



## CURRENT ENVIRONMENTAL SOLUTIONS

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### Six-Phase Heating™ for Rapid LNAPL and Benzene Remediation

Client: U.S. Army Corps of Engineers

Design Engineer: William Heath

Location: Savannah, Georgia

Project Manager: Chris Thomas

Duration: March - August, 2002

#### SITE

In late 2001, Current Environmental Solutions (CES) was contracted to design, build and operate a Six Phase Heating™ (SPH) system at a military installation in the Southeastern United States.

The site is a flat grassy area located between the main taxiway and the main runway on an airfield. The last of ten 25,000 gallon fuel tanks were removed in 1998 from a former fuel handling area. Soil samples were collected and monitoring wells were installed as part of the closure activities at the site. As a result of the sampling activities, light non aqueous phase liquid (LNAPL), consisting of a mixture of gasoline and diesel, and a larger dissolved phase benzene plume was identified roughly down gradient of the former buried tanks.

The total estimated area affected by the benzene plume covered 30,000 ft<sup>2</sup>. The LNAPL layer was up to two feet thick and covered an area of approximately 10,000 ft<sup>2</sup>. The contamination extended from 8 feet below grade surface (ft bgs) to 16 ft bgs. All told, the total volume of soil and groundwater requiring treatment was approximately 8,900 yd<sup>3</sup>. The subsurface soil mainly consisted of silty sand grading to sand with depth. Groundwater was typically encountered at 10 ft bgs.



Bird's Eye View of Electrode Field

The following objectives were set for the for the SPH remediation:

- 1) to remove the LNAPL, and
- 2) to reduce the groundwater benzene concentrations to the previously derived alternate concentration limits (ACL) of 469 µg/L.

**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. The technique uses conventional 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. The heat also initiates VOC degradation through various pathways. 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.

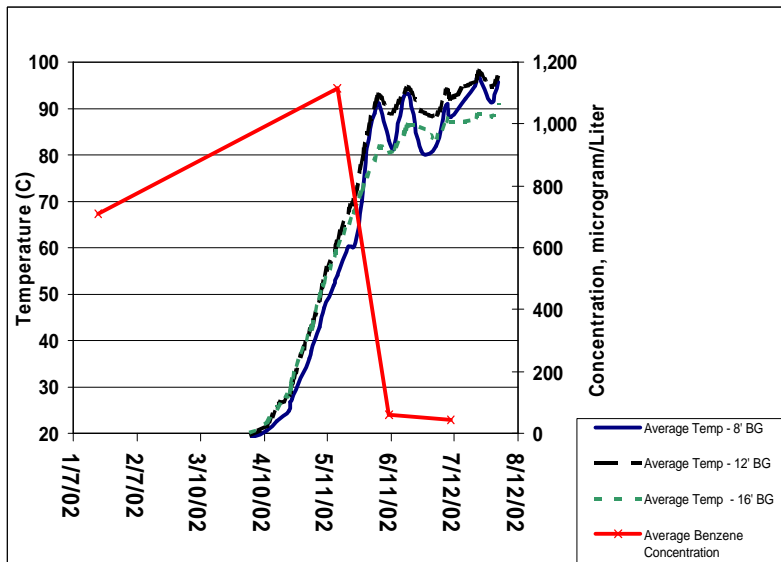
**APPLICATION** The system consisted of 111 electrodes, 18 Soil Vacuum Extraction (SVE) wells and 5 Dual Vacuum Extraction (DVE) wells. System start-up began on March 18, 2002 and the system ran until August 5, 2002. Vapor was discharged to the atmosphere under permit, while the extracted groundwater was treated in an air-stripping tower, tested, and then discharged into the ground.

**RESULTS**

Through four months of operation, nearly 1,678,000 kW-hrs of energy was input into the subsurface. Boiling temperatures were achieved 60 days after heating, as predicted by CES. More importantly, the electrodes operated as designed, and efficient power coupling remained constant throughout the remediation.

The process worked so well that the system operation was slightly slowed due to high lower-explosive-limit (LEL) management. An LEL meter was set to shut the system down if the vapor concentration exceeded 30%. To control the rate of vapor being recovered during the heat up stage, the VE system had to be operated at partial capacity. By the end of the pilot, an estimated 40,000 pounds of contamination was removed in four months of operation

The SPH remediation was a resounding success. The operation of the system resulted in the boiling of the groundwater across the site. All of the LNAPL was removed from the site and the dissolved phase benzene concentrations were reduced to an average of 61 µg/L, far surpassing the ACLs and thus achieving both treatment objectives.



**Summary of Site Data Averages**