

Appendix F

Groundwater Management Sub-Plan

Western Harbour Tunnel

May 2024

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Document control

Approval and authorisation

Approved on behalf of ACCIONA by	Andrew Marsonet
Signed	
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Glossary/ Abbreviations

Abbreviation / term	Expanded text
Ancillary facility	A temporary facility for construction of the CSSI including an office and amenities compound, construction compound, material crushing and screening plant, materials storage compound, maintenance workshop, testing laboratory, material stockpile area and car parking facilities. <i>Note: where an approved management plan contains a stockpile management protocol, a material stockpile area located within the construction boundary is not considered to be an ancillary facility.</i>
AIP	Aquifer Interference Policy
ANZECC	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ASS	Acid Sulfate Soils
CEMP	Construction Environmental Management Plan
Construction	Has the same definition as Schedule 1 of the planning approval (SSI #8863)
CSSI	Critical State Significant Infrastructure
DLWC	Department of Land and Water Conservation
DPE	NSW Department of Planning and Environment (formally Department of Planning, Industry and Environment)
DPE – Water	NSW Department of Planning and Environment – Water (formally Department of Planning, Industry and Environment)
DPIE	New South Wales Department of Planning, Industry and Environment
DPIE – Water	New South Wales Department of Planning, Industry and Environment – Water)
EESG	Environment, Energy and Science Group of the Department of Planning, Industry and Environment (formerly known as NSW Office of Environment and Heritage)
EIS	Environmental Impact Statement
EPA	NSW Environment Protection Authority
Environmental Representative (ER)	The Environmental Representative(s) for the CSSI approved by the Planning Secretary
GDEs	Groundwater Dependent Ecosystems

Abbreviation / term	Expanded text
GMP	Groundwater Management Sub-plan
GWMP	Groundwater Monitoring Program
IS	Infrastructure Sustainability
Material harm	Is harm that: (a) Involves actual or potential harm to the health or safety of human beings or to the environment that is not trivial, or (b) Results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding \$10,000 (such loss includes the reasonable costs and expenses that would be incurred in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment)
mbgl	Metres below ground level
MCoA	Minister's Conditions of Approval
MOD2	Western Harbour Tunnel and Warringah Freeway Upgrade TBM solution of crossing Sydney Harbour – Modification 2
NEPM	National Environment Protection (Assessment of Contaminated Land) Measure
Non-compliance	Failure to comply with the requirements of Project approval or any applicable licence, permit or legal requirements
Non-conformance	Failure to conform to the requirements of Project system documentation including the CEMP or supporting documentation
NoW	NSW Office of Water
Planning Approval Documents	Approval documentation as listed under MCoA A1
Project, the	Western Harbour Tunnel project
RAP	Remediation Action Plan
REMM	Revised Environmental Management Measure
Roads and Maritime	Roads and Maritime Services (now Transport for New South Wales)
RtS	Response to Submissions Report
SMART	Specific, Measurable, Attainable, Relevant, Time-based
SSTV	Site Specific Trigger Values
TfNSW	Transport for New South Wales (formerly Roads and Maritime)
WFU	Warringah Freeway Upgrade (a component of the DPIE Approved Western Harbour Tunnel and Warringah Freeway Upgrade project – SSI 8863)

Abbreviation / term	Expanded text
WHT	Western Harbour Tunnel (a component of the DPIE Approved Western Harbour Tunnel and Warringah Freeway Upgrade project – SSI 8863)
WTP	Water Treatment Plant(s)

1 Introduction

1.1 Context

This Groundwater Management Sub-plan (GMP or Plan) forms part of the Construction Environmental Management Plan (CEMP) for the Western Harbour Tunnel (WHT) (the Project), a component of the Western Harbour Tunnel and Warringah Freeway Upgrade project.

This GMP has been prepared to address the requirements of the Minister's Conditions of Approval (MCoA) for the Western Harbour Tunnel and Warringah Freeway Upgrade project (SSI #8863), the Western Harbour Tunnel and Warringah Freeway Upgrade Environmental Impact Statement dated January 2020 (the EIS), the Western Harbour Tunnel and Warringah Freeway Upgrade Response to Submissions report dated September 2020 (the RtS), Western Harbour Tunnel and Warringah Freeway Upgrade TBM solution of crossing Sydney Harbour – Modification 2 (MOD2) and applicable guidelines and legislation.

This Plan describes how ACCIONA propose to manage potential groundwater impacts during the construction of the Project.

1.2 Background and Project description

The Western Harbour Tunnel and Warringah Freeway Upgrade project comprises a new 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 enable the future connection of the Beaches Link and Gore Hill Freeway Connection project.

The Project will connect the approved M4-M5 Link in Rozelle to the Warringah Freeway at North Sydney/Cammeray. The Project will traverse from Rozelle to Cammeray, primarily comprising twin 6.5-kilometre bored/excavated tunnels with a crossing of Sydney Harbour, supported by surface based ancillary facilities.

The EIS was prepared to assess the impacts of construction and operation of the WHT and WFU project. As part of the EIS development, a groundwater specialist paper (*Technical working paper: Groundwater*, Appendix N of the EIS) was prepared to address the groundwater issues. The findings of the groundwater paper were summarised in Chapter 16 (Geology, Soils and Groundwater) of the EIS.

A Response to Submissions Report (RtS) was prepared in response to submissions received on the EIS. The RtS includes clarifications as well as further detail relating to groundwater management issues of the Project. The EIS environmental management measures were revised and included in Part D of the RtS.

The Western Harbour Tunnel and Warringah Freeway Upgrade project was declared to be Critical State Significant Infrastructure (CSSI) by the Minister for Planning and Public Space (the Minister) on 9 November 2020 and approved by the Minister on 21 January 2021.

The MOD2 application proposes to modify the construction methodology across Sydney Harbour from an immersed tube tunnel (IMT) design with transition structures at both ends of the harbour crossing, to a tunnel boring machine (TBM) methodology and to include an additional construction ancillary facility at Emu Plains (WHT13). MOD2 was lodged on 14 July 2023 and was approved by the Planning Secretary on 27 January 2024. The RtS environmental management measures were revised and included in Appendix B2 of the MOD2 report, with specific groundwater measures contained in this Plan.

This Plan covers management of potential impacts on groundwater associated with construction of the Project identified within the Planning Approval Documents.

The documents listed in the planning approval concluded that the construction phase of the Project could potentially impact on groundwater. The measures and management requirements to minimise impacts are detailed within this Plan.

1.3 Scope and staging

The scope of this Plan is to describe how ACCIONA will manage potential groundwater impacts during construction of the Project.

As described in Transport for New South Wales (TfNSW) Staging Report, this Project will be managed in stages with the CEMP. This document addresses WHT Stage 3B and 3C which includes the following scope:

Stage 3B – WHT Northern Tunnelling and Integration works

- Excavation of twin mainline tunnels about 2.5 kilometres long and each accommodating three lanes of traffic in each direction, connecting portals adjacent to the Cammeray Golf Course to the Harbour Crossing section of the tunnel at Berrys Bay.
- Excavation of Falcon Street off-ramp tunnel.
- Excavation of Berry Street on-ramp tunnel.
- Cut and cover infrastructure surface construction at the Ridge Street North construction support site (WHT9), Berry Street and the Warringah Freeway portals.
- Integration works including Mechanical and Electrical (M&E) fit out for the Southern and Northern tunnelling sections, paving, surface connections, ventilation cavern fitout, integration and fitout of the Motorway Operation Centre (MOC) and Motorway Control Centre (MCC)
- Establishment and operation of White Bay (WHT3 – southern portion. The northern portion of WHT3 as described in the EIS will not be used); Ridge Street North (WHT9), and Cammeray Golf Course (WHT10) construction support sites.
- Operation of the City West Link Portal tunnelling support site (WHT12) after the completion of Stage 3A.
- Installation of acoustic structures.
- Utilities connections including but not limited to power, potable water, sewerage.
- Carrying out of surveys, test drilling, test excavations, geotechnical or contamination investigations or other tests or surveys, sampling or investigation.

Stage 3C – WHT Sydney Harbour Crossing

- Excavation of about 1.8 km of twin mainline tunnels using Tunnel Boring Machine (TBM) methodology.
- Construction of launch chambers beneath Birchgrove, and receival chambers and burial beneath the Waverton Peninsula.
- Establishment and operation of an underground slurry treatment plant within an existing ventilation cavern (constructed by the Stage 3A contractor).
- Establishment and operation of an underground Water Treatment Plant.
- Establishment and operation of an underground grout batching plant.
- Access and egress via City West Link Portal (WHT12) for:
 - Spoil removal.
 - Materials and equipment delivery, including concrete tunnel segments and box culverts.
- Use of Ridge Street North (WHT9) as a tunnelling support site, including the construction of an acoustic shed.

- Construction and operation of an additional construction ancillary facility at Emu Plains (WHT13), primarily for the prefabrication and storage of tunnel lining segments, box culverts and other pre-cast concrete elements.

Requirements triggered by the 3B scope of works are identified in Table 3-1 and Table 3-2. For more details on staging refer to the Staging Report, which has been prepared in accordance with MCoA A10.

1.4 Interface with other documents

This Plan is a component of a suite of documents, prepared as part of the implementation of the Project's Environmental Management System. The Environmental Management System overview is described in Section 4.1 of the CEMP.

The key documents that interface with this Plan is outlined in Table 1-1.

Table 1-1 Key interfaces with the GMP

Plan	Interface
CEMP	• Provides details on overall Project staging, interactions between Sub-Plans of the CEMP, and management of cumulative impacts • Provides a framework for how the construction works will be managed • Identifies procedures, processes and management systems that will apply in relation to construction activities • Provides environmental planning and controls for construction including environmental risk assessment, regulatory requirements, protection measures and sustainability requirements
Groundwater Monitoring Program (GWMP)	• Provides details of ongoing groundwater monitoring required throughout Project construction to compare actual construction impacts to predicted impacts.
Soil and Water Management Sub-plan	• Provides details pertaining to how soil and surface water is to be managed during construction of the Project.
Water Reuse Strategy	• Details how water (including groundwater) encountered during construction is to be reused if practicable.
Community Communication Strategy (CCS) and Complaints Management System (CMS)	• Describes how community and stakeholder engagement will be managed and facilitates communication about construction of the project with the community as well as relevant councils and agencies. • Specifies the process for receiving, addressing, resolving and recording complaints as well as outlines the process required in the escalation of a complaint to an independent mediator.
Sustainability Management Plan	• Details the Project's sustainability strategy. • Details how the Project will achieve an adequate Infrastructure Sustainability Council Infrastructure Sustainability (IS) rating.

2 Purpose and objectives

2.1 Purpose

The purpose of this Plan is to describe how ACCIONA will manage potential groundwater during construction of the Project.

This Plan has been prepared to address the applicable statutory requirements and aims to ensure that the commitments in the planning approval are met with regard to impacts to groundwater.

2.2 Objectives

The objective of the GMP is to ensure that all avoidance, mitigation, and management measures relevant to the protection of groundwater are properly implemented.

To achieve these objectives, ACCIONA will undertake the following:

- Ensure appropriate controls and procedures are implemented during Project construction activities to address potential groundwater impacts, as well as manage risks from analysis of relevant construction activities.
- Ensure appropriate measures are implemented to address the relevant MCoA requirements outlined in Table 3-1, as well as the relevant revised environmental management measures outlined in Table 3-2.
- Implement relevant legislation and other requirements detailed in Section 3.1 of this Plan.

Furthermore, ACCIONA will meet the performance outcomes from Table 28-4 of the EIS that are relevant to hydrology and groundwater quality impacts, as required by MCoA C2(d)(i), as identified in Table 2 1 below.

Table 2-1 Performance outcomes identified in the EIS relevant to this Plan

Performance outcome	How performance will be addressed	Records
Water – Hydrology Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised. The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved). Sustainable use of water resources.	In respect to water (hydrology), the project has been developed such that: • Design and construction of the tunnels would minimise groundwater inflow • Opportunities for reuse of treated water during construction has been considered throughout project development • The environmental values of nearby, connected and affected water sources would be improved and/or maintained.	Groundwater monitoring reports Groundwater modelling reports Water Reuse Strategy

Performance outcome	How performance will be addressed	Records
Water – Quality The project is designed, constructed and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and contribute towards achievement of the Water Quality Objectives over time where they are currently not being achieved, including downstream of the project, to the extent of the project impact including estuarine and marine waters (if applicable).	In respect to water (quality), the project has been developed such that it: • Would operate under water quality discharge criteria with consideration of NSW Water Quality Objectives • Would effectively treat water to meet water quality discharge criteria.	Water Pollution Impact Assessment Project Environmental Protection License

2.3 Targets

The following targets have been established for the management of groundwater impacts during the Project Construction activities:

- Ensure compliance with the relevant legislative requirements and the Planning Approval Documents.
- Groundwater drawdown will be monitored and limited to 1 litre/second/kilometre to ensure ongoing beneficial use of groundwater resources.
- Groundwater quality will be monitored to ensure ongoing beneficial use of groundwater resources.
- Ensure groundwater discharged from water treatment plants (WTPs) is treated to sufficient quality to maintain receiving water environmental values.

3 Environmental Requirements

3.1 Relevant legislation and guidelines

3.1.1 Legislation

The main legislation and government policy requirements relevant to this Plan include:

- *Water Act 1912*
- *Water Management Act 2000*
- Water Sharing Plan (DPIE, 2011)
- *Protection of the Environment Operations Act 1997*
- *Contaminated Land Management Act 1997*
- NSW Aquifer Interference Policy (AIP) (NoW, 2012)
- Groundwater Dependent Ecosystems Policy
- NSW State Groundwater Quality Protection Policy
- NSW Water Quality Objectives
- *Waste Avoidance and Resource Recovery Act 2001*.
- Other relevant legislation associated with this GMP is included in Appendix A1 of the CEMP.

3.1.2 Additional approvals, licences, permits and requirements

An Environmental Protection License (EPL) will apply for the Project. The EPL typically prescribes water quality parameters to be measured and associated discharge criteria from licensed discharge points. They also detail the monitoring and analytical requirements by reference to authority publications (e.g., Methods for Sampling and Analysis of Water Pollutants in NSW (EPA 2004)).

In some cases, a Trade Waste Agreement may be sought from Sydney Water for disposal of wastewater into the sewer system, however this is currently not the preferred method of groundwater management and no agreement has been sought at this time.

Section 5.23 of the EP&A Act states that a water use approval under section 89, a water management work approval under section 90 or an activity approval (other than an aquifer interference approval) under section 91 of the Water Management Act 2000, is not required for approved State Significant Infrastructure. The Revised Groundwater Modelling Reports (Section 6.2) as required by CoA E218 will confirm the anticipated extent of groundwater drawdown, tunnel inflows and saline water migration that may occur as a result of the Project. The modelling must be undertaken in consultation with DPE Water and include the results and hydrogeological analyses of at least 12 continuous months of current baseline groundwater monitoring data.

3.1.3 Guidelines and standards

The main guidelines and standards relevant to this Plan include:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC), 2000.
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia (ANZG, 2018)

- Australian Government: Guidelines for the Protection of Groundwater Quality in Australia (Australian Government, 2013)
- Australian Standard for Water Quality Sampling (AS/NZS 5667.11:1998)
- Environment Protection Authority (EPA): Approved methods for Sampling and Analysis of Water Pollutants in NSW (EPA, 2004) Department of Land and Water Conservation (DLWC)
 - NSW Groundwater Dependent Ecosystem Policy (DLWC, 2002)
 - NSW Groundwater Policy Framework Document (DLWC, 1997)
 - NSW Groundwater Quality Protection Policy (DLWC, 1998)
- Chemical Storage and Spill Response Guidelines (Transport for NSW, 2015)
- Guidelines for Assessment and Management of Groundwater (DEC, 2007)
- National Environment Protection (Assessment of Contaminated Land) Measure (NEPM): Schedule B1, Guideline on Investigation Levels for Soil and Groundwater (NEPM, 2013)
- National Health and Medical Research Council: Guidelines for Managing Risks in Recreational Water (NHMRC, 2008)
- National Health and Medical Research Council/Natural Resource Management Ministerial Council: National Water Quality Management Strategy - Australian Drinking Water Guidelines (NHMRC/NRMMC, 2011)
- NSW AIP (NoW, 2012)
- Sydney Harbour Water Quality Improvement Plan, Local Land Services, NSW Government (2015)
- Water Sharing Plan, Greater Metropolitan Regional Groundwater Sources Background Document, Sydney (NoW, 2011)
- Road and Maritime: Dewatering Guideline (RMS, 2011).
- NSW EPA: Waste classification guidelines, Part 4: Acid sulfate soils (NSW EPA, 2014).
- Acid Sulfate Soils Management Advisory Committee: Acid Sulfate Soils Manual (ASSMAC, 1998a) and the Acid Sulfate Soils Assessment Guidelines (ASSMAC, 1998b).
- Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (2004).

3.2 Minister's Conditions of Approval

The MCoA relevant to this Plan are listed in Table 3-1. A cross reference is also included to indicate where and how the conditions are addressed in this Plan or other Project management documents.

3.3 Revised Environmental Management Measures

Relevant Revised Environmental Management Measures (REMMs), as identified in Appendix B2 of the MOD2, are listed in Table 3-2. A cross reference is also included to indicate where and how the conditions are addressed in this Plan or other Project management documents.

Table 3-1 MCoA relevant to the GMP

MCoA No.	Condition Requirements	Document Reference	How Addressed
General			
A5	Where the terms of this approval require a document or monitoring program to be prepared or a review to be undertaken in consultation with identified parties, evidence of the consultation undertaken must be submitted to the Planning Secretary with the document. The evidence must include: (a) documentation of the engagement with the party identified in the condition of approval that has occurred before submitting the document for approval; (b) a log of the dates of engagement or attempted engagement with the identified party; (c) documentation of the follow-up with the identified party where engagement has not occurred to confirm that they do not wish to engage or have not attempted to engage after repeated invitations; (d) outline of the issues raised by the identified party and how they have been addressed; and (e) a description of the outstanding issues raised by the identified party and the reasons why they have not been addressed.	Section 4	Evidence of consultation will be submitted to the Planning Secretary with this document.

MCoA No.	Condition Requirements	Document Reference	How Addressed						
Construction Environmental Management Plan									
C4	The following CEMP Sub-plans must be prepared in consultation with the relevant government agencies identified for each CEMP Sub-plan. Details of all information requested by an agency during consultation must be provided to the Planning Secretary as part of any submission of the relevant CEMP Sub-plan, including copies of all correspondence from those agencies as required by Condition A5.		Section 4 This GMP has been prepared in consultation with the relevant agencies identified in this condition. Evidence of consultation will be submitted to the Planning Secretary with this document.						
		<table><tr><th></th><th>Required CEMP Sub-plan</th><th>Relevant government agencies to be consulted for each CEMP Sub-plan</th></tr><tr><td>(f)</td><td>Groundwater</td><td>DPIE Water, EESG, EPA, Sydney Water (where it is proposed to discharge groundwater into Sydney Water's assets) and relevant council(s)</td></tr></table>			Required CEMP Sub-plan	Relevant government agencies to be consulted for each CEMP Sub-plan	(f)	Groundwater	DPIE Water, EESG, EPA, Sydney Water (where it is proposed to discharge groundwater into Sydney Water's assets) and relevant council(s)
		Required CEMP Sub-plan		Relevant government agencies to be consulted for each CEMP Sub-plan					
(f)	Groundwater	DPIE Water, EESG, EPA, Sydney Water (where it is proposed to discharge groundwater into Sydney Water's assets) and relevant council(s)							
C5	The CEMP Sub-plans must state how:								
(a)	the environmental performance outcomes identified in the documents listed in Condition A1 will be achieved;	Section 2.3	This GMP was prepared in accordance with the environmental performance outcomes identified in the Planning Approval Documents and is evidenced in Section 2.3.						
(b)	the mitigation measures identified in the documents listed in Condition A1 will be implemented;	Section 3.3 and 7	Section 7 and Table 7-1 detail how the mitigation measures identified in the Planning Approval Documents relating to groundwater will be implemented.						
(c)	the relevant terms of this approval will be complied with; and	Section 3.2, 3.3, and 7	Details of how ACCIONA will comply with the relevant terms of approval are listed in this Table, including references to the relevant sections of this GMP.						

MCoA No.	Condition Requirements	Document Reference	How Addressed
(d)	issues requiring management during construction (including cumulative impacts), as identified through ongoing environmental risk analysis, will be managed through SMART principles.	Section 6.2 and Section 7 Section 5.1 of the CEMP (Environmental Risk Assessment Workshop) Section 8.1 of the Groundwater Monitoring Program (Appendix F1)	Groundwater issues requiring management during construction of the Project have been identified through the Planning Approval Documents, and Environmental Risk Assessment Workshop. These issues, including cumulative impacts, have been detailed in Appendix A2 of the CEMP. Environmental risk analysis will be ongoing and regularly reviewed in accordance with Section 5.1 of the CEMP. Groundwater impacts are detailed in Section 6.2. Management and mitigation measures are included in Section 7.
C9	The CEMP Sub-plans must be submitted to the Planning Secretary for approval along with, or subsequent to, the submission of the CEMP but in any event, no later than one month before construction.	Section 2 of the CEMP	The CEMP Sub-plans will be submitted for approval to DPE with or subsequent to the final submissions of the CEMP for DPE approval.
C10	Construction must not commence until the CEMP and all CEMP Sub-plans have been approved, unless otherwise agreed by the Planning Secretary. The CEMP and CEMP Sub-plans, as approved by the Planning Secretary, including any minor amendments approved by the ER must be implemented for the duration of construction. Where construction of the CSSI is staged, construction of a stage must not commence until the CEMP and sub-plans for that stage have been endorsed by the ER and approved by the Planning Secretary.	Section 2 of the CEMP	Construction of the Project will not commence until the CEMP and applicable Sub-plans as per the Staging Report have been approved, unless it is otherwise agreed by the Planning Secretary. The CEMP and CEMP Sub-plans will be implemented for the duration of construction.
Construction Monitoring Programs			
C11	The following Construction Monitoring Programs must be prepared in consultation with the relevant government agencies identified for each to compare actual performance of	Groundwater Monitoring Program (Appendix F1)	The Groundwater Monitoring Program (GWMP) is included at Appendix F1 of

MCoA No.	Condition Requirements	Document Reference	How Addressed						
	construction of the CSSI against the performance predicted in the documents listed in Condition A1 or in the CEMP: <table><tr><td></td><td>Required Construction Monitoring Program</td><td>Relevant government agencies to be consulted for each Construction Monitoring Program</td></tr><tr><td>(d)</td><td>Groundwater Monitoring Program</td><td>DPIE Water, EPA</td></tr></table>		Required Construction Monitoring Program	Relevant government agencies to be consulted for each Construction Monitoring Program	(d)	Groundwater Monitoring Program	DPIE Water, EPA		this GMP and addresses this requirement.
	Required Construction Monitoring Program	Relevant government agencies to be consulted for each Construction Monitoring Program							
(d)	Groundwater Monitoring Program	DPIE Water, EPA							
C12	Each Construction Monitoring Program must provide: (a) details of baseline data available; (b) details of baseline data to be obtained and when; (c) details of all monitoring of the project to be undertaken; (d) the parameters of the project to be monitored; (e) the frequency of monitoring to be undertaken; (f) the location of monitoring; (g) the reporting of monitoring results and analysis results against relevant criteria; (h) details of the methods that will be used to analyse the monitoring data; (i) procedures to identify and implement additional mitigation measures where the results of the monitoring indicate unacceptable project impacts; (j) a consideration of SMART principles; (k) any consultation to be undertaken in relation to the monitoring programs; and (l) any specific requirements as required by Conditions C13 to C14.	GWMP (Appendix F1)	The Groundwater Monitoring Program (GWMP) is included at Appendix F1 of this GMP and addresses this requirement.						
C14	The Groundwater Monitoring Program must include: (a) results from existing monitoring bores and from additional monitoring bores required following a review of the monitoring bore network, with the review based	GWMP (Appendix F1)	The Groundwater Monitoring Program (GWMP) is included at Appendix F1 of this GMP and addresses this requirement.						

MCoA No.	Condition Requirements	Document Reference	How Addressed
	on actual results of existing monitoring and groundwater modelling findings in relation to the final tunnel detailed design; (b) daily measurement of the amount of water discharged from the water treatment plants; (c) water quality testing of the water discharged from treatment plants; (d) monitoring of groundwater levels in aquifers adjacent to the tunnel alignment; (e) monitoring of groundwater levels, electrical conductivity and temperature in key locations between saline water bodies and the tunnel (including beneath high risk sites for contamination); (f) measures to record or otherwise estimate and report groundwater inflows into the tunnels during their construction; (g) methods for providing the data collected under (a) and (b) to Sydney Water where discharges are directed to their assets; and (h) a method for providing the groundwater monitoring data to DPIE Water every three months during construction of the tunnels and portals.		
C17	The Construction Monitoring Programs must be developed in consultation with relevant government agencies as identified in Condition C11. Details of all information requested by an agency during consultation must be provided to the Planning Secretary as part of any submission of the relevant Construction Monitoring Programs, including copies of all correspondence from those agencies as required by Condition A5.	GWMP (Appendix F1)	The Groundwater Monitoring Program (GWMP) is included at Appendix F1 of this GMP and addresses this requirement.
C18	The Construction Monitoring Programs must be endorsed by the ER and then submitted to the Planning Secretary for approval at least one month before the commencement of construction.	GWMP (Appendix F1)	The Groundwater Monitoring Program (GWMP) is included at Appendix F1 of this GMP and addresses this requirement.
C19	Unless otherwise agreed with the Planning Secretary, construction must not commence until all of the relevant Construction Monitoring Programs have been approved by the Planning Secretary, and all relevant baseline data for the specific construction activity has been collected.	GWMP (Appendix F1)	The Groundwater Monitoring Program (GWMP) is included at Appendix F1 of this GMP and addresses this requirement.

MCoA No.	Condition Requirements	Document Reference	How Addressed
C20	The Construction Monitoring Programs, as approved by the Planning Secretary including any minor amendments approved by the ER must be implemented for the duration of construction and for any longer period set out in the monitoring program or specified by the Planning Secretary, whichever is the greater.	GWMP (Appendix F1)	The Groundwater Monitoring Program (GWMP) is included at Appendix F1 of this GMP and addresses this requirement.
C21	The results of the Construction Monitoring Programs must be submitted to the Planning Secretary, and relevant regulatory agencies, for information in the form of a Construction Monitoring Report at the frequency identified in the relevant Construction Monitoring Program. <i>Note: Where a relevant CEMP Sub-plan exists, the relevant Construction Monitoring Program may be incorporated into that CEMP Sub-plan.</i>	GWMP (Appendix F1)	The Groundwater Monitoring Program (GWMP) is included at Appendix F1 of this GMP and addresses this requirement.
Socio-economic, land use and property			
E102	A geotechnical model of representative geological and groundwater conditions must be prepared prior to excavation (that may pose a settlement risk) and tunnelling to identify geological structures and groundwater features. The model must include details of proposed excavations and tunnels, construction staging, and identify surface and sub-surface structures, including any specific attributes, which may be impacted by the CSSI. The Proponent must use this model to assess the cumulative predicted settlement, ground movement, stress redistribution and horizontal strain profiles caused by excavation and tunnelling, including groundwater drawdown and associated impacts, on adjacent surface and sub-surface structures.	Section 7.2	ACCIONA will prepare a comprehensive interpretive geological report on how design and construction will be best managed with in-ground geological risks
E103	The Proponent must undertake a review of surface and sub-surface structures at risk from damage to determine appropriate criteria to prevent damage, prior to excavation and tunnelling works that may pose a settlement risk. Criteria for surface and sub-surface structures which are not included in Condition E104 (Table 9) must be determined in consultation with the owner(s) of the surface and sub-surface structures prior to commencement of any excavation or tunnelling works potentially affecting the surface and sub-surface structures.	Section 7.2	ACCIONA will review at-risk structures and determine appropriate criteria, prior to excavation and tunnelling that may pose a settlement risk. This will be documented as part of Design Reports for the Project
E104	In the case of buildings, roads, parking areas and parks, the appropriate criteria which govern the greatest risk of damage are to be selected from Table 9 unless the Proponent has determined more stringent criteria as a result of Condition E103.	Section 7.2	ACCIONA will apply the described criteria in the absence of new (more stringent) criteria.

MCoA No.	Condition Requirements	Document Reference	How Addressed																				
	Table 9: Settlement Criteria <table> <tr> <th>Surface and Sub-Surface Structures</th><th>Maximum Settlement</th><th>Maximum Angular Distortion</th><th>Limiting Tensile Strain (percent)*</th></tr> <tr> <td>Buildings – Low or non-sensitive properties (i.e. ≤ 2 levels and car parks)</td><td>30 mm</td><td>1 in 350</td><td>0.1</td></tr> <tr> <td>Buildings and pools – High or sensitive properties (i.e. ≥ 3 levels and heritage items)</td><td>20 mm</td><td>1 in 500</td><td>0.1</td></tr> <tr> <td>Roads and parking areas</td><td>40 mm</td><td>1 in 250</td><td>n/a</td></tr> <tr> <td>Parks</td><td>50 mm</td><td>1 in 250</td><td>n/a</td></tr> </table> <i>Note: * As defined in Burland et al. 'Building response to tunnelling – Case studies from construction of the Jubilee Link Extension', London, Thomas Telford (2001)</i>	Surface and Sub-Surface Structures	Maximum Settlement	Maximum Angular Distortion	Limiting Tensile Strain (percent)*	Buildings – Low or non-sensitive properties (i.e. ≤ 2 levels and car parks)	30 mm	1 in 350	0.1	Buildings and pools – High or sensitive properties (i.e. ≥ 3 levels and heritage items)	20 mm	1 in 500	0.1	Roads and parking areas	40 mm	1 in 250	n/a	Parks	50 mm	1 in 250	n/a		This will be documented as part of Design Reports for the Project
Surface and Sub-Surface Structures	Maximum Settlement	Maximum Angular Distortion	Limiting Tensile Strain (percent)*																				
Buildings – Low or non-sensitive properties (i.e. ≤ 2 levels and car parks)	30 mm	1 in 350	0.1																				
Buildings and pools – High or sensitive properties (i.e. ≥ 3 levels and heritage items)	20 mm	1 in 500	0.1																				
Roads and parking areas	40 mm	1 in 250	n/a																				
Parks	50 mm	1 in 250	n/a																				
E105	Should the geotechnical model in Condition E102 identify exceedances of the relevant criteria established by Conditions E103 and E104, the Proponent must implement an instrumentation and monitoring program to measure settlement, distortion or strain as required. The Proponent must also identify and implement appropriate mitigation measures in consultation with the owner(s) of the relevant surface and sub-surface structures prior to excavation and tunnelling works to ensure where possible that the surface and sub-surface structures will not experience exceedances of the relevant criteria. The adopted criteria do not remove any responsibility from the Proponent for the protection of existing surface and sub-surface structures or for rectifying any damage to surface and sub-surface structures resulting from the CSSI.	Section 7.2	ACCIONA will apply the described criteria in the absence of new (more stringent) criteria.																				
E106	Where monitoring indicates groundwater drawdown or settlement is substantially different to predictions or in excess of the limits specified in this approval, the requirements of Conditions E102 to E105 inclusive must be undertaken again within	Section 7.2	Monitoring will be assessed against the model prepared under MCoA E102, and where a substantial difference is observed the preparation of a groundwater model and application of																				

MCoA No.	Condition Requirements	Document Reference	How Addressed
	three months. Model input parameters must be adjusted to calibrate the model so that predictions are better aligned with actual observations		requirements of MCoA E102-105 will be undertaken within three months of the observation being made.
E107	The Proponent must offer pre-construction surveys and must undertake and prepare Preconstruction Condition Survey Reports where the offer is accepted, on the current condition of surface and sub-surface structures identified as at risk from settlement or vibration by the geotechnical model described in Condition E102 and the CNVIS required by Condition E75 or as directed by the Independent Property Impact Assessment Panel (IPIAP) established under Condition E111. The Pre-construction Condition Survey Reports must be prepared by a suitably qualified and experienced person(s) and must be provided to the owners of the surface and sub-surface structures for review prior to the commencement of potentially impacting works.	Section 7.2	ACCIONA will enable pre-construction condition surveys that will be offered and undertaken by a suitably qualified and experienced person where accepted. These surveys will be provided to owners prior to the commencement of potentially impacting works.
E108	Where pre-construction surveys have been undertaken in accordance with Condition E107, subsequent post-construction surveys must be undertaken to assess damage to the surface and sub-surface structures that may have resulted from construction within three months of landowner(s) requests.	Section 7.2	ACCIONA will also enable post-construction condition surveys will be undertaken on all structures that received a pre-construction Condition survey.
E109	The results of the post-construction surveys undertaken under Condition E108 must be documented in Post-construction Condition Survey Reports for each surface and sub-surface structure surveyed. The Post-construction Condition Survey Reports must be prepared by a suitably qualified and experienced person(s). Copies of the Post-construction Condition Survey Reports must be provided to the owner(s) of the structures surveyed no later than four months following the completion of construction activities that have the potential to impact on the subject surface / subsurface structure.	Section 7.2	ACCIONA will provide copies of the Post-construction Condition Survey Reports within the required time-frame.
Sustainability			
E127	A Water Reuse Strategy must be prepared, which sets out options for the reuse of collected stormwater and groundwater during construction and operation. The Water Reuse Strategy must include, but not be limited to: a) evaluation of reuse options.	Section 7.1	Opportunities for water reuse identified in the Water Reuse Strategy will be applied to groundwater (treated and untreated, as applicable) during construction.

MCoA No.	Condition Requirements	Document Reference	How Addressed
	b) details of the preferred reuse option(s), including volumes of water to be reused, proposed reuse locations and/or activities, proposed treatment (if required), and any additional licences or approvals that may be required. c) measures to avoid misuse of recycled water as potable water. d) consideration of the public health risks from water recycling. e) a time frame for the implementation of the preferred reuse option(s). The Water Reuse Strategy must be prepared based on best practice and advice sought from relevant agencies, as required. The Strategy must be applied during construction and operation. Justification must be provided to the Planning Secretary if it is concluded that no reuse options prevail. A copy of the Water Reuse Strategy must be made publicly available.		
Groundwater			
E206	The CSSI must be designed, constructed and operated so as to maintain the NSW Water Quality Objectives where they are being achieved as at the date of this approval, and contribute towards achievement of the NSW Water Quality Objectives over time where they are not being achieved as at the date of this approval, unless an EPL in force in respect of the CSSI contains different requirements in relation to the NSW Water Quality Objectives, in which case those requirements must be complied with.	Section 7.1 Section 6.5 of the GWMP (Appendix F1)	Discharge water will be compliant with this requirement unless the EPL contain additional or alternative discharge criteria.
E208	Unless an EPL is in force in respect to the CSSI and that licence specifies alternative criteria, discharges from construction water treatment plants to surface waters must not exceed: a) the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018 (ANZG 2018) default guideline values for toxicants at the 90 per cent species protection level; b) for physical and chemical stressors, the guideline values set out in Tables 3.3.2 and 3.3.3 of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000; and	Section 7.2 Section 4.2 of the GWMP (Appendix F1)	Discharge water will be compliant with this requirement unless the EPL contain additional or alternative discharge criteria.

MCoA No.	Condition Requirements	Document Reference	How Addressed
	c) for bioaccumulative and persistent toxicants, the ANZG 2018 values at a minimum of 95 per cent species protection level. Where the ANZG 2018 does not provide a default guideline value for a particular pollutant, the approaches set out in the ANZG 2018 for deriving guideline values, using interim guideline values and/or using other lines of evidence such as international scientific literature or water quality guidelines from other countries, must be used.		
E210	If construction stage stormwater discharges are proposed, a water pollution impact assessment will be required to inform licensing consistent with section 45 of the POEO Act. Any such assessment must be prepared in consultation with the EPA and be consistent with the National Water Quality Guidelines, with a level of detail commensurate with the potential water pollution risk.	Section 7.2 Section 6.5 of the GWMP (Appendix F1)	Discharge water will be compliant with this requirement unless the EPL contain additional or alternative discharge criteria.
E216	The Proponent must take measures to limit operational groundwater inflows into each tunnel to no greater than one litre per second across any given kilometre (1L/s/km) (not average ingress rate). Compliance with this condition cannot be determined by averaging groundwater inflows across the length of the tunnel(s).	Section 7.2	The design of the Project will be undertaken in consideration of this requirement, to ensure compliance.
E217	Make good provisions for groundwater users must be provided in the event of a material decline in water supply levels, quality or quantity from registered existing bores associated with groundwater changes from either construction and/or ongoing operational dewatering caused by the CSSI.	Section 7.2 Groundwater Monitoring Program (Appendix F1)	Monitoring will be undertaken to identify loss of yield, and mitigation will be provided in the event of material decline.
E218	Further modelling must be undertaken of groundwater drawdown, tunnel inflows and saline water migration (using particle tracking) prior to finalising the detailed design of the tunnels and undertaking any works that would impact on groundwater flows or levels. The modelling must be undertaken in consultation with DPIE Water and include the results and hydrogeological analyses of at least 12 continuous months of current baseline groundwater monitoring data.	Section 7.2 Groundwater Monitoring Program (Appendix F1)	Background water quality monitoring is described in Section 7.2. Modelling of groundwater drawdown, tunnel inflows and saline migration will be undertaken prior to finalising the detail design. The outcome of the model will be documented in the Groundwater Modelling Report which will be undertaken in compliance with this condition.

MCoA No.	Condition Requirements	Document Reference	How Addressed
E219	The results of the modelling required by Condition E218 must be documented in a Groundwater Modelling Report. The Groundwater Modelling Report must be finalised in accordance with the <i>Australian Groundwater Modelling Guidelines</i> (National Water Commission, 2012), be independently peer reviewed by an expert (agreed to by DPIE Water) and prepared in consultation with DPIE Water. A copy of the Groundwater Modelling Report (including the independent peer review) must be submitted to the Planning Secretary for information prior to finalising the tunnel design. The Groundwater Modelling Report must include details of consultation with DPIE Water. The calibration and modelling to be provided to the independent peer reviewer and DPIE Water must be in an electronic quality-controlled data ready-to-use format.	Section 7.2	Preparation of a Groundwater Modelling Report will be undertaken in compliance with this condition.
E220	The groundwater model must be updated once 24 months of groundwater monitoring data are available and the results of the updated modelling (assessed against all predicted outcomes of the Groundwater Modelling Report that accompanied the final detailed design of the tunnels) be provided to the Planning Secretary and DPIE Water in an updated Groundwater Modelling Report.	Section 7.2	Update of the Groundwater Modelling Report will be undertaken in compliance with this condition.
E221	The total incidental groundwater take from the tunnel should be measured at a minimum monthly and totalled yearly for the life of the CSSI. These volumes must be reported to DPIE Water annually.	Section 8.5 Section 5 of the Groundwater Monitoring Program (Appendix F1)	A Groundwater Monitoring Program has been prepared for the Project and is attached as Appendix F1.

Table 3-2 Revised Environmental Management Measures relevant to this GMP

Ref #	Commitment	Timing	Document Reference	How Addressed
Geology, soils, and groundwater				
SG1	Detailed predictive settlement models will be developed for areas of concern to guide tunnel design and construction methodology, including the selection of options to minimise settlement where required.	Pre-construction	Section 7.2	A revised groundwater model and the preparation of a Groundwater Modelling Report will be undertaken in compliance with this REMM and in compliance CoA E102.
SG2	The viability of domestic bores GW109209, GW107764 and GW108991 will be confirmed prior to construction. If drawdown at the bores exceeds two metres (in accordance with the Aquifer Interference Policy), measures will be taken to 'make good' the impact by restoring the water supply to pre-development levels. The measures taken will be dependent upon the location of the impacted bores and will be determined in consultation with the affected licence holder but could include, deepening the bore, providing a new bore or providing an alternative water supply.	Pre-construction	Section 5.6.3	This has been completed. Refer to detail in Section 5.6.3
SG3	An Independent Property Impact Assessment Panel, comprising geotechnical and engineering experts, will be established prior to the commencement of works to independently verify building condition survey reports, resolve any property damage disputes and establish ongoing settlement and vibration monitoring requirements.	Pre-construction	Section 7.2	An IPIAP will be established prior to the commencement of works.
SG4	Pre-construction building/structure condition surveys will be offered and prepared for properties (and heritage assets) within the zone of influence of tunnel settlement (for example within the 5 millimetre predicted surface settlement contour and within 50 metres of surface works) and within the minimum working distances for cosmetic and structural damage due to vibration. The surveys will be carried out by a suitably qualified person prior to the commencement of the tunnelling and vibration-intensive activities in the vicinity with the potential to affect the building/structure.	Pre-construction Post-construction	Table 7-1	Preconstruction and post construction surveys will be undertaken as defined by this condition.

Ref #	Commitment	Timing	Document Reference	How Addressed
	Within three (3) months of the completion of construction activities that have the potential to impact on the subject surface/subsurface structure, all property owners of buildings for which a pre-construction building condition survey was carried out will be offered a second building condition survey. Where an offer is accepted, post-construction building condition surveys will be carried out by a suitably qualified person. The results of the surveys will be documented in a post-construction building condition survey report for each building surveyed. Copies of building condition survey reports will be provided to the owners of the buildings surveyed within one (1) month of the survey being completed. Any property damage caused by the project will be rectified.			
SG12	Prior to ground disturbance in high-risk acid sulfate areas at Birchgrove Park and Berrys Bay and Whites Creek, testing will be carried out to determine the presence of ASS. If ASS is encountered, they will be managed in accordance with the ASS Manual (Acid Sulfate Soil Management Advisory Committee, 1998).	Construction	Section 6.2.3 Table 7-1	If potential for acidification is deemed a high risk, the groundwater drawdown and quality will be monitored in areas of high-risk during construction. Remedial or mitigating measures to prevent or contain acid generation will be implemented.
SG14	Where groundwater inflows exceed 1 L/s/km during construction, feasible and reasonable measures to manage inflow will be applied.	Construction	Section 6.2 Groundwater Monitoring Program (Appendix F1) Table 7-1	Tunnel inflows of groundwater will be monitored during construction and where inflows exceed 1 L/s/km, management measures will be implemented where feasible and reasonable.

Ref #	Commitment	Timing	Document Reference	How Addressed
SG17	Outcomes of updated groundwater modelling will identify any requirements for further groundwater monitoring, and management of groundwater drawdown and associated impacts.	Pre-construction Construction	Section 7.2 Section 9.2 Section 6 of the Groundwater Monitoring Program (Appendix F1) Table 7-1	GMP and GWMP will be updated if required as a result of the revised groundwater modelling. Groundwater modelling will identify and inform any updates required to this management plan.
SG18	As more information becomes available through ongoing groundwater monitoring, groundwater modelling will be updated. Construction and operational inflow predictions will be updated prior to construction, and operational inflow and impact predictions will be updated at the end of the construction period.	Pre-construction Construction	Table 7-1 Section 7.2 Section 9.2 Section 8.1.1 of the Groundwater Monitoring Program (Appendix F1)	Groundwater monitoring results will be made available to the Project design team to ensure all monitoring data is included in the revised groundwater model and is addressed in all design related solutions to minimise groundwater inflow.
SG19	Additional groundwater baseline monitoring will be carried out during the pre-construction period and will be considered in the development of the groundwater quality monitoring program described in management measure SG20.	Pre-construction	Groundwater Monitoring Program (Appendix F1)	Refer to detail within the Groundwater Monitoring Program.
SG20	A groundwater quality monitoring program will be developed and implemented, taking into consideration the location of areas subject to medium and high risk of groundwater contamination during construction (and operation). Where relevant, modelling/mass balance analysis will be carried out to assess potential impacts on beneficial aquifer use and the likely quality of groundwater inflows. The groundwater monitoring program will be developed in consultation with the Department of Planning and Environment (Water).	Construction	Section 4 Section 6.2 Section 8.3 Appendix F1 – Groundwater Monitoring Program	A GWMP for construction has been developed and is included in Appendix F1. Following completion of pre-construction groundwater monitoring final measures to be documented and implemented with relevant agency consultation undertaken. Design team will carry out further modelling/mass balance analysis where relevant to assess the potential

Ref #	Commitment	Timing	Document Reference	How Addressed
				impacts on beneficial aquifer use and the likely quality of groundwater inflows.
SG21	If the groundwater quality monitoring and associated analysis identifies potential impacts to beneficial aquifer use from the migration of contaminated groundwater, or the quality of groundwater tunnel inflows, feasible and reasonable management measures will be identified and implemented.	Construction	Section 9.1 Table 7-1 Section 6.3 and Section 8 of the Groundwater Monitoring Program (Appendix F1)	Additional groundwater monitoring and management included in Appendices F1 of this report. Following completion of pre-construction groundwater monitoring final measures to be documented and implemented
SG22	As more information becomes available through ongoing groundwater monitoring, groundwater modelling will be updated to refine the predictions documented in the EIS Appendix N (Technical working paper: Groundwater). Inflow predictions will be updated during further design development and operational inflow and impacts predictions will be updated at the end of the construction period. If refined predictions indicate that groundwater inflows and water table drawdown will be greater than the impacts documented in the EIS Appendix N (Technical working paper: Groundwater), feasible and reasonable measures will be implemented.	Construction	Section 8.1.1 of the Groundwater Monitoring Program (Appendix F1) Table 7-1 Section 7.2 Section 9.2	Prior to the commencement of construction an updated Groundwater Modelling Report will be prepared and utilised to refine the predictions documented in the EIS and inform reasonable and feasible mitigation measures.
SG23	Emergency spill procedures will be developed to avoid and manage accidental spillages of fuels, chemicals, and fluids to minimise the risk of human health impacts and contamination of groundwater.	Construction	Soil and Surface Water Management Plan	Storage and handling management measures have been identified in the Soil and Surface Water Management Plan. Emergency Spill procedure has been prepared and included in the Soil and Surface Water Management Plan.

Ref #	Commitment	Timing	Document Reference	How Addressed
Resource use and waste management				
WM5	Opportunities for wastewater reuse and recycling, including recirculating water during tunnel excavation to use for dust suppression and offsite reuse, will be investigated and implemented where feasible and reasonable.	Construction	Water Reuse Strategy. Waste and Reuse Management Plan.	Opportunities to reuse and recycle wastewater during construction is detailed in the Water Reuse Strategy, and the Waste and Resource Management Plan.
WQ3	Discharges from wastewater treatment plants during the construction phase will be required to meet the following discharge criteria: - The relevant physical and chemical stressors set out in of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000), - The ANZG (2018) 90 per cent species protection levels for toxicants generally, with the exception of those toxicants known to bioaccumulate, which will be treated to meet the ANZG (2018) 95 per cent species protection levels, and - The draft ANZG default guideline values for iron (in fresh and marine water) and zinc (in marine water) which are likely to be finalised in October 2020.	Construction	Water Reuse Strategy Section 7.1 Section 6.5 of the GWMP (Appendix F1)	Discharge water will be compliant with this requirement unless the EPL contain additional or alternative discharge criteria. Trade waste licence requirements will be considered upon final groundwater conditions derived from groundwater monitoring during pre-construction.

4 Consultation

4.1 Consultation for plan preparation

This Plan will be developed and finalised in consultation with DPE Water, EESG, EPA and Sydney Water in accordance with MCoA C4(f) and MCoA A5. Consultation with each agency, including responses received and how any issues raised were addressed in the development of this Plan will be provided to the Planning Secretary along with this Plan.

4.2 Ongoing consultation

Ongoing consultation with DPE Water will be undertaken throughout construction in relation to the GWMP (Appendix F1). During construction, Sydney Water will be consulted prior to any works that may result in the discharge of groundwater to their assets. Relevant groundwater monitoring data will also be shared with DPE Water and Sydney Water as required by MCoA C14 (g) and (h).

Any ongoing consultation with agencies, where required, will be undertaken in accordance with Section 7 of this Plan. Community feedback and complaints will be managed in accordance with the Community Communication Strategy and Complaints Management System.

5 Existing Environment

This section describes the existing environment of the Project specific to groundwater and summarises groundwater investigations undertaken to date. The key reference documents are Chapter 16 (Geology, soil and groundwater), and Appendix N (Technical working paper: Groundwater) of the EIS, and the baseline monitoring results which includes 12 months of pre-construction groundwater monitoring targeting (MCoA E218) the main areas of concern identified by the Planning Approval Documents (refer to the Groundwater Monitoring Program in Appendix F1).

The main areas for concern for Stage 3B and 3C construction include:

- Landfill and contaminated sites at Rozelle, Birchgrove and Waverton
- Registered groundwater bores in Rozelle, Birchgrove, and Waverton

The Project Area and relevant context detail is shown on the Sensitive Area Maps included as Appendix A5 of the CEMP. The current project footprint and construction support site are included in Figure 5-1 and Figure 5-2 below.

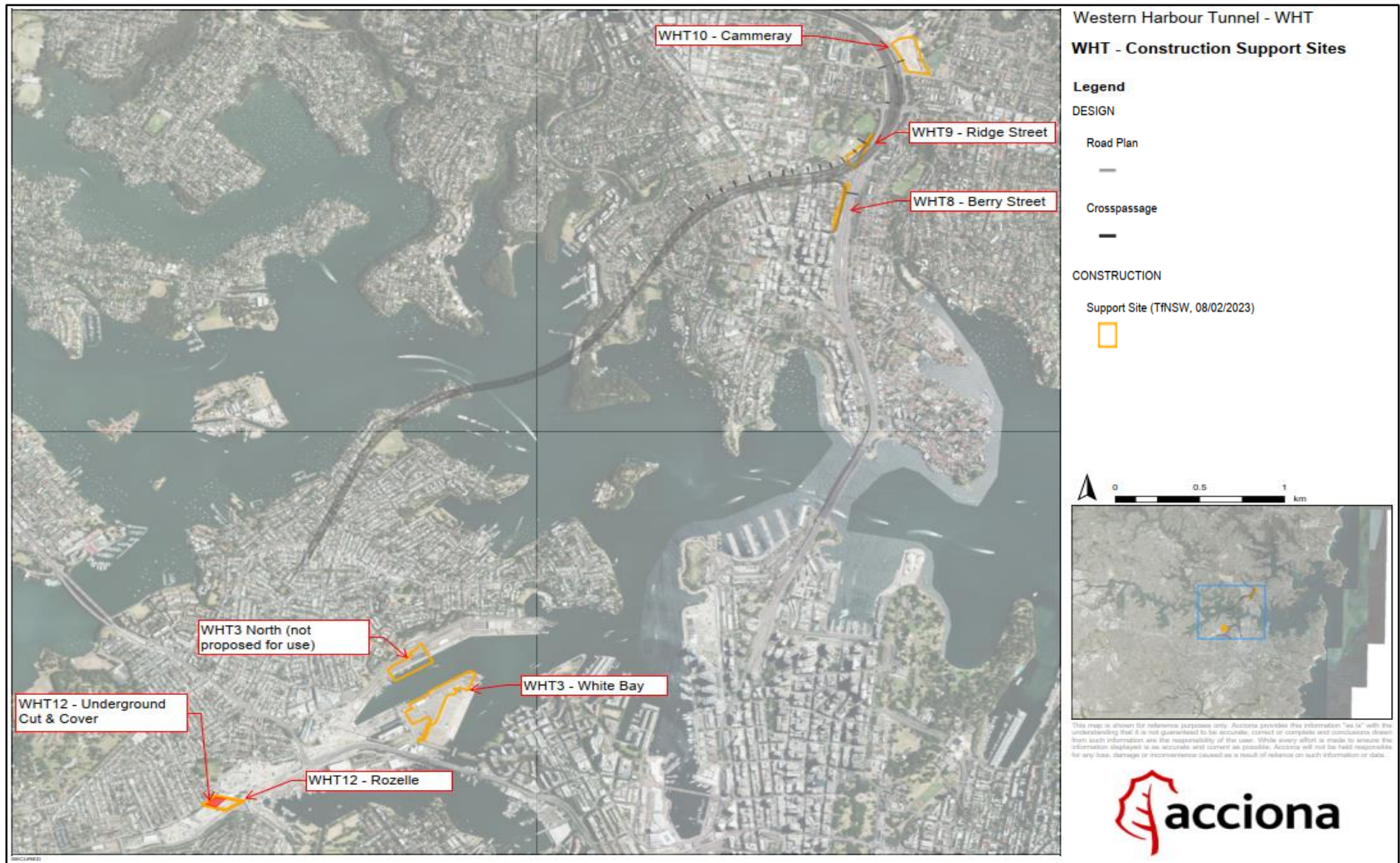


Figure 5-1 Project footprint

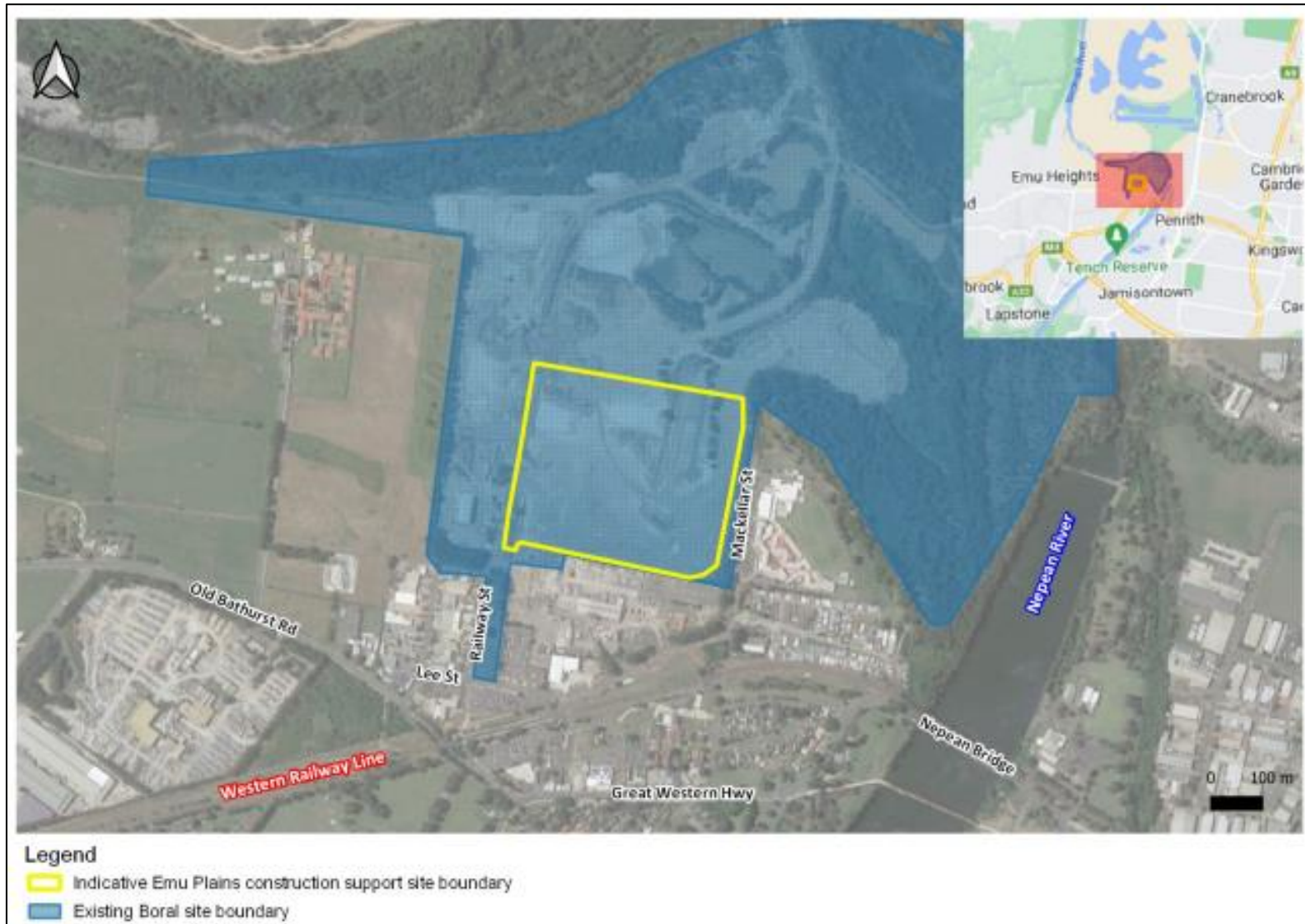


Figure 5-2 Indicative Emu Plains (WHT13) construction ancillary facility footprint

5.1 Overview

The Project transects a highly urbanised environment, where rainfall recharge to groundwater has been reduced by hardstand and roof captured runoff being directed to stormwater. The existing land use, within and adjacent to the Project, consists of established industrial, commercial, recreational, and residential areas.

Groundwater rainfall recharge primarily occurs in parks, gardens, and bushland and from (losing) creeks and water impoundments (e.g. ponds). Groundwater, based on through flow, gradients, and effective storage, ultimately discharges to Sydney Harbour. There are a number of creeks located within or adjacent to the Project alignment, which may be supported by baseflow (gaining creeks).

5.2 Topography

The terrain at southern extent of the Project, within Rozelle, is at an approximate elevation of 10 metres Australian Height Datum (mAHD) and gently undulates towards Birchgrove, located on the southern side of Sydney Harbour. The maximum depth of the harbour in the vicinity of the Harbour Crossing is about 40 metres below sea level on the eastern side adjacent to Balls Head. From Sydney Harbour, there is a moderate incline towards the northern extent of the Project to an elevation of approximately 90 mAHD at the Pacific Highway, North Sydney.

The Emu Plains construction ancillary facility (WHT13) currently consists of fill, compacted, and graded at various levels. The site is raised in the east and slopes towards a drainage channel in the central east of the site. West of the drainage channel the site levels increase and become relatively flat.

5.3 Drainage

The Project is located within an urbanised area where surface water drainage channels are typically highly modified and concrete lined. The following primary watercourses are mapped within the Project area:

- Sydney Harbour: A portion of the Project area crosses the harbour, which is a tidally influenced river mouth and groundwater discharge area.
- Whites Creek: Located in the southern extent of the Project area and flows through the suburbs of Leichhardt and Marrickville. The complete length of the creek has been modified and acts as a stormwater drain, comprising buried pipes in the upper extent and an open brick and concrete lined channel at the lower extent which discharges to Rozelle Bay. The creek, based on construction and elevation, is not recognised to interact with groundwater.
- Willoughby Creek: A small, modified concrete and rock channel. Located northeast of the northern extent of the Project alignment, the creek drains the suburbs of Neutral Bay and Cammeray into Middle Harbour.
- Nepean River: Located approximately 500metres north and east of the Emu Plains (WHT13) construction ancillary facility.

5.4 Geological setting

The Project is located within the Permian to Triassic age Sydney Basin and is primarily underlain by Hawkesbury Sandstone. The Middle Triassic (Anisian) age Hawkesbury Sandstone comprises medium to coarse-grained quartz sandstone with minor shale and laminite lenses. Unidirectional paleoflow in the sandstone, freshwater biota, and abundant mudrock intraclasts indicate fluvial deposition.

The Hawkesbury Sandstone is overlain by the Ashfield Shale in elevated areas. Ashfield Shale comprises black mudstone and grey shale with frequent sideritic clay ironstone bands. Ashfield

Shale is considered a freshwater lacustrine paleoenvironment. It was gradually inundated by brackish water, then shallow marine waters over a long period of time.

The Mittagong Formation, which lies between the Hawkesbury Sandstone and the Ashfield Shale does not occur within the geological setting of the Project area.

The main stratigraphic units encountered within the Project area, from youngest to oldest, are summarised in Table 5-1, and shown on Figure 5-3.

Table 5-1 Geological units

Age	Geological Unit	Unit Thickness
Quaternary	Anthropogenic fill	Generally, <1 m, however, expected to be thicker in areas of land reclamation, back-filled quarries, landfills, stream capture and urban development.
	Estuarine and alluvial sediments	Maximum thickness of 50 m within palaeochannels
	Marine sediment	
Mid-Triassic	Ashfield Shale	Maximum thickness of 60 m
	Hawkesbury Sandstone	Maximum thickness of 290 m

The stratigraphy in the Project area has been intersected by multiple geological structural features including dykes, faults, and joint swarms, typically within the Hawkesbury Sandstone. The presence of faults can be associated with increased groundwater potential.

Further detail on the stratigraphic units, including weathering profiles and implications for hydraulic conductivity is provided in Appendix N of the EIS (Technical working paper: Groundwater, Jacobs 2020a).

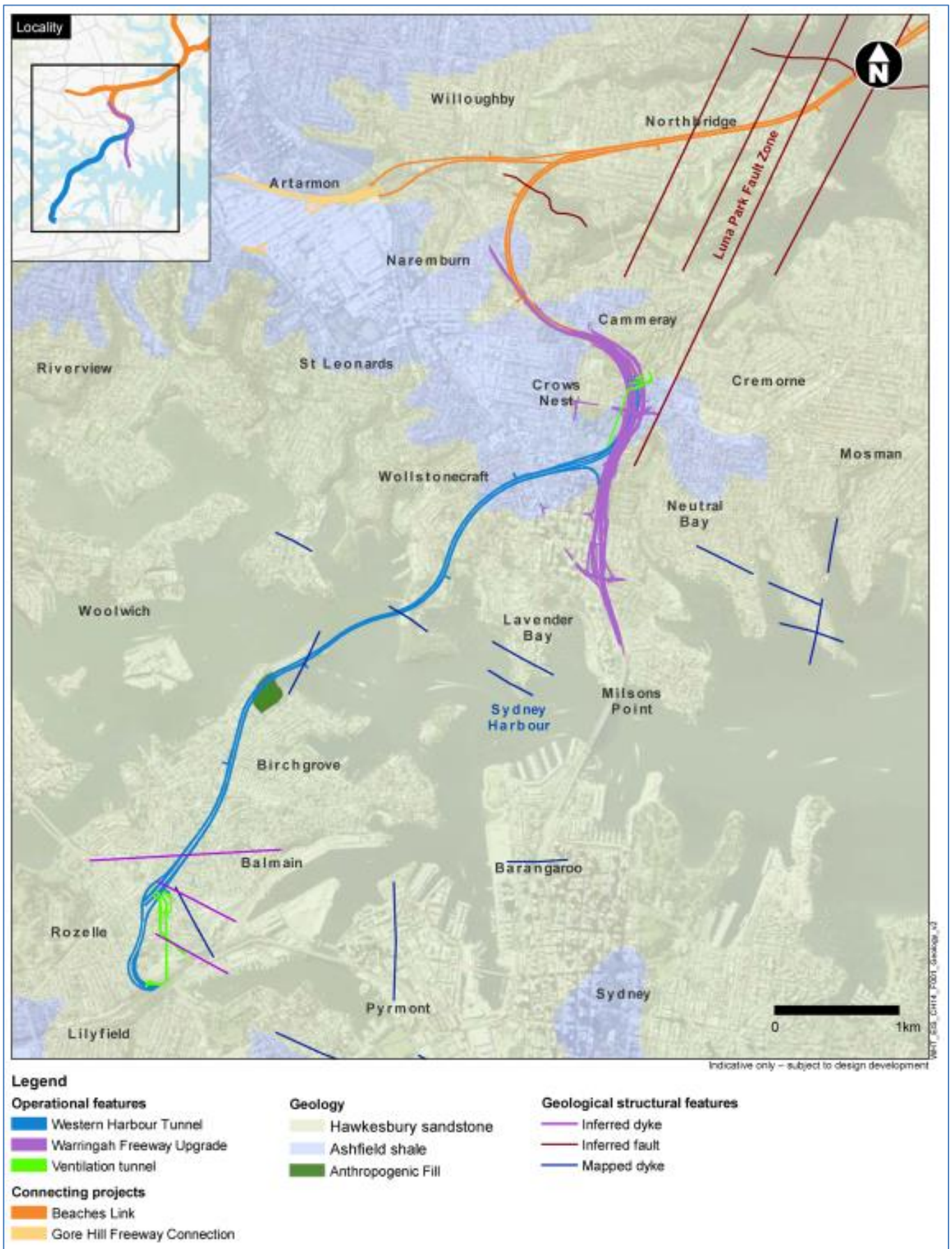


Figure 5-3 Regional Geological Setting (Jacobs, 2020c)

5.5 Hydrogeological setting

5.5.1 Hydrostratigraphic units

The hydrogeological units and structural features within the Project area are described below.

Anthropogenic Fill

The Project is located within an urban setting and therefore it is expected that fill material would be encountered with varying thickness, composition, and compaction.

Thin layers of fill material are commonly used in urban areas for landscaping and minor topography alterations. Thicker layers are associated with construction of major infrastructure and used for land reclamation in areas adjacent to the harbour for development of parkland, residential, industrial, and open space areas.

Palaeochannels

Palaeochannels are infilled with up to 50 m of variably permeable saturated sediments comprising of remnant alluvium, estuarine, and marine deposits. They are associated with a network of ancient river systems that have eroded narrow and deep drainage channels into the underlying shale and sandstone bedrock, which drain east towards Botany Bay (AECOM, 2015).

The occurrence of the palaeochannels within the Project area are generally limited to beneath the area of the harbour with smaller occurrences of paleochannel-style deposits or basal sands potentially occurring in the larger onshore drainages such as Whites Creek, located in the southern extent of the Project area (Jacobs, 2020a). Previous tunnelling projects within Sydney show that palaeochannels are critical in tunnel design. They can store large volumes of surface water and groundwater and are highly transmissive, which can result in increased groundwater inflow into the tunnels. Additionally, there is structural complexity within the rock mass beneath the palaeochannels such as faults and dykes and valley stress relief fracturing (Jacobs, 2020a).

Ashfield Shale

The Ashfield Shale is one of three formations that are collectively known as the Wianamatta Group. The unit is typically 45 to 60 m thick and was deposited during a single regressive episode in the Mid-Triassic in a lacustrine or marine setting. In general, it comprises dark grey to black siltstone/mudstone or laminate (thin alternating layers of siltstone and sandstone) that is sometimes carbonaceous with variable silt and clay particles throughout. The rock structure is laminated but still retains bedding planes.

The rock also contains faulting, fracturing, shears, bedding planes and displays slickensided (evidence of geological faulting) features along some surfaces. The Ashfield Shale weathers to a stiff to hard clay with medium to high plasticity where it is exposed. The weathered profile typically extends to a depth of three to ten metres, although has been found to extend to depths in excess of 40 metres (AECOM, 2015). The Ashfield Shale is only present at ridgelines and outcrops within the northern extent of the Project around the area of the Pacific Highway (Jacobs, 2020a).

Hawkesbury Sandstone

The Hawkesbury Sandstone was deposited in the Late Triassic period in a fluvial paleo-environment and was likely a braided river setting. The unit is a medium to coarse-grained, quartzose sandstone, with interbedded shale beds which can provide local or regional confining layers. The confining layers within the heterogeneous and stratified unit create separate aquifers, with differing water quality and hydraulic heads.

The formation extends across the entirety of the Sydney Basin (up to 290 metres thick) 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 m to greater than five metres but generally occur between one to two metres. Secondary structural features such as joints, fractures, faults and palaeochannels are also present.

The sandstone weathers to a clayey sand residual skeletal soil profile typically one to two metres deep. Within the upper ten metres of the profile a duricrust can sometimes be present where iron cementation has caused the development of ferricrete or silica cementation has caused the development of silcrete. Iron staining is characterised by deep orange and red colouration throughout the rock mass that can be concentrated along water bearing fractures (AECOM, 2015).

5.5.2 Structural features

Multiple geological structural features including dykes, faults, valley stress relief fracturing, and joint swarms intersect the hydrogeological units within the Project area.

Younger Jurassic age basaltic dykes have intruded into the shale and sandstone formations of the Sydney Basin. The dykes are typically oriented between 90° and 120° and between 5° and 35°, consistent with the dominant orientation of faults and joints within the Sydney Basin. The dykes are of variable thickness ranging from less than three metres to up to 16 metres wide (AECOM, 2015).

These intrusive dykes influence the predominant groundwater flow directions within the Hawkesbury Sandstone. The dykes can act as hydraulic barriers when perpendicular to the groundwater flow and can enhance permeability parallel to their strike due to jointing and alteration (contact metamorphism) related to the original intrusion and subsequent weathering.

Dykes can present both a risk to tunnelling and can present hazardous situations if unmanaged, for example, tunnelling in a depressurised aquifer through a dyke and then encountering a fully pressurised formation (compartmentalisation). High groundwater inflows can also be expected when dykes are in proximity to open water bodies such as the Sydney Harbour, as they can provide a conduit for the groundwater flow (Jacobs, 2020a).

Known dykes cross the Project area on the southern side of Sydney Harbour at Yurulbin Park and Rozelle, and on the northern side at Balls Head in Waverton. Numerous unidentified dykes are anticipated to be encountered during construction and the occurrence of the dykes along the Project area is difficult to assess due to the difficulty to map in an urban environment (Jacobs, 2020a).

5.5.3 Aquifer hydraulic properties

Ashfield Shale

The Ashfield Shale is characterised by limited pore space and poor connectivity of the bedding planes and as such forms an aquitard reducing groundwater infiltration to the underlying formations.

Site-specific hydraulic conductivity values, from packer-testing within the Ashfield Shale during previous investigations in the Sydney region, ranged between <0.0001 m/day to 0.73 m/day, which is similar to values reported for the Hawkesbury Sandstone. However, the maximum and arithmetic mean values for the Hawkesbury Sandstone were found to be an order of magnitude greater in the M4-M5 Link project investigation.

Hawkesbury Sandstone

The Hawkesbury Sandstone is characterised as having low to moderate hydraulic conductivity, which is dominated by secondary fracture flow. Hydraulic conductivity testing (comprising packer tests) was conducted during the field investigation program to inform the EIS and to provide hydraulic parameters to support the groundwater modelling (Jacobs, 2020a).

Packer-test results for the Hawkesbury Sandstone are summarised in Table 5-2. The test results ranged over several orders of magnitude; however, the values generally align with previous investigations in the Sydney region (Jacobs, 2020a). Regional packer-testing was undertaken in the Hawkesbury Sandstone across the Sydney Basin during a previous investigation by Tammetta and Hawkes (2009), which indicated there was a trend of decreasing hydraulic conductivity values with depth. The trend was attributed to less frequent fracture spacing and increasing lithostatic pressure with depth. Site-specific permeability results from the marine-based testing are typically

1 to 1.5 orders of magnitude greater than that of the land-based values, which is inferred to reflect the increased occurrence and concentration of structures within the harbour area.

Table 5-2 Estimated hydraulic conductivity values from packer testing for the Hawkesbury Sandstone

Packer Test Area	Minimum Hydraulic Conductivity (m/day)	Maximum Hydraulic Conductivity (m/day)	Mean Hydraulic Conductivity (m/day)	Median Hydraulic Conductivity (m/day)
All land-based tests in the WHT and WFU* Project areas	1.1×10^{-5}	0.17	0.015	0.0012
Rozelle to Birchgrove	5.1×10^{-5}	0.05	0.006	0.002
Waverton	1.1×10^{-5}	0.17	0.021	0.001
Sydney Harbour (marine-based)	2.8×10^{-5}	15.72	0.454	0.026

Source: Appendix N of the EIS (Technical working paper: Groundwater) (Jacobs, 2020)

*Warringah Freeway Upgrade

5.5.4 Regional groundwater flow, recharge, and discharge

Groundwater flow within the Ashfield Shale is poor due to the limited pore space and poor hydraulic connectivity of the bedding planes. The Ashfield Shale is an aquitard, which reduces groundwater infiltration to the underlying formations, including the Hawkesbury Sandstone. The majority of regional groundwater flow through this unit is via saturated fractures and joints, however, these secondary features can reduce the flow locally (AECOM, 2015).

The Hawkesbury Sandstone is a dual porosity aquifer whereby groundwater flow is via primary porosity (interconnected void space between grains of the rock matrix) and secondary porosity via structural features including joints, fractures, faults, shear zones, and bedding planes.

Groundwater flow rate within the Hawkesbury Sandstone is governed by low matrix permeability with the hydraulic conductivity generally within the order of 10^{-3} to 10^{-1} m/day and is dominated by secondary fracture flow. Higher groundwater yields are recorded when saturated fractures are intersected (AECOM, 2015).

Hawkesbury Sandstone groundwater resources are primarily recharged via rainfall infiltration at outcrops (and shallow subcrop). Recharge is low where the Ashfield Shale aquitard overlies the Hawkesbury Sandstone.

Recharge also occurs via infiltration through the soil profile, however, due to the high urbanisation within the Project area, this type of recharge is reliant on vegetated areas such as remnant bush, parks, and grassed areas (Jacobs, 2020a).

Deposits of fill material and alluvium are generally shallow, forming unconfined perched and/or discontinuous aquifers that are recharged primarily from rainfall, with minor contribution from irrigation, leaky service mains, and flow from the underlying bedrock units. Groundwater flow in these deposits occurs as intergranular flow via preferential pathways provided by interconnected lenses of sand and gravel with higher permeability.

Groundwater discharge occurs mainly along the coastal areas, outflowing to the harbour, and as well as through evapotranspiration. Evapotranspiration can be a large component of the water balance when conditions are favourable (shallow water table within the root zone), however, can vary depending on land use and water table depth. Predictive modelling of the WHT and WFU Project areas indicated an effective evapotranspiration depth of 0.5 m.

Minor discharge mechanisms include groundwater bore extraction and groundwater drainage to existing underground infrastructure including unlined tunnels and (leaky) stormwater/sewer lines (Jacobs, 2020a).

5.5.5 Groundwater quality

Salinity concentrations within the Ashfield Shale is highly variable though is typically characterised as brackish or saline¹ due to marine salts contained within the shale. Total dissolved solids (TDS) values typically range between 5,000 mg/L and 12,000 mg/L and can be up to 40,000 mg/L.

The Hawkesbury Sandstone is generally acidic and low salinity; however, the upper portion of the aquifer can have an elevated salinity due to leakage / diffusion from the overlying Ashfield Shale (AECOM, 2015). Groundwater quality within the paleochannels is typically saline, due to leakage from tidal tributaries.

Further detail on groundwater quality identified during background groundwater monitoring are included in the Groundwater Monitoring Program (Appendix F1).

Baseline groundwater monitoring within the vicinity of the Project area commenced in October 2017 and this data has been used to describe the baseline groundwater quality (Jacobs, 2020a). The baseline data was collected from nine standpipe piezometers. A summary of the baseline groundwater quality is included in Table 5-3.

Baseline monitoring was only conducted at a series of standpipe piezometers installed within the Hawkesbury Sandstone, which is the dominate geological unit within the Project area. Other geological units were not monitored (Jacobs, 2020a).

No baseline groundwater quality data was provided in the MOD2 assessment for the Emu Plains (WHT13) construction ancillary facility.

Table 5-3 Baseline groundwater quality of the Hawkesbury Sandstone

Parameter	Hawkesbury Sandstone
EC	Fresh to highly saline (392 µS/cm at B150P to 37,100 µS/cm at B131A). Large range represents the proximity of the bores to the harbour, with higher EC values reported at bores closer to the saline interface. Or ingress of saline water through preferential flow paths as discussed in Section 5.4.2 and 5.4.3
pH	Acidic to slightly basic (4.1 at B181A to 8.0 at B105A).
Major ions	Dominated by sodium and chloride indicating relatively mature groundwater within little recharging influence.
Metals (dissolved)	Maximum levels exceeded the freshwater guideline concentrations ¹ values for boron and copper; and marine guideline concentrations ¹ for cobalt and copper.

EC = electrical conductivity; µS/cm = microSiemens per centimetre
¹ Australia and New Zealand Guidelines for Fresh and Marine Water Quality, 95% level of protection (ANZECC, 2000)

¹ Brackish water contains between 0.5 and 30 grams of salt per litre—more often expressed as 0.5 to 30 parts per thousand (‰), which is a specific gravity of between 1.0004 and 1.0226. Thus, brackish covers a range of salinity regimes and is not considered a precisely defined condition. Water with a salt concentration greater than 30‰ is considered saline.

5.6 Sensitive receptors

5.6.1 Priority groundwater dependent ecosystems

There were no noted priority Groundwater Dependent Ecosystems (GDEs) identified within the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources within 500 m of the Project area. GDEs associated with Quarry Creek and Flat Rock Creek have been identified within 1 km of modelled groundwater drawdown (Jacobs, 2020a).

Assessment of the potential for the Emu Plains (WHT13) construction ancillary facility to support groundwater dependant ecosystems was carried in the MOD2 assessment using the Commonwealth's Bureau of Meteorology Groundwater Dependant Ecosystems Atlas (BOM, 2023). No vegetation within or directly adjoining the site has been mapped as a Groundwater Dependent Ecosystem

5.6.2 Non-priority groundwater dependent ecosystems

A search of non-priority GDEs was conducted and reported in the EIS, Appendix S (Technical Working Paper: Biodiversity Development Assessment Report.) An assessment of a 500 m buffer around the Project using the Bureau of Meteorology's groundwater dependent ecosystem atlas (BOM, 2018) did not identify any non-priority GDEs.

No registered springs were identified within the search areas.

5.6.3 Registered groundwater bores

A review of DPIE Water registered groundwater bores indicates that there are 24 registered bores within 1 km of the Project area, none of which have been identified as Water Access Licence (WAL) users. The majority of the bores (21) are used for monitoring purposes.

There is one bore which has an unknown purpose and three which were installed for abstractive use. These bores are detailed below:

- GW023150.1.1 is located in Cremorne and is used for irrigation purposes. It is located approximately 750 m from the alignment and is installed in the Hawkesbury Sandstone to 1.8 metres below ground level (mbgl).
- GW108991.1.1 is located in Wollstonecraft and is used for water supply. It is located approximately 410 m from the alignment and is installed in the Hawkesbury Sandstone to 168 mbgl.
- GW109209.1.1 is located in Birchgrove and is used for water supply. It is located approximately 270 m from the alignment and is installed to 4.5 mbgl in either an area of fill material or potentially alluvium, which is underlain by Hawkesbury Sandstone.
- GW107764 is located in North Sydney, approximately 680 m from the alignment. Details regarding the drilled depth and bore purpose are unknown; however, it is possible that this bore is used for domestic supply.

REMM SG2 requires that the viability of domestic bores GW109209, GW107764, and GW108991 will be confirmed prior to construction, and if drawdown at the bores exceeds two metres (in accordance with the Aquifer Interference Policy), 'make good' measures will be implemented. In accordance with this requirement, a Groundwater Bore Viability Report (GHD, 2022) has been prepared for TfNSW, which notes the following:

A. GW109209:

Groundwater bore GW109209 was found to be a functional well which is used for water supply. Analysis of a water sample indicates that, based on measurement of electrical conductivity (EC), the water is relatively fresh. This confirms that the well is not recharged from the nearby Mort Bay estuary, but a fresh water source such as direct infiltration from rainfall. Considering the shallow nature of the well and likely source connection to infiltration from rainwater, connection to the regional groundwater table is considered unlikely. It is

considered that impacts to the bore from the project are likely to be minimal and therefore no further action is required.

B. GW107764:

This bore is no longer used. It is therefore considered that there will be no impact to this bore from the project and no further action is required.

C. GW108991

The high SWL in groundwater bore GW108991 suggests that the aquifer source is confined and under reasonable pressure for it to rise to 13 m SWL. If the aquifer is confined and at significant depth below construction, it is unlikely that any drawdown affects from a shallower aquifer will affect this confined aquifer since connectivity between the two is unlikely. It may also reflect that there is minimal groundwater above in a shallower context at this location. It is therefore considered that there will be no impact to this bore from the project. Further to this, despite an extensive search the bore could not be located despite an extensive search and is therefore assumed to no longer exist. No further action is required.

No groundwater wells were identified at the Emu Plains (WHT13) construction ancillary facility, however the MOD2 assessment reviewed groundwater wells listed within 1km of the site which indicates that groundwater is expected to be present at approximately 15 metres to 20 metres below natural ground level.

5.7 Potential groundwater contamination

An assessment of contaminated land risk is provided in the EIS, Appendix M (Technical working paper: Contamination) (Jacobs, 2020b). Areas within the Project that may contain contaminated soil and/or groundwater due to past or present land use practices have been identified. Further assessment of groundwater contamination potential was included in the RtS (Appendix E – Groundwater memorandum (Jacobs, 2020d)), which responded to issues raised by the NSW EPA, DPE Water and the Natural Resources Access Regulator.

During routine monthly baseline groundwater monitoring to inform the EIS, the analytical suite included cations and anions, (dissolved) heavy metals, nutrients, and hydrocarbon compounds. The monitoring bore locations and sample summary are included in Table 5-4.

Table 5-4 Baseline groundwater quality sampling summary

Bore ID	Location	Formation	Number of samples	Comments
B104A	Birchgrove	Hawkesbury Sandstone	7	Metals results considered unreliable due to high pH ²
B105A	Birchgrove		8	Complete results
B112P	Waverton		10	Complete results
B131A	Birchgrove		8	Complete results
B150P	North Sydney		8	Complete results
B181A	Rozelle		8	Complete results
B208	Balmain		6	Metals results considered unreliable due to high pH
B209	Birchgrove		2	Complete results

² Bores with pH > 8.5 are considered likely to have been impacted by an alkaline source, most likely grout contamination during installation.

Bore ID	Location	Formation	Number of samples	Comments
B390	Rozelle		8	Complete results

The following bores within the vicinity of the Project area (see Attachment 1 in the GWMP, Appendix F1 for bore locations) met or exceeded the ANZECC 2000 guidelines for freshwater and marine settings (95% level of protection):

- Boron: bores at North Sydney (B150P), Birchgrove (B131A), and Rozelle Rail Yards (B390) exceeded the freshwater criteria.
- Cobalt: bores at North Sydney (B150P), Waverton (B112P), Birchgrove (B131A), Rozelle (B181A), and Rozelle Rail Yards (B390) met or exceeded the marine criteria.
- Copper: bores at Waverton (B112P), Birchgrove (B104A), Balmain (B208A), Rozelle (B181A), and Rozelle Rail Yards (B390) exceeded freshwater and marine criteria.

Concentrations of hydrocarbon compounds were detected at North Sydney (B150P), Birchgrove (B104A, B105A and B131A), Balmain (B208A), Rozelle (B181A), and Rozelle Rail Yards (B390).

In addition to metals and hydrocarbon compounds detected at the Birchgrove peninsula (B131), elevated concentrations of sulfate and ammonia were also detected. The area is recognised to contain contaminated fill material comprising of slag and ash furnace waste from historical harbour-side industries (Jacobs, 2020b).

Noting the current status of the groundwater quality (pre-construction), there are primary areas with contamination potential along the alignment which were identified and assessed (Jacobs, 2020b).

Contaminated soil and groundwater (including light non-aqueous phase liquid (LNAPL)) has been reported at the Rozelle Rail Yards. Contamination is likely due to historic land use and importation of fill materials of unknown origin. The Rozelle ventilation building cavern for the Project are within the area of contamination however were already constructed and remediated by the Rozelle Interchange Project for the purpose of the proposed use (ventilation building) and has been handed over in a completed state for internal fit-out to be undertaken.

Additional areas of interest that are considered to have a moderate or high risk to groundwater resources included (Jacobs, 2020b):

- Yurulbin Park in Birchgrove: Located above the tunnel alignment.
- Waverton Park in Waverton: Located above the tunnel alignment and consists of contaminated fill material. Groundwater contamination has not been assessed.
- Balls Head Drive (Waverton): Former bulk fuel storage area located above the tunnel alignment. Groundwater quality in this area has not been assessed.
- The White Bay Power Station: Within the vicinity of the White Bay construction support site.

Further investigations are required at the identified contaminated sites and if contamination risks are established, appropriate design (e.g. tanking) and/or management (e.g. treatment) measures will be implemented to remove or suitably reduce the associated risk, as further discussed in Section 7. The updated groundwater modelling will comply with the requirements of Condition E219.

In line with REMM SG13, ground gas investigations will be carried out in Easton Park, Rozelle Rail Yards and Waverton Park to assess for the potential presence of landfill generated gas which could impact on the construction and/or operation of the project.

Ground gas investigations will be carried out in accordance (where applicable) with the Guideline for the Assessment and Management of Sites Impacted by Hazardous Ground Gases (NSW EPA, 2012).

It should be noted that civil works resulting in groundwater drawdown in proximity to the Rozelle Rail Yard, where there is a high risk of the presence of contamination, is primarily attributed to the

M4-M5 Link (Jacobs, 2020d). The M4-M5 Link's approval requirements and groundwater monitoring program at the Rozelle Rail Yard should be sufficient in meeting the Project's monitoring requirements. Any additional requirements are included in the GWMP (Appendix F1).

The MOD2 assessment established that key potential sources of onsite contamination are generally related to filling, the historical use of the site for agricultural purposes and potential impacts to upper soil horizons and shallow from spills or leaks of hydrocarbons and oils. In addition, no excavation to groundwater level is proposed at the Emu Plains (WHT13) construction ancillary site. As such further groundwater management is not considered to be necessary at Emu Plains (WHT13) construction ancillary site. Refer to Soil and Surface Water Management Plan for the management of potential contamination from construction works.

6 Environmental aspects and impacts

6.1 Construction activities

Key aspects of the Project that could result in potential adverse impacts to groundwater include:

- Tunnelling and excavation below groundwater table (including cut and cover and trough structures)
- Dewatering due to groundwater inflows into tunnels
- Operation of WTPs, including wastewater storage and discharge
- Operation of construction vehicles including refuelling and workshops, which can result in spills, leaks, or waste which can alter groundwater quality.

Refer also to the Aspects and Impacts Register included in Appendix A2 of the CEMP.

6.2 Groundwater impacts arising from construction

The potential for groundwater impacts has been identified within the planning approval documentation with potential impacts attributable to construction including:

- Reduced groundwater recharge (alteration of land use).
- Groundwater level decrease (drawdown associated with groundwater inflow into tunnels) including potential impacts on the following:
 - Existing groundwater users.
 - Decrease in the groundwater baseflow to surface water features³ (creek or river gaining systems).
 - Groundwater movement (settlement).
- Groundwater level decrease due to:
 - Pressure relief (artesian) flow at excavations within confined aquifers (removal of cover resulting in groundwater discharge within cut and cover or trough excavations)
- Change in groundwater quality due to the following:
 - Oil and fuel spills or leaks (associated with construction vehicles).
 - Contaminant migration within groundwater from contaminated sites.
 - Artificial recharge due to storage and discharge of (treated) groundwater and surface water impacts as a result of discharges to the groundwater collection and discharge system.
 - Groundwater quality deterioration (blending of water types).
 - Saltwater intrusion.
- Activation of acid sulfate soils.
- Settlement due to groundwater drawdown.
- Buoyancy instability and/or waterlogging issues resulting from groundwater level increases due to alteration of groundwater flow patterns (mounding of groundwater on upgradient side of linear infrastructure).

³ Noting that GDEs have not been identified within the predicted groundwater drawdown extent

- Decrease in groundwater levels on the downgradient side of linear infrastructure (alteration of flow patterns, gradients, and throughflow due to tunnel and portals).
- Cumulative impacts from nearby state significant infrastructure projects with impacts on groundwater.

Relevant aspects and the potential for related impacts have been considered in a risk assessment at Appendix A2 of the CEMP.

Section 7 provides management measures that will be implemented to avoid, minimise, and/or manage the identified potential impacts.

6.2.1 Reduced groundwater recharge

Recharge via rainfall infiltration and surface flow (losing systems) could potentially be reduced as a result of construction activities (the ventilation tunnels and wastewater treatment plant site), however the predictive groundwater modelling (Jacobs 2020a) indicated the groundwater recharge reduction as a result of the Project was negligible (0.04%) as the majority of the Project is underground.

6.2.2 Groundwater level decrease

Groundwater drawdown

Construction of drained tunnels⁴ beneath the water table will cause ongoing groundwater inflow to the tunnel, inducing groundwater drawdown along the tunnel alignment. Actual extent of groundwater level drawdown depends on aquifer hydraulic properties (transmissivity and storage) (i.e. the specific geological conditions present (AECOM, 2017)).

Section 16.4.5 of the EIS noted that modelling of tunnel inflows during the construction phase are on average predicted to be between 0.34 and 0.48 L/s/km, with peak inflows expected to occur in the first year of construction.

The groundwater drawdown extent assessment:

- Used the EIS predictive groundwater model to estimate the zone of influence, drawdown due to the construction, considering only the WHT and WFU construction components of the Western Harbour Tunnel and Warringah Freeway Upgrade Project (Project only scenario).
- Used the groundwater model to predict the cumulative groundwater drawdown impacts considering the WHT and WFU construction components of the Western Harbour Tunnel and Warringah Freeway Upgrade Project in combination with other planned infrastructure projects including:
 - The M4-M5 Link,
 - Sydney Metro Chatswood to Sydenham and
 - Beaches Link, and Gore Hill Freeway Connection (cumulative scenario).

The predictive groundwater models will be updated to predict influences on construction components of the Project as well as the cumulative impacts from the local infrastructure projects, as per GWMM5 and GWMM6 in Table 7-1. Groundwater level decreases outside of the seasonal fluctuation and rate of drawdown will be assessed and compared against predicted drawdown as simulated in the updated groundwater model, as discussed in Section 8.1.2 of the GWMP (Appendix F1) and in Table 7-1 (GWMM7 and GWMM8).

⁴ Groundwater is channelled by means of strip drains to a sump, which leads to a permanent drawdown of the groundwater surrounding the tunnel

Potential impacts to Groundwater Dependent Ecosystems

There are no GDEs identified within the water sharing plan for the Greater Metropolitan Region Groundwater Sources within 500 m of the Project alignment or within the Project only predicted drawdown model area. However, GDEs associated with Quarry Creek and Flat Rock Creek are located within 1 km of modelled drawdown (Project only scenario).

Due to the sensitivity of these groundwater users, water level and quality monitoring will be conducted in accordance with the GWMP (see Section 5 and 6 of the GWMP) to validate model predictions and act as an early warning for corrective actions.

Potential impacts to existing groundwater users

Groundwater modelling was used to predict drawdown at three registered groundwater bores (GW109209, GW107764, and GW108991 (Section 5.4.5)) within the vicinity of the Project area that are potentially being used for water supply.

The Minimal Impact Considerations in the NSW Aquifer Interference Policy (AIP) (DPI Water, 2012) are a cumulative water level decline of no more than 2 m and this requirement is met for GW107764 (1 to 2 m) and GW108991 (<1 m), however, not for GW109209 (2 to 3 m).

The predictive modelling conducted by Jacobs (2020a) indicated:

- GW108991.1.1 is predicted to experience drawdown of less than 1 m at the end of construction, which satisfies the minimal impact considerations of the AIP, requiring no more than 2 m cumulative water level decline.
- Groundwater bore GW109209.1.1 was predicted to experience groundwater level drawdown of 3 m at the end of construction. Thus, the predicted impact would exceed the minimal impact considerations of the NSW AIP (DPI Water, 2012).
- Up to 2 m of drawdown is predicted at GW107764. This impact is within the AIP minimum impact levels
- No predictive modelling was conducted for GW023150.1.1, likely due to the shallow nature of the bore (1.8 m deep).

Potential impacts on surface water baseflow

The Project is located in a heavily urbanised area and drainage channels are typically highly modified and concrete lined.

Whites Creek, located in the southern extent of the Project area, has been modified along its complete length (buried pipes or concrete lines) and therefore is not recognised to interact with groundwater (loss or gain of baseflow).

Willoughby Creek, located in the northern extent of the Project area, has been modified (concrete lined) in the upper reaches. No drawdown for the cumulative scenario was predicted beneath the natural lower portion of the creek and, therefore, not predicted to be impacted.

Ground movement (settlement)

Ground movement (settlement) can occur due to groundwater drawdown and redistribution of stresses in the rock mass due to tunnel excavation.

An assessment of settlement, elevation decrease predictions and possible associated damage to infrastructure, was undertaken by Arup and WSP (2019). The assessment considered the maximum predicted settlement and surface angular distortion at key infrastructure locations.

The assessment indicated that all Project components (with the exception of the access declines at Victoria Road and Berrys Bay) are expected to experience surface settlement impacts of around 10 millimetres (mm). Long term surface settlement of over 40 mm was predicted around the Warringah Freeway dive structure and up to approximately 40 mm predicted along parts of the tunnel between the Western Harbour Tunnel crossing and the Warringah Freeway. All other project components are predicted to be subject to total settlement measurements of 30 mm or less.

Based on these settlement predictions very slight to slight aesthetic damage was predicted to occur to a number of buildings from long-term ground surface settlement.

6.2.3 Groundwater quality

Spills and incidents

There is potential to contaminate groundwater resources through incidents associated with the storage and handling of hazardous materials or refuelling operations during construction activities, particularly if a leak or incident occurs over a paleochannel or fractured sandstone.

Stockpiling of construction materials (oils, fuel, etc.), which may spill or leak, can introduce contaminants that could potentially leach into and contaminate local groundwater (AECOM, 2017).

Intercepting contaminated groundwater

Potential impacts from groundwater drawdown that may arise from areas of environmental interest for existing contamination include the following (Jacobs, 2020a):

- Groundwater:
- The speed and direction of contaminant migration may change due to altered (steeper due to dewatering) hydraulic gradients.
- Lowering of groundwater levels may lead to the contaminant plume disconnecting from the source of contamination.
- Soil:
- Where existing soil contamination has not yet reached the water table, lowering of groundwater levels may act to mitigate, or delay, soil contamination from migrating to groundwater.

Predictive modelling of groundwater drawdown was completed for areas of environmental interest for contamination, within 500 m of the Project alignment. This modelling indicated that drawdown below these areas will generally be minor for the Project, however, there is increased potential for contaminant migration based on the cumulative drawdown scenario.

The cumulative drawdown scenario impacts the contaminated area around Rozelle Rail Yards, largely due to the effect of the M4-M5 Link project. The predicted impact does not meet the Level 1 Minimal Impact criteria of the NSW AIP, which states that the beneficial use of the groundwater source 40 m away from the activity must not be reduced (DPI Water, 2012). It is noted that there are no sensitive receptors between the Project alignment and the contaminated sites, which satisfies the NSW AIP (DPI Water, 2012) (Jacob 2020a).

The approval requirements and groundwater monitoring program implemented for the M4-M5 Link project will form the foundation for managing predicted cumulative impacts (Jacobs, 2020d). Additional proposed monitoring requirements for the Rozelle Rail Yards have been included in the GWMP (Appendix F1).

In general, the risk of intersecting contaminated groundwater decreases with tunnel design depth. Any migration of contaminants, plus altered groundwater due to mixing / blending, would be towards the tunnel where all inflow water will be pumped to designated WTP before being discharged into either the marine or stormwater receiving environments. Discharge criteria are outlined in the MCoA (E208) and Section 6.5.3 of the GWMP (Appendix F1).

Given the overall low hydraulic conductivity of the Hawkesbury Sandstone and the dilution of contaminants through groundwater mobilisation, impact to underground structures resultant from contaminant migration is considered low (Jacobs, 2020a). However, monitoring of groundwater during dewatering activities must be completed to validate model predictions and allow for corrective actions if required (see GWMP Appendix F1). Further, groundwater monitoring will work to inform WTP inputs and required treatment prior to discharge.

Groundwater treatment and surface water impacts

The baseline groundwater quality within the Project area is described in Section 5.4.4 and in further detail in the GMP. In order to prevent adverse impacts on downstream surface water quality, WTP will be installed for water treatment prior to water release at discharge point locations. For further information on the WTPs refer to Section 7.1

Groundwater associated with potential acid sulfate soils

Potential acid sulfate soils (PASS) have been identified within the Project area at Rozelle Rail Yards (Class 1 ASS risk) and Birchgrove Park (Class 2 ASS risk). Additionally, Sydney Harbour, Rozelle Bay, and land adjacent to watercourses such as Whites Creek are identified as having a high probability of acid sulfate soils (Jacobs 2020b). The predictive modelling, for the cumulative scenario, indicated that based on the drawdown predictions there is potential for acid generation.

6.2.4 Utilities

The Project will involve works that would include the protection of existing utilities, construction of new utilities, and relocation of existing utilities. The majority of the utility works for the Project are shallow within existing roads and footpaths above the groundwater table.

No dewatering is expected within these excavations reducing the potential for the Project to impact on shallow groundwater resources. Specific groundwater management measures (GWMM12) are outlined in Table 7-1.

6.2.5 Construction monitoring

A GWMP has been developed to describe how ACCIONA propose to monitor potential impacts to groundwater during construction of the Project (Appendix F1).

7 Environmental control measures

Construction associated with the Project has the potential to impact groundwater within and adjacent to the construction footprint. In order to avoid, mitigate and/or minimise these potential impacts, a range of environmental requirements and control measures are identified in the various environmental documents, including the EIS and other Transport for NSW guidance documents. These specific measures and requirements, along with additional measures identified as best practice, are outlined in Table 7-1. Measures specific to the management of marine impacts will be updated into this document prior to the Harbour Crossing phase.

This chapter has been developed in consideration of the 'SMART Principles' – Specific, Measurable, Achievable, Relevant and Time-based.

7.1 Water Treatment Plants

Water treatment forms a key environmental control measure. Groundwater inflow and construction water would be collected and treated during construction via Construction WTPs. The Construction WTPs will be designed so that discharged water quality is compliant with the relevant discharge criteria provided in MCoA 208/REMM WQ3 or unless the EPL specifies alternative criteria.

Where alternative criteria are proposed, these will be described in a Water Pollution Impact Assessment (WPIA) (aka Water Discharge Impact Assessment) consistent with Section 45 of the POEO Act, in compliance with MCoA 210. This will be used by the EPA in determination of alternate, site-specific criteria, which will be documented in the Project EPL.

Refer to the Groundwater Monitoring Program (Appendix F1) for more details regarding the monitoring of discharge volume and discharge water quality and relevant discharge criteria. Discharge volumes will be continuously monitored at the WTP's via calibrated flow meters, in-line calibrated pH and turbidity sensors with appropriate alerts set to inform management of any drift in WTP performance.

During commissioning of each of the WTPs, a minimum of two rounds of commissioning sampling will be undertaken to confirm their efficacy. The objectives of the commissioning testing will be to determine:

- If the WTPs perform to meet the relevant discharge criteria and what (if any) design or operational modifications may be required to the WTP in order for it to meet the required specifications
- The relationship between TSS and turbidity to allow turbidity to be measured as a proxy for TSS — this will require more samples than for the other parameters and may continue into the post-commissioning phase.

The WTP will not be deemed “commissioned” until two subsequent rounds of testing confirm compliance with relevant criteria.

Where practicable groundwater captured and treated during construction activities is to be used in accordance with the Project's Water Reuse Strategy, to be prepared in accordance with MCoA E127. In doing so, water identified for reuse (rather than discharge) may be subject to different criteria, based on the intention of the reuse, to ensure it is fit for purpose.

Discharge locations will be as described in the Project EPL. In some cases, a Trade Waste Agreement may be sought from Sydney Water for disposal of wastewater into the sewer system, however this is currently not the preferred method of groundwater management and no agreement has been sought at this time.

The process of internal approval for the active discharge of water is included in the SSWMP (Section 7.8).

7.2 Management through Design

There are a number of groundwater management obligations that require technical input from design, geotechnical and groundwater engineers. These are summarised in the sections below. These requirements will be communicated to the Design team to ensure full knowledge of Project design requirements and will be reviewed as part of the Design Review process which includes internal and TfNSW review.

7.2.1 Modelling, monitoring and assessment

7.2.1.1 Settlement

- MCoA E102, REMM SG1: A Geotechnical Model will be prepared to meet the requirements of both MCoA E102 and REMM SG1, of representative geological and groundwater conditions to assess the cumulative predicted settlement, ground movement, stress redistribution, horizontal strain profiles and groundwater drawdown.
- MCoA E103: Review of surface and sub-surface structures at risk from damage to determine appropriate criteria to prevent damage.
- MCoA E104: Implementation of standard settlement criteria (in the absence of new, more stringent criteria to be applied).
- MCoA E105: Implementation of an instrumentation and monitoring plan for the monitoring of settlement, distortion or strain, where the geotechnical model (MCoA E102) identifies exceedance of the applied criteria (MCoA E103 & MCoA E104). Note, the adopted criteria do not remove any responsibility from the Proponent for the protection of existing surface and sub-surface structures or for rectifying any damage to surface and subsurface structures resulting from the CSSI.
- MCoA E106: Repeated process of MCoA E102-105 in the case of a substantial difference between modelling predictions and monitoring outcomes.

7.2.1.2 Groundwater

- MCoA E218: Modelling of groundwater drawdown, tunnel inflows and saline water migration (using particle tracking) in consultation with DPIE Water, including hydrogeological analyses of 12 continuous months of baseline groundwater monitoring data.
- MCoA E219, REMM SG17, REMM SG21, REMM SG22: Preparation of an independently reviewed Groundwater Modelling Report, in accordance with the Australian Groundwater Modelling Guidelines (National Water Commission, 2012) which includes documentation of any additional measures that would be implemented to manage and/or mitigate groundwater impacts.
- MCoA E220, REMM SG18, REMM SG22: Update of the Groundwater Modelling Report following 24 months of groundwater monitoring data.

7.2.2 Groundwater inflow and movement

- MCoA E216, REMM SG14: limit operational groundwater inflows into each tunnel to no greater than one litre per second across any given kilometre (1L/s/km)

7.2.3 Property and community impacts

- MCoA E107-109, REMM SG4: Offer and carry out pre and post construction Condition Surveys at properties and heritage assets that take up the offer. Provide survey reports to property owners within the nominated time frames. Pre construction surveys will be completed (where accepted) prior to the commencement of the tunnelling and vibration-intensive activities in the vicinity with the potential to affect the building/structure/heritage asset.
- REMM SG3: An Independent Property Impact Assessment Panel (IPIAP) will be established by TfNSW and ACCIONA will provide information as requested by the IPIAP.

7.3 Management and mitigation measures

Management and mitigation measures relevant to the project are outlined in Table 7-1. These will be implemented to minimise impacts to groundwater and ensure all commitments and requirements of the project approval are met. These specific management and mitigation measures have been developed to address the requirements of the MCoA and commitments of the REMMs.

Table 7-1 Groundwater management and mitigation measures

ID	Measure/Requirement	Resources needed	When to implement	Responsibility	Reference	Evidence
GWMM1	The design requirements for the management of groundwater impacts, as described in Section 7.2, will be: - Communicated to the Project Design Manager. - implemented/addressed as evidenced through Design Reports and the independent review process and/or documented in the Groundwater Modelling Report. - Included in the Project environmental compliance and auditing processes.	Design Manager	Pre-construction Construction	Environment & Sustainability Manager Design Manager	Multiple sources as detailed in Section 7.2	Design Reports Groundwater Modelling Report
GWMM2	Monitoring of groundwater levels, electrical conductivity and temperature in key locations between saline water bodies and the tunnel and compared to model predictions and groundwater performance criteria applied to the Project. Monitoring requirements are described in the GWMP (Appendix F1).	Suitably qualified person GWMP (Appendix F1) Revised groundwater model	Construction	Environment & Sustainability Manager Design Manager	MCoA C14 (e) MCoA E220 MCoA E221 REMM SG17 REMM SG18 REMM SG20	Groundwater modelling report Groundwater monitoring reports

ID	Measure/Requirement	Resources needed	When to implement	Responsibility	Reference	Evidence
GWMM3	An Independent Property Impact Assessment Panel, comprising geotechnical and engineering experts, will be established prior to the commencement of works to independently verify building condition survey reports, resolve any property damage disputes, and establish ongoing settlement and vibration monitoring requirements.	Independent Property Impact Assessment Panel Condition surveys	Pre-construction Construction	Design Manager	MCoA E107 REMM SG3	Condition surveys
GWMM4	Pre- and (where pre-construction surveys have been accepted and completed) post-construction building/structure condition surveys will be offered and prepared for properties (and heritage assets) within the zone of influence of tunnel settlement and within the minimum working distances for cosmetic and structural damage due to vibration. The surveys will be carried out by a suitably qualified person prior to the commencement of the tunnelling and vibration-intensive activities in the vicinity with the potential to affect the building/structure. Agreements with utility and infrastructure owners will be prepared before tunnel construction starts identifying acceptable limits of settlement, settlement monitoring and actions in the event that settlement limits are exceeded.	Condition surveys Settlement modelling	Pre-construction	Design Manager	MCoA E107-109 REMM SG1 REMM SG4	Condition surveys

ID	Measure/Requirement	Resources needed	When to implement	Responsibility	Reference	Evidence
GWMM5	Emergency spill procedures will be developed to avoid and manage accidental spillages of fuels, chemicals, and fluids to minimise the risk of human health impacts and contamination of groundwater.	Emergency spill procedure	Construction	Construction Manager	REMM SG23 REMM WQ2 Relevant guidelines: Transport for NSW, 2015	Soil and Surface Water Management Plan Adherence to Chemical Storage and Spill Response Guidelines (Transport for NSW, 2018) Training records
GWMM6	The velocity of wastewater treatment plant discharge will be minimised through the application of velocity dampeners (such as rock lined culvert or similar) where there is risk of causing scour impacts on the marine environment.		Construction	Design Manager Environment coordinator	REMM B18	Visual inspections of the discharge points to note any scouring

ID	Measure/Requirement	Resources needed	When to implement	Responsibility	Reference	Evidence
GWMM7	Groundwater intercepted during construction will be managed by capturing the water that enters the tunnels and construction excavations below the water table, or by other suitable measures. All captured inflow will be treated to the criteria specified in MCoA E208 or as otherwise approved by the EPL. Water quality testing of the water discharged from the treatment plants will be carried out to ensure minimal impact on receiving water environments (GWMP Appendix F1).	GWMP (Appendix F1) Suitably qualified person	During construction	Construction Manager Environment Manager	MCoA C14 (c) MCoA E208 REMM WQ3	Discharge monitoring results

8 Compliance management

Compliance of the Project with this GMP will be measured against the targets outlined in Section 2.3 through ongoing monitoring throughout the construction of the Project.

8.1 Roles and responsibilities

The ACCIONA Project Team's organisational structure and overall roles and responsibilities as well as the Environmental Representative and required specialists are outlined in Section 5.7 of the CEMP. Specific responsibilities for the implementation of environmental controls are detailed in Section 7 of this Plan.

8.2 Training and awareness

A range of training tools will be used to ensure compliance with this Plan and build knowledge across the WHT Project workforce and contractors. Training will be undertaken in accordance with requirements detailed in the CEMP.

All employees, contractors and utility staff working on site will undergo site induction training relating to groundwater management issues detailed in relevant aspects of this Plan, particularly construction risks which have the potential to impact on groundwater resources.

The induction training will address elements related to groundwater management including:

- Groundwater monitoring methodology as detailed in GWMP Appendix F1.
- Awareness of the following key guidelines and standards related to groundwater sampling and management:
 - Guidelines for Assessment and Management of Groundwater (DEC, 2007)
 - Australian Standard for Water Quality Sampling (AS/NZS 5667.11:1998)
 - The National Environmental Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM) (2013)
- Project obligations including requirements to assess and classify contamination of site.

Targeted training in the form of toolbox talks or specific training will also be provided to personnel with a key role in groundwater management.

An overview of training methods and awareness of groundwater management issues, methods, for all construction activities including temporary works, is provided in Table 8-1.

Table 8-1 Training Methods and Awareness Methods

Method	Details	Responsibility
Site specific inductions	Site specific inductions will include specific components for groundwater management.	HSEQ Representative(s) Site Supervisor or equivalent
Pre-start meetings	Where relevant, daily pre-start meetings will include an update on groundwater conditions and any further mitigation including changes to data and comments regarding excavation / changes / discharge issues. To be conducted with all workers involved with dewatering and groundwater management.	Site Supervisor or equivalent
Safety, Quality and Environment alerts	Project alerts on groundwater condition updates, changes to groundwater management requirements, and learnings from previous incidents relating to groundwater will be Released	HSEQ Representative(s)

Method	Details	Responsibility
	by the WHT Project and distributed by the Project at toolbox meetings and posted on site notice boards.	

Further details regarding staff induction and training are outlined in Section 5.9 of the CEMP.

8.3 Monitoring and inspections

Section 5 and 6 of the GWMP (Appendix F1) includes details of the groundwater monitoring that has been completed for the preconstruction and groundwater monitoring proposed for the construction phase of the Project, respectively.

The groundwater monitoring, sampling, data analysis, and reporting (as detailed in Section 8.5) will be undertaken by a suitably qualified Environmental Scientist (or equivalent) within the context of the National Environmental Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM 2013).

The GWMP (Appendix F1) provides detailed monitoring requirements including:

- Groundwater monitoring locations.
- Water quality parameters and/or analytes to be monitored.
- Type of monitoring.
- Frequency of monitoring.
- Monitoring methodology.

Pre-and post-construction Condition Survey Reports will be undertaken as described in this document.

Additional requirements and responsibilities in relation to inspections are documented in Section 5.12 of the CEMP.

8.4 Auditing

Internal and external auditing will be undertaken to assess the effectiveness of environmental controls, compliance with this Plan, MCoA and other relevant approvals, licenses and guidelines.

Audit requirements are detailed in Section 5.13 of the CEMP.

8.5 Reporting

Reporting requirements and responsibilities are documented in Section 5.14 of the CEMP. Specific reporting requirements relevant to this GMP are outlined in Table 8-2.

Table 8-2 Reporting

Schedule (during construction)	Requirements	Recipient (relevant authority)
Sydney Water quarterly water monitoring reports (every 3 months) when discharging to Sydney Water assets.	In accordance with MCoA C14(g), Quarterly reports are to include; - Results from monitoring bores - Daily measurement of the amount of water discharged from the water treatment plants Issued within 90 days of the end of the monitoring period.	Sydney Water (Only when discharges are directed to Sydney Water assets)
Quarterly water monitoring data (every 3 months)	In accordance with MCoA C14, Quarterly groundwater data will include: - Daily measurement of the amount of water discharged from the water treatment plants; - Water quality testing of the water discharged from treatment plants; - Factual monitoring results of groundwater levels in aquifers adjacent to the tunnel alignment; - Factual monitoring data of groundwater levels, electrical conductivity and temperature in key locations between saline water bodies and the tunnel (including beneath high risk sites for contamination where identified in the Groundwater Model); - Estimate of groundwater inflows into the tunnels during their construction; For every second quarter this requirement may be achieved by including the data with the six-monthly Groundwater Monitoring Report. Groundwater monitoring data will also be provided in electronic format (excel or csv). Issued within 90 days of the end of the monitoring period.	DPE Water
Groundwater Monitoring Report (every 6 months)	In accordance with MCoA C21, Six-monthly Groundwater Monitoring Report will comprise of: - Daily measurement of the amount of water discharged from the water treatment plants; - Water quality testing of the water discharged from treatment plants; - Monitoring results of groundwater levels in aquifers adjacent to the tunnel alignment; - Factual monitoring data of groundwater levels, electrical conductivity and temperature in key locations between saline water bodies and the tunnel (including beneath high risk sites for contamination where identified in the Groundwater Model); - Estimate of groundwater inflows into the tunnels during their construction;	DPE Water Planning Secretary

Schedule (during construction)	Requirements	Recipient (relevant authority)
	- Interpretation of any data outside the monitoring criteria - Additional mitigation measures Groundwater monitoring data will also be provided in electronic format (excel or csv). Issued within 90 days of the end of the monitoring period.	
Annual monitoring reports	In accordance with MCoA E221 the total incidental groundwater take from the tunnel will be measured at a minimum monthly and totalled yearly for the life of the CSSI. These volumes must be reported to DPIE Water annually. This reporting requirement may be achieved by including the data with an annual total in quarterly groundwater monitoring reports. Issued within 90 days of the end of the monitoring period.	DPE Water Planning Secretary
24 months groundwater model report	In accordance with MCoA E219 and E220, an update of modelling based on comparison of monitoring data (water level change, inflow volumes and rates, and drawdown extent) with predictions. This report is to be interpretive in nature.	DPE Water Planning Secretary

8.6 Non-conformance, Incident Reporting, and Investigation

Non-conformances, incident reporting and subsequent investigation will be undertaken as required in accordance with Section 5.16 of the CEMP.

9 Review and improvement

9.1 Continuous improvement

Continuous improvement of this plan and of monitoring requirements detailed in Section 8.3 of this Plan will be achieved by the ongoing evaluation of environmental management performance against planning approval requirements, environmental policies, objectives and targets for the purpose of identifying opportunities for improvement.

The continuous improvement process will be designed to:

- Identify areas of opportunity for improvement of environmental management and performance
- Determine the cause or causes of non-conformances and deficiencies
- Develop and implement a plan of corrective and preventative action to address any non-conformances and deficiencies
- Verify the effectiveness of the corrective and preventative actions
- Document any changes in procedures resulting from process improvement
- Make comparisons with objectives and targets outlined in Section 2.3.

9.2 Groundwater model update

Further groundwater modelling will be undertaken prior to finalising the detailed design of tunnels and any other activities that may impact groundwater levels or flows. The updated groundwater model will take into consideration a minimum of 24 months continuous baseline groundwater monitoring data collected prior to commencement of construction, in accordance with CoA E218.

The results of the groundwater modelling will be documented in a (pre-construction) Groundwater Modelling Report. The Groundwater Modelling Report will be finalised in accordance with the *Australian Groundwater Modelling Guidelines* (National Water Commission, 2012), independently reviewed by a suitably qualified groundwater specialist and prepared in consultation with DPI Water prior to commencement of construction.

Construction and operational inflow predictions will be updated prior to commencement of construction and operational inflow and impact predictions will be updated at the end of the construction period.

In accordance with CoA E220, following the collection of 24-months of (during construction) groundwater monitoring data the groundwater model will be updated again. The updated model will be provided to the Planning Secretary and DPIE Water in the form of an updated groundwater modelling report. Should the model update indicate additional risk to groundwater users (GDEs and supply bores) or increased drawdown extents, the groundwater monitoring network will be reviewed to establish if further monitoring points are required.

The groundwater model will be updated as required based on the results of this monitoring, and proposed management measures to minimise potential groundwater impacts will be adjusted accordingly. If monitoring results indicate that groundwater inflows and water table drawdown will be greater than the refined model impact, then feasible and reasonable measures will be implemented.

9.3 GMP update and amendment

The processes described in Section 6 of the CEMP may result in the need to update or revise this GMP. This will occur whenever there is a change to the construction scope or methodology that may increase the potential impacts upon groundwater or to address relevant updates to a related sub plan or monitoring program.

Only the Environment and Sustainability Manager (in consultation with the Construction Manager) can amend this GMP. Any update of this plan will require endorsement of the TfNSW Representative, the Environmental Representative and depending on the change, process outlined in Section 6 of the CEMP must be followed where approval from the Planning Secretary prior to implementation of the update is required.

Appendix F1 Groundwater Monitoring Program

Appendix F1

Groundwater Monitoring Program

Western Harbour Tunnel

March 2024

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Document control

Approval and authorisation

Approved on behalf of ACCIONA by	Andrew Marsonet
Signed	
Dated	22 December 2022

Document status

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Glossary/Abbreviations

Abbreviation	Expanded text
AIP	NSW aquifer interference policy
ANZECC / ARMCANZ	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ASS	Acid Sulfate Soils
BTEXN	Benzene, toluene, ethylbenzene, xylene, naphthalene
CEMP	Construction Environmental Management Plan
CoC	Chain of Custody
Construction	Has the same definition as Schedule 1 of the planning approval (SSI #8863)
CSSI	Critical State Significant Infrastructure
DEH	New South Wales Department of Environment and Heritage (formerly EESG)
DoI – Water	New South Wales Department of Industry – Water (formerly DPE – Water)
DPE	New South Wales Department of Planning and Environment
DPIE – Water	Water Group of the Department of Planning, Industry and Environment
EESG	Environment, Energy and Science Group
EC	Electrical conductivity
EIS	Environmental Impact Statement
Environmental Representative (ER)	The Environmental Representative(s) for the CSSI approved by the Planning Secretary
EPA	NSW Environment Protection Authority
EPL	Environment Protection License
GDE	Groundwater Dependent Ecosystem
GMP	Groundwater Management Sub-plan
GWMP	Groundwater Monitoring Program
IMT	Immersed Tube
LoR	Limit of Reporting
Material harm	<i>Is harm that:</i> (a) Involves actual or potential harm to the health or safety of human beings or to the environment that is not trivial, or (b) Results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding \$10,000, (such loss includes the reasonable costs and expenses that would be incurred

Abbreviation	Expanded text
	in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment)
mAHD	Metres Australian Height Datum
Mbgl	Metres below ground level
MCoA	NSW Minister's Conditions of Approval
Minister, the	NSW Minister for Planning and Public Spaces
MOD2	Western Harbour Tunnel and Warringah Freeway Upgrade TBM solution of crossing Sydney Harbour – Modification 2
NATA	National association of testing authorities
Non-compliance	Failure to comply with the requirements of the Project approval or any applicable licence, permit or legal requirements.
Non-conformance	Failure to conform to the requirements of Project system documentation including this CEMP or supporting documentation.
PAH	Polycyclic Aromatic Hydrocarbon
Planning Approval Documents	Approval documentation as listed under MCoA A1
PFAS	Per and Poly Fluoroalkyl Substances
Principal, the	TfNSW
POEO Act	<i>Protection of the Environment Operations Act 1997</i> (NSW)
PPE	Personal Protective Equipment
Project, the	Western Harbour Tunnel
QAQC	Quality Assurance and Quality Control
REMM	Revised Environmental Management Measure
RtS	Response to Submissions Report
SSTV	Site Specific Trigger Values
SWL	Standing Water Level
TfNSW	Transport for New South Wales (formerly Roads and Maritime)
TDS	Total Dissolved Solids
TPH	Total Petroleum Hydrocarbon
TRH	Total Recoverable Hydrocarbon
TSS	Total Suspended Solids
The Project	Western Harbour Tunnelling package P2
VWP	Vibrating Wireline Piezometer
WFU	Warringah Freeway Upgrade
WHT	Western Harbour Tunnel

Abbreviation	Expanded text
WTP	Water Treatment Plant

1 Introduction

1.1 Context

This Groundwater Monitoring Program (GWMP) (or Program) forms part of the Construction Environmental Management Plan (CEMP) for the Western Harbour Tunnel (WHT) (the Project), a component of the Western Harbour Tunnel and Warringah Freeway Upgrade project.

The Program forms Appendix F1 of Groundwater Management Sub-plan (GMP) of the CEMP (Construction Environmental Management Plan).

This Program has been prepared to address the Minister's Conditions of Approval (MCoA), the Western Harbour Tunnel and Warringah Freeway Upgrade Environmental Impact Statement dated January 2020 (the EIS), the Western Harbour Tunnel and Warringah Freeway Upgrade Response to Submissions report dated September 2020 (the RtS), Western Harbour Tunnel and Warringah Freeway Upgrade TBM solution of crossing Sydney Harbour – Modification 2 (MOD2) and applicable guidelines and legislation. This Program has been developed in consideration of the SMART Principles – Specific, Measurable, Achievable, Relevant and Time-based.

1.2 Scope of the monitoring program

The scope of this Program is to describe how ACCIONA will monitor groundwater impacts (if any) during construction of the Project. The monitoring also aims to contribute to determining consistency with modelled impacts for ground settlement, contamination migration, or impacts to groundwater users.

1.3 Implementation

In accordance with MCoA, C18, the GWMP must be endorsed by the Environmental Representative (ER) and then submitted to the Planning Secretary for approval at least one month prior to commencement of construction.

As per MCoA C19, construction on the Project will not commence until the Planning Secretary has approved all required Construction Monitoring Programs (including this GWMP) relevant to the Project.

The GWMP, as approved by the Planning Secretary, including any minor amendments approved by the ER, will be implemented for the duration of construction and for any longer period or as specified by the Planning Secretary, whichever is the greater. Monitoring of groundwater will be undertaken to facilitate an adaptive response, which can be implemented if the construction program were to change, or the observed groundwater pressure response differs to the groundwater model predictions. This adaptive management will address those impacts and manage local groundwater quality.

2 Purpose and objectives

2.1 Purpose

The purpose of the GWMP is to describe how ACCIONA will monitor the extent and nature of potential impacts to the groundwater level and quality during construction of the Project.

This GWMP provides:

- Details of baseline data.
- Details on groundwater monitoring locations.
- Monitoring requirements.
- Monitoring frequency.
- Data management.
- Performance criteria.
- Reporting requirements.
- Guidance for review and improvement of the GWMP.

This GWMP has been prepared from baseline studies undertaken for the EIS. Supplementary groundwater monitoring data collected after the finalisation of the EIS has also been assessed to further evaluate the Project-specific hydrogeological regime(s) and ensure the optimum monitoring program to assess potential impacts of construction on the hydrogeological regime(s).

This Program supplements the GMP, which itself is an Appendix of the CEMP.

Details as required under MCoA and where this has been addressed within this document is included in Table 2-1.

Table 2-1: MCoA requirements for monitoring programs

Ref	Condition Requirements	Where addressed						
C11	The following Construction Monitoring Programs must be prepared in consultation with the relevant government agencies identified for each to compare actual performance of construction of the CSSI against the performance predicted in the documents listed in Condition A1 or in the CEMP: <table><tr><th></th><th>Required Construction Monitoring Program</th><th>Relevant government agencies to be consulted for each Construction Monitoring Program</th></tr><tr><td>(d)</td><td>Groundwater Monitoring Program</td><td>DPIE Water, EPA</td></tr></table>		Required Construction Monitoring Program	Relevant government agencies to be consulted for each Construction Monitoring Program	(d)	Groundwater Monitoring Program	DPIE Water, EPA	This Plan Section 2.3
	Required Construction Monitoring Program	Relevant government agencies to be consulted for each Construction Monitoring Program						
(d)	Groundwater Monitoring Program	DPIE Water, EPA						
C12	Each Construction Monitoring Program must provide: (a) details of baseline data available; (b) details of baseline data to be obtained and when;	Section 3						

Ref	Condition Requirements	Where addressed
	(c) details of all monitoring of the project to be undertaken; (d) the parameters of the project to be monitored; (e) the frequency of monitoring to be undertaken; (f) the location of monitoring; (g) the reporting of monitoring results and analysis results against relevant criteria; (h) details of the methods that will be used to analyse the monitoring data;	Section 4 Section 5 Table 5-1
	(i) procedures to identify and implement additional mitigation measures where the results of the monitoring indicate unacceptable project impacts;	Section 4
	(j) a consideration of SMART principles;	Section 1.1
	(k) any consultation to be undertaken in relation to the monitoring programs; and	Section 2.3
	(l) any specific requirements as required by Conditions C13 to C14.	This Plan
C14	The Groundwater Monitoring Program must include: (a) results from existing monitoring bores and from additional monitoring bores required following a review of the monitoring bore network, with the review based on actual results of existing monitoring and groundwater modelling findings in relation to the final tunnel detailed design;	Section 3
	(b) daily measurement of the amount of water discharged from the water treatment plants; (c) water quality testing of the water discharged from treatment plants;	Section 4.1 Section 4.2.1
	(d) monitoring of groundwater levels in aquifers adjacent to the tunnel alignment; (e) monitoring of groundwater levels, electrical conductivity and temperature in key locations between saline water bodies and the tunnel (including beneath high risk sites for contamination);	Section 4.3 Section 4.4
	(f) measures to record or otherwise estimate and report groundwater inflows into the tunnels during their construction;	Section 4.5
	(g) methods for providing the data collected under (a) and (b) to Sydney Water where discharges are directed to their assets; and (h) a method for providing the groundwater monitoring data to DPIE Water every three months during construction of the tunnels and portals.	Table 5-1

Ref	Condition Requirements	Where addressed
C17	The Construction Monitoring Programs must be developed in consultation with relevant government agencies as identified in Condition C11. Details of all information requested by an agency during consultation must be provided to the Planning Secretary as part of any submission of the relevant Construction Monitoring Programs, including copies of all correspondence from those agencies as required by Condition A5.	Section 2.3
C18	The Construction Monitoring Programs must be endorsed by the ER and then submitted to the Planning Secretary for approval at least one month before the commencement of construction.	Section 1.3
C19	Unless otherwise agreed with the Planning Secretary, construction must not commence until all of the relevant Construction Monitoring Programs have been approved by the Planning Secretary, and all relevant baseline data for the specific construction activity has been collected.	Section 1.3
C20	The Construction Monitoring Programs, as approved by the Planning Secretary including any minor amendments approved by the ER must be implemented for the duration of construction and for any longer period set out in the monitoring program or specified by the Planning Secretary, whichever is the greater.	Section 1.3
C21	The results of the Construction Monitoring Programs must be submitted to the Planning Secretary, and relevant regulatory agencies, for information in the form of a Construction Monitoring Report at the frequency identified in the relevant Construction Monitoring Program. <i>Note: Where a relevant CEMP Sub-plan exists, the relevant Construction Monitoring Program may be incorporated into that CEMP Sub-plan.</i>	Table 5-1

2.2 Objectives

The key objective of the GWMP is to ensure all requirements relevant to groundwater are described, scheduled, and assigned responsibility as outlined in:

- The revised environmental management measures (REMMs) included in the MOD2 report prepared for Western Harbour Tunnel and Warringah Freeway Upgrade project
- Minister's Conditions of Approval granted to the project on 21 January 2021
- Transport for NSW specification G36 Environment Protection (Transport for NSW, 2020)
- The Project's Environment Protection Licence (EPL)
- Relevant legislation and other requirements described in the GMP.

2.3 Consultation

The GWMP has been developed in consultation with DPIE Water and the NSW Environment Protection Authority (EPA) in accordance with MCoA C11(d).

Refer to Section 2 of the CEMP for the consultation requirements relating to the CEMP and all subplans.

Groundwater monitoring data will be provided to DPE Water every three months during construction of tunnels and portals (cut and cover or trough structures), in accordance with MCoA

C14(h) and consultation with DPE Water in relation to the updated Groundwater Modelling Report under MCoA E220.

Ongoing consultation with stakeholders may be undertaken for particular issues pertaining to the Project's impact on groundwater. Community feedback and complaints relating to local groundwater will be dealt with in accordance with the Project Communication Strategy and Complaints Management System.

3 Baseline monitoring

Baseline groundwater monitoring data has been collected from two sources to inform the Project GWMP:

1. Western Harbour Tunnel and Warringah Freeway Upgrade Environmental Impact Statement – Appendix N (Technical working paper: Groundwater) (Jacobs, January 2020); and
2. Additional monitoring undertaken by TfNSW following exhibition of the EIS. This data will continue to be reviewed and may be useful in further refining the groundwater model for the northern most extents of this Project if it presents significant unexpected monitoring results. Whilst the geology of the Project area is extensively documented, if the data significantly varies from existing groundwater model input data the groundwater model may be revised prior to the 24-month monitoring review required by MCoA E220.

No baseline groundwater monitoring was undertaken at the Emu Plains (WHT13) construction ancillary facility as part of the MOD2 assessment. Groundwater is expected to be 15-20m below ground level. In addition, proposed earthwork works at Emu Plains (WHT13) construction ancillary site would consist of limited subsurface excavation of relative shallow depth. No excavation to groundwater level is proposed at the site. As such, groundwater monitoring at Emu Plains (WHT13) construction ancillary facility is not considered hereinafter.

In accordance with MCoA C12 and C14, the GWMP aims to monitor groundwater conditions prior to and throughout construction of the Project to validate predicted groundwater impacts modelled in the Planning Approval documents and the Groundwater Modelling Report as required under MCoA E219 and E220.

Field investigations specific to the Project have been undertaken by consultants including AECOM, GHD, Golder and Associates, Coffey and SMEC to provide hydrogeological data for the project, including:

- Hydrogeological investigations
- Geotechnical investigations
- Contaminated land investigations
- Monitoring reports.

As outlined above, this monitoring occurred in two stages, initially during the EIS; and supplementary monitoring subsequent to EIS preparation. Outcomes are discussed in greater detail in the sections below.

3.1 EIS monitoring

A campaign of geotechnical drilling was carried out as part of the EIS investigations, including land-based drilling along the project alignment, and marine-based drilling through the harbour crossing areas. As described in EIS Appendix N (Jacobs 2020), the drilling program included an assessment for the Western Harbour Tunnel and Warringah Freeway Upgrade, as well as the

Beaches Link and Gore Hill Freeway Connection projects. In total the program in its entirety included:

- 497 individual packer tests (hydraulic testing for estimating hydraulic conductivity) were completed at 86 boreholes, comprising
 - 200 useable packer tests from 59 marine boreholes
 - 241 useable packer tests from 27 land boreholes
- Twenty-three boreholes installed with groundwater monitoring bores
- Six boreholes have completed with vibrating wire piezometer installations.

Completed monitoring bores were subject to groundwater water level and quality sampling, detailed in the EIS¹ and summarised below.

3.1.1 Groundwater Quality

Routine monthly groundwater quality monitoring for the project commenced in October 2017 across six sampling events at eight standpipe piezometers, specific to the WHT Project. Details of the monitoring sites are shown in Table 3-1 and the locations are shown on Figure 3-1. Following a review of this monitoring bore network, based on actual results of existing monitoring and groundwater modelling findings in relation to the final tunnel detailed design, the proposed locations are considered appropriate to provide reliable background data relevant to the final tunnel detailed design.

The baseline groundwater quality sampling program included the following analytes:

- Field physico-chemical parameters, such as pH, electrical conductivity (EC), Redox potential and dissolved oxygen.
- NATA accredited laboratory sampling for all borehole locations:
 - Lab pH and EC
 - Major cation and anions
 - Metals (total and dissolved) - As, Cd, Cr, Cu, Pb, Ni, Zn, Al, Fe, Se and Hg
- NATA accredited laboratory sampling collected adjacent to contaminated sites:
 - the total petroleum hydrocarbons (TPH),
 - total recoverable hydrocarbons (TRH)
 - benzene, toluene, ethylbenzene, and xylene (BTEX).

¹ Groundwater level results are reported in EIS Appendix N Section 5.5.2 and quality results are presented in EIS Appendix N Section 5.5.5.

Table 3-1 EIS Groundwater quality monitoring for WHT

Bore ID	Location (Figure 4-1)	Monitored Formation	No. of samples	Comments
B104A	Birchgrove	Hawkesbury Sandstone	5	Metals results considered unreliable due to high pH ¹
B105A	Birchgrove	Hawkesbury Sandstone	5	Complete results
B112P	Waverton	Hawkesbury Sandstone	8	Complete results
B131A	Birchgrove	Hawkesbury Sandstone	5	Complete results
B150P	North Sydney	Hawkesbury Sandstone	7	Complete results
B181A	Rozelle	Hawkesbury Sandstone	6	Complete results
B208	Balmain	Hawkesbury Sandstone	5	Metals results considered unreliable due to high pH
B390	Rozelle	Hawkesbury Sandstone	7	Complete results

Note 1: Bores with pH >8.5 are considered likely to have been impacted by an alkaline source, most likely grout contamination during installation

Physicochemical parameters

Electrical Conductivity (EC) laboratory measurements ranged from 392 µS/cm at B150P to 37,100 µS/cm at B131A. The variation shown in the data represents proximity to the harbour with the closest bores showing greater influence from proximity to the saline interface. The EC recorded at B131A more or less correlates with seawater salinity.

Anomalously high pH values have been obtained at B104A and B208, with extremely alkaline values in the range 11 to 12 pH units. These values are not considered to be representative of Hawkesbury Sandstone. pH can be naturally influenced by a number of factors, most notably geochemistry, saline intrusion, rainfall recharge and contamination. Bores that displayed a pH of greater than 8.5 were considered to indicate potential influence from an alkaline source, most likely contamination from the grout used in construction. As such, pH data from B104A and B208 have been discounted from this assessment. The remaining pH data set ranges from 4.1 at B181A to 8.0 at B105A.

Major ions

The majority of samples show a dominance of sodium and chloride indicating relatively mature groundwater with little recharging influence. B131A is indicative of seawater, both in major ion composition and salinity. No other bores show any significant saline influences B181A plots separately in the anion field and is more sulfate dominant than chloride dominant. B181A is also the most acidic of the samples with an average pH of 4.8. The low pH and elevated sulfate may be indicative of natural oxidation of sulphide minerals, possibly from shales, in this area.

Heavy metals

Dissolved metal concentrations have been compared against the ANZECC 2000 guidelines for marine and freshwater (95 per cent level of protection). Data considered unreliable due to high pH has been omitted from this analysis. A summary of exceedances of freshwater and marine guideline values is provided as follows and the full results are shown in Appendix D.

- Boron exceeded the freshwater guideline value of 0.37 mg/L in all samples collected from B131A, as well as from samples collected from B150P and B390. These bores are located on the shoreline at Birchgrove, near Berrys Bay, and at Rozelle Rail Yards, respectively. The water quality would be heavily influenced by seawater intrusion at Birchgrove and Berrys Bay

- Cobalt met or exceeded the marine guideline value of 0.001 mg/L in all samples collected from B112P, B131A, B150P, B181A and B390
- Copper showed exceedances of the freshwater and marine guideline values in samples collected from B104A, B112P, B181A, B208A and B390

Hydrocarbons

- Positive results for total petroleum hydrocarbons (TPH) and total recoverable hydrocarbons (TRH) are noted at B104A, B131A, B181A, B208A and B390
- Positive results for benzene, toluene, ethylbenzene, and xylene (BTEX) are noted at B104A, B105A, B131A, B150P and B208A.

3.1.2 Groundwater level

The purpose of the baseline groundwater level monitoring was to establish pre-construction groundwater level (natural) fluctuation, groundwater flow patterns and gradients across the Project to inform groundwater impacts.

A composite water table contour map was established using baseline groundwater data from the groundwater monitoring network, as well as water levels from the DPI Water Pinneena database, and water levels obtained from other nearby projects, including Sydney Metro City & Southwest (Chatswood to Sydenham) (Jacobs, 2016) and M4-M5 Link (AECOM, 2017a). The contours provide a general overview of key groundwater flow directions and trends along the alignment. This is included herein as Figure 3-1 below.

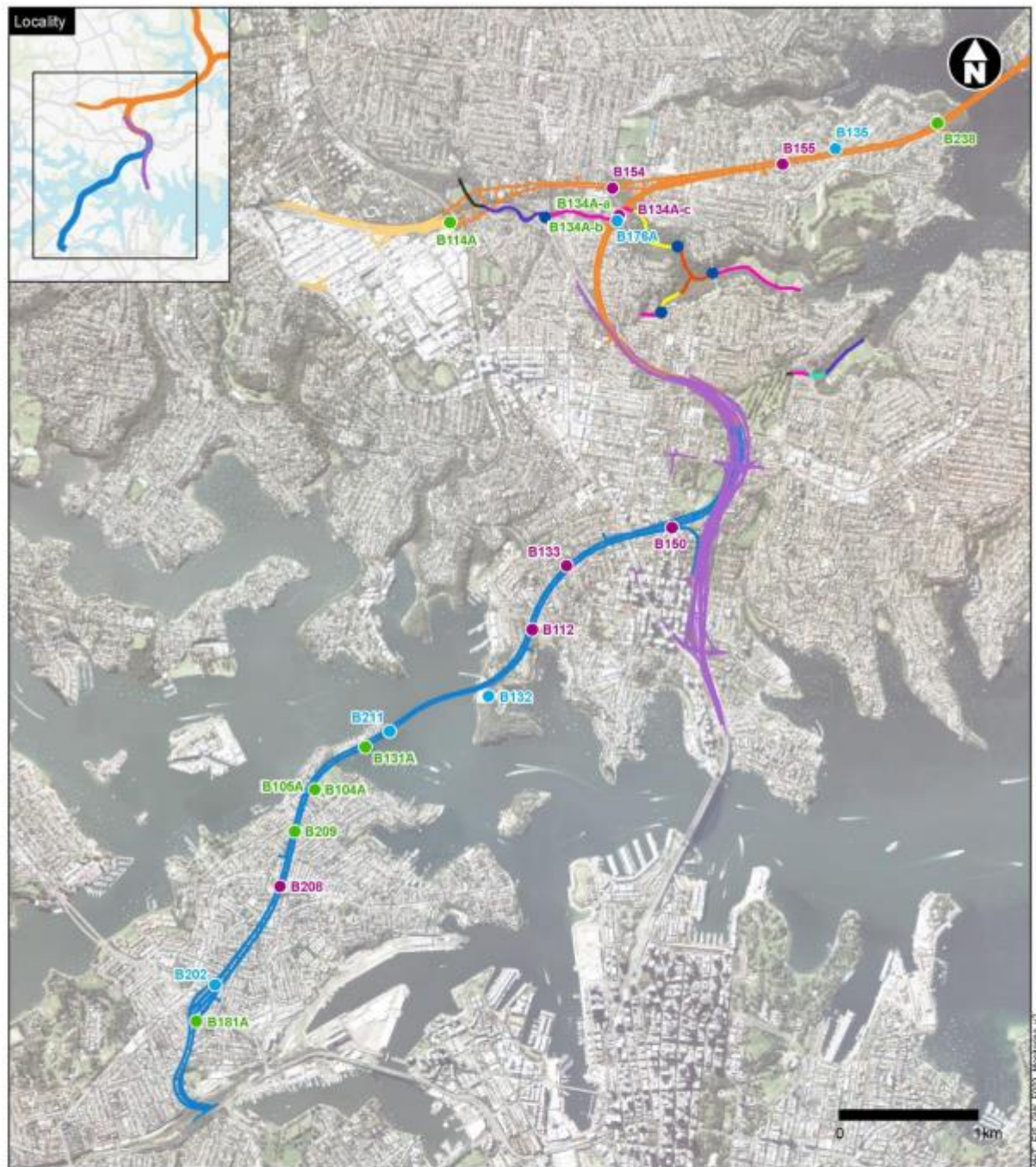


Figure 3-1 WHT Surface and Groundwater monitoring locations (EIS Appendix N, Figure 4-2)

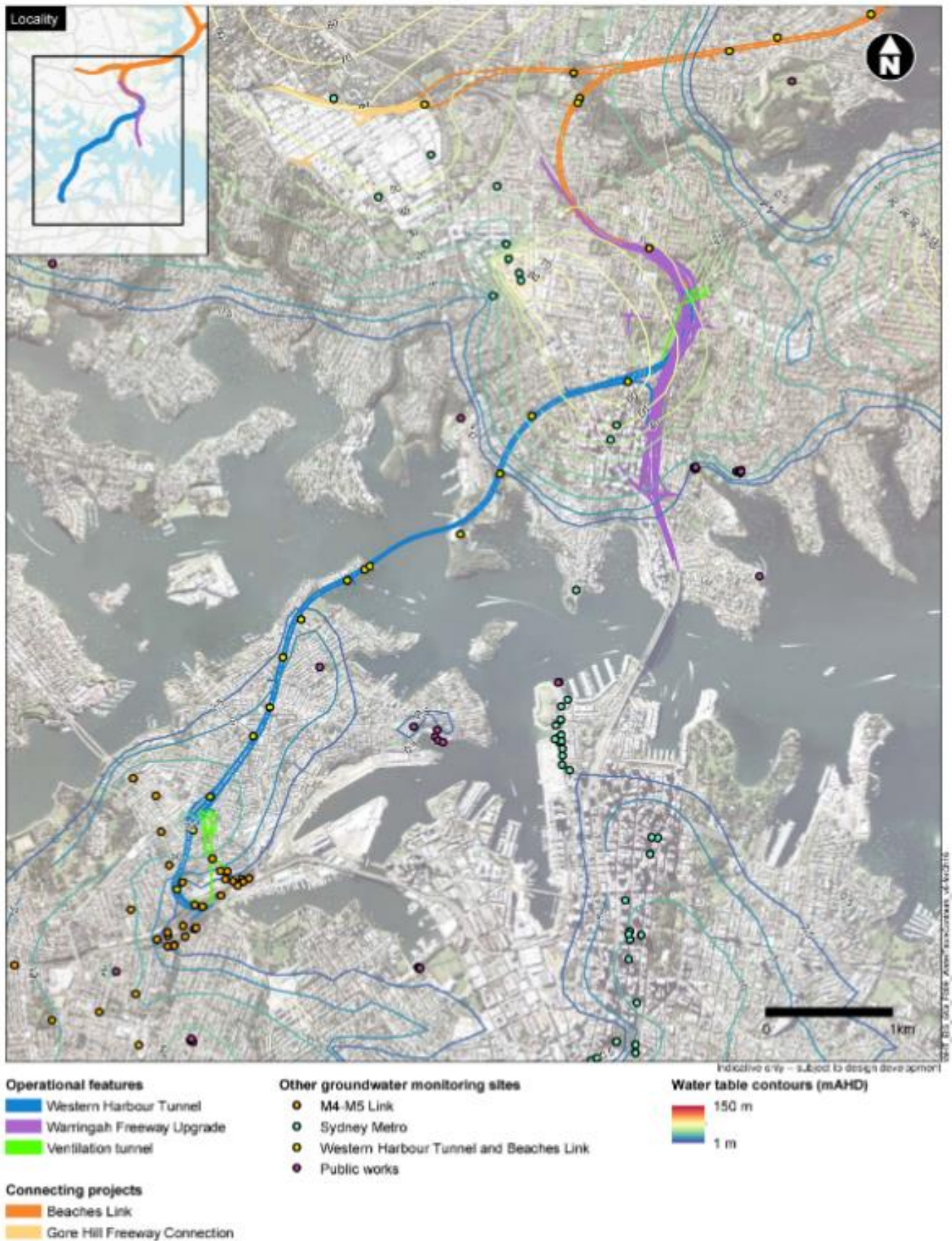


Figure 3-2 Baseline groundwater level monitoring outcomes (EIS Chapter 16, Figure 16-5)

3.2 Pre-construction monitoring

MCoA E218 stipulates that further groundwater modelling is to be completed prior to construction, to achieve a minimum of 12 months continuous baseline groundwater monitoring data. This commenced April 2022 via a monitoring program implemented by TfNSW including:

- A field scientist attending 13 existing monitoring bores to, where possible:
 - Collect manual measurements of standing groundwater levels using an interface probe
 - Download data from water level loggers where present/operational
 - Placement of HYDRAsleeve™ within screened intervals for groundwater sample collection
 - Collection of groundwater samples from HYDRAsleeve™ (approximately one-week post HYDRAsleeve™ installation) for water quality testing (including submission of samples to a National Association of Testing Authorities (NATA) accredited laboratory for testing of a suite of TfNSW determined analytes).
- Installation of water data level loggers and associated telemetry system, and HYDRAsleeves™ at GHD (2022) monitoring bores. Groundwater samples from these monitoring bores.
- Preparation of a factual report, which include:
 - Hydrographs for the existing monitoring bore network
 - Collation and reporting of groundwater analytical and water quality monitoring data (existing monitoring bore network only)
 - Collation and reporting of groundwater level telemetry data from selected GHD (2022) bores (selected bores only).

The pre-construction groundwater monitoring program is intended to be continued until Q1 2024. After which, various selected groundwater bores will be monitoring as part of the construction monitoring program phase. Refer to Section 4.3 and 4.4 for monitoring methodology. The result of the construction monitoring will inform the updated groundwater model and incorporated into the groundwater monitoring report. Refer to Table 5-1.

4 Construction monitoring methodology

The construction groundwater monitoring program includes the following components, which are described further in the sub-sections below:

1. Daily measurement of the volume of water discharged from water treatment plants (MCoA C14(b))
2. Water quality testing of the water discharged from the water treatment plant (MCoA C14(c))
3. Monitoring of groundwater levels in aquifers adjacent to the tunnel alignment (MCoA C14(d))
4. Monitoring of groundwater levels, electrical conductivity and temperature in key locations between saline water bodies and the tunnel (including beneath high-risk sites for contamination) (MCoA C14(e))
5. Measures to record or otherwise estimate and report groundwater inflows into the tunnels during their construction (MCoA C14(f)(h)).

All monitoring and sampling will be documented and transferred to a central electronic database under the responsibility of the Environment Manager.

This data will be reviewed and assessed as detailed in Section 6.

Results for each monitoring location will be recorded on appropriate field sheets (hard copy or digital) using unique sampling identification nomenclature consisting of the sample location (bore ID), date sampled and sampler details. The field sheet will detail:

- Prevailing weather conditions
- Prevailing tidal movement (where applicable)
- Name of sampler
- Monitoring equipment and technique used during sampling
- Time and date of sampling.

Further detail on each of the monitoring requirements are provided in the sections below.

4.1 WTP - discharge water volumes

The wastewater generated in the tunnel would be captured, tested and treated at a construction WTP prior to reuse or discharge, or disposal offsite. Water is not planned to be discharged to Sydney Water assets. In the event water is discharged to Sydney Water assets consultation will be undertaken to confirm if the receiving asset has flow rate constraints and any applicable discharge criteria, to be captured within a Trade Waste Agreement.

Discharge volumes will be recorded at WTP outlet via flow meters. This will enable the calculation of daily discharge totals in accordance with MCoA C14(b). Volume of water will be recorded via flow meters prior to WTP inlet to monitor the volume of water being treated.

Groundwater inflows, actual versus predicted, will be assessed to evaluate the groundwater model and inform construction noting that where groundwater inflows exceed 1 L/s/km during construction, feasible and reasonable mitigation measures will be applied.

As per WQ5 of the REMM, further design development will confirm the local stormwater system capacity to receive construction WTP inflows (to be documented in a Stormwater Drainage Report). Discharge volumes are to be consistent with those outlined in the Stormwater Drainage Report.

4.2 WTP - discharge water quality

Groundwater is typically characterised as containing heavy metals (e.g. iron, manganese, zinc, copper), nutrients (e.g. ammonia, total phosphorous), suspended solids, and hydrocarbon compounds (Jacobs, 2020a). It is expected, given proximity to harbour areas, that groundwater ingress would also be saline.

It is considered that the water treatment plants (WTPs) would need to remove iron, manganese, suspended solids, and hydrocarbon compounds as well as pH correction. The WTPs would also need to address salinity (manage salt loads) and other contaminants such as ammonia.

4.2.1 Parameters and Criteria

As per MCoA E208 and WQ3 of the REMM, discharge water from the construction WTP to surface waters will align with the following water quality criteria (to be amended if there are requirements established in the EPL):

- The relevant physical and chemical stressors set out in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000)

- The ANZG (2018) 90 % species protection levels for toxicants generally, with the exception of those toxicants known to bioaccumulate, which would be treated to meet the ANZG (2018) 95 % species protection levels
- The draft ANZG (2018) default guideline values for iron (in fresh and marine water) and zinc (in marine water)

Where the ANZG 2018 does not provide a default guideline value for a particular pollutant, the approaches set out in the ANZG 2018 for deriving guideline values, using interim guideline values and/or using other lines of evidence such as international scientific literature or water quality guidelines from other countries, must be used.

Parameters and criteria for water discharge will be subject to the requirements of the Project EPL.

4.2.2 Location

Monitoring is to be undertaken at the WTP release valve or the licenced discharge point as identified in the Project EPL.

4.2.3 Data analysis methods

Sampling shall be in accordance with *Approved methods for the sampling and analysis of water pollutants in NSW* (NSW EPA, 2022). Grab samples will be collected manually from WTP discharge points each day (where discharge occurs) and sent to a NATA accredited laboratory for analysis. All samples will be placed into laboratory supplied bottles with the appropriate preservatives.

Samples will be sent daily under CoC protocols to ensure no holding-time breaches are incurred. Standard 5-day turnaround times will be requested for analysis. If exceedances to guideline values are detected, shorter turnaround times (including 72 & 24-hour) will be requested however no timeframes can be guaranteed.

Results for pH and turbidity parameters shall be recorded with a data logger or field sheet. Oil and grease observations shall be recorded on a field sheet. Samples for parameters in Table 6-2 are to be transported to a NATA-accredited laboratory under chain-of-custody protocols of the laboratory.

Monitoring data shall be compared to the discharge criteria.

4.2.4 Management and mitigation

Where WTP detected an exceedance in oil and grease, pH, and turbidity parameters after the initial treatment, the WTP will redirect and retreat the water until water quality is below the parameters criteria before discharging.

The relevant physical and chemical stressors set out in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) will be monitored monthly. On receipt of non-compliant results, the WTP will be immediately re-tested to verify the non-compliance. Should the second monitoring event confirm non-compliance, Exceedances of WTP discharge quality criteria shall be reported to NSW EPA and/or Planning Secretary in accordance with the EPL.

4.3 Groundwater - level

4.3.1 Parameters and criteria

Groundwater levels shall be measured for comparison to predictions in the Groundwater Model. The parameter for groundwater level monitoring is meters. This will be represented against the Australian Height Datum. Vibrating wire piezometers (VWP) will record pore pressure or water level indicators in standpipes.

To verify the continuous measurements recorded by data loggers the standing groundwater level (SWL) will be measured and recorded at each groundwater monitoring bore using an electronic

groundwater level dip meter prior to data download. The SWL (to the nearest millimetre) will be referenced to a known (and consistent) surveyed point at the top of the bore casing. This measurement will be corrected to mAHD using survey data. Spreadsheets will be maintained detailing the conversion method and converted groundwater level measurement.

Barometric data loggers will be installed in select monitoring bores to allow for post-correction of water level data to atmospheric fluctuations. Manufacturer guidance suggests barometric loggers are installed within a 20 km radius of the monitoring bore. Further, as elevation increases barometric pressure decreases; therefore, consideration should be made to ensure installation of barometric data loggers in locations that are representative of elevation changes across the Project. One barometric data logger is deemed suitable for the project as the elevation range along the alignment is less than 100m AHD. Additional loggers may however be included as required for detailed design and to better inform groundwater modelling.

Atmospheric correction of water level data should be conducted as per the following example:

$$WL_{corr} = WL_{abs} - P_{atm}$$

Where:

WL_{corr} = corrected SWL

WL_{abs} = absolute water level as recorded by the data logger) barometric pressure plus water pressure)

P_{atm} = atmospheric pressure as recorded by the barometric logger

Note that due to the variable salinity (density) of groundwater measured across the Project, measured water level will require correction to account for this difference in fluid density a per the following:

$$hf \times \rho_f = hm \times \rho_m$$

Where:

hm = measured water column in bore

ρ_m = density of groundwater in bore based on measured TDS

hf = equivalent freshwater column in the bore

ρ_f is freshwater density

VWPs are equipped with data loggers, which are to be programmed to record pore pressures at six-hourly intervals. Data will be collected weekly and converted to equivalent metres of head (Plate 1).

Plate 1 Example of VWP data collection and conversion

Depth below Ground Surface	Ground Surface Elevation	Timestamp	Frequency	Temperature	Pore Pressure	Equivalent metres of Head	RWL
	mAHD		Hz	°C	kPa		mAHD
408	283.86	27/11/2011 12:00	1707.7	38.96	2483.8	253.2	129.1

4.3.2 Frequency

Automatic water level data loggers will be installed (or maintained from the baseline monitoring phase) to provide continuous data collection recorded at six-hourly intervals.

SWL monitoring will occur during the manual downloads, once per quarter.

4.3.3 Location

Locations utilised will be consistent with those identified in the TfNSW pre-construction monitoring program. Additional locations may be included during the construction phase, as identified through further modelling or predictions. Any changes will be undertaken in consultation with the ER and updated into this Program.

4.3.4 Data analysis

The results of construction groundwater monitoring data will be utilised in a model of groundwater drawdown, tunnel inflows and saline water migration to be documented in an updated Groundwater Modelling Report (as required under MCoA E220). The Groundwater Modelling Report must include:

- assessment of impacts of groundwater drawdown, taking into consideration the NSW Aquifer Interference Policy (DPI, 2012), including potential impacts on licensed bores and groundwater dependent ecosystems.
- a comparison of the results with the modelling results detailed in the planning approval documents.

In accordance with the NSW Aquifer Interference Policy (AIP) (DPI, 2012) minimal impact considerations, groundwater level and pore pressure will be assessed as follows:

- Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40m from any:
 - high priority groundwater dependent ecosystem; or
 - high priority culturally significant site listed in the schedule of the relevant water sharing plan.
- A cumulative maximum of 2m decline in water level or pore pressure at any water supply bore (as per REMM SG02).

If more than 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any:

- high priority groundwater dependent ecosystem; or
- high priority culturally significant site listed in the schedule of the relevant water sharing plan.

4.3.5 Management and mitigation

The results of the construction phase groundwater monitoring will be used to inform an updated version of the groundwater model (required under MCoA E218), and an updated Groundwater Modelling Report which must be updated once 24 months of groundwater monitoring data are available.

In accordance with MCoA E219, the revised Groundwater Modelling Report will include documentation of any additional measures that would be implemented to manage and/or mitigate groundwater impacts not previously identified or identified but at a smaller scale.

4.4 Groundwater - Electrical conductivity and temperature

4.4.1 Parameters and criteria

Salinity concentration shall be compared to predictions in the Groundwater Model. Electrical conductivity shall be measured in micro-Siemens per centimetre (μScm^{-1}). Temperature shall be recorded in degrees Celsius ($^{\circ}\text{C}$).

4.4.2 Frequency

Automatic water level data loggers will be installed (or maintained from the baseline monitoring phase) to provide continuous data collection recorded at six-hourly intervals.

4.4.3 Location

Locations utilised will be consistent with those identified in the TfNSW pre-construction monitoring program, following further review of suitability based on data outcomes, to be determined prior to the commencement of construction in consultation with the ER.

4.4.4 Data analysis methods

Salinity levels will be compared to predictions in the Groundwater Model. Six-monthly salinity data reports will be reviewed to determine if groundwater salinity is substantially different to predictions in the Groundwater Model. If so, model input parameters must be adjusted to calibrate the model so that predictions are better aligned with observed data.

4.4.5 Management and mitigation

As per Section 4.3.5

4.5 Tunnel inflow

4.5.1 Parameters and criteria

REMM SG14 requires where groundwater inflows exceed 1 L/s/km during construction, feasible and reasonable measures to manage inflow will be applied.

Salinity concentration shall be monitored and compared to predictions in the Groundwater Model. Electrical conductivity shall be measured in micro-Siemens per centimetre (μScm^{-1}). Temperature shall be recorded in degrees Celsius ($^{\circ}\text{C}$). Electrical conductivity will be monitored from the tunnel inflow prior to treatment by the wastewater treatment plant to understand saline intrusion.

To understand the volume of groundwater ingressed during construction, a number of flow meters will be installed at key points such as the WTP, potable water supply lines. The combination of these flow meters will be used to calculate the volume of groundwater that has ingressed during construction. An example of how this calculation/determination of water ingress could be achieved is provided in Figure 4-1.

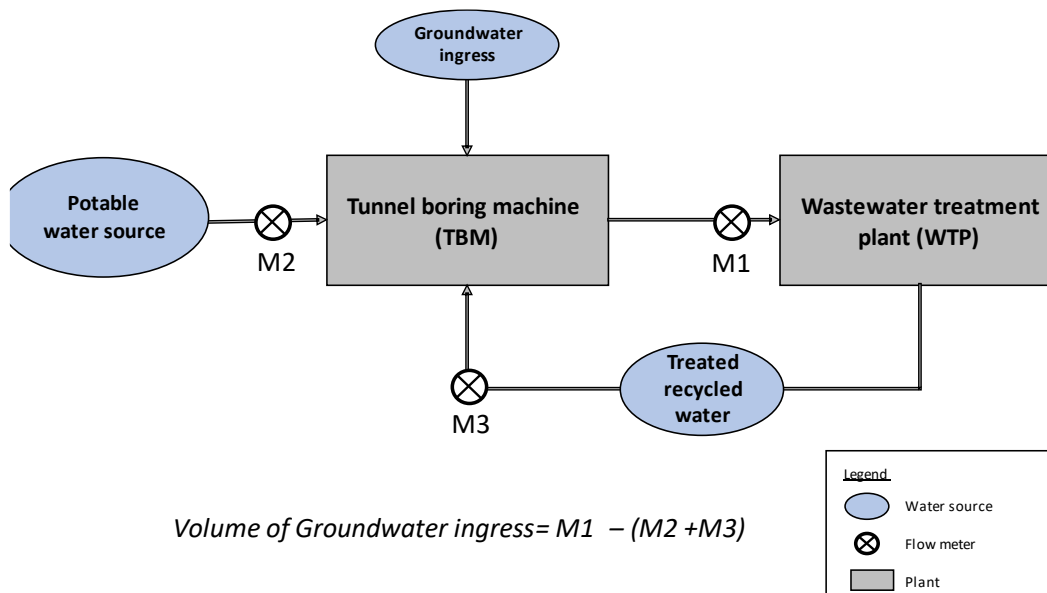


Figure 4-1: Example of how volume of groundwater ingress is calculated

4.5.2 Frequency

Inflows will be continuously recorded via flow meters and collated monthly to allow for the adoption of adaptive management (as required) during construction.

4.5.3 Location

During tunnel construction groundwater inflows will be collected in sumps / collection points at approximately one-kilometre intervals within the tunnel (as per MCoA E216).

4.5.4 Data Analysis Method

A water balance approach will be used to estimate groundwater inflows to the tunnel during construction as follows:

- Tunnel groundwater inflow = Tunnel water outflow – Construction water inflow

4.5.5 Management and mitigation

As per Section 4.3.5

5 Reporting of monitoring results

The specific groundwater reporting requirements during construction of the WHT are outlined in Table 5-1 below.

Table 5-1 Groundwater monitoring reporting

Schedule (during construction)	Requirements	Recipient (relevant authority)
Sydney Water quarterly water monitoring reports (every 3 months) when	In accordance with MCoA C14(g), Quarterly reports are to include; • Results from monitoring bores	Sydney Water (only when discharges are

Schedule (during construction)	Requirements	Recipient (relevant authority)
discharging to Sydney Water assets.	Daily measurement of the amount of water discharged from the water treatment plants Issued within 90 days of the end of the monitoring period.	directed to Sydney Water assets)
Quarterly water monitoring data (every 3 months)	In accordance with MCoA C14, Quarterly groundwater data will include: - Daily measurement of the amount of water discharged from the water treatment plants; - Water quality testing of the water discharged from treatment plants; - Factual monitoring results of groundwater levels in aquifers adjacent to the tunnel alignment; - Factual monitoring data of groundwater levels, electrical conductivity and temperature in key locations between saline water bodies and the tunnel (including beneath high risk sites for contamination where identified in the Groundwater Model); - Estimate of groundwater inflows into the tunnels during their construction; For every second quarter this requirement may be achieved by including the data with the six monthly Groundwater Monitoring Report. Groundwater monitoring data will also be provided in electronic format (excel or csv). Issued within 90 days of the end of the monitoring period.	DPE Water
Groundwater Monitoring Report (every 6 months)	In accordance with MCoA C21, Six-monthly Groundwater Monitoring Report will comprise of: - Daily measurement of the amount of water discharged from the water treatment plants; - Water quality testing of the water discharged from treatment plants; - Monitoring results of groundwater levels in aquifers adjacent to the tunnel alignment; - Factual monitoring data of groundwater levels, electrical conductivity and temperature in key locations between saline water bodies and the tunnel (including beneath high risk sites for contamination where identified in the Groundwater Model); - Estimate of groundwater inflows into the tunnels during their construction; - Interpretation of any data outside the monitoring criteria - Additional mitigation measures Groundwater monitoring data will also be provided in electronic format (excel or csv). Issued within 90 days of the end of the monitoring period.	DPE Water Planning Secretary

Schedule (during construction)	Requirements	Recipient (relevant authority)
Annual monitoring reports	In accordance with MCoA E221 the total incidental groundwater take from the tunnel will be measured at a minimum monthly and totalled yearly for the life of the CSSI. These volumes must be reported to DPIE Water annually. This reporting requirement may be achieved by including the data with an annual total in quarterly groundwater monitoring reports. Issued within 90 days of the end of the monitoring period.	DPE Water Planning Secretary
Groundwater Modelling Report (once 24 months of groundwater monitoring data are available)	In accordance with MCoA E219 and E220, an initial and updated model based on comparison of monitoring data (water level change, inflow volumes and rates, and drawdown extent) with predictions. The updated Groundwater Modelling Report will be undertaken once 24 months of groundwater monitoring data are available. This report is to be interpretive in nature.	DPE Water Planning Secretary
Substantial difference being identified in groundwater monitoring to predictions outlined in the geotechnical model (as required)	In accordance with Condition E106, where monitoring indicates groundwater drawdown or settlement is substantially different to predictions or in excess of the limits specified in the completed geotechnical model, modelling must be undertaken again within three months. Model input parameters must be adjusted so that predictions are better aligned with actual observations	DPE Water Planning Secretary TfNSW Consultation

6 Review and improvement

6.1 Continuous improvement and corrective actions

Continuous improvement of this program will be achieved by the ongoing evaluation of environmental management performance against environmental policies, objectives, and targets for the purpose of identifying opportunities for improvement.

6.1.1 Corrective actions

Should unexpected groundwater conditions be encountered, or groundwater monitoring indicate groundwater quality alteration due to contaminant migration then the following corrective actions / measures could be evaluated and implemented as appropriate:

- Reduction in the open area being dewatered, to reduce the rate of groundwater ingress, groundwater gradients (towards the tunnel(s)) and contaminant migration potential.
- Pump and treat from the vertical groundwater bores, to allow for the capture of possible contaminants migrating in groundwater prior to entering Project work areas.
- Groundwater will then be treated, to meet discharge criteria, before disposal.
- Reduce groundwater ingress into the tunnel through the change in construction approach and schedule, which would allow for the sealing (watertight) of sections of the excavations.
- Preparation of a Remedial Management Plan.
- If activation of ASS occurs the immediate response should be to investigate further to confirm change in conditions and assess the need to dose with lime or to determine if action needs to be taken (e.g. commence groundwater recharge, alter dewatering practice etc / continue monitoring)
- Where groundwater inflows exceed 1L/s/km during construction, feasible and reasonable measures to manage inflow will be applied (i.e. reduction in the area being dewatered, alteration of construction approach and timing)
- Make good provisions for groundwater users will be provided in the event of a material decline in water supply levels, quality or quantity from registered existing bores associated with groundwater changes from either construction and/or ongoing operational dewatering caused by the Project.

6.1.2 Model update

In accordance with MCoA E218 further groundwater modelling was undertaken following review of 12 months continuous baseline data, as part of the submitted Groundwater Model this will be completed in detail following installation of the additional pre-construction monitoring wells.

Following the collection of 24-months of groundwater level data the groundwater model will be updated. The updated model will be provided to the Planning Secretary and DPE Water in an updated groundwater modelling report. Should the model update indicate additional risk to groundwater users (GDEs and supply bores) or increased drawdown extents, the groundwater monitoring network will be reviewed to establish if further monitoring points are required.

The groundwater model will be updated as required based on the results of this monitoring, and proposed management measures to minimise potential groundwater impacts will be adjusted accordingly.

6.1.3 Incidents and Non-compliances

All incidents will be managed in accordance with Section 5.11 of the CEMP. All non-compliances will be managed in accordance with Section 5.15 of the CEMP.

6.2 GW Monitoring Program update and amendment

The auditing and review processes described in Section 5.13 to Section 5.17 of the CEMP may result in the need to update or revise this Program. This will occur whenever there is a change to the construction scope or methodology that may increase the potential impacts in relation to Groundwater or to address relevant updates to a related Sub-Plan or monitoring program (as identified in Table 1-1).

Only the Environment Manager can amend this Monitoring Program. Any update of this Plan will require endorsement by the Environmental Representative and depending on the change, process outlined in Section 6 of the CEMP must be followed where approval from the Planning Secretary prior to implementation of the update is required.