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A MULTISTAGE BAYESIAN SAMPLING STRATEGY FOR AN IMPROVED DNAPL SOURCE ZONE CHARACTERIZATION WITH BETTER SPATIAL PATTERN

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Past improper disposal practices, both legal and illegal, have resulted in a legacy of environmental contamination of soils, surface water, and groundwater. Among the most intractable of these environmental contamination scenarios are those involving the release of dense nonaqueous phase liquids (DNAPL) to the subsurface. Spatial variability of physical and chemical soil/contaminant properties can exert a controlling influence on DNAPLs source zone distribution and entrapment as heterogeneity and nonuniformity in soil properties may cause DNAPL to pool to high saturations at interfaces of textural contrast. The presence of source zones containing DNAPL is usually the single most important factor limiting the characterization and cleanup of contaminated sites. DNAPL source zone characterization is very important for risk assessments, feasibility studies, and identification of appropriate remediation technologies. The extent and configuration of the source zone are also important inputs to multiphase mass transfer models. The accuracy of the estimated DNAPL downstream mass discharge and the magnitude of its quantifiable uncertainty depend upon the amount of information provided by the sample data. Unfortunately, because of the complexities associated with the transport, retention, distribution, and mass transfer limitation of DNAPL, as well as the heterogeneity of the subsurface environments, high sampling density is generally almost not possible, therefore resulting in unsuccessful site remediation. The goal of this work is to create a computer assisted optimal sampling strategy that identifies DNAPL at its source using the least number of soil and/or groundwater samples at minimal cost. The concept is to pre-identify the contaminant source prior to the detailed investigation by incorporating concentration data and updating the sampling strategy as the characterization process proceeds. A multistage Bayesian spatial sampling strategy is proposed herein to select optimal sampling locations and determine minimal sampling density for accurate quantification of mass discharge uncertainty. Application of this methodology to numerically simulated DNAPL plume transects shows that in comparison to grid sampling design, this sampling strategy yields more than 50% reduction in required sampling density for accurate uncertainty modeling. The developed sampling algorithm can be used in real time to guide staged field sampling.

Keywords: DNAPL, Geostatistics, Heterogeneity, Multistage, Bayesian