Using Steam to Solve Groundwater Cooling Problems at TCH Sites

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Background/Objectives. The two most commonly used in situ thermal technologies are thermal conductive heating (TCH) and electrical resistance heating (ERH). Energy is delivered based on the subsurface thermal conductivity and electrical resistivity. The biggest challenge typically encountered is depth specific cooling induced by groundwater flow into or next to the thermal treatment area. The flow of groundwater will not only affect the heat-up and therefore remedial results of the high-flowing horizon, but also geological layers located above and below the zone affected by the flowing groundwater. Groundwater flow rates higher than approximately 0.5-1 ft/day (0.15-0.30 m/day) may be problematic for thermal remedies where TCH and ERH are utilized, because it can carry the heat away faster than it is delivered. If groundwater cannot be slowed down by controlling influx via pumping or a physical barrier, other options need to be considered. In these types of situations, the steam enhanced extraction (SEE) technology is the answer.

Approach/Activities. Steam is injected through screened wells – following the path of least resistance, and therefore will flow in the same zones as the groundwater. It will not only heat the permeable, flowing zones, but also help block the flow of groundwater, by filling the permeable zones with steam. Since the first combined TCH and SEE remedy in 2008, TerraTherm has implemented a total of 7 full scale projects where SEE was utilized to enhance the performance of the TCH systems. Different geologies has been targeted with the approach, including sites with major sand lenses imbedded in clayey horizons, clayey upper zones underlain by high flowing groundwater aquifers, and sites where steam was added to address shallow groundwater flow. The sites include combinations of both shallow and deep sites, and sites both inside and outside buildings. Furthermore the SEE component has been implemented at the sites utilizing different strategies, either planned operation of the steam system from the start of operation, installation of the steam system in the construction phase, but initiation of steam injection into the project, or adding on the steam component entirely in the middle of the project based on heat-up observations.

Results/Lessons Learned. Steam is a powerful tool at thermal sites to overcome excessive cooling as a result of groundwater flowing into the thermal treatment volume. In certain geological and hydrogeological settings the steam component will be the difference between success and failure. This presentation will focus on the input used to evaluate if steam may be needed to reach performance goals at thermal sites, and the associated design considerations are discussed. Examples from several completed combined TCH/SEE sites will be presented, each conducted in unique settings, and important lessons learned from these projects will be presented. Additionally, guidelines for when consultants and thermal technology providers should consider adding a steam component to their thermal design will be presented. This will include rule of thumb-style recommendations for acceptable groundwater flow velocities, and typical well design, spacing and injection strategies for the SEE component.