

Using Modified Stiff Diagrams and 1,1-DCA as Conservative Tracer to Support Site Closure

Anja Verce (av@weiss.com), Trish A. Eliasson and Thomas J. Fojut
(Weiss Associates, Emeryville, California, USA)

Background/Objectives. Soil and groundwater at a former tire and auto maintenance shop in California (Site) have been affected by unintended releases of total petroleum hydrocarbons (TPHs) and chlorinated and aromatic volatile organic compounds (VOCs) from a 500-gallon waste oil underground storage tank (UST) and five in-ground hydraulic lifts. Results of soil and groundwater Site investigations conducted from 1990 to 2015 identified TPH diesel, aromatic VOCs benzene, toluene, ethylbenzene, and total xylenes (BTEX) and chlorinated VOCs tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane (1,1-DCA), cis-1,2-dichloroethene (cis-1,2-DCE), 1,1-DCE and vinyl chloride as Site chemicals of concern (COCs). A remedial over-excavation of the UST and hydraulic lifts was conducted in the 1990s, which resulted in the elimination of TPHs and BTEX as COCs; however, a mass- and diffusion-limited chlorinated solvent plume remains near the former waste oil UST. This plume is likely due to a limited residual source of chlorinated solvent mass that was adsorbed to low permeability clay soil in the vicinity of the former UST. Groundwater sampling data indicate the possibility that low concentrations of these VOCs may be present off-site in the direction of shallow groundwater flow. However, there are multiple VOC sources in the Site's vicinity. One data gap in close proximity to the Site is an undefined extent of a larger mass plume of PCE, TCE and cis-1,2-DCE in shallow groundwater, originating from a neighboring gas service station impacted by automobile service and possibly former dry cleaning equipment. In addition, the length of the chlorinated solvent plume emanating from the Site in the downgradient direction needed to be estimated before Site closure could be granted under the State Water Resource Control Board *Low-Threat UST Closure Policy (LTCP)* for petroleum related contaminants and the Regional Water Quality Control Boards (RWQCB) *Assessment Tool for Closure of Low-Threat Chlorinated Solvent Sites*.

Approach/Activities. Chemical 'fingerprinting' in the form of modified stiff diagrams and traditional hydrogeologic analyses were used to define the limits of the VOC plume affected by the Site. Based on the migration of 1,1-DCA, the most conservative Site contaminant, the VOC plume length emanating from the Site was estimated using U.S. EPA's *Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies* to assess impacts to downgradient surface water.

Results/Lessons Learned. The modified Stiff diagrams were a simple but yet powerful technique to differentiate among multiple sources of similar contaminants in groundwater. The Stiff diagrams of VOC analysis of groundwater samples taken from the Site and the neighboring gas service station show a markedly different chemical pattern. Groundwater samples from the Site exhibit a pattern of 1,1-DCA enrichment with minor presence of PCE and TCE, while the samples from the neighboring site show no presence of 1,1-DCA but significant concentrations of PCE and TCE. Using 1,1-DCA as the most conservative Site contaminant, plume length estimates indicate that maximum contaminant levels will be reached before the VOC plume could reach the nearest surface water body. Based on these and additional vapor intrusion investigations, a determination was made that under the current scenarios, the chlorinated solvent contaminant plume from the former waste oil UST poses a low threat to human health and the environment and water quality objectives will be achieved within a reasonable time frame, allowing for obtaining Site closure from the regulatory agency.