# PCE/TCE REMEDIATION

## From Impermeable Clay

Client: Department of Energy
Savannah River Site,
Aiken, South Carolina
November 1983

Early in the development of Six-Phase Heating (SPH), it underwent a full-scale demonstration by its developers at Pacific Northwest National Laboratory and the Department of Energy (DOE), at the DOE Savannah River site. This demonstration was conducted to show that SPH could enhance the performance of conventional soil-venting techniques in removing volatile organic compounds (VOCs) from tight lithologies.
It was also intended to gather cost and engineering data for the further development of SPH technology.

### SITE

The soil in the vadose zone of the SPH demonstration site had been contaminated with perchloroethylene (PCE) and trichloroethylene (TCE). The greatest contamination occurred within a 10-ft thick clay lens, which was sandwiched between two highly permeable sand layers at about 30 ft below grade (bg). Within this layer, the level of contamination was 100-200 parts per million of both PCE and TCE.

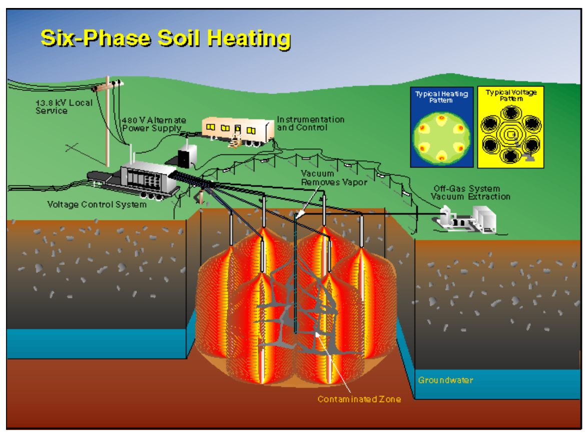


ILLUSTRATION OF THE SPH SYSTEM

### TECHNOLOGY

SPH is emerging as a leading technology in difficult in-situ soil and groundwater remediation. It has proved an efficient, rapid means of remediating soil contaminated by volatile and semi-volatile organic contaminants.

SPH uses polyphase electricity to resistively heat the soil and groundwater to the boiling point of water. This increases the volatility of contaminants, which improves the effects of vacuum extraction. Once steam is generated in situ, it acts as a carrier gas which strips out contaminants from the soil or groundwater. The steam is collected from the subsurface by a soil vapor extraction process, and treated aboveground by conventional means such as activated carbon, and catalytic oxidization.



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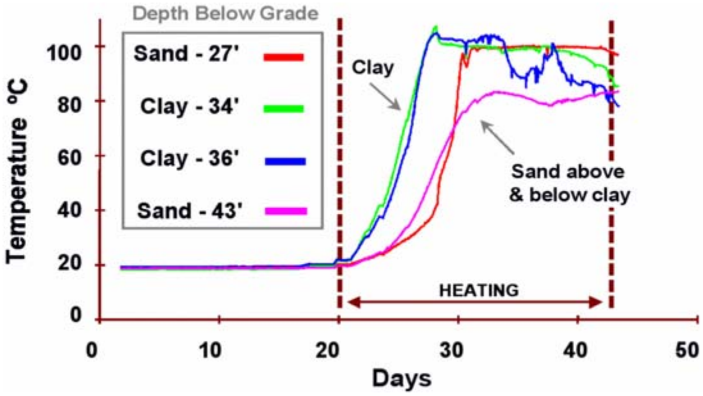
## APPLICATION

The SPH electrodes were constructed in a 30-ft diameter hexagon pattern, to a depth of 45 ft bg. During the course of 25 days, approximately 100,000 kWh of electrical energy was applied to the subsurface at, on average, 200 kW. At least 1,430 $yd^3$ of soil was heated to above 70 °C.

In the first eight days of heating, the subsurface temperature within the diameter of the electrode pattern was raised to 100 °C. This temperature was maintained for about 17 days while data was collected on soil moisture removal rates, subsurface heating patterns, steam collection and offgas VOC concentrations.

## RESULTS

Analysis of almost 200 soil samples indicated that SPH had removed 97 % of the VOCs in the clay layer and 100 % from the sand layers. The demonstration results indicated that SPH rapidly heated and remediated low-permeability soil lenses containing VOCs. Approximately 1,430 $yd^3$ of soil was treated, including soil beyond the diameter of the electrode pattern. Heating was uniform within each soil layer, but the clay layer became heated sooner than the sand layers and reached a higher final temperature.




VERTICAL TEMPERATURE PROFILES

Within the electrode field, the median contaminant removal rate from the clay zone was 99.7 % after only 25 days of heating. Vertical soil temperature profiles (see Figure 1) showed that the tight clay lens, which contained most of the contamination, was heated faster and to higher temperatures as compared to the surrounding soils. This was expected, as the clay lenses represented a more electrically conductive pathway than the sand layers above and below it. Horizontal soil temperature profiles showed that effective heating extended beyond the electrode field by a distance of approximately 40 % of the diameter of the hexagon.

During the SPH process, subsurface steaming resulted in the generation of 19,000 gal of water at the SPH condenser. The peak removal rate was 1,500 gal of condensed steam per day. The production of steam enabled SPH to strip contaminants from the soil matrix and achieve remediation efficiencies exceeding 99 %.

The energy use was 70 kWh/$yd^3$ of treated soil, which amounted to \$5/$yd^3$ of treated soil (assuming an electricity rate of \$0.07 per kWh).

## CONCLUSIONS

The field demonstration proved that SPH could preferentially heat and rapidly remediate lenses of low-permeability soil containing relatively high concentrations of VOCs.



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