Multi phase hydrocarbon extraction

A significant project involving the identification of migrating petroleum product in fractured media (bedrock), and the remediation of the free phase and dissolved contaminant plume is underway at a gas dispensing facility, north of Guelph. Remediation is progressing well with over 6,000 pounds of petroleum product recovered so far.

Geologists and engineers from ALTECH Environmental Consulting Ltd. were able to study the migration of the contaminants in the fractured media's shallow aquifer through borehole advancement. Using this information, they designed a carefully placed well manifold system to extract the petroleum product, with emphasis on free phase removal.

A remediation system was built that can be operated by computer both on-site, and by remote telemetry at Altech offices in Toronto. The system incorporates high vacuum extraction applied to the interior of the recovery wells, and an above ground treatment system which includes, but is not limited to, oil/water separation, air stripping and catalytic oxidation to handle both the air and liquid contaminant streams.

Operators can monitor the real time parameters and make adjustments to system as required, from either the on-site computer based interface or through telemetry at the Altech offices. This provides for the most cost-effective solution for a difficult problem.

The challenge with fractured media (bedrock)

Remediation in fractured media is extremely challenging. Because of the fractured nature of the bedrock, the quantity of the free phase (and to a certain extent the dissolved phase) contamination is difficult to quantify. The free phase hydrocarbon contamination becomes trapped in the discrete fractures, creating 'pockets' of contamination. These pockets may occur both above and below the static average groundwater level due to vertical migration which is controlled in part by seasonal water fluctuations. Because of this unpredictability, modelling capture zones and hydraulic conductivity using standard techniques, such as those used for standard pump and treat systems, is unreliable. The most effective approach is to utilize a mass extraction technique where the contamination is removed from the bedrock and brought to the surface for treatment.

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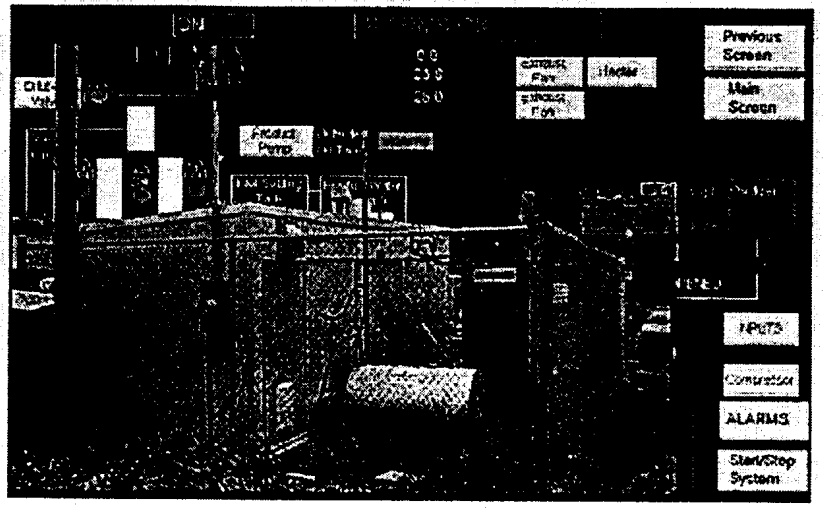

Figure 1. Operating system (foreground), control screen (background).

The recovery system

To deal with the challenges of fractured media, Altech has designed a multi phase vacuum extraction system (MPX system) to 'pull' the contaminants from the bedrock. The system is based on applying a vacuum to a series of recovery wells hooked up to a manifold system. Each of the recovery wells are valved separately, providing flexible control. With this strong vacuum, as much as 19 pounds per day of product have been extracted from the fractured media based on the daily monitoring results.

Each of the recovery well drop tubes are positioned to extract from a depth below surface that maximizes the vacuum influence on the free phase contamination, while at the same time minimizes the potential for unwanted migration of dissolved phase contamination. At this position the principles or mechanisms of removal are three fold, namely:

- Physical suction of the dissolved phase and gas phase contamination from the fractures in the rock through the recovery of groundwater and vapour ingress in the recovery wells;
- Straightforward extraction of free product in the well;
- Driving the volatility of dissolved product in the water table by lowering the vapour pressure of the hydrocarbon through agitation in the near surface.

As the contamination is extracted from the subsurface, the liquids and vapours are separated in the above ground portion of the MPX system. Generally, the intention of the system is to drive the hydrocarbons that cannot be effectively recovered as free product into the vapour phase. The arrangement of the treatment system is a proprietary design which incorporates the mechanisms of cyclonic action, oil/water separation, air stripping, and carbon absorption. All water effluents are discharged to the municipal sewer system in compliance with bylaw standards. The air stream is directed to catalytic oxidation for final destruction of all hydrocarbon contaminants.

The vacuum extraction system has been working since September 1998 and progress toward full remediation has been excellent. The remediation system has operated reliably over this period. The system is monitored and operated on a daily basis remotely from Altech's offices in Toronto. Using telemetry, staff are able to operate the unit using a number of control screens similar to **Figure 1.** The operating parameters of the system are monitored in real time and the operator can make adjustments to any part of the system as required.

In addition to routine operating adjustments, staff have successfully implemented a number of troubleshooting manoeuvres remotely when non routine operating problems have occurred. This has minimized the need for more expensive on-site operation and emergency

service calls. In addition, staff are on site regularly to monitor groundwater levels, and to reposition the extraction points as groundwater levels in the recovery wells fluctuate.

Advantages of the system

As expected, remediation in fractured media (bedrock) is a challenge for any contaminant. Multi phase vacuum extraction is the most efficient, cost-effective approach for the remediation of hydrocarbons.

Vacuum extraction of contaminants is well matched to fractured media where typical groundwater modelling and remediation is of limited value. Using an applied vacuum, as opposed to more straightforward pumping systems, increases the zone of influence on the water table and increases the potential to remove both the liquid and gas phase through the fractures. Analogous to sucking material through a straw, the bedrock contains the suction of the vacuum and directs it to the fractures. The vacuum system does not discriminate between the liquid and vapour and 'pulls' all contaminants to treatment. The key to minimizing the extraction of excess water into the treatment system is careful control of the extraction points in the well.

In summary, the extraction and treatment equipment has performed well over the 18 month period of the project. It has proven to be an effective choice as a remediation strategy. Remote operation of the unit has helped control costs and, for the several problems that have occurred, troubleshooting the situation remotely by computer has proven to be effective.