RICHARD CROOKES CONSTRUCTIONS

JANUARY 2019

JORDAN SPRINGS PUBLIC SCHOOL ENVIRONMENTAL SITE ASSESSMENT 14 - 28 CULLEN AVENUE, JORDAN SPRINGS, NSW 2747

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Jordan Springs Public School Environmental Site Assessment
14 - 28 Cullen Avenue, Jordan Springs, NSW 2747

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ABBREVIATIONS

ABC	Ambient background concentration
ACL	Added contaminant limit
ACM	Asbestos containing material
BTEX compounds	Benzene, toluene, ethylbenzene and xylene
CEC	Cation exchange capacity
CHCs	Chlorinated hydrocarbons
CSM	Conceptual site model
DP	Deposited Plan
DQI	Data quality indicator
DQO	Data quality objective
DSI	Detailed site investigation
EIL	Ecological investigation level
ESL	Ecological screening level
F1	TRH C_6-C_{10} minus BTEX compounds
F2	TRH >C_{10}-C_{16} minus naphthalene
F3	TRH >C_{16}-C_{34}
F4	TRH >C_{34}-C_{40}
HIL	Health investigation level
HSL	Health screening level
LEP	Local environmental plan
LGA	Local government area
mAHD	Metres Australian Height Datum
mBGL	Metres below ground level
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NEPM	*National Environment Protection (Assessment of Site Contamination) Measure 1999* (as amended 2013)
NL	Non-limiting
NSW EPA	New South Wales Environment Protection Authority
OCPs	Organochlorine pesticides

OPPs	Organophosphate pesticides
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PID	Photoionisation detector
PQL	Practical quantitation limit
PSI	Preliminary site investigation
QA/QC	Quality assurance/quality control
RPD	Relative percentage difference
SAQP	Sampling, analysis and quality plan
SOP	Standard operating procedure
SWL	Standing water level
TCLP	Toxicity characteristic leachate procedure
TEQ	Toxicity equivalent quotient
TRH	Total recoverable hydrocarbons
US EPA	United States Environmental Protection Agency
VOCs	Volatile organic compounds

EXECUTIVE SUMMARY

Richard Crookes Constructions (RCC) commissioned WSP Australia Pty Ltd (WSP) to undertake an environmental site assessment at the 14-28 Cullen Avenue, Jordan Springs NSW 2474 (‘the site’). The site comprises an area of vacant land approximately 30,000 m^2 which is proposed for redevelopment. The proposed redevelopment will comprise the construction of a primary school in the south-east portion of the site, with a playing field in the northern portion of the site.

Based on the site inspection and review of documents it was concluded that potential contamination sources identified at the site included:

- uncontrolled fill materials used historically to level the site and surrounding area
- historical or recent localised filling or waste dumping
- potential asbestos containing materials (ACM) from imported materials
- possible minor leaks/spills of oil/petrol from vehicle activity on or adjacent to site
- pesticides used historically and recently to maintain the site
- urban dryland salinity associated with saline groundwater, local land clearing and changed hydrological conditions

Potential contaminants of concern associated with the above activities included:

- heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc)
- total recoverable hydrocarbons (TRH),
- benzene, toluene, ethylbenzene and xylene (BTEX),
- polyaromatic hydrocarbons (PAHs),
- organochlorine and organophosphate pesticides (OCPs/OPPs),
- polychlorinated biphenyls (PCBs)
- asbestos
- herbicides
- trinitrotoluene (TNT)
- hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
- Salinity and sodicity indicator analytes including pH, electrical conductivity (EC), chloride, sulfate and exchangeable cations

Surface soils are generally non-saline to slightly saline. This indicates that in the sites current form, site structures at the surface are unlikely to be affected by dryland urban salinity. Salinity on the site appears to generally increase with depth. Deeper structures (including footings, piles and service trenches) should have salinity resistant materials incorporated into their design.

Soils tested on the site were generally sodic in nature with sodicity increasing with depth. Sodic soils present an elevated erosion hazard on-site. Development works should be planned to accommodate for the elevated potential for erosion and sediment generation in runoff and the final development should ensure adequate protection of soils (e.g. through maintenance of vegetation coverage).

Based on the analytical results, there was negligible soil contamination impact identified on or beneath the site. Soil samples reported no contaminants of concern above the adopted health or environmental guidelines, therefore WSP are of the opinion that the site is suitable for the proposed development.

1 INTRODUCTION

1.1 BACKGROUND

WSP Australia Pty Ltd (WSP) was commissioned by Richard Crookes Construction (RCC) to undertake an environmental site assessment at the 14-28 Cullen Avenue, Jordan Springs NSW 2474 (‘the site’). The location and boundaries of the property and the site are shown on Figures 1 and 2 respectively.

The site comprises an area of approximately 28,360 m^2, which is currently vacant. redevelopment is proposed for the site which will comprise the construction of a primary school in the south-east portion of the site, with a playing field in the northern portion of the site.

1.2 OBJECTIVES

The objectives of the investigation were to:

- assess the current contamination status of the site
- assess the potential risks associated with contamination (if identified) at the site, with respect to the proposed future land use as a school
- provide recommendations for potential management or remediation requirements, if required
- undertake salinity testing and provide a salinity assessment for the site.

2 SCOPE OF WORKS

Prior to the commencement of the Stage 2 detailed site investigation (DSI), a desktop review of available current and historical background information pertaining to the site was undertaken in order to establish whether there were any known environmental concerns associated with the site. The findings of this review were then used to prepare a sampling, analysis and quality plan (SAQP) outlining the proposed DSI scope of work and methodology.

The DSI works were undertaken in accordance with the SAQP, and the findings of the desktop review are provided in Section 4 of this report.

The scope of works for the DSI comprised:

- mechanical boring at 40 different locations (TP01-TP40) across the site, using a hand auger to a depth of 1.5 metres below ground level (mBGL) in conjunction with a drill rig to reach a maximum depth of 3.2 mBGL
- collection of soil samples at locations from the surface (0.0-0.1 mBGL), 0.2-0.3 mBGL, 0.4-0.5 mBGL, 0.9-1.0 mBGL, and every metre thereafter (every 0.5 m in the boreholes selected for salinity testing, including in the fill)
- collection of asbestos presence/absence samples at the same depths as the soil samples from all locations
- laboratory analysis of selected representative soil and asbestos samples for the contaminants of concern identified at the site
- preparation of this DSI report which focuses on assessing the soil contamination status of the site (including a dryland salinity assessment), assessing the need for remediation at the site, and evaluating the suitability of the site for the proposed potential future land use.

3 SITE LOCATION AND SETTING

3.1 SITE LOCATION AND IDENTIFICATION

The general site identification details are provided in Table 3.1.

Table 3.1 Summary of general site information

SITE ADDRESS	14-28 CULLEN AVENUE, JORDAN SPRINGS, NSW 2474
Site identification	The site is legally defined as Lot 22 of deposited plan (DP) 1194338.
Local government area (LGA)	Penrith City Council
Site area (approximately)	28,360 m^2
Current site use	The site remains vacant at the current time with no development features present, with dense grass covering the majority of the property. Multiple large gravel patches are present around the gate entrances onto the site.
Surrounding land uses	A childcare centre is present immediately adjacent to the south west of the site, with residential properties surrounding the site to the north, west and south. A small creek is present on the eastern boundary line, with the Jordan Springs Dog Park beyond. A large manufactured lake is present to the south of the site on the other side of Cullen Avenue, with a small shopping centre present to the south west.
Proposed site use	The site is proposed to be developed into a primary school in the south-eastern portion with a playing field in the northern portion of the site.

3.2 SITE INSPECTION

The site was inspected on 4 June 2018 by a WSP environmental scientist and the following observations were noted:

- The site is predominantly surrounded by residential housing to the north, west, east and south. There is a small creek that runs parallel along the eastern boundary of the site, with a cycleway, dog park and large patch of eucalypt forest beyond. To the south, the creek continues to eventually terminate into a manufactured lake on the other side of Cullen Avenue. To the north there is a public oval with residential properties beyond. A small shopping complex, Water Gum community park and residential housing are present to the west
- The site (area to be developed) comprises an open grassed field that is slightly sloping to the south
- No asbestos containing materials (ACM) was observed during the site walkover and during field works
- An assessment of salinity indicator landscapes, surface features and plants was undertaken during the fieldwork.

An aerial plan showing the site features is presented as Figure 2 in Appendix A and site photographs are presented within Appendix B.

3.3 TOPOGRAPHY AND SURFACE WATER DRAINAGE

The site is situated at approximately 40 metres Australian Height Datum (mAHD) and slopes towards the south. This is generally consistent with the level of the surrounding properties. The site appears to have a low potential for flooding, based on the Council’s flood planning map as well as the lack of significantly sized water bodies surrounding the site.

The nearest surface water body is a small unnamed creek adjacent to the eastern boundary which terminates in a unnamed manmade lake approximately 150 metres to the south of the site.

3.4 GEOLOGY

The regional geological map of the area (Geological Survey of NSW, 1983, Geological Series Sheet 9130 (Edition 1), Sydney, Scale 1: 100,000 indicates that the site is underlain by Bringelly Shale as part of the Wianamatta Group, which comprises of shale, claystone, fine to medium grained lithic sandstone as well as coal and tuff.

The CSIRO Australian Soil Resource Information System (ASRIS), http://www.asris.csiro.au/index_ie.html, accessed 15 June 2018, indicates that soils underlying the site are mapped as having an extremely low probability of the occurrence of acid sulfate soils (ASS).

The NSW DIPNR (2003) *Salinity Potential in Western Sydney 2002* map indicates that the site and immediate surrounds is situated in an area of moderate salinity potential. Areas of high salinity potential associated with local waterways are located further to the north and south of the site.

3.5 HYDROGEOLOGY

A review of the licenced borehole register on the NSW Government Water Information website (http://allwaterdata.water.nsw.gov.au/water.stm) indicates that there are no registered groundwater bores within 500 m radius of the site.

4 SITE HISTORY REVIEW

4.1 HISTORICAL SEARCHES

A review of historical land use information pertaining to the site was undertaken to identify any known environmental concerns. A summary of the searches undertaken is provided in Table 4.1.

Table 4.1 Summary of historical search results

SEARCH	RESULTS
Titles search	A historical land title search indicated that the section of the site referred to as Portion 111 Parish Londonderry part of The Commonwealth of Australia portfolio from 1941 until 1979, upon which the property was referred to as Lot 1 in various deposited plans until 1989. Formerly, from 1941 to 1945, the property was being used for military purposes by the defence force. From 1992 until 1999, the property and surrounding land remained as Lot 1 under various deposited plan numbers, and was acquired by Australian Defence Industries Pty Limited. From 1993 until the present day, the site and surrounding land listed under various lot and deposited plan numbers, was acquired by St Marys Land Limited. The results of the historical land title search are provided in Appendix D.
Dangerous Goods Search	This has been requested and had not been received at the time of writing. Once received this information will be incorporated and this report will be updated and re-issued.
EPA online notice records	An online search of the NSW EPA *Protection of the Environment Operations Act 1997* public register (http://www.epa.nsw.gov.au/prpoeoapp/) indicated that there are no issued licences within a 1 km radius of the site. An online search of the NSW EPA contaminated land record database (http://www.epa.nsw.gov.au/prclmapp/searchregister.aspx) indicated that there are no current or former notices related to any property in the suburb of Jordan Springs. There are multiple current notices that have been issued to four sites within the LGA of Penrith City Council, however, these sites are more than 3 km away from the site.

4.2 PREVIOUS ENVIRONMENTAL INVESTIGATIONS

WSP were provided with a site audit statement (HLA-Envirosciences Pty Ltd, 1999) which covered the site as well as a large proportion of the surrounding area. The auditor certified that the site is suitable for a range of uses, including for primary schools.

Geotech Testing Pty Ltd undertook fill testing across the site to satisfy requirements of the Penrith City Council development application and the results are presented in *Jordan Springs – Education Site and Village Oval, 11 Lakeside Parade and 14-52 Cullen Avenue, Penrith City Council DA 13/0686 – Condition Nos 13, 16, 24 and 25(c), Statement of Compliance (2015).* This report detailed that 19,000 m^3 of virgin excavated natural material (VENM) was previously imported onto the site, and a VENM report was provided to Geotech Testing. No information was provided to WSP regarding the placement and location of the VENM material.

EIS undertook a desktop study to identify any past or present potentially contaminating activities at the site, and to identify the potential for site specific contamination. The findings of this study are presented in *Preliminary Environmental Site Assessment, 14-28 Cullen Avenue, Jordan Springs, NSW* (EIS, 2017). The study documented the following key findings:

- fill material had been imported across the site and specifically in the north-east corner of the site in the location of the former dam. EIS (2017) states that the fill extends to depths of over 2 mBGL as presented on JK Geotechnics borelogs. However, WSP was not provided with this report
- unknown if the military/defence were using the land for possible fuel or explosives storage
- potential use and or storage of pesticides associated with the Landscape Solutions compound
- potential hazardous building materials in former buildings and through demolition activities (although WSP note that the historical aerial photographs show that no former buildings have been identified at the site)

In addition to the potential contamination sources identified, the site is located in an area of high risk of dryland salinity.

EIS (2017) also stated that unexploded ordinance could pose a potential risk to site users. However, WSP note that the Department of Defence Unexploded Ordnance website does not list the site as having any occurrence of exploded ordnance.

- Potential contaminants of concern were identified as:
  - heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc)
  - total recoverable hydrocarbons (TRH)
  - benzene, toluene, ethylbenzene, xylenes and naphthalene (BTEXN)
  - polycyclic aromatic hydrocarbons (PAHs)
  - organochlorine pesticides (OCPs)
  - organophosphate pesticides (OPPs)
  - polychlorinated biphenyls (PCBs)
  - herbicides
  - volatile organic compounds (VOCs)
  - trinitrotoluene (TNT)
  - hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
  - asbestos.

4.3 PRELIMINARY CONCEPTUAL SITE MODEL

Based on the site inspection and the desktop review of site setting and historical land use information, a preliminary conceptual site model (CSM) was prepared. This is summarised in Table 4.2 below.

Table 4.2 Preliminary CSM

Likely sources of impact	Likely sources of impact at the site include: — uncontrolled fill materials used historically to level the site and surrounding area — historical or recent localised filling or waste dumping — potential asbestos containing materials (ACM) from imported materials — possible minor leaks/spills of oil/petrol from vehicle activity on or adjacent to site — pesticides used historically and recently to maintain the site — urban dryland salinity associated with saline groundwater, local land clearing and changed hydrological conditions.
Potentially impacted media	Soil: Impacts and ACM from contaminated fill, building debris or waste materials, minor fuel leaks, or from pesticides used on-site. Soil sodicity and salinity. Groundwater/water bodies: Migration from soil impacts, although this is considered unlikely given widespread soil contamination is considered unlikely.
Contaminants of concern	Contaminants of concern at the site comprise: — heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc) — TRH and BTEX compounds — PAHs — OCPs/OPPs — PCBs — VOCs — asbestos. — herbicides — TNT — RDX — Salinity and sodicity indicator analytes including pH, electrical conductivity (EC), chloride, sulfate and exchangeable cations
Migration pathways	Potential migration pathways include: — vertical migration of contaminants in soil from infiltration of rain water — migration of contaminants through underground service trenches — run-off from surface contaminants in rain water entering the small creek to the east — volatilisation of hydrocarbon contamination — airborne migration of contamination in dust or vapour.

Potential exposure pathways	Potential exposure pathways include: — inhalation of dust or vapours by site users or nearby site users — ingestion or dermal contact with contaminated surface soils or near surface soils by future residential site users or excavation/maintenance workers — ingestion or dermal contact with contaminated water downgradient of the site through the use of downgradient surface water bodies and the small creek present to the east — direct exposure of structures to aggressive soil conditions.
Potential sensitive receptors	Based on the site setting, sensitive receptors potentially include: — proposed site structures (specifically to aggressive soil conditions) — underlying soil and groundwater — the small creek adjacent to the eastern boundary of the site — current open space users and students of the future school proposed to be built on site — ingestion or dermal contact with contaminated water downgradient of the site through the use of downgradient surface water bodies for recreation — surface watercourses receiving groundwater from the site, possibly including the Cooks River located immediately to the south of the site — occupiers of residential properties surrounding and downgradient of the site — on-site and off-site construction or utility workers (those working within service pit trenches).

5 DATA QUALITY OBJECTIVES

Systematic planning is critical to successful implementation of an environmental assessment and is used to define the type, quantity and quality of data needed to inform decisions. The United States Environmental Protection Agency (US EPA) has defined a process for establishing data quality objectives (DQOs) (US EPA, 2000a and 2000b), which has been referenced in the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM, as amended 2013).

DQOs ensure that:

- the study objectives are set
- appropriate types of data are collected (based on contemporary land use and chemicals of concern)
- the tolerance levels are set for potential decision making errors.

The DQO process is a seven-step iterative planning approach. The outputs of the DQO process are qualitative and quantitative statements which are developed in the first six steps. They define the purpose of the data collection effort, clarify what the data should represent to satisfy this purpose and specify the performance requirements for the quality of information to be obtained from the data. The output from the first six steps is then used in the seventh step to develop the data collection design that meets all performance criteria and other design requirements and constraints. The DQO process adopted for the DSI works is outlined in Table 5.1.

Table 5.1 DQO process

STEP	DESCRIPTION	OUTCOMES
1	State the problem	WSP understand the site is to be redeveloped for the construction of a primary school in the south-east portion of the site, with a playing field in the northern portion of the site. The purpose of the DSI works is to determine the contamination status of soils beneath the site and assess the potential for urban dryland salinity to impact upon site development.
2	Identify the decisions/goal of the investigation	The decisions to be made based on the results of the investigation are as follows: — has the soil been adequately sampled? — were all the contaminants of concern analysed? — have salinity indicator parameters been assessed in the field and by the laboratory? — is there sufficient data to prepare the DSI report? — is there a risk to future users or occupiers of the site?
3	Identify the inputs to the decision	The inputs required to make the above decisions are as follows: — geological and hydrogeological data — concentrations of contaminants of concern and salinity indicator parameters in soil — site assessment criteria for soil (outlined in Section 7) — observation data including presence of odours and discoloration of the soil — distribution of identified soil contamination.
4	Define the study boundaries/ constraints on data	The boundaries of the investigation have been identified as follows: — spatial boundaries: the spatial boundary of the investigation area is defined as the geographical extent of the investigation area and the potential receptors of concern that need to be considered by the study. — temporal boundaries: the date of the project inception to the completion of the fieldwork under the proposed investigation.

STEP	DESCRIPTION	OUTCOMES
5	Develop a decision rule	The purpose of this step is to define the parameters of interest, specify the action levels and combine the outputs of the previous DQO steps into an ‘if…then…’ decision rule that defines the conditions that would cause the decision maker to choose alternative actions. The parameters of interest are concentrations of contaminants of concern and salinity indicator parameters (as listed in Table 4.2) in soil. An assessment of the concentrations of the contaminants of concern and interpretation of salinity indicator parameters is to be undertaken to develop the DSI and the suitability for the current open space and proposed future land use. Should concentrations exceed the adopted assessment criteria remedial and management options will be considered.
6	Specify limits on decision errors	The acceptable limits on decision errors to be applied in the investigation and the manner of addressing possible decision errors have been developed based on the data quality indicators (DQIs) of precision, accuracy, representativeness, comparability and completeness and are presented in Table 5.2 and 5.3. Soil pH tested by the NATA accredited laboratory was compared against the field pH screening results for the relevant sample locations and depths.
7	Optimise the design for obtaining data	The purpose of this step is to identify a resource-effective data collection design for generating data that satisfies the DQOs. This assessment has been designed considering the information and data obtained during the desktop review and site inspection (Sections 3 to 4). The resource effective data collection design that is expected to satisfy the DQOs is described in detail in Section 6 (methodology). To ensure the design satisfies the DQOs, DQIs (for accuracy, comparability, completeness, precision and reproducibility) have been established to set acceptance limits on field methodologies and laboratory data collected.

DQIs for sampling techniques and laboratory analyses of collected soil samples define the acceptable level of error for this validation assessment. The adopted field methodologies and data obtained have been assessed by reference to DQIs as follows:

- Precision: a quantitative measure of the variability (or reproducibility) of data
- Accuracy: a quantitative measure of the closeness of reported data to the true value
- Representativeness: the confidence (expressed qualitatively) that data are representative of each media present on the site
- Comparability: a qualitative parameter expressing the confidence with which one data set can be compared with another
- Completeness: a measure of the amount of useable data (expressed as a percentage) from a data collection activity.

A summary of the field and laboratory DQIs for the validation assessment are provided in Tables 5.2 and 5.3 below.

Table 5.2 DQIs for field techniques

DQI	
Precision	— standard operating procedures (SOPs) appropriate and complied with — collection of inter-laboratory and intra-laboratory duplicates
Accuracy	— WSP SOPs appropriate and complied with — collection of field and trip blanks and trip spikes
Representativeness	— appropriate media sampled
Comparability	— same SOPs used on each occasion — experienced sampler — climatic conditions (temperature, rainfall, wind) considered — same type of samples collected
Completeness	— SOPs appropriate and complied with — all required samples collected

Table 5.3 DQIs for laboratory

DQI	**ACCEPTABLE LIMITS**
Precision	
Analysis of laboratory duplicates for: — PAHs, TRH, BTEX, total metals, PCB's, OCP / OPPs in soil	<10% x PQL - ±30% RPD 4-10% x PQL - ±50-70% RPD <4% x PQL - ± 2 x PQL
Analysis of laboratory prepared trip spikes (one per day per batch volatiles)	70-130%
NATA certified laboratories	NATA accreditation for analyses performed
Accuracy	
Analysis of laboratory prepared trip blanks (one per batch)	Non-detect for contaminants analysed
Analysis of rinsate blanks (one per day)	Non-detect for contaminants analysed
Analysis of laboratory blanks	Non-detect for contaminants analysed
Analysis of laboratory matrix spikes, laboratory control samples and surrogate recoveries	70-130% inorganics/metals 60-140% organics 10-40% semi-volatile organic compounds
Analysis of laboratory duplicates for: — PAHs, TRH, BTEX, total metals, PCB's, OCP / OPPs in soil	<10% x PQL - ±30% RPD 4-10% x PQL - ±50 -70% RPD <4% x PQL - ± 2 x PQL

DQI	ACCEPTABLE LIMITS
Representativeness	
All required samples analysed	as per Section 6 of this report.
Comparability	
Sample analytical methods used (including clean-up)	as per NEPM (2013)
Same units	justify/quantify if different
Same laboratories	justify/quantify if different
Sample practical quantification limits (PQLs)	less than nominated criteria
Completeness	
All critical samples analysed	as per Section 6 of this report.
All required analytes analysed	
Appropriate methods and PQLs	as per NEPM (2013)
Sample documentation complete	
Sample holding times complied with	

6 SAMPLING AND ANALYSIS PROGRAM

6.1 SAMPLING RATIONALE

This SAQP for the DSI was developed by WSP with respect to a mixture of grid-based and targeted locations adopted to sufficiently assess the site. For grid-based sampling, Table A in the NSW EPA 1995, *Sampling Design Guidelines* provides the recommended minimum number of sampling points required for site characterisation based on detecting circular hot spots by using a grid-spaced sampling pattern. The guidelines indicate that a minimum of 40 sampling points are recommended for a 30,000 m^2 site, which would allow for extensive coverage of the site using the grid-spaced sampling pattern. Sampling locations are summarised in Table 6.1 below, with sample locations shown on Figure 2.

Table 6.1 Sampling Rationale

TEST PIT ID	LOCATION JUSTIFICATION	NO. OF PRIMARY SAMPLES TO BE ANALYSED
TP01 to TP18	Grid pattern targeting fill in the vicinity of the future playing field.	18 – heavy metals, TRH, PAHs, BTEX, asbestos 9 – OCPs, OPPs, PCBs 5 – VOCs, TNT, RDX
TP19 to TP20	Targeting the former dam area which may have been backfilled with imported fill.	2 – heavy metals, TRH, PAHs, BTEX, asbestos, OCPs, OPPs, PCBs
TP21 to TP34, TP36, TP37, TP40	Grid pattern targeting fill in the vicinity of the future buildings.	17 – heavy metals, TRH, PAHs, BTEX, asbestos 9 – OCP, OPP, PCBs 5 – VOCs, TNT, RDX
TP35, TP38 and TP39	Targeting the Landscape Solutions compound	3 – heavy metals, TRH, PAHs, BTEX, asbestos 1 – OCPs, OPPs, PCBs 6 –herbicides
20 test pit/borehole locations	Sampling locations will be selected on site depending on the site slope for salinity assessment.	70 – pH and electrical conductivity 20 – sulfate and chloride 20 – CEC

A hand auger was used to reach 1.5 mBGL in all 40 borehole locations (TP01 to TP40), to prevent damage to potentially unidentified underground services. The drill rig was then used to progress the boreholes to a minimum depth of 2-3 mBGL, or 0.5 m into natural material, whichever occurred first, with exception of 20 select locations that were also selected for salinity testing, which were extended to a minimum depth of 3 mBGL. The majority of boreholes across the site were able to reach a minimum depth of 3 mBGL.

Six soil samples were collected from each borehole, comprising:

- three surface / near surface samples (0.1 mBGL, 0.3 mBGL and 0.5 mBGL) collected from every borehole location across the site.

- three deeper samples were also collected (1.0 mBGL, 2.0 mBGL, 3.0 mBGL), to assess the condition of the residual material below the fill material at the surface.
- further samples were collected where significant changes in geology occurred or if specific inclusions were noted.

The site history indicated that groundwater impacts at the site were not considered likely and, thus, a soil investigation was undertaken. It was therefore considered appropriate to investigate soil contamination only during the DSI, with the understanding that a groundwater investigation may need to be considered at a later stage should significant soil contamination be identified at the site.

6.2 FIELDWORK

6.2.1 SOIL SAMPLING METHODOLOGY

Table 6.2 Drilling and soil sampling methodology

ACTIVITY	DETAILS
Service location	Prior to breaking ground, all investigation locations were checked for the presence of buried services by an experienced service locator and cross-checked with DBYD plans obtained from asset owners.
Soil bore locations	Following the clearing of locations, intrusive investigation works were undertaken at the site from 4 to 7 June 2018. A hand auger was used by a WSP environmental scientist to manually advance all 40 boreholes to a maximum depth of 1.5 mBGL, to prevent extensive damage to unidentified underground services. From this depth, a drill rig was used to further advance the boreholes to a minimum depth of 3 mBGL for both the salinity and non-salinity targeted boreholes. Soil bore locations are shown on Figure 2 presented in Appendix A.
Drilling method	Each location was hand augured to 1.5 mBGL to minimise the potential for unidentified underground services to be damaged. Each of the boreholes was progressed to target depth using a drill auger to gain a clear understanding of the geology.
Borehole logging	Soil logging was completed based on field interpretation and was generally in accordance with the Australian Standard 1726–1993 *Geotechnical Site Investigations*. Borehole logs are presented in Appendix C.
Field screening	Soil samples were screened in the field using a PID to assess VOC concentrations. The PID was calibrated to a known concentration of isobutylene gas at the commencements of each day of field work. Calibration certificates are included in Appendix F. Soil samples were tested in a number of boreholes for field pH as an indicator of soil chemistry.

ACTIVITY	DETAILS
Soil sampling method	Soil sampling was undertaken in general accordance with the SAQP for the site, WSP field procedures and Australian Standard AS4482.1.2005. Samples were collected at the following nominal depths: immediately beneath the site surface (approximately 0.0 – 0.1 mBGL) — 0.3 mBGL — 0.5 mBGL — 1.0 mBGL — 2.0 mBGL — 3.0mBGL. Samples were scheduled for analysis based on field observations and screening results. Soil samples were collected directly from the hand auger head or drill auger and placed into laboratory supplied containers. To minimise the risk of cross-contamination, new disposable nitrile gloves were worn during sample collection and all non-disposable sampling equipment was cleaned between samples and sample locations. For the volatile constituent analysis, in accordance with AS 4482.2-1999 Guide to the sampling and investigation of potentially contaminated soil - Volatile substances, a solvent extraction with subsampling method was used. A soil sample of volume considerably larger than that required for the determination, was collected and placed in a borosilicate glass container such that was no headspace. The container was then sealed, cooled to 4°C and transported to the laboratory in this condition. Samples were given unique identification numbers containing the soil boring location and depth. Samples were placed in eskies with appropriate chain-of-custody documentation and preserved on ice after collection and during shipment to the laboratories. Samples were shipped to laboratories accredited by the National Association of Testing Authorities (NATA) for the analyses to be undertaken.
Decontamination procedure	All equipment requiring decontamination (hand auger, trowel) was washed using potable water between sample locations.
Sample preservation	Soil samples for laboratory analysis were collected in laboratory supplied and appropriately preserved containers. Samples were stored on ice on-site and in transit to the laboratory. Samples were received by the laboratories within the required holding times accompanied by chain of custody documentation.
Borehole completion	Soils were be returned to the bore in the order removed and reinstated to a standard to minimise hazards such as trips and falls.
Storage of waste soil	No waste soil was produced.
Surveying of borehole locations	A hand-held global positioning system (GPS) was used to record the coordinates of each sampling location for future reference.

ACTIVITY	DETAILS
Survey of salinity indicator landscapes and vegetation	During the field investigations the WSP field team undertook a preliminary landscape assessment of the site and surrounds with the intent of highlighting geomorphic features indicative of salinity impacted landscapes as well as areas of scalding, salt crusts, water logging, etc. WSP also inspected the site and surrounds for the presence of salinity indicator plants. These field assessments were undertaken in accordance with the following: — NSW DLWC (2002), *Indicators of Urban Salinity* — NSW DIPNR (2005), *Salinity Indicator Plants.*
Quality assurance/quality control (QA/QC)	The following QA/QC samples were collected: — duplicate sample pairs (intra-laboratory and inter-laboratory) were collected in the field at the rate of 1 in 20 primary samples for analysis by each of the primary and secondary laboratories — one equipment rinsate blank was collected and analysed per day of soil investigations. The rinsate was collected to assess the effectiveness of the decontamination processes implemented during the field works program — four trip spikes accompanied the shipment of samples during the journey from the preparing laboratory to the field sampling location, and back to the analytical laboratory. The trip blank was analysed for BTEXN to assess potential cross-contamination from volatiles — four trip blanks accompanied the shipment of samples during the journey from the preparing laboratory to the field sampling location, and back to the analytical laboratory to assess potential cross-contamination from volatiles. The trip blank was analysed for BTEXN and volatile TRH (C_6-C_{10}).

6.3 LABORATORY ANALYSIS

Selected soil samples collected were submitted to the primary analytical laboratory for analysis for contaminants of concern at the site. Soil samples were selected based on a combination of sample location and field observations, including PID results.

Primary samples and intra-laboratory samples were analysed by Australian Laboratory Services Pty Ltd (ALS), with inter-laboratory duplicate samples analysed by SGS Australia Pty Ltd (SGS). Both laboratories are accredited by NATA for the analytical suites requested, with the exception of asbestos quantification.

Table 6.3 below provides a summary of the laboratory analytical schedule for soil samples for the DSI.

Table 6.3 Laboratory sampling and analysis plan - Soil

ANALYTE	PRIMARY SAMPLES	DUPLICATES/ TRIPLICATES	RINSATE BLANK	TRIP BLANK	TRIP SPIKE
TRH	40	4	4	4	-
BTEX compounds	40	4	4	4	4
PAHs	40	4	-	-	-
8 heavy metals	40	4	-	-	-
OCPs/OPPs	23	4	-	-	-
PCBs	23	4	-	-	-
VOCs	6	-	-	-	-
RDX	6	-	-	-	-
Herbicides	6	-	-	-	-
TNT	6	-	-	-	-
Asbestos (quantitative)	40	-	-	-	-
pH and electrical conductivity	70	-	-	-	-
sulfate and chloride	20	-	-	-	-
CEC	20	-	-	-	-

7 ASSESSMENT CRITERIA FOR THE SITE

The assessment criteria for the investigation have been based on an analysis of land uses and potential receptors. Based on this, assessment criteria provided in the following guidelines have been identified as being applicable for assessing laboratory analytical data:

- NEPM (2013) including:
  - Health investigation levels (HILs)
  - Health screening levels (HSLs)
  - Ecological Investigation Levels (EILs)
  - Ecological Screening Levels (ESLs)
- 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, Part 2: Application Document* (Friebel & Nadebaum, 2011).

7.1 HEALTH INVESTIGATION LEVELS AND HEALTH SCREENING LEVELS

To assess the presence and extent of soil contamination at a site, the NSW EPA refers to the NEPM (2013) which provides health investigation levels (HILs) and health screening levels (HSLs) for the assessment of impacted soil.

HILs provide an assessment of potential risk to human health from chronic exposure to contaminants, and have been developed based on land use setting. As the purpose of this investigation is to assess the site against both the current and potential future land (as a school), both the 'HIL A' criteria for low density residential land use with gardens/accessible soil and the 'HIL C' criteria for public open space land use have been adopted.

HSLs have been developed for selected petroleum compounds and fractions and are applicable to assessing human health risk via the vapour intrusion and inhalation pathway. The HSLs depend on specific soil physicochemical properties and land use scenarios. They apply to different soil types and depths. For the purpose of this investigation, both the 'HSL A' criteria for low density residential land use with gardens/accessible soil and the 'HSL C' criteria for public open space land use have been adopted.

HSLs have been adopted based on a subsurface comprising of silt. This soil type has been selected based on the soil profile observed at the site.

The CRC CARE Technical Report No. 10 (Friebel & Nadebaum, 2011) provides HSLs for petroleum hydrocarbons specifically for vapour inhalation for intrusive maintenance workers in shallow trenches, and for direct contact. These have also been adopted.

The soil assessment criteria for this investigation is summarised in Table 7.1.

Table 7.1 Soil assessment criteria – HILs/HSLs

ANALYTE	**LOW DENSITY RESIDENTIAL LAND USE**						**PUBLIC OPEN SPACE LAND USE**						**MAINTENANCE/EXCAVATION WORKERS**			
	HSL A (in silt)[1] (mg/kg)				**HIL A[2] (mg/kg)**	**Direct contact[3] (mg/kg)**	**HSL C (in silt)[1] (mg/kg)**				**HIL C[2] (mg/kg)**	**Direct contact[3] (mg/kg)**	**HSLs (in silt)[4] (mg/kg)**			**Direct contact[3] (mg/kg)**
	0 to <1 m	**1 to <2 m**	**2 to <4 m**	**4 m +**			**0 to <1 m**	**1 to <2 m**	**2 to <4 m**	**4 m +**			**0 to <2 m**	**2 to <4 m**	**4 m +**	
TRH/BTEX compounds																
TRH C_6-C_{10}	-	-	-	-	-	4,400	-	-	-	-	-	5,100	NL	NL	NL	82,000
TRH C_6-C_{10} minus BTEX (F1)	40	65	100	190	-	-	NL	NL	NL	NL	-	-	-	-	-	-
TRH $>C_{10}$-C_{16}	-	-	-	-	-	3,300	-	-	-	-	-	3,800	NL	NL	NL	62,000
TRH $>C_{10}$-C_{16} minus naphthalene (F2)	230	240	440	NL	-	-	NL	NL	NL	NL	-	-	-	-	-	-
TRH $>C_{16}$-C_{34} (F3)	-	-	-	-	-	4,500	-	-	-	-	-	5,300	-	-	-	85,000
TRH $>C_{34}$-C_{40} (F4)	-	-	-	-	-	6,300	-	-	-	-	-	7,400	-	-	-	120,000
Benzene	0.6	0.7	1	2	-	100	NL	NL	NL	NL	-	120	250	160	NL	1,100
Toluene	390	-	-	-	-	14,000	NL	NL	NL	NL	-	18,000	NL	NL	NL	120,000
Ethylbenzene	-	-	-	-	-	4,500	NL	NL	NL	NL	-	5,300	NL	NL	NL	85,000
Xylene (Total)	95	210	NL	NL	-	12,000	NL	NL	NL	NL	-	15,000	NL	NL	NL	130,000
PAHs																
Naphthalene	4	NL	NL	NL	-	1,400	NL	NL	NL	NL	-	1,900	NL	NL	NL	29,000
PAHs (Total)	-	-	-	-	300	-	-	-	-	-	300	-	-	-	-	-
Benzo(a)pyrene TEQ[5]	-	-	-	-	3	-	-	-	-	-	3	-	-	-	-	-
OCPs/OPPs																
HCB	-	-	-	-	10	-	-	-	-	-	10	-	-	-	-	-
Heptachlor	-	-	-	-	6	-	-	-	-	-	10	-	-	-	-	-
Aldrin & dieldrin	-	-	-	-	6	-	-	-	-	-	10	-	-	-	-	-
Chlordane	-	-	-	-	50	-	-	-	-	-	70	-	-	-	-	-
Endosulfan	-	-	-	-	270	-	-	-	-	-	340	-	-	-	-	-
DDE, DDD & DDT	-	-	-	-	240	-	-	-	-	-	400	-	-	-	-	-
Endrin	-	-	-	-	10	-	-	-	-	-	20	-	-	-	-	-
Methoxychlor	-	-	-	-	300	-	-	-	-	-	400	-	-	-	-	-
Chlorpyriphos	-	-	-	-	160	-	-	-	-	-	250	-	-	-	-	-
PCBs																
PCBs (Total)	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-
Heavy metals																
Arsenic	-	-	-	-	100	-	-	-	-	-	300	-	-	-	-	-

ANALYTE	LOW DENSITY RESIDENTIAL LAND USE						PUBLIC OPEN SPACE LAND USE						MAINTENANCE/EXCAVATION WORKERS			
	HSL A (in silt)[1] (mg/kg)				HIL A[2] (mg/kg)	Direct contact[3] (mg/kg)	HSL C (in silt)[1] (mg/kg)				HIL C[2] (mg/kg)	Direct contact[3] (mg/kg)	HSLs (in silt)[4] (mg/kg)			Direct contact[3] (mg/kg)
	0 to <1 m	1 to <2 m	2 to <4 m	4 m +			0 to <1 m	1 to <2 m	2 to <4 m	4 m +			0 to <2 m	2 to <4 m	4 m +	
Cadmium	-	-	-	-	20	-	-	-	-	-	90	-	-	-	-	-
Chromium	-	-	-	-	100[6]	-	-	-	-	-	300[6]	-	-	-	-	-
Copper	-	-	-	-	6,000	-	-	-	-	-	17,000	-	-	-	-	-
Lead	-	-	-	-	300	-	-	-	-	-	600	-	-	-	-	-
Mercury	-	-	-	-	40	-	-	-	-	-	80	-	-	-	-	-
Nickel	-	-	-	-	400	-	-	-	-	-	1,200	-	-	-	-	-
Zinc	-	-	-	-	7,400	-	-	-	-	-	30,000	-	-	-	-	-

(1) NEPM (2013) Schedule B1 Table 1A(3) Soil HSLs for vapour intrusion (mg/kg)
(2) NEPM (2013) Schedule B1 Table 1A(1) Health investigation levels for soil contaminants (mg/kg)
(3) CRC CARE (2011) Table A4 Soil HSLs for direct contact (mg/kg)
(4) CRC CARE (2011) Table A3 Soil HSLs for vapour intrusion (mg/kg)
(5) Benzo(a)pyrene toxicity equivalent quotient (TEQ), calculated as a sum of weighted selected PAHs. Further details available in NEPM (2013) Schedule B2
(6) HIL for chromium VI adopted for total chromium as a conservative approach

- No assessment criteria available
NL Non-limiting due to maximum vapour concentrations being below the acceptable health risk level

7.2 ECOLOGICAL SCREENING LEVELS AND ECOLOGICAL INVESTIGATION LEVELS

The NEPM (2013) provides ecological screening levels (ESLs) for TRH, PAH and BTEXN compounds for use as an initial screening risk assessment to determine whether laboratory analysed concentrations of contaminants potentially pose a risk to plant growth. For the purpose of this investigation, ESLs for 'urban residential and public open space' land uses with fine-grained soil textures have been considered. These are outlined in Table 7.2.

Table 7.2 Soil assessment criteria – ESLs

ANALYTE	ESLS FOR URBAN RESIDENTIAL AND PUBLIC OPEN SPACE (mg/kg dry soil)
TRH C_6-C_{10} minus BTEX (F1)	180
TRH >C_{10}-C_{16} minus naphthalene (F2)	120
TRH >C_{16}-C_{34} (F3)	1,300
TRH >C_{34}-C_{40} (F4)	5,600
Benzene	65
Toluene	105
Ethylbenzene	125
Xylene (Total)	45
Benzo(a)pyrene	0.7

The NEPM (2013) also provides ecological investigation levels (EILs), which were developed for metals, naphthalene and pesticides. The EILs take into consideration the physiochemical properties of soil and contaminants and the capacity of the local ecosystem to accommodate increases in the contaminant levels. The EILs are derived using the following equation:

$$EIL = added\ contaminant\ limit\ (ACL) + ambient\ background\ concentration\ (ABC)$$

The ABC is the background contaminant level and requires measurement at appropriate reference points at the site. The ACL, which is provided in the NEPM (2013), is the maximum contaminant concentration added to the naturally occurring background level, exceedances of which may result in adverse effects on plant health. EILs corresponding to urban residential land use were applicable for this investigation and are further discussed in Section 8.2.2.

7.3 SALINITY AND SODICITY CHARACTERISATION

Salinity and sodicity results were assessed against the rankings presented in NSW DLWC (2002), *Site Investigations for Urban Salinity*. Table 7.3 below presents these rankings based on calculated salinity (derived from EC_e calculated from EC and ESP calculated from exchangeable sodium measured against total cation exchange capacity).

Table 7.3 Salinity and Sodicity Ranking System (DLWC 2002)

SOIL SALINITY RANKING	
EC_e <2 dS/cm	Non-saline
EC_e 2-4 dS/cm	Slightly saline
EC_e 4-8 dS/cm	Moderately saline
EC_e 8-16 dS/cm	Very saline
EC_e >16 dS/cm	Highly saline
SOIL SODICITY RANKING	
ESP <5 %	Non-sodic
ESP 5-15 %	Sodic
ESP >15%	Highly sodic

8 INVESTIGATION RESULTS

8.1 SUBSURFACE CONDITIONS

The subsurface profile at the site comprised silty clay fill materials at all investigation locations, underlain by dark brown and then red clay, with occasional shale layers in between. At three boreholes, sandy material and a sandstone layer was encountered towards 3.0 mBGL. Fill materials generally comprised brown and dark brown fine grained silty sand materials with anthropogenic inclusions such as brick and glass fragments, with plastics and ceramics.

Headspace analysis of VOCs was undertaken on all soil samples collected using a calibrated PID. PID readings reported ranged from 0.0 to 0.12 ppm, suggesting that soils were unlikely to contain significant concentrations of VOCs.

No ACM was identified on the ground surface during the site walkover.

intrusive drilling works, no asbestos containing material was identified on the ground surface across the site.

Environmental borehole logs (including GPS coordinates and PID readings) are provided in Appendix C, and sampling locations are shown on Figure 2.

8.2 ANALYTICAL RESULTS

Selected soil samples collected from boreholes and surface sampling locations were analysed for contaminants of concern. Soil samples were selected based on a combination of sample location (to provide site coverage) and field observations (to target areas of potential concern).

The following sections provide a summary of the results of the soil investigation. More detailed summary tables of analytical results are provided in Tables E1 to E6 in Appendix E, and laboratory reports are provided in Appendix G.

8.2.1 HILS/HSLS

Table 8.1 provides a summary of the number of primary samples analysed, analytes tested for, minimum/maximum constituent concentrations, and samples that exceeded the adopted HILs and/or HSLs for the site.

Table 8.1 Summary of soil analytical results with respect to HILs/HSLs

NO. OF PRIMARY SAMPLES	ANALYTE	CONC. (mg/kg)		SAMPLES EXCEEDING ADOPTED HILS/HSLS		
		Min.	Max.	Low density residential	Public open space	Maintenance/ excavation workers
TRH/BTEX compounds						
40	TRH C_6-C_{10}	<10	<10	-	-	-
40	TRH C_6-C_{10} minus BTEX (F1)	<25	<25	-	-	NA
40	TRH >C_{10}-C_{16}	<50	<40	-	-	-
40	TRH >C_{10}-C_{16} minus naphthalene (F2)	<50	<50	-	-	NA
40	TRH >C_{16}-C_{34} (F3)	<90	150	-	-	-
40	TRH >C_{34}-C_{40} (F4)	<100	<100	-	-	-
40	Benzene	<0.2	<0.2	-	-	-
40	Toluene	<0.5	<0.5	-	-	-
40	Ethylbenzene	<0.5	<0.5	-	-	-
40	Xylene (Total)	<0.5	<0.5	-	-	-
PAHs						
40	Naphthalene	<0.5	<0.5	-	-	-
40	PAHs (Total)	<0.5	<0.5	-	-	NA
OCPs/OPPs						
23	Heptachlor	<0.05	<0.05	-	-	NA
23	Aldrin & dieldrin	<0.05	<0.05	-	-	NA
23	Chlordane	<0.05	<0.05	-	-	NA

NO. OF PRIMARY SAMPLES	ANALYTE	CONC. (mg/kg)		SAMPLES EXCEEDING ADOPTED HILS/HSLS		
		Min.	Max.	Low density residential	Public open space	Maintenance/ excavation workers
23	Endosulfan	<0.05	<0.05	-	-	NA
23	DDE, DDD & DDT	<0.2	<0.2	-	-	NA
23	Endrin	<0.05	<0.05	-	-	NA
23	Methoxychlor	<0.2	<0.2	-	-	NA
23	Chlorpyriphos	<0.05	<0.05	-	-	NA
PCBs						
23	PCBs (Total)	<0.1	<0.1	-	-	NA
Asbestos						
40	Bonded ACM / Friable asbestos and asbestos fines	Non detect		-		-
Heavy metals						
40	Arsenic	<5	11	-	-	NA
40	Cadmium	<1	<1	-	-	NA
40	Chromium	6	39	-	-	NA
40	Copper	9	39	-	-	NA
40	Mercury	<0.1	<0.1	-	-	NA
40	Nickel	<2	27	-	-	NA
40	Zinc	11	78	-	-	NA

8.2.2 EILS/ESLS

8.2.2.1 EIL CONCENTRATIONS

As discussed in Section 7.2, EIL concentrations are required to assess the potential ecological impacts of metals, pesticides and naphthalene contamination.

Tables 1B(4) and 1B(5) of the NEPM (2013) provide generic EILs for aged arsenic and lead, and fresh DDT and naphthalene in soils (irrespective of their physicochemical properties). Aged values are applicable for contamination present in soil for at least two years. EILs are provided for various land uses including ‘areas of ecological significance’, ‘urban residential and open space’ and ‘commercial and industrial’. The ‘urban residential and open space’ land use EILs have been considered for this investigation.

Table 8.2 outlines the EILs (generic and derived) for this investigation.

Table 8.2 Generic and calculated EIL concentrations

ANALYTE	**NEPM (2013) EILS (mg/kg)**
	URBAN RESIDENTIAL AND OPEN PUBLIC SPACES
Arsenic[1]	100
Chromium (III)[2]	190
Copper[4]	60
DDT[1]	180
Lead[3]	1,100
Nickel[2]	30
Zinc[5]	70
Naphthalene[1]	170

(1) NEPM (2013) Schedule B1 Table 1B(5) Generic EILs for aged As, fresh DDT and fresh naphthalene in soils irrespective of their physicochemical properties

(2) NEPM (2013) Table 1B(3) Soil-specific added contaminant limits for aged chromium III and nickel in soil

(3) NEPM (2013) Schedule B1 Table 1B(4) Generic added contaminant limits for lead in soils irrespective of their physicochemical properties

(4) NEPM (2013) Table 1B(2) Soil-specific added contaminant limits for aged copper in soils

(5) NEPM (2013) Table 1B(1) Soil-specific added contaminant limits for aged zinc in soil

8.2.2.2 COMPARISON OF ANALYTICAL RESULTS WITH ESLS/EILS

Table 8.3 summarises soil concentrations which exceeded the adopted ESLs/EILs for ‘urban residential and open public spaces’ land use adopted for the site.

Table 8.3 Summary of soil ESL/EIL exceedances

ANALYTE	SAMPLES EXCEEDING ADOPTED ESLS/EILS
	URBAN RESIDENTIAL AND OPEN PUBLIC SPACES
TRH/BTEX compounds	
TRH C_6-C_{10} minus BTEX (F1)	-
TRH >C_{10}-C_{16} minus naphthalene (F2)	-
TRH >C_{16}-C_{34} (F3)	-
TRH >C_{34}-C_{40} (F4)	-
Benzene	-
Toluene	-
Ethylbenzene	-
Xylene (Total)	-
PAHs	
Naphthalene	-
Benzo(a)pyrene	
OCPs	
DDT	-
Heavy metals	
Arsenic	-
Chromium (III)	-
Copper	-
Lead	-
Nickel	-
Zinc	-

8.3 SALINITY AND SODICITY INVESTIGATION RESULTS

8.3.1 FIELD OBSERVATIONS

During the field investigations, observations of the geomorphology and landscape characteristics of the site and surrounds were made. The site itself appears to have been regraded in parts and areas of open unvegetated land may have been the result of vehicle movement rather than salinity. No substantial evidence of soil erosion was identified on the site during the field investigation.

The creek and associated floodplain to the east, north and south of the site were well vegetated with a range of plants including salinity indicator plants identified in the NSW DIPNR (2005), *Salinity Indicator Plants* (most notably spike rush and swamp oak). In addition to these plants other plants with a lower tolerance to saline soil and groundwater conditions (e.g. eucalypts) were identified around the site and on the floodplain indicating that saline soils were not substantially affecting plant growth at the time of the investigation.

For the purposes of this salinity assessment, the geology on the site has been split into specific units. This division is to allow for assessment of lateral distribution of salinity rankings across the investigation area to identify zones with elevated risk.

- Fill: Identified in TP02 only and comprising clayey silt with wood and bricks (maximum depth 0.5mBGL)
- Topsoil/Organic Rich Layer: Predominantly clayey silt but also comprising sandy silt with higher composition of organic matter compared to other units in the stratigraphy. Generally ranged in depth from surface to between 0.3 and 1.0 mBGL (though identified as 2.0 mBGL in TP35 and TP37)
- Residual Clay/Weathered Shale: situated beneath the topsoil/organic rich layer and comprising clays and silty clays with varying amounts of shale gravels
- Weathered Sandstone: Encountered at depth in only two test pits (TP18 and TP21) from between 3.0 and 2.0 metres in depth respectively.

8.3.2 LABORATORY RESULTS

The results of the laboratory analysis were interpreted based on the guidance presented in NSW DLWC (2002), *Site Investigations for Urban Salinity*. The results of that interpretation are presented in Appendix E.

8.3.2.1 SALINITY RESULTS

Salinity has been assessed across the site based upon distribution within the soil units identified above. Salinity rankings have been derived from derivation of the EC_e and comparison against NSW DLWC (2002), *Site Investigations for Urban Salinity*.

- Fill: The samples collected from the fill material in TP02 was found to be non-saline to slightly saline.
- Topsoil/Organic Rich Layer: The majority of the soil samples analysed for salinity indicators were found to be non-saline to slightly saline. Three sample locations (TP27, TP32 and TP39) held a ranking of moderate salinity within this soil unit. These locations were situated in the south of the site.
- Residual Clay/Weathered Shale: Three sample locations (TP04, TP14 and TP37) held a ranking of non-saline but saline conditions were found to be prevalent in this soil unit. The majority of the soil samples analysed for salinity indicators were found to be slightly saline to moderately saline.
- Weathered Sandstone: All three samples collected from TP18 and TP21 in this soil unit returned a very saline ranking.

8.3.2.2 SODICITY RESULTS

With the exception of one non-sodic sample result (TP39_01), all soils assessed for sodicity across the investigation area held exchangeable sodium percentages (ESP) indicating sodic or highly sodic conditions. Generally, less sodic conditions were identified in the overlying topsoil/organic rich layer (though with the exception of one sample, all still indicative of sodic conditions). Deeper soils generally held ESPs indicative of highly sodic soils.

9 QUALITY ASSURANCE AND QUALITY CONTROL

The DQIs for sampling techniques and laboratory analyses of collected representative samples define the acceptable level of error required for this investigation. The DQI assessment is presented in Table 9.1.

Table 9.1 Data quality indicators

DQI	DESCRIPTION	APPLICABILITY
Representativeness	The confidence that the data are representative of each media present on the site. Expresses the degree to which sample data accurately and precisely represents a characteristic of a population or an environmental condition. Controlled through selecting sampling locations that exemplify site conditions and obtaining suitable samples.	Consistent and repeatable sampling techniques and methods were utilised.
Precision	The quantitative measure of the variability (or reproducibility) of data. Expressed as relative percentage differences (RPDs), assessed by determining the RPDs between the original and duplicate samples tested. Validity of the data is questioned if the RPD limits are exceeded and upon further investigation a reason cannot be determined.	Work was conducted in accordance with WSP standard procedures. The precision of the data was assessed by calculating the RPDs of duplicate samples following AS 4482.1 (2005).
Accuracy	The quantitative measure of the closeness of reported data to the true values. Accuracy can be undermined by such factors as field contamination of samples, poor preservation or preparation techniques.	Accuracy was assessed by using equipment blanks and laboratory QA/QC analytical results (including laboratory control samples, spikes, and reference samples).
Completeness	The measure of the amount of usable data from a data collection activity. Valid chemical data are the values that have been identified as acceptable or validated.	The completeness goal was set at there being sufficient valid data generated during the study. Measurements made were judged to be valid measurements.
Comparability	The confidence that data may be considered to be equivalent for each sampling analytical event, i.e. the confidence with which one data set can be compared with another. Achieved through qualitative assessment of QA/QC procedures, using comparable field sampling, laboratory sample preparation and analytical procedures and reporting units.	The sampling was in general accordance with the sampling and analysis procedures and as per standard industry procedures. Each sample was analysed using identical methods for each analyte and laboratory practical quantitation limits (PQLs) were consistent over each laboratory batch. A check laboratory was used to provide data to make a comparative assessment of variability between laboratories.

Table 9.2 summarises conformance to specific QA/QC procedures.

Table 9.2 Data quality assurance

ITEM	OBJECTIVES MET
Environmental consultant	The environmental consultant maintains quality assurance systems certified to AS/NZS ISO 9001:2000. Qualified and experienced environmental scientists with 1 to 5 years' experience completed field works.
Procedures	All work was conducted in accordance with relevant statutory work health and safety (WHS) and environmental sampling guidelines, as well as standard company WHS and environmental field procedures. Standard field sampling sheets were used. Details recorded included WSP staff and contractors present, time on/off-site, weather conditions, calibration records and comments.
Sampling	Collection of samples was undertaken by appropriately qualified and experienced personnel following WSP standard field procedures which are based on industry accepted standard practice. Chain of custody was used to ensure the integrity of samples from collection to receipt by the laboratory.
Field equipment	Equipment was serviced and calibrated as per the manufacturer requirements.
Equipment decontamination	Undertaken after each sampling episode where equipment used was not dedicated. Rinsate blanks to be non-detect for the potential contaminants (one rinsate blank per day). Field sampling procedures conformed to WSP QA/QC protocols to prevent cross contamination, preserve sample integrity, and allow for collection of a suitable data set from which to make technically sound and justifiable decisions with data of satisfactory usability. QA/QC sample results are presented in in Appendix E.
Transportation	Samples were stored in chilled eskies on-site and during transport via courier to the laboratory. A chain of custody form was completed on-site and sent with the samples. The laboratory confirmed receipt of the samples and specified the condition on delivery and the scheduled analyses. Appropriate holding times were met. Trip blank samples were carried during field works (at a rate of one per sample batch) to assess contamination through field activities and transport. Results were below laboratory PQLs.
Field QA/QC	Four rinsate blank was collected during the soil field works and analysed for TRH and BTEX compounds. All results were below PQLs. Four trip blanks were analysed for BTEX compounds and naphthalene. All results were below PQLs. One trip spike was analysed for BTEX compounds. Recovery results were reported between 88% and 90%. This was considered acceptable. QA/QC sampling was undertaken to industry standard procedures including approximately 1 in 20 blind duplicates (intra-laboratory) to the primary laboratory and approximately 1 in 20 blind duplicates (inter-laboratory) to the secondary laboratory. Field and laboratory acceptable limits are between 30-50% RPD as stated by AS 4482.1-1997. Non-compliances have been documented in Section 9.2 of this report.
Laboratory analysis	Analysis was carried out by laboratories with NATA certification for the required analyses. Detection limits were considered sufficient to enable comparison against the appropriate guidelines.

ITEM	OBJECTIVES MET
Acceptable limits for QA/QC samples	Primary laboratory QA/QC acceptance limits for recovery of surrogates, control samples are matrix spikes to be 70 to 130% for organics and 80 to 120% recovery for inorganics and waters. All method blanks to be less than PQL.
Reporting	Report generally complies with the NEPM (2013).

9.1 FIELD QA/QC

The following sections discuss the field QA/QC program. Summary tables of QA/QC results are provided as Table E7 in Appendix E, and the results for internal and external QA/QC procedures are provided within the laboratory analysis reports in Appendix G.

9.1.1 BLIND DUPLICATES

9.1.1.1 ANALYTICAL PROGRAM

The field QA/QC soil sampling program comprised collection and analysis of four intra-laboratory duplicate (QA02, QA04, QA05 and QA07) and four inter-laboratory duplicate (QA02A, QA04A, QA05A and QA07A) of primary soil samples TP34_0.1, TP26_0.15, TP09_0.5 and TP05_0.3 respectively and these samples were analysed for the same analytical suite as the corresponding primary samples.

No field duplicate analysis was undertaken for asbestos quantification. The purpose of collecting duplicate samples is to measure the potential for inaccuracy in sample results due to field or laboratory procedures. Analysis of anonymised duplicate samples by the primary and secondary laboratories serves to determine the degree to which sample analyses which should provide identical results do, in fact, provide them. The way this is measured is through the calculation of RPDs.

For contaminants which are discrete within the matrix being sampled, such as bonded asbestos, fibrous asbestos or asbestos fines in soil, the duplication of a particular sample does not logically support the objective of duplicate sampling. Chemical contaminants tend, through a variety of processes, to diffuse towards homogeneous concentrations. However, as asbestos contamination represents foreign bodies present in the soil which do not diffuse except through mechanical mixing there is no logical expectation of similar quantities in any two discrete samples, even two samples split from one larger one. Therefore, the results of the analyses of two such samples should not be expected to adhere to the same RPD criteria by which chemical contaminants are measured.

9.1.1.2 RPDS

RPDs were calculated for the primary and duplicate samples for assessment of the data quality, in particular for assessment of the reproducibility of the analytical data measurements or ‘precision’ given the adopted field and laboratory methods.

The RPDs were calculated using the formula below, and the results are presented in Tables E7in Appendix E.

$$RPD\% = \frac{|Ro - Rd|}{|(Ro + Rd)/2|} \times 100\%$$

Where Ro is the primary sample and Rd is the primary duplicate.

The RPD values were compared to the 30–50% RPD acceptance criterion outlined in Australian Standard AS 4482.1 (for non- and semi-volatiles in soil) and NEPM (2013) Schedule B3. For volatile compounds no published RPD acceptance criteria exists, however RPDs of <100% are considered acceptable where concentrations are at least 10 times the PQL. RPDs for results less than the PQL were not calculated. In instances where results were greater than the PQL for the one sample, but below PQL for the corresponding primary or duplicate sample, a result equal to the PQL was adopted in order to calculate an RPD.

RPD exceedances were reported as follows:

- Exceedance for chromium (74%) and its corresponding inter-laboratory duplicate (QA02A).
- Exceedances for arsenic (100%) and its corresponding inter-laboratory duplicate (QA04A).
- Exceedances for nickel (85%) and zinc (74%) for primary sample TP09_0.5 and its corresponding inter-laboratory duplicate (QA05A).

It is considered that these RPD exceedances are generally a function of low concentrations of these contaminants being present (less than 10 times the PQL), and that laboratory precision in terms of percentage differences is inherently low when analysing low concentrations.

All other RPDs were considered to be acceptable.

9.1.2 BLANKS/SPIKES

Four rinsate blanks, four trip blank and one trip spike were also collected and analysed for each day of field work. All results for blank samples were below PQLs.

Results for the trip spike were between 80% and 90%, considered to be acceptable.

Quality control parameter frequency compliance, provided by both laboratories, indicated that quality control analysis was undertaken within the required frequency and matrix spike recoveries were reported to be within recovery limits.

9.2 SUMMARY OF QA/QC RESULTS

WSP considers that the sample collection, documentation, handling, storage and transportation procedures utilised are of an acceptable standard and the analytical results provided by the laboratories are deemed reliable and complete, therefore the data are considered fit for purpose.

It is considered that the QA/QC procedures and results were acceptable and that the conclusions of the report have not been significantly affected by the sampling or analytical procedures. Based on the results of laboratory QA/QC samples and the sampling and handling procedures used for the collection and analysis of soil, the data were considered representative and appropriate for use in this assessment.

10 DISCUSSION OF RESULTS

10.1 SOIL

10.1.1 SOIL LABORATORY RESULTS

Soil analytical results are provided in Appendix E with laboratory certificates provided in Appendix G.

Soil samples were generally collected from soil surface (0.0-0.1 mBGL), 0.2-0.3 mBGL, 0.4-0.5 mBGL, 0.9-1.0 mBGL, and every metre thereafter (every 0.5 m in the boreholes selected for salinity testing, including in the fill). At least one sample was analysed from each investigation location.

Concentrations of TRH fractions, OCPs, OPPs, PAHs and PCBs in all soil samples selected for analysis were below the laboratory limit of reporting (LOR) or below the adopted assessment criteria.

Heavy metal concentrations were below the site assessment criteria in all samples.

Asbestos fibres were not detected in any of the 40 samples tested.

10.2 SALINITY AND SODICITY RISK

Soil at the surface was generally non-saline to slightly saline with some zones of moderately saline soils in the south of the site. The underlying residual clays and weathered shales were predominantly ranked slightly to moderately saline. The deeper weathered sandstone identified in TP18 and TP21 were found to be very saline.

The results indicate a general increase of salinity with depth. Soil salinity can impact upon plant growth, suitability of surface water bodies as habitat and affect construction materials and site infrastructure.

Soil testing for ESP indicated that soils on the site were generally sodic to highly sodic with soil sodicity increasing with depth. Soil sodicity reduces the ability of colloids to bind together and thus increases the risk of soil erosion.

10.3 UPDATED CSM

A key component of understanding the risks posed by potential contaminants, and how to manage them is the development of a contaminant Conceptual Site Model (CSM). In essence for a risk to exist there must be a source of contamination, a potential receptor (e.g. a human or ecological community) and a plausible pathway that links the two. This is known as a source-pathway-receptor analysis. If any one of these components is absent there is no unacceptable risk.

Table 10.1 provides a qualitative risk assessment by considering the potential for a pathway to develop between various sources and receptors.

Table 10.1 Source Pathway Receptor analysis

POTENTIAL SOURCE	PLAUSIBLE PATHWAY	POTENTIAL RECEPTOR	QUALITATIVE RISK	COMMENTS / RATIONALE
Heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc), TRH and BTEX compounds, PAHs, OCPs/OPPs, PCBs, VOCs, asbestos, herbicides, TNT, RDX.	Direct contact or ingestion	Future construction workers	Negligible	All soil results obtained in this investigation are less than direct contact criteria (hydrocarbons) and adopted assessment criteria.
		Future site occupants	Negligible	No soil results obtained in this investigation exceeded health investigation levels for low density residential use.
	Vapour intrusion	Future site occupants	Negligible	No soil results obtained in this investigation exceed HSLs on the site.
	Uptake by plants	Site Flora	Negligible	No soil results obtained in this investigation exceeded ecological thresholds or EILs.
	Migration in groundwater	Ecology of nearby creeks and ponds	Negligible	No soil results obtained in this investigation exceeded ecological thresholds or EILs.
Salinity and sodicity indicator analytes including pH, electrical conductivity (EC), chloride, sulfate and exchangeable cations in soil	Direct exposure of structures to aggressive soil conditions	Future structures on site	Medium	The results indicate a general increase of salinity with depth. Soil salinity can impact construction materials and site infrastructure.
	Potential for erosion and sediment generation in runoff	Future development works	Medium	Soils tested on the site were generally sodic in nature with sodicity increasing with depth. Sodic soils present an elevated erosion hazard on-site.

11 CONCLUSIONS

WSP Australia Pty Ltd (WSP) was commissioned by RCC to undertake an environmental site assessment at the site. The location and boundaries of the property and the site are shown on Figures 1 and 2 respectively.

The site comprises an area of vacant land approximately 28,360 m^2 and the proposed redevelopment will comprise the construction of a primary school in the south-east portion of the site, with a playing field in the northern portion of the site.

The objectives of the investigation were to:

- assess the current contamination status of the site
- assess the potential risks associated with contamination (if identified) at the site, with respect to the proposed future land use as a school
- provide recommendations for potential management or remediation requirements, if required
- undertake salinity testing and provide a salinity assessment for the site.

The scope of works for the DSI comprised:

- mechanical boring at 40 different locations (TP01-TP40) across the site, using a hand auger to a depth of 1.5 metres below ground level (mBGL) in conjunction with a drill rig to reach a maximum depth of 3.2 mBGL
- collection of soil samples at locations from the surface (0.0-0.1 mBGL), 0.2-0.3 mBGL, 0.4-0.5 mBGL, 0.9-1.0 mBGL, and every metre thereafter (every 0.5 m in the boreholes selected for salinity testing, including in the fill)
- collection of asbestos presence/absence samples at the same depths as the soil samples from all locations
- laboratory analysis of selected representative soil and asbestos samples for the contaminants of concern identified at the site
- preparation of this DSI report which focuses on assessing the soil contamination status of the site (including a dryland salinity assessment), assessing the need for remediation at the site, and evaluating the suitability of the site for the proposed potential future land uses.

Surface soils are generally non-saline to slightly saline. This indicates that in the sites current form, site structures at the surface are unlikely to be affected by dryland urban salinity. Salinity on the site appears to generally increase with depth. Deeper structures (including footings, piles and service trenches) should have salinity resistant materials incorporated into their design.

Soils tested on the site were generally sodic in nature with sodicity increasing with depth. Sodic soils present an elevated erosion hazard on-site. Development works should be planned to accommodate for the elevated potential for erosion and sediment generation in runoff and the final development should ensure adequate protection of soils (e.g. through maintenance of vegetation coverage).

Based on the analytical results, there was negligible soil contamination impact identified on or beneath the site. Soil samples reported no contaminants of concern above the adopted HILs, EILs or HSL guidelines, therefore WSP are of the opinion that the site is suitable for the proposed development.

12 LIMITATIONS

Scope of services

This environmental site assessment report (the report) has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the client and WSP (scope of services). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

Reliance on data

In preparing the report, WSP has relied upon data, surveys, analyses, designs, plans and other information provided by the client and other individuals and organisations, most of which are referred to in the report (the data). Except as otherwise stated in the report, WSP has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. WSP will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP

Environmental conclusions

In accordance with the scope of services, WSP has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

On all sites, varying degrees of non-uniformity of the vertical and horizontal soil or groundwater conditions are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of soil and/or groundwater conditions encountered. The conclusions are based upon the data and the environmental field monitoring and/or testing and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of contaminants or emissions.

Also, it should be recognised that site conditions, including the extent and concentration of contaminants, can change with time.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

Report for benefit of client

The report has been prepared for the benefit of the client and no other party. WSP assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of WSP or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

Other limitations

WSP will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

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