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Cost Estimating Tools and Resources for Addressing Sites Under the Brownfields Initiative

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Technology Transfer and Support Division
National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, OH 45268

Foreword

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for reducing risks from threats to human health and the environment. The focus of the Laboratory's research program is on methods for the prevention and control of pollution to air, land, water and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites and groundwater; and prevention and control of indoor air pollution. The goal of this research effort is to catalyze development and implementation of innovative, cost-effective environmental technologies; develop scientific and engineering information needed by EPA to support regulatory and policy decisions; and provide technical support and information transfer to ensure effective implementation of environmental regulations and strategies.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

E. Timothy Oppelt, Director
National Risk Management Research Laboratory

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Introduction

Background

Many communities across the country contain brownfields sites, which are abandoned, idle, and under-used industrial and commercial facilities, where expansion or redevelopment is complicated by real or perceived environmental contamination. Concerns about liability, cost, and potential health risks associated with brownfields sites often prompt businesses to migrate to "greenfields" outside the city. Left behind are communities burdened with environmental contamination, declining property values, and increased unemployment. The U.S. Environmental Protection Agency's (EPA's) Brownfields Economic Redevelopment Initiative was established to empower states, site planners, and other community stakeholders to work together in a timely manner to prevent, assess, safely clean up, and sustainably reuse brownfields sites. (EPA Brownfields homepage at *http://www.epa.gov/brownfields)*

The cornerstone of EPA's Brownfields Initiative is its Pilot Program. Under this program, EPA is funding more than 200 brownfields assessment pilot projects in states, cities, towns, counties, and tribes across the country. The pilot projects, each funded at up to $200,000 over two years, bring together community groups, investors, lenders, developers, and other affected parties to address the issues associated with assessing and cleaning up contaminated brownfields sites and returning them to appropriate, productive use. In addition to the hundreds of brownfields sites being addressed by these projects, over 40 states have established brownfields programs.

Purpose

EPA has developed a series of guides, including this document, to help communities, states, municipalities, and the private sector more effectively address brownfields sites. The other guides in this series contain information on characterizing and cleaning up different types of brownfields sites (classified according to former industrial use). This guide contains information on cost-estimating tools and resources for addressing cleanup costs at brownfields sites and is designed to be used in conjunction with the other guides in the series. Brownfields decision-makers may need to estimate the cost of cleanup to determine if the site is a viable candidate for redevelopment or to evaluate proposals from potential cleanup contractors. Thus, the purpose of this document is to provide information about the cost-estimating process and the specific cost-estimating tools and resources available. Generally, two key factors affecting costs are the type and nature of the contamination present and the intended future use of the site. These will dictate to a large extent the appropriate cleanup methods that should be implemented.

Many planners, developers, and other brownfields decision-makers may choose to use consultants who are experienced in hazardous waste site cleanups to prepare cost estimates at brownfields sites. However, it is useful for a planner/developer to be able to provide guidance to individuals performing the cost estimate and to have enough knowledge to provide an informed review of proposed cost estimates. The guidance and resources described in this document are based on cost information obtained from hundreds of cleanup projects.

The guide provides general information on the cost-estimation process, including summaries of different types of cost estimates. The guide also outlines the process for developing "order of magnitude" cost estimates. Descriptions of specific cost-estimating information sources, databases, and models are provided.

timates generally prepared for projects include the order of magnitude estimate, the budget estimate, and the definitive estimate. These estimates are used during different stages of a project with increasing levels of accuracy, as shown in Figure 1.

Figure 1 plots the three types of estimates against the expected accuracy of the estimate, based on the amount of information typically available to the cost estimator at certain stages of the project. For example, an order of magnitude estimate typically has the largest margin of error because it is performed in the initial stages of a project when only relatively little information is known. Conversely, a definitive estimate typically has a smaller margin of error because it is performed at a later stage of a project when presumably most of the needed information is known. The percentages provided in the descriptions of the three estimates below offer an indication of how much the final actual costs can vary from those using each type of estimate.

Order of Magnitude Estimate

For an order of magnitude estimate, historical costs for similar types of projects are often used to calculate a "ballpark" figure for the project. An order of magnitude estimate is completed at the initial stages of a cleanup, when minimal information is available. The cost of a project at this stage is frequently estimated by multiplying the number of "units" of a particular type of contamination (e.g., the number of cubic feet of contaminated sludge) by a pre-established cost for cleanup per unit (e.g., dollars per cubic foot) using a particular technology. An order of magnitude estimate is expected to be between +50% and -30% of the actual cost of the project.

Budget Estimate

The budget estimate is prepared during the intermediate stages of the planning process. A higher level of accuracy is expected than that achieved with the order of magnitude estimate because more project-specific information is known. A budget estimate assesses the cost of each project component to compute an estimated total project cost. Several activities and cost items are grouped into a "system" that relates to the phase of cleanup. These systems are generally listed in the order in which they are employed in the cleanup. Budget estimates are sometimes referred to as assemblies or systems estimates. A budget estimate is expected to be between +30% and -15% of the actual cost of the project.

Definitive Estimate

A detailed cleanup plan design is required to produce a definitive estimate. This type of estimate is typically conducted once site characterization and/or a substantial portion of the design is completed. A definitive estimate is normally prepared by multiplying the quantity of each item needed by its unit price, and summing the line item totals. Developing a definitive estimate is time-consuming, but it is generally more accurate than other estimates because more is known about the site. Definitive estimates are sometimes referred to as unit price, quantity take-

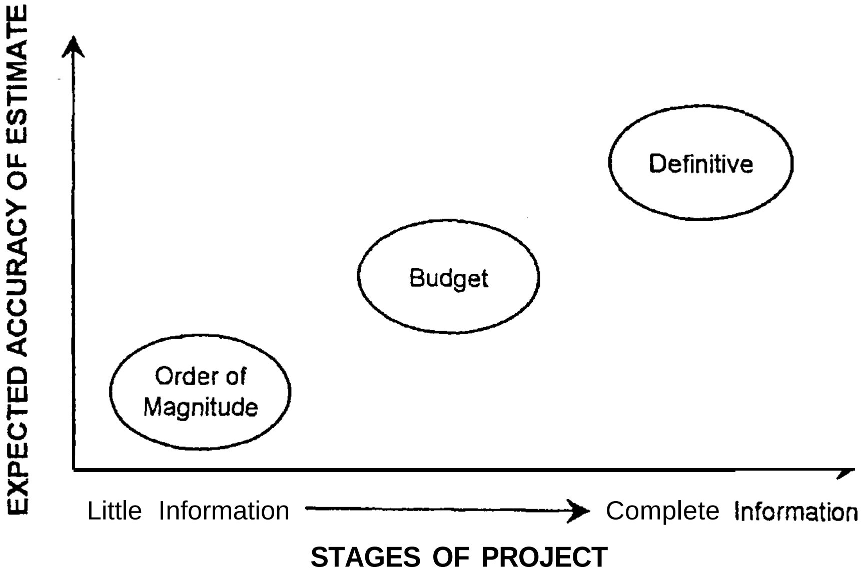

Figure 1. When an order of magnitude estimate is developed in a brownfields project.

Notice

The U.S. Environmental Protection Agency through its Office of Research and Development funded and managed the research described here under Contract No. 68-D7-0001 to the Eastern Research Group (ERG). It has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

off, or bottom-up estimates. It is expected that the definitive estimate will be between +15% and -5% of the actual cost of the project.

How Reliable is a Cost Estimate

It can be difficult to develop a reliable cost estimate at the early stages of a site cleanup, yet this is the point at which a reliable estimate is most needed, particularly for brownfields projects. When considering whether or not it would be financially beneficial to redevelop a brownfields site, stakeholders must weigh the expected costs associated with cleanup against the projected market value of the property early in the process.

In general, cost estimates are more reliable when

- The cleanup project is relatively simple and straightforward in terms of the level of effort and resources required.
- The cleanup design is detailed and specific.
- The project has progressed to the point where most critical information is known.

A cost estimate is usually less reliable when a project is more complex, the cleanup design is not thoroughly developed, and the project is in its initial stages. This cost-estimating guide is designed to aid project managers evaluating a potential redevelopment site early in the process.

Chapter 2
Developing an Order of Magnitude Cost Estimate

This section contains information important to developing an order of magnitude estimate. Collecting information for the order of magnitude cost-estimation process can be broken down into five basic steps. These steps provide only a preliminary framework for developing an order of magnitude estimate. Planners should remember that site-specific factors must always be taken into consideration when evaluating the reliability of their estimate.

The order of magnitude estimate is a preliminary cost estimate and planners should not expect that estimated costs will equal actual costs. The purpose of the estimate at this early stage of the project is to mitigate, not eliminate, the cost uncertainty associated with most cleanup actions and to screen potential brownfields sites for redevelopment. Figure 2 represents where the order of magnitude estimate occurs in the brownfields cleanup and redevelopment process and how it contributes to the decision-making process.

Steps to Organize Cost Information

Planners can use the five steps described below to organize information for an order of magnitude cost estimate for brownfields projects. Information gathered from historical site data, a visual site inspection, and preliminary site assessment data (as available) is used. The steps are outlined in Table 1.

Step 1: Define the Contamination Issues and Cleanup Objectives

Succinctly define the contamination problems that need to be addressed at the site. Identify each contamination issue and corresponding cleanup objective (e.g., preventing direct contact by people with contaminated soil; controlling surface water runoff; preventing contact with harmful building materials). This helps the planner organize the entire project into separate components to facilitate cost-estimate preparation.

BROWNFIELDS COST/BENEFIT DECISION PROCESS

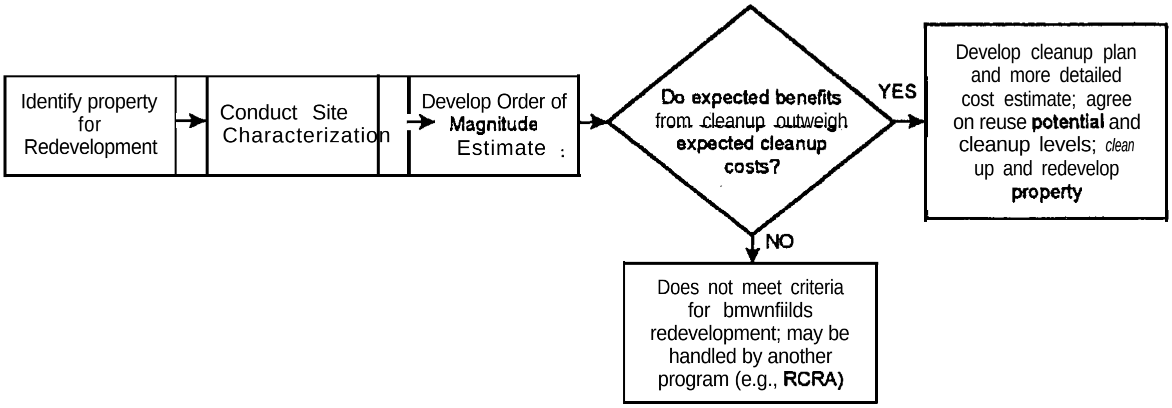

Figure 2. Expected accuracy of different types of cost estimates at different stages.

Table 1. Steps to Organize Cost Information

Step 1	Step 2		Step 3	Step 4	Step 5
Contamination Issues and Cleanup Objectives	Critical Parameters		Impact of Unknown Parameters	Cleanup Alternatives	Estimated cost
	Known	Unknown			

Step 2: Iden tify Critical Parameters of Contamination Issues

For each contamination issue, identify the critical known and unknown parameters that will affect the cost. Parameters that should be evaluated are those that have significant potential to drive costs and may include contaminant concentration levels, the extent of contamination, the volume of contaminated media, anticipated future site use, required cleanup levels, and hydrogeological conditions.

Step 3: Cite Potential Impact of Unknown Parameters

Determine the extent to which the unknown parameters have the potential to impact the total cost of the project. Uncertainty levels associated with critical parameters should be described. if the potentiai impact of these unknown parameters is substantial, a large contingency should be included in the estimate.

Step 4: Identify Cleanup Alternatives

Review the contamination issues and identify cleanup alternatives. For some issues, such as tank removal, there are few options. For others, there may be a number of options and planners should seek advice from knowledgeable professionals to determine (1) conditions which may affect the technology's anticipated performance, and (2) the factors about which regulators are likely to have concerns. Several databases and models, which are discussed later in this guide, can be used as sources of information for identifying alternatives.

Step 5: Determine Cost of Each Cleanup Alternative and Compare Costs

Planners can use the cost information and models described later in this guide and talk with qualified cleanup professionals to obtain cost data on the various cleanup alternatives. In general, the extent of needed site characterization, the cleanup technologies used and the completion schedule will drive the cost of addressing each contamination issue. Both initial cleanup and operation and maintenance (O&M) costs should be included. Examples of common costs include site preparation work, soil excavation, site restoration, and sampling and analysis. For each major activity, estimate unit costs for each alternative (which can be done using unit price books, cost databases, or software tools described later in this guide). Compare the costs of the alternatives to determine which are feasible to implement. If a cleanup technology or treatment is selected that requires ongoing operation and maintenance (e.g., pumping; monitoring groundwater quality over time), consideration should be given to how many years the cost estimate should be carried into the future and what discount rate should be used.

Appendix A presents a case study of how cleanup costs were estimated for a brownfields site in New Orleans, Louisiana. This case study illustrates some of the guidance provided in this document and shows how some of the software described later can be used.

Planners may find it useful to organize the information gathered during the steps described above into an easy-to-read table like that shown in Table 1. Such a table organizes critical project data and facilitates development of cost estimates.

and other resources with cost information relevant to brownfields sites.

For more information about CLU-IN, access CLU-IN on the Internet at *http://www.clu-in.org.*

Technology Focused Tools

These resources may provide more detailed information on costs associated with specific characterization and cleanup technologies.

Historical Cost-Analysis System (HCAS)

HCAS is an on-line database that provides information on 60 completed remedial projects that were conducted by different federal agencies. The information is useful for developing rough Order of Magnitude estimates through comparisons to similar projects. HCAS was developed by the Interagency Cost-Estimating Group for Hazardous, Toxic, and Radioactive Waste (HTRW-ICEG). HTRW-ICEG was formed in 1989 under the sponsorship of EPA and includes representatives from EPA, DOE, the U.S. Army Corps of Engineers, U.S. Navy, U.S. Air Force, and other federal agencies. HTRW-ICEG uses HCAS to collect and distribute environmental remediation cost data from public and private sources. HCAS is free to member agencies.

Users can quickly find analogous projects through an easy-to-use data query system based on the following five Category Codes:

- Waste Location (e.g., landfills, waste piles, groundwater)
- Technical Approach (e.g., on-site containment/collection, off-site treatment)
- Summary Level Work Breakdown Structure (e.g., site work, surface water collection and control)
- Contaminated Media (e.g., soil, sludge, water/other liquid)
- Waste Type (e.g., hazardous, hazardous and radioactive)

The HCAS database requires minimal input to extract useful data. HCAS does not normalize or manipulate data; it simply provides historical information that can be analyzed. It should be noted that the cost data in HCAS is historical and is not updated.

For more information about HCAS, contact

On the Internet
http://globe.lmi.org/lmi_hcas

or
Logistics Management Institute
2000 Corporate Ridge
McLean, VA 22102-7805
(703) 917-9800

Vendor Field Analytical and Characterization Technologies System (VendorFACTS) Web Site

The VendorFACTS web site contains information provided by over 90 vendors of innovative technologies for site and waste characterization. The system includes cost and performance data on more than 130 technologies for the detection and quantification of pollutants in air, soil, and water, as well as various screening technologies such as immunoassay kits. Some of the representative technologies listed in the system include air measurement equipment, analytical detectors, gas chromatographs, chemical reaction-based indicators, and soil gas analyzers. VendorFACTS is a Windows-based, menu-driven database that is available free of charge.

For more information about VendorFACTS, call the hotline at I-800-245-4505; or access VendorFACTS on the Internet at

http://www.clu-in.com/vfacts1.htm
or
http://www.prcemi.com/vfacts/

The Vendor Information System for Innovative Treatment Technologies (VISITT)

VISITT is a free, user-friendly database that provides data on almost 350 innovative technologies (70 percent of which are commercially available). VISITT provides cost and performance data and enables the user to build queries according to the conditions at a particular site by using several search criteria. Information in VISITT is provided directly by vendors and is not edited by EPA.

Several of the cost-estimating models discussed below are expensive, and users should be well-versed in the intricacies of both environmental remediation and cost modeling to use the models. Some vendors use their cost-estimation tools to provide customers with an estimate for a fee.

The Remedial Action Cost Engineering and Requirements System (RACER)

RACER is a parametric budget estimating system that uses over 100 cost models to estimate the costs of 15 "typical" Air Force cleanup projects. The 15 projects are complex and have numerous components, and therefore use several different cost models to compute a project estimate. The cost models are based on generic engineering solutions derived from historic project information, government laboratories, vendors, contractors, and engineering analysis. RACER was designed to produce estimates at early phases of cleanup projects when limited site information is available. It also produces progressively more detailed and defensible estimates at each subsequent phase of a project. It is designed to provide preliminary estimates for cleanups, after contaminants and concentrations have been identified. RACER does not identify the remedy needed at a site; rather, it is used after the remedy, technology, and site approach decisions have been made, enabling users to model multiple treatment trains to find the most cost-effective solution.

RACER is an engineering design-based model that uses algorithms in its methodology. The user inputs all known project parameters, as prompted by the system (e.g., volume of contaminated material, levels and types of contaminants, site dimensions, well depth and diameter). Using information from a historical database of similar projects, the system provides "default" values for any input parameters that are unknown but necessary to generate the estimate. RACER's algorithms then produce a design and generate a cost estimate. RACER can also provide an estimated cost range that plots the potential cost values with their probabilities of occurrence. Federal agencies can use RACER at no cost. RACER is sometimes referred to as RACER/ENVEST.

RACER was developed by Delta Research Corporation under contract to the Air Force Civil Engineering Support Agency. It is now distributed and supported by Talisman Partners Ltd. For more information about RACER, contact

Talisman Partners Ltd.
5460 South Quebec Street, Suite 100
Englewood, CO 80111
(303) 771-3103

TANK RACER

TANK RACER is a variation of RACER that provides cost estimates for cleanups at underground storage tank (UST) sites. Produced through an interagency agreement between the U.S. Air Force and EPA, it is distributed by Talisman Partners Ltd. TANK RACER is Windows-based software customized to address smaller Underground Storage Tank (UST) sites (e.g., filling stations). It estimates costs for all phases of UST remediation, including site assessment, tank closure, remedial design, remedial action, site work and utilities, and operations and maintenance. TANK RACER is able to estimate costs for alternative technologies including air sparging, soil vapor extraction, bioventing, groundwater extraction wells, landfarming, thermal desorption, bioremediation, and natural attenuation.

Users enter unit costs into TANK RACER's database to generate tailored, location-specific cost estimates. Unlike other models in which certain cost information cannot be altered, TANK RACER provides great flexibility by allowing the user to change all default parameters used in calculating the total cost, including default quantities and unit costs. TANK RACER training should be considered prior to using the software.

For more information about TANK RACER, contact

Talisman Partners Ltd.
5460 South Quebec Street, Suite 100
Englewood, CO 80111
(303) 771-3103

Success and Cost-To-Complete Environmental Cost-Estimating System (CTC)

U.S. Cost, Inc., has developed two cost-estimating tools that may be applicable to brownfields sites, Success and CTC. Success is a Windows-based package that uses the RACER algorithms also known as "RACER 2". Unlike RACER, Success allows the user to view its algorithms and alter equations and calculations if a specific project warrants it (the user should understand the implications of the changes being made). Success uses eight major decision-tree models to create treatment train scenarios and select appropriate treatment technologies. This package also determines the dollar amount based on the quantities cleaned up at each node of the decision tree and totals the amounts of all nodes to develop the overall cost estimate. Much like a blank electronic spreadsheet, Success must be attached to a database to generate useful information. This software supports most commercial databases, including the R.S. Means and Richardson Engineering databases. Success can be used at the beginning of a project to generate preplanning estimates and at later stages of a project to generate quantity take-off estimates.

Under contract to the U.S. Navy, U.S. Cost, Inc., customized Success to develop CTC, which is used as the environmental estimating model in "cost-to-complete" exercises for Navy and Army cleanup sites worldwide. The CTC model uses historical data from the Navy database as needed.

U.S. Cost, Inc., sells the Success software; CTC is generally not available to non-government users, but the data set associated with it can be obtained at no charge from the U.S. Department of the Navy.

For more information about Success and/or CTC, contact

On the Internet
http://www.uscost.com

or
U.S. Cost, Inc.
One Premier Plaza, Suite 850
5605 Glenridge Drive
Atlanta, GA 30342
(800) 955-1385 or (404) 252-1385

Unique Services

These resources provide specialized services such as case studies, cost-contingency information, and probability estimates. Other specialized services may also be available; check EPA's home page on the Internet for additional services.

Cost and Performance Reports (Case Studies)

Cost and Performance Reports are standard case study reports prepared by member agencies of the Federal Remediation Technologies Roundtable (FRTR). FRTR member agencies, including the EPA, DOD, and DOE, have developed and abstracted 37 case studies of site remediation projects. The case studies present cost and performance information for full-scale remediation efforts and several large-scale demonstration projects. They were prepared retrospectively, based on information and interviews with project personnel. The reports contain information on the site, contaminants and media treated, technology used, the technology vendor, a summary of cost and performance data, and points of contact.

Individual case study reports are organized by technology into a four-volume set, Bioremediation; Groundwater Treatment; Soil Vapor Extraction; and Thermal Desorption, Soil Washing, and *In Situ* Vitrification. A fifth guide, entitled Abstracts of Remediation Case Studies, presents abstracts of all case studies in easy-to-read tables and short descriptions. Review of the case study abstract tables can identify those projects that are applicable to a particular brownfields project. Planners can then refer to a particular guide in the four-volume set for more detailed information. The case studies show unit costs for some projects and identify which key factors potentially affect project cost. Where possible, costs are specified as pre-treatment costs, post-treatment costs, and actual treatment costs. It is important to note that several projects in the case study series represent early applications of technologies, and therefore the costs for using these technologies may change in the future as firms gain experience with design and operation.

For more information about the Cost and Performance Reports, contact

On the Internet
http://www.clu-in.com/
or
http://www.frtr.gov

or
National Technical Information Service
(NTIS) Sales

5285 Port Royal Road
Springfield, VA 22161
(800) 553-NTIS (6847)
(703) 605-6900 (fax)

HazRisk

HazRisk is a cost-estimating system developed by Independent Project Analysis, Inc., that predicts how accurate a cost estimate is. The three main components of HazRisk are cost estimating, remediation scheduling, and contingency analysis; it contains data from more than 500 environmental remediation projects conducted by DOE, EPA, the U.S. Army Corps of Engineers, and numerous private companies. Approximately 50 percent of the projects in the database are government-managed. The U.S. Army Corps of Engineers uses the contingency analysis portion of the HazRisk model for all other environmental remediation projects such as underground tank removals; this component of the system may also be useful when developing brownfields cost estimates.

To use HazRisk's cost contingency analysis component, users enter project and site information and select a confidence level of 10, 25, 50, 75, or 90 percent. The confidence level represents the degree of certainty that the actual cost will not exceed the system's cost estimate. For example, choosing a confidence level of 90 percent means that there would be only a 10 percent chance that the actual remedial action cost would exceed the estimated cost. From this information, HazRisk uses probability and statistical methods to compare project information and cost items from a remedial action to its database. Using a contingency allocation model, HazRisk then presents findings that show the probability of cost growth versus contingency percentage. HazRisk can be obtained at a cost.

For more information about HazRisk, contact

Independent Project Analysis, Inc.
1150 Sunset Hills Road, Suite 300
Reston, VA 22090
(703) 709-0777

SmartSampling

The U.S. Department of Energy (Sandia National Laboratories and Oak Ridge National Laboratory) has developed a risk-based method for analyzing site characterization data to maximize cleanup effectiveness at the lowest cost. To evaluate alternative cleanup designs, SmartSampling uses geostatistics and probability-mapping techniques to generate maps and cost curves. The probability maps depict the likelihood of a contaminant level exceeding a targeted value (action level). The maps also include quantitative descriptions of uncertainty. Mapping of probability estimates can assist in identifying the most cost-effective alternatives for cleanup design and quantifying the risks associated with each alternative. The user must input sampling data, action levels that represent acceptable human health risk levels, and costs of cleanup alternatives. Cleanup costs are compared for each identified action level. In addition, SmartSampling can help determine optimal locations for additional samples that may reduce actual remediation costs and reduce the risk that undetected contamination is left in place. The method has been demonstrated on several projects since 1992 and is ready for large-scale deployment.

For more information about SmartSampling, contact

Sandia National Laboratories, (505) 845-0011, or
Oak Ridge National Laboratory, (423) 576-1555

Preliminary Estimate of Remediation Costs Service (PERCS)

Talisman Partners Ltd. uses RACER to provide the PERCS estimating service to parties who need to estimate potential remediation costs and liabilities. Users complete several forms providing information about the site, including prior and current use, soil and groundwater conditions, precipitation, and contaminant information; a sketch plan of the site; a typical boring log of the site; and test results showing contaminant concentrations. Talisman Partners Ltd. processes this information and uses it to understand the site characteristics and nature of the remediation project, and to select the treatment train and sampling and analysis efforts required to remediate the site. Talisman Partners Ltd. then uses RACER to develop a preliminary cost estimate. The user receives the PERCS Estimate Summary Report, which includes a technical and cost summary and detailed estimates of the capital and operations and maintenance costs for the installation and operation of the remedial treatment train.

For more information about PERCS, contact

Talisman Partners Ltd.
5460 South Quebec Street, Suite 100
Englewood, CO 80111
(303) 771-3103

Chapter 4
Conclusion

Brownfields redevelopment contributes to the revitalization of communities across the U.S. Reuse of these abandoned, contaminated sites spurs economic growth, builds community pride, protects public health, and helps maintain our nation's "greenfields," often at a relatively low cost. This document contains information on cost-estimating tools and resources for addressing cleanup costs at brownfields sites and is designed to be used in conjunction with other guidances and references. Obtaining an estimate of the cost to cleanup brownfields sites is an important component of the overall decision making process for planners. This document has been prepared to present different types of cost estimates: an Order of Magnitude Estimate, a Budget Estimate and a Definitive Estimate. These types of estimates are developed at different stages of a project and are intended to result in increasing levels of certainty of the ultimate cost. Cost-estimating information, models and services are also described. The cost of cleaning up a site will be determined by the accuracy of site assessment data and the cleanup goals which are based on expected future use of the site.

Appendix A
Example of Cost Estimate: Powers Junction

Introduction

This appendix presents an example of a brownfields cleanup cost estimation. The information in this appendix is excerpted from the report "Technical Assistance for Sampling and Analytical Support; Powers Junction Brownfield Site, New Orleans, Louisiana; Brownfield Assessment and Recommendations Report" prepared for the Region 6 Office of the U.S. Environmental Protection Agency in Dallas, Texas, by PRC Environmental Management, Inc., received under Work Assignment No. 008-AN-SP-0600, under Response Action Contract (RAC) No. 68-W6-0037. Some of the information was edited for the purposes of this guide.

A) Site Description and History

The U.S. Environmental Protection Agency (EPA) designated the Powers Junction site as a pilot project under its Brownfields Economic Redevelopment Initiative. The Powers Junction site is located at 19001 Chef Menteur Highway, New Orleans, LA. The 3-acre site is composed of several parcels, with the largest parcel having dimensions of 388 feet by 350 feet by 624 feet. The privately-owned site is surrounded by the Bayou Sauvage National Wildlife Refuge. Until the early 1970s, a truck stop and service station were operated at the site. From the early 1970s to 1995, a truck repair facility was operated at the site. According to local U.S. Fish and Wildlife Service (FWS) representatives, some maintenance activities associated with the former truck repair facility were conducted in the northeast sector of the site, next to a former motel.

PRC Environmental Management, Inc., (PRC) served as the environmental contractor on the site. PRC performed sampling and analytical services at the Powers Junction brownfield site during February 1997. The purposes of the sampling and analytical work were to (1) determine whether contaminants are present at the site, and (2) if they are present, determine the locations, levels, and extent of contamination.

Current Site Conditions (as of October 31, 1997)

The former truck stop and service station building (which is the only remaining permanent structure onsite) and a small inhabited mobile trailer are on the site. A concrete foundation is all that remains of a recently demolished motel. Seven underground storage tanks (USTs) are located at the site. Four gasoline USTs are located in the fueling area in front of, and south of, the existing building. A 4-inch-thick concrete pad covers the surface of the front fueling area. Three diesel fuel USTs are located behind, and north of, the existing building. Gravel and shell cover the surface of the rear fueling area. Surface soil (0 to 2 feet below ground surface [bgs]) characteristics varied horizontally and vertically at the site. The southern half of the site, where most of the fueling operations were conducted, consisted of (1) gravelly fill mixed with sand, shell, and some asphalt from 0 to 1 foot bgs, and (2) a grey silty clay mixed with sand and gravel from 1 to 2 feet bgs. The northern half of the site consisted of (1) a grey sandy clay mixed with shell and organic material near the surface, and (2) an olive brown to gray clay from 1 to 2 feet bgs. According to local FWS officials, the water table is at about 4 feet bgs at the site, and local shallow groundwater flow is to the south and southeast. A surface water body, identified as a borrow canal, is located next to the site to the north.

B) Field Sampling Investigation

During the sampling investigation, PRC collected samples from the following: (1) surface and subsurface soil, (2) shallow water table, (3) USTs,

(4) borrow canal sediments, and (5) building materials from the existing building.

(7) Surface and Subsurface Soil Investigation

PRC conducted soil sampling at 28 of 30 probe locations for field analyses by using a sampling grid layout. A Geoprobe was used to probe at each intersection of the sampling grid. PRC conducted field analyses of each soil increment for the following parameters:

- Volatile organic compounds (VOC)
    - Benzene, toluene, ethylbenzene, xylenes (BTEX)
    - Methyl tertiary-butyl ether (MTBE)
    - 1,2,4-Trimethylbenzene and 1,3,5-trimethylbenzene
    - Total petroleum hydrocarbons (TPH) for gasoline (TPH-gasoline)
- Semivolatile organic compounds (SVOC)
    - Polynuclear aromatic hydrocarbons (PAH)
    - TPH for diesel fuel (TPH-diesel)
- Total metals

Field analysis for organics was conducted by using gas chromatography (GC). Field analysis for total metals was conducted by using X-ray fluorescence (XRF) spectrometry. Nine confirmatory split samples including one duplicate sample were collected at eight soil probe locations and shipped to Contract Laboratory Program (CLP) laboratories to compare field analytical results to CLP laboratory analytical results.

(2) Shallow Water Table Investigation

PRC collected a groundwater grab sample for field analysis to determine whether TPH fuels were present in the shallow water table.

(3) Borrow Canal Investigation

On February 21, 1997, PRC collected a sediment grab sample (designated C6-Sediment) from the shoreline of the borrow canal at a location east-northeast of Probe C6, for field analysis to determine whether site runoff had impacted the surface water body and potentially contaminated the sediments (Figure 3). Section 4.3 discusses the analytical results.

(4) Underground Storage Tanks (LIST) Investigation

PRC inspected the seven USTs through their fill ports (access ports) by using a water level indicator, Kolor Kut colormetric fuel gauging paste, and Sludge Judges PRC determined that each of the four gasoline USTs was a 3000-gallon horizontal tank, 18 feet long and 64 inches in diameter. PRC collected a grab sample from one of the gasoline USTs for field GC analysis to confirm the presence of TPH fuels.

The three diesel fuel USTs were not labeled; however, based on the location of the USTs (behind the store) and the nature of their contents (diesel fuel odor), PRC assumed that the USTs stored diesel fuel. Based on field measurements and industry standards, PRC determined that two of the three diesel USTs were 3000-gallon horizontal tanks, measuring 18 feet long and 64 inches in diameter. PRC could not determine the dimensions of UST No. 7 on the basis of field measurements.

(5) Existing Truck Stop and Service Station Building Investigation

CDM Federal Programs Corporation (CDM) assisted the Louisiana Department of Environmental Quality (LDEQ) in collecting 14 asbestos samples from uniform areas within, and outside of, the existing building. CDM also tested 18 different areas within the existing building for lead-based paint.

C) Investigation Results

This section summarizes the analytical results for the samples collected at the Powers Junction site. PRC followed analytical guidelines outlined in the site-specific quality assurance project plan. Analytical data were compared to EPA screening levels and LDEQ risk-based corrective action levels (CAL) to determine areas of concern.

(1) Surface and Subsurface Soil Investigation Results

Analytical results indicate three distinct areas of soil contamination: (1) the gasoline fueling area in the vicinity of the gasoline USTs, which is contaminated with benzene and TPH-gasoline; (2) the diesel fueling area in the vicinity of the diesel USTs, which is contaminated with TPH-diesel, PAHs, and lead; and (3) the former truck repair area in the northeast sector of the site, which is contaminated with metals.

Analytical results indicated that one or more of the four gasoline USTs were leaking into the shallow water table. Contamination appeared to be vertically limited to the water table (4 feet bgs) and top 4 feet of soil, and horizontally limited to the gasoline fueling area. In the vicinity of the diesel fueling area, several PAHs were detected at (1) concentrations exceeding the EPA Region 6 Human Health Media-Specific Screening Levels for residential, and in some cases industrial, soil from 0 to 1 foot bgs, and (2) decreasing concentrations from 1 to 2 feet bgs. No PAHs were detected at 4 feet bgs. Field and CLP analysis indicated that the diesel USTs were not leaking. Surface PAH and TPH-diesel contamination may be attributable to historical diesel fuel spillage, overflow from one of the tanks, or proximity to a highway. Analysis of soil samples in the vicinity of the former truck repair area detected chromium and lead at concentrations exceeding the EPA Region 6 Human Health Media-Specific Screening Levels for residential soil.

(2) Results of Shallow Water Table Investigation

Analysis of a groundwater sample collected from the area immediately south of the gasoline USTs, detected benzene, ethylbenzene, and TPH-gasoline. Benzene and ethylbenzene concentrations exceeded EPA drinking water maximum contaminant levels (MCLs) for these VOCs. The TPH-gasoline concentration exceeded the proposed LDEQ CAL for groundwater. The shallow groundwater is not used locally as a drinking water source; therefore the MCLs may not apply to the shallow water table. Analytical results indicated that one or more of the four gasoline USTs are leaking into the shallow water table.

(3) Borrow Canal Investigation Results

Analysis of a sediment sample collected from the southern shore of the borrow canal did not detect organic contaminants at concentrations above EPA Region 6 Human Health Media-Specific Screening Levels for soil. No metals analysis was conducted.

(4) Underground Storage Tanks Investigation Results

Analysis of the contents of the USTs confirmed that (1) the four USTs in front of the existing building contained gasoline or a mixture of gasoline and water, and (2) the three USTs behind the existing building contained diesel fuel or a mixture of diesel fuel and water.

(5) Truck Stop and Service Station Building Investigation Results

Asbestos was detected in five of 14 building material samples. Lead was detected in three of 18 paint surfaces tested.

D) Analytical Results

Analytical results were compared to (1) EPA Region 6 Human Health Media-Specific Screening Levels for industrial and residential soil and (2) proposed LDEQ risk-based CALs for petroleum hydrocarbons in industrial and non-industrial soil, in order to establish remedial action levels for the Powers Junction site.

Analytical results indicate that the contents of one or more of the four gasoline USTs are leaking into the shallow water table. Contamination appears to be (1) vertically limited to the water table (4 feet bgs) and top 4 feet of soil, and (2) horizontally limited to the gasoline fueling area. The data indicated the following exceedances in soils within the gasoline fueling area

- EPA Region 6 screening levels and LDEQ CALs for industrial soil
  - Benzene at Probe Al B1
- EPA Region 6 screening levels and LDEQ CALs for residential or nonindustrial soil

    - Benzene at Probes Al and A2
    - TPH-gasoline at Probe Al B1

Analytical data indicate that the diesel USTs are not leaking. Diesel fuel contamination appears to be limited to the top 2 feet of soil and to the area defined by Probes A3, A4, and B3. Analyses of soil from Probes B2 and Cl revealed no diesel-related contamination. The data indicated the following exceedances in soils within the diesel fueling area

- EPA Region 6 screening levels and LDEQ CALs for industrial soil
    - PAHs at Probes A3 and A4
- EPA Region 6 screening levels and LDEQ CALs for residential or nonindustrial soil
    - PAHs at Probes A3 and A4
    - TPH-diesel at Probe B3
    - Lead at Probe A4

Surface PAH and diesel fuel contamination within the diesel fueling area may be attributable to (1) historical diesel fuel spillage from the nearby fueling island, (2) overflow from diesel UST No. 7, which has an open fill port, and/or (3) the proximity of U.S. Highway 11 and its associated roadway paving activities, including asphalt resurfacing and road surface runoff.

Analytical results indicate the presence of chromium, lead, and TPH-diesel from 0 to 1 foot bgs in the vicinity of the former truck repair area. No organic constituents were detected at concentrations above the EPA Region 6 Human Health Media-Specific Screening Levels for industrial and residential soil. The data indicated the following exceedances in soils within the former truck repair area

- No exceedances in soils of EPA Region 6 screening levels and LDEQ CALs for industrial soil
- EPA Region 6 screening levels and LDEQ CALs for residential or nonindustrial soil
    - Chromium at Probes E2 and E3
    - Lead at Probe El

Analytical results indicate chromium at Probes A6, B6, and D1 which are not associated with the gasoline and diesel fueling areas, or the former truck repair area at concentrations exceeding EPA Region 6 screening level for residential soil. At Probe Dl , the chromium concentration also exceeds the EPA Region 6 screening level for industrial soil.

Lead-based paint and asbestos-containing material (ACMs) are in the existing building.

Additional Investigative Activities Required

Before remedial activities can begin, additional sampling and subsurface investigation may be required at the site, including the following:

- Determine the extent of contamination, in the shallow water table and subsurface soil, resulting from one or more leaking gasoline USTs.
- Determine the orientation of the diesel fuel USTs to facilitate removal, and evaluate surrounding soils for any potential contamination resulting from leaks.
- Before the existing building is demolished, conduct a thorough assessment for asbestos and lead-based paint.
- If the site is to be developed for residential use, collect and analyze additional confirmatory samples from hot spot locations, such as Probes A6 and B6, to confirm these areas of potential remedial concern, which are not associated with historical fueling and truck repair activities.
- For remedial options other than excavation and off-site disposal, characterize the soil matrix to determine their compatibility with remedial processes.
- In the case of excavation and off-site disposal, the disposal facility may require that soils be analyzed for metals using toxicity characteristic leaching procedure (TCLP) or other off-site disposal requirements.

E) Cleanup Alternatives and Associated Costs

FWS is interested in redeveloping the site as an environmental education center (industrial use) for the Bayou Sauvage Wildlife Refuge area. However, as directed by EPA Region 6, PRC evaluated cleanup options for the site on the basis of both industrial and residential soil screening levels.

Based on current site conditions, and analytical results from the field investigation, PRC proposes the following four cleanup alternatives:

- Cleanup Option 1: Excavation and Off-site Treatment and Disposal (Risk-based approach)
    - UST removal and decommissioning
    - Demolition of existing building
    - Excavation and off-site treatment and disposal of soils contaminated with benzene and TPH-gasoline
    - Risk-based cleanup approach to remaining surface soil contaminated with TPH-diesel, PAHs, and chromium (industrial use scenario)
- Cleanup Option *2:* Excavation and Off-site Treatment and Disposal
    - UST removal and decommissioning
    - Demolition of existing building
    - Excavation and off-site treatment and disposal of soils contaminated with benzene and PAHs
    - Excavation and off-site disposal of soils contaminated with metals (residential use scenario); for the industrial use scenario, surface soil areas contaminated with chromium will be revegetated.
- Cleanup Option 3: Excavation, On-site Bioremediation (Landfarming) and Off-site Disposal
    - UST removal and decommissioning
    - Demolition of existing building
    - Excavation and on-site bioremediation (landfarming) of soils contaminated with TPH fuels and PAHs; for the industrial use scenario, chromium-contaminated soils will be revegetated.
    - Excavation and off-site disposal of soils contaminated with metals (residential use scenario)
- Cleanup Option 4: Excavation, *In* situ Bioremediation (Bioventing) and Off-site Disposal
    - UST removal and decommissioning
    - Demolition of existing building
    - *In situ* bioremediation (bioventing) of soils contaminated with TPH-gasoline and benzene
    - Revegetation of surface areas of soil contaminated with chromium (industrial use scenario)
    - Excavation and off-site disposal of soils contaminated with TPH-diesel, PAHs, and metals (residential use scenario)

PRC estimated preliminary costs for the proposed cleanup options by using (1) the Environmental Cost Handling Options Solution (ECHOS) Cost Data Book (Delta Technologies Group 1995), and (2) vendor price quotes. Tables 1, 2, 3, and 4 present the cost estimate for each of the proposed cleanup options.

The following assumptions apply to all of the proposed remedial options:

- Concrete to be removed is nonhazardous.
- All remedial options include demolition of the existing building (120 feet long by 50 feet wide by 10 feet high) and concrete (about 100 cubic yards [yd^3]), and removal of the seven 3000-gallon USTs.
- Radius of influence (about 4,000 square feet [ft^2]) for contamination at a probe

soil (O-2 feet bgs) (Probe D1) (Site Preparation).

- Backfill the excavated area with unclassified fill from an off-site source (Site Earthwork).

Costs will increase considerably to meet residential cleanup levels, based on the following variations:

- Excavate an estimated 1,500 yd^3 of TPH- , PAH-, and benzene-contaminated soil associated with the fueling areas (Probes A3, Al B1, and B3) (Site Earthwork).
- Treat the 1,500 yd^3 of TPH-, PAH-, and benzene-contaminated soil offsite by using low-temperature thermal desorption, followed by off-site landfill disposal as nonhazardous waste (Disposal).
- Excavate an estimated 2,100 yd^3 of soil (0 to 2 feet bgs) contaminated with PAHs, chromium, and lead (Probes A4, A6, B6, D1 , El, E2, and E3) (Site Earthwork).
- Dispose of the 2,100 yd^3 metals-contaminated soil off site, in a Class I hazardous waste landfill (Disposal).
- Backfill the excavated area with unclassified fill from an off-site source (Site Earthwork).

If the metals-contaminated soil passes TCLP analysis for barium, chromium, and lead, disposal costs will be substantially lower, based on off-site treatment for TPH-diesel and PAHs, followed by disposal as nonhazardous waste.

Cleanup under Option 2 would require about 1 to 2 months to complete.

Cleanup Option 3: Excavation, On-Site Bioremediation and Off-Site Disposal

Cleanup Option 3 involves the following tasks for industrial cleanup levels:

- Demolish and dispose of the existing building and concrete (Site Preparation).
- Excavate and decommission the seven 3000-gallon USTs, including at least one leaking gasoline UST (UST Decommissioning).
- Excavate an estimated 1,200 yd^3 of PAH- and benzene-contaminated soil associated with the fueling areas (Probes A3, A4, and Al B1) (Site Earthwork).
- Fertilize, seed, and sprig the 4000 ft^2 area of chromium-contaminated soil (0 to 2 feet bgs) (Probe D1) (Site Preparation).
- Treat the 1,200 yd^3 of PAH- and benzene-contaminated soil on-site by using bioremediation (land treatment 2 feet deep by 0.4 acre) (On-Site Bioremediation).
- Backfill the excavated areas with 1,500 yd^3 of bioremediated soil (soil volume increases 20 percent [+300 yd^3] after land treatment) (On-Site Bioremediation).

Costs will increase considerably to meet residential cleanup levels, based on the following variations:

- Excavate an estimated 1,500 yd^3 of TPH- , PAH-, and benzene-contaminated soil associated with the fueling areas (Probes A3, Al B1, and B3) (Site Earthwork).
- Treat the TPH-, PAH-, and benzene-contaminated soil on site by using bioremediation (landfarming) (On-Site Bioremediation).
- Excavate an estimated 2,100 yd^3 of soil (0 to 2 feet bgs) contaminated with PAHs, chromium, and lead (Probes A4, A6, B6, D1, El, E2, and E3) (Site Earthwork).
- Dispose of the 2,100 yd^3 of metals-contaminated soil off site in a Class I hazardous waste landfill (Disposal).
- Backfill the excavated areas with the 1,800 yd^3 of bioremediated soil (soil volume increases 20 percent [+300 yd^3] after land treatment) (Site Earthwork).
- Use off-site unclassified fill to supplement backfilling any remaining areas (Site Earthwork).

Chromium concentrations are not reduced by using this method; however, mixing with soils not contaminated with chromium may reduce the metals concentration by dilution. Treated soils are returned to the excavation from where they originated. Duration of treatment can last from 6 to 18 months, depending on the degradation rates of the contaminants that are being treated.

Cleanup Option 4: Excavation, *In Situ* Bioremediation and Off-Site Disposal

Cleanup Option 4 involves the following tasks for <u>industrial cleanup levels</u>:

- Demolish and dispose of the existing building and concrete (Site Preparation).
- Excavate and decommission the seven 3000-gallon USTs, including at least one leaking gasoline UST (UST Decommissioning).
- Excavate an estimated 600 yd^3 of PAH-contaminated soil from the diesel fueling area (Probes A3 and A4) (Site Earthwork).
- Treat the 600 yd^3 of PAH-contaminated soil off site by using low-temperature thermal desorption, followed by disposal as nonhazardous waste (Disposal).
- Fertilize, seed, and sprig the 4,000-ft^2 area of chromium-contaminated soil (O-2 feet bgs) (Probe D1) (Site Preparation).
- Treat the area contaminated with TPH-gasoline and benzene (Probe Al B1) by using in situ bioremediation (bioventing) (In Situ Bioremediation).

As an alternative, land treatment may be used to treat, on site, the soil contaminated with PAHs.

Costs will increase considerably to meet <u>residential cleanup levels</u>, based on the following variations:

- Excavate an estimated 600 yd^3 of soil contaminated with TPH-diesel and PAHs from the diesel fueling area (Probes A3 and B3) (Site Earthwork).
- Treat the 600 yd^3 of TPH- and PAH-contaminated soil off site by using low-temperature thermal desorption, followed by disposal as nonhazardous waste (Disposal).
- Excavate an estimated 2,100 yd^3 of soil (0 to 2 feet bgs) contaminated with TPH-diesel, PAHs, chromium, and lead (Probes A4, A6, B6, D1, El, E2, and E3) (Site Earthwork).
- Dispose of the 2,100 yd^3 of metals-contaminated soil off site in a Class I hazardous waste landfill (Disposal).
- Treat the area contaminated with TPH-gasoline and benzene (Probe Al and B1) by using *in* situ bioremediation (bioventing) (*In Situ* Bioremediation).
- Backfill excavated area with unclassified fill from an off-site source (Site Earthwork).

If the metals-contaminated soil passes TCLP analysis for barium, chromium, and lead, disposal costs will be substantially lower, based on disposal as nonhazardous waste. As an alternative, land treatment may be used, on site, to bioremediate the soil contaminated with TPH-diesel, PAHs, and metals; this will eliminate the costs of transportation, off-site disposal, and off-site backfill. Metals concentrations are not reduced by using this method.

Duration of treatment can last from 6 to 18 months, depending on the degradation rates of the contaminants that are being treated.

Appendix A References

Delta Technologies Group. 1995. Environmental Cost Handling Options and Solutions (ECHOS) Cost Data Book.

Louisiana Department of Environmental Quality (LDEQ). 1997. Proposed LDEQ Risk-Based Corrective Action Program (Draft). March 14.

PRC Environmental Management, Inc., (PRC). 1997a. Field Sampling Plan for Powers Junction Brownfield Site, New Orleans, LA. February 4.

PRC Environmental Management. 1997b. Quality Assurance Project Plan for Powers Junction Brownfield Site, New Orleans, LA, February 14.

Table A1. Cost Estimate for Cleanup Option 1: Excavation and Off-site Treatment and Disposal (Risk-Based Approach)

Item/Description	Unit	Unit Cost	Industrial Quantity	Industrial Cost ($)
Site Preparation				
Demolish reinforced concrete	CY	51.06	100	5,106
Demolish existing building	CF	0.06	60,000	3,600
Load and haul debris	CY	3.57	1,000	3,570
Fertilize, seed, and sprig surface soil	SY	1.10	1,350	1,485
Preparation **Subtotal**				**$13,761**
UST Decomissioning				
Excavate and load on trailer, 3000-gallon	Each	465.00	7	3,255
Remove sludge	Each	172.00	7	1,204
Dispose of sludge	Gallon	2.45	200	490
Known leaking UST excavation	Each	465.00	1	465
Haul tank to salvage dump, 100-mile RT	Each	525.00	7	3,675
UST Subtotal				**$9,089**
Site Earthwork				
1 CY hydraulic excavator	CY	3.14	600	1,884
Loading into truck	CY	1.55	600	930
Backfill, unclassified fill, 6-inch lift, offsite	CY	7.35	675	4,961
Earthwork Subtotal				**$7,775**
Sampling, Testing, and Analysis				
Soil lab analysis: TCLP metals	Sample	693.81	5	3,469
Soil lab analysis: BTEX	Sample	123.69	10	1,237
Soil lab analysis: PAHs	Sample	298.37	10	2,984
Soil lab analysis: metals, each (8)	Sample	148.41	5	742
Analytical Subtotal				**$8,432**
Disposal				
Transportation 100-mile RT, 20-CY loads	Mile	3.38	3,000	10,140
Waste stream evaluation fee	Each	494.71	1	495
Low-temperature thermal desorption	Ton	69.41	810	56,222
Dump charges for construction debris	CY	18.42	1,000	18,420
Landfill nonhazardous waste disposal	CY	44.00	600	26,400
Disposal Subtotal				**$111,677**
Total Cost				**$150,734**

Notes

Unit costs were obtained from the ECHOS Environmental Restoration Unit Cost Book and vendor price quotes.

Hazardous waste disposal at Class I Landfill.

Soil density is assumed to be 100 pounds/CF.

BTEX	Benzene, ethylbenzene, toluene, and xylenes.
CF	Cubic foot.
CY	Cubic yard.
ECHOS	Environmental cost handling options and solutions.
PAH	Polycyclic aromatic hydrocarbons.
RT	Round trip.
SY	Square yard.
TCLP	Toxicity characteristic leaching procedure.
UST	Underground storage tank.

Table A2. Cost Estimate for Cleanup Option 2: Excavation and Off-site Treatment and Disposal

Item/Description	Unit	Unit Cost	Industrial Quantity	Industrial Cost ($)	Residential Quantity	Residential Cost ($)
Site Preparation						
Demolish reinforced concrete	CY	51.06	100	5,106	100	5,106
Demolish existing building	CF	0.06	60,000	3,600	60,000	3,600
Load and haul debris	CY	3.57	1,000	3,570	1,000	3,570
Fertilize, seed, and sprig surface soil	SY	1.10	450	495	0	0
Preparation Subtotal				$12,771		**$12,276**
UST Decomissioning						
Excavate and load on trailer, 3000-gallon	Each	465.00	7	3,255	7	3,255
Remove sludge	Each	172.00	7	1,204	7	1,204
Dispose of sludge	Gallon	2.45	200	490	200	490
Known leaking UST excavation	Each	485.00	1	485	1	465
Haul tank to salvage dump, 1 OO-mile RT	Each	525.00	7	3,675	7	3,675
UST Subtotal				$9,069		$9,089
Site Earthwork						
I-CY hydraulic excavator	CY	3.14	1,200	3,768	3,600	11,304
Loading into truck	CY	1.55	1,200	1,860	3,600	5,580
Backfill, unclassified fill, 6-inch lift, offsite	CY	7.35	1,425	10,474	4,450	32,708
Earthwork Subtotal				**$16,102**		$49,592
Sampling, Testing, and Analysis						
Soil lab analysis: TCLP metals	Sample	693.81	5	3,469	5	3,489
Soil lab analysis: BTEX	Sample	123.69	10	1,237	10	1,237
Soil lab analysis: PAHs	Sample	298.37	10	2,984	10	2,984
Soil lab analysis: metals, each (8)	Sample	148.41	5	742	5	742
Total petroleum hydrocarbons	Sample	116.67	0	0	10	1,167
Analytical Subtotal						$9,598
Disposal						
Transportation 1 OO-mile RT, 20-CY loads	Mile	3.38	6,000	20,280	16,000	54,080
Waste stream evaluation fee	Each	494.71	1	495	2	989
Low-temperature thermal desorption	Ton	69.41	1,620	112,444	2,025	140,555
Dump charges for construction debris	CY	18.42	1,000	18,420	1,000	18,420
Landfill nonhazardous waste disposal	CY	44.00	1,200	52,800	1,500	66,000
Landfill hazardous waste disposal	Ton	233.32	0	0	2,835	661,462
Disposal Subtotal				**$204,439**		**$941,507**
Total Cost				$250,832		**$1,022,062**

Notes

Unit costs were obtained from the ECHOS Environmental Restoration Unit Cost Book and vendor price quotes.

Hazardous waste disposal at Class I Landfill.

Soil density is assumed to be 100 pounds/CF.

BTEX	Benzene, ethylbenzene, toluene, and xylenes.
CF	Cubic foot.
CY	Cubic yard.
ECHOS	Environmental cost handling options and solutions.
PAH	Polycyclic aromatic hydrocarbons.
RT	Round trip.
SY	Square yard.
TCLP	Toxicity characteristic leaching procedure.
UST	Underground storage tank.

Table A3. Cost Estimate for Cleanup Option 3: Excavation, On-site Bioremediation (Landfarming) and Off-site Disposal

Item/Description	Unit	Unit Cost	Industrial Quantity	Industrial Cost ($)	Residential Quantity	Residential Cost ($)
Site Preparation						
Demolish reinforced concrete	CY	51.06	100	5,106	100	5,108
Demolish existing building	CF	0.06	60,000	3,600	60,000	3,600
Load and haul debris	CY	3.57	1,000	3,570	1,000	3,570
Fertilize, seed, and sprig surface soil	SY	1.10	450	495	0	0
Preparation Subtotal				$12,276		**$12,276**
UST Decomissioning						
Excavate and load on trailer, 3000-gallon	Each	465.00	7	3,255	7	3,255
Remove sludge	Each	172.00	7	1,204	7	1,204
Dispose of sludge	Gallon	2.45	200	490	200	490
Known leaking UST excavation	Each	465.00	1	465	1	465
Haul tank to salvage dump, 100-mile RT	Each	525.00	7	3,675	7	3,675
UST Subtotal				$9,089		$9,089
Site Earthwork						
1 -CY hydraulic excavator	CY	3.14	1,200	3,768	3,600	11,304
Loading into truck	CY	1.55	1,200	1860	3,600	5,580
Backfill, unclassified fill, 6-inch lift, offsite	CY	7.35	0	0	2.600	19,110
Earthwork Subtotal				**$5,628**		$35,994
Sampling, Testing, and Analysis						
Soil lab analysis: TCLP metals	Sample	693.81	5	3,469	5	3,469
Soil lab analysis: BTEX	Sample	123.69	10	1,237	10	1,237
Soil lab analysis: PAHs	Sample	298.37	10	2,984	10	2,984
Soil lab analysis: metals, (8)	Sample	148.41	5	742	5	742
Total petroleum hydrocarbons	Sample	116.67	0	0	10	1,167
Analytical Subtotal				**$8,432**		$9,598
Disposal						
Transportation 100-mile RT, 20-CY loads	Mile	3.38	0	0	10,500	35,490
Waste stream evaluation fee	Each	494.71	0	0	1	495
Dump charges for construction debris	CY	18.42	1,000	18,420	1,000	18,420
Landfill hazardous waste disposal	Ton	233.32	0	0	2,835	661,462
Disposal Subtotal				**$18,420**		$715,867
Onsite Bioremediation						
Land treatment, 2 feet deep	Acre	8,762.22	0.40	3,505	0.50	1,752
Backfill, unclassified fill, 6-inch lift, onsite	CY	4.78	1,500	7,170	1,800	8,604
Onsite Bioremediation Subtotal				$10,675		**$10,356**
Total Cost				$64,520		**$793,181**

Notes

Unit costs were obtained from the ECHOS Environmental Restoration Unit Cost Book and vendor price quotes.

Hazardous waste disposal at Class I Landfill.

Soil density is assumed to be 100 pounds/CF.

BTEX	Benzene, ethylbenzene, toluene, and xylenes.
CF	Cubic foot.
CY	Cubic yard.
ECHOS	Environmental cost handling options and solutions.
PAH	Polycyclic aromatic hydrocarbons.
RT	Round trip.
SY	Square yard.
TCLP	Toxicity characteristic leaching procedure.
UST	Underground storage tank.

Table A4. Cost Estimate for Cleanup Option 4: Excavation, *In situ* Bioremediation (Bioventing) and Off-site Disposal

Item/Description	Unit	Unit Cost	Industrial Quantity	Industrial Cost ($)	Residential Quantity	Residential Cost ($)
Site Preparation						
Demolish reinforced concrete	CY	51.06	100	5,106	100	5,106
Demolish existing building	Cubic foot	0.06	60,000	3,600	60,000	3,600
Load and haul debris	CY	3.57	1,000	3,570	1,000	3,570
Fertilize, seed, and sprig surface soil	SY	1.10	450	495	0	0
Preparation Subtotal				$12,771		**$12,276**
UST Decomissioning						
Excavate and load on trailer, 3000-gallon	Each	465.00	7	3,255	7	3,255
Remove sludge	Each	172.00	7	1,204	7	1,204
Dispose of sludge	Gallon	2.45	200	490	200	490
Known leaking UST excavation	Each	465.00		485	1	465
Haul tank to salvage dump, 1 OO-mile RT	Each	525.00	7	3,675	7	3,675
UST Subtotal				$9,089		$9,089
Site Earthwork						
1-CY hydraulic excavator	CY	3.14	600	1,884	2,700	8,478
Loading into truck	CY	1.55	600	930	2,700	4,185
Backfill, unclassified fill, 6-inch lift, offsite	CY	7.35	750	5,513	3,370	24,770
Earthwork Subtotal				$8,327		$37,433
Sampling, Testing, and Analysis						
Soil lab analysis: TCLP metals	Sample	693.81	5	3,469	5	3,469
Soil lab analysis: BTEX	Sample	123.69	10	1,237	10	1,237
Soil lab analysis: PAHs	Sample	298.37	10	2,984	10	2,984
Soil lab analysis: metals, (8)	Sample	148.41	5	742	5	742
Total petroleum hydrocarbons	Sample	116.67	0	0	10	1.167
Analytical Subtotal				**$8,432**		$9,598
Disposal						
Transportation 1 OO-mile RT, 20-CY loads	Mile	3.38	3,000	10,140	13,500	45,630
Waste stream evaluation fee	Each	494.71	1	495	2	989
Low-temperature thermal desorption	Ton	69.41	810	56,222	810	56,222
Dump charges for construction debris	CY	18.42	1,000	18,420	1,000	18,420
Landfill nonhazardous waste disposal	CY	44.00	600	26,400	0	0
Landfill hazardous waste disposal	Ton	233.32	0	0	3,645	850,451
Disposal Subtotal				**$111,677**		$971,713
***In situ* Bioremediation**						
Bioventing, 5 feet deep	Lump sum	12,163.08	1.00	12,163	1.00	12,163
***In situ* Bioremediation Subtotal**				$12,163		$12,163
Total Cost				**$162,458**		**$1,052,272**

Notes

Unit costs were obtained from the ECHOS Environmental Restoration Unit Cost Book and vendor price quotes.

Hazardous waste disposal at Class I Landfill.

Soil density is assumed to be 100 pounds/CF.

BTEX	Benzene, ethylbenzene, toluene, and xylenes.
CY	Cubic yard.
ECHOS	Environmental cost handling options and solutions.
PAH	Polycyclic aromatic hydrocarbons.
RT	Round tip.
SY	Square yard.
TCLP	Toxicity characteristic leaching procedure.
UST	Underground storage tank.

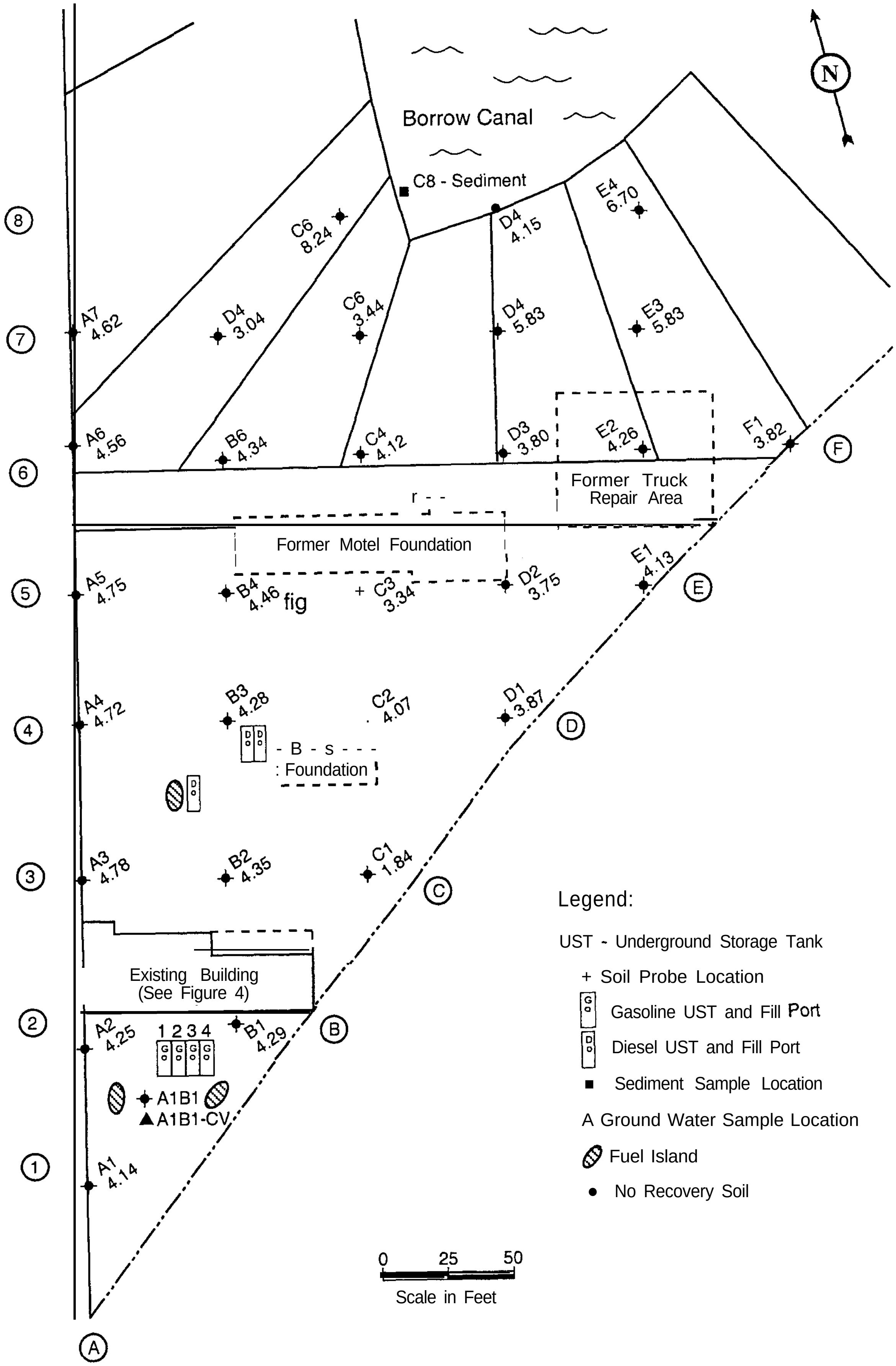

Figure Al. Soil probe location map.

Appendix B
Abbreviations and Acronyms

bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CAL	corrective action levels
CLP	Contract Laboratory Program
CLU-IN	The Hazardous Waste Clean-Up Information Web Site
CTC	Success and Cost-To-Complete Environmental Cost Estimating System
DOD	Department of Defense
DOE	Department of Energy
DTG	Delta Technologies Group, Inc., (DTG)
ECHOS	Environmental Cost Handling Options and Solutions (ECHOS)
EPA	U.S. Environmental Protection Agency
FRTR	Federal Remediation Technologies Roundtable
ft^2	square foot
GC	gas chromatography
GPR	Ground-Penetrating Radar
HazRisk	A cost estimating system developed by Independent Project Analysis, Inc., that predicts how accurate a cost estimate is
HCAS	Historical Cost Analysis System
HTRW-ICEG	Developed by the Interagency Cost Estimating Group for Hazardous, Toxic, and Radioactive Waste
ITER	Innovative Technology Evaluation Report
LDEQ	Louisiana Department of Environmental Quality
MTBE	Methyl tertiary-butyl ether
NERL-LV	EPA's National Exposure Research Laboratory in Las Vegas
NRMRL	EPA's National Risk Management Research Laboratory
O&M	Operations and Maintenance
ORD	Office of Research and Development
PAH	Polyaromatic Hydrocarbon
PERCS	Preliminary Estimate of Remediation Costs Service
RAC	Response Action Contract
RACER	Remedial Action Cost Engineering and Requirements System
RCRA	Resource Conservation and Recovery Act
SITE	EPA's Super-fund Innovative Technology Evaluation
svoc	Semi-Volatile Organic Compound
TPH	Total Petroleum Hydrocarbon
UST	Underground Storage Tank
VISITT	Vendor Information System for Innovative Treatment Technologies
voc	Volatile Organic Compound
XRF	X-ray fluorescence
yd^3	cubic yard

Appendix C
Glossary of Key Terms

The following is a list of specialized terms that are useful to understanding the Cost Estimating Tools and Resources for Addressing Sites Under the Brownfields Initiative.

Air Sparging - In air sparging, air is injected into the ground below a contaminated area, forming bubbles that rise and carry trapped and dissolved contaminants to the surface where they are captured by a soil vapor extraction system. Air sparging may be a good choice of treatment technology at sites contaminated with solvents and other volatile organic compounds (VOCs). *See* also *Soil Vapor Extraction* and *Volatile Organic Compound.*

Bioremediation - Bioremediation refers to treatment processes that use microorganisms (usually naturally occurring) such as bacteria, yeast, or fungi to break down hazardous substances into less toxic or nontoxic substances. Bioremediation can be used to clean up contaminated soil and water. *In* situ bioremediation treats the contaminated soil or groundwater in the location in which it is found. For ex situ bioremediation processes, contaminated soil must be excavated or groundwater pumped before they can be treated.

Bioventing - Bioventing is an *in situ* cleanup technology that combines soil vapor extraction methods with bioremediation. It uses vapor extraction wells that induce air flow in the subsurface through air injection or through the use of a vacuum. Bioventing can be effective in cleaning up releases of petroleum products, such as gasoline, jet fuels, kerosene, and diesel fuel. *See* also *Bioremediation* and Soil *Vapor Extraction.*

Brownfields - Brownfields sites are abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination.

Clean up - Clean up is the term used for actions taken to deal with a release or threat of release of a hazardous substance that could affect humans and/or the environment.

Contaminant- A contaminant is any physical, chemical, biological, or radiological substance or matter present in any media at concentrations that may result in adverse effects on air, water, or soil.

Disposal- Disposal is the final placement or destruction of toxic, radioactive or other wastes; surplus or banned pesticides or other chemicals; polluted soils; and drums containing hazardous materials from removal actions or accidental release. Disposal may be accomplished through the use of approved secure landfills, surface impoundments, land farming, deep well injection, ocean dumping, or incineration.

Dual-Phase Extraction - Dual-phase extraction is a technology that extracts contaminants simultaneously from soils in saturated and unsaturated zones by applying soil vapor extraction techniques to contaminants trapped in saturated zone soils. See also *Soil Vapor Extraction.*

Electromagnetic (EM) Geophysics - EM geophysics refers to technologies used to detect spatial (lateral and vertical) differences in subsurface electromagnetic characteristics. The data collected provide information about subsurface environments.

Gas Chromatography - Gas chromatography is a technology used for investigating and assessing soil, water, and soil gas contamination at a site. It is used for the analysis of VOCs and semi-volatile organic compounds (SVOC). The technique identifies and quantifies organic compounds on the basis of molecular weight, characteristic fragmentation patterns, and retention time. Recent advances in gas chromatography considered innovative are portable, weather-proof units that have self-contained power supplies. *See* also *Semi-Volatile Organic Compound.*

Ground-Penetrating Radar (GPR) - GPR is a technology that emits pulses of electromagnetic energy into the ground to measure its reflection and refraction by subsurface layers and other features, such as buried debris.

Groundwater - Groundwater is the water found beneath the earth's surface that fills pores between such materials as sand, soil, or gravel and that often supplies wells and springs.

Hazardous Substance - A hazardous substance is any material that poses a threat to public health or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive. If a certain quantity of a hazardous substance, as established by EPA, is spilled into the water or otherwise emitted into the environment, the release must be reported. Under certain federal legislation, the term excludes petroleum, crude oil, natural gas, natural gas liquids, or synthetic gas usable for fuel.

Hydrocarbon - A hydrocarbon is an organic compound containing only hydrogen and carbon, often occurring in petroleum, natural gas, and coal.

Landfarming - Landfarming is the spreading and incorporation of wastes into the soil to initiate biological treatment.

Lead - Lead is a heavy metal that is hazardous to health if breathed or swallowed. Its use in gasoline, paints, and plumbing compounds has been sharply restricted or eliminated by Federal laws and regulations. *See* also *Heavy Metal.*

Leaking Underground Storage Tank (LUST) - LUST is the acronym for "leaking underground storage tank." *See* also *Underground Storage Tank.*

Natural Attenuafion - Natural attenuation is an approach to cleanup that uses natural processes to contain the spread of contamination from chemical spills and reduce the concentrations and amounts of pollutants in contaminated soil and groundwater. Natural subsurface processes, such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials, reduce concentrations of contaminants to acceptable levels. An in situ treatment method that leaves the contaminants in place while those processes occur, natural attenuation is being used to clean up petroleum contamination from leaking underground storage tanks (LUST) across the country.

Operation and Maintenance (O&M) - O&M refers to the activities conducted at a site, following remedial actions, to ensure that the cleanup methods are working properly. O&M activities are conducted to maintain the effectiveness of the cleanup and to ensure that no new threat to human health or the environment arises. O&M may include such activities as groundwater and air monitoring, inspection and maintenance of the treatment equipment remaining on site, and maintenance of any security measures or institutional controls.

Polyaromatic Hydrocarbon (PAH) -A PAH is a chemical that contains more than one fused benzene ring. They are commonly found in petroleum fuels, coal products, and tar.

Pump and Treat - Pump and treat is a general term used to describe cleanup methods that involve the pumping of groundwater to the surface for treatment. It is one of the most common methods of treating polluted aquifers and groundwater.

Resource Conservation and Recovery Act (RCRA) - RCRA is a Federal law enacted in 1976 that established a regulatory system to track hazardous substances from their generation to their disposal. The law requires the use of safe and secure procedures in treating, transporting, storing, and disposing of hazardous substances. RCRA is designed to prevent the creation of new, uncontrolled hazardous waste sites.

Semi-Volatile Organic Compound (SVOC) - SVOCs, composed primarily of carbon and hydrogen atoms, have boiling points greater than 200 C. Common SVOCs include PCPs and phenol.

Site Assessment - A site assessment is the process by which it is determined whether contamination is present on a site.

Soil Boring - Soil boring is a process by which a soil sample is extracted from the ground for chemical, biological, and analytical testing to determine the level of contamination present.

Soil Gas - Soil gas consists of gaseous elements and compounds that occur in the small spaces between particles of the earth and soil. Such gases can move through or leave the soil or rock, depending on changes in pressure.

Superfund- Super-fund is the trust fund that provides for the cleanup of significantly hazardous substances released into the environment, regardless of fault. The Superfund was established under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and subsequent amendments to CERCLA. The term Superfund is also used to refer to cleanup programs designed and conducted under CERCLA and its subsequent amendments.

Superfund Amendment and Reauthorization Act (SARA) - SARA is the 1986 act amending Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) that increased the size of the Super-fund trust fund and established a preference for the development and use of permanent remedies, and provided new enforcement and settlement tools.

Thermal Desorption - Thermal desorption is an innovative treatment technology that heats soils contaminated with hazardous wastes to temperatures from 200 to 1,000 F so that contaminants that have low boiling points will vaporize and separate from the soil. The vaporized contaminants are then collected for further treatment or destruction, typically by an air emissions treatment system. The technology is most effective at treating VOCs, SVOCs, and other organic contaminants, such as PCBs, PAHs, and pesticides. It is effective in separating organics from refining wastes, coal tar wastes, waste from wood treatment, and paint wastes. It also can separate solvents, pesticides, PCBs, dioxins, and fuel oils from contaminated soil. *See* also *Semi-Volatile Organic Compound* and *Volatile Organic Compound.*

Total Petroleum Hydrocarbon (TPH) - TPH refers to a measure of concentration or mass of petroleum hydrocarbon constituents present in a given amount of air, soil, or water.

Underground Storage Tank (UST) -An UST is a tank located entirely or partially underground that is designed to hold gasoline or other petroleum products or chemical solutions.

Voluntary Cleanup Program (VCP) -A VCP is a formal means established by many states to facilitate assessment, cleanup, and redevelopment of brownfields sites. VCPs typically address the identification and cleanup of potentially contaminated sites that are not on the National Priorities List (NPL). Under VCPs, owners or developers of a site are encouraged to approach the state voluntarily to work out a process by which the site can be readied for development. Many state VCPs provide technical assistance, liability assurances, and funding support for such efforts.

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