

## Adaptive Remediation Management of a Groundwater Cleanup Project

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**Background/Objectives.** The Botany Groundwater Cleanup Project is very large and complex. It follows more than 60 years of chlorinated solvent manufacturing at the then ICI Australia Pty Ltd site in Botany, about 6 miles south of Sydney's Central Business District.

**Approach/Activities.** In the 1980s volatile chlorinated hydrocarbons (vCHCs) began impacting production bores at the Botany site. In 1993-1996 a comprehensive investigation was undertaken of groundwater, surface water, soil, sediments, air and marine biota contamination, leading to a human health risk assessment and an evaluation of remediation technologies. It confirmed contamination in all media tested, and identified up to nine source areas. Follow-up monitoring showed that the groundwater contamination was mobile and evolving.

Initial works to prevent shallow groundwater ingress into an unlined stormwater drain significantly improved surface water quality discharging into Botany Bay. In situ groundwater remediation technologies were also evaluated. In 1999 a pilot-scale reactive iron barrier was installed. Testing over a decade provided encouraging results. Bioremediation investigations began in 2000, and have continued in many stages with several microcosm and column studies, development of highly effective dehalorespiring cultures, and several field trials of electron donor enhancement and bioculture augmentation. Several source area remediation technologies have been evaluated, including surfactant-enhanced in situ chemical oxidation, conductive and electrical resistance heating, and hydraulic displacement. None has progressed beyond laboratory-scale trials, as it has been determined that at this stage source area remediation would have limited impact on expediting the clean-up.

In 2003 the NSW Environment Protection Authority (EPA) issued a Notice of Clean-Up Action requiring hydraulic containment and ex situ treatment of extracted groundwater. In less than two and a half years Orica designed, built and commissioned a pump and treat system comprising three hydraulic containment lines and treatment capacity up to 3.8 MMUSgal/day to meet all relevant fresh and marine water quality standards. Contaminants include almost every chlorinated methane, ethane and ethene, as well as natural iron, volatile fatty acids and salts. Treatment processes include air strippers, thermal oxidation and off-gas treatment, multi-media filters, activated carbon beds, biological aeration filters, pressure filters, and reverse osmosis membranes. During the first five years of operation several significant adaptations of the unit processes were made to ameliorate operational challenges, harness biological activity, and reduce energy consumption and greenhouse gas emissions.

Supporting this continuous improvement is a strategy review process that incorporates triennial review workshops involving international experts, remediation specialists and consultants, NSW EPA and Orica. The workshops review progress to date, and technologies being deployed and researched. The international experts provide independent assessments and advice on the current approaches, and whether other technologies warrant investigation. This innovative approach helps ensure best available technologies and techniques are researched and applied.

**Results/Lessons Learned.** The Botany Groundwater Cleanup Project continues to evolve – both at the fundamental research level and at the full-scale implementation. Adaptations and enhancements are driven by the evolving conditions in the aquifer and technology advances.