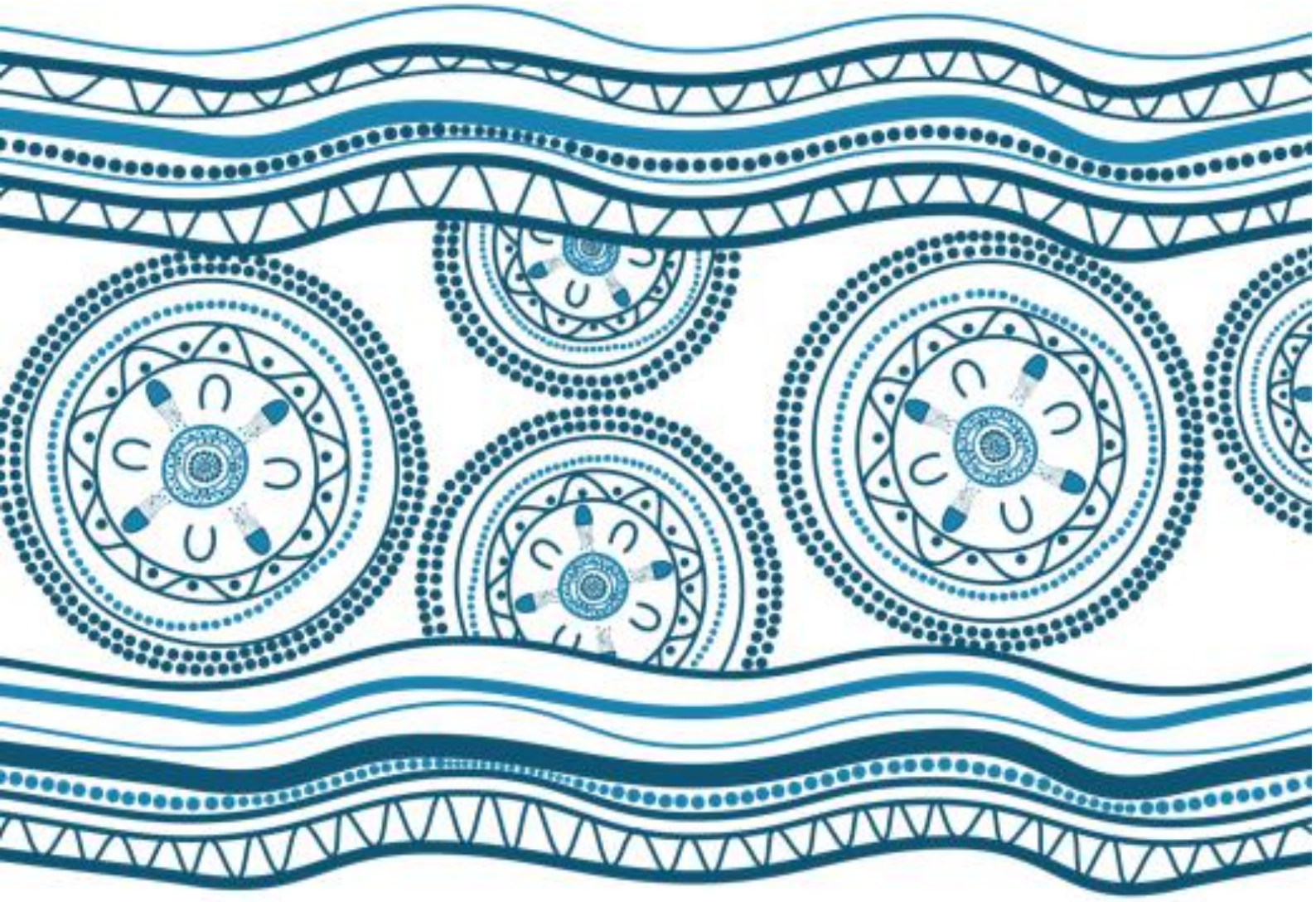
Appendix R

Groundwater Assessment Report



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Transport for NSW

Kamay Ferry Wharves Project

Groundwater Assessment Report

KFW01-ARUP-BPW-EN-RPT-000057

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Executive summary

Transport for New South Wales is seeking approval to reinstate the ferry wharves at La Perouse and Kurnell in Botany Bay. The project would allow for an alternative connection between La Perouse and Kurnell and bring multiple benefits to the local community.

As part of this project an Environmental Impact Statement (EIS) needs to be undertaken to assess the risks of the project on the surrounding environment. This report supports the EIS and assesses the risks to groundwater and groundwater receptors as a result of the project and provides recommendations for mitigation.

A desktop study was undertaken to characterise the existing hydrogeological environment. The Kamay Ferry Wharves project area lies within relatively low elevations around Botany Bay, where coastal sand deposits of the Botany Bay Groundwater Source are prevalent overlying Hawkesbury Sandstone bedrock.

Groundwater in the area is expected to be close to ground surface surrounding the project due to most of the project area lying near sea level, with groundwater flow likely discharging to Botany Bay. Baseline groundwater quality is expected to be poor due to the projects' proximity to Botany Bay and the Tasman Sea, as well as the organic contamination present within the Botany Bay Groundwater Source.

The installation of the ferry wharf structures for is not anticipated to result in significant, widespread impacts to the groundwater environment. Groundwater dewatering may be required for the construction of utility and car park (at La Perouse) excavations, which are likely to encounter anticipated high groundwater levels within the project areas at La Perouse and Kurnell.

Contents

1 Introduction

1.1 Purpose of this report

The purpose of this report is to present the groundwater assessment for the Kamay Ferry Wharves project. This report also details the baseline groundwater conditions around the proposed ferry wharves at La Perouse and Kurnell, to assess the potential impacts to groundwater as a result of the project, and to recommend mitigation measures required to address these impacts.

1.2 Project overview

Transport for New South Wales (Transport for NSW) is seeking approval to reinstate the ferry wharves at La Perouse and Kurnell in Botany Bay (the project) under Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) as State significant infrastructure. The project would allow for an alternative connection between La Perouse and Kurnell rather than by road. The primary purpose of this infrastructure would be to operate a public ferry service to service visitors to the area and by the local community for cultural and recreational purposes. It would also provide supplementary temporary mooring for tourism-related commercial vessels and recreational boating.

The project provides opportunities for significant cultural and economic benefits to the local Aboriginal community by providing improved access to culturally significant sites. It is also expected to deliver benefits and opportunities to wider communities on either side of Botany Bay such as investment opportunities in a ferry service and other new visitor/tourist experiences.

Key features of the project include:

- Two new wharves, one at La Perouse and one at Kurnell that would include:
  - Berth for ferries (to accommodate vessels up to 40 metres long)
  - Berth for recreational and commercial vessels (to accommodate vessels up to 20 metres long)
  - Sheltered waiting areas and associated furniture
  - Additional space within waiting areas to accommodate other users such as fishing and those using recreational vessels
  - Signage and lighting
- Landside paving, access ramps, seating and landscaping at the entrance to the wharves
- Reconfiguration of existing car parking areas at La Perouse to increase the number of spaces (including provision of accessible parking and kiss-and-ride bays)
- Reconfiguration of footpaths around the new car parking area at La Perouse
- Provision for bike racks at La Perouse
- Installation of utilities to service the wharves.

The total construction period is anticipated to take up to 13 months, starting in early 2022. The construction of the two wharves will occur at the same time with landside and waterside works occurring simultaneously.

A concept design has been developed for the project, which forms the basis of this assessment. This hydrogeological assessment supports the Environmental Impact Statement (EIS) prepared for the project.

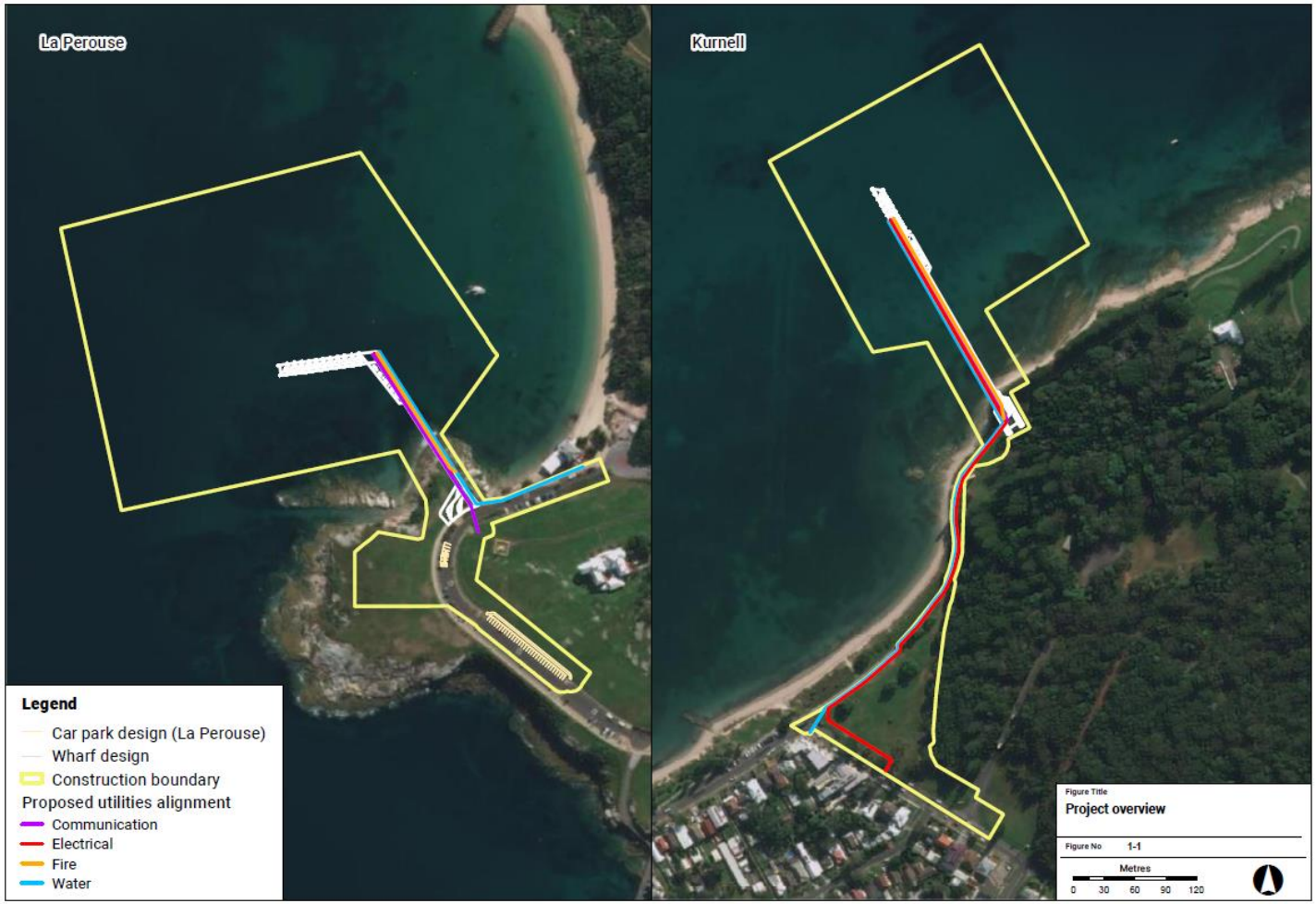

Figure 1-1: Project overview

1.3 SEARs relevant to this report

Table 1-1 identifies the Secretary's Environmental Assessment Requirements (SEARs) which are relevant to this technical assessment.

Table 1-1: SEARs for groundwater

SEARs relevant to this technical report	Where addressed in this technical report
1. Assessment of Key Issues* Key issues and impacts are assessed objectively and thoroughly to provide confidence that the project will be constructed and operated within acceptable levels of impact.	
1. The level of assessment of likely impacts must be proportionate to the significance of, or degree of impact on, the issue, within the context of the project location and the surrounding environment. The level of assessment must be commensurate to the degree of impact and sufficient to ensure that the Department and other government agencies are able to understand and assess impacts.	Section 4, 5 and 6
2. For each key issue the Proponent must: (a) describe the biophysical, social and economic environment, as far as it is relevant to that issue, including baseline data that is reflective of current guidelines where relevant; (b) describe the legislative and policy context, as far as it is relevant to the issue; (c) identify, describe and quantify (if possible) the impacts associated with the issue, including the likelihood and consequence (including worst case scenario) of the impact (comprehensive risk assessment), the impact (comprehensive risk assessment), the impacts of concurrent activities within the project and cumulative impacts; (d) demonstrate how potential impacts have been avoided (through design, or construction or operation methodologies); (e) detail how likely impacts that have not been avoided through design will be minimised, and the predicted effectiveness of these measures (against performance criteria where relevant); and detail how any residual impacts will be managed or offset, and the approach and effectiveness of these measures.	Sections 4 to 8
3. Where multiple reasonable and feasible options to avoid or minimise impacts are available, they must be identified and considered, and the proposed measure justified taking into account the public interest.	Sections 7 and 8
9. Soil, Water and Contamination The environmental values of land, including soils, subsoils, marine sediments and landforms, are protected. Risks arising from the disturbance and excavation/dredging of land or marine sediments and disposal of materials are minimised, including disturbance to acid sulfate soils, site contamination and water quality (surface and groundwater).	
1. Assess the potential impacts of the project on soil, water and contaminated material and marine sediments, including:	
(a) acid sulfate soils (including impacts of acidic runoff offsite);	Section 5

SEARs relevant to this technical report	Where addressed in this technical report
(b) potential for mobilisation of sediments and any contaminated sediment as a result of dredging and excavation, transportation and disposal of contaminated material/sediments; and	Section 5
(c) appropriate mitigation and management measures to safeguard the environment and people during construction and operation.	Section 7
2. Assess the impacts of the project on water quality including:	
(a) the nature and degree of impact on receiving waters;	Sections 5 and 6
(b) mitigating effects of proposed stormwater and wastewater management during and after construction; and	Section 7
(c) the impact of sediment plumes associated with the operation of the facility on water quality (e.g. proximity of propellers to the substrate and proximity to sensitive environs).	This SEAR is not relevant to groundwater and is addressed in Chapter 17, Soil, water and contamination.
Agency comments	
DPIE – NRAR & Water	
• Assessment of impacts on surface and groundwater sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Sections 5 and 6
• Proposed surface and groundwater monitoring activities and methodologies.	Monitoring not proposed due to limited impacts
• Consideration of relevant legislation, policies and guidelines, including the NSW Aquifer Interference Policy (2012), the Guidelines for Controlled Activities on Waterfront Land (2018) and the relevant Water Sharing Plans (available at https://www.industry.nsw.gov.au/water).	Sections 2 and 4
Environment Energy and Science Group (EES) (DPIE)	
Water and soils 9. The EIS must map the following features relevant to water and soils including:	
(a) Acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Planning Map).	Section 4
(b) Rivers, streams, wetlands, estuaries (as described in s4.2 of the Biodiversity Assessment Method).	This SEAR is not relevant to groundwater and is addressed in other technical reports (Appendix I, Biodiversity Development Assessment Report and Appendix S, Surface Water Assessment Report)
(c) Wetlands as described in s4.2 of the Biodiversity Assessment Method.	This SEAR is not relevant to groundwater and is addressed in other technical reports (Appendix I, Biodiversity

SEARs relevant to this technical report	Where addressed in this technical report
	Development Assessment Report)
(d) Groundwater.	Section 4
(e) Groundwater dependent ecosystems	Section 4
(f) Proposed intake and discharge locations	This SEAR is not relevant to groundwater and is addressed in Chapter 17, Soil, water and contamination
10. The EIS must describe background conditions for any water resource likely to be affected by the development, including:	
(a) Existing surface and groundwater.	Section 4
(b) Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations.	This SEAR is not relevant to groundwater and is addressed in other technical reports (Appendix S, Surface Water Assessment Report)
(c) Water Quality Objectives (as endorsed by the NSW Government http://www.environment.nsw.gov.au/ieo/index.htm) including groundwater as appropriate that represent the community's uses and values for the receiving waters.	Section 4
(d) Indicators and trigger values/criteria for the environmental values identified at (c) in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government.	Section 4
(e) Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions http://www.environment.nsw.gov.au/research-andpublications/publications-search/risk-based-framework-for-considering-waterwayhealth-outcomes-in-strategic-land-use-planning	This SEAR is not relevant to groundwater and is addressed in other technical reports (Appendix S, Surface Water Assessment Report)
11. The EIS must assess the impacts of the development on water quality, including:	Sections 4 and 7
(a) The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction.	Sections 4 and 7
(b) Identification of proposed monitoring of water quality.	No monitoring proposed due to limited anticipated impacts
(c) Consistency with any relevant certified Coastal Management Program (or Coastal Zone Management Plan).	This SEAR is not relevant to groundwater and is addressed in Chapter 18, Coastal processes

SEARs relevant to this technical report	Where addressed in this technical report
12. The EIS must assess the impact of the development on hydrology, including:	
(a) Water balance including quantity, quality and source.	Section 4
(b) Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas.	Sections 5 and 6
(c) Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems.	Sections 5 and 6
(d) Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (e.g. river benches).	This SEAR is not relevant to groundwater and is addressed in other technical reports (Appendix S, Surface Water Assessment Report)
(e) Changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water.	Sections 5 and 6
(f) Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options.	Section 7
(g) Identification of proposed monitoring of hydrological attributes.	No monitoring proposed
Environment Protection Authority	
Water - Quality The Proponent must:	
(a) state the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values;	Sections 4, 5 and 7
(b) identify and estimate the quality and quantity of all pollutants that may be introduced into the water cycle by source and discharge point and describe the nature and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm to human health and the environment;	Section 4
(c) identify the rainfall event that any water quality protection measures will be designed to cope with;	This SEAR is not relevant to groundwater and is addressed in Chapter 17, Soil, water and contamination
(d) assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;	Sections 5 and 6
(e) demonstrate how construction and operation of the project will, to the extent that the project can influence, ensure that: − where the NSW WQOs for receiving waters are currently being met they will continue to be protected; and − where the NSW WQOs are not currently being met, activities will work toward their achievement over time;	This SEAR is not relevant to groundwater and is addressed in Chapter 17, Soil, water and contamination

SEARs relevant to this technical report	Where addressed in this technical report
(f) justify, if required, why the WQOs cannot be maintained or achieved over time;	This SEAR is not relevant to groundwater and is addressed in Chapter 17, Soil, water and contamination
(g) demonstrate that all practical measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented;	Sections 7 and 8
(h) identify sensitive receiving environments (which may include estuarine and marine waters downstream) and develop a strategy to avoid or minimise impacts on these environments;	This SEAR is not relevant to groundwater and is addressed in other technical reports (Appendix S, Surface Water Assessment Report)
(i) identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality;	No monitoring proposed due to limited anticipated impacts
(j) consider turbidity curtains around the immediate works site that contain any plume strictly within the work site area to limit the impacts on the surrounding water quality and environs;	This SEAR is not relevant to groundwater and is addressed in Chapter 17, Soil, water and contamination
(k) provide a water quality monitoring plan which also identifies the thresholds which would result in ceasing activities; and	No monitoring proposed due to limited anticipated impacts
(l) consider the impact of sediment plumes associated with the operation of the facility on water quality (e.g. proximity of propellers to the substrate and proximity to sensitive environs).	This SEAR is not relevant to groundwater and is addressed in Chapter 17, Soil, water and contamination, and Chapter 18, Coastal processes
Soil and water The Proponent must:	
(a) assess the impact of the project on acid sulfate soils (including impacts of acidic runoff offsite) in accordance with the current guidelines	Sections 4 and 5
(b) characterise contaminated sediments and pore water within the proposal area, including the assessment of the volume of sediment materials to be dredged, potential for mobilisation of contaminated sediment and pore water	Sections 4 and 5
(c) describe the manner sediment and any contaminated sediments will be dredged and/or excavated	This SEAR is not relevant to the project as no dredging is anticipated.
(d) assess the impacts on soil and land resources (including erosion risk or hazard). Particular attention must be given to soil erosion and sediment and contaminant transport consistent with the practices and principles in the current guidelines.	This SEAR is not relevant to groundwater and is addressed in other technical reports (Appendix S, Surface Water Assessment Report)

SEARs relevant to this technical report	Where addressed in this technical report
(e) identify appropriate mitigation and management measures to safeguard the environment and people during construction and operation	Section 7
(f) identify potential risk to human health, aquaculture activities, seagrasses or the environment;	Section 4
(g) sampling and characterisation of the distribution of contamination should take into account the National Assessment Guidelines for Dredging 2009.	This SEAR is not relevant to the project as no dredging is anticipated.
Contamination The Proponent must:	
(a) assess whether the land is contaminated and determine the nature and extent of any soil, sediment, surface water and groundwater contamination;	Section 4 Appendix Q, Targeted Site Investigation (TSI)
(b) identify the appropriate contamination remediation, mitigation and management measures that are required to safeguard the environment and people during construction and operation;	Section 7 Appendix Q, Targeted Site Investigation
(c) consider the ecological and human health risks posed by the contamination in the context of existing and proposed land uses.	This SEAR is not relevant to groundwater and is addressed in Chapter 17, Soil, water and contamination
(d) ensure any site investigations undertaken, and the subsequent report/s, are prepared in accordance with relevant guidelines made or approved by the EPA under section 105 of the *Contaminated Land Management Act 1997*. Reports must be prepared by consultants certified under either the Environment Institute of Australia and New Zealand's Certified Environmental Practitioner (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia Certified Professional Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme;	This SEAR is not relevant to groundwater and is addressed in other technical reports (Appendix Q, Targeted Site Investigation)
(e) follow the processes outlined in State Environmental Planning Policy 55 - Remediation of Land (SEPP55), to assess the suitability of the land and any remediation required in relation to the proposed use.	This SEAR is not relevant to groundwater and is addressed in other technical reports (Appendix Q, Targeted Site Investigation)
Sutherland Shire Council	
Acid Sulphate Soils The wharf head is located on a class 5 acid sulphate soils area, but the remainder of the wharf will be located in a class 1 acid sulphate soils area. They need to investigate steps to avoid impacting acid sulphate soils, or management them if impacts can't be avoided.	Section 7

2 Policy and planning context

Legislation and regulatory guidelines relevant to this groundwater assessment are provided in Table 2-1.

Table 2-1: Legislation and guidelines relevant to the groundwater resources assessment

Regulation	Description
Water Management Act 2000	The NSW Department of Planning, Industry and Environment (DPIE) *Water Management Act of 2000* (WM Act) governs the issues of water pumping licenses to carry out further pumping work where a sharing license or framework is already in place. The WM Act is primarily a means to manage and safeguard the existence of rivers and aquifers used for commercial purposes.
Water Management (General) Regulation 2018	The Water Management (General) Regulation 2018 gives effect to the WM Act.
NSW Aquifer Interference Policy 2012	The purpose of the *Aquifer Interference Policy* (AIP) is to clarify the role and requirements of the Minister in charge of administering the WM Act in the water licensing and assessment processes for aquifer interferences. Furthermore, the policy aims to clarify the requirements for licensing about aquifer interference activities as well as establishing a consideration and advice structure for potential impact of an aquifer interference activity.
Australian and New Zealand Guidelines for Fresh and Marine Water Quality	The purpose of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality is to achieve the sustainable use of Australia's and New Zealand's water resources by protecting and enhancing their quality while maintaining economic and social development.
Risk Assessment Guidelines for Groundwater Dependent Ecosystems 2012	The risk assessment guidelines are used to manage land and water use activities that pose a potential threat to groundwater dependent ecosystems. The guidelines consist of four volumes that include the conceptual framework, worked examples, identification of high potential groundwater dependent ecosystems and their ecological value for coastal aquifers, and the risk of groundwater extraction on the coastal plains of NSW.
NSW State Groundwater Policy Framework Document 1997	The groundwater policy framework document is used to provide ecologically sustainable management guidance about groundwater quality protection, quantity management, dependent ecosystems, and resources for the people of NSW.
NSW State Groundwater Quality Protection Policy 1998	The groundwater protection policy falls under one of the three sub-categories of the groundwater policy framework document. The focus of this policy is to protect groundwater from polluted subsurface waters and the ecosystems from which these waters are recharged or into which they discharge.
NSW State Groundwater Dependent	The *groundwater dependent ecosystems policy* falls under one of the three sub-categories of the groundwater policy framework document. This document is designed to protect valuable ecosystems that rely on groundwater

Regulation	Description
Ecosystems Policy 2002	to survive, maintain the biophysical functions and preserve these ecosystems for the resources of future generations. Furthermore, the policy provides practical guidelines that can be used as tools to suit a specific need based on a given groundwater dependent ecosystem or environment.
NSW State Environmental Planning Policy 2018 – Coastal Management	The *NSW State Environmental Planning Policy (Coastal Management) 2018 (Coastal Management SEPP)* is focused on ecologically sustainable development that protects environmental assets of the coast, establishing a framework for land use planning to guide decision making in the coastal zone and defines coastal management areas including wetlands under SEPP 14.
NSW Water Sharing Plans	The NSW Office of Water defines Water Sharing Plans so that the equitable sharing of water and resources can occur sustainably and under a strict licensing and approvals process. Water sharing plans fall under the WM Act.
NSW Water quality and river flow objectives	The NSW Water Quality and River Flow Objectives have been set-out for fresh and estuarine surface waters to identify: • The community's values and uses of these surface waters • Water quality indicators to assess the current condition of the waterways. • These water quality and flow objectives are consistent with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000.
NSW Framework for Biodiversity Assessment – Appendix 2	The Framework for Biodiversity Assessment published by the Office of Environment and Heritage comprises the assessment methodology to quantify and describe the impact assessment requirements and assess all biodiversity values for major projects. Appendix 2 relates to the ordering of waterways and riparian buffer distances.
Acid Sulfate Soils Assessment Guidelines (DoP, 2008) / Acid Sulfate Soils Manual 1998	The NSW Government approach and advice to management of acid sulfate soils in New South Wales.

3 Methodology

The methodology undertaken for this groundwater assessment was as follows:

3.1 Baseline desktop analysis

A baseline desktop soil and water assessment were conducted for the La Perouse and Kurnell project areas using publicly available information from the following sources:

- The NSW Seamless Geology datasets of local and regional geology (Colquhoun *et al.*,2020). These provided the geological context of the project area including the following:
  - Geological stratigraphy
  - Geological structural features
  - Local and regional aquifers
- The Department of Planning, Industry and Environment (DPIE) Water Sharing Plan (WSP) for the Greater Metropolitan Region Groundwater Sources 2011 that details the groundwater sources in the area and the legislation and water management for each of these groundwater sources (DPIE, 2011)
- The Bureau of Meteorology (BOM) Groundwater Atlas (BOM, 2020a) which contains information on local groundwater users as well as groundwater dependent ecosystems (GDEs)
- The BOM climate data and rainfall statistics (BOM, 2020b)
- The Acid Sulfate Soils Probability of Occurrence, available from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Online Dataset (CSIRO, 2020), which shows the distribution of acid sulfate soils across the project area
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000) which provides information on relevant water quality guidelines and trigger values for fresh and marine waters.

The above sources of information have been used to present a conceptual model and detailed description of the groundwater environment surrounding the La Perouse and Kurnell project areas.

Geotechnical investigations were also undertaken as part of the project. Due to the limited potential interaction with groundwater and the expected minimal impact at the site (see Section 5 and 6), it was determined that groundwater monitoring would not be undertaken as part of these investigations.

3.2 Assessment of impacts

Groundwater impacts were assessed by analysis of all design elements of the project that may interact with groundwater. Identification of impacts to groundwater and groundwater receptors from these project design elements was undertaken, in order to address the SEARs. This assessment has focused on the following in the vicinity of the La Perouse and Kurnell project areas:

- Groundwater levels, flows and quality
- Existing groundwater users
- GDEs.

In addition, impacts and potential risks associated with groundwater on the new subsurface design features and surrounding infrastructure during construction and operation of the project have been assessed.

3.3 Recommendation of mitigation measures

Appropriate mitigation and management measures have been identified in order to safeguard the environment during construction and operation.

A gap analysis of missing information and recommendations was also conducted for additional site-based works.

4 Existing environment

The La Perouse and Kurnell project areas are situated within the Botany Bay area, regionally situated within the Sydney Basin.

4.1 Topography

The La Perouse construction boundary would be located at, or close to, sea level. The site is located at La Perouse Point, at the southern end of Frenchmans Bay. The ground elevation at the on-land portion of the site ranges from 13 metres above Australian Height Datum (mAHD) at the southern extent to 4 mAHD at the entrance to the ferry wharf. A topographical map of the area surrounding the proposed wharf at La Perouse is shown in the Section 4.2 of Appendix S, Surface Water Assessment Report.

The Kurnell construction boundary would be located at, or close to, sea level. Captain Cook Drive and the proposed ferry wharf are at elevations of approximately 2 to 3 mAHD. The topography of the site gently descends towards Botany Bay to the north-west. A topographical map of the area surrounding the Kurnell Wharf is shown in Section 4.3 of Appendix S, Surface water Assessment Report.

4.2 Geology

As per the 1:100,000 geology map (Figure 4-1 and Figure 4-2**)**, the geology surrounding the project area is typically Cenozoic Age coastal deposits overlying Triassic Age Hawkesbury Sandstone.

4.2.1 Regional geology: Botany Bay setting

The Botany Sand Beds (Cenozoic) are the principal near surface sedimentary unit within the Botany Basin and comprise up to 30 metres of uniformly graded, well-sorted, clean and poorly cemented fine- to medium-grained quartz sands.

In some areas the Hawkesbury Sandstone is found at surface, commonly along the cliff lines, where coastal sand deposits have not been deposited. The Triassic Age Hawkesbury Sandstone is conceptually treated as the lowest hydrogeological unit of interest for the project, due to the predominantly shallow nature of the project.

All geologies found in the Botany Bay area, and their descriptions, are listed in Table 4-1.

Table 4-1: Mapped geological unit descriptions

Geological unit (code)	Description	Depositional Environment	Proximity to project area
Coastal deposits – beach facies (Qbb)	Marine-deposited quartz-lithic fine- to medium-grained sand, shell and shell material, polymictic gravel	Terrestrial - alluvial fan	La Perouse project area
Coastal deposits-bedrock-mantling dune facies (Qbdr)	Marine-deposited and aeolian-reworked fine- to coarse-grained quartz-lithic sand with abundant carbonate, sporadic humic debris in stabilised dunes	Cenozoic Transitional (Marine-Terrestrial) Deposits	Kurnell project area
Estuarine shoreline ridge and dune (Qer)	Fine- to medium-grained lithic-quartz sand (fluvially deposited), very fine- to fine-grained lithic-carbonate-quartz sand (marine deposited), polymictic gravel, silt, clay, shell material	Cenozoic Terrestrial Deposits	Kurnell project area
Undifferentiated coastal deposits (Qb)	Undifferentiated (marine-deposited) quartz-lithic to carbonate fine- to medium-grained sand, indurated sand, shell material, silt, organic mud	Terrestrial - fluvial	Kurnell project area
Coastal deposits – Bay sand sheet (Qbyw)	Medium to fine-grained quartzose sand; slightly shelly; well-sorted	Cenozoic Transitional (Marine-Terrestrial) Deposits	La Perouse and Kurnell project areas
Hawkesbury Sandstone (Tuth)	Medium to coarse grained quartz sandstone with very minor shale and laminate lenses.	Terrestrial – fluvial from Middle Triassic	La Perouse and Kurnell project areas

4.2.2 Local geology

In the La Perouse project area, the majority of the construction is directly into Hawkesbury Sandstone around La Perouse Point. The only exception is the offshore piles which will be installed into the sand deposits along the seabed of Botany Bay, penetrating through to the Hawkesbury Sandstone bedrock at these locations.

At La Perouse, three test pits that were carried out as part of the pre-construction ground investigation for this project, encountered bedrock. These pits were located within the sandstone outcrops along the cliff lines. These pits encountered

bedrock at between 0.8 to 1.3 metres below ground level (mbgl) (10.9 to 11.5 mAHD).

The project area at Kurnell is generally underlaid by the same Cenozoic Age coastal sand deposits and Triassic Age Hawkesbury Sandstone which underlie the La Perouse Wharf. The majority of onshore piles at Kurnell would be into the Hawkesbury Sandstone, whilst the proposed utilities at Kurnell would be installed into the coastal sand deposits and estuarine shoreline deposits.

Again, the only test pits to encounter bedrock at Kurnell were situated in areas where sandstone outcrops, close to the entrance of the new ferry wharf. These pits encountered bedrock at depths of approximately 0.8 to 1.1 mbgl (-1 to 1.6 mAHD).

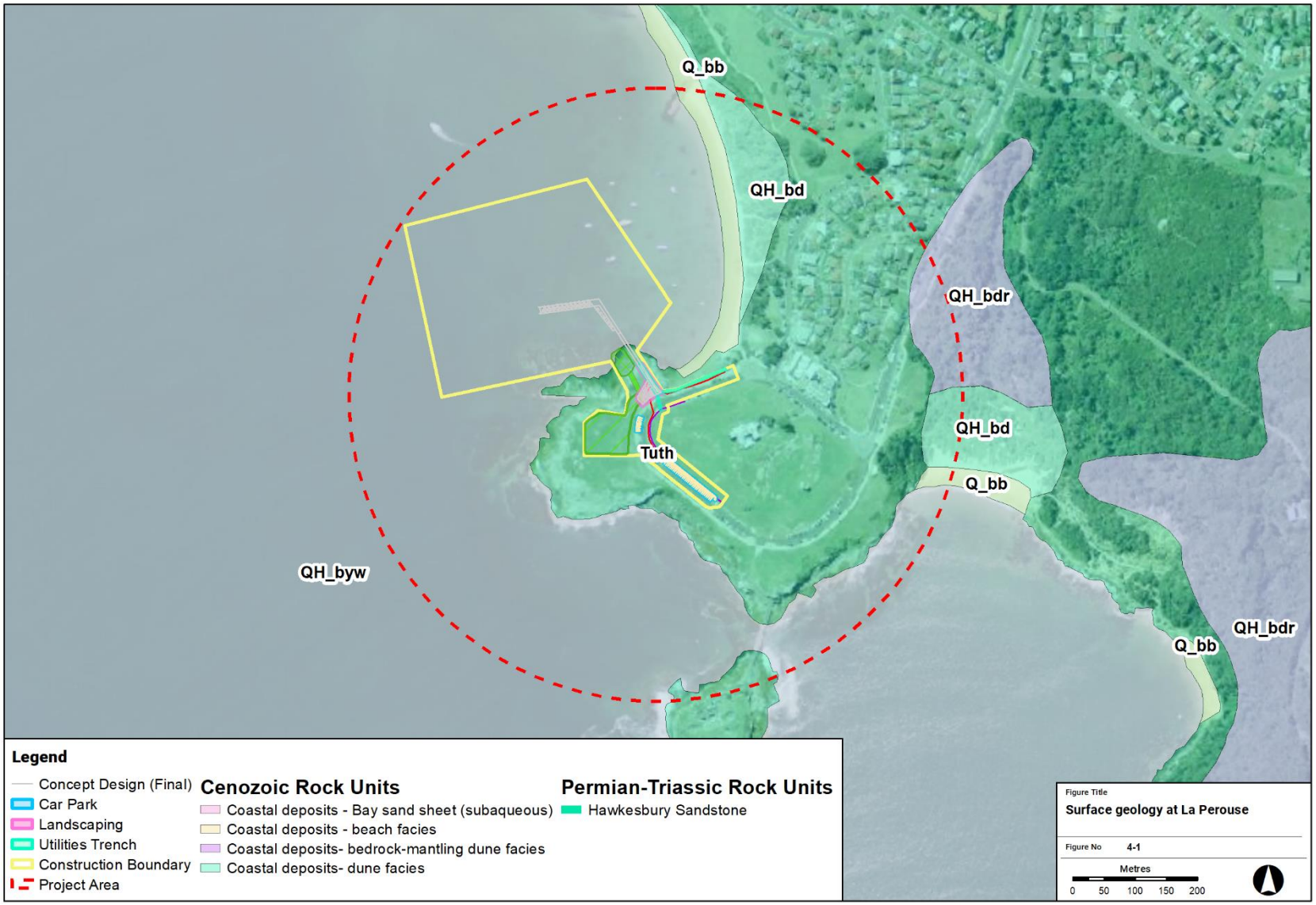

Figure 4-1: Surface geology at La Perouse

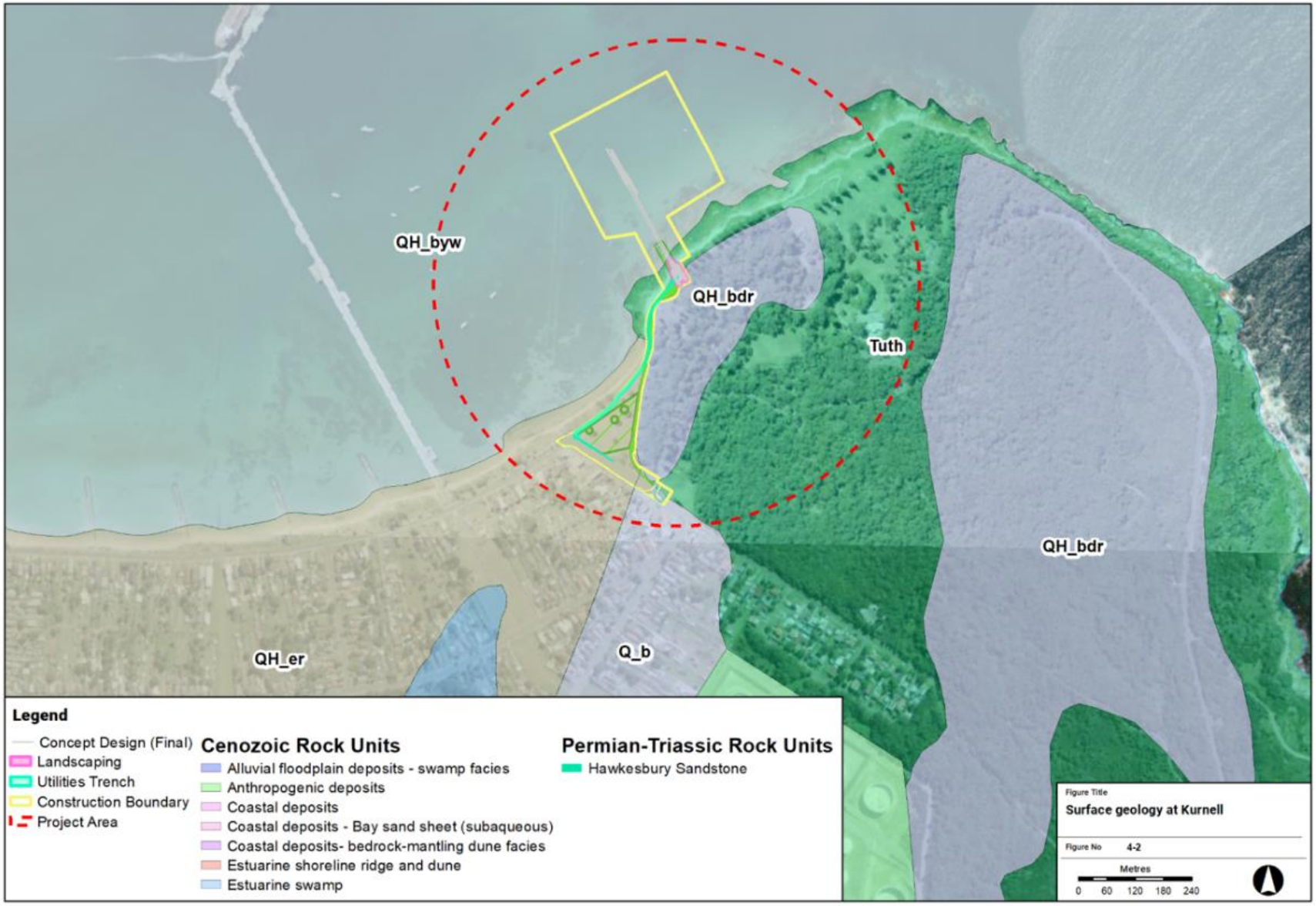

Figure 4-2: Surface geology at Kurnell

4.3 Climate

Sydney has a humid subtropical climate which shifts from mild and cool in the winter to warm and hot in summer. Local rainfall statistics for the site have been taken from the nearest rainfall gauge at Sydney Airport (Station ID: 066037), located approximately seven kilometres and 7.5 kilometres north-east of the La Perouse and Kurnell project areas respectively (Bureau of Meteorology, 2020b) The summary of rainfall observed at Sydney Airport is summarised in Figure 4-3.

The average annual rainfall at this station is 1077.1 millimetres with rainfall being generally higher in the summer and autumn seasons, and lower in the winter and spring seasons.

Recharge to the Botany Sands and Hawkesbury Sandstone aquifers surrounding Botany Bay is from a combination of both direct precipitation in rural areas and leakage from utilities and services in urban areas.

Both the La Perouse and Kurnell project areas are located within the Kamay Botany Bay National Park with limited impermeable surfaces and utilities characteristic of urban settings. Therefore, within the La Perouse and Kurnell project areas, local precipitation is considered the dominant recharge mechanism locally to the unconfined Botany Sands and Hawkesbury Sandstone aquifers (more detail on aquifers provided in Section 0).

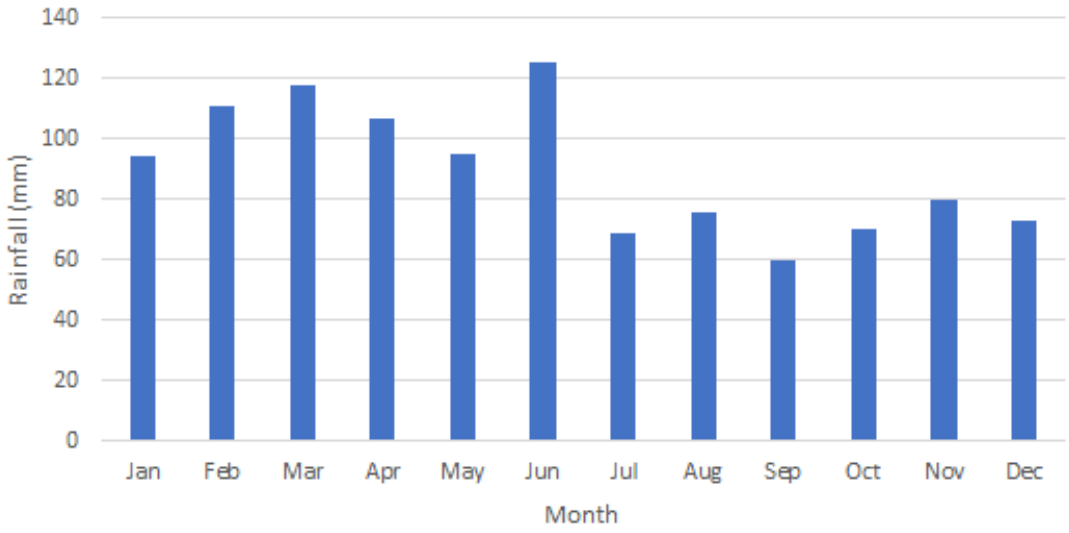

Figure 4-3: Mean monthly rainfall at Sydney Airport AMO – Station ID: 066037

4.4 Hydrogeology

4.4.1 Aquifers

The La Perouse project area is within the Sydney Basin Central Groundwater Source, part of the Greater Metropolitan Region Groundwater Sources 2011 WSP (DPIE, 2011). This groundwater source is associated with the Hawkesbury Sandstone and is generally considered to be a porous rock source where the main flow occurs through the pore spaces in the rock mass (NSW Office for Water, 2011). Where fractures are present, they can significantly increase the conductivity and productivity of the aquifer.

The Kurnell project area is also within the Sydney Basin Central Groundwater Source, though part of the project area (associated with the car parking at La Perouse and utilities at both sites) lies within the Botany Sands Groundwater Source (Botany Sands), also part of the Greater Metropolitan Region Groundwater Sources 2011 WSP. The Botany Sands aquifer is classified as a porous, extensive and highly productive aquifer.

Due to the contamination of groundwater within the Botany Sands, the area has been divided into four management zones (NSW Department of Planning, Industry and Environment, 2020). The locations of these management zones are allocated depending on the source, extent, and type of contamination present, as well as the targeted remediation. This allows for the effective control and local management of water supply works within each zone to protect public health from exposure to potentially contaminated groundwater. In Zone 1, all use of groundwater is prohibited. In Zones 2, 3 and 4, all domestic groundwater use is banned, and all industrial users must test their bore water annually. Part of the La Perouse project area lies within Management Zone 4 of the Botany Sands aquifer. The Kurnell project area does not lie within any contamination management zone.

The project areas at both La Perouse and Kurnell are composed of two aquifer systems; an unconfined aquifer associated with the unconsolidated coastal sands of the Botany Sands and an unconfined to regionally semi-confined aquifer associated with the underlying Hawkesbury Sandstone. There is likely a hydraulic connection between the two aquifers within the project areas.

4.4.2 Groundwater levels and flow

The closest monitoring boreholes (BOM, 2020) are located inland more than 200 metres from the La Perouse project area and do not provide information on the depth to groundwater. However, due to the project being located adjacent to the coastline, the groundwater level is expected to be at, or close to, sea level. Higher groundwater levels may be encountered along topographical high points, such as the cliff lines at La Perouse. This is due to these high points acting as recharge points for groundwater.

The groundwater level within the Kurnell project area is expected to be at, or close to sea level. Bores within 500 metres of the project area indicate that the groundwater level ranges from 0 to 3 metres mbgl.

On-site shallow test pits have been carried out within both the La Perouse and Kurnell study areas as part of the pre-construction ground investigation. At both sites the majority of test pits did not encounter groundwater. At La Perouse, water seepage was encountered in one test pit at 1.15 mbgl (11.57 mAHD) associated with the top of the sandstone bedrock along the La Perouse cliff line.

At Kurnell, groundwater was encountered in one test pit at 0.6 mbgl (1.5 mAHD) within sands of the Botany Sands aquifer. It is noted that these measurements are unlikely to capture the full range of groundwater levels within the project areas, especially in regard to groundwater maximums after prolonged recharge events or high tides. For a conservative approach, groundwater levels haven been taken as at ground level for this assessment and mitigation strategies.

Water levels within the unconsolidated Botany Sands aquifer generally follow topography and will be recharged predominantly by precipitation. The underlying Hawkesbury Sandstone is likely in hydraulic connection with the Botany Sands aquifer. Groundwater flow direction within both project areas will be towards Botany Bay.

4.4.3 Groundwater quality

The groundwater within the La Perouse and Kurnell project areas is potentially saline due to the proximity of both project areas to the saline water bodies of Botany Bay and the Tasman Sea. Groundwater below the permanently submerged level is expected to be saline. Groundwater within the intertidal zones is likely to be in hydraulic connection with the saline sea water allowing for a mixing of the denser saline water with fresher lenses of groundwater overlying them. The salinity of the groundwater at the sites will depend on the degree of mixing between the two water bodies but it is likely that fresh/brackish water will be present below the land sections of the project, and saline groundwater elsewhere.

There is potential for organic contamination around the La Perouse project area, associated with the Botany Sands aquifer. There is no known organic contamination around the Kurnell project area.

4.4.4 Hydraulic parameters

Hydraulic conductivity is a property of soil or rock which describes the ease at which water can move through pore spaces or fractures. Hydraulic conductivities within the Botany Sands are considered relatively high and are expected to range from between 1 and 85 m/day (Hatley, 2004).

Hydraulic conductivities of the underlying Hawkesbury Sandstone are expected to be lower at around 0.001 m/day, though may be higher where an extensive fracture network exists.

4.4.5 Groundwater dependent ecosystems

Based on preliminary desktop studies focusing on the Greater Metropolitan Region Groundwater Sources 2011 WSP, there are no high-priority GDE's located within either the La Perouse or Kurnell project areas.

The BOM GDE Atlas show's that there are small, isolated areas of high-potential and medium-potential sandstone clifftop and coastal sand GDE's at Kurnell within the Kamay Botany Bay National Park. These potential GDE's are surface expressions of groundwater associated with the Hawksbury Sandstone. Although these potential GDE's lie outside the construction boundary of the project, some lie within the project area at Kurnell, close to the utilities works.

4.4.6 Groundwater users

There are seven boreholes located within one kilometre of the La Perouse project area (as shown on Figure 4-4). These bores are used for monitoring or for licensed water supply or industrial purposes, and are all associated with the coastal sands of the Botany Sands Groundwater Source. There is currently an enforced ban on domestic groundwater use in the area and an embargo on new applications for licences to extract groundwater from the Botany Sands Groundwater Source in this location (NSW Government, 2003 and NSW Government, 2007).

There are 98 boreholes located within one kilometre of the Kurnell project area (as shown on Figure 4-5). Boreholes are present to the south and south-west that are used for mix of licensed industrial, water supply, remediation and monitoring purposes. Most of these bores extract groundwater from the coastal sand deposits of the Botany Sands Groundwater Source.

Figure 4-4: Neighbouring Groundwater Users (La Perouse)

Figure 4-5: Neighbouring Groundwater Users (Kurnell)

4.4.7 Acid sulfate soils

Acid sulfate soils (ASS) are sediment deposits that contain iron bearing sulfides. ASS are typically found in swamps and estuaries below 10 mAHD. Left undisturbed ASS are generally harmless and considered potential acid sulphate soils (PASS). If PASS is disturbed by activities such as excavation or lowering groundwater levels, the PASS materials can oxidise rapidly to form sulfuric acid and mobilise aluminium and heavy metals within the subsurface. The generation of acid and toxic heavy metal plumes results in hazards and impacts to the environment and subsurface structures.

A probability of the occurrence of encountering ASS is presented in Figure 4-6 and Figure 4-7. Any works that involve offshore excavations are within an area of high probability of ASS occurrence (>70%). This is associated with the presence of possible marine sedimentary deposits on the floor of Botany Bay. All land-based excavations will be within soils where there is a low (6 to 70%) or an extremely low probability of ASS occurrence (1 to 5%).

4.4.8 Water quality objectives

Groundwater quality objectives should be compared to the ANZECC & ARMCANZ (2000) guidelines for marine water or fresh water. Any plan implemented should adhere to the water quality guidelines and trigger values mentioned in this document.

The Botany Bay area has numerous contaminated sites and therefore the Department of Planning, Industry and Environment has developed a different management approach for the Botany Bay sand aquifers, based on four different contamination management zones, depending on level of contamination.

Surface water quality in La Perouse and Kurnell is influenced by runoff from Cooks River, Georges River and other smaller tributaries that are within the Botany Bay catchment. Suspended sediments concentration in Botany Bay vary due to fluvial and oceanic conditions. During calm conditions, sediment concentrations recorded an average of 5 mg/L, however, after heavy rainfall, concentrations can significantly increase to 25 mg/L across the bay. Information on soil erosion and further information regarding surface water quality objectives is detailed in Appendix S, Surface water assessment report.

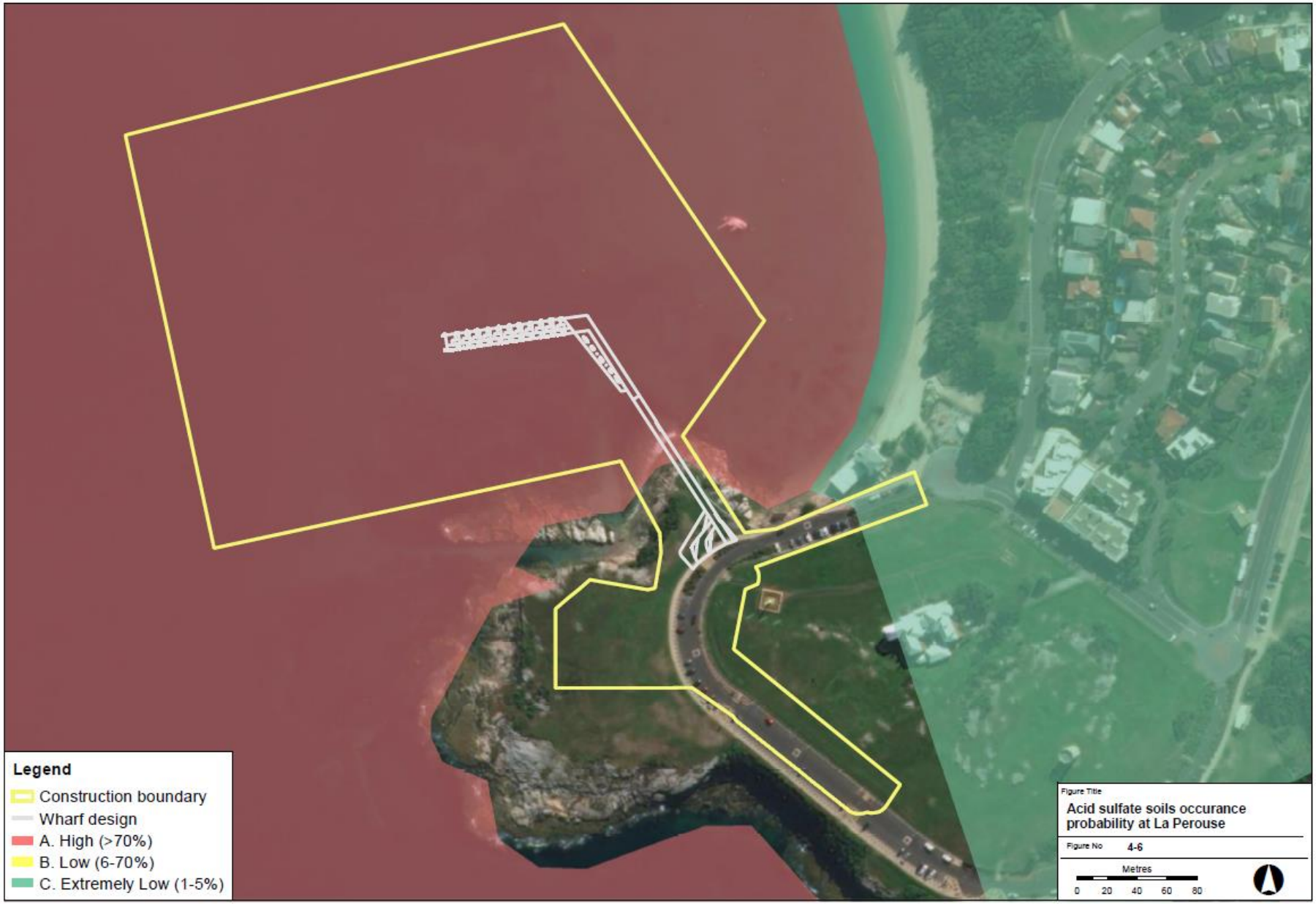

Figure 4-6: Acid Sulfate Soils occurrence at La Perouse

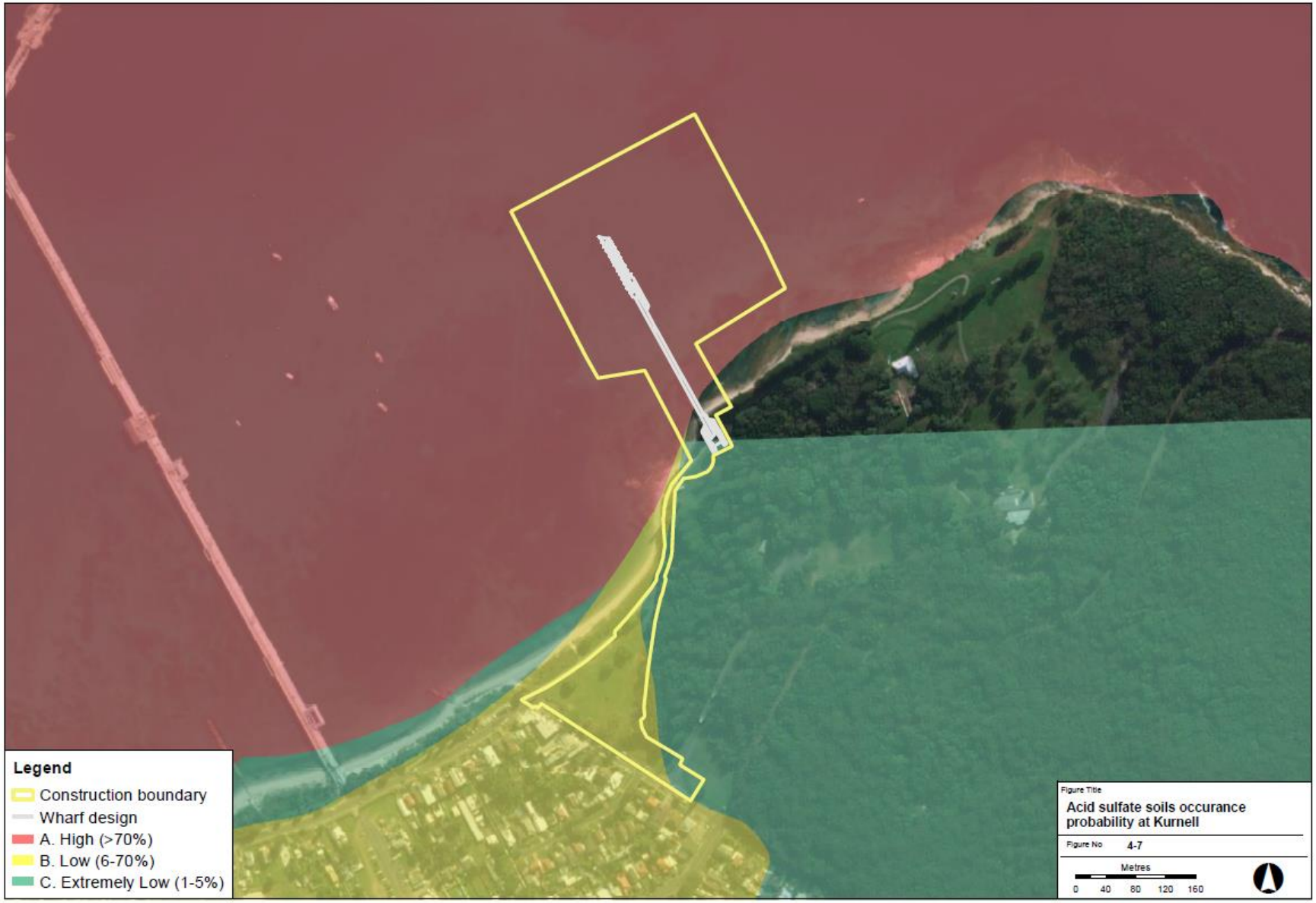

Figure 4-7: Acid Sulfate Soils occurrence at Kurnell

5 Assessment of potential construction impacts

The following section assesses the potential construction impacts as a result of the project without any mitigation. A summary of the risks is presented in Table 7-1 with recommended mitigation measures.

5.1 Impact on groundwater levels, flow and connectivity

5.1.1 Wharf structures

The proposed La Perouse and Kurnell wharves involve deep pile structures which would be installed down to bedrock both onshore and within Botany Bay. Within the Bay these will penetrate fully through the seabed bay sand sheet deposits underneath Botany Bay. These sand deposits will be fully saturated beneath Botany Bay and therefore these construction works are likely to interact with the groundwater within these deposits (which is expected to be saline). Below the bay, lateral groundwater flow is likely to be limited and the pier structures are unlikely to have any impact on groundwater levels or flow.

On land, groundwater flow is expected to be towards the Bay and close to the surface. The deep pile structures may act as barriers to groundwater flow and could cause localised changes in groundwater levels and flow direction. On land at La Perouse, groundwater level is likely to be deeper as a result of topographic variation. In these areas the groundwater level may be below the base of the piles and would have no impact on groundwater.

The spatial extent of pier structures in relation to the wider Botany Sands aquifer and Hawkesbury Sandstone aquifer is limited and therefore potential risks and changes to groundwater levels and flow will be localised and minor, and not considered to be significant in the wider aquifer.

5.1.2 Utilities and car parking

Shallow excavation trenches would be dug for the proposed utilities at both sites and new car park surfaces at La Perouse associated with the new wharves. These excavations may encounter shallow groundwater levels, especially within the estuarine shoreline ridge and dune coastal deposits at Kurnell where groundwater is expected to be high.

Due to no groundwater monitoring taking place as part of this project, it has been assumed for this assessment that groundwater within the onshore part of the project areas is situated at ground level at both La Perouse and Kurnell.

The excavations for the proposed utilities and car park surfaces are of limited depth of up to 900 millimetres. They are anticipated to encounter high groundwater levels and therefore mitigation will need to be put in place to

adequately control and remove the groundwater entering the excavations and dispose of the water back to ground.

The inflow to these trenches is likely to be small and groundwater dewatering activities short-term.

Overall impacts on groundwater levels and flow are likely to be minor due to the shallow nature of the trenches for the utility structures at both sites and car park surfaces at La Perouse, and are expected to only cause localised, temporary changes to groundwater level.

5.2 Impact on groundwater users

5.2.1 Wharf structures

Based on the anticipated groundwater flow direction, which is towards the bay, all groundwater bores are expected to be located upgradient and from the proposed wharves at both La Perouse and Kurnell. The construction of the wharves is unlikely to affect groundwater levels or flow (except very locally) and are not anticipated to affect the flow or yield of the bores of nearby groundwater users.

5.2.2 Utilities and car parking

The earthworks required for the utilities and car parking at La Perouse are located at least one kilometre away from the neatest water supply bore. Therefore, interaction with nearby existing groundwater users is considered unlikely at La Perouse, and the impact on the groundwater users from the trench excavations is expected to be negligible.

The earthworks required for the utility works at Kurnell are located closer to existing groundwater users, with the nearest bore located within the Kurnell project area and approximately 100 metres from the utilities works. However, no impacts are anticipated at these bores regarding flow to, or yield, as all trench structures are shallow in depth and any impacts in the surrounding aquifer will be of limited extent. Therefore, the impact to nearby users is considered negligible.

5.3 Impact on groundwater quality

5.3.1 Wharf structures

The pier structures for both the La Perouse and Kurnell wharves will extend through sand deposits that have a high probability of occurrence for ASS. Any disturbance of these sediments results in a risk of oxidising and mobilising these ASS and causing contamination of the nearby watercourses and aquifers.

On shore and within the intertidal zone the pile structures may interact with less saline water within the Botany Sands and Hawkesbury Sandstone. During piling it is possible that there will a temporary connection between the shallow less saline water and deeper more saline water, leading to mixing and a possible reduction in water quality within the shallow groundwater. The risk is considered minor since

any connection will be temporary (until the pile is grouted) and likely to affect only a small area around the pile. The proposed piling methodology which is likely to be driven tubular steel piles within soils and bored concrete piles within the rock below will form a relatively tight interface minimising the mixing between the marine and groundwaters and reducing the potential impact to groundwater quality.

At La Perouse, on shore piers may be above the regional groundwater level which would have no predicted impact on groundwater quality.

There is potential for organic contamination around the La Perouse project area (NSW Department of Planning, Industry and Environment, 2020), however as the project will not penetrate the Botany Sands aquifer (main source of contamination) in this location, it is considered unlikely that this contamination will be disturbed as part of the project. There is no known organic contamination around the Kurnell project area and therefore no known risk of plume mobilisation in this area.

There is also a minor risk of accidental spills during construction as a result of activities, which may intercept groundwater. Minor releases of contamination due to accidental spillages may locally affect groundwater quality but are unlikely to impact on groundwater users, which are upgradient of the project. The risk of a major spillage event that could affect upgradient groundwater quality through dispersion of contamination is considered negligible.

5.3.2 Utilities and car parking

There is a minor risk of accidental spills during construction as a result of construction activities, which may intercept groundwater.

5.4 Impact on potential GDEs

5.4.1 Wharf structures

There are no high-priority GDE's in the vicinity of the project area and therefore they have not been considered further in this assessment.

The potential GDE's on the BOM GDE Atlas (BOM, 2019) are upgradient of the wharf structures at Kurnell and therefore any potential change or reduction in groundwater baseflow to these features is considered negligible.

5.4.2 Utilities and car parking

The potential GDE's at Kurnell on the BOM GDE Atlas (BOM, 2019) are not within the construction boundary and therefore are not directly impacted by these components of the project.

However, due to the proximity of these potential GDE's to the utilities trench, there is a minor risk of reduction of baseflow temporarily to these potential GDE's as a result of construction and potential dewatering requirements of the trench structures.

6 Assessment of potential operational impacts

The following section details the potential operational impacts as a result of the project without any recommended mitigation. A summary of the impacts is presented in Table 7-1 with recommended mitigation measures.

6.1 Impact on groundwater levels, flow and connectivity

6.1.1 Wharf structures

There is potential for groundwater flow path disturbance from deep in-situ structures associated with the piers of the ferry wharves. This could result in mounding and changes in flow paths around new below ground structures. Impacts on groundwater levels and flow are considered negligible as the spatial extent of these piers in relation to the wider Botany Sands aquifer and Hawkesbury Sandstone aquifer is limited.

6.1.2 Utilities and car parking

The increase in low permeability paved surfaces for the car parking area at La Perouse could result in a permanent reduction in groundwater infiltration, impacting on groundwater levels and flows within the aquifers. This is anticipated to have a negligible impact on the recharge to the unconfined aquifers. The proposed car parking area is small in comparison to the existing car parking areas and the change in impervious area would be minimal with a negligible change to the overall recharge area of the aquifers.

6.2 Impact on groundwater users

Any changes to groundwater flow and recharge rates as part of the operation of the project will be localised and minor. Therefore, no impact from operation is anticipated on groundwater users as all groundwater user bores are located upgradient, and at distance from, the project.

6.3 Impact on groundwater quality

There is potential for contamination of groundwater as a result of accidental spills from operational ferry services. Any accidental spill could reduce the groundwater quality in the vicinity of that spill.

6.4 Impact on potential GDEs

Any changes to groundwater flow and recharge rates as part of the operation of the project will be localised and minor. Therefore, no impact from operation is anticipated on the potential GDE’s identified on the BOM GDE Atlas (BOM, 2019).

7 Environmental management measures

This section provides a summary of the construction and operational risks pre-mitigation described in Section 5 and 6 and the appropriate mitigation measures required for these risks. These are summarised further in Table 7-1.

Table 7-1: Environmental management measures for groundwater impacts

Impacts	Mitigation	Responsibility	Timing
Risks during construction of small to medium scale / lower risk projects in relation to water pollution.	**Soil and Water Management Plan** A Soil and Water Management Plan (SWMP) will be prepared in accordance with QA Specification G38 and implemented as part of the Construction Environmental Management Plan (CEMP). The Plan will identify all reasonably foreseeable risks relating to soil erosion and water pollution associated with undertaking the activity and describe how these risks will be managed and minimised during construction. The plan will include arrangements for managing pollution risks associated with spillage or contamination on the site and adjoining areas.	Transport for NSW / Contractor	Pre-construction / Detailed design
Mitigating risks of surface infiltration or contamination (including accidental spills) to groundwater	In addition to the implementation of general erosion, sediment and water quality control safeguards (above), any sediment basins, stockpiles, washdowns, batch plants, refuelling and chemical storage sites will be lined and/or bunded.	Transport for NSW / Contractor	Pre-construction / Detailed design
Mitigating risks associated with intersecting groundwater	In locations where the project has a high risk of intersecting groundwater, such as cut or fill with a depth greater than 0.5 m management measures will be implemented to minimise potential adverse impacts in accordance with the RTA Technical Guideline for Environmental Management of Construction Site Dewatering: Environmental management of construction site dewatering. That may include, but not necessarily be limited to: • Options to collect and store groundwater, testing as per ANZECC & ARMCANZ (2000) guidelines to enable recharge of the water table (such as via grassed swales).	Transport for NSW / Contractor	Pre-construction / Detailed design / Construction

Impacts	Mitigation	Responsibility	Timing
	• Where recharge is not appropriate or feasible, discharging groundwater to the surface water drainage system following appropriate treatment to ensure discharged water is of sufficient quality.		
Minimise risks during construction of wharf piers/piles of disturbing sediments with high potential ASS.	An Acid Sulfate Materials will managed as part of the CEMP. The measures will be prepared in accordance with the RTA Guidelines for the Management of Acid Sulfate Materials.	Transport for NSW / Contractor	Pre-construction / Detailed design / Construction

8 Summary of residual impacts

This section provides a summary of the construction and operational risks both pre-mitigation and any residual impacts remaining after the implementation of the management measures describe in Section 7. Pre-mitigation and residual impacts are summarised in Table 8-1.

Table 8-1: Summary of pre-mitigation and residual impacts

Potential pre-mitigation adverse impact	Relevant management measures	Potential residual impact after implementation of management measures	Comment on how any residual impacts would be managed
Construction			
Risks during construction of small to medium scale / lower risk projects in relation to water pollution.	A Soil and Water Management Plan (SWMP) will be prepared in accordance with QA Specification G38 and implemented as part of the Construction Environmental Management Plan (CEMP).	Implementation of mitigation measures will reduce likelihood of groundwater pollution occurring during the construction of the project from accidental spills or otherwise. Potential residual minor impact from unforeseeable incidents or if the water management plan is not implemented correctly.	None required.
Mitigating risks of surface infiltration or contamination (including accidental spills) to groundwater	In addition to the implementation of general erosion, sediment and water quality control safeguards (above), any sediment basins, stockpiles, washdowns, batch plants, refuelling and chemical storage sites will be lined and/or bunded.	Implementation of mitigation measures will reduce likelihood of groundwater pollution occurring during the construction of the project from accidental spills or otherwise. Potential residual minor impact from unforeseeable incidents outside of arrangements for managing pollution.	None required.
Mitigating risks associated with intersecting groundwater	In locations where the project has a high risk of intersecting groundwater, such as cut or fill with a depth greater than 0.5 m management measures will be implemented to minimise potential	Trenches are of limited depth and inflows are expected to be limited. Therefore, after mitigation measures, no residual impacts are anticipated.	None required.

Potential pre-mitigation adverse impact	Relevant management measures	Potential residual impact after implementation of management measures	Comment on how any residual impacts would be managed
	adverse impacts in accordance with the RTA Technical Guideline: Environmental management of construction site dewatering.		
Mitigating risks with reduction of local groundwater levels during construction dewatering of the utilities at both sites and car parking structures at La Perouse.	Options to collect and store groundwater will be present at both La Perouse and Kurnell. This groundwater should be tested as per ANZECC & ARMCANZ (2000) guidelines and discharged back to ground to enable recharge of the water table (such as via grassed swales).	Trenches are of limited depth and inflows are expected to be limited. Therefore, after mitigation measures, no residual impacts are anticipated.	None required.
Minimise risks during construction of wharf piers/piles of disturbing sediments with high potential ASS.	An Acid Sulfate Materials Management Plan will be prepared and implemented as part of the CEMP. The Plan will be prepared in accordance with the RTA Guidelines for the Management of Acid Sulfate Materials.	The Acid Sulfate Materials Management Plan should cover all risks associated with disturbance of ASS, though pollution of waterways and groundwater may occur through unforeseeable events.	None required.

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