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Cryogenic Core Collection and High-Throughput Core Analysis: Post-Remediation Performance Assessment

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Background/Objectives. Cryogenic core collection (CCC) was used to conduct post-remediation performance assessment at a former TCE source zone at Site 17, Naval Support Facility Indian Head, Maryland. The source zone remediation, which was completed in 2012, consisted of soil mixing for delivery of zero valent iron (ZVI) and bentonite. The remediation was considered successful based on previously existing groundwater data, as concentrations had generally declined by >4 orders of magnitude. Low levels of TCE and degradation products have persisted, but appear to be steadily declining. For this project, CCC was employed in the summer of 2016 to supplement existing post-remediation performance assessment data. The primary objectives of this work were to assess long-term impacts of the remediation and evaluate the potential for concentration rebound to occur. This project was funded by ESTCP (ER-201587-PR).

CCC generates high-resolution, multi-parameter data that represent subsurface conditions more accurately than either traditional soil coring or groundwater sampling. These improved data can be used to assess spatial distribution of properties and processes, thus enhancing a site conceptual model. Particular advantages of CCC include preservation of low-molecular weight products (e.g., ethene and acetylene), redox sensitive parameters, microbial properties (potentially including RNA), and pore fluid distribution. Ultimately, the goal of CCC is to support remediation decision making based on improved understanding of natural processes.

Approach/Activities. The CCC approach was developed by Oregon Health & Science University, Colorado State University, and Drilling Engineers Inc. under previous SERDP-funded research (ER-1559 and ER-1740). Frozen cores were collected from six locations at the Indian Head site: two within the ZVI-mixed zone and four from downgradient locations. In general, locations were selected near monitoring wells to aid in comparison to existing performance assessment data. Soil cores were frozen in situ, using liquid nitrogen, and then transported (while frozen) to a laboratory at Colorado State University for analysis.

Results/Lessons Learned. The CCC data were used to generate high-resolution vertical profiles of VOCs, gaseous products, and geochemical parameters for each of the six sampling locations. Within the ZVI-mixed former source zone, soil mixing with ZVI appears to have effectively homogenized the former source zone and achieved adequate contaminant/reagent contact. The highest measured TCE concentration within the mixed-soil zone was 0.3 mg/kg (CCC data), a 99.9% reduction from the pre-mixing maximum concentration of 510 mg/kg (conventional coring data). Contaminant concentration rebound appears unlikely within the treated source zone due to the low contaminant mass remaining, ongoing apparent reactivity of ZVI toward TCE, and lack of heterogeneity within the treated soil zone. Downgradient of the treated zone, the CCC data suggest that heterogeneity is a key factor; the presence of chlorinated ethylenes in low-k zones, and assimilation processes occurring within these low-k zones, are likely to govern plume longevity. The presence of degradation products, including ethylene, suggests that ongoing biological degradation of TCE may be occurring within low-k zones.