Thermal Remediation of Karst Limestone at Redstone Arsenal, Alabama

Chad Crownover (TRS Group, Longview, WA, USA)
Lauren Soós (LSoos@ThermalRS.com) (TRS Group, Longview, WA, USA)
Chris Thomas (TRS Group, Longview, WA, USA)
Scott Wilson, P.E. (APTIM, Huntsville, AL, USA)

Background/Objectives. Electrical resistance heating (ERH) was used for the thermal remediation of six sites at Redstone Arsenal (RSA) near Huntsville, Alabama. All six sites feature karst limestone with heavy clay overburden. Five of the sites are located within ½ mile (1 km) and the fourth site is about 5 miles (10 km) away. The sites differ considerably in the characteristics of the limestone. Two of the Sites (RSA-053 and Former Building 7363) feature very hard, competent limestone with no apparent voids or soil inclusions. At sites RSA-095 East, RSA-095 West, RSA-096 and RS-142, the limestone is riddled with soil-filled and water-filled voids; one void was also observed in the vadose zone soil. The largest water-filled void in the RSA-096 treatment volume appears to be about 40 ft by 24 ft (10 m by 7 m) with a height that varies from 3 ft to 12 ft (1 m to 4 m). The limestone variation between the sites provided a comparison of the effects of secondary porosity in a karst environment. In each case, remediation included treatment of soil and extended up to 40 ft (12 m) into saturated limestone. RSA-053 required the remediation of chlorobenzene; the other five sites required the remediation of trichloroethene. The remediations targeted regions where dense non-aqueous phase liquid (DNAPL) was considered very likely, with contaminant concentrations greater than 10% of the water solubility limit. Pre-treatment groundwater concentrations at the sites were as high as 204,000 µg/l chlorobenzene and 1,320,000 µg/l trichloroethene.

Approach/Activities. The goal is to evaporate DNAPL using ERH and create in situ steam as a carrier gas to remove the solvent vapor from low permeability soil and rock. The thermal treatment depth intervals and volumes differed at each site from 15 to 96 feet below grade and 6,200 to 90,100 cubic yards (cy), for a total of over 150,000 cy of thermally treated overburden and limestone. Electrodes with co-located vapor recovery wells were installed at each site using rotosonic drilling. Two of the electrodes that penetrated the RSA-096 large water-filled void were specially modified to enhance heating of the water within the void. In addition, each electrode at RSA-095 East and RSA-095 West was customized for the highly variable bedrock surface, information that was collected during rotosonic casing advancement. The goal was to demonstrate DNAPL removal by achieving an 80% reduction of groundwater concentrations.

Results/Lessons Learned. DNAPL was successfully removed from the target regions as indicated by the groundwater concentration reductions that were observed. In addition, over 55,000 pounds of trichloroethene and chlorobenezene was observed. Competent limestone had higher resistivity than weathered limestone or soil; higher resistivity meant that higher voltages were required to heat the competent rock. However, the higher resistivity did not affect the cost or effectiveness of the remediation. The customized electrodes allowed for efficient energy application in the limestone. Karst voids had no significant effect on remediation performance.