Insights on Risk-Reduction Mechanisms from 12 Years of Operation of a Pump-and-Treat System at the Botany Chlorinated Hydrocarbon 'Mega-Site'

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Background/Objectives. A groundwater extraction and treatment system ("GTP") was installed in 2004 at the Botany site to hydraulically contain a series of high-concentration (near solubility limits) overlapping chlorinated hydrocarbon (CHC) plumes to prevent harm to the environment. The GTP includes 110 extraction wells, 60 integrated hydraulic monitoring wells and a treatment plant that operates at about 4.5-6 ML/day. Treated water is reused for industrial purposes at the site. This paper shows that while the GTP has succeeded in meeting its primary objective to contain the plumes, hydraulic and chemical monitoring has enabled many insights into plume behavior, including small scale hydrogeological properties and surface water interactions that have resulted in some of the most significant risk reductions. In many cases these significant risk reduction mechanisms were not predicted at the commencement of the project.

Approach/Activities. Operation of the GTP has included continuous water level logging via pressure transducers at over 100 locations, cumulative flow logging, fortnightly review of data to assess short-term performance and troubleshooting, sampling of GTP feed water, and groundwater, surface water and air sampling to assess longer-term performance.
Between one and two plume pore volumes have been extracted and the CHC mass removed (1,400 tonnes) is approximately equivalent to the initial dissolved mass estimate (1,500 tonnes). This, and the substantial reduction in plume footprints, shows that advection (and removal via GTP) is the most substantial mass transfer process, with ongoing but decreasing source zone dissolution and an increasing dominance of desorption / back-diffusion in many areas. Recent and ongoing work shows that degradation is likely to be substantial.
Review of monitoring data shows successful containment of the plumes with the groundwater migration pathway to Botany Bay controlled as predicted from numerical modelling. Risks from vapour intrusion pathways have decreased and are now negligible in most areas due to significantly improved quality (CHCs are generally not detected) of shallow groundwater. This is hypothesized to (at least partially) be due to reversal in vertical hydraulic gradients (to downwards) induced by extraction decreasing upflow of highly contaminated deep groundwater. However, the monitoring has identified that the most significant decrease in risks has been due to improved surface water quality in Springvale Drain (a constructed drain that intercepted shallow groundwater and discharges to Botany Bay). Water quality in the drain has improved by up to four orders of magnitude. This is from reduced discharge of CHCs in groundwater in the drain due to lowering of the water table from GTP pumping (as predicted in numerical modelling), but also formation of an overlying freshwater 'lens' that acts as a 'buffer' when the water table does rise during GTP shutdowns or following large rainfall events.

Results/Lessons Learned. Operation and monitoring of the GTP system successfully manages risks from CHCs in groundwater. While the primary objective to contain groundwater plumes has been achieved as predicted, some of the most substantial risk reduction has been achieved by improved shallow groundwater quality due to changes in vertical hydraulic gradients and a three-four order of magnitude decrease in CHC concentrations in Springvale Drain. These improvements were not directly predicted/considered during project development.