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# EPA Engineering Issue

## DATA GAPS IN REMEDIAL DESIGN

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The Regional Superfund Engineering Forum is a group of EPA professionals, representing EPA's Regional Superfund Offices, committed to the identification and resolution of engineering issues impacting the remediation of Superfund sites. The Forum is supported by and advises the Superfund Technical Support Project.

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### Introduction

As the number of Superfund sites in the phases of Remedial Design (RD) and Remedial Action (RA) has grown, we have become increasingly aware of the adverse effects of inadequate or insufficient design data. This paper is intended for use by RPMs as a checklist or reminder to consider certain aspects of RD/RA data needs as early as possible in the life of a Superfund site. Most of the items have been gleaned from the collective memory of EPA and USACE personnel who have learned some of the lessons the hard way.

The items addressed include:

- types of data where quality or quantity is most often found to be inadequate or have the greatest effect on successful RD and RA;
- examples of why these data are needed;
- data needs for particular remediation features;

Many design problems causing schedule slippage or cost overruns in either RD or RA can be attributed to site characterization data that are not sufficient for purposes of design. (No attempt is made in this paper to address potential inadequacies in *interpretation* of the site characterization data.) These data gaps affect not only highly technological treatment processes but also the more mundane aspects of remediation such as caps and liners.

Technical work during the RI/FS phase has typically been considered the province of scientists whereas engineers are given the functional lead during RD/RA. The engineers have not always been requested to provide significant input during RI/FS. Similarly, the scientists have often not been made available during RD/RA. Consequently, some RODs or settlement agreements have dictated remedies that are only marginally appropriate or not effective at all, much more costly than anticipated, or virtually impossible to implement.

The RPM should consider that a broad-spectrum technical assistance team is a key aspect to successful management of the site from beginning to end. Under ideal circumstances, this team should consist of members from organizations other than the contractors used by Superfund. The starting point is the Regional Engineering Forum representative and other Regional technical specialists, such as the Technical Support Sections formed by some Regions or experienced RPMs, who can participate in the peer review process. Other resources include the Technical Support Centers (under the auspices of the OSWER Technology

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(under the auspices of the OSWER Technology Innovation Office Support Project), U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, U.S. Bureau of Mines, state agencies, and so forth.

It should be noted that typically design engineers are accustomed to working from a clearly defined problem. Unfortunately, most subsurface and ground water contamination sites lack the degree of site characterization needed to clearly define the design at the beginning of the RD phase. Therefore, it is important that the scientific disciplines be available throughout the entire RD/RA period to further define site conditions and provide interpretations for the engineer. This will help assure an expeditious and satisfactory implementation of the design.

A few examples of problems associated with incomplete site characterization data follow:

1. Soils properties and handling characteristics are often poorly evaluated or even ignored when considering various remediation technologies which require materials excavation and processing.

2. Volatile emissions during excavation and handling of contaminated soils are often not anticipated.

3. Lack of information on temporal and spatial variations in contaminant loading in ground water remediation decisions can lead to inefficient designs.

4. No pre-ROD consideration of availability of utilities resulting in underestimation of costs or schedule.

5. Poor understanding of the permeability of slurry wall key layer leading to unacceptable leakage.

6. Ground water treatment processes which focus on the contaminants of interest but ignore total ground water chemistry, especially the anions and cations present, will impact the effectiveness of the treatment process.

7. Solvent extraction of explosives from soil is feasible, however, the unrecognized instability of the residue can be disastrous.

8. Cap designs which utilize the cost-effectiveness of geosynthetics but require slopes on which geosynthetics are not stable or caps which require the use of low permeability clays but don't evaluate the availability of suitable clay borrow material can be impractical to construct or very costly.

9. Excavation limits may be defined based on chemical analysis of bore hole samples and not account for contaminant migration along secondary pathways, *e.g.*, root holes. Trenching and careful inspection and sampling may alleviate this problem.

10. The presence of debris or boulders may not be recognized or fully appreciated during the analysis of remedial alternatives if bore holes alone are used to investigate the limits of waste.

The term geochemical is used rather than the more narrow chemical term in order to emphasize the importance of understanding the chemical processes operating in the geological environment in order to implement effective remediations. The importance of quality analytical chemistry is already well understood and appreciated; however, our understanding of ongoing chemical processes needs improvement. The following paragraphs identify some commonly overlooked data requirements and include examples of problems resulting from the data gaps.

***Site Data*** needs are often overlooked in the pre-ROD/consent decree phase and even well into design. Unforeseen cost increases, time delays, and contract modifications can and do result. Some common data needs include:

1. Topographic Surveys - The need should be readily apparent, however, this aspect is often overlooked. In some instances, available general topographic mapping is used without verification. Consequently during RA, excavation, fill overruns or underruns, or impossible site drainage are discovered, which require contract modifications. Property boundary surveys and adequate horizontal and vertical controls are also included in this category.

2. Utility Availability - Water, gas, power, and sewer services required for remedy implementation must be identified. In addition, leaking industrial sewer lines might be contamination sources and previously unidentified utility lines crossing a remediation site can cause contract shutdown pending their relocation or protection.

3. Borrow Availability - In most cases, site remediation, which includes earthwork, *e.g.*, liners, caps, slurry walls, etc., require the utilization of earth materials to effect the remediation when those materials are not available from required on-site excavation, they must be obtained elsewhere and are referred to as borrow. In some areas suitable borrow is scarce. The costs of trucking suitable materials from a distant borrow pit will added significant cost and transportation problems if not recognized. As an example, a 5-acre cap with an average thickness of 3 feet of soil, requires almost 25,000 cubic yards or approximately 1,400 truckloads of suitable earth borrow material. The availability of admixtures, such as fly ash, cement, and lime for stabilization also should be considered in this category.

4. Transportation Network - The proximity of suitable roadways and/or rail lines is important to remedies requiring the transportation of heavy equipment and earth materials into the site or contaminated or treated wastes from the site. Local opposition to frequent heavy truck traffic and damage to streets and roads, especially through residential areas, must be anticipated.

***Geochemical Data*** collection often can be improved to more confidently select effective remedies and better effect quality RD and RA. Some examples include:

1. Multiple Sampling Rounds - In too many cases, remediation decisions are made, which are based on single or poorly timed, multiple ground water sampling rounds. Time allowed for RD often doesn't provide for seasonal sampling. As a result, chemical loading may exceed treatment plant capability, the plant may be overdesigned, or the operating plan is not optimized to accommodate variations in loading.

2. Anion/Cation Analysis - These analyses are inexpensive, yet if they are overlooked in ROD preparation, the designed treatment train may be either more expensive than anticipated or ineffective if not detected during RD. Eh, pH, and TOC are other chemical parameters that must be considered for effective RD.

In addition, caution should be exercised when unusually high metals analyses are obtained from turbid ground water samples. If these analyses are used for treatment plant design, the design and cost estimates can be unrealistic. Total chemistry also impacts well design. Anion and cation precipitates will prematurely clog injection wells if not recognized and treated.

***Geotechnical Data*** must be gathered for many types of remedies, both for purposes directly related to the remedial process and for design auxiliary to the actual remedial process, such as building foundation design or excavations.

1. Soil Moisture Content - The natural moisture content of site soils, especially fine-grained soils, is valuable information both in the pre-ROD and RD phases. As examples, the moisture content of contaminated soil that will received thermal treatment affects fuel consumption, and the moisture content of a fine-grained foundation soil can be an indicator of the soils strength and consolidation characteristics.

2. Atterberg Limits - These parameters define the plasticity of fine-grained soils, give the geotechnical designer an early indication of the strength of that soil, especially when evaluated with moisture content, and can be an indicator of contaminated soil handling and processing characteristics. The test is relatively inexpensive but the results can be very useful.

3. Soil Strength Parameters - Generally not needed prior to the RD phase. Some design features requiring soil strength testing include structure or building foundations, significant excavations, dredging, and slurry wall trenches. Blow counts from Standard Penetration Tests can be used as an early indication of soil strength.

4. Gradations - Some representative gradations or particle size distribution analyses done in the RI/FS phase can be very helpful in estimating approximate permeability and for designing efficient monitoring wells. Gradations are required for the design of such things as collection drains and withdrawal wells and in evaluating soils handling and processing characteristics.

5. Excavatability - While there is no one test or set of tests to define this design parameter, evaluation and judgements should be made in the pre-ROD phases concerning excavatability when excavations of any kind are required in the remedy. Excavatabilty includes such factors as whether the material can be machine excavated, the necessity for blasting, the existence of boulders or cobbles, the need for dewatering, etc. None of the excavatability

factors should be minimized since all of them can greatly impact the final cost of remediation.

6. Landfill Subsidence - Remediations often include capping an existing landfill and perhaps incorporating a gas collection and venting system. Many such landfills are still subsiding with attendant surface disruption capable of adversely impacting the effectiveness of the cap and vent system. Carefully surveyed settlement data collected throughout the RI/FS phase are invaluable for remedy selection and to support design. Settlement data collection should continue through RD and RA and into the operations and maintenance phase if displacements are continuing and significant.

***Hydrogeological Data*** are routinely collected both during the RI/FS and RD phases. However, several aspects will be discussed that are sometimes slighted but can be very important to selection of an effective remedy and to proper design and implementation.

1. Multiple Water Levels - In order to understand the hydrogeological character of the site in sufficient detail to select an effective remedy, it is important that enough water levels be obtained to define both the vertical and horizontal flow directions seasonally and as they respond to both natural and manmade recharge and discharge. For example, at a ground water contamination site in the Plains States, the regional flow is severely distorted locally by irrigation pumping during several months of the year.

2. Detailed Stratigraphy - In too many cases, stratigraphic detail has not been well developed due to poor sample recovery often coupled with too infrequent sampling intervals, lack of geophysical logs, improper sampler selection, field geologists poorly trained in logging methods, or combinations of the above. Even relatively minor variations in lithology have a strong influence on contaminant migration and plume development. This is an important factor during pre-ROD, RD, RA, and even into the operation and maintenance phase of both ground water and vadose zone remediation.

3. Secondary Porosity Features - Joints, defoliation planes, bedding planes, root holes, etc., often strongly influence the overall gross permeability of bedrock materials and fine-grained soils, especially clays. In too many cases, these features are not targeted during site exploration or if they are, the vertical features are difficult to intercept and analyze. Careful consideration of these features is warranted during the RI/FS phase and remedy selection for problems such as contaminated bedrock aquifers, multiple stacked aquifers, and slurry walls keyed into an impermeable layer. For sites such as these, additional characterization also will be needed during RD.

The various types of site characterization data discussed in this paper are not needed or at least not to the same degree for all features of site remediation. The following remediation features were considered:

1. Withdrawal & injection wells
2. Internal drains
3. Slurry walls
4. Slurry wall key layer
5. Caps
6. Chemical stabilization
7. Ground Water treatment
8. Landfills
9. Thermal treatment
10. Soil washing
11. Excavations
12. Dredging
13. Vapor extraction

Table 1 presents a summary of site characterization data determined to be useful or needed for remediation. The table also suggests in which phase or phases of the remediation process it is advantages to acquire the data.

Table 1. Site Characterization Data needed for Remediation

| | | REMEDIATION FEATURE | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DATA | Withdrawl & Injection Wells | Internal Drains | Slurry Walls | Slurry Wall Key Layer | Caps | Chemical Stabilization | Ground Water Treatment | Landfills | Thermal Treatment | Soil Washing | Excavation | Dredging | Vapor Extraction |
| Site Data | Topographic Surveys | 1 | 1,3 | 1,3 | 1,3 | 1,3 | | 1 | 1,3 | 1 | 1 | 1,3 | 1,3,4 | 1 |
| | Utility Availability | 1 | 1 | 1 | | | | 1 | | 1 | 1 | | | 1 |
| Geochemical Data | Borrow Availability | | 2 | 2 | | 1 | | | 1 | | | | | |
| | Transportation Network | | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Multiple Sampling Rounds | 1,3,4 | 1,4 | 1,4 | 1 | | | 1,3,4 | | | | | | 1,3,4 |
| | Anion/Cation Analysis | 1,3,4 | 1,4 | 1 | 1 | | | 1,3,4 | | | | | | |
| Geotechnical Data | Soil Moisture Content | | 1 | 1,3 | 1 | 2,3 | 1,3 | | 1,3 | 1,3 | 1,3 | 1,3 | 1,3 | 1,3,4 |
| | Atterberg Limits | 1 | 1,3 | 1,3 | 1,3 | 2,3 | 1,3 | | 1,3 | 1 | 1 | 1 | 1 | 1 |
| | Soil Strength Parameters | | 2 | 2 | | 2,3 | | 2 | 2 | 2 | 2 | 2,3 | 2 | |
| | Gradations | 1,3 | 1,3 | 1,3 | 1,3 | 1,3 | 1 | | 2,3 | 1 | 1 | 1 | 1 | 1 |
| | Excavatability | | 1 | 1 | 1 | | 1 | | | 1 | 1 | 1 | 1 | |
| Hydrogeological Data | Landfill Settlement | | 1,3 | 1,3 | | 1,3,4 | | | | | | | | |
| | Multiple Water Levels | 1,3,4 | 1,3 | 1,3,4 | 1,4 | 1 | 1,3 | | 1,3,4 | 1 | 1 | 1,3 | | 1,3,4 |
| | Detailed Stratigraphy | 1 | 1,3 | 1 | 1,3 | | 1 | | 1 | | | 1,3 | 1 | 1 |
| | Secondary Porosity Features | 1,3 | 1,3 | 1,3 | 1,3 | | | | 1,3 | | | 1,3 | | 1 |

Recommended Times to Collect Data

1. Limited data in RF/FS phase, greater amount in RD
2. Data collection begins in RD
3. During RA
4. During operation and maintenance