# Numerical Groundwater Modeling to Support Biowall Injection Design and Cost Strategy

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**Background/Objectives.** A current focus area for in situ remediation involves injection techniques and creative applications to provide a technically superior treatment while improving efficiency and reducing cost. The design of these injections typically includes standard hydrogeological calculations, radius of influence estimates, and typical engineering practices. While these techniques are technically acceptable, advanced groundwater modeling can quantitatively improve the understanding of flow patterns, injectant distribution, and flow velocities during injection and recirculation. For this presentation three examples of numerical groundwater modeling are presented for: (1) injectate technical design, (2) cost modeling, and (3) post-injection transport modeling / field verification.

**Approach/Activities.** Numerical finite difference groundwater models were developed to test various substrate breakthrough time versus injection / extraction well spacing in support of a costing model for a biowall injection. Groundwater modeling was completed with MODFLOW 2005 and Groundwater Vistas (Environmental Simulations Inc.). Initial groundwater modeling was conducted under flow-only assumptions, without accounting for non-conservative transport processes such as dispersion and sorption. Simulated flow paths and distribution patterns were compared over temporal variations to reveal how injectate first arrival at an ROI was balanced with head limitations of the biowall media (limited depth and vadose zone). This demonstrated how to optimize the injection spacing, based on a cost model which included all relevant costs (well installation, injection time, and other direct costs). Sensitivity tests were completed to compare variability in porosities of the biowall material. Results were integrated into a cost model to depict the optimal well spacing. Lastly, breakthrough plots were used to calibrate an advection-dispersion model and provide field verification of assumed parameters (porosity, etc.).

**Results/Lessons Learned.** The results indicated that porosity is a sensitive parameter which may affect the results of the cost model. Based a variety of model runs the results indicated that costs are minimized at a well spacing of approximately 70 feet along the barrier wall. Furthermore, the slope of the cost increase is higher beyond the 70 feet spacing and therefore the cost is more sensitive to higher well spacing. Transport modeling provided an improved understanding of porosity and dispersion effects of the injectate.