Kingston Foreshore Development Precinct
Land Development Authority
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Sampling, Analysis and Quality Plan

Kingston Foreshore Development Heritage Precinct

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Kingston Foreshore Development Heritage Precinct

Client: Land Development Authority

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Glossary

Term	Description
ABH	AECOM borehole
AHD	Australian Height Datum
AMG	Australian Map Grid
ANZECC	Australian and New Zealand Environment and Conservation Council
AST	Aboveground Storage Tank
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CLM	Contaminated Land Management Act (1997)
CSM	Conceptual Site Model
CVOC	Chlorinated Volatile Organic Compounds
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
DO	Dissolved Oxygen
DQI	Data Quality Indicator
DQO	Data Quality Objective
EC	Electrical Conductivity
Eh	Redox Potential
EIL	Ecological Investigation Levels
EPA	Environment Protection Authority
ESA	Environmental Site Assessment
GME	Groundwater Monitoring Event
LOR	Limit of Reporting
m bgs	metres below ground surface
m BTOC	metres Below Top of Casing
MW	Monitoring Well
NATA	National Association of Testing Authorities
NEHF	National Environmental Health Forum
NEPC	National Environment Protection Council
NEPM	National Environment Protection (Assessment of Site Contamination) Measure
NSW	New South Wales
OCP	Organochlorine Pesticides
OPP	Organophosphate Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PID	Photoionisation detector

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Term	Description		
PIL	Phytotoxicity Based Investigation Levels		
POEO	Protection of Environment Operations Act		
PSH	Phase Separated Hydrocarbon		
PVC	Polyvinyl Chloride		
QA/QC	Quality Assurance/Quality Control		
RSL	Regional Screening Levels		
SAQP	Sampling Analysis and Quality Plan		
SIL	Soil Investigation Levels		
SVOC	Semi Volatile Organic Compounds		
SWL	Standing Water Level		
TPH	Total Petroleum Hydrocarbons		
UPSS	Underground Petroleum Storage Systems		
USEPA	United States Environmental Protection Agency		
UST	Underground Storage Tank		
VOC	Volatile Organic Compounds		
Units			
km	kilometre	µg/kg	micrograms/kilogram
m	Metre	µg/L	micrograms/litre
mg/kg	milligrams/kilogram	ppm	parts per million
mg/L	milligrams/litre	t	tonne

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1.0 Introduction

1.1 Preamble

AECOM Australia Pty Ltd (AECOM) was engaged by the Land Development Authority (LDA) to prepare a sampling, analysis and quality plan (SAQP) for an Additional Contamination Investigation) at a portion of land within the Kingston Foreshore Development Precinct (KFDP) known as the Heritage Precinct, hereafter referred to as 'the Site'. The Site location, in the context of the wider KFDP, is shown on Figure 1 and the Site layout is shown on Figure 2 (in Appendix A).

The purpose of the Additional Contamination Investigation is to address data gaps identified in the previous environmental site assessment (ESA) undertaken at the Site, which was completed in conjunction with investigations at the adjacent Development Precinct (see Figure 1). The overall purpose of the Additional Contamination Investigation is to assess the suitability of the Site is suitable for continued mixed use, including a weekly market, museum and operational glassworks, car parking and various other commercial facilities. While it is acknowledged that the current zoning of the Site allows for high-density residential land uses, based on the heritage status of the buildings within the Site and the intentions of the current land owners (LDA), it is unlikely that residential development would occur at the Site. The end land use of the Site is therefore considered to be commercial/industrial, in accordance with the exposure scenarios outlined in *the National Environment Protection (Assessment of Site Contamination) Measure*, 1999 as amended in April 2013 (the ASC NEPM).

Following a previous ESA undertaken by AECOM (refer to Section 3.1), the VIC EPA accredited Site Auditor, Mr Roger Parker of Golders Associates Pty Ltd (Golder), identified a number of data gaps that he required to be further considered in order to provide a site audit statement (SAS) for the Site. The key issues identified by the Auditor, comprised:

- Further consideration of contamination associated with the former Burmah Fuel Station, located immediately to the south of the Site and now occupied by high-density residential properties.
- The possibility that light non-aqueous phase liquids (LNAPL) may be present beneath the surface of the Site.
- The requirement for removal and validation of underground storage tanks (USTs) and associated infrastructure.
- The nature and extent of a hydrocarbon plume in groundwater beneath the Site, including the potential for multiple contamination sources.
- The potential for vapour risks associated with hydrocarbons in groundwater, including the potential for preferential pathways such as service trenches.
- The extent of coverage provided by the previous ESA, including beneath existing heritage buildings.
- The location, depth and construction of groundwater monitoring wells.
- The identification of odours at locations where contamination was reported.

The proposed scope of the Additional DSI described in this SAQP is considered to address the above issues and either provide the Auditor with the required level of confidence that the Site is suitable for continued commercial land use or provide sufficient information to develop an appropriate remediation and/or management strategy.

1.2 Objectives

The overall objectives of this SAQP are:

- To describe the scope of and rationale for the additional works proposed for the Site to address the Auditor's concerns and adequately demonstrate that the Site is suitable for ongoing commercial/industrial use and/or support the most appropriate remediation and/or management of the Site, with respect to contamination.
- To ensure that additional soil and groundwater contaminant data are obtained in accordance with NSW Environment Protection Authority (EPA) endorsed guidelines and the ASC NEPM;
- To describe applicable soil and groundwater guidelines to be used for assessing the analytical results obtained.

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- To define the data quality objectives (DQOs) and quality control / quality assurance (QA/QC) procedures for the assessment.

1.3 Scope of Work

In consideration of the Auditor's comments, there are considered to be three main areas where additional works are required to achieve the required confidence that the Site is suitable for ongoing commercial/industrial land use or to support the development of an appropriate remedial/management strategy:

- The **extent** of petroleum hydrocarbon contamination in soil and groundwater beneath the Site, including contamination resulting from:
  - The former Burmah Fuel Station.
  - USTs located adjacent the Fitter's Workshop in the centre of the Site.
  - Other potential sources, including on-site within the Old Bus Depot Markets and off-site.
- The **nature** of petroleum hydrocarbon contamination, including the potential for light non-aqueous phase liquids (LNAPL) to be present and the potential vapour risk to Site users under the current building configuration and future commercial industrial use.

The proposed scope of work is described in detail in Section 7.0 of this SAQP and is summarised below.

Table 1 Proposed Scope of Work

Scope of Work Item	Rationale
Groundwater gauging of all existing wells using an interface probe (IP)	- To assess current conditions and SWLs and guide the installation and construction of new wells - To assess groundwater flow direction and anomalies in groundwater SWLs, potentially indicating preferential groundwater flow pathways. - To assess the potential presence of LNAPL
Decommissioning and reinstallation of two key existing wells proposed (MW11 and MW2) due to changes in SWLs after drilling	- A review of the previous monitoring wells construction details and SWLs will be conducted to assess potential impacts to the representativeness of the samples collected. - The two nominated wells will be replaced due to the potential for LNAPL to be present, which would not necessarily be detected where SWLs have risen above the screened interval of the wells after drilling and installation.
Installation of three soil bores and conversion of each borehole into a groundwater monitoring well at the south and south western boundary of the Site. Soil and groundwater sampling and analysis from each	- To assess the potential for significant contamination to be migrating onto the Site from this former source - To further assess the nature and extent of soil and groundwater impacts at the at the southern Site boundary adjacent the former Burmah Fuel Station
Installation of three soil bores and conversion of each into a groundwater monitoring well, in the vicinity of the USTs adjacent the Fitter's Workshop. Soil and groundwater sampling and analysis from each	- Assess the potential for leaks and spills associated with the UST(s) to have impacted surrounding soil and groundwater and inform a remediation and/or management strategy if necessary. It is noted that due to the location of the UST(s) adjacent a heritage listed building, decommissioning of the UST(s) via removal may not be possible.
Installation of three soil bores and conversion of each into a groundwater monitoring well, in the central	- Historical photographs have indicated the potential for additional, as yet unidentified USTs in

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Scope of Work Item	Rationale
northern portion of the Old Bus Depot Markets (in the vicinity of existing well MW2) where elevated light fraction petroleum hydrocarbons and benzene have been reported.	the northern portion of the Old Bus Depot. Concentrations of total petroleum hydrocarbons (TPH C6-C9) and benzene have been reported in soil and groundwater in this area. - While it is considered possible that the impacts in MW2 are attributable to the onsite migration of contamination from the former Burmah Fuel Station, assessment is required to assess the potential for an additional source and to provide further assessment of the extent of impacts in this area.
Installation of eight sub-slab vapour pins throughout Old Bus Depot Markets (four), Fitters Workshop (two) and Glassworks (two). Sampling from each pin. Collection of ambient air samples from within each building (three)	- Assess the presence of contamination beneath the buildings that may present an unacceptable risk to Site users and inform a remediation/management strategy, as necessary - Soil vapour pins are considered to be the most practicable assessment tool within the heritage listed buildings - Sub-slab pins will be targeted towards locations where elevated soil and groundwater concentrations of CoPC have been reported and will also be used to target potential preferential pathways if identified such as service trenches. - Ambient air samples will be used to assess in-air concentrations of CoPC within occupied areas of the buildings
Groundwater monitoring event (GME) including all existing and newly installed groundwater monitoring wells, and survey of all newly installed wells	- To further assess the nature and extent of contamination in groundwater on the Site with respect to potential risks to Site users and off-site migration
Aquifer testing (rising head tests) on selected wells (up to four)	- To assess groundwater flow velocities and assess the potential for contamination to migrate off-site

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2.0 Site Identification

2.1 Site Details

Table 2 Site Details

Item	Description
Site Owner and Occupier	LDA The Site is currently occupied by: - Old Bus Depot Markets, which occur once per week with the building otherwise unoccupied - Canberra Glassworks (former Power House Complex) - Canberra Fitters Workshop, used intermittently as an art exhibition space - Areas of hard landscaping and car parking
Site Address	Wentworth Avenue, Kingston ACT
Legal Description (Lot and DP)	(part) Block 9 Section 49 (part) Block 12 Section 49
Local Government Authority	ACT Government
Current Zoning	Commercial CZ5 Mixed use
Current Land Use	Mixed commercial uses
Proposed Land Use	Commercial – no change
Site Elevation	Approximately 560 m AHD
Site Area	Approximately 1.7 hectares (ha)
Neighbouring Land Use - North	The KFDP Development Precinct, currently comprising sealed car parking areas, with Telopea Park Substation, Eastlake Parade, high density residential buildings and Lake Burley Griffin beyond
Neighbouring Land Use – East	Undeveloped land known as KFDP Site 3, with Eastlake Parade, mixed use high density residential and commercial buildings and Lake Burley Griffin beyond
Neighbouring Land Use - South	High density residential buildings (partially constructed on the former Burmah Fuel Station site), with Giles Street and high density residential buildings beyond
Neighbouring Land Use - West	Wentworth Avenue with medium density residential buildings and a church beyond.
Site Location	Figure 1
Site Layout	Figure 2

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3.0 Previous Environmental Reports and Data Gaps

3.1 AECOM (2013)

AECOM previously conducted a Phase 2 ESA at the Site and within the KFDP Development Precinct located directly to the north, which was reported in *DRAFT Environmental Site Assessment Kingston Foreshore Development Precinct Package 2, 20 June 2013*. This report (hereafter referred to as 'the Draft Package 2 ESA') was reviewed by the Site Auditor and comment were provided on 8 August 2013.

The Draft Package 2 ESA assessed the suitability of the Site (in conjunction with the Development Precinct) for commercial/industrial land use, and included a total of 60 soil sampling locations and 16 groundwater monitoring wells. Up to 5000 m^2 of the Site was not assessed due to the presence of heritage buildings and services/easements.

Sub-surface conditions at the Site were found to comprise fill materials in approximately half of the soil sampling points, typically beneath the Old Bus Depot Markets and near the Wentworth Avenue (western) Site boundary. Natural soils were described as sandy gravelly clay and siltstone bedrock was also encountered at between 1 and 3.2 m below ground surface (bgs). Stabilised groundwater levels were gauged between 3.2 and 7.7 m bgs over two GMEs, with an average of 4.9 m bgs.

Contamination in soil was found to be limited, comprising:

- **Asbestos** (non-respirable fibre bundles and a fragment of asbestos containing materials [ACM]) in two test pits, both of which are located in the north western portion of the Site. In addition, previous assessment completed by others identified asbestos in service trenches near the Power House Complex (now the Canberra Glassworks).
- **Petroleum hydrocarbons**, including total petroleum hydrocarbons (TPH) and/or benzene at concentrations greater than the NSW EPA (1994) threshold criteria at three sampling locations, all of which are within the boundaries of the Site. Comparison of the data against health screening levels (HSLs) developed by CRC CARE indicated that the results were below the HSLs for soil vapour intrusion in clay soils and for direct contact.

It was acknowledged that there was potential for contamination to occur beneath the heritage listed buildings located on the Site where intrusive investigations were not possible, though the likelihood was considered to be low.

Groundwater impacts were reported as:

- **Petroleum hydrocarbons**, TPH and/or benzene, toluene, ethylbenzene and xylenes (BTEX) in five wells in the vicinity of the Old Bus Depot Markets (i.e. within the Site). The Draft Package 2 ESA reported that the impacts were limited and unlikely to have migrated to Lake Burley Griffin. Furthermore, comparison of the data against CRC CARE HSLs indicated that the concentrations reported were below the HSLs for vapour intrusion.
- **Lead** was reported in one groundwater sample located in the south-western corner of the Site and closest to the former Burmah Fuel Station.
- **Zinc, copper and nickel** were reported in a number of groundwater samples with the concentrations considered to be representative of background conditions.

Overall, The Draft Package 2 ESA concluded that the Site, in conjunction with the Development Precinct, was suitable for continued commercial/industrial land use, subject to the preparation and implementation of a construction management plan (CMP) to address the identified asbestos impacts in soil and any unexpected finds during redevelopment. It was also noted that two USTs, located adjacent the Fitters Workshop should be removed and validated.

3.2 Golder (2013)

As noted above, the Draft Package 2 ESA was reviewed by the Site Auditor and comments provided in Auditor *Comments on the AECOM Draft Environmental Site Assessment, Package 2, Kingston Foreshore Development Precinct, Kingston, ACT, 8 August 2013*.

The Auditors key comments are summarised in Section 1.1.

The scope of works described in this SAQP is intended to satisfy the Auditor's concerns regarding residual contamination and the Site's suitability for future commercial use.

3.3 AECOM (2015)

AECOM has recently prepared a finalised Phase 2 ESA report for the KFDP Development Precinct, dated 18 May 2015 (the Development Precinct ESA). The Development Precinct ESA addressed the Auditor's comments provided in Golder (2013) as far as they related to the Development Precinct.

It is noted that additional works were undertaken since the issue of AECOM (2013), comprising:

- Re-drilling of four boreholes (BH102, BH103, BH111 and BH113) using push-tube sampling methods to characterise fill materials.
- Drilling of six boreholes (BH200 – BH205) in the north-western portion of the Development Precinct (noting that access was not available within the Telopea Park Substation site).
- Purging and sampling groundwater from six monitoring wells (MW01 and MW06-MW10) in December 2013.
- Laboratory analysis of soil and groundwater samples collected during the additional works, described above.

The Development Precinct ESA stated that petroleum hydrocarbons (TPH) were reported in one soil sample (BH107, 1.2 m bgs) at a concentration above the threshold criteria from NSW EPA (1994) but below the CRC CARE HSLs for vapour instruction in clay soils and for direct contact. Heavy metals (lead and zinc) were also reported above the soil assessment criteria (SAC) in one location (BH102). The results from this and surrounding sampling locations indicated that the impact was localised. Based on the proposed concept plan for the redevelopment of the Development Precinct, this location was noted to be within the footprint of a proposed ground-floor commercial property, and was not considered to represent a risk to human health or the environment.

Petroleum hydrocarbons (TPH) were reported in groundwater samples from MW07 (2011) and MW06 (December 2013). The concentrations were reported above the laboratory limit of reporting (LOR) but less than the groundwater assessment criteria (GAC). Copper, nickel and zinc in groundwater were considered to be representative of background conditions.

The Development Precinct ESA concluded that the Development Precinct was suitable for the proposed commercial/industrial and high-density residential land use, subject to the implementation of the CMP.

The CMP was considered necessary to address potential unexpected finds that could be encountered during redevelopment of the Site, including (but not limited to):

- Potential hydrocarbon impacted fill arising from an adjacent diesel generator site.
- Potential asbestos impacts identified in soil during any intrusive maintenance works and/or future development works.
- Unexpected finds of ash waste or fill material containing demolition rubble.
- Unexpected finds of in-ground potential contaminant sources.
- Odorous and/or visually discoloured soils encountered during intrusive maintenance or redevelopment works.
- Processes and procedures for the classification of soil materials prior to off-site disposal or on-site re-use.

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4.0 Conceptual Site Model

4.1 Site Setting and Basis for Assessment Criteria

The Site is located in a former industrial area that is being redeveloped for mixed commercial and high density residential land use. While it is noted that the Site is within an area zoned for 'mixed use' under the Territory Plan, which could also include high-density residential land use, it is understood that the Site will remain commercial in nature for the foreseeable future due to the presence of heritage listed buildings (Power House Complex, now occupied by the Canberra Glassworks and Fitters Workshop). The proposed use(s) for the Site include continued retail space (markets) and a public arts precinct including artist's work and exhibition space and areas of hard landscaping.

Based on the above, the most appropriate assessment criteria for the Site are considered to be Health Investigation Levels (HILs) and HSLs 'D', for commercial/industrial land use exposure scenarios, as outlined in the ASC NEPM.

Where vapour intrusion is considered to be a potentially complete exposure pathway, the HSLs for clay soils and groundwater at 2 to 4 m bgs are considered to be most consistent with Site conditions. However, due to the heterogeneous nature of fill materials, the weathered and possibly fractured nature of the siltstone bedrock and the possibility of coarse-grained backfill material in service trenches creating preferential pathways, assessment against the 'sand' soil profile vapour intrusion HSLs is proposed, to be conservative.

With regards to groundwater, there are no known groundwater abstraction bores within the Site or in the surrounding area. Based on the industrial history of the Site and the Site location in an urban area with reticulated potable water supply, it is considered unlikely that groundwater would be abstracted for any beneficial use such as drinking or irrigation. Potential exposure scenarios associated with groundwater contamination are therefore limited to vapour intrusion or off-site migration to ecological and recreational human health receptors (in Lake Burley Griffin). It is noted that contaminants of potential concern (CoPC) have generally not been identified in samples collected from groundwater monitoring wells within the Development Precinct, which is down hydraulic gradient of the Site.

The propsoed assessment criteria for soil and groundwater are outlined in Section 5.0.

4.2 Geological and Hydrogeological Setting

Previous investigations within the Site and the Development Precinct identified:

- Fill materials comprising gravelly sandy clay (likely to be re-worked natural soils) and road-base type gravels with traces of concrete, metal, terracotta pipe, charcoal and timber. The deepest fill was encountered beneath the Old Bus Depot and adjacent the Wentworth Avenue Site boundary, up to 2.2m.
- Soft to stiff sandy gravelly clay to stiff red clay.
- Weathered siltstone bedrock (encountered between 1 m and 3.2 m bgs).

Groundwater beneath the Site occurs in the siltstone bedrock, with SWLs in the previously installed wells measured between approximately 3 and 8 m bgs. Over the two previous GMEs, SWLs were on average 0.3m deeper in 2013 than in 2011. Based on the SWLs, groundwater flow was inferred to be towards the north, with a hydraulic gradient of 0.006 m/m.

During the previous investigations, SWLs were reported to be above the screened interval in two monitoring wells in 2011 (MW03 and MW04) and in four monitoring wells in 2013 (MW2, MW11, MW12 and MW15). These wells are all located within the Site. The reason for the elevated SWLs is unclear, but may be associated with fractures in the bedrock and preferential groundwater flow pathways.

Of the above wells, two are considered to be of significance with respect to contamination (MW2 and MW15), where the possible presence of LNAPL may not be detected due to the well construction and SWLs. As a result, these wells are proposed to be decommissioned and reinstalled.

4.3 Areas of Environmental Concern and Contaminants of Potential Concern

Based on previous investigations undertaken by AECOM, areas of environmental concern (AEC) and associated contaminants of potential concern (CoPC) are described below.

Table 3 AECs and CoPC

Consideration	AEC	CoPC
On-site	USTs, triple interceptor trap and general workshop activities: - Petroleum hydrocarbons have been identified in soil and groundwater in the vicinity of the USTs near the Fitters Workshop	TPH, BTEX, PAH, lead
	Ash waste associated with the former Power Station. Expected to be restricted to the shallow subsurface due to potential use as filling material - It should be noted that due to the presence of historical building structures within the Site boundary, uncontrolled filling of the Site with powerhouse ash waste materials is considered to be unlikely	PAHs
	Former Blacksmith operations: - Impacts (if any) considered to be limited to shallow surface soils	Metals and PAHs
	Fill materials: - Potentially containing ACM. - Previous investigations indicated that asbestos impacts were limited within the Site	Asbestos
	Former workshops and maintenance areas: - Possible use of degreasers/thinners containing solvents - Note, chlorinated hydrocarbons have not been reported above the LOR during previous sampling events	Chlorinated hydrocarbons, TPH
	Imported fill: Unknown origin and quality	Metals, petroleum hydrocarbons (TPH, BTEX), PAHs, asbestos, pesticides (OCP/OPP), PCBs
	Possible as yet unidentified USTs in the central northern portion of the Old Bus Depot, in the vicinity of MW2	TPH, BTEX, PAHs
Off-site	Site 3: - Ash material identified within the adjacent Site 3 with high concentrations of TPH and PAH	TPH, PAHs
	Former Burmah Fuel Station, to the immediate south of the Site: - Petroleum hydrocarbon impacts have been reported in groundwater in monitoring wells near the southern Site boundary	TPH, BTEX, lead

Previous off-site sources of potential contamination (as identified in AECOM [2013]) such as the Telopea Park Substation are not considered to be relevant to the Site due to their being down gradient.

4.4 Extent of Soil Impacts

Soil impacts have been identified at within the Site as described below:

- Asbestos:
  - Positively identified in two soil samples from test pits TP6 and TP8 in the north-western portion of the Site. The asbestos was reported in the form of a fragment of ACM sheet and a non-respirable fibre bundle. Based on the results, asbestos impacts are considered to be localised and unlikely to represent an unacceptable risk to Site users or the environment, subject to implementation of a management strategy.
- Petroleum hydrocarbons:
  - Heavy fraction TPH (C_{10} – C_{36}) was reported at concentrations greater than NSW EPA (1994) threshold levels at two locations (TP5, 0.6 – 0.8m and MW15, 5.0m). The source of these impacts is not considered to be the same. At TP5, the source is considered likely to be coal-like materials identified in fill, which was not observed at other locations. It is noted that TPH results from deeper samples in TP5 and from adjacent test pits were less than LOR. As a result, and in consideration of the marginal exceedance and the conservative nature of the NSW EPA 91994) threshold criteria, this impact is considered to be localised and unlikely to present an unacceptable risk to human health or the environment.
  - At MW15, the detection of TPH (C_{10} – C_{36}) is considered to be potentially associated with USTs adjacent the Fitter's Workshop. It is noted that heavy fraction TPH was also reported in groundwater at this location. The extent of TPH impact in this area of the Site has not been determined.
  - Light fraction TPH (C_6-C_9) and BTEX were reported in soil at MW2 (11.5 - 12.0m bgs). Light fraction TPH and BTEX were also reported in groundwater at this location, however the groundwater SWL was recorded at 4.485 m bgs. The extent of this impact has not been determined.

No further soil impacts have been reported at the Site. As a result, it is considered that widespread contamination that would preclude the proposed future use of the Site is not present. However, further investigation is required to assess the extent of the petroleum hydrocarbon impacts reported at MW2 and MW15 and the potential for unacceptable risks to future site users or the environment to be present.

4.5 Extent of Groundwater Impacts

Petroleum hydrocarbon impacts have been identified in groundwater beneath the Site. There are considered to be three main areas of concern, comprising:

- The south-western corner of the Site, characterised by MW11 where elevated concentrations of TPH (C_6-C_9), BTEX and naphthalene have been reported. The likely source of this contamination is the former Burmah Fuel Station to the south of the Site. It is noted that all fuel-related infrastructure was removed from the former Burmah site and the property is now occupied by high-density residential buildings. This site was confirmed as suitable for this land use by a NSW EPA accredited Site Auditor.
- The central portion of the Site, within the Old Bus Depot Markets, characterised by conditions reported at MW2 with elevated concentrations of TPH (C_6-C_9), BTEX and naphthalene. Based on historical photographs, there is the potential for as yet unidentified USTs to be present in this portion of the Site, It is also considered possible that this contamination could be associated with the former Burmah Fuel Station and may represent the extent of a groundwater contamination plume within the Site. It is noted that MW16, approximately halfway between MW11 and MW2 also reported moderate concentrations of TPH C_6-C_9 and benzene. It is considered unlikely that this contamination is associated with the USTs (discussed below), due to the inferred groundwater flow direction at the Site and the similar chemical signatures to the impacts reported in MW11. However, this cannot be confirmed at this stage and requires further assessment.
- Adjacent the USTs to the south of the Fitters Workshop, where heavy fraction TPH (C_{10} – C_{36}) has been reported in groundwater. The contamination is considered likely to be associated with the USTs and associated infrastructure and appears to be limited in extent (based on concentrations of TPH (C_{10} – C_{36}) less than the LOR in the next closest wells). It is noted that given the northerly groundwater flow direction, contamination from the USTs could potentially extend beneath the Fitters Workshop and further clarification of potential risks is required.

- It is noted that a series of wells located around the boundaries of the Site have not reported concentrations of petroleum hydrocarbons above the laboratory LORs. The chemical signatures of the hydrocarbon impacts are also not considered to be indicative of sources other than petroleum hydrocarbons (i.e. no solvents, creosote etc) possibly associated with off-site land uses including the print works and sawmill. As a result it is not considered likely that there is an as yet unidentified off-site source of contamination to the south or south-west. Similarly, it is not considered likely that contamination is migrating off-site to the north, though this is required to be confirmed with respect to impacts reported at MW15. The possibility for future migration of impacted groundwater is however, required to be considered.

Heavy metals reported in groundwater are considered likely to be representative of background conditions and are not considered to require further assessment.

4.6 Potential Receptors

Potential receptors of contamination at the Site comprise:

- Current and future Site users, including workers and visitors.
- Current and future intrusive maintenance workers.
- Future users of buildings developed on the Development Precinct, directly north of the Site.
- Recreational users of and ecological receptors within Lake Burley Griffin, as the closest receiving water body.

4.7 Transport Mechanisms and Exposure Pathways

The following transport mechanisms for contamination at the Site have been identified:

Table 4 Contaminant Transport Mechanisms

Transport Mechanism	Details	Notes
Leaching of soil contaminants	Heavy fraction petroleum hydrocarbons have been identified in soils in the vicinity of the USTs and associated with coal-like fill material in the north-west of the Site.	Significant leaching from the coal materials to groundwater is considered unlikely based on the limited extent of the soil impact and the depth of contamination (0.6 – 0.8 m bgs) compared to depth to groundwater at this location (approximately 4-5 m bgs) Leaching of heavy fraction petroleum hydrocarbons in the vicinity of the USTs is considered possible on the basis that groundwater impacts have been reported in this area and the contamination in soils was reported at 5 m bgs, which is consistent with groundwater SWLs.
	Light-fraction petroleum hydrocarbons were reported in bedrock in the centre of the Site (11.5 – 12 m bgs)	Leaching of light fraction petroleum hydrocarbons to groundwater at this location is considered possible based on the identified groundwater impacts.
Groundwater flow	Dissolved and separate-phase hydrocarbons may migrate due to groundwater flow and geology at the Site. Fractures or weathered zones in bedrock (siltstone) may act as preferential pathways for groundwater flow.	The presence of LNAPL has not been confirmed at the Site, but indicators have been observed (oil globules reported at MW15, and elevated concentrations of TPH C_6-C_9 and benzene at MW11). Fractures in the bedrock may facilitate preferential migration of contaminants and migration inconsistent with the expected groundwater flow direction
Vapour migration	Volatile contaminants in soil and groundwater may generate vapours	Volatile CoPC have been reported at elevated concentrations in groundwater and

Transport Mechanism	Details	Notes
	that migrate through the subsurface and accumulate in buildings or other structures (service trenches etc.). Underground service trenches backfilled with coarse-grained materials may also act as preferential pathways for vapour migration	soil in the south western and central portions of the Site. Vapours may therefore migrate and accumulate within the Old Bus Depot and Fitters Workshop. Based on the extent of soil and groundwater impacts identified at the Site, vapour accumulation within the Glassworks building is not considered likely but will be assessed for completeness.

In order for a receptor to be exposed to a chemical contaminant deriving from a site, a complete exposure pathway must exist. An exposure pathway describes the course a chemical or physical agent takes from the source to the exposed individual or receptor.

Based on the preliminary CSM details above, the following exposure pathways exist at the Site.

Table 5 Potentially Complete Exposure Pathways

Source / Identified Impact	Pathway	Receptor	Linkage Potentially Complete?
Soils impacted with heavy fraction TPH (TP5)	Direct contact, ingestion	Site users (workers and visitors) Intrusive maintenance worker	No Yes
	Leaching to groundwater	Groundwater	No
	Vapour migration (unlikely due to semi/non-volatile nature of CoPC, outdoor air)	Site users (workers and visitors) Intrusive maintenance worker	No No
Soils impacted with heavy fraction TPH (MW15)	Direct contact, ingestion	Site users (workers and visitors) Intrusive maintenance worker	No Yes
	Leaching to groundwater	Groundwater Site users (workers and visitors) Intrusive maintenance workers	Yes No Yes
	Groundwater flow	Future users of adjacent sites (Development Precinct) Recreational users of receiving surface waters Receiving surface water ecosystems	Yes Yes Yes
	Vapour migration (unlikely due to semi/non-volatile nature of CoPC, indoor air)	Site users (workers and visitors) Intrusive maintenance worker Future users of adjacent sites (Development Precinct)	Yes Yes Yes
Soils impacted with light fraction TPH and BTEX (MW2)	Direct contact, ingestion	Site users (workers and visitors) Intrusive maintenance worker	No Yes

Source / Identified Impact	Pathway	Receptor	Linkage Potentially Complete?
	Leaching to groundwater	Groundwater Site users (workers and visitors) Intrusive maintenance workers	Yes No Yes
	Groundwater flow	Future users of adjacent sites (Development Precinct) Recreational users of receiving surface waters Receiving surface water ecosystems	Yes Yes Yes
	Vapour Migration	Site users (workers and visitors) Intrusive maintenance worker Future users of adjacent sites (Development Precinct)	Yes Yes Yes
Groundwater impacted with light fraction TPH and BTEX migrating onto, and potentially though, the Site (MW11, MW16, MW2)	Direct contact, ingestion	Site users (workers and visitors) Intrusive maintenance worker	No Yes
	Groundwater flow	Future users of adjacent sites (Development Precinct) Recreational users of receiving surface waters Receiving surface water ecosystems	Yes Yes Yes
	Vapour migration	Site users (workers and visitors) Intrusive maintenance worker Future users of adjacent sites (Development Precinct)	Yes Yes Yes
	Direct contact, ingestion	Site users (workers and visitors) Intrusive maintenance worker	No Yes

4.8 CSM Summary

The Site is located in an area of urban regeneration, however, significant future development of the Site itself is considered unlikely due to the presence of heritage listed buildings. Therefore, the anticipated future land uses is consistent with commercial/industrial exposure scenarios outlined in the ASC NEPM.

The Site comprises mostly sealed surfaces (buildings and hard landscaping), with clay fill and underlying siltstone bedrock. Groundwater is present at approximately 3 - 8 m bgs and data indicates groundwater flows in a northerly direction towards Lake Burley Griffin.

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Localised asbestos and heavy fraction TPH contamination has been identified in soil in the north western portion of the Site. The risk to human health and the environment associated with these impacts is considered to be low and manageable through a CMP. An environmental management plan (EMP) has been developed for the Site and approved by the Site Auditor, which is considered to satisfactorily address the requirements of the CMP as outlined in Section 3.1.

Heavy fraction TPH contamination has also been identified in soil and groundwater in the vicinity of USTs adjacent the Fitters Workshop. The extent of this contamination has not been defined and there are potentially complete pollutant linkages associated with this contamination and Site users, intrusive maintenance workers, groundwater, down-gradient site users and the receiving surface water environment (Lake Burley Griffin). Further assessment is required to assess the following potential risks:

- Vapour migration and accumulation within the Fitters Workshop.
- Risks to intrusive maintenance workers
- Off-site migration of contaminated groundwater, impacting on down gradient receptors.

Light fraction TPH and BTEX contamination has been identified in the south eastern and central portions of the Site, considered likely to be associated with the former Burmah Fuel Station to the south and possibly additional former USTs in the central/northern portion of the Site. The extent of this contamination has not been confirmed and there are potentially complete pollutant linkages between this contamination and Site users, intrusive maintenance workers, groundwater, down-gradient site users and the receiving surface water environment (Lake Burley Griffin). Further assessment is required to assess the following potential risks:

- Vapour migration and accumulation within the Old Bus Depot Markets, including via preferential migration pathways. Risks to users of the Fitters Workshop and Glassworks are considered to be low based on the analytical results received to date in groundwater monitoring wells adjacent these buildings
- Risks to intrusive maintenance workers
- Off-site migration of contaminated groundwater, impacting on down gradient receptors. As noted above, these risks are considered to be low based on the analytical results received from down-gradient monitoring wells within the Site and the adjacent Development Precinct. However the potential for future migration cannot be precluded at this stage.

5.0 Site Assessment Criteria

5.1 General

The current assessment criteria endorsed by the ACT EPA to evaluate soil analytical results are based on the following guidelines:

- ACT EPA, 2000. *Contaminated Sites Environment Protection Policy*
- NSW EPA, 1994. *Guidelines for Assessing Service Station Sites*
- NSW DEC, 2006. *Guidelines for the NSW Site Auditor Scheme (2nd Edition)*
- National Environment Protection Council (NEPC). 1999. *National Environment Protection (Assessment of Site Contamination) Measure*
- *Guidelines* for the Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia (WA DoH, 2009).

AECOM notes that on advice received from the ACT EPA, as the investigation commenced prior to the adoption of the amended ASC (2013) NEPM, previous investigation works were undertaken in accordance with the requirements of the 1999 NEPM. However, for the next stage of works, it is considered appropriate to adopt the ASC NEPM.

Additionally, AECOM proposes to adopt the CRC CARE, Friebel, E and Nadebaum, P (2011) *Health screening levels for petroleum hydrocarbons in soil and groundwater* commercial/industrial land use criteria for petroleum hydrocarbons in soil for assessment if direct contact exposure pathways.

Application of these guidelines to the proposed Additional Contamination Investigation is described below.

5.2 Soil Assessment

5.2.1 Overview

The following soil assessment criteria (SAC) (endorsed by ACT EPA) will be consulted to evaluate whether the soil analytical results represent a potential risk to human health under a commercial/industrial land use:

- NEPC (2013): *Schedule B(1) Guideline on Investigation Levels for Soil and Groundwater* and *Schedule B(2) Guideline on Site Characterisation*, specifically:
  - HIL D (commercial/industrial); and
  - HSL D – Sand – 0 to 1m (commercial/industrial).
- Friebel & Nadebaum (2011) Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE) Health Screening Levels (HSLs) for Petroleum Hydrocarbons in Soil and Groundwater. Soil HSLs, specifically:
  - Direct contact HSL D (commercial/industrial);
  - Intrusive maintenance worker – Direct Contact HSL; and
  - Intrusive maintenance worker HSL – sand 0 - <2m.

The following rationale was applied in the selection of these SAC:

- Commercial/industrial standards (HIL D, HSL D and Industrial land use) will be adopted as they are most applicable to the existing and proposed commercial land use for the Site;
- For HSLs, sand will be selected as the soil type and the shallowest depth to contamination (0-<1m) as these are the most conservative options and are intended to account for preferential pathways through weathered bedrock, fractures of service trenches with coarse-grained backfill.;
- Assumed soil impact (where detected) does not extend off-Site based on the results of the KFDP Package 2 ESA; and
- Ecological screening criteria have not been adopted for soil as there are not considered to be any ecological receptors for soil on-site.

5.2.2 Adopted Soil Acceptance Criteria

The proposed soil assessment criteria (SAC) or the Site are summarised below.

Table 6 Soil Assessment Criteria

	ASC NEPM	ASC NEPM	CRC CARE	CRC CARE	CRC CARE
	HIL D	HSL D – Sand – 0-<1m	HSL D – Direct Contact	IMW – Sand – 0-<2m	IMW – Direct Contact
Benzene		3	430	77	1100
Toluene		NL	99 000	NL	120 000
Ethylbenzene		NL	27 000	NL	85 000
Xylene total		230	81 000	NL	130 000
F1		260	26 000	NL	82 000
F2		NL	20 000	NL	62 000
TPH C16-C34			27 000		85 000
TPH C34-C40			38 000		120 000
Naphthalene		NL	11 000	NL	29000
Benzo(a)pyrene TEQ	40				
PAHs (total)	4000				

All in mg/kg
F1 – TPH C6-C10 less BTEX
F2 – TPH C10 – C16 less naphthalene
Benzo(a)pyrene assess as carcinogenic PAHs in accordance with the ASC NEPM
NL – Not limiting. A vapour source concentration for a petroleum mixture could not exceed a level that would results in the maximum allowable vapour risk for the given scenario

5.3 Groundwater Assessment

5.3.1 Human Health Screening Criteria

A search of registered groundwater bores within a 1 km radius of the Site indicated that no bores are used for beneficial purposes (i.e. drinking water, irrigation, domestic etc.). Additionally, the surrounding commercial and residential areas receive a reticulated potable water supply, therefore the potential for use of groundwater for drinking water purposes or incidental exposure via irrigation is considered to be low.

For vapour intrusion, CoPCs were identified as volatile according to their Henry's Law Constant and vapour pressure as defined by NEPC (2013): *Schedule B2 – Guideline on Investigation Levels for Soil and Groundwater*.

Groundwater HSLs for vapour intrusion (BTEX, TPH and naphthalene) are available for sites where groundwater is deeper than 2.0 m bgl (Friebel, E. and Nadebaum, P., 2011). Depths to groundwater at the Site have been measured between approximately 3 m and 8 m bgs.

The following hierarchy of human health screening criteria is proposed:

- Commercial Worker: NEPC (2013) –HSL D – Sand – 2-4 m (commercial/industrial) ; and
- Intrusive maintenance worker: CRC CARE (2011) - Direct Contact HSL D – Sand – 2-4 m (commercial/industrial).

The most conservative values of the above guidelines were selected and are considered protective of both the commercial worker and intrusive maintenance worker receptors. As for soil, the sand soil profile has been selected to account for variation in fill material, weathered and fractured bedrock and potential coarse-grained backfill in service trenches.

In addition, as potential off-site receptors include recreational users of Lake Burley Griffin, the Australian Drinking Water Guidelines (ADWG) will be used to assess recreational exposure (10 x the ADWG), where available.

5.3.2 Ecological Screening Criteria

The following hierarchy of ecological screening criteria is proposed:

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (ANZECC, 2000). Lake Burley Griffin is the closest receiving water body and is assumed to be a fresh water environment. As such the groundwater results for this assessment have been compared to the ANZECC 2000 Trigger Levels for Fresh Waters with a 95% level of species protection. These include:
  - High Reliability Trigger values;
  - Moderate Reliability Trigger values; and
  - Low Reliability Trigger values (where appropriate).

5.3.3 Groundwater Assessment Criteria

The nominated GAC for the Site are summarised below.

Table 7 Groundwater Assessment Criteria

	Human Health			Ecological
	ASC NEPM - HSL D Sand 2-4 m	CRC CARE – IMW Sand 2-4 m	ADWG – Recreational use	ANZECC Freshwater 95%
Benzene	5		10	950
Toluene	NL		8000	
Ethylbenzene	NL		3000	
Xylene (o)				350
Xylene (total)	NL		6000	
F1	6			
F2	NL			
Naphthalene	NL			
Benzo(a)pyrene TEQ			0.1	

All in ug/L
F1 – TPH C6-C10 less BTEX
F2 – TPH C10 – C16 less naphthalene
Benzo(a)pyrene assess as carcinogenic PAHs in accordance with the ASC NEPM
NL – Not limiting. A vapour source concentration for a petroleum mixture could not exceed a level that would results in the maximum allowable vapour risk for the given scenario

5.4 Vapour Assessment Criteria

Health based investigation levels for comparison of vapour analytical results are selected for the assessment of human health risk. Given the setting of the Site and the surrounding land uses, commercial/industrial receptors have been considered.

Selected assessment criteria are proposed from the following Australian technical report documents, which are considered to be suitable to be applied in the jurisdictions included in the assessment (ACT):

- *Health Screening Levels (HSL) for Petroleum Hydrocarbons in Soil and Groundwater*, Technical Report No. 10, Cooperative Research Council Contamination Assessment and Remediation of the Environmental

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(CRC CARE), 2011 for commercial/industrial (D) land uses are proposed for the purpose of this investigation. As discussed above, as a conservative approach CRC CARE HSL D screening values for sand 0-<1 m bgl are proposed.

- *Petroleum Hydrocarbon Vapour Intrusion Assessment: Australian Guidelines*, Technical Report No. 23, CRC CARE 2013, chronic air guidelines. It is noted that these guidelines are for ambient air and that an attenuation of concentrations would occur from the sub-slab sample location.

The adopted screening values are summarised below.

Table 8 Summary of Assessment Criteria

Analyte	Vapour Screening Criteria (mg/m^3)	Source
Benzene	4	CRC CARE (2011)
Toluene	4800	CRC CARE (2011)
Ethylbenzene	1300	CRC CARE (2011)
Xylene (total)	840	CRC CARE (2011)
Naphthalene	3	CRC CARE (2011)
F1 (TRH C_6-C_{10} minus BTEX) (a)	680	CRC CARE (2011)
F2 (TRH >C_{10}-C_{16} minus naphthalene) (b)	500	CRC CARE (2011)

Notes:

a) F1 - Total Recoverable Hydrocarbons (TRH) C_6 - C_{10} minus benzene, toluene, ethylbenzene and xylenes.

b) F2 - TRH >C_{10}-C_{16} minus naphthalene.

6.0 Data Quality Objectives and Data Quality Indicators

6.1 Data Quality Objectives

To ensure that data of adequate type and reliability are collected and assessed for the investigation, the seven-step Data Quality Objective (DQO) approach, endorsed in the NSW DEC Guidelines for the NSW Site Auditor Scheme 2nd Edition (2006), will be adopted. The DQOs have set quality assurance and quality control parameters for the field and laboratory programs to ensure data of appropriate reliability have been used to assess the environmental condition of the Site.

In determining the type, quantity and quality of data needed to support decisions relating to the environmental condition of the Site, AECOM has undertaken the seven-step process to develop the DQOs in accordance with NSW DEC (2006) guidelines, which is presented in the following paragraphs.

6.1.1 Step 1 – State the Problem

During previous works at the Site, contamination was identified and a number of data gaps remain. The data gaps are required to be addressed to satisfy the Site Auditors previous comments and facilitate the preparation of a site audit statement (SAS) for the Site, confirming that the Site is suitable for continuing commercial/industrial land use.

In summary, additional investigations are required to:

- Assess the potential risk to site users within buildings as a result of soil vapour migration and accumulation.
- Clarify the extent of heavy fraction TPH contamination, including potential LNAPL impacts, in the vicinity of USTs adjacent the Fitters Workshop.
- Clarify the extent of light fraction TPH and BTEX impacts in soil and groundwater in the south western and central portions of the Site and assess the risk of off-site migration.

6.1.2 Steps 2 and 3 – Identify the Decisions to be Made and Inputs Required

Table 9 Data Quality Objectives

Decision	Input
Vapour Assessment	
Are the concentrations of light-fraction TPH and BTEX in soil and groundwater likely to result in an unacceptable risk to Site users in buildings?	Complete additional investigations in the vicinity of the light fraction TPH and BTEX impacts and assess the soil and groundwater analytical results to the vapour assessment criteria provided in the ASC NEPM. Install sub-slab vapour pins and conduct vapour sampling in areas where soil bores/monitoring wells cannot be installed due to access or heritage restrictions.
Are there preferred vapour migration pathways (service trenches, etc) and have these well sufficiently defined and assessed?	Review service diagrams and identify possible services trenches where vapour migration pathways could exist. Target these locations, as far as practicable and safe, with soil bores/monitoring wells or sub slab vapour pins.
UST impacts	
What is the extent of contamination associated with the USTs in soil and groundwater and is this contamination likely to represent an unacceptable risk to Site users in the Fitters Workshop and/or at down-gradient (off-site) receptors?	Install additional soil bores/groundwater monitoring wells in the vicinity of the USTs to assess the lateral and vertical extent of impacts.
Is LNAPL present?	Ensure new groundwater monitoring wells are installed in consideration of the SWLs previously measured at the Site to allow the identification and measurement of LNAPL, if present.

Decision	Input
	Assess concentrations of CoPC against solubility limits.
Light fraction TPH in soil and groundwater in the south wester and centre of the Site	
Has the extent of light fraction TPH and BTEX in soil and groundwater in the central and south western portions of the Site been adequately defined?	Conduct additional groundwater monitoring in existing wells and install new soil bores/monitoring wells to assess the potential lateral extent of soil and groundwater impacts.
Is there potential for off-site migration of this contamination	Conduct a GME including down-gradient monitoring wells to assess the extent of contamination in groundwater. Conduct rising head tests on selected monitoring wells to assess aquifer conditions and groundwater flow rates.
Does this contamination present an unacceptable risk to Site users?	Consider the analytical results in the context of ongoing commercial use using the guidelines presented in the ASC NEPM.

6.1.3 Define the Study Boundaries

The Site is shown on Figures 1 and 2, and is described in Section 2.1. The Additional DSI is a targeted investigation, based on the AECs discussed above. However, it is consider that, when combined with the investigations completed as part of the KFDP Package 2 ESA, sufficient coverage of the Site as a whole will have been achieved.

The vertical extent the Additional DSI will be determined based on field conditions encountered. However, a nominal depth of 8m for new groundwater monitoring wells has been proposed, based on the SWLs previously recorded.

6.1.4 Decision Rules

The development of decision rules relates to the action levels for field blanks, spikes and duplicates and for internal laboratory procedures. A NATA accredited laboratory should be used for all analyses. Assessment procedures of field QA/QC sample results and laboratory QA/QC results are outlined below and in Section 9.1.

Table 10 Development of decision inputs

Aspect	Decision inputs
QA/QC	One in 20 blind duplicates (intra-laboratory), one in 20 (inter-laboratory) one trip spike and one trip blank per sampling event, if sampling volatiles.
Laboratory	Use NATA accredited laboratory and methods for the analytes to be determined appropriate detection limits, assess inter-laboratory and intra-laboratory QA/QC results.
Laboratory Quality Controls	Variation between analytes and between laboratories. If duplicate results are not satisfactory, non-compliance is to be documented in laboratory reports and discussed in the investigation report to assess the impact of non-compliance.
Field blanks, rinsate blanks and method blanks	If blanks exceed the detection limit then non-compliance is to be documented and discussed in the report. The impact of the non-compliance should be assessed in terms of the potential impact on data reliability.
Volatile spiked trip blanks	If the calculated volatile losses for %RPD exceed 30% then non-compliance is to be documented and the potential impact on data reliability discussed in the report.
Recovery of matrix spikes, surrogates and laboratory control samples	If these laboratory recoveries are outside the range of 70% to 140% recovery then non-compliance is to be documented and discussed. Comments on the laboratory analyses QA/QC reports are to be reviewed.
Duplicate samples	If field duplicate calculated RPD exceeds 50% then non-compliance is to be documented and discussed in the report.

6.1.5 Specify performance or acceptance criteria

The require acceptance criteria for data collected are outlined below, in the form of data quality indicators (DQIs) based on the parameters of Precision, Accuracy, Representativeness, Completeness, Comparability and Sensitivity.

Non-compliances with acceptance limits are to be documented and discussed in the report. The DQIs are outlined below.

Table 11 Data Quality Indicators

DQI	Field	Laboratory	Limits
Completeness	All critical locations sampled All samples collected (from grid and depth) AECOM operating procedures appropriate and complied with Experienced samplers Documentation correct	All critical samples analysed and all analytes analysed according to procedures Appropriate methods Appropriate Practical Quality Limits (PQLs) Sample documentation complete Sample holding times complied with	As per the ASC NEPM < nominated criteria As per the ASC NEPM
Comparability	Soil sampling methods will vary between sampling events as push tube sampling techniques are proposed. Experienced samplers Climatic conditions Same types of samples collected	Same analytical methods used (including clean-up) Sample PQLs (justify/quantify if different) Same laboratories (NATA accredited) Same units	As per the ASC NEPM < nominated criteria
Representativeness	Appropriate media sampled according to AECOM procedures All relevant media sampled	All samples analysed according to AECOM procedures. Field meters such as a PID or water quality meter are to be calibrated daily and calibration records maintained.	As per AECOM SOPs
Precision	AECOM procedures appropriate and complied with Collection of blind and split duplicate samples	Analysis of: Blind duplicate samples (1 in 20 samples) Split duplicate samples (1 in 20 samples) Laboratory duplicate samples Laboratory prepared trip blank (1 sampling round)	RPD of 30 to 50% RPD of 30 to 50% RPD of 30 to 50% Recovery >90%

*CoC Contaminants of Concern

All reporting must comply with NSW EPA (1997) *Guidelines for Consultants Reporting on Contaminated Sites,* as applicable.

6.1.6 Optimise the Collection of Data

The collection of data was optimised by the development of an appropriate sampling and analytical strategy based on the previous investigations.

7.0 Sampling Plan and Methodology

7.1 Field Investigation Methodology

7.1.1 Preliminaries

Preliminary activities to be completed prior to conducting the proposed additional investigations include:

- Development of a Site health, environment and safety plan.
- Clearance of proposed intrusive investigation locations using a Dial Before You Dig (DBYD) plans, a service locating subcontractor and a hand auger to a depth of 1.2 m bgs.

7.1.2 Field Investigations

To ensure adequate data is collected to achieve the objectives of the additional investigations, the following field investigations are purposed:

- Conduct a round of groundwater gauging prior to the additional investigations, to measure the current SWLs and presence of LNAPL to guide the installation and construction of additional wells at the Site. All existing wells, if accessible, will be gauged using an interface probe to assess for the presence of LNAPL.
- In the event that conditions are encountered that are not consistent with the previous works, for example, LNAPL in unexpected wells or substantially different SWLs, the scope of additional investigations will be re-assessed.
- Drilling of soil bores at nine locations to an approximate depth of 8 m bgs, to facilitate the collection of soil samples and varying depths in the soil and bedrock profile and further delineate the extent of hydrocarbon impacts at the Site.
- Monitoring wells are to be designed in accordance with minimum construction requirements for water bores in ACT (NUDLC, 2012) and will intersect one lithology/aquifer only with the borehole annulus above the well screen to be infilled with bentonite to isolate other groundwater and surface water.
- Wells will be developed following installation by removing at least ten well volume of water or until the well is dry, to remove sediments associated with the drilling process and increase connectivity with the aquifer.
- Nominal borehole depths are provided (8 m bgs) however, the final monitoring well design including depth, well screen interval and gravel pack interval will be decided in the field by the supervising environmental scientist based on the field logs.
- An assessment of existing monitoring wells will be undertaken and key wells that have been installed with screened interval below the SWL will be decommissioned by redrilling and backfilling with a cement bentonite mix. Borehole decommissioning will be undertaken in accordance with NUDLC, 2012. The current SWL will be confirmed during a round to groundwater gauging prior to the drilling and decommissioning works.
- Conduct one GME to include:
  - gauging of nine newly installed wells, 14 existing monitoring wells on-site and two existing down gradient wells off-site (if accessible);
  - measurement of LNAPL thickness by interface probe and bailer, if identified;
  - surveying the position and top of casing elevation of the new monitoring wells (to m AHD and MGA94); and
  - groundwater sampling of all above wells using low flow purging and sampling techniques.
- Aquifer testing of approximately four monitoring wells to permit assessment of the aquifer permeability.

Note that locations may be adjusted to account for the presence of underground utilities and/or accessibility and similarly, that sampling methodology (eg: drilling methods) may vary slightly.

7.2 Sample Nomenclature

For nomenclature purposes, soil bore and monitoring wells will be designated the "300" series (e.g. MW301).

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All soil samples will have a unique identification number (eg: borehole number and depth). All sampling jars, containers, bottles will be labelled with a project number and task, field identification and date. The analytical data will be imported directly into AECOM's in-house electronic database management system, which eliminates the potential for data transposition error. The AECOM sample nomenclature to be used for the project is provided below.

Table 12 Sample Nomenclature

Sample Location Type	Convention	Example Field Identification
Soil and Groundwater		
Soil bores and groundwater monitoring wells	MW3##	MW301_1.0-1.2 (soil) MW301 (groundwater)
Vapour		
Sub Slab Vapour Pins and ambient air samples	SV1##	SV101
QA/QC Samples		
Field duplicates, inter-laboratory duplicates, rinsate blanks and trip blanks	QC##	QC01.

7.3 Sampling Rationale

To meet the objectives of the additional investigations, a targeted sampling plan has been proposed to respond to specific data gaps.

Table 13 Proposed Sampling Locations

ID	Rationale
MW301	To assess impacts to soil and water as a result of the on-site migration of contaminants from the former Burmah Fuel Station
MW302	To assess impacts to soil and water as a result of the on-site migration of contaminants from the former Burmah Fuel Station
MW303	To assess impacts to soil and water as a result of the on-site migration of contaminants from the former Burmah Fuel Station
MW304	Reinstallation of MW11
MW305	To assess impacts to soil and groundwater as a result of the USTs and associated infrastructure
MW306	To assess impacts to soil and groundwater as a result of the USTs and associated infrastructure and to assess potential northerly extent of the light fraction petroleum hydrocarbon impacts
MW307	To assess impacts to soil and groundwater as a result of the USTs and associated infrastructure and the potential for off-site migration to the north
MW308	Reinstallation of MW2
MW309	To assess impacts to soil and groundwater in the vicinity of MW2
MW310	To assess impacts to soil and groundwater in the vicinity of MW2
MW311	To assess impacts to soil and groundwater in the vicinity of MW2
SV101	To assess sub-slab vapour concentrations in the Old Bus Depot Markets and assess potential risk to Site users
SV102	To assess sub-slab vapour concentrations in the Old Bus Depot Markets and assess potential risk to Site users
SV103	To assess sub-slab vapour concentrations in the Old Bus Depot Markets and assess potential risk to Site users

ID	Rationale
SV104	To assess sub-slab vapour concentrations in the Old Bus Depot Markets and assess potential risk to Site users
SV105	To assess sub-slab vapour concentrations in the Fitters Workshop and assess potential risk to Site users
SV106	To assess sub-slab vapour concentrations in the Fitters Workshop and assess potential risk to Site users
SV107	To assess sub-slab vapour concentrations in the Canberra Glassworks and assess potential risk to Site users
SV108	To assess sub-slab vapour concentrations in the Canberra Glassworks and assess potential risk to Site users
SV109	Ambient air sample collected within Old Bus Depot Workshop
SV110	Ambient air sample collected within Fitters Workshop
SV111	Ambient air sample collected within Canberra Glassworks

Should we just blaze away and do indoor sumas (one per building) in combo with sub-slab pins, in the event that the sub-slabs come back with 'unacceptable hits' ?

7.4 Drilling Programme

The drilling program is to be conducted to collect sufficient soil samples to characterise the soil and to construct monitoring wells at selected locations. Drilling is to commence with a hand auger method to a maximum depth of 1.2 m bgs to minimise the potential for damage to underground services. Drilling is to continue with push tubes to collect undisturbed core samples within the unconsolidated fill and clay. The top of the silstone will be sampled with diamond core drilling.

Drilling is to be conducted by licensed and experienced drilling contractor. Drilled cores are to be collected on-site in core trays and lithologically logged on-site by an AECOM environmental engineer.

Typical borehole construction is to be as follows:

- Drill the hole to the targeted lithology which may vary slightly from the recommended depth;
- The borehole will be drilled at a minimum diameter of 125 mm;
- Clean out the borehole as much as possible removing drilling muds and drill cuttings as much as possible while the drilling rig is set up over the borehole;
- Design the monitoring well targeting one aquifer/lithology with the screen being installed across one lithology only;
- Install machine slotted nominal 50mm diameter casing across the aquifer and to approximately 0.5 m above the SWL, the remainder of the well will be constructed using solid casing.;
- The gravel pack in the annulus will be installed to be around the screen;
- The bentonite seal is to be installed isolating the targeted aquifer from other lithological units;
- The remainder of the borehole annulus is to be infilled with a cement bentonite mix;
- The on-site environmental engineer is to record the monitoring construction well details;
- At the completion of construction the borehole is to be developed by agitating the well with a surge block connected to a Waterra valve pump. The well is to be developed until at least ten well volumes of water have been removed or the well is dry.
- The monitoring well is to be completed with a gatic cover cemented flush with ground level.
- At completion the co-ordinates (ISG grid) and elevation (m AHD) are to be surveyed by a registered surveyor.

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7.5 Hydrogeological Characterisation

The primary methods for estimating hydraulic conductivity are test pumping and slug tests. Test pumping at the Site is not practical since the aquifers are expected to be of low hydraulic conductivity and pumping would not be able to be sustained to stress the aquifer sufficiently and impact observation wells. Pumping the aquifer would also require the collection and disposal of contaminated groundwater. Hence slug tests are the most practical option to estimate groundwater conductivity.

Falling head or rising head tests, also known as or slug tests, will be undertaken to estimate the hydraulic conductivity water bearing zone encountered in weathered siltstone beneath the Site. Slug tests are designed to remove (rising head) or add (falling head) a slug of water and the measured groundwater level response is proportional to the aquifer hydraulic conductivity. Falling head tests can only be conducted on monitoring wells where the well screen is completely submerged. Since the majority of monitoring wells were constructed with the standing water level straddling the well screen (to monitor for the presence of LNAPL) falling head tests are not possible. The tests will be conducted using data loggers to automatically log the water level response.

The slug test procedure is as follows:

1) Measure SWL in the well and time prior to testing.
2) Install the data logger and pressure transducer assembly into the well.
3) Conduct a rising head test by removing a slug of water. There are two main options to remove a slug of water to conduct the rising head test. A bailer can “instantaneously” remove water from the monitoring well however the slug removed is typically only one to two litres and is likely to only draw water from the gravel pack within the borehole annulus. Thus the properties of the aquifer are not measured. A small electro submersible pump can be used to remove a larger volume of water which should draw groundwater from the aquifer. The pump has to be fitted with a non-return valve so water is not allowed to return to the borehole after the pump is switched off. Alternatively the pump can be pulled from the monitoring well as quickly as possible when the standing water level is lowered sufficiently. The quick removal of the pump allows an almost “instantaneous” commencement time as required for the analysis.
4) The time of each test will vary depending on the lithology being tested. The testing of porous sands and fill is likely to be completed in minutes whereas less transmissive shale may take several hours. The objective will be to monitor 75% recovery where possible.
5) At the end of the test measure SWL in the well and time. Check the graph produced by the data logger and if a suitable curve has been produced download the data file and label accordingly.
6) Tests will be conducted from least to most contaminated wells to reduce risk of cross-contamination and decontamination of all equipment as per the groundwater sampling procedures.
7) Aquifer permeability calculations and interpretations will be undertaken post fieldwork, with Aquifer Test software using Hvorslev and Bouwer and Rice Methods.

7.6 Field Programme

7.6.1 Decontamination

Decontamination procedures will include cleaning of soil sampling equipment (e.g.: the hand auger) and groundwater equipment (e.g.: inter face probe, data logger, pumps) prior to the use of the equipment and between sampling events. The equipment will be washed in a deionised detergent solution and rinsed in clean water and dried in air. At a minimum, wash solutions and rinse water will be replaced prior to commencing work at each location. Furthermore, AECOM will ensure the drilling contractor undertakes decontamination of their equipment between borehole locations.

The effectiveness of decontamination procedures will be evaluated by the collection and analysis of rinsate blank samples from the sampling equipment.

7.6.2 Waste Management

Soil cuttings generated during the monitoring well installation works will be placed in 200 L drums for classification and off-site disposal to a licensed waste facility. The drums containing soil cuttings will be labelled with the date filled the borehole identification codes for the origin of the soil, the name of the drilling supervisor and a contact telephone number in case of emergency.

7.6.3 Sample Preservation and Transport

Soil from each sample interval will be packed in a laboratory-prepared and supplied jar with a Teflon-lined lid with minimal head-space. Groundwater samples will be collected into the following laboratory supplied and prepared containers:

- volatile organics (ie: BTEXN, TPH C_6-C_{10},): two 40 mL glass vials, filled so that no headspace remains.
- semi-volatile organics (ie: TPH C_{10}-C_{40} and PAH): one 1000 mL amber glass jar, so that no headspace remains (wherever possible);.
- all soil and groundwater samples will be labelled and placed as soon as practical in an insulated, chilled cooler.

Samples will be kept chilled and transported under chain of custody (COC) protocol to the analytical laboratory. Transport will be by the AECOM field representative and/or laboratory designated courier. Written confirmation of receipt of samples by the laboratories will be obtained and will be assessed by AECOM to ensure that samples were received chilled, intact and within appropriate holding times.

7.7 Soil Sampling

Soil sampling will be undertaken in accordance with AECOM standard procedures. The soil is to be collected from cores from a push tube sample or rotary diamond drilling core, allowing for the collection of relatively undisturbed samples. Push tube and diamond core drilling will be at a minimum diameter of 50 mm diameter.

In summary the soil sampling program will be as follows:

- An environmental engineer will be on-site to direct the drilling and borehole construction program and maintain a geological log of lithologies intersected.
- Soil samples will be collected from each lithology including fill, clay and siltstone.
- Soil samples from depths between 0 and 1 m bgl will be collected from a decontaminated hand auger. Samples from depths greater than 1 m bgl will be collected from push tube cores. A new pair of disposable nitrile gloves will be employed for each sampling event to minimise the risk of cross contamination.
- Soil samples will immediately placed in clean, laboratory prepared 250 ml sampling jars and placed in a chilled esky for transport to the laboratory.
- Additional soil will be placed in a sealed plastic bag for field screening purposes. The bagged samples will screened with a calibrated photoionisation detector (PID) using a 10.6 eV lamp.
- Lithological logs of the soil boreholes will be completed in the field. Soil logs will be completed in accordance with AS1726-1993 and other appropriate Australian and international standards. Soils will be classified in accordance with the Unified Soil Classification System (USCS). Inspection of soils from each sample for the presence of anthropogenic material (i.e. ash, asbestos-cement sheeting etc) will be undertaken;
- Soil cuttings generated during the installation of the groundwater monitoring wells will be placed in labelled 205 L drums for classification and off-site disposal to a licensed waste facility, following approval by ACT EPA.
- Soil duplicate samples will be collected at a rate of 1 per 20 primary samples.
- Soil inter-laboratory (split duplicate samples) will be collected at a rate of 1 per 20 primary samples.

7.8 Groundwater Sampling

Groundwater sampling will be undertaken following the installation and development of the new wells, and will be undertaken approximately 3 to 5 days following installation/development. Groundwater will be sampled from existing wells on-site, two existing well off-site to assess down gradient conditions (MW07 and MW09, if accessible) and all newly installed wells.

The procedure will include:

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- Measurement SWLs within the monitoring wells and evaluation for the presence of LNAPL by an electronic depth to water/interface meter. The meter probe head will be thoroughly cleaned in anionic detergent solution and rinsed with potable water prior to use and between each measurement event.
- Groundwater sampling to be conducted with low flow sampling equipment such as a peristaltic pump for wells where the groundwater level is within three to four metres from ground surface and micropurge sampling equipment will be used for sampling deeper groundwater.
- Purging of well water using low-flow rates (equal or less to 0.5 L/min). Purged water will be passed through a low-flow cell to allow continuous assessment of physio-chemical parameters, including dissolved oxygen (DO), pH, electrical conductivity (EC), redox potential and temperature.
- After recharge of groundwater representative of the surrounding formation (determined by obtaining three consecutive water physio-chemical parameter readings within 10% of each other, or the removal or three well volumes, or the well is purged dry). Groundwater samples will be collected using a low flow pump sampling device, and decanted into laboratory supplied and prepared sample containers.
- A new pair of disposable sampling gloves will be worn for each monitoring well location.

7.9 Soil Vapour Assessment

A building assessment will be undertaken to understand the building use and construction and to determining the most appropriate location to sample sub-slab vapours.

7.9.1 Identification of Sampling Locations

Following the building survey, the following decision process will be employed to identify an appropriate location to install the sub-slab Vapor Pin^{TM}:. A Vapor Pin^{TM} is a re-usable, flush mounted sub-slab soil gas sampling device, which can be installed for the purpose of assessing sub-slab vapour concentrations.

- Identification of previous sampling locations where soil and groundwater impacts were reported (if applicable).
- Identification of preferential pathways (e.g. service trenches).
- Identification of on-site receptors. Sampling locations were targeted to the areas where routine “work” occurs for extended periods (e.g. offices) or where vapours have the potential to accumulate (e.g. in enclosed spaces).
- Identification of potential on-site ambient source zones (e.g. chemical storage areas). Sampling locations would be selected to be located away from these areas, or where possible potential background sources will be removed.
- Identification of building construction to select the appropriate sampling locations, as follows:
  - If building was slab-on-grade construction, sampling locations would be selected to be as close as possible to the potential contaminant source and receptor.
  - If raised construction observed, samples would be collected from the identified crawl space and sub-building access points.
  - If basement areas exist, samples would be collected from the sub-slab area of the basement. If basement areas are identified to be “unfinished” (i.e. unsealed walls or floor areas) ambient air samples would be collected to be representative of potential vapour intrusion concentrations.
  - It is noted that no “confined spaces” will be entered for the collection of vapour samples.
- The PID will be used throughout the building inspection as a screening tool to assist in the identification of potential sampling locations or ambient source zones.
- Due to the Vapor Pin^{TM}:having a small lip following installation, the selected sampling locations would be placed in areas away from high pedestrian traffic zones to minimise the potential for future trip hazards.

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7.10 Installation of Sub-Slab Vapor Pin™

Before commencing intrusive works, clearance of underground services will be undertaken by a licensed professional in accordance with AECOM procedures, as described above. The following procedure will then be used to install the Vapor Pin™:

1) Drill a 1 ½ inch diameter hole at least 45mm into the concrete slab.
2) A drilling guide is then used to drill a ⅝ inch diameter hole through the slab and approximately 25mm into the underlying soil to form a void.
3) The resulting hole is brushed and vacuumed to remove the loose concrete cuttings.
4) The assembled Vapor Pin™ is lowered into the drilled hole and tapped into place using the dead blow hammer.
5) The protective cap is placed on the Vapor Pin™ to prevent vapour loss prior to sampling.
6) The Vapor Pin™ is covered with the stainless steel flush mount cover.
7) Dedicated well tubing (Nylaflow and silicone) and fittings and ferrules are used to create a sample line from the VaporPin™.

7.10.1 Integrity Testing of Sampling Location

Following installation, the Vapor Pin™ will not be sampled for at least 60 minutes to allow sub-slab conditions to equilibrate prior to sampling. Following the equilibration period and prior to sampling, an integrity test on the sub-slab implant using isopropanol would be completed. This test is designed to identify potential leaks in the sample train (due to loose fittings) or as a result of faulty installation.

Isopropanol will be used as a tracer gas for the purposes of conducting the integrity test. To complete the test, an isopropanol soaked rag will be placed over the sub-slab vapour probe, and a shroud placed over the installed probe. 200ml of air is drawn through the sample line with a Kitagawa gas detector sampling pump, for the purpose of detecting the presence of ispopropanol. Where no change in the colour of the Kitagawa tube occurred, leak detection tests are considered to pass.

7.11 Vapour Sampling

7.11.1 Screening Assessment

Following integrity testing, *in situ* gas parameters will be measured for screening purposes.

A photo-ionisation detector (PID) will be used at the time of sampling as an indication of the concentrations of volatile organic compounds (VOCs) in the soil vapour. A multi-gas meter (landfill gas monitor) is also used to monitor soil vapour concentrations of oxygen (O_2), carbon dioxide (CO_2) and methane (CH_4).

Calibration certificates for field equipment will be retained and presented in the Additional DSI report.

7.11.2 Sub-Slab Vapour Sample Collection

The procedure employed for the sampling of soil vapour at the sites will follow guidance from:

- New South Wales Department of Environment, Climate Change and Water (DECCW, 2010), *Vapour Intrusion: Technical Practice Note;*
- CRC CARE 2009, *Technical Report No. 13, Field Assessment of Vapours*;
- CRC CARE 2013, *Technical Report No. 23, Petroleum hydrocarbon vapour intrusion assessment: Australian guidance*;
- Interstate Technology and Regulatory Council (ITRC, 2007) *Vapour Intrusion Pathway. A Practical Guideline;*
- United States Environmental Protection Agency (USEPA) Method SOP#2149 *Soil Gas Sampling and Site Assessment and Mitigation Program Vapour Sampling Procedures* (USEPA, 1991: US San Diego Department of Environmental Health Site Assessment and Mitigation Program, 2002) and;
- AECOM Standard Operating Procedure SOP-SV-005, *Soil Vapour Sampling Using Canisters*.

Summa ® canisters are evacuated stainless steel chambers that provide an active sampling method that enables collection of a gas sample over a specified time period. The regulators allow for the collection of an air sample at a constant rate allowing for a time-weighted average air concentration to be obtained. Summa canisters were used in preference to alternative sample methods because:

- Breakthrough does not occur for air samples;
- Analysis of the sample can be repeated by using the remainder of the sample;
- Moisture has no effect on the canister; and
- Degradation of the collected sample does not occur.

One litre Summa canisters will be utilised for sampling, with stainless steel flow controller attachments and regulators set for sampling over a 20 minute period. Sample rates of approximately 200 mL/min will be targeted, as recommended by CRC CARE (2013).

7.11.3 Ambient Air Sampling

Summa ® canisters as described above will be used to collect ambient air samples within the three main building at the Site. The sample collection time will be determined following review of the occupation of the buildings.

7.12 Analysis

The proposed analysis plan has been developed to provide contamination information at targeted areas within the Site at a range of depth intervals. The CoPCs have been selected on the basis of the previous investigation findings. Exact sample depth increments that will be selected for analysis are not specified herein, as this will be dependent on observed/encountered conditions. Analyses at each borehole location will, however, target both the fill materials and the natural soils.

Analysis of the samples collected during the delineation works will be conducted by Australia Laboratory Services (ALS) and/or Envirolab Laboratories (Envirolab). Both are NATA accredited and registered for the analyses proposed. AECOM notes that the laboratory methods and limits of reporting (LORs) will meet the ASC NEPM requirements. The proposed analytical suite is summarised below.

Table 14 Analytical Plan

Analyte	Number of Primary Samples	Sample Locations
Soil		
TPH/TRH, BTEX, PAH	22	MW301 – MW311
Groundwater		
TPH/TRH, BTEX, PAH	25	MW301 – MW311 EX01 – EX04 MW3 – MW5, MW12 – MW16 MW7, MW9 (off-site)
Soil Vapour		
TPH/TRH BTEX, naphthalene	11	SV101 – SV108

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8.0 Health and Safety

AECOM staff are trained in health and safety procedures for work on contaminated sites. A project specific Health, Safety and Environment (HSE) Plan including task specific Safe Work Method Statements (SWMS) will be prepared (under separate cover) prior to the commencement of field works. The SWMS includes all the specific health and safety procedures for working on the site. SWMS will also be provided by drilling subcontractors.

9.0 Quality Assurance and Quality Control and Data Validation

9.1 QAQC

The objective of the QA/QC program is to provide an assessment of the reliability of the data presented for interpretation for the project in terms of DQO's required for the project.

9.1.1 Field Data Quality Objectives

The following field methods and quality control measures are defined for the investigation to achieve results of sufficient quality to be used in an assessment of the environmental condition of soil and groundwater both on and off-site.

9.1.1.1 Sample Collection, Handling and Preservation

Soil and groundwater samples will be collected in the sample jars and bottles supplied by the selected analytical laboratories. The filled jars and bottles will be stored on ice in a chilled, insulated container until received by the analysing laboratory. Sample numbers, dates, preservation and analytical requirements will be recorded on COC documentation, which will also be delivered to the analytical laboratories.

9.1.1.2 Field Duplicate Samples

Duplicate soil and groundwater samples will be collected in the field at a rate of one in every 20 primary samples and will be analysed at a minimum rate of one per 20 primary samples. The duplicate samples will be obtained from locations suspected of being impacted. Duplicated samples will be labelled so as to conceal their relationship from the laboratory.

Duplicates are used to measure the precision of the sampling and analysis process (sampling, sample preparation, and analysis). Significant variation in field duplicate results may be observed for reasons not related to the analytical process (particularly for volatile analytes or heterogeneous fill).

The overall precision of field duplicates samples and laboratory duplicates is generally assessed by their Relative Percent Difference (RPD), given by:

$$RPD\% = \frac{(C1-C2)}{(C1+C2)/2} \times 100$$

where C1 is the primary sample concentration

C2 is the duplicate sample concentration

RPDs of field and laboratory duplicates will be compared to criteria detailed below in laboratory DQOs.

9.1.1.3 Inter-Laboratory Duplicate Samples

In addition to the collection of field duplicate samples for analysis by the primary laboratory, inter-laboratory duplicates will be submitted to the secondary laboratory for analysis. Inter-laboratory duplicate samples will be analysed at a rate of one per 20 primary samples. The purpose of the inter-laboratory duplicates is to assess the accuracy and precision of the primary laboratory data. The precision of the primary and secondary laboratory data will be assessed by the RPD of the results.

Collection and subsequent selection of samples for analysis by the secondary laboratory will be based upon field observations of potentially contaminated soils (ie: on-site identification by visual, olfactory or PID field screening results).

9.1.1.4 Rinsate Blanks

Rinsate blank samples (from the soil and groundwater sampling equipment) will be collected daily during sampling by running deionised water over the relevant section of the equipment and decanting directly into the laboratory prepared and supplied sample bottles. The rinsate samples will be taken from the final rinse of the equipment after decontamination.

9.1.1.5 Calibration

On-Site screening of samples for VOCs in the field will be undertaken using a portable photoionisation detector (PID) equipped with a 10.6 eV lamp. The PID will be calibrated at least once daily (at the start of each sampling

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day) with 100 ppm isobutylene. Calibration details will be recorded on field sheets, which will be included in the in the Additional DSI Report.

Groundwater geochemical parameters (eg: pH, temperature, redox and electrical conductivity) will be measured using a calibrated water quality meter. Water quality meters will be calibrated daily prior to use in the field. Calibration records will be included in the report.

Groundwater sampling pumps, interface probes and meters will be calibrated and passed by the supplier prior to dispatch to AECOM and use in the field. Supplier calibration records will be included in the report.

9.1.1.6 Trip Blanks

One trip blank will be prepared by AECOM per batch of samples using laboratory supplied deionised water and transported to and from the Site in the same manner as the other samples collected. The sample will then be analysed for TPH C_6-C_9 and BTEX, with the aim of assessing the potential for cross-contamination during sample container preparation and transport to and from the site.

9.1.2 Laboratory Data Quality Objectives

Listed below is the predetermined laboratory DQOs defined for the assessment of the laboratory analytical data:

- maximum acceptable sample holding time is 14 days for organic analyses;
- samples to be appropriately preserved and handled;
- laboratory LOR to be less than the adopted assessment criteria;
- laboratory method blank analyses to be less than the laboratory LOR;
- laboratory duplicate samples to be analysed at a rate of one in twenty samples, when the batch size exceeds five samples. The RPD of the laboratory duplicate sample results are to be less than 50%;
- matrix spike recoveries to be conducted by the laboratory at a rate of one in twenty samples;
- laboratory control sample (LCS) analysis to be conducted at a rate of one in twenty samples; and
- matrix, LCS and surrogate recoveries to be within the range of 70-130%.

9.1.3 Analytical Data Validation

Analytical data validation is the process of assessing if data are in compliance with method requirements and project specifications. The primary objectives of this process are to ensure that data of known quality are reported, and to identify if the data can be used to fulfil the overall project objectives.

Specific elements of data validation that will be checked and assessed for this project are:

- preservation and storage of samples upon collection and during transport to the laboratory;
- sample holding times;
- required limits of reporting:
- frequency of conducting quality control measurements;
- laboratory blanks;
- rinsate blanks;
- trip blanks
- field duplicates;
- laboratory duplicates;
- inter-laboratory duplicates;
- laboratory control samples;
- matrix spike/matrix spike duplicates;
- surrogates; and

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- the occurrence of apparently unusual or anomalous results, e.g. laboratory results that appear to be inconsistent with field observations or measurements.

The overall reliability of the analytical data will be assessed against the Data Quality Indicators as required by NSW EPA (2006).

9.1.4 Analytical Methods

The analytical methods employed by the primary laboratory (ALS) are outlined in **Table 15**.

Table 15 Analytical methods for soil and groundwater

Analyte	Analytical Method	Units
Soil		
TPH C10-C36	USEPA 3510/8015	mg/kg
BTEX/TPHC6-C9	USEPA 5030/8260	mg/kg
PAH	USEPA 3510/8270	mg/kg
Groundwater		
TPH C10-C36	USEPA 3510/8015	µg/L
BTEX/TPH C6-C9	USEPA 5030/8260	µg/L
PAH	USEPA 3510/8270	µg/L

9.1.5 Corrective Actions

Analytical data that fail to meet the predetermined data quality objectives and acceptable limits of accuracy and precision will be managed using the following corrective actions on a case-by-case basis:

- reanalyse suspect samples, provided sample or extract is within holding time;
- evaluate and amend sampling and/or analytical procedures;
- resampling and reanalysis;
- accept the data as an estimate with an acknowledged level of bias and imprecision; and
- discard the data.

In the event that data of questionable reliability are used, restrictions and limitations associated with the use of such data will be clearly identified. Failure to meet the DQOs will be reported and the significance to the outcome of the program will be addressed.

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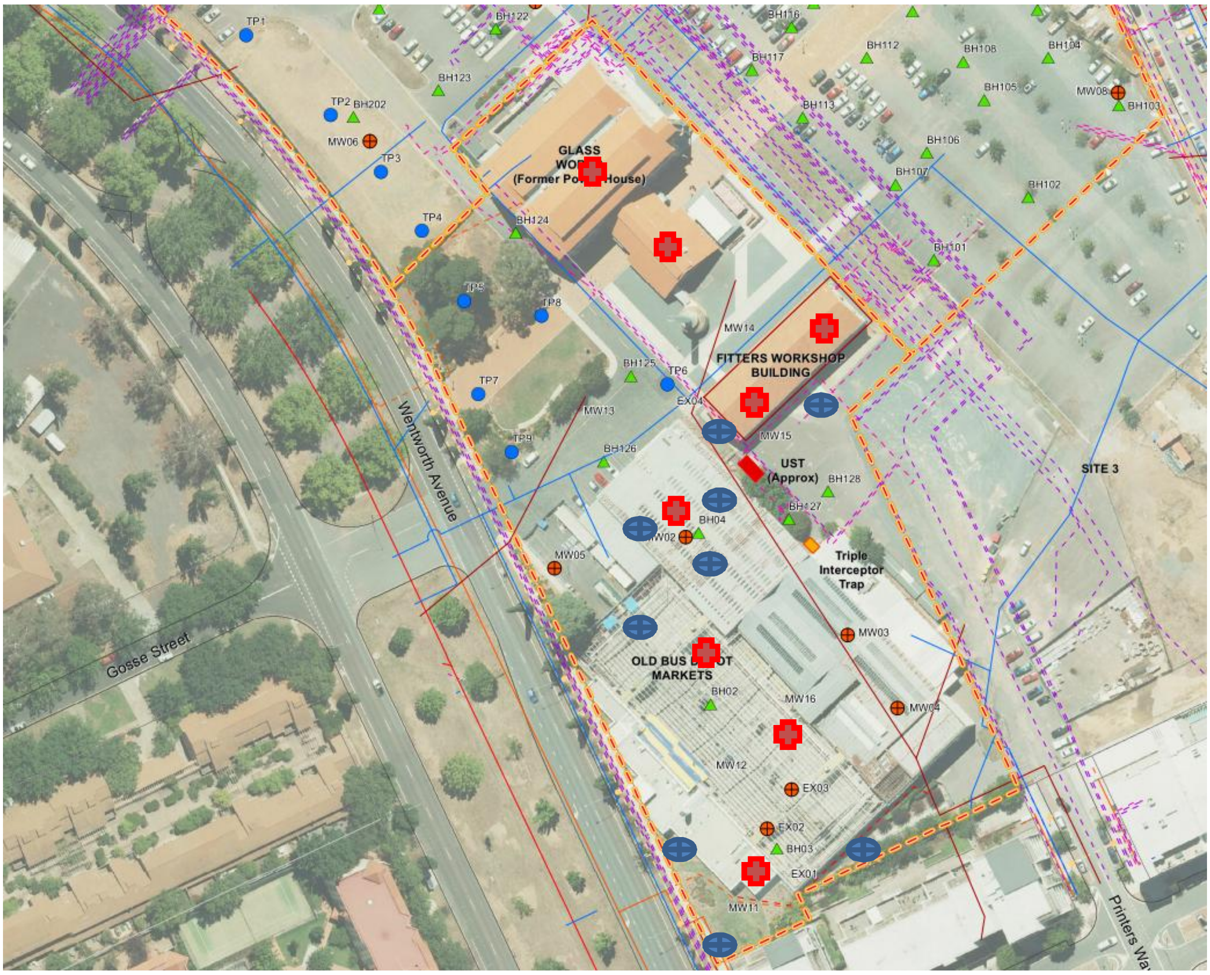
Appendix A

Figures

Kingston Heritage Precinct SAQP



proposed soil vapour sampling locations

proposed soil bore/groundwater monitoring well