3 ASSESSMENT OF ALTERNATIVES

3.1 Introduction

The project involves the remediation of the CPWE area as a requirement of Orica's EPL (No. 2148). Due to the environmental risk associated with not remediating the CPWE and the obligation imposed upon Orica by its EPL, the option of not undertaking the remediation works was not considered viable.

A range of remediation methods and technologies was available to Orica, therefore this section focuses on the alternatives considered in this respect. Orica considered two main remediation methods for the CPWE – thermal technology and bioremediation

3.2 Overview

Orica has been investigating the use of bioremediation for the treatment of the CPWE since the late 1990s. Initial research was undertaken by the University of NSW (UNSW), however, the results were inconclusive. With advances in the bioremediation industry, bioremediation as a treatment option was revisited in 2004 when Orica engaged the Environmental Biotechnology Cooperative Research Centre (EBCRC) to commence a research project to develop technologies for the remediation of the CPWE. The project commenced late 2004.

In addition to the bioremediation research, Orica engaged Thiess Services Pty Ltd (Thiess) in conjunction with GHD Pty Ltd (GHD) and Focus Environmental Inc. (Focus) to undertake an assessment of alternative remediation technologies for the CPWE in early 2005. The work undertaken by Thiess included an initial review of the feasibility of possible remedial options (by GHD) and recommendation of a number of options for more detailed evaluation.

The Thiess (2005) report recommended three options - DTD, *In situ* Thermal Desorption (ISTD) and Indirectly-heated Thermal Desorption (ITD), which were subsequently assessed and considered in greater detail. Orica's intention was to identify one of these technologies as its preferred alternative in the event that bioremediation was determined as being unsuitable for remediating the CPWE. Following extensive review and community consultation (refer to **Section 6** and **Appendix J** for more detail) DTD was selected as the preferred alternative option.

Research by the EBCRC continued through 2005 and into 2006. Over this period many potentially limiting technical issues were identified, including lack of clear evidence of HCB or OCS degradation, poor availability of cyanocobalamin (Vitamin B12, which is an essential supplement to the biodegradation process), and uncertainty with regard to the likely duration of bioremediation activities.

In the face of these uncertainties and technical issues, and due to concerns about the integrity of the CPWE liner and resultant potential emissions to the environment from the CPWE, Orica determined to focus its resources on developing the DTD remediation option.

The technology options assessment work conducted is discussed in more detail in the sections below.

3.3 Assessment of Alternative Remediation Technologies

In 2005 Thiess undertook the assessment of alternative remediation technologies in two stages. The first stage involved an initial screening of remediation technologies, further screening of a shorter list of technologies and then selection of three technologies. The second stage of the assessment included a more detailed engineering evaluation of these selected technologies. The assessment was focused on feasible remediation technologies for the contaminated sand, ash and peat material stored in the CPWE and the adjacent landscaped embankments (if necessary).

3.3.1 Stage 1 Assessment

The first stage of assessment is summarised below, with further details provided in the Thiess (2005) report, *'Feasibility Study: Technology Review for Remediation of Car Park Waste Encapsulation, Botany Industrial Park, Matraville'*, March 2005.

First Phase of Assessment
The first phase of assessment characterised the wastes, establishing a list of possible treatment and disposal technologies for consideration, then initial screening of these technologies was undertaken. The first phase of assessment was undertaken with reference to:

- Commercial Status – the commercialisation and proven status of each remediation technique;
- Suitability – the ability to treat the CPWE material to an acceptable level; and
- Environmental Risk – the potential for environmental impact.

Based on these factors, the highest ranking or 'most preferred' technologies were then selected for further consideration in the second phase of assessment.

Second Phase of Assessment
The most preferred remediation technologies selected for further consideration in the second phase of assessment were as follows:

- Export of the CPWE materials to an overseas treatment facility;
- *Ex situ* mobile high-temperature incineration;
- *Ex situ* cement kilns;
- *Ex situ* DTD;
- ISTD (or i*n situ* electrical conductive heating);
- *In situ* and *ex situ* vitrification;
- *Ex situ* Startech (plasma-electric waste converter)/Plasma Arc Centrifugal Treatment; and
- *Ex situ* ITD with treatment of the condensate by Base Catalysed Decomposition (BCD) or Plascon (In-flight Plasma Arc System).

The second phase of assessment involving a more detailed screening of the above listed technologies. Each technology was assessed in terms of the following parameters:

- Probable cost for establishing the technology and carrying out the treatment operation;
- Likelihood of the technology being successfully approved and implemented; and
- Technical suitability of the technology.

As per the first phase of assessment, a ranking approach was adopted to identify cost effectiveness, technical suitability and the likelihood of gaining regulatory and peak environmental body support. The report concluded that of the selected remediation technologies, DTD, ISTD and ITD coupled with separate treatment of the recovered condensate (by Plascon or BCD) were the three most suitable technologies to treat the CPWE material. The review also recommended that the three options be assessed in greater detail.

Alternative Remediation Technologies – DTD, ITD and ISTD
DTD, ITD and ISTD are thermal technologies involving the application of heat to the contaminated soil to cause the contaminants to separate or vaporise from the soil. The result is 'clean' soil and a gas stream containing the vaporised contaminants. This process of separation is called thermal desorption.

The main differences between the technologies relate to how the heat is applied to the soil, and the type of gas stream treatment system used to treat the resultant contaminated gas stream (off-gas). There are two main types of gas stream treatment systems: a recovery type system and destructive type system. The recovery type system involves cooling the gases and condensing the contaminants into a liquid which is collected and stored for further treatment. The destructive type system involves destroying the contaminants in the gas stream in a thermal oxidiser. ISTD can be fitted with either a recovery type or a destruction type emission control system. A brief review of each of the technologies is provided below:

DTD
DTD is an *ex situ* treatment method requiring the excavation of the waste from the CPWE. To control emissions of dust and odour, the material handling process would be undertaken within an enclosed building, also fitted with an emission control system (ECS). The excavated soil would be stockpiled and screened, to remove any debris, breakdown any large soil particles and homogenise the soil, and then transported via a conveyor system to the DTD Plant for treatment.

There are two main types of DTD plants currently used to treat contaminated material, including chlorinated compounds. They differ principally in terms of the direction of gas and soil flow in the rotary dryer (co-current and counter current), with consequent differences in gas temperatures and the sequence of unit operations used to treat the off-gas. Both types of plants produce similar outcomes in terms of soil treatment levels and air emissions, the latter providing the ECS is Stockholm Convention on Persistent Organic Pollutants (December, 2004) compliant (i.e. includes a thermal oxidiser with appropriate residence time, temperature and turbulence, fast cooling and acid gas scrubbing). For convenience the co-current type of plant is described herein – this consists of a rotary dryer where the feed soil enters at the end where the gas burner is located, so that the soil and combustion gas move in the same direction where they exit at the opposite end. More detail is provided below.

In a DTD Plant, heat is applied directly to the soil in a rotary dryer by intimate mixing of the soil and combustion gases from a gas fired burner that fires inside the dryer. The treated soil passes along the dryer, and then drops into a soil cooler (or pugmill) where the soil is cooled. The cooled soil is then stockpiled, and tested to confirm that contaminants have been removed to an appropriate level.

DTD technology utilises a destructive type gas stream treatment system. The off-gas that arises from the rotary dryer typically passes through a cyclone to remove large dust particles prior to being routed to a thermal oxidiser, where contaminants are destroyed by combustion at a temperature of around 1,000^{o}C. The hot gas stream is then transferred to a quench where water mist is injected to rapidly cool the treated gas. The gas stream then passes through a baghouse, where fine dust particles are removed. An acid gas scrubber is the final step in the gas treatment system where products from the combustion of chlorinated contaminants are neutralised.

A more detailed description of the process is provided in **Section 4** of the EA.

ITD

As for DTD, ITD is an *ex situ* treatment process requiring the excavation of the waste from the CPWE. The excavation and material handling processes described above for DTD are also applicable for ITD.

In an ITD plant, heat is applied to the soil indirectly by radiating through the shell of the rotary dryer. To achieve this, a number of gas fired burners are positioned external to the dryer shell.

ITD plants typically use a recovery type gas treatment system. The off-gas from the rotary dryer is first directed to a particle removal device such as a baghouse, and then to a gas scrubbing and condensing unit. Within this unit, the gases are cooled by water and condensed. The emissions from this process are uncondensable gases. The residues are condensate containing the contaminants and water.

The uncondensable gases then pass through activated carbon to remove any remaining condensable contaminants. The contaminated carbon is recycled through the process. The off-gas is then routed back to the furnace of the plant to combust any carbon monoxide and non-condensable hydrocarbons present. The condensate, which contains the contaminants would be collected and stored (in 200 L drums or equivalent containers) whilst awaiting further treatment. Recovered water is transported to an onsite wastewater treatment facility, where it is treated and then discharged. Treated water may also be used for cooling and rehydrating the treated soil.

The hot treated soil is transported to a soil cooler, where it is re-moisturised and discharged. The cooled soil is transported to a storage area and sampled to confirm that contaminants have been removed to an appropriate level.

The stored condensate, containing concentrated contaminants, would then require a second stage treatment for destruction. This was likely to have involved transport to another off-site facility for treatment.

ISTD

Unlike ITD and DTD, desorption of contaminants in the ISTD process occurs *in situ*. Therefore, excavation of the soil and control of associated emissions from materials handling would not have been required.

The ISTD process involves the installation of a series of heater and vacuum wells in the soil to be treated. The heater wells are installed in a hexagonal pattern arrangement and used to transfer heat into the soil. The vacuum wells are installed in the centre of each hexagon and used to extract the vaporised contaminants (off-gas).

To ensure worker safety and minimise heat loss at the surface, an insulation layer would be placed over the area undergoing treatment. To enable access to the wells and other equipment, concrete is typically placed over the insulation layer.

The heater wells use electrical energy to conductively heat the soil surrounding each well. In the heating process, some contaminants are destroyed *in situ* and some are vaporised.

Like the ITD and DTD processes, the off-gas also has to be treated. ISTD processes have been developed with either a recovery system, like ITD, or a destructive system, like DTD. For the CPWE, a destructive system was considered most suitable because of the high levels of carbon monoxide that would likely be present in the off-gas. A description of this is provided in the DTD section above.

3.3.2 Stage 2 - Detailed Assessment

The second stage of the Thiess (2005) assessment included a more detailed engineering evaluation of the preferred technologies – DTD, ITD and ISTD. A comparison of these technologies is summarised in **Table 3-1**. More detailed information is contained in the following Thiess (2006) reports:

- Stage 3 Feasibility Assessment of DTD;
- Stage 4 Feasibility Assessment of ITD; and
- Stage 5 Feasibility Assessment of ISTD.

Table 3-1: Comparison of Remediation Treatment Solutions

Parameter	DTD	ITD	ISTD
Applicability	Applicable to treat the CPWE materials and the Hypalon® liner. Treatability trials may be necessary to optimise plant configuration.	Applicable to treat the CPWE materials and the Hypalon® liner. Treatability trials may be necessary to optimise plant configuration.	Applicable to treat the CPWE materials.
Cost Effectiveness	Most cost effective of the three solutions.	Moderate cost solution.	Moderate cost solution.
Approvals	Previously approved and undertaken on Allied Feeds site on the Rhodes Peninsula for the treatment of soil impacted with similar contaminants. Received opposition from some peak environmental groups.	Previously approved on Lednez site on the Rhodes Peninsula. Generally supported by peak environmental groups.	Not previously undertaken in Australia, but approval considered possible. Opposition by environmental groups considered likely.
Technical Suitability	Commercialised and proven in previous projects under similar conditions. Suitability considered high.	Commercialised and proven in previous projects under similar conditions. Suitability considered high.	Commercialised and proven in a limited number of mostly small previous projects. Suitability somewhat uncertain, given the potential for perched water in the encapsulation and limited number of projects.
Project Duration	Shortest project duration of the three options.	Moderate project duration.	Longest project duration of the three options.

3.4 Selection of the Alternative Remediation Option

A review of the three preferred alternative remediation options was conducted by Orica and in consultation with the DEC, the Community Participation and Review Committee (CPRC) and the community. Formal discussions on the options commenced with the CPRC at its meeting of

14 April 2005. Community workshops were held on 11 October and 22 November 2005 and 7 February 2006.

At the second workshop (22 November 2005) Orica outlined its concerns for ISTD. Consensus was reached that this technology would not be further pursued for the following reasons:

- the risk of adverse impact on the groundwater was unacceptable (due to the installation of heater and vacuum extraction wells through the base of the CPWE liner); and
- there is less experience with the application of this process on a project scale similar to the CPWE and therefore greater risk.

Based on the detailed review of the technologies and feedback from these workshops, Orica selected DTD as its preferred alternative remediation option. As indicated previously, this was Orica's contingency option for the CPWE should bioremediation prove to be unsuccessful. Orica's decision was communicated to community members at a workshop held on 7 February 2006 and the DEC was informed of this selection on 28 February 2006. Further details on the community consultation undertaken for the technology selection process is provided in **Section 6** and **Appendix J** of the EA.

DTD was selected as the alternative remediation technology for the following reasons:

- Degree proven
  Orica considers DTD to be a proven technology as it has been in use since the mid-1980s. The technology has been applied to around 120 remediation projects, treating approximately 3.5 million tonnes of contaminated material.
- Simplicity of design and operation
  DTD is a relatively 'simple' technology when compared to ITD. Put simply, it is considered that DTD is more robust and easier to operate and maintain as compared to ITD - meaning that the likelihood of operational success for DTD is greater than for ITD.
- Stack Emissions
  Emissions to air for the ITD and DTD technologies are anticipated to be comparable, but ITD has marginally lower emissions than DTD. If designed and operated properly in accordance with the best practice guidance of the Stockholm Convention, emissions from the technologies are not anticipated to cause appreciable health or environmental risks.
- Residues
  As DTD utilises a destructive emission control system to treat the off-gases, there are no residues generated. Consequently, secondary treatment systems are not required. ITD is, by contrast, a technology that requires extensive secondary treatment processes such as BCD or plasma arc to destroy the concentrated residues that are produced. For DTD there is no requirement for treatment, storage and transport of residues, as there is for ITD.
- Project Timeframe
  The anticipated duration of the treatment activity (at the time of the Thiess detailed evaluation) is five months for DTD and eight months for ITD. The reduced timeframe of the DTD operations as compared to the other alternatives would directly translate into a shorter overall project duration with corresponding reduction in associated impacts for the local community.

- Other
  A DTD treatment process is currently in operation at the former Allied Feeds site and has been approved at the Lednez site at the Rhodes Peninsula. Successful, local demonstration of the technology at full scale would provide confidence in this technology and assist in achieving planning approvals and community acceptance.

3.5 Bioremediation

As noted earlier, the EBCRC commenced a bioremediation research project in late 2004. The objectives of this research were:

- To develop novel *in situ* and *ex situ* bioremediation technologies that can be applied generically to soil and aquatic environments polluted with CHCs;
- To develop and demonstrate an efficient and cost-effective strategy for remediation of the CPWE at the BIP; and
- To generate a firm understanding of the ecological phenomena underlying successful bioremediation processes.

The project is being undertaken in a collaborative arrangement, including UNSW, University of Queensland (UQ), Macquarie University (Mac) and Murdoch University (MU). It should be noted that Mac and UQ are no longer part of the project team.

The initial research work conducted by the EBCRC comprised identification of the environmental and biological factors that were limiting natural attenuation. The research concluded that:

- The CPWE soil is low in moisture and essential nutrients – this could be overcome by adding water and nutrients to facilitate bioremediation; and
- The CPWE soil has the right bacteria but they are low in abundance – this could be overcome by adding more bacteria or waiting for them to grow to facilitate bioremediation.

A search of journals and articles was undertaken to identify whether the contaminants present in the car park waste (HCBD, HCB, PCE and OCS) could be broken down biologically. The information found was positive for HCB and PCE, but not for OCS and HCBD.

It was concluded that conditions at the CPWE are appropriate for biological reductive dechlorination and that organisms capable of dechlorination are present. However, in order for this process to be effective at the CPWE, the soil environment must be supplemented with biologically available nitrogen and phosphorus sources which would increase microbial biomass in the soil. On this basis, the EBCRC commenced development of a treatment solution.

With limited information available for HCBD, the EBCRC focused resources on identifying a process that could facilitate degradation of that compound biologically. Subsequently, a treatment solution was developed that resulted in complete dechlorination of HCBD to butadiene. This was seen as a very positive first step to the successful implementation of the technology.

Given that the laboratory investigations with the treatment solution had been positive (in relation to HCBD) Orica applied to the DEC to conduct an *in situ* bioremediation pilot scale field trial. The trial commenced during October 2005 and was completed in April 2006.

3.5.1 *In situ* Bioremediation Pilot Scale Field Trial

The objectives of the pilot field trial were to:

- Demonstrate the efficacy of an *in situ* biostimulation treatment to facilitate reductive dechlorination of HCBD, HCB, OCS and PCE in the CPWE;
- Establish a zone of influence and rates of reductive dechlorination *in situ* for each compound;
- Characterise the impact of the treatment on the microbial community indigenous to the CPWE; and
- Identify metabolic dead ends, toxic breakdown intermediates or adverse affects on soil quality that may occur during the course of treatment.

The trial involved application of a 1,000 L solution made of sodium lactate, diammonium hydrogen phosphate, nanoscale zero valent iron and other constituents to the CPWE soil, in the nominated trial area. Over the next six months, extensive soil sampling and analysis was undertaken within the trial area.

The results from the initial rounds of sampling highlighted issues with moisture retention, indicating that biodegradation may not be occurring. In response, the EBCRC advanced its research on polymers that could be used to hold the treatment solution or moisture in the CPWE soil, and also began assessing the feasibility of treating the CPWE using *ex situ* bioremediation.

The results of the *in situ* trial were not surprising and confirmed that there were no signs of biodegradation. The trial also revealed the following information:

- Pollutant distribution in the CPWE is not consistent (heterogeneous);
- Solution was not evenly distributed (i.e. bell shaped distribution);
- Soil moisture was increased after treatment;
- Soil moisture decreased over time;
- Nutrient limitations within the CPWE soil were resolved by adding nitrogen and phosphorus sources; and
- A depth dependent concentration gradient formed.

Based on these results the following conclusions were drawn:

- Comprehensive distribution of a treatment solution in the CPWE requires a fine scale network of injection points, i.e. a large number of injection wells would need to be installed across the CPWE;
- The treatment solution mobilises the contaminants attached to the ash component of the sand;
- The soil has high hydraulic conductivity, so any treatment solution would need to be immobilised;
- If uncertainties in treatment delivery can be overcome, the biological activity would still need to be tested in the field; and
- *Ex situ* Bioremediation options should be explored.

The results of the pilot trial were presented in a report titled, Commercial-in-Confidence: Report for a Pilot Test of *In situ* Bioremediation of the Car Park Waste Encapsulation (EBCRC 2006), and submitted to the DEC in June 2006. The report is Commercial-in-Confidence as it contains certain Intellectual Property.

3.5.2 Status of *In situ* Bioremediation

Concurrent with the polymer research, Orica commenced the conceptual design for the second *in situ* bioremediation pilot trial including the addition of the treatment solution with polymer to the CPWE soil.

The conceptual design for the treatment technology included placement of a series of injection wells across a nominated area of the CPWE, injection of the treatment solution and monitoring (soil and gas) for the duration of the second pilot trial.

During the development of the conceptual design for the second pilot trial and proposed full scale design a hazard study of the technology was undertaken for the trial application (by Orica).

The hazard study highlighted a number of issues, which Orica considered to be high risk or impossible to overcome including:

- Limitations on the ability to add and adequately distribute liquid and solid treatment solutions and supplements throughout the CPWE contents;
- Potential for negative impact of the treatment solution on the integrity of the liner resulting from biogas generation, elevated temperature and chemical effects;
- Potential for the presence of large solid masses in CPWE to adversely affect placement of injection wells and soil coring for verification/validation; and
- Inability to alter the treatment process once commenced.

For these reasons, Orica decided in mid 2006 that *in situ* bioremediation would no longer be considered a feasible remediation technology for the CPWE and resources would be focused on developing *ex situ* bioremediation. At that point in time it was decided that the EBCRC would continue development of the treatment solution and Orica's engineering resources would continue with the design of the *ex situ* treatment system.

This information was presented to the DEC on 20 June 2006 and to the community at a public workshop on 27 June 2006.

3.5.3 *Ex situ* Bioremediation

The proposal for *ex situ* bioremediation comprised excavation of the CPWE material, placement in large tanks and then addition of the treatment solution (still under development).

Conceptually, the proposal included excavation of the CPWE material and placement in large tanks, which would have required a large staging area somewhere in the order of 20,000 m^2. The former Propathene Plant area (located within the BIP) was identified as the potential staging area for the tanks.

At the time of the proposal development, the treatment solution included several ingredients including zinc powder and activated sludge. Therefore, some form of mixing (the CPWE material with these ingredients) would have been required prior to placement in the tanks. It is likely that an enclosure with an ECS would have been required over the tank staging area initially, to limit impacts on air quality during mixing.

A shed or building, with an ECS, would have been required over the CPWE, for the duration of the remediation project, to control fugitive emissions. The design would have been similar to that proposed for other *ex situ* treatment technologies, including DTD.

The proposal also included a heating system. The research identified that heating the solution (50° C) increases the rate of biodegradation. Also, at the time of proposal development, the EBCRC indicated that gases such as ethene, methane and 1,3-butadiene and small amounts of hydrogen sulphide, were likely to be generated during the initial period of the process. Therefore, a gas collection and treatment system would have been required. However, design of this system had not been considered as details on the full composition of potential gases emitted was not known.

It was determined that a multi-stage remediation (three was the minimum number of stages estimated) would be required to implement *ex situ* bioremediation. Based on information from the EBCRC (it had been stated that bioremediation could take three to five years or longer), it was estimated that remediation of the CPWE using *ex situ* bioremediation could have taken between nine to 15 years.

3.5.4 Status of Bioremediation Research

Table 3-2 provides a summary of the status of the bioremediation research as at August 2006 and the development required to enable application of the technology to the remediation of the CPWE.

Table 3-2: Status of Bioremediation Research and Development

Challenges	Status	What next?
HCBD	The laboratory research has confirmed that the treatment solution degrades HCBD.	The EBCRC needs to address the production of 1,3-butadiene in HCBD breakdown.
PCE	The laboratory research has confirmed that the treatment solution degrades PCE.	Acquire mass balance – see below.
HCB	The treatment solution has not been proven to degrade HCB.	The degradation of HCB is a two step process (anaerobic then aerobic). Therefore, the EBCRC needs to: demonstrate and optimise HCB dechlorination in the CPWE soil in the laboratory; and demonstrate and optimise aerobic degradation of HCB breakdown intermediates.
OCS	The treatment solution has not been proven to degrade OCS.	Assess the environmental and health effects of this compound and whether treatment is required.
Cyanocobalamin (Vitamin B12)	Very effective compound required for the dechlorination process but there is limited supply available in the world.	The EBCRC needs to identify a replacement for cyanocobalamin in dechlorination reactions.
Bioremediation timeframe	Estimates for bioremediation are three to five years or longer.	The EBCRC needs to determine the duration of anaerobic and aerobic incubations for biodegradation.
Biogases	Gases such as ethene, methane and 1,3-butadiene and small amounts of hydrogen sulphide initially would be generated. Full composition of gases has not been defined as all compounds have not been broken down.	The EBCRC needs to define the composition of gases generated in successful degradation of all contaminants.

Challenges	Status	What next?
Mass Balance	This is required to prove that treatment solution has been effective at degrading all contaminants to harmless gases. This has not been completed as degradation of all contaminants has not been demonstrated in the laboratory.	The EBCRC needs to acquire mass balances for the degradation of HCBD, PCE and HCB in the laboratory.
Polymer	Alginate has been selected as the polymer to assist moisture retention.	Although the polymer is not required for *ex situ* bioremediation, the EBCRC will continue work to characterise the longevity of alginate in the CPWE soil.

Considering the above, it was estimated that a treatment solution may be ready for field evaluation within two to three years. Based on this timing, it was estimated that it would be three to four years before the technical capability of bioremediation was demonstrated (i.e., degradation of contaminants, no harmful by-products produced, composition of gases emitted known and characterisation of the remediated product for disposal/re-use) and full scale design could commence.

3.6 Preferred Option for Remediation of the CPWE

On the basis of all the available information, it appeared unlikely that bioremediation (*ex situ* and *in situ*) was a feasible option for remediating the CPWE.

The condition of the CPWE is the main driver for remediation. The CPWE has been on BIP for 27 years and recent inspections indicate that the liner is likely to be leaking – water is seeping in – and also appears more brittle and therefore more susceptible to tears. Monitoring of air emissions and groundwater indicate that conditions have not declined such that there is a risk to human health or environment, but they do indicate that conditions are not improving.

These conditions indicate that remediation is required sooner rather than later. With bioremediation, it was considered likely that it would be five years before remediation could be undertaken (i.e. full scale, three stage program) and then it would be another nine to 15 years (based on current estimates) before remediation would be completed. Therefore, in total, it could take 14 to 20 years to remediate the CPWE.

Orica also considered there was a high degree of novelty, and therefore risk, associated with bioremediation due to the scale (volume of material) and type of contaminants and concentrations being remediated. The limited availability of one of the constituents of the treatment solution – cyanocobalamin (Vitamin B_{12}) - is currently a significant limitation for this technology as a remediation option for the CPWE. Essentially an alternative for this compound needs to be identified for this technology to be viable.

Based on the above, although the progress the EBCRC had made in terms of the research was substantial, Orica considered there was a high degree of technical risk associated with bioremediation as an option for the CPWE, given the current degraded condition of the liner and resultant potential ongoing emissions. Even if bioremediation was proved to be a viable solution, the timing for development and for full scale remediation would have been unacceptable. However, Orica is committed to further research in this area which may result in the use of bioremediation for future remediation projects.

Orica therefore determined to adopt the selected alternative remediation technology – DTD - as the preferred option for remediating the CPWE.

3.7 Conclusion

As described above, Orica undertook an extensive process of reviewing feasible alternatives for the remediation of the CPWE. Whilst bioremediation was originally the preferred option, the field trial and research information indicated that further work was required before this technology could be used to adequately remediate the CPWE. The time required for the development of this technology did not meet Orica's EPL requirements for the CPWE, therefore it was discounted for this particular project.

As bioremediation was not considered viable for this project, Orica reverted to its alternative remediation technology, DTD, as the remediation technology for the CPWE. It is considered that remediation of the CPWE using DTD technology presents the most efficient and appropriate method of remediating the CPWE in accordance with the requirements imposed by Orica's EPL.