

JHCPB Joint Venture

# Groundwater Management Plan

RIC-JHC-MPL-00-PL-300-001

Project	Design and Construction of Rozelle Interchange Project
Design Lot No.	00-PL-300
Document No.	RIC-JHC-MPL-00-PL-300-001
Revision Date	02 March 2021

**Document Approval**

Developed By:				
Name: Adrian Broger			Position: Environmental Coordinator	
Reviewed By:				
Name	Position		Date Reviewed	
Ali Gotch	Planning Approvals Advisor		16/12/2020	
Revision Record				
Rev	Rev Date	Reason for issue	Developed by	Approved by
A	07/03/2019	Natalie Jongebloed	Jacinta Fuller	N/A
B	02/04/2019	Issued for consultation; draft for RMS and ER review	Jacinta Fuller	N/A
00	01/05/2019	For submission to DPIE	Alison Kriegel	N/A
01	23/06/2019	Updated to consider DPIE comments	Alison Kriegel / Charles Scarf	N/A
02	25/07/2019	Updated to consider DP IE comments	Katie Baxter	Charles Scarf / Alison Kriegel
03	31/10/2019	Updated to consider DPIE Water comments	Ivan Juricic	Charles Scarf
04	16/09/2020	Updated to include modifications to the Planning Approval	Ciara Moriarty	Ali Gotch / ER approval
05	16/12/2020	Monitoring program updated	Adrian Broger	DPIE
06	02/03/2021	Monitoring program updated	Adrian Broger	DPIE

## Contents

1. Introduction.....	8
1.1. Context.....	8
1.2. Project background .....	8
1.3. Scope of the Sub-plan.....	8
1.4. Environmental management system overview.....	8
2. Purpose and Objectives.....	9
2.1. Purpose.....	9
2.2. Objectives .....	9
2.3. Environmental performance outcomes and targets.....	9
3. Environmental requirements .....	11
3.1. Relevant legislation and guidelines .....	11
3.1.1. Legislation .....	11
3.1.2. Guidelines and standards .....	11
3.2. Minister's Conditions of Approval.....	12
3.3. Revised Environmental Management Measures.....	16
3.4. Consultation .....	16
4. Existing Environment .....	18
4.1. Overview .....	18
4.2. Topography and drainage .....	18
4.3. Geological setting.....	19
5. Hydrogeological setting.....	19
5.1. Regional groundwater flow, recharge and discharge .....	19
5.2. Hydrogeological units .....	19
5.2.1. Alluvium.....	20
5.2.2. Hawkesbury Sandstone .....	20
5.3. Groundwater levels and flow .....	20
5.3.1. Baseline monitoring .....	20
5.3.2. Alluvium.....	21
5.3.3. Hawkesbury Sandstone .....	21
5.4. Hydraulic properties .....	21
5.5. Groundwater quality .....	21
5.6. Sensitivity receptors .....	22
5.6.1. Priority groundwater dependent ecosystems .....	22
5.6.2. Non-priority groundwater dependent ecosystems .....	22
5.6.3. Registered groundwater bores.....	23
5.6.4. Potential groundwater contamination .....	23
6. Environmental aspects and impacts.....	24
6.1. Construction activities .....	24

6.2.	Impacts .....	24
6.2.1.	Overview.....	24
6.2.2.	Reduced groundwater recharge.....	24
6.2.3.	Groundwater level decrease .....	24
6.2.3.1.	Groundwater drawdown .....	24
6.2.3.2.	Potential impacts to Groundwater Dependent Ecosystems .....	25
6.2.3.2.1.	Priority Groundwater Dependent Ecosystems .....	25
6.2.3.2.2.	Non-priority Groundwater Dependent Ecosystems .....	25
6.2.3.3.	Potential impacts on surface water baseflow .....	26
6.2.3.4.	Ground movement (settlement) .....	26
6.2.4.	Groundwater quality.....	26
6.2.4.1.	Spills and incidents.....	26
6.2.4.2.	Intercepting contaminated groundwater.....	27
6.2.4.3.	Groundwater treatment and surface water impacts .....	27
6.2.4.4.	Groundwater associated with Potential Acid Sulfate Soils .....	27
6.2.4.5.	Soil salinity impacting groundwater .....	27
6.2.4.6.	Saltwater intrusion.....	28
6.2.4.6.1.	Tidal zones.....	28
6.2.5.	Utilities.....	28
6.2.6.	Cumulative impacts .....	28
6.2.6.1.	WestConnex projects .....	29
6.2.6.2.	Other relevant projects .....	29
6.2.7.	Construction monitoring.....	29
7.	Environmental control measures.....	30
7.1.	Water treatment.....	30
7.2.	Other environmental control measures.....	31
8.	Compliance management .....	34
8.1.	Roles and responsibilities.....	34
8.2.	Training.....	34
8.3.	Monitoring and inspection.....	34
8.4.	Licenses and permits .....	34
8.5.	Auditing.....	34
8.6.	Reporting.....	34
9.	Review and improvement.....	36
9.1.	Continuous improvement.....	36
9.2.	Groundwater model update .....	36
9.3.	GWMP update and amendment .....	36
9.4.	WTP performance .....	36
10.	References.....	36

## Table of Tables

Table 1: Performance outcomes .....	9
Table 2: Summary of the Conditions of Approvals relevant to and addressed in this Plan.....	12
Table 3: Summary of consultation for development of the Groundwater Management Plan and Groundwater Monitoring Program .....	16
Table 4: Estimated hydraulic conductivity values form packer testing for the Hawkesbury Sandstone.....	21
Table 5: Summary of baseline groundwater quality within the Project area .....	22
Table 6: Groundwater management and mitigation measures .....	31
Table 7: Reporting requirements.....	35
Table 8: Other Conditions of Approval relevant to the development of this Sub-plan .....	38
Table 9: Revised Environmental Mitigation Measures relevant to the development of this Sub-plan .....	40

## Annexures

Annexure A Conditions of Approval.....	38
Annexure B Groundwater Monitoring Program.....	43

## Glossary / Abbreviations

Abbreviations	Expanded text
ASSMP	Acid Sulfate Soils Management Plan
ANZECC	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
Bi-monthly	Every two months
CEMP	Construction Environmental Management Plan
CoA	Conditions of Approval
CFU	Colony Forming Unit
CSSI	The Critical State Significant Infrastructure, as described in Schedule 1, the carrying out of which is approved under the terms of the SSI 7485 approval
DPIE	NSW Department of Planning, Industry and Environment
DoI Water	NSW Department of Industry Water (formerly DPI Water)
DPI Water	NSW Department of Primary Industries - Water
DPIE Water	NSW Department of Planning, Industry and Environment – Water (formerly DoI Water)
EC	Electrical Conductivity
EIS	M4-M5 Link Environmental Impact Statement
EPA	NSW Environment Protection Authority
EPL	Environment Protection Licence
ER	Environmental Representative
EWMS	Environmental Work Method Statement
GDEs	Groundwater Dependent Ecosystems
GMP	Groundwater Management Plan (this document)
GWMP	Groundwater Monitoring Program
GMR	Groundwater Modelling Report
GWQ	Groundwater quality
JHCPB	John Holland CPB Contractors Joint Venture
mAHD	elevation in metres with respect to the Australian Height Datum
mBGL	metres below ground level
mTOC	metres below top of casing
m/day	metres per day
NRAR	Natural Resources Access Regulator
µS/cm	micro-Siemens per centimetre
REMM	Revised Environmental Management Measures

Abbreviations	Expanded text
Roads and Maritime	Roads and Maritime Services (now Transport for NSW)
SPIR	M4-M5 Link Submissions and Preferred Infrastructure Report
SSTV	Site Specific Trigger Value
TWG	The Water Group
TfNSW	Transport for NSW
SSWMP	Soil and Surface Water Management Sub-plan
WTP	Water Treatment Plant

## **1. Introduction**

### **1.1. Context**

This Groundwater Management Sub-plan (GMP or Plan) and accompanying Groundwater Monitoring Program (GWMP, Annexure B) forms part of the Construction Environmental Management Plan (CEMP) for the Design and Construction of Rozelle Interchange (the Project).

This GMP has been prepared to address the requirements of the Minister's Conditions of Approval (CoA), Project Approvals and all applicable guidance and legislation..

This document acknowledges the authors of the GMP for the M4-M5 Link Mainline Tunnels (Stage One of the M4-M5 Link project) and groundwater report for the Environmental Impact Statement (EIS) (AECOM 2017). Words have been appropriated from these documents within certain sections of this GMP and GWMP to provide continuity across the relevant requirements of the Project.

### **1.2. Project background**

The M4-M5 Link EIS (AECOM 2017) assessed the impacts of construction and operation of the Project on groundwater, within Chapter 19 and Appendix T (Technical working paper: Groundwater). For a detailed understanding and background of the main project, please refer to these documents. The information provided within this report relates only to the Project area.

The EIS identified the potential for minor impacts on groundwater during construction typically associated with drawdown and contamination. However, it concluded any potential impacts could be managed by the standard mitigation and management measures that are described in this GMP. The potential minor impacts on groundwater during construction are discussed in Section 5.

Please refer to Section 1.3 of CEMP for a Project Description.

### **1.3. Scope of the Sub-plan**

The scope of this plan is to describe how John Holland CPB Contractors Joint Venture (JHCPB) proposes to manage and protect groundwater during construction of the project. This document does not address groundwater management within the operational stage of the project.

### **1.4. Environmental management system overview**

The environmental management system overview is described in Section 1.5 of the CEMP.

## 2. Purpose and Objectives

### 2.1. Purpose

The purpose of this plan is to describe how JHCPB proposes to manage and protect groundwater during construction of the Project. This Plan should be read in conjunction with the CEMP.

### 2.2. Objectives

The key objectives of the GMP are to ensure all CoA, REMMs and licence / permit requirements relevant to groundwater are described, scheduled and assigned responsibility as outlined in:

- All documents listed in CoA A1
- Conditions of Approval: SSI-7485,
- The Roads and Maritime Services (Roads and Maritime) Specifications G36, G38 and G40,
- The Project's Environment Protection Licence (EPL), and
- All relevant legislation and other requirements described in Section 3.1 of this Plan.

### 2.3. Environmental performance outcomes and targets

The key objective of the GMP is to ensure that groundwater impacts during construction are minimised and are within the scope permitted by the SSI Approval. This includes ensuring long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are consistent with the Approved Project.

To achieve these objectives, JHCPB will undertake the following:

Table 1: Performance outcomes

No.	Performance Outcome	How addressed	Records	Source
1	Groundwater management during the construction phase of the project will be in accordance with this GMP	This plan outlines how groundwater will be managed during the construction phase of the project.	Audit report	CoA C4 (f)
2	Groundwater monitoring will be undertaken in accordance with the GWMP	Groundwater monitoring is outlined within Section 3 of the GWMP.	Water monitoring report EPL monitoring report Audit reports	CoA C9 (b) CoA C10
3	Water discharged from a Water Treatment Plant (WTP) will be discharged within the defined water quality discharge criteria	The discharge criteria and performance criteria for the water treatment plant are outlined in Section 3.3 of the GWMP.	Water monitoring report EPL monitoring report	EPL
4	Design and construct tunnels to minimise groundwater inflow	The interception of groundwater in regard to design and construction to minimise groundwater inflow is outlined in Section 6.2.4.2.	Detailed design Water monitoring report	EIS, Appendix A
5	Establish water quality discharge criteria with consideration of NSW Water Quality Objectives	The discharge criteria and performance criteria are outlined in Section 3.3 of the GWMP.	This GMP	EIS, Appendix A
6	Effectively treat water to meet water quality discharge criteria	Water will be treated to meet water discharge quality criteria in	Water monitoring report	EIS, Appendix A

No.	Performance Outcome	How addressed	Records	Source
		accordance with Section 7.1 of this plan and Section 3.3 of the GWMP.		
7	Maximise reuse of treated water during construction	Section 7.1 outlines water treatment processes during construction. The water reuse strategy will include details of the preferred reuse options to maximise reuse of treated water.	Water monitoring report	EIS, Appendix A

### **3. Environmental requirements**

#### **3.1. Relevant legislation and guidelines**

##### **3.1.1. Legislation**

All legislation relevant to this GMP is described in Annexure A of the CEMP.

##### **3.1.2. Guidelines and standards**

The main guidelines, specifications and policy documents relevant to this Plan include:

- Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC): National Water Quality Management Strategy, Paper No.4, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1, The Guidelines (ANZECC 2000),
- Environment Protection Authority (EPA): Approved methods for Sampling and Analysis of Water Pollutants in NSW (EPA 2004),
- Department of Planning, Industry and Environment (DPIE): Guideline for riparian corridors on waterfront land (DPE 2012),
- Department of Land and Water Conservation (DLWC):
  - › NSW Groundwater Dependent Ecosystem Policy (DLWC 2002),
  - › NSW Groundwater Policy Framework Document (DLWC 2002),
  - › NSW Groundwater Quality Protection Policy (DLWC 1998),
  - › NSW Groundwater Quality Management Policy (DLWC 2007),
- Department of Water and Energy (DWE): NSW Water Extraction Monitoring Policy (DWE 2007),
- NSW Office of Water (NoW):
  - › NSW Aquifer Interface Policy (NoW 2012),
  - › Water Sharing Plan, Greater Metropolitan Regional Groundwater Sources Background Document, Sydney (NoW 2011), and
- Road and Maritime: Dewatering Guideline (Roads and Maritime 2011).

### 3.2. Minister's Conditions of Approval

The CoA relevant to this plan are listed in Table 2 below. A cross reference is also included to indicate where the condition is addressed in this Plan or other project management documents. Specific CoA relevant to groundwater management for the Project are included within Annexure A.

Table 2: Summary of the Conditions of Approvals relevant to and addressed in this Plan.

CoA No.	Condition requirements	Document reference	How addressed
C4(f)	The following CEMP Sub-plans must be prepared in consultation with the relevant authorities identified for each CEMP Sub-plan and be consistent with the CEMP referred to in the EIS	Section 3.4	This GMP has been prepared in accordance with this condition and describes how JHCPB propose to manage groundwater during construction of the project. This Plan has been provided to The Water Group (formerly DPIE Water)/Natural Resources Access Regulator (NRAR) for consultation.
C5	The CEMP Sub-plans must state how:		
	(a) the environmental performance outcomes identified in the documents listed in Condition A1 as modified by these conditions will be achieved;	Section 2.3 Table 6	This plan was prepared in accordance with the environmental performance outcomes identified in the documents listed in Condition A1 and is evidenced primarily in Section 2.3 and Table 6.
	(b) the mitigation measures identified in the documents listed in Condition A1 as modified by these conditions will be implemented	Section 7	The implementation of groundwater management and mitigation measures identified in the documents listed in Condition A1 are listed in Table 6.
	(c) the relevant terms of this approval will be complied with and	Section 3.2, Table 2, Annexure A	Details regarding how JHCPB propose to comply with the relevant terms of approval are listed in this table and in Annexure A.
	(d) issues requiring management during construction (including cumulative impacts), as identified through ongoing environmental risk analysis, will be managed.	Section 6.2 and Section 7 Table 6 Initial Environmental Risk Assessment (Annexure B of CEMP) Section 6.1 of the GWMP (Annexure B)	Groundwater management issues requiring management during construction of the Project have been identified through EIS, SPIR and Environmental Risk Assessment Workshop. These issues including cumulative impacts have been detailed in Section 6 of this plan and Annexure B of the CEMP. Environmental risk analysis will be ongoing and regularly reviewed in accordance with section 3.2.1 of the CEMP to ensure effective management of groundwater mitigation and management measures listed in Table 6.

CoA No.	Condition requirements	Document reference	How addressed
C6	The CEMP Sub-plans must be endorsed by the ER and then submitted to the Secretary for approval no later than one (1) month prior to the commencement of the construction activities to which they apply	Refer to Section 2.2 of the CEMP	This GMP has been endorsed by the ER on 25 June 2019. The GMP has been submitted to DPIE for approval no later than one month prior to the commencement of construction activities.
C7	Any of the CEMP Sub-plans may be submitted to the secretary along with, or subsequent to, the submissions of the CEMP	Refer to Section 2.2 of the CEMP	This Sub-plan has been submitted for approval to DPIE following submission of the CEMP for DPIE approval.
C8	Construction must not commence until the CEMP and all CEMP Sub-plans have been approved by the Secretary. The CEMP and CEMP Sub-plans, as approved by the Secretary, including any minor amendments approved by the ER, must be implemented for the duration of construction. Where the CSSI is being staged, construction of that stage is not to commence until the relevant CEMP and CEMP Sub-plans have been endorsed by the ER and approved by the Secretary.	Refer to Section 2.2 of the CEMP	Construction will not commence until the CEMP and all CEMP Sub-plans have been approved by DPIE. The CEMP and CEMP Sub-plans will be implemented for the duration of construction.
C9 (b)	The following Construction Monitoring Programs must be prepared in consultation with the relevant authorities identified for each Construction Monitoring Program to compare actual performance of construction of the CSSI against predicted performance.  (b) Groundwater Monitoring Program: DPI Water, Sydney Water and relevant council(s)	Section 3.4 Section 2.3 of the GWMP (Annexure B)	The GWMP has been prepared in accordance with this condition and describes how JHCPB propose to conduct groundwater monitoring during construction of the Project. The GWMP has been provided to The Water Group (formerly DPIE Water) / NRAR, Sydney Water, City of Sydney Council and Inner West Council for consultation.
C10	Each Construction Monitoring Program must provide:  (a) details of baseline data available;	Annexure A and Annexure B of the GWMP	The baseline data is available in Annexure A and Annexure B of the GWMP.

CoA No.	Condition requirements	Document reference	How addressed
	(b) details of baseline data to be obtained and when;	Section 3.1 of the GWMP	The details of baseline data obtained and when are contained in this section.
	(c) details of all monitoring of the project to be undertaken	Section 3.2 of the GWMP	This section details the monitoring to be undertaken with Table 4 outlining the locations of the groundwater monitoring bores
	(d) the parameters of the project to be monitored	Section 3.1.3 of the GWMP	This section outlines the parameters of the project to be monitored with Table 4 outlining the parameters
	(e) the frequency of the monitoring to be taken	Section 3.2 and Section 4 of the GWMP	Outlines the frequency in which monitoring will be undertaken
	(f) the location of monitoring	Section 3.2 of the GWMP	This section details of all monitoring to be undertaken with Table 4 outlining the locations of the groundwater monitoring bores
C12	Each Construction Monitoring Program must include:	Section 4.4 and 3.3.1 of the GWMP	Outlines how the water treatment plant discharge sampling will be undertaken and the frequency.
	(a) Daily measurement of the amount of water discharged from the water treatment plants		
	(b) water quality testing of the water discharged from the water treatment plants	Section 3.3.2 of the GWMP	Outlines the water quality testing of the water discharged from water treatment plants.
	(c) monitoring of groundwater pore pressures in the Hawkesbury Sandstone aquifers adjacent to the tunnel alignment, in consultation with The Water Group	Section 3.2 of the GWMP	Details pore pressure monitoring to be undertaken in consultation with The Water Group

CoA No.	Condition requirements	Document reference	How addressed
	<p>(d) monitoring of groundwater electrical conductivity in key locations between saline water bodies and the tunnel as identified by the project groundwater model including:</p> <ul style="list-style-type: none"> <li>▸ (ii) in the Rozelle area to the north of Rozelle Bay</li> <li>▸ (iii) in the Annandale area to the west of Rozelle Bay</li> <li>▸ (iv) in the Rozelle area to the south east of Iron Cove</li> </ul> <p>with a minimum of two (2) groundwater monitoring wells to be provided in each key location in consultation with Dol Water.</p>	Section 4.3 and Table 4 of the GWMP	Details electrical conductivity to be undertaken.
	(e) measures to record or otherwise estimate and report groundwater inflows into the tunnels during their construction	Section 3.2.4 and 3.3.1 of the GWMP	Outlines how groundwater inflows are calculated and monitored.
	(f) a method for providing the data collected in (a) and (b) to Sydney Water every three (3) months to demonstrate the project's compliance with the discharge criteria and, if applicable, the Proponent's trade waste licence	Table 9 of the GWMP Table 6	Outlines reporting requirements. Data collection and reporting requirements are outlined in Table 6.
	(g) a method for providing the groundwater monitoring data to The Water Group every three (3) months during construction, and	Table 9 of the GWMP	Outlines reporting requirements.
	(h) the installation of a minimum of two (2) groundwater open hole monitoring wells in the north Rozelle/ Lilyfield area to the west of the ventilation tunnel at Iron Cove to monitor groundwater quality and groundwater levels, in consultation with DPI Water.	Section 3.2.2 and Section 3.2.3 of GWMP	Details monitoring wells and locations.

### 3.3. Revised Environmental Management Measures

Refer to Table 8 in Annexure A for all REMMs relevant to the development of this plan.

### 3.4. Consultation

This plan and the GWMP were provided to The Water Group (formerly DPIE Water) in accordance with CoA C4(f) and Sydney Water, Inner West Council and City of Sydney Council in accordance with CoA C9(a). Further to this, the GWMP was provided to DPI Fisheries and EPA in accordance with REMM OGW9. Refer to Section 2 of the CEMP for consultation requirements relating to CEMP and all sub-plans.

Table 3 provides a summary of the consultation undertaken for this GMP and GWMP and the key issues identified by the relevant stakeholders.

Consultation with relevant councils and stakeholders, including any unique local receivers, may be undertaken for issues pertaining to the Project's impact on groundwater. Community feedback and complaints relating to groundwater will be dealt with in accordance with the Communication Strategy and Complaints Management System.

*Table 3: Summary of consultation for development of the Groundwater Management Plan and Groundwater Monitoring Program*

Agency	Contact with agency	Response received	Key issues	Where addressed
Sydney Water	Via email from the Project: <ul style="list-style-type: none"> <li>27/03/19</li> <li>02/04/19</li> <li>17/04/19</li> <li>23/04/19</li> <li>06/05/19</li> </ul>	Meeting on 4/4/19.  Via email to the Project: <ul style="list-style-type: none"> <li>11/04/19</li> <li>17/04/19 Sydney Water provided a single comment.</li> <li>06/05/19 Sydney Water confirmed they had no further comments on the management documents provided to Sydney Water.</li> </ul>	No groundwater discharges would be accepted to a Sydney Water stormwater drain without accompaniment with a licence to pollute issued by the EPA and approval by Sydney Water to do so.	Section 8.3 of the GMP notes that JHCPB will obtain an EPL for licenced discharges. JHCPB will obtain all other required licences and approvals.
The Water Group (formerly DPIE Water)	Via email from the Project: <ul style="list-style-type: none"> <li>27/03/19</li> <li>02/04/19</li> <li>10/04/19</li> <li>17/04/19</li> <li>06/05/19</li> </ul> Via phone from the Project: <ul style="list-style-type: none"> <li>20/06/19</li> </ul> Meeting on 10/7 with JHCPB, RMS and DPIE Water.  Meeting on 10/7 with JHCPB and DPIE Water	Via email to the Project: <ul style="list-style-type: none"> <li>15/04/19 – requesting extension of time.</li> <li>05/07/19 – DPIE Water provided comments on the GMP/GWMP.</li> </ul> Meeting on 10/07/19 with JHCPB, RMS and DPIE Water.  JHCPB facilitated inspection of Sydney Metro Tunnels Martin Place for DPIE Water to view methods and mitigation measures, similar to those planned for this Project.  Meeting on 10/7 with JHCPB and DPIE Water to discuss how DPIE Water comments have been addressed.	<ul style="list-style-type: none"> <li>Additional groundwater monitoring wells</li> <li>Performance criteria for groundwater quality in bores and discharge from the excavation.</li> <li>Figure showing tunnel design and construction monitoring bores.</li> <li>Cross-section drawings showing monitoring bores, tunnels and geology.</li> <li>Additional monitoring reporting requirements.</li> </ul>	<ul style="list-style-type: none"> <li>Additional monitoring wells provided in Section 3.2.1 of the GWMP.</li> <li>Section 3.2.3.1, Section 3.3.2.3 of the GWMP.</li> <li>Revised Figures 1 and 2 provided in the GWMP.</li> <li>Cross-section drawings provided in Annexure C of the GWMP.</li> <li>Table 9 of the GWMP.</li> </ul>

Agency	Contact with agency	Response received	Key issues	Where addressed
Port Authority of New South Wales	Via email from the Project: <ul style="list-style-type: none"> <li>▪ 02/04/19</li> <li>▪ 04/04/19</li> <li>▪ 10/04/19</li> </ul>	Via email to the Project: <ul style="list-style-type: none"> <li>▪ 16/04/19 Port Authority provided comments on the GMP</li> </ul>	Justification to the groundwater monitoring program extent, and why bores currently located within the Port Facility are not included in the monitoring program  Request to be included in the distribution list of groundwater monitoring reports	The three bores shown within the Port Facility were erroneously included in Figure 1 of the GWMP. These bores are not part of the Project's EIS and were not therefore included in the baseline monitoring in the GWMP (see Section 3.1 in the GWMP). These bores have been removed from Figure 1 of the GWMP.  Section 5.1.4 of the GWMP outlines reporting requirements.
Inner West Council (IWC)	Via email from the Project: <ul style="list-style-type: none"> <li>▪ 27/03/19</li> <li>▪ 02/04/19</li> <li>▪ 10/04/19</li> <li>▪ 17/04/19</li> </ul>	Attendance at the Rozelle Interchange Regulator Briefing Session: <ul style="list-style-type: none"> <li>▪ 06/03/2019</li> </ul> Via email to the Project: <ul style="list-style-type: none"> <li>▪ 02/04/19 – IWC confirmed receipt of GWMP</li> <li>▪ 18/04/19 – IWC provided comments on the GWMP.</li> </ul>	A range of aspects that related to the EIS submission, and this Groundwater Management Plan. Key items included: <ul style="list-style-type: none"> <li>▪ Contaminants polluting groundwater</li> <li>▪ Ground movement / Settlement</li> <li>▪ The water objectives and guidelines used</li> <li>▪ Groundwater drawdown</li> <li>▪ Saline water intrusion</li> </ul>	Contamination related to groundwater is addressed within Section 6.2.4.2 of this GMP  Settlement is addressed within Section 6.2.3.4 of this GMP  The main guidelines, specifications and policy documents relevant to this Plan are outlined in Section 3.1.2  Groundwater drawdown is outlined in Section 6.2.3.1.  Saltwater intrusion is outlined in Section 6.2.4.6.
City of Sydney	Via email from the Project: <ul style="list-style-type: none"> <li>▪ 27/03/19</li> <li>▪ 02/04/19</li> <li>▪ 10/04/19</li> <li>▪ 17/04/19</li> </ul> Via phone from the Project: <ul style="list-style-type: none"> <li>▪ 12/06/19</li> </ul>	Via email to the Project: <ul style="list-style-type: none"> <li>▪ 12/06/19 – City of Sydney confirmed they had no comments on the GWMP.</li> </ul>	City of Sydney confirmed they had no comments on this document.	N/A

Agency	Contact with agency	Response received	Key issues	Where addressed
DPI Fisheries	Via email from the Project: ▪ 11/04/19	Via email to the Project: ▪ 12/06/19 – DPI Fisheries confirmed they had reviewed the document and had no comments or objections to the GWMP.	No comments or objections to this document.	N/A
Environment Protection Authority (EPA)	Via email from the Project: ▪ 11/04/19	Via email to the Project: ▪ 15/04/19 – EPA advised they would not review the GWMP.	It is not EPA policy to review management plans.	N/A

## 4. Existing Environment

### 4.1. Overview

The following sections summarise the factors influencing groundwater within the Project area. 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 developments consist of established industrial, commercial, recreational, and residential areas. Groundwater recharge within the GMP primarily occurs in parks, gardens, bushland, and creeks, where it is ultimately discharged to Sydney Harbour. The Project alignment, which this GMP addresses, encompasses the Rozelle interchange network that is situated within Rozelle and Easton Park and extends from the proposed Iron Cove Link joining Victoria Road at Parramatta River to the north, the intersection of Victoria Road and The Crescent at Rozelle Bay to the east, and through to Lilyfield in the south, before linking with the Mainline Tunnel at Annandale and Leichardt.

The following chapter has been summarised to pertinent detail relating to the Project from Chapter 19, Groundwater of the EIS (AECOM 2017).

### 4.2. Topography and drainage

The topography of the Project area is relatively flat and low lying, ranging from sea level (adjacent to Sydney Harbour at Iron Cove and Rozelle Bay) up to approximately 30 m Australian Height Datum (AHD) around Rozelle and Lilyfield.

Most of the Project alignment is located in a heavily urbanised area and is drained by the stormwater network. The primary surface water features in the area are creeks, infilled creeks, and concrete lined canals that discharge into Sydney Harbour via Rozelle Bay and Iron Cove.

The following primary watercourses within the GMP boundary are summarised below:

- Whites Creek: A brick and concrete-lined channel that flows through the suburbs of Leichardt and Marrickville, discharging to Rozelle Bay,
- Johnston's Creek: A lined channel that drains Annandale and Glebe, discharging into Rozelle Bay,
- Dobroyd Canal (Iron Cove Creek): Dobroyd Canal is the lower tidal section of Iron Cove Creek, a concrete lined channel that drains Haberfield, discharging into Iron Cove on the Parramatta River, and
- Easton Park Drain: Water within Easton Park is drained through a conduit located south of Easton Park. The Easton Park drain drains through Rozelle Rail Yards, discharging into Rozelle Bay.

Most the creeks and canals in the Project area are concrete lined, thereby have limited hydraulic connection with the local groundwater resource. However, Sydney Water has proposed to

undertake naturalisation (i.e. removal of the concrete lining) of sections of Dobroyd Canal and Whites Creek (Sydney Water 2017). The naturalisation of creeks will allow for hydraulic connection to the underlying alluvium, particularly during high flows.

### 4.3. Geological setting

The Project area is located within the Permo-Triassic Sydney Basin, which is characterised by sub-horizontal sedimentary sequences, mainly sandstone and shale. The footprint of the Project is primarily underlain by Hawkesbury Sandstone and Quaternary alluvium. Ashfield Shale does not occur within the geological setting of construction works.

The main stratigraphic units encountered within the Project area of this GMP, from youngest to oldest, are:

- Anthropogenic fill,
- Quaternary alluvium (recent beneath creeks, palaeochannels) (minor occurrence), and
- Triassic Hawkesbury Sandstone.

The stratigraphy in the Project area has been intersected by multiple geological structural features including dykes and faults that may impact groundwater flow. Identified features include:

- Dykes identified within the sandstone cutting north of the Rozelle Rail Yards and 150 m east of the Rozelle Rail Yards, and
- Geological faults (a fracture or resulting joints within a rock where displacement may have occurred), which are typically found within the Hawkesbury Sandstone. The presence of faults can be associated with increased groundwater inflows.

Further detail on the stratigraphic units, including weathering profiles and implications for hydraulic conductivity is provided in Appendix T of the EIS (Technical working paper: Groundwater, AECOM 2017).

## 5. Hydrogeological setting

### 5.1. Regional groundwater flow, recharge and discharge

The Sydney Basin comprises sub-horizontal layered clastic sedimentary successions with localised igneous volcanic rocks and dykes, and geological faults. Dykes such as those identified beneath the Hawthorne Canal palaeochannel typically impede groundwater flows. Geological faults, typically found within the Hawkesbury Sandstone, are typically associated with increased groundwater flow.

Groundwater resources are recharged via direct rainfall and the infiltration of surface runoff derived from rainfall. Due to the level of urbanisation within the Project area, this will primarily occur where formations outcrop. Regional groundwater systems discharge via leakage, throughflow, and to local springs, watercourses, and the ocean. The regional groundwater table typically reflects a subdued version of topography.

Groundwater in the Sydney Basin is described at a regional scale in the Water Sharing Plan for the Greater Metropolitan Region (NoW 2011). Within the porous rock aquifer the level of connection between groundwater and surface water is stated as low to moderate. The travel time between shallow groundwater and unregulated rivers is estimated to be years to decades.

### 5.2. Hydrogeological units

Groundwater is present within the following hydrogeological units within the GMP area, described below:

- Quaternary alluvium, and
- Hawkesbury Sandstone.

### 5.2.1. Alluvium

Quaternary alluvium outcrops proximal to the harbour at Rozelle Bay and is present beneath fill, together with slightly older alluvium infilling palaeochannels. These older palaeochannels are ancient river systems that have eroded into the underlying bedrock creating a deeper sequence of variably permeable and saturated sediments that form part of the unconfined aquifer of the Project. The alluvium surrounding creeks is generally of high permeability and the groundwater within the alluvium can be a source of either recharge or discharge, depending on whether an upward or downward hydraulic gradient is present.

The palaeochannels that occur beneath some of the major watercourses or valleys within the Project alignment are saturated, highly transmissive, and extend to depths of up to 25 m.

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

Typically, the creeks along the Project alignment are concrete lined, thereby limiting hydraulic connection with the local groundwater resource.

### 5.2.2. Hawkesbury Sandstone

The Hawkesbury Sandstone is a heterogeneous layered unit characterised as a dual porosity aquifer dominated by secondary fracture groundwater flow. Interbedded shale lenses can provide local or extensive confining layers, creating separate aquifers with different hydraulic properties. Generally, the bulk hydraulic conductivity of the Hawkesbury Sandstone is low, although high groundwater yields can be encountered when saturated fractures are intersected. Increased groundwater flow to tunnels is typically associated with the intersection of such major faults, joints or fractures.

Regionally, groundwater flow is eastward, discharging into Sydney Harbour. Recharge is via rainfall infiltration on fractured outcrops, and through the soil profile and alluvium. Discharge within the Project area is via creeks and evapotranspiration.

Groundwater quality within the Hawkesbury Sandstone is generally mildly acidic and of low salinity in the Project area. The salinity of the upper part of the aquifer, however, can be elevated due to saltwater ingress from Rozelle Bay and the alluvium palaeochannels. Elevated concentrations of dissolved iron and manganese naturally occur within the Hawkesbury Sandstone, which can cause staining when discharged and oxidised. In tunnels, groundwater ingress becomes oxidised, causing dissolved iron and manganese to precipitate and form sludge in drainage lines.

## 5.3. Groundwater levels and flow

### 5.3.1. Baseline monitoring

Baseline groundwater level and groundwater quality monitoring data has been collected from the Project's groundwater monitoring network since June 2016. This baseline dataset is augmented by baseline data and construction data collected since October 2015 for the adjacent M4 East and New M5 projects.

The Project baseline monitoring network was installed between May 2016 and May 2017 and consists of 34 monitoring bores, located within the Project area, intersecting groundwater within the alluvium and Hawkesbury Sandstone. Monitoring bores were designed and constructed to target the expected tunnel zone and allow assessment of potential impacts to groundwater. At one location where alluvium was present, nested monitoring bores were constructed.

Monitoring bores have been designed to target the following hydrogeological formations:

- Alluvium:
  - Five at The Crescent,
  - Four at Rozelle,

- Hawkesbury Sandstone:
  - › 18 at Rozelle,
  - › Three at The Crescent,
  - › Two at Iron Cove, and
  - › Two at Easton Park.

### 5.3.2. Alluvium

At Rozelle, groundwater level fluctuations are generally between 1.0 mAHD to 2.2 mAHD and respond directly to significant rainfall events.

At The Crescent the groundwater table is shallow (0.2 mAHD to 1.7 mAHD) and groundwater levels also respond directly to significant rainfall events. Tidal influences superimpose the general groundwater trend caused by rainfall recharge and are typically between 1 to 6 m.

### 5.3.3. Hawkesbury Sandstone

Baseline groundwater levels within the Hawkesbury Sandstone are currently monitored at 25 monitoring bores within the Project area and varies based on geological setting.

At Rozelle Rail Yards, measured groundwater levels range between 0.8 and 12 mAHD, with the majority being shallow and less than 1.8 mAHD. Groundwater level fluctuations ranged from approximately 0.5 m to 0.8 m and responded closely to rainfall recharge.

At The Crescent, measured groundwater levels within the Hawkesbury Sandstone ranged between 1.4 and 1.6 mAHD. Groundwater levels showed a response to significant rainfall events of more than 30 mm. Superimposed over the fluctuations were daily oscillations with an amplitude between 0.1 m and 0.25 m which correspond to tidal fluctuations from Rozelle Bay.

Groundwater levels measured in nested monitoring wells demonstrated that groundwater is likely discharging from the Hawkesbury Sandstone into the overlying alluvium (except at RZ\_BH01, where the trend is reversed).

## 5.4. Hydraulic properties

Hydraulic conductivity testing (packer tests and laboratory core testing) was conducted during the field investigation program to inform the EIS (AECOM 2017) and to provide hydraulic parameters to support the groundwater modelling. Packer test results are summarised in Table 4. The majority (86%) of packer tests were conducted within the Hawkesbury Sandstone, where most the tunnels are located. Most estimated hydraulic conductivity values are low, suggesting that inflows into the tunnels will be low. No site-specific data was collected during the groundwater investigations (AECOM 2017) for the hydraulic conductivity of the alluvium. Typical hydraulic conductivity values for similar lithology across the Sydney Basin would be expected to range from 0.001 metres per day (m/day) for clayey alluvium up to 1 m/day for sandy alluvium (AECOM 2017).

Table 4: Estimated hydraulic conductivity values from packer testing for the Hawkesbury Sandstone

Hydraulic conductivity (m/day)	
Mean	0.10
Minimum	0.01
Maximum	1.17
Number of tests	181

## 5.5. Groundwater quality

The baseline water quality data is discussed in Section 5.5 of Annexure B and summarised in Table 5. Interpretation of baseline groundwater monitoring data is also included in the EIS (AECOM 2017) and the final baseline interpretive report (AECOM 2018).

Table 5: Summary of baseline groundwater quality within the Project area

Parameter	Alluvium	Hawkesbury Sandstone
EC	Variable: marginal to slightly saline Range: 1,561 to 9,068 $\mu\text{S}/\text{cm}$	Fresh to moderately saline Range: 558 to 16,300 $\mu\text{S}/\text{cm}$
pH	Weakly acidic to weakly basic Range: 5.96 to 8.06	Slightly acidic to strongly basic Range: 5.77 to 12.69
Major ions	Dominated by sodium, magnesium, chloride and bicarbonate. The dominance of sodium and chloride is attributed to tidal influences.	Dominated by sodium and chloride, which may be in part due to the influence of saline water intrusion.
Metals	Maximum levels exceeded guideline <sup>1</sup> concentration values for all but cadmium and nickel. In most cases the exceedance is marginal, indicating that background levels are already elevated.	Maximum levels exceeded guideline <sup>1</sup> concentration values for chromium, copper, iron, lead, manganese, nickel, and zinc. Consistently elevated iron and manganese, which is typical for Hawkesbury Sandstone (McKibbon and Smith 2000).
Nutrients	Nitrite and nitrate concentrations indicate that background nutrient levels are low. Reactive phosphorous levels are also low. Ammonia values exceeded guideline <sup>1</sup> concentration values.	Nitrite and nitrate concentrations indicate that background nutrient levels are low. Reactive phosphorous levels are very low. Ammonia values marginally exceeded guideline <sup>1</sup> concentration value.
Sulfate reducing bacteria <sup>2</sup>	Not assessed	No pattern was assessed for sulfate reducing bacteria because many samples were above the measurement limit (500,000 CFU/mL). Groundwater from the Hawkesbury Sandstone has high sulfate concentrations. When reducing conditions are present, SRB flourish in the absence of oxygen.
Groundwater aggressivity	Not assessed	Mildly aggressive towards concrete piles for average concentrations of chloride, pH, and sulfate. Mildly aggressive towards steel piles for average concentrations of chloride and pH. Severely aggressive towards steel piles for groundwater with low conductivity.

EC = electrical conductivity;  $\mu\text{S}/\text{cm}$  = micro-Siemens per centimetre

<sup>1</sup> Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000)

<sup>2</sup> measured as a colony forming unit (CFU) per 100 mL

## 5.6. Sensitivity receptors

### 5.6.1. Priority groundwater dependent ecosystems

There are no priority Groundwater Dependent Ecosystems (GDEs) identified in the Water Sharing Plan (NoW 2011) within 5 km of the Project alignment.

### 5.6.2. Non-priority groundwater dependent ecosystems

A manmade wetland has been constructed at Whites Creek Valley Park at Annandale, immediately west of Whites Creek. This wetland is unlikely to have any groundwater dependence as it continually receives low flows from Whites Creek.

Vegetation within low lying areas (typically containing alluvium soils) may utilise some portion of shallow groundwater for support. These areas are subject to periodic flooding, which recharges the groundwater in the underlying alluvium.

The above assessments will be confirmed in the Groundwater Modelling Report (GMR), developed in accordance with condition of approval E193, which will assess the impacts of groundwater

drawdown on groundwater dependant ecosystems. The GMR will be developed in consultation with DPIE Water and provided to The Secretary prior to the finalisation of the tunnel design. The GMR will identify if additional mitigations measures are required to prevent adverse impacts on groundwater dependant ecosystems.

### **5.6.3. Registered groundwater bores**

A review of bores registered with DPIE Water (AECOM 2017) indicates that of the registered bores within 2 km of the Project alignment (153 bores), the majority are registered as monitoring bores. Within the Rozelle Interchange, limited registered bores, including monitoring wells, exist at the Rozelle Rail Yards.

Only one of the identified bores is registered for domestic use, a 210 m deep bore (GW110247) at the University of Sydney at Camperdown extracts groundwater from the Hawkesbury Sandstone. The M4-M5 Link Mainline Tunnels Groundwater Management Sub-plan states that owner of GW110247 will be contacted to facilitate ongoing monitoring and to assess drawdown during the construction phase. (LSBJV 2018).

### **5.6.4. Potential groundwater contamination**

An assessment of contaminated land risk is provided in the EIS, Appendix R (Technical working paper: Contamination) (AECOM 2017). Areas within the overarching Project footprint that may contain contaminated soil and/or groundwater due to past or present land use practices have been investigated. During routine monthly baseline groundwater monitoring to inform the EIS, a suite of contaminants was assessed for laboratory analyses including cations and anions, heavy metals, and nutrients.

Site management works for contamination within the Rozelle Rail Yard, located north and northwest of Rozelle Bay, were undertaken in 2017 (AECOM 2018) and were subject to a separate environmental assessment. The review of environmental factors (REF) was approved by Roads and Maritime in April 2017. Contamination investigations undertaken as part of the REF and for the M4-M5 WestConnex Link project confirmed contamination within the Rozelle Rail Yard is likely from historic land use and importation of fill materials of unknown origin. This has resulted in the presence of variable concentrations of heavy metals, PAHs, TRHs, and bonded and friable asbestos in the soils, fill, ballast and existing stockpiles. In addition, contamination of groundwater was also identified with limited exceedances of zinc and copper (one location), zinc (one location) and TRHs, naphthalene and Bis(2-ethylhexyl) phthalate (one location).

The primary risk to groundwater at the Rozelle Rail Yards is the migration of contaminated groundwater due to altered groundwater flow paths from tunnel construction. The remediation of the soils within the Rozelle Rail Yards was completed in 2018 (AECOM 2018b) and therefore has reduced the potential for leachate to contaminate the groundwater.

## 6. Environmental aspects and impacts

### 6.1. Construction activities

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

- Tunnelling and cut and cover construction
- Dewatering of groundwater inflows into tunnels, and
- Operation of Water Treatment Plants (WTP).

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

### 6.2. Impacts

#### 6.2.1. Overview

The potential for impacts on groundwater will be dependent on the nature, extent, and magnitude of construction activities and their interaction with the natural environment. Potential impacts to groundwater attributable to construction, discussed in detail below, include:

- Reduced groundwater recharge,
- Groundwater level decrease (drawdown due to tunnel inflows) including potential impacts on:
  - › GDEs,
  - › Surface water baseflow,
  - › Ground movement (settlement),
- Changes in groundwater quality, as a result of:
  - › Spills and incidents,
  - › Intercepting contaminated groundwater,
  - › Groundwater treatment - Surface water impacts as a result of discharges the groundwater collection & discharge system,
  - › Saline intrusion.
- Impacts to utilities, and
- Cumulative impacts.

Some impacts on groundwater attributable to the Project are anticipated and predicted in the groundwater model (AECOM 2017). Relevant aspects and the potential for related impacts have been considered in a risk assessment in Annexure B of the CEMP. Section 7 of this GMP provides a suite of mitigation measures that will be implemented to avoid or minimise those impacts.

#### 6.2.2. Reduced groundwater recharge

The majority of the Project is below ground and will not directly impact groundwater recharge from rainfall.

The majority of the above ground footprint at Rozelle Rail Yards will be turned over as open space. The above ground built infrastructure footprint represents a small increase including the motorway operations complexes, ventilation infrastructure, substations, and WTP. Given the scale of the above ground footprint a reduction in rainfall recharge is considered negligible (AECOM 2017).

#### 6.2.3. Groundwater level decrease

##### 6.2.3.1. Groundwater drawdown

Construction of drained tunnels beneath the water table is expected to cause ongoing groundwater inflow to the tunnels, inducing groundwater drawdown along the tunnel alignment. Actual groundwater level drawdown would be dependent on a number of factors, including proximity to the tunnel alignment and the specific geological conditions present (AECOM 2017).

In accordance with REMM GW9 investigations (e.g. groundwater monitoring, pump tests, advanced probing) will occur to identify areas where groundwater inflows to the tunnels are likely to be elevated, to guide the development of the detailed design and construction methodology. Groundwater monitoring (i.e. standpipes, piezometers) is currently being undertaken in accordance with the GWMP. The need for additional investigations (e.g. advanced probing, pump tests), including the frequency and location of those investigations, will be identified in the detailed design, and the results will inform construction methodology.

High groundwater inflow during excavation is possible in faulted or fractured zones such as beneath the Rozelle Rail Yard (Whites Creek paleochannel) and in the alluvium (AECOM 2017). Targeted grouting will be undertaken as required through the construction program reducing tunnel inflow.

Potential groundwater drawdown due to the Project construction (to proposed opening in 2023) has been predicted in the groundwater model (see Section 9.2) and the regional extent of the drawdown impacts due to tunnel construction would be minimal considering the generally low hydraulic conductivity of the Hawkesbury Sandstone restricting the extent of drawdown during the relatively short construction time frame (AECOM 2017). Groundwater inflows at the Rozelle interchange are expected to be further restricted, due to the proximity and number of tunnels, ultimately distributing available groundwater across multiple drained systems. Expected total groundwater drawdown is summarised below:

- At the end of construction, the maximum drawdown is predicted to be 42 metres centred on the Rozelle interchange,
- Predicted drawdown centres are discontinuous along the alignment and are a reflection of tunnel depth and timing of excavation, as well as geological boundaries,
- Drawdown is predicted to be up to 10 m within the alluvium. Tunnels have been designed along relevant sections of the Project alignment to ensure that there will be minimal inflow from the alluvium into the tunnels. This would be achieved by providing potential additional measures, such as targeted grouting as required where the portals and cut-and-cover sections intersect alluvium, such as at Rozelle Rail Yards, and
- While the impacts are localised, with two metres or more drawdown extending no further than around 600 metres from the tunnels, the groundwater sink predicted to develop would create a hydraulic barrier along the length of the tunnel alignment, reversing groundwater gradients

### 6.2.3.2. Potential impacts to Groundwater Dependent Ecosystems

#### 6.2.3.2.1. Priority Groundwater Dependent Ecosystems

No priority GDEs are likely to be impacted by groundwater level decrease associated with either the construction or the long-term operation of the Project.

#### 6.2.3.2.2. Non-priority Groundwater Dependent Ecosystems

The manmade wetland constructed at Whites Creek Valley Park at Annandale, immediately west of Whites Creek is unlikely to be impacted during construction because the tunnels are below the alluvium unit.

Areas where the water table is shallow, such as at the Rozelle Rail Yards, are typically subjected to periodic flood inundation, which would provide water for shallow rooted plants that may have some groundwater dependence. Continued flood inundation would recharge to the alluvium, although flows would be reduced due to the installation of flood mitigation measures as part of the project.

In low-lying areas, such as the Rozelle Rail Yards or close to Rozelle Bay the availability of water for plants is not expected to change, given the high permeability of the sandy soils in combination with frequent rainfall events and higher recharge than elevated sites. The above assessments will be confirmed in the GMR, developed in accordance with condition of approval E193, which will assess the impacts of groundwater drawdown on groundwater dependant ecosystems. The GMR

will be developed in consultation with DPIE Water and provided to The Secretary prior to the finalisation of the tunnel design. The GMR will identify if additional mitigations measures are required to prevent adverse impacts on groundwater dependant ecosystems.

### 6.2.3.3. Potential impacts on surface water baseflow

Groundwater modelling (AECOM 2017) indicated that the overall contribution to flow to surface watercourses from groundwater is relatively small, since the watercourses are mostly concrete lined channels. It is expected that the majority of stream flow would be derived from rainfall runoff and tidal inflow. Groundwater inflows to the tunnels that would have the potential to impact surface water levels are unlikely for the section of the tunnels that would be constructed through the Whites Creek alluvium beneath the Rozelle Rail Yards. Permanent works tunnels excavated through the alluvium in the Rozelle Railyards will have engineering measures such as i targeted grouting of the alluvium to mitigate groundwater inflow where required. Interaction between the tunnel and surface water baseflow is also minimised as Whites Creek and Eastern Channel (the principal surface water creeks near proposed tunnel in alluvium) are concrete lined culverts / stormwater pipes and have negligible interaction with groundwater.

Sydney Water is proposing in the future to naturalise parts of Whites Creek. The Project will naturalise the short section between The Crescent and Rozelle Bay. Removal of sections of the concrete-lined base would allow more groundwater and surface water interaction, leading to a higher contribution of baseflow to surface water flow in the creeks, and additional surface water recharge via bed leakage when the water table is below the creek bed (AECOM 2017).

### 6.2.3.4. Ground movement (settlement)

Ground movement (settlement) or subsidence can be caused by the compression of the soil structure due to groundwater drawdown. Within the footprint of the Rozelle Interchange, natural soils are classified as part of the GyMEA residual soil profiles that developed on the weathered Hawkesbury Sandstone bedrock. These soils are typically thin, stiff or medium dense to dense, and of limited compressibility, and as such would be less susceptible to ground settlement. Settlement within the alluvium would be dependent on the amount of groundwater drawdown and is expected to be negligible due to design measures for the shafts, including constructing tanked shafts through the alluvium to minimise groundwater ingress if required. Cut and cover structures through Rozelle Rail Yards are designed to include a lining between the road and soil which mitigates groundwater ingress, which would reduce potential settlement.

During tunnel construction, the bulk hydraulic conductivity of the Hawkesbury Sandstone would decrease due to local and in places global ground support of the tunnel crown and shoulders, decreasing groundwater inflow and thereby reducing potential settlement.

Small scale dewatering of the alluvium and Hawkesbury Sandstone may be required during construction. This could result in an increase in effective stress, leading to ground settlement. Movement in clay soils between hydrogeological units would cause both consolidation settlement and creep settlement, which may result in settlement continuing over an extended period.

## 6.2.4. Groundwater quality

### 6.2.4.1. Spills and incidents

There is potential to contaminate groundwater through incidents associated with the storage of hazardous materials or refuelling operations at the surface, particularly if a leak or incident occurs over the alluvium, a palaeochannel, or fractured sandstone. Stockpiling of construction materials may also introduce contaminants that could potentially leach into and contaminate local groundwater (AECOM 2017).

The risks to groundwater as a result of such incidents would be managed through construction management procedures in accordance with the CEMP. Runoff from high rainfall events during

construction would be managed in accordance with the measures outlined in the Soil and Surface Water Management Sub-plan (SSWMP). Following high rainfall events, groundwater quality impacts would be minor, as the majority of runoff would discharge to receiving waters. Environmental control measures are listed in Section 7.2 and management and mitigation measures in Table 8.

#### **6.2.4.2. Intercepting contaminated groundwater**

There are pockets of soil contamination present across the Project, including within the Rozelle Rail Yards that could contaminate groundwater through the migration of contaminated groundwater plumes towards the tunnels. In general, the risk of intersecting contaminated groundwater decreases with tunnel design depth.

Historic information and limited site investigations indicate the presence of light non-aqueous phase liquid within a relatively small area in the centre of the Rozelle civil and tunnel compound. Tunnelling and portal structures are not expected to intersect this area. A Phase 2 Environmental Site Assessment, in accordance with the Soil and Surface Water Sub Plan, will identify the need for controls or remediation.

In areas where tunnels are to be constructed within the alluvium and palaeochannels, including at the Rozelle Rail Yards, additional mitigation measures including targeted grouting to limit permeability in hydraulic conductive ground and engineered structures such as soldier pile walls and diaphragm walls will be implemented to restrict groundwater ingress from the alluvium entering the tunnels where required.

Where groundwater does enter the tunnels, it is to be pumped and treated at designated water treatment plants before discharge back into the receiving environment. Discharge criteria are outlined in Chapter 17 (AECOM 2017) and Section 3.3 of the GWMP (Annexure B).

Shallow groundwater is likely to be encountered during ground excavation works for the tunnels at the Rozelle Rail Yards. Shallow groundwater requiring treatment will be minimised as excavations will be designed with engineering controls such as shotcrete supplemented concrete soldier pile walls at the edge of excavation mitigating inflow. Shallow groundwater requiring off-site disposal will be treated and tested to ensure compliance with either; a Sydney Water Trade Waste Agreement if in place, or if discharged to the environment in accordance with CoA E186 which requires water discharged from the construction water treatment plant must comply with the ANZECC (2000) 90 per cent species protection level unless the EPL is in force.

#### **6.2.4.3. Groundwater treatment and surface water impacts**

The existing groundwater quality within the Project area is described in Section 5.5. In order to prevent adverse impacts on downstream surface water quality, WTPs will be installed at three locations at Rozelle civil and tunnel site. WTPs will be designed so that the quality of the discharge will be in compliance with the ANZECC derived discharge criteria or the Project EPL. The GWMP provides further detail on the design and discharge criteria for the WTPs (refer Section 7.1 of this GMP and Section 3.3 in Annexure B).

#### **6.2.4.4. Groundwater associated with Potential Acid Sulfate Soils**

Potential acid sulfate soils (PASS) have been identified within natural alluvium sediments beneath the Rozelle Rail Yards. Construction activities in areas of identified PASS may cause the generation of acidic leachate, increasing the acidity of the local groundwater. Any excavation of PASS material would be managed under an Acid Sulfate Soils Management Plan (ASSMP) as discussed in Chapter 15 (AECOM 2017) and provided in SSWMP.

#### **6.2.4.5. Soil salinity impacting groundwater**

Salts are naturally present in soil and rock and can be mobilised in the subsurface by the movement of groundwater. Salt concentrations within the Hawkesbury Sandstone and alluvium are typically variable, with concentrations within the alluvium impacted by tidal influences (seawater).

During the construction of the Rozelle Interchange, there is potential for salts within the Whites Creek alluvium to be mobilised by local dewatering, particularly at the Rozelle Rail Yards and proximal to Whites Creek. Inflow mitigations installed by the Project may cause an impediment to groundwater flow, resulting in localised mounding of the groundwater, which may lead to the dissolution of soil salts. Saline groundwater resulting from the dissolution of soil salts within the Whites Creek alluvium is to be directed towards the modified drainage system. This will remove the mobilised salts from the system (AECOM 2017).

#### **6.2.4.6. Saltwater intrusion**

Over time, saline intrusion is predicted to result in saline water reaching the tunnels. The proportion of saline water flowing into the tunnels, however, would be low during the relatively short construction phase. In addition, the groundwater along the tidal fringe is naturally saline, and the additional slow increase in salinity is unlikely to impact the environment.

A capture zone analysis has been undertaken as part of the groundwater modelling (AECOM 2017) to investigate salt water intrusion within the tunnel catchment areas. From this analysis it was not possible to quantify volumes or concentrations of saline water entering the tunnels and therefore the following discussion is based on a qualitative analysis.

##### **6.2.4.6.1. Tidal zones**

The groundwater model (AECOM 2017) predicts that saline groundwater from the Parramatta River will enter the tunnels at the Rozelle Interchange. Groundwater levels are predicted to decrease below sea level therefore saline waters from tidal zones would flow towards the tunnels and would ultimately enter the tunnels via a hydraulic connection with the alluvium. Initially, the saline water would represent a small fraction of total groundwater entering the tunnels during construction that will continue to increase over time.

Average times for saline water to enter the tunnels are predicted to be more than 100 years with an upper limit expectancy in the order of thousands of years. As a result, groundwater in the tunnel catchment zones would gradually become saline over thousands of years. Since the operational lifetime for major infrastructure is in the order of 100 years, the slow salinity increase should have minimal impacts on the tunnels and infrastructure in the Project's operational lifetime, and negligible impacts during construction.

Groundwater quality (salinity as Electrical Conductivity (EC)) during construction will be routinely monitored at key locations between saline water bodies and the tunnel as identified by the Project groundwater model (AECOM 2017).

Details of the construction groundwater quality monitoring program are presented in the GWMP (refer Section 3 in Annexure B of this GMP).

#### **6.2.5. Utilities**

The Project would involve works that would include the protection of existing utilities, construction of new utilities, and relocation of existing utilities. The majority of the utility works for the Project are very shallow in existing roads and footpaths above the groundwater table. The impacts associated with the Project are likely to be negligible.

#### **6.2.6. Cumulative impacts**

A cumulative impact assessment was undertaken for the EIS (AECOM 2017). The assessment:

- Used the groundwater model to predict the cumulative impacts on groundwater due to the Project in combination with other WestConnex tunnel projects (M4 East and New M5)
- Qualitatively assessed the cumulative impacts of the Project, other WestConnex projects, and other proposed infrastructure projects (Sydney Metro City and Southwest).

### 6.2.6.1. WestConnex projects

During construction, cumulative impacts on groundwater would be greatest at either end of the Project alignment where the Project tunnels would overlap with the tunnels for the M4-M5 Link. Once all three of these WestConnex tunnel projects are operational, cumulative groundwater drawdown impacts due to the three tunnel projects are not predicted to be greater than in any one section of the overall Project footprint (AECOM 2017).

The tunnels and associated lining for each project would be designed and constructed to comply with the groundwater inflow criterion of one litre per second per kilometre for any kilometre length of tunnel. Consequently, the groundwater inflows along the tunnels would vary within a known range. A comprehensive GWMP would be required for each project to confirm that the actual inflows do not exceed the criterion and drawdown does not exceed predictions. The GWMP for the project is provided as Annexure B of this GMP.

Long-term cumulative groundwater tunnel inflows due to the WestConnex tunnel projects may cause groundwater salinity to increase due to surface water from tidal reaches being drawn into or towards the tunnels. Initially, as discussed in Section 6.2.4.6. the saline water would be a small fraction of total tunnel ingress, but this is expected to increase over time as water is drawn from further afield, although it is expected to always be a minor component of total inflow volume and negligible during construction.

### 6.2.6.2. Other relevant projects

The Sydney Metro tunnels are to be constructed as tanked tunnels resulting in negligible impacts on groundwater drawdown. The station boxes are to be constructed and operated as drained shafts and will extract groundwater over time. The closest drained structure is proposed at Rozelle which is close to the boundary of the Project, and it is considered unlikely to have significant cumulative impacts on groundwater drawdown in the Project area. There is potential for the concrete lined tunnels of the Sydney Metro project to create a partial hydraulic barrier to groundwater flow, however the risk is considered low since the tunnels are constructed below the water table.

The Western Harbour Tunnel is currently preparing an EIS for a new crossing of Sydney Harbour involving twin tolled motorway tunnels connecting WestConnex at Rozelle and the existing Warringah Freeway at North Sydney. Sydney Metro is investigating options for new intermediate stations at Camellia/Rydalmere, North Burwood/Five Dock/Kings Bay and Pyrmont, known as the Sydney Metro West Project.

This plan will be updated when more information of the Western Harbour Tunnel and the Sydney Metro West Project become readily available.

### 6.2.7. Construction monitoring

A GWMP has been developed to describe how JHCPB propose to monitor potential impacts to groundwater during construction of the Project (refer Section 3.2 of Annexure B).

## **7. Environmental control measures**

### **7.1. Water treatment**

Water treatment forms a key environmental control measure. Groundwater captured during construction of the Project will be treated at three WTPs at the Rozelle civil and tunnel site (C5). The WTPs will be of a modular design so that they can be modified if required to meet design requirements. WTPs will be designed so that the water will be of suitable quality for discharge to the receiving environment in compliance with the relevant discharge criteria. In accordance with CoA E186 water to be discharged from the water treatment plant must comply with the ANZECC (2000) 90 per cent species protection level unless the EPL is in force.

Refer to Section 3.3 of the GWMP for more details regarding monitoring of discharge volume and discharge water quality and relevant discharge criteria.

The WTPs will undergo commissioning and testing to determine the treatment efficacy of the WTP. During commissioning of each of the WTPs, a minimum of two rounds of commissioning sampling will be undertaken to confirm their efficacy. The WTPs will not be deemed commissioned until the two rounds of commissioning sampling demonstrate compliance with the criteria.

Monthly sampling will be undertaken to ensure that each of the WTPs continues to meet design specifications. The results will be reviewed by trained personnel to ensure that the discharged water meets discharge criteria. Where in-line sensors (typically pH and turbidity) or monitoring identify WTPs performance drift outside of the required criteria measures will be implemented to return the WTPs performance back into the required range. In these instances, water will be retreated to meet appropriate discharge criteria, discharged to trade waste (where permitted), re-used on site (e.g. dust suppression) or disposed offsite at an appropriate licenced liquid waste facility.

Water quality results and an overview of corrective actions will be reported in the six-monthly water monitoring report.

Procedures relating to the management of the WTPs will also be prepared and implemented in an Environmental Work Method Statement (EWMS).

## 7.2. Other environmental control measures

Specific measures and requirements to meet the objectives of this GMP (refer Section 2.2) and to address impacts on groundwater are outlined in Table 6. Based on the mitigation and management measures it is considered that potential groundwater impacts that may arise as a result of the construction of the Project can be effectively managed.

Table 6: Groundwater management and mitigation measures

ID	Measurement/ requirement	When to implement	Responsibility	Reference	Evidence
GWMM1	The tunnels will be designed so there will minimal groundwater inflow from the alluvium (and palaeochannels) into the tunnels.	Design Construction	Design Manager	EIS section 19.5 REMM GW1	Tunnel design
GWMM2	Further assessment of the risk posed by the presence of sulfate reducing bacteria and groundwater aggressivity will be undertaken prior to construction. A corrosion assessment will be undertaken to assess the impact on building materials that may be used in the tunnel infrastructure such as concrete, steel, aluminium, stainless steel, galvanised steel, and polyester resin anchors. The outcomes of the corrosion assessment will be considered when selecting building materials likely to encounter groundwater.	Pre-construction	Design Manager	EIS Section 19.5 REMM GW4	Corrosion assessment / durability report
GWMM3	Potential impacts associated with subsurface components of the Project intercepting and altering groundwater flows and levels will be considered during detailed design. Measures to reduce potential impacts will be identified and included in the detailed construction methodology and the detailed design as relevant.	Design	Design Manager	EIS Section 19.5 REMM GW6	Tunnel design
GWMM4	A detailed groundwater model will be developed by JHCPB. The model will be used to predict groundwater inflow rates and volumes within the tunnels and groundwater levels (including drawdown) in adjacent areas during construction and operation of the Project.	Pre-construction	Design Manager	CoA E192 REMM GW7	Groundwater modelling report
GWMM5	Groundwater inflow and groundwater levels in the vicinity of the tunnels will be monitored during construction and compared to model predictions and groundwater performance criteria applied to the Project.  The groundwater model will be updated based on the results of the monitoring as required and proposed management measures to minimise potential groundwater impacts adjusted accordingly to ensure that groundwater inflow performance criteria are met.	During construction	Environment & Sustainability Manager  Design Manager	REMM GW8	Groundwater model updates
GWMM6	Further investigations (e.g. groundwater monitoring, advance probing, pump tests) will be carried out to identify areas where groundwater inflows to the tunnels are likely to be higher, to guide the development of the detailed design and construction methodology. The investigations will be carried out prior to the commencement of excavations with the potential to result in groundwater inflow at each identified location.	Pre-construction Construction	Design Manager	REMM GW9	Tunnel design

ID	Measurement/ requirement	When to implement	Responsibility	Reference	Evidence
GWMM7	In order to prevent adverse impacts on downstream surface water quality, water treatment plants will be designed so that the effluent will be of suitable quality for discharge to the receiving environment in compliance with the discharge criteria (Section 3.3 of the Annexure B),, the Project EPL, and if applicable, JHCPB's trade waste licence.	Pre-construction and during construction	Construction Manager	CoA E186 REMM SW10	Water monitoring reports
GWMM8	<p>Site-specific trigger values (SSTV) for electrical conductivity (EC) have been developed for each water quality monitoring bore using the baseline data from the EIS (AECOM 2017). The SSTV's were derived by calculating the 80th percentile values of the baseline EC data (refer Section 4.2 of Annexure B). The SSTV's provide an easily identifiable indication of a change in salinity. A management response would be initiated if any of the following occurs:</p> <ul style="list-style-type: none"> <li>• The EC data continuously exceeds the SSTV over the period of three months and depicts a rising trend</li> <li>• The EC data exceeds the SSTV at any time by more than 100%</li> </ul> <p>In the event that one or both of the above EC trigger exceedances are recorded, a review will be initiated to determine the significance of the exceedance(s) and possible causes. The review will assess the historical and surrounding monitoring bore data, and modelling predictions.</p> <p>If the exceedance is determined to be attributable to Project works and outside of modelling predictions for saline intrusion, additional management measures (including review of the groundwater model) may be implemented in consultation with the relevant authorities.</p>	During construction	Environment & Sustainability Manager	CoA C5 CoA C10	Groundwater monitoring reports
GWMM9	<p>Groundwater level decreases outside of the seasonal fluctuation will be assessed and compared against predicted drawdown as simulated in the groundwater model (refer Section 4.2.2 of Annexure B). The assessment will determine whether the observed decrease is attributable to the Project and, if so, whether it aligns with approved predictions.</p> <p>If drawdown is identified outside of model predictions, management actions will be initiated including (but not limited to) a review of baseline groundwater level data in the relevant and surrounding monitoring bores as well as an assessment of groundwater inflow rates into the tunnel.</p>	During construction	Environment & Sustainability Manager Design Manager	CoA E192 REMM GW7 REMM GW8	Groundwater monitoring reports
GWMM10	<p>Identification of a groundwater decrease (beyond seasonal fluctuations in nearby monitoring bores) will be monitored to determine whether the decrease is attributable to dewatering from the Project. The assessment will include a review of groundwater levels in the surrounding monitoring bore network.</p> <p>Where an impact is confirmed, in accordance with the Aquifer Interference Policy (NoW 2012), measures will be taken to 'make good' the impact on an impacted water supply bore. The measures taken could include, for example,</p>	During construction	Environment & Sustainability Manager	CoA E192 REMM GW5	Groundwater monitoring reports

ID	Measurement/ requirement	When to implement	Responsibility	Reference	Evidence
	deepening the bore, providing a new bore or providing an alternative water supply. 'Make good' will only apply to registered bore users.				
GWMM11	In zones where the inflow rates are anticipated to exceed one litre per second per kilometre for any kilometre length of tunnel, detailed design and / or construction methodology techniques will be implemented to limit permeability as required to reduce ongoing groundwater inflow.	During construction	Construction Manager	CoA E190 REMM GW2	Construction reports
GWMM12	Groundwater quality (salinity as Electrical Conductivity (EC)) during construction will be routinely monitored at a minimum of two key locations in consultation with The Water Group between saline water bodies and the tunnel as identified by the groundwater model (AECOM 2017).	During construction	Environment & Sustainability Manager	CoA C12 (d)	Groundwater monitoring results
GWMM13	Groundwater intercepted during construction will be managed by either capturing the water that enters the tunnels, caverns and portals, or by other suitable measures.  All captured inflow will be treated prior to discharge (refer Section 7.1 and Section 3.3 in Annexure B).	During construction	Construction Manager	EIS Section 19.5	Site inspection report
GWMM14	The groundwater model will be used to predict influences on the Project as well as the cumulative impacts from the other WestConnex projects and local infrastructure projects.	Pre-construction and during construction	Design Manager	CoA C5(d)	Groundwater modelling report
GWMM15	A geotechnical model of representative geological and groundwater conditions will be prepared prior to excavation and tunnelling to identify geological structures and groundwater features to assess the cumulative predicted settlement, ground movement, stress redistribution and horizontal strain profiles caused by excavation and tunnelling, including groundwater drawdown and associated impacts, on adjacent surface and sub-surface structures.	Pre-construction and during construction	Design Manager	CoA E101	Geotechnical modelling report

## 8. Compliance management

### 8.1. Roles and responsibilities

The JHCPB Project Team's organisational structure and overall roles and responsibilities are outlined in Section 3.3 of the CEMP. Specific responsibilities for the implementation of environmental controls are detailed in Table 6 of this Plan.

### 8.2. Training

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

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

- Groundwater monitoring methodology and protocols (refer Section 5 of Annexure B), and
- Project obligations including requirements to assess and classify contamination on site.

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

### 8.3. Monitoring and inspection

Section 3 of the GWMP (Annexure B) provides detailed inspection criteria including:

- Groundwater monitoring locations,
- Parameters/analytes to be monitored,
- Type of monitoring,
- Frequency of monitoring, and
- Monitoring methodology.

Additional requirements and responsibilities in relation to inspections are documented in Section 3.3.1 of the CEMP.

### 8.4. Licenses and permits

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

Other relevant licences or permits will be obtained in the lead up to and during construction as required.

### 8.5. Auditing

Audits (both internal and external) will be undertaken to assess the effectiveness of environmental controls, compliance with this Plan, CoA and other relevant approvals, licenses, and guidelines.

Audit requirements are detailed in Section 3.9.3 of the CEMP.

### 8.6. Reporting

Reporting requirements relevant to this GMP are outlined in Table 7 as well as data provision requirements.

Additional reporting requirements for the Project are outlined in Section 3.9 of the CEMP.

Table 7: Reporting requirements

Schedule (during construction)	Requirements	Recipient (relevant authority)
<b>Reporting</b>		
Water monitoring reports (every six months)	<p>Data summary reports presenting tabulated groundwater monitoring data collected during the reporting period. Groundwater level hydrographs (including rainfall) and water quality (EC) results will be presented and SSTV exceedances will be highlighted. Metres of ground excavated and flow rates during construction will be presented.</p> <p>Applicable management responses will be documented. Compliance against discharge criteria will also be presented.</p> <p>Report will present validation of groundwater modelling and determine the need for any necessary adjustments to the GWMP (Annexure B).</p>	DPIE, DPIE Water, Sydney Water, Port Authority of NSW
EPL Monitoring Reports and Annual Returns	<p>EPL monitoring data reports will be prepared in accordance with the requirements of the EPL.</p> <p>An EPL Annual Return will be prepared in respect of each EPL reporting period (typically 12 months).</p>	EPA
<b>Data provision</b>		
Quarterly (every 3 months)	<p>WTP discharge water quality and flow data (raw data collated and tabulated in Excel)</p> <p>To demonstrate compliance with the CoA (C12(f)), project discharge criteria (defined in Section 7.1 this Plan and Section 3.3 of the GWMP), EPL, and if applicable JHCPB's trade waste licence.</p>	Sydney Water
Quarterly (every 3 months)	<p>Groundwater level and groundwater quality (EC) monitoring data (raw data collated and tabulated in Excel)</p> <p>To demonstrate compliance with the CoA (C12(g)).</p>	DPIE Water (formerly DoI Water)

## 9. Review and improvement

### 9.1. Continuous improvement

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

The continuous improvement process will be designed to:

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

### 9.2. Groundwater model update

The results of the groundwater modelling will be documented in a GMR. The GMR will be finalised in accordance with the Australian Groundwater Modelling Guidelines (National Water Commission, 2012) and prepared in consultation with DPIE Water.

The groundwater model will be updated once 24 months of construction groundwater monitoring data are available and the results of the updated modelling provided to the Secretary and DPIE Water in an updated GMR.

### 9.3. GWMP update and amendment

The processes described in Section 3.13 of the CEMP may result in the need to update or revise this Plan. The groundwater model update (Section 9.2) may result in the need to update or revise this Plan. Plan updates will occur on an as needed basis.

Only the Environment and Sustainability Manager, or delegate, has the authority to change any of the environmental management documentation. All amendments to environmental management documentation require endorsement from the Environmental Representative. Minor updates may be approved by the Environmental Representative.

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.

### 9.4. WTP performance

Performance criteria for water to be discharged from the WTP during the construction stage were developed in accordance with CoA E186. The discharge criteria for turbidity, and oil and grease reflect standard EPL requirements for discharges from sedimentation basins. The pH criteria are the default trigger values for chemical and physical stressors for estuaries in South east Australia (refer Table 3.3.2 of ANZECC 2000). Estuarine triggers values are used as the salinity in the receiving environment is typical of the salinity found in estuaries.

The performance criteria for monthly WTP discharge samples are the default trigger values for the protection of 90% of marine species (cadmium, chromium, copper, lead, mercury, nickel and zinc); and for the protection of recreational water quality (iron) as listed in Tables 3.4.1 and 5.2.3 of ANZECC 2000 respectively.

## 10. References

AECOM, 2017. M4-M5 Link: Groundwater Monitoring Interpretative Report, August 2017

AECOM, 2018. M4-M5 Link Rozelle Rail Yards - Tranche 5: Groundwater Contamination Sampling, April 2018

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.

Bureau of Meteorology (BoM) 2012. National Atlas of Groundwater Dependent Ecosystems

Department of Land and Water Conservation (DLWC), 2002. NSW Groundwater Dependent Ecosystems Policy.

DLWC, 1998. NSW Groundwater Policy Framework Document. DLWC, 1998. NSW Groundwater Quality Protection Policy.

DLWC, 1997. NSW Groundwater Quantity Management Policy.

Department of Planning, Industry and Environment (DPIE), 2012. Guideline for riparian corridors on waterfront land.

Department of Water and Energy (DWE), 2007. NSW Water Extraction Monitoring Policy.

Environment Protection Authority (EPA), 2004. Approved Methods for the Sampling and Analysis of Water Pollutants in NSW.

Lendlease, Samsung C&T and Bouygues Construction Australia Joint Venture (LSBJV), 2018. Appendix B6 Groundwater Management Sub-plan, M4-M5 Link Mainline Tunnels, November 2018.

McKibbin D & Smith PC 2000, 'Sandstone Hydrogeology of the Sydney Region', proceedings of the 15th Australian Geological Convention, Sandstone City – Sydney's Dimension Stone and other Sandstone Geomaterials, in EEHSG Geological Society of Australia. Monograph No. 5, GH McNally & BJ Franklin (eds).

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

NSW Roads and Maritime Services, 2017. M4-M5 Link Environmental Impact Statement, August 2017.

NoW, 2012. NSW Aquifer Interference Policy.

Roads and Maritime Services (Roads and Maritime), 2011. Road and Maritime Dewatering Guideline.

## Annexure A Conditions of Approval

Table 8: Other Conditions of Approval relevant to the development of this Sub-plan

CoA No.	Condition Requirements	Document Reference						
C4	The following CEMP Sub-plans must be prepared in consultation with the relevant authorities identified for each CEMP Sub-plan and be consistent with the CEMP referred to in the EIS.	This plan						
	<table border="1"> <thead> <tr> <th></th> <th>Required CEMP Sub-plan</th> <th>Relevant authority(s) and council(s) to be consulted for each CEMP Sub-plan</th> </tr> </thead> <tbody> <tr> <td>f)</td> <td>Groundwater</td> <td>DPI Water</td> </tr> </tbody> </table>			Required CEMP Sub-plan	Relevant authority(s) and council(s) to be consulted for each CEMP Sub-plan	f)	Groundwater	DPI Water
			Required CEMP Sub-plan	Relevant authority(s) and council(s) to be consulted for each CEMP Sub-plan				
f)	Groundwater	DPI Water						
*Port Authority of NSW to be consulted when considering impacts on port land.								
C9	The following Construction Monitoring Programs must be prepared in consultation with the relevant authorities identified for each Construction Monitoring Program to compare actual performance of construction of the CSSI against predicted performance.	Annexure B						
	<table border="1"> <thead> <tr> <th></th> <th>Required Construction Monitoring Programs</th> <th>Relevant authority(s) and council(s) to be consulted for each Construction Monitoring Program</th> </tr> </thead> <tbody> <tr> <td>b)</td> <td>Groundwater Monitoring Program</td> <td>DPI Water, Sydney Water and relevant council(s)</td> </tr> </tbody> </table>			Required Construction Monitoring Programs	Relevant authority(s) and council(s) to be consulted for each Construction Monitoring Program	b)	Groundwater Monitoring Program	DPI Water, Sydney Water and relevant council(s)
			Required Construction Monitoring Programs	Relevant authority(s) and council(s) to be consulted for each Construction Monitoring Program				
b)	Groundwater Monitoring Program	DPI Water, Sydney Water and relevant council(s)						
C10	<p>Each <b>Construction Monitoring Program</b> must provide:</p> <ul style="list-style-type: none"> <li>(a) details of baseline data available;</li> <li>(b) details of baseline data to be obtained and when;</li> <li>(c) details of all monitoring of the project to be undertaken;</li> <li>(d) the parameters of the project to be monitored;</li> <li>(e) the frequency of monitoring to be undertaken;</li> <li>(f) the location of monitoring;</li> <li>(g) the reporting of monitoring and analysis results against relevant criteria;</li> <li>(h) details of the methods that will be used to analyse the monitoring data;</li> <li>(i) procedures to identify and implement additional mitigation measures where results of monitoring are unsatisfactory; and</li> <li>(j) any consultation to be undertaken in relation to the monitoring programs.</li> </ul>	<ul style="list-style-type: none"> <li>a) Annexure B of the GWMP</li> <li>b) Section 3.1 of the GWMP</li> <li>c) Section 3.2 of the GWMP</li> <li>d) Section 3.3.1 of the GWMP</li> <li>e) Section 3.2 and Section 4 of the GWMP</li> <li>f) Section 3.2 of the GWMP</li> <li>g) Section 5.1.4 of the GWMP</li> <li>h) Section 5.1.2 of the GWMP</li> <li>i) Section 6 of the GWMP</li> <li>j) Section 2.3 of the GWMP</li> </ul>						
C12	<p>The <b>Groundwater Monitoring Program</b> must include:</p> <ul style="list-style-type: none"> <li>(a) daily measurement of the amount of water discharged from the water treatment plants;</li> <li>(b) water quality testing of the water discharged from the water treatment plants;</li> <li>(c) monitoring of groundwater pore pressures in the Hawkesbury Sandstone aquifers adjacent to the tunnel alignment, in consultation with DPI Water;</li> </ul>	<ul style="list-style-type: none"> <li>a) Section 4.4 and Section 3.3.2 of the GWMP</li> <li>b) Section 3.3.2 of the GWMP</li> <li>c) Section 3.2 of the GWMP</li> </ul>						

CoA No.	Condition Requirements	Document Reference
	<p>(d) monitoring of groundwater electrical conductivity in key locations between saline water bodies and the tunnel as identified by the project groundwater model including: (i) in the Haberfield / Lilyfield area to the south of Iron Cove,</p> <p>(ii) in the Rozelle area to the north of Rozelle Bay,</p> <p>(iii) in the Annandale area to the west of Rozelle Bay,</p> <p>(iv) in the Rozelle area to the south east of Iron Cove, and</p> <p>(v) in the St Peters area to the north west of Alexandra Canal,</p> <p>with a minimum of two (2) groundwater monitoring wells to be provided in each key location in consultation with DPI Water;</p> <p>(e) measures to record or otherwise estimate and report groundwater inflows into the tunnels during their construction;</p> <p>(f) a method for providing the data collected in (a) and (b) to Sydney Water every three (3) months to demonstrate the project's compliance with the discharge criteria and, if applicable, the Proponent's trade waste licence,</p> <p>(g) a method for providing the groundwater monitoring data to DPI Water every three (3) months during construction, and</p> <p>(h) the installation of a minimum of two (2) groundwater open hole monitoring wells in the north Rozelle / Lilyfield area to the west of the ventilation tunnel at Iron Cove to monitor groundwater quality and groundwater levels, in consultation with DPI Water.</p>	<p>d) Section 4.3 of the GWMP</p> <p>e) Section 3.2.4 and Section 3.3.1 of the GWMP</p> <p>f) Table 9 of the GWMP and Table 6 of this plan</p> <p>g) Table 9 of the GWMP</p> <p>h) Section 3.2.2 and Section 3.2.3 of the GWMP</p>
E101	A geotechnical model of representative geological and groundwater conditions must be prepared prior to excavation and tunnelling to identify geological structures and groundwater features. The model must include details of proposed excavations and tunnels, construction staging, and identify surface and sub-surface structures, including any specific attributes, which may be impacted by the CSSI. The Proponent must use this model to assess the cumulative predicted settlement, ground movement, stress redistribution and horizontal strain profiles caused by excavation and tunnelling, including groundwater drawdown and associated impacts, on adjacent surface and sub-surface structures.	Table 5 GWMM15
E186	The CSSI construction water treatment plant discharge criteria must comply with the ANZECC (2000) 90 per cent species protection level unless an EPL is in force in respect to the CSSI. Discharge criteria for iron during construction must comply with the ANZECC (2000) recreational water quality criteria.	Table 6 GWMM7 Section 9.4
E190	The Proponent must take all practicable 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 cannot be determined by averaging groundwater inflows across the length of the tunnel.	Table 6 GWMM11
E191	The Proponent must identify and commit to the implementation of 'make good' provisions for groundwater users in the event of a decline in water supply levels, quality and quantity from registered existing bores associated with groundwater changes from either construction and/or ongoing operational dewatering caused by the CSSI.	Table 6 GWMM10
E192	The Proponent must undertake further modelling of groundwater drawdown, tunnel inflows and saline water migration (using particle tracking) prior to finalising the design of the tunnels and undertaking any works that would impact on groundwater flows or levels. The modelling must be undertaken in consultation with DPI Water and include the results and hydrogeological analyses of at least 12 continuous months of current baseline groundwater monitoring data from bores identified in the EIS and SPIR. The modelling must also include data from any other existing monitoring bores identified in consultation with DPI Water, as required to supplement baseline data.	Table 6 GWMM4 Section 9.2

CoA No.	Condition Requirements	Document Reference
E193	<p>The results of the groundwater modelling must be documented in a Groundwater Modelling Report. The Groundwater Modelling Report must be finalised in accordance with the Australian Groundwater Modelling Guidelines (National Water Commission, 2012) and prepared in consultation with DPI Water. The Groundwater Modelling Report must include, but not be limited to:</p> <ul style="list-style-type: none"> <li>(a) justification for layer choice;</li> <li>(b) specification and justification of the grid based hydraulic conductivity and storage parameters (specific yield and specific storage) assigned to each layer and/or zone with reference to those values determined from data analyses and the literature;</li> <li>(c) an explanation of how groundwater flow was simulated within each model layer with reference to confined, unconfined or variably saturated flow solutions;</li> <li>(d) an explanation and justification of the drain-cell conductance term(s) applied to the tunnel boundaries to limit tunnel inflows;</li> <li>(e) an explanation and justification of the groundwater recharge values applied across the model domain, including around the modelled specific yield values and the water table fluctuations observed within the monitoring data in response to rainfall-fed groundwater recharge;</li> <li>(f) details (including figures) of the expected changes in groundwater flow directions in the vicinity of landfills, groundwater wells and surface water receptors;</li> <li>(g) cross-section diagrams of geology showing baseline groundwater levels in the monitoring piezometres, and for the predicted baseline condition groundwater levels in 2030 and 2100;</li> <li>(h) statistical evaluation of the model's calibration;</li> <li>(i) details of the groundwater monitoring data inputs (levels and quality);</li> <li>(j) details of the proposed groundwater model update and validation as additional data is collected;</li> <li>(k) assessment of impacts of groundwater drawdown, taking into consideration the NSW Aquifer Interference Policy (DPI, 2012), including potential impacts on licensed bores and groundwater dependent ecosystems;</li> <li>(l) a comparison of the results with the modelling results detailed in the documents referred to in Condition A1; and</li> <li>(m) documentation of any additional measures that would be implemented to manage and/or mitigate groundwater impacts not previously identified.</li> </ul> <p>A copy of the Groundwater Modelling Report must be submitted to the Secretary prior to finalising the tunnel design. The Groundwater Modelling Report must include details of consultation with DPI Water.</p>	Table 6 GWMM4 Section 9.2
E194	The groundwater model must be updated once 24 months of construction groundwater monitoring data are available and the results of the updated modelling provided to the Secretary and DPI Water in an updated Groundwater Modelling Report.	Section 9.2

Table 9: Revised Environmental Mitigation Measures relevant to the development of this Sub-plan

Outcome	Ref#	Commitment	Timing	Reference
Impacts on water quality from the discharge of	SW10	Temporary construction water treatment plants will be designed and managed so that treated water will be of suitable quality for discharge to the receiving environment.	Construction	Table 6 GWMM7

Outcome	Ref#	Commitment	Timing	Reference
treated wastewater during construction		An ANZECC (2000) species protection level of 90 per cent is considered appropriate for adoption as discharge criteria for toxicants where practical and feasible. The discharge criteria for the treatment facilities will be included in the CSWMP.		
High groundwater inflows in excess of the one litre per second per kilometre design criterion, which will cause significant groundwater inflows and groundwater drawdown	GW1	Groundwater inflows within the tunnels will be minimised by designing the final tunnel alignment to minimise intersections with known palaeochannels and alluvium present in the project footprint.	Construction	Table 6 GWMM1
	GW2	Appropriate waterproofing measures will be identified and included in the detailed design to permanently, where reasonable and feasible, reduce the inflow into the tunnels to below one litre per second per kilometre for any kilometre length of the tunnel.	Construction	Section 6.2.3.1, 6.2.6.1 Table 5 GWMM11
	GW3	Appropriate measures will be investigated and implemented at dive structures and shafts and for cut-and-cover sections of the tunnel to minimise groundwater inflow.	Construction	Section 6.2.3.1, 6.2.6.1
	GW9	Further investigations will be carried out to identify areas where groundwater inflows to the tunnels are likely to be elevated, to guide the development of the detailed design and construction methodology. The investigations will be carried out prior to the commencement of excavations with the potential to result in groundwater inflow at each identified location.	Construction	Section 6.2.4.2
Corrosion of building materials by sulfate reducing bacteria	GW4	Further assessment of the risk posed by the presence of sulfate reducing bacteria and groundwater aggressivity will be undertaken prior to construction. A corrosion assessment will be undertaken by the construction contractor to assess the impact on building materials that may be used in the tunnel infrastructure such as concrete, steel, aluminium, stainless steel, galvanised steel and polyester resin anchors. The outcomes of the corrosion assessment will be considered when selecting building materials likely to encounter groundwater.	Construction	Table 6 GWMM2
Groundwater drawdown impacting a water supply well water level by more than two metres	GW5	In accordance with the Aquifer Interference Policy (DPI-Water 2012), measures will be taken to 'make good' the impact on an impacted water supply bore by restoring the water supply to pre-development levels. The measures taken will be dependent upon the location of the impacted bore but could include, for example, deepening the bore, providing a new bore or providing an alternative water supply.	Construction	Table 5 GWMM10
Alteration of groundwater flows and levels due to the installation	GW6	Potential impacts associated with subsurface components of the project intercepting and altering groundwater flows and levels will be considered during detailed design. Measures to reduce potential impacts will be identified and included in the detailed construction methodology and the detailed design as relevant.	Construction	Table 6 GWMM4, GWMM3

Outcome	Ref#	Commitment	Timing	Reference
of subsurface project components				
Actual groundwater inflows and drawdown in adjacent areas exceed expectations	GW7	A detailed groundwater model will be developed by the construction contractor during detailed design. The model will be used to predict groundwater inflow rates and volumes within the tunnels and groundwater levels (including drawdown) in adjacent areas during construction and operation of the project.	Construction	Table 6 GWMM4, GWMM9
	GW8	Groundwater inflow within and groundwater levels in the vicinity of the tunnels will be monitored during construction and compared to model predictions and groundwater performance criteria applied to the project. The groundwater model will be updated based on the results of the monitoring as required and proposed management measures to minimise potential groundwater impacts adjusted accordingly to ensure that groundwater inflow performance criteria are met.	Construction	Table 6 GWMM5, GWMM9

## **Annexure B    Groundwater Monitoring Program**