Appendix B – Human Health Risk Assessment (HHRA)

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HUMAN HEALTH RISK ASSESSMENT & MANAGEMENT

For

Lot 20, Adelaide St
Hazelmere

January 2015

PREPARED FOR:

Wasterock Pty Ltd

Environmental Services

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EXECUTIVE SUMMARY

This Human Health Risk Assessment (HHRA) has been prepared by MDWES, in consultation with MTOX, for Wasterock Pty Ltd (the Client), to address issues associated with the excavation, management and remediation of a former licensed uncontrolled landfill between c.1978 and c.1982. Given the age of the landfill and the uncontrolled nature, there is a risk of encountering contamination and in particular asbestos material, during the excavation and remediation of the landfill. Therefore the development of an HHRA is required due to the risks posed to the site workers and local residents from site operations.

The HHRA is intended to provide complete information to risk managers, specific policy makers and regulators so the best possible decisions can be made. The risk assessment should address the uncertainties and it is important to make the best use of available information. It is equally, if not more important, to explain to stake holders in the HHRA the processes of how these uncertainties will be identified and managed.

This HHRA has been commissioned to establish an appropriate management response to the Site's current contamination during remediation, address potential public health risks, and ensure the suitability of the site for the intended development (Commercial / Industrial). This is on the proviso that appropriate remedial actions are implemented and reported in accordance with the HHRA and other supporting documents already issued (ESMP, AQMP and SMP).

The enHealth (2012) document identifies four key stages for a risk assessment which should be taken into consideration at each stage of development when working through the HHRA process. Issue Identification, Hazard Assessment, Exposure Assessment and Risk Characterisation. The MDWES ESMP developed a preliminary HRA within the conceptual site model which identified the issues and hazard on Site based on established contaminants of potential concern (CoPC). Based on these finding it was recommended that a detailed health risk assessment was undertaken to discuss the effects of potential sources, the significant pathways and the identified sensitive receptors during the remediation of the Site.

Although primarily licensed for inert waste during its operational cycle, a number of non-inert wastes were understood to have been received at the landfill. The non-inert material was received with the knowledge and approval of the regulating authority, which at the time was the Shire of Swan. Records show that the received materials were described as inert building waste, car bodies / parts and asbestos sheeting / pipes / tiles. In addition, it was reported that sludge's containing hydrocarbons, together with emulsified factory wastes, were also accepted. Furthermore, drums (unknown), plus drums of kerosene, bitumen, pesticide-contaminated soils and hospital wastes are also known to have been accepted during its operational life.

Remediation and redevelopment of the Site will require excavation of the landfill and engineered repackaging of the material to allow for an industrial / commercial end use. Excavated soil will be processed and screened as part of the remediation. This material will then be returned to a deep cell on site and will be entombed below an engineered barrier layer. A capping layer will them cover the Site.

The project involves:

- Processing an approximate total of 1,500m^3 per day of historical landfill.
- The removal of timber, brick, concrete, ferrous and non ferrous metals for recycling as excavations progress.

- Management of any asbestos pockets encountered during earth works. These specific areas of asbestos will require immediate water saturation and special attention. Removal will be in accordance with the Site Management Plan (SMP), Environmental Site Management Plan (ESMP) and DoH Guidelines.
- Stable non-leaching remediated soils will be placed within a deep cell two metres below ground level (bgl) to base depth of void. Any asbestos impacted soils encountered will be placed in the deep cell.
- The engineered barrier layer will provide an inert marker layer of crushed compacted construction / demolition material (CDM). The barrier layer will be positioned 1.5 m below finished level and will extend 2 metres below ground level (bgl). The barrier will be a minimum of 0.5 m thick. The barrier will be validated prior to being used on site. Sampling will occur prior to crushing and post crushing to ensure barrier layer material is suitable clean for use.
- Soil for the capping layer will be sourced from the Perth region. The Site's Soil Acceptance and Amendment Facility (SAAF) which will receive Acid Sulfate Soil (ASS) impacted soils, Class I and/or hydrocarbon Impacted soils. These imported soils will be treated and validated to ensure suitability as a capping layer soil. Capping layer will be constructed to a minimum of 1.5 metres thick.

Contamination of the site by Asbestos Containing Material (ACM) fragments, and potentially asbestos fibres, has occurred as a result of questionable historical land filling and waste handling. As a consequence, nearby residents are concerned regarding exposure to asbestos fibres potentially released during the remediation of the Site. However, the site currently exhibits ACM at the surface and so also represents an environmental risk and human health risk if left as it is.

Community health concerns are exacerbated by the site being opposite from domestic housing. Their concerns appear primarily associated with potential asbestos fibre exposure and dust, as a direct result of the excavation and remediation of the Site.

To minimise public exposure, site access shall be restricted to personnel necessary for current remediation, monitoring, and reporting activities. Fencing, signage, and site entry protocols will be maintained until site validation and subsequent regulatory approvals have been achieved.

Similarly, dust suppression at the site will continue, as required, throughout the site remediation process. The maintenance of wind fencing will also assist in control of peak dust releases ('spikes'), while reducing the visual impact of site remediation on nearby residents. In the absence of rain heavy enough to wet the soils, soils will be pre-wet during the initial stages of soil removal to minimise dusts that may result from mechanical disturbance. Subsequent dust suppression will be informed by visual assessment during site activities and real time dust monitoring. As recognised by DoH (2009), dust monitoring provides a useful surrogate measure to evaluate the potential generation and distribution of airborne asbestos fibres.

To demonstrate the effectiveness of the adopted site management measures and alleviate community concerns, a dust monitoring program will be implemented for the duration of the project (full details are in the MDWES ESMP and AQMP). This will provide 'real time air quality data' to identify any exceedance of adopted air quality limits. If any exceedances occur, then a review of the site management plan and the AQMP may be required (DoH, 2009). Any amendment to the AQMP is to be approved by the contaminated site auditor and DER, ensuring that consistency with applicable dust monitoring guidelines is maintained and the primary goal of community protection is achieved.

1 INTRODUCTION

This Human Health Risk Assessment (HHRA) has been prepared by MDWES, in consultation with MTOX, for Wasterock Pty Ltd (the Client). The report is to address health issues associated with the excavation, management and remediation of a former licensed uncontrolled landfill between c.1978 and c.1982. Given the age of the landfill and the uncontrolled nature, there is a risk of encountering contamination and in particular asbestos contaminated material (ACM), during the excavation and remediation stages of redeveloping the Site. Therefore, the development of a HHRA is required due to the risks posed to the site workers and local residents from site operations during the period of remediation.

The HHRA is intended to provide complete information to risk managers, specific policy makers and regulators so the best possible decisions can be made. The risk assessment should address the uncertainties and it is important to make the best use of available information. It is equally, if not more important, to explain to stake holders in the HHRA the processes of how these uncertainties will be identified and managed.

This HHRA has been commissioned to establish an appropriate management response to the Site's current contamination which may be encountered during remediation, address potential public health risks, and ensure the suitability of the site for the intended development (Commercial / Industrial). This is on the proviso that appropriate control measures are implemented and reported in accordance with the HHRA and other supporting documents already issued (ESMP, AQMP and SMP).

Approval and endorsement from the Department of Environment Regulation (DER), Department of Health (DoH) and Environmental Auditor is required before implementation. Once endorsed, then further reporting under the Contaminated Sites Act (CS Act) should prove unnecessary, unless significant contamination is identified during the remediation process. In such circumstances, further consultation with the DER, DoH, Auditor and other stakeholders will be undertaken to determine CS Act reporting requirements, or additional site management responses.

1.1 Site Location

The Site is located within the City of Swan, approximately 14 km east north east of the Perth CBD, 6 km east of the Swan River and 1 km west of the Darling Fault (Figure 1). It is currently vested with Wasterock Pty Ltd and has been since 2006. The Site is located at Lot 20 Adelaide Street, Hazelmere, Perth, herein referred to as 'the Site'.

1.2 Proposed Site Development

The site is intended to be redeveloped into a large scale commercial / industrial business park which would generate commerce and employment for the local community and the Perth region. Consistent with the intended land-use and regulatory guidance (DEC, 2006a; DOH, 2009), the Site shall be remediated to achieve a site classification of *Remediated for Restricted Use,* inclusive of an appropriate memorial on the certificate of title notifying of legacy contaminated materials to be managed *in situ*.

1.3 Previous Reports

Numerous reports and investigations have been undertaken on the subject Site from c.2005 to present. The information and results of these investigations are compiled in the following documents and should be read in conjunction with this assessment:

- FOI 1233/05 by Department of Environment & Conservation (DEC) – Freedom of Information – Lot 20, Adelaide Street, Hazelmere (October 2005).

- 2145245A:PR2_16644.RevA by Parsons Brinckerhoff – Site Investigation (SI) – Hazelmere, WA (July 2006) (see figure 1).
- V392/2007 grw4469 by Knight Frank – Valuation Report – Lot 20 Adelaide Street, Hazelmere, WA (July 2007).
- 476300-0kjcv070709a by Burgess Rawson – Valuation Report – Lot 20 Adelaide Street, Hazelmere, WA (July 2007).
- 60150301 by AECOM – District Storm water Management Strategy – Hazelmere Enterprise Area (June 2010).
- Drilling Logs by Banister Drilling & Irrigation for 20 Adelaide Street, WA. (May 2012).
- E2012-031 (GME) – MDWES – Groundwater Monitoring Event #1 – Adelaide Street Hazelmere (May 2012).
- NTEC Environmental Technology – Groundwater Modelling for the Wasterock Hazelland Landfill Site in Hazelland. (September 2012).
- E2012-031 (GME) – MDWES – Groundwater Monitoring Event #2 – Adelaide Street Hazelmere (August 2012).
- Herring Storer Acoustics – Acoustic Assessment Lot 20 Adelaide Street Hazelmere – Adelaide Street Hazelmere (September 2012). (Ref:15172-2-12131).
- E2012-031 (GWAMP) – MDWES – Groundwater Abstraction for Dust Suppression & Surface Compaction v2 – Adelaide Street Hazelmere (October 2012).
- E2012-031 (GME) – MDWES – Groundwater Monitoring Event #3 – Adelaide Street Hazelmere (January 2013).
- E2013-031 – (SAMP) - MDWES – Soil Amendment Management Plan – Lot 20 Adelaide Street, Hazelmere (March 2013).
- E2012-031 (GME) – MDWES – Groundwater Monitoring Event #4 – Adelaide Street Hazelmere (June 2013)
- E2012-031 (AQMP) – MDWES – Air Quality Management Plan (AQMP) v5 – Adelaide Street Hazelmere, (October 2013).
- E2012-031 (GMES) – MDWES – Annual Groundwater Monitoring Event Summary Report (GMES) v2 – Adelaide Street Hazelmere, (October 2013).
- GRA 7729 by Greg Rowe & Assoc. – Community Management Strategy for Remediation of Former Landfill Site: Lot 20 Adelaide Street, Hazelmere. (March 2014).
- 6045.k.09_09082_SMP by Waste Rock Pty Ltd – Site Remediation Works Agreement and Site Management Plan (Final) – Lot 20 Adelaide Street. (March 2014).
- E2013-031 (ESMP) – MDWES – Environmental Site Management Plan (ESMP) v7 - Adelaide Street Hazelmere, (May 2014).
- E2013-031 (WAA) – MDWES – Works Approval Application (WAA) v2 - Adelaide Street Hazelmere, (May 2014).

2 PROJECT BACKGROUND

2.1 Site History

The Site historically operated as a licensed uncontrolled inert landfill from c.1987 to c.1997, after first being mined for building and construction sand. It was reported that the sand was extracted to six metres below natural ground level, down to the clay substrate and no further. However, anecdotal advice suggests extraction could potentially have been deeper to chase the sand horizon. The mined area was then utilised as an inert landfill once a mineral had been quarried / mined. This was common practice for the time period and location within the Perth region.

Although primarily licensed for inert waste during its operational cycle, a number of non-inert wastes were understood to have been received at the landfill. The non-inert material was received with the knowledge and approval of the regulating authority, which at the time was the Shire of Swan. Although investigations indicate no history of accepting uncontrolled waste, records show that received materials were described as the following; Inert building waste, car bodies parts, asbestos sheeting / pipes and tiles. In addition to this it was reported that sludge's containing hydrocarbons, together with emulsified factory wastes, were also accepted. Furthermore, drums (unknown), plus drums of kerosene, bitumen, pesticide-contaminated soils and hospital wastes were also known to have been accepted during its operational life. Based on the reported waste streams accepted above it is possible that putrescible waste may have been accepted during the life span of the landfill and therefore cannot be discounted at this stage. Only during the remediation phase will this be known.

2.2 Current Site Profile

The Site is an irregular shaped plot of land that has remained redundant and non-operational as a closed landfill since c.1997. The Site has been allowed to vegetate and stabilise from its closure to the present date. Much of the Site is overgrown, with a variety of persistent introduced flora and some juvenile and semi-mature trees have grown. The Site could be described currently as waste land and undeveloped. The Site measures approximately 565 metres in length and 300 metres in width with a total combined area of approximately 16.9 ha.

Within the non-land filled area of the Site along the western boundary, the surface appears to have a generally flat topography that ranges between approximately 26.69 mAHD in the southwest corner, sloping gently upwards to approximately 27.24 mAHD in the northwest corner (c.1990 site survey). The original surface levels have been altered, due to historic sand mining at the Site and its subsequent historical landfill (Parsons Brinkerhoff, 2006).

The Site is bound to the north by undeveloped land and an operational equestrian stable, which includes an oval trotting track, several stables and annex / out buildings. The grounds are not sealed. They are covered with rolled aggregate for vehicle access.

The east of the Site is bound by the Roe Highway (running north to south) and, on the south-east boundary of the Site, there is a small operational sand quarry and land filling operation.

To the south, Adelaide Street runs south-east to north-west, bounding the High Wycombe residential estate.

Immediately to the west of the Site is an ice works and meat processing works. There are also several undeveloped lots of land interspaced with small industrial/commercial premises surrounding the Site. At present, it is perceived that these industrial/commercial operations have little impact or influence on the subject Site.

2.3 Project Overview for Landfill Remediation

Remediation and redevelopment of the Site will require excavation of the landfill which will be engineered and repackaging to allow for an industrial/commercial end use. The excavated soil will be processed and screened on Site as part of the remediation process. This material will then be returned to a deep cell which will be developed on site. The processed material will be entombed below an engineered barrier layer of crushed concrete this will capped with clean cover across the Site.

The project involves:

- Processing an approximate total of 1,500m^3 per day of historical landfill material.
- The duration of the project is expected to take approximately 4-5 years.
- The removal of timber, brick, concrete, ferrous and non-ferrous metals for recycling as excavations progress. Concrete, brick and over-sized rock material will be sent to the Recovery, Remediation and Recycle Facility (RRRF) to be crushed and re-used within the capping layer.
- Management of any asbestos pockets encountered during earth works. These specific areas of asbestos will require immediate water saturation and special attention. Removal will be in accordance with the Wasterock Site Management Plan (SMP), MDWES Environmental Site Management Plan (ESMP) and DoH Guidelines.
- Stable non-leaching remediated soils will be placed within a deep cell two metres below ground level (bgl) to base depth of void. Any asbestos impacted soils encountered will be placed within the deep cell also.
- The engineered barrier will be denoted by a marker layer of crushed compacted Construction & Demolition Material (CDM)). The barrier layer will be positioned 1.5m below finished level and will extend to 2 metres below ground level (mbgl). Thus making the barrier a minimum of 0.5m thick.
- Concrete and over-sized material (<150mm) will be screened and sampled prior to being crushed. ACM material will be picked from the belt and or stockpile. Samples will then be taken from the oversized stockpile for asbestos analysis. Material will be quarantined until laboratory results are obtained. The results will determine acceptance as “clean”. Once validated material can be transported to the crusher, and crushed for the barrier layer. The crushed material will be sampled again for final validation before being used as the barrier layer on site. Only suitable and acceptable barrier material will be used. Unsuitable material will be removed from Site or place within the engineered deep cell.
- Soil for the capping layer will be sourced from the Site’s Soil Acceptance and Amendment Facility (SAAF). The facility will receive impacted Acid Sulfate Soil (ASS) and Class I and/or hydrocarbon Impacted soils from the Perth region. These imported soils will be treated and validated to ensure suitability prior to being used as capping layer soil cover. Soils that fail validation will be placed within the deep cell (if soil volumes are required) or removed from Site. Capping layer will be a minimum of 1.5 metres thick.
- For the duration of the project environmental monitoring will be undertaken to assess air, soil, groundwater and ground gas quality, in terms of human health risks and environmental impact.

2.4 Site Classification

Based on the findings of the historical reports, the Department of Environment Regulation (DER) (formally DEC) classified the Site as 'Possibly Contaminated – Investigation required', on 27 April 2007 (VDM, 2008). In November 2010, the DER revised this judgment and reclassified the Site to '*Contaminated - remediation required'*.

The Site is located at Lot 20 Adelaide Street, Hazelmere, within the City of Swan. Current Site owners Hazelland Pty. Ltd (Owner) have subcontracted Wasterock Pty Ltd (WRK) to undertake the required remediation work, in order to make the Site suitable for the future use (commercial/industrial).

2.5 Identified Contamination

A number of investigative studies have taken place across the Site over the years. These studies have identified varying levels of contamination, primarily caused by Total Petroleum Hydrocarbons (TPH's), Monocyclic Aromatic Hydrocarbons (MAH's), Heavy Metal impacts and Asbestos within the soil matrix on Site. The following sections identify specific Chemicals of Potential Concern (CoPC) for air, soil, groundwater and ground gas.

2.6 Contaminants of Potential Concern - Soil

The Parsons Brinckerhoff Detailed Site Investigation (DSI) identified the following soil Contaminants of Potential Concern (CoPC), based on the information obtained regarding the materials accepted into the landfill:

- Total Petroleum Hydrocarbons (TPH).
- Monocyclic Aromatic Hydrocarbons (MAH's).
- Heavy Metals.
- Asbestos.

2.7 Contaminants of Potential Concern - Groundwater

The groundwater monitoring program undertaken by MDWES identified the following groundwater CoPCs. The identification of CoPCs was based on reported data, historical use, current Site activities, regional soils, proximity to sites classified as contaminated, off-site sources and impacts. The CoPCs comprised the following:

- Dissolved and Total Metals: Arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), manganese (Mn), molybdenum (Mo), nickel (Ni), silver (Ag), selenium (Se), vanadium (V), zinc (Zn), and mercury (Hg).
- Benzene, Toluene, Ethyl Benzene, Xylene (BTEX).
- Polynuclear Aromatic Hydrocarbons (PAH).
- Monocyclic Aromatic Hydrocarbons (MAH).
- Phenolic compounds.
- Total Petroleum Hydrocarbons / Total Recoverable Hydrocarbons (TPH/TRH).
- Total PCB's.
- Organochlorine and Organophosphorus Pesticides (OC/OP).

2.8 Contaminants of Potential Concern - Air

The proposed Site works has the potential to generate dust and other CoPCs identified within the landfill matrix. Therefore, monitoring is a fundamental requirement of the environmental site management plan (ESMP) base on the MDWES AQMP report. During excavation and engineering of the landfill, dust and particulate matter has the potential to be emitted and released. As such, the following air quality CoPCs have been identified as:

- Asbestos fibres.
- Particulate matter.
- Volatile Hydrocarbons.

2.9 Contaminants of Potential Concern – Ground Gas

The proposed remediation of the site could give rise to ground gas generation once the site has been repackaged. All organic material encountered during excavation will be removed during the screening process which will reduce the potential for ground gas generation when the landfill is engineered. The ground gas assessment will be conducted as cells are completed on site to develop a ground gas model and data to present a classification for the future use of the Site.

The following ground gas CoPCs have been identified as part of a ground gas monitoring program.

- Methane (CH_4).
- Carbon Dioxide0 (CO_2).
- Carbon Monoxide (CO).
- Oxygen (O_2).
- Hydrogen Sulfide (H_2S).
- Total Volatile Organic Compound (VOC).

NB: The ground gas monitoring will include readings for atmospheric pressure (mb) and ground gas flow (L/hr).

2.10 DSI – Soil Results

Parsons Brinckerhoff undertook a laboratory assessment of the soils at the Site in 2006. Their report indicates that the majority of fill material was inert construction and demolition waste within a sandy soil matrix. In addition, minor amounts of ACM were identified in several test pit excavations.

As part of the Parsons Brinckerhoff investigation, asbestos analysis was also undertaken. Figure 3 shows landfill elevations and test pit locations. Table 'A' below summarises the soil analytical results.

Table A: Summary of Soil Analytical Results (Parsons Brinckerhoff)

Number of samples analysed	Analyte	Min Conc. (mg/kg)	Max Conc. (mg.kg)	Samples exceeding investigation level*	Samples exceeding Class 1 waste classification
20	Mercury	0.01	0.41	none	TP11_2, TP12_1
20	Arsenic	<2.0	6.8	none	none
20	Cadmium	<2.0	<2.0	none	none
20	Chromium	3.5	24	none	TP8_1, TP9_1, TP9_3, TP10_1, TP10_2, TP11_2, TP12_1
20	Cobalt	<2.0	2.3	none	none
20	Copper	5.8	390	TP3_2,	none

				TP9_1, TP12_1	
20	Lead	12	240	none	All submitted samples
20	Manganese	14	220	none	none
20	Nickel	<2.0	31	none	TP3_2, TP8_1, TP8_2, TP9_1, TP9_2, TP9_3, TP10_1, TP10_2, TP11_2, TP12_1
20	Selenium	<2.0	<2.0	-	none
20	Zinc	18	770	TP6_1, TP9_1, TP9_3	none
20	TPH $C_6 – C_9$	<5	<5	none	none
20	TPH $C_{10} – C_{14}$	<20	30	none	none
20	TPH $C_{15} – C_{28}$	30	710	none	none
20	TPH $C_{29} – C_{36}$	24	850	-	-
20	Benzene	<0.2	<0.2	none	none
20	Ethylbenzene	<1.0	<1.0	none	none
20	Toluene	<1.0	<1.0	none	none
20	Xylenes	<3.0	<3.0	none	None
20	Total PCBs	<1.0	<5.7	TP9_2, TP9_3, TP11_2	None

* EILs Western Australian Ecological Investigation Levels (DoE, 2003)
HIL-Fs Western Australian Health Investigation Levels – For commercial/industrial landuse (DoE 2003)
**Class I Western Australian Contaminant threshold for Class I landfill waste (DoE, 1996)

Exceed Class 1 Waste Classification
Exceeds EIL

Table 'B' below summarises the results of laboratory identification of potential ACM sampled. The table includes the test pit location, description of sample, whether asbestos was detected by polarised microscopy and, if positively identified, the type of asbestos present.

Table B: Summary of Asbestos Laboratory Results (Parsons Brinckerhoff)

Test Pit Location	Description	Type of Asbestos Detected
TP1	Grey Fibrous Sheeting Grey Fibrous Sheeting painted white	Chrysotile, Crocidolite Chrysotile, Amosite
TP3	Pale Brown Flooring White Fibrous backing Brown Fibrous sheeting (curved) Grey Fibrous Sheeting (Painted White)	No Chrysotile No Chrysotile
TP6	Brown Fibrous sheeting	No
TP7	Pale Brown Fibrous Sheeting, Painted Pale Yellow Pale Brown Fibrous Sheeting, Painted White	Chrysotile, Amosite No
TP8	Brown Fibrous sheeting (curved) Brown Fibrous sheeting (curved)	No No
TP9	Brown Fibrous sheeting (curved)	No
TP10	Brown Fibrous sheeting (curved)	No
TP11	Brown Fibrous sheeting (curved)	No
TP12	Grey Fibrous Sheeting painted white	Chrysotile

	Grey Fibrous Sheeting painted white Off White-Flooring Off-White Fibrous backing	Chrysotile, Crocidolite, Amosite No No
TP13	Grey Fibrous Sheeting	Chrysotile, Amosite
TP14	Pale Brown Fibrous Sheeting, painted White Grey Fibrous Sheeting, Painted White	No Chrysotile, Crocidolite

2.11 Principles for Health Risk Assessment and Management

The DoH (2009) and DER guidelines outline a process to address sites contaminated by Metals, Hydrocarbons, ACM and / or nuisance dust that may be deemed a risk to human health and the environment. DoH, like the DER, recommends a staged approach for risk assessment involving:

- Tier 1: screening risk assessment.
- Tier 2: intermediate (simple) risk assessment.
- Tier 3: detailed (site specific) risk assessment.

For a Tier 1 assessment, contamination concentrations are simply compared against the DoH and DER air, soil, groundwater and asbestos investigation criteria levels, while a Tier 2 assessment typically involves adjustment to these assessment levels if the site setting and exposure scenario(s) differ significantly from the assumptions underlying the generic criteria (DEC, 2006b). Progression to a Tier 3 assessment then occurs when greater detail and focus is required on risk-driving factors. The investigations and risk assessment proceed until the level of information is appropriate for the decision making required (enHealth, 2012).

The HHRA adopts a precautionary approach and assumes conservative 'worst case' conditions to provide additional confidence in the degree of protection afforded by the results. The risk to affected parties will be assessed, taking account of the potential asbestos contamination profile, dust, odour and other contamination for key exposure scenarios associated with relevant activities, the proposed remediation, control measures, and the final use of the site.

The HHRA shall achieve the following:

- Develop a rational approach to implementing the methodology of the HHRA.
- Identify the issues associated with remediating the site and how these issues will affect the stakeholders and the local community in term of health risks.
- Provide an evaluation of the hazards associated with the identified issues.
- Determine representative exposure scenarios.
    - Identify and evaluate activities associated with the site at present, during remediation, and long-term management.
    - Identify key receptors and associated exposure profiles.
- Characterise the health-risks from site contamination. Identify the potential contaminants and/or sources which must be addressed at each stage of Site development.
    - Prior to or without development.
    - During remediation.
    - Future use and ongoing investigations.
- Identify health-based requirements for Site management.

3 The Role of Human Health Risk Assessment

A HHRA is intended to fulfil the requirements of the CS Act and comply with guidance papers DoH (2009) and enHealth (2012). Additional MDWES reports and documentation have been published in relation to these matters (See Section 1.3 bibliography).

The HHRA is designed to address pollutants that may cause harm such as the site specific CoPCs identified in section 2. In certain circumstances, occupational health concerns may warrant further assessment and/or engagement with WorkSafe and stakeholders depending on the findings.

The HHRA is a risk assessment tool, rather than a management tool per se. It is important that the HHRA is not used merely to demonstrate more rigorous site management processes, justify preconceived risk management options, or compensate for poor site practices (enHealth, 2012). Rather, this HHRA will be employed as a tool for a systematic evaluation of potential risks to human health. Subsequent management measures are then informed by the risk assessment process to minimise and, where possible, eliminate identified risks. This process shall provide transparency and identify a precautionary remediation approach to ensure the protection of public health in the absence of detailed site assessment data. Provided that the limitations of the HHRA are recognised, defensible site risk management actions may be enacted in the MDWES ESMP. This will be verified in a manner that meets regulatory needs and stakeholders.

The HHRA guides the MDWES ESMP, AQMP, and to some extent the Wasterock Site Management Plan to provide prompt action plan to resolve key issues. This also facilitates community, regulatory, and owner/developer goals for existing and desired future site use (Commercial / Industrial zoning).

This HHRA establishes a conservative risk based approach to the scope of work for any contamination which may be found, and the associated public health concerns. This is presented as a pragmatic approach for Site remediation and management to the sites remediation process. The current projections for the project are that it may take four to five years to remediate the Site completely (this does not include remediation completion monitoring such as post remediation groundwater and ground gas monitoring).

3.1 Considerations on Qualitative vs Quantitative Approach

Although typically desirable in most circumstances, sometimes it is not possible to undertake a quantitative HHRA due to the variability of contamination and associated potential exposures. As examined further in Section 4.1, quantitative estimates of risk can only be calculated with relevant and accurate data available. Particularly with respect to asbestos, a qualitative or semi-qualitative assessment may have to suffice (DOH, 2009). Consequently, the preliminary risk assessment undertaken as part of the MDWES ESMP employed a dual approach of initial screening against site assessment criteria followed by further evaluation using non-numerical risk estimation methods to identify those issues warranting detailed assessment within the HHRA.

Qualitative risk assessment is an enquiry process that generates non-numerical data to provide an ‘understanding of a social and/or human problem’ and can be used to avoid the false sense that the extent of the risk is known precisely. Such understanding may be achieved through building a complex and holistic picture formed with words, to report detailed views based on currently available data. Alternatively, the assessment may adopt a well-defined classification process, where objects and/or material that may impact human health are assigned a classification risk value (High, Low, etc). Either method yields valuable information regarding the nature of the hazards and potential exposures, allowing reasonable estimates of risk to be determined.

In context with the considerations given above, it should also be recognised that numerical criteria remain useful to inform certain aspects of a qualitative risk assessment and associated management. Suitable consideration to assessment levels:

1. Allows most CoPCs to be excluded from a detailed HHRA (i.e. they are screened out).
2. Helps to identify key receptors and exposure pathways for investigation in the HHRA.
3. Helps to define benchmarks for assessment during remediation and thus allows validation of the HHRA and adopted risk management measures.

Air, soil, groundwater and ground gas sampling during and post-remediation of the Site will therefore provide increasing levels of information on the extent of site contamination and how this transposes to health risks. Evaluation of the data may thus prompt re-evaluation or refinement of the initial risk assessment, although the adoption of conservative assumptions by the HHRA makes this unlikely to be necessary for the protection of health. Rather, the data may support less aggressive risk management measures according to the nature of the receptors and potential exposure.

3.2 Risk Assessment Framework

The enHealth (2012) document identifies five key stages for a risk assessment. The framework is based on US, Canadian and Australian models developed through the 1980s, 1990s and 2000s. The five keys stages comprise the following headings with some key factors that should be taken into consideration at each stage of the health risk assessment process (enHealth, 2012).

3.2.1 Issue Identification

- What are the true drivers for the issues being assessed?
- Are intervention strategies available to manage the outcomes of the HHRA?
- Have transportation mechanisms been adequately been considered? (Source-Pathway -Receptor Linkages).

  Transportation mechanisms which could be encountered without control measures have been fully considered and identified in the preliminary HRA in the ESMP report (Section 10 – Conceptual Site Model).

- Are there factors that could affect persistence?

3.2.2 Hazard Assessment

- Have the severity and reversibility of health effects been considered?
- Are there any interactions between the identified hazards and other agents in the environment?
- Is the onset of health effects immediate or delayed?
- Is there a critical window of exposure?
- Have the carcinogenic and/or genotoxic potential of the identified hazards been addressed?
- Is there appropriate dose response data available and has the data been appropriately scaled in translation from environment to human?
- Does a threshold or non-threshold model best describe the data?

3.2.3 Exposure Assessment

Consideration to excavation and crushing processes during site remediation are key to the HHRA. Occupational on-site exposure to dust/particulates may be anticipated to be largely continuous during operations, but periodic when considered on a 24 hours or weekly basis (i.e. clear exposure patterns exist). Meanwhile, potential exposure to asbestos would be episodic and of uncertain frequency and duration if the process of excavation/crushing were left unmanaged. Exposure to off-site receptors may be expected to vary according to the proximity of site activities, weather conditions, and individual behaviour patterns. Therefore, the following points should be considered when assessing exposure.

- What is the duration, timing, frequency and consistency of exposure?
- Is the exposure continuous, intermittent or episodic, or do they show clear patterns?
- Are there any relevant past, current or future exposure patterns to consider?
- Are exposures intergenerational or cumulative, or should they be arrogated?

3.2.4 Risk Characterisation

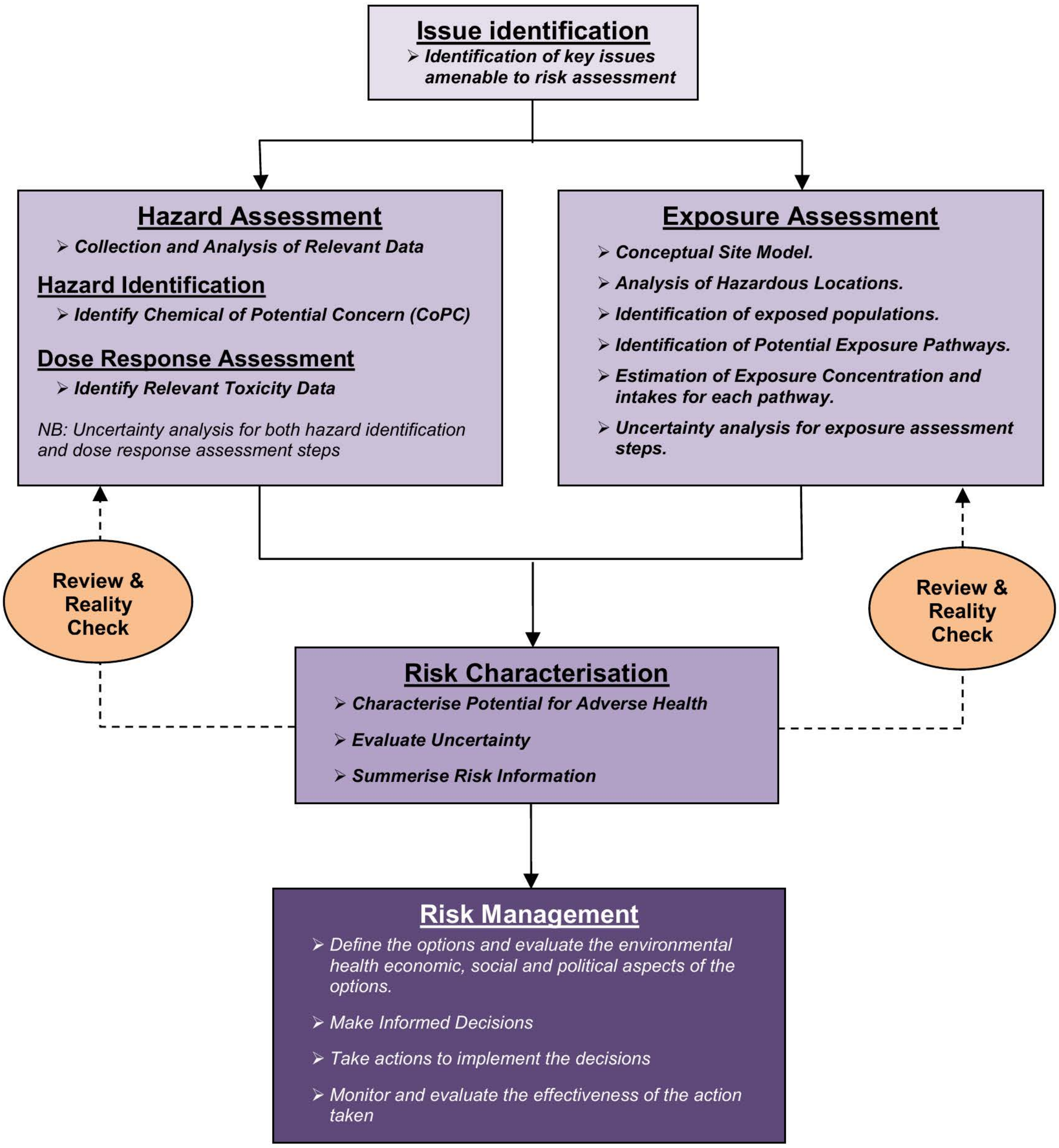
- Has genetic variability in the exposed population (or in source toxicological data) been adequately accounted for?
- Are there individual host characteristics (e.g. age, gender, body weight, pre-existing health conditions, nutritional status, previous exposure or reproductive status) that need to be considered?
- Has the risk assessment been expressed qualitatively or quantitatively?

3.3 Risk Assessment Model

The standard enHealth risk assessment model is presented in Diagram 1. EnHealth (2012) now also provides a revised assessment model that outlines a more holistic framework, which is intended to emphasise the importance of problem formulation for quantitative risk assessment. However, as the HHRA adopts a qualitative assessment approach, comprehensive issue identification is inherently recognised as critical to suitable risk characterisation and subsequent risk management determinations. Notwithstanding, the considerations outlined by enHealth are acknowledged and development of the HHRA is believed to be consistent with the revised framework.

Encompassing the process of health risk assessment and management, stakeholder consultation is considered essential at all stages development. Formal provisions for external consultation are in place for the Hazelmere Project, as reported within the ESMP and the Community Consultation Plan supporting documents. Meanwhile, internal consultation and engagement has been enacted through formal audit requirements and MDWES document distribution and review processes.

Diagram 1: Risk Assessment Model



Risk Assessment Model (Figure 1. enHealth 2012) – Risk Assessment Framework

3.4 Adopted Methodology for HHRA

DoH (2009) identifies the enHealth model for HHRA as an appropriate framework for assessment in Western Australia. The guidelines recommend that proponents follow this methodology for the duration of a project. DoH (2009) further outlines fundamental HHRA principles to ensure that a high quality of assessment is achieved:

- Transparency – Clear discussion through each stage of assessment is required to enable a comprehensive review of the issues and judgments, and draw conclusions, with recommendations and the development of a risk model.
- Data Evaluation – The quality of information used throughout the HHRA needs to be evaluated. Uncertainties and limitations should be assessed to determine any influence this evaluation may have on the findings.
- Justification – Present sound rationale for the choice of methods, information sources, and resolution of conflicts should also be presented.
- Identification of Assumptions – While the use of assumptions is unavoidable, these assumptions should be clearly stated and be justified and reasoned.

MDWES recognises these goals as applicable to the HHRA and they are a fundamental requirement within the scope of the presented assessment. MDWES has therefore sought to achieve consistency with the HHRA principles, as outlined above, and with current Western Australian asbestos assessment policies.

3.5 Scope of the Human Health Risk Assessment

Consistent with the progression of risk assessment outlined in Section 2.11, a preliminary conceptual site model and risk assessment was prepared by the ESMP. Using a risk-matrix approach the assessment weighted professional expertise and experience against the known site history and identified COPCs to provide an initial evaluation of risks to receptors, both prior and during remediation activities. This assessment identified a high level of risk for certain COPCs /receptors and determined that a further detailed assessment was required.

Neither a Tier 1 nor Tier 2 assessment approach, which are reliant upon quantitative estimates, is sufficient to provide the required degree of evaluation. It should be recognised that assessment against quantitative estimates may suffer a variety of limitations and may not be suitable for all circumstances (enHealth, 2012). Importantly, due to the nature of the contaminants identified and Site history (Refer to Section 2.1)[1], the extent and distribution of site contamination cannot be reasonably determined to enable effective comparison against assessment levels in this instance[2]. The degree of uncertainty associated with present and, most likely, any future site investigations would limit confidence in the quantitative estimates derived. Furthermore, while it is possible to implement an exhaustive investigation of

[1] It should be recognised that, due to ACM historically not being recognised as a source of contamination, these materials were disposed of in a manner consistent with any other 'inert' construction and demolition wastes. Hence, though the manner of disposal was controlled, there is no manner in which to ascertain areas in which greater levels of contamination may exist without an exhaustive investigation of the entire landfill profile. Irregular disposal of other waste containers present similar issues for site investigation. In both instances, notwithstanding the minor amounts of liquid that may have leaked from disposal containers, the contaminants are essentially immobile and thus not well suited to typical soil investigation processes. Such site investigations may therefore be costly, with respect to both time and resources, while providing limited information that would allow for meaningful risk assessment against numerical criteria.

[2] EnHealth (2012) provides additional guidance on the limitations of numerical risk estimates. Notably, the precision of quantitative risk estimates is limited by the data available to use in the assessment, which for the Site may be currently considered indicative but not specific. However, to obtain suitably detailed data to provide reasonable quantitative risk estimates would entail a significant degree of site disturbance and thus entail associated risks requiring evaluation.

contamination levels during the remediation process, such investigations would not allow risk assessment prior to works commencing or the appropriate risk management measures to be implemented. Consequently, it is appropriate and necessary that the HHRA adopt a detailed ('Tier 3') qualitative assessment approach[3]. This will ensure that a holistic understanding of the issues may be achieved and appropriate remediation and risk management measures implemented.

The preliminary HRA conducted by the ESMP has highlighted that dust and asbestos fibres potentially released from ACM contaminated soils are the primary hazards to the public and site personnel in terms of human health. On this basis, the focus of the HHRA is ACM contamination and dust/fibre emissions that may arise from site disturbing activities. However, consideration and assessment will also be provided in relation to issues posed by noise/vibration, ground gases, and odour. Although not anticipated to pose significant risks, these items may impact upon health or amenity and, hence, specific considerations for appropriate risk management may be required.

To facilitate prompt resolution of community concerns and to accommodate site redevelopment goals, the HHRA has been prepared using information from previous site investigations (including groundwater monitoring), current project knowledge, and consultation with key stakeholders. It is intended that successful implementation of the HHRA shall achieve site conditions comparable to those preceding the contamination event, allowing further issues to be addressed by separate processes.

[3] EnHealth (2012) acknowledges that there is often no clear break between different tiers of investigation and assessment. Rather, most risk assessments have a screening step and a detailed assessment step. The Site assessment approach is consistent with this process.

4 ISSUE IDENTIFICATION

4.1 Introduction

Issue identification serves to formulate the problems that are to be considered by the risk assessment and thereby clarify the required scope of investigation. It helps to establish the context for risk assessment and management, identifying and evaluating stakeholder concerns, determining the key issues for action, and demonstrating why adopted management actions are appropriate (enHealth, 2012).

The following points are examples of issue identification.

- Community concerns over emissions from a smelter or other industrial facility.
- Community outrage over the proposed development of a communication tower.
- How contaminated sites are managed and the levels of protection required or provided.

During issue identification it is important to recognise that (DOH, 2006):

- Issues are different from hazards and are influenced by perceptions, economics, science, and social factors. The determination of issues is necessary to establish a context for the risk assessment and assists the process of risk management.
- Due to differences in risk perception, stakeholders are likely to have different issues which may need resolving. There should be clear recognition of differing risk perspectives and potential stakeholder conflict.
- All stakeholder issues should be considered, with the level of stakeholder consultation and engagement informed by the level of community concern and complexity of the issues.

The subsequent discussion seeks to integrate relevant information from prior consultation and community engagement. Consideration is given to the goals of the site development, stakeholder perspectives, and regulatory needs to help define the HHRA.

4.2 Current Site Conditions

The site investigation history and contamination potentially associated with the landfill is discussed in detail in Section 2. Based on observations made to date, it can be assumed that the majority of fill material is inert construction and demolition waste in a sand matrix (PB, DSI report). However, in several of the shallow test pits, the presence of asbestos was confirmed by close visual inspection and laboratory analysis. This was reported as bound in grey fibrous sheeting, usually in small fragments. Site walk-over observations indicate that sheeting fragments are currently littered across the surface of the landfill area. These observations indicate that ACM fragments are widely distributed across the site, although the true extent of asbestos contamination will only be identified once the site remediation program begins and associated sampling and documentation processes are enacted (Refer to the ESMP).

Test pits excavated in the locations where the Omex sludge was believed to be buried failed to identify the sludge specifically. However, there were some indicators of hydrocarbon-contaminated material present within soil results. Laboratory analysis confirmed the concentrations of petroleum hydrocarbons were below Ecological Investigation Limits (EILs), although two samples recorded concentrations of heavy metals (copper and zinc) above EIL's. One soil sample also exhibited concentrations of PCB's slightly above EIL's, with the limit of detection of two other samples above EIL's. Concentrations of all soil samples submitted for laboratory analysis were below HILs for commercial sites (HIL-F).

The health concerns that have been expressed by local residents and future site workers can virtually be limited to asbestos (ACM) and dust. These concerns are primarily associated with potential exposure to asbestos fibres and fine particulate dust as a direct result of the excavation and remediation of the Site. Anxiety within the community is exacerbated by the site being across the road from domestic housing, with residents of Adelaide Street located approximately 30m south of the southern boundary of the Site. However, they may not appreciate that the site currently exhibits asbestos at the surface, which represents a human health risk if the Site is left as it is.

4.3 Site Remediation & Management

The remediation and management process is fundamental to understanding the site specific issues that may apply to this project. The following discussion seeks to integrate relevant information from prior consultation, reports and community engagement, in consideration to the goals of the site development, stakeholder perspectives, and regulatory needs.

Focus during the remediation is placed on the potential issues during the processing of excavated landfill material on the Site. With consideration to guidance provided by enHealth (2012), pertinent issues that apply include:

- Chemical pollutants and contaminants in air, soil, water, and ground gas are hazards that may present potential health risks to the site workers, local residents (Adelaide Street, 30m from Southern Site Boundary), and other receptors.
    - **Air -** The proposed site operations have the potential to generate dust and in turn asbestos fibres. The key issue is to minimise the dust and asbestos generation during excavation, screening, and crushing processes and, consequently, potential exposure to receptors. The crushing process is particularly important to consider in this regard, as it is intended to break-down materials into smaller sizes and thus represents a potentially significant pathway of asbestos fibre release from otherwise intact ACM
    - **Soil** – It is anticipated that contaminated soils will be encountered during the excavation process. As previously discussed, primary concerns relate to ACM. However, other soil contaminants such as hydrocarbons and metals may occur in discrete pockets of the landfill material and must also be considered. In this regard, potential exposure may be reasonably anticipated to be localised at source with site workers directly involved in handling these soils. Notwithstanding, there is also potential for odours to be generated (volatile organic compounds) and contaminated soils to be entrained with dusts generated at the site. Contaminated soils thus represent a potential source of exposure to all receptors, particularly local residents whilst excavating along the southern boundary of the Site (Adelaide Street).
    - **Groundwater** – Monitoring events to date have identified contaminant concentrations within the groundwater at levels below relevant health screening levels (Refer to ESMP). Concerns arising from contaminated groundwater are thus anticipated to be minimal and localised at source, with any potential exposure to contaminants restricted to site workers. Given the appropriate use of PPE, it is unlikely that that groundwater will pose a health risk during the project life span.
    - **Ground Gas** – During the remediation ground gas monitoring wells will be installed and monitored as each deep cell is completed. A ground gas model will allow issues to be identified and discussed with the Site end user in terms of

ground gas projection measures if required. However, all organic material will be picked and removed during the screening process. Therefore, generation of gas is anticipated to be low/negligible.

- Consideration should extend to the potential amenity impacts associated with site remediation activities, such as odour, noise, and vibration impacts. These secondary issues can be controlled and managed to reduce nuisance or risks to the local residents and the site workers.
    - It is recognised that amenity impacts may negatively influence stakeholder perceptions of risk and, consequently, may reduce support for the project or provoke desire for additional assessment or management controls that are unwarranted from an objective risk perspective.
    - Visual impacts associated with site remediation and development are frequently considered as detrimental to quality of life for the general public. However, as the site shall be fully enclosed by wind-fencing and not operational at night (i.e. not a source of light pollution), such impacts are considered to be negligible.
    - Various other site operations may on occasion result in quality of life impacts to nearby residents. However, appropriate site management measures may be reasonably expected to limit the frequency and duration of any such events and thus do not warrant individual evaluation.
- Processing of both landfill materials and imported hydrocarbon impacted soils will alter the nature and distribution of associated contamination.
    - Movement and stockpiling and of excavated materials across the site.
    - Mechanical processes are known to degrade the physical integrity of ACM and thereby increase the potential for the release of asbestos fibres. If ACM is subject to crushing, such degradation would be anticipated to be significant.
    - Soil amendment processes for hydrocarbons are intended to reduce contamination by enhancing the bio-degradation process and subsequently liberating contaminants through volatilisation.
- As a fundamental aspect of the remediation approach, material from the landfill will be processed and placed within a deep containment cell (below a capping layer of remediated soil). It is therefore impractical to propose that the Site can be 'free' of asbestos. Risk assessment and management of material remaining *in situ* is required before this site can be declared acceptable for Commercial / Industrial use.

Given the considerations above, it is clear that site remediation activities have health implications if not managed or controlled appropriately, particularly with respect to asbestos. Therefore, in accordance with enHealth (2012) and DoH (2009) guidelines, suitable management and control measures are required to mitigate the health risks to Site workers and the local residents.

Generally, adopted risk management options should be reasonable, appropriate, and acceptable at a site level. Consideration of both future building use and land use is critical in determining the most viable long-term control strategy. Under the National Environment Protection Measure: Assessment of Site Contamination (NEPM) 1999; the preferred order of options for any site clean-up and management is a follows:

- On-site treatment of the soil so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level.

- Off-site treatment of excavated soil, which is returned to the site (within the deep cell), removed to an appropriate facility or used as landfill.

Other options are:

- Isolating the soil by covering with a properly designed engineered barrier.
- Leaving the contaminated material in-situ provided there is no immediate danger to the environment or community.
- Removing contaminated soil to an approved site or facility followed by replacement of clean fill.

The most practical and reasonable approach for managing any health risk should be selected when a site is remediated. Considering the options outlined above, a staged management approach will be implemented during the remediation of the Site. In summary, the remediation will entail[4]:

- Landfill material on Site will remain on-site; consistent with regulatory guidance it will be processed via screening and then placed back into the ground within an engineered deep cell (burial) (DoH, 2009).
- A barrier layer will be placed on top (0.5 m) with 1.5 m of remediated clean capping soil material (creating a 2.0m barrier). The Resource Recovery and Remediation Facility (RRRF) will crush and process concrete excavated on site for the engineered barrier layer (see figure 2 for locations).
- Capping soils will be sourced and imported to site (Class I - Hydrocarbon Impacted or Acid Sulfate Soil Impacted Soils). These soils will be remediated on Site within the area named Soil Acceptance and Amendment facility (SAAF).
- The Site will be separated into an active remediation zone (‘Red Zone’) and a protected area for management offices and staff amenities (‘Green Zone’).

It may thus be understood that overall success of the remediation is reliant upon suitable site management and assessment processes to ensure that both the barrier material and capping soils achieve acceptable standards prior to use. Consequently, by effectively removing the hazard, these measures should also serve to mitigate health risks as the remediation progresses.

4.4 Potential Value Conflicts

EnHealth (2012) outlines a variety of value conflicts that may need to be taken into account during risk assessment and management. Conflicts typically arising during site remediation and development processes may be recognised as the following:

- A desire for rigour in the site assessment and remediation process vs. project demands for timely progression.
- Broad community perspectives of project concerns and benefits vs. those of narrow interest groups.
- Public anxiety, fear, or impatience regarding the assessment process vs. objective scientific analysis.

A key value conflict for the Site includes the trade-off of 4 to 5 years of remediation, versus the retention of the site in the present state. The site is currently unsightly and represents a potential source of public exposure to contaminants such as asbestos fibres and particulate matter liberated from the soil surface. In contrast, the proposed development would remove the aesthetic blight and potential source of contamination. The site is intended to be

[4] Please refer to the ESMP for further details.

redeveloped into a large scale commercial / industrial business park, which would generate commerce and employment that would benefit the local community.

The proposed remediation project has not been favorably received by a small minority within the local community who has good knowledge of the Site's history and the local area. However, the majority of the local community has welcomed the redevelopment of the Site and would be glad to see the clean-up of a local "eye sore", provided that this will be done in a safe and controlled manner.
Accordingly, there is a clear desire by residents for stringent and transparent control to be achieved during the site remediation and how the site is managed. Ongoing conflicts must be acknowledged in this regard, as management measures desired by some residents are not practical or warranted within the scope of the site assessment and management process.

To assist the resolution of such conflicts, the HHRA will provide clear and transparent documentation for the site remediation and management methods adopted. This shall include appropriate justification for all assumptions and judgments made. In addition, during the project the proponent shall remain active and accommodating in addressing community concerns to the extent possible. For all stakeholders, there is recognised value in providing swift action to remediate the site and remove potential health risks, allowing the community to benefit from the change in land use to a business park.

4.5 Summary of Issues

The primary issues to address are the potential health impacts to site workers and local residents during the remediation of the Site, most notably from potential exposure to dusts and asbestos fibres. The process of remediating the landfill material has the potential to liberate dusts and airborne asbestos fibres during excavation, screening, and crushing if not managed properly. Similarly, dust/fibre generation from stockpiled soils is possible if appropriate control measures are not put in place. Meanwhile, the retention of contaminated soils *in situ* requires consideration to ongoing site management measures and suitable assessment and control processes to ensure remediation goals are achieved.

While there is general agreement by all stakeholders that remediation and development of the site is a desirable outcome, concerns and conflict remain regarding the desired methods and associated management requirements. Consequently, a key goal of the HHRA is to help resolve these issues through a clear and transparent assessment approach that suitably informs and supports the risk management measures to be adopted.

5 HAZARD ASSESSMENT

Hazard assessment combines a qualitative evaluation of the presence and capacity of a source to cause adverse health effects (hazard identification), with an evaluation of the relationship between the level of exposure (dose) and the incidence and severity of effect (dose-response assessment) (Asante-Duah, 2002; enHealth, 2012). The hazard assessment may draw upon a wide variety of sources, which must be rigorously assessed for reliability, methodology, and quality (DoH, 2009; enHealth 2012).

5.1 Hazard Identification

Initial identification of primary and secondary hazards have been determined from Site information collected from pervious historical reports. The MDWES ESMP preliminary HRA further examined and ranked these hazards above as part of the conceptual site model and risk-matrix evaluation. In consideration to these prior reviews, the following discussion focuses upon those hazards indicated as requiring further assessment, either to provide additional details or in recognition of the severity of potential impacts. The preliminary HRA is considered to suitably address those hazards not presented herein and should be considered in context with this discussion.

5.1.1 Hazard Sources

Primarily licensed for inert waste during its operational cycle, a number of non-inert wastes were understood to have been received at the landfill. In addition to ACM, it was reported that sludge containing hydrocarbons, emulsified factory wastes, drums (unknown), drums of kerosene, bitumen, pesticide-contaminated soils and hospital wastes are also known to have been accepted during its operational life. Further to existing waste materials on-site, the site remediation process will also import class 1 hydrocarbon impacted and acid sulphate soils for treatment and subsequent use. Consequently, there is a mix of both defined and variable hazard sources that must be addressed by the risk assessment and a balance between conservative assumptions and reasonable judgment regarding their significance.

As considered through the issue identification process, activities associated with the remediation process also influence the nature, distribution, and potential dispersion of hazards. This includes standard occupational hazards that may be associated with operational activities and physical interactions with landfill materials, which are suitably examined by the ESMP and affiliated management reports. Most pertinent to the HHRA, site remediation methods such as screening, crushing, and soil amendment may increase the potential for exposure to certain contaminants.

The following discussion considers both the primary hazard sources and potential secondary hazards arising from site remediation activities.

Landfill Soils

The issue of ACM contamination at the site is prominent. ACM at the surface of the site is visibly evident, while ACM was also routinely accepted for disposal as part of the land fill operations. Test pit investigations conducted by the DSI (Table B) have confirmed distribution of ACM fragments throughout the landfill soils and it is therefore anticipated that further ACM contamination will be encountered during remediation activities. Though previous studies provide no indication of friable materials, it is also plausible that some ACM has become sufficiently degraded such that asbestos fibres maybe present within the landfill material. Consequently, the hazard must be considered to provide a complete assessment of the potential risks.

It is recognised that degraded ACM is more likely to release asbestos fibres from the binding matrix than material that is in good condition. Importantly, as ACM ages the binding matrix degrades and becomes more susceptible to deterioration or destruction. Mechanical and natural weathering processes that may impact ACM thus become increasingly likely to release asbestos fibres. Mechanical degradation of ACM is a particular concern for large scale operations where the disturbance of materials and generation of dusts may be significant (enHealth, 2005; DoH, 2009). Recent Australian studies have also demonstrated that fire damaged ACM may become friable, with the potential for fibre release varying according to the size and intensity of the fire (Noel Arnold, 2006). As incineration may have occurred at this Site in the past, friable asbestos or free asbestos fibres cannot be discounted. However, this will only be determined through the remediation process.

In addition to asbestos, prior soil test pit analyses included heavy metals, hydrocarbons (including BTEX) and PCBs (Table A). Laboratory analysis confirmed the concentrations of petroleum hydrocarbons to be below EILs, although two samples recorded concentrations of heavy metals (copper and zinc) to be above EIL's. One soil sample also exhibited concentrations of PCB's slightly above EIL's, with the limit of detection of two other samples above EIL's. Although these analyses indicate the presence of hydrocarbon contaminated material and above EILs for copper, zinc and PCBs, all soil sample concentrations were below HIL-F levels. Further contaminants associated with this type of historical landfill could include potentially radio-active substances or biological hazards. However, there are no historical records, anecdotal evidence, or actual sampling results to suggest either radio-active substances or biological hazards are present at the Site.

Given consideration to the preceding discussion, CoPCs associated with landfill soils may thus be reasonably limited to ACM, potentially liberated asbestos fibres, and particulate matter (dusts) that may be generated due to site remediation activities. While discrete areas of the landfill may be impacted by other contaminants, or represent specific physical hazards due to the nature of the disposed items, evaluation of the available data suggests that such areas are limited. Consequently, minor soil contaminants do not represent a significant concern and do not warrant further investigation.

Remediation & Resource Recovery Activities

As detailed by the ESMP, several activities associated with the processing of landfill materials and capping soils during site remediation have the potential to generate dusts and odour. Mechanical operations also have the potential to degrade ACM and thereby increase the possibility of asbestos fibre release. In summary, the following processes represent specific hazard sources or may alter the nature of the hazards present:

- Soil excavation will progress through the landfill site from west to east, systematically removing, stockpiling, and sorting landfill material. The sorted soil material will then be repackaged into the open deep cell.
- Vehicle and equipment movement about the site will be required, with frequent loading/un-loading of soils from trucks.
- Soils identified as contaminated will be kept on site, but placed into a covered or enclosed skip until appropriate action can be carried out.
- Soils excavated at the face of the landfill will be pre-sorted by the operators. Using vibration and other separation methods, material fed into the screening plant will be mechanically sorted into different fractions.
- All excavated soils will be re-packaged to provide the material for the deep cell in such a way as to minimise the total volume of void and ensure desired compaction.
- Noise will be generated from vibrating machinery, the lateral movement of trucks, the operation of front end loaders and vehicle reversing alarms.

- As discussed previously, acid sulphate and hydrocarbon soils shall be imported and treated on-site for subsequent use.

Soil Acceptance & Amendment Facility (SAAF)

It is intended that Acid Sulfate Soils (ASS) and Class I hydrocarbon impacted soils shall be brought to the site for remediation, so that they can be later utilised in the capping layer. This process introduces the following hazards (SA EPA, 2005; NSW EPA, 2014):

- Dusts may be generated during the transfer of soils to the SAAF and subsequent mixing processes.
- ASS soils will be lime-dosed and treated to ensure neutralisation of soils. Dusts generated from these soils may thus have greater potential for irritation due to greater acidity/alkalinity than typical soils.
- Volatile organic compounds and odours may present a localised hazard from the SAAF, particularly when the hydrocarbon impacted soils are rotated. It is essential that all emissions to air, land, and water can be thoroughly managed.

Additional details on the operation of the SAAF is provided by the ESMP Soil Amendment Report (ESMP, Appendix F).

5.1.2 Contaminants of Potential Concern (CoPCs)

Consistent with the preceding discussion, the HHRA considers the principal contaminants of potential concern (CoPCs) to be:

- Asbestos
  - ACM for all remediation activities other than the SAAF
  - Friable asbestos or free fibres; particularly with respect to mechanical operations
- Particulate matter
  - Acidic/Alkaline soils associated with the SAAF
  - Dusts generated by all mechanical operations or vehicle/equipment movement
- Volatile Organic Compounds (VOCs)
  - Volatilised hydrocarbons associated with the SAAF

Secondary CoPCs include potential emissions arising during landfill excavations due to disposal of non-inert wastes, odours from the SAAF, and possible ground gas generation once the site has been repackaged.

The known disposition of CoPCs is presented in Section 2 (Tables A & B). However, as previously recognised, this provides indicative data only. The extent of contamination must be assessed on a continuing basis as the site remediation progresses.

5.1.3 Amenity & Quality of Life

In addition to physiological health impacts, amenity and quality of life concerns are recognised as issues to be considered through the health risk assessment process (enHealth, 2012). However, there is little specific guidance provided regarding how these factors should be addressed (DEC, 2006b; DOH 2006; enHealth, 2001; enHealth, 2012).

Accordingly, while such potential impacts associated with the Site remediation are outlined below, this information is not used as a primary basis for HHRA conclusions.

Noise & Vibration

Assessment of the site excavation works has been considered as construction activities, such as any other land development preparation for the use of residential, or commercial / industrial purposes. Noise levels received at the nearest neighbouring residence has been calculated to comply with the Environmental Protection (Noise) Regulations 1997 for the operating times specified. Furthermore, natural barriers are considered likely to provide a significant level of noise attenuation for most of the project's duration. Consequently, the amenity and quality of life impacts from noise and vibration during the Site remediation are unlikely to be any greater than other such projects that are typically approved. Notwithstanding, it must be recognised that residents may be affected intermittently and that peak periods of activity are may prove likely to cause complaints and public discontent. A Construction Noise Management Plan (CNMP) will be developed prior to commencement of landfill remediation activities to address such concerns.

[redacted]

Odour

Odour is recognised as a key amenity impact arising from hydrocarbon contaminated soils (CRC CARE, 2011) and soil bioremediation ('landfarming') processes that may be conducted to treat these soils (SA EPA, 2005; NSW EPA, 2014). Importantly, odour may be associated with a variety of compounds across the range of hydrocarbon fractions as vapours are released. However, the likelihood and severity of odour impacts is difficult to assess as, due to variations in hydrocarbon composition with degradation processes, there is difficulty defining a correlation to hydrocarbon concentrations. Consequently, reported contaminant concentrations may comply with adopted site assessment criteria while an odour impact remains. Notwithstanding, aerobic biodegradation is understood to progressively reduce hydrocarbon vapour concentrations as the process continues (NZMfE, 1999; CRC CARE, 2009).

As operations at the SAAF will be ongoing for much of the duration of the project, it may be anticipated that there will be fluctuating levels of odour emitted as soils are introduced, periodically aerated or relocated, and degradation of hydrocarbons occurs. Consequently, periods of peak odour emission that are a source of discomfort or annoyance to workers and nearby residents cannot be discounted. It is necessary to continually monitor odour levels and complaints against site conditions and operational practices to ensure odour issues may be promptly addressed and emissions, particularly at the site boundary, are minimal.

5.2 Toxicity Assessment

A full examination of the dose-response relationships for the identified CoPCs is not considered appropriate for a qualitative risk assessment. Distinction between quantitative assessment criteria or the merits of alternative supporting data would not be anticipated to significantly influence the overall characterisation of the adverse health effects or their mode(s) of action[5]. Rather, a limited evaluation[6] is provided for the most sensitive health effects upon which the relevant assessment criteria or risk levels are established. Consistent with enHealth (2012), the evaluation includes:

- The relevance of exposure routes and duration
- The interrelationship of potential effects from different exposures
- The potential for differing susceptibilities in population subgroups

The toxicity assessment conducted therefore does not address additional health effects that may occur at concentrations above the established guideline criteria, or the potential interaction between such effects. There is also no evaluation regarding the likelihood of toxic effects being realised or the suitability of assumptions made in the determination of the most sensitive health effect.

5.2.1 Adverse Health Effects & Mode of Action

Asbestos is not typically associated with health effects arising from ingestion, dermal, or ocular, exposure, with concerns limited in practice to inhalation and related respiratory diseases[7] (DOH, 2005, 2009; IPCS, 1986). As airborne contaminants, the primary exposure route of concern for particulate matter and VOCs is also inhalation (USEPA, 2009, 2014). The following assessment therefore focuses upon adverse health effects that may result from inhalation exposure. In this regard it is important to recognise that different health impacts may be pertinent according to the concentration and/or duration and frequency of exposure (enHealth, 2012; NHMRC, 2006). Health effects such as irritation and inflammation are of particular importance to short exposure periods, as the response period may be within minutes or less. For sensitive receptors the severity of these health impacts may be significant and potentially of greater concern than other effects.

Further to the above, it is recognised that direct contact with airborne contaminants may also result in adverse health effects. Most relevant in this regard is dermal/ocular irritation and inflammation, which may result from either chemical toxicity or direct mechanical action (USEPA, 2009, 2014; WHO, 2010). For non-occupationally exposed individuals these adverse health effects may be anticipated to be minor, while occupational hygiene measures would limit impacts to site workers and visitors. However, for some people the effects may be persistent or severe and represent a significant health concern, particularly if this exacerbates pre-existing conditions or other effects of exposure.

[5] Agencies may select different health end-points and safety/uncertainty factors to derive toxicological risk levels. As a qualitative HHRA, a comprehensive review of toxicological profiles to provide a weight of evidence conclusion regarding which risk assessment criteria are preferable has not been undertaken. While there may be different calculation methods or determinations made regarding the supporting studies that should be used to derive quantitative risk criteria or describe the dose-response function, overall there is typically strong agreement across major toxicological reviews regarding the key health impacts, mode(s) of action, and relevant exposure periods.

[6] enHealth (2012) guidance on toxicological information sources has been recognised and consideration in the HHRA consequently restricted to 'level 1' sources. These sources may be anticipated to demonstrate the best consistency between reviews and do not require the same degree of appraisal for relevance, validity, and accuracy as level 2 or 3 sources.

[7] That asbestos causes cancers at other sites is less well established. Gastrointestinal and laryngeal cancer are possible, but the causal relationship with asbestos exposure has not been firmly established; there is no substantial supporting evidence for cancer at other sites. In making a risk assessment for asbestos, the emphasis is placed on the incidence of lung cancer and mesothelioma, the principal hazards (IPCS, 1986).

Asbestos Containing Materials (ACM)

Asbestos toxicity appears to be determined by the physical properties and biopersistence of the fibre. Fibres that are more easily inhaled and resist removal from the lungs are most likely to cause effects. Health effects most commonly associated with exposure to asbestos fibres are asbestosis, lung cancer, and mesothelioma.

Asbestos-related health effects are typically associated with chronic exposures to asbestos fibres, although brief high-level and low-level exposures have also been reported to cause disease. Such effects may be observed following a latency period which could be up to 30 years. Dose-response relationships have been derived which describe the link between asbestos exposure and mesothelioma, lung cancer and asbestosis in the occupational environment. Evidence suggests that a threshold, determined by exposure and fibre properties, may exist for many asbestos-related diseases, particularly asbestosis and lung cancer. Generally, relatively higher and longer exposures to asbestos fibres are required for lung cancer or asbestosis to develop than is required for mesothelioma (enHealth, 2005).

Particulate Matter

The propensity for dust particulates and fibrous dust to have adverse health impacts depends upon the characteristics, size and shape of the particle or fibre (DER 2010 & NEPM). Particle size is not a simple unit of measurement but rather is measured in terms of equivalent aerodynamic diameter (EAD). Aerodynamic diameter is the diameter of a sphere of unit density that has aerodynamic behaviour identical to that of the particle in question. Therefore, particles having the same aerodynamic diameter may have different dimensions and shapes. As such, relatively large fibres with low density (such as asbestos) can behave the same as small spheroid particles which penetrate deeply into the lungs (USEPA, 2004).

Potential particulates include:

- Total suspended particulates (TSP) (DER 2010 & NEPM). Typically TSP is a measure of nuisance e.g. deposition of particles on vehicles and tends to have limited impact on health due to the dominance of large particles (>100 microns EAD) which settle quickly.
- Inhalable dust tends to be made up of particles less than 10 microns EAD and is usually referred to as PM_{10} and is generally measured to gauge the impact of dust. Typically most of the PM_{10} mass inhaled tends to be captured and cleared by the mucociliary system in the upper respiratory system i.e. above the tracheobronchial tree.
- Respirable dust, a sub-set of PM_{10} (generally referred to as $PM_{2.5}$), generally penetrates deep into the lungs and is much more difficult to clear than inhalable particles and consequently tends to have greater health impacts. Generally speaking dust from earthworks tends to be dominated by particles larger than 2.5µm EAD.
- Asbestos fibres are classed as respirable and penetrate deeply into the non-ciliated gas exchange area of the lungs. Because of their physical and chemical inertness, asbestos fibres tend to stay lodged in the delicate lung tissue and can't easily be cleared by the body.
- Respirable crystalline silica (RCS) behaves aerodynamically similar to fibres, penetrating deeply into the gas exchange area of the lungs. Their chemical inertness tends to make them difficult for the body to clear[8].

[8] RCS is recognised as a potential particulate in this discussion for completeness. However, it is not considered a CoPC for this HHRA as soils and sands do not present a significant source of crystalline silica, such as may be associated with quartz dusts. Furthermore, while crystalline silica presents a known occupational hazard of silicosis, non-occupational exposures appear to pose negligible risks. Importantly, the granular form of silica sand is not identified as a health hazard by the literature

- Particles may also contain elemental metals or adsorbed/condensed organic compounds, with depositional fate dependent upon the source and size of the particle.

The health effects associated with exposure to airborne particulate matter are well recognised and documented by numerous toxicological reviews. Within the Australian context, comprehensive consideration of this information is provided by the *National Environment Protection (Ambient Air Quality) Measure – Revised Impact Statement* and, more recently, the *National Environment Protection (Ambient Air Quality) Measure Review (2011)*. While significant new health effects for particulate matter were not identified by the 2011 review, several recommendations were made to assist in minimising risks to population health. These include revision of the standards to take into account new evidence concerning potential health effects, the introduction of compliance standards for $PM_{2.5}$ and an annual average standard for PM_{10}, and the replacement of 'allowable exceedances' with a 'natural events rule'.

While noting the recommendations of the review, it would appear unlikely that implementation within the NEPM framework will be achieved promptly. As stated by the review:

> *The overall finding of the review was that there are advantages to an integrated, risk-based approach; however, achieving it will be an evolutionary process. This evolution will require improvements in exposure assessment and changes in monitoring approaches to support these assessments. It will also require considerable advance planning in order to select appropriate accountability metrics and obtain the information needed to evaluate them.*

Proposed variations to the NEPM are currently subject to the stakeholder review and comment process, with final submissions now being considered as part of the development of a final variation proposal. Hence, it is recommended that the review process be monitored during the project to ascertain any relevant amendments to the Ambient Air Quality NEPM (NEPC, 2014).

Meanwhile, the USEPA has released an exhaustive review of health effects associated with particulate matter and appropriate evaluation methods. This document is recommended for any further detailed consideration required to the issues discussed in this summary review. The extent of toxicity and exposure related information on particulate matter demonstrates the complexity of assessment and the increasing demands to achieve best practice management (USEPA, 2009).

In evaluating the health evidence, a number of factors can be considered in determining the extent to which health effects are "adverse" for health outcomes such as changes in lung function. What constitutes an adverse health effect may vary between populations. Some changes in healthy individuals may not be considered adverse while those of a similar type and magnitude are potentially adverse in more susceptible individuals. In consideration to the issues identified for the Site remediation and potential receptors, the following adverse health effects associated with particulate matter are considered most relevant:

- Evidence that human exposure to inhalable particles can result in significant increases in both morbidity and mortality has become overwhelming.
    - A growing body of evidence both from epidemiological and toxicological studies supports the general conclusion that $PM_{2.5}$ (or components), acting alone and/or in combination with gaseous co-pollutants, are likely causally related to cardiovascular and respiratory mortality and morbidity.

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reviewed. Toxicological assessments undertaken for silicon dioxide identify differences in toxicity according to physical and mineralogical form, with evidence of adverse health effects primarily associated with crystalline silica. However, as low levels of crystalline silica may be present in sand, appropriate care should be taken to ensure that the health of workers is protected (IPCS, 2000; NIOSH, 2002).

- A more limited body of evidence is suggestive of associations between short-term (but not long-term) exposures to ambient coarse-fraction thoracic particles. $PM_{10-2.5}$, may thus contribute under some circumstances to increased human health risks with somewhat stronger evidence for associations with morbidity (especially respiratory) endpoints than for mortality.
- Epidemiologic and toxicological evidence is suggestive of a causal relationship between relevant $PM_{2.5}$ exposures and cancer, with the strongest evidence from the epidemiologic studies of lung cancer mortality.
- Increases in the daily prevalence of respiratory symptoms and medical visits for asthma and other respiratory conditions.
- Small decreases in the level of pulmonary function in healthy children, and in adults with existing disease.

- Upper respiratory irritation may result in severe health impacts for asthmatics. Irritation may be further exacerbated by residual substances adhered to the particles.
- Population subgroups including the elderly and those individuals suffering from pre-existing heart or lung disease are clearly more sensitive to particulate matter exposure. Young children may also be more sensitive, leading to an increased frequency of respiratory tract infections, coughing, and wheezing.
- Preexisting chronic inflammatory conditions, such as diabetes and obesity, may influence particulate matter related health effects. Studies have found some evidence for increased associations for cardiovascular outcomes along with physiological alterations in markers of inflammation, oxidative stress, and acute phase response.
- There is no discernible threshold below which no adverse health effects occur.

***Volatile Organic Compounds* (VOCs)**

The general definition of volatile organic compounds (VOCs) are those organic chemicals whose composition makes it possible for them to evaporate under normal atmospheric conditions. VOCs thus represent a broad range of individual chemicals that each exhibit their own specific toxicity and are subsequently difficult to assess as a group (USEPA, 2014). In this regard, the potential composition of VOCs that may be emitted from contaminated landfill soils cannot be reasonably determined until encountered and assessed during the remediation process. However, for both the landfill and SAAF the primary contaminants identified are residual petroleum hydrocarbons. While other volatile compounds may be encountered during the remediation, it is thus deemed most reasonable to consider those emissions associated with the degradation of hydrocarbons in soil.

The effects on human health will depend mainly on the extent of exposure (length of time, etc), the amount one is exposed to (or concentration), the innate toxicity of the hydrocarbons, and whether exposure occurs via inhalation, ingestion, or skin contact. A variety of other factors can also affect health impacts from such exposure, including pre-existing health status and age. Intake of hydrocarbons from contaminated soil may occur via ingestion, inhalation or dermal (skin) exposure to contaminated soil/dust, and from inhalation of hydrocarbon vapours. Tilling of dry soil can result in ingestion of small but measurable amounts of soil. Recognising these factors, as previously discussed, primary concerns for this HHRA relate to potential exposure via inhalation.

Review of the recognised toxicological databases and profiles reveals that the seminal evaluation of total petroleum hydrocarbon (TPH) mixtures, including composition, environmental behaviour, and toxicity, is that provided by TPHCWG (1997). Importantly, the National Environment Protection (Assessment of Site Contamination) Measure

(Contaminated Sites NEPM) (NEPC, 1999) has previously utilised TPHCWG (1997) as the primary reference source in the derivation of guidance values for TPH. Similarly, the CRC CARE (2008) review of health based criteria identifies that the TPH toxicity information provided by TPHCWG is generally considered the most relevant information available, forming the basis for the majority of assessment levels employed internationally.

The TPHCWG (1997) assessment establishes that:

- Based on studies using mixtures of specific hydrocarbons, it is obvious that the toxic potency of individual compounds can be influenced by the presence of other compounds.
- Limited data is available to assess the adverse health effects associated with TPH. Only 250 of the thousands of compounds within petroleum have been identified. Of the 250 identified, only approximately 40 have enough toxicity data available to develop guidance values and only 95 have any toxicity data whatsoever.
- Some TPH compounds are known to be carcinogenic. Benzene and benzo(a)pyrene provide suitable compounds for the assessment of recognised carcinogenic hydrocarbons.
- For non-carcinogenic effects, TPH toxicity is significantly influenced by the route of exposure and whether compounds are aromatic or aliphatic. Toxicity data on aromatics indicate greater potency than aliphatics.
- Neurological effects are commonly associated with lower molecular weight TPH fractions and some higher molecular weight aromatic TPH fractions, particularly via inhalation exposure.
- Inhalation toxicity data is extremely limited for mid-range and higher molecular weight aromatic hydrocarbons (TPH $C_{>9}$). Quality toxicological data is restricted to a small number of specific compounds such as naphthalene and isopropyl-benzene.
- Hepatoxicity is the dominant adverse health effect associated with higher molecular weight aliphatic TPH fractions (TPH $C_{>9}$) for both oral and inhalation exposure.
- Recognising the lack of toxicological data for higher molecular weight aromatic TPH fractions (TPH $C_{>9}$), hepatic and renal effects are commonly identified as the sensitive adverse effect associated with representative compounds or mixtures.
- Insufficient data is available regarding systemic effects associated with dermal exposure.

Extensively informed by TPHCWG (1997), further consideration to acute, sub-chronic, and chronic health effects is provided by reviews undertaken by the Agency for Toxic Substances and Disease Registry (ATSDR, 1999), the New Zealand Ministry for the Environment (NZMfE, 1999), and the Dutch National Institute of Public Health and the Environment (RIVM, 2001). Relevant findings include:

- Aromatic and low molecular weight hydrocarbons (TPH $C_{<10}$) are those typically associated with acute inhalation effects such as respiratory irritation and central nervous system depression. Excepting respiratory irritation with relatively high levels of exposure, such effects are not identified for higher molecular weight aliphatic TPH fractions.
- Hepatic and neurological effects have been associated with acute oral exposure to mid-range molecular weight hydrocarbons (TPH C_{10} to C_{16}). However the dose-effect relationships are either not well defined, or the effects occurred at fatal doses.
- Health effects that appear to be common to mid-range aromatic molecular weight hydrocarbons (TPH C_{10} to C_{16}) are respiratory irritant effects, neurological effects,

and hepatic and renal effects. However, it is not clear whether these effects are associated with all compounds. Based on commonality of effect with other compounds and indications that naphthalene is one of the more toxic constituents, naphthalene is considered to provide a conservative surrogate indicator of toxicity for the combined fraction. The critical adverse effect for inhalation exposure to naphthalene is damage to nasal and respiratory tissues, while hepatoxicity is associated with non-acute oral exposure.

- Hepatic effects are the common sensitive effect associated with oral exposure to higher molecular weight aromatic hydrocarbons (TPH $C_{>16}$), although renal effects are also observed. There is limited data to assess to inhalation toxicity of this fraction. However, given the typically non-volatile nature of these compounds, inhalation exposure is not expected to occur except through exposure to dust or particles containing PAHs.
- Contact with relatively high concentrations of hydrocarbons may result in a variety of dermal effects. Diesel fuels have been found to produce dermal blisters, while some fuel oils have demonstrated potential for dermal sensitisation. Hydrocarbons in the TPH fraction range C_6 to C_{20} are found to produce the most severe dermal irritation.
- Low level long-term dermal exposure to hydrocarbons has been associated with adverse skin effects such as dermatitis.
- Exposure to vapours and aerosols of mid-range molecular weight aromatic hydrocarbons (TPH C_{10} to C_{16}) has been associated with acute ocular irritancy. Longer term occupational exposures have also been associated ocular damage.

Considering the preceding information, hepatoxicity is identified as the primary sensitive adverse health effect associated with chronic inhalation exposure to hydrocarbons. Significant additional adverse health effects identified for acute and sub-chronic exposures include:

- Ocular and respiratory irritancy associated with acute exposure to vapours or aerosols of aromatic hydrocarbon compounds.
- Potential respiratory damage and inflammation associated with inhalation exposure to mid-range aromatic molecular weight hydrocarbons.
- Dermal effects, both acute (irritation) and chronic (dermatitis, dermal sensitisation), should direct contact with hydrocarbons occur (e.g. via contaminated dusts).

Hence, it may be recognised that the potential toxicity of hydrocarbons is significantly influenced by both composition and the manner in which exposure occurs.

5.2.2 Sensitive Receptors & Potential Interactions

Consideration to the toxicological data (Refer to Section 5.2.1) indicates several sensitive receptors for particulate matter. For the remaining CoPCs, sensitive receptors may be determined in accordance with general toxicological principles. Respiratory irritancy, inflammation, or damage associated with the inhalation of CoPCs therefore identifies several receptors that warrant evaluation:

- **Children -** Consistent with enHealth (2012), due to decreased body weight and proportionally greater respiratory lung volume, children may be anticipated to be generally more susceptible to potential CoPC exposure than adults. For asbestos, children may be also considered generally more sensitive due to the latency in adverse health effects and the longer period available for these effects to occur.
- **Health Conditions –** Irritancy, inflammation, and damage to ocular and respiratory systems associated with exposure to hydrocarbons or particulate matter is likely to

have greater impact upon individuals already suffering from ocular/respiratory damage or conditions. Asthmatics and individuals suffering chronic pulmonary disease are commonly identified as susceptible receptors for respiratory irritation and inflammation effects (NHMRC, 2006). Similarly, individuals with dermal sensitivity or compromised skin conditions may prove more susceptible to contact dermatitis and other dermal effects.

- **Elderly –** The elderly may be recognised as a broad receptor group for whom pre-existing health conditions may be prevalent. Relevant age associated issues include impaired respiratory function, reduced integrity of ocular and dermal tissues, and generally diminished functional capacities of systems involved in detoxification processes.
- **Workers –** The irritancy and neurological effects and ocular/respiratory damage associated with exposure to the COPCs, particularly aromatic hydrocarbons, may be anticipated to be more relevant to individuals in regular direct contact with aerosols or vapours. Examples may potentially include workers involved in the excavation of the landfill or mixing of SAAF soils.

As per the discussion above, there is potential for both particulate matter and hydrocarbon vapours to cause respiratory inflammation and irritancy effects. In general, decrements in respiratory function and associated morbidity may be recognised as common to all CoPCs. However, it should be understood that the potential for interaction is moderated by the pattern of exposure, particularly for sub-chronic health effects. In this regard, the meteorological conditions most likely to generate dusts are not conducive for exposure to volatiles; i.e. windy conditions will generate dust, but disperse volatiles. Similarly, excepting irritancy and inflammation, the primary adverse health impacts associated with each CoPC differ with respect to their mode(s) of toxic action. Hence, while some degree of chemical interaction and combined health impacts from the CoPCs should be acknowledged, it may be reasonably anticipated that this will not significantly influence the overall toxic response.

A toxicological summary of the CoPCs by exposure route and in consideration to relevant sensitive receptors is presented in Table C.

Table C. Toxicological summary for COPCs

Contaminant (by exposure route)	Critical Health Effects & Target Organs	Sensitive Receptors	Category
Inhalation / Vapour			
Asbestos	Respiratory System – lung cancer and mesothelioma.	Children	Chronic
Particulate Matter	Cardiovascular & Respiratory Systems – a wide range of mortality and morbidity effects. Respiratory System - cellular/tissue damage and inflammation associated with metabolism of adsorbed contaminants, acidity/alkalinity, and mechanical irritation.	Children, Elderly, Workers, Health Conditions	Acute, Sub-Chronic, Chronic, Irritant
Hydrocarbons	Hepatoxicity – cellular/tissue damage and inflammation associated with reactive metabolites formed by oxidative metabolism in the liver.	Children, Elderly	Sub-Chronic, Chronic
	Ocular & Respiratory Systems - cellular/tissue damage, irrtancy, and inflammation associated with reactive metabolites formed by oxidative metabolism in ocular/respiratory tissues.	Children, Elderly, Workers, Health Conditions	Acute, Sub-Chronic, Irritant
Dermal/Occular			
Particulate Matter	Skin and eye irritation.	Dermal Sensitivity or Skin	Irritant

		Conditions	
Hydrocarbons	Skin and eye irritation. Dermatitis and potential dermal sensitisation.	Dermal Sensitivity or Skin Conditions	Sub-Chronic, Irritant

6 EXPOSURE ASSESSMENT

Exposure assessment provides an estimate of the magnitude, character, and duration of receptor exposures actually experienced or that may be anticipated in the future. It is important that the exposure assessment considers different risk groups and accurately characterises the population relevant to the assessment. This requires that the nature, size, and likely exposure routes for receptor groups potentially at risk are well described. The physical and chemical characteristics of contaminants must also be carefully examined to understand their behaviour, accumulation and transformation in the environment, prior to receptor group exposures (Asante-Duah, 2002; enHealth, 2012)

6.1 Potential Receptors

As part of the exposure assessment process, it is important to define groups within the population, which may potentially be exposed to site contaminants. This involves consideration of current and likely future activities in the area, the environmental distribution of contaminants, and the location and behaviour of the potential receptor groups.

The stakeholder consultation process may provide useful site-specific data for exposure assessment (enHealth, 2012). This data may include detailed information concerning sensitive receptors that may be affected, or may identify factors that may significantly influence the anticipated level of exposure for certain groups.

The Rowe Group Community Consultation Plan identifies that residences are located within approximately 30 metres of the Site, on the other side of Adelaide Street. These are domestic residences, with families potentially including children and the elderly. The other significant potential receptors are the Site workers, with further consideration given to the office workers and visitors attending Site.

6.2 Potential Exposure

It is well recognised that for a risk to exist, a complete exposure pathway is required between a hazard (source) and potential receptors. However, the exposure pathway may also influence the toxicological route(s) of exposure and significantly affect the nature and severity of impacts that may be experienced by receptors (Asante-Duah, 2002).

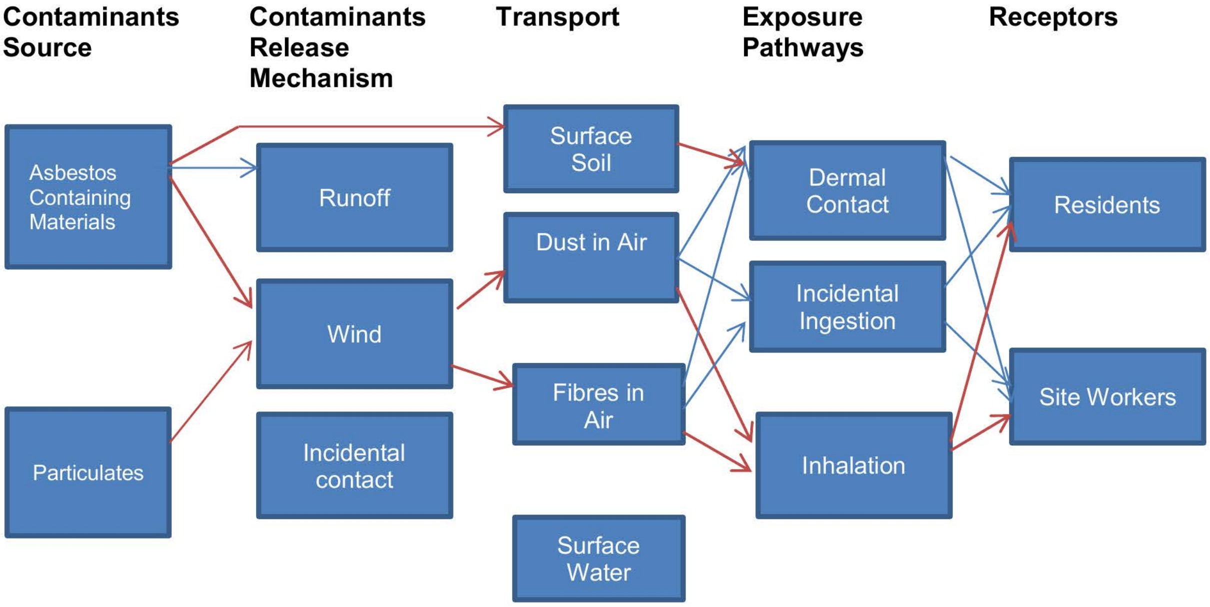
The exposure assessment may also be simplified through the identification of exposure pathways that are not relevant to the HHRA and, while reasonable accommodation for potential changes in exposure conditions should be incorporated, site-specific information may be used to establish factors preventing receptors from coming into contact with different hazardous agents. Consequently, it is important that the HHRA consider all potential exposure pathways (enHealth, 2012).

For a complete exposure pathway to exist, the following elements are typically required (Asante-Duah 2002; DEC, 2006a):

- Hazard source(s).
- Mechanism(s) of chemical contact by receptors.
    - Transport of the hazardous agent in relevant media (soil, water, air).
    - An exposure point.
- Human exposure route(s) (receptor location or activity facilitating chemical contact). Receptor intake and / or exposure (inhalation, ingestion, dermal absorption).

In this case, it is important to note the difference between ACM and asbestos fibres and recognise that degraded ACM is more likely to release asbestos fibres than material that is in good condition (enHealth, 2005; DOH, 2009).

Table D. Human Health Conceptual Site Model



Considering the nature and distribution of potential site contaminants and the relevant receptors, the principle exposure pathway is via inhalation. Other exposure pathways may be reasonably inferred to be negligible (Table D). What must then be further examined is the exposure profile (i.e. pattern of exposure via inhalation) to key receptor groups identified by the hazard assessment. In this regard, the following exposure scenarios are identified as most pertinent:

1) Off-Site Receptors:
   a) Of primary concern are nearby residents (Adelaide Street, 30m from Southern Site Boundary), due to proximity and subsequent potential for interaction with the Site.
   b) Residents may include sensitive receptors such as children, the elderly or those suffering from existing health conditions (Refer to Section 5.2.2).
   c) Relevant exposure may be of Chronic, Sub-chronic, or Acute duration. Quality of life and amenity impacts must also be considered.
   d) Relevant exposure may be of intermittent, periodic, and/or persistent frequency.
   e) Exposure may be significantly influenced by changes in Site operations, individual behavior patterns, and meteorological conditions.
2) On-Site Receptors [Red Zone]:

[redacted]

[redacted]

3) On-Site Receptors [Green Zone / Visitor]:

[redacted]

4) On-Site Receptors [SAAF]

[redacted]

For all scenarios above the extensive dust management procedures to be implemented will minimise potential exposures in practice, particularly for off-site receptors. However, exposures for individual site workers will vary depending upon their role and position (e.g. site manager, excavator, rubble picker, stockpile management).

A summary of the exposure scenarios is presented in Table D.

Table D: Summary of Exposure Scenarios

Receptor	Exposure Pathway	Frequency	Estimated Duration	Source of Exposure
Off-Site: Nearby Residents (Adelaide Street)	Inhalation, Dermal/ocular contact	7 days a week	24 hrs per day	Dust, ACM and Asbestos fibres within the landfill, generated if not suppressed during disturbance and excavation.
On-Site [Red Zone] [redacted]	[redacted]			
On-Site [Green Zone] [redacted] Visitor				
On-Site [SAAF] [redacted]				[redacted]

7 RISK CHARACTERISATION

Risk characterisation integrates the information developed in previous sections of the HHRA to describe the likely risks to receptors. The process defines the probable incidence, degree and severity of adverse impacts associated with relevant exposure scenarios and provides a basis to assess the significance of different risks. The risk characterisation also examines the overall quality of supporting assessments, considering assumptions, uncertainties, and scientific judgments, to establish assessor confidence in risk estimates and conclusions drawn (Asante-Duah, 2002; enHealth, 2012).

Based on the preliminary HRA (ESMP) and the issues identified within this HHRA the primary risks are associated with VOCs, particulate matter, and asbestos fibres being generated during remediation activities and potential worker exposure. CoPCs also have the potential to migrate off-site if not controlled and appropriately managed (Refer to the AQMP and ESMP). Secondary risks such as contaminated soils, physical hazards, odour, noise and vibration are generally considered to be localised. Active remediation zones will be overseen by professional trained staff and engineered, managed, or controlled through on Site procedures and appropriate use of PPE to limit risks to Site workers and potential off-site receptors (Refer to the SMP and ESMP).

The following discussion examines the risks posed by the CoPCs detailed in the hazard assessment (Section 5), according to the exposure scenarios defined (Section 6).

7.1 Off-Site: Nearby Residents

As examined through the issue identification process, nearby residents are in close proximity to the Site and this has provoked significant community angst. Without suitable management practices it may be reasonably anticipated that remediation activities would be likely to pose significant risks. In this regard, prior stakeholder consultation highlights potential exposure to asbestos as the driving issue of concern. However, further consideration to the hazards indicates that exposure to volatile emissions and dusts generated during the site remediation process may also cause significant adverse health effects and prove detrimental to amenity and quality of life.

Notwithstanding the proximity of residents, it is to be understood that potential exposure will be moderated by the Site operations, individual behavior patterns, and meteorological conditions. Hence, regular or prolonged periods of exposure may be reasonably anticipated to be limited as Site operations and meteorological conditions will change through the course of the remediation, while residents may be expected alter their behaviour where possible to reduce, if not minimise, their exposure[9]. Consequently, the potential health risks to nearby residents may be considered high, though not as great as those that may presented on-site.

7.2 On-Site [Red-Zone]

[redacted]

[9] Due to the irritant nature of CoPCs, residents will be prompted to limit their direct exposure. However, it is noted that indirect exposures, such as may result from the ingress of dusts into homes or deposition upon clothing, are not obvious and are unlikely to change behaviour patterns.

[redacted]

7.3 On-Site [Green-Zone]

[redacted]

7.4 On-Site [SAAF]

[redacted]

[redacted]

7.5 Summary of Risk

Nearby residents are at ongoing risk from both asbestos and particulates if the site is not remediated. However, if remediated there will be a risk period of 4 to 5 years, primarily relating to potential asbestos and particulate matter exposure. There may also be quality of life and amenity impacts arising from odours and irritancy associated with volatile emissions. Without the implementation of suitable risk management measures, remediation of the Site therefore represents a high level of risk to the community.

[redacted]

A variety of risk management measures (as discussed in the following section and the ESMP) are proposed to minimise the risks associated with the exposure scenarios considered. Based upon the existing knowledge of potential contaminants and sensitive receptors, if these control measures are suitably implemented the potential risks are likely to be very low for off-site receptors. Similarly, risks for site workers would also be greatly reduced, though this would vary based upon their role (e.g. site operations manager, excavator, rubble picker, stockpile management).

A summary of risks according to exposure scenario is presented in Table E.

Table E: Risk Summary

Receptor	Current Risk if Landfill is not remediated	Remediation of Site (Excavation of Landfill) NO protective measures	Remediation of Site (Excavation of Landfill) WITH protective measures (Suppression and PPE)
Off-Site: Nearby Residents (Adelaide Street)	Moderate	Moderate to High	Very Low
On-Site [Red Zone] [redacted]	[redacted]		
On-Site [Green Zone] [redacted]			
On-Site [SAAF] [redacted]			

* The exact nature and duration of potential exposure cannot be reliably assessed at this stage.
** Not Applicable – Workers not present on Site.
*** Intermittent exposure would be limited

8 SITE MANAGEMENT

The risk assessment recognises the Site issues, hazards, receptors associated with the remediation and redevelopment of the Site. This is based on the identified potential contamination which has been determined within the MDWES – ESMP, HRA conceptual site model, and full consideration to the relevant factors influencing risk.

There are a number of goals for the site management and remediation process to achieve a positive outcome, these are presented in the MDWES ESMP and Wasterock Site Management Plan. All measures proposed will be implemented with transparency, be fully documented, and supported by a clear rationale to provide regulatory confidence of an appropriately managed Site.

Remediation and validation processes will provide outcomes (reports) to demonstrate exposure to receptors has been minimised. The reports will validate regulatory requirements to demonstrate that contamination has been remediated to acceptable levels. Achieving the remedial targets would require no further reporting under the CS Act, thus the site development can continue.

"The primary goal is ensuring that the health and safety of site workers and public is protected, minimizing potential exposures in a cost effective and timely manner".

Key health and safety goals during site remediation and management include:

- **Off-Site: Nearby Residents (Adelaide Street)**
    - Achieving the ongoing management of the air quality "on site" during remediation, through dust suppression, vehicle controls and site management plans. This is to ensure that dust and asbestos does not impact the local residents health.
    - Continuous on going monitoring (soil, air, water and ground gas) for the duration of the project, to validate the management and control measures procedures in place.
    - Community consultation to include transparency and clear concise validation data.
    - Contingencies and immediate response actions. To ensure that if there is a breach or exceedance the exposure duration is limited, managed and controlled. This will be achieved through a review process to reduce the risk of re-occurrence.
- **On-Site [Red-Zone]: Remediation Workers**

[redacted]

[redacted]

- **On-Site [Green-Zone]: Site Manager, Office Staff, Visitor**

[redacted]

- **On-Site [SAAF]: Remediation Workers**

[redacted]

- **Amenity:**
    - Remediation, through dust suppression, vehicle controls and site management plans. This is to ensure that dust does not impact the local residents.
    - Continuous ongoing monitoring (soil, air, water and ground gas) for the duration of the project, to validate the management and control measures procedures in place.

The measures to be implemented to achieve these goals are considered in further detail in the following sections.

Additional site remediation and management goals include:

- <u>Achieving remediation goals within in a timely and safe manner: -</u>
    - The current vegetation (trees and bushes) on site will be retained until the landfill is to be remediated i.e. the site will not be stripped as a whole. Working sections will only be stripped as required, thereby minimising potential emissions of airborne particulate and fibre and limiting the duration of potential exposure for both site workers and nearby residents.
    - Community concerns regarding potential exposure will be alleviated with a swift and visible response through conservative assessment criteria and trigger values. This will provide transparency within data produced, to give greater confidence in overall site management and remediation.
    - Undertake an environmental sampling and monitoring program (MDWES ESMP and AQMP) using published assessment criteria (air, soil, groundwater and ground gas) to demonstrate the effectiveness of on Site remediation.
        - Suspect material will be sampled and analysed to verify the presence (or not) of asbestos e.g. ACM pipes.
        - Suspect sludge's and groundwater found will be sampled and disposed of accordingly.
        - All soils on site once screened will be returned and packed within the deep engineered cell (accept over sized screened material <150mm).
        - The oversized material on site (concrete, brick) will be utilised to create an engineered barrier layer. There is potential that this oversized material may

contain asbestos. This will be managed through a sampling and validation program to classify the oversized material before it is crushed (asbestos risks associated with crushing). ACM will be picked and removed during excavation and screening. Once stockpiled sampling will be undertaken in accordance with DoH stock pile sampling regime. Only validated "clean" will be allowed to be crushed. Before being utilised as barrier material final sampling and validation will be taken to ensure the crushed material is suitable.

        - All soils accepted to the SAAF will validated before being utilised as capping soil material. Soil accepted should be accompanied with laboratory certification. Sampling of soils will be required to ensure suitability for capping layer.
        - Once the engineered cells have been completed, barrier layer and clean capping soils have been applied ground gas monitoring wells will be installed to assess any ground gas generation.
    - Site remediation and validation will not be affected as the soils become potentially unworkable following extended winter rains.
    - Costs for protracted site management will be minimised to the extent practicable.
    - Once the landfill material is processed, it will be placed back into deep cell and encapsulated with an engineered barrier layer.
    - Once the remediation of the project has been completed the continued groundwater and ground gas monitoring program will continue to assess any environmental impacts.
- <u>Adoption of measures that are both robust and cost effective, such that: -</u>
    - Landfill removal from site is limited and the disposal of contaminated waste is minimised.
    - Remediation and validation may be achieved simultaneously, without significant iteration of process.

A summary of actions to achieve the site remediation and management goals is provided in Table F.

Table F: Summary of Site Remediation and Management Goals & Actions

Goal	Action	Reporting
Health Protection *(Dust Generation)*	• Dust suppression • RPE, PPE & Job Safety Analysis • Air quality monitoring • Immediate response actions • Review of procedures • Contingency measures	Environmental Site Management Plan (ESMP) Air Quality Management Plan (AQMP) Human Health Risk Assessment (HHRA) Site Validation & Audit Report (SVAR)
Health Protection *(Asbestos)*	• Dust suppression • PPE & Job Safety Analysis • Sampling during the excavation process, prior to crushing • Validation sampling post crushing to ensure suitability of barrier material • Air quality monitoring • Immediate response actions • Review of procedures • Contingency measures	Environmental Site Management Plan (ESMP) Air Quality Management Plan (AQMP) Human Health Risk Assessment (HHRA) Site Validation & Audit Report (SVAR)

Prompt Remediation	• Processed and placed in deep cell and capped • Contingency measures	Environmental Site Management Plan (ESMP)
Regulatory Notification	• HHRA submission and approval • Any exceedances are reported • Exceedances are addressed and ESMP and SMP are revised • Contingency measures	Human Health Risk Assessment (HHRA) Site Validation & Audit Report (SVAR)

8.1 Predisposing Conditions

Particulate matter and asbestos fibre are the principal CoPCs for this Site which have been determined from previous reports, ESMP and preliminary HRA. Health risks from ACM in soil will depend on the potential for asbestos fibres to be released, become airborne, and then inhaled. Health risks from particulate (dust) matter similarly will depend on their potential to become airborne and inhaled. The nature and degree of risk presented to key receptors has been explored in the previous sections of this HHRA.

Under the NEPM: Assessment of Site Contamination (1999), isolating soil containing ACM by covering it with a properly designed barrier is an option. Health impacts of this option are important, of course, but leaving contaminated matter in-situ is considered an acceptable option, providing there is no immediate danger to the environment or community and the site has appropriate controls measures in place.

Economic considerations are also important. Leaving this untreated “contaminated” site un-remediated leaves a long standing legacy adjacent to a sensitive residential estate.

The Site is within 30 metres of residents, presumably including children and the elderly who may be particularly vulnerable, with an on-going potential risk of exposure to asbestos and particulate matter this has been identified within the risk characterisation section of this report.

Remediation of a contaminated site can be a particularly expensive exercise. Therefore, this project relies on the input of acid sulfate and hydrocarbon-impacted soils (Class I) (SAAF), sourced from the Perth region. The treated soils will provide the ‘clean’ capping layer required over the crushed concrete barrier layer, entombing the engineered landfill material.

A treatment option to collect and remove ACM would be prohibitive, costly and would take considerably longer than the current project projection. Therefore, in-situ retention within a deep cell is the only cost effective option for any offending material.

On-Site containment of asbestos contamination is also the preferred option of DoH (2005), when:

- There is negligible risk of/from exposure
- Asbestos waste is stable and not liable to be disturbed or eroded.
- Over sized material will be sampled and validated for asbestos impact before being utilised within the barrier layer.

For the Hazelmere project the Site conceptual site model (ESMP, HRA) identified the potential source, pathway and receptor risks based on potential contamination. This steered the project to develop a site specific health risk assessment, and as such the requirement for bespoke management of ACM and dust on Site. As long as appropriate current occupational health & safety procedures and monitoring requirements are followed, risks to workers and bystanders, including neighbourhood residents, will be minimised. The DoH (2009) provides guidelines on asbestos management in-situ which are presented within Table G below, with comments on how those conditions apply to the Hazelmere site.

Based upon the health, economic and practical considerations given above, in-situ asbestos management has been selected as the most favorable option for the Hazelmere Site. In undertaking the selection process for remediation on the Site, it is important that all options are considered and the preferred one should be supported by a strong argument to demonstrate that the chosen option is the best option compared to others. Although cost, time, convenience and future owner perception will be important considerations, the arguments presented for selection should be primarily stated in terms of public and worker protection.

The presence of other contaminants may affect the approach taken to or the timing of asbestos remediation. The following considerations may be important:

- Do other contaminants present an immediate threat to health or the environment?
- Will the proposed asbestos remediation option mobile or compromise the other contaminants or visa versa?
- Is a single option or combination of remediation option available that will treat both asbestos and other contaminants?

The main remediation options include; management in-situ, treatment-on-site, and finally removal of the contaminated soil from site. The Hazelmere project will adopt the management and treatment on Site as part of the remediation program. Important consideration to DoH (2009) in assessing the acceptability of a remediation proposal should consist of the following:

- Minimisation of public risk.
- Minimisation of contaminated soil disturbance.
- Minimisation of contaminated material/soil moved to landfill.

In relation to the project the primary concern during the remediation is minimising the dust generation and in turn any potential asbestos fibres from being released.

Table G: DoH (2009) Guidelines for In Situ Asbestos Management

Predisposing Conditions	Comment
Asbestos is buried >2.0 mbgl.	The landfill material will be processed on site and placed within a deep cell greater than 2.0mbgl (landfill material may contain asbestos).
Barrier Layer	An engineered barrier layer will overlay the landfill at 1.5 mbgl. The barrier will comprise compacted crushed concrete recycled from site.
Capping Material	A capping layer of 1.5 metres will overlay the barrier layer. This will comprise imported soils sourced from the Perth region. Soils will be amended on site within the SAAF(ASS or Class I – Hydrocarbon Impacted only).
Distribution of Asbestos and area is still to be determined. This also includes the volume of ACM in 1.7million m^3 of soil (current landfill).	At this time, the asbestos found on site has been superficial, found as small ACM fragments at the surface and within shallow soil horizons. It is uncertain what volumes, if any, are present on site. However, mitigating measures will be in place and include dust suppression, RPE, PPE, visual inspections, air quality monitoring and sampling.
Site will be covered with hard-stand with limited soft landscaping. (commercial)	The site will be remediated for a commercial / industrial end use. Future human health risk associated with soil contact would therefore be low.
Likely to be associated with a Memorial on Title (MOT)	The MOT will state that excavation will not be allowed beyond the engineered barrier layer. Any excavations below this point will require a detailed management plan. The stakeholders are aware of this condition

	being placed on the Site once the remediation has been completed.

8.2 Site Management Approach

DoH (2009) details a management approach for ACM and dust contamination on site:

- Potential contaminating or contamination disturbing activities must cease if concentrations of dust are above assessment limits (detailed comprehensively in the MDWES AQMP).
- The presence and extent of ACM has not been determined on the Site. However, upon discovery, the offending ACM will be assessed, removed and evaluated.
- Remedial measures are to be determined, implemented, and validated by the environmental consultant and stakeholders which should include auditor approval and sign off and part of the MRA.

Principles for Site Assessment and Management of ACM were determined in the preliminary HRA (MDWES ESMP) and have been expanded upon this HHRA. Using those principles, it was determined that the HHRA would thus primarily focus upon ACM and dust contamination. The HHRA has consequently been employed to determine appropriate management commitments to ensure the protection of the workers and the public. Although, the historical information provides some indication of the type of material that maybe encountered within the landfill there is evidence to suggest there maybe be deposited material and 'pockets' which may be of significant human health risk such as fibrous asbestos and fine particulate dust matter.

Based on the material that may be encountered, the Site will require management by the proponent and environmental consultants. This will be in the form of, dust suppression techniques (water cannon and misters), coupled with real time air quality monitoring to assess the air space on site for impact. [redacted]

Adherence to the risk management measures outlined in the ESMP and AQMP shall be validated by assessment against appropriate risk based criteria (as previously discussed). Control measures and validation sampling will ensure appropriate mitigation is achieved and the risks to key receptors is minimised.

The protection measures being presented within the HHRA are based on current and known site levels and assessment criteria. However, the HHRA and Site management control documents will be applied through the lifespan of the project to ensure that the best practicable method has been adopted. If a management control procedure is seen to be insufficient ie: dust suppression, then a review to adoption of a better control procedure will be undertaken. This will be through consultation with the shareholders and endorsed by the contaminated sites auditor prior to being implemented on Site.

[redacted]

Further site management measures to protect public health and ensure suitable communications between stakeholders are presented below.

8.3 Site Management Requirements

To minimise public exposure, site access shall be restricted to personnel necessary for conducting the remediation, monitoring, and reporting activities on Site. Fencing, signage, and site entry protocols established as part of immediate response actions will be maintained until site validation and subsequent regulatory approvals have been achieved (project completion).

Due to the nature of the Site and the potential to encounter asbestos (ACM or fibre) and contaminated material (e.g. hydrocarbons), will require appropriate signage which will be placed at the site at access points (enHealth 2012). This will warn that excavations and remediation are occurring on site for contaminated soils which will include asbestos.

Similarly, dust suppression using sprinklers and misters at the site will be maintained and applied vigorously throughout the site remediation process. Dust suppression is seen a key component to keeping the risk and exposure low.

The maintenance of perimeter fencing will also assist in control of peak dust releases ('spikes'), while reducing the visual impact of site remediation on nearby residents. All perimeter fence breaches/tears are to be repaired immediately so receptors are not impacted (See figure 4).

In the absence of sufficient rain, soils will be pre-wet (drenched) during the initial stages of soil removal to minimise dusts that may result from mechanical disturbance. Subsequent dust suppression will be dictated by real time dust monitoring which will relay data and alarms of elevated dust conditions and also informed by visual assessment during site activities. If dust concentrations persist, resulting in alarms, then the adopted dust suppression techniques shall require a comprehensive review.

It is recognised by DoH (2009), that dust monitoring provides a useful surrogate measure to evaluate the potential generation and distribution of airborne asbestos fibres. The air quality monitoring program will measure the effectiveness of the adopted site management controls (MDWES AQMP). The approach outlined is considered to be consistent with the dust monitoring methods outlined by DoH (2009) and the simplified site assessment process, whilst maintaining the primary intent of ensuring community protection and elevating concerns.

To validate the dust suppression measures, the on-Site air monitoring program will be implemented for the duration of the project (full air monitoring details are presented in the MDWES AQMP). This will provide 'real time air quality data' during work hours, to identify any exceedence of adopted air quality limits. If any exceedances occur, then a review of the site management plan and the AQMP will be required (DoH, 2009) and should be approved by the contaminated site auditor and DER.

[redacted]

8.4 Groundwater for Dust Suppression

MDWES has already conducted a study and issued a report on groundwater abstraction through production bores (see MDWES report – *Groundwater abstraction for Dust Suppression and Surface Compaction* (Oct 2012) presented in the appendix of the MDWES ESMP). The report presents a total of three (3) production bores to be located on Site to provide the water required for dust suppression. The calculated maximum groundwater abstraction rates of 15L/sec, or a total of 821.3m^3/day, have been applied to the Site.

Abstracted water will be taken from the deep aquifer underlain the Site. The use of the production bore water will apply to the following principles in dust suppression measures.

8.5 Dust Suppression during Excavation

The suppression of dust is seen to be the key in the management of any potential ACM material. If dust concentrations are below adopted assessment criteria, as monitored through real time assessment (See MDWES AQMP), then it can be assumed that asbestos or asbestos fibres within the air space on site are also minimised. Similarly, if there is minimal dust within the airspace, the risk of any impact or deposition upon the local residents and their health is also minimised.

Management of dust and potential ACM will be achieved through surface stabilisation and dust suppression in the form of water carts, sprinkler network and misters. These will be made available for the entire excavation and remediation of the Site. Dust suppression will be the key to reducing airborne particulates and therefore potential migration. Validation for the success of the dust suppression will be conducted through air quality monitoring (see AQMP). In addition to this the following measures will also be adopted on Site:

- Major traffic routes into and around the Site will be paved with either bitumen or crushed concrete to minimise noise and dust generation. Dust suppression and/or cleaning will be required on a regular basis to keep dust to a minimum.
- The landfill excavated area will be thoroughly wet down at nominated periods every day, particularly first and last thing before leaving Site. The use of dust suppression will be increased in the summer months due to ‘drying out’ conditions. In the winter months it is perceived that the naturally wetter conditions will provide some suppression and therefore the frequency of supplied water could be reduced. Adequate dust suppression will be achieved through water carts, a sprinkler network and misting machines. The duration and time between dust suppressions will be dependent on the readings from the air monitoring stations and if dust concentrations are approaching the limit values. Dust suppression will also depend on the times of the year and local weather conditions, with increased dust suppression likely to be required in the summer and spring months (November through to May) due to drying conditions.
- Subject to vehicle and machine movements, exposed construction areas (Engineered Cell) will have regular dust suppression similar to that applied at the face of the excavation. Visual assessment of dust levels coupled with ‘real time’ dust monitoring will dictate ‘water suppression’ periods. Preemptive suppression may also be applied
- Before the Site is closed (Sunday and evenings daily), a last ‘dampening down’ of the day will occur, once excavation has ceased and the workers are out of the excavation zone. This will also apply to the area of the engineered deep cell. There will also be a concentrated spray/dose of ‘Dust-X’, which should be sufficient to limit the liberation of soil particles and any ACM material whilst the Site is closed.
- The excavation face of the landfill will be dampened down periodically with sprinkler system/misters (Misting system details Section 8.6 below), as the excavation progresses. If required, a direct jet/sprinkler system will be used to provide water to a particular spot. At the end of the shift and for the next phase of the excavation, the landfill will be wet down considerably for the following day. Misting will also commence first thing before the shift. This is to make sure the landfill material is damp when excavated. These precautionary measures will ensure the landfill face is kept damp and hence limit the liberation of potential fibres and dust when excavating and moving soils.

These processes are aimed at mitigating the effects of wind blown, dry, loose surface sand and any other material from potentially becoming airborne and transporting asbestos fibres.

8.6 Overview of the Misting System

The landfill face and resulting screened stockpiles and screening deck will be wet with misting units (fog cannons) which will be sited in the work area as close as practicable to the workface of the landfill. This is to effectively control any emissions from excavation and during screening processes (screening deck). The misters will provide efficient and effective dust suppression through the work area.

Hydraulic fog cannons are designed for low power and low water use, combining a powerful fan with high launch efficiency of between 20m and 65m which can cover areas of up to 1,000 square metres. Micro nozzles mounted on individual crowns atomise water into billions of micro-fine droplets that readily bond to similar sized airborne dust particles, resulting in an extremely effective means of dust suppression.

Variable water flow allows the user to manage the volume of mist to suit the current conditions and the intensity of the dust present. Water use is reduced dramatically when compared to the amount of water employed by traditional irrigation systems, sprinklers and handheld hoses.

The misting technology effectively captures dust particles of PM_{20} or less, significantly reducing breathable or fugitive dust in the surrounding air.
The benefits of using a misting system over conventional dust suppression are listed below. An image for the use of dust suppression is also presented below.

- Use significantly less water than traditional water sprinklers and hose systems.
- Limit muddy and boggy conditions/problems as there is minimal or no surface water present.
- Reduce clean up costs as the surrounding surface area has little moisture.
- Decrease machine maintenance costs by lowering equipment abrasion rates caused by dust.
- Improve workforce safety with an automated remote controlled system.
- Support local Council and EPA/DER regulations by significantly reducing dust emissions from business operations and facilitating compliance with ambient air quality standards.

Images of a Mister/Fog Cannon

8.7 Dust Suppression during Engineered Fill

The principles outlined with the ESMP and this HHRA will be adopted and applied for soils that have been screened and placed back into the engineered cell. To minimise dust and exposure, all soils will be suppressed using misting/sprinkler network.

8.8 Dust Suppression for On-Site Machines

8.1.1 Screening Deck

The landfill material will be excavated, sorted and screened into the desired sizing, utilising a screening deck (ESMP provides further information on sizing's). Excavated material will be passed through the "grizzly" with the undersized material passing through for sorting. The grizzly and screening deck will be positioned adjacent to the excavation and will be within the zone of influence for the 'fog' misters. The conveyors will also have sprays during the travelling of sized material to ensure suppression.

As the action of screening has the potential to generate dust, the triple deck screening machine proposed will be fitted with a misting system to dampen down the landfill material, as it is being processed and sorted.

The screening deck will also be monitored continuously during operation for air quality, with an air monitoring station positioned on the screening deck at all times (See AQMP).

8.1.2 Excavators and Loaders

The Site excavators and loading machines will also be periodically washed down and cleaned to reduce transposable dust and dust generation (weekly in winter and monthly in summer). Dust monitoring will be conducted on each of the vehicles to assess concentrations and exposure limits. This will also provide another level of monitoring assessment for dust generation at the face of the excavation and work areas.

8.1.3 Speed Limits

Site traffic movement around the site will be limited to a maximum of 30km/h or less to limit dust generation, in addition to reducing noise and vibration.

8.9 Air Monitoring Scope

8.1.1 Overview

The Air Quality Management Plan (AQMP) provides comprehensive information outlining the scope of works, equipment required, methodology, schedules, management and assessment criteria. The following is a synopsis of the AQMP to provide information for this HHRA.

The proposed air quality monitoring program will provide information to facilitate management of excavation works in order to minimise potential exposure of hazardous contaminants to on and off-site receptors.

The program will have a strong focus on verifying that personnel and local residents are not being exposed to elevated airborne concentrations of CoPC as a result of excavation works.

The air quality monitoring program is intended to quickly identify whether excavations in possibly contaminated soils result in airborne concentrations of CoPC exceeding the NIOSH / Safe Work Australia (1995) exposure limits (also endorsed by the WA DER), so that responses such as increased spraying with water or, if necessary, a "stop work" instruction can be implemented, until the levels are again found to be safe.

A continuous air monitoring program will be employed for the duration of the remediation and engineering program:

- Provides real time dust concentration to assist in managing dust suppression activities across the Site.
- Provide real time and time weighted data on the concentration of CoPC across the Site and across the boundaries.

- Validation to ensure the risk of exposure to on site and off site receptors in terms of human health risk which will be in accordance with current air quality assessment criteria.

8.1.2 Air Quality Monitoring Program Overview

The MDWES AQMP identifies the air monitoring program for the remediation of the Site. The following Table H highlights the roles and responsibilities for the air monitoring. The sample locations are depicted on Figure 5 attached to this report.

Table H: Roles & Responsibly for Air Monitoring Program

Parameter measured	Sampling Site / Locations	Task	Timing *	Completed by Whom	Analysis
PM10	AMS1	Ensure TEOM functioning correctly	Commissioning. Calibration. As required	NATA certified specialist consultant	Ensure instrument is installed and functioning correctly
	AMS1 - 6	Review calibration data	First two months	NATA certified specialist consultant	Review data to ensure appropriate aerosol calibration factors used in nephelometer.
	AMS1 - 6	Review real time data	Daily	AQMP Manager or Env. Scientist	Review real-time data
	AMS1, 3, 5	Gravimetric sample collection	Daily for one month and then once per month (over 3 days)	AQMP Manager or Env. Scientist	NATA accredited analysis of sample within 5 working days
	AMS1 - 6	Determine calibration factor for nephelometers	As required	AQMP Manager	Comparison of concurrent nephelometric and gravimetric data to produce Site specific calibration factor for nephelometers
TSP	AMS1	Review real-time data from nephelometers	After one month configure nephelometer to sample TSP rather than PM10	AQMP Manager or Env. Scientist	Review real-time data
	AMS1	Gravimetric sample collection	Weekly	AQMP Manager or Env. Scientist	NATA accredited analysis within 5 working days
Silica Dust (RCS)	AMS1	Sample collection	Weekly	AQMP Manager or Env. Scientist	NATA accredited analysis within 5 working days
Metals	AMS1	Sample collection	Two weekly	AQMP Manager or Env. Scientist	NATA accredited analysis within 5 working days
Asbestos	AMS1 – 6, 10	Sample collection	Daily Mon - Sat	AQMP Manager or Env. Scientist	NATA accredited analysis within 24 hours
	AMS7, 8, 9	Sample collection	Twice daily am: 07:00-12:30 pm:12:30-17:30	AQMP Manager or Env. Scientist	NATA accredited analysis within 24 hours
	AMS11, 12	Sample collection	Twice weekly for two months then schedule reviewed subject to historical results	AQMP Manager or Env. Scientist	NATA accredited analysis within 24 hours.
	AMS13, 14	Sample collection	Daily for two weeks then monthly for six months then schedule reviewed subject to historical results	AQMP Manager or Env. Scientist	NATA accredited analysis within 24 hours.

	NA	Review BoM and Site data	Daily (am)	AQMP Manager	Forecast likely conditions for sample locations
CoPC	MDWES office or Site office	Report	Weekly report for the previous week's results	AQMP Manager	Ensure compliance with Works Approval and Licensing Conditions.
Weather	WMS-1	Collect data	Daily	AQMP Manager or Env. Scientist	Review data, check robustness, check for gaps.
	MDWES office or Site office	Collate data	Daily	Env. Scientist	Check QA/QC of data, check robustness, data gaps, and check against assessment criteria.
Reporting	MDWES office or Site office	Variable	As required	AQMP Manager	NA

NB * unless otherwise stated, sample collection is from start to end of daily works, Monday to Saturday, for full duration of earthworks. Highlighted cells apply to contracted NATA accredited specialist.

8.1.3 Equipment

The Following instruments will be utilised to undertake the air monitoring for the duration of the remediation of the site. This is detailed in the AQMP in sections 9.1 to 9.4. The locations of the monitoring stations are shown on Figure 5.

QA Lite (TES-7200) (Nephelometry) – This provides real time dust concentrations of TSP and PM_{10}.

SKC AirCheck XR5000 Sampling Pump – These are portable battery operated sampling pump utilised for sampling asbestos fibre.

SKC PCXR8 Universal Sampling Pump - These are portable battery operated sampling pumps used for the collection of time weighted gravimetric dust samples, Respirable Crystalline Silica (RCS), and dust containing metsls.

Tapered Element Oscillating Micro-Balance (TEOM) – This provides real time dust concentrations of PM_{10} as per AS/NZS 3580.9.8:2008. The TEOM will be the primary dust monitoring station which will be used to calibrate the other Nephelometers.

Weather Station – Will provide real time data for localised weather patterns on site which will record - wind speed, and wind direction, temperature, rain fall and relative humidity.

8.1.4 Assessment Criteria

The AQMP discusses in detail the rationale for the assessment criteria in section 10 of the report. The following Table I is a summary selected assessment criteria and actionable trigger levels for monitoring during the monitoring of the site.

Table I: Assessment Criteria

CoPC	Limit	Trigger Values and Action
TSP	90 µg/m^3	Daily average > 75 µg/m^3 for more than two days per week:
		Increase dust suppression.
		Monthly average > 80 µg/m^3:
		Investigate additional dust suppression methods including use of ground covers.
PM_{10}	50 µg/m^3	Daily average >40 µg/m^3 at any of AMS1-6:
		Examine dust suppression regime, look at peaks and related site activity and undertake corrective actions as required.
		Daily average >40 µg/m^3 at any of AMS1-6 for two consecutive days:
		As per above, increase wetting down e.g. frequency of events and / or duration.
		Daily average >45 µg/m^3 at any of AMS1-6:
		As per above. Review wind speeds associated with exceedance and consider setting maximum wind speed threshold for reduced sorting throughput.
		Daily average >45 µg/m^3 at 1 pm at any of AMS1-6:
		As per above. Cease reclaimer and excavator operations.
Asbestos Fibre	Off-site and green zone: 0.01 fibre/mL On-site, red zone: 0.1 fibres/mL	Daily average >6 fibres/100 fields at any station AMS1-6, AMS10:
		Investigate site conditions that were likely to have contributed to the result and take appropriate action e.g. increase dust suppression and wetting down. Recount sample. If at AMS10 check user behaviour, ensure boots cleaned before entry and decontamination procedures are being used.
		Daily average >8 fibres/100 fields at any station AMS1-6; AMS10:
		As per above, concurrently undertake SEM of sample to determine asbestos fibre content. Review wind speeds associated with works and consider setting maximum wind speed threshold for reduced sorting throughput until following result shows improvement or that SEM shows calculated asbestos fibres concentration is less than 0.006 fibres/ml. If at AMS10 as per above, Investigate integrity of crib room, look for uncontrolled opening, poor door and window seals, take corrective action.

		Daily average ≥0.01 fibres/ml at any station AMS1-6:
		As per above, significantly reduce reclaimer throughput, reduce amount of excavation undertaken.
		Daily average >0.01 fibres/ml at any station AMS1-6:
		Cease work, investigate source of fibre and rectify before works any remedial earthworks recommence.
		Shift average >0.02 fibres/ml at AMS7, 8 or 9:
		Location in vicinity of remedial earthworks likely to have elevated fibre count. Review dust control methodology, set maximum wind speed threshold for reduced sorting throughput until following result shows improvement or that SEM shows asbestos fibres concentration is less than 0.05 fibres/ml.
		Shift average ≥0.05 fibres/ml at AMS7, 8 or 9:
		As per above, significantly reduce sorting throughput until following result shows improvement or that SEM shows asbestos fibres concentration is less than 0.05 fibres/ml.
		Daily average > 0.01 fibres/ml in monitored vehicles:
		Investigate integrity of HEPA filter and cabin seals, take corrective action, recount sample, operator to wear P2 mask.
		Daily average > 0.02 fibres/ml in monitored vehicles:
		As per above, undertake SEM, operator to wear half face respirator.
		Daily average >0.01 fibres/ml in personnel monitoring samples:
		Investigate site conditions that were likely to have contributed to the result and take appropriate action. Limited access to operations excavation and resorting zone until reduction in concentration.
		Daily average >0.02 fibres/ml in personnel monitoring samples:
		As per above, concurrently undertake SEM scanning of sample to determine asbestos fibre content.
Silica	25 $\mu g/m^3$	Investigate dust suppression at crusher and increase dust suppression control measures as required
Arsenic	5 $\mu g/m^3$	Investigate potential sources of analyte and take appropriate action
Barium	50 $\mu g/m^3$	As per above
Cadmium	1 $\mu g/m^3$	As per above
Chromium	50 $\mu g/m^3$	As per above
Copper	100 $\mu g/m^3$	As per above
Manganese	100 $\mu g/m^3$	As per above
Nickel	100 $\mu g/m^3$	As per above
Lead	15 $\mu g/m^3$	As per above
Zinc	1 mg/m^3	As per above
Mercury	1 $\mu g/m^3$	As per above

Notes: Daily average for real-time averages based on 00:00 am start to day.
Green highlight denotes off-site and green asbestos zones
Orange highlight denotes on-site red asbestos zones Silica is considered to be crystalline.

8.1.5 Air Quality Measures and Protocols

Table I details the adopted assessment criteria which collectively set upper concentration limits for the identified CoPC. The table details an escalating series of actions with the goal of ensuring the specified assessment criteria are not exceeded.

PM10

The monitoring program assumes that PM_{10} is a surrogate for all airborne particulate matter. Conceptually then, accurately measuring and managing the concentration of PM_{10} will ensure that the concentration of all particulate based CoPC remains within acceptable limits.

Three tiers of action criteria provide increasing levels of triggered action to ensure the likelihood of PM_{10} exceedance is minimised. The bulk of Table I details action based on daily averages from the preceding day. However, the one day lag in data acquisition could potentially lead to unexpected exceedances.

To overcome this problem, two tiers of additional control will also be implemented. As noted in Table I, daily 1pm interrogation of the TEOM and nephelometer at AMS3 will allow the AQMP manager to quickly determine what the current day's average PM_{10} concentration and what actions, if any, are required.

Overarching the above controls is the use of programmable alarms on all of the nephelometers. These alarms will signal when the most recently logged concentration exceeds the programmed limits. It is proposed that the instruments are setup with a 10 second time constant and 15 minute logging interval. Such a setup means the instruments measure PM_{10} concentration every 10 seconds, holding these instantaneous measurements for 15 minutes, and then calculating and logging the average. In this way, brief peaks in concentration associated with passing trucks or strong gusts of wind, which can be in the order of mg/m^3, are evened out, preventing redundant alarming. It is proposed that the first alarm set-point is limit is set at 50µg/m^3 with a second alarm set-point at 100µg/m^3. Alarms will be set to SMS appropriate stakeholders.

All alarms will be investigated and available real-time data scrutinised to determine the most appropriate course of action as per Table I. Concurrent 50µg/m^3 alarms will escalate implementation of control measures. Activation of the 100µg/m^3 alarm will trigger SMS messages being sent to key stakeholders. It is likely that the alarm set-points will be routinely assessed and modified as required, to ensure a good balance between production and minimising the risk of PM_{10} exceedances occurring.

Exceedance of action trigger values will generally be related to insufficient dust suppression of the access tracks, excavation zone, remediated land (cover) that has insufficient vegetation cover, the crusher, or a combination of these elements. Dust issues will be exacerbated by strong winds and high temperatures. It is likely that the Site will need to develop a procedure that slows or ceases earthworks and/ or increases dust suppression activities based on weather patterns which includes wind speeds etc. The adoption of wind speeds as a control measure is likely to develop, as working characteristics of the Site unfold over time. In the above context, development and improvement of dust suppression methodologies is likely to be triggered by exceedances of CoPC trigger values.

TSP

TSP is considered a nuisance. At concentrations below 90µg/m^3 it is unlikely any complaints of nuisance dust will be attributed to the Site. However, as the concentration increases, so too does the risk of complaint. As per PM_{10} contingency discussion, two alarm set-points will be configured on the nephelometer, with the first one set at 200µg/m3 and the second at 400µg/m^3. If TSP concentration remains elevated above 90µg/m3 for more than two consecutive weeks, then measures will need to be undertaken to reduce windborne soil leaving the Site. Such measures could include increased ground cover via mulch or vegetative cover. Unsealed roads tend to emit significant amounts of TSP if insufficiently watered. As such, watering rates may need to be increased also.

Asbestos Fibre

Given the 24 hour lag time in sample turnaround, returning a single exceedance should not trigger a shutdown of Site. However, sorting should cease until Site conditions leading to the exceedance have been examined and appropriate steps taken to prevent future exceedance. It is expected that such investigations could be complete within one hour. Concurrently, the offending sample would be further analysed by SEM to differentiate the type of fibre present. If asbestos fibre concentration exceeds half the trigger value, then sorting rates may need to be reduced for several days or until personnel are confident asbestos fibre concentrations have been reduced.

If SEM results indicate asbestos fibre concentrations have exceeded the action criteria, relevant stakeholders will be advised.

Crystalline Silica

If average daily concentrations exceed the silica criteria on two or more consecutive days, then additional dust suppression will be undertaken at the crusher. If this fails to ameliorate concentrations, then additional dust suppression will need to be undertaken within the excavation zone.

Metals

Exceedance of metals criteria will trigger efforts to locate the point source of metal laden dust and rectify.

Corrective actions will comprise of the following:

- Any identification of potential off-site ACM, TSP or Silica deposition is to be confirmed by analytical analysis.
- Ensure that vehicles / mobile plant are operating in wetted down areas, particularly if shallow soils are being disturbed through excavation.
- Increase the water application rate for disturbed areas, particularly if potential ACM has been located. Or exceedances have been identified.
- Potentially reduce the level of earthmoving activity if evaporation rates are drying the soil out quicker than the watering can be applied.
- A potential requirement to apply additional / more suitable physical dust suppressants to inactive work areas if local winds are high.
- Cease all work, if extreme weather conditions are determined to be the prime reason for fibre, TSP or Silica concentrations exceeding the trigger values, particularly if levels have been exceeded on a previous day in similar weather conditions.

8.10 Visual Assessment for Asbestos

The face of the landfill will be assessed at the beginning of the day, during the swapping of the machine pumps (lunch time), between AM and PM monitoring periods and at the end of the shift. Periodically through the day the environmental scientist will attend the face to see if any asbestos has been uncovered, this will be supplemented with an assessment of soil being passed through the screening deck. It should be noted that it will be physically impossible to assess 'all' the excavated soils removed, this process would become a very costly exercise, become time consuming, slow up the project progression and the project duration would balloon potentially into decades. Visual assessment of excavated soils will be validated through sampling for ACM from the over sized (<150mm) material from the screening deck. Only validated material will be allowed to progress to the crushing process. (This is discussed extensively throughout this HHRA). All other asbestos impacted soils will be placed within the deep cell on site.

During excavations if pipework, sheeting or a pocket of asbestos is identified then the on-site Environmental Scientist will assess and sample the suspected material. The suspected asbestos will be removed and stockpiled securely, within a specific covered skip, until it can be identified and dealt with appropriately. This being said it is proposed that all the landfill material (including ACM) will be placed within the deep cell under a 0.5m crushed concrete engineered barrier layer (total 2.0mbgl).

8.11 Validation Sampling for Asbestos

Sampling of the C&D material will occur pre and post crushing. Sampling will be in accordance with DoH (2009) sampling of stockpiled material (a sample every 70m^3), although the post sampling will be less intensive as the pre sample should determine use in the engineered barrier layer or removal to the deep engineer cell on Site.

Where deficiencies in volume occur then there will be a requirement to import C&D waste. This will be visually assessed for asbestos and will be sampled in accordance with the DoH (2009) guidelines for stockpiled material. The C&D imported material will be used within the barrier layer (0.5m). If asbestos is identified then it will not be used within the barrier layer and the offending material will be removed from site or used within the deep engineered cell on Site.

In addition soils brought to the SAAF to be used as capping on Site will be sampled for asbestos if supplied laboratory analysis has not been carried out to show the imported soils are free from asbestos. If soils imported to site for capping are found to contain asbestos material then they will be sent to the deep cell on site or will be removed and disposed of off Site to a licenced facility.

No recommendation is being made to sample processed landfill material, as all material will be placed in the deep engineered cell. It is being assumed that the landfill contains asbestos and is being treated as such. Therefore, in accordance with DoH guidelines, any potential asbestos will be entombed +2.0mbgl beneath a crushed rolled barrier layer sealing it from any end user. It should be noted that we anticipate that a memorial will be placed on the Site stating that no excavations or exposure will be allowed below the barrier layer, to protect any earth worker from exposure and potential health risk.

8.12 Assessment for Hydrocarbons

During the visual inspections of the landfill face and the remediation of soils within the SAAF samples will be taken for photoionisation (PID) detection. The PID will be used to detect concentrations of hydrocarbon odour (VOCs).

8.13 Personal Protective Equipment (PPE)

[redacted]

[redacted]

[redacted]

8.14 Perimeter Fencing

To alleviate probable dust exposure to the sensitive receptors adjacent to the Site (residents), and to abate noise during remediation, a bunded fence has been proposed along Adelaide Street. A soil bund is to be constructed approximately 2.0m in height with a 1.8m security fence on top, which will be shrouded. This will act as a block to winds and noise (proposed bund/fence is shown on figure 3)

The fence has been designed to assist in reducing the wind flow from the Site on to publicly accessible areas and the properties of neighbouring residents.

- The soil bund will be engineered along Adelaide Street, with the bund matted and allowed to “grass in” for additional stability and aesthetics.
- A 1.8m security fence/windscreen will be constructed on the bund with tied shade cloth or hessian.
- The gaps under the fence will be closed off (e.g. sandbags or similar) to reduce particulates and fibres from being released off site.

- Any rips or tears in the fence will be seen as a breach and will be repaired immediately.
- The remainder of the Site will be fenced and secured from the general public. The fence will be shrouded and sandbagged to reduce windblown particulates dispersing off site.

There is a proposed internal compound which will separate the offices, car park and workers changing area from operational areas. These non-operational areas will be fenced off, with shade or hessian cloth tied to the fencing, with no gaps, to reduce dust-blown material from getting under the fencing from the ***red*** into the ***green*** zones. (Final design of the compound is still being considered and proposed however, these principles will also apply to the design of green zone site compound).

It should be noted that within the southern portion of the Site there is a batter/bund which is part of the old landfill. This bund is approximately 5-7 metres in height and runs east to west through the site. During the remediation works, this batter/bund will remain in place as an additional barrier to assist visual amenity, noise and wastewater control. As the remediation works move east this barrier will be removed and remediated as required.

8.15 Wind Blown Soils

During the remediation of the Site the use of dust suppression utilising water has been documented extensively within reports presented by MDWES. Water for dust suppression is seen as the first line of defence for reducing dust, particulate matter and asbestos fibres from leaving the boundaries of the Site. However, it should be noted that the excavation of the site will extend up to 6m below from the current site level. Therefore, a majority of the works will be below ground level, effectively operating in a wind protected depression where wind speeds will be reduced.

Furthermore, the current vegetation on site will be retained and only removed when the remediation gets to that phase. As a result this will reduce the potential for wind blown particulates from being blown around and potentially off site.

9 Management & Contingency Plans

The preparation of contingency measures is required to ensure that, should the adopted site management and remedial actions not prove adequate, appropriate resolution of concerns is achieved without necessitating formal site assessment and reporting under the CS Act. However, if the level of contamination revealed during either the initial or contingency remediation processes proves significant, concern for public health may warrant that the site be reported.

EnHealth (2012) identifies the need for immediate remedial action where 'it is demonstrated that there is potential for people to inhale airborne asbestos fibres". DoH supports this position and recommends various generic and site specific Immediate Response Actions (IRAs) to be developed. As part of this HHRA site-specific IRAs have been developed and risk assessment has been completed for the remediation of the site which includes particulate dust and asbestos material. The IRAs will only come into effect when the remediation of the site begins, not in its current form.

9.1 Failure of Remedial Approach

Potential failure of the adopted remedial methods and site management is considered to be the release of significant levels of dust and/or persistent community dust complaints. In such circumstances, reapplication of dust suppressant across the site will occur and a complete review of operational practices undertaken and mitigating measures in place. This review should also assess the technologies and sampling procedures used to monitor the site. This may mean that additional suppression of soils is required to abate the production of dust and particulate mater and potentially asbestos fibres.

The procedures being recommended within the MDWES ESMP, AQMP and this HHRA are based on current information and legislation. The measures put in place will be assessed constantly to ensure there suitability on Site.

A measure of failure will be based on the concentrations of boundary monitoring and if the wider community complains of dust and particulate matter being deposited on their homes, cars, etc. If this was to occur, indicating that dust movement went beyond the Site boundaries, this will immediately result in the stoppage of Site works and the dust control measures to be reviewed.

In addition if ground water monitoring results conducted for the duration of the project identify significant impact then a sample analysis plan (SAP) will be developed to investigate the 'fate and transport' of offending contaminant(s). Further groundwater monitoring wells will be required to delineate any plume to identify the extent of contamination. It will also have to be determined if the plume is based on operation and was a direct effect of the remediation.

Soil sampling during the project that identified asbestos above assessment will be dealt with in accordance with the management plan. Offending soils will be removed from site or will be placed within the deep engineered cell depending on capacity.

9.2 Contingency Measures

During the remediation of the Site, it is acknowledged that there will be some uncertainty as to the potential contaminants (ie asbestos, hydrocarbons, sludge's, waste etc, etc) which may be present in the soil material. The measures set out in this HHRA try to anticipate the exposure risks of likely contaminants which may be encountered. However, there is always the potential for contamination to be encountered that is outside of this model. The preparation of contingency measures will ensure that should the adopted site management and remedial actions not prove adequate, appropriate resolution of concerns is achieved without necessitating formal site assessment and reporting under the CS Act. However, if the level of contamination revealed during either the initial or contingency remediation processes proves significant, concern for public health may warrant that the site is reported.

Therefore, the following outlines procedures for the identification, isolation, reporting and management of contamination found.

The contingency plan and scenarios will include:

- A designated on-site point of contact (Environmental Consultant) will be responsible for management and response to any non-conformances.
- A chain of command to notify the relevant stakeholders of any breaches or non-conformances with immediate effect.
- The development of a contingence stop notice on site if a serious failure or breach occurs. This will include the ceasing of all site works until the breach/failure is resolved and a solution is determined to the satisfactory of the stakeholders and proponent.
- If a contaminated sludge or landfill water is identified during excavation then sampling will be undertaken of offending material. Appropriate field measurements (e.g. pH) will be taken to define parameters for storage. The offending material will be placed into secure containment on site and will be covered until the laboratory analysis is confirmed. Once confirmed the material can be disposed of appropriately.
- There has been much discussion on asbestos and identification of asbestos within the landfill material. However, if a large pocket or significant volume is uncovered then a cautionary approach will be taken. The site manager will engage site personnel to remove all materials with caution so as not to create an airborne incident which could potentially impact local residents and site workers. Misting will be perpetual to keep the air space and fibres to a minimum. The asbestos will be removed as per the steps outlined in this HHRA and ESMP.
- If remains are found within the landfill material, then a stop notice will be placed on the site and the appropriate authorities will be called to manage the incident area accordingly. Site management will be passed to the specialists and will be handled as an emergency.
- If unexploded ordnance (UO) is discovered within the landfill, then a stop notice will be place on the site. The appropriate authorities (police, fire, ambulance, armed services) will be called to dispose of the UO. Site management will be passed to the specialists and will be handled as an emergency.
- If injury occurs on site then the health and safety procedures will become activated to discover if the cause was human error or as a result of the landfill material.

10 Documentation and Reporting

10.1 Reporting

DoH (2009) clearly identifies the importance of appropriate documentation and reporting to provide transparency and confidence in site remediation, validation, and management processes. Accordingly, it is considered important to maintain descriptive site logs and information for the duration of remediation, reporting on elements including (but not limited to) site access, weather conditions affecting remedial/management actions, community complaints and subsequent response, and any issues arising during soil/waste inspection and handling.

The client has estimated that the operation to fully remediate the Site could take four to five years to complete. Therefore, as part of the environmental monitoring program, MDWES will periodically present reports on the findings.

MDWES will provide these periodical reports to the client, government authorities and the contaminated sites auditor for comment and consideration. If there are any environmental non-conformances or breaches outside these periodical reports (such as elevated dust or asbestos encountered), then an interim report will be issued. The interim report will detail the requirements and any breaches of the management plan with recommendations and solutions.

The reports will include:

- Photographs tracking the progression of the remediation. The photos will also include points of interest, such as identified contamination, breaches or damage occurring on Site.
- Photographs of any ‘hot spots’ of ACM contamination identified.
- A comprehensive record of actions, issues, and ACM contamination identified during remediation.
- Identification of any previously unidentified hazards, which will be fully documented and reported.
- Comprehensive dust monitoring data and explanatory reports for any exceedances of the corrective action or work stoppage criteria. Exceedances will be notified and reports submitted for review as soon as is practicably achievable.
- All reports will ensure that suitable summary information is presented.

10.2 Frequency of Sampling and Reporting

MDWES will periodically present reports on the results taken from site, as the project progresses. The following reports will be presented:

- **Monthly Environmental Site Report** – This report will present information and results relating to soil and air for this period (plus bi-annual groundwater monitoring). The report will include non-conformances or environmental issues that have arisen on site. It will collate and provide information on what has occurred on site, sample frequencies, photos and observations from the month, inclusive of suggestions and any recommendations. The monthly Environmental Site Report will detail and include the following sampling and monitoring reports:
  - Photographs and record of hazards, actions, etc.
  - Weekly Air Monitoring Data
  - Weekly Noise Monitoring Data

- o Weekly Soil Monitoring Data
- o Bi-Annual Groundwater Monitoring Report (probably December and June).

10.3 Community Communication

Community Consultation is already under-way for the project to inform the community of the proposed remediation and to gauge public opinion. Community feedback has already been report within the ESMP report by MDWES and with ROWE Group undertaking the community consultation to date.

The DER's Community Consultation Plan (2006) and DoH (2009) outline several communications and reporting goals relevant for site assessment and management approach. This includes:

- The DER and DoH is to evaluate issues at the site, document relevant processes, and notify the owner as to requirements. In this instance, the owner has engaged appropriate experts to meet the requirements of a community consultation plan and this will continue for the duration of the project.
- In determining the site remediation and management response, consultation with the DER, DoH and environmental auditor will occur as necessary. When reporting, the details of methods adopted and the rationale for remediation, validation, and management will be clear and comprehensive.
- The proponent will be responsible for undertaking appropriate consultation for the duration of site works. Consultation will be interactive where possible, and may vary in extent according to the stakeholders engaged.
- Site remediation and management processes will be fully documented (including photographs). The DER and DoH or an independent auditor will monitor the site clean-up, conduct a final visual inspection, and examine disposal documentation. This information will then be reported, in conjunction with suitable validation data, to demonstrate the effectiveness of the measures adopted.
- If the remediation response is determined to be inadequate, further remediation or a higher level of action may be necessary. This will be assessed and a solution will be presented to the stakeholders for approval and sign off. Once resolved then works on site can continue. The following reports and communication processes are thus considered necessary:
  - o The HHRA, which outlines the site remediation, assesses the associated risks to human health, and scopes the required management response and stakeholder consultation.
  - o Ongoing consultation between the proponent, regulators, auditor and community as implementation of the HHRA, ESMP and AQMP and project proceeds, in terms of issues that may arise.
  - o A Site Validation and Audit report (SVAR), which summarises the outcomes of the remedial work undertaken including consultation occurring during remedial works. The SVAR, shall incorporate an evaluation of the project remediation/validation data. This would include auditor observations of the site clean-up, final visual inspection, and overall implementation of the HHRA.

The HHRA and SVAR (the SVAR is presented at the end of the project) would be submitted to local government, DER, DoH and the environmental auditor, to provide suitable notification and approval of the intended site remediation and management approach, with the subsequent outcomes.

The site management and validation report SVAR, while available for stakeholder review, should require regulatory submission and evaluation. Similarly, stakeholder consultation processes will be fully documented, with the outcomes summarised by the SVAR.

11 Final Actions

A Site Validation Audit Report (SVAR) will be undertaken to demonstrate the effectiveness of the implementation of the HHRA and its suitability for the site at the end of the project. In conjunction with any necessary stakeholder communication, the SVAR will ensure regulators are satisfied with outcomes of the site remediation and management process. Should any outstanding issues be identified, appropriate action, documentation, and reporting will be undertaken to meet regulatory needs.

11.1 Site Inspection & Reporting

A final site inspection and closure report will be provided to document the outcomes of the site remediation process, establish that current site conditions are satisfactory, and provide confidence that issues identified in the HHRA have been appropriately addressed.

The site closure report shall be included as part of the SVAR and will summarise site conditions at the completion of works. The site closure report will provide a statement that dust and ACM contamination has been managed in accordance with the HHRA, in compliance with enHealth and DoH guidelines and the remediation of the landfill has been completed and the soils within have been screened, processed and remediated for commercial use. The report will also detail any breaches or non-compliances and how they were managed and addressed, details of the soil volumes processed and any asbestos encountered. The closure report will summarise the remediation and any ongoing management requirements.

11.2 Regulatory Confirmation & Approval

Upon completion of works, approval for continued site development from both local government and DoH will be sought, based upon the SVAR. The SVAR will summarise relevant remedial activities and site validation outcomes, rather than present detailed documentation and an exhaustive review. This approach is considered consistent with the site assessment approach presented by DoH (2009) and relevant reporting and communication requirements. All relevant data and reports will be available for regulatory consideration upon request. Prior consultation on exceedances of dust management targets or other site issues will ensure that any additional remedial response not outlined by the HHRA is enacted prior to the submission of the SVAR.

11.3 Community Consultation

Following regulatory and local government approval, it is recommended that the SVAR be made available to any interested community members. In addition, communication of summary dust monitoring data and site validation outcomes may assist resolution of any outstanding issues for nearby residents or stakeholders.

11.4 Ongoing Site Management

Once remediation is complete, the Site will be handed over to the developer to begin the construction of the commercial business park. However, as recognised in the MDWES ESMP, ongoing site management will be required in regards to groundwater and ground gas monitoring. The client is aware of its ongoing obligations once the site has been remediated.

Once remediated it is anticipated that a memorial on title will be place on the site which details that no excavation will take place beneath the engineered barrier layer due to the potential health risks.

Groundwater and ground gas monitoring programs should not interfere with the sites development. It is anticipated that a full year of quarterly groundwater monitoring will be required. The results of the post remediation groundwater monitoring will be compared to the historical groundwater monitoring conducted during the remediation of the site. In addition based on current data a full year of monthly ground gas monitoring should also be undertaken to ensure that there are no ground gas issues within the remediated site. This will be presented in a Remediation, Validation & Ongoing Monitoring (RVOM) Report, which is detailed in the ESMP.

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FIGURES

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Client:
WASTEROCK PTY LTD

Project:
Hazelmere Remediation and Regeneration Project

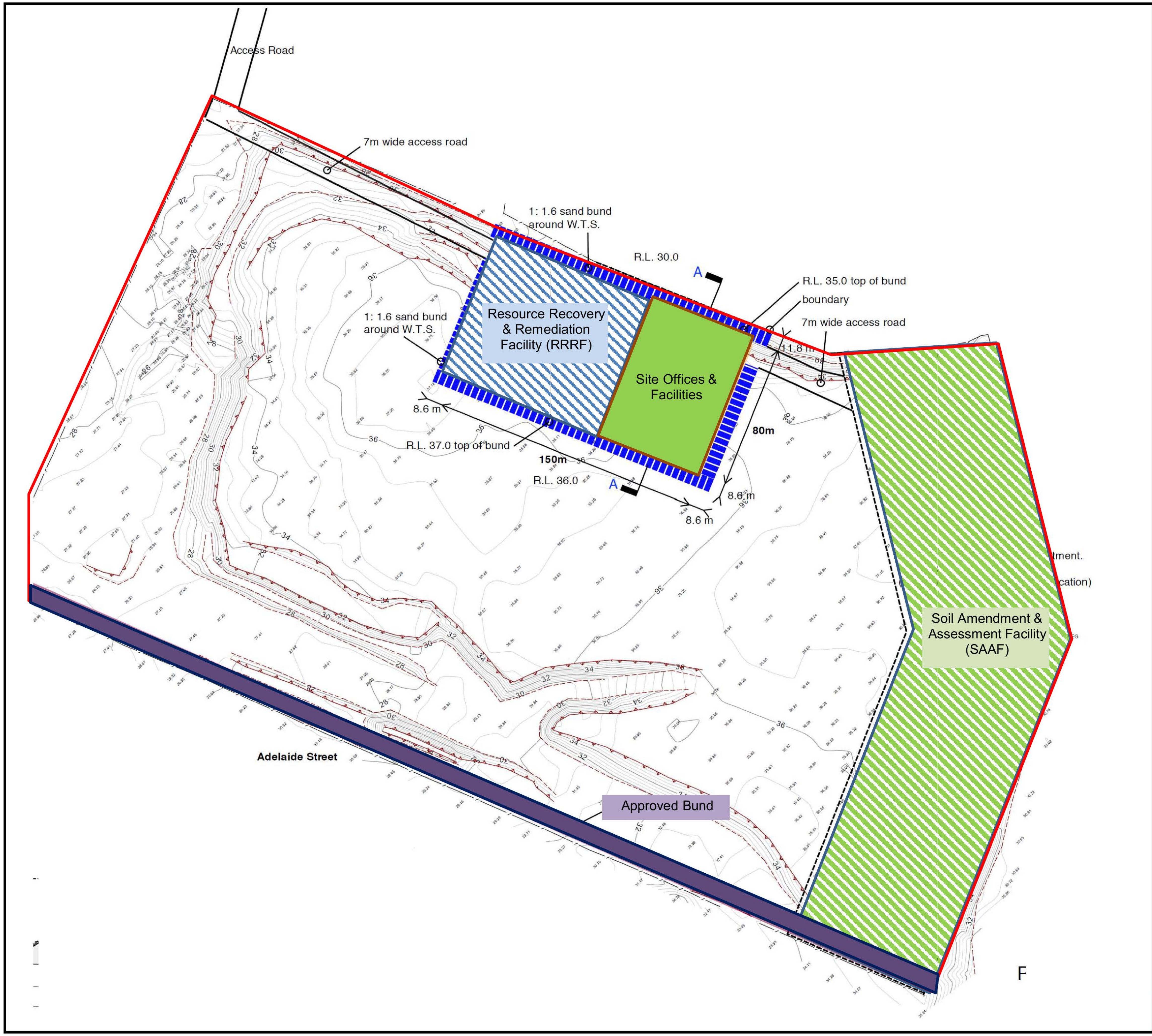
Location:
Lot 20 Adelaide Street, Hazelmere

Drawing Title:
SITE AND REGIONAL VIEW

Notes:
Site Location

Drawn by: Dale A.	Scale: Scale Not Used	North
Date: 10/09/2013		

Project No:	Figure No:	Rev:
E2012 - 031	1	v1



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Client:

WASTEROCK PTY LTD

Project:

Hazelmere Remediation and Regeneration Project

Lot 20 Adelaide Sreet

Drawing Title:

Survey of Site

Notes:

Location of :

Resource Reconvery & Remediation Facility

Soil Amendment & Assessment Facility

Site Boundary

Approved Bund

Drawn by:	Scale:	
MB	0 100 m	North
Date: 7/01/2014		

Project No:	Figure No:	Rev:
E2012 - 031	2	v1

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Project:
Hazelmere Remediation and Regeneration Project

Location:
Lot 20 Adelaide Street, Hazelmere

Drawing Title:
Previous Borehole & Test Locations

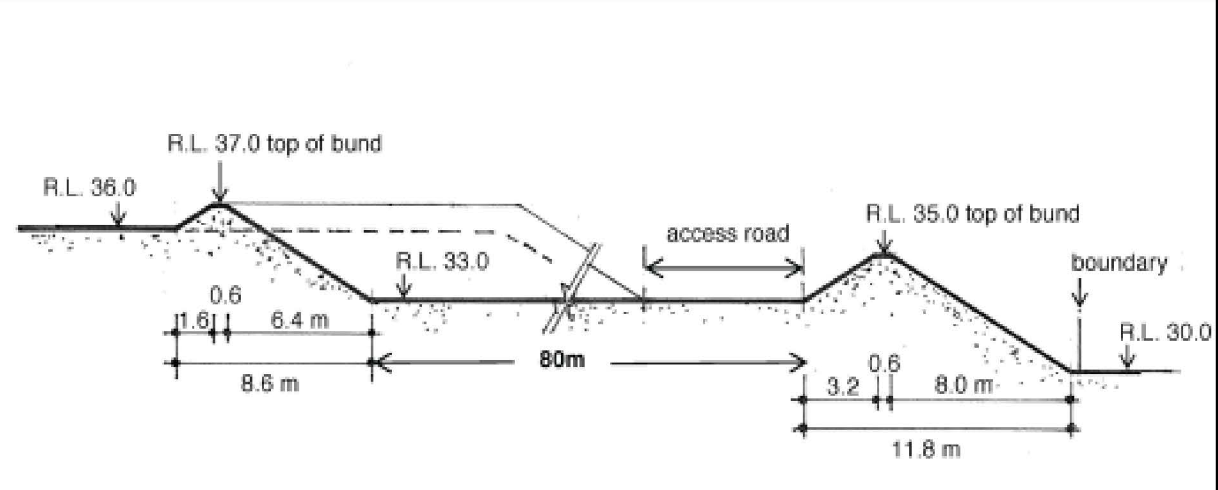
Notes:
TP = Test Pit Location (PB, 2007)

Drawn by: Dale A	Scale: 0 50 m	North
Date: 10/09/2013		

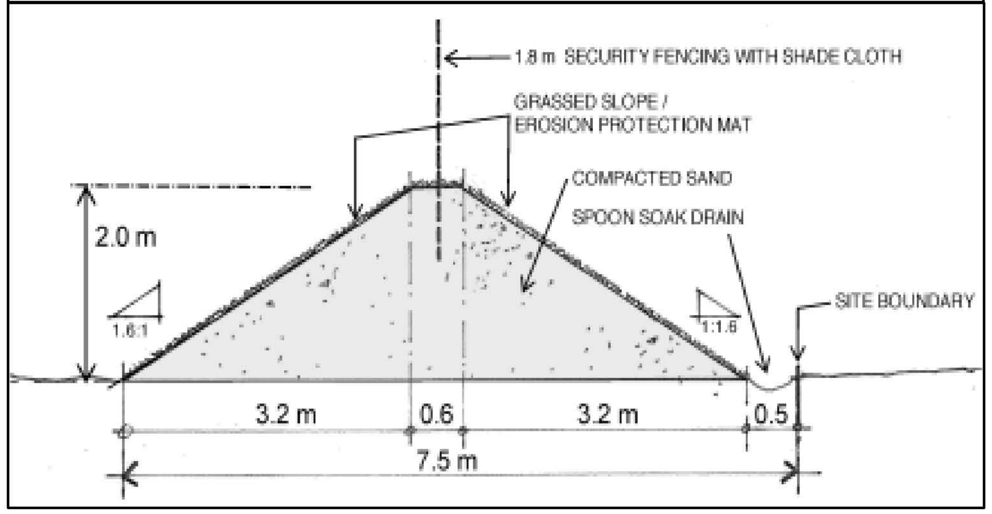
Project No:	Figure No:	Rev:
E2012 - 031	3	v1

NB: The remainder of the site is to be enclosed by fencing / security fencing around the perimeter.

Cross Section A - Detailed View



Cross Section B - Detailed View



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Client:

WASTEROCK PTY LTD

Project:

Hazelmere Remediation and Regeneration Project

Location:

Lot 20 Adelaide Street, Hazelmere

Drawing Title:

Site Setup and Bund Details

Notes:

- Proposed waste transfer area
- Bund
- Maintenance area
- Proposed soil acceptance and treatment facility
- Approved sand bund to Adelaide Street frontage to prevent access and screen the site (see detail)
- Approved vehicle access track connecting site to Talbot Road
- Water supply (polypipe) from bore(s) to water tanks
- Location of groundwater extraction bore(s)
- Contours
- Existing shed to be relocated to works area
- Indicative excavation cells for remediation works to progress west to east
- Vehicle wash down bay
- 2 x 60,000L water tanks
- 97.18 Lot dimensions
- 31.0 Contour labels
- 36 12 Spot heights

• All images supplied by Rowe Group.

Drawn by: Dale A	Scale: Scale not Used	North
Date: 18/09/2013		
Project No: E2012 - 031	Figure No: 4	Rev: v1

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MDW ENVIRONMENTAL SERVICES

Client:

WASTEROCK PTY LTD

Project:

Hazelmere Remediation and Regeneration Project

Lot 20 Adelaide Street, Hazelmere

Drawing Title:

Air Quality Monitoring Station Locations

Notes:

AMS = Air Monitoring Stations

Movable monitoring Stations, to follow the excavation , dust generation at the face.

Personal Monitoring (PM) pumps

Crib room inside green zone compound. To ensure decontamination is happening.

Site Compound (Greenzone)

Red Zone Areas Also includes the Remediation of the historical landfill.

Changing Room and Shower Block

Dust	TES 7200 / TEOM
Asbestos	(SKCPCXR8 / XR5000)
Silica	(SKCPCXR8)
Metals	(SKCPCXR8)
Weather Station	

Wind Direction

Excavation Zone (example)

Drawn by: MB	Scale: 0 50 m	North
Date: 10/09/2013		

Project No:	Figure No:	Rev:
E2012 - 031	5	V2

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Client:

WASTEROCK PTY LTD

Project:

Hazelmere Remediation and Regeneration Project

Location:

Lot 20 Adelaide Terrace, Hazelmere

Drawing Title:

PROPOSED SITE LAYOUT AND REMEDIATION PLAN

Notes:

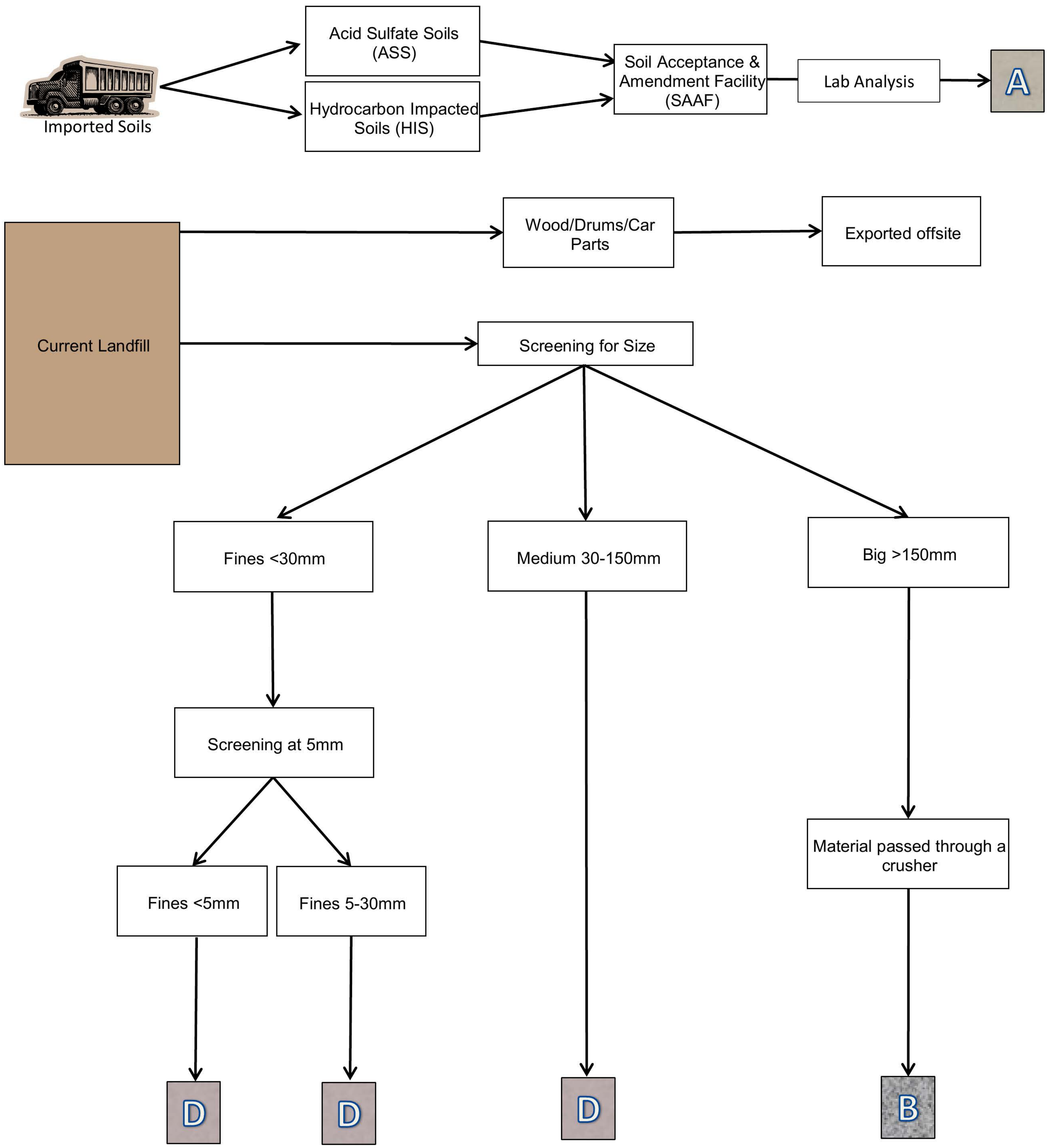
Flow of Excavation

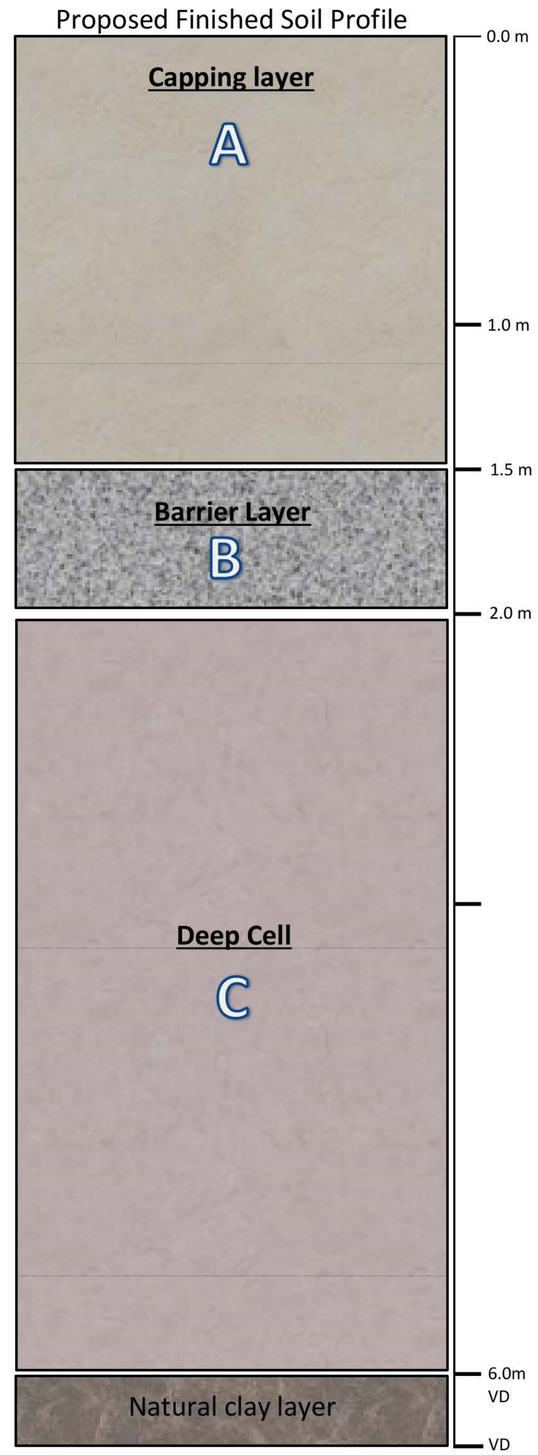
Notes:

Once the red zones have been remdiated then the they will become green zones. The green zones will be excavated and remdiated once the red zones have been cleared.

Drawn by:	Scale:	North
Date: 20/10/2013	Scale not used	

Project No:	Figure No:	Rev:
E2012 - 036	6	v1





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Client:

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Project:

Hazelmere Remediation and Regeneration Project

Location:

Lot 20 Adelaide street, Hazelmere

Drawing Title:

SOIL LIFELINE

Notes:

- Depths indicated are below proposed finished ground level.
- VD = Varying depths dependent on natural levels and the volume of Deep Fill.
- AF/FA = Asbestos Fine and Friable Asbestos laboratory analysis.

Drawn by:	Scale:
Dale A	Not to Scale
Date: 13/09/2013	

Project No:	Figure No:	Rev:
E2012-031	7	v2