# St. Lawrence TECHNOLOGIES

## ABSTRACT

Managing hydrocarbon-contaminated soil is a major environmental challenge. Shell Canada Products Ltd. conducted treatability tests using aerobic biodegradation at its Montréal-Est plant in Québec. This project demonstrated the feasibility of the biodegradation of hydrocarbon-contaminated clay soil in winter conditions. A new method of monitoring the biodegradation process was also applied. Some 3 400m³ of soil, with an average concentration of 6 670 ppm of mineral oils and greases, were treated and decontaminated to a level whereby the soil could be reused as fill material.

CONTAMINATED SOIL

# THE AEROBIC BIODEGRADATION OF HYDROCARBON-CONTAMINATED CLAY SOIL IN WINTER CONDITIONS

## MAIN FEATURES

- **Technology**
  - Soil biodegradation facilitated by mechanical pretreatment
  - Biodegradation in winter conditions in aerated cells
  - Biotreatability protocol to assess process performance.
- **Environment**
  - Concentration of mineral oils and greases reduced to under 1 000 ppm
  - Control of atmospheric emissions and leachates
  - Reuse of treated soil as fill material.
- **Cost**
  - Minimal costs of $50 per tonne
  - Variable costs depending on cell type and level of pretreatment.

ST. LAWRENCE ACTION PLAN

Environment Canada — Conservation and Protection — St. Lawrence Centre
Environnement Canada — Conservation et Protection — Centre Saint-Laurent

Shell Canada Limited

Groundwater Technology

National Research Council Canada — Biotechnology Research Institute
Conseil national de recherches Canada — Institut de recherche en biotechnologie

## PROJECT OBJECTIVES

- To assess the technical, economic and environmental feasibility of the aerobic biodegradation of hydrocarbon-contaminated clay soil in winter conditions.
- To verify whether the technology can reduce hydrocarbon concentration levels to under 1 000 ppm.
- To apply and demonstrate the biotreatability protocol developed by the Biotechnology Research Institute (BRI) for monitoring and quantifying the microbiological, biochemical and ecotoxicological performance of the biotreatment.

**Phases**

I Treatability study.

II Mechanical pretreatment of the soil through screening, nutrient addition and improvement of the soil's physical properties.

III Disposal of pretreated soil in biotreatment cells (1 200 m³), installation of ventilation systems, installation of waterproof sheets and monitoring wells ($CO_2$ and T°C).

IV Sampling, analysing and monitoring the biodegradation process until the desired decontamination levels are reached.

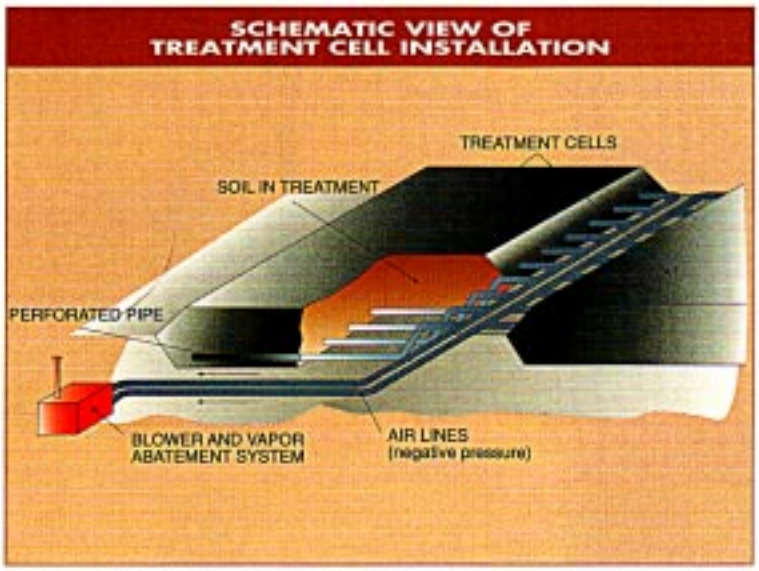
## BACKGROUND

Oil company refineries and distribution centres must regularly dispose of contaminated soil in the course of normal operations. The same problem is experienced by industry, public companies and individuals who use petroleum products. Shell Canada Products Ltd. contracted the services of Groundwater Technology Canada Ltd. to conduct biotreatment testing in order to determine the technical, economic and environmental effectiveness of biotechnologies for treating hydrocarbon-contaminated soil. The Biotechnology Research Institute (BRI) of the National Research Council of Canada applied a biotreatability protocol to measure the treatment's biochemical, microbiological and ecotoxicological performance.

## TECHNOLOGY

The contaminated soil was first mixed with gypsum and wood shavings, along with nitrogenous and phosphatic nutrients using a pulvimixer. This was necessary given that the soil's heterogeneous grain size and overwhelming clay composition make biodegradation difficult. The mixture was then conveyed to a screening and grinding system where the same ingredients were again added at concentrations not exceeding 10% of the volume.

The soil was then placed in three concrete cells equipped with ventilation ducts, and covered with a waterproof sheet. These cells are specially designed to stimulate biodegradation by indigenous bacteria through the regulation of temperature, and of oxygenation, humidity and nutrient levels. A space of 0.75 $m^2/m^3$ is needed for the biotreatability cells. The performance of the test cells was compared to that of the three control cells containing contaminated soil submitted to varying levels of treatment.



# RESULTS

**Efficiency of treatment by aerobic biodegradation**

In eight (8) months, the concentration of hydrocarbons in clay soil was reduced from 6 670 ppm to 794 ppm with the aerobic biodegradation process, for an 88% reduction.

- The mechanical pretreatment of soil improves its physical properties and ensures a better distribution of oxygen and nutrients in the soil.
- The aerobic biodegradation of hydrocarbon occurred in winter conditions. In December 1992, the average temperature in the cells was 19°C, while the average outdoor temperature was -7°C.
- The concentration of volatile compounds from the blower emissions proved to be undetectable.
- No leachate was reported in the drain; the treated soil showed no toxicity and was reused as fill material.

**Demonstration of the biotreatability protocol**

- It was possible to monitor and quantify the biotreatment's microbiological, biochemical and ecotoxicological performance with the BRI's biotreatability protocol.
- It was possible to distinguish between heterotrophic and hydrocarbonoclastic microorganism activity using a combination of gene probes, and respirometric and mineralization testing.
- The mineralization data collected from control compounds marked with carbon-14 confirmed the achievement of the 1000 ppm objective.

**Cost of treatment**

The costs of biotreatment can vary between $35 and $70 per tonne, depending on the type of cells used (temporary or permanent). These costs cover the use of blowers, the addition of nutrients and the environmental monitoring. Pretreatment costs can vary from $10 to $30 per tonne.

# POTENTIAL AND LIMITATIONS

### Potential

Aerobic biodegradation may be applied to soil and sludge contaminated with any type of biodegradable organic substance. When carried out in specially designed cells, the rate of biodegradation can be optimized even as volatile compound emissions and leachate production are controlled.

### Limitations

The process of biodegradation can be influenced by the nature of the contaminants and the physical properties of the soil; biotreatability studies are thus needed to determine treatment limitations and define design criteria. Highly contaminated (60 000 ppm) heterogeneous soils and heavy hydrocarbons may be slower to biodegrade if no additives (oxygen, nutrients) are mixed in; furthermore, biodegradation may be inhibited by the presence of heavy metals.

# INFORMATION

This data sheet is based on the results of a technology development and demonstration project carried out by Groundwater Technology Canada Ltd. for Shell Canada Products Ltd., in cooperation with the Biotechnology Research Institute of the National Research Council of Canada and with the financial support of the St. Lawrence Centre.

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Data sheets may be obtained free of charge from:
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