Pilot-Scale Demonstration of the Horizontal Reactive Media Treatment Well (HRX Well™) for Passive In Situ Remediation

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Introduction

The horizontal reactive media treatment well (HRX Well™) is a novel *in situ* remediation approach for contaminated groundwater (GW) which involves the use of a horizontally drilled well filled with a porous reactive media. The well is installed in the direction of groundwater flow. Due to the "flow focusing" behavior resulting from the strong well-to-aquifer hydraulic conductivity difference, contaminated GW flows into the well and is treated as it passes through the reactive media. Treated GW then leaves the well through the down gradient portion of the well screen. This study aims to demonstrate and validate the HRX Well™ and associated design model. The technology, patented by Arcadis for *in situ* treatment of GW contaminants, is tested at the laboratory and field pilot scale using two different reactive media, granular activated carbon (GAC) and zero-valent iron (ZVI).

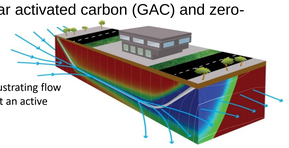


Figure 1. The horizontal reactive treatment well approach illustrating flow focusing and treatment under buildings and infrastructure at an active facility.

TASKS

Laboratory Tank System (LTS)	• Verify contaminant degradation • Simulate long-term weathering of ZVI in a 3-D transport system • Characterize any long-term hydraulic changes
Field Pilot Scale System (PSS)	• Verify existing reactive transport model

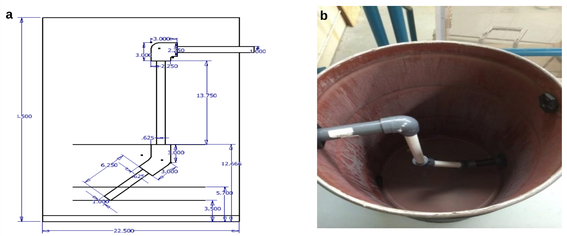


Figure 2. (a) Schematic diagram of the LTS, **(b)** photograph of the LTS.

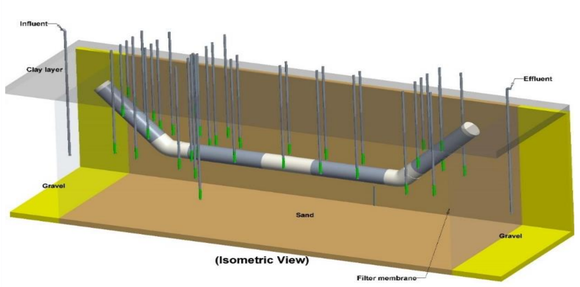


Figure 3. Representation of HRX Well™ PSS test pit design.

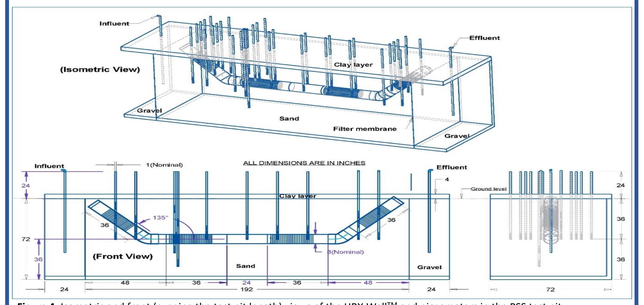


Figure 4. Isometric and front (running the test pit length) views of the HRX Well™ and piezometers in the PSS test pit.

Figure 5. (a) Photograph of fully packed well within the PSS test pit, and **(b)** Photograph of piezometer placement during test pit construction.

LTS Results

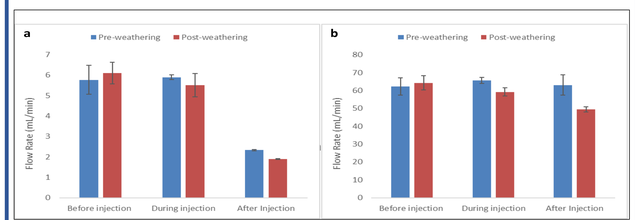
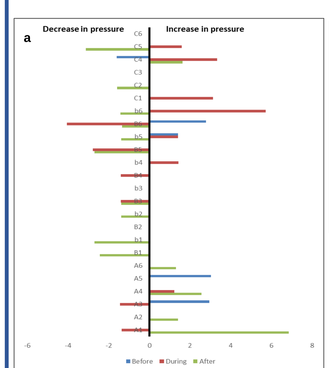


Figure 6. Flow rates (mL/min) through **(a)** the HRX well and **(b)** the aquifer before during and after tracer injection for pre-weathering and post-weathering tests.



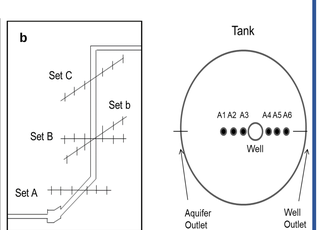


Figure 7. (a) Post-weathering change in manometer levels as % difference relative to pre-weathering conditions before, during, and after tracer tests. Bars appearing on the left of the y-axis indicate a decrease in pressure with weathering, and bars on the right of the y-axis indicate an increase in pressure with weathering. **(b)** Manometer placement within the LTS with depth (on the left) and aerial distance from the well (right).

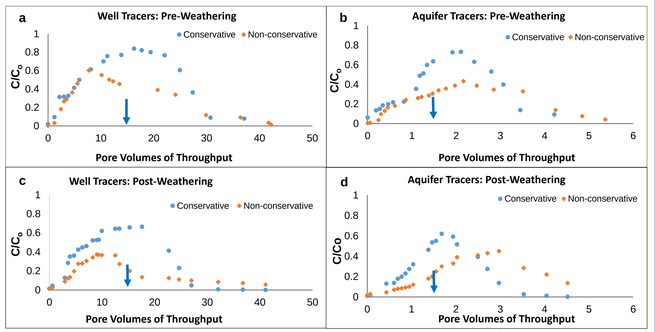


Figure 8. Results of tracer tests comparing the conservative salt tracer and reactive methyl orange tracer for the well **(a and c)** and the aquifer **(b and d)**, before **(a and b)** and after **(c and d)** weathering by ~100 PVs of flow through the well. Arrows note where introduction of tracer was stopped.

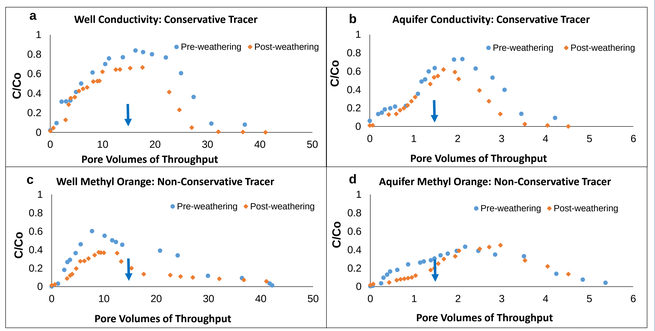


Figure 9 . Results of tracer tests comparing pre- and post-weathering for the well **(a and c)** and the aquifer **(b and d),** and for the conservative salt tracer) **(a and b)** and the reactive methyl orange tracer **(c and d).** Arrows note where introduction of tracer was stopped.

Pilot Scale System Results

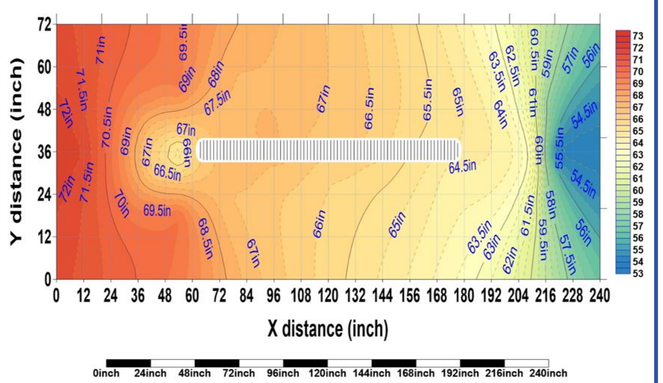


Figure 10. Contour plot of hydraulic head values measured at 40 points within the test pit. Water levels are in inches. The well capture zone is indicated by the steep gradient at the influent end of the HRX well, between 40 and 60 inches on the "distance" axis

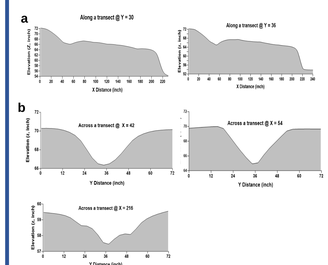


Figure 11. Cross-sections of water levels measured across the test pit; (a) across the length of the test pit at y = 30 and 36 inches (b) water levels across the width of the test pit at x = 42 inches (entrance to HRX well), 54 inches (one foot downgradient from well entrance, and 210 inches (at the exit of the well).

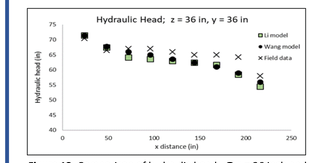


Figure 12. Comparison of hydraulic heads **@** z = 36 inch and y = 36 inch from PSS, Arcadis, and Clarkson models

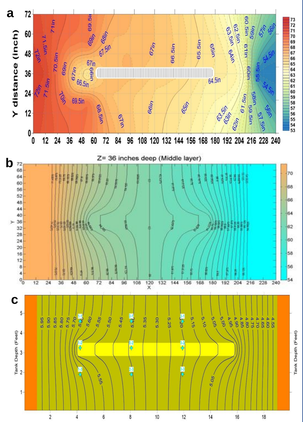


Figure 13. Comparison of contour plot of hydraulic head values heads **(a)** Clarkson field PSS measured at 40 points within the test pit. The well capture zone is indicated by the steep gradient at the influent end of the HRX well, between 40 and 60 inches on the "distance" axis, **(b)** Arcadis Model, and **(c)** Clarkson Model.

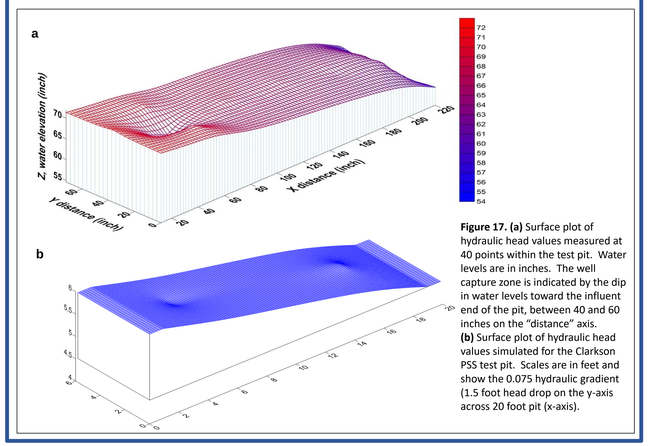


Figure 17. (a) Surface plot of hydraulic head values measured at 40 points within the test pit. Water levels are in inches. The well capture zone is indicated by the dip in water levels toward the influent end of the pit, between 40 and 60 inches on the "distance" axis.
(b) Surface plot of hydraulic head values simulated for the Clarkson PSS test pit. Scales are in feet and show the 0.075 hydraulic gradient (1.5 foot head drop on the y-axis across 20 foot pit (x-axis).

Key Points

- **Laboratory Tank System:** The HRX well captures and treats contaminated water. Flow decreased in both well and aquifer after 100 pore volumes of throughput, which simulated long-term weathering. Tracer movement was more affected by flow in both the well and aquifer than by weathering. Methyl orange was degraded by ZVI in the HRX well, and was not negatively impacted by weathering – rather, weathering increased reactivity.
- **Field Pilot Scale System**: The emplaced HRX well captured 39% of the flow through the aquifer. Measured capture corresponds well with the predicted capture, considering the uncertainty of test pit and well media porosity and *in situ* hydraulic conductivity. Results of measured water levels compares well to the 3-D test pit simulations.

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