Real-Time Data Collection and Interpretation "Why Is It Important?"

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1

Uncertainty in History

"Doubt is not a pleasant condition, but certainty is absurd."

Voltaire,

(1694-1778)
Writer, philosopher, playwright & historian

"As we know, there are known knowns. There are things we know we know. We also know there are known unknowns. That is to say we know there are some things we do not know. But there are also unknown unknowns, the ones we don't know we don't know."

Donald Rumsfeld,

Feb. 12, 2002
U.S. Department of Defense

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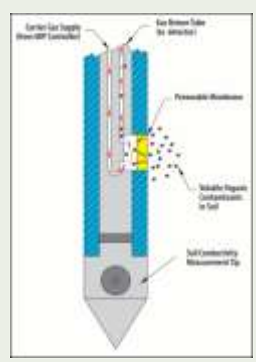
2

What is Meant by "Real-Time?"

Real-time is within a time frame that allows the project team to react to the information while in the field

What are Real-Time Measurement Technologies

- ♦ **Direct sensing tools that provide instantaneous data**
- ♦ **Field-generated sample collection/analysis technologies that require various lengths of time to produce end data**



MIP Probe Schematic

How is Data Collection Different?

- **Provides a greater density of measurements**
  - Chemical
  - Geological
  - Hydrogeological
  - Horizontally, vertically and temporally
- **Uses collaborative data sets**

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How is Data Collection Different?

- **Employs strict field QA/QC to maximize usefulness of data and target confirmatory or collaborative sample analysis where needed**
- **Often uses field-based action levels or response factors with a margin of safety**
- **Uses real-time data management and communication strategies**

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Real-Time Measurement Technologies

Specific Use of Direct Sensing Technologies

Technology	Matrices	Data Provided
Geophysical survey technologies - Total field and Gradient Magnetometry - Gravimetry / Microgravimetry - Seismic Reflection / Refraction - Electrical Resistivity Imaging (ERI) - Frequency Domain Terrain Conductivity - Time Domain Metal Detection - Ground Penetrating Radar (GPR) - Direct Current (DC) Resistivity	Soil, fill, bedrock	Sources, pathways, macro-stratigraphy, and buried objects
Downhole geophysical testing - Natural gamma ray - Self potential - Resistivity - Induction - Porosity/density - Caliper	Soil, fill, bedrock	Lithology, groundwater flow, structure, permeability, porosity, and water quality
Membrane Interface Probe (MIP) and electrical conductivity (EC) probe	Soil, fill, water	EC-based lithology, volatile organic compounds (VOCs), hydrocarbons, and dense non-aqueous phase liquid (DNAPL)
Neutron Gamma Monitors	Soil, water, material surfaces	Radiation
Hydraulic conductivity profilers	Soil, water	Hydraulic conductivity, lithology
Cone penetrometer testing (CPT), high-resolution piezocone	Soil, water	Lithology, groundwater flow

For additional information concerning the technologies listed in this table, readers should refer to the resources available on EPA's Hazardous Waste Clean-Up Information (CLU-IN) Web site (www.clu-in.org).

Specific Use of Field-Generated Systems

Technology	Matrices	Data Provided
Direct push samplers	Water, soil, fill, active soil gas	Sample, physical / visual data
Field-XRF analyzer (screening and bench-top analysis modes)	Soil, sediments, fill, material surfaces	Metals
Laser-induced fluorescence (LIF), UV methods (UVF, UV lamp)	Water, soil, fill	Total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), petroleum as light and dense non-aqueous phase liquid (LNAPL / DNAPL)
Immunoassay (IA) test kits	Water, soil, fill, material surfaces	Semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), PAHs, pesticides, and dioxins/furans, explosives, mercury
Miscellaneous colorimetric kits	Water, air	Water quality, hazardous vapor
Mobile laboratory – definitive data	Water, soil	VOCs, SVOCs, pesticides, PCBs, explosives, metals, and wet chemistry
Field GC and GC/MS – screening data	Water, soil	VOCs, SVOCs, pesticides, PCBs, and explosives
Active and passive soil gas samplers	Soil gas	VOCs, unstable SVOCs
SUMMA canisters	Soil gas, indoor air	VOCs, unstable SVOCs
Passive diffusion samplers	Water, soil gas	VOCs, SVOCs, and contaminant flux
Open-Path Fourier Transform Infrared (OP-FTIR) Spectroscopy	Air, water, soil	VOCs (water), TPHs (soil and water), VOCs and other gases (air)
Permeameter	Soil	Hydraulic conductivity
Membrane Interface Probe – - photoionization detector (PID) - flame ionization detector (FID), - electron capture detector (ECD), - halogen specific detector (XSD)	Soil, fill, water	VOCs, petroleum hydrocarbons, and DNAPL
Conventional drilling technologies	Water, soil, fill, bedrock	Physical/visual data, multiple constituents

For additional information concerning the technologies listed in this table readers should refer to the resources available on www.clu-in.org.

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XRF

What Does An XRF Measure?

- X-ray source irradiates sample
- Elements emit characteristic x-rays in response
- Characteristic x-rays detected
- Spectrum produced (frequency and energy level of detect x-rays)
- Concentration present estimated based on sample assumptions

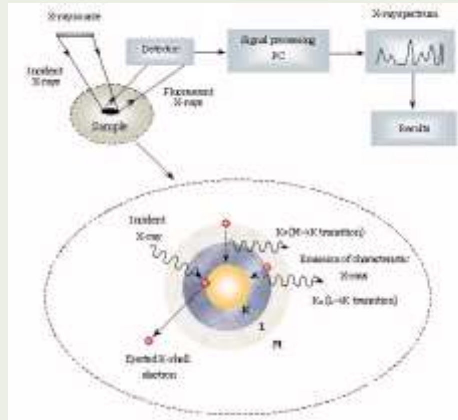
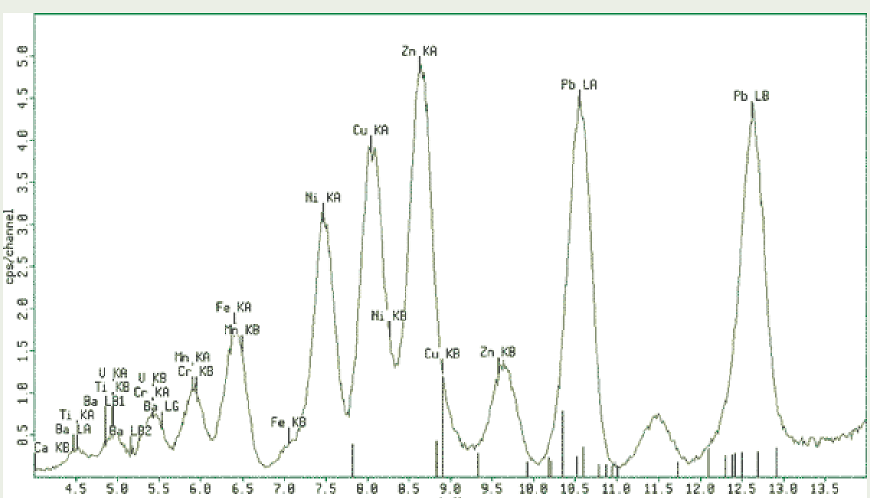


Figure 1: The principle of XRF and the typical XRF detection arrangement

Source: http://omega.physics.uoi.gr/xrf/english/images/PRINCIP.jpg

Example XRF Spectra



Bench-top XRF

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How is an XRF Typically Used?

- ♦ Measurements on prepared samples
- ♦ Measurements through bagged samples (limited preparation)
- ♦ *In situ* measurements of exposed surfaces

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Which Elements Can An XRF Measure?

- **Generally limited to elements with atomic number > 16**
- **Method 6200 lists 26 elements as potentially measurable**
- **XRF not effective for lithium, beryllium, sodium, magnesium, aluminum, silicon or phosphorus**
- **In practice, interference effects among elements can make some elements "invisible" to the detector, or impossible to accurately quantify**

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Collaborative Data Sets and Multiple Lines of Evidence

16

Developing Collaborative Data Sets and Multiple Lines of Evidence

- ♦ **Collaborative data sets are powerful**
- ♦ **Multiple lines of evidence = "weight of evidence"**
- ♦ **One method provides information for when another is required or beneficial**
- ♦ **Control multiple error sources**
- ♦ **Result: increased confidence in the CSM, better decisions, better remedy implementation**

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Addressing Uncertainty and Matrix Heterogeneity

Collaborative Data Sets = Different Methods for Same Analyte, Suite, Physical Property
Multiple Lines of Evidence = Integration of Independent Data Sets

The Missing Link

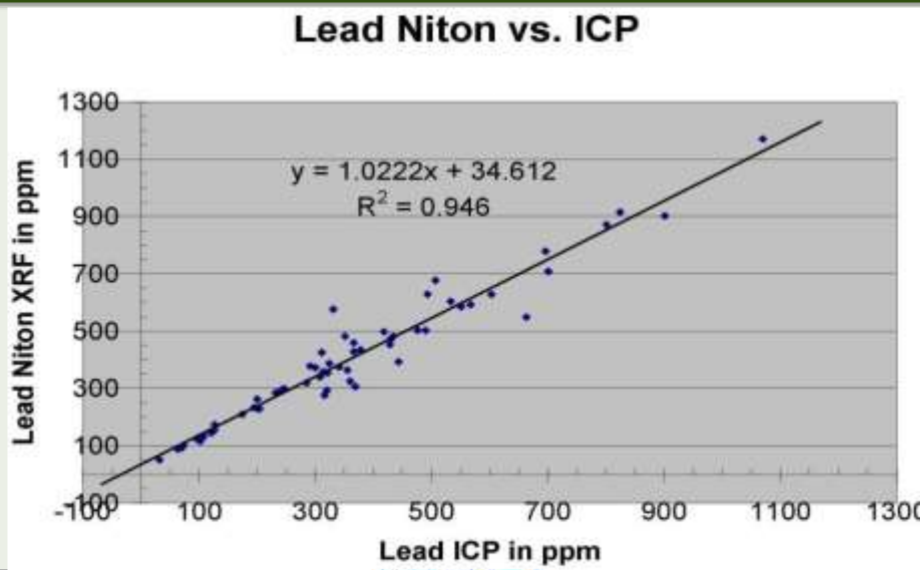
Collaborative data sets and high-resolution also critical for geologic / hydrogeologic information.

- Not just analytical concept.

- In many cases, geologic / hydrogeologic context may be more critical for effective remedy design.

18

Collaborative Data Example



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Examples of Multiple Lines of Evidence

- **Relative hydraulic conductivity in subsurface**
  - CPT
  - Electrical conductivity
  - Hydraulic profiling
- **Vapor intrusion**
  - Soil contaminant concentrations
  - Groundwater depth and contaminant concentrations
  - Soil gas
  - Sub-slab vapor concentrations
  - In-home air concentrations
  - Building construction details

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HRSC for Unconsolidated Environments

Consider This Strategy For Following Site Conditions

- ♦ **Contaminated groundwater in unconsolidated environments**
- ♦ **Stratified layers of varying soil types**
- ♦ **Light and dense non-aqueous phase liquids**
- ♦ **Incomplete or generalized understanding of mass storage and transport in the CSM**

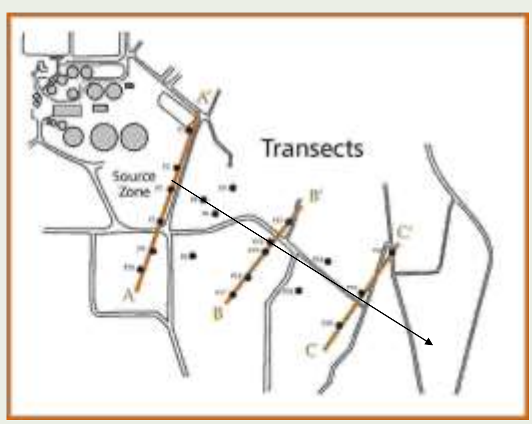
What Type of Investigation is HRSC ?

Subsurface investigation appropriate to the scale of heterogeneities in the subsurface which control contaminant distribution, transport and fate, and that provides degree of detail needed to understand:

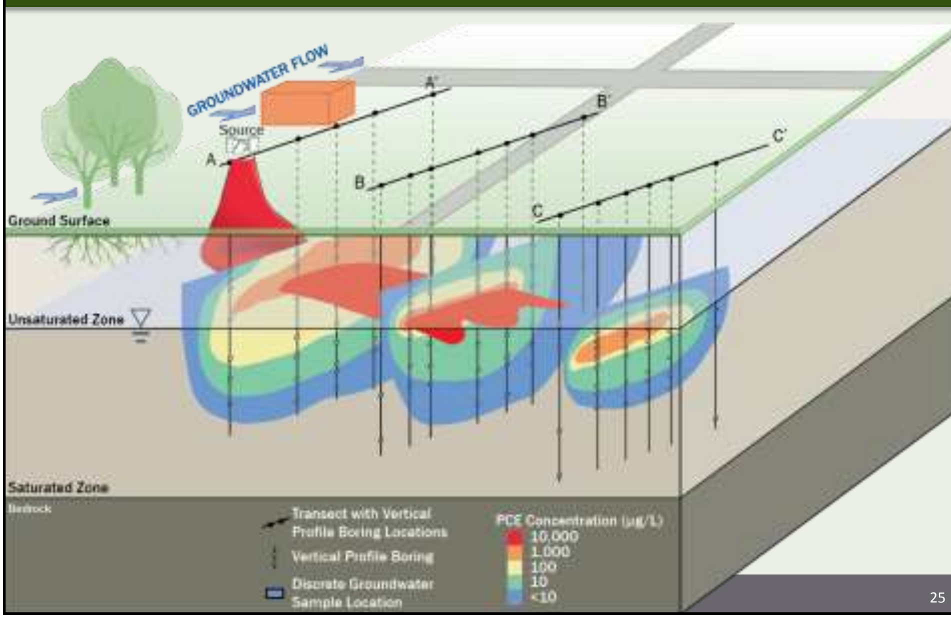
- Exposure pathways
- Processes affecting fate of contaminants
- Contaminant mass distribution and flux by phase and by media (mobile and immobile)
- How remedial measures will affect the problem

SOP for Groundwater Characterization – Transect-Based Profiling Approach

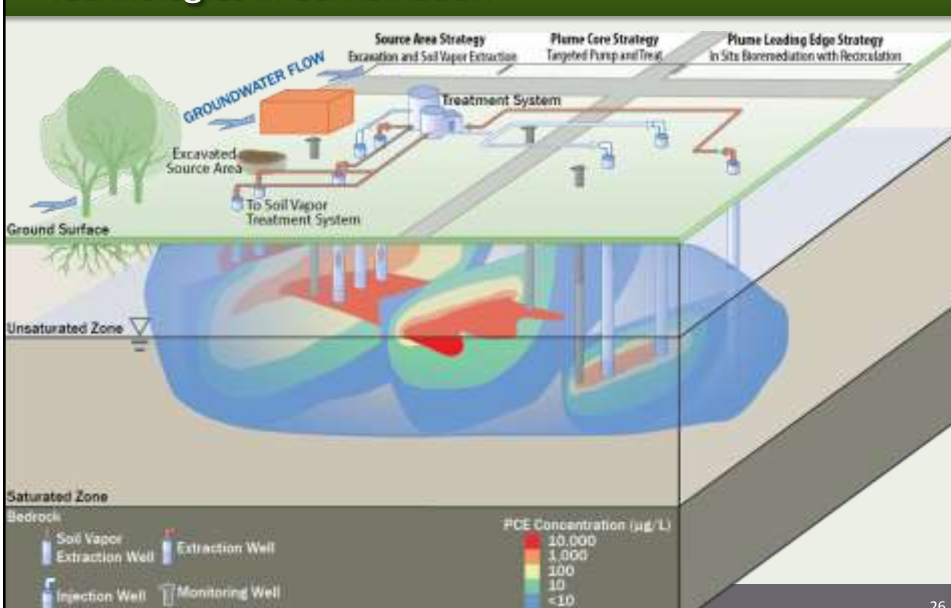
- **<u>Transect</u>: Line of vertical profiles oriented normal to the direction of the hydraulic gradient (groundwater flow)**
- **<u>Sample Interval</u>: Vertical dimension of the sampled portion of the aquifer**
- **<u>Sample Spacing</u>: Vertical distance between samples**



Vertical Profiles of Relative K and Discrete Contaminant Concentrations with Spatial Correlation



Provides Detailed Information for Application of Targeted Technologies in Combination



Case Example:
Wilcox Oil Superfund Site

27

Wilcox Oil Superfund Site

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Wilcox Oil Superfund Site

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Wilcox Oil – Investigation Strategy

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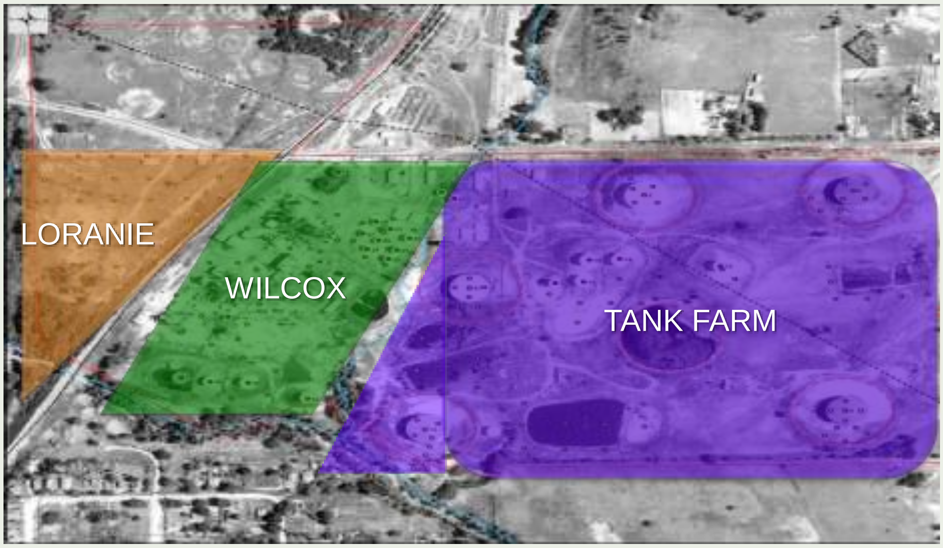
Wilcox Oil – Areas of Investigation



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Wilcox Oil – Loranie Refinery

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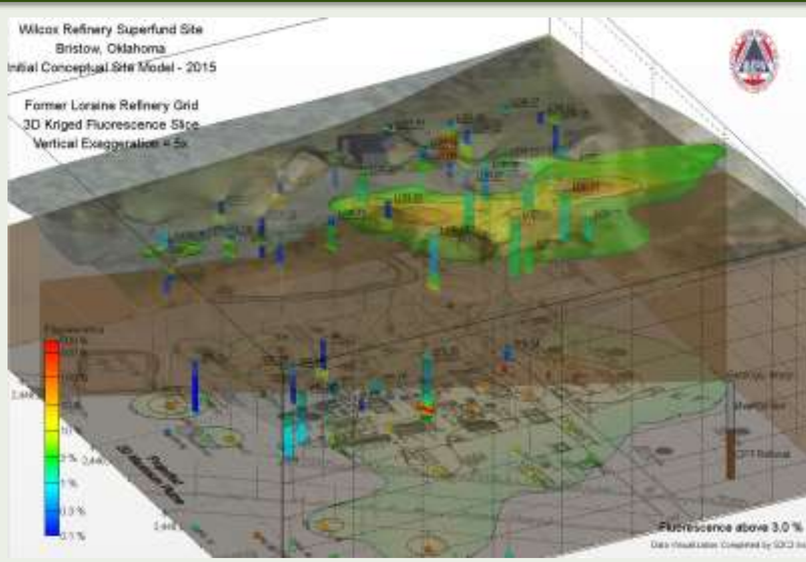
Wilcox Oil – Refinery Area

Wilcox Oil – Tank Farm Area

Wilcox Oil – Use of Real-Time Tools

Wilcox Oil – 3D Visualization at Loraine



Wilcox Oil Superfund Site

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Real Time Tools - Why Is It Important?

- **Scaling**
  - » Can be used on large or small sites
  - » Can be used across most cleanup programs
- **Collaborative Tools**
  - » Multiple lines of evidence
  - » Similar to MNA or VI Guidance
- **High Resolution Site Characterization**
  - » Unknown Heterogeneity
  - » Design & Construction

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Questions?