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SITE AUDIT REPORT

Beaches Link and Gore Hill Freeway Connection Project, NSW

Transport for NSW

21313 SAR199

Quality Management

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This report was prepared in accordance with the scope of services set out in the contract between Geosyntec Consultants Pty Ltd (ABN 23 154 745 525) and the client.

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Executive Summary

This Audit was commissioned by Transport for NSW (TfNSW) to provide an independent review of the appropriateness of a Framework Sampling, Quality and Analysis Plan (SAQP), and supporting preliminary investigations that have been completed as part of State Significant Infrastructure (SSI) application (SSI-8863) for the Beaches Link and Gore Hill Freeway Connection (BLGHFC) project, located within the local government areas of North Sydney, Willoughby, Mosman, Lane Cove and Northern Beaches ('the site').

The BLGHFC project is part of the broader Western Harbour Tunnel and Beaches Link (WHTBL) program of works and spans approximately seven kilometres from the north shore suburbs of Cammeray, Naremburn, and Artarmon to North Balgowlah and Frenchs Forest. The alignment of the BLGHFC project, shown in the broader context of the WHTBL program of works, is presented in Appendix A.

This Site Audit Report (SAR199) and associated Site Audit Statement (SAS199) consider the pre-determination investigation works conducted as part of the Environmental Impact Statement (EIS) and the Framework SAQP. This is a non-statutory Audit and has been conducted in accordance with guidelines made or approved by NSW EPA.

The aim of the Audit is to form an opinion on the appropriateness of the investigation approach outlined in the Framework SAQP, which aims to characterise the contamination of sites, located within the BLGHFC project footprint. Additional information that was subject to review as part of the Audit included:

- Environmental Impact Statement (EIS) specifically the preliminary site investigations set out in Appendix M;
- Response to Submissions Report (i.e. Revised Environmental Management Measures, Section D2); and
- Preferred Infrastructure Report.

The Framework SAQP sets out the assessment guidelines, sampling and analysis strategy, methodologies, data quality objectives and indicators, and reporting requirements for site investigations to be referenced by contractor(s) and their environmental consultant for the development of future site-specific SAQP(s) for the BLGHFC project. These requirements apply to the terrestrial areas of environmental interest (AEIs) identified in the EIS with a moderate to high risk of potential for contamination being present. It is understood that these sites will be subject to future site suitability audits.

The Framework SAQP also provides a decision-making process to determine further testing requirements for the Marine AEIs, and BLGHFC project AEIs that interface with the Western Harbour Tunnel and Warringah Freeway Upgrade project. The decision-making process also includes a framework for the identification and assessment of Additional AEIs. It is understood that Marine AEIs will not be subject to site suitability audits, and that pre-determination investigations were conducted to assist in evaluating sediment disposal requirements, and for sediment management controls.

The Framework SAQP and supporting preliminary investigations are considered to have met the requirements of NSW EPA (2017), other relevant guidelines endorsed under s.105 of the CLM Act and the objectives of this Audit. Where the consultant's work deviated from the guidelines, the Auditor has discussed this within the audit report and is satisfied that these omissions do not affect the conclusions of the Audit, subject to the deficiencies being addressed in future site-specific SAQPs and investigation reports.

On this basis a Section B2 SAS will be issued certifying that, in the opinion of the Auditor, the Framework SAQP provides an appropriate conceptual investigation approach for the development of future site-specific SAQPs for characterising contamination relevant to the BLGHFC project.

Table of Contents

Appendices

1 Introduction

This Audit was commissioned by Transport for NSW (TfNSW) to provide an independent review of the appropriateness of a Framework Sampling, Quality and Analysis Plan (SAQP), and supporting preliminary investigations that have been completed as part of State Significant Infrastructure (SSI) application (SSI-8863) for the Beaches Link and Gore Hill Freeway Connection (BLGHFC) project, located in the local government areas of North Sydney, Willoughby, Mosman, Lane Cove and Northern Beaches ('the site').

This Site Audit Report (SAR199) and associated Site Audit Statement (SAS199) consider the pre-determination investigation works conducted as part of the Environmental Impact Statement (EIS) and a Framework SAQP to form an opinion on the appropriateness the investigation approach to characterise contamination within the BLGHFC project footprint.

This Site Audit Report (SAR199) and associated Site Audit Statement (SAS199) were produced by Rebeka Hall (NSW EPA Accreditation No. 0802) employed by Geosyntec Consultants Pty Ltd (Geosyntec). Rachael Martin and Phil Hutson, Senior Consultants of Geosyntec provided assistance during the course of the audit.

The BLGHFC project is part of the broader Western Harbour Tunnel and Beaches Link (WHTBL) program of works and spans approximately seven kilometres from the north shore suburbs of Cammeray, Naremburn, and Artarmon to North Balgowlah and Frenchs Forest. The alignment of the BLGHFC project, shown in the broader context of the WHTBL program of works, is presented in Appendix A.

This is a non-statutory audit and has been conducted in accordance with guidelines made or approved by NSW EPA. This audit report refers to guidelines that were originally issued by the environmental regulator under the names of the NSW Environmental Protection Authority (EPA), NSW Department of Environmental and Conservation (DEC), NSW Department of Environment and Climate Change (DECC), NSW Department of Environment, Climate Change and Water (DECCW), and NSW Office of Environment & Heritage (OEH) part of the Department of Premier and Cabinet. For consistency, the organisation is referred to as NSW EPA in this report. NSW EPA approved guidelines will be referenced by the name of the organisation at the time of publication.

1.1 Requirements for the Audit

The Audit has been commissioned as part of TfNSW's commitments to the NSW EPA and NSW Department of Planning and Environment (DPE) prior to the determination of the State Significant Infrastructure application (SSI-8862). The Audit will form part of additional information and documentation to be provided to DPE to assist in the assessment of the SSI application.

As part of the SSI-8862 Response to Submissions, NSW EPA recommended that TfNSW be required to submit:

1. A Sampling and Analysis Quality Plan (SAQP) which details how the type, quantity, and extent of contamination for the areas of environmental interest will be assessed.

2. Interim audit advice from an EPA-accredited site auditor commenting on:

    a. the appropriateness of the contamination report prepared by Jacobs as part of this EIS and the SAQP;

    b. whether the areas of environmental interest have been appropriately identified; and

    c. the adequacy of the proposed management measures.

Based on these requirements, TfNSW advised that the specific objectives of the Audit are to:

- 'Review the information, that has been prepared for the Project to date, that addresses contamination and determine whether the works completed complied with the relevant guidelines and whether the results of the works provide a sufficiently robust basis for decisions made in relation to the potential risk of contamination being present. The information on the contamination that is subject to review is presented in the following documents:
  - Environmental Impact Statement (EIS) specifically the preliminary site investigations set out in Appendix M;
  - Response to Submissions Report (i.e. Revised Environmental Management Measures, Part D2); and
  - Preferred Infrastructure Report.
- Review the Framework SAQP to determine whether it has been adequately and appropriately prepared to meet its objectives;
- Provide a Section B2 Site Audit Statement and Site Audit Report that will document the review works completed and that will certify that the Framework SAQP is appropriate for its purpose and where relevant has been prepared in accordance with the guidelines made or approved by the NSW EPA'.

The aim of the current audit engagement is to therefore enable a Section B2 site audit statement (SAS) and associated site audit report (SAR) that forms an opinion on the 'appropriateness of an investigation plan', that is the Framework SAQP, that will enable the characterisation of contamination (where present) at each area of environment interest (AEI) upon which a remedial strategy (or management plan) can be prepared (if required).

1.1.1 Previous Site Audit

The Auditor is unaware of any previous Audits having been conducted at the site.

Given the preliminary nature of the investigations completed to date, it is possible that future detailed site investigations will identify previous Audits completed within one or more of the AEIs within the project footprint. It is anticipated that the findings of any previous audits will be discussed in future contamination investigation reports.

1.2 Overview of Site Audit Process

The Audit has been conducted in accordance with the requirements of the CLM Act 1997, as amended, which (in Part 1, Section 4 definitions) states:

"site audit" means a review:

a. That relates to management (whether under this Act or otherwise) of the actual or possible contamination of land; and

b. That is conducted for the purpose of determining any one or more of the following matters:

   i. The nature and extent of any contamination of the land,

   ii. The nature and extent of any management of actual or possible contamination of the land,

   iii. Whether the land is suitable for any specified use or range of uses,

   iv. What management remains necessary before the land is suitable for any specified use or range of uses, and

v. The suitability and appropriateness of a plan of management, long-term management plan or a voluntary management proposal.

NSW EPA (2017) Contaminated Land Management Guidelines for the NSW Site Auditor Scheme (3rd Edition), describes the site assessment and audit process as:

1. The Consultant is commissioned to assess contamination. The contaminated site consultant designs and undertakes the site assessment and, where required, all remediation and validation activities to achieve the objectives specified by the owner or developer; and
2. The Site auditor reviews the Consultant's work. The site owner or developer commissions the site auditor to review the consultant's work. The auditor prepares a site audit report and a site audit statement at the conclusion of the review, which are given to the owner or developer.

Part 4, Section 53B (6) of the CLM Act 1997 describes that Audits conducted by EPA accredited Auditors must apply:

- The provisions of the CLM Act and the CLM Regulations; and
- The guidelines made or approved by the EPA.

1.3 Relevant Guidelines

Statutory guidelines made by EPA under Section 105 of the CLM Act 1997 at the time of this report are:

- NSW EPA (January 1995) Guidelines for the Vertical Mixing of Soil on Former Broad-Acre Agricultural Land.
- NSW EPA (September 1995) Sampling Design Guidelines.
- NSW EPA (October 1997) Guidelines for Assessing Banana Plantation Sites.
- NSW DEC (2005) Guidelines for Assessing Former Orchards and Market Gardens.
- NSW DEC (2007) Guidelines for Assessment and Management of Groundwater Contamination.
- NSW EPA (2015) Contaminated Sites: Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997.
- NSW EPA (2017) Contaminated Land Management Guidelines for the NSW Site Auditor Scheme (3rd Edition).
- NSW EPA (2020a) Consultants Reporting on Contaminated Land - Contaminated Land Guidelines, noting that some of the reports were prepared prior to the issue of these guidelines and were audited against NSW OEH (2011) Guidelines for Consultants Reporting on Contaminated Sites.
- NSW EPA (2020b) Assessment and Management of Hazardous Ground Gases.
- Guidelines that refer to the:
  - Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC, 2000), are replaced as of 29 August 2018 by the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018), with the exception of the water quality for primary industries component, which still refer to the ANZECC & ARMCANZ (2000) guidelines.
  - National Environment Protection (Assessment of Site Contamination) Measure 1999 are replaced as of 16 May 2013 by the National Environment Protection (Assessment of Site Contamination) Measure 1999 (April 2013).

Statutory guidelines approved by EPA under Section 105 of the CLM Act 1997 at the time of this report are:

- NSW Agricultural/CMPS&F (1996) Guidelines for the Assessment and Clean Up of Cattle Tick Dip Sites for Residential Purposes, NSW Agricultural and CMPS&F Environmental, Canberra.
- Lock, W. H., (1996) Composite Sampling, National Environmental Health Forum Monographs, Soil Series No. 3, National Environmental Health Forum, SA Health Commission, Adelaide.
- ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 3, Primary Industries - Rationale and Background Information.
- NHMRC/NRMMC (2011) Australian Drinking Water Guidelines. National Health and Medical Research Council and National Resource Management Ministerial Council of Australia and New Zealand.
- Department of Health and Ageing and EnHealth Council, Commonwealth of Australia (2012) Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards.
- National Environment Protection (Assessment of Site Contamination) Measure 1999 (April 2013) (ASC NEPM).
- ANZG (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Non-Statutory guidelines include:

- NSW EPA (September 2010) Technical Note: Vapour Intrusion.
- DECCW (January 2010a) UPSS Technical Note: Decommissioning, Abandonment and Removal of UPSS.
- DECCW (January 2010b) UPSS Technical Note: Site Validation Reporting.
- NSW EPA (April 2014a) Best Practice Note: Landfarming.
- NSW EPA (April 2014b) Technical Note: Investigation of Service Station Sites.
- NSW EPA (August 2015) Technical Note: Light Non-Aqueous Phase Liquid Assessment and Remediation.
- NSW EPA (June 2019) Practice Note: Managing Run-Off from Service Station Forecourts.
- NSW EPA (January 2022) Practice Note: Preparing Environmental Management Plans for Contaminated Land.

Other documents referred to by the Auditor:

- WA DoH (2009) Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia.
- DECCW (January 2010c) UPSS Technical Note: Site Sensitivity Assessment.
- CRC Care (2011) Technical Report No. 10 Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater.
- CRC Care (2013) Technical Report No. 23 Petroleum Hydrocarbon Vapour Intrusion Assessment.
- NSW EPA (2014) Waste Classification Guidelines.
- NSW EPA (July 2016) UPSS: Best Practice Guide for Environmental Incident Prevention and Management.
- NSW EPA (November 2016) Guidance Document: Designing Sampling Programs for Sites Potentially Contaminated by PFAS.

- Protection of the Environment Operations (Underground Petroleum Storage Systems Regulation) 2019.
- HEPA (2020) PFAS National Environmental Management Plan, Version 2.0, January 2020 [NEMP 2.0].
- NSW EPA (December 2020) Guidelines for Implementing the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2019.

In addition to the above, the Auditor has given due regard to the provisions of the NSW Government's framework for managing waste under the Protection of the Environment Operations Act 1997 (NSW) (POEO Act 1997) and Waste Avoidance and Recovery Act 2001.

Where relevant, consideration has also been given to technical guidance on the assessment of contamination in NSW as presented on the EPA website.

1.4 Reports Reviewed

This audit report focusses on the adequacy of the following five primary reports (listed in date order) to address the objectives outlined in Section 1.1, specifically to identify any gaps in information to be captured in preparing future site-specific SAQPs:

- Jacobs (December 2020) Beaches Link and Gore Hill Freeway Connection, Technical Working Paper: Contamination, Ref: EIS, Appendix M [Jacobs 2020a], including Annexure C Royal Haskoning DHV (27 November 2020) Contaminant Levels and Results of Elutriate Testing of Sediments Associated with Dredging at Middle Harbour for Installation of the Immersed Tube Tunnel Units, Ref: PA1694-102-104-N008F01-20201127 [Royal Haskoning 2020a].
- TfNSW (November 2021) Beaches Link and Gore Hill Freeway Connection, Submissions Report, Part D2 - Revised Environmental Management Measures [TfNSW 2021a].
- TfNSW (November 2021) Beaches Link and Gore Hill Freeway Connection, Preferred Infrastructure Report, Section 3 – Spit West Reserve Temporary Construction Support Site (BL9) Reconfiguration [TfNSW 2021b].
- TfNSW (November 2021) Beaches Link and Gore Hill Freeway Connection, Preferred Infrastructure Report, Section 5 – Treatment and Loadout of Dredged and Excavated Material not Suitable for Offshore Disposal [TfNSW 2021c].
- GHD (16 May 2022) Framework Sampling, Analysis and Quality Plan, Beaches Link and Gore Hill Freeway Connection Project, Ref: 12522128_REP_Beaches Link SAQP.doc Rev 0 [GHD 2022]

The following supplementary reports (listed in date order) were considered by the Auditor to verify the conclusions presented in the primary reports listed above and/or to provide background information:

- AECOM (6 October 2017) Western Harbour Tunnel and Beaches Link - Geotechnical Investigations Factual Report GFR1, Ref: 60537922 [AECOM 2017a].
- AECOM (23 November 2017) Western Harbour Tunnel and Beaches Link Groundwater Monitoring Report - October 2017, Ref: 60537922-RPEM_0023A [AECOM 2017b].
- Douglas Partners Golder Associates (15 December 2017) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 1, Ref: 1666099-005-R-RevA [DPGA 2017 – 2018].
- AECOM (20 December 2017) Western Harbour Tunnel and Beaches Link Groundwater Monitoring Report -3 November 2017, Ref: 60537922-RPEM_0024A [AECOM 2017c].

- Douglas Partners Golder Associates (22 December 2017) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 2, Ref: 1666099-006-R-RevA [DPGA 2017 – 2018].
- Douglas Partners Golder Associates (19 January 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 3, Ref: 1666099-007-R-RevA [DPGA 2017 – 2018].
- Douglas Partners Golder Associates (9 February 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 4, Ref: 1666099-008-R-RevA [DPGA 2017 – 2018].
- Douglas Partners Golder Associates (20 March 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 5, Ref: 1666099-009-R-RevA [DPGA 2017 – 2018].
- Douglas Partners Golder Associates (29 March 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 6, Ref: 1666099-010-R-RevA [DPGA 2017 – 2018].
- AECOM Coffey (16 April 2018) Western Harbour Tunnel and Beaches Link – Contamination Factual Report (CFR), Ref: 60537922 [AECOM Coffey 2018].
- Douglas Partners Golder Associates (14 May 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Geotechnical Factual Report – Land Investigations, Ref: 1666099-004-R-RevC [DPGA 2018a]
- Douglas Partners Golder Associates (25 May 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Contamination Factual Report – Land Investigations, Ref: 1666099-003-R-RevC [DPGA 2018b]
- Douglas Partners Golder Associates (30 July 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 7, Ref: 1666099-0011-R-RevA [DPGA 2017 – 2018].
- Douglas Partners Golders Associates (9 August 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Contamination Factual Report - Marine Investigations, Ref: 1666099-001-R-Rev C [DPGA 2018c].
- AECOM (22 November 2018) Western Harbour Tunnel and Beaches Link – Groundwater Monitoring Report 6 – April to September 2018 Ref: 60537922-RPEM_0031A [AECOM 2018].
- Douglas Partners Golder Associates (12 December 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 8, Ref: 1666099-012-R-RevA [DPGA 2017 – 2018].
- AECOM (21 March 2019) Western Harbour Tunnel and Beaches Link – Groundwater Monitoring Report 7 – October 2018 to March 2019, Ref: 60537922-RPEM_0032A [AECOM 2019].
- Cardno (January 2020) Beaches Link and Gore Hill Freeway Connection Technical Working Paper: Marine Water Quality, Ref: EIS, Appendix Q – Marine Water Quality [Cardno 2020].
- Environmental Risk Sciences (December 2020) Beaches Link and Gore Hill Freeway Connection Technical Working Paper: Health Impact Assessment. Ref: EIS, Appendix I – Health Impact Assessment [EnRiskS 2020].
- Jacobs (December 2020) Beaches Link and Gore Hill Freeway Connection, Technical working paper: Groundwater, Ref: EIS, Appendix N [Jacobs 2020b].
- Royal HaskoningDHV (December 2020) Beaches Link and Gore Hill Freeway Connection, Hydrodynamic and Dredge Plume Modelling, Ref: EIS, Appendix P [Royal HaskoningDHV 2020b]

- Environmental Risk Sciences (16 September 2021) Review of Recreational Exposures During Dredging Activities, Ref: Memo - Beaches Link and Gore Hill Freeway Connection [EnRiskS 2021].

The following correspondence was provided to the Auditor during the audit:

- DPIE (no date) RFI on EIS – Contamination.
- DPIE email to TfNSW (7 December 2021) Re: Beaches Link contamination.
- TfNSW Letter to DPIE (15 December 2021) Re: Additional information related to contamination.
- DPIE Email to TfNSW (22 December 2021) Re: Proposed Framework SAQP.
- TfNSW Email to DPIE (24 December 2021) Re: Proposed Framework SAQP.
- DPIE Letter to TfNSW (13 January 2022) Re: Additional information related to contamination.

1.5 Audit Correspondence

The Auditor provided feedback to the consultant during the Audit in the form of interim advice letters. A copy of these letters or relevant email correspondence is included in Appendix B together with any relevant TfNSW and/or consultant responses. Where appropriate, these are referred to in the audit report.

2 Site Identification and Description

This section provides details of the BLGHFC construction support sites and AEIs, known land uses, and surrounding properties, that were identified in the Jacobs (2020a) EIS Appendix M – Contamination and considered as part of the Audit. Table 2.1 provides a description of the construction support sites and AEIs, and their locations are provided in Figures in Appendix A.

Table 2.1: BLGHFC Project Construction Support Sites and Corresponding Areas of Environmental Interest Considered as Part of the Audit (if applicable).

Construction Support Site and Suburb	Area of Environmental Interest within (or proximal to) the Construction Support Site
BL1 – Cammeray Golf Course, Cammeray	• B1 – Unsealed areas next to Warringah Freeway – eastern side, Cammeray Golf Course at Cammeray – within footprint of BL1.
Not applicable	• B2 – Unsealed areas next to Warringah Freeway – eastern side (between Miller Street on ramp) at Cammeray. • B3 – Unsealed areas next to Warringah Freeway – western side (between Miller Street and West Street) at Cammeray – above tunnel. • B4 – Unsealed areas next to Warringah Freeway – western side (between West Street and Brook Street) at Crows Nest. • B5 – Unsealed areas next to Warringah Freeway – eastern side (between West Street and Brook Street) at Crows Nest – above tunnel. • B6 – Unsealed areas next to Warringah Freeway – western side (between Brook Street and Willoughby Road) at Naremburn – lateral to tunnel.
BL2 – Flat Rock Drive, Northbridge	• B9 – Access decline portal approximately seven metres below site surface level – within footprint of BL2 and access decline portal. • B10 – Willoughby Leisure Centre and Bicentennial Reserve at Willoughby – above tunnel and adjacent to footprint of BL2, and tunnel portal.
BL3 – Punch Street, Artarmon	• B7 – Within footprint of BL3.
BL4 – Dickson Avenue, Artarmon	• B8 – Freeway Hotel on Reserve Road in Artarmon – within the footprint of the Motorway Control Centre (BL4)
BL5 – Barton Road, Artarmon	No AEIs identified at this location. The Audit does not extend to these sites.
BL6 – Gore Hill Freeway median, Artarmon	No AEIs identified at this location. The Audit does not extend to these sites.
BL7 – Middle Harbour south cofferdam, Northbridge	• B12 – Sediments within Middle Harbour – above tunnel and within footprint of BL7.
BL8 – Middle Harbour north cofferdam, Seaforth	• B12 – Sediments within Middle Harbour – above tunnel and within footprint of BL8.
BL9 – Spit West Reserve, Mosman	• B11 – Reclamation of land – within footprint of BL9. • B12 – Sediments adjacent to the Spit – within footprint of BL9.
BL10 – Balgowlah Golf Course, Balgowlah	• B13 – Balgowlah Golf Course – within footprint of BL10. • B14 – Residential properties along Dudley Street at Balgowlah – within the footprint of BL10.
BL11 – Kitchener Street, North Balgowlah	No AEIs identified at this location. The Audit does extend to this site due to observations made during Auditor site visit. These observations are discussed in further detail in the Audit.
BL12 – Wakehurst Parkway south, Seaforth	• B15 – Residential properties along Judith Street/Kirkwood Street and Wakehurst Parkway at Seaforth – above tunnel and within footprint of BL12.

Construction Support Site and Suburb	Area of Environmental Interest within (or proximal to) the Construction Support Site
Not applicable	• B17 – Wakehurst Parkway, Seaforth to Frenchs Forest – above tunnel footprint and adjacent to BL12.
BL13 – Wakehurst Parkway east	• B16 – Sydney Water Reservoir site (and surrounds) on Kirkwood Street at Seaforth – within footprint of BL13 and lateral to tunnel.
BL14 – Wakehurst Parkway north	No AEIs identified at this location. The Audit does not extend to these sites.

2.1 Site Identification and Details

The BLGHFC project alignment and key project elements (including the proposed locations of the construction support sites) have been provided in the Consultants' reports reviewed and are reproduced in Appendix A. The site identification and land use details, based on current information, is summarised in Table 2.2. The Framework SAQP requires more site-specific information to be provided in preparing site specific SAQP for detailed site investigations.

Table 2.2: Overview of Site Identification

Title	Details
Site Name or Description:	Beaches Link and Gore Hill Freeway Connection Project
Street Address:	The BLGHFC project area spans approximately seven kilometres from the North Shore suburbs of Cammeray, Naremburn, and Artarmon to North Balgowlah and Frenchs Forest. Street address identification details have not been confirmed. Site address details to be identified in future site-specific SAQPs.
Property Description:	Site identification details (Lot and DP) have not been confirmed. Site boundaries and legal identifiers will be outlined in future site-specific SAQPs.
Current Site Ownership/Certificates of Title:	Multiple site owners.
Current Occupier(s):	Multiple current occupiers (including residential, commercial/industrial occupants)
Geographical Coordinates (approximate centre of site identified by the Auditor):	Lat: -33.8005° Long: 151.24688°

Title	Details
Site Area and Dimensions:	The project spans for approximately seven kilometres from the North Shore suburbs of Cammeray, Naremburn, and Artarmon to North Balgowlah and Frenchs Forest. Most of the project comprises tunnels extending from the Warringah Freeway (at Cammeray) and the Gore Hill Freeway (at Artarmon), beneath Middle Harbour and surfacing at the Wakehurst Parkway at Seaforth and the Burnt Bridge Creek Deviation at Balgowlah. Surface work is to occur along the Wakehurst Parkway to Frenchs Forest. The Framework SAQP provides the following site areas specific to the Project Specific Terrestrial AEIs identified in the EIS as having a moderate or high risk of contamination being present: • B7 Punch Street, Artarmon – 5,900 m^2 • B8 Dickson Avenue, Artarmon – 5,500 m^2 • B9 Flat Rock Reserve, Northbridge – 10,400 m^2 • B10 Bicentennial Reserve, Willoughby – 109,200 m^2 • B11 - Spit West Reserve, Mosman – 26,500 m^2 • B13/14 Balgowlah Golf Course and Dudley Street, Balgowlah – 113,000 m^2 • B15 Residential properties Wakehurst Parkway, Seaforth – 10,200 m^2 • B16 Sydney Water Reservoir, Seaforth – 12,300 m^2 • B17 Wakehurst Parkway, Seaforth to Frenchs Forest – 82,700 m^2 The boundaries and dimensions of these will be confirmed in future site-specific SAQPs
Local Government Authority:	The project is located within the following Local Government Authorities (LGAs): • North Sydney • Willoughby • Mosman • Lane Cove • Northern Beaches.
Current Zoning:	The Framework SAQP provides the following current zoning details specific to the Project Specific Terrestrial Areas of Environmental Interest (AEIs) identified in the EIS as having a moderate or high risk of contamination being present: • B7 Punch Street, Artarmon – Public Recreation (RE1). • B8 Dickson Avenue, Artarmon – General Industrial (IN1). • B9 Flat Rock Reserve, Northbridge – Environmental Conservation (E2) and Infrastructure (SP2). • B10 Bicentennial Reserve, Willoughby – Public Recreation (RE1). • B11 Spit West Reserve, Mosman – Public Recreation (RE1). • B13 Balgowlah Golf Course, Balgowlah – Public Recreation (RE1). • B14 Dudley Street, Balgowlah – General Residential (R1). • B15 Wakehurst Parkway – Low Density Residential (R2) and Infrastructure (SP2). • B16 Sydney Water Reservoir – Low Density Residential (R2). • B17 Wakehurst Parkway, Seaforth to Frenchs Forest – Infrastructure (SP2). Current land uses are presented in Table 4.1.
Locality Map:	Provided in Consultants' report figures reproduced in Appendix A.
Trigger for Assessment	TfNSW is seeking approval under Division 5.2, Part 5 of the Environmental Planning and Assessment Act 1979 to construct and operate the Beaches Link and Gore Hill Freeway Connection (the project). The Environmental Impact Statement (EIS) was prepared to address the environmental assessment requirements of the Secretary of the Department of Planning and Environment ('the Secretary's environmental assessment requirements', SEARs).
State or Local Government Statutory Controls Assigned to the Site:	The SAR was prepared during the pre-determination stage of the Beaches Link and Gore Hill Freeway Connection project. As such, there are no consent conditions that can be quoted for the site(s).

2.2 Proposed Development

2.2.1 Project Overview

The Western Harbour Tunnel and Beaches Link program of works will provide additional road network capacity across Sydney Harbour to improve connectivity with Sydney's northern beaches. The Western Harbour Tunnel and Beaches Link program of works includes the following key project elements:

- The Western Harbour Tunnel and Warringah Freeway Upgrade (WHTWFU) project comprises a new tolled motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network and to connect to the Beaches Link and Gore Hill Freeway Connection (BLGHFC) project.
- The BLGHFC project comprises a new tolled motorway tunnel connection from the Warringah Freeway to Balgowlah and Frenchs Forest and upgrade and integration works to connect to the Gore Hill Freeway.

2.2.2 Construction Activities at the Project Specific Terrestrial AEIs

For each Project Specific Terrestrial AEI identified in the EIS as having a moderate or high risk of contamination being present, the following project construction activities are proposed:

- B7 Punch Street, Artarmon – Demolition of existing structures; excavation of tunnel features; construction and operation of temporary site facilities.
- B8 Dickson Avenue, Artarmon – Demolition of existing structures; construction and operation of temporary site facilities.
- B9 Flat Rock Reserve, Northbridge – Excavation of tunnel access decline and main tunnel alignment; construction and operation of temporary site facilities.
- B10 Bicentennial Reserve, Willoughby – Tunnel excavation (no surface works planned).
- B11 Spit West Reserve, Mosman – Construction and operation of temporary site facilities.
- B13/14 Balgowlah Golf Course and Dudley Street, Balgowlah – Demolition of existing structures; excavation of tunnel features and access decline; construction and operation of temporary and permanent site facilities.
- B15 Wakehurst Parkway – Demolition of residential properties, construction, and operation of temporary site facilities.
- B16 Sydney Water Reservoir – Excavation of tunnel features and access decline; construction and operation of temporary site facilities.
- B17 Wakehurst Parkway, Seaforth to Frenchs Forest – Excavation of tunnel features and cut and cover; and widening of Wakehurst Parkway.

2.2.3 Construction Activities at the Marine AEIs

The following project construction activities are proposed for the Marine AEIs identified in the EIS as having a moderate or high risk of contamination being present:

- B11 Spit West Reserve – Construction of the Spit West Reserve construction support site over the marine sediments.
- B12 Middle Harbour – Excavation of sediments during construction of cofferdams; associated dredging and piling work; placement of immersed tube tunnels that will cross Middle Harbour, with connecting driven mainline (terrestrial) tunnels occurring to the north and south.

2.2.4 Construction Activities at WHTWFU Crossover AEIs

The proposed BLGHFU project footprint will interface and connect with existing WHTWFU project elements. The following construction activities have been proposed for the terrestrial 'crossover' AEIs identified in the EIS as having a moderate or high risk of contamination being present:

- B1/B2 Cammeray Golf Course, Cremorne/Cammeray – Construction and operation of temporary site facilities.
- B3/B4/B5/B6 Warringah Freeway, Miller Street to Willoughby Road – Various unsealed areas next to the Warringah Freeway that will interface with the construction footprint.

It is anticipated that works relating to contamination and land use suitability at the above-listed terrestrial Crossover AEIs will be completed as part of the WHTWFU project.

2.3 Auditor Discussion

The information required by NSW EPA (2020a), relating to site identification and condition, was generally provided, and is consistent with observations made during site inspections conducted as part of this Audit except for the following items which will be completed as part of site-specific SAQPs as required by the Framework SAQP:

- Complete site identification details (full street address, Lot and DP numbers) and geographical coordinates for each terrestrial AEI boundary.
- Site owner(s) and current occupier(s) of each AEI.

3 Summary of Reports Reviewed

3.1 Summary of Works

Appendix C provides a summary of the site investigation reports reviewed by the Auditor (primary and supplementary reports identified in Section 1.4), completed as part of the BLGHFC project, and/or the WHTBL program of works (where available).

3.2 Auditor Discussion

The works completed to date contain background information relevant to the project footprint to the extent information is available.

The Auditor considers the preliminary assessments have followed an iterative process to provide background information to assess the potential for contamination across the project footprint and to identify those that pose a medium or high risk and warrant further investigation as outlined in the Framework SAQP.

The Auditor considers that the previous investigations reviewed are suitable for the purposes of this audit, subject to the following key comments being addressed as part of the development of future site-specific SAQPs and investigations. These requirements were communicated during the Audit as documented in interim advice (copies included in Appendix B):

- The EIS, Appendix M – Contamination (Jacobs 2020a) report was prepared to meet the requirements of the Secretary's Environmental Assessment Requirements (Key Issue and Desired Performance Outcome 13. Soils and Contamination), as well as the requirements of the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability Rating tool objectives to minimise pollution generated by the project. In addition, the report considered the now-superseded OEH (2011) Guidelines for Consultants Reporting on Contaminated Sites. As a result, the report does not meet all of the requirements for a Preliminary Site Investigation, as required by the NSW EPA (2020) Consultants Reporting on Contaminated Land Guidelines and Appendix B of the ASC NEPM Schedule 2 Guideline on Site Characterisation (NEPC 2013).
    - As noted in Section 5.2 of this SAR, the Framework SAQP requires the site-specific SAQPs to be prepared in accordance with the relevant guidelines made or endorsed by NSW EPA, including the two key references listed above. Based on these requirements, the Auditor considers that the Framework SAQP provides sufficient instruction to facilitate the development of future site-specific SAQPs that will comply with the appropriate legislation and guidelines.
- A program of various groundwater contamination investigations and monitoring events have been completed within the WHTBL program of works footprint, with the results reviewed in the context of the BLGHFC project. These investigations are summarised in Appendix C. The Auditor notes that most of the available groundwater monitoring data is factual only, without comparison to any guidelines.
    - As discussed in Section 5.2 of this SAR, the Framework SAQP requires this reporting gap to be addressed as part of the development of future site-specific SAQPs. The Auditor considers that the Framework SAQP provides sufficient instruction to require all relevant, previous data to be reported, evaluated and considered in the context of the proposed project construction activities and proposed future land use(s).
- A program of geotechnical investigations has been completed to support the characterisation of the geological, terrain, and subsurface conditions along the proposed alignment of the WHTBL

works program. These investigations are summarised in Appendix C. As commented in the EIS, Appendix M – Contamination (Jacobs 2020a), geotechnical investigations around the Willoughby Leisure Centre and Bicentennial Reserve, Willoughby (B10) did not test specifically for landfill gas. The Auditor considers this to be a data gap based on the site history identifying a historical landfill within the site.

  - As discussed in Section 5.2 of this SAR, the Framework SAQP requires an assessment of hazardous landfill gas at B10. The Auditor considers that the Framework SAQP provides sufficient instruction to require an adequate assessment of hazardous ground gas at this historical landfill site.

- Results of sediment testing in Middle Harbour have been used to determine waste disposal requirements for dredged sediments, potential impacts to sensitive receivers during dredging, and environmental management requirements during dredging. A summary of these investigations is provided in Appendix C. While it is understood that TfNSW does not require site suitability investigations for Marine AEIs, and that the sampling and testing of sediments has been conducted in accordance with the National Assessment Guidelines for Dredging 2009 and approved by the Department of Agriculture, Water and Energy (as advised by TfNSW), there may be instances where contamination in sediments requires further consideration (such as amendments to the tunnel alignment, determination of land-based disposal and/or treatment requirements, or as other information that comes to light with respect to sediment condition).

  - As discussed in Section 5.2 of this SAR, the Framework SAQP requires review of the existing information for Marine AEIs to determine whether additional investigations are required, including an assessment of compliance with the relevant project approvals, and appraisal of the analyte selection. The Auditor considers that the provisions in the Framework SAQP for Marine AEIs will facilitate the identification of any data gaps for sediments. This should include an appraisal of the justification provided for previous analytes that were tested.

4 Evaluation of Conceptual Site Model

4.1 Site Condition and Surrounding Environment

The site condition and surrounds is summarised in Table 4.1, together with any potential sensitive human health and environmental receptors identified. This information has been sourced from the reports listed in Section 1.4 and observations made of each AEI by the Auditor.

Table 4.1: Site Condition and Surrounding Environment

Item	Details
Site inspection:	The Auditor completed site inspection of each potential area of environmental interest listed in Jacobs (2020a) on 25 January 2022 with key observations included in the items below.
Topography of Site and in Relation to Surrounding Land:	Section 1.1.2 of Appendix B of GHD (2022) provides the following topographical information relevant to the project footprint: • The terrain along the BLGHFC project rises from an elevation of around 65 metres AHD at the southern extent of the BLGHFC project at Cammeray and undulates towards Middle Harbour. • Between Middle Harbour and the Warringah Freeway, the BLGHFC project crosses beneath Flat Rock Creek and the upper Willoughby Creek catchment. Both Flat Rock Creek and Willoughby Creek drain to Middle Harbour. • To the north of Middle Harbour the topography has a steep incline up to the ridge line at North Balgowlah, before resuming a moderate incline towards Frenchs Forest, reaching an elevation of around 150 metres AHD at Warringah Road at the northern extent of the BLGHFC project area. • The main surface drainage feature in the northern area of the BLGHFC project is Burnt Bridge Creek at North Balgowlah. The above information is consistent with the general observations made during the site visit.
Summary of Local Meteorology and Climate:	Section 1.1.2 of Appendix B of GHD (2022) provides the following climate data obtained from the Bureau of Meteorology (BOM) website, from the Observatory Hill (BoM Station 66062): • Annual mean maximum temperature at the Observatory Hill weather station is 21.8ºC. • Annual mean minimum temperature of 13.8 ºC. • Most rainfall occurs in the first half of the year, peaking in June. There is then an abrupt seasonal change with the lowest rainfalls occurring in September. • Average annual rainfall is approximately 1215 millimetres (mm) per year.
Current Land Use:	Section 1.1.1 of Appendix B of GHD (2022) provides the following land use details for terrestrial AEIs identified with moderate or high risk of potential contamination: Table 1, B7 Punch Street, Artarmon – the site is used as a public park and includes a public pathway adjacent the Gore Hill Freeway. Table 2, B8 Dickson Avenue, Artarmon – the site is occupied by a hotel, media company and automotive shop. Table 3, B9 Flat Rock Reserve, Northbridge and B10 Bicentennial Reserve, Willoughby - the B9 site is currently used as a publicly accessible bushland Reserve and the B10 site is used as a Leisure Centre with recreational sporting fields. Table 4, B11 Spit West Reserve, Mosman - the site is currently used as a public reserve. Table 5, B13 Balgowlah Golf Course and B14 Dudley Street, Balgowlah – comprise a public golf course and low density residential dwellings respectively. Table 6, B15 Residential properties, Wakehurst Parkway - the site is occupied by residential properties, cleared, grassed blocks of land and bushland, fronting the main roadway Wakehurst Parkway. Table 7, B16 Sydney Water Reservoir - the site is currently used as a reservoir.

Item	Details
	Table 8, B17 Wakehurst Parkway, Seaforth to Frenchs Forest - the site is used as a main road.
Surrounding Land Uses:	Table 1 of Section 1.1.1 of Appendix C of GHD (2022) provides the following surrounding land uses for B7 Punch Street, Artarmon • North – Gore Hill Freeway, Artarmon Park and residential properties • South – Punch Street, followed by various commercial/industrial premises • East – A railway line, followed by residential properties • West – Herbert Street, followed by various commercial/industrial premises. Table 2 of Section 1.1.1 of Appendix C of GHD (2022) provides the following surrounding land uses for B8, Dickson Avenue, Artarmon • North – Gore Hill Freeway, followed by public recreation areas and residential properties • South – Dickson Avenue, followed by various commercial/industrial premises • East – Various commercial/industrial premises • West – Reserve Road, followed by various commercial/industrial premises. Table 3 of Section 1.1.1 of Appendix B of GHD (2022) provides the following surrounding land uses for B9 Flat Rock Reserve, Northbridge and B10 Bicentennial Reserve, Willoughby • North – Residential properties and recreational oval • South – Residential properties (the Auditor also observed an east-west running creek line – Flat Rock Creek – to the south). • East – Public open space and residential properties • West - Residential properties. Table 4 of Section 1.1.1 of Appendix B of GHD (2022) provides the following surrounding land uses for B11 Spit West Reserve • North – Middle Harbour, followed by residential properties of Seaforth • South – Environmental conservation area, followed by residential properties • East – Spit Road, followed by commercial properties • West - Middle Harbour. Table 5 of Section 1.1.1 of Appendix B of GHD (2022) provides the following surrounding land uses for B13 Balgowlah Golf Course and B14 Dudley Street, Balgowlah • North – Kitchener Street and residential beyond • South – Sydney Road and residential and Balgowlah Boys Campus school beyond • East – residential • West – residential, Burnt Bridge Creek and Burnt Bridge Creek Deviation Road. Table 6 of Section 1.1.1 of Appendix B of GHD (2022) provides the following surrounding land uses for B15 Residential properties, Wakehurst Parkway • North – Sydney Water reservoir followed by bushland • South – Environmental Conservation area, residential properties and public sports field • East – Residential properties, followed by Wakehurst Golf Club • West – Garigal National Park. Table 7 of Section 1.1.1 of Appendix B of GHD (2022) provides the following surrounding land uses for B16 Sydney Water Reservoir • North – Bushland • South – Residential properties • East – Wakehurst Golf Club • West – Wakehurst Parkway, followed by Garigal National Park. Table 8 of Section 1.1.1 of Appendix B of GHD (2022) provides the following surrounding land uses for B17 Wakehurst Parkway, Seaforth to Frenchs Forest • North – Frenchs Forest, consisting of residential and recreational areas • South – Residential properties • East – Public bushland

Item	Details
	• West – Public recreation, Garigal National Park and residential areas.
Density of Residential Use in Surrounding Area:	Section 3.10 of Jacobs (2020a) states that at the time of the inspection, the land use surrounding the project was generally low to high density residential, with the following specific observations: • The Gore Hill Freeway Connection is surrounded by low to medium density residential land use. • The land use in Willoughby and Northbridge is primarily low density residential. • The land use of the suburbs of Seaforth, Balgowlah and North Balgowlah is primarily low density residential.
Boundary Condition:	The condition of the AEI boundaries has not been provided in the current reports. It is anticipated that site boundary information will be provided in the future site-specific investigation reports.
Location and Conditions of All Visible Features:	The location and condition of all visible features have not been provided in the current reports. It is anticipated that these site-specific details will be provided in the future site-specific investigation reports.
Site Building Information:	Site building information for each AEI has not been provided in the current reports. It is anticipated that site-specific information will be provided in the future site-specific investigation reports.
Condition and Type of Surface Cover:	Table 9 of Section 1.1.2 of Appendix B of GHD (2022) provides the following general surface cover for terrestrial AEIs identified with moderate or high risk of potential contamination being present: • B7 Punch Street, Artarmon - Buildings, roads, vegetated land and hardstand areas for car parking and shared user paths. • B8 Dickson Avenue, Artarmon - Buildings, roads, and concrete hardstand. • B9 Flat Rock Reserve, Northbridge and B10 Bicentennial Reserve, Willoughby - Grassed and vegetated land, concrete hardstand, and buildings. • B11 Spit West Reserve, Mosman - Grassed and vegetated land, buildings. • B13 Balgowlah Golf Course and B14 Dudley Street, Balgowlah - Grassed land and residential or golf club buildings. • B15 Residential properties, Wakehurst Parkway - Grassed land, concrete hardstand, and residential dwellings. • B16 Sydney Water Reservoir - Buildings, concrete hardstand, water tanks, cleared ground, and vegetated land. • B17 Wakehurst Parkway, Seaforth to Frenchs Forest - Roads, road base, and vegetated land. The Auditor completed a site visit and confirmed the above information. It is anticipated that further information regarding surface cover and condition will be provided in the future site-specific investigation reports.
Chemical Storage and Transfer Areas Including the Presence of Chemical Containers:	Table 4-1 of Section 4.1 of Jacobs (2020) provides the following details regarding chemical storage and containers: • B1/B2 Cammeray Golf Course – Potential for chemical use and storage. • B13 Balgowlah Golf Course – Potential for chemical use and storage. Table 4-2 of Section 4.2.2 of Jacobs (2020) provides the following details regarding chemical storage and containers based on the business directories review: • B7 Punch Street, Artarmon – Potential for chemical use and storage due to commercial/industrial site use. • B8 Dickson Ave/Freeway Hotel, Artarmon – Potential for chemical use and storage due to commercial/industrial site use and neighbouring uses. It is anticipated that future site-specific site inspections will identify additional information pertaining to chemical storage, transfer areas, and the presence of chemical containers.

Item	Details
Summary of Above Ground and Underground Storage Systems and Associated Infrastructure:	Details regarding above ground storage systems and associated infrastructure have not been provided. It is anticipated that these site-specific details will be considered in future site-specific investigations.
Evidence of Debris, Waste Disposal, Lagoons, Drums, Chemical Storage or Other Indicators of Potential Contamination Sources:	Section 3.3.1 of Jacobs (2020a) provides the following details regarding waste disposal at AEI sites B9 and B10: • One of the main areas of fill is located alongside Flat Rock Creek. Following the opening of an incinerator in Flat Rock Gully in the 1930s, Willoughby Council began the disposal of garbage in an open tip below the incinerator in the late 1940s. Over several decades the site of the open tip expanded and is understood to have extended from Willoughby Road in the west to Flat Rock Drive in the east, extending to the immediate eastern side of Flat Rock Drive. Drainage works enclosed part of the creek in a concrete drain and up to 160 feet (about 50 metres) of garbage and landfill was dumped over it. • In 1934 the Walter Burley Griffin Incinerator was built, with ash generated from the incineration of refuse deposited until the incinerator was closed in 1967 when it became obsolete. From the 1940s industrial and domestic waste was tipped and burnt in the area on both sides of Flat Rock Drive and into Flat Rock Reserve, which ceased in 1985. The landscaped area on the east side of Flat Rock Drive is situated on about 30 metres of landfilled waste material and soil fill. Interpretation of historical records indicates that up to 40 metres of fill may have been placed along Flat Rock Creek. Section 4.4.3 of Jacobs (2020a) provides the following details regarding buried waste: • B337 (Cammeray Golf Course) – 4.13 metres of fill material containing some concrete and PVC. • B340 (Cammeray Golf Course) – 1.8 metres of fill containing some sandstone and concrete. • B176 (Bicentennial Reserve) – 30 metres of landfill material. • B177 (Flat Rock Reserve) – 11 metres of fill (limited observations made as hole was wash bored). Section 1.1.3 of Appendix B of GHD (2022) states that at AEI B17 Wakehurst Parkway – Seaforth to Frenchs Forest the aerial imagery indicates the presence of a former landfill, approximately 100 m east of Wakehurst Parkway north and this area is currently occupied by the Aquatic Reserve Baseball Park. The exact operational dates of the landfill are not provided. Section 1.2.1 of Appendix B of GHD (2022) provides the following potential on-site sources of contamination: • B7 Punch Street, Artarmon – Historical hazardous building materials (bridge) and filling; mixed commercial/industrial use of the site and surrounds. • B8 Dickson Avenue, Artarmon – Mixed commercial/industrial use of the site and surrounds. • B9 Flat Rock Reserve, Northbridge and B10 Bicentennial Reserve, Willoughby – Infilling / waste and incinerator operations. • B11 Spit West Reserve, Mosman – Reclamation of land with material of unknown quality; possible boat repairs and maintenance. • B13 Balgowlah Golf Course and B14 Dudley Street, Balgowlah – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Burnt Bridge Creek Deviation; filling with material of unknown quality; degradation of hazardous building materials; chemical use and storage at the golf course. • B15 Residential properties, Wakehurst Parkway – Potential for illegal dumping of hazardous building materials; degradation of hazardous building materials. • B16 Sydney Water Reservoir – Reservoirs coated with lead paint which may flake as a result of degradation; potential for hazardous building material fragments. • B17 Wakehurst Parkway, Seaforth to Frenchs Forest – Illegal dumping of waste; potential historical use of site for fuel storage; degradation of asphalt road surface.
Location of Settlement Ponds:	During the site inspection, the Auditor observed a large, lined pond along the western edge of the Cammeray Golf Course (within the BL1 footprint). TfNSW response to IA1 clarified that this standing water body is a stormwater retention basin and will be relocated as part of the WHTWFU works.

Item	Details
Description and Location of Services and Utilities Including On-site Septic Systems:	Details regarding services and utilities have not been provided in the current reports. It is anticipated that these site-specific details will be provided in future site-specific investigations.
Identification of Electrical Transformers/Substation/ Capacitors:	Details regarding electrical transformers/substations/capacitors have not been provided in the current reports. It is anticipated that these site-specific details will be provided in future site-specific investigations.
Odours:	The Auditor did not encounter any odours during the site visit.
Visible Signs of Contamination:	Section 3.10 of Jacobs (2020a) did not identify any visible signs of contamination during the site inspections. The Auditor did not observe any gross, visible signs of contamination during the site visit.
Presence of Any Stockpiled Material, Imported Soil or Fill Material:	Section 3.10 of Jacobs (2020a) provides the following key observations regarding fill which were made during the site inspections: • Flat Rock Reserve - the western portion of the reserve is elevated (likely to be representative of final fill levels) with the eastern portion dropping steeply in elevation to Flat Rock Creek. • Bantry Bay Reservoir - the eastern portion of the site had been filled, presumably to facilitate construction of the reservoirs. General demolition materials were observed on the surface of the areas surrounding the eastern portion of this site. Section 4.4.3 of Jacobs (2020a) provides the following information regarding fill which was obtained from previous investigations: • Up to 4.13 m of fill was reported at Cammeray Golf Course, Cremorne (AEI B1) • Up to 30 m of landfill material was estimated at Bicentennial Reserve, Willoughby (AEI B10). • Up to 11 m of fill was observed at Flat Rock Reserve, Northbridge (AEI B9). The above information was generally confirmed during the Auditor's site visit, however evidence of extensive filling was observed at the BL11 Construction Support Site (proximal to Burnt Bridge Creek) accessed off Kitchener Rd.
Assessment of Soil Loss or Deposition that has Occurred in the Past and Evaluation of the Future Erosion Potential:	Specific details regarding soil loss or deposition have not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations. Section 3.4 of Jacobs (2020a) states that the surface areas overlying the project comprises heavily urbanised areas including buildings, roadways, hardstands and vegetated areas (ie gardens, grass, trees). Under current conditions, there are likely to be minimal areas of exposed soils within areas overlying the current project which would contribute to a substantial soil erosion hazard.
Surface Water Bodies:	Section 3.2 of Jacobs (2020a) refers to the following surface water bodies that are either within the project footprint or proximal to the project footprint: • Burnt Bridge Creek. • Flat Rock Creek. • Upper Willoughby Creek Catchment. • Bates Creek. • Bantry Bay. • Manly Creek. • Manly Dam. TfNSW response to IA1 confirmed the presence of a stormwater retention basin at Cammeray Golf Course. Table 9 of Section 1.1.2 of Appendix B of GHD (2022) provides the following details regarding the closest surface water bodies to each terrestrial AEI: • B7 Punch Street, Artarmon – Flat Rock Creek located 200 m north-east of the site. • B8 Dickson Avenue, Artarmon – Flat Rock Creek located 750 m north-east of the site. • B9 Flat Rock Reserve, Northbridge and B10 Bicentennial Reserve, Willoughby – Flat Rock Creek adjacent south to southern site boundary.

Item	Details
	• B11 Spit West Reserve, Mosman – Middle Harbour located adjacent to the site. • B13 Balgowlah Golf Course and B14 Dudley Street, Balgowlah – Burnt Bridge Creek intersects the north-western portion of the site. • B15 Residential properties, Wakehurst Parkway – Bantry Bay located 200 m west of the site; Manly dam located 600 m east of the site. • B16 Sydney Water Reservoir – Bantry Bay located 200 m west of the site; Manly dam located 600 m east of the site. • B17 Wakehurst Parkway, Seaforth to Frenchs Forest – Manly Creek located 250 m east of the site at its closest point.
Surface Water Drainage, Run-off and Identification of Ponding Areas:	Specific details regarding surface water drainage run-off and identification of ponding areas at each AEI and adjacent properties have not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Direction of Flow of Water Runoff from the Site and Adjacent Properties:	Specific details regarding the flow of water runoff from each AEI and adjacent properties have not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Depth of Any Standing Water, the Direction and Rate of Flow of Rivers, Streams or Canals:	Section 3.2 of Jacobs (2020a) states that the maximum water depth of the Middle Harbour crossing is around 30 m below sea level. Section 3.2 of Jacobs (2020a) provides the following general details regarding the direction and flow of water bodies that will intersect with the project footprint: • The northern aboveground alignment of the project from Frenchs Forest to North Balgowlah is situated along the catchment boundary between Bates Creek and Bantry Bay to the west, and Manly Creek and Manly Dam to the west. • The main surface drainage feature in the northern area of the project is Burnt Bridge Creek at North Balgowlah. This creek flows east from North Balgowlah, through Balgowlah and then towards Manly Vale and intersects the project at the Burnt Bridge Creek Deviation. • Between Middle Harbour and the Warringah Freeway, the project crosses beneath Flat Rock Creek and the upper Willoughby Creek catchment. Both creeks drain to Middle Harbour. Figure 3-6 of Jacobs (2020a) provides a topography and drainage map relevant to the project footprint and surrounding areas.
Surface Water and Groundwater Use Onsite:	Section 1.3.3 of Appendix B of GHD (2022) states that surrounding suburbs to the project footprint are supplied by a reticulated water supply. There is one groundwater abstraction bore located 500 m from the project footprint, drilled to a depth of 132 m, and unlikely to be impacted by the project. Section 3.8.1 of Jacobs (2020a) states that the abovementioned groundwater bore is located in St Leonards and is used for water supply. The Auditor notes that the groundwater bore mentioned above is approximately 500 m to the west of a portion of the project alignment which includes AEIs B3-B6 (unsealed areas along the Warringah Freeway).
Evidence of Possible Naturally Occurring Contaminants:	The Auditor's review of the NSW Department of Planning, Industry & Environment online map of the Naturally Occurring Asbestos in NSW indicates the site is not located in an area with known naturally occurring asbestos.
Identification of Environmentally Sensitive or Significant Features or Habitats:	Table 9 of Section 1.1.2 of Appendix B of GHD (2022) provides the following information regarding ecologically sensitive areas as they apply to the terrestrial AEIs identified with moderate or high risk of potential contamination being present: • B7 Punch Street, Artarmon – Threatened flora species are present 200 m north of the site. • B8 Dickson Avenue, Artarmon - No ecologically significant areas within 500 m of site. • B9 Flat Rock Reserve, Northbridge and B10 Bicentennial Reserve, Willoughby – This site is zoned as an environmental conservation area with a number of threatened flora and fauna species present at the site. • B11 Spit West Reserve, Mosman - No ecologically significant areas within 500 m of site. The Auditor notes that Spit West Reserve is proximal to The Spit and Middle

Item	Details
	Harbour. These marine and intertidal habitats are considered by the Auditor to be 'sensitive' in the context of contaminated land assessment. • B13 Balgowlah Golf Course and B14 Dudley Street, Balgowlah – Threatened flora species are present on the site and 200 m to the west; threatened fauna species are present 100 m north-east of the site. • B15 Residential properties, Wakehurst Parkway - Garigal National Park is adjacent west of the site and an Environmental Conservation area is adjacent south of the site; threatened fauna habitat is present in the northern portion of the site and adjacent west of the site. • B16 Sydney Water Reservoir – Threatened fauna habitat is present 200 m south-west of the site • B17 Wakehurst Parkway, Seaforth to Frenchs Forest – Garigal National Park is adjacent west of the site boundary and Reserve area is adjacent east of the site; threatened fauna habitat and threatened flora species are present on the site. Table 9 of Section 1.1.2 of Appendix B of GHD (2022) provides the following information regarding Aboriginal heritage as they apply to the terrestrial AEIs identified with moderate or high risk of potential contamination being present: • B7 Punch Street, Artarmon – Potential Aboriginal archaeological deposits are located north of the northern site boundary. • B8 Dickson Avenue, Artarmon - No Aboriginal heritage areas identified within 50 m of the site. • B9 Flat Rock Reserve, Northbridge and B10 Bicentennial Reserve, Willoughby – Potential Aboriginal archaeological deposits are located in the south-eastern portion of Flat Rock Baseball Field and in the south-western portion of Flat Rock Reserve. • B11 Spit West Reserve, Mosman - No Aboriginal heritage areas identified within 50 m of the site. • B13 Balgowlah Golf Course and B14 Dudley Street, Balgowlah – Potential Aboriginal archaeological deposits are located in the western portion of the Balgowlah Golf Course. • B15 Residential properties, Wakehurst Parkway - No Aboriginal engraving sites are located within 50 m of the site. • B16 Sydney Water Reservoir – Multiple Aboriginal engraving sites are located within 50 m of the site. • B17 Wakehurst Parkway, Seaforth to Frenchs Forest - Multiple Aboriginal engraving sites are located within 50 m of the proposed alignment.
Evidence Chemical Substances Have Migrated or are Likely to Have Migrated:	Section 5.2 of Jacobs (2020a) provides the following details regarding contaminant migration: • It is possible that the waste mass beneath Flat Rock Drive construction support site (BL2) and the adjacent Willoughby Leisure Centre and Bicentennial Reserve may present a source of landfill gas. With specific regard to the possible presence of landfill gas beneath the site and the adjacent Willoughby Leisure Centre and Bicentennial Reserve, should the landfill gas be present, there is the potential for it to migrate towards the proposed Flat Rock Drive construction support site (BL2) as a result of formation pressure gradients due to ground disturbance from construction activities associated with the project. The Flat Rock Drive road embankment is an engineered and compacted fill which was formed up to 30 metres high to build the new road in 1968. This embankment forms a distinct separation between areas of historical landfill to the west and to the east of Flat Rock Drive. It is not known whether the road embankment restricts gas flow (if any) between the two areas. Subsurface structures (where present) beneath the road embankment between the two areas may act as conduits for gas movement (if gas is present). • There is a moderate contamination risk associated with the potential presence of groundwater contamination beneath Flat Rock Drive construction support site (BL2), which is likely to be encountered during construction of the access decline tunnel. Known groundwater contamination in adjoining areas (Willoughby Leisure Centre and Bicentennial Reserve) could migrate to the main tunnel works which travel under Willoughby and Northbridge and represents a high contamination risk to the tunnel in this area. Section 6.6 of Jacobs (2020a) provides the following additional detail regarding contaminant migration:

Item	Details
	• Existing monitoring data indicates the presence of groundwater contamination beneath/surrounding the Willoughby Leisure Centre and Bicentennial Reserve and could be migrating towards Flat Rock Reserve. Elevated ammonia concentrations were reported in groundwater samples collected from beneath/surrounding these sites. The ammonia impacted groundwater could impact upon the construction of the tunnel located beneath this area and the construction of the access decline tunnel located adjacent to this area (within Flat Rock Reserve) if not appropriately managed. The sampling and analysis carried out within this area included a suite of general contaminant compounds. Based on the historical landfilling carried out within this area, other contaminant compounds may be present within groundwater.

4.2 Site History

The site history is summarised in this section. This information has been sourced from the reports listed in Section 1.4.

Table 4.2: Site History

Title	Details
Historical Title Search:	Results of historical title searches have not been presented for individual Project Specific Terrestrial AEIs. The absence of this information does not affect the outcome of the audit, however it is anticipated that historical title searches will be conducted during future site specific DSIs.
Local Site Knowledge:	Section 4.5 of Jacobs (2020a) presents a summary of local knowledge for various AEIs mentioned in EIS, Appendix M – Contamination, based on the author's experience in carrying out previous investigations within and next to the project area and knowledge of local areas (refer to Robert F McKillop (2012) Managing our Waste: An environmental history of Flat Rock Creek and the Willoughby Incinerator 1900-2011). The following local knowledge information focusses on activities and contamination sources which may represent a potential contamination risk to the construction and operation of the project: • Willoughby Leisure Centre and Bicentennial Reserve – Small Street at Willoughby: infilling (historical residential, industrial and furnace waste) and incinerator operations (furnace waste) are listed as potential contamination sources. • Flat Rock Reserve at Northbridge – Infilling the construction of Flat Rock Drive in 1968 raised the valley floor by a maximum of approximately 30 m. Prior to 1971, filling comprised putrescible materials, after such time, filling comprised of mostly building waste.
Review of Historical Aerial and Site Photography:	Section 4.1 of Jacobs (2020a) provides a summary of changes in aerial photography, which focussed on key land-based and above ground construction support sites and surface work, specific AEIs and general land uses that could be potentially impacted by the project construction work. Annexure A of Jacobs (2020a) provides the historical aerial photography review for each AEI for the years 1930, 1955, 1961, 1970, 1975, 1983/84, 1986, 1991, 1994, 1997, 2002, and 2005. The review indicates instances where aerial photographs were not available for a particular AEI during a particular year. Section 1.1.3 of Appendix B of GHD (2022) provides the following summary of aerial photographs for the Project Specific Terrestrial AEIs, sourced from Jacobs (2020a): • B7 Punch Street: The site is vacant land prior to 1998, with a railway line, residential properties and commercial/industrial properties present in the surrounding area. Vegetation appears to have been established at the site in approximately 1998. Hampden Road/Herbert Street bridge is observed at the site in 1955 imagery. Demolition of residential and commercial premises and clearing of bushland is evident between 1991 – 1994 to allow for construction of Gore Hill Freeway adjacent north of the site. • B8 Dickson Road (i.e. Freeway Hotel, Reserve Road): Residential properties occupy the site prior to 1975 imagery, in which these are replaced by commercial/industrial properties. The surrounding area comprises residential and commercial/industrial premises in all imagery, however demolition of some properties is evident in 1991 to allow for construction of the Gore Hill Freeway.

Title	Details
	• B9 Flat Rock Reserve & B10 Bicentennial Reserve: Bushland occupies the site, with vacant land, residential and various commercial properties in the surrounding area in 1930. A building, understood to be an incinerator, is present in the northern portion of the site in 1955, with infilling of Flat Rock Drive observed. Further infilling and construction of commercial properties are also observed in the surrounding area. Large scale filling and removal of bushland is observed at the site between 1970 – 1975. Gore Hill Freeway was observed to be constructed south-west of the site between 1986 – 1991. • B11 Spit West Reserve: The site is vacant land undergoing reclamation works on the southern side of the Spit Bridge and west of Spit Road in 1930. The site is unchanged following completed of reclamation works pictured in the 1955 image. The surrounding area includes residential properties, bushland and the Spit Bridge to 2005. A marina is constructed on the eastern side of the Spit circa 1970. • B13/14 Balgowlah Golf Course & Dudley Street: The site is occupied by vacant land and Burnt Bridge Creek in 1930, with the surrounding area comprised of residential, vacant land and bushland. The Burnt Bridge Creek Deviation is evident in 1983/84 imagery, with demolition of residential premises and clearing of bushland occurring in the surrounding region. • B15 Residential properties along Wakehurst Parkway: The site is comprised of bushland prior to 1955 imagery, following 1955 the site is comprised of bushland and residential properties. The surrounding area is predominantly bushland and residential premises to 1961, in which extensive bushland clearing is evident. Construction of a bowling club and golf course is evident in 1970 imagery east of the site. • B16 Sydney Water Reservoir: The site is comprised of bushland and a reservoir in the central portion in 1930, with some clearing of bushland evident in 1955, 1991 and 1994 imagery. A second reservoir appears to have been constructed circa 1970 at the site. The surrounding area is predominantly bushland and residential premises to 1961, in which extensive bushland clearing is evident. Construction of a bowling club and golf course is evident in 1970 imagery to the east of the site (on neighbouring land). • B17 Wakehurst Parkway – Seaforth to Frenchs Forest: Wakehurst Parkway is present in 1930 imagery to present day imagery, with residential premises and bushland present in the surrounding area. It is noted a former landfill was present approximately 100 m east of Wakehurst Parkway north, currently occupied by Aquatic Reserve Baseball Park. The exact operational dates of the landfill are not provided.
Previous Land Use & Chronological List:	Previous land uses (including a chronological list) have not been provided for each AEI. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Historical Site Layout Plans:	Historical site layout plans for each Project Specific Terrestrial AEI have not been provided, however the aerial photography review provides an overview of changes in site conditions over time. It is anticipated that further details will be considered as part of future site-specific investigations.
Description of historical Manufacturing / Industrial Processes and Location, including Transfer Lines:	A discussion regarding historical manufacturing activities has not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Products Discharged during historical Manufacturing:	A discussion regarding products discharged during historical manufacturing has not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Locations of Historical Chemical Storage and Transfer Areas:	A discussion regarding the locations of historical chemical storage and transfer areas has not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Wastes Discharged during historical Manufacturing:	A discussion regarding wastes discharged during historical manufacturing has not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Historical Disposal Locations:	A discussion regarding historical disposal locations has not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.

Title	Details
Historical Discharges to Land, Air & Water:	A discussion regarding historical discharges to land, air and water has not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Historical Product Spill and Loss History:	A discussion regarding historical product spill and loss history have not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Historical Sewer & Services Plans:	Historical sewer and services plans have not been provided. It is anticipated that these site-specific plans will be considered as part of future site-specific investigations.
Earthmoving Activities Carried out on Site:	Details regarding earthmoving activities have not been discussed in detail. It is anticipated that this information will be considered as part of future site-specific investigations.
Previous Offsite Land Uses with Potentially Contaminating Activity:	Details regarding previous offsite land uses with potentially contaminating activity have not been discussed at length. It is anticipated that this information will be considered as part of future site-specific investigations.
Complaint History:	A complaint history has not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
EPA Records:	Section 4.3 in Jacobs (2020a) states the following: • A search of the Contaminated Lands Register for notices identified NSW EPA did identify notices and declarations for the site under Section 58 of the CLM Act 1997, for seven (7) sites within 500 m of the project, including: - Service station at Neutral Bay (150 m south of the project, BL1) - Service Station at Neutral Bay (300 m southeast of the project, BL1) - Service Station at Cammeray (300 m north of the project, Tunnel, Gore Hill Connection surface work) - Service Station at Artarmon (200 m northwest of the project, Gore Hill Connection surface work)) - Service Station at Artarmon (300 m west of the project, Gore Hill Connection surface work) - Service Station at Willoughby (500 m north of the project, BL2) - Service Station at Balgowlah (less than 100 m south of the project, BL10) Table 11 of Section 1.1.4 of Appendix B of GHD (2022) states the following, noting that some sites listed may be duplicated with those listed above: • A search conducted of NSW EPA Contaminated Sites Record of Notices (under Section 58 of the Contaminated Land Management Act 1997 (CLM Act)) and the list of contaminated sites notified to NSW EPA (under section 60 of the CLM Act) indicated that there were seven notified sites registered with NSW EPA within 1 km of the BLGHFC project. - Service station at 447 Pacific Highway, Artarmon (regulation not required) (1 km north-west of B8 Dickson Avenue) - Service station at Corner Sydney Road and Maretimo Street (regulation not required) (adjacent to B13/14 Balgowlah Golf Course and Dudley Street) - Other petroleum facility at 8-10 Roseberry Street (regulation not required) (1 km north-east of B13/14 Balgowlah Golf Course and Dudley Street) - Service station at 432 Pacific Highway, Lane Cove North (currently regulated) (1 km north-west of B8 Dickson Avenue) - Service station at 616-626 Willoughby Road, Willoughby (Regulation under CLM Act not required) (500 m north-west of B10 Bicentennial Reserve) - Service Station at 498 Willoughby Road, Willoughby (Currently regulated under the POEO Act) (200 m north-west of Bicentennial Reserve) - Other industry (former landfill) at Bicentennial Reserve, Flat Rock Gully, Willoughby Leisure Centre (under assessment) (on site B9 Flat Rock Reserve and B10 Bicentennial Reserve). • A search of the public register under Section 308 of the PoEO Act 1997 did not identify any licences referring to the sites.

Title	Details
Summary of Council Records:	Summary of council records has not been provided. It is anticipated that council records will be obtained as part of future site-specific investigations.
Other Licences, Approvals, Trade Waste Agreements:	Details of current licences, approvals and trade waste agreements that may apply to individual AEIs have not been discussed. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
SafeWork NSW Dangerous Goods Licenses/ USTs/ ASTs:	A search of SafeWork NSW registers has not been conducted. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Previous Land Use Potentially Associated with PFAS:	Section 4.4.1 of Jacobs (2020a) states that harbour sediments have been tested for one PFAS compound, and that PFAS and dioxin analysis has not been conducted for sediment samples collected from The Spit. Table 5-1 of Section 5.1 of Jacobs (2020a) lists PFAS as a potential contaminant in Harbour Sediments at AEI B12. PFAS has been considered as a COPC at various AEIs listed in the GHD (2022) Framework SAQP.
Potential Offsite Impacts:	Section 4.2.1 of Jacobs (2020a) states that a Yellow Pages internet search was carried out to assess potential contamination risks associated with current activities and/or operations near the project area. The search was limited to the suburbs within and surrounding the project area including Cammeray, Crows Nest, Naremburn, Artarmon, Willoughby, Northbridge, Seaforth, Balgowlah, North Balgowlah, and Frenchs Forest. The results of the business directory review are presented in Table 4-2 of Jacobs (2020a) and include the following potential offsite impacts: • Multiple mechanical engineering premises. • Multiple dry cleaners. • One plant nursery. • Multiple service stations. • One former landfill.
Site Plans Showing Detailed Site Features:	Site plans showing detailed site features of each AEI has not been presented, however the aerial photography review provides a reasonable representation of changes in site features over time. It is anticipated that these site-specific details will be considered as part of the future site-specific investigations.
Verification of Information Sources:	Section 4 of Jacobs (2020a) states that the following sources were investigated to determine the history of land use within and next to the project: • NSW Land and Property Management Authority, Land and Property Information Division: Historical aerial photographs (1930 to 2005) • NSW EPA Contaminated Sites Register and Record of Notices • Available aerial imagery services including Google Earth, SIX Maps and Metro Map • Yellow Pages business directory. The Auditor considers the information sources relied upon are suitable for the purposes of the EIS.

4.3 Geology, Hydrogeology and Hydrology

The geology, hydrogeology and hydrology are summarised in the following tables. This information has been sourced from the reports listed in Section 1.4.

Table 4.3a Subsurface Conditions – Geology and Soil

Title	Details
Geology Map Conditions:	Section 3.3 of Jacobs (2020a) provides the following: • The geology of the alignment is dominated by the Hawkesbury Sandstone of the Permo Triassic age Sydney Basin. In elevated areas, the Hawkesbury Sandstone is overlain by the Ashfield Shale of the Wianamatta Group. An intermediate formation between the Hawkesbury Sandstone and the Ashfield Shale, the Mittagong Formation, is sometimes identified but is not mapped along the project alignment. In places the Sydney Basin sedimentary formations have been structurally deformed and include the presence of faults, dykes, and joint swarms. • The Sydney 1:100,000 Geological Series Sheet 9130 (NSW Department of Mineral Resources, 1983) indicated that most of the project area is predominantly underlain by Hawkesbury Sandstone (Rh) with isolated occurrences of Ashfield Shale (Rwa) present in the south-eastern portion of the project area (North Sydney and Neutral Bay).
Soil Map Conditions:	Section 3.4 of Jacobs (2020a) states that the Sydney 1:100,000 Soil Landscape Series Sheet 9130 (Soil Conservation of NSW, 1966) indicates that the residual soils within the project area includes the Blacktown, Hawkesbury, Gymea, Lucas Heights, Lambert, Somersby and Glenorie landscape groups. Most of the project area is underlain by the Gymea landscapes with Hawkesbury landscapes surrounding the shorelines. Table 3-2 of Jacobs (2020a) provides a description of each soil unit. Figure 3-8 of Jacobs (2020a) presents the locations and extents of each soil unit. Section 3.7 of Jacobs (2020a) states that none of the soil landscapes within the project area document salinity as a limitation to the landscape type. No council LEPs within the project area contain salinity risk maps. Table 9 of Section 1.1.2 of Appendix B of GHD (2022) provides the following soil landscape details for the Project Specific Terrestrial AEIs: • B7 Punch Street, Artarmon: Gymea/Lambert - found on undulating to rolling low hills on Hawkesbury Sandstone. Soils are shallow to moderately deep yellow earths and earthy sands on crests and inside of benches. • B8, Dickson Avenue, Artarmon: Glenorie - found on low rolling and steep hills. Soils are shallow to moderately deep (less than 100 cm) red, brown and yellow podzolic soils on crests and slopes. Siliceous sands, leached sands and humic gleys on shale lenses and along drainage lines. • B9 Flat Rock Reserve, Northbridge and B10 Bicentennial Reserve, Willoughby: - Majority disturbed terrain - occurs within other landscapes and is mapped as “xx”. Topography varies from level plains to undulating terrain and has been disturbed by human activity to a depth of at least 100 cm. Original soil has been removed, greatly disturbed or buried. - Hawkesbury in eastern portion - found on rugged, rolling to very steep hills on Hawkesbury Sandstone. Soils are shallow (less than 50 cm), discontinuous lithosols/siliceous sands associated with rock outcrops, earthy sands, yellow earths on the inside of benches and along joints and fractures. - Gymea/Lambert in southern portion - found on undulating to rolling low hills on Hawkesbury Sandstone. Soils are shallow to moderately deep yellow earths and earthy sands on crests and inside of benches. • B11 Spit West Reserve, Mosman: Hawkesbury - found on rugged, rolling to very steep hills on Hawkesbury Sandstone. Soils are shallow (less than 50 cm), discontinuous lithosols/siliceous sands associated with rock outcrops, earthy sands, yellow earths on the inside of benches and along joints and fractures. • B13 Balgowlah Golf Course and B14 Dudley Street, Balgowlah: Lambert - found on undulating to rolling low hills on Hawkesbury Sandstone. Soils are shallow to moderately deep yellow earths and earthy sands on crests and inside of benches. • B15 Residential properties, Wakehurst Parkway: Somersby - found on gently undulating to rolling rises on deeply weathered Hawkesbury Sandstone plateau. Soils are moderately deep to deep (100–300 cm) red earths and yellow earths overlying laterite gravels and clays on crests and upper slopes; yellow earths and earthy sands on mid slope; grey earths, leached sands and siliceous sands on lower slopes and drainage lines; gleyed podzolic soils in low lying poorly drained areas.

Title	Details
	• B16 Sydney Water Reservoir: Lambert - found on undulating to rolling low hills on Hawkesbury Sandstone. Soils are shallow to moderately deep yellow earths and earthy sands on crests and inside of benches. • B17 Wakehurst Parkway, Seaforth to Frenchs Forest - Majority Lambert - found on undulating to rolling low hills on Hawkesbury Sandstone. Soils are shallow to moderately deep yellow earths and earthy sands on crests and inside of benches. - Lucas Heights - found on gently undulating crests and ridges on plateau surfaces. Soils are moderately deep (50– cm), hard setting yellow podzolic soils and yellow soloths, yellow earths on outer edges.
Acid Sulfate Soils:	Section 3.6 of Jacobs (2020a) provides the following details: • Acid sulfate soils (ASS) risk maps from the CSIRO ASRIS database were reviewed to ascertain the probability of ASS being present across the project area. Based on this information, the generalised ASS classes and probability across the project area has been assessed as follows: - Middle Harbour – (A) high probability/confidence unknown - Cammeray to Naremburn – (B4) low probability/very low confidence - Naremburn to Northbridge – (C4) extremely low probability/very low confidence - Artarmon to Naremburn – (B4) low probability/very low confidence - Seaforth to Balgowlah – (C4) extremely low probability/very low confidence • A review of the ASS risk maps from the Willoughby LEP 2012 and the Manly LEP 2013 indicated that the project would be located within areas of Class 5 ASS risk or areas with no probable ASS risk (unclassified). The Mosman LEP 2012 identified areas underlying The Spit as an ASS area (land up to 5 metres AHD) but did not provide an ASS class for this area. The ASS risk maps from the Warringah LEP Plan 2011 did not classify the project area as an ASS risk. The North Sydney LEP 2013 does not contain ASS risk maps. The respective LEPs do not cover ASS risk within Middle Harbour. • Figure 3-9 shows that Middle Harbour has a 'high probability of occurrence' of ASS.
Geophysical Data:	Geophysical data has not been provided. Based on Appendix B of Section 1.5.1 of GHD (2022) it is understood that field work preparations will include service location to identify underground services prior to commencement of all works at the proposed intrusive locations.
Logs/Soil Classification Method:	Not applicable for the primary reports reviewed.
Site-specific Geology Conditions:	Section 1.1.5.1 of Appendix B of GHD (2022) provides the following sub-surface conditions for the Project Specific Terrestrial AEIs: • B7 Punch Street and B8 Dickson Avenue - Fill: Gravelly sand and cobbles from surface to 4.5 mbgl - Natural: Clayey silt from 3.0 to 8.5 mbgl - Bedrock: Natural Sandstone underlying clayey silt. • B9 Flat Rock Reserve & B10 Bicentennial Reserve - Fill: Clay and sand fill from surface to 31 m bgl. Inclusions of bricks, concrete and building rubble - Bedrock: Sandstone underlying fill • B11 Spit West Reserve - No previous investigations completed • B13/14 Balgowlah Golf Course & Dudley Street - Fill: Silty and clayey sand and gravels from surface to 1.0 mbgl - Natural: Clayey sand from 1.0 to 2.4 m bgl - Bedrock: Natural sandstone underlying natural clayey sands • B15 Residential properties Wakehurst Parkway & B16 Sydney Water Reservoir

Title	Details
	- Fill: Clayey sand and gravels from surface to 1.0 mbgl - Bedrock: Natural sandstone underlying fill • B17 Wakehurst Parkway, Seaforth to Frenchs Forest - Fill: Gravelly clays and sands from surface to 3.7 mbgl - Bedrock: Natural sandstone encountered at 1.2 to 3.7 m bgl
Soil Bulk Density and Porosity:	Details regarding soil bulk density and porosity have not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Cation Exchange Capacity:	Details regarding cation exchange capacity have not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Soil pH:	Section 5.4.2 of GHD (2022) indicates that soil pH is to be tested in future site-specific DSIs. Section 5.5.5 of GHD (2022) states that groundwater pH is to be measured during field sampling.
Redox Potential:	Details regarding redox potential have not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.
Storativity or Storage:	Details regarding storativity or storage have not been provided. It is anticipated that these site-specific details will be considered as part of future site-specific investigations.

Table 4.3b Subsurface Conditions – Groundwater

Title	Details
Regional Hydrogeology:	Section 3.8 of Jacobs (2020a) states that regional groundwater flow is inferred to be in an east to south easterly direction towards Port Jackson and the Tasman Sea. Section 3.8 of Jacobs (2020a) cites Appendix N (Technical Working Paper: Groundwater) and states that the regional water table across the project area is likely to mimic topography and would flow from areas of high topographic relief to areas of low topographic relief, ultimately discharging to waterways and harbours. Section 3.8 of Jacobs (2020a) adds that deeper groundwater flow would be less controlled by topography and more influenced by the regional structure and stratigraphy of the Sydney Basin. Section 3.8 of Jacobs (2020a) states that groundwater quality within the Hawksbury Sandstone is typically of high quality with low salinity, and of neutral to slightly acidic pH. Groundwater occurring within the Ashfield shale unit is generally of poorer quality, due to high clay mineral content and subsequent higher salinity.
Site-specific Hydrogeology:	Site specific hydrogeology details have not been provided. It is anticipated that these site-specific details will be considered in future site-specific investigations.
Aquifer Types:	Details regarding the type of aquifers underlying the site have not been provided. It is anticipated that these site-specific details will be provided in future site-specific investigations.
Direction and Rate of Groundwater Flow:	Section 3.8 of Jacobs (2020a) states that groundwater flow could not be definitively assessed based on current information. Section 3.8 of Jacobs (2020a) adds that based on the surrounding topography of the project and the location of water bodies, the groundwater would flow in the following directions near the above ground project features: • Easterly direction towards Long Bay (Northbridge) from Cammeray, Naremburn, Willoughby and Artarmon • Southerly direction towards Long Bay and easterly direction towards Middle Harbour from Northbridge

Title	Details
	• Southerly and westerly direction towards Middle Harbour from Seaforth and Killarney Heights • Southerly and south easterly direction towards Burnt Bridge Creek • East and west from Wakehurst Parkway towards Manly Dam and Bantry Bay respectively Section 3.8 of Jacobs (2020a) adds that deeper groundwater flow is less controlled by topography, and more influenced by the regional structure and stratigraphy of the Sydney Basin. Table 9 of Section 1.1.2 of Appendix B of GHD (2022) provides the following groundwater flow information for the Project Specific Terrestrial AEIs: • B7 Punch Street – Easterly towards Northbridge • B8 Dickson Avenue – Easterly towards Northbridge • B9 Flat Rock Reserve & B10 Bicentennial Reserve – Easterly towards Northbridge • B11 Spit West Reserve – Inferred to flow southerly and/or easterly towards Middle Harbour • B13/14 Balgowlah Golf Course & Dudley Street – Southerly and/or westerly towards Middle Harbour • B15 Residential properties along Wakehurst Parkway – Southerly and/or south-easterly towards Burnt Bridge Creek • B16 Sydney Water Reservoir – Southerly and/or south-easterly towards Burnt Bridge Creek • B17 Wakehurst Parkway, Seaforth to Frenchs Forest – Easterly and/or westerly towards Manly Dam and Bantry Bay.
Hydraulic and Piezometric Heads and Hydraulic Gradients, Hydraulic Conductivity and Porosities, Transmissivity	It is anticipated that these site-specific details will be provided in future site-specific investigations where groundwater investigation is warranted
Depth to Groundwater:	Section 3.8 of Jacobs (2020a) states that depth to the water table is likely to be highly variable and could range from close to below ground surface in low lying areas and at depth below elevated ridgelines. Section 3.8 of Jacobs (2020a) adds that localised perched water tables may also occur, as well as multiple water tables resulting from the highly stratified nature of the Hawksbury Sandstone. Table 12 of Section 1.1.5.1 of Appendix B of GHD (2022) provides the following sub-surface conditions for the Project Specific Terrestrial AEIs: • B7 Punch Street and B8 Dickson Avenue - Groundwater previously encountered at approximately 5.0 mbgl • B9 Flat Rock Reserve and B10 Bicentennial Reserve - Groundwater previously encountered between 19 and 25 mbgl. The Auditor anticipates shallow perched water to be encountered over the fill horizon. • B11 Spit West Reserve - No previous investigations completed • B13/14 Balgowlah Golf Course & Dudley Street - Groundwater not encountered in most locations, however observed at 1.3 mbgl in shallow sandstone at one location • B15 Residential properties Wakehurst Parkway & B16 Sydney Water Reservoir - Groundwater not encountered • B17 Wakehurst Parkway, Seaforth to Frenchs Forest - Groundwater previously encountered at 2.5 m bgl
Summary of Existing Monitoring Wells:	Details of monitoring wells at each terrestrial AEI site have not been summarised. It is anticipated that these site-specific details will be considered in future site-specific investigations.
Use of Water Abstraction/Receptor and Beneficial uses:	Section 3.8.1 of Jacobs (2020a) states that a search of the NSW DPIE (Regional NSW) groundwater database identified one registered groundwater well within a 500 metre radius of the project: • GW108224.1.1 is located in St Leonards, about 480 metres from the alignment, and is reported as being used for water supply. The surface geology in the vicinity

Title	Details
	of GW108224.1.1 is Ashfield shale, however the bore is 132.4 metres deep and is inferred to be constructed in the Hawkesbury Sandstone. Section 3.8.1 of Jacobs (2020a) adds that there are two bores (details of groundwater abstraction and use not provided) located in Frenchs Forest, situated approximately 520 m from the northern end of the alignment: • GW020065.1.1 is 114.9 mbgl in Hawkesbury Sandstone. • GW020067.1.1 is 137.1 mbgl in Hawkesbury Sandstone. Table 9 of Section 1.1.2 of Appendix B of GHD (2022) confirmed the presence of the single groundwater bore (GW108224.1.1).
Future Realistic Uses of Aquifer:	Section 1.2.2 of Appendix B of GHD (2022) states that groundwater extraction and associated human receptors were not considered as a potential pathway due to the presence of a reticulated water supply in the BLGHFC project area and surrounding regions. There is one registered water supply bore 500 m from the BLGHFC project alignment, located at St Leonards, drilled to a depth of 132 metres, and is considered unlikely be impacted by potentially contaminated groundwater if present within the investigation area. To be re-evaluated as part of implementing site specific SAQPs.
Groundwater Receptors:	Section 3.9 of Jacobs (2020a) provides the following groundwater receiving environments which could be potentially impacted by contamination (if present) within the project area: • Upper reaches of Flat Rock Creek at Munro Park (Northbridge) and upper reaches of Quarry Creek, (Cammeray), located south-east of the project alignment in the vicinity of the Willoughby Leisure Centre. • Flat Rock Drive. Identified as 'moderate to high potential' for terrestrial groundwater dependent ecosystems (Coastal Sandstone Gully Forest, Sandstone Riparian Scrub and Coastal Sandstone Gully Forest) • Bates Creek (Forestville), about 550 metres west of the project alignment (Wakehurst Parkway). Identified as 'moderate to high' potential for terrestrial groundwater dependent ecosystems (Estuarine Mangrove Forest, Seagrass Meadow and Coastal Sandstone Gully Forest) • Manly Dam Reserve (Allambie Heights), about 650 metres east of the project alignment (Wakehurst Parkway). Identified as 'moderate' potential for terrestrial groundwater dependent ecosystems (Coastal Sandstone Gully Forest and Coastal Sandstone Plateau Heath).
Groundwater Quality Monitored	Section 6.6 of Jacobs (2020a) states that existing groundwater monitoring data indicates that groundwater contamination was present beneath/surrounding the Willoughby Leisure Centre and Bicentennial Reserve and could be migrating towards Flat Rock Reserve. Elevated ammonia concentrations were reported in groundwater samples collected from beneath/surrounding these sites. Ammonia-impacted groundwater could impact upon the construction of the tunnel located beneath this area and the construction of the access decline tunnel located adjacent to this area (within Flat Rock Reserve) if not appropriately managed. The sampling and analysis carried out within this area included a suite of general contaminant compounds. Based on the historical landfilling carried out within this area, other contaminant compounds may be present within groundwater. Jacobs (2020a) presented the following key findings for groundwater impacts, based on the Douglas Partners Golder Associates groundwater monitoring factual reports: • Cobalt, total phosphorous, ammonia, copper, manganese, nickel, boron and zinc, variably exceeded the ANZECC (2000) 95% species protection for freshwater and marine ecosystems. • Manganese, nickel, lead, chromium, sulphate, and arsenic exceeded the NHMRC (2011) drinking water guidelines. • Lead and manganese exceeded NHMRC (2008) recreational water guidelines. Jacobs (2020a) presented the following groundwater impacts, based on the AEC (2019) groundwater monitoring report: • Phosphorous (reactive), phosphorous, nitrate, chromium, cobalt, copper, zinc, manganese, nickel, and boron variably exceeded the ANZECC (2000) 95% species protection for freshwater and marine ecosystems. • Manganese exceeded the NHMRC (2011) drinking water guideline.

Title	Details
	Jacobs (2020a) presented the following groundwater impacts based on the SMEC (2017) monitoring report for the Northern Beaches Hospital Road Connectivity and Network Enhancements Project: • Selected heavy metals variably exceeded ANZECC (2000) 95% species protection criteria for freshwater and marine ecosystems. • TRH and benzene were detected above LOR and associated with nearby service station sites or introductions during the drilling program. • Elevated nitrite was considered associated with fertiliser or within parkland areas. The report concluded that groundwater quality showed no substantial existing contamination. Pre-existing groundwater monitoring date is to be considered in developing site specific SAQPs as required by the Framework SAQP (GHD, 2022).

Table 4.3c Subsurface Conditions – Surface water

Title	Details
Surface Water Receptors:	Section 3.9 of Jacobs (2020a) provides the following surface water receiving environments which could be potentially impacted by contamination within the project area during construction: • Long Bay - Potential impact from the surface work and construction of the following support sites located at Cammeray (Cammeray Golf Course construction support site (BL1)), Artarmon (Punch Street (BL3); Dickson Avenue (BL4); Barton Road (BL5); and Gore Hill Freeway Median (BL6) construction support sites) and Northbridge (Flat Rock Drive construction support site (BL2)). • Middle Harbour – Potential impact from the construction support sites located within Middle Harbour and the Spit West Reserve (ie Middle Harbour south cofferdam (BL7); Middle Harbour north cofferdam (BL8) and Spit West Reserve construction support site (BL9)). In addition, potential impact from the surface work and construction support sites located from Seaforth to Frenchs Forest (ie Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13); and Wakehurst Parkway north (BL14) construction support sites) • Burnt Bridge Creek – Potential impact from the surface work and construction support sites located at Balgowlah (ie Balgowlah Golf Course (BL10) and Kitchener Street (BL11) construction support sites) • Bantry Bay and Manly Dam – Potential impact from the surface work on the Wakehurst Parkway (between Seaforth and Frenchs Forest – Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13); and Wakehurst Parkway north (BL14) construction support sites) Table 9 of Section 1.1.2 of Appendix B of GHD (2022) provides the following potential receptors associated with each Project Specific Terrestrial AEI: • B7 Punch Street and B8 Dickson Avenue – Flat Rock Creek located 200 m north-east of B7, and 750 m north-east of B8. • B9 Flat Rock Reserve and B10 Bicentennial Reserve – Flat Rock Creek adjacent south to southern site boundary (including underground culvert which runs along the southern boundary of the site). • B11 Spit West Reserve – Middle Harbour adjacent to the site. • B13/14 Balgowlah Golf Course & Dudley Street – Burnt Bridge Creek intersects the north-western portion of the site. • B15 Residential properties Wakehurst Parkway & B16 Sydney Water Reservoir – Bantry bay located 200 m west of the site; Manly dam located 600 m east of the site. • B17 Wakehurst Parkway, Seaforth to Frenchs Forest – Manly Creek located 250 m east of the site at its closest point.
Flow Paths for Surface Runoff:	Section 4.4 of GHD (2022) states that future site-specific SAQPs will provide detail on flow paths and surface runoff, recharge and discharge points.

4.4 Preliminary Conceptual Site Model

Table 4.4 provides the Preliminary Conceptual Site Model for the Project Specific Terrestrial AEIs, outlined in the Framework SAQP (GHD 2022).

Table 4.4: Preliminary Conceptual Site Model

<table>
<tr><th>Item</th><th>Conceptual Site Model</th></tr>
<tr><td>Areas of Environmental Concern (AECs) and Contaminants of Potential Concentrations (COPCs):</td><td>Table 15 of Section 1.2.1 of Appendix B of GHD (2022) provides the following on-site AEIs and COPCs:
<table>
<tr><th>Construction Activity / Construction Support Site</th><th>AEC</th><th>Activity or Source</th><th>COPCs</th></tr>
<tr><td>Demolition of existing structures; excavation of tunnel features; construction and operation of temporary site facilities.</td><td>B7 Punch Street</td><td>Historical hazardous building materials (bridge) and filling.
Mixed commercial/industrial use of site and surrounds, including a mechanical workshop and repairer, swim school, veterinarian and a paint supplier.</td><td>Anions and cations, heavy metals*, TRH, BTEX, PAH, PCB, nutrients, perfluoroalkyl and polyfluoroalkyl substances (PFAS), OCP, OPP and asbestos (soil only), cyanide, volatile organic compounds (VOC)</td></tr>
<tr><td>Demolition of existing structures; construction and operation of temporary site facilities.</td><td>B8 Dickson Avenue</td><td>Mixed commercial/ industrial use of site and surrounds, including a tyre fitter, mechanical workshop and repairer, car wash, television production studios, and the Freeway Hotel.</td><td>Anions and cations, heavy metals*, TRH, BTEX, PAH, PCB, nutrients, perfluoroalkyl and polyfluoroalkyl substances (PFAS), OCP, OPP and asbestos (soil only), cyanide, volatile organic compounds (VOC)</td></tr>
<tr><td>B9: Excavation of tunnel access decline and main tunnel alignment; construction and operation of temporary site facilities
B10: Tunnel excavation (no surface works planned)</td><td>B9 Flat Rock Reserve</td><td>Landfill / waste and incinerator operations</td><td>Anions and cations, heavy metals*, TRH, BTEX, PAH, PCB, VOCs, semi volatile organic compounds (SVOCs), phenols, nutrients, dissolved methane, cyanide, ammonia, PFAS, OCP, OPP and asbestos (soil only), landfill gases including methane, carbon dioxide, oxygen and carbon monoxide</td></tr>
<tr><td>Not applicable (construction footprint interface)

(not included in Table 15 of Section 1.2.1 but presented here for completeness, and because testing is</td><td>B10 Bicentennial Reserve</td><td>Former landfill</td><td>Field test (concentration, pressure gradient and flow), carbon dioxide, methane, oxygen, hydrogen sulphide.

Targeted testing proposed only for design and waste classification purposes.

Testing for exit phase not proposed as no surface</td></tr>
</table></td></tr>
</table>

proposed for this site).			works are proposed for this site.
Construction and operation of temporary site facilities.	B11 Spit West Reserve	Reclamation of land with material of unknown quality, possible boat repairs and maintenance.	Heavy metals*, CrVI, TRH, BTEX, PAH, PCB, nutrients, PFAS, OCP, OPP and asbestos (soil only), VOC, organotins,
Demolition of existing structures; excavation of tunnel features and access decline; construction and operation of temporary and permanent site facilities.	B13/14 Balgowlah Golf Course & Dudley Street	Inappropriate handling and disposal of building materials during demolition of buildings for construction of Burnt Bridge Creek Deviation. Filling with material of unknown quality during Burnt Bridge Creek Deviation construction. Degradation of hazardous building materials from structures currently present on the site. Chemicals use and storage at the golf course.	Anions and cations, heavy metals*, TRH, BTEX, PAH, PCB, nutrients, PFAS, OCP, OPP and asbestos (soil only)
Construction and operation of temporary site facilities	B15 Residential properties, Wakehurst Parkway	Degradation of hazardous building materials from structures currently present on the site Potential for illegal dumping of hazardous building materials.	Heavy metals*, TRH, BTEX, PAH, PCB, PFAS, OCP, OPP and asbestos (soil only)
Excavation of tunnel features and access decline; construction and operation of temporary site facilities	B16 Sydney Water Reservoir	Reservoirs coated with lead paint which may flake as a result of degradation. Potential for hazardous building material fragments to be present at site.	Heavy metals*, TRH, BTEX, PAH, PCB, PFAS, OCP, OPP and asbestos (soil only)
Excavation of tunnel features and cut and cover; widening of Wakehurst Parkway	B17 Wakehurst Parkway, Seaforth to Frenchs Forest	Illegal dumping of waste. Potential historical use of site for fuel storage. Degradation of asphalt road surface	Heavy metals*, TRH, BTEX, PAH, PCB, PFAS, OCP, OPP and asbestos (soil only)

*Heavy metals including, but not limited to, arsenic, barium, boron, cadmium, chromium, cobalt, copper, cyanide, iron, lead, manganese, mercury, nickel, zinc.

Item	Conceptual Site Model

Section 1.2.1 of GHD (2022) provides the following **off-site** AEIs and likelihood for contamination:

Suburb and AEI	Activity or Source	Likelihood for contamination
Artarmon - B7 Punch Street and B8 Dickson Avenue	Multiple mechanical engineering premises adjacent to B7 and B8 and 36 mechanical engineering premises within 500 m of the BLGHFC project	Low – likely premises are covered in concrete hardstand and spills would be surficial
B13/14 Balgowlah Golf Course & Dudley Street	Two mechanical engineering premises 300 m east of B13/14. One service station adjacent south of southern boundary of B13/14.	Low – groundwater flow is inferred southerly or westerly. Potential impacts from these premises are unlikely to be impacting the site.
Naremburn - B10 Bicentennial Reserve	One dry cleaner 500 m south of B10	Low – Likely too far from the BLGHFC project to cause impacts
Northbridge - B9 Flat Rock Reserve	One dry cleaner 500 m east of B9	Low – Likely too far from the BLGHFC project to cause impacts.
Seaforth - B15 Residential properties, Wakehurst Parkway	One plant nursery 300 m east of B15	Low – Likely too far from the BLGHFC project to cause impacts
Willoughby - B10 Bicentennial Reserve	One mechanical engineering 500 m north-west of B10. One service station 200 m north-west of B10.	Low – groundwater flow inferred east. Potential impacts from these premises are unlikely to be impacting the site
Frenchs Forest - B17 Wakehurst Parkway, Seaforth to Frenchs Forest	Former landfill 100 m east of B17 (Currently Aquatic Reserve Baseball Park)	Moderate – Fill, including PFAS impacts, may be migrating towards the proposed tunnel alignment. It is unlikely landfill gas impacts present a risk due to the distance from the site

Potential Affected Media:

The consultant has considered the following media to be investigated:

- Soil
- Sediment
- Soil vapour
- Groundwater
- Surface Water
- Air
- Leachate / Seepage
- Hazardous Ground gas

Spatial and Temporal Variations:

The GHD (2022) CSM is based on desk top studies and existing information.

The GHD (2022) SAQP considers weather conditions and seasonal variation for future, site-specific DSIs and monitoring.

Item	Conceptual Site Model
Current and Potential Exposure Source, Pathway and Receptors: **B7, B8, B13/14, B15 (during demolition of existing structures)**	Table 17 of Section 1.2.2 of Appendix B of GHD (2022) considers the following receptors during the construction phase and operational / end use phase (denoted by 'future'): • On site construction workers • Off site commercial / industrial receptors (B7 Punch Street, B8 Dickson Avenue) • Off site residential receptors (B13/14 only Balgowlah Oval) • Off site open space/recreational receptors (B13/B14 only, Balgowlah Oval which adjoins the Balgowlah Golf Course to the south-east and is within the BL10 construction footprint) • Flat Rock Creek (200 m north-east of B7 Punch Street, and 750 m north-east of B8 Dickson Avenue • Burnt Bridge Creek (intersecting B13/14 Balgowlah Oval) • Future commercial / industrial (B7, B8, and southern half of B13/14 (Punch Street, Dickson Avenue, and Balgowlah Golf Course, respectively) • Future Open space / recreational (southern and northern half of B13/14 (Balgowlah Golf Course Section 1.2.2 of Appendix B of GHD (2022) considers the following potentially complete exposure pathways: • Inhalation of dust particles / asbestos fibres • Dermal contact and/or ingestion with soil and/or sediment • Migration of contamination via surface water run-off and groundwater movement to nearby creeks • Direct contact and ingestion of contaminated media
B7, B9, B13/14, B16, B17 (during excavation of tunnel access decline, tunnel features and/or cut and cover. Construction and operation of temporary site facilities, and/or permanent facilities).	Table 17 of Section 1.2.2 of Appendix B of GHD (2022) considers the following receptors during the construction phase and operational / end use phase (denoted by 'future'): • On site construction workers • On site intrusive maintenance workers • Off site intrusive maintenance workers • Off site commercial / industrial receptors (B7 Punch Street) • Off site residential receptors (B9, B13/14 Flat Rock Reserve and Balgowlah Golf Course, respectively) • Off site open space receptors (B13/14 and B16 Balgowlah Oval and Wakehurst Golf Course, respectively) • Groundwater underlying the Project footprint • Flat Rock Creek (200 m north-east of B7 Punch Street) • Flat Rock Creek (adjacent to B9 Flat Rock Reserve) • Burnt Bridge Creek (intersecting B13/14 Balgowlah Golf Course) • Bantry Bay and Manly Dam (200 m west and 600 m east of B16, respectively • Adjacent Flat Rock Drive flora and fauna (B9 Flat Rock Reserve) • Adjacent Garigal Reserve and Manly Dam Reserve flora and fauna (B16 and B17 Wakehurst Parkway east and Wakehurst Parkway Seaforth to Frenchs Forest, respectively • Future commercial / industrial (B7, B16, B17, and southern half of B13/14, Punch Street, Wakehurst Parkway east, Wakehurst Parkway between Seaforth and Frenchs Forest, and Balgowlah Golf Course, respectively. • Future open space/recreational (B9, and southern and northern half of B13/14 Flat Rock Reserve and Balgowlah Golf Course, respectively. Section 1.2.2 of Appendix B in GHD (2022) considers the following potentially complete exposure pathways: • Inhalation of dust particles / asbestos fibres • Inhalation of volatile emissions emanating from contaminated soil, sediment, groundwater, surface water, leachate and seepage. • Asphyxiation and explosion hazards from accumulation of landfill gas (B9 Flat Rock Reserve)

Item	Conceptual Site Model
	• Preferential pathways for landfill gases to accumulate in enclosed spaces, including service trenches (B9 Flat Rock Reserve). • Dermal contact and/or ingestion with soil and/or sediment, surface water, groundwater, leachate and seepage • Migration of contamination via surface water run-off and groundwater movement to nearby creeks • Direct contact and ingestion of contaminated media • Plant uptake of contaminants in root zones (B16 Wakehurst Parkway east) • Downward migration of contaminated soil and surface water to groundwater.
B8, B11, B15 (during construction and operation of temporary site facilities)	Table 17 of Section 1.2.2 of Appendix B of GHD (2022) considers the following receptors during the construction phase and operational / end use phase (denoted by 'future'): • On site construction workers • Off site commercial / industrial receptors (B8 Dickson Avenue) • Off site residential receptors (B15 Wakehurst Parkway south) • Off site open space receptors (B11 Spit West Reserve) • Flat Rock Creek (750 m north-east of B8 Dickson Avenue) • Adjacent Middle Harbour (B11 Spit West Reserve) • Adjacent Garigal National Park (B15 Wakehurst Parkway south) • Future commercial/industrial (B8 Dickson Avenue) • Future open space/recreational (B11 Spit West Reserve) • Future residential with private gardens (B15 Wakehurst Parkway south). Table 17 of Section 1.2.2 of Appendix B of GHD (2022) considers the following potentially complete exposure pathways: • Dermal contact and/or ingestion with soil and/or sediment • Ingestion of contaminated plants for human consumption (vegetable garden) (B15 Wakehurst Parkway south) • Inhalation of volatile emissions emanating from contaminated soil, sediment, groundwater, surface water, leachate and seepage. • Migration of contamination via surface water run-off and groundwater movement to nearby creeks • Direct contact and ingestion of contaminated media • Plant uptake of contaminants in root zones (B16 Wakehurst Parkway east).
B10 (during tunnel excavation / no surface works proposed)	Table 17 of Section 1.2.2 of Appendix B of GHD (2022) considers the following receptors during the construction phase and operational / end use phase (denoted by 'future'): • On site open space/recreational receptorsOn site construction workers • On site intrusive maintenance workers • Off site intrusive maintenance workers • Off site residential receptors • Groundwater underlying the Project footprint • Adjacent Flat Rock Creek • Adjacent Flat Rock Reserve flora and fauna • Future – no change to open space / recreation receptors Table 17 of Section 1.2.2 of Appendix B of GHD (2022) considers the following potentially complete exposure pathways: • Dermal contact and/or ingestion with soil and/or sediment, surface water, groundwater, leachate and seepage • Inhalation of dust particles / asbestos fibres • Inhalation of volatile emissions emanating from contaminated soil, sediment, groundwater, surface water, leachate and seepage. • Asphyxiation and explosion hazards from accumulation of landfill gas • Preferential pathways for landfill gases to accumulate in enclosed spaces, including service trenches

Item	Conceptual Site Model
	• Migration of contamination via surface water run-off and groundwater movement to nearby creeks • Direct contact and ingestion of contaminated media • Plant uptake of contaminants in root zones • Downward migration of contaminated soil and surface water to groundwater.
Discussion of Multiple Lines of Evidence:	Section 1.2.2 of Appendix B of GHD (2022) provides the following discussion items: • The preliminary CSM was developed for each Project Specific Terrestrial AEI identified in Jacobs (2020a). • Receptors may change in the future following the refinement of the project design and confirmation of end uses. • Groundwater extraction and associated human receptors were not considered as a potential pathway due to the presence of a reticulated water supply in the Project area and surrounding regions. • While there is one registered water supply bore 500 m from the Project alignment, located at St Leonards, this is drilled to a depth of 132 metres and is considered unlikely to be impacted by potentially contaminated groundwater if present.
Data Gaps:	Section 4.5 of GHD (2022) states that the site-specific SAQPs must provide details of a data gap and uncertainty assessment. Section 4.8 notes that a refined conceptual site model, including sources, pathways, receptors, and a linkage assessment to determine risks to identified receptors during construction and post-construction, must be provided in the site-specific SAQPs. Section 5.2 of GHD (2022) acknowledges that the preliminary CSM will need to be further developed and refined in the site-specific SAQPs for each Project Specific Terrestrial AEI.

4.5 Auditor Discussion

Most of the information required by NSW EPA (2020a), regarding site condition and history, geology, hydrology, and hydrogeology, has been provided, and is consistent with the Auditor's understanding of the Project Specific Terrestrial AEIs.

Given the preliminary nature of both the Appendix M – Contamination (Jacobs 2020a) and the Framework SAQP (GHD 2022), there are several items required by NSW EPA (2020a) that have not been provided or discussed in detail, however their absence does not affect the outcome of this Audit because the Framework SAQP requires that these be addressed as part of future site-specific SAQPs and subsequent detailed site investigations (DSI):

- Condition of the site boundary
- Location and condition of all site features, including site building information and condition
- Details of chemical storage and transfer areas and presence of chemical containers
- Confirmation of the presence/absence of aboveground storage systems and underground storage systems
- Identification of any settlement ponds
- Description and location of services and utilities including on-site septic systems, electrical transformers/substation/capacitors
- Vegetation type, extent, and condition of vegetation cover
- Assessment of soil loss or soil deposition that has occurred in the past
- Surface water drainage, run-off, and identification of ponding areas
- Direction of flow of water run-off from the site and adjacent properties

- Photographs of the site and surrounding area
- An evaluation of the difference between current site condition and site history
- Historical title search
- Details of previous land uses
- Details, charts and diagrams of previous buildings and site structures, historical site layout plans
- Description of historical manufacturing / industrial processes, any products that were discharged
- Locations of historical chemical storage and transfer areas
- Wastes discharged during manufacturing
- Historical discharges to land, air and water
- Historical sewer and services plans
- Earthmoving activities carried out on site
- Previous offsite land uses with potentially contaminating activity
- Complaint history
- Summary of Council records
- Details of licences, approvals, trade waste agreements
- SafeWork NSW dangerous goods licences, USTs/ ASTs
- Historical site photographs
- Details of the classification method for soil/logs
- Site-specific geology, hydrogeology, aquifer types, and groundwater conditions
- Flow paths for surface runoff
- Recharge sources, discharge points, other hydraulic boundaries
- Preferential water courses.

The Auditor considers that the preliminary conceptual site model established for the AEIs within BLGHFC project footprint is appropriate for the purposes of this audit, and that the COPCs listed are consistent with the site history and subsequent potential contamination impacts.

5 Sampling and Analysis Plan

This section provides a summary of the review of the sampling, analysis and quality plan and associated methodologies to be adopted for the post-determination investigations of the AEIs identified within the BLGHFC project footprint. This information has been sourced from the following document:

- GHD (16 May 2022) Framework Sampling, Analysis and Quality Plan, Beaches Link and Gore Hill Freeway Connection Project, Ref: 12522128_REP_Beaches Link SAQP.doc. Rev 0.

The Framework SAQP is summarised in Section 5.1, and the Auditor evaluation of the Framework SAQP is provided in Appendix D.

A copy of the endorsed Framework SAQP is included in Appendix E.

5.1 Overview and Objectives of Framework SAQP

The Framework SAQP (GHD 2022) provides guidance for the development of future site-specific SAQPs for contamination investigations to be completed post-determination for the BLGHFC project. The Framework SAQP refers to the AEIs identified in the EIS, Appendix M – Contamination as having a moderate to high risk of potential contamination being present, and categorises them as follows:

- **Project Specific T-AEIs** – Terrestrial AEIs located within the project footprint only (i.e. B7 to B11, B13 to B17). Each Project Specific T-AEI requires a detailed site investigation (DSI), and the Framework SAQP outlines the investigation requirements. The objective of the investigations is to provide an assessment of site suitability for the final intended land use (noting that not all final land uses have been identified at the time of preparing the SAQP), or to identify remediation requirements to make the AEI suitable for its intended land use or items to be considered during the construction phase.
- **Crossover T-AEIs** – Terrestrial AEIs located within the BLGHFC and the Western Harbour WHTWFU project footprints (i.e. B1 to B6). Many of the Crossover T-AEIs are already subject to DSIs, and it is likely that investigation and remediation works are either completed or nearing completion. Given the uncertainty regarding the timeframes for these works, these AEIs will be subject to a decision-making process to determine whether site-specific SAQPs will be required.
- **M-AEIs** – Marine AEIs (i.e. B12) located within the project footprint. These AEIs are not subject to site suitability assessments. They were previously subject to intrusive investigations to assess the condition of sediments to be dredged to determine disposal requirements for both offshore disposal and/or to NSW EPA licenced waste facilities, to assess potential impacts to sensitive receptors, and identification of mitigation measures for future disturbance. The Framework SAQP provides a decision-making process for contractors to follow if additional investigations are required.

In addition to the above-listed AEIs:

- **A-AEIs** – Additional AEIs are those that are not currently identified in the EIS but may arise where (i) there is a change in boundary to an AEI; (ii) new moderate- to high-risk AEIs are identified; (iii) changes to the project footprint contain areas of potential moderate to high risk of contamination.

Requirements for a DSI, or other investigative works, for the Crossover T-AEIs, M-AEIs, and A-AEIs are subject to a decision-making process set out in the Framework SAQP. Each contractor responsible for an AEI will be required to implement the Framework SAQP as part of their scope of works.

The Framework SAQP outlines the sampling approach to investigate the following environmental media at each of the T-AEI sites:

- Soil
- Soil vapour
- Surface water
- Sediments
- Groundwater
- Landfill gas (surface and sub-surface)
- Leachate.

5.2 Evaluation of SAQP

The Auditor has evaluated the Framework SAQP (GHD 2022) against the relevant guidelines made or endorsed by NSW EPA. The outcome of the review is tabulated in Appendix D. The Auditor completed a review of draft versions of the Framework SAQP and documented the comments as interim advice (refer to Appendix B).

5.2.1 Data Quality Objectives

The NSW EPA (2017) requires that an Auditor must check key requirements of the sampling and analysis plan proposed by the Consultant and therefore makes the following statements:

- The Auditor confirms that GHD (2022) included a general statement of the predetermined DQOs for field and laboratory procedures (including quantitative DQOs).
- The Auditor confirms that GHD (2022) included a plan to achieve pre-determined DQOs.
- The Auditor confirms that GHD (2022) included procedures to be conducted if the data did not meet the expected DQOs.

5.2.2 Site Assessment Criteria

Site assessment criteria for specific AEIs have not been listed in the Framework SAQP, however the Framework SAQP notes that screening criteria for commercial/industrial, open space and/or residential land uses should be applied once the BLGHFC project design and end uses are finalised.

In addition, the Framework SAQP requires site-specific SAQPs to clearly set out the assessment criteria for each sampling media assessed during the sampling and analytical works, in accordance with NEPM 2013 and the guidelines made or endorsed by NSW EPA. The Framework SAQP also requires the rationale for the selection of assessment criteria, including their associated assumptions and limitations, and a discussion of any deviations from the approved guidelines.

The Framework SAQP presents a list of current guidelines and references to be used for the development of site-specific assessment criteria and requires that future investigations must be completed with reference to criteria in force at that time.

In addition to criteria to assess site suitability, the Framework SAQP requires any waste to be classified in accordance with NSW EPA (2014) Waste Classification Guidelines, Part 1: Classifying Waste is disposed to a landfill facility.

5.2.3 Assessing Urban Development Sites

As required by Appendix A in NSW EPA (2017) Site Auditor Scheme, the Auditor has checked that the following items have been considered as part of the Appendix M – Contamination (Jacobs 2020a) and/or Framework SAQP (GHD 2022), or will be addressed, in future site-specific SAQPs:

- Appendix M – Contamination (Jacobs 2020a) follows the applicable guidelines listed in Section 1.3. Departures from the guidelines are listed in the preceding sections of the SAR and in the Auditor correspondence in Appendix B. Notwithstanding these departures, there is sufficient information provided to enable a conclusion to be made on the appropriateness of the preliminary contamination investigations for the development of the Framework SAQP.
- The Framework SAQP (GHD 2022) considers the applicable guidelines and requires that future site-specific SAQPs be prepared in accordance with the relevant guidelines made or endorsed by NSW EPA, including the Consultants Reporting on Contaminated Land – Contaminated Land Guidelines (NSW EPA 2020) and NEPM 2013 (NEPC 2013). There is sufficient information to enable a conclusion to be made on the appropriateness of the Framework SAQP.
- Aesthetic issues have not been considered in detail but will be assessed as part of future site-specific SAQPs through compliance with Schedule B1 Guideline on Investigation Levels for Soil and Groundwater in NEPM 2013, as required by the Framework SAQP.
- Soils sampling requirements have been considered and specific sampling and assessment details will be outlined in future site-specific SAQPs. Results will be compared against the relevant health-based and ecological investigation levels, and potential for migration of contamination from soils to groundwater will be considered through compliance with NEPM 2013, as required by the Framework SAQP.
- Groundwater sampling requirements have been considered and specific sampling and assessment details will be outlined in future site-specific SAQPs. Results will be compared against the relevant health-based and ecological investigation levels, and an assessment of potential impacts to buildings and structures will be considered through compliance with NEPM 2013, as required by the Framework SAQP.
- Hazardous ground gas sampling requirements have been considered and specific sampling and assessment details will be outlined in future site-specific SAQPs. Results will be compared against the relevant health-based investigation levels and screening levels, as required by the Framework SAQP.
- Issues relating to local area background soil concentrations that exceed relevant investigation levels (of relevance to the BLGHFC project - acid sulfate soils) have been adequately considered and will be addressed in further detail in the site-specific SAQPs. Other issues relating to local background soil concentrations will be assessed through compliance with NEPM 2013.
- The impacts of chemical mixtures have not been considered in detail but will be assessed as required through compliance with NEPM 2013, as required by the Framework SAQP.
- Potential for migration of known and potential contaminants have been appropriately considered, including potential risks to off-site receptors, and are required by the Framework SAQP to be considered in further detail in the future site-specific SAQPs.
- Site management strategies (where relevant) are appropriate, and any post-remediation environmental plans will be determined subject to the results of site-specific DSIs.

5.2.4 Assessment of Risk

The Auditor provides the following assessment of risk:

- The Framework SAQP provides an appropriate approach for the assessment of risk to human health, structures, and the environment for the Project Specific Terrestrial AEIs. The Framework SAQP also provides an appropriate decision-making process to identify additional locations with a moderate to high risk of potential contamination that may be identified.
- The Framework SAQP provides an appropriate approach to assess the potential for off-site migration and to collect sufficient information to determine whether notification under the NSW EPA (2015) Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997 is required.
- The Framework SAQP provides sufficient detail to characterise contamination impacts at the site so that remediation action plans can be developed, where required. Requirements for ongoing management will be re-evaluated at the completion of the project. The EIS Appendix M – Contamination (Jacobs 2020a) identifies that where existing soil contamination is identified within the operational areas of the project and is to be managed on site, appropriate environmental management plans would need to be prepared and implemented during the operational phase of the project. Ongoing obligations for any material capped onsite will need to be determined in consultation with the landowner.

5.3 Auditor Comment on Framework SAQP

The Framework SAQP provides sufficient information, as required by NSW EPA (2020a), to enable the development of the future site-specific SAQPs for individual AEIs. The Framework SAQP also provides an adequate decision-making process for the assessment of any Additional AEIs that may arise because of changes to AEI site boundaries, changes to the project alignment, and/or additional information that may alter the risk rating of site that was previously identified by Jacobs (2020a) as ‘low risk’.

Given the conceptual site model, the Auditor considers the Framework SAQP to be appropriate, however the following is to be addressed:

- The EIS, Appendix M – Contamination (Jacobs 2020a) assigned a risk ranking of ‘low’ for the construction support site located at Kitchener Street, Balgowlah. During the site inspection, and based on prior knowledge, the Auditor has identified uncontrolled filling in this area and considers that the risk classification at this location should be revised to ‘moderate’ or ‘high’ and included as an Additional AEI (A-AEI). The Auditor acknowledges that the Framework SAQP includes a decision-making process to enable the identification of Additional AEIs for future site-specific investigation.
- Under the A-AEI decision making process, the Auditor considers that a preliminary site investigation must be completed at the Kitchener Street, Balgowlah site (BL11). To assess the moderate or high risk of contamination being present, the Auditor recommends that the PSI include a limited sampling program of fill in accessible areas. Based on the findings and laboratory results of the preliminary site investigation, the decision-making process for A-AEIs should be applied to determine if a site specific SAQP for a DSI is required for Kitchener Street, Balgowlah (BL11).

A copy of the endorsed Framework SAQP is included in Appendix E.

6 Site Audit Conclusions

TfNSW commissioned this non statutory audit to provide an independent review of the appropriateness of the pre-determination investigations and a Framework SAQP for the BLGHFC project (primary reports are listed in Section 1.4), in support of the SSI-8862 application.

As part of the SSI-8862 Response to Submissions, the NSW EPA recommended that TfNSW be required to submit:

1. A Sampling and Analysis Quality Plan (SAQP) which details how the type, quantity, and extent of contamination for the areas of environmental interest will be assessed.

2. Interim audit advice from an EPA-accredited site auditor commenting on:

    a. the appropriateness of the contamination report prepared by Jacobs as part of this EIS and the SAQP;

    b. whether the areas of environmental interest have been appropriately identified; and

    c. the adequacy of the proposed management measures.

The Framework SAQP sets out the assessment guidelines, sampling and analysis strategy, methodologies, data quality indicators, and reporting requirements to be referenced by contractor(s) for the development of future site-specific SAQP(s) for the BLGHFC project. These requirements apply to the terrestrial areas of environmental interest (AEIs) identified in the EIS with a moderate to high risk of potential of contamination being present. It is understood that these sites will be subject to future site suitability audits conducted by NSW EPA accredited Site Auditors.

The Framework SAQP also provides a decision-making process to determine further testing requirements for the Marine AEIs, and AEIs that interface with the Western Harbour Tunnel and Warringah Freeway Upgrade project. The decision-making process also includes a framework for the identification and assessment of Additional AEIs. It is understood that Marine AEIs will not be subject to site suitability audits, and that pre-determination investigations were conducted to determine sediment disposal requirements, and requirements for sediment management controls.

The Framework SAQP and supporting preliminary investigations are considered to have met the requirements of NSW EPA (2017), other relevant guidelines endorsed under s.105 of the CLM Act and the objectives of the Audit. On this basis a Section B2 SAS will be issued certifying that, in the opinion of the Auditor, the Framework SAQP prepared by GHD (2022) is appropriate for the development of future site-specific SAQPs for AEIs within the BLGHFC project footprint, subject to consideration of the following:

- Uncontrolled filling identified at the proposed construction support site located at Kitchener Street, Balgowlah (BL11) requires a revision of the risk ranking from ‘low’ to ‘medium’, thereby triggering the decision-making process for A-AEIs to be implemented and for a PSI to be completed. It is recommended that the PSI include a limited sampling program for fill at the Kitchener Street, Balgowlah (BL11) site, with the results to then be utilised to determine the requirement for the development of a future site-specific SAQP and subsequent detailed site investigation.
- Should the project alignment be altered, land within the new footprint should be assessed in accordance with the EIS Appendix M – Contamination risk ranking methodology, and preliminary site investigations should be prepared in accordance with the relevant guidelines made or endorsed by NSW EPA, as required.
- Characterisation of sediments dredged from Middle Harbour will require further waste characterisation for land-based disposal, in accordance with NSW EPA (2014) Waste Classification Guidelines.

- The Site Auditor(s) should be engaged to review site-specific SAQPs and subsequent investigation reports to enable the preparation of site-specific SASs/SARs.

7 Other Relevant Information

This Audit relates only to those matters relevant to the CLM Act 1997, which describes that “The general object of this Act is to establish a process for investigating and (where appropriate) remediating land that the EPA considers to be contaminated significantly enough to require regulation under Division 2 of Part 3”. The SAS and SAR do not seek to provide an opinion regarding other aspects of the environment not related to site contamination, to the suitability of the site in regard to the occupational health and safety legislation, or in regards to the suitability of the engineering design.

By definition, auditing involves the review and critique of Consultants’ work, including site histories, site surveys, subsurface investigations, chemical and physical analyses, risk assessments and modelling. Accordingly, the Auditor relies on the experience, expertise, and integrity of the relevant organisations. The information sources referenced have been used to determine site history and local subsurface conditions. While the Auditor has used reasonable care to avoid reliance on data and information that is inaccurate or unsuitable, the Auditor is not able to verify the accuracy or completeness of all information and data made available.

Sampling and chemical analysis of environmental media is based on appropriate guidance documents made and approved by the relevant regulatory authorities. Conclusions arising from the review and assessment of environmental data are based on the sampling and analysis considered appropriate based on the regulatory requirements and site history, not on sampling and analysis of all media at all locations for all potential contaminants.

Environmental sampling and laboratory analyses were undertaken as part of the investigations reviewed by the Auditor, as described herein. Ground conditions between sampling locations may vary, and this should be considered when extrapolating between sampling points. Chemical analytes are based on the information detailed in the site history. Further chemicals or categories of chemicals may exist at the site which was not identified in the site history.

Changes to the subsurface conditions may occur subsequent to the investigations described herein, through natural processes or through the intentional or accidental addition of contaminants. The conclusions and recommendations reached in this site audit are based on the information provided at the time of the investigations.

Appendix A Figures

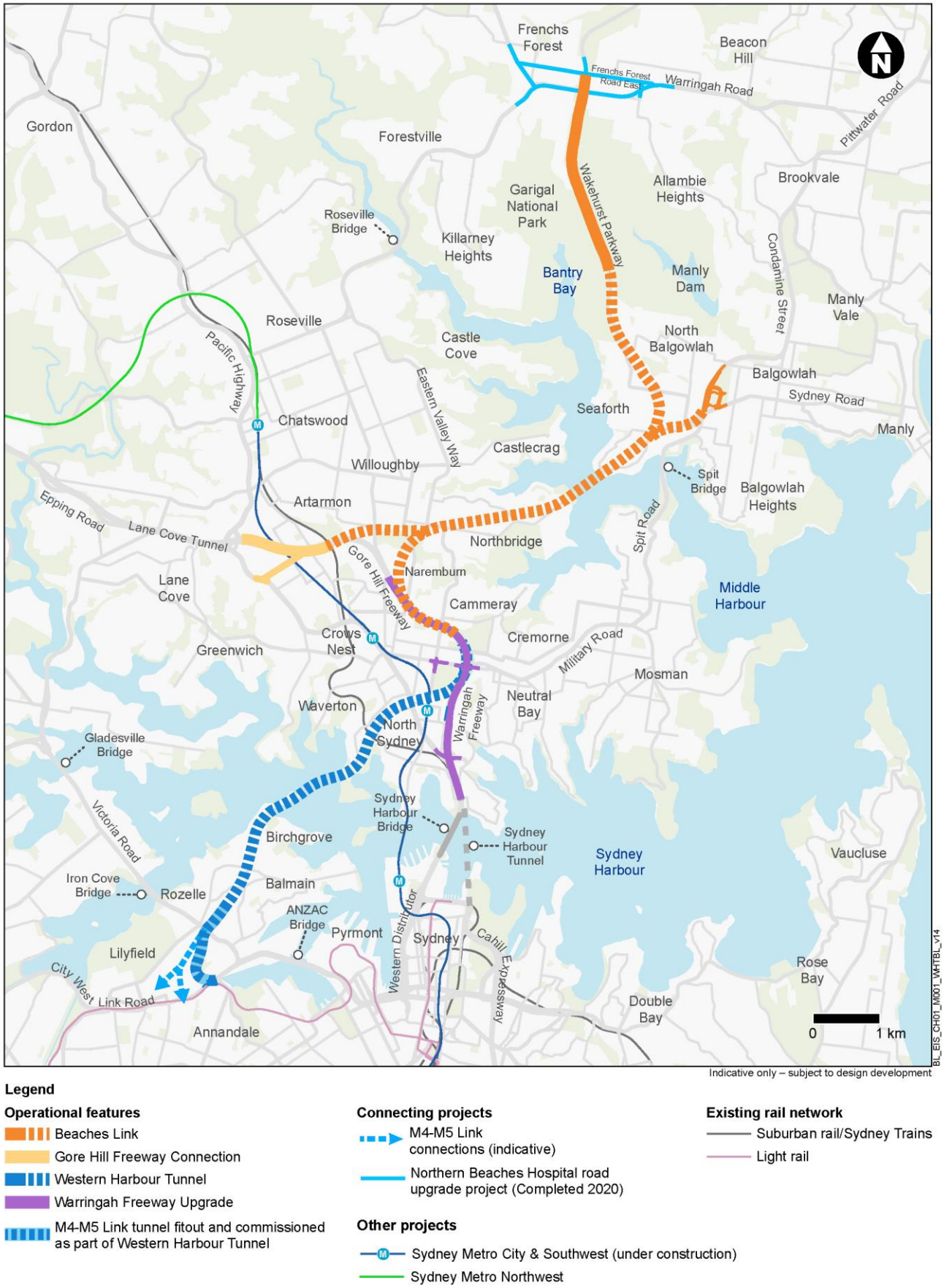

Figure 1-1 The Western Harbour Tunnel and Beaches Link program of works

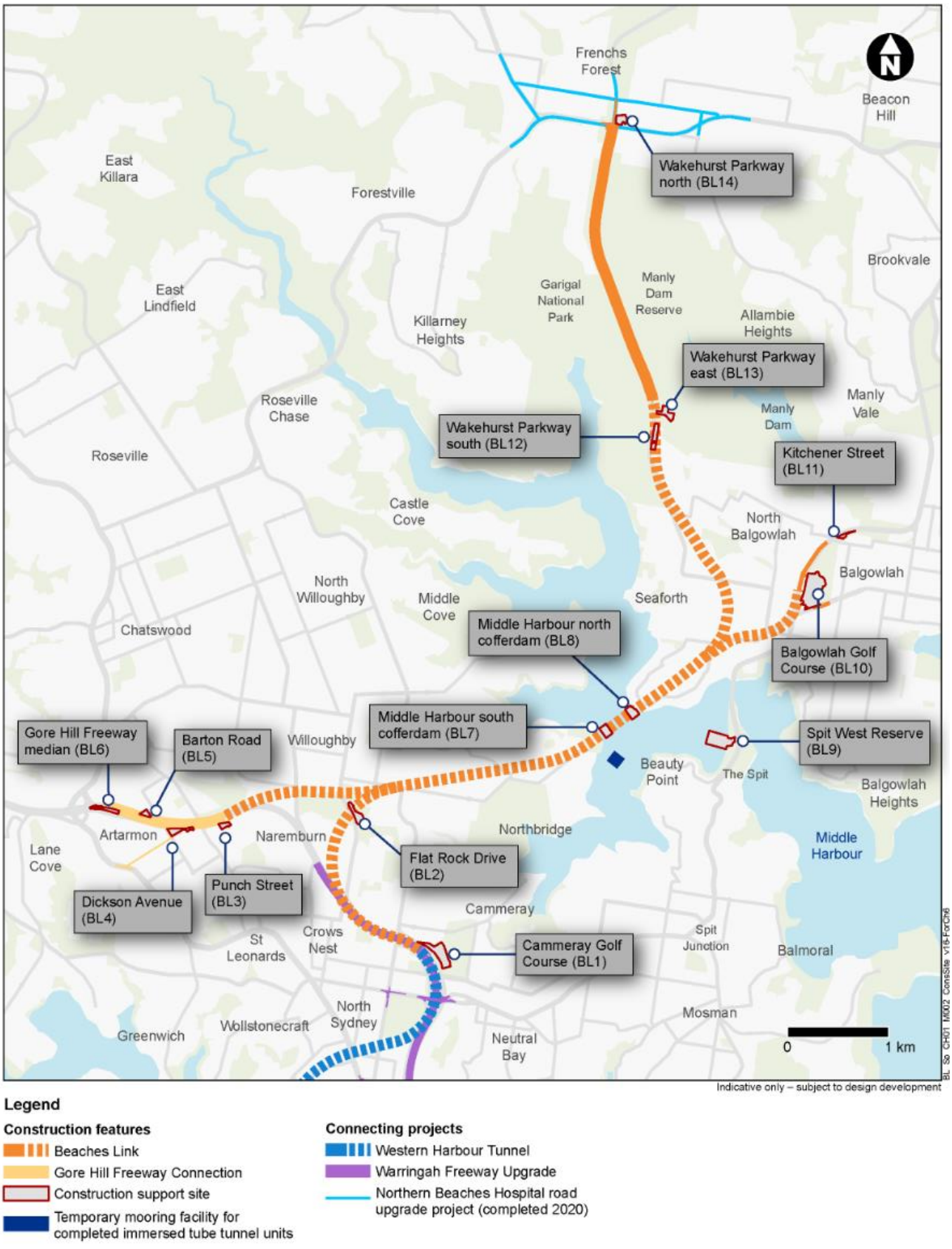

Figure 1-3: Overview of the construction support sites

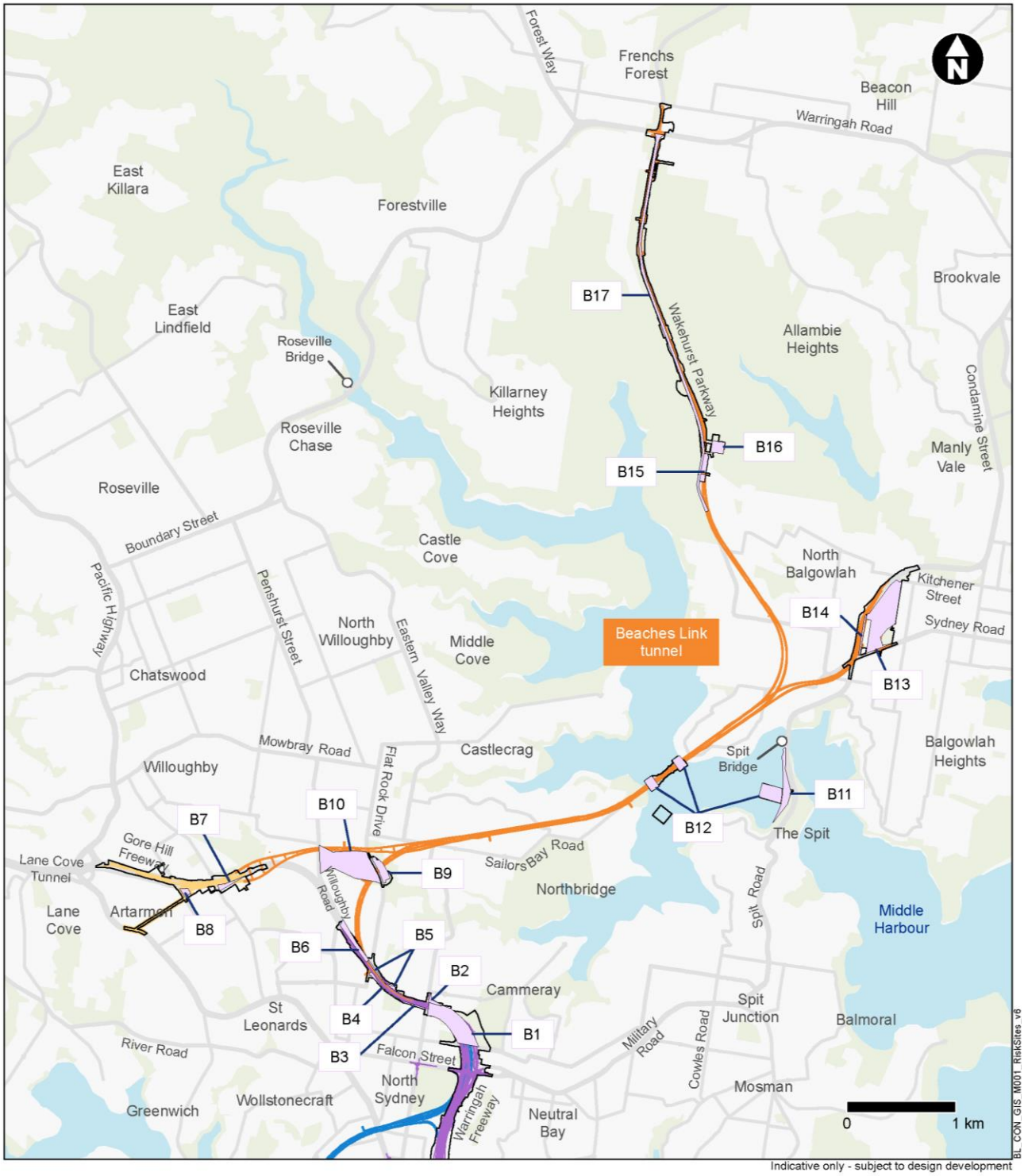

Figure 5-2: AEIs with assigned moderate to high exposure risk rankings

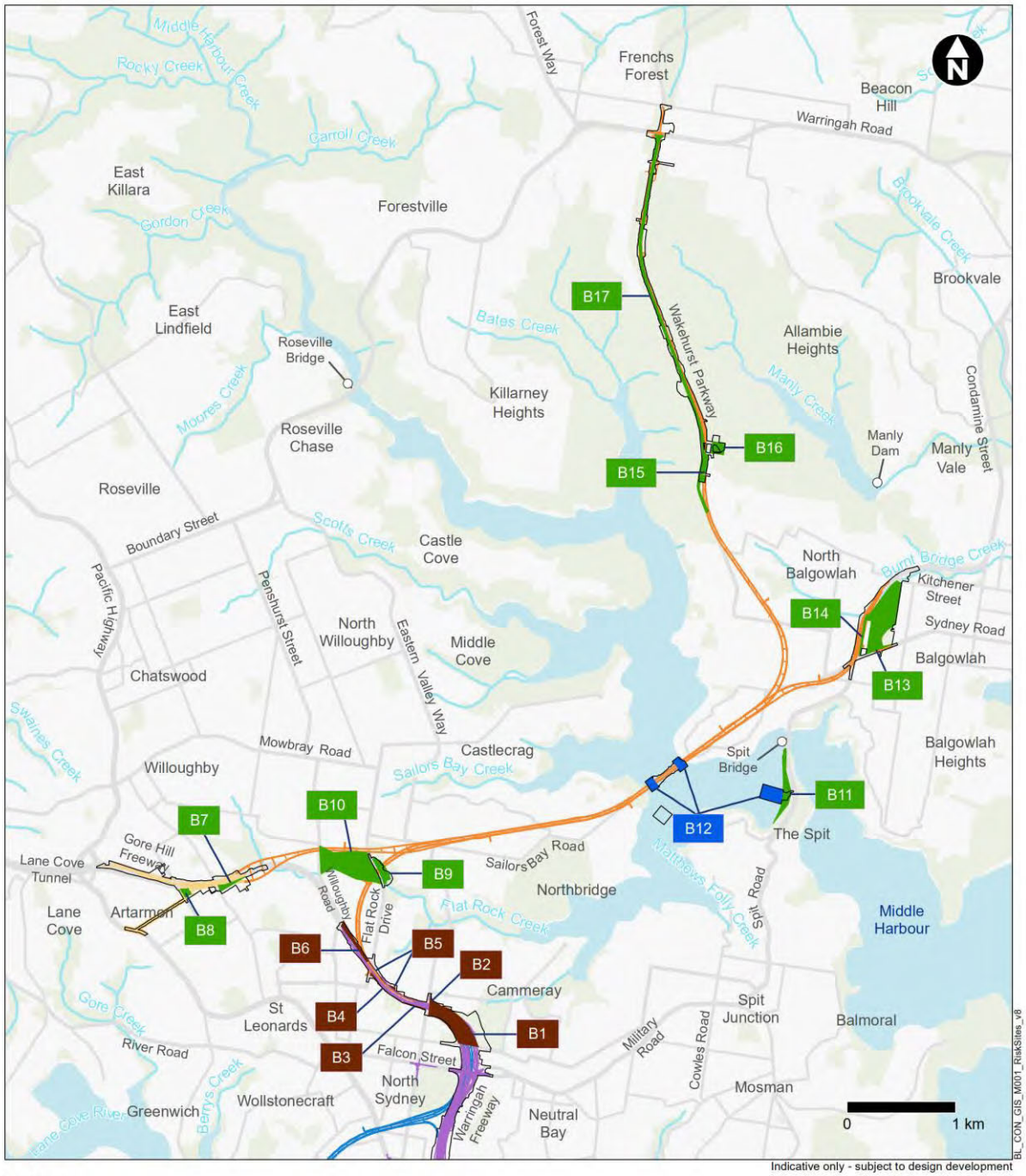

Figure 2 AEIs with moderate to high risk of contamination (TfNSW, 2020b)[1]

[1] As stated further in Section 1.3, moderate risk sites AEI B1 to AEI B6 are not considered in this Framework SAQP as they are part of the Warringah Freeway Upgrade. High risk site AEI B12 is also not considered as it is an overwater construction site as in outside the agreed scope of works for this Framework SAQP.

Appendix B Audit Correspondence

Geosyntec consultants

engineers | scientists | innovators

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2 February 2022

Alex Major
Planning and Environment Coordinator -
Western Harbour Tunnel & Beaches Link
Motorways – Transport for NSW
101 Miller Street
North Sydney NSW 2060

Via email: [redacted]
cc: [redacted]

Dear Alex,

Re: Site Audit Interim Advice No. 1 (IA1) – Review of existing environmental reports for the Beaches Link and Gore Hill Freeway Connection Project

1 Introduction

Transport for NSW (TfNSW) has appointed Rebeka Hall of Geosyntec Consultants Pty Ltd (Geosyntec), a NSW EPA Auditor accredited (No. 0802) under the Contaminated Land Management (CLM) Act 1997, to conduct a non-statutory contaminated land Audit for the proposed Beaches Link and Gore Hill Freeway Connection Project.

The Project location comprises Middle Harbour from the Warringah Freeway and Gore Hill Freeway to the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Killarney Heights, as well as Wakehurst Parkway from Seaforth to Frenchs Forest and proposed upgrade and integration works to connect to the Gore Hill Freeway and Reserve Road at Artarmon ("the site").

The Project is a NSW Government initiative to provide additional road network capacity across Sydney Harbour and Middle Harbour with the objective of improving transport connectivity with Sydney's Northern Beaches. It is understood that the Project is in the early stages, with only concept design and construction methodologies prepared. Site access along the alignment was not available at all locations for additional investigations.

The Project is a State Significant Infrastructure (SSI) development, No. 8862 under Division 5.2 of the NSW Environmental Planning & Assessment Act 1979 (EP&A Act) and requires approval from the NSW Minister for Planning. The Application is currently under Assessment.

2 Objectives of Current Audit

The Audit has been commissioned as part of TfNSW's commitments to the NSW EPA and NSW Department of Planning and Environment (DPE) prior to the determination of the SSI. The Audit will form part of additional information and documentation to be provided to DPE to assist in the assessment of the SSI application.

TfNSW advised that the specific objectives of the Audit are to:

- 'Review the information, that has been prepared for the Project to date, that addresses contamination and determine whether the works completed complied with the relevant guidelines and whether the results of the works provide a sufficiently robust basis for decisions made in relation to the potential risk of contamination being present. The information on the contamination that is subject to review is presented in the following documents:
  - Environmental Impact Statement (EIS) specifically the preliminary site investigations set out in Appendix M;
  - Response to Submissions Report; and
  - Preferred Infrastructure Report.
- Review the Framework SAQP to determine whether it has been adequately and appropriately prepared to meet its objectives;
- Provide a Section B2 Site Audit Statement and Site Audit Report that will document the review works completed and that will certify that the Framework SAQP is appropriate for its purpose and where relevant has been prepared in accordance with the guidelines made or approved by the NSW EPA'.

The aim of the current audit engagement is to therefore enable the preparation of a Section B2 site audit statement (SAS) and associated site audit report (SAR) that forms an opinion on the 'appropriateness of an investigation plan', that is the Framework Sampling Analysis and Quality Plan (SAQP), for the characterisation of contamination (where present) at each area of environment interest (AEI) upon which a remedial strategy (or management plan) can be prepared.

The Audit is being conducted in accordance with the NSW EPA (2017) Contaminated Land Management Guidelines for the NSW Site Auditor Scheme (3rd edition).

3 Scope of Audit and Nature of Interim Advice

NSW EPA (2017) describes the site assessment and audit process as:

1. *Consultant is commissioned to assess contamination*. The contaminated site consultant designs and undertakes the site assessment and, where required, all remediation and validation activities to achieve the objectives specified by the owner or developer; and
2. *Site auditor reviews the consultant's work*. The site owner or developer commissions the Auditor to review the consultant's work. The Auditor then prepares a SAR and SAS at the conclusion of the review, which are given to the owner or developer.

Therefore, the contaminated land consultant and other relevant parties should be satisfied that the work to be conducted conforms to all appropriate regulations, standards and guidelines and is suitable based on the site history and the proposed land use.

It is understood that the Audit is currently non statutory in nature. If development approval conditions require ongoing Auditor involvement, the Audit becomes statutory and requires notification to NSW EPA.

4 Current Interim Advice

In preparing this interim audit advice, the Auditor has reviewed a series of reports related to land contamination assessment.

This Interim Advice focusses on the adequacy of the following primary reports to address the above objectives, specifically any gaps in information to be captured in preparing the Framework SAQP:

- Jacobs (December 2020) Beaches Link and Gore Hill Freeway Connection, Technical Working Paper: Contamination, Ref: EIS, Appendix M [Jacobs 2020a], including Annexure C Royal Haskoning DHV (27 November 2020) Contaminant Levels and Results of Elutriate Testing of Sediments Associated with Dredging at Middle Harbour for Installation of the Immersed Tube Tunnel Units, Ref: PA1694-102-104-N008F01-20201127 [Royal Haskoning 2020a].
- TfNSW (November 2021) Beaches Link and Gore Hill Freeway Connection, Submissions Report, Part D2 - Revised Environmental Management Measures [TfNSW 2021a].
- TfNSW (November 2021) Beaches Link and Gore Hill Freeway Connection, Preferred Infrastructure Report, Section 5 – Treatment and Loadout of Dredged and Excavated Material not Suitable for Offshore Disposal [TfNSW 2021b].
- TfNSW (November 2021) Beaches Link and Gore Hill Freeway Connection, Preferred Infrastructure Report, Section 5 – Treatment and Loadout of Dredged and Excavated Material not Suitable for Offshore Disposal [TfNSW 2021c].

The following supplementary reports were considered to verify the conclusions presented in the primary reports listed above and/or to provide background information:

- AECOM (6 October 2017) Western Harbour Tunnel and Beaches Link - Geotechnical Investigations Factual Report GFR1, Ref: 60537922 [AECOM 2017a].
- AECOM (23 November 2017) Western Harbour Tunnel and Beaches Link Groundwater Monitoring Report - October 2017, Ref: 60537922-RPEM_0023A [AECOM 2017b].
- Douglas Partners Golder Associates (15 December 2017) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 1, Ref: 1666099-005-R-RevA [DPGA 2017 – 2018].
- AECOM (20 December 2017) Western Harbour Tunnel and Beaches Link Groundwater Monitoring Report -3 November 2017, Ref: 60537922-RPEM_0024A [AECOM 2017c].
- Douglas Partners Golder Associates (22 December 2017) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 2, Ref: 1666099-006-R-RevA [DPGA 2017 – 2018].
- Douglas Partners Golder Associates (19 January 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 3, Ref: 1666099-007-R-RevA [DPGA 2017 – 2018].
- Douglas Partners Golder Associates (9 February 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 4, Ref: 1666099-008-R-RevA [DPGA 2017 – 2018].
- Douglas Partners Golder Associates (20 March 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 5, Ref: 1666099-009-R-RevA [DPGA 2017 – 2018].
- Douglas Partners Golder Associates (29 March 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 6, Ref: 1666099-010-R-RevA [DPGA 2017 – 2018].
- AECOM Coffey (16 April 2018) Western Harbour Tunnel and Beaches Link – Contamination Factual Report (CFR), Ref: 60537922 [AECOM Coffey 2018].
- Douglas Partners Golder Associates (14 May 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Geotechnical Factual Report – Land Investigations, Ref: 1666099-004-R-RevC [DPGA 2018]
- Douglas Partners Golder Associates (25 May 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Contamination Factual Report – Land Investigations, Ref: 1666099-003-R-RevC [DPGA 2018b]

- Douglas Partners Golder Associates (30 July 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 7, Ref: 1666099-0011-R-RevA [DPGA 2017 – 2018].
- Douglas Partners Golders Associates (9 August 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Contamination Factual Report - Marine Investigations, Ref: 1666099-001-R-Rev C [DPGA 2018c].
- AECOM (22 November 2018) Western Harbour Tunnel and Beaches Link – Groundwater Monitoring Report 6 – April to September 2018 Ref: 60537922-RPEM_0031A [AECOM 2018].
- Douglas Partners Golder Associates (12 December 2018) Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 8, Ref: 1666099-012-R-RevA [DPGA 2017 – 2018].
- AECOM (21 March 2019) Western Harbour Tunnel and Beaches Link – Groundwater Monitoring Report 7 – October 2018 to March 2019, Ref: 60537922-RPEM_0032A
- Cardno (January 2020) Beaches Link and Gore Hill Freeway Connection Technical Working Paper: Marine Water Quality, Ref: EIS, Appendix Q – Marine Water Quality.
- Environmental Risk Sciences (December 2020) Beaches Link and Gore Hill Freeway Connection Technical Working Paper: Health Impact Assessment. Ref: EIS, Appendix I – Health Impact Assessment.
- Jacobs (December 2020) Beaches Link and Gore Hill Freeway Connection, Technical working paper: Groundwater, Ref: EIS, Appendix N [Jacobs 2020b].
- Royal HaskoningDHV (December 2020) Beaches Link and Gore Hill Freeway Connection, Hydrodynamic and Dredge Plume Modelling, Ref: EIS, Appendix P [Royal HaskoningDHV 2020b]
- Environmental Risk Sciences (16 September 2021) Review of Recreational Exposures During Dredging Activities, Ref: Memo - Beaches Link and Gore Hill Freeway Connection.

The purpose of the current IA is to document Auditor findings following the review of existing information related to site conditions and contamination status. This advice outlines any data gaps identified in the existing information which should be addressed by the appointed consultant as either part of any further investigation works, or as part of any future remedial or validation works that may be required at the site.

5 Auditor Comments

The Auditor has reviewed the primary and supplementary reports against relevant guidelines made or approved by NSW EPA in the context of the TfNSW audit scope and objectives. The information largely meets the guideline requirements, however, the Auditor provides the following comments to be considered by the appointed environmental consultant in preparing the Framework Sampling, Analysis and Quality Plan (SAQP) for the characterisation of site conditions.

Documentation supporting the conclusions in the primary reports (such as factual reports and other EIS documentation) have been cited in accordance with Section 3 of this IA. A detailed appraisal of the information will be documented in the Site Audit Report.

In addition, key observations made by the Auditor during the project site inspection on 25 January 2022 have been included where relevant. Observations were made of each Area of Environmental Interest (AEI) as listed in Table 5-1 of Jacobs (2020a) labelled as B1 to B17 and those sites flagged as ‘not applicable’, and proposed construction support sites (labelled BL1 to BL14) as shown in Figure 1-3 of Jacobs (2020a).

5.1 EIS, Appendix M – Contamination (Jacobs 2020a)

1. General Comments
    a. Please ensure the Framework SAQP and any future site-specific SAQPs are prepared with due consideration of NSW EPA (2020) Consultants Reporting on Contaminated Land Contaminated Land Guidelines, and any other applicable guidelines made or endorsed by NSW EPA.
    b. Please ensure the Framework SAQP provides a high-level overview of the construction activities proposed (e.g. excavation, materials storage, clearance, establishment of compounds) for each AEI. Future site-specific SAQPs are to include detail on the proposed/confirmed construction activities at each AEI.
2. Harbour Sediments
    a. The preliminary waste classification for the grey green mud (up to one metre below the harbour bed) is reported as general solid waste following completion of TCLP testing. Please ensure that the Framework SAQP includes a decision-making process to identify whether additional investigations of harbour sediments are required for waste classification purposes.
    b. Please ensure the Framework SAQP includes a decision-making process to identify whether testing of additional contaminants of potential concern (e.g. PFAS, dioxins, or other emerging contaminants) is required for marine sediments to assess potential impacts on water quality, and subsequent potential health risks, during dredging.
    c. It is understood that prior to ground disturbance in high-risk acid sulfate soil (ASS) areas at Spit West Reserve (B11) and Middle Harbour (B12), testing will be carried out to identify the presence of actual or potential ASS, and to determine whether management of these soils is required in accordance with the revised Environmental Management Measure SG14 (TfNSW 2021a). Please ensure that the Framework SAQP requires future site-specific SAQPs to consider ASS at these locations.
    d. The Auditor understands that additional investigations may be required to determine the vertical and lateral extent of marine sediment contamination in areas of disturbance to facilitate disposal. Requirements for any additional testing (if required) should be outlined in the Framework SAQP.
    e. Elutriate testing of marine sediments was conducted for metals (copper, lead, zinc, silver, mercury) and dioxins (2,3,7,8-Tetrachlorodibenzo-p-dioxin). However, justification for the selection of analytes was not provided. Please consider, as part of developing the Framework SAQP, any limitations of previous elutriate testing and whether testing of additional analytes is required for sediment characterisation and to understand contaminant behaviour.
    f. The Auditor understands that the dredge plume modelling is based on an assumed dredging methodology and the adoption of a range of management measures (including implementation of a water quality monitoring program and a dredge management plan as part of the CEMP). A review and update of the model may be required if the final methodology differs from the model assumptions.
3. Please ensure that the Framework SAQP requires future site-specific SAQPs to consider the results and reliability of any previous investigations in the context of the development and the proposed site end use (if known). All previous and proposed soil, sediment, surface water, groundwater, hazardous ground gas sampling locations should be presented on site plans in the site-specific SAQPs, with all available chemical data (including asbestos) tabulated and compared against the relevant site assessment criteria.
4. Landfill at Flat Rock Drive
    a. Future assessment of the landfill at Flat Rock Drive should consider the presence of hazardous ground gas, landfill leachate, and any associated impacts to groundwater

and potential migration pathways. Please ensure the Framework SAQP requires that the future site-specific SAQPs include a sampling plan to assess these environmental media. Reference should be made to the appropriate guidelines, made or endorsed by the NSW EPA. Any proposed ground gas sampling program should be designed to assess the effects of temporal and climatic fluctuations, and to capture worst-case conditions.

b. Please ensure the Framework SAQP requires consideration of any previous or current environmental monitoring associated with the former landfill at Flat Rock Drive, and any landfill management infrastructure in place such as venting or leachate collection infrastructure.

5. Please ensure that the Framework SAQP requires site-specific SAQPs to consider and discuss the potential impacts of any NSW EPA regulated/notified sites identified in the vicinity of each AEI. The discussion should include an appraisal of the lateral and vertical distance of the tunnel from the identified regulated/notified site, and any conclusions should be supported by an assessment of the local hydrogeological conditions and contaminant behaviour.
6. Please ensure that the Framework SAQP requires the site-specific SAQPs to identify the lateral and vertical distances of the tunnel alignment with respect to each AEI, and to assess whether there is any influence of each AEI on the development. Once the tunnel alignment has been confirmed, the site-specific SAQPs should allow for a decision-making process for the reassessment of any 'low' risk AEIs and/or additional potential AEIs based on their proximity to the confirmed tunnel alignment.
7. It is understood that AEIs B1 to B6 (located within the footprint of the Cammeray Golf Course Construction Support Site (BL1) and/or within the unsealed areas next to the Warringah Freeway above the proposed Beaches Link tunnel alignment) are subject to approvals associated with SSI 8863 for the Western Harbour Tunnel and Warringah Freeway Upgrade (WHTWFU) project, and that contamination impacts within these AEIs are being investigated (and remediated as required) as part of the WHTWFU project. Given that these AEIs will join and/or interface with the BLGHFC project, please ensure that the Framework SAQP requires review of prior investigation and remediation works conducted at these locations to determine their appropriateness for the BLGHFC project works. At a minimum, the review works should identify if there have been any alterations to the site boundary; an appraisal of current site conditions and proposed site end use; details of the BLGHFC construction activities; and an assessment of any conclusions resulting from the investigation and/or remediation works.
8. In instances where there have been: amendments to an AEI boundary; identification of additional AEIs; amendments to the proposed project footprint; or confirmation of the tunnel alignment, please ensure that the Framework SAQP includes a decision-making process for the re-evaluation of the AEIs (including AEIs assessed as 'low' risk) as part of the site-specific SAQPs. The decision-making process should identify whether previous investigations are available for the AEI, and/or the trigger for a preliminary site investigation which should include an appraisal of site history and current site conditions.
9. Based on observations made during the site visit, the Auditor considers that testing is required for fill characterisation and any potential lateral and vertical contamination impacts at the BL11 Construction Support Site in Balgowlah (Kitchener Street), noting that this site is proximal to the ecological receptor, Burnt Bridge Creek. Please ensure that this location is considered in the development of the Framework SAQP.
10. One of the proposed environmental management measures identified in Jacobs (2020a) for contaminated soils includes on-site encapsulation. Please note that decisions regarding this remediation approach will need to be based on the outcomes of future investigations, the proposed end site use, and agreement from the landowner. Please also note that any contaminated material retained on site will be subject to an environmental management plan (EMP), which should be prepared with due consideration of the recently published

NSW EPA (2022) Practice Note - Preparing Environmental Management Plans for Contaminated Land.

11. Please ensure the Framework SAQP includes the foundations for a Conceptual Site Model to be refined on a site-by-site basis in the future site-specific SAQPs.
12. The current groundwater data, does not show an unacceptable risk for the proposed 'tunnelled freeway land use' and concentrations monitored may reflect background/point source conditions. However, please ensure that future consideration is given to the potential for induced migration of impacted groundwater into uncontaminated groundwater (or "less contaminated" groundwater) which could be a POEO Act s120 violation (pollution of waters). The tunnel may draw contaminated groundwater into previously uncontaminated locations.

5.2 Submissions Report, Part D2 - Revised Environmental Management Measures (TfNSW 2021a)

The Auditor has reviewed the revised environmental management measures (REMM) applicable to (known) site contamination issues, and provides the following comments should there be a modification to the tunnel alignment and/or construction support sites:

13. SG8. The Auditor supports the requirement to conduct further investigations at Punch Street, Artarmon (BL3); Willoughby Leisure Centre and Bicentennial Reserve (adjacent to BL2), Willoughby; Flat Rock Reserve, Northbridge (BL2); Spit West Reserve, Mosman (BL9); Balgowlah Golf Course, Balgowlah (BL10); and Wakehurst Parkway (from Seaforth to Frenchs Forest, BL12).
14. Should landfill leachate be identified at the former landfill at Flat Rock Reserve, please ensure that there are appropriate management measures in place to manage, treat and dispose landfill leachate at this location – preferably in the form of a leachate management plan.

5.3 Preferred Infrastructure Report, Section 5 – Treatment and Loadout of Dredged and Excavated Material not Suitable for Offshore Disposal (TfNSW 2021c)

15. The Auditor considers that TfNSW (2021c) presents a practicable approach for the treatment and loadout of dredged and excavated material not suitable for offshore disposal. The Auditor has assumed that these activities will be conducted in accordance with a series of Construction Environmental Management Plan sub-plans (or similar) which will outline the processes and methodologies to be implemented for sediment excavation; treatment and testing regimes; waste management and classification; sediment loading, unloading; and transportation and disposal of waste; environmental monitoring requirements.
16. As per the Revised Environmental Management Measure WQ12 (TfNSW 2021a), the Auditor understands that a dredge monitoring program will be conducted to validate the effectiveness of mitigation measures. The dredge monitoring program will be developed in consultation with NSW EPA (and others).
17. Please ensure that the Framework SAQP considers the disposal requirements for all potential contaminants identified in sediments within Middle Harbour (B12), and that methods employed for waste classification and disposal consider any NSW EPA resource recovery orders/exemptions and chemical control orders.

We request that the above be considered by the appointed environmental consultant in drafting the Framework SAQP. The draft Framework SAQP should then be provided to the Auditor for review. Comments raised above and the outcome of the additional investigations may require amendment to current environmental management plans.

6 Closure

This interim advice does not constitute a SAS or a SAR, but rather is provided to assist the Client in the assessment and management of contamination issues at the site. The information provided herein should not be considered pre-emptive of the final Audit conclusions. It represents the Auditor's opinion based on the review of currently available information to meet the objectives of the engagement. At the completion of the Audit process a SAS and SAR will be issued.

Should you have any queries or wish to discuss any points, please do not hesitate to contact Rachael Martin or the undersigned.

Yours sincerely,

Rebeka Hall
NSW EPA Accredited Site Auditor
Geosyntec Consultants Pty Ltd

Transport for NSW

Site Audit Interim Audit Advice No.1 (IA1) – Review of existing environmental reports for the Beaches Link and Gore Hill Freeway Connection Project

5 May 2022

To	Rebeka Hall NSW EPA Accredited Site Auditor Geosyntec Consultants Pty Ltd Suite 1, Level 9, 189 Kent St Sydney NSW 2000
From	Jack McGovern Senior Manager Environment and Sustainability Environment and Sustainability (Beaches Link) Safety, Environment and Regulation Transport for NSW

Transport for NSW (Transport) has reviewed the Site Audit Interim Audit Advice No.1 (IA1) and confirms that the majority of the matters raised by the Site Auditor are most appropriately addressed by GHD Pty Ltd's Contaminated Land Consultant (CEnvP(SC)) in the Framework Sampling, Analysis and Quality Plan (SAQP) and then, by extension, in the future site-specific SAQPs.

In addition, Transport has provided responses to the comments set out in Section 5 of the IA1 below, noting that the majority of these will be addressed in the Framework SAQP.

Transport provides the following responses to IA1 comments:

1. General comments are addressed in the Framework SAQP, which will outline the requirements for future site-specific SAQPs for Areas of Environmental Interest (AEIs) identified in the Beaches Link and Gore Hill Freeway Connection (BLGHFC) environmental impact statement (EIS).
2. The Framework SAQP details a decision making process for marine sites (and therefore harbour sediments), outlining the requirements that future contractors must consider when determining if future investigations, and therefore site-specific SAQPs, are required. In addition, Transport notes that Elutriate testing was undertaken for all parameters exceeding the National Assessment Guidelines for Dredging (NADG) screening level in accordance with a Sediment Sampling and Analysis Plan agreed with the Commonwealth Department of Agriculture, Water and the Environment (formerly Department of the Environment and Energy). The need for further elutriate testing will be considered as part of the decision making process in the Framework SAQP. The future site auditor to be engaged during the post-approval phase will have regard to dredge management requirements.

3. In accordance with the Framework SAQP, contractors must ensure that all information available at the time of preparation of the site-specific SAQPs is considered and assessed in the development of the site-specific SAQPs. The Framework SAQP also includes a decision making process for AEIs identified in the BLGHFC EIS which overlap with those identified in the EIS for the Western Harbour Tunnel and Warringah Freeway Upgrade (WHTWFU) project. This decision making process will require the future contractor consider the results and reliability of any previous investigations in the context of the condition of those AEIs at that time, the development and the proposed site end use (if known) to determine the need for and scope of a future site-specific SAQP.
4. As per response number 3 above, contractors must ensure that all information available at the time of preparation of the site-specific SAQPs is considered and assessed in the development of the site-specific SAQPs. This will include consideration of any previous or current environmental monitoring associated with the former landfill at Flat Rock Drive, including monitoring undertaken by others. The Framework SAQP specifically requires future contractors consider the presence of hazardous ground gas, landfill leachate and existing landfill management infrastructure in future site-specific SAQPs in accordance with the relevant guidelines;.
5. The Framework SAQP identifies NSW EPA regulated and notified sites within 500m of the project and requires future site-specific SAQPs also consider regulated and notified sites, including their distance from the tunnel alignment.
6. The Framework SAQP requires future site-specific SAQPs consider the lateral and vertical distances of the tunnel alignment with respect to each AEI (including any additional AEIs), including once the tunnel alignment has been confirmed.
7. As per response number 3 above, the Framework SAQP details a decision making process for AEIs identified in the BLGHFC EIS which overlap with those identified in the EIS for the WHTWFU project. This decision making process will require the future contractor consider the results and reliability of any previous investigations and remediation works in the context of the development and the proposed site end use (if known) to determine the need for and scope of a future site-specific SAQP.
8. The Framework SAQP details a decision making process that must be implemented where AEI boundaries and site conditions change, including a re-evaluation of the contamination risks for the respective AEI(s) through review of new information or investigations completed after the EIS.
9. The BLGHFC EIS identified the Kitchener Street construction support site (BL11) as a site that had a low risk of contamination being present, and consequently no further contamination investigation works were deemed to be required. The Framework SAQP details the decision making process for any new AEIs and for those sites where a review of existing information indicates a potential of contamination being present that otherwise was not previously identified. If the auditor considers that investigations are required at the BL11 site to assess the risks of contamination being present in fill materials, then an additional PSI can be undertaken prior to site establishment in order to determine if a detailed site investigation (DSI) is required. If the PSI identifies that a DSI is required then, in accordance with the decision making process in the Framework SAQP, a site-specific SAQP for this DSI

will be prepared and subsequently implemented. Alternatively, if an additional PSI is not undertaken a DSI will be required, in accordance with the decision making process in the Framework SAQP, and a site-specific SAQP for this DSI will be prepared and subsequently implemented.

10. Transport notes the Auditor's comments on the requirements for on-site encapsulation if it is a selected remediation methodology and notes that any remediation action plan will form part of the scope of a future site audit.
11. The Framework SAQP includes the requirement for Conceptual Site Models to be included in future site-specific SAQPs.
12. Transport notes the Auditor's comments on potential groundwater contamination and migration. These matters will be considered during detailed design.
13. Transport notes the Auditor's support for Revised Environment Management Measure SG8.
14. Transport notes the project has committed to DSIs at Flat Rock Reserve, which will be undertaken in accordance with a site-specific SAQP (developed in accordance with the Framework SAQP). Should landfill leachate be identified, this will be managed in accordance with the relevant construction environmental management plan (CEMP) sub-plan.
15. Transport notes the Auditor's comments on the practicable approach for the treatment and loadout of dredged and excavated material considered not suitable for offshore disposal. Transport notes that the loadout of dredged and excavated material will no-longer occur at the Port of Newcastle as outlined in the Preferred Infrastructure Report, Section 5 – Treatment and Loadout of Dredged and Excavated Material not Suitable for Offshore Disposal [TfNSW, (2021c)]. Transport confirms the methodology for the treatment and loadout of dredged and excavated material will be consistent with that previously assessed however will be undertaken at another port or wharf facility comparable with that previously assessed at the Port of Newcastle. The future site auditor to be engaged during the post-approval phase will have regard to the management of dredged and excavated material.
16. Transport notes the Auditor's comments on the commitment for the development of dredge monitoring program.
17. Transport notes its commitments to comply with all relevant state and commonwealth legislation during marine works, including for disposal requirements.

Following on from the above, Transport will provide an updated Framework SAQP to the Site Auditor shortly which will satisfy the above requests.

If Geosyntec have any questions on the above, please contact Jack McGovern at [redacted].

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21313 IA2 FINAL 11 May22

11 May 2022

Alex Major
Planning and Environment Coordinator -
Western Harbour Tunnel & Beaches Link
Motorways – Transport for NSW
101 Miller Street
North Sydney NSW 2060

Via email: [redacted]
cc: [redacted]

Dear Alex,

Re: Site Audit Interim Advice No. 2 (IA2) – Review of GHD (March 2022) Framework Sampling, Analysis and Quality Plan, Beaches Link and Gore Hill Freeway Connection Project

1 Introduction

Transport for NSW (TfNSW) has appointed Rebeka Hall of Geosyntec Consultants Pty Ltd (Geosyntec), a NSW EPA Auditor accredited (No. 0802) under the Contaminated Land Management (CLM) Act 1997, to conduct a non-statutory contaminated land audit for the proposed Beaches Link and Gore Hill Freeway Connection Project.

The Project location comprises Middle Harbour from the Warringah Freeway and Gore Hill Freeway to the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Killarney Heights, as well as Wakehurst Parkway from Seaforth to Frenchs Forest and proposed upgrade and integration works to connect to the Gore Hill Freeway and Reserve Road at Artarmon ("the site").

The Project is a NSW Government initiative to provide additional road network capacity across Sydney Harbour and Middle Harbour with the objective of improving transport connectivity with Sydney's Northern Beaches. It is understood that the Project is in the early stages, with only concept design and construction methodologies prepared. Site access along the alignment was not available at all locations for additional investigations. The legal identifiers, the site area and 'audit boundary' have not been confirmed.

The Project is a State Significant Infrastructure (SSI) development, No. 8862 under Division 5.2 of the NSW Environmental Planning & Assessment Act 1979 (EP&A Act) and requires approval from the NSW Minister for Planning. The Application is currently under Assessment.

2 Objective of Current Audit

TfNSW has advised that the specific objectives of the Audit are to:

- 'Review the information, that has been prepared for the Project to date, that addresses contamination and determine whether the works completed complied with the relevant guidelines and whether the results of the works provide a sufficiently robust basis for decisions made in relation to the potential risk of contamination being present. The information on the contamination that is subject to review is presented in the following documents:
  - Environmental Impact Statement (EIS) specifically the preliminary site investigations set out in Appendix M;
  - Response to Submissions Report; and
  - Preferred Infrastructure Report.
- Review the Framework SAQP to determine whether it has been adequately and appropriately prepared to meet its objectives;
- Provide a Section B2 Site Audit Statement and Site Audit Report that will document the review works completed and that will certify that the Framework SAQP is appropriate for its purpose and where relevant has been prepared in accordance with the guidelines made or approved by the NSW EPA'.

The aim of the current audit engagement is to enable a Section B2 site audit statement (SAS) and associated site audit report (SAR) that forms an opinion on the 'appropriateness of an investigation plan', that is the SAQP will enable the characterisation of contamination (where present) at each area of environment interest (AEI) upon which a remedial strategy can be prepared.

The Audit will be conducted in accordance with the NSW EPA (2017) Contaminated Land Management Guidelines for the NSW Site Auditor Scheme (3rd edition).

3 Scope of Audit and Nature of Interim Advice

NSW EPA (2017) describes the site assessment and audit process as:

1. *Consultant is commissioned to assess contamination*. The contaminated site consultant designs and undertakes the site assessment and, where required, all remediation and validation activities to achieve the objectives specified by the owner or developer; and
2. *Site auditor reviews the consultant's work*. The site owner or developer commissions the Auditor to review the consultant's work. The Auditor then prepares a SAR and SAS at the conclusion of the review, which are given to the owner or developer.

Therefore, the contaminated land consultant and other relevant parties should be satisfied that the work to be conducted conforms to all appropriate regulations, standards and guidelines and is suitable based on the site history and the proposed land use.

It is understood that the Audit is currently non statutory in nature. If development approval conditions require ongoing Auditor involvement, the Audit becomes statutory and requires notification to NSW EPA.

4 Current Interim Advice

In preparing this interim audit advice, the Auditor has reviewed the following document:

- GHD (2 March 2022) Framework Sampling, Analysis and Quality Plan (SAQP), Beaches Link and Gore Hill Freeway Connection Project, Ref: 12522128_REP_Beaches Link SAQP.doc.

The purpose of the current IA is to document Auditor findings following the review of the Framework SAQP. This advice outlines any data gaps and/or items requiring clarification in finalising the SAQP.

5 Summary of SAQP

The Framework SAQP provides guidance for the development of site-specific SAQPs for contamination investigations to be completed post-determination for the Beaches Link and Gore Hill Freeway Connection project (the project). The Framework SAQP refers to the areas of environmental interest (AEIs) identified in the EIS, Appendix M – Contamination. These are sites identified as having a moderate to high risk of potential contamination being present, and have been categorised as follows:

- **Project Specific T-AEIs** – Terrestrial AEIs located within the BLGHFC project footprint only (i.e. B7 to B11, B13 to B17). Each Project Specific T-AEI requires a detailed site investigation (DSI), and the Framework SAQP outlines the investigation requirements. The objective of the investigations is to provide an assessment on site suitability for the final intended land use, or to identify remediation requirements to make the AEI suitable for its intended land use.
- **Crossover T-AEIs** – Terrestrial AEIs located within the BLGHFC project footprint and overlap with the Western Harbour Tunnel and Warringah Freeway Upgrade (WHTWFU) project footprints (i.e. B1 to B6). Many of the Crossover T-AEIs are already subject to DSIs as part of the WHTWFU works, and it is likely that investigation and remediation works are either completed or nearing completion. Given the uncertainty regarding the timeframes for these works, these AEIs will be subject to a decision-making process to determine whether site-specific SAQPs will be required.
- **M-AEIs** – Marine AEIs (i.e. B12) located within the BLGHFC project footprint. These AEIs are not subject to site suitability assessments. They were previously subject to intrusive investigations to assess the condition of sediments to be dredged to determine disposal requirements for both offshore disposal and to NSW EPA licenced waste facilities, to assess potential impacts to sensitive receptors, and identification of mitigation measures for future disturbance. The Framework SAQP provides a decision-making process for contractors to follow if additional investigations are required.
- **A-AEIs** – Additional AEIs that are not currently identified in the EIS. A-AEIs may arise where (i) there is a change in boundary to an AEI; (ii) new moderate- to high-risk AEIs are identified; (iii) changes to the BLGHFC project footprint contain areas of potential moderate to high risk of contamination.

Requirements for a DSI, or other investigative works, for the Crossover T-AEIs, M-AEIs, and A-AEIs are subject to a decision-making process set out in the Framework SAQP. Each contractor responsible for an AEI will be required to implement the Framework SAQP as part of their scope of works.

Each Project Specific T-AEI requires a detailed site investigation (DSI), and the Framework SAQP outlines the overarching investigation requirements. The objective of the investigations is to provide an assessment on site suitability for final intended land use, or to identify remediation requirements to make the AEI suitable for its intended land use.

The Framework SAQP outlines the sampling methodologies required to investigate the following environmental media as part of the DSIs for each T-AEI, as relevant:

- Soil
- Surface water
- Sediments
- Groundwater
- Landfill gas (surface and sub-surface)
- Leachate

6 Auditor Comments

The Auditor has reviewed the GHD (2022) Framework SAQP against relevant guidelines made or approved by NSW EPA, in the context of the TfNSW audit scope and objectives. The Framework SAQP largely meets the guideline requirements, however, the Auditor provides the following comments to be considered by the appointed environmental consultant:

1. General.
    a. Please ensure that the Framework SAQP requires future site-specific SAQPs to be prepared with due consideration of NSW (2020) Consultants Reporting on Contaminated Land – Contaminated Land Guidelines, and any other applicable guidelines made or endorsed by NSW EPA, and relevant items in the ASC NEPM Field Checklists (NEPC 2013).
    b. The introductory sections of the Framework SAQP would benefit from a single, consolidated list of the relevant guidelines that are referenced throughout the remainder of the document. Please refer to:

       https://www.epa.nsw.gov.au/your-environment/contaminated-land/statutory-guidelines?msclkid=d871ae79c11311ecb2cc6d97cebcc904
    c. There are several instances where the Framework SAQP identifies the ‘contractor(s)’ as the responsible party(s) for making decisions regarding various matters to do with the site-specific investigations. Please review each instance where ‘contractor(s)’ is mentioned and clarify whether the ‘contractor’ refers to the remediation/earthworks contractor or the ‘experienced environmental scientist’. The works should be performed by a suitably qualified and experienced environmental consultant.
    d. For completeness, please present the Crossover Terrestrial IEAs and the Marine IEAs on a site plan to enable future ‘contractors’ to identify their locations.
    e. Please include a statement requiring that the site-specific SAQPs are to consider the significance of the lateral tunnel position and depth relative to AEIs.
2. Section 1.1, Project Overview and Background - Paragraph 8 - Please ensure that the Framework SAQP is also drafted with due consideration of NEPM 2013.
3. Section 1.6 – add to last paragraph ‘and in consultation with the Site Auditor’.
4. Section 2.2. AEIs
    a. Please consider including the key attributes that were evaluated for each site in the EIS, Chapter M – Contamination, in assigning each level of risk.
    b. Table 1. It is understood that the EIS, Appendix M – Contamination assigned a risk ranking of ‘low’ for the AEI located at Kitchener Street, Balgowlah. The EIS notes that this ‘n/a’ AEI is ‘adjacent to construction support site footprint BL11’. However, Figure 1 of the Framework SAQP indicates that this is a ‘Construction Support Site’. Can this please be clarified? Please also consider including a definition for ‘construction footprint’ and construction support site’ to differentiate between the two features.
5. Section 3.1. Project Specific T-AEIs – Please include a statement requiring the investigations to also identify requirements for management controls to be implemented during construction activities for inclusion into the CEMP and relevant sub-plans, such as WHS plans.

6. Section 3.2, Crossover T-AEIs, Decision flow chart 1
    a. Decision flow chart 1, Step 2 - There are two very similar considerations for ‘proposed final end use of the site’. Please revise and update as necessary.
    b. Decision flow chart 1, Step 2 - Please provide a timeframe parameter around the ‘age of the report’. Is there a maximum timeframe that will trigger the requirement for additional investigation?
    c. Decision flow chart 1, Step 2 – Please state that review of prior investigations must consider compliance with NSW EPA made or endorsed guidelines for contaminated sites.
    d. Decision flow chart 1, Step 2 – Please correct minor typo.
    e. Decision flow chart 1, Step 3 – If part of the decision-making process is to identify if previous investigations are sufficient to meet the ‘required objectives’, then part of the decision-making process should include a process for identifying the objectives. Please update accordingly.
    f. Based on TfNSW email correspondence of 25 February 2022, the Auditor understands that the outcomes of the decision-making process for Crossover T-AEIs will be reviewed by the future Site Auditor. Should the requirement for Site Auditor review be included in the process?
7. Section 3.3, M-AEIs
    a. Second paragraph – Please identify the scenarios that will trigger the need for the ‘contractor’ to conduct the decision-making process for M-AEIs.
    b. Second paragraph – Realignment of the tunnel footprint should be considered as one of the triggers for conducting the decision-making process of M-AEIs.
    c. Second paragraph – Please include a statement requiring continued engagement with (i) the nominated Site Auditor in regard to waste classification and onshore disposal; and (ii) DAWE/relevant federal agency for offshore disposal.
    d. Second paragraph – It is understood that site suitability assessments of M-AEIs are not required, however it would be useful if the document could please elaborate why this is the case.
    e. Decision Flow Chart 2 – Step 1 – Please add a review item which requires consideration of previous acid sulfate soil investigations, and whether additional testing is required.
    f. Decision Flow Chart 2 – Step 1 – Second last dot point, please include consideration of any physical/chemical amendments (or treatment) that may be required for disposal.
    g. Decision Flow Chart 2 – Step 3 – If part of the decision-making process is to identify if previous investigations are sufficient to meet the ‘required objectives’, then part of the decision-making process should include a process for identifying the objectives. Please update accordingly.
    h. Please correct ‘Error! Reference source not found’, error message.
    i. Table 2 – Should appropriate water quality guidelines be included as reference, or will water quality monitoring be addressed under the CEMP sub-plans for the M-AEI sites?
    j. Table 2 – Please identify the trigger(s) for the requirement of a health risk assessment and include a reference to enHealth (2012) Environmental Health Risk Assessment Guidelines for assessing human health risks from environmental hazards.
    k. Table 2 – Please also include reference to NSW EPA Control Orders created under Part 3, Division 5 of the Environmentally Hazardous Chemicals Act 1985 (e.g. for dioxin-contaminated waste materials and organotin waste materials).

8. Section 3.4, A-AEIs
    a. Please require that the A-AEI decision making process will be used to re-visit the sites classified as ‘low risk’ and n/a sites in the EIS, Chapter M – Contamination. There may be instances where the condition at these previously identified sites changes over time and warrants further consideration. The decision-making process should therefore include the risk ranking attributes used to assign risk at each AEI. Perhaps cross reference Section 2.2 (see comment 4a above)
    b. First dot point – Please identify which AEIs are being referred to here, with due consideration of the AEI categories provided in Section 3.
    c. Second dot point – Please clarify how new AEIs may be identified within or adjacent to the current project footprint.
    d. Second dot point – How does this differ from the third dot point?
    e. Third dot point - Please confirm whether a change in boundary to the current project footprint will trigger the need for a PSI for the new portion of land.
    f. Please require that any previous environmental investigations conducted for A-AEIs consider compliance with NSW EPA made or endorsed guidelines for contaminated sites.
9. Section 3.5, Documentation
    a. Please identify who will be responsible for documenting the results of the decision-making processes for the Crossover T-AEIs, M-AEIs, and A-AEIs.
    b. Please provide a description of items to be included in the reliability assessment, with due consideration of the appropriateness of previous sampling investigations, and an assessment of the quality of the data.
10. Section 4.2, Objectives – Please add that the site-specific SAQPs must also set out the methodologies of the selected sampling and analysis approach.
11. Section 4.4, Site Setting and Environment –Please require that the site-specific SAQPs include a provision for the following additional items in each DSI:
    a. For ‘Site history’, please add ‘in accordance with ASC NEPM Field Checklist ‘Site Information’ sheet’.
    b. Site condition and surrounding environment in accordance with ASC NEPM Field Checklist ‘Site Information’ sheet.
    c. Search of SafeWork NSW Dangerous Goods Licenses/ UST/ AST databases.
    d. Consideration of ecologically sensitive areas and places of heritage significance.
12. Section 4.6.3 – Sampling Plan – Please add that the sampling design and plan selected must also comply with any other relevant NSW EPA made or endorsed guidelines. Consider whether there will be any other approvals required to enable intrusive works on site with ecological sensitive communities or heritage items.
13. Section 4.6.4, Field Methodology
    a. Please add that preliminary works should consider any required approvals to conduct intrusive works at each AEI, such as for ecologically sensitive areas / places of heritage significance.
    b. Please add temporal variation as a consideration for the timing and frequency of fieldwork and monitoring.
14. Section 4.7, Analytical Plan – Please add that the analytical plan must also consider the requirements of any other relevant NSW EPA made or endorsed guidelines.
15. Section 4.8, Reporting

a. Please clarify that the presentation of previous environmental data in the site-specific SAQPs is to include pre-EIS and post-EIS investigations.

b. Please require that the site-specific SAQPs should present all relevant previous sampling points (and groundwater monitoring wells) on a site plan.

c. Third last dot point – Please modify wording to “An assessment of whether the investigations were conducted in compliance with appropriate regulations and guidelines, and any identification of any data gaps to be addressed”. Please also include a requirement for investigation works to be completed in accordance with the most current guidelines, as there may be instances where guidelines listed in the Framework SAQP are repealed or updated prior to execution of works.

16. Section 5, Basis for Project Specific T-AEIs Specific SAQPs – this section contains a lot of good information but it may confuse the issue with the document being a high-level, overarching framework. Would it be better suited as an appendix to the Framework SAQP?

17. Section 5.1.3, Project Specific T-AEIs Historical Aerial Photograph Review, Table 12 – Could the aerial photos in Appendix B be marked up to show the boundary for each AEI location?

18. Section 5.3.2, Soil and Sediment Assessment Criteria, Table 10 - It is noted that asbestos testing will be completed using presence/absence laboratory protocol. Please include requirements for asbestos testing that meet NEPM 2013 for assessing site suitability against HSLs.

19. Section 5.4.1, Data quality objectives for Project Specific T-AEIs - Please include a statement in the DQOs that the Framework SAQP applies only to the moderate and high risk sites identified in the EIS.

20. Section 5.4.2, Sampling and laboratory analysis program for Project Specific T-AEIs:

    a. Please describe how the ‘construction phase’ and ‘operational phase’ proposed minimum soil sampling points are to be applied. For example, at B9 Flat Rock Reserve (10,400 m2), 24 sampling points have been proposed for the ‘construction phase’ and 2 sampling points have been proposed for the ‘operational phase’. Can this approach please be described in greater detail? Any sampling required at the operational phase will be dependent on the outcome of any remediation work or management requirements at the completion of construction. How can the scope be defined now?

    b. Table 23. Please consider changing ‘operational’ phase to ‘exit’ phase, as the current format indicates that sampling will be conducted during operations.

    c. Table 23. For B11 Spit West Reserve, it understood that testing is required for ASS. Please update the COPC column accordingly.

    d. Table 23. If contamination of groundwater is ‘unlikely’ at B13/14, B15, B16, and B17 please provide justification for why groundwater investigations have been scheduled, or will sampling be conducted at existing groundwater monitoring wells in these locations?

    e. Table 23. The COPC field for B17 Wakehurst Parkway, Seaforth to Frenchs Forest includes the following “Asbestos mapping and emu picking”. Emu picking is a remedial strategy. Can this please be clarified in the context of the SAQP?

    f. Table 23. Please clarify why site characterisation is not proposed for B10 – Bicentennial Reserve.

    g. Table 23. It is noted that the number of sampling locations for B13/14 exceeds the NSW EPA (1995) Sampling Design Guidelines. Should this be reconsidered?

    h. Table 23. Please provide the rational for the number of sample locations proposed for B17 – Wakehurst Parkway

21. Section 5.5.2, Soil and sediment sampling

a. Please include a statement recommending that soil samples should not be collected across soil strata/changes in soil horizons, and that a sample should be collected where there is a change in soil strata.

b. Please provide the calibration requirements and appropriate ionising lamp for the PID given the COPC, and include a brief description of the method to screen soils for volatile COPCs using the PID.

c. The preliminary CSM has identified inhalation of asbestos fibres as a potentially complete exposure pathway during construction. Please provide justification for limiting asbestos sampling to presence / absence testing only. The Auditor considers that quantitative asbestos sampling (10L samples and 500 ml samples) in accordance with NEPM 2013 is required to confirm site suitability. Please note that where asbestos is present, asbestos-in-air monitoring using the membrane filter method conducted by an independent asbestos assessor or competent person will be required during construction.

d. Should asbestos be identified or suspected in soils, a denser sampling regime may be required in accordance with Table 1 WA DoH (2009) Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia.

22. Section 5.3.4, Landfill gas contamination assessment - Please note the subsurface criteria 1%v/v also represents the gas accumulation criterion for enclosed structures which triggers further investigation and corrective action.

23. Section 5.3.5, Acid Sulfate Soil Assessment – Please ensure ASS is assessed with due consideration of the National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual, noting the requirements for chromium reducible sulfur testing.

24. Section 5.5.2. Soil and Sediment Sampling - Please add leachate testing (as required) for the assessment of soils and sediments.

25. Section 5.5.3. Groundwater and Leachate Well Installation - Please add that well development should include removal of sediment from wells and reconnection back to the water bearing sequence.

26. Sections 5.5.4, 5.5.8 and 5.6.1.6 (re: Landfill gas) - The NSW EPA 2020 Assessment and management of hazardous ground gases is the primary and most recent guidance document associated with landfill gas in NSW. Please ensure that the referenced sections are amended to reflect the requirements of this document.

27. Section 5.5.9, Waste management

    a. Please include a statement requiring that excess spoil identified for off-site disposal be classified in accordance with NSW EPA 2014 Waste Classification Guidelines.

    b. If waste stockpiles are to be sampled, please include a sampling methodology/density for stockpile sampling.

28. Section 5.5.10, Contingency plan – Please confirm if the environmental controls to be implemented at all sites during the DSIs will be outlined in additional environmental management plans prepared prior to embarking on the DSI field program.

29. Appendix A – Figures 2-7.

    a. Please include the names of the suburbs relevant to each AEI.

    b. Please consider amending the figure titles to read “Moderate to high risk ranked sites requiring further investigation’.

30. Appendix B – Aerial photographs. As requested in an earlier comment, consider outlining the AEIs on the photographs.

We request responses to the above comments, and a copy of the finalised Framework SAQP to complete the Audit documentation.

7 Closure

This interim advice does not constitute a SAS or a SAR, but rather is provided to assist the Client in the assessment and management of contamination issues at the site. The information provided herein should not be considered pre-emptive of the final Audit conclusions. It represents the Auditor's opinion based on the review of currently available information.

Should you have any queries or wish to discuss any points, please do not hesitate to contact Rachael Martin or the undersigned.

Yours sincerely,

Rebeka Hall
NSW EPA Accredited Site Auditor
Geosyntec Consultants Pty Ltd

Transport for NSW

Site Audit Interim Audit Advice No.2 (IA2) – Review of GHD Framework Sampling, Analysis and Quality Plan for the Beaches Link and Gore Hill Freeway Connection Project

16 May 2022

To	Rebeka Hall NSW EPA Accredited Site Auditor Geosyntec Consultants Pty Ltd Suite 1, Level 9, 189 Kent St Sydney NSW 2000
From	Jack McGovern Senior Manager Environment and Sustainability Environment and Sustainability (Beaches Link) Safety, Environment and Regulation Transport for NSW

Transport for NSW (Transport) has reviewed the Site Audit Interim Audit Advice No.2 (IA2) and confirms that the Framework Sampling, Analysis and Quality Plan (SAQP) sets out the requirements for future site-specific SAQPs under a range of scenarios, including through decision-making processes.

Transport has provided responses to the comments set out in Section 6 of the IA2 below and made minor updates to the Framework SAQP where necessary.

Transport provides the following responses to IA2 comments:

1. General comments are addressed in the updated Framework SAQP, including:
    a. Section 1.5 includes a list of standards and guidelines made or endorsed by the NSW Environment Protection Authority (EPA), as well as other relevant publications and Australian Standards (including the National Environment Protection (Assessment of Site Contamination) Measure), including those listed in IA2. These must all be considered in the implementation of the Frameworks SAQP and development of future site-specific SAQPs.
    b. This is satisfied by Section 1.5 of the Framework SAP.
    c. Section 1.6 includes definitions for the key persons referred to within the Framework SAQP.
    d. Figure 2 displays all Areas of Environmental Interest (AEIs) identified within the environmental impact statement (EIS) in a single figure.
    e. Section 4 requires future site-specific SAQPs consider the significance of the lateral tunnel position and depth relative to AEIs.

2. Transport confirms that the Framework SAQP has been drafted with due consideration of the NEPM 2013.
3. Transport will engage a NSW EPA Accredited Site Auditor prior to any detailed site investigation works at AEIs identified in the EIS. This will include a review of site-specific SAQPs and any subsequent contamination investigation works. This is outlined in Section 1.1, Section 1.6, Section 1.7 and Section 4.8.
4. Section 2.2 of the Framework SAQP details all AEIs which were identified by the preliminary site assessment undertaken as part of the BLGHFC EIS as sites having a moderate to high risk of contamination, and therefore required additional investigations.
    a. Reference has been added to the risk assessment matrix included in Section 5 of Appendix M (Contamination) to the EIS.
    b. Figure 1 in the Framework SAQP is taken from the EIS and shows all construction support sites proposed to be used for the BLGHFC project, whether they are related to an AEI or not. Figure 2 has been updated to show all AEIs identified in the EIS as moderate to high risk of contamination, as well as their categorisation. Definitions have been added to the glossary for 'construction footprint' and 'construction support site' to differentiate between the two project features.
5. Section 4.8 of the Framework SAQP includes the requirement for future site-specific SAQPs to contain information demonstrating how the results of the works will be utilised as part of planning for control or management measures to be required during construction activities.
6. Section 3.2 of the Framework SAQP includes a decision-making process for cross-over terrestrial AEIs, to determine if additional investigations are needed and their scope. Transport has amended the text and flow chart in response to the Site Auditor's comments (points a. to f.). This includes ensuring that there is consideration of the age of previous reports, whether the previous reports comply with relevant EPA made or endorsed guidelines, whether there has been any activities which would have changed the site, and whether they are sufficient to enable assessment on site suitability. The implementation of this decision making process will be overseen by a NSW EPA Accredited Site Auditor.
7. Section 3.3 of the Framework SAQP includes a decision-making process for the marine AEIs to determine if additional investigations are required and the scope of these detailed investigations. Transport has amended the text and flow chart in response to the Site Auditor's comments, where relevant and notes the following:
    a. The first step in the flow chart will be required to be undertaken by the future Principal Contractor and their qualified consultant as defined in Section 1.6.
    b. If there are changes to the tunnel footprint/alignment in the harbour, a review of these changes will be undertaken through the A-AEI process outlined in Section 3.4 of the Framework SAQP. Section 3.3 requires a review of the current project footprint.
    c. Section 1.1 and Section 1.5 outline the requirements for engagement of a NSW EPA Accredited Site Auditor. Further clarity has been added around the requirement to engage with the federal Department of Agriculture, Water and Environment (DAWE) in relation to off-shore disposal.

d. Additional clarity has been added as to why site suitability assessments for the bed of the harbour are not required, and that the scope of any future investigations will be limited to potential impacts from construction activities, as well as any material disposal requirements.
e. The specific requirement to review the presence of acid sulfate soils has been added for clarity.
f. Disposal requirements are adequately covered off in the flow chart, including the third bullet point.
g. Step 2 has been updated to reflect the objectives of the decision making process, specifically to determine potential impacts to sensitive receptors and material disposal requirements.
h. Link errors were corrected.
i. Water quality monitoring is part of a separate management processes, including CEMP sub-plan requirements. It is therefore not considered relevant for reference to be added here.
j. Table 2 in Section 3.3 of the Framework SAQP has been updated to include reference to "The Role of Toxicity Testing in Identifying Toxic Substances in Water (enHealth, 2012)".
k. Table 2 in Section 3.3 of the Framework SAQP has been updated to include reference to "NSW EPA Control Orders created under Part 3, Division 5 of the Environmentally Hazardous Chemicals Act 1985".

8. Transport notes that Section 3.4 of the Framework SAQP is designed to capture changes in conditions (or available information) after the EIS which would warrant a review of either previously classified low-risk AEIs or if there are new AEIs. Based on this, Transports notes the following:
    a. Section 3.4 has been updated to require consideration of sites previously identified as low risk in instances where conditions have changed or where review of existing information indicates potential contamination not previously identified. In addition, requirements for consideration of changes to site boundaries of AEIs and the project footprint which overlap AEIs have now been included. Transport does not propose to review low risk AEIs unless conditions or circumstances set out in Section 3.4 occur.
    b. Transport notes that no specific AEIs are being referred to in this section as the purpose of this categorisation is to allow for capture of additional sites not already identified or where new information becomes available, or the site conditions have changed since the EIS ranking such that a change to the risk ranking is considered warranted.
    c. Section 3.4 has been updated to reference circumstance "where the amendments result in the land not previously assessed in the EIS now being within the project footprint".
    d. Duplication within Section 3.4 has been amended.
    e. Section 3.4 has been updated to require that a "change in the boundary to the current project footprint will trigger the need for a PSI for the new portion of land".

f. General text has been added to Section 3 of the Framework SAQP which requires "Any previous environmental investigations conducted for AEIs, and reviewed as part of the decision making process, must consider compliance with NSW EPA made or endorsed guidelines for contaminated sites".

9. Section 3.5 outlines the documentation required for the decision making processes. An appropriately qualified consultant, as per Section 1.6, will be required to document the outcomes. Furthermore, additional detail has been added on what may need to be included in the reliability assessment.
10. "Methodologies" has been added to Section 4.2 of the Framework SAQP, as requested by the Site Auditor.
11. Section 4.4 includes the requirement for future site-specific SAQPs to include details on site history, site condition and the surrounding environment (including sensitive receptors). Furthermore, Section 1.5 outlines all the relevant guidelines and standards made or endorsed by the NSW EPA that must be considered.
12. Additional text has been added to Section 4.6.3 to ensure that the sampling plan must comply with any other relevant NSW EPA made or approved guidelines. This is in addition to the plans and guidelines referenced in Section 1.5.
13. Additional text has been added to Section 4.6.3 and Section 4.6.4 to ensure that temporal variations are considered in methodologies. In addition, Section 4.6.3 requires the principal contractor obtain all relevant approvals required to enable intrusive works prior to implementing the site-specific SAQPs.
14. Section 1.5 outlines all the relevant guidelines and standards made or approved by the NSW EPA that must be considered.
15. Section 4.8 addresses this comment, with requirements for the development of a refined conceptual site model and compliance with relevant guidelines. This section has also been updated to require future site-specific SAQPs present all relevant previous results (pre and post EIS), as well as a Site Plan. Furthermore, Section 1.5 outlines all the relevant guidelines which must be complied with.
16. Additional site specific information for the project specific T-AEIs is now presented in Appendix B, as suggested by the Site Auditor.
17. Historical imagery previously included as an appendix, which were more detailed versions of those presented in Appendix M of the EIS, have been removed. More site-specific marked up versions can be provided in future site-specific SAQPs.
18. Table 18 in Section 1.3.2 of Appendix B has been updated to include the specific requirements for asbestos testing, as per the NEPM 2013 guidelines.
19. Clarity has been added to Section 1.4.1 of Appendix B regarding that the data quality objectives only apply to the moderate to high risk AEIs identified in the EIS.
20. Appendix B of the Framework SAQP includes details on the sampling and laboratory analysis program for the Project Specific T-AEIs. The information presented in Table 21 was developed based on information available at the time of development. Sampling required at the exit phase will be dependent on the outcome of any remediation work or management requirements at the completion of construction, with a preliminary estimate provided in Table 23 based on the site area. Additional corrections to Table 21 comprise:

a. The reference to 2 operational phase points at B9 was a mistake and has been corrected to 24.
b. The term “operational” phase has been corrected to “exit” phase to better reflect the purpose of the sampling.
c. Table 21 of Appendix B has been updated with requirement for ASS testing for B11 Spit West Reserve.
d. The EIS assessment for B13 and B14 indicated groundwater may be impacted and should be tested. For B15, B16 and B17, the EIS assessment indicated that it is unlikely that contamination (if present) would be received by underlying groundwater and/or off-site surface water receptors. Table 21 of Appendix B has been updated to clarify that if contamination is present in soils, it is likely to be surficial and that it is unlikely that contamination would be received by underlying groundwater. The need for groundwater testing will be subject to consideration of the soil investigation results.
e. "Asbestos mapping and emu picking" now removed from COPC column for B17.
f. As no surface works are proposed within the B10 site, clarification has been added to the table to note that sampling will be undertaken for purposes of design and waste classification of tunnel excavation material.
g. The number of samples proposed for B13/14 have been reduced from 150 to 135 to align with the NSW EPA (1995) Sampling Design Guidelines.
h. The number of samples proposed for B17 have been reduced from 105 to 100 to align with the NSW EPA (1995) Sampling Design Guidelines.

21. Section 1.5.2 of Appendix B outlines various methods that must be considered where appropriate. Updates have been made to this section as follows:
    a. Text has been added to require soil samples not be collected across changes in soil strata or soil horizons. Additional samples should be taken where there is a change in soil strata / horizon.
    b. Text has been added to require soil samples be screened for the presence of volatile contamination using a calibrated photo-ionisation detector (PID) where relevant volatile COPCs are to be analysed.
    c. This section has been updated to include the specific requirements for asbestos testing, as per the NEPM 2013 guidelines, for non-friable and fibrous asbestos.
    d. This section has been updated to reflect that should asbestos be identified in soils, a denser sampling regime may be required in accordance with Table 1 WA DoH (2009) Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia.
22. Section 1.3.4 of Appendix B has been updated to include the relevant criteria for landfill gas contamination assessment.
23. Section 1.3.5 of Appendix B has been updated to include the requirement to consider the National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual, noting the requirements for chromium reducible sulfur testing.
24. Section 1.5.2 of Appendix B has been updated to include the requirement to consider testing for leachate.

25. Section 1.5.2 of Appendix B has been updated to include that well development should include removal of sediment from wells and reconnection back to the water bearing sequence.
26. Section 1.5.4, Section 1.5.8 and Section 1.6.1.6 of Appendix B have all been updated to reference the most recent guidance on hazardous landfill gases – "*Assessment and management of hazardous ground gases (NSW EPA, 2020)*".
27. Section 1.5.9 of Appendix B has been updated to require that excess spoil identified for off-site disposal be classified in accordance with NSW EPA 2014 Waste Classification Guidelines. Furthermore, high level information has been added on sampling requirements for any pre-existing stockpiles where compliance with Schedule B2 (NEPC, 2013) is required.
28. Section 1.5.10 of Appendix B has been updated to state that "environmental controls are to be implemented at all sites to prevent migration of potentially impacted material to the surrounding environment".
29. Figures in Appendix A have been updated to include the relevant suburbs and the title has changed to "Areas of Environmental Interest".
30. As per previous response, historical imagery previously included as an appendix, which were more detailed versions of those presented in Appendix M of the EIS, have been removed. More site-specific marked up versions can be provided in future site-specific SAQPs.

Transport has provided the Framework SAQP (Rev 0) to the Site Auditor which satisfies the above requests and adopts the relevant amendments.

If Geosyntec have any questions on the above, please contact Jack McGovern at [redacted].

Appendix C Summary of Works

Appendix C: Summary of Reports Reviewed

Jacobs (2020a)	**Jacobs (December 2020)** **Beaches Link and Gore Hill Freeway Connection, Technical working paper: Contamination** **Ref: EIS, Appendix M**
Report objectives	To identify potential environmental areas of interest (AEI) which would assist in identifying construction limitations/constraints and management options with respect to contamination, and to address the SEARS for soils.
Report scope	• Review of publicly available information. • Review of information provided by TfNSW. • Review of historical aerial photography for the general project area. • Site inspections. • Preparation of report.
Key findings	Based on review of the available information, the following key site conditions were identified: • The alignment is dominated by the Hawkesbury Sandstone. • Fill generally occurs less than one metre thickness in urban areas; and identified up to 40 m in thickness located alongside Flat Rock Creek, in the vicinity of Flat Rock Gully. • Middle Harbour sediments and The Spit sediments were assessed as having a 'high probability' of acid sulfate soils (ASS). • Regional groundwater flow is inferred to be in an east to south-easterly direction towards Port Jackson and the Tasman Sea. Potential groundwater receptors included Long Bay, Middle Harbour, Burnt Bridge Creek, Bantry Bay and Manly Dam. Potential contamination issues at construction support sites (BL1-BL14) and other surface sites based on the aerial photography are summarised as follows: • Uncontrolled fill. • Hazardous building and construction materials. • Particulate matter deposition from vehicles using Warringah Freeway. • Chemical use and storage. • Commercial/industrial land uses. • Land reclamation. • Degradation of asphalt road surface. • Degradation from painted reservoir surfaces. • Uncontrolled stockpiling of materials. • Illegal fly tipping of waste. • Burials (at Crows Nest Cemetery). • Leaks and spills from UPSS infrastructure. • Contaminated sediments. Seven sites (all service stations) were registered with the NSW EPA within 500m of the project alignment. The following key findings were presented for sediment impacts, based on the Douglas Partners Golder Associates (2018) Marine Investigations: • Contamination in sediments were elevated in grey green mud one metre into the harbour bed. Phase III testing indicated copper, lead and zinc may be bioavailable in these sediments; Phase IV testing is required to determine suitability for offshore disposal. • The sediments were classified as general solid waste (GSW) for disposal to NSW EPA licensed facilities. However, given tributyln was detected, land-based disposal would need to be in accordance with NSW EPA chemical control order for organotin waste materials. • Limited samples were collected for ASS testing. A review of the results identified one sample from Middle Harbour (B119WA_VC-A) exceeding criteria. • Offshore disposal is subject to Commonwealth approval.

Based on the Royal Haskoning DHV (2020) elutriate testing, water quality impacts at the dredging site due to dissolved contaminants are not expected.

The following key findings were presented for groundwater impacts, based on the Douglas Partners Golder Associates groundwater monitoring factual reports:

- Cobalt, total phosphorous, ammonia, copper, manganese, nickel, boron and zinc, variably exceeded the ANZECC (2000) 95% species protection for freshwater and marine ecosystems.
- Manganese, nickel, lead, chromium, sulphate, and arsenic exceeded the NHMRC (2011) drinking water guidelines.
- Lead and manganese exceeded NHMRC (2008) recreational water guidelines.

The following key findings were presented for groundwater impacts, based on the AEC (2019) groundwater monitoring report:

- Phosphorous (reactive), phosphorous, nitrate, chromium, cobalt, copper, zinc, manganese, nickel, and boron variably exceeded the ANZECC (2000) 95% species protection for freshwater and marine ecosystems.
- Manganese exceeded the NHMRC (2011) drinking water guideline.

The following key findings were presented for groundwater impacts based on the SMEC (2017) monitoring report for the Northern Beaches Hospital Road Connectivity and Network Enhancements Project:

- Selected heavy metals exceeded ANZECC (2000) 95% species protection criteria for freshwater and marine ecosystems.
- TRH and benzene were detected above LOR which were reportedly associated with nearby service station sites or introduced during the drilling program.
- Elevated nitrite was considered to be associated with fertiliser use within parkland areas.
- The report concluded that groundwater quality showed no substantial contamination.

The following key findings were presented for soil impact exceeding open space and commercial/industrial criteria at four locations (11 boreholes) based on the AECOM and Coffey CFR (2018) report:

- Nickel concentrations exceeded the adopted EIL in three samples at Wakehurst Parkway and Gore Hill Freeway.
- BaP TEQ concentrations exceeded the adopted HILs and EIL at most locations.
- TRH (C10-C16) exceeded the public open space ESL at Wakehurst Parkway.

The Douglas Partners (2018) Contamination Factual Report – Land Investigations reported on soil contamination testing at four locations at Artarmon, North Balgowlah and Balgowlah. Results were compared against residential land use and areas of ecological significance, and therefore were deemed not applicable to the project.

The Douglas Partners Golder Associates Geotechnical Factual Report – Land Investigations (2017) and the AECOM and Coffey (2017) Geotechnical Factual Report (GFR1) identified buried waste materials at the following locations:

- B337 - Cammeray Golf Course – 4.13 m of fill material containing concrete and PVC.
- B340 - Cammeray Golf Course – 1.8 m of fill containing sandstone and concrete.
- B176 - Bicentennial Reserve – 30 m of landfill waste material
- B177 - Flat Rock Reserve – 11 m of fill (based on limited observations).

A local knowledge assessment identified potential contamination impacts at the following locations:

- Willoughby Leisure Centre and Bicentennial Reserve – infilling and incinerator operations potentially including historical residential, industrial and furnace waste.
- Flat Rock Reserve at Northbridge – approximately 30 m of infilling for the construction of Flat Rock Drive, potentially including putrescible material (pre-1971) and building waste (post-1971).

A total of 33 potential areas of environmental interest were identified, and risk-ranked as either low, moderate, or high risk. Of the 33 areas, a total of 42 potential sources of contamination were identified. Of the 42 potential sources of contamination identified, 24 contained contaminant sources considered of moderate or high risk. No further consideration of contamination risk was provided for the 17 sites assessed as low. The moderate to high -risk sites are summarised below:

- Moderate Risk - Unsealed areas of Warringah Freeway may be impacted with hazardous construction waste or particulate matter deposition from vehicles. Potential moderate risk posed during surface works and construction of construction support site at BL2 (Cammeray Golf Course).
- Moderate Risk – Potential for presence of contaminated soil and fill materials due to the degradation of hazardous building materials and/or uncontrolled infilling. Potential moderate risk

posed during construction of the proposed Punch Street construction support site (BL3) at Artarmon.

- Moderate Risk – Potential for contamination due to current and historical commercial/industrial uses of the area. Potential moderate risk during soil excavation during construction of the Motorway control Centre site at the Freeway Hotel site, Reserve Road, Artarmon.
- Moderate Risk – Potential for putrescible and other types of waste in the upper layers of the former landfill at Flat Rock Reserve. Potential moderate risk associated with contamination beneath the Flat Rock Drive construction support site (BL2), likely to be exposed during construction of access decline tunnel and other associated works.
- Unknown Risk – Potential for landfill gas beneath Flat Rock Drive construction support site (BL2) and the adjacent Willoughby Leisure Centre and Bicentennial Reserve. Potential to migrate towards BL2 due to ground disturbance from construction activities. Investigations to date have not specifically tested for landfill gas.
- Moderate Risk – Potential for contamination risk associated with potential groundwater impacts beneath Flat Rock Drive construction support site (BL2), likely to be encountered during construction of the access decline tunnel.
- High Risk – Potential for groundwater contamination in adjoining areas to Flat Rock Drive (i.e. Willoughby Leisure Centre and Bicentennial Reserve) to migrate to the main tunnel works under. Potential high contamination risk to the tunnel in this area.
- Moderate Risk – Potential for soil contamination adjacent to Balgowlah Golf Course, due to hazardous building waste, unknown fill, and degradation of hazardous building materials. Potential moderate risk during construction of Balgowlah Golf Course construction support site (BL10), new open space, recreation facilities, and the Balgowlah connection surface works.
- Moderate Risk – Potential for soil contamination due to degradation of hazardous building materials of former residential premises along Dudley Street, Balgowlah. Potential moderate risk during excavation and exposure of soils during Construction of Balgowlah Golf Course construction support site (BL10).
- Moderate Risk – Potential for soil contamination due to degradation of hazardous building materials of existing residential premises at the corners of Judith and Kirkwood Street with Wakehurst Parkway, Seaforth. Potential moderate risk during excavation and exposure of soils during construction of Wakehurst Parkway south construction support site (BL12).
- Moderate Risk – Potential for contamination due to deposition of degraded materials from the surface of the Sydney Water Reservoir. Potential moderate risk during excavation and exposure of soils during construction of Wakehurst Parkway east construction support site (BL13), Killarney Heights.
- Moderate Risk – Potential for contamination in surface soils adjacent to the Sydney Water Reservoir. Potential moderate risk during excavation and exposure of soils during construction of Wakehurst Parkway east construction support site (BL13), Killarney Heights.
- High Risk – Reported isolated contamination in surface soils due to degradation of asphaltic road surfaces, adjacent to Wakehurst Parkway between Seaforth to Frenchs Forest. Potential high risk given the presence of known contamination during excavation and exposure of soils during upgrade works to Wakehurst Parkway, and adjacent construction of Wakehurst Parkway south construction support site (BL12), Seaforth and Wakehurst Parkway north construction support site (BL14), Frenchs Forest.
- Moderate Risk – Potential for illegally fly tipped waste in areas immediately surrounding the Wakehurst Parkway. Potential moderate risk during excavation and exposure during upgrade works to Wakehurst Parkway.
- Moderate Risk (assumed) – Potential for structures/buildings within the project area to contain hazardous building materials.

The following construction impacts were identified:

- **Soil erosion hazard** – the highest potential for soil erosion is associated with disturbance of soils on existing slopes during construction at the construction support sites and work zones, noting they are not located in areas of steep terrain. Higher soil erosion impacts are more likely to occur in areas adjacent to environmentally sensitive areas (e.g. Garigal NP and Manly Dam Reserve).
- **Acid sulfate soils** – the risk of ASS within the project area was assessed as low to negligible, except for soils within Spit West Reserve and sediments within Middle Harbour. There is also possibility of potential ASS present within the Spit.
- **Salinity** – the risk of areas of saline soils being present within the project area are low to negligible, and salinity was assessed as being unlikely to present a risk to surface water and/or groundwater during project construction.

- **Soil contamination** – Impacts associated with the 12 moderate to high -risk potential AEIs identified, if not appropriately managed, are as follows:
  - Contaminant exposure risk to project personnel and the public.
  - Contaminant exposure risk to environmental receivers.
  - Cross contamination associated with incorrect handling or disposal of spoil/unexpected finds.
  - Contamination of previously clean areas.
- **Sediment contamination** – Contaminated sediments have been identified within Middle Harbour and The Spit and have been assessed as high risk. Sediment disturbance is likely to occur during installation of the immersed tube tunnel and the associated dredging and piling works. Piling works are required to construct support site wharf infrastructure at **Spit West Reserve construction support site** (BL9) and the **immersion pontoon in Middle Harbour**. If not appropriately managed, potential impacts include:
  - Contaminant exposure risk to project personnel.
  - Contaminant exposure risk and sedimentation to marine receivers.
  - Cross contamination associated with the incorrect handling or disposal of spoil/unexpected finds.
  - Accidental spills during transportation of spoil across Sydney and Middle Harbours.

Based on the results of the Royal HaskoningDHV (2020) report, elutriate testing indicates that water quality impacts at the dredging site due to dissolved contaminants would not be expected.

- **Groundwater contamination** – Contaminated groundwater may be encountered during excavation dewatering and tunnelling in the vicinity of potential AEIs. If not managed, potential impacts may include:
  - Contaminant exposure risk to project personnel and the public.
  - Contaminant exposure to environmental receivers.
  - Degradation of aquatic ecosystems.

Contaminated groundwater (elevated ammonia) was identified in vicinity of the Willoughby Leisure Centre and Bicentennial Reserve and could be migrating towards Flat Rock Reserve. The elevated ammonia could impact upon the construction of the tunnel and access decline tunnel located within Flat Rock Reserve. It is noted that other contaminant compounds may be present within groundwater due to historical landfilling.

- **Landfill gas** - Accumulation of landfill gas below ground excavations and enclosed structures could pose asphyxiation or explosion risk. Waste burial areas and potential landfill gas sources were identified at Willoughby Leisure Centre, Bicentennial Reserve, and possibly beneath Flat Rock Reserve. Stage 2 investigations would involve additional boreholes to assess the potential for contamination and landfill gas.

The following **operational impacts** were identified:

- **Soil erosion hazard** – no impacts identified.
- **Acid sulfate soils** – no impacts expected as groundwater drawdown during tunnel operation is unlikely to extend to Spit West Reserve.
- **Salinity** – no impacts identified.
- **Soil contamination** – Where soil contamination is identified within operation areas, appropriate EMPs will need to be prepared during operation to reduce any impacts during operation.
- **Sediment contamination** – Following construction the operational phase of the project is not expected to continue to disturb sediments.
- **Groundwater contamination** – Locations where groundwater contamination is identified adjacent to the operation areas, appropriate engineering controls (e.g. tunnel linings) will need to be installed to remove the risk of groundwater ingress into below ground structures, or manage the risk to receivers via appropriate treatment prior to discharge or reuse.
- **Ground gas contamination** – Locations where ground gas is identified within the operation areas of the project, engineering controls will need to be installed to reduce the risk of gas ingress during operation of the project, such as surface or sub surface extraction, or tanked tunnel construction.

Cumulative impacts with the project may arise due to the Western Harbour Tunnel and Warringah Freeway Upgrade, and the Sydney Metro City & Southwest (Chatswood to Sydenham) project. It was concluded that the potential for the project to result in cumulative impacts was low, assuming the following environmental management measures are implemented.

The recommended **environmental management measures** during construction and operation are summarised below:

	• **Groundwater contamination** – impacts for inflow to be considered during detailed design. • **Soil erosion and sedimentation during construction** – impacts to be managed at all worksites in accordance with current guidance. • **Acid sulfate soils during construction** – prior to excavation in Middle Harbour or ground disturbance at The Spit/Spit West Reserve, testing should be conducted to determine presence of ASS, and if identified, implementation of an appropriate ASSMP will be required. • **Soil contamination during construction** – Potentially contaminated areas (moderate to high risk sites) are to be investigated and managed. Contaminated material that is disturbed is to be separated to prevent cross-contamination with clean material. Contaminated material should be encapsulated on site where appropriate, in accordance with regulatory requirements, or if not suitable for encapsulation, loaded into sealed and covered trucks for disposal. • **Sediment contamination during construction** – Excavated sediments within Middle Harbour will be disposed offshore or disposed to landfill. Sediments disposed to landfill may require treatment. Additional investigations should be required to determine the extent (laterally and vertically) and separation of clean and contaminated bed sediments to facilitate disposal. Sediment transport and distribution in the water column should be managed. • **Groundwater contamination during construction** – Further groundwater investigations should occur in the vicinity of the Willoughby Leisure Centre, Bicentennial Reserve and Flat Rock Reserve. • **Ground gas contamination during construction** – Further detailed contamination studies should include landfill gas investigations in the vicinity of the Willoughby Leisure Centre, Bicentennial Reserve and Flat Rock Reserve to assess the potential presence or absence of gas which could affect construction/operation of the project. • **Ground gas during operation** – Design measures (e.g. tanking, gas drainage, ventilation) to be developed and implemented to reduce risk in tunnels, subsurface, and enclosed structure. • **Complex contamination during construction** – a NSW EPA-accredited Site Auditor to be engaged where contamination is complex. • **Building demolition during construction** – to be conducted and managed in accordance with Australian Standards and other guidelines.
Royal HaskoningDHV (2020a)	**Royal HaskoningDHV (November 2020)** **Beaches Link and Gore Hill Freeway Connection, Contaminant levels and results of elutriate testing of sediments associated with dredging at Middle Harbour for installation of the immersed tube tunnel units Ref: EIS, Appendix M, Annexure C**
Report objectives	To assess sediment contaminant level and results of elutriate testing for sediment proposed to be dredged for the installation of the immersed tube tunnel across Middle Harbour. The elutriate testing was used to provide an indication of potentially soluble contaminants that are susceptible to migration and assess the risk to the environment from these soluble contaminants.
Report scope	• Review of two rounds of sediment sampling and testing results undertaken by Douglas Partners and Golder Associates (2018) • Summarise further investigations by Royal HaskoningDHV to assess the suitability of dredging sediments for offshore disposal • Elutriate testing (on 7 samples) and comparison of results to guidelines values (95% species protection level). The results were then discussed with consideration for the level of natural dilution expected at the dredging site.
Key findings	• Comparison of existing results to the National Assessment Guidelines for Dredging (NAGD) found that the gravelly, muddy sand near the shoreline and sediment below 1m depth are suitable for offshore disposal. The top 1m of grey green mud along the majority of the tunnel alignment is not suitable for offshore disposal. • Metal results for most elutriate samples were below laboratory detection or below the adopted guideline values, however concentrations of copper, lead, zinc and mercury were reported in sample B499 and zinc exceedance in sample B120WA (0.0-0.5m). Dioxin (2,3,7,8-Tetrachlorodibenzo-p-dioxin) was also detected in 3 samples. • Royal HaskoningDHV noted that the highest elutriate exceedance (Zinc in sample B499) would need a minimum natural dilution of approximately 1:24 to satisfy the adopted 95% species protection level. Based on the estimated volume of dredged material released into the water column over a set period of time, the initial natural dilution at the dredging site was estimated by Royal HaskoningDHV at 1:200. Based on this Royal HaskoningDHV concluded that the

	water quality impacts at the dredging site due to dissolved contaminants would not be expected.
TfNSW (2020a)	**TfNSW (November 2021)** **Beaches Link and Gore Hill Freeway Connection, Submissions Report, Part D2 - Revised Environmental Management Measures**
Report objectives	To describe the revised environmental management measures to avoid or reduce environmental impacts during the project, in response to submissions made by the public.
Report scope	Part D2 outlines the revised environmental management measures to avoid or reduce environmental impacts during the project, categorised by each project phase: pre-construction, design, construction, and operational. All revised environmental management measures will be incorporated into the relevant management plans.
Key findings	• Of particular relevance to the current scope of work, revised environmental management measures have been provided for geology, soils and groundwater (SG1 – SG21), and hydrodynamics and water quality (WQ1 – WQ21). • In addition to the environmental management measures typically applied during linear tunnelling and road projects, notable measures are summarised below, which may have some bearing on the scope of the Framework SAQP: - SG1 - The groundwater drawdown model will be progressively updated to refine predictions based on additional information for groundwater levels and contamination. - SG8 – Further investigations of potentially contaminated areas directly affected by the project will be conducted at six key locations. Pending the investigation outcomes, a Remediation Action Plan will be implemented if required. For complex contamination impact, a NSW EPA Accredited Site Auditor will be engaged to audit the work. - SG14 – ASS testing will be conducted in high-risk ASS areas, prior to ground disturbance, at Spit West Reserve and Middle Harbour. - SG15 – Ground gas investigations will be conducted in Flat Rock Reserve to assess potential for landfill gas which could impact construction or operations. - SG18 – Groundwater migration of potential contaminant hazards will be modelled as relevant. - WQ10 – A freshwater quality monitoring program will be implemented at key locations of the project.
TfNSW (2020b)	**TfNSW (November 2021)** **PIR, Section 3 – Spit West Reserve Temporary Construction Support Site (BL9) Reconfiguration**
Report objectives	To describe the alternative construction design plans for the BL9 Construction Support Site at Spit West Reserve, Mosman.
Report scope	The scope of the document includes the background and justification for the proposed reconfiguration of BL9 at Spit West Reserve, Mosman.
Key findings	The proposed location of the Spit West Reserve Temporary Construction Support Site (BL9) is in the water, to the west of Spit West Reserve, with an adjoining land-based site. The site would be used to support construction of the immersed tube tunnel units and include a temporary floating casting facility connected to the Reserve by jetties. The following key activities would occur at BL9: • Concurrent casting of two immersed tube tunnel units along the tunnel alignment for immersion. • Support for dredging works. • Immersed tube tunnel immersion. • Cofferdam construction. Mosman Council's submission identified that the BL9 site activities would impact upon recreational users of the adjoining land-based area, as there are no alternative options nearby for recreational users.

	To address Mosman Council's concerns, TfNSW (2021b) concluded that there are no viable alternative locations for the BL9 site, however the site could be reconfigured to minimise impacts to users by reducing the area of BL9 and increasing the size of the over water area. Impacts of the reconfiguration were assessed against the SEARS issued for the project. Among other items, the assessment did not identify a requirement for additional assessment of geology, soils, and groundwater, hydrodynamics, and water quality.
TfNSW (2020c)	**TfNSW (November 2021)** **Beaches Link and Gore Hill Freeway Connection, Preferred Infrastructure Report, Section 5 – Treatment and Loadout of Dredged and Excavated Material not Suitable for Offshore Disposal.**
Report objectives	To describe the framework for the treatment and loadout of dredged and excavated material not suitable for offshore disposal.
Report scope	The scope of the document provides background to the potential issue, a feasibility assessment to explore alternative options, an overview of the treatment and loadout of dredged and excavated materials not suitable for offshore disposal.
Key findings	Removal of an estimated 163,000 cubic metres of dredged sediment from Middle Harbour is required as part of cofferdam construction, and to form the partial trench for the installation of the immersed tube tunnels at the Middle Harbour crossing. Some Middle Harbour sediments contain elevated concentrations of metallic and non-metallic contaminants from historical sources and contribution from ongoing sources such as stormwater inflow. Of the total estimated volume of sediments to be removed, 12,000 cubic metres of top one metre sediment profile is anticipated to be not suitable for offshore disposal and would require classification in accordance with NSW EPA waste classification guidance, treatment with lime or inorganic polymers to be made spadable in Middle Harbour, transported by barge to a loadout facility, and disposed of at a licensed waste facility. Based on a feasibility assessment, the preferred location of the loadout facility is the Mayfield No. 4 Berth within the Port of Newcastle and identified as the Port of Newcastle construction support site (BL:15). This location is subject to change. Impacts associated with the activities in Middle Harbour and BL15 were assessed against the SEARS issued for the project. Among other items, the assessment identified the requirement for assessment of hydrodynamics and water quality. It is noted that the assessment did not identify a requirement for assessment of geology, soils, and groundwater. The following impacts and/or mitigation measures were identified for Middle Harbour: • Sediment dispersion will be minimised by deep draft silt curtains and closed environmental clamshell. • Water quality impacts at the dredging site due to resuspended contaminants falling back into Middle Harbour is not expected based on the elutriate tests. • A revised environmental management measure has been established to minimise potential for accidental release of lime or the inorganic polymer into the harbour. The following impacts and/or mitigation measures were identified for BL15: • Construction of BL15 does not require any disturbance of soils. The site is entirely impermeable, sealed hardstand. • Transport of treated sediment between Middle Harbour and BL15 will occur during favourable weather conditions to prevent overtopping and spillage. • Load out of the material will take place within two to three metre silt curtains located around the barge. • Any dewatering from the barges will be conducted via a vacuum truck. • Spill containment kits will be available to mitigate any hydrocarbon or chemical spills. • Additional construction environmental management measures will be outlined in a construction environmental management plan.
AECOM (2017a)	**AECOM (6 October 2017)** **Western Harbour Tunnel and Beaches Link - Geotechnical Investigations Factual Report GFR1 Ref: 60537922**

Report objectives	To provide geotechnical information to support the characterisation of the geological, terrain and subsurface conditions along the proposed alignment of the project for the reference design and environmental assessment in the suburbs of Rozelle, Balmain, Blues Point, North Sydney, Northbridge, Cremorne, Cammeray, Mosman, the Spit, Seaforth, Balgowlah, Fairlight, Manly, Brookvale, Pittwater, and Warringah.
Report scope	GFR1 presents factual information obtained from investigations completed up to and including 14 August 2017 and includes records from specialist testing undertaken by sub-contractors. Drilling completed after 14 August is included in GFR2. The scope of the investigations was limited to geotechnical studies conducted at 48 locations along the Western Harbour Tunnel and Beaches Link road corridor. Standpipe monitoring wells were installed in 12 of the geotechnical GFR1 boreholes. This report is factual only and does not provide discussion or interpretation of the results.
Key findings	The report presents factual information based on the results of the geotechnical investigations. Groundwater monitoring results are reported in separate groundwater monitoring reports. Review of the information presented in GFR1 did not identify any details of significance with respect to contaminated land impact for the project.
AECOM (2017b)	**AECOM (23 November 2017)** **Western Harbour Tunnel and Beaches Link Groundwater Monitoring Report - October 2017** **60537922-RPEM_0023A**
Report objectives	The objectives of the report were: • To conduct geotechnical, groundwater and contamination investigations located within the suburbs of Rozelle, Balmain, Waverton, North Sydney, Neutral Bay, Cammeray, Artarmon, Northbridge, Seaforth, Balgowlah, Killarney Heights, and Frenchs Forest along the alignment of the Western Harbour Tunnel and Beaches Link alignment. • To provide factual data to support the characterisation of the subsurface conditions along the proposed alignment which will inform the reference design and environmental assessment. • To collect groundwater levels to assess the natural groundwater level fluctuations and the presence of perched water. • To investigate the presence of contaminated groundwater.
Report scope	Groundwater monitoring wells were installed at 15 locations for monthly monitoring over eight data collection events, each month for the first six months followed by two additional quarterly events. The monitoring was completed in September 2018. The scope of the groundwater monitoring program included: • Installation of 15 standpipe piezometers at selected sites. • Packer testing (hydraulic conductivity) – results presented in GFR1 and GFR2. • Installation of groundwater level monitoring devices. • Slug testing to estimate horizontal hydraulic conductivity. • Collection of physio-chemical groundwater quality parameters. • Collection and analysis of laboratory samples for aggressivity, major cations and anions, and eleven priority dissolved metals.
Key findings	Regional groundwater flow is driven by secondary porosity and fracture flow associated with faults or fracture zones and is varied in nature. The primary porosity is low and zones without fractures or other structural features have low groundwater yield. Water quality is variable and generally improves with depth, distance from the harbour (and where there is no overlying Ashfield Shale). Specific to the Beaches Link Gore Hill Freeway Connection project, relevant groundwater monitoring wells were installed at the following locations: • Balgowlah Cycleway – North Balgowlah • Edgecliffe Esplanade – Seaforth • Ponsonby Parade – Seaforth • McMillan Street – Seaforth • Elliot Street – North Sydney • Small Street – Willoughby

	• Bega Road – Northbridge • Wakehurst Parkway, Killarney Heights and Frenchs Forest • Warringah Freeway – North Sydney • Minnamurra Road – Northbridge • Harwood Place – Seaforth Groundwater samples were tested for selected suite of contaminants of potential concern.
DPGA (2017-2018)	**Douglas Partners Golder Associates** **15 December 2017 (Round 1)** **22 December 2017 (Round 2)** **19 January 2018 (Round 3)** **9 February 2018 (Round 4)** **20 March 2018 (Round 5)** **29 March 2018 (Round 6)** **30 July 2018 (Round 7)** **12 December 2018 (Round 8)** **Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Groundwater Monitoring Factual Report – Round 1 to Round 8** **Ref: 1666099-005-R-RevA (Round 1)** **Ref: 1666099-006-R-RevA (Round 2)** **Ref: 1666099-007-R-RevA (Round 3)** **Ref: 1666099-008-R-RevA (Round 4)** **Ref: 1666099-009-R-RevA (Round 5)** **Ref: 1666099-010-R-RevA (Round 6)** **Ref: 1666099-011-R-RevA (Round 7)** **Ref: 1666099-012-R-RevA (Round 8)**
Report objectives	To provide results of the first round of groundwater monitoring for the Western Harbour Tunnel and Beaches Link project geotechnical investigation. Groundwater monitoring round one is the first of eight monitoring reports over a 12-month period: once per month for six months and then once per quarter for two months.
Report scope	Groundwater monitoring was conducted in wells installed in boreholes drilled as part of the Geotechnical investigations completed by Golder-Douglas. The scope of work for the groundwater monitoring included: • Installation of standpipes in 12 of the geotechnical investigation boreholes. • Installation of multi-level vibrating wire piezometers in five of the geotechnical investigation boreholes. • Development of newly installed groundwater wells. • Deployment of pressure transducers and hydrasleeves in new wells. • Downloading of groundwater data from newly installed wells and piezometers. • Collection of groundwater samples and subsequent analysis for a predetermined suite of chemical analyses (heavy metals, MAH, PAH, TPH, and water quality parameters). • Preparation of the Groundwater Monitoring Factual Reportd (GWFR). This report is factual only and does not provide discussion or interpretation of the results.
Key findings	The report presents factual information based on the results of the groundwater monitoring program. Of relevance to the Beaches Link and Gore Hill Freeway Connection project are results recorded at the following locations. • B114A (terminated in sandstone at 32 mbgl) – Lambs Road, Artarmon. • B127A (terminated in sandstone at 38.95 mbgl) – Bangaroo Street, Balgowlah • B134A-a (terminated in sandstone at 27 mbgl) – Flat Rock Baseball Diamond, Willoughby • B134A-b (terminated in sandstone at 32.5 mbgl) - Flat Rock Baseball Diamond, Willoughby • B134A-c (terminated in sandstone at 76.35 mbgl) - Flat rock Baseball Diamond, Willoughby

- B238 (location not shown on image) (terminated in sandstone at 144 mbgl) – Sailors Bay Road, Northbridge

Results from the chemical analyses were compared against the following criteria:

- ANZECC 2000 (freshwater and marine 95% species protection).
- Australian Drinking Water Guidelines (NHMRC 2011).
- Recreational guidelines (NHMRC 2008).
- HSL A/B for Vapour Intrusion (NEPC 2013).

Round 1 was completed between August and November 2017. The following results were reported above adopted criteria:

- Artarmon (B114A)
  - Marine 95% - Cobalt, pH, total phosphorous
  - Freshwater 95% EC, pH
- Balgowlah (B127A)
  - Marine 95% - pH, total phosphorous
  - Freshwater 95% - EC
- Willoughby (B134A-a, B134A-b)
  - Marine 95% - Cobalt, pH, ammonia, total phosphorous
  - Freshwater 95% - EC and ammonia
  - ADWG – Manganese, benzene
- Northbridge (B238)
  - Marine 95% - pH, ammonia, total phosphorous
  - Freshwater 95% - EC, pH, ammonia
  - ADWG – Benzene

Round 2 was completed between 7 and 16 November 2017. The following results were reported above criteria for Artarmon, Willoughby and Northbridge:

Artarmon (B114A)

- Marine 95% - Cobalt, total phosphorous
- Freshwater - 95% EC
- ADWG – Manganese

- Balgowlah (B127A)
  - Marine 95% - total phosphorous
  - Freshwater 95% - EC
- Willoughby (B134A-a, B134A-b)
  - Marine 95% - Cobalt, pH, total phosphorous
  - Freshwater 95% - EC, pH
  - ADWG – Manganese, benzene
- Northbridge (B238)
  - Marine 95% - pH, ammonia
  - Freshwater 95% - EC
  - ADWG – Benzene

Round 3 was completed between 6 and 7 December 2017. The following results were reported above criteria for Artarmon, Willoughby and Northbridge:

- Artarmon (B114A)
  - Marine 95% - pH
  - Freshwater 95% - EC
  - ADWG – Manganese
- Balgowlah (B127A)
  - Marine 95% - pH, reactive and total phosphorous
  - Freshwater 95% - EC, pH
- Willoughby (B134A-a, B134A-b, B134A-c)

- Marine 95% - pH, cobalt, manganese, ammonia, total phosphorous
- Freshwater 95% - EC, pH, manganese, ammonia
- ADWG – Manganese

- Northbridge (B238)
  - Marine 95% - pH, ammonia, total phosphorous
  - Freshwater 95% - EC, pH, ammonia
  - ADWG – Benzene

Round 4 was completed between 10 and 12 January 2018. The following results were reported for Artarmon, Willoughby and Northbridge:

- Artarmon (B114A)
  - Marine 95% - Cobalt, pH, total phosphorous
  - Freshwater 95% - EC, pH
  - ADWG – Manganese
- Balgowlah (B127A)
  - Marine 95% - Cobalt, copper, zinc, total phosphorous
  - Freshwater 95% - Copper, nickel, zinc, EC
  - ADWG – Chromium, lead, manganese, nickel
- Willoughby (B134A-a, B134A-b, B134A-c)
  - Marine 95% - Chromium, cobalt, copper lead, pH, ammonia, total phosphorous
  - Freshwater 95% - Cadmium, chromium, copper, lead, manganese, nickel, zinc, EC, pH
  - ADWG – Arsenic, chromium, lead, manganese, nickel
  - Recreational – Lead, sulphate (as SO4)
- Northbridge (B238)
  - No data tabulated for Round 4 / lab certificates provided

Round 5 was completed between 6 and 7 February 2018. The following results were reported for Artarmon, Willoughby and Northbridge:

- Artarmon (B114A)
  - Marine 95% - Cobalt, phosphorous
  - Freshwater 95% - EC, pH
  - ADWG – Manganese
- Balgowlah (B127A)
  - Marine 95% - Total phosphorous
  - Freshwater 95% - EC
- Willoughby (B134A-a, B134A-b, B134A-c)
  - Marine 95% - Cobalt, zinc, ammonia, phosphorous
  - Freshwater 95% - Manganese, nickel, EC, pH, ammonia
  - ADWG – Sulphate (as SO4)
- Northbridge (B238)
  - No data tabulated for Round 4 / lab certificates provided

Round 6 was completed between 7 and 8 March 2018. The following results were reported for Artarmon, Willoughby and Northbridge:

- Artarmon (B114A)
  - Marine 95% - Phosphorous
  - Freshwater 95% - Zinc, EC, pH
  - ADWG – Manganese
- Balgowlah (B127A)
  - Marine 95% - Total phosphorous
  - Freshwater 95% - EC
- Willoughby (B134A-a, B134A-b, B134A-c)
  - Marine 95% - Cobalt, pH, ammonia, phosphorous

- Freshwater 95% - Manganese, zinc, EC, pH
- ADWG – Sulphate (as SO4)

- Northbridge (B238)
  - Marine 95% - pH, ammonia
  - Freshwater 95% - EC

Round 7 was completed between 13 June and 02 July 2018. The following results were reported for Artarmon, Willoughby and Northbridge:

- Artarmon (B114A)
  - Sampling not conducted due to significant damage to groundwater monitoring well
- Balgowlah (B127A)
  - Marine 95% - Cobalt, pH, total phosphorous
  - Freshwater 95% - EC
  - ADWG - Manganese
- Willoughby (B134A-a, B134A-b, B134A-c)
  - Marine 95% - Cobalt, pH, ammonia, phosphorous
  - Freshwater 95% - Manganese, EC, pH
  - ADWG – Sulphate (as SO4)
- Northbridge (B238)
  - Marine 95% - pH, ammonia
  - Freshwater 95% - EC

Round 8 was completed between 24 October and 7 November 2018. The following results were reported for Artarmon, Willoughby and Northbridge:

- Artarmon (B114A)
  - Marine 95% - Cobalt, zinc
  - Freshwater 95% - EC, pH
  - ADWG - Manganese
- Balgowlah (B127A)
  - Marine 95% - Total phosphorous
  - Freshwater 95% - Zinc, EC, pH
- Willoughby (B134A-a, B134A-b, B134A-c)
  - Marine 95% - Cobalt, nickel, zinc, pH, ammonia, phosphorous
  - Freshwater 95% - Boron, copper, manganese, EC, pH, ammonia
- Northbridge (B238)
  - Marine 95% - pH, ammonia
  - Freshwater 95% - EC, ammonia

No interpretation was conducted by the Consultants for groundwater quality monitored.

AECOM (2017c)	**AECOM (20 December 2017)** **Western Harbour Tunnel and Beaches Link Groundwater Monitoring Report 3 – November 2017.Ref 60537922-RPEM_0024A**
Report objectives	The objectives of the report were: • To conduct geotechnical, groundwater and contamination investigations located within the suburbs of Rozelle, Balmain, Waverton, North Sydney, Neutral Bay, Cammeray, Artarmon, Northbridge, Seaforth, Balgowlah, Killarney Heights, and Frenchs Forest along the alignment of the Western Harbour Tunnel and Beaches Link alignment. • To provide factual data to support the characterisation of the subsurface conditions along the proposed alignment which will inform the reference design and environmental assessment. • To collect groundwater levels to assess the natural groundwater level fluctuations and the presence of perched water. • To investigate the presence of contaminated groundwater.

Report scope	Groundwater monitoring wells were installed at 15 locations for monthly monitoring over eight groundwater data collection events, each month for the first six months followed by two additional quarterly events. The monitoring was completed in September 2018. The scope of the groundwater monitoring program included: • Installation of 15 standpipe piezometers at selected sites. • Packer testing (hydraulic conductivity) – results presented in GFR1 and GFR2. • Installation of groundwater level monitoring devices. • Slug testing to estimate horizontal hydraulic conductivity. • Collection of physio-chemical groundwater quality parameters. • Collection and analysis of laboratory samples for aggressivity, major cations and anions, and eleven priority dissolved metals.
Key findings	Regional groundwater flow is driven by secondary porosity and fracture flow associated with faults or fracture zones and is varied in nature. The primary porosity is low and zones without fractures or other structural features have low groundwater yield. Water quality is variable and generally improves with depth, distance from the harbour (and where there is no overlying Ashfield Shale). Specific to the Beaches Link Gore Hill Freeway Connection project, the groundwater monitoring wells were installed at the following locations: • Balgowlah Cycleway – North Balgowlah • Edgecliffe Esplanade – Seaforth • Ponsonby Parade – Seaforth • McMillan Street – Seaforth • Elliot Street – North Sydney • Small Street – Willoughby • Bega Road – Northbridge • Wakehurst Parkway, Killarney Heights and Frenchs Forest • Warringah Freeway – North Sydney • Minnamurra Road – Northbridge • Harwood Place – Seaforth Groundwater samples were tested for selected suite of contaminants of potential concern. The report was a factual report without any interpretation of data.
AECOM Coffey (2018)	**AECOM Coffey (16 April 2018)** **Western Harbour Tunnel and Beaches Link – Contamination Factual Report (CFR)** **Ref: 60537922**
Report objectives	To conduct geotechnical and contamination site investigations for packages 1b and 3 of the Western Harbour Tunnel and Beaches Link Project in the suburbs of Rozelle, Balmain, Blues Point, North Sydney, Northbridge, Cremorne, Cammeray, Mosman, the Spit, Seaforth, Balgowlah, Fairlight, Manly, Brookvale, Pittwater, and Warringah. The objectives were as follows: • To obtain waste classification data for material that may be excavated during upgrade works to a depth of 1 mbgl. • To establish baseline conditions at proposed construction site locations. • To obtain waste classification data from construction site locations for material that may be excavated in the vicinity of proposed portal and decline areas.
Report scope	The CFR presents the data for soil samples collected and analysed for CoPC during the geotechnical investigation for Western Harbour Tunnel and Beaches Link alignment, covering fieldwork completed along the project route between 25 July 2017 and 20 September 2017. It is noted that this CFR report is complementary to the Geotechnical Investigations Factual Report 1 (GFR1) which contains data collected up to 14 August 2017 and the Geotechnical Investigations Factual Report 2 (GFR2) which contains data collected between 15 August 2017 and 20 September 2017, and to the monthly groundwater monitoring reports. This report is factual only and does not provide interpretation of the results.

Key findings	Soils were collected from the following locations within the Beaches Link and Gore Hill Freeway project: • Balgowlah golf course (B128) • Wakehurst Parkway (B173-B175, B362-B368, B371, B372) • Warringah Freeway (B304-B307, B312-B314, B323, B327-B332, B337, B340, B342, B343, B348, B349) • Gore Hill Freeway (B354, B358) • Balgowlah Connection (B382, B386) Soils were tested for: • All locations - TRH, BTEX, PAHs, metals, asbestos, and OCP/OPPs. • Gore Hill Freeway – VOCs, PCBs. Soils were compared against open space and commercial/industrial land use scenarios, and waste classification guidelines criteria. The following findings were presented for soil impacts exceeding the adopted criteria: • Copper exceeded the EIL at B348 (Warringah Freeway). • Nickel exceeded the adopted EIL in several samples at Wakehurst Parkway and Gore Hill Freeway. • BaP exceeded the adopted ESLs along the Warringah Freeway and Wakehurst Parkway. • BaP TEQ exceeded HIL C in most samples. • TRH C16-C34 exceeded the ESL in B305 (Warringah Freeway) and B371 (Wakehurst Parkway). • Asbestos was detected at surface in one sample at B340 (Warringah Freeway).
DPGA (2018a)	**Douglas Partners Golder Associates (14 May 2018)** **Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Geotechnical Factual Report – Land Investigations Ref: 1666099-004-R-RevC**
Report objectives	To collect information for the design of alternative tunnelling options at Rozelle, Balmain, Birchgrove, Waverton, North Sydney, Willoughby, Northbridge, Seaforth, and Balgowlah.
Report scope	This Geotechnical Factual Report – Land presents factual results of the terrestrial geotechnical investigation along the proposed tunnel alignments. The contamination investigation is reported in Douglas Partners Golder Associates (25 May 2018) CFR – Land Investigations. The scope of the investigations were limited to geotechnical studies, including continuous methane monitoring during drilling for safety purposes, at Flat Rock Creek, Naremburn/Willoughby. Groundwater monitoring wells were installed in 12 of the land investigation boreholes. This report is factual only and does not provide interpretation of the results.
Key findings	The report presents factual information based on the results of the geotechnical investigations. The following key findings were considered of particular relevance to the Beaches Link and Gore Hill Freeway Connection project: • The topography along the alignment has locally been modified by excavation and the placement of fill. • Around the harbour fill has been placed as part of reclamation activities. • The report identifies the existence of a former landfill at Flat Rock Creek. • Combustible gas was not detected whilst drilling the boreholes in Flat Rock Creek, Willoughby (B176A, B134A-a, B134A-b and, B134A-c). • Subsurface conditions reported in borelog BH134A-a in the Flat Rock Creek former landfill are described as follows: - 0 - 0.15 mbgl CLAY: Brown, filling with some medium grained sand and some rootlets (with grass cover). - 0.15 – 1.5 mbgl CLAY: Brown and grey, filling with some sand, sandstone and shale gravel and cobbles and some building rubble (bricks, concrete and steel reinforcement). - 1.5 – 3.0 mbgl SAND: Brown, medium grained sand, filling with some brown and grey silty clay, brick (fragments and whole), shale gravel and cobbles, timber and some igneous rock cobbles (railway ballast).

- 3.0 – 27 mbgl SILTY CLAY: Brown and grey, filling with some sandstone and shale gravel, cobbles and boulders, timber, igneous rock gravel (road base) and cobbles (railway ballast), silty sand, timber, concrete and brick rubble silt.

- Subsurface conditions reported in borelog BH134A-b in the Flat Rock Creek former landfill are described as follows:
  - 0 - 0.15 mbgl CLAY: Brown, filling with some medium grained sand and some rootlets (with grass cover).
  - 0.15 – 1.5 mbgl CLAY: Brown and grey, filling with some sand, sandstone and shale gravel and cobbles and some building rubble (bricks, concrete and steel reinforcement).
  - 1.5 – 3.0 mbgl SAND: brown, medium grained sand, filling with some brown and grey silty clay, brick (fragments and whole), shale gravel and cobbles, timber, and some igneous rock cobbles (railway ballast).
  - 3.0 – 19 mbgl SILTY CLAY: brown and grey, filling with some sandstone and shale gravel, cobbles and boulders, timber, igneous rock gravel (road base) and cobbles (railway ballast), silty sand, timber, concrete and brick rubble.
  - 19 – 20 mbgl Concrete
  - 20 – 31 mbgl SANDY CLAY: grey, brown and red-brown, and sandstone filling with a trace of ironstone and igneous rock gravel and some concrete rubble.
  - 31 – 32.5 mbgl Mix of sandstone and sandy clay, with some possible filling.
- Subsurface conditions reported in borelog BH134A-c in the Flat Rock Creek former landfill are described as follows:
  - 0 - 0.13 mbgl CLAY: Brown, filling with some medium grained sand and some rootlets (with grass cover).
  - 0.13 – 33.3 mbgl CLAY: Brown and grey, filling with some sand, sandstone and shale gravel and cobbles and some building rubble (bricks and concrete), interspersed with layers of large boulders and rubble.
  - 33.3 – 76.35 mbgl SANDSTONE and SILTSTONE.

'FILL' in boreholes drilled within the former landfill occur at depths typically >30m below ground surface.

DPGA (2018b)	**Douglas Partners Golder Associates (25 May 2018)** **Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Contamination Factual Report – Land Investigations. Ref: 1666099-003-R-RevC**
Report objectives	To provide information on the chemical quality of the soil at several locations along the proposed alignment.
Report scope	The CFR presents the data for soil samples collected and analysed for CoPC during the geotechnical investigation for Western Harbour Tunnel and Beaches Link alignment, covering fieldwork completed along the entire proposed route from Rozelle to the Northern Beaches. Land based contamination investigations were conducted along the alignment of the proposed tunnel beneath Rozelle, Balmain, and Birchgrove, Waverton, North Sydney, Willoughby, Northbridge, Seaforth, and Balgowlah. Samples were collected from four boreholes along the route of the project, and analysed for contamination impacts. This report is factual only and does not provide interpretation of the results.
Key findings	The report identifies there is a former landfill at Flat Rock Creek. Soils were collected from the following four boreholes at three locations within the Beaches Link and Gore Hill Freeway project: • Artarmon (B114A) • North Balgowlah/Seaforth – Barangaroo Street and Kempbridge Avenue (B127A and B129A) • North Balgowlah – Myrtle Street (B242) Soils were tested for TRH, BTEX, PAHs, heavy metals, PCB, asbestos (presence/absence), VOCs, VHCs and OCP/OPPs. Soils were compared against HIL A and EIL/ESL for Areas of Ecological Significance. The following findings were presented for soil impacts exceeding the adopted criteria: • TRH F3 (max, 4560 mg/kg) exceeded the adopted ML and HIL A at surface at B129A and B242.

	• BaP (max, 67.3 mg/kg) exceeded the adopted ESL at surface and at depth at B114A, B129A and B242. • Total PAH (max, 657.1 mg/kg) and BaP TEQ (max, 86.6 mg/kg) exceeded the adopted HIL at surface at B242 and B129A. • Various heavy metal exceedances were reported at all four locations.
DPGA (2018c)	**Douglas Partners Golders Associates (9 August 2018)** **Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Contamination Factual Report - Marine Investigations. Ref: 1666099-001-R-Rev C**
Report objectives	The main objective of the marine component of the contamination assessment was to collect information to assess the requirements for offshore disposal of the dredged sediment, if immersed tube tunnel (IMT) options are chosen. The scope of work was intended to meet the overall requirements of the National Assessment Guidelines for Dredging (NAGD, 2009). However, if an IMT option is selected, additional work would be required to fully comply with the NAGD. In addition, potential contamination at proposed harbour-side tunnel construction sites was assessed.
Report scope	The scope of work was designed based on the understanding that dredging and offshore disposal of sediments are strategies under consideration as part of the construction of the project (subject to approval by the Determining Authority). The investigation was completed to better understand the contamination status of the sediments and whether dredging and offsite disposal are feasible options. The scope of work completed for the marine sediment investigation is summarised as follows: • Collection of sediment samples from 35 sampling locations from Middle Harbour and Sydney Harbour using vibracore methods. • Collection of surficial sediment samples from 53 locations in Berrys Bay and the Spit using grab sampling methods. • Collection of surficial sediment samples from 5 locations within White Bay. • Collection of water samples from within White Bay and Middle Harbour. • Subsequent analysis of the sediments and water for prescribed parameters in general accordance with the NAGD 2009. • Implementation of a quality assurance and quality control program. This report is factual only and does not provide discussion or interpretation of the groundwater conditions and contamination results.
Key findings	Marine investigations were conducted to establish baseline contamination conditions for the upper sediment profile, as these have been identified as possible construction zones. Of relevance to the Beaches Link and Gore Hill Freeway Connection road project are results reported at the following locations: • Site reference 16 – Middle Harbour Crossing (15 sediment sampling locations) - B499W to B503W, B505W to B507W (grab samples to 0.2 m depth) - B511W, B117WA_VC to B122WA_VC (vibracore samples to >3 m depth) - Samples (0.0 to 1.0 m depth) for elutriate analysis were collected from 5 locations in Middle harbour • Site reference 18 – The Spit Reserve (25 grab sampling locations, area of 40,920 m^3) - B452W to B476W (grab samples) • Sea water samples were collected in Middle Harbour to provide representative water for elutriate testing of selected sediment samples. • VOC concentrations were measured in the headspace of collected sediment samples using a PID. Samples were tested for TRH, PAH, OCP, OPP, heavy metals, PCBs, DBT, MBT, TBT, dioxins and furans, PBDEs, HBCDs, pH, SPOCAS and Cr+-, cyanide, phenoxy acid herbicides, VHCs, radionuclides, and PFAS substances. Results of testing were compared against the following criteria: • Sediment and waste classification guidelines. • Sediment quality guidelines specified in National Assessment Guidelines for Dredging 2009 (NAGD 2009) (CoA 2009).

	• High and low interim sediment guideline criteria (ISGC). • NSW EPA Waste Classification Guidelines. The following exceedances of the adopted criteria were reported in Middle Harbour: • Tributylin exceeded the NAGD 2009 guidelines and ISGC-Low criteria • Heavy metals variably exceeded the ISGC-Low and ISGC-High criteria in several locations. • TRH F1 exceeded the NAGD 2009 guidelines • TRH +C10-C40 exceeded the NAGD 2009 guidelines • OCPs exceeded the ISGC-Low criteria • PAHs variably exceeded the ISGC-Low, ISGC-High and NAGD 2009 criteria The following exceedances of the adopted criteria were reported in The Spit: • Heavy metals variably exceeded the ISGC-Low criteria. • PAHs exceeded the ISGC-Low criteria. The following analytes exceeded the NSW EPA Waste Classification criteria CT1: • BaP • Lead
AECOM (2018)	**AECOM (22 November 2018)** **Western Harbour Tunnel and Beaches Link – Groundwater Monitoring Report 6 – April to September 2018. Ref: 60537922-RPEM_0031A**
Report objectives	The report objectives were as follows: • To conduct geotechnical and contamination site investigations for packages 1b and 3 of the Western Harbour Tunnel and Beaches Link Project in the suburbs of Rozelle, Balmain, Waverton, North Sydney, Neutral Bay, Cammeray, Artarmon, Northbridge, Seaforth, Balgowlah, Killarney Heights, and Frenchs Forest, to provide baseline conditions for input into the EIS. • To provide factual data to support the characterisation of the subsurface conditions along the proposed alignment. • To collect groundwater levels to assess the natural groundwater level fluctuations and the presence of perched water. • To investigate the presence of contaminated groundwater.
Report scope	Groundwater monitoring wells were installed at 18 locations for monthly monitoring over eight data collection events, each month for the first six months followed by two additional quarterly events. The monitoring was completed in February 2019 for the last wells that were installed. The 18 locations were selected to intersect groundwater from the major aquifers (Alluvium/Fill and Hawkesbury Sandstone) along the project alignment. The screened interval was selected opposite the expected tunnel depth or adjacent infrastructure where this information was known. The scope of the groundwater monitoring program included: • Installation of 15 standpipe piezometers at selected sites. • Ongoing monitoring of the piezometers. • Packer testing (hydraulic conductivity) – results presented in GFR1 and GFR2. • Installation of groundwater level monitoring devices. • Slug testing to estimate horizontal hydraulic conductivity. • Collection of physio-chemical groundwater quality parameters. • Collection and analysis of laboratory samples for aggressivity, major cations and anions, and eleven priority dissolved metals.
Key findings	Regional groundwater flow is driven by secondary porosity and fracture flow associated with faults or fracture zones and is varied in nature. The primary porosity is low and zones without fractures or other structural features have low groundwater yield. Water quality is variable and generally improves with depth, distance from the harbour (and where there is no overlying Ashfield Shale). Specific to the Beaches Link Gore Hill Freeway Connection project, the groundwater monitoring wells were installed at the following locations: • B128 (terminated in sandstone at 19 mbgl) – Balgowlah Cycleway, North Balgowlah. • **B138P (terminated in sandstone at 137/129.1 mbgl) – Edgecliffe Esplanade, Seaforth.** • B140 (terminated in sandstone at 113.39 mbgl) – Ponsonby Parade, Seaforth.

- B141(terminated in sandstone at 100.16 mbgl) – McMillan Street, Seaforth.
- **B150P (terminated in sandstone at 43/29.3 mbgl) – Elliot Street, North Sydney.**
- B154 (terminated in sandstone at 68 mbgl) – Small Street, Willoughby.
- **B155P (terminated in sandstone at 149/139 mbgl) – Bega Road, Northbridge.**
- **B173 (terminated in sandstone at 9.95 mbgl) – Wakehurst Parkway, Seaforth.**
- B174 (terminated in sandstone at 10.05 mbgl) – Wakehurst Parkway, Seaforth.
- B175 (terminated in sandstone at 10 mbgl) – Wakehurst Parkway, Seaforth.
- **B343 (terminated in sandstone at 45.33 mbgl) – Warringah Freeway, North Sydney.**

Results of the groundwater monitoring program are presented for the groundwater samples collected from locations listed **in bold** above but were not compared to the adopted site assessment criteria (ANZECC 2000).

Based on a spot check review of the heavy metals data, the following exceedances of ANZECC 2000 marine and/or freshwater 95% are summarised below:

- Cobalt, zinc in B128 – (Balgowlah Cycleway, North Balgowlah).
- Cobalt, nickel B138P (Edgecliffe Esplanade, Seaforth)
- Boron, cobalt, nickel, zinc in B150P (Elliot Street, North Sydney).
- Cobalt, copper, zinc in B173 (Wakehurst Parkway, Killarney Heights).
- Boron, cobalt, copper, manganese, nickel, zinc in B174 (Wakehurst Parkway, Seaforth).
- Cobalt, copper, manganese, nickel, zinc in B175 (Wakehurst Parkway, Seaforth).
- Cobalt, copper, zinc in B343 (Warringah Freeway, North Sydney).

AECOM (2019)	**AECOM (21 March 2019)** **Western Harbour Tunnel and Beaches Link – Groundwater Monitoring Report 7 – October 2018 to March 2019. Ref: 60537922-RPEM_0032A**
Report objectives	The report objectives were: • To conduct geotechnical and contamination site investigations for packages 1b and 3 of the Western Harbour Tunnel and Beaches Link Project in the suburbs of Rozelle, Balmain, Waverton, North Sydney, Neutral Bay, Cammeray, Artarmon, Northbridge, Seaforth, Balgowlah, Killarney Heights, and Frenchs Forest, to provide baseline conditions for input into the EIS. • To provide factual data to support the characterisation of the subsurface conditions along the proposed alignment. • To collect groundwater levels to assess the natural groundwater level fluctuations and the presence of perched water. • To investigate the presence of contaminated groundwater.
Report scope	Groundwater monitoring wells were installed at 18 locations for monthly monitoring over eight groundwater data collection events, each month for the first six months followed by two additional quarterly events. The monitoring was completed in February 2019 for the last wells that were installed. The 18 locations were selected to intersect groundwater from the major aquifers (Alluvium/Fill and Hawkesbury Sandstone) along the project alignment. The screened interval was selected opposite the expected tunnel depth or adjacent infrastructure where this information was known. The scope of the groundwater monitoring program included: • Installation of 15 standpipe piezometers at selected sites. • Ongoing monitoring of the piezometers. • Packer testing (hydraulic conductivity) – results presented in GFR1 and GFR2. • Installation of groundwater level monitoring devices. • Slug testing to estimate horizontal hydraulic conductivity. • Collection of physio-chemical groundwater quality parameters. • Collection and analysis of laboratory samples for aggressivity, major cations and anions, and eleven priority dissolved metals.
Key findings	The regional geology and hydrogeology states that groundwater flow is driven by secondary porosity and fracture flow associated with faults or fracture zones and is varied in nature. The primary porosity is low and zones without fractures or other structural features have low groundwater yield.

	Water quality is variable and generally improves with depth, distance from the harbour (and where there is no overlying Ashfield Shale). Specific to the Beaches Link Gore Hill Freeway Connection project, the groundwater monitoring wells were installed at the following locations: • B128 (terminated in sandstone at 19 mbgl) – Balgowlah Cycleway, North Balgowlah. • **B138/B138P (terminated in sandstone at 137/129.1 mbgl) – Edgecliffe Esplanade, Seaforth.** • B140 (terminated in sandstone at 113.39 mbgl) – Ponsonby Parade, Seaforth. • B141(terminated in sandstone at 100.16 mbgl) – McMillan Street, Seaforth. • B149 (terminated in sandstone at 79 mbgl) – Balgowlah Cycleway, North Balgowlah. • **B150/B150P (terminated in sandstone at 43/29.3 mbgl) – Elliot Street, North Sydney.** • B154 (terminated in sandstone at 68 mbgl) – Small Street, Willoughby. • **B155/B155P (terminated in sandstone at 149/139 mbgl) – Bega Road, Northbridge.** • **B173 (terminated in sandstone at 9.95 mbgl) – Wakehurst Parkway, Killarney Heights.** • B174 (terminated in sandstone at 10.05 mbgl) – Wakehurst Parkway, Killarney Heights. • B175 (terminated in sandstone at 10 mbgl) – Wakehurst Parkway, Frenchs Forest. • **B343 (terminated in sandstone at 45.33 mbgl) – Warringah Freeway, North Sydney.** Results of the groundwater monitoring program are presented for the groundwater samples collected from locations listed **in bold** above but were not compared to the adopted site assessment criteria (ANZECC 2000). Based on review of the data, the following exceedances of ANZECC 2000 marine and/or freshwater 95% are summarised below: • Chromium, total and reactive phosphorous in B138P (Edgecliffe Esplanade, Seaforth) • Total and reactive phosphorous, boron in B150P (Elliot Street, North Sydney). • Total and reactive phosphorous in B155P (Bega Road, Northbridge). • Chromium in B173 (Wakehurst Parkway, Killarney Heights). • Ammonia, cobalt, zinc in B343 (Warringah Freeway, North Sydney).
Cardno (2020)	**Cardno (January 2020)** **Beaches Link and Gore Hill Freeway Connection Technical Working Paper: Marine Water Quality. Ref: EIS, Appendix Q**
Report objectives	The purpose of the report is to support the EIS for the project by presenting an assessment of impacts to marine water quality to address the relevant Secretary's environmental assessment requirements. The report focuses on the water quality of Sydney Harbour and potential impacts of the project during construction and operation.
Report scope	The scope of the report includes the following items: • Review existing and historical water quality information to understand the water quality characteristics of Sydney Harbour. • Field data collection to provide ongoing turbidity and total suspended solids measurements to supplement available information. • Dredging effects simulations. • Calculate ecosystem tolerance levels/limits for turbidity and sediment deposition. • Assess operational phase impacts on Sydney Harbour water quality.
Key findings	Based on the key findings and predictions of the effects of the proposed dredging program, Cardno concluded that it is likely that the proposed program of works would have negligible effects on the marine ecosystem of Sydney Harbour. Cardno also concluded that their analysis provides a reasonable level of confidence that the management plans with designated monitoring and triggered response activities would provide the safeguards for the protection of the marine environment.

EnRiskS (2020)	**Environmental Risk Sciences (December 2020)** **Beaches Link and Gore Hill Freeway Connection Technical Working Paper: Health Impact Assessment. Ref: EIS, Appendix I**
Report objectives	The purpose of the report is to support the EIS for the project by presenting a health impact assessment to address the relevant Secretary's environmental assessment requirements.
Report scope	The report reviewed potential impacts which may occur and assessed those impacts in accordance with National guidance. The health impacts associated with contamination were assessed on the basis of Appendix M (Technical working paper: Contamination) of the EIS (Jacobs 2020a).
Key findings	Auditor review of this report was limited to potential impacts from contamination only. Specific to the objectives of the SAR, the following key findings associated with contamination were identified: • Contamination risk issues to the community were considered to be more relevant during the construction phase of the project, as exposures to contaminated soil, sediment, or groundwater would typically occur during the excavation and construction phases, if not managed appropriately. • The document identifies and lists the AEIs posing potential moderate to high risk, as identified in the Jacobs (2020a) EIS, Appendix M – Contamination. The document also acknowledges that further investigations are to be carried out in these areas to determine the extent of contamination, and if significant contamination is identified, appropriate measures are to be implemented via remediation action plans. • The document identifies that during tunnelling works, wastewater treatment plants would be set up and treated to achieve the selected criteria, and that meeting criteria would ensure that any discharges to receiving water bodies would not affect the health of the community using waterways for recreation. • Where existing groundwater contamination has been identified, the document notes that appropriate engineering controls would be installed to remove or manage the risk of any groundwater ingress to the tunnels. Treatment of any groundwater inflows would be treated to meet the adopted criteria prior to discharge. • The document identifies that various contaminants exceed the adopted guideline criteria in the top one metre of harbour sediments, and notes that PFAS and dioxin analysis was not carried out on sediment samples collected from the Spit. The document refers to the Royal Haskoning DHV (2020) Technical working paper: Hydrodynamics and dredge plume modelling, which states that elutriate tests indicate that water quality impacts at the dredging site due to contaminants in resuspended sediments entering the dissolved phase would not be expected. At the piling locations within sediments of Middle Harbour, construction activities are likely to lead to elevated total suspended solids concentrations over small areas and for periods of less than 10 minutes, and unlikely to lead to any measurable effects (based on the Cardno (2020) Technical working paper: Marine Water Quality. For sediments, the document concluded that there would be negligible impacts to recreational users where proposed management measures are adopted. • Based on a review of the potential risks posed to public safety, no issues were identified that had the potential to result in significant safety risks to the community from contamination.
Jacobs (2020b)	**Jacobs (December 2020)** **Beaches Link and Gore Hill Freeway Connection, Technical working paper: Groundwater** **Ref: EIS, Appendix N**
Report objectives	The objectives of the Technical Working Paper are to: • Estimate groundwater inflow for the proposed Beaches Link and Gore Hill Freeway Connection • Estimate groundwater drawdown as a result of the tunnel construction and operation • Estimate changes in groundwater discharge to watercourses as a result of the tunnel construction and operation Estimate the location of the freshwater-saline water interface
Report scope	The scope of the Technical Working Paper is summarised below:

- Develop a conceptual model using the hydrogeological, geologic, water levels, hydraulic testing, and tunnel design information. Construction a 3D conceptual model using the borehole and geological section data.
- Construction a 3D groundwater flow model, calibrate the steady state and transient model, model prediction during and post tunnel project construction and identify area of surface and groundwater impacts

Key findings

The key findings of the Technical Working Paper are summarised below:

- Two 3D MODFLOW model developed in Groundwater Vistas (version 7) was developed, the model was developed using the MODFLOW-USG (unstructured grid) grid with quadtree grid refinement.
- Drain conductance values were assigned to simulated tunnel inflow in the model ranged from 0.13 m2/day to 62 m2/day
- Groundwater inflow in the Cammeray to Middle Harbour Section are predicted to peak in 2025 at a rate of 16.8L/s (average inflow of 1.5L/s/km) and gradually decrease to 6.3 L/s (average inflow of 0.6 L/s/km) in 2128. The high inflow rates are a result of the high permeability zones adjacent to the proposed Middle Harbour tunnel crossing and are expected to occur during the construction phase. Also fill material deposited in the Flat Rock Creek area is overlying a highly permeable fracture zone and groundwater inflow should be monitored and mitigation measures implemented during construction of the tunnel near Flat Rock Creek.
- Groundwater inflow in the Middle Harbour to Wakehurst/North Balgowlah are predicted to peak in 2025 at 11.7L/s (average inflow of 1.2L/s/km) and decreased to 7.6L/s (average inflow of 0.8L/s/km) in 2128. The high inflow rates are a result of the high permeability zones adjacent to the proposed Middle Harbour tunnel crossing and are expected to occur during the construction phase.
- The maximum predicted water table drawdown at the end of the tunnel construction in 2027 is a 28 m near the Gorehill Freeway ramp tunnel, and 16 m near Seaforth. The maximum predicted drawdown at the tunnel elevation is 61m near the Northbridge area and 20m near Seaforth area. The water table drawdown and the drawdown at the tunnel elevation is predicted to reach the harbour on both sides of Middle Harbour near the end of the project construction. The maximum predicted water table drawdown after 100 years is 39 m near the Northbridge area, and 16m near Seaforth. The maximum water table draw down after 100 years is similar to the water table drawdown simulated at the end of construction.
- The baseflow assessment predicted a reduction of 20% of groundwater inflow to the Flat Rock Creek at the end of construction in 2027 and 39% reduction of groundwater inflow to the Flat Rock Creek in based after 100 years of operations. A reduction of 23% of groundwater inflow to the Quarry Creek at the end of construction in 2027 and 69% reduction of groundwater inflow to the Quarry Creek in based after 100 years of operations. A reduction of 79% of groundwater inflow to the Burnt Bridge Creek at the end of construction in 2027 and 96% reduction of groundwater inflow to the Burnt Bridge Creek in based after 100 years of operations. A reduction of 2% of groundwater inflow to the Manly Dam at the end of construction in 2027 and 2% reduction of groundwater inflow to the Manly Dam in based after 100 years of operations. A reduction of 0% of groundwater inflow to the Camp Creek and Sugarloaf Creek at the end of construction in 2027 and 2% reduction of groundwater inflow to the Camp Creek and Sugarloaf Creek in based after 100 years of operations. The model predicts that Willoughby Creek, Sailors Bay Creek and Berrys Creek do not receive groundwater inflow and no baseflow reduction are predicted.
- For density flow a 2D CTRAN/W-SEEP/W model was developed to assess the potential impact for saline instruction in the Northbridge area. Two 2D sections were simulated based the section that passes through the deepest tunnel section of the proposed Beaches Link project and a section near the Flat Rock Creek catchment area. The model predicted negligible saline water instruction impacts due to the distance between the proposed tunnel and the location of the inferred seawater/freshwater interface.

Royal HaskoningDHV (2020b)

Royal HaskoningDHV (December 2020)

Beaches Link and Gore Hill Freeway Connection, Hydrodynamic and Dredge Plume Modelling.Ref: EIS, Appendix P

Report objectives

To assess the potential impact of construction activities and operations related to the Beaches Link and Gore Hill Freeway Connection on the hydrodynamic and water quality of the marine environment.

The report addresses portions of SEARs 9 (Water- Hydrogeology) and 10 (Water Quality).

Report scope	• Description of the existing marine environment (hydrodynamic and water quality data). • Establishment and calibration of the three-dimensional (3D) numerical models used in the impact assessment. • Summary of the dredging methodology and assumptions as they relate to the dredge plume modelling. • Predictive modelling to assess potential construction impacts from temporary cofferdams and silt curtains on the hydrodynamics (BL7 & BL8), construction support site (BL9) on the hydrodynamics and dredging on water quality for the various stages of dredging. • Predictive modelling to assess the potential operational impacts from the immersed tube tunnels on the hydrodynamics and on the flushing characteristics of Middle Harbour upstream of the immersed tube tunnels.
Key findings	The hydrodynamic modelling impacts related to the two temporary construction phase cofferdams (BL7 and BL8) and associated deep silt curtains indicated: • Increased ebb tide current speeds around the Middle Harbour north cofferdam (BL8) at all depths and Middle Harbour south cofferdam (BL7) between the structure and the foreshore at Clive Park but only in the upper water column. • Decrease flood tide current speeds in areas surrounding BL7 and BL8 at all depths. • Small increase in current speeds during both ebb and flood tide in the middle of the channel. • Overall, changes unlikely to result in erosion or accretion of the bed of the harbour or adjacent foreshore. The hydrodynamic modelling impacts related to the Spit West Reserve construction support site (BL9) indicated: • During the ebb and flood tide currents speeds would be reduced along the foreshore surrounding the Spit West Reserve construction support site (BL9). The reductions in current speed are larger during the flood tide • The changes in current speeds are not expected to result in erosion or accretion at the bed of the harbour or foreshore. The hydrodynamic modelling of the operational impacts of the immersed tube tunnels indicated: • Changes in current speeds would be minimal. The most pronounced change would be increased current speeds at the northern bank (Seaforth) during the ebb and flood tide. • Changes in tidal water levels, tidal planes, tidal discharge at the project crossing and the tidal prism would be expected to be minimal. • Tidal flushing times would be slightly longer due to the addition of the sill-like feature created by the immersed tube tunnels; however flushing times would remain rapid. The modelling of dredge plume related water quality impacts during the construction phase incidated: • The extent of the plume of suspended sediment caused by dredging would be relatively small in comparison to the dimensions of the waterway. • Suspended sediment would be transported upstream and downstream of the project crossing, with a slight downstream dominance along the northern bank near Seaforth. • Suspended sediment levels would be higher at the bed of the harbour than at the water surface. • Suspended sediment levels would be highest inside the silt curtains, and generally low in areas outside the silt curtains. • The majority of the deposition due to the dredging activity would occur in the dredging footprint and adjacent to the dredging footprint. Areas of higher deposition would be concentrated in front of the Middle Harbour south cofferdam (BL7) and Middle Harbour north cofferdam (BL8).
EnRiskS (2021)	**Environmental Risk Sciences (16 September 2021)** **Review of Recreational Exposures During Dredging Activities** **Ref: RtS Appendix C Sediment and Marine Water Quality Memos (Appendix C2)**
Report objectives	The memo presents further review of potential recreational exposures that may occur during the proposed dredging works for the BLGHFC project. Specifically, the memo provides additional information that specifically addresses questions raised regarding recreational exposure to Middle Harbour sediments.

Report scope	To meet the objectives, the memo draws on information from the following reports to assess the potential risks from recreational exposure in Middle Harbour during the proposed dredging activities: • Appendix P – Technical working paper: Hydrodynamic and dredge plume modelling. • Appendix M – Technical working paper: Contamination.
Key findings	The key findings of the memo are as follows: • A total of nine existing recreational areas were identified within Middle Harbour, and in the vicinity of The Spit. • The proposed management measures during sediment disturbance are expected to contain mobilised sediments proximal to the proposed works. • Potential exposure to sediments may occur via incidental ingestion of water containing suspended solids and dissolved phase chemicals and via dermal contact. Any ingestion of water was considered to be incidental owing to the fact that it is saline and not palatable. • Using worst-case scenarios to assess potential risks from recreational exposures (i.e. maximum reported suspended solid concentrations of 3 mg sediment/L water, maximum reported 95% UCL contaminant concentrations, maximum elutriate concentrations, and minimum amount of dilution), no risks of concern were identified.

Appendix D Auditor Evaluation of Framework SAQP

Evaluation and Summary of Framework SAQP (GHD 2022).

Sampling Item	EPA Guidelines	Framework SAQP (GHD 2022)	Auditor Comment
Data Quality Objectives (DQOs)	"Data Quality Objectives: Outline of the DQO Process" in Schedule B2 of NEPM (2013).	Section 4.6.1 states that the site-specific SAQPs must clearly set out the DQOs for the investigation works to be completed and clearly document the completion of each of the seven-step process set out in NEPM 2013. Table 20 of Section 1.4.1 of Appendix B presents the following DQOs for the Project Specific Terrestrial AEIs (which apply only to the moderate- and high-risk sites identified in the EIS): 1. The problem: the EIS has identified potential sources of contamination which may have potential to impact human health and/or the environment during construction and operation of the project and potential future land use receptors. 2. Decisions to be made: determine the potential contamination impact at AEIs across the project, as defined in the EIS; determine the sampling and analysis required for AEIs across the project to inform future Site-specific SAQPs; understand potential risks to receptors during construction and following completion of construction works. 3. Inputs to the decision: the EIS, including Appendix M (Contamination) and Appendix N (Groundwater). 4. Study boundary: comprises the boundaries of each AEI site (B7 – B17) (presented at Appendix A, Figures 1 to 7). 5. Decision rules: if chemical concentrations exceed the soil and/or water and/or landfill gas adopted assessment criteria, assessment will be conducted to determine if these constitute unacceptable risk to potential receptors; if concentrations exceed the adopted assessment criteria, further assessment of soil and/or water and or landfill gas may be required to evaluate the need for additional investigation. 6. Limits on decision errors: based on avoiding Type I and Type II errors; DQIs will be used to assess the reliability and useability of the data. 7. Optimise design for obtaining data: achieved through implementation of the Framework SAQP, to be refined in the future by the appointed contractor(s) who will develop site-specific SAQPs through evaluation of observations and analytical results.	The data quality objectives are appropriate for the Project Specific Terrestrial AEIs.
Sampling Pattern Rationale	The EPA (1995) Sampling Design Guidelines (Section 2.3) provides details on judgmental, random, systematic, and stratified sampling pattern.	Section 1.4.2 of Appendix B states that the proposed sampling design was developed in accordance with NSW EPA Sampling Design Guidelines (1995). Based on the information presented in Section 1.4.2, Table 21, it can be inferred that a systematic (grid-based) sampling pattern has been identified for most Project Specific T-AEIs, except for the following: • B10 Bicentennial Reserve will be investigated using an approach targeted for design and waste classification purposes for tunnel route and material that comes from the road header excavation. There are no requirements for site characterisation. • B13/14 Balgowlah Golf Course & Dudley Street will likely be required to be separated into smaller sites, based on size. Section 1.5.8 of Appendix B states that LFG surface emission monitoring will be conducted along gridlines spaced 25 m apart across the inferred surface of the landfilled waste mass. Section 1.6.1.5 of Appendix B states that all fieldwork is to be conducted with reference to the relevant NEPM and PFAS NEMP guidelines which allow all samples to be collected by a set of uniform and systematic methods.	The sampling pattern to be appropriate for the conceptual site model identified.
Sampling Density Rationale:	EPA (1995) Sampling	**For soil**	The sampling density rationale is appropriate for the size of the site.

Sampling Item	EPA Guidelines	Framework SAQP (GHD 2022)	Auditor Comment
	Design Guidelines	Section 1.4.2 of Appendix B states that the proposed sampling design was developed in accordance with NSW EPA Sampling Design Guidelines (1995). Section 1.4.2 of Appendix B clarifies that the proposed sample frequencies are designed to assess site characterisation and not support waste classification. Additional sampling may be required for waste classification purposes. Section 1.4.2 of Appendix B, Table 21 provides the following soil sample densities for the construction / exit phases for each AEI (B7 – B17): • B7 Punch Street (5,900 m^2) – 15 / 15 • B8 Dickson Avenue (5,500 m^2) – 14 / 14 • B9 Flat Rock Reserve (10,400 m^2) – 24 / 24 • B10 Bicentennial Reserve (109,200 m^2) – targeted for design and waste classification purposes; no requirements for site characterisation / none as no surface works proposed • B11 Spit West Reserve (26,500 m^2) – 37 / 37 • B13/14 Balgowlah Golf Course & Dudley Street (113,000 m^2) - 135 / 135 • B15 Residential properties, Wakehurst Parkway (10,200 m^2) – 21 / 21 • B16 Sydney Water Reservoir (12,300 m^2) – 23 / 23 • B17 Wakehurst Parkway, Seaforth to Frenchs Forest – 105 / none as public road Section 1.4.2 of Appendix B, Table 21 identifies that groundwater, surface water/sediment, and landfill gas/ground gas sampling will be variably required for the Project Specific Terrestrial AEIs. **For landfill gas** Section 1.5.8 of Appendix B states that methane should be measured along grid lines spaced 25 m apart across the inferred surface of the landfilled waste mass. Where observations (such as LFG odours or bubbling through ponded water) indicate that significant LFG emissions may occur offset from the gridlines being monitored, additional sampling locations should be included to investigate these possible point sources. **Groundwater** The Auditor assumes that the requirement for groundwater investigations will be determined based on the sub-surface conditions encountered during the intrusive soil investigations, and that groundwater monitoring wells will be installed based on a site-specific basis.	
Locations Shown on Site Plan:	The NSW EPA (2020a) Consultants Reporting on Contaminated Land – Contaminated Land Guidelines requires that sampling locations are shown on a site plan.	Appendix A, Figures 1 – 10 present the locations and current boundaries of the moderate to high-risk Terrestrial AEI sites, the Crossover AEI sites, and the Marine AEI sites. Section 4.6.3 states that each site-specific SAQP must detail the sampling locations, density, depth (or similar) and the number of samples to be collected. Section 4.6.3 adds that the sampling design and plan selected must be appropriately justified as required by Appendix B of the ASC NEPM Schedule B2 Guideline on Site Characterisation (NEPC, 2013).	Sampling locations have not been presented on a site plan, however the Framework SAQP requires these details to be provided in future site-specific SAQPs. The requirement for sample locations to be included in site-specific SAQPs is appropriate.
Sampling Depths	The NSW EPA (2020a) Consultants Reporting on Contaminated Land –	Section 4.6.3 states that each site-specific SAQP must detail the sampling depth. **For soil** Section 4.6.3 states that the sampling design and plan selected must be appropriately justified as required by Appendix B of the	Sampling depths have been considered in appropriate detail for the Framework SAQP.

Sampling Item	EPA Guidelines	Framework SAQP (GHD 2022)	Auditor Comment
	Contaminated Land Guidelines requires information on the depths of samples that were collected. NEPM (2013) Schedule B2.	ASC NEPM Schedule B2 Guideline on Site Characterisation (NEPC, 2013). Section 1.5.2 of Appendix B states that the extent and depth of the soil sampling locations will be determined by the appointed contractor(s). Section 1.5.2 of Appendix B states that soil sampling should be conducted at the surface, 0.2 mbgl, 0.5 mbgl, 1 mbgl and at approximate 1 m intervals thereafter until reaching termination depth. Sediment samples should be collected just below surface level. Section 1.5.2 of Appendix B states that soil samples should not be collected across changes in soil strata or soil horizons and that additional samples should be collected where there is a change in soil strata/horizon. **For landfill gas** Section 1.5.4 of Appendix B states that landfill gas well installation should target the unsaturated (zone). Where vertical stratification of gas concentrations or multiple pathways have been identified, or where these are otherwise deemed likely, multiple wells screened at different depths or multi-port wells, should be installed. **For groundwater** Section 1.5.5 of Appendix B states that standing water levels and well depths will be determined using a water level probe. **For surface water** Section 1.5.7 of Appendix B states that where depth permits, the sample container should be positioned at least 10 cm below the surface water level, and above the sediment bed. **For landfill gas monitoring** Section 1.5.8 of Appendix B states that landfill gas monitoring will likely include landfill gas surface emission monitoring and sub-surface well monitoring. Methane should be measured approximately 50 mm above the ground level. A water level probe to be used to measure standing water levels and the depth to the base of the monitoring wells.	
Selection of Samples for Analysis:	The NSW EPA (2020a) Consultants Reporting on Contaminated Land – Contaminated Land Guidelines. NEPM (2013) Schedule B2	**For soil** Section 4.6.5 states that the analytical plan to be implemented must be detailed in the site-specific SAQPs. Section 1.3.2 of Appendix B, Table 18 states that analysis must be completed in the field and laboratory for non-friable (bonded) asbestos using the NEPM gravimetric procedure (10 L samples) and for AF/FA samples (500 ml). Section 1.5.2 of Appendix B states that soil sampling should be conducted at the surface, 0.2 mbgl, 0.5 mbgl, 1 mbgl, and at approximate 1 m intervals thereafter until reaching termination depth. Section 1.5.2 of Appendix B adds that the appointed contractor(s) is to decide how many samples are to be collected from each borehole, test pit and/or hand auger. **For groundwater and leachate** Section 1.5.5 of Appendix B states that wells should be left to recharge at least one week following development and prior to sampling. Section 1.5.5 of Appendix B states that in instances where the well is low yielding and is purged dry, it should be left to recover. Following recovery of groundwater, grab samples should be collected on the assumption that the groundwater represents the inflow from the hydrostratigraphic unit screened by the well. **For surface water**	The selection of samples for analysis was appropriate.

Sampling Item	EPA Guidelines	Framework SAQP (GHD 2022)	Auditor Comment
		Section 1.5.7 of Appendix B states that surface water samples are to be collected where the embankment of the water body is stable and the water can be safely accessed.	
Sample Splitting Techniques and Statement of QA/QC Sample Frequencies	NEPM (2013) Schedule B3 EPA (2017) Contaminated Land Management Guidelines for the NSW Site Auditor Scheme NSW EPA (2020a) Consultants Reporting on Contaminated Land – Contaminated Land Guidelines	Section 4.6.3 states that the sampling design and plan selected must be appropriately justified as required by Appendix B of the ASC NEPM Schedule B2 Guideline on Site Characterisation (NEPC, 2013). Section 4.6.4 states that the field methodologies to be implemented must be detailed in the site-specific SAQPs. Section 4.7 states that the QA/QC procedures must be prepared to comply with the requirements for QA and QC that is set out in Appendix B of the ASC NEPM Schedule B2 Guideline on Site Characterisation (NEPC, 2013). Section 1.6.1.5 of Appendix B, Table 23 provides the following QA/QC sample frequencies for soil, sediment, and water samples: • Intra-laboratory duplicates – 1 in 20 for primary analytes; 1 in 10 for PFAS analytes. • Inter-laboratory duplicates – 1 in 20 for primary analytes; 1 in 10 for PFAS analytes. • Rinsate blanks – 1 collected for every day of sampling where reusable equipment is used; analysed for metals, TRH, BTEXN, and PFAS. • Trip blanks / trip spikes – 1 for every batch of samples sent to the laboratory; trip blanks analysed for TRH (C6-C9), BTEXN, and PFAS. Section 1.6.2.1 of Appendix B provides the following laboratory quality control procedures that should be applied: • Laboratory duplicates – 1 in 20 samples per analytical batch, or 1 per batch if less than 20 samples in a batch. • Spiked samples – 1 per batch where samples are analysed for organic COPCs. • Laboratory control samples • Surrogate / spikes • Method blanks.	The sample splitting techniques meet the nominated guidelines. The QA/QC sampling frequencies for the investigations comply with NEPM (2013) requirements.
Analytical Methods:	EPA (2017) Contaminated Land Management Guidelines for the NSW Site Auditor Scheme	Section 1.3.2 of Appendix B states that selected soil and sediment samples will be analysed for non-friable (bonded) asbestos using the NEPM gravimetric procedure (10 L samples) and for AF/FA (500 ml or 1 kg samples). \ Section 1.3.2 of Appendix B states that samples identified for waste classification will be subjected to TCLP to estimate the potential for waste to release chemical contaminants into the leaching liquid. Section 1.3.5 of Appendix B states that samples for acid sulfate soil analysis will be tested for titratable peroxide acidity, titratable sulfidic acidity, and peroxide oxidisable sulfur. Section 1.5.2 of Appendix B states that unanalysed soil and sediment samples should be retained on hold in case additional laboratory analysis is required. Section 1.6.2 of Appendix B states that soil and groundwater samples are required to be submitted to a NATA accredited project laboratory for the proposed analytical suite. Section 1.6.1.4 states that drilling additives are to be analysed for PFAS, BTEXN and TRH prior to use.	The analytical methods to be appropriate for the contaminants identified.
Sample Container Selection:	NEPM (2013) Schedule B2 and B3	Section 1.6.1.1 of Appendix B states that soil, sediment, and water samples should be placed directly into dedicated, laboratory supplied sample jars and bottles.	The sample container selection is appropriate for soil, sediment, and water samples.

Sampling Item	EPA Guidelines	Framework SAQP (GHD 2022)	Auditor Comment
		Section 1.6.1.1 of Appendix B adds that when handling samples for PFAS analysis, no Teflon coated materials or aluminium foil are to be used. Section 1.6.1.1 of Appendix B states that soil samples for ASS screening tests and asbestos analysis/PACM should be placed in ziplock plastic bags.	
Sampling Devices / Techniques	NEPM (2013) Schedule B2 and B3 DEC (2007) Groundwater Guidelines	Section 1.5 of Appendix B states that the site-specific SAQPs must detail the field and analytical methodologies to be applied and justify the selection of those methods. Section 1.5.1 of Appendix B provides the following field work preparations that must be conducted prior to mobilising to site for investigation and/or monitoring: • Tailored health and safety management plan. • Obtain DBYD service drawings. • Engage service locator, drillers, licensed asbestos assessor, NATA-accredited laboratories. • Prepare laboratory consumables and sampling equipment. **For Soil** Section 1.5.2 of Appendix B states that the site-specific SAQPs must include the following methodologies (where relevant): • Samples to be collected directly off auger flights, bits, push-tubes, tow of excavator bucket, or hand auger, using disposable nitrile gloves, and ensuring no cross-contamination between soil strata layers. • Visual inspection of all samples, and record field observations on lithological logs (e.g. fill, visual, olfactory indicators of contamination. • Relevant volatile COPCs to be screened using a calibrated PID. • Extent, depth, and number of samples to be determined by the appointed contractor(s). • Samples to be collected from surface, 0.2 mbgl, 0.5 mbgl, 1 mbgl, and approximate 1 m intervals thereafter until termination depth. • Photographs to be taken of soil cores and sampling locations. Section 1.5.9 of Appendix B states that spoil generated during intrusive investigations should be used to reinstate test pits and boreholes, in the reverse order of extraction. Section 1.6.6.1 of Appendix B states that calibration certificates for field instruments are to be retained for record of correct calibration. Section 1.6.6.1 of Appendix B states that an experienced environmental scientist is to undertake the fieldwork and sampling program. **For groundwater and leachate** Refer to section in Table on Groundwater. **For surface water** Section 1.5.7 of Appendix B states the following: • Surface water samples should be collected by hand. The sample container should be positioned at least 10 cm below the surface water level, above the sediment bed, and oriented with the capped opening facing downwards to avoid the collection of surface films. • A long-handled sampler should be used where sampling points cannot be safely accessed. • The procedures apply to seepage if seepage is observed at the time of sampling.	The sampling devices / techniques adopted are appropriate for the contaminants of concern and the conceptual site model identified.

Sampling Item	EPA Guidelines	Framework SAQP (GHD 2022)	Auditor Comment
		• Surface water sampling to be conducted following rainfall events to understand the impacts of wet weather events on contamination concentrations. **For landfill gas** Section 1.5.8 of Appendix B provides the following details: • LFG monitoring will likely include LFG surface emission monitoring and land fill gas sub-surface well monitoring. • Methane surface emissions to be measured using a calibrated surface gas analyser approximately 50 mm above the ground level. A calibrated wind vane anemometer will be used to measure wind speed. • LFG related parameters to be measured in installed landfill gas sub-surface well using a calibrated gas analyser.	
Decontamination Procedures:	Australian Standard AS4482.1 – 2005 NEPM (2013) Schedule B2 and B3	Section 1.5.5 of Appendix B states that where PFAS is proposed within the analytical schedule, reusable components of the pump should be decontaminated with PFAS-free detergent (e.g., Liquinox) and laboratory supplied PFAS-free rinsate water. Section 1.6.1.2 of Appendix B provides the following decontamination procedures for reusable equipment to be conducted prior to and at completion of sampling at each sampling location: • Drilling equipment to be brushed to remove soil on the equipment and washed by high pressure water prior to first time use in the field and between sampling locations. • Sampling equipment and tools to be washed and scrubbed in tap water; followed by rinsing with PFAS-free decontamination solution (e.g., Liquinox) and deionised water. • Prior to sampling, a rinsate sample to be collected from all new equipment brought onto site using laboratory supplied PFAS free water (for analysis by primary laboratory). • All samples must be handled by field staff in accordance with HEPA (2020) requirements and using clean, disposable nitrile gloves, replaced between each sample. Section 1.6.1.2 of Appendix B states that the decontamination process should not comprise a decontamination solution or detergent containing PFAS (e.g. DECON 90). Section 1.6.1.5 of Appendix B states that rinsate blank samples will be obtained by pouring laboratory supplied deionised water over decontaminated sampling equipment into laboratory supplied bottles. One rinsate blank to be collected for every day of sampling where reusable equipment is used.	The decontamination procedures meet the nominated guidelines.
Sample Handling and Preservation Procedures:	NEPM (2013) Schedule B3 AS4482.1 and AS 4482.2	Section 1.6.1.1 of Appendix B provides the following requirements for sample collection and handling: • An experienced environmental scientist is to conduct the field work and sampling program. • All samples to be collected using new disposable nitrile gloves and placed directly into dedicated, laboratory supplied sample jars and bottles. • Sample jars and bottles to be placed into chilled insulated containers for transport to a NATA accredited laboratory. • Labels to be attached to each sampling container showing job number, date, sample location, depth, and sampler initials. • Sample details to be entered onto a Chain of Custody form to accompany the samples to the laboratory. • Chain of Custody form to be used for every batch of samples submitted to the laboratory and provide the scheduled analysis for each sample.	The sampling and handling procedures are appropriate for the contaminants of concern and the conceptual site model identified.

Sampling Item	EPA Guidelines	Framework SAQP (GHD 2022)	Auditor Comment
		• Delivery of samples to comply with sample holding times. • For PFAS analysis, no Teflon coated materials or aluminium foil to be used. All reusable sampling equipment to be made from HDPE or stainless steel and decontaminated prior to use. • Soil samples for ASS screening to be placed in zip lock bags immediately from the ground and placed into ice filled insulated containers for transport to the laboratory. • Samples for asbestos analysis and PACM to be placed into ziplock bags.	
Field Calibration and Screening Protocols	NEPM (2013) B2	**For soil and sediment** Section 1.5.2 of Appendix B states that soil samples should be screened for the presence of volatile contamination using a calibrated PID where relevant volatile COPCs are to be analysed. **For acid sulfate soil assessment** Section 1.3.5 of Appendix B states that field screening (pH_F and pH_{FOX}) for ASS at B11 to be conducted in accordance with the Acid Sulfate Soils Management Advisory Committee (ASSMAC) manual (1998). Field pH and field peroxide criteria are listed. **For groundwater and leachate** Section 1.5.5 of Appendix B states that field parameters measured during purging on a calibrated water quality meter should include at a minimum: Temperature, pH, electrical conductivity (EC), dissolved oxygen (DO) and oxidation reduction potential (ORP). Field parameters should be recorded on field data sheets. **For groundwater level and surface water gauging** Section 1.5.6 of Appendix B states that water level logging may be required to understand seasonal variation and impacts of construction. Ground level loggers (if required) to be installed within existing well casing approx. 1 m from the base of the well. Timing intervals to be determined by contractor(s) but may include every 15 minutes. The data should be validated and calibrated with manual measurements to assess accuracy of the loggers. **For surface water sampling** Section 1.5.7 of Appendix B states that field parameters including temperature, pH, EC, DO and ORP are to be measured at the time of sampling using a pre-calibrated water quality meter and recorded on field sampling sheets. Field observations such as odours or sheen presence should also be recorded on field sampling sheets. **For landfill gas monitoring** Section 1.5.8 of Appendix B states that methane should be measured using a calibrated surface gas analyser (e.g., Huberg Laser One) approximately 50 mm above the ground level along grid lines spaced 25 metres apart across the inferred surface of the landfilled waste mass. A calibrated wind vane anemometer must also be used to measure wind speeds at the site during the LFG surface emission monitoring. Section 1.5.8 of Appendix B adds that LFG related parameters are to be measured in installed landfill gas sub-surface wells using a calibrated gas analyser (e.g., GA5000). A water level probe should be used to measure standing water levels and the depth to the base of the monitoring wells. LFG related parameters to be measured and recorded on field sheets are to include at a minimum: methane, carbon dioxide, oxygen, gas balance, hydrogen sulphide, carbon monoxide, atmospheric pressure, relative (bore) pressure, gas flow. Observations (such as weather) to be recorded on field sheets. **General**	The field calibration and screening protocols to be appropriate for the contaminants of concern and the conceptual site model identified.

Sampling Item	EPA Guidelines	Framework SAQP (GHD 2022)	Auditor Comment
		Section 1.6.1.1 of Appendix B states that calibration certificates for field instruments are to be retained for record of correct calibration. **For landfill gas** Section 1.6.1.6 of Appendix B states that instruments are to be appropriately calibrated over a suitable range in accordance with manufacturer's recommendations.	
Groundwater Monitoring Well Installation	NEPM (2013) Schedule B2 DEC (2007)	Section 1.5.3 of Appendix B provides the following installation details for groundwater and leachate wells: • Groundwater wells to be installed in general accordance with the Minimum Construction Requirements for Water Bores in Australia (National Uniform Drillers Licensing Committee, 2020). • Wells to be constructed using 50 mm PVC class 18 blank and screened casings, or similar. • Screened casing slots to be no greater than 1 mm in width and screened across the water strike; leachate wells to be screened in landfill waste. • Blank and screened PVC casing to be attached to each other using flush mounted factory-threaded joints. • Primary filter pack to be silica sand (or similar) with high coefficient of uniformity, extending at least 0.5 m above the screened PVC casing. • Bentonite pellets to be used as annular sealant, extending at least 0.5 m above filter pack. • Wells to be grouted from top of bentonite to surface. • Wells to be finished with stainless steel monument cover or a flush mounted gatic cover and cemented. Section 1.5.3 of Appendix B adds that due to topographic differences across the project footprint, the length of the screen will differ between locations.	The method of construction is appropriate for the contaminants of concern and the conceptual site model identified
Groundwater Monitoring Well Development & Sampling	NEPM (2013) Schedule B2 DEC (2007) AS5667.11 (1998)	Section 1.5.5 of Appendix B provides the following monitoring well development and survey details: • Wells should be developed following completion using Teflon-free equipment by purging at least three well volumes (where possible) or until dry. • Following installation, the monitoring wells should be accurately surveyed for location and elevation.	The well development and sampling meet the nominated guidelines
Consideration of existing production, residential and other monitoring wells when determining groundwater well locations	NSW EPA (2020a)	Not discussed.	The requirement for identifying locations of existing monitoring wells is more suitable for the site-specific SAQPs.
Other considerations	n/a	Section 3 states that any previous environmental investigations conducted for AEIs, and reviewed as part of the decision-making process, must consider compliance with NSW EPA made or endorsed guidelines for contaminated sites. Section 3.5 states that the decision-making process must be documented and include a summary of findings on the review of existing reports, including the provision of a reliability assessment and relevance of the assessment to the proposed construction activities and end use. Section 4 states that the requirements for the site-specific SAQPs have been prepared to be consistent with the relevant guidelines	The requirement for the assessment of previous environmental investigations is appropriate.

Sampling Item	EPA Guidelines	Framework SAQP (GHD 2022)	Auditor Comment
		made and endorsed by NSW EPA, including the Consultants Reporting on Contaminated Land – Contaminated land guidelines (NSW EPA 2020) and the Appendix B of the National Environment Protection Measures (ASC NEPM) Schedule B2 Guideline on Site Characterisation (NEPC 2013).	

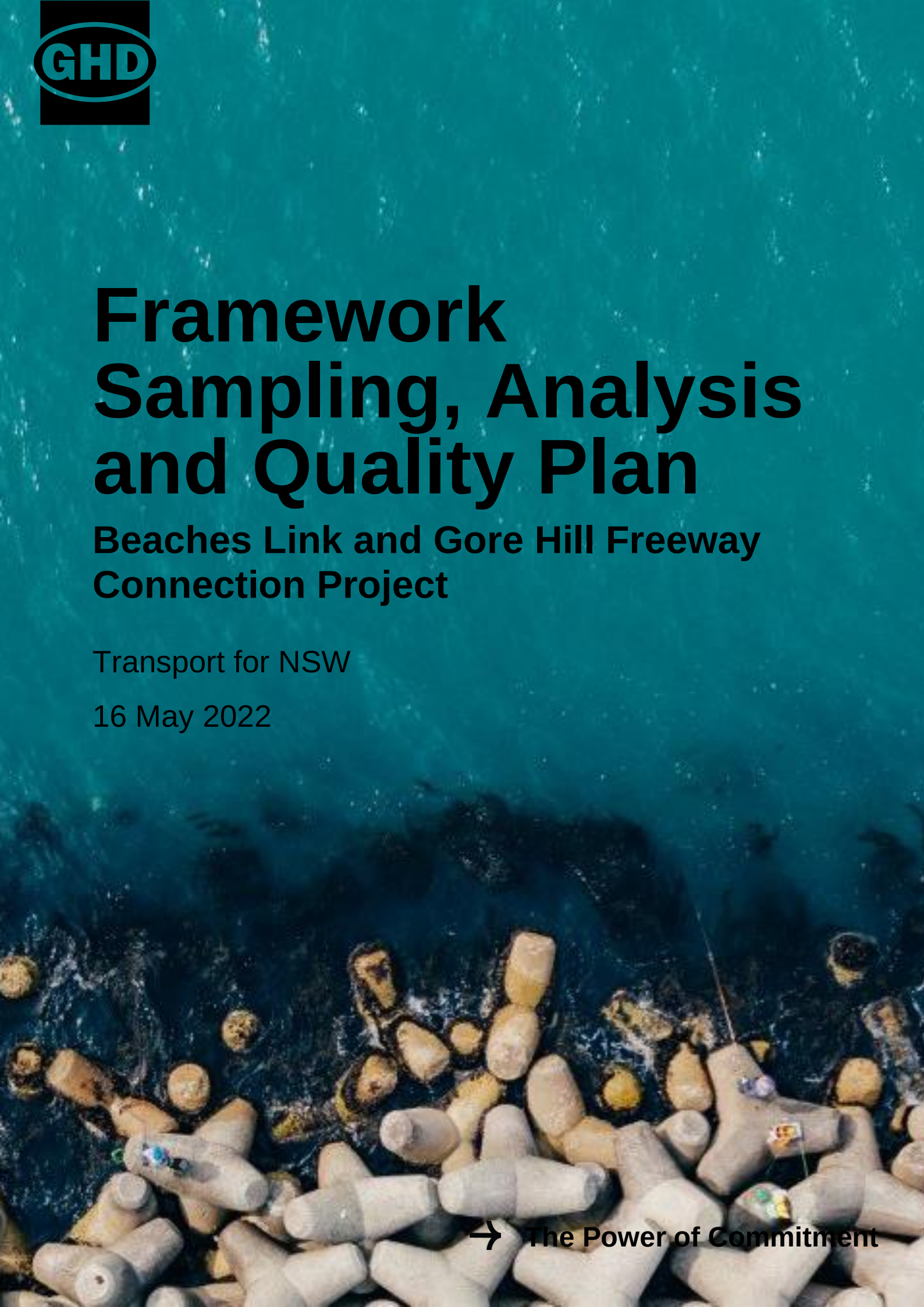
Appendix E Endorsed Framework SAQP (GHD, 2022)

Framework Sampling, Analysis and Quality Plan

Beaches Link and Gore Hill Freeway Connection Project

Transport for NSW

16 May 2022



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Executive summary

GHD Pty Ltd (GHD) was engaged by Transport for New South Wales (Transport) to develop a Framework Sampling Analysis and Quality Plan (Framework SAQP) for the Beaches Link and Gore Hill Freeway Connection project (the BLGHFC project). The BLGHFC project is part of the Western Harbour Tunnel and Beaches Link (WHTBL) program of works, proposed to provide additional road network capacity across Sydney Harbour and Middle Harbour thereby improving transport connectivity with Sydney's Northern Beaches.

Temporary construction support sites and construction sites are required as part of the BLGHFC project, and would include tunnelling and tunnel support sites, civil surface sites, laydown areas, parking, and workforce amenities. Jacobs (TfNSW, 2020b) conducted a desktop review and site inspection of these construction sites and temporary construction support sites and identified several Areas of Environmental Interest (AEIs) with a moderate to high risk of potential contamination being present. The desktop study included a review of project information, including environmental settings, project history and potential historical sources of contamination as detailed in the BLGHFC Environmental Impact Statement (EIS) (TfNSW, 2020a).

Subsequent to the lodgement of the EIS, submissions report and preferred infrastructure report (PIR), Transport has committed to the development of a Framework SAQP to provide the Department of Planning and Environment (the Department) with additional information for consideration in its assessment of the BLGHFC project. Specifically, Transport will provide the following: *A framework sampling analysis and quality plan (Framework SAQP), to set out the general context, justification and sampling and analytical framework that will be adopted post-determination in subsequent site-specific SAQPs.*

It is noted that this Framework SAQP was prepared considering the *Consultant Reporting on Contaminated Land Guidelines* (NSW EPA, 2020) and it provides framework guidance for the future development of site-specific SAQPs required for contamination investigations to be conducted post-determination. The overarching objective of the Framework SAQP is to:

– Provide Transport and the Department with the context, justification and scope of contamination sampling and analysis required across the BLGHFC project; and
– Outline the decision making process and the minimum requirements for contractor(s), in order for them to develop site-specific SAQP(s).

This Framework SAQP documents the generic assessment criteria, the sampling and analysis strategy, methodology and data quality indicators to be referenced by contractor(s) when developing their own site-specific SAQP(s) and reporting requirements.

A NSW EPA Accredited Site Auditor will be engaged to complete a Statutory Site Audit on each moderate to high risk of potential contamination AEI, in accordance with the project approval. This will include a review, as relevant, of the site-specific SAQPs and subsequent contamination investigation works.

Contents

Table index

Appendices

Glossary

Acronym	Definition
AASS	Actual acid sulfate soils
ACM	Asbestos containing materials
ASS	Acid sulfate soils
AEIs	Areas of Environmental Interest
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASSMAC	Acid Sulfate Soils Management Advisory Committee
BaP TEQ	Benzo(a)Pyrene Toxic Equivalence Quotient
bgl	Below ground level
BOD	Biochemical oxygen demand
BLGHFC	Beaches Link and Gore Hill Freeway Connection project
BTEX	benzene, toluene, ethylbenzene and xylenes
BTEXN	benzene, toluene, ethylbenzene, xylenes and naphthalene
CEMP	Construction Environmental Management Plan
CLM Act	Contaminated Land Management Act 1997
COC	Chain of custody
COD	Chemical oxygen demand
Construction footprint	The total area required to facilitate the construction of the project
Construction phase	All activities required to construct the project, including early works, site establishment, tunnelling works, surface road works, earthworks, marine works and testing and commissioning prior to operation. Construction may be staged in and across areas of the project.
Construction support site	A temporary facility required for construction of the project where a compound will be established
COPC	Contaminants of potential concern
CRS	Certified Reference Standard
CSM	Conceptual site model
CT	Contaminant threshold
DO	dissolved oxygen
DPGA	Douglas Partners and Golder Associates
DPIE	Department of Planning, Industry and Environment
DQI	Data quality indicators
DQO	Data quality objectives
DSI	Detailed site investigations
DBYD	Dial before you dig
EC	electrical conductivity
EIL	Ecological investigation levels
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
ESL	Ecological screening levels

Acronym	Definition
Exit phase	Commencement of operation of all or part of the project, including but not limited to opening up the tunnels, surface connections and other built project infrastructure for public use. Operation may be staged in and across areas of the project.
GHD	GHD Pty Ltd
HDPE	High-density polyethylene
HIL	Health investigation levels
HRF	Heavy rainfall benchmark'
HSL	Health screening levels
JSEA	Job Safety and Environmental Analysis
LAA	Licensed Asbestos Assessor
LDPE	Low-density polyethylene
LFG	Landfill gas
LGA	Local government areas
LOR	Limit of reporting
NATA	National Association of Testing Authority
NEMP	PFAS National Environmental Management Plan
NEPC	National Environment Protection Council
NEPM	National Environment Protection (Assessment of Site Contamination) Measure
NHMRC	National Health and Medical Research Council
NSW	New South Wales
OCP	Organochlorine pesticides
OPP	Organochlorine pesticides
ORP	oxidation reduction potential
PAH	Polycyclic aromatic hydrocarbons
PASS	Potential acid sulfate soils
PCBs	Polychlorinated biphenyls
PFAS	Perfluoroalkyl and polyfluoroalkyl substances
PID	Photo-ionisation detector
POEO Act	Protection of the Environment Operations Act 1997
PSI	Preliminary Site Investigation
PVC	Polyvinyl chloride
QA/QC	Quality assurance / quality control
QC	Quality control
RPD	Relative percentage difference
SAQP	Sampling Analysis and Quality Plan
SVOCs	Semi volatile organic compounds
TCLP	Toxicity characteristics leaching procedure
Transport	Transport for NSW
TRH	Total recoverable hydrocarbons
VOCs	volatile organic compounds
WHTBL	Western Harbour Tunnel and Beaches Link

1. Introduction

1.1 Project overview and background

GHD Pty Ltd (GHD) was engaged by Transport for NSW (Transport) to develop a Framework Sampling Analysis and Quality Plan (Framework SAQP) for the Beaches Link and Gore Hill Freeway Connection project (the BLGHFC project). The BLGHFC project is part of the Western Harbour Tunnel and Beaches Link (WHTBL) program of works, proposed to provide additional road network capacity across Sydney Harbour and Middle Harbour thereby improving transport connectivity with Sydney's Northern Beaches.

The BLGHFC project will comprise of a new tolled motorway tunnel connection across Middle Harbour from the Warringah Freeway and Gore Hill Freeway to Balgowlah and Killarney Heights and the surface upgrade of Wakehurst Parkway from Seaforth to Frenchs Forest. Fourteen temporary construction support sites are required as part of the BLGHFC project, and would include tunnelling and tunnel support sites, civil surface sites, laydown areas, parking and workforce amenities; and are labelled BL1 to BL14 and are presented on Figure 1 (as per the Environmental Impact Statement (EIS) (Transport, 2020b).

As part of the EIS, a Preliminary Site Investigation (PSI) (titled as a Technical Working Paper – Contamination as Appendix M of the EIS (TfNSW, 2020b)) was completed by Jacobs on the land and harbour areas to be utilised as construction support sites. The PSI comprised the completion of desktop reviews and site inspections. The results of the PSI identified that several terrestrial sites had a moderate to high potential risk of surface and/or sub-surface contamination being present, and some marine sites (within the harbour) that had a moderate to high risk of contaminated sediments being present.

These sites were nominated in the EIS as 'Areas of Environmental Interest' (AEIs). The EIS stated that, as part of the construction phase of the BLGHFC project, these sites would be subject to further investigations to assess for the presence of contamination. The results of these investigations would then be utilised to determine if any remediation and/or management would be required to be completed as part of the BLGHFC project. The location of these AEI sites is presented on Figure 2 and are labelled B1 to B17 (as per the EIS (Transport, 2020b)).

The NSW Environment Protection Authority's (EPA) submission on the BLGHFC EIS, recommended Transport be required to submit: *A Sampling and Analysis Quality Plan (SAQP) which details how the type, quantity, and extent of contamination for the areas of environmental interest will be assessed.*

Transport lodged the BLGHFC submissions report and preferred infrastructure report (PIR) with the Department of Planning and Environment (the Department) on 4 November 2021. Due to the current stage of the BLGHFC project in the design development and construction planning process, there remain many aspects of the BLGHFC project works that are not sufficiently progressed to allow for the preparation of site-specific SAQPs on the EIS nominated moderate to high risk sites that would satisfy the requirements for SAQPs set out in the NSW EPA *Guidelines for Consultants Reporting on Contaminated Sites* (NSW EPA, 2020).

Following the lodgement of submissions report and PIR, Transport has committed to the development of a Framework SAQP to provide the Department with additional information for consideration in its assessment of the BLGHFC project. Specifically, the Framework SAQP is required to satisfy the following commitments: *A framework sampling analysis and quality plan (Framework SAQP) to set out the general context, justification and general sampling and analytical framework that will be adopted post-determination in subsequent site-specific SAQPs.*

It is noted that the Framework SAQP was prepared considering the *Guidelines for Consultants Reporting on Contaminated Sites* (NSW EPA, 2020) and was also drafted with due consideration of NEPM 2013. The Framework SAQP provides guidance for the future development of site-specific SAQPs required for contamination investigation to be conducted post-determination.

The purpose of the Framework SAQP is to meet the Transport commitment outlined above to ensure that, across the different stages of the BLGHFC project, consistent decision making processes are

achieved for determining whether site-specific SAQPs are required and also the context, justification and scope of contamination sampling and analysis where site-specific SAQPs are required. The requirements of the Framework SAQP will be implemented by contractors, post contract award. The development of site-specific SAQPs will inform the investigation requirements for detailed site investigations (DSIs) or other investigation works for each AEI identified in Appendix M of the EIS as well as for any additional AEIs. The results of the DSIs or other investigation works will determine the requirements, if any, for remediation and/or management.

A NSW EPA Accredited Site Auditor will be engaged to complete a Statutory Site Audit on each moderate to high risk of potential contamination AEI, in accordance with the project approval. This will include a review, as relevant, of the site-specific SAQPs and subsequent contamination investigation works.

1.2 Categorisation of AEIs

The AEI can be categorised as follows:

– Terrestrial AEIs that have been identified by the EIS and are located within the BLGHFC project footprint only - B7 to B11, B13 to B17, herein referred to as ‘Project Specific T-AEIs’;
– Terrestrial AEIs that have been identified by the EIS and that are located within both the BLGHFC project footprint and the Western Harbour Tunnel and Warringah Freeway Upgrade (WHTWFU) project footprints, and are also subject to Infrastructure Approval SSI 8863 – B1 to B6, herein referred to as ‘Crossover T-AEIs’; and
– Marine AEIs that have been identified by the EIS and that are located are within the BLGHFC project footprint - herein referred to a ‘M-AEIs’.

In addition to these AEIs, it is noted that at the time of preparation of this document, the BLGHFC project was in its planning phase and as such, there is a potential for additional AEIs as follows:

– Additional AEIs that are not currently identified by the EIS for the BLGHFC project – herein referred to as ‘A-AEIs’.

Given these different categories of AEIs, Section 3 of this this Framework SAQP provides decision making processes to be applied to each AEI, and any future additional AEIs.

At the time of preparation of this Framework SAQP it was well understood that the Project Specific T-AEIs that are only within the BLGHFC project footprint will require the completion of further investigations, in the form of DSIs. For the Project Specific T-AEIs, this Framework SAQP summarises the information in relation to the environmental setting and history of use of the AEIs, as provided in the EIS and subsequent reports (see Appendix B). This information has been used to set out the preliminary Conceptual Site Model (CSM) and the requirements for the site-specific SAQPs that will be prepared to inform the DSIs.

For the Crossover T-AEIs, M-AEIs and A-AEIs the decision making processes set out in this document will need to be applied by the contractor(s) to determine whether site-specific SAQPs are required for DSIs or other investigative works.

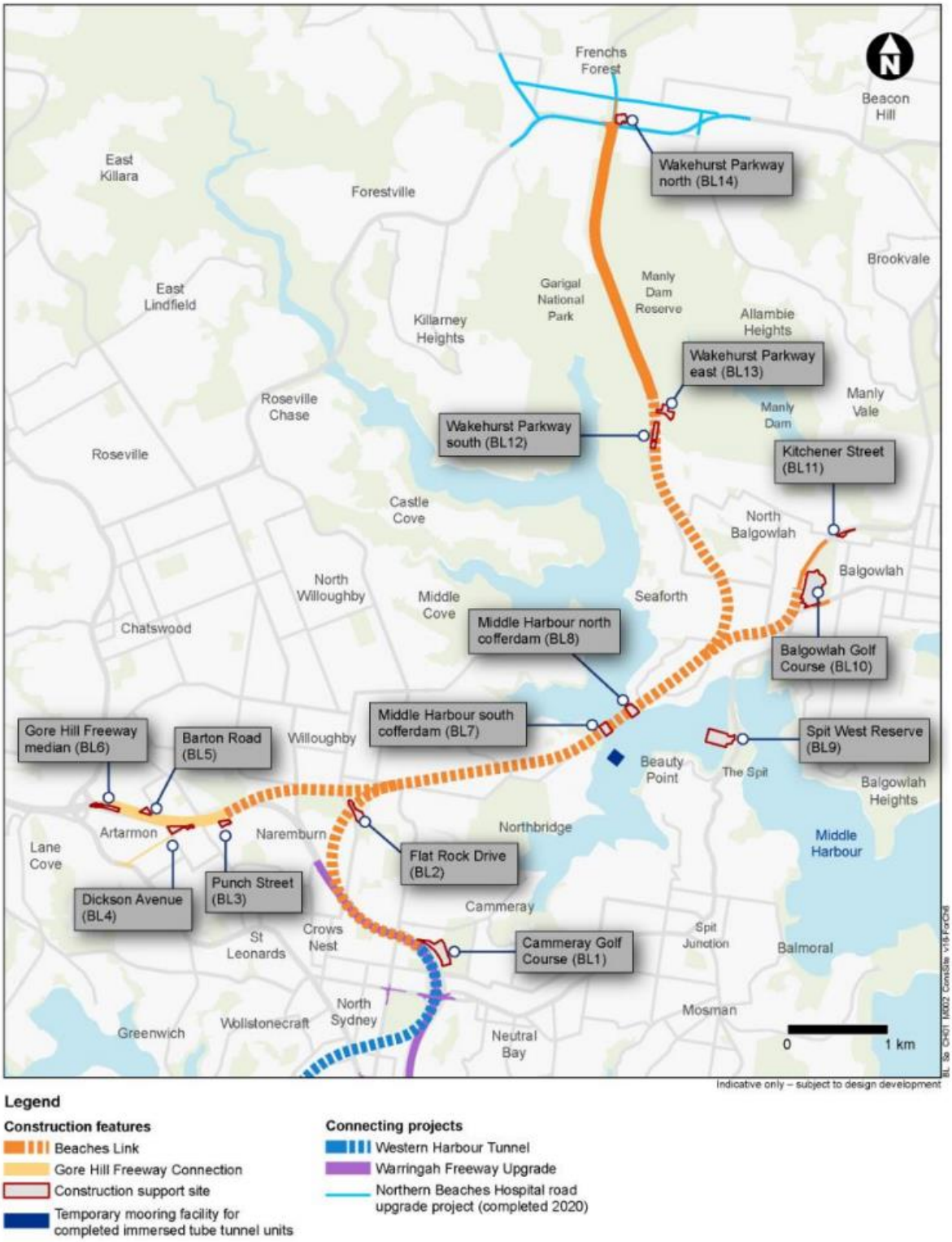


Figure 1 Overview of the construction support sites (TfNSW, 2020b)

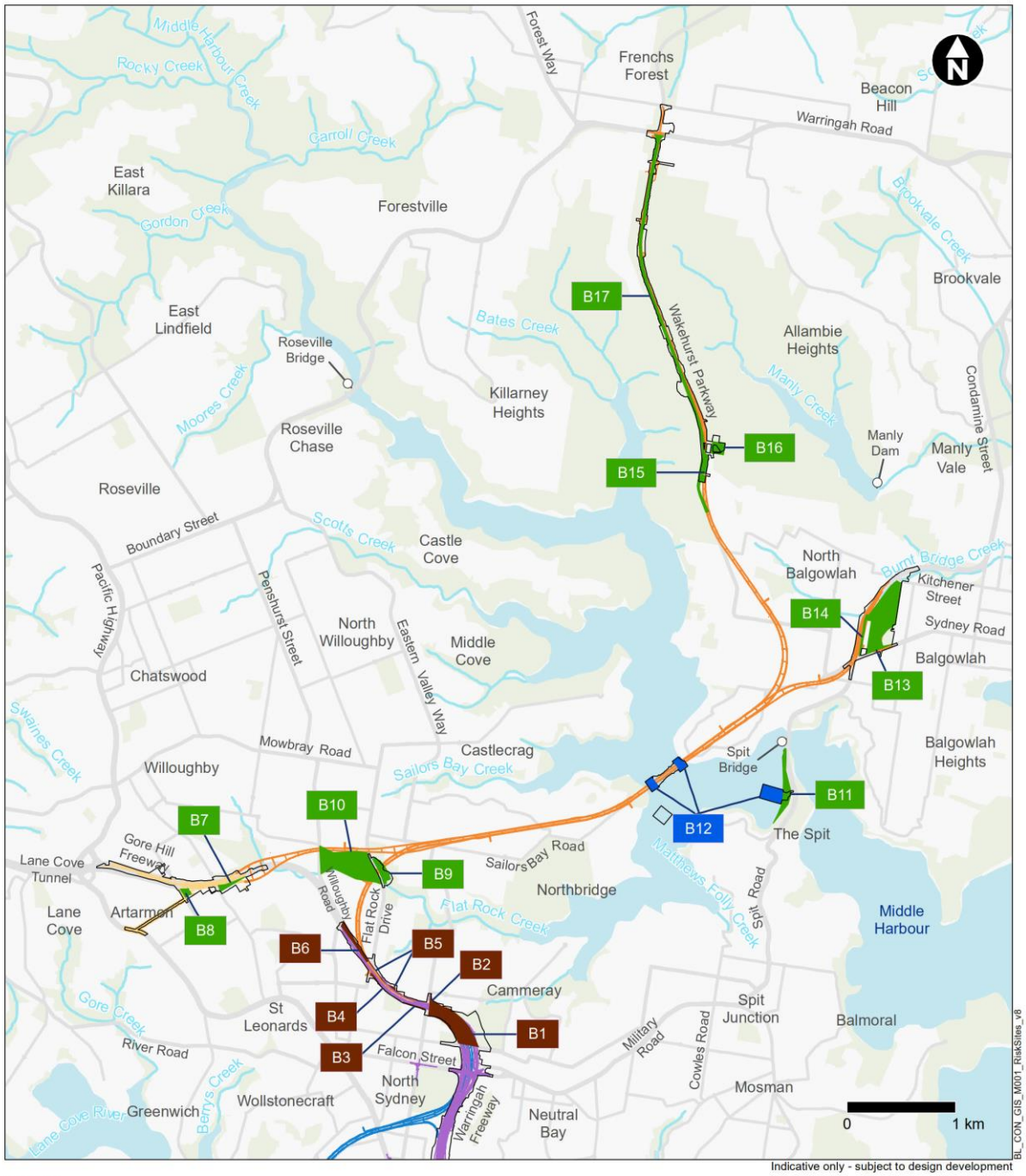


Figure 2 AEIs with moderate to high risk of contamination (TfNSW, 2020b)[1]

[1] As stated further in Section 1.3, moderate risk sites AEI B1 to AEI B6 are not considered in this Framework SAQP as they are part of the Warringah Freeway Upgrade. High risk site AEI B12 is also not considered as it is an overwater construction site as in outside the agreed scope of works for this Framework SAQP.

1.3 Objectives

The overarching objective of this Framework SAQP is:

– To provide Transport and the Department with the context, justification and scope of contamination sampling and analysis required across the BLGHFC project; and
– To outline the decision making processes and the minimum requirements for contractor(s), in order for them to develop site-specific SAQP(s).

This Framework SAQP documents the generic assessment criteria, the sampling and analysis strategy, methodology and data quality indicators to be referenced by contractor(s) when developing the site-specific SAQP(s) and reporting requirements. This allows a consistent approach to be applied across the different stages of the project.

1.4 Framework SAQP scope of work

The scope of this Framework SAQP is as follows:

– The objectives and scope of work (see Section 1.3);
– The change management process (see Section 1.8);
– The AEIs and the decision making process for site-specific SAQPs (see Section 2 and Section 3);
– The BLGHFC project identification and environmental setting (see Section 2); and
– Reporting requirements for the awarded contractor(s) (see Section 4.8).
– For Project Specific T-AEIs (see Appendix B)
    - The preliminary CSM, identifying potential sources, associated contaminants of concern (COPC), exposure pathways and receptors (See Appendix B Section 1.2);
    - The basis of the assessment, including details of the guidelines, policies and legislation that the investigation has been developed for (see Appendix B Section 1.3);
    - The data quality objectives which have been prepared in accordance with the National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM) (National Environment Protection Council (NEPC, 2013) to ensure future field investigations and analyses are undertaken in a way that enables the collection and reporting of reliable data (see Section 4.6.1);
    - The proposed sampling and analytical program, including rationale for sampling (see Appendix B)
    - The proposed sampling and analytical methodology (see Appendix B Section 1.5); and
    - Data quality indicators, including quality assurance and quality control protocols (see Appendix B Section 1.6).

1.5 Guidelines and References

This Framework SAQP has been prepared with reference to the following standards and/or guidelines. The implementation of the decision making processes and preparation of the site-specific SAQP(s) must be completed in accordance with this Framework SAQP and the guidelines and/or standards outlined below.

1.5.1 Statutory guidelines made by the NSW EPA

NSW EPA, 1995. Contaminated Sites: Sampling Design Guidelines, September 1995;

DEC, 2007. Contaminated Sites: Guidelines for the Assessment and Management of Groundwater Contamination, March 2007;

NSW EPA, 2015. Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997, September 2015;

NSW EPA, 2020a. Assessment and management of hazardous ground gases, Contaminated Land Guidelines, amended May 2020; and

NSW EPA, 2020b. Consultants reporting on contaminated land – Contaminated Land Guidelines, updated 5 May 2020.

1.5.2 Statutory guidelines approved by the NSW EPA

ANZECC & ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, October 2000;

enHealth, 2012. Environmental health risk assessment: Guidelines for assessing human health risks from environmental hazards, June 2012;

NEPC, 2013. National Environment Protection (Assessment of Site Contamination) Amended Measure 2013 (No. 1), May 2013; and

ANZG, 2018. Australian & New Zealand: Guidelines for fresh & Marine Water Quality, August 2018.

1.5.3 Non-statutory guidance documents prepared by NSW EPA

NSW EPA, 2014. Waste Classification Guidelines - Part 1 Classifying Waste, November 2014;

NSW EPA, 2016. Environmental Guidelines: Solid Waste Landfills Second edition, April 2016; and

NSW EPA, 2022. Preparing environmental management plans for contaminated land, Practice Note, January 2022 (in consultation).

1.5.4 Other publications

ASSMAC, 1998. Acid Sulfate Soil Manual, August 2018;

NHMRC, 2008. Guidelines for Managing Risks in Recreational Water. Canberra: National Health and Medical Research Council, Australian Government;

Commonwealth of Australia, 2009. National Assessment Guidelines for Dredging 2009;

Australian Government Department of Agriculture and Water Resources, 2018. National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual, June 2018;

Commonwealth of Australia, 2018. National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual;

WA DoH, 2019. Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia, May 2019;

HEPA, 2020. PFAS National Environmental Management Plan Version 2.0, January 2020; and

CRC CARE Technical Reports (www.crccare.com/publications/technical-reports).

NSW EPA (2022). Position statement — WA guidelines for asbestos contaminated sites, April 2022. This position statement has been prepared in response to the publication of the revised Guidelines for the Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia (the WA Asbestos Guidelines) by the West Australian Department of Health on 24 August 2021.

1.5.5 Australian standards

Standards Australia. (1998). Australian Standard AS/NZS 5667.6:1998 Water Quality – Sampling, Guidance on sampling of rivers and streams;

Standards Australia. (1998). Australian Standard AS/NZS 5667.9:1998 Water Quality – Sampling, Guidance on sampling from marine waters;

Standards Australia. (1998). Australian/New Zealand (AS/NZ) Standard 1998, Water Quality – Sampling Part 11: Guidance on Sampling of Groundwaters;

Standards Australia. (1998). Australian/New Zealand Standard AS/NZS 5667.1:1998: Water quality - Sampling - Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples;

Standards Australia. (1999). Australian Standard 4482.2-1999: Guide to the sampling and investigation of potentially contaminated soil guidance, Parts 2: Volatile Substances; and

Standards Australia. (2005). Australian Standard 44821.1-2005: Guide to the sampling and investigation of potentially contaminated soil guidance, Part 1: Non-volatile and semi-volatile compounds.

It is noted that within this Framework SAQP direct reference is made to specific guidelines, regulations and legislation that were in force at the time of preparation of this document. In applying this Framework SAQP those responsible must ensure that the relevant guidelines, regulations and legislation that are applied are those that are in force at that time.

1.6 Persons referred to in the Framework SAQP

In this Framework SAQP the following persons are referred to:

– Transport – Transport for NSW is the Proponent for the BLGHFC project;
– Principal Contractor(s) – The construction company engaged by Transport to deliver various stages of the BLGHFC project;
– Contractor(s) – consultant 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 to complete the works set out in this Framework SAQP as engaged by the Principal Contractor;
– Site Auditor – The NSW EPA Accredited Site Auditor engaged by Transport to review this Framework SAQP and prepare a Section B Site Audit Statement and Site Audit Report that certifies that the Framework SAQP is appropriate for its purpose and, where relevant, has been prepared in general accordance with the guidelines made or endorsed by the NSW EPA; and
– Future Site Auditor - Once project approval has been obtained, Transport will engage a NSW EPA Accredited Site Auditor to complete a site audit on all future contamination works. The scope of any future site audit(s) will include review of the outcomes of the implementation of this Framework SAQP and subsequent stages of works through the delivery of the BLGHFC project.

1.7 Project staging

Once project approval has been obtained, the BLGHFC project will be delivered over a number of stages. Whilst the final staging will be confirmed in the Staging Report, post project approval, the anticipated project staging is as follows:

– Stage 1 – Enabling and early works;
  - Balgowlah Golf Course construction site (B13/14 Balgowlah Golf Course & Dudley Street); and
  - Flat Rock Drive construction support site (B9 Flat Rock Reserve).
– Stage 2 – Gore Hill Freeway Connection project; and
– Stage 3 – Beaches Link project .

Given the size and complexity of each stage, it is likely that multiple contractors will be involved in the delivery of each stage across the various sites.

Due to the staged approach to the delivery of the BLGHFC project, the works required to ensure that contamination is assessed, remediated and / or appropriately managed will also be completed in stages as part of each package of works. This will include a staged approach to the preparation and

implementation of the site-specific SAQPs for the DSIs or other investigation works on the AEIs of moderate to high risk, and also for any subsequent remediation and/or management works required. Each contractor will be required to implement this Framework SAQP as relevant to their scope of works and specific to the land occupied by the contractor and the extent of disturbance, e.g., surface excavation, deep excavation and groundwater disturbance.

A NSW EPA Accredited Site Auditor will be engaged to complete a Statutory Site Audit on each AEI, in accordance with the project approval.

1.8 Change management

This Framework SAQP has been developed based on information available at the time of preparation which includes, but was not limited to, the BLGHFC concept design, identified AEI sites, construction and final land uses, as detailed in the EIS (TfNSW, 2020a). As with any project of the nature and scale of the BLGHFC project, the concept design will continue to be refined during future stages of detailed planning for design and delivery, which will not commence until project approval has been obtained. This will include resolution of a number of project uncertainties identified in Table 28-2 of the EIS (TfNSW, 2020a). It is expected that the outcomes of these future stages of work could result in changes to the extents of the AEIs, construction activities or intended final land use as set out in this Framework SAQP.

If additional areas are identified, the contractors will be required to investigate these areas in accordance with the process outlined in Section 3.

Any changes or inconsistencies between the information presented in this Framework SAQP and that of the site-specific SAQPs developed by the future contractor(s) will be required to be appropriately documented and justified in the site-specific SAQPs.

1.9 Limitations

This report: has been prepared by GHD for Transport for NSW and may only be used and relied on by Transport for NSW for the purpose agreed between GHD and Transport for NSW as set out in Section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than Transport for NSW arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared. The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Transport for NSW, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report, which were caused by errors or omissions in that information.

2. Summary of BLGHFC Project area

2.1 Project area identification

The BLGHFC project area spans approximately seven kilometres from the North Shore suburbs of Cammeray, Naremburn and Artarmon to North Balgowlah and Frenchs Forest. It includes the local government areas (LGA) of North Sydney, Willoughby, Mosman, Lane Cove and Northern Beaches. The location and lateral extent of the BLGHFC project is shown on Figures 1 to 10 in Appendix A.

The construction footprint for the BLGHFC project includes the total area required to facilitate the construction of the project, and includes construction support sites which are defined as temporary facilities required for construction of the project where a compound will be established.

2.2 AEIs

As discussed in Section 1.2 and Section 3, this Framework SAQP applies to sites assessed in Appendix M of the EIS (TfNSW, 2020b) and which were identified to have a moderate or high risk of contamination being present, described as AEIs, as well as any additional AEIs that maybe identified as part of the post approval detailed planning phase of the BLGHFC project.

Project Specific T-AEIs, Crossover T-AEIs and M-AEIs are listed in Table 1 using the nomenclature provided in the EIS (TfNSW, 2020a). It is noted that the numbering of construction support sites and identified AEIs differs between the same sites in the EIS (TfNSW, 2020a) and Appendix M of the EIS (TfNSW, 2020b).

Table 1 outlines the construction support site number and location as referenced in the EIS (TfNSW, 2020a), and the AEI number as referenced in Appendix M of the EIS (TfNSW, 2020b).

Table 1 Construction support site and AEI site summary

Construction support site	AEI	Location	AEI Categorisation
BL1 Cammeray Golf Course	B1/B2 Cammeray Golf Course	Cammeray Golf Course – Park Avenue, Cremorne	Crossover T-AEI
Not applicable (construction footprint interface)	B3/B4/B4/B5/B6 Unsealed areas next to Warringah Freeway	Warringah Freeway – Miller Street to Willoughby Road	Crossover T-AEI
BL3 Punch Street	B7 Punch Street	Punch Street, Artarmon	Project specific T-AEI
BL4 Dickson Avenue	B8 Dickson Avenue	Freeway Hotel, Reserve Road, Artarmon	Project specific T-AEI
BL2 Flat Rock Drive	B9 Flat Rock Reserve	Flat Rock Drive, Northbridge	Project specific T-AEI
Not applicable (construction footprint interface)	B10 Bicentennial Reserve	Willoughby Leisure Centre and Bicentennial Reserve, Willoughby	Project specific T-AEI
BL9 Spit West Reserve	B11 Spit West Reserve	Reclamation of land – Spit West Reserve, Mosman	Project specific T-AEI
BL7/BL8 Middle harbour cofferdams and dredging	B12 Middle Harbour marine works	Middle Harbour – Mosman and Northern Beaches LGAs	M-AEI
BL10 Balgowlah Golf Course	B13/14 Balgowlah Golf Course & Dudley Street	Balgowlah Golf Course at Balgowlah/Residential properties, Dudley Street, Balgowlah	Project specific T-AEI

Construction support site	AEI	Location	AEI Categorisation
BL12 Wakehurst Parkway South	B15 Residential properties, Wakehurst Parkway	Residential properties – Judith Street/Kirkwood Street and Wakehurst Parkway, Seaforth	Project specific T-AEI
BL13 Wakehurst Parkway East	B16 Sydney Water Reservoir	Sydney Water Reservoir site (and surrounds) – Kirkwood Street, Seaforth	Project specific T-AEI
Not applicable (construction footprint interface)	B17 Wakehurst Parkway, Seaforth to Frenchs Forest	Wakehurst Parkway - Seaforth to Frenchs Forest	Project specific T-AEI

For clarity, only the AEI site number will be referenced throughout this report. Detailed figures of each AEI addressed in this Framework SAQP are provided in Appendix A.

Information on the Project Specific T-AEIs and the intended future land use for each Project Specific T-AEI, as provided by Transport is set out in Appendix B. Based on this information, the Preliminary Conceptual Site Models for each Project Specific T-AEIs have also been developed in Appendix B Section 1.2 and indicative sampling and analytical programs are then provided in Appendix B Section 1.4.

3. Decision making process for site-specific SAQPs

The decision making processes that must be applied to each category of AEI to determine the requirement for the development and implementation of site-specific SAQPs for further investigation is discussed in further detail below. Location references and AEI categorisations are listed in Table 1.

Contractors must ensure that all information available at the time of preparation of the site-specific SAQPs is considered and assessed in the development of the site-specific SAQPs. Any previous environmental investigations conducted for AEIs, and reviewed as part of the decision making process, must consider compliance with NSW EPA made or endorsed guidelines for contaminated sites.

In applying the decision making processes set out below, contractors will be required to consider the risk of contamination rankings and any land use changes for all AEIs in order to develop site-specific SAQPs that encompass any changes to contamination risk and land use subsequent to the development of this Framework SAQP.

3.1 Project Specific T-AEIs

The decision for the Project Specific T-AEIs is that site-specific SAQPs must be prepared and implemented on each of these AEIs with the objective of the investigations to be to provide an assessment of site suitability for final intended land use. Where suitability cannot be achieved, the investigations must identify the requirement for remediation or management to make the AEI suitable for its final intended land use.

In order to guide the preparation of the site-specific SAQPs for the Project Specific T-AIEs, the information available on these AEIs, as provided in the EIS (TfNSW, 2020a), has been summarised in Appendix B. This information has been used to set out a preliminary CSM and provide the basis of the requirements for the site-specific SAQPs and is to be utilised by contractor(s) to develop the site-specific SAQPs for the Project Specific T-AEIs in accordance with Section 4.

3.2 Crossover T-AEIs

These AEIs are located across an area of Cammeray and North Sydney where the WHTWFU project will ultimately interface and connect with the BLGHFC project. Transport included these AEIs in the EIS's for both projects to allow for flexibility in staging of the works required to deliver the integration and connectivity between the projects. It was anticipated that works relating to contamination and land use suitability assessment required on these AEIs would be completed by the project that first accessed the AEIs for construction.

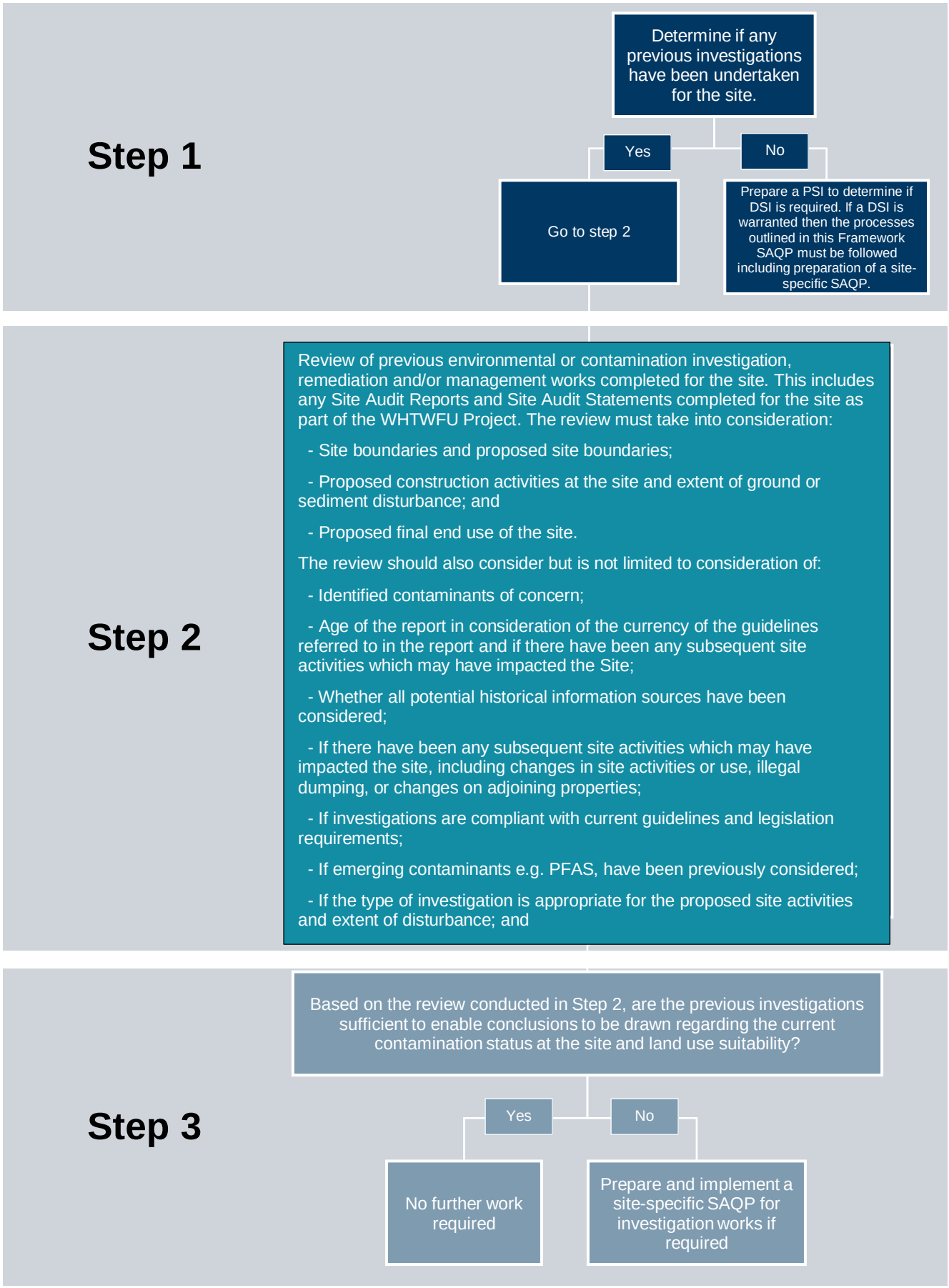
At the time of preparation of this Framework SAQP, progress on the WHTWFU project was well advanced of the BLGHFC project, with early works already underway, main construction activities due to commence in mid-2022 and many of the Crossover T-AEIs already subject to DSIs. Consequently, prior to the commencement of the construction of the BLGHFC project, all investigation works and remediation works on the Crossover T-AEIs, undertaken to comply with SSI-8863 will likely be completed, and construction works either completed or nearing completion.

Given that the timing and nature of the works that may be required by the BLGHFC project on these Crossover T-AEIs is not yet known, a decision making process has been prepared to ensure that any works completed by the WHTWFU project are subject to review and, where possible, relied upon as part of the BLGHFC project. This is to ensure no unnecessary replication of works or further contamination assessment are required where final intended land use suitability has already been assessed and is appropriate to the BLGHFC project,

The decision making process to be applied by contractors to determine whether site-specific SAQPs are required for the Crossover T-AEIs is provided as ***Decision flow chart 1.*** The objective of the review is to determine whether the works completed on the site can:

- be relied upon for the purpose of the BLGHFC project; and
- provide a robust basis for site assessment decisions.

Decision flow chart 1 - Crossover T-AEIs



3.3 M-AEIs

The M-AEIs are those AEIs that were identified in Appendix M of the EIS (TfNSW, 2020b) as marine sites with moderate to high risk of contaminated sediments being present. These M-AEIs have been subject to intrusive investigative works as part of preparation of the EIS, the submissions report and to inform the other approvals. The objective of these investigations comprised assessments of the condition of the sediments to be dredged to determine the requirements for their disposal, both for off-shore disposal under *Commonwealth Environment Protection (Sea Dumping) Act 1981* and also to NSW EPA licenced waste facilities, and additionally to assess the potential impacts to sensitive receptors and mitigation measures during future dredging and sediment disturbance works.

Given the above, the contractor will be required to review the existing information and provide consideration as to whether further investigations into the environmental condition of sediments are required to inform their design and delivery of the marine works, including their compliance with relevant project approvals. The contractor will also be required to continue to engage with the federal Department of Agriculture, Water and Environment (DAWE) and any other relevant federal government agencies as required. A decision making process has been prepared to ensure that site-specific SAQPs are prepared to inform the investigation works where further investigations are deemed to be required.

For clarity, it is noted that the M-AEIs are not required to be assessed for suitability as the trigger for the investigation works relates only to the impacts that construction activities may have to sensitive receptors, and the requirements for disposal of any removed sediments as part of those construction activities.

The decision making process to be applied by contractors to determine whether site-specific SAQPs are required for the M-AEIs is provided as ***Decision flow chart 2.***

Decision flow chart** 2 **- Marine AEIs

Step 1

Review of previous investigations completed in relation to sediments within the M-AEI to determine if works completed are sufficient to meet the relevant requirements in relation to either project approvals, disposal requirements and/or impacts to sensitive receptors. The review must take into consideration:

- Proposed dredging or other construction activities that will disturb sediments;
- Proposed extent of sediment disturbance;
- Requirements for disposal of sediments that are dredged or otherwise removed as part of construction activities;
- Requirements for further assessment of impacts to sensitive receptors;
- Proposed construction activities at the site and extent of ground or sediment disturbance; and
- Potential risk of sediments disturbance to the environment or human health during construction.

The review should also consider but is not limited to consideration of:

- Identified and potential contaminants of potential concern (COPC), including dioxins, and potential bioavailability of COPC
- The potential presence of acid sulfate soils, and handling and disposal options if required;
- Age of the report (in consideration of the currency of the guidellines referred to in the report);
- Whether all potential historical information sources have been considered;
- If there have been any subsequent site activities which may have impacted the site;
- If investigations are compliant with current guidelines and legislation requirements;
- If emerging contaminants e.g. PFAS, have been previously considered;
- If the type of investigation is appropriate for the proposed site activities and extent of disturbance;
- Options to manage sediment to be disturbed during construction, including consideration of on-shore disposal; off-shore disposal; sea dumping and in-shore disposal (in-harbour location);
- Bioavailability of COPCs; and
- The extent of the previous investigation boundaries, including vertical and lateral extents.

Step 2

Based on the review conducted in Step 1, are the previous investigations sufficient to enable conclusions to be drawn regarding potential impacts to sensitive receptors during construction, and sediment disposal requirements?

Yes

No further work required

No

Prepare and implement a site-specific SAQP if required

The guidance framework which must be considered in the development of the M-AEI site-specific SAQPs is provided in Table 2.

Table 2 Marine AEIs – sediment guidance framework

Objective	Scenario	Guidance framework / reference
To determine sediment risk during construction	Environmental / health risk during construction	– Environmental risk: Australian & New Zealand Guidelines for Fresh & Marine Water Quality (Sediment Quality Guidelines) – Health risk: site specific risk assessment, with construction methodology, possible exposure pathways and receptors incorporated – *The Role of Toxicity Testing in Identifying Toxic Substances in Water* (enHealth, 2012) – Schedule B4 of (NEPC, 2013)
To determine options to manage sediment to be disturbed during construction	On shore disposal	– NSW EPA *Waste Classification Guidelines 2014 and PFAS Addendum 2016* and/or Specific NSW EPA resource recovery exemption / orders (follow EPA guidance on applying specific exemption / orders – NSW EPA Control Orders created under Part 3, Division 5 of the Environmentally Hazardous Chemicals Act 1985 (e.g. for dioxin-contaminated waste materials and organotin waste materials)
	Sea dumping (offshore disposal)	– National Assessment Guidelines for Dredging 2009

3.4 A-AEIs

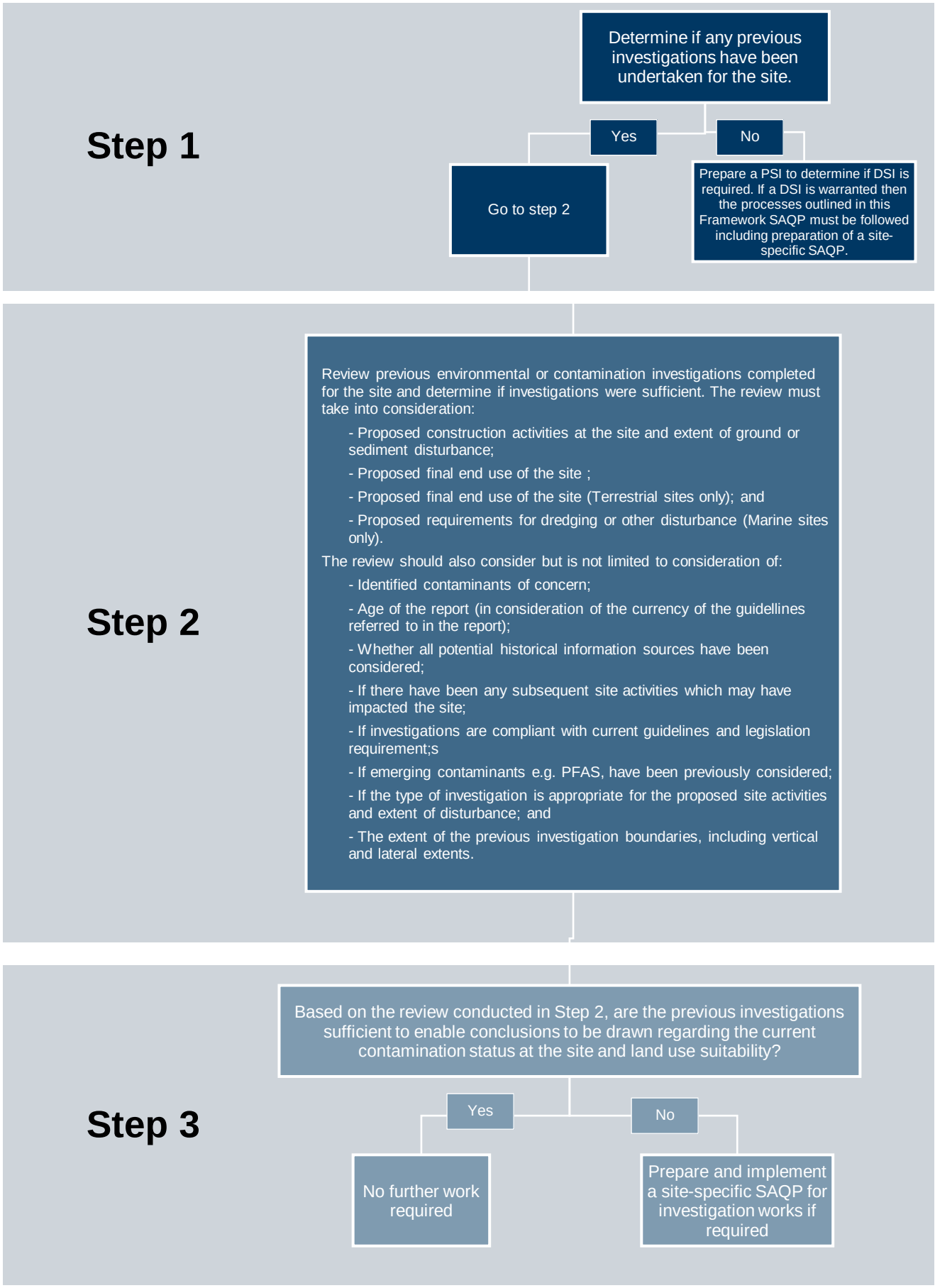
A-AEIs are those AEIs which may arise as a result of the following circumstances:

– Amendments to the boundaries of the AEIs within or adjacent to the current project footprint that were identified in Appendix M of the EIS (TfNSW, 2020b) where the amendments result in the land not previously assessed in the EIS now being within the project footprint;
– Identification of new AEIs within or adjacent to the current project footprint as having a moderate to high risk of contamination being present that had not been identified as an AEI in in Appendix M of the EIS. A change in the boundary to the current project footprint will trigger the need for a PSI for the new portion of land; and
– Any other areas that are located within the project footprint, including those that were identified in Appendix M of the EIS (TfNSW, 2020b) as areas of low risk of contamination being present, where conditions have changed or where review of existing information indicates a potential of contamination being present that otherwise was not previously identified. This includes any changes to surrounding land conditions that could affect the risk of contamination being present on an AEI.

If any of the circumstances listed above arises, consideration must be provided to the risk assessment matrix set out in Section 5 of Appendix M of the EIS (TfNSW, 2020b) and a decision making process has been prepared that ensures that consideration of the potential for contamination to be present is made for such sites and then, if required, subsequent works are completed including the preparation of site-specific SAQPs in accordance with the processes set out in this Framework SAQP.

The decision making process to be applied by contractors to determine whether site-specific SAQPs are required for any site that meets the above circumstances or similar circumstances is shown in ***Decision flow chart 3.***

Decision flow chart 3 - Additional AEIs



3.5 Documentation

The results of the decision-making processes undertaken by the contractor must be documented prior to the preparation of any site-specific SAQPS or undertaking any further investigations or construction activities at the site. The report must detail:

- Attempts made to locate existing reports;
- Outline of proposed construction activities and end use of the site ;
- Summary of findings of the review of the existing reports, including the provision of a reliability assessment (including but not limited to consideration of the appropriateness of previous sampling investigations and an assessment of the quality and reliability of the data), and relevance to the proposed construction activities and end use; and
- Justification for whether additional investigations are / are not required with consideration of relevant guidelines and final intended land use for the BLGHFC project.

4. Site-specific SAQP requirements

The detailed planning and design for the BLGHFC project will commence once planning approval is determined. Contractor(s) must then implement the requirements of this Framework SAQP and apply the decision making processes set out in Section 3 to determine the requirement for preparation and implementation of site-specific SAQPs. The site-specific SAQPs have a critical role in ensuring that the data collected is representative and provides a robust basis for site assessment decisions.

Site-specific SAQPs must be prepared prior to the commencement of the investigation works that they describe, and must consider the significance of the lateral tunnel position and depth relative to AEIs.

The site-specific SAQPs must detail the data quality objectives, sampling design, analytical program, sampling and analytical methodologies to be applied and the data quality indicators and how the works will be reported. These requirements for the site-specific SAQPs are detailed below and have been prepared to be consistent with the relevant guidelines made and endorsed by NSW EPA, including the *Consultants Reporting on Contaminated Land – Contaminated land guidelines* (NSW EPA, 2020) and the Appendix B of the National Environment Protection Measures (ASC NEPM) Schedule B2 Guideline on Site Characterisation (NEPC, 2013).

4.1 Document control

As required by the *Consultants Reporting on Contaminated Land – Contaminated land guidelines* (NSW EPA, 2020) checklist a document control section containing the following information must be presented in the site-specific SAQPs:

– Date;
– Version number;
– Author and reviewer, including certification details; and
– The person that commissioned the report.

4.2 Objectives

The objectives of a sampling and analysis quality plan is to provide the context, justification, methodologies and details of the selected sampling and analysis approach.

The site-specific SAQPs must set out the objectives of the sampling and analytical program to be completed.

4.3 Scope of works

The proposed scope of work must be included in the site-specific SAQPs as required by the *Consultants Reporting on Contaminated Land – Contaminated land guidelines* (NSW EPA, 2020) checklist.

4.4 Site setting and environment

The description of the site setting in the site-specific SAQP must meet the requirements set out in Appendix B of the ASC NEPM Schedule B2 Guideline on Site Characterisation (NEPC, 2013) and the *Consultants Reporting on Contaminated Land – Contaminated land guidelines* (NSW EPA, 2020).

The site-specific SAQPs must detail the following information:

– Site identification in accordance with the ASC NEPM Field Checklist 'Site information' sheet
– Current and future intended land use;
– Site history, including a review of historical aerial photographs;
– Environmental setting;

– Local geology and hydrogeology; and
– Condition of site, including any built structures, vegetation cover and similar that must be based on the results of an inspection of the site;

4.5 Conceptual site model

A CSM provides the framework for identifying sources of contamination, contaminant migration pathways, receptors and exposure mechanisms. The complexity of the CSM should correspond to the scale and complexity of the known or potential contamination impacts. The site-specific SAQP must provide a conceptual site model that details the following:

– Known and potential sources of contamination and contaminants of concern including the mechanism(s) of contamination;
– List of potentially affected media including biota if applicable;
– List of human and ecological receptors (both on- and off-site);
– potential and complete exposure pathways (both on- and off-site, including preferential pathways which are of particular relevance to the assessment of vapour); and
– Data gap and uncertainty assessment; and
– Assumptions underlying the model including:
    - How representative the available data is likely to be;
    - The potential sources of variability and uncertainty; and
    - Importance of identified data gaps are to the objectives of the assessment works.

The conceptual site model developed for the site-specific SAQPs must meet the requirements set out in Appendix B of the ASC NEPM ((NEPC, 2013).

4.6 Sampling, analytical and quality plan

Based on the above information a sampling and analysis quality plan must be developed and included in the site-specific SAQP that sets out the works to be undertaken obtain the necessary representative data for the site.

4.6.1 Data quality objectives

The purpose of establishing data quality objectives (DQOs) is to ensure that the field investigations and subsequent analyses are undertaken in a way that enables the collection and reporting of reliable data on which to base the assessment.

A process for establishing DQOs for a site investigation is defined in Appendix B of the ASC NEPM, Schedule B2 Guideline on Site Characterisation (NEPC, 2013).

The DQO process must be applied to any investigation into the presence of contamination as part of the BLGHFC project to ensure that data collection activities are appropriate and achieve the BLGHFC project objectives. The DQO process involves the following seven steps:

– Step 1: State the problem
– Step 2: Identify the decision
– Step 3: Identify inputs to the decision
– Step 4: Define the study boundaries
– Step 5: Develop a decision rule
– Step 6: Specify limits on decision errors
– Step 7: Optimise the design for obtaining data

The site-specific SAQPs must clearly set out the DQOs for the investigation works to be completed and clearly document the completion of each of the seven step process set out above. It is critical to ensure that the DQOs reference plans, drawings or similar that provide surveyed boundaries of the site to which the investigation is to be completed.

4.6.2 Assessment criteria

The site-specific SAQPs must clearly set out the assessment criteria that is to be applied to the results of the sampling and analytical works and provide the decision making process applied to determine the applicable criteria and demonstrate that it will meet the objectives of the investigation works. The assessment criteria must be provided for each environmental media that is being subject to sampling and analysis and must be utilised and applied in accordance with the ASC NEPM and the guidelines made or endorsed by the NSW EPA.

The assessment criteria section for the site-specific SAQPs must present the rationale for the selection of assessment criteria, including assumptions and limitations of the criteria (relevant to the assessment and current or proposed land use) and any deviations from approved guidelines. Tables listing all selected assessment criteria and references adopted must be included in the site-specific SAQPs.

4.6.3 Sampling plan

An appropriate sampling design must be provided in the site-specific SAQPs. This sampling design must be based on based on accurate and reliable site-specific information (as integrated in the CSM) as far as practicable to obtain sufficient representative data to address the DQOs. The sampling design must detail the sampling locations, density, depth (or similar) and the number of samples to be collected and any other information (such as temporal variations) relevant to achieving the objectives of the assessment. The sampling design and plan selected must be prepared in accordance with the relevant guidelines made or approved by NSW EPA and be appropriately justified as required by Appendix B of the ASC NEPM Schedule B2 Guideline on Site Characterisation (NEPC, 2013). All relevant approvals required to enable intrusive works must be obtained prior to implementing the sampling plan.

4.6.4 Field methodology

The field methodologies to be implemented must be detailed in the site-specific SAQPs. The selection of the most appropriate investigation methodologies must be undertaken with respect to the site setting, each environmental media being subject to investigation, the stage of the investigation, the depth of investigations required and the type of potential contamination being investigated. Consideration should also be provided to temporal variations that may affect methodologies being applied.

The field methods selected must be appropriately justified as required by Appendix B of the ASC NEPM Schedule B2 Guideline on Site Characterisation (NEPC, 2013).

4.6.5 Analytical plan

The analytical plan to be implemented must be detailed in the site-specific SAQPs. The selected schedule of analytes, frequency of analysis, type of analysis and analytical methods to be applied must be detailed and appropriately justified.

The analytical plan selected must be appropriately justified as required by Appendix B of the ASC NEPM Schedule B2 Guideline on Site Characterisation (NEPC, 2013).

4.7 Quality assurance and quality control

Quality assurance (QA) and quality control (QC) are essential elements of the site-specific SAQP. The field QA and QC procedures and laboratory QA and QC procedures must be prepared to comply with the requirements for QA and QC that is set out in Appendix B of the ASC NEPM Schedule B2 Guideline on Site Characterisation (NEPC, 2013).

4.8 Reporting

The site-specific SAQP 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.

All phases of sampling and analysis will be subject to a statutory site audit by a NSW EPA- accredited Site Auditor.

The site-specific SAQPs must address all the requirements set out in this Framework SAQP and must include the SAQP checklist provided as Table 2.2 of the Consultants Reporting on Contaminated Land – Contaminated land guidelines (NSW EPA, 2020) and references to the sections of the SAQP which satisfy the requirements of this checklist.

Site-specific SAQPs must include presentation of the environmental data from pre-EIS and post-EIS investigations.

The site-specific SAQPs must also set out the requirements for the reporting to be prepared as an outcome of the implementation of the SAQP which must be stated to include the following at a minimum:

- Data quality objectives for the investigations works;
- Description of the investigation works undertaken;
- Comparison of soil, sediment, water and gas analytical results to adopted assessment criteria;
- Determination of the reliability of the field and laboratory programs, by reference to the site-specific SAQP DQOs and DQIs;
- Identify any "non-conformances" and how they were addressed or how they affect the reliance on the data;
- Any variations to the site-specific SAQP during implementation and detailed justification for the variation;
- Results of fieldworks and laboratory analytical results;
- Provision of data tables and records and other supporting information, including presentation of all sampling points (and groundwater wells) on a site plan where the consultant will rely on that information;
- A refined conceptual site model, including sources, pathways, receptors and a linkage assessment to determine risks to identified receptors during construction and post-construction
- Information demonstrating that the objectives of the assessment works have been achieved, in particular the results and assessment of the data against both the pre-defined data quality objectives and the site assessment criteria;
- Information demonstrating compliance with appropriate regulations and guidelines, identification of any data gaps to be addressed;
- Information demonstrating how the results of the works will be utilised as part of planning for the control or management measures to be required during construction activities;
- Where required, assessment on the suitability of the AEI for final intended land use and recommendations on the requirements, if any, for remediation and/or management in order to make the AEI suitable; and
- Other information as appropriate, that will apply to the AEI.

5. Summary

Transport has committed to the development of this Framework SAQP to set out the general context, justification and general sampling and analytical framework that will be adopted post-determination in subsequent site-specific SAQPs.

It is noted that the Framework SAQP was prepared in consideration of the *Guidelines for Consultants Reporting on Contaminated Sites* (NSW EPA, 2020) and it provides guidance for the future development of site-specific SAQPs required for contamination investigation to be conducted post-determination.

The Framework SAQP has been developed to ensure that, across the different stages of the BLGHFC project, consistent decision making processes are implemented for determining whether site-specific SAQPs are required, and also the context, justification and scope of contamination sampling and analysis where site-specific SAQPs are required.

The requirements of the Framework SAQP will be implemented by contractors, post contract award. The development of site-specific SAQPs will inform the investigation requirements for detailed site investigations (DSIs) or other investigation works for each AEI identified in Appendix M of the EIS as well as for any additional AEIs. The results of the DSIs or other investigation works will determine the requirements, if any, for remediation and/or management.

The preparation and subsequent implementation of the site-specific SAQPs form the second stage of contamination investigation works for the BLGHFC project. The results from the implementation of the site-specific SAQPs will then be relied upon to determine the requirements, if any, for remediation and/or management to ensure that Transport's obligations with respect to contaminated land (including achieving land suitability), for the BLGHFC project are met.

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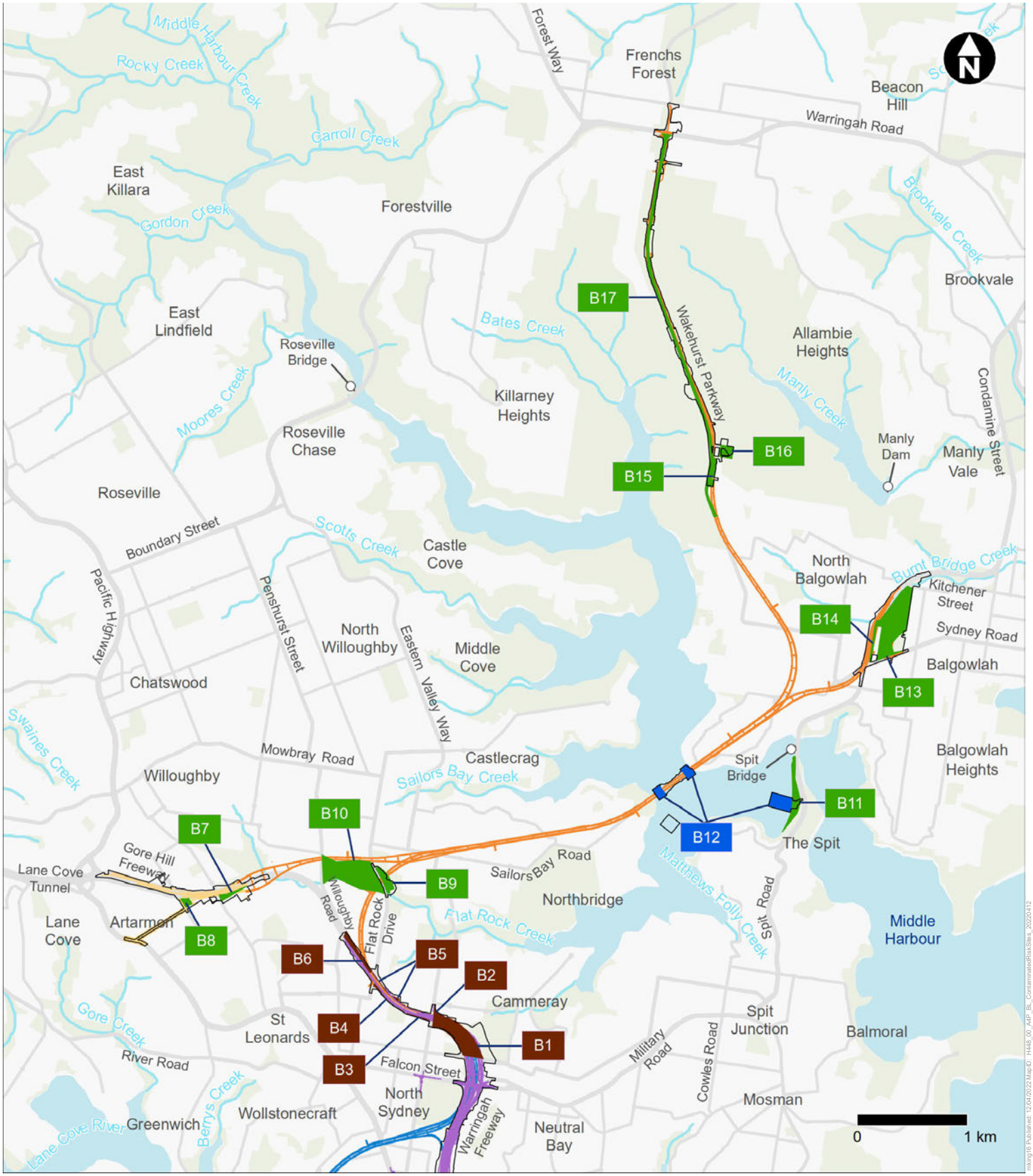
Appendices

Appendix A

Figures



BEACHES LINK
FIGURE 1
KEY

- Beaches Link
- Gore Hill Freeway Connection
- Western Harbour Tunnel
- Warringah Freeway Upgrade
- Construction footprint
- Waterways
- Terrestrial AEIs (T-AEIs)
- Crossover terrestrial AEIs (Crossover T-AEIs)
- Marine AEIs (M-AEIs)
- Additional AEIs (A-AEIs) – refer to decision making process for site-specific SAQPs

NSW GOVERNMENT

mking16 Published: 12/04/2022 Map ID: H448_00_AIP_BL_ContaminatedRiskSites_20220412

BEACHES LINK
FIGURE 2 - AREAS OF ENVIRONMENTAL INTEREST - B1, B2 AND B3

KEY

- Crossover T-AEIs
- Construction footprint
- Road design boundary
- Suburbs

0 35 70 140 Metres

N

NSW GOVERNMENT

BEACHES LINK
FIGURE 3 - AREAS OF ENVIRONMENTAL INTEREST - B3, B4, B5 AND B6

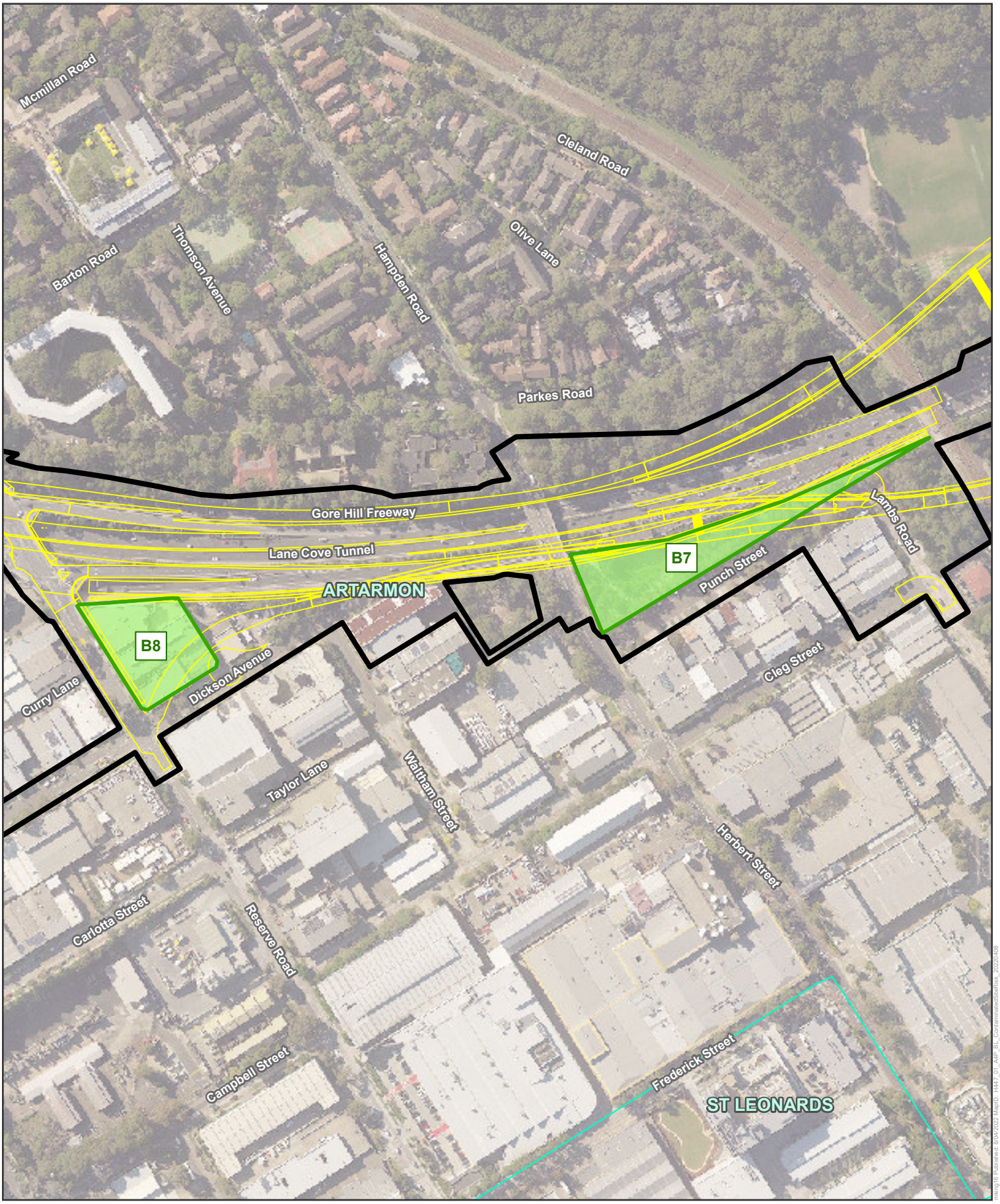
KEY

- Crossover T-AEIs
- Construction footprint
- Road design boundary
- Suburbs

0 35 70 140 Metres

N

NSW GOVERNMENT



BEACHES LINK
FIGURE 4 - AREAS OF ENVIRONMENTAL INTEREST - B7 AND B8

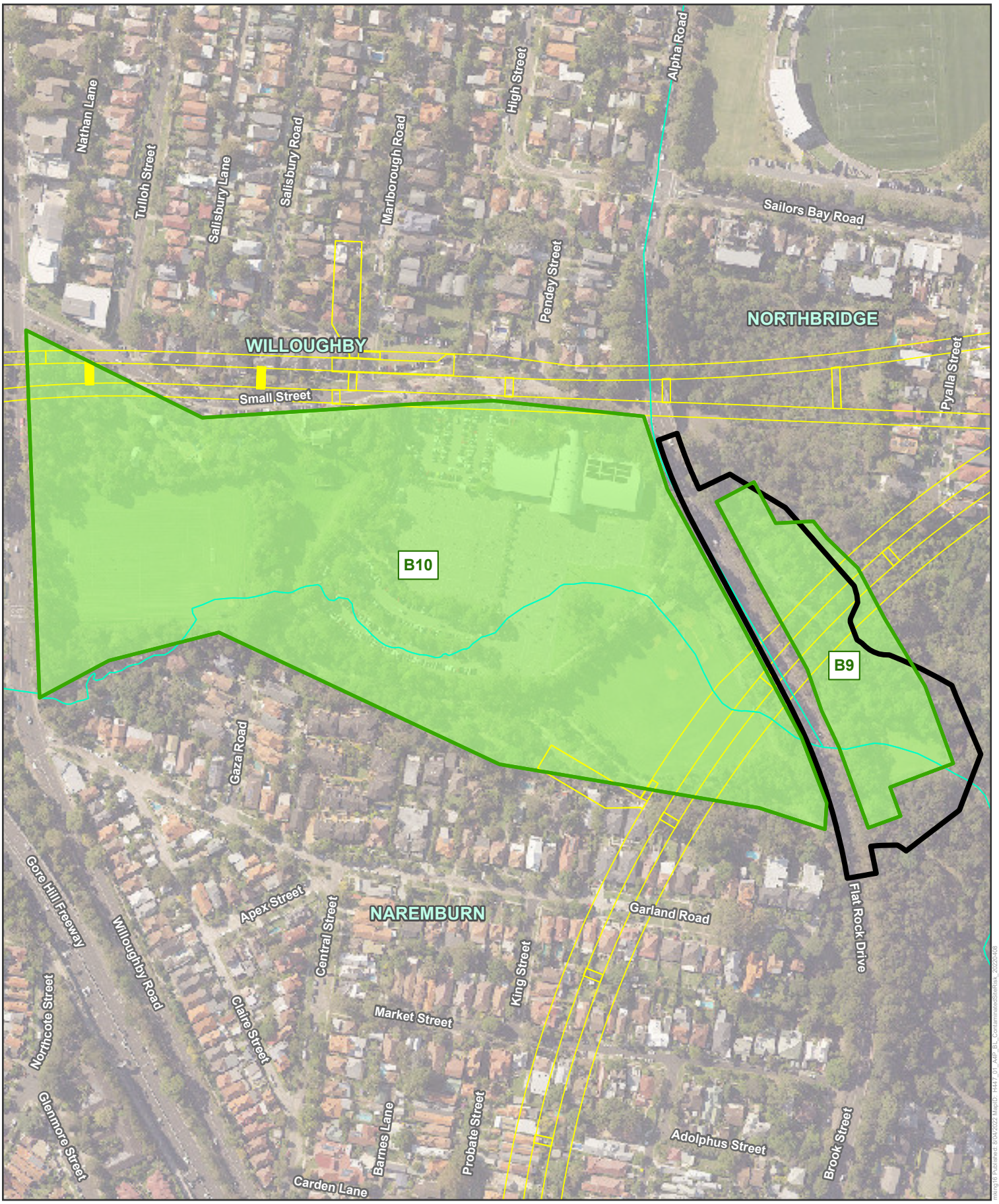
KEY

- T-AEIs
- Construction footprint
- Road design boundary
- Suburbs

0 35 70 140 Metres

N

NSW GOVERNMENT



BEACHES LINK
FIGURE 5 - AREAS OF ENVIRONMENTAL INTEREST - B9 AND B10

KEY

- T-AEIs
- Construction footprint
- Road design boundary
- Suburbs

0 35 70 140 Metres

N

NSW GOVERNMENT

BEACHES LINK
FIGURE 6 - AREAS OF ENVIRONMENTAL INTEREST - B11 AND B12

KEY

- T-AEIs
- M-AEIs
- Construction footprint
- Suburbs

0 35 70 140 Metres

N

NSW GOVERNMENT

BEACHES LINK
FIGURE 7 - AREAS OF ENVIRONMENTAL INTEREST - B12

KEY

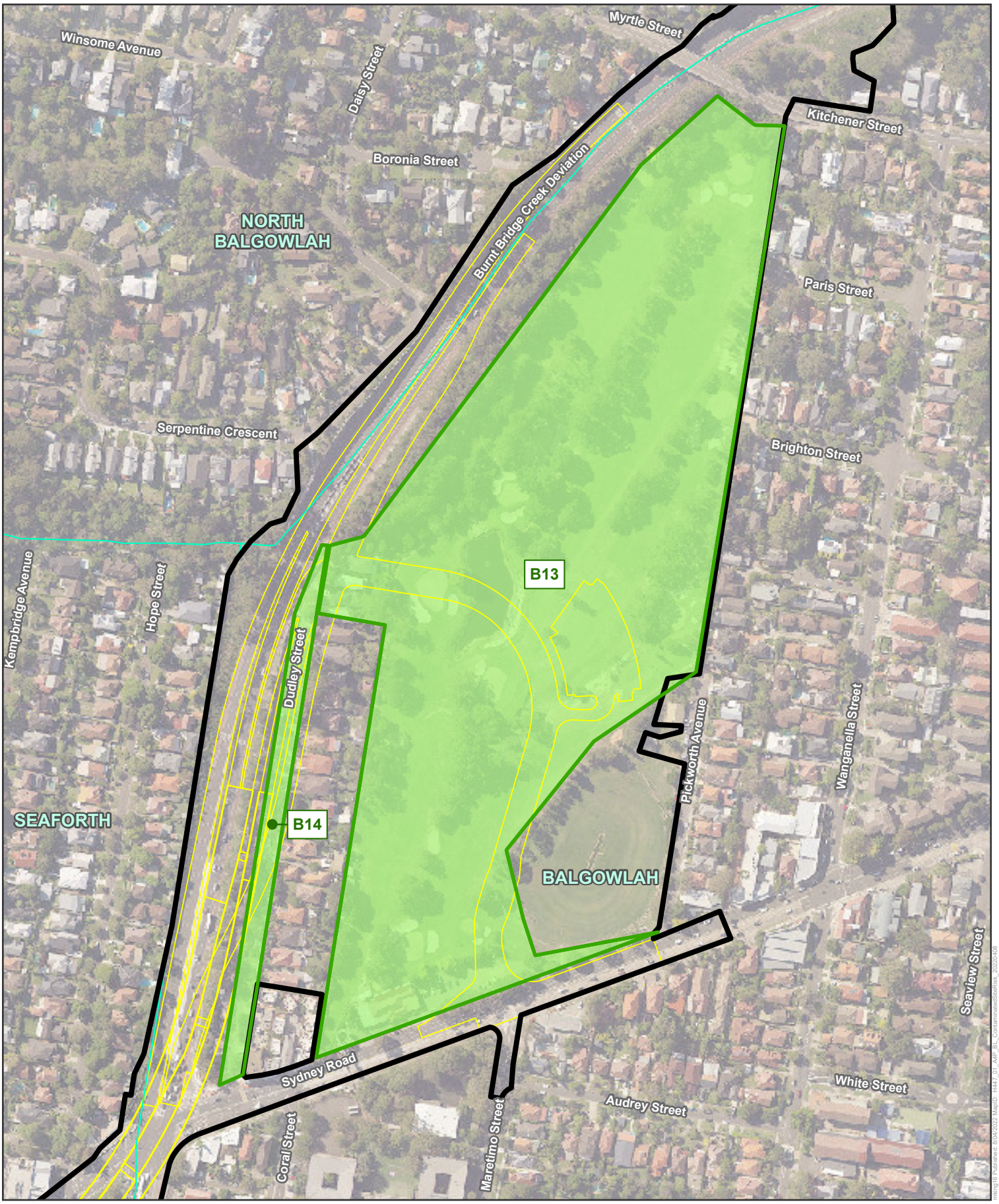
- M-AEIs
- Construction footprint
- Road design boundary
- Suburbs

0 35 70 140 Metres

N

NSW GOVERNMENT

mxmg16 Published: 8/04/2022 MapID: HM47_01_AIP_BL_ContaminatedSiteRisk_20220408



BEACHES LINK
FIGURE 8 - AREAS OF ENVIRONMENTAL INTEREST - B13 AND B14

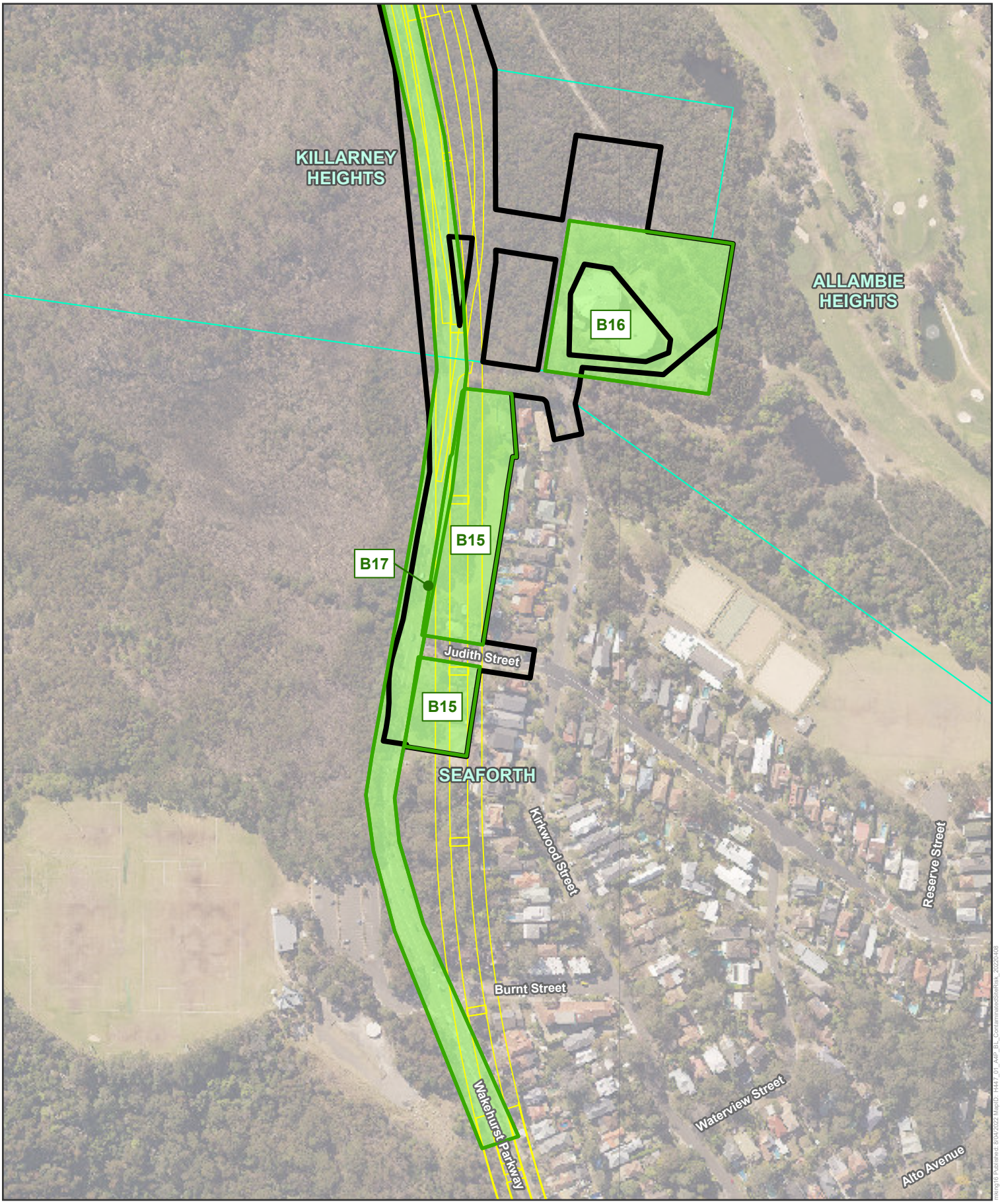
KEY

- T-AEIs
- Construction footprint
- Road design boundary
- Suburbs

0 35 70 140 Metres

N

NSW GOVERNMENT



BEACHES LINK
FIGURE 9 - AREAS OF ENVIRONMENTAL INTEREST - B15, B16 AND B17

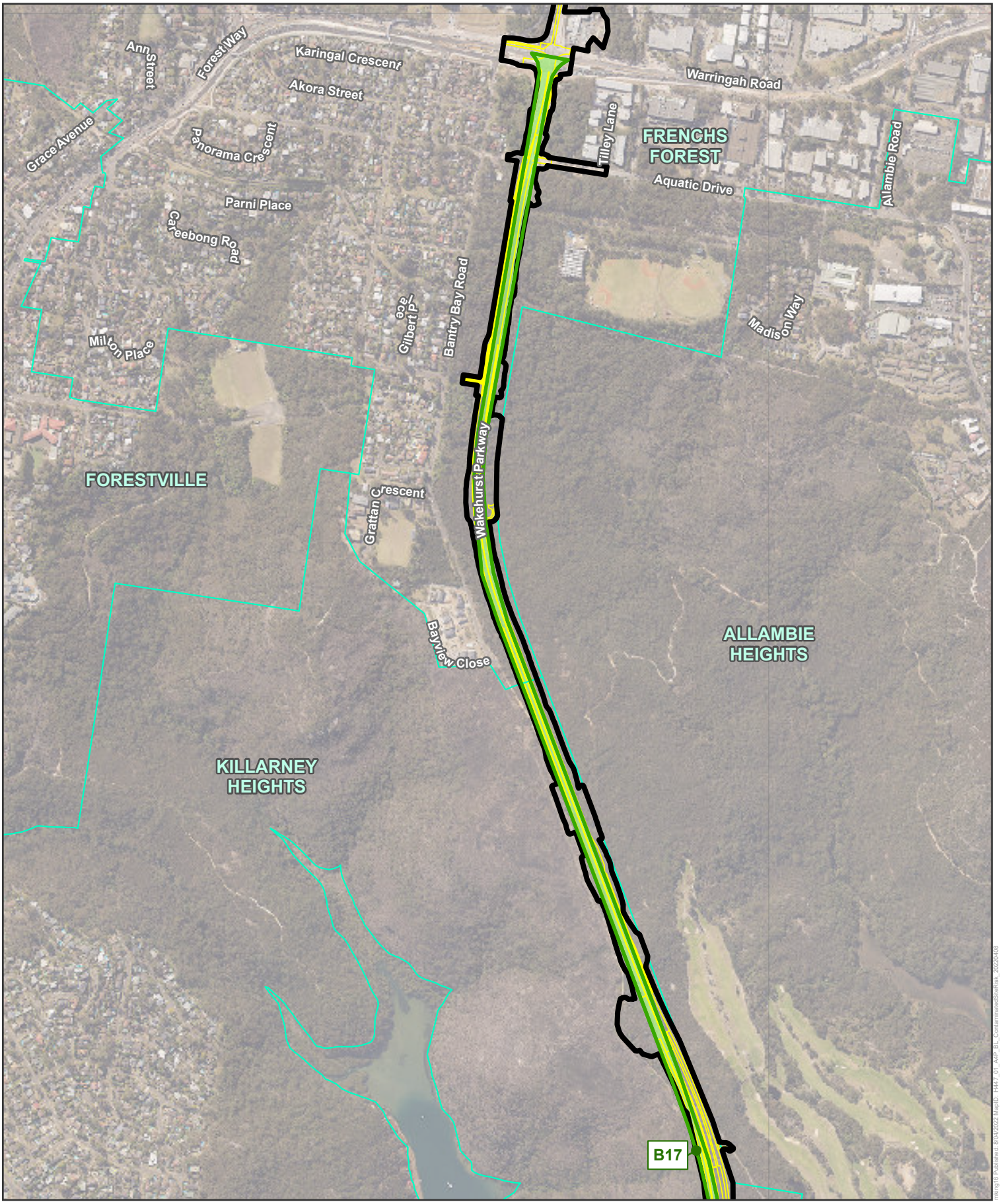
KEY

- T-AEIs
- Construction footprint
- Road design boundary
- Suburbs

0 35 70 140 Metres

N

NSW GOVERNMENT



BEACHES LINK
FIGURE 10 - AREAS OF ENVIRONMENTAL INTEREST - B17

KEY

- T-AEIs
- Construction footprint
- Road design boundary
- Suburbs

0 125 250 500 Metres

N

NSW GOVERNMENT

Appendix B

Project Specific T-AEIs – Basis for site-specific SAQPs

Project Specific T-AEIs - Basis for site-specific SAQPs

Beaches Link Project

Transport for NSW

16 May 2022

→ The Power of Commitment

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Client name	Transport for NSW
Project name	12522128 WHTBL Contamination Consultant
Document title	Project Specific T-AEIs - Basis for site-specific SAQPs | Beaches Link Project
Revision version	Rev 0
Project number	12522128

Document status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
Draft	A	[redacted]	[redacted]		H. Milne (CEnvP SC)		
Draft	B	[redacted]	[redacted]		H. Milne (CEnvP SC)		
Draft	C	[redacted]	[redacted]		H. Milne (CEnvP SC)		
Final	0	[redacted]	[redacted]		H. Milne (CEnvP SC)		

Contents

Table index

1. Project Specific T-AEIs- Basis for site-specific SAQPs

At the time of preparation of the Framework SAQP, it had been determined that the Project Specific T-AEIs will require the preparation and implementation of site-specific SAQPs for DSIs. In order to guide the preparation of the site-specific SAQPs for the Project Specific T-AIEs, the information available on these AEIs, as provided in the EIS (TfNSW, 2020a), has been detailed below. This information has been set out to reflect the requirements for site-specific SAQPs as detailed in Section 4 of the Framework SAQP, and is to be utilised by contractor(s) to develop the site-specific SAQPs for the Project Specific T-AEIs.

Contractors must ensure that all information available at the time of preparation of the site site-specific SAQPs is considered and assessed in the development of the site-specific SAQPs.

1.1 Project Specific T-AEIs condition and environmental setting

1.1.1 Project Specific T-AEIs identification

A summary of the identification details of each AEI for the BLGHFC project is provided in Table 1 to Table 8. The site locality and setting of each AEI site is presented in Figures 4 to 6 and Figures 8 to 10, Appendix A of the Framework SAQP. As noted above the construction works anticipated to be completed on each AEI and the likely future land use are based on information provided within the EIS (TfNSW, 2020d) and as provided to GHD by Transport. It is noted the construction and final land use may change in the future as the project design is finalised.

Table 1 Site identification summary – B7 Punch Street

Site Information	Details
Site area	The B7 site is located at Punch Street, Artarmon, comprising an area of approximately 5,900 m^2.
LGA	The site is located in Willoughby City Council.
Current land use zoning	Public Recreation (RE1).
Current land use	The site is currently used as a public park and includes a public pathway adjacent the Gore Hill Freeway.
Construction Works	Demolition of existing structures; excavation of tunnel features; construction and operation of temporary site facilities.
Future land use	Commercial/industrial – including commercial / industrial properties and road/motorway operations.
Surrounding land Use	North – Gore Hill Freeway, Artarmon Park and residential properties; South – Punch Street, followed by various commercial/industrial premises; East – A railway line, followed by residential properties; and West – Herbert Street, followed by various commercial/industrial premises.
Site inspection	Key information noted during the GHD inspection conducted on 16 July 2021 of site B7 is as follows: - The site is well vegetated with mature trees, shrubs and long grasses. A pedestrian / cycleway path transects the site from east to west, and is adjacent to and overlooking an open gully / stormwater drain and retention pond; and - The site is separated from Punch Street by a high barbed wire topped fence. Public car parking is provided along the northern side of Punch Street, adjacent to the site.

Site Information	Details
	- Immediately north of the site is the Gore Hill Freeway; and - A telecommunications facility is located at the eastern end of the site.

Table 2 Site identification summary – B8 Dickson Avenue

Site Information	Details
Site area	The B8 site is located on the corner of Reserve Road and Dickson Avenue and comprises an area of approximately 5,500 m^2.
LGA	The site is located in Willoughby City Council.
Current land use zoning	General Industrial (IN1).
Current land Use	The site is currently occupied by a hotel, media company and automotive shop.
Construction land use	Demolition of existing structures; construction and operation of temporary site facilities.
Future land use	Commercial/industrial – including commercial / industrial properties and road/motorway operations.
Surrounding land Use	North – Gore Hill Freeway, followed by public recreation areas and residential properties; South – Dickson Avenue, followed by various commercial/industrial premises; East – Various commercial/industrial premises; and West – Reserve Road, followed by various commercial/industrial premises.
Site inspection	Key information noted during the GHD inspection conducted on 16 July 2021 of site B8 is as follows: - The site consists of two storey commercial buildings housing a tyre fitter, mechanical workshop and repairer, car wash, television production studios, and the Freeway Hotel; and - The site surface is fully sealed.

Table 3 Site identification summary – B9 Flat Rock Reserve & B10 Bicentennial Reserve

Site Information	Details
Site area	The B9 site is located at Flat Rock Drive, Flat Rock Reserve, Northbridge, comprising an area of approximately 10,400 m^2. The B10 site is located at Willoughby Leisure Centre and Bicentennial Reserve (between Flat Rock Drive and Willoughby Road), Willoughby, comprising an area of approximately 109,200 m^2.
LGA	The sites are located in Willoughby City Council.
Current land use zoning	Environmental Conservation (E2) and Infrastructure (SP2) (B9) and Public Recreation (RE1) (B10).
Current land Use	The B9 site is currently used as a bushland Reserve and the B10 site is used as a Leisure Centre and recreational park.
Construction land use	B9: Excavation of tunnel access decline and main tunnel alignment; construction and operation of temporary site facilities . B10: Tunnel excavation (no surface works planned).
Future land use	B9: Open space – public recreation parkland. B10: Will remain in its current state (Public Recreation and open space), with an underground tunnel running below the site
Surrounding land Use	North – Residential properties and recreational oval; South – Residential properties; East – Public open space and residential properties; and West - Residential properties.
Site inspection	Key information noted during the GHD inspection conducted on 16 July 2021 of site B9 is as follows:

Site Information	Details
	- The site is comprised of an historical municipal rubbish tip which has been subject to major earthworks and clay capping and revegetation to re-establish the site as a nature reserve; - The site is heavily vegetated with mature trees, bushes and grasses. A network of unsealed gravel pathways and sealed bitumen pathways wind throughout the reserve. A grassed playing field is located at the southern end of the site; and - Stormwater channels and gullies drain runoff from the site southwards into Flat Rock Creek. Key information noted during the GHD inspection conducted on 16 July 2021 of site B10 is as follows: - The site is comprised of an historical municipal rubbish tip which has been infilled and converted to a sporting facility including a baseball diamond, netball and basketball courts, soccer fields, a leisure centre and a children's playground; - The former municipal waste incinerator has been preserved and converted into the Incinerator Café; - The depth of the Flat Rock Creek gully across this site is understood to be 30 metres or more deep; and - Two box culverts drain stormwater underneath the site from west and north towards the eastern outlet at Flat Rock Creek south of site B9.

Table 4 Site identification summary – B11 Spit West Reserve

Site Information	Details
Site area	The B11 site is located at Spit West Reserve, Mosman, comprising an area of approximately 26,500 m^2.
LGA	The site is located in Mosman Municipal Council.
Current land use zoning	Public Recreation (RE1).
Current land Use	The site is currently used as a public reserve.
Construction land use	Construction and operation of temporary site facilities.
Future land use	Open space – recreational parkland.
Surrounding land Use	North – Middle Harbour, followed by residential properties; South – Environmental conservation area, followed by residential properties; East – Spit Road, followed by commercial properties; and West - Middle Harbour.
Site inspection	A site inspection was not conducted by GHD for this site. Key information noted during a desktop review on 27 October 2021 offsite B11 is as follows: - The site comprises publicly accessible reclaimed land which is grassed area to the southern half and is covered with mature trees to the north; - The D'Albora Marinas are located at the northern end of the site, with boat moorings in the harbour immediately west of the site; and - Commercial shops and a restaurant are located within the marina buildings.

Table 5 Site identification summary – B13/14 Balgowlah Golf Course & Dudley Street

Site Information	Details
Site area	The B13/14 site is located at Balgowlah Golf Course and Dudley Street, Balgowlah, comprising an area of approximately 113,000 m^2.
LGA	The site is located in Northern Beaches Council.
Current land use zoning	General Residential (R1) and Public Recreation (RE1).
Current land Use	The site is occupied by Dudley Street, residential properties on Dudley Street and by a Golf Course for the remainder of the site.

Site Information	Details
Construction land use	Demolition of existing structures; excavation of tunnel features and access decline; construction and operation of temporary and permanent site facilities.
Future land use	Balgowlah Golf Course - commercial/industrial and open space land - including road and motorway operations and public recreational space. Dudley Street – commercial / industrial – including road and motorway operations .
Surrounding land Use	Residential in all directions: – North – Kitchener Street and residential beyond; – South – Sydney Road and residential and Balgowlah Boys Campus school beyond; – East – residential; and – West – residential, Burnt Bridge Creek and Burnt Bridge Creek Deviation.
Site inspection	Key information noted during the GHD inspection conducted on 3 August 2021 of site B13/14 is as follows: - The main site is comprised of the Balgowlah Golf Course with access from Sydney Road. The golf course is operational; and - The westernmost site boundary includes a row of houses which front onto Dudley Street, and then Burnt Bridge Creek further to the north.

Table 6 Site identification summary – B15 Residential properties, Wakehurst Parkway

Site Information	Details
Site area	The B15 site is located at Judith Street, Kirkwood Street and Wakehurst Parkway, Seaforth. The site comprises an area of approximately 10,200 m^2.
LGA	The site is located in Northern Beaches Council.
Current land use zoning	Low Density Residential (R2) and Infrastructure (SP2).
Current land Use	The site is occupied by residential properties, cleared, grassed blocks of land and bushland and Wakehurst Parkway.
Construction land use	Demolition of residential properties, construction and operation of temporary site facilities.
Future land use	Residential – including residential land use and private gardens.
Surrounding land Use	North – Sydney Water reservoir followed by bushland; South – Environmental Conservation area, residential properties and public sports field; East – Residential properties, followed by Wakehurst Golf Club; and West – Garigal National Park.
Site inspection	Key information noted during the GHD inspection conducted on 3 August 2021 of site B15 is as follows: - The site is comprised of residential properties and two cleared, grassed blocks along the eastern side of Wakehurst Parkway. The northern half of B15 has a densely vegetated tract of land separating the road from the longest of the two grassed blocks.

Table 7 Site identification summary – B16 Sydney Water Reservoir

Site Information	Details
Site area	The B16 site is located at the Sydney Water Reservoir, Seaforth, comprising an area of approximately 12,300 m^2.
LGA	The site is located in Northern Beaches Council.
Current land use zoning	Low Density Residential (R2).
Current land Use	The site is currently used as a reservoir.
Construction land use	Excavation of tunnel features and access decline; construction and operation of temporary site facilities.

Site Information	Details
Future land use	Commercial/industrial – Sydney Water reservoir.
Surrounding land Use	North – Bushland; South – Residential properties; East – Wakehurst Golf Club; and West – Wakehurst Parkway, followed by Garigal National Park.
Site inspection	Key information noted during the GHD inspection conducted on 3 August 2021 of site B16 is as follows: - The site is the Sydney Water Reservoir for Seaforth and consists of two large tanks and site building infrastructure. The land has been cleared, with sparse mature trees; - The site is fully fenced with barbed wire topped fencing and bound on all sides by dense, mature vegetation; and - Access to the site is via Kirkwood Street.

Table 8 Site identification summary – B17 Wakehurst Parkway, Seaforth to Frenchs Forest

Site Information	Details
Site area	The B17 site is situated on Wakehurst Parkway, extending from Seaforth to Frenchs Forest. The site comprises an area of approximately 82,700 m^2.
LGA	The site is located in Northern Beaches Council.
Current land use zoning	Infrastructure (SP2).
Current land Use	The site is located on Wakehurst Parkway.
Future land use	Commercial / industrial – including road/motorway operations.
Construction land use	Excavation of tunnel features and cut and cover; widening of Wakehurst Parkway.
Surrounding land Use	North – Frenchs Forest, consisting of residential and recreational areas; South – Residential properties; East – Public bushland; and West – Public recreation, Garigal National Park and residential areas.
Site inspection	Key information noted during the GHD inspection conducted on 10 August 2021 of site B17 is as follows: - The site is comprised of the Wakehurst Parkway from Seaforth Oval in the south, to Warringah Road in the north; - Wakehurst Parkway is a busy two way road (single lane in each direction), which is bound on both sides by dense, mature vegetation; and - Fragments of asbestos containing material were noted along the western side of the parkway within bushland and on walking tracks during the site inspection.

1.1.2 Project Specific T-AEIs environmental setting

A summary of the environmental setting of T-AEIs for the BLGHFC project area, as detailed in the EIS (TfNSW, 2020a), Appendix M (Contamination) (TfNSW, 2020b) and Appendix N (Groundwater) (TfNSW, 2020c), is presented in Table 9.

Table 9 Existing environmental setting for Project Specific AEIs

Information	B7 Punch Street	B8 Dickson Avenue	B9 Flat Rock Reserve & B10 Bicentennial Reserve	B11 Spit West Reserve	B13/14 Balgowlah Golf Course & Dudley Street	B15 Residential properties Wakehurst Parkway	B16 Sydney Water Reservoir	B17 Wakehurst Parkway, Seaforth to Frenchs Forest
Ecology (Further detailed in Chapter 19 (Biodiversity) of the EIS).	Threatened flora species are present 200 m north of the site.	No ecologically significant areas within 500 m of site.	The site is zoned as an Environmental conservation area with a number of threatened flora and fauna species present on the site.	No ecologically significant areas within 500 m of site .	Threatened flora species are present on the site and 200 m to the west. Threatened fauna species are present 100 m north east of the site.	Garigal National Park is adjacent west of the site and an Environmental Conservation area is adjacent south of the site. Threatened fauna habitat is present in the northern portion of the site and adjacent west of the site.	Threatened fauna habitat is present 200 m south-west of site.	Garigal National Park is adjacent west of the site boundary and Reserve area is adjacent east of the site. Threatened fauna habitat and threatened flora species are present on the site.
Aboriginal heritage (Further detailed in Chapter 15 (Aboriginal heritage) of the EIS).	Potential Aboriginal Archaeological Deposits are located north of the northern site boundary.	No Aboriginal heritage areas identified within 50 m of the site.	Potential Aboriginal Archaeological Deposits are located in the south-eastern portion of Flat Rock Baseball Field and in the south-western portion of Flat Rock Reserve.	No Aboriginal heritage areas identified within 50 m of the site.	Potential Aboriginal Archaeological Deposits are located in the western portion of the Balgowlah Golf Course.	No Aboriginal heritage areas identified within 50 m of the site.	Multiple Aboriginal engraving sites are located within 50 m of the site.	Multiple Aboriginal engraving sites are located along and within 50 m of the proposed alignment.
Climate (Further detailed in Chapter 26 (Climate change risk & adaptation) of the EIS)	Climate data was obtained from Bureau of Meteorology (BOM) website, from the Observatory Hill (BoM Station 66062) to depict long-term climate statistics across the BLGHFC project area. The annual mean maximum temperature at the Observatory Hill weather station is 21.8ºC and an annual mean minimum temperature of 13.8 ºC. Majority of rainfall occurs in the first half of the year, peaking in June. There is then an abrupt seasonal change with the lowest rainfalls occurring in September. Average annual rainfall is approximately 1215 millimetres (mm) per year.							

Information	B7 Punch Street	B8 Dickson Avenue	B9 Flat Rock Reserve & B10 Bicentennial Reserve	B11 Spit West Reserve	B13/14 Balgowlah Golf Course & Dudley Street	B15 Residential properties Wakehurst Parkway	B16 Sydney Water Reservoir	B17 Wakehurst Parkway, Seaforth to Frenchs Forest
Surface cover (based on GHD site inspection)	Buildings, roads, vegetated land and hardstand areas for car parking and shared user paths.	Buildings, roads, and concrete hardstand.	Grassed and vegetated land, concrete hardstand and buildings.	Grassed and vegetated land, buildings.	Grassed land and buildings.	Grassed land, concrete hardstand and buildings.	Buildings, concrete hardstand cleared ground and vegetated land.	Roads, road base, vegetated land.
Topography and drainage (Further detailed in Chapter 16 (Geology soils and groundwater) and 18 (Flooding) of the EIS)	The terrain along the BLGHFC project rises from an elevation of around 65 metres Australian Height Datum (AHD) at the southern extent of the BLGHFC project at Cammeray and undulates towards Middle Harbour. Between Middle Harbour and the Warringah Freeway, the BLGHFC project crosses beneath Flat Rock Creek and the upper Willoughby Creek catchment. Both Flat Rock Creek and Willoughby Creek drain to Middle Harbour.				To the north of Middle Harbour the topography has a steep incline up to the ridge line at North Balgowlah, before resuming a moderate incline towards Frenchs Forest, reaching an elevation of around 150 metres AHD at Warringah Road at the northern extent of the BLGHFC project area. The main surface drainage feature in the northern area of the BLGHFC project is Burnt Bridge Creek at North Balgowlah.			
Soil landscapes (Further detailed in Chapter 16 (Geology soils and groundwater) of the EIS)	Gymea/ Lambert[1].	Glenorie[2].	Majority disturbed terrain[3] Hawkesbury[4] in eastern portion and Gymea/ Lambert[2] in southern portion.	Hawkesbury[5].	Lambert[2].	Somersby[5].	Lambert[2].	Majority Lambert[2] with Lucas Heights[6].

[1] Gymea/Lambert Soil Landscape is found on undulating to rolling low hills on Hawkesbury Sandstone. Soils are shallow to moderately deep yellow earths and earthy sands on crests and inside of benches.
[2] Glenorie Soil Landscape is found on low rolling and steep hills. Soils are shallow to moderately deep (less than 100 cm) red, brown and yellow podzolic soils on crests and slopes. Siliceous sands, leached sands and humic gleys on shale lenses and along drainage lines.
[3] Disturbed Terrain occurs within other landscapes and is mapped as “xx”. Topography varies from level plains to undulating terrain and has been disturbed by human activity to a depth of at least 100 cm. Original soil has been removed, greatly disturbed or buried
[4] Hawkesbury Soil Landscape is found on rugged, rolling to very steep hills on Hawkesbury Sandstone. Soils are shallow (less than 50 cm), discontinuous lithosols/siliceous sands associated with rock outcrops, earthy sands, yellow earths on the inside of benches and along joints and fractures.
[5] Somersby Soil Landscape is found on gently undulating to rolling rises on deeply weathered Hawkesbury Sandstone plateau. Soils are moderately deep to deep (100–300 cm) red earths and yellow earths overlying laterite gravels and clays on crests and upper slopes; yellow earths and earthy sands on mid slope; grey earths, leached sands and siliceous sands on lower slopes and drainage lines; gleyed podzolic soils in low lying poorly drained areas
[6] Lucas Heights Soil Landscape is found on gently undulating crests and ridges on plateau surfaces. Soils are moderately deep (50– cm), hard setting yellow podzolic soils and yellow soloths, yellow earths on outer edges

Information	B7 Punch Street	B8 Dickson Avenue	B9 Flat Rock Reserve & B10 Bicentennial Reserve	B11 Spit West Reserve	B13/14 Balgowlah Golf Course & Dudley Street	B15 Residential properties Wakehurst Parkway	B16 Sydney Water Reservoir	B17 Wakehurst Parkway, Seaforth to Frenchs Forest
Acid sulphate soil (Further detailed in Chapter 16 (Geology soils and groundwater) of the EIS).	No probable risk of ASS occurrence.			Low probability of ASS occurrence.	No probable risk of ASS occurrence.			
Hydrology (Further detailed in Chapter 17 (Hydrodynamics and water quality) of the EIS).	Flat Rock Creek located 200 m north-east of the site.	Flat Rock Creek located 750 m north-east of the site	Flat Rock Creek adjacent south to southern site boundary (including underground culvert which runs along the southern boundary of the site)	Middle Harbour is adjacent to the site	Burnt Bridge Creek intersects the north-western portion of the site.	Bantry bay located 200 m west of the site. Manly dam located 600 m east of the site.		Manly Creek located 250 m east of the site at its closest point.
Geology (Further detailed in Chapter 16 (Geology soils and groundwater) of the EIS).	Permo-Triassic Hawkesbury sandstone[7].	Permo-Triassic Wianamatta Group[8].	Permo-Triassic Hawkesbury Sandstone Historical records indicate up to 40 m of fill has been placed along Flat Rock Creek.	Anthropogenic reclaimed estuarine land[9]. The Luna Park Fault Zone spans the entire project area, intersecting the BLGHFC project at Middle Harbour.	Permo-Triassic Hawkesbury Sandstone.	Permo-Triassic Hawkesbury Sandstone. Jurassic basaltic dykes intruding the shale and sandstone are known to be present at Seaforth. It is likely numerous other dykes are present.		Permo-Triassic Hawkesbury Sandstone.
Hydro-geology (Further detailed	Groundwater flow inferred to	Groundwater flow inferred to	Groundwater flow inferred to	Groundwater flow inferred to	Groundwater flow inferred to	Groundwater flow inferred to	Groundwater flow inferred to	Groundwater flow inferred to

[7] Permo-Triassic Hawkesbury Sandstone is comprised of medium- to coarse-grained quartz sandstone with minor shale and laminite lenses.
[8] Permo-Triassic Wianamatta Group is comprised of sandstone, siltstone and shale; common bioturbation.
[9] Anthropogenic reclaimed estuarine land includes a natural surface elevation raised by placement of fill over former estuarine swamps and subaqueous estuarine margins.

Information	B7 Punch Street	B8 Dickson Avenue	B9 Flat Rock Reserve & B10 Bicentennial Reserve	B11 Spit West Reserve	B13/14 Balgowlah Golf Course & Dudley Street	B15 Residential properties Wakehurst Parkway	B16 Sydney Water Reservoir	B17 Wakehurst Parkway, Seaforth to Frenchs Forest
in Chapter 16 (Geology soils and groundwater) of the EIS)	flow easterly towards Northbridge. No registered groundwater bores within 500 m of this site.	flow easterly towards Northbridge. No registered groundwater bores within 500 m of this site.	flow easterly towards Northbridge. One groundwater bore (GW108224.1.1) approx. 500 m south-west of Flat Rock Reserve (water supply) installed 132 metres deep. Standing water level is unknown.	flow south and/or east towards Middle Harbour. No registered groundwater bores within 500 m of this site.	flow southerly and/or westerly towards Middle Harbour. No registered groundwater bores within 500 m of this site.	flow southerly and/or south-easterly towards Burnt Bridge Creek. No registered groundwater bores within 500 m of this site.	flow southerly and/or south-easterly towards Burnt Bridge Creek. No registered groundwater bores within 500 m of this site.	flow east and/or west towards Manly Dam and Bantry Bay. No registered groundwater bores within 500 m of this site.

1.1.3 Project Specific T-AEIs historical aerial photograph review

A selection of aerial photographs were reviewed to identify past activities and land uses within the BLGHFC project boundaries was reviewed. These aerial photographs were sourced by Jacobs from Land and Property Information Division and are provided in Appendix M of the EIS (TfNSW, 2020b) for all years with available imagery. These years included 1930, 1955, 1961, 1970, 1975, 1983/84, 1986, 1991, 1994, 1998, 2002, and 2005. A summary of key observations and developments at each of the Project Specific T-AEI sites has been provided in Table 10**.**

Future Project Specific T-AEIs must include a review of the site history, including the available historical aerial photographs.

Table 10 Review of aerial photographs for Project Specific AEIs

Site	Site and surrounds description
B7 Punch Street	The site is vacant land prior to 1998, with a railway line, residential properties and commercial/industrial properties present in the surrounding area. Vegetation appears to have been established at the site in approximately 1998. Hampden Road/Herbert Street bridge is observed at the site in 1955 imagery. Demolition of residential and commercial premises and clearing of bushland is evident between 1991 – 1994 to allow for construction of Gore Hill Freeway adjacent north of the site.
B8 Reserve Road	Residential properties occupy the site prior to 1975 imagery, in which these are replaced by commercial/industrial properties. The surrounding area comprises residential and commercial/industrial premises in all imagery, however demolition of some properties is evident in 1991 to allow for construction of the Gore Hill Freeway.
B9 Flat Rock Reserve & B10 Bicentennial Reserve	Bushland occupies the site, with vacant land, residential and various commercial properties in the surrounding area in 1930. A building, understood to be an incinerator, is present in the northern portion of the site in 1955, with infilling of Flat Rock Drive observed. Further infilling and construction of commercial properties are also observed in the surrounding area. Large scale filling and removal of bushland is observed at the site between 1970 – 1975. Gore Hill Freeway was observed to be constructed south-west of the site between 1986 – 1991.
B11 Spit West Reserve	The site is vacant land undergoing reclamation works on the southern side of the Spit Bridge and west of Spit Road in 1930. The site is unchanged following completed of reclamation works pictured in the 1955 image. The surrounding area includes residential properties, bushland and the Spit Bridge to 2005. A marina is constructed on the eastern side of the Spit circa 1970.
B13/14 Balgowlah Golf Course & Dudley Street	The site is occupied by vacant land and Burnt Bridge Creek in 1930, with the surrounding area comprised of residential, vacant land and bushland. The Burnt Bridge Creek Deviation is evident in 1983/84 imagery, with demolition of residential premises and clearing of bushland occurring in the surrounding region.
B15 Residential properties Wakehurst Parkway	The site is comprised of bushland prior to 1955 imagery, following 1955 the site is comprised of bushland and residential properties. The surrounding area is predominantly bushland and residential premises to 1961, in which extensive bushland clearing is evident. Construction of a bowling club and golf course is evident in 1970 imagery east of the site.
B16 Sydney Water Reservoir	The site is comprised of bushland and a reservoir in the central portion in 1930, with some clearing of bushland evident in 1955, 1991 and 1994 imagery. A second reservoir appears to have been constructed circa 1970 at the site. The surrounding area is predominantly bushland and residential premises to 1961, in which extensive bushland clearing is evident. Construction of a bowling club and golf course is evident in 1970 imagery east of the site.
B17 Wakehurst Parkway - Seaforth to Frenchs Forest	Wakehurst Parkway is present in 1930 imagery to present day imagery, with residential premises and bushland present in the surrounding area. It is noted a former landfill was present approximately 100 m east of Wakehurst Parkway north, currently occupied by Aquatic Reserve Baseball Park. The exact operational dates of the landfill are not provided.

1.1.4 Project Specific T-AEIs contaminated site register review

A search conducted on 17 January 2022 of NSW EPA Contaminated Sites Record of Notices (under Section 58 of the *Contaminated Land Management Act 1997* (CLM Act)) and the list of contaminated sites notified to NSW EPA (under section 60 of the CLM Act) indicated that there were six notified sites registered with NSW EPA within 1 km of the BLGHFC project. These sites are summarised in Table 11.

Table 11 Regulated/notified sites with 500 m of the BLGHFC project

Suburb	Address	Activity	Contamination status	Distance from project / nearest AEI site
Artarmon	477 Pacific Highway.	Service station	Regulation under CLM Act not required	1 km north-west of B8 Dickson Avenue.
Balgowlah	Corner Sydney Road and Maretimo Street.	Service station	Regulation under CLM Act not required	Adjacent south of southern boundary of B13/14 Balgowlah Golf Course & Dudley Street.
Balgowlah	8-10 Roseberry Street.	Other petroleum	Regulation under CLM Act not required	1 km north-east of B13/14 Balgowlah Golf Course & Dudley Street.
Land Cove North	432 Pacific Highway.	Service station	Currently regulated under the CLM Act	1 km north-west of B8 Dickson Avenue.
Willoughby	616-626 Willoughby Road.	Service station	Regulation under CLM Act not required	500 m north-west of B10 Bicentennial Reserve.
Willoughby	498 Willoughby Road.	Service station	Currently regulated under the POEO Act	200 m north-west of B10 Bicentennial Reserve.
Willoughby	Bicentennial Reserve, Flat Rock Gully, Willoughby Leisure Centre.	Other industry	Under assessment	On-site B9 Flat Rock Reserve & B10 Bicentennial Reserve.

1.1.5 Project Specific T-AEIs contamination summary

1.1.5.1 Project Specific T-AEIs sub-surface conditions

The EIS references a number of intrusive investigations undertaken to assess the soil and/or groundwater conditions across various locations within the BLGHFC project area that were completed by Douglas Partners and Golder Associates (DPGA), AECOM and Coffey between 2018 and 2019. The sub-surface conditions encountered during these investigations, relevant to the Project Specific T-AEIs and as presented in the EIS, are summarised are in Table 12.

Table 12 Historical subsurface conditions

AEI site	Lithology	Groundwater
B7 Punch Street & B8 Dickson Avenue	FILL: Gravelly sand and cobbles from surface to 4.5 m bgl. NATURAL: Clayey silt from 3.0 to 8.5 m bgl. BEDROCK: Natural Sandstone underlying clayey silt.	Groundwater encountered at approximately 5.0 m bgl.

AEI site	Lithology	Groundwater
B9 Flat Rock Reserve & B10 Bicentennial Reserve	FILL: Clay and sand fill from surface to 31 m bgl. Inclusions of bricks, concrete and building rubble. BEDROCK: Sandstone underlying fill.	Groundwater encountered between 19 and 25 m bgl.
B11 Spit West Reserve	No previous investigations completed	No previous investigations completed
B13/14 Balgowlah Golf Course & Dudley Street	FILL: Silty and clayey sand and gravels from surface to 1.0 m bgl. NATURAL: Clayey sand from 1.0 to 2.4 m bgl. BEDROCK: Natural Sandstone underlying natural clayey sands.	Groundwater not encountered in most locations, however observed at 1.3 m bgl in shallow sandstone at one location.
B15 Residential properties Wakehurst Parkway & B16 Sydney Water Reservoir	FILL: Clayey sand and gravels from surface to 1.0 m bgl. BEDROCK: Natural sandstone underlying fill.	Groundwater not encountered.
B17 Wakehurst Parkway, Seaforth to Frenchs Forest	FILL: Gravelly clays and sands from surface to 3.7 m bgl. BEDROCK: Natural sandstone encountered at 1.2 to 3.7 m bgl.	Groundwater encountered at 2.5 m bgl.

1.1.5.2 Soil Analytical Results

As stated in the EIS (TfNSW, 2020b), AECOM and Coffey undertook a soil investigation in 2019. The following boreholes and depths were drilled within the Project Specific T-AEIs:

– B128, drilled from surface to 19 m, located at Balgowlah Golf Course;
– B173 to B175, B362 to B368, B371 and B372, drilled to a maximum depth of 56 m, located along Wakehurst Parkway;
– B176 and B177, drilled to a maximum depth of 93 m, located at Flat Rock Drive;
– B354 and B358, drilled to a maximum depth of 14 m, located along Gore Hill Freeway; and
– B382 and B386, drilled to a maximum depth of 27 m, located at Balgowlah.

Soil samples were analysed for heavy metals, polycyclic aromatic hydrocarbons (PAH), total recoverable hydrocarbons (TRH), benzene, toluene, ethylbenzene and xylenes (BTEX), organochlorine pesticides (OCP), organochlorine pesticides (OPP), and selected samples for phenols, volatile organic compounds (VOCs), cyanide, polychlorinated biphenyls (PCB) and asbestos. Analytical results were assessed against open space and commercial/industrial criteria, with the exceedances and field observations of contamination summarised in Table 13.

Table 13 Summary of soil results

Bore ID and depth (bgl)	Location and distance from project	Contaminants above guideline criteria	Guideline exceedance
B175_0.25-0.35 m	Within Wakehurst Parkway (B17).	Nickel.	NEPM (2013) EIL (open space).
B371_0.08-0.10 m		Benzo(a)Pyrene Toxic Equivalence Quotient (BaP TEQ).	NEPM (2013) HIL C (open space).
		Benzo(a)pyrene.	NEPM (2013) ESL (open space and commercial/industrial).
		TRH C_{16}-C_{34}.	NEPM (2013) ESL (open space).
B354_0.55-0.75 m	Gore Hill Freeway – 50 m north of Punch Street (B7).	Nickel.	NEPM (2013) EIL (open space).
B176	South-eastern corner of the baseball diamond (B10).	30 m of fill material (noted as sand, sandstone, shale, gravel and cobbles, some building rubble (bricks and concrete).	

Bore ID and depth (bgl)	Location and distance from project	Contaminants above guideline criteria	Guideline exceedance
B177	Southern portion of Flat Rock Reserve (B9).	11 m of fill material (noted a sandstone cobbles and gravels, building debris, wood, bricks and concrete fragments).	

1.1.5.3 Groundwater Analytical Results

Various groundwater monitoring events were completed by DPGA in 2017 and 2018 and AECOM and Coffey in 2019. These have occurred in up to 10 groundwater wells over 15 sampling events. Further detail is provided in the EIS (TfNSW, 2020b) and a summary of analytical results from these sampled groundwater wells is provided in Table 14. Groundwater samples were analysed for heavy metals, nutrients, PAH, TRH, and BTEX.

Table 14 Summary of groundwater exceedances - across all sampling events

Bore ID	Location and distance from project	Contaminants above guideline criteria	Guideline exceedance
B114A	Artarmon – within Punch Street (B7)	Cobalt, zinc and total phosphorous.	ANZECC (2000) 95% marine water.
		Zinc.	ANZECC (2000) 95% freshwater.
		Manganese and nickel	NHMRC (2011) drinking water.
B127A	North Balgowlah – 400 m west of Balgowlah Golf Course (B13/14).	Cobalt, copper, zinc and total phosphorous.	ANZECC (2000) 95% marine water.
		Cobalt, copper, and zinc .	ANZECC (2000) 95% freshwater.
		Lead, manganese and nickel.	NHMRC (2011) drinking water.
B134A	Bicentennial Reserve and Baseball Diamond, Willoughby – within the south-eastern corner of the baseball diamond (B10).	Cobalt, copper, manganese, nickel, zinc, ammonia and total phosphorous.	ANZECC (2000) 95% marine water
		Boron, cadmium, cobalt, copper, manganese, nickel, zinc and ammonia.	ANZECC (2000) 95% freshwater.
		Arsenic, chromium, lead, manganese, nickel and sulphate.	NHMRC (2011) drinking water.
		Lead and manganese.	NHMRC (2008) recreational.
B238A	Northbridge – 1.5 km west of Spit West Reserve (B11).	Ammonia and total phosphorous.	ANZECC (2000) 95% marine water.
		Ammonia .	ANZECC (2000) 95% freshwater.
B128	Balgowlah – within Balgowlah Golf Course (B13/14).	Cobalt, copper, zinc, reactive phosphorous, total phosphorous.	ANZECC (2000) 95% marine water.
		Copper, manganese and zinc.	ANZECC (2000) 95% freshwater.
		Manganese.	NHMRC (2011) drinking water.
B138	Seaforth – 800 m north-west of Spit West Reserve (B11).	Cobalt, nickel, total phosphorous	ANZECC (2000) 95% marine water.
		Manganese and nickel.	ANZECC (2000) 95% freshwater.
		Manganese .	NHMRC (2011) drinking water.
B155	Northbridge– 1 km north-east of Flat Rock Reserve (B9).	Cobalt, nitrate, reactive phosphorous, total phosphorous.	ANZECC (2000) 95% marine water.
		Chromium and nitrate.	ANZECC (2000) 95% freshwater.
B173	Killarney Heights – within Wakehurst Parkway (B17).	Cobalt, copper and zinc.	ANZECC (2000) 95% marine water.
		Chromium, copper and zinc.	ANZECC (2000) 95% freshwater.
B174		Cobalt, copper, nickel, zinc and total phosphorous .	ANZECC (2000) 95% marine water.

Bore ID	Location and distance from project	Contaminants above guideline criteria	Guideline exceedance
		Boron, copper, manganese, nickel and zinc.	ANZECC (2000) 95% freshwater.
		Manganese.	NHMRC (2011) drinking water.
B175	Frenchs Forest–within Wakehurst Parkway (B17).	Copper, nickel, zinc, nitrate and total phosphorous.	ANZECC (2000) 95% marine water.
		Cobalt, copper, manganese, nickel, zinc and nitrate.	ANZECC (2000) 95% freshwater.
		Manganese.	NHMRC (2011) drinking water.

The EIS (TfNSW, 2020c) noted that heavy metal exceedances of adopted criteria for B238A may be unreliable due to high pH results and have not been considered in the assessment. Exceedances at B134A (Bicentennial Reserve and Baseball Diamond, Willoughby) are likely associated with historical landfilling.

1.2 Preliminary conceptual site model for Project Specific T-AEIs

Appendix M of the EIS (TfNSW, 2020b) presented a Technical Working Paper for contamination and did not include a preliminary conceptual site model (CSM) section, however, discussion of the relevant elements of a preliminary CSM, such as potential sources, were provided. This information has been used as the basis of the preliminary conceptual site model that will need to be further developed and refined in the site-specific SAQPs for each Project Specific T-AEI.

1.2.1 Potential sources of contamination

The sections below detail sources and contaminants of potential concern (COPC) for each Project Specific T-AEI as detailed in Appendix M of the EIS (TfNSW, 2020b). Refined COPC are detailed in Section 1.4.2 associated with the proposed sampling and analytical plan for each Project Specific T-AEI site.

On-site

On-site sources of contamination and associated COPC, as described in Appendix M of the EIS (TfNSW, 2020b) based on historical and current land uses, and GHD's site inspections, are summarised is Table 15. As stated above, COPC are further refined in Section 1.4.2 based on the proposed sampling design and analytical plan for each Project Specific T-AEI.

Table 15 Potential on-site contamination sources and COPC

Construction support site	AEI	Source	COPC
Demolition of existing structures; excavation of tunnel features; construction and operation of temporary site facilities.	B7 Punch Street.	Historical hazardous building materials (bridge) and filling. Mixed commercial/industrial use of site and surrounds, including a mechanical workshop and repairer, swim school, veterinarian and a paint supplier.	Anions and cations, heavy metals*, TRH, BTEX, PAH, PCB, nutrients, perfluoroalkyl and polyfluoroalkyl substances (PFAS), OCP, OPP and asbestos (soil only), cyanide, volatile organic compounds (VOC).
Demolition of existing structures; construction and operation of temporary site facilities.	B8 Dickson Avenue.	Mixed commercial/industrial use of site and surrounds, including a tyre fitter, mechanical workshop and repairer, car wash, television production studios, and the Freeway Hotel.	
B9: Excavation of tunnel access decline and main tunnel alignment; construction and operation of temporary site facilities B10: Tunnel excavation (no surface works planned).	B9 Flat Rock Reserve.	Infilling / waste and incinerator operations.	Anions and cations, heavy metals*, TRH, BTEX, PAH, PCB, VOCs, semi volatile organic compounds (SVOCs), phenols, nutrients, dissolved methane, cyanide, ammonia, PFAS, OCP, OPP and asbestos (soil only), landfill gases including methane, carbon dioxide, oxygen and carbon monoxide.
Construction and operation of temporary site facilities.	B11 Spit West Reserve.	Reclamation of land with material of unknown quality, possible boat repairs and maintenance.	Heavy metals*, CrVI, TRH, BTEX, PAH, PCB, nutrients, PFAS, OCP, OPP and asbestos (soil only), VOC, organotins.
Demolition of existing structures;	B13/14 Balgowlah Golf Course	Inappropriate handling and disposal of building materials during demolition of	Anions and cations, heavy metals*, TRH, BTEX, PAH, PCB, nutrients,

Construction support site	AEI	Source	COPC
excavation of tunnel features and access decline; construction and operation of temporary and permanent site facilities.	& Dudley Street.	buildings for construction of Burnt Bridge Creek Deviation. Filling with material of unknown quality during Burnt Bridge Creek Deviation construction. Degradation of hazardous building materials from structures currently present on the site. Chemicals use and storage at the golf course.	PFAS, OCP, OPP and asbestos (soil only).
Construction and operation of temporary site facilities.	B15 Residential properties, Wakehurst Parkway.	Potential for illegal dumping of hazardous building materials. Degradation of hazardous building materials from structures currently present on the site.	Heavy metals*, TRH, BTEX, PAH, PCB, PFAS, OCP, OPP and asbestos (soil only).
Excavation of tunnel features and access decline; construction and operation of temporary site facilities.	B16 Sydney Water Reservoir	Reservoirs coated with lead paint which may flake as a result of degradation. Potential for hazardous building material fragments to be present at site.	
Excavation of tunnel features and cut and cover; widening of Wakehurst Parkway.	B17 Wakehurst Parkway, Seaforth to Frenchs Forest.	Illegal dumping of waste. Potential historical use of site for fuel storage. Degradation of asphalt road surface.	

Note:

* Heavy metals: Including, but not limited to, arsenic, barium, boron, cadmium, chromium, cobalt, copper, cyanide, iron, lead, manganese, mercury, nickel, zinc.

Off-site

Potential current off-site sources of contamination within 500 m of the BLGHFC project, as described in Appendix M of the EIS based on a review of the current business directory, are summarised in Table 16 relevant to the Project Specific T-AEIs. The address of each potential off-site source is not provided in the EIS.

Table 16 Potential off-site sources of contamination

Suburb and associated AEI	Source	Contamination potential
Artarmon - B7 Punch Street and B8 Dickson Avenue	Multiple mechanical engineering premises adjacent to B7 and B8 and 36 mechanical engineering premises within 500 m of the BLGHFC project.	Low – likely premises are covered in concrete hardstand and spills would be surficial
Balgowlah - B13/14 Balgowlah Golf Course & Dudley Street	Two mechanical engineering premises 300 m east of B13/14. One service station adjacent south of southern boundary of B13/14.	Low – groundwater flow is inferred southerly or westerly. Potential impacts from these premises are unlikely to be impacting the site.
Naremburn - B10 Bicentennial Reserve	One dry cleaner 500 m south of B10.	Low – Likely too far from the BLGHFC project to cause impacts.
Northbridge - B9 Flat Rock Reserve	One dry cleaner 500 m east of B9.	
Seaforth - B15 Residential properties, Wakehurst Parkway	One plant nursery 300 m east of B15.	Low – Likely too far from the BLGHFC project to cause impacts.
Willoughby - B10 Bicentennial Reserve	One mechanical engineering 500 m north-west of B10. One service station 200 m north-west of B10.	Low – groundwater flow inferred east. Potential impacts from these premises are unlikely to be impacting the site.
Frenchs Forest - B17 Wakehurst Parkway, Seaforth to Frenchs Forest	Former landfill 100 m east of B17 (Currently Aquatic Reserve Baseball Park)	Moderate – Fill, including PFAS impacts, may be migrating towards the proposed tunnel alignment. It is unlikely landfill gas impacts present a risk due to the distance from the site.

1.2.2 Preliminary conceptual site model assessment

Based on the information presented in the EIS (TfNSW, 2020a) and as provided by Transport, the following elements of the preliminary CSMs have been developed for each Project Specific T-AEI and are summarised in Table 17 below:

– Potential exposure pathways; and
– Human and ecological receptors at and beyond the BLGHFC project area, both for the construction works proposed and intended future land use.

It is understood that receptors may change in the future following the refinement of the project design and confirmation of end uses.

It is noted that in preparing this preliminary CSM, groundwater extraction and associated human receptors were not considered as a potential pathway due to the presence of a reticulated water supply in the BLGHFC project area and surrounding regions. While there is one registered water supply bore 500 m from the BLGHFC project alignment, located at St Leonards, this is drilled to a depth of 132 metres and is considered unlikely be impacted by potentially contaminated groundwater.

Table 17 Preliminary conceptual site model for each site and construction type

AEI	Proposed construction type	Exposure pathways	Construction phase	Operational / end use phase
			Receptors	Receptors
B7, B8, B13/14, B15	Demolition of existing structures	**Human** - Inhalation of dust particulates from atmospheric dispersion of potential contaminated surficial soil and asbestos fibres (if present); and - Dermal contact and/or ingestion with soil and/or sediment. **Ecological** - Migration of contamination via surface water run-off and groundwater movement to nearby creeks; and - Direct contact and ingestion of contaminated media.	**Human** - On-site construction workers; - Off-site commercial/ industrial receptors (B7 (Punch Street) and B8 (Dickson Avenue) only); - Off-site residential receptors (B13/14 only (Balgowlah Oval)); and - Off-site open space/recreational receptors (B13/14 only (Balgowlah Oval)). **Ecological** - Flat Rock Creek (200 m north-east of B7 (Punch Street) and 750 m north-east of B8 (Dickson Avenue)); and - Burnt Bridge Creek (intersecting B13/14 (Balgowlah Oval)).	Commercial/ industrial (B7, B8, and southern half of B13/14 (Punch Street, Dickson Avenue, and Balgowlah Golf Course, respectively)). Open space/recreational (southern and northern half of B13/14 (Balgowlah Golf Course)).
B7, B9, B13/14, B16, B17	Excavation of tunnel access decline, tunnel excavation, tunnel features and/or cut and cover Construction and operation of temporary site facilities, and/or permanent facilities	Human - Dermal contact and/or ingestion with soil, sediment, surface water, groundwater, leachate and seepage; - Inhalation of dust particulates from atmospheric dispersion of potential contaminated surficial soil and asbestos fibres (if present); - Inhalation of volatile emissions emanating from contaminated soil, sediment, groundwater, surface water, leachate and seepage; - Asphyxiation and explosion hazards from accumulation of landfill gas (B9 only - Flat Rock Reserve); and - Preferential pathways for landfill gases to accumulate in enclosed spaces, including service trenches (B9 only - Flat Rock Reserve).	Human - On-site construction workers; - On-site intrusive maintenance workers; - Off-site intrusive maintenance workers; - Off-site commercial/ industrial receptors (B7 only (Punch Street)); - Off-site residential receptors (B9, B13/14 only (Flat Rock Reserve and Balgowlah Golf Course, respectively)); - Off-site open space/recreational receptors (B13/14 and B16 only (Balgowlah Oval and Wakehurst Golf Course, respectively)); and - Off-site residential and recreational (B17 only (Wakehurst Parkway between Seaforth and Frenchs Forest)). Ecological - Groundwater underlying the BLGHFC project.	Commercial/ industrial (B7, B16, B17, and southern half of B13/14) (Punch Street, Wakehurst Parkway east, Wakehurst Parkway between Seaforth and Frenchs Forest, and Balgowlah Golf Course, respectively)). Open space/recreational (B9, and southern and northern half of B13/14 (Flat Rock Reserve and Balgowlah Golf Course, respectively)).

AEI	Proposed construction type	Exposure pathways	Construction phase	Operational / end use phase
			Receptors	**Receptors**
		Ecological - Migration of contamination via surface water run-off and groundwater movement to nearby creeks; - Direct contact and ingestion of contaminated media - Plant uptake of contaminants present in root zones (typically top two metres of soils) (B16 only - Wakehurst Parkway east); and - Downward migration of contamination from soil and surface water to groundwater.	- Flat Rock Creek (200 m north-east of B7 (Punch Street)); - Flat Rock Creek (adjacent to B9 -Flat Rock Reserve); - Burnt Bridge Creek (intersecting B13/14 (Balgowlah Golf Course)); - Bantry Bay and Manly Dam (200 m west and 600 m east of B16, respectively (Wakehurst Parkway east)); - Adjacent Flat Rock Drive flora and fauna (B9 -Flat Rock Reserve); and - Adjacent Garigal Reserve and Manly Dam Reserve flora and fauna (B16 and B17 (Wakehurst Parkway east and Wakehurst Parkway Seaforth to Frenchs Forest, respectively)).	
B8, B11, B15	Construction and operation of temporary site facilities	**Human:** - Dermal contact and/or ingestion with soil and/or sediment; - Ingestion of contaminated plants for human consumption (vegetable garden) (B15 only - Wakehurst Parkway south); and - Inhalation of volatile emissions emanating from contaminated soil, sediment, groundwater, surface water, leachate and seepage. **Ecological** - Migration of contamination via surface water run-off and groundwater movement to nearby creeks; - Direct contact and ingestion of contaminated media; and - Plant uptake of contaminants present in root zones (typically top two metres of	**Human** - On-site construction workers - Off-site commercial/ industrial receptors (B8 only (Dickson Avenue)); - Off-site open space/recreational receptors (B11 only (Spit West Reserve)); and - Off-site residential receptors (B15 only (Wakehurst Parkway south)). **Ecological** - Flat Rock Creek (750 m north-east of B8 (Dickson Avenue)); - Adjacent Middle Harbour (B11 - Spit West Reserve); - Adjacent Garigal National Park (B15 - Wakehurst Parkway south).	Commercial/ industrial (B8 – Dickson Avenue); Open space/recreational (B11 - Spit West Reserve); and Residential with private gardens (B15 - Wakehurst Parkway south).

AEI	Proposed construction type	Exposure pathways	Construction phase	Operational / end use phase
			Receptors	Receptors
		soils) (B15 only - Wakehurst Parkway south).		
B10	Tunnel excavation (no surface works planned)	**Human** - Dermal contact and/or ingestion with soil, sediment, surface water, groundwater, leachate and seepage; - Inhalation of dust particulates from atmospheric dispersion of potential contaminated surficial soil and asbestos fibres (if present); - Inhalation of volatile emissions emanating from contaminated soil, sediment, groundwater, surface water, leachate and seepage; - Asphyxiation and explosion hazards from accumulation of landfill gas; and - Preferential pathways for landfill gases to accumulate in enclosed spaces, including service trenches. **Ecological** - Migration of contamination via surface water run-off and groundwater movement to nearby creeks; - Direct contact and ingestion of contaminated media; - Plant uptake of contaminants present in root zones (typically top two metres of soils); and - Downward migration of contamination from soil and surface water to groundwater.	**Human** - On-site open space/recreational receptors; - On-site construction workers; - On-site intrusive maintenance workers; - Off-site intrusive maintenance workers; and - Off-site residential receptors. **Ecological** - Groundwater underlying the BLGHFC project; - Adjacent Flat Rock Creek; and - Adjacent Flat Rock Reserve flora and fauna.	No change (open space/ recreation)

1.3 Project specific T-AEIs - basis for assessment

The guidelines and assessment criteria provided in the sections below are based on the current understanding of the Project Specific T-AEI sites, including intended construction works and future end use of each Project Specific T-AEI provided at the time of writing by Transport and in the EIS (TfNSW, 2020b). Nominated criteria is for relevant generic site use scenarios and should be refined during development of future site-specific SAQP(s) by the contractor(s) when the BLGHFC project design and end use is finalised.

1.3.1 Relevant guidelines and standards

The primary guidelines and Australian Standards that outline the sampling methodologies for the investigation are described in Sections 1.3.2 to Section 1.3.5, however additionally include the following standards:

– Australian Standards 44821.1-2005 (2005) and 4482.2-1999 (1999) guidance (*Guide to the sampling and investigation of potentially contaminated soil guidance*, Parts 1 and 2).
– Australian/New Zealand Standard AS/NZS 5667.12-1999 (1999): *Water quality - Sampling, Part 12: Guidance on sampling of bottom sediments*;
– Australian/New Zealand Standard AS/NZS 5667.1 (1998) *Water quality - Sampling - Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples;*
– Australian/New Zealand Standard AS/NZ 5667.11 (1998), *Water Quality – Sampling Part 11: Guidance on Sampling of Groundwaters*;
– Australian/New Zealand Standard AS/NZS 5667.6 (1998) *Water Quality – Sampling, Guidance on sampling of rivers and streams; and*
– Australian/New Zealand Standard AS/NZS 5667.9 (1998) *Water Quality – Sampling, Guidance on sampling from marine waters.*

1.3.2 Soil and sediment assessment criteria

Soil and sediment investigation levels have been adopted from assessment criteria presented in CRC Care (2011), NEPM (2013), NEMP (2020) and NSW EPA (2014) as discussed in Table 18 below.

Given the various receptors identified above in Table 15 during construction activities and at completion of construction for end use receptors, screening criteria for commercial / industrial, open space and/or residential land uses should be applied to the relevant Project Specific T-AEI site once the BLGHFC project design and end uses are finalised.

Table 18 Summary of nominated soil and sediment contamination assessment criteria

Criteria	Guideline name	Site	Details
Health screening levels (HSL) for petroleum hydrocarbons	ASC NEPM	All soils and sediments where hydrocarbons are analysed	The NEPM (2013) presents HSLs for fuel derived petroleum hydrocarbons, which are generic criteria based on a series of reasonably conservative assumptions in order to be protective of human health for a variety of land use types. For the purposes of selecting health-based investigation levels for the project sites, commercial/industrial, open space and/or residential land uses are considered depending on the AEI site as per receptors identified in Table 15.
	CRC Care	All soils and sediments where hydrocarbons are analysed	The CRC Care (Friebel & Nadebaum, 2011) HSLs for petroleum hydrocarbons, for intrusive maintenance workers have been considered. Where HSL values are non-limiting for the protection of human receptors, direct contact values should be adopted as per CRC Care guidelines.
Health investigation levels (HILs) for other contaminants	ASC NEPM	All soils and sediments where metals, PAHs, phenols and pesticides are analysed	For non-petroleum hydrocarbons, the NEPM 2013 HILs have been adopted for commercial/industrial, open space and/or residential land uses (as per receptors identified in Table 15). The HILs take into account direct contact pathways, including incidental ingestion and dermal contact.
Ecological investigation levels (EILs) and ecological screening levels (ESLs)	ASC NEPM	Applicable soil and sediment locations	The NEPM (2013) includes EILs for heavy metals and naphthalene and ESLs for petroleum hydrocarbons. The applicability of ESLs and EILs to the BLGHFC project area should be evaluated by the awarded contractor when developing site-specific SAQP/s. Given that large scale earthworks will occur during the construction, most of the existing ecosystems at the BLGHFC project area will be disturbed. Therefore, it is unlikely EILs and ESLs would be included in the assessment, however they may be considered at sites in which parks and reserves are directly adjacent (B9, B15, B16 and B17) or where open space areas are not proposed to be disturbed during construction works (B10).
Management limits	ASC NEPM	All soils and sediments where hydrocarbons are analysed	The NEPM (2013) includes “management limits” for total petroleum hydrocarbons (TPH). Management limits are applied after consideration of relevant HSLs. Where TPH concentrations are less than the adopted HSL, consideration will be given to management limits for commercial/industrial, open space and/or residential land uses (as per receptors identified in Table 15). The soil texture used will be determined during intrusive activities, however, will most likely utilise a coarse soil texture as a conversative measure.
Asbestos screening criteria	ASC NEPM	Selected soils and sediment samples where asbestos is analysed	Analysis must be completed in the field and laboratory for: – Non-friable (also known as bonded) asbestos using the NEPM gravimetric procedure where the sample volume must be a minimum of 10 L per sample; and Asbestos fines/ fibrous asbestos ('AF/FA') where the sample(s) collected must be a minimum of 500 mL or 1 kg. Please note that the laboratory LOR for presence/absence (0.01%) is higher than the AF/FA HSL criteria (0.001%) (WA DoH, 2009).

Criteria	Guideline name	Site	Details
PFAS screening criteria	PFAS NEMP 2.0	Selected soils and sediment samples where PFAS is analysed	For assessment of PFAS in soil and sediment, human health screening values in the NEMP (2020) for commercial/industrial, open space and/or residential land uses (as per receptors identified in Table 15) will be adopted for screening against PFAS results. This will likely be considered at AEI sites B9 and B10 in the former landfill area.
Waste classification	NSW EPA (2014)	Selected soils and sediment samples	For waste classification purposes, the concentrations of the chemicals in samples analysed will be compared to the criteria in NSW EPA (2014) Waste Classification Guidelines to provide preliminary indications of the classification of waste and material requiring offsite disposal. Waste classification for off-site disposal is required in accordance with the *Protection of the Environment Operations Act* (POEO Act) 1997 and its associated regulations. The classification process for non–liquid wastes (i.e., soil) focuses on the potential for waste to release chemical contaminants into the environment through contact with liquids (leachates). The first test used to chemically assess waste is the Contaminant Threshold (CT) test, which determines the total concentration of each contaminant in the waste sample. The guidelines set different maximum levels for the total concentration of each contaminant in order for waste to be classified as either general solid waste, restricted solid waste or hazardous waste. The toxicity characteristics leaching procedure (TCLP) test estimates the potential for waste to release chemical contaminants into a leaching liquid. The guidelines set different maximum levels of the leachable concentration of each contaminant in order for waste to be classified as general solid waste, restricted solid waste or hazardous waste.

1.3.3 Water assessment criteria

The nominated assessment criteria outlined below for groundwater, surface water, leachate and seepage (if tested) may be used to compare analytical results following field investigations by the appointed BLGHFC contractor(s). Assessment criteria should be further refined by the contractor as part of the site-specific SAQPs. Nominated assessment criteria includes the following:

– NEPC (2013) Health Screening Levels for petroleum hydrocarbons
– CRC Care (2011) Health Screening Levels for petroleum hydrocarbons, for intrusive maintenance workers;
– National Health and Medical Research Council (NHMRC) Recreational waters (2008);
– HEPA (2020) PFAS National Environmental Management Plan (NEMP), Version 2.0
– Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000);
– Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (2018); and
– Kjeldsen et al (2002) Present and Long-term Composition of MSW Landfill Leachate: A Review.

As surrounding suburbs to the BLGHFC project are supplied by a reticulated water supply and only one groundwater abstraction bore is located 500 m from the BLGHFC project, drilled to a depth of 132 m, it is unlikely human groundwater users will be impacted by potentially contaminated groundwater. As such, drinking water criteria has not been considered. Recreational criteria (NHMRC, 2008) has been selected as a conservative measure to assess the potential health risk in relation to direct contact with surface water and groundwater during the construction phase. While groundwater and surface water around the BLGHFC project area is not considered to be used for recreational purposes, this guideline has been adopted as a conservative approach to determine if there is any risk to construction workers that may come in contact with groundwater and surface water.

The assessment of PFAS will likely occur in selected water samples, primarily from AEI sites B9 and B10 in the former landfill area. Criteria from Kjeldsen et al (2002) should also be adopted in this former landfill area to compare to analyte concentrations, particularly in leachate and/or seepage samples.

1.3.4 Landfill gas contamination assessment

AEI sites B9 and B10 are located in the Flat Rock Drive area, known historically to be used as a landfill. This presents potential landfill gas impacts in this area and is subject to gas management criteria listed in the NSW EPA (2016) guidelines. These gas assessment criteria are also referred to in Section 3.6.2 of the NSW EPA (2020) guidelines. Surface gas monitoring and well monitoring would be subject to guidance below, or similar.

Surface transects

– Methane criterion of 500 ppm for intermediate and final capped surfaces.
– In addition to the above criterion, surface monitoring should be performed on calm days with winds below 10 km/hr as per NSW EPA (2016) guidance; and
– Rainfall in the 48 hours preceding surface monitoring should also not exceed circa 28 mm, which is the cut-off level for landfill gas monitoring at the site, calculated using the Department of the Environment and Energy (2017) technical guidelines.

Sub-surface wells

– Methane criterion of 1% (v/v). If methane is detected at concentrations above the threshold level, the occupier must notify the EPA promptly. The subsurface criteria the subsurface criteria 1%v/v also represents the gas accumulation criterion for enclosed structures which triggers further investigation and corrective action; and
– Carbon dioxide criterion of 1.5% (v/v).

1.3.5 Acid sulfate soil assessment

Appendix N of the EIS reports that there is no probable risk of acid sulfate soil (ASS) occurrence across the BLGHFC project, with the exception of AEI site B11, located at Spit West Reserve which comprises a low risk of ASS occurrence. As there is the potential for ASS to be present at this site, analysis of pH and pHfox for soil samples may be required.

The Acid Sulfate Soils Management Advisory Committee (ASSMAC) manual (1998) provides procedures for field screening (pH_F and pH_{FOX}) for actual acid sulfate soils (AASS) and potential acid sulfate soils (PASS). ASS must be assessed with due consideration of the National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual ((Commonwealth of Australia, 2018), noting the requirements for chromium reducible sulfur testing.

Field pH measurements

– pH readings of pH <4, indicate that AASS are possibly present; and

– pH readings of pH >4, indicate the absence of AASS, however does not give any indication of the PASS.

Field Peroxide measurements

– A positive peroxide test indicating one of more of the following may indicate the presence of PASS:
  - Change in colour of the soil from grey to brown tones;
  - Effervescence;
  - Release of sulfur smelling gases such as sulfur dioxide and hydrogen sulphide;
  - A lowering of the soil pH by at least one unit; and
  - A final pH<3.5.

Laboratory analysis

The assessment criteria for ASS adopted for the site includes the acid sulfate action guidelines as stated in the Acid Sulfate Soil Manual (ASSMAC, 1998). The guidelines assess results for ASS testing and determine whether disturbed soils at the site need to be treated or managed. The guidelines for soils with fine to coarse texture are summarised in Table 19.

Table 19 Action criteria for acid sulfate soils

Soil Texture	Description	Action Criteria		
		S_{POS} (%S)	TPA (mole H+/tonne)	TSA (mole H+/tonne)
Soil disturbance < 1000 tonnes				
Coarse	Sands to loamy sands	0.3	18	18
Medium	Sandy loams to light clays	0.6	36	36
Fine	Heavy clays to silty clays	0.1	62	62
Soil disturbance > 1000 tonnes				
Coarse	Sands to loamy sands	0.3	18	18
Medium	Sandy loams to light clays	0.3	18	18
Fine	Heavy clays to silty clays	0.3	18	18

Notes to table:

TPA – Titratable peroxide acidity

TSA – Titratable sulfidic acidity

S_{POS} - Peroxide Oxidisable Sulfur

Given the unknown quantity of soil disturbance at the site, the more stringent action criteria for > 1000 tonnes of disturbance is suggested to be applied, however this should be reviewed as part of the site-specific SAQP.

1.4 Project Specific T-AEIs - sampling and analysis strategy

1.4.1 Data Quality Objectives for Project Specific T-AEIs

The basis for the data quality objectives developed for the Project Specific T-AEIs are defined in and are based on the seven step process set out in the ASC NEPM. The Framework SAQP applies only to the moderate and high risk sites identified in the EIS.

Table 20 Data quality objectives

Steps		Description
1	State the problem	There are a number of potential sources of contamination that have been identified in the EIS and during the preparation of this Framework SAQP (as outlined in Section 1.2). These sources and associated AEIs may have the potential to impact human health and/or the environment during construction and operation of the BLGHFC project and potential future land use receptors.
2	Identify the decision	The key decisions to be made include: – Determine the potential contamination impact at AEIs across the BLGHFC project, as defined in the EIS; and – Determine the sampling and analysis required for AEIs across the BLGHFC project to inform future site-specific SAQP(s) to be developed by the appointed contractor(s) and understand potential risks to receptors during construction and following completion of construction works.
3	Identify inputs to the decision	The information needed to support the decisions identified above at this time includes the EIS, including but not limited to, Appendix M (Contamination, (TfNSW, 2020b)) and Appendix N (Groundwater, (TfNSW, 2020c)).
4	Define the study boundaries	The study boundary comprises the boundaries of each AEI site as shown in Figures 4 to 6 and Figures 8 to 10, (Appendix A of the Framework SAQP)
5	Develop a decision rule	The decision rules to be applied are as follows: – If reported chemical concentrations are above the soil and/or water and/or landfill gas adopted assessment criteria, then soil and/or water and/or landfill gas assessment will be undertaken to review if these constitute an unacceptable risk to potential receptors. In that occurrence, further investigation would be undertaken; and – If concentration(s) of chemical contaminant(s) exceed the adopted assessment criteria, then further assessment of the soil, and/or water and/or landfill gas may be required to evaluate the need for additional investigation.
6	Specify limits on decision errors	Two primary decision error-types may occur due to uncertainties or limitations in the BLGHFC Project data set. This may include: – A sample/site may be deemed to pass the nominated criteria, when in fact it does not. This may occur if contamination is 'missed' due to limitations in the sampling plan, or if the BLGHFC project analytical data set is unreliable; and – A sample/site may be deemed to fail the nominated criteria, in actuality, it may not. This may occur if the BLGHFC project analytical data set is unreliable, due to inappropriate sampling, sample handling, or analytical procedures. The following tasks would be undertaken: – An assessment to understand the likelihood of a decision error being made based on the results of a quality assurance / quality control (QA/QC) assessment and the closeness of the data to the assessment criteria; and – A QA/QC assessment, evaluating the reliability and useability of data, which are expressed as five data quality indicators (DQI).
7	Optimise the design for obtaining data	Achieved by developing this Framework SAQP, which will be refined in the future by the appointed contractor(s) who will create their own by evaluating field observations and analytical results.

1.4.2 Sampling and laboratory analysis program for Project Specific T-AEIs

Based on the summary information presented in Section 4 of this Framework SAQP, consideration has been provided to the likely sampling locations and rationale, laboratory analysis and frequency of sampling that maybe required for each Project Specific T-AEI. The proposed sampling design was developed in accordance with the NSW EPA Sampling Design Guidelines (1995). Sample frequencies stated in the table below consider the area of each Project Specific T- AEI site at the time of reporting and as presented in Figures 4 to 6 and Figures 8 to 10, Appendix A of the Framework SAQP. Sampling required at the exit phase will be dependent on the outcome of any remediation work or management requirements at the completion of construction, with a preliminary estimate provided in Table 21 based on the site area.

Table 21 presents a summary of the required sampling and analytical program, however, these sampling and analytical frequencies may be subject to change following the completion of this Framework SAQP and any change in the program must be justified in the site-specific SAQPs. It is noted the frequency is designed to assess site characterisation and not support waste classification purposes. Additional sampling may be required for the purposes of waste classification (see Section 1.5.9).

Table 21 Sampling design overview

AEI	Surface area of site (m2)	Proposed construction details	Future land use / operational phase	Proposed minimum soil sampling points based on the site area		Investigations to include (Yes/No)			Rationale	
				Construction phase	Exit phase	Groundwater	Surface water / sediment	Landfill gas / Ground gases	COPC	Contamination considerations
B7 Punch Street	5,900	Demolition of existing structures; excavation of tunnel features; construction and operation of temporary site facilities.	Commercial/ industrial	15	15	Yes	Yes	No	**Groundwater** Anions and cations, heavy metals[10], TRH, BTEX, PAH, nutrients, TDS, OCP and OPP. **Surface water** Anions and cations, heavy metals, TRH, BTEX, PAH, nutrients, TDS, OCP and OPP, biochemical oxygen demand (BOD) and chemical oxygen demand (COD). **Soil and sediment** pH, asbestos (presence/absence), TRH, BTEX, PAH, heavy metals, OCP and OPP, PCB, TCLP (PAH and metals).	It is likely that contamination (if present) is located throughout the soil profile due to historical filling, demolition and construction activities (including construction of the Gore Hill Freeway), and commercial/industrial use of the adjacent area. This may be impacting groundwater underlying the site and/or Flat Rock Creek, located 200 m north-east of the site.
B8 Dickson Avenue	5,500			14	14	Yes	Yes	No		It is likely that contamination (if present) is located throughout the soil profile due to historical demolition and construction activities (including construction of the Gore Hill Freeway), and commercial/industrial use of the site and adjacent area. This may be impacting groundwater underlying the site and/or Flat Rock Creek, located 750 m north-east of the site.
B9 Flat Rock Reserve	10,400	Excavation of tunnel access decline and main tunnel alignment; construction and operation of temporary site facilities.	Open space	24	24	Yes	Yes	Yes	**Groundwater** Anions and cations, heavy metals, TRH, BTEX, PAH, nutrients, TDS, VOCs, SVOCs, phenols, PFAS, OCP and OPP, dissolved methane, BOD and COD. **Surface water** Anions and cations, heavy metals, TRH, BTEX, PAH, nutrients, TDS, VOCs, SVOCs, phenols, PFAS, OCP and OPP, dissolved methane, BOD and COD. **Soil and sediment** pH, asbestos (presence/absence), TRH, BTEX, PAH, heavy metals, OCP and OPP, PCB, VOCs, SVOCs, phenols, PFAS, cyanide, ammonia,	It is likely that contamination (if present) is located throughout the soil profile due to historical infilling, associated with the former landfill, and incinerator operations at the sites. Commercial/industrial has also occurred in the adjacent area. This may be impacting groundwater underlying the sites and/or Flat Rock Creek adjacent to the sites.

[10] Heavy metals: Including, but not limited to, arsenic, boron, cadmium, chromium, cobalt, copper, cyanide, iron, lead, manganese, mercury, nickel and zinc

AEI	Surface area of site (m2)	Proposed construction details	Future land use / operational phase	Proposed minimum soil sampling points based on the site area		Investigations to include (Yes/No)			Rationale	
				Construction phase	Exit phase	Groundwater	Surface water / sediment	Landfill gas / Ground gases	COPC	Contamination considerations
									TCLP (PFAS, PAH and metals). **Landfill gas** Field test (concentration, pressure gradient and flow), carbon dioxide, methane, oxygen, hydrogen sulphide	
B10 Bicentennial Reserve	109,200	Tunnel excavation (no surface works planned).	Public recreation	Targeted for design and waste classification purposes for tunnel route and material that comes from the road header excavation. No requirements for site characterisation.	None, as no surface works proposed	Yes	No	Yes		
B11 Spit West Reserve	26,500	Construction and operation of temporary site facilities.	Open space	37	37	Yes	Yes	No	**Groundwater** Anions and cations, heavy metals, TRH, BTEX, PAH, nutrients, TDS, OCP and OPP **Soil** pH, asbestos (presence/absence), TRH, BTEX, PAH, heavy metals, OCP and OPP, PCB, TCLP (PAH and metals), ASS	It is likely that contamination (if present) would be present in surficial soil as the site is reclaimed land, with no known potentially contaminating activities occurring. It is adjacent to Middle Harbour which is considered to be impacted by various sources, prior to construction of the BLGHFC project.
B13/14 Balgowlah Golf Course & Dudley Street	113,000	Demolition of existing structures; excavation of tunnel features and access decline; construction and operation of temporary and permanent site facilities.	Both sites will be used for commercial/ industrial and open space land. The northern half of the site will only comprise of open space land.	Likely required to be separated into smaller sites. Based on size - 135 sampling points.	Likely required to be separated into smaller sites. Based on size - 135 sampling points.	Yes	Yes	Yes	**Groundwater** Anions and cations, heavy metals, TRH, BTEX, PAH, nutrients, TDS **Surface water** Anions and cations, heavy metals, TRH, BTEX, PAH, nutrients, OCP and OPP, BOD and COD, TDS **Soil and sediment** pH, asbestos (presence/absence), TRH, BTEX, PAH, heavy metals, OCP and OPP, PCB, TCLP (PAH and metals) **Landfill gas** Field test (concentration, pressure gradient and flow)	It is likely that contamination (if present) is located throughout the soil profile due to historical filling and demolition and construction activities associated with the Burnt Bridge Creek Deviation, and current potential chemicals stored at the Golf Course. This may be impacting groundwater underlying the sites and/or Burnt Bridge Creek which intersects the north-western portion of the site.
	10,200			21	21		No	No	**Groundwater**	

AEI	Surface area of site (m2)	Proposed construction details	Future land use / operational phase	Proposed minimum soil sampling points based on the site area		Investigations to include (Yes/No)			Rationale	
				Construction phase	Exit phase	Groundwater	Surface water / sediment	Landfill gas / Ground gases	COPC	Contamination considerations
B15 Residential properties, Wakehurst Parkway		Construction and operation of temporary site facilities.	Residential land use including private gardens.			Yes (subject to soil investigation results)			Anions and cations, heavy metals, TRH, BTEX, PAH, nutrients, TDS, OCP and OPP **Surface water** Anions and cations, heavy metals, TRH, BTEX, PAH, nutrients, TDS, OCP and OPP, BOD and COD **Soil** pH, asbestos (presence/absence), TRH, BTEX, PAH, heavy metals, OCP and OPP, PCB, TCLP (PAH and metals)	It is likely that contamination (if present) would be present in surficial soils as the site has been relatively unchanged from 1955 comprising bushland and residential properties. Some degradation of these properties may have occurred. It is unlikely that contamination (if present) would be received by underlying groundwater and/or off-site surface water receptors. Should the soils investigation return results below the selected criteria, groundwater investigation is not considered to be necessary.
B16 Sydney Water Reservoir	12,300	Excavation of tunnel features and access decline; construction and operation of temporary site facilities.	Commercial/ industrial	23	23	Yes (subject to soil investigation results)	Yes	No		It is likely that contamination (if present) would be present in surficial soils as the site has been relatively unchanged since 1930. Some degradation of reservoirs on-site. It is unlikely that contamination (if present) would be received by underlying groundwater and/or off-site surface water receptors. Should the soils investigation return results below the selected criteria, groundwater investigation is not considered to be necessary.
B17 Wakehurst Parkway, Seaforth to Frenchs Forest	82,700	Excavation of tunnel features and cut and cover; widening of Wakehurst Parkway.	Public road	Likely required to be separated into smaller sites. Based on size - 100 sampling points.	None as public road	Yes (subject to soil investigation results)	No - unless excavation interact with groundwater in northern most portion of alignment	No	**Soil** pH, asbestos (presence/absence), TRH, BTEX, PAH, heavy metals, OCP and OPP, PCB, TCLP (PAH and metals)	It is likely that contamination (if present) would be present in surficial soils due to clearing and use of the site for storage and parking in the 1970s and further development possibly including fuel storage in the early 2000s. Fly tipping known to have occurred adjacent to the site bringing potential asbestos containing materials (ACM) waste. It is unlikely that contamination (if present) would be received by underlying groundwater and/or off-site surface water receptors. Should the soils investigation return results below the selected criteria, groundwater investigation is not considered to be necessary.

1.5 Field and analytical methodology

The site-specific SAQPs must detail the field and analytical methodologies to be applied and justify the selection of those methods. The sections below provide some further guidance and requirements for the methodologies that must be detailed within the site-specific SAQPs.

1.5.1 Field work preparations

For each site-specific SAQP, the following activities must be undertaken prior to mobilising to site for the investigation and/or monitoring (where relevant):

- Develop a health, safety and environmental management plan tailored to the BLGHFC project area and proposed scope of work, including Job Safety and Environmental Analysis (JSEA) and/or Construction Environmental Management Plan (CEMP) or similar;
- Obtain all other relevant approvals required to enable intrusive works will be obtained prior to implementing the sampling plan (e.g. for work on sites with ecologically sensitive communities or heritage items);
- Investigation of drilling additives and core boxes as a potential contamination source, specifically relating to PFAS;
- Obtain and review dial before you dig (DBYD) services drawings;
- Engage the services of the following contractors:
    - Service locator to aid in identifying underground services prior to commencement of works at all proposed intrusive locations;
    - Labour – to advance hand augers / test pits into soil and drillers for advancement of boreholes and installation of monitoring wells and gas wells;
    - Licensed Asbestos Assessor (LAA) to undertake emu-picking and asbestos mapping along Wakehurst Parkway;
    - National Association of Testing Authority (NATA) accredited laboratories – to analyse samples; and
- Preparation and order of laboratory consumables (gloves, jars, bottles) and equipment for sampling.

1.5.2 Soil and sediment sampling

Various methods may be utilised to advance into the ground to collect soil samples, including drill rig, excavator bucket, hand auger and grab samples, where relevant. Soil and sediment sampling methods set out in site-specific SAQPs must include the application of the relevant following methodologies:

- Soil samples should be collected directly off of auger flights, bits, push-tubes, tow of excavator bucket or hand auger where relevant. Grab samples should be collected using disposable nitrile gloves. Care should be taken during sampling to ensure no cross contamination occurs between different layers of soil;
- All soil and sediment samples should be visually inspected, and all field observations and subsurface conditions recorded on field lithological logs, including presence of fill materials and any visual or olfactory indications of contamination;
- Where asbestos is visually identified, quantitative asbestos sampling in accordance with NEPM 2013 is required to confirm site suitability;
- Should asbestos be identified in soils, a sampling and analysis regime must be included in the site-specific SAQPs, and must be completed in the field and laboratory for:
    - Non-friable (also known as bonded) asbestos using the NEPM gravimetric procedure where the sample volume must be a minimum of 10 L per sample; and
- Asbestos fines/ fibrous asbestos ('AF/FA') where the sample(s) collected must be a minimum of 500 mL or 1 kg. Please note that the laboratory LOR for presence/absence (0.01%) is higher than the AF/FA HSL criteria (0.001%). (WA DoH, 2009);
- Soil samples should not be collected across changes in soil strata or soil horizons. Additional samples should be taken where there is a change in soil strata / horizon;.

– Soil samples should be screened for the presence of volatile contamination using a calibrated photo-ionisation detector (PID) where relevant volatile COPCs are to be analysed;
– The extent and depth of soil sampling locations will be determined by the appointed contractor(s);
– In general, soil sampling should be conducted at the surface, 0.2 m bgl, 0.5 m bgl, at 1 m bgl and approximate 1 m intervals thereafter until reaching termination depth. Sediment samples should be collected just below surface level;
– The appointed contractor(s) is to decide how many samples are to be collected from each borehole, test pit and/or hand auger;
– Leachate testing should be considered as required in the site-specific SAQPs for the assessment of soils and sediments;
– Unanalysed samples should be retained on hold in case additional laboratory analysis is required; and
– Photographs should be taken of the soil cores and sampling locations.

General sample collection and handling procedures are further detailed in Section 1.6.1.1.

Rock sampling

Core drilling may be used for combined geotechnical and contamination investigation locations. Rock samples should be collected from the recovered and cored rock column. Where practical, field staff should use laboratory provided rinsate water or deionised water to rinse the rock samples prior to submission to the laboratory. Given the recovered rock column may be used for geotechnical assessment purpose, field staff should select rock samples from corebox for analysis of non-volatile COPCs.

1.5.3 Groundwater and leachate well installation

Groundwater wells should be installed in general accordance with the Minimum Construction Requirements for Water Bores in Australia (National Uniform Drillers Licensing Committee, 2020). It is noted that the construction of groundwater wells may differ between consultants and will be specified by the appointed contractor(s).

Construction of groundwater wells should take into account the following general considerations:

– Wells will be constructed using 50 mm polyvinyl chloride (PVC) class 18 blank and screened casings, or similar;
– Screened casing slots (commercial factory manufactured) should be no greater than 1 mm in width and be screened across the encountered water strike. Leachate monitoring wells should be screened in landfill waste;
– Blank and screened PVC casing will be attached to each other using flush mounted factory-threaded joints;
– Primary filter pack material should be uniformly graded clean, coarse, sub-rounded to rounded silica sand or similar material, with a high coefficient of uniformity and will extend at least 0.5 m above the screened PVC casing;
– Bentonite pellets, or similar, should be used as annular sealant extending at least 0.5 m above the filter pack;
– Wells should be grouted from the top of the bentonite to the surface;
– Monitoring wells should be finished with a stainless steel monument cover or a flush mounted gatic cover and cemented (depending on land owner requirements);
– Wells should be developed following completion using Teflon-free equipment by purging at least three well volumes (where possible) or until dry. Well development should include removal of sediment from wells and reconnection back to the water bearing sequence; and
– Following installation, the monitoring wells should be accurately surveyed for location and elevation.

It is noted that due to topographic differences across the BLGHFC project, the length of the screen will differ between locations.

The monitoring wells installed are considered to be valuable as long-term infrastructure and should be retained for future proposed monitoring events where possible. Monitoring wells may also be installed in the same locations as geotechnical boreholes if appropriate.

1.5.4 Landfill gas well installation

Landfill gas wells should be installed in general accordance with NSW EPA. (2020). Assessment and management of hazardous ground gases (NSW EPA, 2020) and EPA Victoria (2015) Best Practice Environmental Management for the siting, design, operation and rehabilitation of landfills: Publication 788.3. The following aspects must be taken into consideration when designing the wells:

- A well screen interval that intercepts as much of the unsaturated (vadose) zone as possible whilst still allowing an adequate gas tight seal to be present/ constructed at the ground's surface;
- Where vertical stratification of gas concentrations or multiple pathways have been identified, or where these are otherwise deemed likely, multiple wells screened at different depths or multi-port wells should be installed;
- Sealing of the well so that any gas accumulating will be retained for sampling;
- Fitted with a cap tapped to take a quick-connect nipple (or a manual valve and nipple) that seals the well and allows easy connection to a measuring instrument; and
- Robustness, durability and accessibility of the well to ensure its suitability for ongoing use.

1.5.5 Groundwater and leachate sampling

Groundwater sampling should be conducted by considering the following:

- Wells should be left to recharge for at least one week following development and prior to sampling;
- Wells should be gauged to determine the standing water levels and depth of well using a water level probe. Depth measurements should be referenced to the top of well casing as an established datum and recorded to the nearest millimetre;
- Wells should be purged and sampled using Teflon-free dedicated and disposable high-density polyethylene (HDPE), or low-density polyethylene (LDPE) when not analysing for PFAS, using low-flow sampling techniques. Using this approach, only dedicated disposal equipment will come into contact with the sample, to reduce the risk of cross contamination between sampling locations;
- Field parameters measured during purging on a calibrated water quality meter should include at a minimum: Temperature, pH, electrical conductivity (EC), dissolved oxygen (DO) and oxidation reduction potential (ORP). Field parameters should be recorded on field data sheets;
- Wells should be purged until stabilisation of parameters, after which the sample should be collected in laboratory supplied bottles. Following sampling, the sample containers should be placed into a chilled cooler box for transport to a NATA accredited laboratory for analysis; and
- If the well is low yielding and is purged dry, it should be left to recover. Following recovery of groundwater levels in the well, grab samples should be collected on the assumption that the groundwater represents inflow from the hydrostratigraphic unit screened by the well. In this instance, measurement of one round of field water quality parameters at the time of sampling would be adopted to provide a cross check and confirm representative formation water is being collected.

Where PFAS is proposed within the analytical schedule, reusable components of the pump should be decontaminated with PFAS-free detergent (e.g., Liquinox) and laboratory supplied PFAS-free rinsate water. The collection point should be placed within the screen interval and the flow rate reduced to achieve a low flow sampling effect whereby water is preferentially drawn in through the well screen. This should be verified through monitoring of the water level during sampling and by avoiding to the extent practicable the drawdown of the water in the well due to pumping.

The appointed contractor(s) is to consider whether ongoing groundwater monitoring is required based on initial investigations.

1.5.6 Groundwater level and surface water gauging

It is understood that water level logging of groundwater and/or surface water may be required, particularly to understand seasonal variation and the impact of construction on the groundwater table and surrounding surface water receptors. A site inspection should be undertaken by the awarded contractor to identify suitable locations for monitoring of the surface water levels if deemed required.

Groundwater level loggers, if required, should be installed within the existing well casing approximately 1 m from the base of the well. A barometric logger should also be installed at a selected groundwater monitoring well to compensate for atmospheric pressure fluctuations and correction of the data (if this data is not available from the nearest weather station).

Timing intervals for data collection will be determined by the appointed contractor(s), however may include collection of data every 15 minutes throughout the duration of project construction.

The data should be validated and calibrated with manual measurements to assess accuracy of the loggers.

1.5.7 Surface water sampling

Where the embankment of the water body is stable and the water body can be safely accessed, surface water samples should be collected by hand, directly into the laboratory supplied sample containers. Where depth permits, the sample container should be positioned at least 10 cm below the surface water level, above the sediment bed and oriented with the capped opening facing downwards to avoid the collection of surface films. Once in position, the container cap should be removed to allow sample collection.

Where sampling points cannot be safely accessed, surface water samples should be collected using a long-handled sampler and decanted into the laboratory supplied sample containers.

Field parameters including temperature, pH, EC, DO and ORP are to be measured at the time of sampling using a pre-calibrated water quality meter and recorded on field sampling sheets. Field observations such as odours or sheen presence should also be recorded on field sampling sheets.

These procedures should likewise be followed if seepage samples are to be obtained following the identification of seepage locations at the time of sampling.

Rainfall events

To understand the impact of wet weather events on contaminant concentrations in surface water locations, surface water sampling events may occur during construction following rainfall events. To determine the trigger for wet weather sampling events, the appointed contractor(s) may choose to adopt the Department of the Environment and Energy (2017) *National Greenhouse and Energy Reporting Scheme Measurement Technical Guidelines for the Estimation of Emissions by Facilities in Australia* definition of a 'heavy rainfall event'. This is a defined as a volume of rainfall recorded within a day that exceeds the 'heavy rainfall benchmark' (HRF) as defined by the following formula:

$$HRF = 2 \times \frac{RF}{MRD}$$

Where:

HRF = heavy rainfall benchmark

RF = the mean monthly rainfall for the month at the nearest Bureau of Meteorology weather station (in this case, Mosman Council (BoM Station 66184) or Observatory Hill (BoM Station 66062).

MRD = the mean number of rainfall days for the month at the nearest Bureau of Meteorology weather station (in this case, Mosman Council (BoM Station 66184) or Observatory Hill (BoM Station 66062).

The timing and frequency of these sampling events should be determined based upon review of BoM rainfall data from the nearest weather station by the awarded contractor.

1.5.8 Landfill gas monitoring

Landfill gas (LFG) monitoring will likely include LFG surface emission monitoring and LFG sub-surface well monitoring as presented below, and should be conducted in general accordance with (NSW EPA, 2020).

LFG surface emission monitoring

Methane should be measured using a calibrated surface gas analyser (e.g., Huberg Laser One) approximately 50 mm above the ground level along grid lines spaced 25 metres apart across the inferred surface of the landfilled waste mass. A calibrated wind vane anemometer must also be used to measure wind speeds at the site during the LFG surface emission monitoring.

Where observations (including LFG odours or bubbling through ponded water) indicate that significant LFG emissions may occur offset from the gridlines being monitored, the monitoring personnel should divert from the gridlines to investigate these possible point sources.

LFG sub-surface well monitoring

LFG related parameters are to be measured in installed landfill gas sub-surface wells using a calibrated gas analyser (e.g., GA5000). Furthermore, a water level probe should be used to measure standing water levels and the depth to the base of the monitoring wells.

LFG related parameters to be measured and recorded on field sheets are to include at a minimum:

– Methane
– Carbon dioxide
– Oxygen
– Gas balance (the volume of the gas monitored that is not methane, carbon dioxide, oxygen, hydrogen sulphide, or carbon monoxide)
– Hydrogen sulphide
– Carbon monoxide
– Atmospheric pressure
– Relative (bore) pressure
– Gas flow

Observations such as the weather conditions and well condition should also be recorded on field sheets. Frequency of events should be determined by the awarded contractor.

1.5.9 Waste management

Spoil generated during intrusive investigations should be used to reinstate test pits and boreholes, in the reverse order of extraction. Spoil from the installation, development and sampling of groundwater wells should be characterised and transported off-site if required to an appropriately licenced waste facility. Further analysis will be used for characterising spoil generated from sampling.

Stockpile sampling should be undertaken in accordance with Schedule B2 (NEPC, 2013) with sampling requirements informed by the site history, the composition of the stockpile and the contaminant(s). The external composition of the stockpile must be documented, along with any excavations into the stockpile. An assessment of the age and surface condition must be undertaken, and the stockpile dimensions determined. Sample numbers, point distribution and collection methodology must be in accordance with Schedule B2 (NEPC, 2013).

Excess spoils comprising waste materials are to be classified in accordance with (NSW EPA, 2014) Waste Classification Guidelines, and where required, removed for off-site disposal by a licensed contractor. Excess spoils comprising natural soil / rock should be placed at surface near the drilled boreholes or test pits, away from areas prone to erosion and nominally compacted to minimise risk of run-off.

Further details on the storage procedure and waste handling should be directed by the appointed contractor(s).

1.5.10 Contingency plan

The site-specific SAQPs must require that control measures to be implemented during the intrusive investigations to protect the surrounding environment and community are appropriately documented by the contractor(s) prior to the commencement of any intrusive investigations. A contingency plan is outlined below, listing potential unexpected events that may arise during the fieldwork and actions that are to be undertaken if unexpected conditions occur:

– Environmental controls are to be implemented at all sites to prevent migration of potentially impacted material to the surrounding environment; and
– If evidence of contamination other than that expected is encountered, additional samples should be collected for assessment by the appointed contractor(s).

1.6 Data quality indicators

The site-specific SAQPs must detail the data quality indicators to be applied during an investigation. The sections below provide some further guidance and requirements for the data quality indicators that must be detailed within the site-specific SAQPs.

1.6.1 Field quality assurance and quality control

1.6.1.1 General sample collection and handling

All fieldwork is to be conducted with reference to the relevant guidelines and standards outlined in Section 1.3.

An experienced environmental scientist is to undertake the fieldwork and sampling program. Borelogs, field sheets and photographs should be prepared for each sampling location and included in the report. A hand-held GPS should be used to record coordinates of sampling locations.

Soil, sediment and water samples should be collected using new disposable nitrile gloves and placed directly into dedicated, laboratory supplied sample jars and bottles. These should then be placed into chilled insulated containers for transport to a NATA accredited laboratory. A label should be attached to each sampling container showing job number, date, sample location, depth and sampler initials. Sample details are to be entered onto a chain of custody (COC) form that will accompany the samples to the laboratory. A COC form should be used for every batch of samples submitted to the laboratory, including the scheduled analysis for each sample to be undertaken. Delivery of samples to the laboratory will need to comply with sample holding times.

When handling samples dedicated for PFAS analysis, as per the NEMP (2020), no Teflon coated materials or aluminium foil are to be used. All re-usable sampling equipment is to be made from HDPE or stainless steel and decontaminated prior to use. For samples where PFAS is not analysed, LDPE materials are able to be used.

Where PFAS is included in the analytical suite, during field sampling of PFAS, the sampling personnel are to adhere to the sampling recommendations as specified in the NEMP (2020), including the following:

– No brand-new field clothing to be worn;
– No waterproof clothing (e.g. GoreTex, Teflon or Tyvek clothing);
– No fast-food wrappers/containers or pre-wrapped foods or snacks; and
– No use of self-sticking notes or similar office products.

Soil samples for ASS screening test should be placed in ziplock plastic bags immediately from the ground and then placed into ice filled insulated containers for transport to the laboratory. Samples scheduled for asbestos analysis and potential asbestos containing materials (ACM) are to likewise be placed into ziplock bags.

Calibration certificates for field instruments are to be retained for record of correct calibration.

1.6.1.2 Decontamination of sampling equipment

To avoid cross-contamination between samples and sampling locations all reusable sampling equipment must be decontaminated prior to and at completion of sampling at each sample location, and where PFAS is proposed in the analytical schedule decontamination should be undertaken in accordance with the NEMP (HEPA , 2020). The decontamination process should not comprise a decontamination solution or detergent containing PFAS (e.g., Decon 90).

The decontamination process should comprise the following:

– Drilling equipment brushed to remove soil on the equipment and washed by high pressure water prior to first time use in the field and between sampling locations;
– Sampling equipment and tools washed and scrubbed in tap water; followed by rinsing with PFAS-free decontamination solution (e.g., Liquinox) and deionised water;
– Prior to sampling, a rinsate sample should be collected from all new equipment brought onto site using laboratory supplied PFAS free water. The primary laboratory will certify the rinsate water; and

– In addition, all samples must be handled by field staff in accordance with HEPA (2020) requirements and using clean disposable nitrile gloves, replaced between each sample.

1.6.1.3 Quality assurance assessment for cross contamination

1.6.1.3.1 Drilling additives

Drilling additives may be used during the investigation to enable drilling to reach the tunnel depth and collection of rock samples. To avoid the potential false concentrations of COPC, i.e., PFAS and hydrocarbons (TRH) in rock and groundwater samples, the awarded contractor should analyse drilling additives for PFAS and hydrocarbon (TRH) and provide the analytical data to Transport prior to using the drilling additives in the field.

An experienced environmental scientist/engineer should collect samples from the drilling contractor's materials for the following drilling additives, or similar, for every batch delivered to the drilling contractor during the investigation program prior to use:

– Clay breaker or similar thinner and dispersing agent;
– Poly Vis 2000 or similar synthetic polymer;
– AMC Det Xtra or similar surfactants;
– AMC Floc Blocks or similar anionic flocculant; and
– LUBRIPLATE or similar PFPE-based grease.

In addition, the tap water used in the field to make the drilling mud and the prepared drilling mud should be sampled on a daily basis. These samples should be submitted to the BLGHFC project laboratory for analysis of benzene, toluene, ethylbenzene, xylenes and naphthalene (BTEXN), TRH and PFAS.

No drilling works should be undertaken until the quality control (QC) sampling and analysis has been completed and the analytical results received.

1.6.1.4 Summary

An example of analyses of drilling additives and plastic core boxes are summarised in Table 22.

Table 22 Pre-start quality control sampling and analysis

Matrix	Details	Drilling contractor yard		In the field	
Drilling additive	Clay breaker or similar thinner and dispersing agent.	One sample per batch	Analysis of PFAS, BTEXN and TRH	-	-
	Poly Vis 2000 or similar synthetic polymer.	One sample per batch	Analysis of PFAS, BTEXN and TRH	-	-
	AMC Det Xtra or similar surfactants.	One sample per batch	Analysis of PFAS, BTEXN and TRH	-	-
	AMC Floc Blocks or similar anionic flocculant.	One sample per batch	Analysis of PFAS, BTEXN and TRH	-	-
	LUBRIPLATE or similar PFPE-based grease.	One sample per batch	Analysis of PFAS, BTEXN and TRH	-	-
	Potable water used for preparation of drilling mud.	-	-	One sample per water supply source	Analysis of PFAS
	Mixed drilling mud.	-	-	One sample per cored borehole	Analysis of PFA, BTEXN and TRH
Rinsate	Plastic core box rinsate	One sample	Analysis of PFAS	One sample per plastic core box if used in the field	Analysis of PFAS
	Drilling equipment	-	-	One sample per key drilling equipment	Analysis of PFAS

1.6.1.5 Field quality control sampling and analysis – soil, sediment and water

All fieldwork is to be conducted with reference to the relevant NEPM and PFAS NEMP guidelines which allow all samples to be collected by a set of uniform and systematic methods. The field QC sampling and analysis program is summarised in Table 23.

Table 23 Field QC sampling program

Field QC samples	Purpose	Rate of collection
Blind (intra-laboratory) duplicates	Used to identify variation in the analyte concentration between samples from the same sampling point.	1 in every 20 samples for primary analytes 1 in every 10 samples for PFAS analytes
Split (inter-laboratory) duplicates	Provide an indication of the repeatability of the results between laboratories.	1 in every 20 samples for primary analytes 1 in every 10 samples for PFAS analytes
Rinsate blank	Used to estimate the amount of contamination introduced during the re-use of sampling equipment. Rinsate blank samples are obtained by pouring laboratory supplied deionised water over decontaminated sampling equipment (e.g. drill bit, hand auger, groundwater probe) into laboratory supplied bottles.	1 taken for every day of sampling where reusable equipment is used. Rinsate blanks are typically analysed for metals, TRH, BTEXN and PFAS.
Trip blank / trip spikes	Used to estimate contamination introduced into samples during transport of samples from the field to the laboratory.	1 for every batch of samples sent to the laboratory. Trip blank samples are typically analysed for TRH (C6-C9 fraction), BTEXN and PFAS.
Trip spike	Used to estimate loss of volatile compounds during transport of samples from the field to the laboratory.	1 for every batch of samples sent to the laboratory. Trip spike samples are typically analysed for BTEXN

Blind and split duplicate samples are to be assessed by calculating the relative percentage difference (RPD) between the primary, blind and split samples. RPD values are calculated using the following equation.

$$RPD(\%) = \frac{(C_o - C_s)}{\left(\frac{C_o + C_s}{2}\right)} \times 100¤$$

Where:

Co = reported from primary sample

Cs = reported concentration from duplicate sample

According to AS 4482.1 – 2005 (Standards Australia, 2005), typical RPDs are expected to range between 30% and 50%; however, this may be higher for concentrations which are close to the laboratory limit of reporting (LOR). The following acceptable RPD limits may be adopted based on standard industry practice and the inherent variability associated with PFAS analysis:

– 200% for concentrations within one to ten times the analyte LOR;
– 50% for concentrations within ten to 30 times the analyte LOR; and
– 30% for concentrations greater than 30 times the analyte LOR.

It is noted that these limits may not always be achieved, particularly in heterogeneous soils.

1.6.1.6 Field QA/QC sampling and analysis – Landfill gas

LFG monitoring QA/QC typically consists of the application and completion of appropriate QC measures in the field, with laboratory-based quality assurance usually only completed where further confirmation of data obtained using portable field equipment is required. The following measures (as outlined in *Assessment and management of hazardous ground gases* (NSW EPA, 2020)) are to be applied as far as reasonably practicable:

- Personal competence of monitoring personnel;
- Selection of appropriate instrumentation;
- Monitoring personnel suitably trained in use of the instruments;
- Review of operations manuals for the selected instruments;
- Review of *Appendix 4, Further guidance on site assessment methodology* in *Assessment and management of hazardous ground gases* (NSW EPA, 2020);
- Review of the landfill gas section of EPA Victoria (2015) Siting, design, operation and rehabilitation of landfills Publication 788.3 August, 2015;
- Instruments are to be appropriately calibrated over a suitable range in accordance with manufacturer's recommendations;
- Instruments will be used and maintained as per the manufacturer's recommendations;
- The relevant monitoring methods outlined in *Assessment and management of hazardous ground gases* (NSW EPA, 2020) are to be followed;
- Monitoring tasks are to be completed under appropriate meteorological/environmental conditions (as far as is practicable);
- Only adequately designed, installed and maintained monitoring locations are to be used (sub-surface geology) this will be confirmed on the review of existing well network report being prepared by the Environmental Consultant; and
- Data is to continuously be assessed during monitoring.

1.6.2 Laboratory QA/QC procedures

Soil and groundwater samples are required to be submitted to a NATA accredited project laboratory for the proposed analytical suite. Samples not selected for analysis should be placed on hold should further testing be required.

1.6.2.1 Laboratory quality control

Laboratory quality control procedures used during the BLGHFC project should include:

- **Laboratory duplicate samples**:
  The analytical laboratory collects duplicate sub samples from one sample submitted for analytical testing at a rate equivalent to one in twenty samples per analytical batch, or one sample per batch if less than twenty samples are analysed in a batch. A laboratory duplicate provides data on the analytical precision and reproducibility of the test result.
- **Spiked Samples**:
  An authentic field sample is 'spiked' by adding an aliquot of known concentration of the target analyte(s) prior to sample extraction and analysis. A spike documents the effect of the sample matrix on the extraction and analytical techniques. Spiked samples are analysed for each batch where samples are analysed for organic chemicals of concern.
- **Certified Reference Standards**:
  A reference standard of known (certified) concentration is analysed along with a batch of samples. The Certified Reference Standard (CRS) or Laboratory Control Spike provides an indication of the analytical accuracy and the precision of the test method and is used for inorganic analyses.
- **Surrogate Standard / Spikes**:
  These are organic compounds which are similar to the analyte of interest in terms of chemical composition, extractability, and chromatographic conditions (retention time), but which are not normally found in environmental samples. These surrogate compounds are 'spiked' into blanks, standards and samples submitted for organic analyses by gas-chromatographic techniques prior to sample extraction. Surrogate Standard/Spikes provide a means of checking that no gross errors have occurred during any stage of the test method leading to significant analyte loss.
- **Method Blank**:
  Usually an organic or aqueous solution that is as free as possible of analytes of interest to which is added all

the reagents, in the same volume, as used in the preparation and subsequent analysis of the samples. The reagent blank is carried through the complete sample preparation procedure and contains the same reagent concentrations in the final solution as in the sample solution used for analysis. The reagent blank is used to correct for possible contamination resulting from the preparation or processing of the sample.

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