

**Guidance for the Evaluation of Immobile Chemicals for the
Impact to Ground Water Pathway**

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I. Introduction

This guidance provides procedures that the person responsible for conducting the remediation may use to evaluate potential impacts to ground water from immobile chemicals. Scientific evidence suggests that some chemicals become more resistant to desorption from soil as contact time increases (Loehr and Webster, 1996; Alexander, 1995; Pavlostathis and Mathavan, 1992). Chemicals that have relatively low transport potential due to their high soil adsorption coefficients, may over time, become irreversibly adsorbed to soil and therefore immobile under normal conditions (Alexander, 1995). Therefore, it can be assumed that these chemicals do not pose a threat to ground water if an adequate zone of clean soil exists between the contamination and the ground water.

If the person can not demonstrate that a contaminant is an immobile chemical or if conditions at the site could cause the contaminant to become mobile, the person is required to develop a site-specific soil remediation standard for the impact to ground water pathway using other guidance that is available from the Department and remediate the soil contamination.

Due to the information that is required to use this guidance, it is only appropriate to conduct this immobile chemical evaluation when the remedial investigation has been completed.

II. Background

To determine which regulated chemicals could be considered immobile, the Department ran several simulations using the SESOIL model (Bonazountas and Wagner, 1984). The basis of the SESOIL model is discussed in another guidance document entitled Using the SESOIL Transport Model to Assess the Impact to Groundwater Pathway. The Department ran the model using the same generic environmental conditions and soil properties that were used for the development of the inhalation soil remediation standards. The Department chose to use the soil properties of a sandy loam soil. The Department assumed that the soil was homogeneous, the organic carbon content was set to a generic value of 0.2% (w/w), and the Freundlich exponent was set to one. For the weather parameters the Department selected a central New Jersey weather station (Trenton, NJ) as an intermediate location between northern and southern New Jersey. The vadose zone was assumed to be 10 feet thick, and 1 foot soil layers were designated. Input parameter values relevant to contaminant transport potential in the soil column are provided in the table below:

SESOIL modeling parameters	
<i>Parameter</i>	<i>Value</i>
Groundwater Depth (ft)	10
Bulk density of soil (g/cc)	1.5
Number of soil layers	2
Soil sublayer thickness (ft)	1
Intrinsic permeability (cm)	2.00E-09
Effective porosity (v/v)	0.25
Disconnectedness index	4
Time increment (days)	1
Length of run (years)	100
Climate station	Trenton, NJ
Organic carbon content	0.20%

The Department conducted several simulations using a model chemical. For these simulations, all chemical properties except the organic carbon (K_{oc}) were set to values that would maximize leaching potential (the Henry's law constant and the diffusion coefficient were set to 1E-6). Then, the Department conducted several simulations with different values for the K_{oc} parameter.

Simulations were conducted for a 100-year time period. This time period was selected because it is near the upper limit of human life expectancy and transport is not likely after this length of time because these chemicals would become irreversibly adsorbed. (The time period for reduced desorption to occur has been reported to be on the order of weeks or months for several chemicals (Loehr and Webster, 1996; Alexander, 1995; Pavlostathis and Mathavan, 1992)). The distance that the model contaminant was predicted to move over a 100 year time period was tabulated for varying K_{oc} values.

Under these conditions, the SESOIL model yields an annual average recharge to groundwater of 11 inches/year, equivalent to the value estimated using the New Jersey Geological Survey infiltration estimator (see Basis and Background document for the inhalation soil cleanup standards regulations).

Simulation results indicated that chemicals with K_{oc} values greater than or equal to 50,000 L/kg (equivalent to a K_d value of greater than 100 L/Kg) moved vertically 11 inches or less during the 100 year simulation period (see table below):

K_{oc} (L/kg)	<i>Distance moved (inches)</i>
100,000	3.6
80,000	5.4
50,000	10.9
30,000	20.5

The Department has determined that the following chemicals are likely to be strongly adsorbed to soil and are, under certain conditions, not likely to impact ground water.

Immobile Chemicals

Aluminum	Di-n-butyl phthalate
Copper	Chlordane
Lead	Chrysene
Vanadium	DDD
Aldrin	DDE
Benzo(a)anthracene	DDT
Benzo(a)pyrene	Dibenz(a,h)anthracene
Benzo(b)fluoranthene	Di-n-octyl phthalate
Benzo(ghi)perylene	Fluoranthene
Benzo(k)fluoranthene	Heptachlor
Bis(2-ethylhexyl phthalate)	Hepachlor epoxide
Butyl benzyl phthalate	Hexachlorobenzene

Hexachloro-1,3-butadiene
Hexachlorocyclopentadiene
Indeno(1,2,3-cd)pyrene
Methoxychlor

PCBs
Pyrene
Toxaphene

III. Procedures for the Evaluation of Immobile Chemicals

The person responsible for conducting the remediation will not be required to remediate soil contaminated with immobile chemicals if the person can demonstrate the following:

1. The contaminant is an immobile chemical listed above;
2. That site conditions described below are not present; and
3. There is a clean zone of at least 2 feet between the soil contamination and the ground water. Sampling must be conducted to demonstrate that contamination is not present above the default impact to ground water soil remediation standard within 2 feet of the water table. The default standard can be determined using the Soil Water Partition Equation guidance document.

Site conditions not compatible with immobile chemical determination

There are several site conditions that can effect the ability of the “immobile” contaminants to migrate to ground water. A contaminant will not be considered an immobile contaminant when any of the following conditions exist:

1. The contaminant was discharged as part of a mixture that could effect the mobility of the contaminant;
2. A co-solvent is present that could effect the mobility of the contaminant;
3. Soil texture at the site is more coarse than a sandy loam, e.g. classified as sands, or if fill material at the site is more coarse than sandy loam;
4. Soil pH has been altered by the discharge of acids or bases; or
5. The contaminant of concern is present at levels associated with free or residual product.

IV. Submission Requirements

The person responsible for conducting the remediation must submit the following information to support their evaluation of immobile chemicals at the site:

- Soil boring logs;

- Analytical results from all soil samples, including samples collected from the 2-foot zone between the contamination and the seasonally high water table;
- A table comparing analytical results with the site specific Impact to Ground Water Soil Remediation Criteria; and
- Discussion and evaluation of all conditions identified in this guidance, including supporting documentation.

V. References

Alexander, M. (1995). How Toxic are Chemicals in Soil? *Environ. Sci. Technol.* 29(11):2713-2717.

Bonazountas, M. and Wagner, J.M. (1984). SESOIL: A Seasonal Soil Compartment Model, Draft Report. Office of Toxic Substances, U.S. Environmental Protection Agency: Washington, DC, PB86112406.

Loehr, R.C. and Webster, M.T. (1996). Behavior of Fresh vs. Aged Chemicals in Soil. *J. Soil Contamination.* 5(4): 361-383.

Pavlostathis, S.G. and Mathavan, G.N. (1992). Desorption Kinetics of Selected Volatile Organic Compounds from Field Contaminated Soils. *Environ. Sci. Technol.* 26(3): 532-538.