Unmixing Dual Aquifer Commingled Plumes with a Bifurcated Tail and Two Distal Discharge Points

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Background/Objectives. This ongoing case involves investigating, managing, remediating and allocating contributions for a 6,200-ft long commingled plume, 145 acres in area, which has impacted groundwater in residential wells, surface water and structures through vapor intrusion. Commingled groundwater contaminants include chlorinated ethenes, chlorinated ethanes, chlorinated methanes, 1,4-dioxane and MTBE/TBA/TAME. Impacted groundwater from multiple sources converges and drains into a unique buried valley aquifer formed over an extensional fault system, forming a dual aquifer plume where overburden contaminates bedrock in recharge areas and upwelling bedrock groundwater contaminates overburden in discharge areas along the fault system. The mixed plume bifurcates approximately 4,000 feet downgradient from the most upgradient sources and moves in two opposite directions; one side discharges to a stream that deeply incises bedrock and the other is actively migrating towards a golf course supply well located 2,000 feet away from the current distal end of the plume. One of our objectives is to make the case that all of our client's contributions follow only the pathway to the stream and not to the supply well. The challenge is that the compound driving the risk and remediation in both arms of the distal plume is TCE, which is common to our client's site as well as multiple offsite sources.

Approach/ Activities. Multiple lines of evidence to evaluate the potential contributions from several off-site sources were investigated and established by determining the hydrological characteristics of the plume, identifying off-site source locations and contributions, and applying forensic dating techniques. Our intrusive methods were limited by the fact that this mile-long plume underlies upwards of 200 residential homes. Non-intrusive mapping of the multiple buried valleys and the bedrock fault system was accomplished using seismic refraction, which informed the design of a minimally-sized monitoring network. Forensic techniques were applied to dissolved contaminants, including Compound-Specific Isotope Analysis (CSIA) for PCE, TCE, 1,2-DCE, and 1,4-dioxane, plume-front dating for various COCs, and the first-order decay rate ratio method for dating 1,1,1-TCA discharges using temporal daughter product (1,1-DCE and 1,1-DCA) concentration data. The complex of commingled plumes was also modeled in 3D using EVS, which will be presented.

Results/Lessons Learned. Our work on this case illustrates the importance of understanding complex groundwater flow regimes, surface water interactions, and the monitoring points and data gaps in 3D. Through the use of hydrogeological and transport principles, source location, concentration history, surface water impacts, and forensic analysis we defined the migration pathways of multiple VOC plumes and separated our client's molecules, to the extent possible, from other PRPs. We will discuss lessons learned on presenting these issues to regulators and implementing a remedial design specific to our client's contributions.