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Report to the Secretary of Energy

August 1994

DEPARTMENT OF ENERGY

Management Changes Needed to Expand Use of Innovative Cleanup Technologies

GAO/RCED-94-205

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-257190

August 10, 1994

The Honorable Hazel R. O'Leary
The Secretary of Energy

Dear Madam Secretary:

The Department of Energy (DOE) faces the major challenge of cleaning up the waste generated by more than four decades of nuclear weapons production. The methods currently available to clean up contamination, however, are often ineffective and extremely expensive, as reflected by the agency's recent estimates that environmental cleanup could cost as much as $300 billion over a 30-year period. Developing less costly and more effective cleanup technologies may be the only way the nation can afford to clean up the vast amounts of waste generated by the nation's nuclear weapons production complex.

Our objective in this review was to evaluate the internal and external barriers that are inhibiting the use of new and innovative technologies in environmental cleanup. This report is one of a series of reports that we are issuing as part of our general management review of DOE.

Results in Brief

Although DOE has spent a substantial amount to develop waste cleanup technology, little new technology finds its way into the agency's cleanup actions. Even where new technology has been successfully demonstrated, agency officials are reluctant to try new approaches, tending instead to choose conventional techniques to clean up their facilities. As a result, opportunities for more effective cleanup solutions may be missed.

DOE's technology problems began by not having a well-coordinated and fully integrated technology development program. The agency's technology needs have neither been comprehensively identified to allow prudent research decisions, nor have various environmental program offices in headquarters and in the field worked together effectively to identify and evaluate all of the possible technology solutions available. Furthermore, internal decision-making processes have prevented a full discussion of the opportunities for new and promising technologies to find their way into cleanup actions.

DOE recognizes these obstacles to technology acceptance and is taking several actions. For example, a plan for restructuring technology

development programs was approved in January 1994. This plan is currently being implemented at headquarters and the field. In addition, field officials have been instructed to more seriously consider new and improved technology. DOE is also working with regulators to achieve greater acceptance of new and innovative technology. While these are welcome changes, it remains to be seen whether the agency's strategy will ensure that all parties are involved in decisions affecting whether new technologies are used to clean up contaminated sites.

Background

DOE faces an enormous and expensive environmental challenge. Over the last 40 years, DOE and its predecessor agencies disposed of more than 1 billion cubic feet of hazardous and/or radioactive waste at weapons production facilities around the country. Since little was understood about the types of waste generated and their effect on the environment, the waste was often stored in drums or cribs or poured directly into the soil—techniques that would not be acceptable by today's standards. Over time, many of the original containers have deteriorated. At such disposal sites, liquid effluents can seep down into the soil and ultimately reach the groundwater. As a result of earlier disposal practices, soil and groundwater contamination is now widespread. Over 5,700 individual contaminated "plumes" have been identified on DOE lands.[1]

To address technology issues, in 1989 DOE established the Office of Technology Development (OTD) within the Office of Environmental Restoration and Waste Management.[2] OTD is responsible for managing a national program to support the technology needs of other environmental program offices. OTD accomplishes its mission by funding a variety of projects to demonstrate the potential of new and improved approaches to cleanup problems. OTD's goal is to ensure that the technology is developed to the stage where it can be commercialized and, thus, available in the private sector. OTD is charged with identifying technologies with DOE-wide potential and has demonstrations under way using such advanced technologies as ground-penetrating radar and bioremediation. (See app. I for more details on these and other new techniques.) For fiscal year 1993, OTD spent $380 million, and the office has spent about $600 million since its creation in 1989.[3]

[1]Plumes are mobile columns of contaminants that are dispersed in soils and groundwater.

[2]In 1994 this office was renamed the Office of Environmental Management.

[3]This figure represents expenditures from 1989 through 1993.

OTD supports the offices of Waste Management and Environmental Restoration within the Office of Environmental Management, which in turn work with DOE field offices, contractors, the states, and the Environmental Protection Agency (EPA) to identify and select the most appropriate technology to apply to a given situation.[4] DOE has entered into enforceable agreements with EPA and the states, thereby committing the agency to milestones for completing cleanup work at each site.[5] In support of the agreements, DOE evaluates a variety of cleanup technologies and recommends the preferred alternative to the regulator (EPA and/or the state). The regulator, in turn, is responsible for approving the technology that will be used to clean up the site. Whether a milestone can be achieved is often dependent on the technology selected for use at a particular site.

Innovative Technology Is Not Being Used to Clean Up Contaminated Sites

The need for improved technologies to clean up contaminated sites is widely recognized by DOE and its stakeholders, which include EPA, the states, and the public. Although OTD and others have conducted several demonstration projects to show the effectiveness of innovative cleanup approaches, new technologies are not being seriously considered or used to clean up DOE's contaminated sites.

DOE has received about $23 billion for environmental management since 1989, yet little cleanup has resulted.[6] Experts agree that many cleanup technologies currently in use are extremely costly and offer only short-term solutions. For example, one of the most commonly used methods for treating contaminant plumes—pump-and-treat—does not remove the contamination source, thus failing as a permanent solution.[7] Furthermore, current technologies to treat waste contaminated by both hazardous and radioactive material—mixed waste—need significant improvement. The vast majority of the agency's waste is mixed waste.[8] DOE

[4]OTD also supports the Office of Facility Transition and Management, which was created in 1992. We concentrated our work on the offices of Environmental Restoration and Waste Management.

[5]We are preparing a report on DOE's overall management of its cleanup program, focusing in particular on the influence of current agreements on cleanup progress.

[6]Only about 10 percent of DOE's contaminated sites have been cleaned or closed.

[7]Pump-and-treat alone is currently used in 22 separate DOE restoration projects and is expected to cost more than $500 million over the life of the projects.

[8]In 1993, DOE estimated that 50 sites in 22 states store about 600,000 cubic meters of such wastes. Over the next 5 years, the agency could generate an additional 920,000 cubic meters of mixed wastes.

recently reported to the Congress that treatment technologies need to be modified for two-thirds of these identified mixed wastes.[9]

DOE's own technology program summary states the technology challenge this way:

"...the development of new technology presents the best hope for ensuring a substantive reduction in risk to the environment and improved worker/public safety within realistic financial constraints."

Using cleanup technology that is faster, cheaper, and safer than conventional approaches is growing in importance. Over the next few years, agreements that DOE has signed require accelerated progress in cleaning up its vast number of contaminated sites. Given the leadtime from proposing solutions to applying them at a given site, DOE is entering a narrow "window" of time in which technical solutions for cleaning up sites must be evaluated and applied.

Many Barriers Limit Use of New and Innovative Technology

The process of choosing a technology for cleanup involves many decisionmakers, requires technical expertise, and is complicated by many stakeholders' competing interests. The pressure to meet agreement milestones also influences the technology evaluation process at a given location—DOE is under pressure to work quickly toward solutions.

We found that new technologies are not being seriously considered or used to clean up DOE's contaminated sites. Senior headquarters environmental officials told us that new technologies have not been rigorously evaluated, much less employed by DOE. On the basis of our discussions with headquarters managers, local officials at two of DOE's largest contaminated sites (the Hanford Site near Richland, Washington, and the Savannah River Site in Aiken, South Carolina), and our analysis of studies, we found that the reluctance to consider newer technology has several basic causes.

- Local officials fear that using new technology may lead to missing milestones should the technology fail. DOE is under pressure to meet its scheduled milestones. DOE is already missing some of its milestones and anticipates more slippages in the future, as the pace of milestones due accelerates over the next few years.

[9]Testimony before the House Armed Services Committee (Apr. 1993).

- Conflicting priorities among stakeholders tend to prevent the approval of innovative approaches for site cleanup. For example, local governments may place a high priority on economic development and job creation and view faster cleanup as a threat to local economies. The public is primarily concerned about risks associated with the cleanup process. As a result, each stakeholder may view the value of an innovative approach differently. Accordingly, DOE must balance the interests of these diverse stakeholder groups, a difficult challenge.
- Field officials, as well as local stakeholders, may not be familiar with newer technologies that could apply to their locations, and thus may associate the newer technologies with an unacceptable level of risk.
- Field officials also often rely on recommendations from on-site contractors who may favor particular technologies on the basis of their own experiences and investments. DOE has long been criticized for its extensive reliance on contractors for technical decisions.

DOE's own studies, and those performed by other organizations, cite similar reasons why innovative technologies are not being applied at contaminated sites. For example, a spokesperson for the Western Governors' Association recently commented that effective and rapid cleanup of federal sites is hampered by a system that relies on traditional technologies selected by "risk averse" cleanup managers, who have no incentive to innovate. The official explained that there is a need to reduce the uncertainty surrounding the performance and cost of innovative technologies.[10]

We previously reported similar barriers inhibiting the development and use of innovative technologies in EPA's technology program. Among other factors, we reported that the lack of reliable information on innovative technologies has led government officials, private contractors, and investors to avoid the possible risks associated with innovative technologies.[11]

Our discussions with EPA regional staffs and state regulators indicate some hesitancy to approve innovative technologies. Regulators are sometimes reluctant to appear lenient with DOE, recognizing that their actions are closely watched by the public. Public frustration often results when regulators allow DOE to miss cleanup milestones. However, regulators also

[10]Comments by the Executive Director, Western Governors' Association, for the Industry Commercialization Roundtable (Aug. 1993).

[11]Superfund: EPA Needs to Better Focus Cleanup Technology Development (GAO/T-RCED-93-94, Apr. 28, 1993).

note that their hesitancy is not as widespread as perceived by DOE field officials and point to several regulatory options that would allow the agency to use innovative technologies in combination with conventional techniques. For example, EPA published a technology innovation strategy in January 1994 designed to stimulate the adoption of new technologies by strengthening the incentives for innovation and reducing barriers within the regulatory framework.[12]

Program Offices Not Working Together Effectively

DOE's internal program problems have also prevented the agency from maximizing its investments in technology development and implementation. Individual offices have not worked together as a well-coordinated and integrated unit to overcome the resistance to using improved technology, nor have offices worked together to develop a comprehensive assessment of technology needs.

Although OTD's mission is to manage a focused technology development program, other program offices within Environmental Management conduct their own projects, which often overlap and conflict with OTD's activities. For example, in 1993, in addition to the $380 million spent by OTD in 1993, the offices of Environmental Restoration and Waste Management spent almost $70 million and over $100 million, respectively, on technology development projects. When asked about these expenditures, headquarters managers explained that OTD develops technologies for problems that are common across the DOE complex, while program offices develop technologies that address problems that are specific to individual sites. However, our analysis of several hundred technology development activities throughout the environmental program offices revealed no clear distinctions between offices in the scope and objectives of projects. For example, descriptions of these activities that are funded because they apply to technology needs at a particular site frequently contain statements that the technologies being developed could be applied at other DOE sites. Thus, it is not at all clear that program offices are funding activities that OTD would not also fund.

DOE also does not have a comprehensive needs assessment from which technology development projects can be ranked and funded in the most effective way. Instead, the current technology-needs assessment process is highly fragmented. Program units have independently examined their technology development needs, and their studies are at various stages of

[12]Technology Innovation Strategy, EPA-543-K-93-002 (Jan. 1994).

completion. DOE field locations have also studied their own specific cleanup needs. For example:

- Although the Office of Environmental Restoration completed an initial description of its needs in 1991 (and updated it in Jan. 1993), OTD reported that these efforts do not provide the specificity needed to determine which technology needs are most pressing. We noted that the level of specific information on the problems at each site varied significantly. For example, the specific size, migration pattern, and contaminants within groundwater would be described in detail at one location, while the information provided at other locations would be described in very general terms such as "a source, a release mechanism, a receptor population, and toxic materials are present"—terms too broad to be useful to OTD.
- The Office of Waste Management has not provided OTD with a description of its needs. Waste Management officials told us that the early needs studies were too general to use. In response, Waste Management is currently conducting an in-depth, site-by-site examination of its current problems.
- DOE field locations are also studying their own specific cleanup needs at their particular sites. At both the Hanford and Savannah River sites, for example, field staff are using local laboratories to identify the kinds of technology that will be needed to clean up those sites.

OTD has also conducted its own needs assessment studies, in the absence of a comprehensive assessment from other program offices. As a result of not having an integrated assessment approach and strategy, OTD and program offices may not be developing the most appropriate technologies. In addition, DOE may be missing opportunities to maximize its funding choices to the areas of highest need or to identify problems that exist at several locations.

Flawed Decision-Making Process

Despite the crucial role technology plays in meeting the cleanup milestones specified in agreements, OTD's technical experts are not part of the decision-making process where technology choices for particular sites are made. For example, OTD does not have a role in negotiating agreements, the critical point in time when cleanup milestones are first established, although achieving these milestones is often dependent on the success of the particular technology used. In addition, OTD is not involved in decisions on potential technology options for the feasibility study phase

of cleanup.[13] Furthermore, OTD is not party to the final decision defining the technology that will be used to clean the site.[14] In the absence of OTD's involvement at such key decision points, the full range of technology choices is not likely to be completely discussed or evaluated.

DOE Has Begun to Address Its Problems

The Office of Environmental Management began restructuring its technology development program in January 1994. Several changes being implemented, as a result of this restructuring, should address many issues discussed in this report. For example, the technology development program activities of the Offices of Waste Management, Environmental Restoration, and Technology Development would be centrally managed and coordinated under the direction of OTD. To help ensure that technology development activities are focused on the most pressing needs, five priority "focus" areas for technology development have been designated. They are the

- high-level waste tank remediation;
- characterization, treatment, and disposal of mixed waste;
- cleanup of contaminant plumes;
- stabilization of landfills; and
- decommission and final disposition of DOE facilities.

The Office of Environmental Management has established management "teams" at headquarters to manage technology development activities. The Office of Environmental Management is also in the process of establishing implementation teams for each of the five areas to facilitate the use of innovative and improved technologies. Management team members include officials from the headquarters program offices—the users of the technology—as well as selected regulators, among others.

The external peer review process for technology development is being modified around the five focus areas. DOE is also establishing performance measures to evaluate the actual use of innovative and improved technologies at the sites. At the field level, where technology decisions are made, site coordination teams have been established to oversee local technology development activities. However, Environmental Management

[13]At the beginning of the feasibility study, field officials select the technologies that will be evaluated as potential cleanup solutions for the site. The study documents the strengths of each technology under consideration and the rationale for the selection of the technology.

[14]The final decision occurs during the development of the Record of Decision, which represents, among other things, EPA's formal approval of the technology that will be used to clean the site.

has not clarified how regulators and other stakeholders will be included in these groups.

Recognizing that new and innovative technologies were not being evaluated, DOE's Office of Environmental Restoration directed its field staff in a July 1993 policy statement to consider new and innovative technologies early in the process of deciding what actions to take at cleanup sites. The goal of this policy was to provide the opportunity for new technologies—as well as conventional ones—to be given equal consideration.

DOE is also expanding research outreach to help ensure that technology development activities among agencies are closely coordinated to maximize benefits and reduce costs. These activities include working with EPA, the Departments of Defense and Interior, and others.

Conclusions

DOE and technology experts recognize that more advanced technologies are needed to meet DOE's significant and costly cleanup problems. DOE's inability to transfer demonstrated technologies to cleanup sites underscores the coordination flaws in DOE's cleanup program. Barriers restrict the wider use of new and promising technologies to clean up defense plant wastes.

Although DOE's new strategy should help correct coordination problems and eliminate duplication and overlap in its technology development program, insufficient emphasis is given to ensuring that all parties—at the level where decisions are made—are knowledgeable about the strengths of the technological innovations being studied. Specifically, DOE has not clarified the roles that stakeholders will play on site teams, yet these are the groups that must ultimately approve the technology to be used at a particular location. Reconciling the many different priorities among local regulators and other stakeholders is crucial to gaining agreement on the best cleanup technology. DOE's July 1993 policy, while a step forward, does not ensure that new technology will actually be selected. Obtaining agreement on an innovative approach is particularly difficult when officials are unfamiliar with innovative approaches and technology experts are not fully involved in the decision-making.

While DOE's new approach to technology development encourages cooperation among Environmental Management's program offices, it does not ensure that field decisionmakers include new technologies in

agreements, preventing promising new techniques from being used to clean up sites—a stumbling block that places pressure on DOE to work more skillfully not only with its own staff, but also with federal and state regulators.

The strategy also does not directly link technology experts with field decisionmakers. OTD's technology staff are not formally involved in discussions of technological solutions to be used at the sites. OTD staff still do not have a role in negotiating/revising agreement milestones with regulators, although the ability to meet a milestone often depends on the technology being used.

Moreover, the strategy does not overcome contractors' resistance to recommending unfamiliar technology. DOE's strategy to commercialize technology results does not guarantee that new technologies are recognized or evaluated by a particular local staff or its on-site contractors.

Recommendations

To ensure that decisionmakers are aware of, and fully evaluate, innovative technologies to the maximum extent possible, we recommend that the Secretary of Energy direct the Assistant Secretary for Environmental Management to (1) fully involve regulators and other stakeholders in making decisions at the local level about the technology to be selected and (2) formally include OTD staff in the evaluation and selection of technologies to be used to clean up DOE sites. For example, OTD staff could be included in the feasibility study and discussions leading to the Record of Decision.

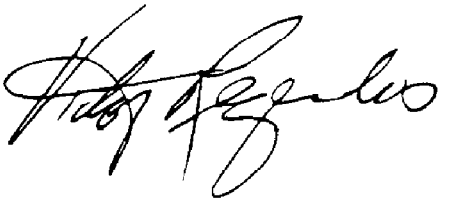
Agency Comments

We discussed a draft of this report with DOE's Assistant Secretary for Environmental Management, the Deputy Assistant Secretary for Technology Development, and staff from the Office of Environmental Restoration and the Office of Environment, Safety and Health. These officials agreed that the draft report accurately described the status of the technology development efforts but believed our report should recognize the progress that DOE has made in restructuring its technology development program. The officials provided updated information to make the report as current as possible; this information has been incorporated into the report where appropriate.

We are sending copies of this report to interested congressional committees and subcommittees and to the Director, Office of Management and Budget. We will also make copies available to others upon request.

If you or your staff have any questions about the information provided in this report, please contact me at (202) 512-3841. Major contributors to this report are listed in appendix III.

Sincerely yours,



Victor S. Rezendes
Director, Energy and Science Issues

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Figures

Abbreviations

DOE	Department of Energy
EPA	Environmental Protection Agency
GAO	General Accounting Office
MAWS	Minimum Additive Waste Stabilization Concept
OTD	Office of Technology Development
VOC	volatile organic compounds

Examples of Technologies Being Demonstrated

The Office of Technology Development (OTD) is responsible for developing new technologies and improving existing technologies to solve environmental management problems. Recognizing that some cleanup challenges, as well as regulatory commitments, cannot be addressed with currently available technologies and that many of these challenges are national in scope, OTD works with its customers—users of technologies—to develop those that have DOE-wide application. Furthermore, since many problems are not unique to the Department of Energy (DOE), OTD coordinates closely with industry, academia, and other agencies. Technologies are being developed to address various phases of cleanup—from characterization and monitoring to treatment and/or remediation—as a unified system.

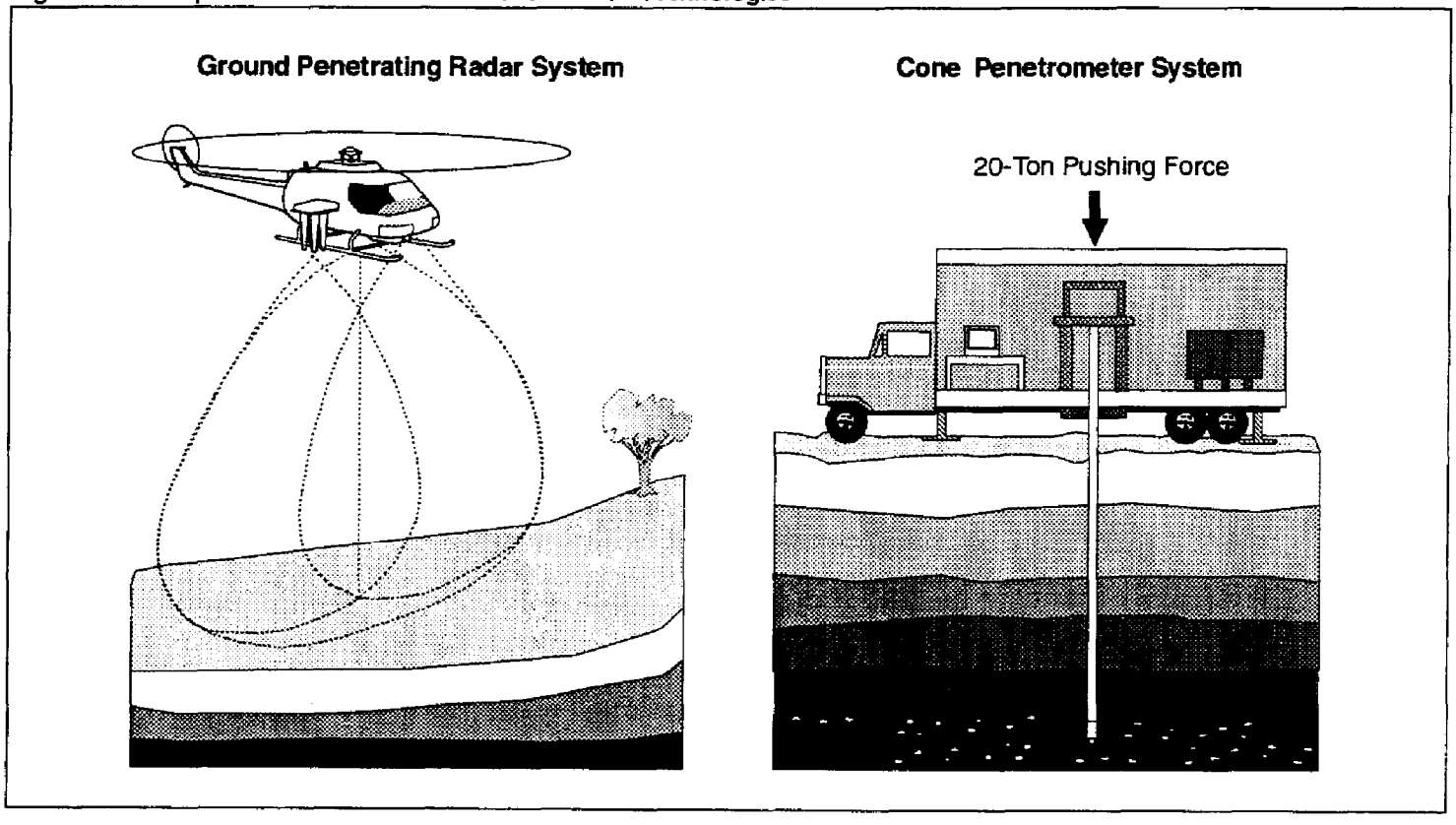
Characterization and Monitoring

DOE defines characterization as the key first step in environmental restoration activity and the area for the greatest potential cost savings to the agency. Currently, Environmental Management estimates that it spends between 40 and 50 percent of its budget on characterization activities. Characterization provides the basis for acquiring the necessary technical information to develop, screen, analyze, and select appropriate cleanup techniques. For example, precise knowledge of the geologic and hydrologic properties of the site must be available to accurately predict how contaminants will behave underground. Until recently, characterization often involved drilling numerous holes in the ground, obtaining samples, and sending the samples to laboratories for analysis. Traditional drilling techniques could introduce additional contamination and expose workers to significant health risks from handling the contaminated by-products.

Recent characterization technologies include ground-penetrating radar and the cone penetrometer, among others, as shown in figure I.1. Ground-penetrating radar is a nonintrusive technology,[15] capable of locating buried objects, such as drums or waste containers and generating two- and three-dimensional images of the buried objects. The cone penetrometer, is quicker and less expensive than conventional drilling and boring operations and can deploy many different state-of-the-art line sampling and instrument devices. Use of the penetrometer lessens potential contamination migration by sealing the hole as the probe is inserted and withdrawn.

[15]In this context, the term "nonintrusive" refers to a technology that does not require holes to be drilled or samples to be taken.

Figure I.1: Examples of Demonstrated Characterization Technologies



Source: Based on illustrations from DOE's Office of Environmental Management.

OTD is also demonstrating technologies that combine characterization of the contamination with monitoring of contamination movement. Innovative sensors, samplers, and real time analytical measuring devices provide information for evaluating and monitoring the effectiveness of ongoing cleanup activities. Examples of these technologies include the borehole sampler, SEAMIST membrane liner, and the mobile laboratory.

The borehole sampler is designed to determine contaminant concentrations vertically without installing multiple wells. The SEAMIST system is designed to collect information from specified depths. Results are used to test the feasibility of various contamination extraction techniques. The mobile field screening laboratory is capable of high-quality, same-day analysis of environmental samples. The laboratory

can be used to rapidly determine the optimal location and number of additional samples needed to describe the contaminants and their migration patterns.

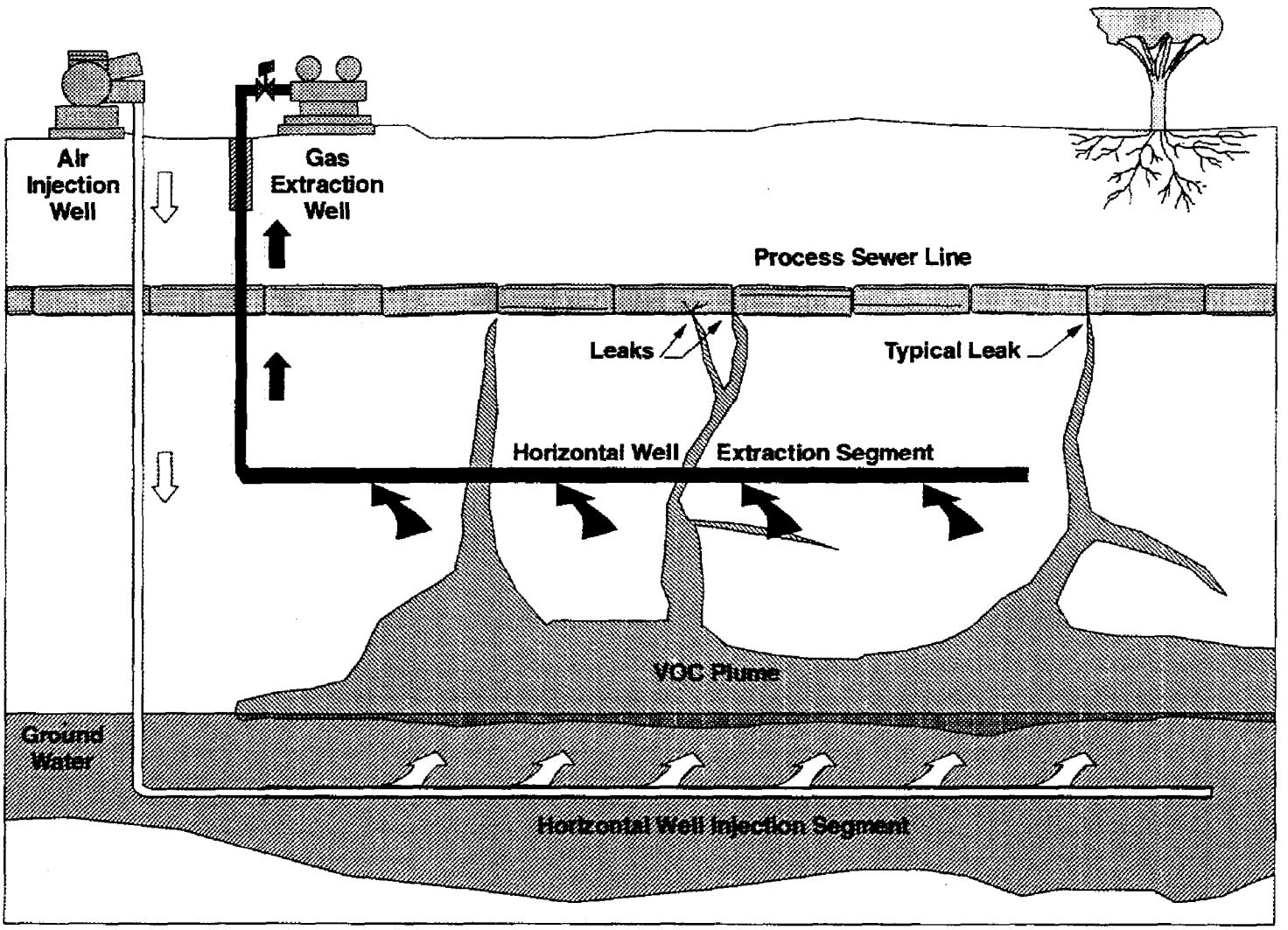
Treatment and Remediation

The technical goal of waste treatment is to process waste into a stable and safe physical form that can be stored or sent to permanent disposal. Conventional means for removal of contaminants include pumping the groundwater to the surface followed by air stripping with above-ground equipment; vacuum extraction of volatile subsurface contamination; or site excavation for physical removal of the contaminated materials. Treatment in place (or in situ), however, remediates subsurface contamination without bringing the contaminated soil or groundwater to the surface.

At two of the largest sites within the weapons complex, DOE is demonstrating several in place treatment techniques. Volatile chemical solvents, which are found throughout the complex, have been specifically addressed through several cleanup systems at the Savannah River Site.[16] For example, one system involves stripping the contaminants from the ground by injecting air into a horizontally drilled well, and then extracting the contaminant-air mixture through another horizontal well drilled above the injecting well. A second treatment technology to augment the system involves heating the ground from within the horizontal well to vaporize liquid contaminants, which can then be removed by air stripping. A third treatment method, bioremediation, involves adding a small amount of methane gas to the injected air, which encourages breakdown of the contaminants by the action of naturally occurring bacteria. Figure I.2 shows that at Savannah River these technologies are being applied to a plume of volatile organic compounds (VOC) that originated from a leaking sewer line.

[16]At Savannah River, degreasing solvents—volatile organic compounds—were used from the early 1950s through 1980. Over 3 million pounds of solvents were released into the subsurface at various outfalls, seepage basins, leaking sewer lines and tanks, and at various waste disposal sites. These VOC releases created both soil and groundwater contamination.

Figure I.2: Diagram of Technologies to Remediate VOCs at Savannah River

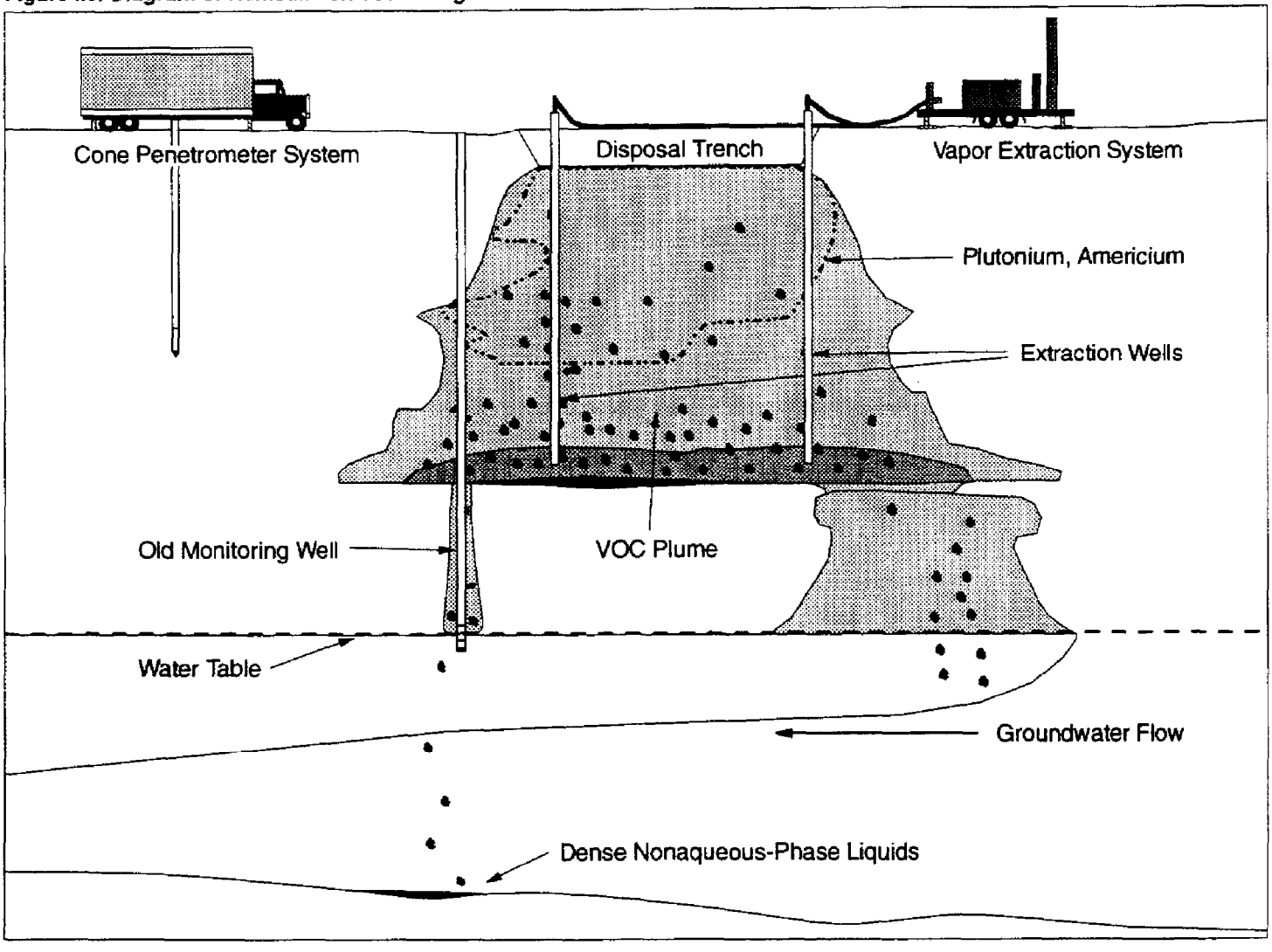


Source: Based on illustration from DOE's Office of Environmental Management.

At the Hanford site, similar in place treatment technologies will be used to address both soil and groundwater contamination. DOE also plans to test techniques to recover americium and plutonium in soil and uranium and chromium in groundwater. Figure I.3 shows some of the technologies

being used at the Hanford site to clean up both VOCs and other contaminants.[17]

Figure I.3: Diagram of Remediation Technologies at Hanford



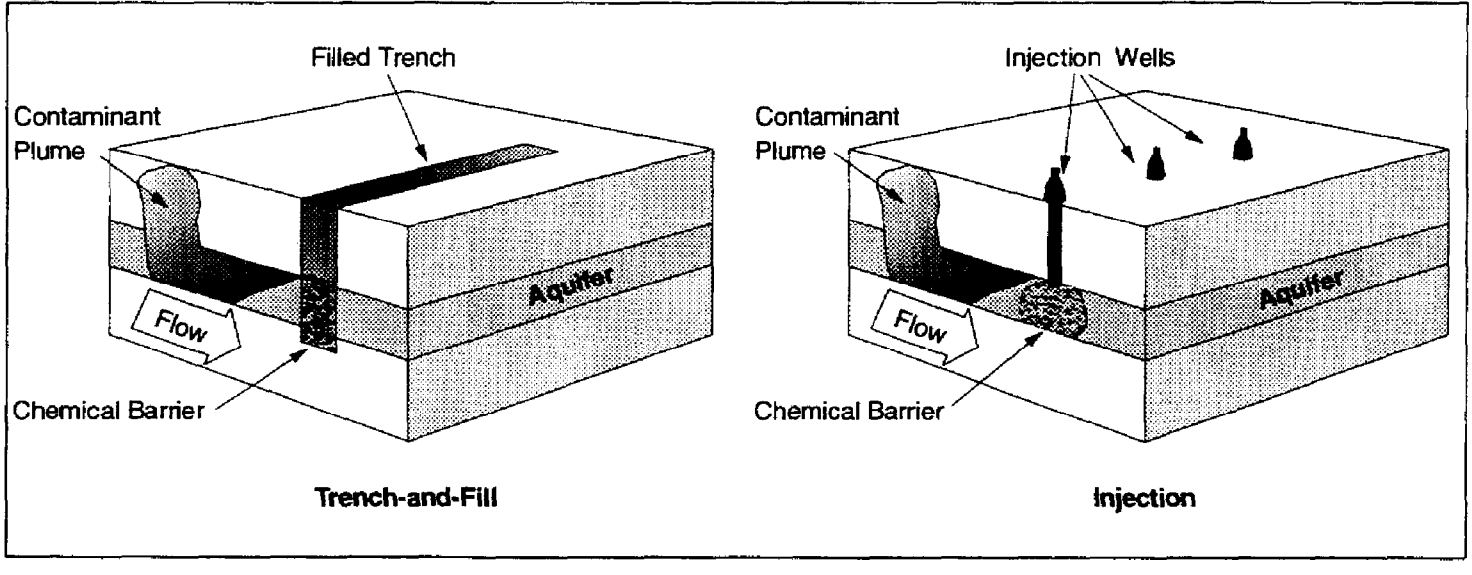
Source: GAO illustration based on DOE data.

[17]The location of the demonstration project at Hanford contains VOCs and other contaminants in both soils and groundwater. More than 580 metric tons of VOCs were disposed at the site between 1955 and 1973, resulting in extensive soil contamination and a plume that extends over 8 square miles.

To halt the flow of contaminated groundwater, Environmental Management plans to evaluate a number of different containment technologies, including flow-through or permeable barriers that strip the contaminants from groundwater, and chemical barriers that immobilize radioactive and mixed waste contaminants, among others. Chemical barriers, for example, are formed by putting chemicals into the subsurface. Groundwater passes through the barrier uninhibited, but dissolved contaminants remain within or near the barrier.

Two methods for constructing chemical barriers—trench-and-fill and injection—are shown in figure I.4.

Figure I.4: Examples of Chemical Barriers



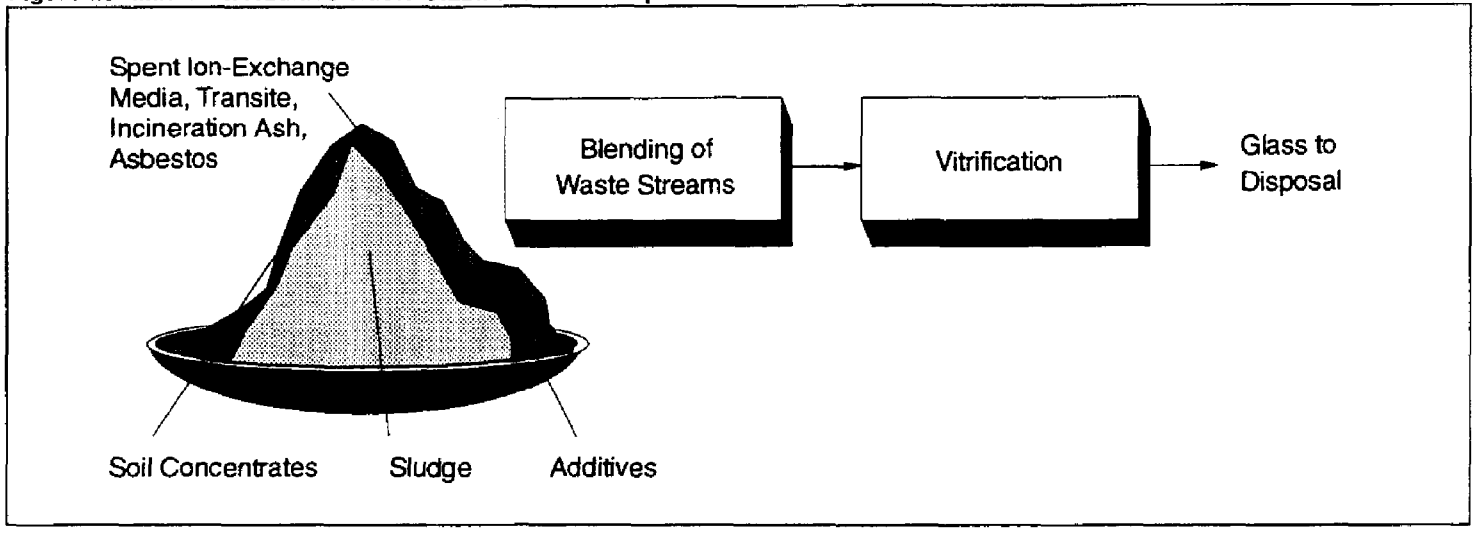
Source: Adapted by GAO from DOE illustration.

The trench-and-fill method involves digging a trench that intercepts the aquifer and then filling the trench with the appropriate chemical barrier material. The injection method pumps chemical barrier material through injection wells into the subsurface.

Treatment technologies are also being demonstrated that minimize the amount of waste created during the cleanup process or reduce the toxicity

of the waste. An example of the former is the Minimum Additive Waste Stabilization (MAWS) system. OTD officials explain the MAWS technology provides an example of the potential savings from new and improved technologies. This approach combines contaminant waste streams, through vitrification technology, into a final, stabilized waste form. Vitrification uses high temperatures—typically between 1,100 and 1,600 degrees Centigrade—to chemically combine wastes and additives into glass. As shown in figure I.5, under the MAWS concept, existing contaminated soils are used as additives to create the glass mixture, thus reducing the overall waste volume and final disposal costs.

Figure I.5: Minimum Additive Waste Stabilization Concept



Source: Based on illustration from DOE's Office of Environmental Management.

Cost reductions from this technology will be significant, according to DOE estimates. For example, applying the conventional, baseline technology, cementation to 1 cubic yard of waste would result in 3.75 cubic yards of stabilized waste for disposal. In contrast, applying MAWS would reduce the resulting waste volume to 0.75 cubic yards for disposal and save about $1,300 per cubic yard in total costs. At one site alone, DOE estimates this would equate to a savings of more than $100 million.

Objectives, Scope, and Methodology

Our objective in this review was to assess the effectiveness of DOE's technology development program for cleanup of hazardous and radioactive waste at DOE's weapons production sites. Because technology is critical to the success of environmental cleanup, we focused on the internal and external barriers to use of newly developed technologies.

To identify the internal and external barriers to the use of new technologies and to determine the frequency with which new technologies are being applied, we interviewed responsible DOE headquarters, field, and contractor officials, as well as EPA and state program representatives, and attended meetings of parties interested in cleanup technologies. We also obtained and reviewed pertinent documents, including DOE's Environmental Restoration and Waste Management Five-year Plans; Office of Technology Development's Operation's Manual and Strategic Investment Plan; the needs assessments prepared by DOE's offices of Environmental Restoration, and Waste Management; and studies on facilitating the use of improved technologies.

To gain a better understanding of OTD's demonstration projects, we visited the location of the project designed to clean up VOCs in nonarid soils, at DOE's Savannah River Site in South Carolina and the corresponding project for arid soil cleanup at DOE's Hanford Site in Washington State.

We performed our review between January 1993 and June 1994 in accordance with generally accepted government auditing standards.

Major Contributors to This Report

Resources, Community, and Economic Development Division, Washington, D.C.	Jim Wells, Associate Director Gary R. Boss, Assistant Director Diane B. Raynes, Assignment Manager Duane G. Fitzgerald, Technical Advisor
San Francisco Regional Office	Ruth-Ann Hijazi, Evaluator-in-Charge Mary K. Colgrove-Stone, Evaluator Karen D. Wright, Evaluator

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