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Title: Good Vibrations – An Innovative Approach to NAPL Increase NAPL Recovery

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Key Topic: Innovative Remediation Technologies

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Client Name: WEC Energy Group

Project Name: South Plant Remediation

Project Location: Waukegan, Illinois

Primary Ramboll Project Staff (Office): Ramboll Midwest

ABSTRACT

Background/Objectives:

Pump and treat under an optimized gradient was selected by the USEPA as the remedy for a site impacted with MGP residuals. A pilot extraction system was installed and operated to refine and optimize the design and operation of the full-scale system. The pilot extraction system was designed to remove DNAPL from the subsurface and evaluate potential treatment requirements.

Approach/Activities:

Ramboll Midwest evaluated several options to determine what technologies could be evaluated in the final weeks of the pilot test to increase the volume of NAPL extracted using the pilot system. Some literature review indicated that in the 1950s, scientists in the oil industry observed increases in oil production following earthquakes near petroleum reservoirs (Beresnev and Johnson, 1994). Subsequent observations of this phenomena were evaluated and in 1964 when scientists began laboratory investigations. More recently, Lovenetti, et. al (1994), Hartoz and Westerhoff (2010), Li (2006), and others have evaluated vibration enhanced mobilization of NAPL (or oil) as a remedial solution in laboratory or field settings. These studies have shown the potential for vibration to increase transport and recovery of NAPL. Vibrations were induced via a downhole pneumatic piston vibrator, powered by the same airline used to operate the DNAPL recovery pump. The range of frequencies identified in the literature that have been effective at enhancing NAPL mobility and recovery were between 50 Hertz (Hz) and 112 Hz. Vibrations were induced at three target frequencies (51, 64, and 75 Hz) for approximately four hours per day for three consecutive days. DNAPL thickness was gauged using standard site procedures and the frequency and amplitude of vibrations were assessed using geophones.

Results/Lessons Learned:

The amplitude associated with the 51 Hz trial was observed on the ground surface up to approximately 20 feet from the well, however the frequency resulted in no meaningful increases in DNAPL thickness in the EW01 well sump. The amplitude associated with the 74 Hz trial was observed up to approximately 30 feet from the well and resulted in no meaningful increases in DNAPL thickness in the well sump. Amplitude associated with the 64 Hz trial was observed up to approximately 50 feet from the well and resulted in an increase of DNAPL thickness from approximately 0.50 ft to 0.97 ft during the four days trial. This resulted in a total of 1.4 gallons of DNAPL accumulation in the well sump over the course of the test, or roughly 0.35 GPD. This flow rate does not appear significant, but when compared against the 0.6 GPD average DNAPL recovery rate from all wells during of the course of Phase 1, this increase of DNAPL recovery rate at one well resulting from vibration-enhanced recovery is notable. The vibrators selected for this trial were pneumatic bin vibrators which are not designed for submerged use. Vibrators functioned well during the first day of four hours of operations; however, the following morning the vibrator did not activate automatically when air was supplied. The vibrator did activate following a gentle hammering and ran continuously for the remainder of the 4-hour

operational period. It was hypothesized that water likely entered the vibration mechanism resulting in ceasing the moving components. Full-scale deployment would need to resolve this issue through either specification of a vibrator intended for submerged use or enclosure of the vibrator within a waterproof housing.

Aspect of Work that Relates to Sustainability:

This solution can potentially reduce the timeframe required for cleanup, thereby reducing energy consumption. The increased NAPL volumes reduce the amount of water being pumped and treated, reducing withdrawals from the aquifer and consumption of the treatment media.