Modeling Approaches to Assess upward DNAPL Migration Potential in Shallow Sediments to Support Remedy Design

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Background/Objectives. Dense non-aqueous phase liquids (DNAPL), which have similar density to water, are susceptible to upward mobilization by upwelling groundwater, such as baseflow to surface waters. Mobilized DNAPL in shallow sediments has the potential to migrate into and impact overlying surface waters, where specific conditions for DNAPL migration are met. The selection, design and implementation of effective and cost-efficient remedies to address migrating DNAPL therefore require detailed delineation of DNAPL distribution and the prediction of migration potential. Two-phase (water-oil) flow modeling provides a means to assess DNAPL migration potential, when used in combination with scale-appropriate investigation tools, including high resolution site characterization (HRSC) and advanced petrophysical/NAPL laboratory methods.

Approach/Activities. The potential for upward DNAPL migration into surface waters is a function of pore fluid pressures and the distribution of DNAPL saturation in overlying sediments. A detailed investigation of the migration potential of DNAPL in native sediments was undertaken to support the selection, design, and implementation of an in situ stabilization (ISS) and capping remedy for a canal site impacted by DNAPL characteristic of manufactured gas plants (MGP). The methodology included: i) deployment of HRSC methods for delineating DNAPL distribution; ii) implementation of an innovative laboratory testing program to determine conditions that lead to DNAPL migration, and; iii) detailed modeling to predict the extent and flux of upward-migrating DNAPL.

The methods and outcome of the predictive modeling based on the HRSC and laboratory data will be discussed. A two-step modeling approach was developed to: i) evaluate threshold conditions for upward mobilization of residual and higher saturation DNAPLs, then; ii) assess the combined effects of DNAPL saturation, volume, emplacement depth and hydraulic gradient on the potential for the DNAPL to migrate to the sediment-surface water interface during the proposed lifetime of the remedy. Existing DNAPL mobility screening algorithms were adapted to assess mobilization vertically upwards and the migration potential of mobile DNAPL assessed through novel application of analytical and numerical two-phase flow modeling techniques.

Results/Lessons Learned. The role of predictive modeling within an integrated strategy to assess DNAPL migration potential in sediments is demonstrated by this case study. Here we illustrate the concepts underpinning application of two-phase flow modeling to DNAPL migration prediction, which were used to inform remedy design and reduce volumes requiring in situ stabilization and therefore project costs.