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Biosplurping

Low Volatility Fuels Recovery

Demonstration Site
Naval Air Station Fallon

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Bioslurping Demonstration Site — NAS Fallon

System Description: A 0.4-hectare site at NAS Fallon was chosen for a demonstration of the bioslurping technology due to the presence of light nonaqueous-phase liquid (LNAPL) on its shallow water table.

Forty-eight extraction wells were installed for incorporation into an interconnected vacuum manifold system on the soil surface. The wells (Figure 1) are approximately 4 meters deep and are constructed of 5-cm-diameter Schedule 40 PVC with 2.1-meter-long, 10-slot well screens. A medium-graded sand filter pack was installed across the screened interval. The rest of the annular space was plugged with a wetted bentonite chip plug to near surface, followed by a concrete surface seal.

A 2.5-cm-diameter PVC suction tube was inserted inside each well through a vacuum-tight well seal. The depth of the tube is adjustable to allow for selective withdrawal of water, free product, and/or soil vapor by placing the suction tube below, at, or above the water table surface. Each suction tube is tied into a larger diameter (10 cm and 15 cm) PVC pipe manifold. The suction tubes are valved to allow for variable flow adjustment, and an in-line sampling port allows for collection of the process fluids being removed from each well. Each well also has a vacuum release valve at the surface to allow for comparison of free-product recovery under vacuum or under atmospheric pressure.

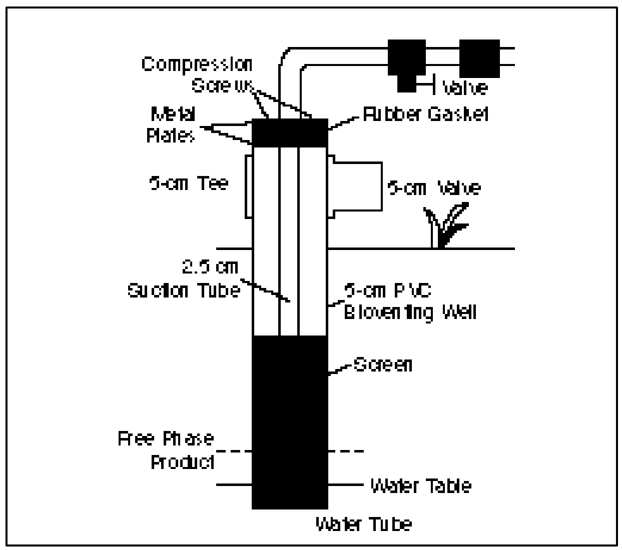

Figure 1
Bioslurper well design.

All of the bioslurper wells are interconnected through a PVC manifold to a 10-hp liquid ring vacuum pump that is capable of pumping water, free-phase petroleum, and soil gas from the wells. The liquid discharge from the pump is processed through an oil/water separator, which is connected to a steel tank for collection of the free phase petroleum and to a PVC tank for collection of the aqueous-phase discharge. Both collection tanks are equipped with float switches for overflow protection. A 5-hp irrigation pump directs the tank water to the Fallon NAS sanitary sewer. The oil/water separator can operate at up to 95 liters/minute. The dewatering pump is fitted with a vacuum assembly through which the soil gas is vented to the open atmosphere. The PVC vent pipe is 3 meters high and 5 cm in diameter. Figure 2 shows the bioventing components.

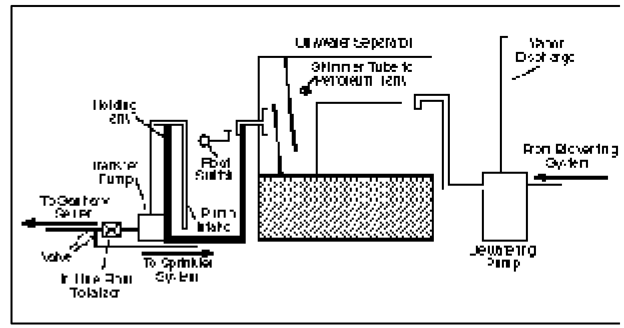

Figure 2
Bioventing system components.

Data Collection: Full-scale startup of the bioslurper system occurred in January 1993. Process monitoring has included tracking the mass of hydrocarbons removed in liquid, gaseous, and dissolved form, and the mass of hydrocarbons remediated via *in situ* biodegradation. The mass of free-phase fuel recovered has been measured daily. The oil/water separator discharge is sampled monthly and analyzed for TPH. Stack vapor discharge is sampled and analyzed for TPH using field instrumentation daily and is sent to a laboratory for analysis quarterly.

Bioslurping Demonstration Site — NAS Fallon (cont'd)

The bioslurper system has been operated to maximize fuel recovery while minimizing the volume of ground water extracted. Free product recovery (FPR) rates have ranged from 10 to 227 liters/day – averaging about 170 liters/day – whereas ground water extraction rates have ranged from 1.1 to 6 liters/minute – averaging about 3 liters/minutes.

Figure 3 presents the cumulative FPR data for the bioslurper system from full-scale startup through week 54. The liquid and vapor mass discharge data show that liquid fuel has accounted for 95 to 97 percent of the total, while ground water has accounted for 0.3 to 0.5 percent; the hydrocarbon vapor release has been 2.5 to 3 percent of the total mass discharged.

The TPH concentration in the aqueous effluent has ranged from 50 to 130 ppm during the 54-week period. The mass of hydrocarbons emitted from the bioslurper system's vapor discharge has averaged approximately 2.3 kg/day.

The bioslurper system has also been operated for several week-long periods without a vacuum, thus simulating a conventional in-well fuel skimmer system. In this skimmer mode, the FPR rates have dropped from an average of 170 liters/day to less than 30 liters/day. Thus, the bioslurper system appears to improve FPR rates almost six fold as compared to a conventional in-well skimming system.

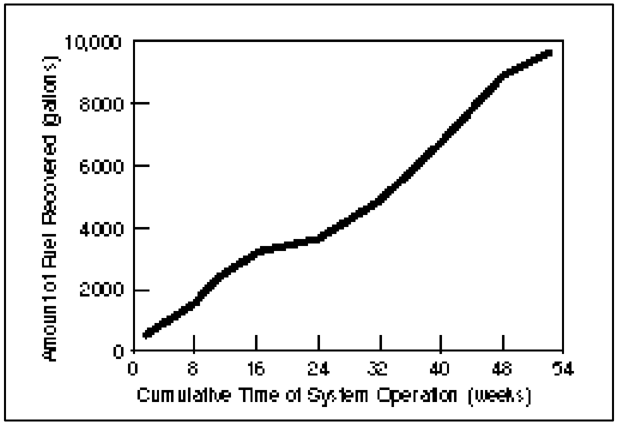

Figure 3
Cumulative free-product recovery data.

What is Bioslurping?

Bioslurping is a method of teaming vacuum-enhanced free product recovery with bioventing.

At many contaminated sites, petroleum contamination is present both in the vadose zone and in the capillary fringe as free product. Regulatory guidelines generally require that free-product recovery take precedence over other remediation technologies, and conventional wisdom has been to complete free product removal activities prior to initiating vadose zone remediation.

With bioslurping, one does not have to make a choice – this system withdraws free-product while also promoting the biodegradation of vadose zone fuel contamination. Bioventing of the vadose soils is achieved by slowly withdrawing soil gas from the recovery well. This promotes the movement of atmospheric oxygen into unsaturated soil pore spaces, thus greatly improving fuel biodegradation rates. Ground water is separated from the free product, treated if required, and discharged; the free product is recovered and can be recycled; and the soil gas vapor is treated, if required, and discharged. In most instances, volatile discharges can be kept below treatment action levels.

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Why Bioslurping?

Low-volatility fuels, unlike gasoline-grade fuels, are not removed effectively by soil venting, but most fuel constituents can be biodegraded under aerobic conditions. Because it takes over three times more oxygen, by weight, than hydrocarbon contaminant to promote complete degradation, using ground water as an oxygen carrier is impractical. Bioventing overcomes this problem by treating unsaturated soils with air.

Conventional free product removal (FPR) skimmer systems are generally inefficient for removing free fuel because they have little effect on free product outside the recovery well, so efficiency relies on the passive movement of fuel into the recovery well. Dual-pump FPR systems increase recovery efficiency by drawing the water table down several feet to create a hydraulic gradient into the well. Although higher recovery rates are achieved, creation and maintenance of the hydraulic gradient can require extraction of large volumes of ground water that must be treated prior to discharge. Systems that rely on ground water drawdown for fuel removal are usually ineffective in soil profiles with low hydraulic conductivities (fine-grained soils) or in high permeability soils with too much or too little ground water flow. In addition, lowering the water table may serve only to trap much of the free product beneath the water table when the water table returns to its normal level.

Bioslurping improves free-product recovery efficiency without requiring the extraction of large quantities of ground water. The bioslurper system pulls a vacuum of 10 to 50 cm of mercury on the recovery well to create a pressure gradient that forces movement of fuel into the well. The system also causes negligible drawdown in the aquifer, thus reducing the problem of free-product entrapment. Bioslurping improves FPR because the pressure gradient works primarily in the horizontal plan of soils, where air permeability and hydraulic conductivity are greatest. Fuel movement toward the well seems to be promoted by both air flow in unsaturated zones and by establishing continuity of fluid flow in saturated soil zones. The applied vacuum also promotes fuel removal from the unsaturated zone by removing pockets of air that prevent gravitational flow of liquid fuel.

The slurping action of the bioslurper system cycles between recovering liquid (free product and/or ground water) and soil gas. Liquid fuel, because it becomes intrained with soil gas during extraction, has been shown to be extractable from wells over 40 feet deep without the need for expensive down-well dedicated pumps.

When free-product removal activities are complete, the bioslurper system can easily be converted to a conventional air injection bioventing system to complete remediation of the vadose zone soils.