DETAILED SITE (CONTAMINATION) INVESTIGATION

Randwick Barracks
373A Avoca Street, Randwick, NSW

Prepared for:

Defence Housing Australia
26 Brisbane Avenue,
Barton, ACT, 2600

SLR

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Defence Housing Australia (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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EXECUTIVE SUMMARY

Defence Housing Australia (herein referred to as 'the Client') commissioned SLR Consulting Australia Pty Ltd (SLR) to undertake a Detailed Site Investigation (DSI) across the eastern portion of Randwick Barracks, adjoining Bundock Street, Randwick, New South Wales (NSW) (herein referred to as 'the site'). The site is located between Joongah, Bunjan, Munda, Gumara and Bundock Streets, Randwick. The site and relevant site features are shown on **Figure 1** and **Figure 2, Appendix A**. The site is approximately 19.5ha in area.

The Jacobs (2020) *Randwick Barracks Preliminary Site Investigation* (PSI) noted that the site had a range of historical land uses including as a Naval Stores Depot (with previously demolished Naval Store buildings), Rifle Range, Grenade Bursting Range and Army Transport Compound. Currently the southern portion of the site remains active as Defence offices with associated carparking, an overflow carpark and a storage yard, whilst the remainder and majority of the site is vacant. Some remnant infrastructure and buildings are present, with approximately 70% vegetation across the site. The PSI identified 17 Areas of Environmental Concern (AECs) which may present the potential for soil, groundwater and/or soil vapour contamination. Fifteen AEC's were onsite, while there was an additional two identified offsite. These locations are:

AEC Number	Reasoning
AEC 1	Site wide debris and fill material
AEC 2	Site wide pesticide use
AEC 3	Rifle Range
AEC 4	Grenade Bursting Range
AEC 5	Site Wide Sewer
AEC 6	Chemical Storage / Storage Yard
AEC 7	Vehicle Storage / Storage Yard
AEC 8	Fuel Infrastructure
AEC 9	Vehicle washing, refuelling and maintenance activities
AEC 10	Oil water separator
AEC 11	Hazardous materials store
AEC 12	Former metal treatment works
AEC 13	Site wide stockpiles
AEC 14	Stormwater infrastructure
AEC 15	Substations
AEC 16	Offsite Randwick Zone Substation
AEC 17	Offsite Former Laundrette

Based on the above AECs and the Jacobs (2020b) Sampling Analysis and Quality Plan (SAQP), the objective of the DSI was to provide an assessment on the contamination status of the site and to determine the suitability of the site for future redevelopment and use as residential and open space. The scope of works undertaken to meet the objective of this DSI included the following tasks:

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- Review of background information: Identification of features of the site and surrounds, local hydrogeology and site history
- Site Walkover: A visual inspection of the site
- Unexploded Ordnance (UXO) survey and clearance of AECs previously used as a Rifle Range and Grenade Bursting Range
- Ground Penetrating Radar (GPR) survey of AECs with fuel infrastructure / Former Heavy Vehicle Transport Yard / Vehicle Washing, Refuelling and Maintenance Activities
- Soil, groundwater and passive soil gas sampling:
  - excavation of 264 test pits to a maximum depth of 2.6 metres below ground level (mbgl). It is noted that where a proposed test pit was located on concrete hardstand, this was advanced as a borehole using a drill rig to a maximum depth of 3 mbgl
  - 75 soil boreholes were drilled to a maximum depth of 4mbgl using a sonic rig as well as a track-mounted rig using pushtube techniques
  - 68 shallow soil boreholes were advanced to a maximum depth of 0.7mbgl using a hand auger as well as a track-mounted drill rig using pushtube techniques
  - sampling of six soil stockpiles (with volumes ranging between 1m^3 and 65m^3)
  - drilling at 65 locations using a Membrane Interface Probe (MIP)
  - installation of 24 groundwater monitoring wells (one within a perched aquifer and the remaining wells in the unconfined aquifer within the Quaternary sediments)
  - Installation of PSG probes at 37 locations to a maximum depth of 1.2mbgl
  - Installation of ASG probes at 6 locations to a maximum depth of 1.2mbgl
  - submission of soil, groundwater and soil vapour samples to a National Association of Testing Authorities (NATA) accredited laboratory for analysis.

The results of this DSI indicated the following:

- As reported in Jacobs (2020a), the site is understood to have been acquired by the Commonwealth of Australia in 1788. The federation of Australia in 1901 resulted the official transfer of the site to the Commonwealth (from the Australian Colonies). The earliest use of the site was for rifle marches, forming part of the Randwick Rifle Range from 1891 until 1924, when the rifle range was closed and used as a small arms school until 1942. The Randwick Naval Stores Depot was constructed in 1943 and consisted of 26 main stores/buildings which stored machinery and dry goods. The stores are understood to have been constructed of timber and asbestos cement cladding, with the stores progressively demolished between 1986 and 2009.
- At the time of inspection and investigation, the central and northern portion of the site was comprised of open space with concrete slabs and vegetation, while the southern portion of the site was an operational Defence facility.
- Land uses surrounding the site included low density residential properties to the north and south, the remainder of Randwick Barracks to the west, with Munda Street Reserve and Randwick Environment Park and Wetlands to the east.

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- As summarised by the AECs, potential sources of contamination identified on site include the widespread presence of bonded asbestos containing materials (ACMs) and building demolition wastes across the site, fill materials, fuel storage, metal treatment works and storage of small quantities of chemicals, attributed to the historical activities on site.
- All Membrane Interface Probe (MIP) locations showed low signal responses with photoionisation detector (PID) responses less than 0.5 x 106 µV, flame ionisation detector (FID) responses less than 2 x 105 µV and halogen specific detector (XSD) responses less than 1 x 105 µV.
- Concentrations of contaminants of potential concern (CoPC) are generally less than the laboratory limits of reporting (LOR) and adopted site assessment criteria in soils, with the exception of:
    - Asbestos in the form of asbestos fibres (fibrous asbestos and asbestos fines) and ACMs which was present across the site and concentrated in the vicinity of the former Naval Stores, particularly in vegetated areas along the northern portion of the site, underlying the vegetated strips lining the verges of the concrete slabs across the site, in fill areas towards the south west boundary of the site, and to a lesser extent on the south eastern portion of the site. The bulk of asbestos impacted soils appears to be in the soil surface to approximately 0.2mbgl.
    - The Benzo(a)pyrene [B(a)P] Toxicity Equivalent Quotient (TEQ) exceeded the Health-based Investigation Level (HIL-A) at 20 locations, with Polycyclic Aromatic Hydrocarbons (PAH) [Total] exceeding HIL A at five (5) locations. B(a)P exceeded the Ecological Screening Levels (ESLs) at eight (8) locations. B(a)P impacted soils were predominantly in the northern and north western portions of the site, and generally encountered in areas also impacted by asbestos. Naphthalene also exceeded the adopted site assessment criteria at three (3) locations.
    - Concentrations of Cadmium, Chromium III+VI, Copper, Lead, Mercury, Nickel or Zinc either singularly or in some combination exceeded the EILs for public open space in 51 samples.
    - The concentrations of Chromium III+VI, Copper, and Lead, either singularly or in some combination exceeded the HILs in 8 samples. It should be noted one sample (0407_TP73_0.1_200619) is reported as exceeding the HIL A for hexavalent Chromium, however the analytical result is for total chromium. Hexavalent chromium is not expected to be present on site, given the historical land uses.
    - Petroleum hydrocarbons at eleven (11) locations exceeding the ESLs in shallow soils.
    - Polychlorinated biphenyls (PCBs) at one (1) location exceeding the HILs in shallow soils.
- Concentrations of contaminants of potential concern in groundwater were generally less than the laboratory limits of reporting in groundwater, with the exception of the following detections exceeding the adopted site assessment criteria:
    - copper and zinc at 13 locations, arsenic and nickel at one location, and lead at two (2) locations. Heavy metal concentrations were relatively consistent across the site and comparable to the background sampling location, hence, heavy metal concentrations in groundwater onsite are considered to be representative of background conditions.
    - Chlorpyrifos (OPP) at one location (GW13a) in one sampling event. This result is considered to be an outlier, as pesticides were generally less than the laboratory limit of reporting in soils and groundwater which indicates the site is unlikely to be the primary or an ongoing source of chlorpyrifos impact to groundwater.

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  - Sum of PFHxS & PFOS in ten (10) locations. It is noted that PFAS was generally not detected in soils sampled onsite and as the site is primarily vacant, the site is unlikely to be the primary or an ongoing source of PFAS impact to groundwater.
  - Chlorinated hydrocarbons - Based on the limited data available i.e., concentrations of tetrachloroethene (PCE), trichloroethene (TCE) and cis-1,2-dichloroethene (DCE) but less than 20% trans-1,2-DCE or 1,1-DCE, SLR have inferred that the most likely source of chlorinated hydrocarbons in the upgradient monitoring wells (GW13a &b, GW14, GW15 and GW18) is offsite (potentially the former laundrette [Dry cleaners] adjacent to the north west corner of the site). Generally, if the ratio of cis-1,2-DCE to trans-1,2-DCE plus 1,1-DCE is greater than about 5:1, then the observed DCE is likely the result of degradation of TCE and/or PCE.
- Passive Soil Gas (PSG) results showed detections of chloroform, tetrachloroethene, toluene and trichloroethene with highest concentrations reported in the northern portion of AEC12 (Former Metal Treatment Works). Concentrations of trichloroethene were found to exceed the adopted site assessment criteria in northern portion of AEC12 in Active Soil Gas (ASG) following the PSG sampling.
- Receptors include on-site commercial/industrial workers (Defence personnel and contractors) associated with site operations, potential future residential users, as well as on-site ecological receptors and offsite ecological receptors (including the Randwick Environment Park – bushland and wetlands formerly part of Randwick Barracks).
- Potential migration pathways and exposure routes were identified such as dermal contact and inhalation of dusts from contaminated soils by site users, as well as groundwater and surface water migration of contaminants associated with the historical use of the site.

Based on the information gathered during the desktop review, the observations made during the site walkover and the results of the sampling undertaken, SLR concludes that the site can be made suitable for a residential land use subject to the following:

- The management of bonded ACM fragments and asbestos (fibrous asbestos and asbestos fines) associated with historical activities on site. This includes the fill material in the high voltage easement on the western boundary of the site.
- The management of elevated concentrations of B(a)P / PAHs and metals in surface soils primarily across the northern portion of the site. Petroleum hydrocarbons and PCBs at discrete locations.
- Further monitoring of the groundwater quality and properties on site, including PFAS, as well as TCE in and surrounding AEC12 (Former Metal Treatment Works). This should include the installation of additional groundwater monitoring bores in the vicinity of AEC12.
- Preparation of a Hazardous Building Material assessment of remaining buildings where they require demolition.

SLR recommends the following:

- Further groundwater monitoring be undertaken to address the data gaps / uncertainties identified above
- Preparation of a Remedial Action Plan (RAP) to detail the remediation, validation and management requirements for the identified contamination in order to confirm the suitability of the site for a change in land use.

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APPENDICES

1 Introduction

SLR Consulting Pty Ltd (SLR) was engaged by Defence Housing Australia (DHA) (the Client) to undertake a Detailed Site (contamination) Investigation (DSI) at the property located at 373A Avoca Street, Randwick NSW (the site). The site, which forms part of the Randwick Barracks, comprises approximately 19.5Ha of Commonwealth-owned land and has been used for military training activities, including a rifle range, grenade bursting range, naval stores depot and army transport compound. DHA is considering options for redeveloping the site for residential use.

The site locality and site plan have been presented in **Figure 1** and **Figure 2** in **Appendix A**, respectively.

This DSI was undertaken with reference to the Sampling Analysis and Quality Plan (SAQP) [Jacobs 2020b; ref: IH107200-005-NP-SAQP-0002-C] and amendments to the SAQP (**Section 6.3**), which were discussed with, and approved by, the NSW EPA accredited contaminated land Auditor (Auditor). The SAQP was prepared on the basis of the Phase I Preliminary Site Investigation (PSI) [Jacobs 2020a; ref IH107200-500-NP-RPT-0002], which indicated that there was a potential for contamination to be present at the site.

2 Background

SLR understands the following:

- The earliest use of the site was for rifle marches, forming part of the Randwick Rifle Range from 1891 until 1924, when the rifle range was closed and used as a small arms school until 1942. The Randwick Naval Stores Depot was constructed in 1943 and consisted of 26 main stores/buildings which stored machinery and dry goods. The stores are understood to have been constructed of timber and asbestos cement cladding, with the stores progressively demolished between 1986 and 2009.
- A PSI was undertaken at the site by Jacobs (Jacobs, 2020a) to assess the contamination status of the site. The PSI concluded that there were 17 Areas of Environmental Concern (AEC) that required investigation to identify potential contamination risks to a future residential land use at the site. The SAQP (Jacobs, 2020b) detailed the nature of the investigations to be undertaken to assess potential contamination risks.
- A DSI was required to be prepared by an appropriately qualified environmental consultant to document the findings of the investigations and meet the objectives of the SAQP (Jacobs, 2020b).

2.1 Proposed Development

The redevelopment of the site is not presently confirmed. However, DHA is undertaking due diligence investigations to inform the decision making process with respect to possible future land use scenarios including low density residential premises.

3 Objectives

3.1 Purpose and Objectives

The purpose of this DSI was to provide the Client with advice on the contamination status of the site to inform the decision making process with respect to possible future land use scenarios.

The objectives of this DSI were as follows:

- To implement the SAQP (Jacobs, 2020b) to assess whether contamination is present within the site at concentrations that could potentially impact human health and/or the environment, including:
  - characterising the extent of chemical contamination associated with historic land use within the site
  - characterising the extent of asbestos contamination in surface soils within the site
  - identifying the potential human and ecological receptors for contamination.
- To provide advice on the suitability of the site (with respect to contamination) for a potential change in land use.
- To obtain sufficient information to develop management actions and a remedial action plan (RAP), if warranted.

4 Scope of Works

To achieve the objectives of the SAQP (Jacobs, 2020b), SLR undertook the scope of work as listed in **Table 4-1**:

Table 4-1 Scope of Works

Item	Description
Project Preliminaries	• Review of the PSI report (Jacobs 2020a) • Review of the SAQP (Jacobs, 2020b) • Preparation of a Health and Safety Plan (HASP) and a Safe Work Method Statement (SWMS) for the fieldwork undertaken • Site walkover to record potential sources of contamination • Review of a Dial Before You Dig (DBYD) search completed by the client for the site prior to location of services • Service location of underground services using electromagnetic technology and/or non-destructive digging at each contamination assessment location. • GPR and UXO clearances were also undertaken in the former Rifle Range and Grenade Bursting Range areas. GPR survey was also undertaken around fuel storage infrastructure.

Item	Description
Fieldwork	Undertook fieldwork between 15 June 2020 and 11 November 2020 including: • excavation of 264 test pits to a maximum depth of 2.6 mbgl. It is noted that where a proposed test pit was located on concrete hardstand, this was advanced as a borehole using a drill rig to a maximum depth of 3 mbgl • drilling of 143 soil boreholes (68 shallow boreholes to a maximum depth of 0.7mbgl, 75 deeper boreholes to a maximum depth of 4 mbgl) • sampling of six (6) soil stockpiles (with volumes ranging between 1m^3 and 65m^3) • drilling at 65 locations using a Membrane Interface Probe (MIP) • installation of 24 groundwater monitoring wells (one well within a perched aquifer, remaining wells in unconfined aquifers) • two rounds of a Groundwater Monitoring Event (GME) on the 24 newly installed groundwater monitoring wells • slug testing of 5 newly installed groundwater monitoring wells • collection of two (2) liquid grab samples from one septic tank and one sewer location on site respectively • sampling of soil gas using passive soil gas probes at 37 locations • sampling of soil gas using active soil gas probes at six (6) locations • Collection of one (1) soil sample and one (1) bore water grab sample at Latham Park, South Coogee NSW (located approximately 640m south east of the site) to establish background conditions in the site surrounds • submission of soil, groundwater and soil vapour samples to a National Association of Testing Authorities (NATA) accredited laboratory for analysis.
Reporting	Preparation of this DSI report.

5 Site Identification, History and Condition

5.1 Site Identification

Table 5-1 below provides the site identification details.

Table 5-1 Site Identification

Item	Description
Site Address	373A Avoca Street, Kingsford NSW 2032
Lot and DP	Part of Lot 37 of DP1150819 Lot 13 DP1042814 Lot 16 of DP1042814 was identified in the PSI (Jacobs 2020a), although this area was determined to be beyond the north eastern boundary of the site. Testpits marked in this area as part of the PSI (2020a) and SAQP (2020b) were therefore excluded from the program, as reviewed by the Auditor. It is noted that this area was previously subject to the preparation of a Site Audit Statement / Site Audit Report (SAS 2002/20A – Community Centre).
Coordinates (approximate centre of site)	33°55’48.47S 151°14’41.89E
Local Government Area	City of Randwick
Zoning	SP1 Special Activities R1 General Residential Note: The PSI (Jacobs 2020a) identified the site to also be within an E1 Environmental Conservation zone, although SLR were not able to identify this as part of this DSI.
Site Area (ha)	Approximately 19.5 Ha
Current Owner	Department of Defence

5.2 Site History

As detailed in the PSI (Jacobs, 2020a) and summarised below, the site had a range of historical land uses including usage as a Naval Stores Depot (noting that the Naval Store buildings have been demolished), Rifle Range, Grenade Bursting Range and Army Transport Compound. Jacobs 2020a considered that the historical land use activities had the potential to cause site contamination and identified Contaminants of Potential Concern (CoPC) associated with each of the potentially contaminating activities. Potentially contaminating activities were subsequently grouped into AECs as discussed in **Section 5.4**.

5.2.1 Previous Investigations

The Jacobs report *Preliminary Site Investigation, Randwick Barracks*, prepared for DHA, 22 April 2020 (Jacobs 2020a) was reviewed as part of the DSI and prior to implementation of the SAQP (Jacobs, 2020b). Previous investigations informing the PSI (Jacobs 2020a) were not provided to SLR and the following summary is based on the PSI review of those investigations.

As part of due diligence to inform redevelopment options for the site, Jacobs prepared a PSI (Jacobs, 2020a) to assess the potential for any contamination associated with the historical land uses and identify potential risks posed by contamination to human and / or environmental health receptors. As part of the PSI, Jacobs undertook a desktop study, including a review of available historical information and government databases, as well as a site inspection. The results of the desktop study identified the following:

- The site has been used for military purposes since the early 1890s and has hosted a variety of former land uses and activities, including a Rifle Range, Grenade Bursting Range, Naval Stores Depot and Army transport compound. The rifle range was present on site between 1891 and 1924. The Randwick Naval Stores Depot was established towards the northern and central portions of the site in 1943, consisting of 26 stores for the storage of a range of materials, including machinery, dry goods, weapons equipment and hazardous materials (type and source unknown). A Transport Store building was established on the eastern boundary of the site between 1965 and 1970 for the storage of miscellaneous non-hazardous items.
- Previous investigations (HLA, 2003) identified that the site buildings were constructed from timber and asbestos cement cladding atop concrete slabs. The Naval Stores were used to store a range of materials including machinery and dry goods. They were demolished in stages between 1986 and 2009, potentially having resulted in the spread of asbestos fragments from building materials across the site. The stores on the southern portion of the site were replaced by the existing buildings (vehicle storage yard, movement control office and associated carpark) between 1982 and 1991.
- A number of site audit statements (SAS) and associated environmental investigations were completed between 2002 and 2004 for areas east and south of the site that were selected for divestment for residential and childcare development, as a well as the Randwick Environment Park. The investigation areas were subject to soil and groundwater assessment, remediation and validation. The SAS considered validation of these areas following remediation to be appropriate, and migration of any remnant contamination to be negligible. CoPCs selected for assessment during the investigation (metals, Total Petroleum Hydrocarbons [TPH], Benzene, Toluene, Ethyl-benzene, Xylenes [BTEX], Organochlorine Pesticides [OCPs], Organophosphate Pesticides [OPPs], Polycyclic Aromatic Hydrocarbons [PAHs], Volatile Organic Compounds [VOCs] and asbestos) were also considered to be present across the wider Naval Store footprint, with these areas considered by Jacobs (2020a) as requiring further investigation.
- Groundwater sampling conducted in between 1995 and 2000 by Egis identified the presence of volatile hydrogenated hydrocarbons (VHHs) in groundwater monitoring wells on the northern and western boundaries of the site at concentrations above the laboratory LOR. The detections were attributed to the sewer line running from the north to the south western portion of the site. Subsequent sampling by Egis in 2002 did not identify VHH in any of the groundwater monitoring wells. VHHs were also found in two out of six locations in the footprint of the former 9FSB Transport Workshop/Store on site (South-East corner of the site) as part of a soil gas sampling program conducted by GHD in 2005. The store was previously used as a metal treatment works.

- A PSI conducted by AECOM in 2019 as part of Defence's 3 Year Regional Contamination Investigation Program identified potential pollution sources in the form of (i) asbestos in soils across the site as a result of demolition of pre-existing buildings; (ii) three former Underground Storage Tanks (USTs) and a former Aboveground Storage Tank (AST) in the former transport compound on the southern portion of the site; (iv) petroleum, oils and lubricants associated with the wash bays and workshops of the Former Heavy Vehicle Yard on the south western portion of the site; and (v) lead impacts in soil from former stop butt use associated with the historic rifle range.
- The northern and central portions of the site are currently vacant, with only the southern portion of the site used as an active Defence facility including offices.

Based on the results of the desktop study and site inspection, Jacobs identified 17 AECs that required investigation to identify potential contamination risks to the current land use and a future residential land use at the site (listed in **Table 5-5**).

Based on the findings of the PSI, Jacobs recommended the completion of a Stage 2 DSI across all identified AECs, and the development of a Construction Environment Management Plan (CEMP) should future development works be undertaken at the site.

5.3 Site Condition

5.3.1 Site Description

On 15 June 2020, an inspection of the site was undertaken by the SLR Field Lead and project consultants experienced in assessing potential contamination. **Table 5-2** details the site observations.

Table 5-2 Site Observations

Item	Observations
Site Use	• Much of the northern and central portions of the site is vacant and unused (approximately 80% of the site), with the exception of an electrical substation on the north western boundary. • The southern portion of the site is occupied by a Storage Yard (including Buildings 503 and 504), the Movement Control Office building and car park area, the Former Heavy Vehicle Transport Yard (Building 502), and an overflow carpark (refer to **Figure 2** in **Appendix A**). These areas (approximately 20% of the site) are actively used by Defence personnel and associated staff.
Weather Conditions	• Sunny 22°C
Site Slope	• The site has an approximate elevation of 30 metres Australian Height Datum (mAHD). Much of the site is flat, with a slight slope towards Joongah Street towards the south and south east.

Item	Observations
Drainage Features	• The site and site buildings were observed to have a formalised below ground stormwater drainage network, with surface runoff from sealed areas expected to be channelled into the drainage system via stormwater drains and pits. Surface water is also expected to directly drain into sandy subsoils in unsealed areas across the site. • Stormwater pits were observed on vegetated strips separating concrete slabs along the central and southern portions of the site, and to the rear of the Vehicle Storage Yard building on the southern portion of the site. A rock lined drain was observed running south from the north eastern boundary of the site towards the concrete slab on the north. • The sitewide drainage network is illustrated in the civil infrastructure network plan included in **Figure 11** in **Appendix A**. The civil infrastructure network plan identifies a number of stormwater discharge points across the site. • Surface water runoff from the northern portion of the site is expected to discharge via stormwater discharge points at the northern and north eastern boundaries of the site. Surface water runoff from the central and southern portions of the site (where hardstand is present) is expected to discharge via the stormwater drainage network into a detention basin located 50m beyond the south east boundary of the site.
Nearby Waterbodies	• The nearest surface water body is a detention basin located within the Randwick Environment Park, approximately 50 m beyond the eastern and south eastern boundaries of the Site. Given the sandy soils onsite and drainage infrastructure, it is unlikely that significant overland surface water flows would exit the site and reach the Randwick Environment Park. It is also noted that Randwick Environment Park was opened around 2010, hence the Randwick Environment Park was unlikely to have received discharges from infrastructure at Randwick Barracks prior to this.
Surface Soils or Hardstand	• Much of the central and southern portions of the site are covered by hardstand areas in the form of concrete slabs and associated accessways from the former Naval Stores. • The existing Movement Control Office, Storage Yard, Movement Control Office and Former Vehicle Maintenance Yard wash area, and associated parking areas on the southern portions of the site are covered by hardstand areas. • Hardstand areas were generally observed to be in moderate to good condition throughout the Site. • The remaining areas (approximately 80% of the site) consisted of unsealed accessways traversing the site, exposed sandy surfaces on the western portion of the site, vegetated strips on the verge of concrete slabs, and dense vegetation in the north western, western, south eastern and southern boundaries.

Item	Observations
Evidence of Cut and Fill	• The site appears to have undergone cut and fill activities to level the site for the development of the former Naval Stores and existing site buildings. This is evident by the steep drop in ground surface levels along the western boundary down to the surface levels of the concrete slabs of the former Naval Stores. • Fill materials were predominantly encountered in testpits advanced in vegetated strips across the site boundaries and along the verges of concrete slabs. Fill materials generally comprise gravelly sands and silty clays. In soil locations the fill contained building materials including concrete rubble, bricks, ceramic, ACM fragments etc.) Refer to **Appendix B** for borehole logs.
Buildings including any potential hazardous materials such as lead paint, asbestos	• Existing buildings on site include the Storage Yard (including Buildings 503 and 504), the Movement Control Office building, and the Former Heavy Vehicle Transport Yard (Building 502) on the southern portion of the site, and the electrical substation shed on the northern boundary of the site. In general these buildings appear to be brick in construction with pressed metal roofing. Hence the likelihood of large quantities of hazardous building materials such as lead based paint, asbestos cement sheeting or PCBs in capacitors to be present is low. • Evidence of pre-existing buildings on site is limited to concrete slab foundations (from the former Naval Stores) across the central and southern portions of the site. Fill materials comprising building materials including ACM fragments within soils appear to be present in vegetation strips across the site. Refer to **Figure 2** in **Appendix A** for the location of these buildings and concrete slabs.
Evidence of manufacturing or industrial processes?	• The site has been previously used for the storage of industrial goods, including chemicals, heavy vehicles, hazardous goods and a metal treatment works. Infrastructure associated with these industrial processes such as concrete slabs and fire hydrants for the former Naval Stores was sighted by SLR on the southern portion of the site during the field investigations. • Evidence of manufacturing processes was not observed.
Evidence of chemical or fuel storage (USTs/ASTs)?	• The PSI (Jacobs 2020a) reported the former Vehicle Transport Yard on the southern portion of the site to have contained: - three (3) former USTs - one (1) former AST - a former above ground oil-water separator - vehicle inspection ramp - former dispensers, fuel lines and vent pipes. With the exception of the former USTs and AST, these structures were sighted by SLR during the field investigations. • A GPR survey indicated some potential anomalies in the ground in the vicinity of the Transport Compound, which were investigated during the soil sampling (refer to **Figures 3-2** and **3-3** in **Appendix A**).

Item	Observations
Evidence of septic tanks?	• SLR observed a septic tank on the vegetated strip immediately north of the southernmost concrete slab on site (concrete slab 9). Refer to **Figure 3-4** in **Appendix A** for sampling locations SEP001 located around the septic tank.
Evidence of waste disposal?	• A number of stockpiles of construction and demolition waste were observed at various locations across the site, as shown on **Figure 3-6** in **Appendix A**. Refer to **Table 8-1** for descriptions of the stockpiles.
Evidence of surface staining?	• Minor staining, presumed to be associated with vehicle parking and minor spills was observed on the hardstand surface of the former transport compound.
Any site vegetation and it's condition	• Much of the north western, western, south eastern and southern boundaries are densely vegetated. • Vegetated strips also line the verges of the concrete slabs across the site. • The vegetation consisted of native and introduced tree, shrub and grass species, and appeared to be in good condition.
Is fencing present?	• The site is secured from the public by fencing around the perimeter.

5.3.2 Surrounding Land Uses

Land uses surrounding the site are detailed in **Table 5-3** below.

Table 5-3 Surrounding Land Uses

Direction	Surrounding Land Use and / or activity
North	• Bundock Street and R2 Low Density Residential properties. • Randwick Zone Substation adjacent to the intersection at Bundock Street and Canberra Street beyond the north western boundary of the site.
South	• Joongah Street and R2 Low Density Residential properties.
East	• R1 General Residential, Munda Street Reserve (RE1 Public Recreation), Randwick Community Centre and childcare facility, Randwick Environment Park and Wetlands (E2 Environmental Conservation) areas.
West	• The wider Randwick Barracks (SP1) and Avoca Street, beyond which are low to medium residential properties.

5.3.3 Geology

The Sydney 1:100,000 Geological Sheet 9130 (Herbert, 1983) indicates that the site and immediate surrounds are predominantly underlain by Quaternary aged medium to fine grained marine sand with podsols. Areas north west and south east of the site are underlain by Triassic aged Hawkesbury Sandstone medium to coarse grained quartz sandstone, with very minor shale and laminate lenses.

5.3.4 Soils

A review of the NSW Office of Environment and Heritage eSPADE soil landscape map (9130tg) found the majority of site to be part of the Botany Lowlands dune systems characteristic of Tuggerah landscapes, with the dominant soil materials being deep Podsols on dunes and Podsols/Humus Podsol intergrades on swales. The northern portions of the site and beyond are characteristic of Newport soil landscapes (9130np), with dominant soil materials being well sorted Siliceous Sands overlying buried sands including yellow Podzolic Soils with sandy topsoils on crests and gentle slopes. Areas to the east and west of the site are characterised by disturbed terrain (9130xx).

Information obtained from the Australian Soil Resource Information System (www.asris.csiro.au) on 15 July 2020 indicated that the site has an extremely low probability of occurrence (1-5%) of acid sulfate soils (ASS). The low probability of ASS is further supported by NSW Government planning portal (www.planningportal.nsw.gov.au), which rated the location as having no known occurrence of ASS.

5.3.5 Hydrogeology

The site overlies the Botany Sands Aquifer within the Botany Basin. The Botany Sands aquifer is a layer of sand containing a large volume of water surrounding Botany Bay south of Sydney, NSW. It is divided into northern, southern and western zones. Only the northern zone is relevant to this site. The aquifer is classified as a “high risk resource” in terms of groundwater quality (Bish *et al*., 2000), due to the presence of a large number of contaminated sites.

Before European settlement, it formed an important source of water for wetlands supporting aboriginal communities. The Botany Sand aquifer was once Sydney’s main water source. It remains an important source of water for parks, municipal and residential gardens, industry and wetlands.

Groundwater occurs in unconsolidated sediments of Quaternary age which overlie a bedrock surface consisting of the Triassic age Hawkesbury Sandstone. These sediments comprise the Botany Sands aquifer and are made up of river, beach and dune sands interbedded with clay and peat lenses. This sequence can be separated into three zones:

- an upper, predominantly sandy section with occasional peat and silt stringers
- a middle section of sand with interbedded peat layers
- a basal section of interbedded clays, peats and sands above the bedrock.

Discontinuous peat beds and indurated sand-rock layers, termed “Waterloo Rock” up to a few metres thick, can occur in the upper section. An extensive area of saline peat underlies Banksmeadow to the north of the Botany Foreshore and west of the Botany Industrial Park.

The most important dynamic stresses on the Botany Sands aquifer are rainfall and groundwater abstraction. For the northern portion of the aquifer, which is assessed here, the main recharge area is in Centennial Park. Substantial recharge also occurs in green space areas (parks and golf courses). Groundwater levels are controlled by Alexandra Canal, the Lachlan Lakes and Swamps, Cooks River and Botany Bay. The water holding capacity of the sand aquifer is enormous as the porosity of the sand aquifer has been estimated to be 25-40% (Hatley, 2004).

Heritage Computing stated in their 2007 study: "*The Botany Sands aquifer has been an important source of water for more than a century. Estimates of groundwater abstraction have varied from about 20 ML/day to about 55 ML/day in the first 50 years since the 1940s (Merrick, 1998). In 1992, usage was reported as 30 ML/day. Since then, there has been no official check on usage due to an absence of meters on most production bores. It is likely that usage declined significantly over the next 10 years, as industrial users close to the bay shut down pumping operations (due to pollution), moved their businesses elsewhere or closed down their operations. Total usage of groundwater during 2000-2002 in the northern part of the Botany Basin was estimated (D. McKibbin, pers. comm.) to be about 20 ML/day. Since then, the Solvay-Interox Borefield that was producing about 2-3 ML/day closed down early in 2004 (C. Koch, pers. comm.), and the Orica pump-and-treat scheme commenced in late 2004 in an interim way, with the full groundwater treatment plant operational from late 2005*". In this investigation no further assessment of water extraction volumes by other users was undertaken.

In 2011, the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources (WSP GMRGS) was released (OoW, 2011). In the WSP GMRGS, the current entitlements in the Botany Sands aquifer were listed as 11,156 ML/year (30.6 ML/day), allocated to 80 users. The long-term average abstraction limit for the Botany Sands aquifer was estimated at 14,684 ML/year, about 40 ML/day.

A search for each groundwater wells within a 500 m radius of the site was undertaken using the NSW Department of Primary Industries Office of Water Groundwater Database (http://realtimedata.water.nsw.gov.au/water). The search was conducted on the 15 July 2020 and indicated that there were six (6) groundwater bores present and are summarised in **Table 5-4**.

In addition to the wells identified above, the PSI (Jacobs 2020a) identified 289 groundwater bores in a 2 km radius of the site, used for commercial and industrial, irrigation, monitoring, recreational, domestic and stock use. The PSI did not identify any Groundwater Dependent Ecosystems (GDEs) within 2 km of the site.

Jacobs (2020a) notes that groundwater flow is variable depending on rainfall and local groundwater pumping activities, and generally occurs between 5 and 9 metres below ground level (mbgl). Typically, groundwater follows surface topography and local drainage patterns, flowing from higher elevations towards lower elevations. Based on two (2) Groundwater Monitoring Events (GMEs) groundwater is expected to flow from the northern portion of the site to the South-East, before flowing towards the south-west from the central portion of the site, as shown by the groundwater contours on **Figures 7-1** and **7-2** in **Appendix A**.

The aquifer beneath the site is expected to recharge through rainfall. Jacobs 2020a notes that the hydraulic conductivity of the aquifer to the south of the site ranged between 4 and 24m/day.

Table 5-4 Registered Groundwater wells within 500 m of the site (Jacobs 2020a)

Well ID	Established	Total Depth (m)	Depth to Bedrock (m)	Standing Water Level (m)	Screened Depth (m)	Bore Type	Purpose	Lithology	Distance from site (m)	Direction from site
GW053 600	01/04/1981	29	Unknown	Unknown	Unknown	Bore	Recreation	Sand, Clay	9m	South East
GW105 431	02/08/2004	30	Unknown	8.10	Unknown	Bore	Recreation	Sand	9m	South East
GW108 596	20/02/2007	16	Unknown	Unknown	Unknown	Spear	Domestic	Sand	45m	North East
GW107 740	19/10/2005	11.5	Unknown	Unknown	Unknown	Bore	Domestic	Sand	72m	South
GW105 496	06/10/2003	10	Unknown	Unknown	Unknown	Bore	Domestic	Unknown	253m	South West
GW044 513	01/01/1959	9.4	Unknown	Unknown	Unknown	Bore	Unknown	Sand, Clay, Sandstone	294m	South East
GW023 841	01/03/1966	4.5	Unknown	Unknown	Unknown	Spear	Domestic	Sand	311m	South West
GW038 591	01/12/1955	10.20	Unknown	Unknown	Unknown	Bore	Recreation	Sand, peat, sandstone, clay	325m	South East

GW107385	08/09/2005	9.50	Unknown	Unknown	Unknown	Spear	Domestic	Sand	334m	South West
GW025716	01/01/1945	4.80	Unknown	Unknown	Unknown	Spear	Domestic	Unknown	340m	South West
GW024206	01/08/1966	5.40	Unknown	Unknown	Unknown	Spear	Domestic	Sand	364m	South West
GW107594	15/10/2005	10.00	Unknown	Unknown	Unknown	Spear	Domestic	Sand	381m	South West
GW110439	24/09/2009	12.00	Unknown	6.00	Unknown	Spear	Domestic	Sand	411m	South
GW024024	01/12/1965	6.00	Unknown	Unknown	Unknown	Spear	Domestic	Sand	438m	South West
GW107765	19/10/2005	12.00	Unknown	9.00	Unknown	Spear	Domestic	Sand	441m	South
GW105962	24/05/2005	14.00	Unknown	Unknown	Unknown	Spear	Domestic	Sand	452m	South West
GW111150	20/10/2010	12.00	Unknown	Unknown	Unknown	Spear	Domestic	Sand	457m	South West

GW110 423	19/03/2009	12.00	Unknown	7.50	Unknown	Spear	Domestic	Sand	477m	South West
GW108 657	14/03/2007	15.00	Unknown	Unknown	Unknown	Spear	Domestic	Sand	481m	South
GW107 289	17/07/2005	14.03	Unknown	10.37	Unknown	Spear	Domestic	Sand	486m	West
GW026 584	01/11/1966	6.00	Unknown	Unknown	Unknown	Spear	Domestic	Sand	495m	South West

5.3.6 Topography and Drainage

The site has an approximate elevation of 30 metres Australian Height Datum (mAHD). The highest point of the site is at the north west corner (in the vicinity of AEC15), with a downward slope towards Joongah Street towards the south and south east. The nearest surface water body is a detention basin located within the Randwick Environment Park, approximately 50 m beyond the eastern and south eastern boundaries of the Site (refer to **Figure 2** in **Appendix A**).

The site is located within the Botany Basin, a natural topographical basin surrounding Botany Bay and the only significant source of groundwater near Sydney. The northern rim of the Botany Basin occurs approximately 3 km to the north of the site, marked by sandstone outcrops bordering Centennial Park. The Botany Basin is formed in a shallow depression in the sandstone bedrock, which has filled with coastal sand dunes and estuarine sediments. The ground elevations rise from less than 5 m AHD around the foreshore of Botany Bay and swampy areas to between 15 and 25 m AHD in the sand dunes, and reaching a maximum elevation of 35 to 40 m AHD at the basin edges (Merrick, 1998). The Cooks and Georges rivers are the main drainage systems of Botany Basin and generally flow in a south-easterly direction into Botany Bay.

As discussed in **Table 5-2** and shown on **Figure 11** in **Appendix A**, the below ground stormwater drainage network is expected to receive surface water runoff from hardstands across the site. Where hardstand is not present, rainfall is expected to percolate through sandy soils into groundwater.

5.4 Areas of Environmental Concern

Based on the information within the PSI (Jacobs 2020a), the following areas of environmental concern (AECs) and associated contaminants of potential concern (CoPC) were identified for the site. These AECs (illustrated in **Figure 3-1, Appendix A**), CoPCs, and corresponding laboratory analytical suite as prescribed in the SAQP (Jacobs 2020b), are summarised in **Table 5-5** below.

Table 5-5 AECs and Contaminants of Potential Concern (CoPC)

AEC	Activity of Concern	CoPCs and Laboratory Analytical Suites
AEC1	Debris and fill material, site wide	**Suite A** - Asbestos, Heavy metals, total recoverable hydrocarbons (TRH), benzene, toluene, ethylbenzene, xylene, naphthalene (BTEXN), polycyclic aromatic hydrocarbons (PAHs), phenols, volatile organic carbons (VOCs), polychlorinated biphenyls (PCBs), organochlorine and organophosphate pesticides (OCP/OPP)
AEC2	Former pesticide use, site wide	OCP/OPP
AEC3	Former Rifle Range, site wide	**Suite E** - Heavy metals, PAHs
AEC4	Former Grenade Bursting Range	**Suite E** - Heavy metals, PAHs **Suite H** – Explosives, unexploded ordnances (UXO) and propellants

AEC	Activity of Concern	CoPCs and Laboratory Analytical Suites
AEC5	Site-wide and Sydney Water Sewers	**Suite C** - Nutrients including nitrate and ammonia, chlorinated hydrocarbons, VHH, sulphates/sulphides, Faecal coliforms, *E.coli*, *Salmonella*, per- and polyfluoroalkyl substances (PFAS), heavy metals
AEC6	Chemical storage at the Storage Yard	**Suite F** - Heavy metals, TPH/BTEXN, PCBs, VHH **Additional** – Asbestos, OCP/OPP
AEC7	Vehicle storage at the Storage Yard	**Suite D** - Lead, TPH/BTEXN, PAH, Phenols **Additional** – Asbestos, Methyl tert-butyl ether (MTBE)
AEC8	Former fuel infrastructure at the Former Heavy Vehicle Transport Yard	**Suite D** - Lead, TPH/BTEXN, PAH, Phenols
AEC9	Former vehicle washing, refuelling and maintenance activities at the Former Heavy Vehicle Transport Yard	**Suite F** - Heavy metals, TPH/BTEXN, PCBs, VHH
AEC10	Oil-water separators at the Former Heavy Vehicle Transport Yard (Building 502) and Vehicle Wash Bay (off-site)	**Suite A** - Asbestos, lead, heavy metals, TPH/BTEXN, PAHs, VOCs, PCBs, OCP/OPP, phenols **Additional** - Polybrominated diphenyl ethers (PBDEs), MTBE
AEC11	Former hazardous materials storage at Former Naval Store 14	**Suite A** - Asbestos, lead, heavy metals, TPH/BTEXN, PAHs, VOCs, PCBs, OCP/OPP, phenols **Additional** - PFAS
AEC12	Former metal treatment works at Former Building 9FSB	**Suite B** - Asbestos, lead, heavy metals, TPH/BTEXN, PAHs, PCBs. **Suite G** - PFAS, VHH **Additional** – OCP/OPP
AEC13	Stockpiles at various locations across the site	**Suite B** - Asbestos, lead, heavy metals, TPH/BTEXN, PAHs, PCBs
AEC14	Stormwater infrastructure in the vicinity of building infrastructure	**Suite G** - PFAS, VHH **Additional** - Asbestos
AEC15	Current and former substations	**Suite B** - Asbestos, lead, heavy metals, TPH/BTEXN, PAHs, PCBs
AEC16	Randwick Zone Substation (off-site)	**Suite B** - Asbestos, lead, heavy metals, TPH/BTEXN, PAHs, PCBs. **Suite G** - PFAS, VHH **Additional** - VOCs

AEC	Activity of Concern	CoPCs and Laboratory Analytical Suites
AEC17	Former launderette (off-site)	**Suite B -** Asbestos, lead, heavy metals, TPH/BTEXN, PAHs, PCBs. **Suite G -** PFAS, VHH **Additional** - VOCs

*The laboratory analytical suite groupings are based on SGS Australia analytical suites.

5.5 Potential Sensitive Receptors

Potential sensitive receptors to contamination on site have been identified in **Table 5-6** below, and are based on the proposed redevelopment of the site for residential purposes provides a list of potential sensitive receptors.

Table 5-6 Potential Sensitive Receptors

Receptor	Type	Description
Human	• Existing site users (Randwick Barracks staff/residents) • Future site users (residents) • Groundwater users (stock watering, irrigation, industrial) • Site visitors • Residents (off-site) • Site maintenance workers • Construction workers for proposed future development.	Potential exposure of human receptors to on-site contamination and contaminant migration via groundwater, surface water, soil gas or dust generation.
Ecological	• Terrestrial ecology (on-site and off-site) • Aquatic ecology (e.g. Randwick Environment Park) (on-site and off-site).	Potential exposure of ecological receptors on-site and off-site through direct contact with potentially contaminated soil or water.

5.6 Current and Future Use

The site forms part of the wider Randwick Barracks, which is currently used as a military base providing administrative support and supply services to mainly army units of the Australian Defence Force. It also provides accommodation for Resident Units and functions as a major transit accommodation hub within the Sydney region for Defence personnel. DHA is presently considering redevelopment options for the site, with potential future uses including sensitive land use scenarios such as low density residential.

6 Sampling and Analysis Quality Program

The scope of the sampling and analysis program (SAQP) is outlined in **Section 4**, with the Data Quality Objectives (DQO) and Data Quality Indicators (DQIs) listed in **Table 6-1** and **Table 6-2** below. The sampling methodology is presented in **Section 6.2**.

6.1 Data Quality Objectives

Table 6-1 presents the Data Quality Objectives (DQOs) that guided the investigation program and methodology.

Table 6-1 Data Quality Objectives

DQO Step	Description
Step 1: State the Problem	Historical and current activities at the site and off site sources have the potential to have impacted on the surface and sub-surface soil and groundwater quality at the site. Accordingly, the presence and extent of potential contamination on site (if any) and potential risks to human health and the environment are not quantified. A DSI including sampling of soils and groundwater is required to assess potential contamination risks, inform management requirements and determine suitability of the site for a potential change land use, which may include low density residential.
Step 2: Identify the decision / goal of the study	The primary objective / goal of the investigation was to assess the nature and extent of chemical and asbestos contamination on site, including the key contaminant transport pathways and human health and ecological receptors. The secondary objective was to assess the suitability of the site for the proposed residential land use, and identify whether further assessment, risk assessment or other management measures are required. This includes the following decisions: 1. Are there CoPC detectable in the soil and groundwater associated with current and historic activities at the site? a. Is there any existing data and is this data valid? b. What are the standard laboratory limits of reporting (LOR) for CoPC in the sample media being assessed? 2. Are there any CoPC impacts within the boundaries of the investigation above laboratory limits of reporting (LOR) for the CoPC? 3. Has the extent of the CoPC impacts to soil and groundwater been identified and determined? 4. Is the investigation approach scientifically suitable and defensible?

DQO Step	Description
Step 3: Identify the information inputs	The primary inputs to assessing the above include: 1. The site history including preliminary Conceptual Site Model (Jacobs 2020a) 2. Location, distribution and intervals of soil, soil gas and groundwater samples at the site 3. Data collected during the assessment, including field measurements, field observations (including soil logs), Membrane Interface Probe (MIP) data, Passive Soil Gas (PSG) data, and laboratory analytical results 4. Outcomes of the assessment of the quality of collected data 5. Investigation criteria including the comparison of laboratory analytical results against adopted investigation criteria.
Step 4: Define the boundaries of the study	The boundaries of the investigation were: 1. Lateral - sampling is limited to the lateral extent of the site as illustrated in **Figure 2** in **Appendix A**. 2. Vertical –sampling is limited to 4 mbgl in soils and 10 mbgl in groundwater. 3. Temporal - the temporal boundary is the sampling undertaken between 15 June 2020 and 11 November 2020.
Step 5: Develop the analytical approach	The investigation program is detailed in **Section 6.2**, with the decision rule: 1. If the laboratory quality assurance/ quality control (QA/QC) data are within the acceptable ranges as specified by the Data Quality Indicators (DQIs) in **Table 6-2**, the data will be considered suitable for use (refer to **Appendix E**). a. If the data is not within acceptable ranges a review of its suitability will be undertaken including an assessment of the need to collect additional data. 2. If the CoPC are reported at concentrations below the adopted investigation criteria, then they are not considered to pose an unacceptable risk to the land use and further assessment is not required. 3. If the CoPC are reported above the adopted investigation criteria, then further review will be undertaken.
Step 6: Specify performance or acceptance criteria	This step examines the certainty of conclusive statements based on the available new site data collected and includes the following points to quantify tolerable limits: 1. A decision can be made based on a certainty assumption of 95% confidence in any given data set. A limit on the decision error will be 5% that a conclusive statement may be a false positive or false negative. A decision error in the context of the decision rule presented above would lead to either underestimation or overestimation of the risk level associated with a particular sampling area. The investigation program in **Section 6.2** has been implemented to minimise the following potential decision errors: 1. Sampling errors may occur when the sampling program does not adequately detect the variability of a contaminant from point to point across the site. 2. Limitations in ability to acquire useful and representative information from the data collected. 3. Measurement errors can occur during sample collection, handling, preparation, analysis and data reduction.

DQO Step	Description
Step 7: Develop the plan for obtaining data.	The Sampling Analysis and Quality Plan (Jacobs 2020b) was Auditor approved and was designed to meet the project objectives in **Section 3.1** and the DQOs outlined above. The work plan was optimised based on the ground conditions encountered during the field program. Changes from the SAQP are noted in **Table 6-4**.

6.1.1 Data Quality Indicators

Based on the DQOs, **Table 6-2** provides the following Data Quality Indicators (DQIs)

Table 6-2 Data Quality Indicators

Field Considerations	Laboratory Considerations	Data Acceptance Criteria
Precision		
• SAQP and Standard Operating Procedures (SOPs) complied with. • Investigation by suitably qualified and experienced personnel • Collection of duplicate (blind and split) samples	Analysis of samples at National Association of Testing Authorities (NATA) accredited laboratories including: • Blind duplicates (intra-laboratory duplicates) • Split duplicates (inter-laboratory duplicates) • Laboratory internal duplicates	• Field duplicates (both blind and split) collected 1 per 10 samples. • Relative Percentage Difference (RPD) calculations for primary and duplicate samples: - <30% RPD - Where RPDs>30%, data to be reviewed for sample heterogeneity and the sample result being <5 times the Laboratory Limit of Reporting (LOR). • Laboratory duplicates and RPDs as per the laboratory procedures.
Accuracy		

Field Considerations	Laboratory Considerations	Data Acceptance Criteria
Appropriate work instructions have been developed for the works and that these are complied with including: • Collection of trip blanks and rinsate samples This is to avoid bias introduced: • By chemicals during handling or transport • From contaminated equipment • From contaminated reagent • During laboratory analysis • During laboratory preparation and analysis (may be increased or reduced) • Precision of preparation of analytical method • During collection/transport (may be increased or reduced	Compliance with analytical holding times. Analysis of: • Trip blanks • Rinsate blanks • Reagent blanks • Method blanks • Matrix spikes • Surrogate spikes • Reference material • Laboratory control samples • Laboratory prepared spikes.	• Trip blanks - COPC <LOR • Rinsate blanks - COPC <LOR • Method blanks – COPC <LOR • Matrix spikes – 70% - 130% • Surrogate spikes – 50% - 150% • Laboratory control samples - 70% - 130%
Representativeness		
Appropriate media sampled in accordance with the SAQP, including: • Samples must be collected to reflect the characteristics of each medium. • Sample analysis must reflect properties of field samples. • Homogeneity of the samples. • Appropriate collection handling, storage and preservation. • Detection of laboratory artefacts (i.e. contamination blanks)	Samples analysed according to the SAQP.	All samples collected in appropriate sampling containers and analysed for the COPC in the SAQP
Comparability		

Field Considerations	Laboratory Considerations	Data Acceptance Criteria
• Standard Operating Procedures implemented by experienced samplers during sampling. • Climatic conditions (temperature, rainfall, wind) recorded to quantify the influence (if any). • Same types of samples collected (size fractions and sample containers) and handled in the same manner.	• Analysis of split sample (1 in 20 samples) • Sample analytical methods across primary and secondary laboratory • Laboratory practical quantification limits (PQLs) and units of measure (justified/quantified if different)	All samples
Completeness		
• Critical locations sampled. • Documentation and record keeping appropriate including borehole logs and Chain of Custody documentation.	• Critical samples analysed in accordance with the SAQP. • Analytes sampled in accordance with SAQP. • Sampling documentation recorded and kept in an appropriate manner.	Critical locations sampled as per **Section 6.2**. All field records and borehole logs complete Sampling undertaken by experienced samplers

6.2 Sampling Methodology

The sampling methodology is summarised in **Table 6-3**.

Table 6-3 Sampling Program

Activities	Details
Desktop review of information relating to AECs	Prior to undertaking fieldworks, the PSI (Jacobs, 2020a) including aerial photographs was reviewed and a walkover of the AEC(s) at the site as per **Table 5-5** undertaken.
Sampling Rationale	To assess the nature and extent of the contamination at the site in accordance with the NSW EPA (1995) *Sampling Design Guidelines* and SAQP (Jacobs 2020b) as follows: • Laterally – with systematic sampling for site wide AECs, and targeted sampling around specific infrastructure (e.g. former fuel infrastructure). • Vertically – targeting the depth (thickness) of fill and groundwater across the site

<table>
<tr><th>Activities</th><th>Details</th></tr>
<tr><td>Dates of Field Activity</td><td>Soil sampling – 15 June 2020 to 3 November 2020
Groundwater sampling:
- GME Round 1 between 20 and 21 July 2020 (GW01 to GW18)
- GME Round 2 between 28 and 30 October 2020 (GW01 to GW23)
MIP locations – 15 June 2020 to 30 June 2020 (undertaken by Numac Drilling Services Australia)
PSG Sampling – 2 July 2020 to 11 November 2020 (undertaken by SGS Australia)
ASG Sampling – 15 October 2020 to 11 November 2020 (undertaken by SGS Australia).</td></tr>
<tr><td>Field Sampler(s)</td><td>SLR Environmental Scientists / Engineers suitably experienced in contaminated site sampling procedures.</td></tr>
<tr><td>Service Location</td><td>A DBYD enquiry and the site's master services plans were obtained by the client prior to location of services, which showed several services on or near the site. Ausgrid, Jemena, NBN Co, Sydney Water, stormwater and Telstra utilities are located within or in areas surrounding the site.
An underground services locator (Geotrace) was contracted to locate and clear services at each borehole / test pit to avoid damage to services. Manual excavation using a hand auger was used after the service locator clearance to prior to drilling.</td></tr>
<tr><td>GPR Clearance</td><td>Ground Penetrating Radar (GPR) and Unexploded Ordnance (UXO) clearances were undertaken by others in the former Rifle Range (AEC 3) and Grenade Bursting Range (AEC 4) areas. A GPR survey was also undertaken around fuel storage infrastructure (AEC 8).</td></tr>
<tr><td>Drilling / Test Pit Excavation</td><td>Testpits were advanced across unsealed and vegetated areas of the site using one 20- tonne and one 13-tonne excavator.
Boreholes were advanced across hardstand areas (following concrete coring) across the site using a sonic rig and track-mounted drill rig (Geoprobe) using push tube techniques.
A drill rig fitted with a Membrane Interface Probe (MIP) was used to assist in field screening soils and site characterisation prior to soil / groundwater sampling in AEC 4 (Former Grenade Bursting Range), AEC 5 (Site wide sewer) AEC 8 (Fuel Infrastructure), AEC 9 (Former Vehicle Washing and Refuelling), AEC 10 (Oil Water Separators) AEC 12 (Former Metal Treatment Works).
A hand auger was used for sampling of soils at shallow depths.</td></tr>
</table>

Activities	Details
Bores Drilled and Target Depths	Sampling locations are detailed on **Figures 3-2 to 3-7, Figures 4 to 6,** and **Figure 8** in **Appendix A**) and summarised below. The following intrusive investigations were undertaken: • 264 test pits were advanced to a maximum depth of 2.6mbgl using a 20-tonne and 13-tonne excavator • 75 boreholes were drilled to a maximum depth of 4mbgl using a sonic rig as well as a track-mounted rig using pushtube techniques • 68 shallow soil boreholes were advanced to a maximum depth of 0.7mbgl using a hand auger as well as a track-mounted drill rig using pushtube techniques • Six soil stockpiles were sampled using a 20-tonne excavator. Noting as per **Table 8-1** a further 17 stockpiles were investigated but did not contain soil. • 65 MIP locations were advanced using MIP rig to a maximum depth of approximately 6mbgl • Installation of 24 groundwater monitoring wells to a maximum depth of 10mbgl • Installation of PSG probes at 37 locations to a maximum depth of 1.2mbgl • Installation of ASG probes at 6 locations to a maximum depth of 1.2mbgl • One background soil borehole was advanced to a maximum depth of 0.9mbgl using a hand auger at Latham Park, South Coogee NSW.
Soil Logging	Soils encountered during drilling were described and logged with reference to the Unified Soil Classification System. Borehole / test pit logs are presented in **Appendix B**, which describe lithology encountered and contain information on PID readings and depth to groundwater. Photographs representative of typical ground conditions are presented in **Appendix C**.
Soil Sampling	Soil samples were collected directly from the excavator bucket, push-tube sleeve, sonic sleeve and/or hand auger. Sampling was undertaken using nitrile gloves, with a new pair of gloves used for each sample to minimise the risk of cross-contamination. The soil samples were placed into laboratory supplied sample containers. Soil samples were placed into a cooler box containing ice whilst on-site and in transit to the laboratory. Soil samples were submitted under Chain-of-Custody (CoC) procedures to NATA accredited laboratories. CoC documentation is presented in **Appendix F**.
Soil Screening	Soil samples were field screened by using a calibrated photo-ionisation detector (PID) equipped with a 10.6 eV lamp, with any odours and any other olfactory signs of contamination were noted on the borehole logs presented in **Appendix B**.

Activities	Details
Stockpile Sampling	Six soil stockpiles (SP007 to SP009, SP013, SP014, and SP018, illustrated in **Figure 3-6, Appendix A**) were sampled using an excavator, with smaller stockpiles sampled using a shovel. Sampling densities were determined in accordance with the *Victorian EPA IRWG702* 2009 guidelines, which were adopted in the absence of NSW specific guidelines in relation to sampling densities for the assessment of stockpiles. As per the IRWG702 2009 guidelines, stockpiles were sampled at a rate of one (1) sample per 25m^3. Samples were collected from each stockpile at depths ranging between 0.2 and 0.5 m below the stockpile surface as per the SAQP (Jacobs 2020b). Stockpile material descriptions are presented in **Table 8-1**.
Asbestos Sieving and Sampling	All asbestos in soil sampling was conducted in accordance with *Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia* 2009 (WA DOH, 2009), the NEPM recommendations (NEPC, 2013) and the SAQP (Jacobs 2020b). Soil samples and potential asbestos containing material (PACM) fragments were collected from locations where asbestos was considered to be a CoPC. Field sieving was conducted at all testpit locations within AEC1 (site wide – debris and fill) to identify asbestos on site as follows: • A 10L sample was collected from the fill horizons identified within the testpit and screened through a ≤7 mm sieve, spread out for inspection on black plastic sheeting (to contrast any ACM within the sample), and inspected for asbestos. • Any presumed ACM and/or Fibrous Asbestos observed after sieving was collected and submitted to the laboratory for identification and to determine a representative weight for weight percentage (% w/w) of asbestos material within the soil. • Where no PACMs were observed within the 10L samples, a 500ml sample was collected from the 10L sample, and submitted for laboratory analysis for asbestos quantification to a detection limit of 0.001% w/w.
MIP	As shown on **Figure 4** in **Appendix A**, 65 MIP locations were advanced to a maximum depth of 6mbgl across areas targeting AEC1 (former UST areas on southern portion of site), AEC5 (sewer line), AEC8 (former fuel infrastructure), AEC9 (former vehicle washing refuelling and maintenance), AEC10 (oil water separator on site) and AEC12 (former metal treatment works). The MIP locations were advanced using a Geoprobe fitted with a MIP by Numac Drilling Services Australia between 15 June 2020 and 30 June 2020.
PSG Sampling	To assist in assessing potential soil gas risks, as shown on **Figure 5** in **Appendix A**, the following PSG probes were installed: • PSG01 to PSG23 on 2 July 2020 across the area forming AEC12 on the south eastern portion of the site. The probes were retrieved on 16 July 2020. • PSG probes PSG24 to PSG33 were installed in the north western portion of the site adjacent to GW14 and GW15, and PSG34 to PSG37 were installed in the north eastern portion of the site adjacent to GW18. The probes were installed on 28 October 2020 to a maximum depth of 1.2mbgl, and were retrieved on 11 November 2020. All PSG probes were installed and retrieved by a Senior Environmental Scientist from SGS Australia. SGS Australia also analysed the PSG probes.

Activities	Details
ASG Sampling	Following review of the PSG sampling, as shown on **Figure 6** in **Appendix A**, the following Active Soil Gas (ASG) probes were installed: • ASG01 to ASG04 were installed on 15 October 2020 in the vicinity of PSG19, PSG20, PS22 and PSG23 on the northern portion of AEC12, to a maximum depth of 1.2mbgl. • ASG probes ASG05 and ASG06 were installed on 11 November 2020 in the vicinity of the Sydney Water sewer alignment (AEC5), adjacent to GW13a and GW13b towards the north western portion of the site, beneath the concrete slab. All ASG probes were retrieved on 11 November 2020. All ASG probes were installed and retrieved by a Senior Environmental Scientist from SGS Australia. SGS Australia also analysed the ASG probes.
Groundwater Sampling	To access groundwater quality, 24 newly installed groundwater monitoring wells (shown on **Figure 7-1** in **Appendix A**) were developed, gauged and sampled. The wells were developed after drilling and installation using a 12V submersible pump fitted with high density polyethylene (HDPE) tubing. The standing water level (SWL) was measured using an interface probe prior to purging and sampling. The monitoring wells were purged and sampled using low-flow sampling techniques via a peristaltic pump as follows: • Field parameters and visual/olfactory observations were recorded prior to sampling at each location. • Physio-chemical parameters including pH, EC, redox potential, and temperature were measured using a calibrated water quality meter fitted with a flow cell. Groundwater samples were collected once at least three consecutive readings of stabilised field parameters were observed. • Groundwater samples were collected directly from the peristaltic pump outlet, with new HDPE tubing used between each well, and transferred to appropriately preserved sample containers provided by the laboratories. • The groundwater samples for metals analysis were field-filtered using dedicated disposable 0.45 micron (µm) in-line groundwater filters. Groundwater monitoring well construction details, depth to water measurements, well development and stabilised groundwater quality parameters collected during sampling are provided in **Table B1** in **Appendix B**.
Slug Testing	To assess the groundwater hydraulic conductivity, slug testing of wells GW13b and GW15 targeting sewer infrastructure (AEC5), wells GW08 and GW10 targeting the former metal treatment works (AEC12), and well GW11 for site coverage, was completed on 30 October 2020 as part of the SAQP (Jacobs 2020b).
Equipment Calibration	Equipment calibration certificates for sampling equipment are presented in **Appendix G**.
Laboratory Analytical Suites	The analytical suites adopted for the soil and groundwater investigation program were based on Table 8.1 of the Jacobs SAQP (2020b), and are listed in **Table 5-5** of this report.

Activities	Details
Laboratory Analysis	Based on the site history, review of the PSI (Jacobs 2020a), SAQP (Jacobs 2020b) and field observations, samples were submitted to NATA accredited laboratories for analysis of the contaminants of potential concern (CoPC) described in **Table 5-5**, as summarised below: 1. 905 primary soil samples, 43 primary groundwater samples, and 3 primary liquid grab samples to SGS Australia (nominated and engaged by the Client) 2. 98 intra-laboratory duplicate soil samples, and 2 intra-laboratory duplicate groundwater samples to SGS Australia 3. 98 inter-laboratory duplicate soil samples, and 2 inter-laboratory duplicate groundwater samples to Eurofins 4. 16 rinsate samples to SGS Australia 5. 29 trip blank/spike pair samples to SGS Australia 6. 37 PSG samples plus 5 duplicate samples 7. 6 ASG samples plus 1 duplicate sample. Analytical results are grouped by the AEC and summarised in **Tables D1** to **D25** in **Appendix D**. CoC documentation is presented in **Appendix F**.
Decontamination Procedure	Non dedicated soil sampling equipment, as well as the interface probe for groundwater sampling, were decontaminated using the triple wash physical method as per the SAQP (Jacobs 2020b). The equipment was scrubbed using a HDPE brush in a bucket of tap water containing PFAS-free Alconox, rinsed in a second bucket containing tap water, and subsequently rinsed using laboratory supplied PFAS-free deionised water prior to the collection of each sample.
Sample and Preservation and Transport	Soil and groundwater samples were placed in laboratory supplied containers and stored on ice in a cooler box while on site and in transit to the laboratory with accompanying Chain of Custody (CoC) documentation.
Borehole reinstatement	Boreholes / test pits were backfilled with soil removed from the bore / test pit as well as clean sand, where required, during drilling / test pit reinstatement to level the area.
Disposal of excess soil and purge water	Excess soil cuttings and water from drilling activities were captured in waste drums located on site. The waste drums are labelled, sealed with waste classification pending off-site disposal. Purged groundwater was collected into sealable jerry cans following groundwater monitoring well development and sampling, then placed in an intermediate bulk container (IBC) located on the northern portion of the site. The IBC is pending off-site disposal.

6.3 Changes from SAQP

Changes to the investigation program from the SAQP (Jacobs 2020b) were implemented upon consultation and approval from the site auditor. As per Section 5.7 of the SAQP (Jacobs 2020b), changes from the SAQP, the rationale for the changes, and pending assessment from the SAQP are presented in **Table 6-4** below.

Table 6-4 Changes from the SAQP (Jacobs 2020b)

AEC	SAQP Scope	Activity Added/Changed	Addendum Scope of Works
AEC 1 / Site Wide	• As per section 7.1.1, Table 7.1, and Figure 5 in Appendix A of the SAQP, 230 testpits were to be advanced in a grid-pattern across AEC01, with allowance for an additional 115 targeted testpits for the identification of ACM hotspots. • As per Table 7.1, 18 new groundwater monitoring wells targeting on site AECs were to be installed across the site.	• Testpits TP122, TP132, TP142, TP152, TP153, TP154, TP166, TP167 and TP168 were located beyond site boundary and therefore omitted from the investigation program. • Testpits TP50 and TP270 were omitted from the investigation program due to proximity to services. • Testpits TP231 to TP271 were added to the investigation program after testpits in vegetated areas and vegetated strips separating the concrete slabs were found to contain fill up to 2mbgl, with asbestos fragments within deep fill (>0.2 mbgl). • Shallow boreholes SH031 to SH036 were advanced across surface soils lining the fence north of Galu Avenue on the south western portion of the site. These shallow boreholes were not proposed in the SAQP (Jacobs 2020b), and were added to the investigation program due to the presence of asbestos fragments along the surface. • Well GW13, which was advanced in the vicinity of the sewer line on the north western portion of the site, was terminated at 1.81mbgl due to encountering rock with the hollow flight auger. This well was designated as GW13a. To meet the scope, a second well GW13b was advanced with a sonic rig to a depth of 9.3mbgl, approximately 8m east of GW13a.	• Groundwater monitoring well GW19 was installed on the south western portion of the site towards Galu Avenue. • GW20 was installed towards the western portion of the site immediately south west of Concrete Slab 14 (see **Figure 2, Appendix A** for Concrete Slab features). • GW21 was installed towards the south eastern portion of the site on the vegetated strip south of Concrete Slab 9. • GW22 was installed towards the northern portion of the site, immediately west of Concrete Slab 17. • GW23 was installed towards the north eastern boundary of the site, east of Concrete Slab 17. • The locations of the 5 newly groundwater monitoring wells are illustrated in **Figure 7-1, Appendix A**. • Slug testing was undertaken on groundwater monitoring well GW11 to provide site coverage.

AEC	SAQP Scope	Activity Added/Changed	Addendum Scope of Works
AEC2	• As per Section 7.1.2 of the SAQP, an additional 32 boreholes were to be sampled to target specific areas where pesticides were expected to have been used more frequently.	• Boreholes BH001 to BH011, BH015, BH017, BH018, BH020 to BH024, BH027, BH028, BH031 and BH032 were omitted from the investigation program. These sampling locations were omitted after analytical results from grid-based sampling generally reported concentrations of pesticides below the adopted investigation criteria. Hence, further specific analysis for pesticides was not considered to be required.	• NA
AEC3 Rifle Range	• Metals including Antimony	• Testing for antimony was not undertaken in soils from the rifle range. Antimony was originally added to lead bullets to improve hardness and stop lead clogging rifling, however military rounds having a full metal jacket have been used by the Australian Army since ~1910. The lead / antimony alloy usually contains between 2-6% antimony. Based on the expected percentage of antimony in lead bullets, and the low levels of lead encountered, SLR does not consider the absence of analytical results for antimony to be a data gap or alter the outcome of this assessment.	• NA

AEC5	• As per Section 7.1.5 of the SAQP, 11 soil sampling locations were to be advanced along the Sydney Water sewer alignment on the northern portion of the site. 10 boreholes were to be advanced to within the service trench of the site sewer. • Samples were also to be collected from within the sewer from accessible locations. Location and number of samples were to be determined once infrastructure was located. • A total of three (3) ASG probes were to be installed along the alignment as an initial assessment for the presence of vapour risk. • Two (2) of the proposed 18 new monitoring wells were to be installed upgradient and downgradient of the sewer infrastructure, with slug testing to be conducted on these wells to investigate migration of impacts.	• 11 MIP locations were proposed to be advanced in the vicinity of the Sydney Water sewer alignment according to Figure 6 of the Jacobs SAQP. 12 MIP locations were advanced in the vicinity of the Sydney Water sewer alignment as part of this DSI, as illustrated in **Figure 4, Appendix A**.	• Sampling locations SYDSEW001 to SYDSEW015, targeting the Sydney Water Sewer on the northern portion of the site. • Sampling locations SEW001 and SEW002, targeting the site sewer on the south eastern portion of the site. • Sampling locations SEP001_BH01 and SEP001_BH02, targeting the septic tank towards the southern portion of the site, as illustrated **Figure 3-4** in **Appendix A**. • All sampling locations targeting AEC5 were advanced to a maximum depth of 4mbgl, and are illustrated in **Figure 3-4, Appendix A**. • Two (2) liquid grab samples, SEP001 and SEW002_GRAB, were collected from the septic tank (SEP001) and the sewer location SEW002 respectively. Location SEW001 was observed to be dry and could not be sampled. • Slug testing was undertaken on groundwater monitoring wells GW13b and GW15 targeting AEC5, as proposed in the SAQP. • ASG probes ASG05 and ASG06 were deployed in the vicinity of GW13a and GW13b (as illustrated in **Figure 6**,

AEC	SAQP Scope	Activity Added/Changed	Addendum Scope of Works
			Appendix A), targeting the Sydney Water sewer alignment as proposed in the SAQP, and also targeting concentrations of chlorinated hydrocarbons detected in GW13a and GW13b during the Round 1 GME in July 2020. • PSG probes PSG34 to PSG37 were deployed in the vicinity of GW18 in the North-East corner of the site (as illustrated in **Figure 5, Appendix A**), targeting the Sydney Water sewer alignment as proposed in the SAQP, and also targeting concentrations of chlorinated hydrocarbons detected in GW18 during the Round 1 GME in July 2020.
AEC6	• As per Section 7.1.6 of the SAQP, eight (8) surface soil locations were to be sampled in order to supplement the grid-based AEC01 investigation in this area.	• Shallow boreholes SH003 to SH005 omitted from the investigation program. These sampling locations were omitted after analytical results of other sampling locations in this area (BH11 to BH13) reported concentrations of CoPCs below the adopted investigation criteria. As a result, further specific analysis for CoPCs in this AEC was not considered to be required.	• NA

AEC	SAQP Scope	Activity Added/Changed	Addendum Scope of Works
AEC7	• As per Section 7.1.7 of the SAQP, 10 surface soil locations were to be sampled in order to supplement the grid-based AEC01 investigation in this area.	• Shallow boreholes SH001, SH006, SH008, SH009 and SH013 omitted from the investigation program. These sampling locations were omitted as shallow sampling locations and grid-based testpit sampling locations advanced in this area provided enough coverage for the AEC. Furthermore, the analytical results from samples collected from this area reported concentrations of CoPCs to be generally below the adopted investigation criteria.	• NA
AEC9	• As per Section 7.1.9 of the SAQP, 10 MIP locations were proposed to be advanced within AEC9.	• 11 MIP locations were advanced within AEC9 as part of this DSI (**Figure 4, Appendix A**).	• NA
AEC10	• As per Section 7.1.10 of the SAQP, six (6) MIP locations were proposed to be advanced within AEC10.	• Four (4) of the 11 MIP locations advanced within AEC8 are also within the footprint of AEC10, and are considered to provide adequate coverage for this AEC, given the MIP results did not indicate the presence of contamination. • Polybrominated diphenyl ether (PBDE) testing was not undertaken, as the site history review did not indicate a source for the wide spread use of brominated flame retardants at the site.	• NA
AEC11	• As per Section 7.1.11 of the SAQP, 10 surface soil locations were to be sampled in order to supplement the grid-based AEC01 investigation in this area, with results from the grid-based sampling also to be used to provide an indication of potential impacts in sub-surface soils in this area.	• Shallow borehole SH017 omitted from the investigation program. This sampling location was omitted after analytical results from other shallow and grid based testpit sampling locations in this area reported concentrations of the target CoPC (PFAS), to be below the adopted investigation criteria.	• NA

AEC	SAQP Scope	Activity Added/Changed	Addendum Scope of Works
AEC12	• As per Section 7.1.12 of the SAQP, three (3) of the proposed 18 new monitoring wells were to be installed across AEC12, with slug testing to be conducted on these wells to investigate migration of impacts.	• NA	• Soil boreholes PSG_BH01 to PSG_BH10 were advanced to a maximum depth of 1mbgl across AEC12, targeting PSG probe locations deployed in July 2020. • Slug testing was undertaken on groundwater monitoring wells GW08 and GW10 targeting AEC12, as proposed in the SAQP. • ASG probes ASG01 and ASG04 were deployed towards the northern portion of AEC12 (as illustrated in **Figure 6, Appendix A**), targeting concentrations of chlorinated hydrocarbons previously detected during the deployment of PSG probes PSG19, PSG20, PSG22 and PSG23 (**Figure 5, Appendix A**).
AEC13	• As per Section 7.1.13 and Table 7.1 of the SAQP, four (4) soil stockpiles and seven (7) non-soil stockpiles on site were to be sampled using test pitting methods.	• Six (6) soil stockpiles and 17 non-soil stockpiles were identified across the site. • Stockpiles SP001 to SP006, SP010 to SP012, SP015 to SP017 and SP019 to SP023 were visually assessed but not sampled as they were comprised of construction and demolition waste and/or mulch material.	• NA

AEC	SAQP Scope	Activity Added/Changed	Addendum Scope of Works
AEC14	• As per Section 7.1.14 of the SAQP, targeted borehole sampling was to be undertaken withing stormwater infrastructure service trenches once their locations were determined. A sample of surface water also to be collected for analysis.	• NA	• Sampling locations STWR01_BH01, STWR01_BH02, and STWR02_BH01, targeting the stormwater network on the southern portion of the site. • The sampling locations targeting AEC14 were advanced to a maximum depth of 4mbgl, and are illustrated in **Figure 3-4, Appendix A.** • All stormwater pits in the vicinity of the sampling locations were observed to be dry and could not be sampled for surface water.
AEC15	• As per Section 7.1.15 of the SAQP, eight (8) surface soil samples and eight (8) boreholes were to be sampled in order to determine the lateral and vertical extent of contamination associated with the former and current substations.	• Shallow boreholes SH025 to SH030 omitted from the investigation program, with eight (8) boreholes and two (2) groundwater monitoring wells proposed to be advanced upgradient and downgradient of the substations instead. This approach provided adequate coverage of the ground conditions given the small area occupied by the substations.	• NA
AEC16 and AEC17	• As per Section 7.1.16 of the SAQP, two new groundwater wells were to be installed on the northern boundary of the site to investigate potential of COPCs associated with these COCs to migrate onto site.	• NA	• In addition to the installation of groundwater monitoring wells GW14 and GW15, PSG probes PSG24 to PSG33 were installed on the north western portion of the site. The PSG probes were installed to target AEC16 and AEC17, and also target concentrations of chlorinated hydrocarbons detected in GW14 and GW15 during the Round 1 GME in July 2020.

AEC	SAQP Scope	Activity Added/Changed	Addendum Scope of Works
Background Sampling	• As per Section 7.1.17 of the SAQP, background conditions were to be determined by installing one (1) borehole and one (1) groundwater well off-site or on the boundary of the site.	• NA	• One (1) soil borehole, LP_BAC was advanced using a hand auger to a maximum depth of 0.9mbgl at the south west corner of the sports field located in Latham Park, South Coogee (**Figure 8, Appendix A**). • One (1) liquid grab sample, LP_BAC_WATER, was collected from a tap running bore water immediately west of the Latham Park Tennis Centre at Latham Park, South Coogee (**Figure 8, Appendix A**). • The background soil and water sampling was undertaken following approval from Randwick City Council.
Groundwater Resolution	• As per Section 7.1.18, two (2) additional groundwater wells were to be installed to provide spatial coverage and higher resolution understanding of groundwater at the site. • One (1) well was to be installed on the western boundary, and one (1) well was to be installed on the southern boundary of the site.	• NA	• Installation of groundwater wells GW20 to GW23 was completed for spatial coverage understanding of groundwater flow and quality at the site.

AEC	SAQP Scope	Activity Added/Changed	Addendum Scope of Works
Former UST areas on southern portion of site	• Not scoped in SAQP.	• Nine (9) MIP locations were advanced in within the carpark of the Movement Control Office (MIP028 to MIP030, MIP052 and MIP053), and within the former heavy vehicle transport yard (MIP024 to MIP027) on the southern portion of the site, which are considered to have housed former USTs, as illustrated in **Figure 4, Appendix A**.	• Four (4) soil boreholes (MIP_BH01 to MIP_BH04) were advanced in the immediate vicinity of the former UST to maximum depth of 1mbgl.

7 Investigation Criteria

7.1 Soil

The results of the site works were evaluated based on the guidelines as prescribed in Section B.1 of the Jacobs SAQP (2020b). These guidelines are based on the following national and international guidance documents:

- National Environment Protection Council (1999, 2013 revision), *'National Environment Protection (Assessment of Site Contamination) Measure'* (NEPM).
- Heads of EPAs Australia and New Zealand (HEPA) 2020, *PFAS National Environmental Management Plan (NEMP)*, Version 2.0.
- Dutch intervention levels
- NSW EPA Waste Classification Guidelines (NSW EPA, 2014) and NSW EPA, (October 2016).
- US EPA - Regional Screening Level (RSL) Resident Soil Table (THQ = 0.1) Ingestion (May 2020)
- US EPA, 2018. Vapor Intrusion Screening Level Calculator (VISL) [WWW Document]. Vap. Intrusion. URL (accessed 5.31.18)
- Western Australian Department of Health (DoH) 2019 '*Guidelines for the Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia*', Consultation Draft November 2019.

7.1.1 Soil Aesthetics

The NEPM (2013) identifies odours, staining and presence of low concern or non-hazardous inert foreign materials in soil or fill from anthropogenic activities as aesthetic issues. While there are no specific numerical aesthetic guidelines prescribed in the NEPM (2013), the NEPM (2013) suggests that aesthetic issues should be assessed further based on factors such as quantity, type, distribution and olfactory nature of soils and foreign material, as well as practical concerns relating to land use and exposure to receptors. For instance, strong odours can be indicative of how receptors can be impacted by vapours on site and migrating from the site.

Indicators of aesthetics issues were assessed during the investigation, with observations documented in the borehole logs (**Appendix B**) and site photographs (**Appendix C**).

7.1.2 Human Health and Ecological Guidelines

To assess the significance of potential contaminant concentrations in soil, reference was made to the National Environment Protection Measure (NEPM) '*Schedule B1 Guideline on Investigation Levels for Soil and Groundwater' (2013*). The NEPM (2013) guidelines provide a framework for the use of investigation and screening levels based on human health and ecological risks.

The following soil health investigation levels (HILs), health screening levels (HSLs), ecological investigation levels (EILs) and ecological screening levels (ESLs) referenced in the NEPM (2013) were adopted as the site assessment criteria for soils as part of this investigation:

- Table 1A(1) Health investigation levels for soil contaminants – Residential A
- Table 1A(3) 'Soil HSLs for vapour intrusion (mg/kg)' – Low-high density residential
- Table 1B(5) Generic EILs for aged As, fresh DDT and fresh naphthalene in soils irrespective of their physicochemical properties – Urban residential and public open space
- Table 1B(6) 'ESLs for TPH fractions F1 – F4, BTEXN and benzo(a)pyrene in soil – Urban residential and public open space'
- Table 1 B(7) Management Limits for TPH fractions F1-F4 in soil - Residential, parkland and public open space
- Table 7. Health screening levels for asbestos contamination in soil – Residential A

The EIL Calculation Spreadsheet developed by CSIRO for the National Environment Protection Council (2010) and; with site specific CEC and pH values where available, was used to calculate EILs for chromium (Cr), copper (Cu), lead (Pb), nickel (Ni) and zinc (Zn). Where site specific information was not available the Average Background Concentration (ABC) was sourced from schedule B5c of the NEPM 1999 for an old suburb with a high traffic volume.

Parameters and calculations to derive site-specific EILs for these analytes are presented in **Table 7-1** below. EILs for cadmium and mercury were derived from the NEPM (1999) guidelines as per the SAQP (Jacobs 2020b).

Table 7-1 Parameters and Calculations to derive site-specific EILs for Cr, Cu, Pb, Ni and Zn

Sample ID	Cation Exchange Capacity (meq/100g)	pH (pH units)	Organic Matter (%)	Clay (%)
LP_BAC_0.0-0.1	5.2	6.9	1	4
LP_BAC_0.4-0.5	3.5	7.4	1	4
LP_BAC_0.8-0.9	7.0	7.6	1	4
Average	**5.2**	**7.3**	**1**	**4**

Analyte	Site Specific EIL*
Cr	300
Cu	120
Pb	1100
Ni	45
Zn	320

*Site Specific EILs derived following input of average CEC, pH, Organic Matter and Clay values from analysed samples and an ambient background level of 0 mg/kg (for conservatism) into EIL Calculation Spreadsheet (NEPC 2010)

Given the potential residential land use for the site, a 'residential with garden/accessible soil' land use scenario (HIL/HSL A) has been adopted for this assessment. The HIL/HSL A is the most conservative investigation level presented within the NEPM 1999 and was adopted for this assessment as the most applicable contaminant investigation level for the purpose of investigating potential risks to future site users.

7.1.3 Asbestos in Soil

The NEPM (1999) provides guidelines for the assessment of asbestos. Levels for various land uses have been adopted from the Western Australian Department of Health, *Guidelines for the Assessment and Remediation of Asbestos Contaminated Sites,* 2009 (WA DoH 2009) as appropriate screening criteria for assessment of asbestos contamination by appropriate sampling and quantification.

For asbestos containing material (ACM) in sound condition, the use of 0.01% w/w asbestos in soil has been adopted. The NEPM (1999) also indicates that no asbestos should be visible in surface soils.

For asbestos that has been highly weathered or can be crumbled under hand pressure (fibrous asbestos or asbestos fines), a limit of 0.001% w/w asbestos in soil has been applied for all land uses.

7.2 Groundwater

Groundwater investigation levels (GILs) are the concentrations of groundwater contaminants above which further investigation (point of extraction) or a response (point of use) is needed. They are applicable to risk assessments for impacts of potentially contaminated groundwater to receptors both on-site and off-site.

To assess the potential for groundwater contamination at the site relating to historical and existing uses of the site and immediate surrounds, SLR has adopted GILs as prescribed in Section B.1.9 of the Jacobs SAQP (2020b). These guidelines are based on the following national and international guidance documents:

- NEPC (2013) Table 1 A(4) Groundwater HSLs for Vapour Intrusion – low density residential, 2 to <4m, SAND
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ) (2000) 95% species level of protection protected for freshwater
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ) (2018) 95% species level of protection for freshwater
- Dutch (VROM 2000) groundwater intervention levels for Total Petroleum Hydrocarbons fractions
- National Health and Medical Research Council (NHMRC 2011), Australian Drinking Water Guidelines
- National Health and Medical Research Council (NHMRC 2008), Guidelines for Managing Risks in Recreational Water
- HEPA (2020) PFAS National Environmental Management Plan Version 2.0 – January 2020
- Canadian Council of Ministers of the Environment (CCME, 2003).

7.3 Soil Vapour

To assess the potential for human health risks presented by a soil gas intrusion pathway, SLR has adopted soil vapour investigation criteria for soil gas samples as prescribed in Section B.1.8 of the Jacobs SAQP (2020b). These guidelines are based on the soil vapour investigation and screening levels referenced in the NEPM (2013).

The SAQP (Jacobs, 2020b) notes that the Vapour Intrusion Screening Level (VISL) Calculator, which is derived from the Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air (US EPA 2015) should also be applied. The VISL calculator which reports risk-based screening level concentrations of volatile contaminants in soil above which further investigation is required. The VISLs have not been applied as the NEPM HSLs are appropriate.

7.4 Waste Assessment Criteria

The waste assessment criteria are based on the NSW EPA *Waste Classification 2014* guidelines and were applied to material requiring off-site disposal at an appropriately licensed waste facility. Waste materials generated on site from intrusive works were classified in accordance with these guidelines.

7.5 Summary of Adopted Site Assessment Criteria

The site assessment criteria for soils, groundwater and soil vapour adopted as part of this investigation are based on the aforementioned national and international guidelines and Appendix B.1 of the SAQP (Jacobs 2020b), and are summarised in **Table 7-2** below.

Table 7-2 Summary of Adopted Site Assessment Criteria

		Soils															Soil Vapour	Groundwater			
Chemical Group	Chemical Name	EILs (mg/kg)	ESLs (mg/kg)	HILs / HSLs (mg/kg)				Management Limits for Coarse Soils (mg/kg)	PFAS Residential with garden/accessible soil (mg/kg)	PFAS Residential with minimal opportunities for soil access (mg/kg)	PFAS Public open space (mg/kg)	PFAS Ecological Protection - Direct Exposure (mg/kg)	PFAS Ecological Protection - Indirect Exposure (mg/kg)	WA DoH 2009 - Soil Asbestos Investigation Criteria - All Site Uses	WA DoH 2009 - Soil Asbestos Investigation Criteria - Residential Use	WA DoH 2009 - Soil Asbestos Investigation Criteria - No Visible Asbestos on Surface Soil	Tier 1 HSLs (µg/m³)	Ecosystem protection levels – Freshwater (µg/L)	Guidelines for Managing Recreational Water (2008) (µg/L)	Protection of Human Health (Drinking Water) (µg/L)	HILs/HSLs (mg/L) Depth 2-<4m
Asbestos	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.001% w/w for FA and AF	0.01 % w/w asbestos for ACM	All forms of asbestos	NA	NA		NA	NA
Metals	Arsenic	100	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	24	100	10	-
	Cadmium	3	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	0 2	20	2	-
a. Hexavalent Chromium	Chromium	300	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	1	500 a	50 a	-
	Copper	120	-	6000	-	-	-	-	-	-	-	-	-	-	-	-	-	1.4	20000	2000	-
	Lead	1100	-	300	-	-	-	-	-	-	-	-	-	-	-	-	-	3.4	100	10	-
	Mercury	1	-	40	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	10	1	-
	Nickel	45	-	400	-	-	-	-	-	-	-	-	-	-	-	-	-	11	200	20	-
	Zinc	320	-	7400	-	-	-	-	-	-	-	-	-	-	-	-	-	8		NC	-
MAH	1,2,4-Trimethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2090	-	-	-	-
	1,3,5-Trimethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2090	-	-	-	-
	Styrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34800	-	-	-	-
PAHs	Carcinogenic PAHs (as B(a)P TEQ)	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Naphthalene	170	-	3	-	-	-	-	-	-	-	-	-	-	-	-	28	16	-	-	NL
	Benzo(a)pyrene	-	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.1	0.01	-
	Total PAHs	-	-	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Phenols	Phenol	-	-	3000	-	-	-	-	-	-	-	-	-	-	-	-	-	320	2	0.2	-
	Pentachlorophenol	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	10	100	10	-
	Cresols	-	-	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
	2-chlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	490	3000	300	-
	4-chlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	220		NC	-
	2,4 – dichlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	160	2000	200	-
	2,4,6 – trichlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	200	20	-
	2,3,4,6 – tetrachlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20		NC	-
TRH	TRH (C6-C9)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	150		NC	-
	TRH (C10-C36)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600		NC	-
	TRH (>C6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	>C16-C34	-	-	4500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		Soils															Soil Vapour	Groundwater			
	>C34-C40	-	-	6300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
				Depth (TRH F1-F4 and BTEX Only)				-	-	-	-	-	-	-	-	-	-	-	-	-	-
				0-<1m	1-<2m	2-<4m	>4m	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F1 (C6-C10*)	-	180	45	70	110	200	700	-	-	-	-	-	-	-	-	-	-	-	-	-
	F2 (>C10-C16*)	-	120	110	240	440	NL	1000	-	-	-	-	-	-	-	-	-	-	-	-	-
	F3 >C16-C34	-	300	4500	-	-	-	2500	-	-	-	-	-	-	-	-	-	-	-	-	-
	F4 >C34-C40	-	2800	6300	-	-	-	10000	-	-	-	-	-	-	-	-	-	-	-	-	-
BTEX	Benzene	-	50	0.5	0.5	0.5	0 5	-	-	-	-	-	-	-	-	-	120	950	10	1	0.9
	Toluene	-	85	160	220	310	540	-	-	-	-	-	-	-	-	-	2000	300	8000	800	NL
	Ethylbenzene	-	70	55	NL	NL	NL	-	-	-	-	-	-	-	-	-	374	140	3000	300	NL
	Xylenes	-	105	40	60	95	170	-	-	-	-	-	-	-	-	-	-	-	-	-	NL
	m,p-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3480	350	-	-	-
	o-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3480	350	NC	NC	-
	Xylene Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	380	6000	600	-
PCBs	Aroclor 1242	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	NC	NC	-
	Aroclor 1254	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	NC	NC	-
	Total PCBs	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OCPs	DDT	180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.006	90	9	-
	DDD + DDE + DDT	-	-	240	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Aldrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NC	NC	NC	-
	Aldrin and Dieldrin	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Dieldrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NC	0.001	0.0001	-
	Chlordane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	20	2	-
	Endosulfan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 2	200	20	-
	Endrin	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.0004	0.00004	-
	Heptachlor	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	3	0.3	-
	HCB	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Lindane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 2	100	10	-
	Methoxychlor	-	-	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mirex	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Toxaphene	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	0 2	NC	NC	-
OPPs	Azinphos methyl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	300	30	-
	Chlorpyrifos	-	-	160	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	100	10	-
	Diazinon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	40	4	-
	Dime hoate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15	70	7	-
	Fenitrothion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 2	70	7	-
	Malathion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	700	70	-
	Parathion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.004	200	20	-
Chlorinated Hydrocarbons	1,2-Dichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	209000	-	-	-	-
	1,2-Dichloropropane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	139	-	-	-	-
	1,1,1-Trichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	260000	-	-	-	-

		Soils															Soil Vapour	Groundwater			
	1,1,2-trichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	6500	0.1	0.01	-
	1,3-Butadiene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31	-	-	-	-
	cis-1,3-Dichloropropene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	234	-	-	-	-
	trans-1,3-Dichloropropene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	234	-	-	-	-
	Carbon tetrachloride	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	156	-	-	-	-
	Chloroform	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41	-	-	-	-
	Chloromethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3130	-	-	-	-
	Hexachloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	360	NC	NC	-
	Hexachlorobutadiene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43	-	-	-	-
	Tetrachloroethene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10000	10	500	50	-
	Vinyl Chloride	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3000	NC	3	0.3	-
Halogenated Benzenes	Chlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1740	-	-	-	-
	m-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	85	-	-	-	-
	o-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6950	-	-	-	-
	p-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	85	-	-	-	-
VOCs	1,4-Dioxane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	187	-	-	-	-
	Benzyl Chloride	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	-	-	-	-
	Chloroe hane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1740	-	-	-	-
	Cyclohexane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	209000	-	-	-	-
	cis-1,2-Dichloroethylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2000	-	-	-	-
	Dichlorobromomethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	-	-	-	-
	1,4-Dioxane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ethylene dibromide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
	Hexane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24300	-	-	-	-
	Heptane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13900	-	-	-	-
	Isopropanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6950	-	-	-	-
	Methyl isobutyl ketone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	104000	-	-	-	-
	p-Ethyltoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NL	-	-	-	-
	trans-1,2-Dichloroethylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2000	-	-	-	-
	Trichloroethylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-
Chlorofluorocarbons	CFC-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NL	-	-	-	-
	CFC-113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	174000	-	-	-	-
	CFC-114	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NL	-	-	-	-
	CFC-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3480	-	-	-	-
Solvents	2-Hexanone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1040	-	-	-	-
	4-Methyl-2-pentanone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Acetone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1070000	-	-	-	-
	Acetophenone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Acrylonitrile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Allyl Chloride	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35	-	-	-	-

		Soils															Soil Vapour	Groundwater			
	Carbon disulfide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24300	-	-	-	-
	Methyl ethyl ketone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Vinyl acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Organics	PBDE Flame Retardants	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	NC	NC	NC	-
	MTBE	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	3600	10000	NC	NC	-
Explosives	HMX	-	-	390	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	RDX	-	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1,3,5 – Trinitrobenzene	-	-	230	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1,3 – Dinitrobenzene	-	-	0.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tetryl	-	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2,4,6 – TNT	-	-	3.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4-Amino, 2,6-DNT	-	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2-Amino-4,6-DNT	-	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4-&2-AM-DNT	-	-	NC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2,4-Dinitrotoluene	-	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2,6-Dinitrotoluene	-	-	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2,4-& 2,6-DNT	-	-	NC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Nitrobenzene	-	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2-Nitrotoluene	-	-	0.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3-Nitrotoluene	-	-	0.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4-Nitrotoluene	-	-	0.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Nitroglycerine	-	-	0.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PETN	-	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Nitrocellulose	-	-	23000000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PFAS	PFOA	-	-	-	-	-	-	-	0.1	20	10	10	NC	-	-	-	-	19	5.6	0.56	-
	PFOS	-	-	-	-	-	-	-	NC	NC	NC	1	0.01	-	-	-	-	-	-	-	-
	PFOS + PFHxS	-	-	-	-	-	-	-	0.01	2	1	NC	NC	-	-	-	-	0.00023	0.7	0.07	-
Sulfate/Sulfite	Sulfate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NC	400	40	-
	Sulfite	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NC	-	NC	-
Nutrients	Nitrate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	700	500000	50000	-
	Ammonia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	900	10	1	-

8 Results

The Investigation results discussed in this section are based on the SAQP and methodology discussion in **Section 6.2**. Figures depicting an overview of the site and AECs are presented in **Figure 1, Figure 2 & Figure 3-1.** Figures depicting investigation locations for soil, stockpiles, groundwater, MIP, PSG, ASG and background soil and water sampling are presented in **Figure 3-2** to **3-7, Figures 4** to **6** and **Figure 8,** and CoPC key exceedances of the adopted assessment criteria are depicted in **Figures 9-1A** to **9-11**. All figures are included in **Appendix A.**

Laboratory analytical results are tabulated in **Appendix D** and laboratory reports have been included in **Appendix F.**

8.1 Field Observations

8.1.1 Site Overview

At the time of this investigation, the operational areas of the site were restricted to the southern portion which included four primary structures. Refer to the points below for a summary of the four primary structures and additional observations from the southern portion of the site.

- Hardstand in the southwestern corner of the site (within AEC01, 02 & 03) was used for storage of vehicles (cars, motor homes and boats) and shipping containers.
- Hardstand in the south eastern corner of the site (within AEC01, 02 & 03 and encompassing AEC08) included an open shed structure historically used for refuelling and fuel storage (AEC08) and storage of shipping containers.
- North of the south eastern hardstand is an operational single-story administrative building (AEC9).
- An open shed structure that was utilised as a vehicle storage yard (AEC07). A chemical storage area was located under the open shed structure and various storage containers were observed at the location (AEC 6).
- The boundary of the old grenade bursting range (AEC04) included an operational sealed road and portions of the open shed structure (AEC07) and the administrative buildings (AEC09).
- Sealed access roads provided connectivity between the four primary structures within the southern portion of the site.
- Numerous stockpiles were inspected (as per **Table 8-1**) and predominately contained refuse in the form of construction and demolition waste. Stockpiles that consisted of soil were analysed for potential contaminants (AEC13).

The central and north eastern portions of the site included areas of concrete hardstand and areas of vegetation towards the south west and north eastern portions. Site observations included the following:

- Seven concrete hardstands that were related to historic naval storage sheds. One hardstand in the north east of the site was defined as AEC11.
- The concrete hardstands were generally bordered by patches of grass and shrubs.

- A narrow area of open vegetation along the western border of the site traverses north-south that comprises grass, shrubs, and some areas of bare ground. ACM fragments were observed scattered across the surface of this area with higher concentrations nearer the western boundary.
- Various subsurface infrastructure including electrical, telecommunications, stormwater and sewage utilities were identified and understood to be decommissioned.

The north western portion of the site consisted largely of overgrown grasses, shrubs and trees. Site observations included the following:

- Access to the area was via a graded track orientated in an approximate east to west direction.
- A drainage channel orientated in an approximate west to east direction ran parallel to the most northern hardstand.
- Numerous stockpiles were inspected and predominately contained refuse in the form of construction and demolition waste. Stockpiles that consisted of soil were analysed for potential contaminants (AEC13)
- Buildings related to an electrical substation were located near the northern boundary of the site (AEC15)
- Intrusive works indicated a perched groundwater table at approximately 1.5 mbgl overlying the sandstone (GW13a).
- Water inflow was observed during test pit excavation at depths ranging from 0.5 (TP198) to 0.8 mbgl (TP235).
- Surface expression of liquid that appeared to be water was observed on a sandstone outcrop located on the northern edge of the drainage channel and approximately 6 meters to the south west of the TP185.
- Subsurface infrastructure such as electrical conduit was identified and understood to be decommissioned.

Photographs taken during the investigation have been presented in **Appendix C**.

8.1.2 Soils

Soils encountered within the southern portion of the site (i.e. AEC 1, 2, 3, 4, 7, 8, 9, 13) can be generally described as:

- Soils beneath the hardstand (0.2 mbgl) in the south western corner of site were generally characterised by dark brown silty sand topsoil to 0.3 mbgl, underlain by grey sand transitioning to a pale grey sand at approximately 0.5 mbgl.
- Soils along the road verge south of Galu Avenue were generally characterised by mulch and dark brown sandy silt topsoil underlain by a geofabric layer at 0.3 mbgl. The geofabric layer was underlain by dark grey sand transitioning to pale grey sand at approximately 0.7 mbgl. Fill was observed above and below the geofabric layer to a depth of approximately 0.5 mbgl.
- Soils within vegetated areas of the site that border the southern boundary of the site and on the verges of hardstand were generally characterised by approximately 0.1 m of dark brown silty sand, underlain by grey sands that transitioned to pale grey sands at 0.5 mbgl. Fill was observed from surface to approximately 0.3 mbgl at some locations.

- Anthropogenic material such as bitumen, concrete rubble, ceramic chips, glass shards and/or bonded asbestos fragments were observed within some layers of the fill and reworked natural within the southern portion of the site.

Soils encountered within the central portion of the site (i.e. AEC 1, 2 & 3) can be generally described as:

- Soils beneath the hardstand pads (0.1 mbgl) were generally characterised by coarse-grained brown or grey sand to 0.2 mbgl, underlain by grey sand that transitioned to a pale grey sand at 0.5 mbgl.
- Soils along the verges of the hardstand pads were generally characterised by dark brown silty sand to 0.2 mbgl, underlain by grey sands that transitioned to pale grey sands at 0.5 mbgl. At some locations the soils profile comprised sandy clays to 0.3mbgl underlain by a geofabric layer, below which were medium grain brown to pale grey sand at approximately 0.5mbgl. Fill was encountered from surface to approximately 0.5 mbgl at some locations.
- Soil within the vegetated area near the western site boundary were generally characterised by medium grain brown or grey sands to 0.2 mbgl, underlain by light grey medium grain sand and orange/brown sand. Fill was encountered from surface to approximately 0.5 mbgl at some locations.
- Anthropogenic material such as glass, plastic, tile chips, metal fragments were observed within some layers of the fill and reworked natural

Soils encountered within the northern portion of the site (i.e. AEC 1, 2 & 3, 11, 13, 15) can generally described as:

- Soils beneath the hardstand pads (generally 0.1m thick) were characterised by approximately 0.2m of fine to coarse-grained brown or grey sand that transitioned to a sand that was predominantly pale grey. Fill was encountered from surface to approximately 0.5 mbgl at some locations.
- Soils along the edges of the hardstand pads were characterised by approximately 0.2m of dark brown sandy clay to topsoil, underlain by grey sands that transitioned to white sands at approximately 0.5mbgl. Where geofabric was observed, soils were characterised by approximately 0.1m of silty clay topsoil. The topsoil was underlain by brown sand above the geofabric to an approximate depth of 0.3 mbgl, before transitioning to medium grain sands predominantly coloured pale grey. Fill was observed above and below the geofabric to a depth of approximately 0.5 mbgl at some locations.
- Soils within the vegetated area in the north western corner of the site were characterised by approximately 0.3m of dark brown sandy clay and silty clay topsoil, underlain by grey sands that transitioned to pale grey sands at approximately 0.5 mbgl. A geofabric layer was observed at some locations at an approximate depth 0.3mbgl, underlying silty clay topsoil. The soil profile transitioned to medium grain sands predominantly coloured pale grey beneath the geofabric layer. Fill was observed above and below the geofabric layer to a depth of approximately 0.6 mbgl at some locations. Mechanical refusal on sandstone occurred at some locations.
- Anthropogenic material such as concrete rubble, ceramic chips, brick fragments, glass shards, grey slag. scrap metal and fragments of bonded asbestos containing material (ACM) were observed within some layers of fill and reworked natural.

The lithology encountered was recorded on field logs which have been presented in **Appendix B**.

8.1.3 Soil Aesthetics

The following soil aesthetic observations were made during the investigation:

- Minor staining presumed to be associated with vehicle parking and minor spills on the hardstand surface of the former heavy vehicle transport yard (AEC8) compound.
- Stockpiles of construction and demolition waste at various locations across the site as described in **Table 8-1**.

8.1.4 Stockpile Material Descriptions

The material descriptions for stockpiled materials identified across the site are presented in **Table 8-1** below. The origins of the stockpiled materials is not presently known. Stockpiles subject to sampling and analysis as part of this DSI have been highlighted in bold text.

Table 8-1 Stockpile Material Descriptions

Stockpile ID	Material Description	Volume (m^3)
SP001	Mulch material.	NA
SP002	Construction and demolition waste comprised of mesh wiring and metal pipes.	NA
SP003	Natural vegetated mound on terrain.	NA
SP004	Construction and demolition waste comprised of felled light pole, corroded piping (possibly old fire hydrant/water outlet).	NA
SP005	Construction and demolition waste comprised of felled light pole, metal pipes, concrete slabs.	NA
SP006	Construction and demolition waste.	NA
SP007	FILL: Loamy sand, loose, fine to medium grained, dark brown, slightly moist, heavily vegetated.	55
SP008	FILL: Loamy sand, loose, fine grained, dark brown, slightly moist, with anthropogenic materials including bricks, plastic, steel, concrete, timber, heavily vegetated.	65
SP009	FILL: Gravelly sand with silt, loose, coarse grained, brown, moist, with anthropogenic materials including bricks, plastic, cement, heavily vegetated.	5
SP010	Mulch material.	NA
SP011	Construction and demolition waste comprised of mesh wiring, large corroded metal container.	NA

Stockpile ID	Material Description	Volume (m^3)
SP012	Construction and demolition waste comprised of a shallow layer of cement spread on surface soils.	NA
SP013	FILL: Loamy sand, loose, fine grained, dark brown, moist	1
SP014	FILL: Silty sand, loose, fine grained, dark brown, slightly moist, with anthropogenic materials including bricks, plastic, cement, heavily vegetated with some mulch present.	45
SP015	Construction and demolition waste comprised of concrete slabs and bricks.	NA
SP016	Construction and demolition waste comprised of a concrete slab.	NA
SP017	Construction and demolition waste comprised of bricks.	NA
SP018	FILL: Silty sand, loose, medium grained, brown, slightly moist, with anthropogenic materials including steel, plastic, cement, paper, mesh, general refuse, and some mulch.	2
SP019	Construction and demolition waste comprised of metal pipes, roofing, household waste (furniture).	NA
SP020	Construction and demolition waste comprised of timber and logs.	NA
SP021	Construction and demolition waste comprised of household waste (furniture, metal containers, sheds, grill).	NA
SP022	Construction and demolition waste comprised of household waste (furniture).	NA
SP023	Mulch material.	NA

8.1.5 Groundwater Levels

Regional groundwater flow direction within the Botany Basin generally conforms to topography and is towards the south towards Botany Bay.

Groundwater levels recorded in the aquifer at the site were used to interpolate groundwater contours. These contours are shown for Groundwater Monitoring Event 1 in July 2020 and Groundwater Monitoring Event 2 in October 2020 in **Figure 7-1** and **Figure 7-2** in **Appendix A**. Both contour plots indicate that groundwater flow in the northern part of the site is generally south-easterly and in the southern part of the site is generally south-westerly towards Botany Bay, with a local hydraulic gradient in the order of 8 m/km (1:125) flattening out to the south of the site. The local hydraulic gradient is thought to be likely higher than the regional hydraulic gradient due to being close to the edge of the Botany Basin.

8.1.6 Aquifer Testing

Following the installation of the 24 monitoring bores, as outlined in **Section 6.2**, five (5) of the groundwater monitoring bores (as listed in **Table 8-2** below and in accordance with the Jacobs SAQP [2020b]) were selected to undertake slug test analysis on to get estimates of aquifer hydraulic conductivity at those bores.

Slug test analysis was undertaken using Aqtesolv aquifer test analysis software, using the Bower-Rice solution method for an unconfined aquifer. A summary of the slug test analysis results is presented in **Table 8-2**.

Analysis of data from bores constructed within the Botany Sands was undertaken focussing on the early-time data, due to the rapid recovery from the slug insertion and subsequent bounce in water level data in these bores. For bore GW15, which was constructed in the Hawkesbury Sandstone, analysis was undertaken focussing on both early-time and late-time recovery data. Individual slug test analysis reports are presented as **Appendix H.**

Table 8-2 Slug Test Analysis Results

Bore	Test	K (m/day)	Lithology
GW08	GW08_FH1	9	Sand
GW08	GW08_RH1	11	Sand
GW10	GW10_FH1	8	Sand
GW10	GW10_FH2	17	Sand
GW11	GW11_FH1	29	Sand
GW11	GW11_RH1	21	Sand
GW13	GW13_FH1	15	Sand
GW13	GW13_RH1	19	Sand
GW15	GW15_FH1	0.005	Sandstone

8.2 Field Screening Results

8.2.1 PID Results

Field PID screening did not indicate the presence of gross hydrocarbon concentrations, with PID readings considered to be low, typically ranging between 0.0 ppm to 2.0ppm. The maximum PID reading was recorded at TP048 (13.4 ppm at a depth of 1.0 mbgl).

8.2.2 Asbestos Containing Material

Fragments of Asbestos Containing Materials (ACMs) were observed on the surface at various locations within the central and northern portion of the site, in non-operational areas (i.e. north of Galu Avenue and AEC07) including:

- In the north western portion of the non-operational areas, single ACM fragments were observed near TP201, TP199 and TP195.
- In the central portion near the western boundary, multiple ACM fragments were observed on the surface near TP94, TP95, TP104 and TP105. The number of ACM fragments increased towards the western boundary fence, especially in the area near TP232, TP266, TP267 and TP261.

8.2.3 MIP

Prior to soil sampling in the following AECs, MIP was used to screen soils at the locations shown on **Figure 4** in **Appendix A.**

The Membrane Interface Probe (or MIP) is a direct push logging technology that is used to locate volatile organic compounds in unconsolidated formations. The MIP is useful for mapping gasoline range petroleum hydrocarbons, halogenated solvents, and natural gas compounds such as methane, and provides real-time high resolution site characterisation.

Volatile contaminants encountered as the probe is driven in, diffuse through a membrane near the tip of the probe. An inert carrier gas continuously sweeps the area behind the membrane and transports the volatile compounds through the trunkline to surface gas phase detectors. Volatile organic compounds are carried by the inert carrier gas to a gas chromatograph which houses three gas phase detectors – the photoionization detector (PID), the flame ionization detector (FID), and the halogen specific detector (XSD). By using all three of these detectors together, the operator can determine a specific compound class compound class of the analytes as well as relative concentrations within the plume.

The MIP probe can also combine the MIP system with two additional sensors - electrical conductivity (or EC) and the Hydraulic Profiling Tool (or HPT), which are described as follows, however, were not a component of this investigation:

- The electrical conductivity dipole sensor is used for mapping soil and pore fluid electrical conductance. This gives us an understanding of subsurface lithology.
- The hydraulic profiling tool uses a down-hole pressure sensor to monitor the pressure required to inject a set flow of water out of the HPT screen. The resulting pressure log is directly related to subsurface permeability. Calculations can be performed on this data to determine static water level, estimates of hydraulic conductivity (K) as well as groundwater specific conductance where the formation allows.

The MIP system performs rapid field screening to determine the presence of VOC contaminants within the subsurface of a site, however, does not provide quantitative data. Accuracy is assessed qualitatively by measuring the agreement between detect and non-detect determinations made by the MIP, followed by laboratory analysis of soil samples. Interpretation of MIP data produced by total detectors is best done by comparing relative responses rather than absolute values.

The MIP screening outputs are presented in **Appendix I**. Results from the MIP screening are summarised below:

- AEC05 – 12 MIP locations were advanced to refusal with termination depths ranging from approximately 1 to 3 mbgl. All locations showed low signal responses with PID responses less than 0.5×10^6 µV, FID responses less than 2×10^5 µV and XSD responses less than 1×10^5 µV.
- AEC08 – 16 MIP locations were advanced to refusal with termination depths ranging from approximately 3 to 6 mbgl. All locations showed low signal responses with PID responses less than 0.5×10^6 µV, FID responses less than 2×10^5 µV and XSD responses less than 1×10^5 µV.
- AEC09 – 11 MIP locations were advanced to refusal with termination depths ranging from approximately 3 to 6 mbgl. All locations showed low signal responses with PID responses less than 0.5×10^6 µV, FID responses less than 2×10^5 µV and XSD responses less than 1×10^5 µV.
- AEC12 – 17 MIP locations were advanced to refusal with termination depths ranging from approximately 3 to 5 mbgl. All locations showed low signal responses with PID responses less than 0.5×10^6 µV, FID responses less than 2×10^5 µV and XSD responses less than 1×10^5 µV. It is noted that MIP037 showed corresponding PID & FID responses, peaking at approximately 0.5 mbgl with values of 0.48×10^6 and 0.9×10^5 µV.
- In two areas of suspected USTs 9 MIP locations were advanced to refusal with termination depths ranging from approximately 3 to 6 mbgl. All locations showed low signal responses with PID responses less than 0.5×10^6 µV, FID responses less than 2×10^5 µV and XSD responses less than 1×10^5 µV.

8.3 Soil Results

Sections 8.3.1 to 8.3.9 provide a summary of the laboratory results for soil samples analysed during the investigation. The soil sampling locations are presented in **Figure 3-2 to Figure 3-3** and **Figure 3-5 to Figure 3-7**. Tabulated soil analytical results including adopted assessment criteria for the investigation are presented as **Table D1 to D16** in **Appendix D** and reports have been included in **Appendix F.**

The analytical results indicate that concentrations of COPCs in soils at the majority of sampling locations are less than the adopted site assessment criteria. Exceedances of the adopted site assessment criteria for CoPCs in soils are shown on **Figures 9-1A** to **9-4B** in **Appendix A**, as discussed below:

- Asbestos (fragments of ACM, fibrous asbestos and asbestos fines) was observed to be widespread across the site.
- TRH - C_6-C_{10} minus BTEX (F1), C_{10}-C_{16} minus naphthalene (F2) and TRH C_{16}-C_{34} (F3).
- BTEXN – Naphthalene.
- Metals - Cadmium, chromium, copper, lead, mercury, nickel & zinc.

- PAHs – Benzo(a)pyrene and PAHs (sum of total).
- PCB (sum of total).

8.3.1 Asbestos

Occurrences of asbestos fibres (fibrous asbestos and asbestos fines) and ACMs were observed to be widespread across the site. Asbestos was primarily detected in testpits advanced across vegetated areas along the northern portion of the site, beneath vegetated strips lining the verges of the concrete slabs across the site, in fill areas towards the south west boundary of the site, and to a lesser extent on the south eastern portion of the site (as illustrated in **Figure 9-4A** and **9-4B, Appendix A**).

Grid-based soil sampling undertaken beneath concrete hardstand areas did not detect asbestos.

8.3.1.1 Shallow fill

- Asbestos fibres (fibrous asbestos and asbestos fines) were detected in shallow fill (≤ 0.2mbgl) at 52 locations across the site.
- ACM fragments were detected in shallow fill (≤ 0.2mbgl) at 25 locations across the site.

8.3.1.2 Deep fill

- Asbestos fibres (fibrous asbestos and asbestos fines) were detected in deeper fill (> 0.2mbgl) at 15 locations across the site.
- ACM fragments were detected in deeper fill (> 0.2mbgl) at 30 locations across the site.
- The deepest occurrences of ACMs were observed towards the south western boundary of the site, with ACMs detected at TP261 at depths ranging between 1.3-2.2mbgl. Asbestos fibres were detected at depths reaching 1.5mbgl beneath vegetated areas at TP231 and TP261 on the south western portion of the site, as well as TP196 on the north western portions of the site.

8.3.2 TRH

All reported TRH concentrations in soils were either below the adopted site assessment criteria or the LOR, with the exception of the following:

- C_{10}-C_{16} minus naphthalene (F2) concentrations exceeded the adopted assessment criteria for Residential Soils (A) of 110 mg/kg and the adopted ESL assessment criteria of 120 mg/kg at three locations within AEC1 (TP013, TP213 and TP237) with concentrations ranging from 130 to 540 mg/kg.
- TRH C_{16}-C_{34} (F3) concentrations exceeded the adopted ESL assessment criteria of 300 mg/kg at ten locations (TP60/AEC7, TP162/AEC11, TP197/AEC1, TP200/AEC1, TP206/AEC1, TP211/AEC1, TP213/AEC1, TP221/AEC1, TP235/AEC1 and TP237/AEC1) with results ranging from 330 to 4,000 mg/kg.
  - F3 concentrations exceeded the adopted Management Limit guideline of 2,500 mg/kg at two locations (TP197/AEC1 and TP213/AEC1) with concentrations of 2,800 and 4,000 mg/kg.

8.3.3 BTEXN

All reported BTEXN concentrations in soils were either below the adopted site assessment criteria or the LOR with the exception of the following:

- Naphthalene concentrations exceeded the adopted HSL guideline of 3 mg/kg at three locations (TP197/AEC1, TP213/AEC1 and TP235/AEC1) with concentrations ranging from 4.5 to 8.9 mg/kg.

8.3.4 Metals

All reported metals concentrations in soils were either below the adopted site assessment criteria or the LOR with the exception of the following:

- Cadmium concentrations exceeded the adopted EIL assessment criteria of 3 mg/kg at one location (TP69/AEC1) with a concentration of 4.7 mg/kg.
- Chromium concentrations exceeded the adopted HIL assessment criteria for Residential Soils (A) of 100 mg/kg at one location (TP73/AEC1) with a concentration of 260 mg/kg.
- Copper concentrations exceeded the adopted EIL assessment criteria of 120 mg/kg at eight locations within AEC1 (TP48, TP111, TP111_BH01, TP213, TP214, TP219, TP220 and TP241), and exceeded the adopted HIL assessment criteria for Residential Soils (A) of 6000 mg/kg at one location (TP111/AEC1), with concentrations ranging from 130 to 6,900 mg/kg.
- Lead concentrations exceeded the adopted EIL assessment criteria of 1100 mg/kg at one location (TP241/AEC1), and exceeded the adopted HIL assessment criteria for Residential Soils (A) of 300 mg/kg at five locations within AEC1 (TP237, TP241, TP241_BH03, TP259 and TP269) with concentrations ranging from 340 to 1,100 mg/kg.
- Mercury concentrations exceeded the adopted EIL assessment criteria of 1 mg/kg at two locations (BH33/AEC15 and TP165/AEC1) with concentrations of 1.7 and 10 mg/kg.
- Nickel concentrations exceeded the adopted EIL assessment criteria of 45 mg/kg at one location (BH33/AEC15) with concentrations of 97 mg/kg.
- Zinc concentrations exceeded the adopted EIL assessment criteria of 320 mg/kg at 28 locations within AEC1 (TP68, TP70, TP111, TP140, TP141, TP151, TP180, TP193, TP194, TP201, TP205, TP207, TP214, TP217, TP219, TP220, TP222, TP229, TP237, TP241, TP242, TP244, TP246, TP247, TP248, TP249, TP260, and TP269), two locations within AEC5 (SEP001_BH02 and SYDSEW03) and three locations within AEC14 (STWR001_BH01, STWR001_BH02, STWR002) with concentrations ranging from 320 to 3,500 mg/kg.
- As shown below in **Table 8-3 below**:
  - Concentrations of Cadmium, Chromium $^{III+VI}$, Copper, Lead, Mercury, Nickel or Zinc either singularly or in some combination exceeded the EILs for public open space in 51 samples, and
  - The concentrations of Chromium $^{III+VI}$, Copper, and Lead, either singularly or in some combination exceeded the HIL A in 8 samples. It should be noted one sample (0407_TP73_0.1_200619) is reported as exceeding the HIL A for hexavalent Chromium, however the analytical result is for total chromium. While hexavalent chromium is not expected to be present on site, speciation of the sample would be required to confirm the absence of CR^{VI}.

Table 8-3 Summary of Metal Exceedances in Soil (mg/kg)

		Cadmium	Chromium (III+VI)	Copper	Lead	Mercury	Nickel	Zinc
HIL A (mg/kg)		**20**	**100**	**6000**	**300**	**40**	**400**	**7400**
EILs Urban residential (mg/kg)		**3**	**300**	**120**	**1100**	**1**	**45**	**320**
0407_TP48_0.1_200618	AEC1, AEC3	<0.3	2.3	610	2	<0.05	1.6	3
0407_TP68_0.1_200617	AEC1, AEC3	0.60	23	66	160	0.12	13	340
0407_TP69_0.1_200617	AEC1, AEC3	5	51	69	210	0.12	10	250
0407_TP70_0.1_200617	AEC1, AEC3	0.40	17	70	160	0.14	10	320
0407_TP73_0.1_200619	AEC1, AEC3	0.70	**260**	26	97	<0.05	2.3	130
0407_TP111_0.1_200626	AEC1, AEC3	0.70	19	**6900**	150	0.15	13	450
0407_TP111_BH01_0.0-0.1_20201015	AEC1, AEC3	-	-	130	-	-	-	-
0407_TP140_0.1_200624	AEC1, AEC3	0.50	25	90	120	0.11	14	480
0407_TP141_0.1_200629	AEC1, AEC3	0.40	21	44	120	0.08	13	320
0407_TP151_0.1_200629	AEC1, AEC3	0.50	19	59	110	0.13	12	370
0407_TP165_0.1_200626	AEC1, AEC3	<0.3	12	71	87	10	7.5	250
0407_TP180_0.1_200625	AEC1, AEC3	0.40	25	50	110	0.23	15	330
0407_TP193_0.1_200625	AEC1, AEC3	0.70	26	78	100	0.13	12	380
0407_TP194_0.1_200625	AEC1, AEC3	0.40	20	65	120	0.18	13	380
0407_TP201_0.1_200618	AEC1, AEC3	0.40	19	71	130	0.1	13	360
0407_TP205_0.1_200618	AEC1, AEC3	<0.3	21	59	97	0.08	12	330

		Cadmium	Chromium (III+VI)	Copper	Lead	Mercury	Nickel	Zinc
HIL A (mg/kg)		**20**	**100**	**6000**	**300**	**40**	**400**	**7400**
EILs Urban residential (mg/kg)		**3**	**300**	**120**	**1100**	**1**	**45**	**320**
0407_TP207_0.1_200618	AEC1, AEC3	0.40	19	87	98	0.2	13	640
0407_TP213_0.1_200623	AEC1, AEC3	0.40	6.4	150	250	0.18	14	240
0407_TP213_0.5_200623	AEC1, AEC3	0.40	6.3	190	170	0.17	17	290
0407_TP214_0.1_200623	AEC1, AEC3	0.40	19	58	110	0.1	13	360
0407_TP214_0.5_200623	AEC1, AEC3	<0.3	1.1	730	43	<0.05	1	27
0407_TP217_0.1_200623	AEC1, AEC3	0.40	27	48	110	0.12	10	340
0407_TP219_0.1_200623	AEC1, AEC3	0.60	26	140	250	0.17	17	600
0407_TP220_0.1_200618	AEC1, AEC3	0.40	18	160	99	0.08	25	320
0407_TP222_0.1_200619	AEC1, AEC3	0.70	8.9	72	180	0.15	9.4	910
0407_TP229_0.1_200622	AEC1, AEC3	0.40	23	50	130	0.1	15	510
0407_TP237_0.5_200624	AEC1, AEC3	0.50	23	67	**550**	0.46	8	400
0407_TP237a_0.4_200624	AEC1, AEC3	<0.3	15	53	89	0.1	9.9	380
0407_TP237b_0.5_200624	AEC1, AEC3	0.60	6.4	24	**530**	<0.05	2.3	3100
0407_TP238_0.1_200625	AEC1, AEC3	0.50	18	61	140	0.1	11	380
0407_TP241_0.1_200625	AEC1, AEC3	0.40	21	72	130	0.13	13	340
0407_TP241_0.5_200625	AEC1, AEC3	1.60	34	260	1100	0.1	16	3500
0407_TP241_BH03_0.0-0.1_20201015	AEC1, AEC3	-	-	-	**730**	-	-	-
0407_TP242_0.1_200625	AEC1, AEC3	0.60	21	74	190	0.08	15	500

		Cadmium	Chromium (III+VI)	Copper	Lead	Mercury	Nickel	Zinc
HIL A (mg/kg)		**20**	**100**	**6000**	**300**	**40**	**400**	**7400**
EILs Urban residential (mg/kg)		**3**	**300**	**120**	**1100**	**1**	**45**	**320**
0407_TP244_0.1_200625	AEC1, AEC3	0.30	46	67	130	0.11	14	**340**
0407_TP246_0.1_200626	AEC1, AEC3	0.70	19	71	180	0.12	13	**400**
0407_TP247_0.1_200626	AEC1, AEC3	0.80	21	92	140	0.07	12	**520**
0407_TP248_0.1_200626	AEC1, AEC3	0.30	24	58	93	0.08	9.7	**330**
0407_TP249_0.1_200626	AEC1, AEC3	0.50	20	110	160	0.09	13	**470**
0407_TP259_0.3_200630	AEC1, AEC3	0.50	45	34	**570**	0.15	35	240
0407_TP260_0.1_200630	AEC1, AEC3	0.80	27	37	260	0.13	7.2	**430**
0407_TP269_0.1_200701	AEC1, AEC3	1.00	10	94	**340**	0.08	6.1	**1400**
0407_PSG_BH07_0.5-0.6	AEC12	<0.3	7.1	43	4	<0.05	**57**	33
0407_PSG_BH09_0.2-0.3	AEC12	<0.3	5.8	33	5	<0.05	**50**	35
0407_LP_BAC_0.8-0.9	Background (off-site)	<0.3	6.4	19	72	0.08	**68**	90
0407_SEP001_BH02_0.2-0.3_201015	AEC5	0.40	29	110	99	0.11	12	**440**
0407_SYDSEW03_0.1-0.2_201016	AEC5	<0.3	17	65	110	0.07	12	**490**
0407_SYDSEW06_0.2-0.3_201016	AEC5	<0.3	1.9	48	**350**	0.09	2.5	110
0407_STWR001_BH01_0.2-0.3_201015	AEC14	0.40	24	79	140	0.08	11	**340**
0407_STWR001_BH02_0.2-0.3_201015	AEC14	0.60	26	79	130	0.11	13	**420**
0407_STWR002_0.2-0.3_201015	AEC14	0.40	22	82	110	0.11	13	**350**
0407_BH33_0.1_200626	AEC1, AEC3	<0.3	7.7	55	6	0.08	**97**	49

		Cadmium	Chromium (III+VI)	Copper	Lead	Mercury	Nickel	Zinc
HIL A (mg/kg)		**20**	**100**	**6000**	**300**	**40**	**400**	**7400**
EILs Urban residential (mg/kg)		**3**	**300**	**120**	**1100**	**1**	**45**	**320**
0407_BH33_0.7_200626	AEC1, AEC3	0.3	15	71	210	1.7	4.4	220

8.3.5 PAHs

All reported PAH concentrations in soils were either below the adopted site assessment criteria or the LOR apart from the following:

- PAH (sum of positive) concentrations exceeded the adopted assessment criteria for Residential Soils (A) of 300 mg/kg at four locations (TP162, TP197, TP213, and TP235/) with concentrations ranging from 490 to 1,600 mg/kg. All PAH (sum of positive) concentrations at these four locations included detections of the following known carcinogenic PAHs: benzo[a]pyrene, benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenzo[a,h]anthracene and indeno[1,2,3-cd]pyrene (B[a]P TEQ).
- The Benzo(a)pyrene toxicity equivalent quotient (B[a]P TEQ) was calculated for 570 primary samples analysed for PAHs, with 20 samples exceeding the B(a)P TEQ HIL A criterion of 3 mg/kg. Given the spread of B(a)P TEQ exceedances in the north and north-western portion of the site, where additional sampling and analysis was undertaken for B(a)P only and the B(a)P result is close to the HIL A B(a)P TEQ criterion of 3mg/kg, these samples have also been assumed to exceed the B(a)P TEQ HIL A criterion.
- Benzo(a)pyrene concentrations exceeded the adopted ESL assessment criteria of 21 mg/kg at eight locations.

While the EPA has not endorsed the benzo(a)pyrene EIL values provided in the CRC CARE 2017, Risk-based management and remediation guidance for benzo(a)pyrene, CRC CARE Technical Report no. 39, if justifiable the NSW EPA accept the use of alternative values to those in the NEPM.

The NEPM B(a)P criterion is considered a low reliability value and following a review of the scientific literature, CRC developed an alternative high reliability EIL. Accordingly, SLR have adopted the conservative high reliability value provided by CRC of 21 mg/kg.

Table 8-4 Summary of PAH (Total), B(a)P and B(a)P TEQ Exceedances in Soil

		PAH (Total)	Benzo(a) pyrene	Benzo(a) pyrene TEQ
HIL A (mg/kg)		**300**		**3**
EILs Urban residential (mg/kg)			**21**	
0407_TP235_0.1_200624	AEC1, AEC3	**490**	**37**	**52**
0407_TP186_0.1_200629	AEC1, AEC3	30	2.9	**4.1**
0407_TP186_0.3_200629	AEC1, AEC3	21	2.3	**3.2**
0407_TP197_0.1_200619	AEC1, AEC3	**1500**	**120**	**170**
0407_TP197_0.5_200619	AEC1, AEC3	79	8.1	**11**
0407_TP200_0.5_200618	AEC1, AEC3	130	10	**14**
0407_TP209_0.5_200619	AEC1, AEC3	73	6.9	**9.5**
0407_TP209_BH02_0.0-0.1_20201016	AEC1, AEC3	-	**27**	**27**

		PAH (Total)	Benzo(a) pyrene	Benzo(a) pyrene TEQ
HIL A (mg/kg)		**300**		**3**
EILs Urban residential (mg/kg)			**21**	
0407_TP210_0.1_200624	AEC1, AEC3	47	5.6	**7.6**
0407_TP211_0.1_200623	AEC1, AEC3	34	4.3	**5.8**
0407_TP211_0.5_200623	AEC1, AEC3	34	3.9	**5.3**
0407_TP213_0.1_200623	AEC1, AEC3	**680**	**53**	**73**
0407_TP213_0.5_200623	AEC1, AEC3	**1600**	**130**	**190**
0407_TP213_BH03_0.0-0.1_20201019	AEC1, AEC3	-	**40**	**40**
0407_TP221_0.5_200619	AEC1, AEC3	75	10	**15**
0407_TP222_BH01_0.5-0.6_201019	AEC1, AEC3	-	**61**	**61**
0407_TP222_BH04_0.5-0.6_201019	AEC1, AEC3	-	**25**	**25**
0407_TP231_0.1_200622	AEC1, AEC3	26	2.5	**3.4**
0407_TP162_0.1_200617	AEC1, AEC3	**560**	**25**	**37**
0407_TP162_BH01_0.4-0.5_20201015	AEC1, AEC3	62	4.9	**7**

8.3.6 PCBs

All reported PCB concentrations in soils were either below the adopted site assessment criteria or the LOR with the exception of the following:

- PCB (sum of total) concentrations exceeded the adopted assessment criteria for Residential Soils (A) of 1 mg/kg at one location (TP222/AEC1) with a concentration of 3 mg/kg.

8.3.7 Per- and polyfluoroalkyl Substances (PFAS)

All reported PFAS concentrations in soils were either below the adopted site assessment criteria or the LOR.

8.3.8 Other COPCs

All remaining analysis suites (including pesticides, explosives and VOCs) were reported at concentrations less than the adopted site assessment criteria and generally below the LOR.

8.3.9 Physico-chemical parameters

8.3.9.1 TOC

- Topsoil exhibited Total Organic Carbon (TOC) concentrations from 1,200 to 420,000 mg/kg with a median of 20,500 mg/kg.
- Subsoil TOC ranged from <500 to 6,300 mg/kg with a median of 3,700mg/kg.

8.3.9.2 CEC

- Topsoil exhibited a Cation Exchange Capacity (CEC) between 0.0 and 120meq/100g and a median of 19.5meq/100g.
- Subsoil CEC ranged from 0.0 to 15.0 meq/100g with a median of 0.3 meq/100g.

8.3.9.3 Organic Matter

- Topsoil exhibited Organic Matter (OM) ranged from 0.2 to 72% with a median of 3.6 %.
- Subsoil OM ranged from <0.1% to 1.1% with a median of 0.7%.

8.3.9.4 pH

- Topsoil pH ranged from 5.6 to 11.5 with a median of 7.1.
- Subsoil pH ranged from 5.5 to 8.8 with a median of 6.5.

8.3.9.5 Exchangeable Sodium Percent

- Topsoil Exchangeable Sodium Percent (ESP) ranged from 0.3 to 4.7 % with a median of 1.4.
- Subsoil ESP ranged from 0.7 to 42.9% with a median of 4.8.

8.3.9.6 Microbial

- Faecal indicator bacteria were not detected in any of the analysed soil samples, with the exception of *Salmonella spp*. in sample SYDSEW08_1.7-1.8.

8.4 Groundwater

Sections 8.4.1 to 8.4.6 provide a summary of the laboratory results for groundwater samples analysed over two (2) groundwater monitoring events (GMEs) undertaken as part of this investigation. The groundwater sampling locations are presented in **Figure 7-1** in **Appendix A**. Groundwater analytical summary tables comparing laboratory results to adopted guidelines for the investigation are presented as **Table D21** in **Appendix D**.

The concentrations of COPCs in groundwater were generally less than the adopted site assessment criteria for all CoPCs with the exception of exceedances for following CoPCs as shown on **Figures 9-5** to **9-8** in **Appendix A**:

- Metals – Arsenic, chromium, copper, lead nickel & zinc.
- Pesticides – Chlorpyrifos.
- PFAS - Sum of PFHxS & PFOS.

8.4.1 Metals

All reported metals concentrations were either below the adopted assessment criteria or the LOR except for the following:

- Arsenic concentrations exceeded the adopted Human Health (drinking water) assessment criteria of 10 µg/L at one (1) location with a concentration of 13 µg/L.

- Chromium concentrations exceeded the adopted Ecological (freshwater) assessment criteria of 1 µg/L at four (4) locations with concentrations ranging from 2 to 6 µg/L.
- Copper concentrations exceeded the adopted Ecological (freshwater) assessment criteria of 1.4 mg/kg at 21 locations with concentrations ranging from 2 to 120 µg/L.
- Lead concentrations exceeded the adopted Ecological (freshwater) assessment criteria of 3.4 mg/kg at seven (7) locations with concentrations ranging from 4 to 9 µg/L.
- Nickel concentrations exceeded the adopted Ecological (freshwater) assessment criteria of 11 µg/L at two (2) locations with a concentration ranging from 11 to 17 µg/L.
- Zinc concentrations exceeded the adopted Ecological (freshwater) assessment criteria of 5 mg/kg at 22 locations with concentrations ranging from 12 to 130 µg/L.
- Mercury results for all samples were below the LOR (0.1 µg/L), which is greater than the adopted assessment criteria for Ecosystem Protection Levels (Freshwater) of 0.06 µg/L, as such exceedances of this criteria are not able to be determined. Noting that as mercury concentrations were generally less than the LOR in soils, mercury is unlikely to be a source of contamination in groundwater.

8.4.2 OCP/OPP

All reported OCP/OPP concentrations were either below the adopted site assessment criteria or the LOR with the exception of the following:

- Chlorpyrifos concentrations exceeded the adopted Ecological (freshwater) assessment criteria of 0.01 µg/L at one location with a concentration of 1.2 µg/L.
- The LORs for pesticides with assessment criteria are generally greater than the adopted assessment criteria for Ecological (Freshwater), as such exceedances of these criteria are not able to be determined. Noting that as pesticide concentrations were generally less than the LOR in soils, pesticides are unlikely to be a source of contamination in groundwater.

8.4.3 PFAS

All reported PFAS concentrations were either below the adopted site assessment criteria or the LOR with the exception of the following:

- Sum of PFHxS & PFOS exceeded the adopted Ecological (freshwater) assessment criteria of 0.00023 µg/L in all 24 samples analysed for PFAS with concentrations ranging from 0.0027 to 0.75 µg/L.
- Sum of PFHxS & PFOS exceeded the adopted assessment criteria for Human Health (drinking water) of 0.07 µg/L in 10 samples with concentrations ranging from 0.11 and 0.75 µg/L.

8.4.4 Chlorinated Hydrocarbons

All reported chlorinated hydrocarbon concentrations were below the LOR (and where published adopted site assessment criteria) with the exception of the following:

- Bromodichloromethane was detected at two locations (GW15 and GW18) with concentrations of 0.8 and 1.8 µg/L.

- Chloroform was detected at four locations (GW13a, GW13b, GW15 and GW18) with concentrations ranging from 0.7 to 6 µg/L with a median of 3.6 µg/L.
- cis-1,2-dichloroethene was detected at two locations (GW14 and GW15) with concentrations of ranging between 3.4 and 6.9 µg/L.
- Tetrachloroethene was detected at two locations (GW14 and GW15) with concentrations of 1.8 and 2.1 µg/L.
- Trichloroethene was detected at three locations (GW10, GW14 and GW15) with concentrations ranging from 0.6 to 2.8 with a median of 1.3 µg/L.

8.4.5 Other COPCs

- TRH, BTEXN, PAH, phenol, explosives and PCB results were below their respective LORs in all samples and below the adopted site assessment criteria.
- The LORs for one or more BTEXN, PAH, phenol and PCB compounds with assessment criteria are greater than the adopted assessment criteria for Ecological (freshwater) or the Human Health (recreational), as such exceedances of these criteria are not able to be determined.

8.4.6 Physico-chemical parameters

Groundwater physico-chemical results are presented in **Table B1** in **Appendix B** and are summarised below:

- pH values ranged from 4.25 (GW17) to 6.32 (GW03) with a median of 5.66, and were indicative of slightly acidic conditions.
- Dissolved oxygen concentrations ranged from 0.00 (GW11) to 7.51 mg/L (GW06) with a median of 4.06 mg/L.
- Electrical conductivity ranged from 90.1 (GW08) to 961.0 µS/cm (GW12) with a median of 257.7 µS/cm, which can be considered indicative of a freshwater environment.
- Redox potential ranged from -157.5 mV (GW13b) to 219.1 (GW19) with a median of 156.8 mV.
- Temperature ranged from 16.9 (GW17) to 20.4 °C (GW11 and GW12).
- Field observations indicated that the groundwater was generally clear to cloudy with no notable odours.
- Wells GW14, GW15, GW16, GW17, GW18, GW22 and GW23 adjacent to the northern site boundary had SWLs ranging between 2.23 (GW17) to 6.34 mbgl (GW18). Wells GW11, GW12, GW13b, and GW20 within the central portion of the site had SWLs ranging between 2.81 (GW13b) to 8.47 mbgl (GW20). Wells GW01, GW02, GW03, GW04, GW05, GW06, GW07, GW08, GW09, GW10, GW19, and GW21 within the southern portion of site had SWLs ranging between 6.37 (GW04 and GW06) to 8.51 mbgl (GW19).
- Faecal indicator bacteria were not detected in any of the analysed groundwater samples.

8.5 Septic and Sewer Water

Sections 8.5.1 to 8.5.5 provide a summary of the laboratory results for liquid grab samples collected from septic tank (SEP001) and site sewer infrastructure (SEW002) on site. The sampling locations are presented in **Figure 3-4 in Appendix A**. Water analytical summary tables comparing laboratory results to adopted guidelines for the investigation are presented as **Table D23** in **Appendix D**.

The analytical results indicate the majority of sample points are within the adopted assessment criteria for all CoPCs. Exceedances comprised of the following CoPCs, and are illustrated in **Figure 9-10, Appendix A**:

- Metals – Copper & zinc.
- PFAS - Sum of PFHxS & PFOS

8.5.1 BTEX

All reported results for BTEX were below the LOR with the exception of the following:

- Toluene was detected at SEW002 with concentrations of 11 µg/L.

8.5.2 Metals

All reported metals results were either below the adopted assessment criteria or the LOR, with the exception of the following:

- Copper concentrations exceeded the adopted Ecological (freshwater) assessment criteria of 1 µg/L at SEW002 with a concentration of 51 µg/L.
- Zinc concentrations exceeded the adopted Ecological (freshwater) assessment criteria of 10 µg/L at SEP001 (39 µg/L) and SEW002 (150 µg/L).

8.5.3 Chlorinated Hydrocarbons

All reported results for chlorinated hydrocarbons were below the LOR with the exception of the following:

- Bromodichloromethane and chloroform were detected in SEW002 with concentrations of 0.7 and 13 µg/L respectively.

8.5.4 PFAS

- Sum of PFHxS & PFOS exceeded the adopted Ecological (freshwater) assessment criteria of 0.00023 µg/L in SEP001 (0.012 µg/L).

8.5.5 Solvents and VOCs

All reported results for solvents and VOCs were below the LOR with the exception of the following:

- Acetone was detected in SEW002 with concentrations of 0.031 µg/L.
- Total VOCs were detected in SEW002 with concentrations of 0.059 µg/L.

8.5.6 Microbial

- Faecal indicator bacteria were not detected in any of the analysed septic and sewer water samples.

8.6 Background Soil and Bore Water Sampling

During the investigation, a background sampling location was negotiated by Jacobs with Randwick City Council for Latham Park. **Sections 8.6.1 and 8.6.2** provide a summary of the laboratory results for the background soil sample (LP_BAC) and bore water grab sample (LP_BAC_WATER) collected from Latham Park, South Coogee NSW, located approximately 640m south east of the site. The sampling locations are presented in **Figure 8 in Appendix A**. Analytical summary tables comparing laboratory results to adopted guidelines for the background soil sample and background water sample are presented as **Table D16 and D23** respectively in **Appendix D**.

8.6.1 Soil

The analytical results indicate the background soil sample (LP_BAC) is within the adopted assessment criteria for all CoPCs. Exceedances comprised of the following CoPCs and are illustrated in **Figure 9-11, Appendix A**:

- Concentrations of metals were generally above the LOR but below the adopted assessment criteria in all analysed samples, with the exception of the following:
    - Nickel concentrations exceeded the adopted EIL assessment criteria of 45 mg/kg at one location (LP_BAC_0.8-0.9) with a concentration of 68 mg/kg.
- All other COPCs were generally detected at concentrations below the LOR.

8.6.2 Bore Water

The analytical results indicate the bore water sample (LP_BAC_WATER) is within the adopted assessment criteria for all CoPCs. Exceedances comprised of the following CoPCs, and are illustrated in **Figure 9-11, Appendix A**:

- Concentrations of metals were generally above the LOR but below the adopted assessment criteria in all analysed samples, with the exception of the following:
    - Copper concentrations exceeded the adopted Ecological (freshwater) assessment criteria of 1 µg/L, with a concentration of 11 µg/L.
    - Zinc concentrations exceeded the adopted Ecological (freshwater) assessment criteria of 8 µg/L, with a concentration of 9 µg/L.
- Sum of PFHxS & PFOS exceeded the adopted Ecological (freshwater) assessment criteria of 0.00023 µg/L, with a concentration of 0.015 µg/L.
- All other COPCs were detected at concentrations below the LOR.

8.7 Soil Gas

Soil gas sampling was undertaken in two stages: i) PSG – screening, followed by ii) ASG, as discussed in **Sections 8.7.1** and **8.7.2**. Refer to **Figures 5** and **6** in **Appendix A** for PSG and ASG sampling locations. **Tables D24** and **D25** in **Appendix D** provide summary tables of the analytical results.

8.7.1 PSG

The laboratory supplied single use Waterloo Membrane Sampler with Low Uptake Rate (WMS-LU™) in sealed bags. The bags and the WMS-LUs had unique matching codes which were recorded on a sampling record sheet together with sampling location identifications. After borehole establishment samplers were deployed and boreholes plugged until samplers were recovered. The detailed sampling procedure was as follows for each sampling location:

- All required fields on the passive sampler transport bag were filled in.
- On a sampling record sheet the unique passive sampler number and sampling location were recorded.
- The nylon tube extension on the PID was inserted into the borehole void and the PID reading recorded on the sampling record sheet.
- Using gloved hands, a passive sampler was removed from the transport bag and placed in the wire holder. The wire holder served to keep the sampler off the walls of the borehole. The sampler was secured to the base of the lay-flat tubing plug with nylon fishing line.
- The sampler was deployed into the void nominally 0.8m from the top of the borehole. The date and the time of deployment were recorded on the record sheet and the transport bag. The borehole was sealed with a sponge inserted into the lay-flat tubing approximately 0.2m from the surface.
- A thin layer of sand and bentonite (approximately 0.05m respectively) was placed over the plug flush with the surface to prevent the ingress of storm water.
- The sampler was exposed for nominally 10 days. The exposure duration was selected to achieve limits of reporting which were lower than selected screening criteria.
- At the end of the exposure period the plug was removed. The nylon tube extension on the PID was inserted into the void and a PID reading recorded on the sampling record sheet. The sampler was then retrieved with gloved hands. The recovery date and the recovery time were recorded on the record sheet and the transport bag.
- The sampler was removed from the wire holder and cleaned of dirt with a gloved hand and placed in a glass vial provided by the laboratory. The vial was re-capped, sealed with Teflon tape, wrapped in aluminium foil and placed in the transport bag for submission to the laboratory.

Sampler deployments were undertaken on 2 July 2020 and 28 October 2020, and retrievals were undertaken on 16 July 2020 and 11 November 2020 respectively. Information about the sample dates, PID readings, chain of custody numbers, the laboratory used, analyses undertaken and the laboratory report number are provided in the sampling record sheets (**Appendix J**).

A total of 37 locations were sampled for passive soil gas (PSG) as follows:

- Sampling locations PSG1 to PSG23 were within AEC12 (former metal treatment works), located along the eastern site boundary in the south eastern portion of the site.
- Sampling locations PSG24 to PSG33 were within the north western boundary of the site adjacent to wells GW14 and GW15, targeting the offsite AECs AEC16 and AEC17 (Randwick Zone Substation and former laundrette respectively).
    - Sampling location PSG24 was destroyed in transit to the laboratory and could not be analysed.
- Sampling locations PSG34 to PSG37 were within the north eastern boundary of the site adjacent to well GW18, targeting AEC5 (Sydney Water sewer utility).

The PSG analytical results were compared to the NEPM Interim soil vapour HILs or NEPM Interim soil vapour HSLs determined in the SAQP, and where appropriate the VISL Tier 1 health screening levels, as summarised below:

- Chloroform concentrations were observed at PSG16, PSG18, PSG22 and PSG23 with detections ranging from 4.9 to 8.8 µg/m³ and a median of 6.1 µg/m³. All detections were below the VISL Tier 1 health screening level of 41.0 µg/m³.
- Trichloroethene (TCE) concentrations were observed at PSG2, PSG6, PSG17, PSG18, PSG18, PSG19, PSG20, PSG21, PSG22 and PSG23 with detections ranging from 5.1 to 4,400 µg/m³ and a median of 165 µg/m³.
    - Locations with exceedances of the adopted site assessment criteria are within the northern portion of AEC12, with detections at PSG17, PSG18, PSG18, PSG19, PSG20, PSG22 and PSG23 ranging from 95 to 4,400 with a median of 290 µg/m³, exceeding the NEPM HIL of 20 µg/m³.
- Tetrachloroethene (PCE) concentrations were observed at PSG2, PSG6, PSG17, PSG18, PSG18, PSG19, PSG20, PSG22, PSG23, PSG34, PSG35, PSG36 and PSG37 with detections ranging from 2.2 to 130 µg/m³ and a median of 15.5 µg/m³, which are all below the NEPM HIL of 2,000 ug/m³.
    - PSG2 and PSG6 were located in the southern portion and PSG17, PSG18, PSG18, PSG19, PSG20, PSG22, PSG23 were located in the northern portion.
    - PSG34 to PSG37 were located in the north western portion of AEC01 adjacent AEC05.
- Toluene concentrations were observed at PSG10 and PSG21 with detections ranging from 2.74 to 6.4 µg/m³, which are all below the NEPM HSL of 1,300,000 ug/m³.
    - PSG21 was located in the northern portion of AEC12, while PSG10 was located in the central portion of AEC12.
- Naphthalene was observed at PSG25 with a detection of 3.3 µg/m³, which is below the NEPM HSL of 800 ug/m³.
    - PSG25 was located in the north eastern portion of AEC01 and south of AEC17.

8.7.2 ASG

Soil gas implants were installed in coarse screening sand to the required depth (see installation log in **Appendix J**). Teflon tubing attached to the sampling location was connected directly to the sampling equipment. The soil gas samples for VOC analysis were collected into specially cleaned and certified 1.4L silonite canisters using a soil gas sampling train to restrict flow to a maximum rate of 200ml/min.

During sampling, the samples were collected from the sample point directly into the canister and sorbent sampling tubes and do not pass though the pump, rotameter or tubing which all have the potential to contaminate the samples.

The canister vacuum pressure is measured during sampling to calculate the volume of sample drawn into the canister. A small amount of vacuum is left in the canister and then measured upon receipt in the laboratory to check if any leaks have occurred during transit.

The sampling procedures based on ASTM Guide D5314-92 (2001) "Standard Guide for Soil Gas Monitoring in the Vadose Zone". The "American Society for Testing and Materials" or ASTM, is an internationally recognised source of testing methods.

The silonite canisters for the VOC sampling are cleaned and analysed prior to sampling to confirm the canisters are not contaminated and capable of achieving the desired detection limits for the compounds of interest in accordance with USEPA TO-15.

Soil gas sampling trains are cleaned and calibrated prior to sampling. Individual mass flow controllers are used for each canister to avoid cross contamination.

The sampling flow rates for the backup sample tubes are set at the commencement of sampling and monitored during sampling to ensure flow is maintained and the formation can sustain the removal of sample from the boreholes. The sampling period is accurately recorded to enable the calculation of the sample volume collected on each of the sorbent sampling tubes.

Rotameters used to measure the flow rates were calibrated onsite each day using a primary standard.

Analysis for VOC's is performed by gas chromatography mass selective detector (GC-MS) analysis. The method is based on USEPA TO15 – "Determination of Volatile Organic Compounds in Air Collected in specially prepared canisters and Analysed by GC-MS" It is from the US EPA Compendium of methods for the determination of Toxic Organic Compounds in Air.

The silonite canisters and soil gas trains used for the VOC sampling are individually analysed and certified clean prior to sampling to ensure they are not contaminated and the background levels in the canisters are low enough to meet the detection limits for the compounds of interest.

Spiked samples are run with the USEPA TO-15 analysis. Spikes are run to confirm the recovery of each compound from the sampling media.

A total of six (6) locations were sampled for active soil gas (ASG):

- Four of the sample locations (ASG01 to ASG04) were within AEC12 (former metal treatment works), located along the eastern site boundary in the south eastern portion of the site.
- The remaining two sampling locations (ASG05 and ASG06) were within AEC6, located in the vicinity of the Sydney Water sewer alignment, adjacent to GW13a and GW13b.

The ASG analytical results were compared to the NEPM Interim soil vapour HILs or NEPM Interim soil vapour HSLs determined in the SAQP, and where appropriate the VISL Tier 1 health screening levels, as summarised below:

- Benzene concentrations were observed at ASG04 with a detection of 16 µg/m³, which is below the NEPM HSL of 1,000 µg/m³. ASG04 was located in the northern portion of AEC12.
- Ethylbenzene concentrations were observed at ASG04 with a detection of 5.7 µg/m³, which is below the NEPM HSL of 330,000 µg/m³.
- m,p-Xylene concentrations were observed at ASG04 with a detection of 19 µg/m³, which is below the VISL Tier 1 health screening of 3,480 µg/m³.
- o-Xylene concentrations were observed at ASG04 with a detection of 21 µg/m³, which is below the VISL Tier 1 health screening of 3,480 µg/m³.
- Chloroform concentrations were observed at ASG01, ASG02, ASG03, ASG04 and ASG06 with detections ranging from 5.6 to 20 µg/m³ and a median of 7.1 µg/m³.
- Trichloroethene (TCE) concentrations were observed at ASG01, ASG02, ASG03, ASG04 and ASG05 with detections ranging from 18 to 2,700 µg/m³ and a median of 2,300 µg/m³. Detections at ASG01, ASG02, ASG03 and ASG04 ranged from 1,900 to 2,700 with a median of 2,400 µg/m³ and exceeded the NEPM HIL of 20 µg/m³. Exceedance locations are within the northern portion of AEC12.
- Tetrachloroethene (PCE) concentrations were observed at ASG01, ASG02, ASG03, ASG04 and ASG05 and ASG06 with detections ranging from 17 to 340 µg/m³ and a median of 67 µg/m³, which are all below the NEPM HIL of 2,000 ug/m³.
- Toluene concentrations were observed at ASG01, ASG04 and ASG05 with detections ranging from 2.9 to 29 µg/m³ and a median of 10 µg/m³, which are all below the NEPM HSL of 1,300,000 ug/m³.
- 1,2,4-Trimethylbenzene concentrations were observed at ASG04 with a detection of 10 µg/m³, which is below the VISL Tier 1 health screening level of 2,090 µg/m³.
- 1,3,5-Trimethylbenzene concentrations were observed at ASG04 with a detection of 7.5 µg/m³, which is below the VISL Tier 1 health screening level of 2,090 µg/m³.

8.8 Data Quality Objective Completion

The results of the Quality Assurance and Quality Control Program are included in **Appendix E,** with a summary of the DQO and DQI completeness summarised in **Table 8-5** and **Table 8-6**. A quality review of the data was conducted. In summary, the data quality review did not identify significant systematic errors in the data collection process. Therefore, the data set is considered to be valid, complete and can be relied upon for the purposes of this assessment.

Table 8-5 Summary of Data Quality Objective Completion

DQO Step	Description and Discussion
Step 1: State the Problem	The presence and extent of potential contamination on site and potential risks to human health and the environment have been assessed by undertaking an intrusive investigation including sampling of soils, soil gas and groundwater at the locations shown on the Figures in **Appendix A**. Laboratory results are summarised in **Appendix D**. In general potential contamination risks have been identified, however, further investigations are required to inform management requirements and determine suitability of the site for a residential land use

DQO Step	Description and Discussion
Step 2: Identify the decision / goal of the study	The sampling to date has assessed the nature and extent of chemical and asbestos contamination on site (with Laboratory results summarised in **Appendix D**), including the key contaminant transport pathways and human health and ecological receptors (as discussed in the CSM in **Section 9**). To assess the suitability of the site for the proposed residential land use, and identify whether further assessment, risk assessment or other management measures is required including further delineation of impacted soils with statistical analysis of results where appropriate.
Step 3: Identify the information inputs	Previous reports were available and used in this assessment (**Section 5.2.1**), as well as the field data (**Appendix B**) and analytical results detailed in **Appendix F**.
Step 4: Define the boundaries of the study	The contamination assessment was completed within the lateral (site boundary – **Figure 2 in Appendix A**), vertical (soils and groundwater as per **Appendix B**) the temporal boundaries stated in the DQOs.
Step 5: Develop the analytical approach	Concentrations of the potential contaminants of concern were deemed to be precise, accurate, representative, complete and comparable. The QA/QC program undertaken as part of the assessment by SLR is presented in **Table E1, Appendix E**, with a review of the laboratory controls presented in **Tables E2** and **E3** of **Appendix E** respectively. Further statistical analysis of SAC exceedances could be undertaken to assist in assessing potential risks.
Step 6: Specify performance or acceptance criteria	Analytical data was compared with the relevant guidelines endorsed under the *Contaminated Land Management Act 1997* as stated in **Section 4** and the QAQC limits as specified in **Appendix E**.
Step 7: Develop the plan for obtaining data.	Works were generally undertaken in accordance with the SAQP (Jacobs, 2020b) and amended as per **Section 6.3**.

Table 8-6 Summary of Data Quality Indicator Completion

DQI	Completeness (Yes / No) and Reference
Use of appropriately qualified and trained staff	Yes – refer to **Table 6-3**.
Decontamination of non-disposable sampling equipment before and between sampling events	Yes – refer to rinsate results in **Table D20** in **Appendix D.** It is noted that in rinstate sample QC317 chloroform, bromochloroethane and PFOS were detected at concentrations close to the LOR. This result is not considered to alter the validity of the equipment decontamination.
Samples were identified using a unique sampling location identifier and sample depth intervals (e.g. AEC01_VB01)	Yes – refer to field logs in **Appendix B and analytical results in Appendix D**
Preservation of samples with ice during transport from the field to the laboratory	Yes – Refer to sample receipt notification in **Appendix F**
Transportation of samples with accompanying COC documentation	Yes – refer to sample receipt notification in **Appendix F**
Compliance with sample holding times	Yes (with some exceptions)– refer to sample receipt notification in **Appendix F and discussion in Appendix E**
Review of results of blind (inter-laboratory) duplicate sample	Yes – refer to results presented in **Table D17** of **Appendix D**
Review of results of split (intra-laboratory) duplicate sample	Yes – refer to results presented in **Table D15** of **Appendix D**
Collection of rinsate and review of analytical results	Yes – refer to results presented in **Table D20** in **Appendix D**
Review of internal analysis of laboratory duplicates, spikes and blanks	Yes – refer to results presented in **Appendix E**

DQI	Completeness (Yes / No) and Reference
Comparison of field and analytical data.	Yes – refer to results presented in **Appendix D** and **Appendix E.**

9 Conceptual Site Model

A refined Conceptual Site Model (CSM) has been prepared taking in to account the guidance provided in with the ASC NEPM and ASTM E1689-95 (2014) Standard Guide for Developing Conceptual Site Models for Contaminated Sites (ASTM, 2014). This CSM was developed to identify Source-Pathway-Receptor (SPR) linkages that may be present noting that further investigations may be necessary to determine whether these SPR linkages are complete. This CSM is based on the following:

- The preliminary CSM (Jacobs, 2020a)
- The findings of this investigation
- Other receptors may be present at the site that have lower exposure than the most sensitive environmental receptor potentially exposed and considered here
- This CSM should be updated/reviewed where site conditions change or further information pertaining to the contamination status of the site has been identified.

The purpose of the Conceptual Site Model (CSM) is to provide an understanding of the nature and extent of potential CoPC impact, potential migration mechanisms, and potential exposure pathways by which identified receptors may be exposed to COPC impact from the site, and to serve as a framework to assess potential risks to human health and ecological receptors.

In accordance with the ASC NEPM (2013), potential risks to receptors are evaluated based on three components:

Source: A potentially hazardous substance that has been released into the environment

Pathway: A mechanism by which receptors can become exposed to the source or derivatives of the source

Receptors: A person, ecosystem or ecological member potentially at risk of experiencing an adverse response following exposure to the source or derivatives of the source

This section presents a refined CSM based on the preliminary CSM included in the SAQP and findings of this investigation.

9.1 Sources of Contamination

The PSI identified 15 on-site AECs relating to historic and current site activities that had the potential to be a source of contamination for soil, groundwater or soil vapour. Based on the findings of this investigation, the likely sources of contamination have been refined as summarised in **Sections 9.1.1** and **9.1.2.**

9.1.1 On Site Sources

Based on the results of the detailed Site Assessment, SLR have identified the following sources of contamination on site:

- soils and fill material impacted by asbestos
- surface soils in the north-western portion of the site impacted by metals and PAHs
- CHC contaminated groundwater was encountered at two locations on site.
    - Concentrations of PCE, TCE and Cis-1,2-DCE were identified in monitoring wells adjacent to the northern boundary of the site, own gradient of a former laundrette / dry cleaners. The lack of trans-DCE in the groundwaters is indicative the cis-DCE is the result of reductive dichlorination of the PCE/TCE.
    - Groundwater in the south-eastern corner of the site near the former metal treatment works (AEC 12)
- SLR consider that there are two sources of PFAS impacting the site:
    - The regional aquifer, with PFAS concentrations generally less than 0.025ug/L
    - PFAS impacted groundwater in the southern portion of the site down gradient of GW07, in the vicinity of GW05 and GW04. The source of this is unknown, but likely associated with the historical activities in this area – former grenade bursting range (AEC04) and former vehicle washing refuelling and maintenance area (AEC09).

9.1.2 Off Site Sources

Off site sources identified are the Randwick Zone Substation (AEC16), located approximately 80 m north and up-gradient of the site and a Former Launderette (AC17), located approximately 21 m north west and up-gradient of the site.

9.2 Transport Pathways

Based on the findings of this investigation, potential pathways identified include:

- Historic and current activities releasing contaminants to soil
- Leaching of contaminants to groundwater
- Migration of contaminants through groundwater
- Surface water run-off of contaminated water and transportation of soil
- Vapour migration from volatile impacted soils
- vapour migration from volatile impacted groundwater
- Extraction of groundwater for irrigation and/or water supply
- Sediment/dust entrainment in wind

9.3 Exposure Pathways and Receptors

Based on the proposed land use of low, medium and high density residential housing, residential exposure scenarios including gardens/accessible soil are used to indicate potential risk and inform the CSM. Additionally, the Randwick Environment Park is potentially an off-site environmental receptor and if contamination migrates off site to the Park, there is potential for off site human and ecological receptors. Potential receptors and pathways of CoPCs are considered to include:

Table 9-1 Human Receptors and Pathways

Exposure Pathway	Receptor
• Incidental ingestion of soil, sediment, or groundwater • Inhalation of soils or dust • Dermal contact with soil, sediment, surface water or groundwater • Vapour inhalation of volatile hydrocarbons	• Current site users • Future site users • Construction workers • Maintenance workers • Off site residents

Table 9-2 Ecological Receptors and Pathways

Exposure Pathway	Receptor
• Direct contact with soil, sediment, surface water or groundwater • Indirect contact with soil, sediment, surface water or groundwater • Ingestion soil, sediment, surface water or groundwater • Ingestion (secondary toxicity/bioaccumulation)	• Terrestrial biota • Aquatic biota

Groundwater to surface water discharge is not considered an exposure pathway, as the site and Randwick Environment Park (the nearest potential surface water receiving body) are at approximately the same elevation (30 mAHD). The stormwater retention pond within the park is approximately 2-3 mbgl or 27-28 mAHD, groundwater at the site is nominally 6-7 mbgl or (23-24 mAHD).

9.4 Risk Screening

Potential transport mechanisms and exposure pathways considered for risk screening together with an assessment of the completeness of the exposure pathways, known as a Source-Pathway-Receptor (SPR) linkage are identified in **Table 9-3**. Where one or more elements of the SPR linkage are missing, the exposure pathway is considered to be incomplete and no further assessment is required. No pathway assessment has been completed for contaminants that did not present above the acceptance criteria, as these pathways are incomplete.

The SPR linkages have been categorised as:

- Complete – linkage is apparent and poses a potential risk to a receptor, where further action may be required.
- Incomplete – linkage is not apparent and does not pose a potential risk to a receptor, no further action may be required.
- Unconfirmed - Insufficient information to assess the completion of a linkage and further information may be required to assess the linkage.

Table 9-3 Conceptual Site Model

Primary Sources (AEC)	COPC	Secondary source	Transport Mechanism	Routes of Exposure	Human or Ecological Receptor	Linkage Status
Regional aquifer	PFAS Metals	Regional groundwater	Groundwater migration Groundwater migration to surface waters	Direct contact Groundwater discharge to surface water Ingestion (secondary toxicity/bioaccumulation)	Terrestrial ecology Aquatic ecology Users of Groundwater Future residents	Potentially Complete
	Copper Zinc Lead	Impacted soils	Transportation of soil to surface waters/drains	Uptake by vegetation Bioaccumulation	Terrestrial ecology Aquatic ecology	Potentially Complete
Site Wide Metals in soils	Copper (>EIL) Zinc (>EIL) Lead (>HIL)	Impacted soils	Transportation of soil to surface waters/drains	Uptake by vegetation Bioaccumulation	Terrestrial ecology Aquatic ecology	Potentially Complete
Off Site Sources (AEC 17- former laundrette)	CHC (PCE, TCE, DCE, Vinyl Chloride)	Impacted Groundwater	Volatilisation Enclosed, Accumulation, Groundwater migration,	Dermal Contact, Inhalation, Groundwater discharge to surface water	Future Residents Construction workers Terrestrial ecology	Potentially Complete
Refuelling / Maintenance (AEC 9)	PFAS	Local groundwater	Groundwater migration Groundwater migration to surface waters	Direct contact Groundwater discharge to surface water Ingestion (secondary toxicity/bioaccumulation)	Terrestrial ecology Aquatic ecology Users of Groundwater Recreational users of Randwick Environment Park Future residents	Potentially Complete

Fill NW corner (AEC 1/ AEC3)	PAH, B(a)P TEQ, B(a)P (>HIL A/B, HIL C)	Impacted Soils	Wind erosion and Atmospheric, Dispersion, Leaching to groundwater, Surface Erosion,	Dermal Contact Inhalation Ingestion (secondary toxicity/bioaccumulation)	Future Residents Offsite residents Construction workers Terrestrial ecology	Potentially Complete
	PCB (>HIL A/B, HIL C)	Impacted Soils	Wind erosion and Atmospheric Dispersion, Stormwater/ Surface Water Transport	Dermal Contact Inhalation	Future Residents Offsite residents Terrestrial ecology	Potentially Complete
Former Metals Treatment Works (AEC12)	TCE	Soil Vapour	Volatilisation Enclosed Accumulation	Dermal Contact Inhalation	Current site users Future site users Construction workers (trenching) Terrestrial ecology	Potentially Complete
		Groundwater	Groundwater migration	Dermal Contact Inhalation Groundwater discharge to surface water		
Historic Demolition Practices Current and Former Substations (Site Wide)	Bonded Asbestos	Impacted soils Fibrous Asbestos (Mechanical crushing and weathering)	Atmospheric Dispersion	Inhalation Ingestion	Current site users Future site users Construction workers Maintenance workers	Potentially Complete

10 Discussion

The following sections provide further discussion on the characterisation soil, groundwater and soil gas results.

10.1 Soils

A detailed investigation was undertaken for soils across the site, which demonstrated that widespread pesticide, hydrocarbon and PFAS contamination is not present at the site. Field PID screening did not indicate the presence of gross hydrocarbon concentrations, with the maximum PID reading being recorded at TP048 (13.4 ppm at a depth of 1.0 mbgl). MIP locations showed low signal responses, including in areas suspected of previously housing former USTs. However, the following impacts to soil have been identified and require further management:

- Asbestos in the form of asbestos fibres (fibrous asbestos and asbestos fines) and ACMs were present across the site and were concentrated in the vicinity of the former Naval Stores, particularly in vegetated areas along the northern portion of the site, underlying the vegetated strips lining the verges of the concrete slabs across the site, in fill areas towards the south west boundary of the site, and to a lesser extent on the south eastern portion of the site (**Figures 9-4A and 9-4B, Appendix A**).
    - Occurrences of ACMs was predominantly observed in surface soils (0 to 0.2mbgl) and up to depths of 2.2 mbgl in discrete portions along the western boundary of the site and around the former Naval Store concrete slabs.
    - Occurrences of asbestos fibres (fibrous asbestos and asbestos fines) were also predominantly observed in surface soils (0-0.2 mbgl) and up to depths of 1.5mbgl in in certain pockets along the western boundary of the site. Occurrences of asbestos fibres and ACMs were not observed beneath concrete hardstand areas that formed the foundation of the former Naval Stores, suggesting that asbestos occurrence across the rest of the site was potentially from the staged demolition of the former Naval Stores.
    - The bulk of asbestos impacted soils appears to be in the soil surface to approximately 0.2mbgl.
    - enHealth (2005) refers to a study by Addison et al. (1988) which demonstrated that the asbestos concentration in air is unlikely to occur above 0.1 f/mL (occupational exposure standard) under controlled conditions where 5 mg/m^3 of respirable dust is generated from soil containing 0.001% asbestos (w/w homogeneous sample) asbestos in dry soil, in air. This study was undertaken to determine a practical limit for the asbestos content of contaminated land below which no further decontamination would be necessary as soil 'free of asbestos' would be unattainable or impractical. In addition, if the asbestos fibre is reasonably well fixed into a bonding matrix and not mechanically disintegrated into dust, it does not present a significant dust hazard
    - The study found that unless considerable dust clouds are generated it would not be possible to measure airborne fibre levels at the levels required. The study recommended a level of 0.001% below which, no action would be required to decontaminate further or to protect workers specifically from asbestos dust.

- B(a)P and B(a)P TEQ was detected at concentrations above the adopted health and ecological assessment criteria at a number of locations, particularly in the northern portion of the site, and to a lesser extent along the western boundary as shown on **Figure 9-3** in **Appendix A**. The B(a)P was generally in shallow soils (0.1 to 0.5mbgl). Given the number of exceedances of the B(a)P criteria and the grid based sampling approach (as shown on **Figure 3-2** in **Appendix A),** the B(a)P impacts soils are considered to be adequately characterised (laterally and vertically) and are widespread across the northern portion of the site. As shown in **Table 10-1** below, there is a strong correlation between B(a)P and B(a)P TEQ exceedances.

Table 10-1 Comparison of B(a)P and B(a)P TEQ exceedance areas

Sample Number	B(a)P	B(a)P TEQ
-	>20 mg/kg	>7.5 mg/kg
0407_TP162_0.1_200617	25	37
0407_TP197_0.1_200619	120	170
0407_TP197_0.5_200619	-	11
0407_TP209_BH02_0.0-0.1_20201016	27	-
0407_TP200_0.5_200618	-	14
0407_TP209_0.5_200619	-	9.5
0407_TP210_0.1_200624	-	7.6
0407_TP213_0.1_200623	53	73
0407_TP213_0.5_200623	130	190
0407_TP213_BH03_0.0-0.1_20201019	40	-
0407_TP221_0.5_200619	-	15
0407_TP222_BH01_0.5-0.6_201019	61	-
0407_TP222_BH04_0.5-0.6_201019	25	-
0407_TP235_0.1_200624	37	52

- Heavy metals, particularly copper, lead and zinc, as well as TRH (F2 and F3), were also observed at concentrations above the adopted ecological assessment criteria at a number of locations. Analytical results from sampling undertaken around these areas generally showed that elevated concentrations of lead were isolated, while copper and zinc was widespread across the site. Given the shallow depths of the detections (0.1 to 0.7mbgl) and groundwater quality (low heavy metal and B[a]P concentrations) at the site, the minimal presence of ecological receptors on site and distance to ecological receptors off-site, it is not considered likely that these COPCs are leachable or would pose a risk to on-site or off-site ecological receptors through groundwater migration.
- Naphthalene and PCBs were detected at concentrations slightly above the adopted human health assessment criteria, and were limited to a small number of locations on the north western portion of the site. Chromium was also detected slightly above the adopted human health assessment criteria at one location on the western boundary of the site. These exceedances were observed at shallow depths between 0.1 and 0.5 mbgl and are considered to be isolated exceedances, which could be managed with the asbestos impacted soils.
- With the exception of *Salmonella spp*. at one location (SYDSEW08_1.7-1.8), faecal indicator bacteria were not detected in any of the analysed soil samples. Analytical results for soil samples collected in the vicinity of the Sydney Water and site sewer infrastructure did not identify the sewer infrastructure as a significant source of contamination to groundwater, and are therefore not considered to pose a risk to the site.

10.2 Groundwater and Sewer Samples

The groundwater investigation across the site including two (2) GMEs and background groundwater sampling found:

- Based on the groundwater SWLs and the proximity of the south eastern boundary of the site to the edge of the Botany Basin, groundwater flow direction in the northern part of the site is generally towards the south-east, while the southern part of the site generally south-westerly towards Botany Bay. The local hydraulic gradient is in the order of 8 m/km (1:125) which decreases towards the south of the site, and is thought to be higher than the regional hydraulic gradient due to being close to the edge of the Botany Basin.
- The majority of the groundwater results were reported to be within the adopted assessment criteria for all COPCs, with the exception of heavy metals, chlorpyrifos and PFAS.
- Heavy metals copper and zinc exceeded the adopted ecological assessment criteria at majority of the monitoring wells. Similar exceedances were also observed in the background bore sample collected from Latham Park in South Coogee. Heavy metal concentrations were also relatively consistent across the site, hence, heavy metal concentrations in groundwater onsite are considered to be representative of background conditions.
- Chlorpyrifos exceeded the adopted drinking water assessment criteria in well GW13a (screened in the perched aquifer), in the vicinity of the Sydney Water sewer line traversing the north western portion of the site. Chlorpyrifos was not detected at the adjacent well GW13b (screened in the sandstone). As such, concentrations of chlorpyrifos are likely to be from surface impacts and restricted to the immediate area.
    - It is also noted that there is a small water column in monitoring well GW13a due to the presence of sandstone at shallow depths in this area.
- PFAS (sum of PFHxS and PFOS) was observed above the adopted ecological assessment criteria in all wells, with exceedances of the adopted drinking water assessment criteria observed in 10 out of 24 wells. The highest concentrations were observed in wells within AEC8 and AEC9. It is noted that PFAS was generally not detected in soils sampled onsite and as the site is primarily vacant, the site is unlikely to be an ongoing source of PFAS impact to groundwater. Based on the distribution of PFAS across it the site SLR consider that there are likely two sources of PFAS impacting groundwater onsite:
    - Based on calculated groundwater flow directions, SLR infer that PFAS concentrations in the upgradient monitoring wells; GW14, GW15, GW16, GW17 and GW18 which contained 0.0260 ug/L, 0.0150 ug/L, 0.0230 ug/L, 0.0200 ug/L and 0.0150 ug/L of PFHxS and PFOS respectively were representative of the broader regional aquifer water quality and unlikely to be attributable to an on-site source.
    - Based on concentrations of PFHxS and PFOS in the downgradient groundwater monitoring wells GW04 (0.75 ug/L) and GW05 (0.43 ug/L) being almost an order of magnitude higher than the upgradient monitoring wells (nominally 0.02 ug/L) and their location in the vicinity of AEC 8 (Former Fuel Infrastructure) and AEC 9 (Former Vehicle Washing Refuelling and Maintenance) SLR inferred that these concentrations likely represent a yet unidentified, onsite source of PFAS which requires further groundwater monitoring.
    - PFAS detected in water sample collected from the disused septic tank (0.012 ug/L) located downgradient of monitoring well GW11 (0.21 ug/L) and upgradient of monitoring well GW21 (0.027 ug/L are considered to be a result of infiltration of local groundwater and representative of local aquifer conditions.

- Chlorinated hydrocarbons were noted above the LOR but below the adopted assessment criteria in wells GW14 and GW15, located downgradient of AEC16 and AEC17, and wells GW13a, GW13b and GW18, along the Sydney Water sewer alignment traversing the northern portion of the site.
  - Based on the limited data available i.e., concentrations of tetrachloroethene, trichloroethene and cis-1,2-dichloroethene but no trans-1,2-DCE or 1,1-DCE, SLR have inferred that the most likely source of chlorinated hydrocarbons in the upgradient monitoring wells (GW13a &b, GW14, GW15 and GW18) is the former laundrette (Dry cleaners) adjacent to the north west corner of the site.
  - Generally, if the ratio of cis-1,2-DCE to trans-1,2-DCE plus 1,1-DCE is greater than about 5:1, then the observed DCE is likely the result of degradation of TCE and/or PCE.
- Liquid grab samples collected from septic tank (SEP001/AEC5) and site sewer infrastructure (SEW002/AEC5) on site exceeded adopted ecological assessment criteria for copper, zinc and PFAS (sum of PFHxS and PFOS). Minor concentrations of chlorinated hydrocarbons and solvents above the LOR were also observed in SEW002. The source of these detections are potentially from AEC12 (Former Metal Treatment Works), as SEW002 is within the AEC12 boundary.
- Faecal indicator bacteria were not detected in any of the analysed groundwater, sewer water and septic water samples, and are not considered to pose a risk to the site.
- From the higher concentrations of phosphorus and nitrogen (Total) detected in monitoring well GW13a it can be inferred that there may be a small leak in the adjacent sewer pipe, however concentrations of COPC's detected in soils and groundwater up gradient and down gradient of the sewer line are relatively consistent, indicating that the sewer line is not a source of contamination at the site.

10.3 Soil Gas

The results of the soil gas investigation demonstrated that the majority of the results were below the adopted assessment criteria with the exception of Trichloroethene (TCE). TCE was detected in the northern portion of AEC12 (Former Metal Treatment works in the south-eastern corner of the site) at concentrations above the adopted site assessment criteria for both PSG and ASG. Maximum sampling depths were to 1.2 mbgl and as there was one detection of TCE in groundwater (GW10 – 2.8 µg/L in the July 2020 GME) and not soil in the vicinity, it is likely the TCE source associated with groundwater off-gassing and concentrations would increase with depth through the vadose zone.

10.4 Data Gaps and Uncertainties

The nature and extent of contamination at the site has generally been characterised, however the following data gaps / uncertainties should be considered at a later stage when the proposed development has been confirmed:

- On-site Data Gaps
  - Delineation of the extent of Trichloroethene (TCE) contamination in groundwater in the vicinity of AEC12. Additional data is required to further understand the source, extent, and migration pathways.
  - The western boundary area associated with underground high voltage electrical infrastructure was not accessible and this area should be considered a data gap, as fill material was encountered in this area. It is noted that while this this area is unlikely to be developable due to the easement surrounding the high voltage electrical infrastructure, further investigations are required to validate the implementation of appropriate management strategies in this portion of the site. The data gap at this location is not considered to affect the approach to managing the broader site.

    - AEC14 (stormwater infrastructure) was not identified during site works and as such, targeted soil and water sampling was not be undertaken, however given the extensive grid-based sampling pattern undertaken, this omission is not considered a significant data gap and no further works are recommended.
    - SLR consider that there are at least two sources of PFAS on site; the first source of PFAS is the regional groundwater aquifer, which contains relatively low levels compared to the identified second source area on site, in the vicinity of the former metal treatment works, chemical storage yard and the former vehicle washing refuelling and maintenance yard. However, while the exact source of the PFAS is unknown, this is not considered a significant data gap.
- Off-site Data Gaps
    - The background groundwater sample indicates that contaminants are present outside of the investigation area (E.g., chlorinated hydrocarbons and PFAS). Additional groundwater monitoring upgradient of the site will allow further consideration of off-site contaminant sources (including PFAS), groundwater flow and the potential impacts to site conditions.

11 Conclusions and Recommendations

Based on a review of the available desktop data, observations made during fieldwork, and the results of laboratory analysis (in the context of the proposed land use scenario for the site), SLR makes the following conclusions:

- As reported in Jacobs (2020a), the site is understood to have been acquired by the Commonwealth of Australia in 1788. The federation of Australia in 1901 resulted the official transfer of the site to the Commonwealth (from the Australian Colonies). The earliest use of the site was for rifle marches, forming part of the Randwick Rifle Range from 1891 until 1924, when the rifle range was closed and used as a small arms school until 1942. The Randwick Naval Stores Depot was constructed in 1943 and consisted of 26 main stores/buildings which stored machinery and dry goods. The stores are understood to have been constructed of timber and asbestos cement cladding, with the stores progressively demolished between 1986 and 2009.
- At the time of inspection and investigation, the central and northern portion of the site was comprised of open space with concrete slabs and vegetation, while the southern portion of the site was an operational Defence facility.
- Land uses surrounding the site included low density residential properties to the north and south, the remainder of Randwick Barracks to the west, with Munda Street Reserve and Randwick Environment Park and Wetlands to the east.
- As summarised by the Areas of Environmental Concern (AECs), potential sources of contamination identified on site include the widespread presence of bonded Asbestos Containing Materials (ACMs) and building demolition wastes across the site, fill materials, fuel storage, metal treatment works and storage of small quantities of chemicals, attributed to the historical activities on site.
- Soil and groundwater sampling has been undertaken across the site, with Contaminants of Potential Concern (CoPC) adequately assessed and characterised based on the AEC.
- Screening of potential volatile organic compound (VOC) impacts using a Membrane Interface Probe (MIP) showed low signal responses with PID responses less than 0.5 x 10^6 µV, FID responses less than 2 x 10^5 µV and XSD responses less than 1 x 10^5 µV, at all locations.
- Soil sampling showed, concentrations of CoPC are generally less than the laboratory limits of reporting and adopted site assessment criteria in soils, with the exception of:
    - Asbestos in the form of asbestos fibres (fibrous asbestos and asbestos fines) and ACMs which was present across the site and concentrated in the vicinity of the former Naval Stores, particularly in vegetated areas along the northern portion of the site, underlying the vegetated strips lining the verges of the concrete slabs across the site, in fill areas towards the south west boundary of the site, and to a lesser extent on the south eastern portion of the site. The bulk of asbestos impacted soils appears to be in the soil surface to approximately 0.2mbgl.
    - The Benzo(a)pyrene [B(a)P] Toxicity Equivalent Quotient (TEQ) exceeded the Health-based Investigation Level (HIL-A) at 20 locations, with Polycyclic Aromatic Hydrocarbons (PAH) [Total] exceeding HIL A at five (5) locations. B(a)P exceeded the Ecological Screening Levels (ESLs) at eight (8) locations. B(a)P impacted soils were predominantly in the northern and north western portions of the site, and generally encountered in areas also impacted by asbestos. Naphthalene also exceeded the adopted site assessment criteria at three (3) locations.

- Concentrations of Cadmium, Chromium $^{III+VI}$, Copper, Lead, Mercury, Nickel or Zinc either singularly or in some combination exceeded the EILs for public open space in 51 samples
- The concentrations of Chromium $^{III+VI}$, Copper, and Lead, either singularly or in some combination exceeded the HIL A in 8 samples. It should be noted one sample (0407_TP73_0.1_200619) is reported as exceeding the HIL A for hexavalent Chromium, however the analytical result is for total chromium. Hexavalent chromium is not expected to be present on site, given the historical land uses.
- Petroleum hydrocarbons at eleven (11) locations exceeding the ESLs in shallow soils.
- PCBs at one (1) location exceeding the HIL in shallow soils.
- Analytical results for soil samples collected in the vicinity of the Sydney Water and site sewer infrastructure did not identify the sewer infrastructure as a significant source of contamination to groundwater, and are therefore not considered to pose a risk to the site.

- Concentrations of contaminants of potential concern in groundwater were generally less than the laboratory limits of reporting in groundwater, with the exception of the following detections exceeding the adopted site assessment criteria:
  - copper and zinc at 13 locations, arsenic and nickel at one location, and lead at two (2) locations. Heavy metal concentrations were relatively consistent across the site and comparable to the background sampling location, hence, heavy metal concentrations in groundwater onsite are considered to be representative of background conditions
  - Chlorpyrifos (OPP) at one location (GW13a) in one sampling event. This result is considered to be an outlier, as pesticides were generally less than the laboratory limit of reporting in soils and groundwater which indicates the site is unlikely to be the primary or an ongoing source of chlorpyrifos impact to groundwater.
  - Sum of PFHxS & PFOS in ten (10) locations. It is noted that PFAS was generally not detected in soils sampled on-site and as the site is primarily vacant, the site is unlikely to be the primary or an ongoing source of PFAS impact to groundwater. SLR considers that whilst regional groundwater is a source of PFAS in groundwater onsite, the elevated PFAS concentrations in groundwater in the vicinity of the former metal treatment works, chemical storage yard and the former vehicle washing refuelling and maintenance yard, requires further groundwater monitoring. However, while the exact source of the PFAS is unknown, this is not considered a significant data gap.
  - Chlorinated hydrocarbons - Based on the limited data available i.e., concentrations of DCE, TCE and DCE but less than 20% trans-1,2-DCE or 1,1-DCE, SLR have inferred that the most likely source of chlorinated hydrocarbons in the upgradient monitoring wells (GW13a &b, GW14, GW15 and GW18) is the former laundrette (Dry cleaners) adjacent to the north west corner of the site. As a rule of thumb, if the ratio of cis-1,2-DCE to trans-1,2-DCE plus 1,1-DCE is greater than about 5:1, then the observed DCE is likely the result of degradation of TCE and/or PCE.
- Passive Soil Gas (PSG) results showed detections of chloroform, DCE, toluene and TCE with highest concentrations reported in the northern portion of AEC12 (Former Metal Treatment Works). Concentrations of trichloroethene were found to exceed the adopted site assessment criteria in northern portion of AEC12 in Active Soil Gas (ASG) following the PSG sampling.

- Receptors include on-site commercial/industrial workers (Defence personnel and contractors) associated with site operations, potential future residential users, as well as on-site ecological receptors and offsite ecological receptors (including the Randwick Environment Park – bushland and wetlands formerly part of Randwick Barracks).
- Potential migration pathways and exposure routes were identified such as dermal contact and inhalation of dusts from contaminated soils by site users, as well as groundwater and surface water migration of contaminants associated with the historical use of the site.

Based on the information gathered during the desktop review, the observations made during the site walkover and the results of the sampling undertaken, SLR concludes that the site can be made suitable for a residential land use subject to the following:

- The management of bonded ACM fragments and asbestos fibres (fibrous asbestos and asbestos fines) associated with historical activities on site. This includes the fill material in the high voltage easement on the western boundary of the site.
- The management of elevated concentrations of B(a)P and metals in surface soils across the northern portion of the site. Petroleum hydrocarbons and PCBs also require management at discrete locations.
- Further monitoring of the groundwater quality and properties on site, including PFAS, as well as TCE in and surrounding AEC12 (Former Metal Treatment Works). This should include the installation of additional groundwater monitoring bores in the vicinity of AEC12.
- Preparation of a Hazardous Building Material assessment of remaining buildings where they require demolition.

SLR recommends the following:

- Further groundwater monitoring be undertaken to address the data gaps / uncertainties identified above.
- Preparation of a Remedial Action Plan (RAP) to detail the remediation, validation and management requirements of the identified contamination in order to confirm the suitability of the site for a change in land use.

This report must be read in conjunction with the limitations set out in **Section 13** of this report.

12 References

AS 4482.1-2005, Guide to Investigation and Sampling of Sites with Potentially Contaminated Soil, Part 1: Non-volatile and Semi-volatile Compounds, 2005

AS 4482.2-1999, Guide to the Sampling and Investigation of Potentially Contaminated Soil, Part 2: Volatile Substances, 1999

Contaminated Land Management Act 1997

Enhealth (2005), Management of asbestos in the non-occupational environment, Department of Health and Ageing, Australian Government

HLA Envirosciences Asbestos Management Strategy, Randwick Defence Site, Randwick, NSW (September 2003a)

Jacobs Randwick Barracks Preliminary Site Investigation. IH107200-500-NP-RPT-0002 Final April 2020 (Jacobs, 2020a)

Jacobs Randwick Barracks Sampling Analysis and Quality Plan. IH107200-005-NP-SAQP-0002 C May 2020 (Jacobs, 2020b)

National Environment Protection Council (NEPC) 1999, 'Schedule B(1) Guideline on Investigation Levels for Soil and Groundwater, National Environment Protection (Assessment of Site Contamination) Measure (NEPM) as amended in May 2013'. (NEPM 2013a)

National Environment Protection Council (NEPC) 1999, 'Schedule B(2) Guideline on Site Characterization, National Environment Protection (Assessment of Site Contamination) Measure (NEPM) as amended in May 2013'. (NEPM 2013b)

National Environment Protection Council (NEPC) 1999, 'Schedule B(5c) Soil Quality Guidelines for Arsenic, Chromium (III), Copper, DDT, Lead, Naphthalene, Nickel & Zinc, National Environment Protection (Assessment of Site Contamination) Measure (NEPM) as amended in May 2013'. (NEPM 2013c)

National Environment Protection Council (NEPC) 1999, 'Schedule B(5b) Methodology to Derive Ecological Investigation Levels in Contaminated Soils, National Environment Protection (Assessment of Site Contamination) Measure (NEPM) as amended in May 2013'. (NEPM 2013d)

National Environment Protection Council (NEPC) 1999, 'Schedule B(5a) Ecological Risk Assessment, National Environment Protection (Assessment of Site Contamination) Measure (NEPM) as amended in May 2013'. (NEPM 2013e)

NSW Environment Protection Authority (EPA) under clause 93 of the Protection of the Environment Operations (Waste) Regulation 2014 requirements for Excavated Natural Material (ENM).

NSW EPA Contaminated Land Guidelines: Consultants Reporting on Contaminated Land 2020.

NSW EPA Waste Classification Guidelines Part 1: Classifying Waste, 2014

NSW Government 2014, 'Managing asbestos in or on soil'.

NSW Work Health and Safety Act, 2011

NSW Work Health and Safety Regulation, 2017

SafeWork NSW 2019, Code of Practice, 'How to Safely Remove Asbestos'.

SafeWork NSW, Code of Practise: How to Manage and Control Asbestos in the Workplace, 2019.

USEPA 2015, Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air (June 2015)

Victorian EPA Industrial Waste Resource Guidelines (soil sampling), 2009 (IRWG702)

13 Limitations

This report is for the exclusive use of Defence Housing Australia. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR Consulting.

This report has been prepared based on the scope of services and in accordance with the auditor approved SAQP prepared by Jacobs (Jacobs 2020b). SLR Consulting cannot be held responsible to the Client and/or others for any matters outside the agreed scope of services. Other parties should not rely upon this report and should make their own enquiries and obtain independent advice in relation to such matters.

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It should be noted that many investigations are based upon an assessment of potentially contaminating processes which may have occurred historically on the site. This assessment is based upon historical records associated with the site. Such records may be inaccurate, absent or contradictory. In addition, documents may exist which are not readily available for public viewing.

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