INVESTIGATION VERSUS REMEDIATION: PERCEPTION AND REALITY

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ABSTRACT

Investigative strategies, not based on project Data Quality Objectives (DQO) and/or not statistically justified, have a high risk of producing non-representative analytical data. The problem is further aggravated by a data validation process that is often devoid of professional judgment. As a result, many site investigation (SI) studies do not provide sufficient or representative chemical data necessary to make solid decisions related to the selection and implementation of remedial actions. Case studies often demonstrate the discrepancy between the commonly grossly underestimated extent, type and magnitude of contamination reported in the SI and the reality that is uncovered during the actual remediation work. Causes for inadequate site investigation work are discussed, and remedies are proposed.

INTRODUCTION

Planning of remedial actions is frequently based upon existing chemical data generated during site investigative studies that usually include such elements as:

- record search
- planning documents preparation
- sampling
- analysis
- data validation and interpretation
- reporting and review by regulatory agencies

One may assume that this kind of effort would produce reliable information of sufficient volume to form the foundation for a remedial action plan. Remedial action case histories have, in fact, proved the opposite - the perception of site conditions based upon site investigation findings does not reflect reality. Use of site investigation data invariably leads to underestimating or overestimating of the extent of contamination, sometimes, on an alarming scale. In either case, ramifications may be substantial with respect to remediation budgets and public perception of the environmental industry.

STATEMENT OF THE PROBLEM

During evaluation of environmental data quality by application of the PARCC parameters, *i.e.* precision, accuracy, representativeness, completeness and comparability, the criterion of *representativeness* is often overlooked or misunderstood. According to the U.S. Environmental Protection Agency (EPA), representativeness is "the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition".[1] Representativeness is a qualitative parameter that depends on proper design of the sampling program.[2,3] The planners of remedial investigations/feasibility studies (RI/FS) often understood this criterion as narrowly relating only to parameter variation at a sampling point, and placed more emphasis on accuracy, precision and completeness of chemical data.

The data may be accurate, precise and complete, but if they are not representative of site conditions, they become useless or even financially damaging. Principal reasons for underestimating or overestimating the extent of contamination that usually originate from improper sampling and analysis design are as follows:

- non-representative samples analyzed for the correct contaminants
- representative samples analyzed for the incorrect contaminants
- non-representative samples analyzed for the incorrect contaminants

All three situations present a distorted view of the site under investigation and are equally useless for planning remediation activities.

In spite of the fact that over the years the environmental industry has accumulated significant experience in RI/FS, a review of the RI/FS reports shows that in the past environmental consultants had a poor understanding of, or ignored, the Data Quality Objective (DQO) process.[4,5] In their work plans, RI/FS firms adhered to strict analytical protocols and data validation to achieve the goals for the data quality indicators instead of focusing on the overall project objectives and the means to fulfill them, such as:

- understanding the intended use of the data
- using screening techniques
- developing representative sampling designs
- statistically evaluating the collected data

During contract negotiations they were forced to reduce the number of samples and sampling locations, while substituting the required-analyses with less expensive and thoroughly irrelevant tests. In one instance in 1996, the previous SI studies had indicated that the site was contaminated with selected semivolatile organic contaminants as determined using EPA Method SW8270 [Gas Chromatography/Mass Spectrometry (GC/MS)]. During Phase II of the same investigation, budget cuts reduced the number of samples from a projected 200 to 39, and substituted the non-selective Diesel Range Organics (SW 8015 Modified) for EPA Method SW 8270.

During budget negotiations Quality Assurance/Quality Control (QA/QC) was the preferred target of "reduction in scope" cutbacks by the project managers and contracting personnel of the negotiating parties. It is obvious that many of the sampling and analyses plans were prepared by engineers and geologists without chemist's participation. Chemists who validated the data did not take part in project planning or execution and did not assist in the interpretation of the data for project decisions.

During review of the project work plans, regulatory agencies often compromised to get at least some work done in a "better than nothing" attitude. Reductions in the comprehensiveness of the field investigation, based on budgetary considerations, schedule-driven approval of incomplete plans, superficial or protocol-oriented reviews by technically unqualified agency personnel, all come back to haunt the stakeholders at remediation time.

CASE STUDIES

The following case studies clearly illustrate the need for more effective site characterization sampling and analysis approach that will generate representative and usable chemical data.

Case Study 1. Pesticide Shop at a Former US Military Installation

Investigation

A small building has been used to store, mix and dispense pesticides for mosquito control. During site investigation, the RI contractor collected four judgment surface samples for Contract Laboratory Program (CLP) organochlorine pesticides and polychlorinated biphenyl (PCB) analysis. The pesticides detected in the soil were *DDT* and *DDE* at concentrations ranging from *0.07 mg/kg to 2.6 mg/kg. Aroclor 1260* was also detected in one of the samples at a concentration of *1.7 mg/kg.* Based on these data, the RI contractor recommended removal and incineration of approximately *75 cubic yards* of contaminated surface soil. Site-specific cleanup levels were established as follows: *DDT* and *DDE* at a concentration of *1 mg/kg,* and *PCBs* at concentrations of *1 mg/kg* for the upper 4 feet of the subsurface and *25 mg/kg* for the soil at 4 feet below ground surface (bgs).

Remediation

In order to better define excavation boundaries, the remedial contractor conducted a thorough surface delineation at the site prior to excavation. A mobile laboratory operated by the remedial contractor developed and validated a screening analytical method for DDT and its metabolites. This screening method which was based on EPA Method SW 8080 with relaxed QC acceptability criteria, produced quantitative data of known quality. The PCB screening was conducted with immunoassay kits with the detection limits of 1 mg/kg and 25 mg/kg.

Due to the low mobility of the contaminants of concern in the subsurface and based on the history of site use, the remedial contractor selected the judgment sampling strategy. Sample locations were initially placed in the areas where the RI contractor detected elevated concentrations of contaminants. Further delineation proceeded laterally to the depth of 4 feet. A total of 60 samples were collected and screened for DDT and DDE. Table 1 summarizes the results of the DDT screening.

Table 1. Summary of DDT screening

DDT Concentrations	Number of samples collected at different depths			
	0.25 feet	2 feet	3 feet	4 feet
Below 1 mg/kg	14	11	4	4
Between 1 mg/kg and 10 mg/kg	12	4	None	None
Greater than 10 mg/kg	3	2	None	None
Maximum DDT concentrations at different depths, mg/kg				
	790	>60	0.2	0.73

The remedial contractor also screened for PCBs a total of 11 surface samples, that were collected from the area of previous PCB detection by the RI contractor. Five out of eleven surface samples had the *PCB concentrations above 1 mg/kg, and the concentrations of PCBs in three of these samples exceeded 25 mg/kg.* Four samples collected at the depth of 4 feet bgs did not contain PCB contamination above the concentration of 1 mg/kg.

Excavation of contaminated soil was guided by the results of screening analyses, with contaminated soil selectively removed from the "hot spot" areas until the cleanup levels had been reached. Confirmation analysis of 136 samples was conducted by an off-site laboratory that used the CLP analytical protocol. *Based on results of field screening, a total of 668 cubic yards of DDT and PCB contaminated soil were removed from the site, compared to 75 cubic yards originally estimated by the RI contractor.*

There were 10 sites at this military installation that were identified by the RI contractor as having limited surface contamination with organochlorine pesticides and PCBs. The RI contractor projected that a total of 735 cubic yards of contaminated soil would be removed from all sites and incinerated. Based on accurate contaminant delineation, the remedial contractor removed a total of 2,300 cubic yards of contaminated soil. The client reviewed the project budget and ruled out incineration as a disposal option due to prohibitively high costs for transportation and disposal. Instead, after conducting a treatability study, the remedial contractor carried out a more cost effective on-site stabilization treatment, followed by disposal at a local landfill.

<u>Case Study 2. A Former Landfill</u>

Investigation

Drums with hazardous waste were buried in a landfill. No records were kept to document the nature of the hazardous waste or the number of drums. In 1985, during Stage 1 site investigation, the RI contractor did not find any significant levels of contaminants at the site, and recommended additional investigation. In 1988 during Stage 2 investigation, another RI contractor conducted magnetic, electromagnetic and electrical resistivity surveys, a soil gas survey and placed 5 soil borings and one monitoring well at the site. Three soil boring samples contained *Total Petroleum Hydrocarbons* (TPH) concentrations of up to *6,700 mg/kg* and various concentrations of benzene, toluene, ethyl benzene and xylenes (BTEX). Shallow buried drums were also uncovered.

In 1993, another RI contractor conducted a Stage 3 site investigation which included the placement of 5 borings to 50 feet bgs, 1 boring to 100 feet bgs, with a total of 12 soil samples collected at various depths. Eight surface soil samples were also collected. All samples were analyzed for Volatile Organic Compounds (VOCs), pesticides, herbicides, Polynuclear Aromatic Hydrocarbons (PAH) and metals, and the data were validated. The only contaminants found in surface soil samples were *PCBs,* with the highest concentration of *54 mg/kg.* The RI contractor unearthed five drums with hazardous waste that contained trichloroethane (TCA) and PCBs. Results of soil boring samples analyses did not show elevated target analyte concentrations and were consistent with the background concentrations at the site.

Based on Stage 1, 2 and 3 site investigation reports, the RI contractor came to the following conclusions:

1. The number of drums remaining in the subsurface was estimated as 10-20. Later, after a second drum burial area was identified, this number was revised upward to 40-50.
2. The size of the drum burial pit was predicted to be 40 feet wide, 40 feet long and 10 feet deep.
3. The drums contained products with PCBs, and were the source of surface soil contamination.
4. The volume of PCB-contaminated soil to be excavated was estimated at 300 cubic yards.

Remediation

A non-time-critical removal action was planned for the site. Site-specific cleanup criteria were set up for PCBs and TCA, and the EPA Region IX Preliminary Remediation Goals (PRGs) for industrial soil served as the cleanup goals for an extensive list of target analyses.

In 1995, a remedial contractor conducted a trenching drum removal action at the site, during which *177 drums were removed.* Drum contents were composited and analyzed for disposal profiling. The *highest PCB* concentration found in the drum samples was *0.91 mg/kg.* The only other target analyses detected at elevated concentrations were the BTEX compounds. Thirty cubic yards of excavated soil were not contaminated with PCBs.

In 1996 another remedial contractor continued drum removal activities at the site. A total of *469 decomposed, leaking drums were removed from a pit which measured 100 feet in length, 55 feet in width and up to 14 feet in depth.* The contents of the drums were composited and characterized for disposal profiling. The major components of the drum contents were diesel fuel and waste oil. One out of eight composite samples had a concentration of *PCB at 2.3 mg/kg,* and five had *TCA* detected at concentrations ranging from *1 mg/kg to 1300 mg/kg.* Soil in some areas of the burial pit was grossly contaminated with diesel fuel and waste oil.

The last remedial contractor extensively characterized surface soil next to the drum pit by collecting 127 surface samples on a 20 foot square grid and screening them for PCBs with immunoassay kits. *As delineated by the site investigation data, the characterized area should have covered 13,200 square feet east of the excavation pit. The actual extent of surface area contamination to the north, east and south of the pit as determined by field screening was 51,000 square feet.* The vertical extent of PCB contamination was limited to the upper two feet of the subsurface. Contaminated soil was selectively removed, and a total of 520 cubic yards of PCB-contaminated soil were disposed of at a Toxic Substances Control Act (TSCA)-permitted facility.

DISCUSSION

Why did these situations happen? In our opinion, they took place because of an incorrect focus of the RI contractor on the accuracy and precision of data, instead of data representativeness.

Comparison of on-site screening results for the pesticide shop in Case Study 1 to the RI results showed a dramatic discrepancy in DDT concentrations. The R:1 contractor disputed the findings of the remedial contractor using the following arguments:

- The RI data were acquired according to the CLP protocols, followed by data validation, therefore, they must be correct.

- The on-site laboratory screening results were too high. Since they were not obtained by the CLP protocol, it was claimed-that they were likely to be incorrect.

To resolve the argument, homogenized split samples were analyzed by the on-site laboratory and an off-site laboratory. The obtained results were comparable, and the concentrations of DDT were in the range of 300 mg/kg.

Data sets obtained by the RI contractor and the remedial contractor were precise, accurate and legally defensible. However, due to inadequate sampling design, the data collected by the RI contractor, were not representative of the site conditions. In our experience, at DDT handling facilities one can expect sporadic distribution of DDT at shallow depths in the subsurface. Surface soil contamination is affected by wind, rain and human activities, and often does not reflect the true site conditions. This project would have benefited if more samples had been collected and screened during the RI phase. *Placing emphasis on expensive analytical protocols and data validation instead of focusing on the sampling design and the project DQOs lead to misleading conclusions on the site conditions and in the selection of remedial options.*

It was apparent that the sampling plans for the landfill project (Case Study 2) were prepared by geologists because the RI/FS report was more detailed in its geology than its chemistry, and the focus of the investigations was on vertical, instead of lateral site delineation. The three RI contractors, who were probably constrained by project budgets, collected a very limited number of samples from the site. No field screening for soil was conducted; instead, emphasis was on placement of expensive deep soil borings and data validation.

Discovery of shallow buried drums during Stage 2 investigation should have alerted the RI contractor to the fact that surface contamination from drum spillage and handling was a distinct possibility, and that more surface characterization would be beneficial. The presence of BTEX and TPH in the subsurface was an indicator that the drums most likely contained petroleum products. Nevertheless, the TPH analyses were not conducted during Stage 3 site investigation. Instead, the RI contractor used a more expensive PAH analysis to delineate the site, without considering the fact that only trace levels of selected PAH are present in refined petroleum products such as diesel fuel and waste oil.

The three site investigations did not provide nearly enough information for estimating the magnitude of the cleanup effort. Inadequate numbers of samples, improper sampling design and analyses provided an unrepresentative picture of the true site conditions. That is why the number of buried drums and the extent of surface soil contamination with PCBs came as a major surprise during removal actions. *The inability of the magnetic, electromagnetic and electrical resistivity surveys to distinguish between 10 and 500-600 steel drums buried at shallow depths makes one wonder if these techniques were properly applied or results were misinterpreted.*

SUMMARY

Remediation plans and projected costs of the remediation contractor are only as good as the conclusions of the latest RI/FS report at hand. Inadequate RI/FS work of the past resulted in a loss of time and money, and caused loss of confidence in the accuracy of future RI/FS projects. Preoccupation of RI/FS contractors with data validation and fear of screening and sample compositing to obtain more representative data are apparent. The prevalent problems as we see them are as follows:

1. In the past, RI/FS work has been driven by the protocol, and not the DQO process.

2. Many RI/FS firms use chemists only for the preparation of the contract-specific Quality Assurance Project Plans and data validation. Professional judgment of chemists has neither been valued nor solicited for data interpretation and preparation of sampling plans.

3. Budgetary considerations often put constraints on the numbers of samples and types of analyses, and therefore adversely affect the sampling design and sampling representativeness.

4. The use of "low bidder" laboratories, procured without the project chemist's recommendations, has been a damaging practice, and in the past it has produced a mountain of questionable data. The problem has been compounded by the management of subcontractor laboratories by non-chemist project personnel who were not knowledgeable in the areas of laboratory procedures and QA/QC protocols.

As an industry, we need to develop a better understanding of the DQO process and the intended use of the data. We can, perhaps, then convince the regulatory community that if the tenets of the old "CLP approach" are dropped, site investigations can be conducted in a more meaningful, productive and cost-effective manner.

New tools for RI/FS are available today, such as numerous EPA-approved field screening methods for a wide range of contaminants, new and innovative techniques, and performance-based analytical methods. Participation of experienced chemists in the development of the DQOs, in the preparation of the sampling and analysis plans, laboratory selection and oversight, and in the interpretation of data for the final report, all of these are paramount ingredients for a successful RI/FS project.

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