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PFAS In-situ Stabilization Treatability Test Work

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Background/Objectives. Poly-and-Perfluoroalkyl Substances (PFAS) include persistent, soluble fluorinated compounds that potentially present a risk to human health and the environment. The application of Aqueous Film-Forming Foams (AFFF) containing PFAS, in particular prolonged application at firefighting training areas, has resulted in long-term sources of PFAS leaching into soil and groundwater. The risk from these persistent and bioaccumulative compounds can be mitigated by reducing their mobility in the subsurface. A treatability test program was designed to explore the in-situ stabilization (ISS) of PFAS in soil and groundwater using commercially-available adsorption media. Physical removal via excavation and groundwater extraction with aboveground treatment are the current state of the practice for management of PFAS source zones. ISS presents an alternative that eliminates ex-situ management of PFAS wastes while protecting groundwater from future leaching. ISS consists of the use of augers and cutting tools to mix soil, water, and reagents in place in the vadose and saturated zones. ISS is a highly-effective method for accessing source mass because it homogenizes soil, reduces geological anisotropy, and provides immediate access to soluble PFAS stored in low-permeable strata. The ISS reduces leachability through stabilization with a reagent and solidification with cement to encapsulate and reduce permeability.
Laboratory tests were conducted with four objectives: 1) establish basic adsorption performance of selected media for PFAS, 2) test performance as a function of pH, 3) compare performance with and without cement, and 4) obtain leachability data to demonstrate potential long-term stability of in-situ treatment.

Approach/Activities. Bulk soil and groundwater samples were collected from an airport site in Australia known to be impacted with PFAS from AFFF use. Three commercially-available media were selected for the test program based on their potential for adsorption of anionic PFAS: Aluminum Hydroxide (AlOH)/Carbon Blend, Pyrolised Cellulose, and Modified Clay. The program consisted of batch contact tests of impacted soil and groundwater mixed in a Liquid/Solid Ratio of 2:1. The batches were mixed on a linear mixing table for 18 hours. Control and duplicate batches were run and pH was monitored at points along the process. After mixing, samples were separated and filtrate samples were analysed for a PFAS suite of 28 compounds using LC/MS/MS method at an accredited commercial lab in Australia. Larger batch contacts were run with soil and groundwater to simulate in-situ soil mixing. Leachability tests were then conducted on treated batches with and without cement.

Results/Lessons Learned. All three reagents tested, AlOH/Carbon Blend, Pyrolised Cellulose, and Modified Clay, demonstrated effective adsorption of PFAAs and have potential for stabilization of PFAS. Modified Clay demonstrated the best removal of sulfonates PFHxS and PFOS which were the main contaminants. The result at the lowest dosage of 5wt% represents better than 99.90% reduction in dissolved-phase concentration. The AlOH/Carbon Blend demonstrated the best overall removal of carboxylate compounds, particularly for short-chain PFCAs such as PFBA. The Pyrolised Cellulose behaved similar to activated carbon and showed a significantly less removal capacity of short-chain PFAAs compared to the AlOH/Carbon Blend and the Modified Clay. The sequential leaching test with treatment by

Modified Clay exhibited up to two order-of-magnitude decrease in leachability over the control sample. The overall mass of PFAS leached was approximately 1% of the total PFAS mass after an estimated 50 pore volumes of leaching. The test work simulation of in-situ soil mixing with stabilisation demonstrates the strong potential of this technology as an effective tool for mitigating migration of PFAS through soil and groundwater.