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Application of LNAPL Mass Flux and Natural Source Zone Depletion to Demonstrate LNAPL Body Stability

Rick Ahlers (rick.ahlers@arcadis.com) (Arcadis, San Diego, CA, USA)

Background/Objectives. The perception that mobile LNAPL (aka “free product” or LNAPL that can drain locally from the formation into a groundwater well) is inherently connected to a risk of LNAPL migration has been, to some degree, dispelled by multiple lines of evidence approaches applied at many sites over many years demonstrating LNAPL body stability. The lines of evidence that have been presented range from pore-scale theory, to core-scale and well-scale testing, to LNAPL body-scale inferences. As is common with a multiple lines of evidence approach, none of these lines of evidence, by themselves, are considered conclusive evidence of LNAPL body stability. At the pore-scale, entry pressure is easily related to LNAPL head and LNAPL thickness, however it only considers the threshold for two-phase invasion rather than the lower barrier to LNAPL migration in a three-phase system. Well-scale LNAPL transmissivity testing, e.g., baildown testing and even LNAPL tracer testing, provides a measure of the bulk LNAPL mobility but provides little to no insight into the potential velocity of LNAPL migration. At the LNAPL-body-scale, experience across many sites has demonstrated that at sites where the primary release has been stopped, the finite mass of LNAPL in the subsurface clearly implies that the LNAPL body will only spread over a finite area. As the time since the primary release increases the probability that expansion of the LNAPL body has naturally stopped increases. However, soil properties and heterogeneity, LNAPL properties, and release volume all are conditions that impose uncertainty on the site-specific time to LNAPL body immobilization. The potential for and application of an alternative, stand-alone metric of LNAPL body stability is examined.

Approach/Activities. For mobile LNAPL to be in a stable configuration, either a) there must be no head gradient across the mobile portion of the LNAPL body, or b) when a gradient is present, there are LNAPL losses equal to the LNAPL mass flux induced by the gradient. Whether LNAPL mass redistribution internal to an otherwise apparently stable LNAPL body was balanced by natural LNAPL losses was examined at the Bemidji, Minnesota research site (Lundy 2012). LNAPL transmissivity testing has become common at many sites, and characterization of the natural source zone depletion (NSZD) rate is becoming more and more common. With these two parameters characterized and combined with LNAPL gauging data and an LCSM, a stand-alone evaluation of LNAPL-body stability can be carried out. The rate of LNAPL mass flux and the rate of NSZD are used to predict a maximum LNAPL migration distance that can be compared to distance to the edge of the LNAPL body.

Results/Lessons Learned. Site-specific LNAPL transmissivity, NSZD, gauging, and LCSM data are used to demonstrate where the LNAPL body under existing conditions is stable. LNAPL transmissivity, NSZD, and LCSM data as well as estimated future LNAPL gradient conditions are used to demonstrate where an LNAPL body under hydraulic control may continue to be stable after hydraulic control is released.