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Remediation Focus

Savannah River Site
A Test Bed for Cleanup Technologies

By Dr. Terry C. Hazen

The effort to develop faster and cheaper ways to clean up the environment can be divided into three basic steps. Between the conceptual spark for developing innovative technology to accomplish the task and performing the actual cleanup lies what is arguably the most crucial step: demonstrating, evaluating and fine-tuning the cleanup method.

The Savannah River Site (SRS), a U.S. Department of Energy facility near Aiken, S.C., provides an ideal proving ground for fulfilling that second step – testing innovative technologies to clean soil and groundwater contaminated with volatile organic compounds (VOCs). Westinghouse Savannah River Co. and several partners have been working since

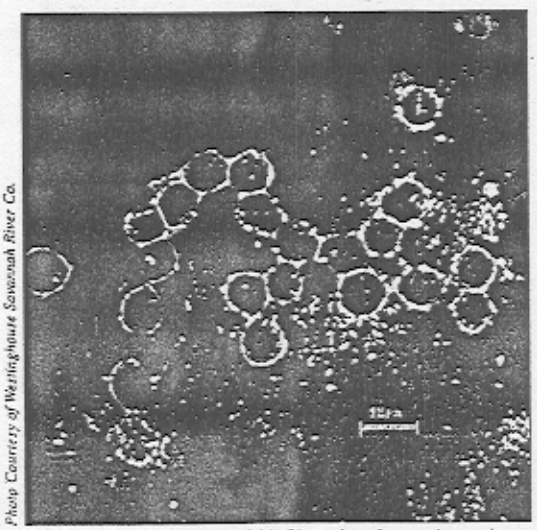

Photo Courtesy of Westinghouse Savannah River Co.

Fungal spores on bacterial biofilm taken from a hazardous waste bioreactor at the Savannah River Site.

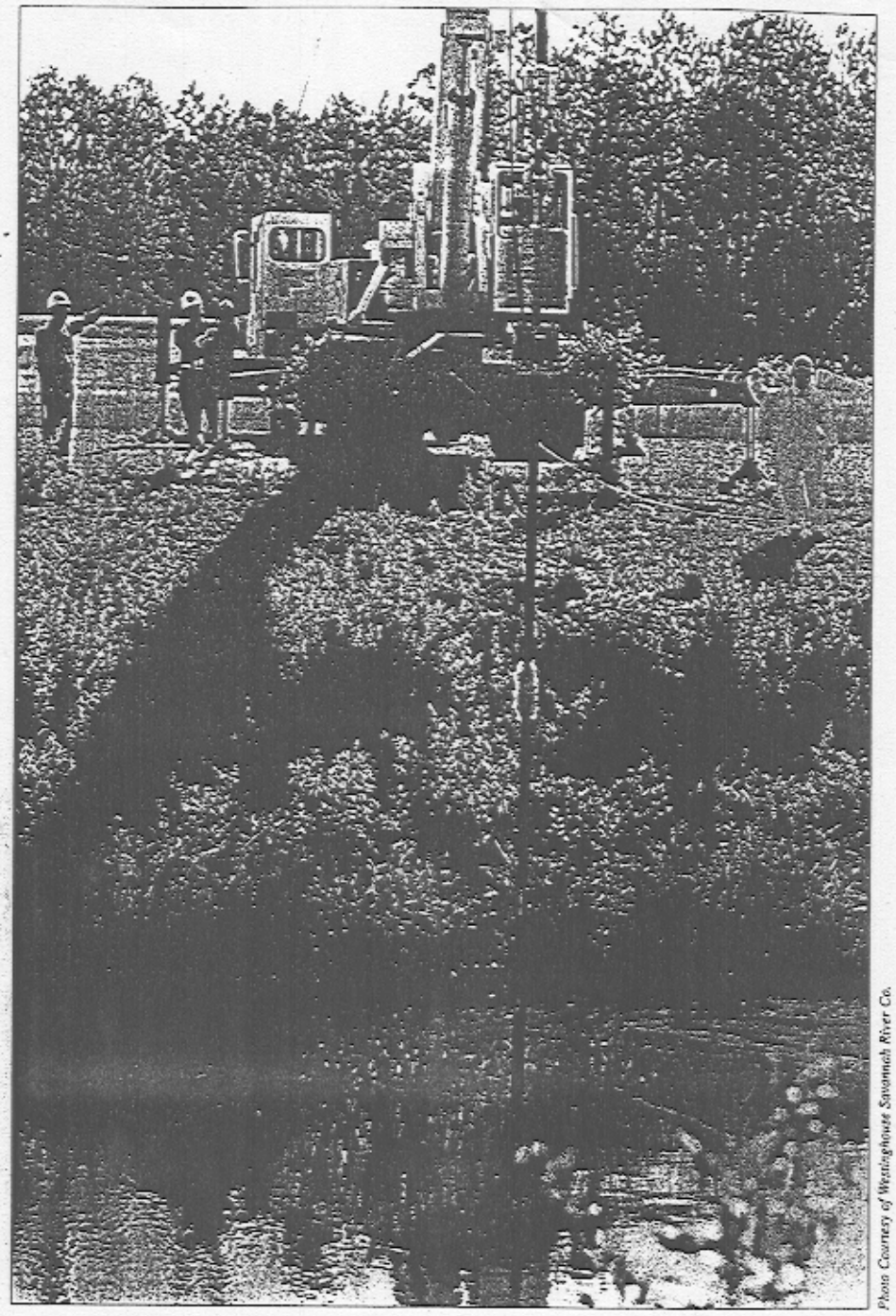

Photo Courtesy of Westinghouse Savannah River Co.

1990 at the contaminated site, which is known as the Integrated Demonstration Site, with funding from DOE's Office of Technology Development. The project has proven so successful that the remediation systems developed by the Westinghouse partners have been transferred to the site's Environmental Restoration Department for actual cleanup of the site.

New Role for Federal Facilities

Historically, SRS supported national defense through the production of nuclear materials. Today, the focus has shifted to waste management and environmental restoration. Savannah River Technology Center—the site's research and development arm—has turned its attention to developing and demonstrating environmental technologies. If a technology solves a common problem, such as VOC contamination, DOE will transfer it to other government facilities and to private industry.

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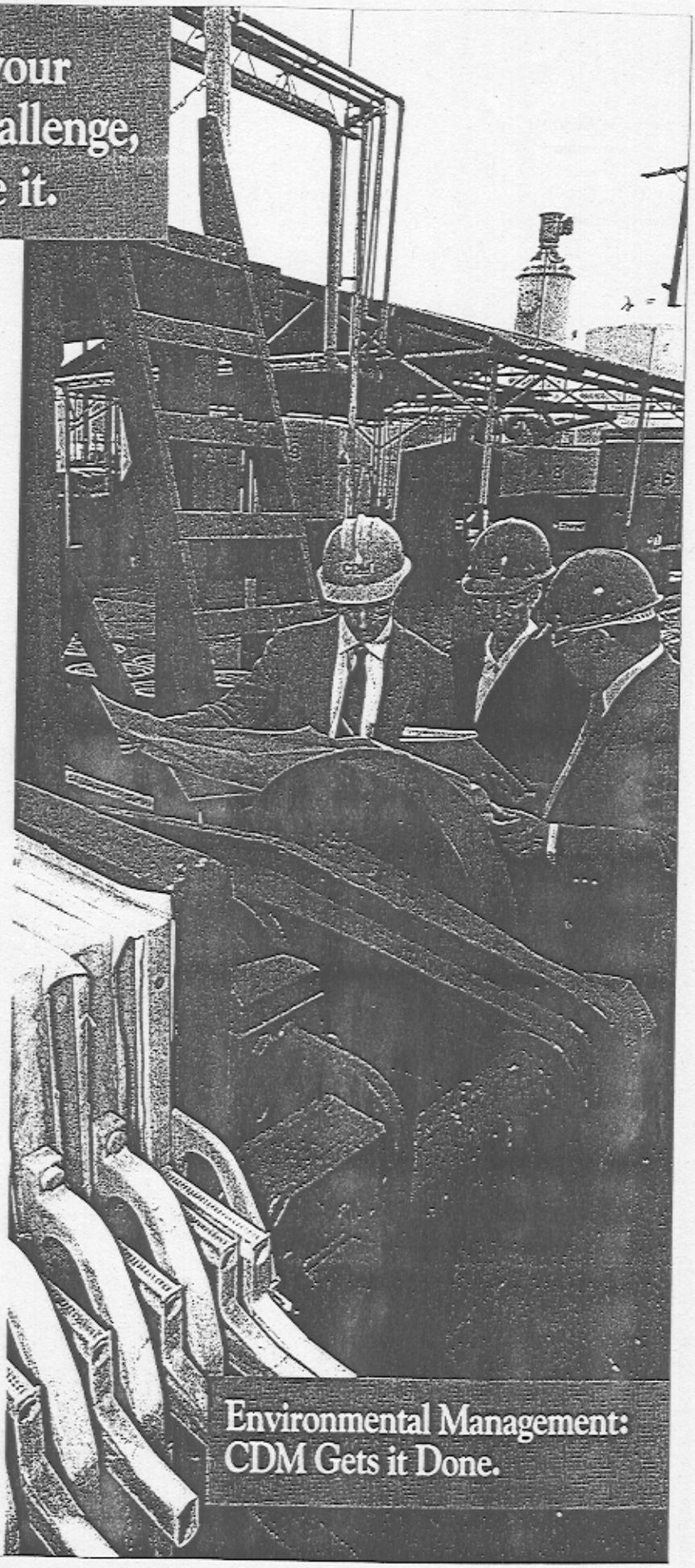

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VOC contamination is one of the nation's most common environmental problems. In the past, federal and industrial facilities used a variety of VOCs as degreasers and cleaning agents, which sometimes resulted in serious soil and water contamination. Traditional technologies such as pump-treat have proven only marginally effective in cleaning up contaminated sites to regulatory standards in a reasonable time—and in a cost-effective manner.

From the 1950s to the early 1980s, VOCs used at the SRS site's fabrication facility were disposed of in a settling basin — an unlined, open air pit. As many as two million pounds of solvents may have been disposed in this manner. The solvents (trichloroethylene, tetrachloroethylene) spread from the settling basin through the vadose zone, and entered the groundwater below the basin. An air stripper installed in 1985 stopped the contaminant plume, which occupies about one square mile below the surface, from spreading further. The stabilized contaminant zone makes an ideal proving ground to test new remedial technologies for this common contamination scenario.

The Technology Center uses the site to orchestrate "integrated" demonstrations, in which various technology developers are brought together with independent experts. They work side-by-side in many facets of the demonstration, sharing site characterization, modeling and monitoring information. Cleanup technologies are studied in context with new methods for characterization, monitoring and related evaluation technologies. Successful systems are fine-tuned and scaled-up for use at other federal sites and licensing to the private sector.

In Situ Alternatives

The conventional way to remove groundwater contaminants — pump-and-treat — has been used extensively at SRS. Indeed, more than 300,000 pounds of solvents have been removed from more than two billion gallons of groundwater at the site. But pump-and-treat has its limits. It can be a slow, costly process, with little guarantee of reducing contamination to drinking level standards.

Cleaning up contaminated soil and water in place, rather than removing and treating, promise improved effectiveness while reducing time, cost and worker exposure. At the SRS Integrated Demonstration, several new in situ technologies using horizontal wells were tested and compared.

Horizontal drilling, developed by the petroleum and utility industries, has proven very effective in conjunction with various cleanup technologies because it provides improved access to the subsurface. Although the wells initially cost more to install, their increased efficiency saves on overall cost. Four different drilling methods were compared for technical performance and cost effectiveness.

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Air Stripping

In the first of many remediation technologies demonstrated at the site, two horizontal wells were installed into highly contaminated soils under an old process sewer line that had leaked VOCs into the subsurface. One well was installed below the water table, within the contaminated zone; air is injected into this lower well. The second well, installed above the water table, is used for vapor extraction.

In the first phase of the demonstration, the upper well was used alone in a simple soil vapor extraction demonstration – basically "vacuuming" contaminants out of the soil. With only the single horizontal well, rather than traditional vertical wells previously tested at the site, the contaminant removal rate increased five-fold. When air was pumped into the lower well and removed through the upper well, the removal rate increased another 15 percent and added aquifer cleanup to the process.

During the 20-week demonstration, 16,000 pounds of solvents were removed. That feat equalled the work of 11 pump-and-treat wells pumping 500 gallons per minute.

Los Alamos National Laboratory conducted cost analyses of the two technologies — and found a cost savings of approximately 40 percent using horizontal well air stripping over pump-and-treat.

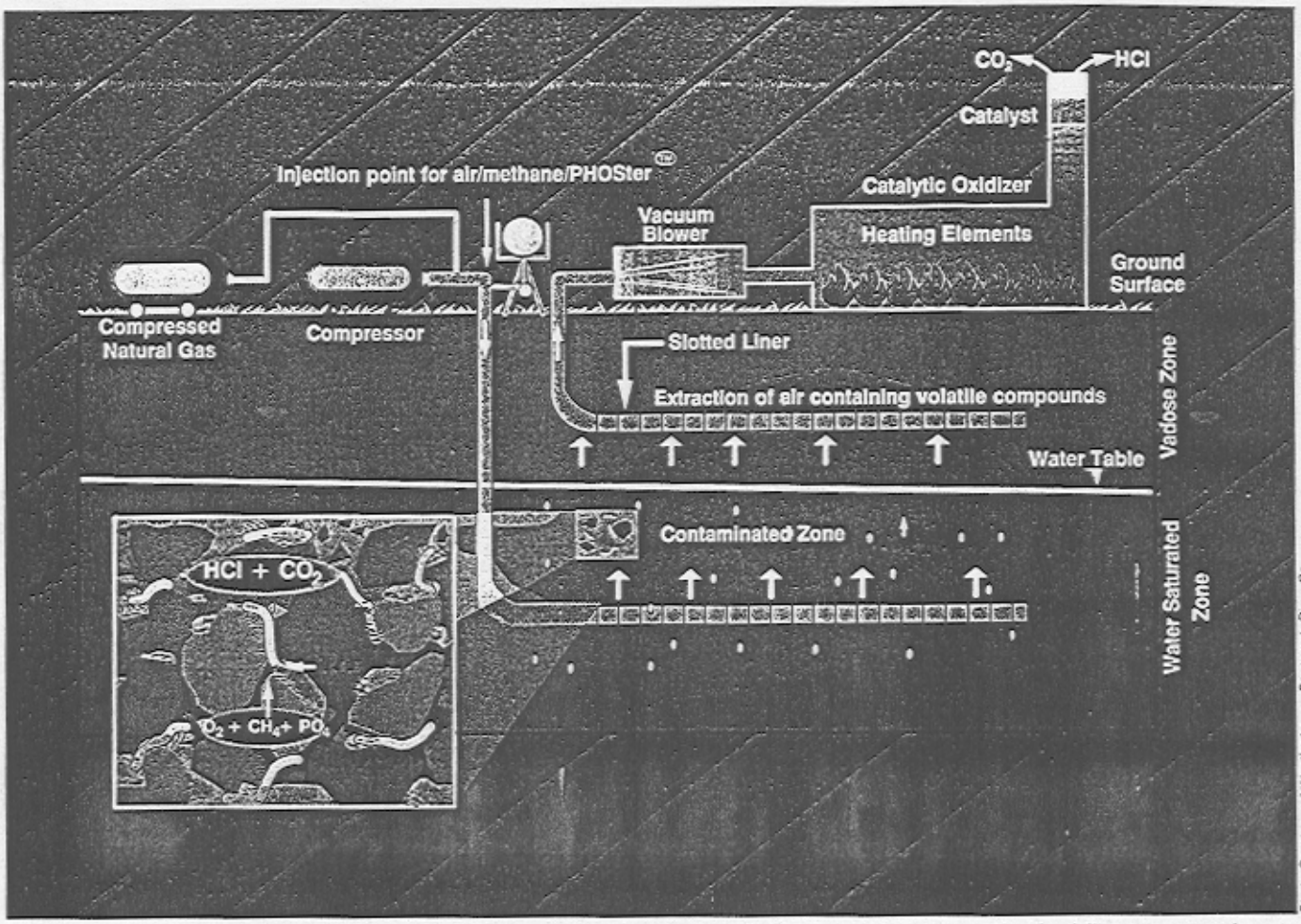
In situ air stripping proved most effective at removing VOCs from the vadose zone, above the water table, spiriting them out of the soil before they entered the groundwater. This fact makes it attractive as an enhancement to pump-and-treat systems, in which the older technology is used to control migration of the entire contaminant plume while in situ air stripping is deployed at source areas and hot spots.

Bioremediation Techniques

A concurrent demonstration at the site examined techniques to spur naturally occurring bacteria to degrade VOCs where they lie.

Bioremediation offers several advantages. First, contaminants are destroyed, not merely moved from groundwater to air. The process does not produce toxic "daughter" products such as vinyl chloride and dichloroethylene. Bioremediation can also reduce the cost and time of remediation projects — Los Alamos National Laboratory analyses show that it could take more than 10 years to remove 95 percent of solvent contamination, while bioremediation would take less than four years. At the SRS Integrated Demonstration site alone, this time reduction would represent a cost savings of $1.6 million. Along with the increased efficiency and decreased cost comes growing public and regulatory acceptance.

To demonstrate bioremediation technology at the site, methane mixed with air was injected through the lower well; gases were extracted from the vadose zone by vacuum and catalytically oxidized to ensure that no VOCs escaped into the atmosphere. The methane/air mixture was held constant; then the methane mixture was alternated with



A demonstration project at DOE's Savannah River Site combines air stripping and bioremediation to treat solvents-contaminated soil. The system uses phosphate to enhance microbial degradation.

plain air on eight-hour and 36-hours shifts.

Pulsing proved to be more effective than a constant flow of methane. First, the methane stimulated bacterial growth. When it was taken away, the stimulated bacteria turned to VOCs for nourishment.

Phosphate Added

In a later refinement, phosphate, another bacterial nutrient, was added to the injected air. The mineral, which fuels biomass growth and reaction rates, was shown to reduce the time needed to destroy contaminants.

Working with Oak Ridge National Laboratory, Pacific Northwest Laboratory, the University of Tennessee and Ecova Corp., the SRS team developed a system called PHOSter, which involves controlled addition of a relatively safe form of organic phosphorus (normally triethyl phosphate) to the injected air. This provides for a more uniform "time release" stimulation. The addition resulted in major improvements in the in situ destruction of chlorinated solvents. In another test, by a customer who used the PHOSter technology at a petroleum bioventing site, the result was a five-fold increase in the bioremediation rate in the first 40 hours.

The demonstration yielded a marked decrease in the concentrations of TCE and PCE. Water contamination decreased by as much as 95 percent, below drinking water standards and even below the detectable limit of two parts per billion in some wells. Concentrations in soil gas declined by more than 99 percent; by the end of the demonstration, we were unable to detect any soil gas concentrations of contaminants in most areas. Sediment concentrations of TCE and PCE declined from 100 parts per billion to non-detectable concentrations in most areas.

Licensing Opportunities

DOE has received a patent on the bioremediation technology and 14 companies have purchased licenses to use it. One, Phillip Environmental Services Inc. (formerly Burlington Environmental), is already successfully applying it at a private industry cleanup site and is also using the technology as the basis for bids on several additional remediation projects.

DOE actively encourages the sharing of expertise with private industry, either through licensing agreements like these, or through Cooperative Research and Development Agreements. Moving the technologies developed or demonstrated at SRS into the marketplace is one of the best ways to ensure that the nation gets full benefit from its investment in the site.

New technologies hold great promise for our ability to clean up and restore the environment. To be used effectively, however, they must be chosen carefully, with great attention to applying the right technology to a given problem. When a technology is adequately demonstrated, using our federal facilities as a test bed, these decisions can be made with confidence.

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