Technical and Regulatory Guidance for Surfactant/Cosolvent Flushing of DNAPL Source Zones

April 2003

Prepared by
Interstate Technology & Regulatory Council
Dense Nonaqueous Phase Liquids Team

EXECUTIVE SUMMARY

This document is intended to serve as a technical and regulatory guide for stakeholders, regulators, technology decision makers, and others involved in selecting and implementing surfactant/cosolvent flushing of dense nonaqueous-phase liquids (DNAPLs) as a remedial action.

Surfactant/cosolvent flushing is a DNAPL-removal technology involving the injection and subsequent extraction of chemicals to solubilize and/or mobilize DNAPLs. The chemicals are injected into a system of wells positioned to sweep the DNAPL source zone within the aquifer. The chemical flood and the solubilized or mobilized DNAPL is removed through extraction wells, and the produced liquids are then either disposed (usually off-site treatment) or treated on site to remove contaminants, and then reinjected to the subsurface to remove additional DNAPL mass.

Surfactant/cosolvent flushing is a mature technology in the petroleum-engineering field of Enhanced Oil Recovery (EOR), supported by decades of research and field tests. Environmental applications are relatively new but have increased in recent years. Field performance has been quantitatively assessed using several methods for a large number of sites. The technology has been shown to be effective for several DNAPL types, including spent degreasing solvents (TCE and TCA), dry cleaning solvents (PCE), heavy fuel oils, and coal tar/creosote. Laboratory work has also demonstrated applicability to PCB-containing mineral oils.

The primary appeal of surfactant/cosolvent flushing is its potential to quickly remove a large fraction of the total DNAPL mass as compared to other technologies. As an in-situ technology, it eliminates the need to excavate, handle, and transport contaminated media. It is applicable as a stand-alone technology or as a component in a "treatment train" consisting of several remedial technologies, depending on site-specific cleanup objectives.

Designing and implementing a DNAPL source-removal operation is an intrinsically complex endeavor. Surfactant/cosolvent flushing activities must be designed in such a way that uncontrolled vertical and horizontal migration of contamination is avoided. A comprehensive understanding of the subsurface environment, multiphase fluid flow, and the physical processes being employed is required to prevent remediation failure and avoid contaminating previously uncontaminated portions of the aquifer.

Technical challenges to the successful use of surfactant/cosolvent flushing include locating and delineating the DNAPL source zone and obtaining an accurate estimate of the initial DNAPL mass and its spatial distribution. Additional requirements include characterizing the hydraulic properties of the aquifer, delivering and distributing the injected chemicals to the targeted zone, and designing the optimum chemical formulation for a given DNAPL composition and soil type. The implementability of surfactant/cosolvent flushing will depend on site-specific geologic conditions and on the type of DNAPL present at the site.

Historically, the primary factors that have limited field demonstrations from proceeding to full-scale applications have been concerns regarding costs of disposal of the effluent, regulatory permitting concerns in allowing underground injection of tracers or flushing agents, and the

overall impact of unremoved DNAPL. Also, there is a general lack of information regarding the technology and a lack of personnel with expertise in applying the technology. It is truly an interdisciplinary and complex technology, requiring expertise in multiphase fluid flow, site and contaminant-specific design, optimization, and control. Selection of a surfactant/cosolvent solution is a process requiring laboratory batch and column studies and field trials. A considerable amount of laboratory work is required before implementation can commence.

To facilitate regulatory and stakeholder acceptance, it is important to include regulators and stakeholders in the decision process that leads to the selection of surfactant/cosolvent flushing as a remedy and to involve them in the process of designing and implementing the flood. There are differences in regulatory requirements based on whether the site is regulated under RCRA or CERCLA, and whether it is a federal facility, a Superfund, state, or private-party lead. While permit requirements are not a direct barrier to surfactant/cosolvent flushing, it is important that the technology user be aware of state-specific permits and/or requirements associated with the Underground Injection Control (UIC) program.

Acceptance of this technology by the regulatory community as a viable remedial alternative continues to grow as pilot and field-scale applications are completed.