

Appendix M

Contamination

Roads and Maritime Services

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Contamination

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Prepared for

Roads and Maritime

Prepared by

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Executive Summary

This Stage 1 contamination investigation has been commissioned for the Western Harbour Tunnel and Warringah Freeway Upgrade project (referred to hereafter as the project).

The objectives of the investigation were to identify potential areas of environmental interest (AEIs) which would assist in identifying construction limitations/constraints and management options for the project with respect to contamination and to address the Secretary's environmental assessment requirements for soils.

Jacobs carried out the following scope of work to achieve these objectives:

- Review of publicly available information from the NSW Environment Protection Authority (EPA), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Soil Resource Information System (ASRIS) database, local business directory, and the NSW Department of Planning, Industry and Environment (DPIE) (Regions, Industry, Agriculture & Resources) groundwater database
- Review of information provided by Roads and Maritime Services (Roads and Maritime)
- Review of historical aerial photography of the general project area
- Carried out a site inspection
- Preparation of this Stage 1 contamination investigation report.

Based on the results of the Stage 1 contamination investigation, informed by the above sources of information, a number of potential AEIs were identified. Historical aerial photographs from several years between 1930 and 2005 were reviewed with a focus on potential contamination issues at key surface disturbance areas and construction support sites associated with the project. Aside from this, eight sites with potential issues of contamination were identified via an online search of the NSW EPA Contaminated Sites Record of Notices, while a further 23 sites were highlighted by a search of the local business directory. No additional sites were identified from a search of the CSIRO, ASRIS, and DPIE publicly available databases. The functional nature of these sites was considered typical of that expected within a highly developed urban area (with considerable commercial/industrial land uses) in proximity to a harbour area.

In consideration of these sites and the activities associated with the construction and operation of the project, a comparative exposure risk ranking has been applied to these AEIs. The potential AEIs with a moderate to high contamination exposure risk ranking are detailed below:

- Soil and groundwater contamination (including light non-aqueous phase liquid – LNAPL) has been reported within/beneath the Rozelle Rail Yards site. The contamination is likely to be associated with the historical land use and potential creek infilling at the site. The degradation of organics within historical infill could generate leachate which could migrate into and contaminate the underlying groundwater. If considerable organic content (eg timber, paper, green waste) is present within infill materials, this could generate landfill gas. The area would be occupied by the Rozelle Rail Yards construction support site (WHT1) and the ventilation building cavern (ie within the greater Rozelle Rail yards site) poses a high contamination risk to construction given that contamination is known to be present within soil and groundwater which are likely to be excavated and exposed during construction activities at the Rozelle Rail Yards construction support site (WHT1) and the excavation of the ventilation building cavern. The excavation of the tunnel could also create preferential pathways for groundwater contamination and landfill gas (if present)
- The potential infilling of Easton Park at Lilyfield could represent a soil, groundwater and potentially gas/vapour contamination source. The degradation of organics within the infill could generate leachate which could migrate into and contaminate the underlying groundwater. If considerable organic content (eg timber, paper, green waste) is present within infill materials, this could generate landfill gas. This area poses a moderate contamination risk to construction considering the potential presence of groundwater contamination and landfill gas. Contaminated groundwater and gas could be exposed during construction of

the tunnel and/or construction could create preferential pathways for the groundwater contamination and landfill gas (if present)

- Slag and ash materials may be present across areas of the Birchgrove Peninsula (including Yurulbin Park) associated with historical disposal practices of wastes from nearby industry sources (eg power stations). These slag and ash materials are generally present within surface fill materials and could be contaminated. Historical industrial land use and demolition of structures at Yurulbin Park may have also contributed to contamination at the site. This area poses a moderate contamination risk to construction considering the potential presence of soil contamination and that soils are likely to be excavated and exposed during construction of the Yurulbin Point construction support site (WHT4)
- Contamination has been reported in sediments present within Sydney Harbour. Contamination is likely to be associated with inputs from the surrounding urbanised catchments, historical industrial operations and the general maritime use within the harbour. The sediments pose a high contamination risk to construction given that contamination is known to be present within sediments which are likely to be excavated and exposed during construction of the Sydney Harbour south cofferdam (WHT5) and Sydney Harbour north cofferdam (WHT6)
- The historical use of the coal loader wharf at Balls Head Road at Waverton may have caused localised contamination associated with the loading and unloading of materials (coal and potentially other materials) and general maritime activities. This area poses a moderate contamination risk to construction considering the potential presence of soil contamination and that soils are likely to be excavated and exposed during construction of the Berrys Bay construction support site (WHT7)
- Soil and rock located beneath the former bulk fuel storage site located at Waverton may contain residual heavy metal and hydrocarbon contamination associated with the former use of the site. This area poses a moderate contamination risk to construction considering the potential presence of contamination (in soil and/or rock) and that soil and/or rock are likely to be excavated and exposed during construction of the Berrys Bay construction support site (WHT7)
- Contaminated fill materials have been reported within Waverton Park. No groundwater samples have been collected from this site. It is possible that the contamination detected in fill could represent a contamination source to groundwater beneath this site. If considerable organic content (eg timber, paper, green waste) is present within infill materials, this could generate landfill gas. This area poses a high contamination risk to construction given that contamination is known within fill material which could impact upon groundwater. Groundwater could be exposed during construction of the tunnel and/or construction could create preferential pathways for groundwater contamination and landfill gas (if present)
- Contamination has been reported in surface soils collected from unsealed areas next to the Warringah Freeway. The contamination could be associated with filling of some of the areas with material of unknown quality during the construction of the Warringah Freeway or potentially from particulate matter deposition from large volume traffic flows using the Warringah Freeway. These areas pose a moderate to high contamination risk to construction given that contamination is known and potentially present within soil which are likely to be excavated and exposed during the carrying out of surface works and construction of the construction support sites adjacent to the Warringah Freeway and the Ridge Street pedestrian bridge as well as the Falcon Street and Ernest Street shared user bridges (WHT8, WHT9, WHT10, WFU2, WFU3, WFU4, WFU5, WFU6, WFU7, WFU8 and WFU9)
- The current and historical use of the Motorway Control Centre site and adjoining properties at Waltham Street at Artarmon may have caused localised contamination associated with the commercial/industrial uses of this area. This area poses a moderate contamination risk to construction considering the potential presence of soil contamination and that soils are likely to be excavated and exposed during construction of the Motorway Control Centre at Waltham Street construction support site (WHT11)

- It is possible that structures and/or buildings located within the project area contain hazardous building materials. Should any structures and/or buildings require demolition to facilitate construction, hazardous building materials (where present) would be managed to reduce the potential for contamination and ensure appropriate handling and waste disposal. In accordance with Australian Standard (AS 2601-2001), *The demolition of structures*, a hazardous building materials audit would be carried out prior to the demolition of any structure and/or building.

With respect to the Secretary's environmental assessment requirements, based on the results of the investigations, the following was concluded:

- Major soil erosion hazards are unlikely to impact on the construction or operation of the project. Standard erosion control measures would be implemented during construction and would be consistent with those detailed in the Landcom (2004) *Managing Urban Stormwater: Soils and Construction*
- Acid sulfate soils (actual and potential) may be present near to the Rozelle Rail Yards and Birchgrove Park or within Sydney Harbour, White Bay and Berrys Bay. Potential acid sulfate soils (ASS) were identified in sediment samples collected from the project investigation area and White Bay. Where sediments in these areas require excavation to facilitate construction, these sediments would need to be assessed for the presence of actual and/or potential ASS prior to excavation. Should ASS be identified and if groundwater is likely to be lowered in areas identified as containing ASS, an appropriate ASS management plan would be developed and implemented in accordance in the ASSMAC (1998) *Acid Sulfate Soil Manual*
- The risk of areas of saline soils being present within the project area is low to negligible
- A number of potential AEIs have been identified which have a moderate to high contamination exposure risk. Further investigations of these sites would be required to quantify the soil contamination risk to construction. These investigations would be carried out before construction activities so that contamination (if present) can be adequately planned for and managed. Any further investigations would be carried out in accordance with NSW EPA guidance endorsed under section 105 of the *Contaminated Land Management Act 1997*. The investigations would be designed in consideration of the potential contamination identified within this report and the proposed construction activities to be carried out on the respective sites (ie investigations should provide lateral and vertical coverage in context of the proposed construction activities across areas which are to be disturbed only). Should soil contamination be identified, appropriate remediation action plans and/or environmental management plans would be developed and implemented to remove or suitably reduce the contamination exposure risks during construction activities
- Contaminated sediments have been identified within Sydney Harbour and would need to be managed where disturbed during construction activities to reduce the exposure risk to workers and environmental receivers. Appropriate construction methodology has been developed to remove or suitably reduce the contamination risks from contaminated sediments during construction activities as detailed in Chapter 6 (Construction work) of the environmental impact statement and Technical working paper: Hydrodynamic and dredge plume modelling (Royal Haskoning, 2019). The technical working paper details dredging methodology to be implemented during construction so as not to cause harm to benthic and marine ecosystems and/or adversely reduce water quality, management and methodologies for excavation of sediments, on-site treatment and off-site disposal (land based and/or offshore disposal)
- Groundwater monitoring has been carried out at selected locations within the project area. Monitoring data indicate that potential groundwater contamination may be present beneath areas of Birchgrove. Further groundwater investigations would need to be carried out to target contaminants of concern, other potential AEIs and to provide additional information to support dewatering (if required) during construction and operation of the project
- Potential gas risks associated with the historical landfilling within areas underlying the historical infilling of Easton Park, Rozelle Rail Yards and Waverton Park have not been quantified. Ground gas investigations

would need to be carried out in these areas to assess the potential presence or absence of gas which could impact upon construction and/or operation of the project.

This Stage 1 contamination investigation report has been prepared to meet the requirements of the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability Rating Tool objectives to minimise pollution generated by the project.

Glossary of terms and abbreviations

Acronym	Meaning
AEIs	Areas of environmental interest
ANZECC	Australian and New Zealand Environment and Conservation Council
ASRIS	Australian Soil Resource Information System
ASS	Acid sulfate soil
ASSMAC	Acid Sulfate Soil Management Advisory Committee
BTEX	Benzene, toluene, ethylbenzene, xylenes
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DIPNR	Department of Infrastructure, Planning and Natural Resources
DPIE	Department of Planning, Industry and Environment (formerly Department of Planning & Environment)
EIL	Ecological Investigation Level
EMP	Environmental Management Plan
EPA	Environment Protection Authority
GDE	Groundwater dependent ecosystem
ISCA	Infrastructure Sustainability Council of Australia
ISQG	Interim Sediment Quality Guidelines
LEP	Local Environmental Plan
LNAPL	Light non-aqueous phase liquid
LPI	Land and Property Information

Acronym	Meaning
NAGD	National Assessment Guidelines for Dredging
NEPM	National Environment Protection Measure
OCP	Organochlorine pesticides
OPP	Organophosphate pesticides
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PFAS	Per- and poly-fluoroalkyl substances
SEARs	Secretary's environmental assessment requirements
TRH	Total recoverable hydrocarbons

1. Introduction

This section provides an overview of the Western Harbour Tunnel and Warringah Freeway Upgrade (the project), including its key features and location. It also outlines the Secretary's environmental assessment requirements addressed in this technical working paper.

1.1 Overview

The Greater Sydney Commission's Greater Sydney Region Plan – A Metropolis of Three Cities (Greater Sydney Commission, 2018) proposes a vision of three cities where most residents have convenient and easy access to jobs, education and health facilities and services. In addition to this plan, and to accommodate for Sydney's future growth the NSW Government is implementing the Future Transport Strategy 2056 (Transport for NSW, 2018), a plan that sets the 40 year vision, directions and outcomes framework for customer mobility in NSW. The Western Harbour Tunnel and Beaches Link program of works is proposed to provide additional road network capacity across Sydney Harbour and to improve transport connectivity with Sydney's northern beaches. The Western Harbour Tunnel and Beaches Link program of works include:

- The Western Harbour Tunnel and Warringah Freeway Upgrade project which 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 project
- The Beaches Link and Gore Hill Freeway Connection project which comprises a new tolled motorway tunnel connection across Middle Harbour from the Warringah Freeway and Gore Hill Freeway to Balgowlah and Killarney Heights and including the surface upgrade of Wakehurst Parkway to Frenchs Forest and upgrade and integration works to connect to the Gore Hill Freeway at Artarmon.

A combined delivery of the Western Harbour Tunnel and Beaches Link program of works would unlock a range of benefits for freight, public transport and private vehicle users. It would support faster travel times for journeys between the Northern Beaches and south and west of Sydney Harbour. Delivering the program of works would also improve the resilience of the motorway network, given that each project provides an alternative to heavily congested harbour crossings.

1.2 The project

Roads and Maritime Services (Roads and Maritime) is seeking approval under Division 5.2, Part 5 of the *Environmental Planning and Assessment Act 1979* to construct and operate the Western Harbour Tunnel and Warringah Freeway Upgrade, which would comprise two main components:

- A new crossing of Sydney Harbour involving twin tolled motorway tunnels connecting the M4-M5 Link at Rozelle and the existing Warringah Freeway at North Sydney (the Western Harbour Tunnel)
- Upgrade and integration works along the existing Warringah Freeway, including infrastructure required for connections to the Beaches Link and Gore Hill Freeway Connection project (the Warringah Freeway Upgrade).

Key features of the Western Harbour Tunnel component of the project are shown in Figure 1-1 and would include:

- Twin mainline tunnels about 6.5 kilometres long and each accommodating three lanes of traffic in each direction, connecting the stub tunnels from the M4-M5 Link at Rozelle to the Warringah Freeway and to the Beaches Link mainline tunnels at Cammeray. The crossing of Sydney Harbour between Birchgrove and Waverton would involve a dual, three lane, immersed tube tunnel
- Connections to the stub tunnels at the M4-M5 Link project in Rozelle and to the mainline tunnels at Cammeray (for a future connection to the Beaches Link and Gore Hill Freeway Connection project)

- Surface connections at Rozelle, North Sydney and Cammeray, including direct connections to and from the Warringah Freeway (including integration with the Warringah Freeway Upgrade), an off ramp to Falcon Street and an on ramp from Berry Street at North Sydney
- A ventilation outlet and motorway facilities (fitout and commissioning only) at the Rozelle Interchange
- A ventilation outlet and motorway facilities at the Warringah Freeway in Cammeray
- Operational facilities including a motorway control centre at Waltham Street, within the Artarmon industrial area and tunnel support facilities at the Warringah Freeway in Cammeray
- Other operational infrastructure including groundwater and tunnel drainage management and treatment systems, signage, tolling infrastructure, fire and life safety systems, lighting, emergency evacuation and emergency smoke extraction infrastructure, CCTV and other traffic management systems.

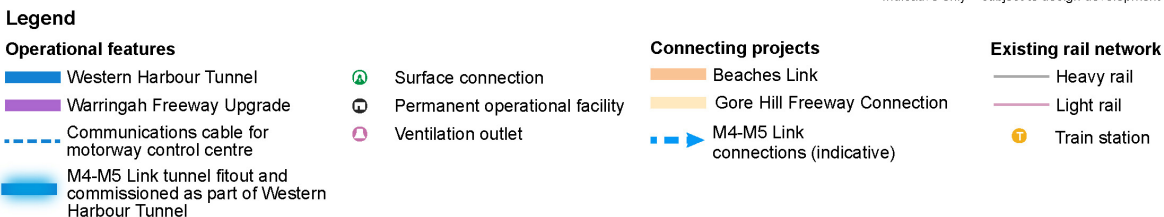
Key features of the Warringah Freeway Upgrade component of the project are shown in Figure 1-2 and would include:

- Upgrade and reconfiguration of the Warringah Freeway from immediately north of the Sydney Harbour Bridge through to Willoughby Road at Naremburn
- Upgrades to interchanges at Falcon Street in Cammeray and High Street in North Sydney
- New and upgraded pedestrian and cyclist infrastructure
- New, modified and relocated road and shared user bridges across the Warringah Freeway
- Connection of the Warringah Freeway to the portals for the Western Harbour Tunnel mainline tunnels and the Beaches Link tunnels via on and off ramps, which would consist of a combination of trough and cut and cover structures
- Upgrades to existing roads around the Warringah Freeway to integrate the project with the surrounding road network
- Upgrades and modifications to bus infrastructure, including relocation of the existing bus layover along the Warringah Freeway
- Other operational infrastructure, including surface drainage and utility infrastructure, signage, tolling, lighting, CCTV and other traffic management systems.

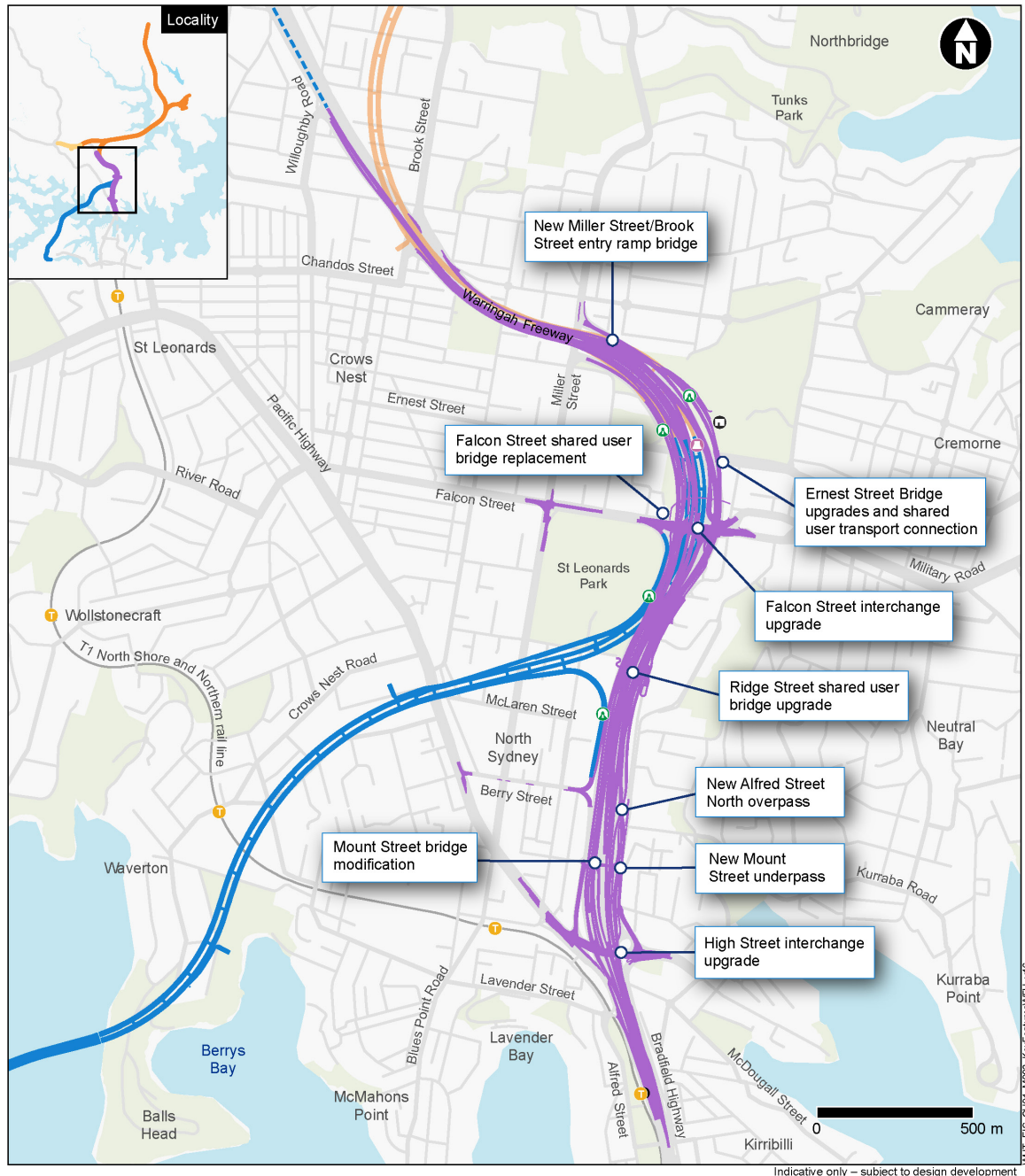
A detailed description of the project is provided in Chapter 5 (Project description) and construction of the project is described in Chapter 6 (Construction work) of the environmental impact statement. The project alignment at the Rozelle Interchange shown in Figure 1-1 and Figure 1-3 reflects the arrangement presented in the environmental impact statement for the M4-M5 Link, and as amended by the proposed modifications. The project would be constructed in accordance with the finalised M4-M5 Link detailed design (refer to Section 2.1.1 of Chapter 2 (Assessment process) of the environmental impact statement for further details).

The project does not include ongoing motorway maintenance activities during operation or future use of residual land occupied or affected by project construction activities, but not required for operational infrastructure. These would be subject to separate planning and processes at the relevant times.

Subject to the project obtaining planning approval, construction is anticipated to commence in 2020 and is expected to take around six years to complete.



Western Harbour Tunnel and Warringah Freeway Upgrade



Legend

Operational features

- Warringah Freeway Upgrade
- Western Harbour Tunnel
- Communications cable for motorway control centre
- Surface connection
- Permanent operational facility
- Ventilation outlet

Connecting projects

- Beaches Link

Existing rail network

- Heavy rail
- Train station

Figure 1-2 Key features of the Warringah Freeway Upgrade component of the project

Western Harbour Tunnel and Warringah Freeway Upgrade

1.3 Key construction activities

The area required to construct the project is referred to as the construction footprint. The majority of the construction footprint would be located underground within the mainline tunnels. However, surface areas would be required to support tunnelling activities and to construct the tunnel connections, tunnel portals and operational ancillary facilities.

Key construction activities would include:

- Early works and site establishment, with typical activities being property acquisition, utilities protection, adjustments and relocations, installation of site fencing, environmental controls (including noise attenuation) and traffic management controls, vegetation clearing, earthworks and demolition of structures, establishment of construction support sites including acoustic sheds and associated access decline acoustic enclosures (where required), temporary relocation of swing moorings within Berrys Bay, and relocation of the historic vessels
- Construction of Western Harbour Tunnel, with typical activities being excavation of tunnel construction accesses, construction of driven tunnels, cut and cover and trough structures and construction of cofferdams, dredging activities in preparation for the installation of immersed tube tunnels, casting and installation of immersed tube tunnels and civil finishing and tunnel fitout
- Construction of operational facilities comprising of a motorway control centre at Waltham Street in Artarmon, motorway and tunnel support facilities and ventilation outlets at the Warringah Freeway in Cammeray, construction and fitout of the project operational facilities that form part of the M4-M5 Link Rozelle East Motorway Operations complex, a wastewater treatment plant at Rozelle and the installation of motorway tolling infrastructure
- Construction of the Warringah Freeway Upgrade, with typical activities being earthworks, bridgeworks, construction of retaining walls, stormwater drainage, pavement works and linemarking and the installation of road furniture, lighting, signage and noise barriers
- Testing of plant and equipment, and commissioning of the project, backfill of access declines, removal of construction support sites, landscaping and rehabilitation of disturbed areas and removal of environmental and traffic controls.

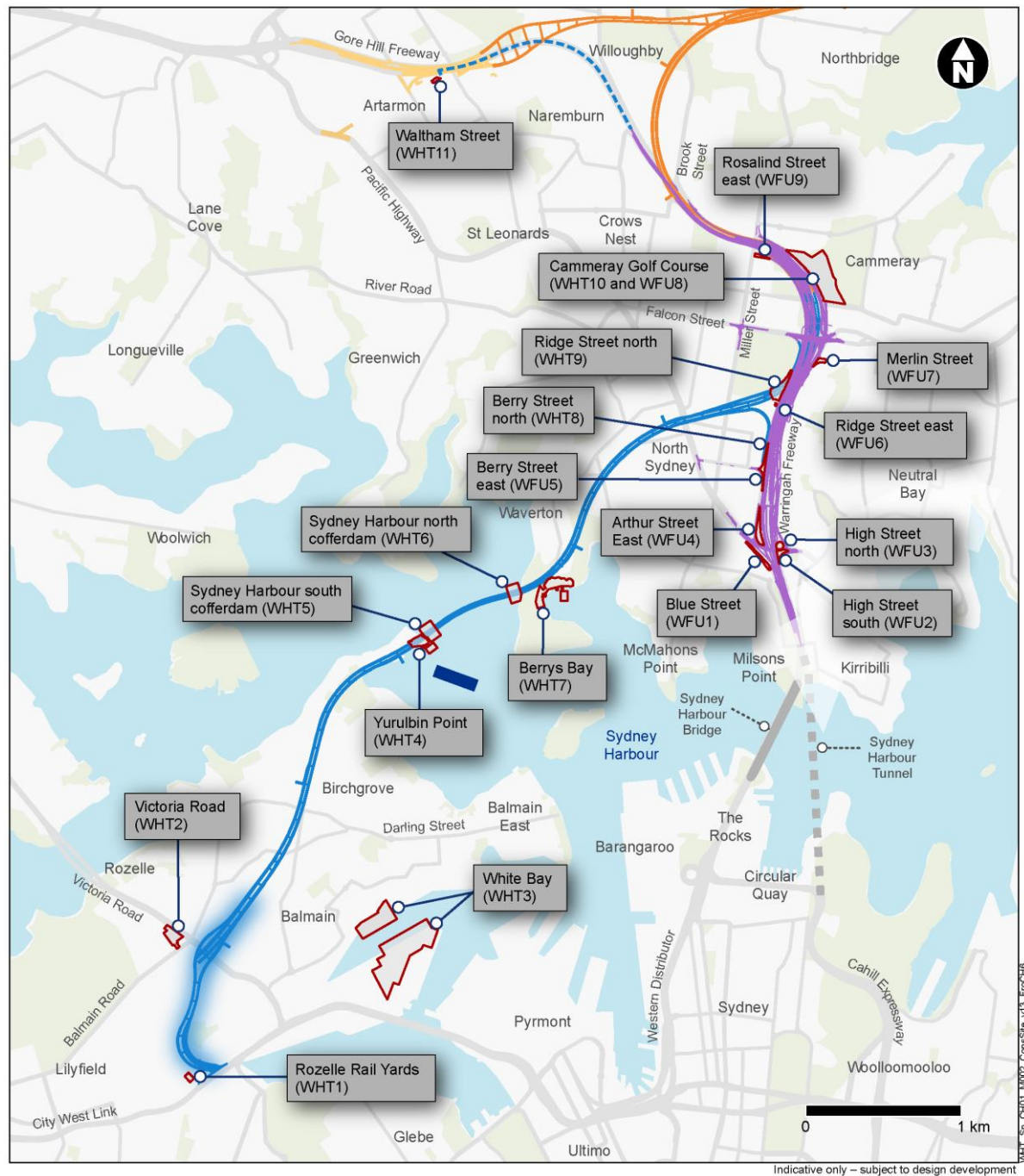
Temporary construction support sites would be required as part of the project (refer to Figure 1-3), and would include tunnelling and tunnel support sites, civil surface sites, cofferdams, mooring sites, wharf and berthing facilities, laydown areas, parking and workforce amenities. Construction support sites for Western Harbour Tunnel are shown in and would include:

- Rozelle Rail Yards (WHT1)
- Victoria Road (WHT2)
- White Bay (WHT3)
- Yurulbin Point (WHT4)
- Sydney Harbour south cofferdam (WHT5)
- Sydney Harbour north cofferdam (WHT6)
- Berrys Bay (WHT7)
- Berry Street north (WHT8)
- Ridge Street north (WHT9)
- Cammeray Golf Course (WHT10)
- Waltham Street (WHT11).

During the construction of the Warringah Freeway Upgrade, smaller construction support sites would be required to support the construction works (as shown on Figure 1-3). These include:

- Blue Street (WFU1)
- High Street south (WFU2)
- High Street north (WFU3)
- Arthur Street east (WFU4)
- Berry Street east (WFU5)
- Ridge Street east (WFU6)
- Merlin Street (WFU7)
- Cammeray Golf Course (WFU8)
- Rosalind Street east (WFU9).

A detailed description of construction works for the project is provided in Chapter 6 (Construction work) of the environmental impact statement.



Legend

Construction features

- Western Harbour Tunnel
- Warringah Freeway Upgrade
- Communications cable for motorway control centre
- Fit out and commissioned as part of Western Harbour Tunnel, constructed as part of WestConnex M4-M5 Link

- Construction support sites
- Mooring site

Connecting projects

- Beaches Link
- Gore Hill Freeway Connection

Figure 1-3 Overview of the construction footprint

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Contamination

1.4 Project location

The project would be located within the Inner West, North Sydney and Willoughby local government areas, connecting Rozelle in the south with Naremburn in the north.

Commencing at the Rozelle Interchange, the mainline tunnels would pass under Balmain and Birchgrove, then cross Sydney Harbour between Birchgrove and Waverton. The tunnels would then continue under Waverton and North Sydney, linking directly to the Warringah Freeway to the north of the existing Ernest Street bridge.

The motorway control centre would be located at Waltham Street, Artarmon, with a trenched communications cable connecting the motorway control centre to the Western Harbour tunnel along the Gore Hill Freeway and Warringah Freeway road reserves.

The Warringah Freeway Upgrade would be carried out on the Warringah Freeway from around Fitzroy Street at Milsons Point to around Willoughby Road at Naremburn. Upgrade works would include improvements to bridges across the Warringah Freeway, and upgrades to surrounding roads.

1.5 Purpose of this report

This report has been prepared to support the environmental impact statement for the project and to address the environmental assessment requirements of the Secretary of the Department of Planning, Industry and Environment (formerly Department of Planning and Environment) ('the Secretary's environmental assessment requirements').

The objectives of the Stage 1 contamination investigation were to identify potential areas of environmental interest (AEIs) which would assist in identifying construction limitations/constraints and management options within the project area with respect to contamination.

The AEIs were considered to be those potential risks associated with soil, groundwater and vapour contamination which may be present as a result of historic and/or current activities carried out on and/or next to the project area.

To achieve these objectives, Jacobs carried out the following scope of work:

- Review of publicly available information from the NSW Environment Protection Authority (EPA), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Soil Resource Information System (ASRIS) database and the NSW Department of Planning, Industry and Environment (Regions, Industry, Agriculture & Resources) groundwater database
- Review of information provided by Roads and Maritime
- Review of historical aerial photography of the general project area
- Site inspection
- Preparation of a Stage 1 contamination investigation report based on the data obtained from the desktop background review and observations from the inspection of the project area. The expected ground conditions are presented together with any potential contamination issues identified and recommendations for further investigations, if required.

1.6 Secretary's Environmental Assessment Requirements

The Secretary's environmental assessment requirements relating to the Stage 1 contamination investigation and where these requirements are addressed in this report are outlined in Table 1-1.

Table 1-1 Secretary's environmental assessment requirements-Soils

Secretary's environmental assessment requirements	Where addressed
1. The Proponent must verify the risk of acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Risk Map) within, and in the area likely to be impacted by, the project.	Section 3.6
2. The Proponent must assess the impact of the project on acid sulfate soils (including impact of acidic runoff offsite) in accordance with the current guidelines and detail the mitigation measures proposed to minimise potential impact.	Sections 6.2, 7.2 and 9
3. The Proponent must assess whether the land and harbour sediment is likely to be contaminated and identify if remediation is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be carried out in accordance with current guidelines.	Sections 4.4 and 9
4. Where contaminated spoil and/or sediments are to be handled at Glebe Island and/or White Bay, the Proponent must provide details of contamination characteristics and measures to manage this spoil to avoid adverse impact to land and water quality.	Sections 4.4, 5 and 9 Refer to Section 6 of Technical working paper: Marine water quality for measures to avoid adverse impacts to water quality. Refer to Section 7.2 of Technical working paper: Hydrodynamics for the proposed dredge methodology
5. The Proponent must assess whether salinity is likely to be an issue and if so, determine the presence, extent and severity of soil salinity within the project area.	Section 3.7
6. The Proponent must assess the impact of the project on soil salinity and how it may affect groundwater resources and hydrology.	Sections 6.3 and 7.3
7. The Proponent must assess the impact on soil and land resources (including erosion risk or hazard). Particular attention must be given to soil erosion and sediment transport consistent with the practices and principles in the current guidelines.	Sections 6.1, 7.1 and 9 Refer to Sections 5.2, 5.4 and 6.4 of Technical working paper: Surface water quality and hydrology for soil erosion and sediment transport
8. The Proponent must assess the impact of any disturbance of contaminated groundwater and the tunnels would be designed so as to not exacerbate mobilisation of contaminated groundwater and/or prevent contaminated groundwater flow.	Sections 6.6, 7.6 and 9 Refer to Section 5.5 of Technical working paper: Groundwater for further information on existing groundwater quality

1.7 Relevant contamination guidelines

In preparing this report, the following guidelines were considered (where relevant):

- Acid Sulfate Soils Management Advisory Committee (1998) *Acid Sulfate Soils Manual*
- Department of Urban Affairs and Planning & NSW EPA (1998) Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Contamination

- Office of Environment and Heritage (2000) Guidelines for Consultants Reporting on Contaminated Sites.

Should further investigations, remediation work and validation be carried out, these activities would need to be carried out in accordance with the following guidelines or other appropriate/endorsed guidelines available at that time:

- Acid Sulfate Soils Management Advisory Committee (1998) Acid Sulfate Soil Manual
- NSW EPA (2015a), Guidelines on the Duty to Report Contamination under the *Contaminated Land Management Act 1997*
- Urban and regional salinity – guidance given in the Local Government Salinity Initiative booklets (www.environment.nsw.gov.au/salinity/solutions/urban.htm) which includes Site Investigations for Urban Salinity (DLWC, 2002)
- Landslide risk management guidelines presented in Australian Geotechnics Society (2007)
- Soil and Landscape Issues in Environmental Impact Assessment (DLWC 2000)
- Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom, 2004) and Volume 2 (A. Installation of Services; B. Waste Landfills; C. Unsealed Roads; D. Main Roads; E. Mines and Quarries) (Department of Environment and Climate Change, 2008)
- Other guidelines made or approved under section 105 of the Contaminated Land Management Act 1997
- Standards Australia (2005) Australian Standard AS 4482.1-2005: Guide to the investigation and sampling of sites with potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds
- Standards Australia (1999) Australian Standard AS 4482.2-1999: Guide to the sampling and investigation of potentially contaminated soils. Part 2: Volatile substances
- Commonwealth of Australia (2009) National Assessment Guidelines for Dredging
- National Environment Protection (Assessment of Site Contamination) Measure 1999 (as revised 2013)
- Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality
- NSW EPA (2014c) Waste Classification Guidelines
- Department of Environment, Climate Change and Water (2009) Guidelines for Implementing the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2008
- NSW EPA (1995) Contaminated Sites: Sampling Design Guidelines
- NSW EPA (2017) Contaminated Sites: Guidelines for the NSW Site Auditor Scheme (3rd Edition)
- Department of Environment and Conservation (2007) Contaminated Sites: Guidelines for the Assessment and Management of Groundwater Contamination
- NSW EPA (2015b) Technical Note: Light Non-Aqueous Phase Liquid Assessment and Remediation
- NSW EPA (2014b) Technical Note: Investigation of Service Station Sites
- NSW EPA (2014a) Best Practice Note: Landfarming
- Department of Environment and Conservation (2005) Information for the assessment of former gasworks sites
- Department of Environment, Climate Change and Water (2010) Vapour Intrusion: Technical Practice Note
- NSW EPA (2012) Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases
- WorkCover NSW (2014) *Managing asbestos in or on soil*.

2. Assessment methodology

In preparing the Stage 1 contamination investigation, the following process was implemented:

- Review of existing land uses along and in vicinity to the project alignment, topography, drainage, geology, soils (including erosions hazard, acid sulfate soils risk and salinity potential), hydrogeology and receiving environments
- Review of historical aerial photographs (1930 to 2005), available aerial imagery services (Google Earth, SIX Maps and Metro Map)
- Searches in the NSW EPA Contaminated Sites Register and Record of Notices and the Yellow Pages business directory
- Review of previous harbour sediment, soil, groundwater and contamination site investigations
- Visual inspections of surface areas above the tunnel alignment, all above-ground project features, nearby land uses and potential areas of environmental interest for contamination.

Based on the above information, areas of environmental interest for contamination were identified as well as their associated comparative risks to environmental receivers, construction limitations and site users in consideration of the potential for contamination and proposed construction activities. The comparative risk has been assessed based on the matrix shown in Figure 2-1.

Assessment Level 1		Assessment Level 2	
		Excavation/Construction Activities	
		Within Project Footprint	Not Within Project Footprint
		Within	Not Within
Contamination Status	Known Contamination	High	Moderate
	Possible Contamination	Moderate	Low
	Low Contamination Potential	Low	Low
		Contamination Distribution Range	
		Assessment Level 3	

Figure 2-1 Comparative risk assessment matrix

Impacts related to soil erosion hazard, acid sulfate soils, salinity and contamination during construction and operation were identified and assessed.

Strategies for the management of potential environmental (soil erosion, ASS, soil salinity) and contamination risks identified associated with the construction and operation of the project have been recommended (where applicable).

3. Existing environment

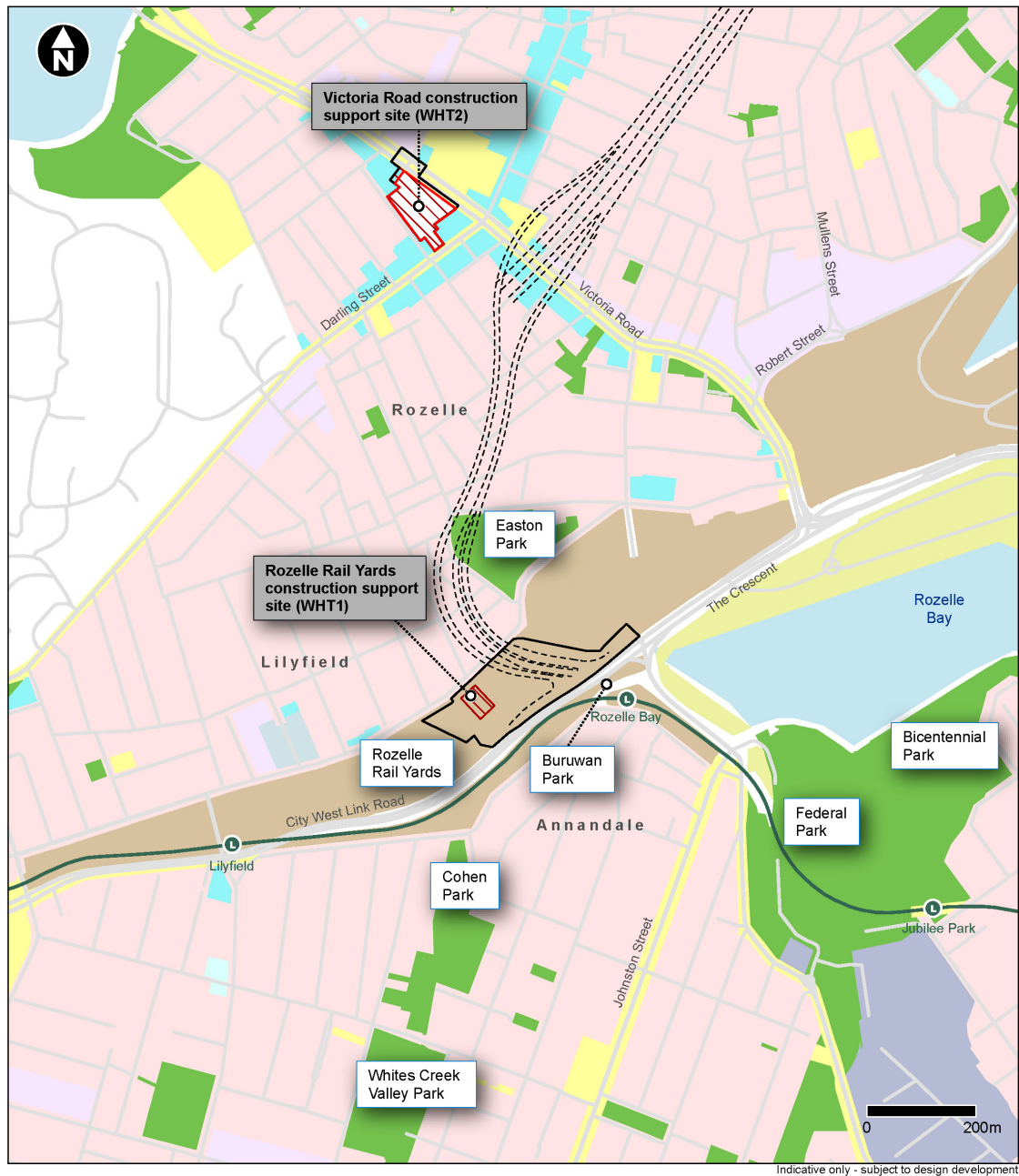
The information presented below is based on a review of publicly available information, and observations made during a project area inspection carried out from publicly accessible areas by Jacobs on 18 September 2017 and 5 April 2019.

3.1 Location and land use zones

The Western Harbour Tunnel component of the project spans 6.5 kilometres from Rozelle through to Cammeray. The Warringah Freeway Upgrade component would extend from North Sydney to Naremburn. The majority of the project would comprise tunnels extending from Rozelle, beneath Sydney Harbour, and surfacing at the Warringah Freeway at North Sydney, extending to Naremburn.

The project would be located within/beneath a range of land use zones as identified in the Sydney Regional Environmental Plan 26 (NSW Government, 2017), Leichhardt Local Environmental Plan 2013 (New South Wales Government, 2013a), the North Sydney Local Environmental Plan 2013 (New South Wales Government, 2013b) and the Willoughby Local Environmental Plan 2012 (New South Wales Government, 2012).

Land use zones for the project area under the respective local planning controls are presented in Figure 3-1a to Figure 3-1e.



Legend

Operational features

- Western Harbour
- Tunnel (tunnel section)

Construction features

- Construction footprint
- Construction support site

Sydney Light Rail

SREP 26

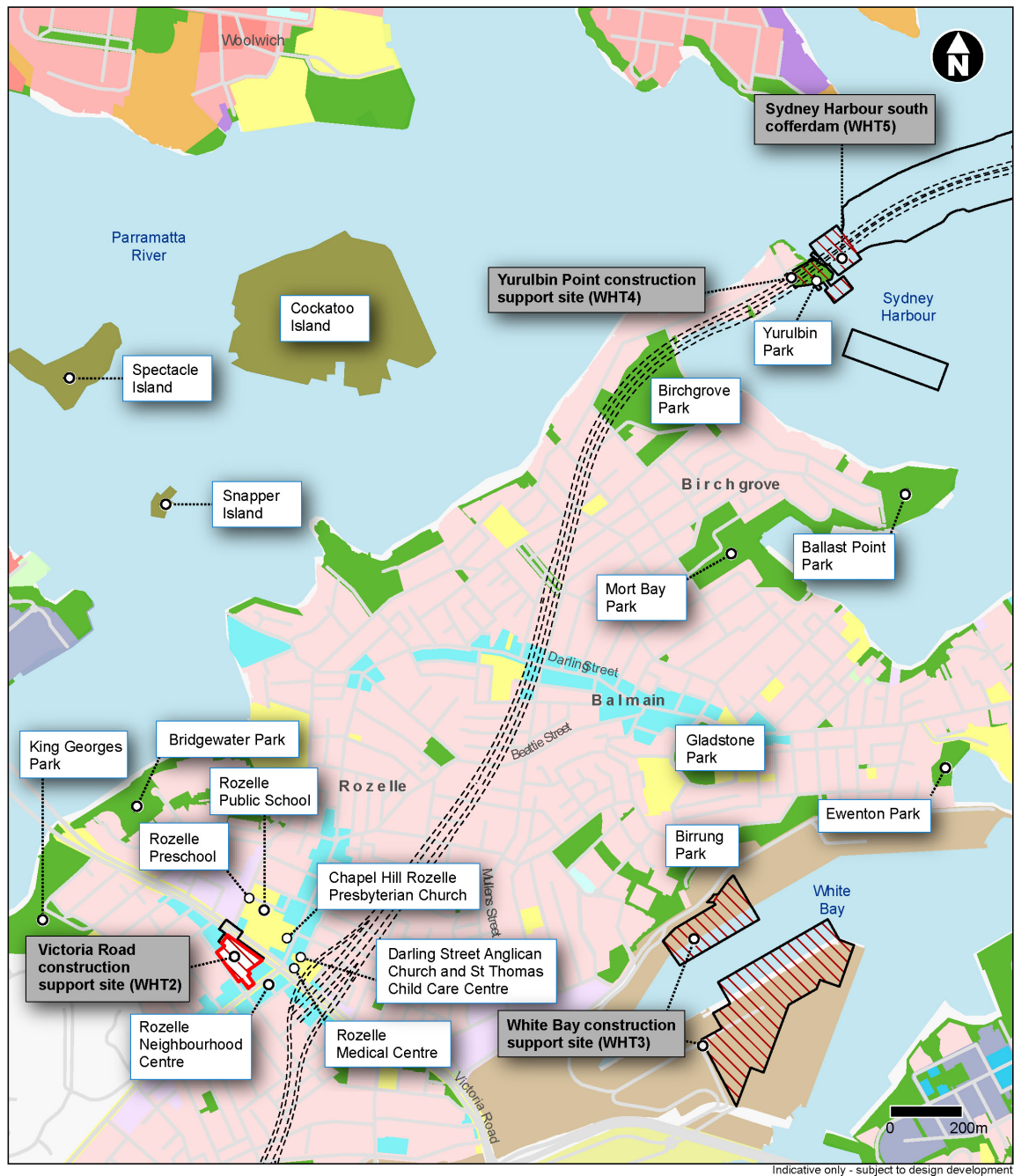
- Port and employment
- Waterfront use

Land use zoning

- B1 Neighbourhood Centre
- B2 Local Centre
- B4 Mixed Use

- B7 Business Park
- IN2 Light Industrial
- R1 General Residential
- RE1 Public Recreation
- RE2 Private Recreation
- SP2 Infrastructure
- DM Deferred Matter

Figure 3-1a Land use zones – Rozelle interchange and surrounds



Legend

Operational features

--- Western Harbour Tunnel (tunnel section)

Construction features

Construction footprint

Construction support site

SREP 26

Port and employment

Public recreation

Waterfront use

Land use zoning

B1 Neighbourhood Centre

B2 Local Centre

B3 Commercial Core

B4 Mixed Use

E2 Environmental Conservation

IN2 Light Industrial

IN4 Working Waterfront

R1 General Residential

R2 Low Density Residential

R3 Medium Density Residential

RE1 Public Recreation

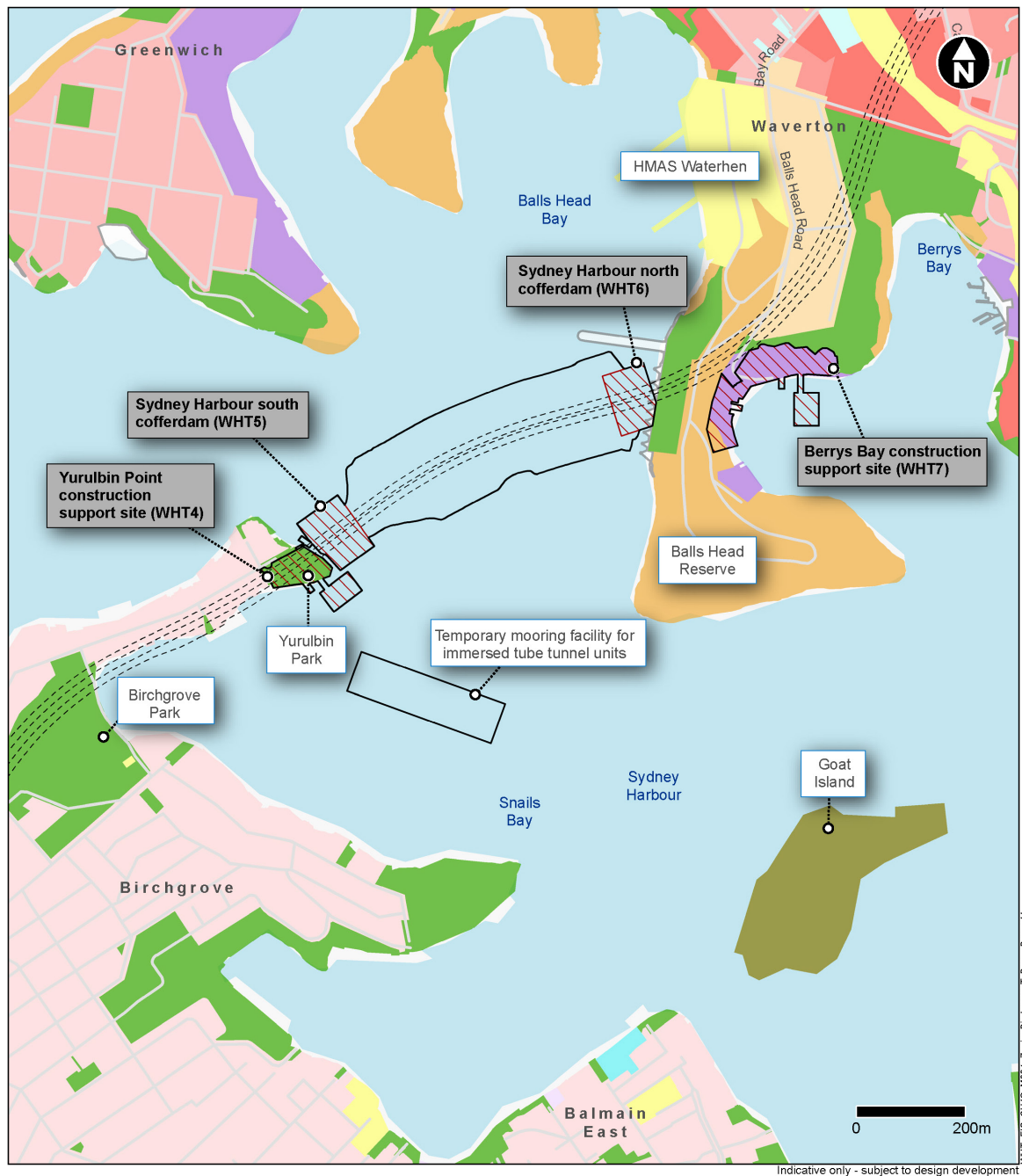
RE2 Private Recreation

SP2 Infrastructure

DM Deferred Matter

Figure 3-1b Land use zones – Rozelle to Birchgrove

Western Harbour Tunnel and Warringah Freeway Upgrade



Legend

Operational features

--- Western Harbour Tunnel (tunnel section)

Construction features

Construction footprint

Construction support site

SREP2005

National Parks

Land use zoning

B1 Neighbourhood Centre

B2 Local Centre

E2 Environmental Conservation

E4 Environmental Living

IN2 Light Industrial

IN4 Working Waterfront

R1 General Residential

R2 Low Density Residential

R3 Medium Density Residential

R4 High Density Residential

RE1 Public Recreation

RE2 Private Recreation

SP2 Infrastructure

UL Unzoned Land

Figure 3-1c Land use zones – Birchgrove to Berrys Bay

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Contamination

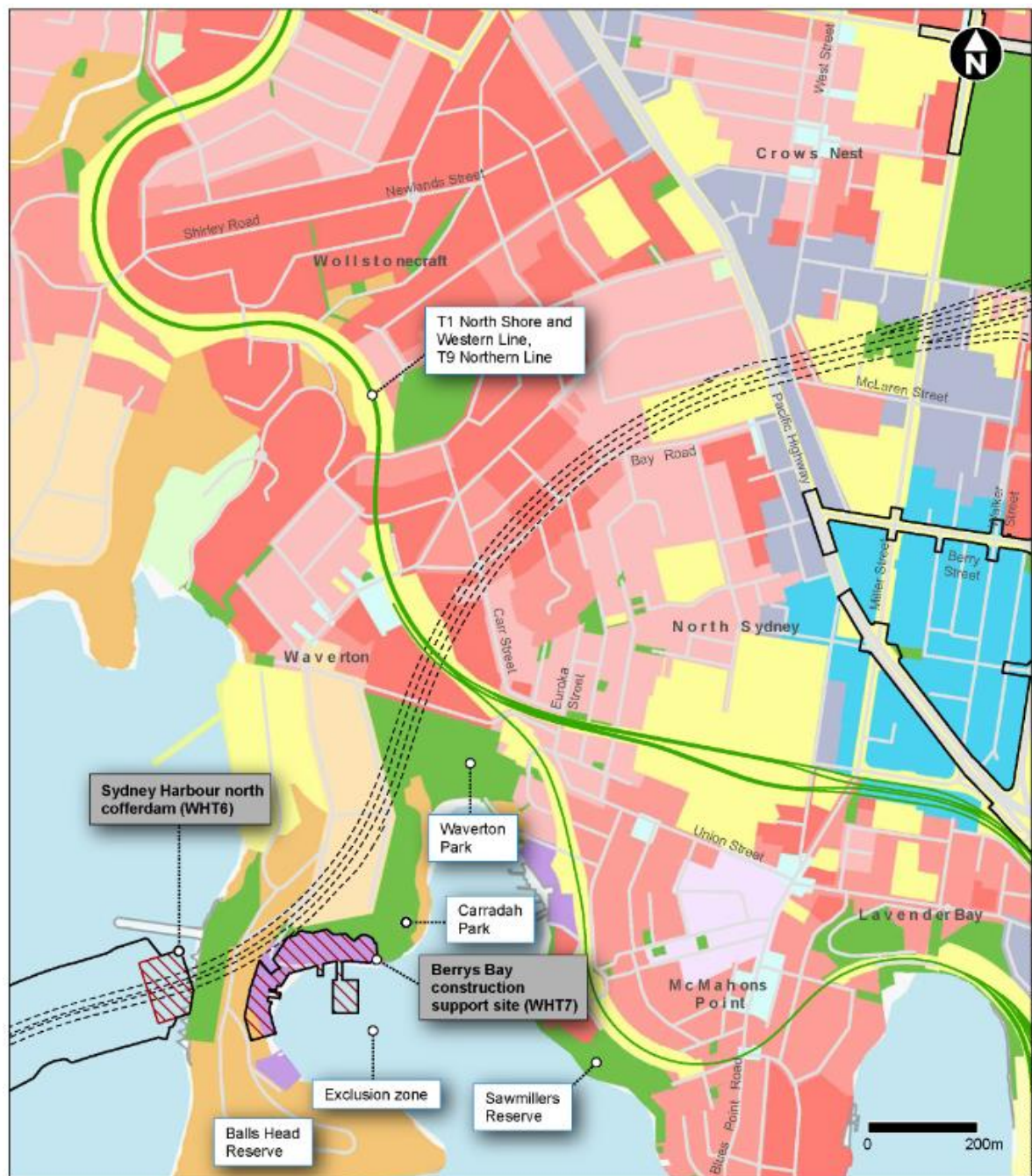


Figure 3-1d Land use zones – Berrys Bay to the Warringah Freeway

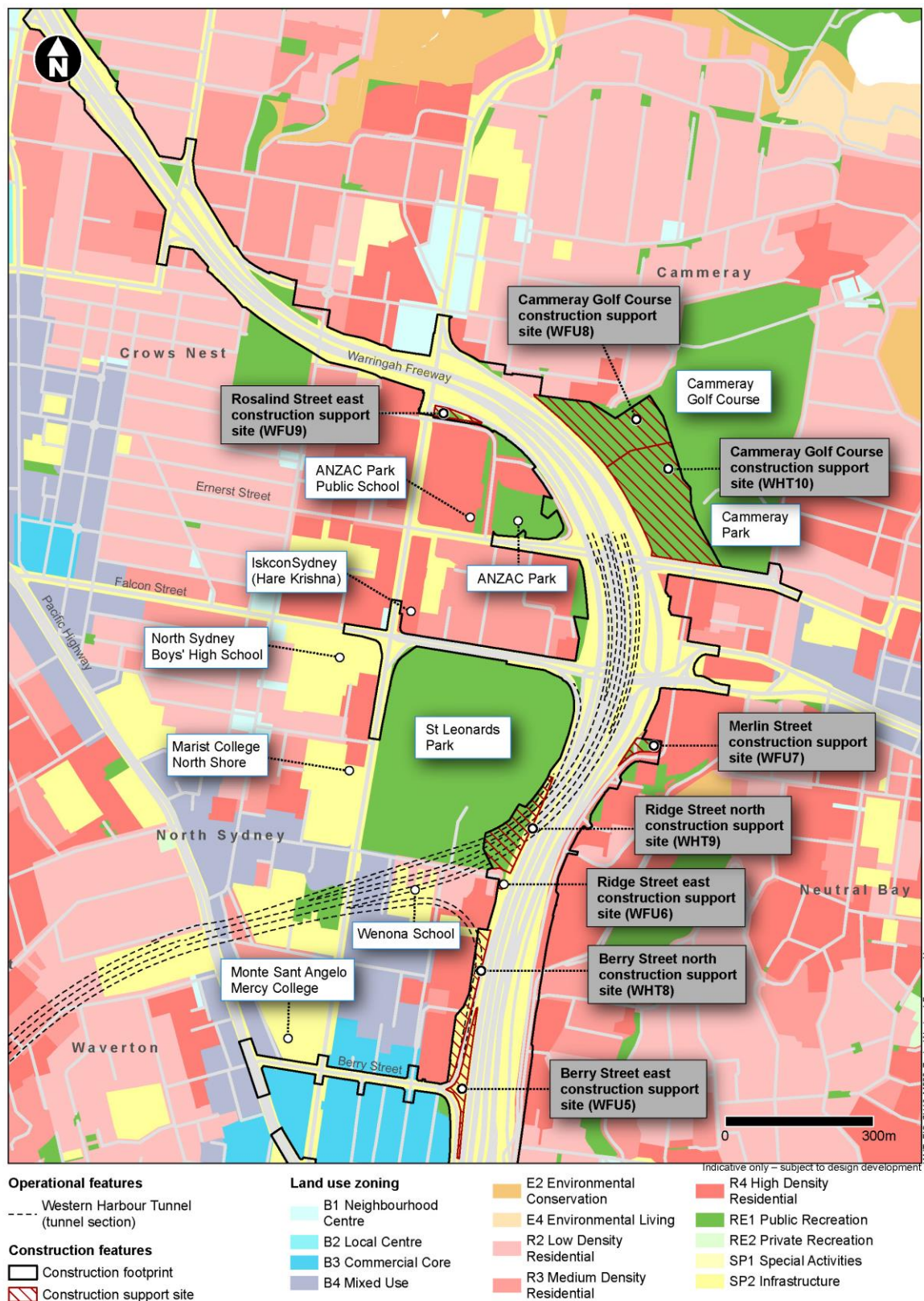


Figure 3-1e Land use zones – Warringah Freeway

Western Harbour Tunnel and Warringah Freeway Upgrade
Technical working paper: Contamination

3.2 Topography and drainage

The terrain along the project rises from an elevation of around 10 metres Australian Height Datum (AHD) at the southern extent of the project at Rozelle and gently undulates towards Birchgrove. The maximum depth of the harbour crossing is around 40 metres below sea level on the eastern side next to Waverton. Once the project crosses Sydney Harbour, the topography has a moderate incline towards North Sydney, reaching an elevation of around 90 metres AHD at the Pacific Highway, North Sydney.

At the time of carrying out the site inspection, there were no obvious areas of inconsistent topography at above ground features of the project which could indicate considerable areas of filling.

Based on information from the NSW Department of Planning, Industry and Environment (Regions, Industry, Agriculture & Resources) website, the project area lies within the 'Sydney Metro catchment of the Sydney basin region'. The Sydney Metro catchment is bounded by the Hawkesbury Nepean catchment to the west and the Tasman Sea to the east. The Sydney Metro catchment consists of eight sub catchments and includes local rivers and channels. The Western Harbour Tunnel and Warringah Freeway Upgrade project would be located within the following sub catchments:

- Parramatta River/Port Jackson
- Middle Harbour.

The Cammeray Dam is located next to the Warringah Freeway. Cammeray Dam forms part of the North Sydney Stormwater Re-use Scheme and receives stormwater runoff from a 94 hectare catchment area which is then used for irrigation on the grass and playing fields at St Leonards Park.

Topography and drainage within the project area are presented on Figure 3-2.

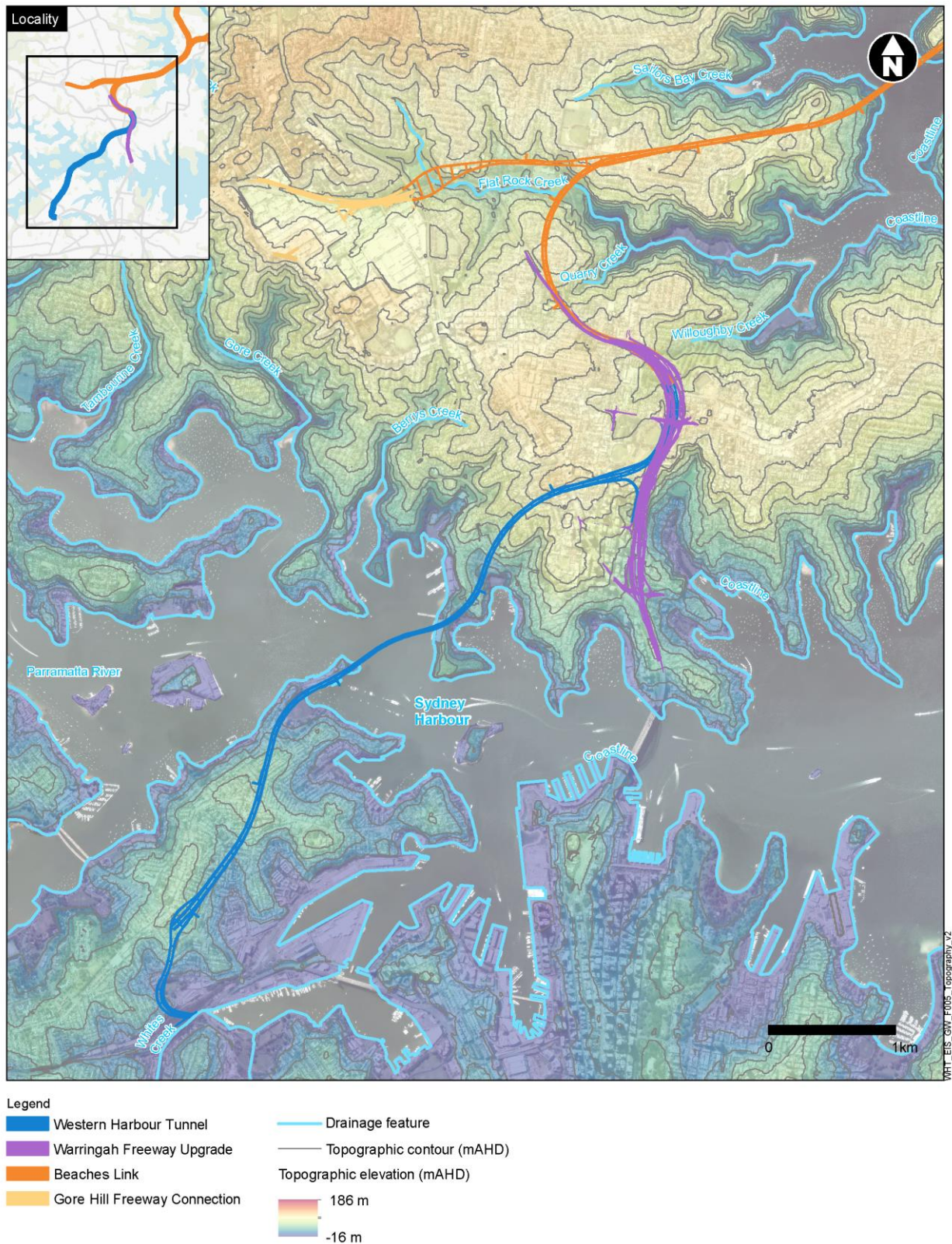


Figure 3-2 Topography and drainage

3.3 Geology

The geology of the alignment is dominated by 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 sediments have been structurally deformed including 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 the majority of the project area is predominately underlain by Hawkesbury Sandstone (Rh) with isolated occurrences of Ashfield Shale (Rwa) present in the north eastern portion of project area (North Sydney and Neutral Bay). Areas of disturbed ground are also found locally within Rozelle Rail Yards, Birchgrove Park and Waverton Park.

A description of the geological formations underlying the project area is provided in Table 3-1 and presented as Figure 3-3.

Table 3-1 Geological units underlying the project area

Unit	Description
Wianamatta Hawkesbury Sandstone (Rh)	Medium to coarse grained quartz sandstone, very minor shale and laminate lenses.
Wianamatta Ashfield Shale (Rwa)	Black to dark grey shale and laminate.

Source: AECOM, 2015. WestConnex New M5 Environmental Impact Statement – Technical working paper: Groundwater Appendix Q, November 2015.

3.3.1 Anthropogenic fill material

In general, a thin layer of fill (less than one metre thick) is commonly encountered in urban areas and is associated with minor modifications to the topography, landscaping and pavement construction. Such fill can be highly variable in composition and compaction.

Thicker deposits of fill are expected towards the mouths of the infilled channels, associated with land reclamation, back filled quarries, landfills, stream capture and urban development in these areas. There is little fill along the Western Harbour Tunnel and Warringah Freeway Upgrade project alignment, with occurrences near Whites Creek and at Birchgrove Park. Small areas of fill are also located at Mort Bay Park just east of the project alignment at Birchgrove, and Badangri Reserve just west of the alignment at Waverton.

3.3.2 Palaeochannels

The occurrence of infilled palaeochannels or palaeovalleys is generally limited to beneath the main harbour areas. Some smaller occurrences of palaeochannel style deposits or basal sands may occur in the larger onshore drainages such as Whites Creek. The deeper sediments within the main palaeovalleys are inferred to be of Pleistocene age.

Experience from previous tunnel projects in Sydney indicates that palaeovalleys are critical in tunnel design because the rock mass beneath palaeovalleys is often more structurally complex due to the association with geological structures such as faults and dykes and valley stress relief. Additionally, they can store and transmit large volumes of surface and groundwater resulting in increased groundwater inflow into tunnels and deep excavations.

Palaeovalley geometry along the project alignment is variable and generally increases in width and depth towards the palaeovalley axes in Sydney and Middle Harbours extending to a maximum depth of 85 metres below sea level near South Head at the entrance to Sydney Harbour.

3.3.3 Jurassic Volcanics

Jurassic basaltic dykes intrude the shale and sandstone formations of the Sydney Basin. The dyke orientations are generally consistent with the main structural orientations and typically strike in two dominant directions:

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Contamination

either between 90 and 120 degrees or between five and 35 degrees. The dykes are of variable thickness ranging from less than three metres and up to 16 metres wide (AECOM, 2015). Dykes typically act as a hydraulic barrier perpendicular to their orientation and can result in partitioning of groundwater. Dykes can also have elevated permeability parallel to strike resulting from jointing and alteration related to the original intrusion and subsequent weathering. As such they can present a risk to tunnelling. If unmanaged, dykes can result in a potentially hazardous situation as tunnelling through a depressurised aquifer can break through the dyke to encounter a fully pressurised formation. Dykes may also provide a conduit for higher groundwater inflows, especially when in proximity to open water bodies such as Sydney Harbour.

Dykes are known to cross the project alignment at Balls Head, while another dyke also runs parallel with the alignment at Yurulbin Park. Other known dykes are projected to intercept the alignment at Waverton and Rozelle. It is also likely that numerous other unidentified dykes would be encountered. It is difficult to map poorly defined outcrops in an urban environment and therefore the frequency of the occurrence of dykes along a linear feature is difficult to assess.

3.3.4 Ashfield Shale

The Ashfield Shale consists of marine deposits made up of clay, silt and sand that has been mildly deformed and has developed into a laminated shale. It is generally a dark grey to black siltstone/mudstone or laminate (thin alternating layers of siltstone and sandstone). In some parts the shale may become carbonaceous with variable silt and clay particles throughout. The shale grades upwards into partly carbonaceous silty shale with siderite nodules and ironstone bands. The unit is laminated although retains bedding planes at some locations. Structural defects are present in the shale such as faults, fractures and shears (AECOM, 2015).

The Ashfield Shale is only present along the project alignment at ridgelines and outcrops around the area of the Pacific Highway. The Warringah Freeway cuts through the Ashfield Shale, exposing the underlying Hawkesbury Sandstone at Cammeray (refer to Figure 3-3).

Where it outcrops, the shale typically weathers to a stiff to hard clay with medium to high plasticity and the weathered profile generally ranges from three metres to 10 metres in depth. However, it has been noted to reach depths greater than 40 metres in former brick pits (AECOM, 2015).

3.3.5 Mittagong Formation

The Mittagong Formation is composed of a series of interbedded dark shale and sandstone of varying thicknesses and is the unit of change from the Ashfield Shale and underlying Hawkesbury Sandstone. The shale beds are very similar to the Ashfield Shale, though it is typically no more than 0.5 metres thick while the sandstone beds are up to five metres thick and are fine to medium grained and contain more silt than the Hawkesbury Sandstone (AECOM, 2015). Due to its reduced thickness, the Mittagong Formation rarely outcrops across the Sydney Basin and has been identified to occur at the contact between the Ashfield Shale and Hawkesbury Sandstone in the project area at North Sydney, Crows Nest and Cammeray.

3.3.6 Hawkesbury Sandstone

The Hawkesbury Sandstone was deposited in a fluvial paleo environment, likely to have been a braided river setting, and as such is highly stratified. The sandstone is ubiquitous across the Sydney Basin and is up to 290 metres thick. The majority of excavations for the Western Harbour Tunnel and Warringah Freeway Upgrade project would be within the Hawkesbury Sandstone unit.

Hawkesbury Sandstone is often described as medium to coarse grained and consists of three main depositional environments, namely: massive sandstone facies; cross bedded or sheet facies; and shale/siltstone interbedded facies. The sheet facies make up about 70 per cent of the unit with primary beds that range in thickness from less than 0.5 metres to greater than five metres but generally occur between one to two metres. Secondary structural features such as joints, fractures and faults are also present.

The sandstone weathers to a clayey sandy soil, typically up to one to two metres in depth. Within the upper ten metres of the profile a duricrust may be present where iron cementation has caused the development of ferricrete or coffee rock, or similarly silica cementation may cause the development of silcrete. Deep orange and

red coloured iron staining is characteristic of the Hawkesbury Sandstone that can be concentrated along water bearing fractures and discontinuities (AECOM, 2015).

3.3.7 Structural geology

3.3.7.1 Bedding

Bedding surfaces in the Hawkesbury Sandstone in this part of the Sydney Basin typically dip gently toward the south at up to five degrees (locally up to 10 degrees). Local increases in dip are generally associated with depositional channel structures. Minor siltstone bands or siltstone breccia zones frequently occur in the base of these channel structures. Primary bedding planes are generally spaced between 0.5 and three metres and may be tight to open. Bedding related structures can include clay infills, crushed seams, in situ weathering, iron staining and limonite coating (AECOM, 2015).

Laboratory testing has shown that the cross bedded or sheet facies does not usually represent planes of weakness in fresh or slightly weathered rock. However, in moderately to highly weathered sandstone the cross beds can form surfaces of incipient parting or low shear strength. Both bedding and cross bed partings in the Hawkesbury Sandstone are typically planar to undulating and rough on a small scale with occasional clay, carbonaceous or mica films and infills (AECOM, 2015).

3.3.7.2 Faults

Figure 3-3 shows the main known structural features in the project area. Within the Sydney region there are four major north to northeast striking fault zones, with the Luna Park Fault Zone being of most significance to the project. Fault zones generally present as joint swarms or brecciated zones and often have associated gauge development. The fault zones have had an important influence on geomorphological development.

These structural features have been recorded at numerous locations within the Sydney Basin and are generally continuous, mappable and relatively predictable, although not always uniformly linear across the Sydney Region (Och et al., 2009).

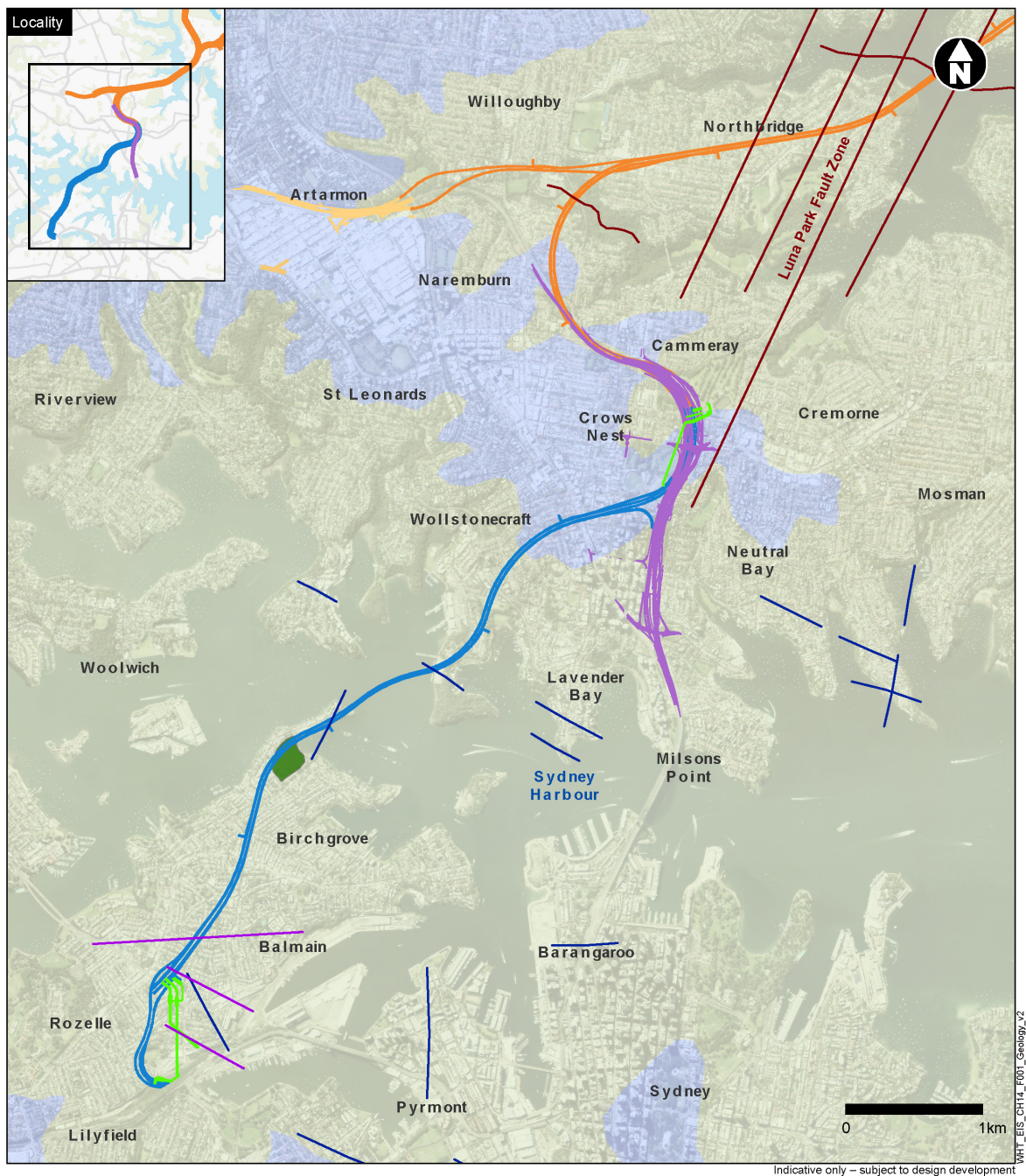
The Luna Park Fault Zone has been shown to comprise up to three metres wide crushed zones with closely spaced jointing and faulting. The faulting shows normal and reverse movement, as well as strike slip offset. Extensions of this fault have been identified at stages along a five kilometres strike length. Other occurrences have been identified at Walsh Bay, Darling Island, Star City Casino and Camperdown to the south and Anderson Park to the north (AECOM, 2015).

Joint spacing varies according to stratigraphy, proximity to near surface weathering and proximity to major geological structures. Assessment of a more regional spread of geotechnical data, from projects such as Sydney Metro North West (previously known as North West Rail Link), M4-M5 Link and Sydney Metro City & Southwest, indicates that jointing within the Hawkesbury Sandstone is typically extremely widely spaced (two metres to up to six metres) with zonal occurrences that are usually moderately widely spaced (60 millimetres to 200 millimetres). More widely spaced jointing of up to 25 metres also occurs (AECOM, 2015).

Localised areas of sub vertical joints may also occur, especially for the north northeast striking set, with spacing from 0.1 metres to 0.5 metres (eg Luna Park Fault Zone, Martin Place Joint Swarm and General Post Office (GPO) Fault Zone). These localised areas are often associated with preferential groundwater flows, deeper weathered profiles and some discrete faulting and brecciation and have a greater vertical continuity than the general population of joints.

Faults, as with dykes, present risks to tunnelling (from a construction workplace health and safety risk perspective) in that they can act as conduits or as barriers to groundwater flow. Groundwater may exploit these enhanced flow zones and present elevated inflows, or a sudden inrush potential where barriers to flow, and depressurisation, are penetrated.

Tunnelling itself can enhance, or exacerbate, the inherent permeability of joints or brecciated zones through stress relief and dilation.



Indicative only – subject to design development

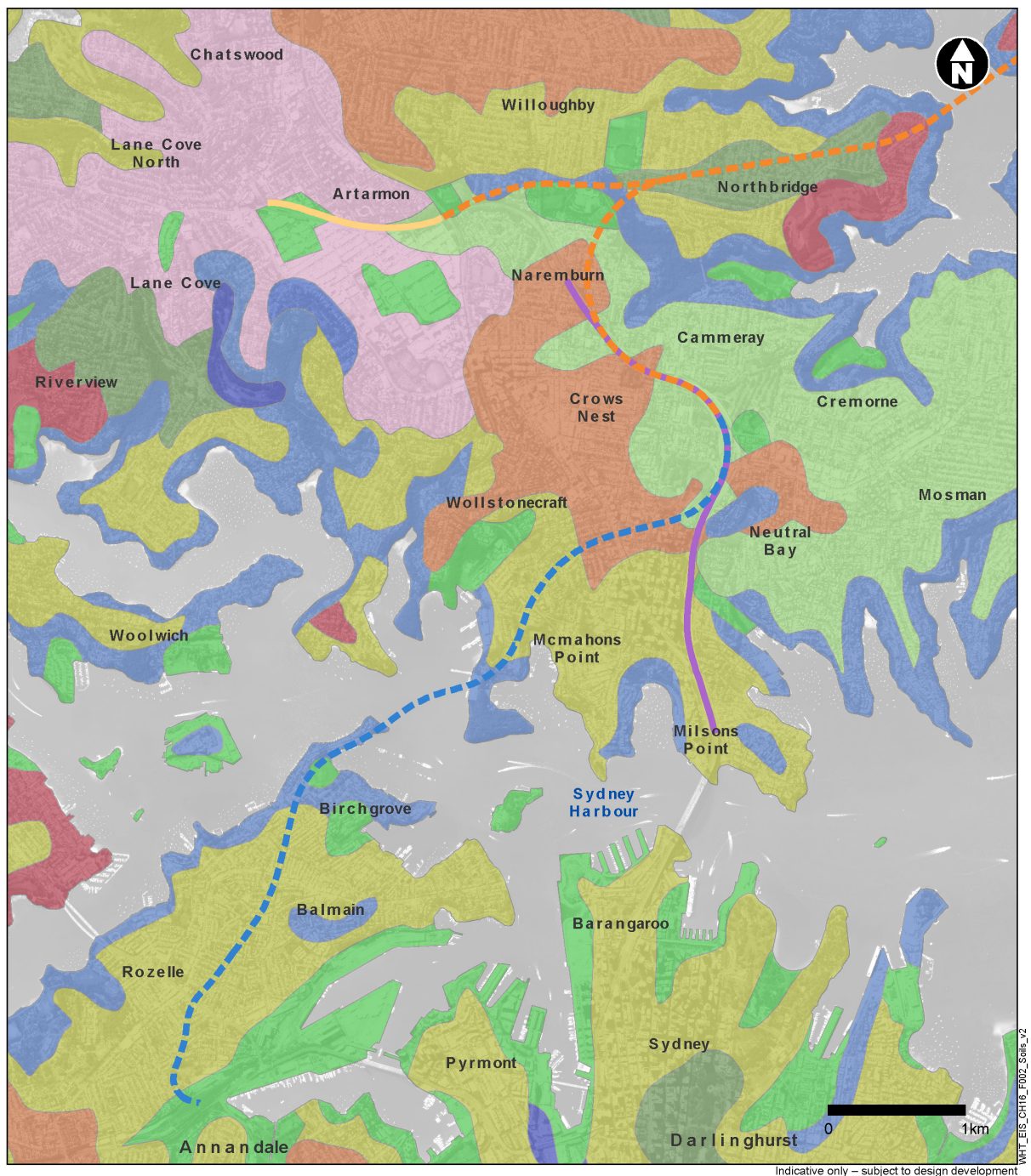
Figure 3-3 Geological units

3.4 Soils

The Sydney 1:100,000 Soil Landscape Series Sheet 9130 (Soil Conservation of NSW, 1966) indicated that the residual soils within the project area included Blacktown (bt), Disturbed (xx), Hawkesbury (ha), Lambert (la) and Gymea (gy) landscape groups. The majority of the project area is underlain by the Gymea landscapes, with Hawkesbury landscapes surrounding the shorelines and isolated occurrence of the Blacktown landscapes around North Sydney. A description of the soils underlying the project area is provided in Table 3-2 and presented as Figure 3-4.

Table 3-2 Soils units underlying the project area

Unit	Description
Blacktown (bt)	<ul style="list-style-type: none"> Landscape – found on gently undulating rises on Wianamatta Group shales with local reliefs of up to 30 metres and slopes of less than five per cent Soils – shallow to moderately deep hardsetting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines Limitations – moderately reactive, highly plastic subsoil, with low fertility and poor drainage.
Disturbed (xx)	<ul style="list-style-type: none"> Landscape – it occurs within other landscapes and is mapped as xx. The topography varies from level plans to undulating terrain and has been disturbed by human activity to a depth of at least 100 centimetres Soils – the original soil has been removed, greatly disturbed or buried. Most of these areas have been levelled to slopes of less than five per cent. Landfill includes soil, rock, building and waste material. The original vegetation has been completely cleared Limitations – are dependent on nature of fill material and include subsidence resulting in a mass movement hazard, soil impermeability leading to poor drainage and low fertility. Care must be taken when these sites are developed.
Gymea (gy)	<ul style="list-style-type: none"> Landscape – found on undulating to rolling low hills on Hawkesbury Sandstone with local reliefs of 20 to 80 metres and slopes of 10 to 25 per cent and rock outcrops of less than 25 per cent Soils – shallow to moderately deep yellow earths and earthy sands on crests and inside of benches Limitations – high soil erosion, rock outcrop, shallow highly permeable soil and very low soil fertility.
Hawkesbury (ha)	<ul style="list-style-type: none"> Landscape – found on rugged, rolling to very steep hills on Hawkesbury Sandstone with local reliefs of 40 to 200 metres, slopes of more than 25 per cent and rock outcrops of more than 50 per cent Soils – shallow (<50 centimetres), discontinuous lithosols/siliceous sands associated with rock outcrops, earthy sands, yellow earths and some yellow podzolic soils on the inside of benches and along joints and fractures Limitations – extreme soils erosion hazard, mass movement (rockfall) steep slopes, rock outcrop, shallow, stony, highly permeable soils with low fertility.
Lambert (la)	<ul style="list-style-type: none"> Landscape – undulating to rolling rises and low hills on Hawkesbury Sandstone. Local relief 20–120 metres, slopes 20 per cent. Rock outcrop greater than 50 per cent. Broad ridges, gently to moderately inclined slopes, wide rock benches with low broken scarps, small hanging valleys and areas of poor drainage. Open and closed heathland, scrub and occasional low eucalypt open woodland Soils – shallow (< 50 centimetres) discontinuous earthy sands and yellow earths on crests and insides of benches; shallow (<20 centimetres) siliceous sands/lithosols on leading edges; shallow to moderately deep (< 150 centimetres) leached sands, grey earths and gleyed podzolic soils in poorly drained areas; localised yellow podzolic soils associated with shale lenses Limitations – very high soil erosion hazard; rock outcrop; seasonally perched water tables; shallow, highly permeable soil; very low soil fertility.



Indicative only – subject to design development

Legend

Operational features

- Western Harbour Tunnel alignment
- Warringah Freeway alignment

Connecting projects

- Beaches Link alignment
- Gore Hill Freeway connection

Soil landscape

- Blacktown
- Deep Creek
- Disturbed terrain
- Glenorie
- Gymea
- Gymea/Lambert
- Hawkesbury
- Lambert
- Lucas Heights
- West Pennant Hills

Figure 3-4 Soils landscape

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Contamination

3.5 Soil erosion hazard

The surface areas overlying the project comprise heavily urbanised areas including buildings, roadways, hardstands and vegetated areas (gardens, grass, trees). 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 (under current conditions).

3.6 Acid sulfate soils risk

Acid sulfate soils (ASS) is the common name given to naturally occurring sediments and soils containing iron sulfides (principally iron sulfide or iron disulfide or their precursors). The exposure of the sulfide in these soils to oxygen by drainage or excavation leads to the generation of sulfuric acid. Areas of ASS can typically be found in low lying and flat locations which are often swampy or prone to flooding.

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:

- Sydney Harbour and Rozelle Bay – (A) high probability/confidence unknown
- Lilyfield to Snails Bay – (B3) low probability/low confidence
- Waverton to Crows Nest – (C4) extremely low probability/very low confidence
- Artarmon – (B4) low probability/very low confidence.

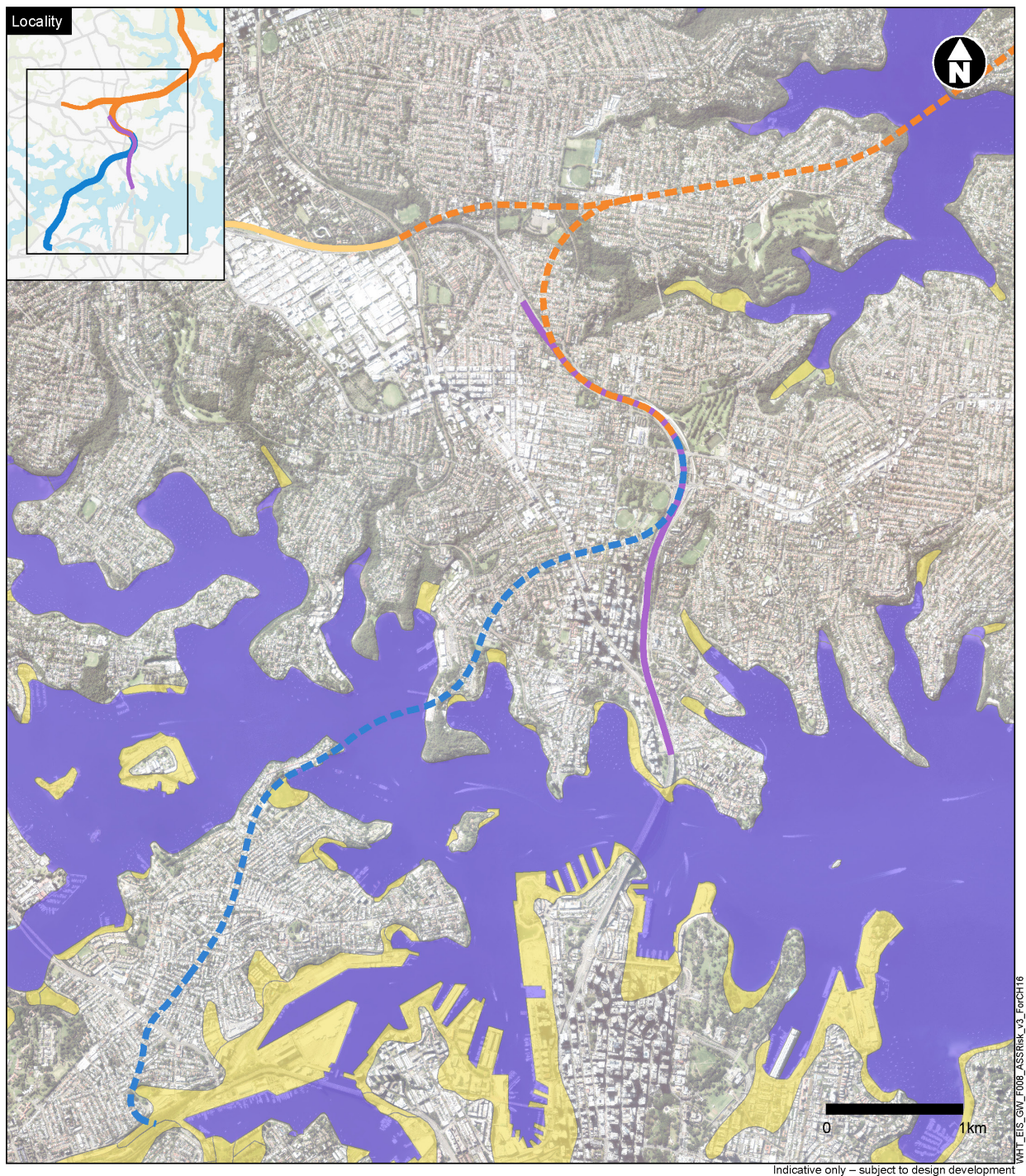
A review of the ASS risk maps from the Leichhardt Local Environmental Plan 2013 (New South Wales Government, 2013a) indicated that the project is located within areas of predominantly Class 5 ASS risk with isolated areas of Class 1 (Rozelle Rail Yards) and Class 2 (Birchgrove Park) ASS risk. The North Sydney Local Environmental Plan 2013 (New South Wales Government, 2013b) does not contain ASS risk maps. The respective LEPs do not cover ASS risk within Sydney Harbour and associated bays.

Land next to watercourses such as Whites Creek are identified as having a high probability of being potential ASS.

The LEP details that development consent is required for the carrying out of the following work which may disturb, expose or drain ASS and cause environmental damage within the respective risk classes:

- Class 1 – Any work
- Class 2 – Work below the natural ground surface and/or work which is likely to lower the water table
- Class 5 – Work within 500 metres of nearby Class 1, 2, 3 or 4 land that is below five metres Australian Height Datum and by which the water table is likely to be lowered below one metre Australian Height Datum on nearby Class 1, 2, 3 or 4 land.

High probability of ASS occurrence (from ASRIS) along the alignment is presented on Figure 3-5.



Legend

Operational features

- Western Harbour Tunnel alignment
- Warringah Freeway alignment

Connecting projects

- Beaches Link alignment
- Gore Hill Freeway Connection

Acid sulfate soil risk

- Acid sulfate soils probability
- High probability of occurrence
- Disturbed terrain

Figure 3-5 ASS probability

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Contamination

3.7 Soil salinity

With reference to the Department of Infrastructure, Planning and Natural Resources (DIPNR) (2002) *Salinity Potential in Western Sydney* map sheet, higher salinity risk in western Sydney is generally associated with residual soils overlying Wianamatta Group Bringelly Shales. Residual soils from this geological unit near drainage lines pose a higher salinity risk potential.

None of the soil landscapes within the project area document salinity as a limitation to the landscape type.

Based on available geological maps, Bringelly Shales are not present within the project area.

No council local environmental plans within the project area contain salinity risk maps.

3.8 Hydrogeology

The Technical working paper: Groundwater notes 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.

Depth to water table is likely to be highly variable and could range from close to ground surface in low lying areas and at depth below elevated ridgelines. Localised perched water tables may also occur, as well as multiple water tables resulting from the highly stratified nature of the Hawkesbury Sandstone.

Deeper groundwater flow would be less controlled by topography and more influenced by the regional structure and stratigraphy of the Sydney Basin. Regional groundwater flow is inferred to be in an east to south easterly direction towards Port Jackson and the Tasman Sea.

The direction of groundwater flow could not be definitively assessed based on current information, although the surrounding topography of the project area and location of water bodies suggests that groundwater would flow in the following directions near the above ground features of the project:

- Southerly to south-easterly direction towards Rozelle Bay from Rozelle
- North-westerly direction towards Iron Cove and south-easterly direction towards White Bay from Balmain
- General northerly direction towards Snails Bay and Sydney Harbour from Birchgrove
- General southerly direction towards Berrys Bay, Balls Head Bay and Sydney Harbour from Waverton and North Sydney
- Easterly direction towards Long Bay from Cammeray.

The groundwater quality in the Hawkesbury sandstone is typically low salinity and of neutral to slightly acidic pH. This is due to the sandstone being dominated by clean quartz/feldspar sand grains. Groundwater contained within the Ashfield shale unit is generally poorer quality than the Hawkesbury sandstone, due to its high clay mineral content, giving rise to a higher salinity.

3.8.1 Groundwater bore search

A search of the NSW Department of Planning, Industry and Environment (Regions, Industry, Agriculture & Resources) groundwater database identified two registered groundwater wells within a 500 metre radius of the project:

- GW108991.1.1 is located in Birchgrove about 270 metres from the project alignment. GW109209.1.1 is installed to a depth of 4.5 metres and utilises a spear point system (suction pumping for low yield shallow groundwater abstraction) for the purposes of water supply. The geological map shows the area as on the margins of an area of fill, or potentially alluvium, underlain by Hawkesbury Sandstone
- GW108991.1.1 is located in Waverton, about 410 metres from the alignment. GW108991.1.1 is used for water supply and is 168 metres deep and installed in the Hawkesbury Sandstone.

3.9 Receiving environments

Based on the available information, receiving environments located near project elements which could be potentially impacted by contamination within the project area (if present) are detailed below:

- Rozelle Bay – Potential impact from the Rozelle Rail Yards construction support site (WHT1) located at Rozelle
- Iron Cove – Potential impact from the Victoria Road construction support site (WHT2) located adjacent to Iron Cove.
- White Bay – Potential impact from the White Bay construction support site (WHT3) located next to White Bay
- Snails Bay – Potential impact from the Yurulbin Point construction support site (WHT4) located at Yurulbin Point at Birchgrove
- Long Bay – Potential impact from the Waltham Street construction support site (WHT11) as well as surface works nearby.

A search in the Groundwater Dependent Ecosystems Atlas (Bureau of Meteorology) carried out on 26 April 2018 found no high priority groundwater dependent ecosystems (aquatic or terrestrial) within 500 metres of the project however it did identify that the northern extent of the Warringah Freeway is upstream of a 'moderate to high potential' terrestrial Groundwater Dependent Ecosystem (GDE) (Coastal Sandstone Gully Forest, Sandstone Riparian Scrub and Coastal Sand Forest) located in the lower reaches of Flat Rock Creek and along Quarry Creek. This site is located around 400 metres north east of the Warringah Freeway Upgrade component.

3.10 Site inspection

A site inspection was conducted on 18 September 2017 and 5 April 2019 by an environmental scientist. The site inspection focused on surface areas above the tunnel alignment and all above ground features of the project, as well as nearby land uses and potential AEIs. The site inspection was only carried out from areas within the project area which were publicly accessible. A second site inspection was carried out on 5 April 2019, however this only looked at additional above ground project elements that were not covered in the first site inspection (ie the motorway control centre at Waltham Street, Artarmon) given then scheme designs.

At the time of the first inspection, the project area consisted primarily of residential, business and commercial/industrial land uses. The land use surrounding the project area was generally low to high density residential and/or commercial. Specific observations made during the site inspection are detailed below:

- Rozelle Rail Yards were vacant and derelict. The site was overgrown with trees and shrubs, and the railway lines appeared not to have been used for many years. At the western end of the railyards was the existing central business district (CBD) and South Eastern Light Rail construction support site. The surrounding land use was primarily commercial/industrial with some low to high density residential land use
- Yurulbin Park was located adjacent to the Birchgrove Ferry wharf and has dense vegetation within it. The park slopes north towards Sydney Harbour
- The project continues north beneath Sydney Harbour to Balls Head Reserve.

The proposed alignment ends and connects with the proposed Beaches Link and Gore Hill Freeway Connection project at the Warringah Freeway. This area comprises the Cammeray Golf Course and large vegetated road verges within an urbanised area.

The proposed location of the motorway control centre comprised general commercial, industrial and office premises.

It should be noted that there is the possibility that site conditions or land use of areas along the project alignment may have changed since site inspections were carried out, particularly in the case of Rozelle Rail Yards, where surface works, including some remediation works, associated with the M4-M5 Link Rozelle Interchange project have been carried out in the interim period. Changes in site conditions and/or land use are considered positive developments at these sites unless stated otherwise, and therefore site conditions as reported during the site inspections are considered the worst case scenario on which this assessment is based.

4. Information review

Several sources were investigated to determine the history of land use within and next to the project. The following list details the sources of historical information and a summary of information provided by each source:

- 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 Maps
- Yellow Pages business directory.

4.1 Historical aerial photography

Historical aerial photographs from the LPI were reviewed for the years: 1930, 1955, 1961, 1970, 1975, 1983/84, 1986, 1991, 1994, 1998, 2002 and 2005. The aerial photography review focused on the key, land-based and above ground construction support sites (detailed in Section 1.3) and surface work, specific AEs and general land use that could be potentially impacted by the project construction work (refer to Chapter 6 (Construction Work) of this environmental impact statement).

The findings of the historical aerial photograph are provided in Tables A.1 to A.12 in Appendix A. A summary is provided in Table 4-1. A review of the historical aerial imagery for the Warringah Freeway Upgrade surface work indicates that the site was generally occupied by residential development up until sometime between 1961 and 1970 when the Warringah Freeway was constructed. Areas of the Warringah Freeway Upgrade surface work away from the Warringah Freeway have changed little within the imagery reviewed with the exception of commercial developments around North Sydney.

Table 4-1 Summary of potential contamination issues – historical aerial photography review

Site	Potential contamination
Construction support sites	
Rozelle Railyards (WHT1)	<ul style="list-style-type: none"> • Residual contamination from historical railway usage • Demolition – Inappropriate handling and disposal of building materials during demolition of on-site structures.
Victoria Road (WHT2)	<ul style="list-style-type: none"> • Fuel storage – Leaks and spills from underground storage tanks and associated infrastructure present with service station.
White Bay South (WHT3)	<ul style="list-style-type: none"> • Residual contamination from historical industrial use • Land reclamation • Demolition – Inappropriate handling and disposal of building materials during demolition of on-site structures.
White Bay North (WHT3)	<ul style="list-style-type: none"> • Residual contamination from historical industrial use • Historical bulk fuel storage next to the site • Land reclamation • Demolition – Inappropriate handling and disposal of building materials during demolition of on-site structures.
Yurulbin Point (WHT4)	<ul style="list-style-type: none"> • Residual contamination from historical industrial use • Demolition – Inappropriate handling and disposal of building materials during demolition of on-site structures.
Berrys Bay (WHT7)	<ul style="list-style-type: none"> • Residual contamination from historical industrial use

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Site	Potential contamination
	<ul style="list-style-type: none"> Historical bulk fuel storage on and next to the site
Berry Street North (WHT8)	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway.
Ridge Street north (WHT9)	<ul style="list-style-type: none"> Filling with material of unknown quality during earthwork associated with construction of the Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway.
Cammeray Golf Course (WHT10)	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway Chemical use and storage at golf course.
Waltham Street (WHT11)	<ul style="list-style-type: none"> Commercial/industrial use of site and surrounding areas.
Blue Street (WFU1)	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of railway line.
High Street South (WFU2)	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway.
High Street North (WFU3)	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway.
Arthur Street East (WFU4)	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway.
Berry Street East (WFU5)	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway.
Ridge Street East (WFU6)	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway.
Merlin Street (WFU7)	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway.
Cammeray Golf Course (WFU8)	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway Chemical use and storage at golf course.
Rosalind Street East (WFU9)	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway.

Site	Potential contamination
Other surface sites	
Modifications and additions to the Rozelle Interchange	<ul style="list-style-type: none"> Residual contamination from historical industrial use Land reclamation (potential infilling with industrial waste of contaminated sediments from adjoining waterways) Demolition – Inappropriate handling and disposal of building materials during demolition of on-site structures.
Warringah Freeway Upgrade and associated local road upgrade surface work	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway Particulate matter deposition from vehicles using the Warringah Freeway.
Communications cable trenching – Warringah Freeway and Gore Hill Freeway	<ul style="list-style-type: none"> Demolition – Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway and Gore Hill Freeway.

4.2 Other information sources

4.2.1 Aerial imagery services

Jacobs carried out a review of available aerial imagery services including Google Earth, SIX Maps and Metro Maps to ascertain current above ground activities and/or operations which could potentially represent contamination sources. The results of the review are presented in Table 4-2.

Table 4-2 Potential contamination sources (aerial imagery review)

Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants
Rozelle Rail Yards	Above tunnel and within footprint of construction support site	Tunnel and Rozelle Rail Yards construction support site (WHT1) (surface)	Residuals from historical railway usage	Surface and sub surface (Depth distribution associated with potential underground storage tanks)	Heavy metals, hydrocarbons, pesticides, asbestos
	Above tunnel and within footprint of construction support site	Tunnel and Rozelle Rail Yards construction support site (WHT1) (surface)	Potential infill of former creek line and adjoining low lying areas	Surface and sub surface (Depth distribution associated with depth of infilling. Infilling materials could comprise historical industrial waste from harbourside industry)	Heavy metals, hydrocarbons, pesticides, PCB, nutrients, cyanide, VOC, asbestos
Factories/warehouses, Lilyfield Road	Adjacent to tunnel (laterally, not vertically)	Tunnel	Commercial/industrial land use (current and/or historic)	Surface and sub surface (Depth distribution associated with potential underground storage tanks)	Heavy metals, hydrocarbons
	Adjacent to tunnel (laterally, not vertically)	Tunnel	Potential infill of former creek line and adjoining low lying areas	Surface and sub surface (Depth distribution associated with depth of infilling. Infilling materials could comprise historical furnace waste from harbourside industry)	Heavy metals, hydrocarbons, pesticides, PCB, nutrients, cyanide, VOC, asbestos

Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants
Easton Park – Corner Denison Street and Lilyfield Road, Rozelle	Above tunnel	Tunnel	Potential infill of former creek line and adjoining low lying areas	Surface and sub surface (Depth distribution associated with depth of infilling. Infilling materials could comprise historical furnace waste from harbourside industry)	Heavy metals, hydrocarbons, pesticides, PCB, nutrients, cyanide, asbestos, landfill gas
Service station – Corner Evans Street and Victoria Road, Rozelle	Adjacent to tunnel (laterally, not vertically)	Tunnel	Leaks and spills from underground petroleum storage infrastructure	Sub surface	Heavy metals, hydrocarbons
Depot (possible council work depot) – Between Llewelyn and Darling streets, Balmain	Adjacent to tunnel (laterally, not vertically)	Tunnel	Residuals from use as a work depot	Surface and sub surface (Depth distribution associated with potential underground storage tanks)	Heavy metals, hydrocarbons, pesticides, asbestos
Sediments within Sydney Harbour	Above tunnel	Tunnel	Contamination associated with industrial use of Sydney Harbour and catchment inputs	Surface to recent (~150 years) depositional extent	Heavy metals, hydrocarbons (mainly Polycyclic aromatic hydrocarbons (PAH)), pesticides, PCB, dioxin, organotins, per- and poly-fluoroalkyl substances (PFAS)
Wharf – Balls Head Drive, Waverton	Above tunnel	Tunnel	Commercial/industrial marine land use (current and/or historic)	Surface	Heavy metals, hydrocarbons, organotins
Berrys Bay Marina – Balls Head Road, Waverton	Adjacent to tunnel (laterally, not vertically)	Tunnel	Commercial/industrial marine land use (current and/or historic)	Surface	Heavy metals, hydrocarbons, organotins

Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants
HMAS Waterhen – Balls Head Road, Waverton	Adjacent to tunnel (laterally, not vertically)	Tunnel	General naval use	Surface and sub surface (Depth distribution associated with potential underground storage tanks)	Heavy metals, hydrocarbons, organotins
Waverton Park – Woolcott Street, Waverton	Adjacent to tunnel (laterally, not vertically)	Tunnel	Potential infill/reclamation next to shore line	Surface and sub surface (Depth distribution associated with depth of infilling)	Heavy metals, hydrocarbons, pesticides, PCB, nutrients, cyanide, VOC, asbestos
North Shore Railway Corridor – next to Waverton Station	Above tunnel	Tunnel	Residual contamination from railway usage	Surface	Heavy metals, hydrocarbons, pesticides, asbestos
Unsealed areas next to Warringah Freeway – Arthur Street, North Sydney	Within footprint of construction support site and surface works	Arthur Street east construction support site (WFU4) and Warringah Freeway Upgrade surface work (surface)	Particulate matter deposition from vehicles	Surface	Heavy metals, hydrocarbons (mainly PAH), asbestos
Unsealed areas next to Warringah Freeway – High Street, North Sydney	Within footprint of construction support site and surface works	High Street south (WFU2) and High Street north (WFU3) construction support sites and Warringah Freeway Upgrade surface work (surface)	Particulate matter deposition from vehicles	Surface	Heavy metals, hydrocarbons (mainly PAH), asbestos

Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants
Unsealed areas next to Warringah Freeway – Eastern side (between Alfred Street and Warringah Freeway), North Sydney	Within footprint of construction support site and surface works	Blue Street construction support site (WFU1) and Warringah Freeway Upgrade surface work (surface)	Particulate matter deposition from vehicles	Surface	Heavy metals, hydrocarbons (mainly PAH), asbestos
Unsealed areas next to Warringah Freeway – Western side (between Berry Street and Warringah Freeway), North Sydney	Within footprint of construction support site and surface works	Berry Street north (WHT8) and Berry Street east (WFU5) construction support sites and Warringah Freeway Upgrade surface work (surface)	Particulate matter deposition from vehicles	Surface	Heavy metals, hydrocarbons (mainly PAH), asbestos
Unsealed areas next to Warringah Freeway – Western side (between Berry Street and Warringah Freeway, west side of on ramp), North Sydney	Within footprint of construction support site and surface works	Berry Street north (WHT8) and Berry Street east (WFU5) construction support sites and Warringah Freeway Upgrade surface work (surface)	Particulate matter deposition from vehicles	Surface	Heavy metals, hydrocarbons (mainly PAH), asbestos
Unsealed areas next to Warringah Freeway – Western side (between Ridge Street and Warringah Freeway), North Sydney	Within footprint of construction support site and surface works	Ridge Street east construction support site (WFU6) and Warringah Freeway Upgrade surface work (surface)	Particulate matter deposition from vehicles	Surface	Heavy metals, hydrocarbons (mainly PAH), asbestos

Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants
St Leonards Park bordering Warringah Freeway and Falcon Street – North Sydney	Within and adjacent to the footprint of construction support site	Ridge Street north construction support site (WHT9)	Particulate matter deposition from vehicles	Surface	Heavy metals, hydrocarbons (mainly PAH), asbestos
Unsealed areas next to Warringah Freeway – Eastern side (between Merlin Street and Warringah Freeway), Neutral Bay	Within footprint of construction support site and surface works	Merlin Street construction support site (WFU7) and Warringah Freeway Upgrade surface work (surface)	Particulate matter deposition from vehicles	Surface	Heavy metals, hydrocarbons (mainly PAH), asbestos
Unsealed areas next to Warringah Freeway – Western side (between Ernest and Falcon Streets), North Sydney	Above tunnel and within footprint of surface works and Falcon Street shared user bridge construction site	Warringah Freeway Upgrade surface work (surface) and Falcon Street shared user bridge	Particulate matter deposition from vehicles	Surface	Heavy metals, hydrocarbons (mainly PAH), asbestos
Unsealed areas next to Warringah Freeway – Eastern side (between Ernest and Falcon streets – between freeway and on ramp), Cammeray	Within footprint of construction support site and surface works	Cammeray Golf Course construction support site (WHT10) and Warringah Freeway Upgrade surface work (surface)	Particulate matter deposition from vehicles	Surface	Heavy metals, hydrocarbons (mainly PAH), asbestos
Unsealed areas next to Warringah Freeway – Western side (Anzac Park from Ernest to Miller Street), Crows Nest	Within footprint of surface works	Warringah Freeway Upgrade surface work (surface)	Particulate matter deposition from vehicles	Surface	Heavy metals, hydrocarbons (mainly PAH), asbestos

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4.2.2 Business directories

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 Yellow Pages internet search was based on matching business types (as best as possible) listed with those activities that may cause contamination as outlined in *Managing Land Contamination Planning Guidelines*. SEPP 55 – Remediation of Land (Department of Urban Affairs and Planning, 1998) The Yellow Pages search was limited to the suburbs within and surrounding the project area including Rozelle, White Bay, Balmain, Birchgrove, Waverton, and North Sydney. The results of the business directory review are presented in Table 4-3.

Table 4-3 Potential contamination sources (business directory review)

	Next to construction footprint
	Within 500 metres of construction footprint
	More than 500 metres from construction footprint

SEPP 55 Activities	General activity description	Yellow Pages business description	Suburb					
			Rozelle	White Bay	Balmain	Birchgrove	Waverton	North Sydney
Acid/alkali plant and formulation	Acid production, chlorine and sodium hydroxide production	Acid (Acid)	No listings within surrounding suburbs					
Agricultural/horticultural activities	Farming, cropping, market gardens, nurseries	Agricultural chemicals (Agri-C), Nurseries (Nurs), Market Gardens (Mark), Farms (Farm)	No listings within surrounding suburbs					
Airports	Airports	Airports (Airp)	No listings within surrounding suburbs					
Asbestos production and disposal	Asbestos disposal sites	Asbestos Disposal (Asbe-D)	No listings within surrounding suburbs					
Chemicals manufacture and formulation	Suppliers	Chemicals industrial (Chem-I), Chemicals manufacturing (Chem-M)	No listings within surrounding suburbs					
Defence work	Bases, depots	Defence Force (Defe-F)	No listings within surrounding suburbs					
Drum re conditioning work	Drum re conditioners	Drum Reconditioning (Drum-R)	No listings within surrounding suburbs					
Dry cleaning establishments	Dry cleaners	Dry Cleaners (Dry-C)	No-D-Lay Dry Cleaning: 714 Darling Street Rozelle (Dry-C)		Balmain Alteration and Fashion: 269 Darling Street Balmain (Dry-C)			TLC Dry Cleaners: 36 Blue Street North Sydney (Dry-C)
			Tiger Dry Cleaners: 575					

SEPP 55 Activities	General activity description	Yellow Pages business description	Suburb					
			Rozelle	White Bay	Balmain	Birchgrove	Waverton	North Sydney
			Darling Street Rozelle (Dry-C)					
Electrical manufacturing (transformers)	Substations, switching and high voltage yards	Transformers (Tran), Transformer Manufacturers (Tran-M), Transformer Oil (Tran-O)	No listings within surrounding suburbs					
Electroplating and heat treatment premises	Metal plating, galvanising, chrome plating	Electroplating (Elcp)	No listings within surrounding suburbs					
Engine work	Mechanics	Engine Reconditioning (Eng-R), Mechanics (Eng-M)	Repco: 1 Wellington Street Rozelle (Eng-M)		Balmain Automotive: 5 North Street Balmain (Eng-M)			Ford Land Company: 231 Pacific Highway North Sydney (Eng-M)
			Prestige Auto Traders: 180 Mullens Street Rozelle (Eng-M)					Trojan Techgroup: 275 Alfred Street North Sydney (Eng-M)
			Fine Serve Automotive: 127 Victoria Road Rozelle (Eng-M)					North Sydney Automotive: 323 Clark Road North Sydney (Eng-M)
			Autotech Rozelle: 73 Victoria Road Rozelle (Eng-M)					
			Robert Street Automotive:					

SEPP 55 Activities	General activity description	Yellow Pages business description	Suburb					
			Rozelle	White Bay	Balmain	Birchgrove	Waverton	North Sydney
			22-26 Robert Street Rozelle (Eng-M)					
			Balmain Service Centre: 16 Mansfield Street Rozelle (Eng-M)					
			DS 17: 780 Darling Street Rozelle (Eng-M)					
			Peugeot Rozelle: 18 Robert Street Rozelle (Eng-M)					
			T&P Auto Clinic: 2 Mansfield Street Rozelle (Eng-M)					
Explosives industry	Ammunition, fireworks	Explosives (Expl)						Dyno Noble: 111 Pacific Highway North Sydney (Expl)
								Explosive Entertainment International: 11 Ridge Street North Sydney (Expl)

SEPP 55 Activities	General activity description	Yellow Pages business description	Suburb					
			Rozelle	White Bay	Balmain	Birchgrove	Waverton	North Sydney
Gas work	Gas work	No listing	No listings within surrounding suburbs					
Iron and steel work	Smelters, foundries	Foundry (Fnd)	No listings within surrounding suburbs					
Landfill sites	Landfills	Landfills (Lnfl)	No listings within surrounding suburbs					
Metal treatment		No listing	No listings within surrounding suburbs					
Mining and extractive industries		Mining (Ming)	No listings within surrounding suburbs					
Oil production and storage	Refineries, recyclers	Lubricants (Oil-L), Refineries (Oil-Ref), Recyclers (Oil-Recyc), Reconditioners (Oil-Recon)	No listings within surrounding suburbs					
Paint formulation and manufacture	Paint manufacturers	Manufacturers (Pnt-M)	Marineware: 18 Robert Street Rozelle (Pnt-M)					
Pesticide manufacture and formulation	Pesticide and chemical manufacture	Insecticides, herbicides and fungicides (Pest)	No listings within surrounding suburbs					
Power stations		Power Station (Pows)	No listings within surrounding suburbs					
Railway yards		No listing	No listings within surrounding suburbs					
Scrap yards	Recyclers	Metal Recyclers (Met-R)	No listings within surrounding suburbs					

SEPP 55 Activities	General activity description	Yellow Pages business description	Suburb					
			Rozelle	White Bay	Balmain	Birchgrove	Waverton	North Sydney
Service stations	Service stations	Service Stations (Serv)	Caltex Woolworths: Cnr Victoria Road and Wellington Road Rozelle (Serv)		Bills Garage: 418 Darling Street Balmain (Serv)			
			Caltex Australia: 121 Victoria Road Rozelle (Serv)					
Sheep and cattle dips	Sheep and cattle dips	Sheep dipping (Shdp)	No listings within surrounding suburbs					
Smelting and refining	See iron and steel work	See iron and steel work	No listings within surrounding suburbs					
Tanning and associated trades	Tanneries	Tanneries (Tann)	No listings within surrounding suburbs					
Waste storage and treatment	Transfer stations, waste treatment facilities	Waste Transfer Station (Wts)	No listings within surrounding suburbs					
Wood preservation		Timber Preservation (Timb)	No listings within surrounding suburbs					

4.3 NSW Contaminated Sites Register

A search conducted on 30 April 2018 on the 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 the NSW EPA (under section 60 of the CLM Act) indicated that there were eight sites registered with the NSW EPA within 500 metres of the project that were either regulated (current notices) or had been notified.

The sites are shown in Figure 4-1 and summarised in Table 4-4.

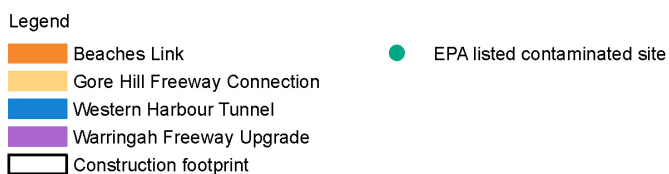
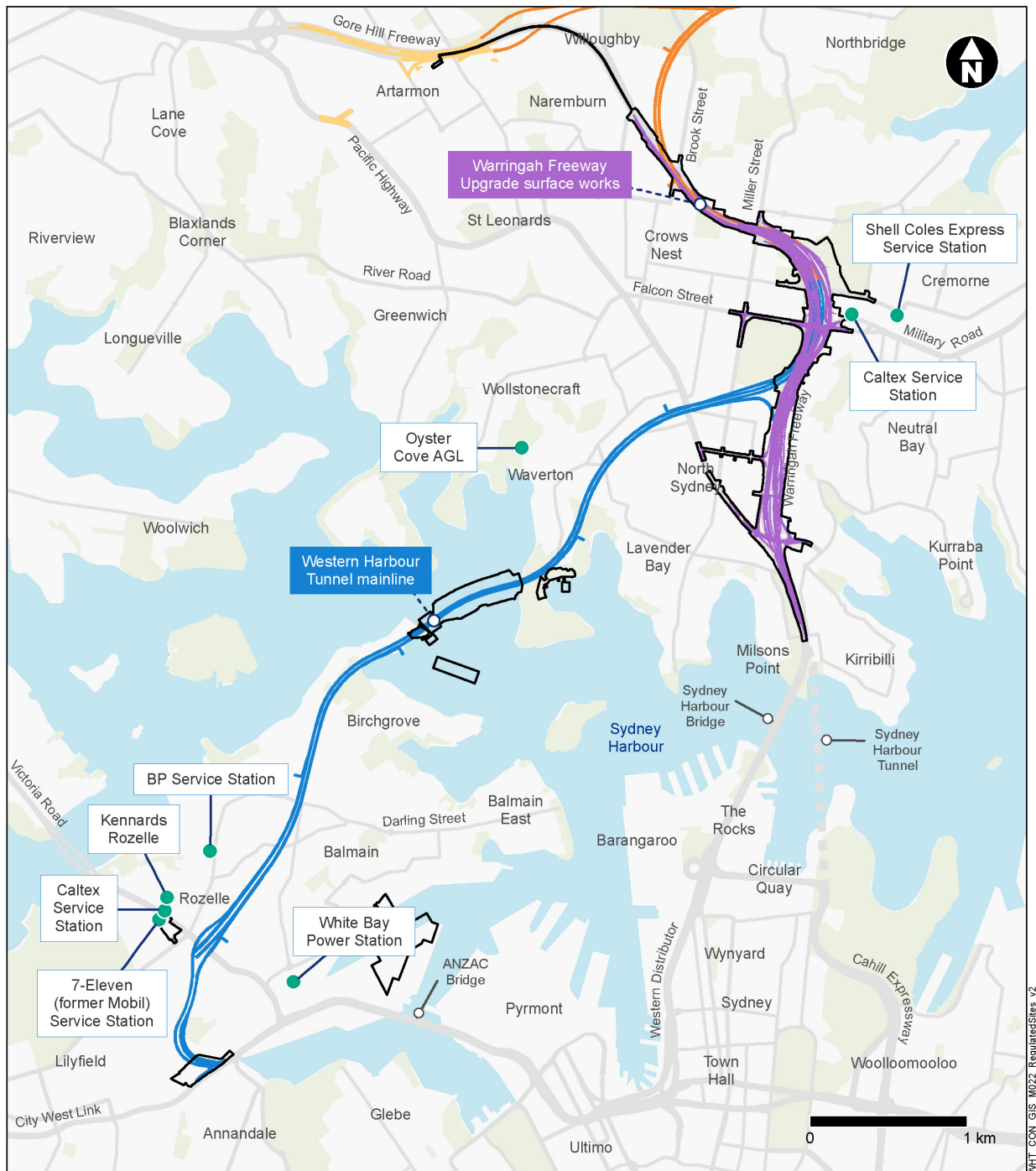


Figure 4-1 Regulated/notified sites within 500 metres of the project

Table 4-4 Regulated/notified sites within 500 metres of the project area

Site	Suburb	Regulated/ notified	Site address	Site activity	Contamination status	Location relative to project	Construction element
1	Rozelle	Notified (section 60)	Robert Street	Other industry	Regulation under CLM Act not required	About 500 m south east of the project	Tunnel
2	Rozelle	Notified (section 60)	178–180 Victoria Road	Service station	Regulation under CLM Act not required	Less than 100 m west of the project (compound) About 300 m west of the project (tunnel)	Victoria Road construction support site (WHT2) and tunnel
3	Rozelle	Notified (section 60)	121 Victoria Road	Service station	Regulation under CLM Act not required	Less than 100 m north of the project (compound) About 300 m west of the project (tunnel)	Victoria Road construction support site (WHT2) and tunnel
4	Rozelle	Notified (section 60)	15–39 Wellington Street	Other petroleum	Regulation under CLM Act not required	About 100 m north of the project (compound) About 300 m north west of the project (tunnel)	Victoria Road construction support site (WHT2) and tunnel
5	Rozelle	Notified (section 60)	Corner Darling Street and Thornton Street	Service station	Regulation under CLM Act not required	About 300 m north west of the project	Tunnel
6	Neutral Bay	Notified (section 60)	16–38 Military Road	Service station	Regulation being finalised	About 100 m south of the project (compound) About 200 m north east of the project (compound) About 200 m north east of the project (tunnel)	Merlin Street (WFU7) and Cammeray Golf Course (WFU8) construction support sites and tunnel

Site	Suburb	Regulated/ notified	Site address	Site activity	Contamination status	Location relative to project	Construction element
7	Neutral Bay	Notified (section 60)	200–204 Ben Boyd Road	Service station	Regulation under CLM Act not required	About 300 m south east of the project (compound) About 500 m north east of the project (compound) About 500 m east of the project (tunnel)	Merlin Street (WFU7) and Cammeray Golf Course (WFU8) construction support sites and tunnel
8	Waverton	Regulated (section 58)	2 King Street	-	Notice for managing remediation	About 500 m west of the project	Tunnel

The NSW EPA notified sites database listed two sites as not being regulated under the CLM Act which were located within 500 metres of the project. These sites were Berrys Bay Woodley's Marina (1 Balls Head Drive, Waverton) and SRA Land (95 Bay Road, Waverton).

The contamination mechanisms associated with activities carried out on the above service station sites are likely to be associated with deeper contamination (ie potentially four to 10 metres below ground level – below underground storage tanks) from leaks from underground fuel infrastructure. In consideration of the contamination mechanisms associated with service station sites, the construction elements, and distance from the project, contamination (if present) would pose a low risk to construction activities across the project.

Contamination exposure risk from service stations located near surface work and construction support sites is likely to be low (ie contamination, if present is likely to be below the depth of construction activities). Four service station sites are near tunnel elements of the project including:

- 178-180 Victoria Road in Rozelle – About 300 metres west of the project
- 121 Victoria Road in Rozelle – About 300 metres west of the project
- Corner Darling Street and Thornton Street in Rozelle – About 300 metres north west of the project
- 16–38 Military Road in Neutral Bay – About 200 metres north east of the project (tunnel).

Considering the lateral and vertical separation between these service stations and the tunnel and the hydrogeological conditions (sandstone and groundwater flow direction not towards project from the respective sites), contamination from the sites (if present) is unlikely to pose a substantial risk to construction and operation of the tunnel.

4.4 Previous contamination site investigations

Information from the following reports was reviewed in preparation of this report:

- *Rozelle Rail Yards – Site Management Works. Review of Environmental Factors. Interim Factual Contamination Report* (AECOM, 2016)
- *WestConnex M4-M5 Link, Environmental Impact Statement* (RMS, M4-M5)
- *WestConnex New M5 Environmental Impact Statement – Technical working paper: Groundwater Appendix G* (AECOM, 2015)

- *Western Harbour Tunnel and Beaches Link Geotechnical Investigation. Contamination Factual Report – Marine Investigations* (Douglas Partners and Golder Associates (DPGA), 2017a)
- *Western Harbour Tunnel and Beaches Link Geotechnical Investigation. Groundwater Monitoring Factual Report – Round One* (DPGA, 2017b)
- *Western Harbour Tunnel and Beaches Link Geotechnical Investigation. Groundwater Monitoring Factual Report – Round Two* (DPGA, 2017c)
- *Western Harbour Tunnel and Beaches Link Geotechnical Investigation. Geotechnical Factual Report – Land Investigations* (DPGA, 2017d)
- *Western Harbour Tunnel and Beaches Link – Contamination Factual Report (CFR)* (AECOM and Coffey, (AEC), 2018)
- *Western Harbour Tunnel and Beaches Link Geotechnical Investigation. Contamination Factual Report – Land Investigations* (DPGA, 2018a)
- *Western Harbour Tunnel and Beaches Link Geotechnical Investigation. Groundwater Monitoring Factual Report – Round Four* (DPGA, 2018b)
- *Western Harbour Tunnel and Beaches Link Geotechnical Investigation. Groundwater Monitoring Factual Report – Round Five* (DPGA, 2018c)
- *Western Harbour Tunnel and Beaches Link Geotechnical Investigation. Groundwater Monitoring Factual Report – Round Six* (DPGA, 2018d)
- *Western Harbour Tunnel and Beaches Link Geotechnical Investigation. Groundwater Monitoring Factual Report – Round Seven* (DPGA, 2018e)
- *Western Harbour Tunnel and Beaches Link Geotechnical Investigation. Groundwater Monitoring Factual Report – Round Eight* (DPGA, 2018f)
- *Western Harbour Tunnel and Beaches Link – Groundwater Monitoring Report 7 – October 2018 to March 2019* (AEC, 2019).

4.4.1 Rozelle Rail Yards

The AECOM (2016) report detailed the results of a soil and groundwater investigation carried out across the Rozelle Rail Yards site. The investigation comprised the following scope of work:

- A total of 51 boreholes were drilled for the collection of soil samples. Selected soil samples were analysed for a range of contaminant compounds, including heavy metals, TRH, BTEX, PAH, pesticides, PCBs and asbestos
- Eleven groundwater wells were sampled and analysed for heavy metals, TRH, semi volatile organic compounds (SVOCs, including PAHs, phenols, OCP and OPP) and volatile organic compounds (VOC including BTEX).

The results of the investigation are summarised below:

- Anthropogenic fill material was encountered in all boreholes across the site ranging in depth from 0.4 to 5.5 metres below ground level. Fill material comprised layers of sandy gravels, gravelly sands, silty sand and sandstone boulders. Common anthropogenic inclusions comprised brick, slag and concrete with minor metal, timber, cloth, ash, netting, coal, porcelain and fragments of asbestos cement sheeting
- Selected soil samples collected from across the site contained concentrations of heavy metals (arsenic, cadmium, copper, lead, nickel and zinc), PAHs and asbestos above adopted human health and ecological criteria
- Groundwater contained generally low concentrations of contaminants with the exception of light non-aqueous phase liquid (LNAPL) encountered within one well.

Western Harbour Tunnel and Warringah Freeway Upgrade

The contamination section of the Roads and Maritime *M4-M5 Link Environmental Impact Statement* details contamination information covering the Rozelle civil and tunnel site (C5) and the Crescent civil site (C6). These areas would cover the Rozelle Rail Yards and surface work.

A summary of the contamination information from the environmental impact statement relevant to the Rozelle civil and tunnel site (C5) is provided below:

- Prior to 1900, the eastern third of the site was part of Rozelle Bay, which was reclaimed to build the Rozelle Rail Yards. From 1914 to the 1930s, the land was acquired by The Commissioner for Railways, which became the Public Transport Commission of New South Wales (1970s) and then State Rail Authority of New South Wales (1980s). The railyards were transferred to Sydney Harbour Foreshore Authority in 2000 (which was absorbed into Government Property NSW in 2015)
- Various industries operated in the Rozelle Rail Yards, including panel beaters, petroleum companies, logistics, boat and seafood businesses
- Historical aerial photographs showed that the City West Link was formerly part of the Rozelle Rail Yards until between 1982 and 1991. Several previous investigations have been carried out at the site, including fill, natural soil and groundwater samples collected as part of a site investigation carried out by AECOM in 2016. Results include some NEPM (2013) health investigation levels and ecological investigation levels being exceeded for some contaminants. Additional contamination investigations were carried out to inform management measures for the Rozelle Rail Yards Site Management Work Review of Environmental Factors (Roads and Maritime, 2016)
- Portions of the site were historically used for railyards, timber yards, soap and candle merchants, crane yards, bitumen plant and boat repairs. Areas next to the site (ie Easton Park), were filled with soil containing elevated concentrations of heavy metals and PAHs from an unknown source
- Soil investigations carried out at the site have identified concentrations of metals (lead, arsenic, cadmium and zinc) and PAHs exceeding the land use criteria for open space and commercial/industrial scenarios in fill and also the presence of asbestos in fill. Petroleum sourced LNAPL was detected in the centre of the site and has not been delineated or the source location identified.

A summary of the contamination information from the environmental impact statement relevant to the Crescent civil site (C6) is provided below.

It is understood that the site has been previously used for marine storage and maintenance purposes. The site history prior to that is unknown. However, there is potential that the area has been filled and was previously part of Rozelle Bay. The Rozelle Rail Yards Site Management Work Review of Environmental Factors (Roads and Maritime, 2016) noted that historical reports indicate Rozelle Bay is one of the most heavily polluted areas of Sydney Harbour.

AECOM carried out soil and sediment investigations at the site in 2017. Some samples reported heavy metal, PAH, PFAS, phthalates and asbestos exceeding the human health United States Environmental Protection Agency residential regional screening levels and NEPM ecological screening levels.

4.4.2 Harbour sediments

Sediment sampling was carried out within the proposed Sydney Harbour crossing and construction support sites at White Bay (WHT3) and Berrys Bay (WHT7) as part of the DGPA (December 2017a) investigation. Sediment samples were collected from a range of depths and analysed for contaminant compounds including heavy metals, TRH, BTEX, PAH, OCP, PCBs, per- and poly-fluoroalkyl substances (PFAS), dioxins, OPP, organotins, dioxins and furans, ASS, cyanide, nutrients, pyrethroids, chlorobenzenes, carbamates, phenols, herbicides, volatile chlorinated and halogenated hydrocarbons and radionuclides. The results of the laboratory analysis were compared against the following guideline criteria:

- ANZECC (2000) *High and Low Interim Sediment Quality Guidelines* (ISQG)

- *National Environment Protection (Assessment of Site Contamination) Measure 1999* (as revised 2013) (NEPM, 2013) Ecological Investigation Levels (EIL)
- Commonwealth of Australia (2009) *National Assessment Guidelines for Dredging* (NAGD).

The results of the sediment sampling indicated that selected contaminants were generally detected above guideline criteria (where available) in samples collected from between zero and one metre below the surface of the sediment. Minor detections of selected contaminants above guideline levels were detected in samples collected from depths of about 1.5 metres. The following contaminants (where tested) were detected above the respective guidelines in selected sediment samples:

- PAH – ISQC (low and high), NAGD
- TRH – NAGD
- OCP – ISQC (low)
- Tributyltin (TBT) – ISQC (low) and NAGD
- Heavy metals – ISQC (low), EIL
- Arsenic – ISQC (high)
- Copper – ISQC (high)
- Mercury – ISQC (high)
- Lead – ISQC (high)
- Silver – ISQC (high)
- Zinc – ISQC (high), EIL.

Contaminant compounds exceeding the nominated criteria at the respective sediment sample locations are provided in Appendix B.

The nominated guidelines (detailed above) do not include criteria for PFAS and dioxins. PFAS (Perfluorooctanoic acid – PFOA, Perfluorooctane sulfonic acid – PFOS, Perfluorohexane sulfonic acid – PFHxS and Perfluorobutanoic acid – PFBA) and dioxins were detected above laboratory levels of reporting in sediment samples collected for Western Harbour Tunnel. Dioxins were detected above laboratory levels of reporting in sediment samples collected from White Bay (PFAS analysis was not carried out on White Bay sediment samples). PFAS and dioxin analysis was not carried out on sediment samples collected from Berrys Bay.

Limited samples were collected for ASS testing as part of the DGPA (December 2017a) investigation. Jacobs have carried out a review of the analytical results in comparison to Table 4.4 of the Acid Sulfate Soils Management Advisory Committee (1998) *Acid Sulfate Soil Manual*. The peroxide oxidisable sulfur results reported at location B482W-B (0.072%) from the Western Harbour Tunnel component investigation area and locations B770-ELU (0.193%), B771-ELU (0.212%), B772-ELU (0.063%), B773-ELU (0.223%) and B774-ELU (0.263) from White Bay exceed the oxidisable sulfur action criteria of 0.03%.

4.4.3 Groundwater

Groundwater quality data have been reported from seven sampling events at six standpipe piezometers by DPGA (2017b, 2017c, 2018b, 2018c, 2018d, 2018e, 2018f). Details of the monitoring sites are provided in Table 4-5.

Table 4-5 Groundwater quality monitoring locations – DPGA

Bore ID	Location	Monitored formation	No. of samples	Comments
B104A	Birchgrove	Hawkesbury Sandstone	6	Metals results considered unreliable due to high pH
B105A	Birchgrove	Hawkesbury Sandstone	7	Complete results
B131A	Birchgrove	Hawkesbury Sandstone	7	Complete results
B181A	Rozelle	Hawkesbury Sandstone	7	Complete results
B208	Balmain	Hawkesbury Sandstone	6	Metals results considered unreliable due to high pH
B209	Birchgrove	Hawkesbury Sandstone	3	Metals results considered unreliable due to high pH

The DPGA (2017b) report indicated that groundwater sampling was carried out from wells B104A (Birchgrove), B105A (Birchgrove), B131A (Birchgrove), B181A (Rozelle) and B209 (Birchgrove). Although present within the analytical tables, the location of well B105A was not identified on the figures contained within the report. Groundwater samples were analysed for common contaminant compounds including heavy metals, nutrients, PAH, TRH and BTEX. Table 4-6 details contaminant compounds detected above the respective water quality guidelines within the groundwater samples collected.

Table 4-6 Groundwater analytical results (DPGA, 2017b)

Bore ID	Location	Compound	Guideline Exceedance
B104A	Birchgrove	Chromium, Copper, Zinc, Ammonia	ANZECC (2000) 95% species protection for freshwater ecosystems
		Nickel, Ammonia	ANZECC (2000) 95% species protection for marine ecosystems
B105A	Birchgrove	Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B131A	Birchgrove	Boron, Manganese, Ammonia	ANZECC (2000) 95% species protection for freshwater ecosystems
		Cobalt, Ammonia, Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B181A	Rozelle	Copper, Zinc	ANZECC (2000) 95% species protection for freshwater ecosystems
		Cobalt, Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B209	Birchgrove	Chromium, Zinc	ANZECC (2000) 95% species protection for freshwater ecosystems

The DPGA (2017c) report indicated that groundwater sampling was carried out from wells B105A (Birchgrove), B131A (Birchgrove), B181A (Rozelle) and B208 (Balmain). Groundwater samples were analysed for common contaminant compounds including heavy metals, nutrients, PAH, TRH and BTEX. Table 4-7 details contaminant compounds detected above the respective water quality guidelines within the groundwater samples collected.

Table 4-7 Groundwater analytical results (DPGA, 2017c)

Bore ID	Location	Compound	Guideline Exceedance
B105A	Birchgrove	Arsenic	ANZECC (2000) 95% species protection for freshwater ecosystems

Bore ID	Location	Compound	Guideline Exceedance
		Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B131A	Birchgrove	Arsenic, Manganese, Zinc, Ammonia	ANZECC (2000) 95% species protection for freshwater ecosystems
		Cobalt, Lead, Zinc, Toluene, Ammonia, Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B181A	Rozelle	Copper, Nitrate	ANZECC (2000) 95% species protection for marine ecosystems
		Nitrate, Total Phosphorous	ANZECC (2000) 95% species protection for freshwater ecosystems
B208	Balmain	Chromium	ANZECC (2000) 95% species protection for marine ecosystems

The DPGA (2018b) report indicated that groundwater sampling was carried out from wells B104A (Birchgrove), B105A (Birchgrove), B131A (Birchgrove), B181A (Rozelle) and B208 (Balmain). Groundwater samples were analysed for common contaminant compounds including heavy metals, nutrients, PAH, TRH and BTEX. Table 4-8 details contaminant compounds detected above the respective water quality guidelines within the groundwater samples collected.

Table 4-8 Groundwater analytical results (DPGA, 2018b)

Bore ID	Location	Compound	Guideline Exceedance
B104A	Birchgrove	Nickel, Ammonia	ANZECC (2000) 95% species protection for freshwater ecosystems
		Nickel, Ammonia, Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B105A	Birchgrove	Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B131A	Birchgrove	Boron, Manganese	ANZECC (2000) 95% species protection for freshwater ecosystems
		Manganese, Benzene	NHMRC (2011) drinking water guidelines
		Manganese, Benzene	NHMRC (2008) recreational water guidelines
		Toluene, Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B181A	Rozelle	Zinc, Nitrate	ANZECC (2000) 95% species protection for freshwater ecosystems
		Zinc, Nitrate, Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B208	Balmain	Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems

The DPGA (2018c) report indicated that groundwater sampling was carried out from wells B104A (Birchgrove), B105A (Birchgrove), B131A (Birchgrove), B181A (Rozelle) and B208 (Balmain). The analytical tables detail results for B208A and not B208. It is assumed that B208A refers to the results from well location B208. Groundwater samples were analysed for common contaminant compounds including heavy metals, nutrients, PAH, TRH and BTEX. Table 4-9 details contaminant compounds detected above the respective water quality guidelines within the groundwater samples collected.

Table 4-9 Groundwater analytical results (DPGA, 2018c)

Bore ID	Location	Compound	Guideline Exceedance
B104A	Birchgrove	Ammonia	ANZECC (2000) 95% species protection for marine ecosystems
		Ammonia	ANZECC (2000) 95% species protection for freshwater ecosystems
B105A	Birchgrove	Benzene	NHMRC (2011) drinking water guidelines
		Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B131A	Birchgrove	Boron, Manganese, Zinc, Ammonia	ANZECC (2000) 95% species protection for freshwater ecosystems
		Cobalt, Zinc, Ammonia, Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
		Manganese, Sulphate	NHMRC (2011) drinking water guidelines
		Manganese, Benzene	NHMRC (2008) recreational water guidelines
B181A	Rozelle	Copper, Zinc, Nitrate, Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
		Zinc, Nitrate	ANZECC (2000) 95% species protection for freshwater ecosystems

The DPGA (2018d) report indicated that groundwater sampling was carried out from wells B104A (Birchgrove), B105A (Birchgrove), B131A (Birchgrove), B181A (Rozelle) and B208 (Balmain). Groundwater samples were analysed for common contaminant compounds including heavy metals, nutrients, PAH, TRH and BTEX. Table 4-10 details contaminant compounds detected above the respective water quality guidelines within the groundwater samples collected.

Table 4-10 Groundwater analytical results (DPGA, 2018d)

Bore ID	Location	Compound	Guideline Exceedance
B104A	Birchgrove	Ammonia	ANZECC (2000) 95% species protection for marine ecosystems
		Ammonia	ANZECC (2000) 95% species protection for freshwater ecosystems
B105A	Birchgrove	Benzene	NHMRC (2011) drinking water guidelines
		Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B131A	Birchgrove	Boron, Manganese, Zinc, Ammonia	ANZECC (2000) 95% species protection for freshwater ecosystems
		Cobalt, Ammonia, Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
		Manganese, Benzene, Sulphate	NHMRC (2011) drinking water guidelines
		Manganese, Benzene	NHMRC (2008) recreational water guidelines
B181A	Rozelle	Copper, Zinc, Nitrate, Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems

Bore ID	Location	Compound	Guideline Exceedance
		Chromium, Zinc, Nitrate	ANZECC (2000) 95% species protection for freshwater ecosystems

The DPGA (2018e) report indicated that groundwater sampling was carried out from wells B104A (Birchgrove), B105A (Birchgrove), B131A (Birchgrove), B181A (Rozelle) and B208 (Balmain). The analytical tables also include results for B209 (Birchgrove). The analytical tables also detail results for B208A and not B208. It is assumed that B208A refers to the results from well location B208. Groundwater samples were analysed for common contaminant compounds including heavy metals, nutrients, PAH, TRH and BTEX. Table 4-11 details contaminant compounds detected above the respective water quality guidelines within the groundwater samples collected.

Table 4-11 Groundwater analytical results (DPGA, 2018e)

Bore ID	Location	Compound	Guideline Exceedance
B104A	Birchgrove	Ammonia	ANZECC (2000) 95% species protection for marine ecosystems
		Ammonia	ANZECC (2000) 95% species protection for freshwater ecosystems
B105A	Birchgrove	Benzene	NHMRC (2011) drinking water guidelines
		Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
		Zinc	ANZECC (2000) 95% species protection for freshwater ecosystems
B131A	Birchgrove	Boron, Copper, Manganese, Zinc, Ammonia	ANZECC (2000) 95% species protection for freshwater ecosystems
		Ammonia, Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
		Manganese, Benzene, Sulphate	NHMRC (2011) drinking water guidelines
		Manganese, Benzene	NHMRC (2008) recreational water guidelines
B181A	Rozelle	Zinc, Nitrate, Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
		Chromium, Copper, Lead, Zinc, Nitrate	ANZECC (2000) 95% species protection for freshwater ecosystems
B208	Balmain	Chromium	ANZECC (2000) 95% species protection for marine ecosystems
		Chromium, Copper	ANZECC (2000) 95% species protection for freshwater ecosystems
B209	Birchgrove	Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems

The DPGA (2018f) report indicated that groundwater sampling was carried out from wells B104A (Birchgrove), B105A (Birchgrove), B131A (Birchgrove), B181A (Rozelle), B208 (Balmain) and B209 (Birchgrove). Groundwater samples were analysed for common contaminant compounds including heavy metals, nutrients, PAH, TRH and BTEX. Table 4-12 details contaminant compounds detected above the respective water quality guidelines within the groundwater samples collected.

Table 4-12 Groundwater analytical results (DPGA, 2018f)

Bore ID	Location	Compound	Guideline Exceedance
B104A	Birchgrove	Zinc	ANZECC (2000) 95% species protection for freshwater ecosystems
		Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B105	Birchgrove	Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B131A	Birchgrove	Boron	ANZECC (2000) 95% species protection for freshwater ecosystems
		Manganese	NHMRC (2008) recreational water guidelines
		Benzene, Sulphate	NHMRC (2011) drinking water guidelines
		Ammonia	ANZECC (2000) 95% species protection for marine ecosystems
B181A	Rozelle	Copper	ANZECC (2000) 95% species protection for freshwater ecosystems
		Zinc, Nitrate, Total Phosphorous	ANZECC (2000) 95% species protection for marine ecosystems
B208	Balmain	Chromium, Iron	ANZECC (2000) 95% species protection for freshwater ecosystems

It is possible that the concentrations of contaminants above guideline levels may represent contamination, especially those reported in well B131A (heavy metals, benzene and toluene) located in Birchgrove which could be associated with historical industrial operations within the local area. It is noted that the Technical working paper: Groundwater indicated that some of the heavy metal results were considered unreliable because of high pH results.

Groundwater quality data has been reported from seven sampling events at up to four standpipe piezometers by AEC (2019). Details of the monitoring sites are shown in Table 4-13.

Table 4-13 Groundwater quality monitoring locations (AEC, 2019)

Bore ID	Location	Monitored Formation	No. of samples	Comments
B112	Waverton	Sandstone	6	N/A
B150	North Sydney	Sandstone	6	N/A
B343	Cammeray	Sandstone	7	N/A
B390	Rozelle	Sandstone	7	N/A

The AEC (2019) report indicated that groundwater sampling was carried out from wells B112 (Waverton), B150 (North Sydney), B343 (Cammeray) and B390 (Rozelle). Groundwater samples were analysed for common contaminant compounds including heavy metals, nutrients, PAH, TRH and BTEX. The AEC (2019) report provided no assessment against groundwater quality criteria. Table 4-14 details contaminant compounds detected above the respective water quality guidelines (adopted from DPGA reports) within the groundwater samples collected.

Table 4-14 Groundwater analytical results (AEC, 2019)

Bore ID	Location	Compound	Guideline Exceedance
B112	Waverton	Phosphorous (reactive), Total Phosphorous, Cobalt, Copper, Nickel, Zinc	ANZECC (2000) 95% species protection for marine ecosystems
		Arsenic, Nickel	NHMRC (2011) drinking water guidelines
		Chromium, Copper, Nickel, Zinc	ANZECC (2000) 95% species protection for freshwater ecosystems
B150	North Sydney	Phosphorous (reactive), Total Phosphorous, Cobalt, Nickel, Zinc	ANZECC (2000) 95% species protection for marine ecosystems
		Boron, Zinc	ANZECC (2000) 95% species protection for freshwater ecosystems
		Manganese, Nickel	NHMRC (2011) drinking water guidelines
B343	Camberay	Ammonia, Phosphorous (reactive), Total Phosphorous, Cobalt, Copper, Nickel, Zinc	ANZECC (2000) 95% species protection for marine ecosystems
		Ammonia, Copper, Manganese, Nickel, Zinc	ANZECC (2000) 95% species protection for freshwater ecosystems
		Manganese	NHMRC (2011) drinking water guidelines
B390	Rozelle	Total Phosphorous, Cobalt, Copper, Zinc	ANZECC (2000) 95% species protection for marine ecosystems
		Copper, Nickel, Zinc	ANZECC (2000) 95% species protection for freshwater ecosystems
		Manganese	NHMRC (2011) drinking water guidelines

It is possible that the concentrations of contaminants above guideline levels may represent contamination. It is noted that the Technical working paper: Groundwater indicated that some of the heavy metal results were considered unreliable because of high pH results.

4.4.4 Soil

The AECOM and Coffey (2018) report indicated that soil sampling for contamination testing was carried out from the following boreholes and depths:

- B390 to B392 (at depths ranging between 0.05 metres and 1.1 metres) located at Rozelle
- B112 (at depths ranging between surface materials to 14.2 metres) located at Waverton
- B304 to B307, B312 to B314, B323, B327 to B332, B337, B340, B342, B343, B348, B349 (at depths ranging between 0.05 to 1.95 metres) located along the Warringah Freeway upgrade section of the project.

Soil samples were analysed for common contaminant compounds including heavy metals, PAH, TRH, BTEX, OCP, OPP with selected samples additionally analysed for phenols, volatile (VOC) and semi-volatile organic compounds (SVOC), cyanide, PCB and asbestos (presence/absence). The results of the sampling and analysis were compared against guidelines for the protection of ecological and human (investigation and screening levels) receivers under open space and commercial/industrial land usage. The analytical results compared to

adopted guidelines are detailed below. Where no discussion is provided, results were less than the respective guidelines.

- Copper concentrations ranged from non-detect to 245 mg/kg and exceeded the adopted open space ecological investigation level (EIL) (90 mg/kg) in two samples (BH348_0.26-0.37 and corresponding duplicate QC725)
- Nickel concentrations ranged from non-detect to 140 mg/kg exceeded the adopted open space EIL (35 mg/kg) in ten samples B305_0.4-0.45 (47 mg/kg), QC627 (duplicate of B305_0.4-0.45) (51 mg/kg), B306_0.3-0.4 (62 mg/kg), B307_0.26-0.4 (81 mg/kg), B328_0.35-0.45 (51 mg/kg), B329_0.3 (46 mg/kg), B332_0.3-0.4 (56 mg/kg), B348_0.26-0.37 (62 mg/kg), QC725 (duplicate of B348_0.26-0.37) (60 mg/kg) and B390_0.05-0.1 (94 mg/kg)
- PAHs concentrations were below the adopted open space health investigation level (HIL) (300 mg/kg) in all samples analysed, with the exception of one sample B305_0.80-0.85 (413 mg/kg)
- Concentrations of benzo(a)pyrene toxicity equivalency quotient (TEQ) – carcinogenic PAHs ranged from non-detect to 25.2 mg/kg and were below the adopted open space HIL (3 mg/kg) for all samples analysed with the exception of two samples B305_0.80-0.85 (25.2 mg/kg) and B337_0.1-0.2 (3.6 mg/kg)
- Benzo(a)pyrene concentrations ranged from non-detect to 17.8 mg/kg and were below the adopted open space ecological screening level (ESL) (0.7mg/kg) for all samples analysed with exception of five samples B305_0.80-0.85 (17.8 mg/kg), B343_0.42-0.45 (0.8 mg/kg), B314_0.05-0.25 (1.9 mg/kg), B337_0.10-0.20 (2.4 mg/kg) and QC611 (duplicate of B391_0.19-0.25) (0.8 mg/kg)
- Benzo(a)pyrene concentrations were below the adopted commercial/industrial ESL (1.4 mg/kg) with exception of three samples B305_0.80-0.85 (17.8 mg/kg), B314_0.05-0.25 (1.9 mg/kg) and B337_0.10-0.20 (2.4 mg/kg)
- TRH concentrations were below the adopted open space health screening levels (HSLs) with the exception of TRH C10-C16 which exceeded the HSL (3800 mg/kg) in B112_13.10-13.20 (13,100 mg/kg) and TRH C16-C34 exceeded the HSL (5300 mg/kg) in B112_13.10-13.20 (24,200 mg/kg)
- TRH concentrations were below the adopted commercial/industrial HSLs with the exception of TRH C6-C10 less BTEX (F1) which exceeded the HSL (240 mg/kg) in B112_13.10-13.20 (1830 mg/kg)
- TRH concentrations were below the adopted open space ESLs with the exception of TRH C6-C10 which exceeded the ESL (180 mg/kg) in B112_13.10-13.20 (1840 mg/kg), TRH C10-C16 which exceeded the ESL (120 mg/kg) in sample B112_13.10-13.20 (13,100 mg/kg) and TRH C16 – C34 which exceeded the ESL (300 mg/kg) in B112_13.10-13.20 (24,200 mg/kg) and B305_0.80-0.85 (1100 mg/kg)
- TRH concentrations were below the adopted commercial/industrial ESLs with the exception of TRH C6-C10 which exceeded the ESL (215 mg/kg) in B112_13.10-13.20 (1840 mg/kg), TRH C10-C16 which exceeded the ESL (170 mg/kg) in sample B112_13.10-13.20 (13,100 mg/kg) and TRH C16–C34 which exceeded the ESL (1700 mg/kg) in B112_13.10-13.20 (24,200 mg/kg)
- Asbestos was not identified in any sample with the exception of B340_0.05-0.25.

The DPGA (2018a) report indicated that soil sampling for contamination testing was carried out from boreholes B106A (at depths of 0.25 metres and 0.7 metres) and B211 (at a depth of 0.2 metres). Both boreholes were located in Yurulbin Park at Birchgrove. Soil samples were analysed for common contaminant compounds including heavy metals, PAH, TRH, BTEX, OCP, OPP. Two samples (B106A/0.25metres and B211/0.2 metres) were also analysed for asbestos (presence/absence). The analytical summary table providing laboratory results compared to the selected investigation criteria was provided. The investigation criteria applied to the soil results were residential land use and areas of ecological significance. These investigation criteria are likely to be overly conservative and not applicable for land use associated with the project (predominantly tunnel, roadways and construction support sites).

The AECOM and Coffey (2018) investigation indicated contamination (ie concentrations above adopted open space and commercial/industrial land use guidelines protective of ecological and human health) in a number of samples. The highest risk of contamination exposure would be those samples containing concentrations above human health guidelines. Exceedances of the human health guidelines were reported at the following project locations:

- Warringah Freeway Upgrades – PAH, benzo(a)pyrene and asbestos in surface and below surface (<1 metre) soils
- Waverton Park – TRH in deep fill (about 13 metres below ground level).

The DPGA (2017d) geotechnical factual report indicated that buried waste materials were encountered at the following locations:

- B314 (St Leonards Park) – 2.2 metres of fill material containing some asphalt, sandstone and concrete
- B337 (Camberay Golf Course) – 4.13 metres of fill material containing some concrete and PVC
- B340 (Camberay Golf Course) – 1.8 metres of fill containing some sandstone and concrete.

4.5 Local knowledge

The following information is based on the author's experience in carrying out previous investigations within and adjacent to the project area and knowledge of local areas: *Contamination Issues at Birchgrove Oval* and *North Sydney History Walk – Waverton Peninsula* (Leichhardt Municipal Council, 2007). The local knowledge information is focused on activities and contamination sources which may represent a potential contamination risk to the construction and operation of the project.

The results of the local knowledge assessment are presented in Table 4-15.

Table 4-15 Potential contamination sources (anecdotal information)

Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants
Birchgrove Peninsula and Park – Louisa Road, Birchgrove	Above	Tunnel	Slag and ash fill material (historical furnace waste from harbourside industry)	Surface	Heavy metals, hydrocarbons, cyanide, asbestos
Former bulk fuel storage – Balls Head Road, Waverton	Above (tunnel) and within (construction support site)	Tunnel and Berrys Bay construction support site (WHT7)	Above ground storage of bulk fuels	Surface	Heavy metals, hydrocarbon

5. Contamination investigation findings

5.1 Potential AEIs investigated

A number of potential AEIs were identified during the information review and site inspection.

Based on the information contained within the preceding sections of this report, Table 5-1 outlines the potential AEIs located near the project area and their associated comparative risks to environmental receivers, construction limitations and site users in consideration of the potential for contamination and proposed construction activities.

The comparative risk has been assessed based on the following metrics shown in Figure 5-1.

Assessment Level 1		Assessment Level 2	
		Excavation/Construction Activities	
		Within Project Footprint	Not Within Project Footprint
Contamination Status	Known Contamination	High	Moderate
	Possible Contamination	Moderate	Low
	Low Contamination Potential	Low	Low
		Within	Not Within
		Contamination Distribution Range	
		Assessment Level 3	

Figure 5-1 Comparative risk assessment matrix

Identified AEIs with assigned moderate to high exposure risk rankings are presented in Figure 5-2.

Table 5-1 Potential areas of environmental interest

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
W1	Rozelle Rail Yards	Above tunnel and within footprint of construction support site	Rozelle Rail Yards construction support site (WHT1), below ground ventilation system and tunnel (surface and depth)	Residual contamination from historical railway usage and historical demolition of on-site structures	Surface and depth (potentially 0 m to > 4.0 m). (Depth distribution associated with potential underground storage tanks)	Heavy metals, hydrocarbons, pesticides, asbestos	High <ul style="list-style-type: none"> Known contamination Excavation activities for construction compound and tunnel within site footprint Excavation activities within potential contamination distribution range (laterally and vertically).
		Above tunnel and within footprint of construction support site	Rozelle Rail Yards construction support site (WHT1), below ground ventilation system and tunnel (surface and depth)	Potential infill of former creek line and adjoining low lying areas	Surface and depth (potentially 0 m to > 2.0 m). (Depth distribution associated with depth of infilling. Infilling materials could comprise historical furnace waste from harbourside industry)	Heavy metals, hydrocarbons, pesticides, PCB, nutrients, cyanide, VOC, asbestos	High <ul style="list-style-type: none"> Known contamination Excavation activities for construction compound and tunnel within site footprint Excavation activities within potential contamination distribution range (laterally and vertically).
N/A	Factories/warehouses, Lilyfield Road	Adjacent to tunnel (laterally, not vertically)	Tunnel (depth)	Commercial/industrial land use (current and/or historical)	Surface and depth (potentially 0 m to > 4.0 m). (Depth distribution associated with	Heavy metals, hydrocarbons	Low <ul style="list-style-type: none"> Possible contamination No excavation activities for tunnel

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
					potential underground storage tanks)		within site footprint <ul style="list-style-type: none"> Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
N/A		Adjacent to tunnel (laterally, not vertically)	Tunnel (depth)	Potential infill of former creek line and adjoining low lying areas	Surface and depth (potentially 0 m to > 2.0 m). (Depth distribution associated with depth of infilling. Infilling materials could comprise historical furnace waste from harbourside industry)	Heavy metals, hydrocarbons, pesticides, PCB, nutrients, cyanide, VOC, asbestos	Low <ul style="list-style-type: none"> Possible contamination No excavation activities for tunnel within site footprint Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
W2	Easton Park – Corner Denison Street and Lilyfield, Rozelle	Above tunnel	Tunnel (depth)	Potential infill of former creek line and adjoining low lying areas	Surface and depth (potentially 0 m to > 2.0 m). (Depth distribution associated with depth of infilling. Infilling materials could comprise historical furnace waste from harbourside industry)	Heavy metals, hydrocarbons, pesticides, PCB, nutrients, cyanide, VOC, asbestos	Moderate <ul style="list-style-type: none"> Possible contamination No excavation activities for tunnel within site footprint Excavation activities within potential contamination distribution range (laterally and

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
							vertically).
N/A	Glebe Island, Rozelle	Adjacent to construction support site footprint	White Bay construction support site (WHT3) (surface)	Historical industrial land use, demolition of on-site buildings/structures, land reclamation	Surface and depth (potentially 0 m to > 2.0 m). (Depth distribution associated with depth of infilling. Infilling materials could comprise historical furnace waste from harbourside industry)	Heavy metals, hydrocarbons, pesticides, PCB, nutrients, cyanide, VOC, asbestos	Low <ul style="list-style-type: none"> Possible contamination No excavation activities within site footprint.
N/A	Container Terminal, Balmain	Adjacent to construction support site footprint	White Bay construction support site (WHT3) (surface)	Historical industrial land use, demolition of on-site buildings/structures, land reclamation, historical nearby bulk fuel storage	Surface and depth (potentially 0 m to > 2.0 m). (Depth distribution associated with depth of infilling. Infilling materials could comprise historical furnace waste from harbourside industry)	Heavy metals, hydrocarbons, pesticides, PCB, nutrients, cyanide, VOC, asbestos	Low <ul style="list-style-type: none"> Possible contamination No excavation activities within site footprint.
N/A	Service station – Corner Evans Street and Victoria Road, Rozelle	Adjacent to tunnel (laterally, not vertically)	Tunnel (depth)	Leaks and spills from underground petroleum storage infrastructure	Depth (potentially > 4.0 m)	Heavy metals, hydrocarbons	Low <ul style="list-style-type: none"> Possible contamination No excavation activities for tunnel within site footprint Potential contamination

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
							distribution unlikely to impact upon tunnelling (based on depth to tunnel).
N/A	Depot (possible council work depot) – between Llewelyn and Darling streets, Balmain	Adjacent to tunnel (laterally, not vertically)	Tunnel (depth)	Residual contamination from use as a work depot	Surface and depth (potentially 0 m to > 4.0 m). (Depth distribution associated with potential underground storage tanks)	Heavy metals, hydrocarbons, VOC, pesticides, asbestos	<p>Low</p> <ul style="list-style-type: none"> Possible contamination No excavation activities for tunnel within site footprint Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
W3	Yurulbin Park, Birchgrove	Above tunnel and within footprint of construction support site	Yurulbin Point construction support site (WHT4) (surface) and tunnel (depth)	Slag and ash fill material (historical furnace waste from harbourside industry), historical industrial land use, demolition of on-site buildings/structures.	Surface (potentially 0-1.0 m)	Heavy metals, hydrocarbons, asbestos	<p>Moderate</p> <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically) Potential contamination distribution unlikely to affect tunnelling

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
							(based on depth to tunnel).
W4	Birchgrove Peninsula and Park – Louisa Road, Birchgrove	Above tunnel and within footprint of construction support site	Yurulbin Point construction support site (WHT4) (surface) and tunnel (depth)	Slag and ash fill material (historical furnace waste from harbourside industry)	Surface (potentially 0-0.5 m)	Heavy metals, hydrocarbons, asbestos	Moderate <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically) Potential contamination distribution unlikely to affect tunnelling (based on depth to tunnel).
W5	Sediments within Sydney Harbour	Above tunnel and within footprint of construction support site	Sydney Harbour south cofferdam (WHT5) and Sydney Harbour north cofferdam (WHT6) (surface) and tunnel (depth)	Contamination associated with industrial use of Sydney Harbour and catchment inputs	Surface to recent (~150 year) depositional extent	Heavy metals, hydrocarbons (mainly PAH), pesticides, PCB, PFAS, dioxin, organotins	High <ul style="list-style-type: none"> Known contamination Dredging activities for construction support site and tunnel within site footprint Dredging activities within potential contamination distribution range.
W6	Wharf – Balls Head Drive,	Above tunnel and within footprint of	Berrys Bay construction support	Commercial/industrial marine land use	Surface (potentially 0-	Heavy metals, hydrocarbons,	Moderate

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Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
	Waverton	construction support site	site (WHT7) (surface) and tunnel (depth)	(current and/or historical)	0.5m)	organotin	<ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically) Potential contamination distribution unlikely to affect tunnelling (based on depth to tunnel).
	Berrys Bay Marina – Balls Head Road, Waverton	Adjacent to construction support site footprint and tunnel (laterally, not vertically)	Berrys Bay construction support site (WHT7) (surface) and tunnel (depth)	Commercial/industrial marine land use (current and/or historical)	Surface (potentially 0-0.5m)	Heavy metals, hydrocarbons, organotin	<p>Low</p> <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint limited to tunnel decline only Excavation activities limited to tunnel decline only which is within potential contamination distribution range for surface work Potential

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
							contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
W7	Former bulk fuel storage – Balls Head Road, Waverton	Above tunnel and within footprint of construction support site	Berrys Bay construction support site (WHT7) (surface) and tunnel (depth)	Above ground storage of fuels	Surface (potentially 0-0.5m)	Heavy metals, hydrocarbons, PFAS	<p>Moderate</p> <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically – surface work only) Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
N/A	HMAS <i>Waterhen</i> – Balls Head Road, Waverton	Adjacent to tunnel (laterally, not vertically)	Tunnel (depth)	General naval use	Surface and depth (potentially 0 m to >4.0 m). (Depth distribution associated with potential underground storage tanks)	Heavy metals, hydrocarbons, VOC, PFAS, organotins	<p>Low</p> <ul style="list-style-type: none"> Possible contamination No excavation activities for tunnel within site footprint Potential contamination

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
							distribution unlikely to impact upon tunnelling (based on depth to tunnel).
W8	Waverton Park – Woolcott Road, Waverton	Above tunnel	Tunnel (depth)	Infill/reclamation next to shore line	Surface and depth (potentially 0 m to > 20 m). (Depth distribution associated with depth of infilling)	Heavy metals, hydrocarbons, pesticides, PCB, nutrients, cyanide, VOC, asbestos	High <ul style="list-style-type: none"> Known contamination (which could impact upon groundwater) Tunnel below site footprint.
N/A	North Shore Railway Corridor – next to Waverton Station	Above tunnel	Tunnel (depth)	Residual contamination from railway usage	Surface (potentially 0-0.1 m)	Heavy metals, hydrocarbons, pesticides, asbestos	Low <ul style="list-style-type: none"> Possible contamination Excavation activities for tunnel within site footprint No excavation activities for tunnel within potential contamination distribution range (vertically).
W9	Unsealed areas next to Warringah Freeway – Alfred Street, North Sydney	Within footprint of construction support site and surface works	Blue Street construction support site (WFU1) and Warringah Freeway Upgrade surface work (surface)	Deposition of particulate matter	Surface (potentially 0-0.1 m)	Heavy metals (mainly lead), hydrocarbons (mainly PAH), asbestos	High <ul style="list-style-type: none"> Known contamination Excavation activities within site footprint Excavation activities within potential contamination

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
							distribution range (laterally and vertically).
W10	Unsealed areas next to Warringah Freeway – High Street, North Sydney	Within footprint of construction support site and surface works	High Street north construction support site (WFU3) and Warringah Freeway Upgrade surface work (surface)	Deposition of particulate matter	Surface (potentially 0-0.1 m)	Heavy metals (mainly lead), hydrocarbons (mainly PAH), asbestos	Moderate <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically).
W11	Unsealed areas next to Warringah Freeway – eastern side (between Arthur Street and Warringah Freeway), North Sydney	Within footprint of construction support site and surface works	Arthur Street east construction support site (WFU4) and Warringah Freeway Upgrade surface work (surface)	Deposition of particulate matter	Surface (potentially 0-0.1 m)	Heavy metals (mainly lead), hydrocarbons (mainly PAH), asbestos	Moderate <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically).
W12	Unsealed areas next to Warringah Freeway – western side (between Mount Street and Ridge	Within footprint of construction support site and surface works	Ridge Street east construction support site (WFU6) and Warringah Freeway Upgrade surface work	Deposition of particulate matter	Surface (potentially 0-0.1 m)	Heavy metals (mainly lead), hydrocarbons (mainly PAH), asbestos	Moderate <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint

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Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
	Street), North Sydney		(surface)				<ul style="list-style-type: none"> Excavation activities within potential contamination distribution range (laterally and vertically – surface work only) Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
W13	Unsealed areas next to Warringah Freeway – eastern side (between Berry Street and Ridge Street), North Sydney	Within footprint of construction support site and surface works	Berry Street east (WFU5) and Cammeray Golf Course (WFU8) construction support sites and Warringah Freeway Upgrade surface work (surface)	Deposition of particulate matter	Surface (potentially 0-0.1 m)	Heavy metals (mainly lead), hydrocarbons (mainly PAH), asbestos	Moderate <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically – surface work only) Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
W14	St Leonards Park bordering Warringah Freeway (between Ridge Street and Falcon Street), North Sydney	Within footprint of construction support site and surface works	Ridge Street north construction support site (WHT9) and Warringah Freeway Upgrade surface work (surface)	Deposition of particulate matter and filling	Surface and depth (potentially 0-2 m)	Heavy metals, hydrocarbons, pesticides, PCB, nutrients, cyanide, VOC, asbestos, PFAS	Moderate <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically – surface work only) Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
W15	Unsealed areas next to Warringah Freeway – western side (between Merlin Street and Warringah Freeway), Neutral Bay	Within footprint of construction support site and surface works	Merlin Street construction support site (WFU7) and Warringah Freeway Upgrade surface work (surface)	Deposition of particulate matter	Surface (potentially 0-0.1 m)	Heavy metals (mainly lead), hydrocarbons (mainly PAH), asbestos	Moderate <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically).
W16	Unsealed areas next to Warringah	Above tunnel and within footprint of	Warringah Freeway Upgrade surface work	Deposition of	Surface (potentially 0-	Heavy metals (mainly lead),	Moderate <ul style="list-style-type: none"> Possible

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Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
	Freeway – western side (between Ernest and Falcon streets), North Sydney	surface works and Falcon Street shared user bridge construction site	(surface) and tunnel (depth)	particulate matter	0.1 m)	hydrocarbons (mainly PAH), asbestos	contamination <ul style="list-style-type: none"> Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically – surface work only) Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
W17	Unsealed areas next to Warringah Freeway – eastern side (between Ernest Street and Falcon Street), Cammeray	Above tunnel and within footprint of surface works and Falcon Street shared user bridge construction site	Warringah Freeway Upgrade surface work (surface) and tunnel (depth)	Deposition of particulate matter	Surface (potentially 0-0.1 m)	Heavy metals (mainly lead), hydrocarbons (mainly PAH), asbestos	Moderate <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically – surface work only) Potential contamination distribution unlikely to

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
							impact upon tunnelling (based on depth to tunnel).
W18	Unsealed areas next to Warringah Freeway – Ernest to Miller Street), Crows Nest	Within footprint of surface works	Rosalind Street construction support site (WFU9) Warringah Freeway Upgrade surface work (surface)	Deposition of particulate matter	Surface (potentially 0-0.1 m)	Heavy metals (mainly lead), hydrocarbons (mainly PAH), asbestos	High <ul style="list-style-type: none"> Known contamination Excavation activities within site footprint Excavation activities within potential contamination distribution range (laterally and vertically).
N/A	Mechanics – Balmain (North Street)	Above tunnel	Tunnel (depth)	Leaks and spills from underground storage infrastructure	Surface and depth (potentially 0 m to > 4.0 m)	Heavy metals, hydrocarbons, VOC	Low <ul style="list-style-type: none"> Possible contamination Excavation activities within site footprint Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
N/A	Dry Cleaners – Rozelle (714 Darling Street)	Adjacent to construction support site footprint and tunnel (laterally, not vertically)	Victoria Road construction support site (WHT2) (surface) and tunnel (depth)	Leaks and spills of solvents	Depth (potentially > 1.0 m)	VOC	Low <ul style="list-style-type: none"> Possible contamination No excavation activities within site footprint

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
							<ul style="list-style-type: none"> No excavation within potential contamination distribution range for construction support site Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
N/A	Dry Cleaners – Rozelle and Balmain	Adjacent to tunnel (laterally, not vertically)	Tunnel (depth)	Leaks and spills of solvents	Depth (potentially > 1.0 m)	VOC	Low <ul style="list-style-type: none"> Possible contamination No excavation activities for tunnel within site footprint Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
N/A	Mechanics – Rozelle	Adjacent to construction support site footprint and tunnel (laterally, not vertically)	Victoria Road construction support site (WHT2) (surface) and tunnel (depth)	Leaks and spills from underground storage infrastructure	Surface and depth (potentially 0 m to > 4.0 m)	Heavy metals, hydrocarbons, VOC	Low <ul style="list-style-type: none"> Possible contamination No excavation activities for construction support site within site

Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
							footprint <ul style="list-style-type: none"> Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
N/A	Mechanics – North Sydney	Adjacent to construction support site footprint	Blue Street construction support site (WFU1) (surface)	Leaks and spills from underground storage infrastructure	Surface and depth (potentially 0 m to > 4.0 m)	Heavy metals, hydrocarbons, VOC	Low <ul style="list-style-type: none"> Possible contamination No excavation activities within site footprint No excavation activities within potential contamination distribution range (surface work only).
N/A	Explosives Industries – North Sydney (111 Pacific Highway)	Adjacent to construction support site footprint	Warringah Freeway Upgrade surface work (surface)	Storage of explosives and associated chemicals	Surface (potentially 0-0.1m)	Heavy metals, semi-VOC (SVOC), nitrogen compounds, sulfates	Low <ul style="list-style-type: none"> Possible contamination No excavation activities within site footprint No excavation activities within potential contamination distribution range (surface work only).

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Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
N/A	Explosives Industries – North Sydney (11 Ridge Street)	Adjacent to tunnel (laterally, not vertically)	Tunnel (depth)	Storage of explosives and associated chemicals	Surface (potentially 0-0.1m)	Heavy metals, semi-VOC (SVOC), nitrogen compounds, sulfates	Low <ul style="list-style-type: none"> Possible contamination No excavation activities within site footprint No excavation activities within potential contamination distribution range (surface work only).
N/A	Paint Manufacture – Rozelle	Adjacent to construction support site footprint and tunnel (laterally, not vertically)	Victoria Road construction support site (WHT2) (surface) and tunnel (depth)	Leaks and spills	Surface (potentially 0-1.0 m)	Heavy metals, hydrocarbons, VOC	Low <ul style="list-style-type: none"> Possible contamination No excavation activities within site footprint No excavation within potential contamination distribution range for surface work Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
N/A	Service station –	Adjacent to construction	Victoria Road construction support	Leaks and spills from underground	Depth (potentially >	Heavy metals,	Low <ul style="list-style-type: none"> Possible

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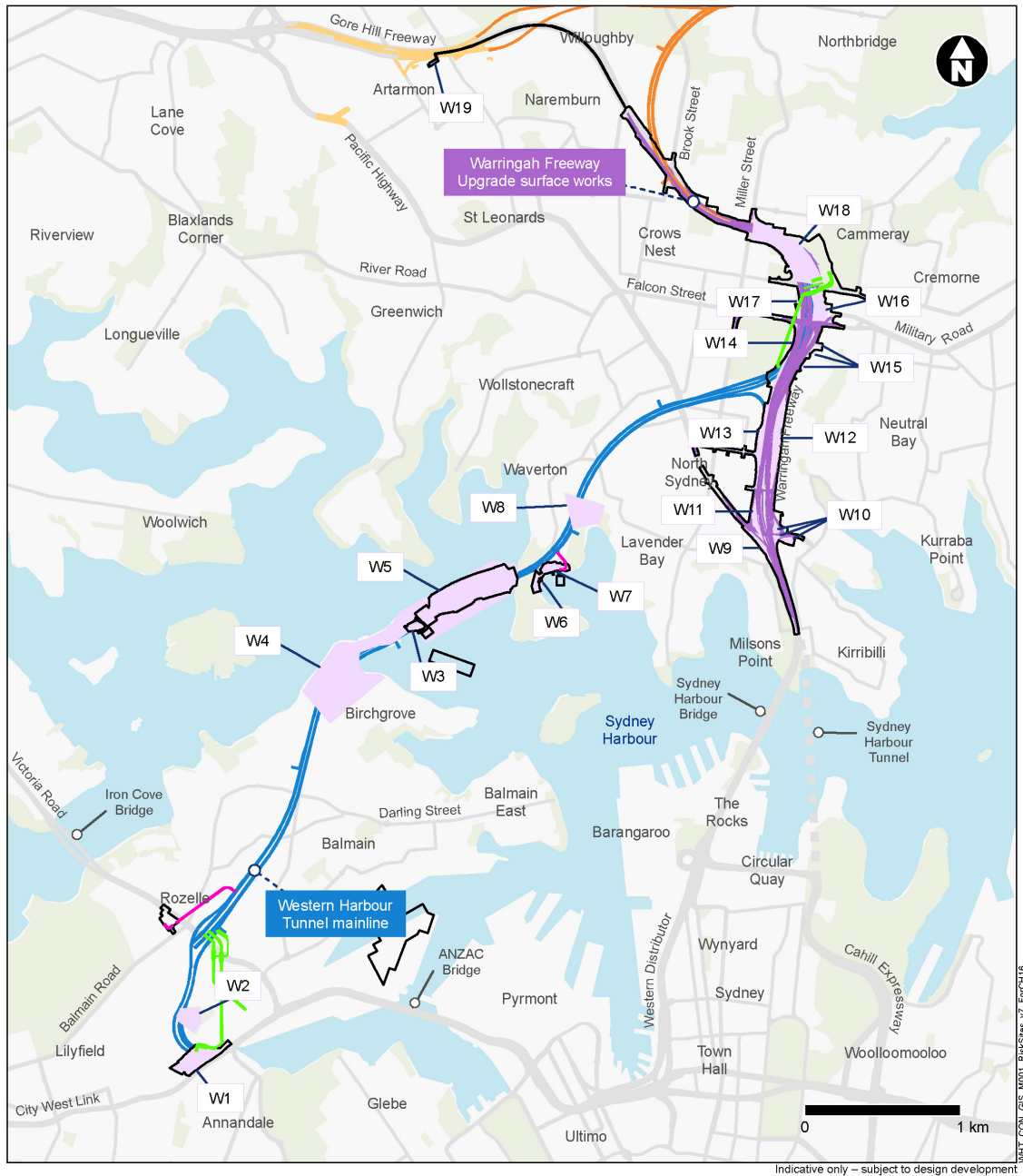
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Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
	Rozelle	support site footprint and tunnel (laterally, not vertically)	site (WHT2) (surface) and tunnel (depth)	petroleum storage infrastructure	4.0 m)	hydrocarbons	contamination <ul style="list-style-type: none"> No excavation activities within site footprint No excavation within potential contamination distribution range for surface work Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
N/A	Service station – Balmain	Adjacent to tunnel (laterally, not vertically)	Tunnel (depth)	Leaks and spills from underground petroleum storage infrastructure	Depth (potentially > 4.0 m)	Heavy metals, hydrocarbons	Low <ul style="list-style-type: none"> Possible contamination No excavation activities for tunnel within site footprint Potential contamination distribution unlikely to impact upon tunnelling (based on depth to tunnel).
W19	Factories/warehouses, Waltham Street at Artarmon	Within footprint of Motorway Control Centre site	Waltham Street construction support site (WHT11) (surface)	Commercial/industrial land use (current and/or historical)	Surface and depth (potentially 0 m to > 4.0 m). (Depth distribution)	Heavy metals, hydrocarbons	Moderate <ul style="list-style-type: none"> Possible contamination Excavation activities

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Figure 5-2 reference	Site	Location relative to alignment	Construction element and anticipated depth	Potential contamination source	Potential contamination distribution	Potential contaminants	Risk ranking
					associated with potential underground storage tanks)		within site footprint and within potential contamination distribution range (laterally and vertically – surface works only).
N/A	Warringah Freeway and Gore Hill Freeway (between Naremburn and Artarmon)	Within trenching footprint	Communications cable trenching (surface and depth)	Inappropriate handling and disposal of building materials during demolition of buildings for construction of Warringah Freeway and Gore Hill Freeway.	Surface and depth (potentially 0-2 m)	Heavy metals, hydrocarbons, pesticides, PCB, asbestos	<p>Low</p> <ul style="list-style-type: none"> • Low contamination potential (in consideration of the relatively recent construction of the Gore Hill Freeway and connection with the Warringah Freeway • Excavation activities within trenching footprint • Excavation activities within distribution range.



Indicative only – subject to design development

Legend

Operational features

- Western Harbour Tunnel
- Warringah Freeway Upgrade
- Ventilation tunnel

Construction features

- Construction footprint
- Access decline

Connecting projects

- Beaches Link
- Gore Hill Freeway Connection

Contaminated sites

- Moderate to high risk contaminated site

Figure 5-2 Areas of environmental interest with assigned moderate to high exposure risk rankings

5.2 Summary of AEI exposure risk

Based on the results of the information review and site inspection, a number of sites within and/or next to the project area are considered to represent a low contamination risk. No further consideration of contamination risk has been provided for these sites.

A summary of the identified AEIs with assigned moderate to high exposure risk rankings is provided below:

- Soil and groundwater contamination (including LNAPL) has been reported within/beneath the Rozelle Rail Yards site. The contamination is likely to be associated with the historical land use and potential creek infilling at the site. The degradation of organics within historical infill could generate leachate which could migrate into and contaminate the underlying groundwater. If considerable organic content (eg timber, paper, green waste) is present within infill materials, this could generate landfill gas. This area poses a high contamination risk to construction given that contamination is known to be present within soil and groundwater which are likely to be excavated and exposed during construction activities at the Rozelle Rail Yards construction support site (WHT1) and the excavation of the ventilation building cavern. Excavation could also create preferential pathways for groundwater contamination and landfill gas/vapour (if present)
- The potential infilling of Easton Park at Lilyfield could represent a soil, groundwater and potentially gas/vapour contamination source. The degradation of organics within the infill could generate leachate which could migrate into and contaminate the underlying groundwater. If considerable organic content (eg timber, paper, green waste) is present within infill materials, this could generate landfill gas. This area poses a moderate contamination risk to construction considering the potential presence of groundwater contamination and landfill gas and that groundwater and gas could be exposed during construction of the tunnel and/or construction could create preferential pathways for the groundwater contamination and landfill gas/vapour (if present)
- The mechanical workshop located at North Street in Balmain is located directly above the tunnel. If underground storage tanks are or were present at the site (associated with current or historical operations), these could represent a source of soil and groundwater contamination. In consideration of the proposed construction design beneath this site (ie approximately 70 metres to tunnel) and geological conditions (ie. groundwater at approximately 20 metres below ground level and within massive sandstone), there is a reduced risk of contamination (if present) from this site impacting upon the construction and operation of the tunnel. The spatial separation between the potential source and the tunnel would reduce the contamination risk from moderate to low
- Slag and ash materials may be present across areas of the Birchgrove Peninsula (including Yurulbin Park) associated with historical disposal practices of wastes from nearby industry (eg power stations). These slag and ash materials are generally present within surface fill materials and could be contaminated. Historical industrial land use and demolition of structures at Yurulbin Park may have also contributed to contamination at the site. This area poses a moderate contamination risk to construction considering the potential presence of soil contamination and that soils are likely to be excavated and exposed during the construction of the Yurulbin Point construction support site (WHT4)
- Contamination has been reported in sediments present within Sydney Harbour. Contamination is likely to be associated with inputs from the surrounding urbanised catchments, historical industrial operations and the general maritime use within the surrounding area. The sediments pose a high contamination risk to construction given that contamination is known to be present within sediments which are likely to be excavated and exposed during construction of the Sydney Harbour south cofferdams (WHT5) and Sydney Harbour north cofferdam (WHT6)
- The historical use of the coal loader wharf at Balls Head Road at Waverton may have caused localised contamination associated with the loading and unloading of materials (coal and potentially other materials) and general maritime activities. This area poses a moderate contamination risk to construction considering the potential presence of soil contamination and that soils are likely to be excavated and exposed during construction of the Berrys Bay construction support site (WHT7)

- Soil and rock located beneath the former bulk fuel storage site located at Waverton may contain residual heavy metal and hydrocarbon contamination associated with the former use of the site. This area poses a moderate contamination risk to construction considering the potential presence of contamination (in soil and/or rock) and that soil and/or rock are likely to be excavated and exposed during construction of the Berrys Bay construction support site (WHT7)
- Contaminated fill materials have been reported at depth within Waverton Park. No groundwater samples have been collected from this site. It is possible that the contamination detected in fill could represent a contamination source to groundwater beneath this site. If considerable organic content (eg timber, paper, green waste) is present within infill materials, this could generate landfill gas. This area poses a high contamination risk to construction given that contamination is known within fill material which could impact upon groundwater. Groundwater could be exposed during construction of the tunnel and/or construction could create preferential pathways for groundwater contamination and landfill gas (if present)
- Contamination has been reported in surface soils collected from unsealed areas next to the Warringah Freeway. The contamination is likely to be associated with the current and historical particulate matter deposition from large volume traffic flows using the Warringah Freeway and filling of some of these areas with material of unknown quality during the construction of the Warringah Freeway. These areas pose a moderate to high contamination risk to construction given that contamination is known and potentially present within soil which are likely to be excavated and exposed during the carrying out of surface works and construction of the construction support sites adjacent to the Warringah Freeway and the Ridge Street pedestrian bridge (WHT8, WHT9, WHT10, WFU2, WFU3, WFU4, WFU5, WFU6, WFU7, WFU8 and WFU9)
- The current and historical use of the Motorway Control Centre site and adjoining properties at Waltham Street at Artarmon may have caused localised contamination associated with the commercial/industrial uses of this area. This area poses a moderate contamination risk to construction considering the potential presence of soil contamination and that soils are likely to be excavated and exposed during construction of the Motorway Control Centre at Waltham Street construction support site (WHT11)
- It is possible that structures and/or buildings located within the project area contain hazardous building materials. Should any structures and/or buildings require demolition to facilitate construction, hazardous building materials (where present) would be managed to reduce the potential for contamination and ensure appropriate handling and waste disposal. In accordance with Australian Standard AS 2601-2001 The demolition of structures, a hazardous building materials audit would be carried out prior to the demolition of any structure and/or building.

6. Assessment of construction impacts

The following information details potential impacts to construction of the project from soil and contamination constraints identified as part of this investigation.

6.1 Soil erosion hazard

Construction of the project has the potential to increase erodibility and transport of soils through surface disturbance and vegetation removal. Increased erosion could result in sedimentation within and around waterways and destabilising slopes in the study area, particularly during periods of rainfall.

Uncompacted or unconsolidated materials (such as excavated and stockpiled soils) have the potential to be transported from construction areas during rain (through surface water runoff) causing downstream sedimentation and during periods of dry and windy conditions (as dust). Sedimentation in natural waterways can result in reduced water quality, flow and degradation of aquatic ecosystems. Dust has the potential to cause general aesthetic issues and deposit on sealed surfaces to be eventually washed into waterways during rainfall events.

The highest potential for soil erosion would be associated with the disturbance of soils on existing slopes during construction. Soil disturbance is only likely to occur at the construction support sites and work zones detailed in Section 1.3. With the exception of Berrys Bay (WHT7), Arthur Street east (WFU4), Berry Street east (WFU5) and Ridge Street east (WFU6), construction support sites and work zones are not located in areas with steep terrain.

6.2 Acid sulfate soils

The excavation of actual and potential ASS and lowering of the groundwater table in the vicinity of ASS during construction could cause the oxidation of sulfidic compounds within these soils which in turn could generate acid runoff, leachate and mobilise other contaminants (namely heavy metals) into the environment. Acidic runoff, leachate and contaminant mobilisation could potentially impact upon the following:

- Contaminant exposure risk to project personnel and the general public
- Contaminant exposure to environmental receptors
- Degradation of terrestrial and aquatic ecosystems
- Damage to existing structures.

Based on the information reviewed, Class 1 and Class 2 ASS risks have been mapped near the Rozelle Rail Yards and Birchgrove Park. ASS are present in sediments within the Western Harbour Tunnel component investigation area and White Bay. There is the possibility of potential ASS being present in sediments within Berrys Bay.

6.3 Salinity

Salinity impacts occur when salts naturally present in soil or groundwater are concentrated at the surface or in shallow soils generally by rising groundwater associated with the removal of deep-rooted vegetation or other activities which could raise the groundwater table above normal seasonal levels. Salts can accumulate to a level which can damage structures and the environment. If present, salinity impacts could potentially occur during construction of the project as a result of soil disturbance during earthworks (namely vegetation removal).

Construction activities are more likely to lower the groundwater table rather than raising it above seasonal levels.

Based on the information reviewed and an understanding on how saline soils are formed, the risk of areas of saline soils being present within the project area are low to negligible. With the unlikely presence of saline soils within the project area, salinity is unlikely to represent a risk to surface water and/or groundwater during construction of the project.

6.4 Contamination – soil

Based on the information reviewed, a number of moderate to high risk potential AEIs have been identified which contain contaminated and potentially contaminated soils.

If contamination risks are not quantified at these AEIs and appropriately managed, construction activities may expose workers, the public and environmental receptors to contaminated soil. Potential impacts as a result of disturbance of contaminated soil without appropriate remediation and/or management may include:

- Contaminant exposure risk to project personnel and the general public
- Contaminant exposure to environmental receptors
- Cross contamination associated with the incorrect handling or disposal of spoil/unexpected finds
- Contamination of previously clean areas.

AEIs containing contaminated and potentially contaminated soils which may be exposed during construction activities include:

- Birchgrove Peninsula (including Yurulbin Park)
- Coal loader wharf at Balls Head Road at Waverton
- Former bulk fuel storage site located at Waverton
- Proposed Motorway Control Centre located at Waltham Street at Artarmon
- St Leonards Park at North Sydney
- Unsealed areas next to the Warringah Freeway.

6.5 Contamination – sediments

Contaminated sediments have been identified within Sydney Harbour. The sediments in Sydney Harbour would potentially pose an impact to construction due to the contamination associated with the historical industrial use (over 150 years) of the harbour and the addition of polluted stormwater runoff originating from nearby urbanised catchments. Contaminated sediments are likely to be disturbed during dredging activities required for the installation of the immersed tube tunnel and piling work to establish wharf structures at the following construction support sites: White Bay (WHT3), Yurulbin Point (WHT4) and Berrys Bay (WHT7) and the immersion pontoon at Snails Bay. Potential impacts as a result of disturbance of contaminated sediment without appropriate remediation and/or management may 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 the transportation of spoil across Sydney Harbour.

Contaminated exposure risks to workers and the environment would depend on the level of sediment disturbance associated with the dredging methodology.

6.6 Contamination – groundwater

Contaminated groundwater may be encountered during construction activities, namely during excavation dewatering and tunnelling in the vicinity of potential AEIs. If groundwater contamination is not assessed and appropriately managed, construction activities may expose workers, the public and environmental receptors to contaminated groundwater via direct contact or discharge to surface waters. Potential impacts as a result of contact with or discharge of contaminated groundwater may include:

- Contaminant exposure risk to project personnel and the general public

- Contaminant exposure to environmental receptors
- Degradation of aquatic ecosystems.

Based on the information reviewed, some groundwater monitoring has been carried out at selected locations within the project area. The monitoring data indicated that potential groundwater contamination may be present beneath areas of Birchgrove. The sampling and analysis carried out within this area included a suite of general contaminant compounds. Based on the historical industrial land use carried out within this area, other contaminant compounds may be present within groundwater.

Based on the information reviewed, groundwater contamination could also be present within other areas within and/or adjacent to the project including:

- Rozelle Railyards
- Easton Park at Lilyfield Road, Rozelle
- Waverton Park.

6.7 Contamination – ground gas

Landfill gas can be generated during the degradation/breakdown of total organic carbon present within organic compounds present in buried wastes. If present within and/or adjacent to the project, landfill gas could accumulate within below-ground excavations and enclosed structures associated with the project at concentrations which could represent an asphyxiation or explosion risk.

Potential waste burial areas and potential landfill gas sources were identified at Easton Park, Rozelle Rail Yards and Waverton Park.

7. Assessment of operational impacts

The following information details potential impacts to operation of the project from soil and contamination constraints identified as part of this investigation.

7.1 Soil erosion hazard

After reinstatement of construction support sites and other areas of soil disturbance following construction of the project and installation of stormwater drainage systems, soil erosion hazards are unlikely to result during the operation of the project.

7.2 Acid sulfate soils

Groundwater drawdown during the operation of the tunnel could cause the lowering of the groundwater table in the vicinity of ASS which could cause the oxidation of sulfidic compounds within these soils which in turn could generate acid runoff, leachate and mobilise other contaminants (namely heavy metals) into the environment. Acidic runoff, leachate and contaminant mobilisation could potentially impact upon the following:

- Contaminant exposure risk to project personnel and the general public
- Contaminant exposure to environmental receptors
- Degradation of terrestrial and aquatic ecosystems
- Damage to structures.

Based on the information reviewed, Class 1 and Class 2 ASS risks have been mapped near the Rozelle Rail Yards and Birchgrove Park in the vicinity of tunnels.

7.3 Salinity

Based on the information reviewed and an understanding on how saline soils are formed, the risk of areas of saline soils being present within the project area are low to negligible. With the unlikely presence of saline soils within the project area, salinity is unlikely to represent a risk to structures and/or surface water (via discharge of groundwater ingress in tunnels) during operation of the project.

7.4 Contamination – soil

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. Implementation of appropriate environmental management plans would reduce the potential impacts from contaminated soil associated with the operation of the project.

Potential contamination of soils within and directly adjacent to the project could occur as a result of spills and leaks of hydrocarbons from vehicles, deposition of vehicle particulates and accidents during operation.

7.5 Contamination – sediments

Following construction, the operation of the project would not continue to disturb sediments.

Potential contamination of sediments directly adjacent to the project could occur as a result of spills and leaks of hydrocarbons from vehicles, deposition of vehicle particulates and accidents during operation.

7.6 Contamination – groundwater

Where existing groundwater contamination is identified within and/or adjacent to the operational areas of the project, appropriate engineering controls would need to be installed to either remove the risk of contaminated groundwater ingress into below ground structures (namely tunnels) or manage the risk to receptors via appropriate treatment prior to disposal, discharge or reuse. Implementation of appropriate engineering controls would reduce the potential impacts from contaminated groundwater to the operation of the project and receptors from discharge.

Potential contamination of groundwater within and directly adjacent to the project could occur as a result of spills and leaks of hydrocarbons from vehicles and accidents during operation.

7.7 Contamination – ground gas

Where existing ground gas is identified within the operational areas of the project, appropriate engineering controls would be installed to reduce the ongoing risk of gas ingress during operation of the project. Engineering controls could include surface or sub-surface extraction or tanked tunnel construction. Implementation of appropriate engineering controls would reduce the potential impacts from ground gas to the operation of the project.

8. Cumulative impacts

Chapter 27 (Cumulative impacts) outlines a list of other infrastructure projects that are currently being carried out, committed to, or proposed for the surrounding areas during the period in which the Western Harbour Tunnel is being constructed or subsequently operated. The key projects in respect to the project and potential cumulative impacts in regard to contamination include:

- Beaches Link and Gore Hill Freeway Connection
- Sydney Metro City & Southwest (Chatswood to Sydenham)
- M4-M5 Link
- Sydney Metro West
- Glebe Island Port and concrete batching plant (Hanson Construction Materials Pty Ltd)
- Glebe Island Multi-User Facility.

Additionally, the following strategic development plans have also been considered given their association with further development proposals:

- The Bays Precinct Urban Transformation Plan
- Waverton Peninsula Strategic Master Plan
- Ward Street Precinct Master Plan (North Sydney)
- St Leonards Park Landscape Masterplan.

The following outlines the potential cumulative impacts from soils and contamination from the Western Harbour Tunnel and Warringah Freeway Upgrade project on the projects in surrounding areas. Without carrying out soil and contamination investigations for the projects surrounding the project or having detailed knowledge of the projects, no comment can be provided with respect to potential cumulative impacts from soils and contamination on the project from these surrounding projects. Potential cumulative impacts from soils and contamination from projects in surrounding areas would need to be detailed in project specific planning approvals and appropriate mitigation measures applied.

Potential cumulative construction soil and contamination impacts from the project on surrounding projects, prior to appropriate mitigation measures being implemented are detailed below.

- Excavation activities and liberation of contamination (as dust or fibres) which could deposit on adjacent land and be transported by surface water flows to surrounding areas
- Dewatering activities and discharge of contaminated water to adjacent land and waterways
- Accumulation of gas within below ground structures and low lying land form features on adjacent land
- Oxidisation of ASS, release of acid runoff and mobilisation of contaminants
- Soil erosion from exposed surfaces by stormwater flows and transportation of sediment onto adjacent land and waterways.

Potential cumulative operation soil and contamination impacts from the project on surrounding projects, prior to appropriate mitigation measures being implemented are detailed below.

- Leaks and spills from vehicles and vehicle accidents discharging offsite onto adjacent land and waterways
- Vehicle particulate deposition (heavy metals, hydrocarbons, asbestos) and rubber (hydrocarbons, heavy metals) from tyre wear on roads being transported from roads in stormwater flows and discharging onto adjacent land and waterways.

Provided that general soil conditions and contamination within AEIs in the project footprint (assessed as part of this report) is managed and mitigated appropriately, sediment (from soil erosion) and contamination within the project footprint is unlikely to be mobilised due to construction and operation of the project and therefore unlikely to have cumulative impacts upon surrounding projects.

AEI risk ranking within this report are for the Western Harbour Tunnel and Warringah Freeway Upgrade project environmental impact statement only. Surrounding projects within the study area should be assessed further for project specific impacts with respect to soil and contamination and not rely on information within this report.

9. Risk management

The following table details strategies for the management of potential environmental (soil erosion, ASS, soil salinity) and contamination risks identified associated with the construction and operation (where applicable) of the project.

Table 9-1 Summary of potential groundwater impacts during construction and operation and associated environmental management measures

Impact	Mitigation and environmental management measure
Design and Operation	
Contamination – groundwater	If contamination risks to the tunnel are established, appropriate design (eg tanking) and/or management (eg treatment) would be implemented to remove or suitably reduce the associated risk.
Construction	
Soil erosion and sedimentation	Erosion and sediment measures will be implemented at all work sites in accordance with the principles and requirements in ' <i>Managing Urban Stormwater – Soils and Construction, Volume 1</i> (Landcom, 2004) and <i>Volume 2D</i> (NSW Department of Environment, Climate Change and Water 2008), commonly referred to as the 'Blue Book'.
Impacts from disturbance of acid sulfate soils	<p>Prior to ground disturbance in high risk acid sulfate areas at Birchgrove Park, Rozelle Rail Yards, Sydney Harbour (tunnel crossing, White Bay and Berrys Bay) and Whites Creek, testing will be carried out to determine the presence of acid sulfate soils.</p> <p>If acid sulfate soils are encountered, they would be managed in accordance with the Acid Sulfate Soil Manual (Acid Sulfate Soil Management Advisory Committee, 1998).</p>
Contamination – soils	Based on the information reviewed, a number of moderate to high risk potential AEIs have been identified. Where extensive investigations have not been carried out (all high to moderate risk sites with the exception of the Rozelle Rail Yards site), potentially contaminated areas directly affected by the project will be investigated and managed in accordance with the requirements of guidance endorsed under section 105 of the <i>Contaminated Land Management Act 1997</i> .
Contamination – sediments	<p>Where sediments require excavation and removal to facilitate construction, there are several potential options for the disposal of sediments. These include:</p> <ul style="list-style-type: none"> Offshore disposal – A permit for the offshore disposal of suitable dredged material has been submitted to the Commonwealth Department of the Environment and Energy. The appropriateness of offshore disposal would need to be assessed in accordance with the Commonwealth of Australia (2009) NAGD Landfill disposal – Sediments not suitable for offshore disposal and requiring disposal to landfill, would be assessed in accordance with the <i>Waste Classification Guidelines</i> (NSW EPA, 2014). Landfill disposal is likely to be appropriate for both clean and contaminated sediments. <p>Sediments to be disposed to landfill (ie not suitable for offshore disposal), are likely to require some initial treatment at an onshore transfer point to reduce water content (ie achieve a spadable condition), reduce odours and neutralisation of ASS (if present) before transport to a suitable licensed landfill facility.</p>

Impact	Mitigation and environmental management measure
	Additional investigations would be required to determine the extent (laterally and vertically) and separation of clean and contaminated sediments to facilitate disposal. Appropriate management measures would be developed to remove or suitably reduce the contamination risks from sediments during construction activities. Where sediments are disturbed as part of construction activities, sediment transport and distribution within the water column would need to be appropriately managed so as not to cause harm to benthic and marine ecosystems and/or adversely reduce water quality.
Contamination – groundwater	<p>To further quantify the risk from groundwater contamination to construction and/or operation of the project (including dewatering), further investigations are required at the following sites:</p> <ul style="list-style-type: none"> • Rozelle Railyards • Easton Park at Lilyfield • Waverton Park. <p>If contamination risks to the tunnel are established, appropriate design (eg tanking) and/or management (eg treatment) measures would be implemented to remove or suitably reduce the associated risk.</p>
Contamination – ground gas	<p>No ground gas investigations are known to have been carried out to assess potential gas issues associated with the historical infilling of Easton Park, Rozelle Rail Yards and Waverton Park. Ground gas investigations would be carried out in these areas to assess the potential presence or absence of gas which could affect construction and/or operation of the project. Ground gas investigations would be carried out (where applicable) in accordance with the following guidance:</p> <ul style="list-style-type: none"> • <i>Guideline for the Assessment and Management of Sites Impacted by Hazardous Ground Gases</i> (NSW EPA, 2012) • <i>Assessing Risks Posed by Hazardous Ground Gases to Buildings Report</i> (C665) (Wilson <i>et al.</i>, 2007).
Operation	
Contamination – ground gas	If ground gas risks to the operation of the project (namely tunnels, subsurface and enclosed structures) are established, appropriate design (eg tanking, gas drainage) and/or management (eg ventilation) measures would be implemented to remove or suitably reduce the associated risk.

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Appendix A. Historical aerial photography

Table A.1 Historical aerial photography review - Rozelle Rail Yard (WHT1) construction support site and Rozelle surface

Date of aerial photography		Site	Surrounding area
1930	No image available		
1955	No image available		
1961	No image available		
1970	No image available		
1975		The majority of Rozelle Rail Yards (WHT1) appears to be railyards. Rozelle Rail Yards (WHT1) is occupied by a number of buildings (large warehouse and workshop type buildings) and rolling stock. The eastern portion of Rozelle Rail Yards (WHT1) (adjoining Rozelle Bay) appears to be used for industrial purposes.	Rozelle Rail Yards (WHT1) is surrounded by established residential (north and south), commercial/industrial land use (north-east and south-west) and railway (east and west). Large above-ground tanks are visible on a property located to the south-east of Rozelle Rail Yards (WHT1). Rozelle Bay is located to the east of Rozelle Rail Yards (WHT1). Earthworks are being carried out on Federal Park.
1983/84		Rozelle Rail Yards (WHT1) is generally unchanged from the 1975 imagery, with the exception of wharf type structures constructed into Rozelle Bay.	Surrounding area is generally unchanged from the 1975 imagery with the exception of the demolition of the large above-ground storage tanks and associated buildings on the property located to the south-east of Rozelle Rail Yards (WHT1). Earthworks are being carried out on the current location of Jubilee Park.
1986	No image available		
1991	No image available		
1994		A number of buildings within Rozelle Rail Yards (WHT1) and the wharf structures in Rozelle Bay have been demolished. The north-western corner of Rozelle Bay has been infilled.	Surrounding area is generally unchanged from the 1983/84 imagery with the exception of the construction of the City West Link to the south of the site and construction of Federal and Bicentennial Parks.




Date of aerial photography		Site	Surrounding area
1998		Rozelle Rail Yards (WHT1) is generally unchanged from the 1994 imagery with the exception of no rolling stock present on-site and wharf structures have been constructed into Rozelle Bay.	Surrounding area is generally unchanged from the 1994 imagery.
2002	No image available		
2005	No image available		

Table A.2 Historical aerial photography review - Victoria Road (WHT2) construction support site

Date of aerial photography		Site	Surrounding area
1930	No image available		
1955	No image available		
1961	No image available		
1970	No image available		
1975		Victoria Road (WHT2) appears to be an area of mixed land use including a large building (likely leagues club) and retail type buildings fronting Darling Street. Possible service station site in the northern portion of Victoria Road (WHT2).	The surrounding area appears to be dominated by established residential with some minor commercial premises fronting main roads (Darling Street, Victoria Road). Larger type buildings (Rozelle Public School) are located to the east of Victoria Road (WHT2).
1983/84		Victoria Road (WHT2) is generally unchanged from the 1975 imagery with the exception of some larger retail type buildings fronting Darling Street.	Surrounding area is generally unchanged from the 1975 imagery.
1986	No image available		


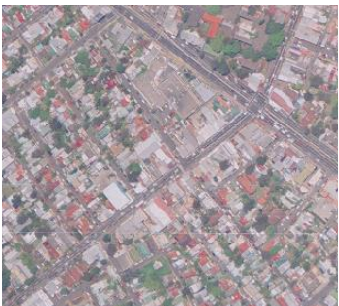
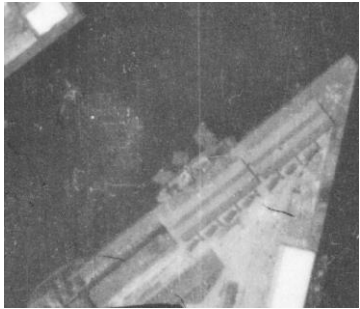
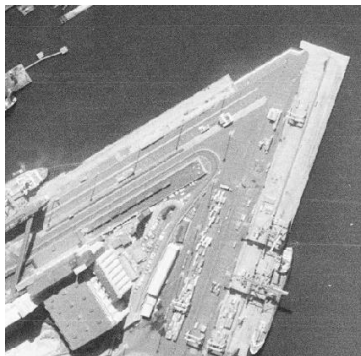

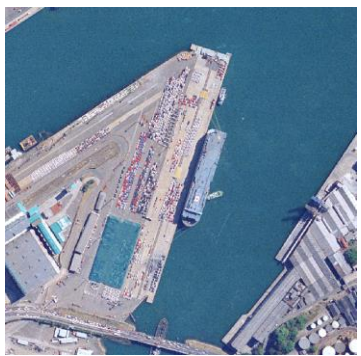

Date of aerial photography		Site	Surrounding area
1991	No image available		
1994		Victoria Road (WHT2) is generally unchanged from the 1983/84 imagery with the exception of additional structures and the possible service station located within the northern portion of Victoria Road (WHT2).	Surrounding area is generally unchanged from the 1983/84 imagery.
1998		Victoria Road (WHT2) is generally unchanged from the 1994 imagery.	Surrounding area is generally unchanged from the 1994 imagery.
2002	No image available		
2005	No image available		

Table A.3 Historical aerial photography review - White Bay (South) (WHT3) construction support site


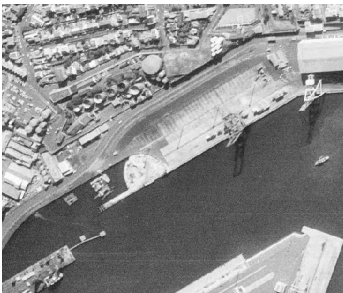

Date of aerial photography		Site	Surrounding area
1930		White Bay (WHT3) (South) appears to be a land-based industrial facility located next to White Bay. White Bay (South) (WHT3) is occupied by a number of buildings (large warehouse type buildings) and wharf structures. Possible stockpile observed (possibly coal for power station). The frontage of White Bay (South) (WHT3) with White Bay is very linear (possible reclamation).	White Bay (WHT3) (South) is surrounded by water (White and Johnstons Bays) to the north, east and south. Areas to the west of the site are not visible in the image.
1955	No image available		
1961	No image available		
1970	No image available		

Date of aerial photography		Site	Surrounding area
1975		Buildings previously observed on White Bay (South) (WHT3) have been demolished, larger wharf structure and cranes (south-eastern portion of site) and grain silos constructed.	Areas to the west of White Bay (South) (WHT3) comprise a power station and other industrial facilities.
1983/84		White Bay (South) (WHT3) is generally unchanged from the 1975 imagery.	Surrounding area is generally unchanged from the 1975 imagery.
1986	No image available		
1991	No image available		
1994		White Bay (South) (WHT3) is generally unchanged from the 1983/84 imagery with the exception of the site being used to store motor vehicles.	Surrounding area is generally unchanged from the 1975 imagery. Construction of the Anzac Bridge to the south of the site has started.
1998		White Bay (South) (WHT3) is generally unchanged from the 1994 imagery.	Surrounding area is generally unchanged from the 1994 imagery. Glebe Island Bridge has been demolished. The Anzac Bridge has been constructed.
2002	No image available		

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Date of aerial photography		Site	Surrounding area
2005	No image available		

Table A.4 Historical aerial photography review - White Bay (North) (WHT3) construction support site

Date of aerial photography		Site	Surrounding area
1930		White Bay (WHT3) (North) appears to be a land-based industrial facility located next to Whites Bay. White Bay (WHT3) (North) is occupied by a number of buildings, a wharf structure and several above-ground storage tanks (possibly fuel storages). The frontage of White Bay (WHT3) (North) with White Bay is very linear (possible reclamation).	The surrounding area comprises established low density residential land use to the north of White Bay (WHT3) (North), industrial land use to the west, Whites Bay and Glebe Island to the south.
1955	No image available		
1961	No image available		
1970	No image available		
1975		White Bay (WHT3) (North) is cleared of former buildings and now comprises wharf structure and crane. Wharf structure extends further into White Bay than that observed in the 1930 imagery (possible reclamation).	Surrounding area is generally unchanged from the 1930 imagery with the exception of a container terminal located to the east of White Bay (WHT3) (North).
1983/84		The wharf structure has been extended along the south-western portion of the site (possible reclamation).	Surrounding area is generally unchanged from the 1975 imagery. Above-ground storage tanks to the north of White Bay (WHT3) (North) have been removed.
1986	No image available		
1991	No image available		

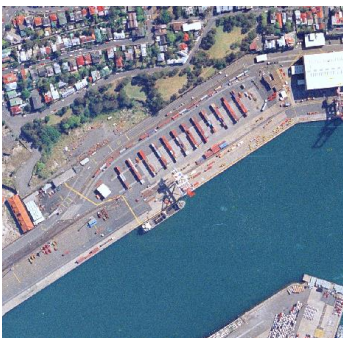

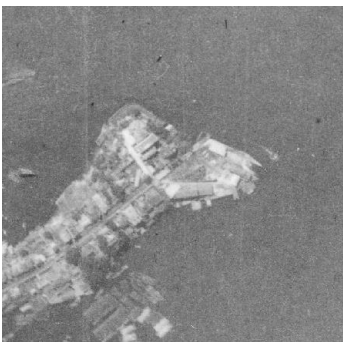

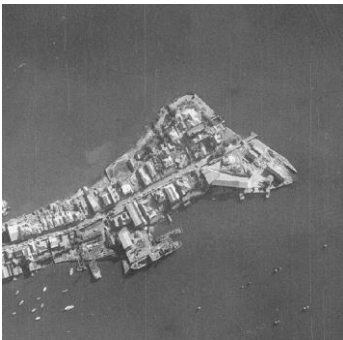






Date of aerial photography		Site	Surrounding area
1994		White Bay (WHT3) (North) is generally unchanged from the 1983/84 imagery with the exception of shipping containers present on White Bay.	Surrounding area is generally unchanged from the 1983/84 imagery.
1998		White Bay (WHT3) (North) is generally unchanged from the 1994 imagery.	Surrounding area is generally unchanged from the 1994 imagery.
2002	No image available		
2005	No image available		

Table A.5 Historical aerial photography review – Yurulbin Point (WHT4) construction support site

Date of aerial photography		Site	Surrounding area
1930		Yurulbin Point (WHT4) appears to be a land-based commercial/industrial facility located next to Snails Bay. Yurulbin Point is occupied by a number of buildings (including a larger warehouse/workshop building) and wharf structures.	Yurulbin Point (WHT4) is surrounded by water (Snails Bay and Port Jackson) to the east and south. Areas immediately to the north and south-west of Yurulbin Point appear to be used for similar activities to those on-site. Established residential areas are present further to the west of Yurulbin Point.

Date of aerial photography		Site	Surrounding area
1955		Yurulbin Point (WHT4) is generally unchanged from the 1930 imagery.	Surrounding area is generally unchanged from the 1930 imagery with the exception of a large residential development present to the north of Yurulbin Point (WHT4).
1961		Yurulbin Point (WHT4) is generally unchanged from the 1955 imagery.	Surrounding area is generally unchanged from the 1955 imagery.
1970		Yurulbin Point (WHT4) is generally unchanged from the 1961 imagery.	Surrounding area is generally unchanged from the 1961 imagery.
1975		Buildings and structures formerly present on Yurulbin Point (WHT4) have been demolished and removed. Yurulbin Point is vacant.	Surrounding area is generally unchanged from the 1970 imagery.

Date of aerial photography		Site	Surrounding area
1983/84		Yurulbin Point (WHT4) appears to be parkland (grass and trees present).	Surrounding area is generally unchanged from the 1975 imagery.
1986		Yurulbin Point (WHT4) is generally unchanged from the 1983/84 imagery.	Surrounding area is generally unchanged from the 1983/84 imagery.
1991		Yurulbin Point (WHT4) is generally unchanged from the 1986 imagery.	Surrounding area is generally unchanged from the 1986 imagery with the exception of the buildings associated with the industrial premises to the west of Yurulbin Point (WHT4) being demolished.
1994		Yurulbin Point (WHT4) is generally unchanged from the 1991 imagery.	Surrounding area is generally unchanged from the 1991 imagery with the exception of the construction of residential buildings on the former industrial premises to the west of Yurulbin Point (WHT4).

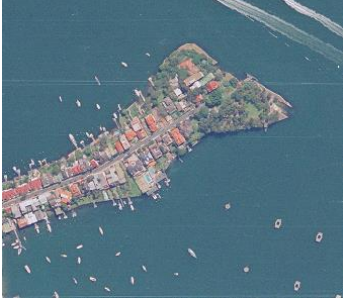

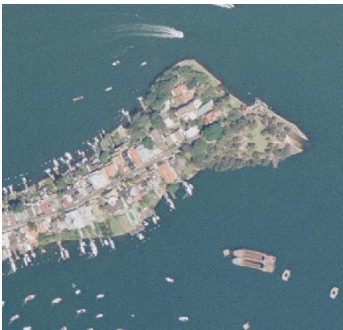


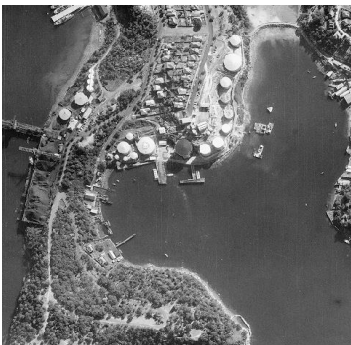




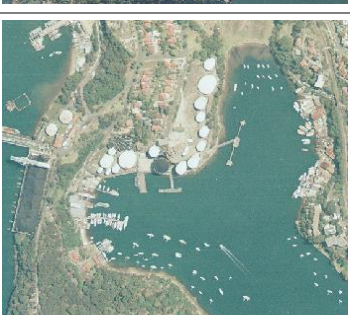

Date of aerial photography		Site	Surrounding area
1998		Yurulbin Point (WHT4) is generally unchanged from the 1994 imagery.	Surrounding area is generally unchanged from the 1994 imagery.
2002		Yurulbin Point (WHT4) is generally unchanged from the 1998 imagery.	Surrounding area is generally unchanged from the 1998 imagery.
2005		Yurulbin Point (WHT4) is generally unchanged from the 2002 imagery.	Surrounding area is generally unchanged from the 2002 imagery.

Table A.6 Historical aerial photography review – Berrys Bay (WHT7) construction support site

Date of aerial photography		Site	Surrounding area
1930		Berrys Bay (WHT7) appears to be a land-based commercial/industrial facility located next to Berrys Bay. Berrys Bay is occupied by a number of buildings and wharf structures. The northern portion of Berrys Bay contains a large above-ground storage tank (possible fuel storage).	Berrys Bay (WHT7) is surrounded by established low density residential areas, bushland, Berrys Bay and a number of industrial land uses including HMAS <i>Waterhen</i> to the north-east. There are a number of above-ground storage tanks (possible fuel storages) to the north-east and west of Berrys Bay (WHT7).

Date of aerial photography		Site	Surrounding area
1955		Additional commercial/industrial development has occurred on Berrys Bay (WHT7) including additional buildings, wharf structures and above-ground storage tanks.	Numerous above-ground storage tanks are present to the north-east and west of Berrys Bay (WHT7). More development appears to have occurred on the HMAS <i>Waterhen</i> site. The coal loader is present to the west of Berrys Bay.
1961		Additional above-ground storage tanks have been constructed within the northern portion of Berrys Bay (WHT7).	Additional above-ground storage tanks have been constructed to the north-east of Berrys Bay (WHT7). Area now occupied by Waverton Park (to the north-east of Berrys Bay) has been reclaimed.
1970		An additional above-ground storage tank has been constructed within the northern portion of Berrys Bay (WHT7).	Surrounding area is generally unchanged from the 1961 imagery.
1975		Berrys Bay (WHT7) is generally unchanged from the 1970 imagery.	Surrounding area is generally unchanged from the 1970 imagery.

Date of aerial photography		Site	Surrounding area
1983/84		Berrys Bay (WHT7) is generally unchanged from the 1975 imagery.	Surrounding area is generally unchanged from the 1975 imagery.
1986		Berrys Bay (WHT7) is generally unchanged from the 1983/84 imagery.	Surrounding area is generally unchanged from the 1983/84 imagery.
1991		Berrys Bay (WHT7) is generally unchanged from the 1986 imagery.	Surrounding area is generally unchanged from the 1986 imagery.
1994		Berrys Bay (WHT7) is generally unchanged from the 1991 imagery.	Surrounding area is generally unchanged from the 1991 imagery with the exception of a new marina facility constructed to the east of Berrys Bay (WHT7) and removal of two above-ground storage tanks to the west of Berrys Bay. No coal present at the coal loader to the west of Berrys Bay.













Date of aerial photography		Site	Surrounding area
1998		All above-ground storage tanks have been removed from Berrys Bay (WHT7).	Above-ground storage tanks to the north of Berrys Bay (WHT7) have been removed. New buildings and wharf structures constructed at HMAS <i>Waterhen</i> .
2002		Berrys Bay (WHT7) is generally unchanged from the 1998 imagery.	Surrounding area is generally unchanged from the 1998 imagery.
2005		Berrys Bay (WHT7) is generally unchanged from the 2002 imagery.	Surrounding area is generally unchanged from the 2002 imagery.

Table A.7 Historical aerial photography review – Berry Street north (WHT8) construction support site

Date of aerial photography		Site	Surrounding area
1930		Berry Street north (WHT8) is covered by residential dwellings. A road runs through the centre of Berry Street north (WHT8) (oriented generally north-east to west).	The surrounding area comprises established residential land use. Open space areas associated with St Leonards Park and North Sydney Oval are located to the north of Berry Street north (WHT8).

Date of aerial photography		Site	Surrounding area
1955		Berry Street north (WHT8) is generally unchanged from the 1930 imagery.	Surrounding area is generally unchanged from the 1930 imagery, with the exception of an area of earthwork to the east of Berry Street north (WHT8) (current location of Forsyth Park).
1961		Berry Street north (WHT8) is generally unchanged from the 1955 imagery.	Surrounding area is generally unchanged from the 1955 imagery with the exception of earthwork being completed at current Forsyth Park site.
1970		Berry Street north (WHT8) is now the verge next to the western side of the Warringah Freeway.	Areas to the east of Berry Street north (WHT8) (ie roads and residential premises) have been demolished for the Warringah Freeway. Residential premises to the west of Berry Street north (WHT8) have been demolished with high density residential apartments constructed.
1975		Berry Street north (WHT8) is generally unchanged from the 1970 imagery.	Surrounding area is generally unchanged from the 1970 imagery.

Date of aerial photography		Site	Surrounding area
1983/84		Berry Street north (WHT8) is generally unchanged from the 1975 imagery.	Surrounding area is generally unchanged from the 1975 imagery with the exception of additional high-rise apartment blocks.
1986		Berry Street north (WHT8) is generally unchanged from the 1983/84 imagery.	Surrounding area is generally unchanged from the 1983/84 imagery.
1991		Berry Street north (WHT8) is generally unchanged from the 1986 imagery.	Surrounding area is generally unchanged from the 1986 imagery.
1994		Berry Street north (WHT8) is generally unchanged from the 1991 imagery.	Surrounding area is generally unchanged from the 1991 imagery.






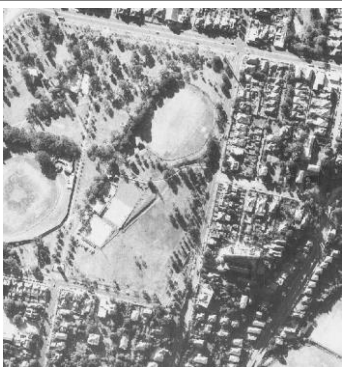
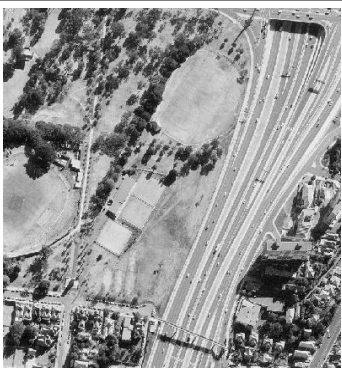





Date of aerial photography		Site	Surrounding area
1998		Berry Street north (WHT8) is generally unchanged from the 1994 imagery.	Surrounding area is generally unchanged from the 1994 imagery.
2002		Berry Street north (WHT8) is generally unchanged from the 1998 imagery.	Surrounding area is generally unchanged from the 1998 imagery.
2005		Berry Street north (WHT8) is generally unchanged from the 2002 imagery.	Surrounding area is generally unchanged from the 2002 imagery.

Table A.8 Historical aerial photography review – Ridge Street north (WHT9) construction support site

Date of aerial photography		Site	Surrounding area
1930		Ridge Street north (WHT9) is a vacant portion of open space within the south-eastern corner of St Leonards Park. No structures are visible on Ridge Street north (WHT9).	The surrounding area comprises established residential land use, open space areas associated with St Leonards Park and North Sydney Oval.

Date of aerial photography		Site	Surrounding area
1955		Ridge Street north (WHT9) is generally unchanged from the 1930 imagery.	Surrounding area is generally unchanged from the 1930 imagery, with the exception of a building and possible bowling greens (North Sydney Bowling Club) constructed to the north-west of Ridge Street north (WHT9).
1961		Ridge Street north (WHT9) is generally unchanged from the 1955 imagery.	Surrounding area is generally unchanged from the 1955 imagery.
1970		A portion of Ridge Street north (WHT9) (south-western corner) has been reclaimed for construction of the Warringah Freeway. Some ground disturbance is evident in the southern portion of St Leonards Park (WHT9).	Areas to the east of Ridge Street north (WHT9) (ie roads and residential premises) have been demolished for the Warringah Freeway.
1975		Ridge Street north (WHT9) is generally unchanged from the 1970 imagery.	Surrounding area is generally unchanged from the 1970 imagery.

Date of aerial photography		Site	Surrounding area
1983/84		Ridge Street north (WHT9) is generally unchanged from the 1975 imagery with the exception that the ground disturbance observed within the southern portion of the site is no longer present.	Surrounding area is generally unchanged from the 1975 imagery.
1986		Ridge Street north (WHT9) is generally unchanged from the 1983/84 imagery.	Surrounding area is generally unchanged from the 1983/84 imagery with the exception of the construction of grandstands within North Sydney Oval.
1991		Ridge Street north (WHT9) is generally unchanged from the 1986 imagery.	Surrounding area is generally unchanged from the 1986 imagery.
1994		Ridge Street north (WHT9) is generally unchanged from the 1991 imagery with the exception of construction of netball courts on-site.	Surrounding area is generally unchanged from the 1991 imagery. Circus present with St Leonards Park (to the north-west of St Leonards Park (WHT9)).









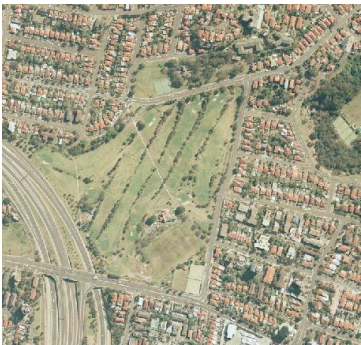
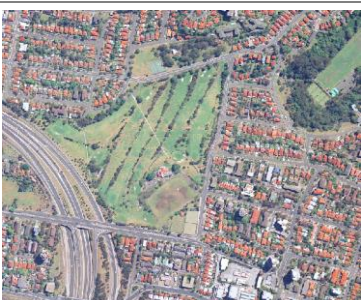
Date of aerial photography		Site	Surrounding area
1998		Ridge Street north (WHT9) is generally unchanged from the 1994 imagery.	Surrounding area is generally unchanged from the 1994 imagery.
2002		Ridge Street north (WHT9) is generally unchanged from the 1998 imagery.	Surrounding area is generally unchanged from the 1998 imagery.
2005		Ridge Street north (WHT9) is generally unchanged from the 2002 imagery.	Surrounding area is generally unchanged from the 2002 imagery.


Table A.9 Historical aerial photography review – Cammeray Golf Course (WHT10) construction support site





Date of aerial photography		Site	Surrounding area
1930		Cammeray Golf Course (WHT10) appears to be a vacant parcel of land (golf course and associated facilities not yet constructed). The Warringah Freeway has not been constructed. Possible tennis courts present within the south-eastern corner of Cammeray Golf Course (WHT10).	The surrounding area comprises established low density residential land use. Residential dwellings are present within the current footprint of the Warringah Freeway.
1955	Not visible		
1961		Cammeray Golf Course (WHT10) is part of the Cammeray Golf Course. The Warringah Freeway has not been constructed.	The surrounding area comprises established low density residential. Residential dwellings are present within the current footprint of the Warringah Freeway.
1970		The majority of Cammeray Golf Course (WHT10) is occupied by the Cammeray Golf Course. The Warringah Freeway is constructed/being constructed in areas to the south-west of Cammeray Golf Course (WHT10).	The surrounding area comprises established low density residential. Some areas of open space and residential land use identified in the 1961 imagery have been demolished to facilitate the construction of the Warringah Freeway.
1975		Cammeray Golf Course (WHT10) is generally unchanged from the 1970 imagery.	Surrounding area is generally unchanged from the 1970 imagery.





Date of aerial photography		Site	Surrounding area
1986		Cammeray Golf Course (WHT10) is generally unchanged from the 1975 imagery.	Surrounding area is generally unchanged from the 1975 imagery.
1991		Cammeray Golf Course (WHT10) is generally unchanged from the 1986 imagery.	Surrounding area is generally unchanged from the 1986 imagery.
1994		Cammeray Golf Course (WHT10) is generally unchanged from the 1991 imagery.	Surrounding area is generally unchanged from the 1991 imagery.
1998		Cammeray Golf Course (WHT10) is generally unchanged from the 1994 imagery.	Surrounding area is generally unchanged from the 1994 imagery.

Date of aerial photography		Site	Surrounding area
2002		Cammeray Golf Course (WHT10) is generally unchanged from the 1998 imagery.	Surrounding area is generally unchanged from the 1998 imagery.
2005		Cammeray Golf Course (WHT10) is generally unchanged from the 2002 imagery.	Surrounding area is generally unchanged from the 2002 imagery.

Table A.10 Historical aerial photography review – Warringah Freeway, Blue Street (WFU1), High Street south (WFU2), High Street north (WFU3), Arthur Street east (WFU4) and Berry Street east (WFU5) construction support sites

Date of aerial photography		Site	Surrounding area
1930		<p>WFU1, WFU2, WFU3, WFU4 and WFU5 are generally located within an area comprising residential land use. Some larger buildings (possible education, offices, commercial) are located within the north-eastern portion of this area.</p> <p>WFU1 is located within an area of disturbed ground (possible railway corridor under construction).</p>	The surrounding area comprises established residential land use, some larger buildings and minor open space.

Date of aerial photography		Site	Surrounding area
1955		WFU1, WFU2, WFU3, WFU4 and WFU5 are generally unchanged from the 1930 imagery with the exception of the railway line that has been constructed.	Surrounding area is generally unchanged from the 1930 imagery.
1961		WFU1, WFU2, WFU3, WFU4 and WFU5 are generally unchanged from the 1955 imagery.	Surrounding area is generally unchanged from the 1955 imagery.
1970		<p>The Warringah Freeway has been constructed.</p> <p>WFU4 and WFU5 are verge areas next to western extent of the Warringah Freeway.</p> <p>WFU2 and WFU3 are verge areas next to eastern extent of the Warringah Freeway.</p> <p>Increase in large buildings (possible commercial office buildings) to the west of the Warringah Freeway.</p>	Areas next to WFU2, 3, 4 and 5 have been cleared (buildings demolished).
1975		WFU1, WFU2, WFU3, WFU4 and WFU5 are generally unchanged from the 1970 imagery. Increase in large buildings (possible commercial office buildings) to the west of the Warringah Freeway.	Surrounding area is generally unchanged from the 1970 imagery.

Date of aerial photography		Site	Surrounding area
1983/84		WFU1, WFU2, WFU3, WFU4 and WFU5 are generally unchanged from the 1975 imagery. Increase in large buildings (possible commercial office buildings) to the west of the Warringah Freeway.	Surrounding area is generally unchanged from the 1975 imagery.
1986		WFU1, WFU2, WFU3, WFU4 and WFU5 are generally unchanged from the 1983/84 imagery.	Surrounding area is generally unchanged from the 1983/84 imagery.
1991		WFU1, WFU2, WFU3, WFU4 and WFU5 are generally unchanged from the 1986 imagery.	Surrounding area is generally unchanged from the 1986 imagery. Portal to the Sydney Harbour Tunnel present within the Warringah Freeway corridor.
1994		WFU1, WFU2, WFU3, WFU4 and WFU5 are generally unchanged from the 1991 imagery.	Surrounding area is generally unchanged from the 1991 imagery.














Date of aerial photography		Site	Surrounding area
1998		WFU1, WFU2, WFU3, WFU4 and WFU5 are generally unchanged from the 1994 imagery.	Surrounding area is generally unchanged from the 1994 imagery.
2002		WFU1, WFU2, WFU3, WFU4 and WFU5 are generally unchanged from the 1998 imagery.	Surrounding area is generally unchanged from the 1998 imagery.
2005		WFU1, WFU2, WFU3, WFU4 and WFU5 are generally unchanged from the 2002 imagery.	Surrounding area is generally unchanged from the 2002 imagery.

Table A.11 Historical aerial photography review – Ridge Street east (WFU6) and Merlin Street (WFU7) construction support sites and Warringah Freeway

Date of aerial photography		Site	Surrounding area
1930		Ridge Street east (WFU6) is a vacant portion of land covered by grass. Merlin Street (WFU7) is covered by residential premises.	The surrounding area comprises established residential land use, open space areas associated with St Leonards Park and North Sydney Oval to the north of Ridge Street east (WFU6). Bushland is located to the east of Merlin Street (WFU7).

Date of aerial photography		Site	Surrounding area
1955		Ridge Street east (WFU6) and Merlin Street (WFU7) are generally unchanged from the 1930 imagery.	Surrounding area is generally unchanged from the 1930 imagery, with the exception of a building and possible bowling greens (North Sydney Bowling Club) constructed to the north-west of Ridge Street east (WFU6).
1961		Ridge Street east (WFU6) and Merlin Street (WFU7) are generally unchanged from the 1955 imagery.	Surrounding area is generally unchanged from the 1955 imagery.
1970		Warringah Freeway has been constructed to the east of Ridge Street east (WFU6). Buildings occupying Merlin Street (WFU7) have been demolished and site appears to be open space.	Areas to the east of Ridge Street east (WFU6) and west of Merlin Street (WFU7) (ie roads and residential premises) have been demolished to facilitate the construction of the Warringah Freeway. Residential properties are present to the north of Merlin Street (WFU7).
1975		Ridge Street east (WFU6) and Merlin Street (WFU7) are generally unchanged from the 1970 imagery, with the exception of a potential lager building constructed next to the northern boundary of Merlin Street (WFU7).	Surrounding area is generally unchanged from the 1970 imagery.
1983/84		Ridge Street east (WFU6) and Merlin Street (WFU7) are generally unchanged from the 1975 imagery.	Surrounding area is generally unchanged from the 1975 imagery.

Date of aerial photography		Site	Surrounding area
1986		Ridge Street east (WFU6) and Merlin Street (WFU7) are generally unchanged from the 1983/84 imagery.	Surrounding area is generally unchanged from the 1983/84 imagery with the exception of the construction of grandstands within North Sydney Oval and high-rise apartment building constructed to the north of Merlin Street (WFU7).
1991		Ridge Street east (WFU6) and Merlin Street (WFU7) are generally unchanged from the 1986 imagery.	Surrounding area is generally unchanged from the 1986 imagery.
1994		Ridge Street east (WFU6) and Merlin Street (WFU7) are generally unchanged from the 1991 imagery.	Surrounding area is generally unchanged from the 1991 imagery. Circus present within St Leonards Park (to the north-west of the site).
1998		Ridge Street east (WFU6) and Merlin Street (WFU7) are generally unchanged from the 1994 imagery.	Surrounding area is generally unchanged from the 1994 imagery.











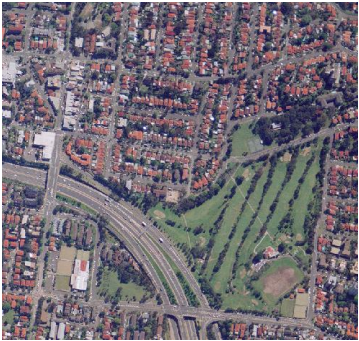

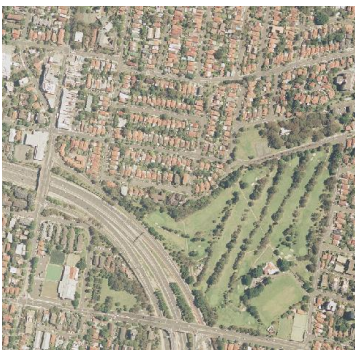
Date of aerial photography		Site	Surrounding area
2002		Ridge Street east (WFU6) and Merlin Street (WFU7) are generally unchanged from the 1998 imagery.	Surrounding area is generally unchanged from the 1998 imagery.
2005		Ridge Street east (WFU6) and Merlin Street (WFU7) are generally unchanged from the 2002 imagery.	Surrounding area is generally unchanged from the 2002 imagery.

Table A.12 Historical aerial photography review – Cammeray Golf Course (WFU8) and Rosalind Street east (WFU9) construction support sites and Warringah Freeway

Date of aerial photography		Site	Surrounding area
1930		<p>Cammeray Golf Course (WFU8) appears to be a vacant parcel of land (golf course and associated facilities not yet constructed). The Warringah Freeway has not been constructed. Possible tennis courts present within the south-eastern corner of the site.</p> <p>Rosalind Street east (WFU9) is occupied by residential buildings.</p>	The surrounding area comprises established low density residential. Residential dwellings are present within the current footprint of the Warringah Freeway.
1955	Not visible		

Date of aerial photography		Site	Surrounding area
1961		<p>Cammeray Golf Course (WFU8) is occupied by Cammeray Golf Course.</p> <p>Rosalind Street east (WFU9) is generally unchanged from the 1930 imagery.</p>	<p>Surrounding areas are generally unchanged from the 1930 imagery with the exception of the construction of bowling greens and associated buildings to the south of Rosalind Street east (WFU9).</p>
1970		<p>The Warringah Freeway has been/is being constructed in areas to the south-west of Cammeray Golf Course (WFU8) and north-east of Rosalind Street east (WFU9). Buildings previously occupying Rosalind Street east (WFU9) have been demolished, Rosalind Street east (WFU9) is now open space.</p>	<p>Previous areas of open space and residential land use identified in the 1961 imagery have been demolished to facilitate the construction of the Warringah Freeway.</p>
1975		<p>Cammeray Golf Course (WFU8) and Rosalind Street east (WFU9) are generally unchanged from the 1970 imagery.</p>	<p>Surrounding area is generally unchanged from the 1970 imagery.</p>
1983/84		<p>Cammeray Golf Course (WFU8) and Rosalind Street east (WFU9) are generally unchanged from the 1975 imagery.</p>	<p>Surrounding area is generally unchanged from the 1975 imagery with the exception of some additional buildings constructed to the south of Rosalind Street east (WFU9).</p>

Date of aerial photography		Site	Surrounding area
1986		Cammeray Golf Course (WFU8) and Rosalind Street east (WFU9) are generally unchanged from the 1983/84 imagery.	Surrounding area is generally unchanged from the 1983/84 imagery with the exception of some additional buildings constructed to the south of Rosalind Street east (WFU9).
1991		Cammeray Golf Course (WFU8) and Rosalind Street east (WFU9) are generally unchanged from the 1986 imagery.	Surrounding area is generally unchanged from the 1986 imagery.
1994		Cammeray Golf Course (WFU8) and Rosalind Street east (WFU9) are generally unchanged from the 1991 imagery.	Surrounding area is generally unchanged from the 1991 imagery.
1998		Cammeray Golf Course (WFU8) and Rosalind Street east (WFU9) are generally unchanged from the 1994 imagery.	Surrounding area is generally unchanged from the 1994 imagery.

Date of aerial photography		Site	Surrounding area
2002		Cammeray Golf Course (WFU8) and Rosalind Street east (WFU9) are generally unchanged from the 1998 imagery.	Surrounding area is generally unchanged from the 1998 imagery.
2005		Cammeray Golf Course (WFU8) and Rosalind Street east (WFU9) are generally unchanged from the 2002 imagery.	Surrounding area is generally unchanged from the 2002 imagery.

Appendix B. Sediment tables

Table B.1 Contaminant compounds exceeding the nominated criteria at sediment sample locations

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
WHT					
B108WA_VC-A	PAH		x		
B111WA_VC-A	TBT		x	x	
	Heavy Metals		x		x
	Mercury	x			
	Lead	x			
	Silver	x			
	Zinc	x			x
	PAH		x		
B111W_VC-B	TBT		x		
	Heavy Metals		x		x
	Mercury	x			
	Lead	x			
	Zinc	x			x
	PAH		x		
B111W_VC-C	Heavy Metals		x		x
	Mercury	x			
	Lead	x			
	Zinc	x			x
	TRH			x	
	PAH		x		
B111WA_VC-D	PAH		x		
B212WA_VC-A	Heavy Metals		x		x
	Mercury	x			
	Lead	x			
	Zinc	x			x
	PAH	x	x	x	
B216WA_VC-A	TBT		x	x	
	PAH		x		
B216W-ELU	PAH	x	x	x	
B478W-A	TBT		x	x	
	Heavy Metals		x		x

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
	Mercury	x			
	PAH		x	x	
B478W-A	PAH		x		
B478W-ELU	TBT		x	x	
	Heavy Metals		x		x
	PAH		x		
B479W-A	TBT		x		
	Heavy Metals		x		x
	Mercury	x			
	PAH		x		
B479W-ELU	TBT		x	x	
	Heavy Metals		x		x
	Mercury	x			
	TRH			x	
	PAH	x	x	x	
B481W-A	Heavy Metals		x		x
	Mercury	x			
	TRH			x	
	PAH		x		
B481W-B	PAH		x		
B482W-A	PAH		x		
B484W-A	Heavy Metals		x		x
	TRH			x	
	PAH		x		
B485W-A	PAH		x		
B487W-A	PAH		x		
B488W-A	Mercury		x		
	PAH		x		
B490W-A	PAH		x		
B490W-ELU	PAH		x		
B493W-A	Mercury		x		
	PAH		x		
B497W-A	TBT		x		

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
	PAH		x		
B498W-A	TBT		x	x	
	Heavy Metals		x		x
	Mercury	x			
	Lead	x			
	Zinc	x			x
	PAH		x		
B498W-B	Heavy Metals		x		x
	Mercury	x			
	Lead	x			
	Zinc	x			x
	TRH			x	
	PAH		x		
B498W-C	Heavy Metals		x		x
	Mercury	x			
	PAH	x	x	x	
B513W-A	Heavy Metals		x		x
	Mercury	x			
	PAH		x		
White Bay					
B770W-ELU	TBT		x	x	
	Heavy Metals		x		x
	Mercury	x			
	Zinc	x			x
	OCP		x		
	PAH		x		
B771W-ELU	TBT		x	x	
	Heavy Metals		x		x
	Mercury	x			
	Zinc	x			x
	TRH			x	
	OCP		x		
	PAH		x	x	

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
B772W-ELU	TBT		x	x	
	Heavy Metals		x		x
	PAH		x		
B773W-ELU	TBT		x	x	
	Heavy Metals		x		x
	Mercury	x			
	Zinc	x			x
	OCP	x	x		
	PAH		x		
B774W-ELU	TBT		x	x	
	Heavy Metals		x		x
	Mercury	x			
	Zinc	x			x
	PAH		x		
Berrys Bay					
B426W	Mercury		x	NP	NP
B427W	TBT		x	NP	NP
	Arsenic		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
B428W	TBT	x		NP	NP
	Arsenic		x	NP	NP
	Copper	x		NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Nickel		x	NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDE		x	NP	NP
	DDT		x	NP	NP
B429W	TBT	x		NP	NP
	Arsenic		x	NP	NP
	Copper	x		NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDE		x	NP	NP
	DDT		x	NP	NP
B430W	TBT	x		NP	NP
	Arsenic		x	NP	NP
	Copper		x	NP	NP
	Lead		x	NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc		x	NP	NP
	PAH		x	NP	NP
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDE		x	NP	NP
	DDT		x	NP	NP
B431W	TBT		x	NP	NP
	Arsenic		x	NP	NP
	Copper		x	NP	NP
	Lead		x	NP	NP
	Mercury	x		NP	NP

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
	Zinc		x	NP	NP
	PAH	x	x	NP	NP
	DDT		x	NP	NP
B432W	TBT		x	NP	NP
	Arsenic		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	DDD		x	NP	NP
	DDT		x	NP	NP
B433W	TBT		x	NP	NP
	Arsenic		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
B434W	TBT	x		NP	NP
	Antimony		x	NP	NP
	Arsenic	x		NP	NP
	Chromium		x	NP	NP
	Copper	x		NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Nickel		x	NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
	DDD	x		NP	NP
	DDE		x	NP	NP
	DDT	x		NP	NP
B435W	TBT	x		NP	NP
	Copper		x	NP	NP
	Lead		x	NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc		x	NP	NP
	PAH	x	x	NP	NP
B436W	TBT	x		NP	NP
	Arsenic		x	NP	NP
	Copper	x		NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDE		x	NP	NP
	DDT		x	NP	NP
B437W	TBT	x		NP	NP
	Arsenic		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDE		x	NP	NP

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
	DDT		x	NP	NP
B438W	TBT		x	NP	NP
	Arsenic		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
B439W	TBT		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
	DDE		x	NP	NP
B440W	TBT		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH		x	NP	NP
B441W	TBT		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
	TRH		x	NP	NP
B442W	TBT	x		NP	NP
	Arsenic		x	NP	NP
	Copper	x		NP	NP
	Lead		x	NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDE		x	NP	NP
	DDT		x	NP	NP
B443W	TBT	x		NP	NP
	Copper		x	NP	NP
	Lead		x	NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc		x	NP	NP
	PAH	x	x	NP	NP
	DDD		x	NP	NP
	DDT		x	NP	NP
B444W	TBT		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDT		x	NP	NP
B445W	TBT		x	NP	NP

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
B445W	Arsenic		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
B446W	TBT		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	DDD		x	NP	NP
	DDE		x	NP	NP
	DDT		x	NP	NP
B447W	TBT		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDE		x	NP	NP
	DDT		x	NP	NP
B448W	TBT		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDE		x	NP	NP
	DDT		x	NP	NP
B449W	TBT		x	NP	NP
	Copper		x	NP	NP
	Lead		x	NP	NP
	Mercury	x		NP	NP
	PAH		x	NP	NP
B450W	TBT		x	NP	NP
	Lead		x	NP	NP
	Mercury		x	NP	NP
	PAH		x	NP	NP
B451W	TBT		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDE		x	NP	NP
	DDT		x	NP	NP
B768W	TBT		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP

Location	Compound	ISGC (high)	ISGC (low)	NAGD	NEPM EIL
	PAH	x	x	NP	NP
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDE		x	NP	NP
	DDT		x	NP	NP
B769W	TBT		x	NP	NP
	Arsenic		x	NP	NP
	Chromium		x	NP	NP
	Copper		x	NP	NP
	Lead	x		NP	NP
	Mercury	x		NP	NP
	Silver		x	NP	NP
	Zinc	x		NP	NP
	PAH	x	x	NP	NP
	TRH		x	NP	NP
	DDD		x	NP	NP
	DDT		x	NP	NP
NP: No assessment provided against respective guidelines in information provided by DPGA.					

