

Using High Resolution Site Characterization and Chemical Fingerprinting and Forensics to Develop Four-Dimensional Conceptual Site Models

Larry Mastera (Larry.Mastera@erm.com), Joe Fiacco, and Brett Shaver (ERM, Boston, MA, USA)

Background/Objectives. In the environmental consulting industry, it is generally accepted that high resolution site characterization (HRSC) tools should be deployed at complex contaminated sites to facilitate development of a rigorous conceptual site model (CSM). By definition, most of these complex sites are very mature and have two to three decades of historical data available for use. Because HRSC data are deemed preferable to lower-resolution data, the historical data are often overlooked or ignored. We have found that historical data can be very useful and, in many cases, critical to developing a rigorous CSM. Ideally, we use a collaborative dataset of older, lower-resolution data with newer, high-resolution data, but in some cases, we have been able to apply the lessons learned from interpreting dozens of HRSC datasets to optimize the value of historical lower-resolution datasets alone.

We have learned that applying chemical fingerprinting and forensics analysis within the context of applicable fate and transport principles allows us to develop much more accurate CSMs. We regularly use the contaminants themselves as tracers to help us understand the groundwater flow system. For sites where we have HRSC data, we can evaluate the mobility of remaining contaminant mass and the potential for that mass to cause risk or be available for treatment. In many cases, we rely more heavily on historical data to define release areas before degradation or remediation processes altered chemical signatures and remediation activities affected the distribution of contaminant mass or hydrogeologic system. In some cases, we have been able to track changes in chemical speciation along a groundwater flow path, confirming an otherwise uncertain interpretation of groundwater flow and contaminant migration.

Approach/Activities. When possible, we first develop geology and hydrogeology models by applying environmental sequence stratigraphy (ESS) when HRSC data are available, augmented by historical data, the scientific literature, and our understanding of relevant scientific principles. We integrate the geology and hydrogeology models with dynamic contaminant distribution models using chemical fingerprinting and forensics analysis. In some cases, the dynamic contaminant distribution models were verified with compound-specific isotope analysis (CSIA). For this talk, we will present data from two sites with complex histories of chlorinated solvent usage where we applied this approach: one overlying near-shore marine deltaic deposits and the other overlying proximal glaciolacustrine deposits. By using this approach, we were able to accurately map multiple source areas and solute plumes originating from both on- and off-site sources. We were also able to interpret evidence of biodegradation to either design a bioremediation strategy or to accurately map plumes, based on our knowledge of these processes and their effect on chemical fingerprints.

Results/Lessons Learned. We will present CSMs based on four-dimensional analysis of both HRSC data and traditional data sets. We will present how we used these models to develop CSMs that were then used to develop site-specific closure strategies. We will compare CSMs developed based on traditional approaches, i.e., compound-specific isoconcentration maps and uninformed groundwater elevation contours, to those developed with our approach. We will show how the CSMs developed using traditional approaches would unlikely lead to site closure outcomes obtained using our approach. We will also discuss the limitations of using HRSC tools

combined with chemical fingerprinting and forensics analysis, and insights on how to optimize this approach on future sites.