Incremental Sampling & Best Practices for Lead Investigations

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Former Chattanooga Foundries

- 60+ foundries historically located in Chattanooga
- Generated spent sand and baghouse dust over many decades
Former Chattanooga Foundries
Foundry-related Waste Material

- Foundry-related waste material: spent sand, bag house dust, other byproducts
- Heterogeneous; can contain lead
- Waste material was used as fill (1890’s – 1970’s)
Initial EPA Involvement

- 2011: resident presented at ER with Pb poisoning
- 2012: EPA removed Pb contaminated soil at 84 residences
- Limited geographic area
- Extent of contamination undefined
- Other residential areas may be similarly impacted
- Risk undefined
Potential Large Urban Lead Site: Where to Begin?

Is all of downtown Chattanooga contaminated?

NO
Objectives of the Investigation

- Collect high quality data to support risk management decisions
- Produce defensible, actionable data that can be used for multiple purposes:
  - Site characterization
  - Time-critical removal decisions
  - Potential NPL listing or other response
  - Future CERCLA Remedial Investigation & Risk Assessment

Defensible Actionable Multiple Uses
Best Practices for Sampling for Lead in Soil

- Establish robust background concentration/range
- Incremental Sampling Method (ISM)
- OLEM Directive for sieving soil at lead sites
- EPA Superfund XRF Field Operating Guide
  - Lead bioavailability testing
  - Develop site-specific cleanup level for lead
Best Practice: Establish Background Level for Lead

Chattanooga Urban Bkg Study

- 5x5 mile grid; 50 randomly selected cells
- Used SAP/QAPP template from larger R4 urban background study
- 7 metals associated with foundries: Pb, As, Cd, Cr, Cu, Ni, Zn; plus PAHs
### Urban Background Results

<table>
<thead>
<tr>
<th></th>
<th>RSL</th>
<th>Mean Bkg (mg/kg)</th>
<th>Urban background 95% UTL (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lead</strong></td>
<td>400</td>
<td>60</td>
<td>175</td>
</tr>
<tr>
<td><strong>Arsenic</strong></td>
<td>0.68</td>
<td>3.4</td>
<td>7</td>
</tr>
<tr>
<td><strong>Chromium</strong></td>
<td></td>
<td>25</td>
<td>33</td>
</tr>
</tbody>
</table>

- Background lead consistent with other cities in SE U.S.
- Robust background dataset ready for RI
- Elevated lead concentration **NOT** “everywhere”
Chattanooga Lead Background vs. 5 Cities

![Box plot comparing lead levels in Chattanooga and 5 other cities](image)
Identify Study Areas
Field Operation
Best Practice: 
Incremental Sampling Methodology (ISM)

Why ISM?
Superior method to derive an unbiased estimate of the mean concentration of a given area (i.e. decision unit)

One ISM sample is collected for each decision unit

Each sample is comprised of 30 aliquots, and produces one concentration that represents the entire decision unit (yard)

Statistically defensible data on which to base decisions

https://www.itrcweb.org/ism-1/
Best Practice: Incremental Sampling Methodology (ISM)

Addresses heterogeneity in soils and variation in contaminant concentrations:
- “microscale” heterogeneity
- “Short-scale” and large scale heterogeneity

1 ft² area of surface soil contains 36 possible 2” diameter core sample locations

Observed short-scale heterogeneity with uranium sample results

IRTC Incremental Sampling Methodology, February 2012, Figures 2-5 & 2-6
Extrapolating Analytical Result to Decision Unit

IRTC Incremental Sampling Methodology, February 2012, Figure 2-7
Guidance for Obtaining Representative Laboratory Analytical Subsamples from Particulate Laboratory Samples

by

Robert W. Gerlach
Lockheed Martin Environmental Services

and

John M. Nocerino
U.S. Environmental Protection Agency

30 aliquot field sample

Subsampling for analysis

Figure 15. A paper cone sectorial splitter with eight sectors.

Guidance for Obtaining Representative Subsamples, Nov. 2003
ISM: Decision Units
Incremental Sampling in Chattanooga
Collecting ISM: Time & Effort

One 30-point composite from a residential yard takes 8 minutes to collect.
Disaggregation and Drying
OLEM Lead Sieving Directive

MEMORANDUM

SUBJECT: Recommendations for Sieving Soil and Dust Samples at Lead Sites for Assessment of Incidental Ingestion

OLEM Directive 9200.1-128

Recommendations for Sieving Soil and Dust Samples at Lead Sites for Assessment of Incidental Ingestion, OLEM Directive 9200.1-128
OLEM Lead Sieving Directive

- Recommends < 150 μm particle size (#100 mesh)
- Incidental ingestion greater for fine particles.
- Dermal adherence greater for fine particles.
- Increased contaminant concentration, mobility, and bioavailability in fine particles.
Dermal Adherence
Sieve of Stacked Mesh (#10 and #100)
Fine Fraction <150 microns
Lead Concentrates in the Fine Fraction

Pb in mg/kg

<table>
<thead>
<tr>
<th>Unsieved</th>
<th>Sieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>603</td>
<td>1016</td>
</tr>
<tr>
<td>837</td>
<td>1832</td>
</tr>
<tr>
<td>1434</td>
<td>4021</td>
</tr>
<tr>
<td>1245</td>
<td>2300</td>
</tr>
<tr>
<td>591</td>
<td>936</td>
</tr>
</tbody>
</table>

At this site, sieved soil has approximately 100 ppm higher concentration than in unsieved.
ISM Includes Representative Subsampling

“One-Dimensional Slab Cake” procedure
Representative subsamples for analysis
Best Practice:
X-Ray Fluorescence Field Operations Guide

Superfund X-Ray Fluorescence Field Operations Guide, EPA Region 4, July 19, 2017 (SFDGUID-001-R0)

- Tool for OSCs and RPMs
- Methodology to collect high quality XRF data for lead and arsenic
- Provides real-time data
- Multiple readings and QA/QC measures
- Produces “definitive” data = data of sufficient quality to use in remedial and removal decisions and in the BLRA
XRF vs Lab Data: Lead

R Squared = 0.98
Excellent agreement between XRF data and lab data.
XRF vs. Lab: Pb

XRF provides reliable, reproducible & defensible data for Pb for this project (n = 300+)
Best Practice:
Site-specific Clean-up Levels for Lead

Best Practice: Lead Bioavailability

Bioavailability
- A measure of the amount of lead absorbed into bloodstream
- Important input in clean up level
Integrated Exposure Uptake Biokinetic (IEUBK) Model

Predicts blood lead levels in children resulting from environmental exposures.

Utilized by EPA to set cleanup goals for lead in soil.
Best Practice: Site-specific Clean-up Levels for Lead

- Use site-specific lead bioavailability in the IEUBK model
- \(\uparrow\)BA will \(\downarrow\)health-based clean-up level
- IEUBK default BA = 30%
- In this case, 33 soil samples were analyzed for lead bioavailability
- Chattanooga site soils BA = 29-50%; mean = 36%
- Other updated inputs to IEUBK used, esp. target blood lead level and ingestion rate
SOP for In Vitro Lead and Arsenic Testing

MEMORANDUM

SUBJECT: Release of Standard Operating Procedure for an In Vitro Bioaccessibility Assay for Lead and Arsenic in Soil and Validation Assessment of the In Vitro Arsenic Bioaccessibility Assay for Predicting Relative Bioavailability of Arsenic in Soils and Soil-like Materials at Superfund Sites

Standard Operating Procedure… OLEM, May 5, 2017
Conclusion of Chattanooga Soil Study

✓ Elevated lead is not “everywhere; can distinguish between suspect material and urban background
✓ Data supports risk management decisions
✓ Unacceptable risk at some properties
✓ Removal warranted at some properties
✓ Remedial action planned
✓ Site-specific cleanup level “options” developed
Q & A