Triad Characterization of Soil Contamination at Former Small Arms Training Ranges

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Site Background

- Fort Lewis, Tacoma, WA
- Two former small arms ranges and a skeet range
  - Miller Hill active 1920-1951
  - Evergreen Infiltration Range active 1950-1965
- Overgrown with trees and grasses
- Investigation and remediation performed under RCRA Agree Order (AO)

Introduction

-A good understanding of the extent of lead contamination is critical to the evaluation of potential remediation techniques.

-Expedited site characterization with dynamic work plans was used as the framework for lead explorations at the former small arms ranges at Fort Lewis.

-The objectives of these investigations were to evaluate the horizontal and vertical extent of lead contamination in a cost effective manner.

-These explorations utilized a strategic investigative process rather than the more traditional phased approach.

-The foundation of the strategic process is an integrated triad consisting of Systematic Planning, Dynamic Work Plans, and Real-time Measurement Technologies.


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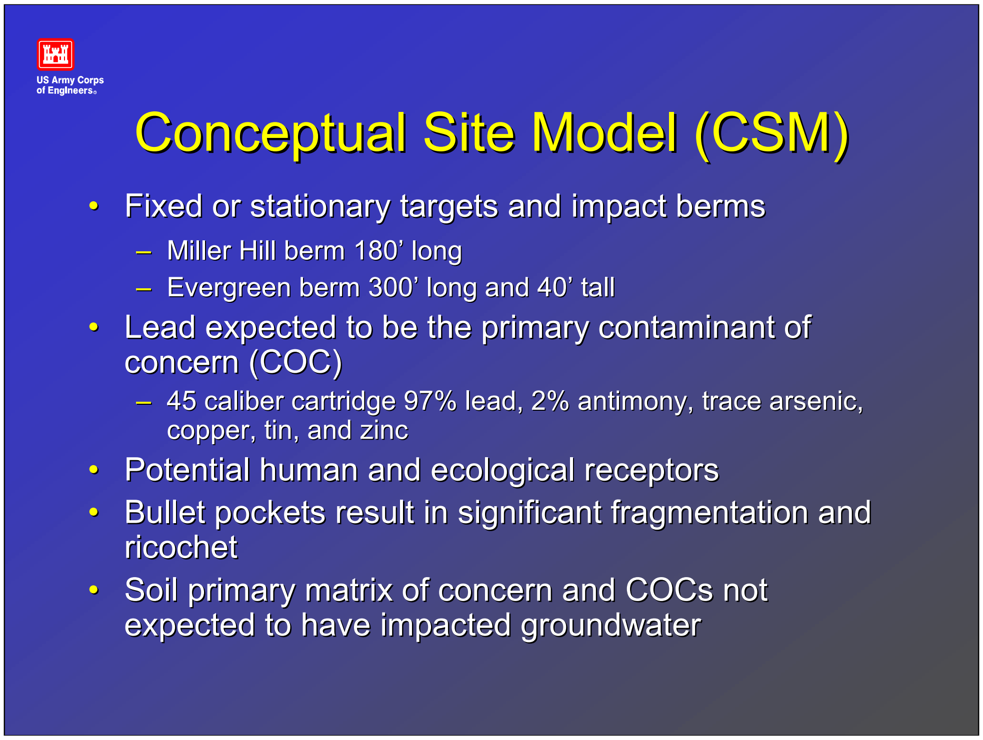
Project Team

- Fort Lewis Public Works
- Seattle District Corps
- WA Department of Ecology
- Core Technical Team
  - Project Chemist/Technical Lead
  - Project Data Coordinator (SADA)
  - XRF Analyst
  - Sampling Staff



Systematic Planning

-Relies on a team of multi-disciplinary experienced technical staff to translate the project goals into realistic technical objectives.

-Identifies decisions, develop decision logic and manages decision uncertainties.

-A powerful planning tool is a conceptual site model (CSM) that crystallizes what is already knows about the site and helps the team focus on what must be learned to make decisions to achieve project objectives.

-The team uses the CSM to direct fieldwork, allowing it to evolve as site work progresses and data gaps are filled.

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Systematic Planning

- Aerial photo review
- Develop GIS maps with range layout
- Risk pathway evaluation and identification of potential action levels
  - 50 ppm, 250 ppm, 400 ppm, and 1000 ppm
- Field recon to identify impact berms and firing points
  - No vegetation on the impact zone
- Develop data management & communication strategy

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Refine Project Objectives

- Confirm the presence of soil contamination
- Confirm lead is the primary COC for defining extent of contamination
- Delineate the vertical and horizontal extent of lead contamination above 50 ppm
- Manage uncertainty around contaminant volume estimates greater than 250 ppm, 400 ppm, and 1000 ppm
- Collect data to determine if contaminated soil would be a RCRA characteristic waste

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Dynamic Work Plan Strategy

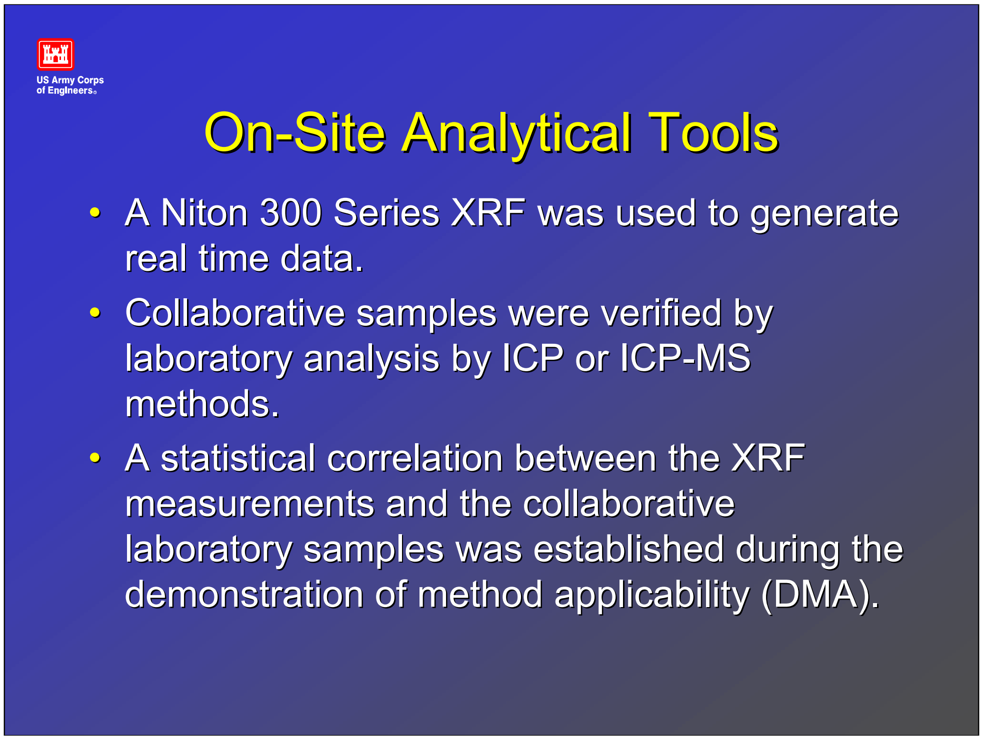
- Sample location density initially driven by process knowledge and site usage
  - 10 foot intervals lengthwise along berm face from 0-1 and 1-2 foot depth
  - Additional sample location determined real-time to define vertical and horizontal boundaries
- Sample support driven by potential remedies
  - Institutional controls, dig and haul, or treatment
  - Soil sieved with number 10 (<2mm)
  - One gallon zip-lock bag filled with soil that was archived
- Data visualization using Spatial Analysis & Decision Assistance (SADA) to maintain close communication with team members as work progressed, and evaluate statistical uncertainty

Dynamic Work Plan

-Success of the exploration hinges on the presence of a senior technical staff in the field to “call the shots” based on the decision logic developed during the planning stage and to cope with unanticipated issues as they develop.

-Utilized data visualization to maintain close communication with technical experts and project manager as work progressed.

-Creates opportunities for real-time decision making to save significant time and money.



On-Site Analytical Tools

- A Niton 300 Series XRF was used to generate real time data.

- Collaborative samples were verified by laboratory analysis by ICP or ICP-MS methods.

-A statistical correlation between the XRF measurements and the collaborative laboratory samples was established during the demonstration of method applicability (DMA).

-Metals tested for: arsenic, lead, copper, antimony, iron, tin, zinc to determine if lead was driver.

-Results: there were exceedances of antimony (several > 32), copper (1 > 2960), arsenic (1 > 20) but only when lead was > 250 ppm. Lead is driver.

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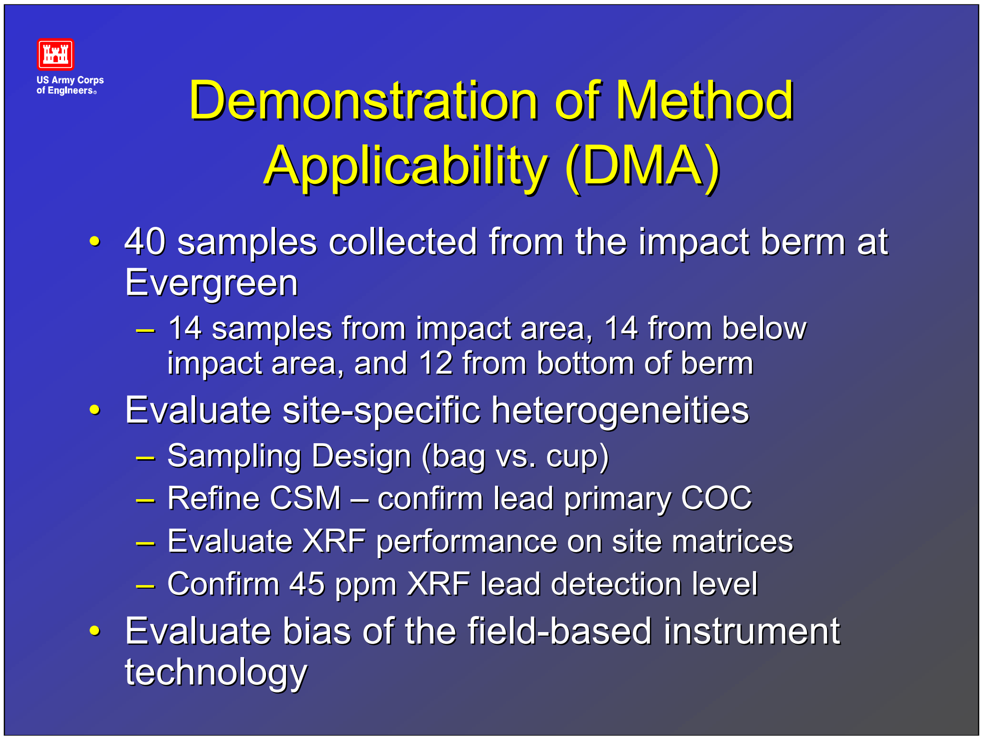
Communication Strategy

- Daily meetings with core technical team
- Weekly update meetings to include project support team
- Data and daily activity summary report posted daily to eRoom
- Written documentation and meetings with regulators on major decision points (i.e. after the demonstration of methods applicability study)



The DMA was planned and accomplished several goals:

•Initial evaluation of site specific heterogeneities that will support further design of the data collection program

– Sampling design (how many samples to collect and where to collect them)
– Refinement of the conceptual site model

•Evaluation of analytical performance on site specific sample matrices

– Determine whether and how to modify methods to improve performance and/or cost-effectiveness

• Evaluate the inherent bias of the field-based instrument technology such that an adequate safety factor can be built into the overall decision uncertainty limits

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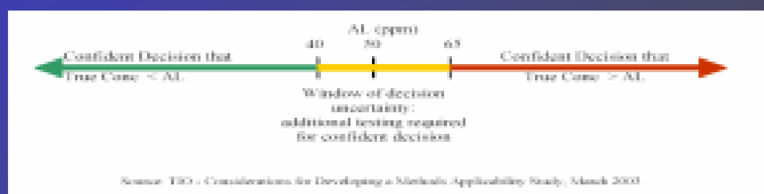
DMA

- Develop uncertainty intervals where it is judged that data can be confidently trusted to declare areas as
  - "Clean" – No further investigation
  - "Dirty" – Remedial action needed
  - "Ambiguous" – Further data required



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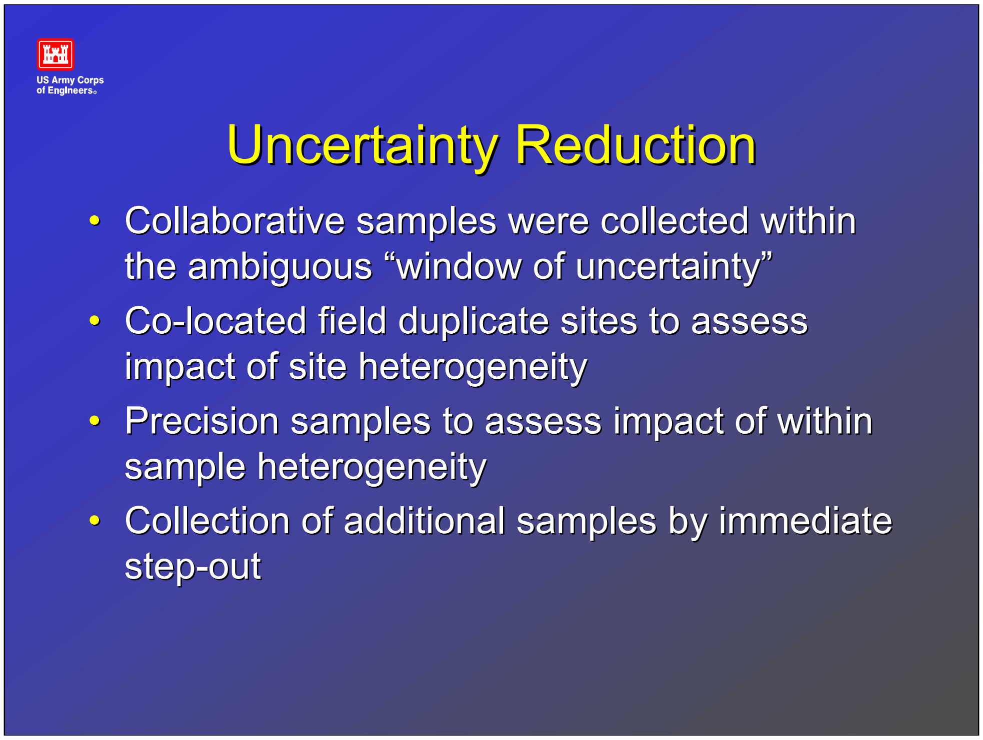
Recommendations from the DMA

- Analyze precision samples when primary result near action levels, if average within uncertainty region next step
  - Below detection to 100 ppm, 200-300 ppm, and 900-1200 ppm
- Collect and measure an XRF cup sample for comparison, if matrix variability is appreciably different, then collect a co-located field duplicate within 2 feet from primary
- If both precision average and XRF cup fall within the uncertainty region, send a collaborative sample for fixed laboratory analysis



QC samples

Co-located field duplicate samples will be collected to assess combined sampling and **field variability**. The co-located field duplicate will be collected from 0.5 to 3 feet way from the primary sampling point. The relative percent difference (RPD) is calculated for the primary and replicate sample results. Field duplicate samples shall be collected for XRF analysis at a minimum frequency of one per every 10 samples during the DMA. The frequency of XRF field duplicates for the remainder of the project will be determined by the ranges seen in the DMA but will not exceed 10 percent. The RPD criteria for XRF results for field duplicates will be less than 50 percent.

Precision. Measure within sample heterogeneity. A 1-gallon baggie of soil.

For FPXRF samples, a precision sample will be measured at a frequency to be determined by the DMA. A precision sample will be a sample that has been analyzed seven times in replicate. If possible, samples near the action level will be selected as the precision sample.

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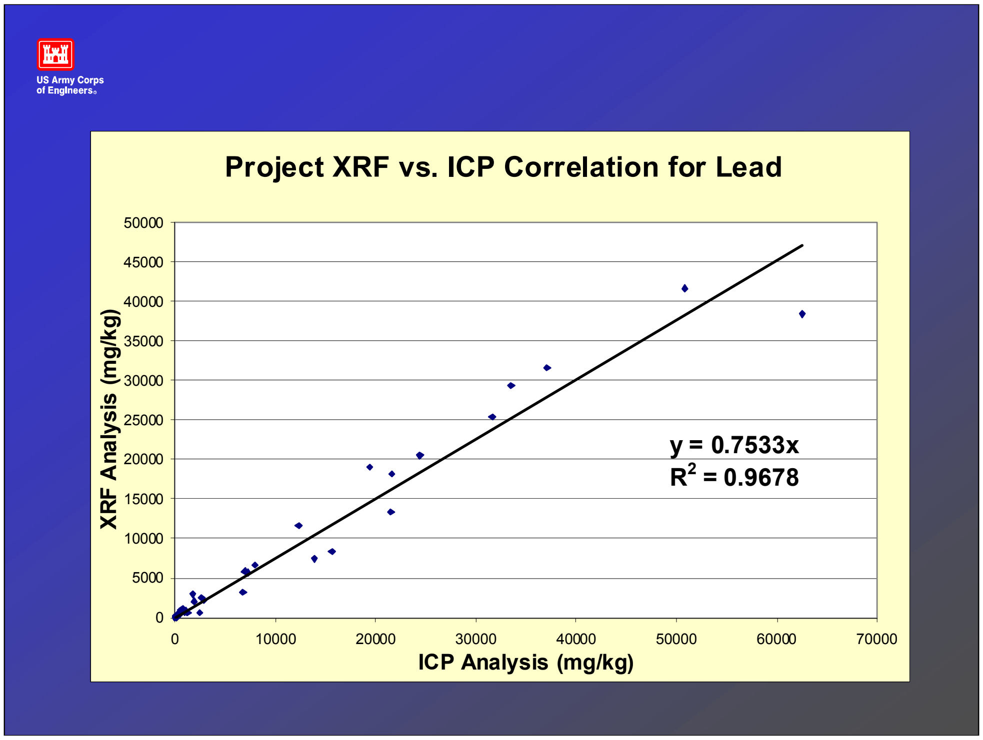


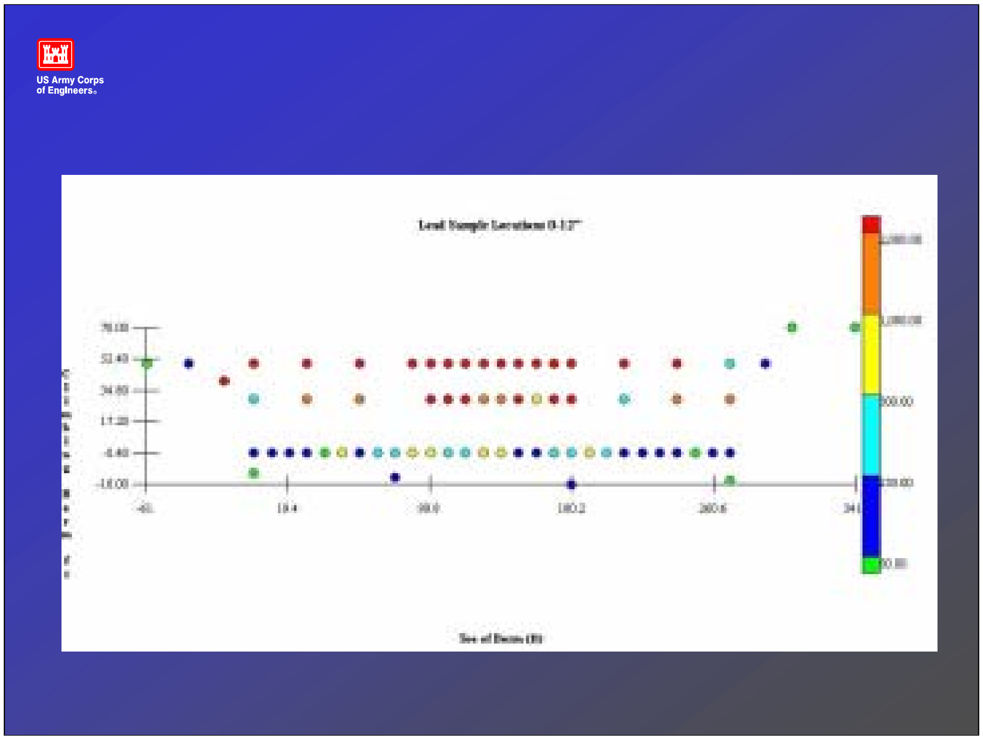
DMA: 40 XRF bag measurements/40 collaborative 100%/20 precision 50%/6 field duplicates 15%

Frequency of QC

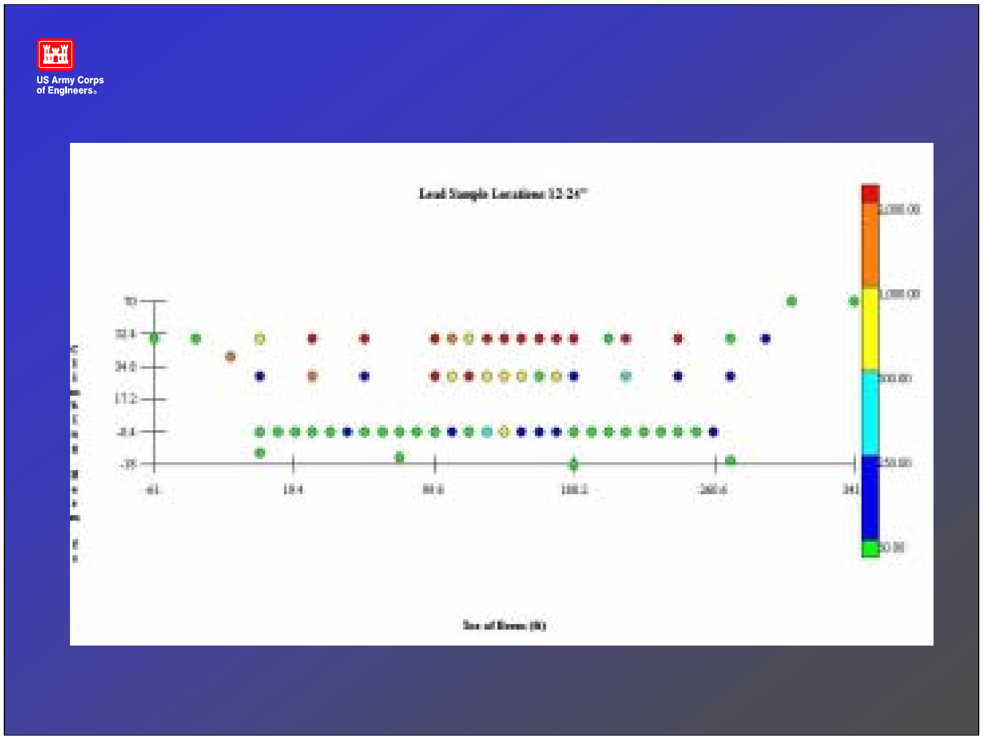
Collaborative 11%

Precision 20%

Duplicates 5%



The initial sampling strategy will be evaluated once real time data from XRF results have been obtained to determine if increased sampling density is required. Software programs such as Spatial Analysis and Decision Assistance (SADA) provides a number of tools for the visualization of data, geospatial analysis, statistical analysis, sampling design and decision analysis (TIEM 2003). Secondary sampling design applications assists in determining additional sample locations, such as placing new sample locations in areas where there is the greatest uncertainty about exceeding the action level, delineating the boundaries of the area of concern.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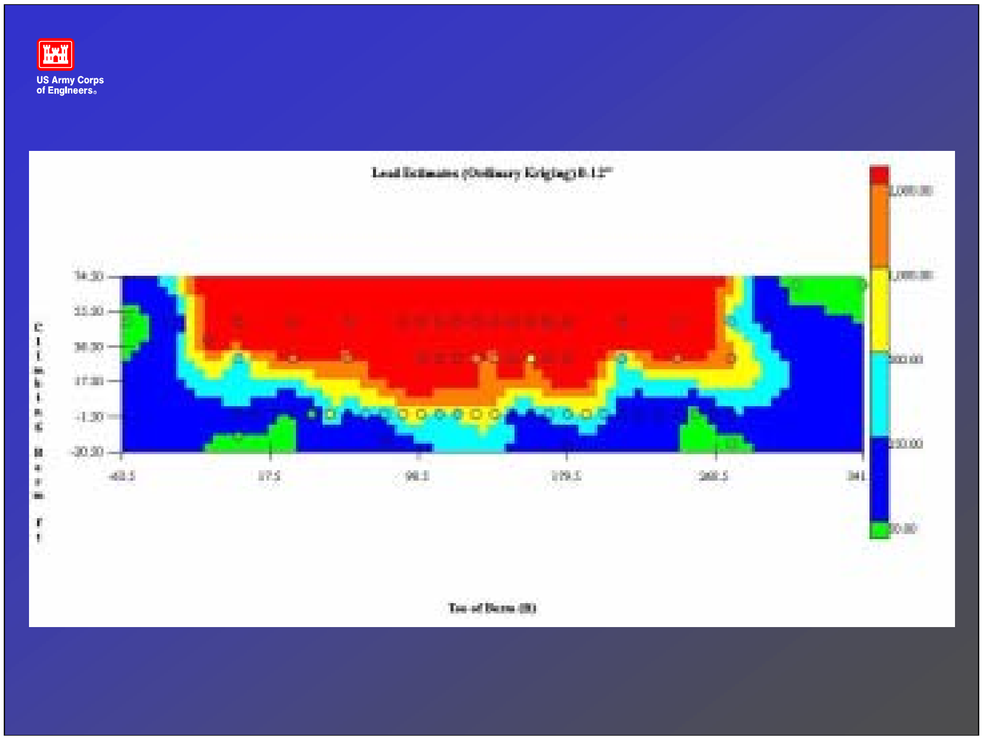
Lead Sample Locations 12-24"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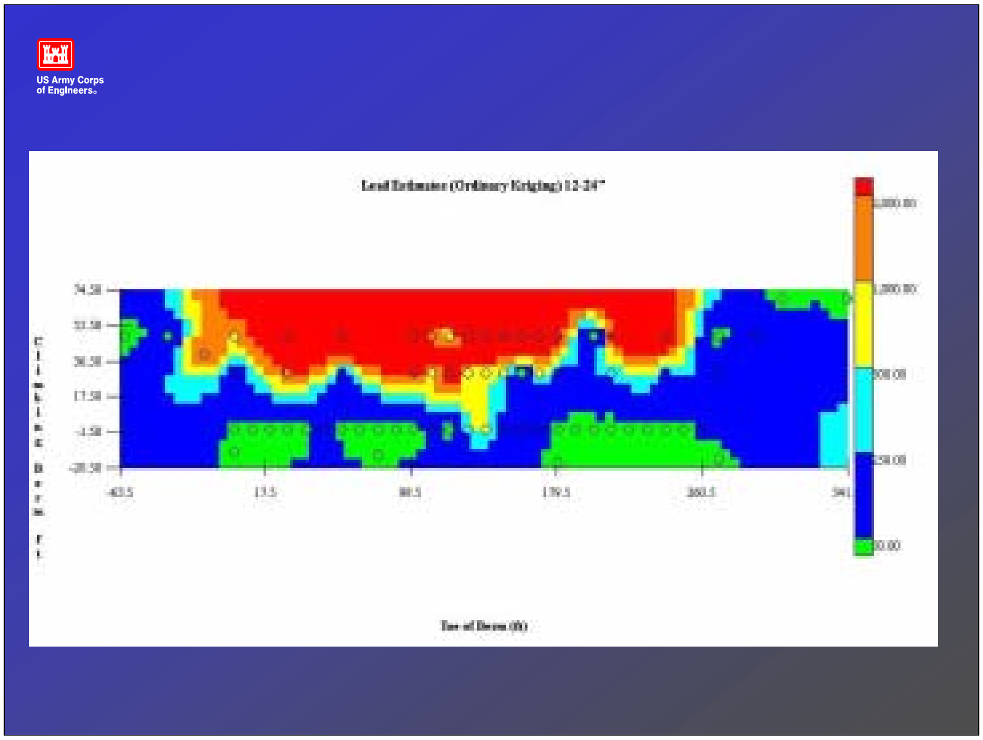
Lead Estimates (Ordinary Kriging) 0-12"
-62.5
17.5
98.5
179.5
260.5
341
Toe of Berm (ft)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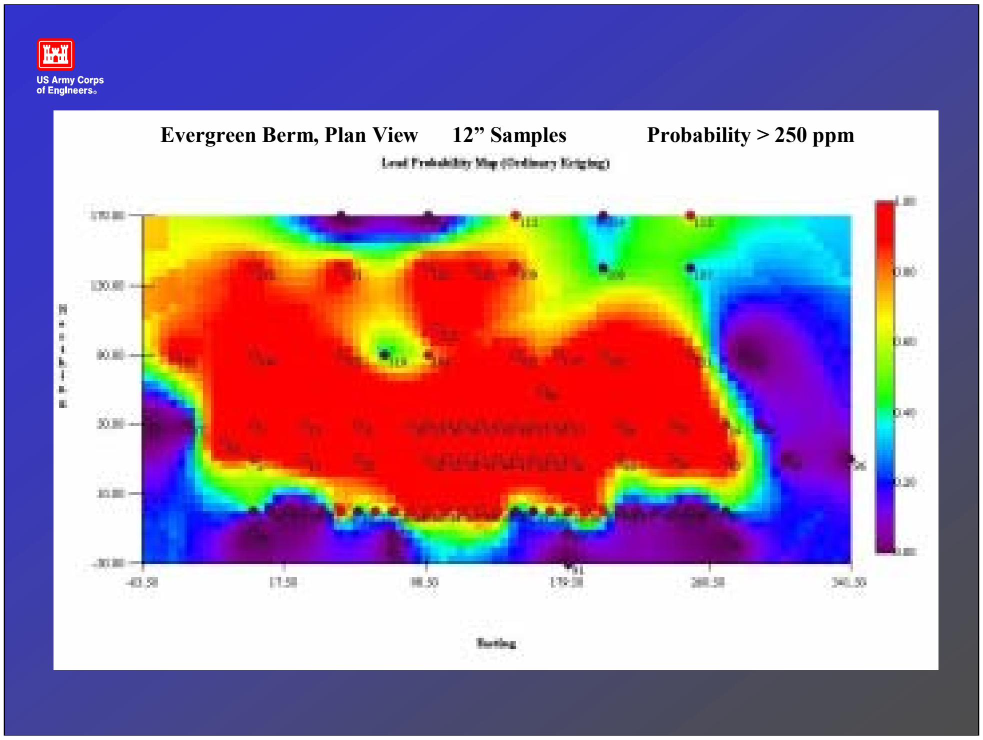
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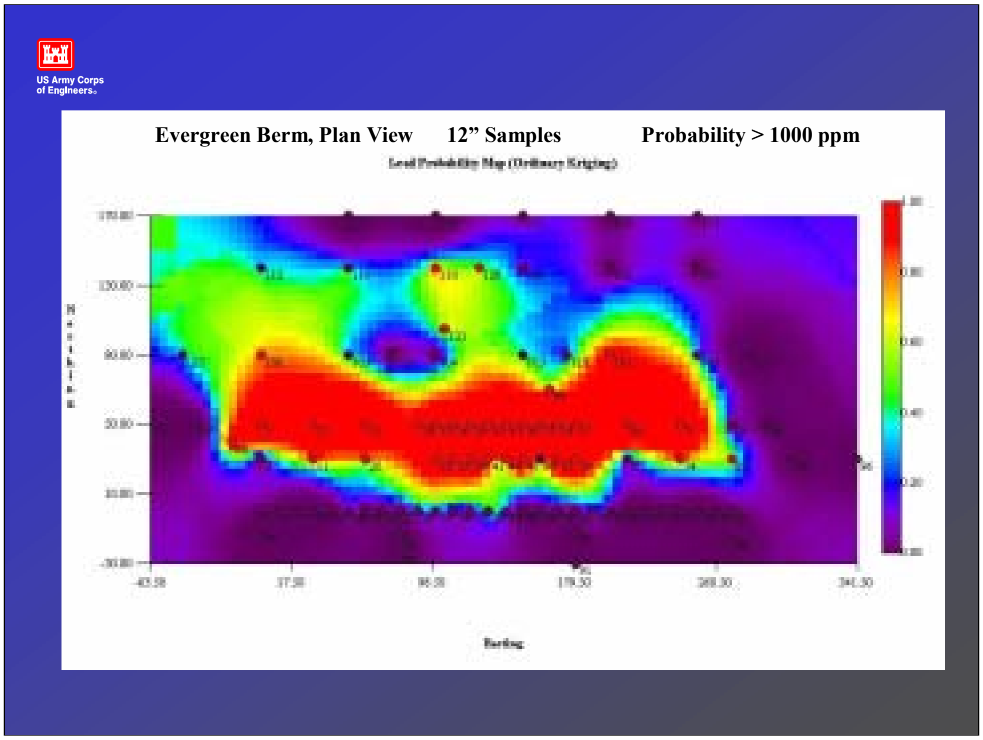
Evergreen Berm, Plan View 12” Samples Probability > 250 ppm
Lead Probability Map (Ordinary Kriging)
Northing
Easting
1.00
0.80
0.60
0.40
0.20
0.00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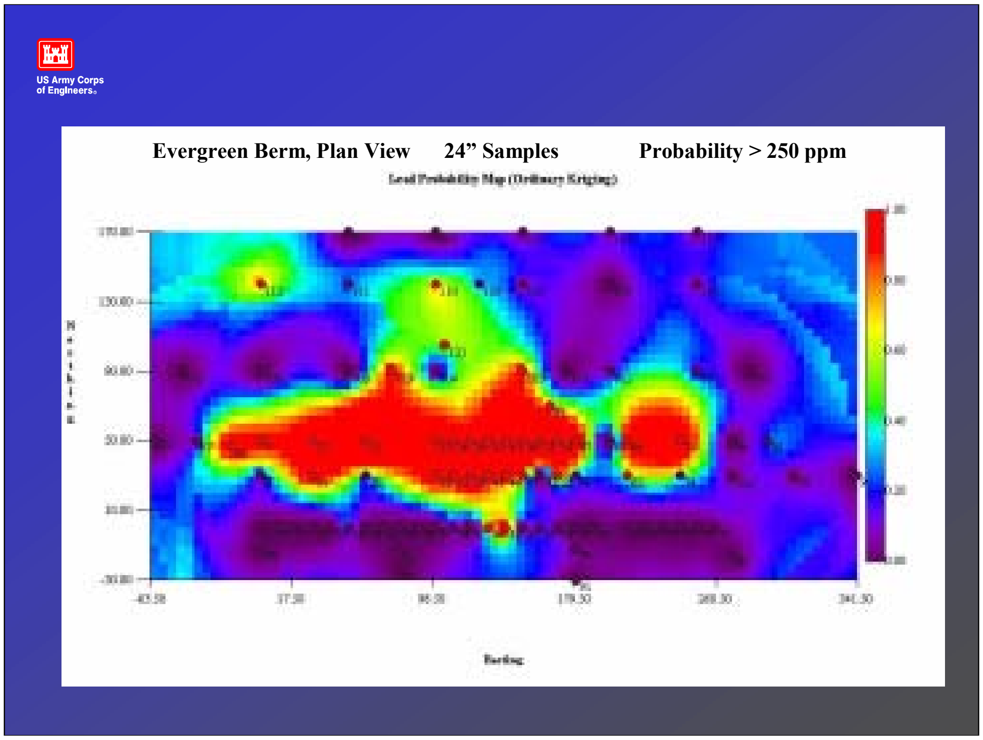
Evergreen Berm, Plan View
12" Samples
Probability > 1000 ppm
Lead Probability Map (Ordinary Kriging)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Evergreen Berm, Plan View
24” Samples
Probability > 250 ppm
Lead Probability Map (Ordinary Kriging)

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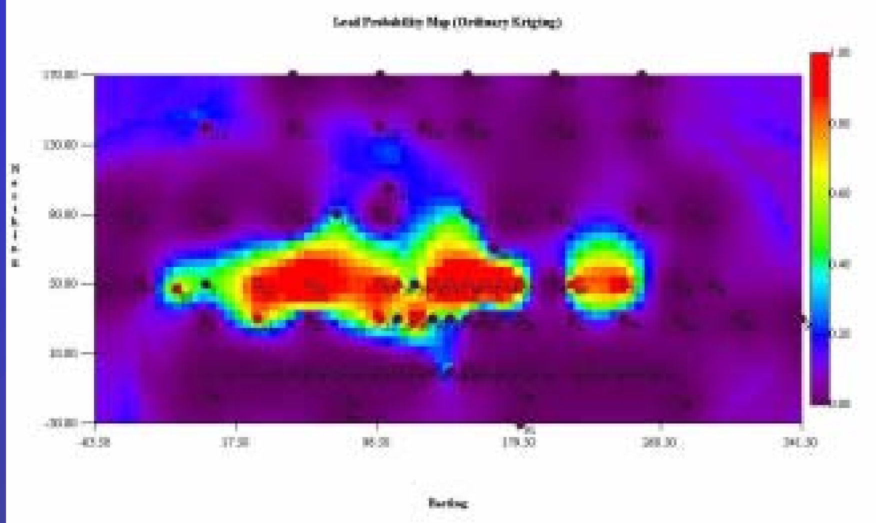
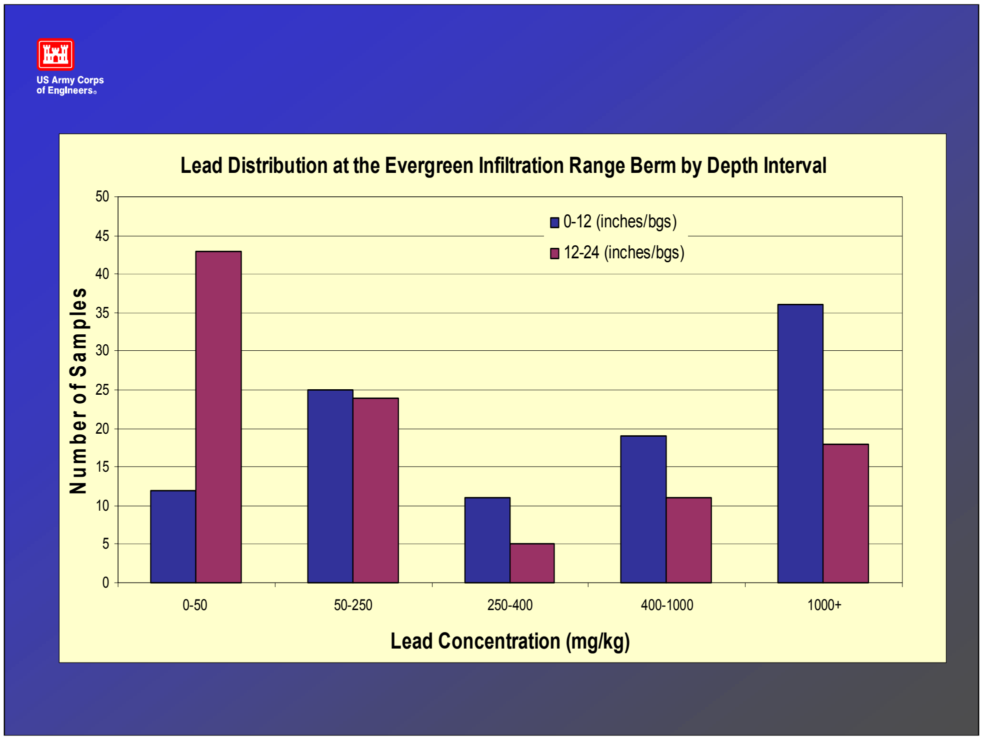
Evergreen Berm, Plan View 24" Samples Probability > 1000 ppm

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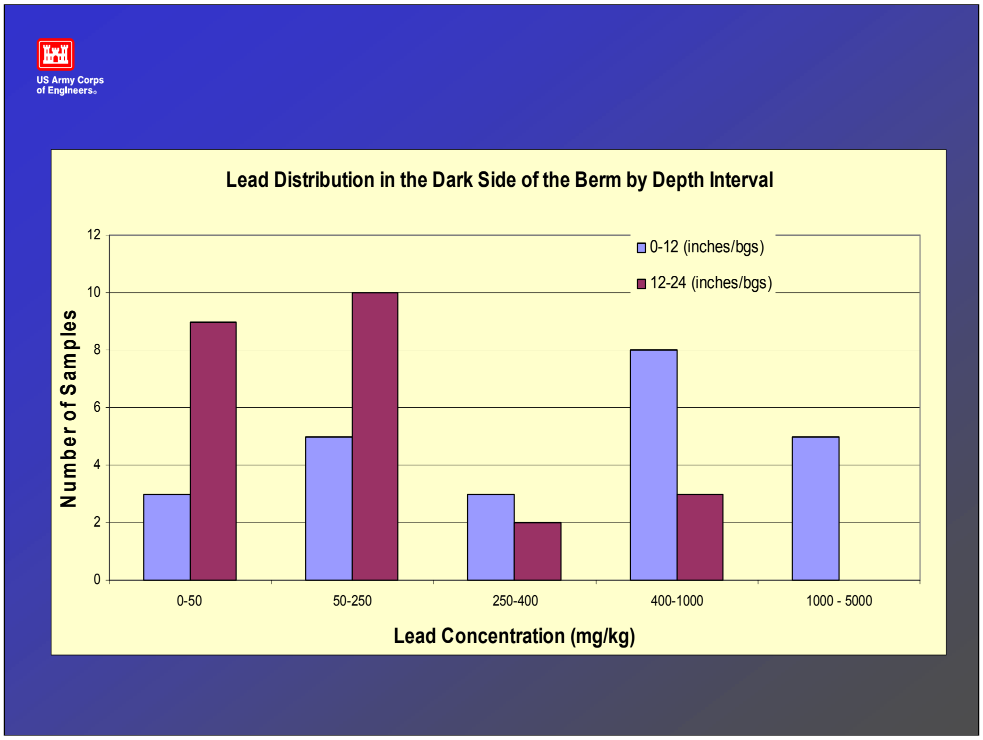
Lead Distribution at the Evergreen Infiltration Range Berm by Depth Interval
0-12 (inches/bgs)
12-24 (inches/bgs)
Number of Samples
0
5
10
15
20
25
30
35
40
45
50
0-50
50-250
250-400
400-1000
1000+
Lead Concentration (mg/kg)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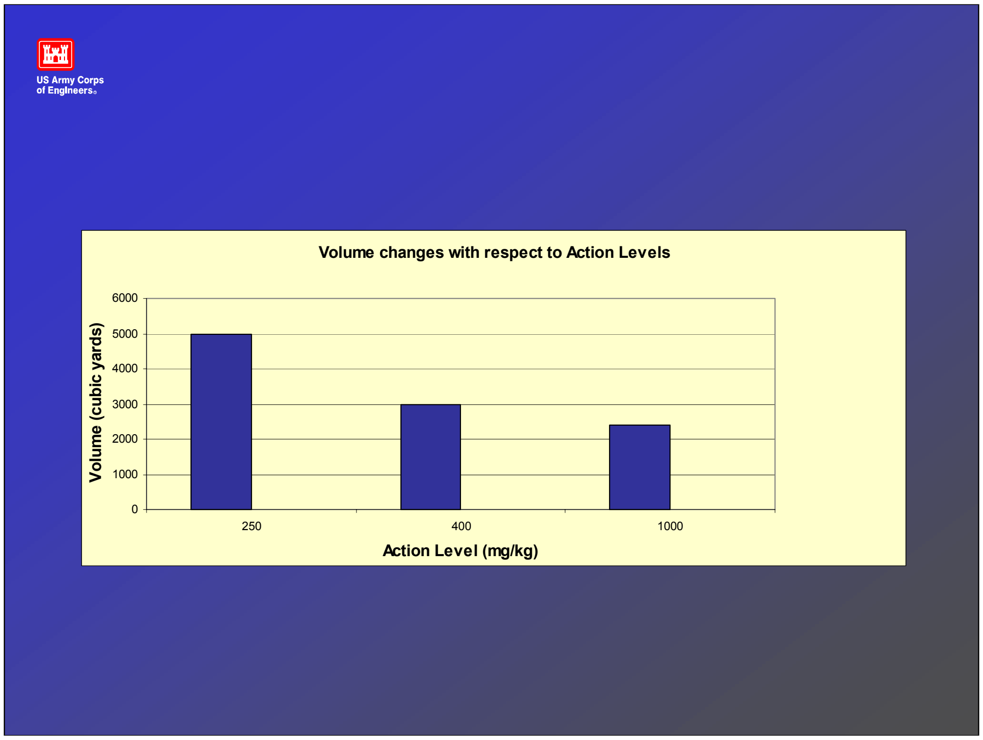
Lead Distribution in the Dark Side of the Berm by Depth Interval
0-12 (inches/bgs)
12-24 (inches/bgs)
Number of Samples
12
10
8
6
4
2
0
0-50
50-250
250-400
400-1000
1000 - 5000
Lead Concentration (mg/kg)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Volume changes with respect to Action Levels
Volume (cubic yards)
6000
5000
4000
3000
2000
1000
0
250
400
1000
Action Level (mg/kg)

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Action Level (mg/kg)	Volume (Yards^3)	Excavation Effort
250	5000	Maximum
400	3000	Moderate
1000	2400	Minimal

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Conclusions

- Dynamic work plan strategies and field measurement technologies can guide sampling locations based on an evolving CSM allowing for rapid delineation of extent of contamination
- Reductions in analytical per sample costs result in increased data density allowing for management of decision uncertainty
- Statistically valid conclusions require both sampling and analytical uncertainties to be managed
- Sufficient data was generated to proceed with feasibility study with reliable contaminated soil estimates

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Software Sources

- Spatial Analysis and Decision Assistance (SADA) http://www.tiem.utk.edu