Evaluating LNAPL Mobility and Transmissivity: A Route to Case Closure

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Background/Objectives. The purpose of this investigation is to demonstrate that removal of light non-aqueous phase liquid (LNAPL; #2 fuel oil and gasoline) at a former manufacturing facility has been completed to the maximum extent practicable and no further action is required. The site is located within the Maryland Coastal Plain Physiographic Province and site sediments consist predominantly of sand and silty sand with discontinuous layers of silts and clays. Environmental investigation and remedial activities began in 1995 when LNAPL was first encountered on the site. A remediation system using vacuum-enhanced groundwater extraction (VEGE) and soil vapor extraction (SVE) began operation in 1998 and was deactivated in 2011 due to diminishing recovery. Manual recovery using sorbent socks/bailers ensued, and from 2013 to 2015 automated LNAPL skimming devices were utilized in several of the on-site monitoring wells to maximize LNAPL recovery. Although LNAPL thicknesses had reduced significantly from 1998 to 2015, measurable quantities were still detected in the on-site monitoring wells. In accordance with the corrective action plan (CAP) developed for the site through the Maryland Department of the Environment (MDE) Oil Control Program (OCP), LNAPL must be removed to the maximum extent possible, which has historically been interpreted by MDE as a non-measurable sheen. In order to achieve case closure, a comprehensive LNAPL mobility study was conducted to provide quantitative evidence that LNAPL has been removed from the site to the maximum extent practicable despite the current and expected long-term presence of measurable LNAPL.

Approach/Activities. The LNAPL mobility study included soil boring advancement, transmissivity testing, analysis of the LNAPL fluid properties, and evaluation of long-term fluid gauging data and volume of LNAPL recovered via the various remedial techniques previously utilized. Skimming tests were completed for all wells containing measurable LNAPL thickness during the study period (November 2015) in order to measure LNAPL transmissivity. Soil cores were collected from eight targeted areas of the site known to contain elevated LNAPL saturation in order to better understand the occurrence, vertical distribution, mobility and recoverability of LNAPL in site soils. Additionally, an undisturbed soil core was collected and immediately frozen with liquid nitrogen to preserve pore structures and fluid saturation, and to minimize movement of liquids within the core. The soil core was photographed under visible and ultraviolet light, and analyzed for several parameters, including fluid saturation, grain size distribution, LNAPL mobility and capillary pressure characteristics. The objectives of these analyses were to obtain quantitative estimates of LNAPL saturation versus depth/grain size, estimate the mobile and residual LNAPL fractions, and measure the capillary pressure parameters of the soil intervals containing the most significant LNAPL impacts.

Results/Lessons Learned. The results of this study indicate through several lines of evidence that the presence of LNAPL poses no significant risk, as transmissivity values are an order of magnitude below the practical recovery range of 0.1 to 0.8 ft^2/day (ITRC, 2009), measured soil LNAPL saturation is low and historic gauging and capillary pressure data demonstrate low potential for migration. On the merit of these observations, MDE approved a CAP addendum allowing LNAPL to remain in place and case closure has been achieved. This case study demonstrates the ability to successfully close LNAPL sites despite historically strict requirements regarding the presence of measurable LNAPL.