IEG Technical Briefing Note No. 9

Multi-Functional Well - IEG MFW™

The **IEG Multi-Functional Well™** (IEG MFW™) has been implemented for the remediation of subsurface contamination caused by hydrocarbon spills. Four different remediation processes can be operated within the same well. At optimal efficiency of each remediation process, successive treatment of the capillary fringes, the vadose zone, and the aquifer can be accomplished. Each treatment process requires only simple modifications of the well configuration. Removal of the contaminants is done primarily through in situ air stripping. The oxygen supplied through the stripping process and additional air injection wells further enhances biodegradation of the contaminants.

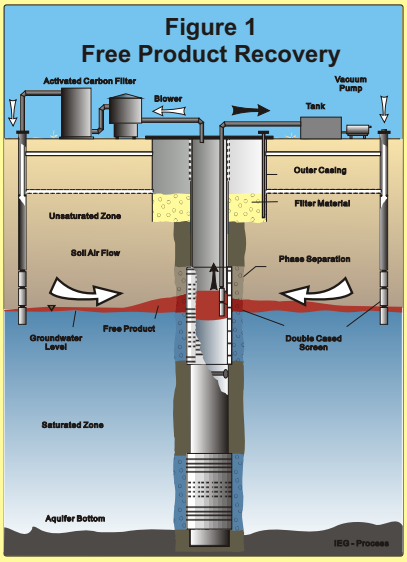

Figure 1
Free Product Recovery

1. Free Product Recovery

Free product floating on the groundwater is removed by applying a vacuum without having to pump groundwater. Free product moves in the direction of the negative pressure gradient (5 - 8 kPa) towards the well in which it accumulates (Figure 1).

In order to control the applied vacuum and thus the amount of oil flowing, an adjustable inner tube is arranged inside the well in such a way that the middle screening section is nearly covered by groundwater and the free product floating on top. Because the free product is flowing towards the well continuously, no high air velocities are required for its transport.

A vacuum pump produces a vacuum inside a receiver tank and the attached piping which is connected to a double-cased screen containing hydrophobic material. The free product is thus transported to the surface. Because no cone of depression is created a downward movement of free product is prevented.

The **IEG MFW™** is an in situ system for the remediation of hydrocarbon contamination in the unsaturated and saturated zones (Figures 1 - 4) using a combination of chemical, physical and biological processes. The system consists of a specially configured inner well (e.g. diameter = 400 mm) with screened sections which are separated by unscreened casings and packers. Additionally, pumps, a stripping reactor under vacuum, and a free product recovery system, operated under vacuum, are required. An outer well casing which forms the treatment chamber (e.g. diameter = 1,000 mm) is arranged coaxially around the inner well and extends from the ground surface down to a depth of approximately 1.0 m. A blower, an off-gas treatment system (e.g. activated carbon filters), a contaminant storage tank, and a vacuum pump are located above ground. Several air injection wells are arranged within the sphere of influence of the **IEG MFW™.**

The well screens are located within the unsaturated zone, near the groundwater table or the capillary fringe, and at the bottom of the contaminated aquifer. Contaminated soil vapour can be removed from both upper screen sections, or from each section separately. Reinjection of the air after its decontamination above ground is also possible, thereby creating a vertical air circulation flow. Alternatively, treated soil vapour can be reinjected through additional air injection wells, thereby creating a horizontally directed air flow. Contaminated groundwater is pumped from one section, and after treatment in the stripping reactor, located in the well head, reinjected into one of the upper screens, thereby inducing a vertical groundwater flow. The circulating flow creates a vertical pressure gradient and forces a vertical movement of the groundwater instead of a simple horizontal flow through highly permeable layers. The flow direction can be reversed depending on the vertical distribution of the contaminants.

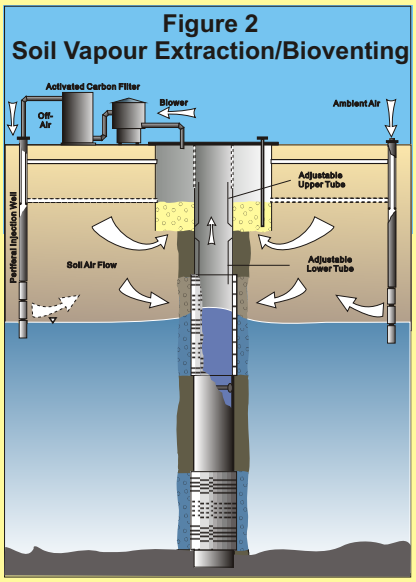

Figure 2
Soil Vapour Extraction/Bioventing

2. Soil Vapour Extraction / Bioventing

In this treatment step the volatile hydrocarbons can be removed from the unsaturated zone by soil vapour extraction. Additional air injection wells arranged in the zone of influence are operated to provide a continuous supply of oxygen enriched air to the subsurface to create the effect of "Bioventing".

At the beginning, soil vapour is extracted from both upper screening sections (Figure 2). Using an adjustable inner tube, the length of the screen can be varied to regulate the airflow depending on the vertical contaminant distribution in the unsaturated zone.

Oxygen enriched air flows from the injection wells through the contaminated unsaturated zone in the direction of the negative pressure gradient towards the **Multi-Functional Well**.

Continued overleaf

- ***Patented design - proven engineering***
- ***Quicker, Smaller, Smarter, Greener***

To discuss your in situ soil and groundwater remediation requirements, or for a free remediation concept and quotation, please contact us

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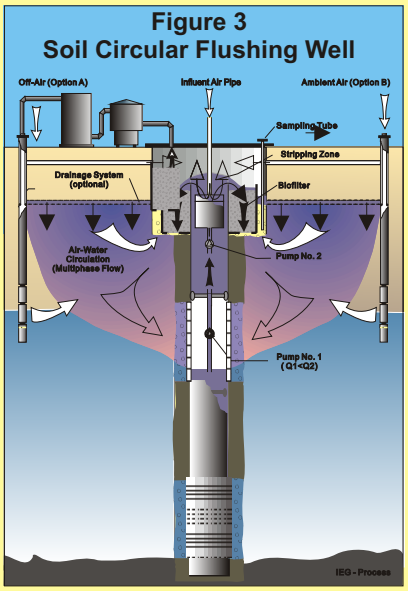
Continued

When the concentration of the volatile hydrocarbons in the off-gas has levelled off, the remediation progress can be improved by inducing a vertical soil circulation flow. In this case, the uppermost screen is completely closed off by the adjustable inner tube. Now soil vapour can be extracted from the lower screen section and can be re-infiltrated into the outer casing.

Due to the heat from the blower the re-infiltrated off-gas aids in the desorption of the contaminants from the soil matrix.The distance of the air injection wells from the **MFW™** depends on the soil characteristics and the lateral contaminant distribution.

Figure 3
Soil Circular Flushing Well



3. Soil Circular Flushing Well™ (SZB™)

The saturation of the soil above the groundwater table is increased by a vertical flow of flushing water. The hydrocarbons remaining in the soil are either removed by in-situ stripping in the well, adsorbed to an optional activated carbon bed above ground, or biodegraded in the well and the unsaturated zone. The water flushing the contaminated soil removes the contaminants and enters the well through the middle screen section (Figure 3). A first pump controls the water quantity circulating through the unsaturated zone.

The flow rate of an optional second pump located just below the stripping reactor is higher than that of the first pump (e.g. the pumping rate of the second pump can be five times that of the first pump). This pump regulates the circulation within the well casing and makes sure that a sufficient stripping rate can be achieved. The water leaving the well through the outer casing is enriched with dissolved oxygen and small air bubbles (100 microns and less) which enhances the growth of the micro-organisms in the area of soil flushing.

Biodegradation can be further enhanced by adding nutrients and/or surfactants. The dissolved oxygen concentration in the water decreases with distance from the **Multi-Functional Well™**. It is at a minimum when it re-enters the well. Air injection wells surrounding the **MFW™** allow to maintain aerobic conditions also at the periphery of the circulation cell.

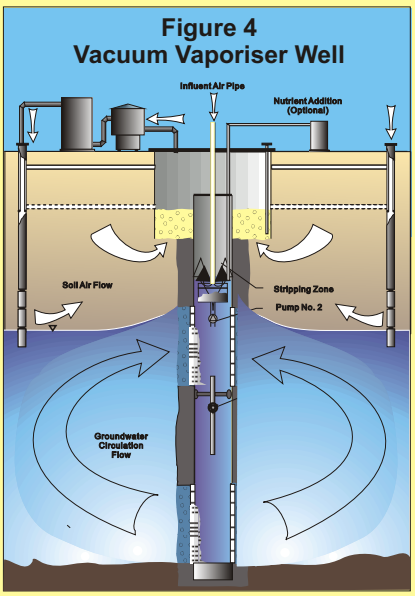
After flowing radially out through the upper screen of the inner well, water accumulates up to a controlled level in the outer well (Figure 3). A water level sensor located in the outer well regulates the operation of the first pump.

The outer casing contains a gravel layer placed on top of the natural soil for better drainage. This filter can easily be exchanged should it clog due to chemical precipitation or excessive biomass growth. In the outer casing the negative pressure due to the vacuum and the hydrostatic head from the water column are in an approximate equilibrium.

Nevertheless water discharges from the negative pressure well due to a continuous supply in a downward direction. Because there is a simultaneous two phase flow of air and water, both phases interact with each other in such a way that a slow but continuous flow develops. The water saturation in the soil controls the flow rate. At a designed water saturation of approx. 40 - 60% the percolation rate of the flushing water is more reduced than that of the air.

As an option a horizontal drainage system can be placed radially just below the ground between the **Multi-Functional Well™** and the air injection wells. Clean water draining into the subsurface is thus cohesive interconnected with the well. This provides a more uniform remediation progress within that drainage area.

Figure 4
Vacuum Vaporiser Well



4. Vacuum Vaporiser Well™ (UVB™)

The **IEG UVB™** technology is a well known method for groundwater remediation. To operate in the **UVB™** mode the stripping reactor and both pumps simply have to be arranged lower in the well. Similar to the **SZB™** mode the remediation progress depends both on in-situ stripping and biodegradation.

Contaminants dissolved in the groundwater are continuously transported to the well head where they are stripped under vacuum. Treated oxygen enriched groundwater and air bubbles leave the well, are re-injected into the groundwater and thus enhance biodegradation in the aquifer (Figure 4). A significantly higher pumping rate can be achieved than with the **SZB™**.

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*The **IEG MFW™** method is a process patented by IEG.*

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