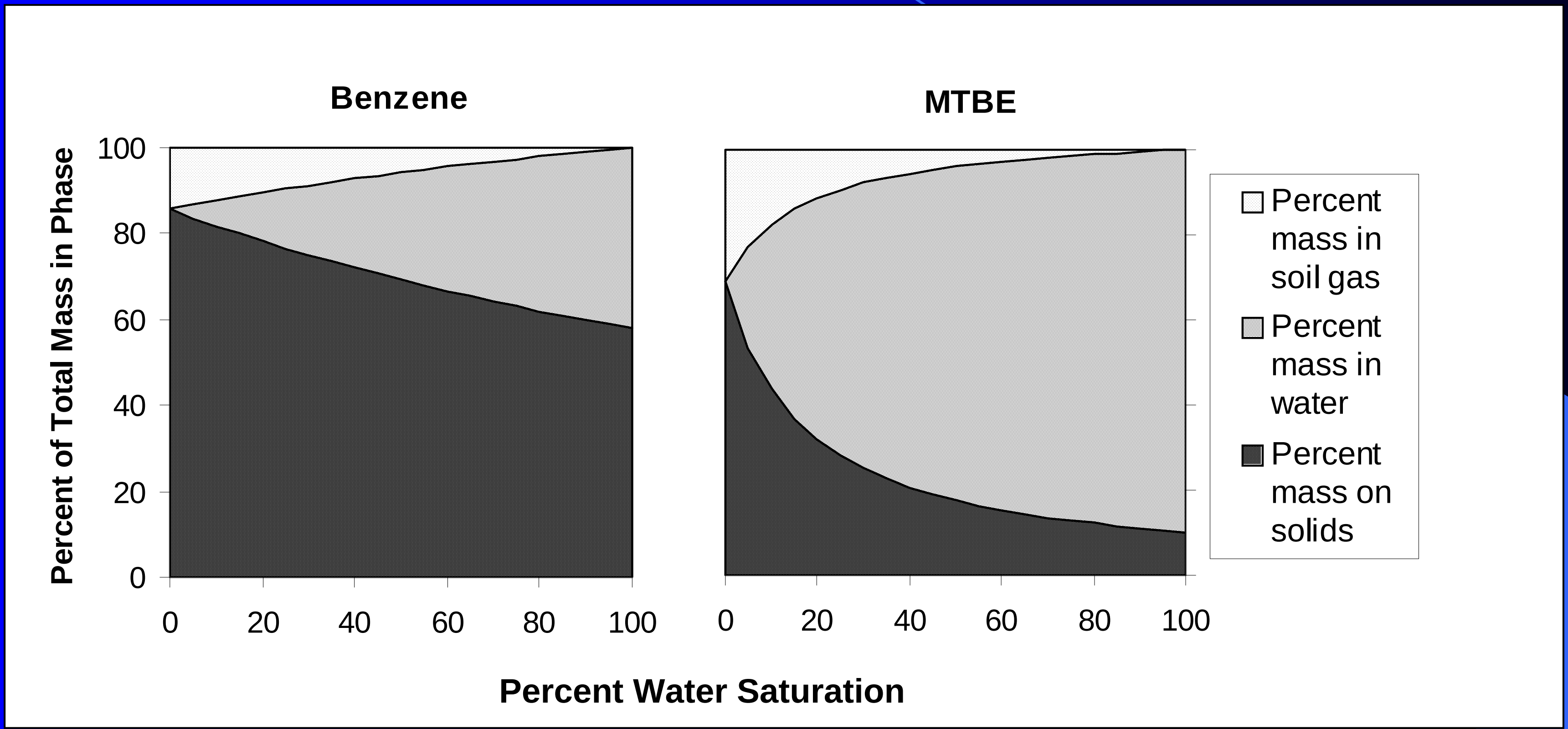
To confirm or refute hypotheses in real time, you must evaluate data in the field

Site Characterization Overview

- Define chemical, physical, and “social” issues
- Identify types and sources of contamination
- Identify potential receptors
- Identify physical conditions influencing contaminant distribution
- Define nature and extent of affected media
- Contaminant fate and transport assessment

Effort and detail should be scaled to threat

Phase Distribution



Soil Conditions: F_{oc} = 0.005, porosity = 0.38, bulk density = 1.7 kg/l

API, 2003

Soil Gas Sampling

- Useful for MTBE?
  - May be useful near NAPL
  - Not likely to be useful in wet soils and/or away from NAPL

Soil Sampling

- Useful for MTBE?
  - If no NAPL is present, almost all the MTBE will be in soil moisture
  - Coarse-grained or dry soils may not detect MTBE
  - More useful in wet soils and near NAPL
  - ADEQ 2003 study: soil samples not a useful predictor of groundwater impact

Groundwater Sampling

- Useful for MTBE?
  - YES - this is the phase in which MTBE resides

Hierarchy of MTBE Concentrations in Water

Example Source	Maximum concentration of MTBE in water
Point-source release (gasoline storage tank, pipeline, etc.)	> 100,000 μg/L
Recreational watercraft (emissions/losses)	~10 - 50 μg/L
Non-point sources (i.e. atmospheric deposition, urban runoff, etc.)	<1 - 20 μg/L

Zogorski et al. 1997; Baehr et al. 1999

Site Characterization: Receptors

- Site workers
- Local residents
- Casual contact at site perimeter
- Water supply wells
- Source and adjacent property and receptor uses:
  - Residential
  - Commercial
  - Fishing
  - Recreation

Site Characterization: Contaminants

- MTBE, TBA and Other Fuel Oxygenates
- Other Contaminants
  - Metals
  - Inorganic chemicals
  - Organic chemicals
    - Volatile
    - Semi-volatile
    - Physical properties
    - NAPL
    - DNAPL

Site Characterization

Physical Conditions

- Surface drainage
- Recharge zones
- Subsurface water-bearing zones
- Natural/actual groundwater gradients

Subsurface Plume Delineation

- High-resolution vs. low resolution
- Effects of heterogeneity on migration
- Three dimensional
  - Coring (continuous, split-spoon, etc.)
  - Geophysics (borehole & surface)
  - CPT (3-channel and piezocone)

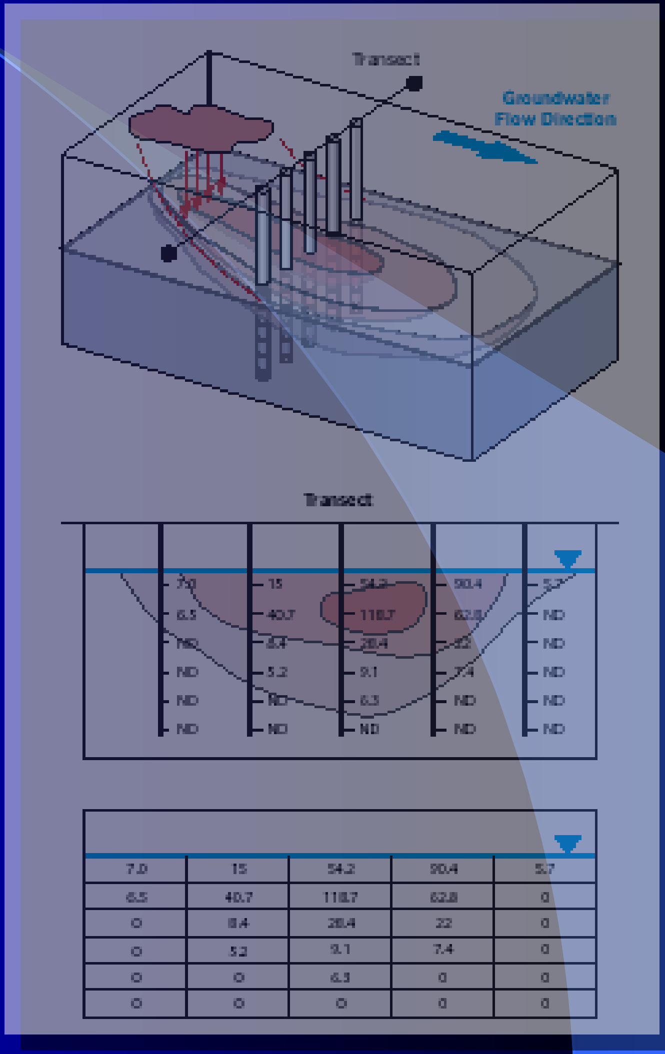
Effort and detail should be scaled to threat

Subsurface Definition: Mass Flux

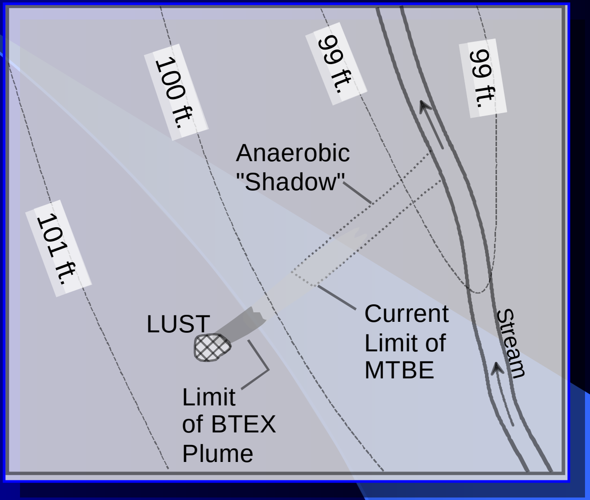
- Vertical transects allow estimates of dissolved mass flux (mass discharge)
- Total flux =

  concentration * flow rate* area

Flux may be useful for assessing threat, attenuation, and remedy performance



Biogeochemical Data



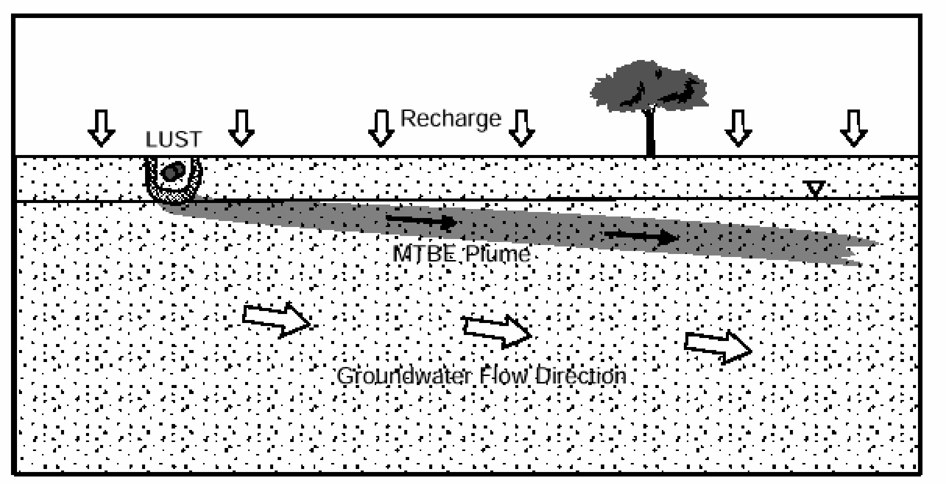
- Geochemical indicators
  - Indication of redox poise
  - Availability of reactants
  - Track MTBE plume trajectory using electron acceptor “shadow”
- Degradation products (e.g., MTBE ->TBA -> HIBA)
- Microcosm studies
- Hyporheic zone (where gw & sw interact)

Impact of Surface Features on Sources & Plumes

- Natural/man-made recharge barriers or recharge enhancements
  - Tight clays, paving, buildings
  - Lakes and ponds
  - Manmade surge basins, storm water basins
  - Conduits connecting aquifer zones
    - **Buildings, foundations, basements**
    - **Wells**

3D Considerations

- Diving Plumes



  – Differences in properties of the oxygenates require differences in approach from BTEX during LUST site characterizations
  – High solubility and slower biodegradation can result oxygenate plumes migrating deeper and farther into aquifers than (BTEX)
  – It is extremely important to vertically characterize the plume by depth-discrete sampling
  – Transects of depth-discrete sampling may be necessary to completely define the plume extent

Site Characterization Tools

- Conventional technologies
  - Wells
  - Direct push
  - Geophysical logging
  - Tracer studies
- Emerging technologies
  - Small diameter and multi-level wells / samplers
  - Direct observation
    - **Smart probes (CPT, ROST, LIF, MIPS, SCAPS)**
    - **Source definition**
  - Hydraulic conductivity performance measurement
    - **Flowmeter surveys**
    - **Hydraulic tomography**

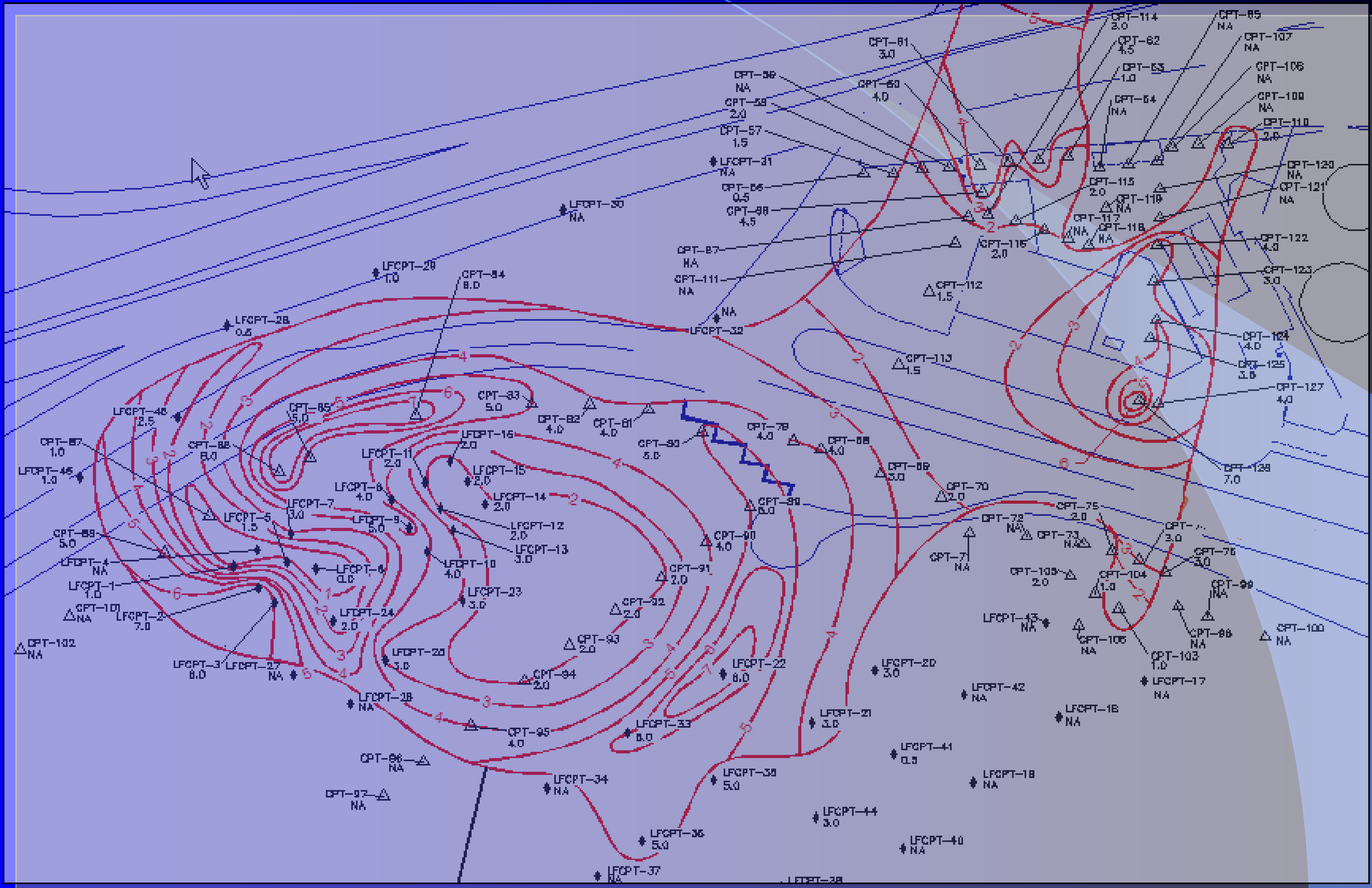
Direct Push Rig

- Quick (samples/day)
- Cost-effective
- Access tight spaces
- Delineate stratigraphy
- Identify high/low K zones
- May reduce number of core samples required
- Depth limited

Use of CPT in Site Characterization

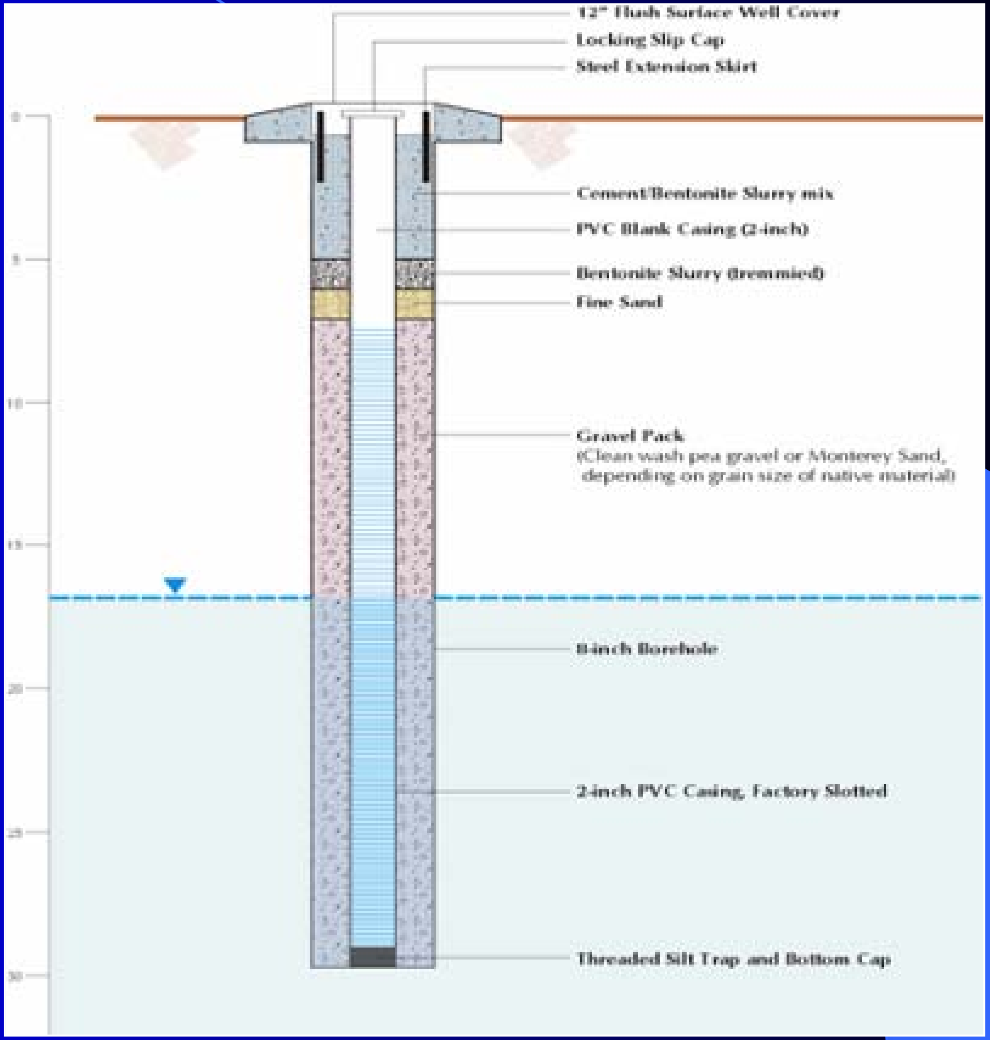
- Subsurface Penetrations
  - Be careful - can generate contaminant pathway
  - Use CPT to define subsurface stratigraphy before boring or drilling
  - Immediately seal all penetrations not destined for future use
  - Do not screen monitoring wells across multiple water-bearing zones
  - Install "nests" of wells to define multiple water-bearing zones

CPT/LIF Can Indicate LNAPL Thickness

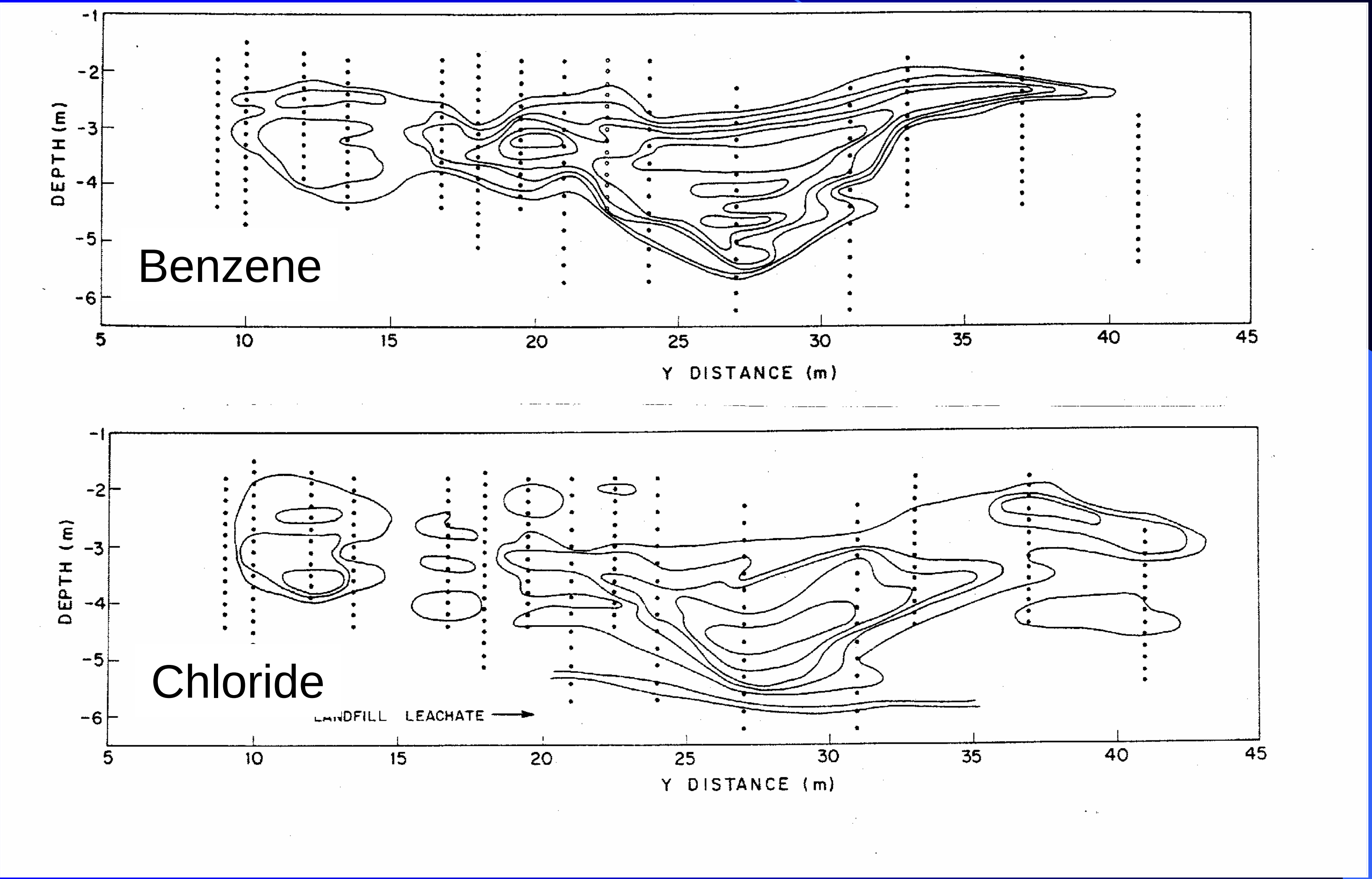


Conventional Monitoring Well

- Advantages
  - Simple
  - Wide acceptance
- Disadvantages
  - Low-resolution
  - Relatively high cost per sample location



Do monitoring wells provide samples that accurately map the distribution of dissolved solutes?



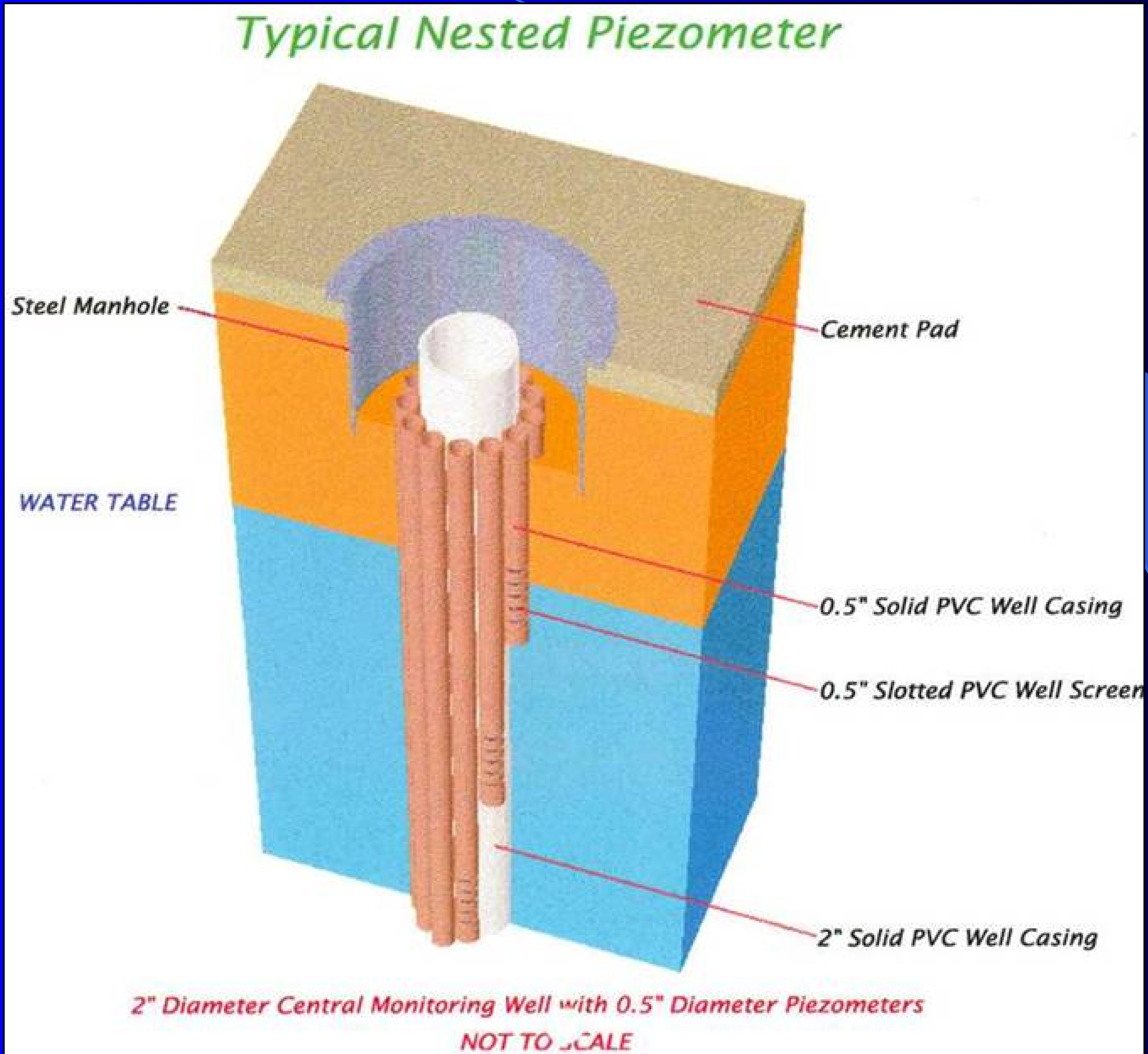
Multi-Level Ground Water Sampling / Monitoring

- Direct Push Technologies
  - Membrane Interface Probe
  - Laser-induced Florescence Probe
  - Discrete Ground Water Sampler
- Long Screened Monitoring Well Methods
  - Low Flow Sampling
  - Down-hole Double Packer Sampling Methods
  - Passive Diffusion Bag Samplers MTBE
- Depth-discrete Groundwater Sampling

Depth-Discrete Groundwater Sampling Tools

- Conventional well nests
- Bundled piezometers
- Continuous Multi-Channel Tubing (CMT™)
- Diffuse Multi-Layer Sampling (DMLS™)
- BarCad wells
- Waterloo
- Westbay
- Flute
- Hydropunch™
- Geoprobe™
- Simulprobe™

Bundled Multi-Level Nested Wells



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