

Appendix F

Groundwater Management Sub-Plan

STW-JHC-PLN-00-EN-002-000006

Western Harbour Tunnel Stage 3A

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Document status

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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
DPI – Water	NSW Department of Primary Industries Water
DPE	NSW Department of Planning and Environment (formerly known as the Department of Planning, Industry and Environment)
DPE Water	NSW Department of Planning and Environment (Water) (formerly known as Department of Planning, Industry and Environment (Water))
DPIE	New South Wales Department of Planning, Industry and Environment (now known as the Department of Planning and Environment)
DPIE – Water	Former New South Wales Department of Planning, Industry and Environment – Water (now known as Department of Planning 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

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Abbreviation / term	Expanded text
EPA	NSW Environment Protection Authority
Environmental Representative (ER)	The Environmental Representative(s) for the CSSI approved by the Planning Secretary
GDEs	Groundwater Dependent Ecosystems
GMP	Groundwater Management Plan
GWMP	Groundwater Monitoring Program
IPIAP	Independent Property Impact Assessment Panel
IS	Infrastructure Sustainability
JHCPB	John Holland CPB Contractors Joint Venture
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
Minister	Minster for Planning and Homes
MCoA	Minister's Conditions of Approval
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
PASS	Potential Acid Sulfate Soils
Planning Approval Documents	Approval documentation as listed under MCoA A1
Project, the	Western Harbour Tunnel Stage 3A

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Abbreviation / term	Expanded text
RAP	Remediation Action Plan
REMMs	Revised Environmental Management Measures
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)
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 Stage 3A of the Western Harbour Tunnel (WHT) project (the Project), a component of the Western Harbour Tunnel and Warringah Freeway Upgrade project.

This GMP has been prepared for the Project to address the requirements of the Minister's Conditions of Approval (MCoA) for the Western Harbour Tunnel and Warringah Freeway Upgrade project (SSI #8863), Planning Approval Documents and applicable guidelines and legislation.

This Plan describes how the Project proposes to manage potential groundwater impacts during the construction of Stage 3A (for further details on staging refer to the Staging Report). Other construction stages, and operational impacts and management measures not associated with the Project are not included within this GMP.

1.2 Background and Project description

The WHT and WFU 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 future connection to the proposed Beaches Link and Gore Hill Freeway Connection project.

The Western Harbour Tunnel (WHT) will connect the approved M4-M5 Link in Rozelle to the Warringah Freeway at North Sydney/Cammeray.

The Western Harbour Tunnel and Warringah Freeway Upgrade project is being constructed in three stages. The Project (Stage 3A) includes the following key features:

- A portion of the twin mainline tunnels connecting the M4-M5 at Rozelle to the Warringah Freeway, near Cammeray, of about 2 kilometres long and commencing from the stub tunnels at the M4-M5 Link in Rozelle and terminating underground at Birchgrove
- Ventilation cavern and tunnel excavation in Rozelle
- Limited in tunnel operational infrastructure including road pavement and drainage to enable Stage 3B works.

The construction of the Project will be supported by two surface based ancillary facilities, located at the Western Harbour Tunnel cut and cover structure in Rozelle (WHT12) and at White Bay in Rozelle (WHT3).

The EIS was prepared to assess the impacts of construction and operation of the WHT and WFU project. As part of the EIS, Appendix N (Technical working paper: Groundwater) 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, with specific groundwater measures contained in Table 3-2 of this Plan.

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

The administration of provisions under the *NSW Environmental Planning and Assessment Act 1979* including the Western Harbour Tunnel and Warringah Freeway Upgrade project's planning

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consent (SSI#8863) is now under the portfolio of the NSW Minister for Planning and Homes (the Minister).

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

Possible impacts on groundwater during construction of the Project include:

- potential geological structure that may influence groundwater behaviour, such as faults that may act as barriers to groundwater flow
- expected changes in groundwater flow directions in the vicinity of landfills, groundwater wells and surface water receptors
- potential drawdown as predicted by the modelling
- potential saltwater intrusion
- potential acid sulfate soils
- potential contaminants groundwater migration
- existing groundwater users.

Further detail on these potential impacts is provided in Section 6.2 and will be managed through the implementation of mitigation and management measures detailed in Section 7.

The Project description is outlined in Section 1.2 of the CEMP.

1.3 Scope of the Sub-Plan

The scope of this GMP is to describe how the Project will manage and protect groundwater resources during construction of the Project. Operational impacts and measures do not fall within the scope of this Plan and, therefore, are not discussed in this GMP.

1.4 Environmental management systems overview

This Sub-plan forms part of the Stage 3A CEMP which provides a structured and systematic approach to environmental management. The CEMP is based on the requirements of the Project Management System (CMS) and the requirements of the CSSI approval.

The CMS is certified to AS/NZS SIO 14001:2015 Environmental Management Systems – requirements with guidance for use. Additional details on the CEMP and Project environmental management system documents are provided in Section 1.5 of the CEMP.

1.5 Interface with other planning documents

This GMP is one of several plans and documents established to manage potential impacts associated with construction of the Project. The key documents that interface with this Plan are outlined in Table 1-1.

Table 1-1 Key interfaces with the GMP

Plan	Interface
CEMP for the Project	• The CEMP provides details on: ◦ Overall Project staging, interactions between the CEMP and other plans, and management of cumulative impacts. ◦ A framework for how the construction works will be managed.

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Plan	Interface
	◦ Procedures, processes and management systems that will apply in relation to construction activities. ◦ 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 Plan	• Provides details pertaining to how soil and surface water is to be managed during construction of the Project. <i>Note: Groundwater may be discharged to surface waters and encountered in soils</i>
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 GMP is to establish how groundwater will be managed during construction of the Project.

This GMP has been prepared to address the applicable statutory requirements and aims to ensure that commitments made, in the planning approval are met with regards to the protection of groundwater conditions.

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, the Project 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, the Project will meet the performance outcomes from the Planning Approval Documents that are relevant to groundwater as detailed in Section 2.3.

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

Performance outcome	How performance will be addressed	Records	Source
Water – Hydrology			
Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised.	In respect to water (hydrology), the project has been developed such that: • Design and construction of the tunnels will minimise groundwater inflow	Groundwater model Appendix F1	EIS Chapter 28 Table 28-4
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).	In respect to water (hydrology), the project has been developed such that: • The environmental values of nearby, connected and affected water sources will be improved and/or maintained.	Water monitoring records	EIS Chapter 28 Table 28-4
Sustainable use of water resources.	In respect to water (hydrology), the project has been developed such that: • Opportunities for reuse of treated water during construction has been considered throughout project development	Quarterly Sustainability Report	EIS Chapter 28 Table 28-4
Water – Quality			

Performance outcome	How performance will be addressed	Records	Source
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: • Will operate under water quality discharge criteria with consideration of NSW Water Quality Objectives • Will effectively treat water to meet water quality discharge criteria.	EPL discharge criteria Water monitoring records	EIS Chapter 28 Table 28-4

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 to ensure ongoing beneficial use of groundwater resources or provide make-good provisions
- Groundwater salinity will be monitored to confirm model predictions. If groundwater inflows exceed 1 litre/second/kilometre during construction, feasible and reasonable measures to manage inflow will be applied
- Ensure groundwater discharged from water treatment plants (WTPs) is treated to sufficient quality to meet relevant MCoA discharge criteria requirements and 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 and Water Management Act 2000
- Water Sharing Plan (DPIE, 2011)
- 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

Additional approvals, licences, permits and requirements to this Plan include the Environment Protection Licence (EPL).

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 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)
- 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)
- Water Sharing Plan, Greater Metropolitan Regional Groundwater Sources Background Document, Sydney (NoW, 2011).

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 the condition is 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.	Table 4-1	This GMP has been prepared in consultation with the relevant agencies identified in MCoA C4(f). A summary of consultation is included in Table 4-1.

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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. <table><tr><td></td><td>Required CEMP Sub-plan</td><td>Relevant government agencies to be consulted for each CEMP Sub-plan</td></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)	This Plan Section 4	This GMP has been prepared in consultation with the relevant agencies identified in this condition. A summary of consultation is included in Table 4-1.
	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 2.2	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 the Project will comply with the relevant terms of approval are listed in this Table, including references to the relevant sections of this GMP.						

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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 3.2.1 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 3.2.1 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 2.2 of the CEMP	This Sub-plan has been submitted to the Planning Secretary for approval one month prior to construction.
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 2.2 of the CEMP	This Sub-plan has been submitted to the Planning Secretary for approval prior to 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 construction of the CSSI against the	Groundwater Monitoring Program (Appendix F1)	The Groundwater Monitoring Program (GWMP) is included at Appendix F1 of this GMP

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MCoA No.	Condition Requirements		Document Reference	How Addressed
	performance predicted in the documents listed in Condition A1 or in the CEMP:			
		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 C16.		GWMP (Appendix F1) details the following requirements: • Section 5 baseline data • Section 6 monitoring details • Section 6 monitoring parameters • Section 6 monitoring frequency • Figure 6-1 monitoring locations • Section 6 reporting of monitoring • Section 6 methods to analyse data • Section 6 procedures to address unacceptable impacts • Section 7 SMART Principles • Section 4 consultation	The GWMP (Appendix F1) details the requirements to meet MCoA C12 and C14 in relation to monitoring, reporting and review

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MCoA No.	Condition Requirements	Document Reference	How Addressed
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; (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.	GWMP (Appendix F1) details the following requirements: • Section 5 results from existing and additional bores • Section 6.2 discharged water treatment plant volumes • Section 6.3 discharged water treatment plant quality • Section 6.4 groundwater levels • Section 6.5 electrical conductivity and temperature • Section 6.6 tunnel groundwater inflow • Section 5 results from existing and additional bores to Sydney Water • Section 6.2 to 6.6 and Section 8 address reporting to DPE Water	The GWMP (Appendix F1) details the requirements to meet MCoA C12 and C14 in relation to monitoring, reporting and review
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.	GMP Section 4 GWMP (Appendix F1) Section 4	A summary of consultation is included in Table 4-1.

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MCoA No.	Condition Requirements	Document Reference	How Addressed
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	Endorsement by the ER is included in the submission of this document to the Planning Secretary.
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) Section 1.3 Section 2.2 of the CEMP	The CEMP provides the process for submitting monitoring programs prior to construction.
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 8.5 GWMP (Appendix F1) Section 1.3	Groundwater monitoring reports will be provided to the Planning Secretary as detailed in Appendix F1.
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) Section 8 Section 8.5	Groundwater monitoring reports will be provided to the Planning Secretary as detailed in Appendix F1.
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	Section 6.2.1 Ground movement (settlement) and Section 7.5.2 Table 7-1 GWMM7 and GWMM9	The requirements of E102 are addressed in the Projects Ground Movement and Settlement Impact Assessments

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MCoA No.	Condition Requirements	Document Reference	How Addressed																				
	tunnelling, including groundwater drawdown and associated impacts, on adjacent surface and sub-surface structures.																						
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 6.2.1 Ground movement (settlement) and Section 7.5.2 Table 7-1 GWMM7 and GWMM9	The requirements of E103 are addressed in the Projects Ground Movement and Settlement Impact Assessments.																				
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. 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 carparks)</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>	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 carparks)	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	Section 6.2.1 Ground movement (settlement) and Section 7.5.2 Table 7-1 GWMM7 and GWMM9	The criteria of E104 are addressed in the Projects Ground Movement and Settlement Impact Assessments.
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 carparks)	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																				

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MCoA No.	Condition Requirements	Document Reference	How Addressed
	<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>		
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.	Ground Movement and Settlement Impact Assessments Section 6.2.1 Ground movement (settlement) and Section 7.5.2 Table 7-1 GWMM7 and GWMM9	The requirements of E105 are addressed in the Projects Ground Movement and Settlement Impact Assessments.
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 three months. Model input parameters must be adjusted to calibrate the model so that predictions are better aligned with actual observations	GWMP (Appendix F1) Section 6.4.7 and 8 GMP Section 8.3	Groundwater monitoring reports provided to the Planning Secretary will identify if groundwater drawdown is substantially different to predictions. Were this to transpire, the requirements of Conditions E102 to E105 inclusive must be undertaken again within three months. This will trigger an adjustment of model inputs.
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	Table 7-1 GWMM8 and GWMM9	The Project will offer Pre-construction surveys and prepare Pre-construction Condition Survey Reports where the offer is accepted, on the current condition of surface and sub-surface structures identified

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MCoA No.	Condition Requirements	Document Reference	How Addressed
	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.		as at risk from settlement or vibration by the geotechnical model described in Condition E102 and the CNVIS described by Condition E75 or as directed by IPIAP.
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. (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.	Section 7.3	E127 is addressed in the Water Reuse Strategy.
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:	Environment Protection Licence Section 7.2	Discharges from construction water treatment plants will comply with the criteria of MCoA E208.

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MCoA No.	Condition Requirements	Document Reference	How Addressed
	(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 (c) for bioaccumulative and persistent toxicants, the ANZG 2018 values at a minimum of 95 percent 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.		
Groundwater			
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).	GWMP (Appendix F1) Section 6.6 – construction inflows GWMP (Appendix F1) Section 6.8 – operational inflows	Groundwater inflows during construction will be monitored as per the Groundwater Monitoring Program (Appendix F1).
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 6.2 Table 7-1 GWMM7 GWMP (Appendix F1) Section 6.7	GWMM7 sets out the requirement for making good provisions for affected users.
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	Table 7-1 GWMM3 GWMP (Appendix F1) Section 6 Groundwater Modelling Report (Hydrogeological I Interpretive Report)	Further modelling has been undertaken of groundwater drawdown, tunnel inflows and saline water migration in a Hydrogeological Interpretive Report and this Plan has

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MCoA No.	Condition Requirements	Document Reference	How Addressed
	results and hydrogeological analyses of at least 12 continuous months of current baseline groundwater monitoring data.		been prepared based on this information.
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.	Table 7-1 GWMM3 Groundwater Modelling Report (Hydrogeological Interpretive Report)	The requirements of E219 are addressed in the Hydrogeological Interpretive Report which is issued to DPE and independently peer reviewed by an expert agreed to by DPE Water.
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 8.5 and 9.1 Table 7-1 GWMM4	Any additional measures identified to manage and/or mitigate groundwater impacts (as per E219(q)) in the updated Groundwater Modelling Report will be incorporated into this GMP as part of the document review process and endorsed by the ER or approved by the Secretary, depending on the outcomes of the findings.
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 8.3 and 8.5 GWMP (Appendix F1) Section 6.6	During construction this will be reported to DPE Water in the Groundwater Monitoring Report.

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3.3 Revised Environmental Management Measures

The REMMs relevant to groundwater, as identified in Part D of the RtS, are listed in Table 3-2 below. This includes reference to required outcomes, the timing of when the commitment applies, relevant documents or sections of the environmental assessment influencing the outcome and implementation.

Table 3-2 REMMs 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.	Prior to tunnel excavation	Section 6.2.1 Table 7-1 GWMM8 and GWMM9	Settlement models are included in Ground Movement and Settlement Impact Assessments
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.	Prior to activities that may impact the bore	Section 4.2, 5.6.3, 6.2.1 Potential impacts to existing groundwater users, 6.2.2 Saline intrusion Table 7-1 GWMM6	Potential impacts to GW109209 is assessed in the Groundwater Model (Hydrogeological Interpretive Report). GW107764 and GW108991 are not in suburbs affected by WHT Stage 3A. In accordance with E217 make good provisions for the bore owner will be provided in the event of a material decline in water supply levels, quality or quantity associated with groundwater changes from construction dewatering caused by the CSSI.
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.	Prior to the commencement of any works which may potentially result in property impacts	CEMP Section 6.2.1 Table 7-1 GWMM8	Establishment of IPIAP in accordance with E111.

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Ref #	Commitment	Timing	Document Reference	How Addressed
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. 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.	Prior to the commencement of potentially impacting works. Offers made within 3 months of completion of construction activities that have the potential to impact of the subject surface/subsurface structure	Table 7-1 GWMM9	Properties eligible for condition surveys will be identified in Ground Movement and Settlement Impact Assessments, or CNVIS or as directed by the IPOAP in accordance with the requirements and criteria of MCoA E107. Impacted residents will be notified of the opportunity for a pre-construction and post-construction building/structure condition survey. Building condition survey reports will be prepared and provided to owners.

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Ref #	Commitment	Timing	Document Reference	How Addressed
SG12	Prior to ground disturbance in high risk acid sulfate areas at Birchgrove Park, Rozelle Rail Yards, Sydney Harbour (tunnel crossing, White Bay and Berrys Bay) and Whites Creek, testing will be carried out to determine the presence of ASS. If ASS are encountered, they will be managed in accordance with the ASS Manual (Acid Sulfate Soil Management Advisory Committee, 1998).	Construction	Section 6.2.2	No direct ground disturbance of Potential Acid Sulfate Soils (PASS) or Acid Sulfate Soils (ASS) is part of the Stage 3A Project. If potential for acidification is deemed a high risk by future revisions of the Groundwater Model report, monitoring to address this risk will be identified in the Groundwater Model report and included in a revision to the Groundwater Monitoring Program. Mitigation measures to prevent or contain acid generation will be implemented if/as appropriate.
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 Section 6.6 of the Groundwater Monitoring Program (Appendix F1) Table 7-1 GWMM1	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. Groundwater inflow data will be reported in the Groundwater Monitoring Report.
SG17	Outcomes of updated groundwater modelling will identify any requirements for further groundwater monitoring, and management of groundwater drawdown and associated impacts.	Prior to finalising the detailed design of the tunnels and undertaking any works that would impact on groundwater flows or levels.	Section 6.2 Section 6 of the Groundwater Monitoring Program (Appendix F1) Table 7-1 GWMM3 and GWMM5	Monitoring recommendations from the Groundwater Model report will be evaluated for inclusion in the Groundwater Monitoring Program.

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Ref #	Commitment	Timing	Document Reference	How Addressed
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.	Prior to finalising the detailed design of the tunnels and undertaking any works that would impact on groundwater flows or levels and 24 months after construction monitoring begins.	Table 7-1 GWMM2, GWMM3 and GWMM5 Section 9.2 Section 8 of the Groundwater Monitoring Program (Appendix F1)	Updates to the Groundwater Model.
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.	Prior to finalising the detailed design of the tunnels and undertaking any works that would impact on groundwater flows or levels.	Section 5.4 and Table 8 of the Groundwater Monitoring Program (Appendix F1)	The following additional groundwater baseline monitoring data has informed the monitoring program; 1. M4-M5 Link Stage 2 (which is highly relevant to the WHT Stage 3A scope due to overlapping footprints) has been used 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.
SG20	A groundwater quality monitoring program will be developed and implemented, taking into consideration the location of areas subject to	Construction	Section 4 Appendix F1 – Groundwater	A GWMP for construction has been developed and is included in Appendix F1.

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Ref #	Commitment	Timing	Document Reference	How Addressed
	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, Industry and Environment (Water).		Monitoring Program	
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 7.5.1 Table 7-1 GWMM6 Section 6.3 and Section 8 of the Groundwater Monitoring Program (Appendix F1)	In accordance with E217, make good provisions for groundwater users will be provided in the event of a material decline in quality at registered existing bores associated with groundwater changes from either construction dewatering caused by the Project.
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.	Prior to finalising the detailed design of the tunnels and undertaking any works that would impact on groundwater flows or levels and 24 months after construction monitoring begins.	Section 8.1.1 of the Groundwater Monitoring Program (Appendix F1) Table 7-1 GWMM3	An updated Groundwater Modelling Report has been prepared to include data from ongoing groundwater monitoring. The additional information and management and mitigation measures have been incorporated into this GMP.

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Ref #	Commitment	Timing	Document Reference	How Addressed
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 Section 7.4 Table 7-1 GWMM10	Storage and handling management measures will be implemented to avoid spills.
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	Construction Water Reuse Strategy Section 7.3 Section 6.5 of the GWMP (Appendix F1)	Opportunities to reuse and recycle wastewater during construction is detailed in the Construction Water Reuse Strategy.
Resource use and waste management				

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Ref #	Commitment	Timing	Document Reference	How Addressed
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 contractor to update reference Section 7.3 Section 6.5 of the GWMP (Appendix F1)	In the event of an inconsistency between WQ# and MCoA E208, then MCoA E208 will prevail to the extent of the inconsistency in accordance with MCoA A3. Discharges from wastewater treatment plants will be in accordance with MCoA E208..

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Table D1-1 of the Response to Submissions Report included the following key issues to be addressed by the Groundwater Management Plan;

- Groundwater management objectives: refer to Section 2.2
- Groundwater management implementation including:
 - Additional modelling requirements: refer to Table 7-1GWMM3
 - Acceptable groundwater inflow levels: refer to Table 7-1 GWMM1
 - Ground movement management and minimisation requirements: refer to Section 7.5.2
- Groundwater mitigation including:
 - Monitoring and inspection requirements: refer to Appendix F1
 - Compliance records: refer to Table 8-1 Reporting

4 Consultation

4.1 Consultation for plan preparation

This GMP has been developed and finalised in consultation with relevant government agencies in accordance with MCoA C4(f). Consultation with each agency, including responses received and how issues raised have been addressed in the development of this Plan are summarised in Table 4-1.

Whilst no water discharge from water treatment plant(s) to Sydney Water assets is proposed, consultation with Sydney Water will be undertaken prior to any proposed discharge to Sydney Water assets and this Plan updated where relevant for ER endorsement or approval by the Secretary, depending on the outcomes of the consultation.

4.2 Ongoing consultation

Ongoing consultation with DPE Water will be undertaken throughout construction as specified in the GWMP (Appendix F1). In addition, relevant groundwater monitoring data and water discharge data from water treatment plant(s) will be shared with DPE Water and Sydney Water, as required by MCoA C14 (g) and (h).

The viability of domestic bore GW109209 will be confirmed prior to construction (REMM SG2). If drawdown at the bores exceeds two metres (in accordance with the Aquifer Interference Policy), 'make good' measures will be implemented. The 'make good' measures undertaken 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, compensation or providing an alternative water supply (note that Bores GW107764 and GW108991 are outside the scope of this Project).

Community feedback and complaints relating to groundwater will be managed in accordance with the Community Communication Strategy and Complaints Management System.

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Table 4-1 Summary of consultation undertaken for the development of this Plan

Agency	Project led engagement	Agency Response Information	Key issues	Where addressed / how addressed	Outstanding issues / why not addressed
GMP (this Plan)					
DPE Water	27/7/2022 – email correspondence to DPIE Water introducing project and offering a project briefing. 27/7/2022 – formal submission of GMP via email. 27/7/2022 – formal submission of GMP via Planning Portal. 18/8/2022 – follow up email to DPIE Water confirming if the agency had any comments on the GMP.	28/7/2022 – email received from DPIE Water that a briefing was not necessary. 19/8/2022 – email received from DPE Water that any comments on the plan would be provided during the week ending 28/8/2022 30/8/2022 – DPE Water response provided via the Planning Portal	Submission of Groundwater Modelling Report and Independent Review of GMR	The GMR is a separate document to the GMP and GWMP. These documents have been provided to DPE Water as requested.	NA
EESG	27/7/2022 – phone call to EESG representative. No answer however a detailed voicemail was left. 27/7/2022 – email correspondence to EESG introducing the project and offering a project briefing. 1/8/2022 – formal submission of the GMP via the Planning Portal. 1/8/2022 – formal submission of the GMP via email.	19/8/2022 – response from EHG (EESG) on the Groundwater Management Plan.	- Administrative changes to Figure 5-1 - Long-term saline intrusion	Figure 5-1 has been updated Saline intrusion is covered in Section 7.5.3. Long-term impacts will be covered in the Operational Groundwater Management Plan	NA

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	18/8/2022 – follow up email to determine whether EESG had any comments on the submitted plan.				
EPA	6/7/2022 - Call to EPA officer advising of imminent submission of management plans for consultation. A briefing on the Project scope was offered and ultimately accepted by the EPA officer. 18/7/22 Call to EPA officer, message left, to discuss management plan consultation and to set a date for a briefing. 28/7/2022 – Project briefing presented to representatives of the EPA to outline Stage 3A. 1/8/2022 – Formal submission of GMP to EPA via email. 1/8/2022 – Formal submission of GMP to EPA via Planning Portal. 9/8/2022 – Follow up email to EPA to determine if comments would be provided. 17/8/2022 – Phone call to EPA to confirm date of comment submission, if any.	23/08/2022 – response received via email from the EPA on the GMP.	• Inclusion of condition E208 in plan • Details on water discharge from Stage 3A	• Condition E208 has been added to Table 3-1 and is also referenced in Section 7.2 • Water treatment and discharge details for Stage 3A works are outlined in Section 7.2 of this Plan.	NA

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Sydney Water	The Project is not proposing to discharge water to Sydney Water assets. If a change occurs where discharge is proposed to a Sydney Water asset consultation with Sydney Water on this Plan will be undertaken.				
Inner West Council	6/7/2022 - Initial contact with IWC to overview the management plans and organise a briefing to be run by the Project. 19/7/2022 - Submission of NVMP to IWC formally via email 19/7/2022 – submission of NVMP formally via Planning Portal 18/7/22 - Project briefing held with key members from IWC to overview Stage 3A. 16/8/2022 – follow up email to IWC to check whether any comments on the plan would be provided.	No comments provided	NA	NA	MA
Groundwater Monitoring Program (Appendix F1 of this Plan)					
DPE Water	27/7/2022 – email correspondence to DPIE Water introducing project and offering a project briefing. 27/7/2022 – formal submission of GMP via email. 27/7/2022 – formal submission of GMP via Planning Portal. 18/8/2022 – follow up email to DPIE Water confirming if	28/7/2022 – email received from DPIE Water that a briefing was not necessary. 19/8/2022 – email received from DPE Water that any comments on the plan would be provided during the week ending 28/8/2022 30/8/2022 – DPE Water response provided via the Planning Portal	Submission of Groundwater Modelling Report and Independent Review of GMR	The GMR is a separate document to the GMP and GWMP. These documents have been provided to DPE Water as requested.	NA

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	the agency had any comments on the GMP.				
EPA	6/7/2022 - Call to EPA officer advising of imminent submission of management plans for consultation. A briefing on the Project scope was offered and ultimately accepted by the EPA officer. 18/7/22 Call to EPA officer, message left, to discuss management plan consultation and to set a date for a briefing. 28/7/2022 – Project briefing presented to representatives of the EPA to outline Stage 3A. 1/8/2022 – Formal submission of GMP to EPA via email. 1/8/2022 – Formal submission of GMP to EPA via Planning Portal. 9/8/2022 – Follow up email to EPA to determine if comments would be provided. 17/8/2022 – Phone call to EPA to confirm date of comment submission, if any.	23/08/2022 – response received via email from the EPA on the GMP.	• Inclusion of condition E208 in GWMP list of conditions • Details on water discharge from Stage 3A	• Condition E208 has been added to Table 3-1 and is also referenced in Section 6.3 of the GWMP. • Water treatment and discharge details for Stage 3A works are outlined in Section 7.2 of the GMP.	NA

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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 additional monitoring undertaken after the EIS.

The Project Area and relevant data is shown on the Sensitive Area Plans included as Appendix A5 of the CEMP.

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 from (losing) creeks and water impoundments (e.g. ponds). Groundwater, based on through flow, gradients, and effective storage, ultimately discharges to Sydney Harbour.

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.

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.

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 5-1.

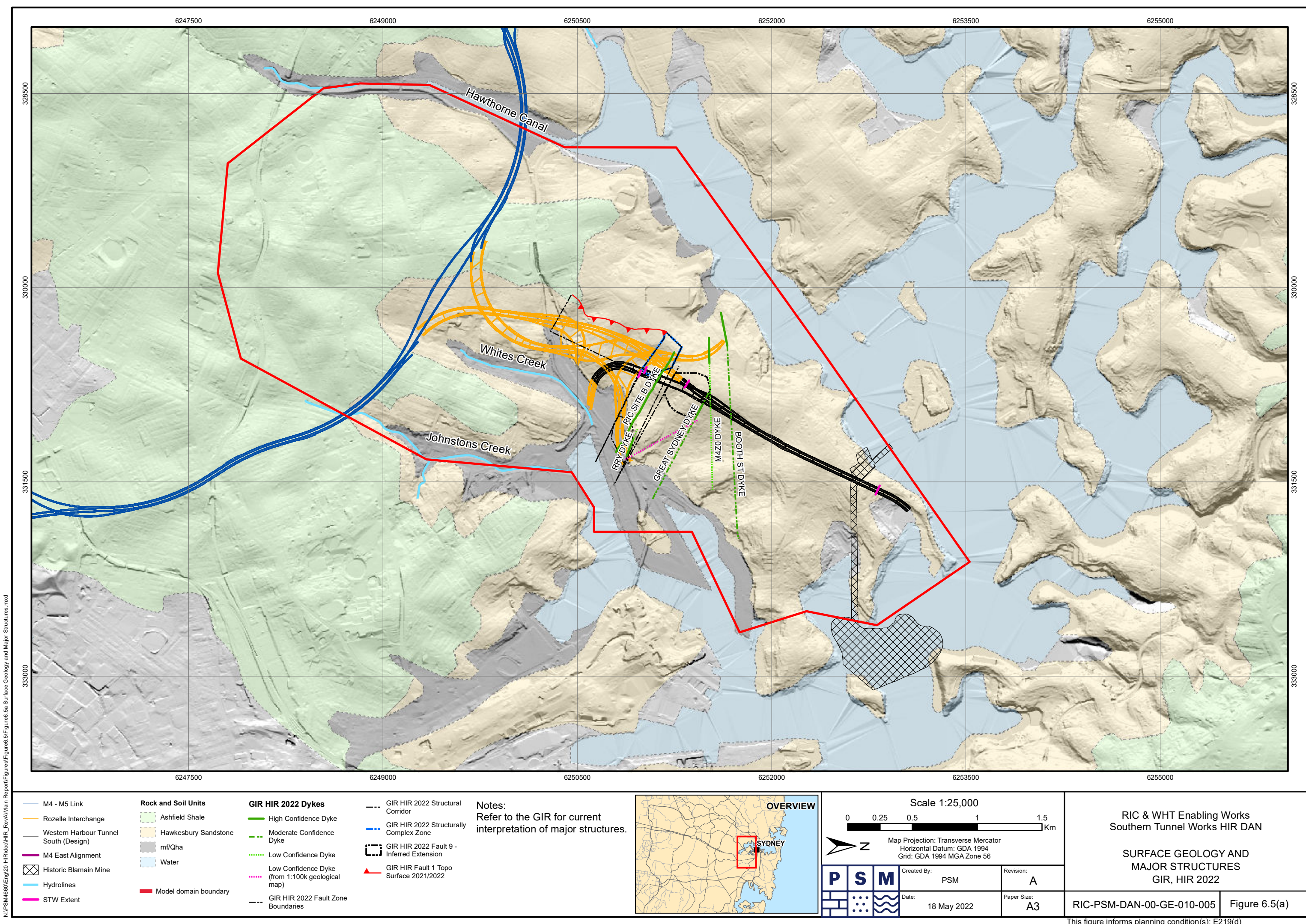
Table 5-1 Geological units

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 5-1 Regional Geological Setting (Jacobs, 2020c)



N:\PSM4660\Eng\20_HIR\doc\HIR_RevA\Main Report\Figures\Figure 6.5a Surface Geology and Major Structures.mxd

Notes:
Refer to the GIR for current interpretation of major structures.



Scale 1:25,000	
0 0.25 0.5 1 1.5 Km	
Map Projection: Transverse Mercator Horizontal Datum: GDA 1994 Grid: GDA 1994 MGA Zone 56	
Created By:	PSM
Date:	18 May 2022
Revision:	A
Paper Size:	A3

RIC & WHT Enabling Works Southern Tunnel Works HIR DAN	
SURFACE GEOLOGY AND MAJOR STRUCTURES GIR, HIR 2022	
RIC-PSM-DAN-00-GE-010-005	Figure 6.5(a)

This figure informs planning condition(s): E219(d)

5.5 Hydrogeological setting

5.5.1 Hydrostratigraphic units

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

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 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

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

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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.

Table 5-2 Packer testing summary and hydraulic conductivity in the Hawkesbury Sandstone

Test Location	Number of Tests	Minimum Hydraulic Conductivity (m/d)	Maximum Hydraulic Conductivity (m/d)	Mean Hydraulic Conductivity (m/d)	Median Hydraulic Conductivity (m/d)
All land-based tests	49	1.1E-05	0.17	0.015	0.0012
Rozelle to Birchgrove	18	5.1E-05	0.05	0.006	0.002
Waverton	31	1.1E-05	0.17	0.021	0.001
Sydney Harbour marine	142	2.8E-05	15.72	0.454	0.026

5.5.4 Regional groundwater flow, recharge, and discharge

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, it can vary depending on land use and water table depth.

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5.5.5 Groundwater quality

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 palaeochannels is typically saline, due to leakage from tidal tributaries.

Baseline groundwater monitoring within the vicinity of the Project area commenced in October 2017¹ 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)

Table 5-3 Baseline groundwater quality of the Hawkesbury Sandstone

Parameter	Hawkesbury Sandstone
EC	Fresh to highly saline (392 $\mu\text{S}/\text{cm}$ at B150P to 37,100 $\mu\text{S}/\text{cm}$ 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; $\mu\text{S}/\text{cm}$ = microSiemens per centimetre

¹ Australia and New Zealand Guidelines for Fresh and Marine Water Quality, 95% level of protection (ANZECC, 2000)

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.

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 identified any GDEs.

No registered springs were identified within the search areas.

5.6.3 Registered groundwater bores

A review of DPE Water registered groundwater bores indicates that there are 5 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 (4) are used for monitoring purposes. There is one bore

that was installed for extractive use. GW109209 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.

Figure 5-2 below shows the location of registered groundwater bores across the entire WHTWUFU project area.

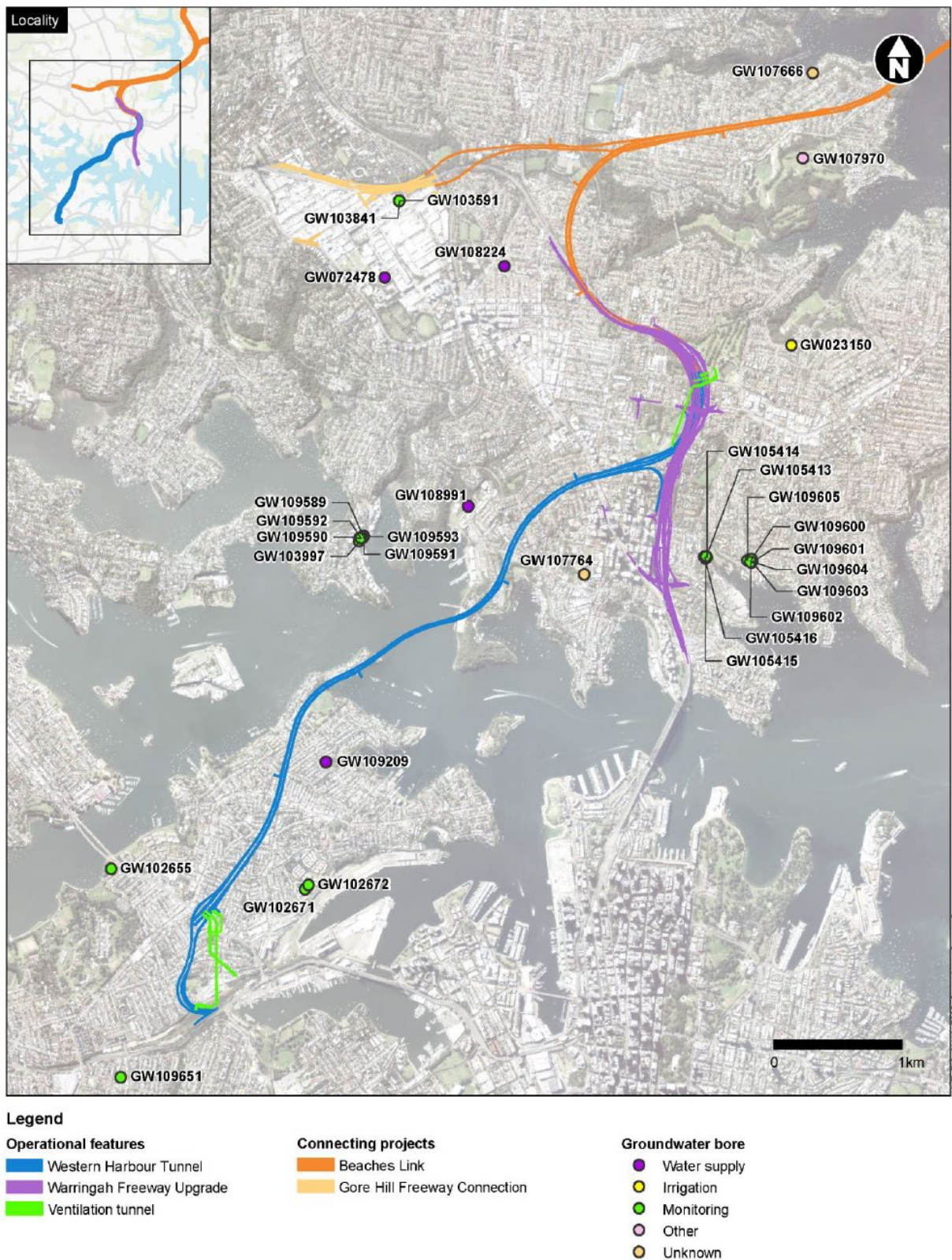


Figure 5-2 Registered groundwater bores

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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 5-3.

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
B131A	Birchgrove		8	Complete results
B181A	Rozelle		8	Complete results
B208	Balmain		6	Metals results considered unreliable due to high pH
B209	Birchgrove		2	Complete results
B390	Rozelle		8	Complete results

The following bores within the vicinity of the Project area (see Figure 6-1 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 Birchgrove (B131A) and Rozelle Rail Yards (B390) exceeded the freshwater criteria
- Cobalt: bores at Birchgrove (B131A), Rozelle (B181A), and Rozelle Rail Yards (B390) met or exceeded the marine criteria
- Copper: bores at Birchgrove (B104A), Balmain (B208A), Rozelle (B181A), and Rozelle Rail Yards (B390) exceeded freshwater and marine criteria.

Concentrations of hydrocarbon compounds were detected at 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).

The relatively few monitoring results above the ANZECC 2000 guidelines for freshwater and marine settings (95% level of protection) are reflective of the generally residential nature of the tunnel alignment and good groundwater quality. The Project construction WTP will remove the above elevated analytes to comply with MCoA E208.

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

Contaminated soil and groundwater (including dense non-aqueous phase liquid (DNAPL)) 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 remediation of the soils within the Rozelle Rail Yards was completed in 2018 (AECOM, 2018) and, therefore, has reduced the potential for leachate to further contaminate the groundwater. Works undertaken by the M4-M5 Link Project in the Rozelle Rail Yards, including a grout curtain between the works and Rozelle Bay and two large cut and cover roadway structures connecting M4 East to ANZAC Bridge create a barrier mitigating contaminant movement through soil towards Rozelle Bay. Additionally deep tunnelling for the M4-M5 Link Project under Rozelle Rail Yards has depressurised local groundwater, significantly limiting groundwater impacts at Rozelle Rail Yards tunnelling for WHT Stage 3A will have.

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

- Easton Park in Rozelle: Located above the tunnel excavated under the M4-M5 Link Project. The park was listed by Jacobs due to a lack of data rather than known contamination. This area will not be impacted by the WHT Stage 3A excavation works.
- Yurulbin Park in Birchgrove: Within the vicinity of the proposed Yurulbin Point construction support site. Yurulbin Park is 430m from the Stage 3A works and is hydraulically dominated by the adjoining harbour. The Project will not interact with contamination at this site.
- The Whites Bay Power Station: Within the vicinity of the proposed White Bay construction support site. The support site for the Stage 3A Project is proposed as a potential laydown. There is no intention to remove the concrete hardstand on Glebe Is.

Due to the limited/negligible interaction the WHT Stage 3A Project will have with the above areas they are considered low risk to the Stage 3A works.

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 is sufficient to meeting the Project's monitoring requirements.

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 below groundwater
- 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:

- 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
- 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.
 - Groundwater quality deterioration (blending of water types).
 - Saltwater intrusion.
 - Activation of acid sulfate soils.
- Settlement due to groundwater drawdown.
- 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. This includes M4-M5 Link. Sydney Metro West are small diameter tanked tunnels which run under the Stage 3A Project.

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

³ Noting that GDEs have not been identified within the predicted groundwater drawdown extent
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Section 7 provides management measures that will be implemented to avoid, minimise, and/or manage the identified potential impacts.

6.2.1 Groundwater level decrease

Groundwater drawdown

Construction of drained tunnels 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)).

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. Modelling will be reassessed during the construction phase (MCoA, E219(a)).

Groundwater inflow monitoring will be undertaken in accordance with the GWMP (Appendix F1). Specific groundwater management measures (GWMM1-GWMM3) are outlined in Table 7-1.

In addition to the EIS assessment a further detailed assessment of groundwater drawdown is modelled in the Project Groundwater Model (Hydrogeological Interpretive Report).

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 GWMM3 and GWMM4 in Table 7-1.

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.

Potential impacts to existing groundwater users

Groundwater modelling was used to predict drawdown at one registered groundwater bore (GW109209 (refer Section 5.6.3)) within the vicinity of the Project area that is potentially being used for water supply.

The Minimal Impact Considerations in the AIP are a cumulative water level decline of no more than 2 m. The Groundwater Model identifies there is a risk GW109209 will experience groundwater level drawdown beyond the minimal impact considerations of the NSW AIP (DPI Water, 2012).

The viability of domestic bore GW109209 will be confirmed prior to the commencement of Construction (REMMS SG2). Ongoing consultation with the owner will be undertaken to understand any changes to the well's productivity.

A make good provision will be implemented if any loss in yield from the bores are recorded where the drawdown impact is over 2 m. This will include provision of alternative water supplies, replacement with a deeper bore, or compensation for additional pumping costs (Jacobs, 2020a). Specific groundwater management measures (GWMM6) are outlined in Table 7-1.

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 in the EIS to interact with groundwater (loss or gain of baseflow).

Ground movement (settlement)

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

Settlement is assessed in Ground Movement and Settlement Impact Assessments. Based on these assessments the Project is designed to ensure compliance with the settlement criteria of MCoA E104.

6.2.2 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 palaeochannel 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 entire WHT 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).

Groundwater treatment and surface water impacts

The baseline groundwater quality within the Project area is described in Section 5.5.5. In order to prevent adverse impacts on downstream surface water quality, a WTP will be installed within the Western Harbour Tunnel cut and cover structure at Rozelle (WHT12) and discharge treated water to stormwater canals draining to Rozelle Bay, an estuarine environment.

WTPs will be designed so that the quality of the discharge will be in compliance with the discharge criteria outlined in the MCoA (E208) and Section 6.5.3 of the GWMP (Appendix F1). Specific groundwater management measures (GWMM11 and GWMM12) are outlined in Table 7-1.

Saline intrusion

Tunnel dewatering causing onshore aquifer drawdown which reduces the hydraulic pressure (removal of fresh / less dense water above sea water) near the coast. The removal of less dense water is one mechanism which will allow for saltwater to intrude into the freshwater aquifer (alteration of the Ghyben-Hertzberg lens), which can potentially impact on the water quality and beneficial users of the aquifer. The one registered bore along the Project alignment (GW109209) is a shallow bore tapping the perched water table. The Groundwater Model does not predict any scenario where this user will be affected by saline intrusion over the construction or operational life of the Project.

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). M4-M5 Link tunnels under the Rozelle Rail Yards and Whites Creek have already affected the groundwater pressure and levels in the area and the risk of acidification has been mitigated through design and monitoring.

7 Environmental control measures

7.1 Groundwater Management Strategies

Construction associated with the Project will impact groundwater within and adjacent to the construction footprint. Environmental risks associated with the Project construction and operation have been identified and evaluated, with respect to groundwater, in the Western Harbour Tunnel and Warringah Freeway Upgrade project EIS (Jacobs, 2020a) and the RtS (Jacobs, 2020d). A summary of environmental risks, specific to groundwater, associated with the construction phase of the Project have been summarised in Section 6.2.

Environmental management measures to be adopted to avoid, mitigate and/or minimise the identified environmental risks are included in the REMM and discussed specific to this GMP in Section 3.3. As per MCoA A1 to A3, the Project must be carried out in accordance with all terms, preventative actions, performance criteria and mitigation measures outlined in the MCoA (and referenced documents), with the MCoA prevailing in the event of inconsistency with other approval documents. MCoA relevant to this GMP are detailed in Section 3.2.

As per CoA C5 (d), environmental management measures required during the construction phase of the Project (inclusive of cumulative impacts) have been developed with consideration of SMART principles:

- **Specific**
- **Measurable**
- **Achievable**
- **Reasonable**
- **Time specific**

Environmental management and mitigation measures relevant to this GMP are detailed in Table 7-1. The GWMP (Appendix F1) provides specific details regarding proposed monitoring required to meet the management measures outlined in Table 7-1.

7.2 Water treatment

7.2.1 Discharge quality

Groundwater captured during construction will be treated at a WTP within the Western Harbour Tunnel cut and cover structure at Rozelle (WHT12). Once treated to the criteria of MCoA E208 the water will be discharged to Rozelle Bay or reused. Specific groundwater management measures are outlined in Table 7-1.

7.2.2 Discharge volume

Discharge volumes and water quality will be monitored at the WTP's in accordance with the Appendix F1 – Groundwater Monitoring Program.

7.3 Water reuse strategy

Where practicable groundwater captured and treated during construction activities is to be used in accordance with the Project's Water Reuse Strategy which is a stand-alone document.

7.4 Emergency spill procedures

There is a risk to groundwater quality as a result of accidental spillages of fuels, chemicals, and fluids. Spills will be avoided by regular maintenance to plant and equipment and bunding of

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hazardous goods. As per REMM SG23, accidental spillages will be managed through an emergency spill procedure (refer to the Stage 3A Soil and Surface Water Management Sub-plan). Further, emergency spill kits will be kept on site during construction. Specific groundwater management measures (GWMM10) are outlined in Table 7-1.

7.5 Management of groundwater drawdown

7.5.1 Existing Groundwater Users

A make good provision will be implemented if any loss in yield from the bores is recorded for drawdown impact over 2 m. This would include provision of alternative water supplies, replacement with a deeper bore, or compensation for additional pumping costs (Jacobs, 2020a). Specific groundwater management measures (GWMM6) are outlined in Table 7-1.

7.5.2 Ground movement

If Ground Movement and Settlement Impact Assessments (MCoA E102 to E105) identify exceedances of the relevant criteria established by MCoA E103 and E104, JHCPB will implement an instrumentation and monitoring program to measure settlement, distortion or strain as required. Project designers will 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.

7.5.3 Saline Intrusion

As identified in the EIS and Groundwater Model saline intrusion is expected over time. Salinity monitoring as required in MCoA C14(e) will be used to validate and if required update the Groundwater Model in accordance with MCoA E220. Specific groundwater management measures (GWMM12) are outlined in Table 7-1.

7.5.4 Activation of Potential Acid Sulfate Soils

Construction activities in areas of identified PASS may cause the generation of acidic leachate, increasing the acidity of the local groundwater. The Project is not expecting to excavate or undertake construction in PASS or ASS. The Groundwater Modelling Report will determine if there is a risk of activation of PASS and any monitoring required.

7.6 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
Groundwater level decrease – groundwater drawdown						
GWMM1	During construction, where groundwater inflows to tunnels exceed 1 L/s/km, feasible and reasonable measures are to be applied to manage inflow.	Detailed design to consider inflows GWMP (Appendix F1)	Construction	JHCPB Construction Manager	REMM SG14	Groundwater Monitoring Report Construction Work Records
GWMM2	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.	Geohydrologist or subject matter expert with equivalent qualification Additional baseline data	Pre-construction And after 24 months of groundwater data	JHCPB Design Manager	REMM SG18	Groundwater Modelling Report
GWMM3	Further groundwater modelling (beyond that undertaken in the documents listed in MCoA A2) 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 baseline groundwater monitoring data collected prior to commencement of construction. The model will be used to refine predicted groundwater inflow rates (total incidental groundwater take) and volumes within the tunnels for one, three and twelve months following commencement of construction.	Geohydrologist or subject matter expert with equivalent qualification Independent Reviewer approved by DPE Water Consultation with DPE Water	Pre-construction	JHCPB Design Manager	MCoA E218 MCoA E219 REMM SG19	Groundwater modelling report incorporating additional monitoring data from Balmain and Birchgrove (if substantially different from model) and data from M4-M5 Link Stage 2 where the monitoring area overlaps with the Project.

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ID	Measure/Requirement	Resources needed	When to implement	Responsibility	Reference	Evidence
	The model will be used to refine predicted groundwater levels (drawdown) in the monitoring piezometers in 2030 and 2100. Along with an assessment of impacts to groundwater in adjacent areas during construction of the Project. The model will include quantitative predictions of contaminant mobilisation risk during both tunnel construction and operation. The results of the groundwater modelling will be documented in a groundwater modelling report. The groundwater modelling report will be prepared in consultation with DPE Water and independently peer reviewed by an expert. The groundwater modelling report will be submitted to the Planning Secretary prior to finalisation of tunnel design and undertaking any works that would impact on groundwater flows or levels.. The groundwater modelling report will include explanation and justification of all model specifications, input parameters, boundary conditions, calibration and uncertainty.					
GWMM3a	Outcomes of the updated modelling will identify any requirements for further groundwater monitoring and	Geohydrologist or subject matter expert with	When developing the groundwater model	JHCPB Design Manager	REMM SG17	Groundwater Model

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ID	Measure/Requirement	Resources needed	When to implement	Responsibility	Reference	Evidence
	management of associated predicted impacts during Project construction.	equivalent qualification				
GWMM4	Groundwater monitoring will be completed during the construction phase of the Project. This data will be reviewed in accordance with the groundwater monitoring program to verify the predicted impacts to groundwater, as detailed in the Groundwater Modelling Report. The groundwater model will be updated following collection of 24 months groundwater monitoring data (during construction). The outcomes of the updated model will be assessed against those included in the groundwater modelling report (pre-construction) and documented in an updated groundwater modelling report. The updated groundwater modelling report will be submitted to the Planning Secretary and DPE Water. Outcomes of the groundwater model will inform any amendments to the groundwater monitoring program to ensure all predicted impacts are being managed.	GWMP (Appendix F1) Revised groundwater modelling report Suitably qualified person Consultation with relevant regulatory and Project stakeholders	Construction And following the collection of 24 months groundwater monitoring data	JHCPB Construction Manager JHCPB Environment & Sustainability Manager JHCPB Design Manager	MCoA C14 MCoA E220 REMM SG18	Groundwater monitoring report Groundwater modelling report

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ID	Measure/Requirement	Resources needed	When to implement	Responsibility	Reference	Evidence
GWMM5	Groundwater inflow and groundwater levels in the vicinity of the tunnels will be monitored during construction and compared to model predictions and in the 24 month Groundwater Model review. The groundwater model will be updated after 24 months of groundwater data is collected or if monitoring results are significantly different to predictions and proposed management measures to minimise potential groundwater impacts adjusted accordingly, to ensure that groundwater inflow performance criteria are met.	Suitably qualified person GWMP (Appendix F1) Revised groundwater model	Construction	JHCPB Environment & Sustainability Manager JHCPB Design Manager	MCoA C14 (d) MCoA E220 MCoA E221 REMM SG17 REMM SG18	Groundwater modelling report Groundwater monitoring reports
Groundwater level decrease – potential impacts to existing groundwater users						
GWMM6	The viability of domestic bore GW109209 will be confirmed prior to construction. If viable and drawdown at the bore is found to exceed two metres (in accordance with the AIP (NoW, 2012), measures will be taken to ‘make good’ the impact. 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.	Suitably qualified person GWMP (Appendix F1)	Pre-construction Construction Operation	JHCPB Environment & Sustainability Manager	MCoA E217 MCoA E219 (n) REMM SG2	Groundwater monitoring reports Consultation records

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ID	Measure/Requirement	Resources needed	When to implement	Responsibility	Reference	Evidence
Groundwater level decrease – ground movement (settlement)						
GWMM7	A geotechnical model of representative geological and groundwater conditions will be prepared to guide tunnel design and construction methodology, including the selection of options to minimise settlement where required. The model will inform a settlement instrumentation and monitoring program.	Geotechnical model	Design Pre-construction	JHCPB Design Manager	MCoA E102 REMM SG1 REMM SG3	Geotechnical modelling report Tunnel Design Reports
GWMM8	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	JHCPB Design Manager	MCoA E107 REMM SG3	IPIAP review records / minutes of selected representative condition surveys
GWMM9	Detailed predictive settlement models will be developed in greater detail for areas of concern to guide tunnel design and construction methodology, including the selection of options to minimise settlement where required. 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	Condition surveys Settlement modelling	Pre-construction	JHCPB Design Manager	MCoA E219 (r) MCoA E102 MCoA E105 MCoA E106 REMM SG1 REMM SG4	Geotechnical modelling report Tunnel design Groundwater monitoring reports (water level) Condition surveys

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ID	Measure/Requirement	Resources needed	When to implement	Responsibility	Reference	Evidence
	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. 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.					
Groundwater quality – spills and incidents						
GWMM10	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	JHCPB Construction Manager	REMM SG23 REMM WQ2	Soil and Surface Water Management Plan
Groundwater quality – groundwater treatment and surface water impacts						
GWMM11	In order to prevent adverse impacts on downstream surface water quality, the construction water treatment plants will be designed so that the effluent will be of suitable quality for discharge to the marine receiving environments in compliance with the discharge criteria (GWMP Appendix F1).	GWMP (Appendix F1) WTP Designer	Pre-construction and during construction	JHCPB Design Manager JHCPB Construction Manager JHCPB Environment &	MCoA C14 (c) MCoA E208 REMM WQ3 REMM B18	Discharge monitoring results Monthly visual inspections of the discharge points to note any scouring if discharging

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ID	Measure/Requirement	Resources needed	When to implement	Responsibility	Reference	Evidence
	The velocity of water treatment plant discharge will be minimised through the application of velocity dampeners (such as rock lined culvert, stormwater network or similar) to avoid scour impacts on the marine environment.			Sustainability Manager		directly to a receiving body (not a concrete lined stormwater network)
Groundwater quality – saline intrusion						
GWMM12	Groundwater levels, groundwater quality (salinity as electrical conductivity (EC)) and temperature) at key locations between saline water bodies and the tunnel will be routinely monitored (GWMP Appendix F1). Salinity monitoring results will be provided to Project geohydrologists for comparison between the model and field data for review of the groundwater model in accordance with MCoA E220.	Engineer GWMP (Appendix F1)	During construction	JHCPB Instrumentation & Monitoring Manager	MCoA C14(e) and E220 REMM SG20	Groundwater monitoring reports

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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 Project Team's organisational structure and overall roles and responsibilities as well as the Environmental Representative and required specialists are outlined in Section 3.3 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 Project workforce and contractors. Training will be undertaken in accordance with requirements detailed in the CEMP.

All personnel working on site will undergo task specific training where their role has a deliverable detailed in this Plan or their role interacts with particularly construction risks which have the potential to impact on groundwater resources.

Further details regarding staff induction and training are outlined in Section 3.5 of the CEMP.

8.3 Monitoring and inspections

Monitoring and inspections are detailed in the GWMP (Appendix F1).

Additional requirements and responsibilities in relation to inspections are documented in Section 3.9.1 and Section 3.9.2 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 3.9.3 of the CEMP.

8.5 Reporting

Reporting requirements and responsibilities are documented in Section 3.9.4 and 3.9.5 of the CEMP. Specific reporting requirements relevant to this GMP are outlined in Table 8-1.

Table 8-1 Reporting

Schedule (during construction)	Requirements	Recipient (relevant authority)
Sydney Water quarterly water monitoring reports (every 3 months) when discharging to Sydney Water assets.	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. (refer MCoA C14(g))	Sydney Water (only when discharges are directed to Sydney Water assets)
Quarterly water monitoring data (every 3 months)	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. (refer MCoA C14)	DPE Water
Groundwater Monitoring Report	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);	DPE Water Planning Secretary

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Schedule (during construction)	Requirements	Recipient (relevant authority)
	- 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. (refer MCoA C21)	
Annual monitoring reports	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. (refer MCoA E221)	DPE Water Planning Secretary
24 months groundwater model report	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. (refer MCoA E219 and E220)	DPE Water Planning Secretary
6 monthly GW109209 consultation record	Consultation record on any change to the supply, quality and quantity of water from the bore.	TfNSW Consultation Manager database

8.6 Non-conformance, Incident Reporting, and Investigation

Non-conformances, incident reporting and subsequent investigation will be undertaken as required in accordance with Section 3.10 of the CEMP.

9 Review and improvement

9.1 Groundwater model update

The results of groundwater modelling will be documented in the Groundwater Modelling Report. The Groundwater Modelling Report will be finalised in accordance with the *Australian Groundwater Modelling Guidelines* (National Water Commission, 2012) and prepared in consultation with DPI Water prior to finalising the detailed design of the tunnels and undertaking any works that would impact on groundwater flows or levels..

In the event groundwater drawdown is substantially different to predictions in the Groundwater Model the Tunnel Design Manager shall undertake a review to determine if there are any unacceptable project impacts. Should unacceptable project impacts be identified, mitigation measures will be developed and implemented. Mitigation measures shall be reported to the Environmental Representative and included in the next Groundwater Monitoring Report to the Planning Secretary and DPE Water.

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 DPE Water in the form of an updated groundwater modelling report.

9.2 GMP update and amendment

The processes described in Section 3.9 to Section 3.13 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 the Environmental Representative and depending on the change, process outlined in Section 2 of the CEMP must be followed where approval from the Planning Secretary prior to implementation of the update is required.

A copy of the updated plan and changes will be distributed to all relevant stakeholders in accordance with the approved document control procedure – refer to Section 3.11.2 of the CEMP.

10 References

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Appendix F1 Groundwater Monitoring Program

Appendix F1 Groundwater Monitoring Program

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Western Harbour Tunnel Stage 3A

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Document control

Revision	Date	Prepared by	Reviewed by	Remarks
Rev A	3/05/2022	Charles Scarf	Ciara Moriarty	Internal review
Rev B	14/06/2022	Charles Scarf	Charles Scarf	JHCPB JV Draft for TfNSW & ER Review
Rev C	13/07/2022	Adrian Broger	Charles Scarf	External revision updated to address TfNSW and ER comments
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Rev 01	16/09/2022	Adrian Broger	Adrian Broger	For DPE
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1 Introduction

1.1 Context

This construction Groundwater Monitoring Program (GWMP) has been prepared by John Holland CPB Contractors (JHCPB) for the Western Harbour Tunnel Southern Works Stage 3A project (the Project) component of the Western Harbour Tunnel and Warringah Freeway Upgrade project.

The GWMP addresses the requirement of the Minister's Conditions of Approval (MCoA), the Western Harbour Tunnel and Warringah Freeway Upgrade Project Environmental Impact Statement (Jacobs 2020a), the revised environmental management measures (REMMs) listed in the Western Harbour Tunnel and Warringah Freeway Upgrade Response to Submissions Report (RtS), and all applicable guidance and legislation.

This Program has been developed as part of the GMP consistent with the note to MCoA C21; *Where a relevant CEMP Sub-plan exists, the relevant Construction Monitoring Program may be incorporated into that CEMP Sub-plan.*

1.2 Scope of the groundwater monitoring program

The scope of this GWMP is to detail how the extent and nature of potential impacts to groundwater during construction of the Project (Stage3A) will be monitored. Operation monitoring and operation measures do not fall within the scope of the construction phase and therefore are not included within the processes contained within the GWMP.

1.3 Implementation of the groundwater monitoring program

The Construction Monitoring Programs for the Project will be endorsed by the Environmental Representative (ER) and then submitted to the Secretary for approval at least one month prior to commencement of construction.

Construction will not commence until the Secretary has approved all of the required Construction Monitoring Programs relevant to that activity.

The Construction Monitoring Programs, as approved by the Secretary, including any minor amendments approved by the ER, will be implemented for the duration of construction and for any longer period set out in the monitoring program or specified by the Secretary, whichever is the greater.

2 Purpose and objectives

2.1 Purpose

The purpose of this GWMP is to detail how the extent and nature of potential impacts to groundwater during construction of the Project will be monitored in accordance with the relevant MCoA.

The GWMP will be implemented to monitor the effectiveness of mitigation measure applied during the construction phase of the project. Monitoring of groundwater will be undertaken to identify potential impacts and ensure a comprehensive management regime can be implemented to address those impacts.

This Program provides details of the groundwater monitoring network, frequency of monitoring, and test parameters. This GWMP is an appendix of the Groundwater Management Sub-plan (GMP), which, itself, is an appendix of the Stage 3A CEMP.

This GWMP is based on baseline studies developed for the project environmental impact statement (EIS) (Jacobs 2020), additional pre-construction monitoring and Rozelle Interchange construction data.

2.2 Objectives

The key objective of the GWMP is to ensure all relevant MCoA, REMMs, and licence/permit requirements for groundwater monitoring for the Project are described, scheduled, and assigned responsibility as outlined in:

- The EIS prepared for Western Harbour Tunnel and Warringah Freeway Upgrade project dated January 2020
- The revised environmental management measures (REMMs) included in the Submissions Report prepared for Western Harbour Tunnel and Warringah Freeway Upgrade project dated September 2020
- Minister's Conditions of Approval for the Western Harbour Tunnel and Warringah Freeway Upgrade Project (SSI-8863) dated 21 January 2021

3 Monitoring Program Requirements

3.1 Minister's Conditions of Approval

The MCoA relevant to the Groundwater Management Plan are listed in Table 3-1 of that Plan. MCoA specific to this Groundwater Monitoring Program are repeated below. A cross reference is also included to indicate where the condition is addressed in this program or other Project management documents.

Table 3-1 MCoA relevant to the GWMP

MCoA No.	Condition Requirements	Document Reference	How Addressed
General			
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	GWMP (Appendix F1, this program) details the following requirements: • Section 5 baseline data • Section 6 monitoring details • Section 6 monitoring parameters • Section 6 monitoring frequency • Figure 6-1 monitoring locations • Section 8 reporting of monitoring • Section 6 methods to analyse data • Section 6 procedures to address unacceptable impacts • Section 7 SMART Principles • Section 4 consultation	The GWMP (Appendix F1, this program) details the requirements to meet MCoA C12 and C14 in relation to monitoring and reporting.

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MCoA No.	Condition Requirements	Document Reference	How Addressed
	(l) any specific requirements as required by Conditions C13 to C16.		
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; (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.	GWMP (Appendix F1, this program) details the following requirements: • Section 5 results from existing and additional bores • Section 6.2 discharged water treatment plant volumes • Section 6.3 discharged water treatment plant quality • Section 6.4 groundwater levels • Section 6.5 electrical conductivity and temperature • Section 6.6 tunnel groundwater inflow • Section 5 results from existing and additional bores to Sydney Water • Section 6.2 to 6.6 and Section 8 address reporting to DPE Water	The GWMP (Appendix F1, this program) details the requirements to meet MCoA C12 and C14 in relation to monitoring and reporting. No treated water is planned to be discharged to Sydney Water assets. In the event water is proposed to be discharged to Sydney Water assets the GMP will be provided for consultation to Sydney Water.
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.	The GWMP (Appendix F1) Section 4 and GMP Section 4	Consultation has been undertaken in accordance with the condition, a summary of consultation included in Section 4 of the GMP. a..

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MCoA No.	Condition Requirements	Document Reference	How Addressed
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) Section 1.3	This Program has been endorsed by the ER. The endorsement has been provided to the Planning Secretary.
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) Section 1.3 Section 2 of the CEMP	Hold points associated with Construction have been established within the CEMP document and these will be met prior to commencement of Construction.
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) Section 1.3 GMP Section 8.5	This monitoring program specifies that the requirements will be implemented for the duration of Stage 3A construction.
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) Section 8	Groundwater Monitoring Reports will be provided to the Planning Secretary and DPE Water quarterly.
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 geotechnical model of representative geological and groundwater conditions meeting the requirements of E102 is included in the Project Ground Movement and Settlement Impact Assessments	The requirements of E102 are addressed in the Projects Ground Movement and Settlement Impact Assessments

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MCoA No.	Condition Requirements	Document Reference	How Addressed
	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.	GMP Section 7	
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 three months. Model input parameters must be adjusted to calibrate the model so that predictions are better aligned with actual observations	GWMP (Appendix F1) Section 6.4.7 and 8 GMP Section 8.3	Groundwater monitoring reports provided to the Planning Secretary will identify if groundwater drawdown is substantially different to predictions. This will trigger an adjustment of model inputs.
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.	GMP Table 7-1 GWMM8 and GWMM9	The Project will offer Pre-construction surveys and prepare Pre-construction 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 described by Condition E75 or as directed by IPIAP.

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MCoA No.	Condition Requirements	Document Reference	How Addressed
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 (c) for bioaccumulative and persistent toxicants, the ANZG 2018 values at a minimum of 95 percent 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.	Environment Protection Licence Section 7.2 of the GMP	Discharges from construction water treatment plants will comply with the criteria of MCoA E208.
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).	GWMP (Appendix F1) Section 6.6 – construction inflows GWMP (Appendix F1) Section 6.8 – operational inflows	Groundwater inflows during construction will be monitored as per the Groundwater Monitoring Program (Appendix F1).
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.	GMP Section 4.2, 5.6.3, 6.2.1 Potential impacts to existing groundwater users, 6.2.2 Saline intrusion 6.2 GMP Table 7-1 GWMM6 GWMP (Appendix F1) Section 6.7 and 8	GMP GWMM6 sets out the requirement for making good provisions for affected users. Section 6.7 details how monitoring of the bore will be undertaken and Section 8 details reporting.

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MCoA No.	Condition Requirements	Document Reference	How Addressed
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.	GMP Section 8.3 and 8.5 GWMP (Appendix F1) Section 6.6 and Section 8	During construction this will be reported to DPE Water and the Planning Secretary in the Groundwater Monitoring Report.

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3.2 Revised Environmental Management Measures

The REMM relevant to the Groundwater Management Plan, as identified in Part D of the RtS, are listed in Table 3-2 of the GMP. This includes reference to required outcomes, the timing of when the commitment applies, relevant documents or sections of the environmental assessment influencing the outcome and implementation. REMMs specific to this monitoring program are repeated below.

Table 3-2 REMM relevant to this GWMP

Ref #	Commitment	Timing	Document Reference	How Addressed
Geology, soils, and groundwater				
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.	Prior to activities that may impact the bore	GMP Section 4.2, 5.6.3, 6.2.1 Potential impacts to existing groundwater users, 6.2.2 Saline intrusion 6.2 GMP Table 7-1 GWMM6 GWMP (Appendix F1) Section 6.7 – beneficial user monitoring and Section 8	Potential impacts to GW109209 is assessed in the Groundwater Model (Hydrogeological Interpretive Report). GW107764 and GW108991 are not in suburbs affected by WHT Stage 3A. In accordance with E217 make good provisions for the bore owner will be provided in the event of a material decline in water supply levels, quality or quantity associated with groundwater changes from construction dewatering caused by the CSSI.

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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	GWMP (Appendix F1) Sections 6.4 and 6.5	The Groundwater Modelling Report identifies requirements for further groundwater monitoring. These have been included in Sections 6.4 and 6.5 of this monitoring Program.
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	GWMP (Appendix F1) Sections 5, 6.4 and 6.5	The following additional groundwater baseline monitoring data has informed the monitoring program when identifying the monitoring locations and parameters in Sections 6.4 and 6.5 of this monitoring Program; 1. M4-M5 Link Stage 2 (which is highly relevant to the WHT Stage 3A scope due to overlapping footprints) has been used. 2. Additional monitoring undertaken by TfNSW following 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.
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).	Construction	GWMP (Appendix F1) Section 5.2.2 – contamination consideration	A groundwater contamination assessment has been undertaken in the Groundwater Model and summarised in this Program. Modelling indicates no change in groundwater quality at the registered bore GW109209 however

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Ref #	Commitment	Timing	Document Reference	How Addressed
	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, Industry and Environment (Water).		GWMP (Appendix F1) Section 6.7 – beneficial user monitoring GWMP (Appendix F1) Section 6.3 – treated groundwater monitoring GWMP (Appendix F1) Section 4 - Consultation	there is a risk of groundwater level reducing. This will be monitored as detailed in Section 6.7. Monitoring of groundwater quality prior to discharge from the tunnel is addressed in Section 6.3 This Program has been developed in consultation with DIE Water.
Resource use and waste management				
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) were finalised in October 2020.	Construction	GWMP (Appendix F1) Section 6.3 – treated groundwater monitoring	Discharges from wastewater treatment plants shall be in accordance with MCoA E208. This is detailed in Section 6.3.

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4 Consultation

This program was provided to Department of Planning and Environment (DPE) Water and the Environmental Protection Agency (EPA) in accordance with CoA C11(d) and REMM SG20.

The Project is proposing to utilise bores from the EIS monitoring network, the M4-M5 Link Stage 2 network and the additional baseline monitoring network established by TfNSW for construction monitoring. TfNSW developed this network in consultation with DPE Water with the objective of providing good coverage along the alignment and to be located near sensitive environmental features or potentially contaminated areas.

A summary of consultation undertaken and issues raised during the initial development of the GWP and GWMP is included in Section 4 of the GMP.

5 Baseline monitoring

In accordance with MCoA C12 & C14(a) this program includes 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. The monitoring bore network as incorporated in the Groundwater Model was reviewed in consultation with DPE Water and additional monitoring locations proposed and included in this program.

Baseline groundwater monitoring data has been collected from three 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)
2. M4-M5 Link Stage 2 monitoring data, which commenced in June 2016 and is ongoing to present. There is substantial physical overlap of the Project (WHT Stage 3A) and the M4-M5 Link Stage 2 tunnels. The geological units and groundwater body that will be encountered by the Project are the same as for M4-M5 Link Stage 2. These similarities enable data from M4-M5 Link Stage 2 to be used with a very high degree of correlation for the Project Groundwater Model. The groundwater body under Rozelle and Balmain has been substantially depressurised by the M4-M5 Link Stage 2 project. Consequently, the baseline data from M4-M5 Link Stage 2 is particularly important as any data collected after tunnelling commenced for M4-M5 Link Stage 2 in November 2019 has been influenced by regional depressurisation due to the M4-M5 Link Stage 2 project.

Data collected from M4-M5 Link Stage 2 is additionally beneficial as it has been assessed for the M4-M5 Link Stage 2 24-month Groundwater Model review. Pells Sullivan Meynink prepared the Groundwater Model for M4-M5 Link Stage 2 and interpreted the monitoring data. Pells Sullivan Meynink have also prepared the Groundwater Model for this Project as an integrated model with the overlapping M4-M5 Link Stage 2 excavations. The robustness of the model is greatly enhanced by utilising long term data monitoring the response to groundwater from 22km of tunnelling at M4-M5 Link Stage 2 in the same geological units and aquifer as this Project

3. 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.

Collated baseline data is presented in the following subsections.

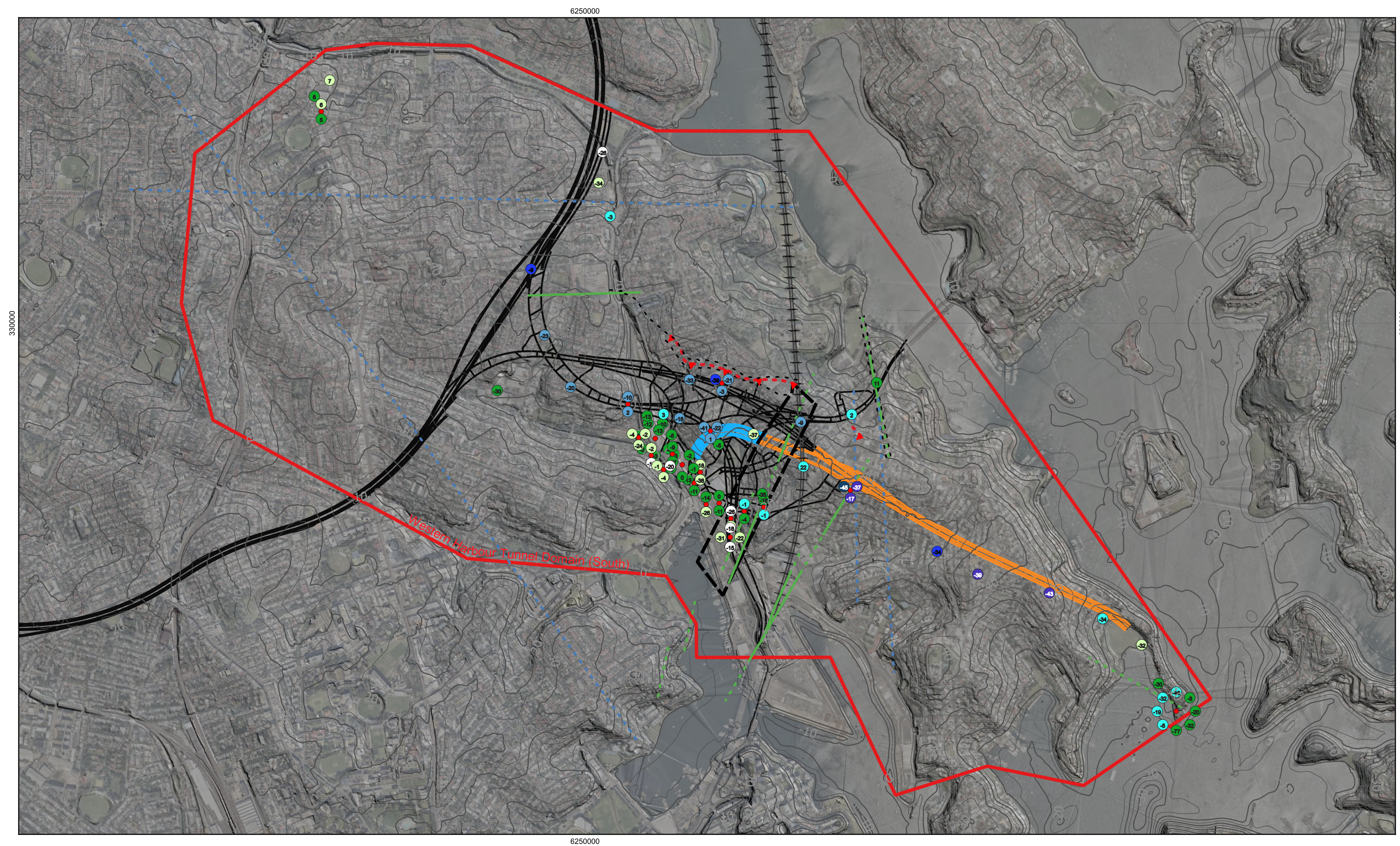
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5.1 Groundwater level

Baseline groundwater levels are presented in Figure 5-1.

Figure 5-1 Baseline groundwater levels

N:\PSM460\Eng20 HIR\loc\HIR_RevMain Report\Figures\Figure7.1-7.4\PSM4660_Figure7.2_to_7.4_RevB.qgz Layout: Figure7.3



Legend

- | | | | | |
|---|-----------------------------------|----------------------|-----------------------------|------------------------|
| Pre RIC excavation
(25/11/2019)
Colour = Depth(m) to GW
Number# = Sensor mAHD | 5 - 10 | Model Domain | 10m Contour | Medium Confidence Dyke |
| 10 - 20 | Control Lines: M4, M5, RIC, WHTS | 5m Contour | Low Confidence Dyke | |
| 20 - 30 | Western Harbour Tunnel South | Structural Bound | GIR Structural Complex Zone | |
| 30 - 40 | Western Harbour Tunnel South PAC3 | Fault | | |
| 0 - 1 | Proposed SMW TBM alignments | High Confidence Dyke | | |
| 1 - 2 | | | | |
| 2 - 5 | | | | |

Notes:
Pre-RIC is taken to be the 25th of November 2019 which is prior to commencement of tunnelling activities (Ramp excavation commenced 4th of September 2019). Figure shows last observation made prior to this date. Contours are topographic elevation.

Scale 1:20,000	
Map Projection: Horizontal Datum: Grid: EPSG:28356	
	Created By: PSM
	Date: 03 May 2022
	Revision: A
	Paper Size: A3

INTERPRETED GROUNDWATER DATA
PRE-RIC GROUNDWATER DEPTHS

RIC-PSM-DAN-00-GE-010-005

Figure 5.1

5.2 Groundwater quality

5.2.1 Salinity

Baseline groundwater salinity is presented in Figure 5-2.

Figure 5-2 Baseline salinity concentration

5.2.2 Groundwater Chemistry

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 5-1.

Table 5-1 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 ¹
B105A	Birchgrove		8	Complete results
B131A	Birchgrove		8	Complete results
B181A	Rozelle		8	Complete results
B208	Balmain		6	Metals results considered unreliable due to high pH
B209	Birchgrove		2	Complete results
B390	Rozelle		8	Complete results

The following bores within the vicinity of the Project area (see Figure 6-1 for bore locations) met or exceeded the ANZECC 2000 guidelines for freshwater and marine settings (95% level of protection):

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

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

Dense non-aqueous phase liquid (DNAPL) groundwater contamination has been reported at the Rozelle Rail Yards. Contamination is due to historic land use. The remediation of the soils within the Rozelle Rail Yards was completed in 2018 (AECOM, 2018) and, therefore, has reduced the potential for leachate to further contaminate the groundwater. Works undertaken by the M4-M5 Link Project in the Rozelle Rail Yards, including a grout curtain between the works and Rozelle Bay and two large cut and cover roadway structures connecting M4 East to ANZAC Br create a barrier mitigating contaminant movement through soil towards Rozelle Bay. Additionally deep tunnelling for the M4-M5 Link Project under Rozelle Rail Yards has depressurised local groundwater, significantly limiting groundwater impacts at Rozelle Rail Yards tunnelling for subsequent WHT Stage 3A. As M4-M5 Link Stage 2 tunnels pass under this contamination source (monitoring to

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

date has not detected the presence of DNAPL in the M4-M5 Link Stage 2 tunnels) and the contamination area is outside the construction footprint of this Project, the contaminant will continue to be monitored by M4-M5 Link and subject to the M4-M5 Link site audit statement process.

The relatively few monitoring results above the ANZECC 2000 guidelines for freshwater and marine settings (95% level of protection) are reflective of the generally residential nature of the tunnel alignment and good groundwater quality. The Project construction WTP will remove the above elevated analytes to comply with MCoA E208. The Groundwater Model prepared in accordance with MCoA E218 and E219 has not identified any contamination areas of concern relative to the Stage 3A Project, beyond DNAPL contamination in Rozelle Rail Yards outside the Project construction footprint, which will be managed by M4-M5 Link Stage 2. Whilst no treated water is planned to be discharged to Sydney Water assets, in the event discharge to Sydney Water assets is proposed then the GMP will be provided to Sydney Water for consultation. The Plan contains data collected under MCoA C14 (a).

6 Construction monitoring and methodology

6.1 Overview

This monitoring program has been designed to meet the objectives identified in Section 2.2 of the GMP. The monitoring program will monitor and collate:

- Daily measurement of the amount of water discharged from the water treatment plant located at the Western Harbour Tunnel cut and cover structure at Rozelle (WHT12) (MCoA C14(b))
- Water quality testing of the water discharged from the water treatment plant (MCoA C14(c))
- Monitoring of groundwater levels in aquifers adjacent to the tunnel alignment (MCoA C14(d))
- 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))
- Measures to record or otherwise estimate and report groundwater inflows into the tunnels during their construction (MCoA C14(f)(h)).

6.2 Discharged water treatment plant volumes

6.2.1 Criteria

There are no criteria for volumes of water discharged from the water treatment plant.

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. In such an instance these criteria will be included in this monitoring program.

6.2.2 Parameters

Water discharged from the water treatment plant will be measured in kilolitres (kl).

6.2.3 Frequency

Daily measurements of the volume of water discharged from the water treatment plant will be undertaken.

6.2.4 Location

Water discharged from the water treatment plant will be measured at the outlet of the water treatment plant.

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6.2.5 Data analysis methods

Daily measurements of the volume of water discharged from the water treatment plant will be performed with an inline flow meter and data logger.

6.2.6 Reporting

Reporting requirements for this Program are outlined in Table 8-1.

6.2.7 Identification of additional mitigation measures

Should the Project become aware of unacceptable environmental impact(s) as a result of discharge volumes, a mitigation program will be implemented in consultation with the Environmental Representative to prevent a recurrence.

6.3 Discharged water treatment plant quality

6.3.1 Criteria

Criteria for water discharged from the water treatment plant will be in accordance with the requirements of MCoA E208 or the EPL as varied from time to time by NSW EPA. These criteria are indicatively included in Table 6-1 and Table 6-2 as the 90 or 100 percentile concentration limits.

6.3.2 Parameters

Parameters to be monitored for water discharged from the water treatment plant will be in accordance with the requirements of the EPL as varied from time to time by NSW EPA. These criteria are indicatively included in Table 6-1 and Table 6-2.

6.3.3 Frequency

Parameters in Table 6-1 will be monitored daily. Parameters Table 6-2 in will be monitored monthly.

Table 6-1 Water treatment plant daily monitoring

Parameter	Unit	100 percentile concentration limit	Sampling method
pH	pH	6.5 - 8.5	Probe
Oil and grease	Visible	None visible	Visual inspection
Turbidity	mg/l	An NTU value calibrated to achieve <50 mg/L equivalent Total Suspended Solids	Probe

Table 6-2: Water treatment plant monthly monitoring

Parameter	Unit	90 percentile concentration limit	100 percentile concentration limit	Sampling method
Arsenic	mg/l	-	0.05	Grab sample
Cadmium	mg/l	-	0.014	Grab sample
Chromium (IV)	mg/l	0.07	-	Grab sample

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Parameter	Unit	90 percentile concentration limit	100 percentile concentration limit	Sampling method
Chromium (III)	mg/l	-	0.15	Grab sample
Copper	mg/l	0.04	-	Grab sample
Iron	mg/l	-	1.5	Grab sample
Lead	mg/l	-	0.03	Grab sample
Manganese	mg/l	-	2.5	Grab sample
Mercury	mg/l	-	0.0007	Grab sample
Nickel	mg/l	-	0.2	Grab sample
Zinc	mg/l	-	0.15	Grab sample

6.3.4 Location

Monitoring is to be undertaken at the licenced discharge point of the water treatment plant.

6.3.5 Data analysis methods

Sampling shall be in accordance with *Approved methods for the sampling and analysis of water pollutants in NSW* (NSW EPA, 2022).

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.

6.3.6 Reporting

Water treatment plant discharge quality data will be reported quarterly to DPE Water during construction of the tunnels. The data will be both in a tabulated and electronic quality-controlled data (csv, excel) ready to use format.

Water treatment plant discharge quality information will be included in the six-monthly Groundwater Monitoring Report to the Planning Secretary and DPE Water.

6.3.7 Identification of additional mitigation measures

Exceedances of water treatment plant discharge quality criteria shall be reported to NSW EPA and the Planning Secretary in accordance with Section 8. In the event of an exceedance an inspection shall be undertaken of the receiving environment to determine if there has been any unacceptable impacts from the Project. Where unacceptable impacts from the Project are identified a mitigation program shall be implemented in consultation with NSW EPA to prevent a recurrence.

6.4 Groundwater levels

6.4.1 Criteria

Groundwater levels shall be compared to predictions in the Groundwater Model.

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6.4.2 Parameters

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 stand pipes.

6.4.3 Frequency

Data loggers shall record pore pressure or water level every six hours.

6.4.4 Location

The location of monitoring is shown in Figure 6-1 and Table 6-3 and Table 6-4. The Project will install multi-level VWP sensors and groundwater level indicators. For piezometers notionally four sensors per monitoring hole will be installed. The typical reduced level for instruments: Hawkesbury Sandstone class III/IV boundary (approx. 20m depth), equidistance between Hawkesbury Sandstone class III/IV boundary and tunnel invert, at the tunnel invert, and 10 to 15 m below the tunnel invert.

Table 6-3 Vibrating Wire Piezometer network summary

VWP ID	Location	Easting (m)	Northing (m)	VWP Elevation at ground level (m AHD)	Bore inclination (degrees)	VWP logger depth (m bgl) ¹
WHT_VWP02	Birchgrove Road/King Street intersection, Balmain	331235.12	6252343.59	42.57	90	60, 70, 80, 95, 115
WHT_VWP03	Punch Park, Balmain	331493.99	6251745.25	15.64	90	55, 65, 80, 95, 115
WHT_BH3017	107 Louisa Road, Birchgrove	331940.20	6253246.28	9.66	90	24.9 and 43.2
WHT_B202	Cross Street, Rozelle	330942.5	6251497.3	34.08	60	Note 1

1. Typical reduced level (RL) for instruments: Class Hawkesbury sandstone (HBSS) III/IV boundary (approx. 20m depth), equidistance between HBSS III/IV boundary and tunnel invert, at the tunnel invert, and 10 to 15 m below the tunnel invert.

Table 6-4 Groundwater gauge stand pipe network

Bore ID	Location	Easting (m)	Northing (m)	Elevation (Ground Leve) (m AHD)	Stick up/down (relative to ground level) (m)**	Total depth of bore (m bgl)	Screen from (m bgl)	Screen to (m bgl)	Sump (m bgl)
WHT_B104a	The Terrace, Birchgrove	331665.80	6252920.80	7.59	Note 1	43.7	39.7	42.7	42.7 to 43.7
WHT_B105a	Deloitte Avenue, Birchgrove	Note 1	Note 1	2.24	Note 1	35.9	32.9	35.9	35.9 to 36.9
WHT_B149	Beattie Street, Balmain	331286.20	6251986.90	28.37	Note 1	65	61	64	64 to 65
WHT_B208	Little Darling Street, Balmain	331415.40	6252215.90	44.07	Note 1	86.68	79.68	85.68	85.68 to 86.68
WHT_B209	Thomas Street, Birchgrove	331520.70	6252619.20	37.29	Note 1	84	77.5	83.5	83.5 to 84
WHT_B181a	Ellen Street, Rozelle	330808.10	6251232.30	30.24	Note 1	10	6.5	9.5	9.5 to 10
WHT_B390	Alice Street, Rozelle	330684.10	6250754.00	10.93	Note 1	20.4	13.3	19.3	19.3 to 20.4
WHT_TMB04d	Hannan Reserve, Rozelle	331089.06	6251161.13	21.642	+0.62	71	70	67	71 to 70
WHT_TMB04m		331092.36	6251159.45	21.61	+0.7	46	45	42	46 to 45
WHT_TMB04s		331094.88	6251157.95	21.737	+0.59	16	15	12	16 to 15
WHT_TMB05d		331059.251	6251911.419	32.755	-0.16	81	80	77	81 to 80

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WHT_TMB05m	Wisbeach Street, Balmain	331055.614	6251914.739	33.081	-0.15	36	35	32	36 to 35
WHT_TMB05s		331052.756	6251917.203	33.359	-0.18	16	15	12	16 to 15
WHT_TMB02d	Beattie Street Car Park, Balmain	331621.382	6252135.821	35.157	-0.07	78	77	74	78 to 77
WHT_TMB02m		331623.474	6252135.753	35.075	-0.07	51	50	47	51 to 50
WHT_TMB02s		331622.328	6252133.29	35.179	-0.08	26	25	22	26 to 25
DMB06d	Elkington Park, Balmain	330961.964	6252450.006	21.045	+0.37	54	53	50	54 to 53
DMB06s		330958.155	6252454.401	20.502	+0.45	16	15	12	16 to 15
WHT_TMB01d	Mort Bay Park, Birchgrove	331973.906	6252640.709	6.079	+0.64	42	41	38	42 to 41
WHT_TMB01m		331971.055	6252638.874	6.03	+0.7	16	15	12	16 to 15
WHT_TMB01s		331967.356	6252636.278	6.035	+0.64	6.6	6.6	3.6	NA
WHT_DMB08d	Birchgrove Oval, Birchgrove	331870.79	6252951.538	7.84	+0.53	46	45	42	46 to 45
WHT_DMB08s		331874.508	6252953.409	7.999	+0.57	11	10	7	11 to 10
WHT_TMB03d	Louisa Road, Birchgrove	331662.444	6253125.4	11.358	-0.12	54	53	50	54 to 53
WHT_TMB03m		331663.326	6253127.298	11.343	-0.16	41	40	37	41 to 40
WHT_TMB03s		331664.511	6253130.005	11.316	-0.13	16	15	12	16 to 15
DMB09s	White Bay Power Station, Rozelle	331443.331	6251204.565	3.199	-0.23	16	15	12	16 to 15
DMB09d		331446.432	6251202.001	3.212	-0.18	46	45	42	46 to 45

1. To be confirmed at next monitoring round.

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6.4.5 Data analysis methods

Pore pressure shall be used in conjunction with gauges in stand pipes to infer groundwater levels. Six-monthly groundwater data reports will be reviewed, in conjunction with settlement data, by the Tunnel Design Manager or delegate if groundwater drawdown or settlement is substantially different to predictions in the Groundwater Model or in excess of the limits specified in this approval. If so, the requirements of MCoA E102 to E105 inclusive must be undertaken again within three months. Model input parameters must be adjusted to calibrate the model so that predictions are better aligned with actual observations.

6.4.6 Reporting

Groundwater level data will be reported quarterly to DPE Water during construction of the tunnels. The data will be both in a tabulated and electronic quality-controlled data (csv, excel) ready to use format.

Groundwater level information will be included in the six-monthly Groundwater Monitoring Report to the Planning Secretary and DPE Water. The Report will state if groundwater drawdown is substantially different to predictions in the Groundwater Model and if the model input parameters are being adjusted to calibrate against monitoring data

After 24-months groundwater level data will be interpreted to inform an updated Groundwater Model in accordance with MCoA E220.

6.4.7 Identification of additional mitigation measures

In the event groundwater drawdown is substantially different to predictions in the Groundwater Model the JHCPB Tunnel Design Manager shall undertake a review to determine if there are any unacceptable project impacts. Should unacceptable project impacts be identified, mitigation measures will be developed and implemented. Mitigation measures shall be reported to the Environmental Representative and included in the next Groundwater Monitoring Report to the Planning Secretary and DPE Water.

6.5 Electrical conductivity and temperature

6.5.1 Criteria

Salinity concentration shall be compared to predictions in the Groundwater Model.

6.5.2 Parameters

Electrical conductivity shall be measured in micro Siemens per centimetre (μScm^{-1}). Temperature shall be recorded in degrees Celsius ($^{\circ}\text{C}$).

6.5.3 Frequency

Data loggers shall record temperature and electrical conductivity every six hours.

6.5.4 Location

Monitoring locations between saline water bodies and the tunnel shown on Figure 6-1 and Table 6-5.

Table 6-5 Electrical conductivity and temperature monitoring network

Bore ID	Location	Easting (m)	Northing (m)	Elevation (Ground Leve) (m AHD)	Stick up/down (relative to ground level) (m)**	Total depth of bore (m bgl)	Screen from (m bgl)	Screen to (m bgl)	Sump (m bgl)
WHT_TMB04d	Hannan Reserve, Rozelle	331089.06	6251161.13	21.642	+0.62	71	70	67	71 to 70
WHT_B104a	The Terrace, Birchgrove	331665.80	6252920.80	7.59	Note 1	43.7	39.7	42.7	42.7 to 43.7
DMB06d	Elkington Park, Balmain	330961.964	6252450.006	21.045	+0.37	54	53	50	54 to 53
DMB09d	White Bay Power Station, Rozelle	331446.432	6251202.001	3.212	-0.18	46	45	42	46 to 45
WHT_B209	Thomas Street, Birchgrove	331520.70	6252619.20	37.29	Note 1	84	77.5	83.5	83.5 to 84
TMB01d	Mort Bay Park, Birchgrove	331973.906	6252640.709	6.079	+0.64	42	41	38	42 to 41
DMB08d	Birchgrove Oval, Birchgrove	331870.79	6252951.538	7.84	+0.53	46	45	42	46 to 45

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6.5.5 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.

6.5.6 Reporting

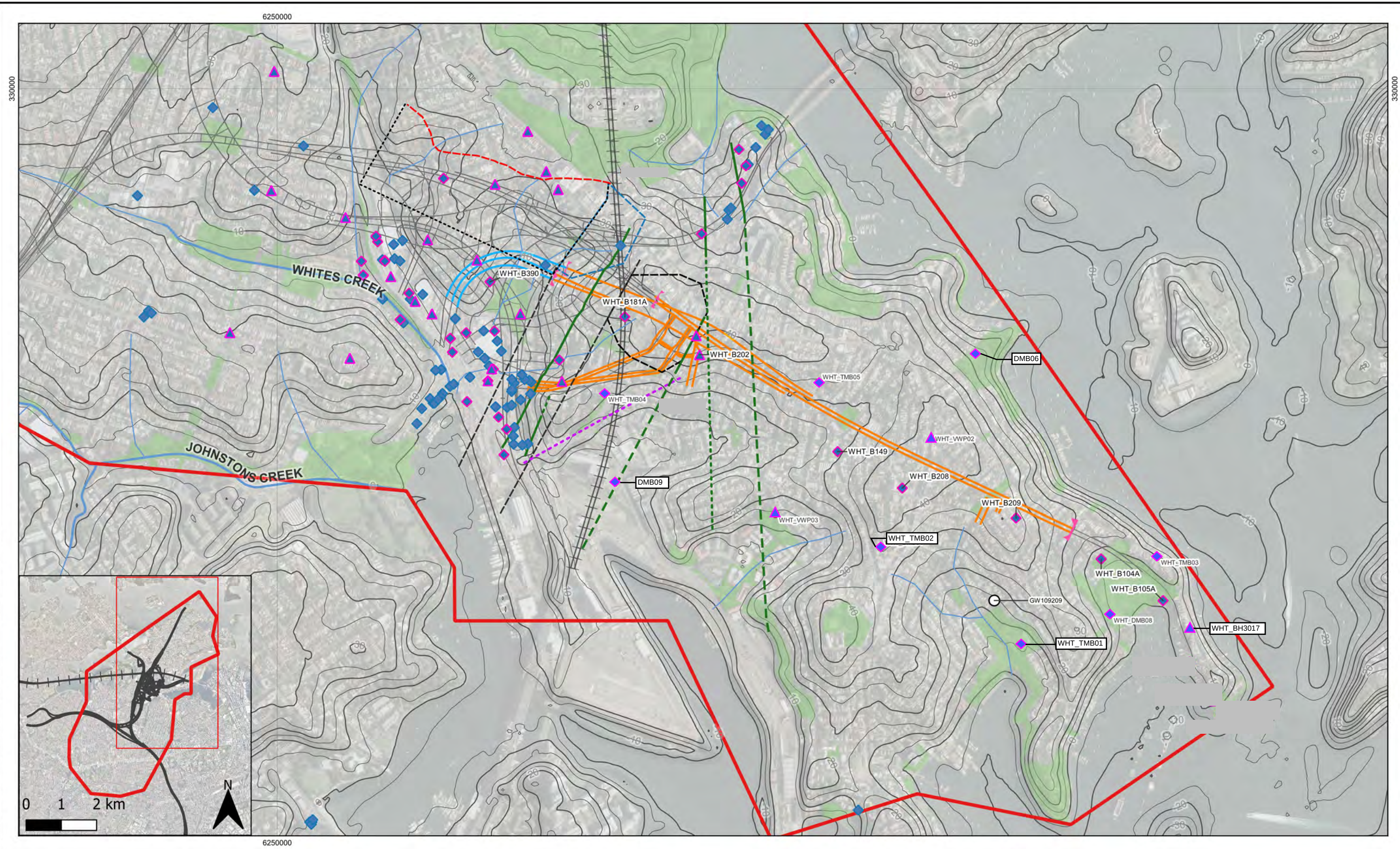
Groundwater salinity data will be reported quarterly to DPE Water during excavation of the tunnels. The data will be both in a tabulated and electronic quality-controlled data (csv, excel) ready to use format.

Groundwater salinity information will be included in the six-monthly Groundwater Monitoring Report to the Planning Secretary and DPE Water. The Report will state if groundwater salinity is substantially different to predictions in the Groundwater Model and if the model input parameters are being adjusted to calibrate against monitoring data.

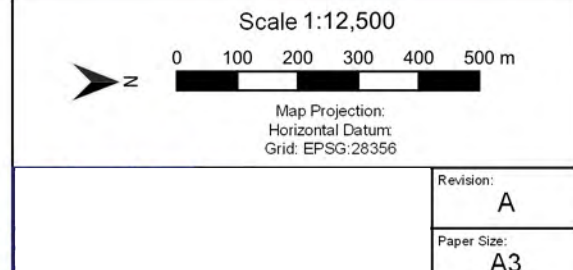
6.5.7 Identification of additional mitigation measures

In the event salinity concentrations are substantially different to predictions in the Groundwater Model the JHCPB Tunnel Design Manager shall undertake a review to determine if there are any unacceptable project impacts. Should unacceptable project impacts be identified, mitigation measures will be developed and implemented. Mitigation measures shall be reported to the JHCPB Environmental Representative and included in the next Groundwater Monitoring Report to the Planning Secretary and DPE Water.

Figure 6-1 Groundwater level and salinity monitoring network



- Legend**
- | | | | | |
|---|--|--|---|--|
| <p>Current, Proposed and Decommissioned</p> <ul style="list-style-type: none"> Standpipe with GW data Standpipe with Sensor Multilevel VWP Registered groundwater supply work | <ul style="list-style-type: none"> Model Domain Control Lines; M4, M5, RIC, WHT Proposed SMW TBM alignments RIC PAC3 | <ul style="list-style-type: none"> WHT STW STW Extent Grass and/or Tree Cover Major Hydrolines Minor Hydrolines | <ul style="list-style-type: none"> High Confidence Dyke Medium Confidence Dyke Low Confidence Dyke Low Confidence Dyke (from 1:100k geological map) Fault 9 - Inferred Extension | <ul style="list-style-type: none"> Fault 1 - Topographic Surface Projection Structural Corridor Structurally Complex Zone Fault Zone Extension |
|---|--|--|---|--|



Stage 3A Groundwater Monitoring Network
(Labeled monitoring points)

Revision: A
Paper Size: A3

Figure 6-1

6.6 Tunnel groundwater inflow

6.6.1 Criteria

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

6.6.2 Parameters

Groundwater inflows will be measured as volume relative to time over distance (L/s/km).

6.6.3 Frequency

Tunnel water outflow and construction water inflow to the tunnel shall be continuously recorded with flow meters (very limited data gaps may occur during maintenance). The meters will be read and recorded monthly.

6.6.4 Location

Measurements will be performed near the tunnel portal.

6.6.5 Data analysis methods

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

Tunnel groundwater inflow = Tunnel water outflow – Construction water inflow

Volumes will be measured with inline flow meters and data loggers.

6.6.6 Reporting

Tunnel groundwater inflow data will be reported quarterly to DPE Water during excavation of the tunnels. The data will be both in a tabulated and electronic quality-controlled data (csv, excel) ready to use format.

Tunnel groundwater inflow rates will be included in the six-monthly Groundwater Monitoring Report to the Planning Secretary and DPE Water.

6.6.7 Identification of additional mitigation measures

In the event tunnel inflow exceeds the criteria over a window in which natural sealing and drawdown related inflow reductions do not mitigate the inflow the JHCPB Tunnel Design Manager shall undertake a review to determine if there are any unacceptable project impacts. Should unacceptable project impacts be identified, mitigation measures will be developed and implemented. Mitigation measures shall be reported to the Environmental Representative and included in the next Groundwater Monitoring Report to the Planning Secretary and DPE Water.

6.7 Existing groundwater users

The Project will liaise with the owner of registered groundwater bore GW109209 for the duration of Stage 3A construction (and at a minimum 6 monthly unless otherwise requested by the owner) to determine if there has been any change to the supply, quality and quantity of water from the bore with specific reference to the NSW Aquifer Interference Policy (AIP). If drawdown at the bore is found to exceed two metres, in accordance with the AIP, measures will be taken to 'make good' the impact. 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, providing an alternative water supply or limited compensation.

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6.8 Operational Groundwater Inflow

6.8.1 Criteria

E216 requires the Proponent to 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). Compliance with this condition will not be determined by averaging groundwater inflows across the length of the tunnels.

6.8.2 Parameters

Groundwater inflows will be measured as volume relative to time over distance (L/s/km).

6.8.3 Frequency

Tunnel water inflows will be determined following tunnel excavation, allowing sufficient time for the efficacy of mitigation measures to be evaluated. This will occur once, prior to completion of Stage 3A works. In the event additional mitigations are required additional testing will be undertaken to verify the efficacy of the mitigations.

6.8.4 Location

Measurements will be performed within the tunnel over distances no greater than 1km.

6.8.5 Identification of additional mitigation measures

Should inflows exceed the operational inflow criteria a design review will be undertaken to identify the appropriate inflow controls most suited to the local geological features.

7 Smart Principles

This Program has been developed using the 'SMART' principles.

- **Specific:** This Program is for WHT Stage 3A monitoring of groundwater. Groundwater monitoring for other stages and operation of the Western Harbour Tunnel and Warringah Freeway Upgrade project will be detailed in other documents outside of Stage 3A
- **Measurable:** Monitoring criteria or purposes are provided in Section 5
- **Actionable:** Monitoring actions succinctly are described in Section 5
- **Realistic:** The requirements of Section 5 are realistically achievable, there is a history of implementation of similar actions on previous infrastructure projects.
- **Timely:** Timing for actions is provided in Section 5. As required by CoA C14 groundwater monitoring data will be provided to DPE Water every three months during the construction of the tunnels and portal for WHT Stage 3A.

8 Reporting

Table 8-1 details the reporting requirements of this program. Quarterly groundwater monitoring reports will be reviewed, in conjunction with settlement data, by the Tunnel Design Manager or delegate to determine if groundwater drawdown or settlement is substantially different to predictions in the Groundwater Model or in excess of the limits specified in this approval. If so, the requirements of MCoA E102 to E105 inclusive must be undertaken again within three months. Model input parameters must be adjusted to calibrate the model so that predictions are better aligned with actual observations

Table 8-1 Monitoring program reporting

Schedule (during construction)	Requirements	Recipient (relevant authority)
Sydney Water quarterly water monitoring reports (every 3 months) when discharging to Sydney Water assets.	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. (refer MCoA C14(g))	Sydney Water (only when discharges are directed to Sydney Water assets)
Quarterly water monitoring data (every 3 months)	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. (refer MCoA C14)	DPE Water
Groundwater Monitoring Report	Six-monthly Groundwater Monitoring Report 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; - 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

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	• 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. (refer MCoA C21)	
Annual monitoring reports	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. (refer MCoA E221)	DPE Water Planning Secretary
24 months groundwater model report	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. (refer MCoA E219 and E220)	DPE Water Planning Secretary
6 monthly GW109209 consultation record	Consultation record on any change to the supply, quality and quantity of water from the bore.	TfNSW Consultation Manager database

9 Compliance management

Compliance of the Project with this monitoring program will be measured against the targets outlined in GMP Section 2 through ongoing monitoring throughout the construction of the Project.

9.1 Roles and responsibilities

The Project Team's organisational structure and overall roles and responsibilities as well as the Environmental Representative and required specialists are outlined in Section 3.3 of the CEMP. The JHCPB Environment & Sustainability Manager is responsible for ensuring this Program is implemented.

9.2 Training and awareness

Personnel undertaking monitoring will be appropriately qualified.

Further details regarding staff induction and training are outlined in Section 3.5 of the CEMP.

9.3 Auditing

Internal and external auditing will be undertaken to assess the effectiveness of environmental controls, compliance with this Monitoring Program.

Audit requirements are detailed in Section 3.9.3 of the CEMP.

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9.4 Non-conformance, Incident Reporting, and Investigation

Non-conformances, incident reporting and subsequent investigation will be undertaken as required in accordance with Section 3.10 of the CEMP.