Bioslurping Improves Efficiency of Petroleum Site Cleanup

CSS PANAMA CITY, NS MAYPORT, FORMER RE-REFINERY

SOUTHDIV in cooperation with Naval Facilities Engineering Service Center (NFESC) and its contractor Battelle (BMI) are in the process of remediating three sites contaminated with waste oil using a vacuum-enhanced oil recovery technology known as bioslurping. This innovative technology recovers a greater percentage of oil than is possible using conventional technologies, thus significantly reducing the time required for cleanup. The technology employs a vacuum pump to extract oil, groundwater, and soil gas from the subsurface. These waste streams are separated and treated aboveground as required based on site logistics and regulatory requirements.

Project Summaries

AOC1: Formerly used over a period of 23 years as a fire-fighting training area. Previous investigations indicated that as much as 5,000 gallons of oil were recoverable at this half-acre site. The oil plume is a result of an estimated 63,000 gallons of flammable liquids spilled and ignited at the site.

SWMU 6&7: Comprised of unlined sludge drying beds and surrounding soils. During the 1970s, the sludge beds collected bilge water containing oily wastes.

Superfund Site: Navy is a PRP at a site where oil re-refining operations took place from 1958 to 1971. Oil-laden clay used in the refining process was placed into unlined pits and buried. Also, several leaks apparently occurred from storage tanks.

A 2- to 4-week-long bioslurper pilot test was performed at each site to evaluate the applicability of the vacuum-enhanced technology and to collect required data to design a full-scale system.

Regulatory Requirements/Community Involvement

- Meetings were conducted with the Remedial Action Board.
- Bimonthly Partnering Meetings are held at NAVSTA Mayport to discuss the status of remedial activities at SWMU 6&7.

Construction Challenges

- Operation of the bioslurper system at AOC1 created an oil/water emulsion resulting in high concentrations of hydrocarbons in the process water. A chemical treatment and dissolved air flotation system was designed and installed to treat the process water prior to discharge to the WWTP.
- The majority of the recovery wells installed inside the sludge drying beds at SWMU 6&7 did not contain oil; however, the concentration of total petroleum hydrocarbons (TPH) in the soil was above regulatory requirements. Therefore, the manifold was redesigned and a blower was installed to inject air into the wells that did not contain oil to stimulate biodegradation of the TPH.
- The soils at the Superfund site are non-uniform, making it difficult to design and operate the bioslurper system. The composition of the waste oil also varies across the site, in some areas resembling lightweight motor oil, and in others resembling a viscous tar-like substance that is difficult to recover. These challenges are being met through system design modifications.

Site Descriptions/Locations:

- Area of Concern 1 (AOC1), Former Fire-Fighting Training Area located at the Coastal System Station, Panama City, FL
- Solid Waste Management Unit (SWMU) 6&7, Former Sludge Drying Beds located at Naval Station Mayport, FL
- Superfund Site, Former Re-Refinery located in South Florida

Team Contacts:

AOC1:	B. K. Moring, P.E., Remedial Project Manager (843) 820-5514
SWMU 6&7:	Adrienne Wilson, Remedial Project Manager (843) 820-5582
Superfund:	Mike Maughon, P.E., SOUTHDIV Technical Lead (843) 820-7422 Harold McGill, Remedial Project Manager (843) 820-5659
Technical Support Contacts:	Mike Maughon, P.E., SOUTHDIV Technical Support (843) 820-7422 Mike Carsley, NFESC Technical Services Representative (805) 982-4890
Contractor Contact:	Stephen Rosansky, BMI, Project Manager (614) 424-7289

Technology:	Vacuum-enhanced free-product recovery (bioslurping)
Contaminant:	Weathered waste oils: fuel oils, diesel, gasoline, and jet fuels
Action Levels:	Free-product source reduction
Legal Driver:	Resource Conservation and Recovery Act

Cost Avoidance Measures

A life-cycle design approach was undertaken at each site to minimize project costs. This approach includes selecting cost-effective treatment equipment and modifying system components as site conditions change. For example:

- At AOC1, the off-gas and water treatment equipment was leased rather than purchased, resulting in significant cost savings to the project when reduced concentrations allowed for the discontinuation and return of the treatment equipment. Removal of the treatment equipment reduced the monthly operation and maintenance cost by more than 50%.
- The life-cycle design approach allows for maximum utility of subsurface installations. For example, recovery wells no longer containing oil were converted to bioventing wells at both AOC1 and SWMU 6&7, thus providing subsurface aeration to promote continuing degradation of hydrocarbons in the subsurface.
- At each of the sites, effective source reduction greatly enhances the efficiency of monitored natural attenuation as a polishing remedy for residual concentrations.

Project Successes

- 4,000 gallons of hydrocarbons were recovered during the first year of full-scale bioslurper operation at AOC1. More than 5,000 gallons of hydrocarbons have been recovered over 22 months of operation.
- The corrective action originally proposed at AOC1 was the installation of a passive recovery trench system. The system was expected to recover 1.6 gal/day; hence 8.5 years would be required to recover 5,000 gallons of oil. The bioslurper system recovered this volume in less than 2 years, resulting in considerable cost savings.
- Prior to installing the bioslurper system at SWMU 6&7, a conventional oil recovery system consisting of 5 sumps and in-well pumps had been in operation. The bioslurper system was more successful at recovering the oil present at the site than the previous system.
- Thermal desorption was the recommended remedial approach for soils at SWMU 6&7. The cost to implement the desorption technology to treat the sludge drying bed soils was several million dollars. This cost did not include the remediation of the oil plume in the soil surrounding the beds. The cost to install and operate the bioslurper system to remove oil and bioremediate all of the contaminated soil is expected to be less than two million dollars.
- Data collected at the Superfund site during the bioslurper pilot test helped convince the regulatory agencies to approve the use of bioslurping at the site rather than the previously mandated solidification/stabilization, thereby achieving a cost savings estimated at approximately $25 million. The full-scale bioslurper system recovered more than 1,000 gallons of oil during the first three months of operation.
- The average oil thickness measured in monitoring wells has decreased at each of the sites, indicating that the bioslurper systems have reduced the extent of the oil plumes.

Lesson Learned

- Weathered, viscous waste oils interfere with measuring devices, including probes and low meters, and making it difficult to quantify the oil recovered by the bioslurper system.
- Scaling occurred in one of the pumps located at SWMU 6&7, causing the pump to freeze. Geochemical modeling was performed to help determine the appropriate treatment to remove the scale buildup.
- At all three sites, the concentration of hydrocarbons in the water and vapor generated by the bioslurper system decreased with time.
- Oil is more effectively recovered from wells located in areas capped with asphalt or concrete than from wells located in grass-covered areas, where vacuum loss is more of a factor.

Figure 1: ***Skid-mounted bioslurper system at Superfund site.***

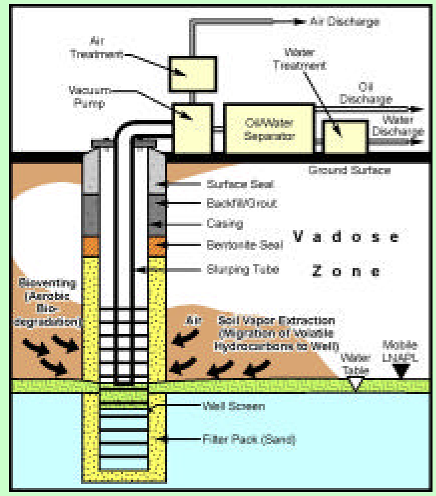

Figure 2: ***Bioslurper process.***

Figure 3: ***Trailer-mounted bioslurper system at SWMU 6 and 7.***

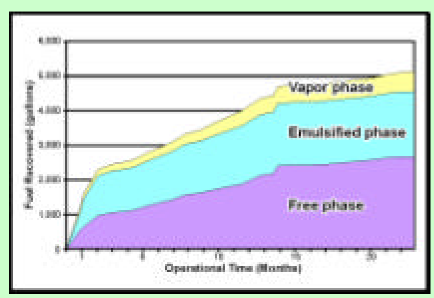

Figure 4: ***Cumulative hydrocarbons recovered at AOC1.***

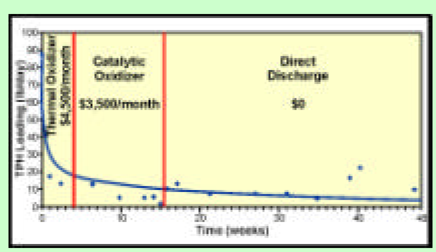

Figure 5: ***System optimization resulted in cost savings.***