A Comprehensive Mass Balance Approach to Quantify Subsurface Natural Losses and Optimize Remediation System Operation

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Background/Objectives. During the early stages after a petroleum hydrocarbon release, contaminant plumes can exhibit characteristics of migration and engineered systems are often installed to physically remove and/or change the composition of light non-aqueous phase liquid (LNAPL). The combined benefits of source reduction by active remediation and re-equilibration time (including growth and acclimation of biodegrading microorganisms) lead to a stable and often receding contaminant plume. At this time, reduced yields of contaminant mass from the remediation system are commonly observed, along with increasing unit costs for operation and maintenance. At this middle stage, remediation teams begin considering remedy transition, or switching to a more effective approach. This presentation presents a mass balance approach that can be used to document LNAPL source and plume attenuation, mass losses, and mass flux. It integrates various existing tools to seek answers to the following common questions:

1. Can I turn off my groundwater extraction and treatment system; are natural processes alone capable of controlling plume migration?
2. How much additional mass removal is the engineered system accomplishing over natural processes?
3. What is the delta or deficiency in natural losses and resultant mass flux that the engineered system must be designed to capture?

Approach/Activities. The proposed analytical approach includes quantification of: (a) natural source zone depletion (NSZD) losses following American Petroleum Institute, 2017; (b) the aquifer biological assimilative capacity following National Research Council, 2000; (c) dissolved contaminant mass flux following Interstate Technology and Regulatory Council (ITRC), 2010; (d) LNAPL mobility following ITRC, 2009 (update pending publication in 2018); and (e) dissolved contaminant trends following United States Environmental Protection Agency, 2011. This novel approach will include a hypothetical scenario on how to integrate results of each analysis into a revised conceptual site model and mass balance. The mass balance is used to understand the net effectiveness of natural processes and its effect on plume dynamics, with a focus on interpretation of the need for additional active remediation measures to stabilize hydrocarbon plumes. The approach and activities implemented, their similarities and differences included, will be described in the presentation.

Results/Lessons Learned. The approach successfully informed the project teams to optimize their remedial strategies, and transition away from a groundwater extraction and treatment system. Findings of this work are consistent with others, such that NSZD rates for middle to late stage petroleum release sites are significant, contaminant mass flux is limited, and, where necessary to stabilize hydrocarbon plumes, the need for engineered remediation systems can be focused on relatively small areas to achieve the largest reduction in risk. The case studies presented also show that rates of NSZD and aquifer assimilative capacity far exceed mass removal from active remediation systems. This calls into question the need for active remediation where institutional controls are acceptable, for example.