Complex DNAPL Site 50-Year Plume Response to Successive Remedial Measures Employed with an Evolving Site Conceptual Model

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Background/Objectives. A 50-year old complex site has gone through progressive refinements to its site conceptual model (SCM), which have directly impacted three generations of site remedial actions. The project site is located in the Mississippi Embayment where 200,000 drums of pesticide manufacturing waste were disposed in shallow trenches creating one of this country's worst carbon tetrachloride groundwater contaminant plumes with large quantities of DNAPL thought to be present in both the vadose and saturated zones. Historically, insufficient data and data interpretation mistakes yielded incomplete and inaccurate SCMs, which resulted in incomplete and failed early generation remedies.

Approach/Activities. Key activities which have impacted the site's aquifers include waste disposal operations (1964–1973), impacted groundwater discharge to surface water (1975–present), landfill capping actions (1980, 1997, and 2016), groundwater extraction and treatment operations (1996–2003), and SVE treatment of the southernmost disposal areas (SDAs) (2009–2013). Multiple groundwater sampling events have been conducted at the site over the last 40 years, which provide a record of the groundwater conditions through time.
The initial SCM was developed in the 1960s and 1970s using data from a single deep borehole/well and a series of shallower boreholes/wells. It consisted of a sandy vadose zone, a sandy water table aquifer, an intermediate clay aquitard, a sandy confined aquifer, and a basal clay aquitard. In the early 1990s, the SCM was revised based on spurious mud rotary logged borehole data to a single water table aquifer system with clay stringers such that the designed and constructed groundwater pump and treatment system unknowingly cross-connected the highly impacted water table aquifer to the underlying essentially non-impacted leaky confined aquifer. The SCM was most recently revised in the 2000s based on reliable sonic borehole data to again include a two aquifer system. At that time, the groundwater extraction wells that cross-connected the two aquifers were plugged and groundwater pump and treatment operations were discontinued.

Results/Lessons Learned. The lateral and downgradient limits of the site's groundwater contaminant plumes have not changed in more than 30 years and are hydraulically contained by natural lateral and downgradient stream discharge zones. Changes in the unconfined aquifer plume footprint and intensity are apparent in a time series of eight carbon tetrachloride iso-concentration maps from 1978 through 2017. The site's unconfined aquifer carbon tetrachloride plume has progressed through three phases during its 50-year history: plume growth to lateral and downgradient hydraulic barriers, some plume mitigation during the pump and treatment phase, and finally some plume mitigation in areas downgradient of the SVE treated SDAs. Given the positive impact SVE remediation of the SDAs has had on the groundwater quality of that source area, SVE remediation is planned to be employed at the remaining, much larger Middle and Northern Disposal Areas prior to any further direct groundwater focused remediation. While peak carbon tetrachloride concentrations have decreased from a high of 64 mg/l (January 1991) to 24 mg/l (May 2017), carbon tetrachloride concentrations in groundwater are projected to remain above the remediation objective of 0.005 mg/l for hundreds if not thousand(s) of years.