Submission No 67

Item C, Tab 19 (1/2)

INQUIRY INTO ENROLMENT CAPACITY IN INNER CITY PUBLIC PRIMARY SCHOOLS

Name: NSW Department of Education

Date received: 27 September 2016

Douglas Partners
Geotechnics | Environment | Groundwater

Remediation Action Plan

Proposed Primary School
14 - 16 Wattle Street, Ultimo

Prepared for
Government Architect's Office

Project 73753.02
March 2015

Integrated Practical Solutions

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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.

	Signature	Date
Author		
Reviewer		

Executive Summary

This Remediation Action Plan (RAP) has been prepared for a proposed primary school at the property located at 14 – 16 Wattle Street, Ultimo (the site). The RAP was commissioned by the Government Architect's Office (GAO) on behalf of the Department of Education and Communities (DEC) by correspondence date 14 March 2014 and 28 January 2015 and was undertaken in accordance with Douglas Partners' proposal dated 4 August 2014. It is understood that the development consent authority is the Department of Planning and Environment.

The assessment process, including review of this RAP, is subject to a Site Audit by an EPA accredited Site Auditor under part 4 of the *Contaminated Land Management (CLM) Act* 1997. of ENVIRON Australia has been appointed as the Site Auditor.

The site has previously been used for a number of activities including a sandstone quarry and Council depot. Filling has been encountered on the site to depths of greater than 9 m below ground level (bgl). Contaminated soils and groundwater have been identified at the site, with contaminant sources including filling of unknown origin and previous use as a Council depot with tar, hot mix and asphalt plants and underground petroleum storage systems.

The objectives of this RAP are to:

- present a summary of the contamination issues identified at the site;
- identify the principals for remediation of the site;
- review the remediation options, and identify those most applicable for the project (the "preferred remediation strategies");
- identify additional works which are likely to be required for implementation of the preferred remediation options;
- assist the client (GAO and DEC) to determine the remediation strategy to be adopted for the project; and
- allow implementation of the remediation in conjunction with a Detailed Remediation and Validation Plan, to be prepared separately once the preferred remediation strategy has been identified.

The RAP does not aim to provide a detailed methodology for the final remediation strategy, and it is anticipated that the Detailed Remediation and Validation Plan or an equivalent technical methodology document will be prepared prior to commencement of remediation.

The scope of remediation is based on the results of previous contamination investigations and the details of the proposed development, and is not transferable to other development proposals at the site.

Based on a review of various remediation technologies, the following preferred remediation strategies were identified:

- Option 1: Source removal (with off-site disposal and/ or on-site bioremediation), partial physical encapsulation of soil and monitored natural attenuation (with possible phytoremediation);

- Option 2: Removal of soil to a nominated depth below proposed ground level (with off-site disposal and/ or on-site bioremediation), partial physical encapsulation and monitored natural attenuation (with possible phytoremediation);
- Option 3: Physical encapsulation of soil, including capping, impermeable barrier wall and vapour management; and
- Option 4: Removal and off-site disposal of all contaminated soil and groundwater.

It is considered that the site can be rendered suitable for the proposed development subject to appropriate further investigation and remediation in accordance with this RAP. A detailed remediation and validation plan with specific technical specification will be required to provide the detailed methodology for the adopted remediation strategy.

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Remediation Action Plan
Proposed Primary School
14 – 16 Wattle Street, Ultimo

1. Introduction

1.1 Background and Objectives

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The assessment process, including review of this RAP, is subject to a Site Audit by an EPA accredited Site Auditor under part 4 of the *Contaminated Land Management (CLM) Act* 1997. Mr Graeme Nyland of ENVIRON Australia has been appointed as the Site Auditor.

1.2 Site Identification and Zoning

Site details are provided in Table 1, below and a drawing showing the site boundary and location is presented on Drawing 1, Appendix A.

Table 1: General Site Information

Item	Description
Site Owner (current)	City of Sydney Council (CoS)
Site Owner (future)	Department of Education and Communities
Proponent	Department of Education and Communities
Lot and DP Number	Lot 2, Deposited Plan 834973
Site Address	14 to 26 Wattle Street, Pyrmont Also known as 14 – 16 Wattle Street, Ultimo
County/Parish	Parish of St Andrew, County of Cumberland
Local Government Authority	City of Sydney (CoS)
Total Site Area	1.219 ha (based on deposited plan)
Current Zoning	B4 – Mixed Use under CoS LEP 2012 (further information provided below)
Current Site Use	Industrial
Proposed Future Land Use	Primary School

An extract from City of Sydney LEP 2012 details land use applicable to Zone B4 and is provided below. Educational establishments are permitted with consent.

"1 Objectives of zone

- *To provide a mixture of compatible land uses.*
- *To integrate suitable business, office, residential, retail and other development in accessible locations so as to maximise public transport patronage and encourage walking and cycling.*
- *To ensure uses support the viability of centres.*

2 Permitted without consent

Home occupations

3 Permitted with consent

Boarding houses; Child care centres; Commercial premises; Community facilities; Educational establishments; Entertainment facilities; Function centres; Hotel or motel accommodation; Information and education facilities; Medical centres; Passenger transport facilities; Recreation facilities (indoor);

Registered clubs; Respite day care centres; Restricted premises; Roads; Seniors housing; Shop top housing; Any other development not specified in item 2 or 4.

4 Prohibited

Extractive industries; Heavy industrial storage establishments; Heavy industries"

1.3 Proposed Development

Plans for future development of the site are still under consideration, but Douglas Partners Pty Ltd (DP) understands that the proposed site use would comprise a primary school. It is further understood that the proposed structures are likely to include a multi-storey building and a free play area. No bulk excavation is understood to currently be proposed for the development, however, detailed excavations for services and foundations are likely.

1.4 Regulatory Background and Requirements

1.4.1 Regulations, Guidelines and References

The following regulations, guidelines and references are applicable, *inter alia*, to contamination management at the site:

Acts

- *Waste Avoidance and Resource Recovery Act* (NSW) 2001;
- *Protection of the Environment Operations Act* (NSW) 1997 (the POEO Act);
- *Contaminated Land Management Act* (NSW) 1997 *(as amended 2008)* (the CLM Act); and
- *Environmental Planning and Assessment Act* (NSW) 1979. Of particular relevance is the State Environmental Planning Policy (SEPP) 55 – *Remediation of Land* (SEPP55).

Council Policies and Plans

- City of Sydney *Local Environmental Plan* 2012 (CoS 2012);
- City of Sydney *Managing Asbestos Policy* 2013 (CoS 2013);
- City of Sydney *Managing Asbestos Guidelines* 2013 (CoS 2013a); and
- City of Sydney *Contaminated Land Development Control Plan* 2004 (CoS 2004).

Guidelines and References

- NSW Environmental Protection Authority (EPA) *Waste Classification Guidelines* (2014) (EPA 2014);
- National Environment Protection Council (NEPC) *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013)* (NEPC 2013);
- NSW Environmental Protection Authority (EPA) *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases* (2012) (EPA 2012);

- NSW Office of Environment and Heritage (OEH) *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites* (reprinted 2011) (OEH 2011);
- NSW DECCW *Vapour Intrusion: Technical Practice Note* September 2010 (DECCW 2010);
- NSW Department of Environment and Climate Change (DECC) *Contaminated Sites: Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997* (2009) (DECC 2009);
- NSW Department of Environment and Conservation (NSW DEC) *Contaminated Sites: Guidelines for the Assessment and Management of Groundwater Contamination* (2007) (NSW DEC 2007);
- NSW Department of Environment and Conservation (NSW DEC) *Contaminated Sites: Guidelines for the NSW Site Auditor Scheme 2nd edition* (2006) (NSW DEC 2006);
- Australian and New Zealand Environment and Conservation Council (ANZECC) / Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000) (ANZECC 2000); and
- NSW Environmental Protection Authority (EPA) *Contaminated Sites: Sampling Design Guidelines* (1995) (EPA 1995).

1.4.2 Regulatory Framework of this RAP

This RAP was prepared in general accordance with the NEPM (2013) and DEC (2006).

This RAP has been prepared to assist the DEC to meet the regulatory requirements for approval of the proposed development under the EP&A Act.

This RAP does not address requirements which may apply under the CLM Act relating to the Duty to Report or contamination significant enough to warrant regulation under the CLM Act. It is noted, however, that there does appear to be a duty to report under the CLM Act for the contamination at the site. Under section 60 of the CLM Act, a person whose activities have contaminated land or a landowner whose land has been contaminated is required to notify DECC [now EPA] when they become aware of the contamination. If required, this RAP, or superseding documents, should be amended as appropriate to address any requirements specified by the EPA under the CLM Act.

2. Previous Reports and Site Information

2.1 Reviewed Reports

The following reports were reviewed as part of this investigation:

- Environmental Investigation Services (EIS) *Environmental Investigation for Proposed Redevelopment of Council Depot at Wattle Street, Pyrmont, NSW* (Report No. E10242S/a, May 1994) (EIS, 1994);
- Coffey Partners International Pty Ltd (Coffey) *Wattle Street Depot, Ultimo, Environmental Site Assessment* (Report No. E2035/1-AF, August 1996) (Coffey 1996);

- Coffey *Wattle Street Depot, Ultimo, Supplementary Environmental Site Assessment* (Report No. E2035/2-AF, July 1997) (Coffey 1997);
- Coffey *Wattle Street Depot, Ultimo, Groundwater Monitoring and Well Installation* (Report No. E2035/6-AF, July 1998) (Coffey 1998);
- DP *Groundwater Monitoring, Wattle Street Depot Ultimo* (Project 30824, May 2002) (DP, 2002a);
- DP *Report on Supplementary Groundwater Monitoring, Wattle Street Depot Ultimo* (Project 30824A, September 2002) (DP, 2002b);
- DP *Report on Supplementary Groundwater Monitoring, Wattle Street Depot Ultimo (Round 3)* (Project 30824B, September 2003) (DP, 2003);
- DP *Report on Additional Environmental Assessment Works, Wattle Street Depot Ultimo* (Project 37334, December 2004) (DP, 2004);
- DP *Remediation Action Plan, Wattle Street Depot Ultimo* (Revision 2, Project 30284D, June 2005) (the RAP);
- Sinclair Knight Merz (SKM) *Site Audit Report, Site Audit 103 by Dr Ian Swane, Review of Remediation Action Plan for Wattle Street Depot, Ultimo NSW 2007* (Project EN01749, July 2005) (SKM 2005);
- DP *Advice on Remediation Requirements and Geotechnical Issues, Wattle Street Depot, Cnr of Wattle & Fig Streets, Ultimo* (Project 73753, December 2013) (DP, 2013); and
- DP *Report on Contamination Investigation, Proposed School 14 - 16 Wattle Street, Ultimo* (Project 73753.01, July 2014) (DP, 2014).

2.2 Site History

In summary, the historic records included in the previous reports indicate the following:-

- The site is located in an area of reclaimed land (from Blackwattle Bay *circa* 1869) extending from Allen Street to Quarry Street;
- The site was used as a quarry and stone handling facility between *circa* 1869 and 1905. Irving (2006)[1] (extracts provided in Appendix B) provides a sketch showing the site in the area of the "Purgatory" and "Hell Hole" quarry areas, with a stone workshop. Irving (2006) notes that Hell Hole was 20 foot below the street level and Purgatory was known for its extremely hard rock, thought to be due to a nearby volcanic dyke. The face of one quarry cut was recorded as being approximately 23 m. Irving (2006) further states that the quarries were progressively backfilled from the late 1890s, with some filling coming from basement excavations at the Queen Victoria Building; and other filling being the subject of court actions against some contractors for dumping refuse, including garbage from other Council areas;
- No information was provided in the previous historical reviews regarding the filling of the site following completion of quarrying works. It is assumed that filling was undertaken in the late 1800s/ early 1900s. It is noted that asbestos was mined and used in Australia during this period;

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[1] Irving R. (2006) *Paradise Purgatory Hell Hole: The Story of the Saunders' Sandstone Quarries, Pyrmont*. Media Masters, SIngapore

- Council leased or acquired the site in 1905. Council structures/ activities at the site included (dates in brackets indicated installation date unless otherwise stated):
  - tar distillation/ heater plant (1905), associated boiler and (underground?) storage tanks (1906), and replacement boilers (1913, 1918, 1922);
  - importation of 300 tonnes of ballast for repair and levelling work (1913-1914);
  - construction of an office block (approved 1916) and concrete roadway constructed (1920);
  - installation of storage boilers for tar (1916);
  - problem with removal of residual oil from tar distilling recorded (1919-1920);
  - installation of additional re-enforced concrete tar storage tank at western end of tar still and tar cast iron tar storage tank moved to Wattle Street (from Fort Street?, semi-underground?) (1925);
  - 1931 – it appears on-site tar plant oil fired, no reference to oil storage;
  - second hot mix plant (1929);
  - new asphalt plant (1936);
  - three 500 gallon oil storage tanks and pumps (1952);
  - lease and construction of substation (*circa* 1953);
  - painters workshop and spray paint booth (1965);
  - several Underground Petroleum Storage Systems (UPSS) (for petrol and kerosene) (installation date unknown). A petrol leak from an existing Underground Storage Tank (UST) was recorded in 1968;
  - chatomix additive used in bituminous asphalt mixes (1974);
  - asphalt plant was converted from diesel to natural gas fired;
  - part of the site has been used for coal tar dipping of wood;
  - all UPSS known to Council removed (early 1990s). No information on removal of associated contaminated soils or validation; and
  - Sediment pits for on-site treatment of wastewater, an air-conditioning plant, dust exhaust plants, a circular saw plant and a disinfection plant were also present at the site. No information is available on their decommissioning;
- Armed Forces research (1943);
- Use as a film set, including stockpiled soils (2013); and
- Used as works depot by Council and others, with works observed to mainly comprise storage (including of soils) (2014).

A new area of concrete was observed to be laid in the vicinity of contamination “Area 5” during fieldwork for DP (2014). Discussion with site personnel indicated this was to cap suspected friable asbestos observed in this area.

2.3 Site Description and Discussion with Personnel Communications

The site was inspected on 22 November 2013 by an experienced Environmental Scientist from DP, and subsequently in April 2014 during fieldwork for DP (2014) (refer to Section 2). The following site description is taken from records during those inspections. A review of an aerial photograph dated 29 November 2014[2] indicated that no significant change in land use had occurred to that described below.

The site is located on the northern corner of the intersection of Wattle and Fig Streets, Ultimo. The site comprises a semi-rectangular-shaped parcel of land.

Topographical relief over the site is generally relatively flat, with a gentle slope towards the west. A sandstone cutting, estimated to be in the order of 10 m in height, forms the north eastern edge of the site. Remnants of concrete and brick walls are present against and on top of the sandstone cutting, particularly in the southern portion. These structures may be related to previous buildings on site (now demolished), retention associated with Jones Street, or cutting stabilisation measures (or a combination). The cutting is heavily vegetated in part.

The storage of multiple items (discussed below) obscured much of the ground surface during the inspection. Observed ground surface cover included unpaved dirt and gravel, concrete and asphalt.

The south eastern portion of the site had been fenced off and was leased to various companies (GMW Urban, Byrne Civil and Ford Civil), and appeared to be used mainly for storage and as distribution yards. Stored items included soil and general construction equipment.

The north western portion of the site was used by Council, and appeared to be used mainly for storage. Council was in the process of sorting and removing some stored items (sandstone blocks, crushed or recycled asphalt / roadbase, timber poles (possibly treated), bricks on pallets, tiles etc) during fieldwork for the DP (2014) investigation.

Apart from the outer façade facing Wattle and Fig Streets, the (presumed) guard house facing Fig Street, and a single brick building within the southern leased areas, the remaining previous buildings on the boundaries to Wattle and Fig Streets were in various stages of demolition / decay, some with only partial shells remaining. All appeared to be of brick construction. There was no evidence of former internal buildings / structures remaining within the site, and only partial remains of concrete walls were present along the southern portion of the eastern boundary (former coal tar distilling and concrete batch plant).

Ground covering at the time of the inspection precluded thorough inspection for signs of concern at the surface (such as UPSS), although none were observed in the clear areas. Metals lids covering pits near the former guard house may be associated with the stormwater system or an oil-water separator.

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[2] As available at nearmap.com

2.4 Adjacent Land Uses

Again the following adjacent area descriptions are taken from the records during inspections by DP in November 2013 and April 2014. Adjacent land uses comprised:

- North East – residential or Jones Street then residential. A multistorey residential development was under construction directly adjacent to the site at the northern end of Jones Street at time of reporting;
- South East - Fig Street, then commercial/ industrial building. Used for warehousing/ storage at time of reporting, building signage indicates previous use as 'Ultimo Trade Centre";
- South West - Wattle Street, then Wentworth Park. Wentworth Park was reclaimed in 1876 to 1880 using silt dredged from the harbour[3]. Prior to reclamation the land had been a swamp impacted by discharges from adjacent land uses including abattoirs, tanneries and a distillery. Post reclamation the land has been mainly used for recreation, however other uses included storage of wool in the World Wars and as an American Army camp during World War 2; and
- North West - a railway easement and Wentworth Park Station (light rail), then commercial/ industrial, then high rise residential.

2.5 Subsurface Conditions

Previous assessments at the site encountered heterogeneous filling to depths to greater than 9 m bgl, overlying sandstone bedrock and/or alluvial sand and clays. These results are consistent with the published mapping, considering the site's previous use as a sandstone quarry that was subsequently backfilled with various types of filling material to present ground levels.

Observed filling during the previous investigations included silty sands, clays and gravels with frequent sandstone boulders, crushed sandstone and igneous rock (likely to include ballast based on site history information), buried concrete and asphalt pavements. Petroleum, tar and creosote odours, free petroleum product and an unidentified black liquid with a diesel odour were observed (DP, 2004).

Sandstone bedrock is present at the site, and has been encountered at depths from 2.1 m to greater than 9 m bgl. A natural alluvial soil profile has been reported as present between the filling and sandstone in some locations, however given the history of the site as a quarry this material may actually be filling.

Groundwater has generally been encountered at depths of between 0.5 and 3 m bgl and from approximately RL 0.4 to RL 1.85 (AHD). Groundwater at the site is expected to be flowing generally towards Blackwattle Bay, although previous reports indicate locally groundwater may be "exiting" from the south west of the site (along Wattle Street) or from the south of the site near the corner of Wattle and Fig Streets (possibly due to underground structures impacting flow direction). Previous reports have indicated possible changing directions of groundwater flow. This has not been confirmed by ongoing monitoring of groundwater. Groundwater at the site may be impacted by tides.

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[3] http://www.wentworthparkgames.org.au/history.html

Based on packer testing, bedrock permeability was assessed to be in the order of 10^{-7} m/s. Based on slug test results, the permeability of the filling was assessed to be in the order of 10^{-5} m/s.

Acid sulphate soil (ASS) has been detected within some of the filling materials.

2.6 Flooding, Surface Water and Stormwater Drainage

The current ground level of the site is understood to be below the 1 in 100 year flood level.

The closest surface water body is Blackwattle Bay, approximately 150 m north west of the site. Blackwattle Bay forms part of the Parramatta River/ Sydney Harbour. A tributary originally entered the Harbour at the Bay.

Surface water run-off drains from the site through drainage pits located on Jones, Fig and Wattle Streets and the railway embankment to the north of the site. It is expected that the stormwater system drains to Blackwattle Bay.

2.7 NSW Office of Water Bore Search

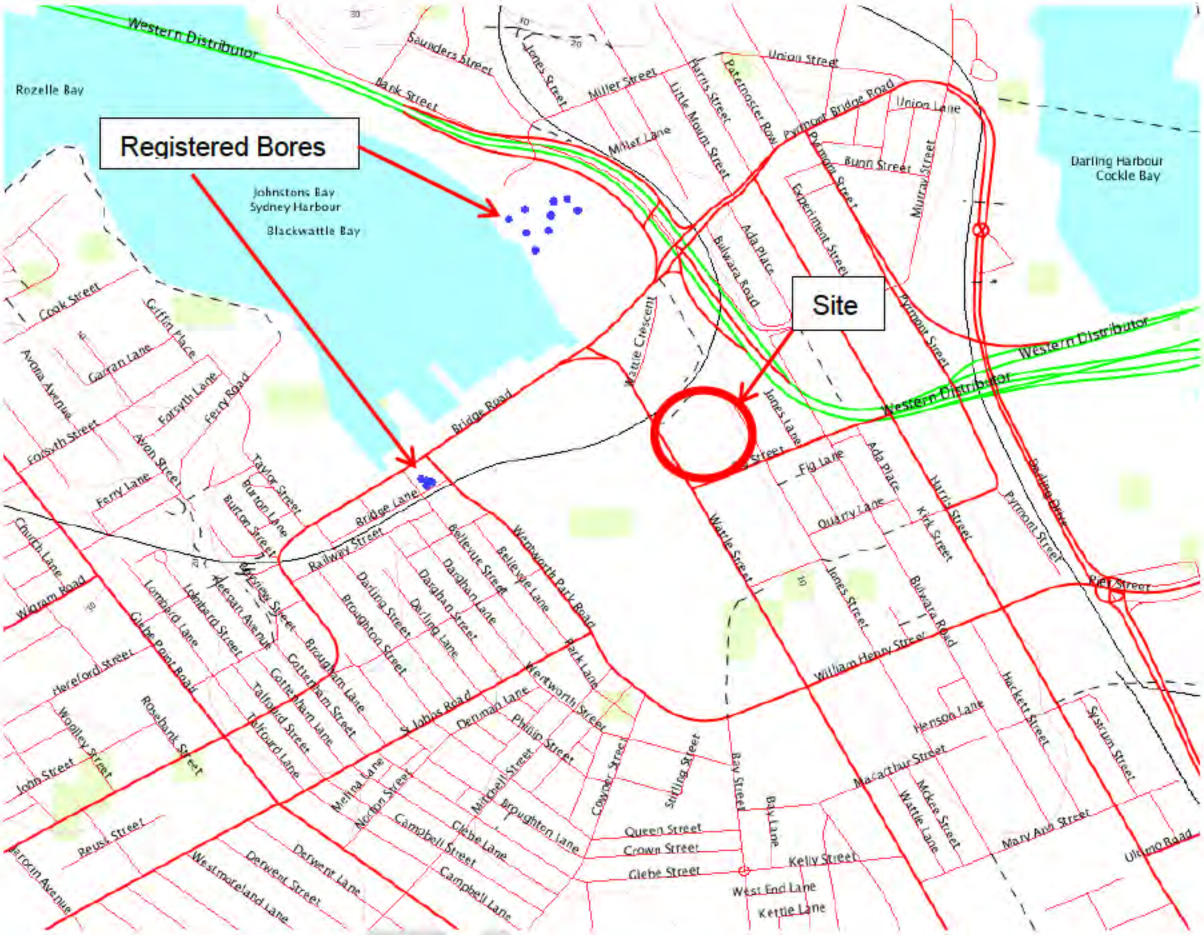
A search of bores registered with the NSW Office of Water (NOW) was undertaken on 8 August 2014, and the map of bores in the area of the site is shown in Figure 1, below.

Two groups of bores were observed to the north west and west of the site, with both groups registered as being monitoring bores.

It is considered unlikely that groundwater from the site would impact any of the bores registered with NOW.

No up-gradient bores with a potential to impact the site were identified.

Figure 1 – NOW Registered Groundwater Bores[4]



2.8 Primary Contaminants of Concern

Based on the previous investigations there is considered to be a significant risk of both light non-aqueous phase liquids (LNAPL) and denser non-aqueous phase liquids (DNAPL) being present at the site. The LNAPL would generally be expected to comprise petroleum-fuel sourced contamination whilst the DNAPL would be expected to be sourced from tar and asphalt sourced contamination. Low levels of solvents and chlorinated hydrocarbons were detected in soil vapour in DP (2014), although these compounds were not detected in groundwater. If significant concentrations of solvents or chlorinated hydrocarbons are present, these could also form a DNAPL at the site.

The main contaminants of concern identified to be present at elevated concentrations at the site are polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPH)[5], benzene, toluene, ethylbenzene and xylenes (BTEX), phenols, arsenic, lead and chromium Other contaminants of

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[4] Map created with the NSW Natural Resource Atlas – www.nratlas.nsw.gov.au 08/08/2014. Copyright © 2014 New South Wales Government. Map has been compiled from various sources and may contain errors or omissions. No representation is made as to its accuracy or suitability.

[5] total petroleum hydrocarbons (TPH) is normally assessed using the screening laboratory test total recoverable hydrocarbons (TRH), which detects TPH along with other organic compounds.

concern potentially present at the site based on the site history include cresols, volatile organic compounds (VOC) (including solvents and chlorinated hydrocarbons), polychlorinated biphenyl (PCB), organochlorine pesticides (OCP), explosive residues and asbestos.

2.9 Extracts from Previous Reports

Selected extracts/ information from previous report is provided as follows:

- A drawing showing available information on fill depths (Appendix A);
- Drawings of previous test locations, and available borehole and test pit logs (Appendix B);
- Bedrock Contours (Coffey 1997) (Appendix B); and
- Selected laboratory results (DP 2014) (Appendix C).

3. Conceptual Site Model

A conceptual site model (CSM) is a representation of site-related information regarding contamination sources, receptors and exposure pathways between those sources and receptors. The CSM provides the framework for identifying how the site became contaminated 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.

Figure 2, below, provides a diagrammatic representation of where risk is present from contamination based on source – pathway – receptor linkages. A risk is only present if a source, pathway and receptor are all present. If one of these is removed, the corresponding risk to human health or the environment is also removed.

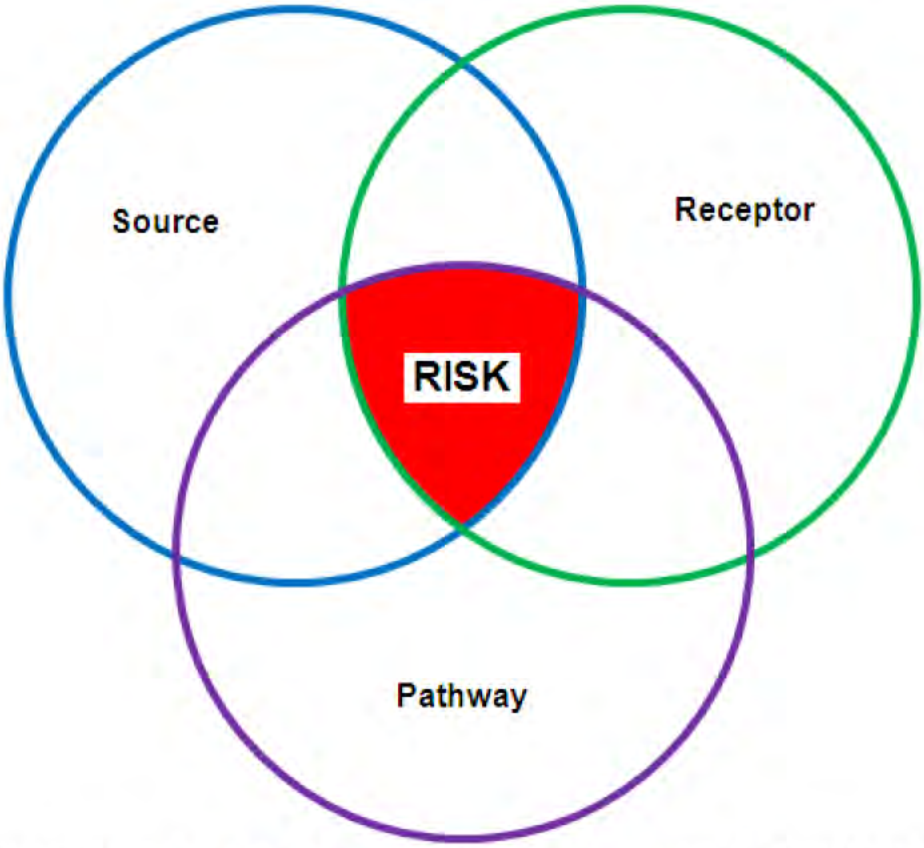

Figure 2: Presence of Risk with Respect to Source – Pathway – Receptor linkages

The CSM has been prepared based on the previous assessment and has been used in determining an appropriate remediation strategy for the site.

3.1 Potential Contamination Sources

The potential contamination sources detailed in Table 2 have been identified. Sources considered to require remediation/ further assessment on the basis of the previous investigation results are detailed below the Table.

Table 2: Potential Contamination Sources and Contaminants of Concern

Potential Source	Description of Potential Contaminating Activity	Contaminants of Concern
Confirmed Sources/ Contaminants Above/ Potentially Above Health Screening/ Investigation Levels		
Imported fill of unknown origin	– Importation of potentially contaminated filling soils	Contaminants detected at the site associated/ possibly associated with the filling include: metals (manganese, lead, arsenic, mercury), PAH, TPH, BTEX, phenol. Asbestos contamination in filling has not been confirmed in the previous investigation reports, but is understood to be present based on communication with Council workers.
Previous land uses	– Tar/ asphalt processing, – Former UPSS (oil, petrol and kerosene) – Former substation – Former wood treatment/ preservation (coal tar dip) – Armed Forces research	PAH, TPH, BTEX phenol, metals (lead, arsenic, mercury – or possibly sourced from the filling)
Unconfirmed Sources/ Potential Contaminants of Concern		
Imported fill of unknown origin	– Importation of potentially contaminated filling soils	Metals (other than as listed above), OCP, PCB, Asbestos
Previous land uses	– Tar/ asphalt processing, – Former UPSS (oil, petrol and kerosene) – Former substation – Former wood treatment/ preservation (coal tar dip) – Spray painting – Armed Forces research	Cresols, PCB, VOC, OCP, explosive residues Also, characterisation of contaminants of concern identified to be present at site in deeper soils is limited.
Current land use	– Stockpiling of soils/ filling – Use of plant (backhoes, forklifts etc)	PAH, TPH, BTEX, VOC, phenol, metals, OCP, PCB
Adjacent land uses	– Reclaimed land (Wentworth Park) – Former industrial land uses in the area (abattoirs, tanneries)	Metals, TPH, ammonia

The current potential contamination sources (S) on the site (or adjacent), and the related contaminants of potential concern (COPC) are therefore as follows:

S1 – Previous and Current Land uses (potentially impacting soil, groundwater and vapour) - metals, PAH, TPH, BTEX, phenol, asbestos, cresols, PCB, VOC, OCP, OPP, ammonia and explosive residues;

S2 – Contaminated Filling - metals, PAH, TPH, BTEX, phenol, asbestos, PCB, OCP and OPP; and

S3 – Adjacent land uses – metals, TPH, ammonia.

In addition to the above COPC, the degradation of organic compounds in soils or groundwater can produce methane and carbon dioxide. The previous vapour testing (DP, 2014) detected methane below the lower explosive limit.

3.2 Potential Receptors

3.2.1 Human Health Receptors

R1 – Construction workers

R2 – Proposed site users (primary school)

R3 – Intrusive maintenance workers

R4 – Land users in adjacent areas (including residential)

3.2.2 Environmental Receptors

R5 – Groundwater

R6 – Surface Water (Blackwattle Bay)

R7 – Ecology

3.2.3 Other Receptors

R8 – Buried infrastructure

R9 – Buildings

3.3 Potential Pathways

Potential pathways for contamination include the following:

P1 – Direct contact with soil or groundwater

P2 – Outdoor inhalation of dust and/or vapours

P3 – Vapour intrusion and indoor inhalation of vapours

P4 – Vapour intrusion and explosion/ fire

P5 – Leaching of contaminants and vertical mitigation into groundwater

P6 – Migration of contaminants in groundwater

P7 – Surface water run-off

P8 – Extraction of groundwater for potable/ agricultural use

3.4 Summary of 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 and receptors are provided in Table 3 below.

Table 3: Conceptual Site Model

Source	Transport Pathway	Receptor	Comments
S1 – Previous and Current Land uses (potentially impacting soil, groundwater and vapour) - metals, PAH, TPH, BTEX, phenol, asbestos, cresols, PCB, VOC, OCP, OPP, ammonia and explosive residues. S2 – Contaminated Filling - metals, PAH, TPH, BTEX, phenol, asbestos, PCB, OCP and OPP. S3 – Adjacent land uses – metals, PAH, ammonia	**Human Health**		
	P1 – Direct contact with soil or groundwater (dermal or ingestion)	R1 – Construction workers	- Complete pathway considered to exist. - Can be managed by adoption of appropriate Work Health & Safety procedures, and compliance with a construction Environmental Management Plan (CEMP) if required under the adopted remediation strategy.
		R2 – Proposed site users (primary school)	- Complete pathway considered to exist. - Can be managed by implementing an appropriate remediation strategy.
		R3 – Intrusive Maintenance workers	- Complete pathway considered to exist. - Can be managed by implementing an appropriate remediation strategy and/ or adoption of appropriate Work Health & Safety procedures.
		R4 – Land users in adjacent areas (including residential)	- No complete pathway considered to exist. - Groundwater is not considered to be accessible by normal means for direct contact down-gradient of the site due to its depth and its poor quality precluding beneficial use.
	P2 – Outdoor inhalation of dust and/or vapours	R1 – Construction workers	- Complete pathway considered to exist. - Can be managed by adoption of appropriate Work Health & Safety procedures, and compliance with a CEMP if required under the adopted remediation strategy.
		R2 – Proposed site users (primary school)	- Complete pathway considered to exist. - Can be managed by implementing an appropriate remediation strategy.

Source	Transport Pathway	Receptor	Comments
		R3 – Intrusive Maintenance workers	- Complete pathway considered to exist. - Can be managed by implementing an appropriate remediation strategy and/ or adoption of appropriate Work Health & Safety procedures.
		R4 – Land users in adjacent areas (including residential)	- Complete pathway considered to exist. - Can be managed by implementing an appropriate remediation strategy and compliance with a CEMP.
	P3 – Vapour intrusion and indoor inhalation of vapours	R1 – Construction workers	- Complete pathway considered to exist. - Can be managed by implementing an appropriate remediation strategy and/or by adoption of appropriate Work Health & Safety procedures.
		R2 – Proposed site users (primary school)	- Complete pathway considered to exist. - Can be managed by implementing an appropriate remediation strategy.
		R3 – Intrusive Maintenance workers	- Complete pathway considered to exist. - Can be managed by implementing an appropriate remediation strategy and/ or adoption of appropriate Work Health & Safety procedures.
		R4 – Land users in adjacent areas (including residential)	- Vapour considered unlikely to be of concern based on vapour assessment results to date. - Can be managed by implementing an appropriate remediation strategy which addresses this issue if determined through additional investigations.
	P6 – Extraction of groundwater for potable/ agricultural use	R1 – Construction workers	- No complete pathway considered to exist. - No groundwater extraction for potable or agricultural use recorded at or down-gradient of the site or likely to occur in the future given the history of industrial land
		R2 – Proposed site users (primary school)	
		R3 – Intrusive Maintenance workers	

Source	Transport Pathway	Receptor	Comments
		R4 – Land users in adjacent areas (including residential)	use and highly urbanised nature of the area around the site.
	Environment		
	P1 – Direct contact with soil or groundwater	R7 – Ecology	- Complete pathway considered to exist. - The contamination at the site is likely to have been present for decades, and any impact to the terrestrial ecology is likely to have already occurred. Given the already degraded value of any terrestrial ecology at the site, and the likely remediation strategies for protection of human health requiring encapsulation, removal or extensive treatment of the soils, it is considered that protection of organisms in the subsurface filling is not warranted and not practical. It is considered that protection of above-ground ecology can be achieved using the strategies adopted for protection of human health.
	P5 – Leaching of contaminants and vertical mitigation into groundwater	R5 – Groundwater R7 – Ecology	- Complete pathway considered to exist. - Migration of contamination into groundwater has occurred. The ecology of the impacted groundwater is likely to be impacted. Mitigation of future impacts will be achieved through adopting an appropriate remediation strategy.
	P6 – Migration of contaminants in groundwater	R5 – Groundwater R6 – Surface Water (Blackwattle Bay) R7 – Ecology	- Complete pathway considered to potentially exist, although previous data and modelling indicates that contamination from the site is unlikely to reach Blackwattle Bay. - Migration of contamination in groundwater at and down-gradient of the site has occurred. The ecology of the impacted groundwater is likely to be impacted. Mitigation of future impacts will be achieved through

Source	Transport Pathway	Receptor	Comments
			adopting an appropriate remediation strategy.
	P7 – Surface water run-off	R6 – Surface Water (Blackwattle Bay) R7 – Ecology	- Complete pathway considered to potentially exist. - Can be managed by implementing an appropriate remediation strategy to prevent surface water coming into contact with underlying contaminated media.
	P8 – Extraction of groundwater for potable/ agricultural use	R6 – Surface Water (Blackwattle Bay) R7 – Ecology	- No complete pathway considered to exist. - No groundwater extraction for potable or agricultural use recorded at or down-gradient of the site, or likely to occur in the future given the history of industrial land use and highly urbanised nature of the area around the site.
	Buildings and Structures		
	P1 – Direct contact with soil or groundwater	R8 – Buried infrastructure R9 – Buildings	- Complete pathway considered to exist. - Potential damage to structures could be managed by use of engineering materials which are resistant to the contaminants of concern in areas where they are likely to be in contact with contaminated media, use of protective barrier layers between contaminated materials and engineered materials, removal or treatment of contaminated soils and groundwater or by a combination of these methods.
	P4 – Vapour intrusion and explosion/ fire	R8 – Buried infrastructure R9 – Buildings	- Complete pathway considered to exist - Can be managed by implementing an appropriate remediation strategy.

4. Remediation Objectives and Acceptance Criteria

4.1 Remediation Objectives

The remediation objectives are to:

- Appropriately address the management of residual soil and groundwater impact that currently poses an unacceptable risk to on-site and potentially off-site human and ecological receptors;
- Render the site suitable, from a contamination perspective, for the proposed primary school development;
- Minimise the risk of harm to human health and the environment during remediation; and
- Minimise the risk of harm to human health and the environment following remediation.

4.2 Remediation Acceptance Criteria

The remediation acceptance criteria will be "*no unacceptable risk to human health or the environment*". The risk will be assessed in general accordance with NEPC (2013).

Risk may be assessed to be acceptable based on:

- no pathway between the contaminant of concern and the receptor being available or foreseeably becoming available in the future; or
- all contaminants of concern being within risk-based site investigation levels. Site investigation levels may comprise generally conservative published levels appropriate for the proposed land use or site-specific concentrations calculated based on a quantitative risk assessment.

Details of the remediation acceptance criteria to be adopted for the adopted remediation strategy will be provided in the detailed remediation and validation plan.

5. Community Consultation

Community consultation and engagement should form an important part in the contaminated land management process for the site.

This RAP addresses technical aspects of remediation, however community concerns should also be considered as part of the decision making process in determining the remediation strategy to be adopted.

To allow informed community input into the process, stakeholders need to be provided with sufficient information, in readily understandable language to allow an understanding of the issues of potential concern and the risks associated with these issues. Given the complexity of contaminated land, both from a technical and regulatory perspective, it is important that these concepts are communicated clearly and transparently. It may be helpful to communicate risks associated with contamination with reference to other risks that the community encounters in everyday life, to allow a more considered understanding of the actual likely impacts from the issues of potential concern.

It is recommended that a specialist is engaged to assist in community consultation on contamination management at the site.

6. Remediation Technology Review

6.1 Regulatory Considerations

DEC (2006)[6] states that *"soil remediation and management is implemented in the following preferred order:*

1. *on-site treatment of the soil so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level;*
2. *off-site treatment of excavated soil so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level, after which the soil is returned to the site;*
3. *removal of contaminated soil to an approved site or facility, followed where necessary by replacement with clean fill;*
4. *consolidation and isolation of the soil on-site by containment within a properly designed barrier.*

If remediation is likely to cause a greater adverse effect than leaving the site undisturbed, remediation should not proceed.

In cases where it is not viable to remediate large quantities of soil with low levels of contamination, alternative strategies should be considered or developed."

A number of remediation strategies are reviewed in the following sections. Some of these are stand-alone strategies whilst others address a specific aspect only. The most appropriate strategy could therefore be a combination of two or more remedial actions.

NSW DEC (2007) covers remediation and management of groundwater and states: *"Where contamination is identified, the management objectives are to protect human and ecological health and to ultimately restore the groundwater to its natural background quality. To achieve these objectives, the following management responses must be considered:*

- *control short-term threats arising from the contamination;*
- *restrict groundwater use;*
- *prevent or minimise further migration of contaminants from source materials to groundwater;*
- *prevent or minimise further migration of the contaminant plume;*
- *clean up groundwater to protect human and ecological health, restore the capacity of the groundwater to support the relevant environmental values and, as far as practicable, return groundwater quality to its natural background quality.*

As a minimum, management of contaminated groundwater should continue until human and ecological health is protected and the capacity of the groundwater to support relevant environmental values is restored.

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[6] NSW DEC, Contaminated Site: Guidelines for the NSW Site Auditor Scheme (2006)

Management responses to groundwater contamination should focus on the greatest threats first, and the benefits of groundwater cleanup must outweigh any incidental negative impacts that could arise."

NSW DEC (2007) further states "*Clean-up objectives for contaminated groundwater should be established in the following preferential order:*

1. *Clean up so natural background water quality is restored;*
2. *Clean up to protect the relevant environmental values of groundwater, and human and ecological health;*
3. *Clean up to the extent practicable."*

Another regulatory consideration is the need for an Environmental Protection Licence (EPL) for some remediation technologies in addition to approvals through the development application process. This is most likely to be required where a waste stream (e.g. contaminants volatilised in extracted vapours/ water) is produced. The need for a licence may add significantly to the pre-remediation approvals time frame requirements.

6.2 On-Site Treatment

On-site treatment can be conducted *in situ* or *ex situ*. *In situ* treatment involves treating the contaminated media in the subsurface. *Ex situ* treatment involves bringing the contaminated soils or groundwater to the surface for treatment by excavation or pumping. Once the contaminated material is at the surface it could be treated by a variety of technologies.

The applicable of various technologies depends on, *inter alia*, the contaminant profile, contaminant depth, soil type, groundwater and bedrock depth. Other considerations also include the required time frame and the availability of the suitably qualified contractors to undertake the work. This is of particular relevance when tight project time frames are a factor in the decision making process.

6.2.1 Soil vapour extraction

This methodology involves extraction of contaminant vapours in the subsurface by applying a vacuum to induce subsurface air flow and removal of volatile and some semi-volatile compounds.

It is considered that this method would not be efficient at removal of PAH, which is a primary COPC at the site.

This method could be used to remove contaminant vapours detected at the site, however the method may take several months to years to reach a steady state extraction concentration. Contaminant concentrations in the subsoil may not be reduced to acceptable levels by the time vapour extraction has met a steady state extraction.

An EPL may be required for this technology.

As such, this method is not considered to be suitable for the proposed project.

6.2.2 *In Situ* Soil Flushing

This methodology involves flushing a zone of contamination in soils above the water table with a solution capable of dissolving the contaminants. The applied solution must be able to be managed in and recovered from the subsurface for treatment and/ or disposal.

An EPL may be required for this technology.

This option is not considered appropriate for the site due to the relatively shallow water table, and high risk of the process flushing contamination into the groundwater.

6.2.3 *In Situ* Chemical Oxidation

This methodology involves application of a chemical oxidant to reduce organic contaminants in soils and groundwater to non-toxic daughter products. Chemical oxidation is most commonly used for groundwater remediation, but can be applied to contaminated soils.

Primary considerations in determining the potential effectiveness of this technique is the ability for oxidation to treat the COPC, the ability to apply the oxidant throughout the treated media, the most effective oxidants for the contaminant and matrix, the need for a catalyst application, the chemistry of the media and the time frame required.

Given the unconsolidated nature of the impacted filling and the mixture of contaminants present, prediction of the migration and impacts of application of an oxidant into the subsoil at the site would be difficult. Oxidation could potentially increase risks from contamination at the site, e.g. by producing heat, amending pH or mobilising contaminants.

The main impediment to use of chemical oxidation for soils at the site is considered to be the difficulty in effectively delivering the oxidant throughout the soil profile. There is also considered to be an elevated risk that the soils will not be successfully treated in the required time frames.

An EPL may be required for this technology.

On the basis of the uncertainty as to the effectiveness of an oxidant, this methodology is not considered further.

6.2.4 *In Situ* Electrokinetic Separation

This methodology comprises application of low-intensity direct current to separate charged species, and can be used for fuels and metals. The contaminant(s) move towards the anode or cathode from where they can be removed or treated.

An EPL may be required for this technology.

The methodology has provided mixed results, and is not considered to have been proven to be sufficiently robust to trial at the site given the tight time frames.

6.2.5 Permeable Reactive Barrier Wall

A permeable reactive barrier (PRB) wall is a wall constructed along the down-gradient alignment of a groundwater plume using materials which react with the contaminant as groundwater flows through it, removing or ameliorating the contaminant by physical or chemical means.

A permeable reactive wall could be appropriate, from a technical perspective, for the remediation of groundwater exiting the site (i.e. for managing off-site risks), with the main issues needing to be determined in assessing its suitability being:

- the likely lifespan, and potential need for the wall to be “renewed” by removal of the depleted reactive material and replacement with new reactive material. If this is likely to be required in the foreseeable future, it would have a potential negative impact on site users as well as a large future cost;
- Accessibility to construct and replenish the barrier wall; and
- Suitable reactive materials and the need for multiple barrier layers to manage different contaminants from the site.

If further testing shows arsenic in groundwater to be an issue requiring remediation, zero valence iron (ZVI) and slag have been shown to be effective technologies. Removal of PAH using PRBs is, however still in the development phase, with organophilic clays as a possible PRB media, but not well proven in field application. Removal or BTEX and TPH would generally involve use of a biobarrier and potential introduction of oxygen releasing media. As such, a PRB which treated all COPC at the site would likely require to be sequenced with different media for the various COPC, and would need strong trial study evidence to show that it would work.

Given the lack of robust evidence that a PRB would work, the likely need for replenishment in the future and the tight time frames, a PRB is not considered appropriate for the project.

6.2.6 Bioventing

This methodology involves introducing a gas into the subsurface to enhance biodegradation. It can include injection or extraction of oxygen rich gas for aerobic bioventing (including air), injection of anaerobic gas for anaerobic bioventing or injection of air and a suitable gas substrate for cometabolic bioventing.

Aerobic bioventing would be the most appropriate for the COPC of petroleum and PAH.

Review of site data indicates that oxygen concentrations at 1.5 m were measured between 1.8 and 12%, with five of the seven results above 4%. The locations with lower oxygen concentrations did not have higher contaminant profiles than some of the locations with higher contaminant levels. This indicates that oxygen may not be a limiting factor in the vadose zone over much of the site. Concentrations of oxygen and REDOX measurements in groundwater also varied across the site from more aerobic to more anaerobic conditions. The locations with the highest petroleum contamination did not appear to be consistently limited by oxygen.

As such, bioventing is not considered to be a suitable remediation strategy for the site. It is further noted, that bioventing would generally be expected to take a number of years to successfully remediate heavier fraction organic contaminants, and as such would not be suitable as a stand-alone strategy given the tight project time frames.

6.2.7 Phytoremediation

This methodology comprises the use of plants to extract, degrade, contain or immobilise contaminants from soil and groundwater. This is a long term strategy, and will not remove risks from contamination in the short term. As such, this strategy is not considered to be suitable to render the site suitable in the proposed project time frames.

This methodology could be used to assist in "polishing" remaining contamination, particularly in groundwater. However trees would be the most appropriate plant for a root depth into the groundwater, and this raises a potential risk if the tree is to require removal or fall over at some time in the future, which is likely to result in damage any capping layer and exposure of any contamination remaining at the site.

Planting of trees down-gradient of the site in Wentworth Park to assist in removal of residual contamination migrating off-site in groundwater may be appropriate in conjunction with another remediation strategy. Having said this, this option may not be acceptable to the owner of Wentworth Park, namely, City of Sydney Council.

6.2.8 Source Removal and Monitored Natural Attenuation

Natural attenuation (NA) comprises the degradation of contaminants over time using natural processes, including dilution, dispersion, chemical and biological degradation and/ or sorption and precipitation to attenuate contaminant concentrations. Monitoring is required to ensure that the attenuation process is proceeding as anticipated to meet reasonable remediation time frames.

Monitored natural attenuation (MNA) is only applicable if the contaminant concentrations are shown not to present an immediate unacceptable risk, if they can reasonably be expected to decrease over time, and if the expected time period required for them to decrease to meet the remediation goals is appropriate with respect to future risks and liabilities.

The continued presence of a source of contamination to groundwater would generally result in a "steady state" contamination concentration in groundwater continuing for the life of the source. As such, removal of any identified source contamination would generally be conducted in conjunction with MNA to allow contaminant concentrations in groundwater to decrease within a reasonable time frame. This would generally include, but not be limited to, removal of NAPL encountered at the site to the extent practicable.

MNA allows the petroleum contamination to naturally attenuate. For this option to be acceptable sufficient data has to be available to show that natural attenuation is occurring in the aquifer, and ongoing monitoring is required to confirm that the natural attenuation continues to occur at an acceptable rate.

MNA can be "enhanced" by the addition of chemicals to increase the rate of NA, generally by increasing dissolved oxygen concentrations in the aquifer.

MNA would not remove immediate risks at the site, but may be suitable, in conjunction with source removal, to address the off-site migration of contamination.

MNA would be expected to take several years or more, and ongoing monitoring would be required to ensure the strategy was working, with a contingency plan developed to be implemented in the monitoring indicated the strategy was not successful. The longer time frames for “complete” remediation are, however, considered to be more acceptable than for an active remediation strategy which could involve remediation infrastructure remaining and potential movement of contamination to the surface to continue after the redevelopment.

Additional management may be required for residual risks from the contaminants during the MNA period.

6.2.9 *In Situ* Thermal Treatment

Thermal treatment technologies generally aim to heat the soil (and in some cases groundwater) to volatilise and extract the contaminants. In addition the use of higher temperatures can vitrify the soils, effectively encapsulating the contaminant. These technologies can be suitable for VOCs, TRH and PAH. Methods include electrical resistivity heating, steam injection and extraction, conductive heating and radio-frequency heating. These methodologies are not commonly used in Australia and some of these methodologies are still in the experimental phase.

Temperatures in excess of 325°C are expected to be required to break down PAH at the site. Lower temperatures (100-200°C) may effectively remove volatiles and solidify tar based contaminants to reduce their potential for migration.

Electrical resistivity heating (ERH) can be used in both the vadose and saturated zone and contaminant extraction can be by vapour or multiphase extraction. This method can remove NAPL.

Steam injection and extraction (SIE) can be used in both the vadose and saturated zone and contaminant extraction can be by vapour or multiphase extraction. This method can remove NAPL. The method uses steam, and requires management to ensure contaminants at the steam “front” are pushed off-site and that less permeable layers are not bypassed. This methodology is particularly applicable in high permeability soils below the water table, where other *in situ* thermal treatments are not optimal.

Conductive heating and radio-frequency heating are most applicable to the vadose zone, and dewatering is likely to be required at the site to allow these methods to be used to treat the full depth of filling.

The extracted vapours and water would then need to be treated and disposed.

An EPL may be required for this technology.

Treatment time frames are generally at least several months, and for the subject site could be in excess of a year. Challenges for these methods for the project would include the depth and volume of filling with the relatively limited experience in Australia and the relative short required treatment time.

Vitrification

This methodology comprises applying very high temperatures (in the order of 1,000 – 2,000°C) to soils to convert them into glass or crystalline solids.

The applicability of the process is dependent on the percentage of alkali metal oxides in the soil to balance electrical conductivity and melting temperatures. No data is available for this parameter at the site.

The process vaporises or pyrolyzes (thermochemically decomposes) organic contaminants and encases most inorganic contaminants.

A vapour collection and treatment system is required to treat the vaporised contaminants.

The site may require dewatering and compaction prior to treatment.

At this stage is appears that the additional costs likely to be associated with vitrification rather than a different *in situ* thermal treatment method are unlikely to be justified. This method is therefore not considered further.

6.2.10 *Ex Situ* Treatment Options - General

Ex situ treatment options include some of those discussed above for *in situ* application, including soil flushing, chemical oxidation and thermal treatment. In general, *in situ* treatment would be considered preferable for the subject site given the extensive excavation that would be required to bring soil and/ or groundwater to the surface, the limited site area to establish an *ex situ* treatment, and the presence of contamination over the majority, if not all of the site. If soils from over the entire site were to be remediated, *ex situ* soil remediation would need to be conducted in stages, either with the treatment infrastructure moved between stages to allow access to the underground contamination, or a pre-treatment excavation and stockpiling of contaminated soil from the proposed treatment area.

The main advantage of *ex situ* treatment would be the significantly enhanced ability to control the application rate, mixing and extraction of contamination.

Some more specific *ex situ* technologies are discussed below.

6.2.11 *Ex Situ* Bioremediation of Soils

This methodology involves providing the optimal conditions for natural microbial organisms to consume bioavailable organic contaminants. Bioremediation does occur *in situ*, and forms an important part of any MNA strategy, however this section discusses *ex situ* biodegradation of contaminants in soils.

Bioremediation is most suitable for petroleum and lighter organic compounds. The applicability of this strategy to more complex compounds, such as heavy end PAH as have been identified at the site is more limited and time consuming. Bioremediation of compounds which are not bioavailable, such as PAH associated with ash or slag is not considered to be a feasible approach.

Successful bioremediation depends on the absence of toxins, composition of microbial population, soil aeration and moisture, temperature, pH and nutrient levels.

For the subject site, bioremediation is expected to be most applicable to the petroleum contaminants. The time frame for bioremediation may not meet the required project time frames, although treatment time frames can be reduced by the addition of nutrients or proprietary specialist products. Bioremediation of petroleum contaminants in soil generally comprises “land farming” which involves the addition of nutrient/ hydrocarbon consuming microorganisms, mixing and aeration. Space is required to allow spreading of the soils in thin layers for treatment.

Release of odours during excavation may potentially be at levels of concern to the local community, which could result in the need for management e.g. by use of odour suppressant or controlled atmosphere enclosures with negative pressure.

It is considered that this methodology may be suitable, in conjunction with other methodologies to form part of the overall remediation strategy for the site.

6.2.12 *Ex Situ* Thermal Treatment of Soils

Ex situ thermal treatment of soils generally involved direct fired desorption (DTD) or indirect fired desorption (ITD). DTD typically destroys volatilised contaminants in the thermal oxidiser chamber. ITD technology allows contaminants to thermally desorb from the solid matrices in the absence of a naked flame and low oxygen environment, with residual contaminants intercepted and recovered from the gas stream by condensation. ITD is generally considered to be safer than DTD for wastes with high contaminant concentration (>25% w/w).

Ex situ thermal treatment plants, including mobile plants, are available in Australia, with various treatment capacities, generally in the order of 3 to 30 tonnes per hour.

An EPL may be required for this technology.

Whilst this technology is considered to be technically suitable for the site, the required time frame, taking into account the expected approval process and staged approach to remediation are expected to be greater than those required by the project.

6.2.13 *Ex Situ* Groundwater Treatment

This methodology would involve extraction of contaminated groundwater, on-site treatment in a specifically designed plant followed by re-injection (or off-site disposal).

This option would need to be conducted in conjunction with a different soil treatment strategy.

The time frame is expected to be in excess of that allowed for in the project time frame, and as such would require that the system continue operation during redevelopment and operation of the school. This would require a dedicated groundwater treatment structure at the site, containing the treatment plant, with contaminated groundwater being present, and ongoing maintenance.

It is considered that this is not ideal given the proposed sensitive use, and as such this option is not considered further.

6.3 Off-Site Treatment and Re-Importation of Treated Materials

This strategy would comprise excavation and off-site transport of all contaminated soil, treatment at an appropriately licensed facility, and following its validation as being appropriately treated, re-importation onto the site.

From a net environmental benefit perspective, this option is considered to be less sustainable than on-site treatment due to the need for transport and additional handling of the soils. In addition, the transport of contaminated materials in itself has a potential risk on human health from the potential for accidents and spills. As such, this option should only be considered if a suitable treatment technology available off-site, could not be operated on site due to either economic or social considerations (such as the potential for unacceptable impacts on neighbouring residents).

Release of odours during excavation may potentially be at levels of concern to the local community, which could result in the need for management e.g. by use of odour suppressant or controlled atmosphere enclosures with negative pressure.

Project time frames are also likely to be a potential issue of concern for this option, although this would depend on the technology and the volume of soil to be treated.

This strategy is expected to be expensive relative to some of the other strategies available, and as such is not considered further at this stage.

Re-importation of treated groundwater is not considered to be practical.

6.4 Off-site Disposal

6.4.1 Soils

Off-site disposal of contaminated soil is considered a suitable option for managing human health and environmental impacts from the contaminated materials. Off-site disposal comprises the excavation of soil, classification of spoil, and disposal to a facility which can legally receive it. Soils classified as Hazardous Waste would require treatment prior to disposal, although the degree of treatment is expected to be less than would be required to remediate the soil for re-use on site. This pre-treatment could occur on site or off site at a suitably licenced facility.

This strategy will result in production of significant quantities of waste requiring transport and disposal to landfill which in itself in an undesirable environmental outcome, with potential risks associated with the transport accidents or spills.

Removal of all contaminated soils from the site will require extensive excavation (expected to be to depths up greater than 9 m). An excavation of this depth will require appropriate management to stabilise the walls and prevent damage to neighbouring properties.

Release of odours during excavation may potentially be at levels of concern to the local community, which could result in the need for management e.g. by use of odour suppressant or controlled atmosphere enclosures with negative pressure.

This strategy is expected to be expensive relative to some of the other strategies available.

The approvals process and implementation may be significantly quicker than some of the more technical remediation options, although potential impacts on neighbouring properties, especially the light rail, could involve a lengthy investigation and approvals process.

Off-site disposal of a portion of the contaminated soil would also be an appropriate strategy in conjunction with other methods. This may include off-site disposal of soils potentially impacting groundwater or producing soil vapour or removal of contaminated soils to a certain depth or from a certain area of the site based on proposed landuse sub areas. Localised off-site disposal of contaminated soil could aim to further decrease the risk and reduce other remediation system requirements (e.g. to potentially allow MNA instead of a barrier wall for groundwater contamination). This is discussed further below.

For removal of filling to bedrock over part of the site could be conducted, the following considerations are relevant:

- Removal of filling from under proposed building locations, in conjunction with source removal for potential groundwater/ vapour sources could remove the need for vapour management;
- Removal of filling from beneath potential areas for future buildings could reduce/ mitigate the need for management of remediation during future building works, and reduce the risk of contaminated soils being brought to the surface during any such works;
- Removal of filling to bedrock, if proposed for part of the site, would be best undertaken, from a cost perspective, in the areas with the shallowest bedrock, mainly in the north of the site. However several metres of filling have still been encountered in boreholes in the northern portion of the site, and many other bore locations have been discontinued in filling;
- Minimising excavation in the north of the site, could reduce the requirements for approval and support of excavation near the light rail. This would, however, result in excavation being undertaken in the southern portion of the site, where filling depths are expected to be on average greatest; and
- The remaining filling would require another form of remediation/ management.

On the basis of the above, it is considered that there is no obvious area where complete removal of filling from a selected portion of the site would result in a significant benefit. It may, however, be worth reviewing the above consideration with respect to preferred building design options as applicable.

For partial removal of filling across the site to a certain depth below ground level, the following considerations are relevant:

- This may allow all materials presenting a potential vapour source to be removed, removing the need for a vapour management system; and

- This could provide a relatively thick physical barrier between site users and residual contamination (i.e. greater than 1 m), reducing the risk of penetrating such a barrier and of future management requirements for maintenance works requiring excavation.

On the basis of the above, it is considered that there could be advantages to removal of filling to a certain depth below the final ground surface. The appropriate depth could be designated based on likely need for penetration (e.g. for underground services, and soft landscaping) or by a risk assessment to identified the optimal depth to reduce risks at the surface from vapours.

6.4.2 Groundwater

Off-site disposal of contaminated groundwater comprises pumping and removal of the groundwater and/or any NAPL and disposal to a facility which can legally receive it. For contaminated water, disposal options generally comprise disposal to sewer under a Trade Waste Agreement (TWA) or disposal to a licenced liquid waste facility. Councils are generally not obliged to receive water impacted by anthropogenic contaminants into the stormwater system.

For large volumes of water, a TWA with Sydney Water would generally be the preferred option, however a number of requirements need to be met in order to obtain and comply with a TWA. These include maximum discharge volumes, maximum allowable limits for various contaminants and other chemical parameters, pre-treatment (e.g. to remove oily residues, solids and to adjust pH), and ongoing monitoring requirements. The fees associated with the disposal would depend on volume and contaminant loading.

Disposal to a licenced liquid waste facility would generally be adopted where liquids fail to meet the requirements of the TWA, or where the total volume to be disposed were insufficient to justify the set up costs associated with obtaining a TWA.

A groundwater cut-off wall would need to be constructed if removal of all contaminated groundwater from the site was to be undertaken, otherwise water would be drawn in from surrounding areas.

This strategy is expected to be expensive relative to the other strategies available.

Off-site disposal of contaminated groundwater would also be an appropriate strategy in conjunction with other methods. This may include dewatering to allow localised soil excavation or disposal of groundwater impacted by NAPL in conjunction with a barrier wall or *in situ* treatment/ MNA strategy. Localised off-site disposal of contaminated groundwater in conjunction with another system would aim to further decrease the risk and to reduce or eliminate the other remediation system requirements (e.g. to potentially allow MNA instead of a barrier wall for groundwater contamination).

6.5 On-Site Consolidation and Isolation

On-site consolidation and isolation (also referred to as on-site containment) systems result in an ongoing liability associated with the contamination at the site and require some degree of long term management. Most containment systems aim to minimise the long term management requirements.

The long term management requirements are usually detailed in an Environmental Management Plan (EMP).

The EMP would need to be legally enforceable and should have an appropriate public notification mechanism such as in the site's Section 149 (2&5) planning certificate and/or under Section 88B of the *Conveyancing Act 1919*. Legal advice would need to be sought regarding this issue, including the most appropriate method for the subject development.

On-site consolidation and isolation options are discussed in the following sub-sections.

6.5.1 Physical Encapsulation

The most common consolidation and isolation system is a physical encapsulation system. The purpose of a physical encapsulation system is to break the exposure pathways. Based on current investigation data, the encapsulation system for the site may need to manage:

- physical contact with the contaminated soil (including dust) and groundwater;
- vapour intrusion; and
- off-site migration of contaminated groundwater.

Physical contact would be managed by construction of a capping system to break the pathway for physical exposure between site users and the underlying contaminated soil.

Vapour intrusion management, if required, can be conducted in a number of ways, including by amending the design of buildings. The chosen strategy would be best decided in conjunction with decisions on the building structure, floor levels, and presence of undercrofts or vented basements.

Management of migration of contamination in groundwater, if required, can be conducted by construction of an impermeable barrier wall. The design and purpose of the wall could vary, with the wall most suitable for the site expected to be an impermeable barrier wall to minimise the flow of contaminated groundwater onto and off the site.

An alternative option for a barrier wall design would be to construct the wall to minimise groundwater flow onto the site only, with the aim being to create a stagnant and controlled zone of groundwater at the site, thereby minimising migration of contamination off the site with groundwater flow. The rock face along the eastern upgradient boundary of the site could be sufficiently minimising groundwater inflow from this direction without the need for an engineered solution along this boundary.

It is considered prudent that prior to deciding to progress with an impermeable barrier wall, that a hydrogeological study be undertaken to model groundwater flow at and around the site, to assist in quantifying the potential benefits of this solution. The study should include a review of the potential for impacts from tidal flow and previous data relating to groundwater flow direction.

6.5.2 *In Situ* Solidification/ Stabilisation

These methodologies aim to reduce the solubility, mobility or toxicity of the contaminant in soils. Solidification works by encapsulating the matrix into a solid form (e.g. by mixing with cement-based or polymer binder). Stabilisation works by acting on the contaminant itself rather than the matrix and can use a range of physical or chemical reactions.

In effect these methods do not remove the contaminant, but rather consolidate it on site by treatment.

Potential issues for this technique at the site include the presence of large cobbles and boulders through the filling, which could impede thorough mixing. In addition, some organic contaminants can interfere with the curing of the cements, and the cement is likely to increase the pH, which can increase the mobilisation of some metals. Cementation processes are generally exothermic, which can lead to a temporary increase in volatilisation of vapours, resulting in a potential for increased risks during the remediation process. Risks from volatilisation during cementation can be managed by capturing vapours at the surface for on-site treatment.

Given the mixtures of COPC at the site, determining an appropriate binder/reactant may be difficult. Treatment trials would be required to assess if the method was suitable for site materials and contaminants, and unless shown otherwise this method should not be assumed to be viable for the site.

Discussions with a contractor based on the volume of soil requiring treatment indicate that this method is likely to be considerably more expensive than encapsulation using a barrier wall and surface capping layer. The applicability of this cost comparison at the site may, however, be impacted by site specific issues such as sensitive infrastructure at the site boundaries.

Given that extensive trials would be required, which could be difficult with the project time frames, and the likely expense compared to other options, this option has not been further considered at this stage.

6.5.3 Hydrodynamic Isolation of the Groundwater

This strategy would aim to isolate the contaminated groundwater underlying the site from the rest of the aquifer using a system of abstraction and recharge bores. This strategy would not address physical contact or vapour intrusion issues, which would need to be dealt with separately.

Hydrodynamic isolation would involve the construction of a series of bores up and down-gradient of the site. The down-gradient bores would be used as abstraction wells pumping water out of the aquifer. The abstracted water could then be fully or partially treated before being re-injected into the aquifer through the up-gradient bores. By manipulating the pumping rate in relation to the underlying groundwater flow velocity the bores can be used to cycle essentially the same mass of water preventing its progression beyond the site boundary. When successfully executed this strategy can effectively isolate the contaminant plume from the surrounding aquifer.

This option is considered to be relatively high risk, with high ongoing maintenance requirements and the need for an on-site treatment and reticulation system. It is therefore not considered to be suitable for the proposed development.

6.6 Risk Assessment

A risk assessment could be undertaken to determine the need for and/ or to refine the scope of remediation. Based on the current data it is considered highly unlikely that a risk assessment would determine that no remediation was required.

A risk assessment would be best undertaken following further investigation and once the preferred remediation options had been identified, to allow for refinement of the strategy. This could allow the determination of site specific remediation criteria, assist in defining areas where targeted remediation could be undertaken with the maximum benefit, and determine the need for active remediation for potential off-site impacts from contaminated groundwater migration.

6.7 No Action

An alternative strategy could be to not remediate the site, i.e. “No Action”. The guidance states that remediation should not proceed where the remediation is likely to cause greater adverse effects than leaving the contamination undisturbed.

Based on the concentrations of contaminants identified at the site, the identified off-site migration of contaminants in groundwater and the proposed sensitive land use it is considered that No Action will not achieve the remediation objectives (Section 4.1).

It is also considered that the remediation options discussed herein provide methodologies by which remediation can occur without unacceptable adverse effects on human health and the environment.

On this basis this strategy is not considered to be suitable for the subject site.

6.8 Assessment of Remediation Options

The main factors considered in assessing the available remediation strategies were:

- Suitability for rendering the site suitable for the proposed school;
- Suitability for mitigating the risk of unacceptable impacts on human health;
- Suitability for mitigating the risk of unacceptable impacts on the environment;
- Ongoing liabilities associated with the site following completion of remediation;
- Robustness and technical confidence in the strategy;
- Likely availability of contractors with suitable experience in the strategy;
- Duration of the remediation works relative to project time frames; and
- Cost (preliminary review only).

This is a technical document, and does therefore not try to anticipate the relative acceptability of various options to the school community and other stakeholders. These may include concerns based on non-technical issues, and should be addressed by clear communication, including on the relative risks associated with the various remediation options. It may assist in communication if the potential risks from contaminated land management issues are also discussed in context with other common risks in society.

Based on this review, the following remediation technologies, which address some or all of the issues of concern were identified for further consideration:

- Bioremediation;
- Phytoremediation (as an offsite "polishing" option);
- Source Removal and Monitored Natural Attenuation;
- Off-site Disposal; and
- Physical Encapsulation.

The following technologies, whilst considered to be potentially technically feasible, have been discounted based on the project timeframes and need for robust field and/ or laboratory trials to show that they would work at the site:

- *In situ* thermal treatment;
- *Ex situ* thermal treatment; and
- *In Situ* Solidification/ Stabilisation.

7. Preferred Remediation Strategies

7.1 Preferred Remediation Strategies and Rationale

The following preferred potential general remediation strategies have been identified, and are considered in more detail below:

- Option 1: Source removal (with off-site disposal and/ or on-site bioremediation), partial physical encapsulation of soil and monitored natural attenuation (with possible phytoremediation);
- Option 2: Removal of soil to a nominated depth below proposed ground level (with off-site disposal and/ or on-site bioremediation), partial physical encapsulation and monitored natural attenuation (with possible phytoremediation);
- Option 3: Physical encapsulation of soil, including capping, impermeable barrier wall and vapour management; and
- Option 4: Removal and off-site disposal of all contaminated soil and groundwater.

Option 1 and 2 differ in the volume and extent of soil removal, with Option 2 involving removal of additional soil. The main advantage of Option 2 relative to Option 1 is the creation of a thicker surface capping between site users and the contained contaminated soil, which also gives more flexibility for installation and maintenance of services and plantings in clean soil. The main relative disadvantage is that option 2 will involve more excavation and disposal of soils than Option 1, with the associated additional financial and environmental costs from transporting, managing and disposing of the soil.

7.2 Option 1: Source Removal, Partial Physical Encapsulation and MNA

Additional data is required to confirm the suitability of this option for the proposed development. The most significant data gap is inadequate characterisation of current groundwater quality at and down-gradient of the site. Full physical encapsulation as per Option 3 provides a suitable contingency plan in the case that the additional groundwater data does not support the Option 1 approach.

7.2.1 Scope of Works

This option would require the following general scope of works:

- Further assessment of groundwater to determine the suitability of MNA as a remediation strategy. The below scope assumes that MNA is suitable. If MNA is found not to be suitable, implement Option 3, or review other options;
- Assess the need for a vapour management system based on additional investigation results. The below scope assumes that a vapour management system is required, if not, this item can be excluded;
- Determine areas requiring source removal based on further soil and groundwater testing results;
- Obtain required approvals, including *inter alia*, development consent, any required approvals from neighbouring asset owners, NSW Office of Water, for disposal of contaminated groundwater, and for treatment/ disposal of hazardous waste;
- Demolition of current site structures, including removal of all hazardous building materials. If some site structures are to be kept (e.g. for heritage purposes), review of allowable excavation in these areas and potential management options. This may require a risk assessment to show no unacceptable risks are present from the retained contaminated soils in the near surface;
- Excavation of identified source zone soils. Classification and treatment of contaminated filling as required. Petroleum contaminated soils may be treated on site by bioremediation to either reduce the waste classification or to render them suitable for re-use on site. Other wastes could be disposed off-site, with on- or off-site treatment prior to disposal as required to “immobilise” the contaminant to prevent release into landfill leachate at levels of concern. Approval for the immobilisation process will be required from the EPA;
- Dewatering and disposal of contaminated water as required to (a) allow excavation of source soils and (b) to remove groundwater sources (including NAPL). This may require some temporary sheet piling or similar in some areas;
- Backfill any localised excavation as required to the level of the base of the capping system in accordance with geotechnical requirements;
- Construct vapour management system (if required) and surface capping. The surface capping would need to extend over the entire site, and should have a minimum thickness of 0.5 m (additional depth may be required for some services which need to be readily accessible). The capping layer will be constructed with “clean soil” (refer to Section 9.4.1). The vapour management system, if required, would be designed to prevent intrusion of vapour into the buildings, and would not be extended into open space/ playground areas;

- Preparation of a Groundwater MNA Plan. This may include plantings in Wentworth Park for phytoremediation;
- Preparation of an Environmental Management Plan (EMP) for management of contained contaminated materials; and
- Preparation of a validation assessment report detailing the works undertaken and results of the assessment, and making a clear statement on the suitability of the site for the proposed use.

7.2.2 Significant Unknowns

The following should be considered in assessing the applicability and budget risks for this option:

- Groundwater quality at and down-gradient of the site has not been sufficiently characterised to confirm the suitability of MNA as a suitable strategy;
- Vapour assessment to date is not sufficient to allow confirmation of the need or otherwise for a vapour management system. It is reasonable to assume that a vapour management system will be installed in the absence of sufficient data to show otherwise;
- The depth, quantity and classification of soil requiring targeted removal has not been defined/ well defined; and
- A treatment methodology for hazardous waste has not been determined.

7.2.3 Additional Investigation

The following additional investigation works are anticipated to be required to allow successful implementation and budgeting of this option. Some of these works may be best undertaken by the Contractor as part of a design and construct contract:

- Groundwater investigation to assess the groundwater quality at the site (including at depth) and off-site;
- Further vapour investigation at the site;
- Identification of target source materials and provisional *in situ* classification of filling; and
- Treatability trials for hazardous waste.

7.3 Option 2: Removal to Nominal Depth, Partial Physical Encapsulation and MNA

Additional data is required to confirm the suitability of this option for the proposed site. The most significant data gap is inadequate characterisation of current groundwater quality at and down-gradient of the site. Full physical encapsulation as per Option 3 provides a suitable contingency plan in the case that the additional groundwater data does not support the Option 2 approach.

7.3.1 Scope of Works

This option would require the following general scope of works:

- Further assessment of groundwater to determine the suitability of MNA as a remediation strategy. The below scope assumes that MNA is suitable. If MNA is found not to be suitable, implement Option 3, or review other options;
- Assess the need for a vapour management system based on additional investigation results. The below scope assumes that a vapour management system is required, if not, this item can be excluded;
- Determine the nominal depth for removal of soils. It is recommended that this be determined taking into account proposed depth of underground services, proposed soft landscape plantings, presence of NAPL, groundwater depth and a risk assessment, if undertaken;
- Determine any areas which may require source removal below the nominal excavation depth based on further soil and groundwater testing results;
- Obtain required approvals, including *inter alia*, development consent, any required approvals from neighbouring asset owners, NSW Office of Water, for disposal of contaminated groundwater, and for treatment/ disposal of hazardous waste;
- Demolition of current site structures, including removal of all hazardous building materials. If some site structures are to be kept (e.g. for heritage purposes), review of allowable excavation in these areas and potential management options. This may require a risk assessment to show no unacceptable risks are present from the retained contaminated soils in the near surface;
- Excavation of soils to the nominal depth of excavation and from any additional identified source zones. Classification and treatment of contaminated filling as required. Petroleum contaminated soils may be treated on site by bioremediation to either reduce the waste classification or to render them suitable for re-use on site. Other wastes could be disposed off-site, with on- or off-site treatment prior to disposal as required to "immobilise" the contaminant to prevent release into landfill leachate at levels of concern. Approval for the immobilisation process will be required from the EPA;
- Dewatering and disposal of contaminated water as required to (a) allow excavation of source soils and (b) to remove groundwater sources (including NAPL). This may require some temporary sheet piling or similar in some areas;
- Backfill any localised excavation as required to the level of the base of the capping system in accordance with geotechnical requirements;
- Construct vapour management system (if required) and surface capping. The surface capping would need to extend over the entire site, and would have the thickness nominated to limit restrictions on service installation and future site maintenance (in the order of at least 1 m is anticipated). The capping layer will be constructed with "clean soil" (refer to Section 9.4.1). The vapour management system, if required, would be designed to prevent intrusion of vapour into the buildings, and would not be extended into open space/ playground areas;
- Preparation of a Groundwater MNA Plan. This may include plantings in Wentworth Park for phytoremediation;
- Preparation of an Environmental Management Plan (EMP) for management of contained contaminated materials; and
- Preparation of a validation assessment report detailing the works undertaken and results of the assessment, and making a clear statement on the suitability of the site for the proposed use.

7.3.2 Significant Unknowns

The following should be considered in assessing the applicability and budget risks for this option:

- Groundwater quality at and down-gradient of the site has not been sufficiently characterised to confirm the suitability of MNA as a suitable strategy;
- Vapour assessment to date is not sufficient to allow confirmation of the need or otherwise for a vapour management system. It is reasonable to assume that a vapour management system will be installed in the absence of sufficient data to show otherwise;
- The depth and quantity and classification of soil requiring targeted removal beyond the nominal depth of excavation has not been defined/ well defined; and
- A treatment methodology for hazardous waste has not been determined.

7.3.3 Additional Investigation

The following additional investigation works are anticipated to be required to allow successful implementation and budgeting of this option. Some of these works may be best undertaken by the Contractor as part of a design and construct contract:

- Groundwater investigation to assess the groundwater quality at the site (including at depth) and off-site;
- Further vapour investigation at the site;
- Identification of target source materials and provisional *in situ* classification of filling; and
- Treatability trials for hazardous waste.

7.4 Option 3: Physical Encapsulation and Impermeable Barrier Wall

It is considered that current site data is sufficient to confirm the suitability of this strategy to remediate the site. Data gaps, as discussed in Section 7.4.2, do however exist which will need to be addressed for detailed design purposes, and result in considerable current uncertainty regarding cost and time frame.

7.4.1 Scope of Works

This option would require the following general scope of works:

- Further assessment of groundwater hydrogeology to determine the detailed design for the impermeable barrier wall;
- Trials to determine suitable matrix for impermeable barrier wall. This would generally comprise a mixture of on-site materials and additives (e.g. bentonite);
- Assess the need for a vapour management system based on additional investigation results. The below scope assumes that a vapour management system is required, if not, this item can be excluded;

- Obtain required approvals, including *inter alia*, development consent, any required approvals from neighbouring asset owners, NSW Office of Water, for disposal of contaminated groundwater, and for treatment/ disposal of hazardous waste;
- Demolition of current site structures, including removal of all hazardous building materials. If some site structures are to be kept (e.g. for heritage purposes), review of allowable excavation in these areas and potential management options. This may require a risk assessment to show no unacceptable risks are present from the retained contaminated soils in the near surface;
- Construction of the impermeable barrier wall. This generally comprises an open trench construction method, with the bentonite slurry used to maintain trench stability during excavation and backfilling. Given the sensitivity and proximity of neighbouring utilities, an alternative method such as use of a piling rig to progressively construct the wall may be considered;
- Undertake excavation as required to reach the level of the base of the capping system;
- Construct vapour management system (if required) and surface capping. The surface capping would need to extend over the entire site, and should have a minimum thickness of 0.5 m (additional depth may be required for some services which need to be readily accessible). The capping layer will be constructed with "clean soil" (refer to Section 9.4.1). The vapour management system, if required, would be designed to prevent intrusion of vapour into the buildings, and would not be extended into open space/ playground areas;
- Preparation of a Groundwater MNA Plan if required for residual off-site impacts. This may include plantings in Wentworth Park for phytoremediation;
- Preparation of an Environmental Management Plan (EMP) for management of contained contaminated materials; and
- Preparation of a validation assessment report detailing the works undertaken and results of the assessment, and making a clear statement on the suitability of the site for the proposed use.

7.4.2 Significant Unknowns

The following should be considered in assessing the applicability and budget risks for this option:

- Detailed design of the impermeable barrier wall has not been determined;
- Vapour assessment is not sufficient to allow confirmation of the need or otherwise for a vapour management system. It is reasonable to assume that a vapour management system will be installed in the absence of sufficient data to show otherwise; and
- A treatment methodology for hazardous waste has not been determined.

7.4.3 Additional Investigation

The following additional investigation works are anticipated to be required to allow successful implementation, budgeting and design of this option. Some of these works may be best undertaken by the Contractor as part of a design and construct contract:

- Assessment of suitable mixtures for the impermeable barrier wall material, including use of site materials;
- Groundwater investigation to assess the groundwater quality off-site and if remediation of off-site groundwater (e.g. by MNA) is required;

- Further vapour investigation at the site (this may include the need for further soil and groundwater testing);
- Treatability trials for hazardous waste in materials requiring removal to allow construction of the capping; and
- Hydrogeological investigation (including review of current data) as required to allow detailed design of the impermeable barrier wall and to provide information for the NSW Office of Water.

7.5 Option 4: Removal and off-site disposal of all contaminated soil and groundwater

Current site data is sufficient to confirm the suitability of this strategy to remediate the site. Data gaps, as discussed in Section 7.5.2, do however exist which result in considerable current uncertainty regarding cost and time frame.

7.5.1 Scope of Works

Removal and off-site disposal of all contaminated soil and groundwater would require the following general scope of works:

- Obtain required approvals, including *inter alia*, development consent, any required approvals from neighbouring asset owners, NSW Office of Water, for disposal of contaminated groundwater, and for treatment/ disposal of hazardous waste;
- Demolition of current site structures, including removal of all hazardous building materials. If some site structures are to be kept (e.g. for heritage purposes), review of allowable excavation in these areas and potential management options. This may require a risk assessment to show no unacceptable risks are present from the retained contaminated soils in the near surface;
- Construction of cut off wall to allow temporary dewatering and excavation of all site filling;
- Dewatering and off-site disposal of contaminated groundwater to a licenced liquid waste facility and/ or under a TWA as required to allow the excavation and remove contaminated groundwater from the site;
- Classification and treatment of contaminated filling. Petroleum contaminated soils may be treated on site by bioremediation to either reduce the waste classification or to render them suitable for re-use on site. Other wastes could be disposed off-site, with on- or off-site treatment prior to disposal as required to "immobilise" the contaminant to prevent release into landfill leachate at levels of concern. Approval for the immobilisation process will be required from the EPA;
- Disposal of filling, including treated hazardous waste, to a suitably licenced waste facility;
- Backfilling of the site with "clean" filling (refer to Section 9.4), which had been approved as suitable for importation by the environmental and geotechnical consultant;
- Placement and compaction of filling in accordance with geotechnical requirements;
- If required, pump and dispose contaminated groundwater which has migrated off-site and/ or implementation of a MNA strategy for off-site groundwater contamination in accordance with Option 1; and
- Preparation of a validation assessment report detailing the works undertaken and results of the assessment, and making a clear statement on the suitability of the site for the proposed use.

7.5.2 Significant Unknowns

The following should be considered in assessing budget risks for this option:

- The depth and quantity of filling and quantity of hazardous waste have not been defined/ well defined;
- A treatment methodology for hazardous waste has not been determined; and
- The groundwater quality at and down-gradient of the site has not been characterised.

7.5.3 Additional Investigation

The following additional investigation works are anticipated to be required to allow successful implementation and budgeting of this option. Some of these works may be best undertaken by the Contractor as part of a design and construct contract:

- Investigation to provide additional information on bedrock depths across the site;
- Provisional *in situ* classification of filling;
- Treatability trials for hazardous waste;
- Groundwater investigation to assess the groundwater quality at the site (including at depth) and off-site; and
- Hydrogeological investigation (including review of current data) to determine volumes and provide information for the NSW Office of Water (as required).

8. Implementation of Remediation Strategy

8.1 Preliminary

8.1.1 Roles and Responsibilities

Principal and Principals Representative

The Principal, DEC, is responsible for the environmental performance of the proposed remediation works, including implementation of acceptable environmental controls. The Principal will retain the overall responsibility for ensuring this RAP is appropriately implemented. The Principal is to nominate a representative (the Principal's Representative - PR), who is responsible for overseeing the implementation of this RAP. The actual implementation of the RAP will, however, be conducted by the Contractor on behalf of the Principal.

The Principal will also be responsible for acquiring all necessary approvals for the remediation works proposed, including approval from the consent authority. The responsibility of some specific approvals may be passed onto the Contractor.

Principal Contractor (the Contractor) and Site Manager

The Principal Contractor (referred to herein as the Contractor) is anticipated to be the party responsible for the day-to-day implementation of this RAP and shall fulfil the responsibilities of the Principal Contractor as defined by WorkCover. It is noted that the Contractor may appoint appropriately qualified sub-contractors and sub-consultants to assist as required.

The Contractor will nominate a Site Manager who will be responsible for day to day site management and first response to any unexpected finds encountered during works.

Environmental Consultant

The Environmental Consultant will provide advice on implementing this RAP, provide waste classification, validate that the site has been appropriately remediated, and provide other advice under the CLM and POEO Acts.

The Environmental Consultant will also liaise with the Site Auditor, Contractor and PR as required to assist the smooth progression of remediation and validation.

Project Surveyor (if required)

The project surveyor will be a Registered Surveyor and will be responsible for undertaking the surveying work at the instruction of the Principal Contractor to confirm, as required:

- Locations of areas for targeted excavation;
- levels and thicknesses of the capping layer; and
- other information on as required.

Asbestos Contractor (if required)

It is recommended that an Asbestos Contractor be engaged or be identified prior to excavation to allow a smooth transition to works should asbestos be identified. Given the information regarding the potential for friable asbestos, a contractor with a Class A licence (issued by WorkCover NSW) is recommended.

The Asbestos Contractor would be responsible for undertaking all asbestos works, and will include a WorkCover NSW licenced employee who is a licenced removalist who will be the works supervisor.

The Asbestos Contractor and Principal Contractor can be the same entity.

Occupational Hygienist (if required)

If asbestos is identified, an Occupational Hygienist will be required to provide, *inter alia*, advice and plans on WHS issues related to the asbestos works, asbestos air monitoring and clearance inspections.

The Occupational Hygienist will be suitably qualified/ licenced as required in accordance with the WHS Regulations.

The Environmental Consultant and Occupational Hygienist can be the same entity.

8.1.2 Programme

A detailed programme and timing of works will be prepared by the Contractor.

8.1.3 Asbestos Contaminated Soils

Given the significant quantities of filling of unknown origin at the site, there is considered to be an elevated risk of asbestos being present to some extent in the filling, even though it has not been confirmed in the current data available for review. Verbal information has indicated that friable asbestos may be present, however this has not been confirmed.

It is also noted that the method of investigation to date at the site has been predominantly drilling, which is inefficient at finding asbestos.

As such, it is recommended that a plan is in place to minimise the delays and additional costs should asbestos be identified. This may include use of an appropriately licenced asbestos contractor, early notification to WorkCover NSW and having a contingency plan ready for asbestos finds.

8.1.4 Material Tracking and Disposal Records

All material movements on or off the site will be tracked by the Contractor, including:

- All excavated materials/ items (including buried concrete/ scrap metal etc);
- All liquids; and
- All imported soils/ crushed rock/ recycled materials.

In addition, movements of materials within the site will also require tracking to ensure that soils of different waste classification, contaminants profiles or treatment status are not mixed. This may be conducted by different methods, including provision of specific stockpiling areas for various material "classes" and/ or tracking of individual materials from source to stockpile to destination, with the assistance of a site grid system.

The Contractor will determine their preferred method of tracking prior to commencement of any excavation and provide this to the Environmental Consultant for approval.

8.1.5 Minimising Cross Contamination

Management measures will be implemented to minimise cross contamination of soils and groundwater during remediation. The scope of these works will be dependent on the remediation strategy to be adopted and works programme.

In general, however, materials of different contaminant "classes" should not be mixed. Hardstand or temporary barriers should be used to prevent cross contamination between stockpiles and underlying soils and vehicles should be washed before moving from a higher contamination area to a lesser contamination area.

8.1.6 Groundwater and Stormwater Management

Groundwater and stormwater will be kept out of contact which other where practical.

All water to be disposed to the stormwater system must be "clean", and must have COPC within the assessment criteria, acceptable pH, suspended solids/ turbidity, priority heavy metals, iron and oil and grease results. Disposal to stormwater also requires approval from City of Sydney Council, which will be sought by the Contractor.

Groundwater and any stormwater which has come into contact with potentially contaminated material will require testing for the COPC prior to off-site disposal.

8.1.7 Adjacent Infrastructure and Assets

Protection measures are likely to be required to mitigate the risk of damaging off-site infrastructure and assets. These include buildings, roadways, footpaths and the light rail.

One or more of the asset owners may have specific requirements, including a specific approvals process.

All works and approvals required to protect adjacent infrastructure and assets must be obtained prior to commencement of works.

8.2 Remediation Plan

Following determination of the preferred remediation option and completion of the further investigations, detailed remediation requirements for implementation of the adopted remediation strategy will be documented in a Detailed Remediation and Validation Plan.

8.3 Validation Plan

Following determination of the preferred remediation option and completion of the further investigations, detailed validation requirements for implementation of the adopted remediation strategy will be documented in a Detailed Remediation and Validation Plan.

8.3.1 Data Quality Objectives and Indicators

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

The validation assessment will be planned in accordance with the following DQOs:

- 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) in accordance with NEPC (2013) Schedule B2 will be completed as part of the validation assessment. The DQIs are:

- Documentation completeness;
- Data completeness;
- Data comparability and representativeness; and
- Data precision and accuracy.

Based on a fulfilment of the DQOs and DQIs an assessment of the overall data quality will be presented in the validation assessment report.

8.3.2 Guidance

The validation will comply with EPA prepared or indorsed requirements including, *inter alia*, those set out or referenced in the following:

- National Environment Protection Council (NEPC) *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013)* (NEPC 2013);
- NSW Environmental Protection Authority (EPA) *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases* (2012) (EPA 2012);
- NSW Office of Environment and Heritage (OEH) *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites* (reprinted 2011) (OEH, 2011);
- NSW Department of Environment and Conservation (DEC) *Contaminated Sites: Guidelines for the Assessment and Management of Groundwater Contamination* (2007) (DEC 2007); and
- NSW Department of Environment and Conservation (DEC) *Contaminated Sites: Guidelines for the NSW Site Auditor Scheme 2nd edition* (2006) (DEC 2006).

8.3.3 Validation Plan Minimum Requirements

The validation plan will be prepared based on an assessment of the data quality objectives for the validation assessment. The validation plan will include the requirements for:

- Site inspections;

- On-site testing, sampling and analysis; and
- Documentation and reporting.

The validation plan will include:

- The requirement for validation assessment to be conducted by an appropriately experienced and qualified environmental consultant;
- The requirement for a photographic record of the remediation and validation work;
- Surveying will be conducted by a registered surveyor;
- Construction quality assurance (as required);
- The required sampling densities;
- The required analytical suite(s);
- The required QA/QC assessment; and
- The requirement for laboratory analysis to be conducted by a National Association of Testing Authorities (NATA) accredited laboratory.

It is anticipated that the Environmental Consultant will maintain a full time presence on site during key remediation and validation works. This will also assist with monitoring requirements for the site management plan.

9. Site Management Plan

9.1 Preparation and Implementation

The Contractor will prepare and implement a Site Management Plan (SMP) for the remediation works, including a Construction Environmental Management Plan (CEMP). The CEMP may be prepared by the Environmental Consultant covering issues specific to management of contamination.

The SMP/CEMP will include, *inter alia*, plans on:

- site management and operation;
- induction requirements;
- roles and responsibilities of organisations and personnel involved in the works;
- work health and safety (WHS), including specific requirements for contaminants;
- emergency response;
- environmental management;
- asbestos management;
- stormwater management and off-site disposal;
- groundwater management and off-site disposal;
- soil management and off-site disposal;

- noise control;
- dust control;
- odour control;
- contingency measures for environmental incidents; and
- unexpected finds protocol.

Some of the above items will require input from the Environmental Consultant.

The contractor will ensure that the site works comply with the following conditions:

- all works are conducted in accordance with the regulatory requirements and site management plan. This will include obtaining any required approvals or licences prior to commencement;
- any waste disposed from the site will be assessed and disposed in accordance the POEO Act and other applicable regulations;
- any soil imported onto the site will be assessed and imported in accordance the POEO Act;
- 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 will be cleaned and secured so that no mud, soil or water are deposited on any public roadways or adjacent areas; and
- noise and vibration levels at the site boundaries comply with the legislative requirements.

9.2 Regulation

Works will comply with all legislative requirements including, *inter alia*, those set out under the following Acts (and their subsequent amendments and regulations):

- Environmentally Hazardous Chemicals Act, 1985;
- Hazardous Chemicals Act, 1985;
- Environmental Offences and Penalties Act, 1989;
- Agricultural and Veterinary Chemicals Act, 1994;
- Protection of the Environment Operations Act, 1997 (POEO Act);
- Contaminated Land Management Act, 1997 (CLM Act);
- Pesticide Act, 1999; and
- Work Health and Safety Act, 2011 (WHS Act)

9.3 Site Operations

Access to the site will be restricted to approved persons. Approved persons will include people working on the project. Appropriate fencing and security will be in place to prevent unauthorised access to the site.

All persons entering the site will either undergo a full site induction, or for one off short visits may undergo an abridged induction subject to their full time supervision by a fully inducted person.

Remediation works will be restricted to the hours as may be set in the Consent Conditions.

It is the PRs responsibility to ensure appropriate personnel are appointed to manage and conduct the remediation and validation works.

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

9.4 Soil Management, Importation and Disposal

9.4.1 Importation of Soil

Any soil, rock or recycled aggregate to be imported onto the site must meet the following requirements:

- They must be legally able to be imported onto the site in accordance with the *Protection of the Environment Operations (Waste) Regulation* 2014 and any required consent approvals;
- The soils must meet the remediation acceptance criteria for the site (refer to Section 4.2);
- The soils must meet the geotechnical requirements for their proposed use;
- The soils must be classified as Virgin Excavated Natural Material (VENM), Excavated Natural Material (ENM) or other materials legally able to be imported onto the site based on a Resource Recovery Exemption. Where available VENM should be imported in preference to ENM. Soils must be assessed in accordance with the EPA requirements;
- Prior to importation appropriate documentation needs to be provided to, and approved by, the Environmental Consultant and the materials must be inspected at the source site to confirm that there are no signs of contamination;
- The material must be inspected during importation by the Contractor, and any materials not meeting the description given in the provided documentation or displaying signs of contamination will be rejected. The Environmental Consultant will also conduct inspection(s) during and/ or following importation to check the same;
- Additional testing of the imported material may be required, as recommended by the Environmental Consultant, commensurate with the documentation and the material type/ classification; and

- Any recycled materials such as crushed concrete or mulch imported onto the site will also require assessment, including laboratory testing, following importation onto the site (the assessment is to include, inert alia, asbestos).

9.4.2 Stockpiling of Contaminated Material

Stockpiles should be managed to minimise the risk of dust generation, erosion and leaching. The measures required to achieve this will depend on the materials in the stockpile and the length of time the stockpile is to remain on site, but should include:

- Restrict the height of stockpiles to reduce dust generation;
- Construct erosion, sediment and runoff control measures;
- Cover stockpiles of contaminated soils to be left on site more than 24 hours, or if windy conditions are expected;
- Keep temporary stockpiles moist, by using water spray where required; and
- Manage the potential for leaching from stockpiles (where required) by placing on a low permeability base. Where this is a potential issue, specific advice should be sought from the Environmental Consultant.

9.4.3 Waste Disposal

All off-site disposal of wastes, where required, will be undertaken in accordance with the POEO Act.

All soil and rock to be removed from the site will be classified in accordance with either:

- The EPA *Waste Classification Guidelines* 2014; or
- A General or Specific Exemption under the *Protection of the Environment Operations (Waste) Regulation* 2014.

No soils will leave the site without a formal waste classification.

9.4.3.1 Assessment of Soil

A waste classification/ exemption assessment will be required for any soils to be disposed off-site. Assessment works will be undertaken by the Environmental Consultant based on previous analytical data, field observation, and where required, additional testing results.

Where appropriate, this should include an assessment of acid sulphate soil (ASS) which may be present in some materials at the site.

The process of assessment will comprise:

- Inspection for signs of concern (e.g. asbestos-containing materials, staining, odours);
- Determination of the source of the material to determine what previous results may be relevant;

- Review of previous results to determine if they are applicable to the subject soils (i.e. materials are of similar description, there are no additional signs of concern which need to be assessed) and if sufficient testing results are available;
- Additional testing and analysis if considered necessary based on the previous results and the material type/ condition. Any testing will need to characterise the subject material appropriately (e.g. including sampling from depth in stockpiles);
- Provision of a report to the Contractor and Principal clearly stating the classification of the subject material; and
- Inspection of the material during excavation and loading and separation of any materials observed to have signs of concern not observed during the classification process.

Based on the results the Environmental Consultant will provide advice on the appropriate disposal/re-use options for the material.

9.4.3.2 Hazardous Waste Management

Hazardous Waste is expected to be encountered on the site, with the primary contaminants of concern being PAH and TRH.

This plan caters for the storage, treatment and disposal of excavated spoil which fails to meet the criteria for direct disposal to a landfill (i.e. Hazardous Waste). Any suspected hazardous waste materials should have their classification confirmed by the Environmental Consultant, including additional sampling and analysis as appropriate.

Hazardous waste will be handled as follows:

- Materials of the same spoil category/ contamination issue will be excavated and placed as separate stockpiles at demarcated and contained locations. The categorisation would be done on the basis of on-site observations and the contaminant exceedances detected;
- Stockpiles of excavated materials will be appropriately bunded with hay bales/sandbags and covered with anchored geotextile or impermeable plastic sheeting, or alternatively placed in an appropriate container e.g. waste skip, with appropriate cover. Materials considered to have the potential to produce contaminated leachate will be stockpiled in an area with an appropriate leachate collection system;
- Where required, additional sampling and analysis of segregated stockpiles may be conducted to determine the concentrations of the target parameters in the excavated materials (e.g. leachability of the contaminants of concern, treatability studies);
- Should the sampling and testing confirm the hazardous waste category and the material is to be disposed of off-site, a treatment methodology will be determined. Appropriate applications will be made to the EPA, and agreement as to the appropriateness of the treatment and disposal method will be obtained from the EPA prior to the removal of such wastes from the site. The treatment may be conducted on- or off-site; and
- An appropriately licensed hazardous waste contractor will be appointed to treat, manage the dispose of the waste in accordance with the methodology agreed with the EPA.

9.4.3.3 Loading and Transport of Spoil

All transport of waste and disposal of materials must be conducted in accordance with the requirements of the POEO Act. All licences and approvals required for disposal of the material will be obtained prior to removal of the materials from the site.

Removal of waste materials from the site shall only be carried out by a licensed contractor holding appropriate licence, consent and/ or approvals to dispose of the waste materials according to the assigned waste classification, and with the appropriate approvals obtained from the EPA, if required.

Details of all soils removed from the site (including VENM) shall be documented by the Contractor with copies of weighbridge slips, trip tickets and consignment disposal confirmation (where appropriate) provided to the Environmental Consultant and the PR. A site log shall be maintained by the Contractor to track disposed loads against on-site origin.

Transport of spoil shall be via a clearly delineated, pre-defined haul route. The proposed waste transport route will be notified to the local Council and truck dispatch shall be logged and recorded by the Contractor for each load leaving the site. A record of the truck dispatch will be provided to the PR.

9.4.3.4 Disposal of Material

All materials excavated and removed from the site shall be disposed in accordance with the POEO Act to a facility/site legally able to accept the material. Copies of all necessary approvals from the receiving site shall be given to the PR prior to any contaminated material being removed from the site. A record of the disposal of materials will be maintained.

All relevant analysis results, as part of waste classification reports, shall be made available to the Contractor and proposed receiving site/ waste facility to enable selection of a suitable disposal location.

Copies of all consignment notes for the transport, receipt and disposal of all materials (including VENM) will be maintained as part of the site log and made available to the Environmental Consultant for inspection and reporting purposes upon request.

9.5 Water Management and Disposal

9.5.1 Management

Management of water should include the following:

- Potentially contamination (e.g. groundwater, run off water which has been in contact with contaminated soil/ water) and likely clean water (e.g. run off water which has not been in contact with contaminated) should be kept separate to reduce disposal costs;
- Separate storage and disposal systems should be in place for “contaminated” and “clean” water;
- The potential for run-off water to become contaminated should be minimised by good on-site stormwater management including diverting surface water away from uncovered contaminated materials;

- Contaminated water (e.g. groundwater from dewatering) should be kept at the surface for as short a period of time as practicable. Ideally such water should be pumped directly to the disposal point; and
- Whilst quantities of water stored at the site should be minimised where possible, sufficient storage capacity for stormwater will be required to allow appropriate testing prior to disposal.

9.5.2 Assessment

Assessment of water quality for off-site disposal will be undertaken by the Environmental Consultant. This will include a review of potential for the water to be impacted by various contaminants, possible disposal options, and determination of a suitable sampling and analysis program. Analysis may include total suspended solids (TSS) and/or turbidity, pH, filterable iron, TRH, PAH, BTEX, VOC and metals. The Environmental Consultant will provide written advice of the results to the PR and Contractor, including comments on potential disposal options.

9.5.3 Disposal of Water

Based on the results of the assessment the Contractor will determine the appropriate disposal method(s). Following determination of the disposal method, disposal will be conducted in accordance with the POEO Act. Record of the disposal will be kept by the Contractor and provided to the PR and Environmental Consultant.

In general, disposal options for liquids include:

- On-site absorption. This option is generally suitable for water with contaminant levels at background quality for the site, and comprises discharge of water onto the ground surface in an area where it will be absorbed into the underlying soils and groundwater. TSS would not be an issue of concern for this method of disposal. This is generally not an acceptable option if there is a potential to mobilise soil or groundwater contaminants;
- Disposal to stormwater. This option is suitable for uncontaminated waters, with low turbidity. All water to be disposed to stormwater needs to meet the requirements of the owner of the stormwater system, which is City of Sydney, and will require their consent. This option may be suitable for rainwater which has not come into contact with contaminated soils or water;
- Disposal to sewer under a Trade Waste Agreement. This method of disposal would require a Trade Waste Agreement with Sydney Water;
- Disposal as a liquid waste to a licensed liquid waste contractor in accordance with the POEO Act, 1997. This method is likely to be costly, however, it allows for off-site treatment and is therefore suitable for wastes with high levels of contaminants; and
- On-site treatment followed by disposal by one of the above methods. If direct disposal by one of the above methods is considered unsuitable due to the water quality or cost, on-site treatment could be conducted prior to disposal. On-site treatment may include for example removal of suspended solids and pH adjustment which are standard requirements for construction sites water prior to disposal to stormwater or sewer.

10. Unexpected Finds Protocol and Contingency Plan

10.1 Unexpected Finds Protocol

All site personnel will be inducted into their responsibilities under this Unexpected Finds Protocol (UFP), which should be included in the Contractors Site Management Plan.

All site personnel are required to report the following to the Site Manager if observed during the course of their works:

- Signs of unexpected environmental concern, e.g. presence of unexpected fibre cement, petroleum, or other chemical odours, unnatural staining, potential contamination sources (such as buried drums or tanks) or chemical spills.

Should signs of concern be observed, the Contractor will, as soon as practical:

- Place barricades around the affected area (the potential area of environmental concern – PAEC) and cease work in that area;
- Notify authorities needed to obtain emergency response for any health or environmental concerns (e.g. fire brigade);
- Notify the PR of the occurrence;
- Notify any of the authorities that the Contractor is legally required to notify (e.g. EPA, Council); and
- Notify the Environmental Consultant.

The PR will notify any of the authorities which the Principal is legally required to notify (e.g. EPA, Council).

Following the immediate response in the UFP, the following contingency plan will be implemented.

10.2 Contingency Plan

The contingency plan for the site is as follows:

- The Environmental Consultant will inspect the PAEC and determine the nature of the issue, whether it comprises an AEC, and the appropriate approach to assessing or (if appropriate) managing the issue;
- The Site Auditor will be informed, if considered necessary, of the PAEC/AEC and the proposed assessment and/or management approach;
- The Environmental Consultant will undertake an assessment considered necessary to determine the management strategy for the AEC;
- If contamination is found and remediation action is considered necessary, a remediation strategy for the AEC will be identified. If this strategy is similar to that all required for other areas of the site it will be implemented following correspondence with the Site Auditor; and

- If the AEC or proposed remediation strategy is significantly different than that detailed in the RAP, a proposed remediation strategy plan will be prepared by the Environmental Consultant for the approval of the Site Auditor and the Consent Authority or Private Certifier (as applicable) will be provided notification of the proposed works.

11. Conclusions

It is considered that the site can be rendered suitable for the proposed development subject to appropriate further investigation and remediation in accordance with this RAP. A detailed remediation and validation plan with specific technical specification will be required to provide the detailed methodology for the adopted remediation strategy.

12. Limitations

Douglas Partners (DP) has prepared this report (or services) for this project 14 – 16 Wattle Street, Ultimo in accordance with DP's proposal SYD140884 dated 4 August 2014 and acceptance received from Government Architect's Office on behalf of the Department of Education and Communities dated 14 March 2014 and 28 January 2015. This report is provided for the exclusive use of the Government Architect's Office and Department of Education and Communities 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 assumptions made are based on a previous sampling program and sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences.

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 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 applicable components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

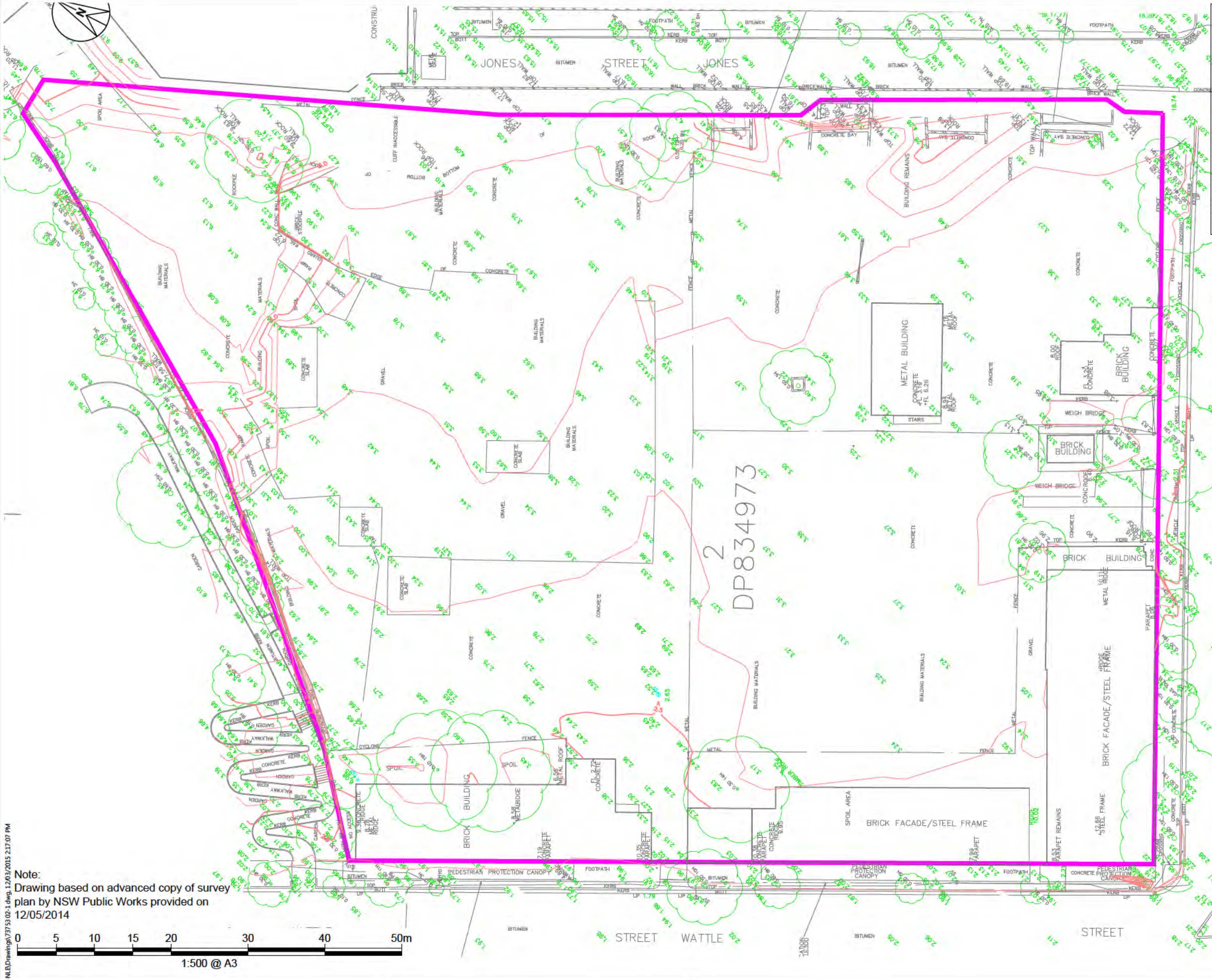
This report has been produced with reference to the *National Environmental Protection (Assessment of Site Contamination) Measure* 1999 as amended (amended 16 May 2013 and approved by the NSW EPA on 11 June 2013) (NEPC, 2013). The report does, however, reference investigations undertaken prior to the issue of NEPC (2013), and this may limit some of the findings herein.

Douglas Partners Pty Ltd

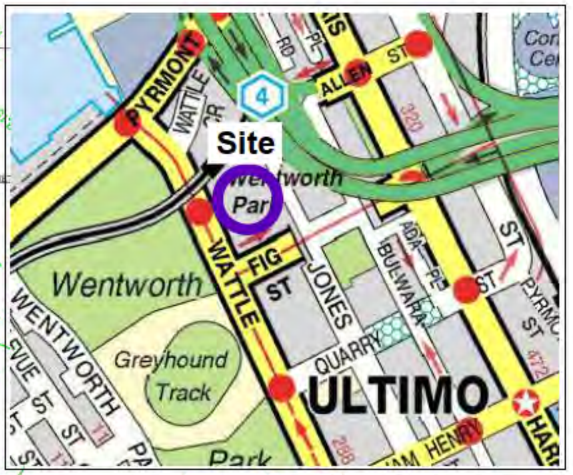
Appendix A

Drawings

About this Report



Note:
Drawing based on advanced copy of survey plan by NSW Public Works provided on 12/05/2014



Locality Plan

LEGEND

- Site boundary
- Contour

P:\73753 02 ULTIMO, RAF NLB\Drawings\73753.02-1.dwg, 12/03/2015 2:17:07 PM

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Government Architects Office		TITLE:	**Site Location**
OFFICE: Sydney	DRAWN BY: PSCH		**Proposed Primary School**
SCALE: 1:500 @ A3	DATE: 12.3.2015		**14-16 Wattle Street, ULTIMO**

PROJECT No:	73753.02
DRAWING No:	1
REVISION:	0

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

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

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.

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

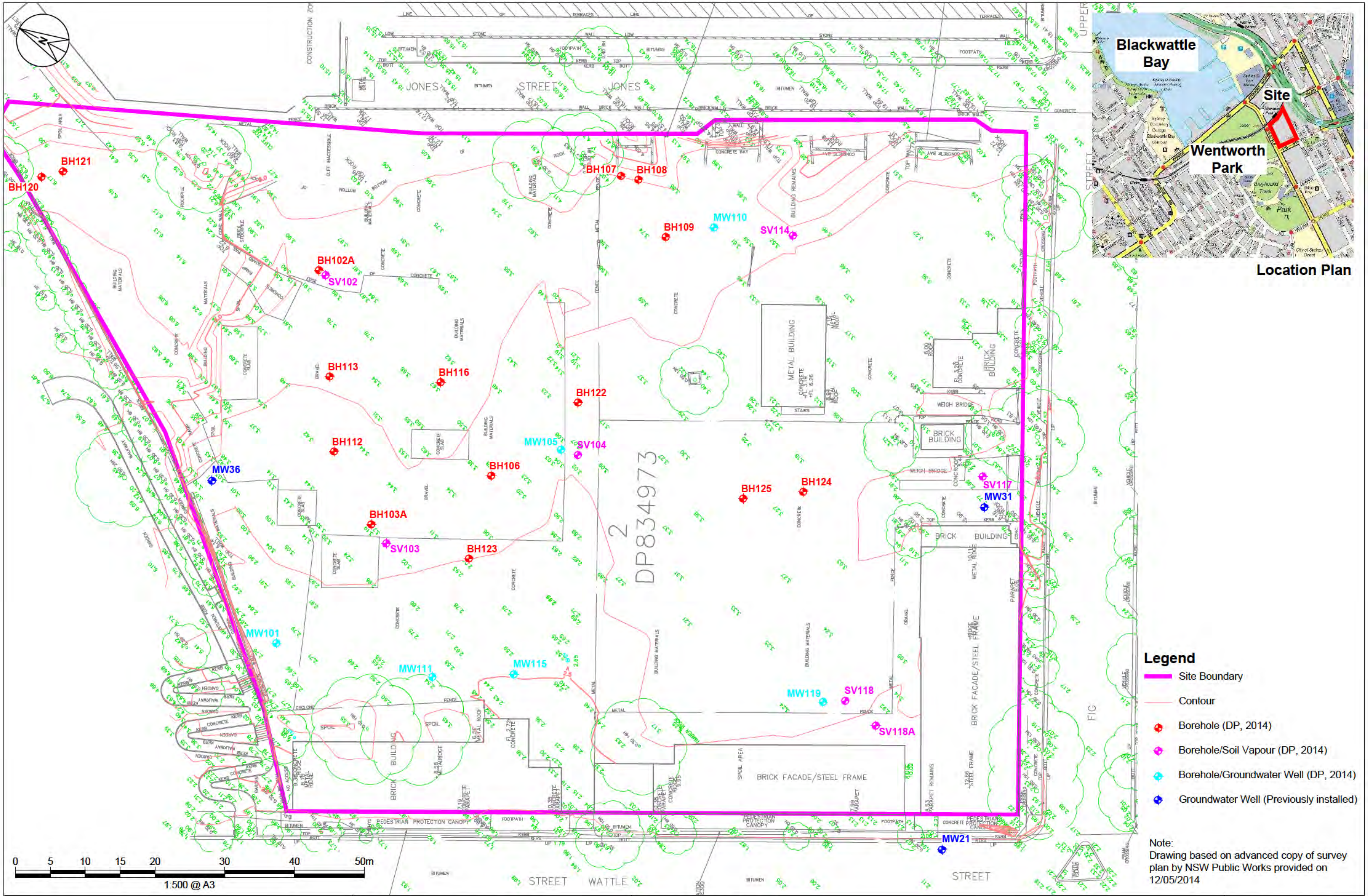
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate 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

Available Field Results from Previous Reports



Note:
Drawing based on advanced copy of survey plan by NSW Public Works provided on 12/05/2014

Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Government Architects Office		
OFFICE: Sydney	DRAWN BY: JCP	
SCALE: As shown	DATE: 13.05.2014	

TITLE: **Sample Locations**
Contamination Investigation
14-16 Wattle Street, Ultimo

PROJECT No: 73753.01
DRAWING No: 1
REVISION: 0

BOREHOLE LOG

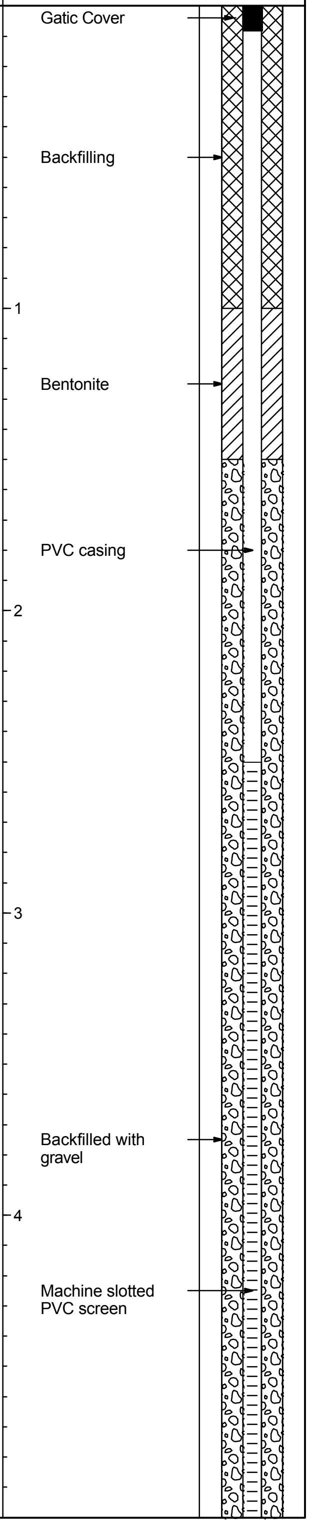
CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 2.69 AHD
EASTING: 332944.7
NORTHING: 6250234.1
DIP/AZIMUTH: 90°/--

BORE No: BH101
PROJECT No: 73753.01
DATE: 7 - 8/4/2014
SHEET 1 OF 2

Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
	CONCRETE					
0.18	FILLING - brown, medium sandy clay filling with sub-angular gravel	A A	0.2 0.3 0.4 0.5			
0.5	FILLING - yellow, fine to medium sand filling					
0.6	FILLING - light brown, medium sand filling with sub-angular gravel	S*	0.9 1 35		6,4,9 N = 13	
1.1	FILLING - red and light brown, clayey, medium sand filling with sub-angular sandstone gravel	A	1.4 1.5			
1.7	FILLING - light brown, clayey, medium sand filling with some sub-angular sandstone gravel	S	1.5 1 95		3,7,5 N = 12	▼
2.2	FILLING - light brown clay and medium sand filling with some sub-angular gravel	A	2.4 2.5			
2.7	FILLING - light brown mottled light grey, clayey, medium sand filling with some sub-angular sandstone gravel					
3.1	FILLING - light brown, clayey, medium sand filling with some sub-angular gravel and some light grey sandstone	S S	2.9 3 35 3.8 3 95		3,3,3 N = 6 25 refusal	
4.7	FILLING - sandstone boulder					
4.9	FILLING - see next page	S	4.8		10,20,15 N = 35	

Well Construction Details



RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.18m; Solid flight auger to 6.0m
WATER OBSERVATIONS: Free groundwater observed at 2.1m
REMARKS: *BD1/070414 collected at 0.9-1.0m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

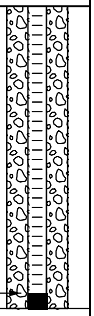
Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 2.69 AHD
EASTING: 332944.7
NORTHING: 6250234.1
DIP/AZIMUTH: 90°/--

BORE No: BH101
PROJECT No: 73753.01
DATE: 7 - 8/4/2014
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - light brown and light grey, medium sand filling with trace sub-angular gravel and sandstone gravel *(continued)*	☒	S	5 25		10,20,15 N = 35		
-3	5.2	SANDSTONE - light grey and brown, extremely weathered sandstone	⁙						
	6 6.0	Bore discontinued at 6.0m - target depth reached							End cap 6
-4	7								7
-5	8								8
-6	9								9
-7									

RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased

TYPE OF BORING: Diacore to 0.18m; Solid flight auger to 6.0m

WATER OBSERVATIONS: Free groundwater observed at 2.1m

REMARKS: *BD1/070414 collected at 0.9-1.0m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

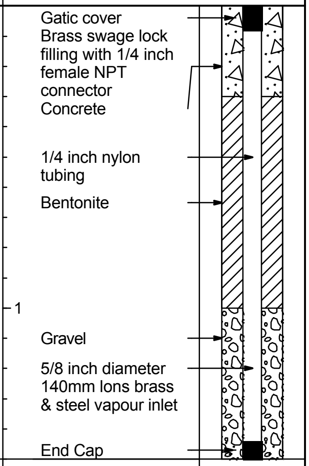
CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.76 AHD
EASTING: 332994.9
NORTHING: 6250251.9
DIP/AZIMUTH: 90°/--

BORE No: BH102
PROJECT No: 73753.01
DATE: 8/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		FILLING - dark brown, silty, fine to medium sand filling and grey silty clay and trace subangular gravel	☒					
				A	0.3 0.5			
3								
				S	0.8 1 25		1,1,2 N = 3	
	1 1.0	FILLING - brown and orange, medium sand with extremely weathered, orange sandstone	☒					
	1.5	Bore discontinued at 1.5m - target depth reached						
2								
	2							
1								
	3							
0								
	4							
-1								

Well Construction Details



RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Solid flight auger to 1.5m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

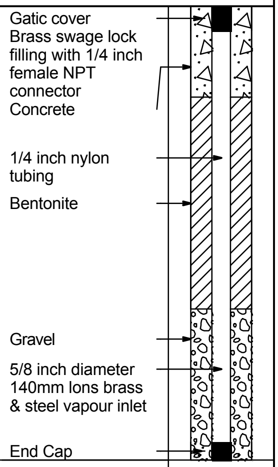
BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.78 AHD
EASTING: 332995.1
NORTHING: 6250253.1
DIP/AZIMUTH: 90°/--

BORE No: BH102A
PROJECT No: 73753.01
DATE: 8/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - dark brown, silty, fine to medium sand filling and grey silty clay and trace subangular gravel	☒						
3									
	1 1.0	FILLING - brown and orange, medium sand with extremely weathered, orange sandstone	☒						1
	1.5	Bore discontinued at 1.5m - target depth reached							
2									
	2								2
1									
	3								3
0									
	4								4
-1									



RIG: DT100
DRILLER: S Salib
LOGGED: RJL
CASING: Uncased
TYPE OF BORING: Solid flight auger to 1.5m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

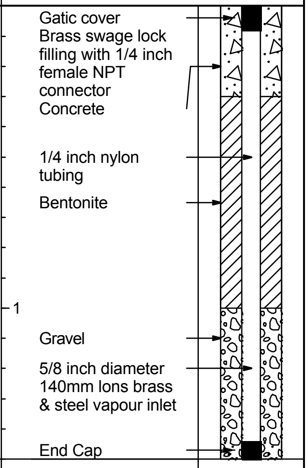
CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.06 AHD
EASTING: 332964.7
NORTHING: 6250226.7
DIP/AZIMUTH: 90°/--

BORE No: BH103
PROJECT No: 73753.01
DATE: 8/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
3		CONCRETE						
	0.2	FILLING - brown, clayey, fine to medium sand filling with subangular gravel		A	0.3 0.5			
	0.6	FILLING - dark brown, silty, fine to medium sand filling with some subangular gravel		A	0.8 1.0			
2	1							
				A	1.3 1.5			
	1.5	Bore discontinued at 1.5m - target depth reached						
1	2							
0	3							
-1	4							

Well Construction Details



RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.2m; Solid flight auger to 1.5m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.22 AHD
EASTING: 332966.1
NORTHING: 6250229.8
DIP/AZIMUTH: 90°/--

BORE No: BH103A
PROJECT No: 73753.01
DATE: 8/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
		CONCRETE							
3	0.2	FILLING - dark brown, clayey, medium sand filling with sub-angular gravel							
	0.3	CONCRETE							
	0.7	Bore discontinued at 0.7m - refusal on concrete							
2	1								1
1	2								2
0	3								3
-1	4								4

RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.7m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

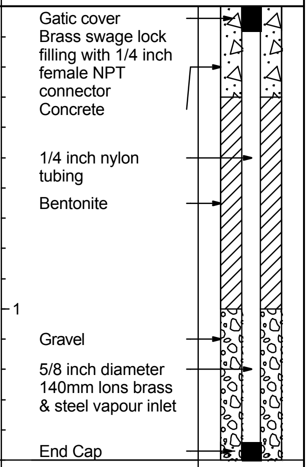
CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.04 AHD
EASTING: 332988.4
NORTHING: 6250208
DIP/AZIMUTH: 90°/--

BORE No: BH104
PROJECT No: 73753.01
DATE: 8/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
3		CONCRETE					
	0.2	FILLING - dark brown, silty, fine to medium silty filling with sub-angular gravel	A	0.3 0.5			
	0.7	FILLING - dark brown mottled red, silty, fine to medium sand with wood pieces and sub-angular gravel	A	0.8 1.0			
2	1.1	FILLING - brown, fine to medium sandy clay filling with wood pieces and sub-angular gravel	A	1.3 1.5			
	1.5	Bore discontinued at 1.5m - target depth reached					

Well Construction Details



RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.2m; Solid flight auger to 1.5m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.03 AHD
EASTING: 332988
NORTHING: 6250210.5
DIP/AZIMUTH: 90°/--

BORE No: BH105
PROJECT No: 73753.01
DATE: 8/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
3		CONCRETE	△						Gatic cover PVC Casing
	0 25	ASPHALT	■						
	0.4	FILLING - brown, silty, fine to medium sand filling with some sub-angular gravel	▨	A	0.4 0.5				
	0.7	FILLING - brown and dark grey, silty, medium sand filling with wood pieces, slight tar odour	▨		0.8				Backfilling
2	0.9 1	FILLING - orange and light brown, medium grained sandstone with some sub-angular gravel	▨	S	1 25		5,4,3 N = 7		
	1.1	FILLING - brown and dark grey, silty, medium sand filling with wood pieces and some subangular gravel	▨	A*	1.3 1.5				
1	1.6 2	FILLING - grey and brown, clayey, fine to medium sand with some sub-angular gravel	▨	S	1.8 2 25		1,3,2 N = 5		Bentonite Backfilled with gravel
	2.5	FILLING - orange, medium grained extremely weathered sandstone (boulder) filling	▨		2.8			▼	
0 -1	3.0 3 4	FILLING - light brown, silty, fine to medium sand filling with traces sub-angular gravel	▨	S	3 25		9,25,17 N = 42		Machine slotted PVC screen End Cap
	4.5	Bore discontinued at 4.5m - target depth reached							

RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.4m; Solid flight auger to 4.5m
WATER OBSERVATIONS: Free groundwater observed at 2.5m
REMARKS: *BD1/080414 collected at 1.3-1.5m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
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BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.20 AHD
EASTING: 332980.1
NORTHING: 6250217.7
DIP/AZIMUTH: 90°/--

BORE No: BH106
PROJECT No: 73753.01
DATE: 8/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
		CONCRETE							
	0 25	FILLING - brown and orange, silty, fine to medium sandy clay filling with some sub-angular gravel		A	0.4 0.5				
	0.6	FILLING - brown and grey, clayey, medium sand filling with some sub-angular gravel		S A	0.8 1 25 1.3 1.5		8,11,6 N = 17		
	1.7	FILLING - yellow-orange and light brown, medium sand filling with some sub-angular gravel		S	1.8 2 25		3,3,3 N = 6		
	2.2	FILLING - dark brown, medium sand filling with some sub-angular gravel		S	2.8 3.15		4,11,25/100mm refusal	▼	
	3.15	Bore discontinued at 3.15m - target depth reached							

RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased

TYPE OF BORING: Diacore to 0.25m; Solid flight auger to 3.0m; SPT 3.0-3.15m

WATER OBSERVATIONS: Free groundwater observed at 2.5m

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.81 AHD
EASTING: 333026.9
NORTHING: 6250220.8
DIP/AZIMUTH: 90°/--

BORE No: BH107
PROJECT No: 73753.01
DATE: 9/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		CONCRETE	△						
	0 21	FILLING - concrete and sub-angular granite cobbles and gravel	▨						
	0.45	FILLING - brown, medium sand filling with sub-angular granite cobbles and gravel	▨	A	0.5 0.6				
	0.7	FILLING - brown, medium sand filling with sub-angular gravel and plant matter	▨	A	0.8 1.0				
	1.5	Bore discontinued at 1.5m - refusal on boulder							

RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased

TYPE OF BORING: Diacore to 0.45m; Solid flight auger to 1.5m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.85 AHD
EASTING: 333027.5
NORTHING: 6250218.3
DIP/AZIMUTH: 90°/--

BORE No: BH108
PROJECT No: 73753.01
DATE: 9/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		CONCRETE	△						
3	0 23 1	FILLING - sandstone, concrete and paving cobbles and sub-angular gravel	⊠						1
2	1.9 2	Bore discontinued at 1.9m - refusal on filling							2
1	3								3
0	4								4
-1									

RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.7m; Rotary to 1.5m; Solid flight auger to 1.9m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.75 AHD
EASTING: 333022
NORTHING: 6250211.1
DIP/AZIMUTH: 90°/--

BORE No: BH109
PROJECT No: 73753.01
DATE: 9/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		CONCRETE							
	0 23	FILLING - sub-angular gravel and medium sand filling with sandstone boulder							
3	0.8	FILLING - brown-yellow and white, medium sandy clay filling with some sub-angular gravel and trace crushed brick		S	0.8 1 25		1,3,3 N = 6		
	1			A	1.3 1.5				
2	1.8	FILLING - brown-orange and dark brown, medium sandy clay filling with some ash and asphalt		S	1.8 2 25		6,12,15 N = 27	▼	
	2								
1				S	2.8 2 85		15/50mm refusal		
	2.9	SANDSTONE - white and grey, highly weathered, medium grained sandstone							
	3								
	3.1	Bore discontinued at 3.1m - target depth reached							
0									
	4								
-1									

RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.75m; Solid flight auger to 3.1m
WATER OBSERVATIONS: Free groundwater observed at 2.0m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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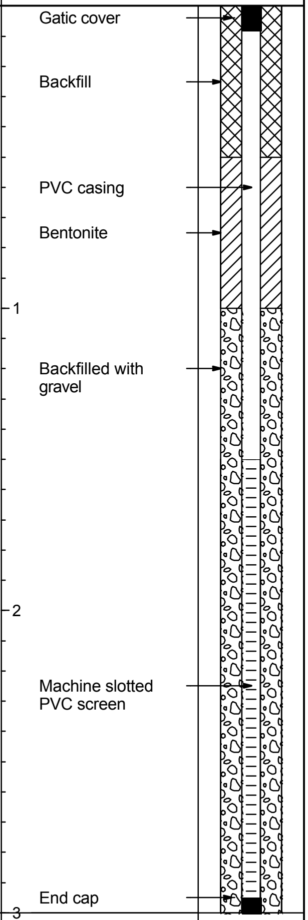
BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.61 AHD
EASTING: 333026.4
NORTHING: 6250205.5
DIP/AZIMUTH: 90°/--

BORE No: BH110
PROJECT No: 73753.01
DATE: 9/4/2014
SHEET 1 OF 1

Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	ASPHALT						
0.45	CONCRETE						
0 66	GRANITE BOULDER						
0.74	FILLING - light brown, medium sandy clay filling with some sub-angular gravel			0.8			
0.9	FILLING - dark brown and black, medium sandy clay filling with some asphalt		S A*	1 25 1.3 1.5		3,4,6 N = 10	
1.7	FILLING - orange-black mottled pink, fine to medium sand filling with some sub-angular gravel		S	1.8 2.1		6,35 refusal	
2.2	FILLING - grey, medium sandy clay filling with some sub-angular gravel		S	2.8 2 88		10/80mm refusal	
3.0	Bore discontinued at 3.0m - target depth reached						



RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.74m; Solid flight auger to 3.1m
WATER OBSERVATIONS: Free groundwater observed at 2.0m
REMARKS: *BD1/090414 collected at 1.3-1.5m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 2.52 AHD
EASTING: 332950.6
NORTHING: 6250212
DIP/AZIMUTH: 90°/--

BORE No: BH111
PROJECT No: 73753.01
DATE: 10/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		CONCRETE						Gatic Cover PVC Casing Backfill
2	0 28	FILLING - brown, clayey, fine to medium sand filling with sub-angular gravel	A	0.3 0.5				
1	0.6	FILLING - dark brown, clayey, fine to medium sand filling with sub-angular gravel and wood pieces	S A	0.8 1 25 1.3 1.5		3,3,4 N = 7		Bentonite
	1.7	FILLING - grey and brown, fine to medium sandy clay filling with some sub-angular gravel	S	1.8 2.0		22,1 refusal	▼	Backfilled with gravel
0	2.3	FILLING - black and grey, clayey, medium sand filling with some ash and trace sub-angular gravel						
-1	2.7	FILLING - grey, silty clay filling (possibly natural)	S S	2.8 3 25 3.8 4.0		7,3,7 N = 10 2,9/60mm refusal		Machine slotted PVC screen
	4.4	SANDSTONE - extremely weathered, grey sandstone						End cap
-2	4.5	Bore discontinued at 4.5m - target depth reached						

RIG: Scout 2 **DRILLER:** J Simon **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.28m; Solid flight auger to 4.5m
WATER OBSERVATIONS: Free groundwater observed at 2.15m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.37 AHD
EASTING: 332972.9
NORTHING: 6250239.3
DIP/AZIMUTH: 90°/--

BORE No: BH112
PROJECT No: 73753.01
DATE: 10/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
		CONCRETE							
3	0 27	FILLING - brown mottled orange, silty, fine to medium sand filling with sub-angular gravel		A	0.3 0.5				
	0.7	FILLING - brown-red-orange and light brown, silty, fine to medium sand filling with some red and grey sandstone cobbles and sub-angular gravel		S	0.8 1 25		2,4,4 N = 8		1
2	1.1	FILLING - dark brown, silty, fine to medium sand filling with sub-angular gravel		A	1.3 1.5				
1	1.7	FILLING - brown-red and orange, silty, fine to medium sand filling with subangular gravel and red sandstone pieces. Petroleum odour		S	1.6 2 05		1,2,2 N = 4	▼	2
0	2.6	FILLING - black, medium sand with sub-angular gravel and crushed sandstone		S	2.8 3 25		2,6,4 N = 10		3
	3.5	SAND - yellow, fine to medium sand							
-1	3.8	SANDSTONE - highly weathered, white and yellow, medium grained sandstone		S	3.8 4 25		2,13,15 N = 28		4
	4.8	Bore discontinued at 4.8m - target depth reached							

RIG: Scout 2 **DRILLER:** J Simon **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.27m; Solid flight auger to 4.0m
WATER OBSERVATIONS: Free groundwater observed at 2.5m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH113
PROJECT No: 73753.01
DATE: 10/4/2014
SHEET 1 OF 2

Depth (m)	Description of Strata	Sampling & In Situ Testing Type	Depth	Sample	Results & Comments	Water
	CONCRETE					
1.1	FILLING - sandstone boulder					
1.75	FILLING - brown, clayey, fine to medium sand filling	A	1.8 2.0			
2.0	FILLING - sandstone boulder	A	2.8 3.0			
3.3	FILLING - orange and grey, silty clayey, fine to medium sand filling with some sub-angular gravel	S	3.4 3 95		13,14,13 N = 27	▼
3.8	FILLING - piece of wood (possible railway sleeper?)					
4.2	FILLING - orange and grey, silty clayey, fine to medium sand filling with trace sub-angular gravel					
4.4	SANDSTONE - extremely weathered, light grey, fine to medium grained sandstone					
5.0						

RIG: Scout 2 **DRILLER:** J Simon **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Solid flight auger to 5.2m
WATER OBSERVATIONS: Free groundwater observed at 3.7m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH113
PROJECT No: 73753.01
DATE: 10/4/2014
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing Type	Sampling & In Situ Testing Depth	Sampling & In Situ Testing Sample	Sampling & In Situ Testing Results & Comments	Water	Well Construction Details
		SANDSTONE - highly weathered, grey, fine to medium grained sandstone	⁘						
	5.2	Bore discontinued at 5.2m - target depth reached							
	6								6
	7								7
	8								8
	9								9

RIG: Scout 2 **DRILLER:** J Simon **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Solid flight auger to 5.2m
WATER OBSERVATIONS: Free groundwater observed at 3.7m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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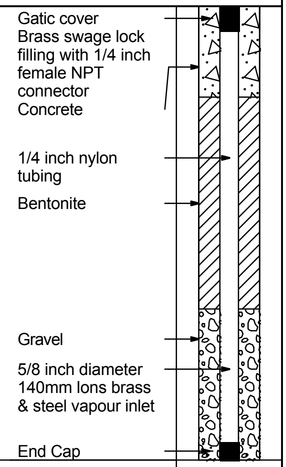
BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.50 AHD
EASTING: 333030.5
NORTHING: 6250194.9
DIP/AZIMUTH: 90°/--

BORE No: BH114
PROJECT No: 73753.01
DATE: 10/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		CONCRETE					
3	0.45	FILLING - sandstone boulder					
	0 65	FILLING - brown and grey, clayey, fine to medium sand with some sub-angular gravel	A	0.8 1.0			
			A	1.3 1.5			
2	1.5	Bore discontinued at 1.5m - target depth reached					



RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased

TYPE OF BORING: Diacore to 0.65m; Solid flight auger to 1.5m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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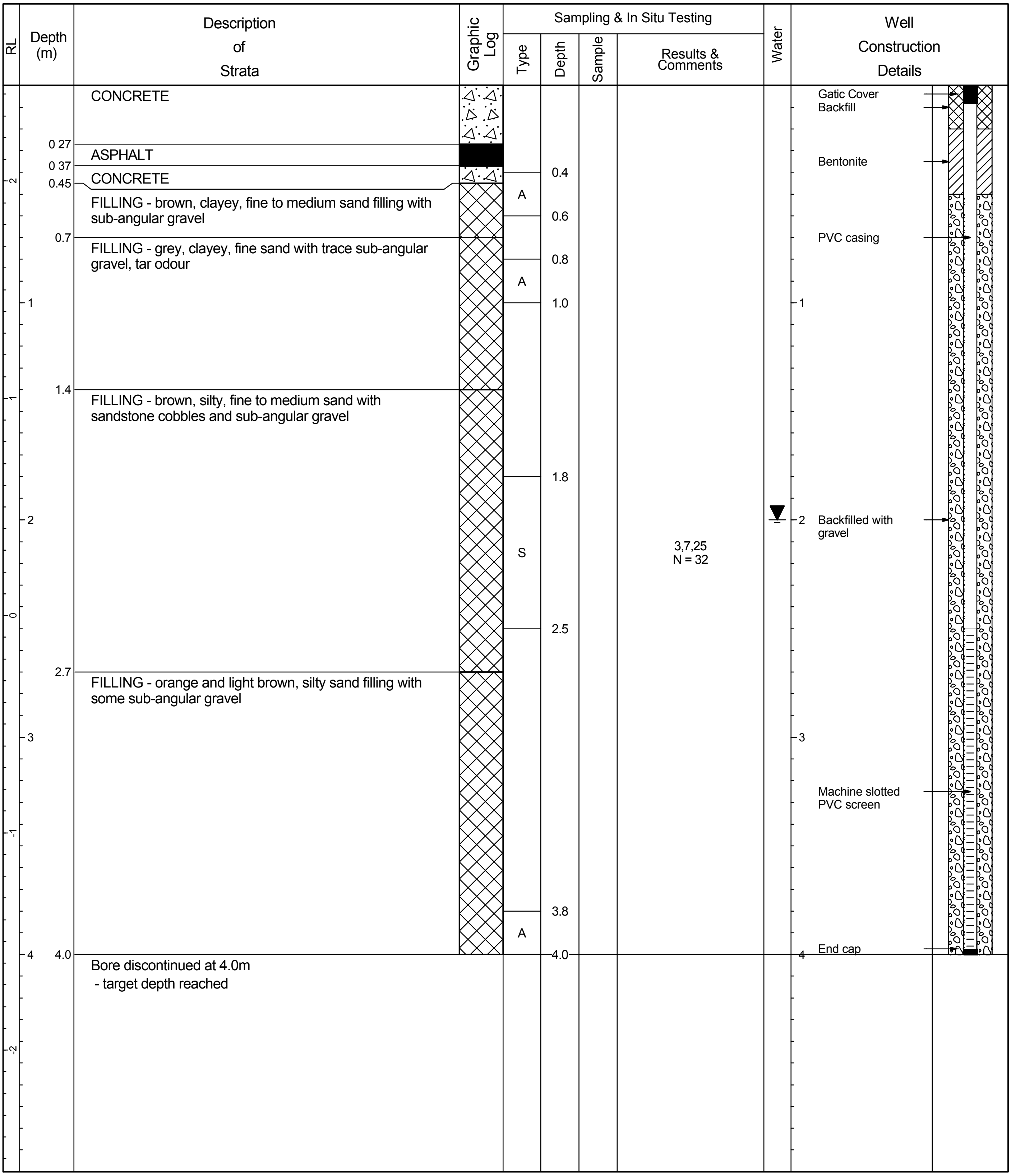
BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 2.44 AHD
EASTING: 332956.3
NORTHING: 6250201.8
DIP/AZIMUTH: 90°/--

BORE No: BH115
PROJECT No: 73753.01
DATE: 11/4/2014
SHEET 1 OF 1



Depth (m)	Description of Strata
	CONCRETE
0 27	ASPHALT
0 37	CONCRETE
0.45	FILLING - brown, clayey, fine to medium sand filling with sub-angular gravel
0.7	FILLING - grey, clayey, fine sand with trace sub-angular gravel, tar odour
1.4	FILLING - brown, silty, fine to medium sand with sandstone cobbles and sub-angular gravel
2.7	FILLING - orange and light brown, silty sand filling with some sub-angular gravel
4.0	Bore discontinued at 4.0m - target depth reached

Type	Depth	Sample	Results & Comments
A	0.4 0.6		
A	0.8 1.0		
S	1.8 2.5		3,7,25 N = 32
A	3.8 4.0		

RIG: DT100 & Scout 2 **DRILLER:** S Salib/J Simon **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.45m; Solid flight auger to 4.0m
WATER OBSERVATIONS: Free groundwater observed at 2.0m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 2.44 AHD
EASTING: 332956.3
NORTHING: 6250201.8
DIP/AZIMUTH: 90°/--

BORE No: BH115A
PROJECT No: 73753.01
DATE: 11/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	CONCRETE							
	0.4	FILLING - sub-angular gravel							
	0.41	CONCRETE							
		Bore discontinued at 0.41m - refusal on concrete							

RIG: DT100 **DRILLER:** S Salib **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Diacore to 0.1m; Solid flight auger to 0.41m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 3.61 AHD
EASTING: 332988.8
NORTHING: 6250230.3
DIP/AZIMUTH: 90°/--

BORE No: BH116
PROJECT No: 73753.01
DATE: 11/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
		FILLING - medium to coarse sand and sub-angular gravel, slag, wood pieces, organic matter, sandstone cobbles and gravel filling with trace glass	▨						
3	0.4	CONCRETE	△						
	0.7	Bore discontinued at 0.7m - refusal due to drill bit breaking							

RIG: Scout 2 **DRILLER:** J Simon **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: Solid flight auger to 0.7m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

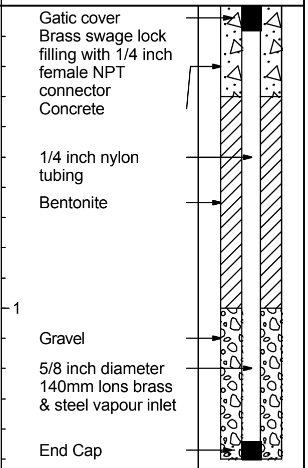
CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: 2.92 AHD
EASTING: 333012.2
NORTHING: 6250155
DIP/AZIMUTH: 90°/--

BORE No: BH117
PROJECT No: 73753.01
DATE: 11/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water
				Type	Depth	Sample	Results & Comments	
		FILLING - dark grey, silty, fine sand filling with trace dark grey clay. Trace metallic (?) fragments (<1mm diameter)	▩	A	0.3 0.6			
	1.0	FILLING - orange, dark grey and light grey, sandstone filling with trace charcoal and slag	▩	S	1.0 1.45		4 3 2 N = 5	
				A	1.5 1.9			
	1.9	Bore discontinued at 1.9m						

Well Construction Details



RIG: Bobcat DT250 **DRILLER:** S Younan **LOGGED:** VK **CASING:** Uncased
TYPE OF BORING: Solid flight auger to 1.9m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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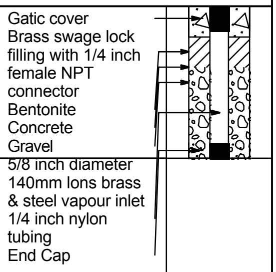
BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH118
PROJECT No: 73753.01
DATE: 11/4/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
		FILLING - dark grey, silty, fine to medium sand filling with some sub-angular gravel. Petroleum odour	▨	E	0.2 0.5				
	0.5	Bore discontinued at 0.5m - target depth reached							
	1								1
	2								2
	3								3
	4								4



RIG: Bobcat DT250 **DRILLER:** S Younan **LOGGED:** VK **CASING:** Uncased
TYPE OF BORING: Solid flight auger to 0.5m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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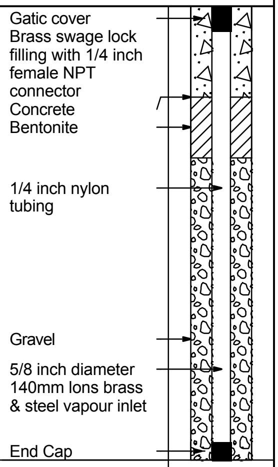
BOREHOLE LOG

CLIENT: Government Architects Office
PROJECT: Contamination Investigation
LOCATION: 14-16 Wattle Street, Ultimo

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH118A
PROJECT No: 73753.01
DATE: 8/5/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
		FILLING - poorly compacted, filling - soil not logged	▨						
	1								1
	1.5	Bore discontinued at 1.5m - target depth reached							
	2								2
	3								3
	4								4



RIG: Hand tools **DRILLER:** RJL **LOGGED:** RJL **CASING:** Uncased
TYPE OF BORING: 20mm sacrificial spearpoint probe
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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