Optimization of Groundwater Recovery and Monitoring Network Facilitated by 3DVA and Innovative Hydrogeologic Evaluation Toolbox

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Background/Objectives. Optimization of long-term groundwater recovery and monitoring well operations often results in a lower future carbon-footprint through revised scale/frequency of activities or through incorporation of new aspects/components that result in a reduced remedial time frame. Optimization of these remedy components is being undertaken at the site of a chemical manufacturing facility with EDB-, EDC-, and chloride-impacted groundwater. The project objectives were to perform 3D Visualization and Analysis (3DVA) and hydrogeological evaluations to update the conceptual site model (CSM) in support of a larger groundwater recovery and monitoring well network optimization effort for the site.

Approach/Activities. A 3D visualization model (3DVM) and digital archive were constructed from existing historical reports, figures, and data. Plume fate and transport was established using the 3DVM based on density-dependent flow of groundwater, a factor that was previously overlooked. 3-D models of the hydrostratigraphic framework and groundwater plumes for contaminants of concern (COCs) were developed to compare their spatial distribution and reveal complex relationships. Data gaps in COC delineation at the site were identified using a proprietary 3-D visualization process to highlight areas of uncertainty for additional characterization. Visualizations developed to illustrate the refined CSM included interactive 3-D models, short movies/animations, and hydrogeochemical cross sections. New cross sections were created by slicing the 3DVM at strategic locations to illustrate hydrogeology, impacted groundwater isovolumes, flow nets, and transport pathways.

Results/Lessons Learned. 3DVA revealed that the contaminated aquifer underlying the site is comprised of a single unit and is not divided into discrete upper and lower zones, as previously conceptualized. Additionally, groundwater plume movement was found to be driven by density, following the upper surface of an underlying clay aquitard/aquiclude which includes a trough that potentially conveys contaminants off site. The use of 3DVA led to optimal citing of five new deep monitoring wells to address existing spatial data gaps in a portion of the aquifer with high uncertainty located downgradient of the former source areas. In addition, 3DVA facilitated selection of a subset of the existing groundwater recovery wells to be further evaluated for feasibility of rehabilitation and reactivation as part of groundwater recovery/treatment system optimization. A field program was developed for further inspection via downwell camera and geophysical tooling, hydraulic testing, and sampling of the recovery wells selected for redevelopment in the optimized system. Geological and analytical data collected from the field program will be used in the 3DVM to identify a location for a new recovery well. Operation of the new recovery well and the selected existing recovery wells will be designed to prevent COC migration off site while discontinuing use of redundant/inefficient recovery wells. Density-adjusted groundwater elevation measurements prior to and during operation of the recovery system will determine the extent of constituent capture. A 3DVM used as a digital archive and nexus for key spatial findings from decades of historical studies can be a vital tool for institutional knowledge storage and transfer, limiting the impacts of staff turnover. Utilizing a 3DVM as the starting point for all graphic-generation activities and spatial analyses throughout the project lifecycle can provide multiple advantages, including leveraging historical findings, reducing rework, and minimizing data gaps. A 3-D visualization-centered approach that conveys complex CSMs visually can build confidence among the project team that the CSM is well-

developed, facilitate regulatory approval of proposed remedial strategies, and improve communication with stakeholders, including the public.