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Empirical Study to Estimate the Air Exchange Rate Within a Trench for Modeling Inhalation Risks

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Background/Objectives: Human health risk assessments require the evaluation of existing and future exposure pathways and receptors. This often includes an evaluation of construction worker exposure to volatile constituents migrating from contaminated soil and groundwater into a trench (“trench scenario”). Evaluation of the trench scenario can be tied to assessment of the vapor intrusion pathway since many of the same data and analytical techniques may be applied to both. The trench scenario may represent a “worst case scenario” for construction worker exposure since air flow into and out of the trench is limited because the width of the trench is narrower than the depth. The trench scenario can be a human health risk driver, particularly for sites with large contaminant footprints, and often requires the use of institutional or engineered controls to manage risks. Therefore, it is important to develop a methodology for evaluating the trench scenario that more accurately predicts exposure concentrations so that the risks can be better understood and the need for engineered or institutional controls applied more appropriately.

Approach/Activities: While many of the pathways evaluated as part of a human health risk assessment (e.g., direct exposure via dermal absorption or ingestion) have well-defined exposure parameters to estimate the exposure concentration and subsequent risk for a receptor, this is not the case for the trench scenario. Many practitioners estimate the inhalation exposure point concentration by combining a vadose zone model to estimate transport of vapors from the source into the trench, with a box model to estimate the exposure point concentration following mixing of the volatile constituents with atmospheric air in the trench. There are two primary assumptions that must be made: (1) the trench dimensions and (2) the air exchange rate within the trench (typically expressed in air changes per hour, or “ACH”). Industry best practices and professional judgement can be employed to constrain the modeled trench dimensions and regulatory agencies have recommended using a default air exchange rate of 2 ACH for trenches that are deeper than they are wide (VDEQ, 2016). These default air exchange rates are based on historical studies of air flow between tall buildings in an urban setting, but have not been substantiated by measuring actual air exchange within a trench. Therefore, a field study was performed to measure the air exchange rate within a series of trenches to provide more representative default air exchange rates. Trenches were installed over a light nonaqueous phase liquid (LNAPL) source on a former refinery with no impediments to air movement (e.g., above grade structures in proximity to the trenches). Meteorological data, with an emphasis on wind direction and speed, were continuously monitored throughout the study to understand the relationship of ACH with meteorological factors.

Results/Lessons Learned: The default air exchange rate for trenches of 2 ACH was determined to be overly conservative, resulting in gross over estimations of inhalation risks for a construction worker working in a trench. The estimated air exchange rates were between 34 and 79 ACH, with an average of 46 ACH, when relatively low wind speeds (between 3.5 and 7 mph) were present. Use of these empirically derived air exchange rates would be applicable at any site with comparable meteorological conditions and would be conservative for sites with higher average ambient wind speeds.