Evolving Conceptual Site Models (CSMs) in Real-time for Cost Effective Projects

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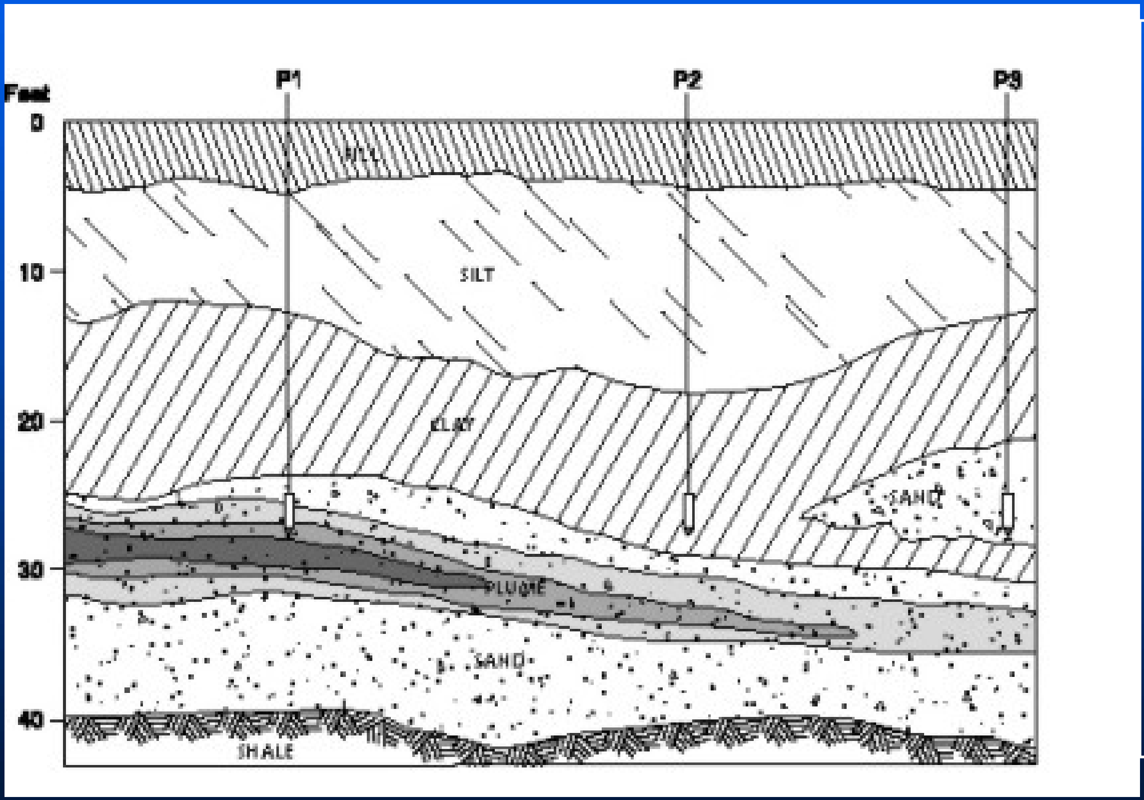
The Term “Conceptual Site Model”

- This term has a number of different (but related) environmental meanings:
  - preliminary stage in creating a computer or physical model
  - focused risk assessment or geologic evaluation
  - an integration of all relevant information assembled for the purposes of investigating or remediating a site
- This workshop focuses on the latter definition

The Data Problem

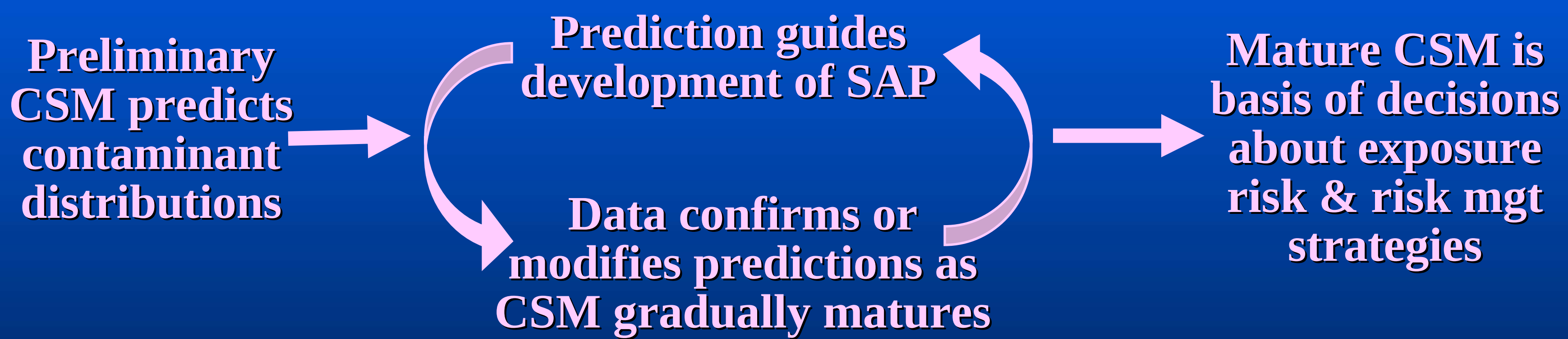
How to Manage Uncertainty



- Where are you going to sample?
- How many samples are you going to take?
- Can you get a representative sample?
- When will I have enough data?

CSMs Are Critical!!

- Whether or not openly articulated, a CSM is the basis of all site decision-making. Many unacknowledged CSMs are based on unjustified assumptions of homogeneity, leading to the generation of non-representative data.



- Working without a CSM is like working blind-folded & handcuffed!

Where Does Uncertainty Lie??

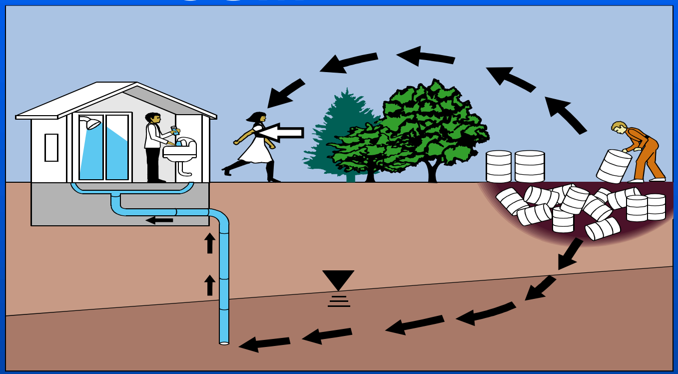
Lack of clarity here

Reuse Plans, Goals, Outcomes

Impact

…means lack of clarity here

CSM



\+

Decisions:

- Exposure risk?
- Cleanup goals
- Data (type, quality)
- Tolerable uncertainty

…which means no foundation for agreement here

Determine

…or here

Approaches to:

- Assessment
- Investigation
- Cleanup Design, Implementation
- Closeout, Long-Term Operations and Maintenance

Tools for:

- Sampling, Analysis, Interpretation
- Cleanup/Remediation
  - Containment
  - Cleanup
  - Controls
- Monitoring, Maintenance

Preliminary CSM

- Highlights **Physical** Features of Site
  - Man-made Structures / Historically Disturbed Areas / Accumulation Points
  - Actual Site Data or Professional Conjecture
    - » Contaminants of Concern
    - » Release Mechanisms
- Incorporates known **Societal** Considerations
  - Future Land Use / Community Goals
  - Potential Exposure Pathways
  - Risk Management Scenarios

Additional Data to Build the Preliminary CSM

- Related information:
  - other nearby contaminated sites – regulatory agencies
  - state geological surveys
  - research by academic institutions
- Professional judgment:
  - scientific knowledge
  - conjecture

Site Data

- Chemical
- Hydrogeological
- Biological
- Geochemical
- Hydrology
- Preferential paths
- Historical activities
- Source areas
- Land use
- Receptors
- Exposure pathways
- Community plans

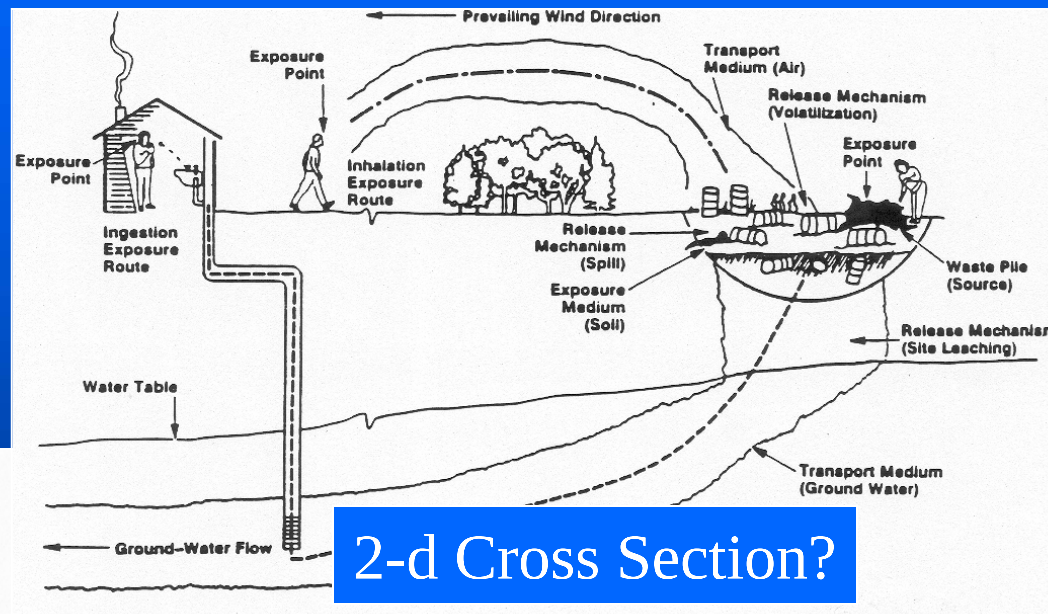
CSM Presentation

- Text
- 2-Dimensional images:
  - Geologic cross-sections
  - Contaminant transport areal views
- 3-Dimensional images
- Flow charts

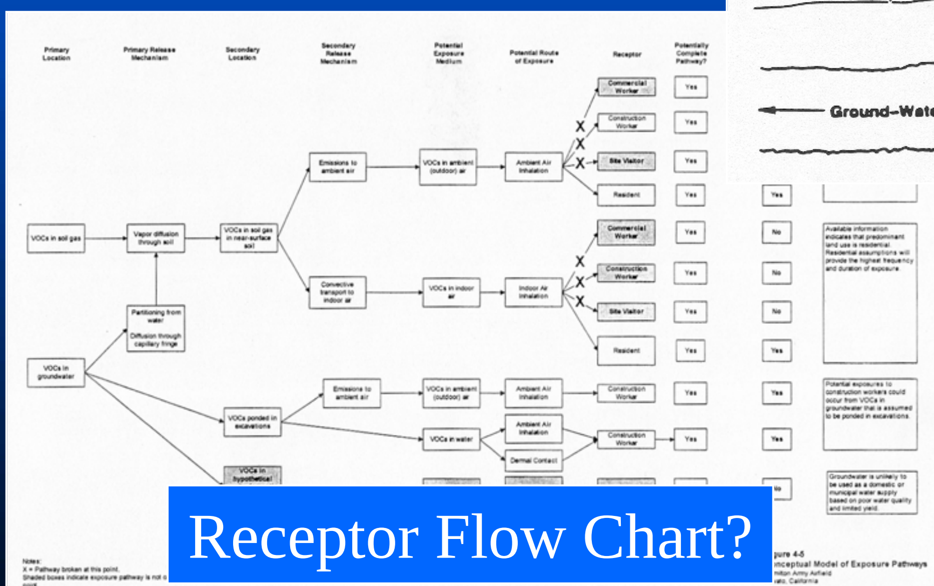
How Might a CSM Appear?

Text?

Computer Model?



2-d Cross Section?

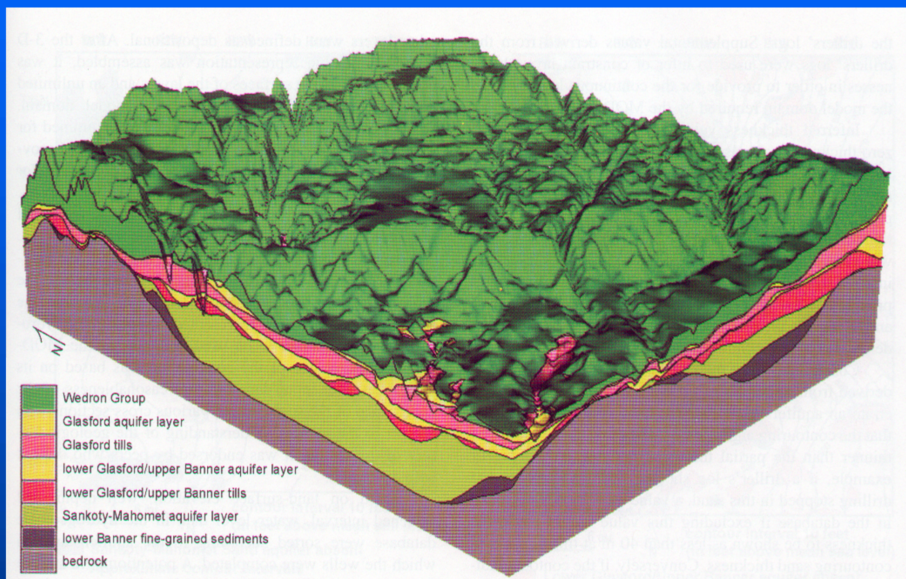


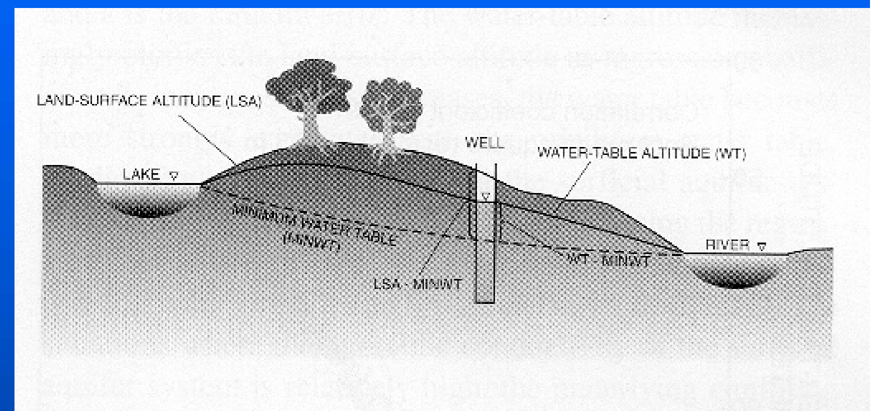
Receptor Flow Chart?

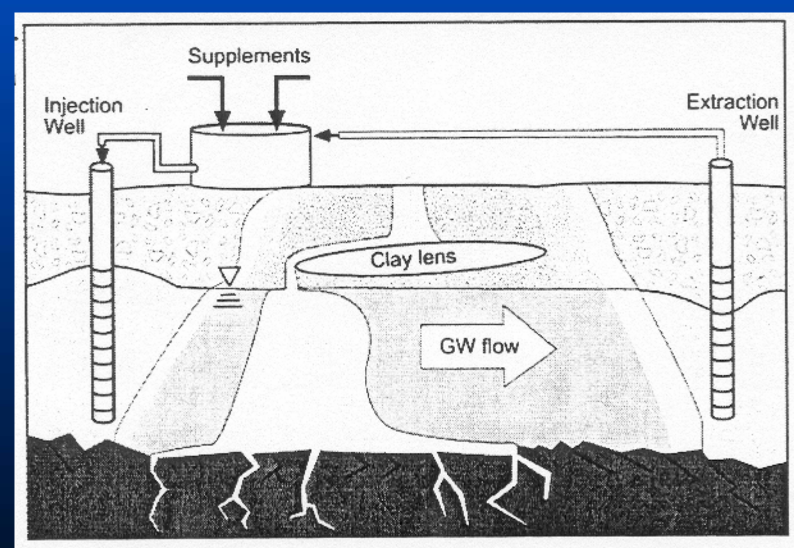
3-d Physical Model?

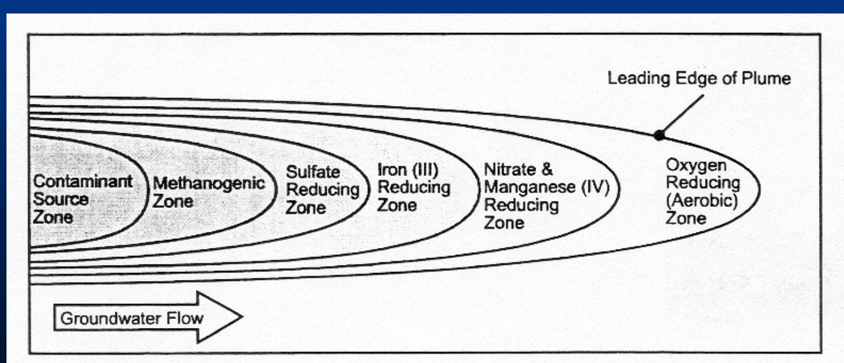
How can we organize this information?

Other Possibilities

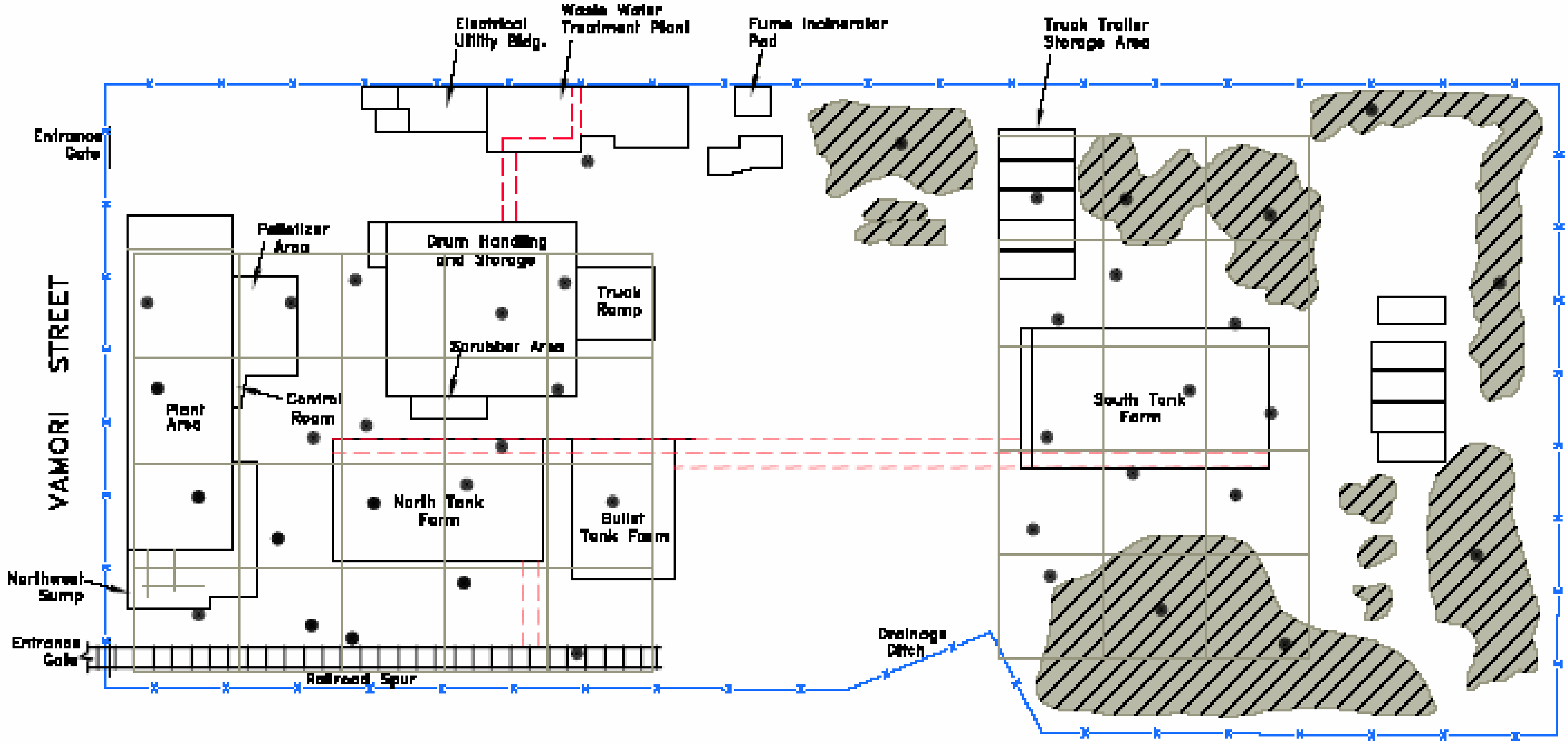


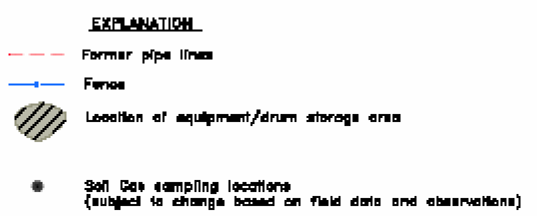






Manufacturing Plant:
The CSM Exploits Existing Knowledge

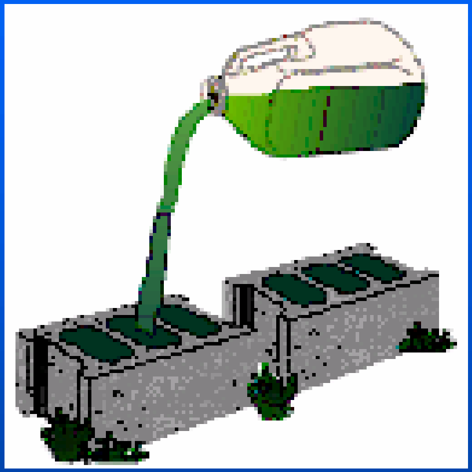




What areas are expected to be contaminated?
What areas are expected to be ~clean?

Example of Macro Population Segregation

- Wenatchee site: 3 distinct soil decision-driven pop's
  - Compliant soil (remain on site)
  - Mild-mod non-compliant soil (landfill)
  - Severely contaminated soil (incinerate)



- If unable to segregate populations, incinerate total volume: ~ $1.2 million (708 tons soil)
- Actual cost to clean closure using Triad = $589K
  - 56 tons incinerated
  - 334 tons landfilled
- Cost if segregation done correctly, but using a traditional site mgt approach ~ $1.2 million

Example of Micro (Within-Sample) Populations

Soil Grain Size Std Sieve Mesh Size (mm diameter)	Pb Conc. for the fraction by AA (mg/kg)
Greater than 3/8" (~10 mm)	10
Between 4-mesh and 3/8" (5 - 9 mm)	50
Between 4- and 10-mesh (5 - 2 mm)	108
Between 10- and 50-mesh (2 - 0.3 mm)	165
Between 50- and 200-mesh (0.3 - 0.07 mm)	836
Less than 200-mesh (<0.07 mm)	1,970

Adapted from ITRC (2003); http://www.itrcweb.org/SMART-1.pdf

How to Manage Uncertainty?

- The ***Evolving Conceptual Site Model***
  - By processing the data each day, and
  - Presenting the updates to the Technical Team, and
  - Allowing everyone to questions its assumptions …
  - The dynamic work plan allows you to address these questions - the next day.
  - So you don't leave the field until the CSM is fully vetted.

Dynamic Work Strategy Must Include:

- Definition of decision process – stay focused on the ultimate goal
- Provide framework for CSM to be tested and sufficiently evolved in the field to the desired level of decision confidence
- Data management at time scales for decisions
- Communication procedures

Decision Rules and Strategies

- Real time decisions based on data produced by field measurement technologies is a major difference between Triad projects and traditional approaches
- Decision rules/strategies allow project participants to feel confident that DQOs will be met and that decision uncertainty is managed
- Decision rules/strategies reflect anticipated contingencies based on the initial CSM and allow evolution of the CSM during project execution
- Decision rules/strategies assign authority for various levels of decisions to field technical staff, project core technical staff and project decision team

Decision Rules and Strategies

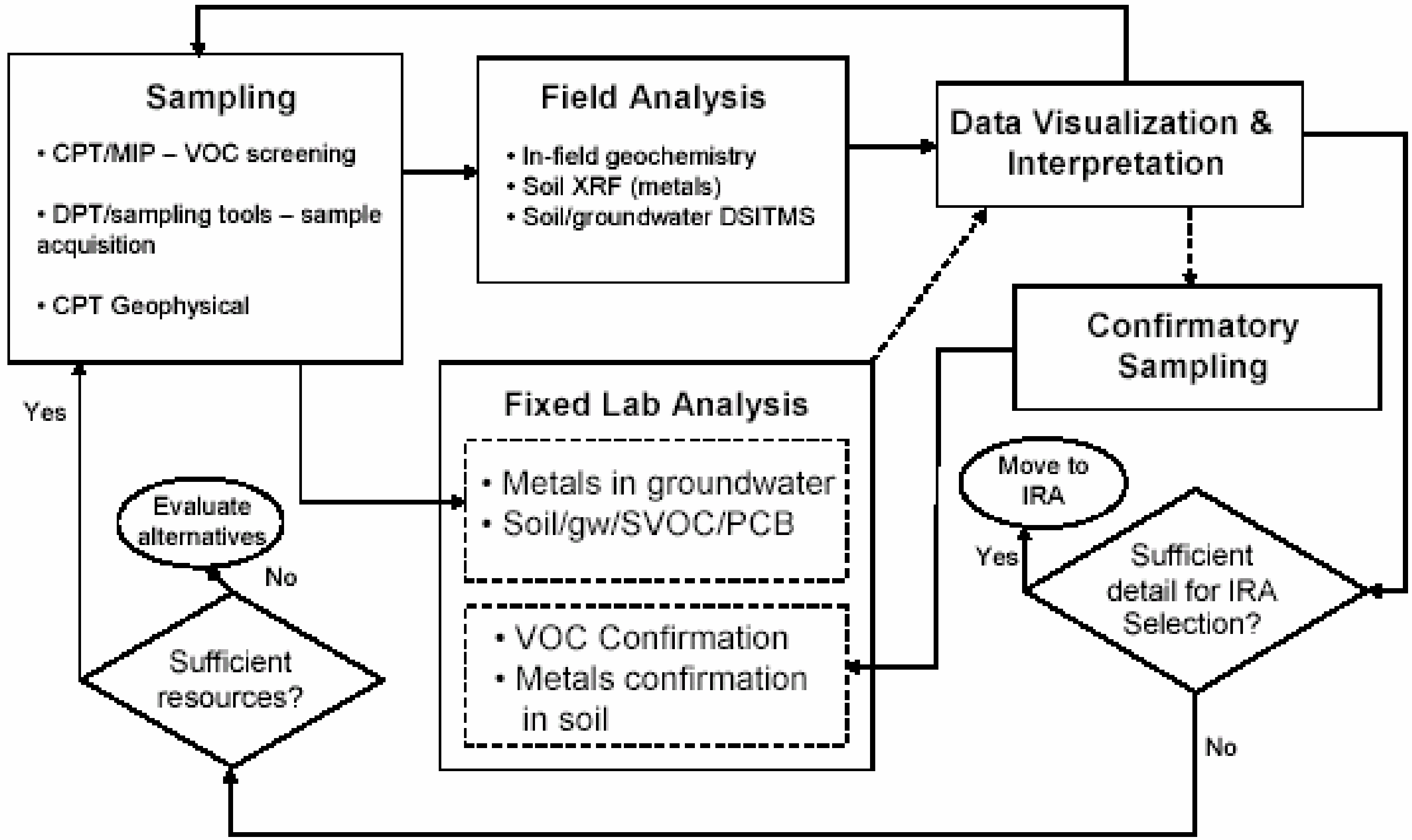


Figure 5. Detailed decision tree for AOC SS24 interim remedial investigation.

Decision Rules and Strategies

- DWS must attempt to anticipate a wide variety of problems, challenges and site conditions (uncertainties)
- Decisions must be allowed to change tools when necessary

Data Management and Communications

- Field measurement technologies produce large volumes of data
- Project QA program must insure decision quality data on the time scale(s) required by project decisions
- Large volumes of data can pose a challenge to conventional methods used to visualize and communicate data to project team members on time scales required
- Similar to decision rules, SOPs for data management and communications ensure responsibilities of project staff are clearly understood

Daily Report Format

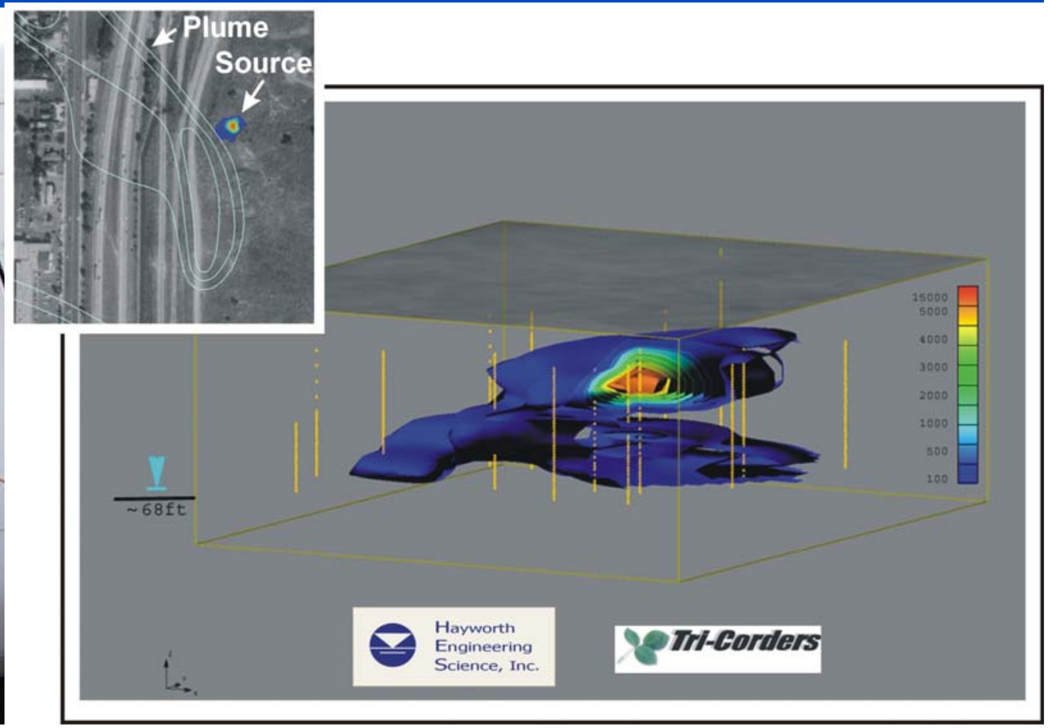
- Contents determined based on needs of the team
- Typical contents
  - Identification of technical staff on site/weather
  - Work completed
  - Decisions made
  - Data verification summary
  - Changes to CSM summarized
  - Recommendations for next days work

Data Management and Communications

On site Decision team meeting are beneficial when feasible

Data Management and Communications

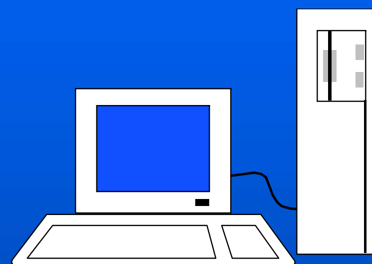
- 3D visualization can be a very important tool to communicate CSM changes when high density data sets are being collected
- Cell telephones, wireless modems, land telephone lines are all useful for communicating in real-time with off site project stake holders



Data Management and Communications

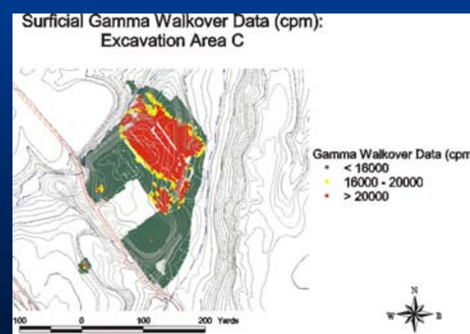
Web-Sharing Data to Link Decision-Makers Who Are Not in the Field

Existing Information
- Base maps
- Geology
- Boring samples
- ……..



Rapid field data acquisition

Results on Web



Decision makers, stakeholders, ..

Slide adapted from Argonne, 2002

http://smartdata.columbiadata.com/site.asp?SiteID=shaw_vint_hill

Columbia Technologies - Site Details - shaw...

Shaw The Shaw Group Inc.™

COLUMBIA TECHNOLOGIES

Wednesday, February 11, 2004

Your Projects

Vint Hill Farms Station

SmartData Solutions™

Site Information

Project Dates

Started: 11/17/2003

Completed: 11/21/2003

Status

Completed

Completed Deliverables

As your order is completed, each item will be added to this screen. Your sitemap is still available by clicking on the "Sitemap" heading below.

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Sitemap

Current Investigations

Daily Reports

Daily QC Report 11-17-03 [85 kb]

Sample Collection Log Sheet Through 11-17-03 [102 kb]

DPT Soil Analytical Results

Soil Analysis Results [46 kb]

Soil Analysis Results [9 kb]

MIP Results

MIP Trapping Results

Passive Diffusion Bag Sampler Results

Passive Bag Analysis Results [22 kb]

Passive Bag Analysis Results [6 kb]

Project Files

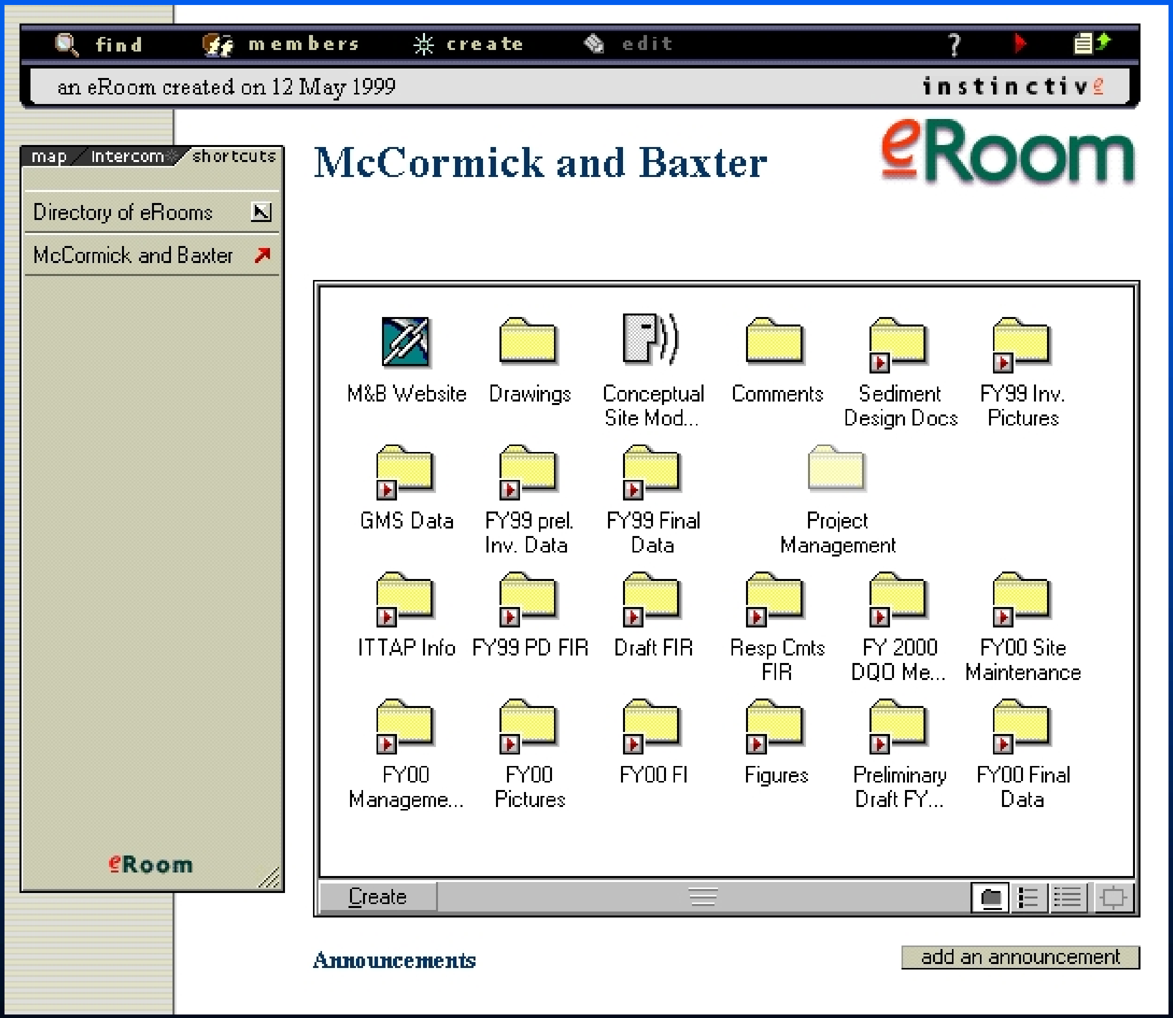
Webcast

View Webcast

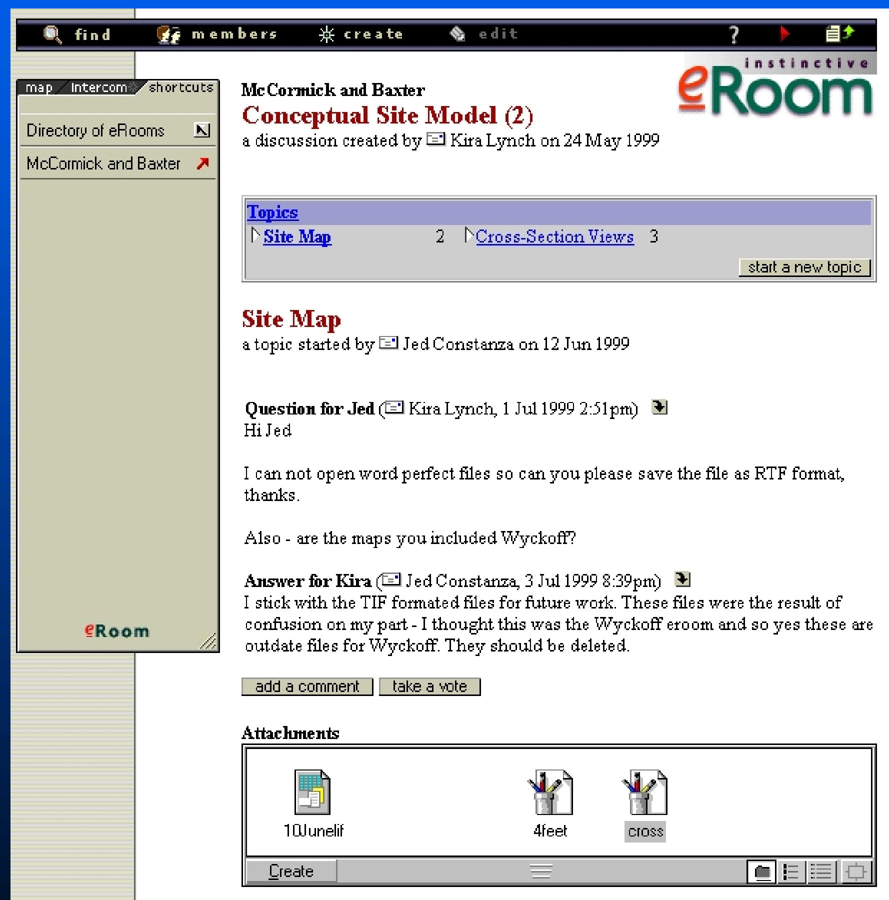
MIP Logs

A15-MIP
A18-MIP
A21-MIP
A30-MIP
C18-MIP
C20-MIP
C23-MIP
D13-MIP
E23-MIP
F20-MIP
F30-MIP
FF20-MIP
G11-MIP
H14-MIP
H23-MIP
J16-MIP
K10-MIP
K24-MIP
K30-MIP
L18-MIP
MW34-4(2)-MIP
MW34-4-MIP
MW34-4-MWMIP

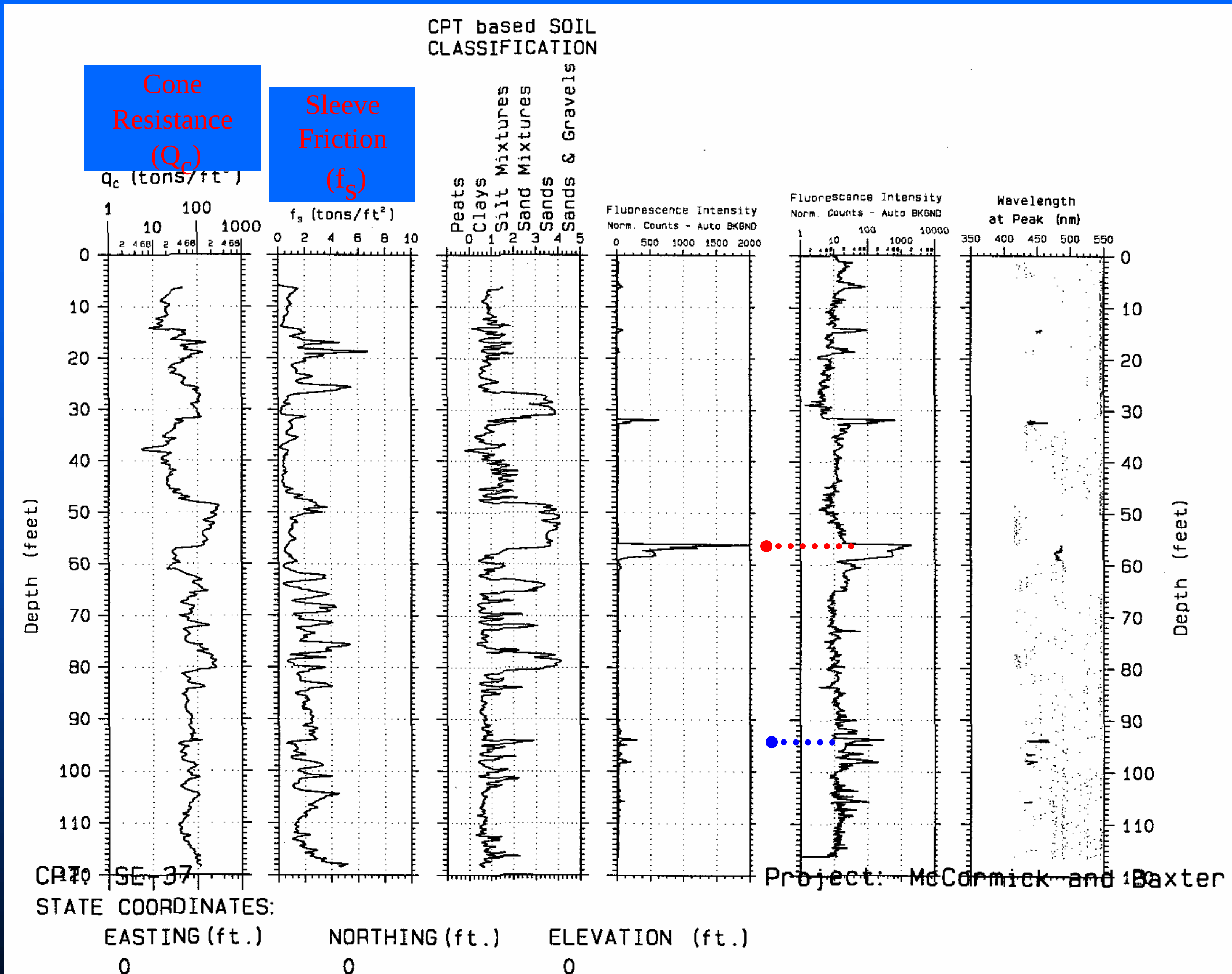
eRoom Main Page

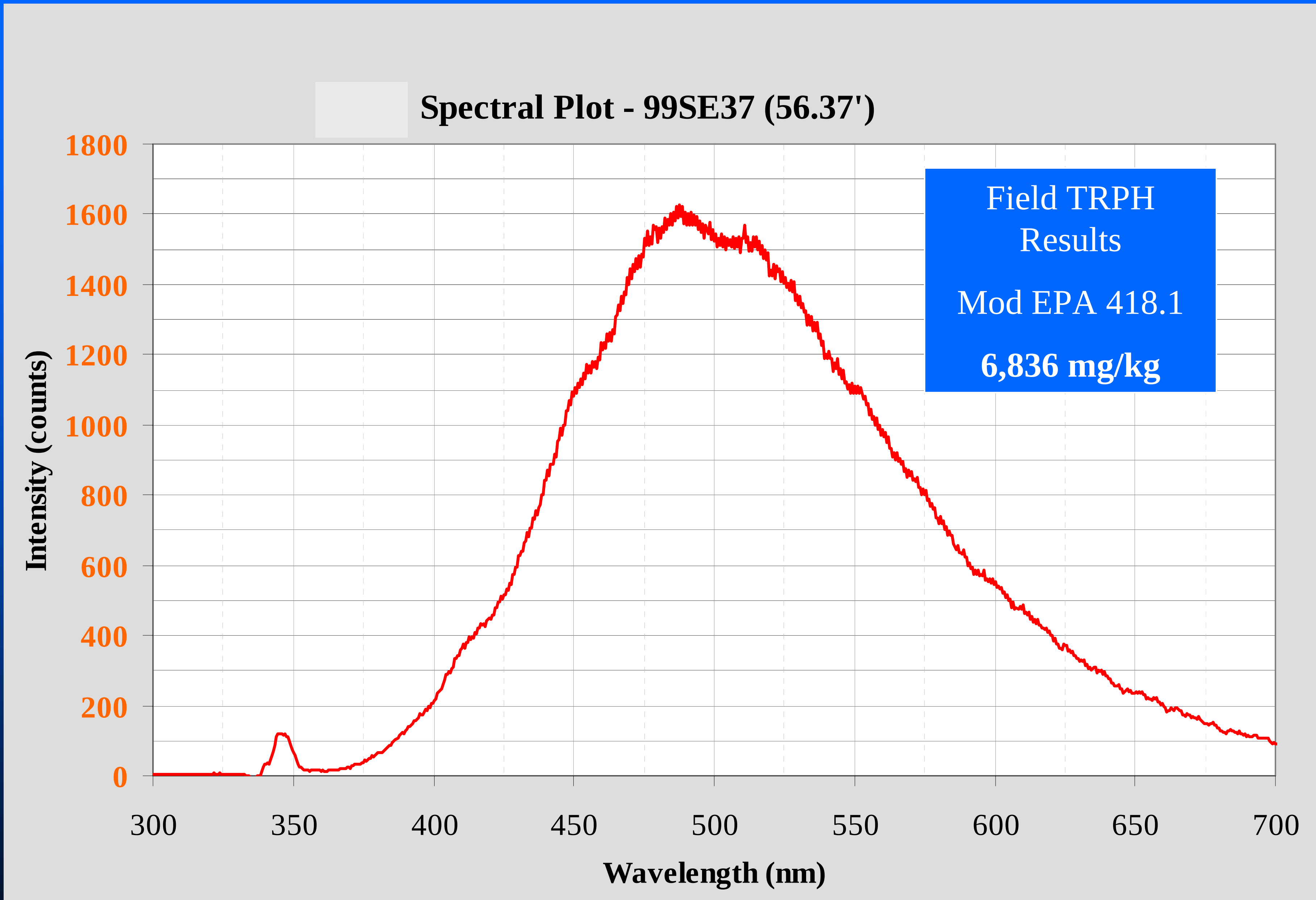


eRoom Sample Page



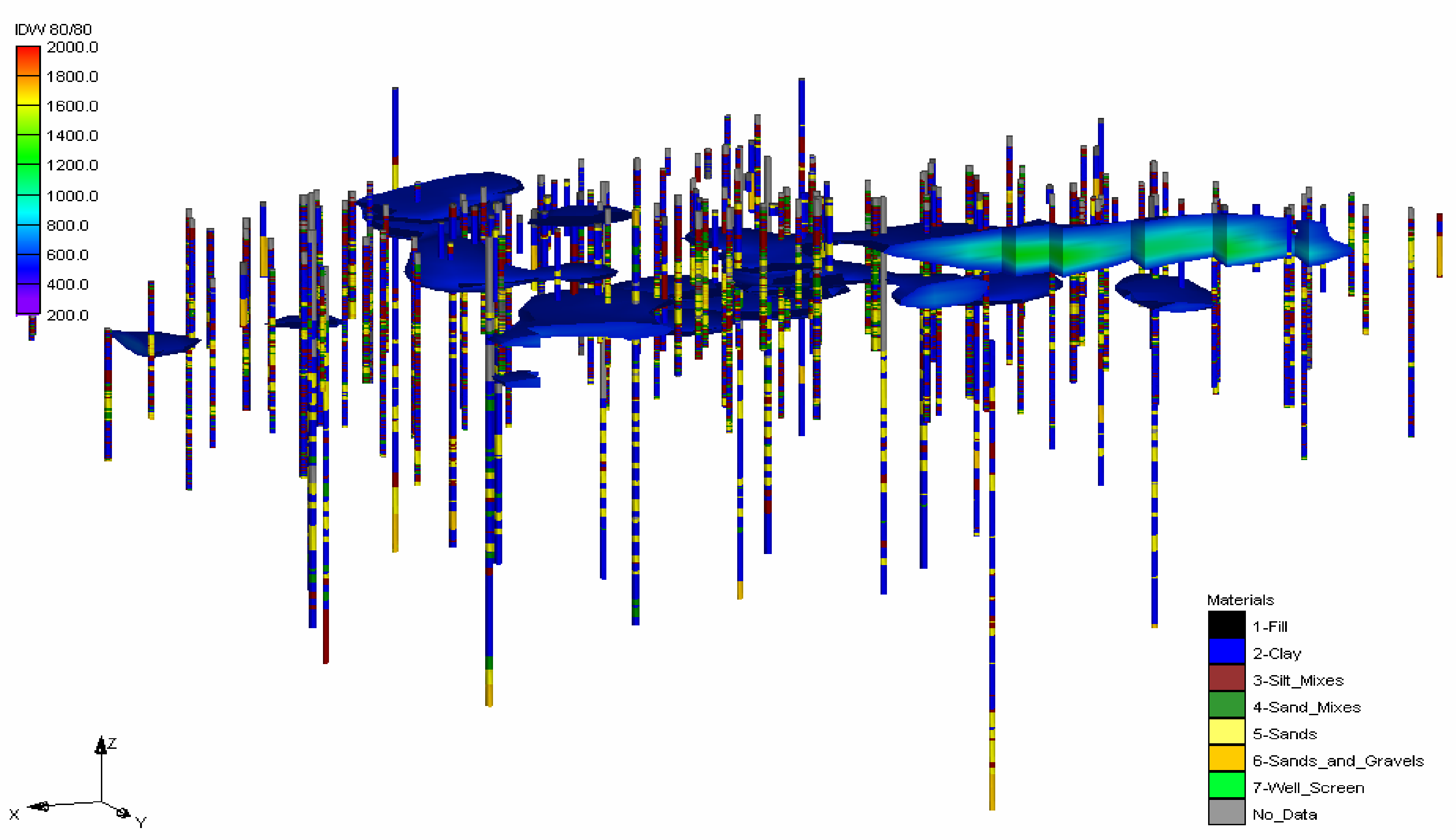
Sonic Drilling


CPT based SOIL CLASSIFICATION
Cone Resistance (Q_c)
Sleeve Friction (f_s)
q_c (tons/ft^2)
f_s (tons/ft^2)
Peats
Clays
Silt Mixtures
Sand Mixtures
Sands
Sands & Gravels
Fluorescence Intensity
Norm. Counts - Auto BKGND
Wavelength at Peak (nm)
Depth (feet)
CPT: SE-37
Project: McCormick and Baxter
STATE COORDINATES:
EASTING (ft.)
0
NORTHING (ft.)
0
ELEVATION (ft.)
0

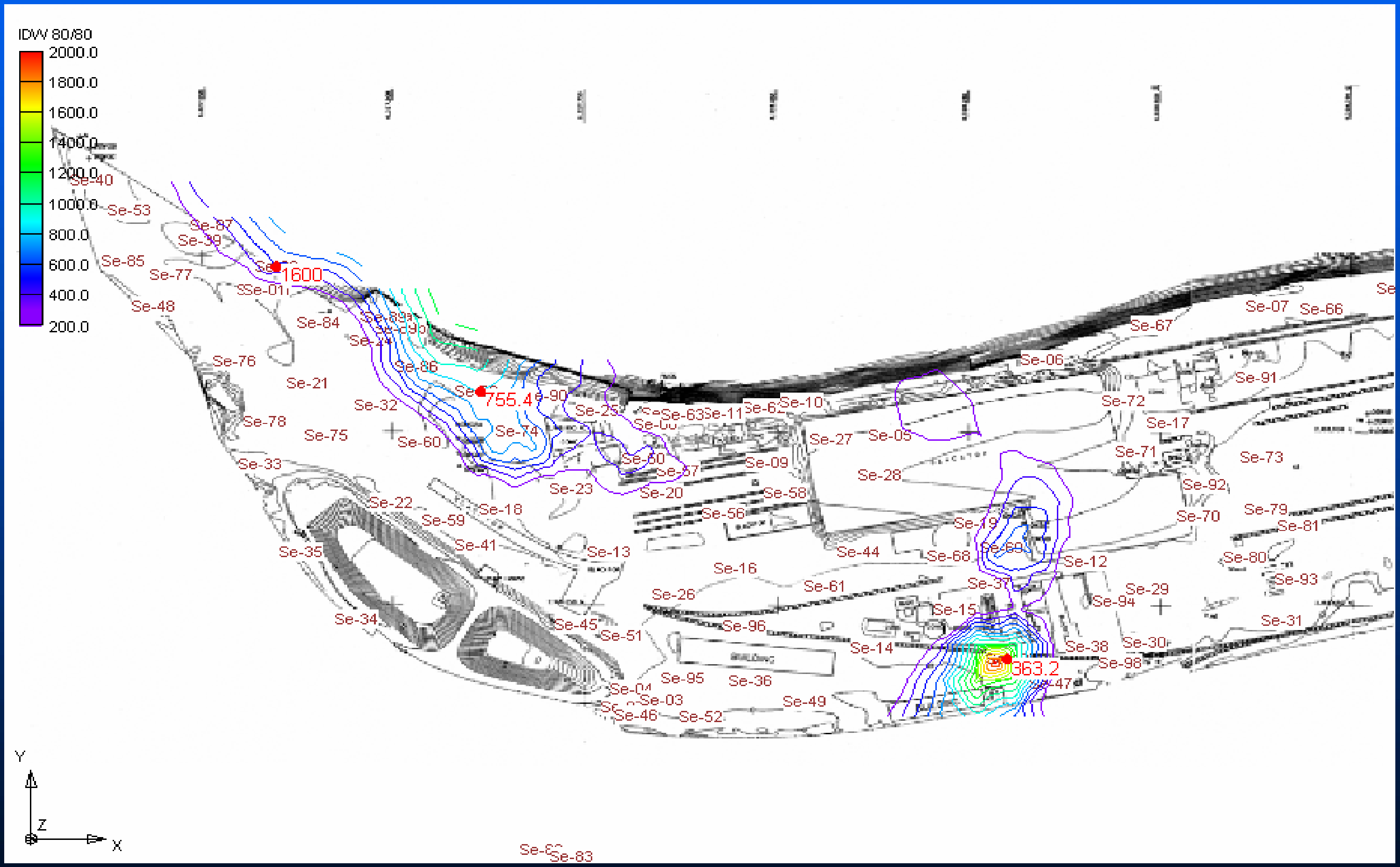


Spectral Plot - 99SE37 (56.37')
Field TRPH
Results
Mod EPA 418.1
6,836 mg/kg
1800
1600
1400
1200
1000
800
600
400
200
0
Intensity (counts)
300
350
400
450
500
550
600
650
700
Wavelength (nm)

Data Management and Communications

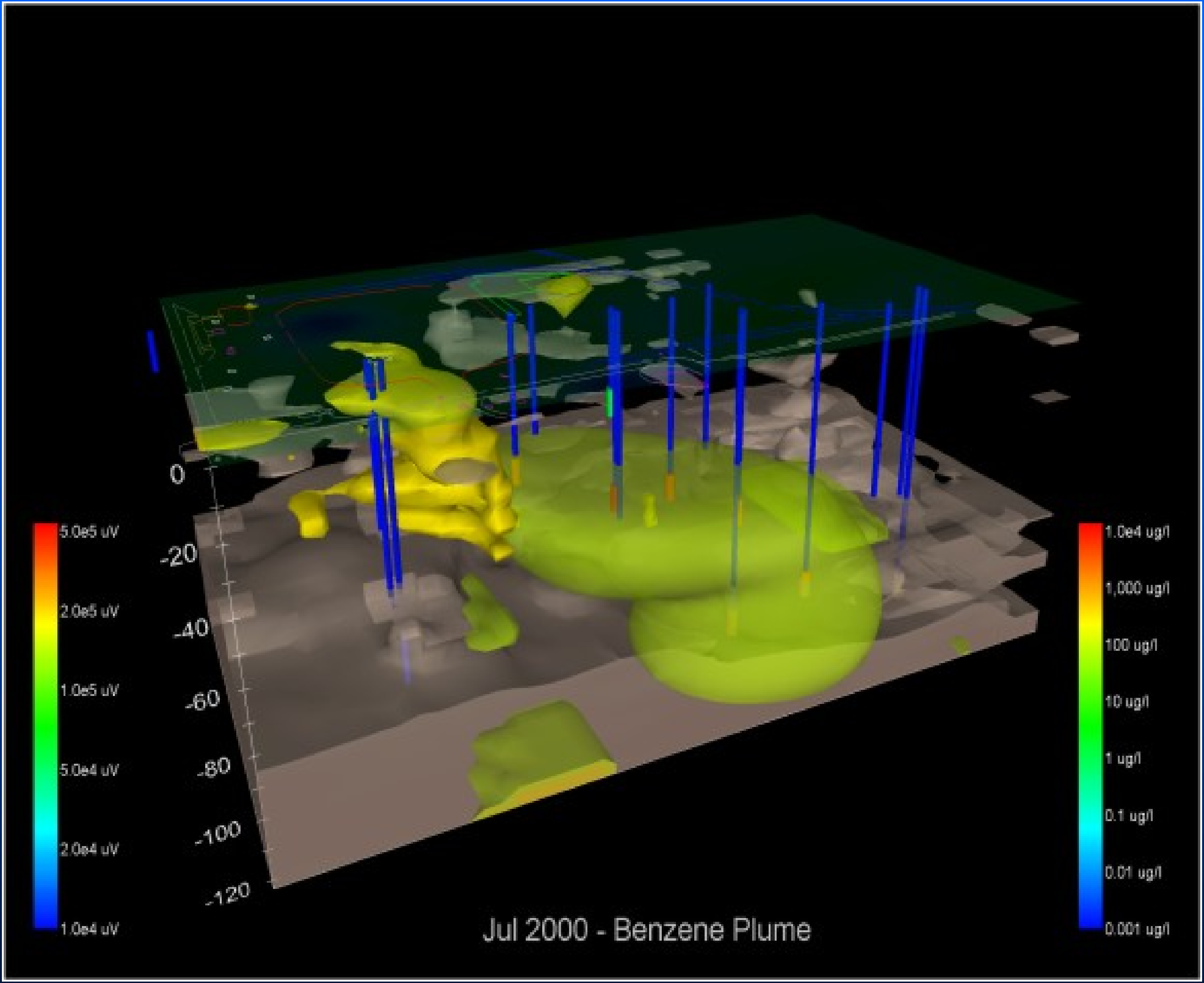


Data Management and Communications

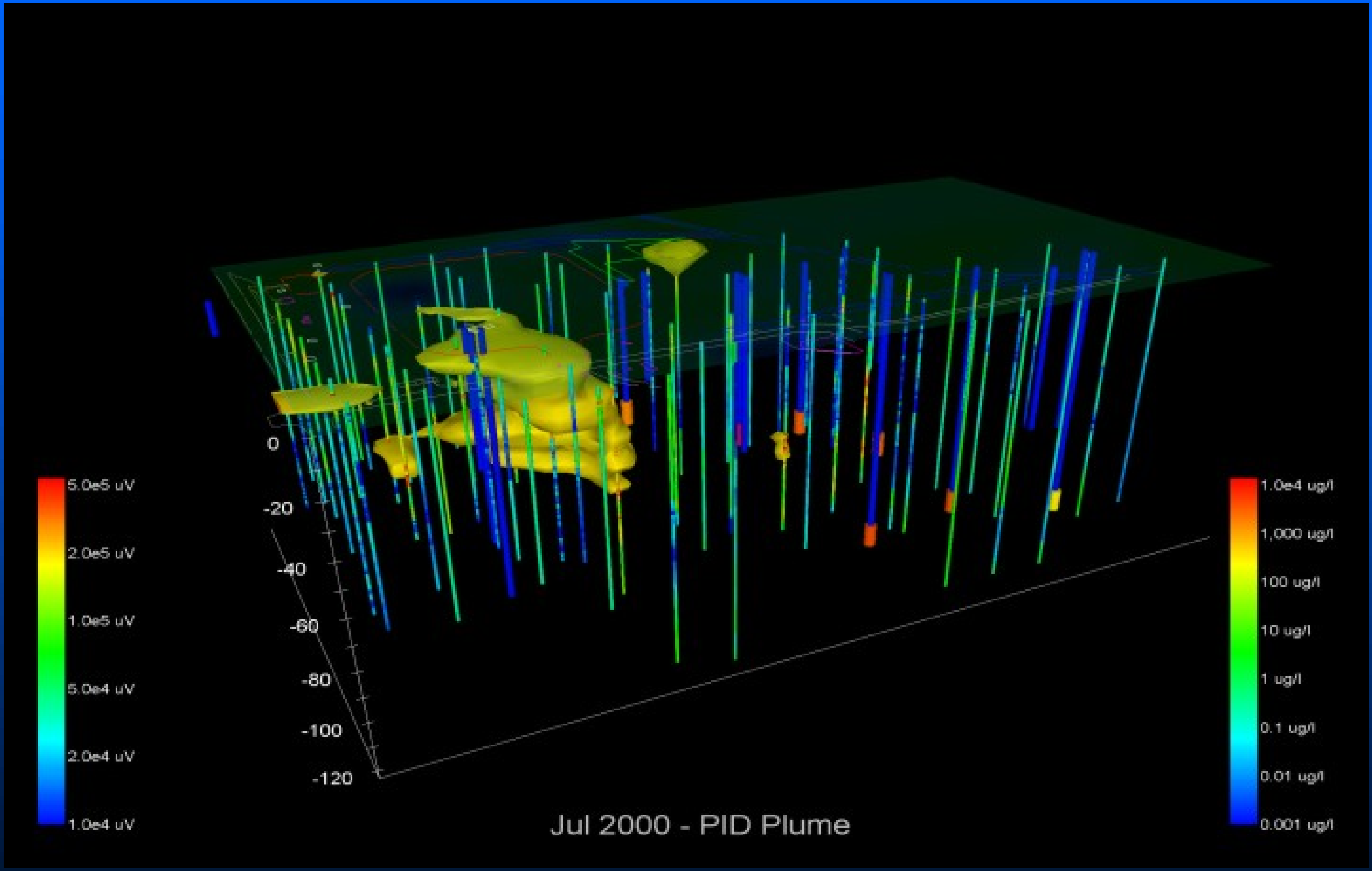


3D Optimization via Web-cast – well data

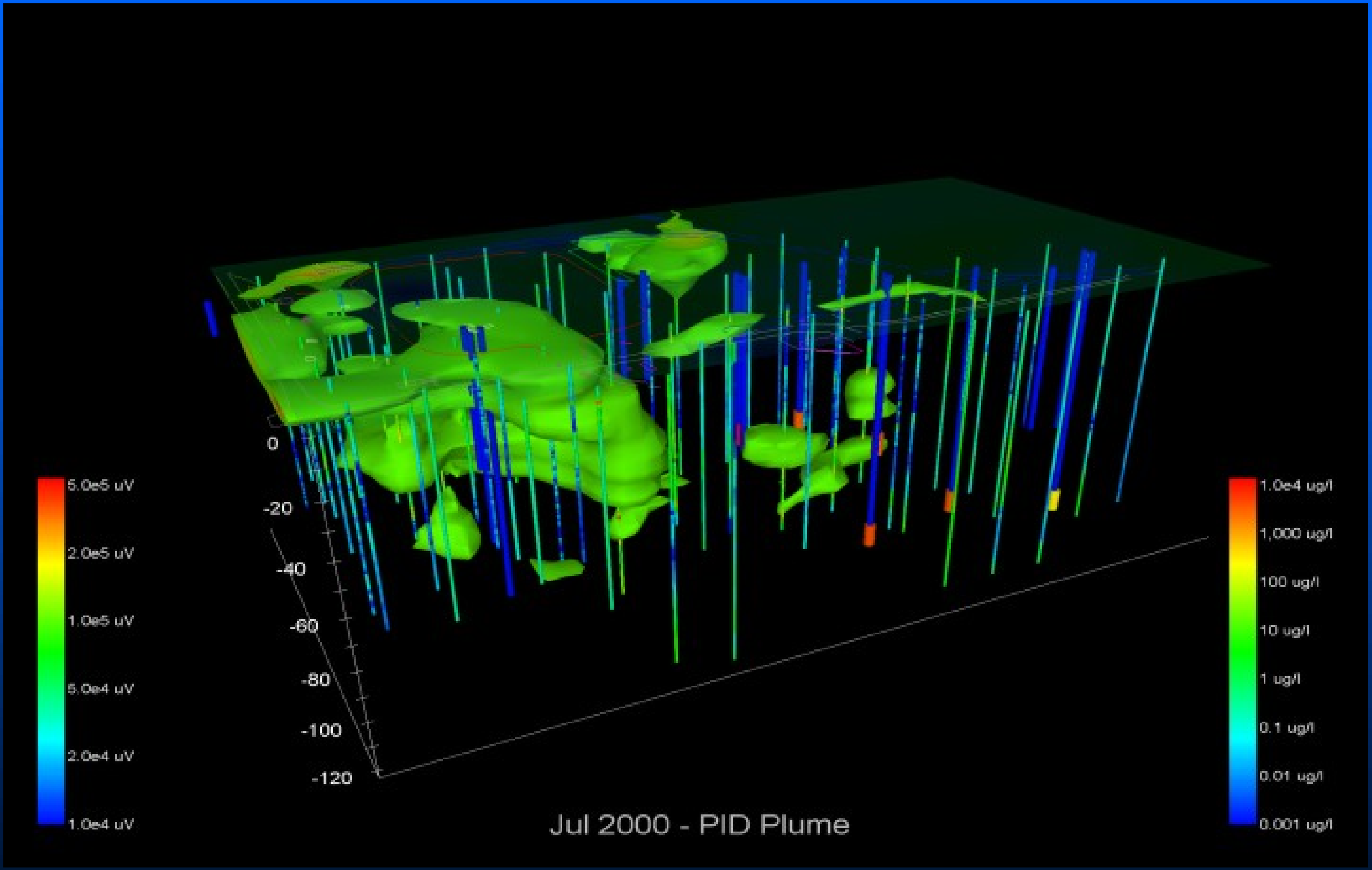
- Do we know the source?
- How many other possible sources do we have?
- What is the extent vertically AND horizontally?
- Where should we place our wells?



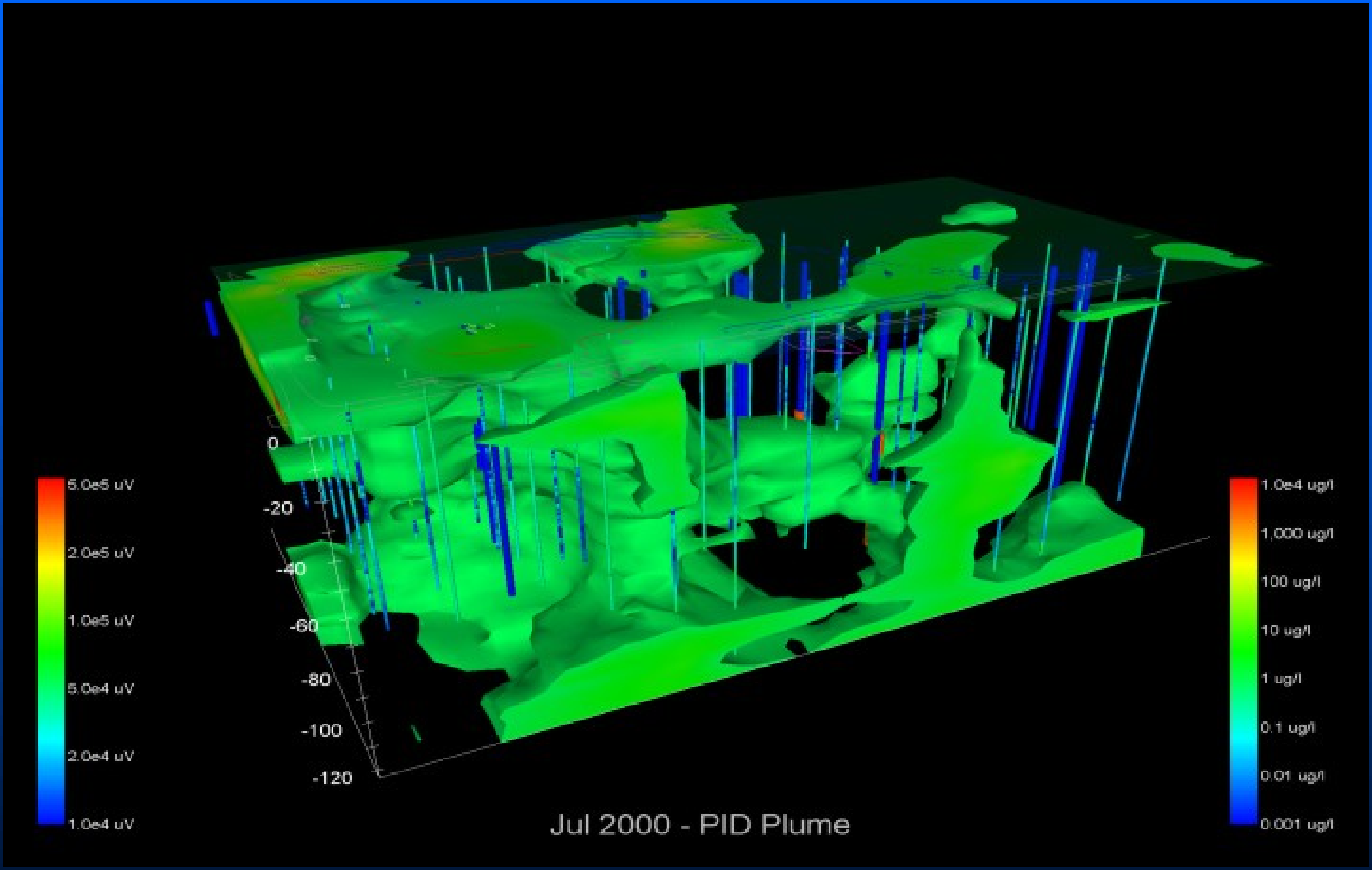
High Definition Mapping – MIP data



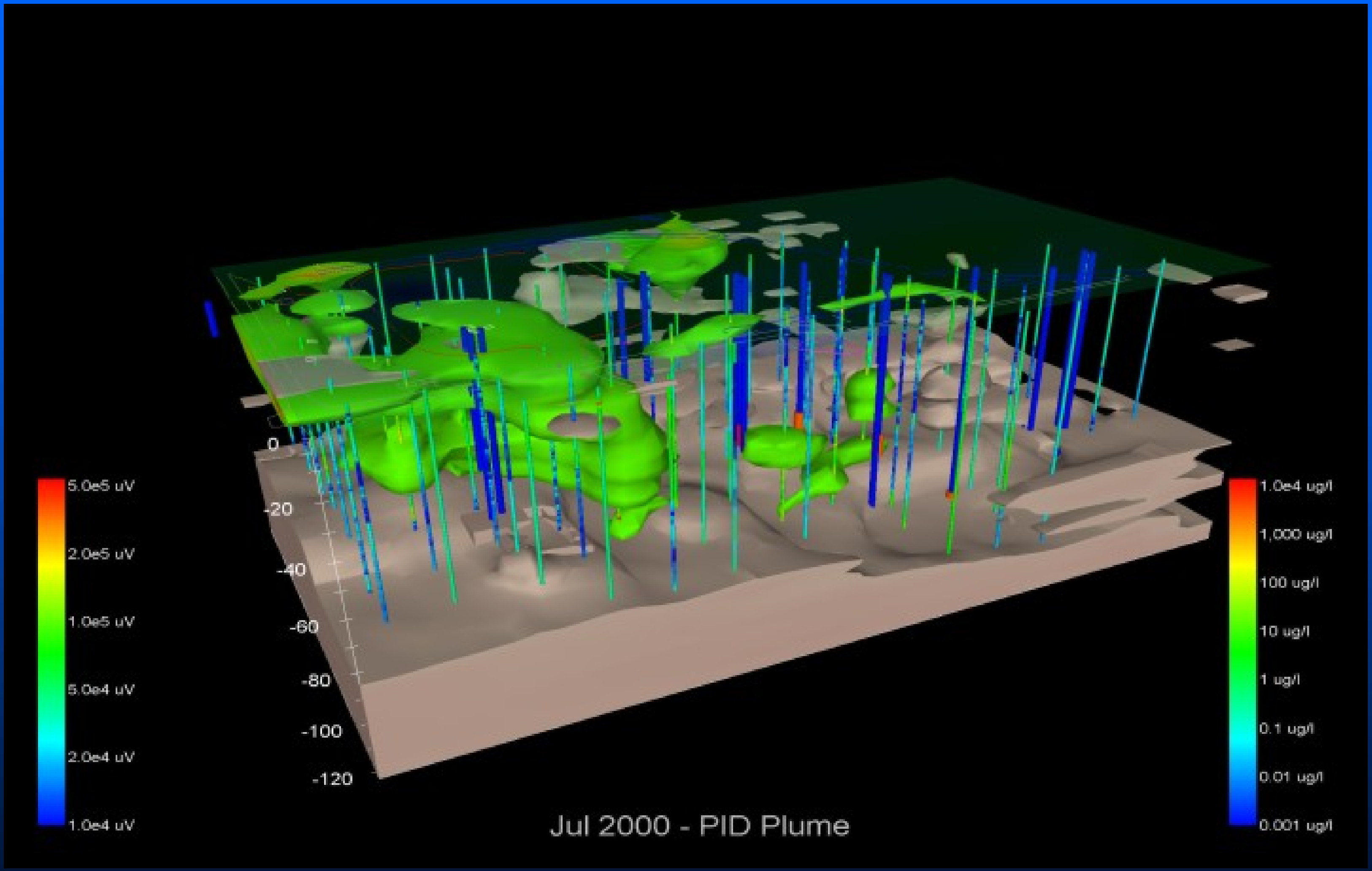
Mid-range extent



Full extent of MIP response



Soil conductivity results



Data Review and Usability Evaluation

TRS Preliminary Data Review			
Date:	11/20/2003		
Data Batch:	FPA 111603		
Sample Handling/Preservation	HCL		Acceptable
Holding time:	9-11 days		Acceptable
COC			Acceptable
Sensitivity	2 ug/L		Acceptable for untreated GW
Calibration	LCS		Acceptable ("LCS" is daily Continuing Cal Check)
Lab Blank	ND		Acceptable
Surrogates	>80%		Acceptable
Matrix Spike	Not Performed		Not qualified - Analyst indicated there were essentially no spurious peaks or interferences. Future data sets will have MS/MSD and duplicates.
Lab Precision	<10% RPD		Acceptable
Field Blanks	ND		Acceptable Trip Blank
Data Completeness			Acceptable
Sensibility			Acceptable
General Commens	These data are usable for the intended purpose.		
	E-flagged result is accepted with qualification. Future samples exceeding the calibration range will be diluted.		
Mike Webb		11/20/2003	
Reviewer		Date	

Regulatory Involvement

- Triad projects differ significantly from conventional project in how regulators are involved in planning and execution
- Triad projects often employ new and innovative technologies in addition to the new Triad approach
- Most successful Triad projects have regulator involvement early and often
- Regulators should be true stakeholders in project success
- The members of the project decision team, including the regulators must trust each other

Regulatory Involvement

- As true stakeholders, regulators take risks and are invested in project success or failure
- The relationship is a partnership and not adversarial: turn the **rectangular table to a round table**

CSM Summary

- Develop iteratively, be open-minded
- Complexity commensurate with required decisions and available data
- Involve all team members – balance with model evolution
- Utilize CSM to develop strategies for uncertainty management

Decision Rule Summary

- Facilitate evolution of the CSM
- Many scenarios should be considered
- Assign authority for decisions
- Complex projects consider pre-mobilization decision logic test
- Plan to encounter and resolve site uncertainty during field work

Benefits

- Communication
- Force integrated data interpretation
- Evaluate potential scenarios
- Make better decisions
- Most importantly – to achieve successful and cost effective environmental restoration

References

- American Society for Testing and Materials (ASTM) International, 1995. *Standard Guide for Developing Conceptual Site Models for Contaminated Sites.* West Conshohocken, PA
- American Society for Testing and Materials (ASTM) International, 1998. *Standard Guide for Site Characterization for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone and Ground Water*. West Conshohocken, PA
- American Society for Testing and Materials (ASTM) International, 2002. Standard Guide for Conceptualization and Characterization of Ground-Water Systems. West Conshohocken, PA.

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- Uddameri, Venki, 2003. “Models: Know Your Type.” *Soil Sediment and Water*. September.
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