Case Study: Use of a Decision Support Tool: Using FIELDS and SADA to Develop Contour Maps of Contaminant Concentrations and Estimate Removal Volumes for Cleanup of Soil at the Marino Brothers Scrapyard Site, Rochester Borough, Pennsylvania

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FOREWORD

This case study is one in a series designed to provide information on use of decision support tools that support the use of data, models, and structured decision processes in decision-making. These case studies include reports on selected tools that have been used to support activities such as site assessment and remediation, data management and visualization, and optimization. They are prepared to offer operational experience and to further disseminate information to project managers, site owners, environmental consultants, and others who wish to screen decision support tools and benefit from their previous use at sites.

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1.0 SITE BACKGROUND

The Marino Brothers Scrapyard is located in Rochester Borough, along the banks of the Ohio River in Beaver County, Pennsylvania. The former scrap yard is situated in an industrial area and is bordered on the north by Railroad Street, on the east by a concrete supplier (Beaver Concrete and Gravel Co.), on the south by the Ohio River, and on the west by commercial properties. The site occupies 3 acres and was operated as a scrap yard from the 1920s until October 1998. The Borough of Rochester now owns the property and is developing a recreational reuse plan for this Brownfields site.

In December 2001, the Pennsylvania Department of Environmental Protection (PADEP) contacted the U.S. Environmental Protection Agency's (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI) to request assistance in developing a systematic plan, based on the Triad approach, for surgical removal of contaminated soil that would allow recreational redevelopment of the site. PADEP conducted a remedial investigation of the site between 1998 and 2001 (Baker 2001). The OSRTI's Brownfields Technology Support Center (BTSC) assisted PADEP with systematic planning for the site, developing a preliminary conceptual site model (CSM) based on data from the RI. This effort culminated in the development of a Statement of Work (SOW) in April 2003 that presented a detailed technical approach for completing further investigation and remediation activities at the site in a single mobilization. The SOW also included a construction cost estimate to help PADEP procure the contractor for site remediation. The construction cost estimate addressed the uncertainty inherent in using analyte-specific concentrations (EPA SW846 Method 6010) to plan a surgical removal effort, while using a performance-based (Toxicity Characteristic Leaching Potential [TCLP]) extraction procedure to make decisions in the field about the excavation and landfill disposal of the excavated soil.

Initial project support included developing a relational database and compiling pre-existing analytical, geologic, and hyrdogeologic information to develop a preliminary CSM. Contaminants of potential concern (COPCs) in soil at the site included metals (particularly lead, iron, arsenic, and mercury) and polychlorinated biphenyls (PCBs). PADEP recommended using medium-specific concentrations (MSCs) for residential exposure to soil, even for evaluation of recreational exposures. However, given the expected property reuse as a recreation area, the project team also developed site-specific exposure standards based on a screening-level risk analysis and a recreational exposure scenario designed to protect a child who would play at the site 2 hours/day, 2 days/week, for 6 months out of the year (52 days/year).

2.0 USE OF DECISION SUPPORT TOOLS

After the work products discussed in the previous section had been developed, the project team used the FIeld EnvironmentaL Decision Support (FIELDS) program, a decision support tool developed by EPA to support sampling and remedial decision-making. FIELDS (http://www.epa.gov/region5fields/htm/software.htm) was used to develop contour maps of contaminant concentrations in soil above residential and site-specific risk-based concentrations (RBCs).

Pre-existing data were processed using Microsoft Access before they were entered into FIELDS. The data were grouped into 2-foot depth intervals because FIELDS is a two-dimensional mapping program. The following 2-foot depth intervals were used for mapping and analysis of COPCs: 0.0 to 2.0 feet below ground surface (bgs), 2.0 to 4.0 feet bgs, 6.0 to 8.0 feet bgs, and 10 to 12 feet bgs. These intervals corresponded to the greatest data density. The 4.0- to 6.0-foot interval, by contrast, contained too few data to contour. A contouring program, such as the natural neighbor (NN) algorithm used in FIELDS, interpolates between scattered data points to calculate concentrations at nodes on a regular grid. (The NN algorithm is an area-weighted interpolation scheme that develops a polygonal mesh as part of the calculation. The resulting grid is not rectangular or user-defined; rather, it is controlled by the data density and distribution.) The resulting matrix of values is smoothed because multiple data points are averaged at each grid node. The greater the density of data, the more smoothing will occur. Therefore, the maximum calculated value is lower than the maximum point value in the input data set. However, this smoothing effect provides a more realistic estimate of ambient concentrations, particularly if used to predict the concentrations that may result from composite sampling.

Analysis Based on PADEP Residential MSCs

Contour maps were created for each COPC and depth interval where the maximum calculated concentrations exceeded the residential MSCs for soil based on PADEP's Act 2 technical guidance. Twenty-seven maps depicting the areal extent of COPC concentrations that exceed PADEP residential MSCs were created. Nine COPCs were found to exceed PADEP residential MSCs in at least one of the four depth intervals. Lead, arsenic, and iron exceeded the PADEP residential MSCs in all four depth intervals, while mercury, cadmium, and the three PCBs (Aroclor 1248, 1254 and 1260) exceeded PADEP residential MSCs only in two depth intervals (upper 4 feet), and antimony exceeded the PADEP residential MSC in the upper three depth intervals.

The distribution and magnitude of some of the COPCs, such as lead, mercury, and PCBs, indicate site-related contamination. Certain inorganic COPCs, such as arsenic, however, may exceed the PADEP residential MSCs primarily as a result of high background concentrations created by the presence of slag commonly used as fill throughout the region.

Analysis Based on Site-Specific Exposure Standards

Site-specific exposure standards were developed to provide a more realistic risk-based estimation of the remedial action possibly required at the site. A FIELDS analysis was again conducted by mapping COPC concentrations that exceeded the site-specific standards developed during the screening level risk analysis. Less than half of the COPCs that exceeded the PADEP residential MSCs were found to exceed the site-specific standards. Arsenic, cadmium, and zinc did not warrant inclusion on the list of COPCs given the use of site-specific standard values. Only lead was found to exceed the site-specific standard at depths below 4 feet.

The analysis of the FIELDS maps also allowed the project team to focus on the COPCs that were expected to most influence the proposed removal action. Figure 1 provides a comparison between two COPCs that exceeded site-specific standards: lead and antimony. This comparison shows that the single antimony hot spot is embedded within an extensive area of lead concentrations above the site-specific standards. Through analysis of maps such as these, the project team realized that lead was the most widespread COPC and that all COPCs above site-specific standards should be encompassed by the mapped extent of lead above the site-specific standard. Consequently, the team recognized that remediation of lead-contaminated soil would remediate other COPCs, making lead the remedial driver.

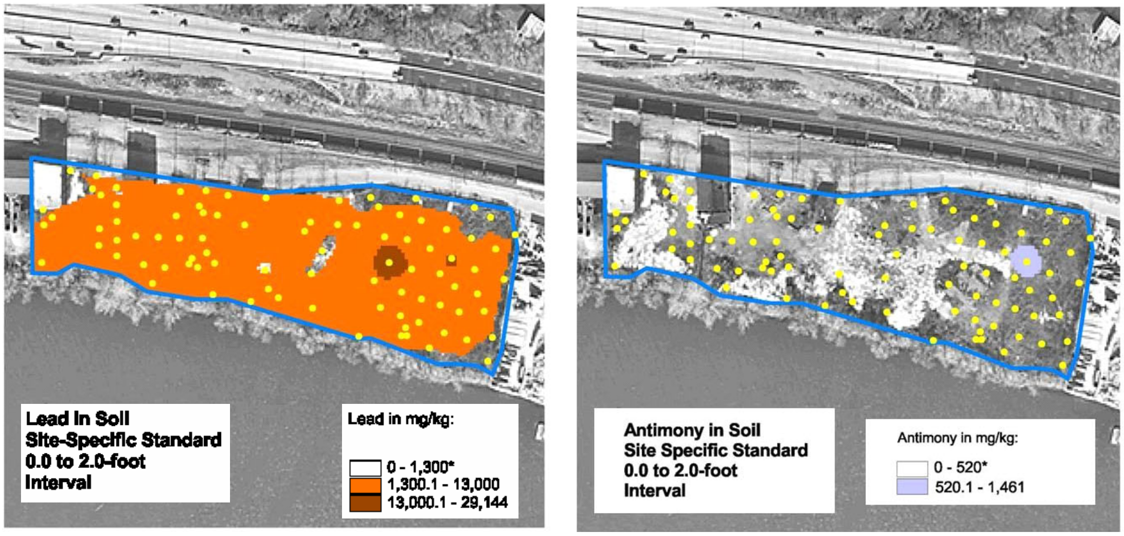
Estimating the Volume of Excavation with FIELDS

The mass/volume calculator included in FIELDS was used to provide a conservative estimate of the volume of soil that must be removed to bring concentrations below site-specific standards for lead and, thus, all of the COPCs.

Lead was used as an indicator COPC for the volume calculations. The site-specific exposure standard for lead (1,300 milligrams per kilogram [mg/kg]) was used as the cutoff; soil with concentrations of lead that exceeded this value was assumed to require removal. The total volume calculated to remove all soil exceeding site-specific standards was 18,043 cubic yards.

FIGURE 1

FIELDS MAPPING: COMPARISON OF CONCENTRATION MAPS FOR LEAD AND ANTIMONY
(Only Concentrations Exceeding Site-Specific Exposure Standards)



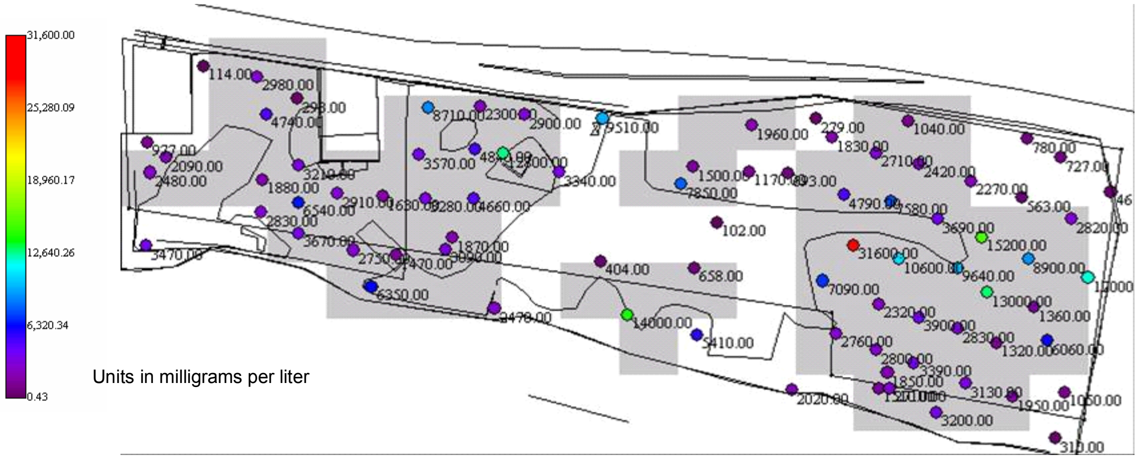
Notes: Asterisk denoted the site-specific exposure standard. Yellow points indicate sampling locations. Blue line indicates property boundary.

Estimating Excavation and Segregation Volumes with SADA

The excavation volume was also calculated using the Spatial Analysis and Decision Assistance (SADA) software developed by the University of Tennessee. SADA (http://www.tiem.utk.edu/~sada/) features fully three-dimensional interpolation; as opposed to the two-dimensional interpolation used in FIELDS. Using SADA provided a more accurate estimate of the soil volume targeted for the surgical removal action, which was 16,853 cubic yards. Figure 2 is an "area of concern" map produced by SADA. The shaded area represents the area to be excavated for one depth interval, based on the full three-dimensional data interpolation conducted with SADA.

FIGURE 2

SADA MAPPING: AREA OF CONCERN FOR LEAD
(Shows Portion of Site where Estimated Concentration of Lead Exceeds Site-Specific Exposure Standards)



In addition to calculating the volume of soil that would require removal, it was necessary to estimate the cost of soil disposal, which involved evaluating concentrations, treatment requirements, disposal destinations, and associated costs of all COPCs (not just lead). This exercise was more challenging because the segregation of soil during excavation into distinct stockpiles and treatment options were complex and depended heavily on the concentration of metals and PCBs in the waste. The key parameters that influenced options for segregation and waste disposal included:

- Concentrations above federal Land Disposal Restrictions (LDRs)
- Classification as hazardous under the Resource Conservation and Recovery Act (based on TCLP results)
- Concentrations above specific landfill permit requirements

A complex decision logic diagram was developed for use in developing a realistic cost estimate that accounted for uncertainty in these parameters. This analysis could not be supported entirely by either FIELDS Version 2.0 or by SADA. SADA, however, provided an easier interface than FIELDS Version 2.0 that could be used to export data in a format that would allow further processing according to the decision logic. SADA's contouring algorithms generate estimated concentrations on a user-defined rectangular grid. The interpolated data were exported in a row/column/result format and captured as two-dimensional arrays in Excel.

Once in Excel, the decision logic was expressed in a series of spreadsheets that processed the two-dimensional arrays of estimated concentrations. Each value in the array represented the concentration of an analyte at a node of the grid used in SADA. Logical operations could be performed on the concentrations estimated at each node by embedding if-then statements in the Excel spreadsheets. (If constituent *X* is above its action level in the volume of soil in a grid cell, then the volume in the grid cell will be grouped in stockpile *Y*.) In this manner, multiple analytes were evaluated against multiple decision rules (action levels) simultaneously through linked spreadsheets. The analysis resulted in a number of hypothetical segregated soil stockpile volumes, based a comparison of the contaminant concentrations versus LDRs and potential TCLP results. The disposal cost for each stockpile was unique and was dictated by the various constituent concentrations. Thus, the decision logic was programmed in Excel using estimated concentrations that were output from SADA.

Soil TCLP data were not available for the site; therefore, a sensitivity analysis was performed to estimate the volumes that might be classified as hazardous waste under RCRA. The analysis used the “twenty times rule,” which assumes that a constituent concentration less than or equal to twenty times its TCLP limit will pass TCLP. This assumption is conservative, but provided an upper bound for expected costs. Other, perhaps more realistic, cost scenarios were developed by assuming that higher concentrations for cost-sensitive constituents, such as mercury, would pass TCLP. A range of potential disposal costs was developed by varying the concentrations of these principal drivers for disposal and incorporating the other identified disposal requirements. This cost analysis showed the economic value of performing selected TCLP testing to reduce the soil volume requiring classification as hazardous waste.

3.0 LESSONS LEARNED

The analysis described above was based on a set of deterministic contouring calculations using the pre-existing data. The actual cost of removal was determined by the results of TCLP tests conducted on composite samples. It was necessary to conduct a sensitivity analysis of three different scenarios because the outcome of the composite sampling and the TCLP test was not known at the time the SOW was prepared. The sensitivity analysis was conducted to manage uncertainty and estimate a range of possible costs. The disposal costs for the different scenarios ranged from \$3.3 million to \$4.6 million. The range in cost became the largest uncertainty in the engineer’s cost estimate, but at least it was quantified.

Each DST displayed different strengths in the analysis. Neither DST, however, could be used to replicate the complex decision logic that guided segregation of the excavated soil into various "stockpiles" based on different disposal requirements and their associated costs.

Together, the two DSTs provided a variety of visualization, estimation (contouring), and delineation tools that were brought to bear on the analysis. Sufficiency of the CSM and its underlying data set was tested by contouring the data using both tools, comparing the results, and conducting a sensitivity analysis to estimate a range of remediation costs that encompassed the uncertainty inherent in the CSM and VSP/SADA model assumptions.

However, the project also illustrated how a single DST may not be able to address all aspects of the decision logic for a complex project. The Triad practitioner must therefore be aware of the advantages and limitations of each DST and must be prepared to use more than one tool, or to devise a customized solution to the problem.

Additional information about this project can be obtained from the Marino Brothers Site Triad Profile, which can be accessed at Triad Central (http://www.triadcentral.org/).

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5.0 REFERENCES

EPA BTSC. "Statement of Work. Applying the Triad Approach to Advance Land Reuse, Marino Brothers Scrap Yard Site." April 2003.