F I N A L   R E P O R T

Proposed Car Park Waste Encapsulation Remediation Human Health Impact Assessment

Prepared for

Orica Australia Pty Ltd

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Glossary of Terms

Absorption - The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acceptable Daily Intake (ADI) - The amount of a chemical a person can be exposed to on a daily basis over an extended period of time (usually a lifetime) without suffering deleterious effects.

Acute exposure - Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Additive effect - A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

Adverse health effect - A change in body function or cell structure that might lead to disease or health problems

Antagonistic effect - A biologic response to exposure to multiple substances that is less than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

ANZECC - Australia and New Zealand Environment and Conservation Council

Background level - An average or expected amount of a substance or material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation - Decomposition or breakdown of a substance through the action of micro-organisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Body burden - The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

Carcinogen - A substance that causes cancer.

Chemical of Potential Concern (COPC) – Chemical present in environmental media at a concentration sufficiently high or there is a sufficiently high degree of uncertainty to warrant further assessment in relation to risks.

Chronic exposure - Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

Dermal contact - Contact with (touching) the skin [see route of exposure].

Detection limit - The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Dose - The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Exposure - Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment - The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure pathway - The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as chemical leakage into the subsurface); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching); and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Groundwater - Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

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Guideline Value - Guideline value is a concentration in soil, sediment, water, biota, or air (established by relevant regulatory authorities, such as the DEC or institutions such as the NHMRC, ANZECC and WHO), that is used to identify conditions below which no adverse effects or nuisance or indirect health effects are expected. The derivation of a guideline value utilises relevant studies on animals or humans and relevant factors to account for inter- and intra-species variations and uncertainty factors. Separate guidelines may be identified for protection of human health and the environment. Dependent on the source, guidelines will have different names such as investigation level, trigger value, ambient guideline, etc.

Hazard Index and Hazard Quotient – Hazard quotient is the ratio of daily chemical calculated for a specific receptor and exposure pathway, to the acceptable or safe dose (ADI, TDI, RfD, etc.) for that chemical. A value less than 1 indicates that the intake is less than the safe intake. A hazard index is the sum of the hazard quotients for all exposure pathways for a receptor.

Ingestion - The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation - The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure - Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

Lowest-observed-adverse-effect level (LOAEL) - The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

MRL – The Maximum Residue Limit (MRL) is the maximum residue concentration from the legal use of an agricultural or veterinary chemical that is recommended as the acceptable maximum concentration in a food.

Metabolism - The conversion or breakdown of a substance from one form to another by a living organism.

NHMRC - National Health and Medical Research Council.

No-observed-adverse-effect level (NOAEL) - The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

Plume - A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or the envelope of a contaminant moving with groundwater.

Point of exposure - The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population - A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Receptor population - People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD) – Specifically refers to a toxicity value identified by the USEPA. The RfD is similar to an ADI or TDI and incorporates uncertainty or safety factors to identify a safe dose assuming daily lifetime exposure to a substance that is unlikely to cause harm in humans.

Reasonable Maximum Exposure (RME) - The RME represents an exposure scenario based on a set of exposure parameters that is representative of expected maximum exposure for that receptor and activity. The RME would not be expected to be exceeded except under highly specific and exceptional circumstances.

Reference concentration (RfC) - The concentration of a specific chemical in air to which a human population may be exposed to without appreciable risk to their health. RfC's are identified by the USEPA.

Risk - The probability that something will cause injury or harm.

Risk reduction - Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

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Route of exposure - The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Serious Risk Concentration (SRC) – SRCs are defined by the Dutch for human health and the environment on the basis of risk assessments relevant to the specific media. The SRCs are used in Dutch legislation to identify Intervention Values that trigger a requirement for remediation. SRCs represent concentrations where risk targets are exceeded for the specific receptor at a generic level (i.e. non site specific).

Surface water - Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Synergistic effect - A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Tolerable Concentration (TC) - A TC (established by WHO) is an airborne concentration to which it is believed that a person can be exposed continuously over a lifetime without deleterious effects. The TC is based on non-carcinogenic effects and is usually calculated by applying uncertainty factors to a NOAEL or LOAEL. As such, the TC is similar to the USEPA reference concentration for inhalation exposures and ADI, TDI or RfD for oral exposures.

Tolerable Daily Intake (TDI) - The term tolerable daily intake (TDI) is used by the International Program on Chemical Safety (IPCS) to describe exposure limits of toxic chemicals and the term acceptable daily intake (ADI) is used by the World Health Organization (WHO) and other national and international health authorities and institutes.

Toxicological profile - An assessment that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology - The study of the harmful effects of substances on humans or animals.

Uncertainty factor - Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

WHO – World Health Organisation

Section 1 Introduction

1.1 Background

The Car Park Waste Encapsulation (CPWE) is located beneath a bitumen car park, which is adjacent to the Olefines Administration building at the north-eastern corner of the Botany Industrial Park (BIP) (refer to Figure 1). The CPWE consists of approximately 45,000 m^3 of contaminated soil (sand/ash/peat) encapsulated within a lined (Hypalon) engineered cell. The cell is capped with sand and a bitumen surface. Soil and other materials, which were placed within the encapsulation, originated from an open area where drummed chlorinated hydrocarbon (CHC) waste had been stored. The material included a wide range of chlorinated compounds including hexachlorobenzene (HCB), hexachloroethane (HCE), hexachlorobutadiene (HCBD), octachlorostyrene (OCS) and tetrachloroethene (PCE).

The CPWE is identified in the New South Wales (NSW) Environment Protection Authority (EPA, now known as the NSW Department of Environment and Conservation, DEC) EHC Licence No. 26 (*Environmentally Hazardous Chemicals Act 1985*) and is subject to the conditions outlined therein. The "HCB Waste Management Plan", endorsed by the Australian and New Zealand Environment and Conservation Council (ANZECC 1996), is also relevant. This plan identifies specific actions and time frames to be addressed by Orica with regard to the waste materials stored in the encapsulation. The requirements of the HCB Waste Management Plan are included in the EHC Licence No. 26.

The following provision of the "HCB Waste Management Plan" is to be met by Orica Australia Pty Limited (Orica) with regards to the CPWE:

7.2.5 *"ICI shall provide to EPANSW and the Community Participation and Review Committee a risk assessment on the car park waste and remedial options. That assessment shall have to be acceptable to EPANSW. The EPANSW and the Community Participation and Review Committee shall be consulted on who undertakes the risk assessment and the scope of the risk assessment."*

An assessment of risks to human health was undertaken by URS Australia Pty Ltd (URS 2002a) that included an evaluation of the existing CPWE with some further review and assessment provided for potential future remedial options. No appropriate remedial options were identified at that time. Ongoing monitoring of emissions from the CPWE has been conducted by URS with a review of risks to human health associated with the existing CPWE incorporated within the Consolidated Human Health Risk Assessment (Consolidated HHRA, URS 2005)[1]. The assessments presented by URS (2002a and 2005) concluded that emissions from the CPWE do not pose an unacceptable risk to human health.

The CPWE is also licensed under POEO Licence No. 2148 (*Protection of the Environment Operations Act 1997*). The Licence identifies monitoring requirements and also time frames by which the CPWE must be remediated.

Further monitoring of the CPWE, in accordance with POEO Licence No. 2148 has indicated that contamination of the surrounding soil is occurring due to the several causes, including degradation of the liner. To further meet licence requirements, Orica commissioned Thiess Services Pty Ltd (Thiess) to conduct an evaluation and assessment of appropriate remediation options for the CPWE. Following a review of the options and extensive community consultation, it was decided that Directly-heated Thermal Desorption (DTD) technology was the most appropriate option. DTD technology has been used for over

[1] The Consolidated HHRA (URS, 2005) provides an assessment of risks to human health associated with exposures in areas located offsite from the BIP. The assessment brings together data and provides an assessment of exposure relevant to the groundwater plumes, Penrhyn Estuary area as well as providing an assessment of current emissions and risks associated with the CPWE. The CHHRA approach and methodology has been developed in consultation with the DEC, NSW Health and an independent reviewer.

20 years at many remediation sites, mainly in the USA, and including at the Allied Feeds site at Rhodes (currently (since May 2006) operated by Thiess)[2].

This report presents the methodology and findings of the Human Health Impact Assessment (HHIA) completed by URS for the preparation of an Environmental Assessment (EA) for the proposed remediation of the CPWE, on behalf of Orica.

1.2 Requirements for Human Health Impact Assessment

The EA is to be conducted in accordance with the Director General's Environmental Assessment Requirements (EARs) issued on the 29th August 2006. More specifically the Director General's Requirements have identified the following with respect to Human Health Impacts:

> *The Environmental Assessment must include an assessment of the human health impacts of the project, undertaken in accordance with the risk assessment approach outlined in Environmental Health Risk Assessment – Guidelines for Assessing Human Health Risk from Environmental Hazards. The Assessment must include:*
>
> – *Justification for the exclusion/inclusion of specific chemicals, along with toxicological profiles of chemicals;*
>
> – *Exposure parameters/scenarios including the development of a multi-exposure pathway risk assessment model to account for inhalation and ingestion pathways;*
>
> – *Consideration of acute/chronic and carcinogenic impacts of chemical exposures by children and adults using Hensley Athletics Field and nearby residences;*
>
> – *Consideration of existing background exposure levels of criteria chemicals, and cumulative risks of any known or expected sources of the chemicals of concern during the remediation process that may contribute to acute of lifetime exposure (e.g. any emissions from the HCB repackaging plant or the GWTP [Groundwater Treatment Plant, GTP]);*
>
> – *Chemicals present at low concentrations but with similar mode of action of other chemicals present at the site[3] must be retained in the risk assessment and a cumulative toxicological effect estimated.*

The overall objective of the health risk assessment is to identify, characterise and evaluate potential risks to human health associated with the operation of the proposed CPWE remediation option. The focus of the health risk assessment is in areas surrounding the proposed process that include adjacent work areas used by employees of Orica (associated with other facilities) and other businesses within the BIP, workplaces in areas outside of the BIP, recreational areas and residential areas (including schools). Potential exposures by workers involved in the ongoing operation of the CPWE remediation project have not been addressed in this assessment and will be addressed in accordance with the risk assessment processes defined in the NSW Occupational Health and Safety (OHS) Regulations. The assessment of human health risk associated with the proposed CPWE remediation has drawn on information and assessments undertaken as part of the EA process. In addition, the methodology adopted for the evaluation of risks to human health follows guidance from enHealth ("Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards", June 2002) and is consistent with methodology adopted for the evaluation of human health risks associated with other aspects of the Orica site.

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[2] Further details on the remediation project currently being undertaken at Rhodes can be found at http://www.rhodesremediation.com.au/

[3] The term "site" has not been defined in the Director General requirements. For the purpose of this assessment the term has been assumed to refer to the CPWE located within the BIP.

Section 2 Assessment Methodology

2.1 General

The methodology adopted in the conduct of the HHIA is consistent with that used to evaluate risks to human health associated with a range of other aspects at and surrounding the Orica site. More specifically this includes the evaluation of risk presented in the HHIA associated with the HCB Waste Repackaging Plant (URS 2006a), Consolidated Human Health Risk Assessment (URS 2005), HCB Car Park Waste Health Risk Assessment (URS 2002a) the HCB Waste Destruction Plant Environmental Impact Statement (EIS) (proposed facility, URS 2001a and 2002b) and the Groundwater Treatment Plant EIS, Human Health Risk Assessment (URS 2004).

The approach taken to the assessment of human health risks is generally in accordance with the protocols/ guidelines recommended by enHealth (2002). These guidelines draw on and are supplemented by those provided in the documents:

- "The Health Risk Assessment and Management of Contaminated Sites" (Contaminated Sites Monograph Series CSMS 1991, 1993, 1996 and 1998 and enHealth 2002b); and
- The National Environmental Protection Measure (NEPM) (Schedule B(4), Guideline on Health Risk Assessment Methodology, 1999), prepared by the National Environmental Protection Council (NEPC)

The above guidance currently provide only general guidance for the completion of these tasks and, as such, the more detailed protocols and guidelines developed by the United States Environmental Protection Agency (USEPA 1989, 1991 and 2001) have been used to provide supplementary guidance.

The conduct of a HHIA can be divided into the following four prime tasks:

- Issue Identification;
- Exposure Assessment;
- Hazard/Toxicity Assessment; and
- Risk Characterisation.

The following presents further detail on the approach adopted in the assessment of risks to human health.

2.2 Issue Identification

This involves an evaluation of the proposed remediation process and potential for emissions to air, water and soil. In particular, this evaluation draws on key assessments associated with the proposal such as the Preliminary Hazard Analysis (PHA) prepared by Sherpa Consulting Pty Ltd (Sherpa, 2006) and Air Quality Impact Assessment for Remediation of the CPWE at the BIP prepared by Pacific Air and Environment Pty Ltd (PAE, 2007) to:

- Identify emissions (acute or chronic) associated with the proposal that have the potential to result in impacts in key assessment areas (workplace, recreational and residential areas surrounding the BIP) during all aspects of the proposed remediation process; and
- Review of the potential emissions associated with the proposed process to identify requirements to further quantify risks to human health and hence identify key chemicals, or chemicals of potential concern (COPCs), which may require detailed quantification in the HHIA.

COPCs are those chemicals which are known or suspected to be present at concentrations high enough to warrant inclusion in the assessment of risks to human health, or to pose a nuisance (e.g. odours). The prime objective of identifying COPCs is to focus the risk assessment on assessing chemicals that have the potential to significantly contribute to risks to human health.

2.3 Exposure Assessment

This task draws on the evaluation undertaken as part of the “Issue Identification” stage and involves a detailed evaluation, identification and quantification (where required) of the potential exposure pathways and all significant population groups.

The exposure assessment is undertaken to be representative of a particular population and does not calculate the exposure for a given individual. Populations are grouped so as to reflect common activities undertaken by that group (such as workers or children) or by the location of the population in relation to the contaminant distribution. For this reason it is important that the exposure assessment be undertaken in such a way that the most sensitive individuals within the potentially exposed population are adequately protected. The exposure assessment has been structured in the following way:

- Identification of the population that may be exposed to the COPCs;
- Identification of the activities by which exposure may take place for each population;
- Identification of parameters which define activity (such as time spent indoors) and physiological exposure parameters (such as body weight and inhalation rate); and
- Identification of the chemical concentration at the point of exposure. This may include the identification and use of models to estimate chemical concentrations for receptors and exposure pathways that cannot be measured directly.

2.3.1 Key Pathways and Receptors

Receptor populations are similar groups of people who live or work in the study area and who may be exposed to the COPCs in the workplace, residence or in recreational areas.

An exposure pathway describes a unique mechanism by which an individual or population may be exposed to chemicals or physical agents at or originating from a source. Each exposure pathway includes:

- a source or release from a source;
- a transport/exposure medium or exposure route; and
- an exposure point.

If any one of these mechanisms is missing (such as transport mechanism or exposure point) then the pathway is considered to be incomplete. An exposure pathway can be considered to be less significant if the potential for a receptor or population to be exposed to the COPCs is considered to be low. This may be due to a number of factors, which may include dilution during the transport from the source to the point of exposure or limited time for exposure.

2.3.2 Quantification of Chemical Intake

When quantifying chemical intake or exposure, the risk assessment process focuses on exposure occurring over a prolonged period, that is chronic exposure that occurs over years and possibly a lifetime. Whilst an activity may occur infrequently (i.e. several days a year), it may occur regularly over a long period and therefore have the potential to increase long term or chronic intake of the chemical.

The assessment presented has addressed potential worst-case exposure to COPCs and exposure has been calculated for a ***Reasonable Maximum Exposure (RME)*** scenario estimated by using intake variables and chemical concentrations that define the highest exposure that is reasonably likely to occur in the area assessed. The RME is likely to provide a conservative or overestimate of total exposure and therefore health risk. This approach follows guidance from enHealth (2002) and NEPC (1999), supplemented by USEPA guidance (USEPA 1989).

The following steps have been followed to estimate chemical intake:

- Identification of ***exposure parameters*** for each of the identified exposure pathways and receptors. These are values that describe the physical and behavioural parameters relevant to the potentially exposed population and the pathway of exposure. Some examples include ingestion rate (e.g. amount of backyard vegetables eaten), inhalation rate (volume of air inhaled during different activities), exposure frequency (i.e. hours per day or days per year), exposure duration (e.g. number of years as a resident, golf player etc.) and body weight. Where available, exposure parameters have been obtained from Australian sources (enHealth 2002b CSMS, 1991, 1993, 1996 and 1998, and NEPC 1999).

- Calculation of ***intake factors***. An intake factor is calculated using the exposure parameters defined above and provides a site specific and receptor specific value which, when multiplied by the concentration of each COPC, provides an estimate of the daily chemical intake of the COPCs for each receptor and pathway.

- Estimation of the ***chemical concentration*** in each medium relevant to the receptor groups and exposure pathways. This involves the use of relevant data from air modelling and modelling of potential concentrations in other media such as soil, fruit and vegetables and mother's milk; and

- Calculation of the ***daily chemical intake*** using the intake factor and the chemical concentration. This is calculated for each exposure pathway assessed for each site using the following equation:

$$\textit{Daily Chemical Intake} = (\textit{Intake Factor} \bullet \textit{Concentration})$$

Assumptions and calculations relevant to the quantification of chemical intake are presented within the assessment.

2.4 Hazard/Toxicity Assessment

The objective of the toxicity assessment is to identify toxicity values for the COPCs that can be used to quantify potential risks to human health associated with calculated intake. Toxicity can be defined as *"the quality or degree of being poisonous or harmful to plant, animal or human life"* (NEPC 1999).

The steps involved in this process include the following:

- Obtain relevant qualitative and quantitative toxicity information on the chemicals of potential concern relevant to the significant exposure pathways being assessed (namely oral, dermal or inhalation); and

- Identify the appropriate toxicity values for assessing both threshold effects and non-threshold carcinogenic effects.

2.4.1 Non-Threshold Response

Non-threshold toxicity values assume that any amount of exposure to the chemical has the potential to result in an increased risk. These chemicals are typically carcinogens with their toxicity values referred to as cancer risk slope factors. The World Health Organisation (WHO) assigns slope factors to chemicals identified as genotoxic carcinogens with other carcinogens identified evaluated on the basis of a threshold response relationship (refer below). A slope factor is an upper bound estimate of the probability of a response occurring following the intake of a chemical over a lifetime via a specific exposure pathway (such as ingestion or inhalation). Therefore the higher the slope factor, the higher the risk that may be associated with a given exposure.

2.4.2 Threshold Response

This relationship assumes that there is a level of exposure below which there is no (or no appreciable) risk of an adverse health effect. This is in contrast to the non-threshold relationship where there is an increased risk associated with any exposure. The WHO identifies threshold chemicals as those which are not suspected of exhibiting carcinogenic effects (non-carcinogens) or those which exhibit non-genotoxic carcinogenicity. Toxicity factors for these chemicals are referred to as an acceptable daily intake (ADI, by the WHO) or reference dose (RfD, by the USEPA) for oral exposures (in units of mg per kg body weight per day) and a tolerable concentration (TC, by WHO) or reference concentration (RfC, by USEPA) for inhalation exposures (in units of mg per cubic metre of air). The lower the ADI, RfD, TC or RfC, the more toxic the chemical and the lower the concentration above which there exists a potential for an adverse health effect.

2.4.3 Identification of Toxicity Values

The identification of toxicity values undertaken in this risk assessment has followed guidance provided by enHealth (2002) and NEPC (1999). enHealth (2002) provides a list of toxicological data sources. These are classified as Level 1, 2 or 3 data, with Level 1 sources recommended. In order of preference the Level 1 sources are:

1) National Health and Medical Research Council (NHMRC) documents and documents from other joint Commonwealth, State and Territory organisations.
2) ADI List from the Therapeutic Goods Administration.
3) WHO documents.
4) enHealth Council documents.
5) National Environmental Health Forum (NEHF) documents.
6) International Agency for Research on Cancer (IARC) monographs.
7) WHO/Food and Agriculture Organisation (FAO) Joint Meeting on Pesticide Residues (JMPR) monographs.
8) National Industrial Chemicals Notification and Assessment Scheme (NICNAS) Priority Existing Chemical (PEC) reports.
9) US Agency for Toxic Substances and Disease Registry (ATSDR) documents.
10) National Toxicology Program (NTP) carcinogenicity appraisals.
11) Organisation for Economic Co-operation and Development (OECD) Standard Information Data Sets (SIDS) and SID Initial Assessment Reports (SIAR).
12) USEPA Reference Doses.

Level 2 sources include peer-reviewed journals and industry publications and reference to Level 2 sources is considered warranted where Level 1 sources do not provide applicable criteria. Level 3 sources are other sources not covered in Levels 1 or 2. The use of Level 3 sources requires justification that no other data are available and that the appraisal presented meets the required level of conservatism as required.

2.5 Risk characterisation

This task provides either a qualitative or quantitative (as required) evaluation of potential risks to human health. The characterisation of risk draws on the "exposure assessment" and "hazard assessment". The determination of potential health impacts will be evaluated on the basis of commonly accepted measures of acceptable risk and discussion on potential implications. The risk characterisation will draw on the data presented in the preceding sections and provide an assessment of acute and chronic risks associated with the proposed remediation process and cumulative impacts associated with exposures that may be derived from the proposed CPWE remediation and other sources (such as the HCB Waste Repackaging Plant, GTP and other sources on the BIP).

Calculations of risk have been undertaken using an in-house Excel spreadsheet-based risk model RiskE (Version 5 2005).

2.5.1 Risk for Non-Threshold Effects

The potential for unacceptable non-threshold carcinogenic risks associated with exposure to COPCs has been evaluated using USEPA methodology.

Non-threshold carcinogenic risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential non-threshold carcinogen. The numerical estimate of excess lifetime cancer risk is calculated as follows:

Carcinogenic Risk = Daily Chemical Intake • Cancer Slope Factor

The total non-threshold carcinogenic risk is the sum of the risk for each chemical for each pathway.

Deciding whether the calculated cancer risk is of concern or not requires identification of an acceptable cancer risk value. The calculation of a cancer risk implies that any exposure to these chemicals may result in an increased risk or probability of contracting cancer over a lifetime. The cancer risk value is expressed as a probability such as 1 in 10,000 ($1x10^{-4}$) or 1 in 1,000,000 ($1x10^{-6}$). At the simplest level these probability values can be converted to population risks as follows:

- An incremental lifetime cancer risk of $1x10^{-6}$, means that in a population of 1 million people which has been exposed to the chemical for their lifetime one additional cancer is predicted over and above the background incidence of cancer in that population (1 million people). For the same population a cancer risk of $1x10^{-4}$ implies that 100 additional cancers are predicted over and above the background incidence (for 1 million people).

These values are extremely low when compared to the background incidence of cancer in our society. The background incidence is in the order of 1 in 4 to 1 in 3 (Fitzgerald 1993). This means that for a population of 1,000,000 around 250,000 individuals are expected to contract cancer over a lifetime. An additional $1x10^{-6}$, risk predicts 1 additional individual may develop cancer.

Specific Australian guidance related to the significance of cancer risk estimates is not currently available. Current USEPA policy states that: *"Where the cumulative site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4} action is generally not warranted unless there are adverse environmental impacts"* (USEPA 1991). If risks are found to be greater than the 10^{-4} probability, then the USEPA recommends that a preliminary remediation goal of 10^{-6} cancer risk be developed as the point of departure (ibid).

A review of the origins of the 10^{-6} cancer risk number has been undertaken by Kelly (1991) and a review of the development of an Australian approach to the assessment of carcinogenic contaminants has been prepared for discussion by Fitzgerald (1993). Both these reviews indicate that the 10^{-6} was suggested by the United States Food and Drug Authority (USFDA) in 1961, as representing the *de minimis* legal risk. That is, the level of risk that can be identified, in a legal sense, as being representative of negligible or trivial risk. As the more recent USEPA policy (quoted above) indicates, the application of cancer risks has seen the acceptance of higher risk values i.e. 10^{-4} or 1 in 10,000 in the assessment of contaminated sites.

The application of cancer risk values in Australia and elsewhere is generally consistent with the USEPA policy. That is, the 10^{-6} risk value is commonly identified as the point of departure from negligible risk and the 10^{-4} risk value is commonly adopted as indicative of unacceptable risks. The 10^{-6} risk value is sometimes used as the basis for defining ambient standards applicable to wide scale population exposure. For example, the NHMRC and the Agricultural and Resources Management Council of Australia and New Zealand (NHMRC/ARMCANZ 2004) have used the 10^{-6} value for the derivation of the Australian drinking water guidelines for genotoxic carcinogens. The WHO, on the other hand, have used the 10^{-5} risk as the basis for the derivation of the WHO drinking water guidelines (WHO 2004) and the Dutch use the 10^{-4} lifetime cancer risk as the basis for the derivation of Human Intervention Values for soil and groundwater for genotoxic carcinogens.

URS understands that a goal of 10^{-5} is generally accepted on a range of sites by a number of DEC accredited auditors as indicating conditions that might warrant specific management or remedial action. The acceptance of the goal is site dependent. URS is not aware of any stated policy by the DEC.

Adopted Risk Targets

Based on the above discussion URS considers that the following guidance with respect to incremental lifetime cancer risks is representative of current practice in NSW:

- Calculated incremental risks below 1×10^{-6} would be considered to be effectively zero;
- Calculated incremental risks between 1×10^{-6} and 1×10^{-5} would be considered acceptable; and
- Calculated risks greater than 1×10^{-4} would be considered to warrant some form of action or management to reduce the risk.

Where risks fall between 1×10^{-5} and 1×10^{-4}, then this may warrant further evaluation of the risks to determine whether action is required to reduce the risks.

URS has adopted a Target Risk value of 1×10^{-5} as indicating conditions that would warrant further assessment. Risk values below 1×10^{-5} are representative of acceptable risks.

2.5.2 Hazard Index for Threshold Effects

The potential for adverse threshold effects, resulting from exposure to COPCs, has been evaluated by comparing an exposure level, expressed as a daily chemical intake, with the adjusted ADI or equivalent threshold value (tolerable daily intake (TDI), RfD or Time Weighted Average (TWA). The resulting ratio is referred to by the USEPA as the hazard quotient (USEPA, 1989) and is derived in the following manner:

$$Hazard\ Quotient = \frac{(Daily\ Intake\ from\ Project)\ or\ (Daily\ Intake\ from\ All\ Sources)}{(ADI) - (Background\ Intake)}$$

The evaluation of risk associated with threshold chemicals involves a comparison of the total daily intake (derived from the CPWE remediation project or cumulative exposures) with the adjusted ADI. The adjusted ADI is that which has been adjusted for background intake from all other sources (taken to refer to typical background sources such as food, water and air that would be the same in all areas of Australia) so that the hazard quotient calculated compares the chemical intake derived from the proposed remediation project (or cumulative sources) with the ADI allowable from sources other than background. If the total daily chemical intake exceeds the adjusted ADI, TDI, RfD or TWA (i.e. if the hazard quotient exceeds one), then this would indicate potentially unacceptable chemical intakes. The hazard quotient does not represent a statistical probability of an effect occurring.

To assess the overall potential for adverse health effects posed by simultaneous exposure to multiple chemicals, the hazard quotients for each chemical and exposure pathway have been summed. The resulting sum is referred to by the USEPA as the hazard index (HI) (USEPA, 1989). The HI approach assumes that multiple sub-threshold exposures to several chemicals could result in a cumulative adverse health effect, and exposures are summed over all intake routes.

If the HI is less than one, cumulative exposure to the site chemicals is judged unlikely to result in an adverse effect. If the index is greater than one, a more detailed and critical evaluation of the risks (including consideration of specific target organs affected and mechanisms of toxic action of the chemicals of concern) would be required to ascertain if the cumulative exposure would in fact be likely to harm exposed individuals.

2.6 Features of the Risk Assessment

The risk assessment has been carried out in accordance with international industry practice and accepted general principles and methodology. However, there are certain features of risk assessment methodology that are fundamental to drawing conclusions on the significance of the results.

These are summarised below:

- The risk assessment is a mathematical procedure which addresses potential exposure pathways based on the process selected, the predicted emissions and the current land use.
- Conclusions can only be drawn with respect to the proposed CPWE remediation option investigated.
- The risk assessment does not include an assessment of risk resulting from exposure to chemicals from historical land uses that may no longer exist in the study area e.g. market gardening or industrial water use.
- The risk assessment does not present an evaluation of the health status of the existing community or workers in the area. Rather, it is a logical process of calculating the amount of potential daily intake of chemicals associated with emission from the proposed CPWE remediation. This estimate is then compared to regulatory and published estimates of daily intakes that a person may be exposed to over a lifetime without unacceptable risks to their health. This is undertaken using guidance recommended and endorsed by Australian regulators in particular the DEC and the NSW Department of Health (NSW Health).
- The risk assessment reflects the current state of knowledge regarding the potential health effects of COPCs identified for the CPWE remediation. This knowledge base may change as more insight into biological processes is gained, further studies are undertaken and more detailed and critical review of information is conducted.

Section 3 Site and Process Description

3.1 Site Location

The BIP is located on the northern side of Botany Bay approximately 11 km south of the Sydney Central Business District (CBD). The BIP occupies approximately 74 ha. The BIP site is an operating industrial site and as such the on-site environment is limited to grassed and small garden areas within the industrial site.

The CPWE was constructed in 1980 adjacent to the Olefines Administration building. The CPWE site is "L" shaped lined with a synthetic liner (Hypalon) envelope – an engineered cell in the north east corner of the BIP (refer to Figures 1 and 2). The cell is capped with sand and a bitumen surface which was utilised as a car park and is currently used for driveway access to the Olefines car park which is adjacent to the western boundary of the CPWE. The encapsulation consists of approximately 45,000 m^3 of soil (sand/ash/peat) contaminated with a range of CHCs including HCBD, HCE, OCS, HCB and PCE.

Soil and other materials, which were placed within the encapsulation, originated from an open area where drummed CHC waste had been stored. Details on the construction of the encapsulation are presented in the Waste Material Characterisation Report (Woodward-Clyde 1998).

The remediation works proposed for the CPWE will take place in two main locations on the BIP:

- The CPWE area (owned by Orica). An Excavation Soil Building (ESB) will be constructed to enclose the excavation area and excavation of the contaminated soil will take place within this building; and
- The former Propathene Plant area (owned by Orica). The soil pre-treatment and remediation (DTD) process will be located in the former Propathene Plant area within the BIP, south west of the CPWE area. The Propathene Plant has been previously demolished and the area is effectively clear. A Feed Soil Building (FSB) will be constructed where all soil preparation activities will take place. The DTD will also be constructed in this area.

Transport of excavated material from the ESB to the FSB will be undertaken by covered truck on internal BIP roads.

3.2 Project Description

A detailed description of the proposed CPWE remediation project is presented in the EA and summarised in both the PHA (Sherpa 2007) and the Air Quality Impact Assessment (PAE, 2007). While it is noted that the detailed design has not yet been completed, in simple terms the proposed project involves the following (refer to Figure 3 for locations):

- Construction of a ventilated ESB fitted with an emission control system (ECS) in the CPWE area and excavation of contaminated material within the ESB, including the Hypalon liner (as necessary).
  - The ESB may be a single large building or a smaller building that is relocated in up to five stages depending on the outcome of detailed design studies and costing. The maximum impact in terms of noise and contaminant emissions will be for the five stage scenario hence this has been selected for the EA assessment.
  - The ESB will completely cover the area of excavation, with each stage covering a minimum area of approximately 3,000 m^2. Excavation of the bitumen cap, sand and encapsulated material will take place within the ESB via the use of an excavator. Excavated material will be stockpiled within the building before being fed to a coarse vibrating screen ("grizzly") by a front end loader to remove oversized materials. Oversized material will be stockpiled and tested for contamination before being disposed to landfill (if not contaminated above landfill acceptance criteria), recycled (where possible) or transported to the FSB for treatment in the DTD Plant. The remaining material will be temporarily stockpiled within the ESB before being loaded into covered trucks for transportation to the FSB. Access to the ESB will be via an air lock entry and exit fitted with an automated wheel wash facility to be used by trucks exiting the building.

- The ESB will be constructed of steel and fitted with louvers for ventilation. An ECS will be constructed and operated to preserve air quality within the building and minimise emissions to the atmosphere. The ECS will be operated to ensure the flow of air into the building. The ECS will comprise a fan, duct work, dust filters, two stage carbon beds and a stack of 30m height. The ECS will be located directly to the west of the CPWE on the existing Qenos car park.
- The ESB will also be serviced by a water treatment facility with expected capacity of some 10,000 m^3 per month to process water encountered within the CPWE as well as truck wheelwash water and other contaminated water recovered during the project. The water treatment facility will likely use a process of filtration and carbon adsorption to treat water to enable reuse in the wheel wash, on treated soil stockpiles for rehydration and dust control, or for disposal to the BIP effluent system or sewer.
- Activities in the ESB would take place for up to twelve hours per day for six days per week with the ECS operated for 24 hours per day.

* The Soil Treatment Area (STA) comprises the FSB, DTD Plant and treated soil stockpiles and is located to the south of the CPWE on the site of the former Propathene Plant.
  - Further handling and testing of excavated material will take place within the FSB before material is fed into the DTD Plant for treatment.
  - Material transported to the FSB will be stockpiled using a front end loader before undergoing further screening and testing for contaminant levels and other characteristics. The material will be blended to achieve a relatively homogenous feed material prior to being loaded into the feed hopper of the DTD Plant. Material will be continually fed into the DTD Plant 24 hours per day at a nominal rate of up to 35 tonnes/hour. Other activities within the FSB, including screening will also take place 24 hours per day.
  - Oversized contaminated materials found within the CPWE (which may include concrete, steel, corroded drums and timber) will be crushed or shredded and fed into the DTD Plant, if requiring treatment.
  - Similar to the ESB, the FSB will be fitted with an air lock and automated wheel wash, louvres and an ECS for air quality control. The ECS for the FSB will operate in the same way as that for the ESB.
  - Transport from the ESB to FSB will be by trucks fitted with solid steel lids. Trucks will be decontaminated prior to exiting both the ESB and FSB.
  - It is anticipated that three trucks would operate on the site up to 12 hours per day, 6 days per week. All truck transport would occur within the BIP, there would be no use of external roads (e.g. Corish Circle).
  - DTD treatment involves desorption of contaminants (separating or vaporising) from soil at temperatures typically in the range of 300°C to 450°C in a rotary dryer under oxidising conditions. Gases generated by the rotary dryer are then subject to an extensive treatment process designed to ensure compliance with stringent air emissions standards. The gas treatment process typically comprises a cyclone to remove large dust particles, thermal oxidiser to destroy organic contaminants, quench to rapidly cool the thermal oxidiser off gas so as to control dioxin formation, baghouse to control dust emissions and an acid gas scrubber to remove acidic gases generated by the oxidation of chlorine and sulphur compounds present in the feed material. Clean, treated gas is to be vented to the atmosphere via the scrubber stack which will be 30m high.
* Clean, treated soil will be stockpiled in the south and west of the STA with drains and bunds provided to manage runoff. An additional overflow stockpile area has been identified on Orica land to the east of the STA. Stockpiles will be stabilised with spray grass or other such treatment and will be wetted when necessary to control dust. Clean soil (that meets adopted criteria as defined in the Remedial Action Plan, RAP) will be retained until completion of remediation works on the CPWE

when it will be trucked back to the CPWE excavation for the reinstatement of the area to the level of Corish Circle. Surplus clean soil will be retained for future reuse on other Orica land within the BIP.

- All buildings and plant will be removed on completion of soil remediation.

Overall, the remediation project is expected to take approximately 18 months comprising:

- Site establishment and construction (including DTD Plant commissioning - Proof of Performance (PoP) testing) – approximately 26 weeks;
- Excavation and treatment – approximately 30 weeks;
- Decommissioning and demobilisation – approximately 14 weeks; and
- Reinstatement of site – approximately 14 weeks (NB Concurrent with demobilisation).

3.3 Setting of BIP and CPWE Area

3.3.1 Topography and Drainage

The BIP is located on an area of former sand dunes and coastal swamps within the Botany Basin. The elevation of the site drops from around 20 m above sea level on the eastern side of the site to less than 5 m above sea level on the western side. An extensive low-lying area (less than 5 m above sea level) which was formerly swampy occurs to the west of the site. Natural drainage on the site is towards two drains, Springvale and Floodvale Drains, which drain the low-lying area southwards to Botany Bay. The drains enter Botany Bay via Penrhyn Estuary, which was formed by the reclamation of the Port Botany Container Terminal area.

Springvale and Floodvale Drains were excavated in the 1870s prior to the establishment of the ICI Australia Operations Pty Ltd (ICI)[4] Botany Site in the early 1940s, to assist in the drainage of Veterans Swamp and surrounding areas. The urban stormwater systems follow the natural fall of the land and discharge mainly into Springvale and Floodvale Drains or the drains to the east of the site.

The CPWE is situated on an elevated area formed from coastal sand dunes, it is elevated above surrounding areas due to the encapsulation. The car park is relatively flat. The upper section of the CPWE is approximately 2 m higher then the surrounding land to the south, east and north. The CPWE is approximately 6 m above the land to the west.

On the BIP itself, uncontaminated stormwater discharges into Springvale Drain. Treated trade waste effluent is discharged into the Sydney Water sewer system.

3.3.2 Geology

In general, the site is underlain by the Botany Sands, a sequence of predominantly unconsolidated to semi-consolidated permeable sands. These are interspersed with lenses and layers of peat, peaty sands, silts and clay that become more common in the lower part of the sequence. The sand sequence which is 30 to 60 m thick is underlain by sandstone rock (Hawkesbury Sandstone) which has a very low permeability compared to the sand deposits. Peat layers have been noted in many shallow foundation boreholes drilled over wide areas of the site.

[4] ICI Australia Operations now known as Orica Australia Pty Ltd

3.3.3 Hydrogeology

In general, the Botany Sands contain and transmit groundwater and are referred to as the Botany aquifer. The main groundwater recharge areas are in the higher sandy country to the north and east of the site. Water table gradients indicate that groundwater flows predominantly in a westerly and south-westerly direction towards Botany Bay, however the inferred shallow groundwater flow direction in the vicinity of the CPWE is in a south-easterly direction. The variation in groundwater flow in the vicinity of the CPWE is likely to be due to groundwater extraction from Qenos production bores located in the general vicinity of the CPWE. Based on information provided by Orica, these production bores have been active since the 1980s and are still active, producing between 1 and 2 ML/day in total.

The Botany aquifer is one of the few high yielding, low salinity coastal aquifers in NSW. It was one of the early sources of water for Sydney and it remains an important source of industrial water in the Botany area. A number of groundwater bores have been identified within the residential areas located to the east and west of the site. Not many of the bores within the residential area have been registered, however anecdotal information indicates that residential bores are reasonably common in the area assessed along the western margin of the ‘Northern Plumes’ of contaminated groundwater. A Groundwater Extraction Exclusion Area has been declared by the Department of Natural Resources (DNR) that encompasses the BIP (including the CPWE), Hensley Athletics Field and residential/commercial areas south of Fraser Avenue, east of the CPWE as illustrated in **Figures 1** and **2**.

3.4 Surrounding Land Use

The current land uses, based on council zoning, in the immediate vicinity of the BIP and CPWE are shown on **Figures 1** and **2.** The following land uses occur within a distance of 2 km of the BIP:

- Residential;
- School;
- Commercial (including offices and shops);
- Industrial (including food processing);
- Recreational (golf courses, playing fields, Penrhyn Estuary and Botany Bay); and
- Public open space.

More specifically, land use in the area adjacent to the CPWE includes the following:

Direction from CPWE	Description and Land-Use
North	Commercial properties are located adjacent to the northern boundary of the CPWE/BIP site. It is noted that commercial/industrial buildings have been constructed on land immediately adjacent to the CPWE.
East	Corish Circle is located adjacent to the eastern side of the CPWE/BIP site. The Hensley Athletics Field (recreational area) is located across Corish Circle with residential properties located further east across Denison Street.
South	The BIP extends to the south of the CPWE with the former Propathene Administration building, Gate 4 and Olefines Administration building located closest to the CPWE.
West	The BIP extends to the west of the CPWE with the Olefines car park and Olefines Administration building located closest to the CPWE. A commercial and light industrial development is located further to the west of the Olefines Administration building (outside the BIP).

Section 3 Site and Process Description

In addition the following can be noted with respect to land-use in the surrounding areas:

- The nearest residential areas are in Denison Street (approximately 160 m to the east / southeast of the CPWE) and in Eastlakes / Pagewood (approximately 400 m to the north-west of the CPWE).
- Banksmeadow Primary School is located approximately 1000 m south west, Matraville Primary School is located approximately 800 m south east and Pagewood Primary school is located approximately 600 m north west of the Site.
- A number of businesses involved in food manufacturing or distribution are located in the area. These include:
  - Kellogg (Aust.) Pty Ltd (Kellogg's) - snack foods, cereals etc - is a food manufacturing facility located approximately 800 m west of the proposed remediation facility (DTD Plant) and 1 km west of the CPWE.
  - A juice factory (Nudie Juice) has reopened on Corish Circle, approximately 300 m north of the proposed remediation facility and approximately 150 m north of the CPWE.
  - There was also a food distribution company (Gazelle Foods Pty Ltd) in Denison Street, near the corner of Smith Street which is opposite Hensley Athletics Field. The facility no longer exists and the site has been cleared awaiting development.
  - A food manufacturing facility (soy products are produced and distributed) exists within 19A Baker Street, located approximately 400 m to the west of the CPWE and approximately 400 m north west of the proposed remediation facility. A bakery/patisserie is also located approximately 500 m north west of the CPWE and approximately 600 m north west of the remediation facility.
  - Eastgardens shopping centre across Wentworth Avenue also has typical food outlets. None of these are food manufacturing or repackaging facilities. However, a childcare centre is located at the shopping centre.
  - Immediately north of the CPWE is an industrial building leased out to various industrial users, including a bakery and food repackaging company. The remaining businesses are of a general industrial non-hazardous nature.

Section 4 Previous Assessments

4.1 Introduction

At present the CPWE remains an enclosed encapsulation. Potential issues that may be associated with emissions derived from the existing CPWE have been assessed during previous human health risk assessments and ongoing monitoring. In particular, assessments presented with the following reports are of most significance with respect to the assessment of risks to human health associated with existing impacts and potential remediation:

- Consolidated Human Health Risk Assessment (referred to as the Consolidated HHRA) prepared by URS, 2005; and
- HCB Waste Management Plan, HHRA (Car Park Waste) prepared by URS, 2002.

The following presents further detail on the assessments and outcomes presented.

4.2 Consolidated Human Health Risk Assessment

A HHRA was undertaken to provide an overall review of human health risk issues in areas surrounding the Botany Industrial Park (BIP). This included an assessment of the potential for human exposure to groundwater contaminants derived from the BIP as well as emissions from the CPWE located on the site. The Consolidated HHRA (URS 2005) presents an evaluation of risk to human health on the basis of data collected up until the end of February 2005 with an addendum issued (URS 2006d) that addressed additional data collected to May 2006 from residential bores located in Collins Street, Pagewood, and Dent Street, Botany.

The assessment presented with respect to the CPWE involved quantification of inhalation exposures by recreational users of Hensley Athletics Fields, residents living in areas close to the CPWE, workers in areas adjacent to the BIP and workers within the BIP. The assessment was undertaken on the basis of emission data collected from the surface of the CPWE up until the end of February 2005. The data were used within an air dispersion model to provide estimates of potential concentrations in air in recreational, residential and work areas. The key chemicals identified in the assessment were HCBD, HCE and PCE.

The calculated risks to human health associated with emissions to air from the existing CPWE were assessed and considered to be acceptable in all areas.

Following completion of the assessment presented within the Consolidated HHRA (URS, 2005), works have been undertaken to remediate soil along the eastern embankment (above the liner) with additional lining and landscaping installed. Emissions testing along the eastern embankment following completion of these works has shown a decrease in emissions to air (URS 2006b). Further sampling of emissions from the CPWE (URS 2006c) has provided data consistent with that considered within the calculations presented within the Consolidated HHRA (URS 2005).

4.3 HCB Waste Management Plan Human Health Risk Assessment

This report presented an initial assessment of risks to human health associated with emissions from the CPWE. The report presented an assessment of risks to human health associated with the existing encapsulation (based on data collected to 2000) as well as issues that may be relevant during the potential remediation and major failure of the encapsulation in accordance with the requirements of the "HCB Waste Management Plan" (ANZECC 1996).

The assessment concluded that risks to off-site residential, recreational, industrial and on-site industrial workers associated with emissions to air from the existing CPWE do not represent an unacceptable risk to human health. In addition, potential risks associated with accidental damage or failure of the CPWE have been evaluated and are not expected to represent an unacceptable risk to human health.

4.3.1 Consideration of Issues Relevant to Remediation

In accordance with the requirements outlined in the “HCB Waste Management Plan” (ANZECC 1996), the assessment was required to address potential issues associated with remediation. At the time when the assessment was undertaken the review of remediation options was in progress and it was not known which technology or group of technologies would ultimately be possible. However, to provide a review of potential issues that may be associated with remediation of the CPWE, it was assumed that such remediation would occur in situ. The assessment of potential risks associated with the potential for such remediation to occur involved the establishment of maximum acceptable concentrations within the breathing zone of residential, recreational and occupational groups. From this the maximum allowable rates of emissions from the encapsulation were estimated using back-calculation.

As part of this process, future chemicals of potential concern (FCOPCs) were identified following review of available soil gas data collected from within the encapsulation. It was assumed that in the event that the CPWE was remediated FCOPCs identified within the encapsulation have the potential to be of concern in the ambient air and should be considered further in any such assessment. Soil gas data collected from within the encapsulation as part of the Waste Characterisation Study (Woodward-Clyde 1998) were reviewed. All volatile chemicals detected were screened against adopted screening levels relevant to short-term exposures[5]. The soil gas concentrations detected were screened directly against the adopted short-term screening levels assuming no dilution or dispersion following release, treatment or discharge. Hence the screening approach adopted is considered to be appropriate and conservative in the identification of volatile chemicals that warrant further consideration during any future remediation process.

Table 4.1 presents a summary of the soil gas data collected, the adopted short-term screening levels and chemicals that were identified as FCOPCs (shaded rows).

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[5] Adopted short-term screening levels were derived from Region IX Preliminary Remediation Goals (PRGs) for ambient air. The PRGs are presented for long-term exposures and hence a modifying factor was applied to adjust the level to those relevant to short-term exposures (refer to report for further detail, URS 2002a).

Section 4 Previous Assessments

Table 4-1 Summary of Soil Gas Concentrations

Chemical	Soil Gas Concentration* ($\mu g/m^3$)			PRG Short-Term
	Minimum	Average	Maximum	($\mu g/m^3$)
tetrachloroethene (PCE)	1.6×10^6	2.6×10^6	4.4×10^6	3.2×10^0
trichloroethene (TCE)	9.7×10^3	2.8×10^4	5.4×10^4	1.7×10^{-1}
1,2-dichloroethene	1.2×10^3	1.5×10^4	2.7×10^4	3.7×10^2
1,1-dichloroethene	6.3×10^3	1.3×10^4	2.7×10^4	2.1×10^3
vinyl chloride (VC)	1.0×10^3	3.6×10^3	9.4×10^3	1.1×10^{-1}
1,1,2-trichloroethane	1.1×10^1	4.4×10^2	1.3×10^3	1.2×10^{-1}
1,1,1-trichloroethane	3.1×10^1	3.8×10^2	1.1×10^3	2.3×10^4
1,1-dichloroethane	1.3×10^3	7.8×10^3	2.1×10^4	5.2×10^2
1,2-dichloroethane (EDC)	7.7×10^1	6.4×10^3	2.2×10^4	7.4×10^{-2}
carbon tetrachloride (CTC)	3.8×10^{-1}	8.9×10^0	4.3×10^1	2.6×10^1
chloroform (CFM)	1.3×10^3	1.4×10^4	4.2×10^4	8.4×10^{-2}
methylene chloride (dichloromethane)	5.6×10^2	1.8×10^3	2.7×10^3	4.1×10^0
chloromethane	3.7×10^2	5.8×10^2	1.3×10^3	9.5×10^1
trichlorofluoromethane	1.3×10^{-1}	1.3×10^1	6.0×10^1	7.3×10^3
dichlorodifluoromethane	3.9×10^1	1.9×10^2	8.6×10^2	2.1×10^3
1,1,2-trichloro-1,2,2-trifluoroethane	0	5.3×10^0	3.3×10^1	3.1×10^5

Notes:
* Statistics of samples collected, analysed and reported by Woodward-Clyde, 1998.
PRG Short-Term – Region 9 Preliminary Remediation Goals (2004) adjusted for Short-Term exposure.
Shaded rows indicate chemicals where the measured concentration (average) exceeds the PRG Short-Term.

Semivolatile chemicals were not analysed from the soil gas samples collected. To assess the semivolatile chemicals that may be of potential concern with respect to risk to human health, the results for soil samples collected from within the encapsulation have been utilised. The semivolatile chemicals detected were hexachlorobenzene (HCB), hexachlorobutadiene (HCBD), hexachloroethane (HCE), octachlorostyrene (OCS), pentachlorobenzene and polychlorinated biphenyls (PCBs). For the purpose of this assessment these semivolatiles have been considered as FCOPCs.

In summary the following chemicals were identified as FCOPCs for the assessment of risks associated with remediation options:

- PCE;
- TCE;
- 1,2-dichloroethene (cis- and *trans* –isomers);
- 1,1-dichloroethene;
- vinyl chloride;
- 1,1,2-trichloroethane;
- 1,1-dichloroethane;
- 1,2-dichloroethane;

- chloroform;
- methylene chloride (dichloromethane);
- chloromethane;
- HCB;
- HCBD;
- HCE;
- OCS;
- Pentachlorobenzene; and
- PCBs.

These FCOPCs were further considered within this assessment. The list of FCOPCs was provided to Thiess to ensure that emission estimates and subsequent air dispersion modelling (PAE 2007) included all these chemicals. It is noted that no more comprehensive sampling has been undertaken within the CPWE to supplement the data utilised and considered in identifying FCOPCs.

Section 5 Identification of Issues

5.1 General

Potential human health impacts that may be associated with the proposed CPWE remediation project have been assessed by evaluating the following:

- Emissions and exposures associated with **construction** of the FSB and DTD Plant that will be constructed on the BIP in the former Propathene area (refer to **Figure 3**). During construction there is the potential for exposure to dusts that may be generated during this phase of the project.
- The potential sources for emissions to air during **operation of the proposed CPWE remediation project** - the potential for sources emissions are listed in Section 5.3.1.
- Emissions to air that may occur during **abnormal operating scenarios**.

The following presents a review of potential emissions and health impacts that may be associated with the construction and operational phases of the project with an emphasis on the evaluation of processes and issues which have the potential to result in impacts to human health. The focus of the assessment is the potential for exposures to occur in a number of key areas. For the purpose of this assessment the following is defined:

- **CPWE site** – refers to all areas proposed to be utilised for the purpose of the CPWE remediation project;
- **BIP** – refers to areas located within the BIP that are outside of the CPWE site; and
- **Off-site** – refers to all areas (workplace, recreational and residential) surrounding the BIP.

Issues associated with exposures by workers involved in all aspects of the CPWE remediation project will be addressed in accordance with NSW OHS Regulations and have not been considered further in this assessment.

The review of potential emissions during construction and operation of the proposal has drawn on information and evaluations presented in the Air Quality Impact Assessment (PAE 2007) and PHA (Sherpa 2007). Where relevant, the assessment of the potential significance of issues that may be identified has drawn on health risk assessments presented in previous investigations undertaken on the site.

5.2 Construction

Dust emissions that may be generated during the construction phase of the project have been reviewed in the Air Quality Impact Assessment (PAE 2007). PAE identified that dust emissions from the construction phase of the project would not be expected to result in off-site nuisance impacts due to the short duration of the construction phase, sealed access roads and implementation of dust mitigation measures (as outlined by PAE) within the Construction Environment Management Plan.

Provided dust mitigation measures are implemented, there are no issues associated with the construction phase of the project that warrant further consideration within the health impact assessment.

5.3 Operation of Proposed CPWE Remediation Project

5.3.1 General

The proposed operation of the CPWE remediation project has been described in detail, including proposed air emission controls, building characteristics, stack heights, and potential emissions in the Air Quality Impact Assessment (PAE 2007). The following emissions to air have been identified from the proposed project:

- ESB stack venting treated air from the ECS on the ESB building;
- FSB stack venting treated air from the ECS on the FSB building;
- DTD Plant stack emissions;
- Fugitive chlorinated organic compounds emitted from the ESB during relocation of the enclosure between stages;
- Fugitive chlorinated organic compounds emitted from covered trucks transporting waste from the ESB to the FSB;
- Fugitive dust emissions from the treated soil stockpiles;
- Fugitive dust emissions from the trucks transporting treated soil from the stockpiles to the car park for reinstatement; and
- Fugitive dust emissions from the treated soil reinstatement activities at the car park.

The remediation of material from the CPWE is expected to be undertaken to achieve soil concentrations outlined within the RAP (HLA 2007). The soil concentrations associated with the treated soil are expected to be suitable for long-term use within an industrial area that may include re-instatement within the car park (with no requirement for encapsulation). Hence consideration of exposures derived from the treated soil is associated with dust emissions rather than issues associated with chlorinated chemicals.

Based on the proposed remediation process and control systems, there is the potential for the following exposures to emissions generated during the project:

- Inhalation exposures (acute and chronic) by workers on the BIP in areas adjacent to the CPWE site;
- Inhalation exposures (acute and chronic) by workers in areas surrounding the BIP;
- Inhalation exposures (acute and chronic) by recreational users of the Hensley Athletics Field and other recreational areas in areas surrounding the CPWE site;
- Exposures by residents to emissions to air. Key issues are expected to be associated with inhalation exposures (acute and chronic) and potential multiple pathway exposures (chronic) to chemicals considered to be persistent and bioaccumulative and that may deposit onto and accumulate in soil and home-grown produce.
- Cumulative exposures in workplace, recreational and residential areas associated with emissions derived from the proposed CPWE project as well as other key emission sources identified in the area. Other key emission sources considered (as modelled in the Air Quality Impact Assessment, PAE 2007) include the following:
  - <u>Background</u> criteria pollutant levels (derived from Randwick data);

- Orica Sources:
  - GTP Stack;
  - Hydrogen Chloride (HCl) Burner Vent Stack (Chlorine Plant);
  - Weak Gas Vent Stack (Chlorine Plant);
  - Area remaining after removal of decommissioned cells building near the Chlorine Plant (Old Chlorine Plant);
  - Store J Stack (HCB Waste Repackaging Plant); and
  - Store H Stack (HCB Waste Repackaging Plant).
- Qenos Sources:
  - Two Coal Boiler Stacks (Site Utilities);
  - Gas Boiler Stack (Site Utilities);
  - Five Furnace Stacks (Olefines Plant);
  - Two Ground Furnace Stacks (Olefines Plant);
  - Elevated Flare Stack (Olefines Plant); and
  - Ground Flare (Alkatuff Plant).
- Huntsman Sources:
  - Hot Oil Furnace (Surfactants Plant).

5.3.2 Air Quality Assessment

The Air Quality Impact Assessment (PAE 2007) provides full detail on emission sources, air dispersion modelling and the air quality impact assessment undertaken to address regulatory and the Director General's EARs for the proposed project. The impact assessment presented included modelling of a number of pollutants considered relevant for the operation of the CPWE project (including other sources in the area) with estimated ground level concentrations and deposition rates provided for further consideration within the Air Quality Impact Assessment as well as the HHIA. Details presented within and derived from modelling associated with the Air Quality Impact Assessment that are relevant to the assessment of health impacts are further discussed in the following sections.

5.3.3 Chemicals of Potential Concern

The air impacts assessment has provided a detailed evaluation of potential emissions to air from the proposed CPWE remediation project. A comparison of the predicted impacts from the CPWE remediation project as well as cumulative impacts, with regulatory requirements has been undertaken in the Air Quality Impact Assessment (PAE 2007). This assessment indicates that emissions from the proposed remediation project (incorporating derived emission rates[6] for sulphuric acid and hydrogen fluoride) meet these regulatory requirements. These regulatory criteria (DEC, 2005) are protective of toxic effects (i.e. health effects associated with potential exposures every day by the general public) and, as such, potential health impacts associated with emissions of sulphuric acid and hydrogen fluoride do not warrant further consideration.

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[6] Emission rates have been derived for these pollutants to ensure that predicted ground level concentrations meet relevant air quality criteria from the DEC. These derived emission rates are therefore maximum permissible rates. It is understood that Thiess has indicated that these emission rates can be achieved.

Section 5 Identification of Issues

In addition to the air quality assessment, emissions to air need to be further evaluated with respect to health risk based levels. The following key emissions have been evaluated further.

Criteria Air Pollutants

The evaluation of "criteria" pollutants (carbon monoxide, nitrogen dioxide, photochemical oxidants (ozone), sulphur dioxide, lead and particles as total suspended particulates (TSP) and PM_{10}) using the ambient air criteria as set out in the NEPM is considered to be an appropriate basis for the assessment of the potential for adverse health effects. The NEPM (Ambient Air) guidelines have been established to allow *"for the adequate protection of human health and well-being"* (NEPC 2003). It is noted that when reviewing the criteria set out in the NEPM for Ambient Air Quality, the criteria are designed for use in assessing regional air quality and are not intended for use as site boundary or atmospheric dispersion modelling criteria. They are, however, a useful guide in the evaluation of expected air quality for criteria pollutants (proposed CPWE remediation project as well as background and other sources) with respect to the protection of human health and well-being. As all modelled emissions from the CPWE remediation project for criteria pollutants are below the ambient air criteria relevant to the protection of long-term health, further assessment is not considered to be required.

Other Chemicals

The evaluation of other emissions from the CPWE remediation project on the basis of NSW DEC (2005) Impact Assessment Criteria undertaken in the Air Quality Impact Assessment (PAE 2007) involved the comparison of predicted ground level concentrations with the relevant assessment criteria. These criteria are not comprehensive and are not considered appropriate for the assessment of long-term risk to human health or to assess exposure via pathways other than inhalation that might be applicable to the deposition and accumulation of particulates. As such, all the FCOPC identified in Section 4.3.1 have been further considered within the health impact assessment to ensure that the assessment considers cumulative risks associated with exposure to all these chemicals, including those expected to be present at low concentrations.

On this basis, no further screening of the FCOPC has been undertaken and all have been adopted as COPC with respect to the assessment of inhalation exposures.

It is also noted that the Air Quality Impact Assessment has also considered emissions of dioxins and mercury (not present as element mercury). These chemicals are not volatile or semivolatile, however they have been assessed as particulate emissions from the proposed CPWE remediation project. As these non-volatile chemicals are expected to be present in the area from a number of other sources and there is a large degree of uncertainty associated with the modelling of mercury emissions from the CPWE remediation project, it is considered warranted to include these chemicals as COPC within the health impact assessment to ensure that cumulative impacts can be addressed.

Some of the chemicals emitted are regarded as persistent in the environment with the potential to bioaccumulate and as such, exposure may occur via pathways other than inhalation. The persistent and bioaccumulative chemicals may accumulate in soil and in home-grown fruit and vegetable produce and may find their way into breast milk resulting in potential exposure by infants.

On the basis of the information presented in Appendix A with respect to the COPC considered in this assessment, **mercury, dioxins, HCB, HCBD, HCE, OCS, pentachlorobenzene and PCBs** have been identified as persistent and bioaccumulative. Hence these chemicals have been further assessed with respect to multi-pathway exposures.

Summary of COPC Identified

The following presents a summary of the COPC identified and considered further within this assessment with respect to long-term exposures.

COPC	Significant with Respect to Inhalation Exposures	Persistent and Bioaccumulative – Multi-pathway Exposures
Volatile COPC		
tetrachloroethene (PCE)	√	
trichloroethene (TCE)	√	
cis-1,2-dichloroethene	√	
trans-1,2-dichloroethene	√	
1,1-dichloroethene	√	
vinyl chloride (VC)	√	
1,1,2-trichloroethane	√	
1,2-dichloroethane (EDC)	√	
1,1-dichloroethane	√	
chloroform (CFM)	√	
dichloromethane (DCM)	√	
chloromethane	√	
Semi-Volatile COPC		
hexachloroethane (HCE)	√	√
pentachlorobenzene	√	√
hexachlorobutadiene (HCBD)	√	√
hexachlorobenzene (HCB)	√	√
octachlorostyrene (OCS)	√	√
polychlorinated biphenyls (PCBs)	√	√
Non-Volatile COPC		
dioxin	√	√
mercury *	√	√

* The assessment of mercury is discussed in further detail in Section 6.2.

5.4 Upset Operating Conditions

Potentially hazardous incidents that may be associated with the operation of the proposed facility were identified within the PHA (Sherpa 2007) following a number of workshops held with Orica and Thiess personnel. It is noted that facilities of the type proposed have been operating for about 20 years and have undergone a number of improvements and refinements. Personnel involved in the workshops had experience in the operation of such technology.

The process adopted and presented within the PHA identified a range of incident scenarios associated with upset conditions. These scenarios that have the potential to result in off-site impacts were further addressed within the PHA, with others identified as potential issues that warrant further consideration within the Air Quality Impact Assessment (PAE 2007) and the HHIA. Potential incidents that required further consideration within this assessment have been identified (based on likelihood and the potential to result in increased emissions of volatile contaminants to air) as:

- Ventilation failure in the ESB and/or FSB. Fan failure may lead to a loss of airflow into the building resulting in emissions of volatile chemicals via any building apertures. Periodic inspection and maintenance of the fans will be undertaken. Control measures incorporated include alarms (audible and visible) with a procedure to shut down louvers and building doors. Any emissions from the building during such an incident would be limited to less than 10 minutes' duration.

- Once the carbon beds are fully loaded, contaminants in the exhaust air would pass through them untreated and be emitted to atmosphere. Such a scenario is considered to be highly unlikely as there are monitoring and mitigating measures in place to ensure the likelihood of occurrence is low there is a high rate of dilution within the ventilation air.
- Failure of natural gas supply leading to a shutdown of the DTD, resulting in continued volatilisation and release of partially treated emissions including dioxins. In addition an operating malfunction in TO temperature may lead to dioxin formation. Control of the TO temperature within the optimum range is very important in maximising contaminant destruction and rapid quenching is very important to prevent recombination and combustion products forming dioxins. A malfunction may occur when there is a loss of quench water, poor temperature control leading to poor TO efficiency. Control measures include monitoring of TO, water flow, temperature with alarms and trip to stop soil feed conveyor and initiate shutdown of the DTD.

  The worst-case emissions would be expected to occur as a result of a loss of natural gas supply and the emission of partially treated contaminants from the DTD stack. Emissions associated with such an incident could, in the worst case, continue for up to 15 minutes before emergency power is established to allow a controlled shutdown.

Review of these incidents suggests that the scenario considered with respect to the loss of natural gas supply provides a worst-case scenario associated with potential emissions from the proposed facility. Hence potential impacts associated with this scenario warrant further consideration within the HHIA.

Section 6 Hazard/Toxicity Assessment

6.1 Introduction

As outlined in Section 2.4, the quantification of potential risk associated with exposure to the COPC identified requires the assessment of non-threshold and/or threshold effects. Toxicity values relevant to the quantification of non-threshold or threshold effects have been identified for each of the COPC identified following guidance from enHealth (2002) and NEPC (1999) in accordance with toxicological data sources outlined in Section 2.4.

6.2 Toxicity Reviews

Toxicity profiles have been prepared for the COPCs identified with the exception of PCBs and dioxins. These profiles provide a review of potential health effects associated with exposure and identification of relevant toxicity values for the quantification of risk associated with oral, dermal and inhalation exposures. The toxicity profiles for the COPCs identified in this assessment are presented in Appendix A of this report.

The Department of the Environment and Heritage (DEH) has undertaken an extensive review of dioxins in Australia and has published a summary document "*National Dioxins Program, Dioxins in Australia: A Summary of the Findings of Studies conducted from 2001 to 2004*" (DEH, 2004). This document provides a summary of key exposures and health effects associated with dioxins and is also included in Appendix A of this report for reference. It is expected that dioxin-like PCBs will be assessed as part of the dioxin assessment on the basis of the approach outlined in the DEH (2004) document. The assessment of other indicator PCBs have been assessed on the basis of the approach outlined by RIVM (2001) and NEPM (1999).

Table 6.1 presents a summary of the toxicity evaluation and data identified for use in this risk assessment. It is noted that many of the toxicity values have been reviewed by the DEC and NSW Health as part of the completion of the Consolidated HHRA (URS, 2005) and ongoing risk assessment reviews.

The evaluation of potential exposure to mercury emissions from the proposed facility has adopted a conservative approach. Two toxicity values are presented in Table 6.1 that are relevant to the assessment of exposures to mercury. Limited data are available with respect to expected mercury emissions from the proposed CPWE remediation project (and other sources such as the GTP) hence the evaluation undertaken in estimating potential daily intake has been conservative. It is not considered likely that a significant proportion of the mercury released from the CPWE remediation facility will be in the form of methyl mercury (which is usually found in fish). Rather the mercury emitted from the proposed facility is more likely to be in the form of inorganic chlorides and oxides. Hence where only inhalation exposures have been assessed, it has been assumed that mercury is in the form of inorganic chloride. However for the assessment of residential exposures associated with inhalation and multi-pathway exposures, mercury has been assumed to be presented as methyl mercury in all media. As the toxicity data available for methyl mercury are more conservative than for inorganic mercury, this approach is expected to overestimate potential intake and risk associated with exposures to mercury.

The toxicological data presented are considered to be appropriate for the assessment of chronic risks to human health associated with the potential exposure to the COPCs. It is accepted that toxicological data have some uncertainties (as outlined in Section 8 of this report). However, the approaches adopted by the different regulatory bodies in determining the relevant toxicological values are considered to be conservative and likely to overestimate the risks.

Details associated with the potential assessment of short-term, acute exposures and health impacts associated with the COPCs identified are discussed further within Section 7.2.

Section 6 Hazard/Toxicity Assessment

Table 6-1 Summary of Toxicity Data Relevant to COPCs Identified

Chemical	Non-Cancer Toxicity Endpoint	Animal Carcinogen and Mechanism	Genotoxic	Oral Slope Factor $(mg/kg/day)^{-1}$	Oral TDI (mg/kg/day)	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Inhalation TC (or equivalent) (mg/m^3)	TWA [6] (mg/m^3)	Potential for background intake
tetrachloroethene (PCE)	Liver, kidney, CNS	Yes, P, C, MG	No	T	0.014[3]	T	0.2[2]	335	Yes (34%)
trichloroethene (TCE)	CNS, liver	Yes, P, C, MG	Equivocal	T	0.00146[1]	$4.3x10^{-7}$ [2]	NT	54	Yes, low
cis-1,2-dichloroethene	Liver	Insufficient data	Potential	T	0.01 [4]*	T	O	793	Negligible
trans-1,2-dichloroethene	Liver	Insufficient data	No	T	0.017 [1]	T	O	793	Negligible
1,1-dichloroethene	Liver and kidney	Limited data	No	T	0.046 [1]	T	0.2 [2]	20	Negligible
vinyl chloride (VC)	Liver	Yes, G	Yes	1.15 adulthood 2.3 lifetime [1]	NT	$4.4x10^{-6}$ adulthood $8.8x10^{-6}$ lifetime [4]	NT	13	Negligible
1,1,2-trichloroethane	Liver, immune	Yes, C	No	T	0.004[4]	T	O	55	Negligible
1,2-dichloroethane (EDC)	Liver	Yes, M,G	Yes	0.012[1],[3]	NT	$(0.5 to 2.8)x10^{-6}$ [2] $2.8x10^{-6}$ proposed	NT	40	Negligible
1,1-dichloroethane	Kidney and CNS	Limited data	No	T	0.1 [4]*	T	0.5 [4]*	412	Negligible
chloroform (CFM)	Liver, kidney, CNS	Yes, P, C	No	T	0.013[1]	$4.2x10^{-7}$ [2*]	0.14[2]	10	Yes (50%)
dichloromethane (DCM)	Liver, kidney, CNS	Yes, M	No	T	0.0012[3]	T	1[5]	174	Yes (20%)
chloromethane	CNS	No	Equivocal	T	I	T	0.018 [2]	103	Yes (10%)
hexachloroethane (HCE)	Kidney, CNS	Yes, C, MG	No	T	0.001[4]	T	O	9.7	Negligible
pentachlorobenzene	Liver	Insufficient data	No	T	0.01 [1]	T	O	Adopt data for HCB as surrogate	Negligible
hexachlorobenzene (HCB)	Liver	Yes, NG	No	T	0.00016[1]	T	O	0.002[7]	Negligible
hexachlorobutadiene (HCBD)	Kidney	Yes, M,C	Equivocal	T	0.0002[3]	T	O	0.21	Negligible
octachlorostyrene (OCS)	Liver and kidney	Insufficient data	No	T	0.00031 [8]	T	O	Adopt data for HCB as surrogate	Negligible
dioxin (TEQ)	Hormonal, reproductive and developmental	Yes	No	T	$2.3x10^{-9}$ [9]	T	O	NA	Yes (54%)
Polychlorinated biphenyls (PCBs)	CNS, thyroid, endocrine system	Yes	No	T	0.00001 [5]*	T	O	0.5 (minimum value proposed)	Yes (50%)
mercury (Hg)	Elemental: CNS Inorganic: Kidney Methyl: CNS	No Equivocal Yes	--- No No	T	0.00071[1] for total mercury and 0.00023 for methylmercury[1]*	T	0.001[2] total mercury	Elemental/divalent :0.025 Monovalent Inorganic 0.1 Alkyl: 0.01 Aryl: 0.1	Yes (15% for methyl mercury and 50% for inorganic mercury)

Notes associated with data presented in Table

(1) Derived from WHO Drinking Water Guidelines (1993, 1996, 1998, 2004 and rolling revisions)
(1*) Derived from WHO guidelines using inhalation data
(2) Derived from WHO Air Quality Guidelines (2000, 2000b or current CICAD reviews (relevant for chloroform and PCE). Where a range is presented, the most conservative value (higher unit risk and lower ADI) has been adopted.
(2*) Noted to be a conservative approach as threshold may be appropriate
(3) Derived from NHMRC Australian Drinking Water Guidelines (2004)
(4) Derived by USEPA (IRIS evaluations)
(4)* Derived from HEAST – peer reviewed US source
(5) Derived by ATSDR (chronic exposures)
(5)* Derived by RIVM (2001) for sum of seven indicator PCBs (not including dioxin-like PBCs which are to be assessed on basis of dioxin TEQ as per WHO TEQ approach). Approach for individual PCB based on Aroclor 1254 which is consistent with ATSDR MRL (chronic), with 50% adopted to account for multiple PBCs to be present. RIVM value consistent with the ADI adopted in derivation of the HIL for PCBs (NEPM 1999).
(6) Occupational data available from Australian Safety and Compensation Council (ASCC) except where noted, TWA values based on 8-hour average
(7) Occupational data available from ACGIH, TWA value based on 8-hour average
(8) Data available from Health Canada
(9) Dioxin evaluation presented by NHMRC as presented by Therapeutic Goods Administration (TGA), endorsed 2002. Value recommended for use in risk assessment

O Inhalation exposure evaluated using oral data as no relevant chronic inhalation data available

I Oral exposures evaluated on the basis of inhalation data as no chronic oral data are available

T Threshold approach adopted, hence no oral slope factor or inhalation unit risk considered relevant

NT Non-threshold approach adopted NA Not available

NG = Non-genotoxic C = Cytotoxic P = Peroxisome proliferation

G = Genotoxic M = metabolite mediated with questionable relevance to humans

MG = species specific α2-microglobulin mechanism

TEQ = Toxicity Equivalence

Section 7 Health Impact Assessment

7.1 Introduction

This section provides a more detailed review of health impacts associated with key issues identified with respect to the operation of the proposed CPWE remediation project (refer to Section 4). This involves the quantification of risks to human health associated with the following:

- Inhalation (acute and chronic) exposure to COPCs identified in air following normal emissions from the operation of the CPWE remediation project;
- Multiple pathway exposure to persistent and bioaccumulative COPCs which may be emitted to air during normal operation of the CPWE remediation project; and
- Inhalation (acute and chronic) exposure to COPCs identified in air following worst-case upset condition.

The potential for impacts within the BIP and off-site areas associated with the proposed CPWE remediation project has been modelled in the Air Quality Impact Assessment (PAE 2007). The modelling undertaken has provided predicted ground level concentrations (GLCs) and deposition rates (for persistent and bioaccumulative chemicals) for all the COPCs identified for consideration within the HHIA associated with emissions to air from the following:

- CPWE remediation sources only;
- Other sources in the area as listed in Section 5.3.1; and
- CPWE remediation sources plus emissions from all other sources to assess cumulative impacts.

The modelling predicts maximum GLCs located at any point across a modelled receptor grid as well as at a number of off-site locations representative of key residential, school and recreational areas. These include the following (refer to **Figure 1** which illustrates the following receptor locations):

- Receptor 1: Botany Golf Course;
- Receptor 2: Banksmeadow Primary School;
- Receptor 3: Garnet Jackson Reserve;
- Receptor 4: Pagewood Primary School (corner Holloway Street and Dalley Avenue);
- Receptor 5: Botany Athletic Centre Grandstand (Hensley Athletics Field);
- Receptor 6: Botany Athletic Centre Running Track (Hensley Athletics Field);
- Receptor 7: Denison Street north (residential area);
- Receptor 8: Denison Street north 2 (residential area);
- Receptor 9: Denison Street south (residential area);
- Receptor 10: Guides Hall;
- Receptor 11: Retirement Village;
- Receptor 12: Our Lady of the Annunciation School;
- Receptor 13: Marist Brothers High School;
- Receptor 14: Childcare Centre;
- Receptor 15: St Agnes Primary School;

- Receptor 16: South Sydney High School;
- Receptor 17: Matraville Primary School; and
- Receptor 18: Kellogg's (representative of large food manufacturing plant in area).

In addition data relevant to the following areas have also been used within the HHIA:

- Maximum on-site: maximum concentration estimated within the BIP; and
- Maximum off-site: maximum concentration estimated for all areas located off the BIP, typically located on the boundary of the BIP.

The concentrations (and deposition rates) estimated have been evaluated further within this assessment with respect to potential acute (short-term) and chronic (long-term) health effects. The following sections present further detail associated with the assessment undertaken.

7.2 Acute Exposures

Acute exposures, short duration exposures to higher concentrations, may occur during normal operation of the CPWE remediation project as well as during accidental releases. Predicted short-term maximum GLCs associated with normal operations and accidental releases for all COPCs identified have been assessed against relevant acute criteria.

A range of different criteria are available for the assessment of potential human health effects associated with short-term emissions to air. No single organisation or methodology has developed acute criteria values or benchmarks for all potential compounds of concern. Hence, a hierarchical approach has been utilised for selecting existing guidelines for acute inhalation exposure levels.

Acute inhalation exposure criteria have been developed by a number of organisations which include: American Conference of Governmental Industrial Hygienists (ACGIH); Occupational Safety and Health Administration (OSHA); National Institute of Occupational Safety and Health (NIOSH); American Industrial Hygiene Association (AIHA), National Research Council on Toxicology (NRCT) USEPA; ATSDR, California Environmental Protection Agency (CalEPA); National Advisory Committee (NAC) and the US Department of Energy (DOE); Subcommittee on Consequence Assessment and Protective Actions (SCAPA); and National Occupational Health and Safety Commission (NOHSC).

The acute inhalation exposure criteria have been established by the above organisations and agencies to:

- Be protective of a range of exposure groups including occupational workers, military personnel and the general public;
- Based on a range of exposure durations, typically relevant to the exposure group, but ranging from 15 minutes, to 8 hours (typically for occupational settings) to 24 hours; and
- Protective of a range of toxicological endpoints such as mild discomfort, irritation, serious debilitating and potentially life-threatening effects up to and including death.

The hierarchical approach utilised in this assessment is based on that recommended by the USEPA Office of Solid Waste and detailed in the document "Human Health Risk Assessment protocol for Hazardous Waste Combustion Facilities" (Draft, USEPA 1998). The hierarchical approach is focused on the protection of the general public and is summarised below in order of preference:

1) Acute Exposure Guideline Levels (AEGLs) developed by the NAC/AEGL Committee and available from the USEPA;
2) Emergency Response Planning Guidelines (ERPGs) developed by the AIHA and SCAPA;
3) Acute Reference Exposure Levels (ARELs) developed by the CalEPA;

4) Temporary Emergency exposure limits (TEELs) developed by SCAPA; and

5) SCAPA toxicity-based approach as presented by the DOE.

Appendix B of this report presents further detail on each of these guideline and relevant basis for the levels proposed by each agency. Acute exposure criteria are established for the protection of a range of health effects. These range from **Level 0** to **Level 1** which is protective of all individuals, including sensitive groups, from mild transient effects; **Level 2** which is protective of individuals who may be exposed without developing irreversible or serious health effects (injury); **Level 3** which is generally the maximum concentration below which individuals will not experience life-threatening effects.

The predicted maximum off-site short-term GLCs (associated with relevant averaging period) of COPCs from the proposed CPWE remediation project during normal operations and upset conditions (including contributions from other sources) have been compared with the acute exposure criteria selected using the above approach. The comparison, presented in Tables 7.1 and 7.2, is expressed as a percentage of the GLC against the relevant criteria. It is noted that the comparison has been undertaken on the basis of the maximum modelled concentration that occurs in all areas off-site, likely to be on the boundary of the BIP. Hence the assessment presented is considered conservative for all areas (residential, recreational and workplace) as GLC are lower in the off-site receptor areas.

Section 7 Health Impact Assessment

Table 7-1 Assessment of Acute Exposure - Normal Operation of CPWE Remediation

Chemical	Comparison of Maximum Predicted GLC with Acute Exposure Criteria (% GLC/criteria)			
	Level 0 No Appreciable Risk	Level 1 Irritation	Level 2 Injury	Level 3 Life-Threatening
tetrachloroethene (PCE)	0.1%	<0.05%	<0.05%	<0.005%
trichloroethene (TCE)	<0.001%	<0.001%	<0.001%	<0.001%
cis-1,2-dichloroethene	<0.001%	<0.001%	<0.001%	<0.001%
trans-1,2-dichloroethene	<0.001%	<0.001%	<0.001%	<0.001%
1,1-dichloroethene	<0.001%	<0.001%	<0.001%	<0.001%
vinyl chloride (VCM)	<0.1%	<0.001%	<0.001%	<0.001%
1,1,2-trichloroethane	<0.001%	<0.001%	<0.001%	<0.001%
1,2-dichloroethane (EDC)	<0.001%	<0.001%	<0.001%	<0.001%
1,1-dichloroethane	<0.001%	<0.001%	<0.001%	<0.001%
chloroform (CFM)	<0.01%	<0.01%	<0.001%	<0.001%
dichloromethane (DCM)	<0.001%	<0.001%	<0.001%	<0.001%
chloromethane	<0.001%	<0.001%	<0.001%	<0.001%
hexachloroethane (HCE)	<0.1%	<0.05%	<0.05%	0.001%
pentachlorobenzene	<0.001%	<0.001%	<0.001%	<0.001%
hexachlorobutadiene (HCBD)	0.2%	<0.01%	<0.001%	0.001%
hexachlorobenzene (HCB)	0.3%	<0.1%	<0.001%	<0.001%
octachlorostyrene (OCS)#	0.04%	<0.01%	<0.001%	<0.001%
dioxin	<0.001%	<0.001%	<0.001%	<0.001%
mercury (as total, inorganic)##	1.7%	0.7%	0.5%	<0.01%
polychlorinated biphenyls PCBs)	<0.001%	<0.001%	<0.001%	<0.001%

Notes:
No criteria are available for OCS, hence criteria have been adopted from HCB for the purpose of providing a conservative assessment.
Mercury in air assessed as inorganic mercury only.
NA – not assessed as no criteria available.

Section 7 Health Impact Assessment

Table 7-2 Assessment of Acute Exposure - Upset Condition Worst-Case Upset Release Scenario for CPWE Remediation

Chemical	Comparison of Maximum Predicted GLC with Acute Exposure Criteria (% GLC/criteria)			
	Level 0 No Appreciable Risk	Level 1 Irritation	Level 2 Injury	Level 3 Life-Threatening
tetrachloroethene (PCE)	0.1%	<0.1%	<0.01%	<0.01%
trichloroethene (TCE)	<0.001%	<0.001%	<0.001%	<0.001%
cis-1,2-dichloroethene	<0.001%	<0.001%	<0.001%	<0.001%
trans-1,2-dichloroethene	<0.001%	<0.001%	<0.001%	<0.001%
1,1-dichloroethene	<0.001%	<0.001%	<0.001%	<0.001%
vinyl chloride (VCM)	<0.01%	<0.001%	<0.001%	<0.001%
1,1,2-trichloroethane	<0.001%	<0.001%	<0.001%	<0.001%
1,2-dichloroethane (EDC)	<0.001%	<0.001%	<0.001%	<0.001%
1,1-dichloroethane	<0.001%	<0.001%	<0.001%	<0.001%
chloroform (CFM)	<0.01%	<0.01%	<0.001%	<0.001%
dichloromethane (DCM)	<0.001%	<0.001%	<0.001%	<0.001%
chloromethane	<0.001%	<0.001%	<0.001%	<0.001%
hexachloroethane (HCE)	<0.1%	<0.1%	<0.01%	<0.001%
pentachlorobenzene	<0.001%	<0.001%	<0.001%	<0.001%
hexachlorobutadiene (HCBD)	9%	0.2%	<0.1%	<0.1%
hexachlorobenzene (HCB)	24%	48%	<0.1%	<0.001%
octachlorostyrene (OCS)#	33%	11%	<3%	<0.5%
dioxin	<0.001%	<0.001%	<0.001%	<0.001%
mercury (Hg, as total, inorganic)##	4%	1.5%	1.1%	<0.1%
polychlorinated biphenyls PCBs)	<0.01%	<0.01%	<0.001%	<0.001%

Notes:
No criteria are available for OCS, hence criteria have been adopted from HCB for the purpose of providing a conservative assessment.
Mercury in air assessed as inorganic mercury only.
NA – not assessed as no criteria available.

The maximum GLCs predicted for the potential acute exposure to COPCs released from the remediation project during normal operations and upset conditions are less than the relevant acute exposure assessment criteria. Hence no short-term irritation or injury effects are expected to be associated with emissions from the proposed CPWE remediation facility.

As the comparison presented considered the maximum predicted short-term concentration of each COPCs in all off-site areas (likely to be at the boundary of the BIP) associated with emissions from the CPWE remediation project and all other sources in the area, the assessment is relevant to all groups in the areas surrounding the CPWE site. This includes workplace, recreational and residential areas.

7.3 Chronic Exposures

Potential chronic, or long-term, exposures to emissions from the proposed CPWE have been assessed for workers (on and off the site), recreational users, residents and other commercial areas surrounding the BIP. The assessment presented is based on the assumption that the CPWE remediation project will operate for approximately 2 years. It is considered likely that the operation of the facility will be for an 18 month period (refer to Section 3.2), however to address potential uncertainty and to provide a reasonably conservative assessment of potential long-term exposures, an operational period of 2 years has been assumed. The following sections present key assumptions can calculations undertaken for the assessment of exposures within the workplace, recreational, residential and other commercial areas.

7.4 Workplace Exposures

Potential risks to human health within work areas located within the BIP and in adjacent off-site areas have been assessed further with respect to potential long-term inhalation exposures. The following presents a summary of the exposure parameters utilised in the quantification of inhalation exposures within these work areas.

Workplace Exposures

Receptor Population		Exposure Pathways		Chemical Concentrations		Exposure Parameters
Industrial/ commercial worker (within BIP and off-site)	→	Inhalation of emissions from CPWE remediation process	→	Maximum modelled ground level air concentration within BIP and off-site areas (annual average)	→	Body weight of 70 kg Workday exposure for 8 hours indoors and 2 hours outdoors per day for 240 days/year for 2 years (expected duration of the remediation project). Inhalation of 1.17 m^3 air per hour indoors and 2.2 m^3 air per hour outdoors.

The calculation of potential intake and risk (relevant to both non-threshold and threshold risks) for each COPC has been undertaken using the methodology presented in Section 2 and toxicity data identified in Section 6, and is presented in Appendix C. The following tables present a summary of the calculated risks for non-threshold (Table 7.3a) and threshold (Table 7.3b) chemicals associated with exposures in work areas within the BIP and off-site to emissions derived from the proposed CPWE only as well as cumulative impacts associated with emissions from the CPWE remediation and other sources considered.

Table 7-3a Calculated Non-Threshold Risk - Workplace Exposures (Inhalation)

	Impacts from CPWE Remediation Only		Cumulative Impacts from CPWE Remediation and Other Sources	
	Calculated Non-Threshold Risk		Calculated Non-Threshold Risk	
Non-Threshold COPCs	**Adult Workers On Site**	**Adult Workers Off Site**	**Adult Workers On Site**	**Adult Workers Off Site**
trichloroethene (TCE)	1.3×10^{-11}	8.8×10^{-12}	1.1×10^{-9}	4.6×10^{-10}
vinyl chloride (VC)	2.6×10^{-11}	2.1×10^{-11}	2.8×10^{-9}	1.2×10^{-9}
1,2-dichloroethane (EDC)	1.6×10^{-12}	1.0×10^{-12}	1.1×10^{-9}	5.1×10^{-10}
chloroform (CFM)	5.4×10^{-13}	3.6×10^{-13}	2.3×10^{-10}	9.7×10^{-11}
TOTAL NON-THRESHOLD RISK	**4×10^{-11}**	**3×10^{-11}**	**5×10^{-9}**	**2×10^{-9}**
Target Risks: Zero Risk **Acceptable Risk**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**

Notes:
Risk values from the spreadsheet have been rounded to no more than two significant figures, with totals presented to one significant figure; hence the sum of individual risks may not add up exactly to the total presented.

Table 7-3b Calculated Threshold Risk – Workplace Exposures (Inhalation)

	Impacts from CPWE Remediation Only		Cumulative Impacts from CPWE Remediation and Other Sources	
	Calculated Threshold HI		Calculated Threshold HI	
Threshold COPCs	**Adult Workers On Site**	**Adult Workers Off Site**	**Adult Workers On Site**	**Adult Workers Off Site**
tetrachloroethene (PCE)	0.000028	0.000024	0.051	0.031
cis-1,2-dichloroethene	0.000019	0.000013	0.0000019	0.000013
trans-1,2-dichloroethene	0.0000011	0.00000078	0.0000011	0.00000078
1,1-dichloroethene	0.00000078	0.00000061	0.000016	0.0000069
1,1,2-trichloroethane	0.000020	0.000012	0.000020	0.000012
1,1-dichloroethane	0.00000010	0.000000073	0.00000010	0.000000073
chloroform (CFM)	0.00000064	0.00000042	0.00028	0.00012
dichloromethane (DCM)	0.000000063	0.000000042	0.000000097	0.000000075
chloromethane	0.0000073	0.0000053	0.0000073	0.0000053
hexachloroethane (HCE)	0.0000081	0.0000041	0.057	0.035
pentachlorobenzene	0.00000016	0.000000086	0.00000016	0.000000086
hexachlorobutadiene (HCBD)	0.019	0.012	0.019	0.012
hexachlorobenzene (HCB)	0.00026	0.00014	0.00026	0.00014
octachlorostyrene (OCS)	0.000019	0.0000098	0.000019	0.0000098
dioxin	0.0002	0.000084	0.0002	0.00016
mercury (Hg, as total, inorganic)	0.0018	0.00071	0.045	0.020
olychlorinated biphenyls (PCBs)	0.000042	0.000022	0.000042	0.000022
TOTAL THRESHOLD HI	**0.2**	**0.1**	**0.2**	**0.1**
Target HI – Acceptable Risk	**<1**	**<1**	**<1**	**<1**

Notes:
Risk values from the spreadsheet have been rounded to no more than two significant figures, with totals presented to one significant figure; hence the sum of individual risks may not add up exactly to the total presented.

Calculated non-threshold and threshold risks associated with long-term exposures by workers to emissions from the proposed CPWE remediation project as well as cumulative exposures in areas surrounding the CPWE site are lower than the target risk values adopted that are considered representative of acceptable and zero (negligible) risk. On this basis risks to workers in all areas surrounding the proposed CPWE site are considered to be acceptable.

7.5 Recreational Exposures

Potential risks to human health in recreational areas surrounding the CPWE site have been assessed further with respect to potential long-term inhalation exposures. Worst-case exposures have been assessed on the basis of recreational exposures at the Hensley Athletics Field located adjacent to the CPWE site. The following presents a summary of the exposure parameters utilised in the quantification of inhalation exposures within these recreational areas.

Recreational Exposures

Receptor Population	Exposure Pathways	Chemical Concentrations	Exposure Parameters
Adult Recreational (Athletics Field and in grandstand) →	Inhalation of emissions from CPWE remediation process →	Modelled ground level air concentration at athletics field and grandstand (annual average) →	Body weight of 70 kg Exposure for 3 hours per day (exercising) and up to 8 hours per day in grandstand. It is assumed adults may regularly use athletics field 2 days per week (104 days per year) for 2 years (expected duration of remediation project). Inhalation rate of 3.5 m^3 air per hour for exercising (running at 8 km/hr) or 1.17 m^3 air per hour for sitting in grandstand.
Older Child Recreational (Athletics Field) (aged 5-15 years) →	Inhalation of emissions from CPWE remediation process →	Modelled ground level air concentration at athletics field (annual average) →	Body weight of 34.5 kg Exposure for 4 hours per day for 104 days/year for 2 years. Inhalation rate of 2.2 m^3 air per hour (equivalent to running at 7.2 km/hr)
Younger Child Recreational (Grandstand) (aged 0-5 years) →	Inhalation of emissions from CPWE remediation process →	Modelled ground level air concentration at athletics field and grandstand (annual average) →	Body weight of 13.2 kg Exposure for up to 8 hours watching sporting events for 104 days/year for 2 years. Inhalation rate of 0.6 m^3 air per hour within grandstand

The calculation of potential intake and risk (relevant to both non-threshold and threshold risks) for each COPC has been undertaken using the methodology presented in Section 2 and toxicity data identified in Section 6, and is presented in Appendix D. The following tables present the calculated risk for non-threshold (Table 7.4a) and threshold (Table 7.4b) chemicals associated with exposures in residential areas (worst-case exposures within Hensley Athletics Field) associated with emissions derived from the proposed CPWE remediation project only as well as cumulative impacts associated with emissions from the CPWE remediation and other sources considered.

Table 7-4a Calculated Chemical Non-Threshold Raisk - Recreational Exposure (Inhalation)

	Impacts from CPWE Remediation Only				Cumulative Impacts from CPWE Remediation and Other Sources			
	Calculated Non-Threshold Risk				Calculated Non-Threshold Risk			
Non-Threshold COPCs	**Adults in Grandstand**	**Young Children in Grandstand**	**Adult Recreational**	**Older Children Recreational**	**Adults in Grandstand**	**Young Children in Grandstand**	**Adult Recreational**	**Older Children Recreational**
trichloroethene (TCE)	1.3×10^{-13}	6.9×10^{-13}	2.3×10^{-12}	3.9×10^{-12}	1.0×10^{-11}	5.5×10^{-11}	2.1×10^{-11}	3.5×10^{-11}
vinyl chloride (VC)	5.1×10^{-12}	2.8×10^{-11}	1.1×10^{-11}	1.8×10^{-11}	7.7×10^{-11}	4.2×10^{-10}	1.5×10^{-10}	2.5×10^{-10}
1,2-dichloroethane (EDC)	1.1×10^{-13}	5.9×10^{-13}	2.0×10^{-13}	3.5×10^{-13}	1.7×10^{-11}	9.4×10^{-11}	3.4×10^{-11}	5.8×10^{-11}
chloroform (CFM)	4.1×10^{-14}	2.2×10^{-13}	8.0×10^{-14}	1.4×10^{-13}	2.2×10^{-12}	1.2×10^{-11}	4.0×10^{-12}	6.8×10^{-12}
TOTAL NON-THRESHOLD RISK	**5×10^{-12}**	**3×10^{-11}**	**1×10^{-11}**	**2×10^{-11}**	**1×10^{-10}**	**6×10^{-10}**	**2×10^{-10}**	**4×10^{-10}**
Target Risks: Zero Risk **Acceptable Risk**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**

Notes:

Risk values from the spreadsheet have been rounded to no more than two significant figures, with totals presented to one significant figure; hence the sum of individual risks may not add up exactly to the total presented.

Table 7.4b Calculated Threshold Risk Recreational Exposures (Inhalation)

	Impacts from CPWE Remediation Only				Cumulative Impacts from CPWE Remediation and Other Sources			
	Calculated Threshold HI				Calculated Threshold HI			
Threshold COPCs	**Adults in Grandstand**	**Young Children in Grandstand**	**Adult Recreational**	**Older Children Recreational**	**Adults in Grandstand**	**Young Children in Grandstand**	**Adult Recreational**	**Older Children Recreational**
tetrachloroethene (PCE)	0.0000023	0.000013	0.0000047	0.000008	0.00024	0.0013	0.00044	0.00075
cis-1,2-dichloroethene	0.0000015	0.000008	0.0000029	0.000005	0.0000015	0.000008	0.0000029	0.000005
trans-1,2-dichloroethene	0.000000091	0.0000005	0.00000019	0.00000032	0.000000091	0.0000005	0.00000019	0.00000032
1,1-dichloroethene	0.000000011	0.00000006	0.0000024	0.00000028	0.00000016	0.00000086	0.00000044	0.00000074
1,1,2-trichloroethane	0.0000013	0.0000071	0.00000002	0.0000041	0.0000013	0.0000071	0.00000002	0.0000041
1,1-dichloroethane	0.000000009	0.00000005	0.00000002	0.00000003	0.000000009	0.00000005	0.00000002	0.00000003
chloroform (CFM)	0.000000048	0.00000026	0.000000095	0.00000016	0.0000026	0.000014	0.0000047	0.0000080
dichloromethane (DCM)	0.000000005	0.00000003	0.0000000096	0.000000016	0.0000000077	0.000000042	0.000000017	0.000000029
chloromethane	0.00000063	0.0000035	0.0000013	0.0000022	0.00000063	0.0000035	0.0000013	0.0000022
hexachloroethane (HCE)	0.00000011	0.00000061	0.0000017	0.0000029	0.00065	0.0035	0.0012	0.0020
pentachlorobenzene	0.000000009	0.00000005	0.000000015	0.0000000026	0.000000009	0.00000005	0.000000015	0.0000000026
hexachlorobutadiene (HCBD)	0.000099	0.00054	0.0028	0.0048	0.0013	0.00070	0.0029	0.0049
hexachlorobenzene (HCB)	0.00000065	0.0000035	0.000033	0.000056	0.00000094	0.0000051	0.000034	0.000057
octachlorostyrene (OCS)	0.000001	0.0000055	0.0000017	0.0000029	0.0000010	0.0000055	0.0000017	0.0000029
dioxin	0.000013	0.000071	0.000025	0.000042	0.000021	0.00011	0.000043	0.000072
mercury (Hg,as total, inorganic)	0.000096	0.00052	0.00018	0.00031	0.00010	0.00056	0.00020	0.00034
polychlorinated biphenyls (PCBs)	0.0000023	0.000012	0.0000039	0.0000067	0.0000023	0.000012	0.0000039	0.0000067
TOTAL THRESHOLD HI	**0.0002**	**0.001**	**0.003**	**0.005**	**0.001**	**0.006**	**0.005**	**0.008**
Target HI – Acceptable Risk	**<1**	**<1**	**<1**	**<1**	**<1**	**<1**	**<1**	**<1**

Notes:

Risk values from the spreadsheet have been rounded to no more than two significant figures, with totals presented to one significant figure; hence the sum of individual risks may not add up exactly to the total presented.

Calculated non-threshold and threshold risks associated with long-term exposures by recreational users of the adjacent Hensley Athletics Field to emissions from the proposed CPWE remediation project as well as cumulative exposures in areas surrounding the CPWE site are lower than the target risk values adopted that are considered representative of acceptable and zero (negligible) risk. On this basis risks to recreational users of Hensley Athletics Field and surrounding areas are considered to be acceptable.

7.6 Residential Exposures

The quantification of risk associated with long-term exposures in residential areas requires the assessment of the following:

- Assessment of inhalation exposures by residents to all COPCs identified in emissions from the proposed CPWE (including cumulative impacts); and
- Assessment of multi-pathway exposures by residents to persistent and bioaccumulative COPCs identified (including cumulative impacts).

7.6.1 Inhalation Exposures

Potential exposures by residents in areas surrounding the proposed CPWE site are expected to be of most significance due to the potential for residents to be at home for longer periods of time, particularly for more sensitive groups such as infants. In addition residents may spend time within other areas surrounding the CPWE site such as recreational areas (e.g. Hensley Athletics Field), schools and community centres. To provide a conservative assessment of potential long-term exposures by residents to emissions that may be derived from the proposed CPWE (and cumulative impacts) risks have been calculated on the basis of the maximum concentrations estimated from all off-site receptors (namely the maximum concentrations reported from residential receptors, recreational receptors, schools and community centres).

This approach is expected to overestimate risks in residential areas, however it is considered appropriate as it allows for the assessment of potential multi-pathway exposures to chemicals within all areas accessed by residents including recreational areas and schools (likely to be associated with deposition to and accumulation within soil).

The following presents a summary of the exposure parameters utilised in the quantification of inhalation exposures within residential areas.

Residential Exposures

Receptor Population	Exposure Pathways	Chemical Concentrations	Exposure Parameters**
Adult Resident →	Inhalation of emissions from CPWE remediation process →	Maximum modelled ground level air concentration from all off-site receptors (annual average) →	Body weight of 70 kg Exposure for 24 hours per day (i.e. whole day at home) for 337 days/year for 2 years (expected duration of remediation project) Inhalation of 1.17 m^3 air per hour indoors (20 hours) and 2.2 m^3 air per hour outdoors (4 hours).
Child Resident (aged 0-5 years, most sensitive)* →	Inhalation of emissions from CPWE remediation process →	Maximum modelled ground level air concentration from all off-site receptors (annual average) →	Body weight of 13.2 kg Exposure for 24 hours per day (i.e. whole day at home) for 337 days/year for 2 years Inhalation rate of 0.45 m^3 air per hour indoors (20 hours) and 1.25 m^3 air per hour outdoors (4 hours)
Infant (aged 0-1 years)# →	Inhalation of emissions from CPWE remediation process →	Maximum modelled ground level air concentration from all off-site receptors (annual average) →	Body weight of 6 kg Exposure for 24 hours per day (i.e. whole day at home) for 337 days/year for 1 year (time spent as an infant) Inhalation rate of 0.19 m3 air per hour (daily inhalation rate for all activities by children under 1 year of age)

Notes:

* A child aged 0 to 5 years is considered to be more sensitive to exposure at home as they are more likely to spend more hours per day at home and have a lower body weight (resulting in a higher intake per kg of body weight)

** It is assumed that indoor and outdoor air concentrations are equal and that chemicals in air are primarily in a vapour phase.

\# Inhalation by infants calculated as it is an important pathway of exposure, particularly when multi-pathway exposures are also considered for infants.

The calculation of potential intake and risk (relevant to both non-threshold and threshold risks) for each COPC has been undertaken using the methodology presented in Section 2 and toxicity data identified in Section 6, and presented in Appendix E. The following tables present the calculated risks for non-threshold (Table 7.5a) and threshold (Table 7.5b) chemicals associated with inhalation exposures by adults, young children and infants to emissions derived from the proposed CPWE only as well as cumulative impacts associated with emissions from the CPWE remediation and other sources considered.

Table 7.5a Calculated Non-Threshold Risk - Residential Inhalation Exposures

	Impacts from CPWE Remediation Only			**Cumulative Impacts from CPWE Remediation and All Other Sources**		
	Calculated Non-Threshold Risk			**Calculated Non-Threshold Risk**		
Non-Threshold COPCs	**Adult Residents**	**Young Children**	**Infants**	**Adult Residents**	**Young Children**	**Infants**
trichloroethene (TCE)	2.3×10^{-11}	5.3×10^{-11}	1.9×10^{-11}	7.2×10^{-10}	1.7×10^{-9}	5.9×10^{-10}
vinyl chloride (VC)	1.1×10^{-10}	2.6×10^{-10}	9.2×10^{-11}	4.0×10^{-9}	9.1×10^{-9}	3.2×10^{-9}
1,2-dichloroethane (EDC)	2.4×10^{-12}	5.6×10^{-12}	2.0×10^{-12}	8.2×10^{-10}	1.9×10^{-9}	6.7×10^{-10}
chloroform (CFM)	9.0×10^{-13}	2.1×10^{-12}	7.4×10^{-13}	1.5×10^{-10}	3.4×10^{-10}	1.2×10^{-10}
TOTAL NON-THRESHOLD RISK	$\mathbf{1 \times 10^{-10}}$	$\mathbf{3 \times 10^{-10}}$	$\mathbf{1 \times 10^{-10}}$	$\mathbf{6 \times 10^{-9}}$	$\mathbf{1 \times 10^{-8}}$	$\mathbf{5 \times 10^{-9}}$
Target Risks: Zero Risk **Acceptable Risk**	$<1 \times 10^{-6}$ $<1 \times 10^{-5}$	$<1 \times 10^{-6}$ $<1 \times 10^{-5}$	$<1 \times 10^{-6}$ $<1 \times 10^{-5}$	$<1 \times 10^{-6}$ $<1 \times 10^{-5}$	$<1 \times 10^{-6}$ $<1 \times 10^{-5}$	$<1 \times 10^{-6}$ $<1 \times 10^{-5}$

Notes:

Risk values from the spreadsheet have been rounded to no more than two significant figures, with totals presented to one significant figure; hence the sum of individual risks may not add up exactly to the total presented.

Table 7.5b Calculated Threshold Risk – Residential Inhalation Exposures

	Impacts from CPWE Remediation Only			Cumulative Impacts from CPWE Remediation and Other Sources		
	Calculated Threshold HI			Calculated Threshold HI		
Threshold COPCs	**Adult Residents**	**Young Children**	**Infants**	**Adult Residents**	**Young Children**	**Infants**
tetrachloroethene (PCE)	0.000052	0.00012	0.000084	0.013	0.029	0.021
cis-1,2-dichloroethene	0.000033	0.000076	0.000054	0.000033	0.000076	0.000054
trans-1,2-dichloroethene	0.0000020	0.0000047	0.0000033	0.0000020	0.0000047	0.0000033
1,1-dichloroethene	0.0000016	0.0000038	0.0000027	0.000012	0.000027	0.000019
1,1,2-trichloroethane	0.000029	0.000068	0.000048	0.000029	0.000068	0.000048
1,1-dichloroethane	0.00000019	0.00000044	0.00000031	0.00000019	0.00000044	0.00000031
chloroform (CFM)	0.0000011	0.0000025	0.0000018	0.00018	0.00041	0.00029
dichloromethane (DCM)	0.00000011	0.00000025	0.00000018	0.00000021	0.00000049	0.00000035
chloromethane	0.000014	0.000033	0.000023	0.000014	0.000033	0.000023
hexachloroethane (HCE)*	Multi-pathway exposures assessed – Refer to Sections 7.5.2 and 7.5.3					
pentachlorobenzene*	Multi-pathway exposures assessed – Refer to Sections 7.5.2 and 7.5.3					
hexachlorobutadiene (HCBD)*	Multi-pathway exposures assessed – Refer to Sections 7.5.2 and 7.5.3					
hexachlorobenzene (HCB)*	Multi-pathway exposures assessed – Refer to Sections 7.5.2 and 7.5.3					
octachlorostyrene (OCS)*	Multi-pathway exposures assessed – Refer to Sections 7.5.2 and 7.5.3					
dioxin*	Multi-pathway exposures assessed – Refer to Sections 7.5.2 and 7.5.3					
mercury (Hg, as methyl mercury)*	Multi-pathway exposures assessed – Refer to Sections 7.5.2 and 7.5.3					
polychlorinated biphenyls (PCBs)	Multi-pathway exposures assessed – Refer to Sections 7.5.2 and 7.5.3					
TOTAL THRESHOLD HI	**0.0001**	**0.0003**	**0.0002**	**0.01**	**0.03**	**0.02**
Target HI – Acceptable Risk	**<1**	**<1**	**<1**	**<1**	**<1**	**<1**

Notes:

Risk values from the spreadsheet have been rounded to no more than two significant figures, with totals presented to one significant figure; hence the sum of individual risks may not add up exactly to the total presented.

* Chemicals identified as persistent and bioaccumulative hence exposures have also been calculated for multi-pathway exposures, refer to Section 7.5.2 for calculations and 7.5.3 for summary of total risk.

7.6.2 Assessment of Multiple Pathway Exposures

The potential health impacts associated with persistent and bioaccumulative chemicals that may be released to air during the proposed CPWE remediation project have also been assessed. In particular the potential for multiple pathway exposures to persistent and bioaccumulative chemicals has focused on the worst-case emissions derived during normal operations of the CPWE remediation project. Emissions that may be associated with abnormal or upset conditions (refer to Section 5.4), such as the failure of the gas-supply to the DTD Plant, are only likely to result in a short-duration (15 minutes) release of chemicals which, if deposited onto surrounding soil, would be diluted in soil with ongoing long-term natural deposition processes. Hence exposures are expected to be of less significance and do not warrant quantification within this assessment.

The emission to air of chemicals that are considered to be persistent and bioaccumulative in the environment has the potential to result in exposure in off-site areas to occur by a number of pathways in addition to inhalation. These exposure pathways are associated with the potential for these chemicals to deposit (wet and dry deposition) onto soil and waterways and accumulate throughout the environment in a range of media.

Following release to the atmosphere, persistent chemicals may be deposited onto the soil by a process of dry or wet deposition resulting in increased concentrations in surface soil and dust. Exposure to these deposited chemicals in off-site area may then occur via ingestion of the soil and dermal absorption following skin contact with the soil.

Once present within soil, persistent chemicals have the potential to be taken up and accumulate in plants and animals. Animal accumulation may result in increased concentrations of the persistent chemicals in meat, eggs or milk produced from these animals. The Botany area is neither rural nor semi-rural. Rather, it is an urban area where meat, egg and milk producing livestock are unlikely to be present; hence potential intake of persistent chemicals via this mechanism is not considered to warrant further assessment.

There is the potential for some residential properties to have backyard gardens which have home-grown produce such as fruit and vegetables, hence the potential accumulation of persistent chemicals within edible plants and subsequent consumption by residents is considered to be a relevant exposure pathway.

Persistent chemicals may also be deposited into waterways in the surrounding area. In addition, deposited dusts may run off from surrounding surfaces and end up within the waterways or leach to groundwater. Once in the waterways, there is the potential for fish and birds to accumulate these chemicals. The waterways surrounding the BIP are principally Botany Bay, associated stormwater drains and Penrhyn Estuary. The deposition of chemicals derived from the proposed CPWE remediation project into water bodies such as the drains, estuary and Botany Bay would be expected to be associated with substantial dilution of the deposited chemicals as part of the normal processes of stormwater run off. The effect of this dilution means that there will be an insignificant impact on the potential concentrations of these chemicals within the water, and hence fish and other aquatic organisms.

Following intake of persistent and bioaccumulative chemicals into the human body via the range of exposure pathways, there is the potential for these chemicals to accumulate in body tissues and fat. In particular persistent organic chemicals have the potential to accumulate in breast milk fat. Hence there is the potential for nursing infants to be exposed to these chemicals during breastfeeding.

On this basis, the following are identified as key exposure pathways relevant to off-site populations, in particular residents, and potential emissions to air associated with the proposed CPWE remediation project (consistent with the pathways identified and assessed as part of the GTP EIS (URS, 2004) and Proposed HCB Waste Repackaging Plant HHIA (URS, 2006a) in consultation with DEC and NSW Health):

- Inhalation of persistent chemicals in air by residents in the area surrounding the site;
- Direct contact (ingestion and dermal) by residents with soil that may have accumulated the persistent and bioaccumulative chemicals;
- Ingestion of home-grown produce by residents grown in soil which have accumulated the persistent and bioaccumulative chemicals; and
- Ingestion of persistent and bioaccumulative organic chemicals by infants during breastfeeding.

The quantification of potential exposure and chemical intake has been undertaken using the methodology adopted in the calculation of multiple exposure pathways presented in the GTP EIS (URS 2004) as presented in Appendix F. To provide a conservative assessment of potential long-term exposures by residents to emissions that may be derived from the proposed CPWE (and cumulative impacts) risks have been calculated on the basis of the maximum concentrations and deposition rates estimated from all off-site receptors (namely the maximum concentrations reported from residential receptors, recreational receptors, schools and community centres).

The assessment has considered the potential for deposition to occur over the duration of the project, which has been conservatively assumed to be 2 years. Once in the soil, it has been conservatively assumed that the chemicals persist for a period of up to 12 years (the half-life of dioxins (DEH 2004), the most persistent of the COPC) where exposures may occur via incidental contact and ingestion of soils (and dust) and ingestion of home-grown crops grown in the area.

This approach is expected to overestimate risks in residential areas, however it is considered appropriate as it allows for the assessment of potential multi-pathway exposures to chemicals within all areas accessed by residents including recreational areas and schools (likely to be associated with deposition to and accumulation within soil). As such the approach adopted is considered to provide a conservative assessment of potential risk associated with residential exposures that may involve living close to the CPWE, using the Hensley Athletics Field and other recreational areas and attending school in the area.

In addition, the approach adopted is considered to provide a conservative assessment of potential issues that may be associated with the deposition of chemicals within buildings used to process, prepare and/or package food products. The maximum predicted concentration and deposition rates in these food production sites are lower than the maximum adopted in this assessment. It is expected that deposition rates would be lower inside buildings and, as crops are not grown in the area for processing and packaging, the potential uptake of chemicals into packaged foods will not be associated with issues derived from being grown in the area, rather they will be associated with simple deposition of soil/dusts within the building. Hence risks are expected to be lower than assessed for residential exposures in all areas surrounding the CPWE site.

The following presents a summary of the residential exposures assessed with respect to the persistent and bioaccumulative chemicals HCB, HCBD, HCE, OCS, dioxin, pentachlorobenzene, mercury and PCBs. Note that the assessment presented for mercury is considered highly conservative as no removal of mercury from the DTD stack has been considered in the air modelling and the form of mercury in the environment following emission and deposition is methyl mercury (refer to Section 6.2 for further discussion on mercury assumptions with respect to toxicity).

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Residential Exposures – Multi-Pathway

Receptor Population	Exposure Pathways	Chemical Concentrations	Exposure Parameters
			Parameters relevant for all pathways Body weight of 70 kg Exposure for 24 hours per day (i.e. whole day at home) for 337 days/year
	Inhalation of persistent and bioaccumulative chemicals	Refer to Section 7.5.1 for detail on inhalation exposures	
Adult Resident	Ingestion and dermal contact with chemicals in soil	Soil concentrations estimated using soil accumulation model (refer to Appendix F)	Ingestion of 25 mg of soil per day by adults. Once ingested it is assumed that 100% is absorbed into the body. Exposure assumed over 12 years (half-life of most persistent COPCs in soil). When outdoor it is assumed that the hands, forearms and lower legs get dirty each day (4580 cm^2 of skin). Once dirty it is assumed that 0.51 mg of soil adheres to each cm^2 of skin. In addition when on the skin, 1% of HCB, HCBD, HCE, OCS and pentachlorobenzene; 3% dioxin, 14% PCBs and 0% of mercury are absorbed through the skin. Assume an adult will wash at the end of each day resulting in up to 12 hours of the day dirty.
	Ingestion of home-grown fruit and vegetable crops	Uptake of chemicals in plants calculated assuming concentration is the sum of deposition and uptake from soil by roots (refer to Appendix F)	An adult may consume 469 g fruit and vegetables each day, of which 35% is home-grown resulting in 164 g/day of home-grown produce consumed. It is assumed that 100% is absorbed via ingestion. This is averaged over the year as some days an adult may consume more and others none or much less. Exposure assumed over 12 years.

Residential Exposures – Multi-Pathway

Receptor Population	Exposure Pathways	Chemical Concentrations	Exposure Parameters
Child Resident (aged 0-5 years, most sensitive)			**Parameters relevant for all pathways** Body weight of 13.2 kg Exposure for 24 hours per day (i.e. whole day at home) for 337 days/year for 5 years
	Inhalation of persistent and bioaccumulative chemicals	Refer to Section 7.5.1 for detail on inhalation exposures	
	Ingestion and dermal contact with chemicals in soil	Soil concentrations estimated using soil accumulation model (refer to Appendix F)	Ingestion of 100 mg of soil per day by children. Once ingested it is assumed that 100% is absorbed into the body. When outdoors it is assumed that the hands, legs and feet get dirty each day (2,100 cm^2 of skin). Once dirty it is assumed that 0.51 mg of soil adheres to each cm^2 of skin. In addition when on the skin, 1% of HCB, HCBD, HCE, OCS and pentachlorobenzene; 3% dioxin, 14% PCBs and 0% of mercury are absorbed through the skin. Assume a child may not wash at the end of each day resulting in up to 24 hours of the day dirty.
	Ingestion of home-grown fruit and vegetable crops	Uptake of chemicals in plants calculated assuming concentration is the sum of deposition and uptake from soil by roots (refer to Appendix F)	A child may consume 202g fruit and vegetables each day, of which 35% is home-grown resulting in 70.7 g/day of home-grown produce consumed. It is assumed that 100% is absorbed via ingestion. This is averaged over the year as some days a child may consume more and others none or much less.
Infant/ Young Child (0 to 1 years)	Ingestion of accumulated chemicals in breast milk	Concentrations or organic chemicals such as dioxins, HCB, HCBD, HCE, OCS, pentachlorobenzene and PCBs estimated using model based on maternal intake as outlined in Appendix F.	Body weight of 6 kg (average for 3 month age, DEH 2004, National Dioxins Program, Technical Report 12). It is assumed that exposure (breastfeeding) occurs for 12 months (1 year) Ingestion of 0.751 kg/day breast milk (DEH 2004 for 3 months of age). It is assumed that there is 3.7% lipid content in the mother's milk (DEH 2004) It is also assumed that 90% is absorbed following ingestion (USEPA 1998 and DEH 2004)
	Inhalation of persistent and bioaccumulative chemicals	Refer to Section 7.5.1 for detail on inhalation exposures	

The calculation of potential intake and risk (relevant to the assessment of threshold risk) for the persistent and bioaccumulative COPCs identified has been undertaken on the basis of multiple pathway exposures using the methodology presented in Section 2 and toxicity data identified in Section 6, and is presented in Appendix F. The following table (Table 7.6) presents the calculated threshold risks associated with multi-pathway exposures by adults, young children and infants to emissions derived from the proposed CPWE only as well as cumulative impacts associated with emissions from the CPWE remediation and other sources considered.

Table 7-6 Calculated Intake and Threshold Risk - Multi-Pathway Exposures to Persistent and Bioaccumulative COPCs

	Calculated Intake and Risk for Persistent and Bioaccumulative COPCs								
Exposure	**HCE**	**Pentachlorobenzene**	**HCBD**	**HCB**	**OCS**	**Dioxin**	**Mercury (methyl)**	**PCBs**	**Total from All Chemicals**
Adults									
Intake via all exposure pathways (mg/kg/day)									
Inhalation	1.7×10^{-8}	2.0×10^{-9}	5.6×10^{-6}	5.3×10^{-8}	7.0×10^{-9}	4.1×10^{-13}	4.1×10^{-7}	2.6×10^{-10}	
Soil Ingestion	8.3×10^{-10}	1.8×10^{-12}	3.2×10^{-9}	5.0×10^{-11}	5.2×10^{-9}	2.6×10^{-16}	5.2×10^{-10}	2.1×10^{-13}	
Dermal Contact with Soil	3.9×10^{-10}	8.4×10^{-13}	1.5×10^{-9}	2.3×10^{-11}	2.5×10^{-9}	3.7×10^{-16}		1.3×10^{-12}	
Ingestion of Home-grown Crops	7.0×10^{-8}	1.2×10^{-10}	5.6×10^{-7}	3.3×10^{-9}	3.6×10^{-7}	1.4×10^{-14}	5.5×10^{-8}	1.3×10^{-11}	
Total Intake from Proposal (mg/kg/day)	8.8×10^{-8}	2.1×10^{-9}	6.2×10^{-6}	5.6×10^{-8}	3.7×10^{-7}	4.3×10^{-13}	4.7×10^{-7}	2.7×10^{-10}	
Background Intake (not local) (%TDI)	0%	0%	0%	0%	0%	54 %	50%	50%	
TDI (mg/kg/day, refer to Section 6)	0.001	0.01	0.0002	0.00016	0.00031	2.3×10^{-9}	0.00023	0.00001	
Risk (Threshold HI)	**0.00009**	**0.0000002**	**0.03**	**0.0004**	**0.001**	**0.0004**	**0.004**	**0.00005**	**0.04**
Cumulative Exposure									
Intake from Proposal (mg/kg/day)	8.8×10^{-8}	2.1×10^{-9}	6.2×10^{-6}	5.6×10^{-8}	3.7×10^{-7}	4.3×10^{-13}	4.7×10^{-7}	2.7×10^{-10}	
Intake from GTP, HCB Stores and Other Sources (mg/kg/day)	4.3×10^{-5}	NA	3.3×10^{-7}	2.6×10^{-9}	NA	2.6×10^{-13}	6.0×10^{-8}	NA	
Total Intake from All Sources (mg/kg/day)	4.3×10^{-5}	2.1×10^{-9}	6.5×10^{-6}	5.9×10^{-8}	3.7×10^{-7}	6.9×10^{-13}	5.3×10^{-7}	2.7×10^{-10}	
Risk (cumulative threshold HI)	**0.04**	**0.0000002**	**0.03**	**0.0004**	**0.001**	**0.007**	**0.005**	**0.00005**	**0.08**

	Calculated Intake and Risk for Persistent and Bioaccumulative COPCs								
Exposure	**HCE**	**Pentachlorobenzene**	**HCBD**	**HCB**	**OCS**	**Dioxin**	**Mercury (methyl)**	**PCBs**	**Total from All Chemicals**
Young Children (0-5 years)									
Intake via all exposure pathways (mg/kg/day)									
Inhalation	3.9×10^{-8}	4.6×10^{-9}	1.3×10^{-5}	1.2×10^{-7}	1.8×10^{-8}	9.4×10^{-13}	9.4×10^{-7}	5.9×10^{-10}	
Soil Ingestion	1.8×10^{-8}	3.8×10^{-11}	6.9×10^{-8}	1.1×10^{-9}	1.1×10^{-7}	5.6×10^{-15}	1.1×10^{-8}	4.4×10^{-12}	
Dermal Contact with Soil	1.9×10^{-9}	4.1×10^{-12}	7.4×10^{-9}	1.1×10^{-10}	1.2×10^{-8}	1.8×10^{-15}		6.5×10^{-12}	
Ingestion of Home-grown Crops	1.6×10^{-7}	2.7×10^{-10}	1.3×10^{-6}	7.5×10^{-9}	8.1×10^{-7}	3.8×10^{-14}	1.3×10^{-7}	2.9×10^{-11}	
Total Intake from Proposal (mg/kg/day)	2.2×10^{-7}	4.9×10^{-9}	1.4×10^{-5}	1.3×10^{-7}	9.5×10^{-7}	9.9×10^{-13}	1.1×10^{-6}	6.3×10^{-10}	
Background Intake (not local) (%TDI)	0%	0%	0%	0%	0%	54 %	50%	50%	
TDI (mg/kg/day, refer to Section 6)	0.001	0.01	0.0002	0.00016	0.00031	2.3×10^{-9}	0.00023	0.00001	
Risk (Threshold HI)	**0.0002**	**0.0000005**	**0.07**	**0.0008**	**0.003**	**0.0009**	**0.009**	**0.0001**	**0.09**
Cumulative Exposure									
Intake from Proposal (mg/kg/day)	2.2×10^{-7}	4.9×10^{-9}	1.4×10^{-5}	1.3×10^{-7}	9.5×10^{-7}	9.9×10^{-13}	1.1×10^{-6}	6.3×10^{-10}	
Intake from GTP, HCB Repackaging Plant and Other Sources (mg/kg/day)	1.0×10^{-4}	NA	7.6×10^{-7}	6.1×10^{-9}	NA	6.3×10^{-13}	1.4×10^{-7}	NA	
Total Intake from All Sources (mg/kg/day)	1.0×10^{-4}	4.9×10^{-9}	1.5×10^{-5}	1.4×10^{-7}	9.5×10^{-7}	1.6×10^{-12}	1.2×10^{-6}	6.3×10^{-10}	
Risk (cumulative threshold HI)	**0.1**	**0.0000005**	**0.08**	**0.0009**	**0.003**	**0.002**	**0.01**	**0.0001**	**0.2**

	Calculated Intake and Risk for Persistent and Bioaccumulative COPCs								
Exposure	**HCE**	**Pentachlorobenzene**	**HCBD**	**HCB**	**OCS**	**Dioxin**	**Mercury (methyl)**	**PCBs**	**Total from All Chemicals**
Infants									
Intake via all exposure pathways (mg/kg/day)									
Inhalation	2.8×10^{-8}	3.2×10^{-9}	9.1×10^{-6}	8.6×10^{-8}	1.1×10^{-8}	6.7×10^{-13}	6.7×10^{-7}	4.2×10^{-10}	
Ingestion of breast milk	3.4×10^{-9}	3.6×10^{-8}	1.3×10^{-6}	9.5×10^{-7}	6.3×10^{-6}	1.8×10^{-11}		9.1×10^{-9}	
Total Intake from Proposal (mg/kg/day)	3.1×10^{-8}	3.9×10^{-8}	1.0×10^{-5}	1.0×10^{-6}	6.3×10^{-6}	1.9×10^{-11}	6.7×10^{-7}	9.6×10^{-9}	
Background Intake (not local) (%TDI)	0%	0%	0%	0%	0%	54 %	50%	50%	
TDI (mg/kg/day, refer to Section 6)	0.001	0.01	0.0002	0.00016	0.00031	2.3×10^{-9}	0.00023	0.00001	
Risk (Threshold HI)	**0.002**	**0.000004**	**0.05**	**0.006**	**0.02**	**0.02**	**0.006**	**0.002**	**0.1**
Cumulative Exposure									
Intake from Proposal (mg/kg/day)	3.1×10^{-8}	3.9×10^{-8}	1.0×10^{-5}	1.0×10^{-6}	6.3×10^{-6}	1.9×10^{-11}	6.7×10^{-7}	9.6×10^{-9}	
Intake from GTP, HCB Stores and Other Sources (mg/kg/day)	6.8×10^{-5}	NA	5.8×10^{-7}	4.9×10^{-8}	NA	1.1×10^{-11}	6.1×10^{-8}	NA	
Total Intake from All Sources (mg/kg/day)	6.8×10^{-5}	3.9×10^{-8}	1.1×10^{-5}	1.1×10^{-6}	6.3×10^{-6}	3.0×10^{-11}	7.3×10^{-7}	9.6×10^{-9}	
Risk (cumulative threshold HI)	**0.07**	**0.000004**	**0.06**	**0.007**	**0.02**	**0.03**	**0.006**	**0.002**	**0.2**

Notes:

Risk values from the spreadsheet have been rounded to no more than two significant figures, with totals presented to one significant figure; hence the sum of individual risks may not add up exactly to the total presented.

7.6.3 Summary of Residential Exposures and Risk

Tables 7.7a and 7.7.b present the total non-threshold and threshold risks calculated for residential exposures to COPCs assessed in emissions from the proposed CPWE remediation project associated with inhalation and multi-pathway exposures presented above. The tables also present a summary of total risk associated with cumulative exposures to emissions from the CPWE and other sources in the area.

Table 7.7a Calculated Non-Threshold Risk - Total Residential Exposures

	Impacts from CPWE Remediation Only			Cumulative Impacts from CPWE Remediation and All Other Sources		
	Calculated Non-Threshold Risk			Calculated Non-Threshold Risk		
Non-Threshold COPCs	**Adult Residents**	**Young Children**	**Infants**	**Adult Residents**	**Young Children**	**Infants**
trichloroethene (TCE)	2.3×10^{-11}	5.3×10^{-11}	1.9×10^{-11}	7.2×10^{-10}	1.7×10^{-9}	5.9×10^{-10}
vinyl chloride (VC)	1.1×10^{-10}	2.6×10^{-10}	9.2×10^{-11}	4.0×10^{-9}	9.1×10^{-9}	3.2×10^{-9}
1,2-dichloroethane (EDC)	2.4×10^{-12}	5.6×10^{-12}	2.0×10^{-12}	8.2×10^{-10}	1.9×10^{-9}	6.7×10^{-10}
chloroform (CFM)	9.0×10^{-13}	2.1×10^{-12}	7.4×10^{-13}	1.5×10^{-10}	3.4×10^{-10}	1.2×10^{-10}
TOTAL NON-THRESHOLD RISK	**1×10^{-10}**	**3×10^{-10}**	**1×10^{-10}**	**6×10^{-9}**	**1×10^{-8}**	**5×10^{-9}**
Target Risks: Zero Risk **Acceptable Risk**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**	**$<1 \times 10^{-6}$** **$<1 \times 10^{-5}$**

Notes:
Risk values from the spreadsheet have been rounded to no more than two significant figures, with totals presented to one significant figure; hence the sum of individual risks may not add up exactly to the total presented.

Table 7.7b Calculated Threshold Risk - Total Residential Exposures

	Impacts from CPWE Remediation Only			**Cumulative Impacts from CPWE Remediation and Other Sources**		
	Calculated Threshold HI			**Calculated Threshold HI**		
Threshold COPCs	**Adult Residents**	**Young Children**	**Infants**	**Adult Residents**	**Young Children**	**Infants**
tetrachloroethene (PCE)	0.000052	0.00012	0.000084	0.013	0.029	0.021
cis-1,2-dichloroethene	0.000033	0.000076	0.000054	0.000033	0.000076	0.000054
trans-1,2-dichloroethene	0.0000020	0.0000047	0.0000033	0.0000020	0.0000047	0.0000033
1,1-dichloroethene	0.0000016	0.0000038	0.0000027	0.000012	0.000027	0.000019
1,1,2-trichloroethane	0.000029	0.000068	0.000048	0.000029	0.000068	0.000048
1,1-dichloroethane	0.00000019	0.00000044	0.00000031	0.00000019	0.00000044	0.00000031
chloroform (CFM)	0.0000011	0.0000025	0.0000018	0.00018	0.00041	0.00029
dichloromethane (DCM)	0.00000011	0.00000025	0.00000018	0.00000021	0.00000049	0.00000035
chloromethane	0.000014	0.000033	0.000023	0.000014	0.000033	0.000023
hexachloroethane (HCE)*	0.000017	0.000039	0.000028	0.041	0.094	0.067
pentachlorobenzene*	0.00000020	0.00000046	0.00000032	0.00000020	0.00000046	0.00000032
hexachlorobutadiene (HCBD)*	0.028	0.065	0.046	0.030	0.068	0.048
hexachlorobenzene (HCB)*	0.00033	0.00076	0.00054	0.00035	0.00080	0.00056
octachlorostyrene (OCS)*	0.000023	0.000052	0.000037	0.000023	0.000052	0.000037
dioxin*	0.00039	0.00089	0.00063	0.00057	0.0013	0.00093
mercury (Hg, as methyl mercury)*	0.0029	0.0066	0.0047	0.0031	0.0072	0.0051
polychlorinated biphenyls (PCBs)	0.000051	0.00012	0.000083	0.000051	0.00012	0.000083
TOTAL THRESHOLD HI	**0.04**	**0.09**	**0.1**	**0.1**	**0.2**	**0.2**
Target HI – Acceptable Risk	**<1**	**<1**	**<1**	**<1**	**<1**	**<1**

Notes:
Risk values from the spreadsheet have been rounded to no more than two significant figures, with totals presented to one significant figure; hence the sum of individual risks may not add up exactly to the total presented.
* Chemicals identified as persistent and bioaccumulative hence exposures have also been calculated for multi-pathway exposures. Other COPCs have been assessed on the basis of inhalation exposures only.

In relation to the assessment of residential exposures presented above the following is noted:

Calculated Non-Threshold Risk:

- Calculated non-threshold risks are associated with inhalation exposures only as none of the non-threshold COPCs are considered persistent and bioaccumulative.
- Non-threshold risks are dominated by emissions derived from other emission sources such as the GTP. Impacts derived from the operation of the proposed CPWE remediation project contribute less than 2% of the total non-threshold risk from all sources.
- Calculated non-threshold risks associated with potential exposures by residents to emissions derived from the CPWE remediation project as well as cumulative exposures are lower than the adopted risk targets considered representative of acceptable and zero (negligible) risks.

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Calculated Threshold Risk

- Calculated threshold risks for adults and children are dominated by exposures to persistent and bioaccumulative COPCs, in particular HCBD emissions (75%) from the CPWE remediation project. When cumulative exposures are considered, calculated threshold risks are dominated by HCBD (31%), HCE (43%), PCE (13%) and mercury (3.3%). Key contributors to cumulative exposures include the HCB Waste Repackaging Plant (HCE emissions) and the GTP (dioxin emissions).
- Calculated threshold risks for infants are dominated by exposures to persistent and bioaccumulative COPCs, in particular HCBD (44%) emissions from the CPWE remediation project. When cumulative exposures are considered, calculated threshold risks are dominated by HCBD (23%), HCE (32%) and mercury (0.2%).
- Key contributors to cumulative exposures include the HCB Waste Repackaging Plant (HCE emissions) and the GTP (dioxin emissions).
- Approximately 90% of total intake associated with persistent and bioaccumulative COPCs for adults and children is derived from inhalation exposures. This is expected as the duration of the remediation project is 2 years, which limits the potential for deposition and accumulation within soil and fruit and vegetable produce.
- The evaluation of infant exposure indicates that over 90% of intake is derived from ingestion of HCB, OCS, dioxin and pentachlorobenzene which may accumulate in breast milk. Intakes of HCBD and HCE that may accumulate in breast milk contribute less to the total risk, comprising 13% (HCBD) and 11% (HCE) of the total intake for each chemical. This is due to the fact that HCBD and HCE do not persist within the body for as long as the other chemicals.
- Calculated threshold risks associated with potential exposures by residents to emissions derived from the CPWE remediation project as well as cumulative exposures are lower than the adopted risk targets considered representative of acceptable and zero (negligible) risks.

Diagrams 7.1 and 7.2 present a graph of the calculated threshold residential risk associated with exposures to emissions derived from the CPWE remediation project (Diagram 7.1) and cumulative exposures to emissions from the CPWE remediation project as well as other emission sources in the area (such as the HCB Waste Repackaging Plant project and the GTP). The diagrams illustrate the dominance of multi-pathway exposures to persistent and bioaccumulative COPCs, and the contribution of the CPWE emissions to the cumulative risk (only of significance for HCBD). Note that the risk presented in these diagrams is as a logarithmic scale.

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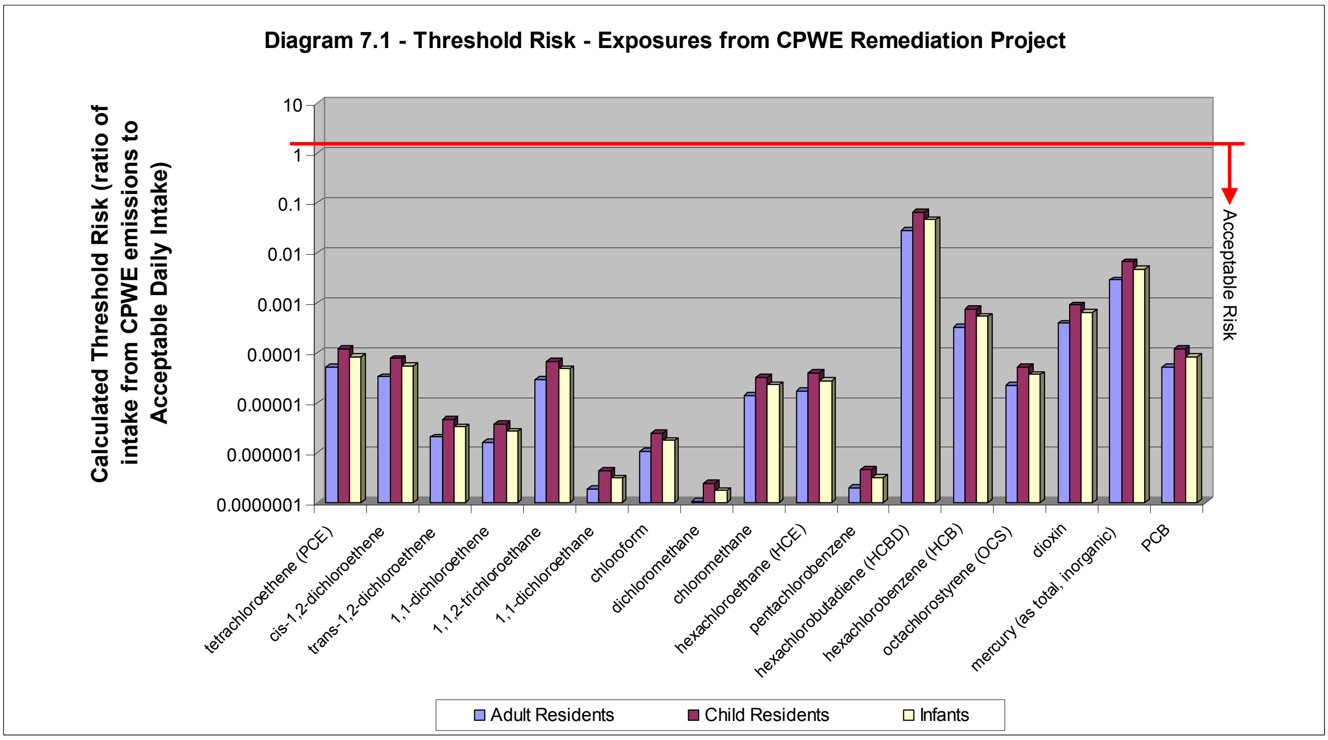
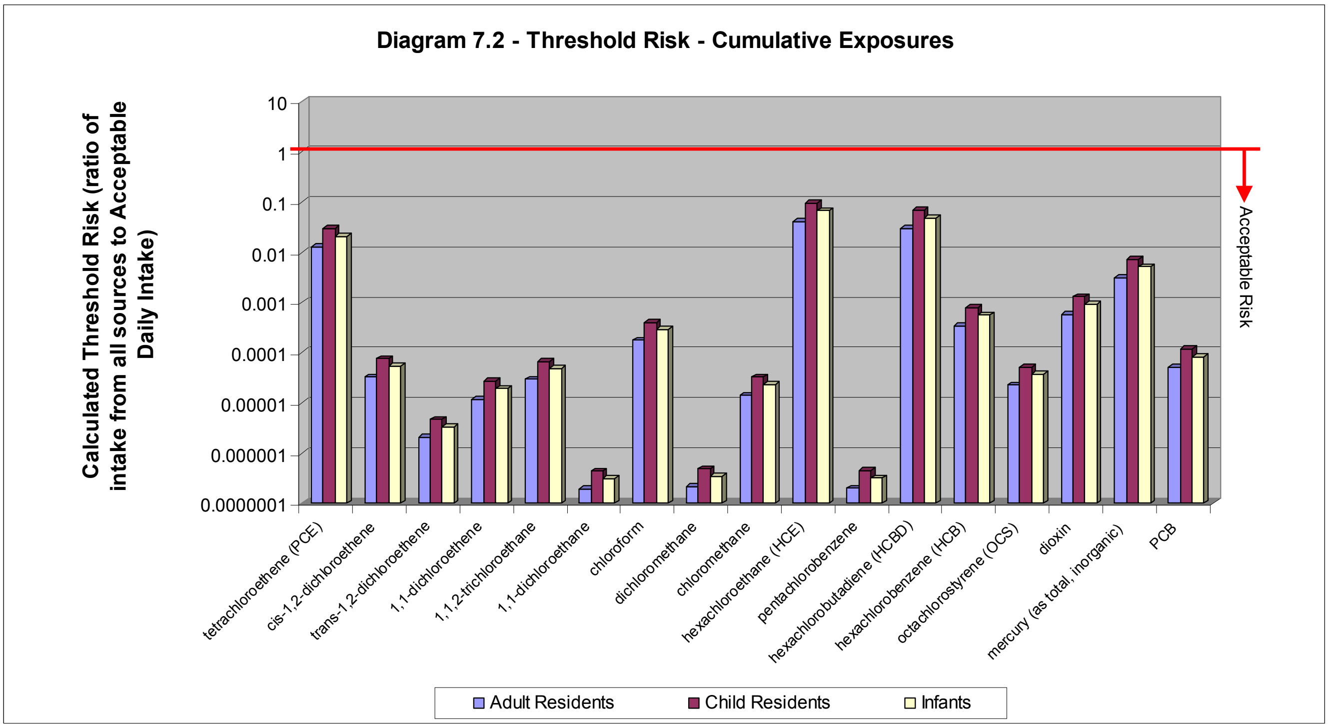




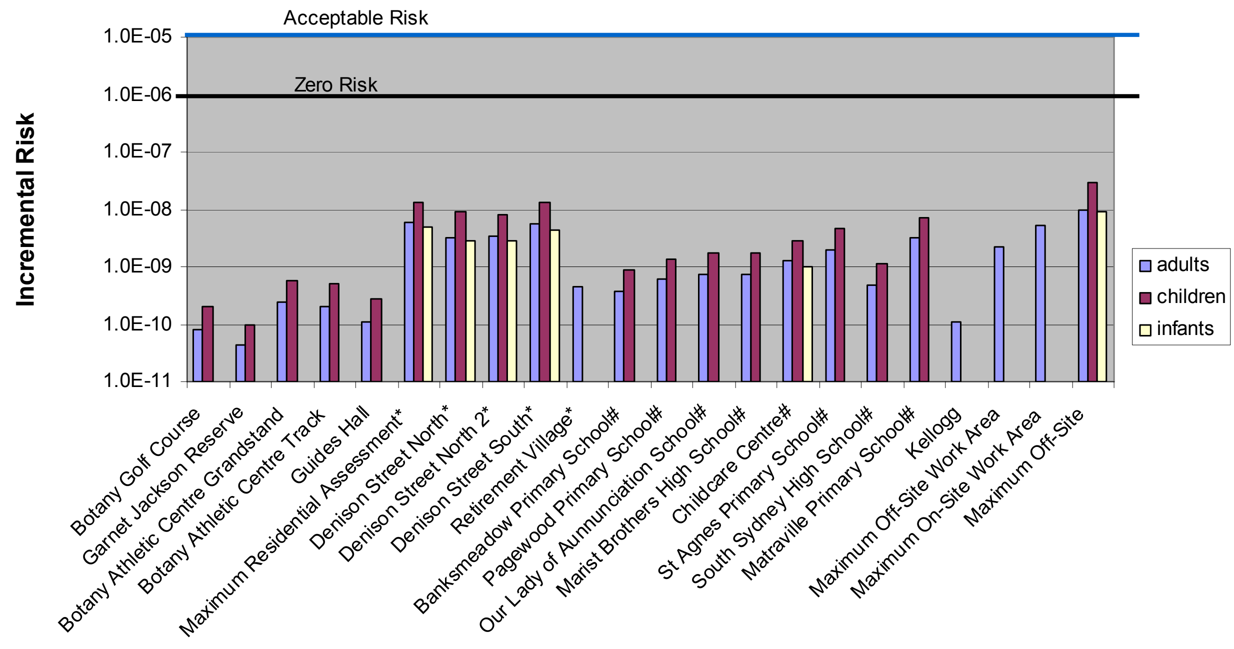
7.7 Cumulative Impacts in All Areas

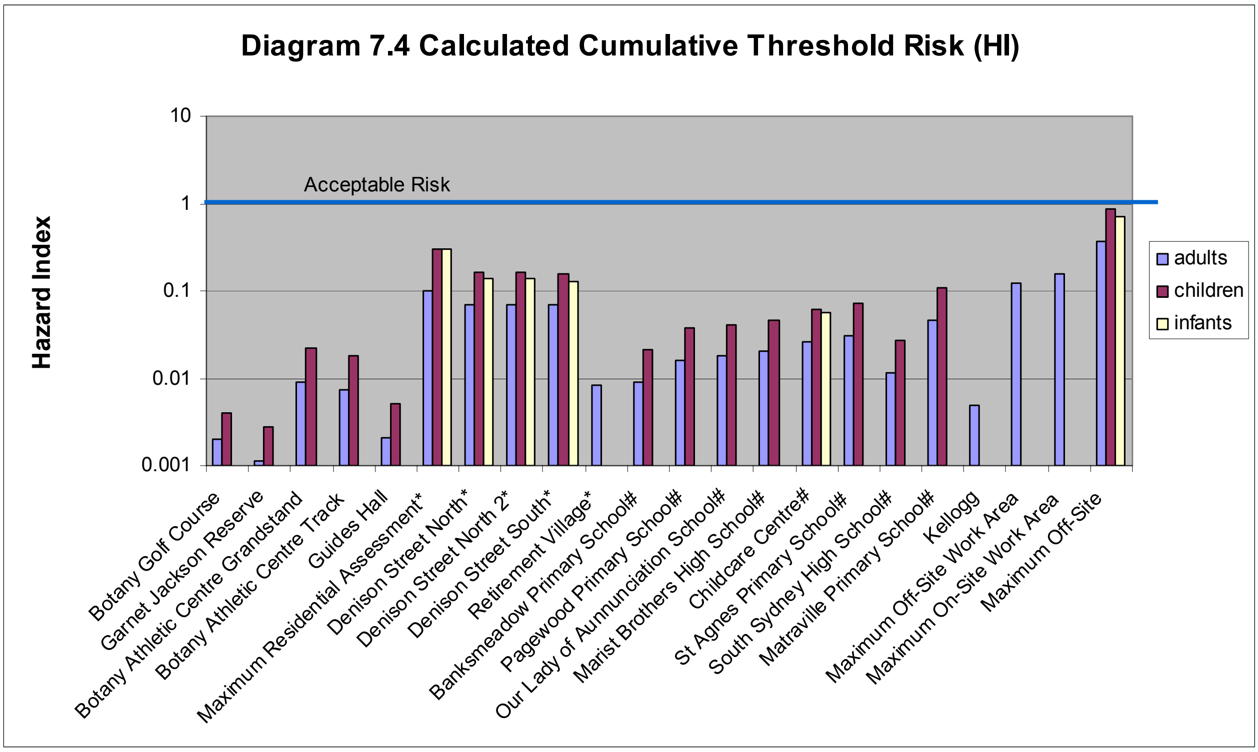
The total cumulative risk to human health associated with the operation of the proposed CPWE remediation project (and all other emission sources in the area) is presented in Diagrams 7.3 (non-threshold risk) and 7.4 (threshold HI) for all receptor areas evaluated in this assessment. Areas evaluated include:

- Maximum on-site and off-site areas where workplace exposures (inhalation only) have been calculated;
- Worst-case residential exposures (multi-pathway) associated with maximum concentration and deposition rates derived from all off-site receptor locations;
- Off-site residential and school areas (multi-pathway exposures);
- Off-site recreational areas (inhalation exposures only); and
- Worst-case exposure based on maximum off-site concentrations and deposition rates and consideration of residential (multi-pathway) exposures. This is currently not a realistic scenario; however it has been presented for the purposes of discussion.

The diagrams illustrate that cumulative impacts associated with emissions derived from the proposed CPWE remediation and other emission sources in the area for all COPCs are less than the acceptable (non-threshold risk of 1×10^{-5} and threshold HI of 1) and negligible (non-threshold risk of 1×10^{-6}) levels adopted. It is noted that non-threshold risks associated with emissions from the CPWE only contribute less than 2% of the total non-threshold risk presented in Diagram 7.3. Threshold risks associated with emissions from the CPWE remediation only contribute between 30% (infants) and 50% (children) of the total threshold HI presented in Diagram 7.4.

Diagram 7.3 Calculated Cumulative Non-Threshold Risk





Notes:
* Risks calculated on the basis of multi-pathway exposures by adults, children and infants assuming residential exposure.
# Risks calculated in school areas on the basis of multi-pathway exposures by adults and children assign similar exposure to those adopted for residential areas.

There are a number of food manufacturing facilities located within the areas surrounding the BIP, with the potential for such businesses to be located directly adjacent to the CPWE in the existing commercial/industrial areas. Risks to workers in these facilities have been assessed (on the basis of maximum on-site and maximum off-site concentrations) and considered to be low and acceptable. In addition, the following can be noted with respect to the potential for contamination of food products:

- The worst-case assessment (maximum off-site) of risk presented above has considered residential exposures based on the maximum off-site concentration and maximum off-site deposition rate. These maximum levels occur on the boundary of the CPWE with levels lowering with increasing distance from the CPWE. Risks to human health associated with this worst-case scenario are considered low and acceptable.

- The assessment of residential exposures considers intakes from a number of exposure pathways including those associated with the deposition (over 2 years) of persistent and bioaccumulative chemicals in soils and dusts, exposure to these soils and dusts, uptake into plants, consumption of produce and infant exposures via breastmilk.

- The manufacturing businesses in the area do not involve the growing of crops where there is the potential for chemicals to accumulate within the edible portions of the plants. Hence any exposure associated with the production of food products in the area will only be associated with direct deposition to the surface of the products or ingredients. This can only occur of the products or ingredients are uncovered.

- Any food manufacturing is expected to occur within a building where there is a lower potential for dusts to settle (compared with direct deposition to outdoor plants and soils). In addition it is expected that food products and ingredients will only be uncovered for a short duration (hours at most) compared with the assumptions used in the assessment of residential exposures (deposition to soils over 2 years and deposition onto fruit and vegetable crops over 70 days). At other times food products and ingredients will be contained within the manufacturing process, covered or packaged eliminating the potential for chemicals to directly deposit onto the food products.

- If a consumer were to purchase and consume such products, exposure may (if at all) only occur via the consumption of that product. It is assumed that most consumers of the products will be located away from the CPWE where all other exposures considered in the residential exposure scenario (baseline exposures and in particular inhalation exposures that dominate risks) are incomplete (zero). If the consumers were in the vicinity of the CPWE, exposures are not expected to be greater than calculated for the consumption of home-grown fruit and vegetable produce or direct exposure to soils.
- On the basis of the above discussion exposures by workers and consumers of any food products that may be manufactured in areas located adjacent to or within the areas surrounding the CPWE are expected to be lower than presented in the worst-case (maximum off-site) scenario. Risks to human health are therefore considered low and acceptable for these businesses and products.

7.8 Overall Evaluation of Impacts

The characterisation of risk associated with the operation of the proposed CPWE remediation project has identified the following for the key receptors and pathways identified:

- Normal operation of the CPWE remediation project:
  - Short-term, acute, exposures associated with emissions to air derived from the proposed CPWE remediation project only as well as cumulative exposures have been assessed. Impacts to human health associated with acute exposures in all areas surrounding the site are considered to be low.
  - The evaluation of long-term, chronic, exposures has focused on potential inhalation exposure to COPCs identified in air following emissions to air in recreational areas (in particular the Hensley Athletics Field) and work areas within the BIP and off-site (including the manufacture of food products) from all aspects of the proposed remediation project and multiple pathway exposures by residents in areas surrounding the CPWE site (inhalation, ingestion and dermal contact with chemicals in soil, ingestion of home-grown fruit and vegetable crops and accumulation of chemicals in breast milk and subsequent exposure by infants).
  - Exposure to emissions derived from the proposed CPWE remediation project only as well as cumulative exposures to emissions from the CPWE remediation project and other emission sources in the area have been assessed.
  - Relevant receptors have been identified as residents (inhalation and multiple pathway exposure), recreational groups (inhalation only) and workers (inhalation only).
  - The total HI values for all receptor groups evaluated for all threshold COPCs fall below 1. This indicates that the estimated intake associated with reasonable maximum exposures by all receptor groups to emissions from the CPWE remediation project as well as cumulative exposures, fall below the acceptable intake for the COPCs as defined by the ADI (or equivalent including background intakes).
  - The total incremental lifetime risk for all receptor groups evaluated for all non-threshold COPCs associated with emissions from the CPWE remediation project and cumulative exposures falls below the incremental risk level of 10^{-6} adopted as representative of negligible or effectively zero risk.
  - The evaluation of risk to human health associated with emissions during normal operation of the proposed CPWE remediation project, including cumulative risks, is therefore considered to be low and representative of negligible risks.

- Upset Operating Conditions:
  - Short-term, acute, exposures associated with emissions to air derived from worst-case upset conditions identified from the proposed CPWE remediation project only as well as cumulative exposures have been assessed. Impacts to human health associated with acute exposures during such an event in all areas surrounding the site are considered to be low.
  - Due to the short duration of upset condition identified, no long-term exposure assessment was considered to be necessary.
  - On this basis the evaluation of risk to human health associated with emissions during upset operating conditions (worst-case scenario) is therefore considered to be low and representative of negligible risks.

These calculated levels of risk are indicative of acceptable levels of risk for potential exposures to the proposed CPWE remediation project as well as cumulative impacts.

Section 8 Uncertainties

In general, the uncertainties and limitations of a health impact assessment can be classified into the following categories:

- Data;
- Receptor exposure assessment; and
- Toxicological assessment.

The risk assessment process following enHealth, NEPC, ANZECC/NH&MRC and USEPA guidance documents provides a systematic means for organising, analysing and presenting information on the nature and magnitude of risks to public health posed by chemical exposures. Despite the advanced state of the current risk assessment methodology, uncertainties and limitations are inherent in the risk assessment process. This section discusses the uncertainties and limitations associated with this risk assessment. Table 8.1 summarises the major uncertainties associated with the conduct of the health impact assessment and their potential effect on the outcome and conclusions.

Table 8-1 Uncertainties

Uncertainty	Potential Impact	Comments
Issue Identification		
Available data on the proposed operation of the CPWE remediation project. In particular potential emissions to air from all aspects of the remediation project have been estimated on the basis of limited data.	May underestimate or overestimate emissions.	Emission estimates have been provided by Thiess for use within the air dispersion modelling, the output of which is utilised within the health impact assessment. Limited data are available on the concentrations and distribution of contaminants within the CPWE, hence the emission estimates may have underestimated actual emissions. Conversely, due to the lack of data, conservative assumptions have been adopted which may result in an overestimation of emissions and risk.
Exposure Assessment		
Use of assumptions to characterise potential exposures to chemicals in the air.	Over-estimate actual risk.	All exposure assumptions have been based on relevant guidance or scientific judgement. The assumptions tend to be conservative, particularly those adopted for the assessment of reasonable maximum exposure.
Use of maximum GLC and deposition rate in the calculation of chemical intake.	Over-estimate actual risk.	The maximum GLC or deposition rate identified in off-site receptor areas from the air dispersion modelling is likely to overestimate exposure in key areas assessed.
Models used to estimate soil concentrations, plant concentrations and breast milk concentrations.	Underestimate or over-estimate actual risk.	Models have not been fully validated for all chemicals and soil types. In general, the models adopted are generally considered to be conservative.
Toxicological Assessment		
Extrapolating from one species to another. Extrapolating from the high exposure doses, usually used in experimental animal studies, to the lower doses usually estimated for human exposure situations.	Over-estimate actual risk	The majority of the toxicological knowledge of chemicals comes from experiments with laboratory animals, although there may be interspecies differences in chemical absorption, metabolism, excretion and toxic response. There may also be uncertainties concerning the relevance of animal studies using exposure routes that differ from human exposure routes. In addition, the frequent necessity to extrapolate results of short-term or subchronic animal studies to humans exposed over a lifetime has inherent uncertainty.

Section 8 Uncertainties

Uncertainty	Potential Impact	Comments
		In order to adjust for these uncertainties, ADIs and RfDs incorporate safety factors that may vary from 10 to 1,000. The USEPA assumes that humans are as sensitive to carcinogens as the most sensitive animal species. The policy decision, while designed to minimise the potential for underestimating risk, introduces the potential to overestimate carcinogenic risk. It also does not allow for the possibility that humans may be more sensitive than the most sensitive animal species. The model used by the USEPA to determine slope factors is a linearised multistage model, which provides a conservative estimate of cancer risk at low doses and is likely to overestimate the actual slope factor. It is assumed in this approach that a genotoxic mechanism applies, however, most carcinogens do not actually cause cancer by this mechanism. The result is that the use of slope factors has the general effect of overestimating the incremental cancer risks.
Evaluating risks to mixtures of chemicals assumes dose additivity.	May over estimate or under estimate actual total risk.	The approach for evaluating risks to mixtures of chemicals assumes dose additivity and does not account for potential synergism, antagonism or differences in target organ specificity and mechanism of action. In general, the additive approach has the effect of overestimating the risks. This is because chemicals that have no additive effects are included together as well as chemicals which may have additive effects.

Section 9 Conclusions

Impacts to human health associated with the construction and operation of the proposed CPWE remediation project have been evaluated using a systematic approach as outlined in guidance provided by enHealth (2002). This includes the identification of key issues, evaluation and quantification of exposure, evaluation and quantification of hazards or chemical toxicity and the characterisation of risk.

On the basis of the information available on the proposed CPWE remediation project the following key issues have been identified and have been evaluated in detail in the health risk assessment:

- Inhalation exposures (acute and chronic) by residents, recreational users in the area (particularly within the Hensley Athletics Field located adjacent to the CPWE) and workers (within the BIP and in off-site areas) to chemicals identified in air following normal and upset emissions from all aspects of the proposed remediation project;
- Multiple pathway exposure by residents (and consumers of produce manufactured in areas adjacent to and surrounding the CPWE) to persistent and bioaccumulative chemicals which may be emitted to air during normal emissions from all aspects of the proposed remediation project; and
- Consideration of potential cumulative impacts that may be derived from emissions from the proposed CPWE remediation project and other key emissions in the area, including the HCB Waste Repackaging Plant and the GTP.

The assessment presented has indicated that potential exposures (including cumulative exposures) by residents, recreational users of areas surrounding the CPWE and workers are negligible and representative of acceptable risks to human health.

In addition to this conclusion, review of the proposed CPWE remediation project with respect to potential risk to human health has highlighted the following:

- The construction and operation of the proposed CPWE remediation project is expected to be undertaken using an appropriate OHS Plan for construction workers on the site as well as long-term employees in the facility. The plan should require the preparation of safe work method statements to address specific activities as outlined within the PHA (Sherpa, 2007);
- All operational procedures and controls noted in the PHA (Sherpa 2007) should be followed; and
- All mitigation measures associated with construction and operation of the proposed CPWE remediation plant noted within the Air Quality Impact Assessment (PAE 2007) should be followed.

The assessment of operational conditions (normal and worst-case releases) has been based on estimated emissions from the facility which are expected to be conservative; however emissions from the facility once operational should be monitored and re-evaluated against the assumptions used in this assessment. It is noted that the proposed CPWE remediation project aims to reduce concentrations of chemicals in soils to a level that presents no unacceptable risk to human health associated with use of the material within a commercial/industrial setting (on the BIP).

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Section 11 Limitations

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