Adaptive Adaptation: Flexibility of Recirculation to Accommodate Plume Change

Nick Miller (Nicholas.Miller@arcadis.com; Novi, MI)
Matthew Schnobrich (Lexington, KY)
David Sonders (Atlanta, GA)

Background/Objectives. An iterative approach to remediation was employed using dynamic groundwater recirculation (DGR) and enhanced reductive dechlorination (ERD) technologies to remediate a 1.7-acre chlorinated volatile organic compound (CVOC) plume within a shallow confined aquifer in southern Michigan. Trichloroethene (TCE) concentrations ranged from 10 micrograms per liter (µg/L) to 46,000 µg/L across the site prior to initiation of the recirculation program. Treatment incorporated continuous DGR recirculation with periodic carbon substrate (i.e. molasses) dosing to maximize both contaminant flushing and biological degradation processes. Upon observation of stagnation late in the dechlorination process, carbon substrate addition was discontinued to leverage stand-alone DGR to flush low-level residual CVOCs and provide dissolved oxygen to restore the native aquifer redox poise and foster aerobic vinyl chloride (VC) destruction. The objectives of this breadth of work were: 1) to remediate onsite TCE impacts to meet regulatory standards via ERD injections; 2) promote a hydraulic gradient to accelerate the cleanup time and extend the reach of the soluble carbon substrate addition by use of DGR technologies; and 3) test the viability of aerobically dechlorinating (VC).

Approach/Activities. DGR operations began in June of 2015, with approximately 2.6 million gallons of groundwater recirculated to date. Approximately 800 gallons (2,500 pounds) of concentrated molasses were periodically added to the injection stream. While operation of a DGR system is inherently adaptive, the operation of this system was unique in that system modifications were required to respond to performance changes, including: 1) the injection concentration of the molasses was continually optimized to mitigate ex situ biological fouling; 2) ex situ ferrous iron oxidation was employed to mitigate geochemical fouling; 3) operations were transitioned from anaerobic to aerobic processes to address elevated VC; and 4) a methane mitigation strategy was initiated to address fugitive migration.

Results/Lessons Learned. Adaptive site management was critical to capturing the collective benefit of both ERD and DGR. While ERD utilization increased overall operational costs, it translated to reduced remedial time. Recirculation processes enabled considerable expansion of the area of reactive zone influence, but required proactive process equipment cleaning and supplemental infrastructure to promote operational efficiency. Key illustrations of positive remedial outcomes include: 1) a significant reduction in TCE plume footprint combined with daughter product transformation and ethene generation; 2) enhancement of the hydraulic gradient across the treatment area to expand carbon substrate delivery and pore flushing; and 3) mitigation of fugitive methane generation. Collective operations resulted in the reduction of TCE in the primary source area from 46,000 µg/L to below detection limits within 10 months of operating the DGR system. Further, transition of recirculation operations from anaerobic to aerobic programs provided a means to collectively address residual VC and minimize secondary water quality changes within the plume.