A Stochastic Modeling Approach to Evaluate the Value of Additional Information for Site Characterization and Remediation

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Background/Objectives. Site characterization is a process of reducing uncertainty, with the eventual aim of the development of an accurate conceptual site model (CSM) that is appropriate for the remedial objectives of a site. The economic costs of a CSM and remediation are highly variable and dependent on many factors. Understanding which elements of site characterization translate to the highest value data for remediation planning are currently unclear. Large-scale virtual site datasets (VSD) were analyzed using stochastic modeling approach to assess the effects of increasing site characterization information on remediation strategy, success and cost.

Approach/Activities. Large-scale VSDs, developed by simulation, have been investigated (virtually) by several teams comprising experienced and senior industry practitioners. Each VSD represents a chlorinated hydrocarbon dense non-aqueous liquid (DNAPL) source and plume distributions within variably complex aquifer settings. CSMs and remediation plans prepared for each VSD have been analyzed using a two-step stochastic modeling approach: (i) calibrate uncertain site parameters (e.g. hydraulic conductivity, source mass and discharge, biodegradation rates etc.) modeled through probability distributions and; (ii) identify the best remediation strategy for minimal cost. Optimal remediation of the calibrated models was achieved by minimizing a cost function based on typical rates for enhanced in-situ bioremediation (EISB). The amount of site information used to estimate model parameters was increased stepwise to determine the effects on remediation success and costs. The central component of this approach is a semi-analytical mathematical model to simulate DNAPL source depletion and dissolved phase transport over time in response to natural and engineered conditions. In the inverse modeling mode, the CSM data provided by the investigating teams are used to calibrate the simulation model and to estimate parameter covariances and residual prediction error. Forward predictions of remediation performance and cost are performed for defined remediation strategies, operating rules and remediation criteria. Design optimization is performed to determine values of remediation design variables that minimize the expected cost.

Results/Lessons Learned. The outcome of this project will be a factor in identifying the key parameters which, through reduction of uncertainty, lead to cost-effective and efficient remediation. This work will support development of guidance based on scientific principles that determine the value of data and the value of current site investigation practices.