10 *CONCEPTUAL SITE MODEL (CSM) REVIEW*

Conceptual site models (CSM) were prepared by both AEC (onsite; 2015a) and URS (offsite; 2016). It is understood that both assessors were in agreement on the CSMs for onsite and offsite conditions and that these CSMs combined to form the basis of the solute transport model developed by URS (2014) and reviewed by AEC.

10.1 *GENERAL*

According to the EPA publication *Site Contamination: Guidelines for the Assessment and Remediation of Groundwater Contamination* (February 2009), a CSM is a fundamental part of hydrogeological characterisation, and should be developed prior to intrusive groundwater investigations being undertaken.

The CSM is a representation of the physical hydrogeological system and its hydrological behaviour. The CSM should identify complete and potential exposure pathways between sources and receptors, including possible new exposure pathways (e.g. those created by a change in land use).

At this site, the CSMs describe the groundwater occurrence and condition in the vicinity of AA1, how former activities and infrastructure at AA1 have interacted with groundwater, and potential pathways by which chemical substances may migrate at and downgradient of AA1.

The Auditor considers the CSMs developed and detailed by both assessors as adequate. A summary of the CSMs developed by both assessors is detailed below.

10.2 *SUMMARY OF CSM*

Both AEC and URS have developed a CSM for onsite and offsite conditions. The Auditor requested that both Assessors confer and agree on the CSMs to ensure consistency across both assessment reports. The Auditor has reviewed these CSMs and considers that they adequately address the components as required in SA EPA guidance documents.

The CSMs have been developed based on soil and groundwater investigations conducted to date. Both utilise on and off site conditions pertaining to encountered geology and hydrogeology, soil and groundwater quality and potential pathways and receptors, as required [refer to AEC section 12 (2015) section 6 (2015a) and URS section 5 (2014 and 2016)]. A hydrogeological cross section, traversing both on and offsite was provided by URS (2016; Figure 5-1). It provides a diagrammatical representation of the encountered geology and hydrogeology along with identified source(s) of chlorinated hydrocarbons. However, the cross section does not show potential pathways and receptors of potential impacts.

URS (2016) notes that the bore logs do not indicate consistent geology and there is considerable uncertainty surrounding the process definition and locations of the aquifer units.

In AEC (2015a), the CSM, Figure O (pre area B remediation) and Figure P (post area B remediation) details geology and hydrogeology, as well as potential pathways and receptors of potential impacts. Refer to *Figure 15 Annex A,* which is a copy of AEC Figure P.

10.2.1 Local and Regional Geology and Hydrogeology

The general geological sequence at the site area comprises:

- Quaternary sediments of fluvial and marine origin of the order of 50 metres thickness. The surface geology is likely to be the Pooraka Formation overlying the Hindmarsh Clay;
- Tertiary sediments of mainly marine origin up to 200 metres thickness that underlie the Quaternary sediments; and
- Precambrian basement approximately 200-250 mbgl.

Natural material encountered in AA1 was generally consistent with the geology expected, i.e. red brown silty clays and clays to approximately 4 – 6 metres (interpreted as Pooraka Formation) with clay becoming pale brown to grey with calcareous inclusions (interpreted as Keswick Clay). This is underlain by grey clay with orange brown mottling (interpreted as Hindmarsh Clay formation) (AEC, 2015a). URS (2016) stated that it is *"not possible from the available information to state with confidence the thickness of the Quaternary aquifers, their degree of hydraulic separation from each other or the thickness of intervening low permeability layers, and it is possible that these may vary across the area of investigation"*. However, both AEC and URS consider the Q1 unit to be approximately 3 – 6 m thick.

A regional hydrogeological cross section (Figure 20 AEC 2015a) indicates that there may be three Quaternary aquifers (Q1, Q2 and Q3) and three Tertiary aquifers (T1, T2 and T3) beneath the site.

Relationships between various aquifers based on groundwater levels has been interpreted by both AEC and URS. Vertical hydraulic gradients indicate that downward leakage from the uppermost aquifer Q1, the one of most interest in terms of contamination, is unlikely to occur to the underlying aquifer, Q2, under current hydraulic conditions.

Further information related to geology and hydrogeology, in particular the groundwater flow regime for the Q1 aquifer, is summarised in *Section 8.7* of this audit report.

Additional aspects of the CSMs are summarised below:

10.2.2 *Natural Groundwater Chemistry*

AEC (2015a) note that onsite field records indicate that the pH of groundwater is generally neutral and the groundwater fresh to slightly brackish. These field parameters were relatively consistent during 2012 to 2014. The Auditor agrees with this interpretation of the field records.

Groundwater salinity has remained within approximately 1,000 mg/L to 1,500 mg/L TDS from 2010 to date.

A combined Piper/Schoeller plot was generated by AEC (2015a) using Q1 data reported groundwater cations and anions between 2012 and 2014. No discernible pattern was identified with potential impact of localised recharge likely to vary (AEC, 2015a).

Offsite field parameter observations indicate that the groundwater is pH neutral with redox potential indicating generally oxidising conditions (URS, 2014).

10.2.3 *Sources of Recharge and Extraction*

URS (2016) note that the general flow regime is likely to be driven by recharge in the Adelaide Hills to the east and discharge to the coast to the west which the Auditor concurs with.

AEC (2015a) notes that recharge specifically to the uppermost aquifer (Q1) typically occurs as a result of two major mechanisms:-

a) rainwater infiltration across the unpaved open space area; and

b) groundwater through-flow from up hydraulic gradient locations.

Generally, infiltration rates are likely to be low due to the combined effects of urbanisation (increased ground surface cover), the lining of surface drainage features with concrete and the high evaporation potential, which exceeds rainfall for most months of the year (based on the data presented in the Australian Bureau of Meteorology (BOM) website) (AEC 2015a).

However, during demolition and remediation stages localised recharge via infiltration may have occurred as evidenced by groundwater salinity and Piper plots of groundwater in AA1 (AEC, 2015a).

There are no onsite watercourses or water bodies deep enough to intersect the water table and to act as discharge areas for the uppermost aquifer at and in the vicinity of the site (AEC 2015a).

Based on the regional data presented in Gerges (2006) report (refer Section 6.1.2 of AEC(2015a) report) the discharge point for both the uppermost aquifers (Q1 and Q2) is likely to be the Gulf of St Vincent located approximately 5.5 km to the west of AA1.

The groundwater level in the Q2 aquifer was measured to be approximately 2 – 0.5 m (average 0.4 m) higher than in the overlying uppermost (Q1) aquifer. This indicates the potential for upward leakage from Q2 into Q1. Therefore the Q2 aquifer is not considered to be a discharge point for the uppermost (Q1) aquifer (AEC, 2015a).

Recharge to the deeper aquifers (Q2, Q3 and Tertiary) occurs via rainfall infiltration at the areas where these aquifers are exposed at the ground surface. Such areas have not been identified within the site area. The site specific and regional groundwater level hydrographs for the Q2 and T1 aquifers show a typical groundwater level fluctuation pattern indicating that the recharge of the deeper aquifers is likely associated with the regional rainfall recharge. The area of discharge for the deeper aquifers is also the Gulf of St Vincent (AEC 2015a).

10.2.4 Identified Contaminants

AEC (2015a) detail the contaminants of concern identified during groundwater monitoring as:

- Volatile chlorinated hydrocarbons, including tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (DCE) and vinyl chloride;
- Inorganics (nitrate and total organic carbon);
- Metals (boron, hexavalent chromium, lead, molybdenum, manganese, nickel and zinc);
- Petroleum hydrocarbons (TPH); and
- BTEX compounds.

It is noted that, since remediation of the site (i.e. full monitoring event in April 2013), lead, molybdenum and BTEX compounds have not been reported in groundwater at concentrations above adopted criteria. Molybdenum concentrations above adopted criteria were also only reported in groundwater from the onsite Tertiary bore, T1 and are not considered to be related to former site activities.

Volatile chlorinated hydrocarbons and nitrate were identified in groundwater both onsite and offsite. The plume of contaminated groundwater offsite in the downgradient groundwater flow direction to the west/northwest is discussed further below. The remaining contaminants, metals (boron, hexavalent chromium, manganese, nickel, zinc), and TOC were identified on site only.

AEC (2015; Figure N), presented results for groundwater monitoring bores MWD and MWAL and noted that "*PCE results exceed 1% of PCE solubility which may be indicative of past or present existence of DNAPL*". URS (2016) likewise made this point, as well as suggesting that this may also possible apply to bore MWBK, representing a potential ongoing source of PCE as a DNAPL.

Refer to *Section 12.3* of this report for discussion of groundwater monitoring and identified contaminants.

10.2.5 Contaminated Groundwater Plume

Investigations to delineate the extent of groundwater contamination were commenced by AEC in 2008 onsite and extended offsite from 2009. Figures L, M and N (AEC 2015a) detail the extent of onsite groundwater contamination, i.e. exceedances.

The results of offsite groundwater monitoring indicate that there is offsite contamination of groundwater by the following compounds:

- Volatile chlorinated hydrocarbons, PCE, TCE, DCE and vinyl chloride; and
- Nitrate (URS (2016).

The inferred lateral extent of PCE concentrations which represent the most extensive area of groundwater concentration that exceeds drinking water guideline are shown in *Figure 4 Annex A*. This figure indicates that there are two plumes both extending generally northwest from the former Hills Industries site. The northern plume width is approximately 50 – 200 m and extends approximately 1,000 to 1,200 m from the western boundary of the site. The southern plume is smaller with lower concentrations and is approximately 120 m wide and extends less than 500 m from the site boundary (URS, 2016).

URS (2016) also plotted PCE concentrations against distance along the apparent centreline of the northern plume (Figure 5-4), commencing at South Road. This indicates a clear trend of PCE concentrations declining with distance from the site. Similar plots for TCE and DCE (cis-1,2-DCE) concentrations (daughter products of PCE) reveal that the downgradient extents of these plumes (concentrations that exceed drinking water guidelines (EPA South Australia, 2003)) are much shorter than for PCE. Molar fractions of PCE, TCE and DCE concentrations along the apparent centreline of the northern plume suggests an onsite source of PCE in the vicinity of bores MWAL and MWD. The increasing proportion of DCE down gradient is possible evidence for the degradation of PCE to TCE and then to DCE.

Nitrate concentrations reported in groundwater both on and offsite are considered to be sourced at least in part from onsite historical activities. URS (2016) note that the higher nitrate concentrations do not coincide with the highest PCE concentrations and as such the nitrate and PCE originate from different sources.

In 2008/2009 AEC installed three deeper monitoring bores (screened in the Q2 aquifer), adjacent to shallower (Q1) bores; one of these bores has since been decommissioned. Concentrations of contaminants of concern in groundwater from these bores were lower than in groundwater from the adjacent Q1 bores. The highest PCE concentrations reported in groundwater from the Q2 bores remained below the adopted drinking water guidelines. Section 10.2.3 discusses the potential for vertical leakage between the Q1 and Q2 aquifers. URS (2016) report that the lateral extent of contamination in the Q2 aquifer or in other underlying aquifers has not been investigated offsite. This is because contamination of the deeper aquifers, if present, would not contribute to health risks associated with vapour inhalation due to the intervening confining layers/aquifer units and the known water quality at the water table off site (the majority of offsite bores are installed in the Q1 aquifer). URS therefore only considered impacts in the Q1 aquifer when assessing risks associated with groundwater contamination offsite. The Auditor concurs with this approach.

10.2.6 Modes of Chemical Migration

As detailed by URS (2016) PCE is a volatile, dense, non-aqueous phase liquid (DNAPL) with an aqueous solubility reported to be 206 mg/L. If released into groundwater as a DNAPL it tends to sink until it reaches a low permeability layer that it cannot penetrate or until its mass is reduced (by leaving a trail of residual PCE along its path) such that there is insufficient mass for continued movement of the liquid. However, as it migrates downward it may also migrate laterally, spreading out in response to localised heterogeneities in the aquifer. Under some environmental conditions, typically characterised as chemically reducing conditions, dissolved PCE can degrade into less-chlorinated ethenes by a process of successive dehalogenation, producing daughter products as follows:

PCE → TCE → DCE → VC → Ethene

URS (2016) detail the following mechanisms that could have contributed to the fate and migration of the identified contaminants:

- PCE (DNAPL). A number of mechanisms are available that control the migration of PCE as a DNAPL, including:
  - Gravity-driven migration down through permeable materials;
  - Potential lateral migration within the unsaturated and saturated zone to follow pathways of higher permeability; and
  - Potential lateral migration at the base of an aquifer along the top of the underlying low permeability layer (only occurs while sufficient mass remains).

  However, URS note that although migration by these mechanisms is likely to have occurred in the past, when primary sources were active (e.g. as inferred at the northwest corner of the ironing tables workshop), such migration is likely now to have ceased due to the lack of additional driving head and PCE mass, and to DNAPL mass being held in residual saturation within pore spaces through which it has migrated (URS 2016 Pg 42). Remediation activities are likely to have further removed DNAPL as a driving head from the aquifer.

- Dissolved contaminants – PCE, TCE, DCE, VC and nitrate:

    - Advection (dominantly lateral migration in the down-gradient direction with groundwater flow, as indicated by the inferred elongate shape of the PCE plume, extending offsite to the west);

    - Dispersion (longitudinal and transverse spreading of the dissolved contaminant as it migrates down-gradient). Typically, longitudinal dispersion is much greater than lateral dispersion, especially in advection-dominated systems such as at Edwardstown (resulting in relatively long, narrow plumes);

    - Diffusion (this can occur in any direction in response to concentration gradients). However, diffusion is generally minor relative to advection and dispersion except in formations with very low permeability or low gradient (not the case at Edwardstown);

    - Sorption of contaminants onto aquifer materials, and the potential of subsequent desorption if conditions change. The significance of sorption for organic compounds such as chlorinated ethenes is dependent mainly on the fraction of organic carbon in the formation. URS advised that soil samples tested by URS from offsite bores were found to contain <0.5% organic carbon indicating that sorption is likely to be relatively minimal in this area;

    - Potential degradation of chlorinated ethenes; and

    - Volatilisation of volatile contaminants from the groundwater surface and capillary fringe into the unsaturated zone.

- Vapour phase contaminants (PCE, TCE, DCE and VC):

    - Diffusion through the soil profile in response to concentration gradients;

    - Potential for advective flow associated with soil vapour movement caused by atmospheric pressure changes over time (generally in relatively close proximity to the surface);

    - Potential for contaminant sorption onto soil particles and dissolution into soil moisture; and

    - Potential for contaminant degradation.

The presence of daughter products of PCE, both onsite and offsite, implies that some degradation has occurred in the past, especially since the majority of DCE is the cis-1,2-DCE isomer, preferentially produced by reductive degradation. However, the current geochemical conditions of groundwater do not appear to be conducive to further degradation.

10.2.7 Groundwater Modelling

URS (2014) undertook analytical solute transport modelling. The USEPA software BIOCHLOR was used and the results of the modelling indicated:

- Overall the PCE, TCE and DCE plumes are likely to be in approximate steady state, such that ongoing flux of PCE dissolving and desorbing from the assumed secondary source area within the former Hills Industries site is balanced by ongoing natural attenuation processes (incorporating advection, dispersion, volatilisation and possible degradation);

- The source is assumed to have been active for at least 40 years;

- Contaminant losses could plausibly be due mainly to volatilisation from the water table. Other potential mechanisms for mass loss from the shallow aquifer include contaminant degradation and potential downward migration to deeper aquifers, although both of these are assessed as likely to be relatively minor.

The modelling has been reviewed by the onsite Assessor (AEC) and the Auditor who considers this acceptable for the purpose of this audit.

10.2.8 Contamination Sources

The primary source of the northern chlorinated hydrocarbon plume is likely to be from the northeast corner of the former Ironing Tables Workshop (EES, 2007; designated Area B) with an additional source associated with Pit 4 in the northwest corner of the site. PCE contaminated soil was removed from both areas (refer to *section 13* for further discussion).

The source of the southern plume has not been identified by either URS or AEC. The audits of both AA3 and AA2 have also not discerned a potential source for this plume.

It is possible that the historical groundwater flow regime in the vicinity of the site may have differed to current flows, i.e. there may previously have been a component of groundwater flow to the southwest. This would account for the southern plume as well as the reported trace concentrations of chlorinated hydrocarbons above laboratory detection limits but below assessment criteria in groundwater from bores in AA2 and AA3 (Refer to audit reports for packaged areas AA2 and AA3 for reported results).

Nitrate concentrations are likely to be sourced from historical onsite activities involving the use and/or storage of cyanide or ammonia or other nitrogen compounds. The reported concentrations of nitrate at background bore MWAZ suggest that an additional source of nitrate from offsite to the southeast may also exist.

Likewise, AEC(2015a) note that TCE was reported to exceed the adopted guideline in monitoring bore MWAZ in 2009, indicating the presence of TCE and light fraction hydrocarbon (C6 – C9) in groundwater at the eastern portion of the site may be partially attributed to the offsite sources.

10.2.9 Background Groundwater Quality

SA EPA detail in the *Guidelines for the assessment and remediation of groundwater contamination* that site contamination does not exist at a site if the chemical substances present on or below the surface of the site are the results of the natural environment and not present as a result of an activity that has occurred at the site or elsewhere.

An assessment of background groundwater quality undertaken by AEC (2015a) was limited to the Q1 aquifer. Based on inferred groundwater flow direction, onsite bores MWAM and MWAZ and, to a lesser extent MWB and MWE, were considered to be located in upgradient locations and potentially representative of background groundwater conditions. It was also noted by AEC that all onsite bores are installed in areas of historic potentially contaminating activities. Of the identified contaminants in groundwater, it is considered that boron and likely zinc reflect background concentrations. Molybdenum was reported in groundwater from the deeper T1 aquifer only. It has not been identified as a contaminant of concern and no background groundwater information related to this analyte is available. It is considered the remaining identified contaminants were sourced, wholly or partly (in the case of nitrate and TCE), from historical onsite activities.

The Auditor agrees with this assessment of background groundwater quality.

AEC (2015a) detail that elevated nitrate concentrations exceeding the drinking water guideline are considered indicative of ambient groundwater quality in the region but may also be related to former site activities. The historical storage and use of cyanide and ammonia on site may have contributed to nitrate concentrations as a result of nitrogen series transformations that can occur in groundwater.

A Beneficial Use Assessment (BUA) and determination of background concentrations has been completed by both Assessors with this information reviewed and discussed by the Auditor and detailed below.

10.2.10 *Beneficial Use Assessment (BUA) Of Groundwater*

A Beneficial Use Assessment (BUA) of groundwater was undertaken by both Assessors (AEC 2015a) and URS 2016). It is noted that AEC undertook a separate assessment of the Quaternary aquifers and the Tertiary aquifers. URS only considered the Quaternary Q1 aquifer. The Auditor has reviewed these BUAs and has considered all aquifers. A summary of the Assessors' onsite and offsite BUA is presented with the Auditor's assessment in *Table 10.1* below.

Table 10.1 Beneficial Use Assessment of Groundwater

Beneficial Use	**Assessor**		**Auditor**	
	Onsite AEC	Offsite URS	Onsite	Offsite
Aquatic Ecosystems – fresh and marine	No freshwater or marine water receptors have been identified onsite, not considered a beneficial use.	Freshwater – nearest watercourse is the Sturt River which is not considered a likely receptor and so not considered a beneficial use. Marine – Gulf of St Vincent is 4 km down gradient, not considered a beneficial use	Agree with assessor.	Agree with assessor.
Potable Use	Potable use unlikely for future use onsite as reticulated water available, not considered a beneficial use.	Reported salinity of groundwater in area in the range of 1,000 – 2,000 mg/L. Potential for potable use. Considered a beneficial use.	Although the use is unlikely due to the low yield and the availability of reticulated water, there is the potential for potable use and this must therefore be considered a beneficial use.	Agree with assessor, especially because of the presence of existing domestic bores.
Recreation & aesthetics	No current receptors and low bore yields in Q1 aquifer, considered unlikely for future use. However, potential for use of T1 aquifer. Considered a beneficial use.	As above.	As there is the potential for offsite groundwater users to fill pools/ spas, the potential for future onsite users to fill pools/spas is also considered possible and this is therefore considered a beneficial use.	Agree with assessor.

Beneficial Use	Assessor		Auditor	
	Onsite AEC	Offsite URS	Onsite	Offsite
Agricultural Use - Irrigation	As above	As above	As per potable.	Agree with assessor, beneficial use.
Agricultural Use - Livestock watering	Neither current nor future site use compatible with these values.	Not compatible with down gradient residential use, not considered a beneficial use.	Agree with assessor.	Agree with assessor.
Agricultural Use - Aquaculture	As above.	Not compatible with down gradient residential use, not considered a beneficial use.	Agree with assessor.	Agree with assessor.
Industrial	Bore yields of Q1 aquifer insufficient to support this use, use considered unlikely. However potential use of T1 aquifer is considered possible. Considered a beneficial use.	Not compatible with down gradient residential use, not considered a beneficial use.	As AA1 is currently and is proposed to include light industrial, considered a beneficial use.	As the areas surrounding AA1, immediately adjacent to AA2 to the west are light industrial, this beneficial use is considered possible.
Buildings and Structures	Footings of new site development may interact with groundwater and so considered a beneficial use.	Not assessed.	Excavations, services and buildings especially with regard to the basement construction, foundations may be deeper than groundwater, and so beneficial use possible.	Considered a beneficial use, especially as the water table is shallower to the west.
Human Health – Vapour Intrusion	Acceptable risk to human health if no low density constructed and so not considered a beneficial use.	Acceptable risk to human health unless concurrent exposure via both groundwater bore used for irrigation or recreation as well as inhalation and groundwater used for showering/bathing and main source of drinking water.	Considering all potential uses of the site in the future, vapour intrusion has the potential to impact on humans, and so is considered a beneficial use.	Considering the potential for use of groundwater for potable use or concurrent irrigation or recreation as well as inhalation in the future, possible risk to human health. Considered a beneficial use.

10.2.11 *Nature and Extent of Soil Impacts*

Concentrations of copper, lead, nickel, and zinc above the NEPM EILs were reported remaining in a number of locations across the site post remediation. Exceedances of benzo(a)pyrene and hydrocarbons (F3) above the NEPM ESLs were also reported in a number of locations across the site, with the majority of exceedances occurring in fill.

Concentrations of cadmium, lead, nickel, zinc and carcinogenic PAHs above NEPM HIL A were reported (lead, nickel at P18BW/3 and carcinogenic PAHs at Area H, Area F, TP426/ 427, TP211, Pit 2 and Pit 20) above NEPM HIL B and concentrations of lead above HIL D were also reported.

Groundwater monitoring results do not indicate potential impacts from these contaminants, with reported concentrations generally less than LOR. One exceedance of nickel just above the drinking water criteria was reported as were a number of exceedances of Agricultural – Aquaculture criteria, however this beneficial use has not been deemed as compatible with on or offsite site uses.

Leachability testing was conducted for a selected number of soil samples with reported concentrations of various analytes, heavy metals and PAHs, exceeding adopted assessment criteria. No exceedances of the soil investigation levels detailed in SA EPA *Waste Disposal Information Sheet - Current criteria for the classification of waste – including Industrial and Commercial Waste (Listed) and Waste Soil* were identified.

Remediation and validation works conducted have removed soil representing the majority of exceedances of NEPM HIL B. Exceedances that have not been characterised as statistically acceptable to remain on site have been detailed in Figure 38 by AEC (2015). Refer to *Section 15* for details of the current site condition post remediation and validation works.

It is also noted that areas of ash/cinders/charcoal were scattered across AA1, refer to Figure B in AEC SRA (2015). Although remediation and validation works have been undertaken in these areas, some areas of ash/cinder/charcoal remain insitu. One such area, TP447/Pit 20 the validation results were reported exceeding HIL B criteria and are to be managed by way of CEMP, refer to *section 12.9* for further discussion, and one area, BH111, ashy material remained as the material appeared to be a localised hot spot and was not considered by AEC to pose a risk based on the heavy fractions reported, depth of impact (2.4 mbgl) and localised nature.

10.2.12 *Potential Receptors & Exposure Pathways*

An assessment of the potential receptors and exposure pathways was discussed by both Assessors. Refer to Section 5.6 of URS (2016), and Section 6.6 of the AEC (2015a) reports.

The Auditor has reviewed these and found that they are consistent with those identified by the Auditor in S*ection 16* of this report.

10.3 *AUDITOR'S REVIEW*

The Auditor's review of the information contained within the CSM sections of the AEC and URS DRAs has indicated that the conceptual site models were adequate for the purpose of the audit.

11 ASSESSMENT REVIEW – PRELIMINARY SITE INVESTIGATION

Two preliminary investigations were undertaken of the larger Former Hills Industries Site, including AA1. These included a Phase I Environmental Site Assessment completed by PB in 2006 and then a Limited Environmental Site Assessment completed by EES in 2007. The further investigations undertaken by AEC have relied on these reports.

Further details regarding these reports are provided below:

11.1 PHASE 1 ENVIRONMENTAL SITE ASSESSMENT – PARSONS BRINKERHOFF (2006)

Parsons Brinkerhoff (2006) undertook a Phase 1 Environmental Site Assessment at the entire Hills Industries site (Audit Areas 1, 2 and 3). This assessment involved a detailed desktop study and site history to identify activities that have, or may reasonably be inferred to have, been carried out on or near AA1 and that had the potential to cause site contamination. Where such activities were noted, likely chemical contaminants associated with these activities were nominated.

The report also included a summary of historical works undertaken on the Former Hills Industries site between 1996 and 1999 including groundwater investigations, groundwater remediation and health risk assessment on the former Mobil Fuel dispensing facility located within AA1.

Pertinent to AA1, the report made specific observations and noted anecdotal evidence related to the site. At the time of the site visit, demolition works had not occurred. The existing infrastructure and activities that occurred within them were documented, with anecdotal evidence provided of historical infrastructure and activities based on comments from Mr Bob Hill-Ling who was a descendant of the original founders of the Hills Industries site and worked as an engineer at the site from its inception in the mid-1950s until his retirement in October 2005. Mr Hill-Ling was the Chairman and Managing Director of Hills Industries for a period of approximately 27 years. This information was used to develop a figure of current and historical site use, refer to *Figure 4 Annex A* which provides details of historical site activities (2006 and earlier). The Auditor also completed a spreadsheet of historical information regarding buildings, infrastructure and site activities to understand potential contaminating activities and chemicals of concern. Refer to *Annex E* for this.

Based on the available information regarding site ownership and land use, the following potentially contaminating activities detailed as having, may have, occurred at AA1 (refer to *Annex E* for more detailed information):

PB detail the following potentially contaminating activities:

- former use of underground tanks (USTs) for the storage and dispensing of fuels;
- former/current use of aboveground tanks (ASTs) for the storage and dispensing of fuels;
- historical storage and use of a range of chemicals;
- current storage and use of a range of chemicals;
- historical on-site chemical disposal;
- use of in-ground sumps to collect waste chemicals;
- presence of asphalt paving;
- use of termiticides;
- use of weedicides;
- historical use of a weighbridge;
- historical vehicle maintenance activities including use of a hoist and vehicle servicing pits;
- historical use of a vehicle washdown area;
- use of oil within electricity transformers;
- presence of asbestos building products;
- presence of fluorescent light fittings;
- vehicle parking.

It is considered possible that the following potentially contaminating activities may also have occurred at the site:

- use of fill materials from unknown source(s);
- commercial fuel storage/dispensing facility;
- on-site disposal of combustion products due to historical use of wood-fired boilers;
- preservation of timber for use in furniture manufacture;
- presence of remnant ballast material associated with former rail siding;
- historical use of agricultural chemicals;
- historical presence of a sheep or cattle dip.

The PB report also detailed potentially contaminating activities for the other areas of the Former Hills Industries site, i.e. AA2 and AA3. Refer to *Tables 9.4 and 9.5* for PCAs identified on and offsite which may directly or indirectly impact on AA1.

No intrusive investigations were completed as part of the PB assessment.

PB concluded "*given the number of light industrial properties are, or have been, located within the vicinity of the Hills Industries site, it is considered possible that groundwater contamination may be present within this general area as a result of past or present chemical use and/or fuel storage practices. One such site could be …Castle Plaza*" which "*included a petrol station approximately 250 m south of Raglan Avenue.*"

The PB investigation was undertaken prior to the engagement of the Auditor.

An asbestos register for the entire Former Hills Industries site was provided, located in Appendix R of the PB report. It is understood that buildings and structures identified as containing asbestos were appropriately managed during demolition and removal works, refer to *section 13* which discusses site remediation. Asbestos was included as a PCOC and included as a soil investigation analyte.

Asbestos materials identified as present on the site included asbestos cement sheeting, zelemite (electrical board), formed asbestos cement and malthoid sealant. The condition of these materials ranged from poor to good and although these materials were listed as bonded, some were noted to contain visible exposed fibres. In addition, some asbestos signage was recorded as already in place, however, not all asbestos containing materials were labelled.

11.2 AUDITOR'S OPINION REGARDING ADEQUACY OF ASSESSMENT

The desktop Phase 1 investigation described in *Section 11.1* above did not include any intrusive works, however, the assessment was the only documented account of potentially contaminating activities. Considering this is the only report which details AA1 pre demolition, it is heavily relied upon for understanding AA1 activities. Subsequent investigations have been carried out to characterise the contamination status of AA1 based on this desktop report (as detailed in *Section 12* below).

12 ASSESSMENT REVIEW - SCREENING AND DETAILED RISK ASSESSMENTS

The Auditor has discussed both the Screening Risk Assessment and Detailed Risk Assessments completed on and offsite in this one section.

12.1 GENERAL

A number of onsite and offsite investigations have occurred for AAl.

Environmental Earth Sciences (EES) (2007) undertook a Limited Environmental Site Assessment at the entire former Hills Industries site (Areas 1, 2 and 3), undertaking a soil assessment and limited groundwater assessment. The purpose of the assessment was to evaluate the potential for particular site activities to have impacted on underlying soil and groundwater and assess the works necessary to render the site suitable for ongoing commercial and industrial land use.

AEC have supervised the demolition and removal of above and below ground infrastructure and undertaken soil, groundwater and soil vapour assessment, including removal of the majority of identified soil impacted areas across AA1.

URS have undertaken groundwater, soil vapour, indoor air quality and utility pit assessment works in offsite areas to the west and north of AA1.

AEC and URS have completed initial screening risk assessments (AEC 2014 and URS 2014) identifying that groundwater is contaminated due to historical site activities, thus requiring Detailed Risk Assessments to be completed (AEC 2015a and URS 2016).

The results of the limited investigations undertaken by EES (2007) have been incorporated into the AEC SRA (2015). Although both onsite and offsite assessments have been conducted separately, the Auditor has considered both as part of this audit.

12.2 SOIL ASSESSMENT

No offsite soil assessment has been conducted as part of AA1 investigations.

12.2.1 General

EES undertook a limited assessment of the former Hills Industries site (Audit Areas 1, 2 and 3). The purpose of the EES assessment was to evaluate the potential for particular site activities to have impacted on underlying soil and groundwater and assess the works necessary to render the site suitable for ongoing commercial and industrial land use. EES undertook soil assessment works in 2007.

AEC undertook further assessment works (2008 - 2014) to further investigate and delineate the identified impacts and undertake works necessary to render the site suitable for mixed use purposes. AEC undertook works prior to, during and post the demolition of site infrastructure. It is noted that the demolition of buildings and subsurface infrastructure involved validation works considered in *section 13* of this audit report.

Pertinent to AA1, the following sampling, analysis and evaluation was undertaken.

12.2.2 Sampling Locations

A Sampling location plan was provided by EES, a copy of which is provided in Appendix A, and discussed in Section 5.2, of the EES report (copy provided as Appendix D of the onsite SRA (AEC, 2015), with the locations also noted within *Figure 9 Annex A*.

A Sampling location plan was provided by AEC within Figure 31 of the AEC SRA (2015) report, a copy of which is also located in *Annex A as Figure 9.*

12.2.3 Sampling Plan and Sampling Methodology

EES undertook soil investigation works in April 2007. EES drilled/excavated 72 soil bores/test pits (BH1 – BH52, BH55 – BH70 and BH92 – BH95) and three soil surface samples (T1 – T3). The program was based on targeted potential contaminating sources, e.g. storage and use of a range of chemicals, historical onsite chemical disposal, use of inground sumps/drains to collect waste chemicals, vehicle servicing, and transformers, and to provide site coverage. Refer to *Section 5.2.2* of the EES report for the soil sample location rationale. Test pits were placed in low trafficked areas while bore holes were chosen in less accessible areas or high traffic areas.

The methodology was detailed as follows:

- Soil bores/ test pits were extended through fill, where applicable, into natural underlying soil or refusal on impenetrable material by way of drilling (push tube, geoprobe), hand auger or by test pitting. Bores were drilled to generally 2 to 3 metres, however drilling was extended to 5 to 6 metres around tanks or where odorous were detected to determine the vertical extent of contaminant migration. The Auditor notes that details regarding the method of test pitting was not provided;
- Soil encountered was logged, including pH, texture and odour;
- Samples were collected using disposable nitrile gloves which were replaced between each sampling event;
- Samples were collected at regular intervals per soil bore/test pit, one within fill, one at natural and one every 1-2 metres. Samples also appear to have been taken at changes in lithology or based on field observations such as odour or PID readings. (Refer to section 8.7.2 for details of the lithology encountered across AA1);

- Field screening of soil samples was based on colour, texture, odour, pH of soil profiles and screening of samples using a Photoionisation Detector (PID) to identify any volatile organic compounds. The majority of PID readings were < 2ppm. However, there were a number of bores and test pits where PID was detected above 2ppm. Samples were taken at these locations and were often further delineated as part of remediation works, discussed in Section 13 of this audit. The Auditor has reviewed the bore and test pit logs and confirmed the identification of samples for analysis. Any observations considered by the Auditor requiring further investigation were followed up by AEC in their continuing investigations to close out;
- Soil samples were placed into laboratory supplied glass jars, labelled, stored on ice and were provided to the primary laboratory by way of chain of custody;
- No information regarding decontamination has been provided;
- Insufficient methodology and assessment of QA/QC of field and laboratory procedures was provided in the report, noting that "further details on the QA/QC results can be provide upon request". A subsequent report provided by EES titled "Addendum to Environmental Earth Sciences NSW Report Number 107053 – Quality Assurance and Quality Control Document", dated December 2011 was provided. The document provided further information, however the following deficiencies were noted by the Auditor:
    - Blanks, spikes and rinsate samples – It is noted in the addendum that no trip blanks or rinsate samples were taken. This approach is considered inadequate:
        - Rinsate samples. During soil sampling EES used a number of field tools coming in contact with the soil samples, including a spatula for preparing the soil samples, push tubes and hand auger. As there was a requirement that these instruments were decontaminated between samples, there is a demonstrable need for rinsate blanks to also be taken; and
        - Trip blanks – Considering the soil and groundwater samples were potentially high in volatile contaminants there was a demonstrable need for trip blanks to be taken to confirm no cross contamination of volatiles during shipping.
        - Duplicate Sampling. The number of duplicates taken on site during the works do not meet Australia Standard 4482.1 nor EES's own internal minimum frequencies specified in Section 2, Table 2. Stated actual frequency of duplicates was 1 per 42 for intra laboratory duplicates and 1 per 75 for inter laboratory duplicates for soils. No groundwater duplicates were taken; and
        - Calibration of field instruments – insufficient information provided regarding field instrument calibration, such as frequency.

As such, AEC recommended, and the Auditor approved, undertaking duplicate test pitting and sampling of a number of EES sample locations to confirm EES results. These are detailed below.

AEC installed and excavated 121 bore holes (BH101 – BH113, BH126, BH401 – BH405, BH501 – BH502) and 176 test pits (TP101 – BH141, TP201 – TP228, TP401 – TP457, CTP1 – CTP9, FTP1 – FTP33, HTP1 – HTP8) and 12 trenches (TP1 – TP12). Also, 8 duplicate test pits were excavated to confirm EES results (TP301 – TP308). These works formed part of AEC further assessment works to assess potential soil and groundwater contamination within AA1. These investigations commenced in 2008, prior to the Auditor's engagement, and were completed in 2014.

The rationale for the investigation locations, including EES locations, are detailed in Table 6 of the SRA (AEC 2015). The locations have also been included in the Site History spreadsheet developed by the Auditor located in *Annex E*. In summary, the locations were a mixture of targeted locations based on potentially contaminating historical activities, identified areas of concern, those identified during EES investigations, i.e. Areas A – F, H and during AEC investigations, and site coverage, including ascertaining the existence or otherwise of below ground infrastructure across the site.

A draft Sampling & Analysis Plan (version 2), to be read in conjunction with AEC comments within a Site History Sheet developed by the Auditor (Refer to *Annex F* for a copy) was provided by AEC in May 2013 for additional works (TP401 – TP457 and TR1 – TR8). The previous version was reviewed by the Auditor with this updated plan reflecting the comments provided. Further to discussions with the Auditor, the proposed trench locations were revised with the Auditor confirming same in email dated 16 May 2013. The Auditor has confirmed that the works conducted after this time were consistent with this plan.

The methodology was detailed as follows:

- Soil bores were drilled using mechanical drilling equipment and push tube methods with samples collected from the soil cores, once logged;

- Samples were collected at regular intervals per soil bore, one at the surface (ranging from 0.05 – 0.4 mbgl), one at natural (from 0.3 – 3.8 mbgl) and one every metre and one at the base of the bore (ranging from 1.9 – 4.9 mbgl). (Refer to section 8.7.2 for details of the lithology encountered across AA1);

- Test pits and trenches were excavated using an excavator where soil samples were obtained directly from the excavator bucket, or from the site of the pits using decontaminated hand trowels;

- Samples were collected at regular intervals per test pit, generally at the surface in fill or disturbed natural (ranging from 0.0 to 0.4 mbgl), one at natural (from 0.1 to 3.4 mbgl), one at regular intervals ranging from 1 – 3 metres, and generally one at the base of the test pit (ranging from 0.2 – 4.9 mbgl). Refer to section 8.7.2 for details of the lithology encountered in AA1;

- Samples were screened in the field using a Photoionisation Detector (PID) to identify any volatile organic compounds. The majority of PID readings were < 2ppm. However, there were a number of bores and test pits where PID was detected above 2ppm, some up to 5,000 ppm. These bores were often further delineated as part of remediation works, discussed in Section 13 of this audit.

- No PID readings were provided for any of the samples in test pits named - TP 201 – 227, CTP1 -CTP 9, FTP1 – FTP33, HTP1 – 8, TP301 – 308;

- Soil samples were placed into laboratory supplied glass jars, stored on ice and delivered to the laboratory under Chain of Custody procedures;

- All locations were logged by an AEC qualified practitioner (refer to Annex G for bore holes/ test pit/ trench logs located within the EES and AEC assessment reports);

- Decontamination was carried out between soil bore sampling locations using high pressure water cleaning units. For test pits and trenches, decontamination of the hand trowels were conducted as follows:

  - All adhered soil and/or other matter was removed by means of scrubbing and flushing with clean water; and

  - The sampling equipment was then scrubbed in a phosphate free detergent solution (Decon 90) before being rinsed in two stages of clean tap water;

- QA/QC samples were collected for the entire investigation area, including intra laboratory (MGT Environmental) and inter laboratory (ALS) laboratory duplicate samples at a rate of 1:20, one rinsate sample and one trip blank was also collected.

The Auditor's representative undertook a site visit to AA2 during site investigations on that audit site, including review of trench excavations and test pitting conducted by AEC. This was conducted in November 2012. Similar works were conducted on AA1 by the same Assessor.

Auditor verification samples were taken revealing comparable results.

The Auditor considers the methodology for soil sampling from 2008 – 2014, pre and post auditor involvement as appropriate for the purposes of this audit.

12.2.4 *Sampling Analysis*

AEC (2015) have detailed the soil sampling analytical program in Table 7 of the SRA report. This table also details the assessment conducted by EES in 2007. For EES bores/ test pits all surface fill and/or reworked natural and 12 locations were analysed for heavy metals. Targeted bores/test pits were also analysed for TPH, BTEX, PAH, VOCs, with a small number analysed for PCBs, those in the vicinity of site transformers, phenols, OCPs and cyanide and fluoride.

Analysis conducted by AEC was based on further investigation/ delineation of EES limited investigation results, i.e. areas of concern, historical potentially contaminating activities and observations while undertaking the investigations. The majority of the analysis reflected these as well as contaminants of concern detailed in the Site History Sheet in *Annex E*. Targeted sampling and analysis also reflected onsite observations while undertaking works, such as soil staining, odours and PID readings. Asbestos was also included as an analyte based on the location of identified asbestos containing materials, identified in the PB report.

Based on AA1 area of 4.76 hectares (ha), 55 sampling points are recommended by the Australian standard AS4482.1 - 2005. This provides a 35.6 diameter of the hotspot that can be detected with 95% confidence. The number of sampling points meets this recommended number of sampling points following a grid based approach, however further targeted soil sample locations were required in response to identified potentially contaminating activities. A series of exploratory trenches were also excavated across AA1 to locate unknown infrastructure associated with previous land uses.

It is noted that URS (2015) undertook sampling and analysis of one soil sample below the water table at the base of each groundwater monitoring bore upon drilling and prior to installation in 2011. The analysis was limited to TOC, the results of which were below LOR (<0.5) in all bores except one bore (MWBH) the TOC was reported to be 1.0 % (URS, 2014)

12.2.5 *Summary of Relevant Field and Analytical Results*

Field Observations

EES soil investigations encountered fill material at depths generally ranging from 0.0 – 0.8 mbgl, under hardstand areas across the site, with deeper areas of fill reported up to 1.8 m bgl (BH1), likely to represent backfilled infrastructure.

EES (2007) summarises the fill material as consisting of crushed weathered granite and coarse sand or other gravel with brick charcoal and quite frequently some ash and clinker. Occasionally the fill contained glass, wood, bitumen, or metallic debris. Areas of encountered voids or refusal were also noted in the borehole logs, reflective of historical infrastructure either removed or remaining insitu.

The following were of note:

- Ash/coke were identified at a number of bore/test pit locations across AA1, refer to Figure 38 in the AEC SRA for details of combustion waste identified within both EES and AEC soil investigation locations;
- Bores with high reported PID readings and/or odours were:
  - BH13 and BH17 - noted with high PID readings and strong odours;
  - BH20, BH25, BH27 – reported with faint solvent odour;
  - BH30 and BH32 – reported with PAH odour;
  - BH36 - strong hydrocarbon odour reported;
  - BH46 – high PID, hydrocarbon odour and hydrocarbon staining;
  - BH47 – high PID and diesel odour;
  - BH68 – PAH and hydrocarbon odours; and
  - BH69 - high PID and solvent odour.
- Voids/rubble/ deep fill were also identified in the following bores:
  - BH1 and BH17 and BH48 – fill to 1.8 mbgl, 1.2 mbgl and 1.1 mbgl, respectively;
  - BH26 void noted as a tram maintenance pit and BH70 a number of voids at depth; and
  - BH48 and BH29 refusal on rubble.

Beneath the fill material the natural soil encountered comprised a thin (0.1m thick silty sandy clay material with a dark brown colour. This was the natural topsoil. Beneath the topsoil (where present) the natural subsoil consisted of a deep red/brown stiff to plastic heavy clay with occasional charcoal inclusions. This layer was generally about 1 metre thick and graded to light brown, red brown of yellow brown mottled clay with carbonates present. Below 5.5 metres the clays became inter-bedded with sand lenses in which free moisture was observed at the base of BH13.

Two cross sectional stratigraphies are provided as Figures 7a and 7b of EES report. The locations of which are shown on Figure 6.

The Auditor has reviewed these cross sections and confirm they reflect the encountered lithology as reported by EES.

The encountered lithology by AEC (pre demolition) was generally consistent with that encountered by EES and URS.

AEC note (AEC, 2015) that prior to demolition works fill depth ranged from 0.2 to 3.6 metres in thickness (typically approximately 0.2 – 0.4 metres in the eastern portion of the site and 0.8 – 1.0 metres in the western portion of the site). Various fill materials were identified including: -

- sands and sandy clays with crushed rock inclusions (particularly sub-slab);
- silty clays with various secondary inclusions such as crushed rock, red brick fragments, ash and cinder inclusions (potentially material from historical cut and fill);
- clays with brick and ash inclusions;
- Deep pockets of fill material were identified as follows: -
  - sands and clays (with poor sample recovery) were identified in BH111, BH112, TP204, TP205, TP210 – TP212, TP215 and TP227 located in the Clothesline / Playtime Building. Drilling refusal at 2.5 mbgl in BH111 and 0.4 mbgl in TP218. This is likely to be associated with infrastructure relating to former sub-slab access tunnels which were subsequently removed; and
  - sand with crushed rock was encountered to 3.6 metres below ground level in BH126. This is in the location of the backfilled tank pit of the former fuel dispensing facility.
- Grey staining and hydrocarbon / solvent odour was noted in natural clays from 1 to 4.5 metres in the soil bores located BH102 – BH107 located in and around the Press Shop and Auto Press Shop. Strong hydrocarbon odour and staining was also noted in the base (3.6 mbgl) of the backfilled tank pit located to the west of the TV/Antennas Building;
- Combustion waste – ash, cinders, coke and charcoal were identified across the site, locations, EES and AEC, are detailed in Figure 38 of the AEC SRA report. It is noted however that some trenches have not been detailed in this figure, i.e. TR5, 9, 10 and 12;
- Selected samples from each soil bore, test pit and trench were screened for volatile organic compounds in the field using a PID and noted on the logs. Observations such as odour and staining were also noted on the logs. AEC (2015) have tabulated the PID readings and observations in Table 14. Samples were analysed in consideration of these observations. The Auditor has reviewed the logs and considers that appropriate sampling and analysis was undertaken in consideration of these observations. Appropriate remediation and validation of areas of concern have been undertaken, refer to *Section 13* of this report.

Based on work conducted after the demolition and removal of the majority of the onsite infrastructure, the following lithology was encountered, AEC (2015) detail that fill depth ranged from 0.2 to 4.1 metres in thickness (average 0.57m) across the site. Fill material averaged approximately 0.5 metres in the eastern and central portion of the site and 0.7 metres in the western portion of the site. Various fill materials were identified including: -

- sands and sandy clays with crushed rock inclusions;
- silty clays and sandy clays with various secondary inclusions such as crushed rock, red brick and slate fragments, ash and cinder inclusions (potentially material from historical cut and fill); and
- clays with brick and ash inclusions.

Deep pockets of fill material (i.e. >1m) were identified as follows: -

- Silty, gravelly sand and cobbles in TP436 in the approximate location of a former transformer and sump adjacent the former Auto Press;
- Silty sands with secondary inclusions of crushed rock, brick and concrete fragments in TP442, TP446 and TR5 located in the footprint of the former Clothesline and Satellite Dishes Building;
- Sandy silt with crush rock and brick fragment inclusion in TR7, the location of backfilled Pits 5 and 6; and
- Deep (4m) backfill sands in the location of the former USTs (part of the former fuel dispensing facility) located to the west of the TV Antennas Building (TR8).

The Auditor also notes the following observations gleaned from section 5.1.2 of the AEC report (2015):

- Fill to a depth of 1.2 mbgl in Trench 5 (TR5) located in the Clothesline building;
- Fill to a depth of 1.4 mbgl encountered during excavations of Trench 7 (TR7) as it was excavated through the backfilled excavation of Pit 6.

Ashy materials were identified in discrete lenses, particularly in the north western portion of the site. The location of identified combustion waste soil impact locations is in Figure B in the SRA (AEC 2015). Grey staining and hydrocarbon odour was noted in deep backfill sands and natural clays 3.5 to 4.3 metres in the backfilled UST pit located adjacent the TV Antennas Building. A plan demonstrating the approximate depths of fill material across the site (based on 2013 investigations) is presented in Figure 32 (AEC 2015).

The Auditor has reviewed the observations during site investigations, pre and post demolition works, and considers the details provided by AEC as reflecting such observations.

Laboratories used and NATA Accreditation

An assessment of the analysis of the laboratories and their respective analytical methods was undertaken by the Auditor.

For EES investigations, NATA accredited laboratories have been used including MGT Labmark (MGT) and Australian Laboratory Services (ALS) in Clayton Victoria as the primary and secondary laboratories, respectively. Analytical methods employed by the laboratories were considered appropriate for this investigation.

As detailed above, AEC undertook duplicate sampling and analysis in a number of the EES sample locations to confirm EES reported results.

For AEC investigations, MGT analysed primary and blind field duplicate samples and ALS analysed inter-laboratory duplicate (ILD) samples. Both laboratories are accredited by the National Association of Testing Authorities (NATA) for the analyses performed. Samples of soil for assessment for asbestos containing materials and/or asbestos fibre were submitted to AECs NATA accredited testing laboratory

Laboratory reports and chain of custody forms were provided in Appendix O of the AEC (2015) report.

Analytical Methods

Laboratory analytical methods for soil analysis have been reviewed by the Auditor and considered acceptable. A review of the quality assurance for soil sampling is provided in *Section 14 (Table 14.1*).

Soil Analytical Results

A summary of reported soil results prior to remediation/validation from EES and AEC investigations is presented in Table 15 of the AEC SRA report (2015). It is noted that the majority of the investigation works were undertaken prior to the amended NEPM (2013). It is also noted that AEC has compared the results with the most conservative proposed land use criteria, i.e. HIL B, however not the most conservative land use possible. The Auditor is required to assess all potential future land uses, and so has also reviewed the results against HIL A, C and D.

Reported concentrations of analytes that exceeded the adopted EILs/ ESLs criteria, majority within fill materials and ashy lenses across the site, are detailed in the table below:

Table 12.2 Soil Analytical Results – EILs and ESLs

Analyte	Adopted Assessment Guideline Exceedance
Arsenic	NEPM EIL (100 mg/kg urban residential/public open space) - one exceedance at BH18 at 0.3 – 0.4 mbgl, reporting concentration of 152 mg/kg
Chromium (total)	NEPM EIL (690 mg/kg urban residential/public open space and 1,100 mg/kg commercial and industrial - one exceedance BH3 0.1 – 0.3 mbgl reporting a concentration of 1370 mg/kg and two exceedances at Pit 18,(VP18_B1 and VP18_B4 (urban only), reporting concentrations of 2,300 mg/kg and 1,100 mg/kg, respectively.
Copper	NEPM EIL (110 mg/kg urban residential/public open space and 150 mg/kg commercial and industrial) - number of locations ranging from 120 mg/Kg to 3,900 mg/kg exceeding both criteria
Lead	NEPM EIL (1,100 mg/kg urban residential/public open space and 1,800 mg/kg commercial and industrial) - number of exceedences of both criteria
Nickel	NEPM EIL (40 mg/kg urban residential/public open space and 60 mg/kg commercial and industrial) - number of exceedences of both criteria
Zinc	NEPM EIL (290 mg/kg urban residential/public open space and 420 mg/kg commercial and industrial) number of exceedences of both criteria
Benzo(a)pyrene	NEPM ESL (0.7 mg/kg urban residential/ public open space and 1.4 mg/kg commercial and industrial), as well as NEPM HIL A (3 mg/kg)[3]– number of exceedences of both criteria
Hydrocarbons – F3(C16- C34)	NEPM ESL – F3 (300 mg/kg urban residential/public open space and 1,700 mg/kg commercial and industrial) – number of exceedances ranging from 380 – 2,800 mg/kg of urban residential with one exceedance of commercial and industrial (FTP 25 (0.1 – 0.2 mbgl) of 2,800 mg/kg.
1. AEC (2015) 2. EES (2007) 3. SA EPA correspondence dated 3 July 2015, regarding ASC NEPM ESLs for Benzo(a)pyrene, refer to *section 7.2.1*	

Exceedances have been presented in Table 15 and Figure 33 of the AEC SRA 2015. It is noted that the range of reported results in Table 15 do not include all reported results, such that a number of the results appear less than reported, including lead, tin, benzo(a)pyrene, PAHs (total) carcinogenic PAHs. However, the accurate exceedances of concern have been appropriately included in the subsequent tables within the SRA.

Reported concentrations of analytes that exceeded the adopted HILs/ HSLs criteria have been summarised in the table below:

Table 12.3 Soil Analytical Results – HILs and HSLs

Analyte	Adopted Assessment Guideline Exceedance
Arsenic	NEPM HIL A (100 mg/kg) - one exceedance at BH18 at 0.3 – 0.4 mbgl, reporting concentration of 152 mg/kg. No exceedance of HIL B
Cadmium	NEPM HIL A (20 mg/kg) at a number of locations at depths ranging from 0.0 – 1.0 mbgl (within fill/ashy lens) at locations BH3, BH6, BH50, TP221, TP401, TP402.

Analyte	Adopted Assessment Guideline Exceedance
	NEPM HIL B (150 mg/kg) - one exceedance at BH3 reported 206 mg/L at 0.1 – 0.3 mbgl, beneath the Maintenance workshop and attributable to former plating operations undertaken in this area
Lead	NEPM HIL A (300 mg/kg), HIL B (1,200 mg/kg) and HIL D (1,500 mg/kg) - number of exceedences up to 3,600 mg/kg, all reported occurring in fill.
Nickel	NEPM HIL A (400 mg/kg) – four exceedances (BH02 (0.4 – 0.45 mbgl) of 7,300 mg/kg, TP401 0.9 – 1.0 mbgl of 1400 mg/kg, P18BW (3.2 – 3.4 mbgl) at 2,100 mg/kg, TP402 0.3 – 0.4 mbgl at 640 mg/kg and TP433 0.0 – 0.1 mbgl at 630 mg kg; NEPM HIL B (1,200 mg/kg) - three exceedances (BH02, TP401 and P18BW detailed above). NEPM HIL D (6,000 mg/kg) - one exceedance (BH02).
Zinc	NEPM HIL A (7,400 mg/kg) - number of exceedences of criteria NEPM HIL B (60,000 mg/kg) - one exceedance at TP434 0.5 – 0.6 mbgl of 67,000 mg/kg.
Hydrocarbons – TPH C10 – C36 (refer discussion below)	NSW EPA (1,000 mg/kg) - 9 exceedances – BH2 (11,670 mg/kg), BH17 (2,090), BH24 (1420 mg/kg), BH27 (1070), BH36 (6590), BH111 (7900), TP203 (1245), TP 402 (1570), TP433 (1070)
Hydrocarbons – TPH C6 – C9 (refer discussion below)	NSW EPA (65 mg/kg) - 6 exceedances – BH13 (2490), BH17 (1270), BH18 (464), BH36 (102), BH103 (290), BH 105 (350)
Hydrocarbons – TPH C16 – C36 – Aromatics	NEPM (1999) HIL D (300 mg/kg) – 8 exceedances – BH2, BH17, BH24, BH27, BH36, BH68, BH111 and TP402 (detailed in Table 19)
PAHs – Total	NEPM HIL A (300mg/kg) – exceedances at two locations, FTP1 of 430 mg/kg and FTP 18 at 390 mg/kg, both samples taken at surface level (0.0 – 0.1 mbgl
Carcinogenic PAHs	NEPM HIL A (3 mg/kg) and NEPM HIL B (4 mg/kg) - a number of exceedences in fill, of concentrations up to 50.2 mg/kg NEPM HIL D (40 mg/kg) - two locations FTP 17 and FTP 18, both at depth of 0.0 – 0.1 mbgl, both reporting concentrations of 50.2 mg/kg. Refer to Table 20 in AEC SRA for details of locations
Chlorinated Hydrocarbons – PCE	Concentrations of PCE ranging from <0.5 to 3,600 mg/kg were reported across the site. Exceedances of site specific criteria were reported at BH17, TP102, TP106, TP118, TP136 and TP401 and BH19 (DCE). These locations were used for remediation/ validation works across the site. The criteria utilised were those created for Scenario 2 – Building with 1 level car park basement over residual soil impacts at 5 m depth (groundwater impacts remain) onsite workers. PCE calculated to be 6.5 mg/kg. The locations were in the north east corner of the Ironing Tables building and the north west corner of the site. Refer to Figure 36 for solvent impact locations (Note not include TP 401 (3600 mg/kg)).
Asbestos	NEPM HSL A-D Asbestos containing materials, in the form of small cement sheet debris fragments in surface fill material, were reported in two locations (TP408 and TP418).
1. AEC. (2015) 2. EES (2007) 3. ERS (2015)	

As previously detailed, the majority of assessment works at AA1 were undertaken prior to the release of CRC CAREs *Health Screening levels for* *petroleum hydrocarbons in soil and groundwater* in 2011 and the amended NEPM 2013. As such, the Assessor (AEC and EES) relied on other criteria to assess reported concentrations of petroleum hydrocarbons and BTEX compounds above laboratory limits of reporting to assist with assessment, remediation and validation works. AEC utilised NSW EPA guidance for initial screening of reported concentrations of TPH and BTEX compounds. Aromatic/aliphatic speciation was then conducted of those heavy fraction TPH concentrations based on inferred ratios from a 2013 sampling event results. Refer to Tables 18 and 19 within the AEC SRA 2015 report (both investigation and remediation/validation sample locations are included). The methodology has been reviewed and considered adequate for the purpose of this audit. These formed the basis for remediation/validation decisions made.

It is noted that an exceedance for BTEX compounds is noted however there are no criteria for samples within clay at that depth.

Leachate analysis was undertaken by AEC on selected samples to assess potential risks to groundwater from heavy metals. A comparison of the results against the acceptable leachate concentrations for Intermediate Landfill Cover detailed in the SA EPA Waste Disposal Information Sheet: EPA 889/10 *Current criterial for the classifications of waste-including Industrial and Commercial Waste (Listed) and Waste Soil"* revealed no exceedances.

Asbestos

AEC (SRA 2015) reported that asbestos containing materials (ACM) were reported in two locations (TP408 and TP418). ACM was reported in the form of small cement sheet debris fragments in surface fill material.

12.3 GROUNDWATER ASSESSMENT

12.3.1 General

As with the soil assessment, EES undertook a limited assessment of the former Hills Industries site (Audit Areas 1, 2 and 3). EES utilised the existing onsite bores for the purpose of assessing whether onsite activities had impacted on underlying groundwater. AEC undertook further assessment works, installing groundwater monitoring bores both on and offsite to further investigate and delineate the identified impacts. URS, replacing AEC offsite, commenced offsite investigations in 2011 with the installation of a further 10 groundwater monitoring bores and ongoing monitoring.

Pertinent to AA1, the following sampling, analysis and evaluation was undertaken.

Groundwater monitoring bores were not installed as part of EES's limited investigation, however existing onsite bores, MW1 and MW2, located in the vicinity of the former underground fuel store in the western end of the site were sampled. A sample was also collected from the main water supply bore for the site, called "treatment", however understood to be bore T1. (These samples were analysed for heavy metals, TPH, BTEX and major anions and cations).

AEC commenced onsite groundwater investigations in 2008 with extension of investigations offsite in 2009 and 2010.

URS installed 10 groundwater monitoring bores offsite in 2011 and continued offsite groundwater investigations from 2011 to date. URS also undertook groundwater sampling of 2 private groundwater monitoring bores (at 3 Stanton Street and 28 Towers Terrace) in the residential area. Refer to *section 4* regarding community consultation with regard to this monitoring.

With regard to the previous investigations related to the onsite Mobil fuel dispensing facility formerly in the west of the site, URS (2014) detail that "*no measurable thicknesses of petrol LNAPL (light non-aqueous phase liquid) were identified during the investigations in the 1990s. High concentrations of dissolved phase hydrocarbons including BTEX compounds…were reported in groundwater samples from two onsite bores (MW1 and MW2) but the concentrations declined considerably over the subsequent years and were below laboratory reporting limits when sampled in 2012 and 2013*". Refer to *section 11.1* where this facility is detailed.

12.3.2 Sampling Locations

Sampling location plans were provided by AEC and URS, copies of which are provided in *Annex A* as *Figure 9* and *Figure 10*, respectively.

The groundwater monitoring bores locations were selected to allow for a determination of inferred groundwater flow and assist with assessment of background groundwater conditions, as well as to target identified potential sources of groundwater contamination. Additional bores were drilled and installed as required to delineate identified groundwater impacts, in particular offsite.

The onsite groundwater investigation comprised the installation and sampling of 28 groundwater monitoring bores and the sampling of 3 existing groundwater monitoring bores (MW1, MW2 and T1). The rationale for the bore locations is presented in Table 46 of the AEC SRA (2015) report as well as detailed in *Annex E*. The locations of the offsite bores were to allow for the delineation of offsite groundwater impacts. The Auditor considers the rationale for the bore locations and their installation to be adequate for the purpose of this audit.

The majority of the onsite and offsite bores targeted the upper aquifer, Q1. AEC also installed three deeper groundwater monitoring bores adjacent to shallower bores resulting in 3 nested pairs.

Refer to *Section 8.7.4* for lithology encountered onsite. The groundwater monitoring bore details for both on and offsite are in *Table 12.3* below:

Table 12.3 Groundwater Monitoring Bores

Bore ID	DWLBC Permit	Date Drilled	Total Depth (mbgl)	Screen Interval (mbgl)	SWL (mbtoc) 2013	Groundwater Elevation (mAHD)
			ONSITE			
MWA	157170	10/11/08	7.8	4.8 – 7.8	-	DEM
MWA′	183631	07/07/09	7	4 - 7	5.46	22.39
MWB	157171	10/11/08	7.75	4.75 – 7.75	6.49	22.77
MWC	157172	10/11/08	7.0	4 - 7	-	DEM
MWC′	NAv	07/07/09	6.0	NAv	5.70	22.08
MWD^	157173	11/11/08	7.75	4.75- 7.75	-	DEM
MWC_Q2	191132	22/06/10	20	14 - 20	5.30	22.47
MWD_Q2^	167897	22/07/09	21	15 - 21	-	DEM
MWD	220546	05/04/13	7	4 - 7	6.05	22.43
MWE	157174	11/11/08	6.8	4 - 7	5.42	22.78
MWF	157175	11/11/08	7.6	4.6 – 7.6	-	DEM
MWF′	191135	29/06/10	7.0	4 - 7	5.28	22.07
MWG	157176	12/11/08	7.3	4.3 – 7.3	-	DEM
MWG′	191136	08/07/09	6.5	3.5 – 6.5	5.19	21.56
MWH	157177	12/11/08	7.2	4.2 -7.2	4.84	21.43
MWH_Q2	191133	22/06/10	20	14 - 20	5.01	21.96
MWI	157178	13/11/08	6.2	3.2 – 6.2	4.62	21.41
MWJ	157179	13/11/08	6.6	3.6 – 6.6	-	DEM
MWJ′	191137	07/07/09	6.5	3.5 – 6.5	5.44	21.60
MWK	157180	13/11/08	6.9	3.9 – 6.9	5.50	22.30
MWL	156250	14/11/08	6.7	3.7 – 6.7	4.91 (2008)	22.61-
MWM	157181	06/11/08	6.6	3.6 – 6.6	4.55	21.39
MWN	167893	06/08/09	7	4.0 – 7.0	6.40	22.65
MWO	167894	06/08/09	6.0	3 - 6	Blocked	-
MWP	167895	13/08/09	6.7	3.7 – 6.7	4.450 (2010)	22.34
MWQ	167896	13/08/09	6.5	3.5 – 6.5	-	DEM
MWQ*	191138	07/07/09	6.75	3.7 – 6.7	5.78	22.17
MWAK	183632	07/07/09	6.0	3 - 6	Blocked	-
MWAL	183633	07/07/09	7.0	4 - 7	5.75	22.21
MWAM	183634	07/07/09	7.0	4 - 7	5.19	23.53
MWAN	183635	07/07/09	6.0	3 - 6	5.46	21.97
MWAO	183631	07/07/09	6.0	3 - 6	Missing	-
MWAY	197397	30/11/10	6.5	3 - 6	5.24	21.95
MWAZ	197398	30/11/10	7.5	4.5 – 7.5	5.82	22.90
MWBK	229336	21/01/14	6.6	3.6 – 6.6	4.16	22.99
MWBL	229337	21/01/14	6.9	3.9 – 6.9	4.43	23.4
MW1	Existing well	NAv	8.2	NAv	4.51	21.54
MW2	Existing well	NAv	8.6	NAv	4.57	21.44
T1	Tertiary well	NAv	52 (2015)	NAv	NAv	-
			OFFSITE			
MWR	170050	Jul-2010	6	3-6	3.89	21.68
MWS	170051	Jul-2010	6	3-6	3.80	21.68
MWT	170052	Jul-2010	6.5	3.5-6.5	3.62	21.57
MWU	183488	Jul-2010	6.5	3.5-6.5	3.75	21.91
MWV	184485	Jul-2010	6.5	3.5-6.5	3.59	21.67
MWW	184483	Jul-2010	6	3-6	3.63	21.02
MWX	184482	Jul-2010	6	3-6	3.37	20.88
MWY	183492	Jul-2010	5.5	2.5 – 5.5	3.37	20.87
MWZ	183491	Jul-2010	5.5	2.5 – 5.5	3.26	20.97
MWAA	183490	Jul-2010	5.5	2.5 – 5.5	3.49	21.39
MWAB	183489	Jul-2010	5.5	2.5 – 5.5	3.63	21.64
MWAC	191125	Jul-2010	5.5	2.5 – 5.5	3.64	21.63
MWAD	191126	Jul-2010	6	3 - 6	3.84	21.52

Bore ID	DWLBC Permit	Date Drilled	Total Depth (mbgl)	Screen Interval (mbgl)	SWL (mbtoc) 2013	Groundwater Elevation (mAHD)
MWAE	191127	Jul-2010	5.5	2.5 – 5.5	3.53	21.55
MWAF	191124	Jul-2010	5.5	2.5 – 5.5	3.43	21.02
MWAG	191122	Jul-2010	5.5	2.5 – 5.5	3.11	20.01
MWAH	191121	Jul-2010	5.5	2.5 – 5.5	3.24	19.81
MWAI	191123	Jul-2010	5.5	2.5 – 5.5	3.23	20.45
MWAJ	191120	Jul-2010	7	4 - 7	3.58	20.39
MWAP	197399	Dec-2010	5	2 - 5	2.62	20.20
MWAQ	197400	Dec-2010	5	2 - 5	3.07	18.37
MWAR	197401	Dec-2010	5	2 - 5	2.96	17.86
MWAS	197402	Dec-2010	5.5	2.5 – 5.5	2.93	17.91
MWAT	197403	Dec-2010	5	2 - 5	3.45	18.81
MWAU	197404	Dec-2010	5	2 - 5	2.55	16.37
MWAV	197405	Dec-2010	5.5	2.5 – 5.5	2.62	16.37
MWAW	197406	Dec-2010	5	2 - 5	2.54	16.54
MWBA	200773	Apr-2011	6	1.5 - 6	2.87	19.02
MWBB	200774	Apr-2011	6	1.5 – 6	2.89	17.35
MWBC	200772	Apr-2011	6	1.5 – 6	2.77	20.71
MWBD	200775	Apr-2011	6	1.5 – 6	2.85	16.25
MWBE	200776	Apr-2011	6	1.5 – 6	2.55	15.50
MWBF	200777	Apr-2011	6	1.5 – 6	2.66	15.14
MWBG	200780	Apr-2011	6	1.5 – 6	3.57	20.79
MWBH	200778	Apr-2011	6	1.5 – 6	3.20	17.75
MWBI	200781	Apr-2011	6	1.5 – 6	2.25	15.48
MWBJ	200779	Apr-2011	6	1.5 – 6	3.31	21.27

DEM – demolished
NAv – Not available
- Not applicable as groundwater well blocked, missing, or destroyed.
On-site
SWL and groundwater elevation for April 2013 monitoring event with the exception of MWBK and MWBL at August 2014
Off-site
Date Drilled - first gauging round
SWL and groundwater elevation measured for January 2013.

The Auditor has reviewed the bore constructions logs and considers that the bores have been drilled and installed appropriately. It is noted that a number of bores have been demolished/decommissioned while site works have been undertaken. AEC (2015a) noted that the bores were decommissioned in accordance with the general specifications provided with the decommissioning permits; decommissioned by a licensed driller pressure-grouting the bores from the base to ground level. Decommissioning permits were sought for the majority of the bores, however, no decommissioning records were kept.

A review of the lithology and bore construction details of the onsite and offsite groundwater monitoring bores has revealed general consistency of bore installation across the groundwater monitoring bore network and that they have appropriately targeted the Q1 (or Q2 when applicable) aquifer.

12.3.3 *Sampling Plan and Sampling Methodology*

EES undertook groundwater monitoring using existing wells. No sampling plan was provided and the methodology of the monitoring detailed in the report is limited, instead referring to the EES soil, gas and groundwater sampling manual, which has not been sighted by the Auditor. Information provided in the EES report (EES, 2007) included:

- Standing Water Levels (SWLs) were gauged prior to purging and sampling;
- Field parameters were measured (pH, electrical conductivity, temperature, redox potential and dissolved oxygen); and
- Samples were placed immediately in ice filled coolers.

AEC undertook groundwater investigations which included:

- Obtaining bore construction permits for each groundwater monitoring bore prior to the commencement of drilling (refer to Appendix J of AEC (2015) report for copies of bore permits);
- Drilling and installation of 28 groundwater monitoring bores onsite and 28 groundwater monitoring bores offsite. Drilling of groundwater monitoring bores. For those bores targeting the Q1 aquifer, the bores were drilled to a maximum depth of 8.0 mbgl, using solid flight auger drilling technique. The screened intervals extended 3 m from the base of the bore. For both bores targeting the Q2 aquifer, the bores were drilled to a maximum depth of 21 m with a 6 m screened interval from the base. The deeper monitoring bores were drilled using solid flight auger drilling technique through the first water bearing layer (Q1) into the underlying aquitard material and the first water bearing horizon cased off and grouted. The drill hole was then extended into the deeper water bearing interval using mud rotary drilling;
- Logging of the soil encountered at each groundwater monitoring bore location by an AEC field engineer and recording construction details (refer to Appendix J of AEC (2015) report for bore construction details and Table 12.3 of this report);
- Developing all bores, as reported by AEC, using dedicated 'Waterra' tubing and footvalves until at least 3 bore volumes of groundwater were removed and purged water contained minor sediments;
- Undertaking groundwater monitoring on fifteen occasions from 2008 to date, with the last round of onsite monitoring undertaken in December 2014. AEC ceased offsite groundwater monitoring in 2011, with all results discussed and incorporated into the URS report (2014);
- Gauging of groundwater SWL from the top of casing prior to sampling, with groundwater elevations and inferred flow direction contour plan presented in Figures 31-34 (AEC, 2015a) for various monitoring events. A

site plan showing the locations of the groundwater monitoring bores located onsite is provided in Figure I (AEC, 2015), and the inferred groundwater flow direction is shown in Figure J (AEC, 2015). During gauging, an interface probe was used to check for phase separated hydrocarbons (free product) in the gauged groundwater monitoring bore. Water quality parameters (pH, temperature, conductivity, oxidation reduction potential and dissolved oxygen) were monitored during purging, and sampling was only undertaken when these parameters had stabilised. It is noted that on one occasion "free phase" was detailed as encountered during groundwater gauging during the April 2014 monitoring event in MW2. Gauging of that well on the subsequent two days did not indicate the presence of "free phase". Although the bore was originally installed to determine potential groundwater contamination associated with historical Mobil facility underground fuel tanks, no "free phase" has been identified subsequently and analytical results were not suggestive of product in groundwater at this location. The reporting of "free phase" is considered to be an error of equipment used by staff undertaking the gauging of bore MW2;

- Groundwater monitoring bores were generally purged and sampled using a Waterra sampling device with dedicated tubing for the 2008 – 2010 sampling events, with low flow micro purging technique utilised for all the monitoring events after that time, where possible. On occasion dedicated Waterra equipment, such as low flow pumps and tubing, was used;
- All samples were placed in appropriate containers containing preservative where required and provided by the laboratory for the analyte of concern. Groundwater samples collected for heavy metal analysis were filtered in the field using a Stericup pre-sterilised 150 ml vacuum driven disposable filter (0.45 um) prior to being placed in acid preserved sample containers provided by the testing laboratory; and
- All samples were stored on ice in an insulated container immediately following sampling and delivered under similar conditions to the analytical laboratory with accompanying chain of custody documentation.

Groundwater monitoring, post November 2013, was generally consistent with the Auditor endorsed Groundwater and Soil Vapour SAP (AEC 2013a).

The Auditor's representative attended an onsite groundwater monitoring event in 2012 conducted by AEC which covered the entire former Hills Industries site, i.e. all three audit areas including AA1 bores. Although the review was conducted while sampling an AA3 bore with a duplicate sample taken from that location, the review is considered relevant for AA1. It was noted that monitoring was conducted generally consistent with relevant groundwater sampling guidelines. Recommended updates to sampling techniques to improve the sampling results included positioning the micro purge pump 1 m above the bore depth, recording the bore depth on field sheets, and measuring the standing water levels of the bores pre and post dedicated tubing removal.

URS have undertaken offsite groundwater investigations since April 2011. This has included:

- Drilling and installation of 10 groundwater monitoring bores, additional to the 28 bores installed by AEC offsite, in April 2011;
- Obtaining bore construction permits for each groundwater monitoring bore prior to the commencement of drilling (refer to Appendix C of URS 2014) report for copies of bore permits);
- Drilling and installation of 10 groundwater monitoring bores targeting the Q1 aquifer. The bores were drilled to a maximum depth of 6 mbgl, initially using a hand auger to 1.2 mbgl depth and then advanced using solid stem auger drilling. A screened interval of 4.5 m was installed from the base of each bore;
- Logging of the soil encountered at each groundwater monitoring bore location (refer to Appendix C of URS report (2014));
- Developing all bores using a disposable bailer to remove a minimum of 4 bore volumes of water and sediment;
- A site plan showing the location of all the groundwater monitoring bores located offsite is provided in *Figure 10* and interpreted groundwater level contours in *Figure 12, Annex A;*
- Groundwater monitoring was undertaken on 7 occasions from 2011 to date with the last round undertaken October 2014. All bores were monitored in January 2012 and January 2013 with selected bores gauged and sampled in other monitoring events;
- Monitoring of the bores with initial gauging of groundwater SWL from the top of the casing prior to sampling. No non-aqueous phase liquids were reported;
- Purging and sampling of groundwater monitoring bores using the low-flow purging system except when the yield was too low or the sediment content to high. In those conditions, bores were sampled using disposable bailers; and
- All samples were collected into laboratory supplied bottles, stored on ice and sent to a NATA accredited laboratory for analysis.

Groundwater monitoring was consistent with the Auditor endorsed SAP, dated March 2011.

The Auditor considers the gauging and sampling methodology for groundwater monitoring conducted to date as adequate for the purposes of this audit.

12.3.4 *Summary of Relevant Field and Analytical Results*

Field Observations

Standing water levels measured in the bores onsite ranged from 3.65 to 5.56 mbtoc (AEC, 2014a), while offsite the depth to groundwater ranged from approximately 1.76 m to 4.14 mbtoc (URS, 2014).

The inferred groundwater flow direction both onsite and offsite is towards the west with a shallow hydraulic gradient. *Figures 11 and Figures 12 Annex A* show the most recent groundwater elevations.

Field water quality parameters for the most recent full monitoring events are summarised in *Table 12.4* below.

Table 12.4 Groundwater Monitoring Bore Water Quality Parameters - Summary

Location	Standing Water Level (mbtoc)	pH	Temp (°C)	EC (mS/cm)	Field Redox Potential (mV)	Dissolved Oxygen (ppm)
Onsite	3.645 to 5.558	6.75 – 7.71	18.3 – 22.2	0.92 – 4.08	-137 - 153	0.22 – 5.88
Offsite	1.76 m to 4.14	6.08 – 7.75	21.5 – 25.3	1.77 – 5.06	-39 – 230 (Converted to Eh (SHE) 135 – 457)	0.00 – 2.94
Source: AEC – onsite gauging from October 2014 event (2014a) with remainder from SRA (April 2013 monitoring event) (2015). URS –from April 2014 monitoring event, URS (2014c) SHE: Standard Hydrogen Electrode						

A comparison of standing water levels in Q2 and Q1 bores indicates that the standing water levels in Q2 were higher than those of Q1 bores, consistent with historical gauging results.

Laboratories used and NATA Accreditation

An assessment of the analysis of the laboratories and their respective analytical methods was undertaken by the Auditor.

For EES and AEC investigations, NATA accredited laboratories have been used including MGT and ALS as the primary and secondary laboratories, respectively. Analytical methods employed by the laboratories were considered appropriate for this investigation.

For URS investigations, NATA accredited laboratories have been used including ALS and MGT as the primary and secondary laboratories, respectively. Analytical methods employed by the laboratories were considered appropriate for this investigation.

Laboratory reports and chain of custody forms were provided in Appendix C of the EES (2007) report, Appendix O of the AEC (2015) report and Appendix D of the URS (2014) report.

Analytical Methods

Laboratory analytical methods for groundwater analysis have been reviewed by the Auditor and considered acceptable. A review of the quality assurance for groundwater sampling is provided in *Section 14 (Table 14.2 and Table 14.3).*

Groundwater Analytical Results

Major anions and cations results were evaluated using Piper Plots and Schoeller diagrams (refer to Figure 39, AEC 2015a). AEC considers the plots indicate a mixture of various groundwater fingerprints with no discernible pattern. This indicates some potential variability in groundwater recharge occurring within the site area. Typical cation/anion ratios for bores located primarily in the western portion of the site were identified (Figure 40, AEC 2015a) and indicated relatively lower proportions of sodium and bicarbonate , which may be indicative of a smaller influence from the localised groundwater recharge (AEC, 2015a).

Onsite Total Dissolved Solids (TDS) measured in the samples collected during the April 2013 sampling event, consistent with the concentrations reported in 2012, ranged from 480 mg/ to 2,400 mg/L (AEC, 2015). TDS values offsite were estimated based on EC values and ranged from 1,180 – 3,000 mg/L (URS, 2014).

The Auditor considers that the analytical program adequately allowed for an assessment of PCOC against screening criteria, understanding of groundwater chemistry and understanding of potential bioremediation potential.

The historical analytical results for onsite groundwater monitoring are located in Table 17 (AEC 2015). Exceedances of adopted criteria (April 2013 monitoring event) are detailed in the table below. It is noted that as bores MWBK and MWBL were installed after April 2013, the results for the subsequent reporting events have been used for these bores only.

The historical analytical results for offsite groundwater monitoring are located in Table B2 (URS, 2016). Exceedances of adopted criteria (April 2014 monitoring event) are detailed in the table below

Table 12.5 AA1 Groundwater Monitoring Results – Q1 and Q2: Exceedances of Criteria

Analyte	Onsite	Offsite
Volatile chlorinated hydrocarbons – PCE*	Drinking water criterion (0.04 mg/L) exceeded in groundwater from a number of bores with concentrations reported up to 25 mg/L (MWD, MWG, MWH, MWJ,	Drinking water criterion (0.04 mg/L) exceeded in groundwater from a number of bores, MWAD, MWAH, MWAI, MWAP, MWAS, MWAV, MWBG, MWS with

Analyte	Onsite	Offsite
	MWK, MWAL, MWBL). Site Specific criterion (12 mg/L) exceeded in groundwater from MWD. Potential for PCE to be present as a DNAPL in the vicinity of MWD and MWAL.	concentrations reported up to 1.05 mg/L.
Volatile chlorinated hydrocarbons – TCE*	Drinking water criterion (0.02 mg/L) exceeded in groundwater from a number of bores with concentrations reported up to 0.18 mg/L (MWD, MWG, MWH, MWK, MWAL, MWBK, MWBL). Site specific criterion (0.15 mg/L) exceeded in groundwater from MWD.	Drinking water criterion (0.02 mg/L) exceeded in groundwater from a number of bores – MWAH, MWBG and MWS up to reported concentrations of 0.09 mg/L.
Volatile chlorinated hydrocarbons – DCE*	Drinking water criterion (0.06 mg/L) exceeded in groundwater from a number of bores with concentrations reported up to 0.23 mg/L (MWG, MWH, MWJ, MWK, MWBL)	Drinking water criterion (0.06 mg/L) exceeded in groundwater from one bore, MWS, with a reported concentration of 0.068 mg/L.
Volatile chlorinated hydrocarbons – vinyl chloride*	Drinking water criterion (0.0003 mg/L) exceeded in groundwater from a number of bores with concentrations reported up to 0.008 mg/L (MWG and MWK).	Drinking water criterion (0.0003 mg/L) exceeded in groundwater from one location, MWS, with reported concentration of 0.0018 mg/L.
Nitrate	Freshwater aquatic ecosystems criterion (7.2 mg/L) and Drinking water criterion (10 mg/L) in groundwater from the majority of bores (up to 82 mg/L). The Agricultural – Livestock criterion (30 mg/L) was exceeded in groundwater from bores MWE and MWAZ.	Freshwater aquatic ecosystems criterion (7.2 mg/L) and Drinking water criterion (10 mg/L) in groundwater from MWAA, MWAB, MWAG, MWAI, MWBC, MWT, MWX, MWZ. Concentrations in groundwater from the following bores were above the Freshwater aquatic ecosystems criterion only (MWAC, MWAD, MWAF, MWAH, MWAP, MWAQ, MWAR, MWBG, MWBJ, MWU, and MWV).
TOC	Marine aquatic ecosystems (10 mg/L) and Freshwater aquatic ecosystems criterion (15 mg/L) was exceeded in groundwater from one bore location, MWF (50 mg/L). The LOR was 25 mg/L in the April 2013 monitoring event so it is unclear if further exceedances occurred at this time.	Not analysed
Boron	Drinking water criterion (0.3 mg/L) was exceeded in groundwater from the majority of bores (up to 1.2 mg/L). Agriculture – Irrigation criterion (1 mg/L) was exceeded in	Not analysed

Analyte	Onsite	Offsite
	groundwater from three bores (MWK, MWN and MWAL).	
Hexavalent chromium	Freshwater aquatic ecosystems criterion (0.001 mg/L) was exceeded in groundwater from two bores, MWH and MWJ with concentrations reported up to 0.06 mg/L. Marine water aquatic ecosystems (0.0044 mg/L) and Drinking water criterion (0.05 mg/L) was exceeded in groundwater from one bore MWJ.	Not analysed
Manganese	Drinking water criterion (0.5 mg/L) and Agricultural – Aquaculture criterion (0.1 mg/L) were exceeded in groundwater from MWA, MWG, MWM, MW2 (aquaculture only).	Not analysed
Nickel	Drinking water criterion (0.02 mg/L) was exceeded in groundwater from one bore MWM (0.03 mg/L).	Not analysed
Zinc	Agricultural – Aquaculture criterion (0.005 mg/L) was exceeded in groundwater from MWC, MWC_Q2, MWD, MWF, MWH, MWH_Q2, MWK, MWM, MWN, MWAM, MW1 and MW2 (concentrations up to 0.036 mg/L).	Not analysed
1. AEC (2015) 2. URS (2014c) * specific criteria for risks relating to vapour inhalation from groundwater impacts have been assessed in *Section 12.4*		

Concentrations of other analytes in groundwater were below the laboratory limits of reporting and/or adopted groundwater assessment criteria with the exception of bicarbonate, chloride, fluoride, trans-1,2-dichloroethene, bromoform, chloroform, 1,1,1-trichloroethane and chloromethane on AA1 which did not have reported criteria. All LORs were less then adopted criteria with the exception of ecological criteria for organochlorine pesticides and potable water criteria for carbon tetrachloride, hexachlorobutadiene and vinyl chloride.

It is noted that the reported ranges of the chemicals of concern onsite were either lower after the completion of the site remediation and removal of identified potential sources of groundwater impacts or were within the previously reported ranges. AEC (2015a) state that this "*demonstrates that the remediation works undertaken have successfully removed the majority of the groundwater impact sources*" with which the Auditor concurs.

An Auditor groundwater validation sample was collected at AA3, (VS01_29/3/12) from groundwater monitoring bore MUA1_GW1 and results were comparable to the results for MUA1_GW1 from the sample collected by AEC. Refer to Annex G (AEC 2015) for laboratory results and Chain of Custody.

A number of Section 83A notifications for AA1 were completed by AEC (refer to *Annex J* for a copies of the notifications) to advise SA EPA that groundwater under AA1 and in the vicinity of AA1, was contaminated.

The Auditor considers that the groundwater investigations undertaken onsite and offsite are adequate for the purposes of this audit.

12.3.5 Modelling

Groundwater modelling was undertaken by URS and is detailed in the report, *944-956 South Road, Edwardstown, Off-site Groundwater Investigations, Screening Risk Assessment and Solute Transport Modelling* (URS, 2014). A summary of the modelling and findings are provided below.

The objective of the groundwater modelling was to assess whether the offsite chlorinated hydrocarbon plumes were stable or likely to increase or decrease in area and to assess the change in contaminant concentrations in time (URS, 2014). The modelling was undertaken using BIOCHLOR, a US EPA screening model for natural attenuation of chlorinated hydrocarbons (version 2.2, release date 2002). BIOCHLOR models solute transport with biotransformation through first-order decay (which is considered to represent combined mass loss through volatilisation, vertical migration and biotransformation. The model was considered appropriate by URS due to the advection dominated transport conditions as evidenced by relatively long and narrow plumes. The modelling was originally undertaken by URS in 2011 and simulated results were compared to groundwater monitoring data collected in 2013.

The modelling input parameters consisted of site specific parameters for hydraulic gradient and conductivity (as described in Table 6.2 of URS (2014)). Soil parameters were determined for sand-silt-clay environment, with organic carbon partition coefficients sourced from US Department of Energy's Risk Assessment Information System. The organic carbon content was assumed to be zero. During calibration model inputs of longitudinal dispersivity, contaminant decay rates and the width of the source zone were varied through comparison of concentrations in groundwater from monitoring bores along the plume line and at cross-sections of 160 m and 1,000 m downgradient of the source zone. With the inclusion of mass losses attributable to ongoing loss of contaminants through volatilisation and degradation the simulated and measured groundwater concentrations appeared to be consistent at and down-gradient of the source (URS, 2014). The half life (including volatilisation) of PCE used in the model was in the order of 8 to 10 years which was modelled with a source zone thickness of 5 metres. Contaminant half-lives of PCE, TCE and DCE were calibrated based on model results and are considered to represent both biodegradation and volatilisation.

The modelling was undertaken in two zones representing 0 to 600 m down gradient of the source and greater than 600 m down gradient of the source. Modelling results indicated that equilibrium was reached using a source zone duration of approximately 40 years.

On the basis of the modelling, the observed plume was considered to have formed more than 40 years ago and modelling results suggest that "*overall, the PCE, TCE and DCE plumes are likely to be in approximate steady state such that the ongoing flux of PCE dissolving and desorbing from the assumed secondary source area within the former Hills' site is balanced by ongoing natural attenuation processes (incorporating advection, dispersion, volatilisation and possible degradation" (URS, 2014)*. This modelling was considered to be consistent with the predominantly stable trends of PCE, TCE and DCE concentrations in groundwater from offsite bores. The increasing trends in concentrations in groundwater from MWS (and MWH) were considered due to either a shift in the plume centreline or an increased rate of infiltration from the source area (potentially during source excavation or post demolition of the site).

Sensitivity analysis was conducted on a number of parameters and indicated that modelled concentrations were:

- Very sensitive to seepage velocities;
- Reasonably sensitive to longitudinal and transversal dispersivity;
- Not able to reach steady state when a fraction of organic carbon was present;
- Sensitive to changes in PCE half life due to the combination of volatilisation and degradation occurring, whereas TCE, DCE and vinyl chloride half-lives did not affect the plume concentrations; and
- Sensitive to source width and source concentration.

The Auditor considers the modelling conducted to be adequate for the purpose of this audit.

12.4 VAPOUR ASSESSMENT

12.4.1 General

AEC commenced soil vapour investigations onsite at AA1 in 2010 to assess the potential vapour impacts arising from soil and groundwater conditions. In addition, AEC undertook an off-site soil vapour investigation to the west of AA1 during 2011 which was continued by URS in 2012.

In addition to the soil vapour investigation, an indoor air assessment was undertaken in 2011 by SA EPA and subsequently by URS in 2012, which also incorporated investigations within utility pits and privately owned groundwater bores.

Community engagement was required to be undertaken as part of the soil vapour investigations in the offsite residential areas to the west, as detailed in *section 4* of this report.

12.4.2 Sampling Locations

Sampling location plans were provided by AEC and URS, reproduced in *Figure 13 Annex A*.

The on-site soil vapour monitoring locations were positioned to allow for determination of soil vapour conditions above the highest concentrations of PCE and at the down-gradient boundary along the centre line of the solvent groundwater plume (AEC, 2015). The bores consisted of nested soil vapour bores installed to a depth of 1.5 and 3.0 mbgl (AEC, 2015).

Off-site soil vapour bores consisted of five soil vapour bores, including nested soil vapour bores installed to a depth of 1.0 and 2.5 mbgl, located alongside Railway Terrace and two locations within the extent of the delineated plume (on Stanton St and Inglis St) (URS, 2016).

Indoor air sampling and associated soil vapour sampling from a further seven soil vapour bores was undertaken at seven residential properties located within the inferred groundwater plume area (URS, 2016).

Utility pit sampling was undertaken at three locations within the inferred groundwater plume area along Railway Terrace, Stanton Street and Inglis Street (URS, 2016).

12.4.3 Sampling Plan and Sampling Methodology

AEC (2015) and URS (2016) undertook the following soil vapour investigations:

- Drilling and installation of two nested soil vapour monitoring bores onsite and fourteen soil vapour monitoring bores offsite, including four nested soil vapour bores. Two of the onsite bores (SVB1_1.0 and SVB1_3.0) were replaced post remediation works;

- Soil vapour monitoring has been undertaken by AEC in November 2010, August 2012, December 2013 and October 2014 and by URS in April 2011, June 2012 and May 2013 (utility pits only);

- Soil encountered at each soil vapour monitoring bore location was logged and construction details recorded (refer to Appendix H of AEC (2015) and Appendix E (URS 2016) for bore construction details);

- Soil vapour bores were drilled by AEC onsite to depths between 1.5 and 3.0 mbgl using a solid flight auger. The screened intervals installed from the base of the bore were 0.2 m, from 1.3 – 1.5 mbgl and 2.8 – 3.0 mbgl . The screened interval from the base of the bore for the replacement bores (SVB1A_1.5 and VB1A_3.0) was 1.0 and 2.5 m, respectively, i.e. from 0.5 – 1.5 mbgl and 0.5 – 3.0 mbgl, respectively;
- Offsite soil vapour bores were drilled and installed by AEC to various depths ranging between 1.0 and 3.0 mbgl using solid auger. The screened intervals installed from the base of the bores was 0.2 m;
- URS installed soil vapour bores to depths of 1.5 mbgl by hand auger, except for bores VMB7 – VMB9 which were drilled from 1.2 – 1.5 m depth using solid stem auger. The screened intervals from the base of each bore was 0.3 m, from 1.2 – 1.5 mbgl;
- Soil vapour quality parameters (oxygen, carbon dioxide, methane) were monitored using a landfill gas meter and VOCs using a photoionisation detector during purging, with sampling only undertaken once these parameters were stabilised;
- Sampling pumps were typically set at 100mL/min to collect soil vapour samples within thermal desorption tubes and 12mL/min for collecting soil vapour samples within SUMMA canisters;
- All samples were placed in appropriate containers. In most case Summa canisters were used for collection, however thermal desorption sampling tubes were used in November 2010 by AEC; and
- Leak testing of the soil vapour bores was undertaken using isopropanol (AEC) or helium testing (URS).

Refer to *Section 8.7.4* for lithology encountered onsite and offsite during installation.

The Auditor has reviewed the bore constructions logs and considers that the bores have been drilled and installed appropriately.

A review of the lithology and bore construction details of the onsite and offsite soil vapour monitoring bores has revealed consistency across the soil vapour monitoring bore network.

Utility pit vapour sampling was carried out by URS in June 2012 and May 2013 by placing 1.5 metres of Teflon tubing within the pit and attaching it to a summa canister outside the pit. Field screening was carried out using a PID and a landfill gas meter.

Indoor air sampling was undertaken in June 2012 by URS by placing a 6 litre summa canister inside the lounge room of each residence. A second canister was placed on a bench in the bathroom in two properties.

The monitoring has been conducted consistent with the Auditor endorsed SAPs (AEC 2012a and 2013a and URS 2012).

12.4.4 *Summary of Relevant Field and Analytical Results*

Field Conditions

Onsite – Oxygen concentrations were reported highest at VMB1 with lower concentrations reported within deeper soil vapour bores. Carbon dioxide was highest in VMB2_3.0 at 9.4% (AEC, 2015).

Offsite – Oxygen concentrations in 2012 were reported at 20.9%. No methane or carbon dioxide was reported (URS, 2016). Although the oxygen concentrations are noted to be high, comparable with atmospheric conditions, leak testing was conducted by URS at each sampling event and reported less than 1% helium within the sample train. Therefore, the results are considered to be indicative of conditions within the subsurface. .

Laboratories used and NATA Accreditation

An assessment of the analysis of the laboratories and their respective analytical methods was undertaken by the Auditor.

For AEC investigations, NATA accredited laboratories have been used including Envirolab Services, Leeder Consulting, eurofins-MGT and ALS as the primary and secondary laboratories, respectively. Analytical methods employed by the laboratories were considered appropriate for this investigation.

For URS investigations, NATA accredited laboratories have been used including Air Toxics (USA) and National Measurement Institute as the primary and secondary laboratories, respectively. Analytical methods employed by the laboratories were considered appropriate for this investigation.

Laboratory reports and chain of custody forms were provided in Appendix I of the AEC (2015) report and Appendix F of the URS (2014) report.

Analytical Methods

Laboratory analytical methods for analysis of vapours have been reviewed by the Auditor and considered acceptable. A review of the quality assurance for - vapour sampling is provided in *Section 14 (Table 14.2 and Table 14.3).*

Analytical Conditions

The results of the soil vapour quality based on the 2010 and 2012 to 2014 soil vapour monitoring events on-site indicate reported exceedances for PCE, TCE and DCE in soil vapour bores VMB1 and VMB2 at both depths. Vinyl chloride was reported above the screening criteria during the 2010 assessment but not in subsequent sampling rounds.

During soil vapour assessment in 2013 and 2014 a number of compounds were identified on AA1 with no criteria available for assessment. Environmental Earth Sciences (ERS) subsequently derived Tier 1 soil vapour screening criteria for residential land use, detailed in an Addendum letter (2015a) to the On-Site VRA. All detected concentrations of analytes in soil vapour were below these criteria except for 1,2-dibromoethane. It was noted that this chemical is not expected to be a potential contaminant of concern at the site and as it was used as an antiknock agent in petrol, it is often reported at low concentrations like this in ambient air and soil vapour, concluding that it is possible this detected occurred due to emissions from cars or spillage of fuel at the nearby workshop. The Auditor agrees with the criteria derived and the conclusions.

Off-site soil vapour bores reported exceedances of PCE (VMB3, VMB5, VMB8 and 27A Towers Terrace), TCE (at 10 of 14 off-site soil vapour bores) and DCE at individual locations and sampling events (VMB3 at 2.5 mbgl).

Indoor air screening reported PCE, TCE, DCE and VC at concentrations below the relevant screening criteria at all locations during the indoor air monitoring event.

Assessment of air concentrations within the utility pit were below the assessment criteria, except for TCE at Angus Avenue and Railway Terrace in 2013.

12.4.5 Assessment of Vapour Risks

The assessment of volatile risks associated with chlorinated hydrocarbons (PCE, TCE, DCE, VC) in groundwater at AA1 was considered separately for on-site and off-site situations in the documents listed and the details of the assessment are described below:

- *On-site:* Environmental Risk Sciences, *On-site Vapour Risk Assessment, 944-958 South Road, Edwardstown,* May 2015 and *Addendum to On-Site VRA: 944-958 South Road, Edwardstown SA*, 10 November 2015 (discussed above);.
- *Off-site*: URS, *944-956 South Road, Edwardstown, Detailed Risk Assessment for Off-site Groundwater Contamination*, October 2014.

On-site

The potential risks associated with chlorinated hydrocarbons on-site were assessed by Environmental Risk Sciences (ERS, 2015). The risk assessment focussed on potential volatile risks arising from soil gas concentrations of TCE, PCE, DCE and VC measured at the site. Toxicity data for the risk assessment was applied in accordance with details outlined in ASC NEPM (2013).

Receptors for potential exposure to vapours arising from groundwater and soil vapour impacts were considered to be:

- Commercial/industrial with or without an underground basement car park;
- Mixed use comprising of commercial/retail premises on the ground floor and medium/high density residential on the upper levels for scenarios with and without an underground basement car park;
- Standard residential comprising low to medium density residential with and without a level of basement car park;
- Intrusive maintenance workers; and
- Open space.

Exposure parameters for the scenarios were determined using guidance from enHealth2012, CRC CARE 2011, ANZECC, 1992, supplemented with data from USEPA. Full details of the parameters used within the risk assessment are available in ERS, 2015. For scenarios where a basement was modelled the basement was assumed for parking or storage (not for living) in accordance with the requirements for the Building Code of Australia.

Breathing zone exposure concentrations were modelled from groundwater and soil vapour data using the Johnson and Ettinger vapour transport model (US EPA, 2003) for indoor air and ASTM vapour transport model (ASTM, 2002) for outdoor air.

Margins of Safety were calculated for each scenario based on groundwater and soil vapour data. A margin of safety greater than 1 was considered acceptable. The individual margin of safety was considered acceptable for all scenarios with the exception of vapours arising from groundwater into a slab on grade residence. It should be noted that using the soil vapour data for the same scenario (slab on grade residence) the individual margin of safety is 1. Application of cumulative effects indicates the potential for risk from vapour arising from groundwater into a slab on grade residential property.

Maximum groundwater concentrations which would not result in an unacceptable risk were estimated for the more significant exposure scenarios (residential building slab on ground) and mixed use slab on grade with retail at the base. Maximum acceptable groundwater concentrations were calculated for a margin of safety of 1. The maximum acceptable groundwater concentration was reported as:

Table 3.6 Maximum Acceptable Groundwater Concentrations

Analyte	Onsite Specific Groundwater Criteria – Mixed Use Slab on Grade	Onsite Specific Groundwater Criteria – Residential Slab on Grade
	mg/L	**mg/L**
Trichloroethene (TCE)	1	0.15
cis-1,2-dichloroethene	5	0.75
Tetrachloroethene (PCE)	85	12
Vinyl Chloride	0.35	0.05
1. ERS, 2015		

It was concluded that there were no unacceptable risks to receptors for potential exposure to vapours arising from groundwater and soil vapour impacts for the following scenarios:

- Commercial/industrial – with buildings constructed as slab-on-grade and exposures may occur by long-term workers within these buildings;

- Commercial/industrial with underground car park – this includes a multi-storey development with 1 level of basement car park (extending to 3 m depth) where exposures by long-term workers may occur in the basement as well as in work areas located on the ground or upper floors;

- Mixed use (including medium/high density residential) – with buildings constructed as multistorey buildings on a slab, with commercial/retail premises on the ground floor and residential on the upper floors. Exposures by both long-term workers and residents may occur in these buildings;

- Mixed use (including medium/high density residential with potential basement use) – this includes a multi-storey development with 1 level of basement car park (extending to 3 m depth) with mixed commercial and residential areas above. Exposures by long-term workers and residents may occur in the basement as well as in work areas located on the ground or upper floors;

- Standard residential with basement – this includes a medium to high density residential building with 1 level of basement car park (extending to 3 m depth). Exposures by residents may occur in the basement as well as on the ground or upper floors;

- Public open space – where exposures may occur by residents or workers in outdoor/open spaces only; and

- Workers involved in excavations involved in excavations for the purpose of constructing new buildings above the impacted groundwater, including those with 1 level of basement, and maintaining subsurface services.

It was concluded that the risks to receptors for potential exposure to vapours arising from groundwater and soil vapour impacts were considered unacceptable for the standard residential scenario "*low to medium density residential homes constructed on a slab where exposures by residents may occur within the home*". Further details of the onsite RA are located in Appendix G of AEC DRA (2015a).

Off-site

Assessment of risks associated with chlorinated hydrocarbons (PCE, TCE, DCE, and VC) identified within the groundwater and soil vapour off-site was undertaken by URS (URS, 2016). Toxicity data for the risk assessment was applied in accordance with details outlined in ASC NEPM (2013). The compounds were considered to have background concentrations representative of the LOR.

Receptors for potential exposure to vapours arising from groundwater and soil vapour impacts were considered to be:

- off-site residents. As well as a standard slab-on-ground residential assessment, the off-site resident assessment included a variety of scenarios with a basement and groundwater use for irrigation, recreational use and showering. Residents using shallow groundwater for potable use were also assessed;
- off-site intrusive maintenance workers were assessed using shallow excavations of <1.5 m and deep excavations/utility pits;
- off-site commercial workers were not assessed as concentrations of groundwater impacts within the commercial areas were lower than those reported within the residential area;
- recreational users of parks were not assessed as exposure would be less than the off-site residents; and
- visitors to residential properties were not assessed as exposure would be less than the off-site residents.

Exposure parameters for the scenarios were determined using guidance from enHealth2003, enHealth 2010, CRC CARE 2011, ANZECC, 1992, supplemented with data from USEPA. Full details of the parameters used within the risk assessment are available in URS, 2016.

Breathing zone exposure concentrations were modelled from groundwater and soil vapour data using the Johnson and Ettinger vapour transport model (US EPA, 2003) for indoor air, ASTM vapour transport model (ASTM, 2002) for outdoor air and Guidelines for the Assessment and Management of Petroleum Hydrocarbon Contaminated Sites in New Zealand (August 2009) for estimating sprinkler and irrigation model.

Modelling was undertaken using a slab-on-ground and basement scenario. Subsurface conditions were defined as 0.5 m of sand fill and 2.2 m of sandy clay with the water table underlying the sandy clay. The maximum groundwater and soil vapour concentrations measured off-site were applied as the input concentration within the model.

Indoor air concentrations modelled from soil vapour and groundwater were compared to measured indoor air concentrations collected within a residence. The modelled and measured indoor air concentrations showed good agreement.

Total lifetime risks were calculated using three lifetime phases (adult residents, older and younger child residents). For a slab on grade and basement scenario for off-site residents (not using groundwater) the non-threshold carcinogenic risk was calculated between 5E-07 and 1E-06 and threshold hazard quotients were calculated between 0.1and 0.3, therefore indicating no unacceptable risks.

Risks calculated for groundwater use for irrigation, recreational or showering indicated that an unacceptable risk is likely to exist when showering was included within the scenario but not when only irrigation or recreational use was included.

Risks calculated for groundwater for intrusive maintenance workers and commercial/industrial workers indicated no unacceptable risk to workers.

Groundwater concentrations off-site were reported at concentrations that exceeded the relevant drinking water guidelines. At locations where PCE is less than the drinking water guideline, exposure through other pathways is unlikely to result in a risk as other pathways are considered to contribute less than 10% of the target risk levels.

On the basis of the risk assessment, URS concluded that there is:

- no unacceptable risk to off-site residents who do not use groundwater, whether or not they have a basement and do not have a basement;
- no unacceptable risk to residents with or without a basement who use groundwater only for irrigation or irrigation and recreation;
- an unacceptable risk to residents with or without a basement who use groundwater for irrigation, recreation and showering;
- no unacceptable risk to intrusive maintenance workers or commercial workers;
- an unacceptable risk to:

- *Off-site residents (if any) who use the shallow groundwater for showering/bathing as well as for irrigation and recreation. Unacceptable health risks would only exist where the groundwater contains concentrations of PCE and TCE above approximately 0.50 mg/L and 0.03 mg/L respectively. Based on the most recent testing, this may apply to a zone extending up to 150 m west from Railway Terrace, within the area bounded by Stanton Street to the west, Fuller Street to the north and Johnson Street to the south.*

- *Off-site residents (if any) who use the shallow groundwater as a primary source of potable drinking water. Unacceptable health risks would only exist where contaminant concentrations exceed drinking water guideline levels. Monitoring results suggest this may apply in a zone extending up to 1 km west of the former Hills' site. (URS, 2016)*

Further details on the off-site risk assessment are available in URS (2016).

12.5 RELEVANCE OF ECOLOGICAL AND/ OR HUMAN HEALTH GUIDELINES ADOPTED FOR THE ASSESSMENT OF RISK

The Auditor considers that appropriate and relevant ecological and human health guidelines have been adopted by each Assessor, both onsite and offsite, for the proposed future and current land uses.

12.6 NATURE AND EXTENT OF ANY SITE CONTAMINATION

The Screening Risk Assessments and Detailed Risk Assessments provided by both on and offsite Assessors. Refer to *Section 12.9* for details of onsite contamination.

12.7 AUDITOR'S OPINION OF ADEQUACY OF THE ASSESSMENT WORKS

The review of documentation provided by the Assessors (refer to Annex C for copies of same), as outlined in the previous sections of this audit report indicates that the information contained within the documents is adequate for the purposes of the audit. The information provided:

- Distribution and frequency of sampling locations to obtain a valued judgement of the contamination status of AA1, both on site and offsite, in the context of the purposes of the investigation;
- Accuracy and reproducibility of analytical results, verified by a program of QA/QC sampling;
- Analytical suites sufficient to identify the broad spectrum of likely contaminants; and
- Soil, groundwater, and soil vapour contamination sampling procedures suitable to produce accurate results for the purposes of the audit.

12.8 *Statement Of Compliance With Guidelines Issued By EPA*

The Auditor considers the Assessor reports (AEC and URS) followed the guidelines applicable at the time of the investigation.

12.9 *Auditor's Opinion On Nature And Extent Of Site Contamination*

The Auditor is of the opinion that the nature and extent of site contamination was sufficiently assessed by AEC and URS for the purposes of the audit.

The majority of impacted contaminated soil has been removed from AA1. Remaining contaminants include those in localised pockets of soil containing copper, lead, nickel, chromium (total) and zinc exceedances above NEPM EILs, and benzo(a)pyrene and hydrocarbons (TRH $>C_{16}$-C_{34} (F3)) exceedances above NEPM ESLs.

The concentrations of chemical substances remaining in site soils above HILB are minor exceedances of lead, nickel and carcinogenic PAHs. A number of the exceedances have been deemed statistically acceptable to remain onsite by AEC (2015), which was conducted in accordance with Section 3.0 of Schedule B1 of the ASC NEPM. A number of exceedances of NEPM HIL A remain in site soils for cadmium, lead, nickel, zinc, and carcinogenic PAHs. Refer to *Figure 8* for the location of remaining site soils above HIL A & B.

As such, the Auditor considers that contamination of soil that is not trivial exists onsite. Based on the proposed future mixed use of the site for medium-high density residential/commercial/retail, the contaminated soil is not considered to pose a health risk to onsite future occupants or risk to the environment, however may pose a risk to site workers. A CEMP and SMP have been developed to mitigate risks to stakeholders, both of which are located in *Annex H* attached.

Potential aesthetic impacts of ash/cinders and waste materials remaining insitu are considered to be a low risk.

Groundwater quality is considered to be impacted by onsite sources resulting in contamination (chlorinated hydrocarbons, metals (boron, hexavalent chromium, manganese, nickel, zinc) nitrate, and TOC that is not trivial existing onsite and migrating offsite.

The primary source of the northern chlorinated hydrocarbon plume is likely to be from the northeast corner of the former Ironing Tables Workshop with an additional source associated with Pit 4 in the northwest corner of the site. Refer to *Figure 8* for the location of these likely source areas and *Figure 14* for the extent of chlorinated hydrocarbon plume (PCE) on and offsite.

12.10 *OFFSITE MIGRATION OF CHEMICAL SUBSTANCES*

There is evidence of offsite migration of chlorinated hydrocarbons and nitrate sourced from AA1 by movement through groundwater. An assessment of offsite groundwater quality and the risk to human health has been adequately assessed by URS (2014 and 2016).

13 *REMEDIATION REVIEW*

13.1 *PURPOSE AND OBJECTIVES*

AEC undertook remediation and validation works identified from previous investigations works and as the site's buildings and infrastructure, above and below ground, were demolished and removed.

13.2 *REMEDIATION MANAGEMENT PLAN*

The majority of remediation and validation works were conducted prior to Auditor involvement.

A Remediation Management Plan (AEC, 2011) was prepared and endorsed by the Auditor, letter dated 25 March 2011, specifically relating to EES Area of Concern B (Area B) only. The RMP related to the removal and remediation of Pit 9 identified as the primary source of soil and groundwater contamination, i.e. historical PCE baths in the north east corner of the Ironing Tables building

The goal of the remediation was to remove the solvent impacted soil to mitigate the risk of on-going groundwater contamination and to clean-up the most heavily solvent impacted portion of the site (identified to date) to allow for the on-going use of the area for commercial / industrial purposes.

The soil remediation goal is to clean-up the solvent impacted portion of the site to levels acceptable for on-going use for commercial/industrial purposes. Soil remedial options and treatment technologies were assessed as part of the document. Site-specific criteria for clean-up (i.e. validation screening) and vapour (i.e. PID readings during excavation) were derived.

Groundwater remediation was not considered at this stage.

Refer to *Annex C* for a copy of the plan and endorsement.

Works were conducted in accordance with the plan, refer to *Section 13.3.4* for further details.

13.3 *SUMMARY OF REMEDIATION WORKS CONDUCTED*

AEC (2015) have summarised the remediation and validation works, and the rationale for the works, in Table 26 and includes:

- Structures removed and validated;
- USTs removed and validated; and
- Soil impact delineation.

The Auditor has detailed the works in *Annex E* as well showing the relationship between historical potential contaminating activities and identified on site infrastructure, investigations and remediation/validation works completed.

13.3.1 *Sampling Location Plans*

AEC has detailed each area that has been remediated and validated, reproduced on *Figure 7 Annex A*. Refer to *Section 13.3.4* for details of each area.

Figure 8 Annex A also provides those locations of remaining impacted soils above HIL A & B.

13.3.2 *Laboratories used and NATA accreditation*

The NATA accredited laboratories used were the same as those used in soil investigation works, refer to *Section 12.2.4.*

13.3.3 *Soil Delineation and Validation Analytical Methods*

Refer to the analytical methods detailed in the Soil Investigation *Section 12.2.4.*

13.3.4 *Soil Delineation and Validation Analytical Results*

AEC (2015) provides details of the methodology for each identified area, in *Section 6*, of the SRA report including:

- Area of concern and its location. The rationale for the works was provided in Table 26;
- Photographs; and
- Validation sample details, including figures of their location. It is noted that NEPM 1999 criteria was used as the remediation targets as the majority of the works were conducted prior to the implementation of the amended NEPM. As such, AEC has reviewed the validation results against the amended NEPM. Where exceedances of HIL B have been identified, AEC has statistically characterised the immediate area where the exceedance was reported. The approach adopted by AEC (2015) is consistent with NEPM (2013) which requires "*the maximum and the 95% UCL of the arithmetic mean contaminant concentration should be compared to the relevant Tier 1 screening criteria...The results should also meet the following criteria:*
  - *The standard deviation of the results should be less than 50% of the relevant investigation or screening level, and*
  - *No single value should exceed 250% of the relevant investigation or screening level." (NEPM 2013)*

The Auditor considers this approach acceptable.

AEC (2015) noted that "base validation samples from TP434 were not collected as the material is considered visually distinct to the natural material below with all lateral samples reported below the acceptable screening criteria." The exceedance of HIL B reported was zinc of 67,000 mg/L at 0.5 – 0.6 mbgl. The Auditor considers this approach acceptable due to the depth of the original exceedance of 0.5 – 0.6 mbgl and no reported exceedance in the lateral validation samples.

There were a considerable number of underground structures and tanks identified at the site. To minimise the potential for other unknown underground infrastructure remaining onsite, at the request of the Auditor a number of trenches were excavated across the site to close out the potential for their future identification. As a result of this work, the Auditor is satisfied that a sufficient number of locations across the site targeting potential underground infrastructure have been suitably investigated.

Asbestos. AEC (2015) advise that prior to demolition works commencing, all asbestos containing materials were removed from the buildings with asbestos clearance certificates and airborne fibre monitoring detailed in Appendix F (AEC 2015). The Auditor has reviewed these certificates and considers the management of asbestos containing materials on the site as adequate.

Stockpile information, including waste soil classification for reuse/disposal. Materials excavated were stockpiled on hardstand surfaces or high density polyethylene. Those displaying visual and/or olfactory impacts were covered with plastic until removed from site. Stockpile samples were analysed and classified in accordance with SA EPA *Standard for the production and use of waste derived fill.* The results of the classification either deemed the material suitable to remain on site or disposed offsite. In a number of cases, soil classified as ILC were considered acceptable to remain onsite by the Auditor, however at depth, for example Pit 4 material could remain onsite however at a depth of 2 – 4 mbgl. Refer to *Annex C* for communications between the Auditor and AEC dated 30 May 2011 regarding the reuse of material onsite. The number of samples required to classify a stockpile was based on the Victorian EPA *Soil Sampling Guideline – Offsite Management and Acceptance to Landfill* which stipulates a minimum number of 3 samples for stockpiles up to 250 m3. The Auditor has reviewed the management of stockpiled soils and considers that they have been appropriately managed. The Auditor has not considered the management of waste soils taken offsite for disposal purposes, i.e. any offsite processing undertaken by third parties.

Samples of the contents of site infrastructure, such as USTs, were also analysed and classified to assess how the material is to be managed.

The remediation and validation works has resulted in the removal of the majority of impacted soil from the site and classification of the remaining insitu soil as suitable to remain for mixed use purposes. It is noted, however, that due to the implementation of the amended NEPM, some areas of insitu soil, although below commercial and industrial screening criteria, exceed mixed use screening criteria. These locations are identified in *Figure 8, Annex A*. Also, some areas of impacted soil could not be further removed as their locations, such as on the boundary of the site, did not allow their excavation.

Imported fill was used to re-instate the areas post removal of infrastructure and impacted soils. The fill was subject to appropriate testing, utilising the SA EPA Waste Screen with all results meeting the EILs with the exception of two manganese results. The results were below the HILs and concentrations were consistent with those of existing insitu site soil concentrations. The Auditor considers the use of imported fill appropriate.

Remaining soil impacts above HIL A & B have been detailed in *Figure 8 Annex A*. The Auditor has detailed the remaining soil impacts above the adopted criteria as follows:

Table 13.1 Soil Analytical Results – EILs and ESLs

Analyte	Adopted Assessment Guideline Exceedances	
	Pre Remediation	**Post Remediation**
Arsenic	NEPM EIL (100 mg/kg urban residential/public open space) - one exceedance at BH18 at 0.3 – 0.4 mbgl, reporting concentration of 152 mg/kg	No exceedances - BH18 exceedance removed as part of remediation works
Chromium (total)	NEPM EIL (690 mg/kg urban residential/public open space and 1,100 mg/kg commercial and industrial - one exceedance BH3 0.1 – 0.3 mbgl reporting a concentration of 1370 mg/kg and two exceedances at Pit 18, VP18_B1 and VP18_B4 (urban only), reporting concentrations of 2,300 mg/kg and 1,100 mg/kg, respectively.	BH3 exceedance removed as part of remediation works, NEPM EIL (690 mg/kg urban residential/public open space and 1,100 ng/kg commercial and industrial – two exceedances at Pit 18, VP18_B1 and VP18_B4 (urban only), reporting concentrations of 2,300 mg/kg and 1,100 mg/kg, respectively.
Copper	NEPM EIL (110 mg/kg urban residential/public open space and 150 mg/kg commercial and industrial) - number of locations ranging from 120 mg/Kg to 3,900 mg/kg exceeding both criteria	NEPM EIL (110 mg/kg urban residential/public open space and 150 mg/kg commercial and industrial) Number of locations ranging from 120 mg/kg to 2,100 mg/kg.
Lead	NEPM EIL (1,100 mg/kg urban residential/public open space and 1,800 mg/kg commercial and industrial) - number of exceedances of both criteria	NEPM EIL (1,100 mg/kg urban residential/public open space and 1,800 mg/kg commercial and industrial) - number of exceedances of both criteria remaining
Nickel	NEPM EIL (40 mg/kg urban residential/public open space and 60 mg/kg commercial and industrial) - number of exceedances of both criteria	NEPM EIL (40 mg/kg urban residential/public open space and 60 mg/kg commercial and industrial) - number of exceedances of both criteria
Zinc	NEPM EIL (290 mg/kg urban residential/public open space and 420 mg/kg commercial and industrial) number of exceedances of	NEPM EIL (290 mg/kg urban residential/public open space and 420 mg/kg commercial and industrial) number of

Analyte	Adopted Assessment Guideline Exceedances	
	Pre Remediation	Post Remediation
	both criteria	exceedances of both criteria
Benzo(a)pyrene	NEPM ESL (0.7 mg/kg urban residential/ public open space and 1.4 mg/kg commercial and industrial) – number of exceedances of both criteria	NEPM ESL (0.7 mg/kg urban residential/ public open space and 1.4 mg/kg commercial and industrial) – number of exceedances of both criteria
Hydrocarbons – F3(C16- C34)	NEPM ESL – F3 (300 g/kg urban residential/public open space and 1,700 mg/kg commercial and industrial) – number of exceedances ranging from 380 – 2,800 mg/kg of urban residential with one exceedance of commercial and industrial (FTP 25 (0.1 – 0.2 mbgl) of 2,800 mg/kg.	NEPM ESL – F3 (300 g/kg urban residential/public open space and 1,700 mg/kg commercial and industrial) – number of exceedances ranging from 380 – 2,800 mg/kg of urban residential with one exceedance of commercial and industrial (FTP 25 (0.1 – 0.2 mbgl) of 2,800 mg/kg.

Table 13.2 Soil Analytical Results – HILs and HSLs

Analyte	Adopted Assessment Guideline Exceedances	
	Pre Remediation	Post Remediation
Arsenic	NEPM HIL A (100 mg/kg) - one exceedance at BH18 at 0.3 – 0.4 mbgl, reporting concentration of 152 mg/kg. No exceedance of HIL B	No exceedances
Cadmium	NEPM HIL A (20 mg/kg) at a number of locations at depths ranging from 0.0 – 1.0 mbgl (within fill/ashy lens) at locations BH3, BH6, BH50, TP221, TP401, TP402. NEPM HIL B (150 mg/kg) - one exceedance at BH3 reported 206 mg/L at 0.1 – 0.3 mbgl, beneath the Maintenance workshop and attributable to former plating operations undertaken in this area	NEPM HIL A (20 mg/kg) at a number of locations at depths ranging from 0.0 – 1.0 mbgl (within fill/ashy lens) at locations BH6, BH50, TP401 and VP18_B4. No HIL B exceedances
Lead	NEPM HIL A (300 mg/kg), HIL B (1,200 mg/kg) and HIL D (1,500 mg/kg) - number of exceedences up to 3,600 mg/kg, all reported occurring in fill.	NEPM HIL A (300 mg/kg), HIL B (1,200 mg/kg) and HIL D (1,500 mg/kg) - number of exceedances of HIL A remaining. Three exceedances of HIL B (BH6 (0.2 – 0.3 mbgl) of 1,380 mg/kg, TP224 (0.3 – 0.4 mbgl) of 1,400 mg/L and P18BW/3 (3.2 – 3.4 mbgl) of 2,100mg/kg) with P18BW/3 exceedance of HIL D (1,500 mg/kg). BH6, P18BW/3 and TP224 concentrations considered statistically acceptable (HIL B) to remain onsite.
Nickel	NEPM HIL A (400 mg/kg) – four exceedances (BH02 (0.4 – 0.45 mbgl) of 7,300 mg/kg, TP401 0.9 – 1.0 mbgl of 1400 mg/kg, P18BW (3.2 – 3.4 mbgl) at 2,100 mg/kg, TP402 0.3	NEPM HIL A (400 mg/kg) – three exceedances (TP401 0.9 – 1.0 mbgl of 1400 mg/kg, P18BW/3 (3.2 – 3.4 mbgl) at 2,100 mg/kg, and TP433 0.0 – 0.1 mbgl at 630 mg kg. In addition,

Analyte	Adopted Assessment Guideline Exceedances	
	Pre Remediation	Post Remediation
	– 0.4 mbgl at 640 mg/kg and TP433 0.0 – 0.1 mbgl at 630 mg kg; NEPM HIL B (1,200 mg/kg) - three exceedances (BH02, TP401 and P18BW detailed above). NEPM HIL D (6,000 mg/kg) - one exceedance (BH02).	a number of validation locations at Pit 18 have reported concentrations of nickel above HIL A that were not further excavated and validated. NEPM HIL B (1,200 mg/kg) – three remaining exceedances (TP401, VP18_B4 and P18BW detailed above) considered statistically acceptable to remain.
Zinc	NEPM HIL A (7,400 mg/kg) - number of exceedences of criteria NEPM HIL B (60,000 mg/kg) - one exceedance at TP434 0.5 – 0.6 mbgl of 67,000 mg/kg.	NEPM HIL A (7,400 mg/g) – number of exceedances of criteria remain. No remaining HIL B exceedances
Hydrocarbons – TPH C10 – C36 (refer discussion below)	NSW EPA (1,000 mg/kg) - 9 exceedances – BH2 (11,670 mg/kg), BH17 (2,090), BH24 (1420 mg/kg), BH27 (1070), BH36 (6590), BH111 (7900), TP203 (1245), TP402 (1570), TP433 (1070)	No exceedances
Hydrocarbons – TPH C6 – C9 (refer discussion below)	NSW EPA (65 mg/kg) - 6 exceedances – BH13 (2490), BH17 (1270), BH18 (464), BH36 (102), BH103 (290), BH 105 (350)	No exceedances
Hydrocarbons – TPH C16 – C36 – Aromatics	NEPM (1999) HIL D (300 mg/kg) – 8 exceedances – BH2, BH17, BH24, BH27, BH36, BH68, BH111 and TP402 (detailed in Table 19)	No exceedances
PAHs – Total	NEPM HIL A (300mg/kg) – exceedances at two locations, FTP1 of 430 mg/kg and FTP 18 at 390 mg/kg, both samples taken at surface level (0.0 – 0.1 mbgl)	No exceedances
Carcinogenic PAHs	NEPM HIL A (3 mg/kg) and NEPM HIL B (4 mg/kg) - a number of exceedences in fill, of concentrations up to 50.2 mg/kg NEPM HIL D (40 mg/kg) - two locations FTP 17 and FTP 18, both at depth of 0.0 – 0.1 mbgl, both reporting concentrations of 50.2 mg/kg. Refer to Table 20 in AEC SRA for details of locations	NEPM HIL A (3 mg/kg) and NEPM HIL B (4 mg/kg) - a number of exceedances in fill remain. These are located in Area F, Area H and TP430, TP211, TP426 and TP427. Exceedances also noted within the walls of Pit 20 validation works (VP20_E2, VP20_W2 and VP20_B4) and base of Pit 2 (VP2B2). TP430 reported concentrations deemed statistically acceptable to remain.
Chlorinated Hydrocarbons – PCE	Concentrations of PCE ranging from <0.5 to 3,600 mg/kg were reported across the site. Exceedances of site specific criteria were reported at BH17, TP102, TP106, TP118, TP136 and TP401 and BH19 (DCE). These locations were used for remediation/ validation works across the site. The criteria	No exceedances of the site specific criteria post remediation. The remediation of Area B did report concentrations of PCE up to 16 mg/kg in an area at the base of Cell C4 (groundwater interface). This was considered to be potentially indicative of a point source of groundwater impact relating to the

Analyte	Adopted Assessment Guideline Exceedances	
	Pre Remediation	Post Remediation
	utilised were those created for Scenario 2 – Building with 1 level car park basement over residual soil impacts at 5 m depth (groundwater impacts remain) onsite workers. PCE calculated to be 6.5 mg/kg. The locations were in the north east corner of the Ironing Tables building and the north west corner of the site. Refer to Figure 36 for solvent impact locations (Note not include TP 401 (3600 mg/kg).	former solvent bath. Insitu contaminant mass assessment was undertaken with the drilling of three new soil bores – BH403 – BH405. Concentrations of the soil samples were below the site specific criteria. Refer to *section 13.3.7* for further information.
Asbestos	NEPM HSL A - D Asbestos containing materials, in the form of small cement sheet debris fragments in surface fill material, were reported in two locations (TP408 and TP418 as well as TP447).	No exceedances remain
1. AEC (2015) 2. EES (2007) 3. ERS (2010)		

It is noted that soil containing a number of the exceedances of criteria above HIL B remain onsite. The exceedances of HIL B that have not been deemed acceptable to remain are detailed on *Figure 8 Annex A*. (It is noted that the Auditor has also noted exceedances of HIL A criteria on *Figure 8 Annex A*)

The Auditor considers that these remaining impacted insitu soils are acceptable for the proposed future use of the site, however onsite works will need to be subject to an onsite Construction Environmental Management Plan (CEMP). Refer to S*ection 17* of this report for further discussion.

All remediation and validated areas have been summarised in Table 44 in AEC SRA report (AEC, 2015) and detailed in *Figure 7 Annex A*.40

13.3.5 *Summary of Treatment, Offsite Disposal of Waste Materials And Compliance With EPA Requirements*

Refer above.

13.3.6 *Quality Control Procedures*

The Auditor considers that the QA/QC procedures utilised by AEC for the purpose of this audit to be adequate. Refer to *Section 14* for further discussion.

13.3.7 *Subsequent Validation and/or Monitoring*

Subsequent soil bores, BH403 – BH405, were drilled along the inferred chlorinated hydrocarbon plume line immediately to the west of the remediated Area B to assess remaining soil quality post remediation. The results revealed PCE concentrations of <0.5 (9.9 – 10 m) to 4.4 mg/kg (5.4 – 5.5m) at bore BH403, immediately adjacent to the excavated area, and <0.5 (>7.9m) to 0.23 mg/kg (6.4 – 6.5m) with no hydrocarbon impacts reported in bore BH404. These results are below the adopted site screening criteria of 6.5 mg/kg.

Ongoing groundwater monitoring and soil vapour assessment has been conducted across the site during and post remediation works. A Groundwater Monitoring & Management Plan (GMMP) has been developed and is proposed to be implemented upon completion of the audit. Refer to *Section 13.5* for further discussions.

13.4 REMEDIATION OPTIONS ASSESSMENT

A Remediation Options Assessment (ROA) was included in the RMP for the remediation of PCE impacted soils at Area of Concern B, refer to *Section 13.2*. The ROA did not address groundwater contamination.

At the request of the Auditor, an updated ROA was completed in 2015 (AEC, 2015b) regarding the options for remediation of remaining onsite contamination of soil and groundwater. With respect to soil impacts remaining on AA1 the ROA concluded that significant remediation works had been completed and that the existing conditions were suitable for proposed future use.

The ROA reported that groundwater impacts existing as site contamination in AA1 were sourced from the site. Based on the remediation works, the ROA focussed on the remediation to date of solvent impacts within the northern portion of the site. Groundwater impacts, including isolated heavy metals and nitrates, were not considered necessary for remediation assessment due to limited impacts at the site and AEC's assessment that there were no future beneficial uses of groundwater underlying the site.

The objective of the groundwater remediation conducted onsite was to:

- remove on-going sources of contamination to the extent necessary;
- restore beneficial uses of land and groundwater at the site; and
- prevent risk to human health and/or the environment.

The ROA stated that while continued active remediation was likely to reduce solvent concentrations in groundwater, it was not required to achieve the remediation goals as the majority of the source zone was removed during soil excavation, no beneficial uses were present at the site and no unacceptable risk was reported based on the risk assessment of remaining soil and groundwater impacts on and off-site.

The ROA considered the following technologies for removal of inorganic contaminants including metals, metalloids and nitrate from groundwater at AA1:

- precipitation/coagulation/flocculation through transformation of the dissolved contaminant into an insoluble solids that can be removed by filtration;
- separation through concentration of contaminated waste water;
- ion exchange of ions from the aqueous phase on an exchange medium; and
- phytoremediation using plants to remove, transfer and destroy contamination.

With regard to the chlorinated solvents and non-halogenated volatile organic compounds in groundwater, the ROA considered the following remediation technologies:

- air stripping through exposure of contaminated water to air;
- liquid phase carbon absorption by allowing adsorption of contaminants on activated carbon;
- multi-phase extraction through application of a high vacuum system;
- air sparging by injecting air to allow volatilisation;
- physical barriers to contain and/or divert groundwater;
- in-situ chemical oxidation/reduction through conversion of contaminants to more stable, less toxic compounds;
- enhanced bioremediation through introduction of micro-organisms to allow degradation to innocuous end products;
- monitored natural attenuation by monitoring the natural attenuation process to ensure that the attenuation is occurring at a rate that prevents impacts to the wider environment.

Each remediation technology was assessed according to applicability, permissibility, relative cost and treatment time to provide a rating summation calculation. The ROA considered the following site specific issues regarding groundwater impacts at the site including the:

- range of contaminants present at the site;
- pH of soil and groundwater and the limit on the treatment ability or the requirement to adjust the pH;
- large size of the impacted area (onsite and offsite); and

- proximity of residential properties that limit the noise generated during remediation.

On the basis of the ROA, portable multiphase vacuum extraction, pump and treat, in-situ chemical oxidation/reduction, enhanced bioremediation and monitored natural attenuation were considered reasonably suited for the site. An active remediation process was not considered a necessity as the remediation objectives, including acceptable risks to human health and the environment and restoration of likely beneficial uses, have been achieved. Of the five, monitored natural attenuation was considered the most viable as major source removal works have occurred, the plume area is large and the impacts to residents is likely to be greater than the benefit of restoring the limited beneficial uses off-site. Therefore MNA was considered to be the least obtrusive, most cost effective and viable remediation option as field conditions were deemed to be unconducive to other remediation strategies.

13.5 GROUNDWATER MONITORING AND MANAGEMENT PLAN

After selection of monitored natural attenuation as the preferred remediation option for AA1, at the request of the Auditor a Groundwater Monitoring & Management plan (GMMP) was prepared for AA1 and the off-site area (AEC, 2015b). Refer to *Annex G* for a copy of the GMMP.

The objective of the GMMP is to regularly monitor the plume to assess for stability, identification of potential changes in level of risk to human health and the environment from the groundwater plume on-site and off-site and establishment of management measures to be implemented in the event of an increasing trend in plume extent or risk.

Vicinity Centres is considered to be responsible for implementation of the GMMP on-site, while Hills Limited is considered responsible for off-site implementation. Both entities have provided their written agreement to the implementation of the GMMP, refer to *Annex C* for copies of these letters.

13.6 RTEN OPINION

13.6.1 List of Reports Reviewed

In the provision of this RTEN opinion, the Auditor has:

- Reviewed on and offsite assessment reports, detailed in Section 12, and considers that they have adequately considered:
  - The nature and extent of the site contamination; and
  - The risk of the site contamination on human health and/or the environment.

- reviewed the ROA, detailed above, and considers that it has been completed in accordance with EPA Guidelines;
- Reviewed the GMMP, as the preferred remediation option was for monitored natural attenuation;
- Considered the data adequate to support the proposed remediation.

Refer to the attached *Remediation to the Extent Necessary Opinion* including RTEN Checklist, located in *Annex K*.

The proposed future remediation of ongoing groundwater monitoring, as detailed in the GMMP is considered by the Auditor to be technically feasible and practicable. The GMMP allows for regular review of the monitoring results and the GMMP itself.

13.6.2 Summary of remedial works undertaken

The remediation works undertaken at AA1 has been detailed in *section 13.3* of this report. This has included the removal and validation of all onsite above and below ground structures and identified impacted areas.

13.6.3 Risks to future occupiers

Based on the post remediation condition of the site, the risks to future occupiers based on the proposed mixed use, are considered to be low.

13.6.4 Recommendations on the installation of the remediation technology

The proposed future remediation of ongoing groundwater monitoring, as detailed in the GMMP, is technically feasible and practicable. The GMMP allows for regular review of groundwater quality, both on and offsite, and the requirements of the GMMP itself.

13.6.5 Recommendations for ongoing review of the remediation system and monitoring results

Refer to *Section 13.5.4.*

13.6.6 Recommendations regarding the establishment of prohibition or restriction zone (if appropriate)

Based on the risks to human health, it is recommended that a prohibition or restriction zone on taking groundwater over AA1 and extended over an area adjacent to the site, including the identified chlorinated hydrocarbon plume to the west of the site, detailed in *Figure 16 Annex A.*

13.6.7 *Consideration of responsibility of the appropriate person*

Both Vicinity Centres and Hills Limited have provided their written agreement to the implementation of the GMMP, refer to *Annex C* for copies of these letters.

13.6.8 *Any other recommendations that the auditor considers necessary for RTEN to be achieved*

No further recommendations regarding the achievement of RTEN are considered necessary.

13.6.9 *Recommendations on controls on the beneficial use*

No further recommendations regarding controls on the beneficial use are considered necessary.

13.6.10 *Opinion that the RTEN process will achieve the proposed outcomes in the proposed timeframe*

The Auditor considers that the RTEN will achieve the proposed outcomes. However, no set timeframes for monitored natural attenuation have been provided as the duration is unknown, but likely to be greater than 10 years.

13.7 *AUDITOR'S OPINION OF ADEQUACY, QUALITY AND COMPLETENESS OF REMEDIATION*

The review of documentation provided by the consultant (AEC, 2015) in relation to the remediation of the identified areas, as summarised in *Table 12.1* that the information contained within the document is adequate for the purposes of the audit. The information provided:

- Distribution and frequency of validation sampling locations to obtain a valued judgement of the contamination status of the remediated areas;
- Accuracy and reproducibility of analytical results, verified by a program of QA/QC sampling;
- Analytical suites sufficient to identify the previously identified contaminants of concern; and
- Sampling procedures suitable to produce accurate results for the purposes of the audit.

The Auditor is of the opinion that contaminated soils identified during AA1 investigations have been adequately removed from AA1. The soils to be removed from site have been appropriately analysed, classified and disposed. Imported material has also been appropriately analysed and used onsite.

The Auditor considers that the validation of remedial works was conducted in accordance with applicable EPA guidelines and the works were adequate, complete and of sufficient quality.

13.8 Statement On Compliance With Guidelines Issued By The EPA

The Auditor considers the remediation and validations works, including ROA and RMP, followed the applicable guidelines at the time of the remediation works.

14 DATA QUALITY EVALUATION

14.1 QUALITY OF SITE ASSESSMENT DATA

14.1.1 Scope of Investigations

The Auditor considers that the scope of works for all investigations was sufficient for assessing the conditions of contamination at AA1.

14.1.2 Data Quality Objectives

A review of data quality for AA1, including validation investigations by AEC has been undertaken by the Auditor based on NEPM 1999/2013 and AS4482 objectives. This review has considered the following elements:

- Review of the sampling and analytical plans (SAPs), where available and applicable;
- Review of data quality based on the verification of field Quality Assurance and Quality Control (QA/QC) procedures, evidence of the proper transference of samples (chain-of-custody documentation) and sample analysis (and extraction) within the recommended holding times;
- Review of the findings of sample analyses against field observations and measurement;
- Analysis of duplicate (blind and split) samples by an independent laboratory and compliance with data quality indicators (DQIs);
- Analysis of field trip and/or field equipment rinsate samples and compliance with DQIs;
- Use of NATA-approved analytical procedures; and
- Review of internal laboratory QA/QC analyses including analysis of reagent blanks, spike recoveries and duplicates against laboratory DQIs.

Validation of analytical data is undertaken to assess the quality and suitability of the data to assess AA1 condition and to meet the project objectives. The assessment reviews:

- Compliance with sampling and analysis procedures;
- The collection of representative data for AA1 under investigation; and
- Quality control measures used to estimate the precision and accuracy of the data.

The Auditor's review of the data quality assurance and quality control completed by AEC, EES and URS for the purpose of the environmental audit, is set out in *Tables 14.1 and 14.2*. The tables also provide commentary on the issues considered by this review.

14.2 CRITICAL REVIEW OF DATA QUALITY INDICATORS (DQIS)

14.2.1 *General*

Site Auditors are required to check that the following DQIs, which relate to both field and laboratory procedures, have been appropriately assessed by the primary consultants in their reports:

- Completeness – a measure of the amount of useable data (expressed as %) from a data collection activity;
- Comparability – the confidence (expressed qualitatively) that data may be considered to be equivalent for each sampling and analytical event;
- Representativeness – the confidence (expressed qualitatively) that data are representative of each media present on-site;
- Precision – a quantitative measure of the variability (or reproducibility) of data; and
- Accuracy (bias) – a quantitative measure of the closeness of reported data to the true value.

The Auditor completed a review of the DQIs for on-site soil assessments (post-remediation and validation sampling of Area B, Area F, Area H and Pit 4), on-site groundwater and soil vapour assessments (as referenced in AEC 2015), off-site groundwater and soil vapour assessments (as referenced in URS, 2016, URS, 2014b and URS, 2013d). The Auditor comments on the above DQIs are provided below:

14.2.2 *Completeness*

In terms of completeness, the reported soil, soil vapour, indoor air quality and groundwater results are considered sufficiently reliable to assess the current environmental condition of AA1 as well as the identified areas offsite.

14.2.3 *Comparability*

A proportion of the soil investigations undertaken by EES were duplicated by AEC to ensure comparability and therefore reliance on both EES and AEC results.

A comparison of EES and AEC results was undertaken to ensure comparability between the two Assessor results.

A comparison of URS and AEC results was also undertaken to ensure comparability between onsite and offsite groundwater and soil vapour results.

In terms of comparability, the results from different dates of sampling can be compared satisfactorily, since the samples were collected, preserved and handled in a similar manner, and no significant temporal conditions would have influenced the reliability of sample collection. Furthermore, the chemical analyses were carried out using similar, NATA certified analytical methods.

14.2.4 Representativeness

In terms of representativeness, the results are considered reliable to provide an acceptable indication of the environmental condition of the appropriate media present on AA1, i.e. fill materials, natural soils and groundwater.

14.2.5 Precision and Accuracy

Based on the results of the analyses of duplicate samples submitted by AEC and URS, and the results of the internal laboratory QC analyses reported by MGT and ALS, the soil, soil vapour, indoor air quality and groundwater sample results are considered in terms of precision and accuracy to be reliable for the purposes of this audit.

14.3 AUDITOR'S OVERALL RESPONSE TO DATA QUALITY

The overall quality of the data (from both field and laboratory) is considered to be acceptable for interpretive use and that the analytical results were sufficiently accurate and precise, and to draw reliable conclusions concerning the contamination status of AA1. Refer to *Tables 14.1, 14.2 and 14.3* below.

Table 14.1 Summary of QA/QC Review for Critical Site Contamination Data on AA1 (soil) (as per ASC NEPM 2013, Schedule B2, Appendix C)

AEC Environmental, Environmental Site Assessment and Screening Risk Assessment, Audit Area 1, Portion of Former Hills Industries Site, Corner of South Road and Ackland Street, Edwardstown, South Australia, September 2015. (This review only looked at quality assurance from validation of Pit 4, Area B, Area H and Area F and sampling undertaken post-remediation in 2013)

Data Quality Indicator	**Consideration**	**Requirement satisfied (Yes/No)**	**Auditor Comments**
Completeness:	A measure of the amount of usable data from a data collection activity		
Field considerations	All critical locations sampled	Yes	Based on the review the validated soil samples were collected from walls and base of the excavations and stockpiles at an appropriate rate. The location of test pits completed post-remediation is on a grid pattern and provides a cross-section of the conditions on the site.
	Soil samples collected (from grid and at depth) are sufficient to characterise the soil conditions	Yes	Soil samples were collected on a grid (2013), at depth and from excavation works. The soil samples are considered sufficient to characterise the site. Post remediation sampling were completed at a rate consistent with the AS 4482.1-2005 for sampling of soils.
	Sufficient background soil samples recovered from off-site locations to determine ambient background concentrations (ABCs) for metals	No	Background soil samples were not collected from off-site. Soil samples collected in less impacted regions of AA1 can be considered to be representative of background conditions.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Sufficient groundwater samples were collected to characterise the spatial and temporal conditions.	No	The groundwater assessment consisted of grab samples collected from the base of the excavation in Area B. Two groundwater samples were collected for analysis. Assessments of soil vapour and groundwater QA have been undertaken in *Table 14.2*.
	Standard Field Operating Procedures (SOPs) approved and complied with	Yes, with conditions.	Standard operating procedures were not provided. A remediation management plan was provided with respect to remediation activities at AA1. The report indicates that works were undertaken in accordance with the remediation management plan. A sampling and analysis plan was provided for the 2013 soil sampling locations.
	Experienced sampler	Yes	It is considered that suitably qualified staff were utilised by AEC.
	Field documentation correct (e.g. field forms, CoC documentation)	No	Soil remediation field forms were not provided within the report to assess documentation. Relevant field information is provided within figures and tables and is not considered to represent a data quality issue. CoC documentation was available for soil validation sampling analysis and 2013 soil sampling locations.
Laboratory considerations	All critical samples analysed according to Sampling and Analysis Quality Plan (SAQP)	Yes, with conditions.	A remediation management plan was provided for Area B and works were undertaken in accordance with the RMP for Area B. No SAQP or RMP were provided for Areas F or Area H or Pit 4. The auditor considers that all critical validation soil samples were analysed as detailed within the SRA. A sampling and analysis plan (SAP) was provided by AEC for the post-remediation soil sampling and all critical samples were analysed in accordance with the SAP and subsequent personal correspondence with AEC regarding the trenching.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	All analytes analysed according to SAQP	Yes, with conditions.	As mentioned above SAQPs or RMPs were not provided for all locations. In Area B sampling was undertaken in accordance with the RMP. For other areas the relevant analytes of concern (i.e. PAHs or CHCs) were analysed. For Area F and Area H validation samples were only analysed for PAHs. Post-remediation test pit samples were analysed for a range of analytes in accordance with the COPCs for each section of AA1.
	Appropriate methods and LORs	Yes	Appropriate methods of sampling were undertaken for test pitting and soil validations. LORs are considered to be appropriate for the purpose of the assessment.
	Sample documentation complete	Yes, with conditions.	Sample names as displayed by laboratory are consistent with CoCs provided by field staff. Information provided by the laboratory during 2013 test pitting indicated that a number of missing samples, extra samples or incorrectly labelled samples were received at the laboratory (approximately six samples of greater than 150 samples). The incorrectly labelled samples were placed on hold or logged according to the COC (where a transcription error had occurred).
	Sample holding times complied with	Yes, with conditions.	Laboratory reports indicate that no soil samples from Area B, F, H or Pit 4 were assessed outside holding time. During test pitting in 2013, glycol analysis was undertaken outside of holding time. Additional analysis was also requested following initial analysis for specific locations and samples. This secondary analysis was requested outside of the relevant holding time. A majority of the analysis was undertaken within holding time, therefore the Auditor considers that the analysis can be relied upon.
Comparability:	The confidence (expressed qualitatively) that data may be considered to be equivalent for each sampling and analytical event		
Field considerations	Same SOP used on each occasion	Yes	The remediation practice appears similar for each Area of AA1. The 2013 soil sampling plan appears similar for each location.
	Experienced sampler	Yes	See above.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Climatic conditions (temperature, rainfall, wind, etc.)	Yes	Climatic conditions are not recorded within the report.
	Same types of samples collected (filtered, size, fractions, etc.)	Yes	No variations were made to the sample types used in the investigation (soil).
Laboratory considerations	Sample analytical methods used (including clean-up)	Yes	NATA approved methods were used and were consistent through the assessment period.
	Sample LORs (justify if different)	No	See above.
	Same laboratories used (justify if different)	Yes	ALS laboratories were used during the investigations as the primary laboratory, Eurofins MGT were used as a secondary laboratory for 5 QC samples). ALS and MGT are both NATA accredited. During 2013 soil sampling, Eurofins MGT was used as the primary laboratory and ALS laboratories was used as the secondary laboratory.
	Same units used (justify if different)	Yes	The same units from the laboratory reports were used in the analytical tables, with the exception of soil vapour samples where laboratory reports were not included within the report. For the soil vapour samples a comparison of the laboratory reports to the tables indicate correct units.
Representativeness:	The confidence (expressed qualitatively) that data is representative of each medium present on the site		

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
Field considerations	Appropriate media sampled according to SAQP	Yes, with conditions.	A SAQP or RMP was not available for all remediation works. A RMP was available for Area B. The Auditor considers that the appropriate media (soil) was sampled and groundwater, where appropriate at the base of the excavation. A SAP was provided for the 2013 soil sampling and soil sampling was undertaken in accordance with the SAQP. Assessments of soil vapour and groundwater QA have been undertaken in *Table 14.2*.
	Compliance with the frequency of field QA samples as per AS4482.1	Yes	Samples were collected at the required frequency of duplicates and triplicates of 1 per every 20 primary samples. Trip blanks were collected at one per trip. No rinsate blanks were collected as soil samples were placed in individual clean jars.
	All media identified in SAQP sampled	Yes, with conditions.	See above.
Laboratory considerations	All samples analysed according to SAQP	Yes, with conditions.	See above.
Precision:	A quantitative measure of the variability (or reproducibility) of data		
Field considerations	SOPs appropriate and complied with	Yes	The scope of work as detailed within the report was approved by the auditor. Compliance to field consideration points although not documented in details appears to be sufficient.
	Equipment decontaminated between samples	Yes	Equipment was decontaminated between samples by cleaning and washing with decon 90.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
Laboratory considerations	Analysis of minimum 5% field duplicates (intra-laboratory) and 5% triplicates (inter-laboratory). RPDs >30% should be reviewed for cause (e.g. instrument calibration, extraction efficiency, appropriateness of the method used, etc.).	Yes, with conditions.	No quality assurance was undertaken on validation samples from Pit 4. Quality assurance was undertaken for Area F consisting of three laboratory duplicates and three laboratory triplicates. The RPDs were above the acceptability limit for TPH and Cr VI in one of the laboratory duplicate. One laboratory duplicate and one laboratory triplicate was collected from Area H. The RPDs for PAHs were above the acceptability limit in the inter-laboratory and intra-laboratory duplicates. Three duplicates and three triplicates were collected from Area B. The RPDs reported a level above the acceptability limit in one of the triplicates. Four duplicates and three triplicates were analysed during 2013 soil sampling. The RPDs were reported above the acceptability limit for at least one of the following compounds barium, copper, PAHs, arsenic, cadmium, cobalt, nickel and TPH C15-C28 in five of the duplicate or triplicate samples. The level of laboratory duplicate samples is considered sufficient to meet the requirements. The differences in RPDs are considered to represent heterogeneity of contaminants within the soil strata and were not considered to impact the quality of data.
	Analysis of laboratory duplicates at minimum one per batch or two for batched with more than 10 samples. RPDs >30% should be reviewed.	Yes, with conditions.	The frequency of laboratory duplicates analysed was sufficient to meet requirements of ASC NEPM Schedule B3 and ALS QCS3. Laboratory duplicates reported a higher than acceptable variability for mercury and TPH C15-C36 and PAHs. The differences in RPDs are considered to represent heterogeneity of contaminants within the soil strata and were not considered to impact the quality of data. For 2013 soil sampling the laboratory duplicates reported a higher than acceptable variability for at least one of the following compounds – chromium, arsenic, PAHs, TRH, lead, 1,2,4-trimethylbenzene or 1,3,5-trimethylbenzene. The differences in RPDs are considered to represent heterogeneity of contaminants within the soil strata and were not considered to impact the quality of data.
	Laboratory prepared volatile trip spikes	No	Trip spikes were not used as part of the investigation, however this is not considered to have a significant effect on the quality of the data set.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
Accuracy or bias:	A quantitative measure of the closeness of reported data to the true value		
Field considerations	SOPs appropriate and complied with	Yes	No SOP was provided however the scope of work/sampling analysis plan/ remediation management plan was approved and agreed to by the auditor. Soil samples were reported in some cases to have a head space present. This was not considered to affect the quality of the data.
Laboratory considerations	Analysis of field/trip blanks	Yes	Trip and rinsate blanks were analysed and reported no exceedances of the LOR. One trip blank sample was reported as broken on receipt at the laboratory during the 2013 soil sampling. The other trip blanks collected during the 2013 soil sampling were reported below the LOR.
	Analysis of rinsate blanks	Yes, with conditions.	Rinsate blanks were analysed and reported no exceedances of the LOR. During the 2013 soil sampling, the rinsate blanks were unable to be analysed for chromium due to collection within incorrect containers. The rinsate blank was analysed for the other components and reported no exceedances of the LOR.
	Analysis of method blanks	Yes	The frequency of laboratory method blanks was sufficient to meet the requirements of ASC NEPM Schedule B3 and all results were reported as non detects.
	Analysis of matrix spikes	Yes, with conditions.	Matrix spikes were within acceptable limits for Pit 4, Area B, F and H. Matrix spikes were within acceptable limits during 2013 soil sampling, with the exception of a zinc matrix spike which was unable to be determined.
	Analysis of surrogate spikes for organic analytes	Yes, with conditions.	Surrogate spikes were analysed for organic analytes. Surrogate spikes were within acceptable limits with the exception of dibutylchlorendate, p-terphenyl-d14, tetrachloro-m-xylene, fluorobenzene and 2-fluorobiphenyl during some of the surrogate spike analysis for the 2013 soil sampling.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Analysis of laboratory control samples at minimum one per batch.	Yes, with conditions.	The frequency of laboratory control samples was considered consistent with the requirements of the ASC NEPM Schedule B3. Laboratory control spikes were reported to exceed the recovery limit for hexachlorobutadiene, chlorotoluene, 1,2,3-chlorobenzene and 1,2,4-chlorobenzene in one sample. The exceedance was not considered to affect the quality of the data as compounds did not represent COPCs.
	Analysis of laboratory-prepared spikes (for volatile analytes)	No	Trip spikes were not used as part of the investigation.

Table 14.2 Summary of QA/QC Review for Critical Site Contamination Data on AA1 for Groundwater and Soil Vapour (as per ASC NEPM 2013, Schedule B2, Appendix C)

AEC Environmental, Groundwater and Soil Vapour Monitoring Event Report – Audit Area 1 Portion of Former Hills Industries Site, Corner of South Road and Ackland Street, Edwardstown, South Australia (December 2014) (Report Ref: 3698/AA1/GWME_03/01)

AEC Environmental, Environmental Site Assessment and Detailed Risk Assessment, Audit Area 1, Portion of Former Hills Industries Site, Corner of South Road and Ackland Street, Edwardstown, South Australia, September 2015. (Review of April 2013 GME and December 2013 SVME)

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
Completeness:	A measure of the amount of usable data from a data collection activity		
Field considerations	All critical locations sampled	Yes	Groundwater: The SAP (Ref: 3698) indicates nine locations (MWD, MWE, MWF, MWH, MWH_Q2, MWJ, MWK and MWAL) were to be sampled. All proposed locations were sampled including two further locations (MWBK and MWBL) were also sampled. (Section 2.1 of report). Based on the review, the groundwater sampling locations provided an overview of the groundwater conditions, with a particular focus on areas of identified soil impact. Soil Vapour: The SAP (Ref: 3698) indicates three locations (VMB1-3.0, VMB2-1.5, and VMB2-3.0) were to be sampled. All proposed locations were sampled.
	Soil samples collected (from grid and at depth) are sufficient to characterise the soil conditions	Not Applicable	Soil samples were discussed separately in *Table 14.1*.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Sufficient background soil samples recovered from off-site locations to determine ambient background concentrations (ABCs) for metals	Not Applicable	Soil samples were discussed separately in *Table 14.1*.
	Sufficient groundwater samples were collected to characterise the spatial and temporal conditions.	Yes	All locations proposed for sampling in the SAP (Ref: 3698) were sampled. The groundwater assessment consisted of twenty-six groundwater monitoring wells on AA1 in the Q1 aquifer, three groundwater monitoring wells within the Q2 aquifer and one groundwater monitoring well within the T1 aquifer. Groundwater sampling was conducted at least annually between 2008 and 2014 at some of the groundwater monitoring wells within the network. Soil vapour sampling was completed between 2010 and 2014.
	Standard Field Operating Procedures (SOPs) approved and complied with	Yes, with conditions	The groundwater sampling methodology was conducted using a micro-purging technique as per the requirements of EPA publication 669. It is noted however, that DO readings do not appear to be stabilised as par EPA publication 669 (+/- 10%) for MWAL and MWF, where there is a 11% difference between the third last reading and the last reading. Standard operating procedures for 2013 were not provided the methodology for the groundwater and soil vapour monitoring event is included within the SRA (AEC. 2015). The Auditor considers that the methodology outlined within the SRA are acceptable.
	Experienced sampler	Yes	AEC staff undertook the groundwater and soil vapour sampling. The field staff are considered to be experienced.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Field documentation correct (e.g. field forms, CoC documentation)	Yes, with conditions	Groundwater Groundwater field sampling sheets have been provided. Calibration certificates of the groundwater sampling equipment including the water quality metre and the flow-flow pump have been included. Soil Vapour Sampling: Soil vapour sampling sheets have not been provided during October 2014 SVME. Soil vapour sampling sheets and COC were available for the December 2013 SVME.
Laboratory considerations	All critical samples analysed according to Sampling and Analysis Quality Plan (SAQP)	Yes	All critical vapour soil and groundwater samples were analysed in accordance with the SAP (Ref: 3698) The details within the SRA indicate that all critical samples were analysed for the relevant analytes.
	All analytes analysed according to SAQP	Yes	All analytes were analysed according to the SAP (Ref: 3698) The details within the SRA indicate that all critical samples were analysed for the relevant analytes.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Appropriate methods and LORs	No	Appropriate methods of sampling were undertaken for soil vapour and groundwater samples. Groundwater Sampling The groundwater sampling methodology was generally in accordance with EPA publication 699 and was applied for all the groundwater sampling undertaken. Groundwater results displayed certain results which exceeded the SLs or HILs. The exceedances are outlined/tabulated in the report. LORs of VC were raised in few instances. It's unclear why this was the case. The summary tables however, do not provide an individual column for LORs. Sample LORs for organochlorine pesticides and PAHs were above the criteria for ecological protection and drinking water, respectively, in groundwater. Soil Vapour Sampling No field sheets provided in December 2014. Can't confirm if the sampling methods are correct. For December 2013 the field sheets indicated that sampling methods were correct. Soil vapour sampling displayed certain results which exceeded the SLs or HILs. The exceedances are outlined/tabulated in the report.
	Sample documentation complete	Yes	COCs provided, all sample documentation is correct.
	Sample holding times complied with	Yes	COCs provided, all sample documentation is correct, with the exception of hydrochloric acid in April 2013 GME.
Comparability:	The confidence (expressed qualitatively) that data may be considered to be equivalent for each sampling and analytical event		

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
Field considerations	Same SOP used on each occasion	Yes	The same SOP was used within the April 2013 GME. Details within the SRA indicate that different sampling equipment methods and different analytes were assessed in different GMEs completed between 2008 and 2014. The same SOP was used within the December 2013 SVME. Details within the SRA indicate that different sampling equipment methods and different analytes were assessed in different SVMEs completed between 2010 and 2013.
	Experienced sampler	Yes	See above.
	Climatic conditions (temperature, rainfall, wind, etc.)	Yes, with conditions	Yes, climate conditions were recorded for groundwater in 2014 but not in 2013. Climate conditions were recorded on the soil vapour field sheets in December 2013. Field sheets were not provided in October 2014.
	Same types of samples collected (filtered, size, fractions, etc.)	Yes	Yes, all completed correctly.
Laboratory considerations	Sample analytical methods used (including clean-up)	Yes	NATA approved methods were used and were consistent through the assessment period.
	Sample LORs (justify if different)	Yes	Yes, all completed correctly. Sample LORs for organochlorine pesticides and PAHs were above the criteria for ecological protection and drinking water, respectively, in groundwater.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Same laboratories used (justify if different)	Yes	Groundwater Sampling Eurofins MGT was the primary laboratory, and ALS the secondary laboratory. Both are NATA accredited. Soil Vapour Sampling In the October 2014 Envirolab was the primary laboratory, ALS was the secondary laboratory. Both are NATA accredited. In the December 2013 SVME Envirolab Services Pty Ltd was used as the primary laboratory and ALS Laboratory was used as the secondary laboratory. Both are NATA accredited.
	Same units used (justify if different)	Yes	The same units from the laboratory reports were used in the analytical tables.
Representativeness:	The confidence (expressed qualitatively) that data is representative of each medium present on the site		
Field considerations	Appropriate media sampled according to SAQP	Yes	The appropriate media was sampled according to the auditor approved work plan, including both groundwater and soil vapour. Points added by the client were also taken into consideration. A SAQP was not available for all groundwater and soil vapour sampling. The media were considered appropriate for the assessment.
	Compliance with the frequency of field QA samples as per AS4482.1	Yes	One duplicate and triplicate, one equipment rinsate, and one trip blank in October 2014 for groundwater sampling. Three duplicates and triplicates, rinsates and trip blanks for April 2013 groundwater sampling. One duplicate and triplicate, one equipment isopropynol control sample, and one trip blank were collected during December 2013 and October 2014 soil vapour sampling.
	All media identified in SAQP sampled	Yes	See above.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
Laboratory considerations	All samples analysed according to SAQP	Yes	All samples were analysed according to the auditor approved workplan. The Auditor considers the analysis appropriate, where a workplan was not provided.
Precision:	A quantitative measure of the variability (or reproducibility) of data		
Field considerations	SOPs appropriate and complied with	Yes	The scope of work was created by AEC with input from the client and was approved by the auditor. Compliance to field consideration points although not documented in details appears to be sufficient.
	Equipment decontaminated between samples	Yes	Decontamination of sampling equipment was completed with results satisfactory.
Laboratory considerations	Analysis of minimum 5% field duplicates (intra-laboratory) and 5% triplicates (inter-laboratory). RPDs >30% should be reviewed for cause (e.g. instrument calibration, extraction efficiency, appropriateness of the method used, etc.).	Yes	Groundwater Sampling One duplicate and triplicate, per 11 samples in December 2014. Two duplicates and two triplicates were collected during the April 2013 GME. RPDs were reported above the acceptable criteria for zinc, TPH C6-C9 and ammonia in at least one sample pair. Soil Vapour Sampling 1 duplicate and triplicate, per 10 samples in October 2014. Soil vapour sampling in 2013 reported RPDs above the acceptable criteria for xylene and ethylbenzene.
	Analysis of laboratory duplicates at minimum one per batch or two for batched with more than 10 samples. RPDs >30% should be reviewed.	Yes	Groundwater Sampling and Soil Vapour Sampling The frequency of laboratory duplicates analysed was sufficient to meet requirements of ASC NEPM Schedule B3 and ALS QCS3.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Laboratory prepared volatile trip spikes	No	Trip spikes were not used as part of the investigation, however this is not considered to have a significant effect on the quality of the data set.
Accuracy or bias:	A quantitative measure of the closeness of reported data to the true value		
Field considerations	SOPs appropriate and complied with	Yes	No SOP is mentioned in the report however the scope of work/work plan was approved and agreed to by the auditor.
Laboratory considerations	Analysis of field/trip blanks	Yes	2 trip blanks were analysed during December 2014, of which 1 was for groundwater, and 1 was for soil vapour. Analyses were reported below the laboratory limit according to the results summary tables. One trip blank was analysed during December 2013 soil vapour monitoring and analysis indicated all concentrations below the LOR. Three trip blanks were analysed during April 2013 for groundwater. Analyses indicate concentrations below the LOR.
	Analysis of rinsate blanks	Yes	1 rinsate blank sample was reported for groundwater in December 2014 and three in April 2013. This equates to one per day for each medium. Concentrations were reported below the LOR. Soil vapour sampling was assessed for leaks using isopropanol during December 2013 SVME and reported concentrations below the limit of reporting.
	Analysis of method blanks	Yes	The frequency of laboratory method blanks was sufficient to meet the requirements of ASC NEPM Schedule B3 and all results were reported as non detects.
	Analysis of matrix spikes	Yes	Yes, all completed. Matrix spikes in the April 2013 GME were not completed for chloride, nitrate, ferrous iron and benzene as background levels were above the 4x spike level.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Analysis of surrogate spikes for organic analytes	Yes	Surrogate spikes were analysed for organic analytes.
	Analysis of laboratory control samples at minimum one per batch.	Yes	Yes, all completed.
	Analysis of laboratory-prepared spikes (for volatile analytes)	No	Trip spikes were not used as part of the investigation.

Table 14.3 Summary of QA/QC Review for Critical Site Contamination Data Off-site (as per ASC NEPM 2013, Schedule B2, Appendix C)

URS Off-site Groundwater Monitoring, 944 – 956 South Road, Edwardstown, April 2014

URS, 944 -956 South Road, Edwardstown, Detailed Risk Assessment for Off-site Contamination, January 2016

URS, Hills Edwardstown – May 2013 Utility Pit Vapour Monitoring, 27 August 2013

Data Quality Indicator	**Consideration**	**Requirement satisfied (Yes/No)**	**Auditor Comments**
Completeness:	A measure of the amount of usable data from a data collection activity		
Field considerations	All critical locations sampled	Yes	Groundwater sampling was undertaken on all off-site groundwater monitoring wells. The distribution of groundwater monitoring wells is considered to adequately characterise the groundwater conditions off-site. Soil vapour sampling was conducted on a portion of the off-site soil vapour bores (8 residential bores and 4 existing). Annual soil vapour sampling was undertaken at all locations. The review was undertaken for the limited soil vapour sampling. The limited soil vapour bore network is considered to characterise the soil vapour conditions off-site. Indoor air sampling was conducted at seven residences with two samples collected from two of the residences. Utility pit air sampling was conducted at three utility pits, adjacent to groundwater, soil vapour and indoor air sampling locations.
	Soil samples collected (from grid and at depth) are sufficient to characterise the soil conditions	No	Soil assessment was not undertaken for the investigation off-site. The source of the plume was known to exist at AA1 therefore the absence of soil data was not considered to impact the quality of the data as the source of the groundwater and vapour impact was known.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Sufficient background soil samples recovered from off-site locations to determine ambient background concentrations (ABCs) for metals	No	Soil sampling was not undertaken as the source of the groundwater and soil vapour impact was known, therefore no background concentrations were required.
	Sufficient groundwater samples were collected to characterise the spatial and temporal conditions.	Yes	Groundwater samples were collected from the thirty-seven groundwater wells. No LNAPL/DNAPL was detected in any gauged well. The auditor considers that there are sufficient data points to characterise the condition of groundwater. All monitoring wells off site were sampled in April 2014. Previous groundwater sampling was undertaken between 2011 and 2014 to assess the temporal and seasonal groundwater conditions. Ten of the groundwater monitoring wells were assessed quarterly to account for seasonal variation. Sufficient indoor air samples collected to account for spatial variability. Two samples were collected from two of the houses to account for variability within the residence. Indoor air samples were collected on one sampling occasion. The absence of temporal variability was not considered to impact the quality of the data based on the concentration identified and the additional data available (soil vapour and groundwater). Sufficient soil vapour samples were collected to account for spatial and temporal variability. Utility pit samples were sufficient to characterise the conditions down gradient of the site. Temporal variability was assessed by collection of three rounds of utility pit sampling.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Standard Field Operating Procedures (SOPs) approved and complied with	Yes	The groundwater monitoring report used was considered appropriate for this assessment by the auditor. All monitoring wells were sampled using low flow purge with the exception of MWY, which had tree roots and was sampled by disposable bailer. The soil vapour standard field operating procedures as outlined within the DRA are considered appropriate for this assessment by the auditor. The indoor air SOPs detailed within the report were considered appropriate for this assessment by the auditor. The utility pit sampling procedure outlined within the report was considered by the auditor to be appropriate for the assessment.
	Experienced sampler	Yes	It is considered that suitably qualified staff were utilised by URS. Indoor air sampling was contracted to Air Toxics Ltd and sampling was conducted by an experience sampler.
	Field documentation correct (e.g. field forms, CoC documentation)	Yes	Groundwater gauging and sampling forms and CoCs are all included in the report. All CoCs are signed as received by the laboratory (ALS). Soil vapour sampling forms are included in the report. The CoCs for soil vapour sampling were not included within the report. Indoor air and utility air sampling forms and COCs are included in the report.
Laboratory considerations	All critical samples analysed according to Sampling and Analysis Quality Plan (SAQP)	No	SAQPs were not provided for groundwater monitoring, indoor air or utility pit sampling. The auditor considers that all critical groundwater, indoor air and utility air samples were analysed as detailed within the DRA. All critical soil vapour samples were analysed in accordance with the SAQP.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	All analytes analysed according to SAQP	No	SAQPs were not provided for groundwater monitoring, indoor air or utility pit sampling. All analytes, chlorinated hydrocarbons and nitrate (for groundwater only), were analysed according to the requirement for off-site assessment. Soil vapour samples were analysed in accordance with the SAQP.
	Appropriate methods and LORs	Yes	Appropriate methods of sampling were undertaken for groundwater, soil vapour, indoor and utility air samples. Each medium displayed certain results which exceeded the SLs or HILs. The exceedances are outlined/tabulated in the report. LORs are considered to be appropriate for the purpose of the assessment. The groundwater sampling methodology was generally in accordance with SA EPA (2007) Regulatory Monitoring and Testing, Groundwater Sampling and was applied for all the groundwater sampling undertaken.
	Sample documentation complete	Yes	Sample names as displayed by laboratory are consistent with CoCs provided by field staff.
	Sample holding times complied with	Yes	Laboratory reports inform that no groundwater samples were analysed outside of recommended holding times in April 2014. Groundwater analysis of nitrate and nitrite in privately owned bores off-site was outside the holding time. This was not considered to impact the analytical quality of the nitrate and nitrite. Laboratory reports indicate that soil vapour, indoor and utility air samples were analysed within acceptable holding times.
Comparability:	The confidence (expressed qualitatively) that data may be considered to be equivalent for each sampling and analytical event		

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
Field considerations	Same SOP used on each occasion	Yes	The groundwater monitoring report used was considered appropriate for this assessment by the auditor. All monitoring wells were sampled using low flow purge with the exception of MWY, which had tree roots and was sampled by disposable bailer. For utility air sampling, variability within the data was stated to potentially result from variations in air sampling methodology between the two consultants that completed the sampling (AEC and URS).
	Experienced sampler	Yes	See above.
	Climatic conditions (temperature, rainfall, wind, etc.)	Yes	Climatic conditions were recorded on the field sheets, which are present in the report.
	Same types of samples collected (filtered, size, fractions, etc.)	Yes	No variations were made to the sample types used in the investigation (groundwater, soil vapour/indoor air/ utility pit).
Laboratory considerations	Sample analytical methods used (including clean-up)	Yes	NATA approved methods were used and were consistent through the assessment period.
	Sample LORs (justify if different)	No	See above.
	Same laboratories used (justify if different)	Yes	ALS laboratories were used during the investigations as the primary laboratory, Eurofins MGT were used as a secondary laboratory for 5 QC samples). ALS and MGT are both NATA accredited. Analysis of indoor and utility air samples was undertaken by Air Toxics Ltd and National Measurement Institute. Analysis of soil vapour samples was undertaken by Eurofins Air Toxics Ltd and National Measurement Institute.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Same units used (justify if different)	Yes	The same units from the laboratory reports were used in the analytical tables, with the exception of soil vapour samples where laboratory reports were not included within the report. For the soil vapour samples a comparison of the laboratory reports to the tables indicate correct units.
Representativeness:	The confidence (expressed qualitatively) that data is representative of each medium present on the site		
Field considerations	Appropriate media sampled according to SAQP	No	A SAQP was not available for groundwater, indoor air and utility pit air. The Auditor considers that the appropriate media was sampled, including groundwater, indoor air, utility pit air and soil vapour. Soil samples were not assessed as the source of the impact was known within AA1.
	Compliance with the frequency of field QA samples as per AS4482.1	Yes	Samples were collected at the required frequency of duplicates and triplicates of 1 per every 20 primary samples, rinsate blanks is one per day and trip blanks is one per trip for groundwater. No rinsate and trip blanks were collected during indoor air, utility air and soil vapour sampling. This was not considered to impact the quality of the data as individual equipment (Summa canisters designated tubing) was used for each sampling location. A duplicate sample was not collected for the indoor and utility air analysis. A triplicate sample was collected. This was not considered to impact the quality of the data as correlations between the groundwater and soil vapour data was completed.
	All media identified in SAQP sampled	No	See above.
Laboratory considerations	All samples analysed according to SAQP	No	See above.
Precision:	A quantitative measure of the variability (or reproducibility) of data		
Field considerations	SOPs appropriate and complied with	Yes	The scope of work as detailed within the report was approved by the auditor. Compliance to field consideration points although not documented in details appears to be sufficient.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Equipment decontaminated between samples	Yes	Decontamination of sampling equipment was undertaken according to the scope of work within the groundwater monitoring report. Rinsate blanks completed during groundwater sampling indicate that decontamination was acceptable. Individual sampling equipment was used for soil vapour, indoor air and utility pit air sampling.
Laboratory considerations	Analysis of minimum 5% field duplicates (intra-laboratory) and 5% triplicates (inter-laboratory). RPDs >30% should be reviewed for cause (e.g. instrument calibration, extraction efficiency, appropriateness of the method used, etc.).	Yes	Duplicate and triplicate groundwater, soil vapour and indoor air samples (triplicate only) were reported in the acceptable range for reproducibility. Triplicate utility air samples for PCE were reported outside of the acceptable range for reproducibility. The highest value was reported in the primary sample, which has been considered within the analysis. This was not considered to impact the reliability of the data set as multiple rounds of sampling were undertaken.
	Analysis of laboratory duplicates at minimum one per batch or two for batched with more than 10 samples. RPDs >30% should be reviewed.	Yes	The frequency of laboratory duplicates analysed was sufficient to meet requirements of ASC NEPM Schedule B3 and ALS QCS3.
	Laboratory prepared volatile trip spikes	No	Trip spikes were not used as part of the investigation, however this is not considered to have a significant effect on the quality of the data set.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
Accuracy or bias:	A quantitative measure of the closeness of reported data to the true value		
Field considerations	SOPs appropriate and complied with	Yes	No SOP is mentioned in the report however the scope of work/work plan was approved and agreed to by the auditor.
Laboratory considerations	Analysis of field/trip blanks	Yes	Three trip blanks were analysed during the groundwater phase of work which was considered appropriate for the number of samples collected. No trip blanks were analysed during the soil vapour, indoor air and utility pit phase of work. The absence of trip blanks was not considered to impact the quality of the data as results were consistent with previous assessments.
	Analysis of rinsate blanks	Yes	One groundwater rinsate blank sample was analysed for the report. All concentrations were below the limit of reporting. Rinsate blank samples were not collected during soil vapour, indoor air and utility pit sampling, as individual canisters were applied within each analysis.
	Analysis of method blanks	Yes	The frequency of laboratory method blanks was sufficient to meet the requirements of ASC NEPM Schedule B3 and all results were reported as non detects.
	Analysis of matrix spikes	Yes	Matrix spikes were not analysed for nitrate as background interference was too great and the spike exceeded for one sample for trichloroethene as the recovery was greater than the upper limit, which may have over-measured the concentration. The matrix spike was only greater during one laboratory analysis. Matrix spikes for sulphate and nitrite were not determined and trichloroethene was reported below the lower limit, during groundwater monitoring at privately owned off-site locations.
	Analysis of surrogate spikes for organic analytes	Yes	Surrogate spikes were analysed for organic analytes.

Data Quality Indicator	Consideration	Requirement satisfied (Yes/No)	Auditor Comments
	Analysis of laboratory control samples at minimum one per batch.	Yes	The frequency of laboratory control samples was considered consistent with the requirements of the ASC NEPM Schedule B3.
	Analysis of laboratory-prepared spikes (for volatile analytes)	No	Trip spikes were not used as part of the investigation.

15 AUDITOR OPINIONS

15.1 ASSESSMENT OF THE FINAL STATUS AND CONDITION OF THE SITE

An assessment of the final status and condition of AA1 for mixed use land use including commercial (extension of the Castle Plaza Shopping Centre), light commercial/industrial with an option for the incorporation of medium-high density residential use is detailed below:

15.1.1 *Imminent Environmental Hazard*

The Auditor is not aware of any imminent environmental hazard associated with AA1.

15.1.2 *Condition of Soil*

The concentrations of chemical substances remaining in site soils are minor exceedances of NEPM HIL B for lead, nickel and carcinogenic PAHs. A number of the exceedances have been deemed statistically acceptable to remain onsite. A number of exceedances of NEPM HIL A remain in site soils for cadmium, lead, nickel, zinc, and carcinogenic PAHs.

Concentrations of chemical substances remaining on AA1 above NEPM EILs (urban residential/public open space and commercial and industrial) are copper, lead, nickel, and zinc. These are in localised pockets of fill. Exceedances of NEPM ESL (urban residential/public open space and commercial and industrial) are benzo(a)pyrene and hydrocarbons (TRH >C_{16}-C_{34} (F3)).

Intersected minor isolated areas containing ash/cinders/ charcoal remaining in situ are considered minor.

The remediation of Area B reported concentrations of PCE above the adopted site screening criteria, however, subsequent contaminant mass assessment undertaken did not report any exceedances of site criteria. The reported concentrations of PCE in a number of groundwater monitoring bores may indicate the presence of DNAPL such that soil at depth may contain residual PCE. It is the Auditor's opinion that contamination of soil that is not trivial exists at AA1.

15.1.3 *Condition of Groundwater*

Groundwater quality is considered to be impacted by onsite sources resulting in contamination. Concentrations of chlorinated hydrocarbons (PCE, TCE, DCE and VC) have exceeded drinking water criteria. The primary source of the northern chlorinated hydrocarbon plume is likely to be from the northeast corner of the former Ironing Tables Workshop with an additional source associated with Pit 4 in the northwest corner of the site. Refer to *Figure 8* for the location of these likely source areas and *Figure 14* for the extent of chlorinated hydrocarbon plume (PCE) on and offsite.

Concentrations of nitrate were reported above freshwater aquatic ecosystems, drinking water and agricultural (livestock) beneficial uses. Concentrations of manganese above drinking water and Agricultural – aquaculture were reported.

Concentrations of total organic carbon (TOC) and nickel at one location and hexavalent chromium at two locations just exceeding the criteria are considered minor.

Reported concentrations of boron and zinc, although above assessment criteria, are considered to reflect background groundwater conditions.

The offsite condition of groundwater is also considered to be impacted by the onsite sources resulting in contamination. Concentrations of chlorinated hydrocarbons (PCE, TCE, DCE and VC) have exceeded drinking water criteria and concentrations of nitrate were reported above freshwater aquatic ecosystems, drinking water and agricultural (livestock) beneficial uses.

The chlorinated hydrocarbons in groundwater onsite and offsite provide a source of organics to soil vapour. The potential impacts of this based on the results of soil vapour monitoring and risk assessments are discussed below.

It is the Auditor's opinion that contamination of groundwater that is not trivial exists on AA1 and offsite.

15.1.4 Condition of Surface water

There is no surface water at AA1 and so no investigations have occurred. Although the offsite condition of groundwater is considered to be impacted, the impacted groundwater has been delineated and modelled such that impacts above adopted criteria are unlikely to extend to the nearest water body.

15.1.5 Condition of Vapour

The results of soil vapour monitoring onsite indicate reported exceedances of PCE, TCE and DCE of adopted criteria at depths of 1.5 and 3.0 mbgl.

Chlorinated hydrocarbons in vapour exceeded the adopted criteria at a number of offsite locations.

No exceedances were reported following indoor air monitoring and TCE was reported at a concentration above the assessment criterion in vapour from one utility pit.

15.2 *NATURE AND EXTENT OF CONTAMINATION*

The Auditor is of the opinion that the nature and extent of site contamination was sufficiently assessed and delineated by AEC onsite for the purposes of the audit and that:

- AA1 has been remediated such that the sources of contamination, and contaminated soil that poses a risk to the proposed land uses has been removed from AA1, except for some minor areas of lead, nickel and carcinogenic PAHs;
- Remaining soil with reported analyte concentrations above the NEPM EILs and ESLs, and reported concentrations of lead, nickel and carcinogenic PAHs above NEPM HIL B are not deemed to present a risk to future onsite workers or residential occupants, however may present a minor risk to intrusive site construction workers and a minor risk to plants;
- The reported concentrations of PCE in a number of groundwater monitoring bores may indicate the presence of DNAPL such that soil at depth may contain residual PCE;
- Concentrations of PCE and degradation products in groundwater are considered to reflect onsite source areas, and significant sources of chlorinated solvents (including PCE at concentrations that may indicate the presence of DNAPLs) have been identified onsite;
- The primary source of the northern chlorinated hydrocarbon plume is likely to be from the northeast corner of the former Ironing Tables Workshop with an additional source associated with Pit 4 in the northwest corner of the site. Refer to *Figure 8* for the location of these likely source areas and *Figure 14* for the extent of chlorinated hydrocarbon plume (PCE) on and offsite;
- Concentrations of PCE, TCE and DCE in soil vapour indicated exceedances of screening criteria;
- Risk to onsite receptors for potential exposure to vapours, sourced from groundwater and/or soil (DNAPL), were considered acceptable for all assessed scenarios, with the exception of the standard residential scenario - "*low to medium density residential homes constructed on a slab where exposures by residents may occur within the home*";
- Concentrations of total organic carbon, heavy metals (hexavalent chromium, manganese and nickel), in groundwater are considered to reflect historical onsite storage and use;
- Concentrations of nitrate onsite are considered to reflect historical onsite storage and use of N-containing compounds;

- Lower nitrate concentrations than those measured in groundwater at some locations on site may be related to more regional, ambient conditions; and
- Concentrations of zinc and boron in groundwater onsite are likely to be attributable to up gradient groundwater quality.

15.3 OFF-SITE CONTAMINATION

The Auditor is of the opinion that the nature and extent of site contamination was sufficiently assessed by URS offsite for the purposes of the audit and that:

- Concentrations of PCE and degradation products in groundwater are considered to reflect onsite source areas, as significant sources of chlorinated solvents (including PCE at concentrations that may indicated the presence of DNAPLs) have been identified onsite Refer to *Figure 8* for the location of these likely source areas and *Figure 14* for the extent of chlorinated hydrocarbon plume (PCE) on and offsite;
- Concentrations of nitrate are considered to reflect an up gradient source, likely the former Hills site and further upgradient source(s);
- Offsite indoor air screening reported PCE, TCE, DCE and VC at concentrations below the relevant screening criteria;
- Air concentrations within utility pits were below assessment criteria except for TCE at one location; and
- Calculated risks to identified receptors for potential exposure to vapours sourced from groundwater were considered acceptable except for the potential scenario from the potable use of groundwater within the plume where PCE concentrations are above the drinking water guideline.

16 AUDITOR RISK ASSESSMENT

This section outlines the Auditor's assessment of actual or potential risk posed by the final condition of AA1 to human health, groundwater, surface water and the environment.

16.1 TYPICAL RISK PATHWAYS POSED BY CONTAMINATED SOIL AND GROUNDWATER

Soil (and groundwater) contamination can result in potential hazards on and off-site. The "source-pathway-receptor" model is used by the Auditor to assess the hazards. That is, the hazard presented by a source of contamination can travel via one or more pathways and impact on a receptor (people, animals, plants, etc.). The most common receptors are:

- humans living, working, or recreating on or near a potentially contaminated site (or remotely in the case of indirect exposure to contaminants);
- plants grown on AA1 soil or in the wider ecosystem; and
- animals (pets, other domestic species, or animals in the food chain of an affected ecosystem).

Another potential impact of contamination, which is not a hazard, is aesthetic impairment (visual and odour) and this can be critical in restricting land use. Potential impacts on engineering structures (particularly building foundations) from chemicals remaining within the soil are also assessed by the Auditor.

All of the above factors are reviewed within an assessment of the contamination hazards and risks at this site. For an assessment of the level of risk from contaminants at AA1, consideration is given to potential human health risks from long term residence including the presence of children, given the proposed residential site use. However, potential ecological risks resulting from migration of contaminants have also been considered.

Potential exposure routes for hazards to human receptors from contaminated sites include:

- ingestion of contaminated soil (mainly by infants in the range 1 - 5 years);
- ingestion of contaminated groundwater;
- ingestion of contaminated plants and animals (on-site or via the food chain);
- inhalation of vapours from AA1;
- inhalation of contaminated dusts; and
- dermal contact with contaminated soil, surface water or groundwater.

16.2 RESIDUAL CONTAMINATION SOURCES

16.2.1 *Soil Quality at the Site*

The concentrations of chemicals of concern were reported above NEPM HIL A for cadmium, lead, nickel, zinc and carcinogenic PAHs. The concentration of lead in one location was reported above NEPM HIL D.

The concentrations of chemicals of concern are below NEPM HIL B and or the site specific soil criteria, with the exception of a number of locations with elevated concentrations of lead and nickel (one location) and carcinogenic PAHs. Concentrations of copper, lead, nickel and zinc, and NEPM ESLs for benzon(a)pyrene and hydrocarbons (but exceed NEPM EILs for copper, lead, nickel, and zinc, and NEPM ESLs for benzo(a) pyrene and hydrocarbons (TRH >C_{16}-C_{34} (F3)) exceeded NEPM EILs. Therefore, soil contamination exists onsite that is not trivial.

The reported concentrations of PCE in a number of groundwater monitoring bores may indicate the presence of DNAPL such that soil at depth may contain residual PCE.

Under the proposed development of AA1 for mixed use, including commercial/light industrial and medium – high density residential, the majority of soil will not be accessible.

An assessment of the harm, detriment or risk to beneficial uses of AA1 is considered low.

16.2.2 *Groundwater Quality at the Site*

Groundwater assessment identified significant groundwater contamination sourced from AA1. It is the Auditor's opinion that contamination of groundwater that is not trivial does exist onsite.

The DWLBC bore information revealed there is groundwater abstraction in the locality for possible potable and irrigation use hydraulically down hydraulic gradient of AA1. The low yield and availability of reticulated water supply makes the use of abstracted groundwater unlikely for potable use however there is the potential for such use, as well as recreational use, both on and offsite. The use of groundwater for irrigation is considered likely, as currently utilised for such purposes offsite. Ongoing irrigation use at the Bowling Club and racecourse, are likely to continue from deeper Tertiary aquifers. Due to the existence of an industrial bore onsite, the use of groundwater for industrial purposes on and offsite is considered possible

16.3 RECEPTORS

16.3.1 *Human Health*

The Auditor has assessed the potential harm, detriment or risk to beneficial uses of AA1 posed by the current condition of AA1 as low for all relevant beneficial uses of soil and groundwater with the following exceptions:

- Onsite
  - Low density residential use (i.e. homes constructed on a slab where exposures by residents may occur within the home) is considered unacceptable in areas where groundwater is impacted with chlorinated solvents (i.e. along the plume centre line along the northern site boundary).
- Offsite
  - Unacceptable levels of risk are predicted under the less likely scenarios that groundwater is extracted and plumbed to a house for showering/bathing and/or is used as the main source of drinking water.

The Auditor also considers that there is a risk that downward migration of contaminants in the Q1 aquifer may occur if pumping from deeper aquifers, in particular the Tertiary aquifer, changed the current hydrogeological regime.

Future Site Occupants (onsite) - In the Auditor's opinion, the current soil and groundwater status does not represent a risk of potential harm or detriment to human health associated with high density residential use of AA1 or other less sensitive uses. However, due to the concentrations of chlorinated hydrocarbons in groundwater, and the potential vapour risks associated with chlorinated compounds, the Auditor has included a recommendation regarding the use of groundwater at AA1 and the construction of habitable basements and ground floor residences.

Existing and Future Site Occupants (offsite) - In the Auditor's opinion, the current groundwater status does not represent a risk of potential harm or detriment to human health associated with current site uses, including low density residential use with the exception of the potential scenario from the potable use of groundwater within the plume where PCE concentrations are above the drinking water guideline. However, due to the concentrations of chlorinated hydrocarbons in groundwater, and the potential vapour risks associated with chlorinated compounds, the Auditor has included a recommendation regarding the use of groundwater offsite and the construction of habitable basements.

Construction Workers (onsite) – A limited number of impacted soil locations remain onsite that exceed the NEPM HIL B. Also, groundwater standing water levels may be encountered during construction. The risk to construction and maintenance workers are deemed to be medium. The Auditor has included a recommendation regarding the management of soils during onsite construction works.

Maintenance Workers (onsite and offsite) – The Auditor considers the risk to maintenance workers onsite and offsite to be low.

Local Groundwater Users - Groundwater registered bores in the area are used for domestic and irrigation purposes. The SA EPA has designated the impacts located down hydraulic gradient that are under investigation due to the chlorinated solvent plume likely to be sourced from AA1. They have requested the public refrain from using groundwater for any purposes. The risk from the identified contaminants in groundwater, in particular chlorinated hydrocarbons and nitrate, above drinking water criteria, are deemed to be unacceptable. The Auditor has included recommendations regarding the use of groundwater within the delineated offsite plume and regarding the construction of habitable basements.

Air - no areas of impacted soil or groundwater onsite have been identified as affecting air quality as the reported concentrations of PCE are sufficiently low.

16.3.2 Surface Waters

The risk to surface waters in the vicinity of AA1 is considered low due to the distance to the closest surface water body is the Gulf of St Vincent, over 5 km from AA1. Exceedances of marine water aquatic ecosystems criteria have been reported onsite for TOC and hexavalent chromium, however offsite groundwaters were not tested for these analytes. It is considered by the auditor that the exceedances, just above the adopted criteria, are unlikely to impact on the marine water quality over 5 km to the west of AA1.

16.3.3 Flora and Fauna

The concentration of chemicals of concern in the onsite shallow fill soils marginally exceed the NEPM EILs for copper, lead, nickel, and zinc and exceedances of benzo(a)pyrene and hydrocarbons (F3) above the NEPM ESLs. Also taking into account interim EPA advice in relation to B(a)P ESLs (see *Section 7.2.1* above), the Auditor considers that these exceedances indicate there is a potential that plant growth for some flora species in the shallow fill may be affected, especially for some exotic species. Overall however the Auditor considers that the present condition of the site is sufficiently protective of ecological receptors.

16.3.4 Buildings and Structures

The pH of the soil samples analysed from AA1 ranged from 4.6 to 9.4, just outside the adopted assessment criteria for buildings and structures.

For the proposed mixed use land use, the Auditor considers that soil quality does not represent a potential for harm or detriment for buildings and structures in contact with soil.

16.3.5 Aesthetics

A number of sample locations identified ash/cinders in fill across the site, however these were considered to be limited in extent and to not represent potential detriment to the use of AA1 for high density residential use and less sensitive land uses.

For the proposed mixed use land use, soil aesthetics do not represent a potential for harm or detriment.

16.4 POTENTIAL FOR OFF-SITE MIGRATION

Site derived soil contamination has been identified at AA1 that is likely to impact on off-site receptors. Identified groundwater contamination, is considered to be sourced from the site and is likely to continue to flow off-site to the west. However, the identified plumes to the west of the site have been shown to be in an approximate stable state.

16.5 SUMMARY OF ASSESSMENT OF RISK

The Auditor has assessed the potential harm, detriment or risk to beneficial uses of AA1 posed by the current condition of AA1 as low for all relevant beneficial uses of soil and groundwater with the following exceptions:

- On-site
    - Low density residential use (i.e. homes constructed on a slab where exposures by residents may occur within the home) is considered unacceptable in areas where groundwater is impacted with chlorinated solvents (i.e. along the plume centre line along the northern site boundary).
- Off-site:
    - Unacceptable levels of risk are indicated under the less likely scenarios that groundwater is extracted and plumbed to the house for showering/bathing and/or is used as the main source of drinking water.

The Auditor also considers that there is a risk that downward migration of contaminants in the Q1 aquifer may occur if pumping from deeper aquifers, in particular the Tertiary aquifer, changes the current hydrogeological regime.

17 AUDITOR DETERMINATIONS AND AUDIT OUTCOMES

17.1 AUDITOR DETERMINATIONS

The Auditor determinations are set out as follows:

- The environmental site assessment undertaken by AEC and others was considered to be adequate to determine the contamination status of AA1;
- The environmental assessment undertaken by URS was considered to be adequate to determine the groundwater status off-site, within the EPA designated "Area under Investigation";
- The overall sampling frequency (i.e. test locations and selection of samples) is considered to be acceptable. The analytical parameters are considered by the Auditor to be sufficient to adequately characterise AA1 on and off-site;
- The quality assurance/quality control methodology and procedures employed by AEC and URS are considered to be acceptable for the purpose of this audit and provide adequate confidence that soil and groundwater data were representative of the conditions at AA1, with groundwater data representative of the condition of groundwater off-site;
- AA1 has been remediated such that the sources of contamination, and contaminated soil that poses a risk to the proposed land uses, have been removed from AA1, to the extent necessary;
- Concentrations of carcinogenic PAHs in soil on-site do not pose unacceptable human health risks for the proposed future mixed use land use including commercial (extension of the Castle Plaza Shopping Centre), light commercial/industrial with an option for the incorporation of medium-high density residential use, however they may pose a risk to future construction workers on-site;
- Reported concentrations of heavy metals in fill on AA1 are marginally above EILs and benzo(a)pyrene and hydrocarbons (F3) ESLs and as such may pose a risk to growth of some plant species that have their root systems in, or uptake nutrients from, site soil in a low density residential scenario (e.g. exotic garden species, fruit trees or vegetable gardens). Nevertheless, the present condition of the AA1 site is considered to be sufficiently protective of ecological receptors;
- No unacceptable aesthetic issues associated with AA1 soils for the proposed future mixed use land use including commercial (extension of the Castle Plaza Shopping Centre), light commercial/industrial with an option for the incorporation of medium-high density residential use scenarios;
- Although on-site soils were not specifically assessed for acid sulphate soil conditions, no field indicators suggesting acid sulphate soils were reported

or observed and as such the Auditor has no reason to suspect that these conditions exist at AA1. The Auditor therefore considers that the potential is low for impact by sulphate or chloride substances on steel and concrete building materials in contact with soil;

- The reported concentrations of PCE in a number of groundwater monitoring bores may indicate the presence of DNAPL such that soil at depth may contain residual PCE;
- The Auditor considers that the observed PCE contamination plume in groundwater is likely to be in an approximate steady state;
- The Auditor considers that the observed northern chlorinated solvent plume in groundwater is likely to be sourced from the northeast corner of the former Ironing Tables Workshop with an additional source associated with Pit 4 in the northwest corner of the site;
- Concentrations of PCE and degradation products in groundwater are considered to reflect on-site source areas, and significant sources of chlorinated solvents (including PCE at concentrations that may indicate the presence of DNAPLs) have been identified on-site;
- Concentrations of PCE, TCE and DCE in soil vapour on-site indicated exceedances of screening criteria;
- Risk to on-site receptors for potential exposure to vapours, sourced from groundwater and/or soil (DNAPL), were considered acceptable for all assessed scenarios, with the exception of the standard residential scenario - "*low to medium density residential homes constructed on a slab where exposures by residents may occur within the home*";
- Concentrations of total organic carbon, heavy metals (hexavalent chromium, manganese and nickel), in groundwater on-site are considered to reflect historical on-site storage and use;
- Concentrations of nitrate in groundwater on-site are considered to reflect historical on-site storage and use of N-containing compounds;
- Lower nitrate concentrations than those measured in groundwater at some locations on site may be related to more regional, ambient conditions;
- Concentrations of zinc and boron in groundwater on-site are likely to be attributable to up gradient groundwater quality;
- Concentrations of nitrate in groundwater off-site are considered to reflect an up gradient source, likely the former Hills site and further upgradient source(s);
- Offsite indoor air screening reported PCE, TCE, DCE and VC at concentrations below the relevant screening criteria;

- Air concentrations within utility pits were below assessment criteria except for TCE at one location;

- Calculated risks to identified receptors for potential exposure to vapours sourced from groundwater were considered acceptable except for the potential scenario from the potable use of groundwater within the plume where PCE concentrations are above the drinking water guideline;

- The Auditor considers the likelihood of use of groundwater within the Quaternary aquifer for any purpose is low. However, due to the existence of a number of operational bores within close proximity of AA1 using groundwater for domestic and irrigation purposes, and previously on-site for industrial purposes, there is the potential for groundwater from the shallow Quaternary or Tertiary aquifers under and within close proximity to AA1 to be used;

- Based on an on-site vapour risk assessment conducted by ERS (2015) for AA1, the Auditor considers that the vapour risks from current concentrations of volatile compounds (PCE) in groundwater in AA1 are not significant for future development scenarios provided there are no habitable basements and ground floor residences;

- Based on the offsite vapour risks assessment conducted by URS (2016) for AA1, the Auditor considers that the vapour risks from current concentrations of volatile compounds (PCE) in groundwater within the offsite plume are not significant for all identified scenarios provided that:

    1. groundwater is not extracted and plumbed to a residence for showering/bathing, or is used as the main source of drinking; and

    2. any future habitable basements within the area identified in *Figure 16 Annex A* include an engineered soil vapour mitigation system. Any such system must be designed and installed by a qualified and experienced person(s).

- The Auditor considers that the potential for other off-site effects of contaminant migration from AA1, e.g. as a result of leaching of soil contamination to groundwater or via stormwater runoff or airborne dust, is minimal.

17.2 AUDIT OUTCOMES

The Auditor provides clear statements on the following:

The nature and extent of any site contamination present or remaining on or below the surface of the site

The Auditor concludes that site contamination exists at AA1.

The nature and the horizontal and vertical extent of soil contamination on AA1 has been determined. Soil with reported analyte concentrations above the NEPM EILs and ESLs, and reported concentrations of lead, nickel and carcinogenic PAHs above NEPM HIL B remain on-site. Soil concentrations exceeding HIL B are shown in *Figure 8 Annex A*.

The nature and extent of groundwater contamination underlying AA1 has been determined. Groundwater has been reported with concentrations of chlorinated hydrocarbons, nitrate, total organic carbon, heavy metals (hexavalent chromium, manganese and nickel), zinc and boron above the adopted screening criteria. Concentrations of PCE and degradation products in groundwater off-site are considered to reflect on-site source areas and nitrate concentrations off-site are also considered to reflect up gradient sources, likely the former Hills site and further upgradient sources. The primary source of the northern chlorinated hydrocarbon plume is likely to be from the northeast corner of the former Ironing Tables Workshop with an additional source associated with Pit 4 in the northwest corner of the site. Refer to *Figure 8* for the location of these likely source areas and *Figure 14* for the extent of chlorinated hydrocarbon plume (PCE) on and off-site;

Site contamination exists in soils and groundwater that is not trivial in that it could pose potential harm to the health or safety of humans or environmental values.

The suitability of the site for a sensitive use, or another use or range of uses

The Auditor concludes that AA1 is suitable for a restricted range of uses:

- Medium to high density residential (minimal access to soil) with no habitable basements1 and ground floor residences; or
- Commercial or Retail use; or
- Industrial use.

Further restrictions on the range of site uses are detailed in *Section 17.4.*

The range of uses is consistent with the proposed Castle Plaza Activity Centre Development Plan Amendment, being *mixed use land use including commercial (extension of the Castle Plaza Shopping Centre), light commercial/industrial with an option for the incorporation of medium-high density residential use."*

Other sensitive uses, such as child care centre, pre-school or primary school are not considered suitable uses at the site.

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[1] Habitable basements would include subsurface spaces used for human occupation including places of work, recreational rooms, bedrooms, living areas, etc. but excluding car parks, wine cellars, storage rooms, etc.

What remediation is or remains necessary for a specified use or range of uses?

The Auditor concludes that site contamination does exist at AA1 and remediation remains necessary. The implementation of a GMMP, CEMP and SMP are required for the suitable range of uses, detailed above. Refer to *Section 17.5* for ongoing site management requirements onsite.

17.3 *FURTHER REMEDIATION RECOMMENDATIONS*

The Auditor recommends the implementation, within 60 days of the date of this Audit Report, of the *Groundwater Monitoring & Management Plan - Former Hills Industries Site Edwardstown South Australia* prepared by AEC Environmental dated February 2016.

17.4 *RESTRICTIONS ON SITE USE*

AA1 is restricted to the following uses:

- Medium to high density residential (minimal access to soil) with no habitable basements[2] and ground floor residences; or
- Commercial or Retail use; or
- Industrial use.

These restricted uses are subject to conditions on the use of land and waters.

The conditions regarding the use and taking of waters for all uses in relation to environmental harm from chemical substances in those waters at AA1, the nature and extent of which are detailed in *Section 15.2*, are:

- A GMMP (AEC, 2016) is to be implemented at AA1 until such time that an EPA-accredited Site Contamination Auditor and EPA consider it is no longer required. The minimum duration of monitoring must be five (5) years from the date of this site contamination audit report. Vicinity Centres and Hills Limited have provided letters to the Auditor, dated November 2015 and February 2016, respectively, agreeing with the GMMP recommendations and committing to ongoing groundwater monitoring.

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[2] Habitable basements would include subsurface spaces used for human occupation including places of work, recreational rooms, bedrooms, living areas, etc. but excluding car parks, wine cellars, storage rooms, etc.

- No extraction of groundwater for any purpose from all aquifers, other than for the purposes of monitoring or remediation.

The conditions on the use of land to manage chemical substances at AA1, the nature and extent of which are detailed in *Section 15.2,* to ensure its suitability for the proposed uses are:

- Prior to completion and occupation of any redevelopment of the site, any soft landscaped areas proposed for the development (eg garden beds and lawns, but excluding paved areas) should be completed with a surface layer of at least 0.5m thickness of clean soil (eg commercially available topsoil).

- A CEMP (AEC, 2015c) is to be implemented at the site for any proposed redevelopment and/or construction works undertaken at AA1 where excavation works may be conducted.

- A SMP (Greencap, 2016) is to be implemented at the site for ongoing site management for any proposed excavation works conducted.

The City of Marion has provided written advice on the implementation of the Auditor's proposed restrictions on site use, both on and off-site. Refer to *Annex J* for copies of such written advices.

17.5 REQUIREMENTS FOR ONGOING MANAGEMENT

The Auditor requires the implementation, within 60 days of the date of this Audit Report, of the *Groundwater Monitoring & Management Plan - Former Hills Industries Site Edwardstown South Australia* prepared by AEC Environmental dated February 2016' *Construction Environmental Management Plan - "Audit Area 1" Portion of Former Hills Industries Site Corner of South Road & Ackland Street Edwardstown South Australia* prepared by AEC Environmental dated September 2015; and Site Management Plan - *"Audit Area 1" Portion of Former Hills Industries Site Corner of South Road & Ackland Street Edwardstown South Australia* prepared by Greencap (formerly AEC Environmental Pty Ltd) dated January 2016 refer to *Annex G* and *Annex H*, respectively, for copies of these plans.

18 AUDIT CONDITIONS AND RECOMMENDATIONS

18.1 AUDIT CONDITIONS

The following conditions are required by the Auditor relating to the audit site for:

Planning and Development

1. AA1 is restricted to the following uses:

- Medium to high density residential (minimal access to soil) with no habitable basements[3] and ground floor residences; or
- Commercial use; or
- Industrial use.

Environmental Monitoring

2. A GMMP (AEC, 2016) is to be implemented at AA1 until such time that an EPA-accredited Site Contamination Auditor and EPA consider it is no longer required. The minimum duration of monitoring must be five (5) years from the date of this site contamination audit report. Vicinity Centres and Hills Limited have provided letters to the Auditor, dated November 2015 and February 2016, respectively, agreeing with the GMMP recommendations and committing to ongoing groundwater monitoring.

Site Management

3. Prior to completion and occupation of any redevelopment of the site, any soft landscaped areas proposed for the development (eg garden beds and lawns, but excluding paved areas) should be completed with a surface layer of at least 0.5m thickness of clean soil (eg commercially available topsoil).

4. A CEMP (AEC, 2015c) is to be implemented at the site for any proposed redevelopment and/or construction works undertaken at AA1 where excavation works may be conducted.

5. A SMP (Greencap, 2016) is to be implemented at the site for ongoing site management for any proposed excavation works conducted.

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[3] Habitable basements would include subsurface spaces used for human occupation including places of work, recreational rooms, bedrooms, living areas, etc. but excluding car parks, wine cellars, storage rooms, etc.

Vicinity Centres has provided a letter to the Auditor, dated November 2015, agreeing with the CEMP and SMP recommendations and committing to implement these at the site, as required.

Water Restrictions

6. No extraction of groundwater for any purpose from all aquifers, other than for the purposes of monitoring or remediation.

18.2 RESTRICTION OR PROHIBITION ON TAKING WATER AFFECTED BY OFFSITE CONTAMINATION

The Auditor recommends EPA consider a restrictive/prohibition zone on the taking of groundwater for any purpose from all aquifers in the vicinity of AA1 considering the PCE plume under AA1 and extending to the west of AA1, as shown in *Figure 14 Annex A,* as well as the potential implications of groundwater extraction from deeper aquifers on the shallower aquifers.

The Auditor considers that groundwater extraction from the deeper tertiary aquifers may have implications on the hydrogeological regime in the vicinity of the site and may induce vertical leakage from the shallower Q1 aquifer. A 200 m diameter zone from AA1 is considered as a potential zone of influence.

18.3 OTHER RECOMMENDATIONS

It is recommended that:

- For the existing residential area containing contaminated groundwater west of a portion of Railway Terrace as far as being practicable and enforceable, in the area defined in *Figure 16 Annex A*, any new habitable basements, greater than 2.0 metres depth, in existing or future houses should incorporate a soil vapour mitigation system, comprising a proprietary membrane and passive venting layer, designed and installed by a qualified and experienced person(s), so that soil vapours can be safely ventilated to the atmosphere; and

- A copy of the SCAR should be provided to all future land owners

The Auditor considers that the recommended soil vapour mitigation system for new habitable basements be applied to those properties where the reported PCE concentration in groundwater is 500 ug/L or more along with an approximately 50 m buffer. The Auditor considers that this extent reflects the current and potential future risk to residents.

19 LIMITATIONS OF THIS REPORT

This Site Contamination Audit Report has been prepared in accordance with relevant South Australian EPA technical guidelines. The Site Contamination Audit Statement represents the Auditor's opinion of the environmental condition of Audit Area 1 (AA1) and its suitability for beneficial uses at the date the Statement is signed. AA1 is defined the site at 944-956 and 958 South Road, including 1 and 5-7 Ackland Street, Edwardstown, South Australia.

It is acknowledged that the audit report may be used by Vicinity Centres, Hills Limited, the Environment Protection Authority and the City of Marion Council in reaching their conclusions about AA1. The scope of work performed in connection with the audit report may not be appropriate to satisfy the needs of any other person.

The advice provided herein relate only to the audit of soil and groundwater conditions at AA1 and must be reviewed by a competent engineer or scientist, experienced in contaminated site investigations, before being used for any other purpose.

The advice tendered in this report is based on information obtained from the investigation locations, test points and sample points as set out in the reports listed herein. It is emphasised that the actual characteristics of the subsurface and surface materials may vary significantly between adjacent test points and sample intervals and at locations other than where observations, explorations and investigations have been made. Sub-surface conditions, including groundwater levels and contaminant concentrations can change in a limited time. This should be borne in mind when assessing the data.

It should be noted that because of the inherent uncertainties in sub-surface evaluations, changed or unanticipated sub-surface conditions may occur that could affect total project cost and/or execution. ERM does not accept responsibility for the consequences of significant variances in the conditions.

An understanding of AA1 conditions depends on the integration of many pieces of information, some regional, some site specific, some structure-specific and some experienced-based. Hence this report should not be altered, amended or abbreviated, issued in part or issued incomplete in any way without prior checking and approval by ERM. ERM accepts no responsibility for any circumstances which arise from the issue of a report which has been modified in any way as outlined above.

Opinions and judgements expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal opinions. Legal advice can only be given by qualified legal practitioners.

This report and audit have not been carried out for the purposes of assessing the geotechnical or horticultural suitability of soil and fill on AA1 (for foundations or establishment of gardens and lawn). Purchasers of AA1 should be advised of this.

In the event that changes in conditions on or near AA1 either exist or occur after the date of signing of this Audit Report, the Auditor disclaims responsibility for the occurrence or ownership or effects of such conditions or materials, whether they are hazardous or otherwise.

20 REFERENCES

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