Contamination | Remediation | Geotechnical

TOGA WICKS PARK DEVELOPMENTS PTY LTD

Remediation Action Plan

182-198 Victoria Road & 28-30 Faversham Street, Marrickville, NSW

E24098.E06_Rev00
7 February 2019

Document Control

Report Title: Remediation Action Plan

Report No: E24098.E06_Rev0

Copies	Recipient
1 Soft Copy (PDF – Secured, issued by email)	Mr Matt Dobbs Toga Wicks Park Developments Pty Ltd Level 5, 45 Jones Street, Ultimo NSW 2007
2 Original (Saved to Digital Archives) (Document2)	EI Australia Suite 6.01, 55 Miller Street, Pyrmont NSW 2009

Author	Technical Reviewer
[redacted]	
MICAELA GREEN Environmental Scientist	**NATHAN FOSTER** Senior Environmental Scientist

Revision	Details	Date	Amended By
0	Original	7 February 2019	-

Table of Contents

Schedule of Tables

Appendices

EXECUTIVE SUMMARY

BACKGROUND

This Remediation Action Plan (RAP) outlines the procedures that will be used to remediate the site identified as 182-198 Victoria Road & 28-30 Faversham Street, Marrickville, NSW ('the site') to a condition suitable for mixed retail and residential use with minimal access to soils, without the need for ongoing environmental monitoring.

Based on previous investigations, near surface (≤1.5 mBGL) soils impacted with heavy metals (copper, lead, nickel and zinc), total recoverable hydrocarbons (TRH), polycyclic aromatic hydrocarbons (PAH), poly-fluoroalkyl substances (PFAS) and asbestos are present across the site. Remediation is therefore required to enable the developer to meet its obligations under *State Environmental Planning Policy 55 - Remediation of Land* (SEPP 55) and other guidelines made or approved under Section 105 of the *Contaminated Land Management Act 1997* (CLM Act 1997).

REMEDIATION STRATEGY

The preferred approach involves bulk excavation and disposal of impacted materials, to mitigate risks associated with the contaminants of potential concern (COPCs). The predicted excavation depth is 1.5 m below ground level (BGL; minimum), chasing any hotspot as validation sampling and testing dictate. On-site isolation may be considered a secondary option, if zones of deep (>3 mBGL), non-asbestos impacted soils are identified and/or economic (cost) constraints are apparent.

The main site remediation works will include, though not necessarily be limited to:

- Stage 1 – Site Preparation (including building demolition)
- Stage 2 – Site Inspection and Assessment of Building Footprints
- Stage 3 – Groundwater Investigation
- Stage 4 – Asbestos-Impacted Fill Excavation and Off-site Disposal
- Stage 5 – Remaining Site-Wide Fill Soil Excavation and Off-site Disposal
- Stage 6 – Final Soil Validation
- Stage 7 – Validation Report Preparation

CONTINGENCY ACTION

Should unexpected finds be discovered during the course of the remediation program, or should any phase of the validation identify residual, high level contamination requiring additional remediation, then the procedures described under the Unexpected Finds Protocol (**Section 9.8**) and/or the Validation Plan (**Section 10.1**) will be implemented, until the remediation goals have been achieved and the site is deemed suitable for the intended land use.

In concluding, EI considers that the site can be made suitable for mixed commercial and medium density, residential use with limited access to soil, through the implementation of the works described in this RAP.

1. INTRODUCTION

1.1 Background

Mr Matt Dobbs of Toga Wicks Park Developments Pty Ltd (the client) engaged EI Australia (EI) to prepare a Remediation Action Plan (RAP) for 182-198 Victoria Road and 28-30 Faversham Street, Marrickville, NSW (henceforth 'the site').

The site is located approximately 6 km south-west of the Sydney central business district, within the Local Government Area of Inner West Council (**Figure 1**). It was further identified as comprising Lot 6 in Deposited Plan (DP) 226899, Lot 100 in DP 1239681, Lot 1 in DP 74200, Lot 10 in DP 701368 and Lot 4 in DP 226899. The land (7,262 m^2 in total area; **Figure 2**) was bound by Victoria Road to the west, with commercial, residential and recreational properties comprising the immediate surroundings.

At the time of the investigation phase, the site was being used for commercial purposes and four principal buildings were present (**Figure 2**), identified as follows:

- Smash Repairs Workshop;
- Spray Painting Workshop;
- Stone Cutting Workshop; and
- Offices.

Based on previous investigations (summarised in **Section 3**), near surface (≤1.5 m below ground level (BGL)) soils are impacted with heavy metals (copper, lead, nickel and zinc), total recoverable hydrocarbons (TRH), polycyclic aromatic hydrocarbons (PAH), poly-fluoroalkyl substances (PFAS) and asbestos.

In light of the identified contamination, remediation is required to enable the developer to meet its obligations under *State Environmental Planning Policy 55 - Remediation of Land* (SEPP 55) and other guidelines made or approved under Section 105 of the *Contaminated Land Management Act 1997* (CLM Act 1997). This RAP outlines the proposed remediation and validation works that will render the site suitable for mixed commercial and residential use with minimal access to soils, without the need for ongoing environmental monitoring.

1.2 Proposed Development

The proposed development involves demolition of all existing structures, followed by the construction of a multi-storey, mixed use retail and residential building, overlying a basement car parking facility (**Appendix B**). For assessment purposes, retained deep soils are proposed to be retained between the northern, eastern and west site and basement boundaries.

1.3 Objectives

The objectives of this RAP are to:

- Set remediation goals that ensure the site will be suitable for the proposed use, posing no unacceptable risk to human health or the environment;
- Document the procedures to reduce risks to acceptable levels for the proposed site use;
- Establish the safeguards required to complete the remediation in an environmentally acceptable manner; and

- Identify the necessary approvals and licenses required by regulatory authorities.

1.4 Regulatory Framework

The following regulatory framework and guidelines were considered during the preparation of this RAP.

1.4.1 Regulatory Framework

- Contaminated Land Management Act 1997 (CLM Act 1997);
- Environmental Planning and Assessment Act 1997, in particular State Environment Protection Policy 55 - Remediation of Land (SEPP 55);
- Protection of the Environment Operations Act 1997 (POEO Act 1997);
- Marrickville Local Environment Plan 2011; and
- Work Health and Safety Act 2011 (WHS Act 2011).

1.4.2 Guidelines

- EPA (1995) Sampling Design Guidelines;
- EPA (2015) Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997;
- EPA (2017) Guidelines for the NSW Site Auditor Scheme;
- NEPM (2013) Schedule B(1) Guideline on Investigation Levels for Soil and Groundwater;
- NEPM (2013) Schedule B(2) Guideline on Site Characterisation; and
- OEH (2011) Guidelines for Consultants Reporting on Contaminated Sites.

1.5 Scope of Work

In order to achieve the above objectives and comply with the OEH (2011) *Guidelines for Consultants Reporting on Contaminated Sites*, the scope of work for this RAP included:

Review of the available data relevant to the remediation of the site, provided by the previous investigation reports;

- Definition of remediation goals and acceptance criteria;
- Review of the latest technical literature and case studies for remediation technologies relevant to the site;
- Technical assessment of alternative remediation technologies;
- Selection of the most appropriate remedial strategy (or combination of strategies) for the site;
- Provision of information so that remedial works may be carried out in accordance with relevant laws and regulations;
- Provision of guidance on approvals and licences required for the remedial works, under current legislation (e.g. SEPP 55);
- Provision of information to assist the contractor(s) in their preparation of a Work Health and Safety Plan and other site management/planning documents; and

- Development of a sampling, analysis and quality strategy for hotspot delineation and post-remedial validation.

The proposed remediation strategy involves disposal of impacted soils, to mitigate risks associated with metals, TRH, PAH, PFAS and asbestos. The validation phase requires confirmation of the effectiveness of the remedial activities, providing a statement of the environmental conditions of the site, with respect to the proposed development.

This RAP also outlines measures for the excavation, stockpiling, management and disposal of spoil, water and sediment controls, as well as a contingency plan to handle any additional contamination that may be identified during the site remedial works. The measures provided in this RAP are brief and are designed to accompany site-specific management plans, including a Construction Environment Management Plan (CEMP). These measures do not replace any other requirements for the site as a whole. A complete set of site specific management plans should be developed and adhered to. An outline of management measures to be addressed is provided in **Section 8.3**.

1.6 Deviations from this RAP

While it may be possible to vary the sequence and/or details of the actual remediation and validation works to meet site constraints, a qualified Environmental Scientist/Engineer will be appointed to the project to ensure that:

- Critical stages of the site remediation/validation process (including, but not limited to, proper site induction of site personnel in relation to contamination hazards and environmental management issues, marking of remediation areas, inspection of environmental monitoring systems, implementation of specified control measures and validation sampling), are appropriately supervised, implemented and documented, with the relevant data collected for environmental reporting purposes; and
- Any deviations from the works specified in this RAP are properly documented and approved, as required under the OEH (2011) *Guidelines for Consultants Reporting on Contaminated Sites*.

Performing remedial works without the presence of a qualified environmental engineer/scientist when necessary, may lead to project delays and extra costs, especially where additional environmental investigation requirements are imposed by an independent consultant or EPA-accredited Site Auditor.

Waste materials removed from the site without proper characterisation (i.e. waste classification), may lead to regulatory action and potential penalties, as described under the *Waste Regulation 2014*, the *Protection of the Environment Operations Act 1997* and the *Contaminated Land Management Act 1997*.

2. SITE DESCRIPTION

2.1 Property Identification, Location and Physical Setting

The site identification details and associated information are presented in **Table 2-1**. The site location is shown in **Figure 1**, while the layout is shown in **Figure 2**.

Table 2-1 Site Identification, Location and Zoning

Attribute	Description
Street Address	182-198 Victoria Road and 28-30 Faversham Street, Marrickville, NSW 2204
Location Description	Approximately 6km south west of Sydney CBD, bound by Victoria Road to the west. Commercial (light industrial), residential and recreational properties comprise the immediate surroundings.
Geographical Coordinates	Northern corner of site (datum GDA94-MGA55): Easting: 885095.825, Northing: 6240120.153 (Source: http://maps.six.nsw.gov.au)
Site Area	7,262 m² (True North Surveys Ref. 8333DU; dated: 01/09/16)
Lot and Deposited Plan (DP)	Lot 6 in DP226899, Lot 100 in DP1239681, Lot 1 in DP74200, Lot 10 in DP701368 and Lot 4 in DP 226899 (192-198 Victoria Road & 28-30 Faversham Street)
State Survey Marks	One State Survey Mark (SSM) is situated in close proximity to the site: ▪ SS47493 (at intersection of Victoria Road and Mitchell Street). (Source: http://maps.six.nsw.gov.au)
Local Government Authority	Inner West Council
Parish	Petersham
County	Cumberland
Current Zoning	B4 – Business Zone (Marrickville Local Environment Plan, 2011)
Current Land Uses	Commercial and light industrial, including offices, the manufacture and sale of stonework benchtops (stone cutting workshop), a smash repairs workshop and a spray painting workshop. Car parking in the centre of Lot 10 in DP 701368.

2.2 Surrounding Land Use

The site was situated within an area of mixed land use (predominantly commercial / light industrial, but also residential and recreational). Uses of surrounding land are further described in **Table 2-2**.

Table 2-2 Surrounding Land Uses

Direction Relative to Site	Land Use Description
North east	Commercial / industrial properties.
South east	A commercial lot, followed by a large area that is predominantly industrial in use and Sydenham Road.
South west	Wicks Park (also housing an electrical sub-station), followed by Victoria Road and residential properties.
North west	Victoria Road, followed by commercial and then residential properties. Residential properties are of high density closer to the site, decreasing in density further west.

Wicks Park (directly south) and Marrickville Public School (250m north-west) were identified as sensitive receptors within proximity of the site.

2.3 Regional Setting

Regional topography, (hydro)geology and soil landscape information are summarised in **Table 2-3**.

Table 2-3 Regional Setting Information

Attribute	Description
Topography	The site is generally flat, with a slight decline to the south east (≤5°). The highest elevation is located in the north corner (RL 3.3 mAHD), the lowest is located halfway down the eastern border, just north of the stone cutting workshop (RL 1.81 mAHD). (True North Surveys survey plan, Ref. 8333DU, dated 01/09/2016)
Site Drainage	Consistent with the general slope of the site. Stormwater is assumed to flow south-east towards Alexandra Canal via drainage systems discharging to various stormwater easements and the municipal stormwater system.
Regional Geology	According to the 1:100,000 scale Coastal Quaternary Geological Sheet (Sydney), the site is underlain by anthropogenic deposits consisting of modern disturbed land (Qmx). According to the Sydney 1:100,000 Geological Sheet, the site is underlain by Holocene deposits consisting of peat, sandy peat and mud (Qhs).
Soil Landscapes	The Soil Conservation Service of NSW Soil Landscapes of the Sydney 1:100,000 Sheet (Chapman and Murphy, 1989) indicated that the site overlies a Birrong (bg) landscape, which typically includes 'level to undulating alluvial floodplain draining Wianamatta Group Shales. Dominant soil materials include dark brown, pedal silty clay loam, bleached hardsetting clay loam, orange mottled silty clay, brown mottled silty clay and light grey mottled saline clay. [Note: Soils encountered during the investigation phase were considered to be consistent with those from Disturbed Terrain, as described by Chapman and Murphy (1989)]

Attribute	Description
Acid Sulfate Soil (ASS) Risk	The Marrickville Council Local Environmental Plan 2011 - Acid Sulfate Soils Risk Class 1:1,000 Scale Map indicated that the site lies within a *Class 2* ASS area. According to the Botany Bay Acid Sulfate Soil Risk Map (1:25,000 scale; Murphy, 1997), the subject land lies within the map class description of *Disturbed Terrain*. In such cases, soil investigations are required to determine the presence of acid sulfate soil (ASS). Based on findings from the investigation phase, site soils to 7.5 mBGL (at least) did not contain significant quantities of actual and potential ASSs.
Likelihood and Depth of Filling	Based on observations from the investigation phase, filling is present across the entire site and approximately 0.1-1.9 m in thickness.
Typical Soil Profile	Anthropogenic filling (Silty Sandy CLAY / Gravelly SAND / Silty GRAVEL, with some building rubble and ash; 0.1-1.9 m thickness), overlying natural (Sandy) Silty CLAY and Clayey SAND (2.6-7.4 m thickness) and (weathered) sandstone.
Depth to Groundwater	Groundwater was encountered between 0.3-2.1 m below ground level (BGL) during the investigation phase and the inferred flow direction was south east, toward Alexandra Canal.
Aquifer Type	Unconfined to partially confined with (Sandy) Silty CLAY and Clayey SAND forming the upper geological layer overlying sandstone bedrock.
Groundwater Salinity	Based on findings from the investigation phase, local groundwater is slightly acidic (pH 5.25-5.95) and slightly saline to brackish (EC: 831-5,347 µS/cm).
Groundwater Flow Direction	Alexandra Canal, located approximately 2 km south-east of the site. Alexandra Canal is understood to be tidally influenced and thus is considered to be a marine system for impact assessment purposes. It drains into Botany Bay (via the Cooks River).
Nearest Surface Water Feature	Alexandra Canal, located approximately 2 km south-east of the site. Alexandra Canal is understood to be tidally influenced and thus is considered to be a marine system for impact assessment purposes. It drains into Botany Bay (via the Cooks River).

3. PREVIOUS INVESTIGATION

3.1 Previous Investigation Reports

The following reports were completed during the site investigation phase:

- Aargus (2014a) *Geotechnical Investigation Report*. Aargus Pty Ltd Report Ref. GS5611/1A, Revision 0, dated 22 January 2014;
- Aargus (2014b) *Detailed Site Investigation*. Aargus Pty Ltd Report Ref. ES5611/2, Revision 0, dated 30 April 2014;
- Aargus (2014c) *Acid Sulfate Soils Assessment*. Aargus Pty Ltd Report Ref. ES5611/3, Revision 0, dated 8 May 2014;
- Aargus (2018) *Due Diligence*. Aargus Pty Ltd Ref. ES7185, Revision 0, dated 16 March 2018; and
- EI (2019) *Additional Site Investigation Report*. EI Australia Pty Ltd Ref. E24098.E03.Rev0, dated 25 January 2019.

The various Aargus (2014a, 2014b, 2014c, 2018) investigations concerned 182-198 Victoria Road and 18-28 Faversham Street, Marrickville (comprising 1.037 hectares in total area). All were commissioned by E&D Danias Pty Ltd (Danias Group) ('the landowner'). The EI (2019) additional investigation was specific for the current site and was commissioned by Toga Wicks Park Developments Pty Ltd.

A summary of the tasks and key findings from the investigation phase is outlined in the next section. Refer also to **Figure 2** for the sample exceedance plan, as well as **Appendix C** for summaries of the analytical results.

3.2 Summary of Previous Investigation Findings

Table 3-1 Summary of Previous Investigation Works and Findings

Assessment Details	Project Tasks and Findings
Geotechnical Investigation (Aargus, 2014a)	
Objective	To assess the ground conditions and general geotechnical design requirements of the land. Recommendations for the design and construction of future development were provided in the corresponding report.
Scope of Works	The scope of works included: ▪ Review of Dial-Before-You-Dig plans; ▪ A site walkover inspection; ▪ Underground services location, using electromagnetic detection equipment; ▪ Mechanical auger drilling of three boreholes (BH1, BH2 and BH3), drilled to depths of 4.3-8 mBGL; ▪ Standard Penetrometer Tests (STPs) within the boreholes, to assess in situ strength of subsurface layers; ▪ Collection of soil samples during drilling, for laboratory analysis of pH, salinity and aggressivity to steel and concrete; and

Assessment Details	Project Tasks and Findings
	▪ Data interpretation and reporting. Note 1 The field works for this investigation coincided with the Aargus (2014b) DSI, for which a total of twenty-two (22) bores were drilled, identified as BH1-BH22. At BH14, BH17 and BH20, a groundwater monitoring well was installed (identified as GW1, GW2 and GW3, respectively). Note 2 BH2, BH18 and BH19 and BH20 (GW3) were all located on the 18-28 Faversham Street portion. Note 3 The geotechnical component was based on logs and STPs from bores BH1, BH2 and BH3 (drilled to 4.9m, 8m and 4.3m BGL, respectively), as well as the standing water levels (SWLs) measured in GW1, GW2 and GW3.
Findings	The majority of the site was covered by 0.1-0.2 m thick concrete pavement. The driveway at 182 Victoria Road was comprised of silty gravel, roadbase. Based on the logs for boreholes BH1, BH2 and BH3, the subsurface conditions were generalised as: ▪ FILL grey and brown, soft, loose, silty sandy clay, gravelly sand and silty gravel (0.1-0.35 m thickness); overlying ▪ REWORKED IN SITU SOILS greenish grey with red mottling and dark grey, medium plasticity, soft to firm, moist, silty clays (0.6-1.0 m thickness); overlying ▪ ALLUVIAL SOILS grey with reddish mottling, medium to high plasticity, firm to stiff, moist, silty clay (1.0-1.4 m thickness); overlying ▪ RESIDUAL SOILS grey with red mottling, medium to high plasticity, firm to very stiff, moist, silty clay and sandy clay (1.4-5.0 m thickness); overlying ▪ SANDSTONE grey with dark brown / red mottling and iron staining, fine to medium grained, extremely weathered, very low strength, with some clay bands (from 3.8-7.6 mBGL onwards). Groundwater was encountered during the borehole drilling, at depths varying from 2.6-4m BGL. SWLs in GW1-GW3 were measured at 1.45-4.33m BGL (17 October 2013) and 1.15-1.23m BGL (29 October 2013). Natural site soils were found to be non- to slightly saline (≤2 dS/m electrical conductivity), slightly alkaline (7.9-8.4 pH) and non-aggressive to steel and reinforced concrete.
Detailed Site Investigation (Aargus, 2014b)	
Objectives	The primary objectives of this DSI were as follows: ▪ Identify potential areas where contamination may have occurred from current and historical activities; ▪ Identify potential contaminants associated with potentially contaminating activities; ▪ Assess the potential for soils and groundwater to have been impacted by current and historical activities; and ▪ Assess the suitability of the site for redevelopment.
Scope of Works	The scope of works for this DSI included: ▪ Review historical land use, based on titles information, aerial photographs, groundwater bore searches, EPA notices, council records, anecdotal evidence, services location and records on waste management practices; ▪ Review of the physical site setting and conditions, based on an inspection, including research of the location of sewers, drains, holding tanks and pits, spills, patches of discoloured vegetation, etc; ▪ A soil boring and sampling program, involving the drilling of twenty-two (22) bores distributed across the site adopting a systematic grid pattern, allowing for accessibility and site features (BH1-BH22; BH2, BH18, BH19 and BH20 being

Assessment Details	Project Tasks and Findings
	located on the 18-28 Faversham Street portion); ▪ Groundwater monitoring well installation and sampling (at BH14 (GW1), BH17 (GW2) and BH20 (GW3)); ▪ Laboratory analysis of representative (fill and natural) soil and groundwater samples for the contaminants of potential concern (COPCs), with comparison of the results against regulatory guidelines; ▪ The integration of a Quality Assurance / Quality Control (QA/QC) program, involving both field and laboratory QC samples; and ▪ Data interpretation and reporting, including recommendations for additional investigation and site management, where relevant.
Findings	The site history review established that the site was developed for commercial and residential purposes in the 1930s (or thereabouts). Commercial and light industrial activities increased over time and included spray painting, car (body) repairs, steel fabrication, sculpture works and stone masonry. A diverse range of chemicals were stored and used on the land, such as acids and alkalis, solvents (in particular paints and dry cleaning agents), petroleum hydrocarbon oils, adhesives and detergents. At the time of the Aargus (2014) investigations, 182-198 Victoria Road was occupied by a large warehouse with attached offices in the south western portion (occupied by Rosa Stone), a residential property and small warehouse with spray booth in the north-western portion (occupied by smash repair business), three warehouses in the central northern portion (occupied by Gorilla Construction and used for metal work), concrete access / parking areas and an unsealed driveway along the northern boundary. 18-28 Faversham Street was occupied by commercial buildings / proprietors. The search for Water NSW registered bores established that five (5) groundwater bores were located within a 1 km radius of the site, all of which were for monitoring purposes. The corresponding drilling depths were 1.3-4.25 mBGL. During the soil boring / sampling program: ▪ No hydrocarbon odours were detected in any of the examined soils; ▪ Hydrocarbon-like staining was observed at BH5, BH6, BH7 and BH18; and ▪ No fragments of FCS were detected in any of the examined soils. Soil headspace samples were screened in-field for volatile organic compounds (VOCs) using a portable photoionisation detector (PID). PID measurements ranged from 0-0.7 ppm, indicating no widespread contamination by volatile (petroleum) hydrocarbons. Elevated concentrations of lead, zinc, copper and carcinogenic PAHs (including benzo(a)pyrene) were identified in the soil materials at boreholes BH1, BH2, BH4, BH5, BH6, BH7, BH8, BH9, BH10, BH11, BH12, BH13, BH14, BH18, BH19, BH20, BH21 and BH22. Asbestos contamination was also present in the fill at hotspots BH1 (chrysotile asbestos), BH7 (chrysotile and crocidolite asbestos) and BH22 (chrysotile asbestos), the BH7 filling containing a trace of trichloroethene (TCE; 1 mg/kg) as well. Overall, the maximum depth of contamination was 1.3 mBGL. Groundwater was encountered during the borehole drilling, at depths varying from 2.6-4 mBGL. SWLs in GW1-GW3 were measured at 1.45-4.33 mBGL (17 October 2013) and 1.15-1.23 mBGL (29 October 2013). The inferred hydraulic gradient was south-easterly (towards Alexandra Canal, 1.8 km distance). The local groundwater was slightly acidic to neutral (pH: 5.95-6.85), brackish to saline (EC: 1,192-5,134 µS/cm) and low in dissolved oxygen (DO: 1.58-1.74 mg/L). Elevated concentrations of dissolved heavy metals (copper and zinc) were identified in the groundwater samples from GW1 and GW2. The levels of all other COPCs were below either the corresponding quantitation limit, or the adopted assessment criterion.

Assessment Details	Project Tasks and Findings
Conclusions and Recommendations	Aargus (2014b) concluded that the site required “review, additional works and/or delineation”, given the presence of heavy metals (lead, zinc and copper), PAHs and/or asbestos in the majority of the test bores. Upon collation of all the data, an appropriate remedial / management strategy would then be developed, culminating in the preparation of an RAP in accordance with EPA guidelines.
ASS Assessment (Aargus, 2014c)	
Objective	To determine the presence of ASS.
Scope of Works	Review of geological and soil landscape maps for the area (including an ASS risk map), a site walkover inspection, targeted soil boring and sampling (boreholes BH1-BH3; coinciding with the geotechnical / DSI bores), laboratory analysis of selected natural soil samples for pH (including 30% peroxide pH (pHfox)), data interpretation against recognised ASS criteria and reporting.
Findings	None of the examined soils displayed evidence (visual or olfactory) of the presence of ASS, actual or potential. For the tested (representative) samples, all pHf values were well above 4, the threshold below which is indicative of actual ASSs. Following 30% peroxide digestion of the samples, all pHfox values were well above 3, the threshold below which is indicative of potential ASSs. These results suggested “a lack of unoxidised sulphides”.
Conclusions	Aargus concluded that the soils at the site (to 7.5 mBGL, at least) did not contain significant quantities of actual and potential ASSs. It was considered that the net acid generating ability of the soils was minimal.
Due Diligence (Aargus, 2018)	
Objective	To review the contamination status of the site, based on the results from the completed (Aargus, 2014) investigations. Note 1 An additional eight boreholes (identified as A, B, C, D, F, G, H and I) were drilled as part of this study, complementing the twenty-two (22) bores constructed for the Aargus (2014b) DSI. The locations of these bores were not presented on a sampling location plan in the corresponding report; however, it was stated they were “placed in the central and north eastern portion of the buildings on Faversham Street, and within the south eastern warehouse on Victoria Road”.
Findings	Site filling varied in thickness between 0.5-1.9 m, the average depth being 0.7 m. The general soil profile was: ▪ FILL (0.5-1.9 m thickness); overlying ▪ CLAY (0.6-5.5 m thickness); overlying ▪ SHALE. ASSs were not present beneath the site. The SWL was approximately 1.5 mBGL, with the aquifer being in natural clay. Groundwater quality complied with the acceptance criteria. Fill soil hotspots of lead, PAHs and/or asbestos were identified at twelve (12) of the thirty (30) borehole locations, assuming the land use scenario was residential with minimal access to available soils (i.e. medium density, apartment / units). These locations were BH1, BH2, BH4, BH5, BH6, BH7, BH14, BH18, BH19, BH20, BH21 and BH22. Note 1 BH2, BH18, BH19 and BH20 (GW3) were all located on the 18-28 Faversham Street portion; hence, only eight (8) of the identified hotspots applied to the current site, those being BH1, BH4, BH5, BH6, BH7, BH14, BH21 and BH22, which displayed

Assessment Details	Project Tasks and Findings
	elevated PAHs and/or asbestos (lead only exceeding the EIL in some cases).
Recommendations	Aargus stated that: ▪ An additional investigation report was required, covering soil and groundwater; and ▪ A remedial action plan would also be required for the site.
ASIR (EI, 2019)	
Objectives	The primary objectives of this investigation were to: ▪ Investigate the degree of any potential contamination by means of intrusive sampling and laboratory analysis, for relevant contaminants of concern; and ▪ Where site contamination was confirmed, make recommendations for the appropriate management of any contaminated soils and/or groundwater.
Scope of Work	The scope of works for the ASIR was as follows: ▪ Review relevant topographical, (hydro)geological and soil landscape maps for the project area; ▪ Review the previous (Aargus, 2014) environmental assessments; ▪ Searches of NSW EPA databases which held records relating to the *Contaminated Land Management Act 1997* and *Protection of the Environment Operations Act 1997*; ▪ Location of existing underground services, assisted by plans supplied by Dial-Before-You-Dig and a site walkover inspection, the latter including a ground penetrating radar (GPR) survey; ▪ Construction of boreholes at eleven locations across accessible areas of the site (identified as BH1M, BH2, BH3M, BH6M, BH7, BH9M, BH10, BH11, BH12, BH13 and BH14M), the drilling depths being to a maximum of 13.4 m below ground level (or prior refusal); ▪ Multiple level soil sampling within fill and natural soils at each of the bores; ▪ Installation of a groundwater monitoring well in five of the bores (BH1M, BH3M, BH6M, BH9M and BH14M), constructed to standard environmental protocols, to investigate potential groundwater contamination; ▪ One round of groundwater sampling from each of the constructed monitoring wells; ▪ Laboratory analysis of selected soil and groundwater samples for relevant analytical parameters; and ▪ Data analysis and reporting.
Findings	There was no evidence, by way of a fill / dip point, to suggest that an underground petroleum storage system (UPSS) was present on the site. The site was free of statutory notices issued by the EPA. The sub-surface layers were comprised of anthropogenic filling (Silty Sandy CLAY / Gravelly SAND / Silty GRAVEL, with some building rubble and ash; 0.1-1.9 m thickness), overlying natural (Sandy) Silty CLAY and Clayey SAND (2.6-7.4 m thickness) and (weathered) sandstone. Groundwater was encountered between 0.3-2.1 mBGL in the monitoring wells, with the inferred flow direction being south easterly, toward Alexandra Canal. Local groundwater was considered to be slightly acidic (pH 5.25-5.95) and slightly saline to brackish (Electrical Conductivity: 831-5,347 µS/cm). Near surface (≤1.5 mBGL) soils contaminated by PAHs and asbestos were present on the site, with concentrations of these COPCs exceeding the human health-based soil investigation levels (SILs) for residential settings with minimal access to soils. The PAH and asbestos contamination was not considered to be gross (i.e. high level);

<table>
<tr><th>Assessment Details</th><th>Project Tasks and Findings</th></tr>
<tr><td></td><td>however, it was generally widespread in lateral terms, being identified at ten separate sampling locations across the site:
▪ Aargus (2014):BH1, BH4, BH5, BH6, BH7, BH14, BH21 and BH22;
▪ EI (2019): BH9M and BH13.
Heavy metal (copper, lead, nickel and zinc), TRH and PFAS contamination of soil was also apparent; however, for these COPCs, the impacts were of concern to ecological values, rather than human health.
In terms of the vertical extent of contamination, the imported fill layer contained most of the contaminant load; however, some of the reworked (disturbed) natural soils were also impacted.
Based on the analytical results, ASSs were not present onsite (to 7.5 mBGL, at least).
The local groundwater was contaminated by heavy metals (copper, nickel and zinc), volatile (chlorinated) hydrocarbons (toluene, ethylbenzene, xylenes, trichloroethene (TCE) and acetone) and PFAS. Further groundwater monitoring was thus warranted.</td></tr>
<tr><td>Conclusions and Recommendations</td><td>EI concluded that the site could be made suitable for the proposed development, given that the following recommendations were undertaken:
▪ Preparation and implementation of a Remediation Action Plan (RAP), which:
‣ Outlined the management of soils impacted with heavy metals (copper, lead, nickel and zinc), TRH, PAH, PFAS and asbestos.
‣ Designed supplementary investigations for further groundwater monitoring as part of the site validation program.
‣ Validated excavated areas to ensure soils and groundwater are suitable for the proposed development.
‣ Validated any material being imported to the site in accordance with EPA guidelines, to confirm its suitability for the proposed (residential) land use.
▪ Preparation of a final site validation report by a qualified environmental consultant, certifying site suitability for the proposed development.</td></tr>
</table>

4. CONCEPTUAL SITE MODEL (CSM)

EI (2019) presented a conceptual site model (CSM), assessing plausible linkages between potential contamination sources, migration pathways and environmental receptors. In summary, it was proposed that contamination - receptor linkage may exist if impacted soil came into contact with human skin, or ingestion was made. The CSM is outlined in more detail below.

4.1 Generalised Subsurface Profile

Anthropogenic filling (Silty Sandy CLAY / Gravelly SAND / Silty GRAVEL, with some building rubble and ash; 0.1-1.9 m thickness), overlying natural (Sandy) Silty CLAY and Clayey SAND (2.6-7.4 m thickness) and (weathered) sandstone.

4.2 Potential Contamination Sources

The primary sources of potential contamination were:

- Imported fill soils of unknown origin, distributed across the entire site;
- Impacts from commercial and industrial activities at the site and its immediate surroundings;
- Hazardous materials, including asbestos-containing materials (ACMs) and lead-based paints, from previous and existing building fabrics; and
- Deep natural soils with residual impacts, representing secondary sources of contamination.

4.3 Contaminants of Potential Concern

Based on the site contamination appraisal, the COPCs were initially considered to be heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc), C_6-C_{40} total petroleum / recoverable hydrocarbons (TPHs / TRHs), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs; including chlorinated VOCs (CVOCs) and the monocyclic aromatic hydrocarbon compounds benzene, toluene, ethylbenzene and xylenes (BTEX)), organochlorine and organophosphate pesticides (OCPs / OPPs), polychlorinated biphenyls (PCBs), phenols, per and poly-fluoroalkyl substances (PFAS), pH, and asbestos.

Based on the completed investigation phase, the COPCs of relevance to this RAP were narrowed to:

- **Soil** - heavy metals (copper, lead, nickel and zinc), C_6-C_{40} TRHs, PAHs, PFAS and asbestos.
- **Groundwater** - dissolved heavy metals (copper, nickel and zinc), VOCs (CVOCs and BTEX) and PFAS.

4.4 Receptors and Exposure Pathways

The potential exposure pathways and receptors are summarised in **Table 3-2**.

Table 3-2 Receptor and Exposure Pathways

Medium	Transport Mechanism	Exposure Pathway	Potential Receptor	Likelihood of Exposure
Soil, Rock	Surface spillage direct to subsurface soil/rock via percolation; some sorption on the soil matrix.	Dermal contact Ingestion	Future site occupants. Construction and maintenance workers.	Exposure potential moderate, as considerable chance of direct contact with soils/rock, based on the proposed development. For remediation and construction workers, appropriate health and safety protocols should be implemented.
Vapour	Volatilisation, following surface spillage and/or percolation.	Inhalation	Future site occupants. Construction and maintenance workers. Off-site residents.	Exposure pathway low as volatile contaminants only detected at trace levels. Some potential for asbestos fibre exposure, however, if dusts are released. OHS measures are required during remediation and construction works.
Groundwater	Vertical and horizontal (south easterly) infiltration through clay and bedrock	Dermal contact Ingestion	Future site occupants. Construction and maintenance workers. Off-site residents.	Exposure potential moderate, due to significant chance of direct contact with groundwater, based on the proposed development and high water table.

4.5 Existing Site Contamination

Site fill and disturbed / re-worked natural soils to ≤1.5 mBGL were contaminated by PAHs and asbestos, as well as heavy metals (copper, lead, nickel and zinc), TRH (F2/F3) and PFAS (PFOS), although the latter three COCPs were of concern to ecological values, rather than human health.

The contamination was not considered to be gross (i.e. high level); however, it was generally widespread in lateral terms and included Aargus (2014) sampling locations BH1, BH4, BH5, BH6, BH7, BH14, BH21 and BH22, as well as EI (2019) locations BH9M and BH13 (Ref. **Figure 2**).

4.6 Suggested Remediation Strategy

Based on all existing characterisation data, the site required remediation in order for it to be made suitable for mixed commercial / residential land use. Given that the proposed redevelopment included bulk excavation up to 3 mBGL for construction of the basement car parking facility (**Appendix B**), the most feasible remediation strategy involves contaminated soil disposal at EPA-licensed landfill facilities.

To this end, the near-surface (≤1.5 mBGL) soils were classified in accordance with the EPA (2014a) *Waste Classification Guidelines* as part of the EI (2019) additional site investigation.

4.6.1 Asbestos Waste

Fill soils in the vicinities of BH1, BH7 and BH22 (Aargus, 2014) and BH13 (EI, 2019) were classified as *Special Waste (Asbestos Waste)*, due to the presence of ACMs. These soils must be treated (i.e. excavated) first during the remediation phase.

It is suggested that at each test location, the entire fill layer will be removed from within an area of approximately 3 m x 3 m at the surface (that being the minimum zone of remediation), with additional wall and/or base excavations conducted as dictated by the validation program. The corresponding soil validation samples will be screened for asbestos (at least).

4.6.2 General Solid Waste

All remaining fill soils across the site, plus any reworked / disturbed natural soils to ≤1.5 mBGL, were classified as *General Solid Waste (Non-Putrescible)*. This includes the PAH-impacted materials in the vicinities of BH4, BH5, BH6, BH14 and BH21 (Aargus, 2014) and BH9M (EI, 2019).

It is acknowledged that some of the PAH (including benzo(α)pyrene) data for the site-wide filling exceeded the respective EPA (2014a) *SCC1 General Solid Waste* and *SCC2 Restricted Solid Waste* thresholds. However, pursuant to the provisions in Clause 28 of the *Protection of the Environment Operations (Waste) Regulation 1996*, the EPA has authorised the general approval of the immobilisation of PAHs, including benzo(a)pyrene, in ash- / coal- contaminated, excavated materials (Approval Number 1999/05). This approval is based on the theory that the residual PAHs will be naturally immobilised (i.e. strongly bound) within a vitrified carbonaceous and siliceous matrix.

The filling from this site was considered to comply with this waste stream because:

- Its colour (typically (dark) grey and brown), texture (silty sandy clay / gravelly sand / silty gravel, with building rubble and ash) and use (imported fill) were consistent with being an ash- / coal-contaminated, soil material;
- It did not contain any free liquid; and
- Despite elevated concentrations of total PAHs (up to 819 mg/kg) and benzo(α)pyrene (up to 52 mg/kg), the TCLP-leachable levels were negligible (<0.0001 mg/L for benzo(α)pyrene).

Therefore, in accordance with the provisions of EPA General Approval Number 1999/05 and the procedures set out in the EPA (2014a) *Waste Classification Guidelines*, the remaining, (non-ACM) site-wide filling was classified as General Solid Waste.

Upon removal of the site-wide fill, exposed surface soil validation samples will be screened for asbestos, PAHs, heavy metals (including copper, lead, nickel and zinc), TRHs and PFAS (at least).

5. REMEDIATION GOALS & CRITERIA

5.1 Remediation Goals

The remediation goals for this RAP are consistent with *SEPP 55* and Council's contaminated land policy and include:

- Meeting the conditions of the planning consent, to render the site suitable for the proposed land use(s);
- Demonstrating that the proposed remediation strategy for the site is environmentally justifiable practical and technically feasible;
- Adopting clean-up criteria appropriate for the future use of the site to mitigate possible impacts to human health and the environment;
- Mitigating possible off-site migration of contaminants (including migration in existing utilities such as the sewer, stormwater and other subsurface pipes or service trenches);
- Consideration of the principles of ecologically sustainable development in line with Section 9 of the *Contaminated Land Management Act 1997*;
- Minimising waste generation under the *Waste Avoidance and Resource Recovery Act 2001*;
- To remediate all contamination at the site, so there are no unacceptable risks to off-site receptors; and
- Demonstrating that the plans for management of remediation work consider work health and safety, environmental management, community relations and site contingencies.

5.2 Remediation Criteria

As the proposed site development includes the change in use to a more sensitive land use, the following soil remediation criteria outlined in **Table 5-1**, which are based on NEPM (2013) *Schedule B1 Guideline on Investigation Levels for Soil and Groundwater*, will be adopted as clean up levels for the applicable areas of the site:

Table 5-1 Adopted Investigation Levels for Soil and Groundwater

Environmental Media	Adopted Guidelines	Rationale
Soil	NEPM, 2013 Soil HILs, EILs, HSLs, ESLs & Management Limits for TPHs	**Soil Health-based Investigation Levels (HILs)** Basement and building footprint: NEPM (2013) HIL-B for residential settings with limited soils access. Retained Deep Soils: NEPM (2013) HIL-C for recreational / open space settings. Paved Road Shareway: NEPM (2013) HIL-D for commercial / industrial settings **Soil Health-based Screening Levels (HSLs)** Basement and building footprint: NEPM (2013) HSL-D for commercial / industrial exposure settings. *EI note that basements can be assessed against HSL-D for vapour intrusion in accordance with NEPM (2013) Table 1A(3) Note (1).*

Environmental Media	Adopted Guidelines	Rationale
		Retained Deep Soils: NEPM (2013) HSL-C for recreational / open space settings. Asbestos HSLs WADOH (2009) assessment criteria, as presented in NEPM (2013). **Ecological Investigation Levels (EILs) / Ecological Screening Levels (ESLs)** EILs / ESLs were considered relevant for the retained deep soils. EILs / ESLs only apply to the top 2 m (root zone). The derived EIL criteria presented by EI are based on the addition of conservative Added Contaminant Limit (ACL) criteria and the Ambient Background Concentration (ACL) for an old high traffic suburb. The adopted ESL criteria presented by EI are based on conservative coarse grained criteria. **Management Limits for Petroleum Hydrocarbons** Should the ESLs and HSLs be exceeded for petroleum hydrocarbons, soil samples would also assessed against the NEPM 2013 *Management Limits* for the TRH fractions F1 – F4 to assess propensity for phase-separated hydrocarbons (PSH), fire and explosive hazards & adverse effects on buried infrastructure.
	HEPA (2018) human health-based PFAS guidelines	Criteria for PFAS are not provided under NEPC (2103) and for this reason, the HEPA (2018) human health-based PFAS guidelines for the investigation of residential sites with minimal opportunities to soil access, as well as the interim soil ecological-based guidelines for indirect exposure within residential settings, will be adopted.
Groundwater	NEPM, 2013 GILs for Marine Waters (ANZG, 2018 Trigger Values) Groundwater HSLs for Vapour Intrusion	**Groundwater Investigation Levels (GILs) for Marine Water** NEPM 2013 provides GILs for marine water aquatic ecosystems, which are based on the ANZECC & ARMCANZ 2000 Trigger Values (TVs) (now superseded by ANZG, 2018). The marine criteria were considered relevant as the closest, potential surface water receptor was Alexandra Canal. For petroleum hydrocarbons, the PQL for each TRH fraction was adopted as the GIL for aquatic ecosystems, as per the guidance provided in DEC (2007) *Guidelines for the Assessment and Management of Groundwater Contamination*.
	NEPM, 2013 Groundwater HSLs for Vapour Intrusion	**Health-based Screening Levels (HSLs)** The NEPM 2013 groundwater HSLs for vapour intrusion were used to assess for potential human health impacts from residual vapours resulting from petroleum, BTEX and naphthalene impacts. The *HSL-D* thresholds for commercial / industrial exposure settings could be applied for groundwater underneath the basement car park.
	HEPA (2018)	Guideline values for site investigations in Australia (specifically the freshwater values for 95% species protection in slightly-moderately disturbed aquatic ecosystems and the health-based drinking water criteria.

The contaminant threshold values relating to the adopted soil and groundwater remediation criteria are tabulated in **Appendix D, Table D-1** and **Table D-2**. Conformance with the soil remediation criteria will be deemed to have been attained when validation samples from similar lithology and depth show contaminant concentrations that are below the specified criteria, or, as a minimum, the 95% upper confidence limit (UCL) mean concentration value for each contaminant in the remediated area (i.e. across the excavated surface), is below the respective acceptance criterion.

5.3 Waste Criteria

In accordance with the EPA (2014a) *Waste Classification Guidelines* (the 'Waste Guidelines'), all soils designated for off-site disposal must be pre-classified into one of the following groups: *General Solid Waste*, *Restricted Solid Waste* or *Hazardous Waste*. Any soils containing asbestos will also be classified as *Special Waste - Asbestos Waste*.

Soil classification is dependent on chemical assessment of total and leachable levels using NATA-registered laboratory methods for each relevant contaminant, the results being interpreted against the respective EPA (2014a) thresholds. These thresholds are presented in **Appendix D, Tables D-2** and **D-3**. Note, leachable concentrations are determined using the *Toxicity Characteristics Leaching Procedure* (TCLP).

Should the analytical results exceed the SCC2 and/or TCLP2 thresholds, then the materials will be classified as *Hazardous Waste*. In such cases, material stabilisation treatment with EPA approval may be required prior to offsite disposal. Unexpected material may need to be segregated depending on the source of the waste, prior to conducting waste classification assessment. This approach is discussed in more detail under *Contingency Management* in **Section 8.7**.

In accordance with the *NSW Waste Regulation 2014*, waste soils must only be disposed to a facility that is appropriately licenced to receive the incoming waste. It is therefore recommended that confirmation is obtained from the waste facility prior the material(s) being removed from the site.

Refer to **Section 3.5** and **Appendix C** for waste classifications of the near-surface (≤1.5 mBGL) fill and disturbed / re-worked natural soils of this site.

6. DATA QUALITY OBJECTIVES

In accordance with the US EPA (2006) *Data Quality Assessment* and the EPA (2017) *Guidelines for the NSW Site Auditor Scheme*, Data Quality Objectives (DQO) will be proposed by the EI team to determine the appropriate level of data quality needed for the specific requirements of the project. The DQO process to be applied for this remediation is documented in **Table 6-1**.

Table 6-1 Summary of Project Data Quality Objectives

DQO Steps	Details
1. State the Problem Summarise the contamination problem that will require new environmental data, and identify the resources available to resolve the problem; develop a conceptual site model.	Historically the site has been used for residential and commercial purposes (since the 1930s, at least). Imported filling present across the entire property. The surroundings include several commercial premises. A conceptual site model is presented in **Section 4**. The site is required to be rendered suitable for the proposed development (mixed commercial and medium density residential use). Previous investigations indicated the presence of PAH, asbestos, metal, TRH, and PFAS impacted soils (≤1.5 mBGL).
2. Identify the Goal of the Study (Identify the decisions) Identify the decisions that need to be made on the contamination problem and the new environmental data required to make them.	Based on the objectives outlined in **Section 1.3**, the following decisions are identified: ▪ Has the nature, extent and source of any on-site soil, vapour and/or groundwater impacts been defined? ▪ What impact do the site specific, geologic and hydrogeological conditions have on the fate and transport of any impacts that may be identified? ▪ Does the level of impact coupled with the fate and transport of identified contaminants represent an unacceptable risk to identified human and/or environmental receptors on- or off- site? ▪ Will site soils and groundwater require further remediation and/or special management before the site can be used for residential purposes?
3. Identify Information Inputs (Identify inputs to decision) Identify the information needed to support any decision and specify which inputs require new environmental measurements.	Inputs to the decision making process include: ▪ The proposed land use and development layout; ▪ Previous investigations performed at the site, summarised in **Section 3**; ▪ Soil validation sampling of remedial excavation surfaces; ▪ Laboratory analytical results of soil validation samples; ▪ Groundwater samples and laboratory analytical results; and ▪ Assessment of analytical results in relation to the remediation criteria. At the end of the validation, a decision must be made regarding whether the environmental conditions are suitable for the proposed development, or if additional investigation and/or remedial works are required.
4. Define the Boundaries of the Study Specify the spatial and temporal aspects of the environmental media that the data must represent to support decision.	**Lateral** – The cadastral site boundaries. **Vertical** – From the existing ground surface, fill and natural soil horizons, to the base of contaminated soil and underlying water-bearing zones (1.5m BGL, at least). **Temporal** – Results are valid on the day of data and sample collection, and remain valid as long as no changes occur on-site, or contamination (if present) does not migrate on-site or on to the site from off-site sources.

DQO Steps	Details
5. Develop the Analytic Approach (Decision rule) To define the parameter of interest, specify the action level, and integrate previous DQO outputs into a single statement that describes a logical basis for choosing from alternative actions.	Laboratory analytical results will be accepted if: ▪ All contracted laboratories are accredited by NATA for the analyses undertaken; ▪ All detection limits (or limits of reporting (LORs)) fall below the remediation criteria; ▪ RPDs for duplicate samples are within accepted limits; and ▪ Laboratory QA/QC protocols and results comply with NEPM requirements.

6. Specify Performance or Acceptance Criteria (Specify limits on decision errors)
Specify the decision-maker's acceptable limits on decision errors, which are used to establish performance goals for limiting uncertainties in the data.
	Specific limits for this project are to be in accordance with National and NSW EPA guidance, and appropriate indicators of data quality and standard procedures for field sampling and handling. This includes the following points to quantify tolerable limits:
	▪ The null hypothesis for the remediation of soils is that the:
	  ‣ 95% Upper Confidence Limits (UCLs) of the mean for contaminants of concern exceed the adopted remediation criteria across the site;
	▪ The collection of pit (remediation area) wall and base soil samples (minimum 5 per pit = four walls and one base);
	▪ The collection of 18 final surface soil samples on a 20 m grid, to allow detection of a circular hotspot with a nominal radius of 12 m with 95% certainty (EPA, 1995);
	▪ The acceptance of the site as validated will be based on that:
	  ‣ The 95% UCL of the mean of the data will satisfy the given site criterion. Therefore a limit on the decision error will be 5% that a conclusive statement may be incorrect;
	  ‣ The standard deviation of the results is less than 50% of the relevant remediation acceptance criterion; and
	  ‣ No single result exceeds the remediation acceptance criterion by 250% or more.
	▪ Soil concentrations for the COPCs that are below investigation/validation criteria made or approved by the NSW EPA will be treated as acceptable and indicative of suitability for the proposed land use(s).

7. Develop the Detailed Plan for Obtaining Data (Optimise the design for obtaining data) Identify the most resource-effective sampling and analysis design for general data that are expected to satisfy the DQOs.	▪ Written instructions will be issued to guide personnel in the required fieldwork activities. ▪ Soil remedial excavation is to be performed as per **Section 8**. Soil validation sampling is to be completed as per the methodology prescribed in **Section 10**. ▪ Validation sampling procedures will be implemented to optimise data collection for achieving the DQOs. Review of the results will be undertaken to determine if further excavation and/or additional sampling is warranted. Additional investigations would be considered to be warranted where soil concentrations are found to exceed the remediation criteria relevant to the proposed land use(s).

7. REMEDIATION TECHNOLOGY

7.1 Regulatory Overview

Section 16 in Volume 1 of the NEPC (2013) guidelines indicates that the preferred hierarchy for site remediation options and/or management is:

- On-site treatment of the contamination, so that it is destroyed or the associated risk is reduced to an acceptable level; and
- Off-site treatment of the contamination, so that it is destroyed or the associated risk is reduced to an acceptable level, after which the soil/water is returned to the site; or, if the above are not practicable:
- Consolidation and isolation of the contamination on-site, by containment with a properly designed barrier; and
- Removal of contaminated material to an approved waste facility, followed, where necessary, by replacement with appropriate material; or
- Where the assessment indicates remediation would have no net environmental benefit or would have a net adverse environmental effect, implementation of an appropriate management strategy.

When deciding which option to choose, the sustainability (environmental, economic and social) of each option should be considered, in terms of achieving an appropriate balance between the benefits and effects of undertaking the option.

Other considerations to mitigate groundwater contamination measures, as outlined by the EPA (2007) *Guidelines for the Assessment and Management of Groundwater Contamination*, include:

- Notifying of the affected property (under the *CLM Act 1997*) and the downgradient receptors;
- Containment of the contamination plume;
- Active or passive clean-up of contaminated groundwater (this may include the concept of clean-up to the extent practicable (CUTEP)), which may include ongoing monitoring of groundwater and/or contingency plans and management plans to mitigate risks; and
- Legislative control through restricting groundwater use in and down-gradient of the contaminant plume.

For this site, a number of remediation options were reviewed to examine the suitability of each method, the surrounding properties, geological and hydrogeological limitations and the following considerations:

- Development requirements (mixed commercial and medium density residential, with limited access to soils);
- Prioritisation of works in areas of most concern;
- Ability of remedial method to treat contamination with respect to material and infrastructure limitations;
- Remedial timetable;

- Defensible method to ensure the site is remediated to appropriate levels / validation criteria; and
- Regulatory compliance.

7.2 Remedial Technologies Review

A number of soil remediation options were reviewed, examining the suitability of each with due regard for the surrounding land uses, as well as the geological and hydrogeological limitations.

Brief discussion of the various remediation technology options is provided in **Appendix E**. Each of the available remediation technologies, except ones not commonly used in Australia (for instance *in-situ* thermal or steam injection), are summarised in terms of their suitability for treatment of soils and groundwater in **Table 7-1**.

Table 7-1 Remedial Technology Review

Remediation methodology	Description	Advantages	Disadvantages	Suitability
No Action	'No Action' can be considered if: ▪ There is no measurable contamination; ▪ Contaminant concentrations are below assessment guidelines; ▪ Contaminants are not mobile; or ▪ Exposure to contaminated soils is unlikely.	No remediation costs Creates minimal disturbance to the site Retains material on-site	Not applicable to the kind of contamination encountered at the site. Contamination would remain in situ allowing potential vapour intrusion and off-site migration of contamination and impacts on groundwater. Would pose limitations on land use options. Requires an Environmental Management Plan and ongoing monitoring.	Not Suitable – as the key objective of the remedial strategy is to make the site suitable for medium density residential use without the need for ongoing monitoring.
On-site bioremediation (biostimulation)	Excavated soils are thoroughly broken down and aerated, mixed with microorganisms and nutrients, stockpiled and aerated in above ground enclosures.	Cost effective if soils are utilised on-site. Lower disposal costs. Limited requirement to import fill material to site. Retains material on-site.	Significant area of site required to land farm material. Undefined remediation timeframe. Potential for odour problems. Not suitable for metals and asbestos contamination.	Not suitable – as will not be effective for metals and asbestos, the time frame for achieving the required reductions in concentrations would be extended and ongoing monitoring would be required for the interim period.
In situ treatment	In situ treatment of impacted soils by soil vapour extraction (SVE), steam stripping, ISCO or injection of oxygen releasing compounds.	Creates minimal disturbance to the site (no excavation). Cost effective for large scale site remediation projects of light to mid-weight petroleum hydrocarbons. Potential to simultaneously remediate dissolved phase hydrocarbons in site groundwater.	Expensive establishment and on-going costs. Potential for odour problems. Requires detailed design, pilot trials and management. SVE requires high vacuum pressure over a long period and will not work in saturated conditions.	Not suitable – this method is designed for widespread hydrocarbon impacted soils. Since the present dataset does not provide evidence of widespread (hydrocarbon) contamination, this is not considered to be an economically viable option. SVE could be considered a secondary option, if deep (>3 mBGL) hydrocarbon contamination is identified.

Remediation methodology	Description	Advantages	Disadvantages	Suitability
Consolidation and/or capping	Risk minimisation approach where impacted soils are managed on-site by capping the ground surface with a clean, impermeable layer of fill material (or hardstand).	Effectively removes risk to human health by eliminating exposure pathways.	Importance of capping materials. Contamination would remain in situ, and if not satisfactorily characterised, could result in impacts to groundwater and potential off-site migration of contamination. Would pose limitations on land use options. Requires an Environmental Management Plan and ongoing monitoring.	Suitable – an EMP with ongoing monitoring / inspection would be required, due to the retention of contaminated materials on the site. On-site isolation could be considered a secondary option to offsite disposal, if economic (cost) constraints apply.
Excavation and off-site disposal	Excavate / extract impacted materials. Transport directly to a licensed landfill facility. Re-instate site with imported clean fill material.	Fast – impacted material removed immediately, significantly reducing potential for impact to groundwater. No storage or treatment problems. Reduced vapour/odour issues as impacted materials removed from site. Minimal design and management costs.	Transfer of waste to another location (licensed waste facility). High costs associated with the disposal of waste soils / bedrock and importation of clean backfill. Requires waste classification prior to disposal, keeping of thorough waste records, waste tracking and reporting. Sustainability issues related with disposal to landfill.	Suitable – for meeting the key project objective to make the site suitable for medium density residential use without the need for ongoing monitoring. This will remove contamination sources and prevent vertical migration to the groundwater system.
Natural attenuation	Allowing the contaminants to biodegrade naturally following removal of the contamination source.	No remedial excavation of site. Retains materials on site. Sustainable, cost effective remediation method.	Slow process. Potential for contamination to further impact on the groundwater aquifer and nearby environmental receptors. Would require Environmental Management Plan and ongoing monitoring. Not suitable for metals and asbestos.	Not Suitable – as will not be effective for metals and asbestos and thus will not address immediate soil impacts.

7.3 Preferred Remediation Option

Based on the assessment of available technologies, the proposed site development (mixed commercial and medium density residential use), the potential risks to human health and the environment, and the relative cost effectiveness of feasible techniques, the preferred remedial option for the site is complete and thorough off-site disposal of all impacted (fill) soils to licensed waste facilities, followed by site reinstatement with validated, imported excavated natural materials (where required).

Alternatively, on-site isolation of contamination by containment with a properly designed barrier may be conducted, but as a secondary option.

Since the proposed bulk excavation depth is up to 3 mBGL, the water-bearing zones in the underling sandstone are likely to be intercepted during the remediation / basement construction phase. Supplementary investigations of local groundwater quality (i.e. additional GMEs) are to form part of the site validation program, the data from which will form the basis of a dewatering management plan, should extraction and disposal be deemed necessary.

7.4 Site Preparation, Licences & Approvals

7.4.1 Consent Requirements

In accordance with *SEPP 55 - Remediation of Land*, the category of the remediation works defines whether consent is required prior to their commencement. Under SEPP 55, works where there is the potential for significant environmental impact are classed as *Category 1* and require development consent. *Category 2* works pose a low potential for environmental impact and do not therefore require prior consent. The determination for the subject site is outlined in **Table 7-2**.

Table 7-2 Remediation Works Category Determination

Significant Environment Impact	Yes/No	Category
Designated Development or State Significant Development	No	2
Critical or threatened species habitat	No	2
Have significant impact on threatened species, populations, ecological communities or their habitats	No	2
In area identified environmental significance such as scenic areas, wetlands (see list*)	No	2
Comply with a policy made under the contaminated land planning guidelines by the council.	Yes	2
Is work ancillary to designated development	Yes	2

Note 1 Environmental significance list -coastal protection, conservation or heritage conservation, habitat area, habitat protection area, habitat or wildlife corridor, environment protection, escarpment, escarpment protection or escarpment preservation, floodway, littoral rainforest, nature reserve, scenic area or scenic protection, or wetland.

Based on the above assessment, the remediation works for the site are considered Category 2 and will not require development consent. Category 2 works do, however, require notification to the consent authority; therefore, Council should be notified 30 days before their commencement. The 30-day limit does not prevent Council intervention after that time for a breach of the *EPA Act 1997* or non-compliance with *SEPP 55*. The notification also serves as the basis for updating Council records on properties in the local government area and must:

- Be in writing;
- Provide contact details for the notice;

- Briefly describe the remediation work;
- Show why the work is considered Category 2 remediation work;
- Specify the property description and street address on which the remediation work is to be carried out;
- Provide a location map; and
- Provide estimates for commencement and completion dates of the work.

Provision of this RAP, as well as an indication of commencement and completion dates of the works in writing, is usually sufficient to meet the requirements of this notification.

7.4.2 Development Consent & Control Plans

All works should be in accordance with the Inner West Council DCP and any development consent issued by Council for the development.

7.4.3 Other Licence Requirements

The appointed site contractor should prepare an appropriate Construction Environmental Management Plan (CEMP), health and safety plans and any other plans required under the Council DA and DCP. Where asbestos removal is required, the contractor must be appropriately licensed to perform such works.

8. REMEDIATION WORKS

8.1 Remediation Strategy

The preferred approach involves bulk excavation and disposal of impacted materials, to mitigate risks associated with PAHs, asbestos, heavy metals (copper, lead, nickel and zinc), TRHs and PFAS. The predicted excavation depth is 1.5 mBGL (minimum), chasing any hotspot as validation sampling and testing dictate. On-site isolation may be considered a secondary option, if zones of deep (>3m BGL), non-asbestos impacted soils are identified and/or economic (cost) constraints are apparent.

Hence, the main site remediation works will include, though not necessarily be limited to:

Stage 1 – Site Preparation (including building demolition)

Stage 2 – Site Inspection and Assessment of Building Footprints

Stage 3 – Soil Management

> **Option 1** – Waste Classification and Offsite Disposal
>
> **Option 2** – Cap and Contain

Stage 4 – Groundwater Investigation

Stage 5 – Final Soil Validation

Stage 6 – Validation Report Preparation

CONTINGENCY ACTION

Should unexpected finds be discovered during the course of the remediation program, or should any phase of the validation identify residual, high level contamination requiring additional remediation, then the procedures described under the Unexpected Finds Protocol (**Section 9.8**) and/or the Validation Plan (**Section 10.1**) will be implemented, until the remediation goals have been achieved and the site is deemed suitable for the intended land use.

8.2 Remediation Methodology

8.2.1 Stage 1 – Site Preparation

The site is to be prepared in accordance with the requirements of the management plan outlined in **Section 9**. This includes the establishment of environmental controls, site access, security, fencing, warning signage and preparation of a Health Safety and Environment Plan. A project plan is to be developed to outline engineering design for building demolition, excavation support (if required), water treatment requirements and design, staging of excavation works, stockpiling, waste stabilisation, waste material loading, traffic management and waste tracking.

As part of the site preparation phase and preliminary tasks, remediation workshops are to be conducted with the appointed contractor(s) to further develop any remedial measures, excavation plans and environmental management requirements. The site contractors are to prepare a staging, or project, plan that outlines the basic stages of their remediation works, which include:

- Sequence of areas to be demolished and/or excavated (Referring to the EI (2019) Hazardous Materials Survey; EI Report E24098.E10_Rev0 dated 29 January 2019);

- Areas designated for waste segregation, screening and storage (stockpiling), amenities, soil and groundwater treatment (if required);
- Truck movement and loading, to mitigate impacts to surrounding land and infrastructure; and
- Proposed environmental mitigation measures.

8.2.2 Stage 2 – Site Inspection and Assessment of Building Footprints

After site demolition, including the removal of any hardstand surface cover, an inspection of the exposed ground surface must be undertaken by qualified persons to confirm the absence of asbestos-containing materials (ACMs) and check for evidence of potential contamination (i.e. previously unidentified hotspots).

Emphasis shall be given to the former building footprints and the northern boundary. If previously unidentified contamination is suspected, additional characterisation of (fill) soils in such areas will be performed, by way of intrusive soil sampling and laboratory analyses. A minimum of five sampling locations (boreholes / test pits), distributed across the designated footprint, is recommended for this purpose, with representative samples to be tested for heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc), TRHs, VOCs (including CVOCs and BTEX), PAHs, phenols, OCPs, OPPs, PCBs, asbestos, PFAS, pH and EC. The analytical results would be combined with the existing data set, to assist the waste (re-) classification of site (fill) soils designated for disposal, as well as evaluation against the human-health and ecological acceptance criteria applicable for residential exposure settings with limited access to soil.

Should ACM fragments be discovered, these will be bagged and disposed from the site by a Class B1 licensed asbestos removal contractor, whom will provide appropriate documentation confirming disposal for validation reporting purposes.

8.2.3 Stage 3 – Soil Management

Option 1 – Waste Classification and Offsite Disposal

Asbestos-Impacted Fill Excavation and Off-site Disposal

Fill soils in the vicinities of BH1, BH7 and BH22 (Aargus, 2014) and BH13 (EI, 2019) were classified as *Special Waste (Asbestos Waste)*, due to the presence of ACMs (Ref. **Sections 3.2** and **3.5**). These soils will be excavated first during the remediation phase and disposed accordingly under that waste classification.

At each test location (Ref. **Figure 3**), the entire fill layer will be removed from within an area of approximately 3 m x 3 m at the surface (that being the minimum zone of remediation). The remediation area should be marked in a way to withstand external conditions and should be readily identifiable during the remedial works program, to enable contaminated soil chase-out excavations and revalidation, if necessary. The excavated fill soils will be loaded directly onto a transport vehicle (i.e. licensed tipper).

The remedial excavations must be conducted under the supervision of a suitably qualified environmental professional. Should dusts and/or odours be significant enough to cause nuisance at a site boundary, then measures for their control should be adopted, as described under the unexpected finds protocol in **Section 9.8**. Plant, machinery and / or other equipment to be used should be dedicated to the individual excavation, and should be free of all solid materials prior to the start of the remedial works.

For each remediation area, a minimum of five (four wall and one base) validation samples will be collected from the exposed surfaces using a hand trowel. These soil validation samples will be screened for PAHs and asbestos (at least), with comparison of the data against the RAC (Ref. **Section 5.2**).

Additional wall and/or base excavations will be conducted as dictated by the validation program (i.e. if/where asbestos is detected in the corresponding soil validation sample). Impacted pit walls will be further excavated by at least 1-2 m lateral extension; an impacted pit base will be excavated by at least 1-2 m depth, or into the undisturbed natural soil layer.

Remaining Site-Wide Fill Soil Excavation and Off-site Disposal

Upon completion of the asbestos remediation (i.e. Stage 3), the remaining site-wide fill will be bulk excavated. Determination of the need for disturbed / re-worked natural soil or any other surface area (e.g. a building footprint) to be remediated will depend on the Stage 2 inspection and compliance of the respective sample data against the RAC.

The following procedure will be adopted:

1 The entire fill layer will be removed from within the proposed basement footprint. If necessary, the excavation will be extended laterally, to ensure that all PAH-impacted filling materials in the vicinities of BH4, BH5, BH6, BH9, BH14 and BH21 (Aargus, 2014), and BH3M and BH9M (EI, 2019) are included (Ref. **Figure 3**).

2 Plant, machinery and / or other equipment to be used should be dedicated to the individual excavation, and should be free of all solid materials prior to the start of the remedial works.

3 The (fill) soils to 1.5 mBGL have been classified as *General Solid Waste* (Ref. **Sections 3.2** and **3.5**). Ideally, they will be excavated and loaded directly onto licensed transport vehicles.

4 Should the temporary stockpiling of excavated soils be necessary, materials designated for disposal must be isolated on an impermeable surface (such as a plastic liner, or retained hardstand). Stockpiles should also be protected from wind to avoid airborne dispersion of particles.

5 Any soils with odour, heavy staining and/or the presence of waste, oils, ash, salts or other visible contamination are to be isolated (stockpiled) from other excavated materials, for additional waste classification sampling and testing. Under the *NSW Waste Regulation 2014*, different waste streams must be kept separate. **Soils with different waste classifications cannot be loaded onto the same waste transport vehicle, for landfill disposal purposes.**

In accordance with Section 7.5.2 in Schedule B2 of the NEPC (2013) guidelines, as well as the EPA (2014a) *Waste Classification Guidelines*, the waste classification procedure for soil shall be as follows:

- An equivalent minimum sampling density of one sample per 25 m^3, with a minimum of three samples for single waste stream volumes of less than 75 m^3;
- All samples will be analysed for heavy metals (8 metals), TRHs, VOCs (including CVOCs and BTEX), PAHs, PCBs, OCPs, OPPs, asbestos and PFAS, with testing for leachability using the TCLP method where total contaminant concentrations exceed the *CT1 General Solid Waste* thresholds;
- For each round of sample collection (or at a frequency of 1:20 samples), one intra-laboratory (blind field) duplicate, one inter-laboratory (split field) duplicate and one rinsate blank shall be included in the batch, for QC purposes;
- A Waste Classification Certificate will be prepared for each separate waste, or stockpile, detailing the interpreted soil waste classification to enable off-site disposal to an appropriately licensed waste landfill facility.

If the stockpiled material contains concentrations of contaminants that exceed the disposal guidelines for *Restricted Solid Waste* (i.e. the materials are classed as potentially *Hazardous Waste*), they will be held on-site pending the determination of alternative disposal arrangements and/or on-site treatment. If required, disposal consent will be sought from the EPA prior to spoil transport. Contingency measures to handle and manage the disposal of spoil materials that fail to meet landfill threshold criteria are provided in **Section 9.6**.

Option 2 – Cap and Containment

This remedial option has been provided as an option subject to further testing (including leachability testing to identify potential risks to groundwater from leachable contamination) and Council approval. Following stockpiling and sufficient chemical characterisation, fill materials could be placed in layers in a suitable excavated area onsite in accordance with ANZECC (1999) *Guidelines for the Assessment of On-site Containment of Contaminated Soil*, subject to geotechnical recommendations and compaction requirements for use as engineered filling.

Following establishment of the final contaminated fill levels, a high visibility demarcation layer (geotextile) is to be installed over the contaminated fill. Non-contaminated engineered filling is to be placed over the demarcation layer. These soils may be ENM or VENM won from the site, or imported and classified with certifcation. The engineered filling over the demarcation layer may vary in thickness depending on the type of construction (footings, service trenches etc.), however should not be less than 500 millimetres in thickness (see **Figure 8.1**). Service trenches, stormwater lines, and other infrastructure would be excavated and constructed as necessary within the overlying clean soils, ensuring the demarcation layer (geotextile) is installed over the contaminated fill and remains undisturbed during works.

A long term environmental management plan (EMP) will be required and attached to the title of land for ongoing monitoring and management of the capped and contained soils. The EMP will include provisions of regular inspection and maintenance as necessary. The EMP would also outline if further monitoring of the capped material is required. An as-built survey plan will be required to detail the depth of contaminated soils for the construction of the placed impacted fill, demarcation layer and suitable 'clean' capping layer.

Risk to workers is to be managed under a construction environmental management plan (CEMP).

Should a cap and contain solution be ultimately preferred over the preferential waste classification and offsite disposal approach, a RAP addendum should be prepared to detail the procedures and process to be implemented for the cap and contain solution, including required measures for validation of the contained filling and capping structure.

8.2.4 Stage 4 – Groundwater Investigation

A groundwater monitoring event (GME) will be undertaken following the site inspection stage, and either at the completion or during the bulk excavation of fill soils, in order to assess the condition of local groundwater and inform any additional remediation and/or dewatering management measures required during the excavation program. The GMEs should be conducted prior to the commencement of bulk excavation of VENM soils and site dewatering (if required).

The GMEs will include sampling from the existing (Aargus (2014b) and EI (2019)) groundwater monitoring wells (Ref. **Figure 2**). Hence, it is highly recommended that all such wells be protected during building / pavement demolition and land clearance.

All wells will be inspected, gauged and developed (if required) to confirm functionality. If a well is compromised it may require replacement. A well-head elevation survey will also be conducted, to enable confirmation of the groundwater flow regime (i.e. the inferred hydraulic gradient).

A low-flow method will used to collect representative groundwater samples. All samples will be laboratory analysed for the identified COPCs (at least), those being dissolved heavy metals (copper, nickel and zinc), VOCs (CVOCs and BTEX) and PFAS, as per **Section 4.3**.

Should residual contaminants in groundwater be found at concentrations exceeding the adopted GILs (**Section 5.2**), a risk assessment will be performed to determine if groundwater impacts pose unacceptable risks to human health and/or the environment. The risk assessment will determine the need for further assessment (i.e. more GMEs) and/or groundwater remediation (e.g. extraction, or an alternative technology).

8.2.5 Stage 5 – Final Soil Validation

After removal of the site-wide fill, the following validation procedure shall be undertaken.

1. A detailed site walkover inspection will be conducted by a team led by the Environmental Management Coordinator / Remediation Supervisor to confirm that the excavated site surface is free of any visual signs of contamination. Should ACM fragments be discovered, these will be bagged and disposed from the site by a *Class B1* licensed asbestos removal contractor, who will provide appropriate documentation confirming disposal for validation reporting purposes.
2. Validation samples will be collected from 0.1-0.2 m below the final excavation / exposed surface using a hand trowel. The sampling locations shall be arranged in a systematic, 20m grid pattern across the site (minimum of 18 samples), to allow detection of a circular hotspot with a nominal radius of 12 m with 95% certainty (EPA, 1995).
3. One intra-laboratory (blind field) duplicate, one inter-laboratory (split field) duplicate and one rinsate blank will also be collected for QC purposes.
4. Each validation sample will be screened for asbestos, PAHs, heavy metals (including copper, lead, nickel and zinc), TRHs and PFAS (at least).
5. Any results showing that elevated concentrations (above the adopted RAC) are present will trigger appropriate chase-out excavations, to remediate the impacted zone. A minimum area of approximately 3 m x 3 m at the surface will be excavated, to at least 1-2 m depth, or into the undisturbed natural soil layer.
6. Should the deeper excavation of impacted natural soils extend to more than 1 m in depth, then localised shoring will be employed to prevent excavation wall collapse. The shoring system will require technical approval by a qualified and experienced structural engineer.
7. Additional spoil resulting from further chase out excavations under Steps 5 and 6 above, will be stockpiled and assessed for waste classification as per point 4 of **Section 8.2.4**, followed by appropriate offsite disposal (or relocation to an area of proposed (future) hardstand, should economic constraints be apparent). This will be followed by revalidation of the new excavation.
8. Steps 5, 6 and 7 will be repeated until all validation results for excavation surfaces (walls and bases) indicate analyte concentrations that are below the relevant RAC.
9. Under no circumstances will impacted soils with different waste classifications be mixed. Remedial excavations, including the hammering of any bedrock, must be conducted under the supervision of a suitably qualified environmental professional. Should dusts and/or odours be significant enough to cause nuisance at a site boundary, then measures for their control should be adopted, as described under the unexpected finds protocol in **Section 9.8**.

Validation of Imported Backfill Soils

Should excavated areas require reinstatement (e.g. remedial excavations extend beyond the proposed basement footprint), soils imported to the site must be supplied by approved and reputable landscape suppliers. Imported backfill soils must be certified as meeting the NSW EPA *Virgin Excavated Natural Material* (VENM) classification, prior to importation to the site. To deem soils suitable for reuse on the subject site, the following confirmation procedure should be undertaken:

- All imported soils brought to the site should be certified as VENM by the supplier;
- No soil or rock is to be imported onto the site for backfilling purposes, unless the supporting documentation is approved by the appointed Environmental Project Manager; and
- Imported backfill soils placed within the areas where accessible soils are proposed must be assessed against ecological criteria using the following methodology:
  - Collect one soil sample per 100 m^3 of imported soil assigned to accessible soil areas;
  - Analyse samples for chemicals of concern (heavy metals, TRHs, BTEX, PAHs, OCPs, OPPs, PCBs and asbestos), plus the physicochemical parameters pH, electrical conductivity (EC) and cation exchange capacity (CEC);
  - Assess the analytical results against the NEPC (2013) *Ecological Investigation Levels* (EILs) and *Ecological Screening Levels* (ESLs) for urban residential and public open space settings; and
  - Should the assessed samples be unsuitable for the ecological use proposed, the soils should be removed and replaced, with follow-up ecological assessment using the above procedure, which should be repeated until the ecological assessment shows that accessible soils meet the relevant EILs and ESLs.

Deviations from the Proposed Validation Plan

The proposed sampling plan may be varied due to site constraints; however, guidance from the appointed Environmental Project Manager must be sought to ensure that any deviations are properly documented, as required under the OEH (2011) guidelines. Where anomalies in fill/soil consistency are noted (such as odour, heavy staining and/or the presence of waste, oils, ash, salts or other visible contamination), additional sampling and analysis may be necessary and guidance in this regard should be sought from the appointed Environmental Project Manager.

More details in relation to validation sample collection and handling are provided in **Section 10.1**.

8.2.6 Stage 6 – Validation Report Preparation

A validation report will be prepared in accordance with the OEH (2011) *Guidelines for Consultants Reporting on Contaminated Sites* and EPA (2017) *Guidelines for the NSW Site Auditor Scheme*, as described in **Section 10.2**.

8.3 Remediation Schedule

An estimated schedule for the remedial works is detailed below in **Table 8-1**. The proposed schedule is based on the remedial works being completed as outlined in this RAP and is dependent on Council approval of any DA and conditions of consent.

Table 8-1 Indicative Site Remediation Schedule

Timeframe	Action
Start	Council Approval of Remediation Plan
Week 1/3	Stage 1 – Site Preparation
Week 4	Stage 2 – Site Inspection and Assessment of Building Footprints

Timeframe	Action
Week 5/7	Stage 3 – Groundwater Investigation
Week 5/7	Stage 4 – Asbestos-Impacted Fill Excavation and Off-site Disposal
Week 8/12	Stage 5 – Remaining Site-Wide Fill Soil Excavation and Off-Site Disposal
Week 13/14	Stage 6 – Final Soil Validation
Week 14/18	Stage 7 – Validation Reporting

8.4 Remedial Contingencies

At this stage it is anticipated that the proposed remedial technology should be effective in dealing with the contamination present; however, remedial contingencies may be required should the scenarios detailed in **Table 8-2** arise.

Table 8-2 Remedial Contingencies

Scenario	Remedial Contingencies/Actions Required
Highly contaminated soils not identified during previous investigation are encountered, particularly at site boundaries	Follow the unexpected finds protocol as detailed in **Section 9.8** of this RAP. Work to be suspended until the Environmental Project Manager can further assess impacted soils/ materials and associated risks.
Underground tanks are encountered at the site	Systems to be removed and the excavations appropriately validated and backfilled by experienced contractor. Tank removal works reported by appropriate environmental consultant in accordance with EPA (2014b) Technical Note: Investigation of Service Station Sites and Australian Standard AS4976 (2008). Follow the unexpected finds protocol as detailed in **Section 9.8** of this RAP.
Highly impacted sludges are uncovered	The leachability of heavy metals and hydrocarbons will need to be assessed before disposal options are considered. Follow the unexpected finds protocol as detailed in **Section 9.8** of this RAP.
Significant asbestos wastes are encountered	Work to be suspended and asbestos work removed by a suitably qualified contactor, in accordance with SafeWork NSW regulations. Follow the unexpected finds protocol as detailed in **Section 9.8** of this RAP.
Residual soil impacts remain on-site near site boundary	Review/assess potential vapour hazard. If there is a vapour risk additional remedial measures may be required including installation of a vapour barrier or passive or active vapour extraction system.
Changes in proposed excavation depth	Review of the remediation works completed for the site.
Contaminated groundwater (including LNAPL or DNAPL) encountered	Review groundwater conditions on site. May require further groundwater investigations / remediation and longer-term management plan. Any dewatering may require approval under the *Water Management Act 2000*. Remedial measures may include, source removal, natural attenuation, bioremediation, PSH recovery using active pumping (including hydraulic control), installation of a groundwater permeability barrier or similar or in-situ oxidation or stabilisation.

Scenario	Remedial Contingencies/Actions Required
Groundwater contaminant plume is identified and is migrating off-site or there are increases in concentration due to increased infiltration	Review contaminant increase and analytes. Review active remediation alternatives (if necessary). Ensure down-gradient monitoring is undertaken. Carry out fate and transport modelling (if required) and assess the need for further action.
Contamination is identified near heritage items or significant trees (if identified)	Stop work. Review contaminant concentrations and risks to heritage items / flora. Assess human health and environmental risks if contamination remains in place. Review natural attenuation options.
Changes in proposed future land uses at the site	Review of the remediation works completed for the site.

9. SITE MANAGEMENT

9.1 Responsibilities and Contacts

The responsibilities for the various parties involved with the remediation program are outlined in **Table 9-1**.

Table 9-1 Site Management Responsibilities

Responsible Party	Details/Contacts	Responsible for:
Principal Project Manager (PPM)	Toga Wicks Park Developments Pty Ltd	Overall management of the site remedial activities.
Property Owner and Site Contractor	Owner: Dina Danias & Danias Holdings Pty Ltd Contractor: Toga Constructions NSW Pty Ltd	Notification of the site conditions to the NSW Environmental Protection Authority (EPA) under the duty to report contamination under the *Contaminated Land Management Act 1997*. Registration of details of Site Audit Statement (if required). Implementation of and compliance with the RAP. Notification to contractors of the existence of a RAP. Provision of copies of the current RAP. Provision of copies of this RAP to accompany the Development Application (DA). Notification of next future site owner of the existence of a RAP.
Environmental Management Coordinator / Remediation Supervisor	TBC	Ensuring that the site remediation works are carried out in an environmentally responsible manner. Liaising between the appointed Environmental Consultant and Council providing regular updates and informing of any problems encountered. Ensuring that all environmental protection measures are in place and are functioning correctly during site remediation works. Reporting any environmental issues to owner.
Demolition, Earthworks and/or Remediation Contractor	TBC	Undertaking building demolition, with reference to the EI (2019) Hazardous Materials Survey (EI Report E24098.E10_Rev0, dated 29 January 2019). Ensuring that all operations are carried out as identified in the RAP, as directed by the PPM and EMC. Inducting all employees, subcontractors and authorised visitors on procedures with respect to site works, WHS and environmental management procedures. Reporting any environmental issues to EMC. Maintaining site induction, site visitor and complaint registers. Ensuring that fugitive emissions and dust potentially leaving the confines of the site are suitably controlled and minimised. Ensuring that water containing any suspended matter or contaminants must not leave the site must be minimised

Responsible Party	Details/Contacts	Responsible for:
		and suitably controlled, so as not to pollute the environment. Ensuring that vehicles are cleaned and secured so that no mud, soil or water is deposited on any public roadways or adjacent areas. Ensure that noise and vibration levels at the site boundaries comply with the legislative requirements. On-site management and implementation of the remedial works and coordination of validation works, documentation, notifications, and permits required to conduct remedial works to a standard suitable of obtaining approval from the NSW EPA-Accredited Site Auditor and the NSW EPA. Preparation of a Construction Environmental Management Plan (CEMP) and Work Method Statement.
Environmental Consultant	TBC	On-site management and implementation of the remedial works and coordination of validation works, documentation, notifications, and permits required to conduct remedial works to a standard suitable of obtaining approval from the NSW EPA-Accredited Site Auditor and the NSW EPA. Complete validation sampling and monitoring as requested by the Remediation Contractor as required by the RAP. Liaise between remediation contractor and the client.
Local Council	Inner West Council	The RAP will accompany the DA and implementation of the RAP shall become a condition of the Development Consent. Ensuring requirements of Development Consent and other planning instruments are met.
Qualified Independent Consultant – NSW Accredited Site Auditor (if required)	TBC	Review of RAP, Site Validation Report. Review of updates, revisions or amendments as applicable. Provide interim audit advice of consultant or client submissions. Conduct inspections during remedial works.

9.2 Materials Handling and Management

Table 9-2 summarises the measures that must be implemented in respect of materials handling during excavation and remediation works at the site.

Table 9-2 Materials Handling and Management Requirements

Item	Description/ Requirements
Earthworks contractors	Excavation of fill materials should be completed by a suitably qualified contractor to ensure: ▪ All site staff are aware of the environmental and health and safety requirements to be adhered to; ▪ There is no discernible release of dust into the atmosphere as a consequence of the works; ▪ There is no discernible release of contaminated soil into any waterway as a consequence of the works; and ▪ There are no pollution incidents, health impacts or complaints.

Item	Description/ Requirements
Stockpiling of materials	All stockpiles will be maintained as follows: ▪ Stockpiles must be located on sealed surfaces such as sealed concrete, asphalt, or high density polyethylene; ▪ Should stockpiles be placed on bare soils, these soils should be placed on yet to be remediated areas. Contaminated materials should only be stockpiled in locations that do not pose any environmental risk (e.g. hardstand areas); ▪ Excavated soils should be stored in an orderly and safe condition (≤2 m height); and ▪ Stockpiles should be battered with sloped angles to prevent collapse. ▪ Stockpiles should be covered after being lightly conditioned by sprinkler to prevent dust blow and control odours; ▪ Air emissions to be controlled by using a hydrocarbon mitigation agent such as BioSolve®, Pinkwater®, or Anotech (or equivalent product selected by the contractor) in combination with the fine mist spray in the impacted area during disturbance and stockpiling of materials; ▪ Should the stockpile remain in situ for over 24 hours, silt fences or hay bales should be erected around each stockpile to prevent losses from surface erosion (runoff); and ▪ Stockpiles will be strategically located to mitigate environmental impacts while facilitating material handling requirements.
Loading and transport of waste materials	Prior to being assigned to an appropriate waste disposal facility, all waste fill/soils will be classified in accordance with the EPA (2014a) *Waste Classification Guidelines*. If prior immobilisation treatment of the waste soils is required, disposal consent will be obtained from the NSW EPA prior to spoil transport. Loading of excavated stockpiles / materials will be as follows: ▪ Removal of waste materials from the site shall only be carried out by a recognised contractor holding the appropriate EPA NSW licenses, consents and approvals; ▪ All trucks transporting soils from the site are to be covered with tarpaulins (or equivalent); ▪ Measures shall be implemented to ensure no contaminated material is spilled onto public roadways or tracked off-site on vehicle wheels. Such measures should include the use of a wheel washing/cleaning facility, placed before the egress point on the site, and should be able to handle all vehicles and plant operating on-site; ▪ Residue from the cleaning facility should be collected and either dewatered on site in a contained / bunded area, or disposed as a slurry to an approved facility. Such residue will be deemed contaminated unless proven otherwise; ▪ All deliveries/disposals of soil, materials equipment or machinery should be completed during the approved hours of remediation and exit the site in a forward direction; ▪ Transport of contaminated material off the site is to be via a clearly distinguished haul route; ▪ Trucks transporting soil, materials, equipment and machinery shall comply with all road traffic rules, minimise noise, vibration and odour to adjacent premises, utilise state roads and minimise use of local roads; and ▪ Waste must be transported less than 150km from the source (POEO 1997, Waste 2014) and landfills are required to be licensed for the category of waste they are scheduled to receive.

Item	Description/ Requirements
Material tracking	Materials excavated from the site must be tracked from the time of their excavation until their disposal. Tracking of the excavated materials must be completed by recording the following: ▪ Origin of material; ▪ Material type; ▪ Approximate volume; and ▪ Truck registration number. Disposal locations will be determined by the remediation contractor. Disposal location, waste disposal documentation (weighbridge dockets) and the above listed information should be provided to the remediation consultant for reporting purposes.
Material visual inspection prior to validation sampling	Following the completion of remedial works as specified within this RAP, the following applies: ▪ A suitably qualified environmental scientist should undertake a visual inspection of the work area. If visual observations indicate contamination, the earthworks contractors should rectify any issues arising from the inspection (i.e. further excavation or 'chasing out' until soils show no evidence of contamination based on visual inspection and/or odours). ▪ Following satisfactory completion of the visual inspection, validation sampling of soils should be completed. Validation sampling is discussed in **Section 10**. Only following satisfactory validation will remedial works be deemed as completed.

9.3 Management Measures

All work should be undertaken with due regard to the minimisation of environmental effects and to meet all statutory environmental and safety requirements. A CEMP should be developed for the site works by the site contractor/builder, which takes into account relevant guidance including, but not limited to:

- DA Conditions of Consent;
- *Marrickville Local Environmental Plan 2011*; and
- *Managing Urban Stormwater, Soils and Construction*, Volume 1: 4th Edition (March 2004).

Overall site management requirements related to the remedial works are presented in **Table 9-3**.

Table 9-3 Site Management Measures

Category	Measure
Demolition (including Asbestos Management)	Appropriate measures shall be taken to ensure that demolition works are completed in accordance with SafeWork NSW standards and codes of practice. In particular, all ACMs and lead-based paints should be managed in accordance with SafeWork NSW codes of practice and Australian Standards. The EI (2019) Hazardous Materials Survey (EI Report E24098.E10_Rev0, dated 29 January 2019) provides information relating to the location of hazardous materials on the site, as well as the recommended methods for their handling and disposal. Post demolition, site walkover inspections will be performed to visually screen the site and assess for visible evidence of fibre cement sheeting (FCS), which could potentially be ACM. All detected fragments of FCS must therefore be collected and bagged for appropriate offsite disposal.

Category	Measure
Site Stormwater Management and Control	Appropriate measures shall be taken to ensure that potentially contaminated water does not leave the site. Such measures will include, but not be limited to: ▪ Diversion and isolation of any stormwater from any contaminated areas; ▪ Provision of sediment traps including geotextiles or hay bales; and ▪ Discharge of any water to drains and water bodies must meet the appropriate effluent discharge consent condition under the *Protection of the Environmental Operations Act 1997*.
Soil Management	Appropriate measures shall be taken to ensure soils are excavated using a methodology appropriate to reduce nuisance dust and odours from leaving the boundary, and are disposed of in accordance with the *Protection of the Environment Operations (Waste) Regulation 2014*.
Dust and Odour	Control of dust and odour during the course of the remediation works shall be maintained by the contractor to ensure no nuisance dust or odours are received at the site boundary according to requirements of the Marrickville LEP 2011. A minimum of four monitoring points on the four site boundaries would be established and monitoring for asbestos fibres, odour and/or VOCs would commence immediately prior to the remedial excavations. Action levels and specific control measures would be described in the site CEMP and may include, but not necessarily be limited to the following: ▪ Site wide water spraying, as and when appropriate, to eliminate wind-blown dust; ▪ Use of mist sprays, and/or sprinklers on stockpiles, fill screening areas and loaded fill to lightly condition the material; ▪ Use of tarpaulin or tack-coat emulsion or sprays to prevent dust blow from stockpiles or from vehicle loads; ▪ Covering of stockpiles or loads with polythene or geotextile membranes; ▪ Restriction of stockpile heights to 2 m above surrounding site level; ▪ Ceasing works during periods of inclement weather such as high winds or heavy rain; ▪ Use of vapour masks or respirators for works near VOC-impacted areas; and ▪ Regular checking of the fugitive dust and odour issues to ensure compliance with the CEMP requirements, undertaking immediate remedial measures to rectify any cases of excessive dust or odour (e.g. use of misting sprays or odour masking agent). EI notes the Council Contaminated Land Policy requires that "No odours shall be detected at any boundary of the site during remediation works by a Council officer who is authorized under the POEO Act and who is relying solely on their sense of smell." Should significant odours be detected, and / or unexpected USTs be identified, which are found to be odorous, additional control measures for odour control may be required under the Inner West Council contaminated land policy, being: ▪ Use of appropriate covering techniques such as plastic sheeting to cover excavation faces; ▪ Use of fine mist sprays / hydrocarbon mitigation agent on the impacted areas/materials (examples of mitigation agents include BioSolve® Pinkwater®, or Anotech, however a similar product may be selected by the contractor); and ▪ Adequate maintenance of equipment and machinery to minimize exhaust emissions. It is advised that all site workers use adequate dust masks during soil excavation and that machine operators remain within an enclosed, air conditioned cabin.

Category	Measure
Noise and Vibration	Noise and vibration will be restricted to reasonable levels. All plant and machinery used on site will be noise muffled to ensure emissions do not breach statutory levels as defined within the Marrickville LEP 2011.
Hours of Operation	Working hours will be restricted to those specified by Council, which are defined as being 7am to 7pm weekdays and 7am to 5pm Saturdays; no Sunday work permitted. These hours may differ from DA conditions, and DA conditions specified for the site must be adhered to.
Community Engagement	Community engagement should be carried out in accordance with Schedule B(8) of NEPC (2013). Prior to the commencement of any remediation works at the site, every owner and occupier of any land located either wholly or partly within 100 m of the boundary of the premises (including local council and the RMS) should be notified at least 30 days in advance. The notice should include: ▪ Advice of demolition and excavation work to be carried out on the premises; ▪ State the time and date such work is to commence; ▪ Indicate that the works are being conducted to minimise any risk of site contamination impacting on off-site receptors; ▪ Provide appropriate site signage at an easily readable location on the site fencing, including site contact name and phone number to be contacted should any matter arise; and ▪ Provide contact information and procedure for registering any complaints.
Incident Management and Community Relations	While various environmental management and occupational safety plans will be developed to protect human health and the environment, incidents may occur which pose a risk to the various stakeholders. To mitigate these risks and ensure that a suitable response is carried out quickly, a response plan to any incident that may occur on site should be prepared and various responsibilities assigned. The site health and safety plan and environmental management plan should document these procedures and responsibilities, and incident contact numbers should be maintained in an on-site register. All other relevant emergency contact numbers such as Police, Fire Brigade, and Hospital should be listed in the Health and Safety Plan and posted on-site for easy access.

9.4 Amendment of RAP

The RAP must be amended and re-issued in one, or more, of the following circumstances:

1 There is a change in the proposed land-use, as defined in NEPC (2013) Schedule B1, Table 1A(1);

2 There is modification to the Certificate(s) of Title;

3 Contaminated material found within the site is different to that described in this RAP; and/or

4 There is a modification to NSW environmental or planning legislation affecting the RAP.

9.5 Distribution of RAP

The RAP and any subsequent amendments must be distributed to the following parties:

1 Current Site Owner;

2 NSW EPA Accredited Site Auditor (if appointed); and/or

3 Inner West Council; and

4 Remediation Contractor responsible for demolition, remedial works, construction, management and maintenance of the site.

9.6 Contingency Management

Contingency plans for anticipated problems that may arise on-site during the course of the site demolition and remediation are presented below in **Table 9-4**.

Table 9-4 Contingency Management

Anticipated Problems	Corrective Actions
Chemical / fuel spill	Stop work, notify above site project manager. Use accessible soil or appropriate absorbent material on site to absorb the spill (if practicable). Stockpile the impacted material in a secure location, sample and determine the appropriate disposal/treatment option.
Excessive dust	Use water sprays to suppress the dust or stop site activities generating the dust until it abates.
Excessive noise	Identify the source, isolate the source if possible, modify the actions of the source or erect temporary noise barriers if required.
Excessive odours / vapours	Stage works to minimise odours/vapours. If excessive organic odours/vapours are being generated, stop works and monitor ambient air across site for organic vapours with a PID and odours at site boundaries. Implement control measures including respirators for on-site workers, use of odour suppressants, wetting down of excavated material. EI notes that no nuisance odours shall be detected at any site boundary as part of the remedial works. Should odour emissions be detected at or beyond the site boundary, it is recommended, as part of the CEMP and community consultation procedure, that the Remediation Contractor and the Principal Project Manager: ▪ Notify the owners and occupiers of premises adjoining and across the road from the site regarding potential odour issues. Notification should be in writing. This is also required by the Council's Contaminated Land Policy. ▪ In the notification, as well as on street signage, provide contact details of the site personnel for anyone who may be concerned by odour emission during the remediation. ▪ Temporarily pause site works to allow for excess odour to subside to a level acceptable by off-site receptors, should it be necessary, after implementation of the above-listed control measures. ▪ Record logs for volatile emissions and odours. Such records should be kept on-site and made available for inspection on request.
Excessive rainfall	Ensure sediment and surface water controls are operating correctly. If possible divert surface water away from active work areas or excavations.
Water in excavations	Collect samples and assess against relevant EPA (2014a) *Waste Classification Guidelines*, to enable disposal options to be formulated. If groundwater is intercepted, sampling must be conducted to determine its contamination status and waste category, in accordance with EPA (2014a) *Waste Classification Guidelines*. Based on the investigation data to date, the interception of local groundwater will not be encountered; hence, the disposal of water at a licenced waste facility and/or to the local sewer / stormwater system will not be required.
Leaking machinery or equipment	Stop the identified leak (if possible). Clean up the spill with absorbent material. Stockpile the impacted material in a secure location, sample and determine the appropriate disposal/treatment option.

Anticipated Problems	Corrective Actions
Failure of erosion or sedimentation control measures	Stop work, repair failed control measure.
Unearthing unexpected materials, fill or waste	Stop activities, contact the site project manager. Follow the unexpected finds protocol as detailed in **Section 9.8** of this RAP. Prepare a management plan if required, to address the issue.
Identification of cultural or building heritage items	Stop work and notify site project manager. Follow the unexpected finds protocol as detailed in **Section 9.8** of this RAP. Prepare action or conservation plan as required.
Equipment failures	Ensure that spare equipment is on hand at site, or that the failed equipment can be serviced by site personnel or a local contractor.
Complaint Management	Notify Client, Project Managers and Environmental Consultant (if required) following complaint. Report complaint as per management procedures. Implement control measures to address reason of complaint (if possible). Notify complainant of results of remedial actions.

9.7 Work Health and Safety Plan

As required by the NSW *Work Health and Safety Act 2011* and associated regulations, a Work Health and Safety (WHS) Plan should be prepared by the Principal Contractor. The purpose of this plan is to manage the health and safety of site workers and nearby residents, and address such issues as site security, exclusion zones, excavation safety, vibration, noise, odour and dust levels. The plan should address the risks during the remediation works and cover site specific requirements associated with the contaminants present within the site soils (including vapour) and groundwater.

The site officer responsible for implementing health and safety procedures should induct all site personnel so that they are aware of and comply with, the requirements of this document. It is the contractor’s responsibility, with assistance from client/owner(s) of the site to ensure that all other permits, approvals, consents or licences are current. The hazards and mitigation measures relevant to the remedial works are presented in **Table 9-5**.

Table 9-5 Remedial Hazards

Anticipated Problems	Corrective Actions
Chemical Hazards	Contaminated sites have chemical substances that may present a risk to human health and the environment. COPCs and associated risks are as detailed within the Conceptual Site Model in **Section 4.** The site specific WHS plan should set out controls to mitigate any potential risks.
Physical Hazards	The following hazards are associated with conditions that may be created during site works: ▪ Heat exposure; ▪ Buried services; ▪ Noise, vibration and dust; ▪ Electrical equipment; and ▪ The operation of heavy plant equipment.

Anticipated Problems	Corrective Actions
Personal Protective Equipment and Monitoring	Personnel should, wherever possible, avoid direct contact with potentially contaminated material. Workers are to ensure that surface waters or groundwater is not ingested or swallowed and that direct skin contact with soil and water is avoided. Standard PPE with the addition of disposable P2 dust masks as specified for the contractor will be sufficient for the prescribed remedial works.

9.8 Unexpected Finds Protocol

Should unexpected finds be encountered, the approach in **Table 9-6** should be followed.

Table 9-6 Unexpected Finds Protocol

1. In the event of an unexpected find, immediately cease work and contact the site foreman.
2. Site foreman to construct temporary high visibility barricading to prevent worker access to the area. Foreman to apply appropriate stormwater/sediment control measures.
3. Site foreman to take arrange an inspection by the Environmental Consultant
4. Environmental Consultant to undertake a detailed site inspection and collect representative samples for analysis as per documented sampling procedures outlined in this RAP.
5. Environmental Consultant to assess field screening and/or laboratory analytical results against documented site Remediation Acceptance Criteria outlined in this RAP
   - If substance is assessed as not presenting a risk to human health, then:
     - Site foreman to remove safety barricades and environmental controls and continue works
   - If substance is assessed as presenting a risk to human health, then:
     - Environmental Consultant to supervise remediation & undertake validation sampling as per Remediation/Validation Plan
     - Site foreman to remove safety barricades and environmental controls and continue works
6. Environmental Consultant to submit an assessment/validation/clearance to site foreman for distribution to Client and appropriate regulatory authorities. An addendum to RAP should be submitted.

10. VALIDATION SAMPLING AND ANALYSIS QUALITY PLAN

The remediation of the site will be deemed acceptable based on the achievement of the following two validation objectives:

1. ***Remedial Excavations*** – Validation of the remedial excavations will continue to the extent of the impacts as defined by delineation testing, and resulting contaminant concentrations are within the Remediation Acceptance Criteria (**Section 5.2**).
2. ***Backfill Materials*** – Should backfilling be required, validation of imported fill materials used for the backfilling of remediated areas would be required to verify their suitability for the proposed land use
3. ***Groundwater*** – Concentrations in groundwater are to be within the adopted Groundwater Investigation Levels (GILs; Ref **Section 5.2**), or (if exceeding) the regional background concentrations, or (if exceeding) demonstrated to not constitute unacceptable human-health and ecological risks to both on and off site receptors.

10.1 Validation Soil Sampling Methodology

Validation sampling will be undertaken following the removal of contaminated material to ensure that the vertical and lateral extents of the impacts have been defined. Should residual contamination be identified, it would be “chased out” where appropriate until material exceeding the validation criteria has been removed.

The collection of validation samples will be based on:

- Visual and olfactory observations; and
- Screening of material using a photo-ionisation detector (PID) for the presence of elevated levels of volatile organic compounds (VOCs), if olfactory observations dictate.

All samples will be transported to NATA-accredited laboratories, under strict ‘chain of custody’ (COC) conditions.

More detailed (specific) methodology is described in **Table 9-1**.

Table 9-1 Validation Sample Collection and Handling Procedures

Action	Description
Sample Collection (soils)	Soil validation sampling will be directly from the exposed surface of excavation, or from the material brought to the surface by the backhoe/excavator bucket. Sampling data shall be recorded to comply with routine chain of custody requirements.

Action	Description
Sampling Frequency	Remediated Excavations (Validation Sampling): ▪ Minimum of five (four wall and one base) samples per asbestos hotspot pit (i.e. vicinities of BH1, BH7 and BH22 (Aargus, 2014b) and BH13 (EI, 2019)). ▪ Final (remediated) site surface to be sampled adopting a 20 m grid, equating to a minimum of 18 surface validation samples for a 7,262 m^2 area. ▪ Minimum of three samples per stockpile footprint (if comprised of contaminated material not placed on impervious surface). ▪ Imported Backfill Materials (VENM Validation Sampling): ▪ 1 sample per 100 m^3 for VENM materials (lower sampling frequency may be accepted for uniform materials, subject to approval by the environmental consultant).
Sampling, Handling, Transport and Tracking	The use of stainless steel sampling equipment. All sampling equipment (including hand tools or excavator parts) to be washed in a 3% solution of phosphate free detergent, followed by a rinse with potable water prior to each sample being collected. Direct transfer of the sample into new glass jars or plastic bags is preferred, with each jar / plastic bag individually sealed to eliminate cross contamination during transportation to the laboratory. Label sample containers with individual and unique identification including project number, sample number, sampling depth, date and time of sampling. Place sample containers into a chilled, enclosed and secure container for transport to the laboratory. Provide chain of custody documentation to ensure that sample tracking and custody can be cross-checked at any point in the transfer of samples from the field to the environmental laboratory.
Sample Containers and Holding Times	Metals - 250g glass jar / refrigeration 4°C / 6 months (maximum holding period). TRH/VOCs - 250g glass jar / refrigeration 4°C / 14 days (maximum holding period). Semi-VOCs (including PAHs and pesticides) - 250g glass jar / refrigeration 4°C / 14 days (maximum holding period). Asbestos - resealable plastic (polyethylene) bag (doubled) / no refrigeration / indefinite holding time. PFAS - dedicated 250g plastic jar (Teflon-free) / refrigeration 4°C / 14 days (maximum holding period)
Laboratory Analysis	Each hotspot pit sample obtained for soil validation purposes will be analysed for asbestos and PAHs (at least). Final surface validation samples will be analysed for asbestos, PAHs, heavy metals (including copper, lead, nickel and zinc), TRHs and PFAS (at least). Testing of imported (non-validated) materials intended for backfilling of excavated areas and/or landscaping shall include, but not necessarily be limited to, the minimum suite specified for imported fill under the EPA (2014a) guideline (e.g. heavy metals, TRHs, BTEX, PAHs, OCPs, OPPs, PCBs and asbestos), plus the physicochemical parameters pH, EC and CEC.

Action	Description
Field QA/QC	Quality assurance (QA) and quality control (QC) procedures will be adopted throughout the field sampling program to ensure precision and accuracy of validation data, which will be assessed through the analysis of rinsate blanks and blind / split field duplicate samples (collected at 10% / 20% ratio of the number of primary samples, respectively). Appropriate procedures will be undertaken to prevent cross contamination, in accordance with the consultant's standard operating procedures manual. This means: ▪ Standard operating procedures are followed; ▪ Site safety plans are developed prior to works commencement; ▪ Blind / split duplicate samples are collected and analysed; ▪ Samples are stored under secure, temperature controlled conditions; ▪ Chain of custody documentation is employed for the handling, transport and delivery of samples to the contracted environmental laboratory; and ▪ Contaminated soil, fill or groundwater originating from the site area is disposed in accordance with relevant regulatory guidelines. In total, field QA/QC will include one in 10 samples to be tested as intra-laboratory (blind field) duplicates, one in 20 samples to be tested as inter-laboratory (split field) duplicates (ILD), one intra-lab VOC trip blank per sample batch, one intra-lab VOC trip spike per sample batch and one equipment wash blank per sample batch.
Laboratory Quality Assurance and Quality Control	The contract laboratory will conduct in-house QA/QC procedures involving the routine analysis of: ▪ Reagent blanks; ▪ Matrix spike recoveries; ▪ Laboratory duplicates; ▪ Calibration standards and blanks; ▪ Control standards and recovery plots; and ▪ QC statistical data.
Achievement of Data Quality Objectives	Based on the analysis of quality control samples (i.e. duplicates/replicates and in-house laboratory QA/QC procedures), the following data quality objectives are required to be achieved: ▪ Conformance with specified holding times; ▪ Accuracy of spiked samples will be in the range of 70-130%; and ▪ Field and laboratory duplicates will have a precision average of +/- 30% relative percent difference (RPD), depending on (fill) soil heterogeneity and analyte concentrations relative to the corresponding LORs. An assessment of the overall data quality will be presented in the final validation report, in accordance with the OEH (2011) and EPA (2017) guidelines.

10.2 Validation Reporting

All fieldwork, chemical analyses, discussions, conclusions and recommendations will be documented in a validation report for the site. The validation report will be prepared in general accordance with requirements of the EPA (2011) *Guidelines for Consultants Reporting on Contaminated Sites* and EPA (2017) *Guidelines for the NSW Site Auditor Scheme* and must confirm that the site has been remediated to a suitable standard for the proposed development.

The Validation Report will be submitted for Site Auditor (if required) and/or Council review at the completion of the remediation works program.

11. CONCLUSIONS

Based on the information available from previous investigations of the site, this RAP has been prepared to guide the recommended remediation works at 182-198 Victoria Road and 28-30 Faversham Street, Marrickville, NSW.

The preferred strategy involves bulk excavation and disposal of impacted materials, to mitigate risks associated with PAHs, asbestos, heavy metals (copper, lead, nickel and zinc), TRHs and PFAS. The predicted minimum excavation depth is 1.5 mBGL, chasing any hotspot as validation sampling and testing dictate. On-site isolation may be considered a secondary option, if zones of deep (>3 mBGL), non-asbestos impacted soils are identified and/or economic (cost) constraints are apparent.

The main site remediation works will include, though not necessarily be limited to:

Stage 1 – Site Preparation (including building demolition)

Stage 2 – Site Inspection and Assessment of Building Footprints

Stage 3 – Asbestos-Impacted Fill Excavation and Off-site Disposal

Stage 4 – Remaining Site-Wide Fill Soil Excavation and Off-site Disposal

Stage 5 – Groundwater Investigation

Stage 6 – Final Soil Validation

Stage 7 – Validation Report Preparation

CONTINGENCY ACTION

Should unexpected finds be discovered during the course of the remediation program, or should any phase of the validation identify residual, high level contamination requiring additional remediation, then the procedures described under the Unexpected Finds Protocol (**Section 9.8**) and/or the Validation Plan (**Section 10.1**) will be implemented, until the remediation goals have been achieved and the site is deemed suitable for the intended land use.

In concluding, EI considers that the site can be made suitable for mixed commercial and medium density residential use with limited access to soils, through the implementation of the works described in this RAP.

12. STATEMENT OF LIMITATIONS

This report has been prepared for the exclusive use of Toga Wicks Park Developments Pty Ltd, whom is the only intended beneficiary of our work. The scope of the investigations carried out for the purpose of this report was limited to those agreed with Toga Wicks Park Developments Pty Ltd.

No other party should rely on the document without the prior written consent of EI, and EI undertakes no duty, or accepts any responsibility or liability, to any third party who purports to rely upon this document without EI's approval.

EI has used a degree of care and skill ordinarily exercised in similar investigations by reputable members of the environmental industry in Australia as at the date of this document. No other warranty, expressed or implied, is made or intended. Each section of this report must be read in conjunction with the whole of this report, including its appendices and attachments.

The conclusions presented in this report are based on a limited investigation of conditions, with specific sampling locations chosen to be as representative as possible under the given circumstances.

EI's professional opinions are reasonable and based on its professional judgment, experience, training and results from analytical data. EI may also have relied upon information provided by the Client and other third parties to prepare this document, some of which may not have been verified by EI.

EI's professional opinions contained in this document are subject to modification if additional information is obtained through further investigation, observations, or validation testing and analysis during remedial activities. In some cases, further testing and analysis may be required, which may result in a further report with different conclusions.

REFERENCES

ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, October 2000.

ANZG (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Governments and Australian State and Territory Governments, Canberra ACT, Australia, August 2018.

Australian Standard (2005) Table E1 – Minimum Sampling Points Required for Site Characterisation, in Guide to the Investigation and Sampling of Sites with Potentially Contaminated Soil - Part 1: Non-Volatile and Semi-Volatile Compounds. Standards Australia, AS4482.1-2005.

Chapman GA and Murphy CL (1989) Soil Landscapes of the Sydney 1:100 000 sheet, Soil Conservation Service of NSW, Sydney, September 1989.

DEC (2007) Guidelines for the Assessment and Management of Groundwater Contamination. NSW Department of Environment and Conservation, DEC 2007/144, June 2007.

DMR (1983) Sydney 1:100,000 Geological Series Sheet 9130 (Edition 1). Geological Survey of New South Wales, Department of Mineral Resources.

EPA (1995) Sampling Design Guidelines. Environment Protection Authority of New South Wales, Contaminated Sites Unit, EPA 95/59, September 1995.

EPA (2014a) Waste Classification Guidelines. Environment Protection Authority of New South Wales, EPA 2014/0796, November 2014.

EPA (2014b) Technical Note: Investigation of Service Station Sites. Environment Protection Authority of New South Wales, Contaminated Sites Unit, EPA 2014/0315, April 2014.

EPA (2015) Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997. Environment Protection Authority of New South Wales, EPA 2015/0164, September 2015.

EPA (2017) Guidelines for the NSW Site Auditor Scheme (3rd Edition). Environment Protection Authority of New South Wales, EPA 2017P0269/121, October 2017.

HEPA (2018) PFAS National Environmental Management Plan. Heads of EPAs Australia and New Zealand, January 2018.

Murphy CL (1997) Acid Sulfate Soil Risk of the Botany Bay Sheet, Department of Land and Water Conservation, Sydney, Second Edition. Supplied by the Sydney South Coast, Geographical Information Systems Unit.

NEPC (2013) Schedule B1 Guideline on Investigation Levels for Soil and Groundwater, Schedule B2 Guideline on Site Characterisation and Schedule B4 Guideline on Site-Specific Health Risk Assessments, from the National Environmental Protection (Assessment of Site Contamination) Amendment Measure 2013. National Environmental Protection Council, April 2013.

OEH (2011) Guidelines for Consultants Reporting on Contaminated Sites. NSW Office of Environment and Heritage, OEH 2011/0650.

USEPA (2006) Data Quality Assessment: A Reviewers Guide - EPA QA/G-9R. USEPA Office of Environmental Information, EPA/240/B-06/002, February 2006.

USEPA (2018) Regional Screening Levels (RSLs) – Summary Tables (TR=1E, HQ=1), USEPA Office of Environmental Information, May 2018.

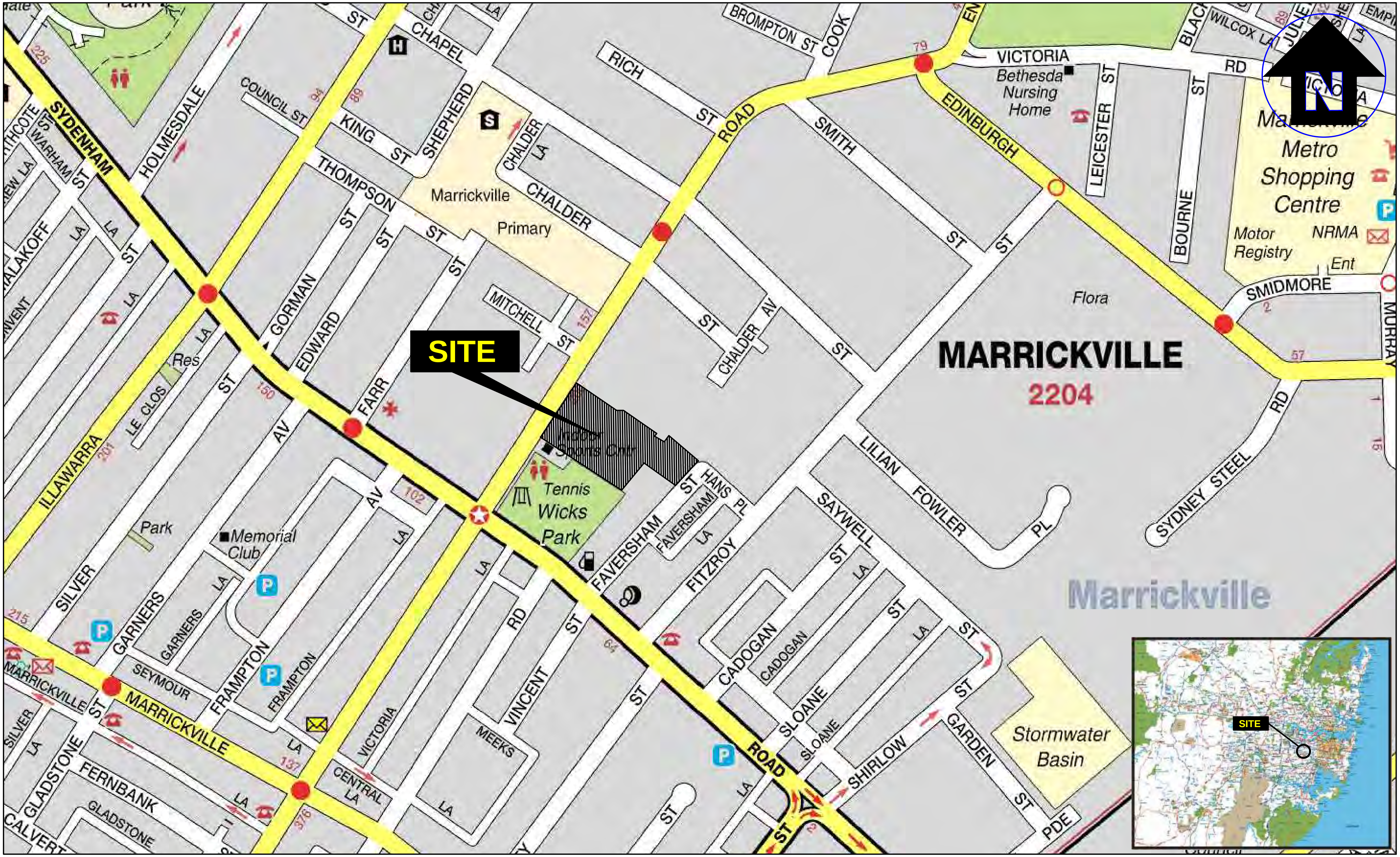
WADOH (2009) Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia. Published by the Western Australian Department of Health, May 2009.

ABBREVIATIONS

ACM	Asbestos-containing materials
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASS	Acid sulfate soil
B(α)P	Benzo(α)Pyrene (a PAH compound and known carcinogen)
BGL	Below Ground Level
BH	Borehole
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
COC	Chain of Custody
COPCs	Chemicals of Potential Concern
CSM	Conceptual Site Model
CT	Contaminant Thresholds
CVOCs	Chlorinated Volatile Organic Compounds (a sub-set of the VOC analysis suite)
DA	Development Application
DEC	Department of Environment and Conservation, NSW (see OEH)
DECC	Department of Environment and Climate Change, NSW (see OEH)
DECCW	Department of Environment, Climate Change and Water, NSW (see OEH)
DNAPL	Dense Non-Aqueous Phase Liquid
DO	Dissolved Oxygen
DP	Deposited Plan
DQO	Data Quality Objectives
EC	Electrical Conductivity
EIL	Ecological Investigation Level
EPA	Environment Protection Authority
EMP	Environmental Management Plan
ENM	Excavated Natural Material
ESL	Ecological Screening Level
F1	C_6-C_{10} TRH less the sum of BTEX concentrations (Ref. NEPC (2013) Schedule B1)
F2	>C_{10}-C_{16} TRH less the concentration of naphthalene (Ref. NEPC (2013) Schedule B1)
GIL	Groundwater Investigation Level
GME	Groundwater Monitoring Event
HIL	Health-based Investigation Level
HSL	Health-based Screening Level
km	Kilometres
LNAPL	Light Non-Aqueous Phase Liquid
LOR	Limit of Reporting (quantitative limit for the respective laboratory analytical method)
m	Metres
m AHD	Metres Australian Height Datum
m AHD	Metres Australian Height Datum
m BGL	Metres Below Ground Level
µg/L	Micrograms per Litre
mg/L	Milligrams per Litre
mV	Millivolts
MW	Monitoring Well
NATA	National Association of Testing Authorities, Australia
NEPC	National Environmental Protection Council
NSW	New South Wales
OCPs	Organochlorine Pesticides
OEH	Office of Environment and Heritage, NSW (formerly DEC, DECC, DECCW)
OPPs	Organophosphate Pesticides

PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
pH	Potential Hydrogen (a measure of acidity / alkalinity)
PID	Photoionisation Detector
PQL	Practical Quantitation Limit (limit of detection for respective laboratory instruments)
PSH	Phase Separated Hydrocarbons
QA/QC	Quality Assurance / Quality Control
RAC	Remediation Acceptance Criteria
RAP	Remediation Action Plan
SIL	Soil Investigation Level
SRA	Sample Receipt Advice (document confirming laboratory receipt of samples)
SVE	Soil Vapour Extraction
SWL	Standing Water Level
TCLP	Toxicity Characteristics Leaching Procedure
TDS	Total Dissolved Solids (a measure of water salinity)
TEQ	Toxicity Equivalent Quotient
TP	Test Pit
TPH	Total Petroleum Hydrocarbons (superseded term equivalent to TRH)
TRH	Total Recoverable Hydrocarbons
UCL	Upper Confidence Limit
UPSS	Underground Petroleum Storage System
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VENM	Virgin Excavated Natural Material
VOCs	Volatile Organic Compounds

Appendix A - Figures



eiaustralia
Contamination | Remediation | Geotechnical

Suite 6.01, 55 Miller Street, PYRMONT 2009
Ph (02) 9516 0722 Fax (02) 9518 5088

Drawn:	L.C.
Approved:	C.M.
Date:	12-02-19
Scale:	Not To Scale

TOGA Wicks Park Developments Pty Ltd

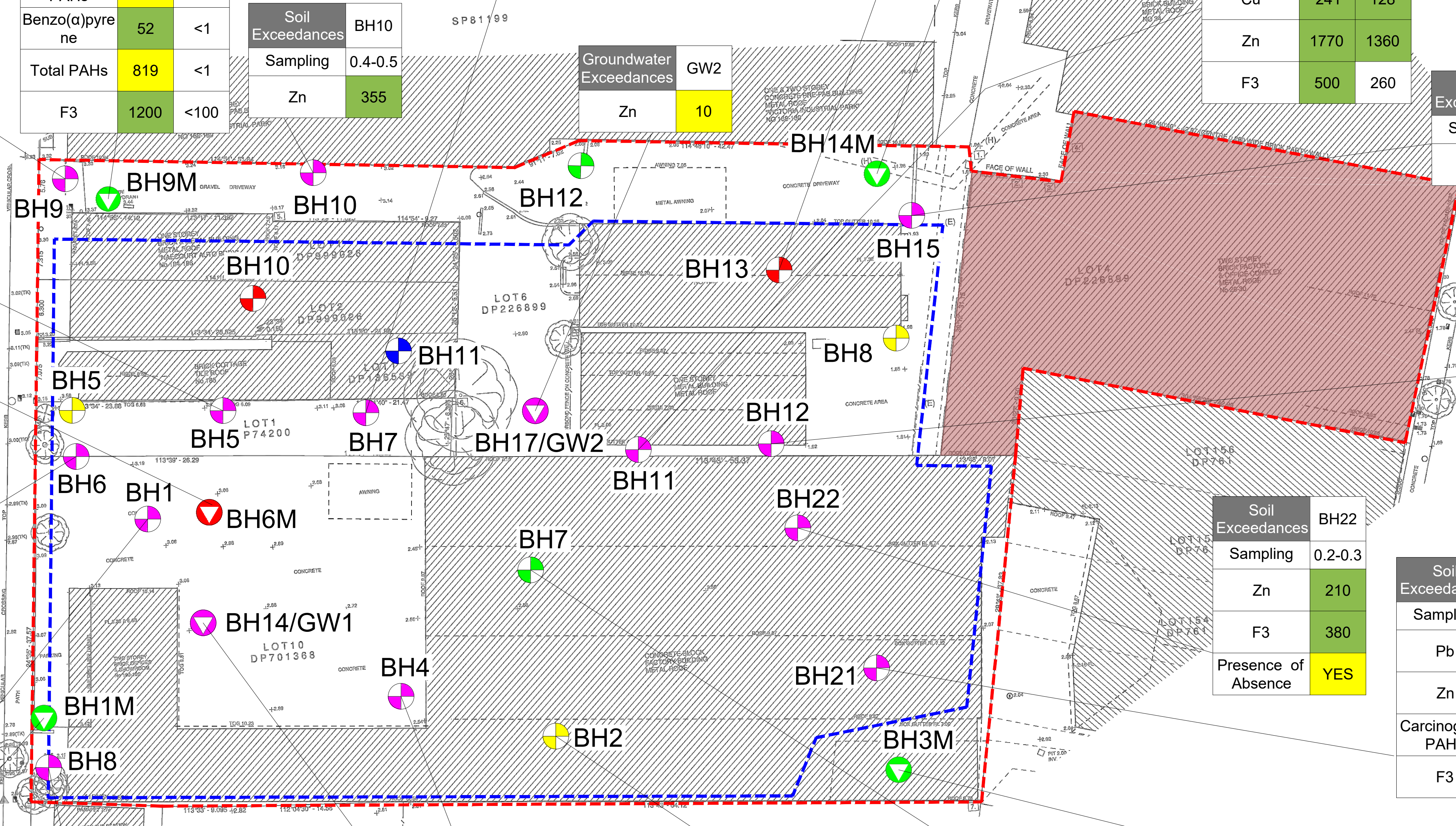
Remedial Action Plan

182 - 198 Victoria Rd & 28-30 Faversham St, Marrickville, NSW

Site Locality Plan

Figure: 1

Project: E24098 E06_Rev0



Soil Exceedances	BH5
Sampling	0.2-0.4
Cu	275
Pb	1176
Zn	1200
Carcinogenic PAHs	5.2

Soil Exceedances	BH9	D1
Sampling	0.4-0.6	
Zn	1310	945
F3	520	230

Soil & Groundwater Exceedances	BH9M	BH9M-1
Sampling	0.2-0.3	
Cu	110	<1
Ni	8.9	82
Zn	360	26
Carcinogenic PAHs	74	NA
Benzo(α)pyrene	52	<1
Total PAHs	819	<1
F3	1200	<100

Soil Exceedances	BH10
Sampling	0.4-0.5
Zn	355

Soil Exceedances	BH7	
Sampling	0.4-0.6	1.1-1.3
Zn	760	272
Presence of Absence	YES	NA

Groundwater Exceedances	GW2
Zn	10

Soil Exceedances	BH13
Sampling	0.3-0.4
Zn	310
Presence of Absence	YES
PFOS	0.013

Soil & Groundwater Exceedances	BH14M	BH14M-1
Sampling	0.2-0.3	
Ni	12	71
Zn	200	150

Soil Exceedances	BH11	D4
Sampling	0.2-0.4	
Cu	241	128
Zn	1770	1360
F3	500	260

Soil Exceedances	BH15	D3
Sampling	0.3-0.5	
F3	<100	300

Soil Exceedances	BH12	
Sampling	0.3-0.5	0.7-0.9
Cu	260	18
Pb	758	63
Zn	1490	318
F3	350	NA

Soil & Groundwater Exceedances	BH6M		BH6M-1	GWQD 1
Sampling	0.2-0.3	1.2-1.3		
Cu	210	21	3	3
NI	15	110	50	52
Zn	720	1.2	220	23
Ethylbenzene	<0.1	<0.3	5	6
F2	<50	190	<50	<50
PFOS	0.037	NA	0.08	NA
PFOS + PFHxS	0.037	NA	0.08	NA

Soil Exceedances	BH6
Sampling	0.2-0.4
Cu	134
Pb	947
Zn	994
Carcinogenic PAHs	5.8

Soil Exceedances	BH1
Sampling	0.0-0.5
Presence of Absence	YES

Groundwater Exceedances	BH1M-1
Ni	58
Zn	35
PFOS	0.01

Soil Exceedances	BH8
Sampling	0.1-0.3
Cu	113
Zn	760

Soil & Groundwater Exceedances	BH14	GW1
Sampling	0.2-0.3	
Cu	171	2
Zn	439	7
Carcinogenic PAHs	9.1	NA

Soil Exceedances	BH4	D2
Sampling	0.3-0.5	
Zn	378	575
Carcinogenic PAHs	7.7	NA
F3	270	300

Soil Exceedances	BH2
Sampling	0.2-0.3
Zn	250

Soil Exceedances	BH7	
Sampling	0.2-0.3	1.4-1.5
Ni	18	43
Zn	230	1.2

Soil & Groundwater Exceedances	BH3M	BH3M-1
Sampling	0.3-0.4	
Ni	15	64
Zn	120	45
F3	420	<100

Soil Exceedances	BH22
Sampling	0.2-0.3
Zn	210
F3	380
Presence of Absence	YES

Soil Exceedances	BH21
Sampling	0.3-0.5
Pb	962
Zn	960
Carcinogenic PAHs	10
F3	1120

0 5 10 20 30
Approx. Scale (m)

Map Source: True North Surveys Pty Ltd, Drawing No.: 8333DU Dated: 01-09-2016

LEGEND

- Approximate site boundary
- Approximate basement boundary
- Approximate location of borehole not being tested
- Approximate enviro borehole location
- Approximate enviro monitoring well location
- Approximate Geo-tech borehole location
- Approximate combined borehole location
- Approximate combined monitoring well location
- Approximate borehole location (Aargus, 2014)
- Approximate monitoring well location (Aargus, 2014)
- Human Health Criteria
- Ecological Criteria
- Proposed shareway (not assessed)

eiaustralia
Contamination | Remediation | Geotechnical

Suite 6.01, 55 Miller Street, PYRMONT 2009
Ph (02) 9516 0722 Fax (02) 9518 5088

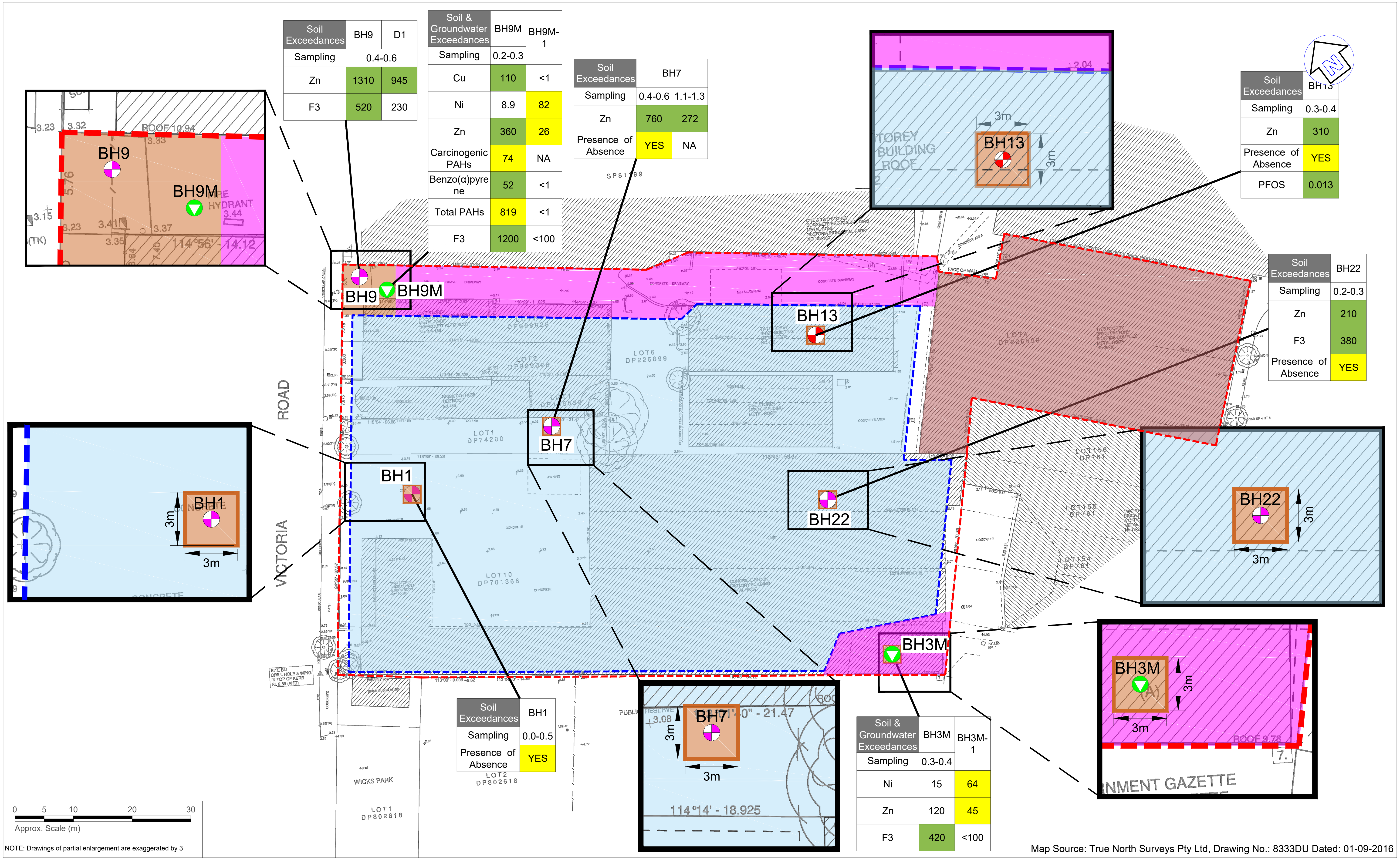
Drawn:	L.C.
Approved:	C.M.
Date:	06-02-19

TOGA Wicks Park Developments Pty Ltd
Remedial Action Plan
182 - 198 Victoria Rd & 28-30 Faversham St, Marrickville, NSW

Groundwater & Soil Exceedances

Figure: 2

Project: E24098 E06_Rev0



Soil Exceedances	BH9	D1
Sampling	0.4-0.6	
Zn	1310	945
F3	520	230

Soil & Groundwater Exceedances	BH9M	BH9M-1
Sampling	0.2-0.3	
Cu	110	<1
Ni	8.9	82
Zn	360	26
Carcinogenic PAHs	74	NA
Benzo(α)pyrene	52	<1
Total PAHs	819	<1
F3	1200	<100

Soil Exceedances	BH7	
Sampling	0.4-0.6	1.1-1.3
Zn	760	272
Presence of Absence	YES	NA

Soil Exceedances	BH13
Sampling	0.3-0.4
Zn	310
Presence of Absence	YES
PFOS	0.013

Soil Exceedances	BH22
Sampling	0.2-0.3
Zn	210
F3	380
Presence of Absence	YES

Soil Exceedances	BH1
Sampling	0.0-0.5
Presence of Absence	YES

Soil & Groundwater Exceedances	BH3M	BH3M-1
Sampling	0.3-0.4	
Ni	15	64
Zn	120	45
F3	420	<100

LEGEND

- Approximate site boundary
- Approximate enviro borehole location
- Approximate combined monitoring well location
- Approximate borehole location (Aargus, 2014)
- Human Health Criteria
- Ecological Criteria
- Approximate 'Hotspot' area to be excavated prior to basement excavation
- Approximate retained soils area
- Approximate area of basement excavation
- Proposed shareway (not assessed)

eiaustralia
Contamination | Remediation | Geotechnical
Suite 6.01, 55 Miller Street, PYRMONT 2009
Ph (02) 9516 0722 Fax (02) 9518 5088

Drawn:	L.C.
Approved:	C.M.
Date:	06-02-19

TOGA Wicks Park Developments Pty Ltd
Remedial Action Plan
182 - 198 Victoria Rd & 28-30 Faversham St, Marrickville, NSW

Remedial Excavation Plan

Figure: 3

Project: E24098 E06_Rev0

Appendix B - Plans of the Proposed Development

CLIENT
Toga Development & Construction
Level 5, 45 Jones Street Ultimo NSW 2007

Rev	Date	Approved by	Revision Notes
A	08.11.18	JF	PRE-DA MEETING

PRELIMINARY

Project Title
Wicks Park
182-198 Victoria Rd Marrickville NSW

Drawing Title
GA Plans
Basement 02

Scale: **1:200 @A1, 50%@A3**
Project No. **18003**
Drawn by **TURNER**
North
Status: **For Information**
Dwg No. **A-DA-008**
Rev A

TURNER
Level 7 **ONE** Oxford Street
Darlinghurst NSW 2010
AUSTRALIA
T +61 2 8668 0000
F +61 2 8668 0088
turnerstudio.com.au

NOTES

THIS DRAWING IS COPYRIGHT © OF TURNER. NO REPRODUCTION WITHOUT PERMISSION. UNLESS NOTED OTHERWISE THIS DRAWING IS NOT FOR CONSTRUCTION. ALL DIMENSIONS AND LEVELS ARE TO BE CHECKED ON SITE PRIOR TO THE COMMENCEMENT OF WORK. INFORM TURNER OF ANY DISCREPANCIES FOR CLARIFICATION BEFORE PROCEDING WITH WORK. DRAWINGS ARE NOT TO BE SCALED. USE ONLY FIGURED DIMENSIONS. REFER TO CONSULTANT DOCUMENTATION FOR FURTHER INFORMATION.

DLCS Quality Endorsed Company ISO 9001:2008, Registration Number 20476
Nominated Architect: Nicholas Turner 6695, ABN 86 064 084 911

CLIENT

Toga Development & Construction
Level 5, 45 Jones Street Ultimo NSW 2007

Rev	Date	Approved by	Revision Notes
A	08.11.18	JF	PRE-DA MEETING

PRELIMINARY

Project Title
Wicks Park
182-198 Victoria Rd Marrickville NSW

Drawing Title
GA Plans
Basement 01

Scale: 1:200 @A1, 50%@A3
Project No. 18003
Drawn by TURNER
North
Status: For Information
Dwg No. A-DA-009
Rev A

TURNER
Level 7 ONE Oxford Street
Darlinghurst NSW 2010
AUSTRALIA
T +61 2 8668 0000
F +61 2 8668 0088
turnerstudio.com.au

PRELIMINARY
SUBJECT TO CONSULTANT ADVICE INCLUDING:
TRAFFIC ENGINEER
CIVIL AND FLOOD
STORMWATER/SEWER AND EASEMENTS
INFRASTRUCTURE

TOTAL PREFERRED RETAIL GFA TO BE CONFIRMED

NOTES

DLCS Quality Endorsed Company ISO 9001:2008, Registration Number 20476
Nominated Architect: Nicholas Turner 6695, ABN 86 064 084 911

CLIENT
Toga Development & Construction
Level 5, 45 Jones Street Ultimo NSW 2007

Rev	Date	Approved by	Revision Notes
A	08.11.18	JF	PRE-DA MEETING

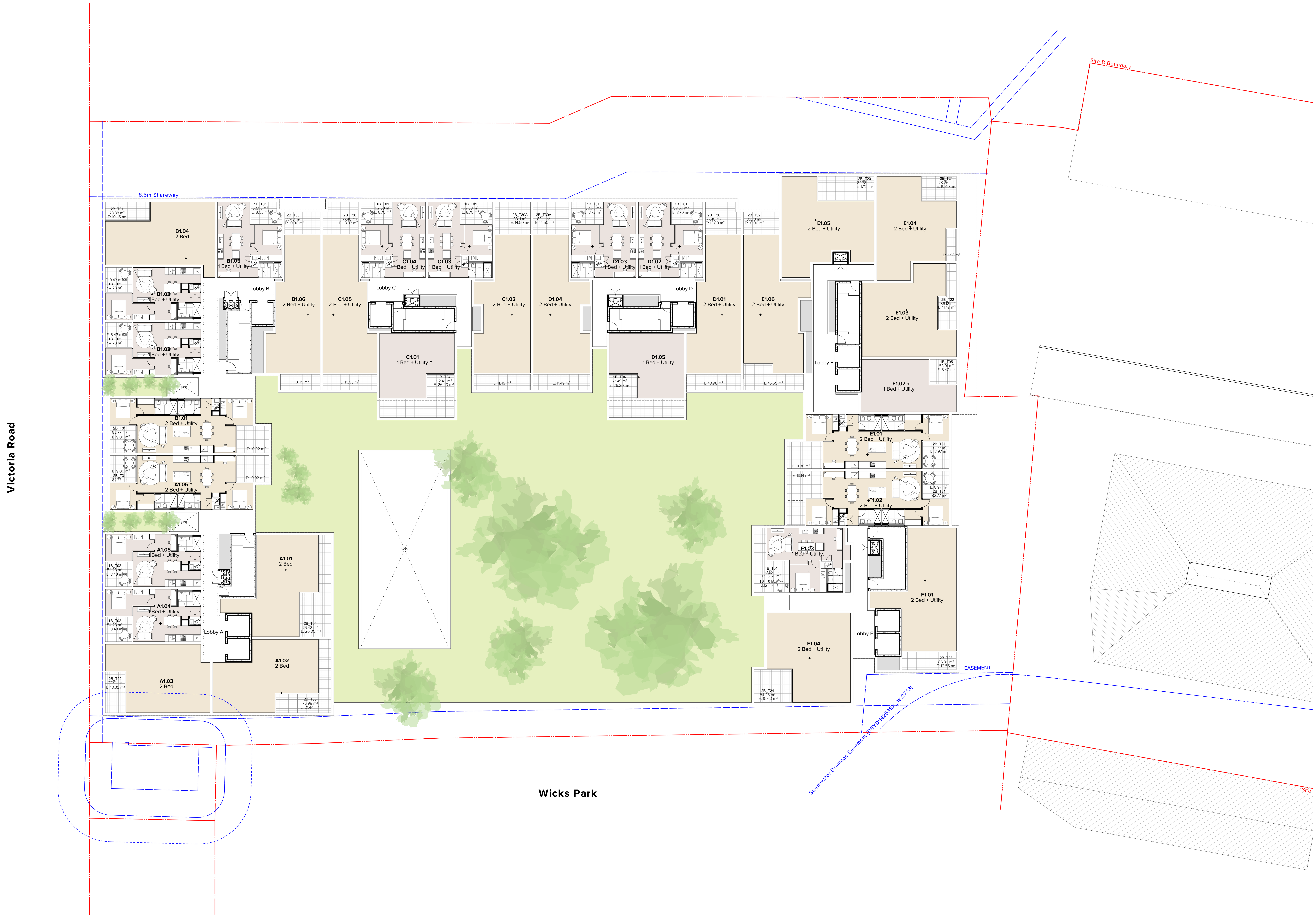
PRELIMINARY

Project Title
Wicks Park
182-198 Victoria Rd Marrickville NSW

Drawing Title
GA Plans
Ground Level

Scale: 1:200 @A1, 50%@A3
Status: For Information
Project No.: 18003
Dwg No.: A-DA-010
Drawn by: TURNER
Rev: A
North

TURNER
Level 7 ONE Oxford Street
Darlinghurst NSW 2010
AUSTRALIA
T +61 2 8668 0000
F +61 2 8668 0088
turnerstudio.com.au



PRELIMINARY
SUBJECT TO CONSULTANT ADVICE INCLUDING:
TRAFFIC ENGINEER
CIVIL AND FLOOD
STORMWATER/SEWER AND EASEMENTS
INFRASTRUCTURE

TOTAL PREFERRED RETAIL GFA TO BE CONFIRMED

NOTES

CLIENT

Toga Development & Construction
Level 5, 45 Jones Street Ultimo NSW 2007

Rev	Date	Approved by	Revision Notes
A	08.11.18	JF	PRE-DA MEETING

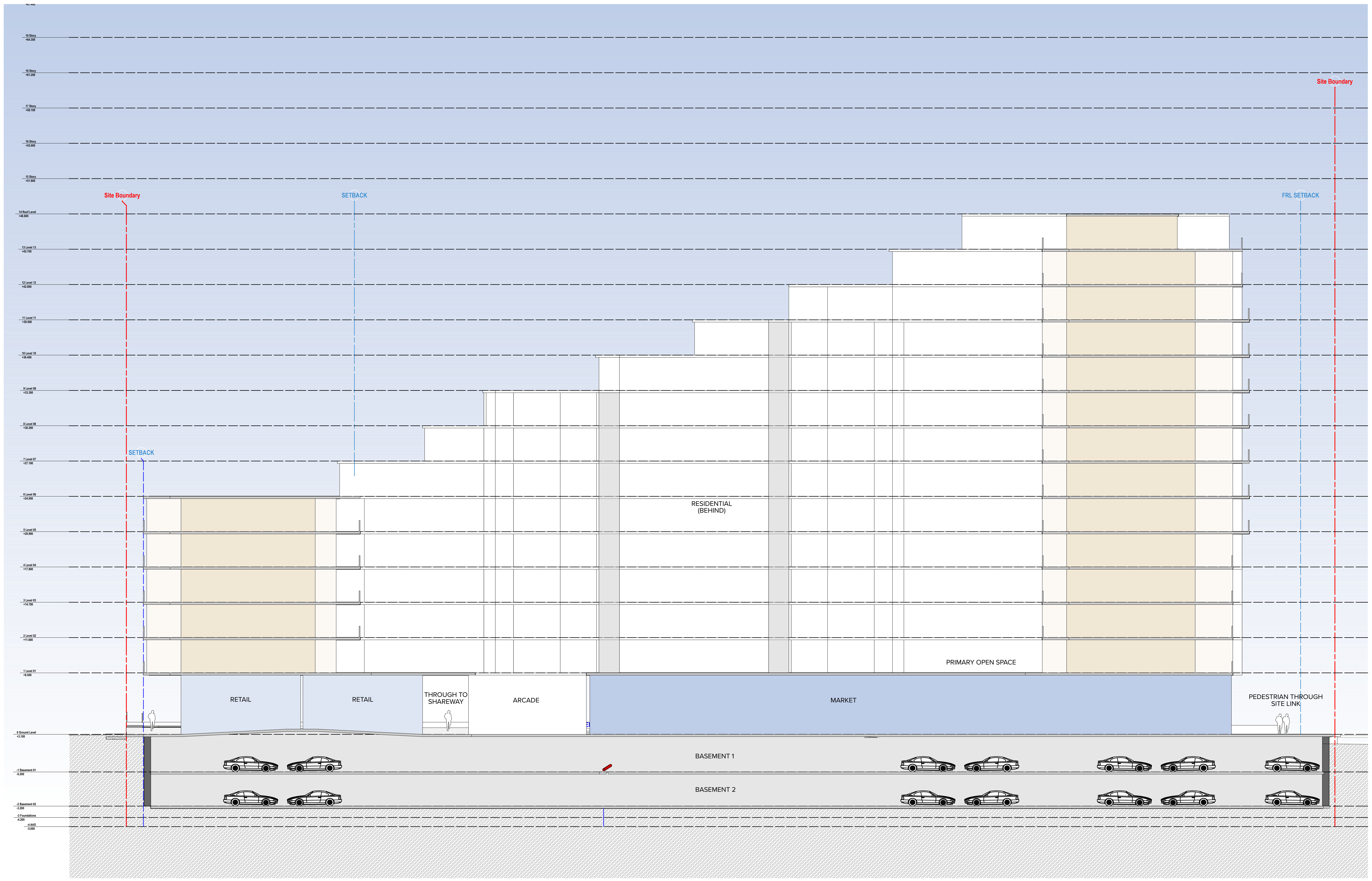
PRELIMINARY

Project Title
Wicks Park
182-198 Victoria Rd Marrickville NSW

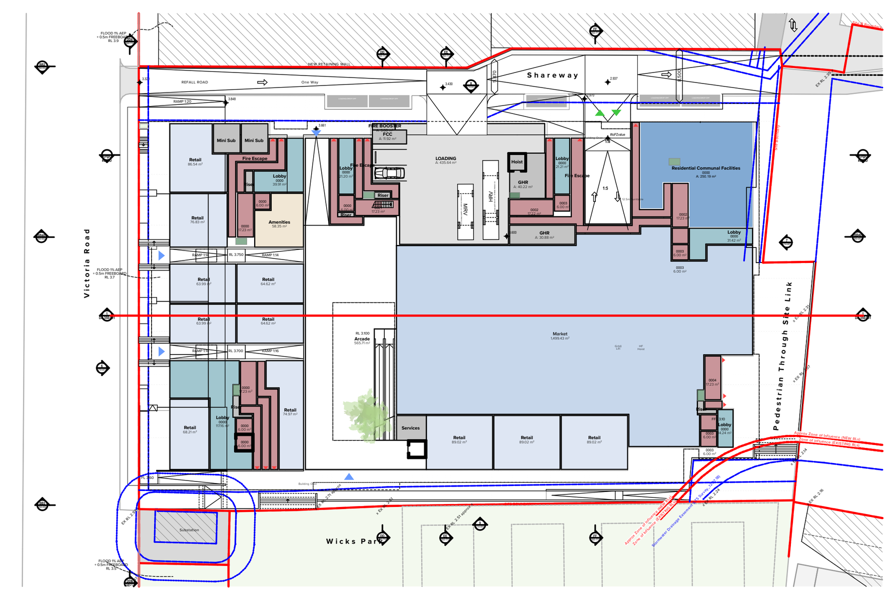
Drawing Title
GA Plans
Level 01

Scale: 1:200 @A1, 50%@A3
Status: For Information
Project No.: 18003
Dwg No.: A-DA-011
Drawn by: TURNER
Rev: A
North

TURNER
Level 7 ONE Oxford Street
Darlinghurst NSW 2010
AUSTRALIA
T +61 2 8668 0000
F +61 2 8668 0088
turnerstudio.com.au



1 East West Section AA 1:200



NOTES

DLCS Quality Endorsed Company ISO 9001:2008, Registration Number 20476
Nominated Architect: Nicholas Turner 6695, ABN 86 064 084 911

CLIENT
Toga Development & Construction
Level 5, 45 Jones Street Ultimo NSW 2007

Rev	Date	Approved by	Revision Notes
B	05.09.18	JF	FOR INFORMATION

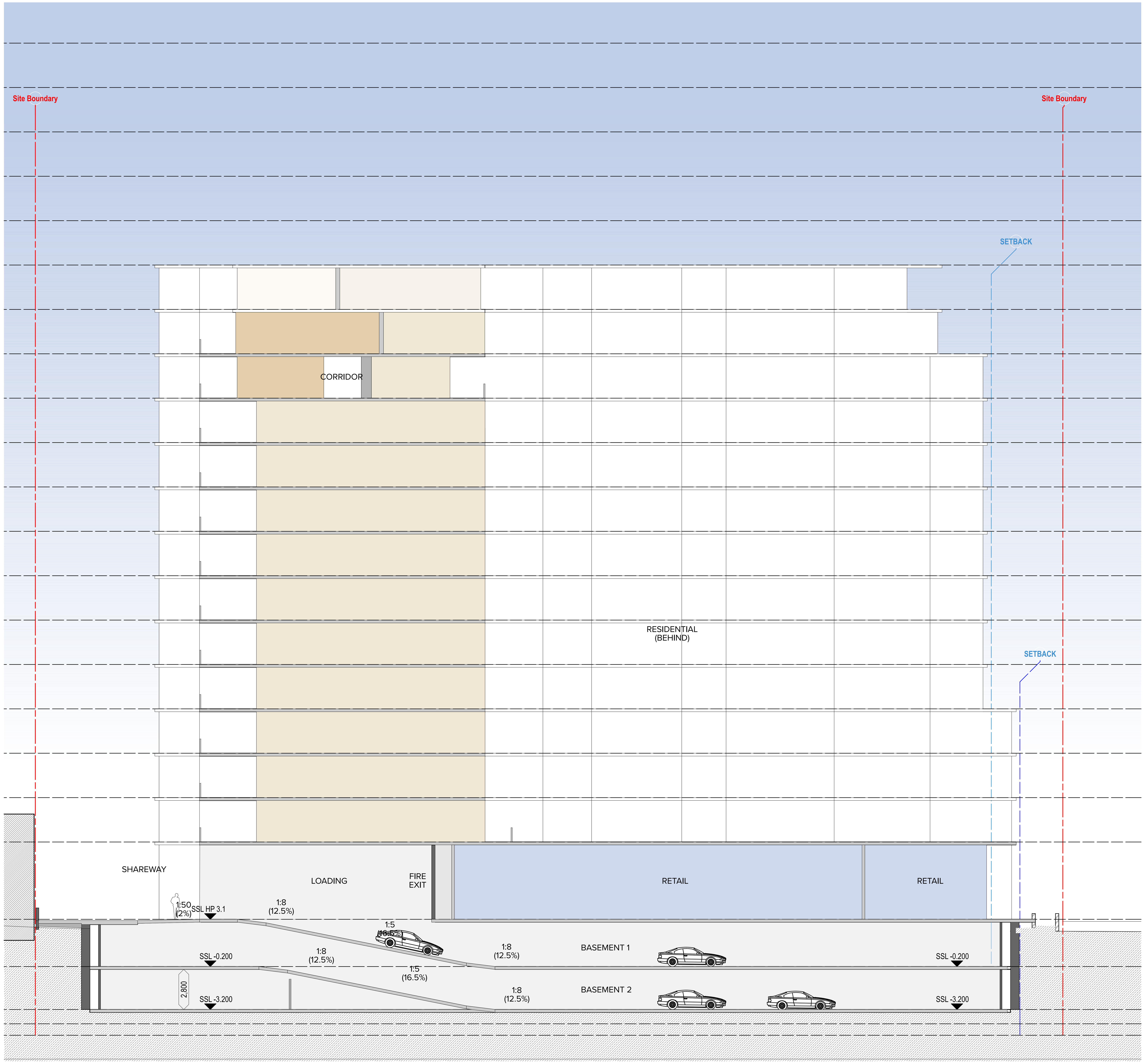
PRELIMINARY

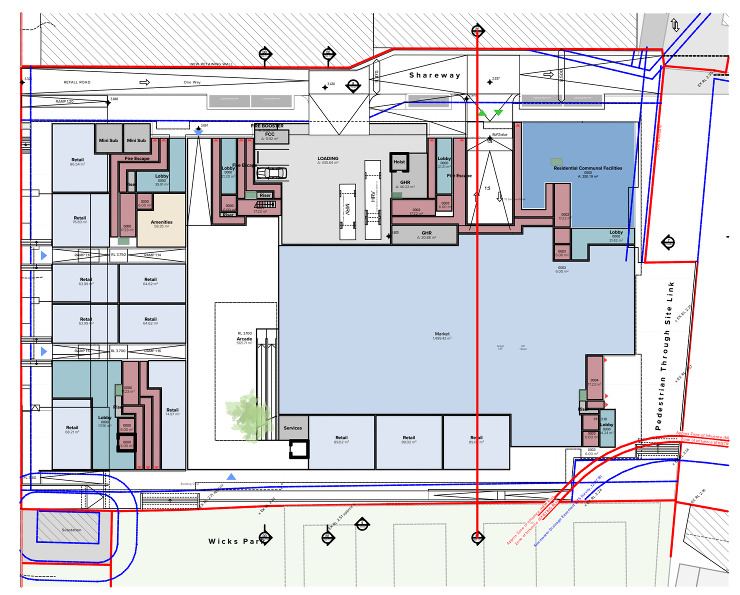
Project Title
Wicks Park
182-198 Victoria Rd Marrickville NSW

Drawing Title
GA Sections
Section AA

Scale: 1:200, 1:1000 @A1, 50%@A3
Project No.: 18003
Drawn by: TURNER
North
Status: For Information
Dwg No.: DA-350-001
Rev: B

TURNER
Level 7 ONE Oxford Street
Darlinghurst NSW 2010
AUSTRALIA
T +61 2 8668 0000
F +61 2 8668 0088
turnerstudio.com.au





NOTES

THIS DRAWING IS COPYRIGHT © OF TURNER. NO REPRODUCTION WITHOUT PERMISSION. UNLESS NOTED OTHERWISE THIS DRAWING IS NOT FOR CONSTRUCTION. ALL DIMENSIONS AND LEVELS ARE TO BE CHECKED ON SITE PRIOR TO THE COMMENCEMENT OF WORK. INFORM TURNER OF ANY DISCREPANCIES FOR CLARIFICATION BEFORE PROCEDING WITH WORK. DRAWINGS ARE NOT TO BE SCALED. USE ONLY FIGURED DIMENSIONS. REFER TO CONSULTANT DOCUMENTATION FOR FURTHER INFORMATION.

DLCS Quality Endorsed Company ISO 9001:2008, Registration Number 20476
Nominated Architect: Nicholas Turner 6695, ABN 86 064 084 911

CLIENT

Toga Development & Construction
Level 5, 45 Jones Street Ultimo NSW 2007

Rev	Date	Approved by	Revision Notes
D	05.09.18	JF	FOR INFORMATION

PRELIMINARY

Project Title
Wicks Park
182-198 Victoria Rd Marrickville NSW

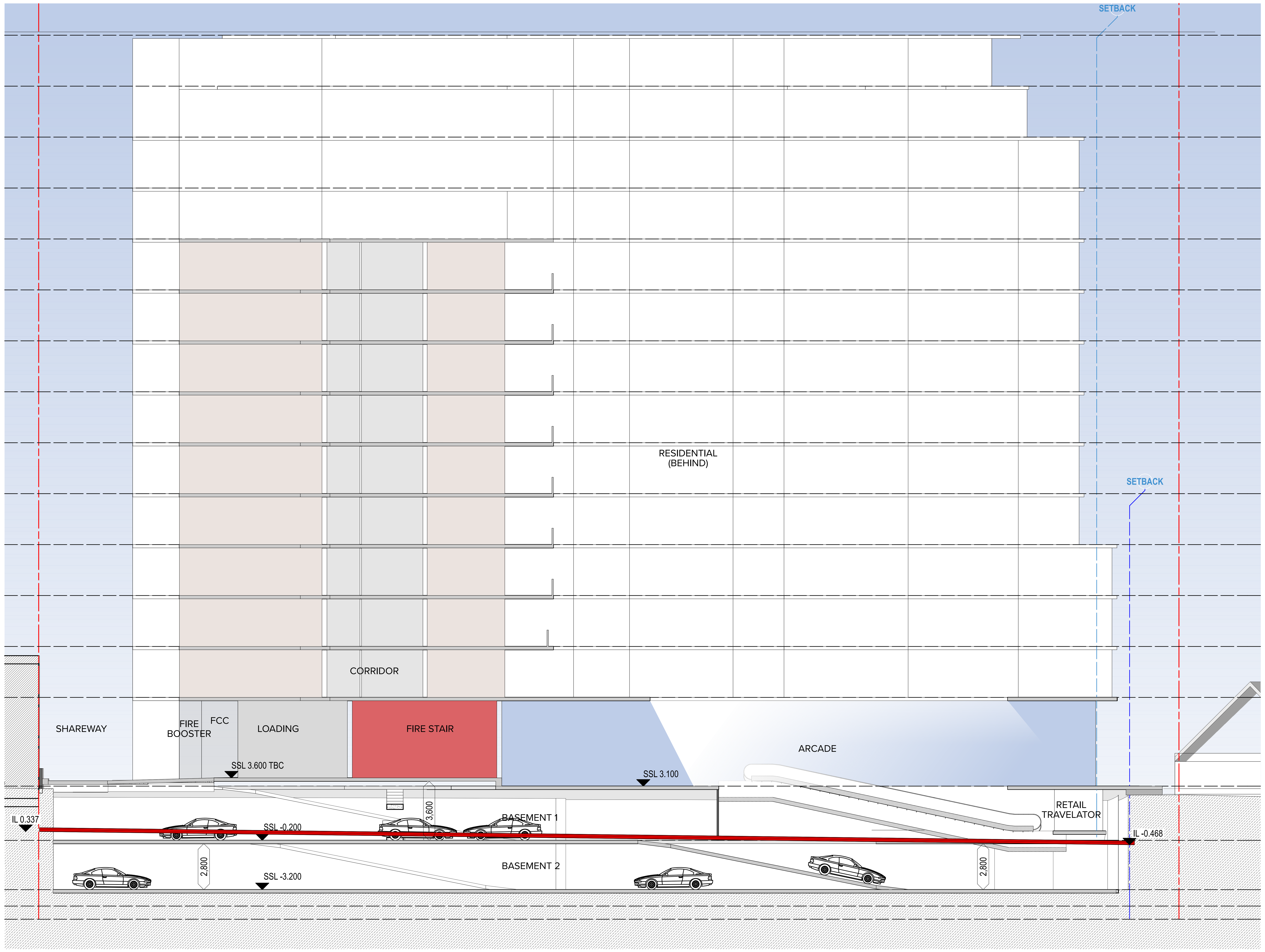
Drawing Title
GA Sections
Section FF

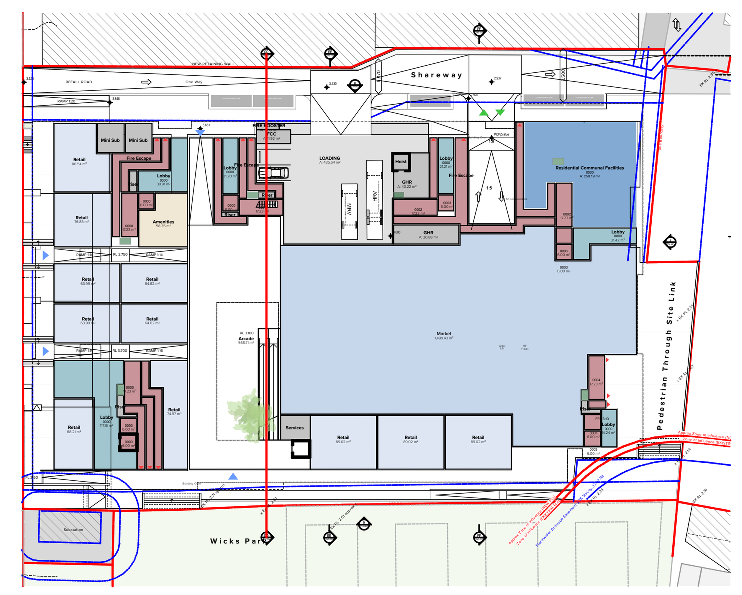
Scale: **1:150, 1:1000 @A1, 50%@A3**
Project No.: **18003**
Drawn by: **TURNER**
North
Status: **For Information**
Dwg No.: **DA-350-111**
Rev: D

TURNER

Level 7 **ONE** Oxford Street
Darlinghurst NSW 2010
AUSTRALIA

T +61 2 8668 0000
F +61 2 8668 0088
turnerstudio.com.au





CLIENT

Toga Development & Construction
Level 5, 45 Jones Street Ultimo NSW 2007

Rev	Date	Approved by	Revision Notes
C	05.09.18	JF	FOR INFORMATION

PRELIMINARY

Project Title
Wicks Park
182-198 Victoria Rd Marrickville NSW

Drawing Title
GA Sections
Section DD

Scale	Project No.	Drawn by	North
1:150, 1:1000 @A1, 50%@A3	18003	TURNER	
Status	Dwg No.	Rev	
For Information	DA-350-112	C	

TURNER

Level 7 **ONE** Oxford Street
Darlinghurst NSW 2010
AUSTRALIA

T +61 2 8668 0000
F +61 2 8668 0088
turnerstudio.com.au

Appendix C – Summary of Results from the Investigation Phase

Table T1 - Summary of Soil Analytcial Results - Site Assessment against Residential and Recreational/Open Space Trigger Values t **E24098 - Marrickville**

Sample ID	Depth (m)	Heavy Metals										PAHs						BTEX				TRH				TPH		Pesticides		PCBs	Asbestos	PFAS			Phenols	VOCs	
		As	Cd	Cr	Cu	Pb	Pb TCLP	Hg	Ni	Ni TCLP	Zn	Carcinogenic PAHs (as B(a)P TEQ)	Benzo(a)pyrene	Benzo(a)pyrene TCLP	Total PAHs	Total PAHs TCLP	Naphthalene	Benzene	Toluene	Ethylbenzene	Total Xylenes	F1	F2	F3	F4	C6-C9	C29-C36	OCPs	OPPs	Total	Presence / Absence	PFOA	PFOS	PFOS + PFHxS	Total	Tetrachloroethene (PCE)	Trichloroethene (TCE)
Argus 2014 (ES5611/2 - Detailed Site Assessment)																																					
Fill Soils																																					
BH1	0-0.5	4	0.2	12	9	27	NA	<0.1	2	NA	188	<1	<0.05	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	<100	<50	<25	<50	NA	NA	NA	YES	NA	NA	NA	NA	NA	NA
BH1	0.5-1.0	4	0.2	13	131	21	NA	<0.1	8	NA	56	<1	<0.05	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	<100	<50	<25	<50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH3	0-0.5	1	<0.1	4	1	14	NA	<0.1	1	NA	5	<1	<0.05	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	<100	<50	<25	<50	ND	NA	NA	No	NA	NA	NA	NA	NA	NA
BH4	0.3-0.5	5	0.8	9	35	128	NA	0.1	3	NA	378	7.7	4.9	NA	<1	NA	0.2	<0.2	<0.5	<1	<2	<25	<50	270	170	<25	170	ND	NA	<0.7	No	NA	NA	NA	NA	NA	NA
BH5	0.2-0.4	11	3.4	28	275	1176	NA	0.9	19	NA	1200	5.2	3.1	NA	<1	NA	0.1	<0.2	<0.5	<1	<2	<25	<50	270	200	<25	180	ND	NA	<0.7	No	NA	NA	NA	NA	NA	NA
BH6	0.2-0.4	6	0.8	16	134	947	NA	0.5	11	NA	994	5.8	3.5	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	260	170	<25	170	ND	NA	<0.7	NA	NA	NA	NA	NA	NA	NA
BH7	0.4-0.6	10	0.5	14	68	518	NA	0.3	10	NA	760	3.3	1.75	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	<100	<50	<25	<50	ND	NA	<0.7	YES	NA	NA	NA	<1	<0.5	1
BH8	0.1-0.3	4	1.1	43	113	527	NA	0.2	8	NA	760	NA	NA	NA	NA	NA	NA	<0.2	<0.5	<1	<2	<25	<50	210	210	<25	190	ND	NA	NA	No	NA	NA	NA	NA	NA	NA
BH9	0.4-0.6	10	0.5	14	34	156	NA	<0.1	16	NA	1310	3.3	1.7	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	520	380	<25	420	ND	NA	<0.7	No	NA	NA	NA	<1	NA	NA
BH10	0.4-0.5	10	0.3	9	19	73	NA	<0.1	8	NA	355	1	0.4	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	<100	160	<25	110	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
BH11	0.2-0.4	9	1	18	241	376	NA	<0.1	9	NA	1770	1.6	0.6	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	500	320	<25	340	ND	NA	<0.7	No	NA	NA	NA	<1	NA	NA
BH12	0.3-0.5	21	1.3	33	260	758	NA	0.3	26	NA	1490	<1	0.6	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	350	280	<25	280	ND	NA	<0.7	No	NA	NA	NA	<1	NA	NA
BH13	0.2-0.4	8	<0.1	17	8	28	NA	<0.1	2	NA	32	1.6	0.7	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	<100	<50	<25	<50	ND	NA	<0.7	No	NA	NA	NA	NA	NA	NA
BH14	0.2-0.3	5	0.8	15	171	229	NA	0.2	6	NA	439	9.1	5.5	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	190	210	<25	170	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
BH15	0.3-0.5	16	<0.1	23	8	37	NA	<0.1	6	NA	17	<1	<0.05	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	<100	<50	<25	<50	ND	NA	<0.7	No	NA	NA	NA	<1	NA	NA
BH16	0.3-0.5	7	0.1	21	15	67	NA	<0.1	6	NA	60	<1	<0.05	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	<100	<50	<25	<50	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
BH17	0.3-0.5	4	<0.1	15	9	41	NA	<0.1	2	NA	26	<1	<0.05	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	<100	<50	<25	<50	ND	NA	<0.7	No	NA	NA	NA	<1	<0.5	<0.5
BH21	0.3-0.5	16	1.7	25	86	962	NA	0.3	9	NA	960	10	6.1	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	1120	440	<25	690	ND	NA	<0.7	No	NA	NA	NA	NA	NA	NA
BH22	0.2-0.3	12	0.3	19	26	279	NA	0.1	4	NA	210	2.8	1.5	NA	<1	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	380	270	<25	320	ND	NA	<0.7	YES	NA	NA	NA	NA	NA	NA
D1 (duplicate of BH9)	0.4-0.6	15	0.5	11	32	209	NA	<0.1	10	NA	945	NA	NA	NA	NA	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	230	240	<25	230	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2 (duplicate of BH4)	0.3-0.5	11	1.2	11	48	191	NA	0.1	9	NA	575	NA	NA	NA	NA	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	300	240	<25	240	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3 (duplicate of BH15)	0.3-0.5	15	<0.1	22	5	33	NA	<0.1	5	NA	16	NA	NA	NA	NA	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	300	240	<25	170	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4 (duplicate of BH11)	0.2-0.4	6	0.6	13	128	270	NA	<0.1	6	NA	1360	NA	NA	NA	NA	NA	<0.1	<0.2	<0.5	<1	<2	<25	<50	260	290	<25	290	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Natural Soils																																					
BH1	1.0-1.5	6	<0.1	14	10	13	NA	<0.1	1	NA	22	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH3	0.5-1.0	5	<0.1	14	9	18	NA	<0.1	1	NA	33	<1	<0.05	NA	<1	NA	<1	<0.2	<0.5	<1	<2	<25	<50	<100	<50	<25	<50	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH3	1.0-1.5	4	<0.1	14	8	17	NA	<0.1	1	NA	16	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH4	0.9-1.0	5	0.3	11	22	82	NA	0.1	4	NA	172	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH5	0.8-1.0	4	<0.1	13	10	24	NA	<0.1	2	NA	61	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH6	0.9-1.0	4	<0.1	13	14	30	NA	<0.1	2	NA	92	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
BH7	1.1-1.3	2	0.2	15	19	81	NA	<0.1	2	NA	272	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH9	0.8-1.0	7	<0.1	12	7	23	NA	<0.1	2	NA	83	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH10	0.8-1.0	4	<0.1	13	8	27	NA	<0.1	2	NA	72	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH11	0.7-0.9	12	0.2	17	16	39	NA	<0.1	4	NA	174	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH12	0.7-0.9	12	0.3	18	18	63	NA	<0.1	4	NA	318	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH13	0.8-1.0	5	0.2	13	23	131	NA	0.1	4	NA	150	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH14	0.6-0.8	4	<0.1	14	8	24	NA	<0.1	1	NA	31	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH15	0.9-1.0	10	<0.1	16	2	10	NA	<0.1	1	NA	6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH16	0.8-1.0	7	<0.1	21	2	20	NA	<0.1	1	NA	11	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH17	0.7-0.8	3	<0.1	15	6	28	NA	<0.1	2	NA	16	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EI 2019 - Current Investigation (24098.E03.Rev0 - Additional Site Investigation)																																					
Fill soils																																					
BH1M_0.2-0.3		5.5	< 0.4	12	28	220	NA	0.5	6.3	NA	130	3.8	2.5	<0.001	28.7	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	< 50	< 100	< 100	< 20	< 50	< 0.1	ND	< 0.5	No	< 0.005	< 0.005	< 0.005	NA	<0.5	<0.5
BH2_0.2-0.3		48	< 0.4	25	69	290	0.18	1.1	9.8	NA	250	1.7	0.9	NA	6.6	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	< 50	< 100	< 100	< 20	< 50	< 0.1	ND	< 0.5	No	< 0.005	< 0.005	< 0.005	NA	<0.5	<0.5
BH3M_0.3-0.4		3.6	< 0.4	8.2	18	260	NA	0.3	15	NA	120	2.9	1.8	NA	17.8	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	< 50	420	270	< 20	330	< 0.1	ND	< 0.5	No	< 0.005	0.0087	0.0087	NA	<0.5	<0.5
BH6M_0.2-0.3		7.8	1.1	15	210	390	0.18	0.6	15	NA	720	1.6	0.8	NA	6.1	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	< 50	< 100	< 100	< 20	< 50	< 0.1	ND	< 0.5	No	< 0.005	0.037	0.037	<1	<0.5	<0.5
BH6M_0.7-0.8		4.4	< 0.4	16	23	55	NA	0.2	< 5	NA	130	1.2	< 0.5	NA	< 0.5	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	96	230	< 100	< 20	130	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
BH7_0.2-0.3		4.2	< 0.4	19	82	130	NA	0.3	18	NA	230	1.6	0.8	NA	6.5	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	< 50	< 100	< 100	< 20	< 50	< 0.1	ND	< 0.5	No	< 0.005	0.018	0.018	<1	<0.5	<0.5
BH9M_0.2-0.3		7	0.4	14	110	310	0.15	0.2	8.9	NA	360	74	52	<0.001	819	<0.001	< 5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	53	1200	180	< 20	320	< 0.1	ND	< 0.5	No	< 0.005	0.0079	0.0079	NA	<0.5	<0.5
BH10_0.3-0.4		2.6	< 0.4	5.3	18	140	NA	0.1	< 5	NA	180	1.2	< 0.5	NA	2.2	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	< 50	< 100	< 100	< 20	< 50	0.57	NA	< 5	No	< 0.005	< 0.005	< 0.005	<1	<0.5	<0.5
BH12_0.0-0.1		10	< 0.4	21	12	31	NA	< 0.1	9.8	NA	11	1.2	< 0.5	NA	< 0.5	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	< 50	< 100	< 100	< 20	< 50	< 0.1	ND	< 0.5	No	< 0.005	< 0.005	< 0.005	NA	<0.5	<0.5
BH13_0.3-0.4		45	0.7	10	51	180	NA	0.2	15	NA	310	1.2	< 0.5	NA	< 0.5	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	< 50	< 100	< 100	< 20	< 50	< 0.1	ND	< 0.5	YES	< 0.005	0.013	0.013	NA	0.7	<0.5
BH13_0.7-0.8		15	< 0.4	22	16	65	NA	0.2	8.8	NA	46	1.2	< 0.5	NA	< 0.5	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	< 50	< 100	< 100	< 20	< 50	NA	NA	NA	No	NA	NA	NA	NA	<0.5	<0.5
BH14M_0.2-0.3		11	0.4	20	39	93	NA	0.3	12	NA	200	1.2	< 0.5	NA	2.5	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	< 50	130	< 100	< 20	65	< 0.1	ND	< 5	No	< 0.005	< 0.005	< 0.005	NA	<0.5	<0.5
QD1		15	< 0.4	18	31	85	NA	0.2	11	NA	150	NA	NA	NA	NA	NA	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	< 20	< 50	160	< 100	< 20	72	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Natural soils																																					
BH1M_0.7-0.8		4.6	< 0.4	19	17	36	NA	< 0.1	19	NA	1.2	< 0.5	< 0.5	NA	< 0.5	NA	< 0.1	< 0.1	< 0.1	< 0.3	< 0.3	< 50	< 100	< 100	<100	< 50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH2_1.8-1.9		12	< 0.4	18	< 5	10	NA	< 0.1	5.4	NA	1.4	0.7	5.1	NA	< 2	NA	< 0.1	< 0.1	< 0.1	< 0.3	< 0.3	< 50	< 100	< 100	<100	< 50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH3M_1.7-1.8		< 2	< 0.4	14	< 5	9.9	NA	< 0.1	< 5	NA	1.2	< 0.5	< 0.5	NA	< 0.5	NA	< 0.1	< 0.1	< 0.1	< 0.3	< 0.3	< 50	< 100	< 100	<100	< 50	NA	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
BH6M_1.2-1.3		4.2	< 0.4	16	21	37	NA	< 0.1	110	<0.05	1.2	< 0.5	< 0.5	NA	< 0.5	NA	< 0.1	< 0.1	< 0.1	< 0.3	< 0.3	74	190	< 100	<100	110	NA	NA	NA	NA	NA	NA	NA	NA	<1	<0.5	<0.5
BH6M_1.7-1.8		14	< 0.4	21	12	21	NA	< 0.1	15	NA	1.2	< 0.5	< 0.5	NA	< 0.5	NA	< 0.1	< 0.1	< 0.1	< 0.3	<0.3	< 50	< 100	< 100	<100	< 50	NA	NA	NA	NA	NA	NA	NA	NA	<1	<0.5	<0.5
BH7_1.4-1.5		3.8	< 0.4	16	7.5	30	NA	< 0.1	43	<0.05	1.2	< 0.5	< 0.5	NA	< 0.5	NA	< 0.1	< 0.1	< 0.1	< 0.3	< 0.3	< 50	< 100	< 100	<100	< 50	NA	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
BH12_0.7-0.8		14	< 0.4	27	< 5	17	NA	< 0.1	< 5	NA	1.2	< 0.5	< 0.5	NA	< 0.5	NA	< 0.1	< 0.1	< 0.1	< 0.3	< 0.3	< 50	< 100	< 100	<100	< 50	NA	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
BH14M_1.2-1.3		2.6	< 0.4	< 5	< 5	9.6	NA	< 0.1	< 5	NA	1.2	< 0.5	< 0.5	NA	< 0.5	NA	< 0.1	< 0.1	< 0.1	< 0.3	< 0.3	< 50	< 100	< 100	<100	< 50	NA	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
Statistical Analysis																																					
Maximum concentration		48	3.4	43	275	1176	0.18	1.1	110	<0.05	1770	74	52	<0.001	819	<0.001	0.2	0	0	0	0	74	190	1200	440	110	690	0.57	0	0	0	0	0.037	0.037	0	0.7	1
EI Maximum Concentrations		48	1.1	27	210	390	0.18	1.1	110	<0.05	720	74	52	<0.001	819	0	0	0	0	0	0	74	190	1200	270	110	330	0.57	0	0	0	0	0.037	0.037	0	0.7	0
95% UCL		NC	NC	NC	78.29	309.3	NC	NC	11.82	NC	437	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SILs																																					
HIL B - Residential		500	150	500 Cr(V1)	30,000	1200		120	1200		NR	4			400															1					45,000		
HSL D - *Commercial / Industrial* Soil texture classification –Sand [1]	Source depths (0 m to <1 m. BGL)																NL	3	NL	NL	230	260	NL														
	Source depths (1 m to <2 m. BGL)																NL	3	NL	NL	NL	370	NL														
	Source depths (2m to <4 m. BGL)																NL	3	NL	NL	NL	630	NL														
	Source depths (4 m+)																NL	3	NL	NL	NL	NL	NL														
EIL / ESL - [1]		100		165	90	690			35		190		33 *				170	50	85	70	105	180	120	300	2,800			180									
Management Limits – *Recreational / Open space* Coarse grained soil texture [1]																						700	1000	2500	10000												
Asbestos contamination HSL – B (Residential) Bonded ACM (%w/w)																															0.05						
Asbestos contamination HSL for Non Bonded / Friable Asbestos (%w/w)																															0.001						
HEPA (2018) PFAS Human Health Criteria for Residential with minimal opportunities for soil access[4]																																20		2			
HEPA (2018) PFAS ecological guideline values for Residential land use[4]																																	0.01				
NSW EPA 2014 [2] General Solid Waste	CT1 (mg/kg)	100	20	100		100		4	40				0.8		200			10	288	600	1,000					650	10000	< 50			If detected material is Special Waste - Asbestos Waste	50		20		14	10
	TCLP1 (mg/L) / SCC1 (mg/kg)	5.0 / 500	1.0 / 100	5 / 1,900		5 / 1,500		0.2 / 50	2 / 1,050				0.04 / 10		NR / 200			0.5 / 18	14.4 / 518	30 / 1,080	50 / 1,800							NA / <50								0.7 / 25.2	0.5 / 18
NSW EPA 2014 [3] Restricted Solid Waste	CT2 (mg/kg)	400	80	400		400		16	160				3.2		800			40	1,152	2,400	4,000					2600	40000	NA								56	40
	TCLP2 (mg/L) / SCC2 (mg/kg)	20 / 2,000	4 / 400	20 / 7,600		20 / 6,000		0.8 / 200	8 / 4,200				0.16 / 23		NR / 800			2 / 72	57.6 / 2,073	120 / 4,320	200 / 7,200							NA / <50								2.8 / 100.8	2.0 / 72

Notes:

All results are recorded in mg/kg (unless otherwise stated)

(yellow)	Highlighted values indicates concentration exceeds Human Health Based Soil Criteria (HIL B / HSL D)
(blue)	Highlighted indicates NEPM 2013 criteria exceeded and / or NSW EPA 2014 waste classification met (without TCLP analysis)
(green)	Highlighted values indicates concentration exceeds Ecological Investigation/Screening Levels (EILs/ESLs)
HIL C	NEPC 1999 Amendment 2013 'HIL B' - Health based recreational / open space soil settings.
HSL C	NEPC 1999 Amendment 2013 'HSL D' Health Based Screening Levels for recreational / open space soil settings.
EIL/ESL	Ecological Investigation/Screening Level - based on NEPM 2013 criteria
NL	'Not Limiting' - The soil vapour limit exceeds the soil concentration at which the pore water phase cannot dissolve any more of the individual chemical.
ND	'Not detected' i.e. all concentrations of the compounds within the analyte group were found to be below the laboratory limits of detection.
NA	'Not Analysed' i.e. the sample was not analysed.
NC	Not Calculated - (In the case of Carcinogenic PAHs, results was not calculated as Total PAHs were below the NEPM 2013 criteria of 4 mg/kg for Carcinogenic PAHs).
1	Coarse Grained soil values were applied, being the most conservative of the material types.
2	NSW EPA 2014 General Solid Waste Thresholds, in Waste Classification Guidelines, Table 1 (CT1) and Table 2 (TCLP1 / SCC1)
3	NSW EPA 2014 Restricted Solid Waste Thresholds, in Waste Classification Guidelines, Table 1 (CT2) and Table 2 (TCLP2 / SCC2)
4	HEPA 2018
F1	To obtain F1 subtract the sum of BTEX concentrations from the C6-C10 fraction.
F2	To obtain F2 subtract Naphthalene from the >C10-C16 fraction.
F3	(>C16-C34)
F4	(>C34-C40)
*	CRC Care (2017)

eiaustralia

Table T2 - Summary of Groundwater Analytcial Results

E24098 - Marrickville

Sample ID	Heavy Metals								PAHs			BTEX				TRH				TPH		VOCs		PFAS			Phenols	
	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Benzo(a)pyrene	Total PAHs	Naphthalene	Benzene	Toluene	Ethylbenzene	Total Xylene	F1*	F2**	F3***	F4****	C6-C9	C29-C36	Trichloroethene (TCE)	2-Propane (Acetone)	PFOA	PFOS	PFOS + PFHxS	2-Methylphenol (O-Cresol)	Total
Argus 2014 (ES5611/2 - Detailed Site Assessment)																												
GW1	<5	<1	<1	2	<1	<0.1	2	7	<0.2	<0.2	<0.2	<1	<1	<1	<2	<10	<100	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA
GW2	<5	<1	<1	<1	<1	<0.1	5	10	<0.2	<0.2	<0.2	<1	<1	<1	<2	<10	<100	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA
EI 2019 - Current Investigation (24098.E03.Rev0 - Additional Site Investigation)																												
BH1M-1	<1	<0.2	<1	<1	<1	<0.1	58	35	<1	<1	<1	<1	<1	<1	<3	<20	<50	<100	<100	<20	<100	3	ND	0.08	0.01	0.01	ND	<3
BH3M-1	1	<0.2	<1	<1	<1	<0.1	64	45	<1	<1	<1	<1	<1	<1	<3	<20	<50	<100	<100	<20	<100	ND	ND	<0.01	<0.01	<0.01	ND	<3
BH6M-1	<1	<0.2	1	3	<1	<0.1	50	220	<1	<1	2	<1	1	5	7	<20	<50	<100	<100	<20	<100	ND	11	0.04	0.08	0.08	ND	<3
BH9M-1	<1	<0.2	<1	<1	<1	<0.1	82	26	<1	<1	<1	<1	<1	<1	<3	<20	<50	<100	<100	<20	<100	ND	ND	<0.01	<0.01	<0.01	ND	<3
BH14M-1	2	<0.2	1	<1	<1	<0.1	71	150	<1	<1	<1	<1	<1	<1	<3	<20	<50	<100	<100	<20	<100	ND	18	0.02	<0.01	<0.01	7	4
GWQD1 (Duplicate of BH6M-1)	<1	<0.2	2	3	<1	<0.1	52	23	NA	NA	NA	<1	<1	6	9	<20	<50	<100	<100	20	<100	ND	ND	NA	NA	NA	ND	<3
GILs																												
ANZG (2018) GIL – **Marine Water**	NR	0.06[2]	27.4 (Cr III) / 4.4 (Cr VI)[4]	1.3[4]	4.4[4]	0.1[2]	7[2]	15[3,4]	0.1[5]	NR	50[2]	500[2,3]	180[5]	5[5]	75	6000	NL	100[1]	100[1]									
ANZG (2018) GIL – **Freshwater**	NR	0.7[2]	3.3 (Cr III)[5] / 0.4 (Cr VI)[4,3]	1.4[4]	3.4[4]	0.06[2]	8[2]	8[4]	0.1[5]	NR	16[4]	950[4,3]	180[5]	80[5]	75	6000	NL	100[1]	100[1]									
HEPA (2018) PFAS National Environmental Management Plan Guidelines – **Recreational**																								5.6		0.7		
HEPA (2018) PFAS National Environmental Management Plan Guidelines – **Drinking Water**																								0.56		0.07		
HEPA (2018) PFAS National Environmental Management Plan Guidelines – **Marine Water**																								19	0.00023[6]	NR		
HEPA (2018) PFAS National Environmental Management Plan Guidelines – **Freshwater**																								19	0.00023[6]	NR		
NEPM HSL D (Commercial / Industrial) – 2 m to < 4 m												5,000	NL	NL	NL	1000	1000											
NEPM HSL D (Commercial / Industrial) – 4 m to < 8 m												5,000	NL	NL	NL	1000	1000											
GIL (Drinking Waters)	10	2	0.05 (Cr VI)	200	10	1	20		0.01			1	800	300	600													

Notes:	All results and criteria are in µg/L, unless otherwise noted.
(yellow highlight)	Highlighted values indicate concentrations exceed the adopted GIL.
GIL (Marine Waters)	NEPM 2013 Schedule B1 . Groundwater investigation level for marine waters ecosystem
HSL D	Health screening level for commercial / Industrial sites, as per Table 1A(4) of NEPM 2013 Schedule B1. HSL for Sand was adopted to ensure most conservative values were used. HSL are applied based on the estimated source depth of groundwater at each monitoring well.
NL	Not Limited (Ref. NEPM 2013, Schedule B1, Table 1(A)4)
NR	No recommended assessment criteria are currently available for the indicated parameter(s).
PQL	(Laboratory's) Practical Quantitation Limit
NT	Not tested.
*	F1 = TRH C6-C10 less BTEX
**	F2 = TRH C10-C16 less Naphthalene
***	F3 = TRH C16-C34
****	F4 = TRH C34 - C40
1	ANZECC (2000) provides 7 µg/L as an assessment guideline for total petroleum hydrocarbons. Since the laboratory practical quantitation limits (PQL) is higher than the ANZECC guideline, the PQL has been adopted as the interim GIL, as prescribed in DEC (2007).
2	The 99% Trigger Values were adopted for this assessment due to bioaccumulation potential of associated analytes. Ref. ANZG (2018) and HEPA (2018)
3	Indicated threshold value may not protect key species from chronic toxicity. Ref. ANZG (2018).
4	Low reliability 95% trigger values were adopted. Ref. Section 8.3.7, ANZG (2018)
5	Unkown species protection percentage. Ref. ANZG (2018)
6	As the laboratory PQL is above the criterion, PQL is used as a working level for assessment.

Table T3 - Soil Analytcial Results: Acid Sulfate Soils **E24098 - Marrickville**

Sample ID	Material	Analysis			
		pH (Field)	pHfox	Strength of Reaction	pH Difference (pH f - pH fox)
Previous Investigations (Aargus 2014)					
BH1_0.5-1.0	Fill	8.5	5.9	-	2.6
BH1_1.0-1.45	Silty CLAY	8.3	5.7	-	2.6
BH1_3.5-4.0	Sandy CLAY	7.5	5.4	-	2.1
BH2_0.5-1.0	Fill	8.4	5.9	-	2.5
BH2_2.0-2.5	Silty CLAY	8	5.7	-	2.3
BH2_4.0-4.5	Sandy CLAY	7.5	5.2	-	2.3
BH2_7.0-7.5	Gravelly Sandy CLAY	7.6	5.1	-	2.5
BH3_0.5-1.0	Reworked Silty CLAY	8.4	6.1	-	2.3
BH3_1.5-2.0	Silty CLAY	7.9	5.8	-	2.1
BH3_3.0-3.5	Sandy CLAY	7.6	5.4	-	2.2
Current Investigation (EI Australia)					
BH7_1.4-1.5	Silty CLAY	6.3	5.1	Extreme	1.2
BH7_2.4-2.5	Silty CLAY	6.5	4.9	Moderate	1.6
BH7_3.1-3.2	Silty CLAY	6.3	5.6	Moderate	0.7
BH7_4.0-4.1	Silty CLAY	6.4	6.1	Moderate	0.3
BH14M_1.2-1.3	Silty CLAY	6.9	5.4	Moderate	1.5
BH14M_1.8-1.9	Silty CLAY	6.8	5.2	Moderate	1.6
BH14M_2.9-3.0	Silty CLAY	7.4	7.4	Extreme	0
BH14M_3.8-3.9	Clayey SAND	6.8	6.4	Moderate	0.4
SILs					
ASSMAC (1998) Screening Criteria	**Indicator of PASS**	NR	<3.5	NR	NR
	Indicator of AASS	<4.0	NR	NR	NR

Notes:

(blue)	Criteria exceeding
(yellow)	Exceeding ASSMAC, 1998 criteria

NR No reference criteria available in current regulatory tools.

eiaustralia

Appendix D – Remediation Criteria

Table D-1 Soil Remediation Criteria

Chemical	Unit	HIL A 1a	HIL B 1b	HSL A& B 11	EIL 2a	ESL 2b
Metals						
Arsenic – As	mg /	100 3	500 3	-	100	-
Cadmium - Cd	mg /	20	150	-	100	-
Chromium(VI) – Cr(VI)	mg /	100	500	-	415	-
Copper – Cu	mg /	6000	30,000	-	125	-
Lead – Pb	mg /	300	1,200	-	126	-
Mercury – Hg (inorganic)	mg /	40	120	-	NA	-
Nickel – Ni	mg /	400	1,200	-	135	-
Zinc – Zn	mg /	7,400	60,000	-	350	-
Petroleum Hydrocarbons						
F1 4	mg /	-	-	45	-	180
F2 5	mg /	-	-	110	-	120
F3 6	mg /	-	-	-	-	300
F4 7	mg /	-	-	-	-	280
Polycyclic Aromatic Hydrocarbons (PAH)						
Naphthalene	mg /	-	-	3	170	-
Benzo(α)pyrene	mg /	-	-	-	-	0.7
Carcinogenic PAHs (as B(α)P TEQ) 8	TEQ	3	4	-	-	-
Total PAHs 9	mg /	300	400	-	-	-
Monocyclic Aromatic Hydrocarbons (BTEX)						
Benzene	mg /	-	-	0.5	-	50
Toluene	mg /	-	-	160	-	85
Ethylbenzene	mg /	-	-	55	-	70
Xylenes (total)	mg /	-	-	40	-	105
Chlorinated Volatile Organic Compounds						
Tetrachloroethylene (PCE)	mg/kg	24 10				
Trichloroethylene (TCE)	mg/kg	0.94 10				
cis-1,2-dichloroethylene (cis 1,2 DCE)	mg/kg	1600 10				
Vinyl chloride (VC)	mg/kg	0.059 10				
Asbestos		HSL A	HSL B			
Asbestos (friable or fines)	w / w	0.001%	0.001			
Asbestos (bonded)	w / w	0.01%	0.04%			

Note 1 Health-based investigation levels:
- (a) HIL A - Residential with garden/accessible soil (home grown produce <10% fruit and vegetable intake (no poultry), also includes childcare centres, preschools and primary schools, Ref. NEPM 2013, Schedule B1, Table 1A(1).
- (b) HIL B - Residential with minimal opportunities for soil access; includes dwellings with fully and permanently paved yard space such as high-rise buildings and apartments, Ref. NEPM 2013, Schedule B1, Table 1A(1).

Note 2 Ecological investigation levels:

(a) EIL – Generic EIL for aged Arsenic and Naphthalene, Calculated EILs for other metals in urban residential and public open space settings with due regard for background concentrations, soil cation exchange capacity, texture and pH, Ref. NEPM 2013, Schedule B1, Tables 1B(1) to 1B(5).
(b) ESL – Ecological Screening Level for F1, F2, F3, F4, BTEX and Benzo(a)pyrene in coarse texture soils in urban residential and public open space settings, Ref. NEPM 2013, Schedule B1, Table 1B(6).

Note 3 Arsenic: HIL assumes 70% oral bioavailability. Site-specific bioavailability may be important and should be considered where appropriate (refer Schedule B7).
Note 4 F1: concentration of TRH C_6-C_{10} fraction minus the sum of BTEX concentrations.
Note 5 F2: concentration of TRH >C_{10}-C_{16} fraction minus the concentration of Naphthalene.
Note 6 F3: concentration of TRH >C_{16}-C_{34}.
Note 7 F4: concentration of TRH >C_{34}-C_{40}.
Note 8 Carcinogenic PAHs: HIL is based on the 8 carcinogenic PAHs and their TEFs (potency relative to B(a)P) adopted by CCME 2008 (refer Schedule B7). The B(a)P TEQ is calculated by multiplying the concentration of each carcinogenic PAH in the sample by its B(a)P TEF, given below, and summing these products.
Note 9 Total PAHs: HIL is based on the sum of the 16 PAHs most commonly reported for contaminated sites (WHO 1998). The application of the total PAH HIL should consider the presence of carcinogenic PAHs and naphthalene (the most volatile PAH). Carcinogenic PAHs reported in the total PAHs should meet the B(a)P TEQ HIL. Naphthalene reported in the total PAHs should meet the relevant HSL.
Note 10 USEPA 2015 Region 9 Screening Levels (RSLs) for Resident Soils.
Note 11 Soil HSLs for vapour intrusion assuming coarse texture (sand) soils and a contamination source at 0m to <1m depth.

Table D-2 Waste Classification without Leachate Testing

Contaminant	Maximum Values of Specific Contaminant Concentration for Classification without TCLP	
	General Solid Waste CT1 (mg/kg)	Restricted Solid Waste CT2 (mg/kg)
Arsenic	100	400
Asbestos	**“Special Waste - Asbestos Waste”** if ANY Asbestos is present	
Benzene	10	40
Benzo(a)pyrene	0.8	3.2
Cadmium	20	80
Chromium (VI)	100	400
Cyanide (amenable)	70	280
Ethylbenzene	600	2,400
Lead	100	400
Mercury	4	16
Nickel	40	160
Petroleum hydrocarbons C6-C9	650	2,600
Petroleum hydrocarbons C10-C36	10,000	40,000
Polychlorinated biphenyls (PCB)	<50	<50
Polycyclic aromatic hydrocarbons (total PAH)	200	800
Tetrachloroethylene (PCE)	14	56
Toluene	288	1,152
Trichloroethylene (TCE)	10	40

Contaminant	Maximum Values of Specific Contaminant Concentration for Classification without TCLP	
Vinyl Chloride (VC)	4	16
Xylenes (total)	1,000	4,000

Note 1 N/A = not applicable (assessed using SCC1 and SCC2 values, only) see **Table D-3**

Table D-3 Waste Classification using TCLP and SCC Values

Contaminant	Maximum Values for Leachable Concentration and Specific Contaminant Concentration when used together			
	General Solid Waste		Restricted Solid Waste	
	Leachable Concentration	Specific Contaminant Concentration	Leachable Concentration	Specific Contaminant Concentration
	TCLP1 (mg/L)	SCC1 (mg/kg)	TCLP2 (mg/L)	SCC2 (mg/kg)
Arsenic	5.0	500	20	2,000
Asbestos	**"Special Waste - Asbestos Waste"** if ANY Asbestos is present			
Benzene	0.5	18	2	72
Benzo(a)pyrene	0.04	10	0.16	23
Cadmium	1.0	100	4	400
Chromium (VI)	5	1,900	20	7,600
Cyanide (amenable)	3.5	300	14	1,200
Ethylbenzene	30	1,080	120	4,320
Lead	5	1,500	20	6,000
Mercury	0.2	50	0.8	200
Nickel	2	1,050	8	4,200
Petroleum hydrocarbons C6-C9	N/A	650	N/A	2,600
Petroleum hydrocarbons C10-C36	N/A	10,000	N/A	40,000
Polychlorinated biphenyls (PCB)	N/A	<50	N/A	<50
Polycyclic aromatic hydrocarbons (total PAH)	N/A	200	N/A	800
Tetrachloroethylene (PCE)	0.7	25.2	2.8	100.8
Toluene	14.4	518	57.6	2,073

Contaminant	Maximum Values for Leachable Concentration and Specific Contaminant Concentration when used together			
Trichloroethylene (TCE)	0.5	18	2	72
Vinyl Chloride (VC)	0.2	7.2	0.8	28.8
Xylenes	50	1,800	200	7,200

Note 2 N/A = not applicable (assessed using SCC1 and SCC2 values, only)

eiaustralia

Appendix E – Review of Remedial Options and Technologies

REVIEW OF REMEDIATION OPTIONS & TECHNOLOGIES

A number of soil remediation options were reviewed to examine the suitability of each method, in considering the remedial options available for the site, the surrounding lands and the geological and hydrogeological limitations, the following issues have been considered:

- Prioritisation of works in areas of most concern;
- Ability of remedial method to treat contamination with respect to natural and infrastructure limitations;
- Remedial timetable;
- Cost effectiveness;
- Defensible method to ensure the site is remediated to appropriate levels / validation criteria; and
- Regulatory compliance.

The following sections provide details on various remediation options for the material found on site.

E.1 FILL, SOILS & RESIDUAL CLAYS

E.1.1 Bioventing

Bioventing stimulates the natural *in situ* biodegradation of aerobically degradable compounds in soil by increasing oxygen flow to existing soil microorganisms. In contrast to soil vapour vacuum extraction, bioventing uses low air flow rates to provide only enough oxygen to sustain microbial activity. Oxygen is most commonly supplied through direct air injection into residual contamination in soil. In addition to degradation of adsorbed fuel residuals, volatile compounds are biodegraded as vapours move slowly through biologically active soil. Bioventing techniques have been successfully used to remediate soils contaminated by petroleum hydrocarbons, non-chlorinated solvents, some pesticides, wood preservatives, and other organic chemicals.

Factors that may limit the applicability and effectiveness of the process include:

- A high water table within 1-2m of the surface, saturated soil lenses, or low permeability soils all may reduce bioventing performance.
- Vapours can build up in basements or underneath buildings within the radius of influence of air injection wells. This problem can be alleviated by extracting air near the structure of concern.
- Extremely low soil moisture content may limit biodegradation and the effectiveness of bioventing.
- Monitoring of off-gases at the soil surface may be required.
- Aerobic biodegradation of many chlorinated compounds may not be effective unless there is a co-metabolite present, or an anaerobic cycle.

E.1.2 Enhanced Bioremediation

Enhanced bioremediation is a process in which indigenous or inoculated micro-organisms (e.g. fungi, bacteria, and other microbes) degrade organic contaminants found in soil and/or ground water, converting them to harmless end products. Nutrients, oxygen, or other additives are used to enhance bioremediation and contaminant desorption from subsurface materials. In the presence of sufficient oxygen (aerobic conditions), and other nutrient elements, microorganisms will ultimately convert many organic contaminants to carbon dioxide, water, and microbial cell mass. In the absence of oxygen (anaerobic conditions), the organic contaminants will be ultimately metabolized to methane, limited amounts of carbon dioxide, and trace amounts of hydrogen gas. Under sulfate-reduction conditions, sulfate is converted to sulfide or elemental sulfur, and under nitrate-reduction conditions, nitrogen gas is ultimately produced.

Factors that may limit the applicability and effectiveness of the bioremediation process include:

- Interaction between the soil matrix and microorganisms influence the results;
- Contaminants may be subject to leaching requiring treatment of the underlying ground water;
- Preferential flow paths may severely decrease contact between injected fluids and contaminants throughout the contaminated zones (Note: the system should not be used for clay, highly layered, or heterogeneous subsurface environments because of oxygen (or other electron acceptor) transfer limitations);
- High concentrations of heavy metals, highly chlorinated organics, long chain hydrocarbons, or inorganic salts may be toxic to microorganisms;
- A surface treatment system, such as air stripping or carbon adsorption, may be required to treat extracted groundwater prior to re-injection or disposal; and
- The length of time required for treatment can range from 6 months to 5 years and is dependent on many site-specific factors.

E.1.3 Capping and Containment

The “cap and contain” method employs a risk minimisation approach similar to “ongoing management”, where impacted soils are managed on site so as not to pose an ongoing risk to the environment or human health. Impacted soils are contained by the placement of an impervious barrier or clean fill materials on top of the impacted material to prevent exposure to site occupiers, workers or the environment. The base of this “clean zone” would be clearly marked by a demarcation barrier to indicate that below this depth workers could potentially be exposed to contamination, which would then trigger additional health, safety and environmental controls.

Capping and containment may be an appropriate remedial option for soil containing both organic and inorganic contaminants that contain residual contamination, particularly if the mix of contaminants is not easily treated. The conditions for this remedial action alternative are:

- The contaminant is relatively non-mobile, including low volatility, insoluble and has low migration potential in a soil matrix;
- The primary exposure route to the contaminant and risk to human health is through direct dermal contact, dust inhalation or soil ingestion;
- The primary exposure route for the environment is mitigated through low leaching potential or migration to groundwater; and
- The contained area can be monitored and incorporated into any final land-use plans.

In the use of capping and containment, the focus of the response is to prevent contact with, or exposure to the contaminated soils by human receptors and/or eliminate transport by water to off-site receptors.

E.1.4 Chemical Oxidation/Injection

Chemical oxidation remedial strategies involve the addition of an oxidising agent to the soil or groundwater. The rate and extent of degradation of a target chemical of concern is dependent on its susceptibility to oxidative degradation as well as the site conditions, such as pH, temperature, the concentration of oxidant, and the concentration of secondary oxidant-consuming substances such as natural organic matter.

Factors which may limit the applicability and effectiveness of chemical oxidation include:

- Requirement for handling large quantities of hazardous oxidizing chemicals due to the oxidant demand of the target organic chemicals and the unproductive oxidant consumption of the formation;
- Some chemicals of concern are resistant to oxidation; and
- There is a potential for process-induced detrimental effects.

E.1.5 Excavation and Off-site Disposal

Excavation and disposal of contaminated wastes is a frequently used option, typically used when a rapid site remediation program is required or where significant subsurface contamination exists that is potentially impacting on sensitive off-site receptors. Wastes must be classified in accordance with the NSW EPA guidelines.

Based on the required disposal of the landfill material, this option would adequately address the remediation goals through the removal of the contaminants from the site. Furthermore, with the removal of any identified contaminated fill soils, the long-term liability associated with soil contamination shall be minimised, along with substantial improvement of subsurface site conditions with regard to contamination of soil and groundwater.

E.1.6 Land Farming

Ex situ land-farming is a proven treatment for petroleum hydrocarbon impacted soils. In general the higher the molecular weight or number of rings in a compound, the slower the degradation rate.

Factors that may limit the applicability and effectiveness of the land farming include:

- The large amount of space required;
- Conditions affecting biological degradation of contaminants (e.g., temperature, rain fall) are largely uncontrolled, which increases the length of time to complete remediation;
- Only suitable for organic contaminants;
- Volatile contaminants, such as solvents, must be pre-treated because they would volatilise into the atmosphere, causing air pollution;
- Dust control is an important consideration, especially during tilling and other material handling operations; and
- Runoff collection facilities must be constructed and monitored.

E.2 GROUNDWATER

E.2.1 Enhanced Bioremediation

Bioremediation is a process in which indigenous micro-organisms (i.e. fungi, bacteria, and other microbes) degrade organic contaminants found in soil and/or ground water.

Enhanced bioremediation attempts to accelerate the natural biodegradation process by providing nutrients, electron acceptors, and competent degrading microorganisms that may otherwise be limiting the rapid conversion of contamination organics to innocuous end products.

Oxygen enhancement can be achieved by either sparging air below the water table or circulating hydrogen peroxide (H_2O_2) throughout the contaminated ground water zone. Under anaerobic conditions, nitrate is circulated throughout the ground water contamination zone to enhance bioremediation. Additionally, solid-phase peroxide products (e.g. oxygen releasing compound (ORC)) can also be used for oxygen enhancement and to increase the rate of biodegradation.

Air sparging below the water table increases ground water oxygen concentration and enhances the rate of biological degradation of organic contaminants by naturally occurring microbes. Air sparging also increases mixing in the saturated zone, which increases the contact between ground water and soil. Oxygen enhancement with air sparging is typically used in conjunction with soil vapour extraction (SVE) or bioventing to enhance removal of the volatile component under consideration.

During hydrogen peroxide enhancement, a dilute solution of hydrogen peroxide is circulated through the contaminated ground water zone to increase the oxygen content of ground water and enhance the rate of aerobic biodegradation of organic contaminants by naturally occurring microbes.

Solubilized nitrate is circulated throughout ground water contamination zones to provide an alternative electron acceptor for biological activity and enhance the rate of degradation of organic contaminants. Development of nitrate enhancement is still at the pilot scale. This technology enhances the anaerobic biodegradation through the addition of nitrate.

Bio-enhanced remediation strategies are slow and may take several years for plume clean-up.

E.2.2 Air Sparging

In air sparging, air is injected into a contaminated aquifer where it traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes contaminants by volatilization. This injected air helps to flush (bubble) the contaminants up into the unsaturated zone where a vapour extraction system is used to remove the vapour phase contamination.

In principal the more volatile a contaminant the more appropriate air sparging as a remediation strategy is. Methane can be added to the system to enhance co-metabolism of chlorinated organics.

Factors that may limit the applicability and effectiveness of the process include:

- Preferential air flow pathways reducing the contact between sparged air and the contaminants;
- Air injection wells must be designed for site-specific conditions; and
- Soil heterogeneity may cause some zones to be relatively unaffected.

E.2.3 Chemical Oxidation

In a chemical oxidation system oxidants are added to the system in order to oxidise the chemical of concern to less toxic species. The chemical oxidants most commonly employed include peroxide, ozone and permanganate. These oxidants cause the rapid and complete chemical destruction of many toxic organic chemicals while some chemicals are subject to partially degradation and subsequently reduced by bioremediation.

In general oxidants are capable of achieving high treatment efficiencies (e.g. >90%) for unsaturated aliphatic (e.g. trichloroethylene [TCE]) and aromatic (e.g. benzene) compounds, with very fast reaction rates (90% destruction in minutes). Field applications have clearly affirmed that matching the oxidant and *in situ* delivery system to the contaminants of concern

(COCs) and the site conditions is the key to successful implementation and achieving performance goals.

Oxidation using liquid hydrogen peroxide (H_2O_2) in the presence of native or supplemental ferrous iron (Fe^{+2}) produces Fenton's Reagent which yields free hydroxyl radicals (OH^-). These strong, nonspecific oxidants can rapidly degrade a variety of organic compounds. Fenton's Reagent oxidation is most effective under very acidic pH (e.g. pH 2 to 4) and becomes ineffective under moderate to strongly alkaline conditions. The reactions are extremely rapid and follow second-order kinetics.

Ozone gas can oxidize contaminants directly or through the formation of hydroxyl radicals. Like peroxide, ozone reactions are most effective in systems with acidic pH. Due to ozone's high reactivity and instability, O_3 is usually produced onsite, and requires closely spaced delivery points (e.g. air sparging wells). *In situ* decomposition of the ozone can lead to beneficial oxygenation and bio-stimulation.

The following factors may limit the applicability and effectiveness of chemical oxidation:

- Requirement for handling large quantities of hazardous oxidizing chemicals due to the oxidant demand of the target organic chemicals and the unproductive oxidant consumption of the formation.
- Some COCs are resistant to oxidation.
- There is a potential for process-induced detrimental effects.

Further research and development is ongoing to advance the science and engineering of *in situ* chemical oxidation and to increase its overall cost effectiveness.

E.2.4 Reactive Barrier Wall

Construction of a permeable reactive barrier (PRB) involves the subsurface emplacement of reactive materials through which a dissolved contaminant plume enters on one side of the PRB and treated water exits the other side. This *in situ* method for remediating dissolved-phase contaminants in groundwater combines a passive chemical or biological treatment zone with subsurface fluid flow management.

PRBs can be installed as permanent or semi-permanent units. The most commonly used PRB configuration is that of a continuous trench in which the treatment material is backfilled. The trench is perpendicular to and intersects the groundwater plume.

Alternately low-permeability walls can be used to direct a groundwater plume toward a permeable treatment zone.

E.2.5 Pump and Treat

As its name implies a pump and treat remedial involves the pumping of contaminated of ground water pumping include removal of dissolved contaminants from the subsurface, and containment and treatment the water. The treated groundwater is then either re-introduced into the aquifer or disposed off-site.

The criteria for well design, pumping system, and treatment are dependent on the physical site characteristics and contaminant type. Treatment options may include a train of processes such as gravity segregation, air strippers and activated carbon filters designed to remove specific contaminants.

The first step in determining whether ground water pumping is an appropriate remedial technology is to conduct a site characterization investigation. Site characteristics, such as hydraulic conductivity, will determine the range of remedial options possible. Chemical properties of the site and plume need to be determined to characterize transport of the contaminant and evaluate the feasibility of ground water pumping. To determine if ground water pumping is appropriate for a site, one needs to know the history of the contamination event, the properties of the subsurface, and the biological and chemical contaminant characteristics. Identifying the chemical and physical site characteristics, locating the ground water contaminant plume in three dimensions, and determining aquifer and soil properties are necessary in designing an effective ground water pumping strategy.

The following factors may limit the applicability and effectiveness of ground water pump and treat options as a remedial option:

- The time frame required to achieve the remediation goal;
- The pumping system fail to contain the contaminant plume as predicted;
- Residual saturation of the contaminant in the soil pores cannot be removed by ground water pumping;
- A pump and treat option is not suitable for contaminants with:
  - high residual saturation;
  - high sorption capabilities; and
  - homogeneous aquifers with hydraulic conductivity less than 10^{-5} cm/sec;
- Potential high operating costs;
- Biofouling of the extraction wells and associated treatment stream may severely affect system performance;
- Subsurface heterogeneities, may severely affect system performance;
- Potential toxic effects of residual surfactants in the subsurface; and
- Drawdown pumping generally produces large volumes of water requiring storage and or treatment.

E.2.6 Excavation

Excavation and disposal of contaminated wastes is frequently used, typically when a rapid site remediation program is required, or where significant subsurface contamination exists that is potentially impacting on sensitive off-site receptors. Excavation can also be used to remove primary sources of any groundwater contamination (such as buried tanks or drums and waste disposal areas) and remove the secondary sources of impact (contaminated fill, residual soils and impacted bedrock and bedrock fractures such as joints and bedding planes).

E.3 REMEDIATION OPTIONS

The various remediation options were reviewed to assess their suitability against the various subsurface materials at the site and whether the option meets the primary objectives of the remediation works program, as discussed in **Section 6**.