Barometric Pumping with a Twist: VOC Containment and Remediation without Boreholes

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Abstract

Most of the planned remediation sites within the DOE complex are contaminated with volatile organic compounds (VOCs). In many instances the contamination sources lie near the surface, have not reached the water table, and do not pose an immediate threat. Volatiles emanating from these sources typically disperse over a soil volume much greater than the initial source. The remediation solution being developed in this project serves as an in-situ contaminant and extraction methodology for sites where most or all of the contamination resides in the vadose zone soil. The approach capitalizes on the advective soil gas movement resulting from barometric pressure oscillations, and is inherently inexpensive due to its passive design. Called BERT, for Barometrically Enhanced Remediation Technology, this system is unique as a passive remediation tool because it does not require boreholes to accomplish its function.

Oscillations in barometric pressure are both diurnal, corresponding to daily heating and cooling of the atmosphere, and of longer time periods, resulting from the passage of weather fronts. Daily variations will average 4 to 5 millibars (one millibar is roughly one thousandth of an atmosphere) while those due to weather front passage can be 25 or more millibars. As the barometric pressure rises, a gradient is imposed on the soil gas which drives fresh surface air into the soil. As it drops, gas vents upward from the soil into the atmosphere. The total movement of soil gas is dependent primarily on the magnitude and period of the pressure oscillations, the soil gas permeability, and the depth to an impermeable boundary. This boundary can be the water table, bedrock, or extensive layers of very low permeability material, such as caliche or clay. Since the fractional change in atmospheric pressure is small (typically 0.5 percent) the overall soil gas displacement during the daily cycle is also small (with an estimated range of centimeters to meters).

With the BERT system, displacement of soil gas is controlled using surface features which impede the downward movement of vapors, but allow upward movement. The system incorporates a surface seal, a plenum, and an extraction vent value. Directly above the contaminant plume a layer of highly permeable material, such as pea gravel, is placed on the surface to form a collective plenum for the upward-moving soil gas. An impermeable membrane is placed over the collection plenum and extends outward over the soil surface to form a buffer zone, which controls the radial movement of air flowing into the soil during the high pressure periods. The plenum is connected

to the atmosphere with a high volume vent valve, open only when soil gas is moving upward (during a drop in the barometric pressure). In operation the system ratchets the soil gas upward by allowing normal upward flow during barometric lows but restricting downward air flow during high pressure cycles.

The Idaho National Engineering Laboratory Radioactive Waste Management Complex (RWMC) is the site for the first demonstration of this barometric pumping remediation system. The Subsurface Disposal Area (SDA) is a 96 acre fenced disposal area inside the RWMC. During the 1960s and 1970s mixed wastes containing volatile organic compounds and radioactive wastes were buried at the SDA in shallow waste disposal pits, trenches, and soil vaults rows (typically less than 20 ft deep). The geology of the SDA consists of surficial sediment deposits overlaying thick basalt deposits. Irregularities in the soil thickness (ranging from 1 to 23 ft) reflect the surface undulations of the underlying basalts. The surface soils consist of gravely sand and fine-grained colian deposits. The water table is at approximately 600 ft. The bulk of the contamination detected during soil gas surveys is in the form of chlorinated hydrocarbons, primarily carbon tetrachloride, trichloroethylene, chloroform, and tetrachloroethylene. The area chosen for this demonstration is identified as Pit 2. In the area of interest the peak soil gas contaminant concentration was 111 ppm of carbon tetrachloride. This disposal pit received slightly over 1000 barrels of sludge between 1954 and 1965.

The demonstration system was installed at the INEEL RWMC in December, 1996. It has operated continuously since then and the test is expected to continue at least through March 1998. The installation consists of a 100 ft square surface scal installation, with a 30 ft diameter collection plenum and vent system located at its center. The system is monitored continuously (at 45 minute intervals) for soil gas pressure and temperature, and 2 to 4 times daily gas samples are collected for oxygen and carbon dioxide analysis. Detailed soil gas surveys are conducted periodically to quantify the effect of the surface treatment system on the soil gas contaminant concentration distribution.

Evaluations of the monitoring data to date have resulted in the following observations:

- The system is extracting soil gas at a rate of 3 to 10 times anticipated (as predicted by the barometric pumping process alone) due to the winds which occur at the same time as the drop in barometric pressure. Vent rates range from 10 to 37 cubic meters per day. The predicted average vent flow rate was 4 cubic meters per day.

- During the coldest months (January and February) the system vent flow decreased, suspected due to freezing of the soil moisture beneath the pleum. After the soil temperatures rose above freezing, the vent flow returned to normal.

- The surface seal induced higher soil temperatures (by 1 to 1.5 C) than those in the soil not covered by the seal.

- Soil gas surveys show the vent system is releasing soil gas with contaminant concentrations diluted approximately 50% (compared to the soil gas 0.5 ft in the soil beneath the collection plenum), suspected due to horizontal leakage beneath the surface seal.