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Can Thermal Remediation Be Sustainable? Use of Modelling to Optimize Design

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Background/Objectives. Thermal remediation using steam enhanced recovery was evaluated for two sites impacted by light nonaqueous phase liquid (LNAPL). Both sites have similar geologies that are comprised of relatively high permeability sand and gravel deposits, with one site located in the UK and the other in the US. The targeted depths of treatment at the two sites range from 4 m below ground level (bgl) in the UK to 60m bgl in the US. Thermal modelling, using PC based PetraSimTM software, was conducted at both sites to evaluate the heating methodology and associated heat energy consumption, predict heating duration and determine the optimum well spacing and recovery mechanism to achieve the target treatment temperature (TTT) in the most energy efficient manner.

Approach/Activities. Two different methods of heating were assessed at the UK site. The application of combined steam injection and in situ thermal desorption (ISTD) was initially modelled to obtain a TTT of 150ºC, which could not be reached using steam alone, to enable contaminant recovery via volatilization. The model assumed 36 ISTD locations at a 6 m spacing to simulate 113kg/hr of heat input per well to the vadose zone, coupled with simultaneous injection of steam into six wells placed on 16 m on-center spacing within the saturated zone at a flow rate of 40 kg/hr of steam per well. A second model was conducted after data from a bench test suggested the LNAPL could be mobilized, rather than volatilised, at temperatures between 70 and 90ºC thereby enabling use of steam only. The second model assumed 19 injection wells (4 m ROI) at a flow rate of 79 kg/hr/well (1,500 kg/hr total).

At the US Site, two scenarios were modeled to evaluate total steam injection at rates of 2,050 and 5,000 kg/hr total flow, with a corresponding well spacing of 10 m (50 wells) and 14 m (41 wells), respectively. The objective of the model was to estimate the timeframe needed to achieve the TTT of 70ºC, the temperature required for LNAPL mobilization.

Results/Lessons Learned. At the UK site, the combined ISTD/steam injection scenario showed that the TTT would be achieved after 3 months, using a predicted energy consumption of 9,434,920 kg. However the use of steam alone predicted a much lower steam consumption of 3,285,000 kg was needed to achieve the reduced TTT within the same time frame, representing a 65% energy saving. This highlights the benefits of the bench test data to confirm the lower TTT, enabling a change to a lower carbon footprint heating method.

At the US Site, the TTT was predicted to be reached within a time period of 5 or 19 weeks, depending on well spacing and steam flow rates. The 19 week time period reflects lower steam injection rates and greater spacing of the injection wells, with an associated steam consumption of 6,543,600kg; however when steam flow rates were doubled and well spacing decreased, steam consumption decreased to 4,200,000 kg, a 35% energy reduction.

Data from both projects and modelling efforts will be presented to illustrate the energy, cost and time savings that can be made via the modelling process to optimize the balance of steam input

and well spacing. When combined with a bench test, sustainability can be further improved as seen at the UK site via a change in TTT allowing a change in heating technique.