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

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First A Little History

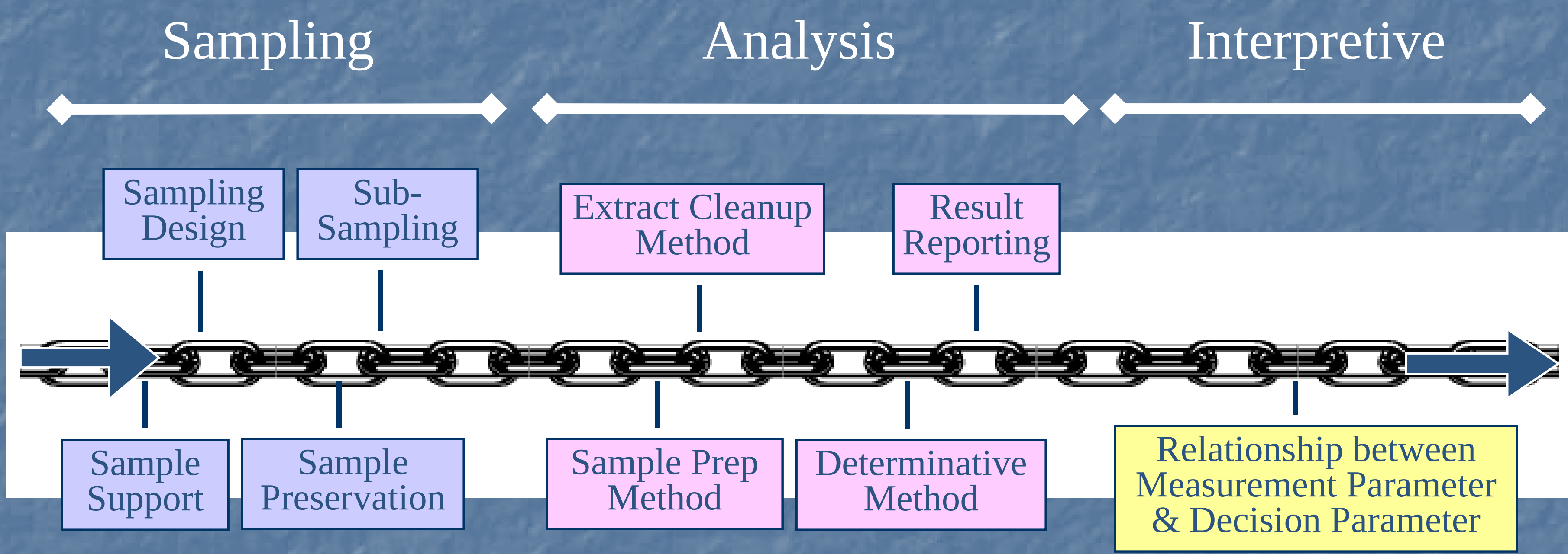
"Doubt is not a pleasant condition, but certainty is absurd."

Voltaire, humanist, rationalist, & satirist (1694 -1778)

"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."

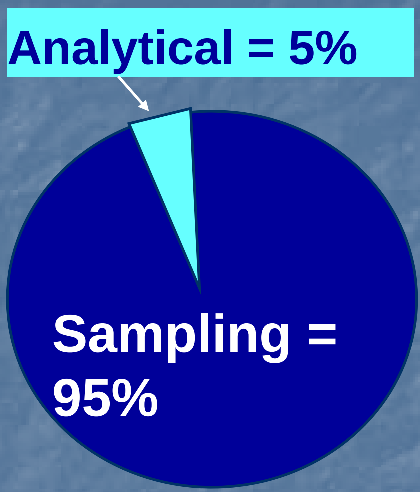
Donald Rumsfeld, Feb. 12, 2002
Department of Defense

Decision Quality Only as Good as the Weakest Link in the Data Quality Chain



Each link represents a **variable** contributing toward the quality of the analytical result. All links in the **data quality chain** must be intact for data to be of decision-making quality!

Sampling vs. Analytical Uncertainty



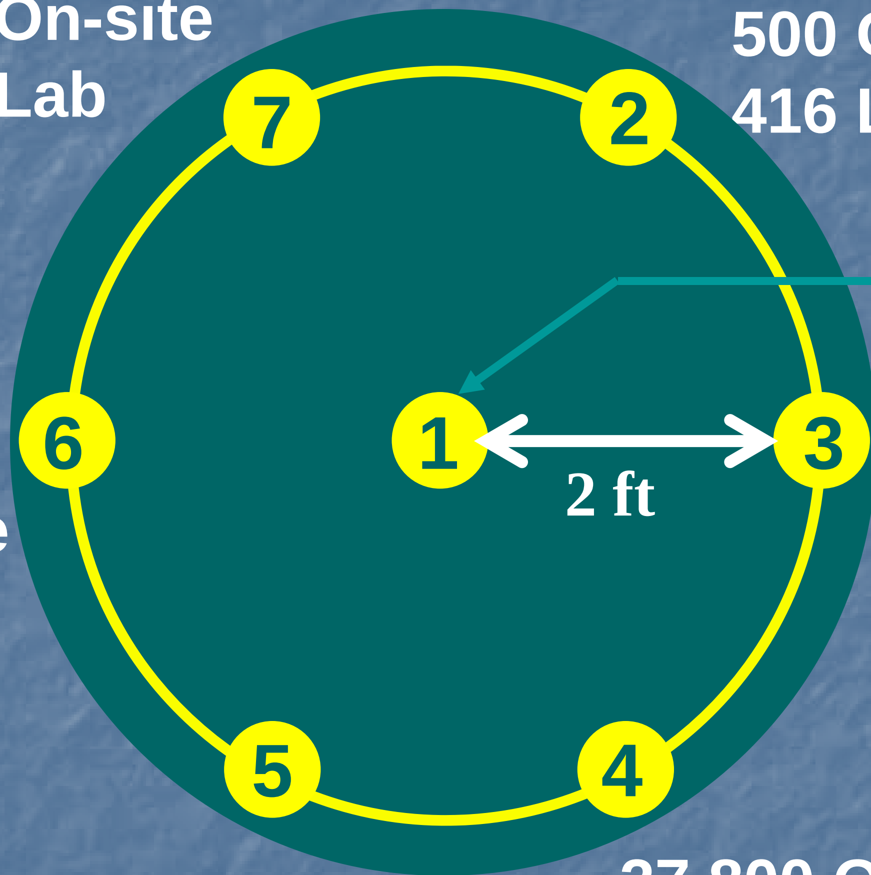
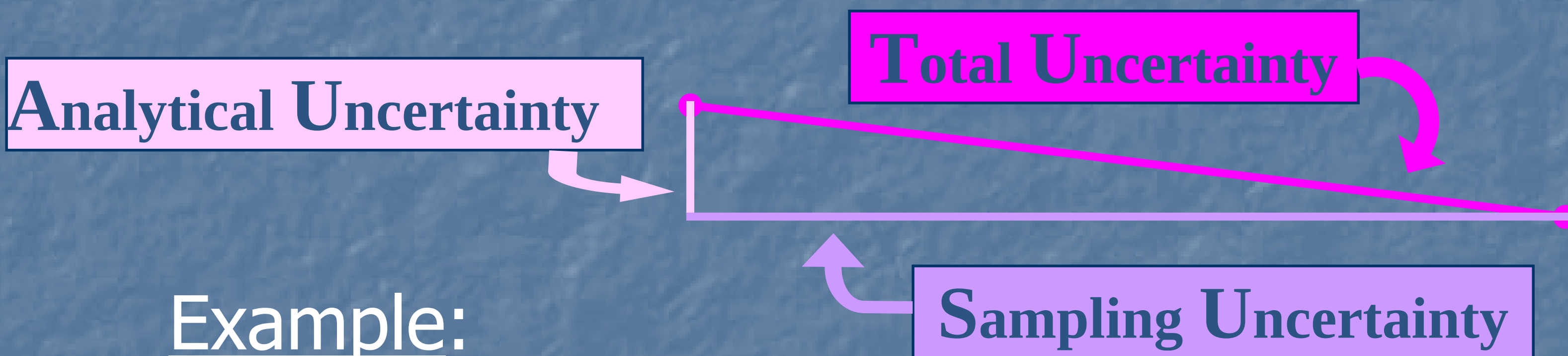


Figure adapted from Jenkins (CRREL), 1996

Uncertainty Math Magnifies Weakest Link's Effects in Data Quality Chain

Uncertainties add according to ($a^2 + b^2 = c^2$)



Example:

- AU = 10 ppm, SU = 80 ppm: **TU = 81 ppm**
- AU = 5 ppm, SU = 80 ppm: **TU = 80 ppm**
- AU = 10 ppm, SU = 40 ppm: **TU = 41 ppm**
- AU = 20 ppm, SU = 40 ppm: **TU = 45 ppm**

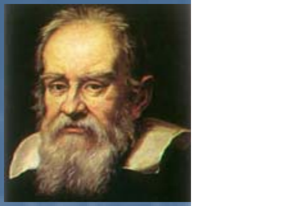
Real-Time Data

- Really "Within-Time"
  - Results/information in time to facilitate dynamic work strategies
    - Field analytical methods (XRF, IA, UV, colorimetric)
    - Direct sensing tools (MIP, LIF, EC, CPT)
    - Geophysical tools (EM, resistivity, GPR)
    - Mobile labs, field GC, modified methods
    - Quick turn fixed based lab analysis
  - Can benefit from "demonstration of method applicability" (DMA), field based investigation levels, decision logic, decision support tools

DMA History

"I think that in the discussion of natural problems we ought to begin not with the Scriptures, but with experiments, and demonstrations."

Galileo Galilei



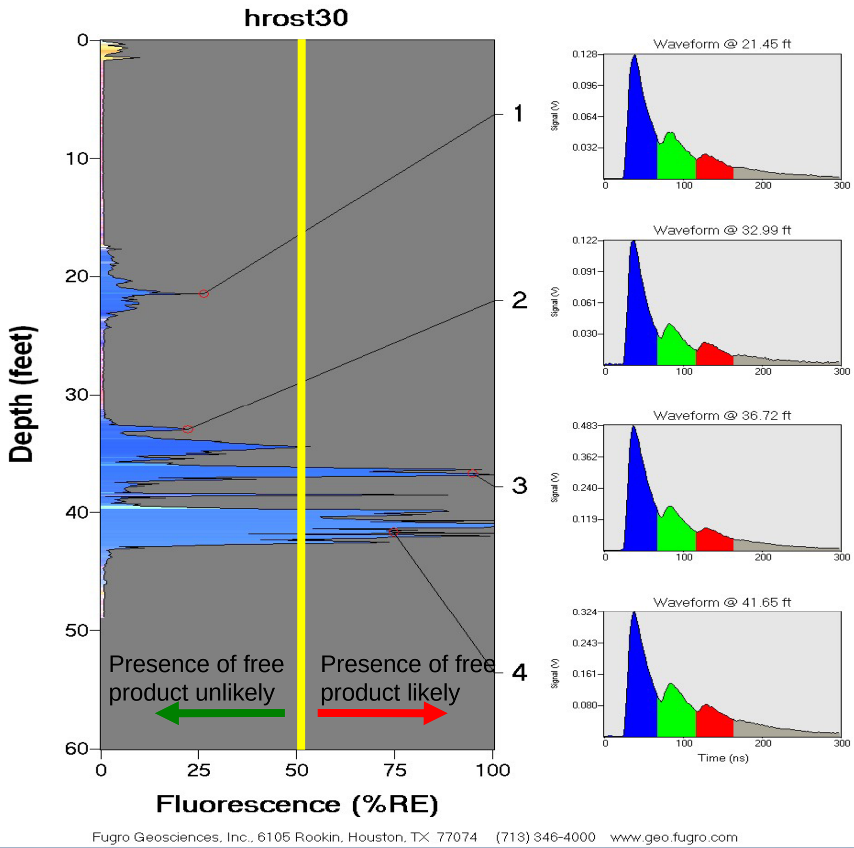
- Concept founded in SW-846, performance based measurement (PBMS) initiative http://www.epa.gov/sw-846/pbms.htm
- Initial site-specific performance evaluation
  - Analytical and direct sensing methods
  - Sample design, sample collection techniques, sample preparation strategies
  - Used to select information sources for field and off-site
- Goal is to establish that proposed technologies and strategies can provide information appropriate to meet project decision criteria

Just A Few DMA Benefits

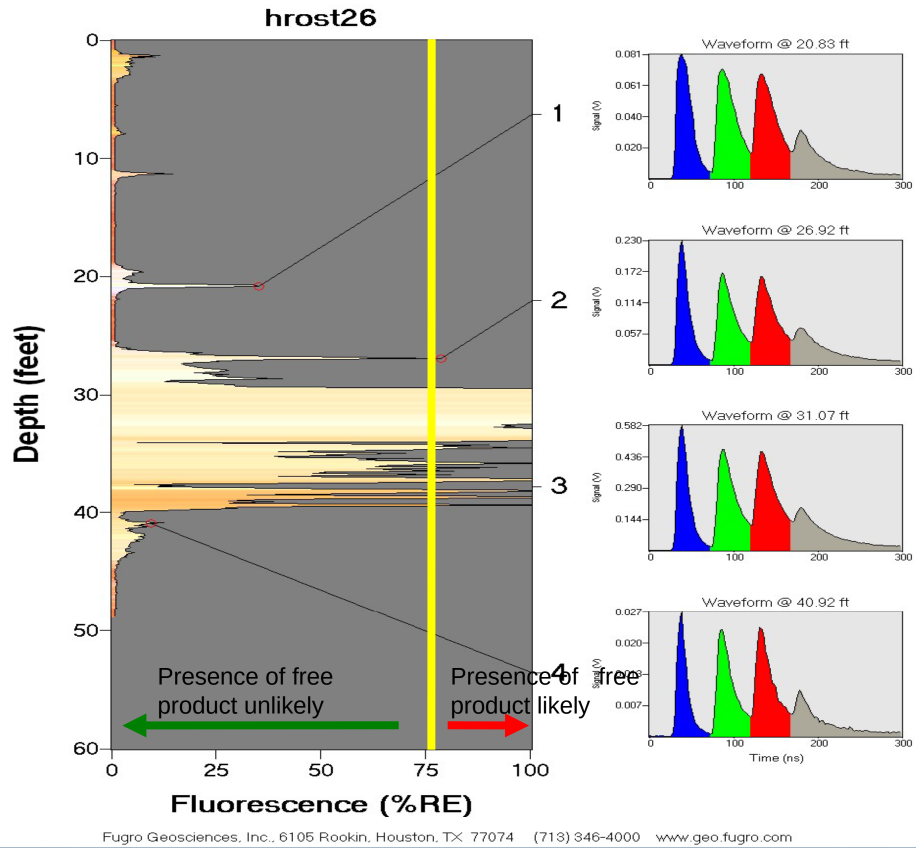
- Augment planned data collection and CSM development
- Test drive Decision Support Tools (DSTs)
  - Sampling and statistical tools
  - Visualization tools, data management tools
- Develop relationships between visual observations and direct sensing tools
- Flexibility to change tactics based on DMA rather than full implementation
- Establish initial decision logic for DWS
- Evaluate existing contract mechanisms
- Optimize sequencing, load balance, unitizing costs
- The "Brownfields perception"

Example Correlations Between LIF Response and Free Product

Free Product At >50% Relative Fluorescence for Gasoline



Free Product At >75% Relative Fluorescence for Oil



Real-Time Data Allows. . .

- The use of dynamic work strategies
- Continuous updates to CSM
- Target and manage greatest uncertainties as they are identified
- Optimize well placement/screen interval
- Limit mobilizations/prioritize data gaps
- Choose collaborative samples
- Combine traditionally segmented activities/ Monitor in-situ remedy effectiveness

Collaborative Data Sets Address Analytical and Sampling Uncertainties

Increasing Information

Cheaper/rapid (lab? field? std? non-std?) **analytical methods**

↓

Targeted high density sampling

↓

Manages CSM & sampling uncertainty

Costlier/rigorous (lab? field? std? non-std?) **analytical methods**

↓

Low DL + analyte specificity

↓

Manages analytical uncertainty

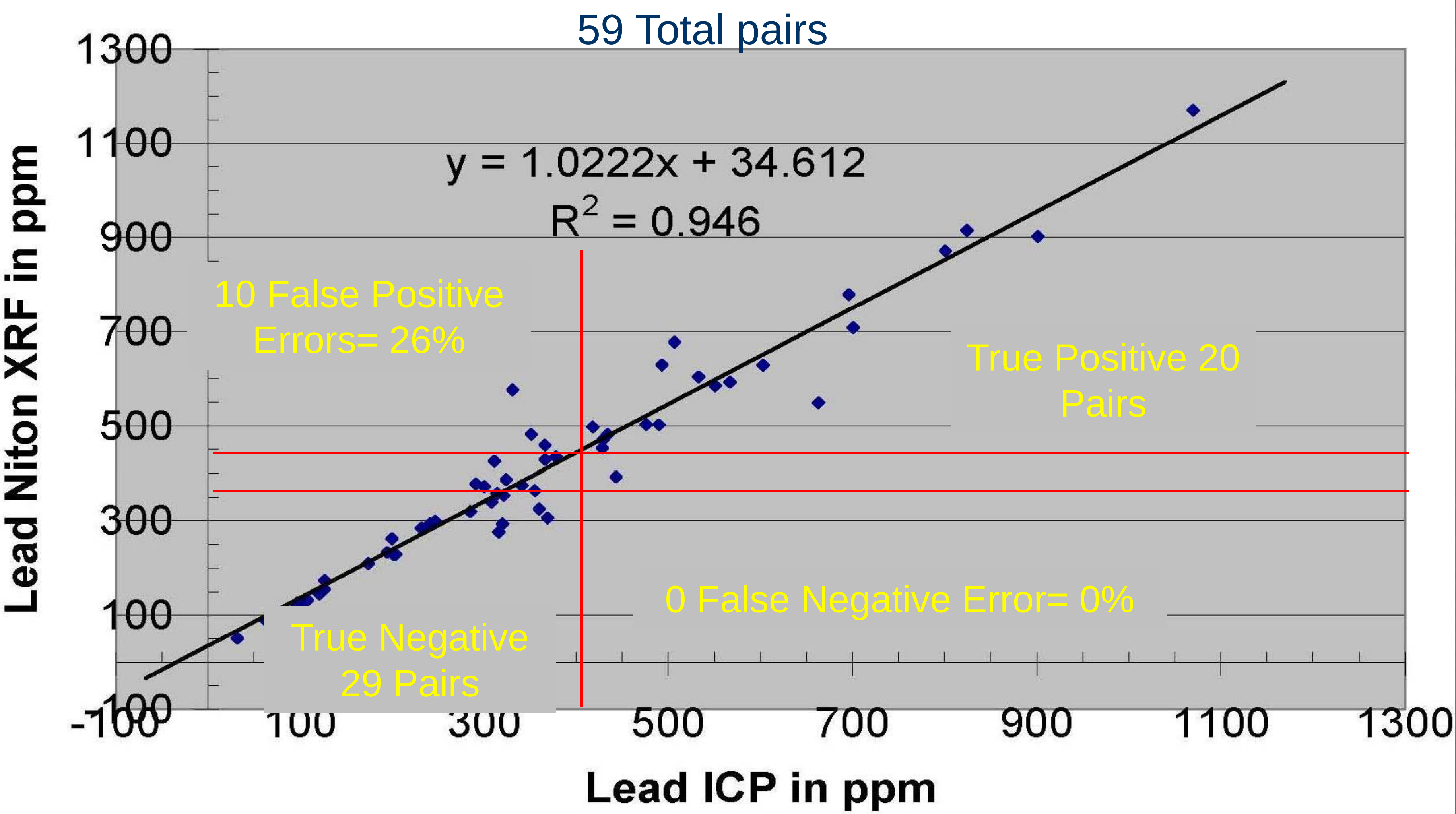
Collaborative Data Sets

Real-time Measurement Systems and Collaborative Data Sets

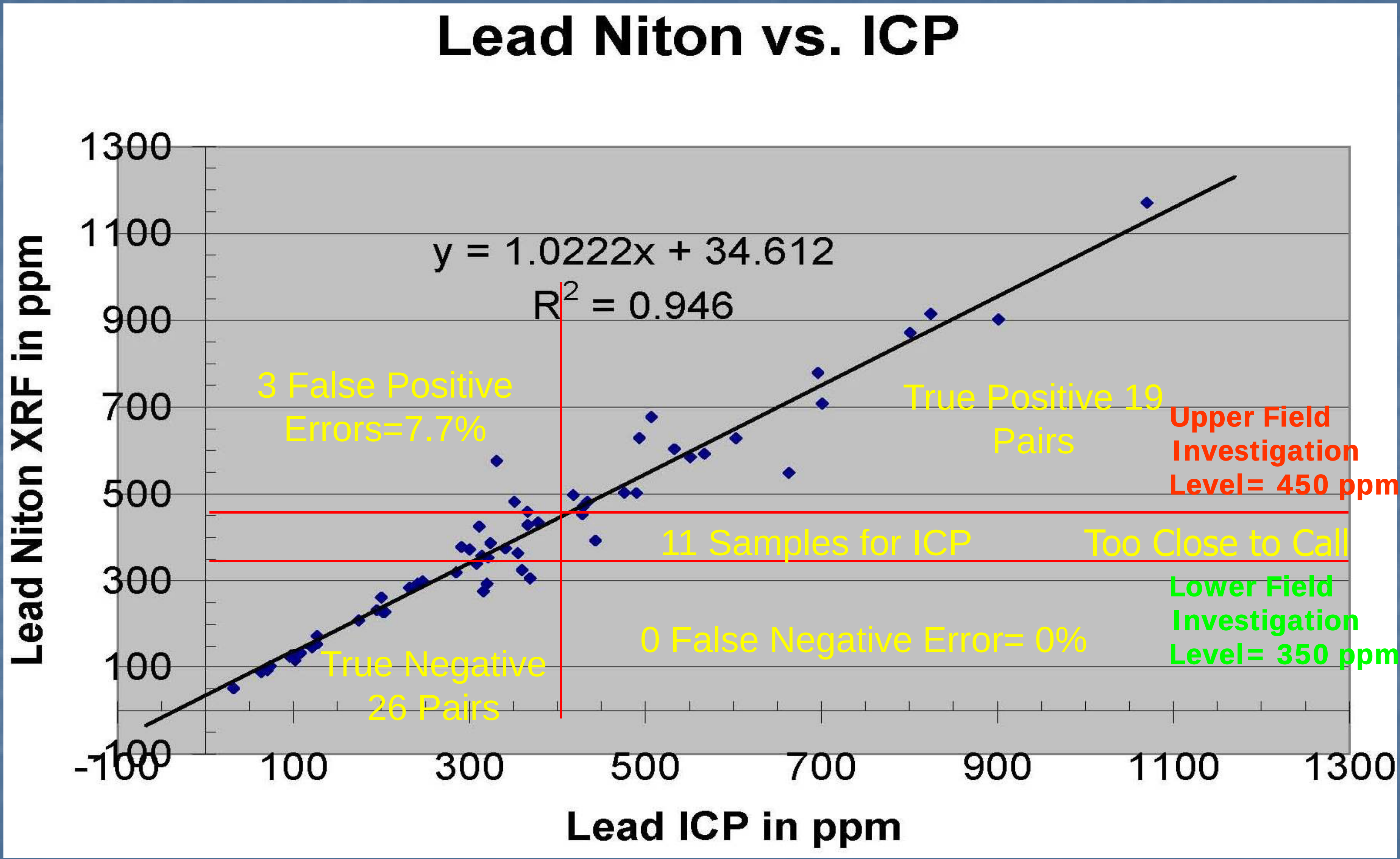
DQOs for Superfund guidance
"For the data to be definitive, either analytical or total measurement error must be determined." (p. 43)

- Field based action levels or investigation levels
  - Levels for field analytics or direct sensing tools that trigger action
    - Collection of collaborative data
    - Step outs, additional sampling or analysis, well placement, etc.
    - Remedy implementation
      - Removal
      - Confirmation of clean (sometimes required)

Lead Niton vs. ICP



3 Way Decision Structure With Region of Uncertainty



Real-Time Data Interpretation

- Critical Part II of Real-Time

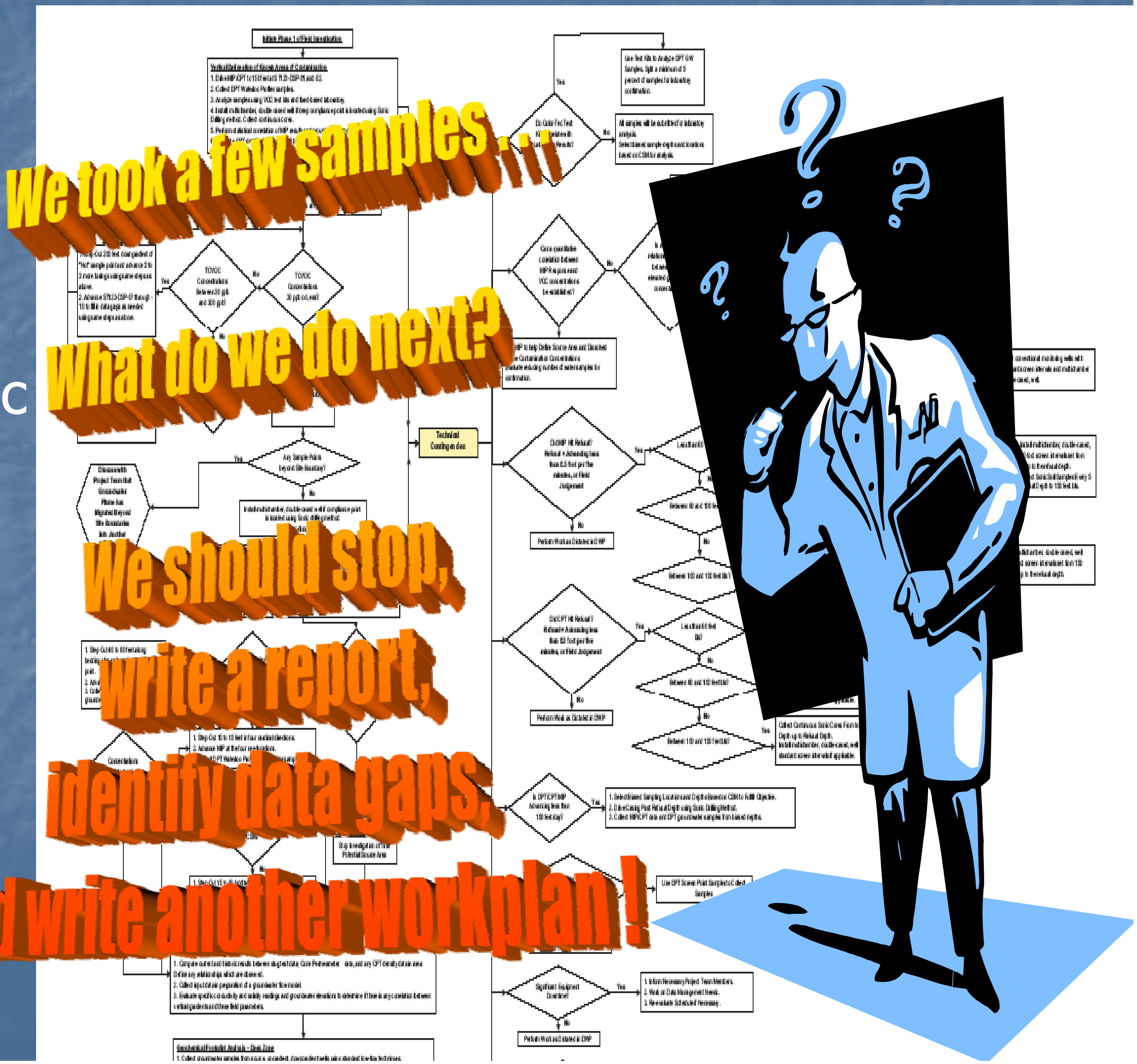
  Collect, process, visualize, make decisions, communicate with stakeholders
  - Visualization software
    - Freeware like SADA, FIELDS, RAT, VSP
    - Commercial products: EVS, GMS, EQuIS
  - Decision support tools
    - Freeware http://www.frtr.gov/decisionsupport/
    - Commercial and proprietary software

Dynamic Work Strategies

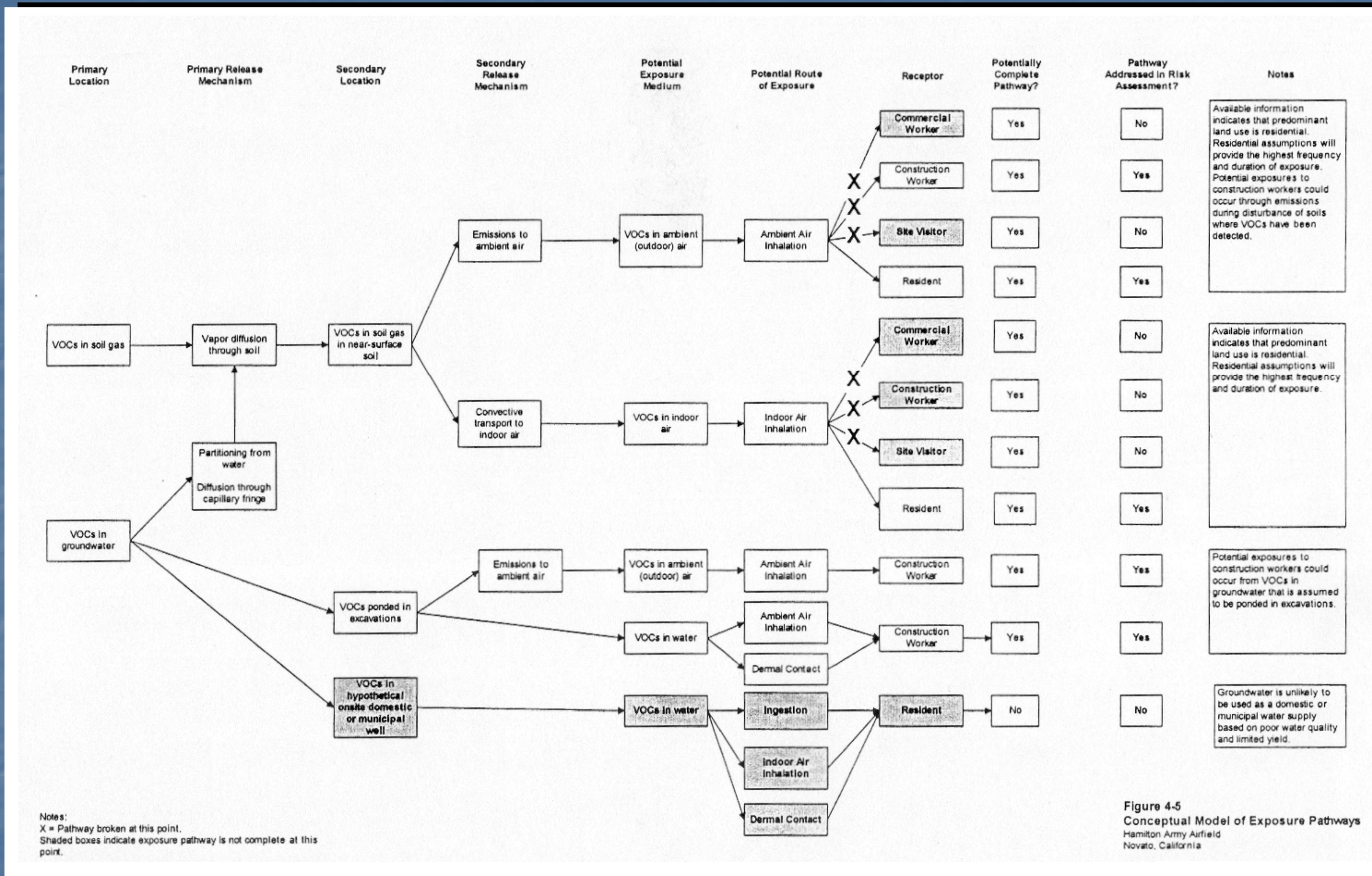
- From this…
- To this……

Detailed decision logic

- Program
- Project
- Field effort
- Sampling
- Contaminant



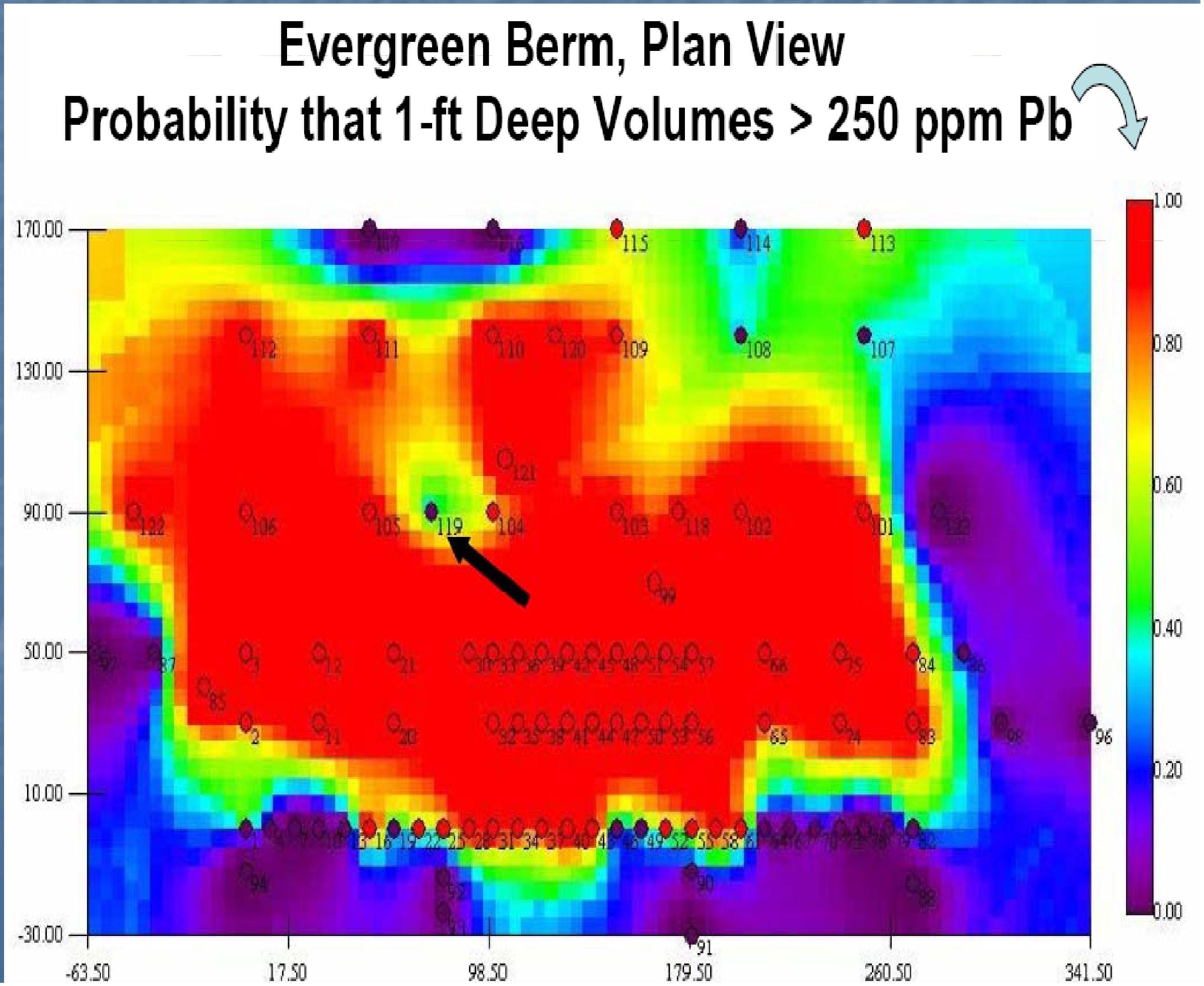
Conceptual Site Models



Decision Support Tools

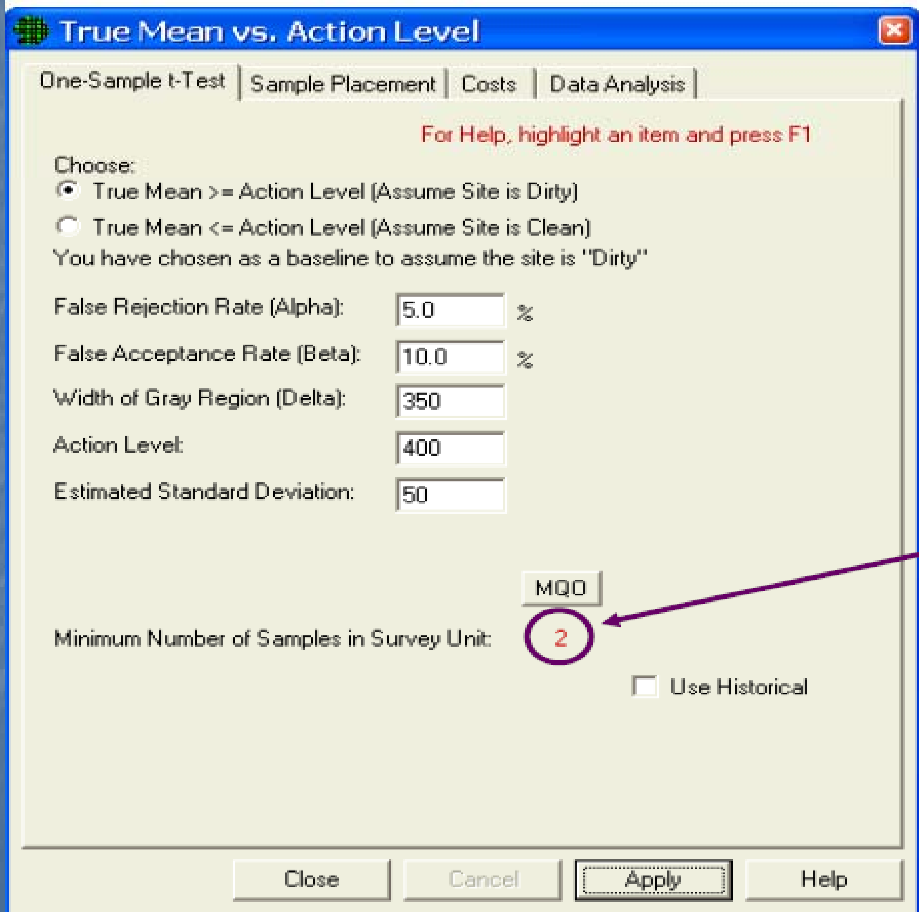
- From this…
- To this……

  Geostatistics using SADA



Statistical Sampling Design

Choose wisely: It Makes a Big Difference in Sample Numbers!



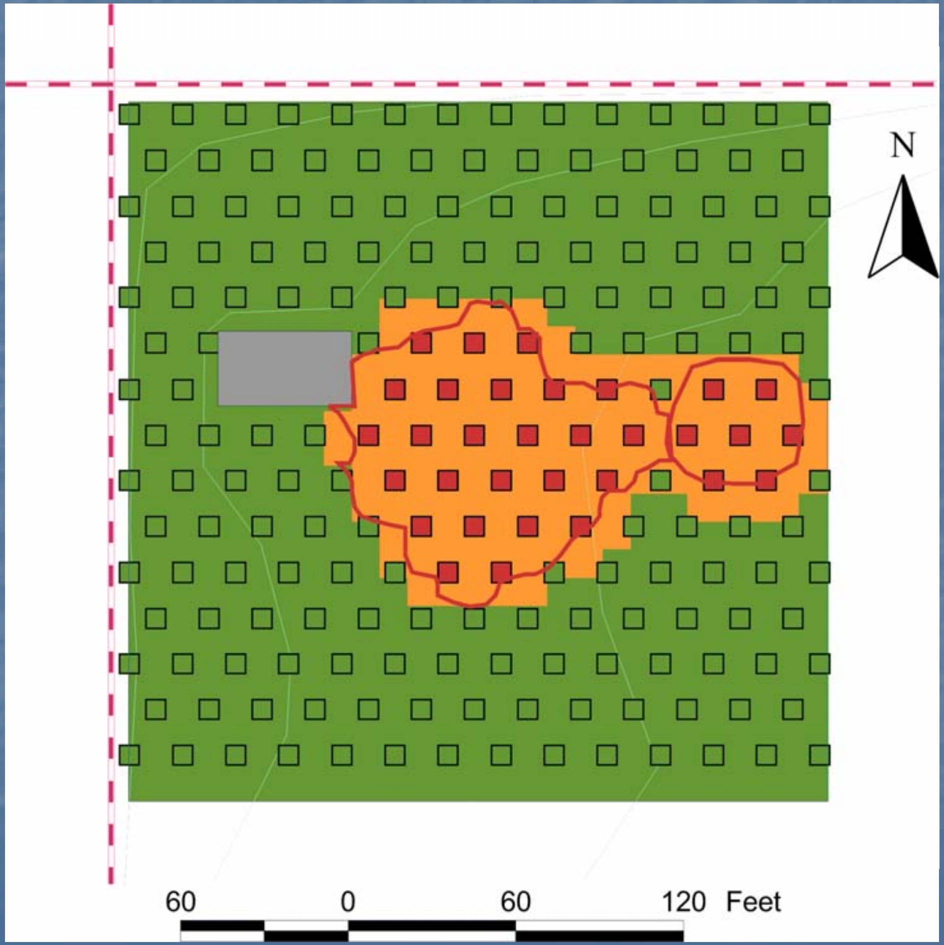
Actual mean closer to AL --->

Increasing variability ---->

GR width: **StDev**	350 ppm	200 ppm	100 ppm
50 ppm	2	3	4
200 ppm	5	10	36
300 ppm	8	21	79

Sampling Design

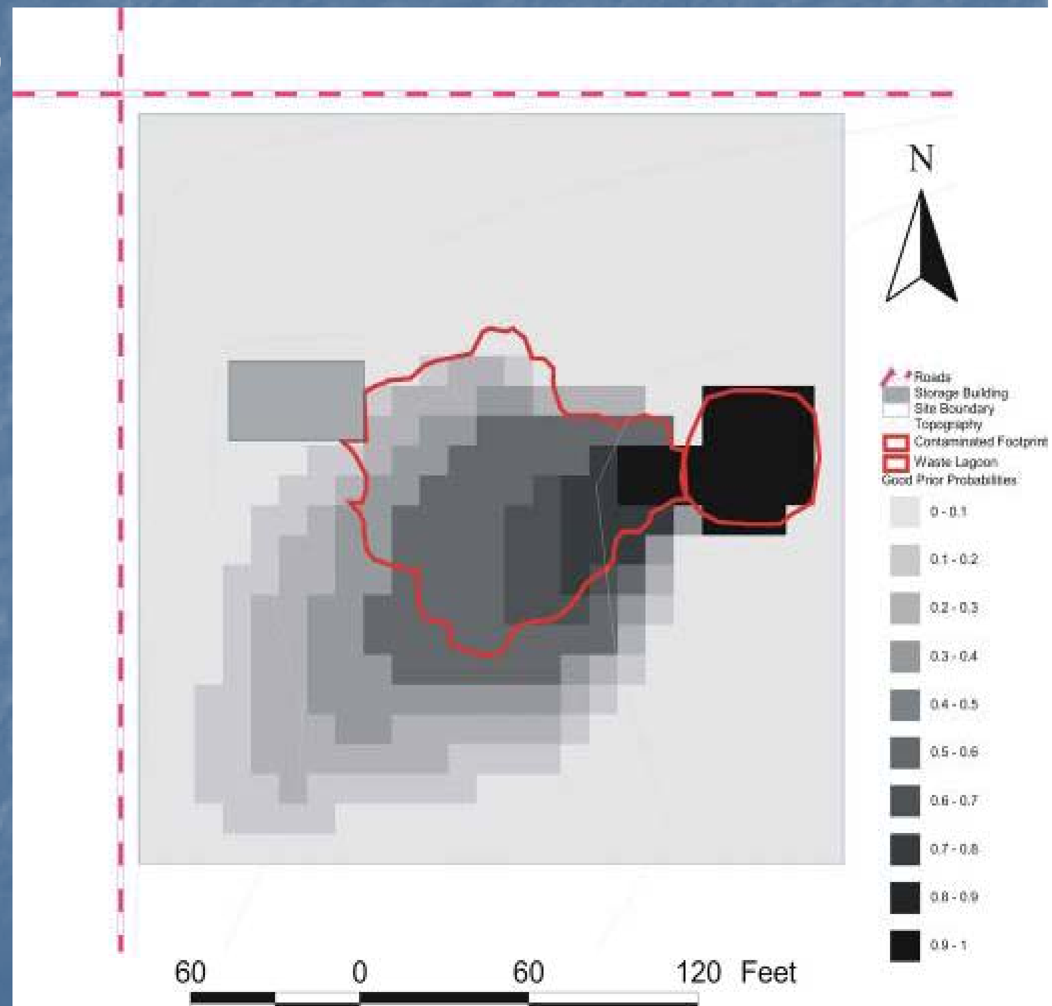
- Triangular grid program
- 203 samples allocated
- Observed error rates:
  - Missed contamination: 0 ft^2
  - Incorrectly excavated clean: 3,500 ft^2 (35% over-excavation)



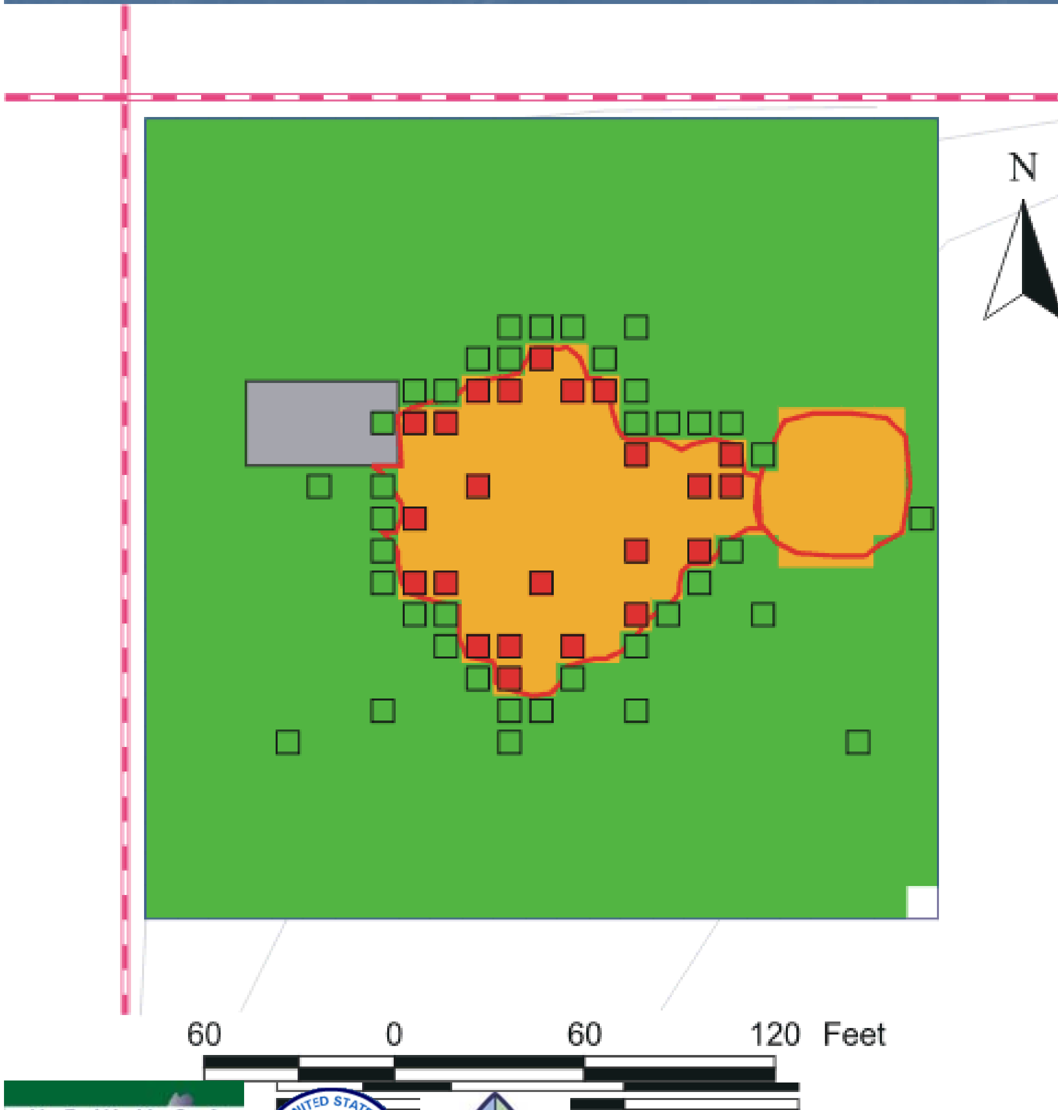
Initial Conceptual Site Model

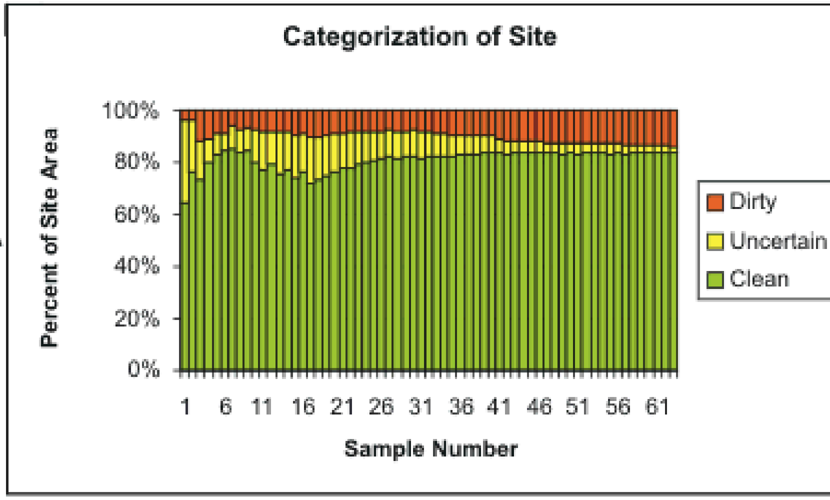
Addressing the Unknown

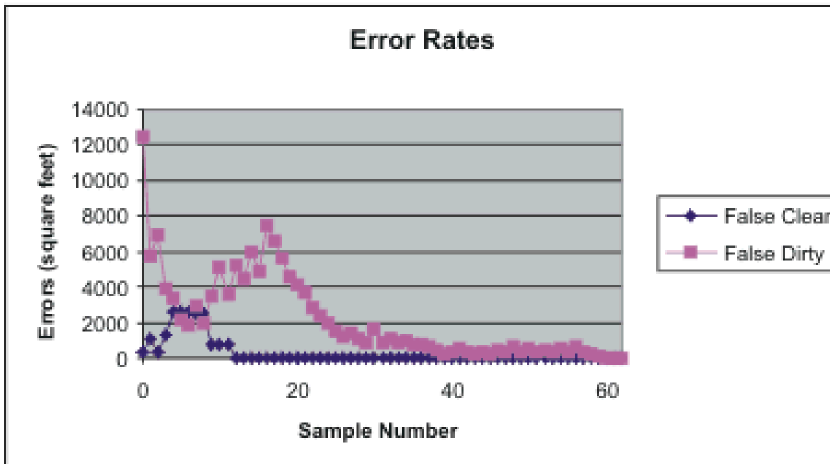
- Based on soft information, assign probability of contamination being present
- Map shows this CSM pictorially, color-coded based on contamination probability
- This CSM drives subsequent sampling decisions & becomes an important point of concurrence for stakeholders



GeoBayesian Adaptive Sampling Progression

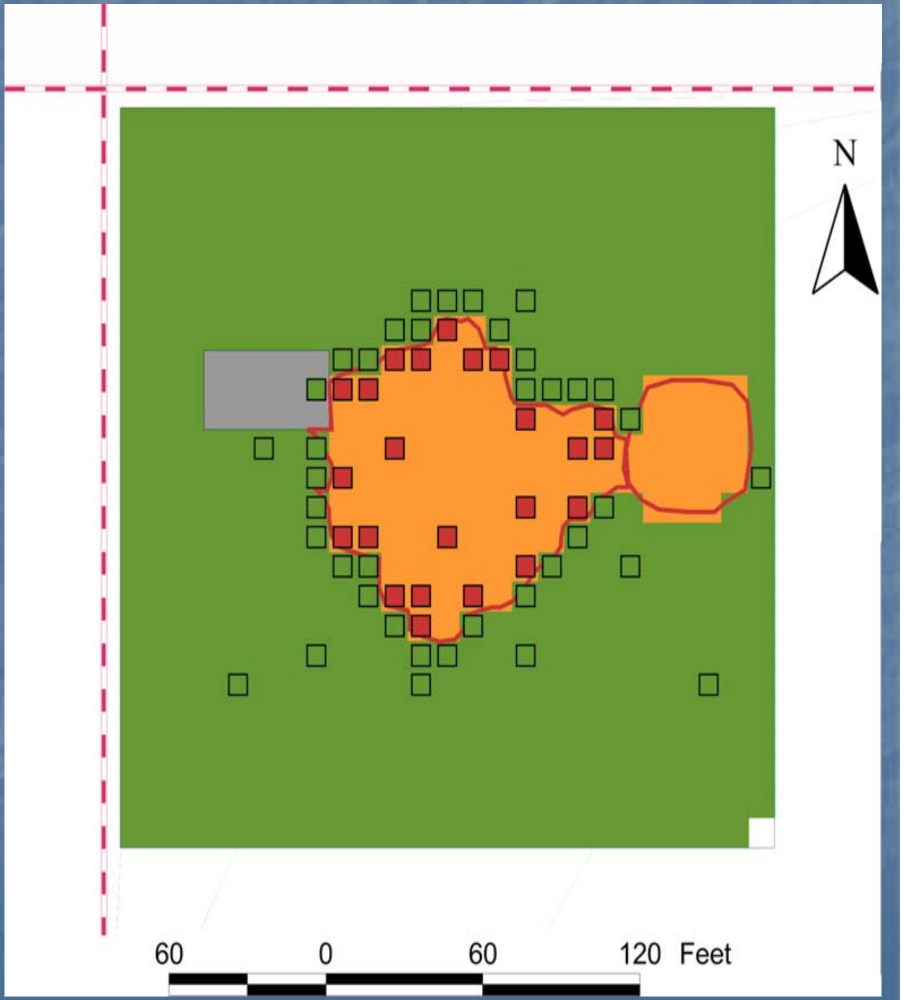






Adaptive Program Performance

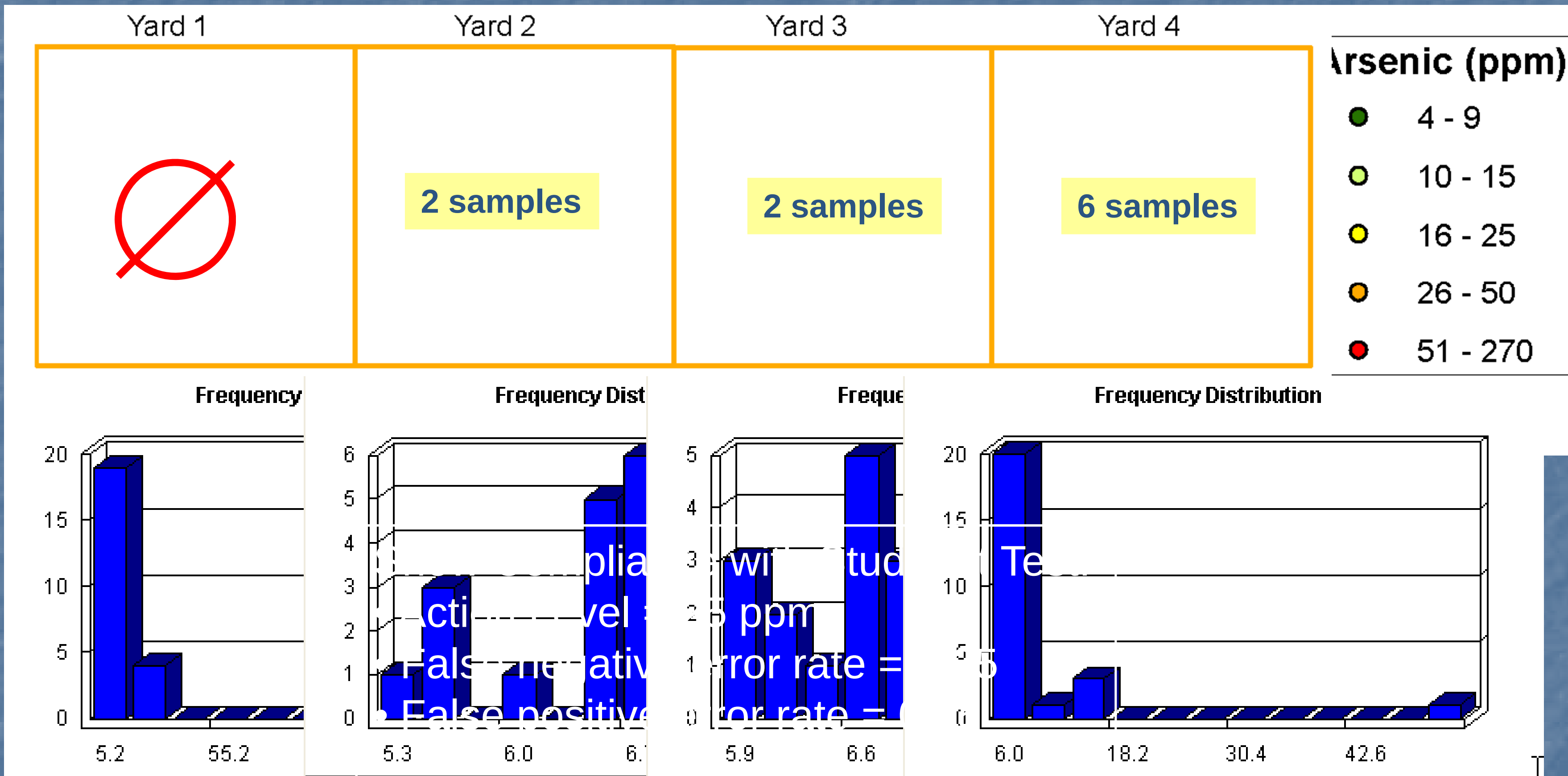
- Completely done with 62 samples
- After only 22 samples, outperformed traditional 203 sample grid program from an error rate perspective
- Requires real-time measurements



Another Example....

- 4 residential backyards screened by XRF for arsenic with action level of 25 ppm averaged over yard
- Use XRF to determine:
  - whether each yard is likely above or below action level, and
  - if below, how many laboratory samples are required to statistically show it?

Here’s what the yards look like:



How many samples are required?

Yard 1	Yard 2	Yard 3	Yard 4
• average = 24 ppm	• average = 6.8 ppm	• average = 7.0 ppm	• average = 10 ppm
• stdev = 41 ppm	• stdev = 0.7 ppm	• stdev = 0.7 ppm	• stdev = 9 ppm

Real-Time Data Experiences Lessons Learned

- Linear regression- can be helpful or misleading
- Heterogeneity- large scale, small scale, and within sample
  - Don’t expect collaborative data to compare any better than 2 labs or even the same lab
- Focus on decision quality
- Data management and communication are key
- Structure vendor contracts to include some DMA principles
- Evaluate contingencies
- Particular instruments ≠ technology generalizations

Brownfields Technical Support Center

http://www.brownfieldstsc.org/index.cfm

- Technical support services
  - Facilitate systematic planning
  - Build/refine conceptual site model
  - Sampling design, scope of work, sequencing
  - Real-time measurements, field analytics/collaborative data sets
  - Statistical data analysis
  - Decision support tools
  - Work-plan development/review
  - Remedy optimization
  - Monitoring network optimization
  - Independent design reviews

Comprehensive Sources

- Hazardous Waste Cleanup Information (CLU-IN) Internet Site
  - http://clu-in.org
- Triad Resource Center
  - http://www.triadcentral.org
- EPA Internet site
  - http://www.epa.gov
- Federal Remediation Technologies Roundtable
  - http://www.frtr.org
- Field Analytical Technology Encyclopedia (FATE)
  - http://fate.clu-in.org/
- Brownfields Technology Support Center
  - http://www.btsc.org
- Interstate Technology Regulatory Council (ITRC)
  - http://www.itrcweb.org