Vertebrae™ Segmented Wells for Monitoring Contaminant Mass Discharge

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Background/Objectives. Contaminant mass flux/discharge provides a framework for identifying key source areas and downgradient transport pathways, presenting a representative measure of plume dynamics and risk to receptors. Additionally, mass flux/discharge provides a path forward for prioritizing sources, evaluating remedy options, and focusing remedial approaches. Consequently, long-term mass flux/discharge reduction is increasingly key to successful remedial strategies. New approaches that focus on monitoring mobile contaminant mass and measuring changes in mass flux/discharge over time will increasingly become more frequently implemented in the future. Flux-focused monitoring approaches are relevant for any type of contaminant source zone and will be particularly important for assessing the risk and migration activities for per- and polyfluoroalkyl substances (PFAS). The purpose of this ESTCP demonstration (ER20-5026) is to field validate the Vertebrae™ segmented nested horizontal well system (Vertebrae well system or VWS) for reliable long-term monitoring of contaminated mass flux/discharge from source zones and high-concentration areas and for quantifying changes in mass flux/discharge over time as a result of remedy actions and other plume dynamics. Flux measurement methods specific to the VWS will be developed and demonstrated through field testing and method comparisons.

Approach/Activities. The VWS is installed in a single small diameter horizontal bore that contains multiple isolated screen segments; essentially it is a multi-port well installed horizontally. The VWS is unique with many discrete zones running horizontally along its length with separate, small diameter tubing plumbed from each screen to the surface. Tremied grout is used to isolate the individually tailored screen interval lengths. The Vertebrae technology can be applied as a variation of the conventional vertical well transect approach and can be implemented as a complement or alternative. The difference is the monitoring points are installed horizontally instead of vertically, improving coverage along the width of the plume at targeted depths with highest concentrations or flux. The approach is novel and advantageous as multiple closely spaced measuring points across a transect can be easily installed from a single boring (reducing costs) and contaminant zones that may have been previously inaccessible via vertical boreholes can be characterized. An accurate understanding of contaminant distribution within the site hydrostratigraphy is still required to optimize placement of the horizontal wells and to select target intervals for monitoring zones. High resolution site characterization data were utilized to develop a baseline mass flux/discharge determination for a transect downgradient of a source area and to determine optimal placement of the horizontal wells. Mass flux/discharge determinations from data collected from the VWS were completed using Earth Volumetric Studio™ software as well as tabulated based on estimates of hydraulic conductivity, Darcy flux, and gradient from field methods including hydraulic profiling borings, hydraulic and tracer testing, and fiber optic distributed temperature sensing.

Results/Lessons Learned. Three 500-ft long VWS were successfully installed with the screen intervals successfully placed within target high concentrations/flux zones. The VWS were used to obtain quarterly precise and repeatable mass discharge measurements over the one-year monitoring period. The technology is generally applicable to any type of groundwater contamination and can support more reliable risk assessment and remedy performance assessment and optimization activities.