

# GROUNDWATER & ENVIRONMENT NEWSLETTER

A PERIODIC NEWSLETTER COMPILED  
FOR HYDROGEOLOGICAL &  
ENVIRONMENTAL PROFESSIONALS  
IN W.A. INDUSTRY, MINING &  
RESOURCE COMPANIES

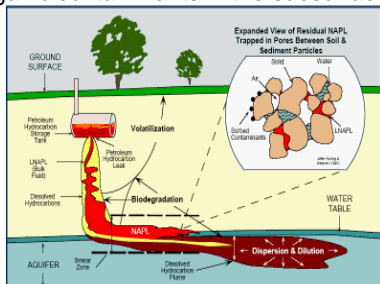
Issue August 2009

## Remedial Options for Hydrocarbon Contaminated Aquifers

Organic contaminants in surface or groundwater pose a serious risk to due to their persistence and toxicity at low concentrations. They may be either less dense (i.e. 'lighter') than water, & hence float on the water table (e.g. most hydrocarbons/ petroleum/ diesel/ paraffin/ oils etc), termed Light Non-Aqueous Phase Liquids, or may be denser, & sink through the water table & accumulate at the aquifer base (e.g. solvents, pesticides), i.e. L/DNAPL.

Hydrocarbons released at the ground surface can migrate downwards through the vadose (unsaturated) zone and accumulate within the capillary fringe above the water table. LNAPL or 'free-product' floats on the water table as Phase Separated Hydrocarbons (PSH), forming a distinct phase (e.g. contaminant/ water/ air) within the aquifer. PSH may then form an ongoing source of dissolved phase contaminants to impact on groundwater quality.

Several processes influence the fate of organic contaminants in the subsurface.



Source: API

The recovery of hydrocarbons from aquifers can be complicated as LNAPL may be trapped in pore spaces, retained within the capillary fringe or in non/ poorly connected fractures.

### Groundwater Remediation

The main steps in the decision process include:

- Source identification/ removal
- Plume delineation
- Determining remedial objectives
- Choosing the best remedial process

### Source Identification/ Removal

The site & spillage history needs to be assessed, including the source (e.g. leaking tank/ pipeline) & nature (e.g. fuel) of the contamination, whether it is fresh or old/ degraded, whether it is a single 'slug', (i.e. one-off) or, where leakage is ongoing, it must be stopped.

### Plume Delineation

Once hydrocarbons reach the water table, a plume of PSH and/or dissolved phase contaminants may develop. A site investigation including monitoring bores is needed to assess the extent of the plume & the aquifer properties.

### Determining Remedial Objective/s

The degree to which clean-up is needed & selection of the best remedial method depends on the sensitivity of groundwater usage (e.g. abstractions/ dependent ecosystems/ discharge to water courses) & possible site uses post remediation.



The initial requirement of regulatory authorities is the removal of any non-aqueous phase liquids to the maximum extent practicable so that there is no remaining source of contaminant in the aquifer. Clean-up goals/ targets are set during the development of a Remedial Action Plan (RAP) for the site.

### Remedial Process Selection

Selection of the most suitable remedial process depends on:

- Hydrogeological/ aquifer setting
- Contaminant physical properties (e.g. L/DNAPL, volatility, viscosity/ mobility)
- Identified risks to other users or the environment
- Chemical properties (e.g. solubility, sorption)
- Land use (current/ proposed)
- Access to the aquifer
- Risks (toxicity etc)
- Time constraints
- Relative costs
- Regulatory approval

### Numerical Modelling

Models are developed to predict the movement of contaminants & groundwater, to assess the risk to other downgradient receptors, & to assess the response to pumping/ vacuum extraction etc. This allows a recovery design to be optimised, prior to construction. Additional bores & monitoring may be needed to test the model predictions.

### Remedial Options

Remediation of hydrocarbon contaminated groundwater involves removing the source of hydrocarbon as a priority and then removing or containing the plume of contaminants within an aquifer. Many methods have been devised and used to treat the many types of contaminants in a wide variety of aquifer systems, including:

- Groundwater Pump and Treat (P&T)
- Air Sparging
- Vapour Extraction Systems
- Permeable Reactive Barrier ('Reactive gates')
- Bioslurping
- Bioremediation using Oxygen Releasing Compounds (ORC)
- Bioremediation Using Hydrogen Releasing Compounds
- Monitored Natural Attenuation (MNA)

We will review the applicability & pros/cons of these techniques in future newsletters.

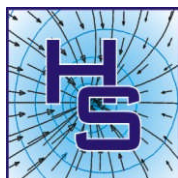
### Next issue –Groundwater Pump and Treat



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