coffey

SITE SPECIFIC REMEDIAL ACTION PLAN FOR THE HAYMARKET PLANNING APPLICATION,

HAYMARKET, SYDNEY NSW

Prepared for:

Lend Lease Development Pty. Ltd.
30 The Bond, 30 Hickson Road
Millers Point, NSW 2000

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Written/Submitted by:

Matthew Locke
Senior Associate

Reviewed/Approved by:

Michael Dunbavan
Senior Principal

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ABBREVIATIONS

µg/L	micrograms per litre
ACM	Asbestos Containing Materials
AEC	Area of Environmental Concern
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASLP	Australian Standard Leaching Procedure
ASS	Acid Sulfate Soil
ASSMP	Acid Sulfate Soil Management Plan
bgs	below ground surface
BH	Borehole
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
btoc	Below Top of Casing
C6-C36	Hydrocarbon chainlength fraction
COPC	Chemicals of Potential Concern
CSMP	Construction Site Management Plan
DBYD	Dial Before You Dig
DQO	Data Quality Objectives
EMP	Environmental Management Plan
EPA	Environmental Protection Authority of NSW
eV	Electron Volt
GIL	Groundwater Investigation Level
HHERA	Human Health & Environmental Risk Assessment

HIL	Health Investigation Level
HIL	Health Investigation Level
HSIS	Safe Work Australia's Hazardous Substance Information System (HSIS)
HSL	Health Screening Level
INSW	Infrastructure NSW
IP	Interface Probe
LLD	Lend Lease Development (Development Manager for The Haymarket on behalf of Darling Harbour Live)
LOR	Limit of Reporting
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
mV	millivolt
MW	Monitoring Well
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NEPM	National Environment Protection (Assessment of Site Contamination) Measure as revised 2013
NHMRC	National Health & Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
OEH	Office of Environment & Heritage of NSW
PAH	Polycyclic Aromatic Hydrocarbon
PASS	Potential Acid Sulfate Soils
PID	Photoionisation Detector
ppmv	parts per million by volume

PSH	Phase Separated Hydrocarbons
QA, QC	Quality Assurance, Quality Control
RAP	Remedial Action Plan
RB	Rinsate Blank
RPD	Relative Percent Difference
SAQP	Sampling Analysis & Quality Plan
SCEC	Sydney Convention and Exhibition Centre
SCr	Chromium Reducible Sulfur (S_{CR})
SEC	Sydney Entertainment Centre
SEPP	State Environmental Protection Policy
SHFA	Sydney Harbour Foreshore Authority
SICEEP	Sydney International Conference Exhibition and Entertainment Precinct
SOP	Standard Operating Procedures
SVOC	Semi Volatile Organic Compound
SWL	Static Water Level
TB	Trip Blank
TCLP	Toxicity Characteristic Leaching Procedure
TPH	Total Petroleum Hydrocarbon
TRH	Total Recoverable Hydrocarbon
TS	Trip Spike
VENM	Virgin Excavated Natural Material
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

Darling Harbour Live is seeking development consent to redevelop the site for a mixture of residential and commercial uses with associated public realm comprising managed landscaped and paved areas.

Coffey prepared this RAP to be consistent with EPA reporting guidelines and to address issues for consideration listed in Section 3.5.4 of the Managing Contaminated Land: Planning Guidelines SEPP 55 – Remediation of Land (DUAP/EPA 1998).

The site is located within the Haymarket district of Sydney's Central Business District and comprises the SEC, associated car park and surrounding public realm. The site covers an area of approximately 3.8ha and is bound by Pier Street to the north, Hay Street to the south, a light rail corridor to the west and Harbour Street to the east. The boundaries of the site are defined by the survey drawing prepared by Rygate Surveyors provided in Appendix B.

The site historically formed a part of Long Cove (i.e. currently known as Cockle Bay), with much of the site being used as a mill pond to support the Dixon Steam Mill complex which was established in 1813 immediately north of the site. The site was gradually reclaimed over a period of approximately 40years using materials dredged from Sydney Harbour or from excavations associated with the construction of the Sydney Rail Terminus. The historic land uses of the site indicates that following reclamation in c.1865, the site was used for a variety of storage uses associated with wharves and Darling Harbour Goods Yard located further to the north. The site was used as a city market, council depot and rail corridor between 1930 and 1980 prior to being redeveloped for the SEC and associated car park.

The Dixon Steam Mill complex operated to the north of the site between 1813 and c.1910 and included steam engine, brewery, soap works, a salting works and manufacture and bottling of soda water. A galvanising works was established within the mill complex in 1860 to the north of the site (i.e. at the intersection of Pier and Harbour Street, and to the north of Factory Street), which operated in the area until c.1910. Land to the north of the site operated as a railway siding and goods yard during this period.

The Ultimo Power Station was established to the immediate west of the site in 1899 and remained operational until the 1960s before being redeveloped as a museum. Records indicate that the site did not form part of the power station however a number of abandoned intake conduits reportedly passed under the northwestern part of the site.

In summary, four site investigation programmes were undertaken by Coffey between June 2011 and January 2013 across the SICEEP and a review was undertaken of results relevant to the site in the context of the site redevelopment proposals. The investigations identified soils and groundwater within the site which reported concentrations exceeding generic assessment criteria. A Human Health and Ecological Risk Assessment (HHERA) was subsequently commissioned to assess the potential health and ecological risks in the context of the proposed development.

Based on the results of the HHERA, two localised areas of soil contamination in the area proposed for development have been identified within fill materials that present potentially unacceptable health risks to future site occupants. No unacceptable ecological risks associated with groundwater have been identified within the site. The RAP presents an approach to remediate and validate these areas of soil contamination and thereby mitigate the unacceptable risks identified.

If the remediation is carried out in accordance with this RAP, Coffey concludes the site can be made suitable for the proposed development comprising a mixture of uses, including commercial, high-rise residential and landscaped/paved public open space as described in Section 1.6.

1 INTRODUCTION

1.1 General

Coffey Environments Australia Pty Ltd (Coffey) was commissioned by Lend Lease Development (LLD) to prepare a detailed Remedial Action Plan (RAP) for the redevelopment of The Haymarket (herein referred to as the 'site') for a mixture of commercial and residential uses. This commission was in response to the Coffey proposal dated 5th April 2013 (ref: ENAURHOD04498AB-P06).

1.2 Background

Darling Harbour Live (formerly known as 'Destination Sydney'- a consortium comprising AEG Ogden, Lend Lease, Capella Capital and Spotless) was announced by the NSW Government in December 2012 as the preferred proponent to transform Darling Harbour and create the new Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP).

The SICEEP Site has been divided into three distinct redevelopment areas – Bayside, Darling Central and The Haymarket. This document relates to The Haymarket as shown in the figure below.

Figure 1.1: Overview illustrating the location of The Haymarket relative to other areas within SICEEP

Darling Harbour Live is seeking to lodge a series of Development Applications to redevelop the site. It is proposed to remediate the site pursuant to these development applications. This detailed Remedial Action Plan supports State Significant Development Applications lodged for the redevelopment of the site for a mixture of commercial, public open space and residential uses. It is contemplated the site is to be redeveloped in stages, as detailed within Appendix E.

1.3 Objective

The objective of the RAP is to:

- Establish remediation goals for the site that will ensure that the remediated site will pose no unacceptable health or environmental risk under the proposed uses of the site.
- Establish remediation goals for the site that will ensure that the remediated site will pose no unacceptable health or environmental risk to construction workers during the remediation works and subsequent construction activities associated with the development.
- Evaluate remediation options to address identified areas of contamination, and justify selection of a preferred remedial option.
- Develop an overarching remediation strategy around the preferred remedial option to mitigate the potential contamination risks at the site to allow it to be made suitable for the proposed mixed use development.
- Establish procedures and activities that are required for validating remediation works.
- Outline requirements for a site management plan to be implemented during the remediation works.
- Outline the regulatory compliance requirements for remediation works.

Because the report(s) on contamination investigation for the site previously undertaken by Coffey for the Sydney Harbour Foreshore Authority (SHFA) and Infrastructure NSW (INSW) did not include interpretation of the results and assess the extent of remediation in the context of the redevelopment scheme proposed by LLD, the RAP will also:

- Provide a summary of the investigations carried out to date and assess whether these investigations are sufficient to adequately characterise the site.
- Interpret investigation results relevant to the site in the context of the proposed development and identify areas of soil and groundwater contamination which have the potential to pose a risk to human health and surrounding environmental receptors.
- Develop contingency plans to manage unexpected finds that may be encountered during the redevelopment of the site.

1.4 Site Definition

LLD commissioned a detailed survey by Rygate Surveyors to define the boundaries of the site in the context of existing and proposed land parcels. The survey information is presented in Rygate Surveyors drawings:

- Drawing No. 76098_1 “Showing Proposed Lot Dimensions, Haymarket Remediation” (dated 18 November 2013).

- Drawing No. 76098_2 “Showing Proposed Lot Dimensions, Proposed SICEEP Haymarket Boundary and Existing Title Locations, Haymarket Remediation” (dated 18 November 2013).
- Drawing No. 76098_3 “Showing Proposed Lot Dimensions, Proposed SICEEP Haymarket Boundary and Existing Title Locations, Haymarket Remediation” (dated 18 November 2013).
- Drawing No. 76098_4 “Showing Proposed Lot Dimensions, Proposed SICEEP Haymarket Boundary and Existing Title Locations, Haymarket Remediation” (dated 18 November 2013).

1.5 Current Land Use

The site is located within the Haymarket district of Sydney’s Central Business District and comprises the Sydney Entertainment Centre (SEC), associated car park and surrounding public realm. The location and extent of the site is shown in Figures 1 and 2 respectively.

1.6 Proposed Land Uses

Coffey was provided with the following documents that formed the basis of LLD’s Stage 1 Development Application for The Haymarket and which generally describe the proposed development on the site:

- Destination Sydney Drawing No. MCD AR D101 ‘Architectural Concept Design – Ground Level Plan’(Rev. F; dated 21st February 2013)
- Destination Sydney Drawing No. MCD AR D102 ‘Architectural Concept Design – Podium Level Plan’(Rev. D; dated 21st February 2013)
- Destination Sydney Drawing No. MCD AR D103 ‘Architectural Concept Design – Typical Towers Plan’(Rev. B; dated 21st February 2013)
- Destination Sydney Drawing No. MCD AR D104 ‘Architectural Concept Design – Roof Level Plan’(Rev. E; dated 21st February 2013)
- Destination Sydney Drawing No. MCD AR SS110 ‘Architectural Concept Design – Section AA’(Rev. B; dated 18th February 2013)
- Destination Sydney Drawing No. MCD AR SS111 ‘Architectural Concept Design – Section BB’(Rev. B; dated 21st February 2013)
- Destination Sydney Drawing No. MCD AR SS112 ‘Architectural Concept Design – Section CC’ (Rev. B; dated 18th February 2013)

The above listed drawings are provided in Appendix A.

With reference to the above drawings, the proposed development on the site comprises:

- Residential (with minimum access to soil), retail and commercial premises at ground level with associated public realm comprising managed landscaped and paved areas.
- A realignment of Darling Drive to provide space for residential (including student) accommodation in two multi-storey buildings along the western edge of the site. Destination Sydney Drawing No. MCD AR D101shows that habitable residential accommodation will be provided within the upper floors, with lobby and service functions provided at ground floor.

- Car parking, commercial premises, residential accommodation (including private open space above the podium car parking), child day-care centre and retail premises above ground level.
- Areas of bio swales commensurate with the principles of water sensitive urban design.
- No basement structures are currently proposed.

The footprints of the proposed buildings, including an outline of the tower forms over podium deck, are shown in Figure 2.

1.7 Available Contamination Assessments

Information from the following reports was used to prepare this RAP:

- Coffey Geotechnics (July 2011); *Environmental Desk Study: Proposed Sydney International Convention and Entertainment Centre, Darling Harbour* prepared for SHFA.
- Coffey Geotechnics (August 2011a for SHFA) *Geotechnical Investigation Report: Proposed Sydney International Convention and Entertainment Centre, Darling Harbour* prepared for SHFA.
- Coffey Geotechnics (August 2011b); *Contamination Investigation, Sydney International Convention and Entertainment Centre* prepared for SHFA.
- Coffey Geotechnics (May 2012); *Geotechnical Investigation Report: Proposed Sydney International Convention Exhibition and Entertainment Precinct (SICEEP), Darling Harbour, Sydney* prepared for INSW.
- Coffey Geotechnics (June 2012a for INSW); *Stage 1 – Preliminary Environmental Investigation, Sydney International Conference Exhibition and Entertainment Precinct (SICEEP), Darling Harbour, Sydney* prepared for INSW.
- Coffey Geotechnics (June 2012b); *Stage 2 – Detailed Site Investigation: Sydney International Convention Exhibition and Entertainment Precinct (SICEEP), Darling Harbour, Sydney* prepared for INSW.
- Coffey Geotechnics (August 2012); *Supplementary Site Investigation: Sydney International Convention Exhibition and Entertainment Precinct (SICEEP), Darling Harbour, Sydney* prepared for INSW.
- Coffey Geotechnics (January 2013); *Supplementary Site Investigation: Factual Report, Sydney International Convention Exhibition and Entertainment Precinct (SICEEP), Darling Harbour* prepared for INSW.
- Coffey Environments (February, 2013); *Site Investigation Factual Report: Haymarket Precinct, Darling Harbour, Sydney, NSW* prepared for INSW.
- Coffey Environments (March 2013); *Overarching Remedial Action Plan: Haymarket Precinct, Darling Harbour, Sydney, NSW* prepared for LLD.
- EnRiskS (15 November 2013); *Site Specific Human Health & Ecological Risk Assessment – The Haymarket* (Rev. F - Final Site Specific HHERA for The Haymarket Planning Applications)

2 SITE IDENTIFICATION & SETTING

2.1 Site Location

The site is located within the Haymarket district of Sydney's Central Business District and comprises the Sydney Entertainment Centre (SEC), associated car park and surrounding public realm. The location of the site is shown in Figure 1

Based on the detailed site survey, the site comprises of the following existing parcels of land:

Locality: Haymarket

Local Government Area: City of Sydney

Parish: St Andrew

County: Cumberland:

- Lot 1 DP827982
- Part Lot 205 DP771841
- Part Lot 210 DP771841
- Part Lot 200 DP1165804
- Lot 201 DP1165804
- Part Lot 1 DP 612907
- Part Lot 2 DP 612907
- Lot 2 DP827982
- Part Lot 800 DP1164281
- Part Lot 33 DP870306
- Part Lot 2 DP 868663
- Part Lot 1 DP 812344
- Lot 503 DP812423

Based on the draft plan of subdivision the site comprises of the following draft proposed parcels of land.

- Lots 114 to 132 Inclusive D.P (Pre-existing Plan Number (PPN) or as nominated by LPI)

The final proposed parcels will be subject to the sequence of, and registration of plans of subdivision.

Detailed survey drawings prepared by Rygate Surveyors for LLD are provided in Appendix B.

2.2 Site Description

The site occupies an area of approximately 3.8ha and is generally bound by Pier Street and the off-ramp linking Pier Street and Darling Drive to the north. Hay Street forms the southern boundary to the site. The light rail corridor forms the west and Harbour Street to the east. In general, the topography of the site is relatively level. The site layout provided in Figure 2. The co-ordinates of the site boundary are summarised on the plans prepared by Rygate Surveyors presented in Appendix B.

The SEC covers the eastern part of the site and comprises a multi-storey building used principally for concerts, sporting and community events. A variety of restaurants, bars and administration/offices exist in areas surrounding a central performance arena. Two loading docks exist along the western façade of the building. Coffey understand that no significant basement structures exist within the SEC.

The SEC multi-storey car park is situated in the western portion of the site. A coach parking area is also established at ground level along the western façade of the car park.

The area between these two structures comprises a secure loading dock for the SEC. A portable cabin used by security staff is located on the north boundary of the loading dock area.

The public realm surrounding the SEC and adjoining car park comprises predominantly concrete, asphalt and brick paved footpaths. Various landscaped areas exist within the site where mature trees are present, having been introduced with construction of the SEC in the late 1980s.

An elevated monorail track formerly crossed the south eastern corner of the site and continued parallel to the southern boundary of the site.

A narrow landscaped verge exists to the west of Darling Drive, extending along the western site boundary. This verge slopes up from kerbside to approximately 1 to 2m above the road surface.

The north western boundary of the site is formed by Pier Street and the off-ramp linking Pier Street and Darling Drive. The north eastern site boundary is formed by the public realm just south of Little Pier Street.

2.3 Surrounding Land Uses

The land uses surrounding the site include:

Table 2.1: Summary of Land Uses Surrounding the Site

North	• Sydney Conference and Exhibition Centre (SCEC), Tumbalong Park and surrounding Darling Harbour public realm exist to the north/northwest. • The Novotel Rockford Hotel is located immediately north of Little Pier Street at the eastern part of the site, beyond which lies the Sydney Chinese Garden of Friendship.
South	• Immediately south lies the light rail corridor. • Paddy's Markets and UTS Library are located further south beyond the light rail corridor.
East	• Harbour Street and a variety of restaurants and hotels beyond.
West	• The light rail corridor and the Powerhouse Museum beyond.

2.4 Geology

Published geological records indicate the fill material overlies Quaternary-aged alluvium, which comprises gravel, sand, silt and clay deposits.

Fill materials comprised heterogeneous mixtures of gravelly sand, sandy gravel, gravelly clay, clay and sandy clay/silt. The thickness of fill materials recorded at the site varied between 0.4mbgs and 5.0mbgs. Anthropogenic inclusions observed within the fill included discrete ash layers, concrete, brick, glass, porcelain/ceramic, and metal fragments. A fibrous board was also recorded in one location (BH119).

Previous investigations (Coffey; August 2011b, June 2012b, August 2012) reported the presence of potential acid sulfate soils (PASS) and actual acid sulfate soils (ASS) within natural alluvial deposits. The alluvial deposits are underlain by residual soil and rock of Triassic-aged Hawkesbury Sandstone Formation which comprises sandstone, quartz and shale.

Sandstone bedrock beneath the SEC is intersected by the Great Sydney Dyke, which comprises a dolerite intrusion through the sandstone. The dyke is oriented southeast-northwest through the southern part of the site (Coffey, August 2011a). Site-specific geology is summarised in Table 2.2.

Table 2.2: Site-Specific Geology

Material / Origin	Top of Unit (mbgs)	Thickness of Unit (m)	Material Description
Fill	0	0.4 to 5.0	Fill materials were encountered across the site under surface covering typically comprising reinforced concrete, asphalt or brick paving of approx. 0.1m to 0.3m thick. Fill materials comprised heterogeneous mixtures of sand, gravel, clay and silt. Cobbles and boulders of sandstone were also encountered in several boreholes. Anthropogenic inclusions observed within the fill included discrete ash layers, bonded asbestos containing material (ACM) (BH119 only), concrete, brick, glass, porcelain/ceramic, and metal fragments. A number of in-ground obstructions were also encountered. Fill thicknesses typically ranged between 2m to 4m although thicker fill deposits were recorded along the western edge of the SEC car park (NBH25; BH4, BH1) and central area of the site associated with the reclamation of the low lying land at the southern end of Cockle Bay. Thinner fill was encountered in boreholes along the western façade of the SEC although reliability of reported fill thickness in this area is uncertain due to the presence of obstructions.

Material / Origin	Top of Unit (mbgs)	Thickness of Unit (m)	Material Description
Alluvium	2.1 to 4.5	1.3 to 12 (Where encountered)	Alluvium comprised clayey sands and clays with occasional shell layers and natural organic matter. Previous investigations (Coffey; August 2011b, June 2012b, August 2012) have reported the presence of PASS and ASS. Alluvial deposits were thickest within the central part of the site (i.e. BH5, BH6, BH7) with these deposits typically thinning to the east and west of the site.
Residual Soil	5.8 to 10.8	0.6 to 2.9 (Where encountered)	Previous investigations recorded residual soils comprising of Sand, clayey sand or sandy clay (Coffey; August 2011b, June 2012b, August 2012, January 2013).
Weathered Sandstone	5.6 to 15.8	0.1 to >4.0	Sandstone encountered during previous investigations (Coffey, August 2011b, June 2012b) comprised weathered, fine to medium grained orange, pale grey, brown sand or clayey sand.

2.5 Hydrogeology

Recent ground investigations (Coffey, January 2013) reported groundwater strikes at depths between 2.4mbgs (BH120) to 3.0mbgs (BH118, BH127) which generally coincided with the upper alluvial deposits. Coffey (August 2011) reported that groundwater flows in a northerly direction towards Cockle Bay.

A review of the New South Wales Natural Resource Atlas[1] indicated that no registered groundwater bores are located within a 500m radius of the site (Coffey 2012a).

Standing groundwater levels were measured in MW120 continually between 10 and 14 January 2013 using a data logger to assess a possible influence from tidal fluctuations in Cockle Bay (Coffey, January 2013). Groundwater levels measured over this 5 day period ranged between 0.751mAHD and 0.788mAHD. The observed period of variation was between one and several days, which suggests that tidal fluctuations in Cockle Bay have negligible influence on groundwater levels within the site.

[1] Available: http://nratlas.nsw.gov.au

2.6 Hydrology

No water bodies are located within the site. Cockle Bay is the nearest surface water feature and is located approximately 475m to the north.

Coffey (June 2012b) notes that several artificial water features are present within the SICEEP and surrounding areas (e.g. Sydney Chinese Garden of Friendship site). Coffey understands these water bodies are hydraulically separated from the underlying groundwater.

3 SITE HISTORY

3.1 Summary of Historical Uses of the Site

A detailed appraisal of the historical uses of the site is presented within the Environmental Desk Study report (Coffey, July 2011). This information has been supplemented from the following additional sources of information that have been prepared in support of the DA for the redevelopment of the SICEEP:

- Tanner Kibble Denton Architects (Feb 2013); Statement of Heritage Impact - Sydney International Convention Centre, Exhibition & Entertainment Precinct (SICEEP), Darling Harbour.
- Casey & Lowe (March 2013); Non-Indigenous Archaeological Assessment and Impact Statement for SSDA1; Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP).

Reference has also been made to the following additional information in collating the appraisal of historic site uses:

- Godden Mackay Pty Ltd (Aug 1991); Little Pier St Precinct Archaeological Assessment.
- Sydney Harbour Foreshore Authority; Heritage and Conservation Register for Pier St Precinct published by the Sydney Harbour Foreshore Authority[2].

Table 3.1 presents a summary of historical uses of the site and surrounding land.

Table 3.1: Chronological summary of historical site uses

Period	Description of Land Uses
1794/95	The first grants of land on the western side of Cockle Bay were made to John Malone, William Mitchell and Thomas Jones in 1794 and 1795 (TKD, Feb 2013). Land uses at this time are not specified.
1802	Early map extract of Sydney Town indicates the site forms part of Long Cove, with various creeks and watercourses feeding into wetlands. (Source: Plan de la Ville de Sydney; published 1802). No development is indicated in the vicinity of the site.
1803/04	John Harris was granted land which appears to encompass the site. In 1804, Mr Harris establishes residential dwellings in Ultimo near to the site. C&L (Mar 2013) note that Mr Harris leased parts of his estate at this time and these areas were noted as 'gardens'. At this time, up to 18 residential dwellings were established on the eastern shore of Cockle Bay.

[2] Available: http://www.shfa.nsw.gov.au/sydney-About_us-Our_heritage_role-Heritage_and_Conservation_Register.htm&objectid=160)

Period	Description of Land Uses
1807	Cockle Bay was reportedly used to accommodate an overflow of shipping from Sydney Cove with 'tidal mudflats extending to George Street (east) and Ultimo Road (south), which suggests the site remained partially or entirely submerged at this time.
1813	Dixon[3] Steam Mill established within the Pier Street Precinct; namely an area between the current Little Pier and Pier Streets to the north of the site (SHFA). It remains uncertain whether the footprint of the mill extended beneath the site at this time. The mill was reportedly used for milling grains such as wheat and corn. A reservoir was established in an area to the south of the mill to provide a source of freshwater for the mill. Based on available map extracts (C&L Mar 2013; TKD Feb 2013), the freshwater pond (referred to as 'Dixons Pond') appears to encompass the majority of the site and extends to George Street (east) and Hay Street (south). Western parts of the site are reportedly mudflats (C&L, Mar 2013), and no development is indicated at this time.
1820-30s 1826/27	Dixon Steam Mill diversifies into brewing and soap manufacture. An additional steam engine is added to the mill and the brewery was established on 'adjacent ground' though there is some uncertainty where the brewery was established relative to the site. The Dixon Steam Mill site was also used as a general store advertising a variety of goods including ham, salted beef, tobacco, china and fabric by 1821 (C&L, Mar 2013). Figure 3 shows the extent of the Dixon Mill complex in 1828, which indicates that the mill was partly on the northeastern part of the site. The southern part of the site comprises the mill pond and reservoir. The remainder of the site remains part of the Dixon Ponds and/or undeveloped mudflats. Reclamation of Cockle Bay shoreline commenced in 1826/27. The material used for reclamation comprised 'sand and silt ….. obtained by dredging in various parts of the harbour, the material being deposited where possible'. The location and extent of reclamation completed at this time is not reported.
1830-40s	The Dixon estate included 'Old' and 'New' steam engines, wharf, dam wall, salting company, three store buildings or rooms, a dwelling and gardens. The sale of items from the estate also indicates that Dixon may have also operated a timber saw mill in this area (C&L, Mar 2013). Map extracts presented in TKD (Feb 2013) indicate that land to the west of the Dixon Steam Mill remained submerged as part of Cockle Bay in 1836, suggesting that

[3] Dixon appears as both 'Dickson' and 'Dixon' within the variety of historical records reviewed. Coffey have adopted Dixon throughout this report.

Period	Description of Land Uses
	reclamation activities had not fully encroached the remainder of the site at this time. It remains uncertain whether development of the western part of the site (i.e. the western foreshore of Cockle Bay) had commenced at this time.
1840-60s	The Dixon Estate was leased to several tenants and used for various purposes including storage, and manufacture and bottling of soda water. C&L (Mar 2013) report that reclamation of the foreshore surrounding the mill site occurred in 1849 although the Dixon wharf appears still operational indicating that much of the site remained submerged at this time. It is also noted that a salting company operates adjacent to the steam mill. During the early 1850s, the Dixon wharf is reconfigured with the new structure indicating that localised reclamation at the north of the site may not have occurred. It is not known whether the structure was built on fill in the style of a breakwater or a timber jetty built on piles over the water (C&L; Mar 2013). Map extracts from 1853 indicate the southeastern extent of the freshwater pond had been filled, which is likely to include the southeastern area of the site. Four structures are also established within smaller subdivided lots along the foreshore of the freshwater lake (Source: Surveyor General's Sketchbooks SRNSW Vol. 6 Fol. 70.71; dated 1853). The use of these structures is not stated. A railway line was constructed along the western foreshore of Cockle Bay linking the harbour to Sydney Railway Terminus (Redfern) in 1855. TKD (Feb 2013) report that fill resulting from excavation to form the Sydney Railway Terminus and associated yards was used to reclaim land. C&L (Mar 2013) report that the reclamation had subsumed Dixon's Wharf and millpond site by 1865. TKD (Feb 2013) indicate that industrial activity in the locality diversified around 1860 when Simon Zollner set up a galvanising works in part of Dixon's Mill.
1870s	Figure 4 shows a map extract from 1870 show the area to the south of Pier Street (which currently comprises the SEC and adjoining car park), to comprise numerous subdivided areas. Hay Street appears to traverse diagonally through the western part of the site. The eastern part of the site is intersected by Belmore Street, Factory Street, Darling Street and several narrow lanes. The Zollner galvanising works is established at the intersection of Pier and Harbour Street, and to the north of Factory Street. It is assessed that the southern edge of this factory is located to immediately adjacent to the northeastern site boundary. Land to the north of Pier Street is annotated as 'Reserved for Railway Purposes'. This land was later developed as Iron Wharf which connected with the Darling Harbour Goods Yard (est. 1874) within the northern part of the current SICEEP.
1880-90s	Expansion of Darling Harbour Goods Yard occurred during this period, which included a refrigerated meat market to the northwest of the site, Fresh Frozen Food and Ice Company established to the northwest (i.e. where Chinese Gardens are established),

Period	Description of Land Uses
	and Goldsbrough Mort's large woolstore (Pyrmont Street). Livestock was also brought to Darling Harbour by rail for export. TKD (Feb 2013) indicate that animal pens were established within the site and extended to Thomas Street (south of Hay Street). TKD (Feb 2013) note that the main slaughterhouse/abattoir was located in Glebe and meat market located to the north of the Darling Harbour Goods Yards. Sydney's first hydraulic pumping station was established to the north of the site in 1891. The Ultimo Power House was built in 1898-99 immediately west of the site. Records reviewed for the Power Station indicate that the water intake, outtake and ash disposal conduits pass under the existing Sydney Convention and Exhibition Centre to the north of the site.
1900-10	Figure 5 presents a map extract from 1903 which shows the site is developed with numerous structures. TKD (Feb 2013) indicate significant expansion of the railway and associated infrastructure occurred between 1903 and 1908 where a wheat store and coal handling plant were established within close proximity to the site. Godden Mackay (Aug 1991) indicate that the site was mostly used storage at this time. A Salvation Army shelter was established to the south of Pier Street. Figure 5 indicates that railway sidings were established immediately north of the site and Pier Street. The Zollner Galvanising Works appear to have expanded with an additional structure now present parallel with Factory Lane to the north of the site. The Ultimo Power Station and associated railway sidings are shown to the west of the site.
1910-40s	Decline of wharf operations as Darling Harbour south of Pyrmont Bridge was becoming too shallow for large vessels. Iron Wharf demolished during the 1920s. The 1930 aerial photographs (Figure 6) indicate the site is dissected by several roadways and is covered by various buildings and structures that appear to be commercial/industrial in nature. Rail yards, including railway sidings, are present to the immediate north/northwest of the site beyond Pier Street. A railway line is present to the immediate west of the site adjacent to the Ultimo Power Station. A large warehouse, or similar, of unknown purpose is present to the immediate south beyond Hay Street. Godden Mackay (Aug 1991) indicate a Council Depot was established in the northwestern part of the site in 1932. During the 1930s a new Vegetable Market building was erected on the site of the SEC. An Inward Goods Building was constructed circa 1943 (TKD, Feb 2013) although it is unclear from this report where this structure was established in relation to the current site boundary.
1949	City Markets No. 4 was established within the site in 1949 (Godden Mackay, Aug 1991).
1950-80s	The site remains in use as a market place until the early 1980s when the SEC was established in 1983. Ultimo Power Station decommissioned in 1963 and converted to a museum in early 1980s. Aerial photographs for the period (refer Figures 7 and 10) indicate the rail yards

Period	Description of Land Uses
	located to the north/northwest of the site until the early 1980s, and where later decommissioned as part of the redevelopment of Darling Harbour for the bicentennial celebrations in 1988. This included the existing Sydney Convention and Exhibition Centre, Tumbalong Park and Chinese Gardens.
1990s	Aerial photograph (Figure 11) indicates that no significant change to site features is noted. The Market City building and University of Technology campus were constructed to the south of the site beyond Hay Street. The Novotel Rockford Hotel is established to the northeast of the site in 1999. The hydraulic pumping station (the 'Pumphouse') structure remains and has been converted to a restaurant and bar. The Powerhouse Museum is established in the former Ultimo Power Station structure. The monorail is visible to the south of the SEC and car park.
2000 - Present	With the exception of the removal of the Sydney Monorail elevated track in the second half of 2013, no other significant changes have occurred to land uses within or immediately surrounding the site during this period.

3.2 Dangerous Goods Search

Stored chemical information database (SCID) records held by NSW WorkCover were obtained and reviewed as part of the environmental desk studies prepared for the site (Coffey; July 2011, June 2012a). The NSW WorkCover records indicated no registration for the storage and/or use of dangerous goods at the site.

Coffey (2012a) identified three licences associated with the storage of dangerous goods within the Sydney Convention and Exhibition Centre (SCEC) to the north of the site. These licences are for storage of compressed gases. Coffey considers that these dangerous goods do not pose a source of potential contamination in soil or groundwater.

3.3 Contaminated Land Register

A review of the NSW Office of Environment and Heritage Contaminated Land Record[4] indicated that the site and immediately surrounding area are not subject to any notices under the Contaminated Land Management Act 1997.

[4] Available: http://npws.nsw.gov.au/prclmapp/searchregister.aspx

4 AREAS OF ENVIRONMENTAL CONCERN AND CONTAMINANTS OF POTENTIAL CONCERN

4.1 Areas of Environmental Concern

From a review of available historical information presented in Section 3 the following Areas of Environmental Concern (AEC) have been identified on site. Figure 12 illustrates the approximate extent of the AEC identified.

- The natural alluvial deposits may contain ASS.
- The Dixon Steam Mill was established to the northeast of the site between Little Pier Street and Pier Street. By 1828, records indicate that the mill encroached on the northeastern boundary of the site. The southern part of the site comprised a mill pond. The mill complex was reportedly used for grain milling although expanded into other uses including bottling soda water, brewing, soap manufacture and salting. Ash from coal fired boilers on this site represents a potential source contamination although at the time the mill was operational, the site was submerged as part of the mill pond or Cockle Bay. Furthermore, as water within the mill pond was the source of freshwater used within the mill complex, it is likely that wastes and other discharges from the complex were disposed to the seaward side of the reservoir, and hence it is considered unlikely that ash from the mill was a significant source of contamination within the site whilst the mill was operational. The mill was decommissioned as the mill pond was reclaimed and therefore materials from the steam mill (including ash from the boilers being decommissioned) may have been a local source of fill material used to reclaim land locally. Ash from the steam mill is likely to comprise a source of Polycyclic Aromatic Hydrocarbons (PAH) and heavy metals.
- Fill materials were used to reclaim Cockle Bay. Historic records indicate this fill derives from two primary sources; namely, dredging spoil from unknown areas of Sydney Harbour, and excavations to form the Sydney Railway Terminus and associated yards. C&L (Mar 2013) also note that 'private reclamations occurred in a frequently piecemeal manner and are difficult to document. The granting of reclaimed land often occurred a long time after it had taken place.' In summary, records indicate that the reclamation of Cockle Bay appears to have occurred over some 40years from 1826 to 1865. Coffey considers that fill materials may contain elevated levels of heavy metals, organic compounds and PASS[5]. Given the period that reclamation activities occurred, and the different sources of fill materials, contamination associated with fill material is anticipated to be randomly distributed.
- Records indicate that following the reclamation of mill pond and Cockle Bay, animal pens were established within the site during the 1880s. These records suggest that the site was used to store animals temporarily prior to transportation. These historic uses have the potential to generate a source of organic animal wastes which may build up within the soils. These wastes can cause a build of nitrate and ammonia within the soil although given the nature of these contaminants, that it has been approximately 130years since this land use occurred within the site and the

[5] Given that potential ASS is likely to have oxidised prior to placement on-site, the likelihood of ASS in fill soils is considered to be low.

redevelopment of the site during the 1930s and subsequently 1980s, Coffey considers that contaminants associated with animal waste residues pose a very low environmental risk.

- By 1900, much of the site had been developed. Records indicate that many of the structures present within the site were used for storage purposes associated with the rail yards to the north of the site. Reportedly, a number of these warehouses were used to store wheat and coal but are likely to also have stored other materials. Records indicate that the footprint of Darling Drive historically comprised part of the rail corridor linking the Sydney Terminus with the Darling Harbour Goods Yards to the north of the site. Contaminants typically associated with these uses comprise heavy metals, fuels/oils, solvents and forms of asbestos (classified as bonded ACM, fibrous asbestos and asbestos fines).
- The site was largely in use as a Council Depot and market place from 1930s to 1980s. The COPC associated with these broad land uses vary according to the types of activities carried out and goods stored within a particular part of the site. No detailed records are available to provide further information regarding these activities but may comprise various heavy metals, solvents, fuels and oils. Weathering, periodic alteration and/or demolition of these structures may also have released hazardous materials into the ground including asbestos containing materials (bonded ACM and asbestos fines), lead and zinc.
- The site was redeveloped in the 1980s as the SEC and a car park, and has remains substantially unchanged until the present. No point sources of potential contamination likely to pose an unacceptable environmental risk have been identified.

The following AEC have been identified off site adjacent to the site:

- A hydraulic pumping station was established to the north of the site in 1891. Any ash from the coal-fired pumps disposed as fill material on the site comprises a potential source of PAH and heavy metal contamination.
- The Zollner galvanising works was located immediately north of the site. Galvanising process adopted in 1890 is likely to have comprised covering iron in molten zinc (known as hot dipping), or galvanic-paint[6]. Certain caustic and acidic solutions may have been used to clean and preparing iron in advance of zinc coating. It is assessed that this former land use has the potential to represent a source of heavy metal contamination. Other potential COPC from this historic land use may also include zinc chloride (used as a flux in the galvanising process), ash from coal-fired boilers, and may also include other constituents including oils, greases and solvents associated with the maintenance of the plant.
- Records indicate that a railway siding and large storage shed encroached onto the central northern part of the site in the early 1900s. Contaminants typically associated with these uses comprise heavy metals, fuels and oils and forms of asbestos.

[6] These processes were used at the precursor to modern ‘electro-galvanising’ or ‘hot-dip’ galvanisation processes used today.

- The former Ultimo Power Station was established immediately west of the site in 1898 and operated as a coal-fired power station until 1963 when it was decommissioned. Coal was delivered to the power station via the rail corridor which forms the western boundary to the site. Given the developed nature of the site during this period, it is considered unlikely that ash from the power station was placed within the site in large quantities. Records indicate that ash from the power station was disposed via an underground conduit to a barge in Cockle Bay (C&L; Mar 2013). During operation, it is considered likely that the power station stored various quantities of fuel oils and chemicals associated with maintaining and cleaning the turbines and boilers. Accidental spillages/leaks may have occurred during the operation of the power station which may have given rise to contamination which could affect the site. COPC associated with the power station may include TPH, PAH, heavy metals, solvents and bonded ACM and asbestos fines.

4.2 Contaminants of Potential Concern

In summary, the following COPC were identified and considered when analysing soil and/or groundwater samples collected during investigations carried out in four separate phases by Coffey between June 2011 and January 2013:

a) Heavy metals including Arsenic, Cadmium, Copper, Chromium, Mercury, Nickel, Lead and Zinc.

b) Total petroleum hydrocarbons (TPH)

c) Benzene, toluene, ethylbenzene, xylene (BTEX)

d) Polycyclic aromatic hydrocarbons (PAH)

e) Volatile organic compounds (VOC)

f) Semi volatile organic compounds (SVOC)

g) Asbestos in soil (as bonded ACM, fibrous asbestos and asbestos fines)[7]

h) Acid sulfate soil

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[7] Terminology adopted within this document in relation to asbestos is adopted from Section 4.4 in Schedule B1 of NEPC (1999). That is:

Bonded Asbestos Containing Material (Bonded ACM) comprises asbestos containing material which is in sound condition where asbestos is bound in a matrix (e.g. cement, resin etc.).

Fibrous Asbestos (FA) comprises friable asbestos material including severely weathered cement sheet, insulation products, woven asbestos material etc. that can be broken or crumbled by hand pressure.

Asbestos Fines (AF) comprises free fibres, small fibre bundles and small fragments of ACM that pass through a 7mm x 7mm sieve.

5 SUMMARY OF PREVIOUS INVESTIGATIONS

5.1 General

Four site investigation programmes were undertaken by Coffey between June 2011 and January 2013. These site investigation programmes were undertaken by Coffey under engagement of both SHFA and INSW. Results from these investigations, without interpretation, have been collated into the following report under engagement of LLD:

- Coffey Environments (February, 2013); *Site Investigation Factual Report: Haymarket Precinct, Darling Harbour, Sydney, NSW* prepared for LLD.

The above report presents factual information from these investigations, a summary of investigation and sampling methods used and a summary of laboratory data relevant to the site.

It is noted that the above report considers a slightly different site boundary to that presented herein. This has resulted in several investigation positions falling slightly outside the current investigation boundary; namely NBH24, CBH/MW6, CBH/MW9, CBH10 and BH118. However Coffey considers that these positions are still relevant for the purpose of this RAP.

The following section provides a general overview of the scope of these four investigation programmes. A detailed description of the investigation and sampling methods used during these investigations is provided within the individual reports as listed in Section 1.7.

5.2 Scope of Investigation Completed

The following investigation works have been completed within the site:

- Intrusive investigation of the subsurface including observation, logging and collection of soil samples for characterisation and quality control from 45 boreholes within the site boundary. Soil logging and sampling was undertaken by suitably qualified and experienced environmental professionals in accordance with Coffey's Standard Operating Practices (SOP), which are based on relevant Australian standards and good industry practice. Borehole logs are presented in Appendix C.
- Analysis of selected soil samples from each borehole for selected COPC from:
  a) Heavy metals (Arsenic, Cadmium, Copper, Chromium, Mercury, Nickel, Lead and Zinc)
  b) Total petroleum hydrocarbons (TPH),
  c) Polycyclic aromatic hydrocarbons (PAH),
  d) Benzene, toluene, ethylbenzene and total xylene (BTEX),
  e) Volatile and Semi-volatile organic compounds (VOC / SVOC), and
  f) Forms of Asbestos.
  g) Screening for Potential Acid Sulfate Soils (pH_f/$pH_{FOX,}$ chromium reducible sulfur)
- Installation of seven groundwater monitoring wells within the site; identified as MW1, MW12, MW13, MW25, MW30, MW120 and MW124. Installation of two groundwater monitoring wells immediately down hydraulic gradient of the site; namely MW6 and MW9.

- Analysis of groundwater samples from eight of the above wells for a range of COPC including TPH, BTEX, PAH, VOC, and SVOC. Location MW124 was dry during the monitoring event.
- Collation of field records and tabulation of relevant laboratory results from the four investigation programmes.

The following additional aspects of investigation were included in the Supplementary Site Investigation (Coffey Jan 2013):

- Collection of field duplicate samples at a frequency of approximately 1 duplicate for every 3 primary samples and laboratory analysis for TPH, PAH, BTEX and VOC/SVOC to assess the heterogeneity of fill material.
- Analysis of selected samples in accordance with the Australian Standard Leaching Procedure (ASLP) using a neutral leaching solution as an indication of potential for groundwater impact, and the Toxicity Characteristic Leaching Procedure (TCLP) to provide results for a preliminary assessment of waste classification.
- Field filtered duplicate groundwater samples were collected from MW6, MW9, MW20, MW25, MW30 and MW120. These samples were analysed for PAH compounds to assess the proportion of reported PAH concentrations attributable to fine sediment suspended in groundwater samples.
- Installation of data loggers in four monitoring wells across the SICEEP, including well MW120 within the site, to record the variability of groundwater levels continually over several days.

The location of the investigation locations for the above works is also shown in Figure 13. Borehole logs are presented in Appendix C.

Analytical sample results are summarised in Table 1 to 13 provided in Appendix D.

5.3 Review of Investigation Sampling, Analysis & Quality Control

5.3.1 Soil Sampling Pattern and Density

A detailed appraisal of the site's historical uses has not identified particular point sources of potential contamination within the site, rather several historic activities and land uses which appear to cover large parts of the site which may have resulted in a randomly distributed contamination throughout the soil profile. As such, boreholes were positioned to provide a regular sampling pattern across the site where this was practical given existing site constraints. Samples from these boreholes were scheduled for a broad range of COPC consistent with these land uses.

Because investigations were undertaken successively, judgemental sampling was also adopted with certain boreholes used to target locations where elevated COPC were identified during a previous phase of investigation (Coffey; Aug 2012). The positions used for judgemental sampling include:

- Boreholes CBH5/CBH5A, CBH6, CBH7/CBH7A and CBH8 were positioned to target the area surrounding Boreholes NBH24 and EB1 where elevated concentrations of TPH and PAH were identified.
- Boreholes CBH9, CBH10 and CBH11 were positioned to target the area surrounding Boreholes NBH29 and BH10 where elevated concentrations of TPH and PAH were identified.

Coffey consider this approach to be consistent with the Sampling Design Guidelines (NSW EPA, 1995).

The detailed review of historical records identified several potential sources of contamination which adjoined the site. On review of the available investigation data for the site, Coffey notes the following:

- Chemical testing was carried out for the range of COPC identified within the desk study, with certain laboratory testing targeted to reflect field observations and soil headspace screening results regarding analysis for VOC/SVOC and acid sulfate soil.
- Forty-seven (47) borehole locations were established within the site, from which 197 soil samples were scheduled for chemical analysis. Soil samples recovered from boreholes BH7 and BH16 were not scheduled for chemical analysis.
- Distances between borehole locations typically range between 10m and approximately 40m in areas that were readily accessible to drilling plant; namely, surrounding the SEC car park and Darling Drive.
- Access restrictions prevented achieving a similar sampling density within the footprint of the SEC building, areas where major underground services are present, and in areas adjacent to the light rail and former monorail corridors (i.e. particularly to the south of the SEC car park and along Darling Drive). In these areas, a lower sampling density was achieved with distances between sampling positions ranging between 45m and 65m.
- Changes to details of the former site boundary for the purpose of the RAP resulted in five boreholes now being located slightly outside the current site boundary; namely NBH24, CBH/MW6, CBH/MW9, CBH10 and BH118. The results from these locations are considered relevant to the site, particularly in relation to the assessment of potential contamination impacts deriving from historical land uses identified off site to the north; namely the Dixon Steam Mill complex (and associated uses - bottling soda water, brewing, soap manufacture and salting), hydraulic pumping station, Zollner Galvanising Works, railway sidings and stores. Table 5.1 presents a summary of the off-site sources of potential contamination, associated COPC and borehole references targeting boundary conditions relevant to these potential off site AEC.

Table 5.1: Summary of boreholes used to assess boundary conditions near potential off site AEC

Potential Off Site AEC	Location	COPC	Boreholes Assessing Relevant Boundary Conditions
• Dixon Steam Mill, • Zollner Galvanising Works • Hydraulic pumping station	Little Pier Street Precinct to northeast of the site	• Heavy metals • PAH • TPH • Solvents • Asbestos (as Bonded ACM, Fibrous asbestos and Asbestos fines)	BH5, BH6, BH10, CBH11, NBH29, NBH23, CBH/MW9, BH/MW12, BH118, CBH10

Potential Off Site AEC	Location	COPC	Boreholes Assessing Relevant Boundary Conditions
Ultimo Power Station and railway sidings to the west	Western boundary of the Site	• TPH, • PAH, • Heavy metals, • Solvents • Asbestos (as Fibrous asbestos and Asbestos fines).	BH122, BH122A, BH123, BH123A, BH/MW124
Warehouses and associated railway sidings	Northern boundary of the site	• Heavy metals, • TPH • PAH • Asbestos (as Bonded ACM, Fibrous asbestos and Asbestos fines).	CBH/MW6, NBH24

- Samples collected from BH7 and BH16 were not scheduled for chemical testing. However, borehole logs for these boreholes indicate that that ground conditions at these two locations are reasonably consistent with ground conditions observed in adjacent boreholes (i.e. similar fill types and anthropogenic inclusions). Furthermore, gross contamination or distinctive odours were not recorded in BH7 or BH16. The borehole logs from BH7 and BH16 present information which informs the understanding of ground conditions at these locations, and hence these locations are considered valid investigation positions.

Table 5.2 provides a summary of the investigation density relative to the AEC identified within and adjacent to the site.

Table 5.2: Summary of Investigation Density by AEC

AEC	Area (ha)	Investigation Locations	Location Density	Recommended Minimum Density[1,2]	Separation of Adjacent Locations
Fill materials	3.8	47	12.4	12.7	5m to 65m
Market Place	1.9	25	13.1	15.3	5m to 65m
Council Depot	1.4	17	12.1	17.6	5m to 60m
Railway Sidings	0.4	5	12.5	27.5	8m to 40m

AEC	Area (ha)	Investigation Locations	Location Density	Recommended Minimum Density[1,2]	Separation of Adjacent Locations
Dickson Mill Complex, Galvanising Works & Hydraulic Pumping Station[2]	0.35	11	31.4	28.8	10m to 30m

Notes:

1. Table A, Third Column of the Sampling Design Guidelines (NSW EPA, 1995). Recommended Minimum Density values were adjusted for the specific AEC area using interpolation where a value is not provided within Table A for that specific AEC area.
2. Investigation density is presented as investigation locations per hectare.
3. Investigation density includes three boreholes beyond the site boundary; namely CBH/MW9, CBH10 and BH118.

The investigation density achieved relative to the Market Place, Council Depot and Railway Sidings were lower than the minimum investigation density recommended by the Sampling Design Guidelines (NSW EPA, 1995). This reflects areas within the site where current uses restricted access to drilling plant (e.g. SEC, Darling Drive and southern part of the SEC car park).

The investigation density achieved relative to the former Dixon Mill Complex, Galvanising Works and Hydraulic Pumping Station which were located within and immediately adjacent to the northeastern corner of the site exceeds the minimum investigation density recommended within the Sampling Design Guidelines (NSW EPA, 1995).

With regard to assessing fill materials used historically to reclaim land at the southern end of Cockle Bay and subsequent redevelopment of the site, the investigation density was slightly lower than the minimum investigation density recommended by the Sampling Design Guidelines (NSW EPA, 1995). However as initial reclamation activities took place over period of 40years, this has likely resulted in the random distribution of contamination within fill materials. The Sampling Design Guidelines recommend a systematic sampling programme where the distribution of contamination is expected to be random. Given the access restrictions present within the site, it was not possible to establish a systematic sampling grid, and therefore the distance between sampling locations in certain areas of the site is more than that recommended by the Sampling Design Guidelines. As such, the degree of uncertainty associated with unexpected contamination associated with fill materials present in these areas is assessed to be greater. Conversely, in other areas of the site where the distance between sampling locations is less, the degree of encountering unexpected contamination is assessed to be proportionally less.

In summary, following the review of the available site history information and available investigation data, Coffey recognises that some uncertainty remains regarding the presence of potentially unidentified contamination between investigation positions. However, Coffey considers that investigations carried out to date are adequate for the purpose of:

- Characterising the nature of contamination (soil and groundwater) expected within the site for the type and extent of redevelopment proposed.
- Developing a Conceptual Site Model and strategy to manage the known types of contamination present within the site to make the site suitable for the proposed uses.
- Developing a framework to manage unexpected contamination encountered during the redevelopment of the site.
- Developing a framework to manage asbestos impact in fill material reasonably assumed to be encountered during the redevelopment of the site.

Coffey considers that uncertainty regarding the presence of potentially unidentified contamination between investigation positions and likely asbestos impact in fill can be addressed as part of Unexpected Finds and Contingency Planning that are further discussed in Section 12 of this RAP.

5.3.2 Groundwater Investigation & Sampling

The rationale for selection of groundwater monitoring well locations comprised:

- Establish wells around the perimeter of the site as well as within the site to assess groundwater flow direction because of the likely influence of sandstone ridges to the east and west of the site,
- Placement of two wells down gradient of areas where soil contamination had been previously identified; namely, MW6 and MW9.

5.3.3 Quality Assurance / Quality Control Procedures (QA/QC)

Previous investigation programmes adopted a range of quality control measures to assess the reliability of field and laboratory procedures. A detailed appraisal of the QA/QC procedures is presented within the individual investigation reports listed in Section 1.6 and findings are summarised in this section.

Field QC measures included the collection and analysis of duplicate and triplicate samples, equipment rinsate samples, and inclusion of laboratory prepared trip blank and trip spike samples. Samples were collected in laboratory provided containers, with preservatives as applicable, and transported to the laboratory under Chain of Custody control.

Chemical analysis was undertaken by laboratories that are NATA-accredited for the analysis they performed. Furthermore, these laboratories performed an internal QA/QC assessment where laboratory prepared duplicates, method blanks, matrix spikes and surrogate spikes and surrogates were analysed to assess measurement bias associated with particular analytical techniques and sample matrices.

6 ASSESSMENT CRITERIA

6.1 Soils - Health Investigation Levels

The assessment criteria proposed for this project were sourced from:

- NEPC (1999) National Environment Protection (Assessment of Site Contamination) Amendment Measure (NEPM) (No. 1) as registered 2013.
- Friebel and Nadebaum (2011); CRC CARE Technical Report No. 10 – Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater
- US EPA Region 9 Regional Screening Levels for Soil under Residential and Industrial land uses (November 2012)

NEPC (1999) provides health and ecological based soil investigation levels for various exposure settings. Coffey understands that the site will be redeveloped for mixture of uses, including commercial, high-rise residential and landscaped/paved public open space. With reference to information provided to Coffey by LLD describing the proposed development, we consider that the exposure setting for future mixed uses after completion of construction is reasonably represented by that for high density residential use (i.e. residential with minimal opportunities for soil access including dwellings with permanently paved yard space, high rise apartments and flats).

LLD indicated that a child day-care centre may be established within the development at levels above ground floor. Although no further, specific details of the child day-care centre are available at this stage, the screening criteria adopted assumed that the exposure setting for infants attending a day-care facility within the upper floors of the development would be similar to that of a high rise residential setting with minimal access to soils.

Because the locations and extent of public open space within the development has not been finalised, available soil data was also compared to health investigation levels (HIL) for public open spaces.

Coffey considers that the exposure setting for future remediation and construction works on the site and workers within the proposed commercial/retail elements of the proposed development is represented by that for commercial / industrial land uses.

Therefore the following were adopted for this assessment based on Schedule B1, Guideline on Investigation Levels for Soil and Groundwater (NEPC, 1999):

Table 6.1: Source of Health-based soil investigation levels

Land Use Scenario	Source of Health-based Soil Investigation Levels
High Density Residential	• Table 1A(1),Column B - Health Investigation Levels for Residential uses with minimum access to soil (HIL B). • Table 1A(3), Column A/B – Health Screening Levels (HSL) for vapour intrusion for Residential uses (HSL B).
Recreational &	• Table 1A(1),Column C - Health Investigation Levels for Recreational Parks, Open Space and Playgrounds (HIL C).

Land Use Scenario	Source of Health-based Soil Investigation Levels
Public Open Space	• Table 1A(3), Column C – HSL for vapour intrusion for Recreational/Open Space uses (HSL C). • Table 7 – Health screening levels for asbestos contamination in soils
Remediation / Construction Worker Future Commercial / Industrial Worker	• Table 1A(1),Column D - Health Investigation Levels for Commercial/Industrial (HIL D). • Table 1A(3) Column D – HSL for vapour intrusion for Commercial / Industrial uses (HSL D). • Table 7 – Health screening levels for asbestos contamination in soils

For compounds where soil vapour HSL exceeds the chemical constituent saturation concentration, HSL for direct contact pathways published within CRC CARE Technical Report No. 10 (Friebel and Nadebaum; 2011) have been adopted as the health risk screening level for this assessment. For compounds where the soil vapour HSL exceeds the chemical constituent saturation concentration, HSL for direct contact pathways in Table B4 of CRC CARE Technical Report No. 10 (Part 2) have been adopted as the health-based investigation level for relevant compounds for this assessment. The values adopted assume conservative assumptions regarding site conditions; namely, sandy soil profile and contamination is present within the upper 1m of soil.

Coffey considers that the HSL presented within CRC CARE Technical Report No. 10 have been developed on a scientifically defensible basis and has been subject to independent and expert peer review prior to publication. Consequently, Coffey considers that the approach described in CRC CARE Technical Report No. 10 may be adopted for health risk screening regarding the presence of petroleum hydrocarbons in the subsurface, within the limitations of that report.

Coffey notes that laboratory data available for this site reports TPH using slightly different carbon chain fractions. Specifically, laboratory data presented within the earlier investigations (Coffey; Aug 2011, June 2012b) present TPH data using equivalent carbon chain fractions that differ slightly from that adopted within NEPC (1999). For the purposes of this assessment, the following carbon chain fractions are considered broadly analogous, and the corresponding HSL have been adopted as preliminary screening criteria.

Table 6.2: TPH Carbon Chain Fractions

Format of TPH Carbon Chain Fractions presented in Coffey (Aug 2011 and June 2012b),	Format of TPH Carbon Chain Fractions presented in Coffey (Aug 2012, Jan 2013)	TRH Carbon Chain Fraction Numbers (NEPC, 1999)
TPH C6 – C9	TPH C6 – C9	F1
TPH C10 – C14	TPH C10 – C16	F2
TPH C15 – C28	TPH C16 – C34	F3
TPH C29 – C36	TPH C34 – C40	F4

For organic compounds where no national or state endorsed health-based soil investigation levels are currently available, US EPA Region 9 Regional Screening Levels (dated November 2012) for soil under Residential and Industrial land uses (as applicable) were adopted where any such compound was reported above the laboratory Limit of Reporting (LOR)[8]. For SVOC and VOC where no authoritative screening levels are readily accessible, the LOR was used as a preliminary screening level.

NEPC (1999) provides guidance on the assessment of soils impacted by forms of asbestos, including health screening levels for asbestos contamination in soil for a range of land uses. Coffey notes that soil sampling design for assessment of asbestos contamination for previous investigations on this site were not consistent with recommendations recently issued under Schedule B(2), Guideline on Site Characterisation (NEPC, 1999). For this reason, a preliminary assessment criterion of “no form of asbestos detected” is adopted as the Soil Investigation Level for this RAP.

A summary of the adopted health-based soil investigation levels is provided in Table 6.3. Tables 1 to 3 in D provide a summary of the laboratory data against the adopted health based soil investigation levels.

Table 6.3: Soil Investigation Levels – Human Health

Contaminant	Future High Density Residential Use Source: HIL B & HSL B[1] (mg/kg)	Public Open Space Source: HIL C & HSL C[1] (mg/kg)	Remediation/ Construction Workers & Future Commercial Workers Source: HIL D & HSL D[1] (mg/kg)
Arsenic	500	300	3000
Cadmium	150	90	900
Chromium (VI)	500 [5]	300 [5]	3600 [5]
Copper	30,000	17,000	240,000
Nickel	1200	1200	6000
Lead	1200	600	1500
Zinc	60,000	30,000	400,000
Mercury	120	80	730
F1 (TRH C_6-C_9 – BTEX)	45 [2]	5100 [3]	260 [2]
F2 (TRH C_{10}-C_{16} – Naphthalene)	110 [2]	3800 [3]	20,000 [3]

[8] US EPA Region 9 Regional Screening Levels for Residential Land Uses sourced from: http://www.epa.gov/region9/superfund/prg/

Contaminant	Future High Density Residential Use Source: HIL B & HSL B[1] (mg/kg)	Public Open Space Source: HIL C & HSL C[1] (mg/kg)	Remediation/ Construction Workers & Future Commercial Workers Source: HIL D & HSL D[1] (mg/kg)
F3 TRH C_{16}-C_{34}	5,800 [3]	5300 [3]	27,000 [3]
F4 TRH C_{34}-C_{40}	8100 [3]	7400 [3]	38,000 [3]
Benzene	0.5 [2]	120 [3]	3 [2]
Toluene	160 [2]	18,000 [3]	99,000 [2]
Ethylbenzene	55 [2]	5300 [3]	2700 [3]
Total Xylene	40 [2]	15,000 [3]	230 [2]
Naphthalene	3	1900 [3]	11,000
Carcinogenic PAH as Benzo(a)pyrene TEQ [4]	4	3	40
Total PAHs	400	300	4000
Lindane	0.52 [6]	0.52 [6]	2.1 [6]
Other VOC	LOR	LOR	LOR
Other SVOC	LOR	LOR	LOR
Asbestos (as Bonded ACM Fibrous asbestos and Asbestos fines)	No form of asbestos detected	No form of asbestos detected	No form of asbestos detected

Notes:

1. Table 1A(1) - Schedule B1, Guideline on the Investigation Levels for Soil and Groundwater (NEPC, 1999)
2. Table 1A(3) - Schedule B1, Guideline on the Investigation Levels for Soil and Groundwater (NEPC, 1999)
3. Table A4 – Soil Health Screening Levels for Direct Contact (CRC Care Technical Report No.10 (Friebel and Nadebaum; 2011)
4. TEQ = Toxicity Equivalent Quotient
5. Soils were tested for Total Chromium, which comprises both Chromium (III) and Chromium (VI) valence states. The HIL for Chromium (VI) has been adopted as a conservative assessment threshold.
6. US EPA Region 9 Remediation Screening Level for Residential Land Uses for Lindane (also referred to as Gamma-Hexachlorocyclohexane) was adopted as a screening level for future high density residential and open space exposure settings, US EPA Region 9 Remediation Screening Level for Industrial Land Uses for Lindane was adopted as an initial screening level for the future Commercial/Retail and remediation and construction exposure settings.

Where reported concentrations of contaminants in soil exceed the criteria in Table 6.2, potential human health risks posed by these constituents were considered in detail in the Human Health and Ecological Risk Assessment (EnRisk, 15 November 2013).

6.2 Soils - Aesthetic Criteria

Although no specific numeric aesthetic guideline values are provided, NEPC (1999) requires the consideration of aesthetic issues (as a result of contamination), arising from soils within the site. The following assessment criteria were adopted when considering soil aesthetics:

- no highly malodorous soils, taking into consideration the natural state of the soil;
- no staining or discolouration in soils , taking into consideration the natural state of the soil;
- no large or frequently occurring foreign materials present (to the extent practicable); and
- no bonded ACM or fibrous asbestos visible in surface soils.

6.3 Soils – Ecological Investigation Levels

NEPC (1999) provides ecological investigation levels (EIL) that are considered protective of terrestrial ecosystems for the following land uses:

- Areas of ecological significance (not applicable to this site)
- Urban residential areas and public open space
- Commercial/industrial development

EIL for chromium (III), copper, lead, nickel and zinc are concentrations which are the sum of a relevant Ambient Background Concentration (ABC) and Added Concentration Limit (ACL). EIL for arsenic, DDT and naphthalene are listed as concentrations of total contamination which do not vary with ABC. EIL for TPH fractions, BTEX and benzo(a)pyrene are listed as ecological screening levels which are also concentrations of total contamination for which a background concentration does not apply.

EIL principally apply to soils within the root or habitation zone (i.e. typically the top 2m of soil). However, given that there is the potential that deeper soils may be placed at shallower depths during the redevelopment of the site, the EILs were applied to analytical data for samples collected throughout the soil column.

Where applicable, ABC values for the site are based on the 25th percentile ambient background concentrations for 'Old Suburbs, High Traffic in NSW' presented within Olszowy et.al. (1995). As site specific soil physiochemical properties were not collected during previous investigations, conservative assumptions were adopted for soil pH, Cation Exchange Capacity (CEC) and percentage clay in deriving EIL. Given that the site has extensive historic use extending back to the early 19th century, the EIL adopted also assume the contamination present is aged.

Table 6.4 summarises the EIL adopted for this assessment. Where applicable, assumptions about soil properties used in deriving an EIL are provided as footnotes to Table 6.4.

Table 6.4: Ecological Investigation Levels

Chemical Constituent	Ecological Investigation Levels	
	Residential Land & Public Open Space (mg/kg)	Commercial / Industrial Land (mg/kg)
Arsenic	100 [1]	160 [1]
Chromium (III)	260 [2]	430 [2]
Copper	120 [3]	160 [3]
Nickel	35 [4]	60 [4]
Lead	1260	1960
Zinc	350 [5]	480 [5]
F1 (TPH C_6-C_9 – BTEX)	180	215
F2 (TPH C_{10}-C_{16} – Naphthalene)	120	170
F3 (TPH C_{16}-C_{34})	300	1700
F4 (TPH C_{34}-C_{40})	2800	3300
Benzene	50	75
Toluene	85	135
Ethylbenzene	70	165
Xylenes	105	180
Naphthalene	170 [1]	370 [1]
Benzo(a)pyrene	0.7	0.7

Notes:

1. Table 1B(5) - Schedule B(1), Guideline on the Investigation Levels for Soil and Groundwater (NEPC, 1999)
2. The Added Contaminant Limit (ACL) selected for Chromium III assumes a clay content of 2.5%. ABC value adopted was 13mg/kg.
3. The ACL selected for Copper assumes a soil pH of 7.0, CEC of 5cmol$_c$/kg and Soil Organic Carbon of 1%. ABC value adopted was 28mg/kg.
4. The ACL selected for Nickel assumes a CEC of 5cmol$_c$/kg. ABC value adopted was 5mg/kg.
5. The ACL selected for Zinc assumes a soil pH of 7.0 and CEC of 5cmol$_c$/kg. ABC value adopted was 122mg/kg.
6. EIL for TPH and BTEX compounds assume soils are coarse grained.

6.4 Groundwater Investigation Levels (GIL)

Given the site's historical commercial and industrial use of reclaimed land at the southern end of what was Long Bay, Coffey considers that the site is not located above a water bearing zone which has the potential for use as a drinking water resource. Consequently, the adoption of Australian Drinking Water Guidelines (NHMRC & NRMMC, 2011) is not considered appropriate as groundwater investigation levels. Coffey notes that the salinity of the groundwater being close to that of seawater also precludes its consideration as a potential drinking water resource. NSW Office of Water records showed that no registered groundwater bores are located within a 500m radius of the site.

Groundwater from the site is expected to flow to the north and discharge into the southern end of Cockle Bay, which is considered to be a highly modified marine habitat. Thus, protection of marine species and aesthetic quality for recreational waters are identified as relevant environmental values, and groundwater quality has been assessed against the following criteria:

- ANZECC/ARMCANZ (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Protection of Aquatic Ecosystems. Marine trigger values for protection of 95% of species.
- DEC (2005); Marine Water Quality Objectives for NSW Ocean Waters – Sydney Metropolitan and Hawkesbury-Nepean

ANZECC/ARMCANZ (2000) advocates a site-specific approach to developing guideline trigger values based on such factors as local biological affects data, the current level of disturbance of the ecosystem, etc. The ANZECC/ARMCANZ (2000) guidelines present ‘low risk guidelines trigger values’ which are defined as concentrations of key performance parameters below which there is a low risk that adverse biological effects will occur. It is important to note that these are not threshold values at which an environmental problem is likely to occur if exceeded. Rather, if the trigger values are exceeded, then further action is required which may include either additional site-specific investigations to assess whether or not there is an actual problem, or the implementation of management / remedial actions.

It is understood that NSW EPA’s policy is that the trigger values for the protection of 95% of aquatic ecosystems should be used except where contaminants are potentially bioaccumulative in which case the trigger values for protection of 99% of species is recommended. Therefore, we have selected trigger values for protection of 95% of marine water species for the majority of contaminants, and 99% of marine water species for bioaccumulative contaminants for comparison purposes.

ANZECC/ARMCANZ (2000) states that there is currently insufficient data to derive high reliability trigger values for a number of COPC for the site. For these contaminants, low reliability trigger values have been adopted.

ANZECC/ARMCANZ (2000) states that there is currently insufficient data to derive a high reliability trigger value for TPH but propose a low reliability trigger value for TPH of 7μg/L. This guideline is generally considered by industry to be overly conservative and is also well below the TPH detection limit that most laboratories can achieve. Therefore the laboratory limit of reporting (LOR) is adopted as appropriate practical screening value for TPH assessment (NSW DEC, 2007).

NSW DEC (2007) *Guidelines for the Assessment and Management of Groundwater Contamination* states that where the generic groundwater investigation level (GIL) is below the laboratory LOR, the LOR should be used instead of the existing generic GIL.

The Marine Water Quality Objectives considered relevant for Cockle Bay (i.e. the nearest receiving waters near to the site) include aquatic ecosystems (i.e. aquatic ecosystem health), secondary contact recreation (i.e. boating and wading) and visual amenity.

A summary of the adopted groundwater investigation levels for chemical stressors is presented in Table 6.5.

Table 6.5: Summary of Groundwater Investigation Levels (chemical stressors)

Analyte	Laboratory Limit of Reporting (µg/L)	ANZECC 2000 [1] (µg/L)	Adopted GIL (µg/L)
pH	-	-	7.0 – 8.5
Arsenic	1	2.3	2.3
Cadmium	0.2	0.7	0.7
Chromium (Total)	1	4.4 [c]	4.4
Copper	1	1.3	1.3
Lead	1	4.4	4.4
Mercury	0.1	0.1	0.1
Nickel	1	7	7
Zinc	1	15	15
Benzo(a)pyrene	0.01	0.1	0.1
Naphthalene	0.05	50	50
Anthracene	0.01	0.01	0.01
Phenanthrene	0.05	0.6	0.6
Fluoranthene	0.05	1.0	1.0
TPH C_6-C_9	40	-	40 [a]
TPH C_{10}-C_{14}	100	-	100 [a]
TPH C_{15}-C_{28}	200	-	200 [a]
TPH C_{29}-C_{36}	200	-	200 [a]
Benzene	1	500	500
Toluene	1	180	180
Ethylbenzene	1	5	5
Xylene (m & p)	2	75 [b]	75
o-Xylene	1	350	350

Notes:

1. Australian and New Zealand Environment and Conservation (2000) National Water Quality Management Strategy – Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Where insufficient data is available to derive a reliable trigger value, low reliability values have been adopted from Section 8.3.7 of this publication.

(a) In the absence of a nominated guideline value, the laboratory LOR has been taken as the nominal trigger value for the presence of TPH compounds in groundwater as will be used as the GIL (NSW DEC, 2007).

(b) Adopted assessment criteria for m&p Xylene is based on the m-Xylene, which is the lowest trigger value for the two Xylene isomers.

(c) Groundwater Investigation Level for Chromium (VI) adopted for Chromium (Total) as a conservative assessment measure.

7 SITE CONTAMINATION ASSESSMENT

7.1 General

The following sections present a discussion on the laboratory results obtained from site contamination assessment in the context of each identified AEC.

Chemicals that reported concentrations above the assessment criteria presented in Section 5 are summarised in Tables 1 and 6 in Appendix D.

7.2 Fill Materials of Unknown Origin

Fill materials were to reclaim Long Bay to form the current area south of Cockle Bay, including the site. Historic records indicate the reclamation of Cockle Bay appears to have occurred over some 40years from 1826 and 1865 using fill derived from excavations to form the Sydney Railway Terminus and dredging spoil from unknown areas of Sydney Harbour. Private reclamations also took place during this period using fill materials from unknown sources. Periodic redevelopment of the site may have also introduced fill materials from other unknown sources.

As part of previous investigations, 124 samples of fill materials from 45 boreholes across the site were collected and analysed for a range of COPC listed in Section 4. A discussion on the various types of contamination identified within the fill materials within the site is presented in the following sections.

7.2.1 Hydrocarbon Contamination within Fill Materials

TPH and PAH compounds characterised by heavier molecular weights were encountered in numerous samples from the fill materials. Benzo(a)pyrene comprised typically 5% to 10% of the Total PAH reported at these locations, which is characteristic of combustion by-products such as ash and charcoal.

Where the characteristic relationship described above is not apparent, reported TPH concentrations are often indicative of a release of petroleum fuel or the disposal of waste oil. Potential locations of a localised fuel or oil spillage have been identified in:

- NBH29 - potentially associated with one of a variety of historic sources noted in this area including the Dixon Steam Mill complex, Zollners Galvanising Works, Hydraulic Pumping Station (refer to discussion in Section 7.3) or a recent fuel/oil spillage associated with the former City Market.
- BH124 – possibly associated with impact derived from the adjoining Ultimo Power Station
- EB1 – potentially derived from historic fuel/oil spillage associated with the former council depot.

The TPH reported within soil samples at the above locations fall predominantly within the C_{15}-C_{36} range although some notable impact was reported within the C_{10}-C_{14} range in BH124. The impact at the above boreholes also correlates with field observations of moderate to strong hydrocarbon odours.

Coffey notes that volatile petroleum hydrocarbon compounds having higher solubilities and vapour pressure (e.g. TPH C_6-C_9 and monoaromatic compounds such as benzene) were not detected within fill materials within the site, except for TPH C_6-C_9 at a low concentration of 21mg/kg in sample NHB24_1.5-1.95.

Three individual SVOC compounds (not being PAH) were reported in soil samples at two locations having concentrations above the relevant soil assessment criterion or laboratory LOR (as a default screening level). These included:

- Lindane (an organochlorine pesticide) and 2-Naphthylamine reported in sample BH124 (4.6-4.8mbgs) located within lower fill materials/reworked natural alluvial materials and associated with moderate hydrocarbon odours and black staining. A possible source of this contamination impact may relate to fill materials present at this location, or impact from the adjoining former Ultimo Power Station (refer discussion in Section 7.5).
- 4-Nitrophenol at BH128 (2.9-3.0mbgs) located within at the interface between the fill/upper Alluvium correlating with slight 'organic' odours. No direct correlation has been identified with known historical land uses of this part of the site.

No other VOC or SVOC were detected above the relevant soil assessment criterion or laboratory LOR.

7.2.2 Distribution of Hydrocarbon Contamination

Field duplicate samples (in addition to quality control duplicates) were collected during the December 2012 investigations (Coffey; Jan 2013) to assess the short scale (i.e. centimetres) variability of COPC within fill materials on the site. In summary, 19 field duplicate samples were collected using a split tube sampler from 13 boreholes across the site and analysed for TPH, PAH, BTEX and VOC/SVOC (the latter where elevated PID readings and/or visual/olfactory evidence of potential contamination was identified).

VOC and SVOC were analysed in one primary and field duplicate sample pair from BH124 (4.6-4.8m). With the exception of Lindane and 2-naphthylamine, other SVOC and VOC were reported below the LOR. The RPDs for Lindane and 2-naphthylamine were 36% and 13% respectively.

Table 7.1 summarises the primary and field duplicate sample pairs, and their corresponding RPD for TPH C_{10}-C_{36} and Total PAH.

Table 7.1: Summary of Primary and Field Duplicate Pairs & Relative Percent Differences

Sample Location	Sample Interval	Relative Percent Difference	
		Total PAH	TPH C_{10}-C_{36}
BH120	0.03-0.13m	N/A	N/A
	1.5-1.6m	71% **	83.6% *
BH121	0.5-0.6m	17% #	N/A
BH121A	1.0-1.1m	55% **	91% *
BH122A	1.5-1.6m	59% **	N/A
BH123	1.5-1.6m	75% **	71% *
BH123A	1.0-1.1m	67% **	40% #
BH124	2.9-3.0m	N/A	98% **
	4.6-4.8m	N/A	14% **

Sample Location	Sample Interval	Relative Percent Difference	
		Total PAH	TPH C_{10}-C_{36}
BH125	0.23-0.33m	5% **	19% **
BH125A	0.5-0.6m	N/A	N/A
	2.0-2.1m	N/A	N/A
BH126	0.5-0.6m	N/A	N/A
BH127	0.3-0.5m	N/A	N/A
	1.5-1.6m	62% **	27% *
BH128	0.28-0.38M	158% *	N/A
	1.5-1.6M	50% *	N/A
BH129	0.24-0.28M	N/A	N/A
	1.0-1.1m	0% #	N/A

Notes:

* = indicates the reported concentrations in one sample is greater than 10 times the LOR;

** = indicates the reported concentrations in both samples are greater than 10 times the LOR.

= both samples reported concentrations less than 10 times the LOR.

N/A indicates concentrations of one or both samples were reported below the LOR and hence, an RPD was not calculated.

The RPD for Total PAH, for seven samples which reported concentrations at 10 times (or above) the LOR, ranged between 5% and 75% with an average RPD of 56%. Similarly for TPH C_{10}-C_{36}, for three samples which reported concentrations 10 times (or above) the LOR, the RPD values were 14%, 19% and 98%. Based on the summary presented in Table 7.1, Coffey considers that the distribution of PAH and TPH C_{10}-C_{36} compounds have a moderate degree of variability within discrete horizons of fill materials present on site.

Comparison of analytical data from individual boreholes was also made to assess variability in the vertical distribution of soil contamination within the fill materials present. In summary, Coffey considers that the vertical distribution of soil contamination within the fill:

- In general, typically appears to occur as layers within fill material, rather than being consistently present throughout the fill deposits.
- The rate of change in contaminant concentration vertically through the fill, which is typically 2m to 4m deep, appeared to be substantially greater relative to the reported difference in concentration between the primary and field duplicate samples presented in Table 7.1. For example, RPD for Total PAH and TPH C_{10}-C_{36} between sample intervals of 0.5m were reported above 150%. This variability may be indicative of different ‘filling events’ associated with the historic reclamation and redevelopment activities on the site.

7.2.3 Inorganic Contamination within Fill Materials

Concentrations of Arsenic, Cadmium, Chromium, Copper, Mercury, Nickel and Zinc were reported below health-based soil assessment criteria in all samples for residential, public open space and commercial/industrial land use settings.

Concentrations of lead were detected above the health-based soil assessment criterion of 600mg/kg for public open space in two samples, with only one sample exceeding the health-based soil assessment criterion of 1200mg/kg for high density residential uses. The highest reported concentration of lead was 2,700mg/kg in a sample from BH121A at 1.5-1.6mbgl. This sample taken from BH121A represented a layer of clayey fill material which included pieces of concrete, rock, brick and rusted metal and which extended from 0.8mbgl to the top of natural alluvium at 2.3mbgl. Given the observed conditions, Coffey considers that the elevated concentrations of lead at BH121A are attributable to inclusions of rusted metal pieces, possibly as lead based paint, solder or plumbing material. Similar rusted metal pieces were not observed in fill materials in boreholes surrounding BH121A, nor elsewhere on the site. Coffey considers that this occurrence is an isolated case.

Concentrations of lead were reported above the public open space health-based soil assessment criterion in a sample from BH126 (1.4-1.5mbgl). Samples analysed from BH126 at depths 0.5-0.6mbgl and 2.4-2.5mbgl reported concentrations below 100mg/kg suggesting the elevated concentration of lead is relatively localised within the fill material at this location. In the context of the 121 soil samples analysed for lead, concentrations of lead were reported in the large majority (approximately 90%) of soil samples at concentrations less than 130mg/kg, suggesting that the reported occurrence of the higher concentrations of lead at BH121A and BH126 are relatively isolated occurrences.

7.2.4 Asbestos Contamination within Fill Materials

Forms of asbestos were detected in three soil samples from two borehole locations; namely BH119 and BH13. During drilling at location BH119, a ‘fibrous sheet’ was encountered at 0.33mbgl, which was suspected to be bonded ACM. A fragment of this sheet, together with soil samples taken from one interval above the sheet and two different intervals below the sheet were collected from the borehole and scheduled for asbestos analysis. Analysis of the bonded ACM fragment confirmed the presence of chrysotile asbestos. No asbestos fibres were identified in trace analysis of soil samples from above or below the location of the bonded ACM, which suggests that asbestos fines are unlikely to be present within fill material around the sheet. Asbestos fines were also encountered (in the form of fibre bundles[9]) at location BH13 (approximately 5m north of BH119) at depths of 1.5mbgs and 2.5mbgs. Forms of asbestos were not detected in any of the other 88 soil samples scheduled for asbestos analysis as part of the four investigation programmes.

7.3 Little Pier Street Precinct

The Little Pier Street Precinct is established immediately to the northeast of the site. The following land uses were historically established in this area:

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[9] Fibre bundles are considered to be equivalent to ‘asbestos fines’ in NEPC (1999) and Safe Work Australia (2011).

- Dixon Steam Mill complex comprising the Dixon Steam Engine and associated uses; namely; bottling soda water, brewing, soap manufacture and salting.
- Zollner Galvanising Works
- Hydraulic pumping station

Forty one (41) soil samples were retained from nine boreholes and analysed for heavy metals, PAH, TPH and VOC/SVOC (where elevated PID readings and/or visual/olfactory evidence of indicated likely presence). A summary of the investigation findings relevant to these AEC are provided below:

- Concentrations of heavy metals and TPH were reported below the corresponding health based soil assessment criteria in all soil samples retained from this area of the site.
- BTEX, VOC and SVOC compounds were reported below the LOR in samples from this area of the site.
- Concentrations of Benzo(a)Pyrene and Total PAH were reported above the corresponding health based soil assessment criteria in approximately 20% of soil samples from this area of the site for residential land and public open space, with a maximum reported concentrations of 20mg/kg (BH10_1.0-1.1m) and 300mg/kg (NBH29_0.9-1.0m) respectively. The concentrations are indicative of combustion by-products such as ash and charcoal, and may derive from the known historical land uses noted above.

7.4 Former Railway Sidings and Warehouses

Land to the north of Pier Street was historically used for transport and storage uses to support the wharf operations established along the foreshore of Cockle Bay. The locations of the closest rail sidings and warehouses to the site are shown on Figure 12.

Two investigation locations; namely CBH6/MW6 and NBH24 were established between the site boundary and the former warehouses and sidings to assess this area. Nine soil samples from these locations were submitted for chemical analysis for the COPC identified. A summary of the investigation findings relevant to this AEC is provided below:

- No form of asbestos was identified in 4 samples submitted for analysis.
- Concentrations of heavy metals were reported below the corresponding health based soil assessment criterion.
- Benzo(a)Pyrene and Total PAH were reported at concentrations above the health based soil assessment criteria in one sample of fill material from NBH24 at 1.5-1.95mbgl. Analysis of soil samples above and below this horizon reported concentrations of these constituents below the soil assessment criteria suggesting the impact is present within a discrete horizon. Visual and olfactory indications also support this data. As similar contamination was identified at location EB1 (i.e. approx. 20m southeast of NBH24), it remains uncertain whether this impact derives from the former rail sidings to the north, or from the council depot which was located within the site between 1930s and 1980s.

7.5 Former Ultimo Power Station

The Ultimo Power Station operated on land immediately west of the site between 1899 and 1963. Although the power station was outside the site boundaries, records indicate that intake conduits for cooling water were constructed across the northwestern part of the site. Five boreholes were established along the western site boundary to assess whether potential contamination sources associated with the former power station had impacted ground conditions in this area of the site. Twenty-eight (28) soil samples were scheduled for analysis for a range of COPC considered relevant to the former power station. A summary of the investigation findings relevant to this AEC is provided below:

- Concentrations of heavy metals were reported below the corresponding health based soil assessment criteria.
- No form of asbestos was identified in 9 samples submitted for analysis.
- No volatile petroleum hydrocarbons were reported in any samples.
- Benzo(a)Pyrene was reported at concentrations exceeding the health based soil investigation level in three samples (of 29 analysed), with maximum reported concentrations of 30mg/kg (BH123_1.5-1.6m). With reference to the reported concentration of Total PAH, these concentrations are indicative of combustion by-products such as ash and charcoal, which may derive from the former power station.
- TPH reported at BH124 correlates with moderate hydrocarbon odours and staining at depths between 2.9 and 4.8mbgl. A summary of the TPH C_{10}-C_{36} concentrations reported from samples recovered from BH124 is presented in Table 7.2 to provide an indication of the contamination profile recorded through the soil column.

Table 7.2: TPH concentrations reported from samples recovered from BH124

Sample Depth	Reported TPH Concentrations (mg/kg)			
	TPH C_{10}-C_{14}	TPH C_{15}-C_{28}	TPH C_{29}-C_{36}	TPH C_{10}-C_{36}
0.5 – 0.6m	<50	<100	<100	<100
1.5 – 1.6m	<50	<100	<100	<100
2.5 – 2.6m	<50	<100	<100	<100
2.9 – 3.0m	620	3800	350	4,770
3.4 - 3.5m	630	2700	220	3,550
3.8 – 3.9m	<50	<100	160	160
4.6 - 4.8m	630	3200	310	4,140

The contamination profile recorded at BH124 indicates that soils from the surface to 2.5mbgl has negligible contamination. Hydrocarbon impact is present in a discrete horizon from approximately 2.9m to 4.8mbgl. The sample from 4.8m depth in BH124 was the deepest analysed and may not represent the lower vertical extent of hydrocarbon impact at this location. BH124 was drilled to top of sandstone at 5.6m depth and a very slight hydrocarbon odour and a headspace screening result of

4.9ppm is reported on the borehole log. Historic records associated with the power station identified a cooling water intake conduit close to BH124. Backfill around this structure (if present or otherwise) may represent a preferential pathway for contamination to migrate onto the site, possibly reulting in the hydrocarbon impact reported at this location.

- Coffey note that the concentrations of TPH C_{10}-C_{14} did not exceed the soil health investigation levels for commercial industrial land uses or public open space in BH124. From the proposed development information provided by LLD (refer Appendix A), Coffey understands that proposed development of this part of the site would comprise student accommodation with residential areas on upper floors and with ground floor space utilised as a lobby/storage/service areas.
- Lindane (an organochlorine pesticide) and 2-Naphthylamine reported in sample BH124 (4.6-4.8mbgl) located within lower fill materials/reworked natural alluvial materials and correlated with moderate hydrocarbon odours and black staining. No other VOC or SVOC were identified.

7.6 Acid Sulfate Soils

The results of the laboratory analysis of field pH (pH_F) and pH after oxidation (pH_{FOX}) indicate a high likelihood for the presence of acid sulfate soils given:

- The nature of the stratum within which the samples were collected (i.e. natural alluvium comprising grey to black low to high plasticity clay or dark grey medium, plasticity silty clay);
- The difference between the pH_F and the pH_{FOX} values; and
- The vigorous chemical reactions that were observed during field screening.

Based on these results and the site geology, Coffey considers that potential acid sulfate soil (PASS) is present in natural alluvium where it occurs below the water table within the site.

7.7 Soil Aesthetics

With reference to the adopted aesthetic criteria set out in Section 6.2, the table below provides a summary of the visual and olfactory indications of contamination found during Coffey's investigations. Odours and discolouration associated with natural alluvial soils are not included in Table 7.3.

Table 7.3: Visual and Olfactory Indications of Contamination

Location	Depth (mbgs)	Notes / Comment
BH4	2.3	Slight hydrocarbon odour. No staining observed.
BH10	1.1	Slight to Strong tar-like odour potentially associated with asphalt gravel encountered within the fill
BH11	0.7	Bitumen-like odour
BH119	0.33	Fibrous sheet, confirmed as bonded ACM encountered within fill material.

Location	Depth (mbgs)	Notes / Comment
BH124	3.0 – 5.6	Slight to moderate hydrocarbon odour. Black staining observed at 3.0mbgs.
BH128	2.0	Slight black staining.

In summary, anthropogenic inclusions were encountered throughout the fill materials on site. These included discrete ash layers, fibrous board (BH119 only) and fragments of concrete, brick, glass, metal and porcelain/ceramics. The borehole logs in Appendix C provide further detail on the location and depth of these specific observations.

A number of in-ground obstructions were also encountered and these are summarised in Table 7.4.

Table 7.4: Summary of Obstructions Encountered

Location	Depth (mbgs)	Description of Obstruction
BH1	0.1	Concrete slab approximately 0.5m thick.
BH6	0.5	Concrete slab 0.08m thick.
	0.7	Concrete slab 0.16m thick.
BH8	0.5	Asphalt and concrete slab (former pavement?) encountered.
BH9	0.8	Asphalt and concrete slab (former pavement?) encountered.
BH10	0.3	Concrete slab approximately 0.2m thick.
BH12	0.6	Concrete slab approximately 0.1m thick.
BH14	1.5	Concrete slab approximately 0.3m thick.
BH15	0.3	Concrete slab approximately 0.1m thick.
NBH23	0.2	Concrete slab approximately 0.1m thick.
BH121	0.6	Concrete slab. Borehole terminated and repositioned to BH121A.
BH125	1.1	Hard, unidentified surface encountered. Borehole terminated and repositioned to BH125A.
BH125A	0.9 - 0.95	Asphalt slab.
	1.0 – 1.15	Concrete slab approximately 0.15m thick.

Location	Depth (mbgs)	Description of Obstruction
BH129	0.5 – 1.0	Concrete slab approximately 0.5m thick.

7.8 Soils – Potential Ecological Risks

Tables 4 and 5 in Appendix D present a comparison of the soil analytical data against the EILs listed in Table 6.4. In summary, concentrations of arsenic, copper, lead, nickel, zinc, TPH C10-C14/C10-C16, TPH C15-C28/C16-C34 and Benzo(a)pyrene were reported in samples of fill materials at concentrations above the EILs adopted for this assessment. The potential risks to existing and proposed landscaping were considered further within the HHERA (summarised in Section 9).

7.9 Groundwater Contamination

Analysis of groundwater samples collected from across the site indicates a pH neutral, brackish to saline environment which is consistent with historical reclamation of the land and with the proximity of the site to Cockle Bay.

The results of laboratory analyses reported concentrations of dissolved organic compounds less than the investigation levels listed in Section 6.4. No Phase Separated Hydrocarbon (PSH) was observed in any of the monitoring wells.

Concentrations of PAH compounds were identified above the LOR in groundwater samples from MW9, MW25, MW30. Duplicate samples were collected from these boreholes and filtered in the field to remove fine sediment suspended within the groundwater sample as a result of sampling disturbance. Coffey notes that for the hydrogeological conditions in the water bearing zone on the site, groundwater in an undisturbed state is not expected to include fine suspended sediment. In summary, the analysis of filtered duplicate samples reported no detectable concentrations of these PAH compounds. This suggests that PAH compounds reported in unfiltered samples are attributable to the inclusion of fine suspended sediment rather than dissolved within the groundwater itself. On this basis, Coffey considers that groundwater in the vicinity of these wells is not impacted by dissolved PAH compounds.

Compounds including BTEX, VOC and SVOC were below the LOR. TPH C_6-C_9 was identified in one groundwater sample from MW120 at 30µg/L which is slightly above the LOR (20µg/L). On review of the soil results, TPH C_6-C_9 and other indicator compounds such as Benzene, Toluene, Ethylbenzene, Xylene were below the LOR in the seven soil samples collected from BH120 immediately prior to well construction. Furthermore, soil headspace readings ranged from 0.9ppm to 10ppm suggesting a low likelihood that volatile hydrocarbons are present within the soil.

Concentrations of TPH C_{10}-C_{14}, C_{15}-C_{28} and TPH C_{10}-C_{36} were also below the LOR in groundwater samples from across the site.

Results for groundwater quality obtained during three monitoring events showed that certain heavy metals were reported at concentrations above the relevant groundwater investigation levels (GILs), specifically:

- Copper and/or zinc concentrations exceeded the GILs in at least one sample in each of the four groundwater monitoring events.

- Lead and chromium (total) were reported in one sample from BH1 at concentrations slightly above the GIL of 4.4µg/L[10] (same for both metals). Lead and chromium were not detected in groundwater samples from other locations.
- Arsenic was recorded at concentrations slightly above the GIL of 2.3µg/L in samples from BH13, MW25 and MW120.

Given that these heavy metals are widely utilised in industry, slightly elevated concentrations in groundwater are a common occurrence in urban environments. The reported concentrations are considered to be representative of background levels in the locality of the site rather than being attributable to current and/or historical activity specific to the site.

In summary, Coffey concludes that groundwater from the site discharging to Cockle Bay is unlikely to detract from the relevant water quality objectives stated in the guideline (DEC 2007), and no groundwater contamination, which is considered significant enough to warrant detailed investigation or remediation, has been encountered.

Coffey note the following uncertainties associated with groundwater quality at the site:

- There has only been one round of groundwater sampling for recently installed monitoring wells; namely BH1, BH12, BH13, MW120. As such, the variability in groundwater quality at these locations remains uncertain.
- Monitoring well MW124 was reported 'dry' during the January 2013 monitoring event and given that the base of the well was at the top of sandstone, groundwater at this location appears to be in sandstone bedrock. Soils impacted with TPH and SVOC were reported at this location at depths below 2.9m. Groundwater quality in this part of the site remains uncertain.

[10] Coffey notes that the Chromium GIL relates to the more toxic hexavalent form of chromium, however chromium present in this groundwater sample is likely to comprise the less toxic Chromium (III). Furthermore, ANZECC/ARMCANZ (2000) indicates high sulfate concentrations make chromium toxicity unlikely, in marine and estuarine conditions. Whilst specific sulfate testing was not carried out as part of this investigation, the site falls within a reclaimed estuarine environment where ASS screening and Chromium Reducible Sulfur analysis indicate the presence of available sulfate within the alluvial deposits.

8 CONCEPTUAL SITE MODEL

8.1 Sources of Contamination

Based on the findings of recent ground investigations and discussion of contamination within each AEC presented in Section 7, the following presents a summary of the contamination identified:

- Widely distributed contamination, being -
    - PAH (and TPH) contamination encountered in unsaturated fill materials that potentially derive from the land reclamation activities and periodic redevelopment of the site over the past 150years.
    - Potential and actual acid sulfate soils derived within naturally occurring alluvial soils present along the former palaeochannel of Cockle Bay (i.e. Long Cove).
- Localised contamination within the site, including -
    - Localised TPH (as oil) contamination encountered at:
        a) NBH29 which is likely to have derived from historic land uses which may include the former City Market, hydraulic pumping station and/or Dixon Steam complex,
        b) BH124 – which may originate as off-site contamination which has moved preferentially beside a water intake conduit associated with the former Ultimo power station
        c) EB1 – which may be associated with historic spillages/leaks from within the former council depot.
    - Localised lead contaminated fill located at BH121A and BH126 that may be attributable to inclusions of rusted metal pieces, possibly as lead based paint, solder or plumbing material.
    - Semi-volatile hydrocarbon contamination encountered at BH124. A possible source of this contamination impact may relate to fill materials present at this location, or off-site impact from the adjoining former Ultimo Power Station
    - Semi-volatile hydrocarbon contamination encountered at BH128. No direct correlation has been identified with known historical land uses in this part of the site.
    - Bonded ACM and asbestos fines encountered in shallow fill materials at BH119 and BH13.

8.2 Exposure Pathways

The key environmental pathways and exposure routes by which contaminants identified at the site may reach environmental and human receptors are assessed to include:

- Ingestion of soils
- Dermal contact with soil
- Inhalation of dusts, vapours and fibres

- Infiltration and leaching from unsaturated soils to shallow groundwater
- Vertical and lateral contaminant migration through the saturated zone
- Contaminant migration along preferential flow pathways (e.g. existing service corridors, building foundations etc.)
- Surface runoff / overland flow
- Excavation dewatering (unlikely given shallow excavations less than 2m deep are intended for construction)

8.3 Receptors

8.3.1 Human Receptors

The redevelopment of the site will introduce the following receptors:

- Construction workers
- Future residents (high rise and student accommodation)
- Childcare centre user (located within upper floors of proposed development)
- Future workers within the retail/commercial premises on site
- Recreational user accessing the surrounding public realm
- Car park user
- Construction workers (future maintenance event)

8.3.2 Ecological Receptors

The primary ecological receptor currently identified in relation to the site is aquatic species within Cockle Bay, which is located approximately 475m north of the site. Groundwater within the fill and natural alluvium is considered to be hydraulically connected to Cockle Bay.

It is noted that stormwater drainage surrounding the site is also likely to discharge to Cockle Bay and potentially represents a preferential pathway between the site, particularly during the redevelopment of the site.

Landscaping currently present within the site, and planting introduced are also identified as ecological receptors.

8.4 Plausible Exposure Pathways

The followings sections present a discussion of the plausible exposure pathways associated with ground conditions recorded on site in the context of LLD's current site redevelopment concepts. Figure 14 presents a Conceptual Site Model which seeks to illustrate these plausible exposure pathways.

8.4.1 Human Health

Table 8.1 provides a summary of the plausible exposure pathways relevant to the human receptors identified above.

Table 8.1: Summary of plausible exposure pathways for human receptors

Receptor	Contaminated Media	Plausible Exposure Pathway (No Mitigation)				Comments
		Inhalation Indoors	Inhalation Outdoors	Ingestion	Dermal Contact	
Construction Workers during redevelopment	Soil	n	**P**	**P**	**P**	Workers during the redevelopment of the site and during future maintenance events may be exposed to contaminated fill materials via direct exposure routes, inhalation/ingestion of dust, and inhalation of vapours from SVOC identified within the site.
Construction worker (future maintenance event)	Soil	n	**P**	**P**	**P**	
Future residents (high density and student accommodation)	Soil	**P**	p	p	p	Based on the proposed development, the most significant pathway and complete pathway relates to the inhalation of vapours within the indoor air environment following occupation of the proposed buildings. Residents may also be exposed to contaminated fill materials via direct exposure routes and inhalation of dust in areas where soft landscaping is provided within publically accessible areas surrounding the proposed development. Similarly, retail/commercial workers and users of the child care centre may also be exposed to contaminated fill materials within the public realm, particularly where these users access this space during breaks or for recreation.
Childcare centre user (upper floors of proposed development)	Soil	**P**	p	p	p	
Retail/commercial Workers	Soil	**P**	p	p	p	
Car Park User	Soil	**P**	p	p	p	
Recreational Users	Soil	n	**P**	**P**	**P**	Following the redevelopment of the site, recreational users may be exposed to contaminated fill materials via direct exposure routes and inhalation of dust in areas where soft landscaping is provided within publically accessible areas. Inhalation of vapours from SVOC identified within the site may also occur in publically accessible areas.

Notes:

P = plausible complete pathways

p = partially complete pathway depending on site conditions/exposure scenario

n = pathway not complete

8.4.2 Ecological Receptors

Previous investigations have recorded concentrations of certain COPC in soil and groundwater samples above the adopted investigation levels. Soil leachate and impacted groundwater have the potential to adversely affect aquatic receptors within Cockle Bay.

Stormwater drainage surrounding the site is likely to discharge into Cockle Bay. The demolition of existing buildings and removal of surrounding hard paved surfaces during construction will expose soils.

During the construction period, surface water runoff from the site has the potential to carry soils into the surrounding stormwater system and discharge into Cockle Bay and may pose a potential risk to aquatic species in Cockle Bay.

Landscaping currently present within the site and planting introduced as part of the redevelopment of the site have the potential to be adversely affected by exposure to contamination within fill materials.

9 HUMAN HEALTH & ECOLOGICAL RISK ASSESSMENT

9.1 Overview

LLD appointed Environmental Risk Sciences Pty Ltd (EnRiskS) to prepare a Human Health and Ecological Risk Assessment (HHERA) for the proposed redevelopment of the site. The findings of the HHERA are presented in:

- EnRiskS (15 November 2013); *Site Specific Human Health & Ecological Risk Assessment – The Haymarket* (Rev. F - Final Site Specific HHERA for The Haymarket Planning Applications)

The HHERA was prepared using the investigation data presented within the reports listed in Section 1.7, and presents a site specific assessment of potential risks to human health and identified environmental receptors in the context of the development proposed by LLD. In summary, the HHERA considered the following exposure scenarios:

- Residential (high rise and student accommodation)
- Commercial/retail worker
- Recreational (open space)
- Car park user
- Construction workers undertaking intrusive ground works
- Other construction workers not directly involved with ground works
- Maintenance worker undertaking intrusive ground works post completion
- Aquatic organisms in Cockle Bay
- Plants in landscaped areas where trees will be planted into existing soil

9.2 Summary of HHERA Findings

9.2.1 Assessment of Potential Health Risks

The predictive modelling presented within the HHERA was based on a number of approaches and assumptions that are expected to result in a conservative estimation of risk. These assumptions included the following:

- The use of maximum soil concentrations recorded during the previous investigations and assumed that this maximum concentration existed at all locations across the site.
- The use of conservative exposure assumptions.

The predictive modelling presented within the HHERA concludes the following with regard to human receptors:

- Risks to construction workers who undertake intrusive works during the development of the site were assessed to be low and at an acceptable level. Similarly, risks to other construction workers (e.g. who undertake earthworks at the site for the first year of the project and are then involved in constructing the buildings) were assessed at an acceptable level.

- Risks to children and adults using the site for recreation and living in the apartments at the site were assessed to be low and acceptable.
- Risks to workers employed in retail/commercial areas on the ground floor or within the car parks as an attendant were assessed to be above acceptable levels. The unacceptable risks were predominantly attributable to the vapour inhalation pathway, with the dermal and ingestion pathways contributing approximately 15% of the total risk.

Site Specific Target Levels (SSTL) were derived to guide remediation of identified unacceptable risks. These SSTL have been adopted as remediation acceptance criteria in this RAP and are presented in Section 10.2.

9.2.2 Assessment of Potential Ecological Risks

The HHERA identified a number of PAH and heavy metals that were above screening levels for phytotoxicity. EnRiskS (15 November 2013) notes that most of the site will be covered by buildings or areas of hard paving, with two of the three areas currently allocated for soft landscaping already supporting vegetation which does not appear to be affected by soil contamination. On this basis, no specific remedial works are proposed to protect existing vegetation that will be retained by the development, or for vegetation introduced as part of the site redevelopment.

The HHERA concluded that the maximum levels of the contaminants in groundwater are low but are above water quality guidelines for some samples while the mean and median values are quite close or below the water quality guidelines (EnRiskS, 15 November 2013). EnRiskS notes that the site is approximately 475m from Cockle Bay and considers that groundwater will be sufficiently diluted by the tide by the time it reaches Cockle Bay.

EnRiskS also states that for current site conditions, groundwater quality does not appear to be impacted by the presence of contaminants in fill materials on the site. Consequently, changes to current site conditions resulting from redevelopment of the site are unlikely to have the potential to increase the risk to aquatic ecosystems in Cockle Bay. On the basis of the findings of the HHERA developed by EnRiskS, Coffey conclude that the remediation of groundwater at the site is not required.

10 REMEDIATION STRATEGY

10.1 Remediation Goal

Based on a detailed site-specific assessment of the nature, type and extent of contamination in the context of the development proposed by LLD, potential risks associated with contamination have been identified. The goal of the proposed remediation works is to make the site suitable for the proposed uses by mitigating potential unacceptable risks associated with contamination.

A further goal in implementing the proposed remediation works is to carry out the remediation works in a manner so as to minimise exposure risks to the public in the areas surrounding the site.

10.2 Key Stakeholders

The stakeholders directly involved in the remediation project are listed in Table 10.1.

Table 10.1: Remediation Project Stakeholders

Role	Organisation
Site Owner	**Sydney Harbour Foreshore Authority** Level 6, 66 Harrington Street The Rocks, Sydney NSW 2000
Developer	**Darling Harbour Live Consortium** **c/o Lend Lease Development Pty Ltd.** 30 The Bond, 30 Hickson Road Millers Point, Sydney NSW 2000
NSW Government Representative	**Infrastructure NSW** Level 15, 167 Macquarie Street, Sydney, NSW
Environmental Consultant	**Coffey Environments Australia Pty Ltd.** Level 19, Tower B, Citadel Towers 799 Pacific Highway, Chatswood NSW 2067 (or others nominated by Lend Lease Development Pty Limited)
Remediation Contractor	Contractor nominated by Lend Lease Development Pty Limited

10.3 Remediation Acceptance Criteria

10.3.1 Soils - Human Health Criteria

The HHERA was used to develop SSTL to mitigate identified potential unacceptable health risks. These SSTL have been adopted as remediation acceptance criteria (RAC) and are summarised in Table 10.2.

Criteria for asbestos contamination in soil have been adopted from Table 7 in Schedule B1 – Guideline on Investigation Levels for Soil and Groundwater (NEPC 1999).

Table 10.2: Remediation Acceptance Criteria (RAC)[1]

Chemical	RAC for Future Building Footprints[2]	RAC for Future Open Space[2]
Benzo(a)Pyrene TEQ	50mg/kg	20mg/kg
TPH C_{10}-C_{14}	360mg/kg [3]	360mg/kg [3]
TPH C_{15}+	2,300mg/kg [3]	2,300mg/kg [3]
Naphthalene	7mg/kg	Not limited
2-Naphthylamine	0.8mg/kg [4]	0.8mg/kg [4]
Bonded ACM [5,6]	No visible Bonded ACM in surface soils (top 0.1m), and not more than 0.04%w/w Bonded ACM in fill to a depth of 0.3m below level of construction disturbance	No visible Bonded ACM in surface soils (top 0.1m), and not more than 0.02%w/w Bonded ACM in the upper 1.5m of fill
Asbestos Fines / Fibrous Asbestos[5,6]	No visible fibrous asbestos and asbestos fines in surface soils (top 0.1m), and not more than 0.001%w/w fibrous asbestos and asbestos fines and no respirable asbestos fibres in fill to a depth of 0.3m below level of construction disturbance	No visible fibrous asbestos and asbestos fines in surface soils (top 10cm), and not more than 0.001%w/w fibrous asbestos and asbestos fines and no respirable asbestos fibres in the upper 1.5m of fill

Notes:

1. Other than for asbestos impact, adopted from the Site Specific Human Health and Ecological Risk Assessment for The Haymarket Planning Applications- (EnRisks, 15 November 2013). RAC are based on the conservative assumption that the contaminant concentration in soil exists at all locations across the site.
2. Includes construction workers and maintenance workers involved in shallow excavations up to 1m deep.
3. Assumes a 50/50 split between aromatic/aliphatic compounds, as discussed in Section 5.3 of the HHERA.
4. Single reported concentration in sample BH124: 4.6-4.8m bgs.
5. The vertical limits of asbestos assessment are based on Table 7, Sampling Methods for Evaluating Asbestos Contamination, in Schedule B2 of NEPC (1999).
6. Detailed assessment of asbestos impact would occur if a grid based site inspection by a competent environmental professional identified visual indications of asbestos impact, such as bonded ACM, fibrous asbestos or visible asbestos fines.

ASS and PASS have been encountered within the site. Specific guidance regarding the management of ASS/PASS for this site is provided within the Acid Sulfate Soil Assessment and Preliminary Management Plan (Coffey; March 2013). In summary, periodic screening of soil cuttings from remediation and other construction excavations to be screened for the presence of ASS using the field peroxide screening test based on methodology presented within Appendix I of the ASS Manual (ASSMAC; 1998). Soils with a pH of below 4, following oxidation with hydrogen peroxide will be managed as ASS.

10.4 Soils - Aesthetic Criteria

Section 3.6 in Schedule B1 of NEPC (1999) recommends that soils should not be discoloured, malodorous nor contain deposits of monolithic materials (e.g. steel, timber, concrete) or putrescible refuse. Given that anthropogenic materials within the fill materials have been found frequently, the following aesthetic criterion has been proposed for landscaped areas where existing site soils may be exposed at surface:

- No visible anthropogenic inclusions (e.g. bricks, concrete, metal, timber fragments, ash, bonded ACM, etc.), and no aesthetic impairment from discolouration of the soil or odours shall be present within surface soils in soft landscaped areas.

10.5 Location and Likely Extent of Remediation Required

10.5.1 Provisional Remediation Areas

To evaluate the location and extent of potential soil remediation works, available soil data were compared to the RAC presented in Table 10.2. This data comparison exercise is presented in detail in Tables 13 and 14 in Appendix D. Table 10.3 provides a summary of the location and the anticipated extent of remediation required to mitigate the potentially unacceptable human health risks identified.

Table 10.3: Assessed Location and Potential Extent of Remediation

Area	Contamination Type	Location (Depth)	Assessed Potential Extent
1	Benzo(a)pyrene TEQ Naphthalene TPH C_{15+}	EB1 (1.4-1.5m)	• Based on the investigation locations established surrounding EB1, the assessed potential lateral extent of impact is approximately 1600m^2 to 1700m^2. • Sample EB1 (2.0-2.1m) reported TPH C_{15+}, Benzo(a)pyrene TEQ and Naphthalene below the RAC. No samples were analysed from EB1 above 1.4m. Provisional remediation excavation depth assessed to be 2.0m
2	Benzo(a)pyrene TEQ	BH125 (0.3m)	• Based on the investigation locations established surrounding BH125, the assessed potential lateral extent of impact is approximately 100m^2 to 150m$^{2.}$ • Naphthalene was also identified at a concentration above the SIL, but below the RAC for Open Space.

Area	Contamination Type	Location (Depth)	Assessed Potential Extent
3	a) Bonded ACM b) Asbestos Fines	a) BH119 (0.33m) b) BH13 (1.5m) and BH13 (2.5m)	• A fibrous sheet containing chrysotile asbestos was encountered at BH119 (0.33mbgl). Soil samples taken from one interval above the sheet and two different intervals below did not report the presence of asbestos fines. • Asbestos fines were encountered as fibre bundles at location BH13 (approximately 5m north of BH119) at depths of 1.5mbgs and 2.5mbgs.
4	Benzo(a)pyrene TEQ	BH 11 (0.5m)	• Based on the few investigation locations surrounding BH11, the assessed potential lateral extent of impact is approximately 150m^2 to 300m^2.
5	Benzo(a)pyrene TEQ TPH C_{15+}	a) BH 10 (1.1-1.3m) b) BH 29 (0.4-0.5) c) BH 29 (0.9-1.0)	• The development plan indicates the Open Space may coincide with this impacted area. • Based on the investigation locations established surrounding BH10 and BH 29, the assessed potential lateral extent of impact is approximately 300m^2 to 450m^2. • Benzo(a)pyrene TEQ was reported above the Open Space RAC at BH 10 and BH 29 between approximately 1 and 1.5m below surface. TPH C_{15+} was reported above the Open Space RAC at BH 29 only in the upper 0.5m of fill.

The potential extent of soil remediation required for the site is shown in Figure 15. The horizontal and vertical extent of contamination may be extended from the assessed extents during excavation and validation works as sub-surface soils are exposed and assessed.

10.5.2 Impacted Area at Depth at BH 124

Coffey notes that TPH C_{10}-C_{14} and TPH C_{15+} were reported at concentrations that exceed the RAC in samples obtained from BH124 at depths between 2.9 and 4.8mbgl. This impact showed no reported TPH C_6-C_9 or naphthalene. Samples from the interval from the surface to 2.9mbgl reported all TPH fractions below the LOR. Coffey understands that the proposed development of this part of the site would comprise student accommodation on upper floors with ground floor space utilised for lobby/storage/service uses. As no basement structures are proposed for this building, and given the depth of this impact, Coffey considers that construction works should not disturb the impacted area in a way which might cause exposure of construction workers to contaminated soil nor materially change the location of the impact. Groundwater was not encountered within unconsolidated material in a monitoring well (MW 124) installed in the area.

EnRiskS (email communication with Coffey, 15 November 2013) provided a screening risk assessment relevant to the identified impact at BH124 for the proposed construction and future use of land west of

Darling Drive (specifically, referred to as Stage 3B in Figure 2) for student accommodation. This screening assessment assumes that the exposure scenario for this location can be changed from that assumed in the HHERA (EnRisks, 15 November 2013). Given the depth below surface of the soil with the identified levels of contamination at BH124, EnRiskS expects that construction workers will not be exposed directly to impacted soil as noted in the paragraph above. If there is no direct contact with impacted soil, then soil ingestion and dermal contact and dust inhalation pathways are no longer complete. Consequently, the vapour pathway remains the only complete exposure pathway. This means that exposure could still occur to TPH C_{10}-C_{14} but exposure to TPH C_{15+} is no longer possible for impacted soil at this depth.

Using the same vapour modelling setup as for the HHERA with a change of depth to soil contamination from 0.2 m to 3 m (based on no detected impact at 2.6m and detection at 2.9-3.0m), EnRiskS estimated concentrations in a room on the ground floor or first floor of the building as shown in Table 10.4.

Table 10.4: Vapour Intrusion Assessment for TPH Impact at 3m Depth in BH 124

Chemical	Concentration in soil	Vapour Concentration on first floor if contamination present at 0.2m below slab	Vapour Concentration on first floor if contamination present at 3m below slab	Vapour Concentration on ground floor (should work or retail areas be present) if contamination present at 0.2m below slab	Vapour Concentration on ground floor (should work or retail areas be present) if contamination present at 3m below slab
TPH C_{10}-C_{14} aromatic	315 mg/kg	0.029 mg/m^3	0.0081 mg/m^3	0.29 mg/m^3	0.081 mg/m^3
TPH C_{10}-C_{14} aliphatic	315 mg/kg	0.21 mg/m^3	0.059 mg/m^3	2.1 mg/m^3	0.59 mg/m^3

Using the above estimated indoor air concentrations based on vapour intrusion from contamination at 3m depth, EnRiskS estimated that the non-cancer human health risk for the vapour inhalation pathway dropped from 0.35 to 0.1 for the first floor apartments. Similarly, for the ground floor the risk reduced from 0.9 to 0.25. In all cases if there is no exposure via ingestion or dermal contact or dust inhalation EnRiskS considered that potential health risk posed by identified TPH impact at BH124 are low and acceptable.

10.5.3 Estimated Soil Volumes in Provisional Remediation Areas

Based on available investigation data and the expected lateral extent and depth of contamination, volumes of soil requiring remediation were estimated and are volumes are listed in Table 10.5. These volume estimates have inherent uncertainty due to reliance on interpolation of information between sampling points, limitations in field observations and investigation techniques (i.e. particularly with regard to Area 2 and soils impacted with ACM and Area 4 where surrounding data is sparse). Based on Coffey's experience, an uncertainty of plus or minus 30% in the volume estimates is not unusual.

Table 10.5: Assessed Potential Volume Estimates

Scenario	Assessed Potential Estimated Volumes (m^3) [1]	Assessed Potential Volume if uncertainty of -30% is observed in volume of material (m^3) UNDERESTIMATE Scenario	Assessed Potential Volume if uncertainty of +30% is observed in volume of material (m^3) OVERESTIMATE Scenario
Area 1 – soil impacted with TPH C15+, Benzo(a)pyrene and Naphthalene	3,400	2,380	4,420
Area 2 – soil impacted with Benzo(a)pyrene	50	35	65
Area 3 – soils impacted with bonded ACM and asbestos fines	400	280	520
Area 4 – soil impacted with Benzo(a)pyrene	125	90	160
Area 5 – soil impacted with TPH C15+ and Benzo(a)pyrene	600	400	800

Notes:

1. Based on estimated areas shown in Figure 15.

These volume estimates represent in-situ (bank) volumes. The volume of soil will increase following excavation by between 20% and 30%[11].

10.6 Remediation Options Assessment

Section 10.6 summarises remediation options that were considered for management of unsuitable soil materials in Provisional Remediation Areas. Section 12 describes a contingency plan for managing unexpected contamination that may be encountered in other areas of the site during construction activity. Section 12 also provides a management strategy for likely wide-spread asbestos impact in fill.

[11] The bulking factor does not allow for swelling that may result from absorption of rainfall, surface water or groundwater.

10.6.1 'Do Nothing' Approach

Given that the overall remedial goal is to make the site suitable for the proposed mixed uses, a 'do nothing' option is not considered to be acceptable as potentially unacceptable risks have been identified in relation to future retail/commercial workers on site.

10.6.2 Hazard Removal & Replace with Validated Site Derived Fill or Imported Materials

This option would comprise excavation of contaminated material that has chemical concentrations above the adopted remediation acceptance criteria and disposal of these materials to an appropriately licensed facility following appropriate classification according to NSW EPA guidelines. Excavation voids would then be backfilled to the extent required with validated fill obtained on site or imported materials.

The advantages of this option include the removal of the contaminant, eliminating the need for on-going management of the land, as well as reducing restrictions on future land use following remediation and validation. The disadvantages of utilising this option include increased costs and environmental impacts associated with waste transport and disposal, and importation of appropriate materials to backfill the void created by removal of contaminated soils.

10.6.3 On Site Treatment and Reuse

The treatment of contaminated soils could involve either ex-situ or in-situ techniques utilising biological, chemical and/or physical processes.

In-situ treatment techniques are likely to be less successful in treating organic contaminants within heterogeneous fill materials and given that some excavation is likely to be required for construction of foundations and the removal of in-ground obstructions, ex-situ treatment techniques are considered a more applicable approach to on-site treatment. In-situ treatment of ASS is not applicable.

Excavated materials could be beneficially reused as backfill following successful treatment and validation thereby offering cost and environmental benefits through the reduction of soils requiring offsite disposal. Volumes of fill required may be less than the volume of soil requiring remediation where earthworks are required for foundations, lift pits, service trenches etc. Furthermore, space and time constraints may also limit the applicability of some ex-situ treatment technologies in particular where staged occupation of the development is proposed.

10.6.4 Isolation of Contamination and On-site Management

Isolation of contamination may be achieved by a layer separating future site users on the surface of the redeveloped site from contact with contaminated material below the separation layer. It may comprise soils, road or pavement construction materials of a specified form and thickness, the ground slab for a building or other techniques such as geosynthetic barriers. On-site management refers to selective placement of materials in certain areas or below certain depths that would effectively mitigate human health risks.

Investigation data has indicated that soil contamination identified has low mobility as it does not appear to have adversely affected the quality of groundwater underlying the site. The potential health risks associated with the contamination identified within the site result from vapour inhalation (indoors) and direct exposure (i.e. ingestion/inhalation and dermal contact).

The redevelopment of the site will generally maintain hard surfacing which would effectively separate site users from existing fill materials. Selective placement of materials excavated from remediation areas, beneath buildings would isolate this contamination and thereby negate the need for an Environmental Management Plan (EMP) to manage exposure risks over the longer term.

Areas of soft landscaping could also be engineered to form a separation layer. This may comprise the placement of geotextile barriers to separate and reduce mixing of imported topsoil from the existing fill material. An EMP would be required to manage potential risks associated with possible future disturbance of the contained contamination where contaminated materials were to be placed in areas of soft landscaping.

10.7 Preferred Remediation Option

The preferred remediation option to address soils contaminated with hydrocarbons (Areas 1, 2, 4 and 5) and ACM (Area 3) is hazard removal. The primary factors considered during the appraisal of the options outlined above are as follows:

- Hazard removal provides improved confidence in remediation performance.
- Hazard removal will eliminate the need for longer term management measures
- Increased flexibility for the development as it progresses from concept to final design.
- Greater certainty in remediation work programme and cost plan, and potentially more suited to staged development and occupation across the site.
- The option would allow the site to be made suitable for the proposed mixed uses.

The preferred remediation option to manage ASS encountered during the remediation and redevelopment of the site is via ex-situ treatment on site using powdered lime ($CaCO_3$).

10.8 Sequence of Works

The remediation and site redevelopment works associated with the current Stage 2 development application comprises three distinct stages. Consequently, site establishment tasks may need to be undertaken on more than one occasion. Appendix E provides an overview of the plan for remediation for each development plot.

An indicative sequence of works is outlined in the following sections for the proposed soil remediation activities.

10.8.1 Preliminaries

Prior to any works commencing on the site, notifications to third parties and obtaining licences, approvals and permits (including asbestos impacted fill removal), will need to be undertaken. Further information regarding notifications, licenses, approvals and permits is presented in Section 14.

10.8.2 Site Establishment

This will include the establishment of (where relevant):

- work area fencing and temporary site facilities.
- Environmental monitoring and occupational health and safety controls.

- Stockpiling areas.
- Vehicular haul roads and transit routes onto and off the site.
- Location, isolation, relocation, protection and/or termination of services potentially affected by the remediation works.
- Demolition and removal of above ground structures, and removal of existing ground slabs and pavements, where required.
- Establish groundwater management and controls
- Establishing contingency planning and controls to address unexpected finds

As the remediation and site redevelopment works may be undertaken in several stages, site establishment tasks may need to be undertaken on several occasions.

10.8.3 Remediation Excavation – Area 1

Following demolition of the SEC car park, remediation excavation will be progressed vertically and laterally from investigation position EB1 to a depth of approximately 2mbgl (or as required to remove the contamination). Due to the established boundary conditions to the north of Area 1, the excavation will be terminated an appropriate distance south of the Pier Street off-ramp which will not pose a risk of subsidence to the road. Where required, ancillary works such as vertical excavation supports via means of shoring and other protections, temporary access arrangements and controls, environmental controls/monitoring, groundwater management systems/controls and the like would be established and implemented as part of the remediation works process. Excavated soils will be placed in designated stockpiling area (in conjunction with suitable environmental protection/control works) on site pending waste classification and disposal, or may be loaded directly into trucks for disposal using waste classification from available results.

The remediation excavation will be monitored by an appropriately qualified environmental engineer for visual and olfactory indications of contamination. The excavation will be progressed to an extent where soil materials can be validated against the criteria set out within Table 10.2.

Based on available groundwater level data obtained from MW120 (located approximately 40m southeast of EB1), groundwater was observed at a depth of 1.9mbgl with no discernible variation due to tidal influence. On this basis, it is currently considered unlikely that dewatering of the remediation excavation will be required, although some localised water management may be necessary pending the actual extent of the contamination and to further facilitate validation of the excavation.

10.8.4 Remediation Excavation – Area 2

Following demolition of structures attached to the western side of the SEC building, remediation excavation will be progressed vertically and laterally to the extent practicable from investigation position BH125 to a depth of approximately 0.5mbgl (or deeper if required to remove the contamination). No ancillary works such as shoring or dewatering are expected to be required as part of the remediation works in Area 2. Excavated soils will be placed in a designated stockpiling area (in conjunction with suitable environmental protection/control works) on site pending waste classification and disposal, or may be loaded directly into trucks for disposal using waste classification from available results.

The remediation excavation will be monitored by an appropriately qualified environmental engineer for visual and olfactory indications of contamination. The excavation will be progressed to an extent where soil materials can be validated against the criteria listed in Table 10.2.

10.8.5 Remediation Excavation – Area 3

Both bonded ACM and asbestos fines were identified in samples of fill material recovered from two investigation locations in the south-western corner of the site; namely BH119 and BH13 which are approximately 10m apart. During drilling works at BH119, a bonded ACM, as a sheet of building material, was observed at 0.33mbgl. No suspected bonded ACM was observed in BH13. An appropriately licensed contractor with a permit to removed asbestos materials or asbestos impacted soils (as applicable) would be engaged to supervise asbestos removal work in Area 3. The area around BH119 will be excavated to expose bonded ACM for removal taking care not to break up the ACM and potentially cross contaminate surrounding fill material.

The lateral extent of bonded ACM is uncertain and the area immediately around the known occurrence of bonded ACM will be investigated under the guidance of an appropriately qualified and experienced professional and supervision by an appropriately licensed asbestos removal contractor. Coffey considers that removal of bonded ACM in Area 3 may only become practical once the SEC has been demolished. Bonded ACM will be removed (i.e. via hand picking or additional excavation) to the extent required to satisfy Remediation Acceptance Criteria (RAC) in Table 10.2.

Fill impacted with asbestos fines was also encountered at location BH13 (approximately 10m north of BH119) at depths of 1.5mbgs and 2.5mbgs. The remediation excavation resulting from removal of bonded ACM will be extended (if not already in that vicinity) and will be deepened sufficiently to demonstrate that RAC are satisfied.

The remediation excavation will be extended at BH13 to depths of 2.5mbgl (or deeper if required). Soil materials from the excavation will be observed for the presence of fibrous materials / asbestos fines. The excavation will be extended laterally until no visible fibrous materials / asbestos fines are evident, and to an extent where soil materials can be validated for asbestos fines (as fibres in soil) against the criterion set out in Table 10.2.

Following asbestos removal from Area 3, validation sampling and analysis will occur to demonstrate that compliance with RAC. Sampling methods will be consistent with those recommended in of Schedules B1 and B2 of NEPC (1999).

Fill materials excavated from this area shall be stockpiled separately and covered. These materials will be classified as waste prior to removal to a licensed disposal facility.

Ancillary works such as air monitoring, vertical excavation supports via means of shoring and other protections, temporary access arrangements and controls, environmental controls/monitoring, groundwater management systems/controls and the like would be established and maintained as part of the remediation works in Area 3. Appropriate dust suppression measures must be used by the licensed contractor during the excavation works, which may include wetting of soils using water/surfactant mix and/or the erection of protective enclosures under negative pressure.

10.8.6 Remediation Excavation – Area 4

Following demolition of the SEC building, remediation excavation will be progressed vertically and laterally from investigation position BH11 to a depth of approximately 0.5mbgl (or deeper if required to remove the contamination). No ancillary works such as shoring or dewatering are expected to be required as part of the remediation works in Area 4. Excavated soils will be placed in a designated stockpiling area (in conjunction with suitable environmental protection/control works) on site pending waste classification and disposal, or may be loaded directly into trucks for disposal using waste classification from available results.

The remediation excavation will be monitored by an appropriately qualified environmental engineer for visual and olfactory indications of contamination. The excavation will be progressed to an extent where soil materials can be validated against the criteria listed in Table 10.2.

10.8.7 Remediation Excavation – Area 5

Following demolition of the SEC building, remediation excavation will be progressed vertically and laterally to the extent practicable from investigation positions BH10 and BH29 to a depth between 1.0m and 1.5mbgl (or as required to remove the contamination). Ancillary works such as shoring or benched excavation may be required as part of the remediation works in Area 5. Excavated soils will be placed in a designated stockpiling area (in conjunction with suitable environmental protection/control works) on site pending waste classification and disposal, or may be loaded directly into trucks for disposal using waste classification from available results.

The remediation excavation will be monitored by an appropriately qualified environmental engineer for visual and olfactory indications of contamination. The excavation will be progressed to an extent where soil materials can be validated against the criteria listed in Table 10.2.

10.8.8 Soil Stockpiling and Waste Classification

As required, soils excavated from the remediation areas will be stockpiled in areas designated by the appointed contractor for assessment for waste classification purposes. Attempts will be made to segregate cleaner soils from those which exhibit indications of hydrocarbons or probable forms of asbestos.

Suitable environmental controls to prevent spread of contaminated material, including movement as dust or suspended solids in stormwater runoff, will be implemented as part of the works. An overview of soil management practices is provided in Section 13.

Waste classification and management procedures are discussed in detail in Section 16.

10.8.9 Management of Acid Sulfate Soils

ASS may be encountered in deeper excavations, where it is necessary to extend these excavations into natural alluvial soils. Specific guidance on the management ASS at this site is provided within the Acid Sulfate Soil Assessment and Preliminary Management Plan (Coffey; March 2013).

In summary, the ASS Management Plan requires periodic screening of excavated alluvial soil from remediation works and construction activity for the presence of ASS using the field peroxide screening test based on methodology presented within Appendix I of the ASS Manual (ASSMAC; 1998). Soils with a pH below 4, following oxidation with hydrogen peroxide will be managed as ASS.

Excavated soils managed as ASS will be placed in a specially prepared treatment pad for treatment via application of lime to the soil. Typically, lime will be applied to the soil by hand or light weight truck followed by mixing using light weight rotovators or similar tools.

10.8.10 Offsite Disposal

Stockpiled soils will be transported offsite for disposal at landfill licensed to accept the classified waste.

10.8.11 Backfilling

The excavation resulting from the remedial works will be backfilled under appropriate engineering controls with material that meets the minimum quality requirements set out within Table 10.2 or Section 11.4 where materials are imported to backfill remediation excavations.

11 VALIDATION PLAN

11.1 Soil Validation Objective

The intent of the soil validation works is to collect suitable and adequate data to assess whether the following key remediation objectives have been achieved; namely:

a) that the potential risks associated with the identified areas of unacceptable contamination have been mitigated to an acceptable level, and

b) the site has been made suitable for development for the proposed uses.

11.2 Validating Remediation Excavations

The intent of the remediation validation works is to collect suitable data to assess whether the RAC outlined in Table 10.2 have been achieved.

The excavation works will be monitored by an appropriately qualified environmental consultant. The base and walls of the excavations will be assessed for visual and olfactory evidence of potential contamination. PID screening of residual soils may be undertaken where hydrocarbon contamination has been identified.

Samples will be collected from the base and walls of the remediation excavation, using the following sampling densities:

- Base – at least 1 sample from the base or one sample per $25m^2$
- Walls – at least 1 sample per wall or 1 sample per 10 linear metres. Collection of samples at multiple depths at each sampling point should be considered, based on visual, olfactory and PID screening results.

The location and depth of validation sampling locations will be recorded and presented within the Validation Report. Where appropriate, photographs will also be taken to provide a visual indication of soil conditions at the extent of the remediation excavation.

Validation for potential asbestos impact in fill on a site-wide basis is discussed in Section 12.4.

If a soil excavation surface is considered to be aesthetically impacted or the validation sample analytical results do not satisfy the RAC, then additional soil will be excavated, until aesthetic quality is acceptable and/or validation results of the soil surface satisfy the RAC.

11.3 Reuse of Soils Derived from Remediation Areas

Selected soil materials derived from Remediation Areas 1, 2, 4 and 5 may be used as fill material within the site. Soil materials derived from Remediation Area 3, and any other remediation area impacted with asbestos will not be used as fill material within the site.

Materials proposed for reuse will be sampled to assess the chemical quality to demonstrate that these materials meet the required reuse criteria. The frequency of sampling and chemical testing of soil materials proposed for reuse shall be a minimum of one sample and associated testing per $100m^3$ of each material type, to demonstrate compliance with reuse criteria set out below, and a minimum of 6 tests per stockpile.

Chemical reuse criteria need to consider the COPC identified in Section 4.2. It is proposed that soil samples collected from soils proposed for reuse within the site are screened against the corresponding HIL and HSL presented within Tables 1A(1), 1A(2) and Table 7 within in Schedule B1 of NEPC (1999). This assessment process would be used to guide the applicability of placing certain materials within areas proposed for particular land uses (e.g. soils that report concentrations of Lead that exceed the Residential HIL would not be used in areas designated for residential or public open land uses but may be used beneath buildings designated for retail/commercial uses). Where concentrations of COPC exceed the HIL/HSL, further consideration of the RAC presented in Table 10.2 would be undertaken, or implementation of aspects of the unexpected finds protocol presented in Section 12.

The volume and placement location(s) of validated fill material from the Remediation Areas will tracked using a materials tracking register developed by the contractor. These records will be presented within the Validation Report.

11.4 ASS Validation

With regard to ASS, the Preliminary Acid Sulfate Management Plan (Coffey, March 2013) requires validation sampling to be carried out prior to reuse of these materials as backfill on site. If liming is carried out, validation testing would comprise one sample per $250m^3$ to be analysed using the field peroxide screening test, with at least 10% of these samples analysed using the chromium reducible sulfur (S_{CR}) test

The volume and placement location(s) of validated fill material will tracked by the contractor using a materials tracking register. These records will be presented within the Validation Report.

11.5 Imported Fill Validation

11.5.1 Imported Fill Acceptance Criteria

Where imported fill material is required to supplement site derived materials to establish the proposed construction formation level, materials imported to site must be either:

- Virgin Excavated Natural Material (VENM), or
- Excavated Natural Material (ENM) and subject to the specific requirements stipulated within the Excavated Natural Material Exemption (NSW OEH, 2012), which has been summarised below:

Prior to importing material to site, the following fill sampling plan will be implemented:

- A visual inspection of the source site and the proposed fill material (must be exposed); and
- Collection and laboratory analysis of the minimum number of samples of the fill material per source, as required by the Sample Design Guidelines (NSW EPA; 1995) or Excavated Natural Material Exemption (NSW OEH, 2012), whichever is greater.

Where ENM is imported to site as fill the Generator must provide a written statement of compliance that this material complies with relevant conditions of the ENM general exemption, and shall provide a copy of the relevant sampling plan and test results for the imported ENM.

The source site, volume, associated chemical test certificates and placement locations of the imported fill material will be tracked by the appointed contractor. These records will be presented within the Validation Report.

11.5.2 Imported Fill Reporting

Subject to receipt of adequate VENM certification documentation from the appointed contractor, the environmental consultant will advise the contractor and LLD of the suitability of the material (from a contamination perspective) for importation to the site.

It is noted that other non-contamination related criteria may also need to be met (e.g. engineering or geotechnical requirements) although such is considered beyond the scope of this document.

11.5.3 Imported Fill Tracking

The source site, volume and placement location(s) of the imported fill material will tracked by the contractor. These records will be presented within the Validation Report.

11.6 Validation Plan for Open Space Areas

Open space areas comprise those areas within the site which fall outside of the footprint of the proposed buildings. Open space areas include areas which are covered with hard surfaces (i.e. block paving, road pavement etc.) or landscaped areas. Landscaped areas may comprise areas that are introduced as part of the development, or existing landscaped areas which are retained.

11.6.1 Validation Sampling Plan for Open Space Areas

Soil samples will be collected from relevant in-situ materials[12] to demonstrate that areas of open space are suitable for use. These samples shall be collected from two discrete depths; namely near surface (0.0-0.2m) and deeper soils (0.8-1.0m). The sampling depths proposed consider both members of the public and workers using open space areas, and construction/maintenance workers involved in shallow excavation works in open space areas.

Samples will be analysed to enable validation against the SSTLs for TRH, PAHs and forms of asbestos.

As a guide, soil samples will be collected on a regular 10m by 10m grid although the sampling density shall be adjusted to ensure that a sufficient number of samples are collected from each open space area to provide a dataset that is commensurate with the site use, and enables comparison with the SSTLs which can be supported by statistics, where appropriate.

11.6.2 Validation of Aesthetic Criteria - Visual Inspection Protocols

To verify that the open space areas meet the aesthetic criteria set out within Section 10.4, an inspection shall be carried out by the environmental consultant of the soils exposed in these areas prior to establishment of paving, planting or turf introduced as part of the proposed development. This visual inspection shall record the condition of the shallow soils exposed in these areas using photographs correlated with a summary of any observed visual or olfactory indications of contamination.

[12] Relevant in-situ materials comprise existing site soils that will remain in-situ following development. The validation plan for topsoil and/or engineered fill materials imported to site is provided in Section 11.5.

To the extent practicable, validation of existing fill materials for possible presence of asbestos impact will occur as described in Section 12.4.4 and chemical characterisation of fill samples selected using professional judgement will also occur.

12 DATA GAPS, UNCERTAINTIES & CONTINGENCY PLANNING

12.1 Data Gaps & Uncertainties

The site has been subject to numerous assessments and programmes of investigation to characterise the site history and identify and delineate areas of the site that have been affected by contamination. Following the review of the available site history information and investigation data, the following potential data gaps and uncertainties have been identified:

- The presence of potentially unidentified contamination between investigation positions, or in areas where limited investigation data is currently available.
- Potential for additional asbestos impacted soils.
- Presence of potentially unidentified structures or conduits that contain deleterious materials.
- Potential variability in groundwater quality, where monitoring wells have been sampled on one occasion (e.g. BH1, BH12, BH13, BH120).
- Groundwater quality in the vicinity of BH/MW124.

The above data gaps and uncertainties have been used to develop the Unexpected Finds Protocol presented in Section 12.2, to assess the potential for escalation of level of identified contamination (Section 12.3) which currently does not warrant remediation, and to develop the Management Strategy for Possible Asbestos Impact in Fill presented in Section 12.4.

12.2 Unexpected Finds Contingency Plan

12.2.1 Management of Unexpected Finds

Should unexpected contamination or aesthetically unacceptable material be encountered onsite as assessed by the environmental consultant monitoring the remediation activities, works will stop in the affected part of the site. This area will be isolated to minimise potential for disturbance to the affected soils. The sub-contractors on site, the environmental consultant and LLD will be notified immediately of the unexpected find.

Due to the potential variability in both the nature and extent of an unexpected find, it is not considered reasonable to define specific remedial strategies for contamination associated with the unexpected find. However, it is considered reasonable to follow the preferred method for remediation option assessment, as that presented in Section 10.7. Assessment and management of unexpected finds will be subject to Site Auditor review.

If wastes are likely to be generated as a result of managing unexpected finds, a methodology for waste classification is presented in Section 16.

An outline of some potential unexpected finds, including the initial response process, is presented in Section 12.2.4.

12.2.2 Training and Induction of Personnel

Personnel involved in earthworks on site are to be inducted on the identification of potential unexpected finds and asbestos awareness. The induction can be undertaken at the time of general site induction and refreshed periodically at toolbox meetings.

Induction to provide awareness of all types of possible unexpected finds is not practicable. In general, a precautionary approach will be employed and the unexpected finds procedure outlined in the following section will be implemented.

Additionally, it is noted that some forms of potential contamination may not be associated with any visual or olfactory indications in the field. The unexpected finds procedure will not provide protection against such impacts.

12.2.3 Unexpected Finds Procedure

Should an unexpected actual or suspected contamination be encountered during the development works, the following procedure applies:

1. Stop work in the potentially hazardous area as soon as it is safe to do so and move to the upwind side of the area, or away from the area.
2. Assess the potential immediate risk to human health posed by the unexpected find and assess if evacuation or emergency services need to be contacted.
3. Delineate an exclusion zone around the affected area using fencing and/or appropriate barriers and signage. Additional control measures may be required for odours and/or volatile compounds: odours suppression and no smoking signage.
4. Contact the appointed environmental consultant for advice and request a site visit to undertake an assessment of the unexpected find. The Site Auditor should be informed of the find once a preliminary assessment is made.
5. The environmental consultant will assess the unexpected find and provide advice regarding:
   a) Preliminary assessment of the contamination and need for immediate management controls;
   b) What further assessment and/or remediation works are required and how such works are to be undertaken in accordance with contaminated site regulations and guidelines;
   c) Preparation of an addendum to the remediation action plan (if necessary) or provide clean up advice;
   d) Remediation works required (where applicable);
   e) Validation works required following remediation works (if applicable).
6. Works are not to recommence in the affected area until appropriate advice has been obtained from the environmental consultant and the environmental consultant has provided relevant information to the Site Supervisor, particularly for considering change to the Site Safety Plan.
7. If it is deemed safe to do so by the Site Superintendent, works may resume in the affected area.

12.2.4 Potential Unexpected Finds

Based on findings of previous investigations and site history, potential unexpected finds which could reasonably be expected within the site are summarised in Table 12.1.

Table 12.1: Summary of Non-specific Unexpected Finds

Potential Unexpected Find	Observed Characteristic	Key Contaminant of Concern
Buried dry waste materials	May include a variety of waste materials including wood, plastic, metal fragments, building rubble (e.g. concrete, brick, asphalt, forms of asbestos etc.).	Heavy metals, TPH, PAH, forms of asbestos
Buried putrescible wastes	Putrescible waste materials typically comprise decomposed organic waste materials intermixed within the fill materials on site, with an associated characteristic rotten egg type odour. Such materials should not be confused with decomposed plant matter found within the natural alluvial soils.	Nutrients, gaseous emissions (CH_4, CO_2, H_2S)
Structures or conduits containing deleterious materials	Could be identified as follows: • A buried tank or former process pipelines; • Deeper sand fill sometimes with visual/olfactory indications of contamination • Presence of small concrete footings surrounding by odorous of visually impacted soils and/or groundwater.	TPH, BTEX, PAH, lead
Ash or slag deposits	Ash materials typically light weight, grey and white sand and gravel sized (1mm to 10mm) particles. Slag materials can be varied in consistency and colour and may comprise pale grey to blue/green/grey, and be loose or cemented. Slag gravels can be very angular and appear to have a vesicular (i.e. ‘honeycomb’) shape.	PAH, heavy metals
Hydrocarbon Compounds	May be identified by a hydrocarbon odour which may vary in strength from weak (just detectable) to very strong (easily detectable at a distance from the source). The odour may or may not be accompanied by specific areas of dark staining (black-grey) or larger scale discolouration of strata from a previously identified ‘natural colour’ e.g. staining of orange and brown clay to dark grey and green. May also be visible as a distinct coloured sheen on water within an excavation.	TPH, BTEX, PAH, lead
Other unusual odours	• Solvent odour • Acetone odour • Alcohol odour • Sulfur (rotten egg) odour (possibly associated with ASS)	Various

Potential Unexpected Find	Observed Characteristic	Key Contaminant of Concern
	• Acidic (Acetic/Formic/Citric) odour. • Ammonia odour • Caustic odour	

12.3 Localised Contamination - Known

Previous investigations have identified several areas of the site where soil contamination has been identified although the final extent of this contamination remains uncertain. Effect on groundwater quality at a localised scale of several metres is uncertain however available results do not indicate an increase in impact with groundwater flow through the site. Known localised contamination areas are summarised in Table 12.2.

Table 12.2: Summary of Known Localised Contamination

Sampling Location	Type of Impact	Likely Occurrences	Contaminants of Concern
BH124	Hydrocarbon compounds in soils	Contamination was identified at 2.9mbgl in this area. The suspected source of this contamination related to an abandoned intake conduit associated with the former Ultimo Power Station, which may have acted as a preferential pathway. Groundwater quality in this area of the site also remains uncertain. It is possible that evidence of hydrocarbon impacted soils will be encountered in areas along the former intake conduit (where this remain in-situ) and associated pipe bedding materials. Groundwater impacted by hydrocarbons may also be present in areas to the north (i.e. down hydraulic gradient).	TPH, BTEX, PAH, SVOC
NBH29 BH10 CBH11	Hydrocarbon compounds in soils	Contamination was identified at depths between 0.9mbgs and 1.3m below ground surface. The lateral extent of this contamination could not be delineated in the southern direction beneath the SEC.	TPH, PAH
BH128	Hydrocarbon compounds in soils	An isolated occurrence of 4-Nitrophenol (an SVOC) was located at BH128 at depths between 2.9-3.0mbgl. The source of impact remains unknown but may relate to a historic discharge associated with the former city market place or council depot. The vertical extent of SVOC impact at BH128 in soils below 3.0m, and groundwater quality in this area also remains uncertain.	SVOC (TPH, PAH)
BH121A	General demolition	Pieces of metal were observed in clayey fill material together with pieces of concrete, stone, brick and ceramics. This fill material is approximately 1.5m thick and was placed over natural alluvium.	Lead

Sampling Location	Type of Impact	Likely Occurrences	Contaminants of Concern
	waste	Reported concentrations of TPH and PAHs indicated that ash was also present in this layer of fill.	
BH119 BH13	Bonded ACM and asbestos fines in soil	Bonded ACM and asbestos fines were encountered in BH119 and BH13 respectively. Bonded ACM was encountered as a distinct fibrous board at 0.33mbgl during drilling. The lateral extent of this material is unknown. Asbestos fines were encountered at depths of 1.5m and 2.5mbgl at BH13. It remains uncertain whether the source of these fines relate to the bonded ACM encountered at BH119 (approx. 10m south)	Bonded ACM and asbestos fines
ASS and PASS	Acidification of soils	ASS and PASS have been identified in natural alluvial soil at the site. Alluvial materials may be encountered during deeper excavations. The location and extent of these excavations is unknown at this time and guidance on the management of ASS/PASS is provided within the Acid Sulfate Soil Assessment and Preliminary Management Plan (Coffey; March 2013)	ASS and PASS

12.4 Management Strategy for Possible Asbestos Impact in Fill Material

12.4.1 Nature of Possible Asbestos Impact

The long history for the site of uncontrolled land reclamation, use of the site for various commercial and industrial activities and the demolition of historical buildings which almost certainly included asbestos cement building materials indicates that asbestos impact is likely to occur widely in fill materials. Constraints on investigation precluded the use of excavations which are a preferred method of asbestos assessment in fill (Table 7 in Schedule B2 – Guideline on Site Characterisation; NEPC 1999), and information is only available from boreholes.

Historically, asbestos was a component of many building materials, such as sheets used for cladding (fibrolite), corrugated roofing (Super 6), electrical switch boards, asbestos cement pipes and vinyl tiles. The function of asbestos in these products was generally to provide tensile strength and this mineral was also resistant to weathering. Modifications to and demolition of buildings in which asbestos cement products were used commonly resulted in shattering of materials to reduce the bulk of the waste material. Much of the waste was removed from the site to landfill, or for use as general fill at another location. Inevitably, fragments of asbestos cement material remained to form the typical wide-spread occurrence of asbestos impact observed on many historically filled sites, such as the Haymarket precinct.

Because of the wide-spread but scattered nature of asbestos impact in fill, the approach to asbestos management used in buildings is not amenable to fill material. This situation is compounded by the fact that most occurrences remain hidden in the sub-surface.

If site inspection by a competent environmental professional identifies visual indications of asbestos impact in fill materials, then detailed assessment of the impacted area will be undertaken in accordance with Schedule B2 of NEPC 1999 under control of a safe work management plan specific to that identified area. The management of asbestos impact is discussed in following sections.

12.4.2 Approach to Management of Possible Asbestos Impact in Fill Material

The approach to management of possible asbestos impact in fill material for this RAP is to provide sufficient information to establish appropriate controls and/or mitigation for protection of health of construction workers and to demonstrate that any remaining asbestos impact in fill does not pose an unacceptable health risk to the proposed future use of the site. Development of the site will result in two potential exposure scenarios:

1. Building footprints which are accessible to a controlled group only during the construction period; and
2. Open space which is accessible to a controlled group only during the construction period and is accessible to the general public and maintenance workers after the construction period.

Coffey reasonably assumes that after buildings are constructed within the site, that the fill material beneath those buildings will not be accessible during future normal use and maintenance of those buildings. Thus, the potential receptors are construction workers on those building sites and the commercial/industrial exposure scenario identified in Table 7, Health screening levels for asbestos contamination in soil (Schedule B1, NEPC 1999), is considered by Coffey to be applicable.

In areas designed for future use as open space, controlled access applies only during the construction period, which is followed by uncontrolled access, including possible shallow excavation of the subsurface for services installation and/or maintenance.

12.4.3 Management of Possible Asbestos Impact in Fill Material within Building Footprints

For each building footprint, management of possible asbestos impact within that particular construction area will comprise:

- Grid-based inspection of exposed areas by a competent environmental professional.
- More than one inspection would occur when excavation resulted in materials being exposed over a period of more than a few days.

If potential asbestos impact is identified during the inspection, then:

- Assessment of the occurrence of asbestos impact across the area to a depth of at least 0.3m below the applicable depth of construction disturbance, or the base of fill material (whichever is shallower). Assessment will be consistent with that described in Section 11.3 of Schedule B2 – Guideline on Site Characterisation (NEPC 1999). The sampling density will not be less than that generated by points on a 10m square grid and will be modified according to the shape of the construction area.
- Assessment will use trenching or test pits to expose the subsurface at sampling locations. If Bonded ACM (or friable asbestos) is observed, then assessment of percentage by weight will be made using a 10 litre sample. At each sampling location, a 0.5 litre sample of fill will be

collected for analysis of asbestos fines by the method described in AS 4964-2004. This procedure is consistent with that described in Section 11.3.2 in Schedule B2.

- Assessment of potential risk to health of construction workers will refer to relevant screening criteria listed in Table 10.3.
- Reduction of any unacceptable risk to health of construction workers through removal and/or isolation of hazardous material under the supervision of an appropriately licensed contractor with a permit for asbestos removal on the site (or affected part) and with appropriate air monitoring around the asbestos removal area. Validation of the affected area after removal of asbestos impacted fill will be in accordance with the asbestos assessment procedure described above.
- Provide asbestos awareness training to construction workers as part of site induction.
- Record occurrence of forms of asbestos identified within the building footprint and track asbestos impacted waste materials to demonstrate proper off-site handling of this material.

12.4.4 Management of Possible Asbestos Impact in Fill Material within Open Space Areas

Within future open space areas, management of possible asbestos impact within that particular construction area will comprise:

- Grid-based inspection of exposed areas by a competent environmental professional.
- More than one inspection would occur when excavation resulted in materials being exposed over a period of more than a few days.

If potential asbestos impact is identified during the inspection, then:

- Assessment of the occurrence of forms of asbestos across the area to a depth of at least 1.5m below the design surface level or 0.3m below the depth of construction disturbance (whichever is deeper), or the base of fill material (if shallower than the former depth limit). Assessment will be consistent with that described in Section 11.3 of Schedule B2 – Guideline on Site Characterisation (NEPC 1999). The sampling density will not be less than that generated by points on a 10m square grid and will be modified according to the shape of the construction area.
- Assessment will use trenching or test pits to expose the subsurface at sampling locations. If Bonded ACM (or friable asbestos) is observed, then assessment of percentage by weight will be made using a 10 litre sample. At each sampling location, a 0.5 litre sample of fill will be collected for analysis of asbestos fines by the method described in AS 4964-2004. This procedure is consistent with that described in Section 11.3.2 in Schedule B2.
- Assessment of potential risk to health of future users of open space areas, including maintenance workers involved in shallow excavation, will refer to relevant screening criteria listed in Table 10.3. Coffey notes that these health screening criteria are conservative for construction workers.
- Reduction of any unacceptable risk to health of future users of open space areas through removal and/or isolation of hazardous material under the supervision of an appropriately licensed contractor with a permit for asbestos removal on the site (or affected part) and with appropriate air monitoring around the asbestos removal area. Validation of the affected area

after removal of asbestos impacted fill will be in accordance with the asbestos assessment procedure described above..

- Provide asbestos awareness training to construction workers as part of site induction.

12.4.5 Asbestos Screening for Re-use of Fill Material derived On-site

Before ground is disturbed for construction, possible presence of forms of asbestos will be assessed as described above. If excavated material is considered for re-use on any part of the site, then the results from asbestos assessment will be compared to health screening criteria relevant to the location proposed for re-use of that fill. Validation for other chemical and aesthetic characteristics of material proposed for reuse will also occur.

12.4.6 Reporting

Outcomes of implementation of this Management Strategy for Possible Asbestos Impact in Fill Material will be included in the Remediation and Validation Report.

13 SITE MANAGEMENT FOR REMEDIATION WORKS

13.1 General

The contractor appointed to carry out remediation works will prepare and implement a plan for Site Management for Remediation Works (SMRWP) that addresses environmental risks associated with the remediation. The SMRWP should address the following aspects:

13.1.1 Access Control

Access to the site will be restricted to authorised staff and contractors who have been inducted and appropriately trained for the works being undertaken. It is envisaged that the remediation contractor will control site access.

A fence or hoarding will be installed and maintained around the perimeter of the site.

Signage, including remediation contractor details and contact numbers, will be erected near the access gate to the site. The signage will remain displayed on the site entrance throughout the duration of the remediation works.

13.1.2 Water Management

In order to minimise the need for treatment/disposal of potentially contaminated surface water from excavations, the contractor will implement controls to divert surface water away from open excavations as part of the remediation works. The contractor's diversion of surface water should not disrupt existing operations within the site or contribute to adverse impacts to adjoining land. Groundwater ingress may also occur during excavation works and based on available groundwater quality data, these waters would require treatment to reduce suspended sediment (and possibly, dissolved chemicals) prior to disposal to sewer or stormwater connections. Management options for water include:

- pumping, transport and disposal offsite at a licensed liquid waste facility;
- on-site treatment and discharge to Cockle Bay via stormwater connections to a criteria acceptable to an approved by the relevant authorities; or
- on site treatment and discharge to sewer under a trade waste agreement to a criteria acceptable to an approved by the relevant authorities.

As the site redevelopment process is likely to occur in stages, and varying constraints placed on the stormwater/sewer network, one or more of the above options may not be available during a particular period of the project. For these reasons, LLD has not finalised a preferred water management option.

At this stage, further consideration will need to be given to both water quantity and quality in selecting a management option and consultations with the responsible regulatory authorities to determining whether treatment is necessary to meet the applicable discharge quality and quantity thresholds.

The following additional information would be gathered to guide the selection of an appropriate option to manage surplus water from the site during remediation and construction:

- Further characterisation of groundwater quality at the site. This shall comprise the collection of a groundwater sample from each of the nine groundwater monitoring wells established on site. These samples would be analysed for the range of COPC listed in Section 4.2 together with iron, manganese, major anions and cations, and alkalinity.

- Characterisation of background quality conditions of Cockle Bay through the collection of surface water samples at three separate locations; namely, two locations at the southern end of Cockle Bay coincident with existing (or likely proposed discharge locations), and one reference location further the north in Cockle Bay to support meaningful interpretation of chemical quality of water samples collected at the southern end of Cockle Bay. Surface water samples would be analysed for the same parameters as those for groundwater.
- Assess the suitability of groundwater for discharge to Cockle Bay via a local stormwater connection, or for discharge to a sewer connection.
- Assess the need for treatment prior to discharge. Based on available data, treatment is likely to comprise flow equalisation following by sedimentation/flocculation to remove suspended sediment. The requirement for supplementary treatment techniques depend on the outcome of water chemistry results, and required quality thresholds.
- Develop appropriate procedures for monitoring to periodically check that water discharges meet the required quality and quantity limits.
- Prepare a preliminary assessment of the likely groundwater inflow during remediation/construction activities

The required scope of any required water management works will be described in a Remediation Works Plan.

13.1.3 Fill/Soil Management

Stockpiles will be designated and handled to ensure that fill/soil materials are properly tracked and classified according to contaminant concentrations and minimise the potential for different classes of waste to be mixed.

Stockpiles will be placed on hardstand areas. If hardstand areas are not available, a reasonably robust, impermeable barrier will be placed on the ground where soils are to be stockpiled to minimise cross-contaminating areas of the site.

Stockpiles will be bunded with sediment control barriers to mitigate runoff from the stockpile to surrounding areas. Stockpiles potentially containing forms of asbestos shall be covered and stockpiles separate to other materials.

Stockpiles will not be placed near the site boundary, footpaths, roadways, gutters or storm water pits.

Stockpiles will be positioned and formed to minimise potential for stockpile erosion where possible.

The height of stockpiles shall not significantly exceed the height of site boundary hoarding to minimise dust generation from the site.

Soil or sediment must not leave the site as a result of vehicle, plant and equipment movements. To limit the potential for tracking of soil or sediment off site via vehicle, plant or equipment movement:

- vehicles, plant and equipment on the site will be kept to a practical minimum;
- vehicle, plant and equipment entry to and exit from the site will be kept to a practical minimum; and
- plant and equipment will be washed down before it leaves the site.

Guidance on the management and treatment of ASS/PASS is provided in the Acid Sulfate Soil Assessment and Preliminary Management Plan (Coffey. March 2013). In summary, soils deemed to be ASS will be stockpiled separately from other materials and placed within the designated ASS treatment area.

The required scope of the soil management works will be described in a separate Remediation Works Plan.

13.1.4 Noise Controls

Noise producing machinery and equipment will only be operated during working hours as approved by local Council and/or NSW OEH. Australian Standard *AS2436-1981 Guide to noise control on construction, maintenance and demolition sites* outlines guidelines for the minimisation of noise on construction and demolition sites and these will be followed at all times.

No “offensive noise” as defined under the *Protection of the Environment Operations Act 1997* should be created during remediation works/activities.

Mechanical plant, equipment and the like used during remediation works/activities will use practical and reasonable noise attenuating devices and measures to minimise noise being transmitted from the site. All equipment and machinery must be properly maintained and operated in an efficient manner to minimise the emission of noise.

13.1.5 Dust Control

Generation of dust during remediation works may occur. Site activities will be managed to minimise the generation of dust and the movement of dust off the site.

The following strategies will be implemented to minimise dust generation and dust movement:

- wetting down of dry soils during excavation and loading;
- covering loads during transportation;
- application of shade cloth or similar to perimeter fencing;
- limiting excavation and loading activities during high winds;
- wetting down stockpiles and/or covering with plastic/geofabric; and
- maintaining stockpile heights below the heights of perimeter fencing.

During the remediation works in Area 3, appropriate asbestos fibre suppression measures shall be used by the licensed contractor during excavation and handling of potentially impacted soils. These may include wetting of soils using water/surfactant mix and/or the erection of protective enclosures under negative pressure. Ancillary works including boundary monitoring and controlled access would be in place to further mitigate the risk of releasing asbestos fibres to the surrounding environment.

13.1.6 Odour Control

Generation of odours during the remediation works may occur (i.e. from known/unknown contamination, natural alluvial soils) although are expected to be intermittent and detectable over short durations.

No “offensive odours” as defined under the *Protection of the Environment Operations Act 1997* should occur outside the site boundary during remediation works/activities.

The following odour monitoring and management procedures may be used:

- undertaking the excavation works in a staged manner to limit the surface area and amount of potentially odorous materials being exposed;
- where offensive odours are detected, apply odour suppressants; and
- covering of transported soil, to suppress the release of the odours.

If required based on specific work tasks, vapour monitoring will be carried out by the appointed contractor and/or the environmental consultant during the remediation excavation works using calibrated photoionisation detectors (PID) to assess for the presence of ionisable VOC. Air quality within workers’ breathing zones will be monitored during the remediation works using the PID as a screening tool. Workers will stop work and withdraw from the work area when PID readings are greater than 10ppm in the workers’ breathing zone. Where monitoring identifies a continual breach of this threshold, the contractor shall consider other forms of risk management (e.g. use of respirators, alternate work methods etc.).

Vapour monitoring may also be required in the event that odorous or visually contaminated materials are encountered during the ground enabling construction works.

13.1.7 Hours of Operation

The actual hours of operations will be determined by development consent conditions. Typically, remediation work is allowed during the following hours:

- Monday – Friday 0700hrs – 1800hrs
- Saturday 0800hrs – 1300hrs
- Sunday & Public Holidays No work undertaken

13.1.8 Communication & Complaints

Communication and complaints received for the site will be reported to LLD representative. All communications and complaints will be assessed and an appropriate response, corrective and/or preventative action implemented (as necessary).

A communication and complaints register will be operated on site to ensure that concerns of local residences and businesses are recorded and addressed.

13.1.9 Emergency Preparedness and Response

The Principal Contractor shall prepare plans to respond to incidents and emergencies (e.g. fires, spills or other uncontrolled releases) in advance of commencing the works. The Principal Contractor shall inform employees, sub-contractors and site visitors of the response plans and emergency protocols during site inductions.

14 REGULATORY, NOTIFICATION, LICENCE AND APPROVAL REQUIREMENTS

14.1 Regulatory

The remedial works will be undertaken in accordance with, but not limited to, all relevant sections of:

- AS 2601-2001: The demolition of structures.
- NSW DECC 2009, 'Waste Classification Guidelines'
- Work Health and Safety Act 2011
- Work Health and Safety Regulations 2011
- Protection of the Environment Operations Act 1997 and associated Regulations;
- DUAP/EPA (1998) Managing Land Contamination: State Environmental Planning Policy No 55 Remediation of Land

Relevant guidelines made or approved by the NSW EPA under Section 105 of the Contaminated Land Management Act 1997 including:

- DEC (2006); Guidelines for the NSW Site Auditor Scheme, 2nd edition
- NSW EPA (1995); Guidelines for Consultants Reporting on Contaminated Sites
- DEC (2007); Guidelines for the Assessment and Management of Groundwater Contamination
- DECC (2009); Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997
- Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites, published by Australian and New Zealand Environment and Conservation Council (ANZECC) and the National Health and Medical Research Council (NHMRC) (January 1992)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality, published by ANZECC and Agriculture and Resource Management Council of Australia and New Zealand, Paper No 4 (October 2000)
- NEPC (1999) National Environment Protection (Assessment of Site Contamination) Amendment Measure (NEPM) (No. 1) as registered 2013, and associated Schedule B guidelines.

This RAP has been prepared having regard to the above regulations and guidance documentation.

14.2 Planning Consent

Coffey understands that remediation works form part of proposed redevelopment of a portion, or portions, of the Haymarket Precinct for which planning consent is being sought through a series of State Significant Development Application.

Appendix E provides an overview of the likely sequencing of the staged implementation of remediation and development proposed for the site.

14.3 Licences, Approvals and Permits

All parties involved in the remedial works will ensure that they hold all relevant licences, approvals and permits for demolition activities, excavation activities and transport of wastes. This may include, but not be limited to:

- NSW Department of Fair Trading Contractor Licence
- WorkCover NSW Demolition Licence
- WorkCover NSW Notification of Demolition
- Asbestos removal contractor licence. Notification to WorkCover NSW five days before asbestos removal work is commenced.
- Trade waste agreement from Sydney Water (where discharge of surplus water to sewer is proposed) or City of Sydney Council in consultation with the NSW EPA (where discharge of surplus water to stormwater system/Cockle Bay is proposed)

It is also envisaged that approval and permits will be required from Sydney Harbour Foreshore Authority to co-ordinate the proposed demolition, remediation and construction activities so as to minimise impacts on the remainder of the SICEEP.

15 QUALITY ASSURANCE AND QUALITY CONTROL

Validation of remediation will be undertaken in accordance with a Sampling, Analytical and Quality Plan (SAQP). The approach to developing the SAQP is presented below.

15.1 Remediation Sampling Analytical and Quality Plan

Data Quality Objectives (DQOs) for validation activities have been developed generally in accordance with the seven step process outlined in NSW DEC (2006).

15.1.1 Step 1 – State the Problem

The primary objective is to assess whether the site has been made suitable for the proposed uses.

The main problems are:

- how should the soils be validated;
- what validation sampling design should be used; and
- what contaminants should be analysed for and by what method to be useful for assessment?

15.1.2 Step 2 – Identify the Decision

The decisions that are required to be made in this project include:

- is the data sufficient for assessing site suitability for proposed redevelopment; and
- does the soil present an unacceptable risk to human health or the environment, or have unacceptable aesthetic quality, for the proposed land uses?

15.1.3 Step 3 – Identify Inputs to the Decision

The primary inputs to assessing the above include:

- the results and findings of previous assessments carried out on the site;
- data collected during remediation and validation works, including field measurements, observations and laboratory results;
- the RAC presented within Section 10.3;
- outcome of the quality assessment of relevant data; and
- applicable regulatory guidelines.

15.1.4 Step 4 – Define the Study Boundaries

Based on available data, the anticipated lateral and vertical extent of the proposed remediation is discussed in Table 10.3 and illustrated provisionally in Figure 15.

An assessment of ASS/PASS present in alluvial soils on the site is presented in Coffey (March 2013).

The lateral and vertical extent of contamination may be extended from the assessed extents during excavation and validation works as sub-surface soils are exposed and further assessed.

15.1.5 Step 5 – Develop a Decision Rule

The decision rules for the project will be as follows:

- if the results of the analytical data quality control assessment are acceptable, then the data will be deemed suitable for the purposes of the project. In this regard, data will be assessed against completeness, comparability, representativeness, precision and accuracy; and
- if the reported assessment and validation results are below the RAC, then the site soils will be considered suitable for proposed uses.

15.1.6 Step 6 – Specify Acceptable Limits on Decision Errors

There are two types of error:

- deciding that the soils are suitable for the proposed land use when they are not; and
- deciding that the soils are not suitable for the proposed land use when they are.

Where practicable, the assessment will aim to conclude with 95% confidence that the site soils are suitable for the proposed land use. Consequently, the 95% UCL of the mean concentrations of chemicals of potential concern will be used where applicable and where sufficient data is available to support this statistical method.

Confidence in reliability of other validation methods (e.g. field observations) will be based on:

- appropriate levels of qualification and experience in the personnel undertaking the relevant validation task; and
- use of Coffey standard operating procedures and other considerations described in NSW DEC (2006) and NEPC (1999).

15.1.7 Step 7 – Optimise the Design for Obtaining Data

Validation methods and sampling will target contaminants of concern based on information from previous contamination assessments. Validation sampling/observations will focus on the base and walls of the excavation after removal of hydrocarbon and/or asbestos impacted fill.

Validation of treated ASS will be applied at a minimum rate of one sample per 250m^3 treated soil and/or a minimum of 6 samples per treatment batch.

15.2 Fieldwork QA/QC

15.2.1 Preparation

Sampling equipment required for fieldwork will include the following (where appropriate):

- notebook/indelible marker pens;
- stainless steel sampling trowel;
- decontamination buckets;
- deionised or distilled water and Decon 90 detergent;

- laboratory prepared sample containers with Teflon lined lids
- insulated containers and ice;
- disposable latex gloves;
- personal protective equipment (PPE); and
- camera.

15.2.2 Soil Sampling, Preservation and Storage Procedure

Samples will be collected using a decontaminated stainless steel trowel or scooped directly into the laboratory prepared container using a fresh pair of nitrile gloves. The soil sample will be lightly packed into the container with headspace minimised to avoid the loss of volatiles. Samples proposed for asbestos analysis will be placed into a separate zip lock bags.

The sample containers will be labelled with a project number, sample location, sample depth (where applicable) and date the sample was collected.

Soil samples will be analysed on a discrete basis. Composite sampling and analysis methods will not be used.

Sample storage and preservation will be undertaken in accordance with Table15.1.

Table 15.1: Soil Sample Preservation and Storage

Analyte	Sample Volume and Container Type	Sample Container Preservative	Storage / Transport
TPH C_6 - C_{40}	1 x 250ml glass & Teflon lined lid	None	Minimal headspace Attempt to cool to 6°C
BTEX	1 x 250ml glass & Teflon lined lid	None	
PAH	1 x 250ml glass & Teflon lined lid	None	
VOC/SVOC	1 x 250ml glass & Teflon lined lid	None	
Forms of Asbestos	Double zip lock bag (Grab Samples for fragments of bonded ACM) 1 x 500mL plastic container with screw top (Sample for asbestos fines analysis)	None	Air tight and labelled for asbestos analysis No special requirements
Heavy Metals	1 x 250ml glass & Teflon lined lid	None	No special requirements

Analyte	Sample Volume and Container Type	Sample Container Preservative	Storage / Transport
ASS	1 x zip lock bag 1 x 250ml glass/plastic container (SCr analysis)	None	Test immediately on site Cool to 6°C or freeze where sample is dispatched to laboratory for analysis

15.2.3 Decontamination Procedures

Non-disposable sampling equipment coming into in contact with soils and groundwater will be decontaminated before and between sampling events to minimise the possibility of cross contamination between samples and minimise the risk of impacting sample integrity. The decontamination process will include the following procedure:

- removal of soil/groundwater residue from the equipment with a clean plastic brush in potable water;
- washing the equipment in a solution of Decon 90 (or similar) detergent and potable water; and
- rinsing the equipment in potable water.

15.2.4 Storage and Transport Procedures

The sample containers will be transported to the NATA accredited analytical laboratory with the Chain of Custody form recording the following information:

- project reference;
- date of sampling;
- sample identifications;
- matrix and container details
- preservation methods
- name of sampler;
- required analysis;
- turnaround times required; and
- signatures of sender and receiving laboratory.

A copy of the Chain of Custody record will be kept in the project file. Samples will be transported to the laboratory with sufficient time to perform analysis within the applicable holding period.

15.2.5 Intra-laboratory Duplicates

Intra-laboratory field duplicates will be collected on an average frequency of one sample per twenty samples collected for chemical analysis (5%). The analytical results of the two spilt samples will be compared to assess the precision of the sampling protocol and to provide an indication of variation in the sample source.

15.2.6 Inter-Laboratory Duplicates

Inter-laboratory field duplicates will be collected on an average frequency of one sample per twenty samples collected for chemical analysis (5%). The analytical results of the two split samples will be compared to assess the precision of the sampling protocol, provide an indication of variation in the sample source and to assess the accuracy of the primary laboratory.

15.2.7 Rinsate Samples

Rinsate samples will be prepared in the field using empty bottles and the distilled water/potable water used for the cleaning of sampling equipment. These samples will be a check on field decontamination procedures and sample device cleanliness. A rinsate sample will be collected and analysed for each day of field work carried out, where non-disposable sampling equipment has been used. Where non-disposable sampling equipment has been used and the same decontamination procedures are being used regularly for similar sampling equipment (and previous rinsate sample analysis has returned acceptable results), it will be appropriate to use rinsate samples on a “spot check” frequency rather than for each day of field work carried out.

15.2.8 Trip Blanks

Trip blanks are samples of organic free soil prepared by the laboratory and are a check on sample contamination originating from sample transport, shipping and site conditions. The blank will remain with the sample containers during sampling and during the return trip to the lab. At no time during these procedures will the blanks be opened. Upon return to the lab the blank will be analysed, if needed, as any other field sample. A trip blank will be used and analysed for a batch of samples released to the laboratory, where the contaminants being assessed are volatile in nature (e.g. BTEX or TRH F1). Where the same sampling and transport procedures are being used regularly for samples proposed for volatile analysis (and previous trip blank analysis has returned acceptable results), it will be appropriate to use trip blanks on a “spot check” frequency rather than for every batch.

15.2.9 Trip Spikes

Trip spikes are samples prepared by the laboratory with a pre-determined concentration of BTEX and are a check on sample preservation during sample storage and transport. The spike will remain with the sample containers during storage and transport. At no time during these procedures will the spike be opened. Upon return to the lab, the spike will be analysed, if needed, as any other field sample. A trip spike will be used and analysed for a batch of samples released to the laboratory, where the contaminants being assessed are volatile in nature (e.g. BTEX or TRH F1). Where the same storage and transport procedures are being used regularly for samples proposed for volatile analysis (and previous trip spike analysis has returned acceptable results), it will be appropriate to use trip spikes on a “spot check” frequency rather than for every batch.

15.3 Laboratory QA/QC

15.3.1 Laboratory Selection

The primary and secondary laboratories selected for this project shall hold NATA-accredited methods for the analyses to be undertaken. Laboratory Quality Control would include the following:

- the laboratory analysis of samples will be undertaken by a NATA accredited environmental testing laboratory;
- the NATA accredited environmental testing laboratory will implement a quality control plan conforming to the National Environmental Protection (Assessment of Site Contamination) Measure 1999 (NEPM) Schedule B3 Guideline for Analysis of Potentially Contaminated Soils;
- the laboratory will include reagent blanks, spike samples, duplicate spikes, matrix spikes, and surrogates spikes and duplicates to assess the laboratory quality control.

15.3.2 Data Assessment

The laboratory quality control data will be assessed as follows:

- checking that the reporting limits and procedures are satisfactory;
- checking that the samples are analysed within holding times;
- checking that laboratory blanks / reagent blanks are less than the laboratory reporting limits;
- checking the reproducibility of samples by calculating the Relative Percentage Differences (RPDs) between primary and duplicate laboratory samples submitted for chemical analysis; and
- checking that spikes, surrogate spikes, matrix spikes and duplicate matrix spike recoveries are within acceptable control limits.

Data Quality Indicators that will be adopted for quality control samples are presented in Table 15.2

Table 15.2: Data Quality Indicators for Quality Control Samples

Type of Quality Control Sample	Control Limit
Duplicate Samples	RPD within 30% and 50%for inorganic and organic analytes respectively. Where the reported soil concentration is less than 10 times LOR, no limit applies. For groundwater samples, the following will apply: • If the reported concentration is less than 4 times the LOR, then no limit applies and reasonableness of RPDs will be considered; • If the recorded concentration is 4or more times LOR then an RPD of 50% will apply.

Type of Quality Control Sample	Control Limit
Spikes	Recoveries within the following ranges 70% - 130% for organics 60% - 140% for inorganics / metals
Blanks and Rinsate Samples	Analytes not detected.

16 WASTE CLASSIFICATION

16.1 General

This section summarises the preliminary assessment findings of the waste classification of materials likely to be generated from the redevelopment of the site, and sets out a procedure to be used in order to classify waste prior to transport offsite for disposal.

16.2 Preliminary Assessment of Waste Classifications

Results from laboratory analysis indicate that the majority of fill material underlying the site should classify as General Solid Waste – Non-Putrescible in accordance with the waste classification guidelines and following analysis using the Toxicity Characteristic Leaching Procedure (TCLP).

The concentrations of benzo(a)pyrene (as a single compound, rather than a TEQ concentration) and Total PAH at sample location EB1 (1.4-1.5m) in Remediation Area 1 and of benzo(a)pyrene at sample location BH125 (0.23-0.33m) in Area 2 exceed the threshold concentrations for Restricted Solid Waste. As such the fill materials at, and in the vicinity of Remediation Areas 1 and 2 would provisionally classify as Hazardous Waste. Soils derived from Remediation Area 3 would need to be managed as asbestos waste.

Coffey notes that several individual samples reported concentrations of certain contaminants which exceed the General Solid Waste threshold (refer Table 8; Appendix D). Coffey recommended that the waste classification of these materials is reassessed following excavation as a more representative soil samples could be collected from a stockpile than from a borehole. Furthermore, the reassessment is supported by the use statistical techniques in accordance with the procedures set out within the Waste Classification Guidelines (DECCW; 2009).

Given the presence of alluvial and residual clays beneath the fill underlying the site, PASS may be present within alluvial material if excavated. Alluvial material that contains PASS will require neutralisation and would be classified as General Solid Waste for off-site disposal to landfill.

16.3 Waste Classification Criteria

The waste material will be assessed in accordance with Waste Classification Guidelines (NSW DECCW, 2009 – as amended from time to time).

16.4 Waste Soil Sampling Plan

As noted above, the preference for soil sampling for waste classification purposes will be via sampling of a stockpile. The material will be assessed by a suitably qualified environmental consultant prior to removal and disposal offsite. This assessment will include:

- inspection of the stockpiled material, or review of a relevant photographic record; and
- collection and laboratory analysis of spatially representative samples of the soil material.

One sample per $100m^3$ will be collected using hand tools and/or mechanical excavation where a significant volume of soil is present within the stockpile being assessed.

Samples collected of waste soil will be analysed for TRH, BTEX, PAH, heavy metals and forms of asbestos.

It is noted that this sampling and analytical schedule is for general waste classification. The sampling frequency and analytical schedule may need to be adjusted on a "case by case" basis, depending on factors such as:

- the volume of the material;
- the homogeneity of the material; and
- the visual assessment of the material.

Where sampling of stockpiled soil material is not practical or feasible, sampling of in-situ material would be used. The sampling plan would be designed so to gather sufficient evidence and collect samples for chemical characterisation that are representative of the waste materials being classified. Where in-situ classification is used, excavation of the material will be observed to confirm that the materials are reasonably consistent with those assessed for the in-situ waste classification.

16.5 Waste Classification Reporting

The environmental consultant will prepare a letter, advising the classification of the waste. These reports will be provided within the Validation Report.

16.6 Waste Tracking

The source location, volume, classification and destination of waste material removed from site will be tracked by the appointed contractor. The contractor shall maintain a materials tracking register along with consignment dockets confirming receipt of the material at the disposal facility. These records shall be presented within the Validation report.

17 VALIDATION REPORTING

The validation report aims to provide an independent verification that remedial goals associated with site works have been met and the site is suitable for its ongoing or future uses.

Reports should be prepared by a suitably qualified and experienced environmental consultant and will be submitted to the planning authority to support the discharge of conditions relating to land quality.

At the completion of remediation and validation works, a validation report will be prepared in general accordance with the relevant sections of NSW EPA Guidelines for Consultants Reporting on Contaminated Sites (NSW OEH, 2011) and other relevant guidance documentation.

The validation report will include:

- Executive Summary
- Scope of Work
- Site Identification
- Summary of Site History
- Summary of Site Condition and Surrounding Environment
- Summary of Geology and Hydrogeology
- Remediation Activities Undertaken (including extent and observations of excavation/s, waste documentation and imported fill documentation)
- Validation Sampling and Analysis Plan (including Methodology)
- Field QA / QC
- Laboratory QA / QC
- QA / QC Data Evaluation
- Basis for Validation Criteria
- Validation Sampling Results (including sample descriptions)
- Site Characterisation
- Ongoing Site Monitoring Requirements (if any)
- Conclusions and Recommendations

Validation reporting may be undertaken in a phased manner to align with the remediation and site redevelopment activities to support the phased occupation of the site.

18 SUMMARY AND CONCLUSIONS

The site is located within the Haymarket district of Sydney's Central Business District and comprises the SEC, associated car park and surrounding public realm. The site covers an area of approximately 3.8ha and is bound by Pier Street to the north, Hay Street to the south, a light rail corridor to the west and Harbour Street to the east.

Darling Harbour Live intends to lodge a series of State Significant Development Applications to redevelop the site for a mixture of residential and commercial uses with associated public realm comprising managed landscaped and paved areas. It is likely that the remediation and site redevelopment works will be undertaken in several stages. Appendix E provides an overview of the plan for remediation for each development plot.

Coffey prepared this RAP to be consistent with EPA reporting guidelines and to address issues for consideration listed in Section 3.5.4 of the Managing Contaminated Land: Planning Guidelines SEPP 55 – Remediation of Land (DUAP/EPA 1998).

The RAP presents a detailed appraisal of the historical uses of the site and surrounding land. In summary, the site historically formed a part of Cockle Bay with much of the site being submerged and used as a mill pond to support the Dixon Steam Mill complex that was established in 1813 immediately north of the site. The site was gradually reclaimed over a period of approximately 40years using materials dredged from Sydney Harbour or from excavations associated with the construction of the Sydney Rail Terminus. The historic land uses of the site indicates that following reclamation in c.1865, the site was used for a variety of storage uses associated with wharves and Darling Harbour Goods Yard located further to the north. The site was used as a city market and council depot between 1930 and 1980 prior to being redeveloped for the SEC and associated car park.

Several potentially significant historical land uses have also been identified within the vicinity of the site including the Dixon Steam Mill complex (steam engine, brewery, soap works, a salting works and manufacture and bottling of soda water, hydraulic pumping station and galvanising works) immediately northeast of the site, a railway siding and goods yard to the north, and the Ultimo Power Station immediately to the west of the site. None of these uses are current.

Four separate phases of investigation were undertaken by Coffey between June 2011 and January 2013 and data from these investigations forms the basis of the RAP. A review was undertaken of results relevant to the site in the context of the site redevelopment proposals, which identified a number of Areas of Environmental Concern within and immediately surrounding the site. The density of investigation locations is lower than the minimum requirements recommended in the NSW EPA Sampling Design Guidelines, however, given the nature of historical site use and physical constraints to access parts of the site, Coffey considers that investigations carried out to date are adequate for preparation of this RAP.

The investigations identified soils and groundwater within the site which reported concentrations exceeding generic assessment criteria published within Schedule B1 of the NEPC (1999), relevant guidelines by NSW EPA under Section 105 of the NSW *Contaminated Land Management Act 1997* and other authoritative publications. A Human Health and Ecological Risk Assessment (HHERA) was subsequently commissioned to assess the potential health and ecological risks in the context of the proposed development.

In summary, based on the results of the HHERA, five localised areas of soil contamination have been identified within fill materials that present potentially unacceptable health risks to future site occupants and/or users. No unacceptable risks associated with groundwater were identified within the site. The RAP presents an approach to remediate and validate these areas of soil contamination and thereby mitigate potentially unacceptable risks. This RAP also presents a strategy to manage unexpected finds of contamination that may be encountered during construction and to manage likely asbestos impact which may be wide-spread in fill material.

If the remediation is carried out in accordance with this RAP using the preferred remedial option, then Coffey concludes the site should be made suitable for the proposed development.

The reader should refer to the 'Important Information about Your Coffey Environmental Report' which follows References.

19 REFERENCES

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- Coffey Environments (March 2013); *Acid Sulfate Soil Assessment and Preliminary Management Plan; Haymarket Precinct, Darling Harbour, Sydney NSW*
- DUAP/EPA (1998); Managing Land Contamination: Planning Guidelines - SEPP 55 Remediation of Land
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- NSW DEC (2007) Guidelines for the Assessment and Management of Groundwater Contamination. ISBN 978 1 74122 366 8

- NSW DECCW (2009); Waste Classification Guidelines - Part 1: Classifying Waste
- NSW EPA (1995) Sampling Design Guidelines. ISBN 0-7310-3756-1.
- NSW EPA (2011) Guidelines for Consultants Reporting on Contaminated Sites. ISBN 0 7310 3892 4.
- Olszowy, H., et.al (1995); Trace Element Concentrations in Soils from Rural and Urban Areas of Australia [Contaminated Sites Monograph Series No.4]
- US EPA Region 9 Regional Screening Levels for Soil under Residential and Industrial land uses (November 2012)

Important information about your **Coffey** Environmental Report

Introduction

This report has been prepared by Coffey for you, as Coffey's client, in accordance with our agreed purpose, scope, schedule and budget.

Your report has been developed for a specific purpose as agreed by us and applies only to the site or area investigated. Unless otherwise stated in the report, this report cannot be applied to an adjacent site or area, nor can it be used when the nature of the specific purpose changes from that which we agreed.

The report has been prepared using accepted procedures and practices of the consulting profession at the time it was prepared, and the opinions, recommendations and conclusions set out in the report are made in accordance with generally accepted principles and practices of that profession.

The report is based on information gained from environmental conditions (including assessment of some or all of soil, groundwater, vapour and surface water) and supplemented by reported data of the local area and professional experience. Assessment has been scoped with consideration to industry standards, regulations, guidelines and your specific requirements, including budget and timing. The characterisation of site conditions is an interpretation of information collected during assessment, in accordance with industry practice.

Limitations of the Report

The analyses, evaluations, opinions and conclusions presented in this report are based on that purpose and scope, requirements, data or information, and they could change if such requirements or data are inaccurate or incomplete.

This report is valid as of the date of preparation. The condition of the site (including subsurface conditions) and extent or nature of contamination or other environmental hazards can change over time, as a result of either natural processes or human influence. Coffey should be kept appraised of any such events and should be consulted for further investigations if any changes are noted, particularly during construction activities where excavations often reveal subsurface conditions.

In addition, advancements in professional practice regarding contaminated land and changes in applicable statues and/or guidelines may affect the validity of this report. Consequently, the currency of conclusions and recommendations in this report should be verified if you propose to use this report more than 6 months after its date of issue.

The report does not include the evaluation or assessment of potential geotechnical engineering constraints of the site.

Interpretation of factual data

Environmental site assessments identify actual conditions only at those points where samples are taken and on the date collected. Data derived from indirect field measurements, and sometimes other reports on the site, are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended actions.

Variations in soil and groundwater conditions may occur between test or sample locations and actual conditions may differ from those inferred to exist. No environmental assessment program, no matter how comprehensive, can reveal all subsurface details and anomalies. Similarly, no professional, no matter how well qualified, can reveal what is hidden by earth, rock or changed through time.

The actual interface between different materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions.

Recommendations in this report

This report assumes, in accordance with industry practice, that the site conditions recognised through discrete sampling are representative of actual conditions throughout the investigation area. Recommendations are based on the resulting interpretation.

Should further data be obtained that differs from the data on which the report recommendations are based (such as through excavation or other additional assessment), then the recommendations would need to be reviewed and may need to be revised.

Report for benefit of client

Unless otherwise agreed between us, the report has been prepared for your benefit and no other party. Other parties should not rely upon the report or the accuracy or completeness of any recommendation and should make their own enquiries and obtain independent advice in relation to such matters.

Coffey assumes no responsibility and will not be liable to any other person or organisation for, or in relation to, any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report.

To avoid misuse of the information presented in your report, we recommend that Coffey be consulted before the report is provided to another party who may not be familiar with the background and the purpose of the report. In particular, an environmental disclosure report for a property vendor may not be suitable for satisfying the needs of that property's purchaser. This report should not be applied for any purpose other than that stated in the report.

Data should not be separated from the report

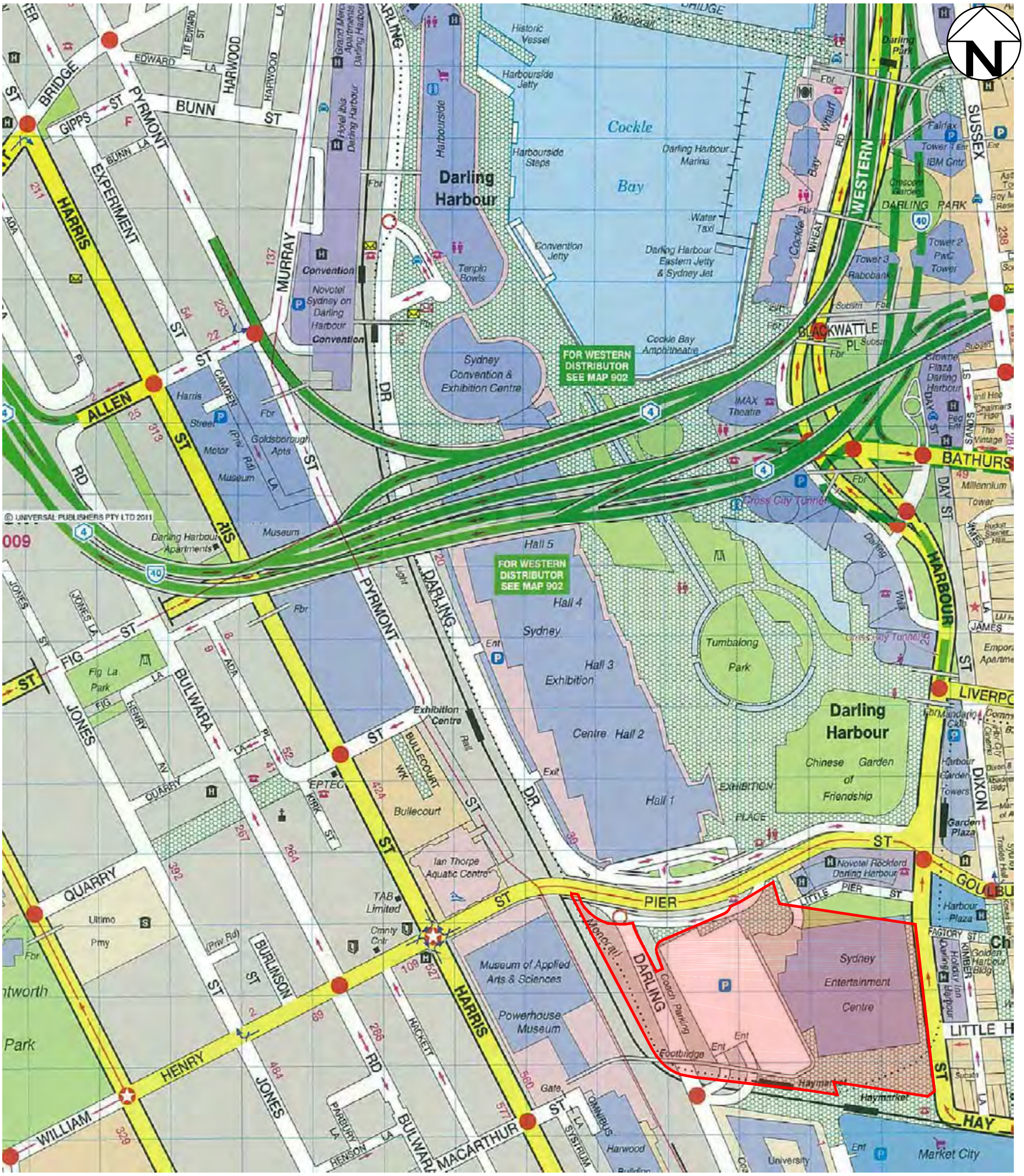
The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, laboratory data, drawings, etc. are customarily included in our

reports and are developed by scientists or engineers based on their interpretation of field logs, field testing and laboratory evaluation of samples. This information should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.
This report should be reproduced in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties.

Responsibility
Environmental reporting relies on interpretation of factual information using professional judgement and opinion and has a level of uncertainty attached to it, which is much less exact than other design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. As noted earlier, the recommendations and findings set out in this report should only be regarded as interpretive and should not be taken as accurate and complete information about all environmental media at all depths and locations across the site.

Figures

Site Specific Remedial Action Plan
Haymarket, Sydney NSW



50 0 50 100 150 200 250

Horizontal Scale (metres) 1:5000

SOURCE: UBD STREET DIRECTORY GREGORYS
SYDNEY, NEW SOUTH WALES
47TH EDITION, 2012, MAP: E & G

LEGEND

SITE BOUNDARY
(REFER TO APPENDIX B, RYGATE PLAN No. 75813-3 FOR SURVEY DETAIL)

drawn	MV	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client:	LEND LEASE DEVELOPMENT
approved	ML		project:	HAYMARKET PRECINCT, DARLING HARBOUR SYDNEY, NEW SOUTH WALES
date	18/11/13		title:	SITE LOCATION MAP
scale	AS SHOWN		project no: ENAURHOD04498AA-D02	figure no: FIGURE 1
original size	A4			

PLOT DATE: 18/11/2013 12:33:51 PM DWG FILE: \\CHATFS01.CORP.COFFEY.COM.AU\DATA$\ENVI\PROJECTS\ENAURHOD\ENAURHOD04 GOV\ENDI\ENAURHOD04400-04499\ENAURHOD04498 LEND LEASE DEV HAYMARKET\ENAURHOD04498AA\FIGURES\ENAURHOD04498AA-D03.DWG

LEGEND

- SITE BOUNDARY (REFER TO APPENDIX B, RYGATE PLAN No. 75813-3 FOR SURVEY DETAIL)
- LIGHT RAIL CORRIDOR
- BUILDING FOOTPRINT
- INDICATIVE TOWER FORMS OVER PODIUM
- INDICATIVE STAGING BOUNDARY

NOTE:
STAGING BOUNDARIES ARE INDICATIVE OF DEVELOPMENT APPLICATION BOUNDARIES.

revision	description	drawn	approved	date

AERIAL IMAGE SOURCE: GOOGLE EARTH PRO 6.6.2.6613
AERIAL IMAGE ©: 2012 SINCLAIR KNIGHT MERZ
2012 WHEREIS SENSIS PTY LTD

15 0 30 60
Scale (metres) 1:1500

drawn	MV
approved	ML
date	16/12/13
scale	1:1500
original size	A3

coffey

client:	LEND LEASE DEVELOPMENT
project:	HAYMARKET PRECINCT, DARLING HARBOUR SYDNEY, NEW SOUTH WALES
title:	SITE LAYOUT PLAN
project no:	ENAURHOD04498AA-D02
figure no:	FIGURE 2

revision	description	drawn	approved	date

LEGEND

APPROXIMATE SITE BOUNDARY

Approx. Scale (metres) 1:1500

drawn	MV
approved	ML
date	18/11/13
scale	1:1500
original size	A3

coffey

client:	LEND LEASE DEVELOPMENT
project:	HAYMARKET PRECINCT, DARLING HARBOUR SYDNEY, NEW SOUTH WALES
title:	1828 HISTORIC MAP EXTRACT
project no: ENAURHOD04498AA-D02	figure no: FIGURE 3

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IMAGE SOURCE: ALLOTMENTS IN SECTIONS 123&4 PARISH OF ST ANDREW, CITY OF SYDNEY, 1870.

revision	description	drawn	approved	date

LEGEND

APPROXIMATE SITE BOUNDARY

Approx. Scale (metres) 1:1500

drawn	MV
approved	ML
date	18/11/13
scale	1:1500
original size	A3

coffey

client:	LEND LEASE DEVELOPMENT
project:	HAYMARKET PRECINCT, DARLING HARBOUR SYDNEY, NEW SOUTH WALES
title:	1870 HISTORIC MAP EXTRACT
project no:	ENAURHOD04498AA-D02
figure no:	FIGURE 4

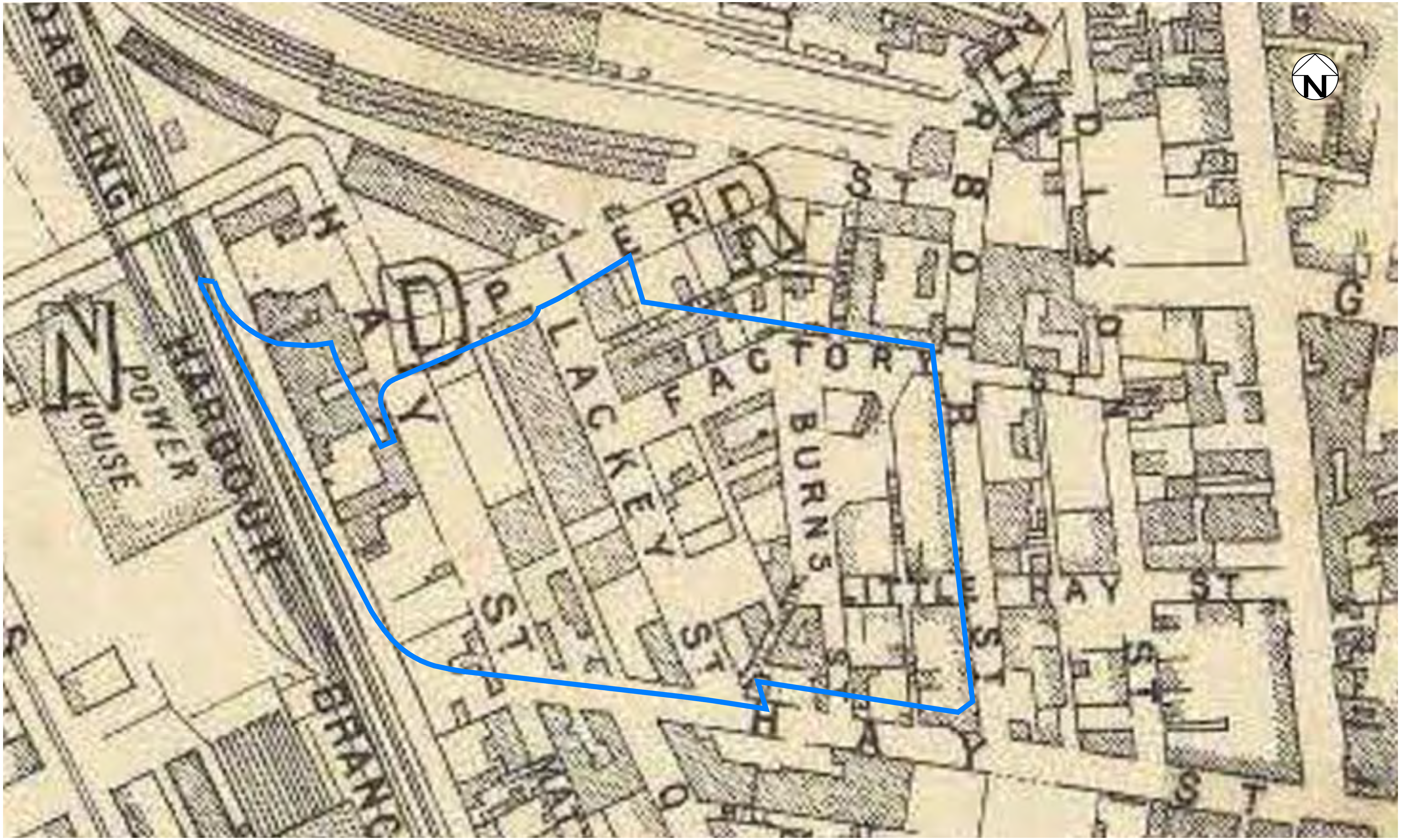

IMAGE SOURCE: CITY OF SYDNEY ARCHIVES.

revision	description	drawn	approved	date

LEGEND

APPROXIMATE SITE BOUNDARY

Approx. Scale (metres) 1:1500

drawn	MV
approved	ML
date	18/11/13
scale	1:1500
original size	A3

coffey

client:	LEND LEASE DEVELOPMENT
project:	HAYMARKET PRECINCT, DARLING HARBOUR SYDNEY, NEW SOUTH WALES
title:	1903 HISTORIC MAP EXTRACT
project no: ENAURHOD04498AA-D02	figure no: FIGURE 5

revision	description	drawn	approved	date

LEGEND

APPROXIMATE SITE BOUNDARY

drawn	MV
approved	ML
date	18/11/13
scale	NTS
original size	A3

coffey

client:	LEND LEASE DEVELOPMENT
project:	HAYMARKET PRECINCT, DARLING HARBOUR SYDNEY, NEW SOUTH WALES
title:	1930 AERIAL PHOTOGRAPH
project no: ENAURHOD04498AA-D02	figure no: FIGURE 6

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