Using High Resolution Site Characterization to Improve Remedy Design and Implementation

Federal Remediation Technologies Roundtable

Stephen Dyment
U.S. EPA Office of Superfund Remediation and Technology Innovation
dyment.stephen@epa.gov

What is "Optimization"

(Working Definition / March 2011)

Systematic site review by a team of independent technical experts, at any phase of a cleanup process, to identify opportunities to improve remedy protectiveness, effectiveness and cost efficiency, and to facilitate progress toward site completion.

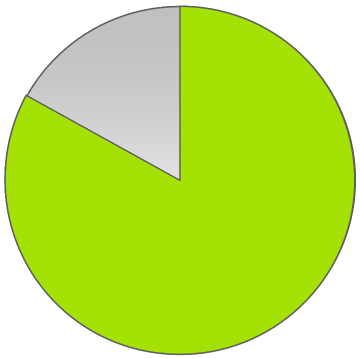
Background on EPA Optimization Efforts

- 2000 – Piloted optimization at 20 Fund-lead P&T sites
- 2002 – Began applying monitoring optimization for ground water sites, MAROS evaluations
- 2004 -- Superfund adopted the "Action Plan for Remedy Optimization" for Fund-lead P&T sites
- 2007 – Began applying optimization during remedy design and remedy redesign stages, branching out beyond P&T and Fund-lead
  - RP lead sites, State lead, Federal facilities
  - Former Industrial facilities, landfills, sediment sites, mining sites, etc.
  - NAPL recovery, thermal remediation
  - Sediment capping
  - Biosparging
  - Soil capping
  - NAPL recovery, chemical oxidation
  - Air sparging / soil vapor extraction/ groundwater recirculation wells
  - Barrier walls
  - Constructed wetlands
  - Surface water collection and treatment, water diversion
- Currently – Triad Approach, Green Remediation, and Five Year Review assistance all incorporated into optimization

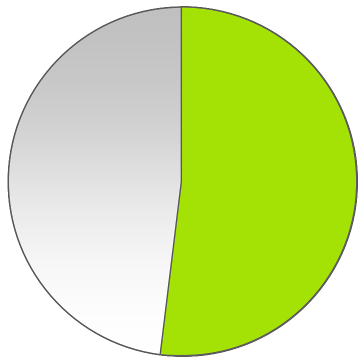
Optimization Results To Date

Based on an analysis of 52 of 100 optimized sites

- Cost savings



83% cost savings opportunities



52% cost savings opportunities > $1 million

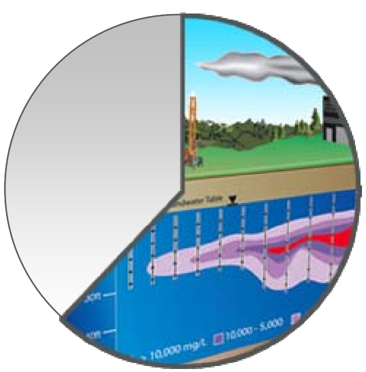
Similarly positive findings for the other 48 optimized sites…

and >$350M in potential cost savings/avoidance for all 100 sites.

- Improved protectiveness

19% eliminate or confirm no ecological exposures

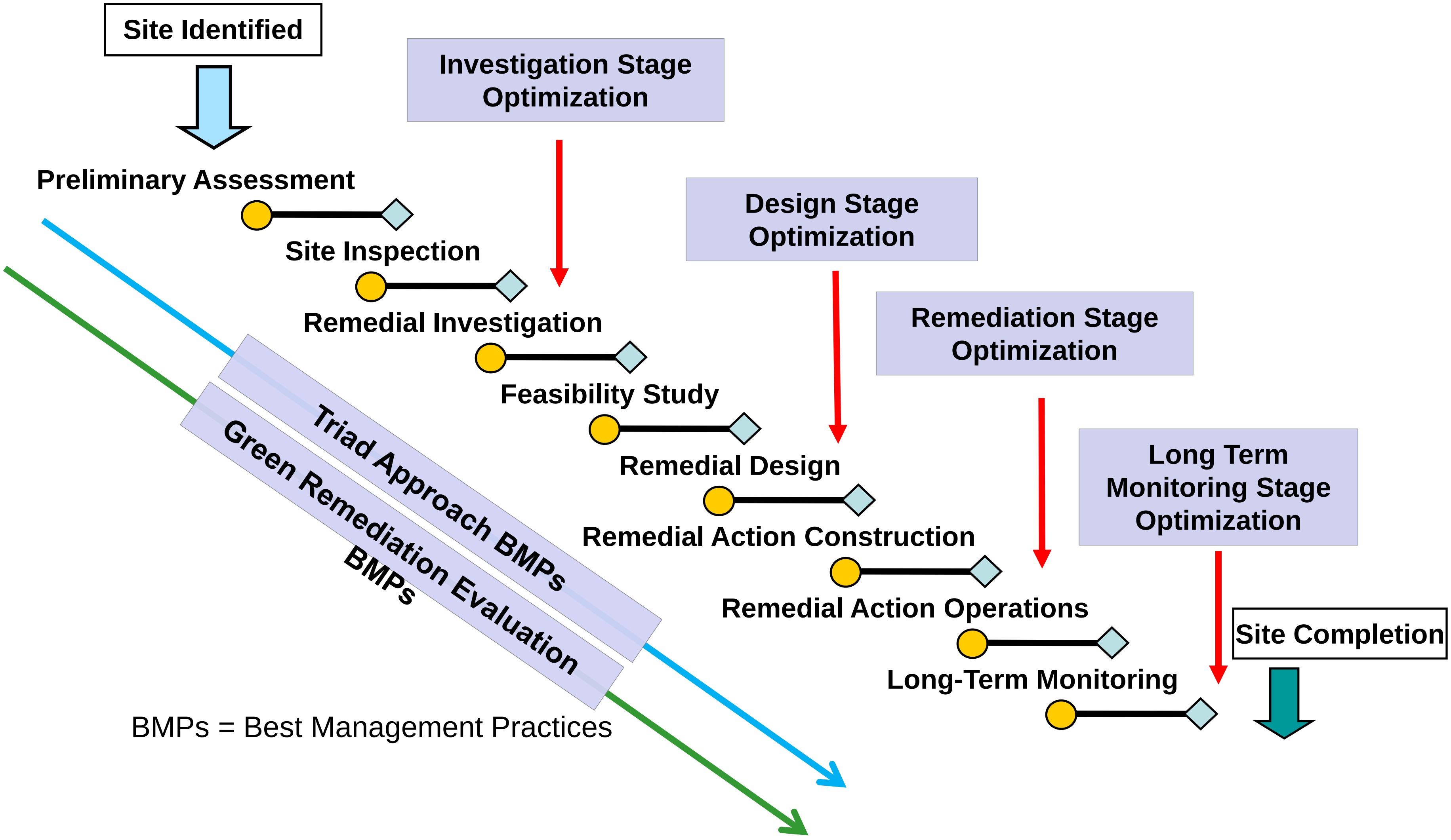
33% eliminate or confirm no human exposures



62% improve or confirm control of plume migration

~45% of sites include recommendations for CSM or characterization improvement!

Optimization Applied at Every Stage of the Pipeline



BMPs = Best Management Practices

Common Themes Emerge

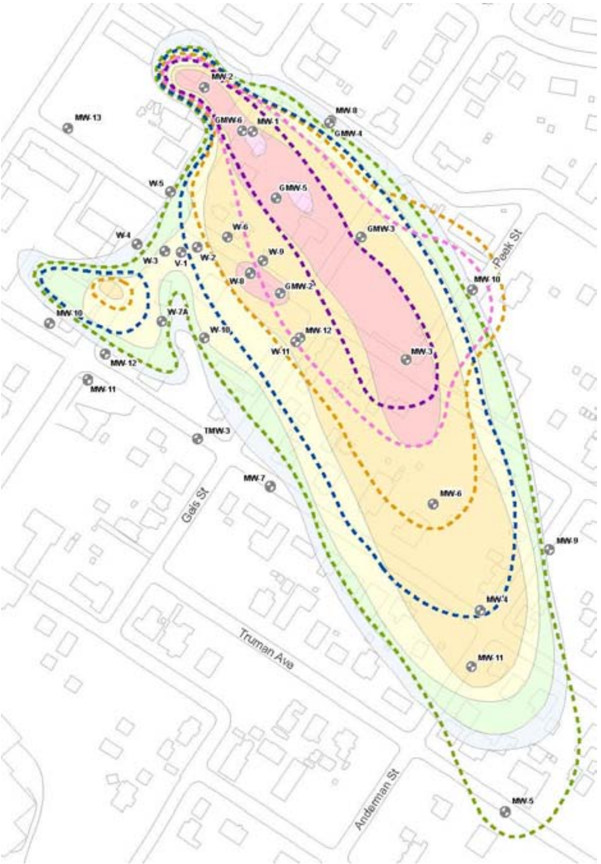
- Need for improved CSMs including use of existing information
  - CSM chemistry and hydrogeology critical factors in assessing cost-effective alternatives
- Insufficient characterization
  - Source delineation, concentrated mass transport (mass flux), aquifer structure and COC properties
- Data management
- Cost control- overwhelming the matrix
  - Large footprint vs. small footprint sites
  - Source treatment (e.g., SVE, ISCO) incomplete, combined remedies and active treatment zones

CSM Evaluation in Post-Construction Optimization

- CSM is THE tool necessary for assessing cost-effective alternatives to current remedies
- Examples from optimization warrior (USACE)
  - Region 9 RP lead, disposal pits received liquid waste – SVE removing >4000 lb/VOCs per quarter for >4 years
    - Optimization study indicates DNAPL likely, recommends aggressive source treatment
  - Region 5 State lead, historical machine shop/retail strip mall, building limits source investigation for VOCs
    - ISCO pilot shows significant reduction, team reluctant to go full-scale, afraid still won't turn off P&T
    - Optimization recommends further source characterization and aggressive treatment

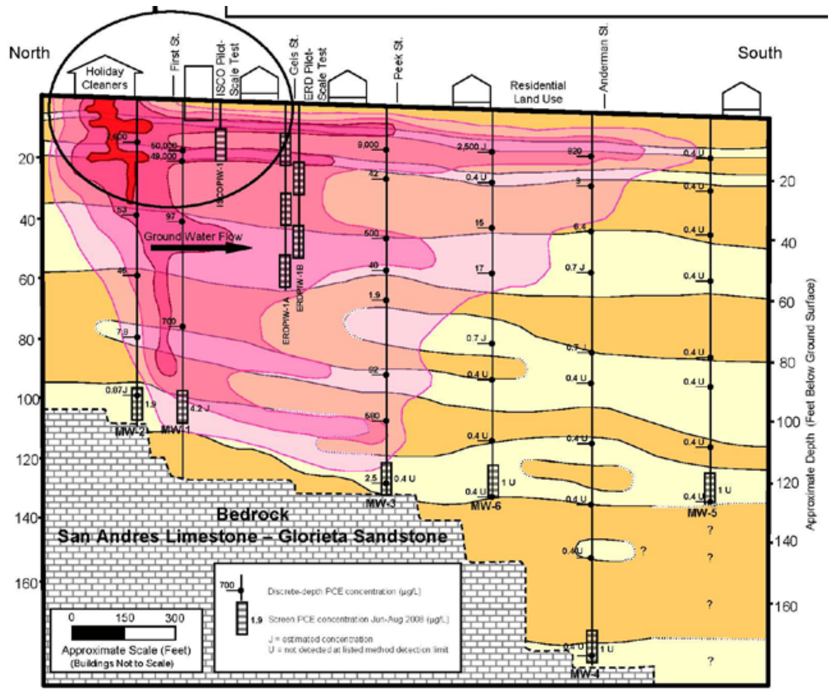
Optimization Case Study
Grants Chlorinated Solvents

- Optimization conducted during early design stage
- Large PCE plume from former dry cleaners
- ROD signed in June 2006
  - In-situ thermal remediation
  - In-situ chemical oxidation
  - In-situ bioremediation
  - Vapor mitigation
- Pre-design activities (with more investigation) underway during optimization
- Limited data available relative to other sites in design stage
- $29 million ROD estimate for remediation



Grants Chlorinated Solvents Optimization Findings

- Presence of contamination in thin lenses
- Potential for substantial mass to have already migrated from source area
- Potentially less mass in subsurface than assumed in ROD cost estimates
- Need for additional information to help refine/confirm CSM
- Cost for remediation documented in ROD is likely overestimated



The early design phase was a good opportunity to contribute to the CSM.

Grants Chlorinated Solvents Optimization Recommendations

- Based on additional characterization (that remains to be collected)
  - Reconsider thermal remediation for source area, or at least refine treatment volume and location ***(technology/approach & CSM)***
  - Reevaluate remedy approach for plume core and amounts of chemicals/nutrients for remediation ***(technology/approach)***
  - Reconsider remedial goals and time frames for comparing alternatives and determining progress… affects exit/remedial strategy ***(strategy & performance monitoring)***
  - Use extracted groundwater for chemical blending/injection ***(technology/approach)***
- Monitoring well locations/screen intervals suggested ***(performance monitoring)***

"Reconsider" and "reevaluate" suggest iterative/dynamic process.

Grants Chlorinated Solvents

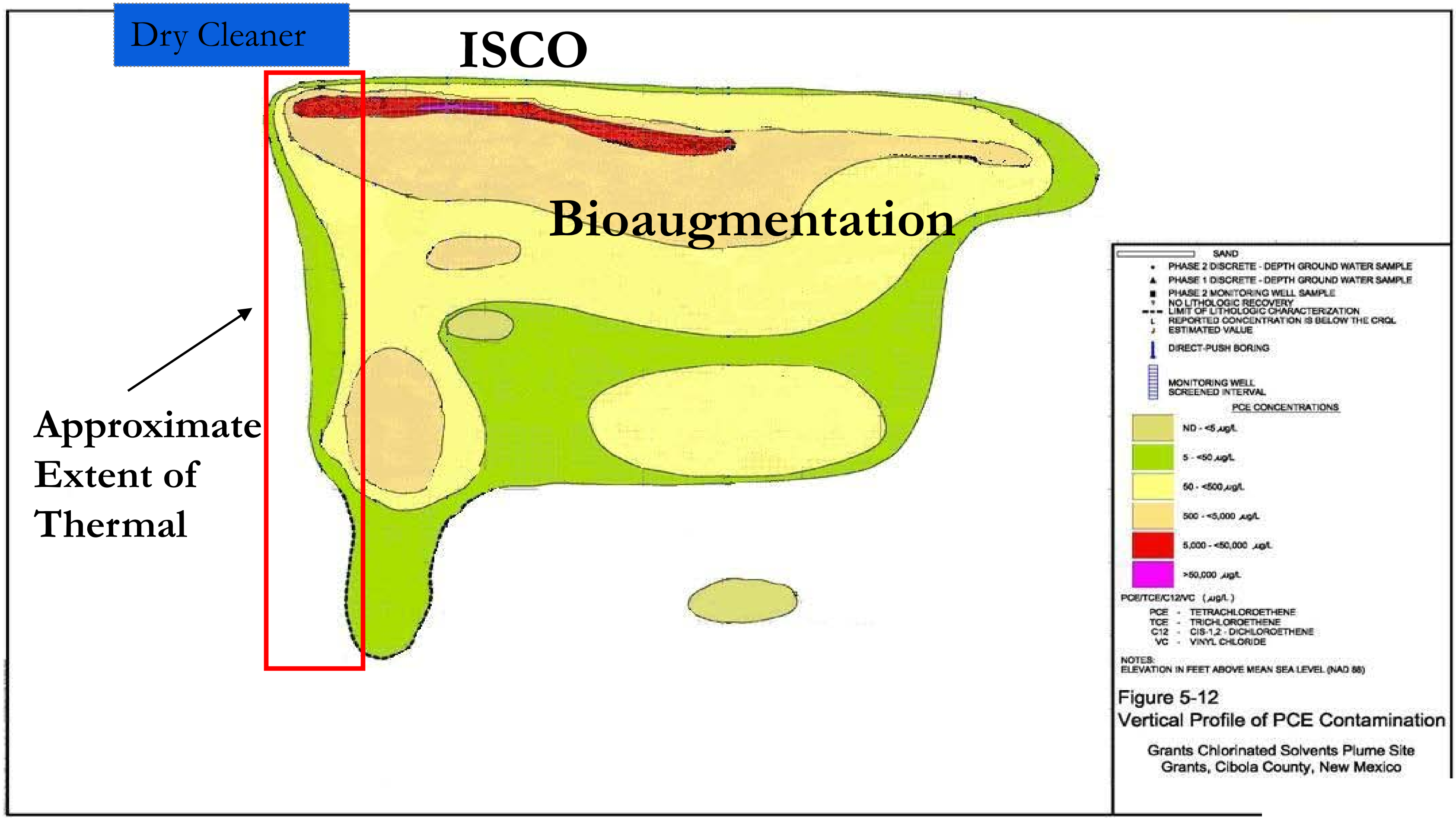
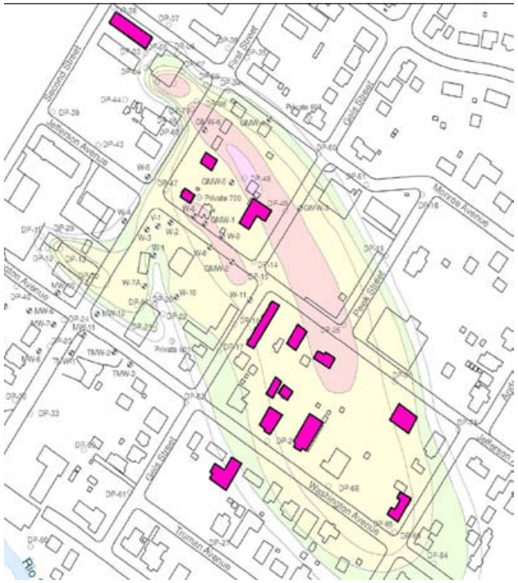


Figure 5-12
Vertical Profile of PCE Contamination

Grants Chlorinated Solvents Plume Site
Grants, Cibola County, New Mexico

Grants Solvents- Changes to Remedy Design from Optimization Review

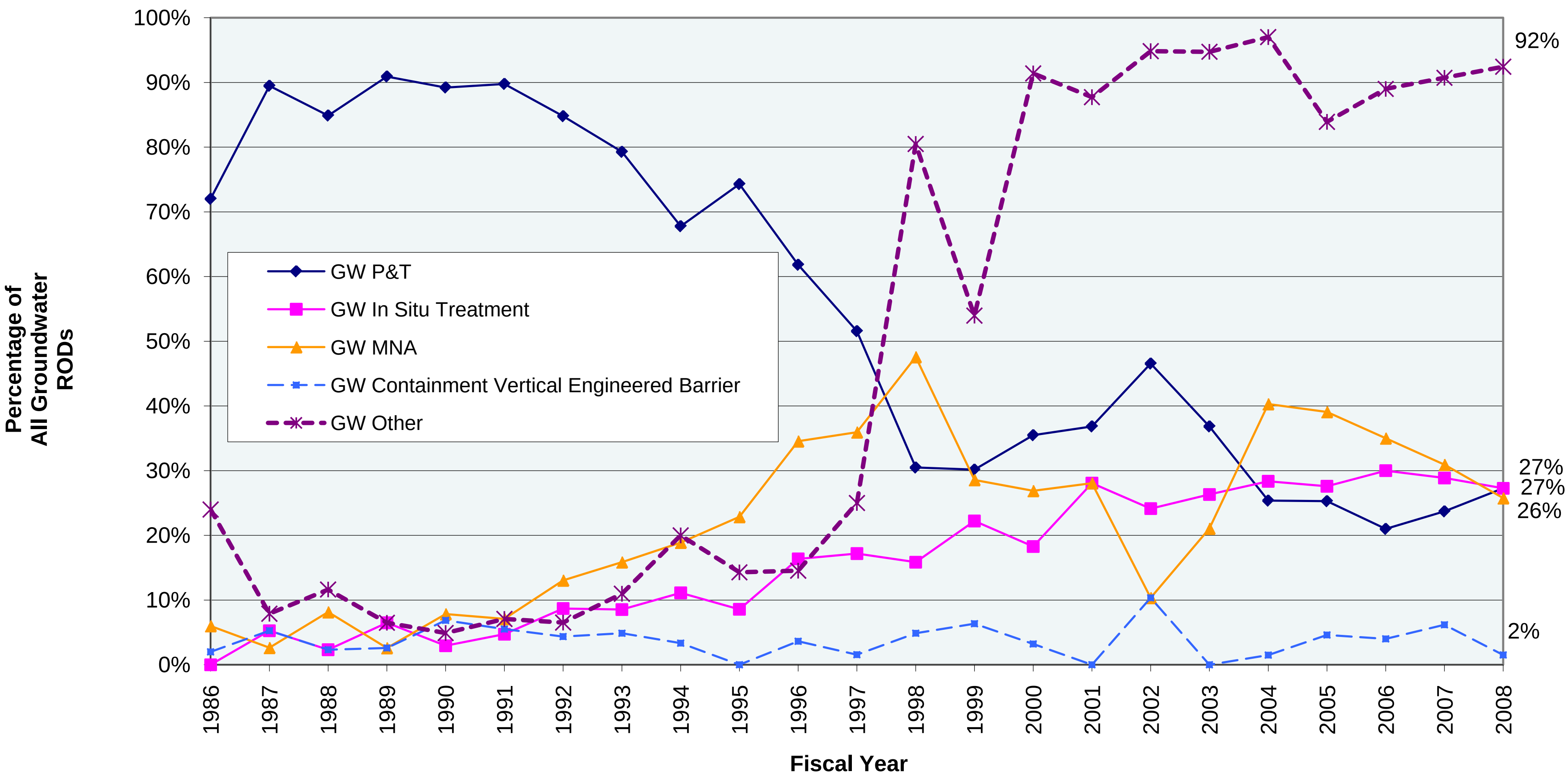
- Additional source area characterization completed
- Additional monitoring wells installed and screened appropriately
- Area for thermal remediation reduced in size and relocated
- MNA being considered for a portion of the plume (reducing the area for active remediation)
- Chemical/nutrient amounts being reevaluated
- Revised cost estimate is $11 million lower



CSM Life Cycle Mimics Project Stages

General Environmental Cleanup Steps	CSM Life Cycle	Best Management Practices: SPP	Best Management Practices: DWS/RTMT	CERCLA - Superfund	RCRA	Brownfields	UST	VCUP Varies by State	IRP/ERP	MMRP
Site Assessment	Preliminary CSM → Baseline CSM			Preliminary Assessment (PA) Site Inspection (SI) National Priorities List (NPL) No Further Remedial Action Planned (NFRAP)	Facility Assessment (RFA)	Phase I Environmental Site Assessment (ESA)	Initial Site Characterization Initial Response	PA SI	PA SI	PA SI MR Site Prioritization Protocol (MRSPP)
Site Investigation and Alternatives Evaluation	Characterization CSM Stage			Remedial Investigation/ Feasibility Study (RI/FS) Removal Actions - Emergency/ Time Critical/Non-Time-Critical	Facility Investigation (RFI) Corrective Measures Study (CMS)	Phase II ESA	SI Corrective Action Plan (CAP)	RI/FS	RI/FS NFRAP	RI/FS
Remedy Selection	Design CSM Stage			Proposed Plan Record of Decision (ROD)	Statement of Basis (SB) Final Decision and Response to Comments	Remedial Action Plan (RAP)	Cleanup Selection	ROD	Proposed Plan ROD	Remedy Selection
Remedy Implementation	Remediation/ Mitigation CSM Stage			Remedial Design (RD) Remedial Action (RA) – Interim and Final	Corrective Measure Implementation (CMI)	Cleanup and Development	Corrective Action - Low-impact site cleanup - Risk-based remediation - Generic remedies - Soil matrix cleanup	RD RA	RD RA – Interim and Final Remedy in Place (RIP)	RD Time Critical Removal Action (TCRA) RA RIP
Post-Construction Activities	Post-Remedy CSM Stage			Operational & Functional Period Operation & Maintenance (O&M) Long term monitoring (LTM) Optimization Long Term Response Action (Fund-lead groundwater/surface water restoration)	O&M On-site inspections and oversight	Property Management Long-term O&M Redevelopment Activities (Private- and Public-led)	LTM	O&M LTM	Shakedown period Operating Properly and Successfully O&M LTM	Shakedown period Long Term Management
Site Completion				Construction Complete (CC) Preliminary or Final Close Out Report (PCOR/FCOR) Site Completion - FCOR Site Deletion O&M as appropriate	Certification of Completion Corrective Action Complete with Controls or without Controls	CC Property Management	No Further Action (NFA)	CC	Response Complete (RC) NFA	RC NFA

Trends in RODs and Decision Documents Selecting Groundwater Remedies (FY1986 - 2008)
Total Groundwater RODs and Decision Documents = 1,727



- Groundwater Other includes institutional controls and other remedies not classified as treatment, MNA, or containment.
- Note: Other remedies selected prior to 1998 may be under represented in figure.
- RODs and decision documents may be counted in more than one category.
- RODs from FY1986 – 2004 include RODs and ROD amendments.
- Decision documents from FY2005 – 2008 include RODs, ROD amendments, and select ESDs

Collaborative Data Sets Address Analytical

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

↓

Targeted high-density sampling

↓

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

↓

Low DL + analyte specificity

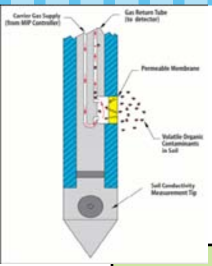
↓

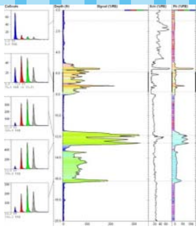
Manages CSM, Spatial variability& sampling uncertainty

Manages analytical uncertainty

Collaborative Data Sets

Leads Us Back to the Need for High Resolution Tools are Important- But Also How We Deploy



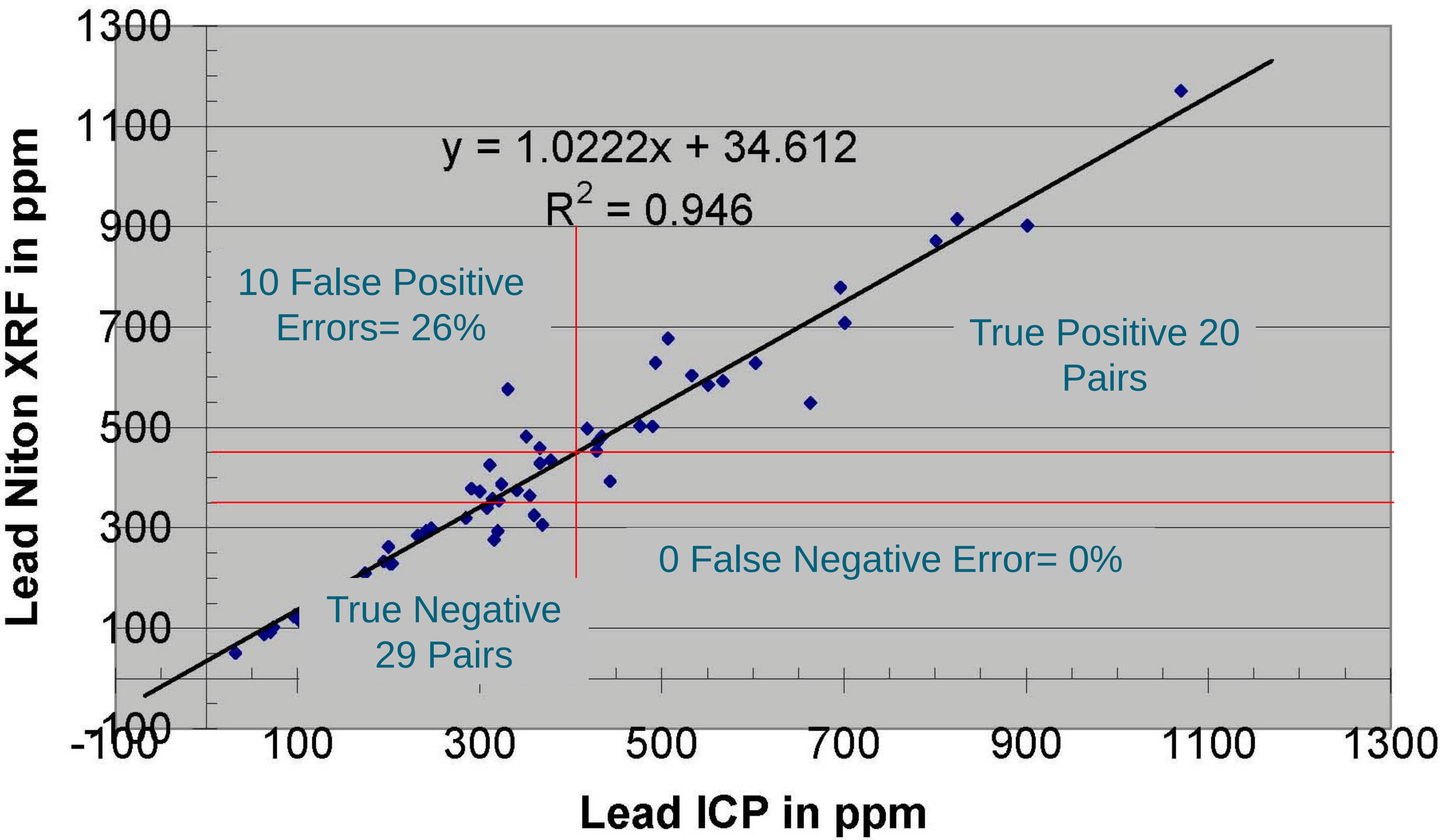


Examples of tools that provide real-time data

Technology	Matrices	Data Provided
LIF/UV methods (Lasers, UV lamp)	Water, soil	TPH, PAH, Coal Tar
Geophysical tools – surface EM, Resistivity, GPR , acoustic	Soil, fill, bedrock	Sources, pathways, macro-stratigraphy, and buried objects
XRF (screening and definitive)	Soils, material surfaces	Metals
MIP (ECD, PID, FID, ECD, XSD)	Soil, water	VOCs, hydrocarbons, and DNAPL
Neutron Gamma Monitors	Soil, water, material surfaces	Radiation
Hydraulic conductivity profilers	Soil, water	Hydraulic conductivity, lithology
Geophysics – downhole (natural gamma ray, self potential, resistivity, induction, porosity/density, and caliper)	Soil, fill, bedrock	Lithology, groundwater flow, structure, permeability, porosity, and water quality
CPT, high-resolution piezocone	Soil, water	Lithology, groundwater flow

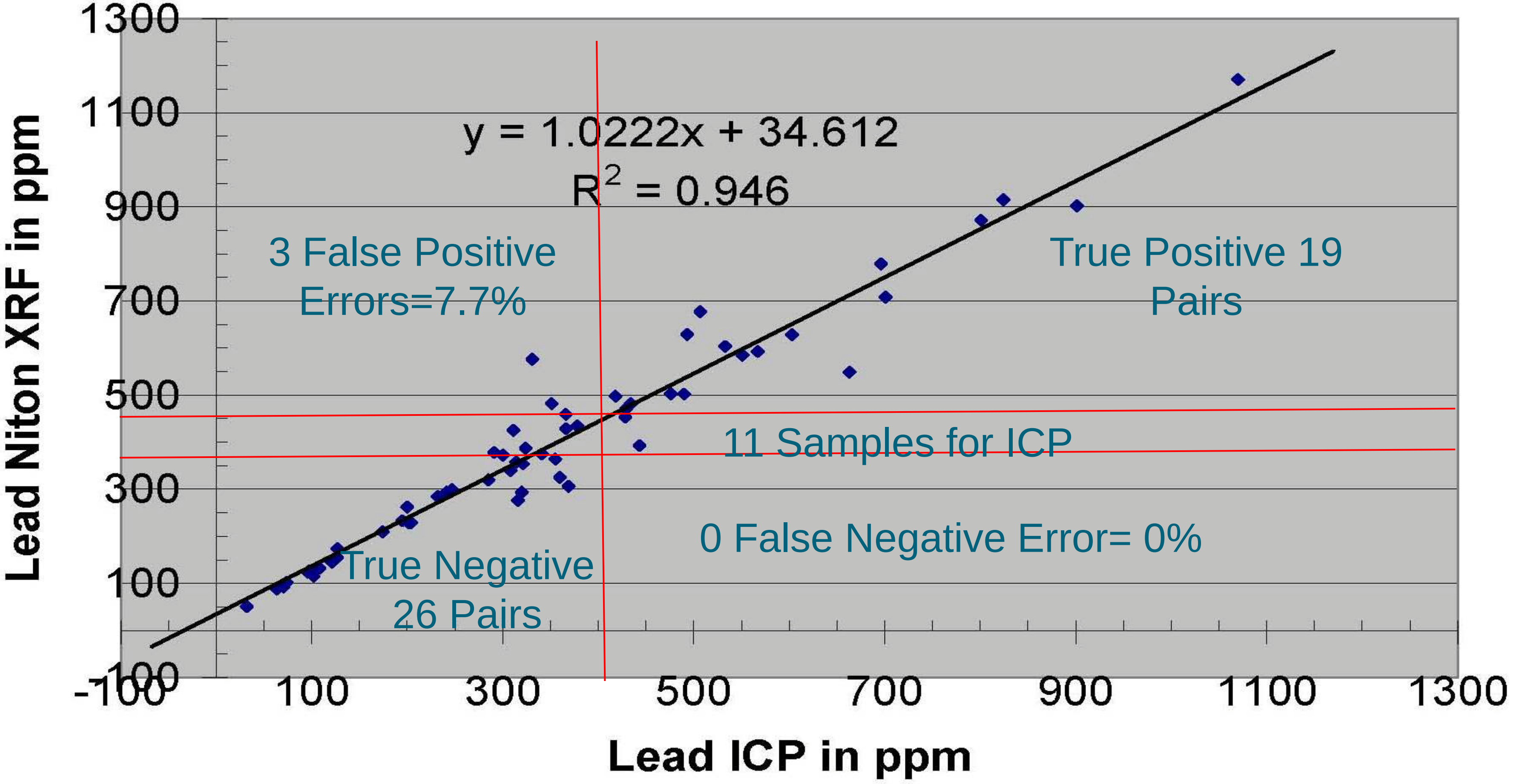
Lead Niton vs. ICP

59 Total pairs

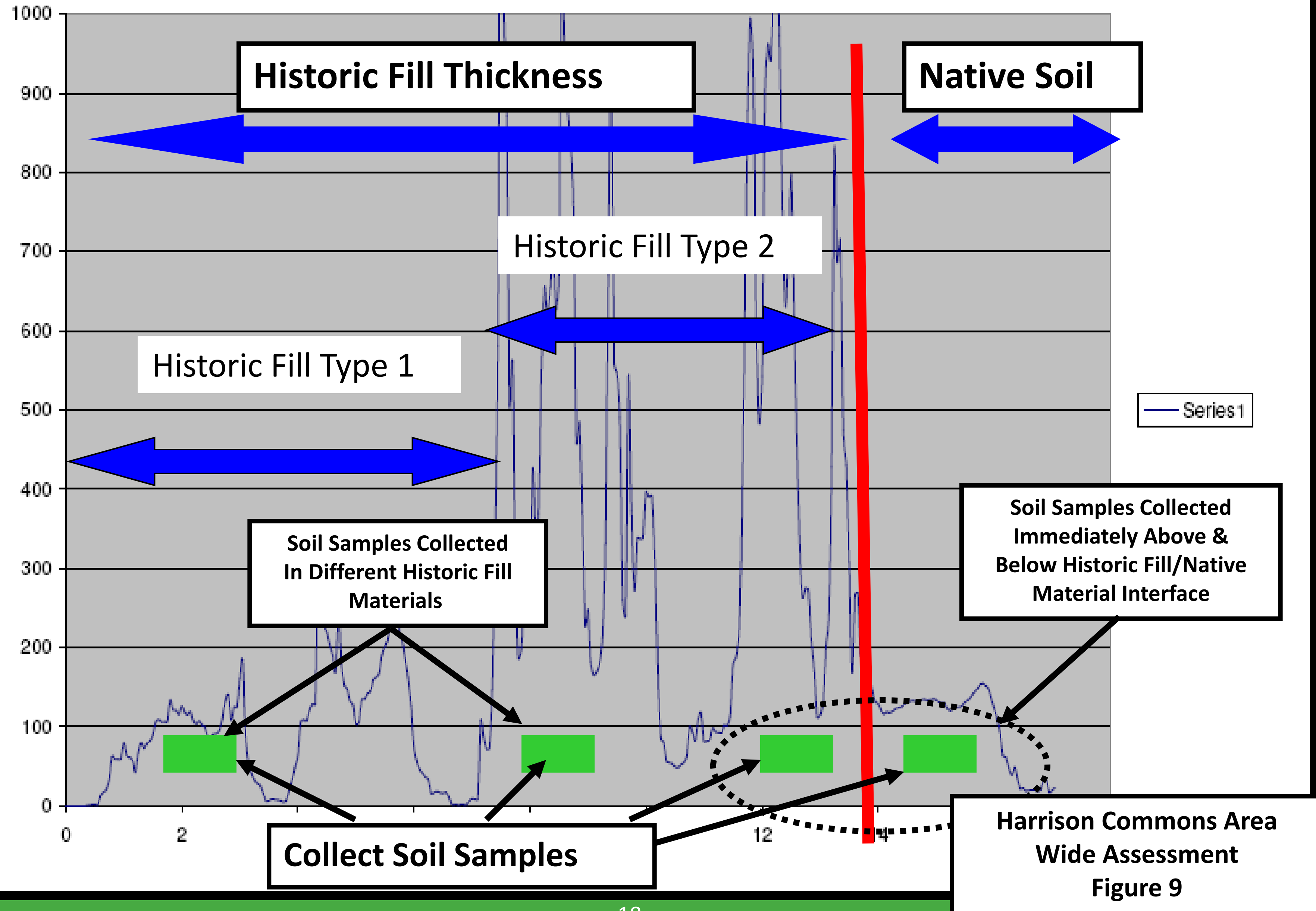


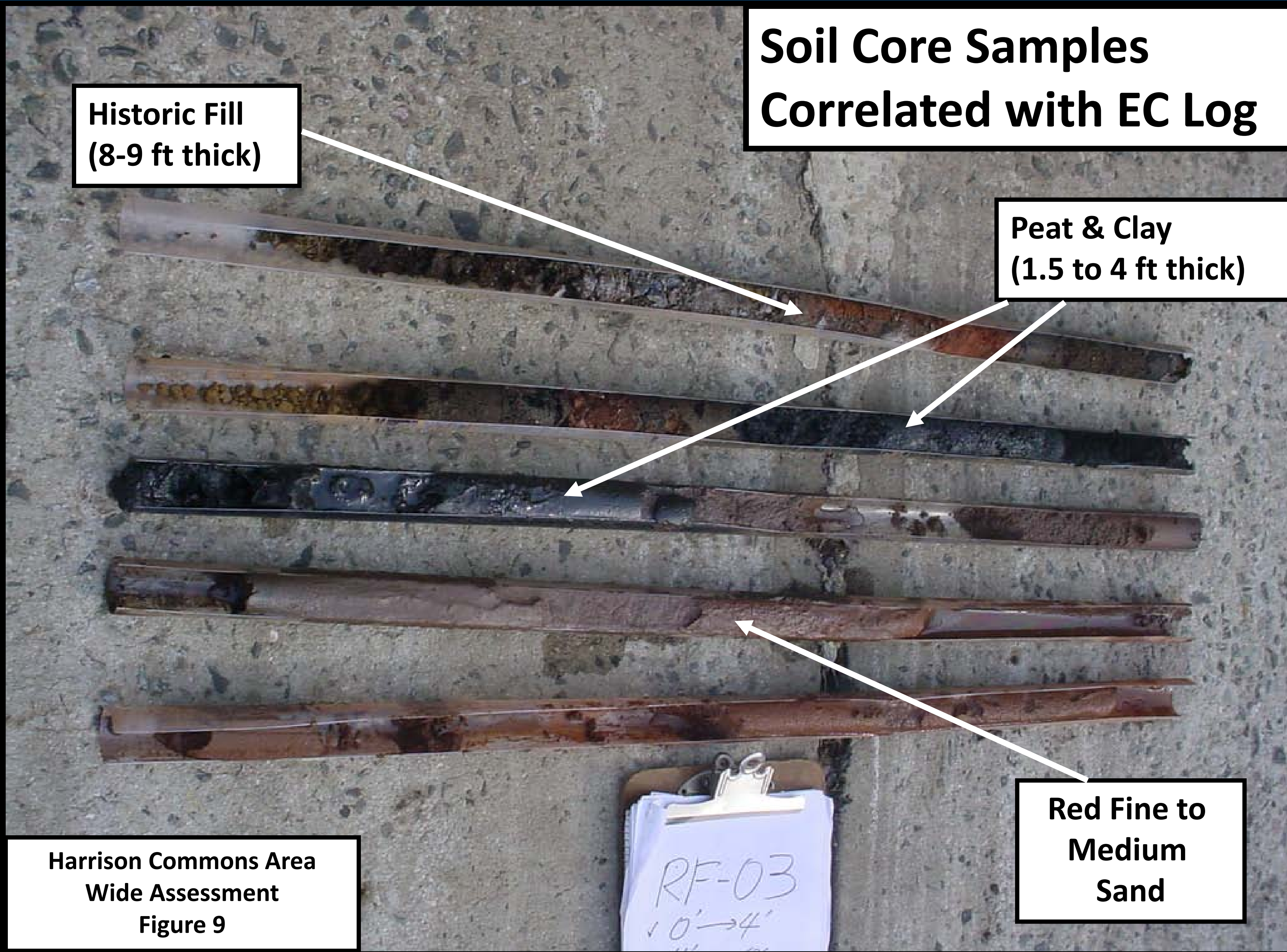
3-Way Decision Structure
With Region of Uncertainty

59 Total pairs



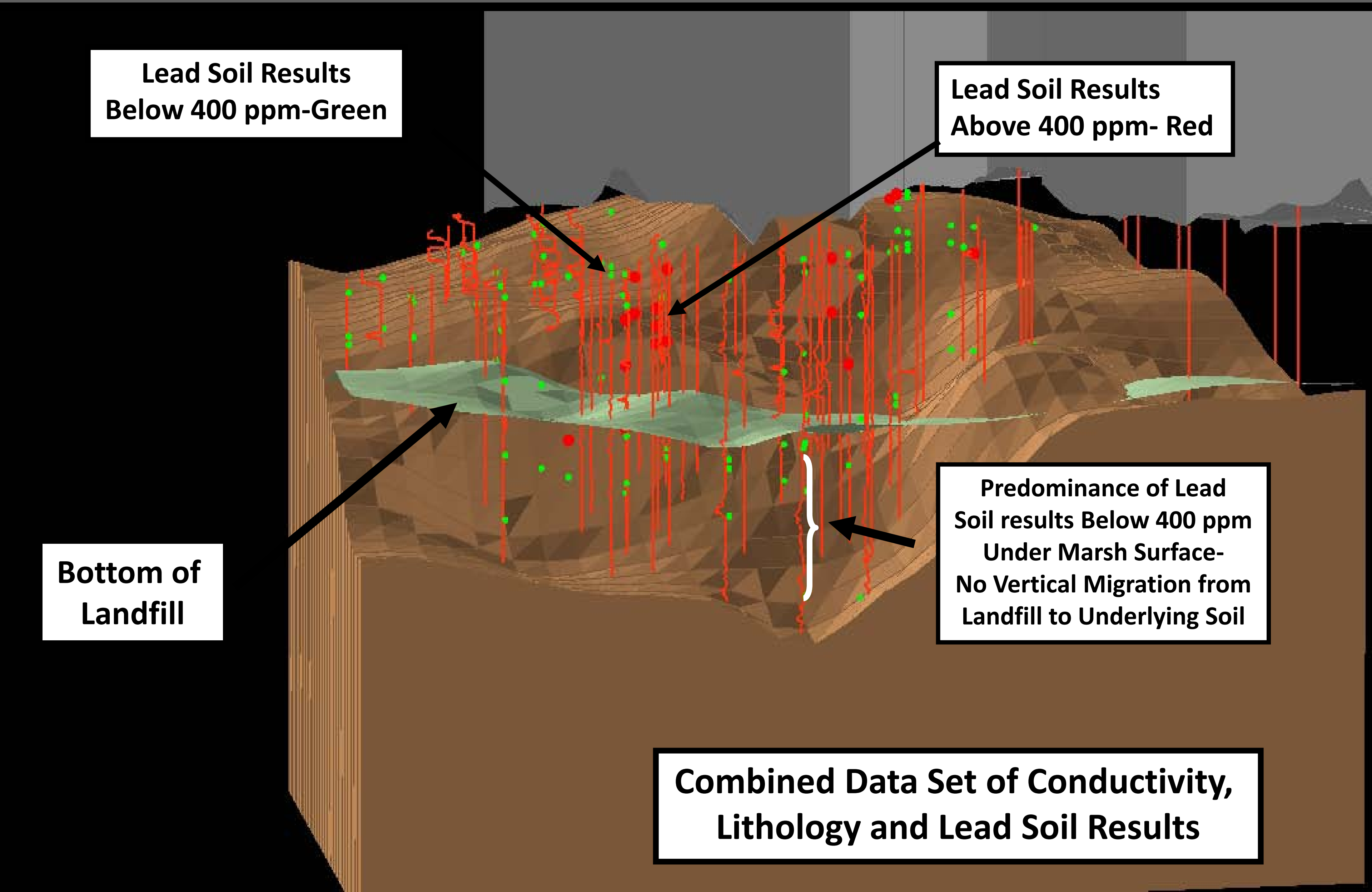
Analysis Of Soil Conductivity Log to Select Soil Sampling Intervals





Soil Core Samples
Correlated with EC Log
Historic Fill
(8-9 ft thick)
Peat & Clay
(1.5 to 4 ft thick)
Red Fine to
Medium
Sand
RF-03
0'→4'
Harrison Commons Area
Wide Assessment
Figure 9

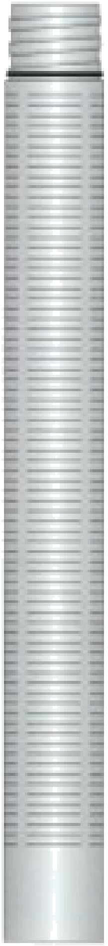
Example of Collaborative Data Set



Increasing the Value of High Resolution Approaches

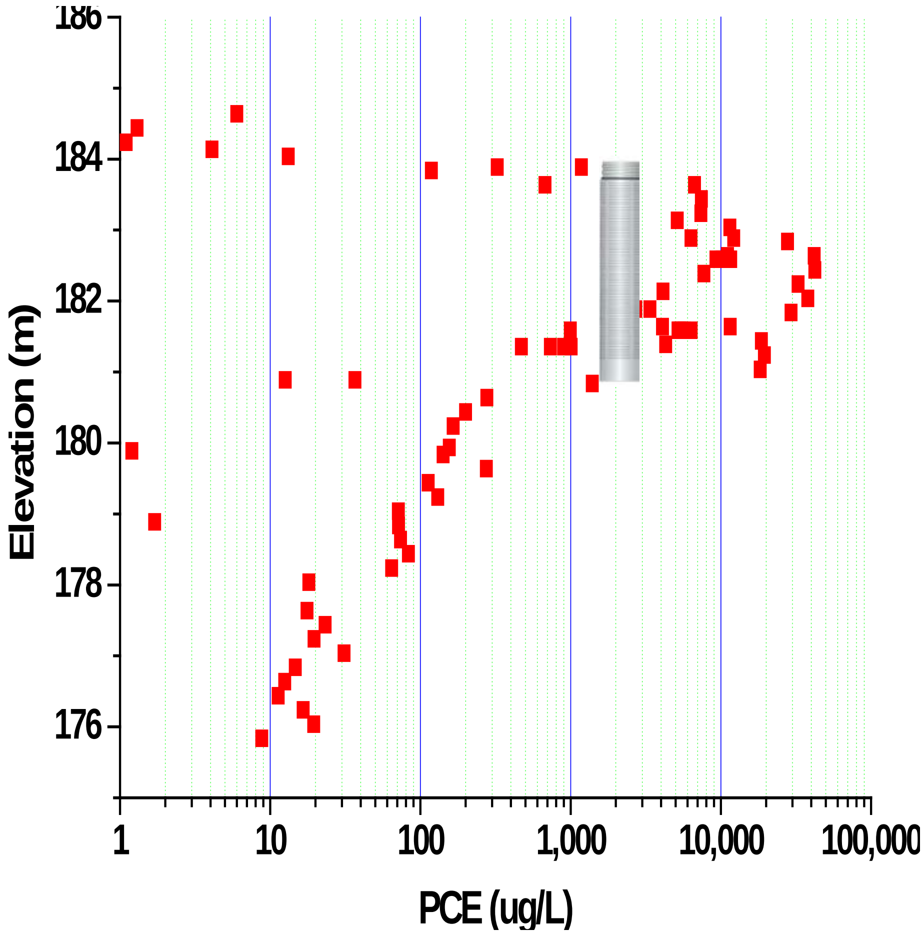
- Dynamic work strategies- facilitated by real time measurements and decision logic
- Collaborative data sets
  - Multiple independent data sets
- Deployment
  - Transects vs. hope and poke
  - Depth profiling
  - Groundwater elevation gradients can be poor predictors of localized flow
  - Remedy areas of focus, mature plume areas vs. invasion fronts

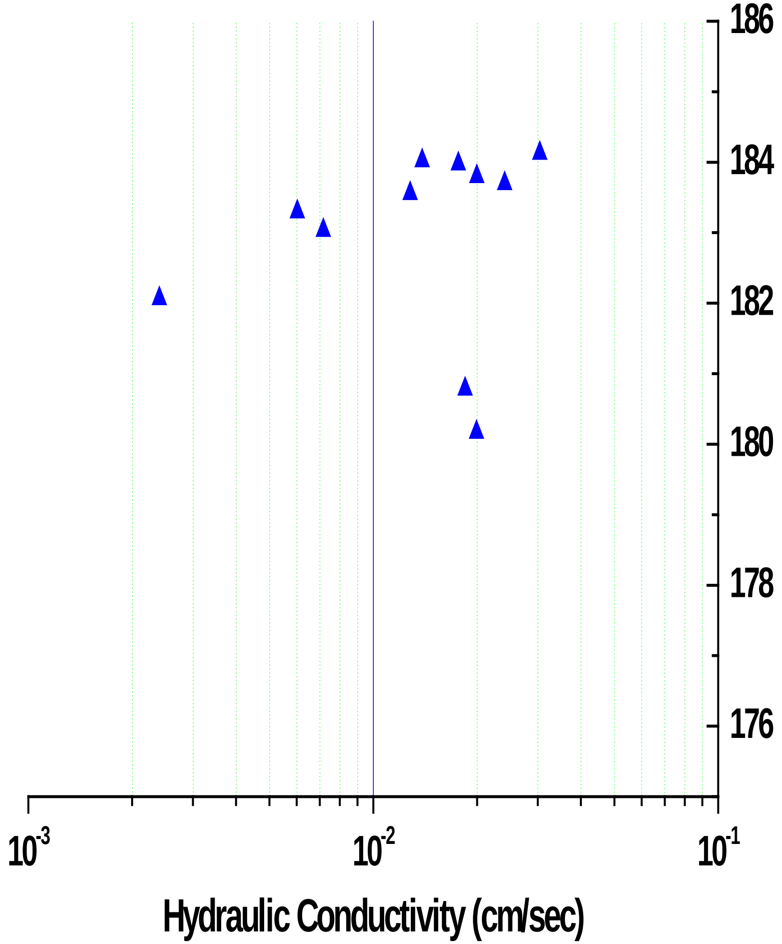
Groundwater Challenges
How "well" do you understand your site?



- **Technology used influences your resulting site understanding**
- **Size of measurement must be appropriate for scale of heterogeneity**
  - Variability of hydraulic conductivity / other parameters
  - Steep concentration gradients – vertically and at plume edges
  - Heterogeneous distribution of DNAPL sources
- **Conventional monitoring wells are not optimal <u>investigation</u> tools**
  - Wells yield depth-integrated, flow-weighted average data
  - Cannot discern heterogeneities that control contaminant transport
  - Good technology for long-term <u>monitoring</u>
- **Beware biased well locations [hope & poke]**
  - Majority of uncertainty comes from data gaps between wells [hope]
  - Majority of investigations rely on limited number of wells [poke]
- **BMP- Transects and vertical profiling**
  - Effectively delineate groundwater impacts
  - Find appropriate monitoring well locations and screen intervals

Effects of depth-integrated, flow weighted averaging
Well results less than vertically profiled concentrations

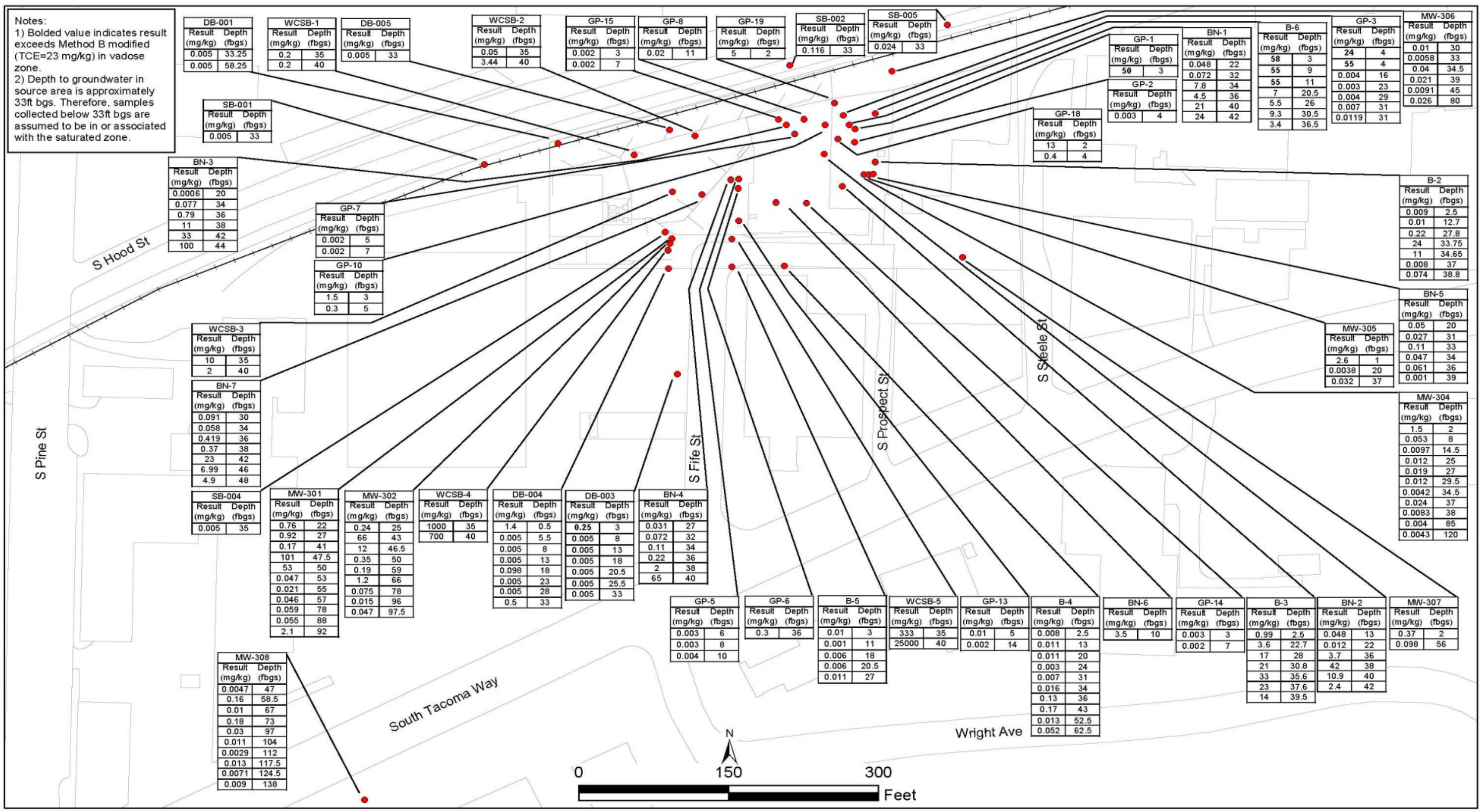




Waterloo APS™

Conceptual Site Model

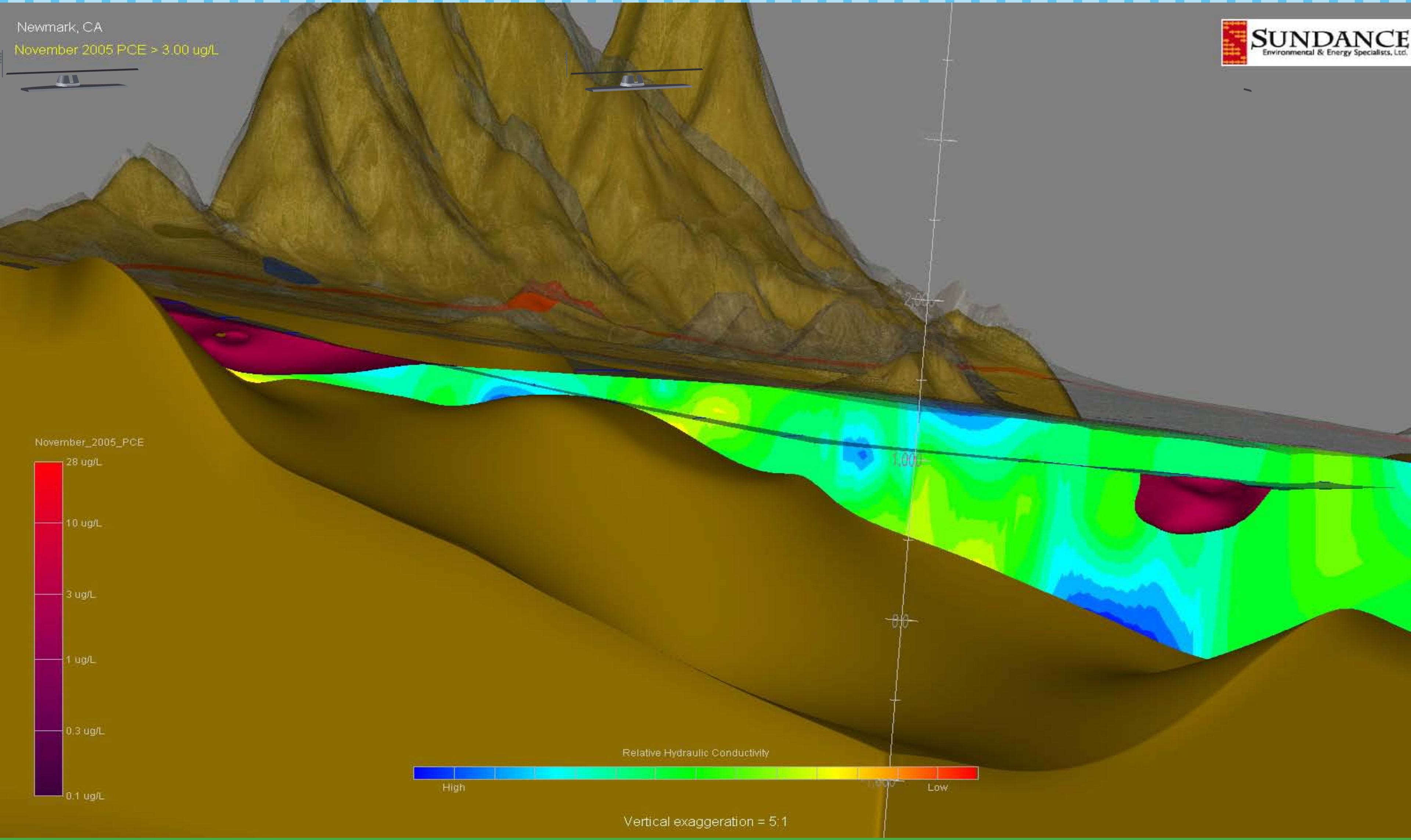
Are We Effectively Using Data or Confusing Data?



Well 12A Superfund Site
Tacoma, Washington

Figure 2-6
Trichloroethylene in Soil

The Value of Seeing the Whole Picture in 3-D



Where Do We Go From Here?

- Continued improvements to CSMs
  - Lifecycle use as a planning, management, decision making tool
  - 3D visualization and decision support tools (DST matrix)
  - Data management
- Characterization strategies and tools
  - For soil projects incremental and composite designs, adaptive QC targets areas of highest variability
  - Mapping mass storage vs. transport zones (Tool needs- CPT example)
  - Aquifer characteristics (gradients, velocity)
  - Contaminant and reagent mass transfer behavior
- Outreach and training
  - High resolution site characterization course under development
  - Continued technical support- 3D, tools, strategies, identify research needs (tools and strategies)

Questions