

# A Case Study of the Anatomy of a Dynamic High Concentration Chlorinated Solvent Plume and Consequences on Remedial Strategy

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#### Background

### Stage1 (1989-1990)

- Stage 1 Preliminary investigation initiated in 1989 by EPA and Orica (then ICI Australia) to investigate the presence of chlorinated hydrocarbons in dry weather discharges from a stormwater pipe into surface water system.
- Revealed widespread groundwater contamination in shallow groundwater beneath the ICI Plant site and adjoining property (Southlands).

#### Stage2 (1993-1996)

- The investigation had identified a number of potential DNAPL sources from the manufacturing of chlorinated solvents, and had identified a complex mixture and distribution of multi-sourced dissolved-phase chlorinated solvent plumes.
- Shallow groundwater discharge to surface water drains resulted in contamination of both surface water and sediments with subsequent transport to Botany Bay. The largest contaminant mass discharge to the environment occurred through the Southlands portion of Springvale Drain (40 kg/day), which represents approximately 40% of contaminant mass discharge to the environment, through just 4% of the groundwater flow.

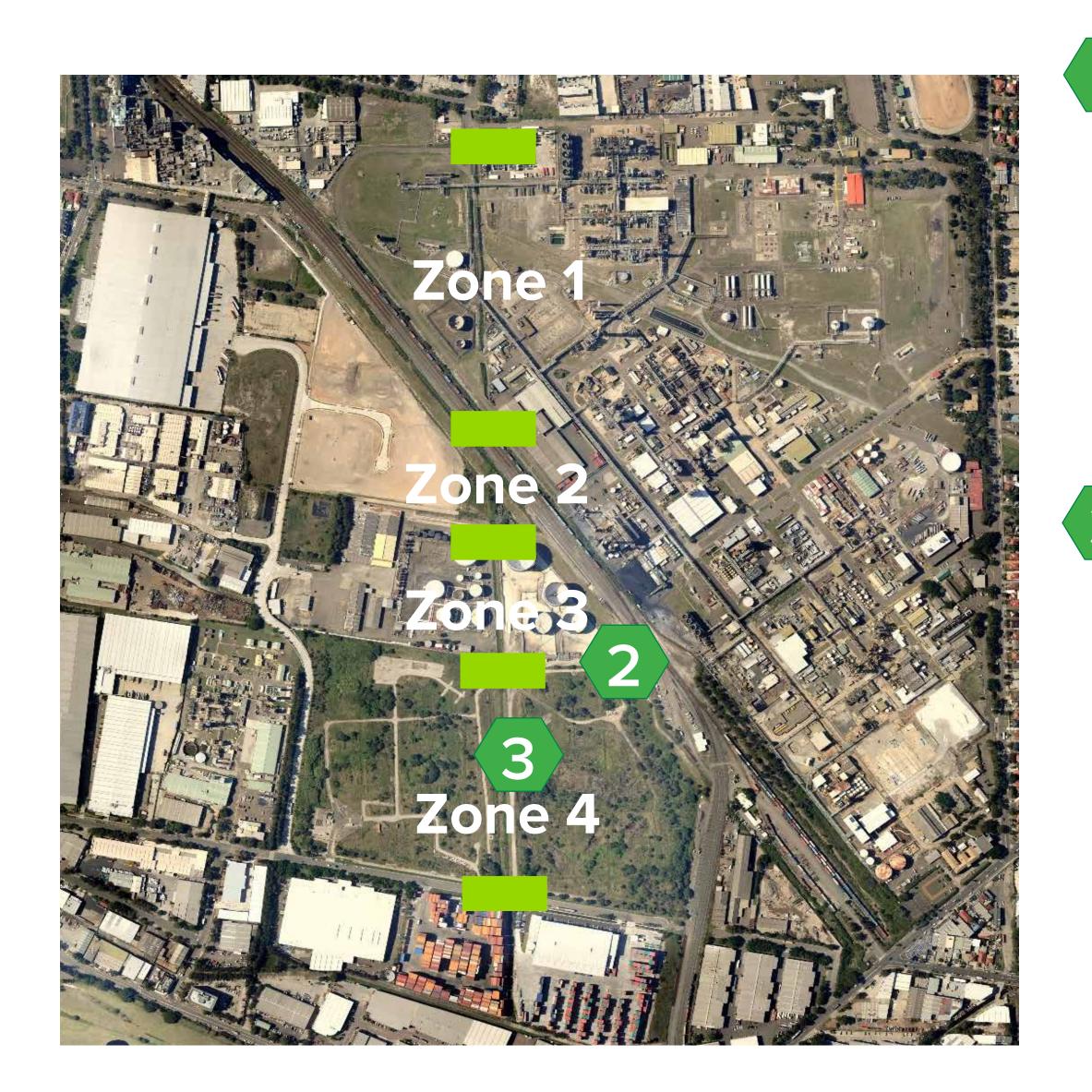


- A remedial strategy was developed which prioritised remedial activities to mitigate risks to human health and the environment.
- References: Duran, J.M., J.L. Vogan and J.R. Stening (2000). Reactive Barrier Performance in a Complex Contaminant and Geochemical Environment. Second International Conference on the Remediation of Chlorinated and Recalcitrant Compounds. Monterey, California, May 22-25, 2000

Konzuk, J., D. Major, M. Duhamel, C. Repta, J. Stening, E. Biddles, J. Fairweather and J. Duran (2007). Evaluation of Bioremediation for Treatment of Multi-Contaminant Plume. Ninth International In Situ and On-Site Bioremediation Symposium. Baltimore, Maryland, May 7-10, 2007

Newell, C. J., S. K. Farhat, D. T. Adamson and B. B. Looney (2011). Contaminant Plume Classification System Based on Mass Discharge. Ground Water Vol 49, pp 914–919.

## **Stage 3 Remediation Works**

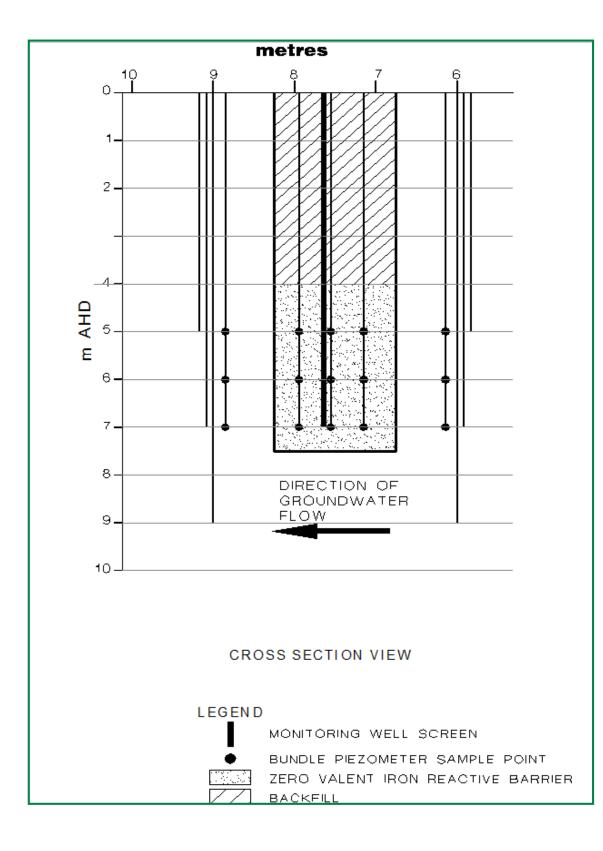


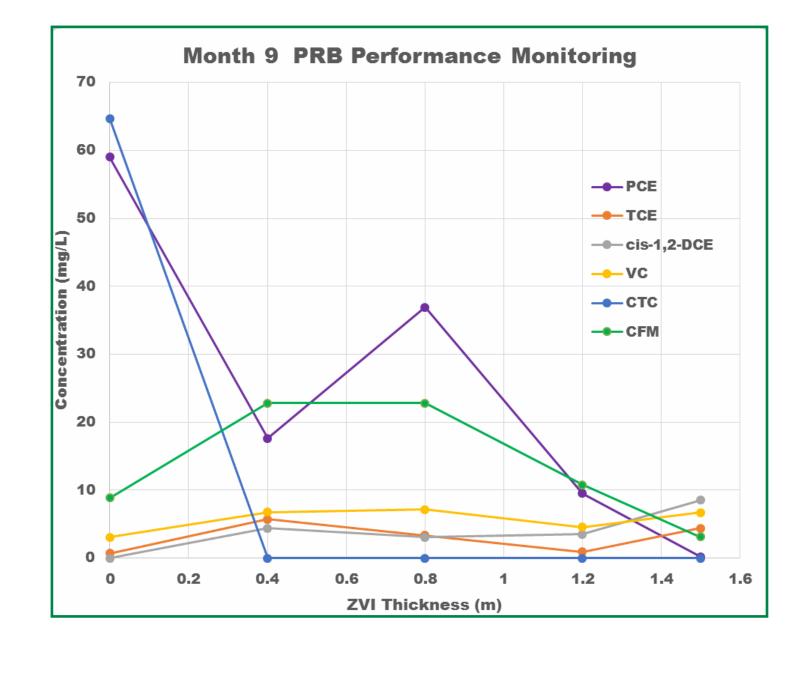
Initial Stage 3 remedial works included relining stormwater pipe to prevent seepage of contaminated groundwater and discharge to Springvale Drain/ Botany Bay.

Re-routing Springvale Drain through Southlands and excavation of contaminated sediments to prevent ongoing migration to Botany Bay.

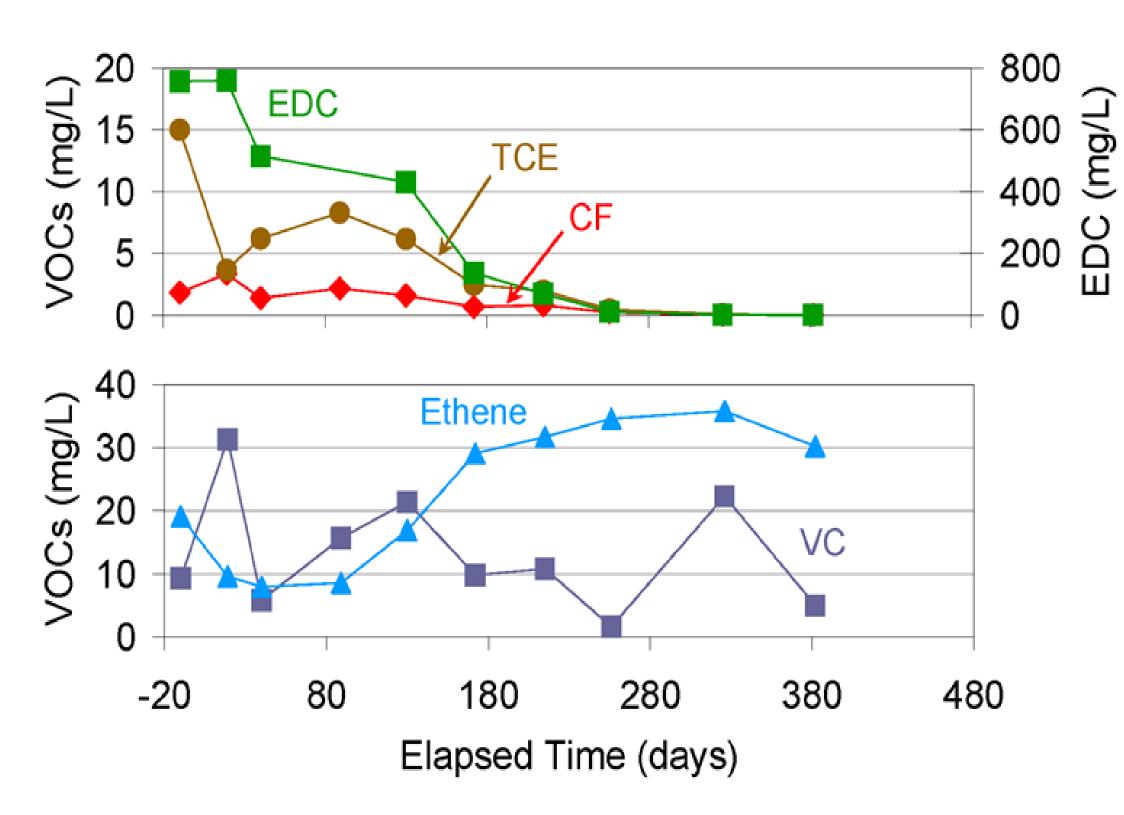
Remedial works for shallow groundwater discharge to surface drains included installation of a pilot scale Zero Valent Iron (ZVI) Permeable Reactive Barrier (PRB) in February 1999 (Duran et al, 2000)

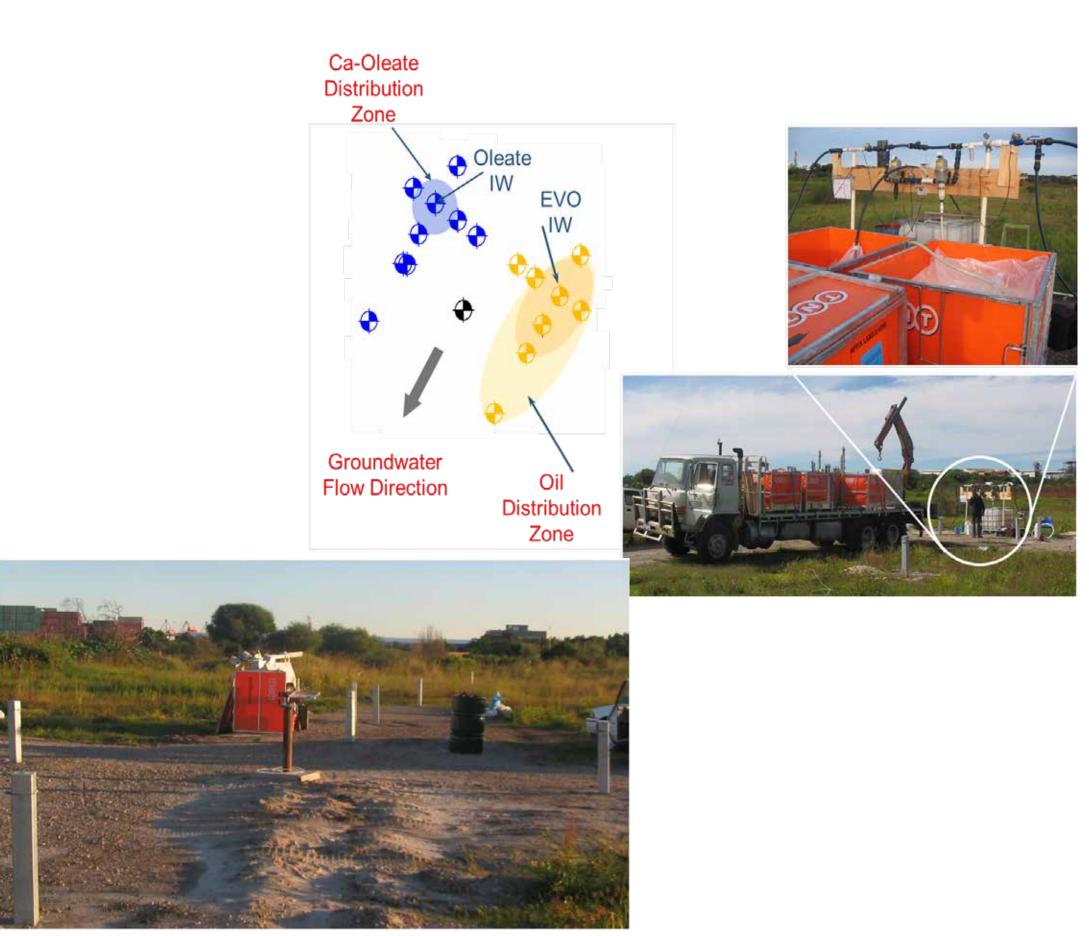






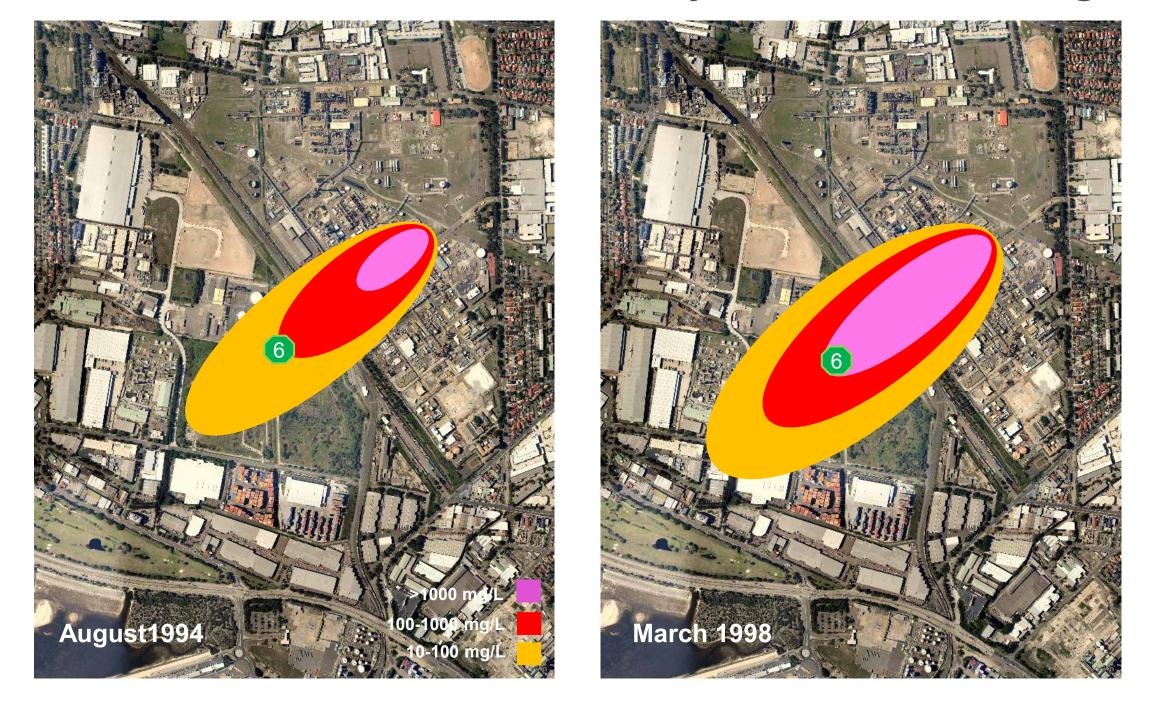
A bench scale, pilot scale and full-scale Enhanced In Situ Bioremediation program was nplemented (Konzuk et al, 2007).



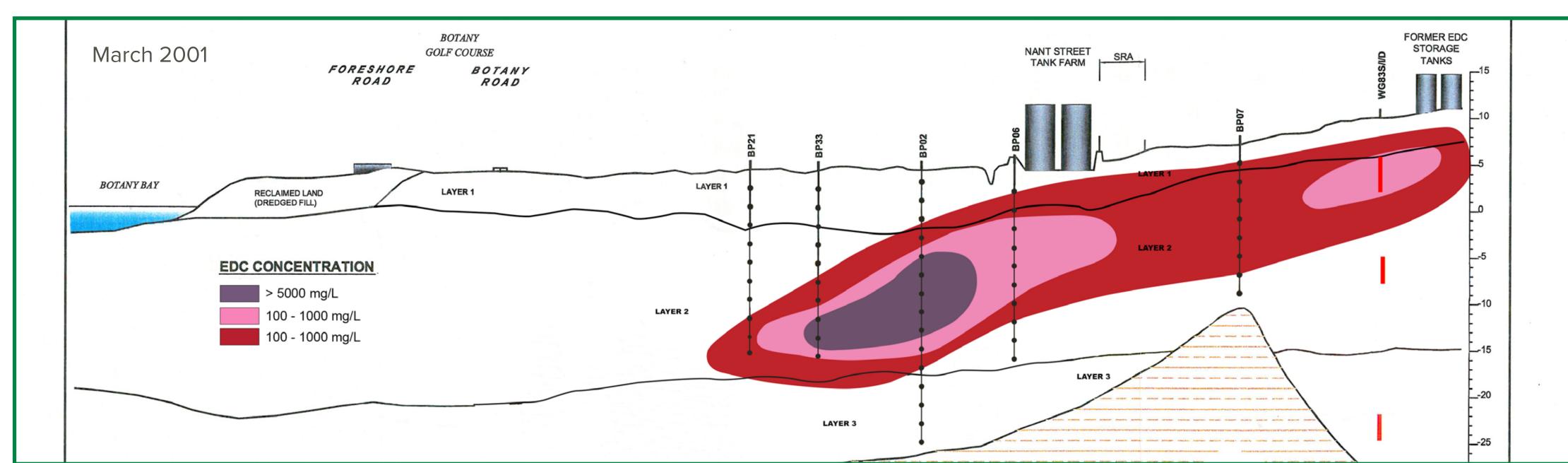


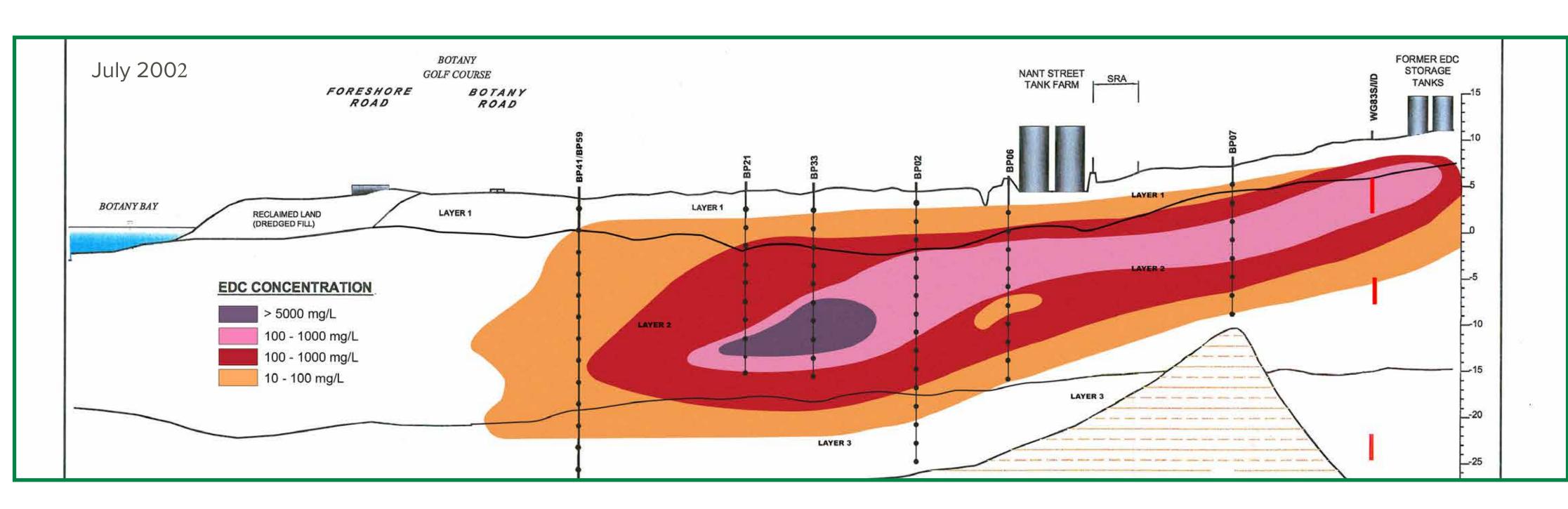
#### Arrival of a Magnitude 10 Plume

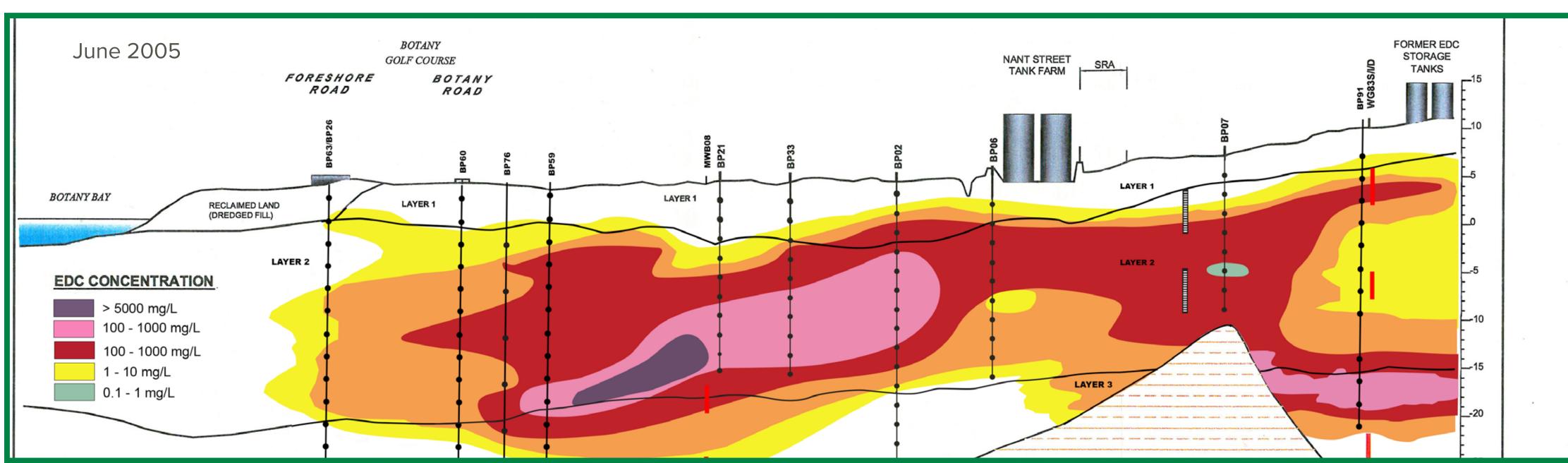
An extensive network of groundwater wells and a monitoring program was in place which was largely aimed at confirming the stability of the plumes and supporting the monitoring of proposed remedial activities. In March 1998, the concentration of 1,2-dichloroethane herein referred to as ethylene dichloride (EDC), in a sentinel monitoring well, within the C1 Plume, increased by an order of magnitude



Investigations and intensive monitoring was implemented to understand the potential cause of the sudden increase in EDC concentrations which involved the installation a series of new multilevel piezometers.







The high resolution of the groundwater monitoring both spatially and temporally was able to establish with a high degree of precision the rate of plume migration, which was estimated to be in the order of 110 m/year.

The plume velocity was similar to estimated groundwater seepage velocity with a retardation factor of 1.36, consistent with the low sportive properties of EDC.

Characterization and monitoring of the plume between the inferred source and the plume front confirmed the presence of a high concentration core or "slug" of EDC with concentrations in excess of 5000 mg/L. The mass discharge of the plume core was estimated to be over 600 kg/day – Magnitude 10 Plume (Newell et al, 2011)

#### Lessons Learned

It was postulated that the slug was likely caused by the remobilization of DNAPL within the source zone by intrusive investigations (Cone Penetrometer Testing) at the start of the Stage 2 Survey. The monitored plume velocity and distance travelled correlated well with timing of intrusive investigations.

Other observations of the intensive monitoring of the plume suggested downwards vertical migration within the aquifer, contrary to the vertical hydraulic gradient, potentially as a result of density-driven flow due to the high concentration of the plume core.

The discovery of the high concentration and rapidly moving plume, which migrated beyond the site boundary, eventually resulted in the issue a cleanup notice from the EPA, which mandated implementation of a hydraulic containment system, which effectively resulted in abandoning the existing remedial strategy.

