ANSWERS TO QUESTIONS ON NOTICE

1. **Continuation of my answer to Mr Vietch's question – page 20 of transcript – What do you think was the adequacy of consideration around alternative options and the measuring of the impact on those two sites?**

In a Flood Study commissioned by Willoughby Council and dated August 2016 the Flat Rock Creek catchment is described as having a total area of 7 square kilometres and including the suburbs of Artarmon, Willoughby, Naremburn, Northbridge, St Leonards, Cammeray and Crows Nest. The study shows inundation of some of the area up to 1 metre every 2 years and extensive inundation of the Tunks Park playing fields from Flat Rock Creek every 10 years.

As regards Cammeray Golf Course, the Detailed Site Inspection Report (DSI) prepared for the preliminary works program has gone through a number of versions. Each of these versions has been prepared by Jacobs one of the partners in the Sydney Program Alliance which is actually doing the preliminary works.

The first version of the DPI WEPA became aware of was Rev 03 dated 6.07.21. WEPA had this DSI reviewed by Dr Bill Ryall, a retired EPA accredited auditor, who identified many failings including: the inadequate extent of sampling, the inadequate management of sampling, the inadequate type of sampling, and inappropriate averaging of the results of sampling to bring the results under the relevant Health Investigation Levels (HILs).

WEPA made a complaint to the DPIE dated 10 August pointing out these failings and requesting that the Conditions of Approval requiring the DSI to be reviewed by an 'independent EPA accredited auditor' be complied with, and work cease until this was done. DPIE has refused to have the DSI reviewed as required on the basis, as we understand it, that relevant 'disturbance' of the site is not occurring at this stage. DPIE provided WEPA with photographs showing sections of the site after work had been completed prompting WEPA to obtain its own photographs of current work showing disturbance. WEPA's provision of these photographs made no difference to DPIE and WEPA has complained to the NSW Ombudsman in relation to DPIE's failure to enforce the Conditions of Approval.

The NSW Ombudsman has advised WEPA that, due to its lack of technical expertise, it may not be able to resolve the issue but its investigation is on foot.

This situation is of enormous concern. The Cammeray Golf Course is one of the major construction sites for the Western Harbour Tunnel/ Warringah Freeway Upgrade. WEPA made DPIE aware that our review of the DSI had been done by a retired EPA accredited auditor shortly after sending our letter of 12 August. WEPA provided the DPIE with photographs clearly showing 'disturbance'. The DSI was not prepared by anyone independent but by someone (Jacobs) who stood to gain from the work proceeding and to lose if the cost of the work was increased due to site contamination.

These concerns are heightened by aspects of the most recent version of the DSI – Rev 05 - which seems to have been prompted by WEPA's complaint of 10 August and its meeting with DPIE on 13 August to discuss its complaint.

Rev 05 acknowledges a number of the issues raised by Dr Ryall which hadn't been acknowledged in Rev 03 e.g. the heterogenous nature of the fill (page 7), without addressing his statement that this makes averaging of results inappropriate.

Rev 05 also fails to repeat the assertion made in Rev 03, at page 13, that three sample points where PAHs and asbestos were discovered had locations that "was not clear. Therefore, it is not known whether these sample points are located within the investigation areas .. and this data was excluded." Instead Rev 05, at page 19, states the results from those sample points are now of no concern anyway, without any suggestion that the location of the sample points is not clear. It needs to be noted that this change of approach has occurred in the context of an investigation as to whether there has been a breach of section 10.6 of the EP&A Act which makes it an offence to make a false or misleading statement in documents including DSIs, an investigation instigated by WEPA's complaint of 10 August.

WEPA has been told that it will be informed of the outcome of the investigation into whether section 10.6 has been breached and that the outcome should be known by now but has heard nothing so far regarding the outcome. WEPA is concerned that DPIE has allowed the DSI to be 'cleaned up' so that it will be relieved of any obligation to take action to seek a penalty pursuant to section 10.6. Given that this aspect of the DSI would never have been 'cleaned up' had it not been for WEPA bringing this matter to the attention of the DPIE, the question arises as to what else has been missed and would those matters be capable of being 'cleaned up' in the sense of being declared to be of no consequence.

In conclusion, regarding the adequacy of measurement of impact of the projects on the two sites mentioned, using the management of contamination as a case study, it is impossible to be confident that the impact is being properly managed. Rather the situation would seem to be that the regulator, DPIE, is prepared to:

- ignore failures to properly assess contamination when such failures are brought to its attention
- ignore its own Conditions of Approval and not require an independent review of DSIs and, depending on the outcome of the investigation into breach of section 10.6, fail to discourage the making of false and misleading statements in DSIs

2. Continuation of my answer to Ms Boyd's question at page 22 of transcript

In addition to what Dr Foley said about the risk to Aboriginal heritage from vibration I would like to draw the Committee's attention to the condition in relation to vibration monitoring which WEPA's submission suggested should be imposed.

It is commonplace in relation to residential developments to impose a condition requiring vibration monitoring to protect e.g. rock overhangs, with work ceasing once the vibrations reach a certain level, so as to prevent damage.

If such conditions can be imposed in that context, conditions at least as stringent should be imposed here, where there is both Aboriginal heritage and landscape protection at stake.

FLAT ROCK CREEK CATCHMENT
FLOOD STUDY
AND OVERLAND FLOW MAPPING

VOLUME 1 – REPORT

AUGUST 2018

Job No: AR418	Date: August 2018	Principal: SAB
File: FRCFS_V1_Report [Rev 2.0].doc	Rev No: 2.0	Author: TDR/SAB

FOREWORD

The State Government's Flood Policy is directed at providing solutions to existing flooding problems in developed areas and to ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through the following four sequential stages:

1.	Flood Study	Determines the nature and extent of flooding.
2.	Floodplain Risk Management Study	Evaluates management options for the floodplain in respect of both existing and proposed development.
3.	Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.
4.	Implementation of the Plan	Construction of flood mitigation works to protect existing development. Use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

This report is an update of the Flat Rock Creek Flood Study of March 2006 which was jointly funded by Willoughby City Council and the then Department of Natural Resources (now Office of Environment and Heritage).

The updated study was commissioned by Willoughby City Council with the objective of incorporating the results of more recent hydraulic modelling undertaken in the catchments of the Local Government Area. The updated study used two-dimensional (in plan) hydraulic modelling of the channel and floodplain, based on the TUFLOW software and supersedes the results of the 2006 investigation which used a one-dimensional, cross-sectional hydraulic model of Flat Rock Creek and its Southern Tributary upstream of Willoughby Road, based on the HEC-RAS software.

The Flood Study constitutes the first stage of the Floodplain Management process for this area to define flood behaviour under current conditions. It is intended that the results of this study will be used for the future Floodplain Risk Management Study of the Flat Rock Creek catchment.

FLOODPLAIN RISK MANAGEMENT PROCESS

Established by Willoughby City Council, and includes community groups and State Agency specialists

The Flat Rock Creek Flood Study (Lyall & Associates, 2006) documented the flooding patterns along the reach of Flat Rock Creek between Artarmon Reserve and Willoughby Road, as well as the reach of the Southern Tributary between Talus Reserve and Willoughby Road.

An LGA-wide overland flooding investigation was carried out in 2009, which broadly examined the nature and extent of overland flow throughout the Study Area.

Involves the compilation of existing data and the collection of additional data.

Involves detailed hydrologic and hydraulic modelling of the existing stormwater drainage system.

The Floodplain Risk Management Study will determine options which will seek to reduce the impact of flooding on the community in consideration of social, ecological and economic factors.

Preferred floodplain management options will be publicly exhibited and the responses from the community incorporated in the Plan. The Plan will then be formally approved by Council following the public exhibition period.

Implementation of the Plan will allow Council to reduce the impact of flooding on the community through flood, property, and response modification measures. The measures may include structural works, planning controls, flood warnings, flood readiness and response plans, ongoing data collection and monitoring.

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APPENDICES

LIST OF FIGURES (BOUND IN VOLUME 2)

NOTE ON FLOOD FREQUENCY

The frequency of floods is generally referred to in terms of their Annual Exceedance Probability (**AEP**) or Average Recurrence Interval (**ARI**). For example, for a flood magnitude having 5% AEP, there is a 5% probability that there will be floods of equal or greater magnitude each year. As another example, for a flood having a 5 year ARI, there will be floods of equal or greater magnitude once in 5 years on average. The approximate correspondence between these two systems is:

ANNUAL EXCEEDANCE PROBABILITY (AEP) %	AVERAGE RECURRENCE INTERVAL (ARI) YEARS
0.2	500
0.5	200
1	100
2	50
5	20
10	10
20	5
50	2
1 EY	1

In this report floods are referred to in terms of their AEP. Events that are more frequent than those of 50% AEP are expressed as X Exceedances per Year (**EY**). For example, a design event with a 6 month recurrence interval is expressed as having 2 EY.

The report also refers to the Probable Maximum Flood (**PMF**). This flood occurs as a result of the Probable Maximum Precipitation (**PMP**). The PMP is the result of the optimum combination of the available moisture in the atmosphere and the efficiency of the storm mechanism as regards rainfall production. The PMP is used to estimate PMF discharges using a model which simulates the conversion of rainfall to runoff. The PMF is defined as the limiting value of floods that could reasonably be expected to occur. It is an extremely rare flood, generally considered to have a return period greater than 1 in 10^5 years.

ABBREVIATIONS

AEP	Annual Exceedance Probability (%)
AHD	Australian Height Datum
AMC	Antecedent Moisture Condition
ARF	Areal Reduction Factor
ARI	Average Recurrence Interval (years)
ARR	Australian Rainfall and Runoff (IEAust, 1987)
BoM	Bureau of Meteorology
Council	Willoughby City Council
CL	Continuing Loss
DTM	Digital Terrain Model
EY	Exceedances per Year
FDM	Floodplain Development Manual (NSW Government, 2005)
FPA	Flood Planning Area
FPL	Flood Planning Level
FRMS	Floodplain Risk Management Study
FRMS&P	Floodplain Risk Management Study and Plan
HHWSS	Highest High Water Solstice Spring (tidal event)
GDSM	Generalised Short Duration Method
GS	Gauging Station
IFD	Intensity-Frequency-Duration
IL	Initial Loss
LGA	Local Government Area
LiDAR	Light Detecting and Ranging
OEH	Office of Environment and Heritage (formerly Department of Environment, Climate Change and Water [DECCW])
PFI	Peak Flow Identifier
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation

Chapter 8 of the report contains definitions of flood-related terms used in the study.

SUMMARY

S.1 Study Objectives

The study objective was to define flood behaviour in the Flat Rock Creek catchment in terms of water levels, flows and flooding patterns for design storms ranging between 1 Exceedances per Year (**EY**) and 0.2 per cent Average Exceedance Probability (**AEP**), as well as for the Probable Maximum Flood (**PMF**). **Figure 1.1** shows the extent of the Flat Rock Creek catchment.

The scope of the study included investigation of both main stream flooding which occurs along Flat Rock Creek and its tributaries (referred to herein as the Brooks Street, Southern, Northern, Burra Road and Willoughby Road tributarys), as well as major overland flooding which occurs as a result of surcharges of Willoughby City Council's (**Council's**) pit and pipe stormwater network.

The study forms the first step in the floodplain risk management process for the Flat Rock Creek catchment and is a precursor of the future Floodplain Risk Management Study and Plan (***FRMS&P***) which will consider the impacts of flooding on existing and future urban development, as well as potential flood mitigation measures.

S.2 Study Method

The flood study involved the following activities:

- The collection of flood data (reported in **Appendix A**). Flood marks for historic flood events which occurred in August 1986, March 1994 and April 1998 along Flat Rock Creek were taken from previous investigations. Pluviographic rainfall data recorded at the Bureau of Meteorology's (**BoM's**) Chatswood Bowling Club rain gauge (Station No. 066011) were also obtained.
- The forwarding to residents in the Flat Rock Creek catchment of a Community Newsletter and Questionnaire introducing the study objectives and seeking information on historic flood behaviour. Respondents reported flooding problems dating back to the late-1980s, mostly associated with surcharging of the local stormwater system. Several instances of problems were identified as occurring in the last few years, in particular an event which occurred on 6 June 2016. Whilst there were no quantitative data available in the form of historic flood marks for this event, five respondents provided anecdotal information on depths of overland flow and drainage patterns which could be used for model testing purposes. Analysis of rainfall data recorded at Chatswood Bowling Club indicated that the 6 June 2016 storm was between about a 1 EY and 50% AEP event for durations which are critical for maximising flows in the catchment. The hydrologic and hydraulic models were tested using the rainfalls that were recorded at the Chatswood Bowling Club during the storm event. The results are reported in **Appendix A.**
- The hydrologic modelling of the Flat Rock Creek catchment to determine discharge hydrographs. The hydrologic modelling was based on the DRAINS rainfall-runoff software. This software derived discharge hydrographs resulting from historic and design storms.
- Application of the discharge hydrographs to a hydraulic model comprising the main arm of Flat Rock Creek, its major tributaries and major overland flow paths. The hydraulic model extended from the headwaters of the Flat Rock Creek catchment to its outlet to Long Bay on the eastern side of Tunks Park. The TUFLOW two-dimensional modelling system was adopted for the hydraulic analysis.

- Presentation of study results as water surface profiles, as well as diagrams showing indicative extents and depths of inundation, the provisional flood hazard and the hydraulic categorisation of the floodplain into floodway and flood fringe areas.
- Sensitivity studies to assess the effects on model results resulting from variations in model parameters such as hydraulic roughness of the floodplain, catchment imperviousness, the effects of a total and partial blockage of the piped drainage system, elevated tidal levels in Midlle Harbour, and the effects on flooding patterns resulting from future climate change.

After testing the models for the 6 June 2016 storm, design storm rainfalls ranging between 1 EY and 0.2% AEP were derived using procedures set out in the 1987 version of *Australian Rainfall and Runoff* (**ARR**) (IEAust, 1987) and applied to the hydrologic models to determine discharge hydrographs. The PMF was also modelled. Flooding patterns derived by TUFLOW for the design storm events are described in **Chapter 6** of the report, with exhibits presented in **Volume 2**.

S.3 Presentation of Results

Figures 6.1 to **6.10** show the TUFLOW model results for the 1EY, 50, 20, 10, 5, 2, 1, 0.5 and 0.2 per cent AEP floods, together with the PMF. These diagrams show the indicative extents and depths of inundation in the study area. **Table B1** in **Appendix B** gives the peak design flows at a number of key locations within the study catchment.

Design water surface profiles along Flat Rock Creek, the Southern Tributary, the Northern Tributary, Burra Road Tributary and Willoughby Road Tributary are shown on **Figure 6.11**, while **Figure 6.12** shows stage and discharge hydrographs at selected locations throughout the study area.

Diagrams showing the *provisional flood hazard* for the 5 and 1% AEP storm events, as well as the PMF are shown on **Figures 6.13** to **6.15**, while the *hydraulic categorisation* of the floodplain for the 1% AEP storm event and the PMF are shown on **Figures 6.16** and **6.17**.

Several runs of the TUFLOW hydraulic model were carried out to test the sensitivity of flood behaviour to changes in hydraulic roughness of the main stream and floodplain and catchment imperviousness, as well as a total and partial blockage of the piped stormwater system. The impact on flood behaviour of increases in rainfall intensities and sea levels due to future climate change was also assessed. The results of these sensitivity analyses are shown on **Figures 6.18** to **6.27**. The analyses showed that increases in peak 1% AEP flood levels would lie within the 300 mm and 500 mm freeboard allowances which are usually applied to 1% AEP peak flood levels for setting minimum floor levels for future development located in areas affected by major overland flow and main stream flooding, respectively.

S.4 Interim Flood Planning Area

The Interim Flood Planning Area (**FPA**) and Interim Flood Planning Levels *(***FPL's***)* for main stream flooding along Flat Rock Creek and its tributaries are shown on **Figure 6.28**. The FPA represents the area which will be subject to flood related development controls for main stream flooding and comprises the area lying within the extent of the 1% AEP flood plus an allowance of 500 mm for freeboard. These interim data will be confirmed as part of the future *FRMS&P*.

S.5 Summary of Flood Behaviour

- The Flat Rock Creek catchment drains eastwards from the Pacific Highway through residential and commercial/industrial areas in the suburbs of Artarmon, Cammeray, Naremburn, Northbridge, St Leonards and Willoughby, through Tunks Park and eventually discharges to Long Bay in Middle Harbour. It has a total area of 7.0 km^2 at this point, 1.0 km^2 of which lies within the North Sydney Council LGA.
- The existing piped drainage system generally has a hydrologic capacity between 1 EY and 50% AEP. The magnitude of surcharging flows progressively increases for more severe storms, with the flows conveyed overland through residential allotments, generally following the route of the trunk stormwater systems and natural grade of the catchment.
- **Figures 6.7** shows the results of hydraulic modelling of the 1% AEP storm event. Flooding in the catchment is of a "flash flooding" nature, with flood levels rising to a peak in less than an hour of the commencement of heavy rainfall.
- Depths of overland flow in the residentially developed portion of the catchment do not generally exceed 600 mm during a 1% AEP event. However, depths of inundation of greater than 1.0 m does occur in existing development at the following locations during an event of this return period:
    - the intersection of Hampden Road and Francis Road, Artarmon;
    - Penkivil Street, Willoughby;
    - between Gorman Street and Armstrong Street, Willoughby;
    - the intersection of Small Street and Tulloh Street, Willoughby;
    - between Frederick Street and Taylor Lane, Artarmon;
    - the southern end of George Place, Artarmon; and
    - the western end of Walter Street, Willoughby.
- Depths of inundation in existing development will exceed 1.0 m during a 1% AEP storm event at the following locations:
    - in the rear of properties which lie on the southern bank of the main arm of Flat Rock Creek on Olympia Road and Park Road, Naremburn;
    - in the rear of properties which lie on the northern bank of the main arm of Flat Rock Creek on Walter Street, Willoughby;
    - in the rear of residential properties which lie on the southern bank of the main arm of Flat Rock Creek on Garland Road and Gaza Road, Naremburn;
    - on both banks of the Southern Tributary between Evans Lane and the Gore Hill Freeway in Naremburn;
    - on the western side of Herbert Street in St Leonards;
    - along the alignment of the Northern Tributary between Weedon Road and Artarmon Reserve in Artarmon;
    - between Roberts Street and Hampden Lane in Artarmon;
    - on the western side of Hampden Road near Artarmon Railway Station in Artarmon;
    - between Valetta Lane and Elizabeth Street in Artarmon;

  - on the northern side of Penkivil Street in Willoughby;
  - between Gorman Street and Artarmon Road in Willoughby;
  - on the northern side of Small Street in Willoughby;
  - between Market Street and Garland Road in Naremburn;
  - on the northern side of Quiamong Road in Naremburn;
  - between George Place and the Gore Hill Freeway in Artarmon;
  - between Sawyer Lane and Hotham Parade in Artarmon;
  - on the northern side of Fredrick Street in Artarmon; and
  - between Reserve Road and Herbert Street in Artarmon.
- Basement carparks will be inundated during a 1% AEP storm event at the following locations:
  - George Place, Artarmon;
  - Frederick Street, Artarmon;
  - Waltham Street, Artarmon;
  - Herbert Street, St Leonards;
  - Penkivil Street, Willoughby;
  - Small Street, Willoughby; and
  - Quiamong Road, Naremburn.
- Flood damages to residential development could arise due to the discharge of flow through private property. Matching the extents of inundation determined in this flood study with the footprints and floor levels of existing residential development will be undertaken in the future *FRMS&P* to estimate damages resulting from a range of flood events. This will enable a priority list of mitigation measures to be prepared.

S.6 Issues for Consideration in the *FRMS&P*

The models developed for this flood study could be used in the future *FRMS&P* for the catchment which would enable Council to comprehensively manage the flood risk. In addition to finalising the Interim FPA and FPL's, and setting appropriate controls over future development in flood prone areas, the *FRMS&P* would include an assessment of available management options including:

- Property Modification measures such as: flood related controls over future development, voluntary purchase of residential property in high hazard areas and raising of floor levels of residences located in low hazard areas.
- Response Modification measures including: improvements to flood warning and emergency management procedures, improvements to the community's awareness of flooding.
- Flood Modification measures such as: levees, detention basins and improvements to hydraulic capacity of channels and floodways.

1 INTRODUCTION

1.1 Study Background

This report presents the findings of an investigation of flooding in the Flat Rock Creek catchment and has been commissioned by Willoughby City Council (**Council**). The focus of the study was the definition of flooding patterns in the portion of the Flat Rock Creek catchment which lies within the Willoughby City Local Government Area (**LGA**), although hydrologic modelling was undertaken to determine contributions of flow in the existing drainage system from the southern portion of the catchment lying in the North Sydney Council LGA.

Figure 1.1 shows the location of the catchment, which drains residential and commercial areas in the suburbs of Artarmon, Willoughby, Naremburn, Northbridge, St Leonards, Cammeray and Crows Nest before flowing across Tunks Park and discharging to Long Bay in Middle Harbour.

The study objective was to define flood behaviour in terms of water levels, flows and flooding patterns for design storms ranging between 1 Exceedances per Year (**EY**) and 0.2% Average Exceedance Probability (**AEP**), as well as for the Probably Maximum Flood (**PMF**). The investigation involved rainfall-runoff hydrologic modelling of the Flat Rock Creek catchment, and application of these flows to a hydraulic model of the existing drainage system to assess peak water levels and flow patterns. The model results were interpreted to present a detailed picture of flooding under present day conditions.

The results of the present study supersede those presented in the *Flat Rock Creek Flood Study* (Lyall & Associates (**L&A**), 2006), as well as the *Overland Flooding Investigation* undertaken for the whole of the Willoughby City LGA (L&A, 2009). The work undertaken in these studies is summarised in **Chapter 2** and **Appendix A**.

1.2 Approach to Flood Modelling

1.2.1. Hydrologic and Hydraulic Modelling

Flood behaviour was defined using a two-staged approach to flood modelling involving the running in series of:

1. The hydrologic model of the sub-catchments comprising the Flat Rock Creek catchment based on the DRAINS rainfall-runoff software.
2. The hydraulic model of the Flat Rock Creek catchment drainage system, based on the TUFLOW software.

The DRAINS model computed discharge hydrographs, which were then applied to the TUFLOW hydraulic model at relevant sub-catchment outlets. The TUFLOW model used a two-dimensional (in plan) grid-based representation of the natural surface based on a Light Detecting and Ranging (**LiDAR**) survey of the catchment, as well as piped drainage data supplied by Council. Field survey supplied by Council and others provided additional data on ground surface levels and piped drainage details.

The TUFLOW model was used to route flow from the headwaters of the Flat Rock Creek catchment to its outlet. The model included the main arm of Flat Rock Creek and its tributaries, as well as details of the stormwater pit and pipe network. The TUFLOW model was also used to assess the impact of elevated water level in Middle Harbour on flooding behaviour.

1.2.2. Model Testing

There are no streamflow data available for the Flat Rock Creek catchment. Consequently it was not possible to formally "calibrate" the DRAINS model to reproduce recorded discharges. The approach adopted was therefore to test the ability of the hydrologic and hydraulic models in combination to reproduce observed flooding patterns.

While several flood marks have been surveyed along the southern side of the concrete and brick lined reach of Flat Rock Creek where it runs between the extensions of Grandview Street and Park Road for the August 1986, March 1994 and April 1998 storm events (refer **Figures A2.1** for locations), several key features which influence flood behaviour in the middle reaches of the creek system have been altered since the occurrence of these events. For example, the Gore Hill Freeway was constructed along the line of the creek in 1991, as was a large detention basin in Artarmon Reserve. This was followed by the widening of the freeway and the raising of the aforementioned basin spillway in 2006 as part of the Lane Cove Tunnel project. Largescale commercial and industrial development has also occurred in the upper reaches of the catchment south of the Gore Hill Freeway. L&A, 2006 also found that the rainfall that was recorded at the Chatswood Bowling Club was not representative of the rain that fell over the Flat Rock Creek catchment during the April 1998 storm, further complicating the model calibration process.

No quantitative data relating to more recent storm events were identified within the Flat Rock Creek catchment during the community consultation process, with information mainly limited to observations of flooding in the local street system and individual allotments which were reported during the community consultation process. For example, a number of residents provided anecdotal information on flooding that occurred as a result of heavy rain that fell on 6 June 2016.

The approach adopted was to test the ability of the DRAINS and TUFLOW models to reproduce observed flooding patterns for the June 2016 storm event. In this case, "best estimates" of model parameters were used based on previous investigations, experience and engineering judgement.

The model testing procedure is summarised in **Chapters 3** and **4**, with further details contained in **Appendix A**.

1.2.3. Design Flood Estimation

Design storms were derived using procedures set out in the 1987 version of *Australian Rainfall and Runoff* (**ARR**) (IEAust, 1987) and then applied to the DRAINS model to generate discharge hydrographs. These hydrographs constituted input to the TUFLOW hydraulic model.

An "envelope" approach was adopted for defining design water surface elevations and flow patterns throughout the study area. The procedure involved running the model for a range of scenarios, for both catchment-driven flooding and flooding in Middle Harbour, to define the upper limit (i.e. the envelope) of expected flooding for each design flood frequency.

1.3 Layout of Report

Chapter 2 contains background information including a brief description of the study catchment and its drainage system, identification of previous flooding investigations, a summary of the community consultation that was undertaken as part of this present study, and a brief history of flooding within the catchment.

Chapter 3 deals with the hydrology of the Flat Rock Creek catchment and describes the development of the DRAINS hydrologic model which was used to generate discharge hydrographs for input to the hydraulic model.

Chapter 4 deals with the development of the TUFLOW hydraulic model which was used to analyse flood behaviour in the study area.

Chapter 5 deals with the derivation of design discharge hydrographs, which involved the determination of design storm rainfall depths over the catchment for a range of storm durations and conversion of the rainfalls to discharge hydrographs.

Chapter 6 details the results of the hydraulic modelling of the design floods. Results are presented as water surface profiles and plans showing indicative extents of inundation for a range of design flood events up to the PMF. A provisional assessment of flood hazard and hydraulic categorisation is also presented. (The assessment of flood hazard according to velocity and depth of floodwaters is necessarily *"provisional"*, pending a more detailed assessment which includes other flood related criteria, to be undertaken during the preparation of the future Floodplain Risk Management Study and Plan (**FRMS&P**).

The results of various sensitivity studies undertaken using the TUFLOW model are also presented, including the effects of changes in hydraulic roughness, partial blockage of the piped stormwater system, increases in catchment imperviousness and potential increases in rainfall intensities and sea levels due to future climate change. This chapter also deals with the selection of interim Flood Planning Levels (**FPL's**) for the study area.

Chapter 7 contains a list of references.

Chapter 8 contains a list of flood-related terminology that is relevant to the scope of the study.

Appendix A provides details of the collection of historic flood data and describes the testing of the hydrologic and hydraulic models.

Appendix B (bound in **Volume 2**) contains a table setting out peak flows that were extracted from the TUFLOW model at representative locations within the drainage system.

Figures referred to in both the main report and the appendices are bound in a separate volume of the report (refer **Volume 2**).

2 BACKGROUND INFORMATION

2.1 Catchment Description

The Flat Rock Creek catchment has a total area of about 7 km^2 at its outlet to Long Bay and includes the suburbs of Artarmon, Willoughby, Naremburn, Northbridge, St Leonards, Cammeray and Crows Nest (refer **Figure 1.1**). **Figure 2.1** shows the extent of the stormwater pit and pipe network that controls the runoff from the Flat Rock Creek catchment.

The catchment drains generally from west to east, extending from its headwaters in the vicinity of the Pacific Highway to its outlet to Long Bay. A 1 km^2 portion of the catchment that is located on the southern side of the study area lies within the North Sydney Council LGA. The North Shore Railway bisects the catchment in a north-south direction, while the Gore Hill Freeway splits the catchment in an east-west direction.

The major watercourses in the catchment include the main arm of Flat Rock Creek, two tributary arms on its southern side (denoted herein as the "Southern Tributary" and "Brook Street Tributary") and three tributary arms on its northern side (denoted herein as the "Northern Tributary", "Burra Road Tributary" and "Willoughby Road Tributary").

The catchment predominantly comprises low to medium density residential development on the eastern side of the North Shore Railway, with pockets of higher density residential and commercial development located adjacent to the Artarmon Railway Station and along Willoughby Road. West of the North Shore Railway, the portion of the catchment that is located to the south of the Gore Hill Freeway predominantly comprises commercial and industrial type development, while the portion to its north predominantly comprises high density residential development.

Areas of open space within the catchment include Gore Hill Oval, Talus Reserve, Naremburn Park, Artarmon Reserve, Bicentennial Reserve and Tunks Park.

Royal North Shore Hospital is located in the headwaters of the catchment in the vicinity of St Leonards Railway Station. A number of schools and aged-care facilities are also located within the catchment.

2.2 Layout of Drainage System

2.2.1. Flat Rock Creek

The natural drainage characteristics of the Flat Rock Creek catchment have been altered by residential, commercial and industrial development. The construction of the Gore Hill Freeway in 1991 along the route of the original creek has also altered the natural drainage system and its flood storage characteristics.

A piped trunk drainage line was constructed in 1991 in conjunction with the Gore Hill Freeway project, extending from the Pacific Highway in Artarmon to the North Shore Railway. The freeway and its drainage system were later upgraded as part of the Lane Cove Tunnel project in 2006.

Four lateral drainage lines join the piped trunk drainage line from the south and control runoff from a 0.75 km^2 catchment, while five lateral drainage lines which control runoff from a 0.36 km^2 join from the north.

The piped trunk drainage line discharges to a densely vegetated section of open channel about 130 m upstream (west) of the North Shore Railway. Flow in the open section of channel is conveyed under the railway line via an Armco type steel culvert which has a diameter of about 4 m.

The section of Flat Rock Creek which runs between the rail corridor and Willoughby Road was constructed in the 1930's and comprises a covered channel above which is located a vegetated floodway that caters for surcharge flows where it runs between the railway corridor and Chelmsford Avenue, and a concrete and brick lined channel which is about 4 m wide and 2 m deep where it runs from Chelmsford Avenue to Willoughby Road.

Artarmon Reserve was converted to a dual purpose playing field/detention basin in the early 1990's as part of the Gore Hill Freeway construction. The objective was to reduce the peak flows generated by the northern portion of the catchment (i.e. the Northern Tributary and Burra Road Tributary) in order to offset the increase in peak flows generated by the new freeway.

Flows are conveyed through a single span stone arch bridge at Willoughby Road. A 3 m wide by 3 m high box culvert commences at the downstream face of the bridge and runs beneath Bicentennial Reserve before discharging to a channel which commences about 280 m to the east of Flat Rock Drive. Flow which exceeds the capacity of the box culvert surcharges onto the surface of Bicentennial Reserve where it is conveyed overland in an easterly direction along the alignment of a shared pedestrian/bicycle path. Overland flow is conveyed beneath Flat Rock Drive via a pedestrian underpass (refer **Figure 2.1** sheet 3 for location) before discharging to the aforementioned channel.

Flat Rock Creek continues as an open channel for a distance of about 750 m, where it is then enclosed for a distance of about 800 m beneath Tunks Park.

2.2.2. Southern Tributary

The Southern Tributary drains in a northerly direction from the Pacific Highway in St Leonards and has a total catchment area of about 1 km^2 at its confluence with the main arm of Flat Rock Creek.

Gore Hill Oval, which is located in the headwaters of the catchment, acts as a sink point for capturing runoff which is generated by a 0.2 km^2 catchment which lies to the west of Reserve Road. The trunk drainage line ranges in size from a single 900 mm diameter pipe where it runs beneath Gore Hill Oval to a single 1200 mm wide by 1350 mm high reinforced concrete box at Evans Lane.

Downstream of Evans Lane, runoff is conveyed in a concrete and brick lined channel which runs along the back fences of several residential properties and has a maximum bed slope of about 3 per cent.

At a location about 70 m north (downstream) of Ruth Street, flow conveyed in the lined channel enters a box culvert which runs under Willoughby Road, where it joins the 3 m wide by 3 m high box culvert which runs under Bicentennial Reserve.

2.2.3. Brook Street Tributary

The Brook Street Tributary drains in a north-easterly direction from Chandos Street in St Leonards and has a total catchment area of about 0.9 km^2 where it joins the main arm of Flat Rock Creek. About 75 per cent of the Brook Street Tributary catchment lies in the North Sydney Council LGA.

The existing trunk drainage line controlling runoff from the Brook Street Tributary catchment ranges in size from a single 1200 mm diameter pipe at Chandos Street to a single 1350 mm diameter pipe where it discharges to an open channel near the intersection of Marks Street and Quarry Street. A number of minor lateral drainage lines discharge to the trunk drainage system along its length.

2.2.4. Northern Tributary

The Northern Tributary drains in an easterly direction from Cambridge Road in Artarmon and has a total catchment area of about 0.7 km^2 where it drains to the detention basin in Artarmon Reserve.

The main trunk drainage line controlling runoff from the Northern Tributary catchment ranges in size from a single 375 mm diameter pipe at Cambridge Road to a single 900 mm wide by 1050 mm high box culvert at Weedon Road. Downstream of this location the trunk drainage line continues to run in an easterly direction toward Artarmon Bowling Club beneath a shared pedestrian/bicycle path as either an arch culvert or a concrete and brick lined channel which has been fitted with a concrete lid. Runoff is conveyed under Artarmon Reserve in the covered channel where it joins the main arm of Flat Rock Creek on the northern side of the Gore Hill Freeway.

Overland flow that surcharges the trunk drainage line ponds in the Artarmon Reserve detention basin. The rate at which runoff can discharge from the detention basin is controlled by a single 1500 mm diameter pipe that was fitted with a 1080 mm diameter orifice plate in 2006 as part of the Lane Cove Tunnel project.

The major lateral drainage lines in the catchment have their headwaters in the vicinity of Mowbray Road in Artarmon and Stafford Road near its intersection with Stewart Street.

2.2.5. Burra Road Tributary

The Burra Road Tributary drains in a southerly direction from Mowbray Road in Artarmon and has a total catchment area of about 0.6 km^2 where it drains to the detention basin in Artarmon Reserve. The main trunk drainage line ranges in size from a single 900 mm diameter pipe at Brand Street to a single 2100 mm wide by 1600 mm high box culvert where it discharges to an open channel which extends downstream of Burra Road.

Four lateral drainage lines run under the raised embankment that forms the North Shore Railway on the eastern side of Hampden Road, as do two pedestrian underpasses that are located near Artarmon Railway Station.

Based on information and advice provided by Council, it was determined that the following three partial blockages are present within the existing piped stormwater drainage system in the vicinity of Artarmon Railway Station (refer **Figure 2.1** sheet 1 for location):

- Blockage B1 — The accumulation of debris in the invert of the 1100 mm diameter pipe that crosses the North Shore Railway has resulted in a 25 per cent reduction in its waterway area.
- Blockage B2 — The construction of a sewer or water main through the 1200 mm diameter pipe that runs along the southern side of Valetta Lane coupled with the accumulation of debris behind the intrusion has resulted in a 50 per cent reduction in its waterway area.
- Blockage B3 — The construction of a sewer or water main through the culvert beneath No. 2 Elizabeth Street coupled with the accumulation of debris behind the intrusion has resulted in a 50 per cent reduction in its waterway area.

2.2.6. Willoughby Road Tributary

The Willoughby Road Tributary drains in a southerly direction from Mowbray Road in Willoughby and has a total catchment area of about 0.6 km^2 where it joins the main arm of Flat Rock Creek. The trunk drainage line ranges in size from a single 450 mm diameter pipe at Penkivil Street to a single 2400 mm wide by 1300 mm high box culvert where it runs under Small Street. The culvert continues as a single 1800 mm wide by 1500 mm high box culvert where it joins the main arm of Flat Rock Creek south of Bicentennial Reserve.

The catchment is drained by a number of lateral piped drainage lines that typically follow the alignment and grade of the local road network. The largest of these lateral drainage lines commences near the intersection of Mowbray Road and Patton Lane in Willoughby, where it runs in a southerly direction through several residential properties before joining the trunk drainage line in Julian Street.

2.3 Gore Hill Park Redevelopment

Council advised that it intends to redevelop Gore Hill Oval in the near future as part of the Gore Hill Park Redevelopment Project (refer **Figure 2.1**, sheet 1 for location). The project involves the upgrade of the sporting facilities (including the realignment of the Gore Hill Oval) and the construction of a 4000 m^3 on-site detention tank beneath the surface of the oval. The purpose of the on-site detention tank is to reduce the existing flood risk downstream of the oval. As construction of the on-site detention system is expected to commence in 2017, its attenuating effects have been taken into account as part of the present investigation.

2.4 Previous Investigations

The following flooding and drainage investigations have been have undertaken since 1987:

- *Drainage Investigation on Flooding in Flat Rock Creek Catchment (Lyall & Macoun Consulting Engineers* (**LMCE**), 1987)
- *Flat Rock Creek Flood Study* (Snowy Mountains Engineering Corporation (**SMEC**), 1995)
- *Working Paper Twelve – Hydrology and Hydraulics* (WP12, 2001) (prepared as part of the Environmental Impact Statement for the Lane Cove Tunnel Project)
- *Lane Cove Technical Memorandum. Technical Memo 007: Flat Rock Creek Flood Assessment* (Parsons Brinkerhoff (**PB**), 2004)
- *Flat Rock Creek Flood Study* (L&A, 2006)
- *Overland Flooding Investigation – Willoughby City Area* (L&A, 2009)

- *Flat Rock Creek – Updated Flood Study* (L&A, 2011)
- *Proposed Redevelopment Site at No. 2 Elizabeth Street, Artarmon – Drainage and Overland Flow Investigation* (L&A, 2014)

Appendix A of this report contains a brief overview of the abovementioned studies.

2.5 Community Consultation

To assist with data collection and promotion of the study, a Community Newsletter and Questionnaire was prepared and distributed to residents and business owners via Council's "Have Your Say" webpage. Sixty-three responses (63) were received by 19 February 2017 (the closing date for submissions). Of those that responded, eighteen (18) respondents noted that they had observed flooding in or adjacent to their property. A discussion on the findings of the community consultation process, as well as a comparison of observed and modelled flood behaviour is contained in **Appendix A** of this report.

The draft *Flood Study Report* was placed on public exhibition over the period 16 September 2017 to 15 October 2017. Residents in flood affected areas were invited to view the draft report and provide comment via Council's "Have Your Say" webpage, by phoning Council and/or attending a meeting with a Council representative. Council also presented the findings of the study at a Community Information and Consultation Evening which was held at Council Chambers on 14 September 2017.

Six submissions were received by Council, with the two main issues raised by the respondents being as follows (with the subsequent response provided by the Consultant given in *italics*).

- Several respondents were concerned that the exhibited extents and depths of inundation within specific properties were either not consistent with observed patterns of overland flow or did not appear to account for the presence of local drainage or topographic features that may influence localised flow patterns.

  The structure of the hydraulic model that has been developed is considered to adequately represent the key features that control overland flow behaviour for the purposes of a catchment-wide investigation, noting that it is not practical to incorporate internal property drainage systems and other local topographic features such as raised gardens beds, retaining walls, boundary fences, etc into the hydraulic model within the scope of the present investigation.

  Additional modelling was undertaken to verify the accuracy of the TUFLOW model results in several properties located along Hector Road.

  The definition of overland flow patterns at an individual allotment level would require detailed property survey which is outside the scope of the present investigation.

- Several respondents questioned the current flooding classifications applied to their property by Council and queried how the current classifications would be impacted by the present investigation.

  Current classifications will be reviewed by Council once the present investigation is finalised and adopted for use.

Following the conclusion of the community consultation process the draft *Flood Study Report* was updated to incorporate minor amendments.

2.6 Historic Flooding in the Study Area

As mentioned, several historic flood marks have been surveyed on the southern side of Flat Rock Creek where it runs between the extension of Grandview Street and Park Road for storm events that occurred in August 1986, March 1994 and April 1998.

The piped drainage system in the Flat Rock Creek catchment is of limited capacity and based on anecdotal reports has surcharged during several large storms over the past 30 years.

The experiences of respondents to the Newsletter/Questionnaire mainly relate to instances of "flash flooding" resulting from surcharge of internal property drainage systems, as well as elements of Council's piped drainage system.

Very limited information was provided by the respondents relating to specific flooding patterns in the study area, with five (5) respondents advising that they had observed flooding in or adjacent to their property in a storm event that occurred on 6 June 2016, while a further six (6) provided information on locations that are impacted by flooding on a "frequent" basis. While a further seven (7) respondents reported flooding in the study area, they did not nominate the date when it occurred.

3 HYDROLOGIC MODEL DEVELOPMENT AND TESTING

3.1 Hydrologic Modelling Approach

The assessment of the runoff characteristics of the Flat Rock Creek catchment was based on a hydrologic model that was developed using the DRAINS software. DRAINS is a simulation program that converts rainfall patterns to stormwater runoff and generates discharge hydrographs. These hydrographs are routed through networks of piped drainage systems, culverts, storages and open channels to calculate hydraulic grade lines and analyse the magnitude of overland flows. Discharge hydrographs generated by DRAINS can also be used as inflows to hydraulic models (such as the TUFLOW two-dimensional hydraulic modelling software used in the present study) to determine flooding patterns. The latter approach is particularly useful for modelling complex flood behaviour involving multiple flow paths and has been used in the present study. Further discussion on the DRAINS modelling approach is contained in **Section A3.2** of **Appendix A** of this report.

3.2 Hydrologic Model Layout

Figure 2.1 shows the layout of the various sub-catchments which comprise the DRAINS hydrologic model for the study area.

As the primary function of the DRAINS model was to generate discharge hydrographs for input to the TUFLOW hydraulic model (which routed the flows through the drainage system), piped reaches and overland flow paths linking the various sub-catchments were not incorporated in the model.

Careful consideration was given to the definition of the sub-catchments which comprise the hydrologic model to ensure peak flows throughout the drainage system would be properly routed through the TUFLOW model. In addition to using the LiDAR-based contour data, the location of surface inlet pits was also taken into consideration when deriving the boundaries of the various sub-catchments.

Percentages of impervious area were assessed using Council's aerial photography and cadastral boundary data. Sub-catchment slopes used for input to the DRAINS model were derived from average slope values computed by terrain analysis of the LiDAR survey data.

3.3 Hydrologic Model Testing

3.3.1. General

Although rainfall data and flood marks were available for the August 1988 and March 1994 storm events, these events were not modelled as the pre-Gore Hill Freeway catchment characteristics were not able to be determined. The April 1998 storm was also not considered for calibration as L&A, 2006 found that the rainfall data recorded by the Bureau of Meteorology (**BoM**) operated pluviometer at Chatswood Bowling Club (Station No. 066011) were not representative of the rain that fell over the Flat Rock Creek catchment.

The only quantitative data available to assist in the model testing process were depths of rainfall that were recorded at Chatswood Bowling Club during the storm that occurred on 6 June 2016. The recorded rainfalls were applied to the DRAINS model which was used to generate discharge hydrographs. The hydrographs were then applied to the TUFLOW model and the computed flooding patterns compared with several observations that were made by residents in Hector Road in Willoughby and Olympia Road in Naremburn (refer **Section A3.5** in **Appendix A** of this report for further discussion).

3.3.2. DRAINS Model Parameters

DRAINS requires information on the soil type and infiltration losses to determine the depth of excess rainfall, as well as information on the piped drainage system and the time of travel of the flood wave through the catchment. Infiltration losses are of two types: Initial Loss (**IL**) arising from water which is held in depressions which must be filled before runoff commences, and a Continuing Loss (**CL**) rate which depends on the type of soil and the duration of the storm event.

Model testing was undertaken with the following parameters:

- Soil Type = 3
- AMC = 3
- Paved area depression storage = 2.0 mm
- Grassed area depression storage = 10.0 mm
- Paved flow path roughness = 0.02
- Grassed flow path roughness = 0.07

These parameters have been adopted in a number of similar urban flood study investigations that have been undertaken for other catchments within the Willoughby City LGA.

3.3.3. Results of Model Testing

The discharge hydrographs generated by DRAINS, when applied to the TUFLOW hydraulic model, gave reasonable correspondence with observed flood behaviour. The DRAINS model parameters set out above were therefore adopted for the design flood estimation described in **Chapter 5**.

4 HYDRAULIC MODEL DEVELOPMENT AND TESTING

4.1 The TUFLOW Modelling Approach

TUFLOW is a true two-dimensional hydraulic model which does not rely on a prior knowledge of the pattern of flood flows in order to set up the various fluvial and weir type linkages which describe the passage of a flood wave through the system.

The basic equations of TUFLOW involve all of the terms of the equations of unsteady flow. Consequently the model is "fully dynamic" and once tuned will provide an accurate representation of the passage of the floodwave through the drainage system (both surface and piped) in terms of extent, depth, velocity and distribution of flow.

TUFLOW solves the equations of flow at each point of a rectangular grid system which represent overland flow on the floodplain and along streets. The choice of grid point spacing depends on the need to accurately represent features on the floodplain which influence hydraulic behaviour and flow patterns (e.g. buildings, streets, changes in floodplain dimensions and hydraulic roughness, etc).

River, channel and piped drainage systems can be modelled as one-dimensional elements embedded in the larger two-dimensional domain, which typically represents the wider floodplain. Flows are able to move between the one and two-dimensional elements of the model, depending on the capacity characteristics of the drainage system being modelled.

The TUFLOW model developed for the Flat Rock Creek catchment allows for the assessment of potential flood management measures, such as detention storage, increased channel and floodway dimensions, augmentation of culverts and bridge crossing dimensions, diversion banks and levee systems. All of these measures will need to be considered during the preparation of the future Floodplain Risk Management Study and Plan (***FRMS&P***) for the Flat Rock Creek catchment.

4.2 TUFLOW Model Setup

4.2.1. Model Structure

The layout of the TUFLOW model that was developed for the Flat Rock Creek catchment is shown on **Figure 4.1**. The model comprises the pit and pipe drainage system, sections of open channel which are modelled by cross sections, as well as overland flow paths which are modelled by the rectangular grid.

The following sections provide further details of the model development.

4.2.2. Two-Dimensional Model Domain

An important consideration of two-dimensional modelling is how best to represent the roads, fences, buildings and other features which influence the passage of flow over the natural surface. Two-dimensional modelling is very computationally intensive and it is not practicable to use a mesh of very fine elements without excessive times to complete the simulation, particularly for long duration flood events. The requirement for a reasonable simulation time influences the way in which these features are represented in the model.

A grid spacing of 2 m was found to provide an appropriate balance between the need to define features on the floodplain versus model run times, and was adopted for the investigation. Ground surface elevations for model grid points were initially assigned using a Digital Terrain Model (**DTM**) derived from LiDAR survey data, and updated using ground survey data where such data were available.

Figure 4.2 shows the location and extent of survey (additional to the LiDAR data) which was supplied by Council and others in the form of a series of DTM's and incorporated in the TUFLOW model. **Figure 4.2** also shows the extent of the DTM which defined finished surface levels for the Gore Hill Park Redevelopment which was also incorporated in the TUFLOW model.

Ridge and gully lines were added to the TUFLOW model where the grid spacing was considered too coarse to accurately represent important topographic features which influence the passage of overland flow. The elevations for these ridge and gully lines were determined from survey data where available, or otherwise from inspection of LiDAR survey or site-based measurements.

Gully lines were also used to represent various sections of creek remote from residential development in the lower parts of the catchment where it was not necessary to precisely represent the conveyance capacity of these watercourses. The use of gully lines ensured that positive drainage was achieved along the full length of these watercourses, and thus avoided creation of artificial ponding areas as artefacts of the 'bumpy' nature of the underlying LiDAR survey data.

The footprints of a large number of individual buildings located in the two-dimensional model domain were digitised and assigned a high hydraulic roughness value relative to the more hydraulically efficient roads and flow paths through allotments. This accounted for their blocking effect on flow while maintaining a correct estimate of floodplain storage in the model.

It was not practicable to model the individual fences surrounding the many allotments in the study area. They comprised many varieties (brick, paling, colorbond, etc) of various degrees of permeability and resistance to flow. It was assumed that there would be sufficient openings in the fences to allow water to enter the properties, whether as flow under or through fences and via openings at driveways. Individual allotments where development is present were digitised and assigned a high hydraulic roughness value (although not as high as for individual buildings) to account for the reduction in conveyance capacity which will result from fences and other obstructions stored on these properties.

4.2.3. One-Dimensional Model Elements

All of the piped elements contained in Council's asset database and which influence the passage of flow were included in the TUFLOW model (2718 pipes and 237 box culverts), with the smallest conduit size measuring 100 mm in diameter. Selected pipe and culvert details were also available as part of previous survey undertaken for Council, and this information was used to supplement the asset database as appropriate.

Limited information was available on pipe invert levels, therefore an assumed cover of 600 mm was adopted for those drainage elements where invert levels or depth measurements were not available. Adjustments were made to the assumed invert levels where this approach resulted in a negatively graded reach of pipe or culvert.

Several types of pits are identified on **Figure 4.1**, including junction pits which have a closed lid and inlet pits which are capable of accepting overland flow. Council's asset database contained only limited information in regard to inlet pit types and dimensions. Therefore it was not possible to define inlet capacity relationships for incorporation in the TUFLOW model. The capacity of the piped drainage system is therefore based on the hydraulic capacity of the pipes as determined by the model[1].

Pit losses in the various piped drainage networks were modelled using the approach whereby energy loss coefficients at pipe junctions are re-calculated at each time step of the simulation. The losses are based on a range of variables including the inlet/outlet flow distribution, the depth of water within the pit, expansion and contraction of flow through the pit, the horizontal deflection angle between inlet and outlet pipes, and the vertical drop across the pit.

Eighty eight cross sections derived from detailed ground survey data were used to define the in-bank waterway area of Flat Rock Creek and the Southern Tributary. A further 29 cross sections derived from LiDAR survey data were used to define several road crossings of the Gore Hill Freeway. The location of all 117 cross sections are shown on **Figure 4.1**.

4.2.4. Model Parameters

The main physical parameter for TUFLOW is the hydraulic roughness. Hydraulic roughness is required for each of the various types of surfaces comprising the overland flow paths, as well as for the cross sections representing the geometric characteristics of the various river and creek channels. In addition to the energy lost by bed friction, obstructions to flow also dissipate energy by forcing water to change direction and velocity and by forming eddies. Hydraulic modelling traditionally represents all of these effects via the surface roughness parameter known as "Manning's n". Flow in the piped system also requires an estimate of hydraulic roughness.

There are very limited historic flood level data available to assist with the tuning of the model for roughness. Assessment of Manning's n values for the open sections of the drainage system was relatively straightforward, as cross sections taken normal to the direction of flow have traditionally been used when modelling one-dimensional waterways. Creek roughness was estimated from site inspection, past experience and values contained in the engineering literature.

The process of ascribing roughness to the various types of surfaces encountered on the two-dimensional floodplain, where flow was generally shallow and of low velocity, was more difficult. Initial experiments showed that peak flows were quite sensitive to the adopted value of Mannings n. Increasing n resulted in the retarding and storage of water on the upper reaches of the floodplain, with a reduction in downstream flood peaks.

Adoption of high values of n had the potential to over-attenuate the downstream flow, resulting in flood levels that were on the low side. These effects emphasised the need for undertaking sensitivity studies prior to final selection of values for design (see **Section 6.3**) and also confirmed the appropriateness of the two-stage (hydrologic-hydraulic) modelling approach adopted for this study.

Table 4.1 presents the "best estimate" of hydraulic roughness values adopted for model testing. These values gave reasonable correspondence with observed flood behaviour, and were also adopted for design purposes.

[1] Pit inlet capacity was incorporated in the hydraulic model between Gore Hill Oval and St Leonards Railway Station as part of a detailed site investigation that was undertaken concurrently with the present investigation.

TABLE 4.1
"BEST ESTIMATE" OF HYDRAULIC ROUGHNESS VALUES
ADOPTED FOR TUFLOW MODEL TESTING

Surface Treatment / Model Element	Manning's n Value
Concrete pipes / box culverts	0.015
Asphalt or concrete road surface	0.02
Well-maintained grass cover (e.g. sports field)	0.03
Grass or Lawns	0.045
Trees / Shrubs	0.08
Creek channel	0.05 – 0.08
Creek bank	0.1
Allotments (between buildings)	0.1
Buildings	10

The adoption of a value of 0.02 for the surfaces of roads, along with an adequate description of their widths and centreline/kerb elevations, allowed an accurate assessment of their conveyance capacity to be made. Similarly, the high value of roughness adopted for buildings recognised that these structures will completely block the flow but are capable of storing water when flooded.

Figure 4.3 is a typical example of flow patterns derived from the above roughness values. This example applies for the 1% AEP design storm event and shows overland flows through residential allotments between Penkivil Street and Edward Street, Willoughby.

The left hand side of the figure shows the roads and inter-allotment areas, as well as the outlines of buildings, which have been individually digitised in the model. The right hand side shows the resulting flow paths in the form of scaled velocity vectors and the depths of inundation. The buildings with their high values of hydraulic roughness block the passage of flow, although the model recognises that they store floodwater when inundated and therefore correctly accounts for flood storage. The flow is conveyed via the road reserves and through the open parts of the allotments. Similar information to that shown on **Figure 4.3** may be presented at any location within the model domain (which is shown on **Figure 4.1**) and will be of assistance to Council in assessing individual flooding problems in the floodplain.

4.3 Model Boundary Conditions

4.3.1. Inflow Hydrographs

The locations where sub-catchment inflow hydrographs were applied to the TUFLOW model are shown on **Figure 4.1**. These comprise both point-source inflows at selected inlet pits and channel reaches, and distributed inflows via "Rain Boundaries".

The Rain Boundaries act to "inject" flow into the TUFLOW model, firstly at a point which has the lowest elevation, and then progressively over the extent of the Rain Boundary as the grid in the two-dimensional model domain becomes wet as a result of overland flow.

4.3.2. Downstream Boundary Conditions

The primary downstream boundary of the TUFLOW model comprises a tailwater representing the tidal conditions in Long Bay. Due to the relatively short duration of catchment-driven storm events affecting the study area, harbour water levels were applied to the TUFLOW model as a static tailwater.

A second downstream boundary type comprising a stage-discharge relationship was used to model overland flow which exits the two-dimensional model domain at several locations around its perimeter. A third downstream boundary type comprising a free draining culvert arrangement was also used to model the influx of overland flow to the Lane Cove Tunnel.

<u>Tidal Harbour Water Levels</u>

For the purpose of this present investigation, a static harbour water level of RL 1.0 m AHD was adopted for the simulation of local catchment flood events in the absence of any storm-driven tailwater influence. This downstream boundary condition was also adopted for the simulation of historic flood events. A water level of RL 1.0 m AHD approximates the peak water level reached on average once or twice per year during a Highest High Water Solstice Spring (**HHWSS**) tide.

<u>Storm-Driven Harbour Water Levels</u>

OEH's *"Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments"* (DECCW, 2010) contains an appendix that deals with modelling the interaction of catchment and coastal flooding for different classes of tidal waterway. The appendix may be used to derive scenarios for coincident flooding from those two sources for both present day conditions and conditions associated with future climate change[2].

For a catchment draining directly to the ocean via trained or otherwise stable entrances, such as is the case for Flat Rock Creek, DECCW, 2010 offers the following alternative approaches for selecting storm tidal conditions under present day conditions. In order of increasing sophistication they are:

- A default tidal hydrograph which has a peak of RL 2.6 m AHD for the 1% AEP event; or 2.3 m AHD for the 5% AEP event. This default option is acknowledged in DECCW, 2010 as providing a conservatively high estimate of tides for these types of entrances.
- A site-specific analysis of elevated water levels at the downstream boundary location. The analysis should include contributions to the water levels such as tides, storm surge, wind and wave set up. The analysis should also examine the duration of high tidal levels, as well as their potential coincidence with catchment flooding. This approach requires a more detailed consideration of historic tides and the entrance characteristics, but provides information which is more directly relevant to a particular catchment.

The latter approach has been adopted for the purpose of this present investigation. Design still[3] water levels applicable to the lower reaches of Sydney Harbour were obtained from Watson & Lord (2008), and are shown in **Table 4.2** over.

[2] Note that further discussion of the potential impact that future climate change induced sea level rise may have on storm-driven harbour water levels, and the resultant effects on flood behaviour within the study area, is provided in **Section 6.4.3**.

[3] Still water levels include astronomical tide and storm surge components, but exclude influences from local storm effects such as wind setup and local wave conditions.

An allowance of 0.3 m to account for local storm effects such as wind setup and wave conditions was added to the design still water levels to yield the design peak 'storm tide' levels (also shown in **Table 4.2**) that were adopted for assessment of harbour-driven flooding in the study area.

TABLE 4.2
DESIGN HARBOUR WATER LEVELS

Event	Design Still Water Level(1) (m AHD)	Design Peak Storm Tide Level (m AHD)
1 EY	1.24	1.54
50% AEP	1.28	1.58
20% AEP	1.32	1.62
10% AEP	1.35	1.65
5% AEP	1.38	1.68
2% AEP	1.42	1.72
1% AEP	1.44	1.74

1. Source: Watson & Lord (2008).

A flood envelope approach was adopted for defining design water surface elevations and flow velocities throughout the study area. The procedure involved running the model for a range of scenarios, for both catchment-driven flooding and inundation of the lower reaches of the study area as a result of elevated harbour water levels, to define the upper limit (i.e. the envelope) of expected flooding for each design flood frequency.

Derivation of design flood envelopes to define the upper limit of expected flooding for each flood frequency (i.e. as a result of both catchment flooding and storm-driven harbour water levels) is presented in **Section 4.4**. The impact of elevated water levels in the harbour on flood behaviour in the study area is presented in the hydraulic modelling of design floods in **Chapter 6**.

4.4 Derivation of Design Flood Envelopes

The process undertaken for deriving the design flood envelopes for the study area was as follows:

- **Step 1** – Run the hydraulic model for local catchment storms of various return periods and durations in combination with the HHWSS tide level. [The static water level of RL 1.0 m AHD was adopted as the downstream boundary of the hydraulic model for these runs].
- **Step 2** – Combine the results of **Step 1** to create an envelope of maximum catchment flood levels for each return period (i.e. the results of running storms of the same return period but different duration were combined to create a single envelope for that return period).
- **Step 3** – Run the hydraulic model for local catchment storms in combination with peak design storm tide levels of various return periods. [The static water levels shown in **Table 4.2** were adopted as the downstream boundary of the hydraulic model for these runs].

- **Step 4** – Prepare a final set of flood envelopes for each return period using a combination of the envelopes derived from **Step 2**, and a corresponding storm tide condition from **Step 3**. **Table 4.3** over the page sets out the combination of local catchment and storm tide conditions which were used to compile the design flood envelopes for the study area.

The storm durations modelled for assessment of local catchment flooding ranged between 25 minutes and 6 hours. Storms of shorter duration, typically the 25, 60 and 90 minute duration events were generally critical in terms of maximising peak flood levels within the upper and middle reaches of the catchment (i.e. in areas above the tidal influence). Following an initial assessment of storm durations of up to 6 hours, a storm duration of 60 minutes was found to be critical in terms of maximising peak flood levels at the outlet to Long Bay and adjacent areas of the lower Flat Rock Creek catchment.

TABLE 4.3
DERIVATION OF DESIGN FLOOD LEVEL ENVELOPES

Design Flood Envelope	Catchment Flood	Harbour Boundary Condition
1 EY	1 EY [1]	HHWSS peak tide level (i.e. RL 1.0 m AHD)
	1 EY [2]	1 EY design storm tide level (i.e. RL 1.54 m AHD)
50% AEP	50% AEP [1]	HHWSS peak tide level (i.e. RL 1.0 m AHD)
	50% AEP [2]	50% AEP design storm tide level (i.e. RL 1.58 m AHD)
20% AEP	20% AEP [1]	HHWSS peak tide level (i.e. RL 1.0 m AHD)
	20% AEP [2]	20% AEP design storm tide level (i.e. RL 1.62 m AHD)
10% AEP	10% AEP [1]	HHWSS peak tide level (i.e. RL 1.0 m AHD)
	20% AEP [2]	10% AEP design storm tide level (i.e. RL 1.165 m AHD)
5% AEP	5% AEP [1]	HHWSS peak tide level (i.e. RL 1.0 m AHD)
	20% AEP [2]	5% AEP design storm tide level (i.e. RL 1.68 m AHD)
2% AEP	2% AEP [1]	HHWSS peak tide level (i.e. RL 1.0 m AHD)
	10% AEP [2]	2% AEP design storm tide level (i.e. RL 1.72 m AHD)
1% AEP	1% AEP [1]	HHWSS peak tide level (i.e. RL 1.0 m AHD)
	5% AEP [2]	1% AEP design storm tide level (i.e. RL 1.74 m AHD)
0.5% AEP	0.5% AEP [1]	HHWSS peak tide level (i.e. RL 1.0 m AHD)
	5% AEP [2]	1% AEP design storm tide level (i.e. RL 1.74 m AHD)
0.2% AEP	0.2% AEP [1]	HHWSS peak tide level (i.e. RL 1.0 m AHD)
	5% AEP [2]	1% AEP design storm tide level (i.e. RL 1.74 m AHD)
PMF	PMF [1]	HHWSS peak tide level (i.e. RL 1.0 m AHD)
	1% AEP [2]	1% AEP design storm tide level (i.e. RL 1.74 m AHD)

1. Indicates use of local catchment floods for durations ranging between 25 minutes and 6 hours (for 1 EY to 0.2% AEP), or 15 to 60 minutes (for PMF).
2. Indicates use of local catchment flood for duration of 60 minutes only.

5 DERIVATION OF DESIGN FLOOD HYDROGRAPHS

5.1 Design Storms

5.1.1. Rainfall Intensity

The procedures used to obtain temporally and spatially accurate and consistent Intensity-Frequency-Duration (**IFD**) design rainfall curves for the study catchment area are presented in IEAust, 1987. Design storm rainfalls for a 1 EY event and AEP's of 50, 20, 5, 2, 1, 0.5 and 0.2 per cent were derived for storm durations ranging between 25 minutes and 6 hours. The procedure adopted was to generate an IFD dataset for the catchment by using the relevant charts in IEAust, 1987. These charts included design rainfall isopleths, regional skewness and geographical factors.

5.1.2. Areal Reduction Factors

The rainfalls derived using the processes outlined in IEAust, 1987 are applicable strictly to a point. In the case of a catchment of over tens of square kilometres area, it is not realistic to assume that the same rainfall intensity can be maintained. An Areal Reduction Factor (**ARF**) is typically applied to obtain an intensity that is applicable over the entire catchment.

However, as the area of the study catchment is relatively small (7.0 km^2), the reduction in rainfall intensity would be quite small. Furthermore, the purpose of this present study is to define flood behaviour not only in the lower reaches of each catchment, but also in the middle and upper reaches where the contributing catchment areas are much smaller in size.

Accordingly, no reduction in design point rainfalls was made for this present study (i.e. an ARF of 1.0 was adopted).

5.1.3. Temporal Patterns

Temporal patterns for various zones in Australia are presented in IEAust, 1987. These patterns are used in the conversion of a design rainfall depth with a specific AEP into a design flood of the same frequency. Patterns of average variability are assumed to provide the desired conversion. The patterns may be used for AEP's down to 0.2 per cent where the design rainfall data is extrapolated for storm events with an AEP less than 1 per cent.

The derivation of temporal patterns for design storms are discussed in Volume 1 of IEAust, 1987 and separate patterns are presented in Volume 2 of IEAust, 1987 for AEP's ≥ 3.3 per cent and AEP's < 3.3 per cent. The second pattern is intended for use for rainfalls with AEP's down to 1 per cent, and down to 0.2 per cent in those cases where the design rainfall data in IEAust, 1987 are extrapolated for larger AEP's.

5.2 Probable Maximum Precipitation

Estimates of Probable Maximum Precipitation (**PMP**) were made using the Generalised Short Duration Method (**GSDM**) as described in the BoM's update of Bulletin 53 (BoM, 2003). This method is appropriate for estimating extreme rainfall depths for catchments up to 1,000 km^2 in area and storm durations up to 6 hours.

The steps involved in assessing PMP for each study catchment are briefly as follows:

- Calculate PMP for a given duration and catchment area using depth-duration-area envelope curves derived from the highest recorded US and Australian rainfalls.
- Adjust the PMP estimate according to the percentages of the catchment which are meteorologically rough and smooth, and also according to elevation adjustment and moisture adjustment factors.
- Assess the design spatial distribution of rainfall using the distribution for convective storms based on US and world data, but modified in the light of Australian experience.
- Derive storm hyetographs using the temporal distribution contained in BoM, 2003, which is based on pluviographic traces recorded in major Australian storms.

5.3 Derivation of Design Discharges

The DRAINS model was run with the parameters set out in **Section 3.3.2** to obtain design hydrographs for input to the TUFLOW hydraulic model.

The storm duration of 25 minutes was generally found to be critical for maximising peak flows for individual sub-catchments. Peak PMF flow rates for individual sub-catchments computed by DRAINS for the critical 15 minute PMP storm duration were between 3.3 and 5.3 times the magnitude of peak 1% AEP flow rates. These values lie within the range of expected multiples for a small urban catchment.

6 HYDRAULIC MODELLING OF DESIGN FLOODS

6.1 Presentation and Discussion of Results

6.1.1. Water Surface Profiles and Extents of Inundation

Figures 6.1 to **6.10** show the TUFLOW model results for the 1 EY, 50, 20, 10, 5, 2, 1, 0.5 and 0.2 per cent AEP storm events, as well as the PMF. These diagrams show the indicative extents and depths of inundation in the study area for storms of varying AEP. **Table B1** in **Appendix B** presents peak flows at a number of key locations within the study area.

In order to create realistic results which remove most of the anomalies caused by inaccuracies in the LiDAR survey (which has a design accuracy such that 95 per cent of the points have an accuracy in level of 300 mm), a filter was applied to remove depths of inundation over the natural surface less than 100 mm. This has the effect of removing the very shallow depths which are more prone to be artefacts of the model, but at the same time giving a reasonable representation of the initiation of the various overland flow paths with increasing flood magnitude. The depth grids shown on the figures have also been trimmed to the building polygons, as the results do not represent the depth of above-floor inundation in individual properties. The depth of flow within the footprint of individual buildings can also be over-estimated due to the adoption of a high hydraulic roughness value. The floor levels of individual buildings will be surveyed as part of the future *FRMS&P* and used to assess the economic impact of flooding in the Flat Rock Creek catchment.

Figure 6.11 shows the design water surface profiles along Flat Rock Creek, the Southern Tributary, the Northern Tributary, Burra Road Tributary and the Willoughby Road Tributary, while **Figure 6.12** shows stage and discharge hydrographs at selected locations along the major watercourses in the study area. The height to which water levels reach relative to adjacent road and bridge deck levels is also shown on **Figure 6.12**.

The results confirm the "flash flood" nature of the Flat Rock Creek catchment, with flood levels generally peaking less than 60 minutes after the commencement of rainfall.

6.1.2. Accuracy of Hydraulic Modelling

The accuracy of results depends on the precision of the numerical finite difference procedure used to solve the partial differential equations of flow, which is also influenced by the time step used for routing the floodwave through the system and the spacing of the two-dimensional grid adopted for describing natural surface levels in the drainage paths. Open channels are described by cross-sections normal to the direction of flow, so their spacing also has a bearing on the accuracy of the results. The results are also heavily dependent on the accuracy of the LiDAR survey data, which as noted above has a design accuracy of 300 mm.

Given the uncertainties in the LiDAR survey data and the definition of features affecting the passage of flow, maintenance of a depth of flow of at least 200 mm is required for the definition of a "continuous" flow path in the areas subject to shallow overland flow approaching the main arm of the creek. Lesser modelled depths of inundation may be influenced by the above factors and therefore may be spurious, especially where that inundation occurs at isolated locations and is not part of a continuous flow path. In areas where the depth of inundation is greater than 200 mm threshold and the flow path is continuous, the likely accuracy of the hydraulic modelling in deriving peak flood levels is considered to be between 100 and 150 mm.

Use of the flood study results when applying flood related controls to development proposals should be undertaken with the above limitations in mind. Proposals should be assessed with the benefit of a site survey to be supplied by applicants, in order to allow any inconsistencies in results to be identified and given consideration. This comment is especially appropriate in the areas subject to shallow overland flow, where the errors in the LiDAR survey data or obstructions to flow would have a proportionally greater influence on the computed water surface levels than in the deeper flooded main stream areas.

Minimum floor levels for residential and commercial developments should be based on the 1% AEP flood level plus appropriate freeboard to cater for uncertainties such as wave action, effects of flood debris conveyed in the overland flow stream and precision of modelling. The selection of an interim set of Flood Planning Levels (**FPL's**) which were then used to define the extent of the interim Flood Planning Area (**FPA**) (i.e. the area over which minimum floor level requirements for residential and commercial development apply) is presented in **Section 6.5**.

The sensitivity studies and discussion presented in **Section 6.3** provide guidance on the suitability of the recommended allowance for freeboard under present day climatic conditions. In accordance with OEH recommendations (DECCW, 2007), sensitivity studies have also been carried out (refer **Section 6.4**) to assess the impacts of future climate change. Increases in flood levels due to future increases in rainfall intensities may influence the selection of FPL's. However, final selection of FPL's is a matter for more detailed consideration during the preparation of the future *FRMS&P*.

6.1.3. Main Stream Flooding Behaviour

The key features of main stream flooding in the Flat Rock Creek catchment are as follows:

Flat Rock Creek

- As shown on **Figure 6.12**, water levels in Flat Rock Creek and its tributaries typically rise to their peak less than 60 minutes after the onset of heavy rain.
- Stormwater commences to surcharge the concrete lined reach of Flat Rock Creek between the Gore Hill Freeway and Willoughby Road for events as frequent as 50% AEP. Depths of inundation in the backyards of existing residential development that is located on the right (southern) overbank of the creek exceed 1.0 m during floods with AEP's less than 20 per cent.
- The backwater effects of the Willoughby Road crossing of Flat Rock Creek extend further upstream with increasing flow. In a 1% AEP storm event, the backwater extends as far upstream as a gross pollutant trap that is located about 550 m upstream of the road crossing.
- Downstream of Willoughby Road, stormwater commences to surcharge the trunk drainage system for events as frequent as 50% AEP, where it forms an overland flow path along the southern side of Bicentennial Reserve. Depths of inundation along the overland flow path exceed 1.0 m during floods with AEP's less than 20 per cent.
- Overland flow discharges to the Flat Rock Drive pedestrian underpass for events as frequent as 20% AEP, while floodwater surcharges onto the road for events as frequent as 10% AEP.

- Depths of inundation will exceed 1.0 m during a 1% AEP storm event in the rear of existing developments which lie on both banks of the main arm of Flat Rock Creek in Olympia Road, Park Road and Garland Road in Naremburn, as well as Walter Street in Willoughby.

Southern Tributary

- Gore Hill Oval will operate as a sink point for overland flow which enters onto its surface for storm events with AEP's as low as 0.2 per cent.
- Stormwater commences to pond in the low point in Herbert Street that is located about 80 m north of its intersection with the Pacific Highway for events as frequent as 10% AEP. Depths of inundation at this location exceed 700 mm in a 1% AEP storm event.
- Runoff is generally contained within the inbank area of the Southern Tributary downstream of Evans Lane during storms with AEP's down to 20 per cent. The road crossings at Mitchell Street (1% AEP), Dalleys Road (10% AEP), Dargan Street (5% AEP) and Ruth Street (2% AEP) are overtopped in less frequent storm events.
- Depths of inundation will exceed 1.0 m in existing developments which lie on both banks of the Southern Tributary between Evans Lane and the Gore Hill Freeway in Naremburn during a 1% AEP storm event.
- Stormwater surcharges the entrance to the culvert that is located about 70 m downstream of Ruth Street during a 20% AEP storm event, where it flows in a northerly direction and discharges to the main arm of Flat Rock Creek immediately upstream of Willoughby Road.

Brooks Street Tributary

- A continuous overland flow path is shown to be present through residential development between Chandos Street and Wheatleigh Street in a 20% AEP storm event. Depths of overland flow do not exceed 400 mm along this flow path during a 1% AEP storm event.

Northern Tributary

- A continuous overland flow path is shown to be present in a 50% AEP storm event along the alignment of the stormwater drainage system which runs between Shepherd Road and Artarmon Reserve. Depths of overland flow exceed 1.0 m in residential development immediately upstream of Smith Road in a 50% AEP storm event.
- Depths of overland flow along the Northern Tributary do not exceed 700 mm between Shephard Road and Weedon Road and are generally greater than 1.0 m at regular intervals between Weedon Road and Artarmon Reserve during a 1% AEP storm event.
- **Table 6.1** over the page shows that the Artarmon Reserve Detention Basin is at the point of overtopping in a 1% AEP storm event.

TABLE 6.1
DESIGN FLOOD LEVELS AND AVAILABLE FREEBOARD
ARTARMON RESERVE DETENTION BASIN

AEP (%)	Peak Water Level (m AHD)	Available Freeboard(1) (m)
1 EY	-	-
50	55.89	2.31
20	56.53	1.67
10	56.85	1.35
5	57.27	0.93
2	57.80	0.40
1	58.22	-0.02
0.5	58.33	-0.13
0.2	58.44	-0.24
PMF	58.98	-0.78

1. Based on the spillway elevation of RL 58.20 m AHD.

Burra Road Tributary

- The capacity of the piped stormwater drainage system in the vicinity of Artarmon Railway Station is reduced due the three partial blockages discussed in **Section 2.2.5**. Major ponding is shown to occur in Brand Street beneath the North Shore Railway and in Hampden Road about 50 m to the south of its intersection with Brand Street in a 1EY and 50% AEP storm event, respectively. The depth of inundation will exceed 1.0 m in both locations in a 1% AEP storm event.
- A continuous overland flow path is shown to be present in several residential properties that are located between Elizabeth Street and Burra Road in a 20% AEP storm event. Depths of overland flow will generally be less than 400 mm along this flow path during a 1% AEP storm event, with isolated pockets of up to 700 mm occurring in several locations.
- Stormwater is generally confined to the inbank area of the Burra Road Tributary downstream of Burra Road for storm events with AEP's down to 1 per cent.
- Depths of inundation will exceed 1.0 m in existing development which lies between Valetta Lane and Elizabeth Street during a 1% AEP storm event.

Willoughby Road Tributary

- Figure **6.11**, sheet 3 shows that high ground downstream (south) of Penkivil Street causes runoff that surcharges the piped drainage system to pond to a depth of about 250 mm in the road reserve in a 1EY storm event, increasing to about 1.5 m in a 1% AEP storm event.
- A continuous overland flow path is shown to be present along the alignment of the piped drainage system between Julian Street and Gorman Street in a 20% AEP storm event. Depths of overland flow will reach up to 500 mm at regular intervals along this flow path and exceed 800 mm in several isolated areas during a 1% AEP storm event.

- Stormwater will surcharge the piped drainage system between Gorman Street and Armstrong Street during a 50% AEP storm event, resulting in depths of inundation that exceed 1.0 m in a trapped low point that is located on the western side of Willoughby Road adjacent to existing development. The depth of inundation will exceed 3.0 m at this location in a 1% AEP storm event.
- Stormwater that surcharges the piped drainage system in Small Street ponds in a trapped low point that is located at its intersection with Tulloh Street. The depth of inundation at this location will exceed 2.0 m in a 1% AEP storm event
- Depths of inundation in existing development will exceed 1.0 m during a 1% AEP storm event at the following locations:
  - on the northern side of Penkivil Street in Willoughby;
  - between Gorman Street and Artarmon Road in Willoughby; and
  - on the northern side of Small Street in Willoughby.
- Basement carparks will be inundated during a 1% AEP storm event at Penkivil Street, Willoughby and Small Street, Willoughby.

6.1.4. Areas Affected by Major Overland Flow

The majority of flow in the industrial and commercial area west of the North Shore Railway and south of the Gore Hill Freeway is generally contained within the piped drainage system for storms with AEP's down to 20 per cent. However, overland flow paths are shown to be present in more frequent storm events at the following locations:

- Stormwater surcharges the piped drainage system in the vicinity of Cleg Street and Waltham Street in Artarmon (refer drainage line along which Peak Flow Identifier (**PFI**) Q42 is located on Sheet 2 in the series) during a 1EY storm event. As a result, several industrial properties in this area are affected by overland flow. Depths of inundation in industrial development in the trapped low point bounded by Taylor Lane to the north, Herbert Street to the east, Cleg Street to the south and Waltham Street to the west exceed 1.0 m in a 1EY event and 3.0 m in a 1% AEP event[4].
- Stormwater surcharges the existing drainage system in the vicinity of Sawyers Lane in Artarmon (refer PFI Q46 on Sheet 2) and ponds behind industrial development between Sawyers Lane and Hotham Parade for events as frequent as 50% AEP.
- Stormwater surcharges the piped drainage system in Georges Place, Artarmon (refer PFI Q36 on Sheet 1) and ponds against the noise wall that runs along the northern side of the Gore Hill Freeway for storm events as frequent as 50% AEP. Depths of inundation in the road reserve exceed 1.6 m in a 1% AEP storm event.
- An overland flow path is present in existing residential development that is located adjacent to the pedestrian footpath between Robert Street and Hampden Lane in Artarmon in a 50% AEP storm event.

[4] The present investigation does not take into account any on-site detention systems that may be present in the commercial / industrial allotments in Artarmon and may therefore overestimate the peak flow in the stormwater drainage system.

Depths of overland flow in the residentially developed portion of the catchment are generally less than 300 mm at the 20% AEP level. However, depths of overland flow along the following overland flow paths are shown to exceed 300 mm at the 10% AEP level:

- between Kitchener Road and Broughton Road in Artarmon (refer PFI Q36 on Sheet 1);
- between Eric Road and Benton Avenue in Artarmon;
- between Artarmon Road and Cameron Avenue in Artarmon;
- between Cambridge Road and Tindale Road in Artarmon (refer PFI Q18 on Sheet 1);
- between Stafford Road and Shepherd Road in Artarmon (refer PFI Q24 on Sheet 1);
- between Stafford Road and the Northern Tributary in Artarmon (refer PFI Q25 on Sheet 1);
- between Stafford Road and Onyx Road in Artarmon (refer PFI Q26 on Sheet 1);
- between Penkivil Street and Edward Street in Willoughby (refer PFI Q34 on Sheet 1);
- between Frenchs Road and Small Street in Willoughby (refer PFI Q35 on Sheet 1);
- between Market Street and Garland Road in Naremburn (refer PFI Q45 on Sheet 3); and
- between Ulric Lane and Upper Cliff Avenue in Northbridge.

While depths of overland flow along the abovementioned flow paths exceed 300 mm at the 10% AEP level, they generally do not exceed 600 mm at the 1% AEP level.

Depths of inundation in existing development will exceed 1.0 m during a 1% AEP storm event at the following locations:

- on the western side of Herbert Street in St Leonards;
- between Roberts Street and Hampden Lane in Artarmon;
- on the western side of Hampden Road near Artarmon Railway Station in Artarmon;
- between Market Street and Garland Road in Naremburn;
- on the northern side of Quiamong Road in Naremburn;
- between George Place and the Gore Hill Freeway in Artarmon;
- between Sawyer Lane and Hotham Parade in Artarmon;
- on the northern side of Fredrick Street in Artarmon; and
- between Reserve Road and Herbert Street in Artarmon.

Basement carparks will be inundated during a 1% AEP storm event at the following locations:

- George Place, Artarmon;
- Frederick Street, Artarmon;
- Waltham Street, Artarmon;
- Herbert Street, St Leonards; and
- Quiamong Road, Naremburn.

6.2 Flood Hazard Zones and Floodways

6.2.1. Provisional Flood Hazard

Flood hazard categories may be assigned to flood affected areas in accordance with the procedures outlined in NSW, 2005. Flood prone areas may be provisionally categorised into *Low Hazard* and *High Hazard* areas depending on the depth of inundation and flow velocity. Flood depths as high as a metre, in the absence of any significant flow velocity, could be considered to represent Low Hazard conditions. Similarly, areas of flow velocities up to 2.0 m/s, but with small flood depths could also represent Low Hazard conditions. Interpolation may be used to assess flood hazard in areas subject to intermediate depths of inundation and flow velocities.

Provisional Hazard diagrams for the 5% and 1% AEP events, as well as the PMF based on Diagram L2 of NSWG, 2005 are presented on **Figures 6.13**, **6.14** and **6.15**, respectively.

For the 5% AEP storm event, high hazard flooding encroaches into existing residential development which is located on both banks of the concrete and brick lined reaches of Flat Rock Creek and the Southern Tributary.

High hazard flooding is also present in the 5% AEP storm event along overland flow paths that run through existing development in the following areas:

- between Shepherd Road and Artarmon Reserve on the Northern Tributary in Artarmon;
- in the vicinity of Penkivil Street on the Willoughby Road Tributary in Willoughby;
- between Borlaise Street and Small Street on the Willoughby Road Tributary in Willoughby; and
- between Robert Street and Hampden Lane in Artarmon.

High hazard flooding in the 5% AEP storm event resulting from major ponding occurs in the following areas:

- between Reserve Road and Taylor Lane in St Leonards;
- in George Place on the northern side of the Gore Hill Freeway in Artarmon;
- on the western (upstream) side of the North Shore Railway along Hampden Road in Artarmon; and
- at the western end of Walter Street in Willoughby.

For the 1% AEP storm event, high hazard flooding encroaches into existing development in the following areas:

- between Reserve Road and Herbert Street on the Southern Tributary in Naremburn;
- between Brand Street and Burra Road on the Burra Road Tributary in Artarmon;
- between Lower Cliff Avenue and Tunks Park in Northbridge; and
- immediately downstream of Frederick Street in St Leonards.

For the PMF event, the width of the high hazard zone increases significantly, mainly along Flat Rock Creek and its major tributaries. Other isolated areas of high hazard, which typically relate to relatively shallow but faster-moving overland flow, occur along and across roadways and down relatively steep sloping areas which fall toward the central threads of the main tributaries.

The Flood Hazard assessment presented herein is based on considerations of depth and velocity of flow and is *provisional* only. Other considerations would be taken into account in the future *FRMS&P* for the catchment before a final determination of Flood Hazard is made.

These other factors include:

- Size of flood – major floods though rare can cause extensive damage and disruption.
- Effective warning time – flood hazard and flood damage can be reduced by sandbagging entrances, raising contents above floor level and also by evacuation if adequate warning time is available.
- Flood awareness of the population – flood awareness greatly influences the time taken by flood affected residents to respond effectively to flood warnings. The preparation and promotion by Council of Flood Studies and Floodplain Risk Management Studies and Plans increases flood awareness, as does the formulation and implementation of response plans by NSW State Emergency Service (Local Flood Plans) for the evacuation of people and possessions.
- Rate of rise of floodwaters – situations where floodwaters rise rapidly are potentially more dangerous and cause more damage than situations in which flood levels increase slowly.
- Duration of flooding – the duration of flooding (or length of time a community is cut off) can have a significant impact on costs associated with flooding. This duration is shorter in smaller, steeper catchments.
- Evacuation problems and access routes – the availability of effective access routes from flood prone areas directly influences flood hazard and potential damage reduction measures.

Provisional hazard categories may be reduced or increased after consideration of the above factors in arriving at a final determination. A preliminary qualitative assessment of the influence of the above factors on the *provisional flood hazard* (i.e. the hazard based on velocity and depth considerations only) is presented in **Table 6.2**.

Factors which would increase the flood hazard in **Table 6.2** are balanced by considerations reducing the hazard. Consequently, on balance there appears to be no reason to adjust the *provisional flood hazard*. This preliminary assessment of the "true hazard" will need to be reviewed as part of the future *FRMS&P* investigation, based on the floor levels of affected residential properties.

TABLE 6.2
INFLUENCE OF FLOOD RELATED PARAMETERS ON
PROVISIONAL FLOOD HAZARD
(PRELIMINARY ASSESSMENT)

Parameter	Influence on Provisional Hazard	Flood Characteristics
Size of flood	-1	Flooding in the overland flow paths is comparatively shallow in developed areas, with no sudden increases in depth of flow or alternative flow paths developing with increasing severity of flooding.
Effective warning time	+1	Due to the rapid response of the catchments a short warning time less than one hour after the commencement of heavy rainfall is available, which would tend to increase the provisional flood hazard.
Flood awareness	+1	Flood awareness may be relatively low due to the long period between the occurrence of the last major storm on the catchment (April 1998).
Rate of rise of floodwater	+1	Flooding is of a “flash flooding” nature, with flood levels rising to a peak in less than an hour of the commencement of heavy rainfall.
Duration of flooding	-1	The duration of the flood peak is quite short. The flood recedes less than one hour after the cessation of heavy rainfall (ref. **Figure 6.12**).
Evacuation problems	– 1	On the overland flow paths, the flow is comparatively shallow and there is easy evacuation by foot from the residential areas to higher ground, although vehicular access would be interrupted for up to an hour due to some of the streets acting as floodways. Overall, evacuation problems would not be significant

Legend 0 = neutral impact on provisional hazard
+1 = tendency to increase provisional hazard
-1 = tendency to reduce provisional hazard

6.2.2. Floodways

According to NSWG, 2005, the floodplain may be subdivided into the following three hydraulic categories:

- Floodways;
- Flood storage; and
- Flood fringe.

Floodways are those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with obvious naturally defined channels. Floodways are the areas that, even if only partially blocked, would cause a significant re-distribution of flow, or a significant increase in flood level which may in turn adversely affect other areas. They are often, but not necessarily, areas with deeper flow of areas where higher velocities occur.

Flood storage areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. If the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.

Flood fringe is the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

Floodplain Risk Management Guideline No. 2 Floodway Definition, offers guidance in relation to two alternative procedures for identifying floodways. They are:

- **Approach A**. Using a *qualitative approach* which is based on the judgement of an experienced hydraulic engineer. In assessing whether or not the area under consideration was a floodway, the qualitative approach would need to consider; whether obstruction would divert water to other existing flow paths; or would have a significant impact on upstream flood levels during major flood events; or would adversely re-direct flows towards existing development.
- **Approach B**. Using the hydraulic model, in this case TUFLOW, to define the floodway based on *quantitative experiments* where flows are restricted or the conveyance capacity of the flow path reduced, until there was a significant effect on upstream flood levels and/or a diversion of flows to existing or new flow paths.

One quantitative experimental procedure commonly used is to progressively encroach across either floodplain towards the channel until the designated flood level has increased by a significant amount (for example 0.1 m) above the existing (un-encroached) flood levels. This indicates the limits of the hydraulic floodway since any further encroachment will intrude into that part of the floodplain necessary for the free flow of flood waters – that is, into the floodway.

The *quantitative assessment* associated with **Approach B** is technically difficult to implement. Restricting the flow to achieve the 0.1 m increase in flood levels can result in contradictory results, especially in unsteady flow modelling, with the restriction actually causing reductions in computed levels in some areas due to changes in the distribution of flows along the main drainage line.

Accordingly the *qualitative approach* associated with **Approach A** was adopted, together with consideration of the findings of Howells et al, 2004 who defined the floodway based on velocity of flow and depth. Howells et al suggested the following criteria for defining those areas which operate as a "floodway" in a 1% AEP storm event:

- Velocity x Depth greater than 0.25 m^2/s **and** Velocity greater than 0.25 m/s; or
- Velocity greater than 1 m/s.

Flood storage areas would be identified as those areas which do not operate as floodways in a 1% AEP storm event but where the depth of inundation exceeded 0.3 m.

The portion of the flow path which did not reach the above threshold values would be denoted the "flood fringe".

The hydraulic categorisation for the 1% AEP storm event along Flat Rock Creek and its tributaries and overland flow paths was assessed in accordance with the Howells et al approach and is shown on **Figure 6.16**. While floodway areas in the Flat Rock Creek catchment generally align with the areas subject to high hazard flooding in a 1% AEP storm event (refer **Section 6.2.1** for discussion), additional floodway areas are present at the following locations:

- Between Chandos Street and Wheatleigh Street on the Brooks Street Tributary in St Leonards;
- along the three overland flow paths between Stafford Road and the Northern Tributary in Artarmon;
- between Artarmon Road and Artarmon Railway Station parallel to Tindale Road in Artarmon;
- between Artarmon Road and Artarmon Reserve in Artarmon;
- between Penkivil Street and Edward Street in Artarmon;
- between Frenchs Road and Small Street in Willoughby; and
- between Calbina Road and Flat Rock Creek in Northbridge.

Flood storage areas are generally confined to the Artarmon Reserve detention basin, Gore Hill Oval, the reach of Flat Rock Creek which is subject to backwater influences from Willoughby Road and the trapped low points along the overland flow paths identified in **Section 6.1.2**.

The assessed hydraulic categories for the PMF events are shown on **Figure 6.17**. By comparison with the 1% AEP storm event, the PMF "floodway" is significantly wider along the central threads of the main streams and there are significant "'floodways" in the lateral lines bordering the main trunk lines.

While the Howells et al approach generally results in a continuous "floodway" being developed along the extents of the main arms of the creeks, it does lead to some discontinuities in the definition of "floodway" areas in the built-up parts of the catchment. Further refinement of the "floodway" areas will need to be undertaken as part of the future *FRMS&P* investigation.

6.3 Sensitivity Studies

The sensitivity of the hydraulic model was tested to variations in model parameters such as hydraulic roughness, blockage of pipes, catchment imperviousness and the effects of elevated harbour water levels. The main purpose of these studies was to give some guidance on the freeboard to be adopted when setting floor levels of development in flood prone areas, pending the completion of the future *FRMS&P* for the catchment. The results are summarised in the following sections.

6.3.1. Sensitivity to Hydraulic Roughness

Figure 6.18 shows the difference in peak flood levels (i.e. the "afflux") for the 1% AEP 60 minute duration storm resulting from an assumed Manning's n roughness of 0.2 in allotments, compared with the best estimate value of 0.1. This figure also identifies areas where land is rendered flood free, or where additional areas of land are flooded.

Along Flat Rock Creek and its tributaries, as well as along a number of overland flow paths that follow the lateral drainage lines, the higher roughness provides additional resistance to the passage of flow causing the flow to lose momentum. Water is detained in allotments, resulting in minor increases in peak flood levels by up to 200 mm. Increases in peak flood level are typically accompanied by minor increases to flood extents.

Figure 6.19 shows the afflux for the 1% AEP 60 minute duration storm resulting from an assumed 20 per cent increase in roughness (compared with best estimate values) along the open channels of the creeks and other heavily vegetated areas throughout the Flat Rock Creek catchment. The typical increase in peak flood level along the middle to upper reaches of the drainage system would be up to 200 mm. The increase in extents of inundation in land bordering the channels would not be significant.

6.3.2. Sensitivity to Blockage of Pipes

The mechanism and geometrical characteristics of blockages in the piped system are difficult to quantify and would no doubt be different for each storm event. Realistic scenarios would be limited to one or two pipes becoming partially blocked during a storm event. However, for the purposes of this study, analyses were carried out with the cross sectional areas of all pipes and conduits reduced for storm events with varying AEP's. The following blockage scenarios were assessed:

- 100% blockage of all conduits in a 20% AEP storm event; and
- 50% blockage of all conduits in a 1% AEP storm event.

This represents a case which is well beyond a blockage scenario which could reasonably be expected to occur and is presented for illustrative purposes.

Figure 6.20 shows the afflux for the 20% AEP 60 minute duration storm resulting from 100 per cent blockage of the existing stormwater drainage system. Peak flood levels would be increased by a maximum 700 mm along Flat Rock Creek and its tributaries, as well as the trapped low points along the major overland flow paths (refer **Section 6.1.4**), while the increase in peak flood levels would generally be less than 300 mm along the overland flow paths. The extent of inundation would increase significantly as a result of a 100% blockage of the existing stormwater drainage system.

Figure 6.21 shows the afflux for the 1% AEP 60 minute duration storm resulting from a 50 per cent blockage. While peak flood levels would increase by up to 300 mm along Flat Rock Creek and its tributaries, and up to 200 mm along the overland flow paths, the extent of inundation would not increase significantly in these areas. Greater increases in peak flood level and also the extent of inundation occur in the flood storage areas, particularly in the vicinity of Artarmon Reserve, Gore Hill Oval, Marden Street, Herbert Street and Small Street.

6.3.3. Sensitivity to Increase in Catchment Imperviousness

The increased rate of development within the Willoughby City LGA has the potential to increase the rate and volume of runoff in the Flat Rock Creek catchment, as well as increase the frequency of surcharge of the local stormwater drainage system. Whilst larger developments are subject to on-site detention requirements as set out in the Willoughby Development Control Plan, 2006, minor amendments to existing development may result in an increase in the impervious area within individual allotments. The impact that future development could have on flooding and drainage patterns in the study area was assessed by assuming a 10 per cent increase in the fraction impervious in the sub-catchments that are presently urbanised.

Figure 6.22 shows that future development, if uncontrolled will generally have a negligible effect on peak flood levels along the major overland flow paths, but will increase peak flood levels by up to 100 mm along Flat Rock Creek, its tributaries and in the trapped low points along the overland flow paths described in **Section 6.1.4**.

6.4 Climate Change Sensitivity Analysis

6.4.1. General

Scientific evidence shows that climate change will lead to sea level rise and potentially increase flood producing rainfall intensities. The significance of these effects on flood behaviour will vary depending on geographic location and local topographic conditions. Climate change impacts on flood producing rainfall events show a trend for larger scale storms and resulting depths of rainfall to increase. Future impacts on sea levels are likely to result in a continuation of the rise which has been observed over the last 20 years.

OEH recommends that its guideline *Practical Considerations of Climate Change* (DECC, 2007) be used as the basis for examining climate change induced increases in rainfall intensities in projects undertaken under the State Floodplain Management Program, according to procedures set out in NSWG, 2005. The guideline recommends that until more work is completed in relation to the climate change impacts on rainfall intensities, sensitivity analyses should be undertaken based on increases in rainfall intensities ranging between 10 and 30 per cent. On current projections the increase in rainfalls within the service life of developments or flood management measures is likely to be around 10 per cent, with the higher value of 30 per cent representing an upper limit. Under present day climatic conditions, increasing the 1% AEP design rainfall intensities by 10 per cent would produce a 0.5% AEP flood; and increasing those rainfalls by 30 per cent would produce a 0.2% AEP event.

The NSW Government had previously adopted a *Sea Level Rise Policy Statement* (NSWG, 2009) to support adaptation to projected sea level rise impacts. The policy statement included sea level rise planning benchmarks for use in assessing potential impacts of projected sea level rise in coastal areas, including flood risk and coastal hazard assessment. These benchmarks were a projected rise in sea level (relative to 1990 mean sea level) of 0.4 m by 2050 and 0.9 m by 2100, based on work carried out by the Intergovernmental Panel on Climate Change and CSIRO. OEH recommends in its guideline *Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments (DECCW, 2010)* that these benchmark rises should be used to assess the sensitivity of flood behaviour to future sea level rise.

The NSW Government announced its Stage 1 Coastal Management Reforms in September 2012. As part of these reforms, the NSW Government no longer recommends state-wide sea level rise benchmarks, with local councils now having the flexibility to consider local conditions when determining local future hazards. However, Council considers that the guidance in DECCW, 2010, and in particular the use of the above-mentioned sea level rise benchmarks, remains an appropriate basis for the assessment of potential impacts of sea level rise throughout the LGA.
The impacts of climate change and associated effects on the viability of floodplain risk management options and development decisions may be significant and will need to be taken into account in the future *FRMS&P* for the Flat Rock Creek catchment using site specific data.

At the present flood study stage, the principal issue regarding climate change is the potential increase in flood levels throughout study area. In addition it is necessary to assess whether the patterns of flow will be altered by new floodways being developed for key design events, or whether the provisional flood hazard will be increased.

In the future *FRMS&P*, it will be necessary to consider the impact of climate change on flood damages to existing development. Consideration will also be given both to setting floor levels for future development and in the formulation of works and measures aimed at mitigating adverse effects expected within the service life of development. When setting floor levels for future developments in planning policies for a developed catchment like Flat Rock Creek, it will also be necessary to consider the impact of decisions on the existing streetscape.

Mitigating measures which could be considered in the future *FRMS&P* include the implementation of structural works such as culvert and channel improvements, improved flood warning and emergency management procedures and education of the population as to the nature of the flood risk.

6.4.2. Sensitivity to Increased Rainfall Intensities

As mentioned, the investigations undertaken at the flood study stage are mainly seen as sensitivity studies pending more detailed consideration in the future *FRMS&P*. For the purposes of the investigation, the design rainfalls for 0.5% and 0.2% AEP storm events were adopted as being analogous to flooding which could be expected should present day 1% AEP rainfall intensities increase by 10 and 30 per cent, respectively.

Figure 6.23 shows the afflux resulting from an increase of 10 per cent in 1% AEP rainfall intensities. The increase in peak flood levels along Flat Rock Creek and its tributaries is typically between 50 and 200 mm, with some isolated areas experiencing afflux of around 300 mm. Typical increases along overland flow paths are in the 10 to 50 mm range.

Figure 6.24 shows the afflux for a 30 per cent increase in 1% AEP rainfall intensities. The increase in peak flood levels is typically between 100 and 300 mm along Flat Rock Creek and its tributaries and between 20 to 100 mm along overland flow paths. The peak flood levels in Flat Rock Creek upstream of Willoughby Road will increased by over 500 mm resulting in an increase in the extent of inundation in existing residential development in this area.

It is noted that a new flow path is shown to develop through Bicentennial Reserve for both a 10 and 30% increase in 1% AEP rainfall intensities.

6.4.3. Sensitivity to Rises in Sea Level

For the purposes of the investigation, sensitivity analyses were carried out to assess the impact a future 0.4 m (2050 conditions) and 0.9 m (2100 conditions) rise in sea level will have on the design 1% AEP flood envelope for the study area. Adoption of the benchmark rises would result in the following design peak 1% AEP storm tide levels:

- 2050 conditions = 2.14 m AHD (i.e. 1.74 m AHD + 0.4 m)
- 2100 conditions = 2.64 m AHD (i.e. 1.74 m AHD + 0.9 m)

Figures 6.26 and **6.27** show the afflux for the design 1% AEP flood envelope resulting from the above increases in harbour water level.

These figures show that increases in peak flood level are confined to the lower reaches of the study area immediately adjacent to Long Bay. Under 2050 conditions, increases in peak flood level do no encroach into Tunks Park, while under 2100 conditions, increases in peak flood level extend slightly upstream (west) of this location. Impacts do not propagate upstream along the various lateral drainage lines that flow into Flat Rock Creek or directly into the harbour due to the steepness of both the catchment terrain and piped drainage systems.

6.5 Selection of Interim Flood Planning Levels

After consideration of the TUFLOW results and the findings of the sensitivity studies outlined in **Sections 6.3** and **6.4**, a freeboard allowance of 500 mm was adopted for determination of Interim *FPL's* for main stream flooding in the Flat Rock Creek catchment. Interim FPL contours developed on that basis and the associated Interim FPA are shown on **Figure 6.28**.

While further consideration will need to be given during the preparation of the future *FRMS&P* to the derivation of minimum floor level requirements in future development, based on the findings of the sensitivity studies it is considered that the adoption of interim freeboard allowances of 300 mm and 500 mm in areas affected by major overland flow and main stream flooding, respectively would be appropriate.

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8 FLOOD-RELATED TERMINOLOGY

Note: For an expanded list of flood-related terminology, refer to glossary contained within the Floodplain Development Manual, NSW Government, 2005).

TERM	DEFINITION
Afflux	Increase in water level resulting from a change in conditions. The change may relate to the watercourse, floodplain, flow rate, tailwater level etc.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger events occurring in any one year (see average recurrence interval).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI)	The average period in years between occurrences of a flood of a particular magnitude or greater. In a long period of say 1,000 years, a flood equivalent to or less than a 1% AEP event would occur 10 times. The 1% AEP flood has a 1% chance (i.e. a one-in-100 chance) of occurrence in any one year (see annual exceedance probability).
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving (e.g. metres per second [m/s]).
Flood fringe area	The remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood Planning Area (FPA)	The area of land inundated at the Flood Planning Level.
Flood Planning Level (FPL)	A combination of flood level and freeboard selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans.
Flood prone land	Land susceptible to flooding by the Probable Maximum Flood. Note that the flood prone land is synonymous with flood liable land.
Flood storage area	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event (i.e. flood prone land).

TERM	DEFINITION
Floodplain Risk Management Plan	A management plan developed in accordance with the principles and guidelines in the *Floodplain Development Manual, 2005*. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
Floodway area	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted Flood Planning Level and the peak height of the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such and wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change. Freeboard is included in the flood planning level.
High hazard	Where land is subject to a combination of flood water velocities and depths greater than the following combinations: 2 metres per second with shallow depth of flood water depths greater than 0.8 metres in depth with low velocity. Damage to structures is possible and wading would be unsafe for able bodied adults.
Low hazard	Where land may be affected by floodway or flood storage subject to a combination of floodwater velocities less than 2 metres per second with shallow depth or flood water depths less than 0.8 metres with low velocity. Nuisance damage to structures is possible and able bodied adults would have little difficulty wading.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
Merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well-being of the State's rivers and floodplains.
Overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
Peak discharge	The maximum discharge occurring during a flood event.

TERM	DEFINITION
Peak flood level	The maximum water level occurring during a flood event.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land (i.e. the floodplain). The extent, nature and potential consequences of flooding associated with events up to and including the PMF should be addressed in a floodplain risk management study.
Probability	A statistical measure of the expected chance of flooding (see annual exceedance probability).
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall which actually ends up as stream flow, also known as rainfall excess.
Stage	Equivalent to water level (both measured with reference to a specified datum).

APPENDIX A

FLOOD DATA COLLECTION AND MODEL TESTING

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ANNEXURES

LIST OF FIGURES (BOUND IN VOLUME 2)

A1. INTRODUCTION

A1.1 Scope of Work

This Appendix deals with the following matters:

- The findings of the community consultation process undertaken as part of the study, which was aimed at collecting historic flood data in the Flat Rock Creek catchment.
- Compilation of relevant historic flood data from previous investigations.
- The results of testing the hydrologic and hydraulic model for historic storm events in the Flat Rock Creek catchment.

A1.2 Flood Modelling Approach

As described in the Main Report, modelling flood behaviour within the study area involved:

- The development of a hydrologic model of the Flat Rock Creek catchment to determine discharge hydrographs. The hydrologic modelling was based on the DRAINS rainfall-runoff software. This software derived discharge hydrographs resulting from historic and design storms.
- The development of a hydraulic model of Flat Rock Creek, its tributaries and overland flow paths based on the TUFLOW two-dimensional (in plan) software. The TUFLOW model was used to route the discharge hydrographs through the Flat Rock Creek catchment drainage system and convert the flows to water levels, indicative flood extents and flow patterns.

For the purposes of testing the models (described in this Appendix), pluviographic rainfall data for the historic storm event of 6 June 2016 were analysed and applied to the DRAINS hydrologic model to estimate discharge hydrographs, which were then applied to the TUFLOW hydraulic model of Flat Rock Creek, its tributaries and overland flow paths. This phase of the investigation led to the selection of model parameters for design flood estimation which are described in the Main Report.

A1.3 Layout of Appendix

Section A2 deals with the collection of historic flood data, identification of significant past flood events and analysis of historic storm rainfall data for these events.

Section A3 describes the results of testing the models for the historic floods and compares the results with observed behaviour.

The Community Newsletter and Questionnaire issued at the commencement of the study is included in **Annexure A1** to this Appendix.

A2. COLLECTION OF HISTORIC FLOOD DATA

A2.1 Previous Investigations

A2.1.1 Drainage Investigation on Flooding in Flat Rock Creek Catchment (LMCE, 1987)

LMCE, 1987 was prepared for the then Roads & Traffic Authority (**RTA**) (now Roads & Maritime Services (**Roads & Maritime**)) to assess the potential impacts of the Gore Hill Freeway on flooding. The flood mitigation works proposed to offset the impacts of the freeway included a detention basin in Artarmon Reserve to control flows from the Northern Tributary which discharges to Flat Rock Creek in the vicinity of Chelmsford Avenue. LMCE, 1987 used the RORB runoff-routing software to assess flood flows and the HEC-2 hydraulic modelling software to assess water surface levels along the open channel section of Flat Rock Creek.

Design Drawings subsequently prepared by Lyall & Macoun Consulting Engineers (**LMCE**) in 1988 show the flood works proposed at that time to mitigate the impacts of the original Gore Hill Freeway construction.

A2.1.2 Flat Rock Creek Flood Study (SMEC, 1995)

This investigation used the RAFTS rainfall-runoff software to assess flows and the MIKE 11 dynamic flow model to assess water surface levels in Flat Rock Creek between Chelmsford Avenue and Willoughby Road. Flood level data were collected for flood events which occurred on 10 August 1986 and 7 March 1994.

A2.1.3 Working Paper Twelve - Hydrology and Hydraulics (WP12, 2001)

WP12, 2001 was prepared as part of the Environmental Impact Statement for the Lane Cove Tunnel Project. This investigation included a flood study of the Flat Rock Creek catchment to assess the impacts of the proposed extension of the Gore Hill Freeway on flooding characteristics. The study was undertaken using DRAINS and HEC-RAS and was of a reconnaissance nature, based on then existing sources of survey and drainage data.

A2.1.4 Lane Cove Tunnel Technical Memorandum. Technical Memo 007: Flat Rock Creek Flood Assessment prepared (PB, 2004)

PB, 2004 was prepared to meet the Scope of Works and Technical Criteria and the Minister's Conditions of Approval 234 for the Lane Cove Tunnel Project. The investigation comprised an assessment of flows and water levels along Flat Rock Creek to quantify the potential increases in flows that could occur as a result of the widening of the Gore Hill Freeway associated with the Lane Cove Tunnel Project. The study was undertaken using the DRAINS rainfall-runoff software to assess flows and the HEC-RAS hydraulic modelling software to assess water surface levels in the lower reaches of Flat Rock Creek between Chelmsford Avenue and Willoughby Road.

A2.1.5 Flat Rock Creek Flood Study (L&A, 2006)

L&A, 2006 was commissioned by Council to define flood behaviour along the section of Flat Rock Creek between the North Shore Railway and Willoughby Road, as well as the section of the Southern Tributary between Waters Road and Willoughby Road.

A Community Newsletter was prepared and distributed to 150 residents bordering Flat Rock Creek and the Southern Tributary. Two flood marks were identified and subsequently levelled along Flat Rock Creek for a flood that occurred in April 1998. However, it was found that the rainfalls actually experienced over the Flat Rock Creek catchment were less than those recorded at the nearby Chatswood Bowling Club.

The DRAINS hydrologic model developed as part of PB, 2004 was updated to provide sufficient detail to define inflow boundaries along Flat Rock Creek and the Southern Tributary.

A HEC-RAS hydraulic model also developed as part of PB, 2004 was updated to include a downstream rating curve that more accurately defined the hydraulics of the Willoughby Road arch culvert and used as the basis for defining flooding patterns in terms of peak flood levels, depths of inundation and flow velocities. The model was also updated to include the Southern Tributary. The hydraulic model was used to define flood behaviour for floods ranging between 20% and 0.5% AEP, as well as the PMF.

A2.1.6 Overland Flooding Investigation – Willoughby City Area (L&A, 2009)

Council commissioned a city-wide "screening" study to broadly define flooding patterns and identify properties potentially at risk of flooding from a 1% AEP flood.

The study used two-dimensional hydraulic modelling of the channel and floodplain based on the TUFLOW software. Flows generated by a rainfall-runoff model of the catchment based on the DRAINS software were applied to a TUFLOW hydraulic model which routed the floodwave through the drainage system and assessed flooding patterns and indicative extents of inundation.

The results of the overland flooding investigation provided Council with initial information on flooding throughout the LGA pending the completion of a formal flood study undertaken according to the procedure set out in the NSW Government's Floodplain Development Manual (NSWG, 2005.

Properties in flood prone areas of the various catchments were assessed as being subject to either *"Main Stream Flooding"* or *"Local Overland Flooding"* depending on the dominant flood producing mechanism. In broad terms, *Main Stream Flooding* occurs when the trunk drainage systems (whether open channel or piped) surcharge and flows extend on to the surrounding floodplain, forming continuous flow paths for the conveyance of floodwaters. *Local Overland Flooding* results from runoff which travels as shallow sheet flow over grassed and paved surfaces in individual allotments or along roads en route to the trunk drainage system (i.e. in areas upstream of the formal drainage system), or which surcharges the minor piped drainage systems in the catchment headwaters and the lateral sub-catchments bordering the trunk drainage system.

Local Overland Flooding was further differentiated into *"Local Drainage"* and *"Major Drainage"* classifications, based on the severity of flooding involved. Areas subject to *Local Drainage* problems typically involved depths of overland flow up to 300 mm, while for *Major Drainage* overland flow depths typically exceeded that value.

These flood classifications are currently being used by Council to apply flood-related development controls in flood prone areas of the LGA.

A2.1.7 Flat Rock Creek – Updated Flood Study (L&A, 2011)

In 2011, Council commissioned L&A to update the Flat Rock Creek Flood Study in order to consolidate the hydraulic modelling that was developed as part of L&A, 2006 into a single up-to-date hydraulic model based on the TUFLOW software package.

The TUFLOW model developed as part of L&A, 2011 included the reach of Flat Rock Creek between the North Shore Railway and Willoughby Road, as well as the reach of the Southern Tributary between Talus Reserve and Willoughby Road. The detention basin in Artarmon Reserve was also incorporated in the hydraulic model.

Results were presented as water surface profiles and plans showing indicative extents and depths of inundation for storms ranging between 20% and 0.5% AEP, as well as for the PMF. A provisional assessment of flood hazard was also presented. The investigation also included an assessment of the effects of partial blockage of the waterway at Willoughby Road by debris, as well as the potential impacts of future climate change on peak 1% AEP flood levels.

A2.1.8 Proposed Redevelopment Site at No. 2 Elizabeth Street, Artarmon – Drainage and Overland Flow Investigation (L&A, 2014)

In 2014, L&A undertook a drainage and overland flow investigation on behalf of Council for its proposed redevelopment of No. 2 Elizabeth Street in Artarmon. The objective of the study was to define overland flow behaviour in the vicinity of the site for storms with frequencies ranging between 20% and 1% AEP.

The DRAINS and TUFLOW models that were developed as part of L&A, 2009 were used as the basis for defining flood behaviour in the vicinity of the site. The structure of these models was refined to incorporate significantly more detail on the piped stormwater drainage system, as information in this regard was limited at the time of L&A, 2009. Detailed site survey data were also incorporated into the adjusted TUFLOW model that was established to represent present day conditions, as were three partial blockages that were known to exist within Council's piped stormwater drainage system in the vicinity of the site.

The study also identified he presence of the three blocked pipes that are referred to in **Section 2.2.5** of the Main Report.

A2.2 Community Newsletter

A2.2.1 General

A Community Newsletter and Questionnaire was prepared and distributed to residents in the Flat Rock Creek catchment via Council's "Have Your Say" webpage to gain knowledge of historic flood behaviour in the study area (refer **Attachment A**). Sixty three (63) responses were received by the end of the community consultation period on 19 February 2017. Of those that responded, eighteen (18) respondents noted that they had observed flooding in or adjacent to their property. **Figure A2.1** shows the location of the respondents to the questionnaire, whilst a summary of the comments regarding observed historic flood behaviour is provided in **Annexure A2**.

Of those that reported drainage problems, most appeared to result from surcharge of the street drainage or of inter-allotment drainage systems. Various instances of water entering allotments by flow down driveways were reported. Several respondents identified instances where water exceeded the capacity of the concrete lined reach of Flat Rock Creek between the Gore Hill Freeway and Willoughby Road and surcharged into their backyards, but did not reach their dwelling.

Various instances of flooding were identified by respondents, dating back as far as the late-1980's. However, many reports related only to a year or season/month in which flooding occurred, rather than specific events.

A2.2.2 Rainfall Events Identified by Respondents

The only specific event that was identified by respondents to the questionnaire was a storm that occurred on 6 June 2016. One respondent who lives on Olympia Road, Naremburn (*QR_05*) noted that the concrete lined section of Flat Rock Creek surcharged, resulting in stormwater ponding in their backyard. This may have occurred as a result of a build-up of debris in this section of channel that was identified by another respondent (*QR_24*).

Three respondents who live on Hector Road, Willoughby identified that they experienced overland flow through their property during the 6 June 2016 storm event. During the event, overland flow surcharged the road reserve and flowed through the backyards of the properties before discharging to Edward Street. Whilst all three respondents experienced stormwater ponding to a depth of at least 300 mm in their backyard, only one respondent experienced above-floor inundation that caused approximately $70,000 worth of damage.

A2.2.3 Summary

For flood information to be of direct use in the testing of the hydrologic/hydraulic models, it is necessary to have evidence of the date the flood occurred and the peak flood level that was reached. Unfortunately the historic flooding data identified by the consultation process is limited to anecdotal information regarding depths of flooding and patterns of overflow for the storm event which occurred on 6 June 2016

A2.3 Historic Storm Data

A2.3.1 General

Figure A2.1 shows the location of the historic flood marks for storm events that occurred in August 1986 and March 1994 (Source: SMEC, 1995), as well as the storm event that occurred in April 1998 (Source: L&A, 2006). **Figure A2.1** also shows the location of anecdotal information on flooding patterns obtained through the Community Consultation process, including five responses relating to flooding that occurred during the storm of 6 June 2016. **Table A2.1** shows the recorded flood level at the surveyed flood marks.

TABLE A2.1
HISTORIC FLOOD MARKS

Flood Mark Identifier(1)	Storm Event	Surveyed Flood Level (m AHD)
FM_1986.1	August 1986	47.73
FM_1986.2		46.84
FM_1986.3		45.9
FM_1986.4		46.25
FM_1994.1	March 1994	47.05
FM_1994.2		45.45
FM_1998.1	April 1998	45.8
FM_1998.2		45.6

1. Refer **Figure A2.1** for location of flood marks.

Figure A2.2 (left hand side) shows the cumulative rainfall depths for the various historic storm events recorded at the BoM operated rainfall gauge at the Chatswood Bowling Club (GS 066011) (refer **Figure A2.1** for location), while **Figure A2.2** (right hand side) shows a comparison of the recorded rainfall with the intensity-frequency-duration curves for design storms ranging between 30 minutes and 12 hours duration.

A2.3.2 August 1986 Storm

The 5 August 1986 storm was a long duration event, with the heaviest falls recorded in the afternoon between 12:00 to 16:00 hours. About 300 mm of rain fell in the Chatswood area over the 24 hour period ending at 09:00 hours on 6 August 1986. **Figure A2.2** shows that rainfall intensities over the Flat Rock Creek catchment, as recorded at the Chatswood Bowling Club gauge, were generally in the range 5-10% AEP for storm durations ranging between 30 minutes and 1 hour.

A2.3.3 March 1994 Storm

The 7 March 1994 storm was essentially a two hour storm event during which 60 mm of rain fell between 4:30 and 6:30 in the morning, which is equivalent to a design storm event with and AEP greater than about 20 per cent.

A2.3.4 April 1998 Storm

Approximately 222 mm was recorded in the 24 hours to 09:00 on 11 April 1998, with the most intense burst occurring over the 30 minute period from 11:50 to 12:20 hours on 10 April, when 72.5 mm was recorded.

Figure A2.2 shows that the April 1998 storm event was equivalent to a 1% AEP design storm event for storm durations ranging between 30 minutes and 1 hour that are generally critical for maximising flows throughout the Flat Rock Creek catchment.

L&A, 2006 assessed the areal distributions and temporal patterns of rainfall associated with the April 1998 storm event and found that the rainfall recorded at the Chatswood Bowling Club gauge record was not representative of the rain that fell across the Flat Rock Creek catchment.

A2.3.5 June 2016 Storm

The storm that occurred on 6 June 2016 was a long duration event that was associated with a large East Coast Low that caused damage along the east coast of New South Wales. About 220 mm was recorded at the Chatswood Bowling Club over the 24 hour period ending at 21:00 on 6 June 2016. The heaviest falls occurred in the 3 hour period between 11:00 and 14:00, where about 60 mm of rain was recorded by the gauge.

Figure A2.2 shows that the 6 June 2016 storm event was equivalent to between a 1 EY and 50% AEP event for durations ranging between 30 minutes and 1 hour that are generally critical for maximising flows throughout the Flat Rock Creek catchment.

A3 MODEL DEVELOPMENT AND TESTING

A3.1 Procedure Adopted for Testing the DRAINS and TUFLOW Models

The procedure adopted for testing the flood models of Flat Rock Creek, in situations where historic flood data are available, would involve the collection and analysis of rainfall data to ascertain the temporal and areal distribution of rainfall over the catchment. These rainfalls would then be applied to the model to generate flows within the catchment.

In situations where there is a stream gauging station located in the catchment, the modelled discharge hydrograph would then be compared with historic hydrographs and model parameters varied until a fit was achieved. Similarly, when sufficient data are available on historic flood levels along the channel it is possible to use the known discharges and adjust the parameters of the hydraulic model to achieve a fit between recorded and modelled levels. Thus it would be possible to achieve independent calibration of each of the models (hydrologic and hydraulic) in turn. However, in most situations the streams are not gauged and data is usually limited to some isolated flood marks along the stream plus some recorded rainfall data.

In the case of flooding on the Flat Rock Creek catchment, the only quantitative data available to assist in model testing were surveyed flood level data along Flat Rock Creek between Chelmsford Avenue and Willoughby Road for the August 1986, March 1994 and April 1998 storm events. This data was not able to be used in the model tuning process due to the major changes that have occurred since the occurrence of events, coupled with the finding of L&A, 2006 that the rainfall that was recorded at the Chatswood Bowling Club during the April 1998 storm was not representative of the rain which fell over the Flat Rock Creek catchment.

Annexure A2 summarises the comments that were made by several respondents to the Community Questionnaire in relation to observed flood behaviour in the Flat Rock Creek catchment. The 6 June 2016 storm event was modelled, and the results compared with the descriptions of flooding patterns provided by the five respondents that experienced flooding during the event. Several others respondents described locations within the catchment that have been observed to flood “frequently”, and were compared to the results of running the TUFLOW model for a 50% AEP design storm event.

A3.2 Brief Review of DRAINS Modelling Approach

The DRAINS software has been developed primarily for use in modelling the passage of a flood wave through urban catchments. The hydrologic model in DRAINS uses time-area calculations and Horton infiltration procedures to calculate sub-area discharge hydrographs that are assumed to enter the drainage system, subject to constraints imposed by its entrance and conveyance capacity. DRAINS is able to calculate hydraulic grade lines throughout the piped stormwater drainage network. However, this capability within DRAINS was not utilised for the present investigation. The TUFLOW software was used for the hydraulic analysis of the piped stormwater network.

DRAINS uses the depression storage (or initial loss) model for rainfall applied to impervious surfaces and the Horton infiltration model for rainfall applied to pervious surfaces. Horton’s equation is the most common relationship for describing infiltration capacity in a soil. It describes the decrease in capacity as water is progressively absorbed by the soil, and has the form:

$$f = f_c + (f_0 - f_c).e^{-kt} \quad (4.1)$$

where: f is the infiltration capacity (mm/h) at time t;

f_0 and f_c are the initial and final constant rates of infiltration (mm/h);

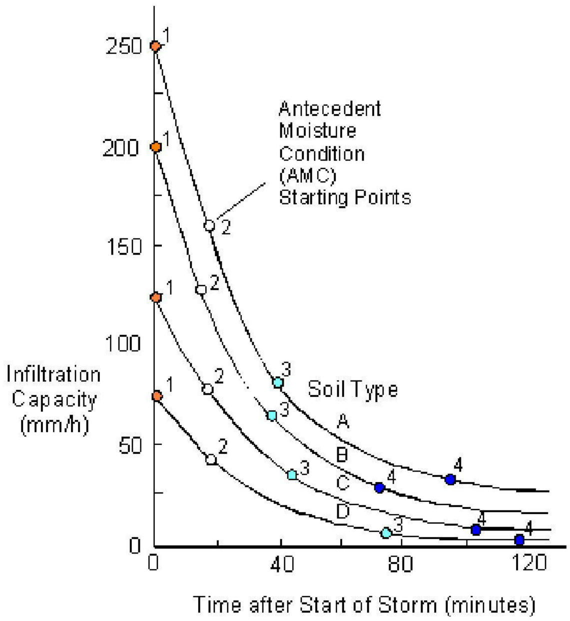
k is a shape factor (fixed at a value of 2 /h in ILSAX); and

t is the time from the start of rainfall (h).

The soil type specified in DRAINS determines values for f_0 and f_c. There are four soil types involving different infiltration characteristics:

- Type 1 (or A) low runoff potential, high infiltration rates (sand and gravels),
- Type 2 (or B) moderate infiltration rates and moderately well-drained,
- Type 3 (or C) slow infiltration rates (may have layers that impede downward movement of water),
- Type 4 (or D) soils with high runoff potential, very slow infiltration rates (consisting of clays with a permanent high water table and a high swelling potential).

Users can specify a number between 1 and 4. DRAINS will interpolate between the standard infiltration factors applying to values of 1, 2, 3 or 4. The infiltration curves for these standard soil types are presented in the adjacent illustration.



Antecedent rainfall is the rainfall that occurs prior to the start of a storm event. It increases soil moisture levels and affects rates of infiltration into the soil.

The Antecedent Moisture Condition (**AMC**) is a parameter used in the loss calculations to specify the wetness of a catchment at the start of a storm. It is used to set the starting levels for infiltration relationships.

An AMC number corresponds to a starting point on an infiltration curve, as shown in the illustration. The curve defines the rate at which rainwater can penetrate into the soil. During a storm event, this will decrease, due to the soil becoming wetter, soil swelling and other effects. In research on DRAINS and related models, it has proved to be reasonably accurate to relate the AMC value of 1 to 4 to the rainfall in the previous 5 days.

Model testing was undertaken with the following parameters:

- Soil Type = 3
- AMC = 3
- Paved area depression storage = 2.0 mm
- Grassed area depression storage = 10.0 mm
- Paved flow path roughness = 0.02
- Grassed flow path roughness = 0.07

These parameters have been applied in a number of similar urban flood study investigations, including studies for other catchments within the Willoughby City LGA.

A3.3 TUFLOW Model Parameters

The historic flood level data along Flat Rock Creek was not able to be used in the model tuning process due to the major changes that have occurred since the occurrence of the earlier storm events, coupled with the finding of L&A, 2006 that the rainfall that was recorded at the Chatswood Bowling Club during the April 1998 storm was not representative of the rain which fell over the Flat Rock Creek catchment. The process of ascribing roughness to the various types of surfaces encountered on the two-dimensional floodplain of the Flat Rock Creek catchment was therefore based largely on past experience and values contained in the engineering literature.

Table A3.1 presents the "best estimate" of hydraulic roughness values within the Flat Rock Creek catchment that were adopted for model testing.

TABLE A3.1
"BEST ESTIMATE" OF HYDRAULIC ROUGHNESS VALUES
ADOPTED FOR TUFLOW MODEL TESTING

Surface Treatment	Manning's n Value
Asphalt or concrete road surface	0.02
Well-maintained grass cover (e.g. sports field)	0.03
Grass or Lawns	0.045
Trees / Shrubs	0.08
Creek channel	0.05 – 0.08
Creek bank	0.1
Allotments (between buildings)	0.1
Buildings	10

A3.4 Adjustments to TUFLOW Model Structure

In order to tune the hydraulic model to the observed flood data for the June 2016 storm event, it was necessary to make the following adjustments to the structure of the TUFLOW model which had been set up to reflect present day (2017) conditions:

- A reach of channel in the vicinity of Olympia Road (refer location of Questionnaire Response *QR_24* on **Figure A3.1 Sheet 2** for location) was assigned a 25% blockage to reflect the observations made by the resident (refer **Annexure A2** for details of response).

A3.5 Results of Model Testing – June 2016 Storm Event

Figure A3.1 shows the TUFLOW model results for the June 2016 storm event, as well as the plan location of several respondents to the Community Questionnaire who observed flooding in or adjacent to their property. **Annexure A2** summarises the comments that were made by the aforementioned respondents to the Community Questionnaire in relation to flooding that they observed during the storm event. In general, the model was able to reproduce flooding behaviour which was observed by the respondents.

A3.6 Summary

The hydrologic and hydraulic models were considered to provide satisfactory correspondence with the flood behaviour expected from a significant storm event, in regard to:

- expected flows along the open sections of the drainage system;
- modelled overland flow paths and flooding patterns; and
- expected property affectation.

An assessment of the modelled results against locations of historic flooding problems as reported by respondents to the questionnaire is presented in **Annexure A2**. Street numbers of properties are not presented in the Annexure to protect the privacy of respondents. The TUFLOW model generally reproduced expected overland flow behaviour in the Flat Rock Creek catchment.

ANNEXURE A1

COMMUNITY NEWSLETTER / QUESTIONNAIRE

FLAT ROCK CREEK CATCHMENT FLOOD STUDY AND OVERLAND FLOW MAPPING

WILLOUGHBY CITY COUNCIL
City of Diversity

Willoughby City Council has engaged consultants to undertake a *Flood Study* which will define flooding patterns along Flat Rock Creek as well as overland flows which run through the urbanised parts of Flat Rock Creek Catchment. The investigation will also define drainage patterns which arise as a result of surcharge of the local stormwater drainage system. Please see the back of this page for the approximate extent of the study area.

The various stages of the *Flood Study* will be as follows:

- Survey throughout the catchment and collection of data on historic flooding.
- Preparation of computer models of the catchments to determine flows for both historic storms and design floods.
- Preparation of computer based hydraulic models of the creek and floodplain to determine flooding and drainage patterns, flood levels and depths of overland flow.
- Preparation of a *Flood Study* report which will document the findings of the investigation. The draft *Flood Study* report will be placed on public exhibition following completion of the investigation seeking community feedback on its findings.

The results of the *Flood Study* will provide Council with information on the nature and extent of flooding to assist with planning of development, pending the completion of the *Floodplain Risk Management Study* that will form the next stage of the Floodplain Management Process.

From our initial review of historic rainfall and streamflow data, we have identified the occurrences of several significant flood events in the study area over the past 30 years. These floods are identified below in descending magnitude of severity:

Rank	***Date of Flood***
1	April 1998
2	August 1986
3	November 1984
4	April 1988

To assist the consultant, information on any of the above events, or other floods which you may have experienced is being sought. Several questions relating to flooding in the study area are set out on the attached Questionnaire. Please take a minute or two to read these questions and provide responses where you can. Please return your completed questionnaire in the reply paid envelope provided by **Friday 23rd December 2016**. No postage stamp is required. If you have misplaced the supplied envelope or wish to send an additional submission the address is:

Willoughby City Council
PO Box 57
Chatswood NSW 2057

Any information you provide will remain confidential and will only be used as statistical data for the *Flood Study.*

Community Newsletter

LEGEND

Catchment Boundary
Railway
Watercourse Line
Park/Reserve

Lyall & Associates

FLAT ROCK CREEK CATCHMENT
FLOOD STUDY AND OVERLAND FLOW MAPPING

STUDY AREA

FLAT ROCK CREEK CATCHMENT FLOOD STUDY AND OVERLAND FLOW MAPPING

WILLOUGHBY CITY COUNCIL
City of Diversity

Community Questionnaire

1. Contact Name: ____

   Address: ____

   Home Phone Number: ______________________________________

   Mobile Number: ____

   Email: ____

2. How long have you lived in this location?

   _________ years

3. Has your property ever been inundated by stormwater from the streets or channels in the past?

   [ ] Yes [ ] No

   If yes, when did it occur and which part(s) of your property was affected? (Please provide a short description such as: duration of flooding, source of water, flow directions, etc. Refer example below.)

	Location	Date / Time / Description
[✓]	**EXAMPLE ONLY** Driveway	9 May 2013 @ 2 pm – driveway flooded from direction of street, continued for 10 – 15 minutes. Floodwaters continued through property down northern side of house.
[ ]	Driveway	
[ ]	Building (below floor level)	
[ ]	Building (above floor level)	
[ ]	Garage	
[ ]	Front yard	
[ ]	Backyard	
[ ]	Shed	
[ ]	Other (please specify)	

4. If stormwater flooding affected your property in the past, what damages occurred as a result?

____

____

____

5. Are you aware of any other flooding problems in the study area? (The attached map may be useful to mark the location of any problem areas).

____

____

____

6. Please provide dates of historic flooding, even if it is only the year in which the event occurred. Rank the floods from the most severe to the least severe.

1. __________ 2. __________ 3. __________ 4.__________

7. For the floods you have listed, do you have any records of the height the floodwaters reached? For example, a flood mark on a building, shed, fence, light pole, etc.

[ ] Yes [ ] No

If yes, please provide a short description of the location of the flood mark(s), maximum depth of flooding, source and or direction of water, etc. Refer example below.

	Location	**Maximum Depth (m)**	**Description**
[✓]	**EXAMPLE ONLY** Residential	0.3 m	9 May 2013, just after 2 pm - depth of floodwaters along northern side of house reached 0.3 m adjacent to front steps.
[ ]	Residential		
[ ]	Commercial		
[ ]	Park		
[ ]	Road/ Footpath		
[ ]	Other (please specify)		

8. Do you have any photos, videos or other evidence of the flood marks that you have identified?

[ ] Yes [ ] No

If yes, could you please provide as much detail as possible, including whether you would be willing to provide Council with electronic copies of any photos/videos? You may wish to email any flood data that you have directly to Council (refer email address below).

9. Do you have any information on pipe blockage or the inundation of local roads due to water surcharging the local stormwater drainage system?

[ ] Yes [ ] No

If yes, could you please identify the location? Could you also comment on the nature of the blockage and/or the duration and depth of the flooding in the local road network?

10. If you have any additional information which you believe would assist Council in completing the *Flood Study*, please provide details of such below. (Note that additional space is provided on the back of this page should you need it).

Thank you for your assistance in completing this Questionnaire. Please send the completed Questionnaire using the replied paid envelope.

For any further enquiries, please contact the Drainage/Design Engineer, Mr Scott Kavanagh on 9777 1059 or email

Scott.Kavanagh@Willoughby.nsw.gov.au

COMMENTS

Please write any further comments you may have here:

ANNEXURE A2

QUESTIONNAIRE RESPONSES
RELATED TO OBSERVED AND MODELLED FLOOD BEHAVIOUR

ANNEXURE A2
SUMMARY OF QUESTIONNAIRE RESPONSES RELATED TO OBSERVED AND MODELLED FLOOD BEHAVIOUR

Response Identifier	Location	Flood Event	Observed Flood Behaviour/ Other Comment	Model Verification Comments
QR_01	Olympia Road, Naremburn	April 2007	• Concrete-lined channel surcharged and ponded to a depth of approximately 0.3 m in the backyard.	• Storm event not modelled as part of present investigation.
QR_05(1)	Olympia Road, Naremburn	June 2016	• Stormwater ponded in the backyard.	• TUFLOW model shows water ponding in backyard to a depth of about 480 mm.
QR_07	Godfrey Street, Artarmon	Unknown [Summer 2008]	• After extremely heavy rainfall, runoff surcharged southern gutter of Godfrey Street resulting in shallow overland flow through property. • Stormwater ponded to a depth of approximately 0.1 m in garage for less than one hour.	• Storm event not modelled as part of present investigation.
QR_11(2)	Hamilton Avenue, Naremburn	Frequent	• Stormwater system on the corner of Palmer Street and Hamilton Avenue, Naremburn surcharges during periods of heavy rain. • Walking track from Flat Rock Gully to Tunks Park floods during periods of heavy rain. Tunks Park takes a long time to absorb the water.	• TUFLOW model shows water ponding to a depth of about 0.25 m in a 50% AEP design storm event in road reserve. • TUFLOW model shows about 0.8 m^3/s surcharges the piped drainage system in Palmer Street in a 50% AEP design storm event.
QR_14(1)	Hector Road, Willoughby	June 2016	• Runoff surcharged the road reserve and flowed in a southerly direction along driveway. • Stormwater ponded to a depth of about 0.4 m in the backyard of the property. • Stormwater ponded to a depth of about 0.3 m in the back room of house causing approximately $70,000 of damage.	• TUFLOW model shows shallow runoff (Depths less than 0.1 m) surcharging Hector Road onto driveway. • TUFLOW model shows stormwater ponding to a depth of about 0.4 m in the backyard of property.
QR_15(2)	Nulgarra Street, Northbridge	Frequent	• Runoff flows into backyard from properties located further uphill during periods of heavy rainfall.	• Localised flooding patterns not reproduced by TUFLOW model
QR_17(2)	Artarmon Road, Artarmon	Frequent	• Runoff surcharges road reserve and flows in a westerly direction through property to Artarmon Reserve.	• TUFLOW model shows stormwater surcharging Artarmon Road into the property in a 50% AEP storm event.

Refer over for footnotes.

ANNEXURE A2 (Cont'd)
SUMMARY OF QUESTIONNAIRE RESPONSES RELATED TO OBSERVED AND MODELLED FLOOD BEHAVIOUR

Response Identifier	Location	Flood Event	Observed Flood Behaviour/ Other Comment	Model Verification Comments
QR_19[2]	Bicentennial Reserve	Frequent	• Stormwater ponds on the western side of Flat Rock Drive near the baseball diamond in Bicentennial Reserve after any significant rainfall.	• TUFLOW model shows stormwater ponds to a depth of about 0.5 m in this area in a 50% AEP storm event
QR_21	Artarmon Road, Artarmon	Unknown [2010]	• Stormwater inundated the shared path under Artarmon Road (near Sydney Road).	• Storm event not modelled as part of present investigation.
QR_24[1]	Olympia Road, Naremburn	June 2016	• Fallen tree blocked concrete-lined channel behind property causing sudden rise in flood levels in channel which resulted in shallow ponding in backyard. • Extent of ponding did not reach house.	• TUFLOW model shows stormwater ponding to a depth of about 0.6 m in backyard. • TUFLOW model shows stormwater extending to edge of existing dwelling.
QR_30[2]	Woonona Road, Northbridge	Frequent	• Stormwater frequently surcharges the drainage swale located adjacent to the footpath on the eastern side of Woonona Road, Artarmon where it flows in an easterly direction through properties at very shallow depths.	• TUFLOW model shows shallow overland flow (depths less than 0.1m) through properties located on the eastern side of Woonona Road, Artarmon in a 50% AEP design storm event.
QR_31[2]	Robert Street, Artarmon	Frequent	• Stormwater frequently surcharges Robert Street and flows in an easterly direction along footpath toward Hampden Lane.	• TUFLOW model shows a continuous overland flow path along the footpath in a 50% AEP design storm event.
QR_34[1]	Hector Road, Willoughby	June 2016	• Runoff surcharged the road reserve and flowed in a southerly direction along driveway. • Stormwater ponded to a depth of about 0.3 m in the backyard of property.	• TUFLOW model shows runoff surcharging Hector Road into property. • TUFLOW model shows stormwater ponding to a depth of about 0.2 m in the backyard of property.
QR_40	Brand Street, Artarmon	Unknown [Easter 2004]	• Runoff flowed along footpath that runs parallel to the North Shore Railway between Raleigh Street and Brand Street at a depth of approximately 0.1 m. • Stormwater ponded to a depth of approximately 0.5 m at low point in Brand Street	• Storm event not modelled as part of present investigation.

Refer over for footnotes.

ANNEXURE A2 (Cont'd)
SUMMARY OF QUESTIONNAIRE RESPONSES RELATED TO OBSERVED AND MODELLED FLOOD BEHAVIOUR

Response Identifier	Location	Flood Event	Observed Flood Behaviour/ Other Comment	Model Verification Comments
QR_49	Small Street, Willoughby	Early 1980's, then once more in late 1980's / or early 1990's	• Stormwater ponded to depths greater than 1.0 m in basement level of building in the early 80's causing approximately $25,000 in damages. • Less severe flooding occurred again in the late 1980's / early 1990's.	• Storm event not modelled as part of present investigation.
QR_52(1)	Hector Road, Willoughby	June 2016	• Runoff entered property via driveway and from adjacent property. • Stormwater ponded to a depth of about 0.3 m against western side of building. • Continuous overland flow path flowed in an easterly direction through backyards of adjacent properties towards Edward Street.	• TUFLOW model shows runoff entering property from Hector Road and adjacent properties. • TUFLOW model shows stormwater ponding to a depth of about 0.45 m on western side of building. • TUFLOW model replicated continuous overland flow path.
QR_56	Onyx Road, Artarmon	Unknown [January 2016]	• Runoff entered the property from backyard of properties located on Artarmon Road.	• Storm event not modelled as part of present investigation.
QR_61	Cleland Road, Artarmon	Unknown	• On-site detention was back flooded due to blockage in local stormwater system and surcharged into underground carpark, causing damage to items stored in garage.	• Storm event not modelled as part of present investigation.

1. Refer **Figure A2.1** for cross reference to Response Identifier for June 2016 storm event.
2. Observed flood behaviour for "frequent" storm events has been checked against TUFLOW model results for the 50% AEP design storm event. Refer **Figure 6.2** for cross reference to Response Identifier.

Site Investigation Report – Cammeray Golf Course (WP12)

Document No. SPA-JGA-REP-ENV-WP12-1-0007

Rev	Date	Prepared by Name	Reviewed by Name	Approved by Name	Remarks
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table of Contents

Important note about your report

The sole purpose of this report is to present the findings of a site investigation carried out by Jacobs for the Sydney Program Alliance (SPA) within the construction footprint of the proposed construction support site at Cammeray Golf Course, Cammeray NSW, as part of the Warringah Freeway Upgrade (WP12).

All reports and conclusions that deal with sub-surface conditions are based on interpretation and judgement and as a result have uncertainty attached to them. You should be aware that this report contains interpretations and conclusions which are uncertain, due to the nature of the investigations. No study can investigate every risk, and even a rigorous assessment and/or sampling programme may not detect all problem areas within a site.

This report is based on assumptions that the site conditions as revealed through sampling and information provided by SPA are indicative of conditions throughout the site. The findings are the result of standard assessment techniques used in accordance with normal practices and standards, and (to the best of Jacobs' knowledge) they represent a reasonable interpretation of the current conditions on the site.

Sampling techniques, by definition, cannot determine the conditions between the sample points and so this report cannot be taken to be a full representation of the sub-surface conditions. This report only provides an indication of the likely sub surface conditions.

Conditions encountered when site work commences may be different from those inferred in this report, for the reasons explained in this limitation statement. If site conditions encountered during site works are different from those encountered during Jacobs' site investigation, Jacobs reserves the right to revise any of the findings, observations and conclusions expressed in this report.

The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report.

In preparing this report, Jacobs has relied upon, and presumed accurate, information provided by the SPA and from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. The reliance on provided information is governed by the specific limitations as detailed in the respective information sources. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, SPA, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and SPA. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Executive summary

Jacobs Group (Australia) Pty Ltd (Jacobs) undertook an assessment of potential contamination with respect to the Western Harbour Tunnel and Warringah Freeway Upgrade project for the Sydney Program Alliance (SPA).

> *This assessment was limited to the proposed temporary construction support areas (associated with the Early Works program) within the larger alignment area. Hence, was not inclusive of the larger alignment beyond the specific 'sub areas' nominated within this report.*

This specific report refers to the sub portions (i.e. proposed support areas) of the Cammeray Golf Course, Cammeray, located within the designated alignment. ***This executive summary should be read with consideration of the discussion provided in Section 1 of this report.***

The purpose/objective of this investigation was to:

- o Evaluate previous contamination data, assess critical data gaps and collect additional data to address critical data gaps.

  This evaluation was primarily framed by the scope of the Early Works Program and the designated 'sub-areas' within the alignment.
- o Provide advice on the contamination status of the area(s) and the need for further assessment/management in the context of the proposed Early Works program and the protection of construction workers undertaking the Early Works program.
- o Review the collated contamination data with respect to providing a response to the risk management strategy detailed in Appendix M of the EIS (2020) and the conditions of approval from the Western Harbour Tunnel and Warringah Freeway Upgrade (SSI-8863).

The following conclusions and recommendations were made based on the scope/limitations of the combined SMEC/Jacobs assessment:

<u>Conclusions</u>

- Odorous and contaminated soil was reported at one location (BH15_D_CGC). However, statistical analysis of the data set showed that reported contamination levels were (on average) below the guideline values for the proposed construction use of the site.
- Reported concentrations for all other contaminant compounds in soil were below the adopted guideline values (for all individual sample results).
- Asbestos was not identified by the laboratory in any of the samples submitted for asbestos identification and asbestos containing materials were not observed by Jacobs while collecting the soil samples.
- The report of 'distinct asphalt odours' at BH15 may also be indicative of a larger area of contamination within this area. The observation of similar fill across the investigation area combined with the heterogenous nature of fill suggests that there is the potential for unexpected contamination to be encountered in other areas of the site.

<u>Recommendations</u>

For areas in the vicinity of BH15, no sub-surface works are to be undertaken until either of the following options are implemented:

1. Further investigations to assess the extent and degree of odorous materials at and in the vicinity of location BH15; or

2. The Construction Environmental Management Plan should clearly identify the area around BH15 as a 'known area of contamination' with strict restrictions on subsurface excavation in this area without approval and supervision of an environmental consultant.

For all other areas of the site (i.e. areas within the footprint of the proposed construction support site exclusive of areas in the vicinity of BH15), the following is recommended:

- Given the presence of other building waste/debris (including asphalt), there is a potential for undiscovered soil contamination and/or asbestos containing materials to also be present within fill. The potential for undiscovered soil contamination and/or asbestos containing materials to be present within the subsurface should be noted within the Construction Environmental Management Plan (including an unexpected finds procedure).

- The Construction Environmental Management Plan should also give consideration for the potential to odours soil to be encountered during any subsurface excavation works and appropriate procedures developed/implemented to minimise odour generation and/or exposure.

- The Construction Environmental Management Plan should also ensure that any disturbance of the site surface is managed appropriately. For example, minimise dust generation, surface water/sediment runoff from the site, etc.).

<u>General recommendations</u>

- As noted in Section 1 of the report, it is recommended that further consideration be given to the definition of 'disturbance' in relation to the Early Works program and subsequent Main Works contract.
- Further consideration should also be given to the definition of 'risk' used by the EIS (and how sites were classified), and how this differs from the interpretation of 'risk' implied by the approval conditions. Consequently, the potential for additional site data to support a 'lower risk rating' should also be considered.

1 Introduction

Jacobs Group (Australia) Pty Ltd (Jacobs) undertook an assessment of potential contamination with respect to the Western Harbour Tunnel and Warringah Freeway Upgrade project for the Sydney Program Alliance (SPA).

> *This assessment was limited to the proposed temporary construction support areas (associated with the Early Works program) within the larger alignment area. Hence, was not inclusive of the larger alignment beyond the specific 'sub areas' nominated within this report.*

This specific report refers to the six sub portions (i.e. proposed support areas) of the Cammeray Golf Course, Cammeray, located within the designated alignment.

The proposed extent of the six separate construction support areas is presented on **Figure 1-1** (north western portion of CGC) and **Figure 1-2** (south western portion of CGC).

Figure 1-1: Proposed construction support site extent (north western portion of CGC)

Figure 1-2: Proposed construction support site extent (south western portion of CGC)

1.1 Background

This assessment report was prepared in relation to the Western Harbour Tunnel and Warringah Freeway Upgrade project. Key considerations relevant to the development of this report are noted below:

- Environmental Impact Statement (EIS, January 2020) – Predominantly a 'desktop' assessment of potential contamination. The EIS attributed a 'risk ranking' to sub areas of the alignment.

  The evaluation criteria used to determine the 'risk ranking' as detailed in the EIS (January, 2020) was based on the potential for contamination to be present and the likelihood of excavation occurring (with such areas where both of these events area likely to occur, given a medium to high risk ranking).

  Importantly, the 'risk ranking' in the EIS does not appear to be based on the likelihood of a human health or environmental risk. The "risk ranking" detailed in the EIS was used to identify construction limitations/constraints and management options within the project area with respect to contamination.

  Therefore, the inference that areas classified as medium/high risk also represent a medium/high risk to human health and the environment is potentially misleading.

- The planning approval for the project *Western Harbour Tunnel and Warringah Freeway Upgrade (SSI-8863)* includes several conditions related to contamination (namely E115 to E124).

  With respect to these conditions we have the following comments:

- **Appraisal of 'risk' -** Several conditions infer that high levels of contamination are present within the alignment that present a potential a risk to human health and that extensive assessment and potential remediation is required to assess and ameliorate the risk to human health.

  This interpretation of 'risk' does not appear to be aligned with the definition of 'risk' adopted by the EIS.

  Also, there does not appear to be provision of an intermediary step(s) where further site-specific assessment and consideration of likely human health risks to construction workers can be undertaken and that the outcomes of such an assessment could results in a revision to the classification of a 'moderate/high risk rating' to a lower risk ranking.

- **Type/Timing of construction works** - Condition 115(a) states *"Prior to the commencement of any work that would result in the disturbance of moderate to high risk contaminated sites as identified in the documented listed in Condition A1, a Detailed Site Investigations must be undertaken".*

  - 'Disturbance' is not defined in the condition but is assumed to mean the primary construction works associated with construction of the freeway (not ancillary activities undertaken in preparation of the primary construction work (e.g. soil sampling, maintenance of underground services, etc.)).
  - The exclusion of 'low' risk contaminated sites implies that a Detailed Site Assessment is not required for 'low risk' contaminated sites. Therefore, further augmenting the need to clarify the definition of 'risk' and revision of the risk ranking (as discussed above).

- **Scope/timing of contamination assessment** - Condition E117(i) requires a Detailed Site Investigation report that conclude "*whether the land is suitable (for the intended final land use) or can be made suitable through remediation*."

  Such a conclusion would require conformation of the following:

  - Clear designation of the land area requiring a suitability statement. Typically, this would either be a Title boundary or a survey area.
  - The proposed final land use.
  - The final design/layout of the freeway (post construction). This would need to include areas proposed to be excavated/filled, final design levels and proposed finished paving materials.
  - Soil contamination data representative of the near surface soils where such future soils will be exposed to future occupants. With respect to this point we note that many areas of the proposed alignment will be excavated, reshaped and/or filled. With the final soil quality of these areas unknown at this time.

  Given the above points, it is difficult to estimate the scope of work and time required to satisfy this objective. Further, the need undertake a Statutory Contaminated Land audit to make a suitability statement remains a possibility. In the event that a Statutory audit was required to satisfy this condition, the time required to collect the required information and complete the audit is estimated to be 6-12 months.

  Further, it should be noted that any such 'suitability statement' with respect to the final land use made prior to the commencement of the Main Works contract would likely be negated by the construction work required to deliver the Main Works contract.

  Hence, any such 'statement of suitability' is most likely best made at the completion of the construction works.

1.2 Current stage of the construction program

The current phase of the construction program is related to the 'Early Works Program' and includes various site establishment activities related to the preparation of the site for the Main Works contractor. These works include:

- Establishment of temporary site construction facilities and equipment storage areas. These area(s) were to be used primarily for construction support activities (e.g. temporary site shed, vehicle parking, laydown areas for equipment/supplies, etc.)
- Note that these areas were 'sub-areas' within the larger alignment corridor
- Oversite of assessment activities to support the future Main Works contractor
- Identification, management and potential relocation of underground services.

The above works are predominantly related to above ground construction works with minimal disturbance of subsurface soils. Where subsurface soil removal is required (e.g. for soil sampling), this work is covered by strict protocols to ensure any potentially contaminated soil is managed appropriately and risk to human health and the environment is negated. Therefore, these works are not considered meet the definition of 'disturbance' as described in Condition E117(i).

1.3 Acknowledgment of pre-existing contamination status of sites

With respect to any known and/or potential contamination within the freeway alignment, it should be acknowledged that any such contamination (as identified by the EIS) is likely to have been present for many years.

Similarly, the current/previous site use is predominantly public open space and therefore access of the public to these areas has been relatively unrestricted.

The history of contamination and use appears to be incongruous with Conditions E117(i) and E118 to E122, unless it is concluded that these conditions are intended to apply to sites where:

a) significant levels of contamination are identified that present a human health risk to construction workers and/or future users of the site; and/or

b) the exposure scenario applied to a site is changed by the proposed freeway construction (e.g. soil contamination that was buried becomes exposed at the surface by excavation).

1.4 Key assumptions and limitations

With respect to the scope of this assessment, the following assumptions and limitations are relevant:

- The assessment was undertaken within a very limited timeframe (i.e. approximately 3-4 weeks from initiating field works to reporting). Therefore, there was no opportunity to conduct follow up assessment of areas where contamination was reported (or suspected based on field observations). As a result, Jacobs have adopted conservative conclusions with respect to the potential presence of contamination and the implementation of preventative exposure measures.

- Assessment of potential contaminants was limited to the potential contaminants of concern identified in the EIS relevant to this investigation area.

- The Jacobs field assessment (and the SMEC field assessment) were conducted prior to the establishment/occupation of the site by the Early Works contractor. Therefore, the proposed ancillary support areas were approximated from information provided by SPA.

- Consideration of the potential impact to the health of construction workers a key primary focus of this assessment.

- The investigation only targeted soils within the footprint of the proposed construction support site area.

- Soil data was the most relevant media for exposure by construction workers. Therefore, collection of near surface soils (i.e. up to 1m depth) soil data was the focus of the assessment. Other exposure pathways (e.g. contact/drinking groundwater, indoor vapour inhalation of soil vapour) were considered highly unlikely to occur given the proposed used of the site and the implementation of an environmental/soil management plan. The rationale for not targeting other media is provided below:

    - Should soil contamination be identified (i.e. above concentrations for commercial/industrial land use), recommendations for additional investigations and/or remedial measures for air, hazardous ground gases, surface water, groundwater, soil vapour, separate phase contaminants, sediments, infrastructure (e.g. concrete), biota and dust would be provided (if considered relevant).

    - No receiving surface water bodies are located on and/or adjacent to the site.

    - Groundwater is not anticipated to be intersected (i.e. no contact with construction workers, no extraction to support construction) as part of the proposed works.

- The assessment of asbestos was primarily based on visual observation with limited laboratory analysis. Note that this investigation does not constitute full characterisation of the site for the potential presence of asbestos nor does the results of this investigation represent an 'asbestos clearance'.

- Where the magnitude and/or potential extent of contamination was unclear (following this assessment), Jacobs have recommended conservative soil management measures as a precaution.

- This assessment was not designed to provide in-situ classification of soils for off-site disposal. In the event that off-site disposal of soils is required, EPA guidelines with respect to off-site soil appropriate classification/disposal will need to be considered.

- Ecological receptors were not relevant for the proposed occupation of the site for the purposes of construction activities since:
    - The majority of existing surface vegetation at the site will be removed during the construction/occupation period.
    - The proposed use of the site as a construction support site will have minimal landscaping opportunities.
    - The site is located within a heavily urbanised area and soils beneath the investigation area are unlikely to represent a sensitive terrestrial ecosystem that requires protection.
    - The site will not be used for growing produce (e.g. fruit and vegetables) the construction/occupation period.

2 Purpose/objective of this investigation

Given the points raised in Sections 1.1 to 1.4, the purpose/objective of this investigation was to:

- Evaluate previous contamination data, assess critical data gaps and collect additional data to address critical data gaps.
- This evaluation was primarily framed by the scope of the Early Works Program (as described in Section 1.2 above) and the designated 'sub-areas' within the alignment.
- Provide advice on the contamination status of the area(s) and the need for further assessment/management in the context of the proposed Early Works program and the protection of construction workers undertaking the Early Works program.
- Review the collated contamination data with respect to providing a response to the risk management strategy detailed in Appendix M of the EIS (2020) and the conditions of approval from the Western Harbour Tunnel and Warringah Freeway Upgrade (SSI-8863).

Key aspects used to frame this purpose/objective were:

- A Construction Environmental Management Plan will be developed for all construction related activities (including the ancillary support areas) undertaken as part of the Early Works program. This plan will include soil management protocols and unexpected finds procedures.
- The area(s) were to be used primarily for construction support activities e.g. temporary site shed, vehicle parking, laydown areas for equipment/supplies, etc.
- Incidental excavation or soil movement (i.e. to install temporary services, level areas for vehicle access) maybe required, however, bulk soil excavation was not required.
- Exposure scenario - Occupation/use of the site was to be consistent with a construction work site (e.g. 8 hours per day, 6 days per week). The duration of occupation for construction workers was likely to be less than 5 years. Note the duration of the Early Works program is approximately 2 years.
- Commercial/industrial soil quality guidelines were the most relevant exposure scenario for the proposed site use (i.e. construction workers during the Early Works program). However, we note that the published reference guideline values are based on a much longer exposure period (i.e. 30 years). Therefore, direct application of the published NEPC (2013) guidelines to the proposed site exposure was conservative.
- All workers occupying the site(s) will be inducted into the safety and environment procedures relevant to works involving contact with potentially contaminated soils.
- No permanent structure would be built within the investigation areas during the proposed use for construction support activities.
- To facilitate the proposed use of the site most of the surface vegetation would be cleared (except for significant trees).
- The general public will not have unrestricted access to the site(s) for the duration of the construction program.

3 Summary of previous assessment work

3.1 Environmental Impact Statement

Appendix M of the EIS (2020) prepared for the Western Harbour Tunnel and Warringah Freeway Upgrade project detailed the following with respect to contamination at the proposed construction support site.

Site	*Location relative to alignment*	*Construction element and anticipated depth*	*Potential contamination source*	*Potential contamaination distribution*	*Potential contaminants*	*Risk ranking*
Unsealed areas next to Warringah Freeway – Ernest to Miller Street), Crows Nest	*Within footprint of surface works*	*Warringah Freeway Upgrade surface work (surface)*	*Deposition of particulate matter*	*Surface (potentially 0-0.1 m)*	*Heavy metals (mainly lead), hydrocarbons (mainly PAH), asbestos*	*High* • *Known contamination* • *Excavation activities within site footprint* • *Excavation activities within potential contamination distribution range (laterally and vertically)*

It is Jacobs understanding that the statement of *"Known contamination"* for this area (from the EIS report) is based the *'Western Harbour Tunnel and Beaches Link – Contamination Factual Report (CFR)'*, (AECOM and Coffey, (AEC), 2018. The reported contamination was related to Polycyclic Aromatic Hydrocarbons (PAHs) (at two locations) and asbestos containing materials (at one location). However, the location of these sample points, in relation to the investigation area (i.e. the Cammeray Golf Course) being assessed by Jacobs, was not clear. Therefore, it is not known if these sample points are located within the investigation areas (subject of this report), and this data was excluded.

3.2 SMEC 2020

SMEC were commissioned by TfNSW to undertake a contamination investigation within and adjacent to the Warringah Freeway which also included areas to be occupied by the proposed construction support. The following summary should be read in conjunction with the SMEC (2020) report.

The objective of the SMEC (2020) investigation was to collect and provide factual data to TfNSW for the purpose of informing prospective tenderers of the project of the contamination and geotechnical conditions along the proposed WFU alignment.

Note: The SMEC assessment was undertaken to assess the broader alignment area and therefore the sample locations did not necessarily correlate with the proposed 'sub-areas' nominated for the Early Work program. This is discussed further in Section 3 and 4.

The following investigation works were undertaken by SMEC at the site:

- Soil sampling from 13 investigation locations (WFU_BH074 to WFU_BH080, WFU_BH082, WFU_BH083, WFU_BH085, WFU_BH089, WFU_BH099 and WFU_BH100 within the proposed construction footprint and two location immediately adjacent to the construction footprint (WFU_BH081 and WFU_ BH108). All soil investigation were drilled to a maximum depth of 4.8 metres below ground level (mbgl) with WFU_BH079 drilled to 14.5 mbgl to facilitate the installation of a groundwater well. All locations were drilled to intersection with natural materials (maximum fill depth of 4.1 mbgl at location WFU_BH100).

- One groundwater wells (WFU_BH079) was installed and sampled.

No further discussion on groundwater quality is provided as groundwater is not anticipated to be intersected (i.e. no contact with construction workers, no extraction to support construction) as part of the proposed works (refer to the key exclusions detailed in Sections 1 and 2).

Sample locations undertaken as part of the SMEC (2020) investigation are presented on **Figure 3-1, Figure 3-2** and **Figure 3-3**.

Figure 3-1: SMEC (2020) investigation locations - CGC (figure sourced from the SMEC, 2020)

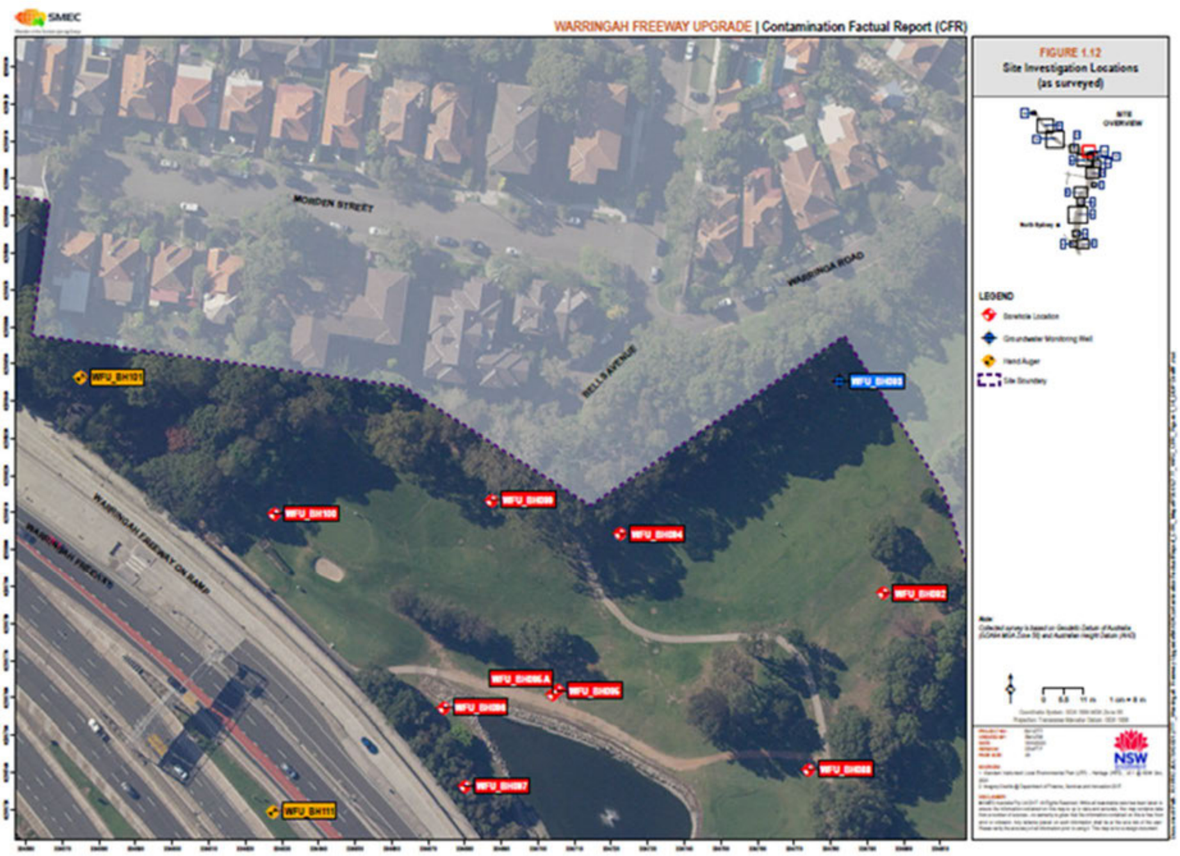
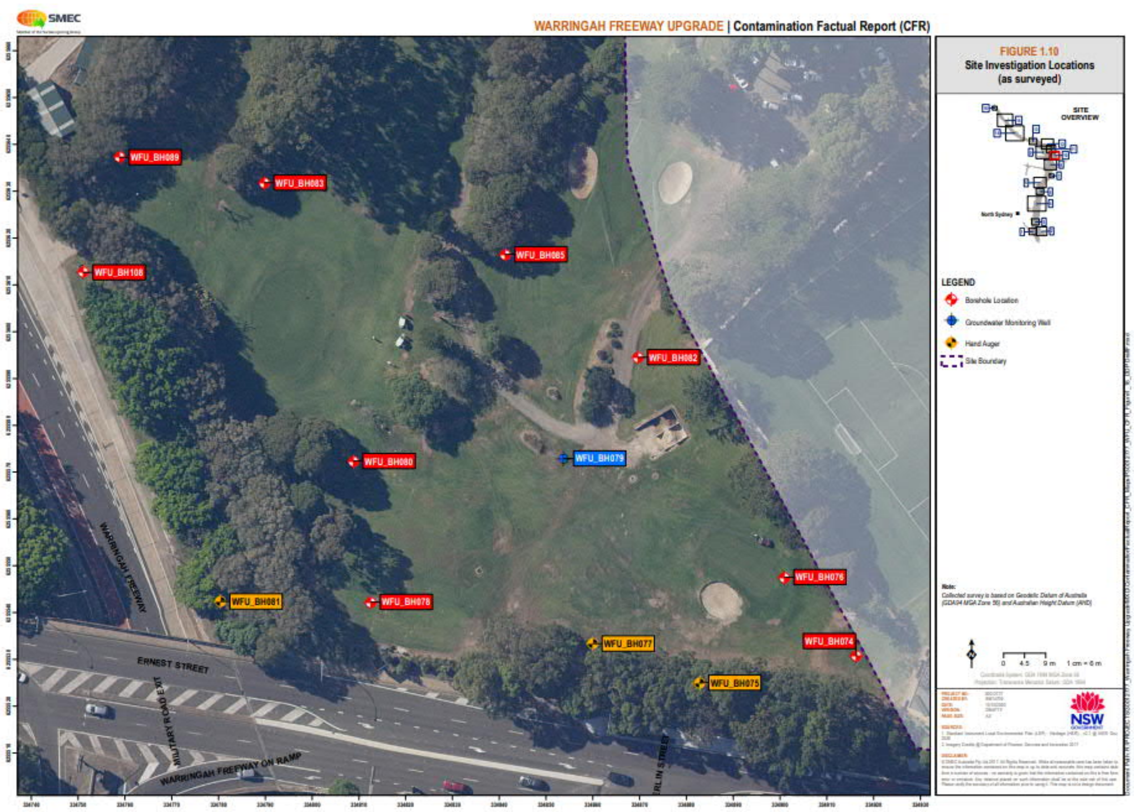


Figure 3-2: SMEC (2020) investigation locations - CGC (figure sourced from the SMEC, 2020)

Figure 3-3: SMEC (2020) investigation locations - CGC (figure sourced from the SMEC, 2020)



4 Description of the Investigation Area(s)

The site consists of six separate construction support areas (as defined by SPA) within the southern western and north western portions of the Cammeray Golf Course adjacent to the Warringah Freeway and Ernest Street, Cammeray NSW. The proposed construction support site areas comprise two main portions of land directly adjacent to the Warringah Freeway and four smaller, disconnected areas which will be temporarily used during installation of services.

At the time of undertaking this assessment, the majority of the proposed construction support site areas comprised grass surfaces and scattered trees (tees, fairways, greens, landscaping) associated with the golf course.

A maintenance area (buildings, parking, storage, wash bays) was present to the north of the main south western construction support area. Some drums, general wastes (e.g. wood, pipework, building materials) and vegetation wastes are present within and adjoining the maintenance area. Note: the maintenance area was not located within the proposed ancillary support area (for the Early Works program) that was the subject of this assessment.

A skate park was present within the eastern portion of the main south western construction support area.

The proposed construction support sites were bound by residential areas to the north, the golf course and tennis courts to the east, Ernest Street to the south and the Warringah Freeway to the west.

The general topography across the proposed construction support site areas is gently undulating and slopes generally down from the northern and southern boundaries of the golf course towards a low topographical point within the north eastern portion of the golf course.

The combined 'site area' is approximately 14,000 m^2. Data review and specific scope of field work

As noted in the previous sections of this report, not all of the SMEC data was relevant to the sub area(s) of the Early Works program. Jacobs reviewed the SMEC (2020) investigation to assess potential data gaps and developed a scope of work to effectively 'fill the gaps' in order to bring the data set to a minimum standard to allow evaluation of the extent and nature of contamination.

Based on this review, the investigation strategy adopted to supplement the SMEC (2020) data are detailed in **Table 4-1.**

Table 4-1: Information review and proposed investigation strategy

Aspect	Reference	SMEC (2020) investigation	Additional assessment undertaken (by Jacobs) to supplement the SMEC data
Number and location of soil borehole locations	NSW EPA (1995) Sampling Design Guidelines recommends a minimum of 24 grid-based locations for the site size (approximate construction footprint of 14,000 m^2).	13 locations within and two locations directly adjacent to the construction footprint.	15 additional locations.

Aspect	Reference	SMEC (2020) investigation	Additional assessment undertaken (by Jacobs) to supplement the SMEC data
Sample depth	The EIS refers to 'surface deposition' as the likely source of contamination.	All soil investigation (with the exception of one location) were drilled to intersection with natural materials. The maximum fill depth encountered was 4.1 mbgl. One borehole was drilled to a depth of 14.5 mbgl to facilitate the installation of a groundwater well. The depth of the SMEC (2020) investigation extended to intersection with the underlying natural materials (extending beyond the potential contamination distribution as detailed in the EIS and likely to extend beyond contamination at depth potentially associated with fill materials).	Collection of near surface soils (to approximately 1 m depth). This is inclusive of surface soils.
Sample analysis	Appendix M EIS (2020) identified the potential contaminants of concern for the site including heavy metals (mainly lead), hydrocarbons (mainly PAH), asbestos	Heavy metals, Total Recoverable Hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, Xylenes (BTEX), PAH, pesticides, Polychlorinated Biphenyls (PCB), asbestos. Note the SMEC assessment included additional contaminant analysis not required by the EIS.	Jacobs analytical schedule included the potential contaminants of concern as identified in the EIS including heavy metals (including lead), PAH and asbestos. For completeness, data analysis by Jacobs also included all SMEC data.
Frequency of sample analysis	Not applicable	Two samples were analysed per borehole	Two samples to be analysed per borehole.

5 Site investigation

The following information details the fieldworks undertaken during the Jacobs investigation. It should be reiterated that the Jacobs investigation is supplementary to the information contained in the SMEC (2020) investigation and attempts to fill data gaps to:

- Meet the minimum sampling points as detailed in the NSW EPA (1995) guidelines.
- Provide lateral and vertical coverage of the proposed construction extents.
- Assess the potential for contamination of the site as detailed in Appendix M: Contamination of the Environmental Impact Statement, January 2020 (EIS Appendix M, 2020).

5.1 General overview

The fieldwork for the investigation was undertaken over three days between 28 April and 12 May 2021. The investigation was undertaken by a contaminated site consultant from Jacobs who was responsible for undertaking the work, site observations, excavation logging and sample collection.

5.2 Soil investigation

Fifteen locations (BH06, BH07, BH08, BH09, BH10, BH11, BH12, BH13, BH14, BH15, BH16, BH17, BH18, BH19 and BH20) were excavated using decontaminated hand tools (hand auger and crowbar) to 1.0 mbgl (or refusal).

A total of 28 investigations locations (13 locations by SMEC and 15 locations by Jacobs) exceeds (24 locations required to conform) to the minimum sampling points required for site characterisation based on detecting circular hot spots by using a systematic sampling pattern as detailed in the NSW EPA (1995) *Contaminated Sites – Sampling Design Guidelines* for a site of approximately 14,000 m^2. The depth of the SMEC (2020) investigation extended to intersection with the underlying natural materials (extending beyond the potential contamination distribution (i.e. 0-0.1 mbgl) as detailed in the EIS Appendix M (2020) and likely to extend beyond contamination at depth potentially associated with fill materials (maximum fill depth extending to 4.1m bgl).

Two of the SMEC investigation locations (WFU_BH081 and WFU_BH108) were located immediately adjacent to the western boundary of the south western construction support areas. The contamination mechanism for the site (as detailed in the EIS) was particulate deposition which is likely to result in diffuse contamination distribution (i.e. relatively low levels of contamination spread across large areas). These two investigations locations are also likely to be representative of the contamination mechanism across the areas of the golf course adjacent to the Warringah Freeway (considering the diffuse nature of particulate deposition) and have been used to assess the potential for contamination across the construction footprints.

The approximate investigation locations undertaken by SMEC (2020) and Jacobs are presented on **Figure 5-1** (south western portion of CGC) and **Figure 5-2** (north western portion of CGC).

Figure 5-1: Approximate investigation locations (south western portion of CGC)

Approximate Jacobs investigation location

Approximate SMEC investigation location

Figure 5-2: Approximate investigation locations (north western portion of CGC)

Approximate Jacobs investigation location

Approximate SMEC investigation location

5.3 Depth intervals of sampling

Selected soil samples were collected from the investigation locations at the surface (0.0 – 0.1 mbgl) and at depths of 0.25 mbgl, 0.5 mbgl, and 1.0 mbgl or at discreet sampling depths where potential contamination was observed.

5.4 Method of sample collection

All soil samples were collected as grab samples from below the surface of the grass and from a decontaminated hand auger at depth. Samples were transferred to sample containers by Jacobs field staff by hand using disposable nitrile gloves. New nitrile gloves were used for the collection of each sample.

Care was taken to ensure that representative samples were obtained from the depth required and that the integrity was maintained, which is particularly important when dealing with potentially volatile components.

5.5 Sample containers, method of sample storage and handling

All soil samples were placed in jars provided by the primary laboratory Envirolab Services (Envirolab). The jars were completely filled with soil, labelled with the date, unique sampling point identification and sampler information.

The soil jars, once filled with sample and sealed, were immediately placed in an esky / cool box in which ice had been added. At the end of the sampling program the samples in the esky / cool box were transported to the primary laboratory. Custody seals were placed on the esky / cool box for delivery to the laboratory.

An inter-laboratory duplicate was sent to the secondary laboratory Eurofins Scientific (Eurofins).

5.6 Decontamination procedures

The hand auger and crowbar were decontaminated between sample locations by washing with a solution of phosphate free, PFAS free, laboratory grade detergent (Liquinox) and potable water and rinsed with potable water.

5.7 Sample logging

Experienced Jacobs field staff completed soil logs for the excavation locations. The logs recorded the following data:

- Sample number and depth.
- Soil classification, colour, consistency or density, moisture content and obvious indications of contamination.
- Depth of excavation.
- Excavation refusal.
- Method of excavation.

5.8 Laboratory analysis

Soil samples were selected for laboratory analysis based the potential contaminants for the site as detailed in the EIS Appendix M (2020). A summary of the laboratory testing undertaken is detailed in **Table 5-1.**

Table 5-1: Laboratory testing

Laboratory Test	Quantity
Heavy metals (As, Cd, Cr, Cu, Pb, Ni, Hg, Zn),	30 primary and 4 QAQC
Hydrocarbon compounds (PAH)	30 primary and 4 QAQC
Asbestos (presence/absence)	15 primary

5.9 Analytical parameters and methods

Jacobs commissioned Envirolab and Eurofins as the primary and secondary laboratories, respectively. All laboratories are National Association of Testing Authorities (NATA) accredited for the testing undertaken.

Where appropriate, the soil samples were analysed in accordance with NEPC National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended 2013 (NEPC, 2013) guidelines using methods based on US Environment Protection Agency (US EPA) and American Public Health Association (APHA) approved analytical methods.

6 Quality control plan

Field and laboratory QA/QC requirements compliant with NEPC (2013) requirements (where applicable) were undertaken as part of the fieldwork program as outlined below.

6.1 Field QA/QC program

6.1.1 Environmental samples

Environmental samples or field samples were the representative soil samples collected for analysis to determine aspects of their chemical composition.

6.1.2 Blind replicate sample

A blind replicate sample was provided by the collection of two environmental samples from the same location. These samples were preserved, stored, transported, prepared and analysed in an identical manner. As a minimum, the results of analyses on the blind replicate sample pairs were assessed by calculating the Relative Percentage Differences (RPDs) between the results. The RPD was calculated as the difference between the results divided by their mean value and expressed as a percentage. If the RPD exceeded the value adopted for any analytes, additional investigation would be required, or justification provided for not conducting additional investigation.

Blind replicate samples should be collected at a rate of one duplicate for every 20 environmental samples in accordance with AS 4482.1-2005 *Guide to the sampling and investigation of potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds* (AS 4482.1-2005).

6.1.3 Blind triplicate sample

A blind triplicate sample was provided by the collection of two environmental samples from the same location. These samples were preserved, stored, transported, prepared and analysed in an identical manner. One of the samples was transported to a secondary laboratory for analysis. As a minimum, the results of analyses on the blind triplicate sample pairs were assessed by calculating the Relative Percentage Differences (RPDs) between the results. The RPD was calculated as the difference between the results divided by their mean value and expressed as a percentage. If the RPD exceeded the value adopted for any analytes, additional investigation would be required, or justification provided for not conducting additional investigation.

Blind triplicate samples should be collected at a rate of one duplicate for every 20 environmental samples in accordance with AS 4482.1-2005.

6.2 Laboratory QA/QC programme

The reliability of test results from the analytical laboratories was monitored according to the QA/QC procedures used by the NATA accredited laboratory. The QA/QC program employed by Envirolab (the primary laboratory) and Eurofins (the secondary laboratory) specified holding times, extraction dates, method descriptions, CoC requirements, analysis, laboratory levels of reporting (LORs) and acceptance criteria for the results. Laboratory QA/QC requirements undertaken by Envirolab and Eurofins are based on NEPC (2013) requirements and are outlined below.

6.2.1 Laboratory duplicate samples

Laboratory duplicates provided data on analytical precision for each batch of samples.

Laboratory duplicates were performed at a rate of one duplicate for batches of 8-10 samples with an additional duplicate for each subsequent ten samples.

6.2.2 Laboratory control samples

Laboratory control samples consisted of a clean matrix (de-ionised water or clean sand) spiked with a known concentration of the analyte being measured. These samples monitored method recovery in clean samples and were used (where required) to evaluate matrix interference by comparison with matrix spikes.

6.2.3 Surrogates

For organic analyses, a surrogate was added at the extraction stage in order to verify method effectiveness. The surrogate was then analysed with the batch of samples and percentage recovery calculated.

6.2.4 Matrix spike

Matrix spikes consisted of samples spiked with a known concentration of the analyte being measured, in order to identify properties of the matrix that may hinder method effectiveness. Samples were spiked with concentrations equivalent to 5 to 10 times the LOR and percentage recovery calculated.

6.2.5 Method blanks

Method blanks (de-ionised water or clean sand) were carried through all stages of sample preparation and analysis at a rate of approximately 10%. Analyte concentrations in blanks should be less than the stated LOR. Reagent blanks were run if the method blank exceeded the LOR. The purpose of method blanks was to detect laboratory contamination.

6.3 Data acceptance criteria

The QA/QC was assessed against the Data Acceptance Criteria (DAC) provided in **Table 6-1**.

Table 6-1: QA/QC compliance assessment

QA/QC element	DQI	Objectives	Acceptance criteria
Field QA			
Standard procedures	Precision Accuracy Representativeness Completeness	All sampling undertaken by suitably qualified and experienced personnel. Adherence to the relevant work instructions including record keeping.	No deviation from standard procedure All appropriate field records kept and maintained
Sample collection, preservation, handling and analysis	Accurate Representativeness	Analysis within holding times. Samples collected into appropriate containers for the analysis with suitable preservation upon collection. Samples received at the laboratory in good condition and appropriately chilled.	Use of laboratory supplied sample containers including glass jars with Teflon lined lids for general contaminants. Preservation and storage of samples chilled in ice chests and transported to laboratories under chain of custody documentation. Attempt to appropriately chill samples (<5°C), with ice. Samples

QA/QC element	DQI	Objectives	Acceptance criteria
			remain not waterlogged and in separate bags to ice. Samples extracted and analysed within holding times relevant for the sample matrix. Use of NATA accredited laboratories for the analysis undertaken.
Decontamination	Accuracy Representativeness Precision Comparability	Prevention of cross-contamination between sampling locations.	Decontamination using triple wash system for all reusable equipment
Calibration	Precision Representativeness	Calibration of field measuring equipment as specified by the manufacturer and retaining of cal bration records.	Daily check of equipment against known standards Cal bration of equipment if observed to be outside of acceptable range from standard Cal bration of field measuring equipment at the rate specified by the manufacturer Cal bration records for each event
Data handling	Comparability Completeness	Appropriate labelling of sampling containers Central database of correct field and laboratory data.	Labelling of sample containers to include a unique sample identification number, date of collection, samplers' initials and project number. Field data and laboratory reports undergo review.
		Field QC	
Blind replicate/triplicate samples	Precision Comparability	To ensure the primary data is reliable and fit for purpose. The assessment of blind duplicate and split replicate samples is undertaken by calculating the Relative Percent Difference (RPD) of the replicate or split concentration compared with the original sample concentration. The RPD is defined as: $RPD = 100 \times \frac{\lvert X1 - X2 \rvert}{Average}$ Where: X1 and X2 are the concentration of the original and blind or split samples.	Analysed for the same chemicals as the primary sample. Typical RPDs are noted in AS 4482.1-2005 as between 30 – 50%. RPDs exceeding the acceptable range may be considered acceptable for heterogeneous material or where: ▪ No Limit (When the average concentration is < 10 times the LOR) ▪ 0 – 50% RPD (When the average concentration is 10 to 20 times the LOR)
		Laboratory QA/QC	
Laboratory duplicates	Precision	To ensure precision of the analysis method and replicability of analysis due to potential sample heterogeneity.	As per laboratory QC report

QA/QC element	DQI	Objectives	Acceptance criteria
		Assessment as per blind replicates and split samples	
Matrix spike recoveries Laboratory Control Samples Surrogates	Accuracy	To assess the effect of the matrix, laboratory control samples and surrogates on the accuracy of the analytical method used. Assessment is undertaken by determining the percent recovery of the known spike or addition to the sample. $\% \text{ Recovery} = 100 \times \frac{C - A}{B}$ Where: A = Concentration of analyte determined in the original sample; B = Added Concentration; C = Calculated Concentration.	As per laboratory QC report
Method blanks	Accuracy	To assess potential bias introduced by the laboratory analytical method for a relevant analyte. A method blank assesses the component of the analytical result introduced from laboratory equipment. Each blank is analysed as per the original samples.	Analytical result < LOR

7 Quality assurance / quality control

For the purpose of assessing the quality of data presented in this report, Jacobs collected and analysed blind replicate samples, while the laboratory completed their own internal QC. The current section of this report is focused on the presentation of the results of these QC samples, adherence to Quality Assurance (QA) systems and discussion of deviations, if any from the DAC.

7.1 Field quality assurance

All samples were collected by experienced Jacobs environmental scientists under established Jacobs protocols. Adherence to Jacobs protocols by experienced field staff trained in sample collection and handling techniques ensures the quality and representativeness of the samples collected.

Specific assessment of the field QA is discussed below:

- Standard procedures: Sampling was completed in accordance with standard procedures. Field records were kept and maintained.
- Sample collection, preservation, handling and analysis: All analysis was undertaken within holding times, samples were collected into appropriate containers for the analysis with suitable preservation upon collection, samples were received at the laboratory in good condition and appropriately chilled and laboratories were NATA accredited.
- Decontamination: All sampling equipment was decontaminated (triple washed) between investigation locations.
- Calibration: No equipment requiring calibration was used as part of the investigation
- Data handling: All samples were appropriately labelled. Laboratory data was reviewed and processed using ESDat.

7.2 Field quality control

The following QC samples were collected for laboratory analysis:

- Blind replicate: DUP C (duplicate of primary soil sample BH09_C_CGC)
- Blind replicate: DUP E (duplicate of primary sample BH16_D_CGC)
- Blind triplicate: DUP D (triplicate of primary soil sample BH09_C_CGC)
- Blind triplicate: DUP F (triplicate of primary soil sample BH16_D_CGC).

Two blind replicate samples were analysed to assess the quality control during the field sampling program. This equates to 6.7% blind replicate analysis. This blind replicate analysis exceeds and therefore conforms to AS 4482.1-2005.

The RPDs for all analytes for the soil blind replicate pairs conformed to the DAC with the exception of the RPDs between BH09_C_CGC and DUP C for total PAHs and lead. The sample collected for the blind replicate pair consisted of fill (sandy clay). It is inherently difficult to obtain representative duplicate samples from fill materials which cannot be homogenised in order to retain the integrity of volatile compounds (i.e. naphthalene). None of the analytes detected in either sample exceeded the adopted investigation levels for commercial / industrial land use. The RPD exceedances of lead and total PAHs between BH09_C _CGC and DUP C are unlikely to affect the usability of the data set.

Two blind triplicate samples were analysed to assess the quality control during the field sampling program. This equates to 6.7% blind triplicate analysis. This blind triplicate analysis exceeds and therefore conforms to AS 4482.1-2005.

The RPDs for all analytes for the soil blind triplicate pairs conformed to the DAC with the exception of the RPDs between BH16_D_CGC and DUP F for selected heavy metals. The sample collected for the blind triplicate pair consisted of fill (sandy clay). It is inherently difficult to obtain representative duplicate samples from fill materials which cannot be homogenised in order to retain the integrity of volatile compounds (i.e. naphthalene). None of the analytes detected in either sample exceeded the adopted investigation levels for commercial / industrial land sue. The exceedances of selected heavy metals between BH16_D_CGC and DUP F are unlikely to affect the usability of the data set.

RPD results for soil blind replicate and triplicate pairs are detailed in **Table A** presented in **Appendix A**.

7.3 Laboratory quality assurance

All analysis was undertaken by NATA accredited laboratories using NATA accredited analytical methods.

7.4 Laboratory quality control

Where undertaken, laboratory QC data is presented in full in the laboratory certificates in **Appendix B**.

7.4.1 Laboratory duplicates

Where undertaken, the RPDs for the laboratory samples conformed to the DAC.

7.4.2 Laboratory control samples

Where undertaken, the recoveries for all laboratory control samples conformed to the DAC.

7.4.3 Surrogates

Where undertaken, the recoveries for all laboratory surrogate samples conformed to the DAC.

7.4.4 Matrix spikes

Recoveries for all matrix spike samples conformed to the DAC with the exception of the recoveries for selected PAH compounds and heavy metals in matrix spike sample 268815-36. Envirolab reported that percent recovery for the matrix spike was not possible to report as the high concentration of analytes in sample/s 268815-36 have caused interference. Percent recovery was not possible to report due to the inhomogeneous nature of the element/s in the sample/s. However, an acceptable recovery was obtained for the laboratory control sample.

These exceptions are not expected to compromise the integrity of the data.

7.4.5 Method blanks

Where undertaken, all method blanks reported analyte concentrations below the laboratory LOR and therefore conformed to the DAC.

7.4.6 Sample holding times

All soil samples were extracted and analysed within the specified holding times.

7.4.7 Sample condition

All samples were received by the analytical laboratory in correctly preserved and chilled containers with no reported breakages. The individual sample receipts are presented with the laboratory reports in **Appendix B**.

7.5 QA/QC assessment

It is concluded that the fieldwork program and laboratory data are of acceptable quality and are considered useable in making conclusions and recommendations regarding the condition of soils at the site.

8 Site assessment criteria

8.1 Aesthetics

The National Environment Protection (Assessment of Site Contamination) Measure 1999, revised 2013 (NEPC, 2013) notes that there are no specific numeric aesthetic guidelines, however site assessments require a balanced consideration of the quantity, type and distribution of foreign material or odours in relation to the specific land use and its sensitivity. Consideration includes chemically discoloured soils, large quantities of various types of inert refuse and their depth etc.

8.2 Health investigation levels

To evaluate the significance of the reported soil concentrations with respect to the proposed use, Jacobs compared the analytical testing results against the soil quality guidelines published in the NEPC (2013) (i.e. health-based soil investigation (HIL) levels).

The HILs for a commercial/industrial land use (HIL-Setting D), NEPC (2013) were used to evaluate the significance of contamination.

The published guidelines adopted were based on a commercial/industrial land use as these were the most relevant exposure scenario for the proposed site use. However, we note that the published HIL guidelines are based on a much longer exposure period (i.e. 30 years). Therefore, direct application of the published HIL guidelines (for commercial/industrial) to the proposed site exposure (i.e. less than 5 years) was conservative.

As per the guidance provided in the NEPM (2013), average concentrations in soil were used to assess contaminant concentrations with respect to the guidelines rather than individual results. The NEPM also states that in order to use the average concentration of a contaminant, the data set must meet the following criteria:

- No single value should exceed 250% of the relevant investigation or screening level; and
- The standard deviation of the results should be less than 50% of the relevant investigation or screening level'.

Where the above criteria are not met, then the average concentration should not be used and the individual results must be directly compared to the guideline levels.

Published guidelines are also available for the evaluation of soil vapour exposure resulting from soil contaminated with petroleum hydrocarbons (Health Screening Levels (HSLs)). Jacobs have included HSLs for comparison to the soil assessment results. However, adoption of HSL guideline values is conservative given the proposed (temporary) use/occupation of the site (e.g. no permanent structures for occupation).

The HSLs defined within the NEPC (2013) relate only to the volatile fractions of the petroleum hydrocarbons range i.e. BTEX, naphthalene and TRH C6 – C10, TRH C10 – C16. Based on the presence of fill material across the site, HSLs for coarse grained sand to 0-1 m have been adopted.

The Jacobs assessment also considered the potential presence of asbestos. However, this was limited to:

- Field observations during the collection of soil samples (by Jacobs staff), and
- Testing of selected soil samples by the laboratory for the 'presence or absence' of asbestos.

We note that this was level of assessment does not constitute full characterisation of the site for the potential presence of asbestos nor is an 'asbestos clearance' provided by Jacobs. The potential for asbestos to be discovered during the occupation of the site should be considered within the management plan for any works on site (e.g. unexpected finds protocols).

The adopted soil quality guidelines are detailed in **Table 8-1**.

Table 8-1: Adopted soil quality guidelines (mg/kg)

Compounds / Fraction	Soil Investigation Levels
	Commercial/Industrial
Heavy Metals	
Arsenic (total)	3,000 [1]
Cadmium	900 [1]
Chromium (VI)	3,600 [1]
Copper	240,000 [1]
Lead	1,500 [1]
Mercury (inorganic)	730[1]
Nickel	6,000 [1]
Zinc	400,000 [1]
Cyanide (free)	1,500 [1]
Polychlorinated Biphenyls (PCBs)	
PCBs	7 [1]
Polycyclic Aromatic Hydrocarbons (PAHs)	
Naphthalene	11,000 [3]
BaP TEQ	40 [1]
Total PAH	4,000 [1]
Total Recoverable Hydrocarbons (TRH) [3]	
C6-C10	26,000
>C10-C16	20,000
>C16-C34	27,000
>C34-C40	38,000
Organochlorine Pesticides (OCP)	
DDT+DDE+DDD	3,600 [1]
Aldrin and dieldrin	45 [1]
Chlordane	530 [1]
Endosulfan	2,000 [1]
Endrin	100 [1]
Heptachlor	50 [1]
HCB	80 [1]

Compounds / Fraction	Soil Investigation Levels
	Commercial/Industrial
Methoxychlor	2,500 [1]
Mirex	100 [1]
Toxaphene	160 [1]
F1, F2 and BTEX (based on SAND soil type) #	
Depth (m)	0 – <1
F1 (C6-C10 minus sum of BTEX concentrations)	260 [2]
F2 (>C10-C16 minus naphthalene)	NL [3]
Benzene	3 [2]
Toluene	99,000 [3]
Ethylbenzene	27,000 [3]
Xylenes	81,000 [3]
Naphthalene	11,000 [3]
Asbestos	
All forms of asbestos	No asbestos in any form present in soil samples analysed or observed on surface soils and in excavated materials

[1] NEPC (2013) Table 1 A(1) Health investigations levels for soil contaminants – Commercial / Industrial D.
[2] NEPC (2013) Table 1 A(3) Soil HSLs for vapour intrusion – Commercial / Industrial D, 0 to <1, SAND
[3] HSL-D Commercial / Industrial, Direct Contact detailed within Table A4, Friebel, E & Nadebaum, P 2011, Soil Health screening levels for direct contact, Technical Report 10.
NL – NL indicates the HSL is not limiting (see Footnote 5, Table 1A(3)).
TEQ – Toxic Equivalent.
Soil Vapour as the primary Exposure Pathway to impact potential receptors.

9 Results

9.1 Site stratigraphy

A summary of the sub-surface material excavated from the investigation locations is provided in **Table 9-1**.

Table 9-1: Summary of sub-surface materials

BH06	
Co-ordinates: Lat: 33º49.634S; Long: 151º12.941'E	
Depth range (mbgl)	**Material description**
0.0	Grass
0.0-0.25	FILL: clayey silt with gravel (fine to medium grained, sub-angular), dark brown, fine grained, rootlets, loose, dry
0.1	Brick fragments present
0.2	Increased gravel content (coarse, angular)
0.25-0.8	FILL: sandy CLAY with sandstone boulder, moist, fine to coarse, dark brown.
0.3	Colour change to light brown.
0.4	Blue metal inclusions, colour change to white/light brown
0.5	As above with gravel (fine to medium, sub-rounded)
0.7	As above with colour change to brown/dark grey, wet.
0.8	Refusal on rock at 0.8mbgl. End of borehole.
BH07	
Depth range (mbgl)	**Material description**
0.0	Grass
0.0 - 0.5	FILL: clayey silt, dark brown, loose, fine grained, rootlets, dry
0.2	as above with some gravel/sandstone, coarse, subrounded
0.5 – 0.8	FILL: silty clay, dark brown, fine grained, moist
0.7	Tree root fragment
0.8 – 1.0	FILL: sandy clay, dark brown, fine to coarse grained, moist
0.9	Asphalt inclusions and glass, and decreased sand content
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).
BH08	
Co-ordinates: Lat: 33º49.639'S; Long: 151º12.913'E	
Depth range (mbgl)	**Material description**
0.0	Grass
0.0-1.0	FILL: sandy clay with silt, dark brown, rootlets, loose, moist.
0.1	Increased clay content
0.25	Colour change to light brown, possibly natural.
0.35	Increased moisture content.
0.7	As above with wet soil.
0.8	Sandstone inclusion (medium gravel), rootlets.
1	Colour change to red. End of borehole at 1.0mbgl (limit of investigation).

BH09	
Depth range (mbgl)	**Material description**
0.0	Grass
0.0-0.35	FILL: sandy silty clay, dark brown, fine to coarse grained, rootlets, moist
0.2	As above with some gravel, medium to coarse, subrounded
0.35 – 1.0	FILL: sandy clay, light brown, fine to coarse grained, moist
0.75	Colour change to brown mottled dark brown, tree root fragment
0.80	Colour change to dark brown mottled orange
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).
BH10	
Depth range (mbgl)	**Material description**
0.0	Grass
0.0 - 0.55	FILL: silt sandy clay with gravel, dark brown, fine to coarse grained, gravel coarse and rounded, rootlets, moist
0.2 – 0.55	Sandstone fill/cobbles. Borehole relocated two additional locations within one metre of original location
0.55	Glass fragments present
0.55	Excavation terminated at 0.55 mbgl (refusal in fill material/sandstone cobbles).
BH11	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.6	FILL: silty sandy clay, dark brown, rootlets, fine to coarse grained, moist
0.2	Asphalt inclusions and partial tree root
0.4	Sandstone layer, white
0.6 – 1.0	FILL: clay with minor sand content, brown, fine to coarse grained, moist
0.8	Colour change to dark brown.
1.0	Colour change to brown, wet. Excavation terminated at 1.0 mbgl (limit of investigation).
BH12	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.9	FILL: silty sandy clay, dark brown, rootlets, fine to coarse grained, moist
0.3	Asphalt/charcoal layer with orange sandstone gravel and glass fragments
0.6	Sandstone boulders, PVC, concrete fragments/boulders
0.9 – 1.0	FILL: sandy clay, brown, fine to coarse grained
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).
BH13	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.3	FILL: silty sandy clay, dark brown, rootlets, moist.
0.2	As above with gravel, coarse, subangular
0.3 – 1.0	FILL: sandy clay, light brown, rootlets, fine to coarse grained
0.6	Becoming loose and dry
0.7	Colour change to white
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).

BH14	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.5	FILL: sandy silty clay, brown, fine to coarse grained, rootlets, moist
0.2	Sandstone gravel and asphalt
0.25	Sandstone boulder
0.5 – 0.95	FILL: sandy clay, light brown, fine to coarse grained, moist
0.6	Sandstone gravel/rock fragments, medium to coarse
0.75	Colour change to white/cream
0.95 – 1.0	FILL: clay, white, fine grained
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).
BH15	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.3	FILL: clayey silt, dark brown, fine to coarse grained, rootlets, dry
0.15	As above with coarse gravel (sandstone), medium to coarse
0.3 – 1.0	FILL: sandy clay with gravel, mottled red/brown/yellow, fine to coarse grained, medium to coarse gravel, subrounded, dry
0.6	Colour change to red and stiff
0.65	Colour change to brown/orange/dark brown, partial tree root
0.85	Asphalt layer
1.0	Distinct asphalt odour. Excavation terminated at 1.0 mbgl (limit of investigation).
BH16	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.55	FILL: silty clay, dark brown, fine grained, rootlets, moist
0.15	As above with gravel, medium to coarse, subangular
0.4	Asphalt layer
0.55 – 0.7	FILL: sandy clay with gravel, white/brown, fine to coarse grained, medium to coarse, subrounded gravel (sandstone), moist
0.6	White sandstone layer
0.7 – 1.0	FILL: sandy clay with few gravel, brown/red, fine to coarse grained, gravel angular and coarse, moist
1.0	Becoming mottled white/brown/orange and moist. Excavation terminated at 1.0 mbgl (limit of investigation).
BH17	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.6	FILL: sandy silty clay with few gravel, dark brown, rootlets, fine to coarse grained, medium to coarse gravel, angular, dry
0.25	Tile fragment present
0.6 – 1.0	FILL: sandy clay with some gravel, brown, fine to coarse grained, medium to coarse gravel, subangular, moist
0.62	As above with large rock fragments (moved borehole 0.3 m east – refusal in fill)
0.65	Clay pipe fragment
0.7	Clay becoming stiffer

1.0	Excavation terminated at 1.0 mbgl (limit of investigation).
BH18	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.25	FILL: silty clay with sand, dark brown, rootlets, fine to coarse grained, moist
0.15	As above with some gravel, mottled light brown/dark brown
0.25 – 0.9	FILL: sandy clay, brown mottled orange, fine to coarse grained, moist
0.6	Clay pipe fragment
0.9	Excavation terminated at 0.9 mbgl (refusal in fill).
BH19	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.25	FILL: silty clay with sand, dark brown, rootlets, fine to coarse grained, moist
0.1	Rock fragments present, coarse, angular
0.25	FILL: sandy clay, brown, fine to coarse grained, moist
0.5	Asphalt inclusions
0.6	Increased gravel/rock fragments, coarse, subangular
1.0	Concrete fragments and asphalt inclusions. Excavation terminated at 1.0 mbgl (limit of investigation).
BH20	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.35	FILL: silty sandy clay, dark brown, rootlets, fine to coarse grained, moist
0.15	Sandstone gravel/boulder present
0.35	FILL: sandy clay: brown mottled red and white, fine to coarse grained, moist
0.5	Increased sandstone and rock fragments/gravels, coarse
0.7	Large rock fragment present
0.9	Colour change to light brown
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).

9.2 Aesthetics

Fill was identified at all locations to the limit of the investigation (1.0 mbgl). The fill material comprised topsoil/fill overlying sandy clays, sandstone gravels, and occasional construction waste (asphalt, concrete, clay pipe, tile). The boreholes which were observed to contain asphalt materials had a distinct asphalt odour.

The SMEC assessment also reported similar type of fill across the investigation area extending until the underlying natural surface was encountered. However, SMEC did not note the presence of odorous soils.

Potential asbestos containing materials were not visually observed on the surface in there near vicinity of the investigation locations by Jacobs.

Given the presence of building waste/debris within the fill, there is a potential for asbestos containing materials to also be present. Jacobs do not recommend further assessment of the site for asbestos, however, the potential for asbestos containing materials to be present within the subsurface should be noted within the Construction Environmental Management Plan (including an unexpected finds procedure).

The report of ‘distinct asphalt odours’ at BH15 may also be indicative of a larger area of contamination within this area. The observation of similar fill across the investigation area combined with the heterogenous nature of fill is an indication that other areas of odorous and/or contaminated fill remain ‘unidentified’.

Given the time constraints related to this assessment, Jacobs have recommended application of conservative preventative exposure measures for the proposed construction use of the site. In the event that the proposed preventative exposure measures are not practicable to implement during the proposed (construction) use of the site, then additional assessment is likely to be required.

9.3 Soil analytical results

Soil analytical results from samples collected from the SMEC and Jacobs investigations in comparison to the adopted HIL/HSL are discussed below.

Analytical results (SMEC and Jacobs combined) are provided in **Table B** presented **in Appendix A**. Laboratory certificates of analysis from the Jacobs investigation are presented in **Appendix B**.

Reported concentrations of contaminant compounds were below the adopted HIL/HSL with the exception of the benzo(a)pyrene TEQ reported in sample BH15_D_CGC at a depth of 1mbgl in fill at concentrations exceeding the adopted HIL. This result was consistent with a distinct ‘asphalt’ odour and asphalt ‘layer’ was also encountered at this location.

No other sample collected by SMEC or Jacobs reported contamination at concentrations above the adopted HIL/HSL.

Asbestos was not identified by the laboratory in any of the samples submitted for asbestos identification.

9.4 Statistical data analysis

The following information provides a summary of the data obtained from the SMEC (2020) and the Jacobs investigations.

The data summary has only been undertaken on the potential contaminants for the site (heavy metals, PAH) as detailed in Appendix M of the EIS (2020) prepared for the Western Harbour Tunnel and Warringah Freeway Upgrade project and other compounds tested for by SMEC (TRH, BTEX, pesticides, PCB) which have a respective adopted HIL/HSL.

The data summary assumes the following:

- Only those contaminant compounds which have HIL/HSL have been subject to statistical analysis.
- Where concentrations of contaminant compounds have been reported at less than the laboratory levels or reporting (LOR), these results have been reported as half the LOR to enable statistical analysis.
- The data summary has been prepared for fill materials only.

The data summary is detailed in **Table 9-2**.

The benzo(a)pyrene TEQ reported in sample BH15_D_CGC (88mg/kg) was the only individual sample with concentrations reported above the guideline value (40 mg/kg). Statistical analysis of the data set indicated the average soil concentration for B(a)P TEQ (4.35 mg/kg) was below the adopted soil quality guideline value and that application of the average concentration was acceptable based on the statistical analysis recommended by the NEPM.

Table 9-2: Data summary

Contaminant	No. samples analysed	Maximum concentration (mg/kg)	95% UCL concentration (mg/kg)	Arithmetic mean concentration (mg/kg)	Standard deviation (mg/kg)	Adopted HIL/HSL	No. samples above HIL/HSL	No of samples with a 95%UCL above HIL/HSL	Arithmetic mean above HIL/HSL	Maximum concentration >250% of HIL/HSL	Standard deviation >50% of HIL/HSL
Naphthalene	68	11	0.599	0.33	1.3099	11,000	0	0	No	✓	✓
Total PAH's	68	1900	91.52	44.70	229.7537	4,000	0	0	No	✓	✓
B(a)P TEQ	68	**88**	6.68	4.35	11.4130	40	**1**	0	No	✓	✓
Arsenic	68	36	5.341	4.38	4.7027	3,000	0	0	No	✓	✓
Cadmium	68	3	0.541	0.45	0.4704	900	0	0	No	✓	✓
Chromium	68	23	11.41	10.54	4.2441	3,600	0	0	No	✓	✓
Copper	68	480	42.89	30.60	62.3196	240,000	0	0	No	✓	✓
Lead	68	697	130.9	105.88	122.6795	1,500	0	0	No	✓	✓
Mercury	68	3	0.503	0.39	0.5616	730	0	0	No	✓	✓
Nickel	68	12	4.123	3.55	2.8038	6,000	0	0	No	✓	✓
Zinc	68	533	101.7	83.40	89.8356	400,000	0	0	No	✓	✓
Benzene	34	0.025	NV	0.03	0.0000	3	0	0	No	✓	✓
Toluene	34	0.025	NV	0.03	0.0000	99,000	0	0	No	✓	✓

Contaminant	No. samples analysed	Maximum concentration (mg/kg)	95% UCL concentration (mg/kg)	Arithmetic mean concentration (mg/kg)	Standard deviation (mg/kg)	Adopted HIL/HSL	No. samples above HIL/HSL	No of samples with a 95%UCL above HIL/HSL	Arithmetic mean above HIL/HSL	Maximum concentration >250% of HIL/HSL	Standard deviation >50% of HIL/HSL
Total Xylenes	34	0.025	NV	0.03	0.0000	81,000	0	0	No	✓	✓
Ethylbenzene	34	0.025	NV	0.03	0.0000	27,000	0	0	No	✓	✓
TRH C6 - C10	34	5	NV	5.00	0.0000	26,000	0	0	No	✓	✓
TPH C6 - C10 less BTEX (F1)	34	5	NV	5.00	0.0000	260	0	0	No	✓	✓
TRH >C10-C16	34	25	NV	25.00	0.0000	20,000	0	0	No	✓	✓
TRH >C10 - C16 less Naphthalene (F2)	34	25	NV	25.00	0.0000	20,000	0	0	No	✓	✓
TRH >C16-C34	34	1200	194.8	134.12	206.1142	27,000	0	0	No	✓	✓
TRH >C34-C40	34	440	87.63	67.65	67.8259	38,000	0	0	No	✓	✓
HCB	34	0.025	NV	0.03	0.0000	80	0	0	No	✓	✓
Aldrin + Dieldrin	34	0.025	NV	0.03	0.0000	45	0	0	No	✓	✓
Chlordane	34	0.025	NV	0.03	0.0000	530	0	0	No	✓	✓
DDD+DDT+DDE	34	0.025	NV	0.03	0.0000	100	0	0	No	✓	✓
Endosulfan	34	0.025	NV	0.03	0.0000	2,000	0	0	No	✓	✓
Heptachlor	34	0.025	NV	0.03	0.0000	50	0	0	No	✓	✓

Contaminant	No. samples analysed	Maximum concentration (mg/kg)	95% UCL concentration (mg/kg)	Arithmetic mean concentration (mg/kg)	Standard deviation (mg/kg)	Adopted HIL/HSL	No. samples above HIL/HSL	No of samples with a 95%UCL above HIL/HSL	Arithmetic mean above HIL/HSL	Maximum concentration >250% of HIL/HSL	Standard deviation >50% of HIL/HSL
Methoxychlor	34	0.1	NV	0.10	0.0000	2,500	0	0	No	✓	✓
Total PCBs	34	0.05	NV	0.05	0.0000	7	0	0	No	✓	✓

✓ Arithmetic mean/individual concentration/maximum concentration/standard deviation soil concentration below soil quality guideline and/or acceptable statistical evaluation criteria.

x Arithmetic mean/individual concentration/maximum concentration/standard deviation soil concentration above soil quality guideline and/or unacceptable statistical evaluation criteria.

NV – No variance

10 Conclusions and recommendations

The following conclusions and recommendations were made based on the scope/limitations of the combined SMEC/Jacobs assessment data.

Conclusions

- Odorous and contaminated soil was reported at one location (BH15_D_CGC). However, statistical analysis of the data set showed that reported contamination levels were (on average) below the guideline values for the proposed construction use of the site.
- Reported concentrations for all other contaminant compounds in soil were below the adopted guideline values (for all individual sample results).
- Asbestos was not identified by the laboratory in any of the samples submitted for asbestos identification and asbestos containing materials were not observed by Jacobs while collecting the soil samples.
- The report of 'distinct asphalt odours' at BH15 may also be indicative of a larger area of contamination within this area. The observation of similar fill across the investigation area combined with the heterogenous nature of fill suggests that there is the potential for unexpected contamination to be encountered in other areas of the site.

Recommendations

For areas in the vicinity of BH15, no sub-surface works are to be undertaken until either of the following options are implemented:

1. Further investigations to assess the extent and degree of odorous materials at and in the vicinity of location BH15; or
2. The Construction Environmental Management Plan should clearly identify the area around BH15 as a 'known area of contamination' with strict restrictions on subsurface excavation in this area without approval and supervision of an environmental consultant.

For all other areas of the site (i.e. areas within the footprint of the proposed construction support site exclusive of areas in the vicinity of BH15), the following is recommended:

- Given the presence of other building waste/debris (including asphalt), there is a potential for undiscovered soil contamination and/or asbestos containing materials to also be present within fill. The potential for undiscovered soil contamination and/or asbestos containing materials to be present within the subsurface should be noted within the Construction Environmental Management Plan (including an unexpected finds procedure).
- The Construction Environmental Management Plan should also give consideration for the potential to odours soil to be encountered during any subsurface excavation works and appropriate procedures developed/implemented to minimise odour generation and/or exposure.
- The Construction Environmental Management Plan should also ensure that any disturbance of the site surface is managed appropriately. For example, minimise dust generation, surface water/sediment runoff from the site, etc.).

General recommendations

- As noted in Section 1 of the report, it is recommended that further consideration be given to the definition of ‘disturbance’ in relation to the Early Works program and subsequent Main Works contract.
- Further consideration should also be given to the definition of ‘risk’ used by the EIS (and how sites were classified), and how this differs from the interpretation of ‘risk’ implied by the approval conditions. Consequently, the potential for additional site data to support a ‘lower risk rating’ should also be considered.

11 Approval response

The following section must be read in context with the scope and associated limitations discussed throughout this report.

Table 11-1: Responses to risk management strategy

Risk management strategy (EIS Appendix M, 2020)	Response
Based on the information reviewed, a number of moderate to high risk potential AEIs have been identified. Where extensive investigations have not been carried out (all high to moderate risk sites with the exception of the Rozelle Rail Yards site), potentially contaminated areas directly affected by the project will be investigated and managed in accordance with the requirements of guidance endorsed under section 105 of the Contaminated Land Management Act 1997.	The EIS Appendix M (2020) identified the site as a high contamination risk site. The investigations (SMEC and Jacobs) undertaken at the site have been undertaken in general accordance with guidance endorsed under Section 105 of the Contaminated Land management Act 1997. Although the concentration of benzo(a)pyrene TEQ in one sample exceeded the HIL/HSL, the data summary indicated that the standard deviation, arithmetic mean and 95% upper confidence limit of benzo(a)pyrene TEQ were below the soil quality guideline and/or acceptable statistical evaluation criteria. Reported concentrations for all other contaminant compounds in soil were below the adopted HIL/HSL for a commercial / industrial use of the site (for all individual sample results). Jacobs did not observe potential asbestos containing materials in the vicinity of the investigation locations or within materials excavated as part of the investigation. Therefore, specific management (i.e. remediation as defined by the Contaminated Land Management Act 1997) of contamination is not required at the site under a commercial/industrial land use setting.

Table 11-2: Responses to condition of approvals

Number	Condition of approval	Response
E115	Prior to the commencement of any work that would result in the disturbance of moderate to high risk contaminated sites as identified in the documented listed in Condition A1, a Detailed Site Investigations must be undertaken by a Contaminated Land Consultant certified under either the Environment Institute of Australia or New Zealand's "Certified Environmental Practitioner" (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia "Certified Professional Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme	Refer to Section 1 of this report for description of the scope of work and limitations associated with this report. As noted in Section 1, we recommend further consideration be given to the definition of 'disturbance' in relation to the Early Works program and subsequent Main Works contract. Also, further consideration should also be given to the definition of 'risk' used in the EIS (and how sites were classified), and how this differs from the interpretation of 'risk' implied by the approval conditions. Consequently, the potential for additional site data to support a 'lower risk rating' should also be considered. The assessment report was reviewed/completed by a Contaminated Land Consultant certified under either the Environment Institute of Australia or New Zealand's "Certified Environmental Practitioner" (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia "Certified Professional

Number	Condition of approval	Response
		Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme.
E116	A Detailed Site Investigation Report must be prepared and submitted to the Planning Secretary for information following the completion of Detailed Site Investigations required by Condition E115. The report must be prepared in accordance with relevant guidelines made or approved by the EPA under section 105 of the *Contaminated Land Management Act 1997* (NSW) and prepared by a Contaminated Land Consultant certified under either the Environment Institute of Australia or New Zealand's "Certified Environmental Practitioner" (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia "Certified Professional Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme. Nothing in this condition prevents the Proponent from preparing individual Site Contamination Reports for separate sites	The investigations (by SMEC and Jacobs) undertaken at the site have been undertaken in general accordance with guidance endorsed under Section 105 of the Contaminated Land management Act 1997 and other relevant guidelines. This assessment report was reviewed/completed by a Contaminated Land Consultant certified under either the Environment Institute of Australia or New Zealand's "Certified Environmental Practitioner" (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia "Certified Professional Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme.
E117	The Detailed Site Investigation Report must provide details on:	
	(a) primary sources of contamination, for example potentially contaminating activities, infrastructure (such as underground storage tanks, fuel line, sumps or sewer lines) or site practices;	The EIS Appendix M (2020) did not identify point sources of contamination within the investigation area. The EIS identified particulate deposition as the most likely source of contamination. The Jacobs investigation was designed to evaluate contamination associated with particulate deposition across the site. The SMEC (2020) investigation inadvertently assessed potential impacts associated with particulate deposition at the site. Jacobs did not observe any primary sources of contamination during the assessment. Odorous and contaminated soil was reported at one location (BH15 D CGC). However, this contamination was considered to be associated with fill across the area containing heterogeneous concentrations of contamination. Statistical analysis of the data set showed that reported contamination levels in fill were (on average) below the guideline values for the proposed construction use of the site.
	(b) contaminant dispersal in air, hazardous ground gases, surface water, groundwater, soil vapour, separate phase contaminants, sediments, infrastructure (e.g. concrete), biota, soil and dust;	Contaminated soil reported at BH15 D CGC was located approximately 1m below the site surface. The contaminated B(a)P TEQ is not volatile and has a low solubility. Left undisturbed this contamination is expected to have negligible impact on the proposed temporary construction use of the site.

Number	Condition of approval	Response
		In the event that fill is disturbed and relocated onsite, soil management practices during movement and following relocation (to be included in the Construction Environmental Management Plan) should be implemented to minimise exposure, dust and runoff.
	(c) contaminant characterisation and behaviour (volatility, leachability, speciation, degradation products and physical and chemical conditions on-site which may affect how contaminants behave);	As noted above for (b).
	(d) potential effects of contaminants on human health, including the health of occupants of built structures (for example arising from risks to service lines from hydrocarbons in groundwater, or risks to concrete from acid sulphate soils) and the environment;	Odorous and contaminated soil was reported at one location (BH15 D CGC). However, statistical analysis of the data set showed that reported contamination levels were (on average) below the guideline values for the proposed construction use of the site. Therefore, the potential effect of this contamination on human health was considered to be neglig ble (based on the proposed construction use of the site). Further to the above conclusion (and as a conservative measure), Jacobs recommended the following For areas in the vicinity of BH15, no sub-surface works are to be undertaken until either of the following options are implemented: 1. Further investigations to assess the extent and degree of odorous materials at and in the vicinity of location BH15 and within the associated construction footprint; or 2. The Construction Environmental Management Plan should clearly identify the area around BH15 as a 'known area of contamination' with strict restrictions on subsurface excavation in this area without approval and supervision of an environmental consultant. For all other areas of the site (i.e. areas within the footprint of the proposed construction support site exclusive of areas in the vicinity of BH15), the following is recommended: • Given the presence of other building waste/debris (including asphalt), there is a potential for undiscovered soil contamination and/or asbestos containing materials to also be present within fill. The potential for undiscovered soil contamination and/or asbestos containing materials to be present within the subsurface should be noted within the Construction Environmental Management Plan (including an unexpected finds procedure). • The Construction Environmental Management Plan should also give consideration for the potential to odours soil to be encountered during any subsurface excavation works and

Number	Condition of approval	Response
		appropriate procedures developed/implemented to minimise odour generation and/or exposure. • The Construction Environmental Management Plan should also ensure that any disturbance of the site surface is managed appropriately. For example, minimise dust generation, surface water/sediment runoff from the site, etc.).
	(e) potential and actual contaminant migration routes including potential preferential pathways;	Refer to (d).
	(f) the adequacy and completeness of all information available for use in the assessment of risk and for making decisions on management requirements, including an assessment of uncertainty;	Refer to Section 1 of this report for the assumptions and limitations related to this report. The assessment undertaken was considered to be adequate to meet these objectives with the resultant recommendation for application of conservative preventative exposure measures during the occupation of the site for construction activities associated with the Early Works program.
	(g) the review and update of the conceptual site model from the preliminary and detailed site investigations;	The EIS assumed surface deposition was the primary source of contamination. However, the assessment identified subsurface fill as a potential source of contamination requiring management.
	(h) nature and extent of any existing remediation (such as impervious surface cappings);	No existing remediation infrastructure was observed or documented at the site.
	(i) whether the land is suitable (for the intended final land use) or can be made suitable through remediation.	Refer to Section 3 of this report for the assumptions and limitations related to this report. Contamination was not reported above the adopted guideline values for the proposed construction sue of the site. However, conservative preventative exposure measures have been recommended (refer to (d) above).
E118	Should remediation be required to make land suitable for the final intended land use, a Remediation Action Plan must be prepared or reviewed and approved, by consultants certified under either the Environment Institute of Australia and New Zealand's Certified Environmental Practitioner (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia Certified Professional Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme. The Remedial Action Plan must be prepared in accordance with relevant guidelines made or approved by the EPA under section 105 of the Contaminated Land Management Act 1997 and must include measures to remediate the	Remediation is not required.

Number	Condition of approval	Response
	contamination at the site to ensure the site will be suitable for the proposed use when the Remedial Action Plan is implemented. The Remedial Action Plan must be submitted to the Planning Secretary for information prior to undertaking remediation.	
E119	The Remediation Action Plan must include measures to remediate the contamination at the site to ensure the site will be suitable for the proposed use and detail how the environmental and human health risks will be managed during the disturbance, remediation and/or removal of contaminated soil/sediment or groundwater. Nothing in this condition prevents the preparation of individual Remediation Action Plans for separate sites.	Not applicable.
E120	Prior to commencing remediation, a Section B Site Audit Statement(s) must be prepared by a NSW EPA-accredited Site Auditor that certifies that the Remediation Action Plan is appropriate and that the site can be made suitable for the proposed use. The Remedial Action Plan must be implemented and any changes to the Remedial Action Plan must be approved in writing by the NSW EPA accredited Site Auditor. Nothing in this condition prevents the Proponent from engaging the Site Auditor to prepare Site Audit Statements for separate sites.	Not applicable.
E121	A Section A1 or A2 Site Audit Statement (accompanied by an Environmental Management Plan) and its accompanying Site Audit Report, which state that the contaminated land disturbed by the work has been made suitable for the intended land use, must be submitted to the Planning Secretary and Council after remediation and no later than prior to the commencement of operation of the CSSI. Nothing in this condition prevents the Proponent from obtaining Section A Site Audit Statements for individual parcels of remediated land.	Not applicable.
E122	Contaminated land must not be used for the purpose approved under the terms of this approval until a Section A1 or A2 Site Audit	Not applicable.

Number	Condition of approval	Response
	Statement is obtained which states that the land is suitable for that purpose and any conditions on the Section A Site Audit Statement have been complied with.	
E123	An Unexpected Finds Procedure for Contamination must be prepared before the commencement of work and must be followed should unexpected contamination or asbestos (or suspected contamination) be excavated or otherwise discovered. The procedure must include details of who will be responsible for implementing the unexpected finds procedure and the roles and responsibilities of all parties involved. The procedure must be submitted to the Planning Secretary for information.	An Unexpected Finds Procedure for contamination (to be included in the Construction Environmental Management Plan) will be prepared before the commencement of work.
E124	The Unexpected Finds Procedure for Contamination must be implemented throughout construction.	An Unexpected Finds Procedure for contamination (to be included in the Construction Environmental Management Plan) will be prepared before the commencement of work.

Appendix A – Tables

Table A: RPD Results

		Sample ID	BH09_C_CGC	DUP C	RPD (%)	BH09_C_CGC	DUP D	RPD (%)	BH16_D_CGC	DUP E	RPD (%)	BH16_D_CGC	DUP F	RPD (%)
		Depth (m)	0.5	-		0.5	-		1	-		1	-	
		Date	11/05/2021	11/05/2021		11/05/2021	11/05/2021		12/05/2021	12/05/2021		12/05/2021	12/05/2021	
Compounds	Units	LOR												
Benzo(a)pyrene TEQ calc (zero)	mg/kg	0.5	<0.5	<0.5	0	<0.5	<0.5	0	<0.5	<0.5	0	<0.5	<0.5	0
Benzo(a)pyrene TEQ calc(half)	mg/kg	0.5	<0.5	<0.5	0	<0.5	0.6	82	<0.5	<0.5	0	<0.5	0.6	82
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	0.5	<0.5	<0.5	0	<0.5	1.2	131	<0.5	<0.5	0	<0.5	1.2	131
Benzo[b+j]fluoranthene	mg/kg	0.5	-	-	-	-	<0.5	-	-	-	-	-	<0.5	-
Acenaphthene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Acenaphthylene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Anthracene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Benzo(a)anthracene	mg/kg	0.1	<0.1	0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	0.5	164
Benzo(a) pyrene	mg/kg	0.05	<0.05	0.3	143	<0.05	<0.5	0	0.1	0.1	0	0.1	<0.5	86
Benzo(b+j) & Benzo(k)fluoranthene	mg/kg	0.2	<0.2	<0.2	0	<0.2	-	-	<0.2	<0.2	0	<0.2	-	-
Benzo(g,h,i)perylene	mg/kg	0.1	<0.1	0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Benzo(k)fluoranthene	mg/kg	0.5	-	-	-	-	<0.5	-	-	-	-	-	<0.5	-
Chrysene	mg/kg	0.1	<0.1	0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	0.5	164
Dibenz(a,h)anthracene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Fluoranthene	mg/kg	0.1	<0.1	0.3	100	<0.1	<0.5	0	0.2	0.1	-	0.2	0.7	111
Fluorene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Naphthalene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Phenanthrene	mg/kg	0.1	<0.1	0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Pyrene	mg/kg	0.1	<0.1	0.2	67	<0.1	<0.5	0	0.1	0.1	0	0.1	0.8	156
PAHs (Sum of total)	mg/kg	0.5	-	-	-	-	<0.5	-	-	-	-	-	2.5	-
Total +ve PAHs	mg/kg	0.05	<0.05	1.3	**185**	<0.05	-	-	0.4	0.4	0	0.4	-	-
Arsenic	mg/kg	2	<4	<4	0	<4	2.2	10	<4	<4	0	<4	3.8	**62**
Cadmium	mg/kg	0.4	<0.4	<0.4	0	<0.4	<0.4	0	<0.4	<0.4	0	<0.4	<0.4	0
Chromium (III+VI)	mg/kg	1	20	19	5	20	13	42	18	19	5	18	23	**24**
Copper	mg/kg	1	2	3	40	2	<5	22	4	2	67	4	<5	46
Lead	mg/kg	1	10	17	**52**	10	7.7	26	5	3	50	5	5.3	6
Mercury	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.1	0	<0.1	<0.1	0	<0.1	<0.1	0
Nickel	mg/kg	1	2	2	0	2	<5	22	<1	<1	0	<1	<5	0
Zinc	mg/kg	1	6	14	80	6	6.9	14	8	4	67	8	<5	105
Moisture Content	%	0.1	9.6	10	4	9.6	11	14	11	10	10	11	11	0
Moisture Content (dried @ 103°C)	%	1	-	-	-	-	-	-	-	-	-	-	-	-

Table B: Analytical Results

				SPA 2021																																	
			Sample ID	BH06 A CGC	BH06 C CGC	BH07 A CGC	BH07 D CGC	BH08 A CGC	BH08 D CGC	BH10 A CGC	BH10 B CGC	BH09 A CGC	BH09 C CGC	DUP C	DUP D	BH11 B CGC	BH11 D CGC	BH12 A CGC	BH12 B CGC	BH13 A CGC	BH13 D CGC	BH1 A CGC	BH1 C CGC	BH15 A CGC	BH15 D CGC	BH16 A CGC	BH16 D CGC	DUP E	DUP F	BH17 A CGC	BH17 C CGC	BH18 A CGC	BH18 C CGC	BH19 A CGC	BH19 B CGC	BH20 A CGC	BH20 D CGC
			Depth (m)	0	0.5	0	1	0	1	0	0.25	0	0.5	-	-	0.25	1	0	0.25	0	1	0	0.5	0	1	0	1	-	-	0	0.5	0	0.5	0	0.25	0	1
			Date	28/0 /2021	28/0 /2021	28/0 /2021	28/0 /2021	28/0 /2021	28/0 /2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Compounds	Commercial/Industrial	Units	LOR																																		
Polycyclic Aromatic Hydrocarbons																																					
Naphtha ene	11,000	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	0.2	<0.1	<0.1	<0.5	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthy ene		mg/kg	0.1	0.1	0.2	0.2	1.1	<0.1	<0.1	0.	0.	0.2	<0.1	<0.1	<0.5	1.5	<0.1	0.1	0.2	0.	<0.1	0.2	0.1	0.	6 9	0.7	<0.1	<0.1	<0.5	0.2	0.9	0.2	0.7	0.2	0.6	0.	<0.1
Acenaphthene		mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18	0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
Fluorene		mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.5	0.	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	29	0.2	<0.1	<0.1	<0.5	<0.1	0.1	<0.1	0.3	<0.1	0.3	0.1	<0.1
Phenanthrene		mg/kg	0.1	0.	0.2	0.	2.5	0.1	<0.1	0.	1.	0.7	<0.1	0.1	<0.5	5.	<0.1	0.3	0.7	0.6	<0.1	0.6	0.3	1.2	300	2.7	<0.1	<0.1	<0.5	0.6	1.8	0.5	3.1	0.	2.6	1.5	<0.1
Anthracene		mg/kg	0.1	0 2	0.1	0.1	0.8	<0.1	<0.1	0.2	0.5	0.2	<0.1	<0.1	<0.5	5.8	<0.1	0.1	0.3	0.3	<0.1	0.2	<0.1	0.	93	1	<0.1	<0.1	<0.5	0.2	0.8	0.2	1.1	0.2	0.8	0.5	<0.1
Fluoranthene		mg/kg	0.1	1.1	0.8	1	7	0.6	<0.1	1.3	3	2	<0.1	0.3	<0.5	13	<0.1	1	1.9	2.3	<0.1	2	0.8	3.6	60	10	0.2	0.1	0.7	1.5	7.1	1.	6.5	1.5	.8	3.9	0.2
Pyrene		mg/kg	0.1	1 2	0.9	1.1	7.	0.6	<0.1	1.2	2.6	1.7	<0.1	0.2	<0.5	11	<0.1	0.9	1.6	2.3	<0.1	1.7	0.7	3.1	3 0	8.5	0.1	0.1	0.8	1.3	6.7	1.2	5.	1.		3.5	0.2
Benzo(a)anthracene		mg/kg	0.1	0 7	0.7	0.7	5.3	0.	<0.1	0.8	1.7	1.1	<0.1	0.1	<0.5	6.6	<0.1	0.5	1	1.6	<0.1	1.1	0.	1.8	200	5.8	<0.1	<0.1	0.5	0.8	5.1	0.7	3.	0.9	2.5	2.1	0.1
Chrysene		mg/kg	0.1	0 6	0.5	0.5	3.8	0.3	<0.1	0.6	1.	0.9	<0.1	0.1	<0.5	5.2	<0.1	0.5	0.8	1.	<0.1	0.9	0.	1.6	170	.	<0.1	<0.1	0.5	0.6	.1	0.6	2.6	0.7	1.9	1.8	0.1
Benzo(b j)fluoranthene		mg/kg	0.2	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Benzo(k)fluoranthene		mg/kg	0.2	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Benzo(b,j k)fluoranthene		mg/kg	0.2	1	1	1	7.3	0.7	<0.2	1	1	0.9	<0.2	<0.2	<0.5	5.3	<0.2	0.5	0.8	2.7	<0.2	0.9	0.	2	110	.	<0.2	<0.2	<0.5	1		0.6	2.	0.8	2	2	<0.2
Benzo(a)pyrene		mg/kg	0.05	0.7	1	0.76	5.	0.	<0.05	0.85	3.	2.1	<0.05	0.3	<0.5	13	<0.05	1.1	2	1.7	<0.05	2.2	0.96	3.6	28	11	0.1	0.1	<0.5	0.78	11	1.	6.1	1.9	.3		0.2
Indeno(1,2,3-c,d)pyrene		mg/kg	0.1	0.	0.6	0.5	2.7	0.2	<0.1	0.5	0.9	0.6	<0.1	<0.1	<0.5	3.5	<0.1	0.	0.6	1	<0.1	0.6	0.3	1	66	3	<0.1	<0.1	<0.5	0.	2.8	0.	1.6	0.5	1.1	1.1	<0.1
Dibenzo(a,h)anthracene		mg/kg	0.1	<0.1	0.2	<0.1	0.8	<0.1	<0.1	0.1	0.2	0.2	<0.1	<0.1	<0.5	0.9	<0.1	0.1	0.2	0.2	<0.1	0.2	<0.1	0.3	20	0.8	<0.1	<0.1	<0.5	0.1	0.8	<0.1	0.	0.1	0.3	0.3	<0.1
Benzo(g,h,i)perylene		mg/kg	0.1	0 5	0.8	0.6	3.5	0.3	<0.1	0.7	1.3	0.8	<0.1	0.1	<0.5	.9	<0.1	0.5	0.8	1.3	<0.1	0.9	0.	1.5	83	3.9	<0.1	<0.1	<0.5	0.6	.2	0.6	2.1	0.8	1.5	1.6	<0.1
Total vePAHs	,000	mg/kg	0.05	7	7.	7.1	8	3.7	<0.05	8.	18	11	<0.05	1.3	<0.5	76	<0.05	6.2	11	16	<0.05	12	.8	20	1900	57	0.	0.	2.5	8.	50	7.7	36	9.	26	22	0.78
Benzo(a)pyrene TEQ calc (zero)	0	mg/kg	0.5	1	1.5	1	7.7	0.6	<0.5	1.3	.1	2.5	<0.5	<0.5	<0.5	15	<0.5	1.	2.	2.5	<0.5	2.7	1.1	.3	**88**	13	<0.5	<0.5	<0.5	1.2	13	1.6	7.3	2.3	5.2	.9	<0.5
Benzo(a)pyrene TEQ calc(half)	0	mg/kg	0.5	1	1.5	1.1	7.7	0.6	<0.5	1.3	.1	2.5	<0.5	<0.5	0 6	15	<0.5	1.	2.	2.5	<0.5	2.7	1.1	.3	**88**	13	<0.5	<0.5	0.6	1.2	13	1.7	7.3	2.3	5.2	.9	<0.5
Benzo(a)pyrene TEQ calc(PQL)	0	mg/kg	0.5	1.1	1.5	1.1	7.7	0.7	<0.5	1.3	.1	2.5	<0.5	<0.5	1 2	15	<0.5	1.	2.	2.5	<0.5	2.7	1.2	.3	**88**	13	<0.5	<0.5	1.2	1.2	13	1.7	7.3	2.3	5.2	.9	<0.5
Heavy Metals																																					
Arsen c	3,000	mg/kg		<	<		8	<	<	7	12	<	<	<	2 2	13	<	<	<	36	<	5	<		<	5	<	<	3.8	<	6		<	<	<	5	<
Cadmium	900	mg/kg	0.	<0.	<0.	<0.	<0.	0.6	<0.	<0.	<0.	<0.	<0.	<0.	<0.	0.7	<0.	<0.	<0.	<0.	<0.	<0.	<0.	3	0.5	<0.	<0.	<0.	<0.	<0.	<0.	<0.	<0.	0.	<0.	<0.	<0.
Chromium	3,600	mg/kg	1	8	6	9	23	5	11	11	10	10	20	19	13	17	9	7	11	9	12	8	13	15	16	12	18	19	23	6	11	11	6	9	1	10	7
Copper	2 0,000	mg/kg	1	13	3	2	90	12	<1	28	19	20	2	3	<5	79	3	15	32	18	1	11	7	16	69	57		2	<5	18	19	21	11	20	23	23	
Lead	1,500	mg/kg	1	100	19	130	510	53	2	150	160	150	10	17	7.7	530	8	72	200	220	32	6	7	85	1 0	150	5	3	5.3	56	110	110	110	110	110	130	9
Mercury	730	mg/kg	0.1	0.1	<0.1	0.	1.9	0.7	<0.1	1.2	2.3	0.5	<0.1	<0.1	<0.1	0.9	<0.1	0.3	1	0.3	<0.1	<0.1	<0.1	0.5	0 2	0.5	<0.1	<0.1	<0.1	0.2	1	0.2	0.1	0.2	0.2	0.2	<0.1
Nickel	6,000	mg/kg	1	2	2	5	9	3	<1	11	3	3	2	2	<5	10	1	3	3	5	3		2		10		<1	<1	<5	6	3	7	2			3	1
Zinc	00,000	mg/kg	1	59	9	150	200	57	5	150	1 0	8	6	1	6 9	300	21	59	88	62	<1	55		62	1 0	110	8		<5	61	73	97	8	90	82	8	6
Inorganics																																					
Moisture Content		%	0.1	17	8.6	16	18	21	18	30	17	23	9.6	10	11	20	13	23	17	20	17	18	8.8	11	2	27	11	10	11	23	12	31	12	23	12	23	8.2
Asbestos																																					
Sample mass tested		g		Approx. 35g		Approx. 25g		Approx. 35g		Approx. 35g		Approx. 35g				Approx. 35g		Approx. 35g		Approx. 0g		Approx. 35g		Approx. 5g		Approx. 35g				Approx. 35g		Approx. 35g		Approx. 35g		Approx. 35g	
Samp e Descript ion		-		Brown ine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks				Brown fine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained so l & rocks		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained so l & rocks				Brown fine-grained soil & rocks		Brown ine-grained soil & rocks		Brown fine-grained soil & rocks		Brown ine-grained soil & rocks	
Asbestos ID in soil	ND	-		No asbestos detec ed at reporting limit of 0.1g/kg: Organ c fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting lim t of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting imit of 0.1g/kg: Organ c ibres detected				No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting imit of 0.1g/kg: Organ c ibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting lim t of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting imit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting imit of 0.1g/kg: Organic fibres detec ed				No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbes os detected at repor ing limit of 0.1g/kg: Organic fibres de ected		No asbestos detected at reporting imit of 0.1g/kg: Organ c ibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organ c fibres detected	
Trace Analysis	ND	-		No asbestos detected		No asbestos detected		No asbestos detected		No asbestos detected		No asbestos detected				No asbestos detected		No asbestos detected		No asbestos detected		No asbestos detected		No asbestos detected		No asbestos detected				No asbestos detected		No asbes os detec ed		No asbestos detected		No asbestos detected	
Benzene Toluene Ethylbenezene Xylenes																																					
Benzene	3	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Toluene	99,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Xy ene (m & p)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Xy ene (o)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Xy ene (tota)	81,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Ethylbenzene	27,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Total BTEX		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Total Recoverable Hydrocarbons																																					
C6-C10	26,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
C6-C10 (F1 minus BTEX)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
C10-C16	20,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
C10-C16 (F2 minus Naphthalene)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
C16-C3	27,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
C3 -C 0	38,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
C10-C 0 (Sum of tota)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
C10-C1		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
C15-C28		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
C6-C9		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
C29-C36		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
C10-C36 (Sum of tota)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Halogenated Benzenes																																					
Hexachlorobenzene	80	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Organochlorine Pesticides																																					
, -DDE		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
a-BHC		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Aldrin		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Aldrin Dieldrin	5	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
b-BHC		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Chlordane	530	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Chlordane (cis)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Chlordane (trans)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
d-BHC		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
DDD		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
DDT		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
DDT DDE DDD	3,600	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Dieldrin		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Endosulfan	2,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Endosulfan I		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Endosulfan II		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Endosulfan sulphate		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Endrin	100	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Endrin a dehyde		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Endrin ketone		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
g-BHC (Lindane)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Heptachlor	50	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Heptachlor epoxide		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Methoxychlor	2,500	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Organophosphorus Pesticides																																					
Azinophos methyl		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Bromophos-ethyl		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Carbophenothion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Chlorfenvinphos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Chlorpyrifos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Chlorpyrifos-methyl		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Diazinon		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Dichlorvos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Dimethoate		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Ethion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Fenitrothion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Malathion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Methyl parathion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Monocrotophos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Prothiofos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Polychlorinated Biphenyls																																					
PCBs	7	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Pesticides																																					
Demeton-S-methyl		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Fenamiphos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Parathion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Pirimphos-ethyl		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-

Notes

Bold Exceeds human health investigation levels for commercial/industrial land use

Table B: Analytical Results

SMEC 2020

Compounds	Commercial/Industrial	Units	Sample ID	WFU BH07	WFU BH07	WFU BH07	WFU BH075	WFU BH075	WFU BH076	WFU BH076	WFU BH076	WFU BH077	WFU BH077	WFU BH078	WFU BH078	WFU BH078	WFU BH079	WFU BH079	WFU BH079
			Depth (m)	0.0-0.1	0.-0.5	1.0-1.1	0.0-0.1	0.-0.5	0.0-0.1	0.-0.5	1.0-1.1	0.0-0.1	0.-0.5	0.-0.5	2.0-2.1	3.0-3.1	0.0-0.1	0.-0.5	1.0-1.1
			Date	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07 2020	7 07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	8/07/2020	8/07/2020	8/07 2020
		Units	LOR																
Naphthalene	11 000	mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	0.5	0.5
Acenaphthylene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	0.5	0.5
Acenaphthene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	0.5	0.5
Fluorene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	0.5	0.5
Phenanthrene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	1.2	1.2	2.3	0.5	1.1	0.5	0.5	0.5
Anthracene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.9	0.5	0.5	0.5	0.5	0.5
Fluoranthene		mg/kg	0.1	<0.5	<0.5	<0.5	0.9	0.5	<0.5	<0.5	<0.5	2.2	3.6	7	0.5	1.9	0.5	0.6	0.5
Pyrene		mg/kg	0.1	<0.5	<0.5	<0.5	0.9	0.5	0.5	<0.5	<0.5	2.1	3.6	7.6	0.5	2	0.5	0.6	0.5
Benzo(a)anthracene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	1	1.8	3.9	0.5	0.8	0.5	0.5	0.5
Chrysene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.8	1.6	2	0.5	0.7	0.5	0.5	0.5
Benzo(b j)fluoranthene		mg/kg	0.2	<0.5	<0.5	<0.5	0.6	0.5	<0.5	<0.5	<0.5	1.2	2.	8	0.5	0.7	0.5	0.5	0.5
Benzo(k)fluoranthene		mg/kg	0.2	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.6	1	2.1	0.5	0.5	0.5	0.5	0.5
Benzo(b,j k)fluoranthene		mg/kg	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene		mg/kg	0.05	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	1	1.9	3.9	0.5	0.6	0.5	0.5	0.5
Indeno(1,2,3-c,d)pyrene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.6	1	2.3	0.5	0.5	0.5	0.5	0.5
Dibenzo(a,h)anthracene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7	0.5	0.5	0.5	0.5	0.5
Benzo(g,h,)perylene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.7	1.3	2.9	0.5	0.5	0.5	0.5	0.5
To al vePAHs	,000	mg/kg	0.05	<0.5	<0.5	<0.5	2.	0.5	0.5	<0.5	<0.5	11.	19.9	3.1	0.5	7.8	0.5	1.2	0.5
Benzo(a)pyrene TEQ calc (zero)	0	mg/kg	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	1.	2.5	6	0.5	0.8	0.5	0.5	0.5
Benzo(a)pyrene TEQ calc(half)	0	mg/kg	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1.6	2.8	6	0.6	1	0.6	0.6	0.6
Benzo(a)pyrene TEQ calc(PQL)	0	mg/kg	0.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.8	3	6	1.2	1.	1.2	1.2	1.2
Arsenic	3,000	mg/kg		<5	6	<5	<5	6	6	5	5	6	11	<5	<5	<5	<5	6	5
Cadmium	900	mg/kg	0.	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium	3,600	mg/kg	1	6	8	6	11	8	11	9	12	10	10	8	3	7	6	7	6
Copper	2 0,000	mg/kg	1	9	1	<5	33	5	18	5	5	26	26	80	<5	<5	13	6	5
Lead	1,500	mg/kg	1	35	39	<5	153	16	69	5	13	170	171	72	8	12	79	32	5
Mercury	730	mg/kg	0.1	<0.1	0.2	<0.1	0.5	0.1	0.2	<0.1	<0.1	0.5	0.7	0.1	0.1	0.1	0.2	0.1	0.1
Nickel	6,000	mg/kg	1	2		<2	6	2		2	2	5	5		<2	<2	2	2	2
Zinc	00,000	mg/kg	1	32	0	<5	93	9	170	5	5	115	108		<5	8	66	7	5
Moisture Content		%	0.1	10.	13	10.3	6.3	.9	32.8	16.2	13.7	21	15.1	10.9	12.3	9.3	28.7	17.	17.5
Sample mass tested		g																	
Sample Description		-																	
Asbestos ID in soil	ND	-		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trace Analysis	ND	-		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	3	mg/kg		<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	0.5	0.5
Toluene	99 000	mg/kg		<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	0.5	0.5
Xylene (m & p)		mg/kg		<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	0.5	0.5
Xylene (o)		mg/kg		<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	0.5	0.5
Xylene (total)	81 000	mg/kg		<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	0.5	0.5
Ethylbenzene	27 000	mg/kg		<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total BTEX		mg/kg		<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	0.5	0.5
C6-C10	26 000	mg/kg		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C6-C10 (F1 minus BTEX)		mg/kg		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C10-C16	20 000	mg/kg		<50	<50	<50	<50	<50	50	50	50	50	<50	<50	<50	<50	<50	<50	<50
C10-C16 (F2 minus Naphthalene)		mg/kg		<50	<50	<50	<50	<50	50	50	50	50	<50	<50	<50	<50	<50	<50	<50
C16-C3	27 000	mg/kg		<100	<100	<100	180	<100	<100	<100	<100	<100	160	3 0	<100	<100	<100	<100	<100
C3 -C 0	38 000	mg/kg		<100	<100	<100	130	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C10-C 0 (Sum of total)		mg/kg		<50	<50	<50	310	<50	50	50	50	50	160	3 0	<50	<50	<50	<50	<50
C10-C1		mg/kg		<50	<50	<50	<50	<50	50	50	50	50	<50	<50	<50	<50	<50	<50	<50
C15-C28		mg/kg		<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	220	<100	<100	<100	<100	<100
C6-C9		mg/kg		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C29-C36		mg/kg		<100	<100	<100	150	<100	<100	<100	<100	<100	<100	170	<100	<100	<100	<100	<100
C10-C36 (Sum of total)		mg/kg		<50	<50	<50	150	<50	50	50	50	50	<50	390	<50	<50	<50	<50	<50
Hexachlorobenzene	60	mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05
, -DDE		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05
a-BHC		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05
Aldrin		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05
Aldrin Dieldrin	5	mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05
b-BHC		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05
Chlordane	530	mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05
Chlordane (cis)		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05
Chlordane (trans)		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05
d-BHC		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05
DDD		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05
DDT		mg/kg		<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.2	0.2	0.2	0.2	0.2
DDT DDE DDD	3,600	mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Dieldrin		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Endosulfan	2,000	mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Endosulfan I		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Endosulfan II		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Endosulfan sulphate		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Endrin	100	mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Endrin aldehyde		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Endrin ketone		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
g-BHC (Lindane)		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Heptachlor	50	mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Heptachlor epoxide		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Methoxychlor	2,500	mg/kg		<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.2	0.2	0.2	0.2	0.2
Azinophos methyl		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Bromophos-ethyl		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Carbophenothion		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Chlorfenvinphos		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Chlorpyrifos		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Chlorpyrifos-methyl		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05
Diazinon		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05
Dichlorvos		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05
Dimethoate		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05
Ethion		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05
Fenthion		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05
Malathion		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05
Methyl parathion		mg/kg		<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.2	0.2	0.2	0.2	0.2
Monocrotophos		mg/kg		<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.2	0.2	0.2	0.2	0.2
Prothiofos		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05
PCBs	7	mg/kg		<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1	0.1	<0.1
Demeton-S-methyl		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05
Fenamiphos		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05
Parathion		mg/kg		<0.2	<0.2	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.2	0.2	0.2	0.2	<0.2
Pirimphos-ethyl		mg/kg		<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05

Compounds	WFU BH080	WFU BH080	WFU BH080	WFU BH081	WFU BH081	WFU BH082	WFU BH082	WFU BH082	WFU BH083	WFU BH083	WFU BH083	WFU BH086	WFU BH086	WFU BH086	WFU BH089	WFU BH089	WFU BH089	WFU BH099	WFU BH099	WFU BH099	WFU BH100	WFU BH100	WFU BH100	WFU BH108	WFU BH108	WFU BH108
Depth (m)	0.-0.5	1.0 1.1	2.0-2.1	0.0-0.05	0.35-0.	0.0-0.1	0.-0.5	1.2-1.	0.0-0.1	0.-0.5	1.0-1.1	0.0-0.1	0.-0.5	1.0-1.1	0.0-0.1	1.0-1.1	2.0-2.1	0.0-0.1	1.0-1.1	2.0-2.1	0.0-0.1	1.0-1.1	3.85-3.86	0.0-0.1	0.-0.5	2.8-2.9
Date	7/07/2020	7/07/2020	7/07/2020	30 07 2020	30/07/2020	9 07 2020	9/07/2020	9 07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6 07 2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	9/07/2020	9/07/2020	9/07/2020	28/07/2020	28/07/2020	28/07/2020
		Polycyclic Aromatic Hydrocarbons																								
Naphthalene	0.5	<0.5	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.8	0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5
Acenaphthylene	0.5	1.2	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.9	0.5	<0.5	<0.5	<0.5	<0.5	7.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	1.3	<0.5	<0.5	0.5
Acenaphthene	0.5	<0.5	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5
Fluorene	0.5	<0.5	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	1.1	<0.5	<0.5	<0.5
Phenanthrene	2	6.7	0.5	0.5	<0.5	0.7	0.7	<0.5	0.9	5	0.5	<0.5	<0.5	<0.5	<0.5	23.1	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	17.3	0.7	1.7	0.5
Anthracene	0.5	1.	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	1.2	0.5	<0.5	<0.5	<0.5	<0.5	7.1	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	.1	<0.5	0.6	0.5
Fluoranthene	3	6.8	0.5	0.8	1.1	2	1.9	<0.5	2	10.	0.5	0.8	<0.5	<0.5	1.	50.1	<0.5	0.8	<0.5	<0.5	<0.5	0.5	21.0	1.7	.	0.5
Pyrene	2	5.9	0.5	0.8	1.1	2	1.8	<0.5	2	9.1	0.5	0.9	<0.5	<0.5	1.	6.2	<0.5	0.8	<0.5	<0.5	<0.5	0.5	16.	1.7	3	0.5
Benzo(a)anthracene	1.7	2.	0.5	0.5	0.5	1	1	<0.5	0.9	.	0.5	<0.5	<0.5	<0.5	0.7	23.6	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	7	0.8	1.9	<0.5
Chrysene	1.7	2.3	0.5	0.5	<0.5	0.9	0.9	<0.5	0.9		0.5	<0.5	<0.5	<0.5	0.6	20.8	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	6.6	0.7	1.8	0.5
Benzo(b j)fluoranthene	2.1	2.8	0.5	0.5	0.7	1.5	1.	<0.5	1.1	5.3	0.5	0.6	<0.5	<0.5	1.2	29.7	<0.5	0.5	0.5	<0.5	<0.5	<0.5	6.3	0.9	2.7	<0.5
Benzo(k)fluoranthene	1.1	1.2	0.5	0.5	<0.5	0.6	<0.5	<0.5	<0.5	2.6	0.5	<0.5	<0.5	<0.5	<0.5	10.	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	2.6	<0.5	1.0	0.5
Benzo(b,j k)fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.8	2.1	0.5	0.5	0.6	1.2	1.1	<0.5	0.9	3	0.5	<0.5	<0.5	<0.5	0.9	25.2	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	5.9	0.7	2.5	<0.5
Indeno(1,2,3-c,d)pyrene	1.2	1.3	0.5	0.5	<0.5	0.8	0.6	<0.5	0.5	2.6	0.5	<0.5	<0.5	<0.5	0.6	1 6	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	2.	<0.5	1.3	<0.5
Dibenzo(a,h)anthracene	0.5	<0.5	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	3.	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5
Benzo(g,h,)perylene	1.6	1.6	0.5	0.5	<0.5	1	0.8	<0.5	0.7	3.1	0.5	<0.5	<0.5	<0.5	0.7	17.3	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	3.1	0.6	1.6	<0.5
To al vePAHs	21.7	35.7	0.5	1.6		11.7	10.2	<0.5	9.9	53.7	0.5	2.3	<0.5	<0.5	7.5	282	<0.5	2.1	0.5	<0.5	<0.5	<0.5	97.6	7.8	23.8	<0.5
Benzo(a)pyrene TEQ calc (zero)	2.	2.9	0.5	0.5	0.7	1.8	1.	<0.5	1.2	5.9	0.5	<0.5	<0.5	<0.5	1.2	36.8	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	8.3	0.9	3.2	0.5
Benzo(a)pyrene TEQ calc(half)	2.7	3.2	0.6	0.6	1	1.8	1.7	0.6	1.	6.1	0.6	0.6	0.6	0.6	1.	36.8	0.6	0.6	0.6	0.6	0.6	0.6	8.3	1.2	3.5	0.6
Benzo(a)pyrene TEQ calc(PQL)	2.9	3.	1.2	1.2	1.3	2.1	2	1.2	1.7	6.	1.2	1.2	1.2	1.2	1.7	36.8	1.2	1.2	1.2	1.2	1.2	1.2	8.3	1.5	3.7	1.2
		Heavy Metals																								
Arsenic	<5	<5	<5	<5	5	5	<5	5	<5	7	<5	11	<5	<5	<5	7	<5	6	6	<5	5	6	10	5	<5	<5
Cadmium	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	3	<1	<1	<1	<1	<1
Chromium	10	9	2	11	10	8	8	2	8	1	8	8	8	3	5	16	16	12	10	13		7	11	9	10	5
Copper	71	0	<5	18	20	37	51	5	16	125	9	17	<5	<5	1	171	<5	25	<5	<5	13	<5	56	1	19	<5
Lead	293	216	6	163	81	1 3	117	5	7	697	30	73	<5	<5	89	222	8	128	22	36	67		66	83	15	<5
Mercury	0.7	1.5	0.1	0.1	0.2	0.	0.	<0.1	0.1	1.6	0.1	0.2	<0.1	<0.1	0.1	0.7	<0.1	0.1	0.1	<0.1	0.5	<0.1	0.1	0.2	3	<0.1
Nickel	5	3	<2	7	12	6	3	2	<2		<2	2	<2	<2	<2	8	<2	10	<2	<2	2	<2	<2	7	3	<2
Zinc	1	115	6	78	287	16	198	5	61	318	53	9	<5	<5	56	533	5	129	1	15	5	9	66	97	105	<5
		Inorganics																								
Moisture Content	13.6	13.3	12.8	16.6	13.1	26.5	11.8	23.3	12	11.2	12.6	18.3	10.8	12.7	1 .6	13.8	15.6	35	7.5	10.2	28.3	16.3	16.	25.3	10	25.6
		Asbestos																								
Sample mass tested																										
Sample Description																										
Asbestos ID in soil	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trace Analysis	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		Benzene Toluene Ethylbenzene Xylenes																								
Benzene	0.5	<0.5	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5
Toluene	0.5	<0.5	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5
Xylene (m & p)	0.5	<0.5	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5
Xylene (o)	0.5	<0.5	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5
Xylene (total)	0.5	<0.5	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5
Ethylbenzene	0.5	<0.5	0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5
Total BTEX	0.5	<0.5	0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5
		Total Recoverable Hydrocarbons																								
C6-C10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C6-C10 (F1 minus BTEX)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C10-C16	<50	50	<50	<50	50	<50	<50	50	<50	50	<50	<50	<50	<50	<50	<50	<50	50	<50	50	50	<50	<50	<50	50	<50
C10-C16 (F2 minus Naphthalene)	<50	50	<50	<50	50	<50	<50	50	<50	50	<50	<50	<50	<50	<50	<50	<50	50	<50	50	50	<50	<50	<50	50	<50
C16-C3	100	210	<100	<100	<100	180	120	<100	<100	300	<100	<100	<100	<100	130	1200	<100	<100	<100	<100	<100	<100	00	<100	1 0	<100
C3 -C 0	<100	<100	<100	<100	<100	120	<100	<100	<100	110	<100	<100	<100	<100	<100	0	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C10-C 0 (Sum of total)	100	210	<50	<50	50	300	120	50	<50	10	<50	<50	<50	<50	130	16 0	<50	50	<50	50	50	<50	00	<50	1 0	<50
C10-C1	<50	50	<50	<50	50	<50	<50	50	<50	50	<50	<50	<50	<50	<50	<50	<50	50	<50	50	50	<50	<50	<50	50	<50
C15-C28	<100	150	<100	<100	<100	<100	<100	<100	<100	190	<100	<100	<100	<100	<100	750	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C6-C9	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C29-C36	<100	100	<100	<100	<100	130	<100	<100	<100	180	<100	<100	<100	<100	<100	660	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C10-C36 (Sum of total)	<50	250	<50	<50	50	130	<50	50	<50	370	<50	<50	<50	<50	<50	1 10	<50	50	<50	50	50	<50	<50	<50	50	<50
		Halogenated Benzenes																								
Hexachlorobenzene	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
		Organochlorine Pesticides																								
, -DDE	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
a-BHC	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Aldrin	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Aldrin Dieldrin	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.37	<0.05
b-BHC	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Chlordane	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Chlordane (cis)	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Chlordane (trans)	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
d-BHC	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
DDD	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
DDT	0.2	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2
DDT DDE DDD	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Dieldrin	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.37	<0.05
Endosulfan	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Endosulfan I	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Endosulfan II	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Endosulfan sulphate	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Endrin	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Endrin aldehyde	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Endrin ketone	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
g-BHC (Lindane)	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Heptachlor	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Heptachlor epoxide	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Methoxychlor	0.2	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2
		Organophosphorus Pesticides																								
Azinophos methyl	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Bromophos-ethyl	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Carbophenothion	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Chlorfenvinphos	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Chlorpyrifos	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Chlorpyrifos-methyl	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Diazinon	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Dichlorvos	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Dimethoate	<0.05	<0.05	0.05	<0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Ethion	<0.05	<0.05	0.05	0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Fenthion	<0.05	<0.05	0.05	0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Malathion	<0.05	<0.05	0.05	0.05	0.05	0.05	<0.05	0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Methyl parathion	0.2	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2
Monocrotophos	0.2	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2
Prothiofos	<0.05	<0.05	0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
		Polychlorinated Biphenyls																								
PCBs	0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1
		Pesticides																								
Demeton-S-methyl	<0.05	<0.05	0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Fenamiphos	<0.05	<0.05	0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05
Parathion	0.2	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2
Pirimphos-ethyl	<0.05	<0.05	0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05

Notes

Bold — Exceeds human health investigation levels for commercial/industrial land use

Appendix B – Laboratory certificates

Envirolab Services Pty Ltd
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CERTIFICATE OF ANALYSIS 267823-A

Client Details

Client	Jacobs Group (Australia) Pty Ltd
Attention	Amanda Mullen
Address	Level 7, 177 Pacific Highway, North Sydney, NSW, 2060

Sample Details

Your Reference	**IA216715**
Number of Samples	11 Soils
Date samples received	28/04/2021
Date completed instructions received	28/04/2021

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	29/04/2021
Date of Issue	29/04/2021

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Asbestos Approved By
Analysed by Asbestos Approved Identifier: Ridwan Wijaya
Authorised by Asbestos Approved Signatory: Lucy Zhu

Results Approved By
Dragana Tomas, Senior Chemist
Hannah Nguyen, Senior Chemist
Lucy Zhu, Asbestos Supervisor

Authorised By

Nancy Zhang, Laboratory Manager

PAHs in Soil						
Our Reference		267823-A-21	267823-A-23	267823-A-24	267823-A-27	267823-A-28
Your Reference	UNITS	BH06_A_CGC	BH06_C_CGC	BH07_A_CGC	BH07_D_CGC	BH08_A_CGC
Depth		0.0	0.5	0.0	1.0	0.0
Date Sampled		28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Date analysed	-	28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	0.1	0.2	0.2	1.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	0.4	0.2	0.4	2.5	0.1
Anthracene	mg/kg	0.2	0.1	0.1	0.8	<0.1
Fluoranthene	mg/kg	1.1	0.8	1.0	7.0	0.6
Pyrene	mg/kg	1.2	0.9	1.1	7.4	0.6
Benzo(a)anthracene	mg/kg	0.7	0.7	0.7	5.3	0.4
Chrysene	mg/kg	0.6	0.5	0.5	3.8	0.3
Benzo(b,j+k)fluoranthene	mg/kg	1	1	1	7.3	0.7
Benzo(a)pyrene	mg/kg	0.74	1.0	0.76	5.4	0.4
Indeno(1,2,3-c,d)pyrene	mg/kg	0.4	0.6	0.5	2.7	0.2
Dibenzo(a,h)anthracene	mg/kg	<0.1	0.2	<0.1	0.8	<0.1
Benzo(g,h,i)perylene	mg/kg	0.5	0.8	0.6	3.5	0.3
Total +ve PAH's	mg/kg	7.0	7.4	7.1	48	3.7
Benzo(a)pyrene TEQ calc (zero)	mg/kg	1	1.5	1.0	7.7	0.6
Benzo(a)pyrene TEQ calc(half)	mg/kg	1.0	1.5	1.1	7.7	0.6
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	1.1	1.5	1.1	7.7	0.7
Surrogate p-Terphenyl-d14	%	119	122	118	114	120

PAHs in Soil		
Our Reference		267823-A-31
Your Reference	UNITS	BH08_D_CGC
Depth		1.0
Date Sampled		28/04/2021
Type of sample		Soil
Date extracted	-	28/04/2021
Date analysed	-	28/04/2021
Naphthalene	mg/kg	<0.1
Acenaphthylene	mg/kg	<0.1
Acenaphthene	mg/kg	<0.1
Fluorene	mg/kg	<0.1
Phenanthrene	mg/kg	<0.1
Anthracene	mg/kg	<0.1
Fluoranthene	mg/kg	<0.1
Pyrene	mg/kg	<0.1
Benzo(a)anthracene	mg/kg	<0.1
Chrysene	mg/kg	<0.1
Benzo(b,j+k)fluoranthene	mg/kg	<0.2
Benzo(a)pyrene	mg/kg	<0.05
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1
Total +ve PAH's	mg/kg	<0.05
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5
Surrogate p-Terphenyl-d14	%	116

Acid Extractable metals in soil						
Our Reference		267823-A-21	267823-A-23	267823-A-24	267823-A-27	267823-A-28
Your Reference	UNITS	BH06_A_CGC	BH06_C_CGC	BH07_A_CGC	BH07_D_CGC	BH08_A_CGC
Depth		0.0	0.5	0.0	1.0	0.0
Date Sampled		28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	29/04/2021	29/04/2021	29/04/2021	29/04/2021	29/04/2021
Date analysed	-	29/04/2021	29/04/2021	29/04/2021	29/04/2021	29/04/2021
Arsenic	mg/kg	<4	<4	4	8	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	0.6
Chromium	mg/kg	8	6	9	23	5
Copper	mg/kg	13	3	24	90	12
Lead	mg/kg	100	19	130	510	53
Mercury	mg/kg	0.1	<0.1	0.4	1.9	0.7
Nickel	mg/kg	2	2	5	9	3
Zinc	mg/kg	59	9	150	200	57

Acid Extractable metals in soil		
Our Reference		267823-A-31
Your Reference	UNITS	BH08_D_CGC
Depth		1.0
Date Sampled		28/04/2021
Type of sample		Soil
Date prepared	-	29/04/2021
Date analysed	-	29/04/2021
Arsenic	mg/kg	<4
Cadmium	mg/kg	<0.4
Chromium	mg/kg	11
Copper	mg/kg	<1
Lead	mg/kg	2
Mercury	mg/kg	<0.1
Nickel	mg/kg	<1
Zinc	mg/kg	5

Moisture						
Our Reference		267823-A-21	267823-A-23	267823-A-24	267823-A-27	267823-A-28
Your Reference	UNITS	BH06_A_CGC	BH06_C_CGC	BH07_A_CGC	BH07_D_CGC	BH08_A_CGC
Depth		0.0	0.5	0.0	1.0	0.0
Date Sampled		28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Date analysed	-	29/04/2021	29/04/2021	29/04/2021	29/04/2021	29/04/2021
Moisture	%	17	8.6	16	18	21

Moisture		
Our Reference		267823-A-31
Your Reference	UNITS	BH08_D_CGC
Depth		1.0
Date Sampled		28/04/2021
Type of sample		Soil
Date prepared	-	28/04/2021
Date analysed	-	29/04/2021
Moisture	%	18

Asbestos ID - soils				
Our Reference		267823-A-21	267823-A-24	267823-A-28
Your Reference	UNITS	BH06_A_CGC	BH07_A_CGC	BH08_A_CGC
Depth		0.0	0.0	0.0
Date Sampled		28/04/2021	28/04/2021	28/04/2021
Type of sample		Soil	Soil	Soil
Date analysed	-	29/04/2021	29/04/2021	29/04/2021
Sample mass tested	g	Approx. 35g	Approx. 25g	Approx. 35g
Sample Description	-	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks
Asbestos ID in soil	-	No asbestos detected at repor ing limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected
Trace Analysis	-	No asbestos detected	No asbestos detected	No asbestos detected

Method ID	Methodology Summary
ASB-001	Asbestos ID - Qualitative identification of asbestos in bulk samples using Polarised Light Microscopy and Dispersion Staining Techniques including Synthetic Mineral Fibre and Organic Fibre as per Australian Standard 4964-2004.
Inorg-008	Moisture content determined by heating at 105+/-5 °C for a minimum of 12 hours.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS and/or GC-MS/MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. For soil results:- 1. 'EQ PQL'values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'EQ zero'values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more suscept ble to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'EQ half PQL'values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, the Total +ve PAHs PQL is reflective of the lowest individual PQL and is therefore "Total +ve PAHs" is simply a sum of the positive individual PAHs.

QUALITY CONTROL: PAHs in Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-8	[NT]
Date extracted	-			28/04/2021	[NT]	[NT]	[NT]	[NT]	28/04/2021	[NT]
Date analysed	-			28/04/2021	[NT]	[NT]	[NT]	[NT]	28/04/2021	[NT]
Naphthalene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	108	[NT]
Acenaphthylene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Acenaphthene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	79	[NT]
Fluorene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	84	[NT]
Phenanthrene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Anthracene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluoranthene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	91	[NT]
Pyrene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	93	[NT]
Benzo(a)anthracene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chrysene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	67	[NT]
Benzo(b,j+k)fluoranthene	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(a)pyrene	mg/kg	0.05	Org-022/025	<0.05	[NT]	[NT]	[NT]	[NT]	88	[NT]
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	124	[NT]	[NT]	[NT]	[NT]	128	[NT]

QUALITY CONTROL: Acid Extractable metals in soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-8	[NT]
Date prepared	-			29/04/2021	[NT]	[NT]	[NT]	[NT]	29/04/2021	[NT]
Date analysed	-			29/04/2021	[NT]	[NT]	[NT]	[NT]	29/04/2021	[NT]
Arsenic	mg/kg	4	Metals-020	<4	[NT]	[NT]	[NT]	[NT]	105	[NT]
Cadmium	mg/kg	0.4	Metals-020	<0.4	[NT]	[NT]	[NT]	[NT]	96	[NT]
Chromium	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	98	[NT]
Copper	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Lead	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	96	[NT]
Mercury	mg/kg	0.1	Metals-021	<0.1	[NT]	[NT]	[NT]	[NT]	107	[NT]
Nickel	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	98	[NT]
Zinc	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	96	[NT]

Result Definitions	
NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Asbestos: A portion of the supplied sample was sub-sampled for asbestos analysis according to Envirolab procedures.
We cannot guarantee that this sub-sample is indicative of the entire sample. Envirolab recommends supplying 40-50g of sample in its own container.
Note: Samples were sub-sampled from jars provided by the client.

Envirolab Services Pty Ltd
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www.envirolab.com.au

SAMPLE RECEIPT ADVICE

Client Details	
Client	Jacobs Group (Australia) Pty Ltd
Attention	Amanda Mullen

Sample Login Details	
Your reference	IA216715
Envirolab Reference	267823-A
Date Sample Received	28/04/2021
Date Instructions Received	28/04/2021
Date Results Expected to be Reported	29/04/2021

Sample Condition	
Samples received in appropriate condition for analysis	Yes
No. of Samples Provided	11 Soils
Turnaround Time Requested	1 day
Temperature on Receipt (°C)	8
Cooling Method	Ice Pack
Sampling Date Provided	YES

Comments
Nil

Please direct any queries to:

Aileen Hie	Jacinta Hurst
Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Analysis Underway, details on the following page:

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Sample ID	PAHs in Soil	Acid Extractable metalsin soil	Asbestos ID - soils	On Hold
BH01_A-0.0				✓
BH01_B-0.25				✓
BH01_C-0.5				✓
BH01_D-0.8				✓
BH02_A-0.0				✓
BH02_B-0.25				✓
BH02_C-0.5				✓
QAQC1				✓
QAQC2				✓
BH03_A-0.0				✓
BH03_B-0.25				✓
BH03_C-0.5				✓
BH03_D-1.0				✓
BH04_A-0.0				✓
BH04_B-0.25				✓
BH04_C-0.5				✓
BH04_D-0.9				✓
BH05_A-0.0				✓
BH05_B-0.25				✓
BH05_C-0.5				✓
BH06_A_CGC-0.0	✓	✓	✓	
BH06_B_CGC-0.25				✓
BH06_C_CGC-0.5	✓	✓		
BH07_A_CGC-0.0	✓	✓	✓	
BH07_B_CGC-0.25				✓
BH07_C_CGC-0.5				✓
BH07_D_CGC-1.0	✓	✓		
BH08_A_CGC-0.0	✓	✓	✓	
BH08_B_CGC-0.25				✓
BH08_C_CGC-0.5				✓
BH08_D_CGC-1.0	✓	✓		

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

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Additional Info
Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt.
Requests for longer term sample storage must be received in writing.
Please contact the laboratory immediately if observed settled sediment present in water samples is to be included in the extraction and/or analysis (exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS analysis where solids are included by default.
TAT for Micro is dependent on incubation. This varies from 3 to 6 days.

CHAIN OF CUSTODY FORM - Client

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08 9317 2505 | lab@mpl.com.au

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Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	A. MULLEN
Project Mgr:	R. WAUGH
Sampler:	A.MULLEN / N. KEATEY
Address:	
Phone:	Mob: 0418412330
Email Results to:	amanda.mullen@jacobs.com; michael.stacey@jacobs.com
Email Invoice to:	A. MULLEN

Client Project Name/Number/Site etc (ie report title):	IA216715
PO No. (if applicable):	–
Envirolab Quote No. :	–
Date results required: Or choose:	~~Standard~~ ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply	
Additional report format:	☐ Esdat ☐ Equis
Lab Comments:	

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals 8	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
1	BH01_A	0.0	28/4/21	SOIL	X	X	X		
2	BH01-B	0.25	↓	↓				X	please note
3	BH01-C	0.5			~~X~~	~~X~~		X	24hr TAT.
4	BH01_D	0.8			X	X			
5	BH02_A	0.0						X	
6	BH02_B	0.25			X	X	X		
7	BH02_C	0.5			X	X			
8	~~BH02~~ QAQC1				X	X			
9	QAQC 2				X	X			Please send
10	BH03_A	0.0			X	X	X		QAQC 2 to
11	BH03_B	0.25	↓	↓				X	Eurofins.

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis* 24HR TAT

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD.	**Lab Use Only**
Print Name: A. MULLEN	Print Name: Christine	Job number: 267823. Cooling: Ice / Ice pack / None
Date & Time: 28/4/21 5.10pm	Date & Time: 28/04/21 1720	Temperature: 8°C Security seal: Intact / Broken / None
Signature:	Signature:	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD

CH 28/04/21 # 267823 1/3

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CHAIN OF CUSTODY FORM - Client

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Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	A. MULLEN
Project Mgr:	R. WAUGH
Sampler:	A. MULLEN / N. KEATLEY
Address:	
Phone:	Mob: 0418412330
Email Results to:	amanda.mullen@jacobs.com michael.stacey@jacobs.com
Email Invoice to:	A. MULLEN

Client Project Name/Number/Site etc (ie report title):	IA216715
PO No. (if applicable):	—
Envirolab Quote No. :	—
Date results required:	
Or choose:	Standard ☐ Same Day ☐ 1 day ☒ 2 day ☐ 3 day ☐

Note: Inform lab in advance if urgent turnaround is required - surcharges apply

Additional report format: ☐ Esdat ☐ Equis

Lab Comments:

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals 8	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
12	BH03_C	0.5	28/4/21	SOIL				X	
13	BH03-D	1.0			X	X			
14	BH04-A	0.0						X	
15	BH04-B	0.25			X	X	X		
16	BH04-C	0.5						X	
17	BH04-D	0.95			X	X			
18	BH05-A	0.0			X	X	X		
19	BH05-B	0.25						X	
20	BH05-C	0.5			X	X			
21	BH06_A_CQC	0.0			X	X	X		
22	BH06_B_CQC	0.25						X	

☐ ***Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis***

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD	*Lab Use Only*	
Print Name: A. MULLEN	Print Name: Christine.	Job number: 267823	Cooling: Ice / Ice pack / None
Date & Time: 28/4/21 5.10pm	Date & Time: 28/04/21 1720	Temperature: 8°C	Security seal: Intact / Broken / None
Signature:	Signature:	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

CH 28/04/21 # 267823 2/3

CHAIN OF CUSTODY FORM - Client

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Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	A. MULLEN
Project Mgr:	R. WAUGH
Sampler:	A. MULLEN / N. KEATEY
Address:	
Phone:	Mob:
Email Results to:	amanda.mullen@jacobs.com michael.stacey@jacobs.com
Email Invoice to:	

Client Project Name/Number/Site etc (ie report title): IA216715

PO No. (if applicable): —

Envirolab Quote No. : —

Date results required:

Or choose: ☐ Standard ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day

Note: Inform lab in advance if urgent turnaround is required - surcharges apply

Additional report format: ☐ Esdat ☐ Equis

Lab Comments:

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals 8	PAH	Asbestos (p/a)	ON HOLD	Comments: Provide as much information about the sample as you can
23	BH06_C_CGC	0.5	28/4/21	SOIL	X	X			
24	BH07_A_CGC	0.0	↓	↓	X	X	X		
25	BH07_B_CGC	0.25						X	
26	BH07_C_CGC	0.5						X	
27	BH07_D_CGC	1.0			X	X			
28	BH08_A_CGC	0.0			X	X	X		
29	BH08_B_CGC	0.25						X	
30	BH08_C_CGC	0.5						X	
31	BH08_D_CGC	1.0			X	X			

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD	*Lab Use Only*
Print Name: A. MULLEN	Print Name: Christine.	Job number: 267823 / Cooling: Ice / Ice pack / None
Date & Time: 28/4/21 5.10pm	Date & Time: 28/04/21 1720.	Temperature: 8°C / Security seal: Intact / Broken / None
Signature:	Signature:	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD

3/3

CH 28/04/21 #267823

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CERTIFICATE OF ANALYSIS 268815

Client Details

Client	Jacobs Group (Australia) Pty Ltd
Attention	Michael Stacey
Address	Level 7, 177 Pacific Highway, North Sydney, NSW, 2060

Sample Details

Your Reference	**IA216715**
Number of Samples	48 Soil
Date samples received	12/05/2021
Date completed instructions received	12/05/2021

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	13/05/2021
Date of Issue	13/05/2021

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Asbestos Approved By
Analysed by Asbestos Approved Identifier: Nyovan Moonean
Authorised by Asbestos Approved Signatory: Lucy Zhu

Results Approved By
Dragana Tomas, Senior Chemist
Giovanni Agosti, Group Technical Manager
Lucy Zhu, Asbestos Supervisor
Manju Dewendrage, Chemist

Authorised By

Nancy Zhang, Laboratory Manager

PAHs in Soil						
Our Reference		268815-1	268815-2	268815-4	268815-6	268815-8
Your Reference	UNITS	BH10_A_CGC	BH10_B_CGC	BH09_A_CGC	BH09_C_CGC	DUP C
Depth		0.0	0.25	0.0	0.5	-
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	0.4	0.4	0.2	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	0.4	1.4	0.7	<0.1	0.1
Anthracene	mg/kg	0.2	0.5	0.2	<0.1	<0.1
Fluoranthene	mg/kg	1.3	3.0	2.0	<0.1	0.3
Pyrene	mg/kg	1.2	2.6	1.7	<0.1	0.2
Benzo(a)anthracene	mg/kg	0.8	1.7	1.1	<0.1	0.1
Chrysene	mg/kg	0.6	1.4	0.9	<0.1	0.1
Benzo(b,j+k)fluoranthene	mg/kg	1	1	0.9	<0.2	<0.2
Benzo(a)pyrene	mg/kg	0.85	3.4	2.1	<0.05	0.3
Indeno(1,2,3-c,d)pyrene	mg/kg	0.5	0.9	0.6	<0.1	<0.1
Dibenzo(a,h)anthracene	mg/kg	0.1	0.2	0.2	<0.1	<0.1
Benzo(g,h,i)perylene	mg/kg	0.7	1.3	0.8	<0.1	0.1
Total +ve PAH's	mg/kg	8.4	18	11	<0.05	1.3
Benzo(a)pyrene TEQ calc (zero)	mg/kg	1.3	4.1	2.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	1.3	4.1	2.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	1.3	4.1	2.5	<0.5	<0.5
Surrogate p-Terphenyl-d14	%	119	106	108	111	110

PAHs in Soil						
Our Reference		268815-10	268815-12	268815-13	268815-14	268815-17
Your Reference	UNITS	BH11_B_CGC	BH11_D_CGC	BH12_A_CGC	BH12_B_CGC	BH13_A_CGC
Depth		0.25	1.0	0.0	0.25	0.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Naphthalene	mg/kg	0.3	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	1.5	<0.1	0.1	0.2	0.4
Acenaphthene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	0.4	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	5.4	<0.1	0.3	0.7	0.6
Anthracene	mg/kg	5.8	<0.1	0.1	0.3	0.3
Fluoranthene	mg/kg	13	<0.1	1.0	1.9	2.3
Pyrene	mg/kg	11	<0.1	0.9	1.6	2.3
Benzo(a)anthracene	mg/kg	6.6	<0.1	0.5	1.0	1.6
Chrysene	mg/kg	5.2	<0.1	0.5	0.8	1.4
Benzo(b,j+k)fluoranthene	mg/kg	5.3	<0.2	0.5	0.8	2.7
Benzo(a)pyrene	mg/kg	13	<0.05	1.1	2.0	1.7
Indeno(1,2,3-c,d)pyrene	mg/kg	3.5	<0.1	0.4	0.6	1
Dibenzo(a,h)anthracene	mg/kg	0.9	<0.1	0.1	0.2	0.2
Benzo(g,h,i)perylene	mg/kg	4.9	<0.1	0.5	0.8	1.3
Total +ve PAH's	mg/kg	76	<0.05	6.2	11	16
Benzo(a)pyrene TEQ calc (zero)	mg/kg	15	<0.5	1.4	2.4	2.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	15	<0.5	1.4	2.4	2.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	15	<0.5	1.4	2.4	2.5
Surrogate p-Terphenyl-d14	%	106	108	111	107	115

PAHs in Soil						
Our Reference	UNITS	268815-20	268815-21	268815-23	268815-25	268815-28
Your Reference		BH13_D_CGC	BH14_A_CGC	BH14_C_CGC	BH15_A_CGC	BH15_D_CGC
Depth		1.0	0.0	0.5	0.0	1.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	11
Acenaphthylene	mg/kg	<0.1	0.2	0.1	0.4	6.9
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	18
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	29
Phenanthrene	mg/kg	<0.1	0.6	0.3	1.2	300
Anthracene	mg/kg	<0.1	0.2	<0.1	0.4	93
Fluoranthene	mg/kg	<0.1	2.0	0.8	3.6	460
Pyrene	mg/kg	<0.1	1.7	0.7	3.1	340
Benzo(a)anthracene	mg/kg	<0.1	1.1	0.4	1.8	200
Chrysene	mg/kg	<0.1	0.9	0.4	1.6	170
Benzo(b,j+k)fluoranthene	mg/kg	<0.2	0.9	0.4	2	110
Benzo(a)pyrene	mg/kg	<0.05	2.2	0.96	3.6	28
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1	0.6	0.3	1.0	66
Dibenzo(a,h)anthracene	mg/kg	<0.1	0.2	<0.1	0.3	20
Benzo(g,h,i)perylene	mg/kg	<0.1	0.9	0.4	1.5	83
Total +ve PAH's	mg/kg	<0.05	12	4.8	20	1,900
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5	2.7	1.1	4.3	88
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5	2.7	1.1	4.3	88
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5	2.7	1.2	4.3	88
Surrogate p-Terphenyl-d14	%	111	110	107	104	106

PAHs in Soil						
Our Reference		268815-29	268815-32	268815-33	268815-34	268815-36
Your Reference	UNITS	BH16_A_CGC	BH16_D_CGC	DUP E	BH17_A_CGC	BH17_C_CGC
Depth		0.0	1.0	-	0.0	0.5
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Naphthalene	mg/kg	0.2	<0.1	<0.1	<0.1	0.1
Acenaphthylene	mg/kg	0.7	<0.1	<0.1	0.2	0.9
Acenaphthene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	0.2	<0.1	<0.1	<0.1	0.1
Phenanthrene	mg/kg	2.7	<0.1	<0.1	0.6	1.8
Anthracene	mg/kg	1.0	<0.1	<0.1	0.2	0.8
Fluoranthene	mg/kg	10	0.2	0.1	1.5	7.1
Pyrene	mg/kg	8.5	0.1	0.1	1.3	6.7
Benzo(a)anthracene	mg/kg	5.8	<0.1	<0.1	0.8	5.1
Chrysene	mg/kg	4.4	<0.1	<0.1	0.6	4.1
Benzo(b,j+k)fluoranthene	mg/kg	4.4	<0.2	<0.2	1	4.0
Benzo(a)pyrene	mg/kg	11	0.1	0.1	0.78	11
Indeno(1,2,3-c,d)pyrene	mg/kg	3.0	<0.1	<0.1	0.4	2.8
Dibenzo(a,h)anthracene	mg/kg	0.8	<0.1	<0.1	0.1	0.8
Benzo(g,h,i)perylene	mg/kg	3.9	<0.1	<0.1	0.6	4.2
Total +ve PAH's	mg/kg	57	0.4	0.4	8.4	50
Benzo(a)pyrene TEQ calc (zero)	mg/kg	13	<0.5	<0.5	1.2	13
Benzo(a)pyrene TEQ calc(half)	mg/kg	13	<0.5	<0.5	1.2	13
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	13	<0.5	<0.5	1.2	13
Surrogate p-Terphenyl-d14	%	108	108	109	112	106

PAHs in Soil						
Our Reference		268815-38	268815-40	268815-41	268815-42	268815-45
Your Reference	UNITS	BH18_A_CGC	BH18_C_CGC	BH19_A_CGC	BH19_B_CGC	BH20_A_CGC
Depth		0.0	0.5	0.0	0.25	0.0
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	0.2	0.7	0.2	0.6	0.4
Acenaphthene	mg/kg	<0.1	0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	0.3	<0.1	0.3	0.1
Phenanthrene	mg/kg	0.5	3.1	0.4	2.6	1.5
Anthracene	mg/kg	0.2	1.1	0.2	0.8	0.5
Fluoranthene	mg/kg	1.4	6.5	1.5	4.8	3.9
Pyrene	mg/kg	1.2	5.4	1.4	4.0	3.5
Benzo(a)anthracene	mg/kg	0.7	3.4	0.9	2.5	2.1
Chrysene	mg/kg	0.6	2.6	0.7	1.9	1.8
Benzo(b,j+k)fluoranthene	mg/kg	0.6	2.4	0.8	2	2
Benzo(a)pyrene	mg/kg	1.4	6.1	1.9	4.3	4.0
Indeno(1,2,3-c,d)pyrene	mg/kg	0.4	1.6	0.5	1.1	1.1
Dibenzo(a,h)anthracene	mg/kg	<0.1	0.4	0.1	0.3	0.3
Benzo(g,h,i)perylene	mg/kg	0.6	2.1	0.8	1.5	1.6
Total +ve PAH's	mg/kg	7.7	36	9.4	26	22
Benzo(a)pyrene TEQ calc (zero)	mg/kg	1.6	7.3	2.3	5.2	4.9
Benzo(a)pyrene TEQ calc(half)	mg/kg	1.7	7.3	2.3	5.2	4.9
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	1.7	7.3	2.3	5.2	4.9
Surrogate p-Terphenyl-d14	%	112	104	112	104	108

PAHs in Soil		
Our Reference		268815-48
Your Reference	UNITS	BH20_D_CGC
Depth		1.0
Date Sampled		12/05/2021
Type of sample		Soil
Date extracted	-	12/05/2021
Date analysed	-	12/05/2021
Naphthalene	mg/kg	<0.1
Acenaphthylene	mg/kg	<0.1
Acenaphthene	mg/kg	<0.1
Fluorene	mg/kg	<0.1
Phenanthrene	mg/kg	<0.1
Anthracene	mg/kg	<0.1
Fluoranthene	mg/kg	0.2
Pyrene	mg/kg	0.2
Benzo(a)anthracene	mg/kg	0.1
Chrysene	mg/kg	0.1
Benzo(b,j+k)fluoranthene	mg/kg	<0.2
Benzo(a)pyrene	mg/kg	0.2
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1
Total +ve PAH's	mg/kg	0.78
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5
Surrogate p-Terphenyl-d14	%	107

Acid Extractable metals in soil						
Our Reference		268815-1	268815-2	268815-4	268815-6	268815-8
Your Reference	UNITS	BH10_A_CGC	BH10_B_CGC	BH09_A_CGC	BH09_C_CGC	DUP C
Depth		0.0	0.25	0.0	0.5	-
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Arsenic	mg/kg	7	12	<4	<4	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	11	10	10	20	19
Copper	mg/kg	28	19	20	2	3
Lead	mg/kg	150	160	150	10	17
Mercury	mg/kg	1.2	2.3	0.5	<0.1	<0.1
Nickel	mg/kg	11	3	3	2	2
Zinc	mg/kg	150	140	84	6	14

Acid Extractable metals in soil						
Our Reference		268815-10	268815-12	268815-13	268815-14	268815-17
Your Reference	UNITS	BH11_B_CGC	BH11_D_CGC	BH12_A_CGC	BH12_B_CGC	BH13_A_CGC
Depth		0.25	1.0	0.0	0.25	0.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Arsenic	mg/kg	13	<4	<4	<4	36
Cadmium	mg/kg	0.7	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	17	9	7	11	9
Copper	mg/kg	79	3	15	32	18
Lead	mg/kg	530	8	72	200	220
Mercury	mg/kg	0.9	<0.1	0.3	1.0	0.3
Nickel	mg/kg	10	1	3	3	5
Zinc	mg/kg	300	21	59	88	62

Acid Extractable metals in soil						
Our Reference		268815-20	268815-21	268815-23	268815-25	268815-28
Your Reference	UNITS	BH13_D_CGC	BH14_A_CGC	BH14_C_CGC	BH15_A_CGC	BH15_D_CGC
Depth		1.0	0.0	0.5	0.0	1.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Arsenic	mg/kg	<4	5	<4	4	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4	3	0.5
Chromium	mg/kg	12	8	13	15	16
Copper	mg/kg	1	11	7	16	69
Lead	mg/kg	32	64	7	85	140
Mercury	mg/kg	<0.1	<0.1	<0.1	0.5	0.2
Nickel	mg/kg	3	4	2	4	10
Zinc	mg/kg	<1	55	4	62	140

Acid Extractable metals in soil						
Our Reference		268815-29	268815-32	268815-33	268815-34	268815-36
Your Reference	UNITS	BH16_A_CGC	BH16_D_CGC	DUP E	BH17_A_CGC	BH17_C_CGC
Depth		0.0	1.0	-	0.0	0.5
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Arsenic	mg/kg	5	<4	<4	<4	6
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	12	18	19	6	11
Copper	mg/kg	57	4	2	18	19
Lead	mg/kg	150	5	3	56	110
Mercury	mg/kg	0.5	<0.1	<0.1	0.2	1
Nickel	mg/kg	4	<1	<1	6	3
Zinc	mg/kg	110	8	4	61	73

Acid Extractable metals in soil						
Our Reference		268815-38	268815-40	268815-41	268815-42	268815-45
Your Reference	UNITS	BH18_A_CGC	BH18_C_CGC	BH19_A_CGC	BH19_B_CGC	BH20_A_CGC
Depth		0.0	0.5	0.0	0.25	0.0
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Arsenic	mg/kg	4	<4	<4	<4	5
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	11	6	9	14	10
Copper	mg/kg	21	11	20	23	23
Lead	mg/kg	110	110	110	110	130
Mercury	mg/kg	0.2	0.1	0.2	0.2	0.2
Nickel	mg/kg	7	2	4	4	3
Zinc	mg/kg	97	84	90	82	84

Acid Extractable metals in soil		
Our Reference		268815-48
Your Reference	UNITS	BH20_D_CGC
Depth		1.0
Date Sampled		12/05/2021
Type of sample		Soil
Date prepared	-	12/05/2021
Date analysed	-	12/05/2021
Arsenic	mg/kg	<4
Cadmium	mg/kg	<0.4
Chromium	mg/kg	7
Copper	mg/kg	4
Lead	mg/kg	9
Mercury	mg/kg	<0.1
Nickel	mg/kg	1
Zinc	mg/kg	6

Moisture						
Our Reference		268815-1	268815-2	268815-4	268815-6	268815-8
Your Reference	UNITS	BH10_A_CGC	BH10_B_CGC	BH09_A_CGC	BH09_C_CGC	DUP C
Depth		0.0	0.25	0.0	0.5	-
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Moisture	%	30	17	23	9.6	10

Moisture						
Our Reference		268815-10	268815-12	268815-13	268815-14	268815-17
Your Reference	UNITS	BH11_B_CGC	BH11_D_CGC	BH12_A_CGC	BH12_B_CGC	BH13_A_CGC
Depth		0.25	1.0	0.0	0.25	0.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Moisture	%	20	13	23	17	20

Moisture						
Our Reference		268815-20	268815-21	268815-23	268815-25	268815-28
Your Reference	UNITS	BH13_D_CGC	BH14_A_CGC	BH14_C_CGC	BH15_A_CGC	BH15_D_CGC
Depth		1.0	0.0	0.5	0.0	1.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Moisture	%	17	18	8.8	11	4.2

Moisture						
Our Reference		268815-29	268815-32	268815-33	268815-34	268815-36
Your Reference	UNITS	BH16_A_CGC	BH16_D_CGC	DUP E	BH17_A_CGC	BH17_C_CGC
Depth		0.0	1.0	-	0.0	0.5
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Moisture	%	27	11	10	23	12

Moisture						
Our Reference		268815-38	268815-40	268815-41	268815-42	268815-45
Your Reference	UNITS	BH18_A_CGC	BH18_C_CGC	BH19_A_CGC	BH19_B_CGC	BH20_A_CGC
Depth		0.0	0.5	0.0	0.25	0.0
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Moisture	%	31	12	23	12	23

Moisture		
Our Reference		268815-48
Your Reference	UNITS	BH20_D_CGC
Depth		1.0
Date Sampled		12/05/2021
Type of sample		Soil
Date prepared	-	12/05/2021
Date analysed	-	13/05/2021
Moisture	%	8.2

Asbestos ID - soils						
Our Reference		268815-1	268815-4	268815-10	268815-13	268815-17
Your Reference	UNITS	BH10_A_CGC	BH09_A_CGC	BH11_B_CGC	BH12_A_CGC	BH13_A_CGC
Depth		0.0	0.0	0.25	0.0	0.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Sample mass tested	g	Approx. 35g	Approx. 35g	Approx. 35g	Approx. 35g	Approx. 40g
Sample Description	-	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks
Asbestos ID in soil	-	No asbestos detected at repor ing limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected
Trace Analysis	-	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected

Asbestos ID - soils						
Our Reference		268815-21	268815-25	268815-29	268815-34	268815-38
Your Reference	UNITS	BH14_A_CGC	BH15_A_CGC	BH16_A_CGC	BH17_A_CGC	BH18_A_CGC
Depth		0.0	0.0	0.0	0.0	0.0
Date Sampled		11/05/2021	11/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Sample mass tested	g	Approx. 35g	Approx. 45g	Approx. 35g	Approx. 35g	Approx. 35g
Sample Description	-	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks
Asbestos ID in soil	-	No asbestos detected at repor ing limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected
Trace Analysis	-	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected

Asbestos ID - soils			
Our Reference		268815-41	268815-45
Your Reference	UNITS	BH19_A_CGC	BH20_A_CGC
Depth		0.0	0.0
Date Sampled		12/05/2021	12/05/2021
Type of sample		Soil	Soil
Date analysed	-	13/05/2021	13/05/2021
Sample mass tested	g	Approx. 35g	Approx. 35g
Sample Description	-	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks
Asbestos ID in soil	-	No asbestos detected at repor ing limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected
Trace Analysis	-	No asbestos detected	No asbestos detected

Method ID	Methodology Summary
ASB-001	Asbestos ID - Qualitative identification of asbestos in bulk samples using Polarised Light Microscopy and Dispersion Staining Techniques including Synthetic Mineral Fibre and Organic Fibre as per Australian Standard 4964-2004.
Inorg-008	Moisture content determined by heating at 105+/-5 °C for a minimum of 12 hours.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS and/or GC-MS/MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. For soil results:- 1. 'EQ PQL'values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'EQ zero'values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more suscept ble to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'EQ half PQL'values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, the Total +ve PAHs PQL is reflective of the lowest individual PQL and is therefore "Total +ve PAHs" is simply a sum of the positive individual PAHs.

QUALITY CONTROL: PAHs in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-8	268815-2
Date extracted	-			12/05/2021	1	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Date analysed	-			12/05/2021	1	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Naphthalene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	106	107
Acenaphthylene	mg/kg	0.1	Org-022/025	<0.1	1	0.4	0.3	29	[NT]	[NT]
Acenaphthene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	71	70
Fluorene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	89	87
Phenanthrene	mg/kg	0.1	Org-022/025	<0.1	1	0.4	0.5	22	105	76
Anthracene	mg/kg	0.1	Org-022/025	<0.1	1	0.2	0.2	0	[NT]	[NT]
Fluoranthene	mg/kg	0.1	Org-022/025	<0.1	1	1.3	1.5	14	109	102
Pyrene	mg/kg	0.1	Org-022/025	<0.1	1	1.2	1.3	8	96	84
Benzo(a)anthracene	mg/kg	0.1	Org-022/025	<0.1	1	0.8	0.9	12	[NT]	[NT]
Chrysene	mg/kg	0.1	Org-022/025	<0.1	1	0.6	0.7	15	86	64
Benzo(b,j+k)fluoranthene	mg/kg	0.2	Org-022/025	<0.2	1	1	2	67	[NT]	[NT]
Benzo(a)pyrene	mg/kg	0.05	Org-022/025	<0.05	1	0.85	0.92	8	90	75
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-022/025	<0.1	1	0.5	0.5	0	[NT]	[NT]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-022/025	<0.1	1	0.1	0.1	0	[NT]	[NT]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-022/025	<0.1	1	0.7	0.8	13	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	114	1	119	115	3	109	101

QUALITY CONTROL: PAHs in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-9	268815-36
Date extracted	-			[NT]	17	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Date analysed	-			[NT]	17	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Naphthalene	mg/kg	0.1	Org-022/025	[NT]	17	<0.1	<0.1	0	108	101
Acenaphthylene	mg/kg	0.1	Org-022/025	[NT]	17	0.4	0.4	0	[NT]	[NT]
Acenaphthene	mg/kg	0.1	Org-022/025	[NT]	17	<0.1	<0.1	0	71	68
Fluorene	mg/kg	0.1	Org-022/025	[NT]	17	<0.1	<0.1	0	89	87
Phenanthrene	mg/kg	0.1	Org-022/025	[NT]	17	0.6	0.6	0	103	99
Anthracene	mg/kg	0.1	Org-022/025	[NT]	17	0.3	0.2	40	[NT]	[NT]
Fluoranthene	mg/kg	0.1	Org-022/025	[NT]	17	2.3	2.3	0	102	#
Pyrene	mg/kg	0.1	Org-022/025	[NT]	17	2.3	2.3	0	93	#
Benzo(a)anthracene	mg/kg	0.1	Org-022/025	[NT]	17	1.6	1.6	0	[NT]	[NT]
Chrysene	mg/kg	0.1	Org-022/025	[NT]	17	1.4	1.4	0	86	#
Benzo(b,j+k)fluoranthene	mg/kg	0.2	Org-022/025	[NT]	17	2.7	2.6	4	[NT]	[NT]
Benzo(a)pyrene	mg/kg	0.05	Org-022/025	[NT]	17	1.7	1.6	6	90	#
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-022/025	[NT]	17	1	0.9	11	[NT]	[NT]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-022/025	[NT]	17	0.2	0.3	40	[NT]	[NT]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-022/025	[NT]	17	1.3	1.3	0	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	[NT]	17	115	113	2	107	102

QUALITY CONTROL: PAHs in Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-			[NT]	34	12/05/2021	12/05/2021		[NT]	[NT]
Date analysed	-			[NT]	34	12/05/2021	12/05/2021		[NT]	[NT]
Naphthalene	mg/kg	0.1	Org-022/025	[NT]	34	<0.1	<0.1	0	[NT]	[NT]
Acenaphthylene	mg/kg	0.1	Org-022/025	[NT]	34	0.2	0.2	0	[NT]	[NT]
Acenaphthene	mg/kg	0.1	Org-022/025	[NT]	34	<0.1	<0.1	0	[NT]	[NT]
Fluorene	mg/kg	0.1	Org-022/025	[NT]	34	<0.1	<0.1	0	[NT]	[NT]
Phenanthrene	mg/kg	0.1	Org-022/025	[NT]	34	0.6	0.6	0	[NT]	[NT]
Anthracene	mg/kg	0.1	Org-022/025	[NT]	34	0.2	0.2	0	[NT]	[NT]
Fluoranthene	mg/kg	0.1	Org-022/025	[NT]	34	1.5	1.7	12	[NT]	[NT]
Pyrene	mg/kg	0.1	Org-022/025	[NT]	34	1.3	1.5	14	[NT]	[NT]
Benzo(a)anthracene	mg/kg	0.1	Org-022/025	[NT]	34	0.8	1	22	[NT]	[NT]
Chrysene	mg/kg	0.1	Org-022/025	[NT]	34	0.6	0.8	29	[NT]	[NT]
Benzo(b,j+k)fluoranthene	mg/kg	0.2	Org-022/025	[NT]	34	1	2	67	[NT]	[NT]
Benzo(a)pyrene	mg/kg	0.05	Org-022/025	[NT]	34	0.78	0.93	18	[NT]	[NT]
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-022/025	[NT]	34	0.4	0.5	22	[NT]	[NT]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-022/025	[NT]	34	0.1	0.1	0	[NT]	[NT]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-022/025	[NT]	34	0.6	0.7	15	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	[NT]	34	112	107	5	[NT]	[NT]

QUALITY CONTROL: Acid Extractable metals in soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-8	268815-2
Date prepared	-			12/05/2021	1	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Date analysed	-			12/05/2021	1	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Arsenic	mg/kg	4	Metals-020	<4	1	7	8	13	103	105
Cadmium	mg/kg	0.4	Metals-020	<0.4	1	<0.4	<0.4	0	104	96
Chromium	mg/kg	1	Metals-020	<1	1	11	13	17	101	98
Copper	mg/kg	1	Metals-020	<1	1	28	28	0	96	99
Lead	mg/kg	1	Metals-020	<1	1	150	160	6	100	115
Mercury	mg/kg	0.1	Metals-021	<0.1	1	1.2	1.2	0	111	##
Nickel	mg/kg	1	Metals-020	<1	1	11	10	10	103	97
Zinc	mg/kg	1	Metals-020	<1	1	150	150	0	104	87

QUALITY CONTROL: Acid Extractable metals in soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-9	268815-36
Date prepared	-			[NT]	17	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Date analysed	-			[NT]	17	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Arsenic	mg/kg	4	Metals-020	[NT]	17	36	37	3	108	94
Cadmium	mg/kg	0.4	Metals-020	[NT]	17	<0.4	<0.4	0	109	91
Chromium	mg/kg	1	Metals-020	[NT]	17	9	9	0	106	91
Copper	mg/kg	1	Metals-020	[NT]	17	18	16	12	99	97
Lead	mg/kg	1	Metals-020	[NT]	17	220	210	5	103	#
Mercury	mg/kg	0.1	Metals-021	[NT]	17	0.3	0.3	0	97	##
Nickel	mg/kg	1	Metals-020	[NT]	17	5	4	22	106	90
Zinc	mg/kg	1	Metals-020	[NT]	17	62	59	5	104	125

QUALITY CONTROL: Acid Extractable metals in soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	34	12/05/2021	12/05/2021		[NT]	[NT]
Date analysed	-			[NT]	34	12/05/2021	12/05/2021		[NT]	[NT]
Arsenic	mg/kg	4	Metals-020	[NT]	34	<4	<4	0	[NT]	[NT]
Cadmium	mg/kg	0.4	Metals-020	[NT]	34	<0.4	<0.4	0	[NT]	[NT]
Chromium	mg/kg	1	Metals-020	[NT]	34	6	7	15	[NT]	[NT]
Copper	mg/kg	1	Metals-020	[NT]	34	18	17	6	[NT]	[NT]
Lead	mg/kg	1	Metals-020	[NT]	34	56	60	7	[NT]	[NT]
Mercury	mg/kg	0.1	Metals-021	[NT]	34	0.2	0.2	0	[NT]	[NT]
Nickel	mg/kg	1	Metals-020	[NT]	34	6	6	0	[NT]	[NT]
Zinc	mg/kg	1	Metals-020	[NT]	34	61	67	9	[NT]	[NT]

Result Definitions	
NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

8 metals in soil:
- # Percent recovery is not possible to report due to the inhomogeneous nature of the element/s in the sample/s. However an acceptable recovery was obtained for the LCS.
- ## Percent recovery is not possible to report due to the high concentration of the element/s in the sample/s. However an acceptable recovery was obtained for the LCS.

PAH_S:# Percent recovery for the matrix spike is not possible to report as the high concentration of analytes in sample/s 268815-36 have caused interference.

Asbestos: A portion of the supplied sample was sub-sampled for asbestos analysis according to Envirolab procedures.
We cannot guarantee that this sub-sample is indicative of the entire sample. Envirolab recommends supplying 40-50g of sample in its own container.
Note: Samples were sub-sampled from jars provided by the client.

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SAMPLE RECEIPT ADVICE

Client Details	
Client	Jacobs Group (Australia) Pty Ltd
Attention	Michael Stacey

Sample Login Details	
Your reference	IA216715
Envirolab Reference	268815
Date Sample Received	12/05/2021
Date Instructions Received	12/05/2021
Date Results Expected to be Reported	13/05/2021

Sample Condition	
Samples received in appropriate condition for analysis	Yes
No. of Samples Provided	48 Soil
Turnaround Time Requested	1 day
Temperature on Receipt (°C)	8.0
Cooling Method	Ice
Sampling Date Provided	YES

Comments

Nil

Please direct any queries to:

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Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Analysis Underway, details on the following page:

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Sample ID	PAHs in Soil	Acid Extractable metalsin soil	Asbestos ID - soils	On Hold
BH10_A_CGC-0.0	✓	✓	✓	
BH10_B_CGC-0.25	✓	✓		
BH10_C_CGC-0.5				✓
BH09_A_CGC-0.0	✓	✓	✓	
BH09_B_CGC-0.25				✓
BH09_C_CGC-0.5	✓	✓		
BH09_D_CGC-1.0				✓
DUP C	✓	✓		
BH11_A_CGC-0.0				✓
BH11_B_CGC-0.25	✓	✓	✓	
BH11_C_CGC-0.5				✓
BH11_D_CGC-1.0	✓	✓		
BH12_A_CGC-0.0	✓	✓	✓	
BH12_B_CGC-0.25	✓	✓		
BH12_C_CGC-0.5				✓
BH12_D_CGC-1.0				✓
BH13_A_CGC-0.0	✓	✓	✓	
BH13_B_CGC-0.25				✓
BH13_C_CGC-0.5				✓
BH13_D_CGC-1.0	✓	✓		
BH14_A_CGC-0.0	✓	✓	✓	
BH14_B_CGC-0.25				✓
BH14_C_CGC-0.5	✓	✓		
BH14_D_CGC-1.0				✓
BH15_A_CGC-0.0	✓	✓	✓	
BH15_B_CGC-0.25				✓
BH15_C_CGC-0.5				✓
BH15_D_CGC-1.0	✓	✓		
BH16_A_CGC-0.0	✓	✓	✓	
BH16_B_CGC-0.25				✓
BH16_C_CGC-0.5				✓
BH16_D_CGC-1.0	✓	✓		

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Sample ID	PAHs in Soil	Acid Extractable metalsin soil	Asbestos ID - soils	On Hold
DUP E	✓	✓		
BH17_A_CGC-0.0	✓	✓	✓	
BH17_B_CGC-0.25				✓
BH17_C_CGC-0.5	✓	✓		
BH17_D_CGC-1.0				✓
BH18_A_CGC-0.0	✓	✓	✓	
BH18_B_CGC-0.25				✓
BH18_C_CGC-0.5	✓	✓		
BH19_A_CGC-0.0	✓	✓	✓	
BH19_B_CGC-0.25	✓	✓		
BH19_C_CGC-0.5				✓
BH19_D_CGC-1.0				✓
BH20_A_CGC-0.0	✓	✓	✓	
BH20_B_CGC-0.25				✓
BH20_C_CGC-0.5				✓
BH20_D_CGC-1.0	✓	✓		

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

Additional Info

Additional Info
Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt.
Requests for longer term sample storage must be received in writing.
Please contact the laboratory immediately if observed settled sediment present in water samples is to be included in the extraction and/or analysis (exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS analysis where solids are included by default.
TAT for Micro is dependent on incubation. This varies from 3 to 6 days.

CHAIN OF CUSTODY FORM - Client

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ENVIROLAB GROUP

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PO No.: —
Envirolab Quote No. : —
Date results required:
Or choose: standard / same day / 1 day / 2 day / 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Additional report format: esdat / equis /
Lab Comments: please note 24 hr TAT

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Heavy metals (8)	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
1	BH10_A_CGC	0.0	11/5/21	SOIL	X	X	X		
2	BH10_B_CGC	0.25	↓	↓	X	X			
3	BH10_C_CGC	0.5						X	
4	BH09_A_CGC	0.0			X	X	X		
5	BH09_B_CGC	0.25						X	
6	BH09_C_CGC	0.5			X	X			
7	BH09_D_CGC	1.0						X	
8	DUP C				X	X			
-	DUP D				X	X			Please send
9	BH11_A_CGC	0.0						X	DUP D to
10	BH11_B_CGC	0.25			X	X	X		Eurofins
11	BH11_C_CGC	0.5	↓	↓				X	24 hr TAT

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD	*Lab Use Only*	
Print Name: A. MULLEN	Print Name: C Mulleam	Job number: 268815	Cooling: Ice / Ice pack / None
Date & Time: 12/5/21 3pm	Date & Time: 12/5/21 1510	Temperature: 8.0	Security seal: Intact / Broken / None
Signature: [signature]	Signature: [signature]	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

1/5

CHAIN OF CUSTODY FORM - Client

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Melbourne Lab - Envirolab Services
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Adelaide Office - Envirolab Services
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Brisbane Office - Envirolab Services
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Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Client: JACOBS	Client Project Name/Number/Site etc (ie report title): IA216715
Contact Person: M. STACEY	
Project Mgr: R. WAUGH	PO No.: –
Sampler: A. MULLEN	Envirolab Quote No.: –
Address:	Date results required: Or choose: standard / same day / 1 day / 2 day / 3 day. *Note: Inform lab in advance if urgent turnaround is required - surcharges apply*
Phone: Mob:	Additional report format: esdat / equis /
Email: michael.stacey@jacobs.com	Lab Comments: 24 HR TAT

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Heavy metals (8)	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
12	BH11_D_CGC	1.0	11/5/21	SOIL	X	X			
13	BH12_A_CGC	0.0			X	X	X		
14	BH12_B_CGC	0.25			X	X			
15	BH12_C_CGC	0.5						X	
16	BH12_D_CGC	1.0						X	
17	BH13_A_CGC	0.0			X	X	X		
18	BH13_B_CGC	0.25						X	
19	BH13_C_CGC	0.5						X	
20	BH13_D_CGC	1.0			X	X			
21	BH14_A_CGC	0.0			X	X	X		
22	BH14_B_CGC	0.25						X	
23	BH14_C_CGC	0.5			X	X			

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS	Received by (Company): ELS MD	Lab Use Only 265815
Print Name: A. MULLEN	Print Name: CM	Job number: / Cooling: Ice / Ice pack / None
Date & Time: 12/5/21 3pm	Date & Time: 12/5/21 1010	Temperature: 8.0 / Security seal: Intact / Broken / None
Signature: [signature]	Signature: CM	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD

2/5

CHAIN OF CUSTODY FORM - Client

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Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	M. STACEY
Project Mgr:	R. WAUGH
Sampler:	A. MULLEN
Address:	
Phone:	Mob: 0418412330
Email Results to:	michael.stacey@jacobs.com
Email Invoice to:	

Client Project Name/Number/Site etc (ie report title):	IA216715
PO No. (if applicable):	–
Envirolab Quote No.:	–
Date results required:	
Or choose:	☐ Standard ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply	
Additional report format:	☐ Esdat ☐ Equis
Lab Comments:	24 HR TAT

Sample Information / **Tests Required** / **Comments**

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals (8)	PAH	Asbestos (P/A)	HOLD	Provide as much information about the sample as you can
24	BH14_D_CGC	1.0	11/5/21	SOIL				X	
25	BH15_A_CGC	0.0	↓	↓	X	X	X		
26	BH15_B_CGC	0.25						X	
27	BH15_C_CGC	0.5						X	
28	BH15_D_CGC	1.0	↓		X	X			
29	BH16_A_CGC	0.0	12/5/21		X	X	X		
30	BH16_B_CGC	0.25	↓					X	
31	BH16_C_CGC	0.5						X	
32	BH16_D_CGC	1.0			X	X			
33	~~[illegible]~~ DUP E				X	X			Please send DUP F
–	DUP F		↓	↓	X	X			to Eurofins 24 HR TAT

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS	Received by (Company): ELS MO	Lab Use Only	
Print Name: A. MULLEN	Print Name: CM	Job number: 268815	Cooling: Ice / Ice pack / None
Date & Time: 12/5/21 3pm	Date & Time: 12/5/21 1510	Temperature:	Security seal: Intact / Broken / None
Signature: [signature]	Signature: CM	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

3/5

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Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	M. STACEY
Project Mgr:	R. WAUGH
Sampler:	A. MULLEN
Address:	
Phone:	Mob: 0418 412 330
Email Results to:	michael.stacey@jacobs.com
Email Invoice to:	

Client Project Name/Number/Site etc (ie report title): IA216715

PO No. (if applicable): —

Envirolab Quote No. : —

Date results required:

Or choose: ☐ Standard ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day

Note: Inform lab in advance if urgent turnaround is required - surcharges apply

Additional report format: ☒ Esdat ☐ Equis

Lab Comments: 24 HR TAT

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals (8)	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
34	BH17_A_CGC	0.0	12/5/21	SOIL	X	X	X		
35	BH17_B_CGC	0.25	↓	↓				X	
36	BH17_C_CGC	0.5			X	X			
37	BH17_D_CGC	1.0						X	
38	BH18_A_CGC	0.0			X	X	X		
39	BH18_B_CGC	0.25						X	
40	BH18_C_CGC	0.5			X	X			
41	BH19_A_CGC	0.0			X	X	X		
42	BH19_B_CGC	0.25			X	X			
43	BH19_C_CGC	0.5						X	
44	BH19_D_CGC	1.0	↓	↓				X	

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD	Lab Use Only
Print Name: A. MULLEN	Print Name: CM	Job number: 268815 / Cooling: Ice / Ice pack / None
Date & Time: 12/5/21 3pm	Date & Time: 12/5/21 1510	Temperature: / Security seal: Intact / Broken / None
Signature: A Mullen	Signature: CM	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD

CHAIN OF CUSTODY FORM - Client

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National phone number 1300 424 344

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Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	M. STACEY
Project Mgr:	R. WAUGH
Sampler:	A. MULLEN
Address:	
Phone:	Mob: 0418 412 330
Email Results to:	michael.stacey@jacobs.com
Email Invoice to:	

Client Project Name/Number/Site etc (ie report title): IA216715

PO No. (if applicable): –

Envirolab Quote No. : –

Date results required:

Or choose: ☐ Standard ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day

Note: Inform lab in advance if urgent turnaround is required - surcharges apply

Additional report format: ☒ Esdat ☐ Equis

Lab Comments: 24 HR TAT

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals (8)	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
45	BH20-A-CGC	0.0	12/5/21	SOIL	X	X	X		
46	BH20-B-CGC	0.25	↓	↓				X	
47	BH20-C-CGC	0.5			~~X~~	~~X~~		X	
48	BH20-D-CGC	1.0			X	X		~~X~~	

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD	*Lab Use Only*	
Print Name: A. MULLEN	Print Name: CM	Job number: 268815	Cooling: Ice / Ice pack / None
Date & Time: 12/5/21 3pm	Date & Time: 12/5/21 1510	Temperature:	Security seal: Intact / Broken / None
Signature: [signature]	Signature: CM	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

eurofins Environment Testing

Certificate of Analysis

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Jacobs Group (Australia) P/L NSW
Level 7, 177 Pacific Highway
North Sydney
NSW 2065

Attention: **Michael Stacey**

Report **795087-S**
Project name 1A216715
Project ID 1A216715
Received Date May 14, 2021

Client Sample ID			DUP D
Sample Matrix			**Soil**
Eurofins Sample No.			**S21-My26447**
Date Sampled			**May 11, 2021**
Test/Reference	LOR	Unit	
Polycyclic Aromatic Hydrocarbons			
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2
Acenaphthene	0.5	mg/kg	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5
Anthracene	0.5	mg/kg	< 0.5
Benz(a)anthracene	0.5	mg/kg	< 0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5
Chrysene	0.5	mg/kg	< 0.5
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5
Fluoranthene	0.5	mg/kg	< 0.5
Fluorene	0.5	mg/kg	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5
Naphthalene	0.5	mg/kg	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5
Pyrene	0.5	mg/kg	< 0.5
Total PAH*	0.5	mg/kg	< 0.5
2-Fluorobiphenyl (surr.)	1	%	98
p-Terphenyl-d14 (surr.)	1	%	107
Heavy Metals			
Arsenic	2	mg/kg	2.2
Cadmium	0.4	mg/kg	< 0.4
Chromium	5	mg/kg	13
Copper	5	mg/kg	< 5
Lead	5	mg/kg	7.7
Mercury	0.1	mg/kg	< 0.1
Nickel	5	mg/kg	< 5
Zinc	5	mg/kg	6.9
% Moisture	1	%	11

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Polycyclic Aromatic Hydrocarbons	Sydney	May 14, 2021	14 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Metals M8	Sydney	May 14, 2021	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
% Moisture	Sydney	May 14, 2021	14 Days
- Method: LTM-GEN-7080 Moisture			

eurofins Environment Testing

ABN: 50 005 085 521 web: www.eurofins.com.au email: EnviroSales@eurofins.com

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NATA # 1261
Site # 1254 & 14271

Sydney
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Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Perth
46-48 Banksia Road
Welshpool WA 6106
Phone : +61 8 9251 9600
NATA # 1261
Site # 23736

Newcastle
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Mayfield East NSW 2304
PO Box 60 Wickham 2293
Phone : +61 2 4968 8448
NATA # 1261 Site # 25079

New Zealand

Auckland
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Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Company Name: Jacobs Group (Australia) P/L NSW
Address: Level 7, 177 Pacific Highway
North Sydney
NSW 2065

Project Name: 1A216715
Project ID: 1A216715

Order No.:
Report #: 795087
Phone: 02 9928 2100
Fax: 02 9928 2504

Received: May 14, 2021 8:10 AM
Due: May 17, 2021
Priority: 1 Day
Contact Name: Michael Stacey

Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Polycyclic Aromatic Hydrocarbons	Metals M8	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271								
Sydney Laboratory - NATA Site # 18217						X	X	X
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
Mayfield Laboratory - NATA Site # 25079								
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	DUP D	May 11, 2021		Soil	S21-My26447	X	X	X
Test Counts						1	1	1

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE** pH duplicates are reported as a range NOT as RPD

Units

mg/kg milligrams per kilogram	**mg/L** milligrams per litre	**ug/L** micrograms per litre
ppm Parts per million	**ppb** Parts per billion	**%** Percentage
org/100mL Organisms per 100 millilitres	**NTU** Nephelometric Turbidity Units	**MPN/100mL** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6 2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/kg	< 0.5			0.5	Pass	
Acenaphthylene	mg/kg	< 0.5			0.5	Pass	
Anthracene	mg/kg	< 0.5			0.5	Pass	
Benz(a)anthracene	mg/kg	< 0.5			0.5	Pass	
Benzo(a)pyrene	mg/kg	< 0.5			0.5	Pass	
Benzo(b&j)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Benzo(g.h.i)perylene	mg/kg	< 0.5			0.5	Pass	
Benzo(k)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Chrysene	mg/kg	< 0.5			0.5	Pass	
Dibenz(a.h)anthracene	mg/kg	< 0.5			0.5	Pass	
Fluoranthene	mg/kg	< 0.5			0.5	Pass	
Fluorene	mg/kg	< 0.5			0.5	Pass	
Indeno(1.2.3-cd)pyrene	mg/kg	< 0.5			0.5	Pass	
Naphthalene	mg/kg	< 0.5			0.5	Pass	
Phenanthrene	mg/kg	< 0.5			0.5	Pass	
Pyrene	mg/kg	< 0.5			0.5	Pass	
Method Blank							
Heavy Metals							
Arsenic	mg/kg	< 2			2	Pass	
Cadmium	mg/kg	< 0.4			0.4	Pass	
Chromium	mg/kg	< 5			5	Pass	
Copper	mg/kg	< 5			5	Pass	
Lead	mg/kg	< 5			5	Pass	
Mercury	mg/kg	< 0.1			0.1	Pass	
Nickel	mg/kg	< 5			5	Pass	
Zinc	mg/kg	< 5			5	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	109			70-130	Pass	
Acenaphthylene	%	117			70-130	Pass	
Anthracene	%	108			70-130	Pass	
Benz(a)anthracene	%	119			70-130	Pass	
Benzo(a)pyrene	%	118			70-130	Pass	
Benzo(b&j)fluoranthene	%	115			70-130	Pass	
Benzo(g.h.i)perylene	%	121			70-130	Pass	
Benzo(k)fluoranthene	%	112			70-130	Pass	
Chrysene	%	120			70-130	Pass	
Dibenz(a.h)anthracene	%	119			70-130	Pass	
Fluoranthene	%	109			70-130	Pass	
Fluorene	%	113			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	120			70-130	Pass	
Naphthalene	%	108			70-130	Pass	
Phenanthrene	%	104			70-130	Pass	
Pyrene	%	109			70-130	Pass	
LCS - % Recovery							
Heavy Metals							
Arsenic	%	114			80-120	Pass	
Cadmium	%	115			80-120	Pass	
Chromium	%	112			80-120	Pass	
Copper	%	110			80-120	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Lead			%	112			80-120	Pass	
Mercury			%	104			80-120	Pass	
Nickel			%	110			80-120	Pass	
Zinc			%	106			80-120	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					
Acenaphthene	S21-My12202	NCP	%	125			70-130	Pass	
Anthracene	S21-My12202	NCP	%	121			70-130	Pass	
Benz(a)anthracene	S21-My12202	NCP	%	128			70-130	Pass	
Benzo(a)pyrene	S21-My12202	NCP	%	125			70-130	Pass	
Benzo(b&j)fluoranthene	S21-My12202	NCP	%	122			70-130	Pass	
Benzo(g.h.i)perylene	S21-My16581	NCP	%	108			70-130	Pass	
Benzo(k)fluoranthene	S21-My12202	NCP	%	126			70-130	Pass	
Chrysene	S21-My12202	NCP	%	126			70-130	Pass	
Dibenz(a.h)anthracene	S21-My16581	NCP	%	94			70-130	Pass	
Fluoranthene	S21-My12202	NCP	%	110			70-130	Pass	
Fluorene	S21-My12202	NCP	%	130			70-130	Pass	
Indeno(1.2.3-cd)pyrene	S21-My16581	NCP	%	102			70-130	Pass	
Naphthalene	S21-My12202	NCP	%	121			70-130	Pass	
Phenanthrene	S21-My12202	NCP	%	105			70-130	Pass	
Pyrene	S21-My12202	NCP	%	108			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic	S21-My24182	NCP	%	106			75-125	Pass	
Cadmium	S21-My24182	NCP	%	106			75-125	Pass	
Chromium	S21-My24182	NCP	%	98			75-125	Pass	
Copper	S21-My24182	NCP	%	92			75-125	Pass	
Lead	S21-My11160	NCP	%	99			75-125	Pass	
Mercury	S21-My24182	NCP	%	91			75-125	Pass	
Nickel	S21-My24182	NCP	%	97			75-125	Pass	
Zinc	S21-My24182	NCP	%	105			75-125	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Acenaphthylene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Anthracene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benz(a)anthracene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(a)pyrene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(b&j)fluoranthene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(g.h.i)perylene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(k)fluoranthene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Chrysene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Dibenz(a.h)anthracene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluoranthene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluorene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Naphthalene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Phenanthrene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Pyrene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	

Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic	S21-My26157	NCP	mg/kg	4.7	4.6	3.0	30%	Pass	
Cadmium	S21-My26157	NCP	mg/kg	< 0.4	< 0.4	<1	30%	Pass	
Chromium	S21-My26157	NCP	mg/kg	17	11	41	30%	Fail	Q15
Copper	S21-My26157	NCP	mg/kg	28	16	54	30%	Fail	Q15
Lead	S21-My26157	NCP	mg/kg	14	9.9	37	30%	Fail	Q15
Mercury	S21-My26157	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Nickel	S21-My26157	NCP	mg/kg	8.9	8.6	4.0	30%	Pass	
Zinc	S21-My26157	NCP	mg/kg	42	31	30	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	S21-My26351	NCP	%	7.8	7.9	1.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs
Q15	The RPD reported passes Eurofins Environment Testing's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised by:

Andrew Black	Analytical Services Manager
Andrew Sullivan	Senior Analyst-Organic (NSW)
John Nguyen	Senior Analyst-Metal (NSW)

Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Eurofins shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall Eurofins be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

eurofins | Environment Testing

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Australia

Melbourne
6 Monterey Road
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Phone : +61 3 8564 5000
NATA # 1261
Site # 1254 & 14271

Sydney
Unit F3, Building F
16 Mars Road
Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Perth
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Phone : +61 8 9251 9600
NATA # 1261
Site # 23736

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4/52 Industrial Drive
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NATA # 1261 Site # 25079

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35 O'Rorke Road
Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

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43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Company Name: Jacobs Group (Australia) P/L NSW
Address: Level 7, 177 Pacific Highway
North Sydney
NSW 2065

Order No.:
Report #: 795087
Phone: 02 9928 2100
Fax: 02 9928 2504

Received: May 14, 2021 8:10 AM
Due: May 17, 2021
Priority: 1 Day
Contact Name: Michael Stacey

Project Name: 1A216715
Project ID: 1A216715

Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Polycyclic Aromatic Hydrocarbons	Metals M8	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271								
Sydney Laboratory - NATA Site # 18217						X	X	X
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
Mayfield Laboratory - NATA Site # 25079								
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	DUP D	May 11, 2021		Soil	S21-My26447	X	X	X
Test Counts						1	1	1

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ABN: 50 005 085 521 www.eurofins.com.au EnviroSales@eurofins.com

Australia

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IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Sample Receipt Advice

Company name:	Jacobs Group (Australia) P/L NSW
Contact name:	Michael Stacey
Project name:	1A216715
Project ID:	1A216715
Turnaround time:	1 Day
Date/Time received	May 14, 2021 8:10 AM
Eurofins reference	795087

Sample Information

- ✓ A detailed list of analytes logged into our LIMS, is included in the attached summary table.
- ✓ All samples have been received as described on the above COC.
- ✓ COC has been completed correctly.
- ✓ Attempt to chill was evident.
- ✓ Appropriately preserved sample containers have been used.
- ✓ All samples were received in good condition.
- ✓ Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.
- ✓ Appropriate sample containers have been used.
- ✓ Sample containers for volatile analysis received with zero headspace.
- ✗ Split sample sent to requested external lab.
- ✗ Some samples have been subcontracted.
- N/A Custody Seals intact (if used).

Notes

Contact

If you have any questions with respect to these samples, please contact your Analytical Services Manager:

Andrew Black on phone : (+61) 2 9900 8490 or by email: AndrewBlack@eurofins.com

Results will be delivered electronically via email to Michael Stacey - michael.stacey@jacobs.com.

Global Leader - Results you can trust

GAV 14/5/21 8:10am 295087

CHAIN OF CUSTODY FORM - Client

ENVIROLAB GROUP

National phone number 1300 424 344

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
02 9910 6200 | sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt, Myaree, WA 6154
08 9317 2505 | lab@mpl.com.au

Melbourne Lab - Envirolab Services
25 Research Drive, Croydon South, VIC 3136
03 9763 2500 | melbourne@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
08 7087 6800 | adelaide@envirolab.com.au

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
07 3266 9532 | brisbane@envirolab.com.au

Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Client: JACOBS
Contact Person: M. STACEY
Project Mgr: R. WAUGH
Sampler: A. MULLEN
Address:
Phone: Mob: 0418412330
Email: michael.stacey@jacobs.com

Client Project Name/Number/Site etc (ie report title): IA216715
PO No.: —
Envirolab Quote No.: —
Date results required:
Or choose: standard / same day / 1 day / 2 day / 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Additional report format: esdat / equis /
Lab Comments: Please note 24 hr TAT

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Heavy Metals (8)	PAH	Asbestos (p/a)	HOLD	Comments
1	BH10_A_CGC	0.0	11/5/21	SOIL	X	X	X		Relinquished by
2	BH10_B_CGC	0.25	↓	↓	X	X			EH Sydney
3	BH10_C_CGC	0.5						X	C McKenzie
4	BH09_A_CGC	0.0			X	X	X		13/5/21 1130
5	BH09_B_CGC	0.25						X	CM
6	BH09_C_CGC	0.5			X	X			
7	BH09_D_CGC	1.0						X	
8	DUP C				X	X			
-	DUP D				X	X			Please send
9	BH11_A_CGC	0.0						X	DUP D to
10	BH11_B_CGC	0.25			X	X	X		Eurofins
11	BH11_C_CGC	0.5	↓	↓				X	24 hr TAT

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS
Print Name: A. MULLEN
Date & Time: 12/5/21 3pm
Signature:

Received by (Company): EH SYD
Print Name: C McKenzie
Date & Time: 12/5/21 1510
Signature: CM

Lab Use Only
Job number: 268815
Temperature: 8.0
Cooling: Ice / Ice pack / None
Security seal: Intact / Broken / None
TAT Req - SAME day / 1 / 2 / 3 / 4 / STD

1/5

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Environment Testing

Certificate of Analysis

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Jacobs Group (Australia) P/L NSW
Level 7, 177 Pacific Highway
North Sydney
NSW 2065

Attention: **Michael Stacey**

Report **795091-S**
Project name 1A216715
Received Date May 14, 2021

Client Sample ID			**DUP F**
Sample Matrix			**Soil**
Eurofins Sample No.			**S21-My26456**
Date Sampled			**May 12, 2021**
Test/Reference	LOR	Unit	
Polycyclic Aromatic Hydrocarbons			
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2
Acenaphthene	0.5	mg/kg	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5
Anthracene	0.5	mg/kg	< 0.5
Benz(a)anthracene	0.5	mg/kg	0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5
Chrysene	0.5	mg/kg	0.5
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5
Fluoranthene	0.5	mg/kg	0.7
Fluorene	0.5	mg/kg	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5
Naphthalene	0.5	mg/kg	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5
Pyrene	0.5	mg/kg	0.8
Total PAH*	0.5	mg/kg	2.5
2-Fluorobiphenyl (surr.)	1	%	68
p-Terphenyl-d14 (surr.)	1	%	60
Heavy Metals			
Arsenic	2	mg/kg	3.8
Cadmium	0.4	mg/kg	< 0.4
Chromium	5	mg/kg	23
Copper	5	mg/kg	< 5
Lead	5	mg/kg	5.3
Mercury	0.1	mg/kg	< 0.1
Nickel	5	mg/kg	< 5
Zinc	5	mg/kg	< 5
% Moisture	1	%	11

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Polycyclic Aromatic Hydrocarbons	Sydney	May 14, 2021	14 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Metals M8	Sydney	May 14, 2021	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
% Moisture	Sydney	May 14, 2021	14 Days
- Method: LTM-GEN-7080 Moisture			

Company Name:	Jacobs Group (Australia) P/L NSW	**Order No.:**		**Received:**	May 14, 2021 8:10 AM
Address:	Level 7, 177 Pacific Highway North Sydney NSW 2065	**Report #:**	795091	**Due:**	May 17, 2021
		Phone:	02 9928 2100	**Priority:**	1 Day
		Fax:	02 9928 2504	**Contact Name:**	Michael Stacey
Project Name:	1A216715				

Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Polycyclic Aromatic Hydrocarbons	Metals M8	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271								
Sydney Laboratory - NATA Site # 18217						X	X	X
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
Mayfield Laboratory - NATA Site # 25079								
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	DUP F	May 12, 2021		Soil	S21-My26456	X	X	X
Test Counts						1	1	1

eurofins | Environment Testing

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE** pH duplicates are reported as a range NOT as RPD

Units

mg/kg milligrams per kilogram	**mg/L** milligrams per litre	**ug/L** micrograms per litre
ppm Parts per million	**ppb** Parts per billion	**%** Percentage
org/100mL Organisms per 100 millilitres	**NTU** Nephelometric Turbidity Units	**MPN/100mL** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6 2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Environment Testing

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/kg	< 0.5			0.5	Pass	
Acenaphthylene	mg/kg	< 0.5			0.5	Pass	
Anthracene	mg/kg	< 0.5			0.5	Pass	
Benz(a)anthracene	mg/kg	< 0.5			0.5	Pass	
Benzo(a)pyrene	mg/kg	< 0.5			0.5	Pass	
Benzo(b&j)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Benzo(g.h.i)perylene	mg/kg	< 0.5			0.5	Pass	
Benzo(k)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Chrysene	mg/kg	< 0.5			0.5	Pass	
Dibenz(a.h)anthracene	mg/kg	< 0.5			0.5	Pass	
Fluoranthene	mg/kg	< 0.5			0.5	Pass	
Fluorene	mg/kg	< 0.5			0.5	Pass	
Indeno(1.2.3-cd)pyrene	mg/kg	< 0.5			0.5	Pass	
Naphthalene	mg/kg	< 0.5			0.5	Pass	
Phenanthrene	mg/kg	< 0.5			0.5	Pass	
Pyrene	mg/kg	< 0.5			0.5	Pass	
Method Blank							
Heavy Metals							
Arsenic	mg/kg	< 2			2	Pass	
Cadmium	mg/kg	< 0.4			0.4	Pass	
Chromium	mg/kg	< 5			5	Pass	
Copper	mg/kg	< 5			5	Pass	
Lead	mg/kg	< 5			5	Pass	
Mercury	mg/kg	< 0.1			0.1	Pass	
Nickel	mg/kg	< 5			5	Pass	
Zinc	mg/kg	< 5			5	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	98			70-130	Pass	
Acenaphthylene	%	92			70-130	Pass	
Anthracene	%	96			70-130	Pass	
Benz(a)anthracene	%	97			70-130	Pass	
Benzo(a)pyrene	%	109			70-130	Pass	
Benzo(b&j)fluoranthene	%	104			70-130	Pass	
Benzo(g.h.i)perylene	%	95			70-130	Pass	
Benzo(k)fluoranthene	%	125			70-130	Pass	
Chrysene	%	106			70-130	Pass	
Dibenz(a.h)anthracene	%	85			70-130	Pass	
Fluoranthene	%	90			70-130	Pass	
Fluorene	%	98			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	103			70-130	Pass	
Naphthalene	%	95			70-130	Pass	
Phenanthrene	%	96			70-130	Pass	
Pyrene	%	93			70-130	Pass	
LCS - % Recovery							
Heavy Metals							
Arsenic	%	114			80-120	Pass	
Cadmium	%	115			80-120	Pass	
Chromium	%	112			80-120	Pass	
Copper	%	110			80-120	Pass	

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Lead			%	112			80-120	Pass	
Mercury			%	104			80-120	Pass	
Nickel			%	110			80-120	Pass	
Zinc			%	106			80-120	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					
Acenaphthene	S21-My23419	NCP	%	87			70-130	Pass	
Acenaphthylene	S21-My23419	NCP	%	88			70-130	Pass	
Anthracene	S21-My23419	NCP	%	88			70-130	Pass	
Benz(a)anthracene	S21-My23419	NCP	%	86			70-130	Pass	
Benzo(a)pyrene	S21-My23419	NCP	%	95			70-130	Pass	
Benzo(b&j)fluoranthene	S21-My23419	NCP	%	96			70-130	Pass	
Benzo(g.h.i)perylene	S21-My23419	NCP	%	86			70-130	Pass	
Benzo(k)fluoranthene	S21-My23419	NCP	%	104			70-130	Pass	
Chrysene	S21-My23419	NCP	%	93			70-130	Pass	
Dibenz(a.h)anthracene	S21-My23419	NCP	%	84			70-130	Pass	
Fluoranthene	S21-My23419	NCP	%	78			70-130	Pass	
Fluorene	S21-My23419	NCP	%	89			70-130	Pass	
Indeno(1.2.3-cd)pyrene	S21-My23419	NCP	%	95			70-130	Pass	
Naphthalene	S21-My23419	NCP	%	90			70-130	Pass	
Phenanthrene	S21-My23419	NCP	%	84			70-130	Pass	
Pyrene	S21-My23419	NCP	%	80			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic	S21-My24182	NCP	%	106			75-125	Pass	
Cadmium	S21-My24182	NCP	%	106			75-125	Pass	
Chromium	S21-My24182	NCP	%	98			75-125	Pass	
Copper	S21-My24182	NCP	%	92			75-125	Pass	
Lead	S21-My11160	NCP	%	99			75-125	Pass	
Mercury	S21-My24182	NCP	%	91			75-125	Pass	
Nickel	S21-My24182	NCP	%	97			75-125	Pass	
Zinc	S21-My24182	NCP	%	105			75-125	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Acenaphthylene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Anthracene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benz(a)anthracene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(a)pyrene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(b&j)fluoranthene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(g.h.i)perylene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(k)fluoranthene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Chrysene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Dibenz(a.h)anthracene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluoranthene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluorene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Naphthalene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Phenanthrene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Pyrene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	

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Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic	S21-My26157	NCP	mg/kg	4.1	4.0	3.0	30%	Pass	
Cadmium	S21-My26157	NCP	mg/kg	< 0.4	< 0.4	<1	30%	Pass	
Chromium	S21-My26157	NCP	mg/kg	15	9.6	41	30%	Fail	Q15
Copper	S21-My26157	NCP	mg/kg	24	14	54	30%	Fail	Q15
Lead	S21-My26157	NCP	mg/kg	13	8.7	37	30%	Fail	Q15
Mercury	S21-My26157	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Nickel	S21-My26157	NCP	mg/kg	7.9	7.5	4.0	30%	Pass	
Zinc	S21-My26157	NCP	mg/kg	37	27	30	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	S21-My26625	NCP	%	12	12	1.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs
Q15	The RPD reported passes Eurofins Environment Testing's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised by:

Andrew Black	Analytical Services Manager
Andrew Sullivan	Senior Analyst-Organic (NSW)
John Nguyen	Senior Analyst-Metal (NSW)

Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

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Company Name:	Jacobs Group (Australia) P/L NSW	**Order No.:**		**Received:**	May 14, 2021 8:10 AM
Address:	Level 7, 177 Pacific Highway North Sydney NSW 2065	**Report #:**	795091	**Due:**	May 17, 2021
		Phone:	02 9928 2100	**Priority:**	1 Day
		Fax:	02 9928 2504	**Contact Name:**	Michael Stacey
Project Name:	1A216715				

Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Polycyclic Aromatic Hydrocarbons	Metals M8	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271								
Sydney Laboratory - NATA Site # 18217						X	X	X
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
Mayfield Laboratory - NATA Site # 25079								
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	DUP F	May 12, 2021		Soil	S21-My26456	X	X	X
Test Counts						1	1	1

eurofins Environment Testing

ABN: 50 005 085 521 www.eurofins.com.au EnviroSales@eurofins.com

Australia

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6 Monterey Road
Dandenong South VIC 3175
Phone : +61 3 8564 5000
NATA # 1261
Site # 1254 & 14271

Sydney
Unit F3, Building F
16 Mars Road
Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Perth
46-48 Banksia Road
Welshpool WA 6106
Phone : +61 8 9251 9600
NATA # 1261
Site # 23736

Newcastle
4/52 Industrial Drive
Mayfield East NSW 2304
PO Box 60 Wickham 2293
Phone : +61 2 4968 8448
NATA # 1261 Site # 25079

New Zealand

Auckland
35 O'Rorke Road
Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Sample Receipt Advice

Company name:	Jacobs Group (Australia) P/L NSW
Contact name:	Michael Stacey
Project name:	1A216715
Project ID:	Not provided
Turnaround time:	1 Day
Date/Time received	May 14, 2021 8:10 AM
Eurofins reference	795091

Sample Information

- ✓ A detailed list of analytes logged into our LIMS, is included in the attached summary table.
- ✓ All samples have been received as described on the above COC.
- ✓ COC has been completed correctly.
- ✓ Attempt to chill was evident.
- ✓ Appropriately preserved sample containers have been used.
- ✓ All samples were received in good condition.
- ✓ Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.
- ✓ Appropriate sample containers have been used.
- ✓ Sample containers for volatile analysis received with zero headspace.
- ✗ Split sample sent to requested external lab.
- ✗ Some samples have been subcontracted.
- N/A Custody Seals intact (if used).

Notes

Contact

If you have any questions with respect to these samples, please contact your Analytical Services Manager:

Andrew Black on phone : (+61) 2 9900 8490 or by email: AndrewBlack@eurofins.com

Results will be delivered electronically via email to Michael Stacey - michael.stacey@jacobs.com.

Global Leader - Results you can trust

GTN 14/5/21 8:50 am 795091

ENVIROLAB GROUP / ENVIROLAB SERVICES / mpl

CHAIN OF CUSTODY FORM - Client

ENVIROLAB GROUP
National phone number 1300 424 344

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
02 9910 6200 | sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt, Myaree, WA 6154
08 9317 2505 | lab@mpl.com.au

Melbourne Lab - Envirolab Services
25 Research Drive, Croydon South, VIC 3136
03 9763 2500 | melbourne@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
08 7087 6800 | adelaide@envirolab.com.au

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
07 3266 9532 | brisbane@envirolab.com.au

Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	M. STACEY
Project Mgr:	R. WAUGH
Sampler:	A. MULLEN
Address:	
Phone:	Mob: 0418412330
Email Results to:	michael.stacey@jacobs.com
Email Invoice to:	

Client Project Name/Number/Site etc (ie report title):	IA216715
PO No. (if applicable):	—
Envirolab Quote No.:	—
Date results required:	
Or choose:	☐ Standard ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply	
Additional report format:	☐ Esdat ☐ Equis
Lab Comments:	24 HR TAT

Sample information / **Tests Required**

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy metals (8)	PAH	Asbestos (p/a)	HOLD	Comments (Provide as much information about the sample as you can)
24	BH14_D_CGC	~~[illegible]~~ 1.0	11/5/21	SOIL				X	Relinquished via ELS and C. Mullen 13/5/21 1130 CM
25	BH15_A_CGC	0.0			X	X	X		
26	BH15_B_CGC	0.25						X	
27	BH15_C_CGC	0.5						X	
28	BH15_D_CGC	1.0			X	X			
29	BH16_A_CGC	0.0	12/5/21		X	X	X		
30	BH16_B_CGC	0.25						X	
31	BH16_C_CGC	0.5						X	
32	BH16_D_CGC	1.0			X	X			
33	~~[illegible]~~ DUP E				X	X			
–	DUP F				X	X			Please send out to Eurofins 24 HR TAT

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company):	JACOBS	Received by (Company):	ELS MO
Print Name:	A. MULLEN	Print Name:	CM
Date & Time:	12/5/21 3pm	Date & Time:	12/5/21 1510
Signature:	[signature]	Signature:	CM

Lab Use Only

Job number: 268815	Cooling: Ice / Ice pack / None
Temperature:	Security seal: Intact / Broken / None
TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

Detailed Site Investigation Report – Cammeray Golf Course (WP12)

Document No. SPA-JGA-REP-ENV-WP12-1-0007

Rev	Date	Prepared by Name	Reviewed by Name	Approved by Name	Remarks
00	20.05.2021	[redacted]	[redacted]	[redacted]	
01	31.05.2021	[redacted]	[redacted]	[redacted]	Incorporating JHG comments
02	10.06.2021	[redacted]	[redacted]	[redacted]	Incorporating JHG comments
03	06.07.2021	[redacted]	[redacted]	[redacted]	Revision based on DPIE comments
04	09.08.2021	[redacted]	[redacted]	[redacted]	Incorporating TfNSW comments
05	17.09.2021	[redacted]	[redacted]	[redacted]	Incorporating DPIE comments

Table of Contents

Important note about your report

The purpose of this report is to present the findings of a site investigation carried out by the SPA contamination team for the Sydney Program Alliance (SPA) associated with Stage 1A Works at Cammeray Golf Course, Cammeray NSW, as part of the Early Works Program (WP12) in preparation for the Warringah Freeway Upgrade project.

All reports and conclusions that deal with sub-surface conditions are based on interpretation and judgement and as a result have uncertainty attached to them. You should be aware that this report contains interpretations and conclusions which are uncertain, due to the nature of the investigations. No study can investigate every risk, and even a rigorous assessment and/or sampling programme may not detect all problem areas within a site.

This report is based on assumptions that the site conditions as revealed through sampling and information provided by SPA are indicative of conditions within the investigation area(s) (i.e. the proposed construction support site areas associated with the Early Works Program). The findings are the result of standard assessment techniques used in accordance with normal practices and standards, and (to the best of the SPA contamination teams knowledge) they represent a reasonable interpretation of the current conditions within the investigation area and as limited by the scope of assessment.

Sampling techniques, by definition, cannot determine the conditions between the sample points and so this report cannot be taken to be a full representation of the sub-surface conditions. This report only provides an indication of the likely sub surface conditions.

Conditions encountered when site work commences (i.e. Early Works Program) may be different from those inferred in this report, for the reasons explained in this limitation statement. If site conditions encountered during site works are different from those encountered during the SPA contamination teams site investigation, the SPA contamination team reserves the right to revise any of the findings, observations and conclusions expressed in this report.

The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report.

In preparing this report, the SPA contamination team has relied upon, and presumed accurate, information provided by the SPA and from other sources. Except as otherwise stated in the report, the SPA contamination team has not attempted to verify the accuracy or completeness of any such information. The reliance on provided information is governed by the specific limitations as detailed in the respective information sources. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

The SPA contamination team has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, SPA, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and SPA. Jacobs/SPA accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Executive summary

This executive summary should be read with consideration of the 'Important note about your report' (provided above) and the scope and limitations of this investigation provided throughout this report and specifically in Sections 1 to 4.

Further to the above please note:

- This investigation was limited to the Stage 1A works associated with the Early Works Program within the larger Warringah Freeway Upgrade (WFU) project area. Hence, was not inclusive of the larger project area beyond the specific 'sub areas' nominated within this report.
- The investigation work described within this report was conducted in May 2021, prior to the commencement of any works on site related to the Early Works Program.
- Where required, the investigation provided advice on the contamination status of the area(s) and the need for further assessment/management in the context of the of the Stage 1A Works and the protection of construction workers undertaking the Early Works Program.
- The investigation evaluated compliance with Western Harbour Tunnel and Warringah Freeway Upgrade (SSI-8863) conditions of approval.
- This investigation was designed to be an independent assessment of 'known contamination' (i.e. PAH contamination and asbestos) and potential contamination (heavy metals) identified by the Environmental Impact Statement (EIS, January 2020). The assessment incorporates some of data previously collected by SMEC (as specified in Section 4.2 of this report), that was relevant to the assessment of PAH contamination and asbestos.
- Further, the conclusions of the SPA investigation are not intended to represent a 'suitability' assessment for the proposed use and occupation of the investigation areas during the Early Works Program.

This specific report refers to the sub portions (i.e. proposed support areas) of the Cammeray Golf Course (CGC), Cammeray, located within the WFU project area. **This executive summary should be read with consideration of the discussion provided in Section 1 of this report.**

<u>Purpose/objective</u>

Provide advice on the contamination status of the area(s) and the need for further assessment/management in the context of the Stage 1A Works and the protection of construction workers undertaking the Early Works Program.

The following conclusions and recommendations were made based on the scope/limitations of the assessment:

<u>Conclusions</u>

1) **Condition E117(i)** requires a Detailed Site Investigation report that concludes "*whether the land is suitable (for the intended final land use) or can be made suitable through remediation*."

   Based on the available information presented within this report, SPA conclude that the **investigation areas are not likely to be suitable for all potential unrestricted final land use(s) at this time.** This conclusion is based on (but not limited to) the following reasons:

- This initial Detailed Site Investigation (DSI) is only for the early works. In the next stages of the Warrnigah Freeway Upgrade (WFU) project, there is likely to be a range of construction activities that will involve bulk excavation of material, remediation of contaminated soil (if present), reforming the land, construction of paved surfaces, basements and placement of clean spoil on the respective construction areas. This work is expected to significantly reform the soil profile and therefore change potential exposure scenarios under a potential unrestricted final land use.
- The next stages of construction activities present a risk of potential contamination (e.g. hydrocarbon/fuel spills by the contractor that may increase the level of contamination within the soil).
- The EIS indicates that the final land use of the CGC will be for a Motorway Control Facilities and a re-configured golf course. However, there is currently no detailed design available for the final land use arrangements and there are many unknown design parameters that makes it impossible to accurately determine whether the site is or is not suitable for its intended land use until Final Design is achieved by the Main Works Contractor in 2022.

The investigation areas could be made suitable through remediation/management; however, any such suitability determination is likely to require confirmation of the following (as a minimum).

- The proposed final land use(s).
- Clear designation of the land area requiring a suitability statement. Typically, this would either be a Title boundary or a survey area.
- The final design/layout of the freeway (post construction). This would need to include areas proposed to be excavated/filled, final design levels and proposed finished paving materials.
- Soil contamination data representative of the soils where such future soils will be exposed to future occupants. With respect to this point we note that many areas of the proposed alignment will be excavated, reshaped and/or filled. With the final soil quality of these areas unknown at this time.
- Assessment of groundwater quality and potential groundwater future extraction and use(s).
- Assessment of soil vapour quality and the potential for soil vapour to affect any future structure built on-site (including basements).
- Evaluation of potential off-site sources of contamination and the potential for any off-site source of contamination to affect the potential future on-site land uses.
- Where residual contamination remains on-site (post freeway construction), documentation and management of residual contamination.

2) **Condition E118** – "*Should remediation be required to make land suitable for the final intended land use, a Remediation Action Plan must be prepared or reviewed and approved…*"

Remediation is not required to make the investigation area 'suitable' for the Early Works Program, as potential interaction with soil contamination and/or asbestos will be managed by the Construction Environmental Management Plan (CEMP) for the works.

Determination of the need for remediation (and Remediation Action Plan) to make the site/s suitable for a future use can only be assessed once additional information is provided (i.e. the proposed land use, final development design, etc,) and further assessment is conducted (i.e. soil, groundwater conditions) over the whole WFU project area.

This conclusion also addresses **Conditions E119 and E120**.

3) Fill (including building waste/debris) and contaminated soils were identified within the investigation areas. This fill and soil will require management during the Early Works Program. It is proposed that this management will occur via the implementation of the CEMP.

4) Although the SPA assessment was focused on the areas proposed to be used for the Early Works Program, the results and conclusions of this assessment (with respect to PAH soil contamination and asbestos) are likely to be applicable to all areas of the CGC where fill is present.

5) Odorous and contaminated soil (B(a)P TEQ) was reported at one location (BH15_D_CGC) at 1.0m depth below a layer of asphalt. However, statistical analysis of the data set (as per National Environment Protection (Assessment of Site Contamination) Measure 1999, as revised 2013 - NEPM) showed that reported contamination levels were (on average) below the guideline values for the proposed construction use of the site and that use of the average concentration met the statistical criteria defined in the NEPM.

6) Reported concentrations for all other contaminant compounds in soil were below the adopted guideline values (for all individual sample results).

7) Asbestos was not identified by the laboratory in any of the samples submitted for asbestos identification and asbestos containing materials were not observed by the SPA contamination team (Jacobs) while collecting the soil samples.

8) The report of ‘distinct asphalt odours’ at BH15 may also be indicative of a larger area of contamination within or adjacent to the investigation area. The observation of similar fill across the investigation area combined with the heterogenous nature of fill suggests that there is the potential for unexpected contamination to be encountered in other areas of the site.

9) The SMEC samples collected from the deeper fill (i.e. greater than 1.2m below ground surface, as noted in Section 4.2 and 7.5) was reviewed for inclusion in the overall data set. Note that this data gave an indication of the contamination status of deeper fill at the site. The results of the samples from 0-1.0m below ground surface and the deeper samples indicated a similar contaminant profile. Therefore, fill across the soil profile was expected to be similarly contaminated and require similar management under the CEMP.

10) The SMEC analysis (for TRH, BTEX, pesticides and PCBs) did not indicate contamination that would present a risk to the proposed occupation and use of the site associated with the Early Works Program and therefore further evaluation of these contaminants was considered not to be warranted.

11) As noted in Section 2.3 (viii), this assessment was not designed to provide in-situ classification of soils for off-site disposal. In the event that off-site disposal of soils is required, EPA guidelines with respect to off-site soil classification/disposal will need to be considered.

<u>Recommendations for the Construction Environmental Management Plan (CEMP)</u>

A CEMP has been prepared and is being implemented for the CGC works. The CEMP includes management protocols for soil and water and unexpected contamination finds. This CEMP has been communicated to all on-site staff during induction and tool- box meetings. Compliance with the CEMP and specialist protocols is managed through regular site environmental inspections by the Independent Environmental Representative and the SPA environmental management team. Transport for NSW have also appointed an experienced erosion and sediment control specialist to review soil and water plans and inspect the works as they progress to ensure the risk of migration of any contaminated soil off site is minimised to acceptable levels. The unexpected contamination finds protocol triggers a ‘stop work’ and assessment (with consultation of a suitably qualified/experience environmental professional). This assessment will evaluate the potential for contamination associated with the ‘unexpected find’ and the need for implementation of additional management controls to eliminated/reduce any exposure to the identified contamination/material.

These measures have been incorporated into the CEMP (including the use of PPE) to ensure that all fill/soils encountered are treated as potentially contaminated and managed accordingly. These controls should be sufficiently robust to minimise/eliminate any on-site exposure to site workers and/or offsite migration of potentially contaminated materials by various pathways including air and water. The following recommendations are made specifically for consideration within the CEMP.

The following recommendations are made specifically for consideration within the CEMP for CGC. For areas in the vicinity of BH15, no sub-surface works are to be undertaken until either of the following options are implemented:

a) Further investigations to assess the extent and degree of odorous materials at and in the vicinity of location BH15; or

b) The CEMP should clearly identify the area around BH15 as a ‘known area of contamination’ with strict restrictions on subsurface excavation in this area without approval and supervision of an environmental consultant.

For all other areas of the site (i.e. areas within the footprint of the proposed construction support site exclusive of areas in the vicinity of BH15), the following is recommended:

c) Given the presence of other building waste/debris (including asphalt), there is a potential for undiscovered soil contamination and/or asbestos containing materials to also be present within fill. The potential for undiscovered soil contamination and/or asbestos containing materials to be present within the subsurface should be noted within the CEMP (including an unexpected finds procedure).

d) The CEMP should also give consideration for the potential to odours soil to be encountered during any subsurface excavation works and appropriate procedures developed/implemented to minimise odour generation and/or exposure.

e) The CEMP should also ensure that any disturbance of the site surface is managed appropriately (this includes scrapping of the surface and vehicle movements). For example, minimise dust generation, surface water/sediment runoff from the site, etc.). In the event that off-site disposal of soils is required, EPA guidelines with respect to off-site soil appropriate classification/disposal will need to be considered.

<u>Recommendations relevant to Planning Approval Conditions</u>

f) **Approval Condition E115** - As noted in Section 1 of this report, it is recommended that further consideration be given to the definition of ‘disturbance’ in relation to the Early Works Program and subsequent Main Works contract.

g) **Approval Condition E117(i)** - “whether the land is suitable (for the intended final land use) or can be made suitable through remediation.” As noted in Conclusion (1) of this report, any such suitability statement is likely to require additional assessment/information.

   Further, it is not practical to provide a suitability statement prior to the completion of the freeway construction works as there is the potential for further excavation and removal of soil as well as re-profiling the land and the construction of permanent hard stand surfaces.

   In order to make this assessment, detailed final design plans are required. It is also possible that further contamination may be caused at the site during the main works construction phase (e.g. fuel and oil spills) which may affect the contamination levels within the existing work areas.

h) **Approval Condition E121 and E122** – Provision of Audit Reports/Statements regarding the suitability of the site(s) for a future use.

Considering the staged and dynamic nature of planned construction activities, SPA recommends that further DSI's are undertaken for all forthcoming stages with the final assessment of suitability made at the completion the final stage of the project and when full detailed design for the proposed golf course, Motorway Control Centres and other permanent infrastructure such as pathways, Golf Course Maintenance facilities (e.g. sheds/ material stockpile areas) are known.

Our recommendation is that compliance with this condition is applied at the completion of the construction program (i.e. post demobilisation of construction equipment/structures) to ensure that surplus land is suitable for use by future occupants.

1 Introduction

The Sydney Program Alliance (SPA) contamination team undertook an assessment of potential contamination with respect to the construction support site for Early Works Program of the Western Harbour Tunnel and Warringah Freeway Upgrade project.

Key points for this assessment are noted below:

- The investigation work described within this report was conducted in May 2021, prior to the commencement of any works on site related to the Early Works Program.
- This assessment was limited to the proposed temporary construction support areas including utility works within these construction support areas (associated with the Early Works Program) within the larger Warringah Freeway Upgrade (WFU) project area (subject to the Main Works Program). Hence, was not inclusive of the larger WFU project area beyond the specific ‘sub areas’ nominated within this report.
- The proposed extent of the six separate construction support areas is presented on **Figure 1-1** (north western portion of Cammeray Golf Course (CGC)) and **Figure 1-2** (south western portion of Cammeray Golf Course (CGC)).
- This assessment was designed to be an independent assessment of ‘known contamination’ (i.e. PAH contamination and asbestos) and potential contamination (heavy metals) identified in Appendix M of the Environmental Impact Statement, January 2020 (EIS).
- The SPA assessment was not intended to be a comprehensive assessment of the larger WFU project area (inclusive of the specified investigation areas), for a broad range of potential contaminants and media, with the goal of providing a suitability statement (or similar) for any future land use.
- Further, the conclusions of the SPA assessment are not intended to represent a ‘suitability’ assessment for the proposed use and occupation of the investigation areas during the Early Works Program.
- The assessment incorporates a limited amount of data previously collected by SMEC (as specified in Section 4.2 of this report).

This assessment was designed so that appropriate soil management measures could be adopted during the Early Works Program to manage identified and potential contamination associated with the Early Works Program only (also refer to Section 2 for background, assumptions, and limitations).

The investigations undertaken by SPA at the site have been undertaken in general accordance with guidance endorsed under Section 105 of the Contaminated Land Management Act 1997 and other relevant guidelines and provided to DPIE to meet the requirements of the Early Program scope of works (refer to Section 2.1 below).

Figure 1-1: Proposed construction support site extent (north western portion of CGC)

Figure 1-2: Proposed construction support site extent (south western portion of CGC)

2 Background

This assessment report was prepared in relation to the Western Harbour Tunnel and Warringah Freeway Upgrade project. Key considerations relevant to the development of this report are noted below:

- Environmental Impact Statement (EIS, January 2020) – Predominantly a 'desktop' assessment of potential contamination. The EIS attributed a 'risk ranking' to sub areas of the alignment.

  The evaluation criteria used to determine the 'risk ranking' as detailed in the EIS was based on the potential for contamination to be present and the likelihood of excavation occurring (with such areas where both of these events area likely to occur, given a medium to high risk ranking).

  Importantly, the 'risk ranking' in the EIS does not appear to be based on the likelihood of a human health or environmental risk. The "risk ranking" detailed in the EIS was used to identify construction limitations/constraints and management options within the project area with respect to contamination.

  Therefore, the inference that areas classified as medium/high risk also represent a medium/high risk to human health and the environment under a prescribed land use is potentially misleading.

- The planning approval for the project *Western Harbour Tunnel and Warringah Freeway Upgrade (SSI-8863)* includes several conditions related to contamination (namely E115 to E124).

  With respect to these conditions the following comments are noted:

  1) **Appraisal of 'risk'** - Several conditions infer that high levels of contamination are present within the alignment that present a potential a risk to human health and that extensive assessment and potential remediation is required to assess and ameliorate the risk to human health.

     This interpretation of 'risk' does not appear to be aligned with the definition of 'risk' adopted by the EIS.

     Also, there does not appear to be provision of an intermediary step(s) where further site-specific assessment and consideration of likely human health risks to construction workers can be undertaken and that the outcomes of such an assessment could results in a revision to the classification of a 'moderate/high risk rating' to a lower risk ranking.

  2) **Type/Timing of construction works** - Condition 115(a) states *"Prior to the commencement of any work that would result in the disturbance of moderate to high risk contaminated sites as identified in the documented listed in Condition A1, a Detailed Site Investigations must be undertaken".*

     - "Disturbance" is not defined in the condition (e.g. soil sampling, bulk excavations) and it is uncertain as to how this relates to the Stage 1A work.
     - **Recommendation (f):** the definition of 'disturbance' be clarified with Transport for NSW (TfNSW) and the Department of Planning, Industry and Environment (DPIE).
     - The exclusion of 'low' risk contaminated sites implies that a DSI is not required for 'low risk' contaminated sites. Therefore, further augmenting the need to clarify the definition of 'risk' and revision of the risk ranking (as discussed above).

  3) **Scope/timing of contamination assessment** - Condition E117(i) requires a Detailed Site Investigation report that conclude "*whether the land is suitable (for the intended final land use) or can be made suitable through remediation*."

     Any such conclusion regarding 'suitability' would likely require conformation of the following:

     a) The proposed final land use(s).

b) Clear designation of the land area requiring a suitability statement. Typically, this would either be a Title boundary or a survey area.

c) The final design/layout of the freeway (post construction). This would need to include areas proposed to be excavated/filled, final design levels and proposed finished paving materials.

d) Soil contamination data representative of the soils where such future soils will be exposed to future occupants. With respect to this point we note that many areas of the proposed alignment will be excavated, reshaped and/or filled. With the final soil quality of these areas unknown at this time.

e) Assessment of groundwater quality and potential groundwater future use(s).

f) Assessment of soil vapour quality and the potential for soil vapour to affect any future structure built on-site (including basements).

g) Evaluation of potential off-site sources of contamination and the potential for any off-site source of contamination to affect the potential on-site land uses.

h) Where residual contamination remains on-site (post freeway construction), documentation and management of residual contamination.

Given the above points, it is not practical to estimate the scope of work and time required to satisfy this Condition of approval. Further, the need to undertake a Statutory Contaminated Land audit to make a suitability statement remains a possibility. In the event that a Statutory audit was required to satisfy this condition, the time required to collect the required information and complete the audit is estimated to be 6-12 months.

It should also be noted that any such 'suitability statement' with respect to the final land use made prior to the commencement of the Main Works contract would likely be negated by the construction work required to deliver the Main Works contract and a new suitability statement would need to be provided at the completion of the Main Works contract.

Hence, any such 'statement of suitability' is most likely best made at the completion of the construction works.

Recommendation (g) and (h): Our recommendation is that compliance with this condition is applied at the completion of the construction program (i.e. post demobilisation of construction equipment/structures) to ensure that surplus land is suitable for use by future occupants.

2.1 Current stage of the construction program

The Warringah Freeway Upgrade and Western Harbour Tunnel Project is divided into the following stages:

- Stage 1A- Critical Utilities Installation, Relocation and Protection (CUT).
- Stage 1B- Cammeray Golf Course Adjustment Works.
- Stage 2A- Warringah Freeway Upgrade Early Works.
- Stage 2B- Warringah Freeway Upgrade Main Works.
- Stage 3- Western Harbour Tunnel Project.

The SPA scope, applicable to this DSI is Stage 1A CUT of the WFU with the Stage 2 Main Works to commence in 2022. The Stage 2 scope will inform the final design and layout of the Warringah Freeway and ancillary facilities. It is noted that each of the Stages are required to manage areas of moderate/high potential contamination in accordance with Conditions E115-E118 and accordingly will require each contractor to prepare Detailed Site Investigations (DSI's) for their relevant scope of works. In line with the Stage 1A scope, SPA have prepared a DSI for CGC based on the temporary construction support areas and utility relocations and installations that triggered these works.

Currently the EIS provides a reference design for the following final land uses associated with the CGC area which is associated with this DSI:

- Freeway (Commercial/ Industrial)
- Motorway Ancillary Facilities (Commercial/ Industrial)
- Parklands (Recreational/Public Open Space)
- Golf Course (Recreational/Public Open Space).

As noted above, there are a number of construction activities to be undertaken onsite that will involve further excavation, construction of temporary works/ancillary facilities, access roads, haulage roads, oil/fuel storage facilities and maintenance operations. These activities and the CGC site will all be managed by other contractors after SPA completes the Stage 1A scope in 2022. These activities and the layout, disturbance footprint and final landform/use are all currently being determined by the Stage 2B contractor (CPB/Downer) and TfNSW.

It is noted that SPA will hand these areas over to CPB/Downer in 2022 and the entire site will be developed as a construction support site (WFU8 & WHT10). Final land use will be determined for this broader area once the final design is determined for the areas discussed above.

The current phase (Stage 1A) of the construction program is related to the 'Early Works Program' and includes various site establishment activities related to the preparation of the site for the Main Works contractor. These works are understood to include:

- Establishment of temporary site construction facilities and equipment storage areas. These area(s) were to be used primarily for construction support activities (e.g. temporary site shed, vehicle parking, laydown areas for equipment/supplies, etc.).
- Clearing surface vegetation.
- Note that these areas were 'sub-areas' within the larger alignment corridor.
- Oversite of assessment activities to support the future Main Works contractor.
- Identification, management and relocation of underground services including:
  - Relocation of existing in-ground Ausgrid assets
  - Removal of existing disused in-ground Ausgrid assets
  - Relocation of existing in-ground Sydney Water assets
  - Relocation of existing in-ground communication provider assets.
- Ancillary Facility establishment and operation (including)
  - Staff amenities
  - Off-street car parking
  - Laydown.

The above works are predominantly related to above ground construction works with disturbance of subsurface soils. Where subsurface soil removal is required (e.g. for soil sampling, utility installation), this work is covered by strict protocols to ensure any potentially contaminated soil is managed appropriately and risk to human health and the environment is negated.

2.2 Acknowledgment of pre-existing contamination status of sites

With respect to any known and/or potential contamination within the WFU project area, it should be acknowledged that any such contamination (as identified by the EIS) is likely to have been present for many years.

Similarly, the current/previous site use is predominantly public open space and therefore access by the public to these areas has been relatively unrestricted.

The history of contamination (identified by the EIS) and use appears to be incongruous with Conditions E117(i) and E118 to E122, unless it is concluded that these conditions are intended to apply to areas where:

a) significant levels of contamination have recently been identified that present a human health risk to construction workers and/or future users of the site; and/or

b) the exposure scenario applied to a site is changed by the proposed freeway construction (e.g. soil contamination that was buried becomes exposed at the surface by excavation).

2.3 Key assumptions and limitations for this assessment

With respect to the scope of this assessment, the following assumptions and limitations are relevant:

i. Assessment of potential contaminants was limited to the potential contaminants of concern identified in the EIS relevant to this investigation area.

ii. The SPA contamination team field assessment (and the SMEC field assessment) were conducted prior to the establishment/occupation of the site by the Early Works contractor. Therefore, the proposed ancillary support areas (i.e. the areas of investigation) were approximated from information provided by SPA. These areas were not located via survey.

iii. Consideration of the potential impact to the health of construction workers was the primary focus of this assessment.

iv. The investigation only targeted soils within the footprint of the proposed construction support site area associated with the Early Works Program.

v. Soil data was the most relevant media for exposure by construction workers. Therefore, collection of near surface soils (i.e. up to 1m depth) soil data was the focus of the assessment. Other exposure pathways (e.g. contact/drinking groundwater, indoor vapour inhalation of soil vapour) were considered highly unlikely to occur given the proposed used of the site and the implementation of an environmental/soil management plan. The rationale for not targeting other media is provided below:

    - Should soil contamination be identified during the Stage 1A works that is materially different to that identified by this investigation, then assessment would be required as part the requirements of the CEMP.
    - Groundwater is not anticipated to be intersected (i.e. no contact with construction workers, no extraction to support construction) as part of the proposed works.

vi. The assessment of asbestos was primarily based on visual observation and laboratory analysis for asbestos presence/absence. ***Note that this investigation does not constitute full characterisation of the site for the potential presence of asbestos nor does the results of this investigation represent an 'asbestos clearance'.***

vii. Where the magnitude and/or potential extent of contamination was unclear (following this assessment), the SPA contamination team have recommended conservative soil management measures as a precaution.

viii. This assessment was not designed to provide in-situ classification of soils for off-site disposal. In the event that off-site disposal of soils is required, EPA guidelines with respect to off-site soil classification/disposal will need to be considered.

ix. Ecological receptors were not relevant for the proposed occupation of the investigation areas for the purposes of construction activities (refer to information contained within **Section 11.6**).

3 Purpose/objective of this investigation

Given the points raised in Sections 1 and 2, the purpose/objective of this investigation was to:

- This evaluation was primarily framed by the scope of the Early Works Program (as described in Section 2.1 above) and the designated 'sub-areas' within the greater WFU project area.
- Provide advice on the contamination status of the investigation area(s) and the need for further assessment/management in the context of the proposed Early Works Program and the protection of construction workers undertaking the Early Works Program (Stage 1A).
- Comply with Western Harbour Tunnel and Warringah Freeway Upgrade (SSI-8863) conditions of approval.

For the sake of clarity, the SPA assessment scope did not include the investigation of:

- Any potential chemical contaminants or substance not specifically nominated for assessment by this report (including but not limited to chlorinated hydrocarbons, PFAS, fluoride, chlorobenzenes, phenols, dioxins/furans, phthalates, nutrients, PBDEs, phenols, 1,4-Dioxane, insecticides, micro plastics and potential acid sulphate soils).
- Any area of the greater WFU project area (or greater golf course area), beyond the areas specifically nominated within this report.
- Groundwater.
- Soil vapour.
- Off-site sources of contamination.
- In-situ classification of soils for off-site disposal.

SPA acknowledge that assessment of one (or more) of the above will be required as part of the future development stages and confirmation of the future suitability of the site (post construction), however, the SPA assessment was focused on the use of the investigation areas for Stage 1A.

Key aspects used to frame this purpose/objective were:

- A CEMP will be developed for all construction related activities (including the ancillary support areas) undertaken as part of the Early Works program. This plan will include soil management protocols and unexpected finds procedures. This CEMP will be communicated to all on-site staff during induction and tool box meetings.
- The investigation area(s) were to be used for the activities described in Section 2.1 of the report.
- Incidental excavation or soil movement (i.e. to install temporary services, level areas for vehicle access) maybe required, however, bulk soil excavation was not required.
- Exposure scenario - Occupation/use of the site was to be consistent with a construction work site (e.g. 8 hours per day, 6 days per week). The duration of occupation for construction workers was likely to be less than 5 years. Note the duration of the Early Works Program is approximately 2 years.
- Commercial/industrial soil quality guidelines were the most relevant exposure scenario for the proposed site use (i.e. construction workers during the Early Works Program). However, we note

that the published reference guideline values are based on a much longer exposure period (i.e. 30 years). Therefore, direct application of the published NEPC (2013) commercial/industrial guidelines to the proposed site exposure was conservative.

- All workers occupying the site(s) will be inducted into the safety and environment procedures relevant to works involving contact with potentially contaminated soils.
- No permanent occupiable structure would be built above or below ground within the investigation areas during the proposed use for construction support activities.
- To facilitate the proposed use of the site most of the surface vegetation would be cleared (except for significant trees).
- The general public will not have unrestricted access to the areas occupied for the Early Works Program for the duration of the construction program.

4 Summary of previous assessment work

4.1 Environmental Impact Statement

Appendix M of the EIS (2020) prepared for the Western Harbour Tunnel and Warringah Freeway Upgrade project detailed the following with respect to contamination at the proposed construction support site.

Site	***Location relative to alignment***	***Construction element and anticipated depth***	***Potential contamination source***	***Potential contamaination distribution***	***Potential contaminants***	***Risk ranking***
Unsealed areas next to Warringah Freeway – Ernest to Miller Street), Crows Nest	*Within footprint of surface works*	*Warringah Freeway Upgrade surface work (surface)*	*Deposition of particulate matter*	*Surface (potentially 0-0.1 m)*	*Heavy metals (mainly lead), hydrocarbons (mainly PAH), asbestos*	*High* • *Known contamination* • *Excavation activities within site footprint* • *Excavation activities within potential contamination distribution range (laterally and vertically)*

It is our understanding that the statement of *“Known contamination”* for this area (from the EIS report) is based the *‘Western Harbour Tunnel and Beaches Link – Contamination Factual Report (CFR)’*, (AECOM and Coffey, (AEC), 2018. The reported contamination was related to Polycyclic Aromatic Hydrocarbons (PAHs) (at two locations) and asbestos containing materials (at one location).

With respect to the previous Coffey/AECOM report, please note the SPA Contamination team considered information relevant to ‘known contamination’ identified in the Coffey/AECOM report (i.e. the likely presence of fill and that such fill was likely to contain ***‘known contamination’*** Polycyclic Aromatic Hydrocarbons (PAHs) (which includes Benzo(a)Pyrene (B(a)P)) and asbestos. Specifically,

- The areas subject to our investigation were likely to contain fill including building demolition materials with the potential for asbestos containing materials also to be present.
- Any fill present was likely to contain Polycyclic Aromatic Hydrocarbons (PAHs) (which includes Benzo(a)Pyrene (B(a)P)).
- Given the likely nature of the fill deposition across the site, the distribution of PAH contamination (and asbestos) was likely to be heterogeneous and not equivalent to assessing a point source (i.e. ‘hot spot’ contamination).

Therefore, the assessment of the nature and extent of PAH contamination and asbestos (within heterogenous fill) needed be developed and commensurate with a large data set that allowed statistical evaluation of contamination (i.e. in accordance with NEPM guidelines).

The design of our sampling approach was to collect an independent data set to reduce reliance on historic data collected by third parties.

Following review (by DPIE) of Revision 4 of this report (this is Revision 5), DPIE noted that one of Coffey/AECOM 2018 sample locations (B337_0.1-0.2) reported a Benzo(a)pyrene B(a)P TEQ concentration of (3.6 mg/kg). The SPA Contamination team noted that this reported B(a)P TEQ concentration at B337 was consistent with the findings of our assessment (refer to Section 11) of this report and would not result in a material change to our conclusions/recommendations.

4.2 SMEC 2020

SMEC were commissioned by TfNSW to undertake a contamination investigation within and adjacent to the Warringah Freeway which also included areas to be occupied by the proposed construction support. The following summary should be read in conjunction with the SMEC (2020) report.

The objective of the SMEC (2020) investigation was to collect and provide factual data to TfNSW for the purpose of informing prospective tenderers of the project of the contamination and geotechnical conditions along the proposed WFU alignment.

Important notes with respect to the use of the SMEC report/data

- The SMEC assessment was undertaken to assess the broader WFU alignment area and therefore the sample locations did not necessarily correlate with the proposed ‘sub-areas’ nominated for the Early Work Program. This is discussed further in Sections 6 and 7 of this report. Given the above, the discussion/conclusions of the SMEC (2020) report were not directly applicable to the SPA assessment.

- Two of the SMEC investigation locations (WFU_BH081 and WFU_BH108) were located immediately adjacent to the western boundary of the south western construction support areas. These locations were representative of the general area being investigated for the Early Works Program and were therefore included in the data set.

- The SMEC assessment included collection of samples from a depth greater than 1m, analysis for contaminants not identified by the EIS, and assessment of groundwater. This data was not aligned with the purpose and limitations of the SPA assessment (refer to Sections 1 to 4 of this report), did not indicate the presence of significant other contamination.

- SPA contamination team only adopted soil data from the SMEC report where it met the following criteria:

  - Was collected from within one of the proposed investigation areas (i.e. Early Works area)

  - Was collected between 0 and 1.0m below ground surface (to align with the assessment strategy). However, where deeper samples of fill where available within the investigation areas, this data was also utilised.

  - The SMEC samples collected from the deeper fill (i.e. greater than 1.2m below ground surface (as noted in Section 7.5) was reviewed for inclusion in the overall data set. Given the consistency of the fill description and laboratory results with the SPA data/observations. The SMEC data was considered representative of deeper fill across the investigation area(s) and representative of soil/fill likely to be encountered where deeper excavations are required as part of the Early Works Program.

  - Was analysed for potential contaminants identified in Appendix M of the EIS (2020) (i.e. heavy metals, PAHs and asbestos).

The following investigation works were undertaken by SMEC at the site:

- Soil sampling from 13 investigation locations (WFU_BH074 to WFU_BH080, WFU_BH082, WFU_BH083, WFU_BH085, WFU_BH089, WFU_BH099 and WFU_BH100 within the proposed construction footprint and two location immediately adjacent to the construction footprint (WFU_BH081 and WFU_ BH108).

- All soil investigation were drilled to a maximum depth of 4.8 metres below ground level (mbgl) with WFU_BH079 drilled to 14.5 mbgl to facilitate the installation of a groundwater well. All locations were drilled to intersection with natural materials (maximum fill depth of 4.1 mbgl at location WFU_BH100).

- Analysis of samples for heavy metals, PAHs and asbestos (consistent with the SPA assessment and contaminants identified by the EIS).

- Analysis of samples for other chemical contaminants (Total Recoverable Hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, Xylenes (BTEX), pesticides, Polychlorinated Biphenyls (PCB)) was also conducted by SMEC. The SMEC analysis (for TRH, BTEX, pesticides and PCBs) did not indicate contamination that would present a risk to the proposed occupation and use of the site associated with the Early Works Program and therefore further evaluation of these contaminants was considered not to be warranted. For completeness, a summary table of this SMEC data is provided in **Table 11-3**.

- Note the SMEC assessment included additional contaminant analysis not required by the EIS.

- One groundwater well (WFU_BH079) was installed and sampled.

No further discussion on groundwater quality is provided as groundwater is not anticipated to be intersected (i.e. no contact with construction workers, no extraction to support construction) as part of the proposed works (refer to the key exclusions detailed in Sections 1 to 4 of this report).

Sample locations undertaken as part of the SMEC (2020) investigation are presented on **Figure 4-1, Figure 4-2** and **Figure 4-3**.

Figure 4-1: SMEC (2020) investigation locations - CGC (figure sourced from the SMEC, 2020)

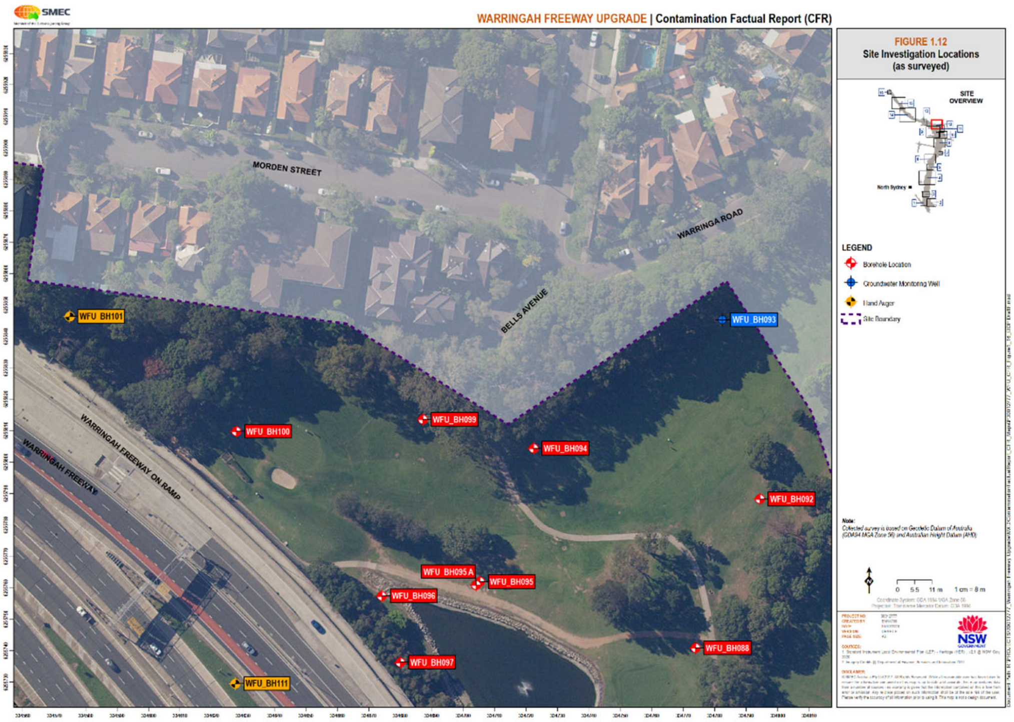

Figure 4-2: SMEC (2020) investigation locations - CGC (figure sourced from the SMEC, 2020)

Figure 4-3: SMEC (2020) investigation locations - CGC (figure sourced from the SMEC, 2020)

5 Description of the Investigation Area(s)

The investigation area(s) consists of six separate construction support areas (as defined by SPA) within the southern western and north western portions of the Cammeray Golf Course adjacent to the Warringah Freeway and Ernest Street, Cammeray NSW. The proposed construction support site areas comprise two main portions of land directly adjacent to the Warringah Freeway and four smaller, disconnected areas which will be temporarily used during installation of services.

At the time of undertaking this assessment, the majority of the proposed construction support site areas comprised grass surfaces and scattered trees (tees, fairways, greens, landscaping) associated with the golf course.

A maintenance area (buildings, parking, storage, wash bays) was present to the north of the main south western construction support area. Some drums, general wastes (e.g. wood, pipework, building materials) and vegetation wastes are present within and adjoining the maintenance area. Note: the maintenance area was not located within the proposed ancillary support area (for the Early Works program) that was the subject of this assessment.

A skate park was present within the eastern portion of the main south western construction support area.

The proposed construction support sites (as detailed in **Section 1**) were bound by residential areas to the north, the golf course and tennis courts to the east, Ernest Street to the south and the Warringah Freeway to the west.

The general topography across the proposed construction support site areas is gently undulating and slopes generally down from the northern and southern boundaries of the golf course towards a low topographical point within the north eastern portion of the golf course.

The combined ‘site investigation area’ is approximately 14,000 m^2.

6 Data review and specific scope of field work

As noted in the previous sections of this report, not all of the SMEC data was relevant to the sub area(s) of the Early Works Program. The SPA contamination team reviewed the SMEC (2020) investigation to assess potential data gaps and developed a scope of work to effectively 'fill the gaps' in order to bring the data set to a minimum standard to allow evaluation of the extent and nature of heavy metal, PAH contamination and asbestos.

The SPA scope of work was focused on 'known contamination' (PAHs and asbestos) and potential contamination (heavy metals) identified by the EIS.

Based on this review, the investigation strategy adopted to supplement the SMEC (2020) data are detailed in **Table 6-1.**

Table 6-1: Information review and proposed investigation strategy

Aspect	Reference	SMEC (2020) investigation	Additional assessment undertaken (by SPA) to supplement the SMEC data
Number and location of soil borehole locations (1)	NSW EPA (1995) Sampling Design Guidelines recommends a minimum of 24 grid-based locations for the site size (approximate construction footprint of 14,000 m^2).	13 locations within and two locations directly adjacent to the construction footprint.	15 additional locations. Total number of sample locations = 30 (including SMEC locations).
Sample depth	The EIS refers to 'surface deposition' as the likely source of contamination.	All soil investigation (with the exception of one location) were drilled to intersection with natural materials. The maximum fill depth encountered was 4.1 mbgl. One borehole was drilled to a depth of 14.5 mbgl to facilitate the installation of a groundwater well. The depth of the SMEC (2020) investigation extended to intersection with the underlying natural materials (extending beyond the potential contamination distribution as detailed in the EIS and likely to extend beyond contamination at depth potentially associated with fill materials).	Collection of near surface soils (to approximately 1 m depth). This is inclusive of surface soils. In accordance with Section 4 of this report, the depth of assessment was based on the likelihood of contact by site occupants during the early works program. Utilisation of existing SMEC data representing fill and natural has been used for materials at depth
Sample analysis (2)	Appendix M EIS (2020) identified the potential contaminants of concern for the site including heavy metals (mainly lead), hydrocarbons (i.e PAHs), asbestos	Heavy metals, Total Recoverable Hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, Xylenes (BTEX), PAH, pesticides, Polychlorinated Biphenyls (PCB), asbestos. Note the SMEC assessment included additional contaminant analysis not required by the EIS.	The analytical schedule included the potential contaminants of concern as identified in the EIS including heavy metals (including lead), PAH and asbestos. For completeness, data analysis by SPA also included relevant SMEC data.

Aspect	Reference	SMEC (2020) investigation	Additional assessment undertaken (by SPA) to supplement the SMEC data
Frequency of sample analysis	Not applicable	Two samples were analysed per borehole	Two samples analysed per borehole.

Notes:

(1) - Since the investigation areas were physically separated it was necessary to distribute the proposed sample locations across the investigation areas. The sample pattern also had to be adjusted to account for the ongoing use of the site as a golf course (i.e. drilling or excavation into a golf green/fairway would have damaged the green/fairway for use and health and safety considerations associated with SPA staff being struck by golf balls) and/or several large trees. However, a greater sampling frequency than the minimum required was undertaken to compensate for this issue. For example, AS4482.1 recommends 24 sample locations, sampling was undertaken at 30 locations (i.e. 25% more than recommended). Further 68 samples were analysed for metals and PAHs (almost three times more than the minimum recommended).

It is also noted that the EPA sampling design guideline is based on AS4482.1 and the 95% confidence of detecting a hypothetical circular 'hotspot' of contamination from a point source of contamination. Systematic (grid based) sampling is recommended for site validation; however, alternate sampling patterns are acceptable for non-validation assessment.

Given the site restrictions (noted above) and the heterogeneous nature of fill within the investigation areas (i.e. non-point source contamination), the sampling strategy undertaken was aligned with the purpose and limitations of this assessment (refer to Sections 1 to 4 of this report) and a judgmental sampling pattern was adopted (as allowed within AS4482.1).

(2) – Sample analysis conducted by SPA contamination team (Jacobs) was based on the potential contaminants identified in Appendix M of the EIS (i.e. heavy metals, PAHs and asbestos). We note that a broader analysis suite was undertaken by SMEC (including TRH, BTEX, pesticides and PCB).

The SMEC analysis (for TRH, BTEX, pesticides and PCBs) did not indicate contamination that would present a risk to the proposed occupation and use of the site associated with the Early Works Program and therefore further evaluation of these contaminants was considered not to be warranted.

However, note that any future assessment of the site for post construction 'suitability' will need to consider a broad range of potential contaminants.

7 Site investigation

The following information details the fieldworks undertaken during the SPA investigation.

With respect to the purpose and limitations of this assessment, refer to Sections 1 to 4 of this report.

7.1 General overview

The fieldwork for the investigation was undertaken over three days between 28 April and 12 May 2021. The investigation was undertaken by a contaminated site consultant who was responsible for undertaking the work, site observations, excavation logging and sample collection.

7.2 Potential sources of contamination

Response to Condition 117(a) – Primary sources of contamination

Imported Fill - Previous studies of the CGC identified that the general area had been filled with imported materials. The imported fill was likely to be heterogenous and contained building debris. Contaminants likely to be present included heavy metals, PAHs and asbestos.

Sampling and analysis of surface soils was undertaken to address potential contamination type (heavy metals, PAH and asbestos) and distribution (surface deposition) detailed in the EIS for the CGC construction support site.

Other potential sources of contamination were not identified (e.g. underground fuel tanks or historic manufacturing practices that could have resulted in point sources of contamination) within the investigation areas.

7.3 Physical and chemical properties of contamination

Response to Condition 117(b) - ***contaminant dispersal in air, hazardous ground gases, surface water, groundwater, soil vapour, separate phase contaminants, sediments, infrastructure (e.g. concrete), biota, soil and dust;***

Response to Condition 117(c) - ***contaminant characterisation and behaviour (volatility, leachability, speciation, degradation products and physical and chemical conditions on-site which may affect how contaminants behave);***

Potential Contaminant	Comments
PAHs (including (B(a)P TEQ)	PAHs are commonly associated with gasworks waste and asphalt. The PAH group (of approximately 16 different PAHs) are generally classed as semi-volatile, however, B(a)P TEQ is non-volatile. Therefore, PAHs (and specifically (B(a)P TEQ)) is unlikely to partition into the soil vapour phase and impact ground gases or disperse into the air. PAHs (including (B(a)P TEQ)) also has a low solubility.

Potential Contaminant	Comments
	Therefore, PAHs (and specifically (B(a)P TEQ)) is unlikely to leach when contacted with water under normal pH conditions. PAHs (including (B(a)P TEQ)) are not expected to have a detrimental effect on concrete (note that asphalt (contains high concentrations of PAHs) is commonly install adjacent to concrete structures). PAHs (including (B(a)P TEQ)) is stable when subject to the environment and not considered to be biodegradable. **Site behaviour** - Note that any soil contamination within the investigation area(s) and beyond, is likely to have been present for many years and is likely associated with the originally filling/levelling of the site. Therefore, any impact to the environment from this contamination would similarly have been occurring for many years. Left undisturbed this contamination is expected to have negligible impact on the proposed temporary construction use of the site as part of the Early Works program. However, where excavation of subsurface soils is required, any excavated material should be managed appropriately to minimise exposure to humans and the environment.
Heavy metals	Heavy metals are commonly associated with imported fill. Note the EIS also identified the potential for lead deposition from the adjacent freeway. Heavy metals are non-volatile. Therefore, heavy metals are unlikely to partition into the soil vapour phase and impact ground gases or disperse into the air. However, note concentrations of metals in soil would likely need to be greater than background concentrations for a measurable impact to water to be observed. Heavy metals are not expected to have a detrimental effect on concrete. **Site behaviour** - Note that any soil contamination within the investigation area(s) and beyond, is likely to have been present for many years and is likely associated with the originally filling/levelling of the site. Therefore, any impact to the environment from this contamination would similarly have been occurring for many years. Left undisturbed this contamination is expected to have negligible impact on the proposed temporary construction use of the site as part of the Early Works program. However, where excavation of subsurface soils is required, any excavated material should be managed appropriately to minimise exposure to humans and the environment.
Asbestos	Asbestos is commonly associated with imported fill containing building debris (as noted on site and the previous identification of a single piece of asbestos containing materials. Asbestos is non-volatile and non-leachable.

Potential Contaminant	Comments
	Therefore, asbestos would not partition into the soil vapour phase and impact ground gases or disperse into groundwater. However, if disturbed asbestos containing materials may lose integrity (i.e. break up) releasing asbestos fibres to the air. Asbestos is not expected to have a detrimental effect on concrete. **Site behaviour** - Note that any asbestos within the investigation area(s) and beyond, is likely to have been present for many years and is likely associated with the originally filling/levelling of the site. Therefore, any impact to the environment from this contamination would similarly have been occurring for many years. Left undisturbed asbestos is expected to have negligible impact on the proposed temporary construction use of the site as part of the Early Works Program. However, where excavation of subsurface soils is required, any excavated material should be managed appropriately to minimise exposure to humans and the environment.

7.4 Soil investigation

Fifteen locations (BH06, BH07, BH08, BH09, BH10, BH11, BH12, BH13, BH14, BH15, BH16, BH17, BH18, BH19 and BH20) were excavated using decontaminated hand tools (hand auger and crowbar) to 1.0 mbgl (or refusal).

The approximate investigation locations undertaken by SMEC (2020) and SPA (2021) are presented on **Figure 7-1**.

It is noted that current design for some utilities within the Golf Course (sewer north and south) have changed since the original investigations were undertaken in Rev 1 of this report).

Where proposed ground disturbance is outside these investigation areas, SPA will be required to undertake further sampling to adjust these investigation areas and update the Conceptual Site Model and DSI accordingly.

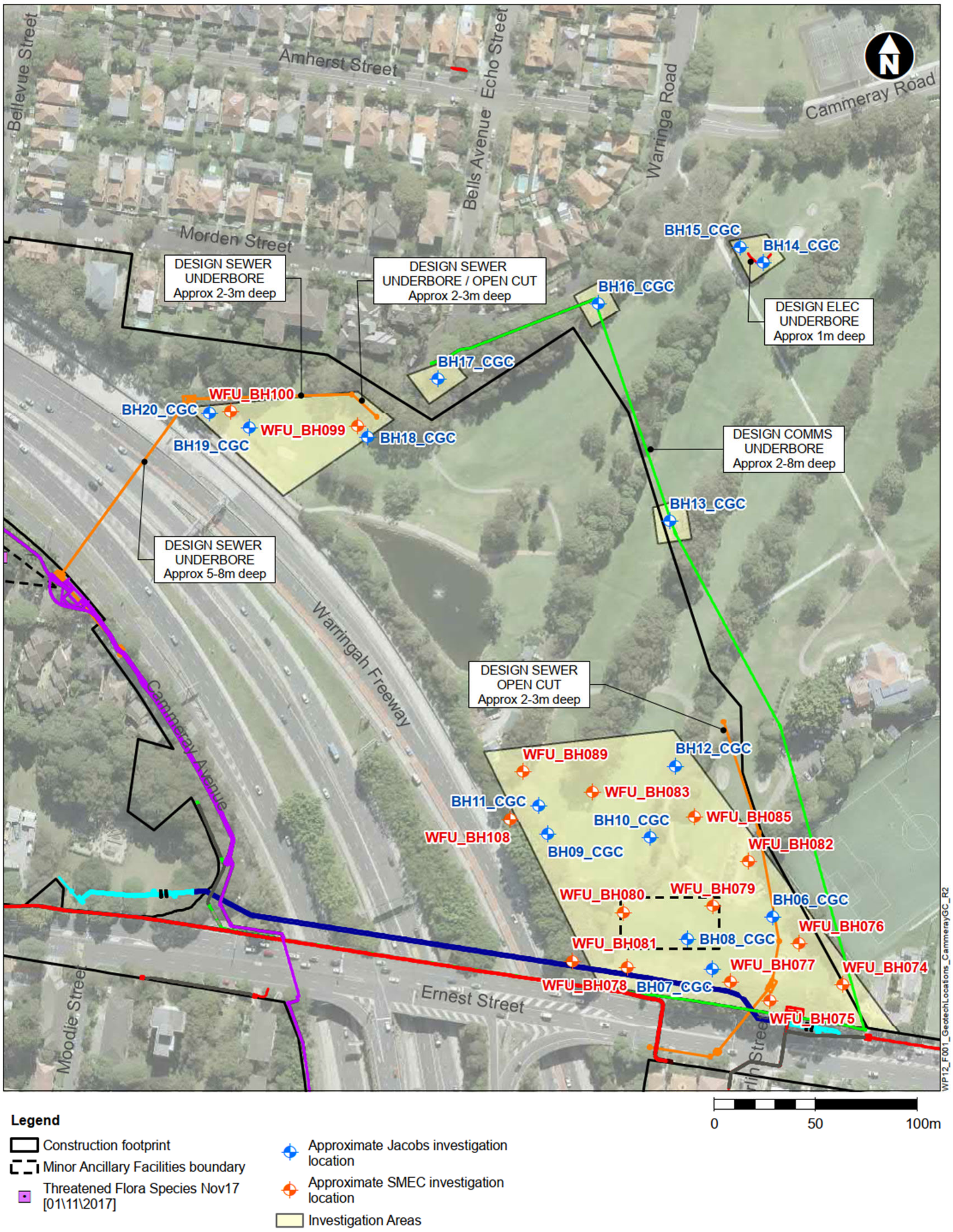

Figure 7-1: Approximate investigation locations - Cammeray Golf Course

7.5 Depth intervals of sampling

SPA collected soil samples from the investigation areas at the surface (0.0 – 0.1 mbgl) and at depths of 0.25 mbgl, 0.5 mbgl, and 1.0 mbgl or at discreet sampling depths where potential contamination was observed.

Note that SMEC had collected deeper soil samples at eight locations (BH078 (2.0-2.1m and 3.0-3.1m), BH080 (2.0-2.1), BH082 (1.2-1.4), BH089 (2.0-2.1), BH099 (2.0-2.1) BH100 (3.65-3.85) and BH108 (2.8-2.9)).

7.6 Method of sample collection

All soil samples were collected as grab samples from below the surface of the grass and from a decontaminated hand auger at depth. Samples were transferred to sample containers by the field staff by hand using disposable nitrile gloves. New nitrile gloves were used for the collection of each sample.

Care was taken to ensure that representative samples were obtained from the depth required and that the integrity was maintained, which is particularly important when dealing with potentially volatile components. As the contaminants of concern (heavy metals, PAH and asbestos) tested for in the samples collected by SPA are not volatile, no PID screening was undertaken by SPA.

SPA acknowledge that the sample collection method (hand auger) had the potential to lose entrainment of asbestos fragments during sampling and for this effect the identification of asbestos fragments. An alternate sampling method (test pits) was considered. This would have resulted in significant disturbance of the subsurface soils in order to provide a higher degree of confidence of the presence/absence of asbestos, however, even this intensive level of assessment would not guarantee all potential asbestos containing materials would be identified and located. Specific site restrictions (i.e. damage to operational golf course areas) would not have allowed for test pits to have been excavated.

Given that the purpose of the SPA assessment aligned with the Stage 1A of the construction program and that a CEMP (with unexpected finds procedure) was to be implemented, further assessment to provide an asbestos clearance certificate (or equivalent level of assessment), was not warranted.

SPA was satisfied that the level of asbestos assessment conducted was fit for purpose and aligned with the objectives stated within this report.

7.7 Sample containers, method of sample storage and handling

All soil samples were placed in jars provided by the primary laboratory Envirolab Services (Envirolab). The jars were completely filled with soil, labelled with the date, unique sampling point identification and sampler information.

The soil jars, once filled with sample and sealed, were immediately placed in an esky / cool box in which ice had been added. At the end of the sampling program the samples in the esky / cool box were transported to the primary laboratory. Custody seals were placed on the esky / cool box for delivery to the laboratory.

An inter-laboratory duplicate was sent to the secondary laboratory Eurofins Scientific (Eurofins).

7.8 Decontamination procedures

The hand auger and crowbar were decontaminated between sample locations by washing with a solution of phosphate free, PFAS free, laboratory grade detergent (Liquinox) and potable water and rinsed with potable water.

7.9 Sample logging

Field staff completed soil logs for the excavation locations. The logs recorded the following data:

- Sample number and depth.
- Soil classification, colour, consistency or density, moisture content and obvious indications of contamination.
- Depth of excavation.
- Excavation refusal.
- Method of excavation.

7.10 Laboratory analysis

Soil samples were selected for laboratory analysis based the potential contaminants for the site as detailed in the EIS Appendix M (2020). A summary of the laboratory testing undertaken is detailed in **Table 7-1.**

Table 7-1: Laboratory testing

Laboratory Test	Quantity
Heavy metals (As, Cd, Cr, Cu, Pb, Ni, Hg, Zn),	30 primary and 4 QAQC
Hydrocarbon compounds (PAH)	30 primary and 4 QAQC
Asbestos (presence/absence)	15 primary

7.11 Analytical parameters and methods

Envirolab and Eurofins were engaged as the primary and secondary laboratories, respectively. All laboratories are National Association of Testing Authorities (NATA) accredited for the testing undertaken.

Where appropriate, the soil samples were analysed in accordance with NEPC National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended 2013 (NEPC, 2013) guidelines using methods based on US Environment Protection Agency (US EPA) and American Public Health Association (APHA) approved analytical methods.

Laboratory certificates from Envirolab indicate that asbestos testing was undertaken by analysing a sub-sample from jars. The Envirolab reports state "w*e cannot guarantee that this sub-sample is indicative of the entire sample."*

SPA note this qualification by the laboratory. However, SPA was satisfied that this qualification did not conflict with the qualitative asbestos assessment undertaken by SPA (as noted in Section 2.3 (vii)) of this report.

7.12 Conceptual Site Model

It is noted that current design for some utilities within the Golf Course (sewer north and south) have changed since the original investigations were undertaken in Rev 1 of this report.

Where proposed ground disturbance is outside these investigation areas, SPA will be required to undertake further sampling to adjust these investigation areas and update the Conceptual Site Model and DSI accordingly.

Response to Condition 117(g) – the review and update of the conceptual site model from the preliminary and detailed site investigations.

A conceptual site model involves consideration of contamination sources, pathways and receptors.

Sources of contamination –

- Previous investigations identified widespread historic fill (of unknown origin) present (or likely to be present across the greater golf course area (and potentially beyond). This fill is known to contain building debris and therefore potentially contain PAHs, heavy metals and asbestos containing materials. The EIS also identified the potential for lead, PAH and asbestos deposition from the adjacent freeway.

- The SPA assessment confirmed the presence of fill at all investigation areas and did not identify any other potential point sources of contamination within the investigation areas.

Pathways –

Any PAHs, heavy metals and asbestos containing materials within the fill was likely to have been present for many years (i.e. site the area was originally filled). The investigation areas are unsealed or uncovered meaning that the underlying contamination has been exposed to environmental conditions for a long period of time. Therefore, contaminant migration/exposure pathways have been present/active for the same period of time.

As discussed in **Section 7.3**, SPA evaluated the physical/chemical properties of the identified contamination related to contaminant migration pathways. The general properties of the contamination present are no to low solubility or volatility. Therefore, these contaminants are expected to be relatively stable in the environment (i.e. if they were soluble/volatile and exposed to the open environment (as soils at the site have been) then they would have already dissociated from the soil matrix.

Left in-situ, the exposure pathways would not change from the pre-existing pathways present for many years.

In the event that subsurface soils are excavated during the Early Works program the additional exposure pathways would need to be considered to ensure contaminated soil was managed appropriately. SPA considered these pathways (e.g. dermal contact, dust ingestion/inhalation, water runoff) within the soil management procedures of the CEMP.

Receptors –

The fill within the investigation area (and greater golf couse) has been subject to unrestricted access for many years. Exposed receptors where/are likely to include:

- The general public (i.e. any one playing golf or attending the site for any other reason).

- Employees of the Cammeray Golf (especially those involved in ‘ground keeping’ and any subsurface digging/excavation).

- Any subcontractors undertaking works at the site (especially those in contact with soil).
- Any other workers undertaking subsurface works (e.g. utility providers).
- Conversely all works undertaken by SPA will be controlled under the CEMP. The CEMP provides:
- Establishment of work areas that exclude access by the general public and any unauthorised people.
- A system for the management of any excavated soil.
- Identification and notification of unexpected finds.
- Use of PPE by site workers.

Implementation of the CEMP will eliminate and/or control the exposure to receptors and is likely to be a significantly higher level of management than previously applied to any works at the Cammeray Golf Course.

Conclusion

SPA considered this 'conceptual site understating' sufficient for the development of site management measures related to the Early Works program (as detailed in the CEMP).

8 Quality control plan

Field and laboratory QA/QC requirements compliant with NEPC (2013) requirements (where applicable) were undertaken as part of the fieldwork program as outlined below.

8.1 Field QA/QC program

8.1.1 Environmental samples

Environmental samples or field samples were the representative soil samples collected for analysis to determine aspects of their chemical composition.

8.1.2 Blind replicate sample

A blind replicate sample was provided by the collection of two environmental samples from the same location. These samples were preserved, stored, transported, prepared and analysed in an identical manner. As a minimum, the results of analyses on the blind replicate sample pairs were assessed by calculating the Relative Percentage Differences (RPDs) between the results. The RPD was calculated as the difference between the results divided by their mean value and expressed as a percentage. If the RPD exceeded the value adopted for any analytes, additional investigation would be required, or justification provided for not conducting additional investigation.

Blind replicate samples should be collected at a rate of one duplicate for every 20 environmental samples in accordance with AS 4482.1-2005 *Guide to the sampling and investigation of potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds* (AS 4482.1-2005).

8.1.3 Blind triplicate sample

A blind triplicate sample was provided by the collection of two environmental samples from the same location. These samples were preserved, stored, transported, prepared and analysed in an identical manner. One of the samples was transported to a secondary laboratory for analysis. As a minimum, the results of analyses on the blind triplicate sample pairs were assessed by calculating the Relative Percentage Differences (RPDs) between the results. The RPD was calculated as the difference between the results divided by their mean value and expressed as a percentage. If the RPD exceeded the value adopted for any analytes, additional investigation would be required, or justification provided for not conducting additional investigation.

Blind triplicate samples should be collected at a rate of one duplicate for every 20 environmental samples in accordance with AS 4482.1-2005.

8.2 Laboratory QA/QC programme

The reliability of test results from the analytical laboratories was monitored according to the QA/QC procedures used by the NATA accredited laboratory. The QA/QC program employed by Envirolab (the primary laboratory) and Eurofins (the secondary laboratory) specified holding times, extraction dates, method descriptions, CoC requirements, analysis, laboratory levels of reporting (LORs) and acceptance criteria for the results. Laboratory QA/QC requirements undertaken by Envirolab and Eurofins are based on NEPC (2013) requirements and are outlined below.

8.2.1 Laboratory duplicate samples

Laboratory duplicates provided data on analytical precision for each batch of samples.

Laboratory duplicates were performed at a rate of one duplicate for batches of 8-10 samples with an additional duplicate for each subsequent ten samples.

8.2.2 Laboratory control samples

Laboratory control samples consisted of a clean matrix (de-ionised water or clean sand) spiked with a known concentration of the analyte being measured. These samples monitored method recovery in clean samples and were used (where required) to evaluate matrix interference by comparison with matrix spikes.

8.2.3 Surrogates

For organic analyses, a surrogate was added at the extraction stage in order to verify method effectiveness. The surrogate was then analysed with the batch of samples and percentage recovery calculated.

8.2.4 Matrix spike

Matrix spikes consisted of samples spiked with a known concentration of the analyte being measured, in order to identify properties of the matrix that may hinder method effectiveness. Samples were spiked with concentrations equivalent to 5 to 10 times the LOR and percentage recovery calculated.

8.2.5 Method blanks

Method blanks (de-ionised water or clean sand) were carried through all stages of sample preparation and analysis at a rate of approximately 10%. Analyte concentrations in blanks should be less than the stated LOR. Reagent blanks were run if the method blank exceeded the LOR. The purpose of method blanks was to detect laboratory contamination.

8.3 Data acceptance criteria

The QA/QC was assessed against the Data Acceptance Criteria (DAC) provided in **Table 8-1**.

Table 8-1: QA/QC compliance assessment

QA/QC element	DQI	Objectives	Acceptance criteria
Field QA			
Standard procedures	Precision Accuracy Representativeness Completeness	All sampling undertaken by suitably qualified and experienced personnel. Adherence to the relevant work instructions including record keeping.	No deviation from standard procedure All appropriate field records kept and maintained
Sample collection, preservation, handling and analysis*	Accurate Representativeness	Analysis within holding times. Samples collected into appropriate containers for the analysis with suitable preservation upon collection. Samples received at the laboratory in good condition and appropriately chilled.	Use of laboratory supplied sample containers including glass jars with Teflon lined lids for general contaminants. Preservation and storage of samples chilled in ice chests and transported to laboratories under chain of custody documentation. Attempt to appropriately chill samples (<5°C), with ice. Samples

QA/QC element	DQI	Objectives	Acceptance criteria
			remain not waterlogged and in separate bags to ice. Samples extracted and analysed within holding times relevant for the sample matrix. Use of NATA accredited laboratories for the analysis undertaken.
Decontamination	Accuracy Representativeness Precision Comparability	Prevention of cross-contamination between sampling locations.	Decontamination using triple wash system for all reusable equipment
Calibration	Precision Representativeness	Calibration of field measuring equipment as specified by the manufacturer and retaining of calibration records.	Daily check of equipment against known standards Calibration of equipment if observed to be outside of acceptable range from standard Calibration of field measuring equipment at the rate specified by the manufacturer Calibration records for each event
Data handling	Comparability Completeness	Appropriate labelling of sampling containers Central database of correct field and laboratory data.	Labelling of sample containers to include a unique sample identification number, date of collection, samplers' initials and project number. Field data and laboratory reports undergo review.
Field QC			
Blind replicate/triplicate samples	Precision Comparability	To ensure the primary data is reliable and fit for purpose. The assessment of blind duplicate and split replicate samples is undertaken by calculating the Relative Percent Difference (RPD) of the replicate or split concentration compared with the original sample concentration. The RPD is defined as: $RPD = 100 \times \frac{\lvert X1 - X2 \rvert}{Average}$ Where: X1 and X2 are the concentration of the original and blind or split samples.	Analysed for the same chemicals as the primary sample. Typical RPDs are noted in AS 4482.1-2005 as between 30 – 50%. RPDs exceeding the acceptable range may be considered acceptable for heterogeneous material or where: ▪ No Limit (When the average concentration is < 10 times the LOR) ▪ 0 – 50% RPD (When the average concentration is 10 to 20 times the LOR)
Laboratory QA/QC			
Laboratory duplicates	Precision	To ensure precision of the analysis method and replicability of analysis due to potential sample heterogeneity.	As per laboratory QC report

QA/QC element	DQI	Objectives	Acceptance criteria
		Assessment as per blind replicates and split samples	
Matrix spike recoveries Laboratory Control Samples Surrogates	Accuracy	To assess the effect of the matrix, laboratory control samples and surrogates on the accuracy of the analytical method used. Assessment is undertaken by determining the percent recovery of the known spike or addition to the sample. $\% \text{ Recovery} = 100 \times \frac{C - A}{B}$ Where: A = Concentration of analyte determined in the original sample; B = Added Concentration; C = Calculated Concentration.	As per laboratory QC report
Method blanks	Accuracy	To assess potential bias introduced by the laboratory analytical method for a relevant analyte. A method blank assesses the component of the analytical result introduced from laboratory equipment. Each blank is analysed as per the original samples.	Analytical result < LOR

8.4 Adequacy of the assessment and uncertainty

Response to Condition 117(f) – the adequacy and completeness of all information available for use in the assessment of risk and for making decisions on management requirements, including an assessment of uncertainty;

Clarification

This report should be read with consideration of the 'Important note about your report" (provided above) and the scope and limitations of this assessment provided thought this report and specifically in Section 1 to 4.

All reports and conclusions that deal with sub-surface conditions are based on interpretation and judgement and as a result have uncertainty attached to them. You should be aware that this report contains interpretations and conclusions which are uncertain, due to the nature of the investigations. No study can investigate every risk, and even a rigorous assessment and/or sampling programme may not detect all problem areas within a site.

Scope of Work

As noted in Section 3 of this report the purpose/objective of this assessment was to:

- Provide advice on the contamination status of the area(s) and the need for further assessment/management in the context of the proposed Early Works Program and the protection of construction workers undertaking the Early Works Program.
- Evaluate compliance with Western Harbour Tunnel and Warringah Freeway Upgrade (SSI-8863) conditions of approval.

- This initial DSI is only for the early works, in the next project stages there is likely to be a range of construction activities that will involve bulk excavation of material, removal off site of contaminated soil material, reforming the land, construction of paved surfaces, basements and placement of clean spoil on the site. This work is expected to significantly reform the soil profile and therefore change potential exposure scenarios. This work is beyond the control of SPA and not able to be assessed.

Assessment of uncertainty

SPA have acknowledged the inherent uncertainty of the assessment program undertaken and have considered this uncertainty with respect to the interpretation of the data, conclusions, recommendations and implementation of the CEMP. The assessment of certainty is provided below.

Aspect	Completeness/uncertainty
Extent and magnitude of PAH (including B(a)P TEQ) and heavy metal contamination in soil	Fill with a similar visual/aesthetic appearance was identified at all sample locations (including deeper soil samples), except for one location BH15 (discussed below). The observation of fill was consistent with the historic deposition of fill across the site and the broader golf course area. Such fill will often demonstrate heterogeneous distribution of contaminants, however, the sample results reported relatively consistent results (for fill) except for BH15. The evaluation of the laboratory data (discussed below) combined with field observations gave SPA a satisfactory level of understanding of PAH and metal contamination likely to be encountered with the investigation areas.
B(a)P (TEQ) contamination reported at location BH15_D_CGC	The B(a)P (TEQ) contamination reported was unique to this sample location. Field observations of an 'asphalt layer' indicated a variation to the fill composition. This result confirmed the SPA hypothesis that fill within the investigation areas (and across the greater area of the golf course) was likely to have heterogeneous inclusions. Further, identification of other similar heterogeneous inclusions would likely require extensive excavation/assessment of the investigation areas. However, even if extensive excavation was conducted SPA could not guarantee the identification of all similar heterogeneous inclusions. To address this uncertainty, SPA made special recommendations with respect to the contamination identified at BH15 and general recommendations applicable to all other investigation areas.
Asbestos	Asbestos (visual or verified) was not identified by the SAP assessment. However, SPA acknowledge that a single asbestos fragment had previously identified been identified on the Cammeray Golf Course. SPA acknowledge that the sample collection method (hand auger) had the potential to lose entrainment of asbestos fragments during sampling and for this effect the identification of asbestos fragments. An alternate sampling method (test pits) was considered. This would have resulted in significant disturbance of the subsurface soils in order to provide a higher degree of confidence of the presence/absence of asbestos, however, even this intensive level of assessment would not guarantee all potential asbestos containing materials would be identified and located. Specific site restrictions (i.e. damage to operational golf course areas) would not have allowed for test pits to have been excavated. Given that the purpose of the SPA assessment aligned with the Stage 1A of the construction program and that a CEMP (with unexpected finds procedure) was to be implemented, further assessment to provide an asbestos clearance and certificate (or equivalent level of assessment), was not warranted. SPA was satisfied that the level of asbestos assessment conducted was fit for purpose and aligned with the objectives stated within this report.

Aspect	Completeness/uncertainty
	As noted above fill within the investigation areas likely to demonstrate heterogeneous distribution of contaminants (including asbestos). To address this uncertainty, SPA made conclusions with respect to the potential to encounter asbestos during any excavation works and recommendations aligned with this conclusion.
Other contaminants	Any potential chemical contaminants or substance not specifically nominated for assessment by this report (including but not limited to chlorinated hydrocarbons, PFAS, fluoride, chlorobenzenes, phenols, dioxins/furans, phthalates, nutrients, PBDEs, phenols, 1,4-Dioxane, insecticides, micro plastics and potential acid sulphate soils). Fill was assessed for the contaminants most likely to be present within fill and as identified by the previous SMEC assessment. The presence of these other contaminants are unlikely to be present at concentrations that would impact on the Stage 1A works (i.e. temporary occupation and use of the site as a construction work area). To address this uncertainty (albeit low), recommendations have been provided to assess oil for off-site disposal in accordance the EPA guidelines and management in accordance with the CEMP (and the unexpected finds protocol).

Conclusion

SPA believe the assessment undertaken was fit for the purpose for which it was intended.

9 Quality assurance / quality control

For the purpose of assessing the quality of data presented in this report, SPA collected and analysed blind replicate samples, while the laboratory completed their own internal QC. The current section of this report is focused on the presentation of the results of these QC samples, adherence to Quality Assurance (QA) systems and discussion of deviations, if any from the DAC.

9.1 Field quality assurance

All samples were collected by experienced environmental scientists under established protocols.

Specific assessment of the field QA is discussed below:

- Standard procedures: Sampling was completed in accordance with standard procedures. Field records were kept and maintained.
- Sample collection, preservation, handling and analysis: All analysis was undertaken within holding times, samples were collected into appropriate containers for the analysis with suitable preservation upon collection, samples were received at the laboratory in good condition and appropriately chilled and laboratories were NATA accredited.
- Decontamination: All sampling equipment was decontaminated (triple washed) between investigation locations.
- Calibration: No equipment requiring calibration was used as part of the soil sampling conducted by SPA.
- Data handling: All samples were appropriately labelled. Laboratory data was reviewed and processed using ESDat.

9.2 Field quality control

The following QC samples were collected for laboratory analysis:

- Blind replicate: DUP C (duplicate of primary soil sample BH09_C_CGC)
- Blind replicate: DUP E (duplicate of primary sample BH16_D_CGC)
- Blind triplicate: DUP D (triplicate of primary soil sample BH09_C_CGC)
- Blind triplicate: DUP F (triplicate of primary soil sample BH16_D_CGC).

Two blind replicate samples were analysed to assess the quality control during the field sampling program. This equates to 6.7% blind replicate analysis. This blind replicate analysis exceeds and therefore conforms to AS 4482.1-2005.

The RPDs for all analytes for the soil blind replicate pairs conformed to the DAC with the exception of the RPDs between BH09_C_CGC and DUP C for total PAHs and lead. The sample collected for the blind replicate pair consisted of fill (sandy clay). It is inherently difficult to obtain representative duplicate samples from fill materials which cannot be homogenised in order to retain the integrity of volatile compounds (i.e. naphthalene). None of the analytes detected in either sample exceeded the adopted investigation levels for commercial / industrial land use. The RPD exceedances of lead and total PAHs between BH09_C _CGC and DUP C are unlikely to affect the usability of the data set.

Two blind triplicate samples were analysed to assess the quality control during the field sampling program. This equates to 6.7% blind triplicate analysis. This blind triplicate analysis exceeds and therefore conforms to AS 4482.1-2005.

The RPDs for all analytes for the soil blind triplicate pairs conformed to the DAC with the exception of the RPDs between BH16_D_CGC and DUP F for selected heavy metals. The sample collected for the blind triplicate pair consisted of fill (sandy clay). It is inherently difficult to obtain representative duplicate samples from fill materials which cannot be homogenised in order to retain the integrity of volatile compounds (i.e. naphthalene). None of the analytes detected in either sample exceeded the adopted investigation levels for commercial / industrial land sue. The exceedances of selected heavy metals between BH16_D_CGC and DUP F are unlikely to affect the usability of the data set.

RPD results for soil blind replicate and triplicate pairs are detailed in **Table A** presented in **Appendix A**.

9.3 Laboratory quality assurance

All analysis was undertaken by NATA accredited laboratories using NATA accredited analytical methods.

9.4 Laboratory quality control

Where undertaken, laboratory QC data is presented in full in the laboratory certificates in **Appendix B**.

9.4.1 Laboratory duplicates

Where undertaken, the RPDs for the laboratory samples conformed to the DAC.

The QC reports for Eurofins laboratory batches (795091-S and 795087-S) reported failures of laboratory duplicate pass limits for Chromium, Copper and Lead.

Table 8-1 of the DSI report details the Data Acceptance Criteria (DAC). For laboratory duplicates, the adopted assessment criteria was “As per laboratory QC report”.

As per the qualifying code provided by Eurofins, “The RPD reported passes Eurofins Environment Testing QC – Acceptance Criteria”.

Considering that the RPD met Eurofins Environment Testing QC – Acceptance Criteria, these laboratory duplicate results are considered acceptable in context of the DAC (i.e. as per laboratory QC report).

9.4.2 Laboratory control samples

Where undertaken, the recoveries for all laboratory control samples conformed to the DAC.

9.4.3 Surrogates

Where undertaken, the recoveries for all laboratory surrogate samples conformed to the DAC.

9.4.4 Matrix spikes

Recoveries for all matrix spike samples conformed to the DAC with the exception of the recoveries for selected PAH compounds and heavy metals in matrix spike sample 268815-36. Envirolab reported that percent recovery for the matrix spike was not possible to report as the high concentration of analytes in sample/s 268815-36 have caused interference. Percent recovery was not possible to report due to the inhomogeneous nature of the element/s in the sample/s. However, an acceptable recovery was obtained for the laboratory control sample.

These exceptions are not expected to compromise the integrity of the data.

9.4.5 Method blanks

Where undertaken, all method blanks reported analyte concentrations below the laboratory LOR and therefore conformed to the DAC.

9.4.6 Sample holding times

All soil samples were extracted and analysed within the specified holding times.

9.4.7 Sample condition

All samples were received by the analytical laboratory in correctly preserved and chilled containers with no reported breakages. The individual sample receipts are presented with the laboratory reports in **Appendix B**.

Laboratory certificates from Envirolab indicate that asbestos testing was undertaken by analysing a sub-sample from jars. The Envirolab reports state "w*e cannot guarantee that this sub-sample is indicative of the entire sample."*

SPA note this qualification by the laboratory. However, SPA was satisfied that this qualification did not conflict with the qualitative asbestos assessment undertaken by SPA (as noted in Section 2.3 (vii)) of this report.

9.5 QA/QC assessment

It is concluded that the fieldwork program and laboratory data are of acceptable quality and are considered useable in making conclusions and recommendations regarding the condition of soils at the site.

10 Site assessment criteria

10.1 Aesthetics

The National Environment Protection (Assessment of Site Contamination) Measure 1999, revised 2013 (NEPC, 2013) notes that there are no specific numeric aesthetic guidelines, however site assessments require a balanced consideration of the quantity, type and distribution of foreign material or odours in relation to the specific land use and its sensitivity. Consideration includes chemically discoloured soils, large quantities of various types of inert refuse and their depth etc.

10.2 Health investigation levels

To evaluate the significance of the reported soil concentrations with respect to the proposed use, SPA compared the analytical testing results against the soil quality guidelines published in the NEPC (2013) (i.e. health-based soil investigation (HIL) levels).

The HILs for a commercial/industrial land use (HIL-Setting D), NEPC (2013) were used to evaluate the significance of contamination.

The published guidelines adopted were based on a commercial/industrial land use as these were the most relevant exposure scenario for the proposed site use (i.e. construction site with no uncontrolled access by the public). However, we note that the published HIL guidelines are based on a much longer exposure period (i.e. 30 years). Therefore, direct application of the published HIL guidelines (for commercial/industrial) to the proposed site exposure (i.e. less than 5 years) was conservative.

As per the guidance provided in the NEPM (2013), average concentrations in soil were used to assess contaminant concentrations with respect to the guidelines rather than individual results. The NEPM (Section 3.2.1) also provides guidance on the use of statistical analysis of the data and use of average concentration of a contaminant, including the following:

- No single value should exceed 250% of the relevant investigation or screening level; and
- The standard deviation of the results should be less than 50% of the relevant investigation or screening level'.

Where the above criteria are not met, then the average concentration should not be used and the individual results must be directly compared to the guideline levels.

Published guidelines are also available for the evaluation of soil vapour exposure resulting from soil contaminated with petroleum hydrocarbons (Health Screening Levels (HSLs)). SPA have included HSLs for comparison to the soil assessment results. However, adoption of HSL guideline values is conservative given the proposed (temporary) use/occupation of the site (e.g. no permanent structures for occupation).

The HSLs defined within the NEPC (2013) relate only to the volatile fractions of the petroleum hydrocarbons range i.e. BTEX, naphthalene and TRH C6 – C10, TRH C10 – C16. Based on the presence of fill material across the site, HSLs for coarse grained sand to 0-1 m have been adopted.

The SPA assessment also considered the potential presence of asbestos. However, this was limited to:

- Field observations during the collection of soil samples (by the field staff), and
- Testing of selected soil samples by the laboratory for the 'presence or absence' of asbestos.

We note that this level of assessment does not constitute full characterisation of the site for the potential presence of asbestos nor is an 'asbestos clearance' provided by the SPA Contamination team. The potential for asbestos to be discovered during the occupation of the site should be considered within the management plan for any works on site (e.g. unexpected finds protocols).

The adopted soil quality guidelines are detailed in **Table 10-1**.

Table 10-1: Adopted soil quality guidelines (mg/kg)

Compounds / Fraction	Soil Investigation Levels
	Commercial/Industrial
Heavy Metals	
Arsenic (total)	3,000 [1]
Cadmium	900 [1]
Chromium (VI)	3,600 [1]
Copper	240,000 [1]
Lead	1,500 [1]
Mercury (inorganic)	730[1]
Nickel	6,000 [1]
Zinc	400,000 [1]
Cyanide (free)	1,500 [1]
Polychlorinated Biphenyls (PCBs)	
PCBs	7 [1]
Polycyclic Aromatic Hydrocarbons (PAHs)	
Naphthalene	11,000 [3]
BaP TEQ	40 [1]
Total PAH	4,000 [1]
Total Recoverable Hydrocarbons (TRH) [3]	
C6-C10	26,000
>C10-C16	20,000
>C16-C34	27,000
>C34-C40	38,000
Organochlorine Pesticides (OCP)	
DDT+DDE+DDD	3,600 [1]
Aldrin and dieldrin	45 [1]
Chlordane	530 [1]
Endosulfan	2,000 [1]
Endrin	100 [1]
Heptachlor	50 [1]
HCB	80 [1]
Methoxychlor	2,500 [1]

Compounds / Fraction	Soil Investigation Levels
	Commercial/Industrial
Mirex	100 [1]
Toxaphene	160 [1]
F1, F2 and BTEX (based on SAND soil type) #	
Depth (m)	0 – <1
F1 (C6-C10 minus sum of BTEX concentrations)	260 [2]
F2 (>C10-C16 minus naphthalene)	NL [3]
Benzene	3 [2]
Toluene	99,000 [3]
Ethylbenzene	27,000 [3]
Xylenes	81,000 [3]
Naphthalene	11,000 [3]
Asbestos	
All forms of asbestos	No asbestos in any form present in soil samples analysed or observed on surface soils and in excavated materials

[1] NEPC (2013) Table 1 A(1) Health investigations levels for soil contaminants – Commercial / Industrial D.
[2] NEPC (2013) Table 1 A(3) Soil HSLs for vapour intrusion – Commercial / Industrial D, 0 to <1, SAND
[3] HSL-D Commercial / Industrial, Direct Contact detailed within Table A4, Friebel, E & Nadebaum, P 2011, Soil Health screening levels for direct contact, Technical Report 10.
NL – NL indicates the HSL is not limiting (see Footnote 5, Table 1A(3)).
TEQ – Toxic Equivalent.
Soil Vapour as the primary Exposure Pathway to impact potential receptors.

11 Results and Discussion

11.1 Site stratigraphy

A summary of the sub-surface material excavated from the investigation locations is provided in **Table 11-1**.

Table 11-1: Summary of sub-surface materials

BH06	
Co-ordinates: Lat: 33º49.634S; Long: 151º12.941'E	
Depth range (mbgl)	**Material description**
0.0	Grass
0.0-0.25	FILL: clayey silt with gravel (fine to medium grained, sub-angular), dark brown, fine grained, rootlets, loose, dry
0.1	Brick fragments present
0.2	Increased gravel content (coarse, angular)
0.25-0.8	FILL: sandy CLAY with sandstone boulder, moist, fine to coarse, dark brown.
0.3	Colour change to light brown.
0.4	Blue metal inclusions, colour change to white/light brown
0.5	As above with gravel (fine to medium, sub-rounded)
0.7	As above with colour change to brown/dark grey, wet.
0.8	Refusal on rock at 0.8mbgl. End of borehole.
BH07	
Depth range (mbgl)	**Material description**
0.0	Grass
0.0 - 0.5	FILL: clayey silt, dark brown, loose, fine grained, rootlets, dry
0.2	as above with some gravel/sandstone, coarse, subrounded
0.5 – 0.8	FILL: silty clay, dark brown, fine grained, moist
0.7	Tree root fragment
0.8 – 1.0	FILL: sandy clay, dark brown, fine to coarse grained, moist
0.9	Asphalt inclusions and glass, and decreased sand content
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).
BH08	
Co-ordinates: Lat: 33º49.639'S; Long: 151º12.913'E	
Depth range (mbgl)	**Material description**
0.0	Grass
0.0-1.0	FILL: sandy clay with silt, dark brown, rootlets, loose, moist.
0.1	Increased clay content
0.25	Colour change to light brown, possibly natural.
0.35	Increased moisture content.
0.7	As above with wet soil.
0.8	Sandstone inclusion (medium gravel), rootlets.
1	Colour change to red. End of borehole at 1.0mbgl (limit of investigation).

BH09	
Depth range (mbgl)	**Material description**
0.0	Grass
0.0-0.35	FILL: sandy silty clay, dark brown, fine to coarse grained, rootlets, moist
0.2	As above with some gravel, medium to coarse, subrounded
0.35 – 1.0	FILL: sandy clay, light brown, fine to coarse grained, moist
0.75	Colour change to brown mottled dark brown, tree root fragment
0.80	Colour change to dark brown mottled orange
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).
BH10	
Depth range (mbgl)	**Material description**
0.0	Grass
0.0 - 0.55	FILL: silt sandy clay with gravel, dark brown, fine to coarse grained, gravel coarse and rounded, rootlets, moist
0.2 – 0.55	Sandstone fill/cobbles. Borehole relocated two additional locations within one metre of original location
0.55	Glass fragments present
0.55	Excavation terminated at 0.55 mbgl (refusal in fill material/sandstone cobbles).
BH11	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.6	FILL: silty sandy clay, dark brown, rootlets, fine to coarse grained, moist
0.2	Asphalt inclusions and partial tree root
0.4	Sandstone layer, white
0.6 – 1.0	FILL: clay with minor sand content, brown, fine to coarse grained, moist
0.8	Colour change to dark brown.
1.0	Colour change to brown, wet. Excavation terminated at 1.0 mbgl (limit of investigation).
BH12	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.9	FILL: silty sandy clay, dark brown, rootlets, fine to coarse grained, moist
0.3	Asphalt/charcoal layer with orange sandstone gravel and glass fragments
0.6	Sandstone boulders, PVC, concrete fragments/boulders
0.9 – 1.0	FILL: sandy clay, brown, fine to coarse grained
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).
BH13	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.3	FILL: silty sandy clay, dark brown, rootlets, moist.
0.2	As above with gravel, coarse, subangular
0.3 – 1.0	FILL: sandy clay, light brown, rootlets, fine to coarse grained
0.6	Becoming loose and dry
0.7	Colour change to white
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).

BH14	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.5	FILL: sandy silty clay, brown, fine to coarse grained, rootlets, moist
0.2	Sandstone gravel and asphalt
0.25	Sandstone boulder
0.5 – 0.95	FILL: sandy clay, light brown, fine to coarse grained, moist
0.6	Sandstone gravel/rock fragments, medium to coarse
0.75	Colour change to white/cream
0.95 – 1.0	FILL: clay, white, fine grained
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).
BH15	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.3	FILL: clayey silt, dark brown, fine to coarse grained, rootlets, dry
0.15	As above with coarse gravel (sandstone), medium to coarse
0.3 – 1.0	FILL: sandy clay with gravel, mottled red/brown/yellow, fine to coarse grained, medium to coarse gravel, subrounded, dry
0.6	Colour change to red and stiff
0.65	Colour change to brown/orange/dark brown, partial tree root
0.85	Asphalt layer
1.0	Distinct asphalt odour. Excavation terminated at 1.0 mbgl (limit of investigation).
BH16	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.55	FILL: silty clay, dark brown, fine grained, rootlets, moist
0.15	As above with gravel, medium to coarse, subangular
0.4	Asphalt layer
0.55 – 0.7	FILL: sandy clay with gravel, white/brown, fine to coarse grained, medium to coarse, subrounded gravel (sandstone), moist
0.6	White sandstone layer
0.7 – 1.0	FILL: sandy clay with few gravel, brown/red, fine to coarse grained, gravel angular and coarse, moist
1.0	Becoming mottled white/brown/orange and moist. Excavation terminated at 1.0 mbgl (limit of investigation).
BH17	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.6	FILL: sandy silty clay with few gravel, dark brown, rootlets, fine to coarse grained, medium to coarse gravel, angular, dry
0.25	Tile fragment present
0.6 – 1.0	FILL: sandy clay with some gravel, brown, fine to coarse grained, medium to coarse gravel, subangular, moist
0.62	As above with large rock fragments (moved borehole 0.3 m east – refusal in fill)
0.65	Clay pipe fragment
0.7	Clay becoming stiffer

1.0	Excavation terminated at 1.0 mbgl (limit of investigation).
BH18	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.25	FILL: silty clay with sand, dark brown, rootlets, fine to coarse grained, moist
0.15	As above with some gravel, mottled light brown/dark brown
0.25 – 0.9	FILL: sandy clay, brown mottled orange, fine to coarse grained, moist
0.6	Clay pipe fragment
0.9	Excavation terminated at 0.9 mbgl (refusal in fill).
BH19	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.25	FILL: silty clay with sand, dark brown, rootlets, fine to coarse grained, moist
0.1	Rock fragments present, coarse, angular
0.25	FILL: sandy clay, brown, fine to coarse grained, moist
0.5	Asphalt inclusions
0.6	Increased gravel/rock fragments, coarse, subangular
1.0	Concrete fragments and asphalt inclusions. Excavation terminated at 1.0 mbgl (limit of investigation).
BH20	
Depth range (m)	**Material description**
0.0	Grass
0.0 – 0.35	FILL: silty sandy clay, dark brown, rootlets, fine to coarse grained, moist
0.15	Sandstone gravel/boulder present
0.35	FILL: sandy clay: brown mottled red and white, fine to coarse grained, moist
0.5	Increased sandstone and rock fragments/gravels, coarse
0.7	Large rock fragment present
0.9	Colour change to light brown
1.0	Excavation terminated at 1.0 mbgl (limit of investigation).

11.2 Site observations and aesthetics

Fill was identified at all locations to the limit of the investigation (1.0 mbgl). The fill material comprised topsoil/fill overlying sandy clays, sandstone gravels, and occasional construction waste (asphalt, concrete, clay pipe, tile). The boreholes which were observed to contain asphalt materials had a distinct asphalt odour.

The SMEC assessment also reported similar type of fill across the investigation area extending until the underlying natural surface was encountered. However, SMEC did not note the presence of odorous soils.

Potential asbestos containing materials were not visually observed on the surface in there near vicinity of the investigation locations by the field scientist..

Given the presence of building waste/debris within the fill, there is a potential for asbestos containing materials to also be present. SPA do not recommend further assessment of the site for asbestos, however, the potential for asbestos containing materials to be present within the subsurface should be noted within the CEMP (including an unexpected finds procedure).

The report of 'distinct asphalt odours' at BH15 may also be indicative of a larger area of contamination within this area or adjacent to the investigation area. The observation of similar fill across the investigation area combined with the heterogenous nature of fill is an indication that other areas of odorous and/or contaminated fill may be present and remain 'unidentified'.

SPA have recommended application of conservative preventative exposure measures for the proposed construction use of the site. These measures are to be incorporated into the CEMP (including the use of PPE) to ensure that all fill/soils encountered are treated as potentially contaminated and managed accordingly. These controls should be sufficiently robust to minimise/eliminate any on-site exposure to site workers and/or offsite migration of potentially contaminated materials.

In the event that the proposed preventative exposure measures are not practicable to implement during the proposed (construction) use of the site, then additional assessment is likely to be required.

11.3 Soil analytical results

Soil analytical results from samples collected by SMEC (relevant data, refer to Section 5.2) and SPA investigations were combined and compared to the adopted HIL/HSL are discussed below.

Analytical results (SMEC and SPA combined) are provided in **Table B** presented in **Appendix A**. Laboratory certificates of analysis from the SPA investigation are presented in **Appendix B.**

Reported concentrations of contaminant compounds were below the adopted HIL/HSL with the exception of the benzo(a)pyrene TEQ reported in sample BH15_D_CGC at a depth of 1mbgl in fill at concentrations exceeding the adopted HIL. This result was consistent with a distinct 'asphalt' odour and asphalt 'layer' was also encountered at this location.

No other sample collected by SMEC or SPA reported contamination at concentrations above the adopted HIL/HSL.

Asbestos was not identified by the laboratory in any of the samples submitted for asbestos identification.

The SMEC samples collected from the deeper fill (i.e. greater than 1.2m below ground surface (as noted in Section 4.2 and 7.3) was reviewed for inclusion in the overall data set. Note that this data gave an indication of the contamination status of deeper fill at the site. The results of the samples from 0-1.0m below ground surfaces and the deeper samples indicated a similar contaminant profile. Therefore, fill across the soil profile was expected to be similarly contaminated and require similar management under the CEMP.

As noted in Section 2.3 (viii), this assessment was not designed to provide in-situ classification of soils for off-site disposal. In the event that off-site disposal of soils is required, EPA guidelines with respect to off-site soil classification/disposal will need to be considered.

11.4 Potential and actual migration routes

Response to Condition 117(e) – potential and actual contaminant migration routes including potential preferential pathways;

Refer to the discussion of sources of contamination provided in **Section 7.2** and the physical and chemical properties of contamination in **Section 7.3**.

Actual migration routes - Note that any soil contamination and/or asbestos within the investigation area(s) and beyond, is likely to have been present for many years and is likely associated with the originally filling/levelling of the site. Therefore, any impact to the environment from this contamination would similarly have been occurring for many years.

Left undisturbed soil contamination and/or asbestos is expected to have negligible impact on the proposed temporary construction use of the site as part of the Early Works Program.

Potential migration routes – Uncontrolled excavation would potentially establish exposure scenarios (i.e. exposure routes) not available to in-situ soil contamination and asbestos.

To manage this issue the CEMP implements soil management and control measures where soil excavation is required.

Note that the average (B(a)P TEQ) concentrations on-site were below the guideline values for a commercial/industrial land use, and recommendations (a) and (b) specifically addressed special additional restrictions with respect to the location with the highest reported concentrations of (B(a)P TEQ).

Furthermore, recommendations (c), (d) and (e), provide further guidance on the management of soils within the investigation areas to mitigate potential exposure scenarios.

11.5 Statistical data analysis

The following information provides a summary of the data obtained from the SMEC (2020) and the SPA investigations.

The data summary assumes the following:

- Only those contaminant compounds which have HIL/HSL have been subject to statistical analysis.
- Where concentrations of contaminant compounds have been reported at less than the laboratory levels or reporting (LOR), these results have been reported as half the LOR to enable statistical analysis.
- The data summary has been prepared for fill materials only.

The data summary is detailed in **Table 11-2** and **Table 11-3**.

95% upper confidence limit (UCL) worksheets are provided in **Appendix C**.

The benzo(a)pyrene TEQ reported in sample BH15_D_CGC (88mg/kg) from 1.0m below ground surface was the only individual sample with concentrations reported above the adopted guideline value (40 mg/kg) for commercial/industrial land use.

A summary of the results from BH15 and BH14 (located approximately 10m to the south east of BH15) is provided below.

Sample depth	BH14	BH15
	B(a)P (TEQ)	

Surface (0-0.1 m)	2.7 mg/kg	4.3 mg/kg
Depth (0.5 m)	1.1 mg/kg	-
Depth (1.0 m)	-	Asphalt encountered at 0.85m 88 mg/kg

With respect to this individual result at BH15, it is important to note that:

- Asphalt was encountered at this location at 0.85m depth and there is a potential that a fragment of asphalt was contained within the underlying soil sample analysed from 1.0m. Therefore, this result may be skewed (higher) than the true B(a)P concentration in soil at this location/depth.
- The surface sample from BH15 (4.3 mg/kg) reported significantly lower concentrations of B(a)P TEQ than the deeper sample (88 mg/kg) from the same location.
- BH14 located approximately 10m to the south east of BH15 reported significantly lower concentrations of B(a)P TEQ in a surface (2.7 mg/kg) and 0.5 m sample 91.1 mg/kg).

The above points indicate that BH15_D_CGC (1.0 m) was potentially impacted by a fragment of asphalt from the overlying asphalt layer. However, a conservative approach was adopted to include this result within the final data set.

Statistical analysis of the data set indicated the average soil concentration for B(a)P TEQ (4.35 mg/kg) was below the adopted soil quality guideline value and therefore application of the average concentration was acceptable based on the statistical analysis recommended by the NEPM.

Although this data analysis indicated that in-situ B(a)P TEQ soil concentrations within the investigation areas do not present a risk to human health for unrestricted commercial industrial use, SPA have proposed conservative management measures be adopted during the proposed Early Works Program (refer to Section 12 of this report) and recommendations (a) to (e).

11.6 Potential effects on human health and environment

Response to Condition 117(d) –potential effects of contaminants on human health, including the health of occupants of built structures (for example arising from risks to service lines from hydrocarbons in groundwater, or risks to concrete from acid sulphate soils) and the environment;

<u>Potential effects on Human Health</u>

Note: exposure scenarios for site workers is discussed in **Section 3** of this report.

Contaminant	Potential effect on human health
PAHs (including (B(a)P TEQ))	As discussed in **Section 11.5** (above) and **Table 11-2** (below), in-situ total PAHs (including (B(a)P TEQ)) were considered not to present a risk to human health to the occupation of the investigation areas during the Early Works Program. Left undisturbed this contamination is expected to have negligible impact on the proposed temporary construction use of the site as part of the Early Works Program.

	However, where excavation of subsurface soils is required, any excavated material (and residual in-situ material) should be managed appropriately to minimise exposure to humans and the environment (as per recommendations (a) to (e)).
Heavy metals	All individual soil results (68 for each heavy metal) were reported below the adopted commercial/industrial guideline value and therefore not considered to present a risk to human health to the occupation of the investigation areas during the early works program. Left undisturbed heavy metals are expected to have negligible impact on the proposed temporary construction use of the site as part of the Early Works Program. However, where excavation of subsurface soils is required, any excavated material (and residual in-situ material) should be managed appropriately to minimise exposure to humans and the environment (as per recommendations (a) to (e)).
Asbestos	The investigation did not report the presence of asbestos (by visual inspection or by laboratory analysis). However, given the presence of fill which does/may contain building debris within all investigation areas (and likely to be present across the greater CGC area), SPA concluded that there is a potential for undiscovered soil contamination and/or asbestos containing materials to also be present within fill. Consequently, SPA recommended the following, *"The potential for undiscovered soil contamination and/or asbestos containing materials to be present within the subsurface should be noted within the CEMP (including an unexpected finds procedure)."* Refer to recommendations (c), (d) and (e).

Potential effects on environment

SPA has undertaken an assessment of surrounding ecological environments that may be impacted by works involving excavation of potentially contaminated materials

during construction activities at the Cammeray Golf Course. The assessment considered the proximity of aquatic and terrestrial Ecological Environments as well as Groundwater Dependent Ecosystems.

Aquatic environments

The construction site at Cammeray Golf Course Discharges into Willoughby Creek. Willoughby Creek is highly urbanised drain which transports urban runoff from the existing Cammeray Golf Course and Surrounding Urban areas into Sydney Harbour near Primrose Park

As noted in the EIS, Willoughby Creek (Table 19.8) Willoughby Creek has not been classified as a sensitive receiving environment and any aquatic fish have been nominated as "Minimally Sensitive" – Class 3 (refer to Table 19.8 of the EIS).

In any case, through the implementation the CEMP, Erosion and Sediment Control Plan, regular site inspections by the independent environmental representative and the experienced, SPA are confident that there will be negligible impact to any aquatic ecosystems as a result of works in Cammeray Golf Course.

To date, there have not been any incidents that would result in discharge of site runoff to Willoughby Creek

Groundwater dependent ecosystems

There are no Groundwater Dependent Ecosystems that would be impacted by the excavation and construction activities at Cammeray Golf Course. There was only one area identified in the EIS located at Flat rock creek to the North of the Work area. Willoughby Creek does not drain into Flat Rock Creek. Therefore, the work will not impact any Groundwater Dependent Ecosystems

Terrestrial ecology

The Cammeray Golf Course Site is a highly disturbed area where substantial clearing activities have previously been undertaken to construct the golf course, the original Warringah Freeway as well as nearby residential and commercial areas.

As such there are no sensitive ecological communities or areas that would be impacted by the ground disturbance and contamination activities at Cammeray Golf Course. This has been confirmed by the Environmental Impact Statement.

In any case, further clearing activities are being undertaken by SPA in the vicinity of the Cammeray Golf Course, with further clearing proposed by the Main Works Contractor.

SPA considers that there will be no impacts to ecologically sensitive areas although if there is an unexpected potential contamination risk to ecological impacts, SPA will manage works in these areas in accordance with the CEMP with particular focus on the following procedures:

- Soil & Water Management Procedure
- Flora & Fauna Management Procedure.

General site environmental management

As part the requirements of the CEMP and protocols detailed above, the management measures and the scope of the Stage 1A works are prioritised to prevent air and water impacts, examples of these controls include:

- Sealing all ancillary facilities with hardstand surface (including CGC).
- Development and installation of ERSED controls in accordance with the Blue Book (endorsed by an independent Soil Conservationist).
- Minimising disturbance footprint as much as possible (in line with the work areas required by the WFU Stage 1A scope).

Table 11-2: Data summary (Combined data from the SPA/SMEC assessment of metals and PAHs)

Contaminant	No. samples analysed	Maximum concentration (mg/kg)	95% UCL concentration (mg/kg)	Arithmetic mean concentration (mg/kg)	Standard deviation (mg/kg)	Adopted HIL/HSL (Commercial/Industrial landuse)	No. individual samples above HIL/HSL	No of samples with a 95%UCL above HIL/HSL	Arithmetic mean above HIL/HSL	Maximum concentration >250% of HIL/HSL	Standard deviation >50% of HIL/HSL
Naphthalene	68	11	0.599	0.33	1.3099	11,000	0	0	No	✓	✓
Total PAH's	68	1900	91.52	44.70	229.7537	4,000	0	0	No	✓	✓
B(a)P TEQ	68	**88**	6.68	4.35	11.4130	40	**1**	0	No	✓	✓
Arsenic	68	36	5.341	4.38	4.7027	3,000	0	0	No	✓	✓
Cadmium	68	3	0.541	0.45	0.4704	900	0	0	No	✓	✓
Chromium	68	23	11.41	10.54	4.2441	3,600	0	0	No	✓	✓
Copper	68	480	42.89	30.60	62.3196	240,000	0	0	No	✓	✓
Lead	68	697	130.9	105.88	122.6795	1,500	0	0	No	✓	✓
Mercury	68	3	0.503	0.39	0.5616	730	0	0	No	✓	✓
Nickel	68	12	4.123	3.55	2.8038	6,000	0	0	No	✓	✓
Zinc	68	533	101.7	83.40	89.8356	400,000	0	0	No	✓	✓

✓ Arithmetic mean/individual concentration/maximum concentration/standard deviation soil concentration below soil quality guideline and/or acceptable statistical evaluation criteria.

x Arithmetic mean/individual concentration/maximum concentration/standard deviation soil concentration above soil quality guideline and/or unacceptable statistical evaluation criteria.

NV – No variance

Table 11-3: SMEC data for TRH, BTEX, pesticides and PCBs (included for reference)

Contaminant	No. samples analysed	Maximum concentration (mg/kg)	95% UCL concentration (mg/kg)	Arithmetic mean concentration (mg/kg)	Standard deviation (mg/kg)	Adopted HIL/HSL	No. individual samples above HIL/HSL	No of samples with a 95%UCL above HIL/HSL	Arithmetic mean above HIL/HSL	Maximum concentration >250% of HIL/HSL	Standard deviation >50% of HIL/HSL
Benzene	34	0.025	NV	0.03	0.00	3	0	0	No	✓	✓
Toluene	34	0.025	NV	0.03	0.00	99,000	0	0	No	✓	✓
Total Xylenes	34	0.025	NV	0.03	0.00	81,000	0	0	No	✓	✓
Ethylbenzene	34	0.025	NV	0.03	0.00	27,000	0	0	No	✓	✓
TRH C6 - C10	34	5	NV	5.00	0.00	26,000	0	0	No	✓	✓
TPH C6 - C10 less BTEX (F1)	34	5	NV	5.00	0.00	260	0	0	No	✓	✓
TRH >C10-C16	34	25	NV	25.00	0.00	20,000	0	0	No	✓	✓
TRH >C10 - C16 less Naphthalene (F2)	34	25	NV	25.00	0.00	20,000	0	0	No	✓	✓
TRH >C16-C34	34	1200	194.8	134.12	206.11	27,000	0	0	No	✓	✓
TRH >C34-C40	34	440	87.63	67.65	67.82	38,000	0	0	No	✓	✓
HCB	34	0.025	NV	0.03	0.00	80	0	0	No	✓	✓
Aldrin + Dieldrin	34	0.025	NV	0.03	0.00	45	0	0	No	✓	✓
Chlordane	34	0.025	NV	0.03	0.00	530	0	0	No	✓	✓

Contaminant	No. samples analysed	Maximum concentration (mg/kg)	95% UCL concentration (mg/kg)	Arithmetic mean concentration (mg/kg)	Standard deviation (mg/kg)	Adopted HIL/HSL	No. individual samples above HIL/HSL	No of samples with a 95%UCL above HIL/HSL	Arithmetic mean above HIL/HSL	Maximum concentration >250% of HIL/HSL	Standard deviation >50% of HIL/HSL
DDD+DDT+DDE	34	0.025	NV	0.03	0.0000	100	0	0	No	✓	✓
Endosulfan	34	0.025	NV	0.03	0.0000	2,000	0	0	No	✓	✓
Heptachlor	34	0.025	NV	0.03	0.0000	50	0	0	No	✓	✓
Methoxychlor	34	0.1	NV	0.10	0.0000	2,500	0	0	No	✓	✓
Total PCBs	34	0.05	NV	0.05	0.0000	7	0	0	No	✓	✓

✓ Arithmetic mean/individual concentration/maximum concentration/standard deviation soil concentration below soil quality guideline and/or acceptable statistical evaluation criteria.

x Arithmetic mean/individual concentration/maximum concentration/standard deviation soil concentration above soil quality guideline and/or unacceptable statistical evaluation criteria.

NV – No variance

11.7 Summary

Based on the results of this assessment the following is noted:

- The primary contaminant reported PAHs (specifically B(a)P TEQ) is associated with heterogeneous fill that is distributed throughout the investigation areas and likely across the surrounding areas and between the investigation area.

- B(a)P TEQ has a low vapour pressure and is generally considered non-volatile. B(a)P TEQ is also noted to have a low solubility.

- The observation of similar fill across the investigation area(s) combined with the heterogenous nature of fill suggests that there is the potential for unexpected contamination to be encountered in other areas of the site.

- Fill present within the investigation areas (and across the greater golf course) is likely to have been present for many years (i.e. since the original filling of the area).

- If left undisturbed this contamination is expected to have negligible impact on the proposed temporary construction use of the site. Since the most likely exposure pathways for site workers would be ingestion and/or dermal adsorption.

  Note that the average (B(a)P TEQ) concentrations on-site were below the guideline values for a commercial/industrial land use, and recommendations (1) and (2) (provided in **Section 12** below) specifically addressed special additional restrictions with respect to the location (BH15) with the highest reported concentrations of (B(a)P TEQ). Potential exposure to contamination within the investigation area is addressed in **Section 11** and recommendations 1 to 5 of the report.

- Despite the absence of a positive asbestos identification by the SPA sampling program, the presence of building waste/debris (including asphalt) indicates there is a potential for undiscovered soil contamination and/or asbestos containing materials to also be present within fill within and between the investigation areas.

- Similarly, presence of building waste/debris indicates there is a potential for undiscovered soil contamination to also be present within fill within and between the investigation areas.

12 Conclusions and recommendations

The following conclusions and recommendations were made based on the scope/limitations of the SPA assessment data.

Conclusions

1) **Condition E117(i)** requires a Detailed Site Investigation report that conclude "*whether the land is suitable (for the intended final land use) or can be made suitable through remediation*."

   Based on the available information presented within this report, SPA conclude that the **investigation areas are not likely to be suitable for all potential unrestricted final land use(s) at this time.** This conclusion is based on the following (but not limited to) reasons:

   - This initial DSI is only for the Early Works Program, in the next project stages there is likely to be a range of construction activities that will involve bulk excavation of material, removal off site of contaminated soil material (if present), reforming the land, construction of paved surfaces and basements and placement of clean spoil on the site. This work is expected to significantly reform the soil profile and therefore change potential exposure scenarios.
   - The next stages of construction activities present a risk of potential contamination (e.g. hydrocarbon/fuel spills that may increase the level of contamination within the soil).
   - The EIS indicates that the final land use of the CGC will be for a Motorway Control Facilities and a re-configured golf course. However, there is currently no detailed design available for the final land use arrangements and there are many unknown design parameters that makes it impossible to accurately determine whether or not the site is suitable for its intended land use until Final Design is achieved by the Main Works Contractor in 2022.

   The investigation areas could be made suitable through remediation/management; however, any such suitability determination is likely to require confirmation of the following (as a minimum).

   - The proposed final land use(s).
   - Clear designation of the land area requiring a suitability statement. Typically, this would either be a Title boundary or a survey area.
   - The final design/layout of the freeway (post construction). This would need to include areas proposed to be excavated/filled, final design levels and proposed finished paving materials.
   - Soil contamination data representative of the soils where such future soils will be exposed to future occupants. With respect to this point we note that many areas of the proposed WFU project will be excavated, reshaped and/or filled. With the final soil quality of these areas unknown at this time.
   - Assessment of groundwater quality and potential groundwater future extraction and use(s).
   - Assessment of soil vapour quality and the potential for soil vapour to affect any future structure built on-site (including basements).
   - Evaluation of potential off-site sources of contamination and the potential for any off-site source of contamination to affect the potential future on-site land uses
   - Where residual contamination remains on-site (post freeway construction), documentation and management of residual contamination.

2) **Condition E118** – "*Should remediation be required to make land suitable for the final intended land use, a Remediation Action Plan must be prepared or reviewed and approved…*"

Remediation is not required to make the investigation area ‘suitable’ for the Early Works Program, as potential interaction with soil contamination and/or asbestos was managed by the CEMP for the works.

Determination of the need for remediation (and Remediation Action Plan) to make the site(s) suitable for a future use can only be assessed once additional information is provided (i.e. the proposed land use, final development design, etc,) and further assessment is conducted (i.e. soil, groundwater conditions) over the whole WFU project area.

This conclusion also addresses **Conditions E118, E119 and E120**.

3) Fill (including building waste/debris) and contaminated soils were identified within the investigation areas. This soil will require management during the Early Works Program. It is proposed that this management will occur via the implementation of a CEMP (refer to recommendations detailed below).

4) Although the SPA assessment was focused on the areas proposed to be used for the Early Works Program, the results and conclusions of this assessment (with respect to PAH soil contamination and asbestos) are likely to be applicable to all areas of the CGC where fill is present.

5) Odorous and contaminated soil (B(a)P TEQ) was reported at one location (BH15_D_CGC) at 1.0m depth below a layer of asphalt. However, statistical analysis of the data set (as per NEPM guidance) showed that reported contamination levels were (on average) below the guideline values for the proposed construction use of the site and that use of the average concentration met the statistical criteria defined in the NEPM.

6) Reported concentrations for all other contaminant compounds in soil were below the adopted guideline values (for all individual sample results).

7) Asbestos was not identified by the laboratory in any of the samples submitted for asbestos identification and asbestos containing materials were not observed by SPA contamination team (Jacobs) while collecting the soil samples.

8) The report of ‘distinct asphalt odours’ at BH15 may also be indicative of a larger area of contamination within or adjacent to the investigation area. The observation of similar fill across the investigation area combined with the heterogenous nature of fill suggests that there is the potential for unexpected contamination to be encountered in other areas of the site.

9) The SMEC samples collected from the deeper fill (i.e. greater than 1.2m below ground surface (as noted in Section 4.2 and 7.3) was reviewed for inclusion in the overall data set. Note that this data gave an indication of the contamination status of deeper fill at the site. The results of the samples from 0-1.0m bgs and the deeper samples indicated a similar contaminant profile. Therefore, fill across the soil profile was expected to be similarly contaminated and require similar management under the CEMP.

10) The SMEC analysis (for TRH, BTEX, pesticides and PCBs) did not indicate contamination that would present a risk to the proposed occupation and use of the site associated with the Early Works Program and therefore further evaluation of these contaminants was considered not to be warranted.

11) As noted in Section 2.3 (viii), this assessment was not designed to provide in-situ classification of soils for off-site disposal. In the event that off-site disposal of soils is required, EPA guidelines with respect to off-site soil classification/disposal will need to be considered.

Recommendations for the Construction Environmental Management Plan (CEMP)

A CEMP has been prepared and is being implemented for the CGC works. The CEMP includes management protocols for soil and water and unexpected contamination finds. This CEMP has been communicated to all on-site staff during induction and tool- box meetings. Compliance with the CEMP and specialist protocols is managed through regular site environmental inspections by the Independent Environmental Representative and the SPA environmental management team. Transport for NSW have also appointed an experienced erosion and sediment control specialist to review soil and water plans and inspect the works as they progress to ensure the risk of migration of any contaminated soil off site is minimised to acceptable levels. The unexpected contamination finds protocol triggers a ‘stop work’ and assessment (with consultation of a suitably qualified/experience environmental professional). This assessment will evaluate the potential for contamination associated with the ‘unexpected find’ and the need for implementation of additional management controls to eliminated/reduce any exposure to the identified contamination/material.

These measures have been incorporated into the CEMP (including the use of PPE) to ensure that all fill/soils encountered are treated as potentially contaminated and managed accordingly. These controls should be sufficiently robust to minimise/eliminate any on-site exposure to site workers and/or offsite migration of potentially contaminated materials by various pathways including air and waterThe following recommendations are made specifically for consideration within the CEMP.

The following recommendations are made specifically for consideration within the CEMP for CGC. For areas in the vicinity of BH15, no sub-surface works are to be undertaken until either of the following options are implemented:

a) Further investigations to assess the extent and degree of odorous materials at and in the vicinity of location BH15; or

b) The CEMP should clearly identify the area around BH15 as a ‘known area of contamination’ with strict restrictions on subsurface excavation in this area without approval and supervision of an environmental consultant.

For all other areas of the site (i.e. areas within the footprint of the proposed construction support site exclusive of areas in the vicinity of BH15), the following is recommended:

c) Given the presence of other building waste/debris (including asphalt), there is a potential for undiscovered soil contamination and/or asbestos containing materials to also be present within fill. The potential for undiscovered soil contamination and/or asbestos containing materials to be present within the subsurface should be noted within the CEMP (including an unexpected finds procedure).

d) The CEMP should also give consideration for the potential to odours soil to be encountered during any subsurface excavation works and appropriate procedures developed/implemented to minimise odour generation and/or exposure.

e) The CEMP should also ensure that any disturbance of the site surface is managed appropriately (this includes scrapping of the surface and vehicle movements). For example, minimise dust generation, surface water/sediment runoff from the site, etc.). In the event that off-site disposal of soils is required, EPA guidelines with respect to off-site soil appropriate classification/disposal will need to be considered.

Recommendations relevant to Planning Approval Conditions

f) **Approval Condition E115** - As noted in Section 1 of this report, it is recommended that further consideration be given to the definition of ‘disturbance’ in relation to the Early Works Program and subsequent Main Works contract.

g) **Approval Condition E117(i)** - “whether the land is suitable (for the intended final land use) or can be made suitable through remediation.” As noted in Conclusion 1 of this report, any such suitability statement is likely to require additional assessment/information.

Further, it is not practical to provide a suitability statement prior to the completion of the freeway construction works as there is the potential for further excavation and removal of soil as well as re-profiling the land and the construction of permanent hard stand surfaces.

In order to make this assessment detailed final design plans are required. It is also possible that further contamination may be caused at the site during the main works construction phase (e.g fuel and oil spills) which may affect the contamination levels within the existing work areas).

h) **Approval Condition E121 and E122** – Provision of Audit Reports/Statements regarding the suitability of the site(s) for a future use.

Considering the staged and dynamic nature of planned construction activities, SPA recommends that further DSI's are undertaken for all forthcoming stages with the final assessment of suitability made at the completion the final stage of the project and when full detailed design for the proposed golf course, Motorway Control Centres and other permanent infrastructure such as pathways, Golf Course Maintenance facilities (e.g sheds/ material stockpile areas) are known.

Our recommendation is that compliance with this condition is applied at the completion of the construction program (i.e. post demobilisation of construction equipment/structures) to ensure that surplus land is suitable for use by future occupants.

13 Approval response

The following section must be read in context with the scope and associated limitations discussed throughout this report.

The results of the SMEC (2020) and SPA investigations in context of the risk management strategy as detailed in the EIS Appendix M (2020) and the draft conditions of approval are presented in **Table 13-1** and **Table 13-2**.

Note that these responses apply only to the construction support site for the Early Works Program.

Table 13-1: Responses to risk management strategy

Risk management strategy (EIS Appendix M, 2020)	Response
Based on the information reviewed, a number of moderate to high risk potential AEIs have been identified. Where extensive investigations have not been carried out (all high to moderate risk sites with the exception of the Rozelle Rail Yards site), potentially contaminated areas directly affected by the project will be investigated and managed in accordance with the requirements of guidance endorsed under section 105 of the Contaminated Land Management Act 1997.	Refer to Section 2 of this report, we recommend consideration be given to the definition of 'risk' used by the EIS (and how sites were classified), and how this differs from the interpretation of 'risk' implied by the approval conditions. Consequently, the potential for additional site data to support a 'lower risk rating' should also be considered. This assessment was limited to the proposed temporary construction support areas (associated with the Early Works program) within the larger freeway alignment area (subject to the Major Works program). Hence, was not inclusive of the larger alignment beyond the specific 'sub areas' nominated within this report. This assessment was designed to assess soil contamination within the Early Works Program areas (for contaminants identified by the EIS) so that appropriate soil management measures could be adopted during the Early Works Program (also refer to Section 2 for background, assumptions, and limitations). Although the concentration of benzo(a)pyrene TEQ in one sample exceeded the HIL/HSL, the data summary indicated that the standard deviation, arithmetic mean and 95% upper confidence limit of benzo(a)pyrene TEQ were below the soil quality guideline and/or acceptable statistical evaluation criteria. Reported concentrations for all other contaminant compounds in soil were below the adopted HIL/HSL for a commercial / industrial use of the site (for all individual sample results). SPA did not observe potential asbestos containing materials in the vicinity of the investigation locations or within materials excavated as part of the investigation. Given the presence of fill at all sample location (containing building waste/debris (including asphalt), there is a potential for undiscovered soil contamination and/or asbestos containing materials to also be present within fill. This contamination could be encountered during activities associated with eh Early Works Program. Hence, SPA adopted a conservative position and recommended the potential for undiscovered soil contamination and/or asbestos containing materials to be present within the subsurface be noted within the CEMP (including an unexpected finds procedure).

Table 13-2: Responses to condition of approvals

Number	Condition of approval	Response
E115	Prior to the commencement of any work that would result in the disturbance of moderate to high risk contaminated sites as identified in the documented listed in Condition A1, a Detailed Site Investigations must be undertaken by a Contaminated Land Consultant certified under either the Environment Institute of Australia or New Zealand's "Certified Environmental Practitioner" (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia "Certified Professional Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme	The EIS identified CGC as a moderate to high potential AEI. The assessment work subject to this report was conducted in early May 2021, prior to occupation of the site for the Early Works Program. This DSI was undertaken under the guidance of a Contaminated Land Consultant certified under either the Environment Institute of Australia or New Zealand's "Certified Environmental Practitioner" (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia "Certified Professional Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme. Also refer to Section 1 to 4 of this report for description of the scope of work and limitations associated with this report.
E116	A Detailed Site Investigation Report must be prepared and submitted to the Planning Secretary for information following the completion of Detailed Site Investigations required by Condition E115. The report must be prepared in accordance with relevant guidelines made or approved by the EPA under section 105 of the *Contaminated Land Management Act 1997* (NSW) and prepared by a Contaminated Land Consultant certified under either the Environment Institute of Australia or New Zealand's "Certified Environmental Practitioner" (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia "Certified Professional Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme. Nothing in this condition prevents the Proponent from preparing individual Site Contamination Reports for separate sites	The investigations (by SMEC and SPA) undertaken at the site have been undertaken in general accordance with guidelines endorsed under Section 105 of the Contaminated Land Management Act 1997 and other relevant guidelines and provided to DPIE. This assessment report was prepared by a Contaminated Land Consultant certified under either the Environment Institute of Australia or New Zealand's "Certified Environmental Practitioner" (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia "Certified Professional Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme.
E117	The Detailed Site Investigation Report must provide details on:	
	(a) primary sources of contamination, for example potentially contaminating activities, infrastructure (such as underground storage tanks, fuel line, sumps or sewer lines) or site practices;	Refer to Section 7.2 of this report.
	(b) contaminant dispersal in air, hazardous ground gases, surface water, groundwater, soil vapour, separate phase	Refer to Section 7.3 of this report.

Number	Condition of approval	Response
	contaminants, sediments, infrastructure (e.g. concrete), biota, soil and dust;	
	(c) contaminant characterisation and behaviour (volatility, leachability, speciation, degradation products and physical and chemical conditions on-site which may affect how contaminants behave);	Refer to Section 7.3 of this report.
	(d) potential effects of contaminants on human health, including the health of occupants of built structures (for example arising from risks to service lines from hydrocarbons in groundwater, or risks to concrete from acid sulphate soils) and the environment;	Refer to Section 11.6 of this report.
	(e) potential and actual contaminant migration routes including potential preferential pathways;	Refer to Section 11.4 of this report.
	(f) the adequacy and completeness of all information available for use in the assessment of risk and for making decisions on management requirements, including an assessment of uncertainty;	Refer to Section 8.4 of this report.
	(g) the review and update of the conceptual site model from the preliminary and detailed site investigations;	Refer to Section 7.12, 7.2, 7.3 and 11.4 of this report.
	(h) nature and extent of any existing remediation (such as impervious surface cappings);	No existing remediation infrastructure was observed or documented at the site.

Number	Condition of approval	Response
	(i) whether the land is suitable (for the intended final land use) or can be made suitable through remediation.	Refer to Conclusion (1) of this report. "*SPA conclude that the* ***investigation areas are not likely to be suitable for all potential unrestricted final land use(s) at this time."*** ***The investigation areas could be made suitable through remediation/management; however, any such suitability determination is likely to require confirmation of the following (as a minimum).*** ▪ ***The proposed final land use(s).*** ▪ ***Clear designation of the land area requiring a suitability statement. Typically, this would either be a Title boundary or a survey area.*** ▪ ***The final design/layout of the freeway (post construction). This would need to include areas proposed to be excavated/filled, final design levels and proposed finished paving materials.*** ▪ ***Soil contamination data representative of the soils where such future soils will be exposed to future occupants. With respect to this point we note that many areas of the proposed alignment will be excavated, reshaped and/or filled. With the final soil quality of these areas unknown at this time.*** ▪ ***Assessment of groundwater quality and potential groundwater future extraction and use(s).*** ▪ ***Assessment of soil vapour quality and the potential for soil vapour to affect any future structure built on-site (including basements).*** ▪ ***Evaluation of potential off-site sources of contamination and the potential for any off-site source of contamination to affect the potential future on-site land uses*** ▪ ***Where residual contamination remains on-site (post freeway construction), documentation and management of residual contamination.***
E118	Should remediation be required to make land suitable for the final intended land use, a Remediation Action Plan must be prepared or reviewed and approved, by consultants certified under either the Environment Institute of Australia and New Zealand's Certified Environmental Practitioner (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia Certified Professional Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme.	Refer to Conclusion (2) of this report. Remediation is not required to make the investigation area 'suitable' for the Early Works program, as potential interaction with soil contamination and/or asbestos was managed by the CEMP for the works. Determination of the need for remediation (and Remediation Action Plan) can only be assessed once additional information is provided (i.e. the proposed land use, final development design, etc,) and further assessment is conducted (i.e. soil, groundwater conditions) over the whole WFU project area.

Number	Condition of approval	Response
	The Remedial Action Plan must be prepared in accordance with relevant guidelines made or approved by the EPA under section 105 of the Contaminated Land Management Act 1997 and must include measures to remediate the contamination at the site to ensure the site will be suitable for the proposed use when the Remedial Action Plan is implemented. The Remedial Action Plan must be submitted to the Planning Secretary for information prior to undertaking remediation.	
E119	The Remediation Action Plan must include measures to remediate the contamination at the site to ensure the site will be suitable for the proposed use and detail how the environmental and human health risks will be managed during the disturbance, remediation and/or removal of contaminated soil/sediment or groundwater. Nothing in this condition prevents the preparation of individual Remediation Action Plans for separate sites.	Refer to Conclusion (2) of this report. Remediation is not required to make the investigation area 'suitable' for the Early Works program, as potential interaction with soil contamination and/or asbestos was managed by the CEMP for the works. Determination of the need for remediation (and Remediation Action Plan) can only be assessed once additional information is provided (i.e. the proposed land use, final development design, etc,) and further assessment is conducted (i.e. soil, groundwater conditions) over the whole WFU project area.
E120	Prior to commencing remediation, a Section B Site Audit Statement(s) must be prepared by a NSW EPA-accredited Site Auditor that certifies that the Remediation Action Plan is appropriate and that the site can be made suitable for the proposed use. The Remedial Action Plan must be implemented and any changes to the Remedial Action Plan must be approved in writing by the NSW EPA accredited Site Auditor. Nothing in this condition prevents the Proponent from engaging the Site Auditor to prepare Site Audit Statements for separate sites.	Refer to Conclusion (2) of this report. Not applicable to the Early Works program However, further evaluation of the need for a Site Audit Statement with respect to site suitable for a future land use (post construction) will be determined following clarification of Condition E117(i).
E121	A Section A1 or A2 Site Audit Statement (accompanied by an Environmental Management Plan) and its accompanying Site Audit Report, which state that the contaminated land disturbed by the work has been made suitable for the intended land use, must be submitted to the Planning Secretary and Council after remediation and no later than prior to the commencement of operation of the CSSI. Nothing in this condition prevents the Proponent from obtaining Section A Site Audit	Refer to Recommendation (h) of this report.

Number	Condition of approval	Response
	Statements for individual parcels of remediated land.	
E122	Contaminated land must not be used for the purpose approved under the terms of this approval until a Section A1 or A2 Site Audit Statement is obtained which states that the land is suitable for that purpose and any conditions on the Section A Site Audit Statement have been complied with.	Refer to Recommendation (h) of this report.
E123	An Unexpected Finds Procedure for Contamination must be prepared before the commencement of work and must be followed should unexpected contamination or asbestos (or suspected contamination) be excavated or otherwise discovered. The procedure must include details of who will be responsible for implementing the unexpected finds procedure and the roles and responsibilities of all parties involved. The procedure must be submitted to the Planning Secretary for information.	An Unexpected Finds Procedure for contamination (is included in the Construction Environmental Management Plan)
E124	The Unexpected Finds Procedure for Contamination must be implemented throughout construction.	An Unexpected Finds Procedure for contamination (is included in the Construction Environmental Management Plan)

Appendix A – Tables

Table A: RPD Results

		Sample ID	BH09_C_CGC	DUP C	RPD (%)	BH09_C_CGC	DUP D	RPD (%)	BH16_D_CGC	DUP E	RPD (%)	BH16_D_CGC	DUP F	RPD (%)
		Depth (m)	0.5	-		0.5	-		1	-		1	-	
		Date	11/05/2021	11/05/2021		11/05/2021	11/05/2021		12/05/2021	12/05/2021		12/05/2021	12/05/2021	
Compounds	Units	LOR												
Benzo(a)pyrene TEQ calc (zero)	mg/kg	0.5	<0.5	<0.5	0	<0.5	<0.5	0	<0.5	<0.5	0	<0.5	<0.5	0
Benzo(a)pyrene TEQ calc(half)	mg/kg	0.5	<0.5	<0.5	0	<0.5	0.6	82	<0.5	<0.5	0	<0.5	0.6	82
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	0.5	<0.5	<0.5	0	<0.5	1.2	131	<0.5	<0.5	0	<0.5	1.2	131
Benzo[b+j]fluoranthene	mg/kg	0.5	-	-	-	-	<0.5	-	-	-	-	-	<0.5	-
Acenaphthene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Acenaphthylene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Anthracene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Benzo(a)anthracene	mg/kg	0.1	<0.1	0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	0.5	164
Benzo(a) pyrene	mg/kg	0.05	<0.05	0.3	143	<0.05	<0.5	0	0.1	0.1	0	0.1	<0.5	86
Benzo(b+j) & Benzo(k)fluoranthene	mg/kg	0.2	<0.2	<0.2	0	<0.2	-	-	<0.2	<0.2	0	<0.2	-	-
Benzo(g,h,i)perylene	mg/kg	0.1	<0.1	0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Benzo(k)fluoranthene	mg/kg	0.5	-	-	-	-	<0.5	-	-	-	-	-	<0.5	-
Chrysene	mg/kg	0.1	<0.1	0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	0.5	164
Dibenz(a,h)anthracene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Fluoranthene	mg/kg	0.1	<0.1	0.3	100	<0.1	<0.5	0	0.2	0.1	-	0.2	0.7	111
Fluorene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Naphthalene	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Phenanthrene	mg/kg	0.1	<0.1	0.1	0	<0.1	<0.5	0	<0.1	<0.1	0	<0.1	<0.5	0
Pyrene	mg/kg	0.1	<0.1	0.2	67	<0.1	<0.5	0	0.1	0.1	0	0.1	0.8	156
PAHs (Sum of total)	mg/kg	0.5	-	-	-	-	<0.5	-	-	-	-	-	2.5	-
Total +ve PAHs	mg/kg	0.05	<0.05	1.3	**185**	<0.05	-	-	0.4	0.4	0	0.4	-	-
Arsenic	mg/kg	2	<4	<4	0	<4	2.2	10	<4	<4	0	<4	3.8	**62**
Cadmium	mg/kg	0.4	<0.4	<0.4	0	<0.4	<0.4	0	<0.4	<0.4	0	<0.4	<0.4	0
Chromium (III+VI)	mg/kg	1	20	19	5	20	13	42	18	19	5	18	23	**24**
Copper	mg/kg	1	2	3	40	2	<5	22	4	2	67	4	<5	46
Lead	mg/kg	1	10	17	**52**	10	7.7	26	5	3	50	5	5.3	6
Mercury	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.1	0	<0.1	<0.1	0	<0.1	<0.1	0
Nickel	mg/kg	1	2	2	0	2	<5	22	<1	<1	0	<1	<5	0
Zinc	mg/kg	1	6	14	80	6	6.9	14	8	4	67	8	<5	105
Moisture Content	%	0.1	9.6	10	4	9.6	11	14	11	10	10	11	11	0
Moisture Content (dried @ 103°C)	%	1	-	-	-	-	-	-	-	-	-	-	-	-

Table B: Analytical Results

				SPA 2021																
			Sample ID	BH06_A_CGC	BH06_C_CGC	BH07_A_CGC	BH07_D_CGC	BH08_A_CGC	BH08_D_CGC	BH10_A_CGC	BH10_B_CGC	BH09_A_CGC	BH09_C_CGC	DUP C	DUP D	BH11_B_CGC	BH11_D_CGC	BH12_A_CGC	BH12_B_CGC	BH13_A_CGC
			Depth (m)	0	0.5	0	1	0	1	0	0.25	0	0.5	-	-	0.25	1	0	0.25	0
			Date	28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Compounds	Commercial/Industrial	Units	LOR																	
Polycyclic Aromatic Hydrocarbons																				
Naphthalene	11,000	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	0.3	<0.1	<0.1	<0.1	<0.1
Acenaphthylene		mg/kg	0.1	0.1	0.2	0.2	1.1	<0.1	<0.1	0.4	0.4	0.2	<0.1	<0.1	<0.5	1.5	<0.1	0.1	0.2	0.4
Acenaphthene		mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	0.1	<0.1	<0.1	<0.1	<0.1
Fluorene		mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.5	0.4	<0.1	<0.1	<0.1	<0.1
Phenanthrene		mg/kg	0.1	0.4	0.2	0.4	2.5	0.1	<0.1	0.4	1.4	0.7	<0.1	0.1	<0.5	5.4	<0.1	0.3	0.7	0.6
Anthracene		mg/kg	0.1	0.2	0.1	0.1	0.8	<0.1	<0.1	0.2	0.5	0.2	<0.1	<0.1	<0.5	5.8	<0.1	0.1	0.3	0.3
Fluoranthene		mg/kg	0.1	1.1	0.8	1	7	0.6	<0.1	1.3	3	2	<0.1	0.3	<0.5	13	<0.1	1	1.9	2.3
Pyrene		mg/kg	0.1	1.2	0.9	1.1	7.4	0.6	<0.1	1.2	2.6	1.7	<0.1	0.2	<0.5	11	<0.1	0.9	1.6	2.3
Benzo(a)anthracene		mg/kg	0.1	0.7	0.7	0.7	5.3	0.4	<0.1	0.8	1.7	1.1	<0.1	0.1	<0.5	6.6	<0.1	0.5	1	1.6
Chrysene		mg/kg	0.1	0.6	0.5	0.5	3.8	0.3	<0.1	0.6	1.4	0.9	<0.1	0.1	<0.5	5.2	<0.1	0.5	0.8	1.4
Benzo(b+j)fluoranthene		mg/kg	0.2	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
Benzo(k)fluoranthene		mg/kg	0.2	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
Benzo(b,j+k)fluoranthene		mg/kg	0.2	1	1	1	7.3	0.7	<0.2	1	1	0.9	<0.2	<0.2	<0.5	5.3	<0.2	0.5	0.8	2.7
Benzo(a)pyrene		mg/kg	0.05	0.74	1	0.76	5.4	0.4	<0.05	0.85	3.4	2.1	<0.05	0.3	<0.5	13	<0.05	1.1	2	1.7
Indeno(1,2,3-c,d)pyrene		mg/kg	0.1	0.4	0.6	0.5	2.7	0.2	<0.1	0.5	0.9	0.6	<0.1	<0.1	<0.5	3.5	<0.1	0.4	0.6	1
Dibenzo(a,h)anthracene		mg/kg	0.1	<0.1	0.2	<0.1	0.8	<0.1	<0.1	0.1	0.2	0.2	<0.1	<0.1	<0.5	0.9	<0.1	0.1	0.2	0.2
Benzo(g,h,i)perylene		mg/kg	0.1	0.5	0.8	0.6	3.5	0.3	<0.1	0.7	1.3	0.8	<0.1	0.1	<0.5	4.9	<0.1	0.5	0.8	1.3
Total +vePAH's	4,000	mg/kg	0.05	7	7.4	7.1	48	3.7	<0.05	8.4	18	11	<0.05	1.3	<0.5	76	<0.05	6.2	11	16
Benzo(a)pyrene TEQ calc (zero)	40	mg/kg	0.5	1	1.5	1	7.7	0.6	<0.5	1.3	4.1	2.5	<0.5	<0.5	<0.5	15	<0.5	1.4	2.4	2.5
Benzo(a)pyrene TEQ calc(half)	40	mg/kg	0.5	1	1.5	1.1	7.7	0.6	<0.5	1.3	4.1	2.5	<0.5	<0.5	0.6	15	<0.5	1.4	2.4	2.5
Benzo(a)pyrene TEQ calc(PQL)	40	mg/kg	0.5	1.1	1.5	1.1	7.7	0.7	<0.5	1.3	4.1	2.5	<0.5	<0.5	1.2	15	<0.5	1.4	2.4	2.5
Heavy Metals																				
Arsenic	3,000	mg/kg	4	<4	<4	4	8	<4	<4	7	12	<4	<4	<4	2.2	13	<4	<4	<4	36
Cadmium	900	mg/kg	0.4	<0.4	<0.4	<0.4	<0.4	0.6	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.7	<0.4	<0.4	<0.4	<0.4
Chromium	3,600	mg/kg	1	8	6	9	23	5	11	11	10	10	20	19	13	17	9	7	11	9
Copper	240,000	mg/kg	1	13	3	24	90	12	<1	28	19	20	2	3	<5	79	3	15	32	18
Lead	1,500	mg/kg	1	100	19	130	510	53	2	150	160	150	10	17	7.7	530	8	72	200	220
Mercury	730	mg/kg	0.1	0.1	<0.1	0.4	1.9	0.7	<0.1	1.2	2.3	0.5	<0.1	<0.1	<0.1	0.9	<0.1	0.3	1	0.3
Nickel	6,000	mg/kg	1	2	2	5	9	3	<1	11	3	3	2	2	<5	10	1	3	3	5
Zinc	400,000	mg/kg	1	59	9	150	200	57	5	150	140	84	6	14	6.9	300	21	59	88	62
Inorganics																				
Moisture Content		%	0.1	17	8.6	16	18	21	18	30	17	23	9.6	10	11	20	13	23	17	20
Asbestos																				
Sample mass tested		g		Approx. 35g		Approx. 25g		Approx. 35g		Approx. 35g		Approx. 35g				Approx. 35g		Approx. 35g		Approx. 40g
Sample Description		-		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks				Brown fine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks
Asbestos ID in soil	ND	-		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected				No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected
Trace Analysis	ND	-		No asbestos detected		No asbestos detected		No asbestos detected		No asbestos detected		No asbestos detected				No asbestos detected		No asbestos detected		No asbestos detected
Benzene Toluene Ethylbenezene Xylenes																				
Benzene	3	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Toluene	99,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Xylene (m & p)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Xylene (o)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Xylene (total)	81,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Ethylbenzene	27,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Total BTEX		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Total Recoverable Hydrocarbons																				
C6-C10	26,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
C6-C10 (F1 minus BTEX)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
C10-C16	20,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
C10-C16 (F2 minus Naphthalene)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
C16-C34	27,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
C34-C40	38,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
C10-C40 (Sum of total)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
C10-C14		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
C15-C28		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
C6-C9		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
C29-C36		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
C10-C36 (Sum of total)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Halogenated Benzenes																				
Hexachlorobenzene	80	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Organochlorine Pesticides																				
4,4-DDE		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
a-BHC		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Aldrin		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Aldrin + Dieldrin	45	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
b-BHC		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Chlordane	530	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Chlordane (cis)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Chlordane (trans)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
d-BHC		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
DDD		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
DDT		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
DDT+DDE+DDD	3,600	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Dieldrin		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Endosulfan	2,000	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Endosulfan I		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Endosulfan II		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Endosulfan sulphate		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Endrin	100	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Endrin aldehyde		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Endrin ketone		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
g-BHC (Lindane)		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Heptachlor	50	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Heptachlor epoxide		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Methoxychlor	2,500	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Organophosphorus Resticides																				
Azinophos methyl		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Bromophos-ethyl		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Carbophenothion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Chlorfenvinphos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Chlorpyrifos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Chlorpyrifos-methyl		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Diazinon		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Dichlorvos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Dimethoate		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Ethion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Fenthion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Malathion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Methyl parathion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Monocrotophos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Prothiofos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Polychlorinated Biphenyls																				
PCBs	7	mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Pesticides																				
Demeton-S-methyl		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Fenamiphos		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Parathion		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Pirimphos-ethyl		mg/kg		-	-	-	-	-	-	-	-	-	-	-			-	-	-	-

Notes

Bold	Exceeds human health investigation levels for commercial/industrial land use

Table B: Analytical Results

				SPA 2021																
			Sample ID	BH13_D_CGC	BH14_A_CGC	BH14_C_CGC	BH15_A_CGC	BH15_D_CGC	BH16_A_CGC	BH16_D_CGC	DUP E	DUP F	BH17_A_CGC	BH17_C_CGC	BH18_A_CGC	BH18_C_CGC	BH19_A_CGC	BH19_B_CGC	BH20_A_CGC	BH20_D_CGC
			Depth (m)	1	0	0.5	0	1	0	1	-	-	0	0.5	0	0.5	0	0.25	0	1
			Date	11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Compounds	Commercial/Industrial	Units	LOR																	
Polycyclic Aromatic Hydrocarbons																				
Naphthalene	11,000	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	11	0.2	<0.1	<0.1	<0.5	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene		mg/kg	0.1	<0.1	0.2	0.1	0.4	6.9	0.7	<0.1	<0.1	<0.5	0.2	0.9	0.2	0.7	0.2	0.6	0.4	<0.1
Acenaphthene		mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	18	0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
Fluorene		mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	29	0.2	<0.1	<0.1	<0.5	<0.1	0.1	<0.1	0.3	<0.1	0.3	0.1	<0.1
Phenanthrene		mg/kg	0.1	<0.1	0.6	0.3	1.2	300	2.7	<0.1	<0.1	<0.5	0.6	1.8	0.5	3.1	0.4	2.6	1.5	<0.1
Anthracene		mg/kg	0.1	<0.1	0.2	<0.1	0.4	93	1	<0.1	<0.1	<0.5	0.2	0.8	0.2	1.1	0.2	0.8	0.5	<0.1
Fluoranthene		mg/kg	0.1	<0.1	2	0.8	3.6	460	10	0.2	0.1	0.7	1.5	7.1	1.4	6.5	1.5	4.8	3.9	0.2
Pyrene		mg/kg	0.1	<0.1	1.7	0.7	3.1	340	8.5	0.1	0.1	0.8	1.3	6.7	1.2	5.4	1.4	4	3.5	0.2
Benzo(a)anthracene		mg/kg	0.1	<0.1	1.1	0.4	1.8	200	5.8	<0.1	<0.1	0.5	0.8	5.1	0.7	3.4	0.9	2.5	2.1	0.1
Chrysene		mg/kg	0.1	<0.1	0.9	0.4	1.6	170	4.4	<0.1	<0.1	0.5	0.6	4.1	0.6	2.6	0.7	1.9	1.8	0.1
Benzo(b+j)fluoranthene		mg/kg	0.2	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Benzo(k)fluoranthene		mg/kg	0.2	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Benzo(b,j+k)fluoranthene		mg/kg	0.2	<0.2	0.9	0.4	2	110	4.4	<0.2	<0.2	<0.5	1	4	0.6	2.4	0.8	2	2	<0.2
Benzo(a)pyrene		mg/kg	0.05	<0.05	2.2	0.96	3.6	28	11	0.1	0.1	<0.5	0.78	11	1.4	6.1	1.9	4.3	4	0.2
Indeno(1,2,3-c,d)pyrene		mg/kg	0.1	<0.1	0.6	0.3	1	66	3	<0.1	<0.1	<0.5	0.4	2.8	0.4	1.6	0.5	1.1	1.1	<0.1
Dibenzo(a,h)anthracene		mg/kg	0.1	<0.1	0.2	<0.1	0.3	20	0.8	<0.1	<0.1	<0.5	0.1	0.8	<0.1	0.4	0.1	0.3	0.3	<0.1
Benzo(g,h,i)perylene		mg/kg	0.1	<0.1	0.9	0.4	1.5	83	3.9	<0.1	<0.1	<0.5	0.6	4.2	0.6	2.1	0.8	1.5	1.6	<0.1
Total +vePAH's	4,000	mg/kg	0.05	<0.05	12	4.8	20	1900	57	0.4	0.4	2.5	8.4	50	7.7	36	9.4	26	22	0.78
Benzo(a)pyrene TEQ calc (zero)	40	mg/kg	0.5	<0.5	2.7	1.1	4.3	**88**	13	<0.5	<0.5	<0.5	1.2	13	1.6	7.3	2.3	5.2	4.9	<0.5
Benzo(a)pyrene TEQ calc(half)	40	mg/kg	0.5	<0.5	2.7	1.1	4.3	**88**	13	<0.5	<0.5	0.6	1.2	13	1.7	7.3	2.3	5.2	4.9	<0.5
Benzo(a)pyrene TEQ calc(PQL)	40	mg/kg	0.5	<0.5	2.7	1.2	4.3	**88**	13	<0.5	<0.5	1.2	1.2	13	1.7	7.3	2.3	5.2	4.9	<0.5
Heavy Metals																				
Arsenic	3,000	mg/kg	4	<4	5	<4	4	<4	5	<4	<4	3.8	<4	6	4	<4	<4	<4	5	<4
Cadmium	900	mg/kg	0.4	<0.4	<0.4	<0.4	3	0.5	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	3,600	mg/kg	1	12	8	13	15	16	12	18	19	23	6	11	11	6	9	14	10	7
Copper	240,000	mg/kg	1	1	11	7	16	69	57	4	2	<5	18	19	21	11	20	23	23	4
Lead	1,500	mg/kg	1	32	64	7	85	140	150	5	3	5.3	56	110	110	110	110	110	130	9
Mercury	730	mg/kg	0.1	<0.1	<0.1	<0.1	0.5	0.2	0.5	<0.1	<0.1	<0.1	0.2	1	0.2	0.1	0.2	0.2	0.2	<0.1
Nickel	6,000	mg/kg	1	3	4	2	4	10	4	<1	<1	<5	6	3	7	2	4	4	3	1
Zinc	400,000	mg/kg	1	<1	55	4	62	140	110	8	4	<5	61	73	97	84	90	82	84	6
Inorganics																				
Moisture Content		%	0.1	17	18	8.8	11	4.2	27	11	10	11	23	12	31	12	23	12	23	8.2
Asbestos																				
Sample mass tested		g			Approx. 35g		Approx. 45g		Approx. 35g				Approx. 35g		Approx. 35g		Approx. 35g		Approx. 35g	
Sample Description		-			Brown fine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks				Brown fine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks		Brown fine-grained soil & rocks	
Asbestos ID in soil	ND	-			No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected				No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected		No asbestos detected at reporting limit of 0.1g/kg: Organic fibres detected	
Trace Analysis	ND	-			No asbestos detected		No asbestos detected		No asbestos detected				No asbestos detected		No asbestos detected		No asbestos detected		No asbestos detected	
Benzene Toluene Ethylbenzene Xylenes																				
Benzene	3	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Toluene	99,000	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Xylene (m & p)		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Xylene (o)		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Xylene (total)	81,000	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Ethylbenzene	27,000	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Total BTEX		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Total Recoverable Hydrocarbons																				
C6-C10	26,000	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
C6-C10 (F1 minus BTEX)		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
C10-C16	20,000	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
C10-C16 (F2 minus Naphthalene)		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
C16-C34	27,000	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
C34-C40	38,000	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
C10-C40 (Sum of total)		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
C10-C14		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
C15-C28		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
C6-C9		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
C29-C36		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
C10-C36 (Sum of total)		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Halogenated Benzenes																				
Hexachlorobenzene	80	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Organochlorine Pesticides																				
4,4-DDE		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
a-BHC		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Aldrin		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Aldrin + Dieldrin	45	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
b-BHC		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Chlordane	530	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Chlordane (cis)		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Chlordane (trans)		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
d-BHC		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
DDD		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
DDT		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
DDT+DDE+DDD	3,600	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Dieldrin		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Endosulfan	2,000	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Endosulfan I		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Endosulfan II		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Endosulfan sulphate		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Endrin	100	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Endrin aldehyde		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Endrin ketone		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
g-BHC (Lindane)		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Heptachlor	50	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Heptachlor epoxide		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Methoxychlor	2,500	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Organophosphorus Pesticides																				
Azinophos methyl		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bromophos-ethyl		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Carbophenothion		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Chlorfenvinphos		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Chlorpyrifos		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Chlorpyrifos-methyl		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Diazinon		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Dichlorvos		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Dimethoate		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Ethion		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Fenthion		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Malathion		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Methyl parathion		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Monocrotophos		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Prothiofos		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Polychlorinated Biphenyls																				
PCBs	7	mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Pesticides																				
Demeton-S-methyl		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Fenamiphos		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Parathion		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Pirimphos-ethyl		mg/kg		-	-	-	-	-	-	-			-	-	-	-	-	-	-	-

Notes

Bold	Exceeds human health investigation levels for commercial/industrial land use

Table B: Analytical Results

				SMEC 2020																				
			Sample ID	WFU_BH074	WFU_BH074	WFU_BH074	WFU_BH075	WFU_BH075	WFU_BH076	WFU_BH076	WFU_BH076	WFU_BH077	WFU_BH077	WFU_BH078	WFU_BH078	WFU_BH078	WFU_BH079	WFU_BH079	WFU_BH079	WFU_BH080	WFU_BH080	WFU_BH080	WFU_BH081	WFU_BH081
			Depth (m)	0.0-0.1	0.4-0.5	1.0-1.1	0.0-0.1	0.4-0.5	0.0-0.1	0.4-0.5	1.0-1.1	0.0-0.1	0.4-0.5	0.4-0.5	2.0-2.1	3.0-3.1	0.0-0.1	0.4-0.5	1.0-1.1	0.4-0.5	1.0-1.1	2.0-2.1	0.0-0.05	0.35-0.4
			Date	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	7/07/2020	8/07/2020	8/07/2020	8/07/2020	7/07/2020	7/07/2020	7/07/2020	30/07/2020	30/07/2020
Compounds	Commercial/Industrial	Units	LOR																					
Polycyclic Aromatic Hydrocarbons																								
Naphthalene	11,000	mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Acenaphthylene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.2	<0.5	<0.5	<0.5
Acenaphthene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fluorene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Phenanthrene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.2	1.2	2.3	<0.5	1.1	<0.5	<0.5	<0.5	2	6.7	<0.5	<0.5	<0.5
Anthracene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.4	<0.5	<0.5	<0.5
Fluoranthene		mg/kg	0.1	<0.5	<0.5	<0.5	0.9	<0.5	<0.5	<0.5	<0.5	2.2	3.6	7	<0.5	1.9	<0.5	0.6	<0.5	4.3	6.8	<0.5	0.8	1.1
Pyrene		mg/kg	0.1	<0.5	<0.5	<0.5	0.9	<0.5	0.5	<0.5	<0.5	2.1	3.6	7.6	<0.5	2	<0.5	0.6	<0.5	4.2	5.9	<0.5	0.8	1.1
Benzo(a)anthracene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1	1.8	3.9	<0.5	0.8	<0.5	<0.5	<0.5	1.7	2.4	<0.5	<0.5	0.5
Chrysene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.8	1.6	4.2	<0.5	0.7	<0.5	<0.5	<0.5	1.7	2.3	<0.5	<0.5	<0.5
Benzo(b+j)fluoranthene		mg/kg	0.2	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	1.2	2.4	4.8	<0.5	0.7	<0.5	<0.5	<0.5	2.1	2.8	<0.5	<0.5	0.7
Benzo(k)fluoranthene		mg/kg	0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	1	2.1	<0.5	<0.5	<0.5	<0.5	<0.5	1.1	1.2	<0.5	<0.5	<0.5
Benzo(b,j+k)fluoranthene		mg/kg	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene		mg/kg	0.05	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1	1.9	3.9	<0.5	0.6	<0.5	<0.5	<0.5	1.8	2.1	<0.5	<0.5	0.6
Indeno(1,2,3-c,d)pyrene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	1	2.3	<0.5	<0.5	<0.5	<0.5	<0.5	1.2	1.3	<0.5	<0.5	<0.5
Dibenzo(a,h)anthracene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(g,h,i)perylene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7	1.3	2.9	<0.5	<0.5	<0.5	<0.5	<0.5	1.6	1.6	<0.5	<0.5	<0.5
Total +vePAH's	4,000	mg/kg	0.05	<0.5	<0.5	<0.5	2.4	<0.5	0.5	<0.5	<0.5	11.4	19.9	43.1	<0.5	7.8	<0.5	1.2	<0.5	21.7	35.7	<0.5	1.6	4
Benzo(a)pyrene TEQ calc (zero)	40	mg/kg	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.4	2.5	6	<0.5	0.8	<0.5	<0.5	<0.5	2.4	2.9	<0.5	<0.5	0.7
Benzo(a)pyrene TEQ calc(half)	40	mg/kg	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1.6	2.8	6	0.6	1	0.6	0.6	0.6	2.7	3.2	0.6	0.6	1
Benzo(a)pyrene TEQ calc(PQL)	40	mg/kg	0.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.8	3	6	1.2	1.4	1.2	1.2	1.2	2.9	3.4	1.2	1.2	1.3
Heavy Metals																								
Arsenic	3,000	mg/kg	4	<5	6	<5	<5	6	6	<5	<5	6	11	<5	<5	<5	<5	6	<5	<5	<5	<5	<5	<5
Cadmium	900	mg/kg	0.4	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium	3,600	mg/kg	1	6	8	6	11	8	11	9	12	10	10	8	3	7	6	7	6	10	9	24	11	10
Copper	240,000	mg/kg	1	9	14	<5	33	<5	18	<5	<5	26	26	480	<5	<5	13	6	<5	71	40	<5	18	20
Lead	1,500	mg/kg	1	35	39	<5	153	16	69	5	13	170	171	72	8	12	79	32	<5	293	216	6	163	81
Mercury	730	mg/kg	0.1	<0.1	0.2	<0.1	0.5	<0.1	0.2	<0.1	<0.1	0.5	0.7	0.1	<0.1	<0.1	0.2	0.1	<0.1	0.7	1.5	<0.1	0.1	0.2
Nickel	6,000	mg/kg	1	2	4	<2	6	<2	4	<2	<2	5	5	4	<2	<2	2	<2	<2	5	3	<2	7	12
Zinc	400,000	mg/kg	1	32	40	<5	93	9	170	<5	<5	115	108	44	<5	8	66	47	<5	144	115	6	78	287
Inorganics																								
Moisture Content		%	0.1	10.4	13	10.3	6.3	4.9	32.8	16.2	13.7	21	15.1	10.9	12.3	9.3	28.7	17.4	17.5	13.6	13.3	12.8	16.6	13.1
Asbestos																								
Sample mass tested		g																						
Sample Description		-																						
Asbestos ID in soil	ND	-		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trace Analysis	ND	-		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene Toluene Ethylbenezene Xylenes																								
Benzene	3	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	99,000	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene (m & p)		mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene (o)		mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene (total)	81,000	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	27,000	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total BTEX		mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Recoverable Hydrocarbons																								
C6-C10	26,000	mg/kg		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C6-C10 (F1 minus BTEX)		mg/kg		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C10-C16	20,000	mg/kg		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C10-C16 (F2 minus Naphthalene)		mg/kg		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C16-C34	27,000	mg/kg		<100	<100	<100	180	<100	<100	<100	<100	<100	160	340	<100	<100	<100	<100	<100	100	210	<100	<100	<100
C34-C40	38,000	mg/kg		<100	<100	<100	130	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C10-C40 (Sum of total)		mg/kg		<50	<50	<50	310	<50	<50	<50	<50	<50	160	340	<50	<50	<50	<50	<50	100	210	<50	<50	<50
C10-C14		mg/kg		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C15-C28		mg/kg		<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	220	<100	<100	<100	<100	<100	<100	150	<100	<100	<100
C6-C9		mg/kg		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C29-C36		mg/kg		<100	<100	<100	150	<100	<100	<100	<100	<100	<100	170	<100	<100	<100	<100	<100	<100	100	<100	<100	<100
C10-C36 (Sum of total)		mg/kg		<50	<50	<50	150	<50	<50	<50	<50	<50	<50	390	<50	<50	<50	<50	<50	<50	250	<50	<50	<50
Halogenated Benzenes																								
Hexachlorobenzene	80	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Organochlorine Pesticides																								
4,4-DDE		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
a-BHC		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Aldrin		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Aldrin + Dieldrin	45	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
b-BHC		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlordane	530	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlordane (cis)		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlordane (trans)		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
d-BHC		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
DDD		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
DDT		mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
DDT+DDE+DDD	3,600	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dieldrin		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan	2,000	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan I		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan II		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan sulphate		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endrin	100	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endrin aldehyde		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endrin ketone		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
g-BHC (Lindane)		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor	50	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor epoxide		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Methoxychlor	2,500	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Organophosphorus Resticides																								
Azinophos methyl		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Bromophos-ethyl		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Carbophenothion		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlorfenvinphos		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlorpyrifos		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlorpyrifos-methyl		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Diazinon		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dichlorvos		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dimethoate		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ethion		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fenthion		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Malathion		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Methyl parathion		mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Monocrotophos		mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Prothiofos		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Polychlorinated Biphenyls																								
PCBs	7	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pesticides																								
Demeton-S-methyl		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fenamiphos		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Parathion		mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Pirimphos-ethyl		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Notes

Bold	Exceeds human health investigation levels for commercial/industrial land use

Table B: Analytical Results

				SMEC 2020																				
			Sample ID	WFU_BH082	WFU_BH082	WFU_BH082	WFU_BH083	WFU_BH083	WFU_BH083	WFU_BH085	WFU_BH085	WFU_BH085	WFU_BH089	WFU_BH089	WFU_BH089	WFU_BH099	WFU_BH099	WFU_BH099	WFU_BH100	WFU_BH100	WFU_BH100	WFU_BH108	WFU_BH108	WFU_BH108
			Depth (m)	0.0-0.1	0.4-0.5	1.2-1.4	0.0-0.1	0.4-0.5	1.0-1.1	0.0-0.1	0.4-0.5	1.0-1.1	0.0-0.1	1.0-1.1	2.0-2.1	0.0-0.1	1.0-1.1	2.0-2.1	0.0-0.1	1.0-1.1	3.65-3.85	0.0-0.1	0.4-0.5	2.8-2.9
			Date	9/07/2020	9/07/2020	9/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	6/07/2020	9/07/2020	9/07/2020	9/07/2020	28/07/2020	28/07/2020	28/07/2020
Compounds	Commercial/Industrial	Units	LOR																					
Polycyclic Aromatic Hydrocarbons																								
Naphthalene	11,000	mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Acenaphthylene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	0.9	<0.5	<0.5	<0.5	<0.5	<0.5	7.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.3	<0.5	<0.5	<0.5
Acenaphthene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fluorene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.1	<0.5	<0.5	<0.5
Phenanthrene		mg/kg	0.1	0.7	0.7	<0.5	0.9	5	<0.5	<0.5	<0.5	<0.5	<0.5	23.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	17.3	0.7	1.7	<0.5
Anthracene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	1.2	<0.5	<0.5	<0.5	<0.5	<0.5	7.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4.1	<0.5	0.6	<0.5
Fluoranthene		mg/kg	0.1	2	1.9	<0.5	2	10.4	<0.5	0.8	<0.5	<0.5	1.4	50.1	<0.5	0.8	<0.5	<0.5	<0.5	<0.5	21.0	1.7	4.4	<0.5
Pyrene		mg/kg	0.1	2	1.8	<0.5	2	9.1	<0.5	0.9	<0.5	<0.5	1.4	46.2	<0.5	0.8	<0.5	<0.5	<0.5	<0.5	18.4	1.7	4.3	<0.5
Benzo(a)anthracene		mg/kg	0.1	1	1	<0.5	0.9	4.4	<0.5	<0.5	<0.5	<0.5	0.7	23.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	7	0.8	1.9	<0.5
Chrysene		mg/kg	0.1	0.9	0.9	<0.5	0.9	4	<0.5	<0.5	<0.5	<0.5	0.6	20.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	6.6	0.7	1.8	<0.5
Benzo(b+j)fluoranthene		mg/kg	0.2	1.5	1.4	<0.5	1.1	5.3	<0.5	0.6	<0.5	<0.5	1.2	29.7	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	6.3	0.9	2.7	<0.5
Benzo(k)fluoranthene		mg/kg	0.2	0.6	<0.5	<0.5	<0.5	2.6	<0.5	<0.5	<0.5	<0.5	<0.5	10.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2.6	<0.5	1.0	<0.5
Benzo(b,j+k)fluoranthene		mg/kg	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene		mg/kg	0.05	1.2	1.1	<0.5	0.9	4.3	<0.5	<0.5	<0.5	<0.5	0.9	25.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	5.9	0.7	2.5	<0.5
Indeno(1,2,3-c,d)pyrene		mg/kg	0.1	0.8	0.6	<0.5	0.5	2.6	<0.5	<0.5	<0.5	<0.5	0.6	14.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2.4	<0.5	1.3	<0.5
Dibenzo(a,h)anthracene		mg/kg	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5
Benzo(g,h,i)perylene		mg/kg	0.1	1	0.8	<0.5	0.7	3.1	<0.5	<0.5	<0.5	<0.5	0.7	17.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3.1	0.6	1.6	<0.5
Total +vePAH's	4,000	mg/kg	0.05	11.7	10.2	<0.5	9.9	53.7	<0.5	2.3	<0.5	<0.5	7.5	282	<0.5	2.1	<0.5	<0.5	<0.5	<0.5	97.6	7.8	23.8	<0.5
Benzo(a)pyrene TEQ calc (zero)	40	mg/kg	0.5	1.6	1.4	<0.5	1.2	5.9	<0.5	<0.5	<0.5	<0.5	1.2	36.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8.3	0.9	3.2	<0.5
Benzo(a)pyrene TEQ calc(half)	40	mg/kg	0.5	1.8	1.7	0.6	1.4	6.1	0.6	0.6	0.6	0.6	1.4	36.8	0.6	0.6	0.6	0.6	0.6	0.6	8.3	1.2	3.5	0.6
Benzo(a)pyrene TEQ calc(PQL)	40	mg/kg	0.5	2.1	2	1.2	1.7	6.4	1.2	1.2	1.2	1.2	1.7	36.8	1.2	1.2	1.2	1.2	1.2	1.2	8.3	1.5	3.7	1.2
Heavy Metals																								
Arsenic	3,000	mg/kg	4	<5	<5	<5	<5	7	<5	11	<5	<5	<5	7	<5	6	6	<5	<5	6	10	<5	<5	<5
Cadmium	900	mg/kg	0.4	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	3	<1	<1	<1	<1	<1
Chromium	3,600	mg/kg	1	8	8	<2	8	14	8	8	8	3	5	16	16	12	10	13	4	7	11	9	10	5
Copper	240,000	mg/kg	1	37	51	<5	16	125	9	17	<5	<5	14	171	<5	25	<5	<5	13	<5	55	41	19	<5
Lead	1,500	mg/kg	1	143	117	<5	74	697	30	73	<5	<5	89	222	8	128	22	36	67	44	65	83	154	<5
Mercury	730	mg/kg	0.1	0.4	0.4	<0.1	0.1	1.6	<0.1	0.2	<0.1	<0.1	0.1	0.7	<0.1	0.1	<0.1	<0.1	0.5	<0.1	<0.1	0.2	3	<0.1
Nickel	6,000	mg/kg	1	6	3	<2	<2	4	<2	2	<2	<2	<2	8	<2	10	<2	<2	<2	<2	<2	7	3	<2
Zinc	400,000	mg/kg	1	164	198	<5	61	318	53	94	<5	<5	56	533	5	129	14	15	54	9	88	97	105	<5
Inorganics																								
Moisture Content		%	0.1	26.5	11.8	23.3	12	11.2	12.6	18.3	10.8	12.7	14.6	13.8	15.6	35	7.5	10.2	28.3	16.3	16.4	25.3	10	25.6
Asbestos																								
Sample mass tested		g																						
Sample Description		-																						
Asbestos ID in soil	ND	-		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trace Analysis	ND	-		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene Toluene Ethylbenezene Xylenes																								
Benzene	3	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	99,000	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene (m & p)		mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene (o)		mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene (total)	81,000	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	27,000	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total BTEX		mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Recoverable Hydrocarbons																								
C6-C10	26,000	mg/kg		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C6-C10 (F1 minus BTEX)		mg/kg		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C10-C16	20,000	mg/kg		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C10-C16 (F2 minus Naphthalene)		mg/kg		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C16-C34	27,000	mg/kg		180	120	<100	<100	300	<100	<100	<100	<100	130	1200	<100	<100	<100	<100	<100	<100	400	<100	140	<100
C34-C40	38,000	mg/kg		120	<100	<100	<100	110	<100	<100	<100	<100	<100	440	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C10-C40 (Sum of total)		mg/kg		300	120	<50	<50	410	<50	<50	<50	<50	130	1640	<50	<50	<50	<50	<50	<50	400	<50	140	<50
C10-C14		mg/kg		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C15-C28		mg/kg		<100	<100	<100	<100	190	<100	<100	<100	<100	<100	750	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C6-C9		mg/kg		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
C29-C36		mg/kg		130	<100	<100	<100	180	<100	<100	<100	<100	<100	660	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C10-C36 (Sum of total)		mg/kg		130	<50	<50	<50	370	<50	<50	<50	<50	<50	1410	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Halogenated Benzenes																								
Hexachlorobenzene	80	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Organochlorine Pesticides																								
4,4-DDE		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
a-BHC		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Aldrin		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Aldrin + Dieldrin	45	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.37	<0.05
b-BHC		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlordane	530	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlordane (cis)		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlordane (trans)		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
d-BHC		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
DDD		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
DDT		mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
DDT+DDE+DDD	3,600	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dieldrin		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.37	<0.05
Endosulfan	2,000	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan I		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan II		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan sulphate		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endrin	100	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endrin aldehyde		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endrin ketone		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
g-BHC (Lindane)		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor	50	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor epoxide		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Methoxychlor	2,500	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Organophosphorus Resticides																								
Azinophos methyl		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Bromophos-ethyl		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Carbophenothion		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlorfenvinphos		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlorpyrifos		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlorpyrifos-methyl		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Diazinon		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dichlorvos		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dimethoate		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ethion		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fenthion		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Malathion		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Methyl parathion		mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Monocrotophos		mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Prothiofos		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Polychlorinated Biphenyls																								
PCBs	7	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pesticides																								
Demeton-S-methyl		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fenamiphos		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Parathion		mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Pirimphos-ethyl		mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Notes

Bold	Exceeds human health investigation levels for commercial/industrial land use

Appendix B – Laboratory certificates

Envirolab Services Pty Ltd
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CERTIFICATE OF ANALYSIS 267823-A

Client Details

Client	Jacobs Group (Australia) Pty Ltd
Attention	Amanda Mullen
Address	Level 7, 177 Pacific Highway, North Sydney, NSW, 2060

Sample Details

Your Reference	**IA216715**
Number of Samples	11 Soils
Date samples received	28/04/2021
Date completed instructions received	28/04/2021

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	29/04/2021
Date of Issue	29/04/2021

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Asbestos Approved By
Analysed by Asbestos Approved Identifier: Ridwan Wijaya
Authorised by Asbestos Approved Signatory: Lucy Zhu

Results Approved By
Dragana Tomas, Senior Chemist
Hannah Nguyen, Senior Chemist
Lucy Zhu, Asbestos Supervisor

Authorised By

Nancy Zhang, Laboratory Manager

PAHs in Soil						
Our Reference		267823-A-21	267823-A-23	267823-A-24	267823-A-27	267823-A-28
Your Reference	UNITS	BH06_A_CGC	BH06_C_CGC	BH07_A_CGC	BH07_D_CGC	BH08_A_CGC
Depth		0.0	0.5	0.0	1.0	0.0
Date Sampled		28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Date analysed	-	28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	0.1	0.2	0.2	1.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	0.4	0.2	0.4	2.5	0.1
Anthracene	mg/kg	0.2	0.1	0.1	0.8	<0.1
Fluoranthene	mg/kg	1.1	0.8	1.0	7.0	0.6
Pyrene	mg/kg	1.2	0.9	1.1	7.4	0.6
Benzo(a)anthracene	mg/kg	0.7	0.7	0.7	5.3	0.4
Chrysene	mg/kg	0.6	0.5	0.5	3.8	0.3
Benzo(b,j+k)fluoranthene	mg/kg	1	1	1	7.3	0.7
Benzo(a)pyrene	mg/kg	0.74	1.0	0.76	5.4	0.4
Indeno(1,2,3-c,d)pyrene	mg/kg	0.4	0.6	0.5	2.7	0.2
Dibenzo(a,h)anthracene	mg/kg	<0.1	0.2	<0.1	0.8	<0.1
Benzo(g,h,i)perylene	mg/kg	0.5	0.8	0.6	3.5	0.3
Total +ve PAH's	mg/kg	7.0	7.4	7.1	48	3.7
Benzo(a)pyrene TEQ calc (zero)	mg/kg	1	1.5	1.0	7.7	0.6
Benzo(a)pyrene TEQ calc(half)	mg/kg	1.0	1.5	1.1	7.7	0.6
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	1.1	1.5	1.1	7.7	0.7
Surrogate p-Terphenyl-d14	%	119	122	118	114	120

PAHs in Soil		
Our Reference		267823-A-31
Your Reference	UNITS	BH08_D_CGC
Depth		1.0
Date Sampled		28/04/2021
Type of sample		Soil
Date extracted	-	28/04/2021
Date analysed	-	28/04/2021
Naphthalene	mg/kg	<0.1
Acenaphthylene	mg/kg	<0.1
Acenaphthene	mg/kg	<0.1
Fluorene	mg/kg	<0.1
Phenanthrene	mg/kg	<0.1
Anthracene	mg/kg	<0.1
Fluoranthene	mg/kg	<0.1
Pyrene	mg/kg	<0.1
Benzo(a)anthracene	mg/kg	<0.1
Chrysene	mg/kg	<0.1
Benzo(b,j+k)fluoranthene	mg/kg	<0.2
Benzo(a)pyrene	mg/kg	<0.05
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1
Total +ve PAH's	mg/kg	<0.05
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5
Surrogate p-Terphenyl-d14	%	116

Acid Extractable metals in soil						
Our Reference		267823-A-21	267823-A-23	267823-A-24	267823-A-27	267823-A-28
Your Reference	UNITS	BH06_A_CGC	BH06_C_CGC	BH07_A_CGC	BH07_D_CGC	BH08_A_CGC
Depth		0.0	0.5	0.0	1.0	0.0
Date Sampled		28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	29/04/2021	29/04/2021	29/04/2021	29/04/2021	29/04/2021
Date analysed	-	29/04/2021	29/04/2021	29/04/2021	29/04/2021	29/04/2021
Arsenic	mg/kg	<4	<4	4	8	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	0.6
Chromium	mg/kg	8	6	9	23	5
Copper	mg/kg	13	3	24	90	12
Lead	mg/kg	100	19	130	510	53
Mercury	mg/kg	0.1	<0.1	0.4	1.9	0.7
Nickel	mg/kg	2	2	5	9	3
Zinc	mg/kg	59	9	150	200	57

Acid Extractable metals in soil		
Our Reference		267823-A-31
Your Reference	UNITS	BH08_D_CGC
Depth		1.0
Date Sampled		28/04/2021
Type of sample		Soil
Date prepared	-	29/04/2021
Date analysed	-	29/04/2021
Arsenic	mg/kg	<4
Cadmium	mg/kg	<0.4
Chromium	mg/kg	11
Copper	mg/kg	<1
Lead	mg/kg	2
Mercury	mg/kg	<0.1
Nickel	mg/kg	<1
Zinc	mg/kg	5

Moisture						
Our Reference		267823-A-21	267823-A-23	267823-A-24	267823-A-27	267823-A-28
Your Reference	UNITS	BH06_A_CGC	BH06_C_CGC	BH07_A_CGC	BH07_D_CGC	BH08_A_CGC
Depth		0.0	0.5	0.0	1.0	0.0
Date Sampled		28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Date analysed	-	29/04/2021	29/04/2021	29/04/2021	29/04/2021	29/04/2021
Moisture	%	17	8.6	16	18	21

Moisture		
Our Reference		267823-A-31
Your Reference	UNITS	BH08_D_CGC
Depth		1.0
Date Sampled		28/04/2021
Type of sample		Soil
Date prepared	-	28/04/2021
Date analysed	-	29/04/2021
Moisture	%	18

Asbestos ID - soils				
Our Reference		267823-A-21	267823-A-24	267823-A-28
Your Reference	UNITS	BH06_A_CGC	BH07_A_CGC	BH08_A_CGC
Depth		0.0	0.0	0.0
Date Sampled		28/04/2021	28/04/2021	28/04/2021
Type of sample		Soil	Soil	Soil
Date analysed	-	29/04/2021	29/04/2021	29/04/2021
Sample mass tested	g	Approx. 35g	Approx. 25g	Approx. 35g
Sample Description	-	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks
Asbestos ID in soil	-	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected
Trace Analysis	-	No asbestos detected	No asbestos detected	No asbestos detected

Method ID	Methodology Summary
ASB-001	Asbestos ID - Qualitative identification of asbestos in bulk samples using Polarised Light Microscopy and Dispersion Staining Techniques including Synthetic Mineral Fibre and Organic Fibre as per Australian Standard 4964-2004.
Inorg-008	Moisture content determined by heating at 105+/-5 °C for a minimum of 12 hours.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS and/or GC-MS/MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. For soil results:- 1. 'EQ PQL'values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'EQ zero'values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more susceptible to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'EQ half PQL'values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, the Total +ve PAHs PQL is reflective of the lowest individual PQL and is therefore "Total +ve PAHs" is simply a sum of the positive individual PAHs.

QUALITY CONTROL: PAHs in Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-8	[NT]
Date extracted	-			28/04/2021	[NT]	[NT]	[NT]	[NT]	28/04/2021	[NT]
Date analysed	-			28/04/2021	[NT]	[NT]	[NT]	[NT]	28/04/2021	[NT]
Naphthalene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	108	[NT]
Acenaphthylene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Acenaphthene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	79	[NT]
Fluorene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	84	[NT]
Phenanthrene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Anthracene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluoranthene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	91	[NT]
Pyrene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	93	[NT]
Benzo(a)anthracene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chrysene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	67	[NT]
Benzo(b,j+k)fluoranthene	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(a)pyrene	mg/kg	0.05	Org-022/025	<0.05	[NT]	[NT]	[NT]	[NT]	88	[NT]
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	124	[NT]	[NT]	[NT]	[NT]	128	[NT]

QUALITY CONTROL: Acid Extractable metals in soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-8	[NT]
Date prepared	-			29/04/2021	[NT]	[NT]	[NT]	[NT]	29/04/2021	[NT]
Date analysed	-			29/04/2021	[NT]	[NT]	[NT]	[NT]	29/04/2021	[NT]
Arsenic	mg/kg	4	Metals-020	<4	[NT]	[NT]	[NT]	[NT]	105	[NT]
Cadmium	mg/kg	0.4	Metals-020	<0.4	[NT]	[NT]	[NT]	[NT]	96	[NT]
Chromium	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	98	[NT]
Copper	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Lead	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	96	[NT]
Mercury	mg/kg	0.1	Metals-021	<0.1	[NT]	[NT]	[NT]	[NT]	107	[NT]
Nickel	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	98	[NT]
Zinc	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	96	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Asbestos: A portion of the supplied sample was sub-sampled for asbestos analysis according to Envirolab procedures.
We cannot guarantee that this sub-sample is indicative of the entire sample. Envirolab recommends supplying 40-50g of sample in its own container.
Note: Samples were sub-sampled from jars provided by the client.

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

SAMPLE RECEIPT ADVICE

Client Details	
Client	Jacobs Group (Australia) Pty Ltd
Attention	[redacted]

Sample Login Details	
Your reference	IA216715
Envirolab Reference	267823-A
Date Sample Received	28/04/2021
Date Instructions Received	28/04/2021
Date Results Expected to be Reported	29/04/2021

Sample Condition	
Samples received in appropriate condition for analysis	Yes
No. of Samples Provided	11 Soils
Turnaround Time Requested	1 day
Temperature on Receipt (°C)	8
Cooling Method	Ice Pack
Sampling Date Provided	YES

Comments

Nil

Please direct any queries to:

[redacted]	[redacted]
Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Analysis Underway, details on the following page:

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12 Ashley St Chatswood NSW 2067
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customerservice@envirolab.com.au
www.envirolab.com.au

Sample ID	PAHs in Soil	Acid Extractable metalsin soil	Asbestos ID - soils	On Hold
BH01_A-0.0				✓
BH01_B-0.25				✓
BH01_C-0.5				✓
BH01_D-0.8				✓
BH02_A-0.0				✓
BH02_B-0.25				✓
BH02_C-0.5				✓
QAQC1				✓
QAQC2				✓
BH03_A-0.0				✓
BH03_B-0.25				✓
BH03_C-0.5				✓
BH03_D-1.0				✓
BH04_A-0.0				✓
BH04_B-0.25				✓
BH04_C-0.5				✓
BH04_D-0.9				✓
BH05_A-0.0				✓
BH05_B-0.25				✓
BH05_C-0.5				✓
BH06_A_CGC-0.0	✓	✓	✓	
BH06_B_CGC-0.25				✓
BH06_C_CGC-0.5	✓	✓		
BH07_A_CGC-0.0	✓	✓	✓	
BH07_B_CGC-0.25				✓
BH07_C_CGC-0.5				✓
BH07_D_CGC-1.0	✓	✓		
BH08_A_CGC-0.0	✓	✓	✓	
BH08_B_CGC-0.25				✓
BH08_C_CGC-0.5				✓
BH08_D_CGC-1.0	✓	✓		

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

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Additional Info

Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt.
Requests for longer term sample storage must be received in writing.
Please contact the laboratory immediately if observed settled sediment present in water samples is to be included in the extraction and/or analysis (exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS analysis where solids are included by default.
TAT for Micro is dependent on incubation. This varies from 3 to 6 days.

CHAIN OF CUSTODY FORM - Client

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ENVIROLAB GROUP
National phone number 1300 424 344

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
02 9910 6200 | sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt, Myaree, WA 6154
08 9317 2505 | lab@mpl.com.au

Melbourne Lab - Envirolab Services
25 Research Drive, Croydon South, VIC 3136
03 9763 2500 | melbourne@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
08 7087 6800 | adelaide@envirolab.com.au

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
07 3266 9532 | brisbane@envirolab.com.au

Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	[redacted]
Project Mgr:	
Sampler:	
Address:	
Phone:	Mob: 0418412330
Email Results to:	[redacted] @jacobs-s.com
Email Invoice to:	[redacted]

Client Project Name/Number/Site etc (ie report title):	IA216715
PO No. (if applicable):	–
Envirolab Quote No. :	–
Date results required:	
Or choose:	~~☒ Standard~~ ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply	
Additional report format:	☐ Esdat ☐ Equis
Lab Comments:	

Sample information / **Tests Required** / **Comments**

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals 8	PAH	Asbestos (c/a)	HOLD	Provide as much information about the sample as you can
1	BH01_A	0.0	28/4/21	SOIL	X	X	X		
2	BH01-B	0.25	↓	↓				X	please note
3	BH01-C	0.5			~~X~~	~~X~~		X	24 hr TAT.
4	BH01_D	0.8			X	X			
5	BH02_A	0.0						X	
6	BH02_B	0.25			X	X	X		
7	BH02_C	0.5			X	X			
8	~~BH0~~ QAQC1				X	X			
9	QAQC 2				X	X			Please send
10	BH03_A	0.0			X	X	X		QAQC 2 to
11	BH03_B	0.25	↓	↓				X	Eurofins.

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis* — 24HR TAT

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD.	**Lab Use Only**	
Print Name: [redacted]	Print Name: [redacted]	Job number: 267823.	Cooling: Ice / Ice pack / None
Date & Time: 28/4/21 5.10pm	Date & Time: 28/04/21 1720	Temperature: 8°C	Security seal: Intact / Broken / None
Signature:	Signature:	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

CH 28/04/21 # 267823 1/3

ENVIROLAB GROUP
ENVIROLAB SERVICES
mpl

CHAIN OF CUSTODY FORM - Client

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ENVIROLAB GROUP
National phone number 1300 424 344

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Melbourne Lab - Envirolab Services
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Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	[redacted]
Project Mgr:	
Sampler:	
Address:	
Phone:	Mob: 0418412330
Email Results to:	[redacted] @jacobs.com [redacted] jacobs.com
Email Invoice to:	[redacted]

Client Project Name/Number/Site etc (ie report title):	IA216715
PO No. (if applicable):	—
Envirolab Quote No. :	—
Date results required:	
Or choose:	☐ Standard ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply	
Additional report format:	☐ Esdat ☐ Equis
Lab Comments:	

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals 8	PAH	Asbestos (p/a)	HOLD													Comments: Provide as much information about the sample as you can
12	BH03_C	0.5	28/4/21	SOIL				X													
13	BH03-D	1.0	↓	↓	X	X															
14	BH04-A	0.0						X													
15	BH04-B	0.25			X	X	X														
16	BH04-C	0.5						X													
17	BH04-D	0.95			X	X															
18	BH05-A	0.0			X	X	X														
19	BH05-B	0.25						X													
20	BH05-C	0.5			X	X															
21	BH06-A-CGC	0.0			X	X	X														
22	BH06-B-CGC	0.25	↓	↓				X													

☐ ***Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis***

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD	***Lab Use Only***	
Print Name: [redacted]	Print Name: [redacted]	Job number: 267823	Cooling: Ice / Ice pack / None
Date & Time: 28/4/21 5.10pm	Date & Time: 28/04/21 1720	Temperature: 8°C	Security seal: Intact / Broken / None
Signature:	Signature:	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

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CHAIN OF CUSTODY FORM - Client

ENVIROLAB GROUP
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Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company: JACOBS
Contact Person: [redacted]
Project Mgr:
Sampler:
Address:
Phone: Mob:
Email Results to: [redacted] @jacobs.com
[redacted] acobs.com
Email Invoice to:

Client Project Name/Number/Site etc (ie report title): IA216715
PO No. (if applicable): —
Envirolab Quote No. : —
Date results required:
Or choose: ☐ Standard ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day

Note: Inform lab in advance if urgent turnaround is required - surcharges apply

Additional report format: ☐ Esdat ☐ Equis
Lab Comments:

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals 8	PAH	Asbestos (p/a)	On HOLD	Provide as much information about the sample as you can (Comments)
23	BH06_C_CGC	0.5	28/4/21	SOIL	X	X			
24	BH07_A_CGC	0.0	↓	↓	X	X	X		
25	BH07_B_CGC	0.25						X	
26	BH07_C_CGC	0.5						X	
27	BH07_D_CGC	1.0			X	X			
28	BH08_A_CGC	0.0			X	X	X		
29	BH08_B_CGC	0.25						X	
30	BH08_C_CGC	0.5						X	
31	BH08_D_CGC	1.0	↓	↓	X	X			

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD	*Lab Use Only*	
Print Name: [redacted]	Print Name: Christine.	Job number: 267823	Cooling: Ice / Ice pack / None
Date & Time: 28/4/21 5.10pm	Date & Time: 28/04/21 1720.	Temperature: 8°C	Security seal: Intact / Broken / None
Signature:	Signature:	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

CH 28/04/21 #267823

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12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 268815

Client Details

Client	Jacobs Group (Australia) Pty Ltd
Attention	[redacted]
Address	Level 7, 177 Pac[redacted]fic Highway, North Sydney, NSW, 2060

Sample Details

Your Reference	**IA216715**
Number of Samples	48 Soil
Date samples received	12/05/2021
Date completed instructions received	12/05/2021

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	13/05/2021
Date of Issue	13/05/2021

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Asbestos Approved By

Analysed by Asbestos Approved Identifier: [redacted]

Authorised by Asbestos Approved Signatory: [redacted]

Results Approved By

[redacted]ior Chemist
up Technical Manager
Supervisor
Chemist

Authorised By

[redacted]

[redacted] Laboratory Manager

PAHs in Soil						
Our Reference		268815-1	268815-2	268815-4	268815-6	268815-8
Your Reference	UNITS	BH10_A_CGC	BH10_B_CGC	BH09_A_CGC	BH09_C_CGC	DUP C
Depth		0.0	0.25	0.0	0.5	-
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	0.4	0.4	0.2	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	0.4	1.4	0.7	<0.1	0.1
Anthracene	mg/kg	0.2	0.5	0.2	<0.1	<0.1
Fluoranthene	mg/kg	1.3	3.0	2.0	<0.1	0.3
Pyrene	mg/kg	1.2	2.6	1.7	<0.1	0.2
Benzo(a)anthracene	mg/kg	0.8	1.7	1.1	<0.1	0.1
Chrysene	mg/kg	0.6	1.4	0.9	<0.1	0.1
Benzo(b,j+k)fluoranthene	mg/kg	1	1	0.9	<0.2	<0.2
Benzo(a)pyrene	mg/kg	0.85	3.4	2.1	<0.05	0.3
Indeno(1,2,3-c,d)pyrene	mg/kg	0.5	0.9	0.6	<0.1	<0.1
Dibenzo(a,h)anthracene	mg/kg	0.1	0.2	0.2	<0.1	<0.1
Benzo(g,h,i)perylene	mg/kg	0.7	1.3	0.8	<0.1	0.1
Total +ve PAH's	mg/kg	8.4	18	11	<0.05	1.3
Benzo(a)pyrene TEQ calc (zero)	mg/kg	1.3	4.1	2.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	1.3	4.1	2.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	1.3	4.1	2.5	<0.5	<0.5
Surrogate p-Terphenyl-d14	%	119	106	108	111	110

PAHs in Soil						
Our Reference		268815-10	268815-12	268815-13	268815-14	268815-17
Your Reference	UNITS	BH11_B_CGC	BH11_D_CGC	BH12_A_CGC	BH12_B_CGC	BH13_A_CGC
Depth		0.25	1.0	0.0	0.25	0.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Naphthalene	mg/kg	0.3	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	1.5	<0.1	0.1	0.2	0.4
Acenaphthene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	0.4	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	5.4	<0.1	0.3	0.7	0.6
Anthracene	mg/kg	5.8	<0.1	0.1	0.3	0.3
Fluoranthene	mg/kg	13	<0.1	1.0	1.9	2.3
Pyrene	mg/kg	11	<0.1	0.9	1.6	2.3
Benzo(a)anthracene	mg/kg	6.6	<0.1	0.5	1.0	1.6
Chrysene	mg/kg	5.2	<0.1	0.5	0.8	1.4
Benzo(b,j+k)fluoranthene	mg/kg	5.3	<0.2	0.5	0.8	2.7
Benzo(a)pyrene	mg/kg	13	<0.05	1.1	2.0	1.7
Indeno(1,2,3-c,d)pyrene	mg/kg	3.5	<0.1	0.4	0.6	1
Dibenzo(a,h)anthracene	mg/kg	0.9	<0.1	0.1	0.2	0.2
Benzo(g,h,i)perylene	mg/kg	4.9	<0.1	0.5	0.8	1.3
Total +ve PAH's	mg/kg	76	<0.05	6.2	11	16
Benzo(a)pyrene TEQ calc (zero)	mg/kg	15	<0.5	1.4	2.4	2.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	15	<0.5	1.4	2.4	2.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	15	<0.5	1.4	2.4	2.5
Surrogate p-Terphenyl-d14	%	106	108	111	107	115

PAHs in Soil						
Our Reference	UNITS	268815-20	268815-21	268815-23	268815-25	268815-28
Your Reference		BH13_D_CGC	BH14_A_CGC	BH14_C_CGC	BH15_A_CGC	BH15_D_CGC
Depth		1.0	0.0	0.5	0.0	1.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	11
Acenaphthylene	mg/kg	<0.1	0.2	0.1	0.4	6.9
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	18
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	29
Phenanthrene	mg/kg	<0.1	0.6	0.3	1.2	300
Anthracene	mg/kg	<0.1	0.2	<0.1	0.4	93
Fluoranthene	mg/kg	<0.1	2.0	0.8	3.6	460
Pyrene	mg/kg	<0.1	1.7	0.7	3.1	340
Benzo(a)anthracene	mg/kg	<0.1	1.1	0.4	1.8	200
Chrysene	mg/kg	<0.1	0.9	0.4	1.6	170
Benzo(b,j+k)fluoranthene	mg/kg	<0.2	0.9	0.4	2	110
Benzo(a)pyrene	mg/kg	<0.05	2.2	0.96	3.6	28
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1	0.6	0.3	1.0	66
Dibenzo(a,h)anthracene	mg/kg	<0.1	0.2	<0.1	0.3	20
Benzo(g,h,i)perylene	mg/kg	<0.1	0.9	0.4	1.5	83
Total +ve PAH's	mg/kg	<0.05	12	4.8	20	1,900
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5	2.7	1.1	4.3	88
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5	2.7	1.1	4.3	88
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5	2.7	1.2	4.3	88
Surrogate p-Terphenyl-d14	%	111	110	107	104	106

PAHs in Soil						
Our Reference		268815-29	268815-32	268815-33	268815-34	268815-36
Your Reference	UNITS	BH16_A_CGC	BH16_D_CGC	DUP E	BH17_A_CGC	BH17_C_CGC
Depth		0.0	1.0	-	0.0	0.5
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Naphthalene	mg/kg	0.2	<0.1	<0.1	<0.1	0.1
Acenaphthylene	mg/kg	0.7	<0.1	<0.1	0.2	0.9
Acenaphthene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	0.2	<0.1	<0.1	<0.1	0.1
Phenanthrene	mg/kg	2.7	<0.1	<0.1	0.6	1.8
Anthracene	mg/kg	1.0	<0.1	<0.1	0.2	0.8
Fluoranthene	mg/kg	10	0.2	0.1	1.5	7.1
Pyrene	mg/kg	8.5	0.1	0.1	1.3	6.7
Benzo(a)anthracene	mg/kg	5.8	<0.1	<0.1	0.8	5.1
Chrysene	mg/kg	4.4	<0.1	<0.1	0.6	4.1
Benzo(b,j+k)fluoranthene	mg/kg	4.4	<0.2	<0.2	1	4.0
Benzo(a)pyrene	mg/kg	11	0.1	0.1	0.78	11
Indeno(1,2,3-c,d)pyrene	mg/kg	3.0	<0.1	<0.1	0.4	2.8
Dibenzo(a,h)anthracene	mg/kg	0.8	<0.1	<0.1	0.1	0.8
Benzo(g,h,i)perylene	mg/kg	3.9	<0.1	<0.1	0.6	4.2
Total +ve PAH's	mg/kg	57	0.4	0.4	8.4	50
Benzo(a)pyrene TEQ calc (zero)	mg/kg	13	<0.5	<0.5	1.2	13
Benzo(a)pyrene TEQ calc(half)	mg/kg	13	<0.5	<0.5	1.2	13
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	13	<0.5	<0.5	1.2	13
Surrogate p-Terphenyl-d14	%	108	108	109	112	106

PAHs in Soil						
Our Reference	UNITS	268815-38	268815-40	268815-41	268815-42	268815-45
Your Reference		BH18_A_CGC	BH18_C_CGC	BH19_A_CGC	BH19_B_CGC	BH20_A_CGC
Depth		0.0	0.5	0.0	0.25	0.0
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	0.2	0.7	0.2	0.6	0.4
Acenaphthene	mg/kg	<0.1	0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	0.3	<0.1	0.3	0.1
Phenanthrene	mg/kg	0.5	3.1	0.4	2.6	1.5
Anthracene	mg/kg	0.2	1.1	0.2	0.8	0.5
Fluoranthene	mg/kg	1.4	6.5	1.5	4.8	3.9
Pyrene	mg/kg	1.2	5.4	1.4	4.0	3.5
Benzo(a)anthracene	mg/kg	0.7	3.4	0.9	2.5	2.1
Chrysene	mg/kg	0.6	2.6	0.7	1.9	1.8
Benzo(b,j+k)fluoranthene	mg/kg	0.6	2.4	0.8	2	2
Benzo(a)pyrene	mg/kg	1.4	6.1	1.9	4.3	4.0
Indeno(1,2,3-c,d)pyrene	mg/kg	0.4	1.6	0.5	1.1	1.1
Dibenzo(a,h)anthracene	mg/kg	<0.1	0.4	0.1	0.3	0.3
Benzo(g,h,i)perylene	mg/kg	0.6	2.1	0.8	1.5	1.6
Total +ve PAH's	mg/kg	7.7	36	9.4	26	22
Benzo(a)pyrene TEQ calc (zero)	mg/kg	1.6	7.3	2.3	5.2	4.9
Benzo(a)pyrene TEQ calc(half)	mg/kg	1.7	7.3	2.3	5.2	4.9
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	1.7	7.3	2.3	5.2	4.9
Surrogate p-Terphenyl-d14	%	112	104	112	104	108

PAHs in Soil		
Our Reference		268815-48
Your Reference	UNITS	BH20_D_CGC
Depth		1.0
Date Sampled		12/05/2021
Type of sample		Soil
Date extracted	-	12/05/2021
Date analysed	-	12/05/2021
Naphthalene	mg/kg	<0.1
Acenaphthylene	mg/kg	<0.1
Acenaphthene	mg/kg	<0.1
Fluorene	mg/kg	<0.1
Phenanthrene	mg/kg	<0.1
Anthracene	mg/kg	<0.1
Fluoranthene	mg/kg	0.2
Pyrene	mg/kg	0.2
Benzo(a)anthracene	mg/kg	0.1
Chrysene	mg/kg	0.1
Benzo(b,j+k)fluoranthene	mg/kg	<0.2
Benzo(a)pyrene	mg/kg	0.2
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1
Total +ve PAH's	mg/kg	0.78
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5
Surrogate p-Terphenyl-d14	%	107

Acid Extractable metals in soil						
Our Reference		268815-1	268815-2	268815-4	268815-6	268815-8
Your Reference	UNITS	BH10_A_CGC	BH10_B_CGC	BH09_A_CGC	BH09_C_CGC	DUP C
Depth		0.0	0.25	0.0	0.5	-
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Arsenic	mg/kg	7	12	<4	<4	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	11	10	10	20	19
Copper	mg/kg	28	19	20	2	3
Lead	mg/kg	150	160	150	10	17
Mercury	mg/kg	1.2	2.3	0.5	<0.1	<0.1
Nickel	mg/kg	11	3	3	2	2
Zinc	mg/kg	150	140	84	6	14

Acid Extractable metals in soil						
Our Reference		268815-10	268815-12	268815-13	268815-14	268815-17
Your Reference	UNITS	BH11_B_CGC	BH11_D_CGC	BH12_A_CGC	BH12_B_CGC	BH13_A_CGC
Depth		0.25	1.0	0.0	0.25	0.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Arsenic	mg/kg	13	<4	<4	<4	36
Cadmium	mg/kg	0.7	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	17	9	7	11	9
Copper	mg/kg	79	3	15	32	18
Lead	mg/kg	530	8	72	200	220
Mercury	mg/kg	0.9	<0.1	0.3	1.0	0.3
Nickel	mg/kg	10	1	3	3	5
Zinc	mg/kg	300	21	59	88	62

Acid Extractable metals in soil						
Our Reference		268815-20	268815-21	268815-23	268815-25	268815-28
Your Reference	UNITS	BH13_D_CGC	BH14_A_CGC	BH14_C_CGC	BH15_A_CGC	BH15_D_CGC
Depth		1.0	0.0	0.5	0.0	1.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Arsenic	mg/kg	<4	5	<4	4	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4	3	0.5
Chromium	mg/kg	12	8	13	15	16
Copper	mg/kg	1	11	7	16	69
Lead	mg/kg	32	64	7	85	140
Mercury	mg/kg	<0.1	<0.1	<0.1	0.5	0.2
Nickel	mg/kg	3	4	2	4	10
Zinc	mg/kg	<1	55	4	62	140

Acid Extractable metals in soil						
Our Reference		268815-29	268815-32	268815-33	268815-34	268815-36
Your Reference	UNITS	BH16_A_CGC	BH16_D_CGC	DUP E	BH17_A_CGC	BH17_C_CGC
Depth		0.0	1.0	-	0.0	0.5
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Arsenic	mg/kg	5	<4	<4	<4	6
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	12	18	19	6	11
Copper	mg/kg	57	4	2	18	19
Lead	mg/kg	150	5	3	56	110
Mercury	mg/kg	0.5	<0.1	<0.1	0.2	1
Nickel	mg/kg	4	<1	<1	6	3
Zinc	mg/kg	110	8	4	61	73

Acid Extractable metals in soil						
Our Reference		268815-38	268815-40	268815-41	268815-42	268815-45
Your Reference	UNITS	BH18_A_CGC	BH18_C_CGC	BH19_A_CGC	BH19_B_CGC	BH20_A_CGC
Depth		0.0	0.5	0.0	0.25	0.0
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Arsenic	mg/kg	4	<4	<4	<4	5
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	11	6	9	14	10
Copper	mg/kg	21	11	20	23	23
Lead	mg/kg	110	110	110	110	130
Mercury	mg/kg	0.2	0.1	0.2	0.2	0.2
Nickel	mg/kg	7	2	4	4	3
Zinc	mg/kg	97	84	90	82	84

Acid Extractable metals in soil		
Our Reference		268815-48
Your Reference	UNITS	BH20_D_CGC
Depth		1.0
Date Sampled		12/05/2021
Type of sample		Soil
Date prepared	-	12/05/2021
Date analysed	-	12/05/2021
Arsenic	mg/kg	<4
Cadmium	mg/kg	<0.4
Chromium	mg/kg	7
Copper	mg/kg	4
Lead	mg/kg	9
Mercury	mg/kg	<0.1
Nickel	mg/kg	1
Zinc	mg/kg	6

Moisture						
Our Reference		268815-1	268815-2	268815-4	268815-6	268815-8
Your Reference	UNITS	BH10_A_CGC	BH10_B_CGC	BH09_A_CGC	BH09_C_CGC	DUP C
Depth		0.0	0.25	0.0	0.5	-
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Moisture	%	30	17	23	9.6	10

Moisture						
Our Reference		268815-10	268815-12	268815-13	268815-14	268815-17
Your Reference	UNITS	BH11_B_CGC	BH11_D_CGC	BH12_A_CGC	BH12_B_CGC	BH13_A_CGC
Depth		0.25	1.0	0.0	0.25	0.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Moisture	%	20	13	23	17	20

Moisture						
Our Reference		268815-20	268815-21	268815-23	268815-25	268815-28
Your Reference	UNITS	BH13_D_CGC	BH14_A_CGC	BH14_C_CGC	BH15_A_CGC	BH15_D_CGC
Depth		1.0	0.0	0.5	0.0	1.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Moisture	%	17	18	8.8	11	4.2

Moisture						
Our Reference		268815-29	268815-32	268815-33	268815-34	268815-36
Your Reference	UNITS	BH16_A_CGC	BH16_D_CGC	DUP E	BH17_A_CGC	BH17_C_CGC
Depth		0.0	1.0	-	0.0	0.5
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Moisture	%	27	11	10	23	12

Moisture						
Our Reference		268815-38	268815-40	268815-41	268815-42	268815-45
Your Reference	UNITS	BH18_A_CGC	BH18_C_CGC	BH19_A_CGC	BH19_B_CGC	BH20_A_CGC
Depth		0.0	0.5	0.0	0.25	0.0
Date Sampled		12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/05/2021	12/05/2021	12/05/2021	12/05/2021	12/05/2021
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Moisture	%	31	12	23	12	23

Moisture		
Our Reference		268815-48
Your Reference	UNITS	BH20_D_CGC
Depth		1.0
Date Sampled		12/05/2021
Type of sample		Soil
Date prepared	-	12/05/2021
Date analysed	-	13/05/2021
Moisture	%	8.2

Asbestos ID - soils						
Our Reference		268815-1	268815-4	268815-10	268815-13	268815-17
Your Reference	UNITS	BH10_A_CGC	BH09_A_CGC	BH11_B_CGC	BH12_A_CGC	BH13_A_CGC
Depth		0.0	0.0	0.25	0.0	0.0
Date Sampled		11/05/2021	11/05/2021	11/05/2021	11/05/2021	11/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Sample mass tested	g	Approx. 35g	Approx. 35g	Approx. 35g	Approx. 35g	Approx. 40g
Sample Description	-	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks
Asbestos ID in soil	-	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected
Trace Analysis	-	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected

Asbestos ID - soils						
Our Reference		268815-21	268815-25	268815-29	268815-34	268815-38
Your Reference	UNITS	BH14_A_CGC	BH15_A_CGC	BH16_A_CGC	BH17_A_CGC	BH18_A_CGC
Depth		0.0	0.0	0.0	0.0	0.0
Date Sampled		11/05/2021	11/05/2021	12/05/2021	12/05/2021	12/05/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date analysed	-	13/05/2021	13/05/2021	13/05/2021	13/05/2021	13/05/2021
Sample mass tested	g	Approx. 35g	Approx. 45g	Approx. 35g	Approx. 35g	Approx. 35g
Sample Description	-	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks
Asbestos ID in soil	-	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected
Trace Analysis	-	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected

Asbestos ID - soils			
Our Reference		268815-41	268815-45
Your Reference	UNITS	BH19_A_CGC	BH20_A_CGC
Depth		0.0	0.0
Date Sampled		12/05/2021	12/05/2021
Type of sample		Soil	Soil
Date analysed	-	13/05/2021	13/05/2021
Sample mass tested	g	Approx. 35g	Approx. 35g
Sample Description	-	Brown fine-grained soil & rocks	Brown fine-grained soil & rocks
Asbestos ID in soil	-	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected
Trace Analysis	-	No asbestos detected	No asbestos detected

Method ID	Methodology Summary
ASB-001	Asbestos ID - Qualitative identification of asbestos in bulk samples using Polarised Light Microscopy and Dispersion Staining Techniques including Synthetic Mineral Fibre and Organic Fibre as per Australian Standard 4964-2004.
Inorg-008	Moisture content determined by heating at 105+/-5 °C for a minimum of 12 hours.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS and/or GC-MS/MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. For soil results:- 1. 'EQ PQL'values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'EQ zero'values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more susceptible to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'EQ half PQL'values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, the Total +ve PAHs PQL is reflective of the lowest individual PQL and is therefore "Total +ve PAHs" is simply a sum of the positive individual PAHs.

QUALITY CONTROL: PAHs in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-8	268815-2
Date extracted	-			12/05/2021	1	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Date analysed	-			12/05/2021	1	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Naphthalene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	106	107
Acenaphthylene	mg/kg	0.1	Org-022/025	<0.1	1	0.4	0.3	29	[NT]	[NT]
Acenaphthene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	71	70
Fluorene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	89	87
Phenanthrene	mg/kg	0.1	Org-022/025	<0.1	1	0.4	0.5	22	105	76
Anthracene	mg/kg	0.1	Org-022/025	<0.1	1	0.2	0.2	0	[NT]	[NT]
Fluoranthene	mg/kg	0.1	Org-022/025	<0.1	1	1.3	1.5	14	109	102
Pyrene	mg/kg	0.1	Org-022/025	<0.1	1	1.2	1.3	8	96	84
Benzo(a)anthracene	mg/kg	0.1	Org-022/025	<0.1	1	0.8	0.9	12	[NT]	[NT]
Chrysene	mg/kg	0.1	Org-022/025	<0.1	1	0.6	0.7	15	86	64
Benzo(b,j+k)fluoranthene	mg/kg	0.2	Org-022/025	<0.2	1	1	2	67	[NT]	[NT]
Benzo(a)pyrene	mg/kg	0.05	Org-022/025	<0.05	1	0.85	0.92	8	90	75
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-022/025	<0.1	1	0.5	0.5	0	[NT]	[NT]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-022/025	<0.1	1	0.1	0.1	0	[NT]	[NT]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-022/025	<0.1	1	0.7	0.8	13	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	114	1	119	115	3	109	101

QUALITY CONTROL: PAHs in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-9	268815-36
Date extracted	-			[NT]	17	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Date analysed	-			[NT]	17	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Naphthalene	mg/kg	0.1	Org-022/025	[NT]	17	<0.1	<0.1	0	108	101
Acenaphthylene	mg/kg	0.1	Org-022/025	[NT]	17	0.4	0.4	0	[NT]	[NT]
Acenaphthene	mg/kg	0.1	Org-022/025	[NT]	17	<0.1	<0.1	0	71	68
Fluorene	mg/kg	0.1	Org-022/025	[NT]	17	<0.1	<0.1	0	89	87
Phenanthrene	mg/kg	0.1	Org-022/025	[NT]	17	0.6	0.6	0	103	99
Anthracene	mg/kg	0.1	Org-022/025	[NT]	17	0.3	0.2	40	[NT]	[NT]
Fluoranthene	mg/kg	0.1	Org-022/025	[NT]	17	2.3	2.3	0	102	#
Pyrene	mg/kg	0.1	Org-022/025	[NT]	17	2.3	2.3	0	93	#
Benzo(a)anthracene	mg/kg	0.1	Org-022/025	[NT]	17	1.6	1.6	0	[NT]	[NT]
Chrysene	mg/kg	0.1	Org-022/025	[NT]	17	1.4	1.4	0	86	#
Benzo(b,j+k)fluoranthene	mg/kg	0.2	Org-022/025	[NT]	17	2.7	2.6	4	[NT]	[NT]
Benzo(a)pyrene	mg/kg	0.05	Org-022/025	[NT]	17	1.7	1.6	6	90	#
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-022/025	[NT]	17	1	0.9	11	[NT]	[NT]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-022/025	[NT]	17	0.2	0.3	40	[NT]	[NT]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-022/025	[NT]	17	1.3	1.3	0	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	[NT]	17	115	113	2	107	102

QUALITY CONTROL: PAHs in Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-			[NT]	34	12/05/2021	12/05/2021		[NT]	[NT]
Date analysed	-			[NT]	34	12/05/2021	12/05/2021		[NT]	[NT]
Naphthalene	mg/kg	0.1	Org-022/025	[NT]	34	<0.1	<0.1	0	[NT]	[NT]
Acenaphthylene	mg/kg	0.1	Org-022/025	[NT]	34	0.2	0.2	0	[NT]	[NT]
Acenaphthene	mg/kg	0.1	Org-022/025	[NT]	34	<0.1	<0.1	0	[NT]	[NT]
Fluorene	mg/kg	0.1	Org-022/025	[NT]	34	<0.1	<0.1	0	[NT]	[NT]
Phenanthrene	mg/kg	0.1	Org-022/025	[NT]	34	0.6	0.6	0	[NT]	[NT]
Anthracene	mg/kg	0.1	Org-022/025	[NT]	34	0.2	0.2	0	[NT]	[NT]
Fluoranthene	mg/kg	0.1	Org-022/025	[NT]	34	1.5	1.7	12	[NT]	[NT]
Pyrene	mg/kg	0.1	Org-022/025	[NT]	34	1.3	1.5	14	[NT]	[NT]
Benzo(a)anthracene	mg/kg	0.1	Org-022/025	[NT]	34	0.8	1	22	[NT]	[NT]
Chrysene	mg/kg	0.1	Org-022/025	[NT]	34	0.6	0.8	29	[NT]	[NT]
Benzo(b,j+k)fluoranthene	mg/kg	0.2	Org-022/025	[NT]	34	1	2	67	[NT]	[NT]
Benzo(a)pyrene	mg/kg	0.05	Org-022/025	[NT]	34	0.78	0.93	18	[NT]	[NT]
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-022/025	[NT]	34	0.4	0.5	22	[NT]	[NT]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-022/025	[NT]	34	0.1	0.1	0	[NT]	[NT]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-022/025	[NT]	34	0.6	0.7	15	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	[NT]	34	112	107	5	[NT]	[NT]

QUALITY CONTROL: Acid Extractable metals in soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-8	268815-2
Date prepared	-			12/05/2021	1	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Date analysed	-			12/05/2021	1	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Arsenic	mg/kg	4	Metals-020	<4	1	7	8	13	103	105
Cadmium	mg/kg	0.4	Metals-020	<0.4	1	<0.4	<0.4	0	104	96
Chromium	mg/kg	1	Metals-020	<1	1	11	13	17	101	98
Copper	mg/kg	1	Metals-020	<1	1	28	28	0	96	99
Lead	mg/kg	1	Metals-020	<1	1	150	160	6	100	115
Mercury	mg/kg	0.1	Metals-021	<0.1	1	1.2	1.2	0	111	##
Nickel	mg/kg	1	Metals-020	<1	1	11	10	10	103	97
Zinc	mg/kg	1	Metals-020	<1	1	150	150	0	104	87

QUALITY CONTROL: Acid Extractable metals in soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-9	268815-36
Date prepared	-			[NT]	17	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Date analysed	-			[NT]	17	12/05/2021	12/05/2021		12/05/2021	12/05/2021
Arsenic	mg/kg	4	Metals-020	[NT]	17	36	37	3	108	94
Cadmium	mg/kg	0.4	Metals-020	[NT]	17	<0.4	<0.4	0	109	91
Chromium	mg/kg	1	Metals-020	[NT]	17	9	9	0	106	91
Copper	mg/kg	1	Metals-020	[NT]	17	18	16	12	99	97
Lead	mg/kg	1	Metals-020	[NT]	17	220	210	5	103	#
Mercury	mg/kg	0.1	Metals-021	[NT]	17	0.3	0.3	0	97	##
Nickel	mg/kg	1	Metals-020	[NT]	17	5	4	22	106	90
Zinc	mg/kg	1	Metals-020	[NT]	17	62	59	5	104	125

QUALITY CONTROL: Acid Extractable metals in soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	34	12/05/2021	12/05/2021		[NT]	[NT]
Date analysed	-			[NT]	34	12/05/2021	12/05/2021		[NT]	[NT]
Arsenic	mg/kg	4	Metals-020	[NT]	34	<4	<4	0	[NT]	[NT]
Cadmium	mg/kg	0.4	Metals-020	[NT]	34	<0.4	<0.4	0	[NT]	[NT]
Chromium	mg/kg	1	Metals-020	[NT]	34	6	7	15	[NT]	[NT]
Copper	mg/kg	1	Metals-020	[NT]	34	18	17	6	[NT]	[NT]
Lead	mg/kg	1	Metals-020	[NT]	34	56	60	7	[NT]	[NT]
Mercury	mg/kg	0.1	Metals-021	[NT]	34	0.2	0.2	0	[NT]	[NT]
Nickel	mg/kg	1	Metals-020	[NT]	34	6	6	0	[NT]	[NT]
Zinc	mg/kg	1	Metals-020	[NT]	34	61	67	9	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

8 metals in soil:
- # Percent recovery is not possible to report due to the inhomogeneous nature of the element/s in the sample/s. However an acceptable recovery was obtained for the LCS.
- ## Percent recovery is not possible to report due to the high concentration of the element/s in the sample/s. However an acceptable recovery was obtained for the LCS.

PAH_S:# Percent recovery for the matrix spike is not possible to report as the high concentration of analytes in sample/s 268815-36 have caused interference.

Asbestos: A portion of the supplied sample was sub-sampled for asbestos analysis according to Envirolab procedures.
We cannot guarantee that this sub-sample is indicative of the entire sample. Envirolab recommends supplying 40-50g of sample in its own container.
Note: Samples were sub-sampled from jars provided by the client.

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12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
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SAMPLE RECEIPT ADVICE

Client Details	
Client	Jacobs Group (Australia) Pty Ltd
Attention	[redacted]

Sample Login Details	
Your reference	IA216715
Envirolab Reference	268815
Date Sample Received	12/05/2021
Date Instructions Received	12/05/2021
Date Results Expected to be Reported	13/05/2021

Sample Condition	
Samples received in appropriate condition for analysis	Yes
No. of Samples Provided	48 Soil
Turnaround Time Requested	1 day
Temperature on Receipt (°C)	8.0
Cooling Method	Ice
Sampling Date Provided	YES

Comments
Nil

Please direct any queries to:

[redacted]	[redacted]
Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Analysis Underway, details on the following page:

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Sample ID	PAHs in Soil	Acid Extractable metalsin soil	Asbestos ID - soils	On Hold
BH10_A_CGC-0.0	✓	✓	✓	
BH10_B_CGC-0.25	✓	✓		
BH10_C_CGC-0.5				✓
BH09_A_CGC-0.0	✓	✓	✓	
BH09_B_CGC-0.25				✓
BH09_C_CGC-0.5	✓	✓		
BH09_D_CGC-1.0				✓
DUP C	✓	✓		
BH11_A_CGC-0.0				✓
BH11_B_CGC-0.25	✓	✓	✓	
BH11_C_CGC-0.5				✓
BH11_D_CGC-1.0	✓	✓		
BH12_A_CGC-0.0	✓	✓	✓	
BH12_B_CGC-0.25	✓	✓		
BH12_C_CGC-0.5				✓
BH12_D_CGC-1.0				✓
BH13_A_CGC-0.0	✓	✓	✓	
BH13_B_CGC-0.25				✓
BH13_C_CGC-0.5				✓
BH13_D_CGC-1.0	✓	✓		
BH14_A_CGC-0.0	✓	✓	✓	
BH14_B_CGC-0.25				✓
BH14_C_CGC-0.5	✓	✓		
BH14_D_CGC-1.0				✓
BH15_A_CGC-0.0	✓	✓	✓	
BH15_B_CGC-0.25				✓
BH15_C_CGC-0.5				✓
BH15_D_CGC-1.0	✓	✓		
BH16_A_CGC-0.0	✓	✓	✓	
BH16_B_CGC-0.25				✓
BH16_C_CGC-0.5				✓
BH16_D_CGC-1.0	✓	✓		

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Sample ID	PAHs in Soil	Acid Extractable metalsin soil	Asbestos ID - soils	On Hold
DUP E	✓	✓		
BH17_A_CGC-0.0	✓	✓	✓	
BH17_B_CGC-0.25				✓
BH17_C_CGC-0.5	✓	✓		
BH17_D_CGC-1.0				✓
BH18_A_CGC-0.0	✓	✓	✓	
BH18_B_CGC-0.25				✓
BH18_C_CGC-0.5	✓	✓		
BH19_A_CGC-0.0	✓	✓	✓	
BH19_B_CGC-0.25	✓	✓		
BH19_C_CGC-0.5				✓
BH19_D_CGC-1.0				✓
BH20_A_CGC-0.0	✓	✓	✓	
BH20_B_CGC-0.25				✓
BH20_C_CGC-0.5				✓
BH20_D_CGC-1.0	✓	✓		

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

Additional Info
Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt.
Requests for longer term sample storage must be received in writing.
Please contact the laboratory immediately if observed settled sediment present in water samples is to be included in the extraction and/or analysis (exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS analysis where solids are included by default.
TAT for Micro is dependent on incubation. This varies from 3 to 6 days.

ENVIROLAB GROUP / ENVIROLAB SERVICES / mpl

CHAIN OF CUSTODY FORM - Client

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Melbourne Lab - Envirolab Services
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Adelaide Office - Envirolab Services
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Brisbane Office - Envirolab Services
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07 3266 9532 | brisbane@envirolab.com.au

Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Client: JACOBS
Contact Person: [redacted]
Project Mgr:
Sampler:
Address:

Phone:
Mob: [redacted]
[redacted] jacobs.com

Client Project Name/Number/Site etc (ie report title): IA216715
PO No.: —
Envirolab Quote No. : —
Date results required:
Or choose: standard / same day / 1 day / 2 day / 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Additional report format: esdat / equis /
Lab Comments: please note 24 hr TAT

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Heavy metals (8)	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
1	BH10_A_CGC	0.0	11/5/21	SOIL	X	X	X		
2	BH10_B_CGC	0.25	↓	↓	X	X			
3	BH10_C_CGC	0.5						X	
4	BH09_A_CGC	0.0			X	X	X		
5	BH09_B_CGC	0.25						X	
6	BH09_C_CGC	0.5			X	X			
7	BH09_D_CGC	1.0						X	
8	DUP C				X	X			
-	DUP D				X	X			Please send
9	BH11_A_CGC	0.0						X	DUP D to
10	BH11_B_CGC	0.25			X	X	X		Eurofins
11	BH11_C_CGC	0.5	↓	↓				X	24 hr TAT

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD	*Lab Use Only*	
Print Name: [redacted]	Print Name: [redacted]	Job number: 268815	Cooling: Ice / Ice pack / None
Date & Time: 12/5/21 3pm	Date & Time: 12/5/21 1510	Temperature: 8.0	Security seal: Intact / Broken / None
Signature:	Signature:	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

1/5

ENVIROLAB GROUP ENVIROLAB SERVICES mpl

CHAIN OF CUSTODY FORM - Client

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03 9763 2500 | melbourne@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
08 7087 6800 | adelaide@envirolab.com.au

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
07 3266 9532 | brisbane@envirolab.com.au

Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Client: JACOBS	Client Project Name/Number/Site etc (ie report title): IA216715
Contact Person: [redacted]	PO No.: –
Project Mgr:	Envirolab Quote No. : –
Sampler:	Date results required:
Address:	Or choose: standard / same day / 1 day / 2 day / 3 day *Note: Inform lab in advance if urgent turnaround is required - surcharges apply*
Phone: Mob:	Additional report format: esdat / equis /
Em[redacted]jacobs.com	Lab Comments: 24 HR TAT

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Heavy metals (8)	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
12	BH11_D_CGC	1.0	11/5/21	SOIL	X	X			
13	BH12_A_CGC	0.0	↓	↓	X	X	X		
14	BH12_B_CGC	0.25			X	X			
15	BH12_C_CGC	0.5						X	
16	BH12_D_CGC	1.0						X	
17	BH13_A_CGC	0.0			X	X	X		
18	BH13_B_CGC	0.25						X	
19	BH13_C_CGC	0.5						X	
20	BH13_D_CGC	1.0			X	X			
21	BH14_A_CGC	0.0			X	X	X		
22	BH14_B_CGC	0.25						X	
23	BH14_C_CGC	0.5	↓	↓	X	X			

☐ ***Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis***

Relinquished by (Company): JACOBS	Received by (Company): ELS MD	265815 *Lab Use Only*
Print Name: [redacted]	Print Name: CM	Job number: / Cooling: Ice / Ice pack / None
Date & Time: 12/5/21 3pm	Date & Time: 12/5/21 1510	Temperature: 8.0 / Security Seal: Intact / Broken / None
Signature:	Signature: CM	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD

CHAIN OF CUSTODY FORM - Client

ENVIROLAB GROUP / ENVIROLAB SERVICES / mpl

ENVIROLAB GROUP
National phone number 1300 424 344

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
02 9910 6200 | sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt, Myaree, WA 6154
08 9317 2505 | lab@mpl.com.au

Melbourne Lab - Envirolab Services
25 Research Drive, Croydon South, VIC 3136
03 9763 2500 | melbourne@envirolab.com.au

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Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	[redacted]
Project Mgr:	
Sampler:	
Address:	
Phone:	Mob: [redacted]
Email Results to:	[redacted] @jacobs.com
Email Invoice to:	

Client Project Name/Number/Site etc (ie report title):	IA216715
PO No. (if applicable):	–
Envirolab Quote No. :	–
Date results required:	
Or choose:	☐ Standard ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply	
Additional report format:	☐ Esdat ☐ Equis
Lab Comments:	24 HR TAT

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy metals (8)	PAH	Asbestos (P/A)	HOLD	Comments: Provide as much information about the sample as you can
24	BH14_D_CGC	1.0	11/5/21	SOIL				X	
25	BH15_A_CGC	0.0	↓	↓	X	X	X		
26	BH15_B_CGC	0.25						X	
27	BH15_C_CGC	0.5						X	
28	BH15_D_CGC	1.0			X	X			
29	BH16_A_CGC	0.0	12/5/21		X	X	X		
30	BH16_B_CGC	0.25	↓					X	
31	BH16_C_CGC	0.5						X	
32	BH16_D_CGC	1.0			X	X			
33	DUP E				X	X			Please send DUP F
–	DUP F				X	X			to Eurofins 24 HR TAT

☐ ***Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis***

Relinquished by (Company): JACOBS	Received by (Company): ELS MO	Lab Use Only	
Print Name: [redacted]	Print Name: CM	Job number: 268815	Cooling: Ice / Ice pack / None
Date & Time: 12/5/21 3pm	Date & Time: 12/5/21 1510	Temperature:	Security seal: Intact / Broken / None
Signature:	Signature: CM	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

CHAIN OF CUSTODY FORM - Client

ENVIROLAB GROUP / ENVIROLAB SERVICES / mpl

ENVIROLAB GROUP
National phone number 1300 424 344

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Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	[redacted]
Project Mgr:	
Sampler:	
Address:	
Phone:	Mob: [redacted]
Email Results to:	[redacted] jacobs.com
Email Invoice to:	

Client Project Name/Number/Site etc (ie report title): IA216715

PO No. (if applicable): —

Envirolab Quote No. : —

Date results required:

Or choose: ☐ Standard ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day

Note: Inform lab in advance if urgent turnaround is required - surcharges apply

Additional report format: ☒ Esdat ☐ Equis

Lab Comments: 24 HR TAT

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals (8)	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
34	BH17_A_CGC	0.0	12/5/21	SOIL	X	X	X		
35	BH17_B_CGC	0.25	↓	↓				X	
36	BH17_C_CGC	0.5			X	X			
37	BH17_D_CGC	1.0						X	
38	BH18_A_CGC	0.0			X	X	X		
39	BH18_B_CGC	0.25						X	
40	BH18_C_CGC	0.5			X	X			
41	BH19_A_CGC	0.0			X	X	X		
42	BH19_B_CGC	0.25			X	X			
43	BH19_C_CGC	0.5						X	
44	BH19_D_CGC	1.0	↓	↓				X	

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD	*Lab Use Only*	
Print Name: [redacted]	Print Name: CM	Job number: 268815	Cooling: Ice / Ice pack / None
Date & Time: 12/5/21 3pm	Date & Time: 12/5/21 1510	Temperature:	Security seal: Intact / Broken / None
Signature: [signature]	Signature: CM	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

ENVIROLAB GROUP ENVIROLAB SERVICES mpl

CHAIN OF CUSTODY FORM - Client

ENVIROLAB GROUP
National phone number 1300 424 344

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08 8967 1201 | darwin@envirolab.com.au

Company:	JACOBS
Contact Person:	[redacted]
Project Mgr:	
Sampler:	
Address:	
Phone:	Mob: [redacted]
Email Results to:	[redacted] jacobs.com
Email Invoice to:	

Client Project Name/Number/Site etc (ie report title): IA216715

PO No. (if applicable): –

Envirolab Quote No. : –

Date results required:

Or choose: ☐ Standard ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day

Note: Inform lab in advance if urgent turnaround is required - surcharges apply

Additional report format: ☒ Esdat ☐ Equis

Lab Comments: 24 HR TAT

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals (8)	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
45	BH20-A-CGC	0.0	12/5/21	SOIL	X	X	X		
46	BH20-B-CGC	0.25	↓	↓				X	
47	BH20-C-CGC	0.5			~~X~~	~~X~~		X	
48	BH20-D-CGC	1.0			X	X		~~X~~	

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS	Received by (Company): ELS SYD	*Lab Use Only*	
Print Name: [redacted]	Print Name: CM	Job number: 268815	Cooling: Ice / Ice pack / None
Date & Time: 12/5/21 3pm	Date & Time: 12/5/21 1510	Temperature:	Security seal: Intact / Broken / None
Signature:	Signature: CM	TAT Req - SAME day / 1 / 2 / 3 / 4 / STD	

5/5

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Certificate of Analysis

Jacobs Group (Australia) P/L NSW
Level 7, 177 Pacific Highway
North Sydney
NSW 2065

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Attention: [redacted]

Report	**795087-S**
Project name	1A216715
Project ID	1A216715
Received Date	May 14, 2021

Client Sample ID			**DUP D**
Sample Matrix			**Soil**
Eurofins Sample No.			**S21-My26447**
Date Sampled			**May 11, 2021**
Test/Reference	LOR	Unit	
Polycyclic Aromatic Hydrocarbons			
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2
Acenaphthene	0.5	mg/kg	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5
Anthracene	0.5	mg/kg	< 0.5
Benz(a)anthracene	0.5	mg/kg	< 0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5
Chrysene	0.5	mg/kg	< 0.5
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5
Fluoranthene	0.5	mg/kg	< 0.5
Fluorene	0.5	mg/kg	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5
Naphthalene	0.5	mg/kg	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5
Pyrene	0.5	mg/kg	< 0.5
Total PAH*	0.5	mg/kg	< 0.5
2-Fluorobiphenyl (surr.)	1	%	98
p-Terphenyl-d14 (surr.)	1	%	107
Heavy Metals			
Arsenic	2	mg/kg	2.2
Cadmium	0.4	mg/kg	< 0.4
Chromium	5	mg/kg	13
Copper	5	mg/kg	< 5
Lead	5	mg/kg	7.7
Mercury	0.1	mg/kg	< 0.1
Nickel	5	mg/kg	< 5
Zinc	5	mg/kg	6.9
% Moisture	1	%	11

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Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Polycyclic Aromatic Hydrocarbons	Sydney	May 14, 2021	14 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Metals M8	Sydney	May 14, 2021	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
% Moisture	Sydney	May 14, 2021	14 Days
- Method: LTM-GEN-7080 Moisture			

Company Name: Jacobs Group (Australia) P/L NSW
Address: Level 7, 177 Pacific Highway
North Sydney
NSW 2065

Project Name: 1A216715
Project ID: 1A216715

Order No.:
Report #: 795087
Phone: 02 9928 2100
Fax: 02 9928 2504

Received: May 14, 2021 8:10 AM
Due: May 17, 2021
Priority: 1 Day
Contact Name: [redacted]

Eurofins Analytical Services Manager : [redacted]

Sample Detail						Polycyclic Aromatic Hydrocarbons	Metals M8	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271								
Sydney Laboratory - NATA Site # 18217						X	X	X
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
Mayfield Laboratory - NATA Site # 25079								
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	DUP D	May 11, 2021		Soil	S21-My26447	X	X	X
Test Counts						1	1	1

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

**NOTE: pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**ug/L:** micrograms per litre
ppm: Parts per million	**ppb:** Parts per billion	**%:** Percentage
org/100mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Environment Testing

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/kg	< 0.5			0.5	Pass	
Acenaphthylene	mg/kg	< 0.5			0.5	Pass	
Anthracene	mg/kg	< 0.5			0.5	Pass	
Benz(a)anthracene	mg/kg	< 0.5			0.5	Pass	
Benzo(a)pyrene	mg/kg	< 0.5			0.5	Pass	
Benzo(b&j)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Benzo(g.h.i)perylene	mg/kg	< 0.5			0.5	Pass	
Benzo(k)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Chrysene	mg/kg	< 0.5			0.5	Pass	
Dibenz(a.h)anthracene	mg/kg	< 0.5			0.5	Pass	
Fluoranthene	mg/kg	< 0.5			0.5	Pass	
Fluorene	mg/kg	< 0.5			0.5	Pass	
Indeno(1.2.3-cd)pyrene	mg/kg	< 0.5			0.5	Pass	
Naphthalene	mg/kg	< 0.5			0.5	Pass	
Phenanthrene	mg/kg	< 0.5			0.5	Pass	
Pyrene	mg/kg	< 0.5			0.5	Pass	
Method Blank							
Heavy Metals							
Arsenic	mg/kg	< 2			2	Pass	
Cadmium	mg/kg	< 0.4			0.4	Pass	
Chromium	mg/kg	< 5			5	Pass	
Copper	mg/kg	< 5			5	Pass	
Lead	mg/kg	< 5			5	Pass	
Mercury	mg/kg	< 0.1			0.1	Pass	
Nickel	mg/kg	< 5			5	Pass	
Zinc	mg/kg	< 5			5	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	109			70-130	Pass	
Acenaphthylene	%	117			70-130	Pass	
Anthracene	%	108			70-130	Pass	
Benz(a)anthracene	%	119			70-130	Pass	
Benzo(a)pyrene	%	118			70-130	Pass	
Benzo(b&j)fluoranthene	%	115			70-130	Pass	
Benzo(g.h.i)perylene	%	121			70-130	Pass	
Benzo(k)fluoranthene	%	112			70-130	Pass	
Chrysene	%	120			70-130	Pass	
Dibenz(a.h)anthracene	%	119			70-130	Pass	
Fluoranthene	%	109			70-130	Pass	
Fluorene	%	113			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	120			70-130	Pass	
Naphthalene	%	108			70-130	Pass	
Phenanthrene	%	104			70-130	Pass	
Pyrene	%	109			70-130	Pass	
LCS - % Recovery							
Heavy Metals							
Arsenic	%	114			80-120	Pass	
Cadmium	%	115			80-120	Pass	
Chromium	%	112			80-120	Pass	
Copper	%	110			80-120	Pass	

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Environment Testing

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Lead			%	112			80-120	Pass	
Mercury			%	104			80-120	Pass	
Nickel			%	110			80-120	Pass	
Zinc			%	106			80-120	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					
Acenaphthene	S21-My12202	NCP	%	125			70-130	Pass	
Anthracene	S21-My12202	NCP	%	121			70-130	Pass	
Benz(a)anthracene	S21-My12202	NCP	%	128			70-130	Pass	
Benzo(a)pyrene	S21-My12202	NCP	%	125			70-130	Pass	
Benzo(b&j)fluoranthene	S21-My12202	NCP	%	122			70-130	Pass	
Benzo(g.h.i)perylene	S21-My16581	NCP	%	108			70-130	Pass	
Benzo(k)fluoranthene	S21-My12202	NCP	%	126			70-130	Pass	
Chrysene	S21-My12202	NCP	%	126			70-130	Pass	
Dibenz(a.h)anthracene	S21-My16581	NCP	%	94			70-130	Pass	
Fluoranthene	S21-My12202	NCP	%	110			70-130	Pass	
Fluorene	S21-My12202	NCP	%	130			70-130	Pass	
Indeno(1.2.3-cd)pyrene	S21-My16581	NCP	%	102			70-130	Pass	
Naphthalene	S21-My12202	NCP	%	121			70-130	Pass	
Phenanthrene	S21-My12202	NCP	%	105			70-130	Pass	
Pyrene	S21-My12202	NCP	%	108			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic	S21-My24182	NCP	%	106			75-125	Pass	
Cadmium	S21-My24182	NCP	%	106			75-125	Pass	
Chromium	S21-My24182	NCP	%	98			75-125	Pass	
Copper	S21-My24182	NCP	%	92			75-125	Pass	
Lead	S21-My11160	NCP	%	99			75-125	Pass	
Mercury	S21-My24182	NCP	%	91			75-125	Pass	
Nickel	S21-My24182	NCP	%	97			75-125	Pass	
Zinc	S21-My24182	NCP	%	105			75-125	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Acenaphthylene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Anthracene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benz(a)anthracene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(a)pyrene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(b&j)fluoranthene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(g.h.i)perylene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(k)fluoranthene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Chrysene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Dibenz(a.h)anthracene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluoranthene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluorene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Naphthalene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Phenanthrene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Pyrene	S21-My26447	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	

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Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic	S21-My26157	NCP	mg/kg	4.7	4.6	3.0	30%	Pass	
Cadmium	S21-My26157	NCP	mg/kg	< 0.4	< 0.4	<1	30%	Pass	
Chromium	S21-My26157	NCP	mg/kg	17	11	41	30%	Fail	Q15
Copper	S21-My26157	NCP	mg/kg	28	16	54	30%	Fail	Q15
Lead	S21-My26157	NCP	mg/kg	14	9.9	37	30%	Fail	Q15
Mercury	S21-My26157	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Nickel	S21-My26157	NCP	mg/kg	8.9	8.6	4.0	30%	Pass	
Zinc	S21-My26157	NCP	mg/kg	42	31	30	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	S21-My26351	NCP	%	7.8	7.9	1.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs
Q15	The RPD reported passes Eurofins Environment Testing's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised by:

[redacted] Analytical Services Manager
Senior Analyst-Organic (NSW)
Senior Analyst-Metal (NSW)

[redacted]

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Eurofins shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall Eurofins be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

Company Name: Jacobs Group (Australia) P/L NSW
Address: Level 7, 177 Pacific Highway
North Sydney
NSW 2065

Project Name: 1A216715
Project ID: 1A216715

Order No.:
Report #: 795087
Phone: 02 9928 2100
Fax: 02 9928 2504

Received: May 14, 2021 8:10 AM
Due: May 17, 2021
Priority: 1 Day
Contact Name: [redacted]

Eurofins Analytical Services Manager : [redacted]

Sample Detail						Polycyclic Aromatic Hydrocarbons	Metals M8	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271								
Sydney Laboratory - NATA Site # 18217						X	X	X
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
Mayfield Laboratory - NATA Site # 25079								
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	DUP D	May 11, 2021		Soil	S21-My26447	X	X	X
Test Counts						1	1	1

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Environment Testing

ABN: 50 005 085 521 www.eurofins.com.au EnviroSales@eurofins.com

Australia

Melbourne
6 Monterey Road
Dandenong South VIC 3175
Phone : +61 3 8564 5000
NATA # 1261
Site # 1254 & 14271

Sydney
Unit F3, Building F
16 Mars Road
Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Perth
46-48 Banksia Road
Welshpool WA 6106
Phone : +61 8 9251 9600
NATA # 1261
Site # 23736

Newcastle
4/52 Industrial Drive
Mayfield East NSW 2304
PO Box 60 Wickham 2293
Phone : +61 2 4968 8448
NATA # 1261 Site # 25079

New Zealand

Auckland
35 O'Rorke Road
Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Sample Receipt Advice

Company name:	Jacobs Group (Australia) P/L NSW
Contact name:	Michael Stacey
Project name:	1A216715
Project ID:	1A216715
Turnaround time:	1 Day
Date/Time received	May 14, 2021 8:10 AM
Eurofins reference	795087

Sample Information

✓ A detailed list of analytes logged into our LIMS, is included in the attached summary table.

✓ All samples have been received as described on the above COC.

✓ COC has been completed correctly.

✓ Attempt to chill was evident.

✓ Appropriately preserved sample containers have been used.

✓ All samples were received in good condition.

✓ Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.

✓ Appropriate sample containers have been used.

✓ Sample containers for volatile analysis received with zero headspace.

✗ Split sample sent to requested external lab.

✗ Some samples have been subcontracted.

N/A Custody Seals intact (if used).

Notes

Contact

If you have any questions with respect to these samples, please contact your Analytical Services Manager:

Andrew Black on phone : (+61) 2 9900 8490 or by email: AndrewBlack@eurofins.com

Results will be delivered electronically via email to Michael Stacey - michael.stacey@jacobs.com.

Global Leader - Results you can trust

Gov 14/5/21 8:10am 295087

CHAIN OF CUSTODY FORM - Client

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ENVIROLAB GROUP
National phone number 1300 424 344

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
02 9910 6200 | sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt, Myaree, WA 6154
08 9317 2505 | lab@mpl.com.au

Melbourne Lab - Envirolab Services
25 Research Drive, Croydon South, VIC 3136
03 9763 2500 | melbourne@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
08 7087 6800 | adelaide@envirolab.com.au

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
07 3266 9532 | brisbane@envirolab.com.au

Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Client: JACOBS
Contact Person: [redacted]
Project Mgr:
Sampler:
Address:
Phone: Mob: [redacted]
[redacted] jacobs.com

Client Project Name/Number/Site etc (ie report title): IA216715
PO No.: —
Envirolab Quote No. : —
Date results required:
Or choose: standard / same day / 1 day / 2 day / 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Additional report format: esdat / equis /
Lab Comments: Please note 24 hr TAT

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Heavy metals (8)	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
1	BH10_A_CGC	0.0	11/5/21	SOIL	X	X	X		Relinquished by ELS Sydney C McKenzie 13/5/21 1130 CM
2	BH10_B_CGC	0.25	↓	↓	X	X			
3	BH10_C_CGC	0.5						X	
4	BH09_A_CGC	0.0			X	X	X		
5	BH09_B_CGC	0.25						X	
6	BH09_C_CGC	0.5			X	X			
7	BH09_D_CGC	1.0						X	
8	DUP C				X	X			
-	DUP D				X	X			Please send DUP D to Eurofins
9	BH11_A_CGC	0.0						X	
10	BH11_B_CGC	0.25			X	X	X		
11	BH11_C_CGC	0.5	↓	↓				X	24 hr TAT

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS
Print Name: [redacted]
Date & Time: 12/5/21 3pm
Signature:

Received by (Company): ELS SYD
Print Name: C McKenzie
Date & Time: 12/5/21 1510
Signature: CM

Lab Use Only
Job number: 268815
Temperature: 8.0
TAT Req - SAME day / 1 / 2 / 3 / 4 / STD
Cooling: Ice / Ice pack / None
Security seal: Intact / Broken / None

1/5

Jacobs Group (Australia) P/L NSW
Level 7, 177 Pacific Highway
North Sydney
NSW 2065

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Attention: **Michael Stacey**

Report **795091-S**
Project name 1A216715
Received Date May 14, 2021

Client Sample ID			DUP F
Sample Matrix			**Soil**
Eurofins Sample No.			**S21-My26456**
Date Sampled			**May 12, 2021**
Test/Reference	LOR	Unit	
Polycyclic Aromatic Hydrocarbons			
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2
Acenaphthene	0.5	mg/kg	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5
Anthracene	0.5	mg/kg	< 0.5
Benz(a)anthracene	0.5	mg/kg	0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5
Chrysene	0.5	mg/kg	0.5
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5
Fluoranthene	0.5	mg/kg	0.7
Fluorene	0.5	mg/kg	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5
Naphthalene	0.5	mg/kg	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5
Pyrene	0.5	mg/kg	0.8
Total PAH*	0.5	mg/kg	2.5
2-Fluorobiphenyl (surr.)	1	%	68
p-Terphenyl-d14 (surr.)	1	%	60
Heavy Metals			
Arsenic	2	mg/kg	3.8
Cadmium	0.4	mg/kg	< 0.4
Chromium	5	mg/kg	23
Copper	5	mg/kg	< 5
Lead	5	mg/kg	5.3
Mercury	0.1	mg/kg	< 0.1
Nickel	5	mg/kg	< 5
Zinc	5	mg/kg	< 5
% Moisture	1	%	11

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Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Polycyclic Aromatic Hydrocarbons	Sydney	May 14, 2021	14 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Metals M8	Sydney	May 14, 2021	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
% Moisture	Sydney	May 14, 2021	14 Days
- Method: LTM-GEN-7080 Moisture			

Company Name: Jacobs Group (Australia) P/L NSW
Address: Level 7, 177 Pacific Highway
North Sydney
NSW 2065

Project Name: 1A216715

Order No.:
Report #: 795091
Phone: 02 9928 2100
Fax: 02 9928 2504

Received: May 14, 2021 8:10 AM
Due: May 17, 2021
Priority: 1 Day
Contact Name: Michael Stacey

Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Polycyclic Aromatic Hydrocarbons	Metals M8	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271								
Sydney Laboratory - NATA Site # 18217						X	X	X
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
Mayfield Laboratory - NATA Site # 25079								
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	DUP F	May 12, 2021		Soil	S21-My26456	X	X	X
Test Counts						1	1	1

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**ug/L:** micrograms per litre
ppm: Parts per million	**ppb:** Parts per billion	**%:** Percentage
org/100mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

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Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/kg	< 0.5			0.5	Pass	
Acenaphthylene	mg/kg	< 0.5			0.5	Pass	
Anthracene	mg/kg	< 0.5			0.5	Pass	
Benz(a)anthracene	mg/kg	< 0.5			0.5	Pass	
Benzo(a)pyrene	mg/kg	< 0.5			0.5	Pass	
Benzo(b&j)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Benzo(g.h.i)perylene	mg/kg	< 0.5			0.5	Pass	
Benzo(k)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Chrysene	mg/kg	< 0.5			0.5	Pass	
Dibenz(a.h)anthracene	mg/kg	< 0.5			0.5	Pass	
Fluoranthene	mg/kg	< 0.5			0.5	Pass	
Fluorene	mg/kg	< 0.5			0.5	Pass	
Indeno(1.2.3-cd)pyrene	mg/kg	< 0.5			0.5	Pass	
Naphthalene	mg/kg	< 0.5			0.5	Pass	
Phenanthrene	mg/kg	< 0.5			0.5	Pass	
Pyrene	mg/kg	< 0.5			0.5	Pass	
Method Blank							
Heavy Metals							
Arsenic	mg/kg	< 2			2	Pass	
Cadmium	mg/kg	< 0.4			0.4	Pass	
Chromium	mg/kg	< 5			5	Pass	
Copper	mg/kg	< 5			5	Pass	
Lead	mg/kg	< 5			5	Pass	
Mercury	mg/kg	< 0.1			0.1	Pass	
Nickel	mg/kg	< 5			5	Pass	
Zinc	mg/kg	< 5			5	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	98			70-130	Pass	
Acenaphthylene	%	92			70-130	Pass	
Anthracene	%	96			70-130	Pass	
Benz(a)anthracene	%	97			70-130	Pass	
Benzo(a)pyrene	%	109			70-130	Pass	
Benzo(b&j)fluoranthene	%	104			70-130	Pass	
Benzo(g.h.i)perylene	%	95			70-130	Pass	
Benzo(k)fluoranthene	%	125			70-130	Pass	
Chrysene	%	106			70-130	Pass	
Dibenz(a.h)anthracene	%	85			70-130	Pass	
Fluoranthene	%	90			70-130	Pass	
Fluorene	%	98			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	103			70-130	Pass	
Naphthalene	%	95			70-130	Pass	
Phenanthrene	%	96			70-130	Pass	
Pyrene	%	93			70-130	Pass	
LCS - % Recovery							
Heavy Metals							
Arsenic	%	114			80-120	Pass	
Cadmium	%	115			80-120	Pass	
Chromium	%	112			80-120	Pass	
Copper	%	110			80-120	Pass	

Environment Testing

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Lead			%	112			80-120	Pass	
Mercury			%	104			80-120	Pass	
Nickel			%	110			80-120	Pass	
Zinc			%	106			80-120	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					
Acenaphthene	S21-My23419	NCP	%	87			70-130	Pass	
Acenaphthylene	S21-My23419	NCP	%	88			70-130	Pass	
Anthracene	S21-My23419	NCP	%	88			70-130	Pass	
Benz(a)anthracene	S21-My23419	NCP	%	86			70-130	Pass	
Benzo(a)pyrene	S21-My23419	NCP	%	95			70-130	Pass	
Benzo(b&j)fluoranthene	S21-My23419	NCP	%	96			70-130	Pass	
Benzo(g.h.i)perylene	S21-My23419	NCP	%	86			70-130	Pass	
Benzo(k)fluoranthene	S21-My23419	NCP	%	104			70-130	Pass	
Chrysene	S21-My23419	NCP	%	93			70-130	Pass	
Dibenz(a.h)anthracene	S21-My23419	NCP	%	84			70-130	Pass	
Fluoranthene	S21-My23419	NCP	%	78			70-130	Pass	
Fluorene	S21-My23419	NCP	%	89			70-130	Pass	
Indeno(1.2.3-cd)pyrene	S21-My23419	NCP	%	95			70-130	Pass	
Naphthalene	S21-My23419	NCP	%	90			70-130	Pass	
Phenanthrene	S21-My23419	NCP	%	84			70-130	Pass	
Pyrene	S21-My23419	NCP	%	80			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic	S21-My24182	NCP	%	106			75-125	Pass	
Cadmium	S21-My24182	NCP	%	106			75-125	Pass	
Chromium	S21-My24182	NCP	%	98			75-125	Pass	
Copper	S21-My24182	NCP	%	92			75-125	Pass	
Lead	S21-My11160	NCP	%	99			75-125	Pass	
Mercury	S21-My24182	NCP	%	91			75-125	Pass	
Nickel	S21-My24182	NCP	%	97			75-125	Pass	
Zinc	S21-My24182	NCP	%	105			75-125	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Acenaphthylene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Anthracene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benz(a)anthracene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(a)pyrene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(b&j)fluoranthene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(g.h.i)perylene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(k)fluoranthene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Chrysene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Dibenz(a.h)anthracene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluoranthene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluorene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Naphthalene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Phenanthrene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Pyrene	S21-My27354	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	

Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic	S21-My26157	NCP	mg/kg	4.1	4.0	3.0	30%	Pass	
Cadmium	S21-My26157	NCP	mg/kg	< 0.4	< 0.4	<1	30%	Pass	
Chromium	S21-My26157	NCP	mg/kg	15	9.6	41	30%	Fail	Q15
Copper	S21-My26157	NCP	mg/kg	24	14	54	30%	Fail	Q15
Lead	S21-My26157	NCP	mg/kg	13	8.7	37	30%	Fail	Q15
Mercury	S21-My26157	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Nickel	S21-My26157	NCP	mg/kg	7.9	7.5	4.0	30%	Pass	
Zinc	S21-My26157	NCP	mg/kg	37	27	30	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	S21-My26625	NCP	%	12	12	1.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs
Q15	The RPD reported passes Eurofins Environment Testing's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised by:

[redacted] Analytical Services Manager
Senior Analyst-Organic (NSW)
Senior Analyst-Metal (NSW)

G[redacted]

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

eurofins Environment Testing

ABN: 50 005 085 521 web: www.eurofins.com.au email: EnviroSales@eurofins.com

Australia

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NATA # 1261
Site # 1254 & 14271

Sydney
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Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
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Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

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Welshpool WA 6106
Phone : +61 8 9251 9600
NATA # 1261
Site # 23736

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NATA # 1261 Site # 25079

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35 O'Rorke Road
Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Company Name:	Jacobs Group (Australia) P/L NSW	**Order No.:**		**Received:**	May 14, 2021 8:10 AM
Address:	Level 7, 177 Pacific Highway North Sydney NSW 2065	**Report #:**	795091	**Due:**	May 17, 2021
		Phone:	02 9928 2100	**Priority:**	1 Day
		Fax:	02 9928 2504	**Contact Name:**	[redacted]
Project Name:	1A216715				

Eurofins Analytical Services Manager [redacted]

Sample Detail						Polycyclic Aromatic Hydrocarbons	Metals M8	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271								
Sydney Laboratory - NATA Site # 18217						X	X	X
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
Mayfield Laboratory - NATA Site # 25079								
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	DUP F	May 12, 2021		Soil	S21-My26456	X	X	X
Test Counts						1	1	1

Sample Receipt Advice

Company name:	Jacobs Group [redacted]tralia) P/L NSW
Contact name:	[redacted]
Project name:	1A216715
Project ID:	Not provided
Turnaround time:	1 Day
Date/Time received	May 14, 2021 8:10 AM
Eurofins reference	795091

Sample Information

✓ A detailed list of analytes logged into our LIMS, is included in the attached summary table.

✓ All samples have been received as described on the above COC.

✓ COC has been completed correctly.

✓ Attempt to chill was evident.

✓ Appropriately preserved sample containers have been used.

✓ All samples were received in good condition.

✓ Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.

✓ Appropriate sample containers have been used.

✓ Sample containers for volatile analysis received with zero headspace.

✗ Split sample sent to requested external lab.

✗ Some samples have been subcontracted.

N/A Custody Seals intact (if used).

Notes

Contact

If you have any questions with respect to these samples, please contact your Analytical Services Manager:

[redacted]

Results will be delivered electronically via email to Michael Stacey - michael.stacey@jacobs.com.

GTN 14/5/21 8:10 am 795091

CHAIN OF CUSTODY FORM - Client

ENVIROLAB GROUP
National phone number 1300 424 344

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
02 9910 6200 | sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt, Myaree, WA 6154
08 9317 2505 | lab@mpl.com.au

Melbourne Lab - Envirolab Services
25 Research Drive, Croydon South, VIC 3136
03 9763 2500 | melbourne@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
08 7087 6800 | adelaide@envirolab.com.au

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
07 3266 9532 | brisbane@envirolab.com.au

Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
08 8967 1201 | darwin@envirolab.com.au

Company: JACOBS
Contact Person: [redacted]
Project Mgr:
Sampler:
Address:

Phone: Mob: 0418412330

Email Results to: [redacted] jacobs.com

Email Invoice to:

Client Project Name/Number/Site etc (ie report title): IA216715
PO No. (if applicable): –
Envirolab Quote No. : –
Date results required:
Or choose: ☐ Standard ☐ Same Day ☒ 1 day ☐ 2 day ☐ 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Additional report format: ☐ Esdat ☐ Equis
Lab Comments: 24 HR TAT

Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	Heavy Metals (8)	PAH	Asbestos (p/a)	HOLD	Comments: Provide as much information about the sample as you can
24	BH14_D_CGC	1.0	11/5/21	SOIL				X	Relinquished via ELS and
25	BH15_A_CGC	0.0	↓	↓	X	X	X		C.Mullenzn
26	BH15_B_CGC	0.25	↓	↓				X	13/5/21 1130
27	BH15_C_CGC	0.5	↓	↓				X	CM
28	BH15_D_CGC	1.0	↓	↓	X	X			
29	BH16_A_CGC	0.0	12/5/21	↓	X	X	X		
30	BH16_B_CGC	0.25	↓	↓				X	
31	BH16_C_CGC	0.5	↓	↓				X	
32	BH16_D_CGC	1.0	↓	↓	X	X			
33	DUP E		↓	↓	X	X			
–	DUP F		↓	↓	X	X			Please send out to Eurofins 24 HR TA

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): JACOBS
Print Name: [redacted]
Date & Time: 12/5/21 3pm
Signature:

Received by (Company): ELS MO
Print Name: CM
Date & Time: 12/5/21 1510
Signature: CM

Lab Use Only
Job number: 268885
Temperature:
TAT Req - SAME day / 1 / 2 / 3 / 4 / STD
Cooling: Ice / Ice pack / None
Security seal: Intact / Broken / None

Form 302_V007

Issue date: 21 April 2021

3/5

Appendix C – 95% Upper Confidence Limit Worksheets

Normal UCL Statistics for Full Data Sets

User Selected Options	
From File	J:\IE\Projects\04_Eastern\IA216700\04 Technical\Contamination\DSI WP12\CGC\95 UCL 180521.wst
Full Precision	OFF
Confidence Coefficient	95%

Naphthalene

Number of Valid Observations	68
Number of Distinct Observations	9
Minimum	0.025
Maximum	11
Mean	0.332
Geometric Mean	0.133
Median	0.25
SD	1.32
Variance	1.741
Std. Error of Mean	0.16
Coefficient of Variation	3.975
Skewness	8.121
Lilliefors Test Statistic	0.466
5% Lilliefors Critical Value	0.107

Data not Normal at 5% Significance Level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.599

Data do not follow a Discernable Distribution (0.05)

May want to try Nonparametric UCLs

Total PAH

Number of Valid Observations	68
Number of Distinct Observations	49
Minimum	0.025
Maximum	1900
Mean	44.7
Geometric Mean	3.387
Median	7.25
SD	231.5
Variance	53575
Std. Error of Mean	28.07
Coefficient of Variation	5.178
Skewness	7.932
Lilliefors Test Statistic	0.423
5% Lilliefors Critical Value	0.107

Data not Normal at 5% Significance Level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	91.52

Data do not follow a Discernable Distribution (0.05)

May want to try Nonparametric UCLs

BaP TEQ

Number of Valid Observations	68
Number of Distinct Observations	32
Minimum	0.25
Maximum	88
Mean	4.354
Geometric Mean	1.786
Median	1.3
SD	11.5
Variance	132.2
Std. Error of Mean	1.394
Coefficient of Variation	2.64
Skewness	6.276
Lilliefors Test Statistic	0.361
5% Lilliefors Critical Value	0.107

Data not Normal at 5% Significance Level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	6.68

Data do not follow a Discernable Distribution (0.05)

May want to try Nonparametric UCLs

As

Number of Valid Observations	68
Number of Distinct Observations	14
Minimum	2
Maximum	36
Mean	4.382
Geometric Mean	3.395
Median	2.5
SD	4.738
Variance	22.45
Std. Error of Mean	0.575
Coefficient of Variation	1.081
Skewness	4.794
Lilliefors Test Statistic	0.308
5% Lilliefors Critical Value	0.107

Data not Normal at 5% Significance Level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	5.341

Data do not follow a Discernable Distribution (0.05)

May want to try Nonparametric UCLs

Cd

Number of Valid Observations	68
Number of Distinct Observations	5
Minimum	0.2
Maximum	3
Mean	0.446
Geometric Mean	0.354
Median	0.5
SD	0.474
Variance	0.225
Std. Error of Mean	0.0575
Coefficient of Variation	1.064
Skewness	4.755
Lilliefors Test Statistic	0.395
5% Lilliefors Critical Value	0.107
Data not Normal at 5% Significance Level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.541
Data do not follow a Discernable Distribution (0.05)	
May want to try Nonparametric UCLs	

Cr

Number of Valid Observations	68
Number of Distinct Observations	19
Minimum	3
Maximum	23
Mean	10.54
Geometric Mean	9.759
Median	10
SD	4.276
Variance	18.28
Std. Error of Mean	0.519
Coefficient of Variation	0.406
Skewness	1.044
Lilliefors Test Statistic	0.178
5% Lilliefors Critical Value	0.107
Data not Normal at 5% Significance Level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	11.41
Data follow Appr. Gamma Distribution (0.05)	
May want to try Gamma UCLs	

Cu

Number of Valid Observations	68
Number of Distinct Observations	40
Minimum	0.5
Maximum	480
Mean	30.19
Geometric Mean	12.64
Median	16.5
SD	62.78
Variance	3942
Std. Error of Mean	7.614
Coefficient of Variation	2.08
Skewness	5.88
Lilliefors Test Statistic	0.318
5% Lilliefors Critical Value	0.107
Data not Normal at 5% Significance Level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	42.89
Data do not follow a Discernable Distribution (0.05)	
May want to try Nonparametric UCLs	

Pb

Number of Valid Observations	68
Number of Distinct Observations	55
Minimum	2
Maximum	697
Mean	105.9
Geometric Mean	52.43
Median	76.5
SD	123.6
Variance	15275
Std. Error of Mean	14.99
Coefficient of Variation	1.167
Skewness	2.79
Lilliefors Test Statistic	0.2
5% Lilliefors Critical Value	0.107
Data not Normal at 5% Significance Level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	130.9
Data follow Appr. Gamma Distribution (0.05)	
May want to try Gamma UCLs	

Hg

Number of Valid Observations	68
Number of Distinct Observations	15
Minimum	0.05

Maximum	3
Mean	0.388
Geometric Mean	0.179
Median	0.2
SD	0.566
Variance	0.32
Std. Error of Mean	0.0686
Coefficient of Variation	1.457
Skewness	2.671
Lilliefors Test Statistic	0.277
5% Lilliefors Critical Value	0.107
Data not Normal at 5% Significance Level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.503
Data do not follow a Discernable Distribution (0.05)	
May want to try Nonparametric UCLs	
Ni	
Number of Valid Observations	68
Number of Distinct Observations	14
Minimum	0.5
Maximum	12
Mean	3.551
Geometric Mean	2.573
Median	3
SD	2.825
Variance	7.979
Std. Error of Mean	0.343
Coefficient of Variation	0.795
Skewness	1.254
Lilliefors Test Statistic	0.18
5% Lilliefors Critical Value	0.107
Data not Normal at 5% Significance Level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	4.123
Data do not follow a Discernable Distribution (0.05)	
May want to try Nonparametric UCLs	
Zn	
Number of Valid Observations	68
Number of Distinct Observations	48
Minimum	0.5
Maximum	533
Mean	83.4
Geometric Mean	39.6

Median	62
SD	90.5
Variance	8191
Std. Error of Mean	10.98
Coefficient of Variation	1.085
Skewness	2.45
Lilliefors Test Statistic	0.18
5% Lilliefors Critical Value	0.107
Data not Normal at 5% Significance Level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	101.7
Data do not follow a Discernable Distribution (0.05)	
May want to try Nonparametric UCLs	

Benzene

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	0.025
Maximum	0.025

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable Benzene was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Toluene

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	0.025
Maximum	0.025

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable Toluene was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Xylenes

Number of Valid Observations	34
Number of Missing Values	34

Number of Distinct Observations	1
Minimum	0.025
Maximum	0.025

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable Xylenes was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Ethylbenzene

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	0.025
Maximum	0.025

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable Ethylbenzene was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

C6-C10

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	5
Maximum	5

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable C6-C10 was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

F1

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	5
Maximum	5

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable F1 was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

>C10-C16

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	25
Maximum	25

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable >C10-C16 was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

F2

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	25
Maximum	25

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable F2 was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

>C16-C34

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	12
Minimum	50
Maximum	1200
Mean	134.1
Geometric Mean	84.1
Median	50
SD	209.2
Variance	43770
Std. Error of Mean	35.88
Coefficient of Variation	1.56
Skewness	4.327

Shapiro Wilk Test Statistic	0.456
5% Shapiro Wilk Critical Value	0.933
Data not Normal at 5% Significance Level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	194.8
Data do not follow a Discernable Distribution (0.05)	
May want to try Nonparametric UCLs	

>C34-C40

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	5
Minimum	50
Maximum	440
Mean	67.65
Geometric Mean	57.57
Median	50
SD	68.85
Variance	4740
Std. Error of Mean	11.81
Coefficient of Variation	1.018
Skewness	5.123
Shapiro Wilk Test Statistic	0.292
5% Shapiro Wilk Critical Value	0.933
Data not Normal at 5% Significance Level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	87.63
Data do not follow a Discernable Distribution (0.05)	
May want to try Nonparametric UCLs	

HCB

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	0.025
Maximum	0.025

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable HCB was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Aldrin+Dieldrin

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	0.025
Maximum	0.025

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable Aldrin+Dieldrin was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Chlordane

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	0.025
Maximum	0.025

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable Chlordane was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

DDD+DDT+DDE

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	0.025
Maximum	0.025

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable DDD+DDT+DDE was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Endosulfan

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	0.025

Maximum	0.025

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable Endosulfan was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Heptachlor

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	0.025
Maximum	0.025

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable Heptachlor was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Methoxychlor

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	0.1
Maximum	0.1

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable Methoxychlor was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

PCB

Number of Valid Observations	34
Number of Missing Values	34
Number of Distinct Observations	1
Minimum	0.05
Maximum	0.05

Warning: There is only one distinct observation value in this data set - resulting in '0' variance!

ProUCL (or any other software) should not be used on such a data set!

The data set for variable PCB was not processed!

If possible, compute and collect Data Quality Objectives (DQOs) based sample size and analytical results.											
The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).											

Willoughby Environmental Protection Association

10 August 2021

Department of Planning Industry and Environment

Cc: Rob Stokes, Minister for Planning; Jim Betts, Secretary, DPIE;

Re: management of contamination at Cammeray Golf Course

I am writing on behalf of the Willoughby Environmental Protection Association Inc. (**WEPA**) in relation to “Site Investigation Report – Cammeray Golf Course (WP12)” by Jacobs Group (Australia), date redacted (**Jacobs Report**). The Jacobs Report is stated to have been carried out for the Sydney Program Alliance (**SPA**).

WEPA is concerned that the Jacobs Report breaches the Conditions of Approval in relation to the Western Harbour Tunnel and Warringah Freeway Upgrade (**WHTWF**) and is seeking to have the DPIE take enforcement action in respect of the breaches.

I understand that WEPA member, Diane Staats, has already spoken to on 16 July and on 3rd August and alerted the DPIE to TFNSW's commitment (SG6), the high levels of benzo(a)pyrene and lead at BH15 and the exclusion of known contaminants in the EIS (asbestos and PAHs), which are discussed in detail below. The purpose of these calls was to enable the DPIE to begin investigations prior to receiving this letter. I understand that it is standard practice for agencies (e.g. EPA and SafeWork NSW) to begin investigations based on verbal complaints, particularly where public safety issues have been raised and immediate action is needed to protect the public.

1. THE RELEVANT CONDITIONS OF APPROVAL BREACHED

1.1 TFNSW commitment (SG6) to undertake specific environment management measures

Conditions of Approval A1 to A3 provide (emphasis added):

A1 The Proponent must carry out the CSSI in accordance with the terms of this approval and generally in accordance with the:

(a) Western Harbour Tunnel and Warringah Freeway Upgrade Environmental Impact Statement – Volumes 1A-B and 2A-J (dated January 2020) (the EIS); and

(b) Western Harbour Tunnel and Warringah Freeway Upgrade Response to Submissions Report (dated September 2020) (the RtS).

*A2 The CSSI must only be carried out in accordance with all procedures, **commitments**, preventative actions, performance criteria and mitigation measures set out in the documents listed in Condition A1 unless otherwise specified in, or required under, this approval.*

A3 In the event of an inconsistency between:

(a) the terms of this approval and any document listed in Condition A1 inclusive, the terms of this approval will prevail to the extent of the inconsistency; and

(b) any document listed in Condition A1 inclusive, the most recent document will prevail to the extent of the inconsistency.

The Response to Submissions Report contains the following section:

After consideration of the issues raised in the public submissions, the environmental management measures for the project have been revised (Table D2-1).

The adjustments to the measures were made to: …

• Modify the wording so that the outcome of a commitment is clearer to implement. Where new commitments have been added or new text has been added to an existing measure, it is in bold text. Where a commitment has been deleted or text from a commitment deleted, it appears as strikethrough text.

All revised environmental management measures would be incorporated into management plans

The relevant part of Table D2-1 is reproduced below. By virtue of the combined operation of conditions A1 to A3, quoted above, Environmental Management Measure SG6 is now a Condition of Approval which needs to be complied with.

Western Harbour Tunnel and Warringah Freeway Upgrade
Submissions report D2-22

D Revised environmental management measures, conclusion and references
D2 Revised environmental management measures

Ref	Phase	Impact	Environmental management measure	Location
SG6	Construction	Impacts on site workers and/or local community through disturbance and mobilisation of contaminated material	Potentially contaminated areas directly affected by the project will be investigated and managed in accordance with the requirements of guidance endorsed under section 105 of the *Contaminated Land Management Act 2008*. This includes, but is not limited to, further investigations in potential areas of environment interest in the project footprint, including: • Easton Park • Birchgrove peninsula (including Yurulbin Park) • Balls Head peninsula • Waverton Park • Warringah Freeway (from North Sydney to Cammeray). Subject to the outcomes of the investigations, a Remediation Action Plan will be implemented in the event that site remediation is warranted ~~prior to construction~~. The Remediation Action Plan will be prepared and implemented in accordance with Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land (Department of Urban Affairs and Planning and EPA, 1998). An independent NSW EPA Accredited site Auditor will be engaged **where contamination is complex** to review **applicable** ~~all~~ contamination reports and evaluate the suitability of sites for a specified use as part of the project.	WHT/WFU

https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=EXH-2682%2120200914T005951.156%20GMT

The contamination revealed by the Jacobs Report is complex because:

- of the difficulties in choosing the appropriate HILs
- the nature, scope and location of the contaminants is uncertain
- of the uncontrolled fill material identified by SMEC
- some samples show an exceedance of recreational HIL values and, if averaging is not applied, of industrial/commercial HIL values
- some of the contamination is odorous contamination
- the Jacobs Report recognises that further testing is needed before there are sub-surface works in areas such as around the hotspot at BH15
- the Jacobs Report recognises the need for a site auditor at least at some stage because of the nature and level of the contaminants being disturbed, potentially impacting sensitive users who may use the golf course and attend neighbouring schools. Normally a site auditor (who has a higher level of expertise and is independent) is involved throughout the whole of the project, rather than at the end of the project

These matters are covered in further detail in section 2.

Accordingly, an independent EPA site auditor needs to be engaged in accordance with SG6.

1.1.1 An independent NSW EPA Accredited site auditor should be engaged even where contamination is not complex

It is of great concern that, as part of the planning approval process, the proponent in its formal response to submissions waters down an undertaking given to members of the public in the EIS i.e. to engage an EPA accredited auditor to review all contamination reports; to a less stringent undertaking i.e. to engage an EPA accredited auditor where contamination is complex to review applicable contamination reports.

It is difficult to see what this watering down is in response to given the EPA's submission on the EIS which relevantly contains the following:

The desktop review identifies several areas of environmental interest, and it is considered that site remediation will be a likely outcome. However, site investigations are required to determine what remedial measures should be implemented. As such, the EPA recommends that the proponent be required to engage a NSW EPA-accredited Site Auditor for the duration of construction to ensure that any work required in relation to soil or groundwater contamination is appropriately managed.
See
https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=PAE-1961%2120200312T064027.397%20GMT

The watering down is also inconsistent with the statement introducing Table D2-1, which contains the modified SG6, i.e.:
After consideration of the issues raised in the public submissions, the environmental management measures for the project have been revised (Table D2-1). The adjustments to the measures were made to:
• Make additional commitments based on the response to submissions within this report

• Make additional commitments based on the findings of further assessments provided within this report
• Make additional commitments based on the additional consultation carried out during the preparation of this report
• Modify the wording so that the outcome of a commitment is clearer to implement.

Members of the public are entitled to believe that commitments made in the EIS will be honoured rather than watered down in documents they are unlikely to be aware of and have no opportunity to respond to.

The Planning Secretary should make directions, if necessary, under Condition A4(a) to require TfNSW to adhere to commitment SG6 in its original form

1.2 Condition E117(i)

This condition requires that a Detailed Site Investigation report provide details on:

(i) *whether the land is suitable (for the intended final land use) or can be made suitable through remediation*.

The Jacobs Report asserts that this condition does not apply because:

these works are not considered (sic) meet the definition of 'disturbance 'as described in Condition E117(i)

This appears to be an error in the Jacobs Report as the word 'disturbance 'does not appear in E117(i) and the discussion in relation to this issue at page 9 of the Jacobs Report refers to condition 115(a) which relates to the need to prepare a Detailed Site investigation report "Prior to the commencement of **any work that would result in the disturbance**" (emphasis added) of a site such as the Cammeray Golf Course site.

Nevertheless, it is sufficiently clear that the authors of the Jacobs Report are arguing that because there won't be disturbance, the suitability of the land for its final use does not need to be considered.

This argument should be rejected for the following reasons:

1. Just because the work immediately proposed is "ancillary" work doesn't mean that there won't be 'disturbance'. The works are said to "include":

    • Establishment of temporary site construction facilities and equipment storage areas. These area(s) were to be used primarily for construction support activities (e.g. temporary site shed, vehicle parking, laydown areas for equipment/supplies, etc.)

    • Note that these areas were 'sub-areas' within the larger alignment corridor

    • Oversight of assessment activities to support the future Main Works contractor

    • Identification, management and potential relocation of underground services.

    Such work clearly involves 'disturbance' of soil and it is such disturbance which poses a contamination risk.

2. The site is a sub-area within one of the major construction sites for the project and as a thorough investigation of it will provide an indication of the suitability of the wider site, it makes sense to do those investigations now rather than later.

1.3 Condition E116

This requires that - *A Detailed Site Investigation Report must be prepared and submitted to the Planning Secretary for information following the completion of Detailed Site Investigations required by Condition E115. The report must be prepared in accordance with relevant guidelines made or approved by the EPA under section 105 of the Contaminated Land Management Act 1997 (NSW)*

For the reasons set out below the Jacobs Report does not comply with the relevant guidelines approved under section 105 of the *Contaminated Land Management Act 1979* (**CLMA**).

2. THE CAMMERAY GOLF COURSE SITE INVESTIGATION REPORT

This section identifies serious shortcomings in the Jacobs Report. Section 2.1 contains shortcomings identified by a senior environmental professional, experienced in the assessment and remediation of contaminated land, who has reviewed the Jacobs Report on behalf of WEPA and sections 2.2 to 2.8 sets out shortcomings WEPA has identified.

2.1 The report does not comply with the guidelines approved under section 105 of the CLMA

The senior environmental professional identified significant failures to comply with the relevant guidelines namely the following schedules of the National Environmental Protection (Assessment of Site Contamination) Measures (**NEPM**):

- Schedule B1: Guideline on Investigation Levels for Soil and Groundwater
- Schedule B2: Guidelines on Site Characterisation

Some of the failures of the Jacobs Report identified by the expert are:

2.1.1 The sampling plan is flawed

The Jacobs Report did not adopt the Data Quality Objectives (DQOs) approach which is a fundamental requirement of Schedule B2.

The seven-step DQO is a critically important process to be followed to ensure the objectives of the DSI are fully complied with so that a conceptual model of the contamination (lateral and vertical extent of potential contamination and relevant chemicals of potential concern) expected to be present on the subject site is defined so that the sampling plan (dimensions of sampling grid, number of sample locations, depth intervals of samples to be collected and sampling method/s) and the analytical plan (chemicals of potential concern) can be finalised.

It is not possible to prepare a reliable DSI if the conceptual model of contamination expected on the subject site is not defined as the final step in the DQO process since this procedure determines the sampling grid, method of sampling, depths of sample collection, sample containers, preservation method/s and chemicals of potential concern that are to be analysed in a commercial chemical laboratory registered by NATA for each chemical analysis or physical test for identification of asbestos fibres.

Sampling locations

The Jacobs Report stated the total area of the six construction support sites was 14 000 square metres and that guidelines made by NSW EPA (Sampling Design Guidelines, 1995) required soil samples to be collected from a minimum of 24 grid-based locations.

The Jacobs Report further stated results of the SMEC report from 13 locations and 15 additional locations were adopted for the DSI and that this number exceeded the number of 24 samples listed in the Sampling Design Guidelines.

However, the sampling guidelines referred to in the Jacobs Report refer to the minimum number of sampling locations required to identify a contamination “hot spot” of dimensions derived in consideration of the conceptual site model, as explained above. The number of sampling locations is determined by the dimensions of a contamination hot spot defined in the conceptual model of site contamination.

It is noted that the sampling guidelines referred to above relate to detection at a 95 % confidence level for a circular contamination hot spot of a radius derived from the conceptual model of contamination expected on the site, employing a square grid. However, inspection of Figures 3-1, 3-2 and 3-3 of the Jacobs Report indicates sampling was not carried out from a square grid, but rather from an undefined, irregular-shaped grid, from which the diameter of a contamination hot spot that would be detected was not defined.

The concept adopted in the Jacobs Report of aggregating the areas of the six construction support sites of environmental concern into one area of 14 000 square metres for the purpose of determining the appropriate number of sampling locations is flawed.

The six construction support sites identified in the Jacobs Report are discrete, being separated by wide intervals and the presence of uncontrolled fill, materials identified by SMEC in all locations tested by them, and the typical inconsistency of types of materials and chemical contaminants of uncontrolled fill materials requires the number of sampling locations at each of the six construction support sites be addressed individually.

Although the sampling locations were identified on Figures 3-1, 3-2 and 3-3, the scale of the figures was not shown. Consequently, the areas of each of the six construction support sites could not be estimated. However, in consideration of the respective areal extents of the six construction support sites, and blindly applying the requirement of Table A of NSW EPA (1995) Sampling Design Guidelines, soil samples are required to be collected from approximately 45 locations.

However, the appropriate number of sampling locations, the depth intervals that samples are to be collected from and the chemicals of potential concern can be identified reliably only after application of the DQO program for the project.

As a consequence of the deficiencies in the sampling program the results documented in the Jacobs Report can apply only to the locations sampled and cannot be used to reliably estimate the extent of contamination on the construction support sites.

2.1.2. Sample collection method inappropriate for VOCs

Soil samples for chemical analysis were collected from a number of depth intervals below ground surface using a hand auger and were placed in glass jars and transported to a NATA registered chemical laboratory in cool containers under chain-of-custody documentation.

Soil samples collected using a hand auger are referred to as 'disturbed 'samples from which volatile components are partially or wholly lost during auguring and transfer of soil samples into the glass jars. Disturbed soil samples are not suitable to be used for chemical analysis of volatile organic compounds such as light petroleum hydrocarbons and benzene, toluene, ethylbenzene and xylenes (BTEX).

The Jacobs Report stated that soil samples were collected from 28 locations, but descriptions of the sub-surface stratigraphy for soils and fill materials (Table 9-1) were provided only for the 15 locations sampled by Jacobs. No descriptions of the soil and fill materials reported by SMEC were provided. As parts of the sample collection procedures, it is common for the presence of volatile organic compounds (light petroleum hydrocarbons and BTEX compounds) be screened on-site shortly after collection using a photoionisation detector (PID). Use of the PID on-site allows additional samples to be collected to better define areas of environmental concern and provides a qualitative means of checking results for VOCs in soil samples reported by the commercial chemical laboratory.

As a consequence of disturbed soil samples being analysed for volatile chemical compounds, the presence of these compounds in the fill materials across the construction support site remains uncertain.

2.1.3 Impermissible averaging of results of analyses

The Jacobs Report stated "… concentrations of contaminant compounds were below the adopted HIL/HSL with the exception of the benzo(a)pyrene TEQ reported in sample BH15_D_CGC at a depth of 1mbgl (sic) in fill at concentrations exceeding the adopted HIL. This result was consistent with a distinct 'asphalt 'odour and an asphalt 'layer 'was also encountered at this location.

No other sample collected by SMEC or Jacobs reported contamination at concentrations above the adopted HIL D level, applicable to sites proposed to be used for commercial/industrial purposes.

Odorous and contaminated soil was reported at one location (BH15). However, statistical analysis of the data set showed that reported contamination levels were (on average) below the HIL D guideline values for the proposed construction use of the site.

However, given uncontrolled fill materials were identified on the construction support sites it is not appropriate to apply the average concentration across all of the sites in the manner applied in the Jacobs Report. It is clear that, if there was the requirement to assess the suitability of the construction support sites, the presence of asphaltic substances in fill would require investigation at additional locations to identify its nature and extent to assess whether remediation of these substances was required.

2.1.4 Other deficiencies identified by expert

The Jacobs Report did not assess the reliability of the results documented in the SMEC report and, consequently, the results documented in the SMEC report cannot be relied on to inform the Jacobs Report. The results reported in the SMEC report should not have been used to support the Jacobs Report without ensuring the reliability of the SMEC results.

The report of 'distinct asphalt odours 'at BH15 may also be indicative of a larger area of contamination within this area. The observation of similar fill across the investigation area combined with the heterogenous nature and complexity of uncontrolled fill, suggest that there is the potential for unexpected contamination to be encountered in other areas of the site. However, the presence of a “larger area of contamination” identified in the Jacobs Report in BH15 provides evidence for the presence of uncontrolled fill materials being present at parts of the six construction support sites where no sampling was carried out by Jacobs and in the locations sampled by SMEC for which the Jacobs Report did not assess their reliability.

2.2 Individual samples exceed guideline values for recreational use

The Jacobs Report states:

> *To evaluate the significance of the reported soil concentrations with respect to the proposed use, Jacobs compared the analytical testing results against the soil quality guidelines published in the NEPC (2013) (i.e. health-based soil investigation (HIL) levels).*
>
> *The HILs for a commercial/industrial land use (HIL-Setting D), NEPC (2013) were used to evaluate the significance of contamination.*

Using the HILS for commercial/industrial use, the Jacobs Report goes on to summarise the results of soil sampling as follows:

> *The benzo(a)pyrene TEQ reported in sample BH15_D_CGC (88mg/kg) was the only individual sample with concentrations reported above the guideline value (40 mg/kg). Statistical analysis of the data set indicated the average soil concentration for B(a)P TEQ (4.35 mg/kg) was below the adopted soil quality guideline value and that application of the average concentration was acceptable based on the statistical analysis recommended by the NEPM*.

The Jacobs Report states that the averaging is permitted by the NEPM which requires that:

> *the data set must meet the following criteria:*
>
> • *No single value should exceed 250% of the relevant investigation or screening level; and*
>
> • *The standard deviation of the results should be less than 50% of the relevant investigation or*
> *screening level*'.

For the reasons set out above, averaging should not have been applied.

The benzo(a)pyrene (BaP) level at BH15 (88 mg/kg) is, however, more than **forty times** the HIL for recreational use (4) and could not, therefore, be averaged if that HIL was applied. Even if it was, the mean level (4.35) is also above the HIL for recreational use.

One sample has a lead level (697) which exceeds the HIL for recreational use (600 mg/kg), although the mean level does not.

The Total PAHs at B15 (1900 mg/kg) also exceeded the recreational HILs (300 mg/kg).

The BaP was high at BH89 at 1 metre - 38.8 mg/kg (nearly 10 times the HIL for recreational use). That is near the boundary close to Warringah Freeway and there is a risk that BaP will be mud-tracked from the construction site as trucks enter and exit the site, with the risk that sensitive users will be exposed to contaminated BaP dust.

2.3 The HILs for recreational use should be used

In considering whether site remediation is warranted it is not appropriate to simply consider the HILs in relation to commercial/industrial land use.

This is because the CLMA is not only concerned with the contaminated land in question but the threat that contamination poses to neighbouring land and the neighbouring land in this case is used for recreational purposes. This is made clear by section 60(3)(a) which provides:

> *(3) A person is required to notify the EPA under subsection (1) or (2) only if—*
>
> *(a) each of the following is true—*
>
> *(i) the substance contaminating the land (the contaminant) or any by-product of the contaminant has entered or will foreseeably enter neighbouring land, the atmosphere, groundwater or surface water,*
>
> *(ii) the regulations prescribe for the purposes of this subparagraph, or the guidelines specify, a level of the contaminant or by-product in the neighbouring land, atmosphere, groundwater or surface water,*
>
> *(iii) the level of the contaminant or by-product after that entry is, or will foreseeably be, above the level prescribed or specified and will foreseeably continue to remain above that level,*

As illustrated by the screenshot below, the six sub-areas considered by the Jacobs Report, are located towards the top of a rim, with the golf course below them and any groundwater from the sites would be expected to migrate in a generally north-easterly direction to Willoughby Creek which then discharges into the waters of Willoughby Bay via Primrose Park.

The Report, at most, only addresses the obligation to notify that arises under section 60(3)(b), which operates independently of section 60(3)(a). But, as discussed, the Jacobs Report does not adequately address even this requirement.

2.4 The report has an overly limited focus

The Jacobs Report has been limited by its chosen focus:

> *Soil data was the most relevant media for exposure by construction workers. Therefore, collection of near surface soils (i.e. up to 1m depth) soil data was the focus of the assessment*

This is not sufficient to address the requirements of the CLMA (as discussed above) or the Conditions of Approval (e.g., E117) which requires consideration of off-site impacts and transmission pathways.

The EPA's *Consultants reporting on contaminated land: Contaminated Land Guidelines* (The EPA Guideline) and NEPM Schedule B2 - *Guideline on Site Characterisation* make clear that the information under E117 is to include:

- a list of human and ecological receptors (both on- and off-site)

- potential and complete exposure pathways (both on- and off-site)

- see page 8 at https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/contaminated-land/20p2233-consultants-reporting-on-contaminated-land-guidelines.pdf?la=en&hash=EBB6758A2DE448534B6FDD5057D280523E423CC7

2.5 Known asbestos and PAHs in the EIS have been excluded without proper inquiry

It is also of concern that the Jacobs Report, at page 13, excludes data from the EIS stating:

> *It is Jacobs understanding that the statement of "Known contamination" for this area (from the EIS) is based on the Western Harbour Tunnel and Beaches Link - Contamination Factual Report, AECOM and Coffey,2018. The reported contamination was related to Polycyclic Aromatic Hydrocarbons (at two locations) and asbestos containing materials (at one location). However, the location of these sample points, in relation to the investigation area, (i.e. Cammeray Golf Course) being assessed by Jacobs, was not clear. Therefore, it is not known if these sample points are located within the investigation area (the subject of this report), and the data was excluded.*

This statement is contrary to the EIS which states that the asbestos was found at a borehole in Cammeray Golf Course (B340_0.05-0.25) - see Appendix M, section 4.4.4, at page 65 and the last dot point on page 64.

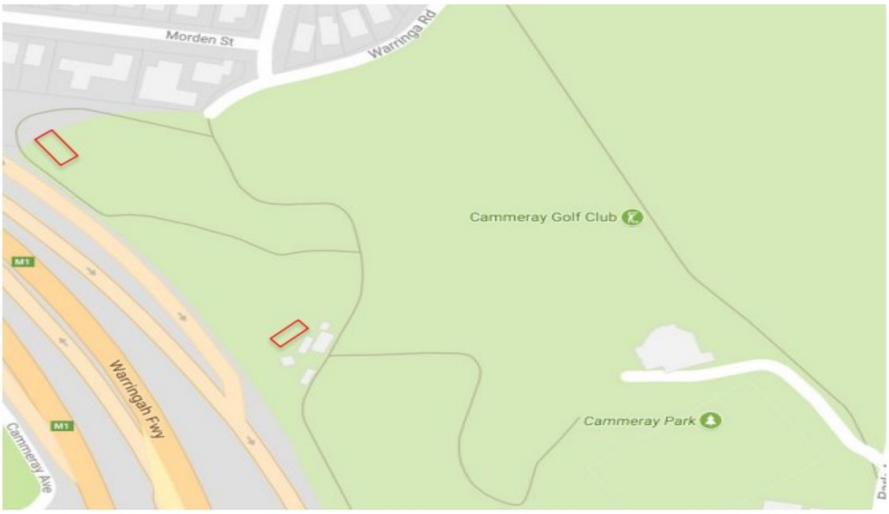
The precise location of the borehole within Cammeray Golf Course would be expected to be precisely recorded and this information would be available to Jacobs via TfNSW.

It also appears that the location of B340 within Cammeray Golf Course could have been established by a simple internet search showing the intended location of the geotechnical investigations carried out in 2017, see: https://roads-waterways.transport.nsw.gov.au/projects/01documents/western-harbour-tunnel-beaches-link/whtbl-cammeray-golf-club-geotech-b337-b338-b339-b340-2017-07.pdf

Which has this map showing the intended investigation areas in Cammeray Golf Course:

Work area

Cammeray Golf Club, Cammeray – geotechnical work sites



Similarly, it is likely that the location of the PAHs can be established. The EIS refers to exceedances of safe levels of benzo(a)pyrene at B337, another borehole at Cammeray Golf Course, and the depth is also given: see page 65 and dot point 4 on page 64 of Appendix M.

WEPA would like to have this matter investigated to assess whether Jacobs should be prosecuted for making a false or misleading statement – see section 10.6 of the *Environmental Planning and Assessment Act 1979* (**EPAA**)in conjunction with clause 285B of the Regulation.

2.6 The Jacobs Report does not stand alone and this is a further breach of the CLMA

The Jacobs Report refers to an investigation by SMEC and a report, "SMEC (2020)", although the title of the report is not referred to.

The Jacobs Report is incomplete as it does not include the SMEC report, which would have provided information about the test results e.g., the reliability of the SMEC results. Nor does it include the AECOM and Coffey report.

The EPA's *Consultants reporting on Contaminated Land Guidelines* (at page 6) states:

> *Each report must stand alone, containing enough information to be readily understood. A summary of certain information can be provided, if relevant information has been included in a previous report prepared by a consultant (unless that information has since been superseded).*

The Jacobs Report does not 'stand alone'. It needs to be read in conjunction with other reports which have not been provided or summarised.

As the SMEC Report has not been provided, the following information has not been included:

- The report only contains a summary of the testing results for soil samples taken by SMEC within the sub-area covered by the Early Works, but not in other areas of the construction site
- The report does not contain groundwater testing results. The Jacobs Report states that one groundwater monitoring well was installed by SMEC, but inspection of Figures 3-1, 3-2 and 3-3 of

the Jacobs Report shows the locations of **three** groundwater monitoring wells. The quality of groundwater for any of the wells was not addressed in the Jacobs Report.

The SMEC Report, including all soil and groundwater results for the whole site, should have been included, as it may indicate whether the construction site as a whole is suitable as a dive site and the likelihood of significant contamination in sub-surface levels.

2.7 The authors of the Jacobs Report are not independent

The Report states:

The sole purpose of this report is to present the findings of a site investigation carried out by Jacobs for the Sydney Program Alliance (SPA)

A business name search shows that the SPA is a business name owned by a partnership consisting of Freyssinet Australia Pty Ltd & Jacobs Group (Australia) Pty Ltd & John Holland Pty Ltd.

It should be noted that Jacobs will be affected if a site auditor is involved at the beginning of the project, rather than at the end as Jacobs is recommending, as it would delay the early works and potentially its role as a development partner (which it is also tendering for).

An EPA accredited site auditor, however, is required to be independent and without a financial interest in the project.

2.8 The Jacobs Report should cover the whole site and not just the six sub-areas currently covered

The Conditions of Approval contemplate that a DSI will be prepared for the whole site before the commencement of any works:

- Condition 115 states that a DSI Report is needed prior to the commencement of work if there is any disturbance of **a moderate to high risk contaminated site**, as identified in the WHT EIS.
- Condition 116 permits the Proponent to prepare individual Detailed Site Investigation Reports for the separate sites but does not contemplate contamination reports only being prepared for parts of sites.

The failure to identify the risk of contamination at the whole site is contrary to the cautionary approach outlined in the SEPP 55 – at page 7:

> *The general principle of the Guidelines is that planning authorities should adopt a cautionary approach when exercising a planning function. The object of this approach is to enable any land contamination issues to be identified and dealt with at* ***an early stage*** *in the planning process in order to prevent harm and reduce delays and costs.*

The SEPP 55 guidelines, at pages 1 and 2, suggest that officials cannot rely on the exclusion of personal liability in section 2.28 of the *Environmental Planning and Assessment Act 1979* if the approach in the SEPP guidelines are not followed.

TfNSW internal guidelines recognise the need for early investigation of a site:

> *It is beneficial to identify contamination early to avoid ongoing impacts. By proactively managing contamination issues, the risk of harm to RMS staff, the community or the environment can be appropriately managed. Where there are concerns that contamination could be present,…, site investigations should be done so associated risks and liabilities can*

be recognised and minimised. Decisions can then be made on any requirements to remediate or otherwise manage any contamination on the site.

Land contamination has the potential to cause off-site pollution and/or the exposure of site workers or the community to contamination. If sites are not managed appropriately, and the condition of the site and surrounds is left to degrade, they may become difficult or expensive to resolve.

https://roads-waterways.transport.nsw.gov.au/business-industry/partners-suppliers/documents/guides-manuals/guideline-management-contamination.pdf

Because of the uncertainties arising from the Jacobs Report not following guidelines required to be followed under the CLMA and the apparent widespread presence of uncontrolled fill materials containing elevated concentrations of some chemical substances, it would be appropriate to carry out a DSI across the entire extent of the golf course.

3. DUTY TO AVOID HARM TO CHILDREN

The DPIE has a duty to avoid potential harm to children in exercising its compliance functions: *Sharma by her litigation representative Sister Marie Brigid Arthur v Minister for the Environmen*t [2021] FCA 560.

Although Sharma specifically considered the threat of personal injury to children from climate change this was an application of the broader principle that decision makers have a duty at common law to prevent personal injury to children in the exercise of their duties. Clearly there is a risk of personal injury to children from contamination in present circumstances due to the proximity of construction to schools, child care centres and pre-schools, and the continuing use of the golf course by sensitive users.

4. CONCLUSION

For the above reasons WEPA is seeking the following actions:

- A new DSI should be prepared, complying with the CLMA and other shortcomings identified above, and cover the entire extent of the golf course
- The DSI should evaluate the site for its intended uses throughout the project and finally
- That DSI should be reviewed by an EPA accredited auditor
- The review should be made publicly available
- All work at the six sub-areas should cease pending completion of the above actions
- The asbestos at B340 should be treated as a hot spot and work on site should cease until the extent of the hot spot is determined after further investigation under the supervision of an EPA accredited site auditor and an asbestos expert

- Any additional investigations, including those identified above, should be carried out before the review by the EPA accredited auditor
- If evidence becomes available of fill materials containing residues from fires on any of the sites to be investigated, testing for PFAS chemicals should be carried out
- The DSI should contain an assessment of whether the site is suitable for its final land use or can be made suitable by remediation
- The nature of the assessment should be such that it won't be negated by any Main Works contract
- Consistent with the CLMA, the proponent should also be required to notify the EPA pursuant to section 60
- If remediation is required such remediation should be completed before any further work is carried out
- The Department should review all Conditions of Approval to ensure compliance and, in particular, ensure that the inadequacies in the investigations identified above are addressed
- If necessary, the Department should impose such additional conditions as may be required pursuant to Condition A4(a) which empowers the Planning Secretary to give written directions
- The Department should investigate whether Jacobs should be prosecuted for having made false or misleading statements in the Jacobs Report with WEPA being advised of the outcome of the investigation

WEPA is aware of complaints about other DSI reports lodged by WEPA member, Diane Staats. WEPA is concerned about the slow speed of the investigations into these complaints as the breaches of the Conditions of Approval raised in those complaints have potential impacts on the health and wellbeing of vulnerable members of the community including children. Given the seriousness of the matters raised in this letter, WEPA would appreciate a response to this letter within 5 business days. If you are unable to respond within this time frame, please phone the number provided below to advise as to a timetable. WEPA reserves its right to escalate this matter to the NSW Ombudsman and the NSW Legislative Council inquiry should there not be a timely response.

Yours sincerely,

John Moratelli

President

Willoughby Environmental Protection Association Inc.

wepa@wepa.org.au; www.wepa.org.au

We attach photos of work carried out at Cammeray Golf Course which were taken yesterday. These photos show that work has been carried out that has resulted in the disturbance of the land at Cammeray Golf Course. Excavators and other digging equipment have been used.

We also note that critical utility installation works are being carried out this week near Warringa Road at Cammeray Golf Course which will involve at least half a metre of excavation.

Accordingly we are writing to seek confirmation that the DPIE will require Sydney Program Alliance to prepare a Detailed Site Investigation Report in accordance with guidelines made or approved by the EPA under section 105 of the *Contaminated Land Management Act 1997* (NSW), including Schedule B1 and B2 of the National Environmental Protection (Assessment of Site Contamination) Measures, and in accordance with the other Conditions of Approval (with relevant reports reviewed by an independent site auditor). We also request that the DPIE require a cessation of works until this has been done.

We are seeking a response to this email within 24 hours.

Thank you for your assistance.

Kind regards,

Diane Staats


KOBELCO

Transport for NSW

16 August 2021

Our ref: 21T-2181

Mr Ted Nye
[redacted]

By email: [redacted]

Dear Mr Nye,

Notice of remitted decision on your access application under the *Government Information (Public Access) Act 2009* (GIPA Act)

Applicant:	[redacted]
File reference:	21T-2181
Decision maker:	
Received date:	13 April 2021
Remitted decision due:	16 August 2021
Date of remitted decision:	16 August 2021

1 **Your access application**

1.1 On 13 April 2021, Transport for NSW (TfNSW) received your valid access application under the GIPA Act which sought access, relevantly, to the following information:

> *"... The report(s), working papers and analysis that support the [Environmental Impact Statement] statements which refer to why rail access is dismissed in the BLRT EIS (refer to Page 4-13, para 4, of the EIS for example)..."*

1.2 In your access application you indicated a preference for receiving correspondence by email at [redacted]

1.3 The Western Harbour Beaches Link and Gore Hill Freeway Connection (**Beaches Link**) is a major road transport project being undertaken by TfNSW, linking the Northern Beaches with the Warringah Freeway and North Sydney, the inner west via the Western Harbour Tunnel, and Macquarie Park via the Gore Hill Freeway connection.

1.4 As part of that project, the NSW Government has published the Environmental Impact Statement (**EIS**) as part of the public consultation process, which is publicly available.[1] The

[1] https://caportal.com.au/rms/bl/documents#eisChapters

EIS includes analysis about the challenges associated with a rail option to the Northern Beaches, which can be summarised as:

- Physical geography (including topology and established rural areas) presenting challenges
- Large implications for cost and amenity during construction, with a long lead time for development.
- The low density of the Northern Beaches means demand would not be high enough.
- The development of high-speed bus is preferable.
- The complexity of origin and routes to travel to the CBD suggests a road development is preferable.

1.5 The access application essentially seeks any analysis or reports which supports this material in the EIS.

1.6 On 11 May 2021, TfNSW identified the Western Harbour Tunnel and Beaches Link Strategic Business Case 2015 (**SBC**) as the information within scope and refused access to that information under s. 58(1)(d) of the GIPA Act. That document is a cabinet document. However on further review of this document it has now been determined that it does not, in fact, fall within the scope of information you seek by this access application (see further at [4.14] below).

1.7 On 26 July 2021, the NSW Civil and Administrative Tribunal remitted the decision to TfNSW pursuant to s. 65(1) of the *Administrative Decisions Review Act 1997* (NSW), such decision to be made by 16 August 2021.

1.8 This is the decision made pursuant to that order.

2 Searches for information

2.1 Under the GIPA Act, TfNSW must conduct reasonable searches to locate the government information for which you have applied.

2.2 The following divisions of TfNSW have conducted searches:

- Infrastructure and Place
- Safety, Environment and Regulation
- Customer Strategy & Technology
- Greater Sydney

3 Decision

3.1 I am authorised by the Principal Officer, for the purposes of section 9(3) of the GIPA Act, to decide your access application.

3.2 I have decided that some of the information:

- is already available to you under section 58(1)(c);
- is not held under section 58(1)(b).

3.3 Please see below a summary of my decision:

Para ref.	Information	Act Ref.	Access
4.21	Land Use Forecast Data	58(1)(c)	Information already available

4.21	Journey to Work Data	58(1)(c)	Information already available
4.26	No further information held	58(1)(b)	Not applicable

Information already available to you (point 1)

3.4 Under section 59 of the GIPA Act an agency can decide that information is already available to an applicant, if the information is of a kind described in that section. The information listed at [3.3] is publicly available information. As this information can be accessed via the links provided in this decision, section 59(1)(e) of the GIPA Act applies. As such, I have decided under section 58(1)(c) that this information is already available to you.

4 Reasons for Decision

4.1 Under section 9(1) of the GIPA Act, you have a legally enforceable right to access the information you asked for, unless there is an overriding public interest against its disclosure.

4.2 Under section 5 of the GIPA Act, there is a presumption in favour of disclosing government information unless there is an overriding public interest against its disclosure.

4.3 In reaching the decision that no further information is held, I must consider whether TfNSW has sufficiently conducted a reasonable search under section 53 of the GIPA Act.

4.4 Two issues arise for consideration:

(i) Are there reasonable grounds to believe that the requested documents exist and are the documents of the agency; and

(ii) Have the search efforts made by the agency to locate such documents been reasonable in all the circumstances of a particular case?

(i) Are there reasonable grounds to believe that the requested information is held by the Agency?

4.5 On 1 December 2012, the NSW Government published the NSW Long Term Transport Master Plan (**Master Plan**), which remains publicly available.[2] It was signed by the Minister for Transport and the Minister for Roads and Ports. That document deals with proposed bus transport to the Northern Beaches and includes the following, without reference to any underlying reports or analysis:

"[Bus Rapid Transit] usually involves very frequent services, exclusive bus roadways and high quality stations and vehicles. BRT can deliver fast travel times when demand is high, but not high enough to make investing in a mass transit such as heavy rail a viable alternative."

4.6 The Master Plan was updated in 2013 and 2014, both of which remain publicly available.[3] That records the following at page 5:

"Released the *Northern Beaches Transport Action Plan,* a $633 million package of public transport and roads improvements including the $233 million Northern Beaches kerbside Bus Rapid Transit project. $25 million was committed in the 2014-15 Budget to commence Bus Rapid Transit development and delivery, including traffic projects for faster and more reliable buses, five new public transport interchanges, modern bus stops and up to 800 commuter car parking spaces. Additional funding was also allocated to

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[2] This document is publicly available: TfNSW, NSW Long Term Transport Master Plan (https://www.transport.nsw.gov.au/newsroom-and-events/reports-and-publications/nsw-long-term-transport-master-plan)

[3] TfNSW, NSW Long Term Transport Master Plan (https://www.transport.nsw.gov.au/newsroom-and-events/reports-and-publications/nsw-long-term-transport-master-plan)

feasibility studies on a motorway tunnel connection between the Northern Beaches and the Warringah Freeway and the CBD."

4.7 The 2014 Update to the Master Plan again records the position that improvements to the Northern Beaches were road and bus improvements. There is no reference to any feasibility studies to be conducted as to rail to the Northern Beaches.

4.8 In June 2012, TfNSW released the Northern Beaches Bus Rapid Transit (BRT) Pre-Feasibility Study. That Pre-Feasibility study did not refer to any commissioned analysis regarding rail to the Northern Beaches, and assessed the value of a road connection which connected to rail at North Sydney (see section 3.4, page 13).

4.9 Significantly, in 2014 Infrastructure NSW developed its State Infrastructure Strategy (**SIS**) which is also publicly available.[4] Infrastructure NSW is a NSW government agency which is responsible to the Premier, and provides advice to Government as to the development of infrastructure strategy.

4.10 The SIS discusses transport solutions for the Northern Beaches being road and bus projects, but does not refer to any feasibility work or analysis undertaken in relation to rail options, or otherwise suggest that it is being considered by Infrastructure NSW or the NSW government.

4.11 In June 2014, the NSW Government developed the Northern Beaches Transport Action Plan. That Plan identifies the action being taken by the NSW government to deliver transport improvements to the Northern Beaches, and planning for future growth in the area. The plan identifies road improvements (including feasibility studies for a Northern Beaches Motorway Tunnel), faster and more frequent ferries to the CBD, and the development of a Kerbside Bus Rapid Transit from Mona Vale to the Sydney CBD (see pages 1, 4, 7 in particular). The Transport Action Plan does not identify rail as an option being considered or pursued.

4.12 Accordingly, leading up to the development of the SBC TfNSW (at the time, Roads and Maritime Services (**RMS**)) was not commissioned to consider or develop a rail option to the Northern Beaches.

4.13 The understanding of TfNSW is that the decision for the Beaches Link to be developed as a motorway tunnel was made prior to the project being transferred to RMS. Accordingly, there is no real expectation that TfNSW would prepare a feasibility report in relation to a government decision which has already been made.

4.14 Consistently with this position, the SBC, which TfNSW prepared, is only directed to the development of road transport. It does not contain the information sought by the access application and it is outside the scope of the access application.

4.15 As noted above at [1.4], the EIS developed as part of that project included brief analysis as to why a rail option to the Northern Beaches presents challenges. Before identifying the reasonable searches which have been undertaken by TfNSW for any analysis or work underlying those statements, I note the following by way of summary:

- There is no reference to any feasibility work being required from TfNSW for a rail link to the Northern Beaches
- At least since 2012, there is no suggestion that the NSW Government has been considering a rail option to the Northern Beaches
- Infrastructure NSW, which advises the NSW Government on major infrastructure strategy, has not publicly referred to any work or priorities relating to a rail link to the Northern Beaches.

4.16 Having regard to the above, I consider it unlikely that TfNSW holds any reports or detailed analysis beyond the statements in the EIS.

[4] Accessible: https://www.infrastructure.nsw.gov.au/media/1090/inf_j14_871_sis_report_book_web_new.pdf

4.17 In circumstances where the SIS was released in 2014 identifying road and bus transport solutions for the Northern Beaches (as discussed in [4.9] above), it could be speculated that either the Department of Premier and Cabinet or Infrastructure NSW could hold information within the scope of this access application request. If held, such information would probably be dated prior to 2014, when the SIS was developed. There is no evidence available to me that Infrastructure NSW has considered any rail options since 2014, and as noted above at [4.10], the SIS does not refer to a rail option being considered.

(ii) Have the search efforts made by the agency to locate such documents been reasonable in all the circumstances of a particular case?

4.18 TfNSW conducted internal searches to identify, review and record the matters identified in paragraphs [4.5] to [4.17] which involved the review of many thousands of pages of documents. Those documents did not refer to any information which would be within scope of the access application, and tended to confirm the position that no further information is held.

4.19 *First,* five separate senior employees in TfNSW have been consulted as to whether they have any knowledge of any reports prepared or any underlying analysis. Each person confirmed that they have no knowledge of such a report held by TfNSW, and expected that one would not exist given the government priority for road transport development to the Northern Beaches.

4.20 *Second,* the searches have included a review of the SBC, including its annexures, which confirmed the position at [4.14].

4.21 *Third*, TfNSW understands that the analysis in the EIS was likely drafted based on pre-existing available raw data including:

- Land use forecasts to 2056, which are published by TfNSW.[5] That data would have informed the EIS analysis that there is unlikely to be sufficient population growth or demand to justify a rail line to the Northern Beaches. The data is accessible by a Travel Zone Explorer – Visualisation, whereby a user can identify an area and access the data on population projection (as at 2016, 2021, 2026, 2031, 2036, 2041, 2046, 2051, and 2056). That data supports the EIS analysis.
- Journey to work data. That data is derived from the five-yearly Census of Population and Housing conducted by the Australian Bureau of Statistics.[6] It is published as part of an Open Data Catalogue. The data also tends to confirm the EIS analysis.[7] Section 4.2.1 of the EIS confirms that Journey to work data for the Warringah Freeway was analysed to determine travel patterns for residents and workers in the project generally
- Household Travel Survey (**HTS**) data, which is published by TfNSW.[8] The HTS collects information on personal travel behaviour in the Sydney Greater Metropolitan Area.[9]

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[5] As this information is available in an interactive format, I do not attach it to this decision. It can be accessed via the following link: https://www.transport.nsw.gov.au/data-and-research/forecasts-and-projections

[6] https://www.transport.nsw.gov.au/data-and-research/passenger-travel/surveys/journey-to-work (Infosheet)

[7] As this information is available in an interactive format, I do not attach it to this decision. It can be accessed via the following link: https://opendata.transport.nsw.gov.au/search/type/dataset?query=%22journey+to+work%22&sort_by=changed&sort_order=DESC

[8] https://www.transport.nsw.gov.au/data-and-research/passenger-travel/surveys/household-travel-survey-hts

[9] As this information is available in an interactive format, I do not attach it to this decision. It can be accessed via the following link: https://opendata.transport.nsw.gov.au/search?query=household%20travel%20survey

4.22 These data inputs would allow a qualified analyst to understand the future demand to the Northern Beaches and produce the kind of analysis which is the subject of this access application.

4.23 Similarly, a qualified analyst is unlikely to require bespoke internal analysis or the commission of a separate, detailed report in order to make the statements in the EIS about the challenging physical geography of the Northern Beaches and longer lead time for new rail development.

4.24 After consultation with the five employees referred to above at [4.19], TfNSW has not identified further information which is held and would be expected to have informed the drafting of Section 4.3 of the EIS.

4.25 *Fourth*, for completeness, TfNSW has undertaken searches of the following divisions which have each confirmed that no information is held which is within scope:

- Safety, Environment and Regulation
- Customer Strategy and Technology
- Greater Sydney

4.26 Taking into account the searches undertaken by TfNSW, I am of the view that there are no reasonable grounds to believe that further information is held by TfNSW. I am satisfied that reasonable searches have been undertaken to identify whether there is any information within scope of the access application held by TfNSW.

5 Disclosure Log

5.1 If information that would be of interest to other members of the public is released in response to a formal access application, an agency must record certain details about the application in its 'disclosure log' (under sections 25 and 26 of the GIPA Act).

5.2 In the letter acknowledging receipt of your application, you were told about the disclosure log. You were also advised of your right to object to the inclusion of details about your access application in the disclosure log.

5.3 As this decision is not releasing any information, I have decided not to include details about your access application.

6 Review rights

6.1 I note that you have commenced proceedings in the NSW Civil and Administrative Tribunal and will have the opportunity to elect to review this decision in those proceedings.

7 Further information

7.1 If you have any difficulty accessing the links in this decision, or have any questions in relation to it, please do not hesitate to contact the Crown Solicitor's Office if you have any questions in relation to this letter.

Yours sincerely,

Senior Lawyer, Government Regulatory & Prosecutions