Investigating field-scale properties and processes that influence uranium behavior at the Hanford 300 Area IFRC using advancements in electrical geophysical imaging

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Accurate modeling and prediction of system-scale uranium behavior in the Hanford 300 Area requires information concerning the distribution of sediment textural properties and how those properties govern physical and geochemical interactions between groundwater and Columbia River water. Electrical geophysical imaging methods have demonstrated utility for providing such information at relatively high resolution over large areas. Improvements in Electrical Resistivity Tomography (ERT) made possible through high performance computing and inversion code advancements were used at the Hanford 300 IFRC to better understand field scale properties and processes controlling uranium transport. Efforts initiated or completed in 2012 include 1) a high-resolution, 3D, geostatistically-constrained ERT characterization of the IFRC well field, 2) time-lapse imaging of river water intrusion into the 300 Area during spring high stage, and 3) time-lapse imaging of surface recharge and infiltration through the contaminated vadose zone.

The IFRC well field was implemented with a dense array of 840 electrodes, enabling high-resolution ERT imaging. Using parallel processing and custom imaging constraints that enable the integration of prior information on known electrical conductivity boundaries and subsurface structural features, a geostatistically accurate image of bulk electrical conductivity was generated and validated with core scale measurements. The results of this constrained inversion displayed a significant improvement over the standard inversion methodology, and revealed subsurface structure that likely plays a significant role in uranium transport. Most notable of these is a thin, spatially continuous, low permeability region dividing the saturated zone that may inhibit vertical contaminant migration. This same region contributed to vertical well-bore flows previously discovered by IFRC researchers.

Exploiting the electrical conductivity contrast between 300 Area groundwater and Columbia River water, SBR project DE-FG02-08ER64561 led by Rutgers University demonstrated the capability to image near-shore groundwater river-water interaction with ERT. In the spring and summer months of 2011 (March to September), 2D ERT arrays were deployed further inland to monitor river water intrusion toward the IFRC well field during high river stage using time-lapse ERT imaging. Results revealed a prominent preferred flow pathway into the 300 Area that is generally consistent with a depression in the lower aquifer boundary unit assumed to be a paleochannel, thus discovering a significant control on groundwater river-water interaction in the 300 Area.

Surface recharge could play a significant role in transporting residual uranium from the vadose zone to the water table, contributing to the persistence of the uranium plume in the 300 Area. Efforts are currently underway to monitor precipitation-induced moisture migration within the vadose using time-lapse surface ERT, cross-hole ground penetrating radar, and neutron moisture logging. Initial results show moisture moving downward relatively rapidly after moderate precipitation events, and stopping at the boundary between backfill and native 300 Area materials. This may indicate backfill materials act as a partial capillary barrier to vertical flow, at least within the IFRC well field region. This effort is ongoing.

Improvements in electrical geophysical characterization and monitoring capabilities enabled by the IFRC are providing information concerning subsurface structure and processes that govern uranium transport in the 300 Area. Ultimately, this information must be used to inform 300 Area flow and transport models. We see significant scientific opportunities in this regard through coupled hydrogeological/geophysical modeling, enabling the use of time-lapse geophysical data for model calibration.