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Report on
Remedial Action Plan

Hornsby Ku-Ring-Gai Hospital Campus Development
Stage 2, Palmerston Road, Hornsby, NSW

Prepared for
Health Infrastructure
c/- APP Corporation Pty Limited

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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1. Introduction

Douglas Partners Pty Ltd (DP) was commissioned by APP Corporation Pty Limited (APP) on behalf of Health Infrastructure to produce a Remediation Action Plan (RAP) for Stage 2 of the Hornsby Ku-Ring-Gai Hospital Campus Development located at Palmerston Road, Hornsby, NSW (the Site, as shown on Drawing 1 in Appendix B). The RAP is required to support the State Significant development application being made by Health Infrastructure to Department of Planning and Environment for redevelopment of the site for continued use as a hospital.

The proposed development is to include:

- A new main hospital entry point;
- Four new 28 bed Inpatient Units;
- New Intensive Care Unit with 12 beds;
- Combined new and refurbished ambulatory care areas;
- Extended Emergency Department including Transit Lounge;
- Increased capacity of the existing Psychiatric Emergency Care Centre from 4 to 6 beds;
- A new pharmacy;
- Two new 28 bed rehabilitation wards and treatment consultation space;
- A new Mortuary;
- Teaching, education and research facilities;
- Administration space for clinical and corporate support;
- Demolition works;
- End of trip facilities;
- Car parking and drop off (on grade); and
- Soft landscaping.

In August 2014, DP completed a Preliminary Contamination Investigation (PCI) and Preliminary Waste Classification for Stages 1 and 2 of the redevelopment (DP, 2014, refer Section 4).

The PCI consisted of a limited sampling programme within the footprint of the proposed redevelopment works. In conjunction with a review of previous site assessments conducted at Hornsby Hospital by DP, the analytical results indicated a low level of leachable contamination at the site, however, asbestos fibres were detected (below laboratory reporting limits) at one location within the filling.

The PCI concluded that the extent of asbestos contamination may be limited to an area in the vicinity of BH114 (refer Drawing 1, Appendix B) and should be subject to further investigations in order to determine the lateral and vertical extent of asbestos contamination and the subsequent remediation action required in line with the proposed works to be undertaken in the affected area / areas of environmental concern (AEC). It was considered that further investigation /remediation is required for the site to be considered suitable for the proposed hospital development.

A RAP is required to establish appropriate remediation objectives, strategies, methodologies and validation processes to enable the identified AEC to be remediated such that the site is suitable for the proposed land use. The RAP also details further investigation requirements and methodologies to determine the locations and extents of AEC requiring remediation.

The RAP has been developed based on available standards and guidelines prepared by the relevant authorities, and the results of the previous contaminated land investigations undertaken by DP at the site as discussed in Section 4.

2. Objectives of the RAP

The overarching objective of the RAP is to facilitate the remediation of the Site in an acceptable manner, with minimal environmental impact, to a condition suitable for the proposed hospital development.

The specific objectives of this RAP are therefore to provide a strategy for site remediation which:

- Minimises impacts from the Site on the environment and on public health and safety during site remediation;
- Maximises the protection of workers involved with site remediation;
- Renders the Site safe, from an environmental perspective, for the proposed land use and substantially reduces potential exposure pathways to contaminants in accordance with remediation acceptance criteria (RAC) as defined in this RAP; and
- Minimises impacts on the local environment during and following site remediation.

3. Site Information

3.1 Site Location and Proposed Redevelopment Area

The site of the proposed redevelopment area is located within the grounds of Hornsby Ku-Ring-Gai Hospital which is bound by Lowe Road to the north, Derby Road to the east, Burdett Street to the south and Palmerston Road to the west. Hornsby Ku-ring-gai Hospital is located within the Hornsby Shire Council local government area (LGA).

The area proposed for redevelopment, identified as Stage 2, occupies a significant portion of the hospital grounds, as indicated on Drawings 1 and 2 in Appendix B.

3.2 Geology, Topography and Hydrology

Reference to the Sydney 1:100,000 Geology Sheet[1] indicates that the hospital is located on the boundary of two geological units, Hawkesbury Sandstone and Ashfield Shale. Hawkesbury sandstone typically comprises medium to coarse grained quartz sandstone with very minor shale and laminate lenses whilst Ashfield Shale typically comprises black to dark-grey shale and laminate.

Hawkesbury sandstone was confirmed during drilling of geotechnical bores across the hospital grounds, however, Ashfield Shale was not encountered (see Section 4 for details).

The site exhibits a fall in gradient in a north-east direction toward Cockle Creek based on 2 m elevation contours intervals[2]. Cockle Creek is the nearest surface water body which flows in a north to south direction and occurs approximately 0.5 km east of the site. Based on the elevation contours and location of receiving water bodies, groundwater underlying the site is anticipated to flow in a north-easterly direction toward Cockle Creek. During the previous investigations (see Section 4 for details), no free groundwater was recorded during drilling.

Based on a review of the NSW Acid Sulphate Soils Map the site does not appear to be in an area of potential acid sulphate soils (ASS).

4. Previous Contamination Investigations

A review of relevant previous contamination investigation reports by others and DP at Hornsby Ku-ring-gai Hospital was conducted and a summary of the findings is presented below. The reports reviewed herein are:

- '*UST Removal and Validation Report, Hornsby Kuring-Gai Hospital, Palmerston Road, Hornsby*, NSW, prepared by JFTA Engineering Services, ref. 7104766-R1a, July 2009 (JFTA, 2009);
- *'Contamination Assessment, Proposed New Building. Hornsby Ku-ring-gai Hospital, Lowe Road, Hornsby'*, ref 73224.01, January 2013 (DP, 2013a);
- *'UPSS Investigation, Hornsby Ku-ring-gai Hospital, Hornsby'*, ref 73224.03, August 2013 (DP, 2013b);
- *'Waste Classification Report, 109 Burdett Street, Hornsby'*, ref 73224.03, August 2013 (DP, 2013c);
- *'Report on Detailed Site Investigation, Hornsby Hospital Redevelopment, 109 Burdett Street, Hornsby'*, ref 73224.03, September 2013 (DP, 2013d); and
- *'Report on Preliminary Contamination Investigation and Preliminary Waste Classification, Hornsby Ku-Ring-Gai Hospital Redevelopment, Stages 1 and 2, Palmerston Road, Hornsby'*, ref 73224.07, August 2014 (DP, 2014).

[1] G Wilson, I D McDonald, P S Roy and C Herbert, Sydney 1:100,000 Geology Sheet Edition 1, 1983
[2] NSW Department of Lands, 2009. NSW 2m Elevation Contours

4.1 JFTA, 2009

The removal and validation of the UST was undertaken by JFTA in 2009..

The area of the storage tank was reported to be located adjacent to Building 18, in the southern end of the hospital grounds, adjacent to Burdett Street. The fuel infrastructure removal works were conducted on 27 and 28 May 2009, whilst validation and reinstatement of the excavations were conducted on 29 May and 1 June. Prior to any decommissioning works taking place, 11,900 L of unleaded petroleum was removed and disposed off-site. Fuel infrastructure comprised: a 25,000 L underground storage tank (observed to be in good condition, with no visible signs of corrosion); a single fuel dispenser; remote fill point; fuel transfer lines; vent pipe; and vent lines.

The final tank pit excavation measured 9 m x 3.5 m x 3.4 m deep (~110 m^3). 75 m^3 of imported fill material was brought to the site to account for the volume of the removed tank and concrete anchors. A total of 12 primary soil samples were collected from the tank pit excavations and from beneath the fuel dispenser, fill point, fuel transfer lines and vent lines. Excavated soils were sampled at three locations from the stockpiled material and a further two samples were collected from the imported fill material.

None of the soil samples were reported by the laboratory to have concentrations of chemicals of potential concern in exceedance of the selected validation criteria and therefore were considered suitable to remain on-site. All excavations were reinstated with a combination of validated excavated soils and imported fill material classified as virgin excavated natural material (VENM).

4.2 DP, 2013a

The contamination assessment was conducted for a proposed development that included the demolition of an existing single storey building for the construction of a new single storey pre-fabricated permanent building with adjacent on grade car park spaces and pedestrian footpaths. The assessment focussed on obtaining factual information on the ground conditions at the site. The proposed development is outside of the Site.

The sub-surface, based on five boreholes drilled across the 0.03 ha site, comprised silty sand topsoil and clayey sands underlain by sandstone. The analytical results were within adopted site assessment criteria (SAC) for the site with reported concentrations found to be within published background levels. A preliminary waste classification also demonstrated that the soils were within threshold criteria for General Solid Waste (non-putrescible).

4.3 DP, 2013b

The underground petroleum storage system (UPSS) investigation comprised testing in the immediate vicinity of a UPSS (also referred to as an underground storage tank (UST)) to assess for leakage / spillage from the UST located in the south east portion of the hospital grounds proposed for redevelopment for the ‘Main Building-STAR’. The UST was reported to no longer be in use at the time of the investigation and may have been decommissioned. As indicated in JFTA (2009) the UPSS had actually been removed and validated in 2009.

Four test bores were drilled hydraulically cross- and down-gradient of the former UST and one bore was converted into a groundwater monitoring well. No oil and or staining were observed in soils or groundwater recovered from the test bores, however slight hydrocarbon odours were noted in Borehole 101 (0.02-0.4 m). Despite this, all results were within the adopted site assessment criteria (SAC) and therefore the investigation did not detect any significant soil or groundwater contamination. Removal of the UST was recommended in accordance with Australian Standards with validation of the excavation pit also recommended (note that the JFTA report confirming removal of the UPSS had not been made available at the time).

The former UPSS sits outside of the Site and is not considered likely to impact on the contamination status of the Site.

4.4 DP, 2013c

The *in situ* waste classification was carried out for the proposed development of the 'Main Building-STAR' for the hospital at 109 Burdett Street (which sits outside the Site). Six bores were drilled across the area which was at the time occupied by a residential property that had been acquired for the hospital expansion. Areas beneath the house and carport were not accessed as part of the investigation.

Subsurface soils comprised silty sand with gravel filling underlain by clays and then low strength sandstone bedrock from 1.4 m to 2.0 m. Based on the total and leachable concentrations of all analytes, materials as described in the borehole logs were classified as General Solid Waste (non-putrescible). Furthermore, the concentrations of all analytes within natural soils were within background ranges and considered classifiable as virgin excavated natural material (VENM). The report recommended additional assessment within the footprint of the house, following demolition.

4.5 DP, 2013d

The report was titled *'Report on Detailed Site Investigation, Hornsby Hospital Redevelopment, 109 Burdett Street, Hornsby'*, dated September 2013 (DP, 2013d).

The proposed redevelopment (construction currently underway), which sits outside of the Site, involved the construction of a five-storey building with no basement level proposed. The investigation was undertaken in two stages, prior to demolition (six boreholes outside of the existing building footprint) and post demolition (three test pits within the building footprint).

Historical information was reviewed for the site and included aerial photographs of the hospital and surrounds, regulatory notices, title deeds for 109 Burdett Street, Hornsby, Section 149 certificates, council records and records on dangerous goods held by WorkCover NSW. Based on the review, two areas of environmental concern were identified and comprised minor fill at the site identified in previous reports and a former weatherboard cottage.

Results indicated that contaminants were within laboratory practical quantitation limits (PQL) for BTEX, OCP, OPP and PCB and detected levels of heavy metals, TRH, PAH and phenols were recorded within filling but below adopted health investigation / screening levels for commercial / industrial (hospital) use.

Visual identification of asbestos containing material (ACM) was made and asbestos fragments were detected within a test pit between depths of 0.0 m-0.2 m by the laboratory. As such, recommendation for removal of the surface impacted by ACM was made.

It was noted that the potential for surface water/groundwater contamination from on-site sources was considered negligible and therefore a groundwater assessment was not undertaken.

Based on the investigation findings, it was considered that the area was compatible with the proposed development subject to the report's recommendations.

4.6 DP, 2014

The report was titled *'Report on Preliminary Contamination Investigation and Preliminary Waste Classification. Hornsby Ku-Ring-Gai Hospital Redevelopment, Stages 1 and 2, Palmerston Road, Hornsby'*, ref 73224.07, August 2014.

The proposed redevelopment included demolition of the existing buildings and the construction of a Medical Imaging Building (1 to 3 storeys), Main Works Building (2 to 5 storeys), a northern extension to the existing HOPE Building and an on-grade car park. A future multistorey car park (2 to 5 storeys) was also to be considered.

Previous reports were reviewed for the site (see Sections 4.1 to 4.4) and a site inspection was completed, followed by intrusive soils sampling. Based on the review and site inspection, three potential sources of contamination were identified, being imported filling of unknown origin, storage / use of oils and fuel based equipment and hazardous building materials in existing buildings to be demolished.

The intrusive soil sampling comprised 14 boreholes which were either drilled or hand augered to depths of between 0.7 m and 9.3 m below ground level (bgl). The boreholes were positioned in accessible areas for geotechnical testing purposes. The borehole locations are shown on Drawing 1, Appendix B.

The subsoil profile found is summarised as:

Pavements: Asphalt (20 mm to 40 mm thick) underlain by roadbase gravel (170 mm to 370 mm thick) in BH101, BH103, BH106 and BH110 to BH113. Concrete slabs (120 mm and 140 mm thick) were intersected at the surface in BH104 and BH105;

Filling: Variably sand, silty sand, clay and gravelly clay filling in BH102, BH104, BH108, BH109 and BH114 to depths of between 0.2 m and 0.7 m;

Clayey Soil: Stiff and very stiff clay and gravelly clay extending to the top of weathered rock;

Bedrock: Extremely low to very low strength sandstone and shale with some low strength bands at depths of between 1.6 m (RL 177.5 m) and 3.1 m (RL 176.3 m) in all boreholes (excluding the hand-augered boreholes). Consistent medium, medium to high and high strength sandstone below depths of between 3 m (RL 176.9 m) and 6 m (RL 174.8 m).

PID readings were low for all soil samples tested and no free groundwater was measured in the boreholes.

The results indicated that whilst slight elevations of TRH (BH111, BH113) and PAH (BH101, BH104, BH106, BH111 and BH113) were detected, all results were within site assessment criteria for the proposed redevelopment works with the exception of sample BH114 within filling (0.2-0.3 m) where loose fibre bundles of chrysotile asbestos was identified. The volume of fibres detected was below the limit of reporting

Based on the field observations and laboratory results, the filling described in the borehole logs BH101-BH113 was preliminarily classified as General Solid Waste (non-putrescible). However, given the presence of asbestos fibres detected at BH114, it was recommended that further testing be conducted in the vicinity of BH114 to give an indication of the likely extent of asbestos contaminated soils and to confirm the above classification for areas between test locations. It was stated that further investigations for waste classification purposes may be most practicable to proceed following demolition of the existing structures on site.

Based on the field observations, the natural stiff clays and sandstone underlying the filling encountered at the test locations were considered to meet the definition of VENM provided that the material is not cross-contaminated, contains fill or other non-VENM material, or contains any signs of environmental or aesthetic concern. As such the natural clay and sandstone observed would be suitable for re-use on site or on other sites subject to prior approvals or consents from the receiving site and relevant authorities.

Overall, the PCI concluded:

'…The PCI consisted of a limited sampling programme within the footprint of the proposed redevelopment works. In conjunction with a review of previous site assessments conducted at Hornsby Hospital by DP, the analytical results indicate a low level of leachable contamination at the site, however, asbestos fibres were detected (below laboratory reporting limits) at BH114 within filling (0.2 m -0.3 m).

The extent of asbestos contamination may be limited to an area in the vicinity of BH114 and should be subject to further investigations in order to determine the lateral and vertical extent of asbestos contamination and the subsequent remediation action required in line with the proposed works to be undertaken in the affected area.

It is considered that further investigations should be undertaken following demolition of the current buildings on site. This would also allow increased accessibility to subsurface soils (preferably investigated using test pit methods) to ascertain the area impacted by asbestos at BH114. Furthermore, validation of the soils (and occupational hygienist clearance) following demolition is recommended given the potential to introduce contaminants (including asbestos) to surficial soils during this process.

Any buildings proposed for demolition and / or refurbishment should be subject to a pre-demolition hazardous building materials assessment by a qualified occupational hygienist.

It is noted that where the proposed development plans require deep excavations beyond the groundwater table, a groundwater assessment should be conducted…'

5. Contamination Summary and Data Gaps

The PCI identified the following three potential sources of contamination, being imported filling of unknown origin, storage / use of oils and fuel based equipment and hazardous building materials in existing buildings to be demolished.

Fourteen boreholes drilled across the investigation area identified only low levels of potential contaminants, however, asbestos fibres were detected (below laboratory reporting limits) at BH114 within filling (0.2 m - 0.3 m).

It is considered that further investigations should be undertaken following demolition of the current buildings on site, given that buildings occupy a large portion of the site, and the potential for the demolition process to impact on surface soils, if hazardous materials are present. The results of further investigation will determine which AEC require remediation in accordance with this RAP for the site to be suitable for the proposed hospital land use.

6. Conceptual Site Model

A conceptual site model (CSM) is a representation of site-related information regarding identified contamination sources, receptors and exposure pathways between those sources and receptors (linkages). A CSM provides a framework to identify potential contamination sources and how potential receptors may be exposed to contamination either in the present or the future (i.e. it enables an assessment of the potential source – pathway – receptor linkages).

A CSM has been established and developed to incorporate all the findings from the PCI. The CSM provided below is the developed CSM.

6.1 Potential Contamination Sources and Contaminants of Concern

Based on the information provided in the PCI, the identified potential sources, description of sources and contaminants of potential concern (COPC) at the site have been revised for the RAP and summarised as follows.

Table 1: Potential Contamination Sources and Contaminants of Concern

Potential Source	Description of Potential Contaminating Activity	Contaminants of Potential Concern
Imported fill of unknown origin	Fill material across the site identified in previous investigations and fill is likely to have been imported across the site for levelling purposes, in particular, the elevated park area proposed for extension of the HOPE Building.	Common contaminants associated with filling are metals, TPH, BTEX, PAH, PCB, OCP, OPP, phenol and asbestos (both fibrous and cemented forms).
Storage / use of oils and fuel based equipment	Minor staining observed on grounds associated with operation equipment and along the base of the northern wall of Building 47. Waste oil pit for storage of kitchen waste oil for collection.	TPH, PAH, BTEX, VOC, metals
Hazardous building materials in existing buildings to be demolished	A number of buildings will be demolished to make way for the proposed development. Given their age, some of the buildings are likely to contain asbestos, lead based paints and / or other hazardous materials.	Asbestos (both fibrous and cemented forms), lead, PCB

The potential contamination sources (S) on and adjacent to the site are therefore as follows:

S1 Filling;

S2 Storage/use of oils and fuel based equipment; and

S3 Existing buildings.

6.2 Potential Receptors

6.2.1 Human Health Receptors

R1 – Current site users (hospital staff, visitors and patients);

R2 – Construction and maintenance workers;

R3 – Final end users (hospital staff, visitors and patients); and

R4 – Adjacent users (predominantly residential and some commercial).

6.2.2 Environmental Receptors

R5 – Groundwater;

R6 – Surface Water (Cockle Creek); and

R7 – Ecology.

6.3 Potential Pathways

Potential pathways for contamination include the following:

P1 – Direct contact with soil (ingestion and dermal);

P2 – Inhalation of dust and/or vapours;

P3 – Leaching of contaminants and vertical mitigation into groundwater;

P4 – Surface water run-off;

P5 – Lateral migration of groundwater; and

P7 – Direct contact of contaminated ground with ecological receptors.

6.4 Summary of Preliminary CSM

A 'source–pathway–receptor' approach has been used to assess the potential risks of harm being caused to human, water or environmental receptors from contamination sources on or in the vicinity of the site, via exposure pathways. The possible pathways between the above sources (S1 to S3) and receptors (R1 to R7) are provided in Table 2 below.

Table 2: Conceptual Site Model

Source	Transport Pathway	Receptor	Risk management action recommended
S1: Filling Metals, TPH, BTEX, PAH, PCB, OCP, OPP, phenol and asbestos. S2: Storage / use of oils and fuel based equipment TPH, PAH, BTEX, VOC, metals	P1: Direct contact with soil (ingestion and dermal)	R1: Current site users R2: Construction and maintenance workers R3: Final end users	Further investigation is required to determine whether the asbestos fibres found in filling at BH114 is isolated or is indicative of widespread ACM impact in the filling across the Site. The further investigations are also recommended to more comprehensively assess the potential for contamination across the Site, including existing building footprints. Sampling should comply with the EPA sampling guidelines. Investigation following building demolition is required due to the potential for contamination resulting from the demolition.
	P2: Inhalation of dust and/or vapours	R1: Current site users R2: Construction and maintenance workers R3: Final end users R4: Adjacent users	
	P3: Leaching of contaminants and vertical mitigation into groundwater	R5: Groundwater	The nearest surface water, body Cockle Creek, is located approximately 0.5 km east of the site. Given that the hospital grounds are predominately paved with artificial drainage across the site, surface water run-off is likely to be intercepted by drainage lines. Furthermore, lateral migration to surface water would attenuate contaminants. Therefore, at this stage it is not considered that a complete exposure pathway exists between the Site and Cockle Creek.
	P4: Surface water run-off	R6: Surface water (Cockle Creek)	
	P5: Lateral migration of groundwater	R4: Adjacent Users (Residential and commercial) R6: Surface water (Cockle Creek)	
	P7: Direct contact of contaminated ground with ecological receptors.	R7: Ecology	Further investigation is required to determine whether the asbestos fibres found in filling at BH114 is isolated or is indicative of widespread ACM impact in the filling across the Site. The further investigations are also recommended to more comprehensively assess the potential for contamination across the Site, including existing building footprints. Sampling should comply with the EPA sampling guidelines. Investigation following building demolition is required due to the potential for contamination resulting from the demolition.
S3: Hazardous building materials Asbestos, lead, PCB	P1: Direct contact with soil	R2: Construction and maintenance workers	
	P2: Inhalation of dust	R1: Current site users R2: Construction and maintenance workers R3: Final end users R4: Adjacent users	

7. Further Investigations

Prior to any remediation/management options being undertaken, further investigations must be implemented to determine the locations and extents of soil contamination across the Site. The approximate area of Stage 2 (the Site) is approximately 2.6 hectares. Under the NSW EPA (1995) *Sampling Design Guidelines*, a total of 36 sampling locations is recommended for site characterisation. As part of the PCI, a total of 14 test locations have already been completed. The recommended investigations include the following:

- At the completion of building demolition, a qualified occupational hygienist is to undertake a walkover to identify any suspected ACM on the site surface. Such finds would be removed by a licensed asbestos management contractor, followed by a surface clearance from the hygienist. Such finds may result in additional targeted investigations beyond that outlined below;
- Two test locations in the vicinity of former BH114 to assess the potential extent of the asbestos find in BH114; and
- Twenty-two (22) additional test locations across the site to maximise site coverage. These include a combination of locations within and outside of existing.

The recommended locations for additional samples are shown on Drawing 2, Appendix B.

The recovered fill and natural soil samples from the above locations will be analysed in a NATA accredited laboratory for contaminants of concern as listed in Table 1.

Based on field observations an assessment of groundwater quality may also be undertaken.

At the completion of the abovementioned works, if asbestos is found to be present in fill soils, it may be possible to supplement the excavations through an assessment of asbestos concentrations in line with the *Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia* (WA DoH 2009), which is endorsed in NEPC (2013). The procedure would be targeted to areas in which asbestos has been identified and may determine that remediation is not required.

At the completion of the field investigations and laboratory testing, a detailed site investigation (DSI) report will be prepared with reference to the NSW EPA reporting guidelines, and as required under SEPP55.

The reported results of the DSI may trigger an amendment or addendum to this RAP.

8. Remediation Goals and Acceptance Criteria

8.1 Remediation Goal

The ultimate goal / objective of the remediation will be to render the Site compatible with the proposed hospital land use.

8.2 Extent of Remediation

The full requirements and extent of remediation at the Site is not known at this stage. However, on the basis of the previous investigations and on the experience of Douglas Partners Pty Ltd (DP) in investigation numerous hospital sites, it is anticipated that the following remediation requirements may eventuate at the Site:

- Asbestos in fill and/or surface soils; may be extensive or localised;
- Metals, TPH or PAH in fill; often associated with ash in fill (e.g. from hospital incinerators); again may be extensive or localised. The previous investigation results suggest this would not be widespread;
- Pesticides in surface soils in and around buildings; not likely to be significant, but possibly localised; and
- TPH in surface soils in areas used extensively by vehicles.

Other forms of contamination may be found through the proposed further investigations.

8.3 Assessment of Remediation Options

A number of remediation options were reviewed with reference to the principles and criteria defined in relevant documents, including, the following:

- NEPC, "*National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013*", 11 April 2013 (NEPC, 2013); and
- NSW EPA, Contaminated Site, "*Guidelines for the NSW Site Auditor Scheme 3rd Edition*", October 2017 (EPA, 2017).

NEPM (2013) states that the preferred hierarchy of options for site clean-up and/or management are as follows:

- On-site treatment of the contamination so that it is destroyed or the associated risk is reduced to an acceptable level; and
- Off-site treatment of excavated soil, so that the contamination is destroyed or the associated risk is reduced to an acceptable level, after which soil is returned to the site; or,

If the above are not practicable:

- Consolidation and isolation of the soil on site by containment with a properly designed barrier; and
- Removal of contaminated material to an approved site or facility, followed, where necessary, by replacement with appropriate material.

Or:

- Where the assessment indicates remediation would have no net environmental benefit or would have a net adverse environmental effect, implementation of an appropriate management strategy.

8.4 Remediation Options

Based on the assessed potential remediation requirements discussed in Section 8.2, the following remediation options were considered:

1. Off-site disposal of contaminated soils to a licensed landfill;
2. On-site strategic placement of the contaminated soils at a suitable depth within suitable areas of the site;
3. On-site treatment so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level; and
4. On-site management (i.e. delineation and capping) of the contaminated soils.

Opportunities and constraints associated with each option were assessed and are broadly summarised in the following sub sections.

8.4.1 Off-Site Disposal

Off-site disposal of contaminated soils comprises the excavation of the contaminated soils, waste classification of soil and disposal to a facility which can legally receive it. Based on previous results, all soils within the sampled areas were suitable for off-site disposal without treatment, subject to appropriate waste classification in accordance with the NSW EPA (2014) *Waste Classification Guidelines*. Based on the PCI, the fill soils in sampled areas were preliminarily classified as general solid waste (non-putrescible) with the exception of asbestos impacted soils at BH114.

Off-site disposal of ACM would involve removal of all ACM fragments and any underlying impacted soils, under an appropriate waste classification to a facility which can legally receive it.

Disposal of the contaminated soils or ACM off-site is technically a straight forward option and could be completed in a relatively short time scale prior to development of the site. The option would remove from the site any maintenance and risk legacy associated with each AEC.

Off-site disposal is, however, an expensive option and the total volume of material that would require disposal would need to be determined through the proposed further investigations and any subsequent delineation assessment.

8.4.2 On-Site Re-Use

On-site re-use involves excavation and placement of soils found that are not suitable for use under a certain land use (e.g. topsoil in an open space area) to another area of the Site in which the soils are suitable (e.g. beneath roads or building slabs). This process would generally be considered where only an ecological risk is determined to be an issue.

Over excavation of the proposed placement area may be required to achieve the proposed site levels. The soils may also need to be buried at depth to reduce the potential ecological risk.

On–site re-use (burial) is not a suitable remediation strategy for any soils which have been identified to present a potential risk to human health unless managed with an engineered designed containment cell with capping and associated environmental management plan (refer to Section 8.4.4).

8.4.3 On-Site Treatment

On-site treatment of metals in soil is technically feasible subject to the metal and the form in which it is present; options include soil washing, soil flushing and electrokinetic treatment. Usually only applicable in high concentrations and high volume, which is not likely to be the case at the Site.

Treatment of the petroleum contamination in soils is technically straight forward. The on-site remediation would generally comprise "landfarming" utilising micro-organisms naturally found in soils to reduce TRH concentrations and in accordance with NSW EPA *Best Practice Note: Landfarming*, April 2014.

Treatment of non-petroleum related PAH in soils is technically feasible, e.g. by direct fired thermal desorption, although treatment trials would need to be conducted to confirm the suitability of the subject material for treatment and costs to treat soil using this method can be high.

Treatment of asbestos contaminated soil can be conducted by hand picking ACM fragments, but is not possible for soil impacted by friable asbestos.

The advantages of the above on-site treatment options are the potential for reduction of concentrations of the contaminants to levels suitable for re-use on the site with minimal, if any, future management requirements. However, the above on-site treatment options would be comparatively expensive for the anticipated volumes, may be time consuming and may occupy large areas of the site during treatment.

8.4.4 Capping and Containment

Capping and containment would involve the excavation and creation of an engineered containment cell followed by the placement of contaminated materials within the containment cell. A physical barrier over the cell would be required to minimise the potential for exposure to contaminated materials. The strategy would reduce the requirement for any off-site disposal with non-leachable contaminated soil placed within the containment cell.

The geotechnical suitability of the placed material would also need to be considered if the cell was located within a proposed building footprint or beneath a road.

The containment cell would require an associated environmental management plan (EMP) and notice on title. Natural material generated during the excavation of the cell could be used to reinstate site levels (i.e. forming the capping medium).

The physical barrier typically comprises either a hardstand (e.g. concrete slab) or a suitable thickness of validated and compacted soil (with various surface treatments depending on the land use).

8.5 Preferred Remediation Strategy

Following discussions with APP, and in consideration of the options and hierarchy discussed in Sections 8.3 and 8.4, the preferred remediation strategy is as follows:

- Relocation of soils from an environmentally unsuitable location to a suitable location, based on ecological risk; and
- On site containment and capping of soils with non-leachable contaminants.

If either of the above options are not viable, then off-site disposal under an assigned waste classification will be adopted as a contingency.

9. Remediation Acceptance Criteria

The remediation works will be validated as meeting an acceptable standard for the proposed hospital land use. The validation protocols will be dependent on the remediation strategies adopted, and will comprise visual inspection, field screening, sample analysis and review of disposal dockets (if disposed off site) as discussed in Section 10.

The remediation acceptance criteria (RAC) for the identified COPC are based on the health investigation levels (HIL), health screening levels (HSL), ecological investigation levels (EIL) and ecological screening levels (ESL) provided in DP (2014) which were established in accordance with Schedule B1 of NEPC (2013).

The RAC are informed by the CSM which identified human and ecological receptors to potential contamination on the site. Analytical results will be assessed (as a Tier 1 assessment) against the site assessment criteria (SAC) comprising the investigation and screening levels of Schedule B1, NEPC (2013). The NEPC guidelines are endorsed by the EPA under the CLM Act 1997. Petroleum based health screening levels for direct contact have been adopted from the *Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE) Technical Report no.10 Health screening levels for petroleum hydrocarbons in soil and groundwater* (2011) as referenced by NEPC (2013).

The investigation and screening levels are applicable to generic land use settings and include consideration of, where relevant, the soil type and the depth of contamination. The investigation and screening levels are not intended to be used as clean up levels. Rather, they establish concentrations above which further appropriate investigation (e.g. Tier 2 assessment) should be undertaken or where certain land-uses may be more suitable. They are intentionally conservative and are based on a reasonable worst-case scenario.

The SAC will also be used for the assessment of analytical data obtained through the further investigations recommended in Section 8.

9.1 Soils Site Assessment Criteria

9.1.1 Health Investigation Levels

The Health Investigation Levels (HIL) and Health Screening Levels (HSL) are scientifically-based, generic assessment criteria designed to be used in the first stage (Tier 1) of an assessment of potential human health risk from chronic exposure to contaminants.

HIL are applicable to assessing health risk arising *via* all relevant pathways of exposure for a range of metals and organic substances. The HIL are generic to all soil types and apply generally to a depth of 3 m below the surface. Site-specific conditions may determine the depth to which HILs apply for other land uses.

HSL are applicable to selected petroleum compounds and fractions to assess the risk to human health via inhalation and direct contact pathways. HSL have been developed for different land uses, soil types and depths to contamination.

The generic HIL and HSL are considered to be appropriate for the assessment of contamination at the site. Given the proposed land use and based on the CSM the adopted HIL and HSL are:

- **HIL-B & HSL-B** – residential end use with minimal access to underlying soils for limited parts of the site which may be used for patients and families who require extended periods at the hospital;
- **HIL-C & HSL-C** - public open space (for areas to be landscaped);
- **HIL-D & HSL-D** - commercial and industrial end use (continuation of present use), and intrusive maintenance workers (also representing construction workers) and
- **HSL** – Intrusive Maintenance Worker (shallow trench).

Health screening levels for the vapour intrusion pathway have been conservatively adopted.

Table 3 shows the HILs that have been adopted by NEPC (2013) Schedule B1, Table 1A(1). Table 3 only includes contaminants to be analysed during the further investigations, not the full list provided in NEPC (2013).

Table 3: Health Investigation Levels

Contaminant	HIL B – Residential (mg/kg)	HIL C – Open Space (mg/kg)	HIL D – Industrial/ Commercial (mg/kg)
Metals and Inorganics			
Arsenic	500	300	3000
Cadmium	150	90	100
Chromium (IV)	500	300	3600
Copper	30,000	17,000	240,000
Lead	1200	600	1,500
Mercury (inorganic)	120	80	730
Nickel	1200	1200	6,000
Zinc	60,000	30,000	400,000
PAH			
Carcinogenic PAH (as benzo(a)pyrene TEQ) [1]	4	3	40
Total PAH	400	300	4000
Phenols			
Pentachlorophenol (used as an initial screen)	45,000	40,000	240,000
OCP			
DDT + DDD + DDE	600	400	3600
Aldrin + Dieldrin	10	10	45
Chlordane	90	70	530
Endosulfan (total)	400	340	2000
Endrin	20	20	100
Hepatchlor	10	10	50
HCB	15	10	80
Methoxychlor	500	400	2500
Other Pesticides			
Chlorpyrifos	340	250	2000
Other Organics			
PCB [2]	1	1	7

Notes:

1 sum of carcinogenic PAH

2 non dioxin-like PCBs only.

Table 4 shows petroleum hydrocarbon compounds adopted from NEPC (2013) Schedule B1, Table 1A(3). The HSLs are based on overlying soil type and depth. HSLs for sand have been used based on the sandy clay fill material encountered at the site in the previous boreholes. Given the general depth of fill encountered in the investigation during the intrusive works, and using the most conservative values, the depth range of 0 m to <1 m has been used.

Table 4: Soil Health Screening Levels for Vapour Intrusion

Contaminant	Soil Type	HSL B – Residential (mg/kg)	HSL C – Open Space (mg/kg)	HSL D – Industrial Commercial (mg/kg)	HSL – Intrusive Maintenance Worker
		Depth 0 m to <1m	Depth 0 m to <1m	Depth 0 m to <1m	Depth 0 m to <1m
Toluene	Sand	160	NL	NL	NL
Ethylbenzene		55	NL	NL	NL
Xylenes		40	NL	230	NL
Naphthalene		3	NL	NL	NL
Benzene		0.5	NL	3	77
TRH C_6-C_{10} less BTEX [F1]		45	NL	260	NL
TRH >C_{10}-C_{16} less naphthalene [F2]		110	NL	NL	NL

9.2 Ecological Investigation and Screening Levels

Ecological Investigation Levels (EIL) have been derived for selected metals and organic compounds and are applicable for assessing risk to terrestrial ecosystems (NEPC, 2013). EIL depend on specific soil physiochemical properties and land use scenarios and generally apply to the top 2 m of soil, which corresponds to the root zone and habitation zone of many species. The EIL is determined for a contaminant based on the sum of the ambient background concentration (ABC) and an added contaminant limit (ACL). The ABC of a contaminant is the soil concentration in a specific locality that is the sum of naturally occurring background levels and the contaminants levels that have been introduced from diffuse or non-point sources (e.g. motor vehicle emissions). The ACL is the added concentration (above the ABC) of a contaminant above which further appropriate investigation and evaluation of the impact on ecological values is required.

The EIL is calculated using the following formula:

EIL = ABC + ACL

The ABC is determined through direct measurement at an appropriate reference site (preferred) or through the use of methods defined by Olszowy et al *Trace element concentrations in soils from rural and urban areas of Australia*, Contaminated Sites monograph no. 4, South Australian Health Commission, Adelaide, Australia 1995 (Olszowy, 1995) or Hamon et al, *Geochemical indices allow estimation of heavy metal background concentrations in soils*, Global Biogeochemical Cycles, vol. 18, GB1014, (Hamon, 2004). ACL is based on the soil characteristics of pH, CEC and clay content.

EIL (and ACLs where appropriate) have been derived in NEPC (2013) for only a short list of contaminants comprising As, Cu, Cr (III), DDT, naphthalene, Ni, Pb and Zn. An *Interactive (Excel) Calculation Spreadsheet* may be used for calculating site-specific EIL for these contaminants, and has been provided in the ASC NEPM Toolbox available on the SCEW (Standing Council on Environment and Water) website (http://www.scew.gov.au/node/941).

The adopted EIL, derived from the *Interactive (Excel) Calculation Spreadsheet* are shown in the following Table 5. The following site specific data and assumptions have been used to determine the EILs:

- The EILs will apply to the top 2 m of the soil profile;
- Given the likely source of soil contaminants (i.e. historical site use/fill) the contamination is considered as "aged" (>2 years); and
- ABCs have been derived using the *Interactive (Excel) Calculation Spreadsheet* using input parameters of aged soil, CEC of 2.4 $cmol_c$/kg and pH of 7 with high traffic and clay content of 15%.

Table 5: Ecological Investigation Levels (EIL) in mg/kg

Analyte		EIL Residential Open Space	EIL Commercial Industrial	Comments
Metals	Arsenic	100	160	Adopted pH of 7 and CEC of 2.4 $cmol_c$/kg]; assumed clay content 15% High traffic area (NSW)
	Chromium III	200	320	
	Copper	65	80	
	Lead	1100	1800	
	Nickel	9	10	
	Zinc	240	300	
PAH	Naphthalene	170	370	

Ecological Screening Levels (ESL) are used to assess the risk of selected petroleum hydrocarbon compounds, BTEX and benzo(a)pyrene to terrestrial ecosystems. ESL apply to the top 2 m of the soil profile as for EIL.

ESL have been derived in NEPC (2013) for petroleum fractions F1 to F4 as well as BTEX and Benzo(a)pyrene. Site specific data and assumptions as summarised in Table 6 have been used to determine the ESL. The more conservative soil type of coarse sand has been adopted. The adopted ESL, from Table 1B(6), Schedule B1 of NEPC (2013) are shown in Table 7.

Table 6: Inputs to the Derivation of ESL

Variable	Input	Rationale
Depth of ESL application	Top 2 m of the soil profile	The top 2 m depth below ground level corresponds to the root zone and habitation zone of many species.
Land use	Range of uses	Hospital
Soil Texture	Coarse	Based on findings noted in previous test bore logs

Table 7: Ecological Screening Levels (ESL) in mg/kg

Analyte		ESL (Residential and open space)	ESL (Industrial Commercial)	Comments
TRH	C6 – C10 (less BTEX) [F1]	180*	215	All ESLs are low reliability apart from those marked with * which are moderate reliability
	>C10-C16 (less Naphthalene) [F2]	120*	170*	
	>C16-C34 [F3]	300	1700	
	>C34-C40 [F4]	2800	3300	
BTEX	Benzene	50	75	
	Toluene	85	135	
	Ethylbenzene	70	165	
	Xylenes	105	180	
PAH	Benzo(a)pyrene	0.7	1.4	

9.3 Management Limits

NEPC (2013) Table 1B(7) provides 'management limits' for TRH fractions, which are applied after consideration of relevant HSLs. The management limits have been adopted to avoid or minimise the following potential effects of petroleum hydrocarbons:

- Formation of non-aqueous phase liquids (LNAPL);
- Fire and explosive hazards; and
- Effects on buried infrastructure e.g. penetration of, or damage to, in-ground services by hydrocarbons.

The presence of site TRH contamination at the levels of the management limits does not imply that there is no need for administrative notification or controls in accordance with jurisdictional requirements. The adopted management limits are shown in Table 8 and have been selected based on the CSM.

Management limits for coarse material are presented in Table 8, since variable clay textures were encountered in the fill samples collected, and coarse texture management limits are more conservative of the two management limits available.

Table 8: Management Limits for TRH Fractions in Soil

TRH Fraction	Soil Texture	Management Limit: Residential / Open Space (mg/kg)	Management Limit: Industrial Commercial (mg/kg)
C_6-C_{10} [F1]	Coarse	700	700
>C_{10}-C_{16} [F2]	Coarse	1,000	1,000
>C_{16}-C_{34} [F3]	Coarse	2,500	3,500
>C_{34}-C_{40} [F4]	Coarse	10,000	10,000

9.4 Asbestos in Soil

Bonded asbestos-containing material (ACM) is the most common form of asbestos contamination across Australia, generally arising from:

- Inadequate removal and disposal practices during demolition of buildings containing asbestos products;
- Widespread dumping of asbestos products and asbestos containing fill on vacant land and development sites;
- Commonly occurring in historical fill containing unsorted demolition materials; and
- Importation of asbestos contaminated building products from China.

Mining, manufacturing or distribution of asbestos products may result in sites being contaminated by friable asbestos including free fibres. Severe weathering or damage to bonded ACM may also result in the formation of friable asbestos comprising fibrous asbestos (FA) and/or asbestos fines (AF).

Asbestos only poses a risk to human health when asbestos fibres are made airborne and inhaled. If asbestos is bound in a matrix such as cement or resin, it is not readily made airborne except through substantial physical damage. Bonded ACM in sound condition represents a low human health risk, whilst both FA and AF materials have the potential to generate, or be associated with, free asbestos fibres. Consequently, FA and AF must be carefully managed to prevent the release of asbestos fibres into the air.

The SAC to be adopted for the assessment of asbestos in the initial further investigation is no asbestos detected at the laboratory reporting limit of 0.1 g/kg.

NEPC (2013) Table 7 provides HSL (w/w) for forms of asbestos in soil, dependent on land use as follows:

- Bonded ACM – 0.01% w/w (residential B); 0.02% (open space); 0.05% (commercial);
- FA and AF (friable asbestos) – 0.001% (all land uses); and

- All forms of asbestos – No visible asbestos for surface soil.

These SAC will be adopted where investigations according to WA DoH (2009) are undertaken.

9.5 Groundwater Site Assessment Criteria

9.5.1 Groundwater Investigation Levels

The Groundwater Investigation Levels (GIL) listed in NEPC (2013) are based on:

- *National water quality management strategy. Australian and New Zealand guidelines for fresh and marine water quality* 2000 (ANZECC & ARMCANZ); and
- *Drinking Water Guidelines*.

The ANZECC *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000) trigger values for toxicants in freshwater for the protection of 95% of species (where available) will be adopted.

The adopted GIL for the analytes included in the investigation, and the corresponding source documents, are shown in Table 9.

Table 9: Groundwater Investigation Levels (in µg/L unless otherwise stated)

Analyte		NEPC (2013)	
		Fresh Water	Drinking Water
Metals	Arsenic (V)	13 as As (V)	10 (Arsenic)
	Cadmium	0.2	2
	Chromium (VI)	1	50
	Copper	1.4	2,000
	Lead	3.4	10
	Mercury (total)	0.06	1
	Nickel	11	20
	Zinc	8	-
PAH	Benzo(a)pyrene	0.1 [c]	0.01
	Naphthalene	16	-
	Anthrancene	0.01 [c]	-
	Phenanthrene	0.6 [c]	-
	Fluoranthene	1 [c]	-

Analyte		NEPC (2013)	
		Fresh Water	Drinking Water
OCP	Heptachlor	0.01	-
	Aldrin + Dieldrin	-	0.3
	Aldrin	0.001 [c]	-
	Dieldrin	0.01 [c]	-
	DDE	0.03 [c]	-
	Lindane	0.2	10
	Chlordane (trans + cis)	0.03	2
	DDT	0.006	9
	Endrin	0.01	-
	Endosulphan	0.03	20
PCB	Total PCB	-	-
	Aroclor 1221	1 [c]	-
	Aroclor 1232	0.3 [c]	-
	Aroclor 1242	0.3	-
	Aroclor 1248	0.03 [c]	-
	Aroclor 1254	0.01	-
Phenols	Phenol	320	-
TPH	C6-C9	150 [f]	150 [f]
	C10-C36	600 [f]	600 [f]
	C6-C10 – BTEX (F1)	-	-
	C10-C16 – Naphthalene (F2)	-	-
MAH	Benzene	950	1
	Toluene	180 [c]	800
	Ethylbenzene	80 [c]	300
	o-xylene	350	600 (xylene)
	m-xylene	75 [c]	
	p-xylene	200	
	Styrene	-	30

Analyte		NEPC (2013)	
		Fresh Water	Drinking Water
VOC	Chloroethene (vinyl chloride)	100 [c]	0.3
	1,1-Dichloroethene	700 [c]	30
	1,2-Dichloroethene	-	60
	Tetrachloroethene (PCE)	70 [c]	50
	Chloroform	370 [c]	3
	Dichloromethane	4,000 [c]	4
	Carbon Tetrachloride	240 [c]	3
	1,1-Dichloroethane	90 [c]	-
	1,2-Dichloroethane	1,900 [c]	3
	1,1,1-Trichloroethane	270 [c]	-
	1,1,2-Trichloroethylene	330 [c]	-
	1,1,2,2-Tetrachlorethane	400 [c]	-
	1,3-Dichlorobenzene	260	-
	Chlorobenzene	5 [c]	300
	1,4-Dichlorobenzene	60	40
	1,2-Dichlorobenzene	160	1,500
	1,2,4-Trichlorobenzene	85	30 (trichlorobenzene)
	1,2,3-Trichlorobenzene	3	
	1,3,5-Trichlorobenzene	8,000 [c]	

Notes:

a: ANZECC & ARMCANZ (2000) Trigger Values for a slightly to moderately disturbed system
b: NHMRC & NRMMC (2011) drinking water criteria (health)
c: insufficient data for reliable trigger value; interim working value or low reliability value used
d: based on aesthetics
e: based on pH 8; refer to ANZECC (2000) for changes to GILs based on pH
f: Airport (Environment Protection) Regulations (1997), Schedule 2 Water Pollution Accepted Limits: Table 1.03 - Accepted Limits of contamination.

9.5.2 Health Screening Levels – Petroleum Hydrocarbons

The generic HSLs published in NEPC (2013) and CRC CARE (2011) are considered to be appropriate for the assessment of contamination in groundwater at the site. Given the proposed land use the adopted HSL are:

- **HSL B** – high density residential;
- **HSL C** – public open space;
- **HSL-D** – Commercial and Industrial; and
- **HSL** - Intrusive Maintenance Worker (shallow trench).

In addition, the HSL adopted is predicated on the following inputs prescribed in Table 10.

Table 10: Inputs to the Derivation of HSLs

Variable	Input	Rationale
Potential exposure pathway	Vapour intrusion (inhalation) with contaminated groundwater as the source	
Soil Type	Sand	The previous intrusive investigations on site show a subsurface comprised predominantly of clay and sandy clays.
Depth to contamination	*2 m to <4 m*	Used as an initial screen. The detection of volatile contaminants in the groundwater may trigger a site specific risk assessment given the proposed basement depths.

The adopted groundwater HSL for vapour intrusion, from Table 1A(4), Schedule B1 of NEPC (2013) are shown in the following Table 11.

Table 11: Groundwater Health Screening Levels (HSL) for Vapour Intrusion (µg/L)

Analyte		HSL-B	HSL-C	HSL-D	HSL – Intrusive Maintenance Worker
TRH	C_6 – C_{10} (less BTEX) [F1]	1000	NL	6000	NL
	>C_{10}-C_{16} (less Naphthalene) [F2]	1000	NL	NL	NL
BTEX	Benzene	800	NL	5000	NL
	Toluene	NL	NL	NL	NL
	Ethylbenzene	NL	NL	NL	NL
	Xylene	NL	NL	NL	NL
PAH	Naphthalene	NL	NL	NL	NL

Note: *NL – Not limiting.*

9.6 Waste Classification Criteria

The waste classification was conducted with reference to the NSW Environment Protection Authority (EPA) *Waste Classification Guidelines* November 2014 (EPA, 2014).

10. Remediation Strategy

The detailed procedures and sequence for the remediation work will rest with the contractor and will depend upon the equipment to be used and the overall sequence of the remediation or development. The proposed remediation strategy is based on the assumed remediation requirements outlined in Section 8.2. The strategy may be modified on the basis of the outcome of the investigations recommended in Section 7.

This section therefore provides an outline of the remediation strategy likely to be implemented as discussed in Section 8.

Any asbestos remediation works must be undertaken by an appropriately licensed asbestos remediation contractor and in accordance with *Work Health and Safety Regulation NSW 2011* and any other applicable WorkCover NSW or Safe Work Australia regulations or guidelines.

10.1 Site Establishment

Prior to the implementation of remediation, the site is to be established in accordance with all NSW legislative requirements.

A qualified and experienced environmental consultant must be engaged to oversee the remediation works, for compliance with the RAP, and to validate the successful completion of remediation. If friable asbestos is found at the site, a qualified and experienced occupational hygienist must also be engaged to provide monitoring services during works involving asbestos.

For all works requiring an A asbestos removal license, air quality monitoring for airborne asbestos fibres should be conducted on a daily basis when works involving the excavation and transport of asbestos and potential asbestos impacted soils are being conducted within the site. The environmental consultant is to conduct the air quality monitoring or manage the works through an experienced contractor. Air quality monitoring must be undertaken by a licenced asbestos assessor for all works requiring a Class A asbestos removal license (i.e. friable asbestos).

If required by the occupational hygienist, a decontamination unit will be set up at the site.

The occupational hygienist will also advise on dust suppression.

10.2 Delineation for Remediation

Prior to commencing with the remedial excavation of soils, the environmental consultant will establish the identity and extent of each area of environmental concern (AEC) to be remediated under the RAP, following completion of the additional investigations outlined in Section 7.

Validation of the remediation excavation and former locations of ACM will be undertaken in accordance with Section 12. A survey of the final remediation excavation areas and depths of any related excavations is to be undertaken and provided to the environmental consultant prior to final validation.

10.3 Relocation of Soils

As discussed in Section 8, where possible relocation of soils from an environmentally unsuitable location to a suitable location, based on ecological risk, will be undertaken, provided the space and the remediation program permits. Soils impacted by contaminants exceeding EIL or ESL only may be suitable for this process, and these soils will be identified by the environmental consultant, as per Section 10.2.

The environmental consultant, in discussion with the client, will identify areas of the site that may be suitable for the placement of these soils. Once determined, the impacted soils will be excavated and placed within the nominated areas at the site, and where possible at a minimum 2 m below as constructed surface levels. Appropriate geotechnical controls and testing will be considered as part of the placement and burial.

Validation of the remediation excavation or former locations of the soils impacted by contaminants exceeding EIL or ESL only will be undertaken in accordance with Section 12. A survey of the final remediation excavation areas and final burial areas, including the depth of cover, is to be undertaken and provided to the environmental consultant prior to final validation.

10.4 Contain and Capping

As discussed in Section 8, on site containment and capping of soils with non-leachable contaminants is one the preferred remediation strategies. This option will typically be viable for contaminants including asbestos, PAH and metals, provided there is sufficient information to establish that the contaminants are not likely to leach.

These soils will be identified by the environmental consultant through the investigations recommended in Section 7, and as per Section 10.2.

The environmental consultant, in discussion with the client, will identify areas of the site that may be suitable for the placement of these soils. The selected areas would need to be prepared to allow for the volume of impacted soils to be placed, and the physical surface barrier to be formed. The selected areas will be those least likely to be subjected to future maintenance or other forms of intrusive access into the future.

Once determined, the impacted soils will be excavated and placed within the nominated and prepared areas at the site, with the physical barrier system (capping system) formed over. Appropriate geotechnical controls and testing will be considered as part of the placement and burial. Typical physical barrier systems for various final end uses are shown on Drawing 3, Appendix B.

Materials used in the capping layers for soil capping strategies will comprise only soils approved by the environmental consultant. These may include site won soils or imported soils classifying as VENM or appropriate for land application under a Resource Recovery Order (RRO) issued by the EPA.

Validation of the remediation excavation or former locations of the soils impacted by contaminants will be undertaken in accordance with Section 12. A survey of the final remediation excavation areas and

final burial and capping areas, including the depth of cover, is to be undertaken and provided to the environmental consultant prior to final validation.

A long term EMP will be prepared by the environmental consultant to ensure the integrity of the physical barrier system into the future.

10.5 Landfill Disposal Contingency

If contaminated materials are found at the Site and these materials are not suitable for the preferred remediation strategy (e.g. potentially leachable) then the off-site landfill disposal contingency will be enacted.

Material requiring disposal from the site will require waste classification in accordance with EPA (2014). Materials are to be sampled at a typical frequency of 1 sample per 100 m^3, or three samples per stockpile, or as directed by the environmental consultant.

All materials excavated and removed from the site as part of the remediation shall be disposed in accordance with the POEO Act, 1997 and to a facility / site legally able to accept the material, under the waste classification assigned. Copies of all necessary approvals from the receiving site shall be given to the Principal prior to any contaminated material being removed from the site.

Details of all contaminated and spoil materials removed from the site as part of the remediation and a record of the disposal of materials will be maintained and documented by the contractor with copies of weighbridge slips, trip tickets and consignment disposal confirmation (where appropriate) provided to the environmental consultant and the Principal. A site log will be maintained by the contractor to track disposed loads against on-site origin.

Validation of the remediation excavation or former locations of the soils impacted by contaminants will be undertaken in accordance with Section 12.

10.6 Contingency for Unexpected Findings

If unexpected conditions are encountered during the remediation (such as buried tanks, unexpected contaminated soil or contaminants including additional ACM), the following general approach will be adopted:

- Stop work in the area of impact and barricade area to prevent access;
- The remediation contractor is to contact the principal and the environmental consultant;
- The environmental consultant will make an assessment of the severity of the find in terms of the potential impact to human health and the environment;
- The environmental consultant will liaise with the principal as required;
- The environmental consultant will provide advice to the principal regarding the recommended course of action;
- The remediation contractor is to implement the agreed management / remedial strategy.

11. Validation Plan

11.1 Validation Data Quality Objectives (DQO)

The objective of the validation plan is to assess the results of post remediation testing against the RAC stated within this RAP and to provide information on environmental impacts which may have resulted from the works.

The validation assessment will be conducted in accordance with Data Quality Objectives (DQOs) and Quality Assurance / Quality Control (QA/QC) procedures to demonstrate the repeatability and reliability of the results.

The following DQOs will be adopted based on those provided in Section 9 and Schedule B2 of NEPC (2013). The DQO process is outlined as follows:

- State the Problem;
- Identify the Decision;
- Identify Inputs to the Decision;
- Define the Boundary of the Assessment;
- Develop a Decision Rule;
- Specify Acceptable Limits on Decision Errors; and
- Optimise the Design for Obtaining Data.

A checklist of Data Quality Indicators (DQI) will be completed as part of the validation assessment.

11.2 Validation of Remedial Excavations

Following the removal of impacted soils from an AEC, the environmental consultant will validate the remedial excavation footprint as follows:

1. Visual inspection of remedial excavation;
2. Sampling and analysis of the soil by the environmental consultant with reference to NEPC (2013) and guidelines as follows:
    - For small to medium excavations (base <500 m^2):
        - Base of excavation: one sample per 25-50 m^2 or part thereof; and
        - Sides of excavation: one sample per 10-20 m length or part thereof. Additional samples will be collected at depths of concern where there is more than one depth of concern (e.g. multiple filling horizons).
    - For Large excavations (>500 m^2):
        - Base of excavation: sampling on a grid at a density in accordance with the EPA *Contaminated Sites: Sampling Design Guidelines* (1995); and

- Sides of excavation: one sample per 20 m length or part thereof. Additional samples will be collected at depths of concern where there is more than one depth of concern (e.g. multiple filling horizons).

3. Analysis of collected samples for COC respective specific each AEC;
4. Where the reported concentration of the COC are greater than the RAC, further chase out of that location will be required and steps 1 to 3 will be repeated. The additional soil generated during the chase out will require remediation with reference to Section 10 specific to the AEC; and
5. A survey of the final remediation excavation areas is to be undertaken and provided to the environmental consultant prior to final validation.

Development works within the site (other than remediation works detailed in this RAP) should only progress following written confirmation by the environmental consultant.

11.3 Validation of Areas of Relocated Soils

The validation of areas to which soils (exceeding EIL or ESL) are relocated will be undertaken as follows:

- The environmental consultant will observe and record the location of the area(s) prior to placement;
- The boundaries and reduced levels of each burial area will be surveyed prior to the placement;
- The boundaries and reduced levels of each area will be taken after the placement of the relocated soils; and
- The environmental consultant will observe and record the placement in each area at completion.

The observations and survey information will form part of the final validation report.

11.4 Validation of Containment and Capping

The validation of areas to which contaminated soils are contained and capped will be undertaken as follows:

- The environmental consultant will observe and record the location of the area(s) prior to placement of any contaminated soils;
- The boundaries and reduced levels of each burial area will be surveyed prior to the placement;
- The contaminated soils will be relocated to the defined containment areas via a designated haulage route;
- The environmental consultant will observe, and survey levels will be taken at the following hold points:
- At completion of placement of the contaminated soils;
- At the laying of the marker layer (observation only); and
- At the completion of the construction of the physical barrier system.

The observations and survey information will form part of the final validation report.

11.5 Quality Assurance Plan

11.5.1 Sample Collection and Handling

The general sampling procedures comprise:

- The use of stainless steel or disposable sampling equipment;
- Decontamination of sampling equipment prior to the collection each sample;
- Labelling of the sample containers with individual and unique identification including Project No. and Sample No.; and
- The use of chain-of-custody documentation so that sample tracking and custody can be cross-checked at any point in the transfer of samples from the field to hand-over to the laboratory.

11.5.2 Field QA/QC

Appropriate sampling procedures will be undertaken to prevent cross contamination. These include:

- Standard DP operating procedures are followed;
- Replicate field samples are collected and analysed;
- Samples are stored under secure, temperature controlled conditions;
- Chain-of-custody documentation is employed for the handling, transport and delivery of samples to the selected laboratory; and
- Proper disposal of contaminated soil, fill or surface water originating from the site.

11.5.3 Laboratory Quality Assurance and Quality Control

A NATA accredited laboratory will be used to conduct analysis. As discussed in Table 1, for consistency with previous investigations, Envirolab Services Pty Ltd must be used as the analytical laboratory for asbestos analysis.

11.5.4 Achievement of Data Quality Objectives

Based on fulfilment of the data quality objectives, an assessment of the overall data quality will be presented in the final validation report.

11.6 Validation Reporting

A validation assessment report will be prepared by the environmental consultant in accordance with EPA NSW *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites* (2011). The objective of the validation report will be to confirm that the site has been remediated to a suitable standard for the proposed redevelopment and that no related adverse human health and

environmental effects have occurred as a result of the works. The validation report will also include a summary of the information from previous investigations.

The validation report will include:

- Documentation of the implementation of the Remedial Strategy;
- Details of the location and total estimated volume of materials excavated and replaced within the site and volume of material removed from the site for disposal as well as the tonnages reported by the licensed landfill;
- Photographic record during the works and of final excavations;
- Survey records of excavations and final levels after fill placement and physical barrier construction;
- Drawings showing contamination assessment sample locations and validation sample locations;
- Detailed analytical results;
- Details of materials imported to the site, as required; and
- Details, including survey records, of the final cover (physical barrier).

12. Site Management Plan

It is the responsibility of the contractor to develop a Site Management Plan detailing site management, environmental management and workplace health and safety (WH&S) plans for the site. This section provides a brief summary of some of the items which need to be included in the Contractor's plans.

Works shall comply with all legislative requirements including, but not limited, to those set out under the following legislation and guidance (and subsequent amendments and regulations):

- *Environmentally Hazardous Chemicals Act 1985* (NSW);
- *Environmental Offences and Penalties Act 1989* (NSW);
- *Protection of the Environment Operations Act (POEO) 1997* (NSW);
- *Protection of the Environment Operations Act 1997 (including POEO Amendment (Scheduled Activities and Waste) Regulation 2008)* (NSW);
- *Work Health and Safety Act 2011* (NSW);
- *How to manage and control asbestos in the workplace Code of Practice*, Safework Australia, 2011a;
- *How to safely remove asbestos Code of Practice*, Safework Australia, 2011b;
- *Code of Practice for the Management and Control of Asbestos in Workplaces*, NOHSC:2018, 2005; and
- *Code of Practice for the Safe Removal of Asbestos 2nd edition*, NOHSC: 2002, 2055.

All remediation works detailed in this RAP are to be conducted by an appropriately Licenced Asbestos Contractor in accordance with the requirements of NSW WorkCover (2008) *Working with Asbestos – Guide 2008*.

12.1 Site Operations

The schedule of remedial works, including timing and staging is to be prepared by the contractor to meet the requirements of this RAP.

Remediation works will be restricted to the approved construction hours for the site.

It is the site owner / developers responsibility to ensure that appropriate personnel are appointed to manage and conduct the remediation and validation works. This will include:

- The principal's representative (PR), who is responsible for overseeing the implementation of this RAP;
- A head contractor, who will be responsible for conducting the remedial works and managing the site; and
- An environmental consultant, who will be responsible for providing advice as required for the remedial works and undertaking the validation works in accordance with this RAP.

Other parties who may be employed to assist in the implementation of this RAP include, but are not limited to, occupational hygienist(s) and asbestos licensed contractor(s).

The PR will be responsible for preparing a list of contacts for the works. The head contractor will be responsible for preparing a list of contacts, including emergency contacts for site operations and provision of signage at the site to allow the public to contact nominated site personnel out of hours.

12.2 Environmental Management

The work shall be undertaken with all due regard to the minimisation of environmental effects and to meet all statutory requirements. The contractor shall have in place a Construction Environmental Management Plan (CEMP) which addresses the following items:

- Site stormwater management plan;
- Soil management plan;
- Noise control plan;
- Dust control plan; and
- Contingency measures for environmental incidents.

The contractor shall also be responsible to ensure that the site works comply with the following conditions:

- Fugitive dust leaving the confines of the site is minimised;

- No water containing suspended matter or contaminants leaves the site in a manner which could pollute the environment;
- Vehicles shall be cleaned and secured so that no mud, soil or water are deposited on any public roadways or adjacent areas;
- Spoil is managed in accordance with Section 11.5 of this RAP; and
- Noise and vibration levels at the site boundaries comply with the legislative requirements.

12.3 Occupational Health and Safety

The contractor should develop a site emergency response plan (ERP) and workplace health and safety plan (WHSP). This will ensure the safety of the personnel working on site, given any likely emergency situation which may occur. The OHSP and ERP should include emergency phone numbers and details of local emergency facilities.

Appropriate fencing and signage should be installed around and within the site to prevent unauthorised access to the site, restricted access remedial areas and deep excavations.

All personnel on site are required to wear the following personnel protective equipment (PPE) at all times:

- Steel-capped boots;
- High visibility clothing; and
- Hard hat meeting AS1801-1981 requirements.

The following additional PPE will be worn, as required:

- Hearing protection meeting AS 1270-1988 requirements when working around machinery or plant equipment if noise levels exceed exposure standards;
- Safety glasses or safety goggles with side shields meeting AS 1337-1992 requirements (as necessary, particularly during demolition);
- Appropriate safety masks (i.e. P1 or P2); and
- Any additional protection identified by the Asbestos Removal Contractor or environmental consultant.

All contractors are required to show compliance with the Work Health and Safety Regulation 2011, including the preparation of a Site Safety Management Plan and Safe Work Method Statements.

13. Conclusion

It is considered that remediation and validation of identified contamination, generally in accordance with this RAP, will render the site compatible with the proposed hospital land-use. In addition, adherence to the RAP should enable appropriate management of any potential impacts on the environment which may occur during the course of the remediation works.

This RAP must be updated at the completion of the additional investigations outlined in Section 7, such that the extents of the areas requiring remediation are identified and the remediation strategy is confirmed.

14. References

1. National Environment Protection Council (2013), *National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013*, 11 April 2013.
2. NSW EPA, Contaminated Site, *Guidelines for the NSW Site Auditor Scheme 3rd Edition*, April 2017.
3. NSW EPA, *Waste Classification Guidelines, Part 1: Classifying Waste*, November 2014.
4. NSW EPA, *Managing Land Contamination, Planning Guidelines, SEPP55 – Remediation of Land*, 1988.
5. NSW EPA Contaminated Sites (2011), *Guidelines for Consultants Reporting on Contaminated Sites*, August 2011.

15. Limitations

Douglas Partners (DP) has prepared this report for this project at Hornsby-Ku-Ring-Gai Hospital Campus Development, Stage 2 in accordance with DP's proposal dated 24 April 2018 and acceptance received from Kris Gracey of APP Corporation Pty Limited on behalf of Health Infrastructure dated 24 April 2018. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of APP Corporation Pty Limited and Health Infrastructure for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific previous sampling and / or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during previous investigations. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and / or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations

or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the environmental components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

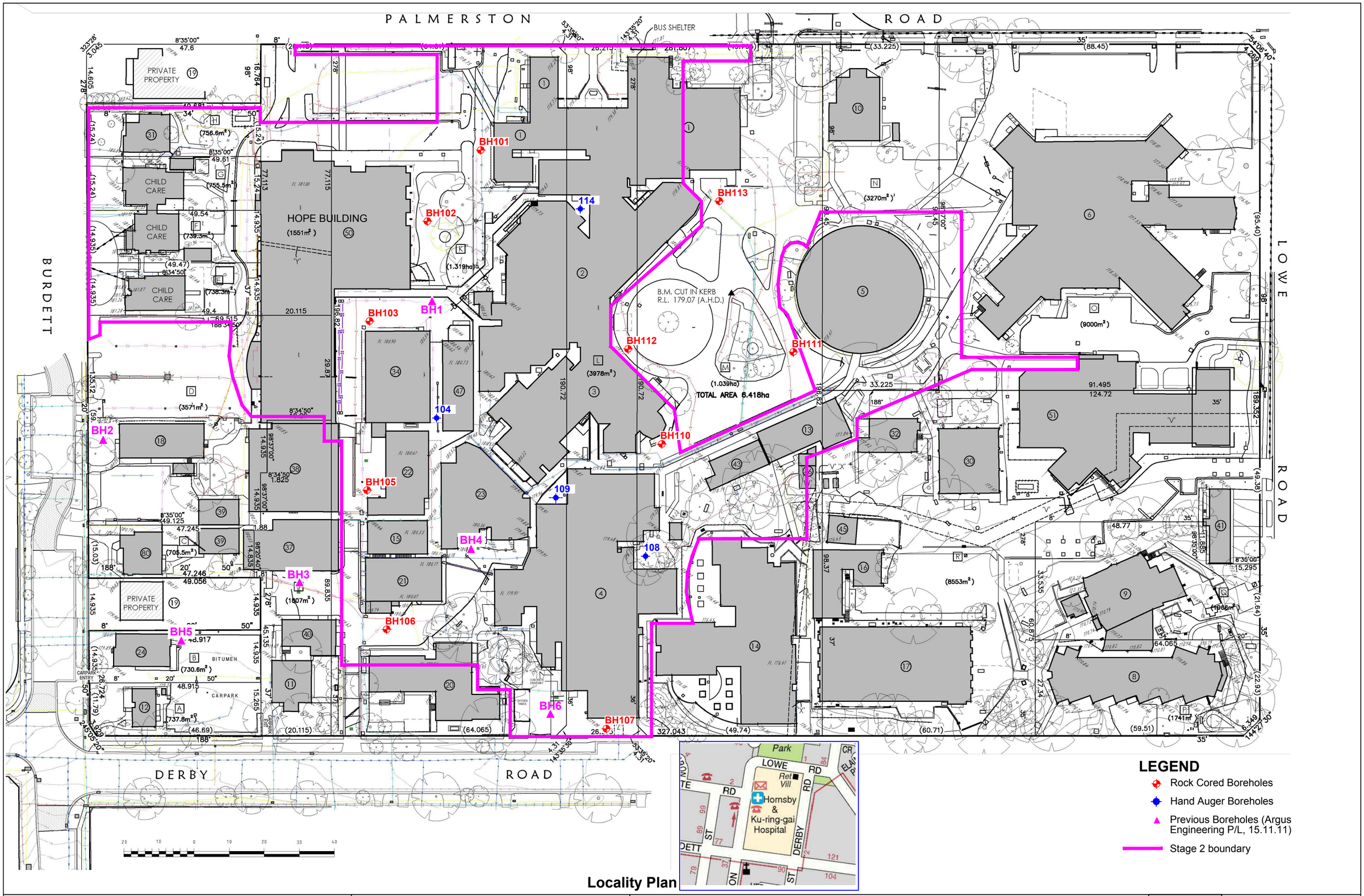
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

Drawings 1 to 3



Locality Plan

LEGEND

- Rock Cored Boreholes
- Hand Auger Boreholes
- Previous Boreholes (Argus Engineering P/L, 15.11.11)
- Stage 2 boundary

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Health Infrastructure	
OFFICE: Sydney	DRAWN BY: PSCH
SCALE: 1:1000 @ A3	DATE: 26.4.2018

TITLE: **Previous Boreholes**
Hornsby Ku-ring-gai Hospital Redevelopment - Stage 2
Palmerston Road, HORNSBY

PROJECT No:	73224.14
DRAWING No:	1
REVISION:	0

PALMERSTON ROAD

BURDETT

LOWE ROAD

DERBY ROAD

BH1 BH2 BH3 BH4 BH5 BH6

BH101 BH102 BH103 BH105 BH106 BH107 BH110 BH111 BH112 BH113

104 108 109 114

HOPE BUILDING (1551m²)

PRIVATE PROPERTY

CHILD CARE

CARPARK

BITUMEN

B.M. CUT IN KERB
R.L. 179.07 (A.H.D.)

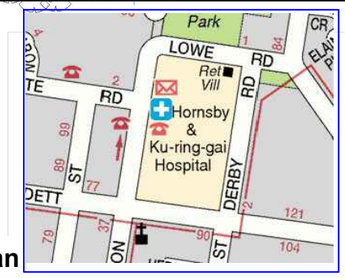
TOTAL AREA 6.418ha

BUS SHELTER

LEGEND

- Previous rock cored boreholes
- Previous hand auger boreholes
- Previous Boreholes (Argus Engineering P/L, 15.11.11)
- Stage 2 boundary
- Proposed borehole

Locality Plan



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Health Infrastructure	
OFFICE: Sydney	DRAWN BY: PSCH
SCALE: 1:1000 @ A3	DATE: 26.4.2018

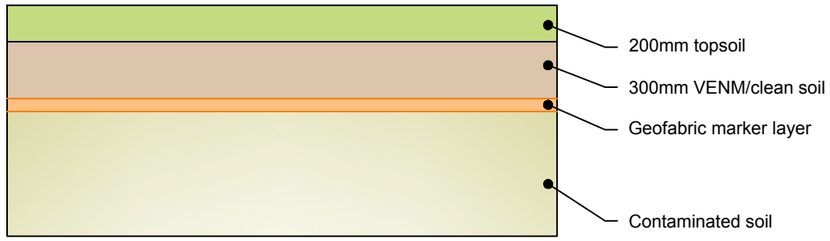
TITLE: **Location of Proposed Boreholes**
Hornsby Ku-ring-gai Hospital Redevelopment - Stage 2
Palmerston Road, HORNSBY

PROJECT No:	73224.14
DRAWING No:	2
REVISION:	0

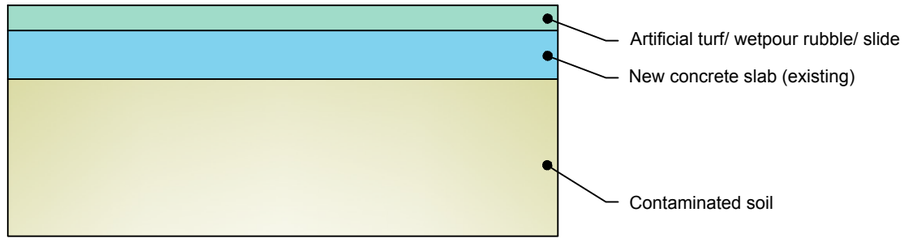
Cap No.1 - Existing Concrete

Cap No.2 - Concrete (As yet constructed)

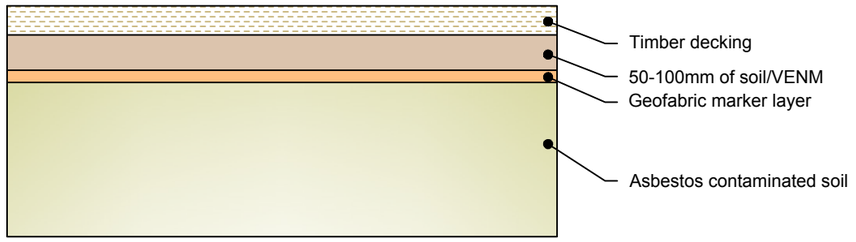
Cap No.3 - Garden Beds/ Landscaping



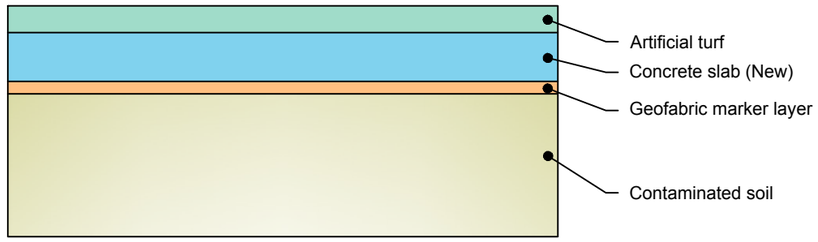
Cap No.4 - Terrace Area



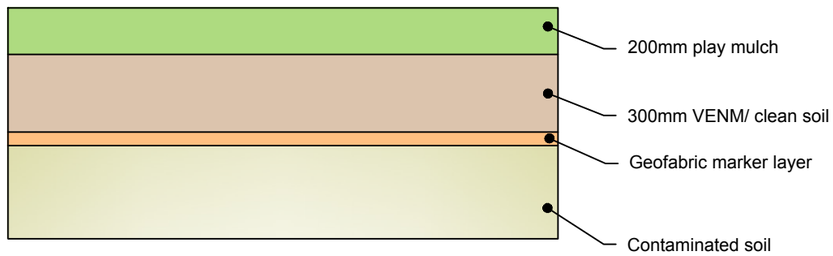
Cap No.5 - Timber Decking



Cap No.6 - Artificial Turf



Cap No.7 - Play Mulch



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Health Infrastructure		TITLE: **Typical Capping Sections** **Remediation Action Plan** **Horsnby Ku-ring-gai Hospital Redevelopment - Stage2**
OFFICE: Sydney	DRAWN BY: PSCH	
SCALE: Sketch only	DATE: 26.4.2018	

N

PROJECT No:	73224.14
DRAWING No:	3
REVISION:	0