DLA Environmental Services
A Pacific Environment company

Remediation Action Plan

Site 9
Corner Sarah Durack Avenue & Olympic Boulevard
Homebush NSW 2127

ECOVE Group

DL3620_S004569

May 2016

PROJECT NAME	Cnr Sarah Durack and Olympic Boulevard- Sydney Olympic Park
PROJECT ID	DL3620
DOCUMENT CONTROL NUMBER	S004569
PREPARED FOR	ECOVE Group
APPROVED FOR RELEASE BY	David Lane
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DOCUMENT CONTROL

VERSION	DATE	COMMENT	PREPARED BY	REVIEWED BY
Version 1.0	11/03/2016		Ashleigh Pickering Sam Butler	Tot Le
Version 2.0	01/04/2016		Sam Butler	Keri Hartog
Version 3.0	4/04/2016		Ashleigh Pickering	Simon Spyrdz
Version 3.1	06/05/2016	Revision following Auditor Comments	Sam Butler	Keri Hartog
Version 3.2	11/05/2016	Revision following Auditor Comments	Sam Butler	Keri Hartog
Version 3.3	18/05/2016	Revsion following SOPA comments	Keri Hartog	Simon Spyrdz

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This report is limited to the scope defined herein. Sampling and chemical analysis of environmental media are based on representative samples, the intensity of those samples being in accordance with the usual levels of testing carried out for this type of investigation and appropriate for the objectives of this report. Due to the inherent variability in environmental media, DLA cannot warrant that the whole overall condition of the Site is identical or substantially similar to the representative samples.

ABBREVIATIONS

ACM	Asbestos Containing Material
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
AST	Above-ground Storage Tank
ASS	Acid Sulfate Soil
B(a)P	Benzo(a)Pyrene
BGL	Below Ground Level
BH	Borehole
BTEX	Benzene, Toluene, Ethyl Benzene, Xylene
COC	Chain of Custody documentation
CLM	Contaminated Land Management
DA	Development Application
DEC	Department of Environment and Conservation (NSW)
DECC	Department of Environment and Climate Change (NSW)
DECCW	Department of Environment, Climate Change and Water (NSW)
DLA	DLA Environmental Services
DP	Deposited Plan
DQO	Data Quality Objective
EC	Electrical Conductivity
EIL	Ecological Investigation Level
EMP	Environmental Management Plan
EPA	Environment Protection Authority (NSW)
ESL	Ecological Screening Level
HIL	Health-Based Investigation Level
LOR	Limit of Reporting
MW	Monitoring Well
NATA	National Association of Testing Authorities, Australia
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NSW	New South Wales
OCP	Organochlorine Pesticides
OEH	Office of Environmental and Heritage
OPP	Organophosphorus Pesticides
OH&S	Occupational Health and Safety
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PID	Photo-Ionisation Detector
PQL	Practical Quantification Limit
QA/QC	Quality Assurance and Quality Control
RAP	Remedial Action Plan
RPD	Relative Percentage Difference
SAC	Site Acceptance Criteria
SAQP	Sampling Analysis and Quality Plan
SEPP	State Environmental Planning Policy
SWL	Standing Water Level
TCLP	Toxicity Characteristic Leaching Procedure
TRH	Total Recoverable Hydrocarbons
UCL	Upper Confidence Limit
UST	Underground Storage Tank
VOC	Volatile Organic Compounds
WHS	Work Health Safety

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1.0 INTRODUCTION

1.1 General

DLA Environmental Services (DLA) was commissioned by ECOVE Group to prepare a Remediation Action Plan (RAP) for the property identified as:

Site 9 – Corner Sarah Durack Ave and Olympic Boulevard, Sydney Olympic Park (the Site)

A RAP provides information on the works which are proposed to manage and remediate contamination identified at the Site. The RAP has been prepared utilising information obtained from previous assessment reports and from experience, knowledge, and current industry practice in the remediation of similar sites.

1.2 Development Controls

The preparation of a Remediation Action Plan was undertaken in anticipation of the Development Approval (DA) Consent. The conditions will require a Remediation Action Plan to be overseen and approved by a NSW EPA Accredited Site Auditor with specialist knowledge in remediated lands and landfill gas systems.

1.3 Objectives

This purpose of this report is to set remediation goals and document the management procedures and environmental safeguards to be implemented to ensure the Site will be rendered suitable for future land use consistent with *Residential B* in the National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No.1) ('NEPM', NEPC, 2013) and the *Environmental Management: Remediated Lands Management Policy* (Sydney Olympic Park Authority Policy), thereby posing no unacceptable risk to human health or the environment generally.

1.4 Scope of Works

In achieving this objective, the RAP will provide:

- Brief summary of the history and environmental setting of the Site;
- Summary of the previous environmental investigations at the Site;
- Definition of the extent of remediation required;
- Review of the currently available remediation options;

- Details of the preferred remediation strategy and an outline of the methodology for the implementation of the selected strategy;
- Details of the adopted validation programme;
- Brief outline of environmental pollution control, community health and safety, and occupational health and safety measures that should be implemented during remedial works;
- Outline of regulatory approvals and licences which may be required; and,
- Outline any potential ongoing monitoring or management requirements to ensure the continued protection of human health and the environment.

1.5 Remediation Guidelines

The RAP has been prepared with consideration to the following guidelines and legislation where relevant:

- *Australian and New Zealand Guidelines for Assessment and Management of Contaminated Sites* (ANZECC, 1992);
- *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites* (NSW EPA, 2011);
- *Contaminated Sites: Sampling Design Guidelines* (NSW EPA, 1995);
- *Contaminated Lands Management Act* (NSW, 1997);
- *Contaminated Lands Management Act Notice Number 28040* (NSW EPA, 2009);
- *Environmental Management: Remediated Lands Management Policy POL10/09* (Sydney Olympic Park Authority Policy, 2014);
- *Guidelines for the NSW Site Auditor Scheme* (NSW EPA, 2nd ed., 2006);
- *Managing Land Contamination, Planning Guidelines, SEPP 55: Remediation of Land* (DUAP, 1998);
- *Managing Asbestos In or On Soil* (NSW WorkCover, 2014);
- *National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No.1)* (NEPC, 2013);
- *Remediated Lands Management* Plan (SOPA, January 2009);
- *Work Health and Safety Act 2011* (NSW) and associated regulations.
- *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases. NSW EPA (2012).*
- *Guidance Document on Management of Methane Gas Adjacent to Landfills.* Alberta Environmental Protection (1999).
- *Guidance on the Management of Landfill Gas.* UK EPA (2004).

2.0 SITE DESCRIPTION

2.1 Site Identification

The Site identification details are summarised in **Table 2a** below:

Table 2a – Site Identification Summary

ITEMS	DETAILS
Site Name	Site 9 – Sydney Olympic Park
Address	Corner Sarah Durack Ave and Olympic Boulevard
Local Government Authority	Auburn City Council
Lot and Deposited Plan	Part Lot 2004 DP 1192085
Development Controls	Auburn Local Environmental Plan 2010
Site Zoning	Major Development – SEPP 2005
Current Use (NEPM 2013 Table 1A(1)	Carpark
Proposed Use (NEPM 2013 Table 1A(1)	Commercial / Industrial & Residential B
Site Area (approx.)	4,836 m^2 (0.48 ha)
Locality Map	Refer to **Figure 1** – Site Location

2.2 Proposed Development

Based on the information provided, the Site is proposed to undergo redevelopment to commercial land use on the ground floor with high density residential and offices on upper levels. This development scenario is consistent with the definition of 'Residential with minimal opportunities for soil access provided in Schedule B7 of the NEPM (NEPC, 2013).

2.3 Boundaries and Surrounding Land Use

The boundary and surrounding landscape features of the Site are summarised in **Table 2b** below:

Table 2b – Boundaries and Surrounding Land Use

DIRECTION	DETAILS
North	Sarah Durack Avenue
East	P3 Carpark
South	Tom Wills Oval and Learning Life Centre
West	Olympic Boulevard

2.4 Site Geology and Soils

Review of the Geological Survey map of NSW Sydney 1:100,000 Geological Series Sheet 9130 (Edition 1) indicates that the Site is underlain by Quaternary sands, silty clays and man-made filling.

Review of the Sydney 1:1 000 000 Soil Map (Sheet 9130) indicated that the Site is underlain by the Blacktown Landscape Group. This is characterised by gently undulating rises with local relief to 30m and slopes usually <5%. Broad rounded crests and ridges with gently inclined slopes. Soils comprise shallow to moderately deep red and brown podzolic soils on crests, upper slopes and well drained areas, and deep yellow podzolic soils and soloths on lower slopes and in areas of poor drainage. Limitations of the soils of the Blacktown landscape group include moderately reactive highly plastic subsoil, low soil fertility and poor soil drainage.

The majority of the site (with the exception of the north western corner) comprises of landfill with existing cap and contain measures, based on site observations the containment measures consist of clay capping at the surface.

2.5 Site Topography

The Site is relatively flat with a gentle slope towards the south east. The elevation of the site ranges from 17m (north west) to 14m AHD (south east).

2.6 Acid Sulphate Soils

Review of the Acid Sulfate Soil Risk Map – Edition Two for Parramatta/Prospect (DLWC 1997) indicated that the Site is within disturbed terrain. No visual indications of acid sulfate soils were observed.

2.7 Salinity and Aggressivity of Soils

The *Salinity Potential in Western Sydney* map (DIPNR, 2002) indicates the Site and the Sydney Olympic Park area generally is within a region of moderate salinity potential.

2.8 Hydrology and Hydrogeology

Approximately 75% of the Site is sealed and rainfall falling on the sealed surface is expected to flow into the underground stormwater drainage system. Approximately 25% of the Site is unsealed and situated on permeable soils. As such, rainfall is expected to infiltrate the unsealed surfaces of the Site, excess rainfall would be expected to flow toward the stormwater drainage system.

A search of the Department of Natural Resources groundwater database was also performed to identify wells in the vicinity of the Site. The search results identified thirteen registered groundwater monitoring wells located within 1km of the Site, the information of which is presented below:

Table 2c – Regional Groundwater Summary Data

WELL ID	DISTANCE FROM SITE (m)	PURPOSE	DEPTH (m)	STANDING WATER LEVEL (m)	SALINITY (µS/cm)
GW111341	N – 365m	Monitoring	8.00	No Data	No Data
GW111342	N – 370m	Monitoring	8.00	No Data	No Data
GW111343	N – 360m	Monitoring	8.00	No Data	No Data
GW102550	W – 700m	Monitoring	4.00	1.80	No Data
GW102553	W – 935m	Monitoring	4.00	1.83	No Data
GW102555	W – 850m	Monitoring	4.00	1.83	No Data
GW102556	W – 915m	Monitoring	4.00	1.83	No Data
GW102557	W – 910m	Monitoring	4.00	No Data	No Data
GW102558	W – 745m	Monitoring	4.00	1.83	No Data
GW102559	W – 750m	Monitoring	4.00	1.83	No Data
GW102561	W – 600m	Monitoring	4.00	1.83	No Data
GW102562	W – 485m	Monitoring	4.0	1.83	No Data
GW102645	S – 800m	Monitoring	10.00	No Data	No Data

Refer to **Appendix B** – Groundwater Works Database Search.

It is expected that localised hydraulic gradient at the site, in particular with the landfill section will be slightly negative with general flow to the centre of the landfill, in order to manage the leachate flow.

2.9 Site Meteorology

The Bureau of Meteorology NSW gives the average annual rainfall for the Sydney Olympic Park area at 884.0mm, with an annual daytime temperature range of 13.9° to 28.4°C, and an annual average temperature of 23.6°C.

2.10 Site History Summary

The area of investigation is known to have received waste and fill material as part of the Golf Driving Range landfill. Unauthorised and uncontrolled dumping of over nine million cubic metres of domestic, commercial and industrial wastes around Homebush Bay was commonplace from the 1950s to the 1980s. Remediation of the Homebush Bay Site commenced in 1994, in partial fulfilment of a commitment to a "green" Olympic Games for September, 2000. The landfill remediation strategy focussed on the consolidation and isolation of wastes and on the management of surface waters and leachates emanating from them. Waste was relocated to large containment mounds (including the golf driving range landfill), which have since been capped and re-landscaped.

The Site is located on the boundary of the landfill and encompasses both fill material and natural soils, with an existing cap and contain approach for the landfill. The Site is bound by the 'P3' car park to the North which is known to have significant concentrations of landfill gas. It is understood that the landfill design in the particular area of the site, includes the excavation of a landfill cell with backfill of unsuitable materials and capping with clay fill materials. It is understood that an inward hydraulic gradient is used to prevent the migration of contaminants off-site. Landfill leachate is collected via a gravity drain which drains into a leachate rising main. However, there is no leachate collection and transfer infrastructure located on the development site and the proposed design for the Site is not expected to compromise the Golf Driving Range leachate management system. The extent of the Golf Driving Range Landfill is included in **Figure 5**.
Previous contamination investigations have identified contaminated material including elevated benzene, toluene, ethylbenzene and xylenes (BTEX), naphthalene and total petroleum hydrocarbons (TPH) on the Site (Section 3.0). The site was redeveloped as part of the wider Sydney Olympic Park area and has been used as an open air car park since approximately 2000.

3.0 SUMMARY OF PREVIOUS INVESTIGATIONS

3.1 Environmental and Geotechnical Investigation, Site 9 Sydney Olympic Park (URS, November, 2002)

A summary of the works and the findings of the assessment are as follows:

- Six boreholes were drilled across the Site with samples collected for contamination and geotechnical investigations. One monitoring well was installed in the investigation (BH112)
- Landfill odours were noted across all boreholes, predominately in the fill material and slightly extending into the residual clay.
- Depth to bedrock varied between 5.7m (BH115) to 9.3m (BH111) to a low strength shale.
- Groundwater was encountered at 5.5m (BH111 and BH112) and 6.0m (BH116) during the investigation works.
- Elevated levels of TPH (C_{10}-C_{36}) were detected with a maximum concentration of 15,318mg/kg (BH112) in soil sample at a depth of 6.0 metres. Elevated levels of ethylbenzene were detected in BH111 at a depth of 7.0 metres with a concentration of 78.8mg/kg. All other samples contained levels of contaminants below the adopted site assessment criteria or below the laboratory level of reporting (LOR).
- Slightly elevated levels of metals (chromium, copper, zinc and mercury) and TPH were detected in groundwater above the adopted trigger values. All other analytes were recorded below the laboratory LOR. The location of the URS Bore Locations are included within **Figure 4a**.

DLA notes that BH111 and BH112 are outside the current scope of assessment.

3.2 Remediation Plan (URS, December 2002)

A summary of the remediation plan is:

- The impacted material identified in previous contamination investigations was above the adopted Site Criteria and required remediation. The preferred remediation method was excavation and off-site removal to a licensed landfill.
- A layer of clean material may be required for any unsealed areas (landscaped) of the Site to mitigate potential exposure of future Site users to the underlying impacted soils.
- The recommended remediation plan was not implemented on the Site as the proposed development of the site at the time did not occur.

3.3 Waste Classification Assessment (Douglas Partners, May 2003)

A summary of the works and the findings of the assessment are as follows:

- A waste classification assessment was conducted to allow redevelopment of the Site. Twelve boreholes were constructed to a maximum depth of 6.5m or refusal.
- Observations on the Site indicated that the subject site forms part of the former municipal landfill site, which was redeveloped as part of the Sydney Olympic precinct. Refuse material was identified during site works with landfill odours.
- Sample results from BH7 (5.0m) recorded concentrations of heavy metal and organic contaminants (BTEX, naphthalene and TPH) in excess of the adopted site assessment criteria. It was assumed that the localised elevated results were due to heavy industrial oily liquid waste or similar substances within the landfill.
- Fragments of asbestos cement sheeting were noted in BH5 (2.9-4.0m) only, although the extent of asbestos impacted material was unknown.
- The material was classified into solid waste and hazardous waste. The solid waste applied to all material below 0.5m bgl, with the exception of material from BH7 (4.5-6m). Hazardous waste applied to the material in the vicinity of BH7 (4.5-6.0m) bgl. The asphalt, topsoil and road base (to 0.5m) were classified as inert waste. The location of the Douglas Partners Bore Locations are included within **Figure 4a**.

3.4 Supplementary Site Investigation (DLA Environmental, February 2016)

A summary of the works and the findings of the assessment are as follows:

- Eight boreholes were drilled in targeted locations to provide coverage of the Site area.
- Levels of total PAH, benzo(a)pyrene and naphthalene were observed in soil samples collected from within the landfill material. PAH BaP TEQ and Total PAHs were detected between depths of 0.5m to a depth of 5.8m. Soil samples for PAH did not exceeded the SAC.
- Low levels of F2 and F3 hydrocarbons were also detected within the landfill and fill materials identified on Site. The contaminants were reported below the Site acceptance criteria and are not expected to migrate off site.
- Asbestos fibres were identified in one borehole (BH7) at a depth of approximately 4.0 metres within landfill material. The asbestos fibres are expected to be contained at depth and are not deemed to be a risk to human health.
- Groundwater monitoring wells installed within the landfill contained elevated levels of methane, phenols, ammonia, total suspended solids (TSS), total organic compounds (TOC) and nitrogen above the laboratory level of reporting (LOR).

- Heavy metal analysis of groundwater identified exceedances of the adopted site criteria across all three sampled monitoring wells. However, none are considered a risk to human or ecological health risk within the urbanised area of the Site.
- Based on a Level 1 Risk Analysis and Assessment of landfill gas production on the Site, the risk has been determined to be 'High Risk'
- Based upon the findings, a corresponding Characteristic Gas Situation (CS) of four (4) for the Site is recommended. In accordance with guideline requirements, gas protection measures for the Site are required.

Site layout and bore locations are included in **Figure 2**. Analytical Summary Data Tables are presented in **Appendix C.**

3.5 Contamination Status

3.5.1 Soils

Fill was identified on the Site to a depth of 7.9 metres consisting of sandy clay, clayey sand, general refuse including plastic, rubber, timber and unidentifiable black mass. Natural soils consists of silty clay and sandy clay ranging in colours red, white, yellow overlaying extremely weathered shale.

No soil samples during the supplementary site assessment were reported concentrations exceeding the Site Acceptance Criteria (SAC) of *Residential B* (NEPM; NEPC 2013) for heavy metals, BTEX, vTRH, sTRH, Naphthalene, B(a)P, Total PAH, PCB or pesticides.

The previous investigations by Douglas (2003) and URS (2002) identified chemical contaminants exceeding the applicable Site acceptance criteria for TRH, BTEX and PCBs.

3.5.2 Groundwater

Groundwater monitoring wells installed within the landfill contained elevated levels of methane, phenols, ammonia, total suspended solids (TSS), total organic compounds (TOC) and nitrogen above the laboratory level of reporting (LOR). The levels of analytes were observed to be higher within the landfill when compared to the monitoring well located outside of the landfill (BH1). Groundwater within the landfill are considered to be leachate.

Some minor concentrations of benzene, toluene, ethylbenzene and xylene were reported above the laboratory LOR. Monitoring wells BH4 and BH8 reported levels of naphthalene and F1, F2 and F3

hydrocarbons (C_6-C_{34}) above the laboratory LOR. No detections of hydrocarbons in the F4 hydrocarbon (C_{34} – C_{40}) fraction were observed in any of the three monitoring wells sampled.

Heavy metal analysis revealed some exceedances with relation to arsenic, cadmium, chromium, copper, nickel and zinc. Elevated levels are expected to be due to the leachate from the landfill material. The levels are not considered significant in the context of a human or ecological health risk within the urbanised area of the Site.

3.5.3 Soil and Landfill Gas

All gas monitoring locations were assessed for relevant landfill gas constituents, weather conditions, soil moisture, flow rates, differential pressure and barometric pressure were recorded. All borehole locations were assessed for major landfill gas constituents Methane (CH_4), Carbon Dioxide (CO_2), Oxygen (O_2), Carbon Monoxide (CO) and Hydrogen Sulphide (H_2S). All sample locations reported concentrations of CH_4, CO_2, CO concentrations above the detection limit of the GFM430 as shown in Table 3a.

Table 3a: Gas monitoring results

ID	DATE	CH_4 (%)	CO_2 (%)	O_2 (%)	FLOW (L/hr)	CO (ppm)	H_2S (ppm)	Balance (%)	Barometric Pressure
BH1	1/02/16	1.4	13.8	12.5	0	1029	86	72.3	998
	5/02/16	0.4	12.1	14.5	0	247	23	12.0	1013
	8/02/16	0.3	17.7	9.4	0	8	1	10.2	1013
BH2	1/02/16	63.8	17.7	0.0	8.1	13	1	18.5	996
	5/02/16	70.7	17.3	0.0	6.4	6	1	73.0	1014
	8/02/16	71.1	18.7	0.0	6.3	2	5	72.6	1014
BH4	1/02/16	63.5	18.0	0.0	5.5	8	0	18.5	996
	5/02/16	70.8	16.8	0.0	6	5	3	12.4	1013
	8/02/16	70.3	16.4	0.0	5.8	5	3	42.1	1013
BH5	1/02/16	45.6	26.0	0.0	1.5	221	11	28.4	997
	5/02/16	55.1	26.9	0.0	2.8	24	2	18.0	1013
	8/02/16	58.5	26.9	0.0	3.9	19	2	13.3	1011
BH7	1/02/16	60.6	25.8	0.0	0.6	8	0	13.6	997
	5/02/16	61.7	25.3	0.0	3.1	13	2	13.0	1013
	8/02/16	64	27.6	0.0	3.4	6	2	14.6	1011
BH8	1/02/16	39.5	18.4	0.0	1.6	13	0	42.1	996

	5/02/16	33.8	15.8	0.0	3.2	8	2	50.4	1012
	8/02/16	33.8	15.8	0.0	3.2	8	2	8.4	1012

The monitoring data collected during Site investigation works is considered to be representative of the Site condition and reliable for use in conducting a risk assessment. The primary hazard has been identified as an explosion occurring due to the presence of methane in the explosive range, either by:

- An accumulation of methane concentrations within the explosive range within on-site buildings, resulting in an explosion; or
- The exposure of machinery during the construction phase to in situ methane concentrations in the explosive range, causing an explosion.

The consequences of an explosion on site are deemed to be severe given that fatalities, very serious injuries and/or catastrophic damage to buildings may occur. The probability of this occurring is considered to be likely given the credible linkage based upon the conceptual site model (CSM) for all necessary elements required for a hazardous event to occur. Based on a Level 1 Risk Analysis and Assessment the risk has been determined to be 'High Risk' due to the identified likelihood and severe consequences of an explosive incident occurring.

Given the determination of the Level 1 Risk analysis and Assessment that a high risk level exists, a Level 2 assessment has been undertaken. A maximum Gas Screening Value (GSV) and Characteristic Gas Situation (CS) for the Site has been determined based upon the *NSW EPA Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases* as shown in **Table 3a**.

The method considers both gas concentrations and borehole flow rates to define a characteristic condition for a site using a calculation of the Gas Screening Value (GSV). The GSV is a multiple of the maximum gas flow rate (litres/hour) from a borehole and the maximum gas concentration (%v/v).

Table 3a: Modified Wilson and Card Classification (Table 6 NSW EPA 2012)

	Characteristic situation	Risk Classification	Gas Screening Value Threshold (GSV) (CH_4 or CO_2) (l/hr)	Additional Factors	Typical source of generation
	1	Very low risk	<0.07	Typically methane 1.0 % v/v and/or carbon dioxide 5 % v/v. Otherwise consider increase to Situation 2	Natural soils with low organic content "Typical" fill

	2	Low risk	<0.7	Borehole air flow rate not to exceed 70l/hr. Otherwise consider increase to characteristic Situation 3	Natural soil, high peat/organic content. "Typical" made ground
	3	Moderate risk	<3.5		Old landfill, inert waste, mine-working flooded
	4	Moderate to high risk	<15	Quantitative risk assessment required to evaluate scope of protective measures.	Mine-working – susceptible to flooding, completed landfill WMP 26B criteria)
	5	High risk	<70		Mine-working Un-flooded inactive with shallow workings near surface
	6	Very high risk	>70		Recent landfill site

GSVs have been calculated for each borehole under consideration. Due to limited monitoring data, the calculation was carried out conservatively for methane and carbon dioxide with the worst-case monitoring values adopted at each monitoring location. The GSV calculation was performed and a range of 0.0 (very low risk) to 4.48 (Moderate to High Risk) was recorded.

Table 3b: Gas Screening and Characteristic Gas Situation Values

ID	Worst Case Values			GSV (l/hr) (CH_4)	GSV (l/hr) (CO_2)	Characteristic Gas Situation	Risk
	CH_4 (%)	CO_2 (%)	Flow (L/hr)				
BH1	1.4	13.8	0	0.0	0.0	1	Very Low
BH2	71.1	18.7	6.3	4.48	1.18	4	Moderate to High
BH4	70.8	16.8	6.0	4.25	1.01	4	Moderate to High
BH5	58.5	26.9	3.9	2.28	1.05	3	Moderate
BH7	64	27.6	3.4	2.18	0.94	3	Moderate
BH8	39.5	18.4	1.6	0.63	0.29	2	Low

Based upon the findings of Table 3b, a corresponding CS of Moderate to High Risk for the Site is recommended. In accordance with NSW guideline requirements, gas protection measures for the Site are required. GSV values and corresponding risk levels are shown in **Figure 3**.

3.5.4 Asbestos

Analysis of asbestos in soils was undertaken in five soil samples during the detailed Site investigation. One sample (BH7-4.0) contained chrysotile fibres. The sample was obtained within fill material from the landfill and fibres were not detected above this depth (4.0 metres). Previous investigations (Douglas Partners, 2003) noted the presence of asbestos containing material (ACM) fragments in BH5 (2.9-4.0m) as located in **Figure 4**.

4.0 CONCEPTUAL SITE MODEL

4.1 Contaminants of Concern

On the basis of the information summarised above, the principal contamination sources are associated with the landfill waste material (TRH, BTEX and PCBs), associated leachate and landfill gases (LFG). Potential LFG contaminants of concern are methane, carbon dioxide, carbon monoxide and hydrogen sulphide. It is also possible there is methane present that is derived from other potential sources of ground gas in the vicinity of the Site which include:

- Mains sewer gas.
- Imported fill and man-made ground.
- Partitioning of methane dissolved in migrating groundwater.

Vapours may arise from volatisation of hydrocarbon wastes but the CSM considered the primary gaseous contaminants to be predominately methane, carbon dioxide, carbon monoxide and hydrogen sulphide e.g the bulk gases that comprise Landfill Gas (LFG). The primary source of this ground gas was from the buried putrescible (biodegradable) waste generated by bacterial decomposition in the former landfill site. In addition to methane and carbon dioxide recent monitoring has measured elevated concentrations of hydrogen sulphide and carbon monoxide.

4.2 Release and Transport Mechanisms

Contaminants generally migrate from a site via a combination of windblown dusts, rainwater infiltration, groundwater migration, and surface water runoff and gas migration. The potential for contaminants to migrate is a combination of:

- The nature of the contaminants (solid/liquid/gas and mobility characteristics);
- The extent of the contaminants (isolated or widespread);
- The location of the contaminants (surface soils or at depth); and,
- The site topography, geology, hydrology and hydrogeology.

As a significant proportion of the Site is within the landfill with an existing cap and contain strategy with the contamination being below ground level, the potential for windblown dust migration of contamination from the Site was considered to be minimal. The potential for migration of contamination via surface water movement and infiltration of water and subsequent migration through the soil profile was considered generally to be moderate given the potential of voids and high permeability of the landfill material. Due to the current landfill containment system (maintaining an

inward hydraulic gradient through collection and extraction of landfill leachate migration of contamination off-site via groundwater movement was considered to be low. It is also noted that the potential for migration of landfill leachate may increase with disruption to the landfill, therefore any design consideration should include the potential for groundwater migration and continued negative gradient towards the centre of the site.

4.2.1 Landfill Gas Transport Mechanisms

The driving force of LFG is affected by a number of variables and for LFG to migrate away from the waste mass a pathway must be available and for migration to be sustained the source of gas must be replenished. CIRIA C665 (2007) describe three main factors that influence LFG migration:

- Pressure differential.
- Diffusion.
- Flow in dissolved form in liquids.

Barometric pressure

The rate of fall of atmospheric pressure is more significant than the actual pressure level in influencing LFG movement in the subsurface. Rapidly falling pressure can lead to a pressure differential between the waste mass and the external atmosphere in general, thus providing a motive force for LFG migration. Once equilibrium of pressure has been reached, even at low barometric pressure, the motive force is removed and the influence of barometric pressure on potential LFG migration is greatly reduced. Barometric pressure changes are documented as one of the most important factors in incidents of LFG explosions.

Rainfall

Precipitation can lead to a reduction in the permeability of the ground surface by sealing migration routes, again leading to a build-up of pressure within a gas body, and the potential for an increase in subsurface migration.

Anthropogenic influences

The potential also exists for LFG to preferentially migrate through subsurface structures such as buried utility lines, where more permeable sands and gravels may have been used during the construction of these services.

4.3 Exposure Pathways

Based on the identified PCOCs, the exposure pathways for the construction / remediation activities on Site include:

- Inhalation of LFG migrating upwards from fill material of unknown origins or impacted surface soils resulting from potential historical activities;
- Potential dermal and oral contact with impacted soils;
- Potential Inhalation of vapours from TRH / BTEX impacted soils;
- Potential dermal and oral contact with shallow groundwater;
- Potential contaminant uptake by vegetation established in the landscaped areas of the Site;

Based on the identified COCs, the exposure pathways for the Site's future occupants include:

- Inhalation of LFG migrating upwards from fill material of unknown origins or impacted surface soils resulting from potential historical activities;
- Inhalation of vapours resulting from BTEX and TRH impacted soils within landfill materials;
- Potential contaminant uptake by site occupants as a result of ingestion via consuming vegetation grown in areas of the Site; and/or,
- Direct ingestion of soil, particularly by young children playing on the ground surface in unsealed areas of the Site.

The LFG generated within the site will fill the available void spaces within the waste mass. The migration of LFG into a pore space results in LFG moving outward as there is a build-up of LFG pressure. Due to methane being less dense than air, there is a natural tendency for the gas to migrate upwards. When the upward movement of the LFG is restricted due to an engineered cap or moisture, the gas will naturally migrate in a lateral direction taking the easiest route out of the site.

The most significant source-pathway-receptor is usually associated with LFG migrating through subsurface soil, rock and man-made services potentially impacting human receptors.
LFG can enter buildings via fractures in subsurface walls and wall cavities. With the exception of specific joints, well-constructed concrete slabs should not have cracks which would act as a pathway. However, there is always a potential for cracks to occur at any location across the slabs, generally as a result of induced stresses during or soon after construction, or from differential settlement or damage during use. Cracks can also occur at the floor/wall perimeter from settlement.

LFG can enter buildings and accumulate via the following routes listed below:

- Beneath suspended floors (cracks or gaps in both solid and suspended floors)
- Joins in walls
- Vertical structures such as foundation piles
- Cracks or gaps in walls and floors
- Settlement voids and joints formed during the construction process
- Around service pipes, ducts and drains.

4.4 Sensitive Receptors

The potential sensitive receptors of environmental impacts present at the Site for construction / remediation include:

- Present and future workers and users of the Site who may potentially be exposed to COCs through direct contact with impacted soils and/or inhalation of LFG / dusts / vapours associated with impacted soils and contaminated groundwater;

The potential sensitive receptors of environmental impacts present at the Site after completion of construction / remediation activities include:

- Residents who may potentially be exposed to COCs through direct contact with impacted soils and/or inhalation of LFG / dusts / vapours associated with impacted soils and contaminated groundwater;
- Maintenance workers conducting activities at the Site, who may potentially be exposed to COCs through direct contact with contaminated groundwater, impacted soils present in excavations/boreholes and/or inhalation of dusts associated with impacted soils; and
- Flora and fauna species established at the Site.

A number of potential risks to human and environmental receptors are summarised below:

Table 4.1: Potential Risks to Human and Environmental Receptors

Aspect	Potential Hazard	Potential risk associated with hazard	Potential type of risk
Human Health	LFG and Air	Explosion and fire	Acute
	Lack of oxygen	Asphyxiation	Acute
	LFG trace toxics	Inhalation	Acute / Chronic
	Soil/dust	Inhalation	Acute / Chronic
	Asbestos	Inhalation	Chronic
	Leachate	Skin Absorption	Acute / Chronic
Ecosystems	LFG	Phytotoxicity	Acute / Chronic
	Soil/dust	Inhalation, Eutrophication of waterways	Acute / Chronic

Aspect	Potential Hazard	Potential risk associated with hazard	Potential type of risk
	Leachate	Absorption, contamination of surface/groundwater	Acute / Chronic
Buildings and Structures	LFG and Air	Explosion and fire	Acute
	LFG	Subsidence	Acute / Chronic
	Leachate	Odour, Corrosion	Acute / Chronic
Aesthetics	LFG	Odour	Acute / Chronic
	Leachate	Odour	Acute / Chronic
Food and Flora	LFG	Phytotoxicity	Acute / Chronic

5.0 SELECTION OF PREFERRED REMEDIAL STRATEGY

5.1 Overview

The *Contaminated Sites: Guidelines for the NSW Site Auditor Scheme* (NSW EPA, 2nd ed., 2006) outlines the hierarchical management of wastes as preferred by the EPA. According to this document, the order of preference for soil remediation and management is:

- On-site treatment of the soil so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level;
- Off-site treatment of excavated soil so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level, after which the soil is returned to the Site;
- Removal of contaminated soil to an approved site or facility, followed where necessary by replacement with clean fill; and,
- Consolidation and isolation of the soil on-site by containment within a properly designed barrier.

This scheme adopts the *Australian and New Zealand Guidelines for Assessment and Management of Contaminated Sites* (ANZECC, 1992). In addition, it is also a requirement that remediation should not proceed in the event that it is likely to cause a greater adverse effect than leaving the Site undisturbed (DEC, 2006).

A review of the available remediation methods and technologies indicates that the following strategies may be applicable to the remediation of the Site:

5.1.1 Excavation and Off-Site Disposal

Landfill disposal is the simplest of all remediation methods, and involves the excavation of the contaminated materials, and disposal off-site to an EPA approved landfill disposal site with appropriate environmental safeguards. The formed excavation is generally then backfilled using clean, validated fill materials.

The selection of an appropriate landfill will normally depend largely upon the results of classification of the wastes. It is sometimes necessary for heavily contaminated soils to be pre-treated prior to disposal, to reduce the concentrations or minimise the mobility of the contaminants. Special criteria are sometimes applicable to certain categories of waste. Contaminants covered by Chemical Control Orders have restrictions placed on their handling and disposal.

5.1.2 On-Site Capping and Containment

On-site capping and containment involves the installation of a physical barrier around the contaminated area to prevent potential migration pathways of contaminants. The predominant contaminants of concern are associated with the landfill waste material (including asbestos) TRH, BTEX PCBs, associated leachate and LFG.

The inclusion of effective gas protection measures, a low permeability capping system and appropriate surface water controls/management is expected to result in the minimisation of landfill gas migration, leachate production and exposure to landfill waste, including asbestos.

A site management plan will need to be implemented for capping to ensure that future excavation work is minimised and where necessary, carried out in strict accordance with appropriate occupational health and safety procedures.

The *Guidelines for the NSW Site Auditor Scheme* (NSW EPA, 2nd ed., 2006) provides a checklist to ensure the following technical issues associated with cap and containment is identified:

- That the design maximises the long term engineering security of the works and minimises the potential for leachate formation;
- Does not include the erection of structures on the capped or contained area that may result in risk of harm to the public health or the environment; and,
- Includes a notification mechanism to ensure that the capped or contained area are protected from any unintentional or uncontrolled disturbance that could breach the integrity of the physical barrier.

5.2 Technical Appraisal

Important considerations (from a technical perspective) in selecting and effectively implementing one of the available remediation strategies for the Site are provided below in **Table 5a**.

Table 5a – Technical Considerations

Technical Considerations	OPTION 1 Capping & Containment	OPTION 2 Excavation and Off-Site Disposal
Human Health Risks	Low – contaminants do not generally constitute a significant risk when contained. Limited personal contact. Moderate - The site already comprises an existing cap and containment strategy and potential disturbance to the cap may generate preferential pathway for leachate, odour and gas migration, as well as the potential offsite disposal of putrescible landfill materials.	High – excavation and direct off-site disposal will cause potential personal contact with putrescible landfilled waste, asbestos, odour and leachate issues.
Reliability	Sound – some potential may exist for contaminant break though if cap breached or not maintained properly. Design and management will ensure minimal access to cap surface is possible.	Satisfactory – system ensures the removal of all contaminated materials.
Regulatory Approvals	Satisfactory –on-site containment is pre-existing due to the landfill and management/maintaining the existing capping is preferred, however reinstatement of the cap with potential re-use of the site for residential / commercial uses provides beneficial outcomes for the site opposed to remaining as a carpark.	Satisfactory – waste will satisfy the *Waste Classification Guidelines* (NSW EPA, 2014).
Site Suitability	Good – Minimal levels of excavation into the subsurface are proposed for the Site.	Low – The extent and depth of landfilled materials on the Site will incur significant expense and high levels of road transport for disposal, as the landfill extends outside of the site, structural considerations would also be required in order to prevent migration of neighbouring landfill and potential slump.
Disruption to Site Structures and Activities	Sound – Inclusion of gas protection/containment measures are integrated into the design of the structure. Works would temporarily remove existing cap and contain within the site, however the cap would be reinstated to provide additional passive mitigation measures.	High – Excavation and off-site disposal is expected to cause significant disruption and delays in project schedule.
Ongoing Liabilities	Moderate – capping system needs to be maintained.	Minimal – all contaminated materials removed.
Contractor Experience	Moderate – contractors available with experience in the implementation of gas protection/containment measures.	Moderate – relatively simple strategy involving only basic technologies however high levels of health and safety would be required.
Availability of Disposal Sites	NA.	Good – landfills available to accept waste.
Implementation Time Frame	Short to moderate.	Moderate.

Based on the analysis undertaken in **Table 5a**, the following salient conclusions are made regarding the technical suitability of the various remediation options for the Site:

- Excavation and off-site disposal offers no constraints on future land use however the option is not considered suitable for the Site predominantly due to the depth and extent of the landfill waste material on the Site. The existing landfill extends beyond the current site boundaries and structural considerations would be required in order to prevent the existing landfill migrating into an open excavation. In addition, this method will have the potential to compromise the existing cap and containment system and leachate collection system on the Site;
- The capping and containment method is the preferred method due to:
    - The cap and contain strategy has low health risks as it only involves a minimal disturbance of the cap and containment system and contaminated soils. Other remediation schemes may result in the release of hazardous landfill waste, LFG, leachate and dust thereby creating a human health risk to remediation workers and nearby residents;
    - No disturbance to the pre-existing leachate collection system;
    - No increase in road traffic;
    - The strategy requires no additional excavation or disposal costs over that which would be normally incurred as part of the proposed development;
    - The cap can be effectively achieved with the proposed surface design therefore requiring no additional works; and
    - The time frame for implementation of the remediation system is relatively short compared excavate and dispose.
    - Would adequately address the potential vapour risks due to TRH and BTEX impacted soils identified in previous investigations.

The primary drawbacks to an On-Site Capping and Containment strategy would be as follows:

- The strategy may require a more diligent maintenance schedule than otherwise anticipated;
- The strategy will require the development and implementation of an Environmental Management Plan (EMP); and
- It is noted that the Site requires notation as containing contamination and is titled accordingly;
- Requirement for ongoing monitoring of landfill gas build-up in buildings; and
- Requirement to maintain the landfill gas management system.

However as there is already an onsite 'capping and containment' system with ongoing monitoring requirements, the implementation adverse effects of the proposed cap and contain with an increased beneficial site usage would be considered to be minimal

5.3 Economic Appraisal

DLA has performed a precursory cost-benefit analysis to assess the viability of the two most applicable remediation options for the Site – excavation and off-Site disposal and capping and containment. A review of typical project component costs, in conjunction with wider considerations regarding long-term liabilities and potential impacts on property value, have concluded that the option of capping and containment is expected to produce the most beneficial economic outcome.

5.4 Preferred Strategy

The Site strategy selected must be the most cost-effective solution, which does not bring about unacceptable long-term liabilities, and which does not impose unreasonable constraints on future Site developments or present operations. The strategy must also be capable of achieving the technical, environmental and economic objectives outlined in this RAP.

Based on the analysis undertaken in previous sections, the preferred remediation method for the Site is **capping and containment**.

It is recognised that material may need to be removed for service trenches and piling spoil, however, these will be classified in accordance with the *NSW EPA 2014 Waste Classification Guidelines* where material is considered excess. Where possible the construction methods will be selected in order to generate the least amount of waste such as driven piles (where structurally suitable) which due to the generally unconsolidated nature of the landfill will generate minimal spoil.

6.0 IMPLEMENTATION OF SELECTED STRATEGY

6.1 General

The remediation strategy developed for the Site will be required to achieve four main aims, namely:

- To negate any appreciable risk of human exposure to contaminated soils and therefore relieve the possibility for significant risk of harm;
- Maintain the integrity of the landfill and related landfill/leachate infrastructure;
- To halt the migration of landfill gas; and,
- To provide an end product desirable for the preferred intended land use.
- The detailed design of the Site will not compromise the Golf Driving Range leachate management system.

The proposed remediation strategy incorporates the following elements:

- Stakeholder consultation;
- Implementation of an accepted Site Environmental Management Plan (SEMP);
- Remediation Notice 28040 to which the Site is subject;
- Site Establishment and Pre-Remedial Works;
- Remediation Works; and,
- Validation Plan.

6.2 Stakeholder Consultation

Prior to implementation of the RAP, it is necessary to secure all relevant approvals and licences and submit notification to council. For a list of potential environmental and planning approvals, refer to **Section 10.0**.

Due to the existing Major Development – SEPP 2005 Site remediation works would fall under Category 1 Remediation.

On approval of the strategy, the stakeholders including on-site management and relevant regulatory bodies will be informed of the intentions and the progress at all stages of the remediation works.

6.3 Implementation of Site Environmental Management Plan

A Site Environmental Management Plan (SEMP) covering the remedial works should be prepared for the Site. Before work commences it is imperative that all issues relating to potential impacts be reviewed. An outline of a SEMP including Remediation Works Management and Health and Safety Plans has been included in **Section 10.0**.

6.4 Site Establishment and Pre-Remedial Works

Initial activities at the Site shall involve the establishment of all plant and equipment necessary for the remediation works. This shall include:

- Establishment of a Project Manager/Contractor's site office of temporary work sheds and amenities for Site workers;
- Establishment of a car parking area for Site workers and visitors to the Site; and,
- Establish the Site Environmental Monitoring Program.

Prior to the commencement of any earthmoving activities, it will also be necessary to install environmental protection safeguards, as well as Site security measures. These measures are outlined as part of the SEMP contained in **Section 10.0**.

6.5 Remediation Works

The remedial works envisioned at the Site are as follows:

- Landfill Gas (LFG) and gas vapour protection measures
- Asbestos and landfill Material
- Management of unexpected finds

6.5.1 LFG Gas Protection Measures

An LFG and gas vapour management system must be installed beneath ground level slabs constructed on the site as part of site development. Management recommendations have been determined with reference to the *NSW EPA Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases (2012),* based on the protection level determined by the process described therein.

6.5.2 Venting and Dilution Measures

Venting and dilution of LFG at the Site is required for the uninhibited flow of ground gasses from occupied areas and to avoid a build-up of gas beneath the sub-floor. The concept of the passive dilution barrier is to form a low pressure area relative to the surrounding gassing ground, to encourage gas to flow towards the sub-floor barrier. This is achieved by incorporating an air filled void and preferential pathway which are connected to collection/dilution ducts. The duct allows a relatively high flow of fresh air through it by means of passive ventilation to the atmosphere. The key advantages of the system are:

- Dilutes gas emissions to tolerable levels.
- Causes a venturi effect in the underfloor vents that enhances gas flow from the ground into the system.

DLA understands a partial under-floor void is part of the building design. The concrete slab will be constructed so that there is a 300 mm void directly on top of compacted fill. The advantages of a sub-floor, above ground air filled void are:

- It will encourage mixing of gases which migrate into the void, therefore reducing the hazard of LFG layering inside the backfill or building.
- The relatively large volume of underfloor void compared to granular infill will require a lower volume flow rate of fresh air to provide adequate ventilation.

The venting and dilution performance criteria and corresponding protection score is as follows:

System Element	Gas Protection Score
Passive sub-floor ventilation with very good performance (steady state concentration of methane over 100% of ventilation layer remains below 1% v/v at a wind speed of 0.3 m/s.	2.5

6.5.3 Floor Slab

It is expected that the current design for the building will comprise a suspended slab with all services hung or cast in to the slab. This is due to the existing landfill and the expected ground movement / ongoing settlement of the landfill. The suspended slab mitigates the potential ground settlement issues which includes, stress fractures and cracking of the slab. The suspended slab will be engineered to receive support from piles anchored into rock and certified by a geotechnical engineer to withstand the development of voids and expected settlement.

The hanging or casting in of the services from the slab will limit the requirement for buried services and provide structural support for the services. This will also mitigate any ongoing settlement issues and potential generations of voids.

Any gas mitigation technology implemented at the site will be flexible to allow for future settlement of the landfill.

Beneath the occupied areas of the development, a reinforced concrete slabs will be constructed to reduce the intrusion of gas from below ground or from potential pathways originating from below ground, including services and relief joints. All joints and penetrations will be sealed with water bars and independent inspection.

The recommended option is to incorporate a reinforced concrete cast in situ or post-tensioned suspended slab with minimal service penetrations and water bars around all penetrations and at joints. The floor slab criteria and corresponding protection scores are as follows:

Preferred Option	System Element	Gas Protection Score
1	Reinforced concrete cast in situ or post-tensioned suspended slab with minimal service penetrations and water bars around all penetrations and at joints.	1.5
2	Reinforced concrete ground bearing foundation raft with limited service penetrations cast into slab.	1
3	Reinforced concrete ground bearing floor slab	0.5

6.5.4 Gas membrane

It is recommended that a gas membrane is installed underneath the concrete slab. Manufacturers of synthetic membranes will provide instructions on how to lay and install them correctly. The main considerations with respect to the installation of a gas membrane are presented in CIRIA guidance (Card, 1995). The requirements are that the membrane should:

- Meet a minimum requirement in hydraulic conductivity of 10^{-9} m/s.
- Overlain with a protective layer to provide mechanical protection from steel fixers and other workers on top of the membrane.
- Be protected once laid either by the use of temporary boarding or sheeting over the whole area. This is not always practical during construction operations because of the need to make provisions for service connections into the building, and for the construction of internal walls and substructures. Once the gas membrane has been installed an inspection should be undertaken to ensure adequate protection measures have been implemented. DLA note that a variety of gas membrane products are available and each should be assessed in their own merits.

Additional notes on the construction of the membrane:

- All jointing and sealing should be in accordance with manufactures recommendations;

- If chloroprene modified asphaltic emulation and catalyst technique (Liquid Boot, Perlastic or equivalent) is used, the application must completely encapsulate the foundation, footings, and walls located below grade;
- All sharp protrusions are removed;
- Smoke tested (or equivalent) to demonstrate integrity of membrane; and,
- Inspected by Suitably Qualified Person.

Service conduits, pits and ducts should all be constructed so as to avoid any opportunity for gas build up within. All services entering the occupied areas should be constructed in such a manner as to avoid providing a pathway for gas to enter the building. Service pits will also be constructed with a liquid boot lining to prevent gas migration directly into the service pit void. The membrane will require independent construction quality assurance and integration with the sub slab system.

The recommended membrane configuration is for the installation and verification by independent construction quality assurance (CQA) with integrity testing and independent validation. The Gas Protection Scores for the installation of a gas-resistant membrane is as follows:

Preferred Option	System Element	Gas Protection Score
1	Proprietary gas-resistant membrane to reasonable levels of workmanship under independent construction quality assurance (CQA) with integrity testing and independent validation	2
2	Proprietary gas-resistant membrane to reasonable levels of workmanship under independent CQA	1

6.5.5 Monitoring

Continuous monitoring of landfill gas concentrations is required to be undertaken during piling operations, any hot works and any other activities that have the potential to be an ignition source of built up explosive gas. In particular, during the installation of the piling system it will be necessary to penetrate the ground with augers.

The recommended and preferred option under the NSW Guidelines is for a permanent monitoring system installed in the underfloor venting and dilution system. The Gas Protection Scores for permanent monitoring systems are as follows:

Preferred Option	System Element	Gas Protection Score
1	Permanent monitoring system installed in the underfloor venting/dilution system	2
2	Permanent monitoring system installed in the occupied space of the building	1

With the implementation of the preferred option of each recommended Gas Protection Measure, an overall Gas Protection Score of 8 is achieved, above the NSW Guidelines for Gas Protection Guidance Score requirement of 5.

Final design, monitoring and CQA measures to ensure the safety of the construction operatives and occupants of future building will be decided following submission of the draft report.

6.5.6 Management of Asbestos and Landfill Material

Asbestos and landfill material identified at depth will be managed through capping and containment remedial strategy. The gas vapour management system proposed (Section 6.5.1) will contain the asbestos at depth. The capping layer will prevent human contact with asbestos and thus reduce the risk to human health.

If material within the landfill is excavated/encountered during Site works, the material should be analysed, classified and disposed of accordingly.

6.5.7 Management of Leachate and Surface Water

Surface water at the site will be directed through appropriate site surface sedimentation water controls in order to minimise surface water entering the landfill and from exiting the site following contact with exposed soils and sediments. Where water comes into contact with waste materials, that water is considered to be leachate. Any leachate water must be dealt with accordingly. The preferred strategy for managing leachate is for it to remain onsite within the landfill.

Due to the proposed construction methods of driven piles and a suspended slab building design the requirement for excavation into the landfill below the cap is minimised. Penetrations into the landfill below the existing cap should be limited to the lift shaft overrun, OSD tank and other minor services.

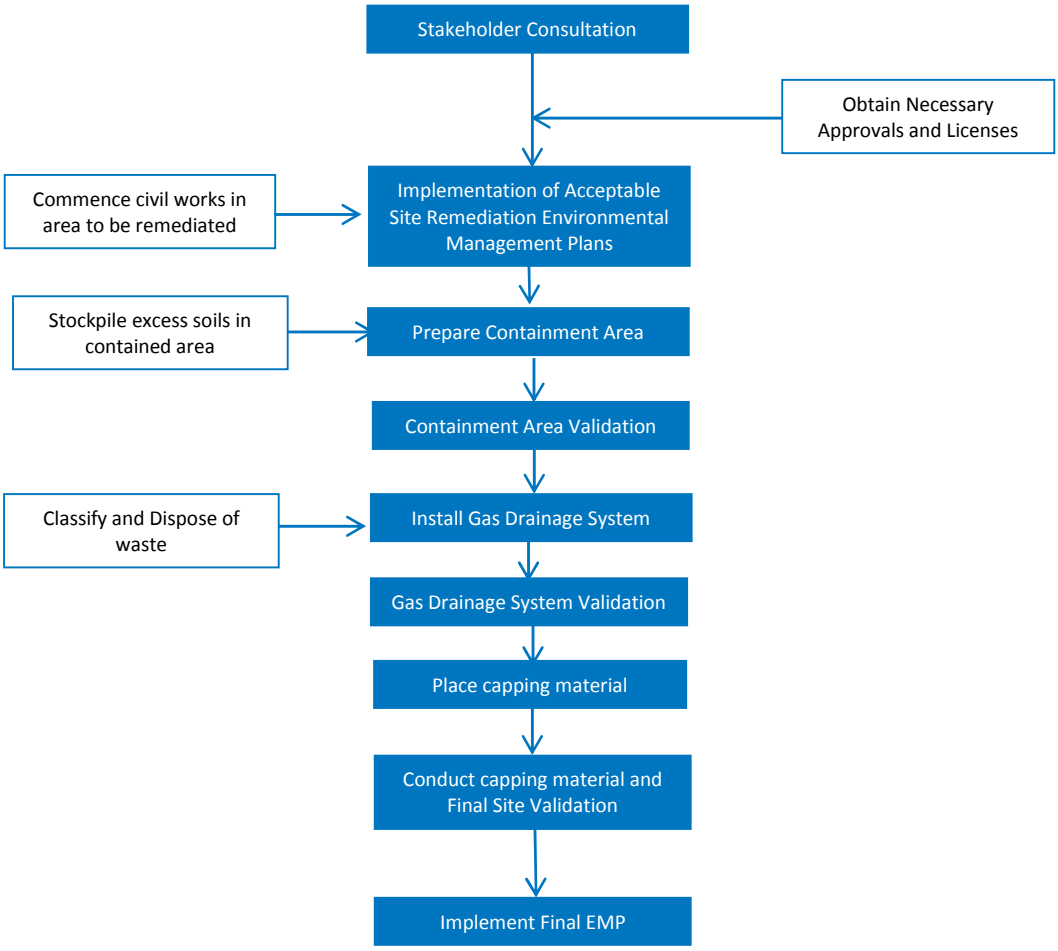
Where excavation penetrations encounter leachate within the landfill appropriate measure should be taken in order to minimise the potential for leachate to be come into contact with the surface, non-landfill materials and personnel at the site due to the potential health and environmental risks. Where leachate is encountered and dewatering or disposal is required leachate will be tankered offsite to a facility that can legally accept that waste.

6.5.8 Management of Unexpected Finds

DLA propose that the Unexpected Finds Protocol (UFP) (**Appendix B**) be used to address any anomalous or unexpected chemical or asbestos contamination issues that are encountered during remediation works.

Should non-compliant material be discovered as a result of the UFP, it will be classified and disposed of in accordance with the *Waste Classification Guidelines* (NSW EPA, 2014) and any WorkCover requirements.

A schematic of the **Remediation Process** is shown below:



7.0 VALIDATION PLAN

7.1 Extent of Validation

Since all soils are in compliance with the proposed land use criteria – *Residential B- High Density Residential* the soil criteria will only be applicable to the unexpected find of suspected contaminated soils, or in the need to assess imported fill materials. A data summary table is included in Appendix C.

For the purpose of this site remediation any materials requiring off-site disposal will need to meet the requirements of the Waste Classification Guidelines (NSW DECCW 2014).

7.2 Validation Procedure

Validation of the Site will initially focus on the presence of asbestos, chemical contamination and landfill gas during construction. The implementation of appropriate cap and containment measures for physical cap and gas mitigation measures and the ongoing validation as determined by the gas management plan. The final validation report will include but it not limited to;

- The extent of contamination (if any) remaining outside the confines of the building slabs;
- Removal of any soils from the site, including classification and disposal;
- Any potential offsite disposal of groundwater (if required);
- Documentation of any material imported to the site for engineering purposes;
- The adequacy of the final design in handling the landfill gas issues;
- Monitoring of landfill gas concentrations within surface soils, within building structures and services and on boundaries;
- Requirements for ongoing site monitoring (if any); and
- Risk of remaining material impacting on future Site users (if any).

7.3 Validation Guidelines

7.3.1 Soil Criteria

To determine Site suitability following remedial works, criteria from the NEPM (NEPC, 2013) Schedule B1 were utilised for Tier 1 validation should unexpected finds relating to soil be encountered for this assessment. With regard to the vapour intrusion criteria, the NEPM (NEPC, 2013) provides Health Screening Levels (HSLs)and Management Limits (MLs) for TRH fractions in soil and groundwater based on concerns regarding ecological impacts, inhalation of vapours and direct contact with contaminant

sources. The material type of 'sand' (or 'coarse') has been used as it offers the most similar correlation to the condition of soils at the Site.

Ecological Screening Levels (ESLs) while may be considered to be applicable within the vicinity of the proposed future garden areas, it is expected that these areas would be heavily landscaped. It is also considered that landscaping of these areas would involve the import of suitable landscape materials and be small in scale and any vegetative would have a limited root zone. Therefore concentrations at depth would not impact future vegetation at the site and therefore are to be assessed on individual sample locations.

While applicable HSL and HIL criteria have been provided the application to soils at the site should only be considered when located above the 'capping' layer or in a location where direct contact is possible. Due to the presence of the cap the mitigation of all direct contact and vapour risk is mitigated.

Table 7a –TRH Soil Criteria for Vapour Intrusion (mg/kg)

ANALYTES	HSL-B (Sand) 0 to <1.0m	HSL-B (Sand) 1.0 to <2.0m	HSL-B (Sand) 2.0 to <4.0m	HSL-B (Sand) 4.0m +	Direct Contact HSL-B
Benzene	0.5	0.5	0.5	0.5	140
Toluene	160	220	310	540	21,000
Ethylbenzene	55	NL	NL	NL	5,900
Xylenes	40	60	95	170	17,000
Naphthalene	5	NL	NL	NL	2,200
F1: $>C_6$-C_{10}	45	70	110	200	5,600
F2: $>C_{10}$-C_{16}	110	240	440	NL	4,200
F3: $>C_{16}$-C_{34}	NA	NA	NA	NA	5,800
F4: $>C_{34}$-C_{40}	NA	NA	NA	NA	8,100

NL = Not Limiting (i.e. the soil vapour concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for the given scenario).

NA = Not Applicable (i.e. NEPM (NEPC, 2013) does not provide HSLs for the F3 and F4 hydrocarbon fractions)..

Vapour Intrusion Criteria sourced from NEPM (NEPC, 2013) *Table 1A(3) – Soil HSLs for vapour intrusion.*
Direct Contact Criteria sourced from Friebel and Nadebaum 2011, Health Screening Levels for petroleum Hydrocarbons in Soil and Groundwater, Part 1: Technical Development Document, *Table A4 – Soil Health Screening Levels for Direct Contact.*

Table 7b – Criteria for Total Recoverable Hydrocarbons ESL and ML (mg/kg)

ANALYTES	ESL (Coarse) Urban Residential and Public Open Space	ML (Coarse) Urban Residential and Public Open Space
Benzene	50	--
Toluene	85	--
Ethylbenzene	70	--
Xylenes	105	--
Benzo(a)Pyrene	0.7	--
F1: $>C_6$-C_{10}	180	700
F2: $>C_{10}$-C_{16}	120	1,000
F3: $>C_{16}$-C_{34}	300	2,500
F4: $>C_{34}$-C_{40}	2,800	10,000

ESLs obtained from NEPM (NEPC, 2013) *Table 1B(6)* – ESLs for TPH fractions, BTEX and benzo(a)pyrene in soil.
MLs obtained from NEPM (NEPC, 2013) Table 1B(7) – Management Limits for TPH fractions F1-F4 in soil.

Table 7c – Site Assessment Criteria for Soils (mg/kg)

	ANALYTES	HIL-B
HEAVY METALS	**Arsenic**	500
	Cadmium	150
	Chromium	500
	Copper	30,000
	Lead	1,200
	Mercury	120
	Nickel	1,200
	Zinc	60,000
PAH	**BaP TEQ**	4
	Total PAHs	400
PCB	**PCB**	1
PESTICIDES	**Aldrin/Dieldrin**	10
	Chlordane	90
	DDT+DDE+DDD	600
	Heptachlor	10
ASBESTOS	**Bonded ACM**	0.04% w/w
	Friable Asbestos/Asbestos Fines	0.001% w/w
	Surface Asbestos (0.1m)	No Visible

Health Investigation Levels soured from NEPM (NEPC, 2013) Table 1A(1)
Asbestos Health Screening Levels sourced from NEPM (NEPC, 2013) Table 7.

7.3.2 Ecological Risk Assessment Criteria

According to NEPM (NEPC, 2013), Schedule B (5a) – *Guideline on Ecological Risk Assessment*, factors that may influence a Risk Management Decision (and therefore determine Ecological Risk Assessment outcomes) are generally based on economic, ecological or societal considerations.

Examples include:

- The size of the site, land value, cost of remediation (economic);
- The type of contaminants present, current and potential site land use, surrounding land use (societal); and,
- The ecological significance (e.g. a rare and endangered species or a species that supports a valued ecological process or a sensitive introduced species of low ecological significance) of the values identified in the Receptor Identification component of Ecological Risk Assessment (ERA) to be protected.

EILs have been implemented to environmentally manage the effect of contaminants on terrestrial ecosystems and species sensitivity. The EILs referenced in this report have been developed for the generic land use setting of urban residential areas and public open space. It is important to note that the contamination is assumed to be aged (>2 years), as fresh contamination associated with current industrial / agricultural activity and chemical spills are not likely present on-site. EILs have been derived for: Arsenic (As), Copper (Cu), Chromium (CrIII), DDT, naphthalene, Nickel (Ni), Lead (Pb) and Zinc (Zn).

Ambient Background Concentration (ABC)

For Ni, CrIII, Zn and Pb (aged contamination), the EILs are the sum of Added Contaminant Limits (ACLs) and Ambient Background Concentrations (ABCs). To establish the ABC of a contaminant, the recommended method is to measure the ABC at an appropriate unpolluted reference site. As an unpolluted references sample was not able to be sampled from the site, the minimum applicable EILs have ben applied. For As, DDT and Naphthalene (aged contamination), the EILs are generically obtained (i.e. not dependent on soil type).

Added Contaminant Limit (ACL)

The Added Contaminant Limit (ACL) is the added contamination (in excess of the ABC). ACLs are applicable to Cr III, Cu, Ni and Zn and are based on soils properties of pH, Cation Exchange Capacity (CEC) and the clay content.

Table 7d – EILs for Soils (mg/kg)

ANALYTES	ABC	SQG	ACL	EIL
Arsenic		100[1]	-	100
Chromium (III)	12	-	400[2]	412
Copper	13	-	215[3]	228
Lead	35	-	1100[4]	1135
Nickel	5	-	560[5]	565
Zinc	73	-	270[6]	343
DDT	-	180[7]	-	180
Naphthalene	-	170[8]	-	170

1 NEPM (NEPC, 2013) Schedule B1 Table 1B(5).
2 NEPM (NEPC, 2013) Schedule B1 Table 1B(3).
3 NEPM (NEPC, 2013) Schedule B1 Table 1B(2). CEC has been used for this calculation.
4 NEPM (NEPC, 2013) Schedule B1 Table 1B(4).
5 NEPM (NEPC, 2013) Schedule B1 Table 1B(3).
6 NEPM (NEPC, 2013) Schedule B1 Table 1B(1).
7 NEPM (NEPC, 2013) Schedule B1 Table 1B(5).
8 NEPM (NEPC, 2013) Schedule B1 Table 1B(5).

Due to the highly disturbed nature of the site and the expected building envelope to extend to all boundaries, EILs and ESLs will only be applied or the purpose of shallow should where substantial vegetative growth or landscaping is proposed. It is considered the application of EILs and ESLs will be limited within the site boundary.

7.3.1 Groundwater Criteria

Criteria for groundwater were obtained from various sources. Where available, trigger levels provided by NEPM (NEPC, 2013) or ANZECC (2000) have been referenced in preference to overseas criteria, however these are limited. The Assessment Criteria for groundwater (should unexpected finds relating to groundwater be encountered) for this assessment are provided below.

Table 7e – Groundwater Investigation Levels (µg/L)

	ANALYTES	NEPM HSL[1] 4m to <8m (mg/L)	NEPM GILS Fresh Water (ug/L)	ANZECC[2] 95% Fresh Water
BTEX	Benzene	0.8	--	950
	Toluene	NL	--	--
	Ethylbenzene	NL	--	--
	m+p-Xylene	NL	--	200
	o-Xylene	NL	--	350
	Total Xylene	NL	--	--
TRH	$C_6 – C_{10}$	1	--	--
	$C_{10} – C_{16}$	1	--	--
HEAVY METALS	Arsenic (III)	--	24	24
	Arsenic (V)	--	13	13
	Cadmium	--	0.2	0.2
	Chromium (III)	--	-	--
	Chromium (VI)	--	1	1
	Copper	--	1.4	1.4
	Lead	--	3.4	3.4
	Mercury	--	0.06	0.06
	Nickel	--	11	11
	Zinc	--	8	8
PAH	B(a)P	--	-	0.2*

NL = If the derived groundwater HSL exceeds the water solubility limit, a soil vapour source concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for the given scenario. For these scenarios, no HSL is presented for these chemicals and the HSL is shown as 'not limiting' or NL.

***** ANZECC (2000) low or moderate reliability trigger values are provided where possible as an indicative guideline only in the absence of a high reliability 95% value.

+ Derived from the US EPA Regional Screening Levels.

1 – NEPM (NEPC, 2013) Table 1C – Groundwater Investigation Levels (GILs).

2 – Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000).

7.3.2 Asbestos Criteria

Asbestos or Asbestos Containing Materials will not be visible at the surface or within the 100mm surface soils. This is in accordance with the NEPC (NEPM 2013). Due to the potential for unexpected finds of asbestos contamination within fill soils, the Site will be subject to an Asbestos Management Plan, which will highlight management practices that must be complied with. An asbestos Unexpected Finds Protocol will be implemented for the Site, providing a framework for the management of any unexpected finds of asbestos containing material on Site.

7.3.3 Landfill Gas Construction Criteria

Methane gas concentrations will be required to be below 5% lower explosive limit (LEL) during all construction works and non-detect within all building and service conduits at building "lock-up" stage. Validation guidelines will be included in the Gas Management Plan for the Site which will consider the 2012 NSW EPA *Guidelines for the Assessment and Management of Sites Impacted Hazardous Ground Gases* (Draft) and the *Draft Environmental Guidelines: Solid Waste Landfills Second edition*.

A Final Validation Report should be prepared by the environmental consultant engaged to validate the remedial works with reference to the NSW EPA (1997) - *Contaminated sites: Guidelines for consultants reporting on contaminated sites.*

7.3.4 Validation of Gas Protection Measures

7.3.4.1 Installation

The installation of the vapour barrier must be documented, photographed and verified by a suitably qualified person. Installation must be undertaken in accordance with the manufacturer's specification for "Liquid Boot" or any approved equivalent product.

7.3.4.2 Effectiveness

The effectiveness of the gas vapour barrier must be validated by a round of monitoring of indoor air quality in the completed building using a NATA accredited method. Air quality must be deemed to be consistent with the human health risk assessment model performed for the Site and meet residential standards.

The validation sampling method and results must be certified as being accurate and complete and approved by the administering authority as part of any site validation process before the building is occupied.

7.3.4.3 Site Suitability Landfill Gas Validation Criteria

To determine Site suitability following remedial works, criteria from the 2012 NSW EPA *Guidelines for the Assessment and Management of Sites Impacted Hazardous Ground Gases* (Draft) and the *Draft Environmental Guidelines: Solid Waste Landfills Second edition*, 2015 were considered in the development of the assessment criteria.

The threshold level for further investigation and corrective action is detection of methane at concentrations above **0.0% (volume/volume)**. DLA consider as the building will be occupied, any detection of methane is unacceptable and therefore must trigger further investigation.

7.4 Validation Report

At the completion of the remediation activities, a Validation Report documenting the works as completed will be prepared. The Validation Report will describe the strategic works undertaken at the Site, assess the result of the validation testing, demonstrate that the objectives of this RAP have been achieved and provide justifications for any deviation, statistically confirm that the remediated Site complies with the Validation Criteria and include any other information as deemed appropriate.

The report should contain a description of all testing and/or monitoring undertaken as part of the remedial works including but not limited to validation results, waste classification of material disposed offsite/imported onsite (if any), and an appropriate discussion of field and laboratory work undertaken. It will also include a statement regarding the appropriateness of the remediated site for the proposed land use and any limitations or ongoing monitoring/management required.

Sufficient information must be provided by a person suitably qualified and competent in the implementation of landfill gas protection measures. The person suitably qualified must certify that sufficient information has been provided and he or she is satisfied that the liner design will be effective and fit for purpose. Verification of the barrier installation must be undertaken by an appropriately qualified person and in accordance with manufacture's specifications.

8.0 SOIL MANAGEMENT

8.1 Importation of Soil

If soils are to be imported onto the Site they must meet the following requirements:

- The soils must be legally able to be imported onto the Site in accordance with the *Protection of the Environment Operations (Waste) Regulation 2005* (NSW) and any SOPA requirements;
- The soils must meet the Validation Criteria (**Table 8a**); and,
- The soils must meet the geotechnical requirements for their proposed use.

It is preferable for all soil materials imported to the Site comprise:

- Virgin Excavated Natural Material (VENM) as per the *Protection of the Environment Operations Act 1997* (NSW);
- Excavated Natural Material (ENM) as per *Excavated Natural Material Order* (NSW EPA, 2014); and/or,
- Road-making materials consisting of quarried material.

The following requirements apply to material imported to the Site:

Table 8a – Imported Material Requirements

	IMPORTATION REQUIREMENTS
ENM	In addition to the ENM criteria specified in the *Excavated Natural Material Order* (NSW EPA, 2014), imported ENM will also meet the Validation Criteria, including the adopted Ecological Investigation Levels (EILs) and Ecological Screening Levels (ESLs), if the ENM is used in unpaved areas within 0-2m of the ground surface.
VENM	For imported VENM Should be in accordance with EPA guidelines and SOPA.
LANDSCAPING	Landscaping materials will be assessed as compliant with the Validation Criteria, including the adopted EILs and ESLs if used within 0-2m of the ground surface.

Material to be imported at the Site will be supported by documentation and visually inspected by the Environmental Consultant demonstrating that the material is meets the above definitions, material without relevant documentation verifying it's classification or does not correspond with the relevant documentation must not be received at the site.

A minimum of five samples for VENM and landscaping material testing are required for imported VENM and landscaping materials. Sampling frequencies in accordance with the *Excavated Natural Material Order* (NSW EPA, 2014) are required for ENM materials. Soils will be analysed for the following contaminants of concern as a minimum: heavy metals, TRH, BTEX, PAH, OCP, PCB and asbestos. ENM testing will include analysis of pH, electrical conductivity and foreign materials.

8.2 Waste Disposal

Waste classification of soils will be carried out in accordance with the *Waste Classification Guidelines* (NSW EPA, 2014) and associated exemptions and approvals. Waste classification data will consist of approximately one sample from 200m^3 of soil. The sample was then analysed for all potential contaminants including toxicity characteristic leaching procedure (TCLP) characteristics. This number of samples will increase for material that demonstrates signs of heterogeneity or whose average concentrations are on the margin between classifications.

9.0 CONTINGENCY PLAN

9.1 Remediation Contingency

If there are events or discoveries made at the Site that would prevent the proposed works complying with the Validation Criteria, or if the selected remediation strategy is not able to proceed, then the following contingencies are devised and should be discussed with the Site Auditor prior to occupation:

Methane Gas management measures do not effectively prevent the migration of LFG into the structure

Option A Implement an in-ground venting system designed to reduce the pressure and/or concentration in the source area and thus reduce the driving force for gas migration.

Option B Building over-pressurisation – Implementing an air conditioning system to maintain air pressure in the building.

Option C Sub-slab over pressurisation – Implement an air pump to achieve a positive pressure relative to the pressure of gas in the ground, thus preventing gas migrating from the ground into the void.

Should any other viable options be identified during the implementation of the remediation plan these should be reviewed and the validity of the options assessed. Prior to the implementation of the remediation contingency all options should be overseen and approved of by a NSW EPA accredited Site Auditor with specialist knowledge in remediated lands and landfill gas systems to certify that they are fit for purpose.

9.2 Unexpected Finds

An Unexpected Finds Protocol (UFP) has been developed as part of the construction planning for implementation during Site works primarily associated with excavation and civil activities. It has been prepared to ensure appropriate management of natural soils / fill which may contain undefined levels of TRH / BTEX, asbestos contamination and other possible contamination scenarios should they be encountered during Site works.

Refer to **Appendix A** – Unexpected Finds Protocol.

10.0 SITE ENVIRONMENTAL MANAGEMENT PLAN

A major component of the remedial works shall involve the installation and maintenance of a Site Environmental Management Plan. It is appropriate for the Contractor to develop an EMP for their component of the works based on the broad guidelines of the RAP. The Site Environmental Management Plan will provide details of the environmental protection and pollution control measures to be implemented during the operational phase of the remedial works.

The pollution control measures have the objective of removing/minimising any adverse impact on the surrounding environment. Details of the pollution control measures to be implemented are documented in the Environmental Management Plan (EMP) for the remediation works which is prepared (and approved) prior to commencement of remedial works.

In order to prepare the Environmental Management Plan for the remedial works a review will be undertaken to identify possible impacts on the surrounding environment. For each potential impact identified the range of pollution control measure(s) available for mitigating the impact was reviewed and the most practicable, efficient and cost effective were identified for implementation.

It was envisaged that there would be a series of control measures that would be common to the various elements of the remedial works. In addition, there are supplementary control measures that would be specific to particular elements of the remedial works.

In the following sections, outlines have been presented of the various pollution control measures that would be implemented during most elements of the remedial works. These form the basis of the Environmental Management Plan that should be read in conjunction with this document.

As discussed in Section 7.3.2, due to the potential for unexpected finds of asbestos contamination within fill soils, the Site will be subject to an Asbestos Management Plan, which will highlight management practices that must be complied with including the requirement for asbestos air monitoring during ground disturbance works. An asbestos Unexpected Finds Protocol will be implemented for the Site, providing a framework for the management of any unexpected finds of asbestos containing material on Site.

A Site Specific Environmental Management Plan detailing all aspects of the site works is to be developed and implemented prior to works commencing.

10.1 Erosion Sedimentation Control Plan

Erosion and run-off control measures will be implemented during all elements of remedial works undertaken. Typically, these measures will be designed to prevent the transport of pollutants (including sediments) out of the remediation area via stormwater/surface run-off.

Generally, no surface run-off and/or water from excavations/pits and trenches within the remediation area will be permitted to discharge, without regulatory authority approval, to the surrounding environment. Run-off control measures will be developed giving consideration to the site conditions in each remediation area, and are likely to include (but not necessarily be limited to) the following:

- Diversion drains, berms, sumps and pumping systems to prevent runoff entering or leaving excavation areas. All water in contact with works will be diverted through the treatment system;
- Any water that comes into contact with the excavation into the landfill waste will be deemed leachate and will be managed as such;
- Truck cleaning areas for use in washing down all vehicles potentially coming into contact with contaminated soil leaving a remediation area; and,
- Use of silt fencing, hay bales and/or oil absorbing booms, as required.

10.2 Noise Control Plan

The impact of noise associated with the site remediation works is acknowledged as a potentially important environmental effect. It will be necessary to minimise noise in accordance with NSW OEH Standards. The methods used to control noise will be dependent upon the equipment being used for particular remedial activities however, it would be expected that the methods would include those commonly used during normal construction and demolition works.

Noise control measures will be developed giving consideration to the site conditions in each remediation area, and are likely to include (but not necessarily be limited to) the following:

Site work will be restricted to the hours specified below;

The use of construction vehicles on-site will be kept to a minimum;

All equipment in operation in open areas on-site shall comply with the requirements of AS 2436-1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites*; and,

Noise monitoring may be conducted during the site remediation program.

10.3 Dust Control Plan

During the course of remediation works dust control measures shall be undertaken to ensure that dust generated from the site is controlled within acceptable levels. These control measures will be

developed giving consideration to the site conditions in each remediation area, and are likely to include (but not necessarily be limited) to the following:

- All vehicles leaving the site will be cleaned on site to remove any potentially contaminated dust;
- Access to water sprays shall be available to water down the excavation/loading if dust generation becomes significant;
- Provision of shade and cloth around perimeter fencing and/or relevant internal work zone fencing;
- Works may be required to cease on windy days if dust generation becomes significant and dust mitigation is not effective;
- Plastic sheeting shall be available to cover excavation faces and stockpiles; and,
- An ambient air-monitoring program shall monitor dust levels at the site boundary, if necessary.

10.4 Odour Control Plan

During the course of remediation works odour control measures shall be undertaken to ensure that possible odours generated on-site are controlled to within acceptable levels. These control measures will be developed giving consideration to the site conditions in each remediation area, and are likely to include (but not necessarily be limited) to the following:

- The prevailing weather conditions shall be considered in the manner in which work is undertaken;
- Plastic sheeting (such as VLDPE or PVC) will be made available at all times on-site to allow for any excavated or disturbed contaminated soils to be covered, if necessary to reduce odour;
- Odour masking agents (such as Biosolve) will be available for use on-site to suppress any nuisance odours not controlled by the above actions, so that ambient air quality at the site boundary is not adversely impacted.
- Application of Biosolve at a rate of 1 part to 5 parts water will be by way of hand held pressure applicator.

10.5 Groundwater Management Plan

During the course of remediation works groundwater management may be required in particular with works such as the excavation of the lift shaft overrun and OSD tank construction. Due to the depth of these excavation it is likely that groundwater may be encountered and will require management under a Groundwater Management Plan to developed as part of the site Construction Environmental Management Plan and implemented throughout the course of works.

The Groundwater Management Plan will require approval from the appointed accredited NSW EPA Site Auditor and SOPA.

10.6 Asbestos Management Plan

During the course of remediation works asbestos management may be required in particular with works such as piling or any intrusive excavation into the existing landfill materials. Due to the identified presence of Asbestos within the landfill an Asbestos Management Plan is required to be developed and implemented throughout the course of works.

10.7 Regulatory Approvals/Licenses

10.7.1 State Environmental Planning Policy (SEPP) 55 'Remediation of Land'

SEPP 55 relates to the decision making process in undertaking remediation of land and making planning decisions in regard to contaminated and potentially contaminated land. It is understood that the proposed remediation works are considered to be classified as 'Category 1' Remediation Works – i.e., not requiring consent.

The remediation work is verified not to be Category 1 by reference to the following information:

- The work is not designated development under Schedule 3 of the *Environmental Planning and Assessment Act 1979* (NSW) or under a planning instrument;
- The work proposed is not on land identified as critical habitat under the *Threatened Species Conservation Act 1995* (NSW);
- Consideration of Section 5 of the *Environmental Planning and Assessment Act 1979* (NSW) indicates that the remediation work is not likely to have a significant effect on threatened species, populations or ecological communities;
- The work is not proposed in an zone identified in a planning instrument as being of environmental significance; and,
- The work does not require consent under another SEPP.
-

10.7.2 Environmental Management: Remediated Lands Management Policy POL10/09 2014

The Sydney Olympic Park Authority (the Authority) Remediated Lands Management Plan should be referenced by persons planning works or development on remediated landfills. The Plan is based on

the Authority's environmental guidelines and is a component of the Authority's environmental management system. It will guide Sydney Olympic Park Authority in exercising stewardship over the lands in its care, and in complying with environmental legislation.

The Plan is the basis for a 'maintenance of remediation notice' (no. 28040) issued under the Contaminated Lands Management Act 1997 applicable to seven of the landfills, and as such is a regulatory instrument, with penalties applying for non-compliance as detailed in the Act. This Notice replaces various former Notices and Declarations that applied to the various landfills under the Contaminated Lands Management Act 1997, Environmentally Hazardous Chemicals Act 1985, and Unhealthy Building Land Act 1990. Relevant conditions of this Notice have been incorporated into this Plan.

10.7.3 Environmental Planning and Assessment Act, 1979

This Act provides a framework for the development of land within NSW, including division of planning responsibilities between tiers of government and requirements for assessment in relation to development of sites for specific uses. This Act provides for the enforcement of conditions upon use of the land via planning instruments including state environmental planning policies such as State Environmental Planning Policy (SEPP) – No 55 – Remediation of Land.

10.7.4 Contaminated Land Management Act, 1997

This Act controls the assessment of contamination and management of contaminated soils and groundwater. The Act also contains guidance for the determination of whether a site is considered to be a Significantly Contaminated Site and allows for accreditation of Site Auditors.

10.7.5 Protection of the Environment Operations Act, 1997

This Act provides a regulatory framework for matters affecting the environment including environmental protection measures. The Act provides for the licensing of activities with the potential to cause harm to human health and/or degradation of the environment, including waste disposal.

The proposed remediation / validation works are not required to be licensed under the *Protection of the Environment Operations Act 1997* (NSW). The works do not comprise:

- Treatment otherwise than by incineration and storage of more than 30,000 cubic metres of contaminated soil originated exclusively from the Site; and,

– Disturbance of more than an aggregate area of three hectares of contaminated soil originating exclusively from the Site.

10.7.6 Work Health and Safety Regulation, 2011

This regulation details the duties for employers to achieve required employee health and safety performance. The requirements of these regulations will require incorporation in the WHS plan and Safe Work Method Statements.

10.8 Health and Safety

10.8.1 Occupational Health and Safety

An Occupational Health and Safety (OH&S) plan is an essential part of all remediation projects, to ensure the health and safety of all personnel working on or visiting the site. All remediation work would be undertaken in accordance with the provisions set out by the *Occupational Health and Safety Act* (2000) and associated Regulations 2001, and any other regulations or directions set out by regulatory authorities.

Typically the OH&S plan would consider a broad range of issues including (but not limited to) the following:

- Characterisation of potential hazards including hazardous materials and site activities (e.g. excavation);
- Air, Landfill Gas, contaminated soil, groundwater, landfill materials, landfill leachate capturing the risks to human and environmental receptors (as described in Table 4.1) and management strategies;
- and dust monitoring required within and at the boundary of the remediation area;
- Personnel and equipment movements to and from the remediation area;
- Training, instruction, and induction of site workers/visitors;
- Toolbox talks on the hazards of landfill gas;
- Appropriate landfill gas (explosive and asphyxiation risk) signage;
- Clear outline of responsibilities for health and safety; and,
- Emergency response plan for injuries or chemical exposure.

Prior to commencing any remediation works, a specific OH&S Plan would be prepared by the Remediation Contractor covering the following aspects:

- Identification of the remediation area and exclusion zones;
- Induction of personnel;
- Hazard identification/locations;
- Appropriate landfill gas (explosive and asphyxiation risk) signage;
- Identification of contaminants of concern and their physical and toxicological properties;
- Description of exposure pathways and personal protection requirements;
- Location of all underground/aboveground services;
- Details of specific work practice procedures to be followed within the designated contaminated areas;
- Monitoring protocols to identify a potentially hazardous practice;
- No smoking areas;
- Emergency information; and,
- Incident reporting.

Occupational Health and Safety Planning involves the development and implementation of systems and procedures into a Health and Safety Plan included in a site Work Method statement. The objectives of these documents are to ensure the health and safety of those undertaking specific tasks on site and the wider community if necessary.

A Health and Safety Plan should be developed for any site work and would typically include the following:

- A clear health and safety policy;
- Requirements for worker health assessments and inductions;
- Identified health and safety training requirements;
- Requirements for occupational health protection and monitoring;
- Site/location specific emergency plan;
- Site/location specific emergency contact details;
- Permit to work/clearance procedures, and
- Task specific safe work method statements.

10.8.2 Personal Hygiene and Decontamination

Appropriate hygiene and decontamination assists with minimising worker exposure and the transportation of potentially contaminated materials from the site to more sensitive home environments.

The following activities are prohibited while working in the hazardous materials area:

- eating;

- drinking;
- chewing gum, and;
- smoking.

Practices that involve contact between the hands and the mouth increase the risk of chemical ingestion. Personal decontamination is required to minimise workers' exposure to, and indirect transportation of potential chemicals of concern. Decontamination involves physically removing material from personnel and equipment. Protective equipment, tools and other equipment are decontaminated by cleaning with detergent water using a soft-bristle brush followed by rinsing with a sufficient quantity of water. Decontamination should be conducted before meal breaks, and at the end of a day's work.

10.8.3 Community Health and Safety

The health and safety of the surrounding community is very important for any remediation works. While it is possible to control the activities of personnel within the remediation area (e.g. ensuring appropriate OH&S procedures and equipment are utilised) it is not normally possible to control the activities of the surrounding community. Therefore, to protect the community health and safety it is necessary to control the remedial works so that no fugitive emissions occur during the remedial works that could have an adverse impact on the surrounding community.

These controls are documented in the Environment Management Plan for the remedial works, although monitoring requirements to confirm the effectiveness of the measures may also be documented in the OH&S Plan. The methodology that would normally be used to develop the control measures is described below.

Firstly, the portions of the community that may be impacted by any fugitive emissions will be identified. Secondly an assessment of the hazard posed by the contaminants and the proposed remedial methodology/technology would be undertaken. This assessment would define the hazard posed by the particular contaminants present in the remediation area using risk assessment techniques (i.e. identifying the hazard or contaminants and the exposure pathway that the potentially at risk community could be exposed to the hazard).

Once these have been identified, a review will be undertaken of control measures available to remove or minimise the risk posed to the surrounding community during the remedial works. Typically the control measures would comprise removal/minimisation of the exposure pathway to the community. As indicated above it may be necessary to undertake monitoring to confirm the effectiveness of the control measures, and if the monitoring indicates a possibility for exposure then contingency

measures may need to be implemented. By way of example control mechanisms could include (but not necessarily limited to) the following:

- Site security measures to prevent access to the contaminated material by the public;
- Dust suppression measures to minimise inhalation and ingestion exposure; and,
- Not undertaking certain work if winds are unfavourable etc.

10.9 Traffic Control Plan

Movement of excavation equipment, trucks and other vehicles involved in the remediation works, to and from the site will be strictly controlled and restricted to a minimum and only take place during approved working hours. All potentially contaminated vehicles leaving the site will be decontaminated in an appropriate truck wash-down area. All vehicles will be visually free of soil before permission to leave a remediation area is granted.

10.10 Hours of Operation

Working hours for on-site remedial works as outlined in the consent conditions or would be set in consultation with the Council, but it is envisaged the likely hours would be as follows:

- Mondays to Fridays 7:00 am to 5:00 pm
- Saturdays 7:00 am to 3:00 pm
- Sundays and Public Holidays No Work Permitted

10.11 Emergency and Out of Hours Contact Numbers

The Site Specific EMP will detail the site Emergency Contact numbers which may include but are not limited to the following.

DLA	94761765	**NSW EPA**	131 555
David Lane	0410494810	**WorkCover NSW**	13 10 50
Poison Helpline	13 11 26		

Nearest Hospital: Concord Repatriation General Hospital – Hospital Road, Concord.

11.0 CONCLUSION

The Site can be made suitable for the intended land-use through remedial works as part of the redevelopment works in accordance with State Environmental Planning Policy No.55 (SEPP 55).

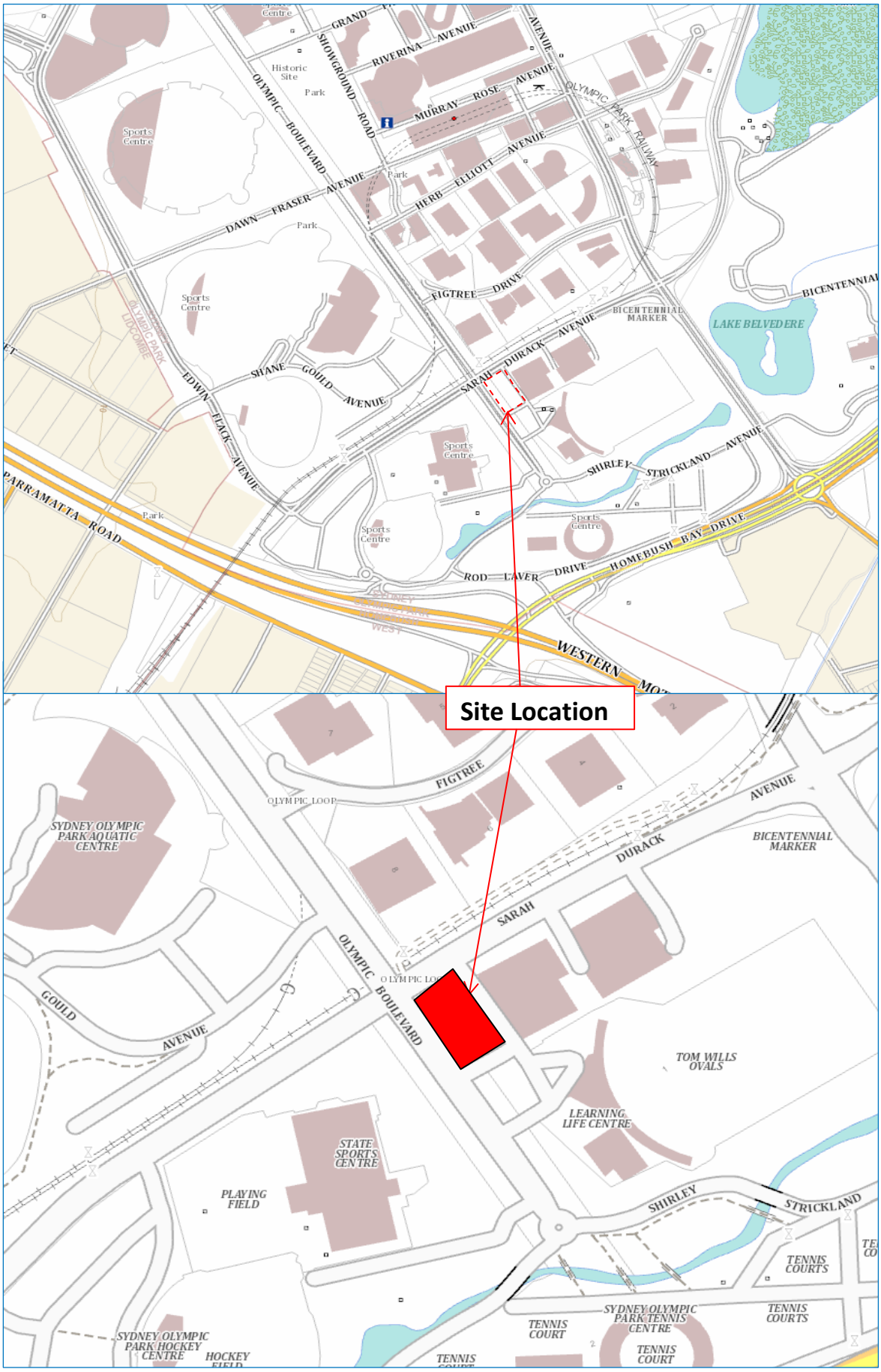
In conclusion this RAP:

- Has been developed in a manner consistent with current industry practice;
- Has selected a preferred remediation strategy based on the site-specific issues and currently available technologies;
- Has presented an outline of the required Site Environmental Management Plan (SEMP) and associated health and safety and remediation management plans to ensure human health and the environment are appropriately protected during the proposed works (**Section 10.0**);
- Has presented an information and consultation program to ensure the stakeholders are informed of the works as they proceed (**Section 10.0**); and,
- Has outlined the means of validation for the completed remediation works.

12.0 REFERENCES

- *Australian and New Zealand Guidelines for the Management of Contaminated Sites* (ANZECC/NHMRC 1992);
- Chapman, G A, Murphy, C L, Tille, P J, Atkinson, G and Morse, R J, *Sydney Soil Landscapes Map*, Series 9130 (1989);
- *Code of Practice for the Safe Removal of Asbestos* (NOHSC, 2nd ed., 2005);
- *Contaminated Land Management Act 1997* (NSW);
- *Contaminated Site: Guidelines for Consultants Reporting on Contaminated Sites* (NSW EPA, 2011);
- *Contaminated Lands Management Act Notice Number 28040* (NSW EPA, 2009);
- *Contaminated Sites: Guidelines for the NSW Site Auditor Scheme* (NSW EPA, 2nd ed., 2006);
- *Contaminated Sites: Guidelines on Significant Risk of Harm from Contaminated Land and the Duty to Report* (NSW EPA 1999);
- *Contaminated Sites: Sampling Design Guidelines* (NSW EPA 1995);
- *Environmental Management: Remediated Lands Management Policy POL10/09* (Sydney Olympic Park Authority Policy, 2014);
- *Environmental Guidelines: Solid Waste Landfills* (NSW EPA, 2015);
- *Guidelines for the Assessment of On-Site Containment of Contaminated Soil* (ANZECC, 1999).
- *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases* (NSW EPA, 2012);
- *Health - Based Soil Investigation Levels, Imray, P & Langley, A, National Environmental Health Forum Monographs, Soil Series No. 2 (2nd Ed), South Australian Health Commission* (NEHF 1998b);
- *How to Safely Remove Asbestos: Code of Practice* (WorkCover, 2011);
- *National Environment Protection (Assessment of Site Contamination) Measure (No.1)* (NEPC, 2013);
- *Managing Land Contamination: Planning Guidelines, SEPP 55 - Remediation of Land* (DUAP, 1998);
- *Storage and Handling of Dangerous Goods Code of Practice 2005*;
- Pacific Southwest, Region 9 Regional Screening Levels (US EPA, 2014);
- *Waste Avoidance and Resource Recovery Act 2001* (NSW);
- *Waste Classification Guidelines* (NSW EPA, 2014); and,
- *Work Health and Safety Act 2011* (NSW) and associated regulations.

FIGURE 1 – SITE LOCATION



DLA Environmental Services A Pacific Environment company Unit 3/38 Leighton Place Hornsby, NSW 2077	**DESIGNED:** DLA **COMPILED:** AP **PROJ. No.** DL3620	SITE LOCATION	
		CLIENT: ECOVE	**DRAWING:** 10.02.16
		LOCATION: Cnr Sarah Durack Ave and Olympic Boulevard, Sydney Olympic Park NSW	**FIGURE:** 1

FIGURE 2 – SITE LAYOUT AND BORE LOCATION

Legend

- Groundwater and Gas Well locations
- Gas Well locations
- Borehole locations
- Site Boundary
- Site Boundary

Approximate Scale

0m 20m 40m

DLA Environmental Services
A Pacific Environment company

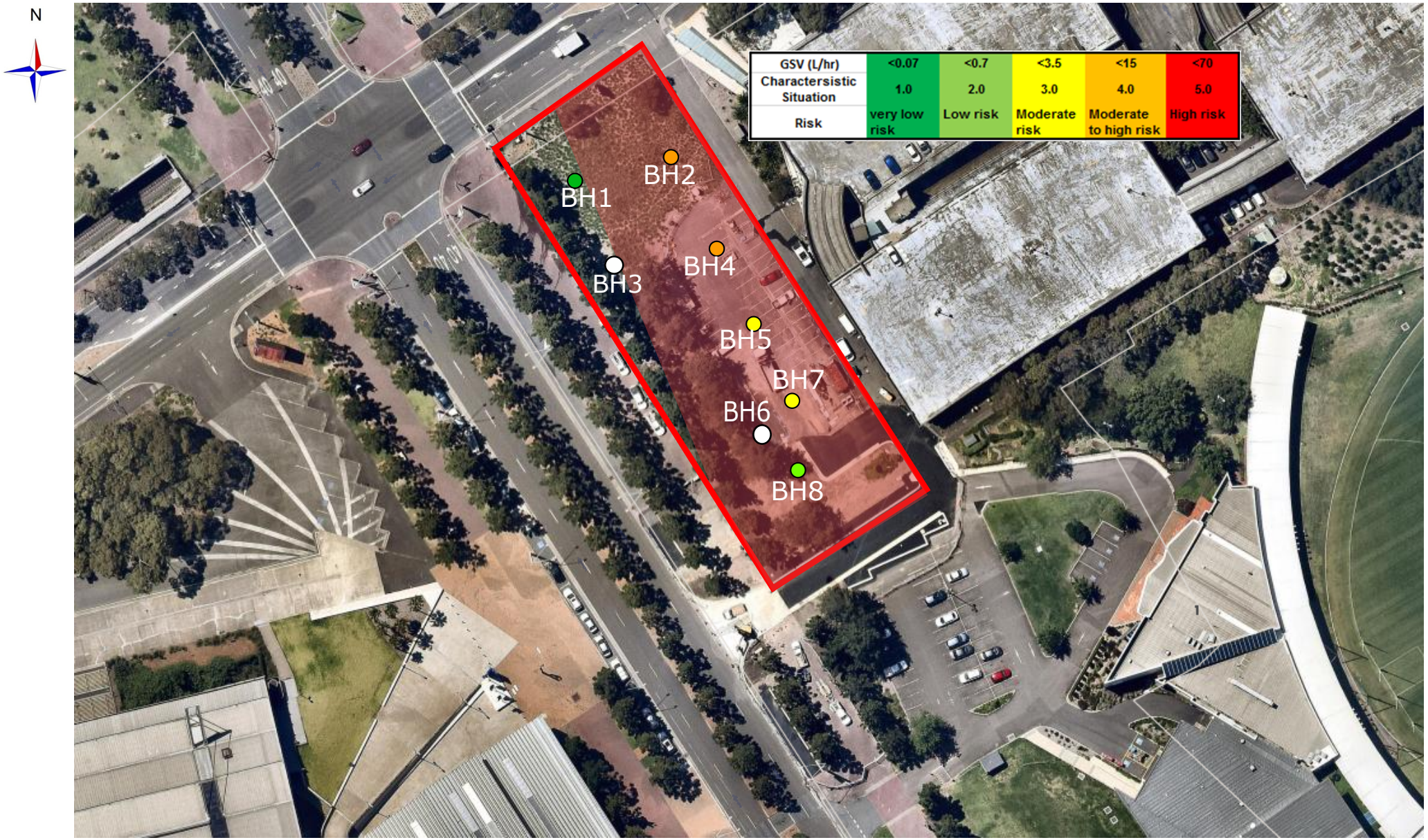
Sydney Office
Phone (02) 9476 1765
Fax (02) 9476 1557

Maitland Office
Phone (02) 4933 0001

Title: Site Layout and Bore Locations

Client	Project No.	Figure No	Date
ECOVE	DL 3620	2	10/02/2015
	Scale: As Shown	Compiled: AP	Revision: R00

FIGURE 3 – SITE LAYOUT AND AREA OF ENVIRONMENTAL CONCERN



Legend

- CS1 - Very Low Risk
- CS2 - Low Risk
- CS3 - Moderate Risk
- CS4 - Moderate to High Risk
- DLA Bore Hole Location
- Site Boundary
- Approximate Extent of Waste

Approximate Scale

0m 20m 40m

DLA Environmental Services
A Pacific Environment company

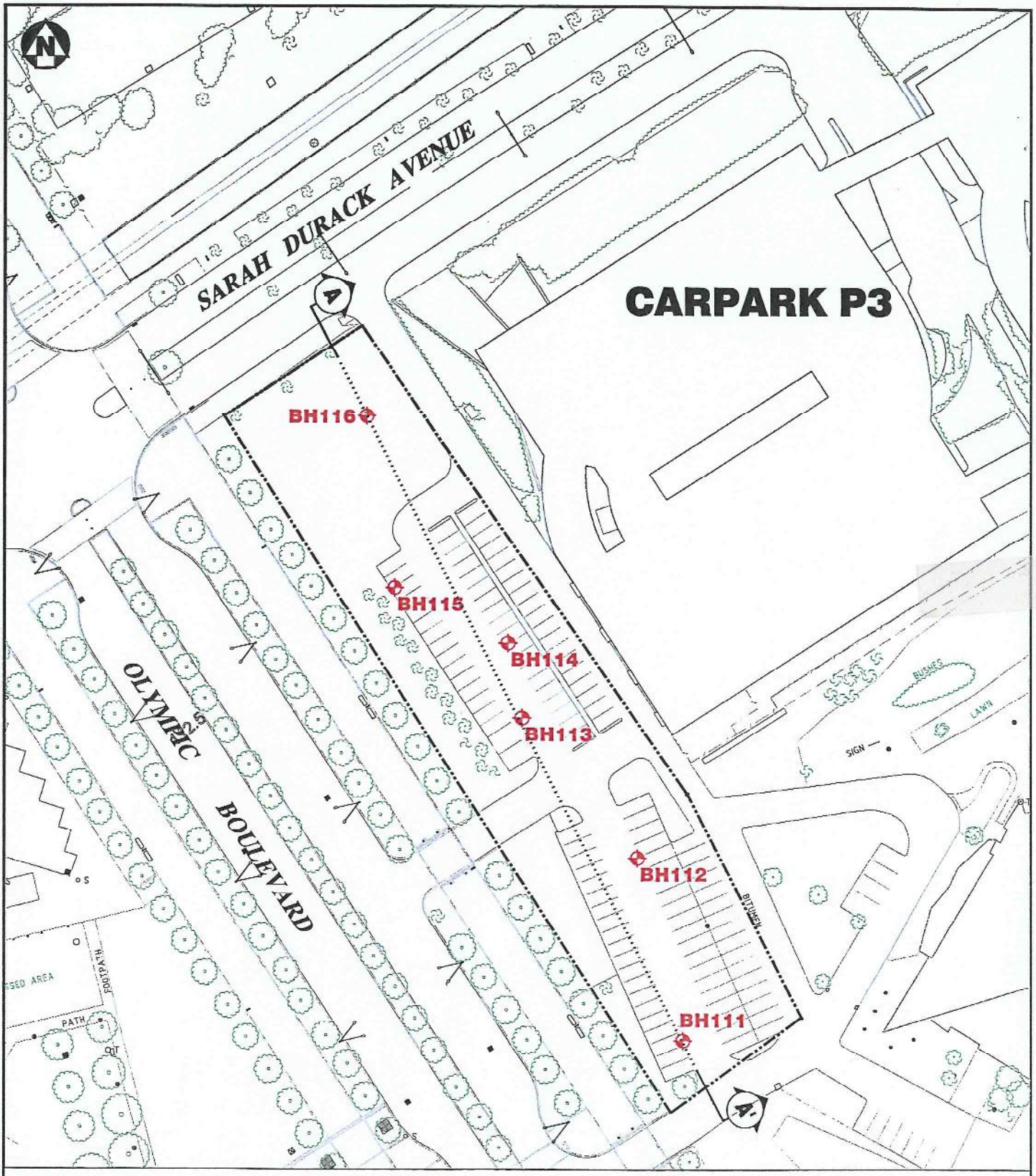
Sydney Office
Phone (02) 9476 1765
Fax (02) 9476 1557

Maitland Office
Phone (02) 4933 0001

Title: Site Layout and Area of Environmental Concern

Client	Project No.	Figure No	Date
ECOVE	DL 3620	3	10/2/2016
	Scale: As Shown	Compiled: SB	Revision: R00

FIGURE 4 – PREVIOUS SAMPLE BORE LOCATIONS



LEGEND

BH116 BOREHOLE LOCATION

SITE BOUNDARY

A CROSS SECTION LOCATION

CLIENT
SYDNEY OLYMPIC PARK AUTHORITY

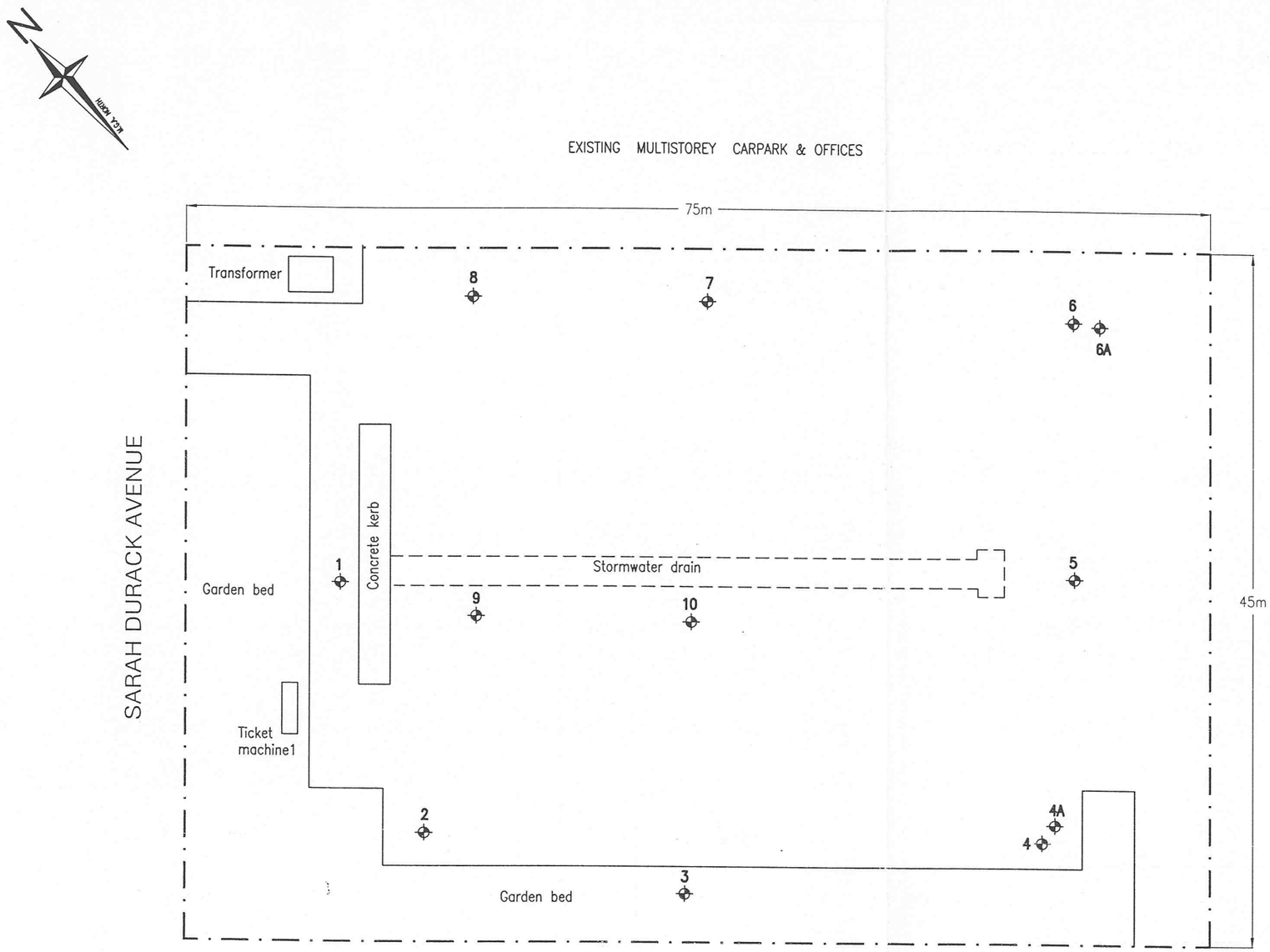
PROJECT
DEVELOPMENT SITE 9

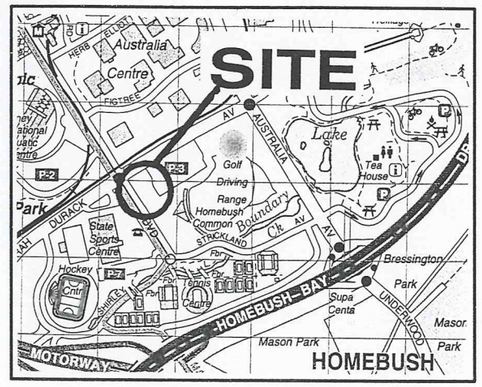
TITLE
BOREHOLE LOCATION PLAN

A4

0 5 10 15 20 25 50
metres

DESIGNED: MM	APPROVED: MM	PROJECT: 50244-004	URS	FIGURE
DRAWN: HC	DATE: 24/11/2	CAD FILE: 002.DWG		2
DATE: 19-11-02	STATUS: DRAFT	REVISION: A		





LOCALITY PLAN

LEGEND

⌖ TEST BORE LOCATION

Douglas Partners
Geotechnics Environment, Groundwater

Sydney, Newcastle, Brisbane, Melbourne, Perth, Wyong, Campbelltown, Townsville Cairns, Wollongong

TITLE:
Location of Test Bores
Waste Classification Assessment
Site 9 Cnr.Sarah Durack Ave & Olympic Boulevard
HOMEBUSH

CLIENT: Colin Gene & Partners			
DRAWN BY: PSCH	SCALE: N.T.S.	PROJECT No: 35932	OFFICE: SYDNEY
APPROVED BY: NDm.		DATE: 13.5.2003	DRAWING No: 1

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FIGURE 5 – EXTENT OF GOLF DRIVING RANGE LANDFILL