Abstract: Dilution-Attenuation Factors at Fuel Hydrocarbon Spill Sites Technical Background Document and Recommendations

Dissolved-phase fuel hydrocarbons being transported by groundwater are subject to dilution and attenuation process as they move through the soil environment. Dilution is caused by hydrodynamic dispersion and results in the spreading and reduction in maximum concentration of a contaminant plume downgradient of the source area. Dilution does not reduce the mass of contaminant in the aquifer. Attenuation of fuel hydrocarbons in groundwater is caused primarily by biodegradation. Attenuation reduces the mass of contaminant in the aquifer, which causes a reduction in concentration downgradient of the source area.

The combined effect of dilution and attenuation may be referred to as the "dilution-attenuation factor" (DAF), which is defined as:

DAF = dilution factor * attenuation factor
= concentration in source area/concentration at downgradient location of interest.

DAFs are useful because they relate the dissolved concentration in the source area to the dissolved concentration at downgradient locations. They can be used in "forward calculations" to assess potential risk at a downgradient location, and in "backward calculations" to assess the concentrations in a source area that presents acceptable risks. Use of a DAF to assess soil cleanup levels requires that the DAF be mathematically formulated to address the compliance point, and that the DAF calculation accurately represents the site conditions and physical processes occurring at the site. The existing ADEC calculation does not meet these requirements for fuel hydrocarbon contaminated sites.

The ADEC uses a DAF in the migration-to-groundwater exposure pathway calculation to assess the concentration in a source area that would cause groundwater contamination above the maximum contaminant level (MCL) or a risk-based standard within a mixing zone located at the downgradient edge of the source zone. The ADEC DAF and migration-to-groundwater calculations assume that the source area is entirely within the vadose zone; allow the mixing zone depth to increase as the source length increases; use a fixed attenuation factor value for all compounds; and assume partitioning only between the dissolved, vapor, and adsorbed phases.

This document presents an alternative DAF calculation that may better support ADEC objective of protecting groundwater. The alternative DAF calculation uses a fixed mixing zone depth; accounts for the presence of a source within the saturated zone; and allows a fixed attenuation rate or a first-order biodegradation rate for dissolved contaminants exiting the source zone upgradient of the compliance point.

Note that the DAF is not typically used in the calculation of risk—rather measured groundwater concentrations are used to assess risk. Also note that if measured groundwater concentrations and predicted groundwater concentrations using the DAF do not agree, then the true DAF at the site is likely different than the DAF used in the predictive calculation.

This document provides background information on dilution and attenuation processes; provides a sensitivity analysis for the ADEC DAF calculation and the proposed alternative DAF calculation; and uses the computer model Modflow and MT3D to help visualize dilution and attenuation at contaminated sites.