Application of Screen Design for Horizontal Injection Wells

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Background/Objectives. Air sparge wells have been demonstrated as a reliable remediation approach to treat groundwater contamination, and horizontal directionally drilled (HDD) wells have long been used for this practice. In many cases horizontal wells allow for the placement of much longer screen section within a contamination plume than can be achieved in a vertical well orientation. While potentially treating a larger area, these long well screens must be properly designed to ensure desired injection rates along the entire screen.

HDD and horizontal wells are being improved with advanced drilling techniques, navigation systems and installation methods. However screen design often falls to a more seat-of-the-pants approach. This feeds the concern of disproportionate flow of air from the well screen with most air discharging from the initial slots of the screen. The objective of this research is to design, implement and monitor a screen design based on previously established fluid mechanics principles. Included is discussion of a highly monitored pilot test horizontal well. Implementing screens based on fundamental fluid mechanics theory advances our understanding of horizontal injection wells and our abilities to optimize well design.

Approach/Activities. Screen design is based on fundamental fluid mechanics principles. The first step in screen design was isolating discharge from one slot. This preliminary research was presented at the Battelle 2014 conference. Building our understanding of flow through one slot, a system design model was developed to predict discharge for a horizontal well screen. The screen design model was presented at the Battelle 2016 conference.

With the theory established and small-scale bench testing completed the model was ready for a real-world application. DTD and Sovereign Consulting teamed to design and install and carefully monitor a horizontal air sparge remediation well. The site of the pilot well is a decommissioned oil refinery in the mid-west. The local site geology consists of alluvial sandy soils below several feet of surface fill/rubble.

DTD designed a screen to discharge approximately 0.2 to 1.0 cfm per foot of screen. The total screen length is 150 ft and the screen is oriented horizontally at a depth of 45 ft below the ground surface. The well screen is located approximately 10 ft below water table. The horizontal well during the fall of 2016. After the horizontal well installation Sovereign Consulting installed vertical monitoring wells in the area. Horizontal well started up April 2017. During startup several different pressures were tested inside of the well to correlate operating well pressures to air discharge rates. Pressures were monitored at both the ends of the well in attempt to determine the variation in discharge from the start to the end of screen. Additionally, nearby monitoring wells measure pressure influences to determine zone of influence.

Results/Lessons Learned. A highly monitored horizontal air sparge well validates fundamental screen design. Operating at the design pressure produces an injection flow rate consistent with model prediction. Pressure drop along the screen is less than 0.5%, indicating uniform injection potential. Monitoring wells indicate that air is distributed along the entire length of screen, but variations in pneumatic conductivity in heterogeneous soils influences the zone of influence.

Application of fundamental screen design and detailed field monitoring increases our understanding of effective horizontal well design. A proper screen design aids in even distribution of air along the entire length of well screen.