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A Resource for MGP Site Characterization and Remediation

Expedited Site Characterization and Source Remediation at Former Manufactured Gas Plant Sites

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U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office
Washington, DC 20460

Notice

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Abstract

The United States Environmental Protection Agency (USEPA), in conjunction with states, industry trade associations (the Edison Electric Institute [EEI], the Utility Solid Waste Activities Group [USWAG], and American Gas Association [AGA]), and individual utilities, has compiled a summary of innovative strategies and technical approaches for expediting site characterization and source material remediation at former manufactured gas plant (MGP) sites. Former MGP sites, as a category of inactive industrial waste disposal sites, contain many similarities in historical industrial activities and the types and distribution of MGP wastes and related contaminants. This trend, coupled with the fact that today's utilities are often the primary owners of (or accept remedial responsibility for) these sites, allows both the regulatory agencies and the utilities to develop approaches to achieving economies of scale and effort in addressing contamination at former MGP sites. Unlike remediation sites of other industries, MGP sites are typically not found at locations where utilities operate today, are often located in the midst of residential communities that have developed around these abandoned industrial locations, and are owned by entities unrelated to the modern utility.

This document was prepared by the USEPA to provide current information on useful approaches and tools being applied at former MGP sites to the regulators and utilities characterizing and remediating these sites. The document outlines site management strategies and field tools for expediting site characterization at MGP sites; presents a summary of existing technologies for remediating MGP wastes in soils; provides sufficient information on the benefits, limitations, and costs of each technology, tool, or strategy for comparison and evaluation; and provides, by way of case studies, examples of the ways these tools and strategies can be implemented at MGP sites.

Innovative strategies for managing former MGP sites, as discussed in Chapter 3 of this document, include multi-site agreements, dynamic work planning, teaming approaches to expedite remedial action planning and execution, and methods for dealing with uncertainty at these sites. Technical innovations for site characterization (Chapter 4) include the availability of direct push and other field screening technologies to complement traditional analytical approaches. Finally, a variety of approaches and technologies have been employed to provide cost-effective solutions to treating the wastes remaining at former MGP sites (Chapter 5).

The information presented in this document is applicable to the characterization and remediation of former MGP sites conducted under traditional remediation programs as well as the large number of MGP sites which are likely to be addressed under voluntary cleanup programs.

Contents

List of Acronyms and Abbreviations

AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
ASTM	American Society of Testing and Materials
atm	atmospheres
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
Btu	British thermal unit
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CERCLIS	Comprehensive Environmental Response Compensation, and Liability Act Information Systems
cis-1,2-DCE	cis-1,2-dichloroethylene
CO	carbon monoxide
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CPT	cone penetrometer
CROW™	Contained Recovery of Oily Wastes
CWM	Chico / Willows / Marysville
DCE	dichloroethylene
DCI	Dust Coating, Inc.
DEC	Department of Environmental Conservation
DEP	Department of Environmental Protection
DEQ	Department of Environmental Quality
DMLS™	diffusion multi-layer sampler
DNAPL	dense non-aqueous phase liquid
DNR	Department of Natural Resources
DQO	data quality objective
DRE	destruction removal efficiency
DTSC	Department of Toxic Substance Control
DUS	dynamic underground stripping
EEI	Edison Electric Institute
ELISA	enzyme-linked immunosorbent assay
EMS	electromagnetic survey
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ERAP	Expedited Remedial Action Program
ESC	expedited site characterization

FS	feasibility study
ft/min	feet per minute
GC	gas chromatography
GCL	geosynthetic clay liner
GIS	geographic information system
gpm	gallons per minute
GPR	ground-penetrating radar
GRI	Gas Research Institute
ha	hectare
HASP	health and safety plan
HCl	hydrogen chloride
HDPE	high-density polyethylene
HPO	hydrous pyrolysis oxidation
HPT	high-performance team
IDW	investigation-derived waste
IGT	Institute of Gas Technology
ISM	in situ bio-geochemical monitor
ISTD	in situ thermal desorption
ISU	Iowa State University
kg	kilogram
LIF	laser-induced fluorescence
LNAPL	light nonaqueous phase liquids
LTTD	low-temperature thermal desorption
LTU	land treatment unit
MART	Mid Atlantic Recycling Technologies, Inc.
MCL	Maximum Contaminant Level
MEC	MidAmerican Energy Corporation
MEW	Missouri Electric Works
µg/L	micrograms per liter
µm	micrometer
mg	milligram
mg/kg	milligrams per kilogram
MGP	manufactured gas plant
mm	millimeter
MSE	microscale solvent extraction
NAPL	nonaqueous phase liquid
NCP	National Contingency Plan
NJDEP	New Jersey Department of the Environment
NMPC	Niagra Mohawk Power Corporation
NO_x	nitrogen oxide
NPL	National Priorities List

NTU	nephelometric turbidity unit
NYSDEC	New York State Department of Environmental Conservation
OUR	oxygen uptake rate
PAH	polycyclic aromatic hydrocarbon
PA	preliminary assessment
PCB	polychlorinated biphenyl
PCE	perchloroethylene
PCP	pentachlorophenol
PEA	preliminary endangerment assessment
PGE	Portland General Electric
PG&E	Pacific Gas and Electric Company
PITT	Partitioning Interwell Tracer Test
PNA	polynuclear aromatic hydrocarbon
ppb	parts per billion
PP&L	Pennsylvania Power & Light Company
ppm	parts per million
PQL	practical quantitation limit
PSE&G	Public Service Electric and Gas Company
psi	pounds per square inch
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RA	remedial action
RAGS	Risk Assessment Guidance for Superfund
RAP	remedial action plan
RCRA	Resource Conservation and Recovery Act of 1976
RD	remedial design
RG&E	Rochester Gas and Electric
RI	remedial investigation
ROD	Record of Decision
ROST™	Rapid Optical Screening Tool
RP	responsible party
SCAPS	site characterization analysis penetrometer system
SI	site investigation
SITE	Superfund Innovative Technology Evaluation
SoCal Gas	Southern California Gas Company
SO_2	Sulfur dioxide
SPLP	synthetic precipitation leaching procedure
SRP	site remediation program
S/S	solidification and stabilization

SVE	soil vapor extraction
SVOC	semivolatile organic compound
TCE	trichloroethylene
TCLP	toxicity characteristic leaching procedure
TEPH	total extractable petroleum hydrocarbons
3-D/3-C	three-dimensional, three-component
TPH	total petroleum hydrocarbons
TSCA	Toxic Substance Control Act
2D	two-dimensional
UCS	ultimate compressive strength
USEPA	United States Environmental Protection Agency
USWAG	Utility Solid Waste Activities Group
VOC	volatile organic compound
WEPCO	Wisconsin Energy Power Company
WRI	Western Research Institute
XRF	X-ray fluorescence

Chapter 1

Introduction

1.1 Background

From the early 1800s through the mid-1900s, manufactured gas plants (MGPs) were operated nationwide to provide gas from coal or oil for lighting, heating, and cooking. The gas manufacturing and purification processes at these plants yielded by-products or gas plant residues that included tars, sludges, lampblack, light oils, spent oxide wastes, and other hydrocarbon products. Although many of these by-products were recycled, excess residues remained at MGP sites. These residues contain polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons, benzene, cyanide, metals, and phenols.

Almost every city in the United States had an MGP; an estimated 3,000 to 5,000 former MGP sites exist across the country, some of which are still owned by the successors to the utilities that founded them. MGPs were typically built on the outskirts of cities that have since grown. As a result, the sites are now often located in inner city areas that are being redeveloped.

MGPs were constructed nationwide with similar facilities and generated similar wastes using defined manufacturing processes. In general, MGPs produced gas by cracking the hydrocarbon chains of feedstocks, primarily oil and coal, and releasing lighter carbon products. These lighter products were given off in the form of gas that was used for household needs. MGP residues were solid or liquid and included creosote, tars, spent oxide residues, and lampblack. The feedstocks and manufacturing processes used at a site, the size of the manufacturing operations, and a site's physical constraints (e.g., proximity to wetlands or vacant lots) were some of the factors that governed the manufacturing and disposal practices at each site.

Although many former MGP sites have been or are currently being investigated and/or remediated, a large number remain unaddressed. In some cases, the same party may be responsible for numerous former MGP sites in a region. The similarities in the configuration and contaminants at these sites provide opportunities to apply innovative approaches that benefit from economies of scale. Former MGP sites offer an ideal opportunity to apply tools and technologies that expedite site characterization and source remediation.

Residues often occur in the same locations at former MGP sites, e.g., near the former gas holders, tar sumps, and lampblack separators. These wastes contain a number of known or suspected carcinogens and other potentially hazardous chemicals. Because of the nature of these residues, there is a limited subset of technologies that are likely to be effective in treating them.

For additional background and historical information on the operations of former manufactured gas plants, the reader is referred to the Additional Sources of Information listed in Chapter 7 of this document.

1.2 Purpose and Scope of Document

There is a general awareness, both in the public and private sectors, of the need for faster, better, and cheaper methods for site characterization and remediation. MGP sites as a class provide opportunities to try new methods of site characterization and waste treatment, and to relate the resulting experiences to other MGP sites. Utilities and other regulatory agencies are recognizing the advantages of such programs, and are currently putting these experiences to use.

Three aspects of former MGP site characterization and remediation are addressed in this document:

- Management tools for expediting site characterization and remediation (Chapter 3)
- Tools and techniques for expediting site characterization (Chapter 4)
- Technologies for treatment of MGP-related wastes in soil (Chapter 5)

Chapter 3, Management Tools for Expediting Site Characterization, describes innovative strategies and gives examples of their use at former MGP sites. Because many of the examples come from ongoing projects, references are provided so readers can contact representatives for follow-up information.

Chapter 4, Tools and Techniques for Expediting Site Characterization, presents information on "tried and true" as well as innovative tools that can be used to expedite characterization of former MGP sites. The following categories of information are presented for each tool or technique:

- Tool or Technique Description
- Operational Considerations
- Applications and Cost
- Benefits and Limitations
- Case Studies
- Contacts

Chapter 5, Technologies for Source Treatment, focuses on the technologies currently available for MGP source (soil and/or MGP residue) treatment. The following information is presented for each technology:

- Tool or Technique Description
- Operation Considerations
- Applications and Cost
- Benefits and Limitations
- Case Studies
- Contacts

The costs provided in this document are based on limited data and are dynamic. Many variables will affect the cost of a tool or technology as applied to a specific site or set of sites. The cost information provided herein reflects an order-of-magnitude guide to costs, and is provided on an informational basis.

Case studies are provided, where available. Additional examples of the application of these strategies, tools, and treatment technologies likely exist. Typical regional variations in MGP sites are identified where relevant or where additional information is available.

Detailed information on the history of former MGPs and their disposal practices is not included in this document. For background and historical information, the reader is referred to Chapter 7, Additional Sources of Information.

Finally, this document specifically does not address groundwater remediation technologies.   A limited amount of information is provided on restoration of non-aqueous phase liquid (NAPL) zones at or below the water table. This is an area of considerable technological development. These issues may be addressed in future guidance document volumes.

Chapter 2

Creating an Expedited Site Characterization and Remediation Program

2.1 Introduction

The process of characterizing and remediating an MGP site or sites involves first determining what contamination is present and where. Once it is clear what wastes are present and at what locations, a selection of treatment and / or management alternatives can be evaluated to identify a preferred remedial approach. Familiarity with the historical operation of MGPs, which was similar at almost all sites, can further expedite the characterization and remediation process. This process typically follows that which is outlined by the National Contingency Plan (NCP) and is often modified by other federal, state, and / or local regulations.

The primary modes by which the site characterization and remediation process can be modified to save time and costs are:

- How the site is “administered” (i.e., how investigations and cleanups are organized and managed)
- The use of innovative and survey-level tools and approaches for expediting the site characterization
- Awareness of and familiarity with the subset of treatment technologies that are proven or promising for the particular types of wastes found at MGP sites

This chapter summarizes the process of streamlining the site characterization and remediation process, by tying together approaches to site management and contamination assessment (described in Chapters 3 and 4) with proven or promising treatment technologies for MGP residues and wastes in soil (Chapter 5).

2.2 Expedited Site Characterization and Remediation

Twenty to twenty-five years ago, in the early days of site characterization and environmental remediation, contaminated site work was scientific study as new disciplines were created and refined to address the work at hand. Typically, site work would begin with the preparation of work plans, followed by a round of field investigations. Samples collected during the field programs were sent to analytical laboratories for analyses, and after about a month, laboratory results were returned and subjected to tabulation, mapping, and other types of data evaluations. The results of the data analyses were documented in a draft report which was distributed to the responsible party and regulatory agencies for review. Meetings typically followed in which detailed discussions were held as to the "correct" interpretation of the data. Eventually, a revised report was prepared and submitted, the conclusion of which typically included recommendations for additional sampling. And so the whole process of work planning-sampling-laboratory analyses-data interpretation-reporting would continue until multiple phases and many years would pass. In all, very large sums of money were spent on "studying" the site before cleanup activities were planned, much less implemented.

In response to outside economic influences (including experience with the economic impacts of site characterization and remediation on businesses), the need for additional urban lands for redevelopment (bringing the Brownfields-type initiative to the forefront), and the maturation of the environmental marketplace, new pressures have been brought to bear to accomplish the same tasks in a smarter, cheaper, and more expeditious manner. For certain types of sites, including former MGP sites, practitioners now have enough experience that they can anticipate the nature of work to be accomplished, foresee the problems that may arise, and select an appropriate remedy from a known subset of treatment technologies. From a menu of technology options, practitioners can select the site characterization and analytical methods that are most likely to yield useful information to support site decisionmaking and remedy selection. When remedial design options are anticipated during the planning stage, data supportive of remedy considerations can be gathered concurrently with characterization information. By involving stakeholders at critical junctures, community and regulator satisfaction can be increased, decreasing the likelihood of legal battles that may delay remedial action and consume financial resources.

Work at former MGP sites can proceed seamlessly from investigation to remediation and closeout. With careful advance planning and the use of rapid turnaround on-site analytical technologies, investigation and cleanup objectives can be achieved in a fraction of the time (and thus at a lower cost) as compared to traditional approaches which rely on a prescriptive, linear progression of phases and tasks. Considerable time savings over the life of the project can be realized by reducing the number of mobilizations to the field and by performing multiple task simultaneously.

There are a number of key elements that comprise new approaches to performing site characterization. The most critical is the need for systematic planning prior to initiating site work. Systematic planning is one of the most cost-effective tasks in environmental remediation. It markedly increases the likelihood that a project will be successfully completed the *first* time, and within budget. It markedly decreases the probability of unpleasant and costly surprises.

Planning should be performed by a core technical team that contains all the expertise needed to adequately address the needs of the site, and that will incorporate the interests and concerns of stakeholders. Expertise vital to nearly all sites, but frequently overlooked, includes the services of a knowledgeable analytical chemist and a statistician familiar with the special concerns of environmental sampling. Planning involves the use of a site conceptual model which identifies the historical uses of the site, potential exposure pathways, cleanup concerns, and future land-use options. Clear articulation of the decision(s) or question(s) that drive the site work is imperative to the planning process. An appreciation for how much uncertainty or risk is acceptable in site decisions is also crucial (i.e., how sure must the decisionmaker be that wrong decisions will not be made). A great deal of time and effort may be consumed reaching consensus on these two issues, but once done, planning of the actual work to be performed at the site can begin and proceed without interruption.

Planning then proceeds in an orderly progression: When the site decision(s) is known, the *type* of information (data) which is required to inform the decisionmakers can be identified. When the amount of uncertainty has been decided, the *quality* of the data needed to meet the uncertainty goals can be determined. Once the type of data and the data quality needs have been determined, then a menu of analytical chemistry methods (for contaminant data) or sampling tools and techniques (for hydrogeological or contaminant information) can be surveyed for a cost-effective means of gathering information. If, during the planning process, it is found that the expense of collecting a data point to meet very stringent uncertainty goals exceeds available resources, the team can "go back to the drawing board," and negotiate with stakeholders over future land use alternatives and the degree of allowable uncertainty.

Selecting an analytical method(s) involves balancing a number of considerations: the data needs, any regulatory requirements, costs, the ability to optimize sample throughput to provide real-time decisionmaking and to match the speed of sample collection, and any anticipated site-specific issues (such as matrix interference). Method selection should be done by a qualified chemist who can weigh the costs and benefits of various methods against site-specific data needs.

Field analytical methods hold a significant potential for cost and / or time savings, and should be included in the pool of analytical options under consideration. The rapid turnaround time supports a dynamic work plan which can decrease the collection and analysis of uninformative samples. Again, a knowledgeable chemist is crucial to avoiding the potential pitfall of the undiscerning use of field analytics.

It is the responsibility of the chemist member of the technical team to stay on top of rapid advancements being made in analytical environmental chemistry, especially as they relate to field methods. Depending on the method, the skill of the operator, and the kinds of calibrations and quality control used, some currently available field technologies can produce results that are just as quantitative as those expected from traditional laboratory services. The ability of field analytical methods to address certain issues, such as defining spatial variability across the site and minimizing the loss of volatile contaminants during sample collection and transport, means that field analytical data can sometimes be *more* reliable and representative than those generated under traditional scenarios.

Of course, the big question about the use of innovative analytical methods and sampling tools is "Will the regulators accept the results?" In general, regulators will often accept results from less-traditional technologies if the rationale for the collection and use of the data has been clearly documented. It is unfortunately true, however, that a heavy reliance has been placed on accepted methods, sometimes to the extent that these methods are viewed as “approved methods” that *must* be used to generate analytical data at contaminated sites. However, as part of their Performance-Based Measurement System initiative, the U.S. Environmental Protection Agency (USEPA) is attempting to change the focus to *what* data quality is required, leaving it up to the regulated entity to select the analytical method to be used.

Finally, by blending advance planning with field analytical methods capable of “immediately” available results, it is possible to implement dynamic work plans to accomplish site work much more efficiently than under traditional approaches. Dynamic work plans offer structured decision logic, such as decision trees or contingency planning, that guides the performance of field activities. A key feature is on-site decisionmaking and direction of field efforts by the technical team based on an evolving site conceptual model which is constantly updated with new information as it becomes available. Dynamic work plans use an adaptive sampling and analysis strategy where subsequent sampling is directly contingent on the interpretation of earlier results, which permits the collection of samples or the installation of wells in locations where the data are truly needed to decrease uncertainty.

To successfully implement a dynamic work plan, more experienced team members must take charge of field work. Increased expense is justified by the increased productivity of field work. For example, there is a decreased need for multiple mobilizations to the field to redirect work after interpretation of results turned around from the laboratory three to four weeks later indicate that important data gaps (and thus uncertainty) still remain; or when it is discovered that some critical analyses failed quality assurance checks and samples must be recollected if the data set is to be complete. Most importantly, the quandary of whether to spend more money on another sampling round to decrease uncertainty or whether to “make do” with the available data is avoided. “Making do” generally means that site decisions or remedial design will be based on inadequate information which increases the risk that the project will ultimately fail to achieve its objectives.

Adequate site characterization is essential to define the nature and extent of contamination so that decisions regarding site cleanup will be done in a scientific and legally defensible yet cost-effective manner. The range of experience and knowledge gained over the past decade is permitting the environmental remediation field to capitalize on new technologies and new ideas. To maintain momentum, practitioners must make the effort required to stay current with developments in their field of expertise. As the pool of available knowledge and technology tools continues to expand, it also becomes important to recognize that a single person cannot be relied upon to do it all – a technical team approach which acknowledges that contributions of geologists, engineers, chemists, biologists, quality assurance experts, risk assessors, statisticians, and regulatory experts is crucial to successful projects.

2.3 Creating the Expedited Site Characterization and Remediation Program

A successful expedited site characterization and remediation program is formed by careful and thoughtful advance planning. As a whole, the program can be broken down into the following four steps or phases. Although these steps appear to be the same basic steps as currently applied at Resource Conversion and Recovery Act of 1976 (RCRA) or Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) sites, the intent is to do the project in a better, faster, and less expensive manner. During each step described below, project implementation and management can be enhanced through the development of relationships (and trust) between stakeholders, frequent and effective communication, flexibility, and contingency planning.

Step 1: Preliminary Conceptual Model Formation
The first vital step in expediting site characterization and remediation is to conduct an initial site evaluation (also known as a Phase I environmental assessment or Preliminary Assessment) to establish baseline conditions at the site. In this assessment, historical information about the site's former operations are gleaned from documents such as:

- Historical aerial photographs
- Sanborn Fire Insurance maps
- As-built site drawings
- Historical operations records
- Historical topographic maps
- Real estate records and title information

Regulatory agency site listings and files are also reviewed as are current site practices. From this assessment, a preliminary site conceptual model is formed, identifying what types of contaminants (if any) may be present at the site (e.g., petroleum hydrocarbons, PAHs, heavy metals), the possible locations of wastes (e.g., gas holders, lampblack separators, tar pits and wells), and any immediate health risks or threats to the environment.

Step 2: Survey-Level Field Program Formulation
Following completion of the preliminary site conceptual model, all possible stakeholders in the project should be identified, briefed with the preliminary conceptual model, and interviewed to obtain their input on the overall project goals and objectives. Possible stakeholders include senior members of the responsible parties' organizations, regulatory agency representatives, third-party owners, public officials, and representatives of the public as required for future land use determination. A survey-level field program is then formulated to collect analytical data to answer the following questions:

- What contaminants are present at the site, if any?

- What are the relative concentrations of the detected contaminants?
- What is the approximate extent of contamination at the site?

It is here the 80/20 rule should prevail; that is, practitioners should aim at getting 80 percent of the information ultimately needed for the project in this round of sampling. The survey-level field program should take advantage of the site characterization and management tools listed in Chapters 3 and 4 to gather a large amount of relatively good quality data in order to determine where the majority of the contamination is located and its chemical composition. A limited site investigation (SI) is usually required to collect this information.

Dynamic work planning is essential to the successful completion of this phase of the project. Sampling and field decisionmaking protocols — rather than specific boring locations — should be outlined in the work plan, allowing an experienced field team to move and sample at those locations dictated by each previous sampling point. Innovative tools should be paired and implemented to allow for real-time on-site analytical data feedback; for example, using direct-push drilling with grab groundwater samplers and immunoassay or colorimetric testing to identify the presence/absence and relative concentrations of subsurface and groundwater contamination, where practicable.

Step 3: Preliminary Treatment Technology Screening, and Focused Field Investigation Formulation and Implementation

Following completion of the survey-level field investigation, the sampling program's results are analyzed with an eye toward site remediation. Those remediation technologies that are the most promising for the site are identified, as are the additional data points necessary to:

- Further refine estimates of contamination volume
- Gather the additional data necessary to aid in evaluation and selection of the best remedial alternative(s) for the site (e.g., geochemical indicators of natural attenuation to see if active groundwater remediation is necessary, soil sieve analyses to determine grain size, soil moisture measurements to determine effectiveness of thermal desorption, etc.)
- Collect additional site-specific data to evaluate uncertainties that may have a significant effect on the remedy selection (e.g., Is shallow groundwater in connection with deeper groundwater-bearing zones? May drinking water be affected?)

From this exercise, one or more focused field investigations are formulated and subsequently implemented to gather only those data necessary to reduce uncertainty to a pre-determined level of comfort and as required to complete remedy selection. Again, work planning should allow for flexibility in the field, permitting additional data collection as deemed necessary by the experienced project team.

Step 4: Remedy Selection and Contingency Planning

Using the results from the focused field investigations or a full-scale subsequent remedial investigation (RI), remediation remedies for the site are evaluated. Taking all factors into account, a remediation selection is made. As part of the remedy selection and remedial design process, contingency planning is conducted to prepare for unexpected changes in site conditions during remediation. The selected remedial program is then implemented and modified as needed to adapt to changing site conditions in order to achieve pre-determined performance-based standards.

The four steps described above are intended to provide a skeleton for an expedited site characterization and remediation program. It is the responsibility of the practitioner to use this as a guide, amending, modifying, and adapting as needed to meet site- or project-specific conditions. There are many variables that will influence the form, scope, and level of effort involved for a site characterization and remediation program. For example, site attributes that may affect the tools used to characterize the site include:

- Site size
- Hydrogeology complexity
- MGP feedstocks used
- Availability of background and historical information

The tools described in general below and in detail in subsequent sections of this document have been selected as those most applicable and available for formulating an expedited program at former MGP sites. Logic and experience will aid in formulation of an appropriate site-specific program.

2.4 Management Tools for Expediting Characterization and Remediation

The process of MGP site characterization and remediation can be expedited by a number of management or administrative approaches. Underlying all these approaches is the need for trust and communication among those with an interest in the site: the site owner, responsible party, regulators, consultants, the public, area residents, etc. Actively involving all stakeholders in the process and creating teams under conditions that foster genuine cooperation are key to facilitating cleanup. If there is trust among all parties involved, there can be flexibility to make decisions in the field as new information is uncovered about the site, without slowing the process down for repeated reviews of new documentation. Effective, cooperative relationships can be fostered by establishing administrative structures and procedures, and / or by chartering teams of stakeholder representatives on a project-by-project basis.

Practical strategies for streamlining MGP site characterizations and remediations are discussed in Chapter 3 and include grouping together nearby or similar sites and negotiating agreements for groups of sites rather than on a site-by-site basis; creating templates for work plans, reports and administrative orders; and knowing early in the process what the eventual use of a site will be so cleanup can be targeted to levels appropriate to that future use. Risk analyses, in the form of tiered or probabilistic risk assessments, can also be used to help establish appropriate cleanup objectives and to aid in the comparison of risks and liability that could remain if various remedial alternatives were implemented. In addition, use of the observational approach to site management can help focus the project on targeting the information needed to assess contamination, getting only as much information as needed to evaluate remedial alternatives, and planning for new information that might emerge about the site as cleanup proceeds rather than trying to eliminate all uncertainties before remediation can begin.

2.5 Tools for Site Characterization

All of the management strategies summarized above rely on targeted field investigations in which sampling locations are chosen based on knowledge of a site's past layout, and on the use of tools that are generally faster and give more immediate results than those used in the past for assessment and cleanup of wastes. Many samples can be collected, and a large amount of survey-level data can be generated in a short time using these innovative tools.

Field surveying tools described in Chapter 4, from direct-push drilling to methods for rapidly sampling soil and groundwater to the use of imaging techniques to locate underground structures, make the process of collecting data on the types, concentrations, and locations of MGP wastes much more rapid than in the past. If management strategies such as site bundling are also used, multiple sites can be assessed together or sequentially, taking advantages of economies of scale.

After the first phase of an investigation has been completed using field surveying tools, further, focused investigations can supply additional data about areas of contamination or uncertainty. This document focuses on tools for rapid field surveys. In some cases, regulators may require data that these tools cannot provide (e.g., low concentrations of PAHs in groundwater). However, because effective field surveying can determine where the majority of the contamination occurs at a site, traditional, time-intensive monitoring (e.g., fixed monitoring wells) to gather additional data can be used only where necessary, saving time and money compared to using these traditional methods to assess the whole site.

2.6 Technologies for Cleaning Up MGP Wastes

Familiarity with the technologies that have proven effective for treating MGP wastes (as described in Chapter 5) may save time in identifying those candidates most applicable to a specific former MGP site. Consider the choice between on-site or off-site asphalt batching and thermal desorption as a treatment for contaminated soil. Since both technologies will produce approximately the same result, considerations such as the amount and types of soil to be treated, the proximity of the MGP site to an off-site fixed facility, and the costs associated with these factors will likely motivate the decision.

2.7 Conclusion

The ability to craft an effective, streamlined site characterization and remediation program comes from both experience and knowledge. Understanding how MGPs were operated and dismantled is the first step — gaining an understanding of what might be below the surface of a site is extremely important. Flexibility, combined with careful planning and the willingness to try something new, can aid in the formulation and successful implementation of an innovative and streamlined investigation and remediation program.

The management strategies and field-survey tools described in this guide will provide information necessary to expedite the site characterization and remediation process. The technologies described are those most likely to be effective in remediating MGP wastes in soils, delineated by this streamlined process.

Chapter 3

Management Tools for Expediting Site Characterization and Remediation

3.1 Introduction

Because of the similarity of former MGP sites nationwide, innovative site management tools have been developed to streamline the characterization and remediation of wastes found at these sites. Using these techniques can reduce the timescale that has been typical for remedial investigation, feasibility study, remedial design, and remedial action (RI/FS/RD/RA) cleanup projects at sites being addressed under traditional programs. These innovative approaches, described below, have two key features: they take advantage of economies of scale, emphasizing ways to address multiple sites simultaneously; and they focus on facilitating communication among the parties involved in cleanup as well as promoting each party's "ownership" of the process. The table on the following pages summarizes the components of these programs.

These site management innovations are currently being applied at MGP sites. Case studies are included below where available. Not every tool will be appropriate in every situation. Parties responsible for former MGP sites can modify the approaches to fit their sites. Similarly, responsible parties can select more than one of the tools discussed below and merge them to tailor a program to a site or set of sites. Reference information is supplied so that readers can contact representatives involved in the specific projects.

Management Tools for Expediting Site Characterization and Remediation

Name	Description	Economies of Scale Advantages	Communication Facilitation
Site Bundling	Bundling multiple MGP sites into one "package" which is then managed, investigated, and as appropriate, remediated as a single entity.	• Saves time and money by reducing the volume of paperwork • Allows for negotiation of lower unit pricing with vendors • Reduces project management and accounting costs through reduction in project administration labor hours • Reduces regulatory agency oversight costs by negotiation one order for multiple sites and having one regulatory project manager	• One regulatory project manager for multiple sites minimizes downtime from lack of education/project understanding • Minimizes duplication in RI/FS/RD/RA program development • Builds trust/relationship between stakeholders by prolonged, multi-site contact
Multi-Site Agreements	Single agreement providing responsible party(ies) and regulatory agency(ies) the opportunity to address environmental conditions under a single, cooperative, mutually beneficial, statewide agreement.	• Comprehensive and consistent statewide strategies • Reduced costs of negotiating agreements/orders • Control of year-to-year costs • Optimized risk reduction	• Agreements tailored to company-specific needs • Central point of contact(s) established within regulatory agency(ies) • Proactive environmental mitigation • Emphasis on cooperation and common sense
Generic Work Plans and Reports	Preparation of generic documents, such as work plans and reports, that can be tailored to a specific site or set of sites.	• Savings from having to prepare only the site-specific sections of a document • Reduced regulatory oversight costs and review time from having all documents from a single entity be organized similarly	• Streamlined decisionmaking from "prequalifying" remediation technologies with local regulatory agencies • Consistent site characterization and application of quality assurance project plans and Health and Safety Plan across multiple sites • Consistent decisionmaking rationales applied to multiple MGP sites
Program/ High Performance/ Design Teams	A team or set of teams formed and chartered to work towards a common goal, promoting communication, expediting decisionmaking, streamlining deliverable preparation, and remediating a site in the most cost- and time-effective manner possible with agreement among all parties involved.	• Shared project vision, mission, and goals for all sites addressed by the team • Reduces overall costs by minimizing document handling and review and project downtime • Reduces overall regulatory oversight costs • Minimizes downtime and backsliding resulting from consultant or regulatory management turnover	• Chartering and common sense of purpose and set of goals promotes communication • Success of team(s) based on development of relationship and trust • Nature of team reduces stakeholder conflict • Team charter formalizes communication process
Early Land-use Determination/ Brownfields	Identification of future site beneficial use prior to site characterization, and integration of the proposed future land use with the planned site remediation.	• Reduces site characterization costs by identifying only those data necessary for evaluation of remediation alternatives to meet proposed future site use • Minimizes remediation costs by focusing on alternatives that can successfully meet future beneficial use needs • Can turn a challenged property into a money-making enterprise	• Focuses regulatory agency(ies) and responsible parties on the project's ultimate goal (site remediation and redevelopment)

Management Tools for Expediting Site Characterization and Remediation

Name	Description	Economies of Scale Advantages	Communication Facilitation
Managing Uncertainty	A method providing a way to determine when sufficient site characterization data have been collected and involving managing uncertainties through the identification of reasonable deviations from original plans and the preparation of contingency plans to address changed site conditions.	• Minimizes downtime during site characterization and/or remediation through upfront contingency planning to address potential changes in site conditions	• Requires flexibility to alter a site investigation and/or remediation in the field based on pre-determined contingency plans. This requires trust and consistent communications between regulatory agency(ies) and responsible party(ies)
Expedited Site Characterization	The combination of tools, strategies, and processes that interlink and synergistically help streamline investigation and remediation processes.	• Reduced costs through streamlined document preparation and review • Reduced costs through the use of field screening and analysis tools • Minimizes project downtime by allowing flexibility in the overall site characterization and remediation processes and through the active management of uncertainty	• Communication and cooperation among responsible parties, regulatory agencies, and third party stakeholders through mediation, facilitation, and high-performance teams • Uses onsite or rapid decisionmaking capabilities • Includes a process for reducing team member turnover and minimizing effects of team member replacement
Legislative Innovation	Alternative regulatory policies for the remediation of contaminated properties by providing for a comprehensive program that includes revised liability, indemnification processes, risk-based cleanups, streamlined remediation processes, and dispute resolution.	• Allows risk-based decisionmaking to optimize remediation alternatives • Apportionment of liability based on fair and equitable principles and orphan share funding • Saves cost by expediting site remediation	• Lead agency designation streamlines regulatory agency communication • Requires public participation per state regulatory guidelines
Dovetailing Business Decisionmaking and Remediation Planning	Combining site remediation with business ventures such as developing affiliate companies or developing joint venture to create a mobile treatment facility.	• Optimize treatment costs by investing in risk-sharing treatment ventures	N/A
Establishing Background PAH Concentrations	Establishing the portion of PAHs at a site that are the result of non-MGP processes such as automobile exhaust, crude oil processing, etc.	• Optimizes volume of soil to be remediated by addressing only those portions of PAH-contaminated soil that are the result of historical MGP processes	N/A
Generic Administrative Orders	Preparation of a single generic administrative order that can be adapted for multiple sites.	• Streamlines the administrative order preparation process • Reduces costs in preparing and negotiating administrative orders	• Familiarity with the generic order allows for site-specific communications/ negotiations on an as-needed basis

3.2 Management Tools for Expediting Site Characterization and Remediation

The following sections describe each site management tool for expediting site characterization and remediation. Because different tools will be appropriate for different sites, no attempt has been made to rank the tools according to their effectiveness.

3.2.1 Site Bundling

Tool Description

Utility companies typically own or are liable for multiple MGP sites. There are many methods that can save time and money during site characterization and remediation. One simple but effective method is bundling multiple MGP sites into one "package," which is then managed, investigated, and remediated as a single entity. Site bundling saves time and costs by:

- Reduction in the volume of paper documentation (e.g., one work plan may be prepared for multiple sites)
- Reduction in project management and accounting costs through a reduction in the number of labor hours required for project administration
- Reduction in regulatory agency oversight costs by negotiating one order for multiple sites and by requiring only one regulatory agency representative for the sites

Additional savings can be achieved by coordinating site investigation and remediation activities for multiple sites located relatively close together. Mobilization costs can be reduced by conducting sampling (e.g., quarterly groundwater monitoring) sequentially at all sites and by purchasing sampling materials in bulk. When the preferred remedial alternative is the same for multiple sites and especially in situations where the sites are located near one another, treatment costs can be reduced by staging treatment processes for all the sites at one location. Savings result from reduced transportation costs and lower unit costs for treating larger volumes of material than would be generated by a single site.

Case Study

MidAmerican Energy Company Multi-Site Thermal Desorption

At the end of 1996, MidAmerican Energy Company (MEC) was preparing to conduct remedial activities at a number of former MGP sites that were relatively close to each other. These sites had fairly small quantities of waste to be treated and were of limited size, which posed potential problems for locating treatment technologies on-site. Because of the sites' proximity, small size, and ownership by one utility, innovative administrative and technical approaches were chosen.

On-site thermal desorption by a mobile treatment unit was identified as a viable remedial alternative for all of the sites. MidAmerican Energy worked with the Iowa Department of Natural Resources (DNR) and USEPA Region VII to locate a thermal desorber at a National Priorities List (NPL) site in Waterloo, Iowa.

Following completion of a rigorous trial burn, the thermal desorption unit was used to treat MGP wastes at the Waterloo site and from three additional sites in Charles City, Hampton, and Independence, Iowa.

Project Milestones

Initially, Independence, Iowa, was the only MEC site where contaminated soils were to be excavated and thermally treated. As the planning for this project proceeded, it became apparent the thermal desorption unit could not be set up on-site because of lack of space. A search began to find a treatment location. An industrial park in Independence appeared to be the first choice. However, the high costs of this choice meant that another option had to be considered. The Waterloo former MGP site in Waterloo, Iowa, already had 12,000 cubic yards of soil removed for treatment, and this site was located 30 miles from Independence. An open excavation existed at Waterloo, and more soil required excavation. Concurrently, MEC determined that removal actions at the Charles City and Hampton former MGP sites would also be beneficial if soil treatment could be arranged. MEC therefore concluded that treatment of excavated contaminated soils from all four sites at one on-site location could be a tremendously cost-effective way to conduct removal actions at all four former MGP sites.

Site	Waterloo	Hampton	Charles City	Independence
Size (acres)	3.4	0.6	1	0.4
Service Years	1901 - 1954	1906 - 1937	1909 - 1949	1880 - 1947
Current Site Use	vacant	electric substation/ storage area	electric substation	vacant
Gas Process Used	coal carbonization, water gas, carbureted water gas	Lowe Water Gas System	Lowe Water Gas System	J.D. Patton Oil Gas Process, Tenney Water Gas Process
Regulatory Status	Under consent order with USEPA Region VII	Under consent order with Iowa DNR	Under consent order with Iowa DNR	Under consent order with Iowa DNR

A summary of the projects milestones is shown below:

- January and February of 1997 - MEC contacts the city managers of Independence, Charles City, and Hampton, Iowa, to discuss the potential remediation of the former MGP sites.
- March and April 1997 - Additional meetings with Iowa DNR and USEPA take place to discuss the possibility of locating a thermal desorption unit at the Waterloo site and thermally treating soils from the other three sites, thermally desorbing the remaining soil at the Waterloo site, and using all the thermally treated soil as backfill at Waterloo.

- May 1997 - MEC adds the Hampton, Charles City, Waverly, and Waterloo sites to the Independence thermal desorption project, and initiates community relations activities in preparation for the project.
- July 1997 - A Thermal Desorption Scope of Work and Contract Documents package is completed. MEC continues to work with the Iowa DNR to develop work plans for the sites under state regulatory oversight and with the USEPA concerning the scope of work at the Waterloo site.
- October 1997 - Final changes are made to the work plans for Hampton, Charles City, and Independence sites. Site preparation begins at Waterloo, with soil excavation initiated at the Hampton site and soil shipping to Waterloo.
- December 1997 - Thermal desorption operations begin in January 1998. Soil excavation continues at all four sites, with thermal desorption operations continuing at the Waterloo site.
- February 1998 - All work, including backfilling, is completed.

Remedial Action Implementation

The cleanup objective at these sites was to remove visibly contaminated soil and to excavate to physical limits, which were determined by site conditions such as buildings, property boundaries, railroad tracks, etc. The criteria for stopping the excavation short of a physical boundary were less than 500 milligrams per kilogram (mg/kg) total PAHs or less than 100 mg/kg total cPAHs (cPAHs) in the 0- to 6-foot range, or less than 3,000 mg/kg total PAHs or less than 200 mg/kg cPAHs at depths greater than 6 feet. The cleanup criterion for the thermally treated soil was less than or equal to 5 mg/kg total PAHs.

The following table shows the amount of soil excavated and treated for each of the four sites:

Site	Tons of Soil Treated
Hampton	3,651
Charles City	2,138
Independence	4,734
Waterloo	14,167
Total	24,690

Treated soils from all four sites were used to backfill a previous excavation at the Waterloo site. All contaminated oversized debris was crushed and thermally treated. Some exceptionally large debris, such as foundations, was decontaminated in place and left in the excavation. All scrap steel was cleaned and sent to a recycler. As a result, nearly all materials removed were thermally desorbed or recycled. A small amount of material, primarily wood debris and tree roots, was taken to the local landfill.

The total cost of the project was $2 million. This cost includes site preparation and installation of utilities; excavation at all the sites; hauling excavated material from Hampton, Charles City, and Independence to Waterloo; backfill and labor to place the fill; and the thermal desorption services including the cost of fuel.

The average cost per ton of soil treated was calculated for the project and is shown in the table below:

Item	Average cost per ton ($)*
Excavation	4.83
Thermal Treatment	47.87
Transportation	12.53
Backfill	4.83
Miscellaneous*	8.62
Total	78.68
* This includes the cost of analysis, engineering services, air monitoring, etc.	

Conclusions

Site bundling resulted in total savings of more than $1 million on this project. The use of a single, central location for treatment of contaminated materials resulted in significant savings compared to the cost of completing the four projects separately; MEC has estimated a savings in excess of $150,000 in costs related to project management. Additional savings of approximately $205,000 were realized by using the treated soil as backfill at the Waterloo site rather than landfilling the treated soil and purchasing clean backfill. Setting up the thermal treatment unit in Waterloo, a central location relative to the other sites remediated, reduced shipping costs. Previous work at the Waterloo site had included shipping soil to the Neal Generating Station near Sioux City, Iowa. By setting up the thermal desorber in Waterloo, MEC saved approximately $575,000 in soil shipping costs. Reduced regulatory oversight and engineering costs were estimated to be in excess of $100,000.

Teamwork was a key component to the successful completion of this project. Iowa DNR and USEPA Region VII personnel reviewed and commented on documents for this project. Because MEC wrote the work plans in-house, the time required to make a change to a work plan and send an updated copy to the regulators was very short. At times a change would be suggested, the pages of the work plan were modified, and copies of the changes were faxed within hours of the discussion. This fast pace kept everyone involved focused on completing the task. Joint effort by state and federal agencies resulted in achieving the goals of site source removal, thermal treatment, and backfill at four sites in a short time.

Contacts

Johanshir Golchin, Iowa Department of Natural Resources, (515) 281-8925

Jim Colbert, USEPA Region VII, (913) 551-7489

Sam Nelson, MidAmerican Energy Company, (712) 277-7851

Dan Klimek, MidAmerican Energy Company, (712) 277-7930

3.2.2 Multi-Site Agreements

Tool Description

Former MGP sites lend themselves to multi-site agreements. Much like strategic plans, multi-site agreements provide both the responsible party(ies) and the state in which the properties are located the opportunity to address environmental conditions under a single, cooperative, mutually beneficial, statewide agreement. Benefits of multi-site agreements include:

- Comprehensive and consistent statewide strategies
- Reduced costs of negotiating agreements/orders
- Agreements tailored to company-specific needs
- Control of year-to-year costs
- A central point of contact that may be established within the state regulatory agency
- Proactive environmental mitigation
- Optimized risk reduction
- Emphasis on cooperation and common sense

Multi-site agreements have currently been implemented in California, Iowa, New York, and Pennsylvania. In all cases, multi-site agreements are developed through negotiations among utilities/companies and regulatory agency(ies) and include a strategic plan for addressing and completing site investigation and remediation.

The Pennsylvania Department of Environmental Protection Multi-Site Agreement Program

The state of Pennsylvania has developed a statewide program for multi-site remediation agreements under the Department of Environmental Protection, Bureau of Land Recycling and Waste Management. Under the Pennsylvania Department of Environmental Protection (DEP) Multi-Site Remediation Agreement program, utilities and other private parties may enter into a form of consent agreement that is fundamentally different than the agreements enforced for parcels owned by individual owners. Instead of imposing requirements with respect to each individual site, the Pennsylvania multi-site agreements require that a specific minimum increment of work be performed each year at the covered sites taken as a whole. A point system is used to measure the work completed, thereby ensuring permit compliance. To a large extent, the volume and type of work performed during a particular year is within the discretion of the business owner. The Pennsylvania multi-site agreements include seven primary elements that distinguish them from other DEP-enforceable remediation agreements:

Element 1: Planning Process—Under the Pennsylvania DEP Multi-Site Remediation Agreement program, a company entering into an agreement with DEP is required to submit an annual and 5-year plan incorporating the following items:

- Identification of anticipated work during the next 1- and 5-year periods
- A list prioritizing the sites covered by the agreement
- The number of points to be earned by the anticipated work
- The estimated costs to be incurred during the next year of work

Under this program, it is the DEP's responsibility to assemble a team including representatives from both regional and central DEP offices, to disseminate information among this team during the course of the agreement, and to respond to submittals with a single set of comments. Any disagreement within the DEP team for the sites must be resolved internally to provide consistent regulatory review and oversight.

An annual planning meeting is held between the party responsible for the sites and the DEP, providing an opportunity to review the proposed plans in a cooperative manner, resolve outstanding issues, and discuss implementation of the agreement.

Element 2: Prioritization of Sites—As noted above, the annual plan is required to prioritize the sites to be covered by the agreement. This prioritization is conducted by evaluating the environmental and human health risks posed by each site and assigning points based on a scoring system that identifies the features that potentially pose the greatest risks. The scoring system varies by agreement and is included as an attachment to the multi-site agreement. This method of risk-based scoring promotes DEP's goal of risk reduction and helps the party responsible for the sites address its areas of highest liability first.

Element 3: Point System/Minimum Annual Point Requirement—The key feature of Pennsylvania DEP's Multi-Site Remediation Agreement program is the point system that measures success in completing remediation activities. Rather than dictating which sites require which activities, the DEP and the party responsible for the site create a list of anticipated components of work required to investigate and remediate the sites covered by the agreement. Points are assigned to each component based on various criteria (or combinations of criteria), including level of effort, cost, environmental benefit, and risk reduction. The DEP and the responsible party then determine the minimum number of points to be completed annually under the agreement, which allows the responsible party the freedom to determine which activities will be conducted in any given year. Failure to meet the minimum annual point requirements may result in penalties and the requirement to "make up" the shortfall in a specified period of time. Conversely, if the responsible party achieves more than the minimum annual point requirement in a given year, it may bank or save the "extra" points and apply them in a subsequent year.

Element 4: Cost Cap—The Pennsylvania DEP is willing to include a cost cap in its multi-site agreements, allowing a responsible party to fall short of its minimum annual point requirement should its total annual costs meet or exceed the cap. The costs that are included in this cap are open to negotiation. The cap gives the responsible party fiscal protection should remediation activities at one particular site turn out to be significantly more expensive than anticipated. In order to include the cost cap in a multi-site agreement, the responsible party must make a financial disclosure.

Element 5: Uniform Process for Review and Approval of Submittals — Pennsylvania's multi-site agreements, like all enforceable agreements in the state, must identify the type and contents of plans and reports to be submitted. Because Multi-Site Remediation Agreement documents require review by a DEP team, a uniform process for review and approval of submittals is also included in the multi-site agreement. Establishing this process during the agreement preparation means that requirements can be applied consistently. The review process can also be streamlined and potentially contentious issues can be resolved up front.

Element 6: Termination —All multi-site agreements prepared by the DEP allow for termination of the agreement by either party upon the agreement's fifth anniversary and every fifth anniversary thereafter. The agreement is limited to a minimum of 5 years, which allows the responsible party to "test the waters" without committing to a long-term process.

Element 7: Interaction with Act 2—Act 2, Pennsylvania's Land Recycling and Environmental Remediation Standards Act, establishes environmental remediation standards to provide a uniform framework for cleanups. Under this act, responsible parties can choose from three types of cleanup standards: background standard, statewide health standard, or site-specific standard. Act 2 describes submission and review procedures to be used under each of the three cleanup standards and provides releases from liability for owners or developers where the site has been remediated according to the standards and procedures of the Act. Under the Pennsylvania DEP's Multi-Site Remediation Agreement program, interaction with Act 2 has, to date, been agreement specific. The Penn Fuel Multi-Site Agreement (discussed below) required the achievement of an Act 2 standard but also allowed DEP to issue a no-further-action letter in lieu of an Act 2 release, thereby relieving Penn Fuel from some of the administrative requirements of Act 2 (Rader, 1997).

Benefits achieved under the Pennsylvania DEP Multi-Site Remediation Agreement program include (Commonwealth of Pennsylvania, 1996a):

- Development of case loads that are manageable by both the DEP and the responsible party
- Reduction of review time and inconsistent responses through the development of the uniform process for review and approval of submissions
- Cost savings from managing multiple sites simultaneously and reducing redundant administrative tasks

- Creation of good will among DEP regions and central office and with the regulated community

The primary disadvantage of the program is the potential deferral of remediation at some of the covered sites. However, by actively managing the sites requiring investigation and remediation and providing credits for work completed ahead of schedule, both DEP and the responsible parties can minimize risk within the context of limited resources.

Case Studies

Pennsylvania Power & Light Co. Multi-Site Agreement

In 1995, Pennsylvania Power & Light Company (PP&L) entered into a multi-site agreement with the Pennsylvania DEP. This agreement formed part of the foundation of Pennsylvania DEP's current Multi-Site Remediation Agreement program. Under this multi-site agreement, PP&L and DEP agreed to develop a model to rank almost 130 potential contaminated sites, including utility poles, substations, power plants, and former MGP sites. To create this model, PP&L and DEP first developed a uniform polychlorinated biphenyl (PCB) standard for all the sites so PP&L could manage the project with consistent interpretations from different DEP regional offices. Next, a system for prioritizing the sites was devised, and a method for tracking progress was designed. A point system was developed to ensure that PP&L kept its cleanup efforts on schedule, and an annual financial cap was set, allowing the company to allocate financial resources over several years (Winsor, 1996).

An example of a former MGP site remediated under the PP&L multi-site agreement is the Lycoming College redevelopment project. At this site, PP&L worked with the college and DEP to remove coal tar left from two large underground holders remaining from the original MGP (PP&L, 1996).

Contact

Don Stringfellow, PP&L, (717) 769-7535

Penn Fuel Multi-Site Agreement

Penn Fuel Gas, Inc., (Penn Fuel) and North Penn Gas Company (North Penn) entered into a multi-site agreement with the Pennsylvania DEP to investigate, and, where necessary, remediate 20 former MGP sites using standards from the Land Recycling Program (Act 2) and to plug 340 abandoned natural gas wells (Commonwealth of Pennsylvania, 1996b). Signed on March 27, 1997, the agreement between DEP, Penn Fuel, and North Penn Gas Company stipulated that, during the following 15 years, Penn Fuel would investigate all 20 of the sites, cleaning up those that require remediation following a schedule based on the potential environmental and health risks, if any, posed by each site. North Penn has also agreed to plug a minimum of 16 abandoned wells per year, with all 340 plugged by the year 2011. Penn Fuel and North Penn have agreed to spend up to a total of $1.75 million a year on investigation and cleanup operations and well plugging.

The Lewistown former MGP site was remediated by Penn Fuel under a multi-site agreement. Built in the early 1800s, this large MGP stood on the southern end of Lewistown, Pennsylvania. At the end of 1996, only two of the former MGP's gas holders remained. Under the multi-site agreement, Penn Fuel removed 100,000 gallons of coal tar and 625,000 gallons of water from inside the two gas holders and then dismantled the tanks. Water from the gas holders was pumped through an oil-water separator and treated with a dual carbon treatment system before disposal. The coal tar was pumped into treatment tanks and blended with a polymer to dewater the tar. The steel from the gas holders was recycled in a steel foundry.

Niagara Mohawk Multi-Site Agreement

Niagara Mohawk Power Corporation (NMPC) currently owns 24 former MGP sites, all inherited from predecessor companies when it was founded in 1950. Twenty-two of the former MGP sites are subject to two consent orders between NMPC and the New York Department of Environmental Conservation (DEC); the two other sites are being addressed separately.

The first of two DEC orders between NMPC and DEC calls for NMPC to:

- Investigate, between 1992 and 1999, coal tar and other wastes at 21 of the former MGP sites currently owned by the company to determine whether any hazardous substances are present and whether they pose a significant threat to the environment or to public health.
- Remediate each site where DEC determines that remedial process is required. Where deemed appropriate, interim measures may be undertaken to remove or control sources of contamination.

Under the second consent order, NMPC will expand and complete the cleanup already under way at the Harbor Point former MGP site in Utica, New York, to include adjacent parcels containing MGP wastes. In addition, the company committed to operate a research center at Harbor Point to evaluate several new technologies for remediation of waste-contaminated materials and to fund in advance DEC's expenses for environmental monitoring, oversight, and administrative costs (New York State Department of Environmental Conservation, 1992).

Under a third consent order that was executed in 1997, NMPC and the DEC expanded the first and second orders to include remedial programs for certain additional sites (including non-MGP sites) to:

- Level future annual costs to be incurred for site investigation and remediation (SIR) activities
- Minimize the impact upon ratepayers of excessive short-term expenditures for concentrated SIR activities
- Minimize potentially excessive burdens on staffing and administrative resources of both NMPC and the DEC

NMPC and the DEC agreed to implement an annual cost cap for SIR activities based on the level of annual costs incurred in recent years.

Contacts

Michael Sherman, Niagara Mohawk Power Corporation, (315) 428-6624

Jim Harrington, NY State Department of Environmental Conservation, (518) 457-0337

3.2.3 Generic Work Plans and Reports

Tool Description

In the site investigation and remediation process, documentation costs leading up to the remediation can be very high. The traditional RI/FS/RD/RA approach typically requires the preparation of one or more versions of a work plan and investigation report (often multiple work plans and reports for multiple phases of work), feasibility study reports, RA plans, removal action work plans, and closure reports. For utilities or private parties with portfolios containing multiple MGP sites, significant savings can come from reducing the costs of documenting and reporting. These savings can result from either preparing single submittals for multiple sites and/or multiple phases of work, or from preparing generic documents that can easily be tailored to a specific site or sites.

Most generic submittal development efforts have focused on field investigative work plans and feasibility studies. Benefits that can be achieved through the preparation of generic templates for these documents include:

- Savings from having to prepare only the site-specific sections of a work plan or feasibility study
- Reduced regulatory oversight costs and review time from having all documents from a single entity be organized similarly
- Streamlined decisionmaking from “prequalifying” remediation technologies with local regulatory agencies (e.g., development of presumptive remedies)
- Consistent site characterization and application of quality assurance project plans (QAPPs) and Health and Safety Plans (HASPs) across multiple MGP sites
- Consistent decisionmaking rationales applied to multiple MGP sites

A key factor in the successful application of generic work plans and feasibility studies is allowing flexibility to move outside the template as necessary for site-specific conditions. Combined with other streamlining strategies (e.g., multi-site agreements), the use of generic deliverables can provide a great time and cost savings to responsible parties and regulatory agencies.

Case Studies

Public Service Electric & Gas Company Generic Remedial Investigation Work Plan

In April and May of 1995, Public Service Electric & Gas Company (PSE&G) met with the New Jersey Department of Environmental Protection (NJDEP) to discuss the potential to work with the NJDEP Site Remediation Program (SRP) to streamline the MGP site remediation process. As a result, an NJDEP / PSE&G Streamlining Team was established. In partnership, the two organizations defined and evaluated the process of investigating and remediating MGP sites and identified opportunities for improvement, consistency of approach, and cost effectiveness. The Streamlining Team identified the quality of the RI workplan submittal as a major area for improvement. The inadequacy of the documents coupled with the separate review and approval cycles of the two organizations considerably lengthened the RI process. The Streamlining Team's solution was to develop a boilerplate RI work plan that met or exceeded NJDEP's technical regulations and guidelines.

In November 1997, PSE&G published a Generic Remedial Investigation Work Plan (PSE&G, 1997). This work plan outlined a data quality objective (DQO) process designed to gather and evaluate all the data necessary to complete an RI in one phase. The DQO process consists of six steps that, when completed, should provide all the data necessary to meet NJDEP's requirements. The six steps are:

Step 1: Understand the MGP facility's history, construction, and operations as they relate to the production and disposition of MGP residuals and the potential for release(s) to the environment.

Step 2: Use the results of Step 1 and the preliminary assessment and site investigation (PA / SI) to develop a preliminary site conceptual model.

Step 3: Develop a vision for future land use, preferably supported by a well-researched, site-specific plan.

Step 4: Develop risk-based RA objectives that define the purpose of the remediation and avoid expenditures on remedial activities that do not meet these objectives.

Step 5: Identify potential remedial methods, proven to be effective at former MGP facilities, that will achieve the RA objectives.

Step 6: Identify applicable regulatory requirements.

The Generic Remedial Investigation Work Plan prepared by PSE&G consists of three volumes. The first volume is the generic work plan itself, containing boiler plates for the descriptive portion of the work plan (e.g., site background, environmental setting, and scope of work). Volume 2 of the work plan contains the QAPP, Standard Operating Procedures for many field activities (e.g., cone penetrometer surveys, rock coring, and aquifer testing), and a list of the minimum safety and health plan requirements and specifications. PSE&G is currently planning to publish a generic RI report in concert with NJDEP.

Contacts

Rich Blackman, Public Service Electric & Gas, (973) 430-8278

Chris Kanakis, New Jersey Department of Environmental Protection, (609) 633-1460

Woerner Max, Public Service Electric & Gas, (973) 430-6413

Southern California Edison Generic Feasibility Study

Faced with investigation and remediation of multiple MGP sites, Southern California Edison (Edison) prepared a “generic FS” to help streamline preparation of site-specific feasibility studies for their MGP sites. This generic FS template is organized like a site-specific FS and contains text that can remain in a site-specific FS, but it also allows the user to “plug-in” site-specific information as appropriate. For example, the document provides a general history of MGP facilities and then prompts the user to add site-specific historical information. The generic FS also provides numerous examples of text and tables to further assist users in preparing a site-specific FS. In all cases, the generic FS assumes:

- The MGP waste is nonhazardous.
- Onsite ex situ remediation is not feasible because of space limitations at the sites.
- The cleanup level is 1 ppm total cPAHs (benzo[a]pyrene equivalent).

Contact

Terry Sciarotta, Southern California Edison, (626) 302-9723

3.2.4 Program/High Performance/Design Team

Tool Description

A Program, High Performance, or Design Team is a team of stakeholders brought together with the intention of creating trust, communication, motivation, and cooperation to collectively solve a problem. Site characterization and remediation is one of many fields in which the use of such a team can expedite, streamline, and reduce the cost of completing a project, with the project being site-specific (as for an MGP site characterization and remediation) or programmatic (e.g., to establish methodologies for dealing with multiple MGP sites) in nature.

A team approach is useful because characterization and remediation of sites:

- Is often too complex for any one person to be able to know of or handle multiple variables.
- Typically has no single solution. The best solution is often one that balances the needs of all stakeholders involved in the site with federal, state, and local regulations.
- Requires multiple areas of expertise to reach a preferred solution.
- Requires that all stakeholders work together to efficiently achieve an acceptable solution.

A High Performance Team (HPT) must concentrate on three major areas where team development typically occurs: problem-solving skills, process improvement, and behavioral performance. The team must learn to work together, be flexible, and be willing to understand and develop team-related problem-solving skills (such as Total Quality Management techniques including causal loop diagraming, popcorn brainstorming, and decision science models). The rules of conduct laid out in the charter must be followed, and the team must regularly revisit its purpose, goals, and methods, seeking individual and team feedback for continuous improvement. At times, a trained facilitator may be required to manage the team-building process and/or to assist the team in overcoming road blocks in the consensus-making process.

Building a team requires time and energy. Effective teams create synergistic results. Beyond pooling skills and understanding, an HPT can speed the remediation process, reduce overall project costs, minimize conflict and misunderstanding with regulators, promote acceptance and support in the local community, minimize downtime and back sliding resulting from consultant or regulatory management turnover, and create relationships and trust between the utility and regulators that extend beyond any single site characterization and remediation. The upfront costs of building the team are typically offset by savings realized later in the project after the team is formed and trust has been built between the team members.

Case Studies

Pacific Gas and Electric Company Chico/Willows/Marysville High Performance Team

In 1994, Pacific Gas and Electric Company (PG&E) initiated the RI/FS/RD/RA process for three former MGP sites in Chico, Willows, and Marysville, California. Recognizing the advantages of streamlining the RI/FS process, PG&E combined or "bundled" the sites into one project. PG&E negotiated one order for the three sites with California Department of Toxic Substances Control (DTSC) and identified representatives from PG&E, each of California's primary regulatory agencies (DTSC and the Regional Water Quality Control Board), along with a PG&E consultant to serve as primary case managers for all three sites. In 1996, PG&E initiated a unique streamlining program, the backbone of which was the Chico/Willows/Marysville (CWM) HPT.

The CWM HPT, as with most similar teams, was made up of a series of focus groups or sub-teams formed solely to promote the project's successful completion. The organization of the CWM HPT comprised all potential project stakeholders (in this case, PG&E, state regulatory agencies, and PG&E's consultant).

The Sponsorship Team was composed of stakeholder representatives with the authority to "sign on the dotted line." These included persons in charge of policymaking and budget authorization. Members of this team included DTSC's Site Mitigation Section Chief and PG&E's vice-president, who oversees all environmental operations. These are the ultimate "owners" of the project.

For the CWM project, a Leadership Team was also formed, consisting of senior representatives from PG&E and the regulatory agencies. California regulatory agencies generally experience a frequent turnover in project managers. Involving senior staff in the HPT process helps ensure continuity of project decisionmaking and regulatory interpretation despite personnel changes. Representatives on this team included PG&E's Director of Site Remediation and DTSC's Site Mitigation Unit Chief.

The Management Team of the CWM HPT is composed of persons charged with actually carrying out the project. Members are PG&E's consultant and regulatory project managers. Separate Task Teams were also formed to address specific issues or problems. For example, Task Teams were formed for community relations and risk assessment.

The first task of the HPT was its charter. This exercise formed the basis for the team's operations. Steps conducted by the HPT during chartering included: identifying unifying goals, objectives, and measures by which the team could evaluate whether it was meeting goals; preparing guidelines for meetings and communications; and identifying the fundamental rules by which the team(s) would operate. Because several HPT members were not familiar with either the RI/FS process or MGP sites, education was also required to ensure that all team members were comfortable with the process and would support decisions. This education was conducted during workshops where HPT members reviewed the operational history and historical documents (MGP facility plans, Sanborn maps, etc.) available for each site. Applicable state and federal regulations and HPT member expectations were also discussed.

The second HPT task was the development of conceptual models for each site to ensure that all HPT members had the same view of site physical conditions, source delineation, transport pathways, and exposure pathways. The team then jointly initiated the first steps of the FS, identifying all possible remedial technologies and screening them to form what all team members (including regulatory agencies) agreed to as a subset of technologies that could be reasonably applied at the three sites (i.e., ex situ thermal desorption and asphalt batching). At this time, the HPT identified two key questions that still needed to be resolved and defined the scope of an additional focused field investigation designed to collect only the data necessary for the HPT to complete the FS with a high degree of confidence.

As of July 1998, the CWM HPT completed site investigations and was in the middle of preparing FSs for the three sites. Although the CWM HPT has been operating for only approximately one year, significant gains (both fiscal and non-fiscal) have been made both on the CWM project and on other PG&E projects with the same regulatory agency oversight. Specifically, the HPT format has promoted better communication among the team members and a notable increase in trust between PG&E and the regulatory agencies. By the completion of the project, the CWM HPT will have:

- Expedited completion and review of the FS for all three sites. As each step of the FS process is completed by the HPT, a technical memorandum is prepared and reviewed by the team. When the FS is complete, these memoranda will be compiled along with an introduction to form the body of the FS. Because each memorandum is reviewed and approved by the HPT as it is prepared, final review of the FS will be a formality.

- Developed an advisory cleanup standard for remediation. This cleanup standard is developed with the recognition that it is a target that the HPT is trying to achieve, and that, given the uncertainties inherent in site remediation, this target may change. The paradigm shift of recognizing the cleanup standard as a target and not an absolute gives the HPT "permission" to be flexible in its remediation and to do what is best for the site, most protective of human health and the environment, and cost and time effective.
- Evaluated a greater array of remedial alternatives and cost savings, by evaluating remediation at three sites at once, than would have been possible for each site if taken individually (i.e., taking advantage of cost savings by negotiating contracts for work at all three sites rather than for each individual site).
- Promoted management of uncertainty through contingency planning prior to remediation, and through HPT communication during remediation to allow for expedited decisionmaking.

Contacts

Robert Doss, Director of Site Remediation, Pacific Gas and Electric Company, (415) 973-7601

Francis Anderson, California EPA, Department of Toxic Substances Control, (916) 255-3733

NJDEP/PSE&G MGP Site Remediation Streamlining Team

In April and May of 1995, PSE&G met with the NJDEP to discuss the potential to work with the NJDEP SRP to streamline the MGP site remediation program. As the result of discussions between the two organizations, the NJDEP / PSE&G Streamlining Team was established with executive sponsors and co-chairs from each organization. The goals of the Streamlining Team were stated as:

In partnership, NJDEP and PSE&G will identify and evaluate the process of MGP site investigation and remediation with the objective of streamlining the process. The Streamlining Team will identify opportunities for improvement, consistency of approach, and cost effectiveness. The Streamlining Team will develop a model that will reflect increased cooperation and teamwork between NJDEP and PSE&G and should provide measurement and oversight of improvement initiatives. Impediments that exist in achieving the above will be identified with improvements recommended (NJDEP / PSE&G, 1996).

The Streamlining Team initially defined major “issues” that are barriers to efficient and effective site remediation, identifying causes and developing solutions for each. The solutions were subsequently grouped by relative ease of implementation and potential for cost and/or time savings. Two basic categories of recommended solutions resulted:

- Solutions that were within the control and authority of the Streamlining Team to implement and would result in relatively greater cost or time savings while ensuring protection of human health and the environment
- Solutions that were beyond the control and authority of the Streamlining Team to implement but would provide relatively greater cost or time savings while ensuring protection of human health and the environment

The Streamlining Team then produced detailed implementation plans for the recommended solutions that were within the control and authority of the team to implement. Solutions that were beyond the control or authority of the Team were sent as recommendations to the NJDEP Green & Gold Task Force Site Remediation Subcommittee.

Using the detailed implementation plan prepared by the Streamlining Team, it was estimated that the time for the RI phase could be shortened by 30 percent and costs for RI work plans could be reduced by approximately 40 percent, that remedial investigation costs could be reduced by 30 to 50 percent, and that remedial investigation report approval time could be shortened by 30 percent to 40 percent.

Solutions included:

- Establish a dedicated NJDEP case team for PSE&G projects to enhance communications, encourage empowerment, enhance consistency of application of regulatory requirements, facilitate increased availability of regulatory staff, and streamline regulatory agency oversight.
- Establish periodic executive level reviews of program initiatives and results.
- Develop standard report “terms and conditions” for all PSE&G sites.
- Establish standard procedures to ensure proper treatment/disposal of wastes and/or contamination.
- Establish joint cycle time targets for delivery and approval of plans, reports, and work-related activities.
- Develop a generic RI work plan, including standard operating procedures, to streamline site-specific work plan preparation and review.

Contacts

Rich Blackman, Public Service Electric & Gas, (973) 430-8278

Woerner Max, Public Service Electric & Gas, (973) 430-6413

Chris Kanakis, New Jersey Department of Environmental Protection, (609) 633-1460

3.2.5 Early Land-Use Determination/Brownfields

Whether an environmentally distressed MGP site is a long-abandoned brownfield or is still owned and operated by a public or private utility, remediation can be expedited by developing an appropriate, beneficial reuse strategy. The remedial approach can then focus on cleaning the site up to a level acceptable for its future use (e.g., residential, industrial or commercial). Early land-use determination usually requires a multi-faceted team (including real estate professionals, land-use planners, local redevelopment agencies and environmental groups, financial analysts, community relations specialists, regulators, insurance professionals, remediation engineers, and others) and depends, ultimately, on the opportunity for local real estate development. Successful projects have identified a beneficial use for former MGP sites that increased their asset value and / or offered multiple other benefits to the local community. This strategy only works when the economics of the project are adequate to support both remedial cleanup and development of the site after cleanup.

The USEPA has recognized that restoring a contaminated property can bring strength and life to a community. They have defined brownfields as abandoned, idle, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination. To promote brownfields redevelopment, the USEPA announced its Brownfields Action Agenda in January of 1995. This agenda outlined four key areas of action for returning brownfields to productive use:

- Awarding Brownfields Pilot Grants
- Clarifying liability and cleanup issues
- Building partnerships with all brownfields stakeholders
- Fostering local workforce development and job training initiatives

In May of 1997, the USEPA expanded its Brownfields Initiative by announcing the *Brownfields National Partnership Action Agenda* which provided a framework for cooperation among governments, businesses, and non-governmental organizations. The Brownfields Partnership addressed all aspects of the brownfields processes with monetary commitments from federal agencies and non-governmental organizations. To date, USEPA has funded more than 120 brownfields pilot projects.

A key to the success of the Brownfields program is the clarification of liability and cleanup issues. To address these issues, USEPA developed guidance promoting early land-use planning discussions and the use of Prospective Purchasers of Contaminated Property Agreements under which USEPA agrees not to sue the buyer of a property for existing contamination. USEPA also developed and issued policies on:

- The issuance of comfort letters (letters sent to stakeholders who need information on USEPA's involvement at potentially contaminated properties)

- Circumstances under which USEPA will not pursue the owners of property where groundwater contamination has migrated to their property in instances where the owner did not contribute to the contamination
- Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA) enforcement against lenders and government entities that acquire property involuntarily
- The Underground Storage Tank Lender Liability Rule

Tool Description

The intent of the early land-use strategy is to evaluate a variety of potential land reuse options (for one site or a portfolio of sites) and to select reuse options that meet the following criteria:

- Local market need
  - Availability of potential developers interested in the reuse option
- Profitable financial analysis
  - Financial analysis including cost of remediation and liability management
  - Reasonable profit and return on investment
  - Insurance products
- Environmental compatibility
  - Regulatory agencies willing to provide “comfort letters” or “covenants not to sue” after remediation is complete
  - Cleanup levels based on reuse approach, limited remediation risks
- Physical feasibility
- Political acceptability (if local community approval is required)
  - Support of community and local government
  - Assurance that zoning changes can be achieved for the planned property use

Typically, real estate reuse specialists evaluate potential reuse options and work with remedial engineers and regulatory analysts to consider the level of cleanup and redevelopment necessary for these options. For options with merit, a financial analysis is developed. The analysis may indicate that the cost of remediation for a given site exceeds the potential revenue for all reuse options considered. When this is the case, early land-use determination will no longer be appropriate unless the owner can include the site within a portfolio of sites that, together, make up a financially feasible reuse package. There are developers who specialize in evaluating and purchasing portfolios of environmentally distressed properties. They evaluate the economics of a portfolio as a whole. If there is sufficient return on investment from the whole portfolio, the loss associated with individual sites that cannot be cost effectively redeveloped is acceptable.

When a site is being considered for a reuse option, the project's success rests on acceptance and buy-in of all parties. Once all affected parties accept the reuse option, a reuse-specific risk-based management plan can be developed and supported by the regulatory agencies with authority over the project. There is significant support within the USEPA and many state environmental regulatory agencies for risk-based approaches to remediation and reuse of historically contaminated industrial properties.

Assuming that stakeholders in the property all accept a recommended reuse option, a development plan and marketing package can be prepared to solicit bids, or the site owner can choose a specific developer for the entire process. Once the developer is selected, insurance can also be used to limit the remediation cost and to specify how remaining or future environmental liability will be apportioned (Daddario, 1997; Voorhees, 1997; Barnett Alexander, 1997).

Case Studies

Bangor Gas Works, Bangor, Maine (Adaptive Reuse of Coal Gasification Superfund Facility to Supermarket)

Coal gasification processing occurred from 1853 to 1963 at the Bangor Gas Works, resulting in widespread coal tar contamination of soil and groundwater at the site. Large quantities of viscous tar had been stored in on-site underground storage tanks. The property was eventually abandoned. The City of Bangor purchased the 4-acre property, located in a mixed residential and commercial area, in 1978. After the purchase, the city discovered an underground tank containing 45,000 gallons of coal tar as well as other underground contamination consisting of subsurface pools of coal tar and related substances. Within 1 mile of the site there are wetlands and the Penobscot River, which supports salmon, rainbow trout, and spring smelt.

In 1978, the City of Bangor alerted the Maine DEP to the site contamination. The Maine DEP oversaw initial remedial actions, which included:

- Filling the underground tank with clay
- Demolishing the old gasification buildings
- Paving over the site to create a parking lot

Subsequent investigations confirmed that these actions would prevent the coal tar from migrating off site.

In 1990, USEPA placed the site on the Comprehensive Environmental Response, Compensation and Liability Act Information Systems (CERCLIS) list. Maine DEP accessed Superfund monies and performed a preliminary assessment of the contamination and a site inspection. The studies concluded that the previous asphalt paving had adequately reduced the potential for migration or direct contact with the contaminated soil through an airborne release. In 1994, after the study results were made public, the City of Bangor, Shaw's Supermarket, and Boulos Developers agreed to build a 60,000-square-foot supermarket on the site and adjacent properties. The project cost was $9.5 million.

A partnership was formed between the City of Bangor, USEPA, and Maine DEP to develop a plan that would permit concurrent cleanup and redevelopment. In 1996, a multi-layer cap was constructed over the areas where coal tar by-products remained, so all sources of contamination would be isolated prior to building. The new supermarket was intended to be the largest in the area and thus would spur economic expansion and downtown redevelopment (USEPA, 1998a).

The Bangor gas works site consists of a number of parcels. In addition to the portion that has been the subject of redevelopment to date, a number of parcels are still being investigated, and as appropriate, remediated.

Site remediation/redevelopment involved a number of actions to address contamination. In the 1970s, with Maine DEP approval, 430,000 gallons of coal tar were removed from the site and burned in a paper mill boiler. Analysis of location, characteristics, and fate and transport aspects of residual contamination indicated that further excavation was not warranted at the time. The site currently has a cap and a passive venting system and is subject to deed restrictions. If conditions warrant, the passive venting can be converted to active extraction.

Contacts

Stan Moses, City of Bangor, Department of Economic Development, (207) 945-4400

John Harris, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, (703) 603-9075

Wisconsin Electric Power Company, Racine, Wisconsin (Adaptive Reuse of Manufactured Gas Plant Site to Mixed Use Development)

Wisconsin Electric Power Company (WEPCO) historically operated a coal gasification plant on 11 waterfront acres in downtown Racine, Wisconsin. Contamination requiring remediation was identified at the site.

Prior to initiating remediation, WEPCO decided to hire a consultant to evaluate potential reuse options for the site. The consultant performed both a physical and marketing analysis. The analysis determined that the property had significant value with potential for a variety of multiple uses that would also assist in revitalization of the city. The reuse option selected was a waterfront community, now known as Gaslight Pointe.

Remedial actions conducted on the Racine site prior to redevelopment included the removal of tar holders and highly contaminated soil. The site was then capped, and a groundwater extraction and treatment system was installed to address groundwater contamination. A soil venting and vapor extraction system was also installed to prevent fume buildup in buildings to be constructed on the site. Gaslight Pointe now includes a marina, townhouses, a hotel, and retail stores.

The development team agreed on a divestment to a specific developer/builder. WEPCO assumed no risk and did not need to invest new capital. The remediation and regulatory approval process focused on the newly recommended redevelopment use.

Gaslight Pointe has been a qualified success. It has resulted in reasonable returns for Wisconsin Energy Corporation as well as providing a source of new jobs and tax revenues for the community (Barnett Alexander, 1997). Most importantly, it has completely transformed a previously blighted property into a significant focal point in the community.

Contact

James W. Lingle, Wisconsin Electric Power Company, (414) 221-2156

3.2.6 Managing Uncertainty (Observational Approach)

Tool Description

Uncertainty is pervasive in the characterization and remediation of all kinds of contaminated sites, including MGP sites. One approach to managing uncertainty is the observational method. This method provides a way to determine when sufficient site characterization data have been collected and involves managing uncertainties through the identification of reasonable deviations from original plans if changed conditions materialize, and contingency plans to address these deviations. The observational approach entails monitoring site conditions during remediation and implementing contingency plans as needed. Using the observational method gives the flexibility to modify an RA to address conditions as they are discovered while still completing the action on time and under budget.

Managing uncertainties when applying one or more remedial technologies at a manufactured gas plant site requires two important pieces of information:

- The input, process, or environmental variables (e.g., contaminant composition, temperature, soil structure, moisture content) that affect a remedy’s success
- The values of those variables throughout the implementation of the remedy

For ex situ remedial processes (e.g., thermal desorption, catalytic oxidation), this information can be obtained with relative ease. Process designers can incorporate the instrumentation and controls necessary to measure the critical process variables and perform adjustments to optimize process performance.

In situ remedial processes are more difficult. Unless a site is very small and/or the process is incredibly adaptive and robust, it is difficult to have all the information needed about the values of critical process variables (e.g., soil moisture). For example, the heterogeneity of subsurface soils and the lack of good subsurface analytical technologies make it virtually impossible to map the values of process variables throughout a site. With today’s technology, the best achievable result is a reasonable estimate of the range of these variables.

Scientists and engineers working on subsurface construction problems (e.g., foundations, dams, tunnels) have found a way to manage the uncertainties associated with in situ remediation. Geotechnical engineers have addressed problems of this nature for decades using the observational method (Peck, 1969). Karl Terzaghi described the conditions for this application almost 50 years ago:

> "In the engineering for such works as large foundations, tunnels, cuts and earth dams, a vast amount of effort goes into securing only rough approximate values for the physical constants that appear in the equations. Many variables, such as the degree of continuity of important strata or the pressure conditions of water contained in the soils, remain unknown. Therefore, the results of computations are not more than working hypotheses, subject to confirmation or modification during construction" (quoted by Peck, 1969).

The table on the fofllowing page summarizes the key elements of the observational approach applied to hazardous waste sites.

Elements of the Observational Approach
■ Explore to establish general conditions
■ Assess probable conditions and reasonable deviations
- Depends on remedial technology
■ Design for probable conditions
- Define remedial end point(s) and how to measure
- Select design/implementation modification for each potential deviation
- Select parameters to observe and define how to measure
- Determine expected values of parameters for remedial technology under probable conditions and deviations
■ Implement remedial technology
- Observe parameters and compare to anticipated values
- Implement preplanned actions if deviations detected

Hazardous waste sites involve uncertain subsurface conditions such as those found by geotechnical engineers at any site but also entail uncertain chemical and biological parameters. The principal differences from the traditional linear study-design-build model and the observational methods are the explicit recognition of uncertainty, characterization of states of uncertainty via scenario development (i.e., deviations), monitoring for deviations, and preplanning for contingencies. This is a management approach with feedback loops and preplanned responses.

The success of the observational approach depends upon the ability to alter a site investigation and/or remediation in the field based on pre-determined contingency plans. Therefore, the observational approach is not suitable for sites where there are no available contingent actions for site conditions within an allowable response time (e.g., a release of contaminants to the atmosphere that cannot be detected in time to implement a contingency plan).

During the past eight years, the observational method has been increasingly used for the remediation of hazardous waste sites because it offers two key benefits:

- The method provides a means to determine when sufficient site characterization data have been collected.

- The method makes it possible to continue the project by managing uncertainty through contingency planning rather than trying to overcome it through additional study or highly conservative remedial design.

Case Studies

An Observational Approach to Removing Light Non-Aqueous Phase Liquids (LNAPLS)

Background

An operating bulk petroleum products storage and transfer facility, 43 hectares in size, contained approximately 11 million liters of light non-aqueous phase liquid (LNAPL) in the vadose zone beneath the site. The LNAPL was composed of approximately 70 percent gasoline-range hydrocarbons and 30 percent diesel-range hydrocarbons and had been located under the site for approximately 68 years. The hydrogeology underlying the site was composed of discontinuous alluvial and eolian Pleistocene deposits of sand, silty sands, silts, clayey silts, and dense clays. Depth to groundwater was approximately 3 to 6 meters below grade, and a cyclic rising and lowering water table resulted in LNAPL being trapped below the water table at some locations and perched above the water table at other locations, depending upon the small-scale subsurface stratigraphy.

During 10 years of site characterization, more than 100 borings and wells were installed at the site. Based on the information gathered from these borings, 60 product-extraction wells were installed to remediate the site. Numerous piezometers and groundwater monitoring wells were also installed to monitoring the performance of the extraction system.

The extraction system installed following the site characterization operated ineffectively because of the site’s stratigraphic heterogeneities. Some wells in the system produced LNAPL beyond expectations while other wells extracted practically no product. After several years of operation, the site owner wanted to expand the LNAPL removal system to increase overall extraction efficiency, but, because of the stratigraphic heterogeneities, there was significant uncertainty regarding how a particular LNAPL removal technology or design would perform in different portions of the site (Haimann, 1996).

Probable Site Conditions

LNAPL flow in the subsurface occurs in the vadose or unsaturated zone and is therefore dominated by capillary forces. Capillary forces are, in turn, highly dependent upon soil type, specifically on pore-throat diameters. Pore-throat diameters vary substantially among different soil types; in alluvial deposits, diameters can vary by nearly the scale of the soil particles themselves. In addition, the soil types above and below LNAPL layer(s) can significantly affect the efficiency of a removal technology by influencing soil moisture and the ability of the LNAPL to move within the vadose zone. At this site, a conventional site remediation approach, where a final remedy with a high likelihood of success is selected, designed, and implemented, would be unlikely to succeed because of the small-scale heterogeneities observed in the subsurface. At a site such as this, the cost and time required to gather sufficient data to fully understand the scale and location of these heterogeneities could exceed the actual cost for several rounds of remediation. Recognizing that such a conventional approach was not an efficient use of resources, those managing the site selected the observational approach.

In a phased observational approach, remediation is implemented in distinct phases, without investigating the entire site, to the extent that sufficiently detailed information is available to design a site-wide system. In effect, each phase of remediation occurs simultaneously as a phase of investigation. In this case, the operation of the system and the response of the subsurface to LNAPL removal were monitored, and data were collected and used to interpret subsurface stratigraphic features. These features were then used to update the subsurface stratigraphic model and to design expansions and/or modifications to the LNAPL removal system.

Remedial Technology Design and Implementation

The initial phases of the project were focused on portions of the site where subsurface stratigraphy was understood well enough to design an LNAPL removal system. The subsurface stratigraphic information used to design this initial extraction phase had been gathered during the field investigations and operations of the early LNAPL removal systems. The effectiveness of the initial extractions was then monitored using subsurface monitoring points located at the edges of the extraction zone to determine reasonable deviations in the monitoring parameters (indicating the relative success of the treatment setup). Subsurface monitoring points included monitoring wells, piezometers, and soil vapor probes, and the types and locations of the monitoring points were varied depending upon the LNAPL removal technology implemented at the specific area (e.g., liquids extraction, vapor extraction, dual-phase extraction, bioslurping). Data collected and evaluated during monitoring included drawdown, product thickness, subsurface vacuum pressures, and vapor concentrations.

The results of the first phases of LNAPL extraction were used to select and design the extraction system for the second phase; the results of the second phase used to design a third, and so on (Haimann, 1996). Continuous monitoring of data during remedial implementation allowed for the implementation of preplanned actions (e.g., increasing number of extraction points) as needed to address site-specific subsurface conditions and uncertainties.

Conclusion

One of the key benefits of the phased approach was the immediate implementation of remediation. Early extraction of the LNAPL prevented further migration from the source. Under a conventional scenario, the elapsed time that would have been lost during an extended site characterization could have led to the additional spread of LNAPL and therefore increased remediation costs. Several other cost savings were realized by implementing the phased observational approach, including (Haimann, 1996):

- A significant reduction in investigation costs. Combining remediation and investigation into one field effort reduced the need for multiple mobilizations and management costs from an extended project schedule.

- Savings resulting from a reduction in liabilities. Early and proactive removal of LNAPL prevented migration in the subsurface and reduced expenses relating to litigation and additional cleanups from off-site contamination.

A reduction in overall project costs resulting from a shortened project duration. Combining remediation with investigation reduced the overall number of phases of field work and reduced the remediation schedule because LNAPL migration was restricted as a result of early remediation.

Application of the Observational Method to the Cleanup of a PCB Spill

Portland General Electric (PGE) operated a steam-powered electricity generating plant on a 28-acre site known as the Station L facility between the early 1900s and 1975. The Station L facility is located in Portland, Oregon, on the east bank of the Willamette River.

As part of a transfer of a portion of the Station L property, PGE initiated an investigation to identify areas where PCBs might have been released. This investigation led to the discovery of a historical PCB spill in the Willamette River. A review of company records showed that a transformer next to the generating plant had failed in 1971. PGE collected sediment samples to determine the extent of contamination and found that an approximately 80- by 120-foot area contained PCB concentrations ranging from non-detect to 286 mg/kg.

During a 2-year period, PGE evaluated different remedial alternatives, submitted RA plans to the Oregon Department of Environmental Quality (DEQ), and conducted a limited action to remove near-shore contaminated sediments exposed during low-flow conditions in the river. In February 1990, DEQ issued a Record of Decision (ROD) that stated that low-volume, diver-operated, performance-standard dredging was the preferred remedial alternative. The performance standard in the ROD was to remove, if practical, up to 2 feet of sediment in areas with PCB concentrations greater than 10 mg/kg. Dredging was to be conducted in a manner that would minimize sediment resuspension. The ROD provided for dewatering and disposal of dredged sediments in an approved disposal facility and water treatment to applicable standards prior to discharge to the Willamette River. Following dredging, the spill area was to be isolated by placing a 6-foot sand, gravel, and rock cap over sediments containing PCB concentrations greater than 1 mg/kg; the cap was to be constructed in a way that would also minimize sediment resuspension (Brown, 1988).

Early in the remedial design, it was recognized that a conventional engineering approach could not be used because the following were highly uncertain:

- Sediment characteristics
- Dredging equipment flow rates required for removing two feet of sediment
- The amount of sediment resuspension associated with low-volume, diver-operated dredging

- Water treatment system flow rate and influent sediment and PCB concentrations
- The amount of sediment resuspension associated with cap construction methods

To manage these uncertainties and meet an the extremely tight project schedule, the observational method was selected.

The observational method was used to manage virtually all areas of uncertainty. The most likely outcome, based on available site characterization data and previous diving contractor experience, was that the suction created by the low-volume, diver-operated dredge would be sufficient to contain any resuspended sediment. Further, it was assumed that the suction action of the dredge would prevent PCB concentrations downstream from the site from rising above the acute aquatic criterion. A reasonable deviation was that dredging would cause conditions that exceeded the acute aquatic criterion for PCBs.

The parameter selected for observation was turbidity because it could be measured in the field in time to implement a contingency plan if a deviation was detected. Direct measurement of PCB concentrations was not selected because sample results could not be obtained in time to implement a contingency plan. To satisfy DEQ's concern for aquatic protection, a correlation between turbidity and PCB concentration in water was developed before dredging was initiated. This correlation was developed by relating suspended sediment concentrations (using site-specific sediments) to turbidity, on the basis of the average PCB concentration in sediments at the site.

Potential contingency plans included increasing the dredge flow rate to increase the capture of resuspended sediments, modifying diver operations to reduce sediment resuspension, and, if neither of these plans worked, stopping dredging and construction of the sand, gravel, and rock cap.

Monitoring conducted during dredging demonstrated that the turbidity did not increase downstream of the site and the acute aquatic criterion was not exceeded. Because no deviation was observed, none of the contingency plans was implemented (Brown, 1988).

Conclusion

The observational method made it possible to implement a relatively innovative RA and still complete the project on time and under budget. During a 4-week period, 22 tons of sediment were removed and more than 500,000 gallons of water were treated. The average depth of sediment removal was 1 foot. PCB concentrations were reduced from an average of 12 mg/kg before dredging to 7 mg/kg after dredging. All of this work was conducted without any observable increase in turbidity, without exceeding the acute aquatic criterion for PCB, and without any contractor change orders. PGE, DEQ, and the contractor considered the project a success (Brown, 1988).

Contact
Dennis M. Norton, Manager, Environmental Services, Portland General Electric, (503) 464-8522

3.2.7 Expedited Site Characterization

Tool Description
The traditional RI/FS process, as commonly practiced during the 1980s and early 1990s, is a phased approach. It consists of an RI requiring iterations of work plan preparation, review, and approval; field work; and report preparation, review, and approval. These steps are all designed to characterize the horizontal and vertical extent of contamination at a site. This phased RI is then followed by the FS to determine an appropriate remedial scenario and often includes additional phases of field investigation to acquire additional data. Following the NCP regulations, the FS leads to preparation of a Remedial Action Plan (RAP) and RD, culminating in the actual RA, which often uncovers unexpected conditions and/or contamination, sending the whole process spiraling back to supplemental RIs and revised FSs. The result is lengthy and costly site investigation/remediation cycles.

Changing regulatory and economic environments requires new strategies to meet the same needs. Private and public entities must now meet environmental responsibilities in a time of tightening budgets and greater pressure to work in a faster and cheaper manner. Thus, processes are being developed to expedite the way RI/FS/RD/RAs are being conducted.

Expedited site characterization and closure involves a number of tools, strategies, and processes that interlink and synergistically help streamline investigation and remediation processes. Components of an expedited site characterization and closure can include the following:

- On-site or rapid decision-making capabilities
- Use of field sampling and analysis tools (such as mobile laboratories and field screening methods) to facilitate real-time data collection and interpretation
- Use of nonintrusive or minimally intrusive geophysical and/or sample techniques
- Communication and cooperation among responsible parties, regulatory agencies, and third-party stakeholders through mediation, facilitation, and HPTs
- Flexibility in the overall site characterization and remediation processes (e.g., setting flexible DQOs)
- Active management of uncertainties regarding the location of former MGP residues and their effects on remediation costs and technologies, through modeling and contingency planning
- A streamlined document preparation and review process

- A process for reducing team member turnover and minimizing the effects of team member replacement

Not all components may be necessary to expedite site characterization. Selections of those component most directly applicable to a site or set of sites can still yield cost and time savings**.**

Argonne National Laboratory Expedited Site Characterization Process

In 1994, Argonne National Laboratory developed an innovative, cost- and time-effective process for preremedial site characterization. The Expedited Site Characterization (ESC) process was developed to optimize site characterization field activities.

The Argonne ESC process:

- Is a process and not a single or specific technology or tool.
- Is flexible and neither site- nor contaminant-dependent.
- Demands the highest levels of accuracy.
- Is scientifically driven within a regulatory framework (i.e., regulatory guidance does not drive the program without science).
- Requires that all field activities potentially affecting the quality of results be addressed in a quality assurance and quality control (QA/QC) plan**.**

The basic steps of the Argonne ESC are:

Step 1: A team is formed, composed of an experienced technical manager with a broad base of experience and a team of scientists (including geologists, geochemists, hydrogeologists, biologists, health and safety personnel, computer scientists, etc.) with diverse expertise and strong field experience.

Step 2: The technical team critically reviews and interprets existing data for the site and its contaminants to determine which data sets are technically valid and can be used in initial design of the field program.

Step 3: After assembling and interpreting the existing data for the site, the technical team visits the site to identify the site characteristics that may prohibit or call for any particular technological approach.

Step 4: After the field visit, the team selects a suite of technologies appropriate to the problem and completes the design of the field program. Nonintrusive and minimally intrusive technologies are emphasized to minimize risk to the environment and public health.

Step 5: A dynamic work plan is prepared, outlining the technical program to be followed. The work plan must allow flexibility; therefore the HASP and QA/QC plan must encompass a broad range of possible work plan alterations.

Step 6: The team implements the field program. Data are collected, reduced, and interpreted each day. At the end of each day, the team meets, reviews results, and modifies the next day's program as necessary to optimize activities that generate overlapping or confirming site details.

Step 7: Daily results and modifications are transmitted to the project sponsor and regulators, allowing both to participate in early data review and decisionmaking for the site.

The ESC is an iterative process that optimizes field activities to produce a high-quality technical result in a time- and cost-effective manner. Because both on-site analytical and multiple hydrogeologic techniques are used, there is very little need to send nearly all samples off-site and to perform massive subsurface sampling in the absence of local hydrogeologic information. By including on-site decisionmaking, the ESC process can significantly reduce the probability of having to return to the site to fill data gaps. As a result, the current multiphase sequence of environmental data acquisition becomes compressed into a single real-time phase typically requiring only months to complete (Burton, 1994).

The Argonne ESC process is not the ideal process for all sites. However, the basic components of the ESC have been applied at other former MGP sites to expedite site characterization and remediation. These basic components are also included in the American Society for Testing and Materials' (ASTM) provisional standard guide for Accelerated Site Characterization for Confirmed and Suspected Petroleum Releases (PS 3-95) (ASTM, 1996). Although the types of contaminants found at former MGP sites are typically more complicated than those found at sites with only petroleum releases, the general process published by ASTM in their provisional standard guide is similar to that outlined for Argonne's ESC program. Both published programs involve review of existing site information and development of a conceptual model prior to sample collection, followed by an on-site iterative process designed to collect, analyze, and interpret all data in a single field program.

Case Studies

Marshalltown Former MGP Site

In 1994 and 1995, USEPA's Ames Laboratory adopted the Argonne National Laboratory's ESC process for demonstration at the Marshalltown former MGP site in Marshalltown, Iowa. The Marshalltown former MGP site was owned by IES Utilities, Inc., and was located in an old industrial area adjacent to an active railroad switching yard and main lines. Gas manufacturing operations occurred between the 1880s and 1950s, resulting in the release of a variety of MGP wastes, including coal tar, petroleum hydrocarbons, condensates, and oxides.

Before the ESC at the Marshalltown site, five rounds of field investigation and/or reporting had been conducted. Data collected during these investigations provided the historical and technical information necessary to select technologies and develop scopes of work for the ESC demonstration.

The ESC methodology applied at the Marshalltown former MGP site incorporated on-site decision-support technologies that enabled site characterizations to be completed in a consolidated package.

The principal characteristics of the Ames ESC were:

- Emphasis on geologic structure and hydrogeology to determine contaminant fate and transport
- Use of technologies by expert operators with flexible data quality objectives
- On-site data processing using mobile laboratories
- On-site decisionmaking
- Preference for nonintrusive or minimally intrusive geophysical techniques
- Minimization of intrusive sampling techniques
- A single team for planning and managing site work

The use of minimally intrusive survey techniques, on-site analytical technologies, and innovative sampling and screening technologies (such as the Site Characterization and Analysis Penetrometer System cone penetrometer unit and GeoProbe™ soil conductivity probe) to determine the local hydrogeologic setting, supported the potential for significant time and cost savings. For example, geophysical survey techniques including ground-penetrating radar, seismic reflection and refraction, electromagnetic offset logging, and borehole logging were applied at the site to define the surface of the bedrock and significant stratigraphic interfaces above the bedrock and to provide information regarding the distribution of PAH contamination (Bevolo, 1996). By including on-site decisionmaking, the Ames ESC process significantly reduced the number of iterations of field investigations that otherwise would have been necessary to fill data gaps. As a result, the typical cycles of work planning, field investigation, and reporting, which often take years to complete, were compressed into months.

Site Characterization

The Site Characterization and Analysis Penetrometer System (SCAPS) cone penetrometer unit, GeoProbe™ soil conductivity probe, and geophysical survey technologies provided very useful and reliable stratigraphic data. Side-by-side comparisons of the direct-push technology logs with previous investigation borehole logs indicated stratigraphic correspondence to within about 1 to 2 feet. It should be noted, however, that the previous data tended to provide a slightly deeper granular/lower cohesive unit contact than direct-push data. Usually, the major unit stratigraphic contacts were easily picked off of both the cone penetrometer testing (CPT) and soil conductivity logs, and were used to create a database from which a three-dimensional site stratigraphic model was generated.

Based on previous site characterization work, the lateral and vertical distribution of the dissolved PAHs and residual NAPL contamination was estimated. Assessment of the nature and distribution of the PAH contaminants was carried out using three types of technologies: Phase I screening technologies (immunoassays, passive and active soil gas, and chemiluminescence), Phase II screening technologies (laser-induced fluorescence probe, soil conductivity probe), and Phase II quantitative technologies (chemical analysis of soil samples with gas chromatography mass spectrometry instruments in field laboratories).

The Phase I contaminant screening technologies were applied in an effort to evaluate their ability to identify the approximate boundaries of the contaminated area. Duplicate soil samples were collected from different depths and analyzed using three different immunoassay techniques and the chemiluminescence system. In addition, passive and active soil gas samples were collected and analyzed from the approximate depths of the soil samples.

The presence or absence of detectable PAHs and the data from each of the three immunoassay analyses correlated fairly well with each other. Results from the chemiluminescence did not correlate as well. Active soil gas measurements for aromatic hydrocarbons and naphthalene showed good agreement with passive soil gas and immunoassay measurements. Overall, the results of the Phase I contaminant screening technologies generally compared well with the previous investigation results. One significant finding of the screening was that PAH contamination existed farther to the west than appeared from previous data.

Phase II contaminant screening was performed using the cone penetrometer laser-induced fluorescence (LIF) sensor system and the GeoProbe™ soil conductivity profiles. Chemical analysis of soil samples collected adjacent to LIF "hits" indicated that although the LIF sensor data could not be considered quantitative, it could reliably detect regions of low, medium, or high contamination. The LIF may be considered the most direct qualitative methodology for indicating regions of PAH contamination.

Phase II quantitative plume delineation efforts were planned and implemented based on results of previous investigations, Phase I and Phase II screening, and an updated site geologic model. The primary technology evaluation function of this part of Phase II was the comparison and assessment of five on-site extraction methods for PAHs in soil (sonication, microscale, microwave-enhanced extraction, thermal desorption, and supercritical fluid extraction).

Conclusion

A significant finding of the study was the potential for inconsistencies in procedures and results even with strict adherence to SW846 methods. The application, versatility, and high quality of data from direct-push technologies were demonstrated at the site.

The study also indicated the potential for significant variation of chemical analysis results for PAHs in soils. The uncertainty and potential variability associated with soil matrix effects, sample selection, and preparation and extraction procedures far outweigh inaccuracies in the chemical analysis methodologies themselves. The Phase I and Phase II screening results, including olfactory and visual data, gave a far better picture of the distribution and extent of contamination than the quantitative analysis results.

The Ames ESC team implemented the ESC model using many of the tools that are essential to ESC, such as a dynamic work plan real-time data analysis and incorporation of stakeholders in the decisionmaking process. Establishing and maintaining close communications with the regulators was viewed as critically important, and significant efforts were made to invite participation from stakeholder groups including local residents, community organizations, educators, students, trade press, local media, etc. (Bevolo, 1996).

Contacts

Dr. Al Bevolo, Ames Laboratory, Iowa State University, (515) 294-5992

Bruce Greer, Alliant Energy, (608) 252-3948

Johanshir Golchin, Iowa Department of Natural Resources, (515) 281-8925

Pacific Gas and Electric Company Chico/Willows/Marysville Former MGPs

In 1994, Pacific Gas and Electric Company (PG&E) initiated the RI/FS/RD/RA process for three of its former MGP sites where Preliminary Endangerment Assessments (PEAs) had been completed in 1991. PG&E chose the former MGP sites in Chico, Willows, and Marysville, California, because they had similar operating histories and MGP-related contaminants, similar geologic settings, and were in close geographic proximity. Recognizing the advantages of streamlining the RI/FS process, PG&E initially combined or "bundled" the sites into one project, negotiating one order for the three sites with the California EPA Department of Toxic Substances Control (DTSC). Representatives from PG&E and its consultant as well as the state's primary regulatory agencies (DTSC and the Regional Water Quality Control Board) were identified to serve as primary case managers for all three sites. In 1996, an alternative, streamlined approach to the RI/FS was proposed and adopted in addition to the site bundling implemented earlier.

Streamlining the RI

By bundling three sites into one "package," PG&E observed immediate cost savings from reducing the volume of paper documentation and negotiating lower unit pricing as a result of larger volumes of laboratory analyses and work than would have applied to a single site. Further cost savings were achieved by negotiating one order with regulatory agencies and incurring oversight costs for only one regulatory agency caseworker for all three sites and by preparing one HASP and one RI work plan for the three sites. This work plan outlined the field sampling protocols and described the decision process by which field crews would identify and justify field sampling locations. These protocols were then used along with a field sampling flowchart in lieu of figures identifying specific locations for sampling. Such predetermined processes for decisionmaking and communications enabled the team to actively manage uncertainty about the extent of onsite contamination. Therefore, the number of field investigations required to adequately characterize the sites was significantly reduced.

The RI field programs developed for the three former MGP sites were further tailored so that field crews went from site to site (Willows and Chico are 45 minutes apart by automobile; Chico and Marysville are approximately one hour apart), circling back after well seals had cured and wells could be developed and sampled. Thus, well development and sampling took place in a short time. As part of the streamlined field program, lower unit pricing was negotiated with subcontractors (drilling and analytical laboratory) by offering larger volumes of work than would have been the case for a single site. Field personnel used in situ samplers (e.g., Hydropunch™ and Simulprobe™ samplers) and field screening tools (Handby colorimetric kits and Petrosense™ probes) to further aid in field evaluations of the extent of contamination. Through site bundling and field decisionmaking (aided by in situ and field screening tools), PG&E saved an estimated $120,000 during the preliminary phase of the RI/FS alone.

Streamlining the FS

As the Chico/Willows/Marysville (CWM) project continued into the FS stage, the project team adopted additional measures to streamline the project. The backbone of these measures was the formation of an HPT, discussed previously in greater detail in Section 3.2.4.

Significant gains have been made to date as a result of the streamlining at the CWM sites. Expenditures have been decreased by bundling of sites and by allowing flexibility to modify field programs during implementation. This flexibility has reduced the number of phases of field sampling required to determine the extent of contamination. In addition, both the CWM project and other PG&E projects with the same regulatory agency oversight have benefitted from the improved communication and trust between PG&E and the regulatory agencies as a result of the HPT's work.

Contact

Robert C. Doss, Pacific Gas and Electric Company, (415) 973-7601

3.2.8 Legislative Innovation

Tool Description

Recognition of the need to change the RI/FS/RD/RA process is not limited to consultants and private organizations; regulatory agencies have also seen the need to streamline site characterization and remediation. Legislative innovations have created a range of programs for regulatory agencies to streamline site remediations in the hope of significantly lessening current and future threats to human health and the environment in a much shorter time period than possible using the traditional RI/FS/RD/RA process. An example is the pilot Expedited Remedial Action Program currently being implemented by the State of California.

California Expedited Remedial Action Program

The California Expedited Remedial Action Program (ERAP) was established under the authority of the Expedited Remedial Action Reform Act of 1994. Its purpose is to test alternative regulatory policies for the remediation of contaminated properties by providing for a comprehensive program that includes revised liability based on fair and equitable standards, indemnification protection through a covenant not to sue, risk-based cleanups based on the ultimate use of sites, streamlined remediation processes, and a dispute resolution process. Because sites involved in the ERAP process follow the California Uniform Agency Review Hazardous Materials Release Sites (California Health and Safety Code Division 20, Chapter 6.65), permits and certification are issued through one lead oversight agency, which minimizes duplicate efforts among regulatory agencies (Cambridge, 1998).

Only 30 sites may participate in the pilot project; participation is voluntary by responsible parties (RPs) for sites. Participants must agree to pay for all oversight costs not paid by another RP or the trust fund designated for “orphan shares;” response costs apportioned to parties that cannot be located, identified, or are insolvent are considered orphan shares. If monies are available in the trust fund established for ERAP, these are refunded to the RPs once a site is certified. Only 10 sites in the pilot program may be designated as orphan share sites (Cambridge, 1998).

Case Study

Alhambra Former MGP Site

In Alhambra, California, Southern California Gas Company (SoCal Gas) elected to participate in the California EPA DTSC and ERAP to expedite cleanup of the Alhambra MGP site.

Site Background

SoCal Gas entered into a Remedial Action Consent Order with the DTSC on May 5, 1994, to perform remedial investigations at the Alhambra MGP. On September 22, 1995, SoCal Gas submitted to DTSC a Notice of Intent to have the site participate in ERAP. The site was admitted into ERAP on November 27, 1995, and thus was no longer subject to the Remedial Action Consent Order. In March 1996, DTSC and SoCal Gas signed an Enforceable Agreement for performing a site investigation and remediation. DTSC became the lead agency for the site cleanup.

The site consists of 20 residential lots on 2.4 acres. An MGP operated at the site from 1906 to 1913. SoCal Gas acquired the property, which had had two previous owners, in March 1939 after the gas plant had been dismantled, and sold the property to an individual in September 1939. This owner then subdivided the property and sold the lots for residential development beginning in 1940.

Investigations prior to the site’s inclusion in ERAP had shown MGP residues—arsenic, lead, and cPAHs—might be present in on-site soils at levels that would exceed risk-based soil concentration goals. Therefore, a site inspection was conducted after the site’s admission into ERAP.

The SI concluded that there was significant, widespread contamination in soils at the site. The level of contamination required excavation and removal to eliminate threats to public health and the environment. The SI also determined that groundwater had not been affected by MGP wastes.

The RA goal for the Alhambra site was to restore the levels of chemical exposure to background conditions. Values were established using a statistical evaluation of a background data set, which consisted of 184 samples collected over 20 different locations in Southern California. The remedial action plan (RAP) proposed the excavation and removal of all contaminated soil from the front and backyards of 18 of the 20 homes located on-site. The RAP also proposed removing all contaminated soil in the crawlspaces underneath each home.

A number of public meetings and other community outreach efforts were undertaken. The site's residential community was multicultural, with the languages spoken among 20 property owners including English, Spanish, Vietnamese, Cantonese, and Mandarin. All fact sheets and public notices were translated into those languages. At the public meeting for the RAP, four translators were present to address questions from the audience. All one-on-one meetings held between on-site residents and DTSC and SoCal Gas representatives had an interpreter present, if needed.

The final RA for the site began on July 23, 1997. The excavation portion of the project was done in phases. Four families would be relocated at a time, and excavation and removal activities would focus on those four properties. A relocation company handled details of moving residents. After completion of excavation activities at each house, backfilling and restoration activities included replacement of all landscaping and hardscaping removed as a result of the remedial activities. Remedial activities at the site were completed on February 13, 1998. The total volume of contaminated soil removed was 9,000 tons. DTSC issued a certificate of completion to SoCal Gas on February 27, 1998. The site evaluation and cleanup under ERAP took just over two years.

Benefits of ERAP

Sites posing the greatest public health or environmental threat are the highest priority for remediation. The Alhambra property was a natural priority because the presence of on-site residents created a high probability of direct exposure. SoCal Gas had reservations about proceeding with remediation in view of uncertainties about the requirements and effectiveness of the cleanup, the interruption to residents' lives, the possible liability resulting from cleanup, and the time and cost involved. The ERAP pilot project provided some assurance that the cleanup would be efficient and made explicit the potential risks and liabilities of remediation. SoCal Gas viewed the most beneficial aspects of ERAP as:

- **"Lead" Agency Designation—**DTSC, as lead agency, communicated with the other state and local agencies involved with the site. Contacts occurred early, during the preparation of the application package for the program. At this stage, DTSC contacted each affected agency to determine its concerns and anticipated level of involvement so these could be incorporated up front. Once the site was selected, DTSC invited these agencies to participate in the site conference that was required within 90 days of site designation. This provided other agencies with an opportunity to raise issues that could then be incorporated into work plans. Once site remediation was completed, DTSC issued a certificate of completion, which provides regulatory clearance from all other state and local agencies regarding hazardous substances issues. This certificate indicates that SoCal Gas's remediation of the site is complete.

- **Guidelines for Public Participation and Involvement—** ERAP provides that the party responsible for a site must comply with DTSC's public participation manual. Public participation was essential to the success of this project. In addition to fact sheets and an information repository, many public meetings, both formal and informal, were conducted to facilitate ongoing discussions. Most notable were the one-on-one discussions with residents. These contacts meant that the project managers considered residents' perspectives when making decisions, such as what types of trees or grass to replant during the landscaping activities and the timing of each activity. The result of the public participation efforts was positive community response to the cleanup.
- **Risk-Based Decisionmaking—**Any remedial action proposed by an RP must leave a site in a condition appropriate to its planned use without any significant risk to human health or the environment. Under ERAP, RPs are provided flexibility when selecting the remedial action; the DTSC does not give special preference to any particular actions. Evaluation of the remedial actions is based on their individual merit in light of site-specific conditions. Although this provision is most applicable to sites that will be used for commercial or industrial purposes, SoCal Gas demonstrated it could be applied to residential sites.
- **Apportionment of Liability Based on Fair and Equitable Principles and Orphan Share Funding —**The process for apportioning liability among parties potentially responsible for a site (e.g., previous and current owners) involves assigning to each a percentage of liability for necessary remedial action at a site. As an alternative to liability determination through judicial process (cost recovery under CERCLA), ERAP provides for DTSC to apportion liability to each RP. For this site, SoCal Gas was able to recover some cleanup costs through DTSC's apportionment of liability to orphan shares.
- **Indemnification through a Covenant Not to Sue —** Within the ERAP enforceable agreement is a requirement for a covenant not to sue under CERCLA between DTSC and the RPs who are signatories to the agreement. This covenant is conditional on performance of all obligations of CERCLA and the conditions outlined in the enforceable agreement. This covenant becomes effective upon completion of the RAP and receipt of the certificate of completion. Because the certificate of completion for the site is issued under the provisions of the Unified Agency Review Law, the RP can qualify for immunity and protection from future liability. However, the covenant not to sue does not apply to natural resource damage claims filed pursuant to CERCLA. SoCal Gas valued the protections afforded by this covenant, which significantly reduced the risk of future claims being made against the company because of the Alhambra site. The ERAP process also provides assurance that other agencies will not take additional enforcement actions in the future.

Conclusion

The Alhambra former MGP site is an example of a site remediated after a residential community was established there. Because residents live on-site, direct exposure to MGP residues was the greatest health risk. The focus of the project was to restore the site to background exposure levels and return the residents to their homes in the shortest amount of time with the least amount of disruption. Of most importance to SoCal Gas was the definition of the time and costs associated with the project and the determination of the company's liability. The ERAP program provided SoCal Gas with assurances regarding risks as well as monetary relief from the ERAP trust fund, which will reimburse costs assigned to orphan shares.

Contact

Megan Cambridge and Adam Palmer, California EPA DTSC, (916) 255-3773

3.2.9 Dovetailing Business Decisionmaking and Remediation Planning

Tool Description

Combining remediation strategies with business decisions can, when the circumstances are appropriate, provide additional opportunities for significant savings in total remedial cost, the effort required to secure permits, or time required to complete the project. The greatest cost and time savings are realized when remediation, land use/reuse, and business considerations can be aligned.

Depending on factors such as the numbers of MGP sites requiring remediation in a given area and the types of wastes involved, a number of business strategies may make sense. Parties responsible for one or more MGP sites may want to consider options such as: entering into a business venture with a local facility that could treat the MGP wastes; purchasing rather than renting remediation equipment; developing an affiliate company that markets cleaned and treated soil and/or provides cleanup services to others after MGP site remediation is complete; or undertaking a joint venture to create a mobile or fixed treatment facility. These options may offer significant savings in total time and cost of a remediation project.

The following list of questions is designed to help determine whether undertaking a remediation business venture might expedite and reduce the long-term costs of remediation:

(1) Are there multiple MGP sites in close proximity that have large volumes of contaminated materials that could be treated using the same remediation technology? (The sites may have multiple owners as long as they have similar wastes.)

(2) Are there other sites in the area with large volumes of similar waste that could also be treated with this remediation technology?

(3) Are there local political, community, and land reuse/redevelopment conditions that would predispose regulators to approve a remediation approach targeting multiple sites?

(4) What are the actual contaminants and their concentration levels?

(5) Do these contaminants lend themselves to off-site remedial treatment that would meet regulatory cleanup criteria? (e.g., non-hazardous vs. hazardous)

(6) Are there conveniently located facilities that could accept the contaminated material as supplemental fuel for blending? Examples include utility boilers, cement kilns, and asphalt batching facilities. Alternatively, is there a local waste treatment facility that could treat these wastes or incorporate a process to do so? If so, could this facility readily expand its permit to incorporate the new treatment process? Does this facility have adequate room to add such a treatment process?

(7) Has the local state environmental regulatory agency approved a permit for the treatment approach of interest in the past?

(8) Is there a regulatory process in place that would allow testing and approving the treatment process for the MGP application?

(9) Is the local operating facility or disposal / treatment company willing to assume financial and other risks in exchange for a guarantee to be given a specific amount of material for treatment?

(10) If there is no local facility in a position to accept the wastes in question, what are the economics of purchasing rather than renting remediation equipment (e.g., thermal desorbers, asphalt batchers)? This analysis should take into consideration the long-term costs of treating all MGP sites for which the party in question is responsible.

(11) Is there a market for cleaned or treated soil from the site(s) (e.g., for clean fill, asphalt, etc.)?

(12) Is there a market at other sites for the same remediation services required at the MGP site(s)?

(13) Are there local operating facilities or disposal treatment companies that are entrepreneurially oriented and willing to assume financial and other risks in exchange for a guaranteed volume of material for treatment?

Reviewing the answers to these questions can help clarify the opportunities to combine remediation efforts for several sites and / or to undertake new business efforts that can continue after remediation of a company's own sites is complete. Opportunities for off-site remedial treatment at fixed treatment facilities are ideal because the process of obtaining environmental permits is simplified if the waste materials are treated at one location. In addition, a fixed facility can draw input (contaminated materials) from a larger area and operate more efficiently than a mobile facility, thereby offering its customers a unit cost reduction borne from the economics of scale. However, it is also possible to form successful business ventures to treat wastes using mobile facilities at multiple sites.

Remediation business ventures are most promising in a geographical area where there has been considerable past utility / industrial activity, so large quantities of contaminated materials requiring remediation are likely to be present. Such areas are likely to already have waste or hazardous waste treatment / disposal facilities, co-burning boilers, cement kilns, and / or asphalt batch plants nearby with whom joint ventures can be undertaken. If off-site (fixed) treatment facilities are not readily accessible, however, there is the possibility of purchasing treatment equipment, developing a mobile facility or entering into a business agreement to construct an off-site facility. The success of a project like this often hinges on the local regulatory agency's willingness to consider such ventures. Whenever there is a local need for redevelopment of several contaminated sites, the area's long-term cleanup needs can be used as an argument to support a proposal for a remediation business venture.

Case Study

Several related case examples are provided for co-burning (Section 5.2.1) and asphalt batching (Section 5.2.3)**.**

Mid Atlantic Recycling Technologies Inc. (MART)

A New Jersey utility owned multiple MGP sites contaminated with typical MGP wastes. Ten of these sites were scheduled for eventual remediation. In considering options to reduce overall remediation costs, the utility evaluated its business options in light of the upcoming remediations. Because the company owned multiple sites with large volumes of contaminated soil, it sought options that would take advantage of economies of scale during remediation. The utility also hoped to return treated soil to the original sites.

In response to the utility's need, two environmental service companies, Casie Protank and American Eco Corporation, formed Mid Atlantic Recycling Technologies Inc. (MART). (Casie Protank owns and operates a waste transportation, transfer, and treatment facility in New Jersey. American Eco Corporation provides environmental, construction, and industrial services.) The utility and its remediation contractor negotiated a 5-year agreement with MART that committed MART to providing financing and then constructing and operating a thermal desorption facility specifically to treat MGP-contaminated soil. The facility is located in Vineland, New Jersey. The intent was that the thermal desorber would also be able to remediate other soils, specifically those contaminated with total petroleum hydrocarbons (TPHs). Construction of the facility cost $9 million and took 7 months; it began accepting MGP soils in July, 1997.

The NJDEP approved a permit for the facility's Astec / SPI low-temperature thermal desorber, requiring it to process contaminated soil to meet risk-based Residential Direct Contact Soil Cleanup Criteria. The desorber system can treat up to 45 metric tons / hour and reaches a treatment temperature of 540° C. After treatment, the soil is analyzed to demonstrate that Residential Direct Contact Soil Cleanup Criteria have been met. The treated soil can then either be returned to the generator or kept on-site and reused.

The first MGP site remediation undertaken by the utility was in an urban area. The site was vacant. Local community leaders wanted to see it converted to a new office complex. The project started in July, 1997, and was completed in 16 weeks.

Although 27,000 metric tons of soil and debris were transported to MART for remediation and the former MGP site is in a high-traffic area, the project did not disrupt local traffic or create an environmental or health hazard. The desorption treatment approach was successful; on the first pass all treated materials met the cleanup criteria specified by NJDEP. Treated soil was returned to the site, and the land was turned over to the community for beneficial use after treatment was complete and the site had been seeded (DiAngelo, 1998).

Contact

Brian Horne, Mid Atlantic Recycling Technologies Inc., Vineland, New Jersey, (609) 696-3435

3.2.10 Establishing Background PAH Concentrations

Tool Description

PAHs are a by-product of the incomplete combustion of organic material, and are found in everything from grilled meats to waste oil to MGP wastes. In today's society, the incomplete combustion of fossil fuels from heating systems, automobile exhausts, garbage incineration, crude oil processing, and many other practices release PAHs into the atmosphere where they tend to adhere to particles in suspension. Some of these suspended particles ultimately fall back on surface soils or aquatic environments. Establishing the background concentration of PAHs at MGP sites is therefore a significant challenge because it is necessary to distinguish the proportion of PAHs that come from MGP site wastes from those produced elsewhere.

In risk assessment, sample concentrations from a site are compared to background concentrations to identify non-site-related chemicals that are found at or near a site. If background risk is a possible concern, it is typically calculated separately in order to accurately evaluate the additional risk to public health or the environment posed by contaminants from a site. According to the Risk Assessment Guidance for Superfund (RAGS), (USEPA, 1989) information collected during a site characterization can be used to screen for two types of background chemicals: naturally occurring chemicals (i.e., those that have not been influenced by humans) and anthropogenic chemicals (i.e., those that are present because of human activity).

However, RAGS goes on to recommend that anthropogenic background chemicals not be eliminated from risk calculations as it is typically difficult to show that the chemicals are present at the site because of operations not related to the site or surrounding area. This presents a dilemma to those remediating MGP sites located in urban areas as the risks associated with background PAH concentrations are often quantified at concentrations above the incremental cancer risk of 10^{-4} to 10^{-6}, the criterion the USEPA most often uses for site restoration.

An alternative to the development of RA objectives based on traditional risk assessment practices is the establishment of background levels of anthropogenic materials and the application of those levels as a standard for site cleanup. This methodology has been applied at MGP sites and is gaining more acceptance as the cost and difficulty of cleaning up to pristine levels, sometimes beyond background concentrations, becomes clear.

Relatively few studies have been published in which PAH concentrations in soil have been quantified. According to one review of literature published in the Journal of Environmental Quality (Edwards, 1983), typical concentrations of benzo(a)pyrene (a known cPAH) in soils of the world range from 100 to 1,000 micrograms per kilogram (µg/kg). A typical range for total PAHs was about 10 times the value for benzo(a)pyrene alone, with the actual measured concentration of benzo(a)pyrene ranging from 0.4 µg/kg in remote regions to 650,000 µg/kg in very highly polluted areas. A second study on the background concentrations of PAHs in New England urban soils (Bradley, 1994) determined that the upper 95 percent confidence interval on the mean was 3 mg/kg for benzo(a)pyrene toxic equivalents, 12 mg/kg for total potentially cPAHs, and 25 mg/kg for total PAHs. The lack of adequate studies on background concentrations of PAHs, along with the need for site-specific information, indicates the demand for the development of a standardized procedure for establishing background PAH concentrations, rather than a single numerical value against which all other PAH values are measured.

A primary consideration in characterizing background levels of anthropogenic materials is the establishment of what constitutes background. In some cases, background has been functionally defined. For example, at CERCLA sites, background is defined as off-site locations that are comparable to the cleanup site in outward environmental characteristics such as geological setting and meteorological conditions. At RCRA sites, background is typically an on-site location where no facility processing or disposal has been known to occur. At any site, this definition is subject to opinion, based upon evaluation of the best available information. Proximity to the facility is a key consideration in specifying the locations that represent background conditions. Clearly, nearby locations are optimal in terms of similarities of geological conditions and deposition of anthropogenic materials, but these locations are also, because of their proximity to the facility, potentially subject to low-grade contamination from the facility. Distant locations may result in differing levels, not so much as a function of facility versus nonfacility contamination but rather as a function of major differences in native conditions and/or proximity to other sources. Definition of appropriate background locations must balance these distances based upon available site history. Once locations are selected to represent background levels, sampling results from those locations can be evaluated to corroborate expectations or to identify locations that do not meet assumptions about background conditions.

The total number of background samples to be collected is the next major consideration. Sample sizes can be directly estimated to achieve prespecified statistical power and confidence by making reasonable assumptions about the two expected “populations” of chemical concentrations (i.e., the site and background). Alternatively, sample size can be indirectly determined by defining a desired spatial coverage, then calculating the total number of samples to be collected by dividing the entire area to be sampled by the predetermined coverage or surface area per sample (e.g., collecting samples using a 25-foot grid with one sample collected per grid element).

The sample size for background characterization should be considered in the context of the sample size for the site being characterized. Statistical power for most comparative tests is optimized with a balanced design. That is, to maximize the ability to differentiate two populations (site versus background), similarly detailed information is necessary about contaminant distributions from the two areas. Optimizing statistical power must be balanced against the practical reality that sampling on the site may already be extensive.

Following collection of samples from background locations or consolidation of data from various sources, the frequency distribution of observed values can be examined. Intuitively, background data are expected to be relatively consistent or at least not to exhibit obviously bi- or multi-modal distributions of observations over the concentration range observed. Probability plots and statistical testing for adherence to commonly observed distributions (e.g., Shapiro-Wilk or Shapiro-Francia for normal or log normal distributions) are common methods to ascertain that data meet these basic assumptions about background conditions. Where data are composited from various sources and/or represent different methods or conditions, preliminary evaluations should also include examining the extent to which sampling factors (e.g., soil sample depths, analytical methods, specific locations) could be reasonably expected to result in different levels of the constituent. Spatial differences are the primary factors in considering background soils. Tests for trend (e.g., Cox or Sen tests) are useful to detect the presence of seasonal cycles and/or increasing or decreasing trends which would either eliminate the location from background designation or indicate the presence of upgradient effects independent of the site under investigation. If there are no significant differences among factor levels, data can be considered to represent a single population that represents background levels of naturally occurring or anthropogenic constituents.

The issue then becomes how to apply the available background information to determine which areas of a site represent incremental potential risk. Sample results from background locations are commonly used to estimate some agreed-upon proportion of the background population (such as an upper bound tolerance limit that defines the concentration corresponding to the 95th of 100 observations, ranked from lowest to highest concentration). That point estimate is then used as an upper limit to identify sample results from the site being investigated that exceed background and therefore require remedial action. The advantage of point comparisons is the relative simplicity of the method and calculations.

Disadvantages to point comparisons are numerous. First, contrary to the recommendations on sample size in the discussion above, the number of observations from background locations is typically smaller than the number of observations from the site. With the exception of uniform distribution, the probability of a sample containing extreme values relative to the overall population is lower than the more commonly occurring values from the center of the distribution. In other words, less commonly occurring values require increased sampling. A reduced sample size may result in an underestimate of variability in background levels. Because the calculated variance of the sampled population is integral in the calculation of the tolerance limit, the reduced sample size may result in a substantial underestimate of the upper concentration levels within the background population. Second, even when applying an upper bound estimate from a background sample, a certain proportion of values that truly represents background will exceed that estimate. For example, 5 percent of background values would be expected to exceed a 95 percent tolerance limit based upon true knowledge of the population. Finally, the statistical power of point-to-point comparisons is limited.

Alternative methods are population-to-population comparisons. For example, t-tests, Kruskal-Wallis tests, or Wilcoxon Ranks Sum tests in which the mean or median from on-site samples are compared to the mean or median from background samples; or the Quantile test which compares the upper end of the two populations (background and site) for statistically significant differences. Because no single statistical method is adequate to definitively define background conditions, a combination of tools (population-to-population and point comparisons) is recommended. Population-to-population comparisons, focusing on the entire distribution as well as upper portions of the observations, provide a more sensitive indication of the extent to which background and site populations compare. Used in conjunction with point estimates (such as tolerance limits or prediction limits), which establish an upper bound for a sample of a prespecified size (as would be established in post-remedy verification sampling), these comparisons optimize application of results from the background sampling effort.

Case Study

Alhambra Former MGP Site

In 1996, SoCal embarked upon the remediation of PAHs at a former MGP site in Alhambra, California. Because background concentrations of PAHs exceeded concentrations corresponding to a one-in-one-hundred-thousand cancer risk, the California EPA agreed that remediation to levels lower than background would not be practical. The first challenge associated with remediating to background included building a database of background PAH concentrations that could be used to characterize background concentrations. In addition, statistical methods had to be selected to support the site characterization and site remediation decisions made in the restoration of the site to background conditions.

Site Background

The Alhambra site had only operated as a MGP from 1906 through 1913. Because oil was the most likely feedstock, the predominant residual expected to be found was lampblack. Aerial graphs showed that the site sat vacant until about 1940, when the first house was built. By about 1948, the site had been subdivided into 20 lots, each with a separate residence.

Site investigations revealed the presence of PAHs in shallow soils. Other chemicals often associated with MGP operations such as metals, cyanides, reduced sulfur compounds, phenolics, and benzene, however, were not detected in soil above local background levels, or were present at levels below those that posed a health threat. Groundwater and soil investigations demonstrated that chemicals had not migrated into groundwater. Based on these findings, the remediation of the site focused on PAHs in soil.

Site remediation was performed under the supervision of the California EPA DTSC. As a risk management policy, the DTSC generally requires post-remediation cancer risks to be closer to the 10^{-6} end of the 10^{-4} to 10^{-6} acceptable risk range recommended in the National Contingency Plan (NCP). Most remediations approved by the DTSC achieve cleanup to a residual cancer risk of 10^{-5} or lower.

Background Database

The database of background PAH concentrations includes analyses of 184 surface soil samples collected from 20 different sites throughout Southern California. The data set was subjected to several statistical tests to determine if the data comprised a homogeneous population. Among the variables probed to explain variations in the data were urban versus rural setting, analytical method, and sample collection technique. After evaluating several different variables that might account for variability in the data, it was concluded that the data could be considered a single data set with a log normal distribution.

Developing the Remedial Action Goal

Using cancer slope factors recommended by California EPA for cPAHs, the concentrations of cPAHs (expressed as benzo(a)pyrene [B(a)P] equivalents) corresponding to 10^{-6}, 10^{-5}, and 10^{-4} cancer risks for a residential exposure scenario are 0.02, 0.2, 2.0 mg/kg, respectively. Using the database of background PAH concentrations in Southern California soils developed as part of this project, the 95% upper confidence level estimate of the mean concentration of cPAHs (expressed as B(a)P equivalents) in soil is 0.24 mg/kg. This concentration does not correspond to a cancer risk above the 10^{-4} upper end of the acceptable risk level recommended in the NCP, but it does correspond to risks in excess of 10^{-6} and 10^{-5}.

Remediating soils in Southern California to PAH concentrations corresponding to cancer risks in the 10^{-6} to 10^{-5} range would require reducing concentrations to levels below background, an impractical goal. Remediating the site to background concentrations would produce a site that posed no incremental risk to humans or the environment beyond that posed by background PAHs. The remediation goal adopted for the site was to restore each residential lot to a condition such that people living at the site would have no more exposure to PAHs than they would have had in the absence of the MGP operations.

Achieving the Remedial Action Goal

Given the objective of restoring the site to background conditions, the ideal remediation would have involved removing all PAHs that originated from the former MGP operations. Over time, however, some of the PAHs from the MGP operations had mixed with soil to such an extent that while the PAH concentrations were elevated above background levels, the soil across much of the site was not visually distinct. The practical approach developed for remediating the site relied on field observation to visually identify lampblack and on statistical evaluations of sampling data to identify areas with PAH concentrations above background levels.

Because there is no single statistical test that could be applied to soil concentration data to determine if the PAHs measured in a particular sample exceed background concentrations, SoCal applied a few different statistical tests to identify areas where concentrations probably exceeded background levels. The statistical tests include both comparisons of point estimates as well as distributions. To evaluate point estimates, the 95^{th} percentile, the upper tolerance limit, and the upper prediction limit were considered. The appropriate test for comparing distributions depended on the nature of the background distribution and the site data. Visual comparisons of plots of the background data set to the data from each lot were revealing, as were more rigorous statistical tests such as a t-test or a Mann-Whitney test. Using these statistical tests, an initial excavation target of 0.9 mg/kg of B(a)P equivalents for the cPAHs was identified. Using the initial site characterization data, soils with B(a)P equivalent concentrations above 0.9 mg/kg were initially identified to be excavated.

Because approximately 5 percent of background soil samples had B(a)P equivalent concentrations above 0.9 mg/kg, leaving some soil with PAH concentrations above this level did not necessarily mean that the PAH concentrations remaining after site remediation exceeded background levels. This was an important practical consideration because some soil with elevated PAHs level were in areas where excavation was not practical (e.g., beneath foundations).

The evaluation of data distributions was particularly important in the determination of whether contamination had spread off-site. Because there is a wide range of PAH concentrations in the background, the occasional detection of a relatively high concentration of PAHs in boundary or off-site samples did not necessarily mean that contamination had spread off-site. The use of a single point estimate (e.g., two standard deviations above the mean, the upper tolerance limit, etc.) as a test for determining whether any single data point represents contamination beyond background can lead to false conclusions.

Demonstrating Achievement of the Remedial Action Goal

Based on the initial evaluation of the distribution of PAHs in soil at the site, the excavation of soils meeting the two initial excavation criteria described above (i.e., visible lampblack and B(a)P equivalent concentrations above 0.9 mg/kg) was predicted to effectively restore each lot to background conditions. Excavation was required on 18 of the 20 lots down to an average depth of 4 to 5 feet, including under crawl spaces and concrete slabs. Following excavation, soil samples were collected from the side walls and bottoms of excavated areas and statistical analyses were performed to determine if each lot had been restored to background conditions. Post-remediation concentrations were also compared to risk-based concentration limits designed to prevent acute or sub-chronic health effects to ensure that none of the material left behind would pose such health risks. The same statistical tests described above for determining whether and where remediation was needed were applied to the post-remediation data to confirm that remediation was complete.

Conclusions

Because risk-based remediation goals for cPAHs were below background levels, a method for developing background-based remediation goals was needed. The traditional reliance on a single point estimate of background (e.g., two standard deviations above the mean), however, can provide false indications of contamination, particularly if there is a substantial overlap in the range of background concentrations and the range of incremental concentrations attributable to MGP operations.

By having a database representative of background concentrations over a sizable geographic region, the characterization of background concentrations coming from the database can be used at the many sites in the region. The size of the database (i.e., 184 data points) allows for a high degree of statistical power in distinguishing background concentrations from elevated concentrations that are presumably related to MGP operations. In addition, through the use of distributional comparisons to supplement point estimate definitions of background levels, this approach can minimize the false identification of background concentration samples as representing contamination.

Contact

Bob Vogel, Southern California Gas Company, (213) 244-5880

3.2.11 Generic Administrative Orders

Tool Description

Generic administrative orders have been developed to streamline the regulatory administrative process. Former MGP sites, as a subset of site characterization and remediation experiences, lend themselves to generic administrative orders and provide the opportunity to address environmental conditions under a consistent, cooperative, mutually beneficial statewide agreement. Benefits of generic administrative orders include:

- Comprehensive and consistent statewide strategies
- Reduced costs in negotiating agreements/orders
- Proactive environmental mitigation
- Emphasis on cooperation and common sense

Case Study

North Carolina MGP Group Generic Administrative Order

In the late 1990s, the North Carolina Manufactured Gas Plant Group (NCMGPG) entered into a memorandum of understanding (MOU) with the North Carolina Department of Environment, Health, and Natural Resources, Division of Solid Waste Management (DSWM) to establish a uniform program and framework for addressing manufactured gas plant sites in North Carolina. Under the MOU, all investigations and, if required, remediation of specific MGP sties are to be addressed pursuant to one or more administrative orders of consent. The MOU did not commit the NCMGPG to investigation and / or remediation any particular former MGP site; rather it simply set in place the framework to be followed should such an investigation / remediation be implemented. Implementation is formalized through the execution of one or more of the generic administrative orders of consent.

In establishing the generic administrative orders and preparing the MOU, the NCMGPG and DSWM agreed to coordinate all North Carolina MGP site investigations and remediations under the authority and jurisdiction of the DSWM in order to ensure that all characterization activities were completed in a uniform manner and to ensure that a single, regulatory agency (DSWM) would take control of oversight of North Carolina former MGP sites. In executing the MOU, the NCMGPG and DSWM agreed to:

- Negotiate in good faith to develop a uniform program and framework for the investigation and, if required, remediation of former MGP sites within the state
- Prioritize MGP sites in the state using the Site Screening and Prioritization System (SSPS) developed by the Electric Power Research Institute
- Discuss and obtain regulatory acceptance of the most nearly applicable cleanup standards that would be applied under CERCLA and Superfund Amendments and Reauthorization Act of 1986, recognizing the need for flexibility in addressing site-specific conditions
- Negotiate in good faith to develop appropriate alternatives to the site assessment and remediation methodologies outlined in the generic administrative orders
- Organize and sponsor group-funded technical seminar(s) and conference(s) highlighting state-of-the-art technologies involving assessment and remediation of former MGP sites

Contact

Brian Nicholson, North Carolina Department of Environment, Health, and Natural Resources, (917) 733-2801 x353

Chapter 4

Tools and Techniques for Expediting Site Characterization

4.1 Introduction

Expedited site characterization (as described in Section 3.2.7) encompasses the use of tools and methodologies that streamline data collection, increase field program flexibility, and allow for real-time on-site access to results. Fundamentals key to an expedited site characterization include:

- On-site or rapid decision-making capabilities
- Use of field and analytical tools that facilitate real-time data collection and interpretation.
- Use of non-intrusive or minimally intrusive geophysical and / or sampling techniques
- Flexibility in the overall site characterization and remediation process

The tools and techniques described in this chapter offer alternatives to, and in some cases, advantages over more traditional approaches to environmental assessment of sites. These tools and techniques are less intrusive, and generally allow completion of data collection in a more expeditious manner. In addition, the majority of these tools allow practitioners immediate, on-site access to results rather than requiring samples be sent to analytical laboratories for analysis. Having the data available in real time while implementing the sampling program allows the investigator to modify the sampling program based on early results. The investigator can then make informed decisions about subsequent sampling locations to cover an area of interest or to define the boundaries of identified problem areas.

In addition to being faster and less intrusive, these tools and techniques are cost-effective, taking many samples and producing a large amount of data in a short time. This is especially useful in expedited site characterizations, where the goal is to first collect more data points of lesser quality in order to focus resources on those areas of greatest concern. Subsequent phases of field work can then be implemented to collect fewer data points of better quality at predetermined locations, if necessary, to complete the site characterization.

These tools and techniques can be combined to form a site-specific expedited field program. Prior to developing such a program, however, thought must be given to the project's data needs and the ways in which the data will be used. Once these DQOs have been formulated, different site characterization tools and techniques can then be brought together, as appropriate for different site conditions. Flexibility in decision-making during the field program will also be required to ensure that only necessary and useable data points are collected. Each tool and technique in this chapter has strengths and weaknesses. The following table summarizes available information. Additional information is presented in the chapter proper for use by the practitioner. The order in which the tools and techniques discussed in this chapter does not reflect any ranking of their relative effectiveness.

Expedited Site Characterization Tools and Techniques

Name	Description	Benefits	Limitations	Approximate Cost
Direct Push Methods/Limited Access Drilling				
Direct Push/Limited Access Drilling (Geoprobe, Power Punch, Strataprobe, Precision Sampling, and others)	Used to collect soil, groundwater and soil gas samples and for identifying stratigraphy and nonaqueous phase liquids.	• Faster, cheaper way to explore subsurface characteristics • Can be linked to on-site analysis for real time mapping • Widely available • Can install small diameter wells and vapor extraction points • Less intrusive • Produces small volume of investigation-derived waste	• Limited range of use (with refusal/depth limited to <100 ft max; typically 25 to 30 feet) • Does not allow for large well installations • Limited use at locations with buried obstructions (e.g., foundations and coarse grain materials) • Potential for cross-contamination from single-tube rigs.	$1,000 - $1,500 per day; typical production 10-15 shallow (<40 ft) pushes per day
Cone Penetrometer	Push sampler used for geologic logging and to collect in situ measurements of geologic properties and pore pressure. Can be used to collect soil gas and groundwater samples.	• Rapid collection of objective stratigraphic information • Can penetrate harder zones than most direct push methods • Produces small volume of investigation-derived wastes	• Does not collect soil samples for analysis or inspection • Large, heavy rig may limit access • Cannot install wells • Potential for cross contamination from single-tube rigs	Typically one-third that of conventional soil borings, on per foot basis
Simulprobe	Driven sampler used to collect soil, groundwater, and soil gas samples through a casing or auger advanced to desired sampling depth.	• Collects soil and either groundwater or soil gas samples at same stratigraphic interval on the same push • Can be used with field instrument to screen for VOCs while pushing • Can be used in conjunction with a variety of drilling methods	• Limited availability • Multiple moving parts increases potential for breakage or sticking • Depth to which sampler can be pushed limited	Tools rent for $150/day or $650/week, plus rig cost of about $1,500 per day.
Hydropunch	Direct push tool used to collect depth-discrete groundwater samples at a discrete level in a single push.	• Collects groundwater sample at a discrete depth • Can be used with field instrument to screen various depths	• Data subject to interference from turbidity • Potential for cross-contamination if sampler is driven across hydrostratigraphic zones	Tools rent for $150/day or $650/week, plus rig cost of about $1500 per day.
Waterloo Profiler	Direct push sampler used to collect depth-discrete groundwater samples at various levels in a single push. Useful in identifying thin, high-concentration plumes that may be missed or underestimated (via dilution) with monitoring well sampling.	• Generates a vertical profile of groundwater quality on a single push (typical vertical separation of about 2 to 5 feet) • Faster and less prone to cross-contamination (vertically) than multiple pushes with conventional push samplers	• Sampling depth generally limited by drilling method • Not applicable to low-permeability settings • Tool available through limited number of vendors	$1,500 to $2,000 per day (2-person crew, including all decon and support equipment); typical production is 150 - 200 ft per day. Waterloo sampler equipment may be purchased from Solinst Canada, Inc., for $US 2,700.

Expedited Site Characterization Tools and Techniques, continued

Name	Description	Benefits	Limitations	Approximate Cost
Multi-Level Groundwater Samplers				
Westbay System	Fixed multi-level sampler built for a specific well installation. Access is through a single standpipe with mechanical "ports" that are opened and closed during sampling. Used to provide multi-level sampling and hydraulic head measurements.	• Provides direct samples of formation water • Allows head measurements	• Mechanically complex • Not adjustable or portable between wells • Requires specially constructed wells	Approximately $30,000 for a 5-level system ranging from 50 feet to 200 feet in depth. Includes installation but not sample analysis.
Waterloo Sampler	Fixed multi-level sampler built for a specific well installation. Access is through bundled flexible tubes that are accessible at the surface. Used to provide multi-level sampling and hydraulic head measurements in specially-constructed well. Smaller "drive point" units available for shallow installation.	• Provides direct samples of formation water • Reduces purge volumes • Removable or permanent systems available	• Mechanically complex • Specially-ordered materials necessary • Removable packer system sometimes difficult to cost-effectively reuse • Requires trained technician for installation	Approximately $25,000 for a 5-level system ranging from 50 feet to 200 feet in depth. Includes installation but not sample analysis.
Diffusion Multi-Layer Sampler (DMLS)	Portable multi-layer dialysis cell passive groundwater sampler. Used to characterize vertical variation in groundwater quality in either open rock boreholes or in wells with long well screens. Can be used to estimate groundwater flow velocity using borehole dilution method.	• Portable between wells • Allows vertical characterization of groundwater in a single borehole or well • Requires no purging	• Not widely used • Does not allow head measurements • May not be appropriate for zones with strong vertical gradients	About $3,000 for 2- to 3-meter-long units. Cost increases with increasing length. Need to add additional costs related to sample analysis and equipment installation.
Discrete Point Samplers				
Discrete Point Samplers	Discrete point sampler used to collect representative groundwater sample at a distinct elevation or points of inflow in either open boreholes or screened wells.	• Permits groundwater sampling from discrete vertical depth • Minimizes mixing of water from different levels during sample collection • Portable	• May require training to operate sampler • May be difficult to obtain complete seal	$150-$2,000 for purchased sampler.

Expedited Site Characterization Tools and Techniques, continued

Name	Description	Benefits	Limitations	Approximate Cost
Analytical Field Screening				
Rapid Optical Screening Tool (ROST)	Sampling and screening technology used to field screen for petroleum hydrocarbons and other contaminants.	• Rapid, real-time geologic and hydrocarbon data • Can be used to converge on area of interest • Works for both fuel (aromatic) hydrocarbons and creosote (polycyclic aromatic hydrocarbons) • Generates little investigation-derived wastes during sampling	• Limited availability • Limited to unconsolidated geology (same as CPT) • Provides only relative concentration data	$4,000 to $4,500 per day (reflects recent cost reduction). Production up to 300 feet per day.
X-Ray Fluorescence (XRF)	Field screening tool used to analyze trace metals in soil, sludges, and groundwater.	• No waste generated • Little sample preparation required • Easily transported to the field	• Limited penetration depths • Susceptible to interference from water, petroleum, and soil variability • Poor detection limits for some metals • Radioactive source in analyzer	$2,000/week.
Colorimetric Field Test Kits	Field test kits used to detect the presence or determine the concentrations of contaminants in soil and water.	• Inexpensive and easy to use • Available for a wide range of concentrations for hundreds of chemicals • Can be used for remote sampling	• Relatively high detection limits • Possible interference by naturally occurring chemicals and other contaminants • Possible difficulty in reading colorimetric matches in low light	Handby Kits - $1300/30 samples PetroFLAG - $800/10 samples Petrosense - $150/week Quick Testr - $275/week
Immunoassay Field Screening	Field test kit used to detect target chemicals in soil and other samplers. Most kits use competitive enzyme-linked immunosorbent assay (ELISA) type.	• Produces rapid, real-time analytical data onsite • Can be used to select samples for laboratory analysis and to define limits of contamination	• Requires site-specific calibration • Does not speciate individual PAHs • Does not work effectively at MGP sites where crude oil was used • Does not produce quantified concentrations of target chemicals • Requires test runs to ensure adequacy	Approximately $20 - $55/sample excluding labor
Mobile Laboratory	Mobile facility providing onsite soil, water, and air analyses.	• Rapid onsite detection of contaminants • May reduce mobilization/demobilization charges for field projects • Can rapidly perform time-critical analyses	• More expensive for standard turn-around analysis • Not all mobile laboratories use USEPA analytical methods	$2,500 to $3,000 for rental; $13 to $30/sample for expendables.

Expedited Site Characterization Tools and Techniques, continued

Name	Description	Benefits	Limitations	Approximate Cost
Geophysical Surveys				
Electromagnetics	Non-intrusive electromagnetic geophysical tool used to locate buried drums, landfills, bulk buried materials, etc. Can be used to determine depth to the water table and to delineate electrically-conductive (high dissolved solids) contaminant plumes.	• Non-intrusive • Can provide large quantities of detailed data in short time	• Need expert subconsultant to plan survey and interpret data • Data affected by power lines and metal buildings, cars, or other large metal items • Problematic in iron-rich soils and fill with large amounts of diffused metal wastes	Approximately $3,500, including data collection and interpretation for a one-acre site.
Seismic Refraction	Non-intrusive geophysical surveying tool used to determine depth to bedrock and/or water table. Can be used to define bedrock surface, buried channels, etc.	• Non-intrusive • Can provide large quantities of detailed data in short time	• Need expert subconsultant to plan, collect, and interpret data • Data subject to interference from complex geologic strata • Needs to be correlated with other site-specific subsurface data • Heavy traffic or numerous surface obstructions may be problematic	Approximately $10,000 including data collection and interpretation for a one week survey.
Ground Penetrating Radar (GPR)	Non-intrusive geophysical surveying tool used to locate buried waste, drums, tanks and voids, and to determine the depth and thickness of soil and bedrock.	• Non-intrusive source and detectors • Can provide large quantities of detailed data in short time	• Need expert subconsultant to plan, collect, and interpret data • Data deteriorates with increasing surface moisture or clay in subsurface • Problematic in iron-rich, deeply weathered soils	$10,000/week for 5 to 7 line miles of interpreted data.
Magnetometry/Metal Detection	Non-intrusive geophysical survey tool used to detect and map buried drums, metallic pipes, utilities and cables, tanks and piping. Also used to delineate trenches and landfills with metal debris.	• Non-intrusive • Relatively easy for non-expert to use • Can provide large quantities of detailed data in short time	• Depth and detail not obtainable • Cannot distinguish between types of metallic objects • Nonferrous metallic objects are invisible	$500/month for equipment rental costs only.
Electric Logging	Includes electrical resistivity methods, induction logs, self-potential logs, and fluid conductivity logs. Uses electrical resistivity to identify different hydrogeologic zones around a borehole.	• Rental equipment available • Specialized training not required • Quantitative data may require corrections	• Requires uncased borehole • Electrical resistivity and self-potential techniques require conductive borehole fluids • No quantitative measurements (other than depth) • Induction logging requires a dry borehole or borehole with non-conductive fluids	$1,200 - $2,500 day. (Can log 5-7 100-foot wells per day.)

Expedited Site Characterization Tools and Techniques, continued

Name	Description	Benefits	Limitations	Approximate Cost
Geophysical Surveys, cont.				
Mechanical Logging	Includes flow-meter and caliper logging. Used to identify water-producing zones. Flow-meter logging provides semi-quantitative flow measurements when used in conjunction with caliper log (which measures borehole size and roughness and locates fractures and washouts).	• Provides direct measurement of vertical flow in well bore	• Flow-meter logging is relative insensitive at low velocities • Most applications of flow-meter logging requires a pumping or flowing well • Caliper logging is required for interpretation of flow-meter log	$500 - $600 per well, when run as part of multiple log suite. Flow-meter only (with caliper) is approximately $1,500 - $2,500 per well.
Acoustic (Sonic) Logging	Uses acoustic energy to determine the relative porosity of different formations. May be used to identify the top of the water table, locate perched zones, and assess the seal between a casing and formation material.	• Useful for characterizing rock aquifers • Allows porosity determination without use of radioactive source	• Not applicable in shallow wells or in unsaturated conditions • Relatively complex test; requires skilled operator for reliable results	$1,500 - $4,500 per well.
Radiometric Logging	Includes neutron logging and natural gamma logging. Used to estimate the porosity and bulk density of a formation and to locate saturated zones outside casing. Gamma logging is used to evaluate downhole lithology, stratigraphic correlation, and clay or shale content.	• Rental equipment available • Specialized training not required • Good tool for performing infiltration studies	• Neutron logging requires handling radioactive source and may be limited to case boreholes • Natural gamma logging may provide a non-unique response • Natural gamma logging may respond to the presence of phosphate minerals of micas or may mistake feldspar for clay or shale	For neutron logging, $2,500 to $5,000 per well depending on well depth and number of other logs run in conjunction. For natural gamma logging, $1,200 - $2,500 day. (Can log 5 - 7 100-foot wells per day).
Thermal Logging	Uses temperature differentials for flow and injectivity profiling, in conjunction with flow-meter logging.	• Supplements flow-meter log for identification of producing zones	• Requires fluid-filled borehole for testing • Interpretation of log complicated if internal borehole flow is present	$500 - $600 per well, when run as part of multiple log suite. Temperature log only $1,500 - $2,500 per well.
Video Logging	Downhole videotaping to provide visual inspection of a well interior, detecting damaged sections of screen and casing, and to detect fractures, solution cracks and geologic contacts in uncased holes.	• Allows visual inspection of the interior of the well	• Requires very clear water for successful survey • Not suitable for open boreholes in unconsolidated formations	$400 to $3,000 per well.

Expedited Site Characterization Tools and Techniques, continued

Name	Description	Benefits	Limitations	Approximate Cost
Soil Gas Surveys				
Passive Soil Gas	Measures relative concentration of contaminants through subsurface detectors sensitive to diffusion.	• Can be more sensitive than active soil gas, soil, or groundwater sampling for detecting presence of trace contaminants • Can be used in areas of low-permeability soil	• Does not measure direct concentration • May be difficult to collect data at depth for vertical characterization • Requires 2 to 4 weeks for sample collection	Approximately $250 per sample location, including analysis and reporting; about $50 - $100 per location installation and retrieval.
Active Soil Gas	Uses a vacuum pump to induce vapor transport in the subsurface and to instantaneously collect samples of contaminants in the vapor phase.	• Provides real-time data • Rapid results allows user to converge on areas of interest • Provides direct measure of vapor concentration • Can be used to evaluate vertical changes in soil gas concentrations	• Samples must be collected at least 10 to 20 feet bgs • Cannot be used in areas of relatively low permeability • May be adversely affected by transient processes (e.g., barometric pressure) and stationary features (e.g., pavement)	Approximately $3,000 to $4,000 per day
Contaminant Migration Evaluation				
Push-Pull Natural Attenuation Test	Injection/withdrawal test (single well) to document and quantify microbial metabolism.	• Can document microbial metabolism, loss of degraded contaminants, production of degradation products, and yield estimates of zero- and first-order decay constants • Can use wells already installed • Provides in situ data	• Not widely used • Can have difficulty when decay rate is slow relative to groundwater flow rates	$12,000 to $15,000 for 2 to 3 wells at one site for BTEX. Costs may be higher for other contaminants (because of more expensive analysis).
Partitioning Interwell Tracer Test (PITT)	Injection/withdrawal test (2 wells) to quantify volume and estimate distribution of nonaqueous phase liquids (NAPLs).	• Can provide quantitative estimates of NAPL volume • Can be used to design remediation methods targeting a NAPL source • Is relatively accurate compared with other in situ tests that utilize point values or small aquifer volumes	• Expensive • Technology is patented • Most experience is with solvents	$100,000 to $400,000 depending on scale of test.
In Situ Bio/Geochemical Monitor (ISM)	Allows for in situ measurement of biochemical reaction rates and retardation factors for both organic and inorganic compounds through the subsurface introduction and monitoring of tracers and reactants.	• Reduces the time and cost of obtaining site-specific biological and geochemical data • Provides in situ measurements of biochemical reaction rates • Provides estimated rates of denitrification during biodegradation • Provides estimated retardation rates for organic and inorganic compounds	• Testing is complex and requires trained personnel • Small aquifer volume tested means results may be affected by small-scale variations in aquifer properties • Typically applicable only with permeabilities $>10^{-4}$ cm/sec	$3,000 for equipment only.

Expedited Site Characterization Tools and Techniques, continued

Name	Description	Benefits	Limitations	Approximate Cost
Other Tools				
Micro-Scale Extraction (for PAHs)	Alternative laboratory extraction procedure for mono- and polycyclic aromatic hydrocarbons, chlorinated phenols, PCBs, mineral oil, and selected nitrogen- and sulfur-containing aromatic hydrocarbons prior to analysis.	• Small sample volumes required • Fast laboratory turnaround times • Minimal laboratory wastes • Quantitative results for individual components	• Relatively new procedure	Dependent upon analysis. Can reduce costs by over 50% in certain situations.
PAH Sample Filtration	In-field or laboratory filtration of water samples prior to PAH analysis to estimate the 'true' dissolved concentration by removing potential for colloidal contribution of PAHs.	• Eliminates high bias in PAH concentration measurements introduced by artificial colloidal entrainment • Inexpensive • Requires minimal training to implement	• Low bias resulting from elimination of naturally-occurring colloidal transport of PAHs • Dissolved or colloidal contaminants may adsorb onto the filter or apparatus	Minimal cost when compared to overall analytical costs. (Typical PAH analysis costs $200 to $300/sample.)
Inverse Specific Capacity Method	Specific application of push sampler (Geoprobe and others) to link groundwater quality data obtained from push sampler with an estimate of hydraulic conductivity in the sampled zone	• Allows vertical profiling of variations in horizontal hydraulic conductivity to be assessed	• Provides hydraulic conductivity for only small volume of aquifer • Need site-specific permeability data from conventional means (pumping or slug tests in wells) to convert specific capacity to hydraulic conductivity • Only appropriate for zones having permeability ranging from 10^{-1} to 10^{-5} cm/sec	Negligible cost, assuming that a peristaltic pump and push sampler already are in use at the site (assumes typical time for test ranges from 5 to 10 minutes).
Hand Augering/Trenching/ Pot Holing	Field surveying and sampling technique.	• Inexpensive where labor is cheap • Can be used to expose buried objects • Discrete and can get into tight locations	• Hand augering and test pits are depth limited • Pot holing and test pits are visible to public • Borehole/slope stability problems • Waste management may be a problem	Materials and equipment costs are minor. Cost is dependent on local labor costs.
Noise and Fugitive Emissions Controls	Barriers and controls to minimize noise and fugitive emissions during site characterization and remediation.	• Protects community and workers • Limits noise and air pollution • Minimizes the migration/transport of contaminants	• May be cost- and effort-prohibitive on a large scale • Controls may make field work logistically more complex and/or limit rate of completion	Ranges from $200-$500/day for water sweeping to >$10,000 for complete site enclosure.

4.2 Tools and Techniques for Expediting Site Characterization

Described below are 13 categories of new and existing tools and techniques that are currently available for expediting characterization of former MGP sites. The cost of using the tools and techniques and the results generated will vary from site to site depending upon accessibility, cost of labor, types and concentrations of contaminants found, hydrogeology, and other characteristics. Although many of these tools and techniques have been used successfully at former MGP sites, practitioners should choose tools based on the particular conditions at their site(s). Where possible, references are listed so that readers can contact representatives of projects where the tools and techniques have been used.

4.2.1 Direct-Push Methods/Limited Access Drilling

Tools in this category provide faster and cheaper ways to explore subsurface characteristics than have been available in the past. These methods are typically less intrusive, generate fewer investigation-derived wastes than past techniques, and permit sample collection in areas with limited clearance. When combined with on-site data analysis, these tools provide a powerful way to survey soil (and groundwater) for contaminants.

Some of the tools described herein may be limited to depths of 25 to 30 feet; others, however, are not depth-constrained. These tools generally create small-diameter boreholes and therefore do not allow for the installation of large wells. In addition, they may only allow for one-time “snapshot” or “grab” sampling. Tools included in this category are:

- Direct-Push Limited Access Drilling Techniques (such as GeoProbe™, Power Punch™, Strataprobe™, and Precision Sampling™)
- Cone Penetrometer
- Simulprobe™ Sampler
- Hydropunch™
- Waterloo Profiler
- Westbay System
- Diffusion Multi-Layer Sampler
- Waterloo System
- Point Sampler or Dual Packer Sampling

4.2.1.1 Direct-Push/Limited Access Drilling

Tool Description

A wide range of direct-push and limited access drilling techniques is available for collecting soil, vapor, and groundwater samples and for identifying stratigraphy or NAPLs. Some vendors, such as GeoProbe™, have also developed specific application probes (e.g., the conductivity probe) that can be used in conjunction with a drilling rig to survey a site or install small-diameter wells. These drilling methods have been successfully applied at former MGP sites for delineating source areas, screening aquifers for plumes before well installation, and collecting subsurface information in hard-to-access areas.

Direct-push drilling rigs typically consist of hydraulic-powered percussion/probing machines designed specifically for use in the environmental industry. "Direct push" describes the tools and sensors that are inserted into the ground without the use of drilling to remove soil and make a path for the sampling tool. These drilling rigs rely on a relatively small amount of static (vehicle) weight combined with percussion for the energy to advance a tool string. The small rig size allows work in limited access areas. Below is a photograph showing a typical direct-push drilling rig.

Operational Considerations

Direct-push drilling rigs, such as the GeoProbe™, are more efficient at drilling in shallow, soft areas but are not typically capable of drilling through a thick subsurface structure such as a gas holder foundation. Although limited in depth and often unable to drill through buried foundations at an MGP site, this technology can provide useful information about the location and depth of buried structures without puncturing them, which would create a route for cross contamination. In addition, this technique is effective for collecting soil, groundwater, and soil vapor grab samples. It is most efficient to depths of approximately 30 to 50 feet (depending on soil type).

Applications and Cost

Vendors of direct-push drilling rigs include GeoProbe™, Power Punch™, Strataprobe™, and Precision Sampling™. This drilling technology is well understood and provides reliable results. The cost of a direct-push drilling rig is approximately $1,000 to $1,500 per day, not including sampling tools and related expenses.

Benefit

- Small rig size suitable for tight spaces around aboveground structures or utility areas such as substations
- Small volume of investigation-derived waste (IDW) produced
- Continuous coring or discrete soil samples both possible
- Sampling of soil, groundwater, and vapor possible along with installation of small-diameter wells

Limitations

- Limited use at locations with buried obstructions (e.g., foundations)
- Potential for cross contamination from single-tube rigs
- Rods can get lost in tight soils
- Small diameter wells installed using these direct-push rigs may be difficult to develop
- Water samples collected from direct-push tubes typically contain considerable suspended sediment; may yield biased results for turbidity-sensitive constituents such as lead and PAHs
- Repeated pushes required from ground surface in order to vertically profile a site (i.e., collect water samples at different depths at the same location) unless special equipment (i.e., Waterloo system) is used
- Impractical (because of slow sample collection) in low-permeability soil or when attempting to collect samples at relatively shallow depths below water table

Case Study

Chico/Willows/Marysville (CWM) Former MGP Sites

Both GeoProbe™ and Precision Sampling™ direct-push drilling rigs were used at PG&E's CWM former MGP sites. The rigs were used to:

- Collect deep soil and grab groundwater samples from within active substations
- Collect grab groundwater samples to delineate the extent of offsite groundwater contamination so that downgradient monitoring wells could be placed at the edges of plumes (to act as sentry wells against continued downgradient plume migration)

- Quickly establish the extent of lampblack and coal tar in shallow soils at the locations of former lampblack separators, lampblack dumps, and tar pits

When the rigs were unable to drill through obstructions, this helped verify the location, depth, and extent of buried foundations. Soil samples from depths beneath former foundations (collected when the drilling rig was able to push through the former foundations) provided information about the types and volume of buried MGP wastes. At locations where cross contamination was a significant concern, Precision Sampling's dual-tube direct-push drilling rig was used to minimize the amount of soil and/or waste that may be transported downward by the driving rod.

4.2.1.2 Cone Penetrometer (CPT)

Tool Description

CPTs were initially developed as engineering tools for determining the capacity of soils to support foundations and pilings. These tools are a quick, reliable, and well-tested means to determine the continuity of stratigraphy, the depth to the water table, and the thickness of stratigraphic layers. More recently, the hydraulic pushing equipment on a modern CPT rig has been used to advance probes and samplers into subsurface soils. Examples of such probes/samplers include vapor samplers, soil samplers, the Hydropunch™, LIF probes, and resistivity probes.

A traditional CPT survey is a continuous penetration test in which a cone-shaped rod is forcibly pushed into the soil with hydraulic rams. Sensors electronically measure the resistance at the cone's tip and along the cone's sides. The function of the relative density of the sediment is then correlated to the soil textures to determine the site's stratigraphy. A schematic figure of a CPT rig is shown below.

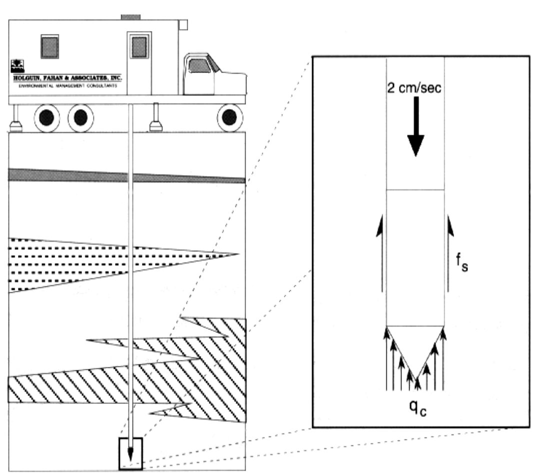


FIGURE 1 - SCHEMATIC DIAGRAM OF CPT
(qc = tip stress, fs = friction stress)

Reference: Holguin, Fahan & Associates, Inc.

Operational Considerations

Modern CPT rigs are capable of collecting the same data as conventional drilling rigs. CPT data are high quality, most often meeting DQOs, cost effective, and typically pose minimal health and safety concerns. In addition, CPT testing does not generate any drill cuttings. CPT drilling rigs can generally penetrate to depths of 100 to 150 feet below ground surface (bgs) in normally consolidated soils. The principal disadvantage of CPT rigs is that they cannot penetrate as deeply as conventional drilling rigs.

Applications and Cost

There are several CPT vendors in the United States, most of whom support both traditional geotechnical CPT projects and modern environmental investigations. The types of CPT-mounted sampling equipment and probes vary, however, among vendors. Costs for CPT are typically about 30 percent (on a per-foot basis) of the cost of conventional soil borings installed using traditional methods such as hollow-stem auger drilling. CPT costs are comparable with the modern direct-push drilling technologies offered by GeoProbe™, Precision Sampling, Inc., and others.

Benefits

- Can penetrate harder zones better than most direct-push methods
- Produces small volume of IDW
- Can be used for sampling groundwater and soil gas

Limitations

- Potential for cross-contamination from single-tube rigs
- Does not allow continuous coring or discrete soil samples
- Cannot be used to install wells
- Large, heavy rig may preclude access to some locations

4.2.1.3 Simulprobe™ Sampler

Tool Description

The Simulprobe™ sampler is a soil, soil gas, and groundwater sampling tool designed to be driven by either push or drive sampling technology. The sampler reduces the potential for cross-contamination by precharging its sample canister with nitrogen and by covering the sampler with a latex condom. Precharging the sampler with nitrogen prevents water from entering the sample canister until the sample is collected. The condom ensures that the sampler remains uncontaminated until driven into undisturbed soil.

One significant advantage of the Simulprobe™ sampler is the ability to obtain a soil core sample at the exact depth where the grab groundwater or soil gas sample was obtained. This allows the user to determine the lithology at the point of sampling. In addition, the Simulprobe™ sample chamber fills at a slower rate than other samplers (controlled by the rate at which the nitrogen is bled off), thereby reducing turbidity. The sampler also has a settling chamber so that any excess sediments that enter the chamber settle out before the water sample is transferred. The adjacent photograph shows a Simulprobe™ sampler.

The Simulprobe™ provides continuous sampling of soil gas in the vadose zone. When the probe is pushed through the vadose zone, soil gas is extracted under the vacuum and measured continuously in an organic vapor analyzer located above ground surface. If desired, a syringe can be inserted and a sample of soil gas can be extracted and analyzed by gas chromatography (GC) at any time.

Operational Considerations

Sampling with the Simulprobe™, as with other similar tools, is limited by the depth to which the tool can be driven. Other geologic conditions, such as flowing sands, also limit the tool's effectiveness and range.

When a grab groundwater sample is collected using the Simulprobe™ sampler, the water canister is first charged with nitrogen (usually 60 pounds per square inch [psi]/100 feet of hydrostatic head), and the entire sample device is covered with a latex condom. The Simulprobe™ is then slowly lowered to the bottom of a borehole and hammered 21 inches into the subsurface to collect a soil core. The device is then pulled back 2 to 3 inches to retract the sliding drive shoe and expose the circular screen. A valve is opened to allow the nitrogen pressure to bleed off from the water canister so water can enter the sample chamber under ambient hydrostatic pressure. After the water sample has been collected, the water canister is repressurized to prevent leakage into the sampling device, pulled out of the borehole, and emptied into appropriate sample containers.

Applications and Cost

The latex condom covering the Simulprobe™ sampler is designed to minimize cross-contamination during sampling, therefore making the Simulprobe™ a tool for grabbing groundwater samples before well installation, especially in areas where cross-contamination is of concern. Combined with push- or hammer-driven sampling (such as GeoProbe™) and in-field analysis, it provides a fast, effective method for obtaining survey-level data for refining monitoring well and groundwater plume locations. In addition, collecting soil samples at the same interval as the sampled groundwater allows for better linkage between hydrostratigraphy and groundwater and contaminant movement in the subsurface.

The rental cost of the Simulprobe™ sampler alone (direct from the vendor) is approximately $150 per day or $650 per week. Drilling costs can add approximately $1,500 per day to total sample collection costs. Sampling depth and frequency, site hydrostratigraphy, and buried obstructions can significantly impact the tool's effectiveness.

Benefits

- Collects soil and either groundwater or soil gas samples at the same stratigraphic interval in the same push
- Can be used with field instruments to screen for volatile organic compounds while pushing
- Field tested and proven
- Can be used in conjunction with a variety of drilling tools
- Latex condom minimizes cross-contamination during sampling
- Nitrogen or helium can be used to purge the canister to create an inert atmosphere before sample collection, thereby improving the quality of chemical parameters for natural attenuation monitoring
- Canister attachments can be used as pneumatic bailers inside wells or boreholes (e.g., for sampling below NAPL layers)

Limitations

- Limited availability (though may be available through local drilling firms)
- Multiple moving parts increase potential for breakage or sticking
- Depth to which the sampler can be pushed / driven limited

Case Study

Chico Former MGP Site

Field investigations conducted at PG&E's Chico former MGP site identified PAHs and petroleum hydrocarbons in the shallow water-bearing zone. However, the hydrostratigraphy below the water-bearing zone was not known, nor was information available on the water quality of deeper water-bearing zones. In order to determine the vertical extent of MGP-related constituents in groundwater and to identify the next deeper, unimpacted zone for monitoring (as a sentry well), the Simulprobe™ sampler was used with resonant sonic drilling. Grab groundwater samples were then collected from the two water-bearing zones directly underlying the shallow groundwater.

The first, deeper water-bearing zone was identified at 47 feet bgs. Grab groundwater samples were successfully collected from this zone using the

Simulprobe™. Because naphthalene-like odors were detected in the field from this groundwater zone, the Simulprobe™ was advanced to the next deeper water-bearing zone, identified at 97 feet bgs. Flowing sands encountered at this depth combined with the vibrations from the resonant sonic drilling jammed the sampler and prevented collection of a grab groundwater sample. Use of the Simulprobe™ is not recommended with a resonant sonic drilling rig or where flowing sands are present.

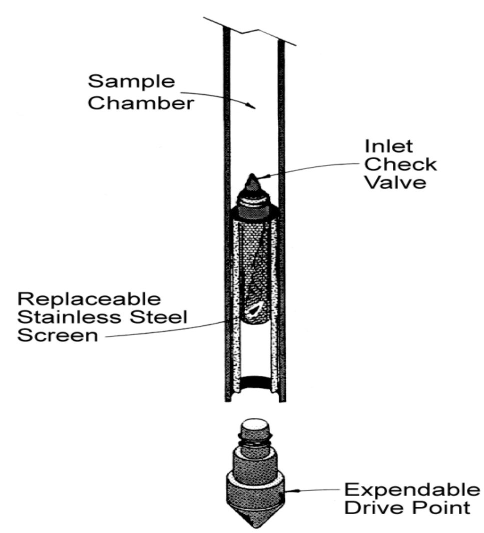
4.2.1.4 Hydropunch™

Tool Description

The Hydropunch™ is a direct-push tool for collecting a depth-discrete groundwater sample inside a boring without installing a well. The Hydropunch™ has been successfully used for collecting grab groundwater samples at former MGP sites to quickly delineate the extent of a groundwater plume without well installation or to quickly determine the best location or depth for screening a monitoring well.

The Hydropunch™ sampler is advanced with a hammer-driven tool to collect a groundwater sample from a particular depth. The sampler is pushed to the proper groundwater sampling zone and then withdrawn to expose an inlet screen. The screened interval is approximately 3 to 5 feet long. Groundwater can be collected from multiple depths within a single borehole although the tool must be withdrawn between samples. The following figure is a schematic diagram of the Hydropunch™ sampler.

Operational Considerations



The key factor affecting the accuracy of groundwater analytical results collected via the Hydropunch™ sampler is the turbidity of the grab sample. Because the sample is collected from a borehole instead of a developed well, the sample may be turbid. If the sample is not filtered before laboratory analysis, hydrophobic chemicals (such as PAHs and metals) sorbed onto the suspended sediments may cause erroneously high concentrations. In addition, the Hydropunch™ sampler limits the sample volume collected per push, so this tool is best used in a permeable zone where there is reasonable recharge into an area 3 to 5 inches thick. It is possible to attach a peristaltic pump to the Hydropunch™ sampler to pump larger volumes of samples if volatilization is not an issue. Finally, as with any single-tube direct-push probe or sampler, there is a potential for cross-contamination between groundwater zones. However this concern can be mitigated by using conductor casings. Floating-layer hydrocarbons may be sampled with a small-diameter bailer lowered through the push rods in one of the Hydropunch™ tools.

Applications and Cost

The Hydropunch™ sampler is a fast and inexpensive method for collecting a groundwater sample without installing a well. The Hydropunch™ is well understood and provides reliable results.

The cost of a Hydropunch™ sampler is approximately $150 per day, in addition to the drilling rig and associated equipment.

Benefits

- Provides reliable data
- Field tested and proven

Limitations

- Data subject to interference from turbidity
- Potential for cross-contamination if sampler is driven across hydrostratigraphic zones

Case Study

Stockton Former MGP Site

Grab groundwater sampling at the Stockton former MGP site was performed using the Hydropunch™ sampling tool for field screening to determine monitoring well locations at the edge of the plume. Samples were collected from two depths and sent to a laboratory for rapid analyses. Sample results were used successfully to determine whether the proposed well locations were at the edge of the groundwater plume (analytical results showed no detectable levels of contamination). Alternate well locations were identified when the Hydropunch™ samples showed detectable levels of contaminants.

4.2.1.5 Waterloo Profiler

Tool Description

The Waterloo Profiler (patent pending) is a groundwater sampling tool designed to collect depth-discrete groundwater samples in a single borehole with one probe entry. The Profiler consists of a tip containing multiple screened ports located around it. The Profiler tip is connected to 3-foot lengths of heavy-duty threaded steel pipe that extends to the ground surface. The Profiler is advanced by pushing, pounding, or vibrating the steel pipe into the ground using one of Precision Sampling, Inc.’s custom-made sampling rigs. Groundwater samples are conveyed to the surface via small-diameter tubing that is attached to a fitting inside the Profiler tip. The internal tubing, made of stainless steel or Teflon, passes up through the inside of the pipes to a pump and sample collection station located at the ground surface (Precision Sampling, 1998). Chemical concentrations in highly stratified formations can vary by several orders of magnitude over vertical distances of 1 foot. One significant advantage of the Waterloo Profiler is its ability to vertically profile contaminants in microstratigraphy without having to withdraw and reinsert the probe. This minimizes cross-contamination and the need for frequent tool decontamination between sample collection. The Profiler can be pushed through clay and silt beds without plugging, which makes vertical profiling easy.

Operational Considerations

Sampling with the Waterloo Profiler, as with similar tools, is limited by the depth to which the tool can be driven. Other geologic conditions, such as fine-grained sediments, also limit the tool's effectiveness and range.

Sample collection with the Waterloo Profiler is the most time-consuming part of sampling operations. Sample collection can vary from 10 minutes per sample in coarse-grained sand and gravel to 30 minutes in fine- to medium-grained sand. Groundwater sampling with the Waterloo Profiler is not recommended for lithology with sediments finer than fine-grained sands because of the lengthy sampling time required.

Applications and Cost

The Waterloo Profiler is a useful tool for rapid vertical profiling of hydrostratigraphy down to a maximum of 100 feet bgs. (Actual maximum depth is dependent on site-specific conditions and is typically shallower than 100 feet). The tool allows for delineation of contaminants in highly stratified formations where microstratigraphy plays a significant role in contaminant migration.

The cost of the Waterloo Profiler plus direct-push rig adds approximately $1,600 per day to total sample collection costs. Sampling depth and frequency, site hydrostratigraphy, and buried obstructions can have significant impact on the tool's effectiveness.

Reference: Precision Sampling, Inc.

Benefits

- Allows multiple depth-discrete groundwater sampling in a single borehole (i.e., sampler does not have to be withdrawn between samples)
- Less prone to cross-contamination than multiple pushes with conventional push sampler

- Can be used with field instruments to screen for volatile organic compounds while pushing
- Field tested and proven
- Allows for delineation of contaminant pathways in microstratigraphy

Limitations

- Profiler available only through a limited number of vendors
- Limited by depth to which the sampler can be pushed / driven
- Shallow groundwater sampling via peristaltic suction-lift pump may cause volatilization of some contaminants during sampling
- Groundwater sample collection recommended only for fine-grain sands and coarser materials

4.2.1.6 Multi-Level Groundwater Samplers

Multi-level groundwater samplers are used to collect groundwater samples at multiple, discrete levels within a single monitoring well. These types of groundwater samplers are equivalent to a series of nested monitoring wells but require only one casing in a single borehole.

The tools discussed below include several types of multi-level groundwater samplers:

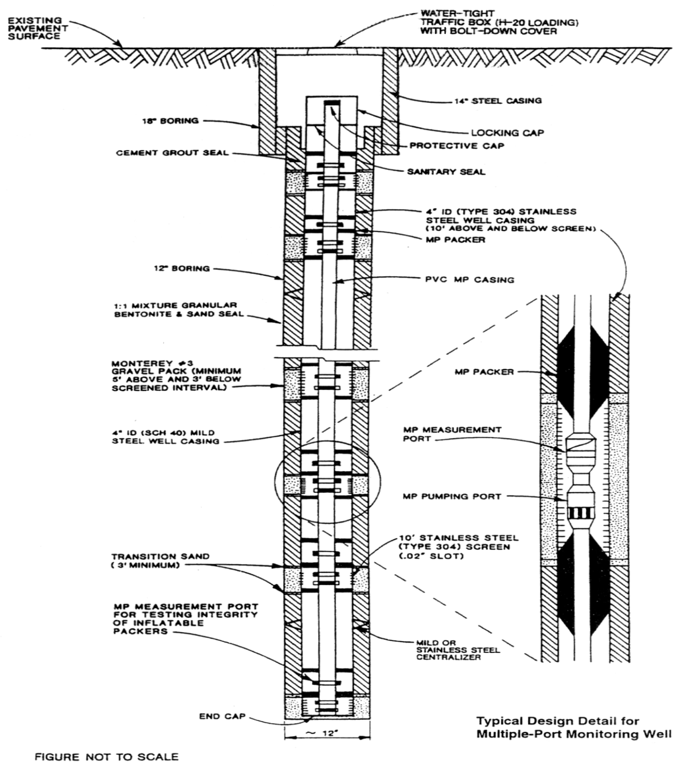
- Westbay System
- Waterloo System
- Diffusion Multi-Layer Sampler (DMLS)

4.2.1.6.1 Westbay System

Tool Description

The Westbay System is a fixed, multi-level sampler built for installation in a multi-port monitoring well. It is designed to collect groundwater samples and hydraulic head measurements at multiple, discrete levels in a single monitoring well. Multi-port monitoring wells are like a series of nested monitoring wells but require only one casing in a single borehole. The Westbay System incorporates valved couplings, casings, and permanently inflated packers into a single instrumentation string that is installed inside a cased borehole with multiple screened intervals, allowing multi-level groundwater monitoring for a fraction of the installation cost of nested monitoring wells.

The following figure shows the typical design detail for a Westbay System multi-port monitoring well.



Typical Design Detail for Multiple-Port Monitoring Well

Operational Considerations

Westbay System multi-port monitoring systems are complex and require trained technicians to install. Monitoring wells must be designed specifically to conform with the Westbay System requirements. Field quality control procedures enable verification of the quality of the well installation and operation of the testing and sampling equipment.

Groundwater samples from Westbay monitoring wells are collected without repeated purging. In addition, Westbay is currently developing instruments to enable the use of in situ sensors to monitor various chemical parameters.

Applications and Cost

The Westbay System is useful for MGP sites where multiple groundwater zones exist and discrete monitoring of multiple screened zones is required.

One of the primary cost savings with the Westbay System is that several discrete groundwater zones can be sampled by installing only one well. Fewer boreholes mean lower drilling costs, a shorter project schedule, and less IDW (e.g., drill cuttings and fluid). This can result in substantial savings in waste management, site access approval, noise abatement, and project management. In addition, fluid samples are collected from the Westbay monitoring wells without repeated purging (the groundwater in each zone is not in contact with the atmosphere), which can lead to significant cost reductions at sites where purge water must be stored, transported, and treated before disposal. The cost of installing a Westbay System is approximately $30,000 for a five-level system that can range from 50 to 200 feet in depth. The price does not include the cost of installing the monitoring well and does not include sample collection or analysis.

Benefits

- Reduces the amount of drilling

- Provides reliable data
- Field tested and proven

Limitations

- Mechanically complex
- Requires well construction to specific Westbay specifications
- Not portable between wells

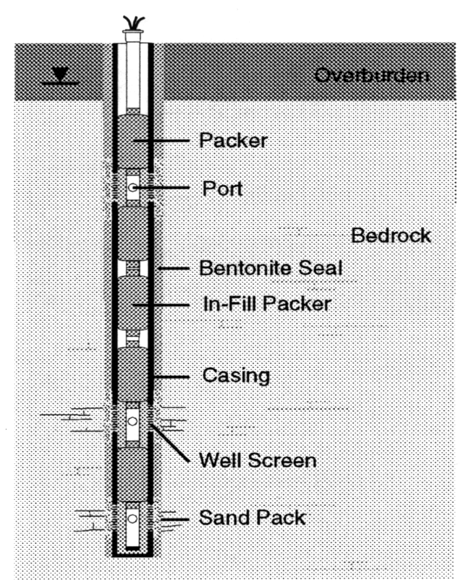
4.2.1.6.2 Waterloo System

Tool Description

The Waterloo System is used to obtain groundwater samples, hydraulic head measurements, and permeability measurements from multiple isolated zones in a single monitoring well. The Waterloo System uses modular components held firmly together to form a sealed casing string composed of casing, packers, ports, a base plug, and a surface manifold. Monitoring ports are isolated by packers at each desired monitoring zone and are individually connected to the surface manifold with narrow-diameter tubing. Formation water enters the port, passes into the stem, and rises to its static level in the monitoring tube attached to the stem. A sampling pump or pressure transducer may be dedicated to each monitoring zone by attachment to the port stem, or the monitoring tubes may be left open to allow sampling and hydraulic head measurements with portable equipment. A section of the sampler is shown in the following figure.

Operational Considerations

A typical Waterloo System can be installed in a few hours by one trained technician and an assistant. Purge volumes are small, and dedicated pumps for all zones can be purged simultaneously. Because the groundwater in each zone is not in contact with the atmosphere, formation water may be sampled without repeated purging. The Waterloo System may be used in hollow-stem augers, temporary casing, or cased and screened wells.



Permanent or Removeable Packers
in Casing or Well Screen

Applications and Cost

The Waterloo System is useful for MGP sites with multiple groundwater zones when discrete monitoring of the zones is required. Project costs may be reduced by limiting the number of wells installed and maximizing the number of groundwater zones sampled. The purge volumes necessary for groundwater sampling using the Waterloo System are likely to be smaller than those from conventional nested monitoring wells.

The cost of installing the Waterloo System is approximately $25,000 for a five-level system that can range from 50 to 200 feet in depth. This price does not include the costs of monitoring well installation or sample collection or analysis.

Benefits

- Reduces the number of wells needed for multiple-zone monitoring
- Reduces purge volumes and may reduce time required for purging/sampling relative to conventional monitoring well requirements
- Provides reliable data
- Removable or permanent systems available

Limitations

- Mechanically complex
- Specially ordered materials necessary
- Removable packer system sometimes difficult to cost-effectively reuse
- Requires trained technician for installation

Contact

Solinst Canada Ltd., (800) 661-2023, www.solinst.com

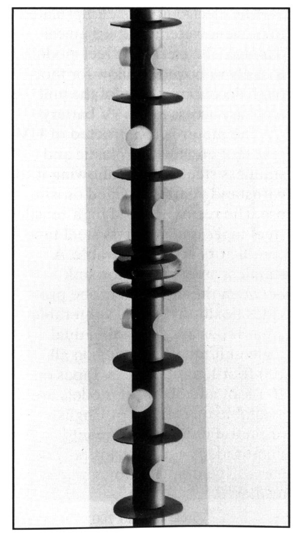
4.2.1.6.3 Diffusion Multi-Layer Sampler (DMLS™)

Tool Description

DMLS ™ is portable, multi-layer device that can collect groundwater samples at multiple intervals in the same monitoring well. The DMLS ™ uses dialysis cells separated by seals that fit the inner diameter of the well. This arrangement allows natural diffusion of groundwater into the unit at different elevations. Once the DMLS ™ is lowered into either an open rock borehole or a groundwater monitoring well with a long screen, the dialysis cells are exposed to water in the borehole and natural diffusion gradients permit external formation water to reach equilibrium with the water in the dialysis cells. The water flowing from the formation into the stratified dialysis cells is separated by seals; therefore, each dialysis cell contains a groundwater sample from a different layer.

The basic unit of the DMLS ™ is a 5-foot-long polyvinyl chloride (PVC) rod with a variable number of dialysis cells and nylon membranes separated from each other by seals. A string of up to five rods can be formed. Vertical layers of groundwater as narrow as 3 inches can be segregated and sampled. The rods fit into 2-inch-diameter and larger wells.

The following figure shows the typical design detail for a DMLS ™ multi-level groundwater sampler.



Operational Considerations

Once the DMLS™ is lowered into a well, it should remain undisturbed for 7 to 10 days to allow stratification of the water flowing from the formation. Once stratification of the formation water is complete and the water in the sampling cells is representative of ambient conditions, the rods are pulled to the surface and the sampling cells are removed and sent to a laboratory for analysis. The sampling cells in the rods can then be replaced, and the process can be repeated. The DMLS™ may be left in the water for periods of time that conform to individual sampling schedules. For example,DMLS™ sampling cells may be collected and replaced every three months.

Because the DMLS™ relies on natural groundwater diffusion principles, no purging is required. The DMLS™ does not permit head measurements.

Applications and Cost

The DMLS™ is useful for MGP sites where monitoring wells have long screens and a vertical characterization of the screened aquifer is desired.

The DMLS™ reduces costs because several vertical groundwater zones can be sampled by installing only one well. Having fewer boreholes reduces drilling costs, shortens project schedules, and produces less secondary waste (e.g., drill cuttings and fluid). The result is substantial cost savings in waste management, site access approval, noise abatement, and project management. Groundwater samples are collected from DMLS™ monitoring wells without repeated purging (the groundwater in each zone is in direct contact with the formation water), which can significantly reduce costs at sites where purge water must be stored, transported, and treated before disposal.

The cost of the DMLS™ is approximately $3,000 for a 10-foot-long unit. The price does not include labor costs for installing the DMLS™ rods, nor does it include costs for sample collection or analysis.

Benefits

- Allows vertical characterization of groundwater in a single borehole or well
- Requires minimal training for installation
- Requires no purging

Limitations

- Not widely used

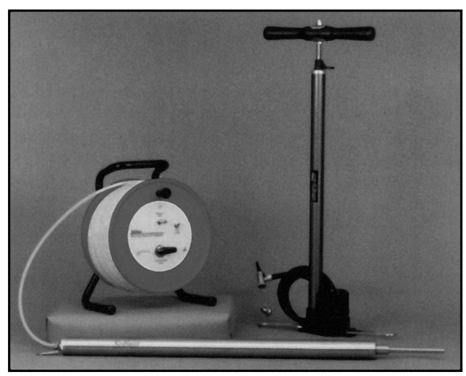
- Does not permit head measurements
- May not be appropriate for zones with strong vertical gradients

4.2.1.7 Discrete Point Samplers

Tool Description

Floating product layers (e.g., LNAPL) or sinking product layers (e.g., DNAPL) may cause stratification of contaminant concentrations in groundwater. Discrete point samplers are used to represent groundwater at distinct elevations or points of inflow in either open boreholes or screened wells. Discrete point samplers are designed to minimize disturbance and/or mixing that would be caused by pumping and purging water from different zones.

Several tools are available that have been designed to collect groundwater samples at discrete points in either open boreholes or in screened wells. Solinst Canada, Ltd., manufactures a number of samplers designed for use in wells screened over multiple water-bearing zones. Two examples are the Model 429 Point Source Bailer and the Model 425 Discrete Interval Sampler. The Model 429 Point Source is a stainless steel bailer with dual ball valves that prevent the mixing of water from multiple depths during retrieval of a sample from a specific depth. The Solinst Model 425 Discrete Interval sampler (shown in the figure below) is a stainless steel sampler connected by tubing that is pressurized before the device is lowered into a well; pressurization prevents water from entering the sampler until the sampling zone is reached. When the desired sampling depth is reached, pressure is released, and hydrostatic pressure fills the sampler and tubing with water directly from the sampling zone. When the sampler is filled, it is repressurized and raised to the surface; the sample is decanted using the sample release device provided, which avoids degassing of the sample (Solinst, 1998).



Solinst also manufactures a Triple Tube Sampler that uses a narrow-diameter pump and packer assembly to seal off a discrete interval in groundwater. A nitrogen-inflated packer is placed just above the desired sampling point within the sampling tube. The packer seals against the walls of the sampling tube and isolates the formation water standing in the tube. A second nitrogen line applies pressure down the sampling tube. The water is pushed to the surface through the coaxial tubing. The cycle is repeated until purging and sampling are complete.

The Solinst Triple Tube Sampler is similar to the Waterloo Profiler multi-level groundwater sampler discussed in Section 4.2.1.5 except that the Solinst sampler is designed to sample from wells whereas the Waterloo Profiler is a direct-push sampler designed to collect grab groundwater samples without boreholes or wells (Solinst, 1998).

Operational Considerations

The Solinst Model 429 Point Source Bailer and the Solinst Model 425 Discrete Interval Sampler do not require or allow purging prior to sampling. It is assumed that a sample collected at a discrete depth is representative of the formation water flowing through the well at that depth. The Solinst Triple Tube Sampler does permit purging of the discrete interval being sampled.

Applications and Cost

Discrete point samplers are useful for field scenarios where heterogeneities exist in the vertical distribution of contaminant concentrations in groundwater in an open borehole or screened well.

The purchase costs for Solinst Model 429 Point Source Bailer, Solinst Model 425 Discrete Interval Sampler, and the Solinst Triple Tube Sampler are approximately $150, $675, and $2,000, respectively.

Benefits

- Permits groundwater sampling from a discrete vertical point in a well or borehole
- Minimizes mixing of water from different levels during sample collection
- Fits in small-diameter wells/boreholes
- Is portable (the Triple Tube Sampler may be dedicated)
- Solinst Triple Tube Sampler is usable for purging in addition to sampling

Limitations

- May require limited training to operate equipment (especially the Triple Tube Sampler)
- May be difficult to obtain a complete seal with the Solinst Triple Tube Sampler

Contact

Solinst Canada Ltd., (800) 661-2023, www.solinst.com

4.2.2 Analytical Field Screening

Field screening tools allow practitioners to detect the presence and determine the estimated concentrations of chemical constituents in the field. As noted above, combining these tools with direct-push grab sampling techniques allows rapid and cost-effective preliminary screening of former MGP sites by pinpointing areas of contamination that require further, focused field investigations. Once these areas are identified, field screening tools can be used to gather further data so that remediation alternatives can be evaluated. In some cases, the tools can also be used to gather confirmatory data during remediation.

Tools included in this category are:

- Laser Induced Fluorescence (LIF) (such as ROST™)
- X-ray fluorescence (XRF) (such as the Spectrace 9000, SEFA-P, or X-MET 880)
- Colorimetric testing (such as Hach Kits, Draeger Tubes, Sensidyne, Handby Kits, PetroSense™, and PetroFLAG™)
- Immunoassay testing (such as Strategic Diagnostics)
- Portable laboratories

4.2.2.1 Rapid Optical Screening Tool (ROST™)

Tool Description

The ROST™ is a sampling and screening technology used to field screen for petroleum hydrocarbons and other contaminants. Like its military sister, the SCAPS, ROST™ is designed to offer a suite of CPT tools on a single platform. Using fiber-optic technology with LIF, ROST™ provides rapid, real-time, in situ delineation of subsurface petroleum hydrocarbon contamination down to depths of 150 feet.

The ROST™ consists of a sensor-tipped, hydraulically advanced, penetrometer probe with a self-contained data collection and analysis system housed within a CPT truck. Additional probes incorporate video imaging technology and soil moisture measurements while the latest CPT sampling devices allow for the collection of soil, water, or gas samples with analytical confirmation or other measurements. A diagram of ROST™/SCAPS is shown in the figure on the following page.

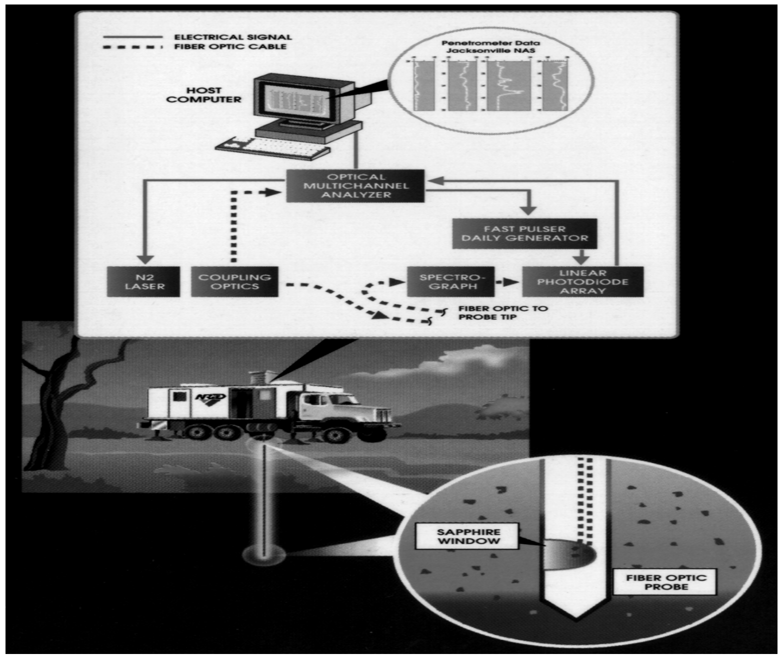
Operational Considerations

Operational considerations with ROST™ sampling technology are similar to those of cone penetrometers. Depths are limited to 100 to 150 feet bgs in normally consolidated soils, shallower in coarser materials. The ROST™ sampling technology does not produce soil cuttings and can provide real-time, in situ field screening for petroleum hydrocarbons. The ROST™ can also detect small deviations in concentrations, thereby making it useful in mapping areas with significant subsurface structures/materials. Microwells can also be installed using this tool.

Applications and Cost

The ROST™ sampling technology is useful for field surveys and initial characterization of sites, and for post-remediation confirmation for petroleum hydrocarbons. The system is limited to the depths of the CPT and by the sensors currently available.

ROST™ costs approximately $4,000 to $4,500 per day with production up to 300 feet (around 10 pushes) per day.



Benefits

- Provides rapid, real-time geology and hydrocarbon data
- Can be used to converge on an area of interest
- Works for both fuel (aromatic) hydrocarbons and PAHs
- Generates little waste during testing/sampling
- Verified by USEPA and certified by California EPA

Limitations

- Limited availability (only two commercial licenses currently held)
- Limited to unconsolidated geology (same as CPT)
- Only relative concentration data provided

Case Study

North Cavalcade Superfund Site, Houston Texas

The North Cavalcade Street Superfund Site is a former wood treating facility, located in northeastern Houston, Texas. The site encompasses approximately 21 acres, and was used for treating wood from 1946 to 1964. Initially, creosote was employed as the primary wood preservative, but later operations also included