3D MODELLING OF CONTAMINATED SITES
MIDWEST AIR AND WASTE MANAGEMENT CONFERENCE
FEBRUARY 24, 2016
Ramboll Environ will present concepts to consider during subsurface characterization and remediation of contaminated sites with an emphasis on 3D (spatial) and 4D (spatiotemporal) data visualizations. Once considered only for big budget projects (e.g., litigation), sophisticated data visualizations have become more accessible, cost effective and integral to efficient site remediation. Key topics presented will include data management, High Resolution Site Characterization (HRSC) and Conceptual Site Models (CSM).

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A premier global consultancy, Ramboll Environ is trusted by clients to manage their most challenging environmental, health and social issues.

We have earned a reputation for technical and scientific excellence, innovation and client service. Our independent science-first approach ensures that our strategic advice is objective and defensible. We apply integrated multidisciplinary services and tailor each solution to our client’s specific needs and challenges.
GLOBAL PRESENCE AND EXPERIENCE
INTRODUCTION

What are three-dimensional data-based models?
What are four-dimensional data-based models?
Why are they useful?
When should they be used?
What is required?
Data – Federal Sources
Data – State & Local Sources
Data - Historical Sources
Previous Site Reports

Figures
Tables
Boring Logs

<table>
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<tr>
<th>LOC</th>
<th>CASING ELEVATION</th>
<th>WATER DEPTH</th>
<th>WATER ELEVATION</th>
<th>TIME</th>
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<tbody>
<tr>
<td>MW-1</td>
<td>12.04</td>
<td>2.71</td>
<td>6.33</td>
<td>1007</td>
</tr>
<tr>
<td>MW-2</td>
<td>12.30</td>
<td>2.75</td>
<td>6.55</td>
<td>1011</td>
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Data - Historical Sources

Historic Aerial Photography, USGS Historical Topographic, Sanborn, BLM, RR Valuation Maps
Data – Site Contemporary

**Contractors:** Laboratory (EDDs), Surveyor, Geophysical, MIP

**Field Collected:** DGPS, Boring Logs, real-time sensors
Data Requirements
Spatial PLUS Temporal Attributes
*Spatiotemporal Coordinates* = XYZ + Time

Metadata
Data Quality
Data Objectives
Data Management - RDBMS – Relational Database Management System

Environmental geology and analytical chemistry data management system.

Relational database that use reference tables (i.e., lookup tables) and data inputs.

Analytical data
Field data (e.g., sample depths, coordinates, soil descriptions)
Third party data (e.g., regulatory criteria)

DATA INTEGRITY
**Data Management**

Data Flow Diagram
Data Summary

Sources and Types
- Geospatial and Tabular
- Regional, State and Local Scale

Historical and Contemporary
- Quantity and Quality
- Level of Effort

Data Management
- Attribution and Documentation
- Data Integrity
Data

Characterization and Remediation Concepts

Decision Support Tools

Case Studies and Workflows

Conclusion
CSM – Conceptual Site Model

“The Conceptual Site Model (CSM) is an iterative, ‘living representation’ of a site that summarizes and helps project teams visualize and understand available information.”


Six Stages of the Project Life Cycle CSM

Development

Preliminary – Synthesis of existing/historic data.
Baseline – Identify data gaps and uncertainties.

Evolution and Refinement

Characterization – Incorporate new data. Reduce spatial uncertainty and close data gaps.
Design – Technology and remedy decision making.
Remediation / Mitigation – Supports remedy implementation and optimization efforts.
Post Remedy – Mature CSM supports reuse planning; documents institutional controls.
Components of a CSM

- Maximize use of available site data.
- May incorporate 2D/3D visualizations and network diagrams.
- Identification of source areas, contaminant pathways, fate and transport.
- Evaluation of ecological and human health risks and exposure pathways.
- Project planning and management tool
- Communication tool
- Iterative, becomes increasingly quantitative and decreasingly conceptual.
HRSC – High Resolution Site Characterization

EPA’s Definition:
High-resolution site characterization (HRSC) strategies and techniques use scale-appropriate measurement and sample density to define contaminant distributions, and the physical context in which they reside, with greater certainty, supporting faster and more effective site cleanup.
Components of HRSC

- High-density data at scale appropriate for site-specific heterogeneity
- Collaborative datasets
- Supports life cycle CSM
- Best Management Principal (BMP)
MIP – Membrane Interface Probe
- Direct Sensing, continuous data stream
- Primarily VOCs - Sensors include PID, FID, ECD, XSD
- Qualitative/semi-quantitative
- Rapid site characterization
- Simultaneously, EC and HPT provide grain size and hydrogeologic data
- Use response to target expensive analytical samples
- High data density, real-time digital data support on-site decision-making
- In use for 15+ years, adherence to SOP and experienced operator important
- No Investigation Derived Waste
MIP + HPT – Vendor-Supplied MiHpt Log – Membrane interface Hydraulic Profiling Tool
EVS/MVS

Environmental/Mining Visualization System

- True 3D volumetric models
- Mature technology, 25 years
- 3D and 4D kriging – animate through time
- Geostatistics
- DrillGuide™ and Well Decommission™ tools.
- Distribute interactive models as 3DPDF/4DIMs
- EVS/MVS, EnterVol (ArcGIS) and Earth Volumetric Studio (2016)
**gINT Boring Log Software**

- gINT RDBMS system
- Data captured in the field (e.g., tablet PCs)
- Boring logs generated directly from the database (e.g., same day logs)
- Customize to include additional data (e.g., CPT, MIP)
- Database connection to EQuIS, ArcGIS, EVS

Analytical plus Geology defines the impact
**Former Lead Smelter**

- 60 acre former lead smelter
- Former operations area on an upland plateau
- Smelter operated from 1900s to 1950s
- Operations generated 1.5 million tons of slag
- Metals-impacted soils, building debris, and former smoke stack debris
- RI completed 2012, remedial activities began in 2013
Former Lead Smelter

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Excavation Summary (cu yd = cubic yards)
- 12,000 cu yd excavated from the lowland
- 108,000 cu yd excavated from the upland

EVS was used to calculate volume of soils in exceedance of multiple regulatory limits, design site excavations, and monitor volumes of excavated and placed material.
**Former Lead Smelter**

- The 2012 Remedial Investigation (RI) provided subsurface characterization data for EVS/MVS
- RI data supplemented with historical data
- Lead, Cadmium and Mercury risk-based drivers
- EVS’ 3D Kriging used to estimate volume of soil exceeding Lead OR Cadmium OR Mercury
- 2012 EVS estimate was 120,000 cu yd
- 2015 completion estimate 108,000 cu yd
Additional 3D Task Completed
Volume estimates along a complex 3D slope (river bluff)
- Original alignment modified by material dumped from upland
- Identified native alignment with historical USGS Topos
- Supplemented with test pit excavations to native soil
- Input into EVS to calculate volume of non-native material, 8,500 cu yd
Additional 3D Task Completed
Excavation and backfill design, soil volume updates in near real time
Additional 3D Task Completed
Evaluation of USACE flood elevation surface
Chlorinated Solvent Site – Applied HRSC and MIP Example

- 150 MIP + 35 collocated Direct Push confirmation soil borings
- Kriging results each day while deployed on-site. (i.e., Triad-based)
- Generates very large datasets - 96,000 records
- Data table for a 30ft bgs boring, 600+ records →
- Data supplied as text files (CSV)
- Database and data loading script created
Combined Boring Log Using gINT and the MIP database

At approximately 20% of MIP locations a collocated direct push (DP) soil boring was completed. Confirmation soil and groundwater samples collected based on MIP response.
Chlorinated Solvent Site – Applied HRSC and MIP Example

- Identified a narrow ‘neck’ of contamination pathway
- Estimates using a treatment volume delineated using only monitoring well results resulted in a treatment volume an order of magnitude greater
- High density data provided a more accurate representation of the plume and significant savings on the ISCO remedy
- Value of a quality model used to make smart decisions
Data
Characterization and Remediation Concepts
Decision Support Tools
Case Studies and Workflows
Conclusion

What are data-based 3D/4D models and why are they useful?
To clear the grey fog of subsurface uncertainty. The ability to visualize and critically evaluate complex 3-dimensional datasets improves clarity and decision confidence.

When should they be used?
Throughout the project lifecycle.

What is required?
Data of known quality.
QUESTIONS?

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Chlorinated Solvent Site – MIP - Electrical Conductivity Model

EC > 140 mSm

EC > 70 mSm

EC > 0 mSm

Electrical Conductivity (mSm)
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