The former Albion explosives factory: cordite and TNT to suburban dream

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Abstract

The Australian Department of Defence operated a 400-hectare explosives factory in the Albion area, located about 15 kilometres from the centre of Melbourne – capital of the Australian state of Victoria. The factory produced a wide range of explosives and raw materials for use in munitions from the 1930s until 1986. About 220 hectares of relatively uncontaminated land was cleared via the Victorian environmental audit system between 1993 and 1997. The authors include two private-sector auditors (TM and PS) who, between 1998 and 2004, were involved in the clearance of the remaining 180 hectares of land where higher levels of contamination were present. Contaminants included TNT, 2,4 and 2,6-DNT and their breakdown products such as MNT and nitrates, very high and very low pH, metals, ammonia and various raw materials used in explosives manufacture. The integration of the assessment and remediation, auditing methods used, proposed land uses, resolution of the difficult ground water pollution issues and impacts on nearby waterways are described in this paper.
Keywords: integration, explosives, TNT, auditing, soil and groundwater contamination, surface water impacts.

1 Introduction

Melbourne, the capital of the Australian state of Victoria is a city of about 3.4 million people. Historically, growth of the suburban fringe of Melbourne has been focused on the southern and eastern sides of the city where infrastructure, soils and perhaps voting intentions favoured development. In more recent years, improved road infrastructure, rising land prices and changing demographic

trends have meant that the areas to the north and west of the city centre have seen greater development than in the past.

The former Albion explosives factory is one such area where development was ready to occur as shown in figure 1. The factory area was located on the eastern end of a vast, largely flat basaltic plain that stretches from near the South Australian - Victorian border approximately 400 kilometres to the inner northern and western suburbs of Melbourne. Typically, soils are reasonably shallow (approximately 2 m to 5 m thick), alkaline to highly alkaline and occur over fractured basalt rock that was deposited in layers of up to 36 m thick.

Groundwater is present in the fractured basalt and typically occurs at depths of about 5 m to 12 m below ground level, with depths of about 8 m being typical for the southern part of the Albion site.

Groundwater salinity varies from about 2500 to around 20,000 milligrams per litre total dissolved solids (TDS) and yields are highly variable as is common for fractured rock aquifers.

The nearest surface water systems are Kororoit Creek, an incised waterway that intersects groundwater along some of its length and Jones Creek, a perched waterway that is classified as the losing stream.

2 Site history and background

The activities related to explosives manufacture were focused on the southern part of the site in the early years of operation, gradually spreading to the north and filling in vacant areas. As is common for these types of facilities, there was wide spacing of critical facilities. Blast deflecting mounds were constructed around many of the critical facilities for safety and risk management reasons.

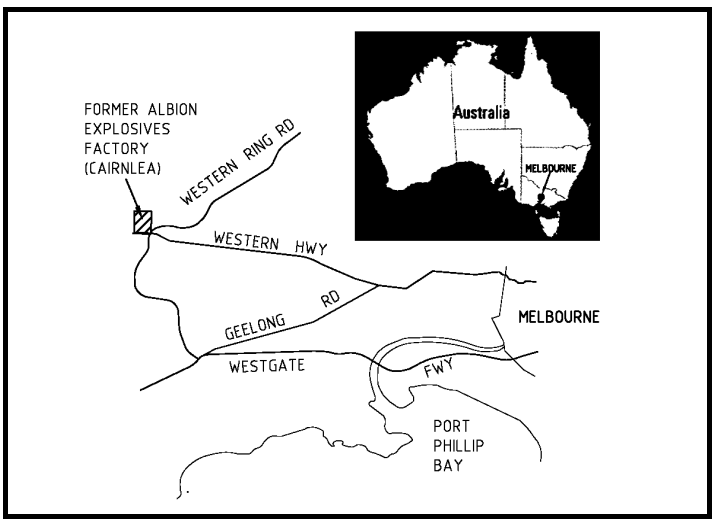

Figure 1: Site location plan – former Albion explosives factory.

The southern part of the Albion site was the location of the nitrating houses, toluene storage tanks, armament chemicals production, main effluent treatment plant and associated pipelines, main production control laboratory and support services for ammonia manufacture and potassium nitrate plant. A manufacturing gasworks was also operated for some periods during the life of the explosives factory.

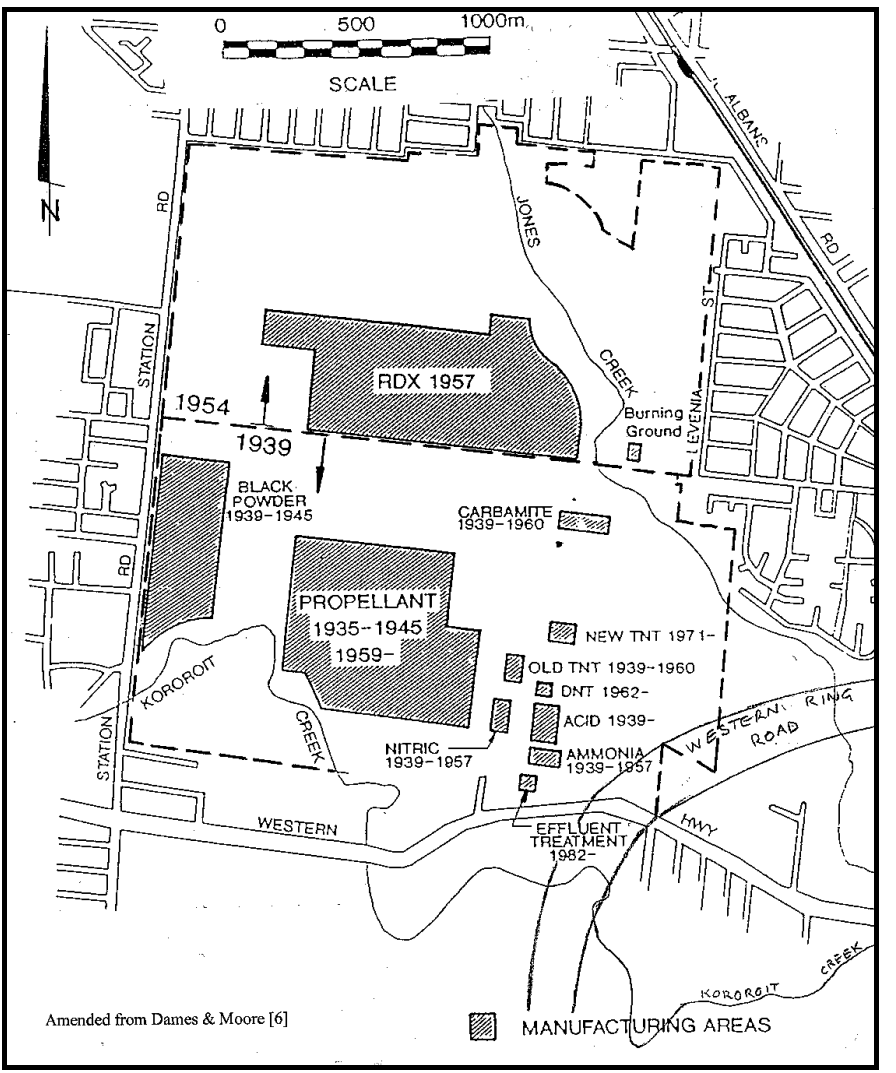

Figure 2: Layout of Albion site, main production areas and location of Kororoit Creek.

3 Assessment of contamination

Reflecting the concentration of facilities, soil contamination was most serious in the southeastern part of the site where trinitrotoluene (TNT) and dinitrotoluene (DNT) manufacture, nitric and sulfuric acid production, ammonia production, gasworks operation, waste treatment and dispose of wastes largely occurred.

Descriptions of the assessment and remediation aspects of the project have been published elsewhere Thornton and Kluckow [1], Sinclair et al. [2] and can be summarised as follows:

- Over 12,000 sample locations were assessed for a range of contaminants including 14 metals, TNT, DNT, mono-nitrotoluene (MNT), petroleum hydrocarbons, sulfate etc.
- About 180,000 cubic metres of contaminated soil and rock were placed in a purpose-built, "state-of-the-art" repository. This repository now forms a landmark hilltop in the otherwise flat landscape. Additional volumes amounting to about 50,000 cubic metres of contaminated soil and rock was excavated, stockpiled and reused in areas proposed for less sensitive uses such as industrial, commercial or open space use or placed in a nearby landfill that was also remediated as part of the project.
- Assessment of groundwater characteristics and contamination was carried out at over 90 groundwater bores; located upgradient of the site, around the principal contamination source areas and as far as 1 kilometre downgradient of the site.
- Assessment of the surface water quality of Jones Creek and Kororoit Creek, including assessment of explosives and nitrate concentrations.

The environmental assessment and remediation design works were carried out for the Victorian Urban Land Corporation (ULC), by Golder Associates. Thiess Services was the remediation contractor and Coffey Partners International Pty Ltd provided auditing services for the project.

4 Status of the Albion site

The Albion site is notable in that it was Commonwealth (national government) owned land within the State of Victoria. There was and remains doubt about to what extent state environmental legislation strictly applies to such land. While the Department of Defence and VicUrban complied with legislative requirements, it was uncertain that the Victorian EPA could have enforced some aspects of its legislation.

In any event, there had been an inquiry by a committee of the national parliament that looked at the approach that had been used prior to 1996 by which time about 220 hectares had been cleaned up and cleared for use. The committee had looked at the cost and effectiveness of cleanup and recommended that the Department of Defence should approach the remediation and development of the remainder of the site in a way that took into account the planned uses on a best value model and considered the difficulty and cost of remediation in its plans.

The Victorian government had introduced a private sector based third party or independent environmental auditor system in 1991, with audits being linked to the land use planning and development procedures of local government. The 220 hectares of the Albion site that had been cleaned up prior to 1996 used this process at a cost of about A$30 million.

ULC developed the concepts recommended by the parliamentary committee and engaged Golder Associates to prepare cost estimates for cleanup of the remaining 180 hectares of land. ULC also engaged the auditors at an early stage to ensure that the approaches adopted, were acceptable to them. The key feature of the clean up plan was the construction of an on-site state-of-the-art repository located on the area of most severe soil contamination and to plan the use the next most severely affected land for commercial or industrial uses. Wherever possible, land would be returned to its highest or best value use. The Victorian EPA supported the concepts contained in the ULC plan and has not placed any formal approval or legal conditions on the conduct of the remediation.

Between 1997 and 2002, the remaining 180 hectares of land had been remediated at a cost of less than A$22 million. Twenty of the 23 audit areas had been cleared and released for residential or open space use. Of the three remaining audit areas, two are proposed to be used for industrial or commercial use and one, containing the repository, for public open space use.

5 Groundwater: clean up to the extent practicable

From about 1999 onwards, an additional step was added to the contaminated land clearance process. This step involved the more detailed consideration of groundwater pollution at or associated with contaminated sites. This procedure, referred to as clean up to the extent practicable (CUTEP), requires the auditor to advise EPA whether the soil pollution had been cleaned up so that some or all the uses of groundwater could be restored.

The advice provided by the auditor to EPA includes summaries of the technical, logistical and financial aspects of relevant groundwater cleanup methods and an opinion as to whether or not any of these are practicable to apply.

As the auditor is not permitted to design or implement clean up measures, this involves the environmental consultant preparing information of the possible clean up measures available to clean up the source of the groundwater pollution, comparing these with the measures actually undertaken and assessing the technical, logistical and financial practicability of the alternative and actual clean up measures used. The auditor then reviews the information prepared by the environmental consultant, clarifies aspects where necessary and advises EPA of his / her opinion as to whether groundwater clean up to the extent practicable has been achieved.

5.1 Potential health impacts of groundwater contamination

The southern plume of contaminated groundwater at Albion contains TNT, DNT MNT and nitrate.

The potential health impact of TNT in groundwater uses was considered to be limited to the area on which the repository was constructed (figure 2) while the potential health impact of DNT was considered to extend to a distance of about 800 m downgradient. The use of groundwater impacted by TNT and DNT was primary contact recreation; i.e. the concentrations of TNT and DNT were considered to exceed those that were protective of the health of recreational users, if groundwater was used in, for example, a swimming pool. It was noted in the assessment of this impact, that the actual use for this purpose was unlikely, due to the variable nature of yields from the fractured basalt rock aquifer, nevertheless was a conceivable use. Use for drinking water was not considered to require protection due to the elevated salinity of the groundwater.

5.2 Potential environmental impacts of groundwater contamination

The nearest water body downgradient of the Albion site is Kororoit Creek (figure 2). Mononitrotoluene (MNT) concentrations were measured in a groundwater bore located close to Kororoit Creek, at concentrations (0.6mg/L) that could potentially impact on the ecosystem of the creek. Nitrate concentrations in groundwater plume were about 30mgNO_3-N/L. When Kororoit Creek was at low flow, nitrate concentrations in the gaining portion of the creek were measured at elevated concentrations (about 4 mgNO_3-N/L).

At the time of the CUTEP assessment, EPA had set a target for nitrogen in the urban streams of western Melbourne of 0.9 mgN/L. Kororoit Creek flows into Port Phillip Bay, which is also considered to be impacted by nitrogen; an impact predominantly arising from the effluent of one of Melbourne's sewerage-treatment facilities. Removal of nitrogen inputs to Port Phillip Bay is an agreed objective of the EPA and water authorities, so removal of the long term input of nitrogen from groundwater at Albion was considered appropriate.

More recently, the State Environment Protection Policy for the Waters of Victoria has been revised and an environmental quality objective for the 75th percentile value for total nitrogen being no greater than 0.6 mg/L has been adopted for the lowland stream segment that includes Kororoit Creek.

6 Remedial approaches assessed in CUTEP advice

Golder Associates [3] screened more than 25 potential methods for their suitability to treat the contaminated groundwater. Following the screening of methods, four pump and treat and passive / reactive wall options were assessed in more detail. The four treatment methods assessed for the pumped groundwater were use of a bioreactor, constructed wetlands, granulated activated carbon and UV oxidation.

None of these options were considered technically strong, given the fractured rock aquifer present and the plume size (more than 800 m long and 300 m wide). Pump and treat options were considered technical feasible, but also considered to require up to 80 additional wells to operate and predicted to lessen the time that the uses of groundwater were affected by about 5 years; i.e. groundwater uses

were predicted to be restored after 20-25 years rather than the 25-30 year period estimated for the "do-nothing" scenario.

Logistical limitations of the options were assessed and these mainly related to the long period of time that would be required for operation of the "pump and treat" systems when there was low discernible benefit as far as groundwater use restoration was concerned.

Financial assessment was restricted to a "pump and treat" option incorporating granular activated carbon which had an estimated cost of approximately A$7 – 8 million.

EPA considered that one further option that should be considered was in-stream nitrogen removal by use of a wetland or macrophyte treatment system. ULC commissioned Ecological Engineering [4] to undertake the assessment of the feasibility of this approach. The assessment concluded that there was insufficient space in the incised valley of Kororoit Creek to support a wetland nitrogen removal option that would effectively remove nitrogen from the waters of Kororoit Creek.

The audit conclusions were that none of these options were practicable to the extent that they would restore groundwater uses in a reasonable time for a reasonable effort; i.e. it would be impracticable to restore groundwater uses in a short time period. Technical, logistical and financial constraints were present that supported this conclusion Coffey [5].

7 Conditions of clearance

It has been determined that there is polluted groundwater downgradient of the main production area at Albion; with the pollutants of greatest concern being DNT, MNT and nitrate. A groundwater quality restricted use zone is applied to the impacted area so that any application for installation of a bore triggers a response by the water authority to prevent bore installation and hence prevent groundwater use.

The remaining three audit areas requiring clearance are proposed to be used for commercial or industrial uses (2 of 3) and public open space (the repository). Conditions of the audit outcomes are likely to be tied to the ongoing ownership or stewardship of the repository.

The proposed conditions for clearance of these areas are likely to include:

- Ongoing groundwater monitoring to assess the changes with groundwater contamination in the future. This is likely to continue for a minimum of five years.
- The setting of trigger levels to precipitate action if groundwater contaminant concentrations exceed them.
- Putting in place contingency plans in the event that trigger levels are exceeded.
- Periodic reassessment of the feasibility of groundwater cleanup.
- Nitrogen offsets; i.e. the Department of Defence or ULC agreeing to fund removal of nitrogen from elsewhere in the catchment to offset the inputs from the groundwater plume to Kororoit Creek.

While it may be impracticable to remove nitrogen from the groundwater plume at present, arrangements for removal of nitrogen from elsewhere in the catchment are practicable and could be supported as an alternative to groundwater clean up.

8 Conclusions

An integrated approach to the assessment, remediation, planned use and auditing of land at a former explosives factory has resulted in about 400 ha of land becoming available for residential, educational, and open space use. Groundwater contamination, surface water impacts and the regulatory response to their presence and possible remediation are the last hurdles remaining before the final 20 ha of commercial and industrial land can be cleared for use and the management regime for the on-site repository can be finalised.

Acknowledgements

The Albion Explosives Factory Remediation is a Commonwealth Department of Defence project. We acknowledge the assistance of the Department and their kind permission to publish the paper.

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