S2-FGJV-ENV-PLN-0010

SNOWY 2.0 MAIN WORKS – WATER MANAGEMENT PLAN

Approval Record			
Document preparation, review and approval		Name in print	Signature
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Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	27.11.2019	Initial draft for SHL review
B	22.5.2020	Update to reflect conditions of approval and revised environmental management measures
C	15.6.2020	For consultation
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments
G	15.10.2020	Revised to address NRAR clarification

Chris Buscall
Environmental Compliance Lead
Snowy 2.0 Project

Via Email: Chris.Buscall@snowyhydro.com.au

19/10/2020

Dear Chris

Snowy 2.0 Main Works (SSI 9687) & Snowy 2.0 Exploratory Works (SSI 9208)
Water Management Plan

I refer to the Water Management Plan which was submitted in accordance with condition 31 of Schedule 3 of the Infrastructure Approval for the Snowy 2.0 Main Works (SSI 9687) and condition 34 of Schedule 3 of the Infrastructure Approval for the Snowy 2.0 Exploratory Works (SSI 9208).

The Department has carefully reviewed the document and notes that it supersedes the approved Water Management Plan for the Exploratory Works and is satisfied that it is prepared in accordance with the conditions.

Accordingly, the Planning Secretary has approved the Water Management Plan (Revision G, dated 14 October 2020). Please ensure that the approved plan is placed on the project website at the earliest convenience.

If you wish to discuss the matter further, please contact Anthony Ko on 8217 2022.

Yours sincerely

Nicole Brewer
Director
Energy Assessments

As nominee of the Planning Secretary

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ABBREVIATIONS AND DEFINITIONS

Acronym	Definition
AFL	Agreement for Lease
AHD	Australian Height Datum
AIP	Aquifer Interference Policy
CoA	Infrastructure Conditions of Approval (SSI 9687)
Construction envelope	The maximum extent within which the disturbance area corridor can move to allow the final siting of infrastructure through the detailed design process
Disturbance footprint	The disturbance footprint as described in the PIR-RTS is the indicative corridor inside the larger construction envelope, where construction works required to build Snowy 2.0 can be carried out.
DAWE	Commonwealth Department of Agriculture, Water and the Environment
DPIE	NSW Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
Exploratory Works	The development of an exploratory tunnel and associated infrastructure described in the Environmental Impact Statement for the *Snowy 2.0 Exploratory Works* (CSSI 9208) dated July 2018, and modified by the: • *Submissions Report* dated October 2018 and additional information provided to the Department on 17 October 2018, 19 November 2018 and 23 January 2019; • *Modification Report* dated 6 June 2019 and associated *Submissions Report* dated 2 September 2019 and amendment letter date 4 October 2019; and • *Modification Report* dated 17 October 2019 and associated *Submissions Report* dated 10 January 2020
EMS	Environmental Management Strategy
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPA	NSW Environment Protection Authority
EPL	Environmental Protection Licence
ESCP	Erosion and Sediment Control Plan
Future Generation	Future Generation Joint Venture
Future Generation-PMS	Project Management System
GMP	Groundwater Management Plan (S2-FGJV-ENV-PLN-0012) (Appendix B)
Incident	An occurrence or set of circumstances that causes or threatens to cause material harm and which may or may not be or cause a non-compliance
KNP	Kosciusko National Park
Lobs Hole site	The development in the vicinity of Lobs Hole, including the GFO1 emplacement area; construction facilities (Main Yard), including workers' accommodation camp and temporary spoil emplacement areas; Main Access Tunnel and Emergency Cable and Ventilation Tunnel portals; and ancillary infrastructure including access roads, substation, cableyard and utilities.
Main Works	The development of an underground power station and associated infrastructure described in the Environmental Impact Statement for the *Snowy 2.0 Main Works* (CSSI 9687) dated September 2019, and modified by the: • *Preferred Infrastructure Report and Response to Submissions – Snowy 2.0 Main Works*, dated February 2020; and

Acronym	Definition
	• Additional information provided to the Department by EMM on 24 March 2020 and 7 April 2020
Marica site	The development in the vicinity of Marica, including the headrace surge shaft; ventilation shaft; construction facility workers' camp; and ancillary infrastructure including access roads and utilities.
Material harm	Is unauthorised harm that: • involves actual or potential harm to the health or safety of human beings or to the environment that is not trivial; or • results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding $10,000, (such loss includes the reasonable costs and expenses that would be incurred in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment)
NPWS	National Park and Wildlife Services
NSW DPI	The NSW Department of Primary Industries within Regional NSW
Plateau site	The development in the vicinity of the Plateau, including the instream barrier in Tantangara Creek and ancillary infrastructure including access roads and utilities.
Plateau area	The plateau area; located to the east of the Snowy Mountains Highway and spanning the area between the highway and Tantangara Reservoir, is typical of elevated alpine environments, dominated by low energy streams, gentle rolling hills and mostly flat floodplains. The plateau area includes the Plateau and Tantangara work sites.
PMF	Probable Maximum Flood
POEO Act	*Protection of the Environment Operations Act 1997*
POEO Regulation	*Protection of the Environment (General) Regulation 2009*
Project	Snowy 2.0 Main Works
Project area	The project area is the broader region within which Snowy 2.0 will be built and operated, and the extent within which direct impacts from Snowy 2.0 Main Works are anticipated. The project area does not represent a footprint for the construction works, but rather indicates an area that was investigated during environmental assessments.
Ravine zone	The ravine area; located mostly to the west of the Snowy Mountains Highway, is characterised by deep gorges and steep sloping ridges, the product of incision from river flow, historic glaciation and structural movement. The ravine area includes the Talbingo, Lobs Hole and Marica work sites.
REMM	Revised Environmental Management Measures
Rock Forest site	The development on the Rock Forest property, including the Rock Forest emplacement area, logistics laydown area and ancillary infrastructure including access roads.
Submissions Report or RTS	Response to Submissions Main Works for Snowy 2.0
SHC Act	*Snowy Hydro Corporatisation Act 1997*
SHL	Snowy Hydro Limited
SSI	State Significant Infrastructure under EP&A Act (Infrastructure Approval 9687)
Talbingo Reservoir site	The development in and around the Talbingo Reservoir, including the Ravine Bay emplacement area; development at Middle Bay, including the water intake and associated structures, barge launch ramp, and construction facilities; and ancillary infrastructure, including access roads and utilities.
Tantangara Reservoir site	The development in and around the Tantangara Reservoir, including the Tantangara emplacement area; water intake and associated infrastructure; barge launch infrastructure; construction and laydown facilities, including workers' camp; fish screens; and ancillary infrastructure, including access roads and utilities.

Acronym	Definition
SWMP	Surface Water Management Plan (S2-FGJV-ENV-PLN-0011) (Appendix A)
WAL	Water Access Licence
Water Group	The Water Group within the Department of Planning Industry and Environment
WM Act	*Water Management Act 2000*
WM Regulation	*Water Management (General) Regulation 2018*
WMP	Water Management Plan (S2-FGJV-ENV-PLN-0010) (this Plan)
WSP	Water Sharing Plan
WTP	Water Treatment Plant

1. INTRODUCTION

1.1. Project Description

1.1.1. Overview

Snowy Hydro Limited (Snowy Hydro) is constructing a pumped hydro-electric expansion of the Snowy Mountains Hydro-electric Scheme (Snowy Scheme), called Snowy 2.0. Snowy 2.0 will be built by the delivery of two projects: Exploratory Works (which has commenced) and Snowy 2.0 Main Works.

Snowy 2.0 is a pumped hydro-electric project that will link the existing Tantangara and Talbingo reservoirs through a series of new underground tunnels and a hydro-electric power station. Most of the project's facilities will be built underground, with approximately 27 kilometres of concrete-lined tunnels constructed to link the two reservoirs and a further 20 kilometres of tunnels required to support the facility. Intake and outlet structures will be built at both Tantangara and Talbingo Reservoirs.

Snowy 2.0 will increase the generation capacity of the Snowy Scheme by an additional 2,000 MW, and at full capacity will provide approximately 350,000 MWh of large-scale energy storage to the National Electricity Market (NEM). This will be enough to ensure the stability and reliability of the NEM, even during prolonged periods of adverse weather conditions.

Salini Impregilo, Clough and Lane have formed the Future Generation Joint Venture (Future Generation) and have been engaged to deliver both Stage 2 of Exploratory Works and Snowy 2.0 Main Works.

1.1.2. Construction Activities and Program

The Snowy 2.0 Main Works Project includes, but is not limited to, construction of the following:

- pre-construction preparatory activities including dilapidation studies, survey, investigations, access etc;
- exploratory works including:
  - an exploratory tunnel to the site of the underground power station;
  - horizontal and test drilling;
  - a portal construction pad;
  - an accommodation camp;
  - barge access infrastructure;
- an underground pumped hydro-electric power station complex;
- water intake structures at Tantangara and Talbingo reservoirs;
- power waterway tunnels, chambers and shafts;
- access tunnels;
- new and upgraded roads to allow ongoing access and maintenance;
- power, water and communication infrastructure, including:
  - a cable yard to facilitate connection between the NEM electricity transmission network and Snowy 2.0;

- permanent auxiliary power connection;
- permanent communication cables;
- permanent water supply to the underground power station; and

- post-construction revegetation and rehabilitation.

The Snowy 2.0 construction program is summarised in Figure 1-1.

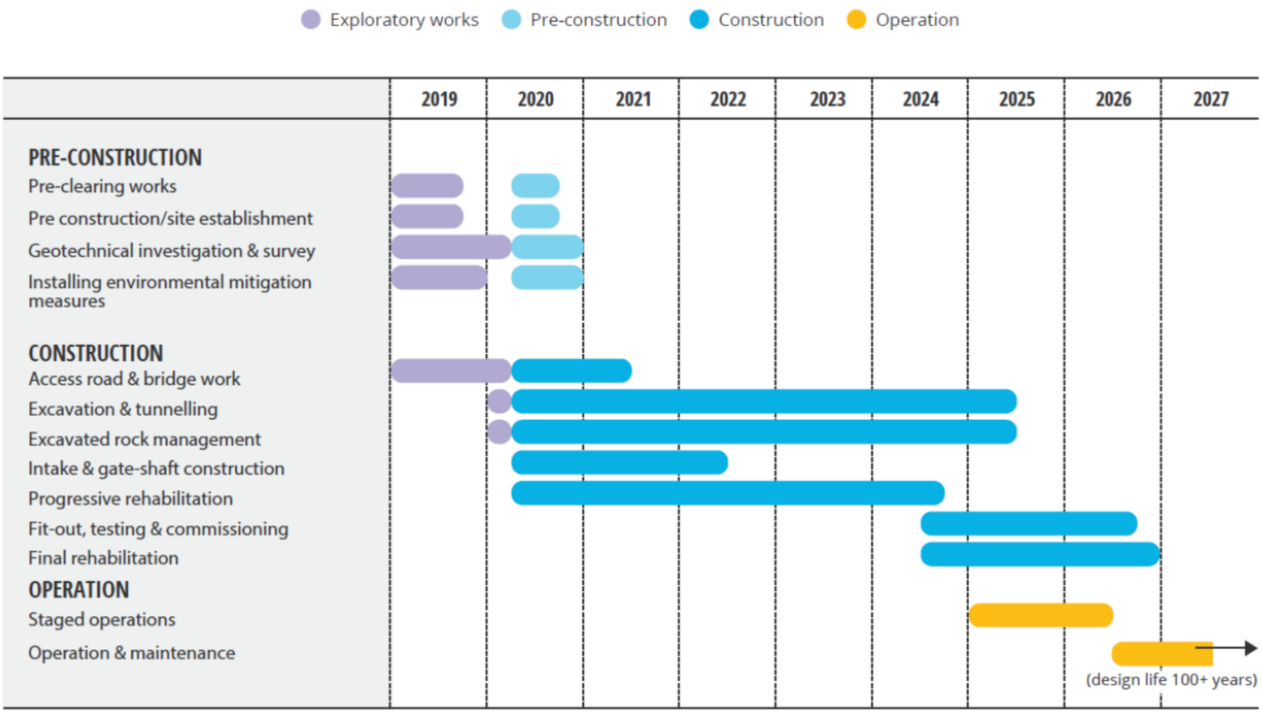


Figure 1-1: Timing of Snowy 2.0

The Snowy 2.0 Main Works Project includes numerous work sites as shown in Figure 1-2. These work sites include:

- Lobs Hole Ravine Road;
- Lobs Hole;
- Marica;
- Plateau;
- Rock Forest;
- Talbingo; and
- Tantangara.

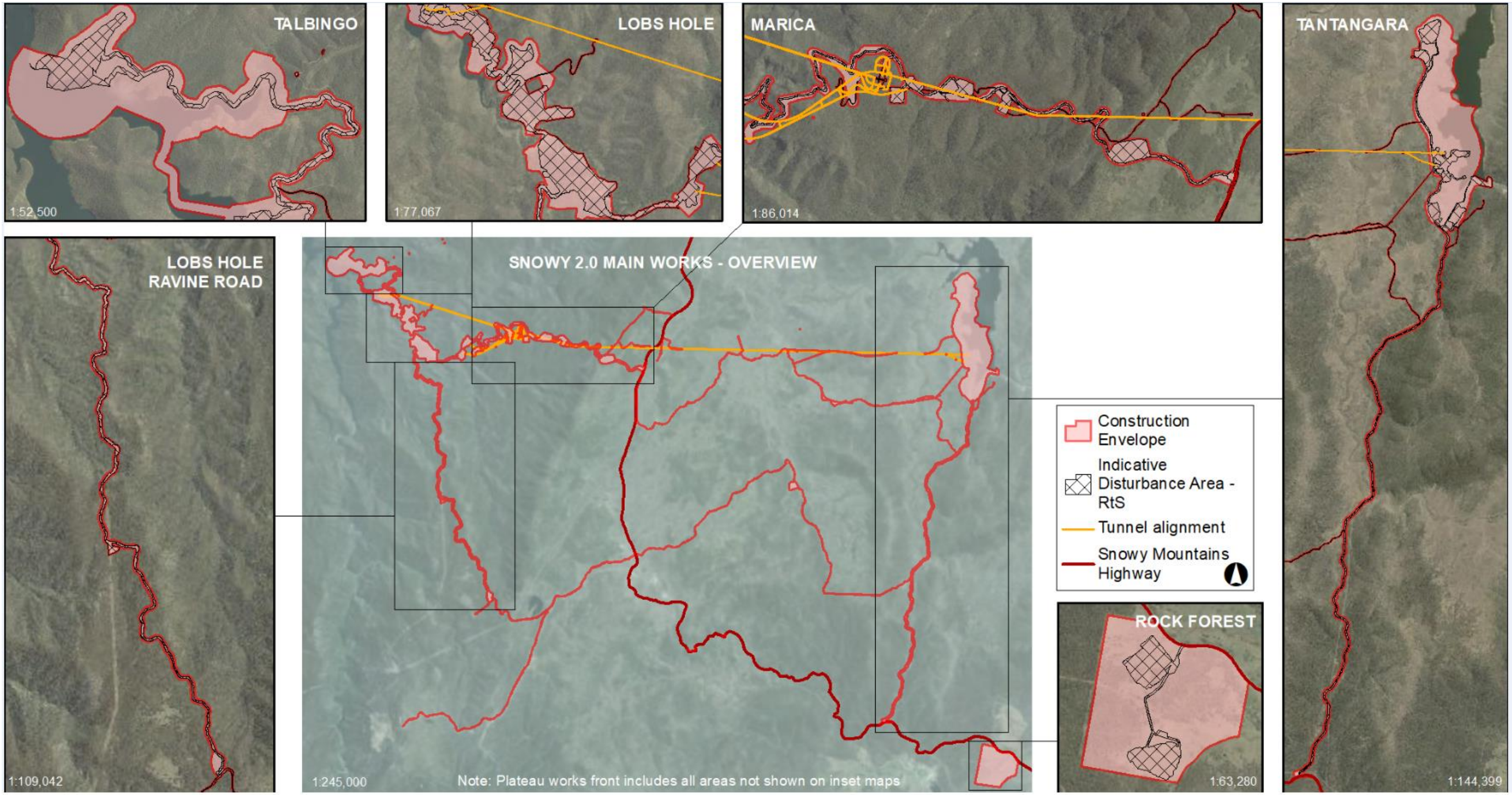


Figure 1-2: Snowy 2.0 Main Works work sites

1.2. Project Approval

On 7 March 2018 the NSW Minister for Planning declared Snowy 2.0 to be State significant infrastructure (SSI) and critical State significant infrastructure (CSSI) under the *Environmental Planning and Assessment Act 1979* (EP&A Act) on the basis that it is critical to the State for environmental, economic or social reasons.

An environmental impact statement for the first stage of Snowy 2.0, the *Environmental Impact Statement Exploratory Works for Snowy 2.0* (Exploratory Work EIS) was submitted to the then Department of Planning and Environment in July 2018 and publicly exhibited between 23 July 2018 and 20 August 2018. Approval for the first stage of Snowy 2.0 was granted for Exploratory Works by the Minister for Planning on 7 February 2019. In accordance with section 5.25 of the EP&A Act, the infrastructure approval for the Exploratory Works was modified on 2 December 2019 and on 27 March 2020.

An environmental impact statement for the second stage of Snowy 2.0, the *Snowy 2.0 Main Works - Environmental Impact Statement* (Main Work EIS) was submitted to Department of Planning, Industry and Environment (DPIE) in September 2019 and was publicly exhibited between 26 September 2019 and 7 November 2019. A total of 222 submissions were received during the public exhibition period, including 10 from government agencies, 30 from special interest groups and 182 from the general public. In February 2020, the response to submissions (RTS or Submissions Report) was issued to DPIE to address the public and agency submissions (*Snowy 2.0 Main Works - Preferred Infrastructure Report and Response to Submissions, February 2020*).

Following consideration of the Main Works EIS and RTS, approval was granted by the Minister for Planning and Public Spaces on 20 May 2020, through issue of Infrastructure Approval SSI 9687.

Further to the Infrastructure Approval, the Main Works RTS includes revised environmental management measures (REMMs) within Appendix C which will also be implemented for the Project.

In addition to the State approval, a referral (EPBC 2018/8322) was prepared and lodged with the Commonwealth Department of Agriculture, Water and Environment (DAWE) (formally Commonwealth Department of Energy and Environment) under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Commonwealth Minister's delegate determined on 5 December 2018 that Snowy 2.0 Main Works is a "controlled action" under the EPBC Act. The EPBC Act referral decision determined that the project will be assessed by accredited assessment under Part 5, Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979.*

1.3. Disturbance area

A key refinement following public exhibition of the Main Works EIS was a change to and clarification of disturbance area terminology. The revised disturbance area terminology as per the SSI-9687 Instrument, Main Works RTS and this Plan is outlined in Table 1-1, with an example shown at Lobs Hole Ravine Road in Figure 1-3

Table 1-1: Disturbance area terminology

Term	Definition	Reasoning
Project area	The project area is the broader region within which Snowy 2.0 will be built and operated, and the extent within which direct impacts from Snowy 2.0 Main Works are anticipated.	The project area does not represent a footprint for the construction works, but rather indicates an area that was investigated during environmental assessments.

Term	Definition	Reasoning
Construction envelope	The envelope within which the disturbance area of the development may be located	As detailed design continues, final siting of the infrastructure (i.e. the disturbance area) can move within the assessed construction envelope subject to recommended environmental management measures and provided it does not exceed the limits defined by the construction envelope.
Disturbance area	The area within the construction envelope where development may be carried out; the precise location of the disturbance area will be fixed within the construction envelope following final design	

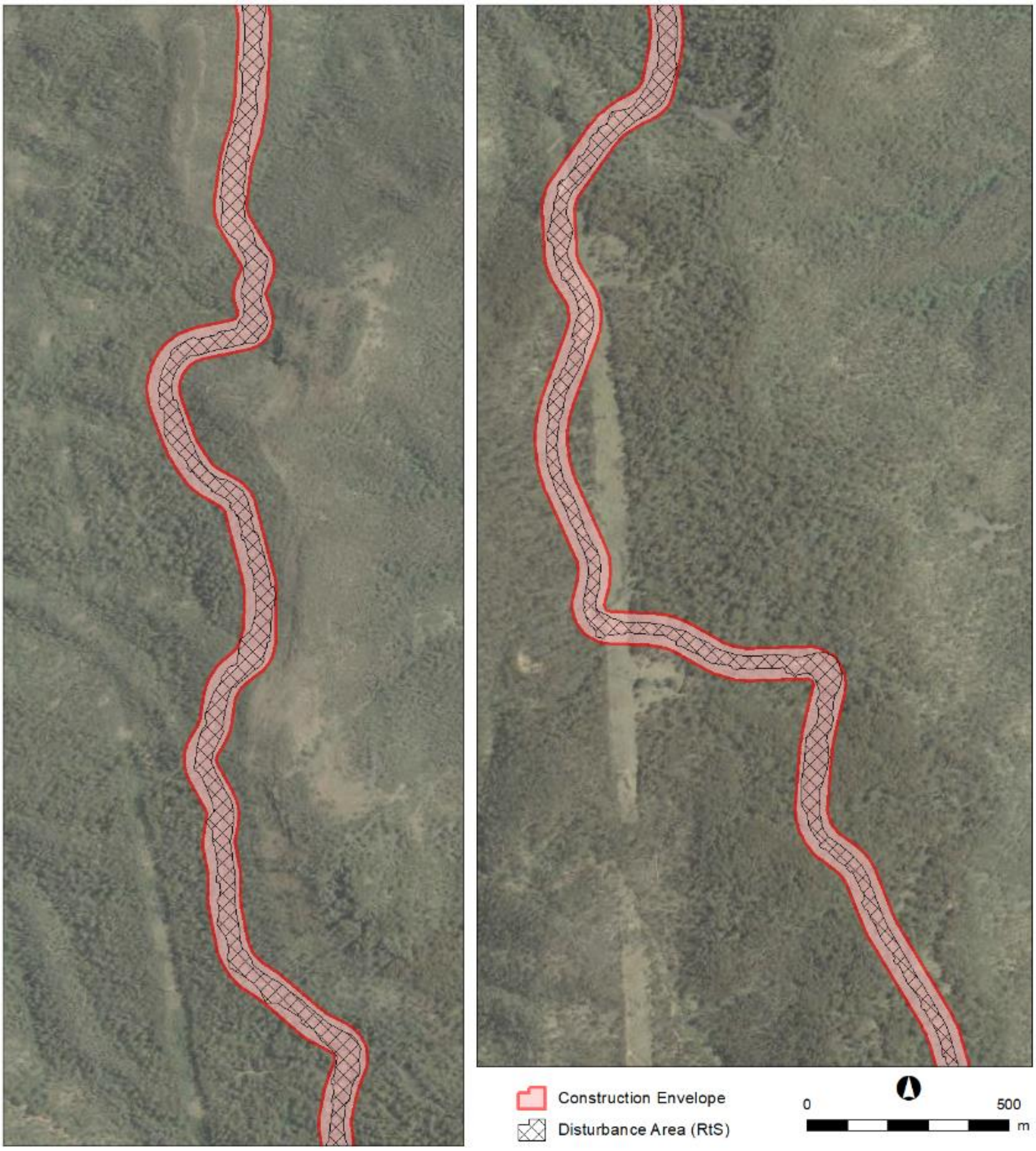


Figure 1-3: Disturbance area and construction envelope

1.4. Works within the Construction Envelope

Where project works are required to occur in locations outside of the disturbance boundary, Future Generation will review the proposed area of clearing against the limits included within condition 5 of schedule 2. The review will be undertaken to ensure that the maximum disturbance area and maximum native vegetation clearing remains within the total areas nominated within the condition. These area limits are included within Table 1-2.

All vegetation clearing which occurs on the project will be monitored regularly to record the extent of clearing which has occurred, and to ensure that the clearing limits are not exceeded.

Table 1-2: Maximum disturbance area and native vegetation clearing

Matter	Exploratory Works	Main Works	Total
Maximum Disturbance Area	126 ha	504 ha	630 ha
Maximum Native Vegetation Clearing	107 ha	425 ha	532 ha

1.5. Environmental Management System

The overall environmental management system for the Project is described in the Environmental Management Strategy (EMS). The EMS forms part of the Project Management System (Future Generation-PMS) and will include any requirements specified in the contract documents, where appropriate. All Future Generation-PMS procedures will support, interface or directly relate to the development and execution of the Plan.

The management plans and post-approval documents for the project include those listed within Figure 1-4.

This Water Management Plan (WMP or Plan) (S2-FGJV-ENV-PLN-0010) has been prepared for the Snowy 2.0 Main Works project, and supersedes the existing Stage 1 and Stage 2 Exploratory Works Water Management Plan. It does not address the operational phase of the project. This Plan forms part of Future Generation's environmental management framework and includes the:

- Surface Water Management Plan (SWMP) (Appendix A) (S2-FGJV-ENV-PLN-0011); and
- Groundwater Management Plan (GMP) (Appendix B) (S2-FGJV-ENV-PLN-0012).

An overview of the Plan structure relative to the elements of water management is shown in Figure 1-5.

This Plan aims to transfer the relevant requirements of the Approval documents into a management plan which can be practically applied on the Project site.

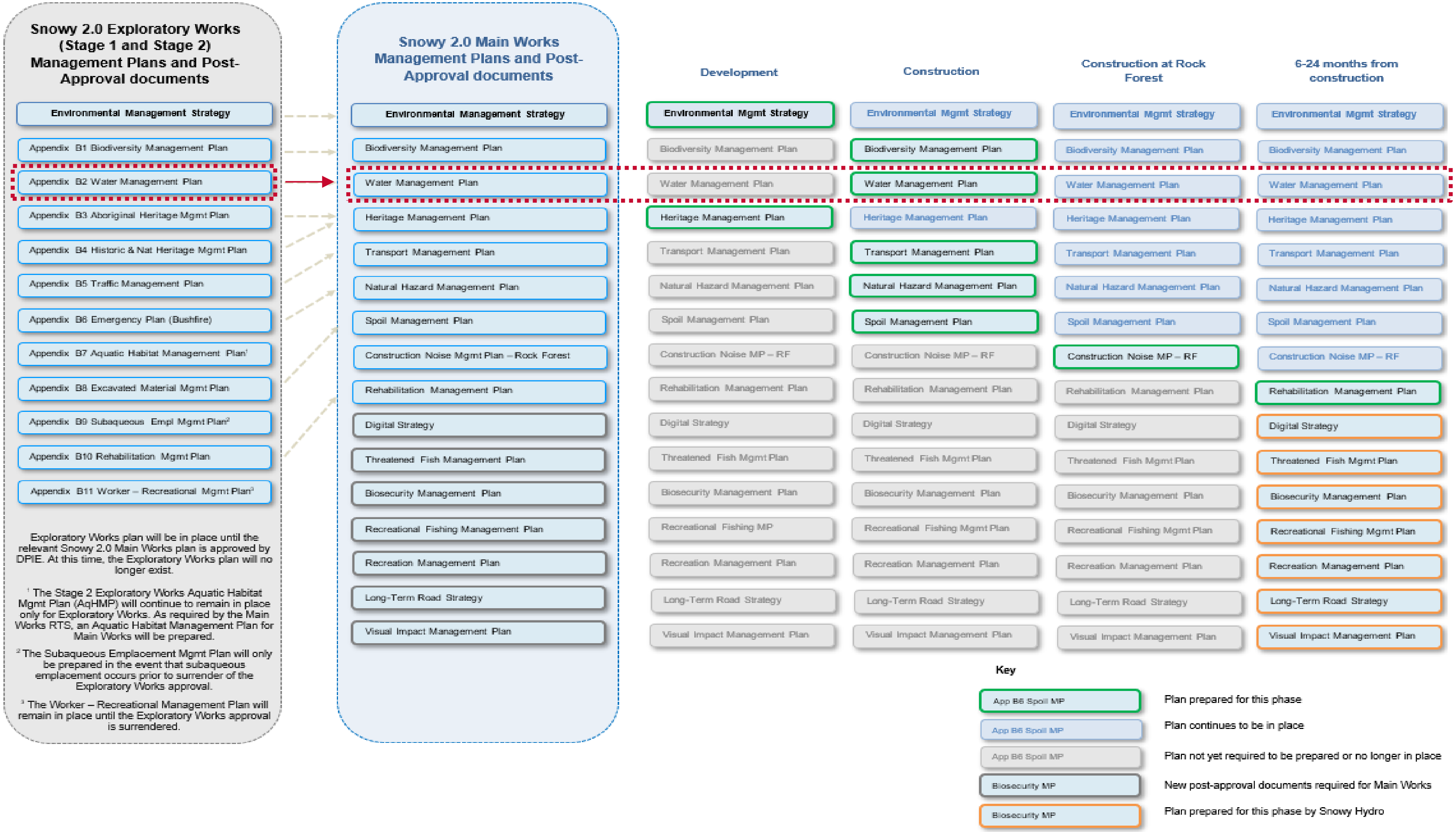


Figure 1-4: Management plans and post-approval documents with the WMP indicated

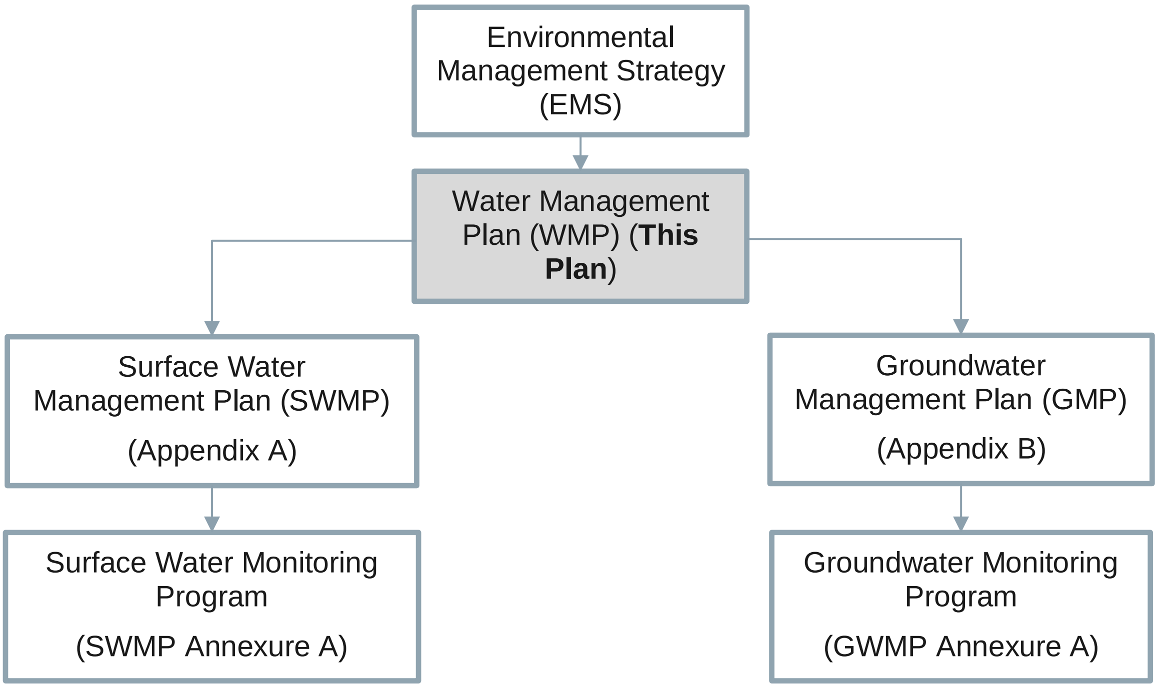


Figure 1-5: Water Management Plan Structure

1.6. Purpose and objective of this plan

The purpose of this Plan is to address the construction environmental management requirements detailed in:

- the Infrastructure Approval (SSI 9687) (Approval) issued for Snowy 2.0 Main Works on 21 May 2020;
- the *Main Works Snowy 2.0 - Environmental Impact Statement*;
- the revised environmental management measures (REMMs) within the Main Works RTS;
- the Infrastructure Approval (SSI 9208) issued for Snowy 2.0 Exploratory Works on 7 February 2019 and modified on 2 December 2019 and 27 March 2020;
- the *Exploratory Works for Snowy 2.0 - Environmental Impact Statement*;
- the *Exploratory Works for Snowy 2.0 – Modification 1 Assessment Report*;
- the *Exploratory Works for Snowy 2.0 – Modification 2 Assessment Report*;
- the REMMs within the Exploratory Works RTS, Exploratory Works Modification 1 RTS, and Exploratory Works Modification 2 RTS; and
- the environmental protection licence (EPL) 21266.

The key objective of this Plan is to detail management measures and inform site procedures for implementation so that water impacts are minimised and within the scope permitted by the Infrastructure Approval. To achieve this, Snowy Hydro and Future Generation will implement:

- appropriate measures to address relevant conditions of approval and REMMs listed within the Submissions Reports, as detailed within Section 2 of this Plan;

- appropriate measures during construction to manage and minimise impacts to water;
- monitoring programs during construction to verify that water impacts are being minimised; and
- corrective actions and contingency measures during construction when triggered.

Specific on-site management measures identified in this plan will be incorporated into site documents where relevant. These site-specific documents will be prepared for construction activities and will detail the management measures which are to be implemented on the ground. Construction personnel will be required to undertake works in accordance with the mitigation measures identified in the site-specific documents.

1.7. Staging

Some distinct work activities require greater detail prior to commencement. Consequently, this Plan will be updated, in consultation with relevant government agencies, and submitted to DPIE prior to the commencement of specific activities as detailed in Table 1-3.

Table 1-3: Activities that require update to this WMP

Activities	Timing
Dredging, channel extraction or underwater blasting	This WMP will be updated for approval prior to dredging, channel extraction or underwater blasting.
Permanent in-reservoir emplacement areas	This WMP will be updated prior to in-reservoir emplacement.
Construction works in the third year for the purposes of determining need/location streamflow monitoring sites	This WMP will be updated in the third year of construction to determine the need for surface water flow monitoring sites and if necessary, suitable locations to monitor potential streamflow impacts (based on additional groundwater monitoring data / revised drawdown predictions).
Operation of Snowy 2.0 Project, including dewatering of the tailrace tunnel during operations.	Operation will be addressed through a separate Snowy Hydro framework or document.

1.8. Plan Preparation

In accordance with schedule 3, condition 31 of the Approval, the WMP has been prepared by suitably qualified and experienced personnel.

This plan was prepared by Dr Rick Van Dam, Water Quality Advice and Dr Richard Cresswell, Eco Logical Australia.

1.9. Consultation

In accordance with schedule 3, condition 31 of the Infrastructure Approval, the WMP is to be prepared in consultation with;

- NSW Environment Protection Agency (EPA);
- National Parks and Wildlife Services (NPWS);
- Department of Planning Industry and Environment– Water (Water Group);
- Natural Resources Access Regulator (NRAR); and
- NSW Department of Primary Industries (NSW DPI)

In accordance with condition 18 of the Commonwealth approval, the WMP is also to be prepared in consultation with the DAWE.

On 15 June 2020, the Plan was issued to stakeholder agencies for review and comment. Comments from consultation have been incorporated into this Plan where appropriate. Response to the comments have been provided back to the stakeholder agencies. Consultation is summarised in Table 1-4.

An agency briefing for the WMP was held on 30 April 2020 and 7 May 2020 with EPA, NPWS, Water Group, NSW DPI and the Biodiversity and Conservation Division (BCD).

Table 1-4: Consultation undertaken for the WMP

Date	Consultation	Outcomes
30/04/2020	EPA, NPWS, Water Group, DPI Fisheries, BCD	Agency briefing (online PowerPoint) providing overview of document structure and surface water management approach.
07/05/2020	EPA, NPWS, Water Group, BCD	Agency briefing (online PowerPoint) providing overview of the development of the surface water monitoring program and groundwater monitoring program.
15/06/2020	NPWS, EPA, Water Group, NRAR, NSW DPI	WMP (revision C) issued to stakeholders for review and comment
26/06/2020	DAWE	WMP (revision D) issued to DAWE for review and comment
08/07/2020	DAWE	Agency briefing (online PowerPoint) providing overview of document structure and water management approach.
03/08/2020	NRAR, Water Group	Amendment to groundwater monitoring network.
24/08/2020	DAWE	Further rationale for adjustment to surface water monitoring locations, details of bushfire impacts on water quality and general clarifications.
09/09/2020	EPA	Amendment to surface water monitoring program, specifically in relation to discharge outlet verification monitoring.

A separate document is proposed to be provided to DPIE and DAWE which details the consultation process, along with Future Generation responses to stakeholder comments and how feedback has been implemented during the action.

1.9.1. Ongoing Consultation

Future Generation will consult with stakeholders identified in schedule 3, condition 31 of the Infrastructure Approval for updates to this WMP.

Where additional monitoring infrastructure is proposed outside the construction envelope (see 6.3.1. Future Generation will review environmental constraints and consult with relevant stakeholders (i.e. NPWS for monitoring infrastructure within the KNP).

2. ENVIRONMENTAL REQUIREMENTS

2.1. Legislation

Legislation relevant to water management includes:

- Environmental Planning and Assessment Act 1979 (EP&A Act);
- *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation);
- *Protection of the Environment Operations Act 1997* (POEO Act);
- *Protection of the Environment (General) Regulation 2009* (POEO General Regulation);
- *Water Management Act 2000* (WM Act);
- *Water Management Amendment Act 2014* (WMA Act);
- *Water Management (General) Regulation 2018* (WM General Regulation);
- Water Sharing Plan for the Murrumbidgee unregulated and alluvial water sources (2012); and
- *Snowy Hydro Corporatisation Act 1997* (SHC Act).

The Surface Water Management Plan (Appendix A) and Groundwater Management Plan (Appendix B) contain legislation applicable to their respective aspects.

Relevant provisions of the above legislation are explained in the register of legal and other requirements included in Appendix A1 of the EMS.

2.2. Conditions of Approval

Table 2-1 details the CoA that are relevant to water management and demonstrates where these conditions are addressed.

Table 2-1: Conditions of approval relevant to water

CoA	Requirement	Where addressed
Schedule 3		
15	**Potential Additional Offsets – Alpine Sphagnum Bogs and Associated Fens** The Proponent must ensure that the development does not cause any exceedances of the following performance measures in the Alpine Sphagnum Bogs and Associated Fens above the Gooandra Volcanics and Kellys Plains Volcanics: (a) negligible change to the shallow groundwater regime supporting the bogs and associated fens when compared to a suitable control site; and (b) negligible change in the ecosystem functionality of the bogs and associated fens.	GMP – Section 7.2.3 and Annexure A Section 2.5.1
16	If the Planning Secretary determines that the development has caused exceedances of the performance measures in condition 15 above, the Proponent must pay additional funds to the NPWS within 3 months of the determination to offset the groundwater-related impacts of the development on the Alpine Sphagnum Bogs and Associated Fens. The Planning Secretary will determine the amount of funds the proponent must pay following consultation with the NPWS, DAWE and the Proponent; and having regard to: (a) The significance of the impacts on the bogs and associated fens; (b) The relevant values from the Biodiversity Offset Payment calculator; and	Biodiversity Management Plan (S2-FGJ-ENV-PLN-0008)

CoA	Requirement	Where addressed
	(c) The likely cost of carrying out the conservation actions required to offset these impacts on the bogs and associate fens. *Note: These funds will be added to the funds paid under condition 12 (Biodiversity Offset Payments) and managed in accordance with the notes under that condition.*	
28	**Water Supply** The Proponent must ensure it has sufficient water for each stage of the development; and if necessary, adjust the scale of development on site to match its available water supply. *Note: Under the Water Management Act 2000, the Proponent must obtain the necessary water licences for the development.*	WMP – Section 2.5.3 SWMP – Section 2.5.3 GMP – Section 2.5.3
29	**Water Pollution** Unless an environment protection licence authorises otherwise, the Proponent must comply with Section 120 of the POEO Act. *Note: Section 120 of the POEO Act makes it an offence to pollute any waters*	SWMP – Table 5-3: SW02, SW22, SW30 GMP – Table 5-1: GW03
30	**Water Mitigation Requirements** The Proponent must:	
	(a) maximise the recycling and reuse of water on site;	WMP – Section 4.2 SWMP – Section 5.1, Section 5.3.1, Table 5-3: SW14
	(b) maximise the diversion of clean water runoff around the disturbance areas;	SWMP – Section 5.1, Table 5-3: SW04, SW06
	(c) minimise the flow rates and velocities of any clean water runoff diversions to adjoining watercourses;	SWMP - Section 5.1, Table 5-3: SW08
	(d) minimise the flooding impacts of the development;	SWMP – Section 5.2, Table 5-3: SW18, SW19 Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090) Spoil Management Plan (S2-FGJV-ENV-PLN-0019)
	(e) minimise groundwater take from the Goonandra Volcanics and Kellys Plain Volcanics using pre and post grouting of the tunnel, to minimise the loss of stream flows in the waterways above these geological formations, including Goonandra Creek and the headwaters of the Eucumbene River;	GMP – Section 5.1 and Table 5-1: GW04, GW05
	(f) minimise erosion and the generation and dispersion of sediment using suitable controls in accordance with the relevant requirements in the *Managing Urban Stormwater: Soils and Construction* guidance series;	SWMP – Section 5.1, Table 5-3: SW03
	(g) design all instream works, particularly the inlet and outlet works, to minimise scour and erosion;	SWMP - Section 5.7, Table 5-3: SW58, SW59
	(h) unless permitted by this approval, avoid carrying out of any development within 40 metres of any watercourse;	SWMP – Section 5.7, Table 5-3: SW51
	(i) carry out all instream works or development within 40 metres of any watercourse generally in accordance with the requirements in the *Guidelines for Controlled Activities on Waterfront Land*;	SWMP – Section 5.7, Table 5-3: SW51, SW52
	(j) treat all wastewater and surplus process water prior to discharging it at the approved discharge points at the Talbingo Reservoir or Tantangara Reservoir;	SWMP – Section 5.3, Table 5-3: SW22, SW30 and Annexure F

CoA	Requirement	Where addressed
	(k) reduce the number of diffuser points for low velocity discharges to the Talbingo Reservoir or Tantangara Reservoir;	SWMP – Section 5.3.4, Table 5-3: SW27, SW35 and Annexure F
	(l) not discharge any surplus process water to the stormwater basins on site;	SWMP – Section 5.3, Table 5-3: SW28
	(m) minimise the surface water quality impacts associated with the development, including: • the development carried out in the vicinity of waterways, particularly in the Talbingo Reservoir, Tantangara Reservoir and Yarrangobilly River; • all instream works, including dredging, channel excavations, underwater blasting, barge infrastructure, fish barriers and screens, culverts and bridges, and service crossings; • the temporary and permanent spoil emplacement areas; • development at the Marica, Plateau and Rock Forest sites; • road works; • the operation of the power station and associated infrastructure, including the operation of the inlets and outlet to minimise sediment distruabnce risks and the dewatering of the trailrace tunnel	SWMP – Section 5, Table 5-3 (All measures) Note the WMP will be updated prior to major sub-surface water works in Talbingo Reservoir and Tantangara Reservoir (including dredging / channel extraction / underwater blasting) for construction of intake structures, and prior to in-reservoir emplacement. A separate document or framework will be prepared prior to operations.
	(n) minimise the risk of spills or leaks on site, and clean up any spills or leaks as quickly as possible;	SWMP – Section 5.4, Table 5-3: SW36, SW37, SW39, SW41, Annexure C (Spill Response Procedure)
	(o) minimise the groundwater quality impacts of the development, particularly through the design of the temporary and permanent spoil emplacement areas and all water storages on site;	GMP – Section 5.4 and Table 5-1: GW09 Spoil Management Plan (S2-FGJV-PLN-0019)
	(p) store chemicals and hydrocarbon products in bunded areas in accordance with the relevant Australian Standards.	SWMP - Section 5.4, Table 5-3: SW41, Annexure C (Spill Response Procedure)
31	**Water Management Plan** Prior to the commencement of construction, the Proponent must prepare a Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must:	This Plan
	(a) be prepared by a suitably qualified and experienced person in consultation with the EPA, NPWS, the Water Group, NRAR and NSW DPI;	WMP - Section 1.9
	(b) include a Site Water Balance for the development and a program to review and update this water balance each calendar year;	WMP - Section 5
	(c) include a Surface Water Management Plan, containing detailed plans for the Talbingo Reservoir, Lobs Hole, Marica, Plateau, Tantangara Reservoir, and Rock Forest sites with: • detailed baseline data on surface water flows and quality in the watercourses that could be affected by the development, and a program to augment this baseline data over time; • detailed criteria for determining the surface water impacts of the development (flows, quality and flooding), including criteria for triggering remedial action (if necessary); • description of the measures that would be implemented to minimise the surface water impacts of the development and comply with the relevant water management requirements in conditions 4,6 and 30 above, including specific plans covering: – the temporary or permanent emplacement of spoil; – dredging, channel extraction and underwater blasting in the Talbingo Reservoir and Tantangara Reservoir	SWMP SWMP – Annexure A Attachment B SWMP – Annexure A Section 1.2 and Annexure A Section 2 SWMP – Section 5,Table 5-3 (All measures). This SWMP will be updated prior to major sub-surface water works in Talbingo Reservoir and Tantangara Reservoir and in-reservoir emplacement. A

CoA	Requirement	Where addressed
	– operation of the discharge points – the design of the inlets and outlets; and – dewatering of the tailrace tunnel during operations; • identify the key risks to the successful implementation of these measures, and describe the contingency measures that would be implemented to address these risks; • a program to monitor and publicly report on the surface water impacts of the development.	separate document or framework will be prepared prior to operations. SWMP – Section 5.14 SWMP – Section 6.7, Annexure A Section 3 and Annexure A Section 7
	(d) include a Groundwater Management Plan with: • detailed baseline data of groundwater levels, yield and quality on the aquifers that could be affected by the development, and a program to augment this baseline data over time; • a program to validate and calibrate the groundwater model for the development as new information is collected; • detailed criteria for determining the groundwater impacts of the development, including criteria for triggering remedial action (if necessary) • a description of the measures that would be implemented to comply with the management requirements in condition 30 above; • a program to monitor and report on: – groundwater inflows to the tunnel; – water take from the groundwater bores and connected water sources; – the impacts of the development on: o regional and local (including alluvial) aquifers; o base flow to surface water sources; *Note: The Proponent may stage the preparation of the Water Management Plan, including the preparation of each of the detailed plans required under the Surface Water Management Plan. However, the detailed plans must be approved prior to any construction occurring on the relevant site.*	GMP GMP – Annexure A Attachment A GMP – Section 8.2 and Table 5-1: GW12 GMP – Section 6.4 GMP – Section 5 and Table 5-1 GMP – Section 6.8 and Annexure A Section 2
38	The Proponent must implement the approved Water Management Plan for the development.	This Water Management Plan will be implemented for the development.
Schedule 4		
5	**Monitoring** The Proponent may undertake monitoring outside the construction envelope of the development provided this monitoring is required under the conditions of this approval and authorised under an approved management plan	WMP - Section 6.3.1

2.3. Revised Environmental Management Measures

During preparation of the Exploratory Works and Main Works Submissions Reports, Revised Environmental Management Measures (REMMs) were developed and are included in Appendix C of the Main Works RTS and Section 8 of the Exploratory Works RTS.

The Main Works and Exploratory Works REMMs relevant to water are listed in Table 2-2 and Table 2-3. Specific section references are identified within the SWMP and GMP. In accordance with CSSI 9687, schedule 2, CoA 3, if there is any inconsistency between the Exploratory Works and Main Works documents, the most recent document will prevail to the extent of the inconsistency (i.e. Main Works). These requirements that conflict, as well as requirements that have been completed have been identified with an asterix and comment.

Table 2-2: Main works (SSI 9687) revised environmental management measures relevant to water

Impact	Reference	Environmental Management Measures	Where addressed
General	WM01	A Water Management Plan will be developed for Snowy 2.0 Main Works that includes:	This Plan
		• proposed mitigation and management measures for all construction water management categories;	WMP – Section 4.1 SWMP - Table 5-3 (All measures) GMP - Table 5-1 (All measures)
		• spill management and response;	SWMP - Annexure C (Spill Response Procedure)
		• a surface and groundwater monitoring program;	SWMP - Annexure A GMP – Annexure A
		• water quality trigger action response plan;	SWMP – Section 6.4, Annexure B GMP – Section 7, Annexure B, Annexure C, Annexure D
		• reporting requirements;	WMP - Section 6.6 SWMP - Section 6.7 GMP – Section 6.8
		• corrective actions;	SWMP – Section 6 GMP – Section 7
		• contingencies; and	SWMP - Section 5.3.1, Section 5.14 and Section 6.4 GMP – Table 5-1: GW13
		• responsibilities for all management measures.	SWMP – Table 5-3 GMP – Table 5-1
		The WMP will be prepared in consultation with DPIE, EPA, WaterNSW and key local stakeholders, and would consider concerns raised during the exhibition and approvals process for the project.	WMP Section 1.9
General	WM02	A water monitoring program will be developed as part of the water management plan to monitor quality and quantity impacts to surface water, groundwater and reservoirs. The water monitoring program will incorporate and update the existing monitoring network and detail monitoring frequencies and water quality constituents.	SWMP - Annexure A GMP – Annexure A
Water quality impacts from stormwater runoff	WM03	Where practical, clean water will be diverted around or through construction areas. Runoff from clean water areas that cannot be diverted will be accounted for in the design of water management systems.	SMWP – Section 5.1, Table 5-3: SW07
Water quality impacts from stormwater runoff	WM04	An Erosion and Sediment Control Plan (ESCP) will be prepared for each construction area that will include relevant information presented in the water management report.	SMWP – Section 5.1, Table 5-3: SW04

Impact	Reference	Environmental Management Measures	Where addressed
Water quality impacts from stormwater runoff	WM05	A suitably qualified erosion and sediment control professional(s) will be engaged to: • oversee the development of ESCPs; • inspect and audit controls; • train relevant staff; and • provide advice regarding erosion and sediment control	SMWP – Section 5.1, Table 5-3: SW05
Groundwater modelling	WM06	The groundwater model developed for Snowy 2.0 Main Works will be validated and, if necessary, recalibrated to new groundwater monitoring data as the monitoring record increases throughout construction. It is recommended that assessment of the monitoring record and groundwater affecting activities, along with model updates, be undertaken at least annually throughout construction and into operation until it is evident that the update frequency can be reduced.	GMP – Section 8.2
Groundwater inflow / drawdown	WM07	Where discrete high flow features are intercepted, pregrouting and secondary grouting from the TBM may be undertaken to enable tunnel construction.	GMP – Section 5.1.4, Section 5.1.5 and Table 5 1: GW05
Water supply	WM08	A water supply system will be established to supply water for potable water use and construction activities. The system will most likely source water from regional groundwater resources, but may also source water from either Tantangara or Talbingo Reservoirs provided licences are available. Extraction from watercourses will be avoided where practicable. The most suitable extraction locations and water sources will be established during detailed design	WMP – Section 2.5.3, Section 5
Reservoir water quality (wastewater management)	WM09	A wastewater management system will be established to manage effluent from construction compounds and accommodation camps. All wastewater will be treated to meet the water quality specifications provided in the water management report and will be discharged to reservoirs. Wastewater discharges to watercourses will be avoided.	SWMP - Section 5.3.2, Table 5-3: SW30
Reservoir water quality (process water management)	WM10	A process water management system will be established to manage water during construction; and to supply water to construction activities. All surplus process water will be treated to meet the water quality specifications provided in the water management report and will be discharged to reservoirs. Process water discharges to watercourses will be avoided.	SWMP - Section 5.3.1, Table 5-3: SW22
Changes to reservoir water quality due to plug removal within the reservoirs	WM11	The specifications and locations of the proposed environmental measures will be determined as part of detailed design, including the installation of silt curtains. They will be designed such that water quality criteria is agreed with the regulators, with the application of a mixing zone if required.	SWMP - Section 5.9, Table 5-3: SW66

Impact	Reference	Environmental Management Measures	Where addressed
Reservoir bed sediments are disturbed by commissioning water flows	WM12	Investigations to minimise the disturbance of bed sediments due to water flows during commissioning will be undertaken as part of detailed design. Potential measures to minimise the disturbance of bed sediments include: • investigate mitigated design measures; • dredging sediments from the potential disturbance zones and placing them in another part of the reservoir; and/or • armouring the sediments in the potential disturbance zones. These options are currently being assessed.	SWMP - Section 5.9, Table 5-3: SW67
Flooding	WM13	Further consideration of flooding conditions and impacts, including flood modelling where necessary, will be undertaken to support future detailed design of both temporary and permanent works.	SWMP - Section 5.2, Table 5-3: SW18
Flooding	WM14	Flood emergency response plans will be developed for both construction and operational phases	Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090)
Impacts to aquatic habitats	AE02	Bridges or culverts would be designed and constructed in accordance with NSW DPI fish passage requirements for waterway crossings (Fairfull & Witheridge 2003) where practicable.	Aquatic Habitat Management Plan (S2-FGJV-PLN-009)
Impacts to aquatic habitats	AE03	Construction works within the channel of a permanent waterway with type 1 or 2 key fish habitat would allow some flow to maintain fish passage at all times and be staged to minimise the total disturbance at any given time.	Aquatic Habitat Management Plan (S2-FGJV-PLN-009)
Soil erosion and sedimentation	SOIL03	Site-based Erosion and Sediment Control Plans (ESCPs) will be prepared or reviewed by a Certified Professional in Erosion and Sediment Control (CPESC) for the construction works.	SWMP – Section 5.1, Table 5-3: SW04
Water Supply	HAZ06	Water supply requirements for firefighting, including the provision of hydrants and hose reels, is designed, constructed in accordance with the relevant Standards and PBP 2018.	Water supply is discussed in WMP Section 2.5.3, SWMP Section 2.5.3 and GMP Section 2.5.3. Construction firefighting requirements are identified in Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090)

Table 2-3: Exploratory works (SSI 9208) revised environmental management measures relevant to water

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Impacts to aquatic habitat and biota during dredging and subaqueous placement	ECO15	1	The subaqueous placement monitoring program for Talbingo Reservoir will be developed and implemented.	Spoil Management Plan (S2-FGJV-PLN-0019) Aquatic Habitat Management Plan (S2-FGJV-ENV-PLN-0032)	
		2	Measures relevant to aquatic ecology will be implemented as described below including: • monitoring of water quality indicators including turbidity, pH and dissolved oxygen within and downstream of the construction area and, if a decline in water quality is detected as a result of the works, investigate potential causes and develop and implement an appropriate response;	SWMP – Annexure A, Table 5-3: SW68	
		3	Measures relevant to aquatic ecology will be implemented as described below including: • the extent of the placement area will be minimised as far as practicable;	Spoil Management Plan (S2-FGJV-PLN-0019)	
		4	Measures relevant to aquatic ecology will be implemented as described below including: • the extent of the dredge footprint will be minimised as far as practicable;	A dredge management plan will be prepared for dredging associated with exploratory works prior to undertaking dredging	
		5*	Measures relevant to aquatic ecology will be implemented as described below including: • subaqueous placement would not occur shallower than 3 m below minimum operating level (i.e. where aquatic habitat, such as aquatic plants are less likely to occur);	Spoil Management Plan (S2-FGJV-PLN-0019)	Main works excavated materials management stipulates placement of drill and blast material in the reservoirs within active storage between minimum operating level and full supply level (RTS Appendix O page 55)
		6	Measures relevant to aquatic ecology will be implemented as described below including: • placement of large rocks within the placement area will occur and is expected to enhance the value of this habitat for fish and mobile invertebrates by providing hard surface and refuges;	Spoil Management Plan (S2-FGJV-PLN-0019)	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
		7	Measures relevant to aquatic ecology will be implemented as described below including: • un-necessary noise and vibration disturbances should be kept to a minimum where practicable to avoid impacts to fish and other aquatic species;	Aquatic Habitat Management Plan (S2-FGJV-ENV-PLN-0032)	
		8*	Measures relevant to aquatic ecology will be implemented as described below including: • removing wood debris from within the dredge footprint and subaqueous placement location and spreading it back into the reservoir in relatively shallow water (0-10 m) where fish are more likely to occur;	Threatened Fish Management Plan	Main Works Sch 3, CoA 24 (f) prevails.
		9*	Measures relevant to aquatic ecology will be implemented as described below including: • where feasible, mapping/identification of aquatic habitats within and adjacent to the subaqueous placement areas and other reference areas to characterise the habitat and place this in context of that present throughout the entire reservoir; and	Aquatic Habitat Management Plan (S2-FGJV-ENV-PLN-0032)	Aquatic habitats identified in RTS Appendix H, item 12 and submission response 27
		10	Measures relevant to aquatic ecology will be implemented as described below including: • mapping of aquatic habitats would include searches for crayfish burrows along the shoreline, as these could indicate the presence of Murray crayfish and would inform the final placement area extent. Deployment of crayfish traps along the shorelines adjacent to the placement area and within the placement area could be used to re-locate any large mobile invertebrates (including any Murray crayfish) from these areas to nearby sections of the reservoir that would not be affected by placement;	Aquatic Habitat Management Plan (S2-FGJV-ENV-PLN-0032)	
		11	Measures relevant to aquatic ecology will be implemented as described below including: • prior to commencement of seismic surveys, smaller releases of compressed air will be undertaken just below the surface;	Aquatic Habitat Management Plan (S2-FGJV-ENV-PLN-0032)	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
		12	Measures relevant to aquatic ecology will be implemented as described below including: • during seismic surveys, operators will be vigilant to potential harm to fish and invertebrates. If any harmed or dead biota are observed during works then this would result in the scaling back of works or review and adjustment of methodology (e.g. magnitude, frequency and/or duration of releases);	Aquatic Habitat Management Plan (S2-FGJV-ENV-PLN-0032)	
Erosion and sediment transport	SOIL02	1	Erosion and sedimentation controls will be implemented as part of the Water Management Plan to minimise erosion potential in accordance with the guideline Managing Urban Stormwater, Volumes 1 and 2, or equivalent.	SWMP – Section 5.1, Table 5-3: SW03, SW04	
Flood risks	FM1.1	1*	Camp and Wallaces bridges will be designed in accordance with AustRoads bridge design standards which require the bridge deck soffit to be located above the 1% AEP flood level;	This scope of works has been completed.	Not required as part of Main Works, completed in Exploratory Works.
Leaching/ running into groundwater/ creeks	WAT01	1	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • minimising direct access to the river by construction vehicles and mechanical plant;	SWMP - Section 5.4, Table 5-3: SW36, SW37, SW38, SW39, SW40 and SW41, Annexure C (Spill Response Procedure) GMP - Section 5, Table 5-1: GW02, GW06, GW07, GW08	
		2	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • regular inspection of construction vehicles and mechanical plant for leakage of fuel and /or oils;		
		3	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • establishing a bunded area for storage of fuel and oils;		
		4	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • refuelling and maintenance of vehicles and mechanical plant at least 50 m from watercourses;		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
		5	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • avoiding as far as possible re-fuelling, washing and maintenance of land-based vehicles and plant within 50 m of watercourses;		
		6	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • reporting spillages to the appropriate officer and immediately deploying spill containment and / or absorption kits as required to restrict its spread;		
		7	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • vehicles, vessels and plant would be properly maintained and regularly inspected for fluid leaks;		
		8	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • emergency spill kits will be kept onsite, at refuelling areas and on all vessels at all times during the Exploratory Works. The spill kit will be appropriately sized for the volume of substances on the vessel. All staff would be made aware of the location of the spill kit and trained in its use;		
		9	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • if any hydrocarbon spills were to occur during soil stripping, the impact will be isolated and clean-up procedures implemented;		
		10	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • areas to be used for long-term storage and handling of hydrocarbons and chemicals will be enclosed with concrete bunds;		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
		11	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • chemicals will be handled and stored as per manufacturer's instructions; and		
		12	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • below ground, refuelling will be undertaken in dry, enclosed, bunded areas;		
Surface and groundwater	WAT02	1	A Surface and Groundwater Monitoring Program will be developed and implemented to monitor the effectiveness of water quality controls.	WMP GMP	
		2	The program will include: • establish monitoring locations to provide suitable baseline and detection monitoring of surface and groundwater parameters;	SWMP – Annexure A GMP – Annexure A	
		3	The program will include: • monitor groundwater inflows indirectly through the process water system and groundwater levels as well as groundwater quality during construction; and	GMP – Annexure A	
		4	The program will include: • set out annual monitoring requirements for Yarrangobilly Caves and plant community types potentially reliant on groundwater.	GMP – Annexure A Biodiversity Management Plan (S2-FGJ-ENV-PLN-0008)	
	WAT03	1	Areas of groundwater inflow will be shotcrete or sealed by other methods to minimise further ingress.	GMP – Section 5.1.4, Section 5.1.5 and Table 5-1: GW05	
	WAT03	2	If groundwater is intercepted and reductions to groundwater inflows to watercourses predicted, then groundwater should be discharged to waterways. This would occur following appropriate treatment of discharge water.	GMP – Section 5.3 and Table 5-1: GW13	
Impacts from barge access construction	WAT04	1*	A dredge environmental management plan (DEMP) and associated mitigation measures will be implemented for dredging and construction of barge access infrastructure including:	A dredge management plan will be prepared for dredging associated with exploratory	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
		2	including: • a water quality monitoring program at the dredge area prior to, during and following completion of dredging and barge access infrastructure construction works;	works prior to undertaking dredging.	
		3	including: • installation of silt curtains around dredging and active construction work areas within waterways;		
		4	including: • selecting uncontaminated granular fill with less than 2% fines and selecting granular bedding material;		
		5	including: • ensuring skip bins for land disposal of excavated material are watertight;		
		6	including: • all activities would be carried out in a manner that minimises the potential for leaks and spills and in compliance with waste handling and disposal procedures outlined in the DEMP;		
		7	including: • establishing a bunded area and sediment and erosion control measures around the land disposal area;		
		8	including: • subaqueous placement of dredge spoil will include the mitigation measures described in WAT17;		
		9*	including: • subaqueous placement of any dredged material would be in a confined placement location rather than spreading the material across a wider section of the reservoir bed;		
		10	including: • a silt curtain would be placed around the backhoe dredger or other suitable equipment at the dredge area; and		
		11	including: • the dredged material once placed on barges would not be drained at the dredging site. Barges for subaqueous placement and skip bins for land placement would be watertight.		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Spills of hydrocarbons	WAT11	1	Procedures to address spills and leaks will be developed and implemented as part of the CEMP.	SWMP – Section 5.4, Table 5 3: SW36, Annexure C (Spill Response Procedure)	
Controls for construction disturbance areas	WM1.1	1	The following controls will be applied to the design of the clean water management system: • where practical, all clean water will be diverted around or through water management areas. Runoff from clean water areas that cannot be diverted must be accounted for in the design of water management systems;	SWMP – Section 5.1, Table 5-3: SW07	
	WM1.2	1*	The following controls will be applied to the design of the clean water management system: • All permanent clean water drainage will be designed and constructed to convey the 1% AEP peak flow and will have adequate scour protection. Temporary clean water drainage will be designed to convey the 50% AEP peak flow;	Not applicable	Main Works Sch 3, CoA 30(b)(c) prevail.
	WM1.3	1*	The following controls will be applied to the design of the clean water management system: • where practical, diversions will seek to avoid materially increasing flow rates in adjoining watercourses; and.	Not applicable	Main Works Sch 3, CoA 30(b)(c) prevail.
	WM1.4	1	The following controls will be applied to the design of the clean water management system: • Where practical, the permanent diversion of drainage lines or watercourses using contour drains will be avoided.	SWMP – Section 5.1, Table 5-3: SW61	
	WM2.1	1*	An Erosion and Sediment Control Plan (ESCP) will be prepared for each construction area.	SWMP – Section 5.1, Table 5-3: SW03, SW04, SW05	Main Works REMM SOIL03, WM03, WM04 and WM05 prevail
		2	Each ESCP will: • consider local soil characteristics, clean water management and the proposed construction methods;		
		3	Each ESCP will: • apply all practical source control and rehabilitation methods; and		
		4	Each ESCP will: • be progressively amended as required during construction.		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
		5	Each ESCP will: • A suitably qualified erosion and sediment control expert will be commissioned to develop and execute each ESCP. The expert will be responsible for overseeing the development of the ESCP and inspecting and auditing controls during implementation. Regular expert input will ensure that erosion and sediment control practices will be established and operated to a high standard and progressively improved.		
	WM2.7	1*	Where appropriate, sedimentation basins will be constructed in accordance with the methods recommended in Managing Urban Stormwater: Soils and Construction: Volume 1 (Landcom 2004) and Volume 2D (DECC 2008). Water treatment chemicals will be applied to sedimentation basins with catchment areas greater than 2,500 m^2 to enhance sedimentation and phosphorus and dissolved metal removal rates. Only water treatment chemicals that have a low risk of increasing the toxicity of treated stormwater will be used. Water treatment chemicals will be applied using an automated chemical dosing and mixing system. The design treatment rate will be the 1-year ARI peak flow.	SWMP – Section 5.1, Table 5-3: SW03, SW04	Revised Main Works SWMP does not include automated chemical dosing systems using alum based PAC due to agency concerns with this methodology for sedimentation basins.
	WM2.2	1	The clean water management controls WM_1.1 to 1.4 apply to all ESCPs.	SWMP – Section 5.1, Table 5-3: SW07, SW08	Main Works Sch 3, CoA 30(b)(c) prevail.
	WM2.3	1	Stockpiles will be located where they are not exposed to concentrated or flood flow. Flood flow is defined as the 20% AEP flood extent. Monitoring for dispersion and erosion of soil stockpiles will be undertaken, particularly on moderately dispersive soils. Addition of ameliorants, such as gypsum and organic matter for dispersive soils will be undertaken as needed.	SWMP – Section 5.2, Table 5 3: SW07 Spoil Management Plan (S2-FGJV-ENV-PLN-0019)	
	WM2.4	1	Soils will be lightly scarified on the contour to encourage rainfall infiltration and minimise run-off. As soon as practicable after respreading, a cover crop will be established to limit erosion and soil loss. This will also provide good mulch for native plant establishment.	SWMP –Table 5-3	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
	WM2.5	1	Sediment traps or filters will be maintained at all discharge locations. The filters will only use non-toxic or materials which will not cause material harm to the environment, including biodegradable or natural materials where practicable. Sediment traps, filters and other appropriate sediment control devices will be installed to target the removal of coarse sediments.	A combination of sediment basins, treatment basins, water treatment drains will be utilised to limit course sediment discharging into adjacent water courses.	
Additional controls for construction areas that are constrained by terrain or the proposed disturbance boundary	WM2.6	1*	Runoff from construction areas that are constrained by terrain or the proposed disturbance boundary and are larger than 2,500 m^2 will be captured in a sump and pumped to a water treatment plant. The water treatment plant will use water treatment chemicals to enhance sedimentation and phosphorus and dissolved metal removal rates using an automated chemical dosing system. Only water treatment chemicals that have a low risk of increasing the toxicity of treated stormwater will be used. The design dewatering and treatment rate will be the 1 in 3-month average return interval (ARI) peak flow	SWMP – Section 5.1, Table 5-3: SW03, SW04	Disturbed areas are directed to sediment basins in accordance with the blue book, and will be managed to avoid discharge to the environment (passively or via water treatment plant systems)
Additional controls for construction areas that are not constrained by terrain	WM2.8	1	When practical, water captured in sedimentation basins will be used for dust suppression.	SWMP – Section 5.1, Table 5-3: SW14	
Water management controls for access roads Controls for all access roads	WM3.1	1*	Sections of Lobs Hole Road that will no longer be required following the construction of the new access roads will be removed and rehabilitated. This will reduce associated sediment loads;	SWMP – Section 5.5, Table 5 3: SW42, SW43, SW44, SW45, SW01, SW46	Main Works converts Lobs Hole Road to a two way road and all areas will be managed as part as final design. There are no sediment basins on Lobs Hole Ravine road due to steep terrain and to minimise clearing impacts on threatened species habitat (WM3.6).
	WM3.2	1	• all cut and fill batters will be stabilised as soon as practicable;		
	WM3.3	1	• the clean water management controls WM_1.1 to 1.4 will apply to the design of all access roads.		
	WM3.4	1	• access road surfaces will be maintained with appropriate aggregate material to reduce the risk of erosion;		
	WM3.5	1	• where practicable and safe to do so access roads will be single cross fall and will grade to a table drain located against the toe of the cut batters. The drains will be stabilised by rock armouring as required;		
	WM3.6	1	• where appropriate, the sedimentation basins established to manage runoff during construction of the access roads will be maintained during the Exploratory Works to provide ongoing treatment of runoff from access roads;		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Additional controls for access roads that are not constrained by terrain or the proposed disturbance footprint.	WM3.7	1*	The sedimentation basins established to manage runoff during construction of the access roads will be modified to be constructed wetland style basins. Constructed wetland style basins will maintain permanent water. An extended detention zone will be established above the permanent water. The extended detention zone will drain slowly through a low flow outlet control. Where practical, runoff from road embankments that have been stabilised by vegetation will be diverted into the clean water drainage system to minimise the contributing catchment area to the constructed wetlands. This will increase the effective size of the basin (in terms of depth of rainfall captured) and will result in a treatment volume that is greater than the 5 day 85th percentile volume that is proposed for sedimentation basins for construction areas.	Main Works converts Lobs Hole Road to a two way road and all areas will be managed as part as final design. There are no sediment basins on Lobs Hole Ravine road due to steep terrain.	Main Works converts Lobs Hole Road to a two way road and all areas will be managed as part as final design. There are no sediment basins on Lobs Hole Ravine road due to steep terrain.
Water management controls for the accommodation camp	WM4.1	1*	A stormwater management plan will be prepared as part of the detailed design of the project. The plan will consider geotechnical constraints including shallow soils.	SWMP – Section 5.6, Table 5-3: SW47, SW48, SW49	Implemented for the Exploratory Works Lob Hole Accommodation Camp.
	WM4.2	1	Clean water from upslope areas will be diverted around the accommodation camp.		
	WM4.3	1	A piped drainage system will be established to capture stormwater and convey it to the proposed water quality improvement ponds. The drainage system will have a 20% AEP capacity. Overland flow paths will be provided as required.		
	WM4.4	1	All pervious areas including batters will be vegetated with endemic native vegetation where practicable.		
	WM4.5	1	Runoff from roof areas will be collected in rainwater tanks where practicable. Captured water will be used for non-potable uses, reducing runoff volumes.		
	WM4.6	1	Source controls including permeable pavers and rain gardens will be used where practicable.		
	WM4.7	1	All runoff from the accommodation camp will be treated in water quality improvement basin(s). The basin(s) will be designed as constructed wetlands where practicable and will provide a water quality improvement function and attenuate peak runoff rates from the accommodation camp.		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
	WM4.8	1	Collectively, the stormwater controls will be sized and configured to achieve the water quality specifications provided in SWA Table 6.12.		
	WM4.9	1	The water quality improvement pond batters will be established using retaining structures or other suitable measures to avoid disturbance of the Watercourse 3 channel.		
Water management controls for the portal construction pad	WM5.1	1*	A stormwater management plan will be prepared as part of the detailed design of the project. The plan will be integrated with the process water system.	SWMP - Table 5-3: SW39, SW07, SW04, SW13	Implemented for the Exploratory Works portal construction pad.
	WM5.2	1	Where practical, all activities that will occur on the portal construction pad with potential to contaminate stormwater runoff will be isolated from the stormwater system through the use of covering (i.e. by a building or roof) and bunding. Water produced within the covered and bunded areas will be either: • managed by the process water system; or • disposed as liquid waste to an appropriate facility.		
	WM5.3	1	Clean water from upslope areas will be diverted through or around the portal construction pad in a designated clean water drainage system.		
	WM5.4	1	A piped drainage system will be established to capture stormwater and convey it to the water management basin. The drainage system will have a 1% AEP capacity. Overland flow paths will be provided as required.		
	WM5.5	1	All aggregate storage and stockpile areas will be bunded to prevent stormwater ingress. Runoff from these areas will be treated in sediment wedge pits or other sediment controls to remove all coarse material. Sediment wedge pits will overflow into the piped drainage system.		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
	WM5.6	1*	All runoff from the portal construction pad and adjoining access road will be conveyed to a water management basin with adequate capacity for at least a 5 day 95th percentile rainfall event and include additional volume to accommodate required water quality treatments (i.e. a total volume of at least 3,750 m^3). The basin will provide a water quality improvement function. Water captured in the basin will be extracted to supply the process water system. Water treatment chemicals will be applied to the water management basin to enhance sedimentation and phosphorous and dissolved metal removal rates. Only water treatment chemicals that have a low risk of increasing the toxicity of treated stormwater will be used. Water treatment chemicals will be applied using an automated chemical dosing and mixing system. The system will be designed to meet the water quality specifications provided in SWA Table 6.16. The design treatment rate will be the 1-year ARI peak flow.		Disturbed areas are directed to sedimentation basins in accordance with the blue book, and will be managed to avoid discharge to the environment (passively or via water treatment plant systems)
	WM5.7	1	The water management basin will be designed to provide a freeboard between its overflow pipe and spillway. The freeboard volume will be calculated to contain probable leaks, spills and firewater runoff volumes. The overflow pipe will have a manual shutoff valve that will enable site management to shut off the overflow pipe to enable the basin to contain any leak, spill or fire water runoff.		
Water management controls for the process water system	WM6.1	1	A process water management system will be established to manage any potentially contaminated water that may be produced by the construction activities.	SWMP – Section 5.3.1, Table 5-3: SW22	
	WM6.2	1	The process water management system will be separated from the stormwater system to avoid uncontrolled overflows associated with stormwater ingress.	SWMP – Section 5.3.1, Table 5-3: SW24	
	WM6.3	1*	The process water system will incorporate a water treatment plant that will treat water to a suitable quality for its proposed use in construction activities. If required to meet water quality criteria, additional treatment will be provided for any water that is discharged to Talbingo Reservoir via the controlled discharge pipeline. This treatment system will meet the water quality specifications provided in Table 4.5 of the RTS.	SWMP – Section 5.3.1, Table 5-3: SW22	This treatment systems will meet the specifications in the Main Works RTS, WMP - Appendix A (SWMP) and EPL.

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
	WM6.4	1*	The process water management system will have the ability to extract water from the portal construction pad's water management basin. This will be done to top-up supply.	SWMP – Section 5.3.1, Table 5-3: SW22	Main Works, process water will be recycled. Water from sediment basins will be used for irrigation and dust suppression.
	WM6.5	1	A reticulation system will be established to enable the process water system to: • extract water from Talbingo Reservoir (as required); and • discharge treated process water into Talbingo Reservoir (as required).	SWMP – Section 5.3.1, Table 5-3: SW22	
Water management controls for the waste water management system	WM7.1	1	Waste water from the accommodation camp will be reticulated to a waste water treatment plant via a sewer system. The sewer system will be designed to restrict stormwater ingress into the waste water system.	SWMP – Section 5.3.2, Section 5.6, Table 5-3: SW32	
	WM7.2	1	Water efficient fittings will be used to minimise waste water loads.	SWMP – Table 5-3: SW34	
	WM7.3	1	Low phosphorus products are to be used for washing activities controlled by site management (i.e. laundry services and mess hall) and encouraged (via education) for general use.	SWMP – Table 5-3: SW50	
	WM7.4	1	The waste water storage system will include emergency storage of untreated waste water. The storage volume will be calculated at detailed design based on analysis of response times from regional waste management contractors to provide emergency trucking and offsite disposal options.	SWMP – Table 5-3: SW30	
	WM7.5	1*	A waste water treatment plant will meet the water quality specifications provided in Table 4.4 of the RTS.	SWMP – Section 5.3.2, Section 5.6, Table 5-3: SW30	This treatment system will meet the specifications in the Main Works RTS, WMP - Appendix A (SWMP) and EPL.
	WM7.6	1	Treated waste water will be disposed to Talbingo Reservoir via the controlled discharge pipeline.	SWMP – Section 5.3.2, Table 5-3: SW30	
Water quality impacts from	WM_8.2	1	During establishment, the water management controls for construction areas (Wm_2.1 to 2.8) will be applied.	SWMP – Table 5-3 Refer to WM_2.1 to 2.8 above	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
rock emplacement areas	WM_8.6	1	Runoff from Lock Hole Gully will be diverted around or through the eastern emplacement area. The diversion works will comprise a dam upstream of the diversion inlet and either a gravity or pump assisted diversion system. The diversion works will have a 1% AEP capacity. The dam upstream of the diversion inlet will be designed as a detention basin and will not permanently hold water. A high-flow diversion drain will be established to convey runoff from Lick Hole Gully around the emplacement area in a controlled manner, avoiding uncontrolled overflows through the emplacement area. This diversion drain will only be engaged if a flood greater than a 1% AEP even occurs.	SWMP – Table 5-3: SW07, SW08	
	WM_8.7	1	Seepage from the eastern emplacement area will be collected in a water management dam. Collected water will either be irrigated to the emplacement (to promote evaporation) or treated in the process water treatment plant. Discharge of seepage water to the Yarrangobilly river will be avoided.	SWMP – Table 5-3: SW15	
Flood risks	FM_1.1	2*	Camp and Wallaces bridges will be designed in accordance with AustRoads bridge design standards which require the: • bridge structure to be designed to withstand a 0.05% AEP event; and	This scope of works has been completed.	This has been completed.
	FM_1.1	3*	Camp and Wallaces bridges will be designed in accordance with AustRoads bridge design standards which require the: • abutments to be protected by appropriately designed scour protection.	This scope of works has been completed.	
	FM_1.2	1	The western emplacement will be designed to prevent the risk of emplacement material being entrained in flood waters during a 1 in 5000 year flood event.	Spoil Management Plan (S2-FGJV-PLN-0019)	
	FM_1.3	1	Flood emergency procedures will be prepared in implemented as part of the Emergency Response Plan.	Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090)	
Borehole drilling	M1.6	1	During borehole drilling slurries used will be of appropriate grade and composition such that it poses no threat to groundwater quality should it infiltrate intersected aquifers.	GMP – Table 5-1: GW08	
Clean water	M1.8	1	Where practicable, all clean water will be diverted around or through sites using cross-path drains or other similar measures to limit impact to existing flow regimes.	SWMP – Section 5.1, Table 5-3: SW07, SW08	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Regrading	M1.9	1	Drill sites that have been modified to allow for vehicle access will be regraded to natural lay of the land as part of the site rehabilitation.	Rehabilitation Management Plan (S2-FGJV-ENV-PLN-0023)	
Refuelling	M1.10	1	A refuelling protocol will be developed for in-reservoir borehole drilling and will be included in the Construction Environment Management Plan (CEMP).	SWMP - Annexure D	
Erosion and sedimentation	M1.11	1	Erosion and Sediment Control Plans will be prepared for all proposed construction sites and drilling pads. These plans will consider local soil characteristics, clean water management and site-specific measures to suit the proposed construction methods.	SWMP – Section 5.1, Table 5-3: SW03, SW04	
Spills	M1.12	1	Geotechnical investigation drilling will be undertaken in accordance with the surface water management plan. The following mitigation measures are included in the existing surface water management plan: • All fuel and hazardous substances used in drilling will be stored in designated areas of the drill pad. Hazardous chemicals will be stored in accordance with relevant standards, including AS 1940:2004. • Designated fuel storage areas will be bunded to mitigate risk of contamination to surface water and soils should spills occur. Refuelling will also be carried out in the designated, bunded area. • Equipment should be appropriately maintained to ensure there are no leaks. • Spill kits will be available on site to contain contamination should any spills outside these bunded areas occur. If used, waste from the spill kits will be disposed of appropriately. • The safety data sheets of all hazardous chemicals required for drilling activities will be made available on site. • All waste produced during drilling will be stored on site in above ground containers, and when required will be taken off-site by vehicles. All waste will be disposed of off-site to an EPA licensed facility.	SWMP - Section 5.4, Table 5 3: SW36, SW37, SW38, SW39, SW40 and SW41, Annexure C (Spill Response Procedure)	
Flooding	M1.13	1	Protocols will be developed for the proposed modification elements for use and storage of plant, equipment and materials in flood prone areas commensurate with the frequency of inundation.	Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090)	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Barge ramp establishment	MOD2 - 001		The following measures will be implemented for barge ramp establishment works at Middle Bay: • all barge ramp construction and dredging works would be closely monitored and carried out according to the Dredge Management Plan, Surface Water Management Plan and Aquatic Habitat Management Plan; • appropriate methods and pre-dredge testing would be implemented to that material is appropriately handled to minimise impacts to aquatic species and habitat; and • removal and subsequent disposal of aquatic macrophytes would be undertaken according to the Dredge Management Plan and / or Waste Management Plan.	A dredge management plan will be prepared for dredging associated with exploratory works prior to undertaking dredging.	

**In accordance with CSSI 9687, schedule 2, CoA 3, if there is any inconsistency between the above documents (Exploratory Works and Main Works), the most recent document will prevail to the extent of the inconsistency (Main Works). However, the conditions of this approval (CSSI 9687) must prevail to the extent of any inconsistency*

2.4. EPBC Approval

The EPBC Act approval for Snowy 2.0 Main Works was granted by DAWE in 2020. This approval was provided for the impact of the Snowy 2.0 Main Works Project on national heritage values of a national heritage place (Sections 15B and 15C of the EPBC Act), listed threatened species and communities (Section 18, Section 18A of the EPBC Act) and listed migratory species (Section 20, Section 20A of the EPBC Act).

Table 2-4 details the EPBC Act Approval conditions which are relevant to water and demonstrates where these conditions are addressed.

Table 2-4: Commonwealth conditions of approval relevant to water

Condition	Requirement	Where addressed
17	To minimise impacts on water resources, the approval holder must comply with conditions 30 – 32 of the NSW approval relating to water management	Refer to Table 2-1
18	The approval holder must prepare the Water Management Plan required by condition 31 of the NSW approval in consultation with the Department, before it is approved by the NSW Planning Secretary	Section 1.7
19	The Water Management Plan must include provisions to make monitoring data (excluding sensitive ecological data) available as part of the monitoring, evaluation and reporting programs required by condition 31c and 31d of the NSW approval	WMP - Appendix A (SWMP) WMP - Appendix B (GMP)
20	Once the Water Management Plan is approved by the NSW Planning Secretary, the approval holder must implement the plan for the duration of the approval, unless otherwise agreed by the Minister in writing.	This WMP will be implemented for the development.

2.5. Licences and Permits

2.5.1. Environment Protection Licence

Environment Protection Licence (EPL) (No 21266) has been issued as part of the Exploratory Works phase for extractive activities. The premise boundary for the Exploratory Works EPL will be expanded to encompasses both Exploratory Works and Main Works activities and the governing schedule activity will be Electricity Generation.

The water quality requirements in the Project EPL will be adhered to and includes surface and groundwater monitoring. At times, the water monitoring requirements of the EPL may differ to that detailed within this Plan, particularly in the event of variations to the EPL. Differences may include changes to the monitoring locations; changes to the frequency of monitoring; or changes to the parameters which are required to be monitored.

Should differences arise, the monitoring requirements of the EPL will take precedence. This will occur until such time that the revised WMP is updated and approved.

2.5.2. Agreement for Lease

Snowy Hydro Limited have established an Agreement for Lease (AFL) with NPWS. A Construction Lease and Works Access Licence will be established with NPWS in order to carry the works in accordance with Main Works, Exploratory Works, CSSI 9687 and the approved management plans.

2.5.3. Water Access Licence

Section 60A of the *Water Management Act 2000* requires that a water access licence be obtained to extract water from a water source.

Section 21 and schedule 4 of the *Water Management (General) Regulation 2018* does however provide exemptions for the requirement to obtain water access licences. This includes clause 7, the exemption for water taken in course of certain aquifer interference activities (i.e. pump testing a bore; or monitoring)

Water access licences would therefore not be required if Snowy Hydro, as the licence holder, are using the water for certain aquifer interference activities (i.e. pump testing a bore; or monitoring) with less than 3ML of groundwater take in a water year.

Any other water required for construction purposes would however require a water access licence. This includes extraction for:

- interception activities (i.e. intercepted groundwater during tunnelling);
- potable uses for human consumption associated with the accommodation camp; and
- process water via the services pipeline from Talbingo and Tantangara Reservoirs for tunnelling and construction activities

Snowy Hydro have secured two groundwater access licences (WAL42408, WAL42960) and a surface water specific purpose access licences (WAL42407) for the Exploratory Works Project. These three licences allow for direct and indirect take of water from the Lachlan Fold Belt (LFB) Murray Darling Basin (MDB) Groundwater Source and direct take from the Upper Tumut water source (i.e. from Talbingo Reservoir).

Snowy Hydro are in the process of securing groundwater licences via Controlled Allocation Order for additional share entitlement from the LFB MDB groundwater source (RO13-19-093), the LFB South Coast groundwater source (RO13-19-192) and a surface water specific purpose access licence (to take water from Tantangara Reservoir) for the Main Works Project. The additional allocation covers the peak predicted annual take modelled for both Main Works and Exploratory Works.

These Water Access Licenses are being processed by the Natural Resources Access Regulator (NRAR) and registration with NSW Land Registry Services (LRS) has commenced. Actual take will be reported to NRAR on an annual basis in accordance with licence conditions.

Table 2-5 summarises the licencing arrangements.

Table 2-5: Water licences

Water Access Licence	Project	Water source	Share (ML)
WAL42407– Specific Purpose Access Licence	Exploratory Works	Upper Tumut water source	227
WAL42408 – Groundwater Licence	Exploratory Works	Lachlan Fold Belt MDB	0
WAL42960 – Groundwater Licence	Exploratory Works	Lachlan Fold Belt MDB	354
RO13-19-093 – via Controlled Allocation	Main Works	Lachlan Fold Belt MDB	3,375
RO1-19-092 – via Controlled Allocation	Main Works	Lachlan Fold Belt South Coast	1,722
Specific Purpose Access Licence (under application)	Main Works	Tantangara Water Source	In progress

2.6. Guidelines

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

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000);
- Managing Urban Stormwater: Soils and Construction (Landcom, 4th Edition March 2004 (reprinted 2006) (the “Blue Book”)) Volume 1 and Volume 2;
- Approved Methods for the Sampling and Analysis of Water Pollutants in NSW – March 2004.

The management plans appended to this Plan contain additional guidelines applicable to their respective aspects. Other reference documents include:

- *Snowy 2.0 Environmental Impact Statement Volume 3, Appendix J, Water Assessment Annexure A, September 2019;*
- *Snowy 2.0 Main Works - Preferred Infrastructure Report and Response to Submissions,* Appendix I, *Revised Water Modelling Report, February 2020;* and
- *Snowy 2.0 Main Works - Preferred Infrastructure Report and Response to Submissions,* Appendix J, *Revised Water Management Report*, February 2020

3. EXISTING ENVIRONMENT

3.1. Topography and Landscape

The Snowy 2.0 Project is mostly located within the KNP and spans the NSW Western Slopes, South Eastern Highlands and Australian Alps Interim Biogeographic Regionalisation for Australia (IBRA) regions. The geomorphic history of the project area is complex and has resulted in a landscape of disrupted drainage patterns, swampy basins and erosion surfaces (Snowy Hydro 2017). This complexity is seen in the diverse landforms present in the area, ranging from valleys to mountain ranges. For the most part, the project area can be broken into two distinctive terrains the incised ravine area and the plateau area.

The ravine area; located mostly to the west of the Snowy Mountains Highway, is characterised by deep gorges and steep sloping ridges, the product of incision from river flow, historic glaciation and structural movement. The ravine area includes the Talbingo, Lobs Hole and Marica work zones.

The plateau area; located to the east of the Snowy Mountains Highway and spanning the area between the highway and Tantangara Reservoir, is typical of elevated alpine environments, dominated by low energy streams, gentle rolling hills and mostly flat floodplains. The plateau area includes the Plateau and Tantangara work zones.

The landscape varies from 545m AHD in the Ravine area (Lobs Hole) leading up the valleys (Marica/ Plateau zones) to the plateau topped Tantangara zone at 1524m AHD.

The Rock Forest work zone is located on farm land south east of the KNP.

3.2. Geology

The project area is located within the south-eastern portion of the Lachlan Fold Belt (LFB) of NSW. The LFB comprises a suite of Ordovician to Devonian sedimentary, igneous and metamorphic rocks that have developed during multiple orogenic periods.

The geology between Talbingo and Tantangara reservoirs (Table 3-1:) is structurally deformed with numerous folds and several major faults associated with the north-south trending Long Plain Fault (LPF) zone.

The project intercepts two major structural blocks. These two structural blocks form distinct geological terrains; the dominantly Silurian Tumut Block in the west (the ravine area), and the dominantly Ordovician Tantangara Block in the east (the plateau area). The terrains are separated by an escarpment caused by movement on the LPF.

The key geological formations for each block are shown in Table 3-1: and Figure 3-1:.

Table 3-1: Key geological formations

Plateau	Ravine
Tertiary Basalt, Kellys Plain Volcanics, Boggy Plain Suite, Peppercorn Formation, Tantangara Formation, Temperance Formation, Shaw Hill Gabro and the Gooandra Volcanics	Boraig Group, Byron Range Group, Ravine Beds and Yarrangobilly Limestone. Within the Tantangara Block

There are eight karst areas in KNP, all of which are developed in Silurian or Devonian limestones. These include Yarrangobilly Caves, a known groundwater dependent ecosystem (GDE) and karst area, and Coolemans Plain karst area; both are recognised in the KNP Plan of Management (DEC 2014) for their cultural and natural significance.

This complex geology, in association with topography, has resulted in a diverse soil landscape. Soils vary significantly in relation to altitude, temperature and rainfall.

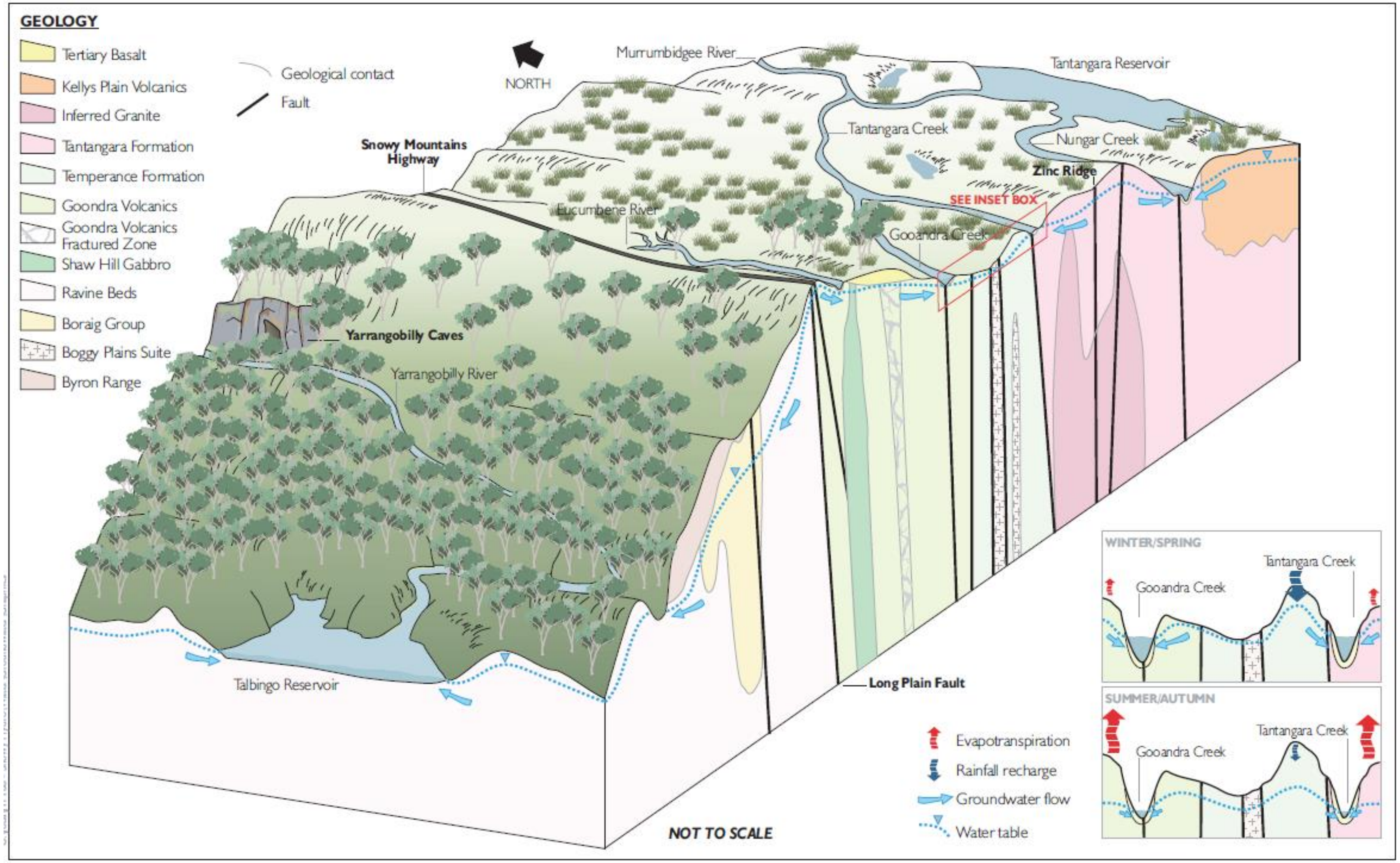


Figure 3-1: Conceptual geological block diagram (EMM, 2019)

3.3. Climate

The project area has an alpine climate that is characterised by cool summers and cold, damp, and snowy winters. The highest and most consistent precipitation occurs in winter to early spring, with precipitation amounts increasing with elevation. Summer and autumn are generally drier and experience greater variation in monthly rainfall. Summer rainfall is generally of higher intensity and of shorter duration than in winter. Climate data for the project area has been sourced from regional Bureau of Meteorology (BoM) and Snowy Hydro rainfall gauges, as well as climate maps produced by BoM. A summary of climate data for the ravine and plateau areas is provided in the Surface Water Management Plan (Appendix A).

3.4. Bushfire

In January 2020, during the Main Works EIS application, significant bushfires occurred within the Project area and northern section of Kosciuszko National Park. The project site at Lobs Hole was severely impacted with much of the groundcover and trees burned, leaving the catchment area with bare soil and no ground protection. Other parts of the Main Works project area including the Plateau, Marica and Tantangara were also impacted by the bushfire to varying degrees.

The bushfires have led to a reduction in ground cover and increase in burnt ash material within and adjacent to the construction envelope. It is likely that, for some time, the existing pre-fire baseline water data that has been gathered and discussed in the Surface Water Management Plan (Appendix A) and Groundwater Management Plan (Appendix B) will differ to the post-fire water quality.

3.5. Water Courses

All water courses are defined as receiving baseflow from groundwater (gaining streams). The key watercourses and the baseline water quality and flood characteristics are described below for the ravine area, plateau area and rock forest and are shown in Figure 3-2 and Figure 3-3. The ravine watercourses generally flow to the Talbingo Reservoir and the Plateau watercourses generally flow into the Tantangara Reservoir. Existing water quality characteristics are discussed in the Surface Water Management Plan (Appendix A).

3.5.1. Ravine

Within the ravine, the Yarrangobilly River is the major regional watercourse that flows into Talbingo Reservoir, downstream of Lobs Hole. Its catchment has an area of 271 km^2 that is wholly within the KNP. The Yarrangobilly River has a number of tributaries within the ravine, including Wallaces Creek, Stable Creek, Sheep Station Creek and Highground Creek. The majority of annual stream flow occurs in late winter and early spring, which is typical for rivers in the Australian Alps.

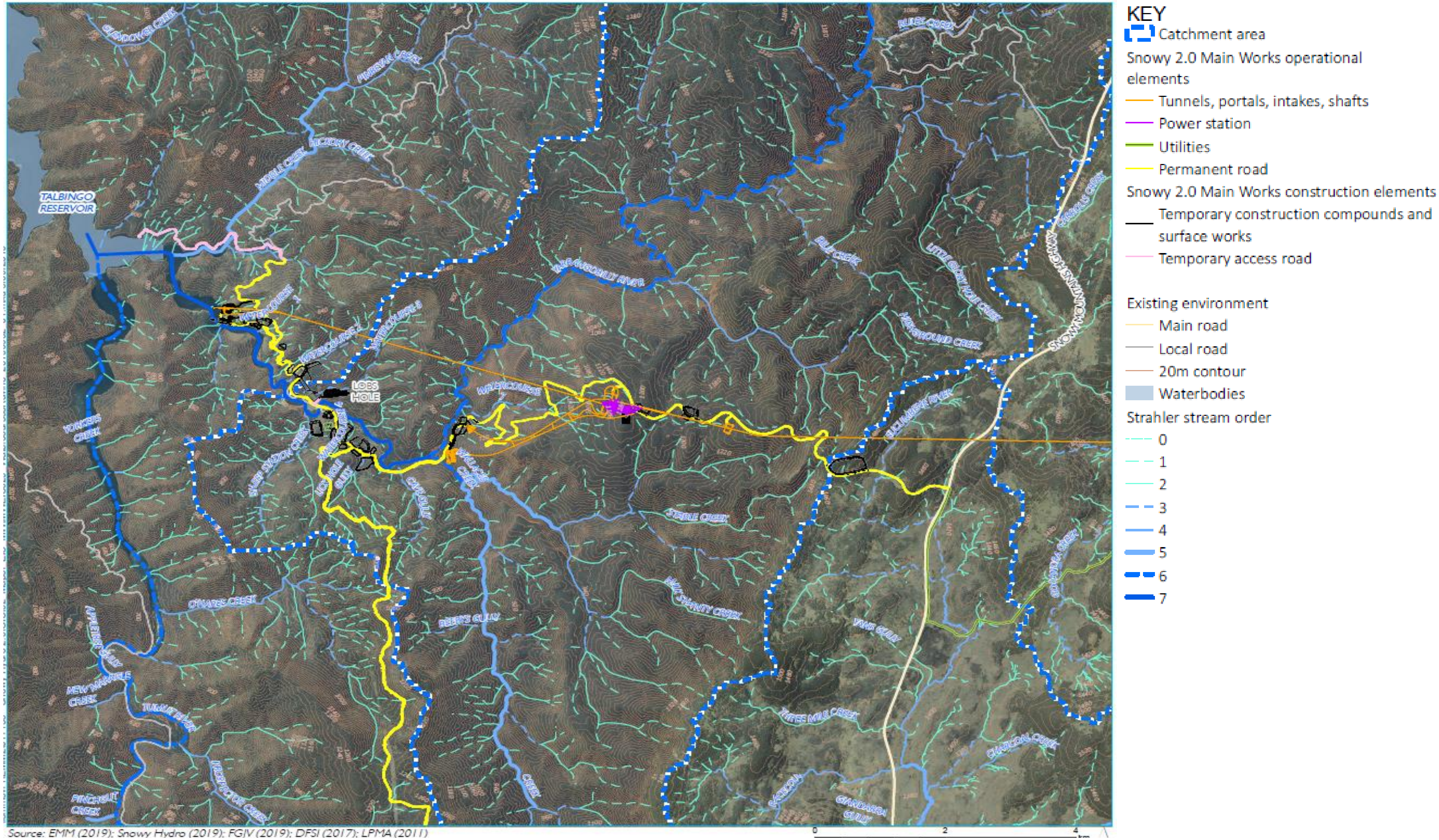
3.5.2. Plateau

The plateau is within the upper reaches of the Murrumbidgee and Eucumbene River catchments, wholly within KNP. The headwaters of the Eucumbene River are in the western plateau, and the river flows in a southerly direction to Lake Eucumbene. The Murrumbidgee River flows from north of the plateau in a south easterly direction into Tantangara Reservoir.

A number of perennial waterways are present across the plateau, that either flow north into the Murrumbidgee River or directly into Tantangara Reservoir, including Gooandra Creek, Tantangara Creek, Nungar Creek and Kellys Plain Creek.

3.5.3. Rock Forest

Rock Forest is in the headwaters of the Goorudee Rivulet catchment, outside of KNP and is nearby to two watercourses, being Camerons Creek and an unnamed 3rd order watercourse.



Source: EMM (2019); Snowy Hydro (2019); FGJV (2019); DFSI (2017); LPMA (2011)

Figure 3-2: Water Courses – Ravine (EMM, 2019)

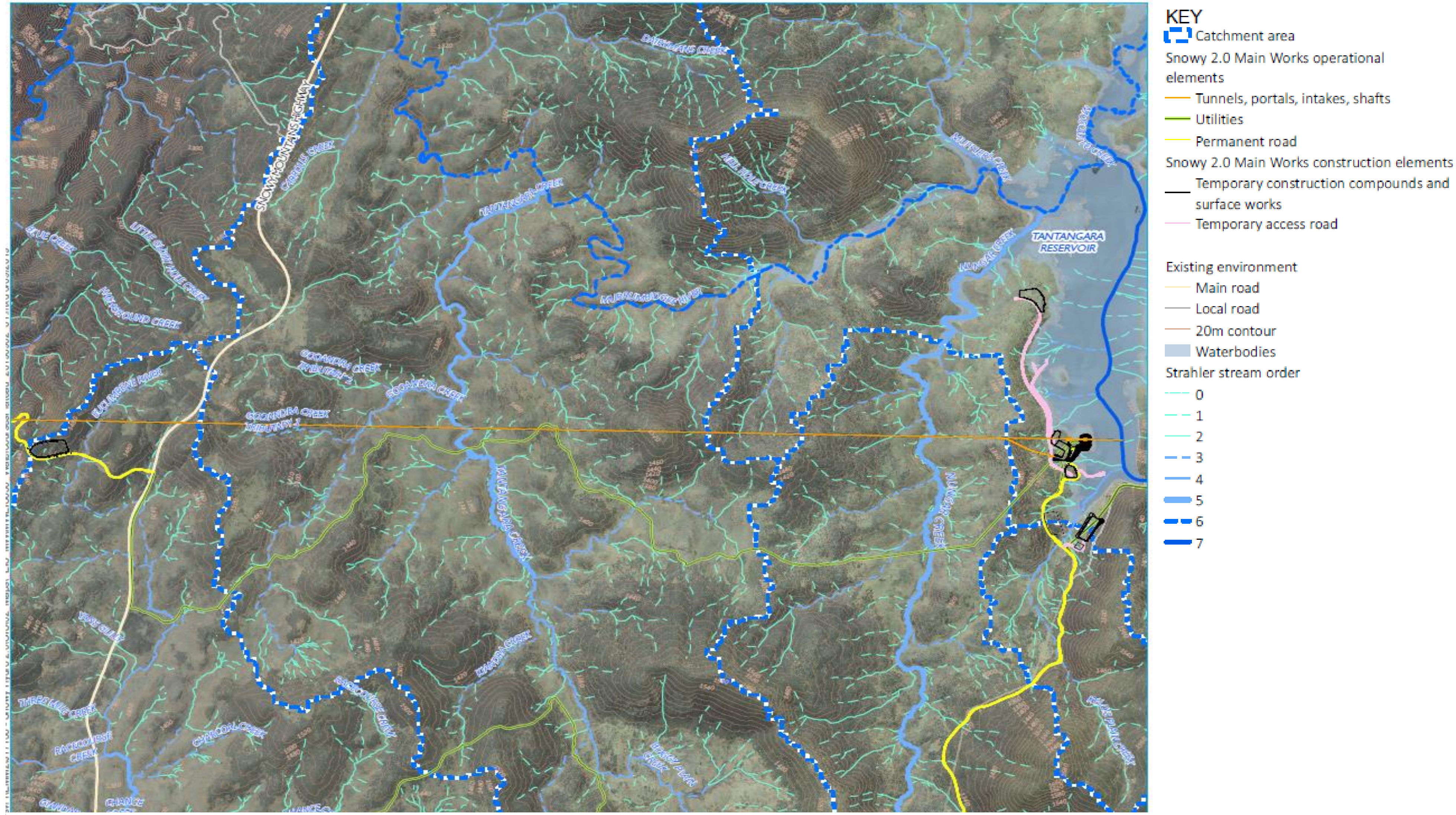


Figure 3-3: Water Courses – Plateau (EMM, 2019)

3.6. Groundwater

The hydrogeological units of the project are:

- alluvium, colluvium and weathered rock: these shallow units are generally recharged by moderate to high rainfall, flooding for alluvial areas and snow melt;
- shallow weathered fractured rock: these units have low to moderate permeability and are recharged by moderate to high rainfall and snow melt (occurring when soil moisture conditions are exceeded); and
- deep fractured rock: recharged by infiltration of rainfall migrating from shallow groundwater systems. Permeability is generally lowest in the central section of the plateau and higher in the east and western areas of the plateau. There is downward flow of groundwater in recharge areas and upward flow in discharge areas.

Measurements from the baseline groundwater monitoring network vary from approximately 1,470 m AHD in the topographically elevated terrain adjacent to the LPF, to approximately 570 m AHD in the topographically lower terrain near Lobs Hole. Groundwater levels may fall outside of this measured range in areas of higher relief and in some of the lower drainage lines, such as the interface between the Yarrangobilly River and Talbingo Reservoir where levels are likely at or close to surface levels of about 545 m AHD.

3.6.1. Ravine

Along the proposed headrace tunnel transect, groundwater levels within the Ravine Beds vary from approximately 1,325 m AHD in the topographically elevated terrain adjacent to the LPF in the east, to approximately 570 m AHD in the topographically lower terrain near Lobs Hole. Groundwater flow direction is generally from east to west, with the LPF area acting as a groundwater divide between the ravine and plateau areas.

Groundwater levels within the ravine do not typically show an obvious response to rainfall events or flow events within the Yarrangobilly River.

3.6.2. Plateau

Along the proposed headrace tunnel transect, groundwater levels vary from approximately 1,470 m AHD in the elevated areas adjacent to the LPF in the west, to approximately 1,170 m AHD in the lower elevated area near Tantangara Creek. Overall, groundwater levels observed along the proposed tunnel alignment indicate that groundwater flow direction is generally west to east from the LPF.

Groundwater levels within the plateau show a moderate to strong response to rainfall events, indicating a moderate to strong connection between surface and the regional groundwater system.

4. WATER MANAGEMENT APPROACH

4.1. Water Management Streams

The four key water management streams for the Project are described in Table 4-1.

Table 4-1: Water management streams

Water management stream	Description	Details of management measures
Stormwater	This refers to surface water runoff from areas disturbed by construction and surface runoff around construction areas (i.e. clean water diversions).	WMP - Appendix A (SWMP)
Process water	This refers to the water supply system for construction activities on the surface and in the tunnel and includes the: • extraction of water from groundwater wells (see Figure 5-1) • extraction of water from reservoirs; • reuse of intercepted groundwater; and • discharge of excess water to the reservoirs.	Water access licencing is discussed in Section 2.5.3. The Project site water balance is discussed in Section 5. Requirements relating to discharges are discussed in the WMP - Appendix A (SWMP). Requirements relating to the groundwater management and monitoring are discussed in WMP - Appendix B (GMP)
Wastewater	This refers to sewage and grey water generated from the accommodation camps and other amenities	WMP - Appendix A (SWMP)
Potable water	This refers to water that has been treated to a potable water standard (i.e. drinking water)	WMP - Appendix A (SWMP)

4.2. Water Reuse

The Project is committed to maximising the reuse and recycling of water. A key mechanism that has been designed is the reuse of process water as much as practicable in order to avoid release into the surrounding water environments.

During tunnelling, intercepted groundwater will be the primary water supply source (i.e. process water) for construction activities. Intercepted groundwater will be pumped to a process water treatment plant and treated. Future Generation will aim to reuse the water from the process water treatments plants in the fire water tanks and the industrial water tank which will be located within the portal / tunnel. This tank will be utilised for in-tunnel activities such as cooling the tunnel boring machine, dust suppression and washing equipment.

Any water that is not able to be reused within the portals / tunnels will be sent to surface tanks for reuse on site. Surface reuse opportunities under the investigation include:

- use in dust suppression on roads;
- wheel wash sites;
- use in compaction of soils;
- use in the emplacement areas;
- general washdown of equipment;
- concreting; and

- establishment of landscaping and rehabilitation.

In addition to process water reuse, stormwater will be harvested from sediment basins wherever practicable and used in water carts.

Further detail regarding the process water supply system is discussed in Section 5.

5. SITE WATER BALANCE

The Project is located in a remote location with no municipal potable water supply available in the area. A water supply system will be established to supply water for potable water use and construction activities. The system is planned to be sourced from licenced groundwater bores (see Figure 5-1) until an extraction pipeline is established to extract raw water for construction use from Talbingo and Tantangara Reservoirs. No surface watercourse extraction is proposed (i.e. the only surface water extraction proposed is from the reservoirs). During tunnelling, intercepted groundwater will become the primary water supply source (i.e. process water) for construction activities.

Treated process water from groundwater ingress into the tunnel will be recycled and re-used back into the tunnel or on site as non-potable water (refer to Section 4.2). Excess treated water that cannot be utilised on site, as well as treated wastewater (sewage) will be discharged via pipe into either the Talbingo or Tantangara Reservoir.

These systems are referred to as the Tantangara and Talbingo systems and will operate independently (i.e. they will not be connected, as delineated in Figure 5-2). Discharges from the treatment systems will be licenced under the Project EPL 21266. During construction, wastewater will be produced at all construction camps and facilities that have amenities.

All water extraction will be appropriately licenced (refer to Section 2.5.3) and required for the scope of works detailed in Section 1.1.2 of this Plan. Should watercourse extraction be required in the future, additional approvals under the Water Management Act would be reviewed and sought as required.

Water extraction (i.e. from groundwater bores, reservoirs and tunnel inflows) and water discharge (i.e. surplus treated process and wastewater) metering will comply with the Australian Standard AS 4747: 'Meters for non-urban supply'. The metering equipment will be installed at water source extraction points and prior to discharge points. Readings will be undertaken manually (the Project are investigating opportunities for electronic monitoring) on an ongoing basis throughout construction (i.e. weekly) and recorded in a project water useage register.

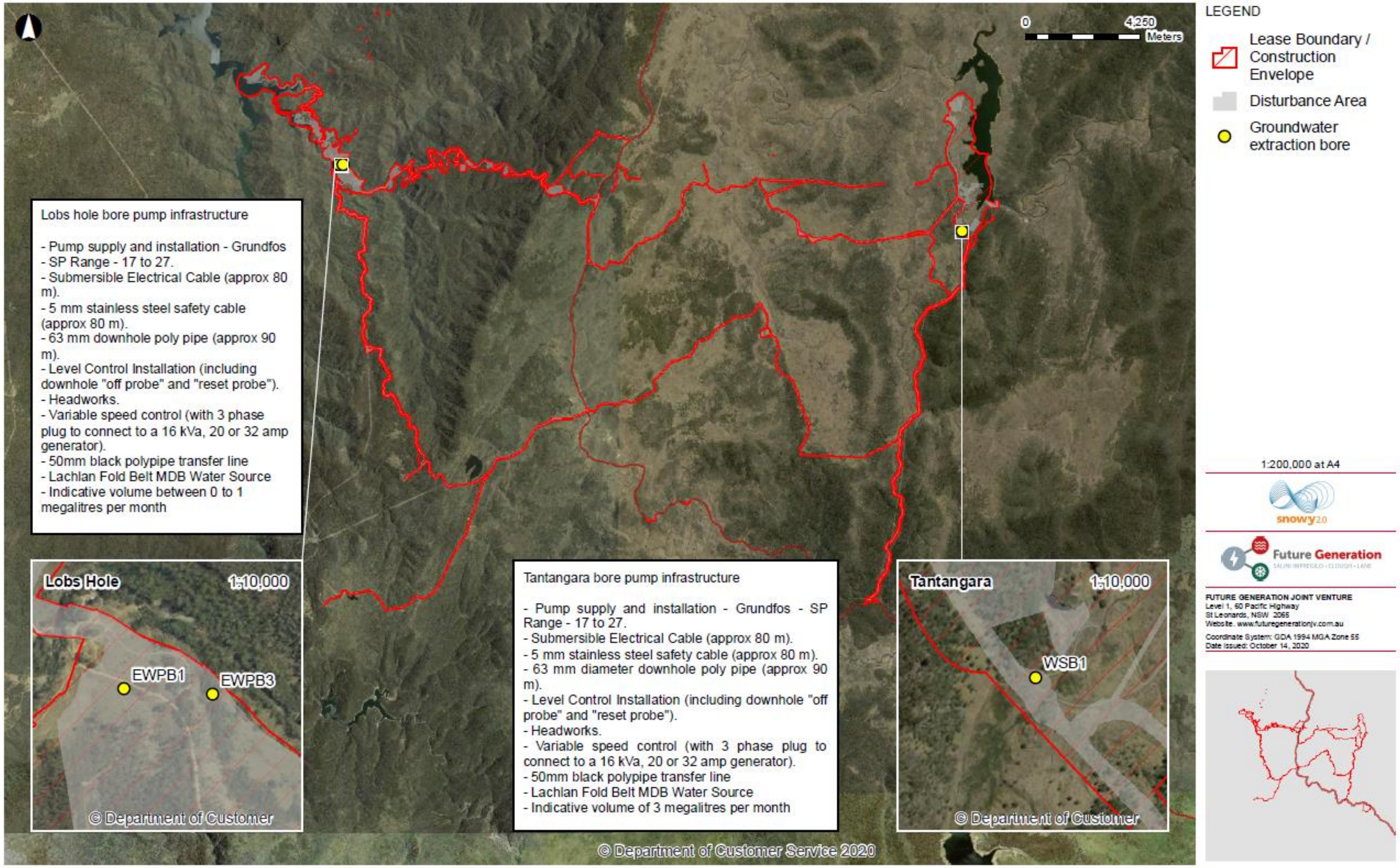


Figure 5-1: Groundwater extraction bores and associated infrastructure

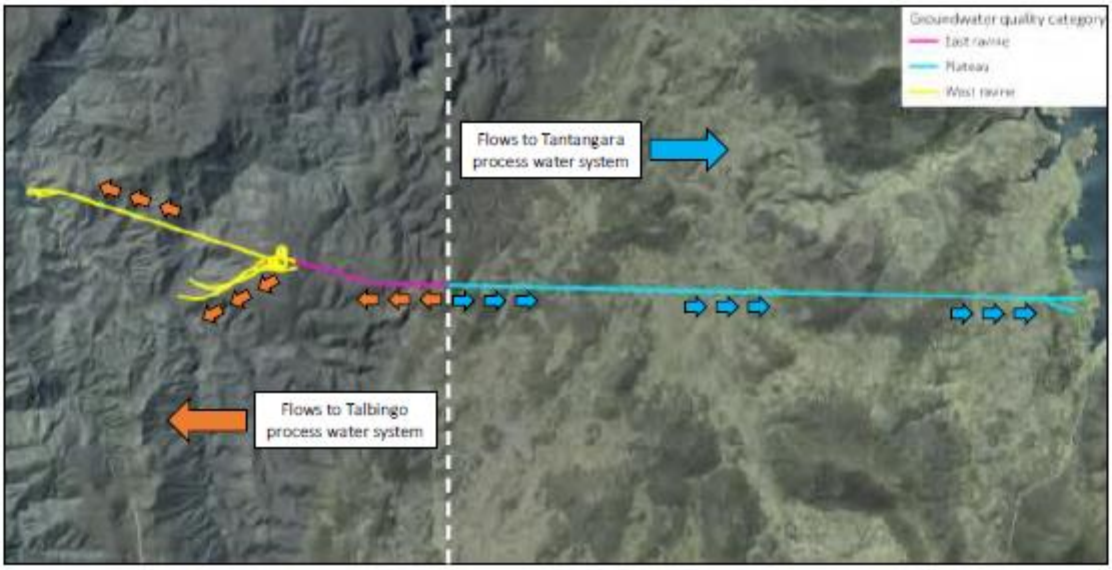


Figure 5-2: Process water system extent (EMM, 2019)

A conceptual overview of the water system with indicative metering locatons is shown in Figure 5-3. All monitoring will be used to track water take in accordance with water access licence requirements and inform the annual revised site water balance.

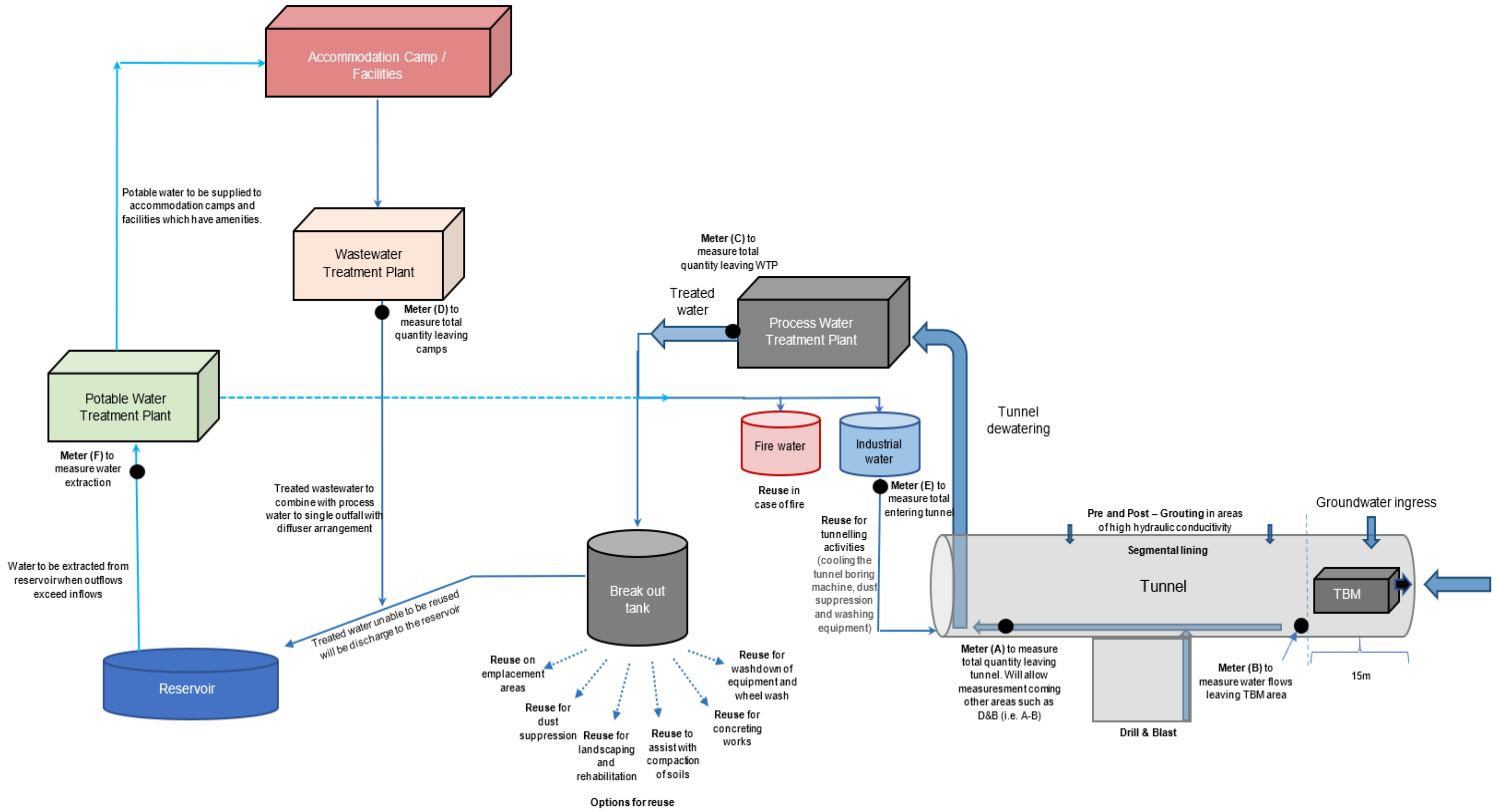


Figure 5-3: Conceptual water management overview (including process water, wastewater and potable water)

A preliminary Site Water Balance (Balance) was completed in the Revised Water Management Report (RTS Appendix J) to estimate the discharge and top-up profiles from the systems over the construction phase of the project. Table 2-1, Figure 5-4 and Figure 5-5 illustrate the following site water predictions;

- The peak discharge from the Tantangara system is expected to occur during the latter end of the construction timeline, with a discharge rate of approximately 3.7 ML/day. From approximately 1.5 years into construction until the start of commissioning the peak discharge from the Talbingo system is estimated to be in the order of 1.3 ML/day;
- The predicted maximum groundwater inflow into the tunnel is 3.9 ML/day in the Tantangara system and 1.2ML/day in the Talbingo system; and
- System top-ups will only be required when net usage exceeds net inflows and will be at peak of 6ML/month for Tantangara and 23 ML/month for Talbingo.

Table 5-1: Peak discharge and top-up rates

Process water system	Peak top-up rate	Peak discharge rate
Tantangara	6 ML/month or 0.2 ML/day	114 ML/month or 3.7 ML/day
Talbingo	23 ML/month or 0.7 ML/day	39 ML/month or 1.3 ML/day

The Balance for month 48 of construction is presented in Figure 5-6 as a snapshot during the construction period. The volume of water that requires management will progressively increase over the tunnel construction period.

The Balance is currently a conceptual model. Future Generation will continue to develop the Balance during construction and the completion of final tunnel design for the purpose of:

- demonstrating the functionality of the process water system;
- estimate the probable range in water transfer volumes; and
- record, update and report on the water transfer volumes each calendar year.

The Balance will be reviewed each calendar year. Where updates are identified, the revised Balance will be updated and included in future revision of this WMP.

This review will involve using monitored quantities to verify predicted quantities, adjust the Balance where required, and provide explanation of any differences between predicted and actual quantities. Any water infrastructure retrospectively added or changes in water access/extraction licences will be included in the revision.

Further details of the Tantangara and Talbingo systems are contained within in Surface Water Management Plan (Appendix A) and Groundwater Management Plan (Appendix B).

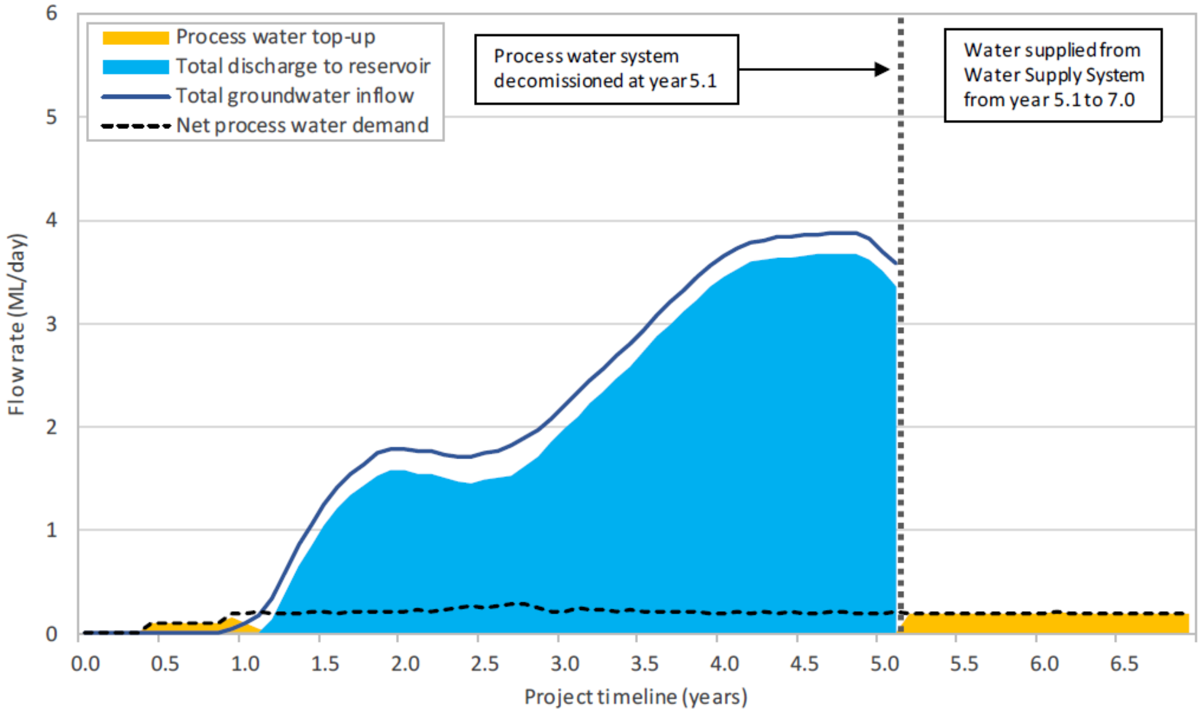


Figure 5-4: Tantangara process water system water balance (EMM, 2020)

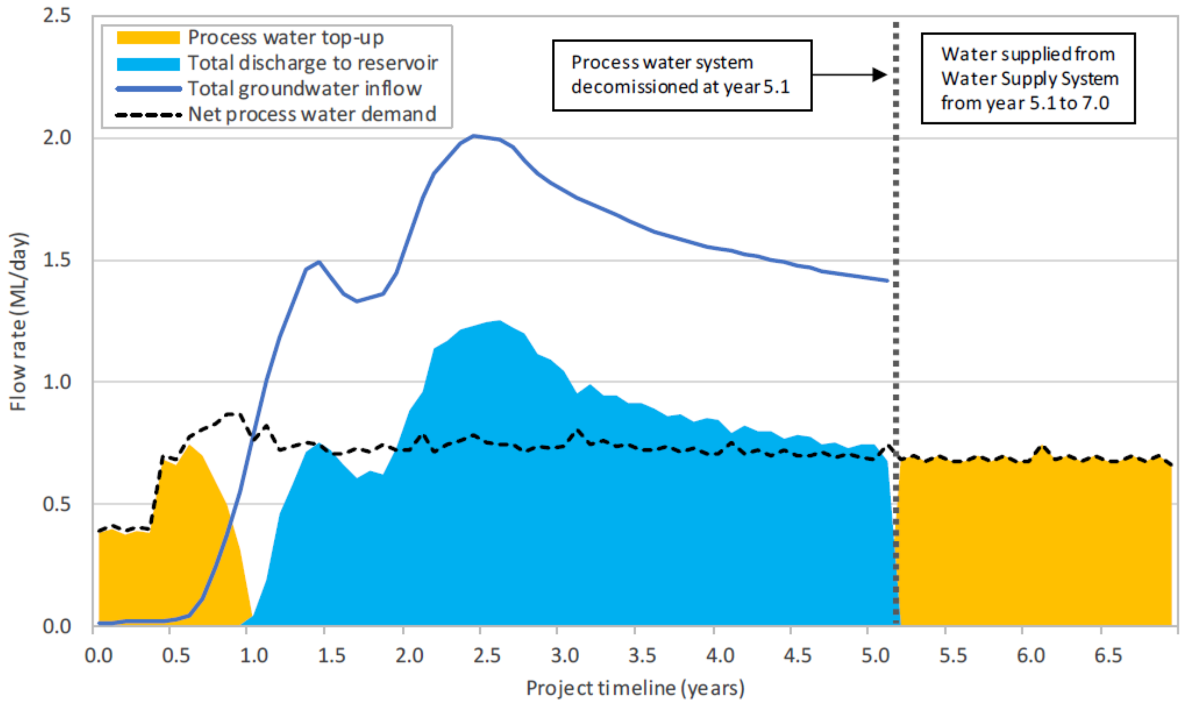


Figure 5-5: Talbingo process water system water balance (EMM, 2020)

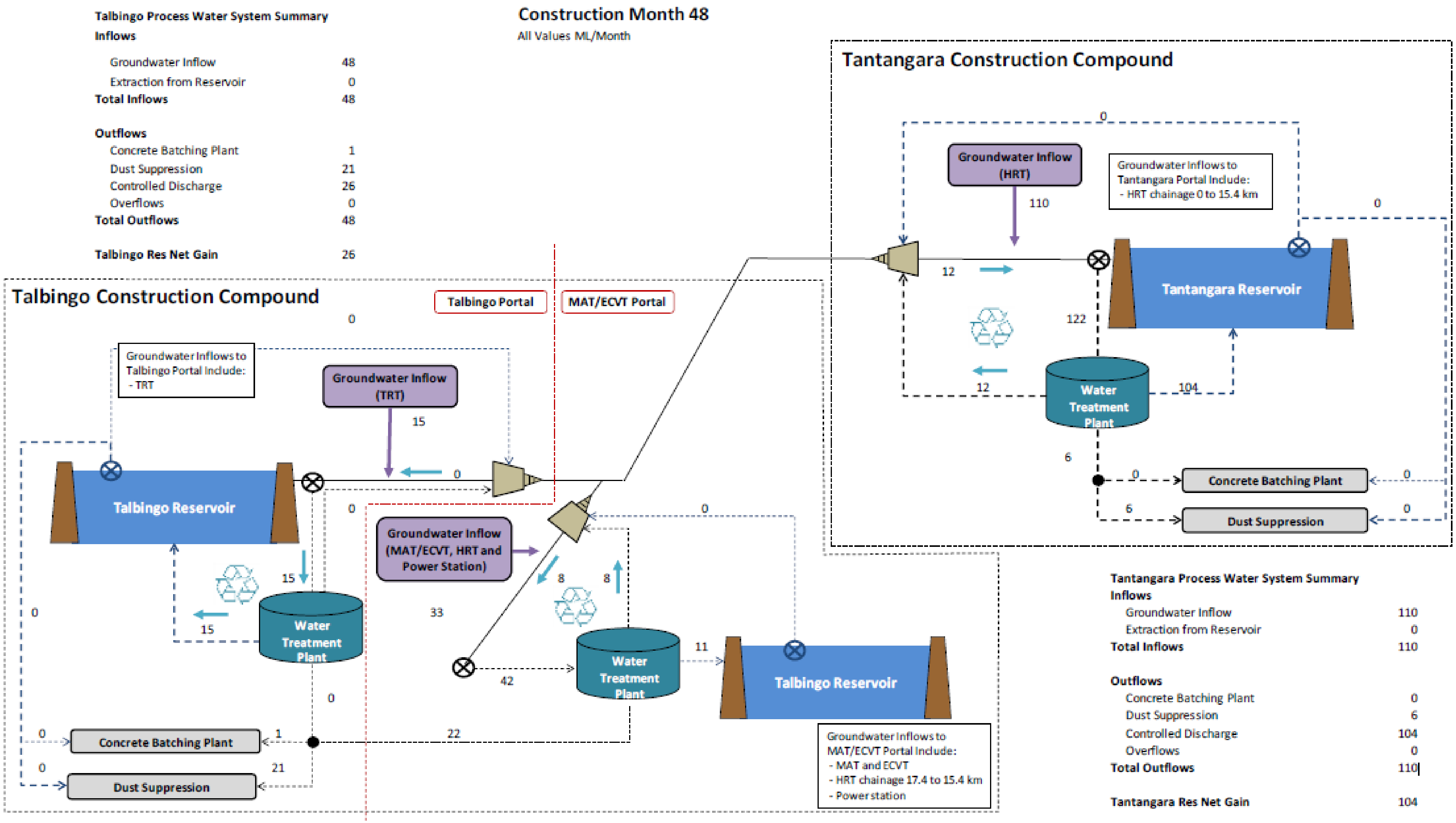


Figure 5-6: Main Works EIS Water Balance flow diagram - Month 48 of construction (EMM, 2020)

6. COMPLIANCE MANAGEMENT

6.1. Roles and Responsibilities

Future Generation's organisational structure and overall roles and responsibilities are outlined in Section 4 of the EMS. Specific responsibilities for the implementation of mitigation measures are detailed in Section 5 of the SWMP and GMP. Regardless of the allocation of responsibilities within this plan, the responsible party is to be assigned in accordance with the Contract

6.2. Inspections

Inspection of water management measures will be undertaken regularly during construction in the form of weekly environmental inspections and rainfall inspections. All inspections will be internally recorded.

Any opportunities for improvement identified through the inspection process will be recorded in an inspection report (minor issues) in accordance with Section 8 of the EMS or an incident report completed in accordance with Section 7 of the EMS. Findings from inspection and incident report(s) will be reported to relevant agencies where required.

6.3. Monitoring

Monitoring will be undertaken to confirm the satisfactory water outcomes are achieved during construction. A summary of the monitoring aspects within this WMP is provided in Table 6-1.

Further details, such as the parameters and frequency of monitoring are included in the Surface Water Management Plan (S2-FGJV-ENV-PLN-0011) and Groundwater Management Plan (S2-FGJV-ENV-PLN-0012).

The findings will be recorded and reported in accordance with Section 6.6.

Table 6-1: Water Management Plan Monitoring Overview

Aspect	Objective
Surface Water Management Plan	
Routine receiving surface water quality monitoring Event based wet weather overtopping water quality monitoring	• inform and assess the performance of management processes/measures that seek to minimise the Project's impact on surface water quality • help determine source and extent of any water quality changes • collect baseline data to characterise water quality and determine site specific values
Groundwater Management Plan	
Groundwater level monitoring Groundwater quality monitoring	• inform and assess the performance of management processes/measures that seek to minimise the Project's impact on regional and local (including alluvial) aquifers and GDEs
Water extraction monitoring	• inform and assess water consumption, site water balance and compliance with water access licences

6.3.1. Monitoring outside construction envelope

In accordance with schedule 4, condition 5 of the Infrastructure Approval, monitoring is permitted outside the construction envelope of the development provided the monitoring is required under the conditions of approval and authorised under an approved management plan.

This WMP includes surface water monitoring and groundwater monitoring inside and outside the construction envelope to monitor the surface water and groundwater impacts of the development (to satisfy schedule 3, condition 31(c) and 31(d) of the Infrastructure Approval).

Generally, monitoring will include the use of hand operated monitoring devices, sampling containers for the collection of water and the use of existing monitoring infrastructure (i.e. groundwater bores installed during project characterisation).

Where additional monitoring infrastructure is proposed outside the construction envelope, Future Generation will review environmental constraints and consult with relevant stakeholders (i.e. NPWS for monitoring infrastructure within the KNP) during the update to the Plan. Micro-siting principles will be implemented to minimise disturbance and compliance tracked against conditions of approval.

The ongoing use of monitoring infrastructure post construction will be determined in a SHL operational document or framework. Where monitoring infrastructure is no longer required, rehabilitation will be undertaken in accordance with the Rehabilitation Management Plan.

6.4. Incidents

Water incidents will be managed in accordance with Section 7 of the EMS and the Snowy Hydro Environmental Incident Process included within Appendix A4 of the EMS.

The Secretary and other relevant agencies will be notified of incidents in accordance with Section 7 of the EMS. Depending on the type and severity of the incident this may include notification to the Department and NPWS in writing for incidents defined under the conditions of approval, notification to the NPWS where required under the Deed of Agreement of Lease and notification to the EPA for pollution related incidents. Snowy Hydro would notify DPIE in writing immediately after they become aware of the incident on site.

6.5. Auditing

Audits will be undertaken to assess the effectiveness of water management measures and overall compliance with this WMP. Audit requirements are detailed in Section 8.3 of the EMS.

6.6. Reporting

Future Generation will report to Snowy Hydro and other agencies as detailed in Table 6-2 on water management aspects related to the Project. During construction, surface water and groundwater monitoring data will be collected, tabulated and assessed against thresholds.

Table 6-2: Reporting requirements relevant to water

Report	Requirement	Recipient
Reporting		
Weekly inspection	EMS Requirement Weekly inspection report undertaken by environmental advisor which includes aspects relevant to the management of water	FGJV Internal Record
Incident Report (related to water)	Infrastructure Approval Schedule 4, CoA 6 The Proponent must notify the Department and NPWS via the Major Projects Portal immediately after it becomes aware of an incident on site. This notice must set out the location and nature of the incident.	Depending on the type and severity of the incident this may include notification to the Department and NPWS in writing for incidents defined under the conditions of approval, notification to the NPWS where required under the Deed of

Report	Requirement	Recipient
	EPL 21266 Incident reports to be provided to EPA in accordance with EPL notification of environmental harm and written report requirements.	Agreement of Lease and notification to the EPA for pollution related incidents. Snowy Hydro will notify DPIE in writing immediately after they become aware of the incident on site.
EPL Monitoring Reports and Annual Returns/Report	EPL 21266 EPL monitoring reports will be prepared in accordance with the requirements of the EPL. An EPL Annual Return/Report will be prepared in respect of each EPL reporting period (typically 12 months)	EPA
Water Access Licence Report (annual)	Water Access Licence Actual water take will be reported to NRAR on an annual basis in accordance with water access licence conditions.	NRAR
Environmental Water Report (every 3 months)	Infrastructure Approval Schedule 3, CoA 31(c)(d) Commentary on the performance of the monitoring programs within the water management plan will be documented in the quarterly environmental water report. Any incidents and key environmental issues will be documented.	Publicly available on project website
Other Aspects		
Site Water Balance	Infrastructure Approval Schedule 3, CoA 31(b) Yearly calendar revision of the Site Water Balance will be undertaken and where updates are identified, the revised Balance will be updated and included in a future revision of this WMP.	Proposed future updates to this WMP will be provided to EPA, NPWS, Water Group, NRAR and NSW DPI.
Groundwater model validation	Infrastructure Approval Schedule 3, CoA 31(d) Yearly calendar groundwater model review, validation and recalibration (as dictated by monitoring results) (undertaken by SHL).	The revised model will be submitted to the relevant agencies on completion.
Updates to this WMP	Section 1.7 of this WMP This WMP will be updated prior to the commencement of the following activities: • dredging, channel extraction or underwater blasting • in-reservoir emplacement works • construction works in the third year for the purposes of determining need / location of streamflow monitoring sites • Snowy 2.0 operations (a separate SHL document or framework may be prepared)	Proposed future updates to this WMP will be provided to EPA, NPWS, Water Group, NRAR and NSW DPI.

APPENDIX A – SURFACE WATER MANAGEMENT PLAN

S2-FGJV-ENV-PLN-0011

SNOWY 2.0 MAIN WORKS – SURFACE WATER MANAGEMENT PLAN

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Environment Consultant	S. Mitchell	S Mitchell
Reviewed by	Technical Specialist	R. van Dam	
Verified by	Environmental Manager	L. Coetzee	
Approved by	Project Director	A. Betti	

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	29.11.2019	Initial draft for SHL review
B	29.05.2020	Revised to address Infrastructure Approval
C	15.06.2020	Revised to address SHL comments. For consultation.
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments
G	15.10.2020	Revised to address NRAR clarification

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ABBREVIATIONS AND DEFINITIONS

Acronym	Definition
AEP	Annual exceedance probability
AFL	Agreement for Lease
Blue Book	*Managing Urban Stormwater: Soils and Construction*. Landcom, (4th Edition) March 2004
BoM	Bureau of Meteorology
CoA	*Infrastructure Conditions of Approval (SSI 9687)*
Construction envelope	The maximum extent within which the disturbance area corridor can move to allow the final siting of infrastructure through the detailed design process
CSSI	Critical State significant infrastructure
DAWE	Commonwealth Department of Agriculture, Water and the Environment
Disturbance footprint	The disturbance footprint as described in the PIR-RTS is the indicative corridor inside the larger construction envelope, where construction works required to build Snowy 2.0 can be carried out.
DOI	NSW Department of Industry
DPIE	NSW Department of Planning, Industry and Environment (formerly DPE)
EIS	Environmental Impact Statement
EMS	Environmental Management Strategy
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPA	NSW Environment Protection Authority
EPL	Environmental Protection Licence
ESCP	Erosion and Sediment Control Plan
Exploratory Works	The development of an exploratory tunnel and associated infrastructure described in the Environmental Impact Statement for the Snowy 2.0 Exploratory Works (CSSI 9208) dated July 2018, and modified by the: • Submissions Report dated October 2018; • Modification Report dated 6 June 2019 and associated Submissions Report dated 2 September 2019; and • Modification Report dated 17 October 2019 and associated Submissions Report dated 10 January 2020
Future Generation	Future Generation Joint Venture
Future Generation-PMS	Project Management System
GDE	Groundwater Dependent Ecosystem
GMP	Groundwater Management Plan
Incident	An occurrence or set of circumstances that causes or threatens to cause material harm and which may or may not be or cause a non-compliance
KNP	Kosciusko National Park
LFB	Lachlan Fold Belt
Lobs Hole site	The development in the vicinity of Lobs Hole, including the GFO1 emplacement area; construction facilities (Main Yard), including workers' accommodation camp and temporary spoil emplacement areas; Main Access Tunnel and Emergency Cable and Ventilation

Acronym	Definition
	Tunnel portals; and ancillary infrastructure including access roads, substation, cableyard and utilities
LPF	Long Plain Fault
Main Works	The development of an underground power station and associated infrastructure described in the Environmental Impact Statement for the Snowy 2.0 Main Works (CSSI 9687) dated September 2019, and modified by the: • Preferred Infrastructure Report and Response to Submissions – Snowy 2.0 Main Works, dated February 2020; and • Additional information provided to the Department by EMM on 24 March 2020 and 7 April 2020
Marica site	The development in the vicinity of Marica, including the headrace surge shaft; ventilation shaft; construction facility workers' camp; and ancillary infrastructure including access roads and utilities.
Material harm	Is unauthorised harm that: • involves actual or potential harm to the health or safety of human beings or to the environment that is not trivial; or • results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding $10,000, (such loss includes the reasonable costs and expenses that would be incurred in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment)
NPWS	National Park and Wildlife Services
NSW DPI	The NSW Department of Primary Industries within Regional NSW
Plateau site	The development in the vicinity of the Plateau, including the instream barrier in Tantangara Creek and ancillary infrastructure including access roads and utilities.
Plateau area	The plateau area; located to the east of the Snowy Mountains Highway and spanning the area between the highway and Tantangara Reservoir, is typical of elevated alpine environments, dominated by low energy streams, gentle rolling hills and mostly flat floodplains. The plateau area includes the Plateau and Tantangara work site.
PMF	Probable Maximum Flood
POEO Act	*Protection of the Environment Operations Act 1997*
POEO Regulation	*Protection of the Environment (General) Regulation 2009*
Process water	Water produced by and used by construction activities.
Project	Exploratory Works and Main Works
Project area	The project area is the broader region within which Snowy 2.0 will be built and operated, and the extent within which direct impacts from Snowy 2.0 Main Works are anticipated. The project area does not represent a footprint for the construction works, but rather indicates an area that was investigated during environmental assessments.
Ravine area	The ravine area; located mostly to the west of the Snowy Mountains Highway, is characterised by deep gorges and steep sloping ridges, the product of incision from river flow, historic glaciation and structural movement. The ravine area includes the Talbingo, Lobs Hole and Marica work sites.
REMM	Revised Environmental Management Measures
Submissions Report or RTS	*Response to Submissions Main Works for Snowy 2.0*
SHC Act	Snowy Hydro Corporatisation Act 1997
SHL (or Snowy Hydro)	Snowy Hydro Limited
SWMP	Surface Water Management Plan (This plan)

Acronym	Definition
Talbingo Reservoir site	The development in and around the Talbingo Reservoir, including the Ravine Bay emplacement area; development at Middle Bay, including the water intake and associated structures, barge launch ramp, and construction facilities; and ancillary infrastructure, including access roads and utilities.
Tantangara Reservoir site	The development in and around the Tantangara Reservoir, including the Tantangara emplacement area; water intake and associated infrastructure; barge launch infrastructure; construction and laydown facilities, including workers' camp; fish screens; and ancillary infrastructure, including access roads and utilities.
WAL	Water Access Licence
Water Group	DPIE Water
Wastewater	Domestic sewer water stream (i.e. from showers, kitchens, laundries and toilets)
WM Act	*Water Management Act 2000*
WMP	Water Management Plan
WM Regulation	*Water Management (General) Regulation 2011*
WQO	Water Quality Objective
WTP	Water Treatment Plan

1. INTRODUCTION

1.1. Project Description

1.1.1. Overview

Snowy Hydro Limited (Snowy Hydro) is constructing a pumped hydro-electric expansion of the Snowy Mountains Hydro-electric Scheme (Snowy Scheme), called Snowy 2.0. Snowy 2.0 will be built by the delivery of two project: Exploratory Works (which has commenced) and Snowy 2.0 Main Works.

Snowy 2.0 is a pumped hydro-electric project that will link the existing Tantangara and Talbingo reservoirs through a series of new underground tunnels and a hydro-electric power station. Most of the project's facilities will be built underground, with approximately 27 kilometres of concrete-lined tunnels constructed to link the two reservoirs and a further 20 kilometres of tunnels required to support the facility. Intake and outlet structures will be built at both Tantangara and Talbingo Reservoirs.

Snowy 2.0 will increase the generation capacity of the Snowy Scheme by an additional 2,000 MW, and at full capacity will provide approximately 350,000 MWh of large-scale energy storage to the National Electricity Market (NEM). This will be enough to ensure the stability and reliability of the NEM, even during prolonged periods of adverse weather conditions.

Salini Impregilo, Clough and Lane have formed the Future Generation Joint Venture (Future Generation) and have been engaged to deliver both Stage 2 of Exploratory Works and Snowy 2.0 Main Works.

1.1.2. Construction Activities and Program

The Snowy 2.0 Main Works Project includes, but is not limited to, construction of the following:

- pre-construction preparatory activities including dilapidation studies, survey, investigations, access etc;
- exploratory works including:
  - an exploratory tunnel to the site of the underground power station;
  - horizontal and test drilling;
  - a portal construction pad;
  - an accommodation camp;
  - barge access infrastructure;
- an underground pumped hydro-electric power station complex;
- water intake structures at Tantangara and Talbingo reservoirs;
- power waterway tunnels, chambers and shafts;
- access tunnels;
- new and upgraded roads to allow ongoing access and maintenance;
- power, water and communication infrastructure, including:
  - a cable yard to facilitate connection between the NEM electricity transmission network and Snowy 2.0;
  - permanent auxiliary power connection;
  - permanent communication cables;

- permanent water supply to the underground power station; and
- post-construction revegetation and rehabilitation.

The Snowy 2.0 construction program is summarised in Figure 1-1.

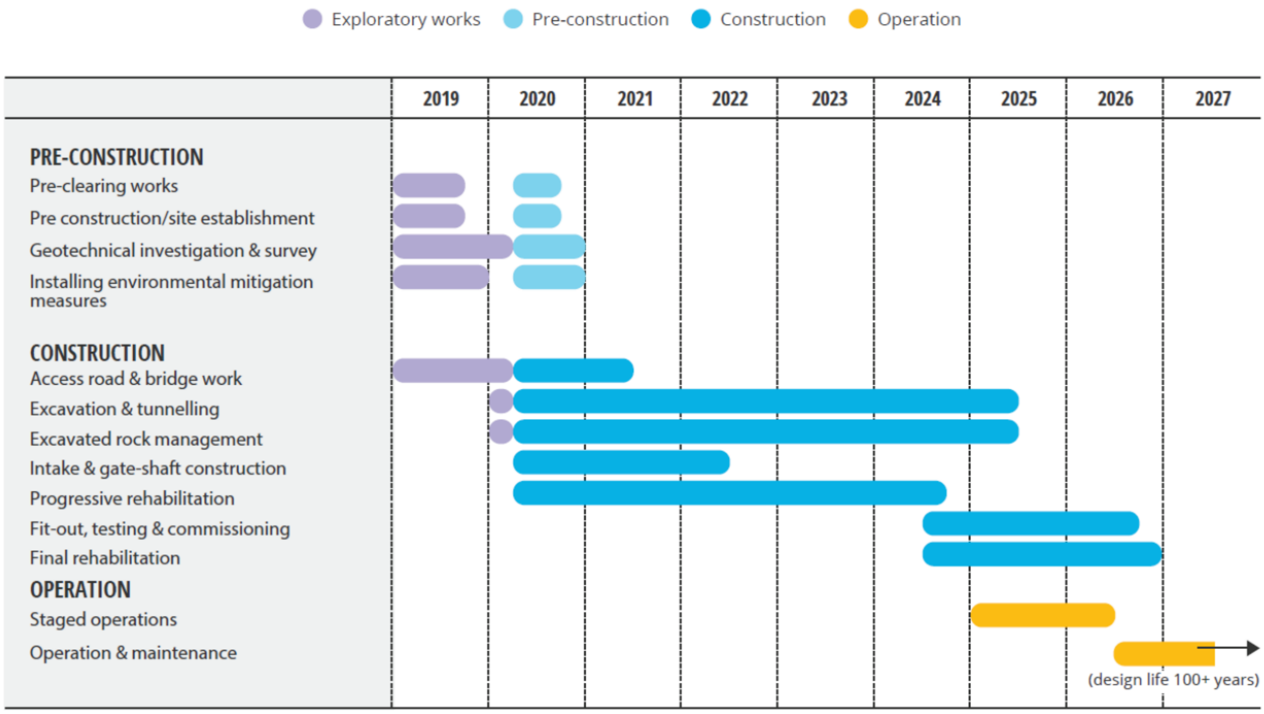

Figure 1-1 Timing of Snowy 2.0

The Snowy 2.0 Main Works Project includes numerous work sites as shown in Figure 1-2.

These work sites include:

- Lobs Hole Ravine Road;
- Lobs Hole;
- Marica;
- Plateau;
- Rock Forest;
- Talbingo; and
- Tantangara.

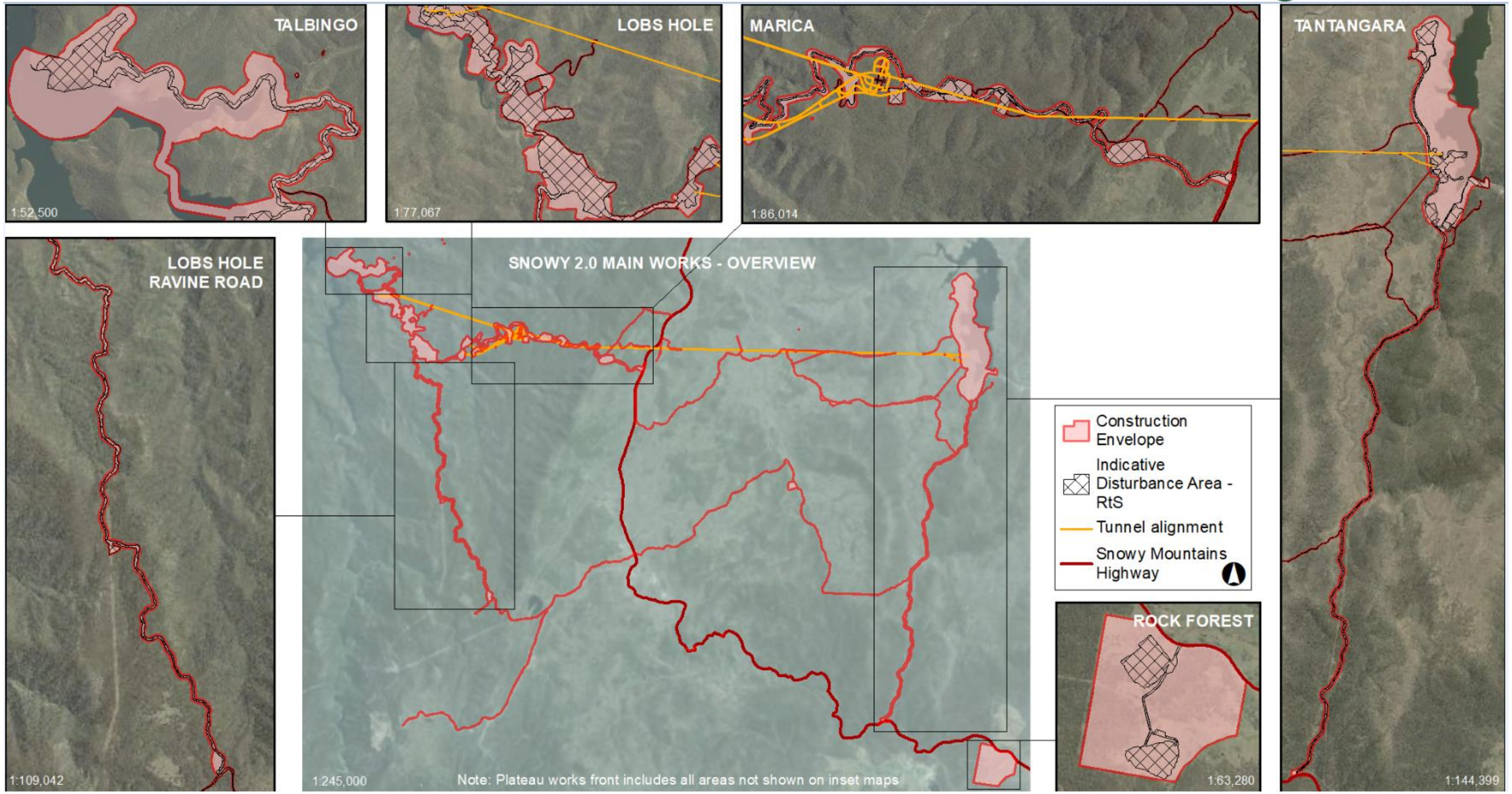

Figure 1-2: Snowy 2.0 Main Works work sites

1.2. Project Approval

On 7 March 2018 the NSW Minister for Planning declared Snowy 2.0 to be State significant infrastructure (SSI) and critical State significant infrastructure (CSSI) under the Environmental Planning and Assessment Act 1979 (EP&A Act) on the basis that it is critical to the State for environmental, economic or social reasons

An environmental impact statement for the first stage of Snowy 2.0, the *Environmental Impact Statement Exploratory Works for Snowy 2.0* (Exploratory Work EIS) was submitted to the then Department of Planning and Environment in July 2018 and publicly exhibited between 23 July 2018 and 20 August 2018. Approval for the first stage of Snowy 2.0 was granted for Exploratory Works by the Minister for Planning on 7 February 2019. In accordance with section 5.25 of the EP&A Act, the infrastructure approval for the Exploratory Works was modified on 2 December 2019 and on 27 March 2020.

An environmental impact statement for the second stage of Snowy 2.0, the *Snowy 2.0 Main Works Environmental Impact Statement* (Main Work EIS) was submitted to Department of Planning, Industry and Environment (DPIE) in September 2019 and was publicly exhibited between 26 September 2019 and 7 November 2019. A total of 222 submissions were received during the public exhibition period, including 10 from government agencies, 30 from special interest groups and 182 from the general public. In February 2020, the response to submissions (RTS or Submissions Report) was issued to DPIE to address the public and agency submissions (*Snowy 2.0 Main Works - Preferred Infrastructure Report and Response to Submissions, February 2020*).

Following consideration of the Main Works EIS and RTS, approval was granted by the Minister for Planning and Public Spaces on 20 May 2020, through issue of Infrastructure Approval SSI 9687.

Further to the Infrastructure Approval, the Main Works RTS include revised environmental management measures (REMMs) within Appendix C which will also be implemented for the Project.

In addition to the State approval, a referral (EPBC 2018/8322) was prepared and lodged with the Commonwealth Department of Energy and Environment (DoEE – now Department of Agriculture, Water and the Environment, DAWE) under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Commonwealth Minister's delegate determined on 5 December 2018 that Snowy 2.0 Main Works is a "controlled action" under the EPBC Act. The EPBC Act referral decision determined that the project will be assessed by accredited assessment under Part 5, Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979.*

1.3. Disturbance Area

A key refinement following public exhibition of the Main Works EIS was a change to and clarification of disturbance area terminology. The revised disturbance area terminology as per the SSI-9687 Instrument, Main Works RTS and this Plan is outlined in Table 1-1, with an example shown at Lobs Hole Ravine Road in Figure 1-3.

Table 1-1: Disturbance area terminology

Term	Definition	Reasoning
Project area	The project area is the broader region within which Snowy 2.0 will be built and operated, and the extent within which direct impacts from Snowy 2.0 Main Works are anticipated.	The project area does not represent a footprint for the construction works, but rather indicates an area that was investigated during environmental assessments.
Construction envelope	The envelope within which the disturbance area of the development may be located.	As detailed design continues, final siting of the infrastructure (i.e. the disturbance area) can move within the assessed construction envelope subject to recommended environmental management measures and provided it does not exceed the limits defined by the construction envelope.
Disturbance area	The area within the construction envelope where development may be carried out; the precise location of the disturbance area will be fixed within the construction envelope following final design.	

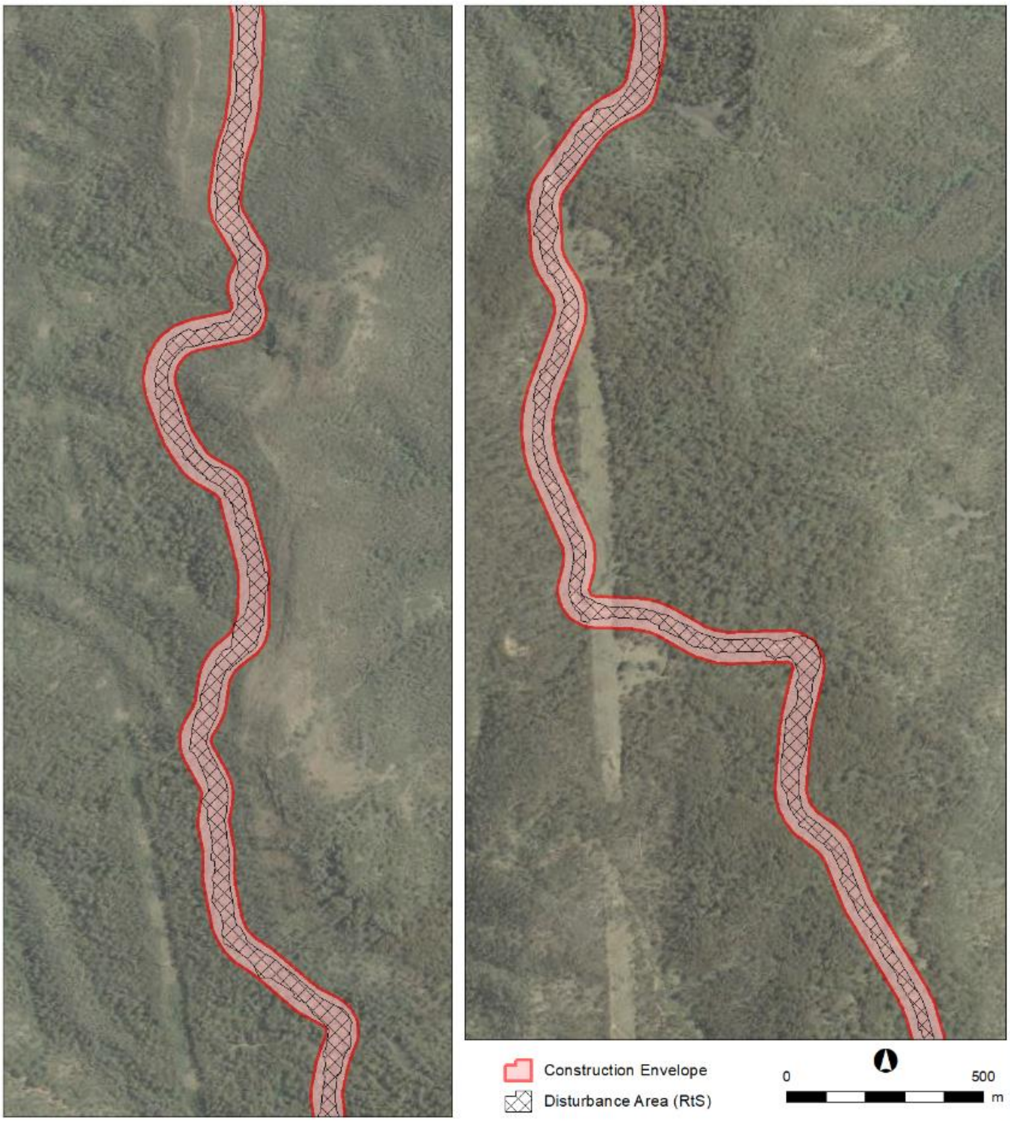

Figure 1-3: Disturbance area and construction envelope

1.4. Works within the Construction Envelope

Where project works are required to occur in locations outside of the disturbance boundary, Future Generation will review the proposed area of clearing against the limits included within condition 5 of schedule 2. The review will be undertaken to ensure that the maximum disturbance area and maximum native vegetation clearing remains within the total areas nominated within the condition. These area limits are included within Table 1-2.

All vegetation clearing that occurs on the project will be monitored regularly to record the extent of clearing which has occurred, and to ensure that the clearing limits are not exceeded.

Table 1-2: Maximum disturbance area and native vegetation clearing

Matter	Exploratory Works	Main Works	Total
Maximum Disturbance Area	126 ha	504 ha	630 ha
Maximum Native Vegetation Clearing	107 ha	425 ha	532 ha

1.5. Environmental Management System

The overall environmental management system for the Project is described in the Environmental Management Strategy (EMS). The EMS forms part of the Project Management System (Future Generation-PMS) and will include any requirements specified in the contract documents, where appropriate. All Future Generation-PMS procedures will support, interface or directly relate to the development and execution of the Plan.

The management plans and post-approval documents for the project include those listed within Figure 1-4.

This Surface Water Management Plan (SWMP or Plan) (S2-FGJV-ENV-PLN-0011) is an appendix to the Water Management Plan (WMP) (S2-FGJV-ENV-PLN-0010) which has been prepared for the Snowy 2.0 Main Works project, and supersedes the existing Stage 1 and Stage 2 Exploratory Works Water Management Plan. It does not address the operational phase of the project.

This Plan forms part of Future Generation's environmental management framework.

An overview of the WMP relative to the elements of water management is shown in Figure 1-5

This Plan aims to transfer the relevant requirements of the Approval documents into a management plan which can be practically applied on the Project site.

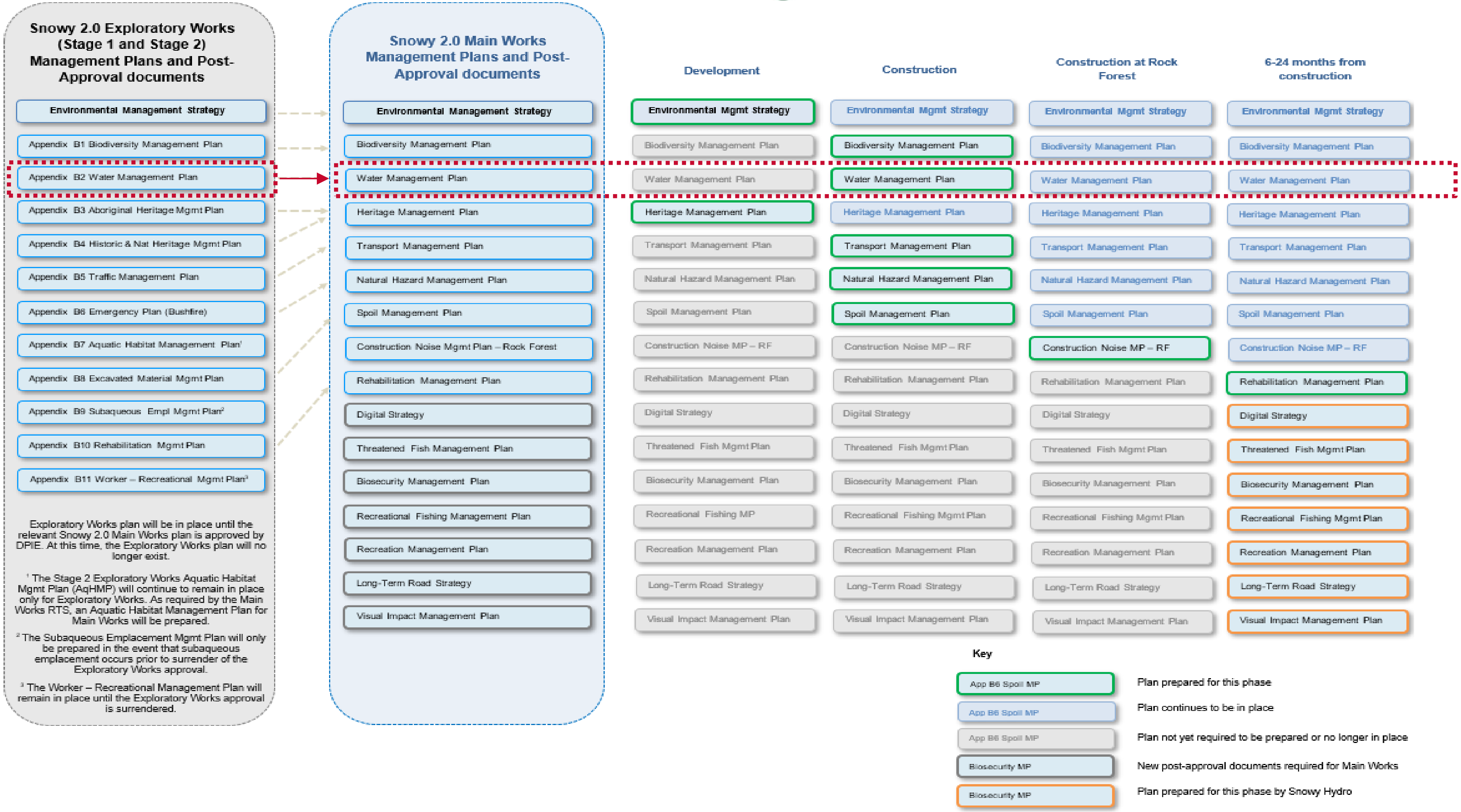

Figure 1-4: Management plans and post-approval documents with the WMP indicated

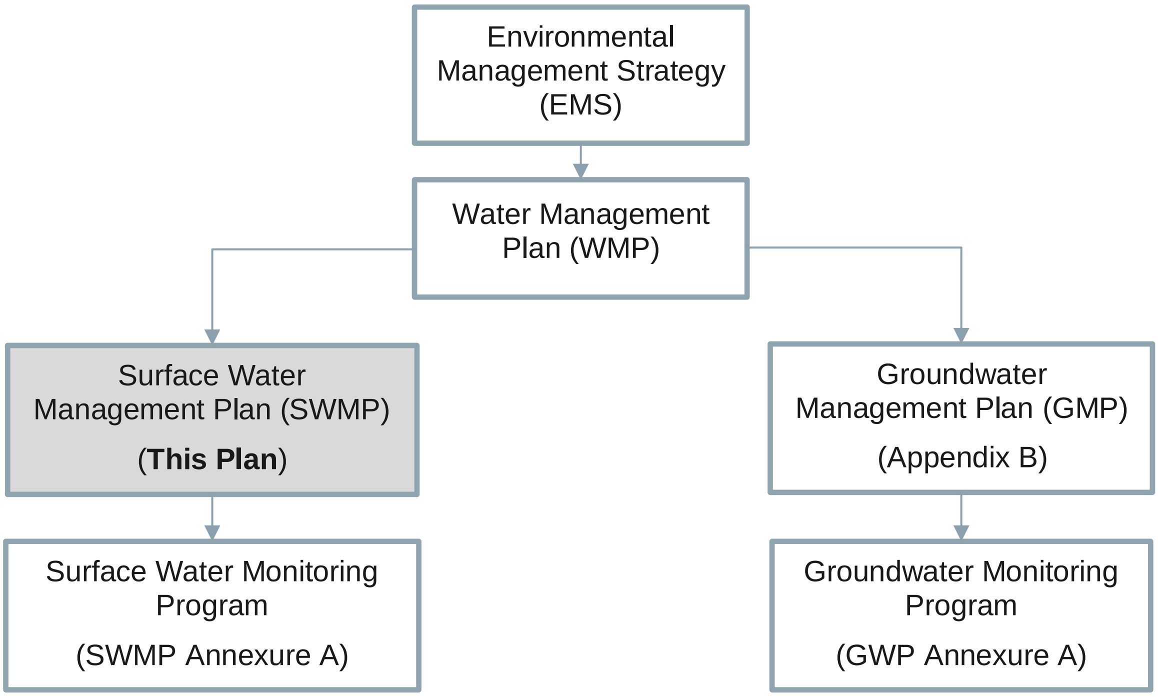

Figure 1-5: Water Management Plan Structure

1.6. Purpose and objective of this plan

This plan has been prepared to address the construction environment management requirements detailed in the:

- the Infrastructure Approval (SSI 9687) (Approval) issued for Snowy 2.0 Main Works on 21 May 2020;
- the *Main Works Snowy 2.0 - Environmental Impact Statement*;
- the revised environmental management measures (REMMs) within the Main Works RTS;
- the Infrastructure Approval (SSI 9208) issued for Snowy 2.0 Exploratory Works on 7 February 2019 and modified on 2 December 2019 and 27 March 2020;
- the *Exploratory Works for Snowy 2.0 - Environmental Impact Statement*;
- the *Exploratory Works for Snowy 2.0 – Modification 1 Assessment Report*;
- the *Exploratory Works for Snowy 2.0 – Modification 2 Assessment Report*;
- the REMMs within the Exploratory Works RTS, Exploratory Works Modification 1 RTS, and Exploratory Works Modification 2 RTS; and
- the environmental protection licence (EPL) 21266.

The objectives of the SWMP are to ensure that impacts on surface water quality are minimised and within the scope permitted by the CoA. To achieve this objective, Snowy Hydro and Future Generation will implement:

- appropriate measures to address relevant conditions of approval and REMMs listed within the Submissions Report, as detailed within Section 2 of this Plan;

- appropriate measures during construction to avoid or minimise potential impacts to surface water quality within the rivers and creeks across the Project;
- a surface water quality monitoring program to assess the effectiveness of the surface water management controls and impacts on the receiving environment;
- construction work activities in a manner to minimise flood impacts and risks; and
- corrective actions and contingency measures during construction when triggered.

1.7. Staging

This Plan contains management measures relevant to surface water, for the following sites:

- Lobs Hole;
- Marica;
- Plateau;
- Rock Forest;
- Talbingo; and
- Tantangara.

Some distinct work activities require greater detail prior to commencement. Consequently, this Plan will be updated, in consultation with relevant government agencies, and submitted to DPIE prior to the commencement of specific activities as detailed in Table 1-3.

Table 1-3: Activities that require update to this SWMP

Activities	Timing
Dredging, channel extraction or underwater blasting	This SWMP will be updated for approval prior to dredging, channel extraction or underwater blasting.
Permanent in-reservoir emplacement areas	This SWMP will be updated prior to in-reservoir emplacement.
Construction works in the third year for the purposes of determining need/location streamflow monitoring sites	This SWMP will be updated in the third year of construction to determine the need for surface water flow monitoring sites and if necessary, suitable locations to monitor potential streamflow impacts (based on additional groundwater monitoring data / revised drawdown predictions).
Operation of Snowy 2.0 Project, including dewatering of the tailrace tunnel during operations.	Operation will be addressed through a separate Snowy Hydro framework or document.

1.8. Plan Preparation

In accordance with the requirements of schedule 3 condition 31 of the Infrastructure Approval this Plan has been prepared by a suitably qualified and experienced person, Dr Rick Van Dam.

1.9. Consultation

In accordance with schedule 3, condition 31 of the Infrastructure Approval and revised environmental management measure (REMM) WM01, the WMP (which includes this SWMP) is to be prepared in consultation with;

- NSW Environment Protection Agency (EPA);
- National Parks and Wildlife Services (NPWS);
- Department of Planning, Industry and Environment – Water Group (Water Group);

- Natural Resources Access Regulator (NRAR); and
- NSW Department of Primary Industries (NSW DPI)

In accordance with condition 18 of the Commonwealth approval, the WMP (including this SWMP) is also to be prepared in consultation with the DAWE.

On 15 June 2020, the plan was issued to stakeholder agencies for review and comment. Comments from consultation have been incorporated into this plan where appropriate. Response to the comments have been provided back to the stakeholder agencies. Consultation is summarised in Table 1-4.

An agency briefing for the WMP was held on 30 April 2020 and 7 May 2020 with EPA, NPWS, Water Group, BCD and NSW DPI.

Table 1-4: Consultation undertaken for this plan

Date	Consultation	Outcomes
30/04/2020	EPA, NPWS, DPI Fisheries, BCD, Water Group	Agency briefing (online PowerPoint) providing overview of document structure and surface water management approach.
07/05/2020	EPA, NPWS, BCD, DoI Water	Agency briefing (online PowerPoint) providing overview of the development of the surface water monitoring program and groundwater monitoring program.
15/06/2020	NPWS, EPA, Water Group, NRAR, NSW DPI	WMP (revision C) issued to stakeholders for review and comment
26/06/2020	DAWE	WMP (revision D) issued to DAWE for review and comment
08/07/2020	DAWE	Agency briefing (online PowerPoint) providing overview of document structure and water management approach.
24/08/2020	DAWE	Further rationale for adjustment to surface water monitoring locations, details of bushfire impacts on water quality and general clarifications.
09/09/2020	EPA	Amendment to surface water monitoring program, specifically in relation to discharge outlet verification monitoring.

A separate document is proposed to be provided to DPIE and DAWE which details the consultation process, along with Future Generation responses to stakeholder comments and how feedback has been implemented during the action.

1.9.1. Ongoing Consultation

Future Generation will consult with stakeholders identified in schedule 3, condition 31 of the Infrastructure Approval for updates to this SWMP (Section 1.7).

Where additional monitoring infrastructure is proposed outside the construction envelope. Future Generation will review environmental constraints and consult with relevant stakeholders (i.e. NPWS for monitoring infrastructure within the KNP).

2. ENVIRONMENTAL REQUIREMENTS

2.1. Legislation

Legislation relevant to water management includes:

- *Environmental Planning and Assessment Act 1979* (EP&A Act);
- *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation);
- *Protection of the Environment Operations Act 1997* (POEO Act);
- *Protection of the Environment (General) Regulation 2009* (POEO General Regulation);
- *Water Management Act 2000* (WM Act);
- *Water Management Amendment Act 2014* (WMA Act);
- *Water Management (General) Regulation 2018* (WM General Regulation);
- *Fisheries Management Act 1994*; and
- *Snowy Hydro Corporatisation Act 1997* (SHC Act).

Relevant provisions of the above legislation are explained in the register of legal and other requirements included in Appendix A1 of the EMS.

2.2. Conditions of Approval

Table 2-1: details the CoA that are relevant to surface water management and demonstrates where these conditions are addressed. For a detailed list of CoA relevant to water, refer to Section 2.2 of the Water Management Plan.

Table 2-1: Conditions of approval relevant to surface water

CoA	Requirement	Where addressed
28	**Water Supply** The Proponent must ensure it has sufficient water for each stage of the development; and if necessary, adjust the scale of development on site to match its available water supply. *Note: Under the Water Management Act 2000, the Proponent must obtain the necessary water licences for the development.*	WMP – Section 2.5.3 SWMP – Section 2.5.3 GMP – Section 2.5.3
29	**Water Pollution** Unless an environment protection licence authorises otherwise, the Proponent must comply with Section 120 of the POEO Act. *Note: Section 120 of the POEO Act makes it an offence to pollute any waters*	SWMP - Table 5-3: SW02, SW22, SW30 GMP – Table 5-1: GW03
30	**Water Mitigation Requirements** The Proponent must:	
	(a) maximise the recycling and reuse of water on site;	WMP – Section 4.2 SWMP – Section 5.1, Section 5.3.1, Table 5-3: SW14
	(b) maximise the diversion of clean water runoff around the disturbance areas;	SWMP – Section 5.1, Table 5-3: SW04, SW06
	(c) minimise the flow rates and velocities of any clean water runoff diversions to adjoining watercourses;	SWMP – Section 5.1, Table 5-3: SW08

CoA	Requirement	Where addressed
	(d) minimise the flooding impacts of the development;	SWMP – Section 5.2, Table 5-3: SW18, SW19 Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090) Spoil Management Plan (S2-FGJV-ENV-PLN-0019)
	(f) minimise erosion and the generation and dispersion of sediment using suitable controls in accordance with the relevant requirements in the *Managing Urban Stormwater: Soils and Construction* guidance series;	SWMP – Section 5.1, Table 5-3: SW03
	(g) design all instream works, particularly the inlet and outlet works, to minimise scour and erosion;	SWMP - Section 5.7, Table 5-3: SW58, SW59
	(h) unless permitted by this approval, avoid carrying out of any development within 40 metres of any watercourse;	SWMP – Section 5.7, Table 5-3: SW51
	(i) carry out all instream works or development within 40 metres of any watercourse generally in accordance with the requirements in the *Guidelines for Controlled Activities on Waterfront Land*;	SWMP – Section 5.7, Table 5-3: SW51, SW52
	(j) treat all wastewater and surplus process water prior to discharging it at the approved discharge points at the Talbingo Reservoir or Tantangara Reservoir;	SWMP – Section 5.3, Table 5-3: SW22, SW30 and Annexure F
	(k) reduce the number of diffuser points for low velocity discharges to the Talbingo Reservoir or Tantangara Reservoir;	SWMP –Section 5.3.4, Table 5-3: SW27, SW35 and Annexure F
	(l) not discharge any surplus process water to the stormwater basins on site;	SWMP – Section 5.3, Table 5-3: SW28
	(m)minimise the surface water quality impacts associated with the development, including: • the development carried out in the vicinity of waterways, particularly in the Talbingo Reservoir, Tantangara Reservoir and Yarrangobilly River; • all instream works, including dredging, channel excavations, underwater blasting, barge infrastructure, fish barriers and screens, culverts and bridges, and service crossings; • the temporary and permanent spoil emplacement areas; • development at the Marica, Plateau and Rock Forest sites; • road works; • the operation of the power station and associated infrastructure, including the operation of the inlets and outlet to minimise sediment distruabnce risks and the dewatering of the trailrace tunnel	SWMP – Section 5, Table 5-3 (All measures) Note this SWMP will be updated prior to major sub-surface water works in Talbingo Reservoir and Tantangara Reservoir (including dredging / channel extraction / underwater blasting) for construction of intake structures, and prior to in-reservoir emplacement. A separate document or framework will be prepared prior to operations.
	(n) minimise the risk of spills or leaks on site, and clean up any spills or leaks as quickly as possible;	SWMP – Section 5.4, Table 5-3: SW36, SW37, SW39, SW41, Annexure C (Spill Response Procedure)
	(p) store chemicals and hydrocarbon products in bunded areas in accordance with the relevant Australian Standards.	SWMP - Section 5.4, Table 5-3: SW41, Annexure C (Spill Response Procedure)
31	**Water Management Plan**	WMP

CoA	Requirement	Where addressed
	Prior to the commencement of construction, the Proponent must prepare a Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must:	
	(c) include a Surface Water Management Plan, containing detailed plans for the Talbingo Reservoir, Lobs Hole, Marica, Plateau, Tantangara Reservoir, and Rock Forest sites with:	This Plan
	• detailed baseline data on surface water flows and quality in the watercourses that could be affected by the development, and a program to augment this baseline data over time;	SWMP – Annexure A Attachment B
	• detailed criteria for determining the surface water impacts of the development (flows, quality and flooding), including criteria for triggering remedial action (if necessary);	SWMP – Annexure A Section 1.2 and Annexure A Section 2
	• description of the measures that would be implemented to minimise the surface water impacts of the development and comply with the relevant water management requirements in conditions 4,6 and 30 above, including specific plans covering: – the temporary or permanent emplacement of spoil; – dredging, channel extraction and underwater blasting in the Talbingo Reservoir and Tantangara Reservoir – operation of the discharge points – the design of the inlets and outlets; and – dewatering of the tailrace tunnel during operations	SWMP – Section 5, Table 5-3 (All measures) Note this SWMP will be updated prior to major sub-surface water works in Talbingo Reservoir and Tantangara Reservoir (including dredging / channel extraction / underwater blasting) for construction of intake structures and prior to in-reservoir emplacement. A separate document or framework will be prepared prior to operations.
	• identify the key risks to the successful implementation of these measures, and describe the contingency measures that would be implemented to address these risks;	SWMP – Section 5.14
	• a program to monitor and publicly report on the surface water impacts of the development.	SWMP – Section 6.7, Annexure A Section 3 and Annexure A Section 7
32	The Proponent must implement the approved Water Management Plan for the development.	The Water Management Plan will be implemented for the development.

2.3. Revised Environmental Management Measures

During preparation of the Exploratory Works and Main Works Submissions Report, Revised Environmental Management Measures (REMMs) were developed and are included in Appendix C of the Main Works RTS and Section 8 of the Exploratory Works RTS.

The Main Works and Exploratory Works REMMs relevant to surface water are listed in Table 2-2 and Table 2-3. In accordance with CSSI 9687, schedule 2, CoA 3, if there is any inconsistency between the Exploratory Works and Main Works documents, the most recent document will prevail to the extent of the inconsistency (i.e. Main Works). These requirements that conflict, as well as requirements that have been completed have been identified with an asterix and comment.

Table 2-2: Main Works REMMS relevant to surface water management

Impact	Reference	Revised Environmental Management Measures	Where addressed
General	WM01	A Water Management Plan will be developed for Snowy 2.0 Main Works that includes:	
		• proposed mitigation and management measures for all construction water management categories;	SWMP – Table 5-3 (All measures) GMP – Table 5-1 (All measures)
		• spill management and response;	SWMP – Annexure C (Spill Response Procedure)
		• a surface and groundwater monitoring program;	SWMP – Annexure A GMP – Annexure A
		• water quality trigger action response plan;	SWMP – Section 6.4, Annexure B (TARPs) GMP – Section 7, Annexure B, Annexure C, Annexure D
		• reporting requirements;	WMP – Section 6.6 SWMP – Section 6.7 GMP – Section 6.8
		• corrective actions;	SWMP – Section 6 GMP – Section 7
		• contingencies; and	SWMP – Section 5.3.1, Section 5.14 and Section 6.4 GMP – Table 5-1: GW13
		• responsibilities for all management measures.	SWMP – Section 5.13, Table 5-3, Section 6.1 GMP – Table 5-1: GW13
		The WMP will be prepared in consultation with DPIE, EPA, WaterNSW and key local stakeholders, and would consider concerns raised during the exhibition and approvals process for the project.	WMP – Section 1.9
General	WM02	A water monitoring program will be developed as part of the water management plan to monitor quality and quantity impacts to surface water, groundwater and reservoirs. The water monitoring program will incorporate and update the existing monitoring network and detail monitoring frequencies and water quality constituents.	SWMP - Annexure A GMP – Annexure A

Impact	Reference	Revised Environmental Management Measures	Where addressed
Water quality impacts from stormwater runoff	WM03	Where practical, clean water will be diverted around or through construction areas. Runoff from clean water areas that cannot be diverted will be accounted for in the design of water management systems.	SMWP – Section 5.1, Table 5-3: SW07
Water quality impacts from stormwater runoff	WM04	An Erosion and Sediment Control Plan (ESCP) will be prepared for each construction area that will include relevant information presented in the water management report.	SMWP – Section 5.1, Table 5-3: SW04
Water quality impacts from stormwater runoff	WM05	A suitably qualified erosion and sediment control professional(s) will be engaged to: • oversee the development of ESCPs; • inspect and audit controls; • train relevant staff; and • provide advice regarding erosion and sediment control	SMWP – Section 5.1, Table 5-3: SW05
Water supply	WM08	A water supply system will be established to supply water for potable water use and construction activities. The system will most likely source water from regional groundwater resources, but may also source water from either Tantangara or Talbingo Reservoirs provided licences are available. Extraction from watercourses will be avoided where practicable. The most suitable extraction locations and water sources will be established during detailed design	WMP – Section 2.5.3, Section 5
Reservoir water quality (wastewater management)	WM09	A wastewater management system will be established to manage effluent from construction compounds and accommodation camps. All wastewater will be treated to meet the water quality specifications provided in the water management report and will be discharged to reservoirs. Wastewater discharges to watercourses will be avoided.	SWMP - Section 5.3.2, Table 5-3: SW30
Reservoir water quality (process water management)	WM10	A process water management system will be established to manage water during construction; and to supply water to construction activities. All surplus process water will be treated to meet the water quality specifications provided in the water management report and will be discharged to reservoirs. Process water discharges to watercourses will be avoided.	SWMP - Section 5.3.1, Table 5-3: SW22
Changes to reservoir water quality due to plug removal within the reservoirs	WM11	The specifications and locations of the proposed environmental measures will be determined as part of detailed design, including the installation of silt curtains. They will be designed such that water quality criteria is agreed with the regulators, with the application of a mixing zone if required.	SWMP - Section 5.9, Table 5-3: SW66
Reservoir bed sediments are disturbed by commissioning water flows	WM12	Investigations to minimise the disturbance of bed sediments due to water flows during commissioning will be undertaken as part of detailed design. Potential measures to minimise the disturbance of bed sediments include: • investigate mitigated design measures; • dredging sediments from the potential disturbance zones and placing them in another part of the reservoir; and/or • armouring the sediments in the potential disturbance zones. These options are currently being assessed.	SWMP - Section 5.9, Table 5-3: SW67

Impact	Reference	Revised Environmental Management Measures	Where addressed
Flooding	WM13	Further consideration of flooding conditions and impacts, including flood modelling where necessary, will be undertaken to support future detailed design of both temporary and permanent works.	SWMP - Section 5.2, Table 5-3: SW18
Flooding	WM14	Flood emergency response plans will be developed for both construction and operational phases	Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090)
Impacts to aquatic habitats	AE02	Bridges or culverts would be designed and constructed in accordance with NSW DPI fish passage requirements for waterway crossings (Fairfull & Witheridge 2003) where practicable.	Aquatic Habitat Management Plan (S2-FGJV-PLN-009)
Impacts to aquatic habitats	AE03	Construction works within the channel of a permanent waterway with type 1 or 2 key fish habitat would allow some flow to maintain fish passage at all times and be staged to minimise the total disturbance at any given time.	Aquatic Habitat Management Plan (S2-FGJV-PLN-009)
Soil erosion and sedimentation	SOIL03	Site-based Erosion and Sediment Control Plans (ESCPs) will be prepared or reviewed by a Certified Professional in Erosion and Sediment Control (CPESC) for the construction works.	SWMP – Section 5.1, Table 5-3: SW04

Table 2-3: Exploratory works (SSI 9208) REMMS relevant to surface water

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Impacts to aquatic habitat and biota during dredging and subaqueous placement	ECO15	2	Measures relevant to aquatic ecology will be implemented as described below including: • monitoring of water quality indicators including turbidity, pH and dissolved oxygen within and downstream of the construction area and, if a decline in water quality is detected as a result of the works, investigate potential causes and develop and implement an appropriate response;	SWMP – Annexure A, Table 5-3: SW68	
		4	Measures relevant to aquatic ecology will be implemented as described below including: • the extent of the dredge footprint will be minimised as far as practicable;	A dredge management plan will be prepared for dredging associated with exploratory works prior to undertaking dredging.	
Erosion and sediment transport	SOIL02	1	Erosion and sedimentation controls will be implemented as part of the Water Management Plan to minimise erosion potential in accordance with the guideline Managing Urban Stormwater, Volumes 1 and 2, or equivalent.	SWMP - Section 5.1, Table 5-3: SW03, SW04	
Flood risks	FM1.1	1*	Camp and Wallaces bridges will be designed in accordance with AustRoads bridge design standards which require the bridge deck soffit to be located above the 1% AEP flood level;	This scope of works has been completed.	This scope of works has been completed.

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Leaching/ running into groundwater/ creeks	WAT01	1	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including • minimising direct access to the river by construction vehicles and mechanical plant; • regular inspection of construction vehicles and mechanical plant for leakage of fuel and /or oils; • establishing a bunded area for storage of fuel and oils; • refuelling and maintenance of vehicles and mechanical plant at least 50 m from watercourses; • avoiding as far as possible re-fuelling, washing and maintenance of land-based vehicles and plant within 50 m of watercourses; • reporting spillages to the appropriate officer and immediately deploying spill containment and / or absorption kits as required to restrict its spread; • vehicles, vessels and plant would be properly maintained and regularly inspected for fluid leaks; • emergency spill kits will be kept onsite, at refuelling areas and on all vessels at all times during the Exploratory Works. The spill kit will be appropriately sized for the volume of substances on the vessel. All staff would be made aware of the location of the spill kit and trained in its use; • if any hydrocarbon spills were to occur during soil stripping, the impact will be isolated and clean-up procedures implemented; • areas to be used for long-term storage and handling of hydrocarbons and chemicals will be enclosed with concrete bunds; • chemicals will be handled and stored as per manufacturer's instructions; and • below ground, refuelling will be undertaken in dry, enclosed, bunded areas;	Section 5.4, Table 5-3: SW36, SW37, SW38, SW39, SW40 and SW41, Annexure C (Spill Response Procedure)	
Surface and groundwater	WAT02	1	A Surface and Groundwater Monitoring Program will be developed and implemented to monitor the effectiveness of water quality controls.	SWMP – Annexure A, Table 5-3: SW68 GMP – Annexure A	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
		2	The program will include: • establish monitoring locations to provide suitable baseline and detection monitoring of surface and groundwater parameters;	SWMP – Annexure A, Table 5-3: SW68 GMP – Annexure A	
Impacts from barge access construction	WAT04	1*	A dredge environmental management plan (DEMP) and associated mitigation measures will be implemented for dredging and construction of barge access infrastructure including:	A dredge management plan will be prepared for dredging associated with exploratory works prior to undertaking dredging.	
		2	including: • a water quality monitoring program at the dredge area prior to, during and following completion of dredging and barge access infrastructure construction works;		
		3	including: • installation of silt curtains around dredging and active construction work areas within waterways;		
		4	including: • selecting uncontaminated granular fill with less than 2% fines and selecting granular bedding material;		
		5	including: • ensuring skip bins for land disposal of excavated material are watertight;		
		6	including: • all activities would be carried out in a manner that minimises the potential for leaks and spills and in compliance with waste handling and disposal procedures outlined in the DEMP;		
		8*	including: • subaqueous placement of dredge spoil will include the mitigation measures described in WAT17;		
		10	including: • a silt curtain would be placed around the backhoe dredger or other suitable equipment at the dredge area; and		
		11*	including: • the dredged material once placed on barges would not be drained at the dredging site. Barges for subaqueous placement and skip bins for land placement would be watertight.		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Spills of hydrocarbons	WAT11	1	Procedures to address spills and leaks will be developed and implemented as part of the CEMP.	SWMP – Section 5.4, Table 5-3: SW36, Annexure C (Spill Response Procedure)	
Controls for construction disturbance areas	WM1.1	1	The following controls will be applied to the design of the clean water management system: • where practical, all clean water will be diverted around or through water management areas. Runoff from clean water areas that cannot be diverted must be accounted for in the design of water management systems;	SWMP – Section 5.1, Table 5-3: SW07	
	WM1.2	1*	The following controls will be applied to the design of the clean water management system: • All permanent clean water drainage will be designed and constructed to convey the 1% AEP peak flow and will have adequate scour protection. Temporary clean water drainage will be designed to convey the 50% AEP peak flow;	Not applicable	Main Works Sch 3, CoA 30(b)(c) prevail.
	WM1.3	1*	The following controls will be applied to the design of the clean water management system: • where practical, diversions will seek to avoid materially increasing flow rates in adjoining watercourses; and.	Not applicable	Main Works Sch 3, CoA 30(b)(c) prevail.
	WM1.4	1	The following controls will be applied to the design of the clean water management system: • Where practical, the permanent diversion of drainage lines or watercourses using contour drains will be avoided.	SWMP – Section 5.1, Table 5-3: SW61	
	WM2.1	1*	An Erosion and Sediment Control Plan (ESCP) will be prepared for each construction area.	SWMP – Section 5.1, Table 5-3: SW03, SW04, SW05	Main Works REMM SOIL03, WM03, WM04 and WM05 prevail
		2	Each ESCP will: • consider local soil characteristics, clean water management and the proposed construction methods;		
		3	Each ESCP will: • apply all practical source control and rehabilitation methods; and		
		4	Each ESCP will: • be progressively amended as required during construction.		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
		5	Each ESCP will: • A suitably qualified erosion and sediment control expert will be commissioned to develop and execute each ESCP. The expert will be responsible for overseeing the development of the ESCP and inspecting and auditing controls during implementation. Regular expert input will ensure that erosion and sediment control practices will be established and operated to a high standard and progressively improved.		
	WM2.7	1*	Where appropriate, sedimentation basins will be constructed in accordance with the methods recommended in Managing Urban Stormwater: Soils and Construction: Volume 1 (Landcom 2004) and Volume 2D (DECC 2008). Water treatment chemicals will be applied to sedimentation basins with catchment areas greater than 2,500 m^2 to enhance sedimentation and phosphorus and dissolved metal removal rates. Only water treatment chemicals that have a low risk of increasing the toxicity of treated stormwater will be used. Water treatment chemicals will be applied using an automated chemical dosing and mixing system. The design treatment rate will be the 1-year ARI peak flow.	SWMP – Section 5.1, Table 5-3: SW03, SW04*	Revised Main Works SWMP does not include automated chemical dosing systems using alum based PAC due to agency concerns with this methodology for sedimentation basins.
	WM2.2	1*	The clean water management controls WM_1.1 to 1.4 apply to all ESCPs.	SWMP – Section 5.1, Table 5-3: SW07, SW08	Main Works Sch 3, CoA 30(b)(c) prevail.
	WM2.3	1	Stockpiles will be located where they are not exposed to concentrated or flood flow. Flood flow is defined as the 20% AEP flood extent. Monitoring for dispersion and erosion of soil stockpiles will be undertaken, particularly on moderately dispersive soils. Addition of ameliorants, such as gypsum and organic matter for dispersive soils will be undertaken as needed.	SWMP – Section 5.2, Table 5-3: SW07 Spoil Management Plan (S2-FGJV-ENV-PLN-0019)	
	WM2.4	1	Soils will be lightly scarified on the contour to encourage rainfall infiltration and minimise run-off. As soon as practicable after respreading, a cover crop will be established to limit erosion and soil loss. This will also provide good mulch for native plant establishment.	SWMP –Table 5-3	
	WM2.5	1	Sediment traps or filters will be maintained at all discharge locations. The filters will only use non-toxic or materials which will not cause material harm to the environment, including biodegradable or natural materials where practicable. Sediment traps, filters and other appropriate sediment control devices will be installed to target the removal of coarse sediments.	A combination of sediment basins, treatment basins, water treatment drains will be utilised to limit course sediment discharging into adjacent water courses.	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Additional controls for construction areas that are constrained by terrain or the proposed disturbance boundary	WM2.6	1*	Runoff from construction areas that are constrained by terrain or the proposed disturbance boundary and are larger than 2,500 m^2 will be captured in a sump and pumped to a water treatment plant. The water treatment plant will use water treatment chemicals to enhance sedimentation and phosphorus and dissolved metal removal rates using an automated chemical dosing system. Only water treatment chemicals that have a low risk of increasing the toxicity of treated stormwater will be used. The design dewatering and treatment rate will be the 1 in 3-month average return interval (ARI) peak flow	SWMP – Section 5.1, Table 5-3: SW03, SW04	Runoff from disturbed areas are directed to sediment basins in accordance with the blue book, and will be managed to avoid discharge to the environment (passively or via water treatment plant systems)
Additional controls for construction areas that are not constrained by terrain	WM2.8	1	When practical, water captured in sedimentation basins will be used for dust suppression.	SWMP – Section 5.1, Table 5-3: SW14	
Water management controls for access roads Controls for all access roads	WM3.1	1*	Sections of Lobs Hole Road that will no longer be required following the construction of the new access roads will be removed and rehabilitated. This will reduce associated sediment loads;	SWMP – Section 5.5, Table 5-3: SW42, SW43, SW44, SW45, SW01, SW46	Main Works converts Lobs Hole Road to a two way road and all areas will be managed as part as final design. There are no sediment basins on Lobs Hole Ravine road due to steep terrain and to minimise clearing impacts on threatened species habitat (WM3.6)
	WM3.2	1	• all cut and fill batters will be stabilised as soon as practicable;		
	WM3.3	1	• the clean water management controls WM_1.1 to 1.4 will apply to the design of all access roads.		
	WM3.4	1	• access road surfaces will be maintained with appropriate aggregate material to reduce the risk of erosion;		
	WM3.5	1	• where practicable and safe to do so access roads will be single cross fall and will grade to a table drain located against the toe of the cut batters. The drains will be stabilised by rock armouring as required;		
	WM3.6	1	• where appropriate, the sedimentation basins established to manage runoff during construction of the access roads will be maintained during the Exploratory Works to provide ongoing treatment of runoff from access roads;		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Additional controls for access roads that are not constrained by terrain or the proposed disturbance footprint.	WM3.7	1*	The sedimentation basins established to manage runoff during construction of the access roads will be modified to be constructed wetland style basins. Constructed wetland style basins will maintain permanent water. An extended detention zone will be established above the permanent water. The extended detention zone will drain slowly through a low flow outlet control. Where practical, runoff from road embankments that have been stabilised by vegetation will be diverted into the clean water drainage system to minimise the contributing catchment area to the constructed wetlands. This will increase the effective size of the basin (in terms of depth of rainfall captured) and will result in a treatment volume that is greater than the 5 day 85th percentile volume that is proposed for sedimentation basins for construction areas.	Main Works converts Lobs Hole Road to a two way road and all areas will be managed as part as final design. There are no sediment basins on Lobs Hole Ravine road due to steep terrain.	Main Works converts Lobs Hole Road to a two way road and all areas will be managed as part as final design. There are no sediment basins on Lobs Hole Ravine road due to steep terrain.
Water management controls for the accommodation camp	WM4.1	1*	A stormwater management plan will be prepared as part of the detailed design of the project. The plan will consider geotechnical constraints including shallow soils.	SWMP – Section 5.6, Table 5-3: SW47, SW48, SW49	Implemented for the Exploratory Works Lob Hole Accommodation Camp.
	WM4.2	1	Clean water from upslope areas will be diverted around the accommodation camp.		
	WM4.3	1	A piped drainage system will be established to capture stormwater and convey it to the proposed water quality improvement ponds. The drainage system will have a 20% AEP capacity. Overland flow paths will be provided as required.		
	WM4.4	1	All pervious areas including batters will be vegetated with endemic native vegetation where practicable.		
	WM4.5	1	Runoff from roof areas will be collected in rainwater tanks where practicable. Captured water will be used for non-potable uses, reducing runoff volumes.		
	WM4.6	1	Source controls including permeable pavers and rain gardens will be used where practicable.		
	WM4.7	1	All runoff from the accommodation camp will be treated in water quality improvement basin(s). The basin(s) will be designed as constructed wetlands where practicable and will provide a water quality improvement function and attenuate peak runoff rates from the accommodation camp.		
	WM4.8	1	Collectively, the stormwater controls will be sized and configured to achieve the water quality specifications provided in SWA Table 6.12.		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
	WM4.9	1	The water quality improvement pond batters will be established using retaining structures or other suitable measures to avoid disturbance of the Watercourse 3 channel.		
Water management controls for the portal construction pad	WM5.1	1*	A stormwater management plan will be prepared as part of the detailed design of the project. The plan will be integrated with the process water system.	SWMP - Table 5-3: SW39, SW07, SW04, SW13	Implemented for the Exploratory Works portal construction pad. Due to constraints, part of the drainage system is not piped.
	WM5.2	1	Where practical, all activities that will occur on the portal construction pad with potential to contaminate stormwater runoff will be isolated from the stormwater system through the use of covering (i.e. by a building or roof) and bunding. Water produced within the covered and bunded areas will be either: • managed by the process water system; or • disposed as liquid waste to an appropriate facility.		
	WM5.3	1	Clean water from upslope areas will be diverted through or around the portal construction pad in a designated clean water drainage system.		
	WM5.4	1	A piped drainage system will be established to capture stormwater and convey it to the water management basin. The drainage system will have a 1% AEP capacity. Overland flow paths will be provided as required.		
	WM5.5	1	All aggregate storage and stockpile areas will be bunded to prevent stormwater ingress. Runoff from these areas will be treated in sediment wedge pits or other sediment controls to remove all coarse material. Sediment wedge pits will overflow into the piped drainage system.		

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
	WM5.6	1*	All runoff from the portal construction pad and adjoining access road will be conveyed to a water management basin with adequate capacity for at least a 5 day 95th percentile rainfall event and include additional volume to accommodate required water quality treatments (i.e. a total volume of at least 3,750 m^3). The basin will provide a water quality improvement function. Water captured in the basin will be extracted to supply the process water system. Water treatment chemicals will be applied to the water management basin to enhance sedimentation and phosphorous and dissolved metal removal rates. Only water treatment chemicals that have a low risk of increasing the toxicity of treated stormwater will be used. Water treatment chemicals will be applied using an automated chemical dosing and mixing system. The system will be designed to meet the water quality specifications provided in SWA Table 6.16. The design treatment rate will be the 1-year ARI peak flow.		Disturbed areas are directed to sedimentation basins in accordance with the blue book, and will be managed to avoid discharge to the environment (passively or via water treatment plant systems)
	WM5.7	1	The water management basin will be designed to provide a freeboard between its overflow pipe and spillway. The freeboard volume will be calculated to contain probable leaks, spills and firewater runoff volumes. The overflow pipe will have a manual shutoff valve that will enable site management to shut off the overflow pipe to enable the basin to contain any leak, spill or fire water runoff.		
Water management controls for the process water system	WM6.1	1	A process water management system will be established to manage any potentially contaminated water that may be produced by the construction activities.	SWMP – Section 5.3.1, Table 5-3: SW22	
	WM6.2	1	The process water management system will be separated from the stormwater system to avoid uncontrolled overflows associated with stormwater ingress.	SWMP – Section 5.3.1, Table 5-3: SW24	
	WM6.3	1*	The process water system will incorporate a water treatment plant that will treat water to a suitable quality for its proposed use in construction activities. If required to meet water quality criteria, additional treatment will be provided for any water that is discharged to Talbingo Reservoir via the controlled discharge pipeline. This treatment system will meet the water quality specifications provided in Table 4.5 of the RTS.	SWMP – Section 5.3.1, Table 5-3: SW22	This treatment systems will meet the specifications in the Main Works RTS, WMP - Appendix A (SWMP) and EPL.

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
	WM6.4	1*	The process water management system will have the ability to extract water from the portal construction pad's water management basin. This will be done to top-up supply.	SWMP – Section 5.3.1, Table 5-3: SW22	Main Works, process water will be recycled. Water from sediment basins will be used for irrigation and dust suppression.
	WM6.5	1*	A reticulation system will be established to enable the process water system to: • extract water from Talbingo Reservoir (as required); and • discharge treated process water into Talbingo Reservoir (as required).	SWMP – Section 5.3.1, Table 5-3: SW22	Two systems are proposed; the Talbingo system and the Tantangara system.
Water management controls for the wastewater management system	WM7.1	1	Wastewater from the accommodation camp will be reticulated to a wastewater treatment plant via a sewer system. The sewer system will be designed to restrict stormwater ingress into the wastewater system.	SWMP – Section 5.3.2, Section 5.6, Table 5-3: SW32	
	WM7.2	1	Water efficient fittings will be used to minimise wastewater loads.	SWMP – Table 5-3: SW34	
	WM7.3	1	Low phosphorus products are to be used for washing activities controlled by site management (i.e. laundry services and mess hall) and encouraged (via education) for general use.	SWMP – Table 5-3: SW50	
	WM7.4	1	The wastewater storage system will include emergency storage of untreated wastewater. The storage volume will be calculated at detailed design based on analysis of response times from regional waste management contractors to provide emergency trucking and offsite disposal options.	SWMP – Table 5-3: SW30	
	WM7.5	1*	A wastewater treatment plant will meet the water quality specifications provided in Table 4.4 of the RTS.	SWMP – Section 5.3.2, Section 5.6, Table 5-3: SW30	This treatment system will meet the specifications in the Main Works RTS, WMP - Appendix A (SWMP) and EPL.
	WM7.6	1	Treated wastewater will be disposed to Talbingo Reservoir via the controlled discharge pipeline.	SWMP – Section 5.3.2, Table 5-3: SW30	
Water quality impacts from rock	WM_8.2	1	During establishment, the water management controls for construction areas (Wm_2.1 to 2.8) will be applied.	SWMP – Table 5-3 Refer to WM_2.1 to 2.8 above	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
emplacement areas	WM_8.6	1	Runoff from Lock Hole Gully will be diverted around or through the eastern emplacement area. The diversion works will comprise a dam upstream of the diversion inlet and either a gravity or pump assisted diversion system. The diversion works will have a 1% AEP capacity. The dam upstream of the diversion inlet will be designed as a detention basin and will not permanently hold water. A high-flow diversion drain will be established to convey runoff from Lick Hole Gully around the emplacement area in a controlled manner, avoiding uncontrolled overflows through the emplacement area. This diversion drain will only be engaged if a flood greater than a 1% AEP even occurs.	SWMP – Table 5-3: SW07, SW08	
	WM_8.7	1	Seepage from the eastern emplacement area will be collected in a water management dam. Collected water will either be irrigated to the emplacement (to promote evaporation) or treated in the process water treatment plant. Discharge of seepage water to the Yarrangobilly river will be avoided.	SWMP – Table 5-3: SW15	
Flood risks	FM_1.1	2*	Camp and Wallaces bridges will be designed in accordance with AustRoads bridge design standards which require the: • bridge structure to be designed to withstand a 0.05% AEP event; and	This scope of works has been completed.	This scope of works has been completed.
	FM_1.1	3*	Camp and Wallaces bridges will be designed in accordance with AustRoads bridge design standards which require the: • abutments to be protected by appropriately designed scour protection.	This scope of works has been completed.	
	FM_1.2	1	The western emplacement will be designed to prevent the risk of emplacement material being entrained in flood waters during a 1 in 5000 year flood event.	Spoil Management Plan (S2-FGJV-PLN-0019)	
Clean water	M1.8	1	Where practicable, all clean water will be diverted around or through sites using cross-path drains or other similar measures to limit impact to existing flow regimes.	SWMP – Section 5.1, Table 5-3: SW07, SW08	
Refuelling	M1.10	1	A refuelling protocol will be developed for in-reservoir borehole drilling and will be included in the Construction Environment Management Plan (CEMP).	SWMP - Annexure D	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Erosion and sedimentation	M1.11	1	Erosion and Sediment Control Plans will be prepared for all proposed construction sites and drilling pads. These plans will consider local soil characteristics, clean water management and site-specific measures to suit the proposed construction methods.	SWMP – Section 5.1, Table 5-3: SW03, SW04	
Spills	M1.12	1	Geotechnical investigation drilling will be undertaken in accordance with the surface water management plan. The following mitigation measures are included in the existing surface water management plan: • All fuel and hazardous substances used in drilling will be stored in designated areas of the drill pad. Hazardous chemicals will be stored in accordance with relevant standards, including AS 1940:2004. • Designated fuel storage areas will be bunded to mitigate risk of contamination to surface water and soils should spills occur. Refuelling will also be carried out in the designated, bunded area. • Equipment should be appropriately maintained to ensure there are no leaks. • Spill kits will be available on site to contain contamination should any spills outside these bunded areas occur. If used, waste from the spill kits will be disposed of appropriately. • The safety data sheets of all hazardous chemicals required for drilling activities will be made available on site. • All waste produced during drilling will be stored on site in above ground containers, and when required will be taken off-site by vehicles. All waste will be disposed of off-site to an EPA licensed facility.	SWMP - Section 5.4, Table 5-3: SW36, SW37, SW38, SW39, SW40 and SW41, Annexure C (Spill Response Procedure)	

Impact	Reference		Revised Environmental Management Measures	Where Addressed	Comment
Barge ramp establishment	MOD2 - 001		The following measures will be implemented for barge ramp establishment works at Middle Bay: • all barge ramp construction and dredging works would be closely monitored and carried out according to the Dredge Management Plan, Surface Water Management Plan and Aquatic Habitat Management Plan; • appropriate methods and pre-dredge testing would be implemented to that material is appropriately handled to minimise impacts to aquatic species and habitat; and • removal and subsequent disposal of aquatic macrophytes would be undertaken according to the Dredge Management Plan and / or Waste Management Plan.	A dredge management plan will be prepared for dredging associated with exploratory works prior to undertaking dredging.	

2.4. EPBC Approval

The EPBC Act approval for Snowy 2.0 Main Works was granted by DAWE in 2020. This approval was provided for the impact of the Snowy 2.0 Main Works Project on national heritage values of a national heritage place (Sections 15B and 15C of the EPBC Act), listed threatened species and communities (Section 18, Section 18A of the EPBC Act) and listed migratory species (Section 20, Section 20A of the EPBC Act).

Table 2-4 details the EPBC Act Approval conditions which are relevant to water and demonstrates where these conditions are addressed.

Table 2-4: Commonwealth Conditions of Approval relevant to water

Condition	Requirement	Where addressed
17	To minimise impacts on water resources, the approval holder must comply with conditions 30 – 32 of the NSW approval relating to water management	Refer to Table 2-1
18	The approval holder must prepare the Water Management Plan required by condition 31 of the NSW approval in consultation with the Department, before it is approved by the NSW Planning Secretary	Section 1.7
19	The Water Management Plan must include provisions to make monitoring data (excluding sensitive ecological data) available as part of the monitoring, evaluation and reporting programs required by condition 31c and 31d of the NSW approval	SWMP – Annexure A SWMP – Section 6.7
20	Once the Water Management Plan is approved by the NSW Planning Secretary, the approval holder must implement the plan for the duration of the approval, unless otherwise agreed by the Minister in writing.	This SWMP will be implemented for the development Refer to Section 6.

2.5. Licences and Permits

2.5.1. Environment Protection Licence

Environment Protection Licence (EPL) (No 21266) has been issued as part of the Exploratory Works phase for extractive activities.

The premises boundary for the Exploratory Works EPL has been expanded to encompasses both Exploratory Works and Main Works activities and the governing schedule activity for Main Works will be Electricity Generation.

At times, the surface water monitoring requirements of the EPL may differ to that detailed within this plan, particularly in the event of variations to the EPL. Differences may include changes to the monitoring locations; changes to the frequency of monitoring; or changes to the parameters which are required to be monitored.

Should differences arise, the monitoring requirements of the EPL will take precedence. This will occur until such time that the revised SWMP is updated and approved.

2.5.2. Agreement for Lease

Snowy Hydro Limited have established an Agreement for Lease (AFL) with NPWS. A Construction Lease and Works Access Licence will be established with NPWS in order to carry the works in accordance with Main Works, Exploratory Works, CSSI 9687 and the approved management plans.

2.5.3. Water Access Licence

Section 60A of the *Water Management Act 2000* requires that a water access licence be obtained to extract water from a water source.

Section 21 and schedule 4 of the Water Management (General) Regulation 2018 does however provide exemptions for the requirement to obtain water access licences. These exemptions include certain aquifer interference activities (i.e. pump testing a bore; or monitoring) in relation to taking up to 3 ML of groundwater from a groundwater source (clause 7)

Water access licences would therefore not be required if Snowy Hydro, as the licence holder, are using the water for dust suppression or for certain aquifer interference activities (i.e. pump testing a bore; or monitoring) with less than 3ML of groundwater take in a water year.

Any other water required for construction purposes would however require a water access licence. This includes extraction for:

- interception activities (i.e. intercepted groundwater during tunnelling)
- potable uses for human consumption associated with the accommodation camp;
- process water via the services pipeline from Talbingo and Tantangara Reservoirs for the tunnelling and associated activities including maintenance facilities.

Snowy Hydro have secured two groundwater access licences (WAL42408, WAL42960) and a surface water specific purpose access licences (WAL42407) for the Exploratory Works Project. These three licences allow for direct and indirect take of groundwater from the Lachlan Fold Belt (LFB) Murray Darling Basin (MDB) Groundwater Source and direct take from the Upper Tumut water source.

Snowy Hydro are in the process of securing groundwater licences via Controlled Allocation Order for additional share entitlement from the LFB MDB groundwater source (RO13-19-093), the LFB South Coast groundwater source (RO13-19-192) and a surface water specific purpose access licence (to take water from Tantangara Reservoir) for the Main Works Project. The additional allocation covers the peak predicted annual take modelled for both Main Works and Exploratory Works.

These Water Access Licenses are being processed by the Natural Resources Access Regulator (NRAR) and registration with NSW Land Registry Services (LRS) has commenced. Actual take will be reported to NRAR on an annual basis in accordance with licence conditions.

Table 2-5 summarises the licencing arrangements.

Table 2-5: Water licences

Water Access Licence	Project	Water source	Share (ML)
WAL42407– Specific Purpose Access Licence	Exploratory Works	Upper Tumut water source	227
WAL42408 – Groundwater Licence	Exploratory Works	Lachlan Fold Belt MDB	0
WAL42960 – Groundwater Licence	Exploratory Works	Lachlan Fold Belt MDB	354
RO13-19-093 – via Controlled Allocation	Main Works	Lachlan Fold Belt MDB	3,375
RO1-19-092 – via Controlled Allocation	Main Works	Lachlan Fold Belt South Coast	1,722
Specific Purpose Access Licence (under application)	Main Works	Tantangara Water Source	In progress

2.6. Guidelines

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

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018);
- *Australian Rainfall and Runoff* (Commonwealth of Australia, 2016);
- *Managing Urban Stormwater: Soils and Construction* (Landcom, 4th Edition March 2004 (reprinted 2006) (the Blue Book)) Volume 1 and Volume 2;
- *Managing Urban Stormwater: Soils and Construction – Volume 2C – Unsealed roads* (DECCW 2008a);
- *Managing Urban Stormwater: Soils and Construction – Volume 2D – Main road construction* (DECCW 2008).
- *Managing Urban Stormwater: Soils and Construction - Volume 2E Mines and quarries* (DECCW 2008);
- *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings. NSW Fisheries, Cronulla*, 16 pp; Fairfull, S. and Witheridge, G. (2003)
- Department of Primary Industries *Guidelines for Controlled Activities on Waterfront Land* (2012);
- NSW Office of Water Guidelines for working within riparian corridors;
- *Approved Methods for the Sampling and Analysis of Water Pollutants in NSW* – March 2004.
- *Environmental Best Management Practice Guideline for Concreting Contractors*, DEC, 2004;
- *NSW Floodplain Development Manual* (2005);
- *Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure* (AP- R232) (Austroads, 2003);
- Australian Standard: AS1940 - 2017, *The Storage and Handling of Flammable and Combustible Liquids* (Standards Australia, 2017);
- Australian and New Zealand Standard: ASNZS 4452 – 1997, *The storage and handling of toxic substances* (Joint Standard Australia/Standard New Zealand Committee, 1997);
- NSW Environment Protection Authority's *Requirements for publishing pollution monitoring data* (EPA 2013).
- NSW Water Quality and River Flow Objectives (DECCW 2006)
- Liquid Chemical Storage, Handling and Spill Management: Review of Best Practice Regulation (DEC 2005); and
- Storing and Handling Liquids: Environmental Protection: Participant's Manual (DEC 2007).

3. EXISTING ENVIRONMENT

3.1. Bushfire

In January 2020, during the Main Works EIS application, significant bushfires occurred within the Project area and northern section of Kosciuszko National Park. The project site at Lobs Hole was severely impacted with much of the groundcover and trees burned, leaving the catchment area with bare soil and no ground protection. Other parts of the Main Works project area including the Plateau, Marica and Tantangara were also impacted by the bushfire to varying degrees.

The bushfires have led to a reduction in ground cover and increase in burnt ash material within and adjacent to the construction envelope. It is likely that, for some time, the existing pre-fire baseline water data that has been gathered and discussed in Annexure A (Surface Water Monitoring Program) will differ to the post-fire water quality. As such, management measures in this Plan have been developed to ensure that any adverse impacts can be adaptively managed throughout the bushfire recovery period.

3.2. Topography and Landscape

The Snowy 2.0 Project is mostly located within the Kosciusko National Park (KNP) and spans the NSW Western Slopes, South Eastern Highlands and Australian Alps Interim Biogeographic Regionalisation for Australia (IBRA) regions. The geomorphic history of the project area is complex and has resulted in a landscape of disrupted drainage patterns, swampy basins and erosion surfaces (Snowy Hydro 2017). This complexity is seen in the diverse landforms present in the area, ranging from valleys to mountain ranges. For the most part, the project area can be broken into two distinctive terrains the incised ravine area and the plateau area.

The ravine area; located mostly to the west of the Snowy Mountains Highway, is characterised by deep gorges and steep sloping ridges, the product of incision from river flow, historic glaciation and structural movement. The ravine area includes the Talbingo, Lobs Hole and Marica work zones.

The plateau area; located to the east of the Snowy Mountains Highway and spanning the area between the highway and Tantangara Reservoir, is typical of elevated alpine environments, dominated by low energy streams, gentle rolling hills and mostly flat floodplains. The plateau area includes the Plateau and Tantangara work zones.

The landscape varies from 545m AHD in the ravine area (Lobs Hole) leading up the valleys (Marica/ Plateau zones) to the plateau topped Tantangara zone at 1524m AHD.

The Rock Forest work zone is located on farm land to the south east and outside of the KNP.

3.3. Geology

The project area is located within the south-eastern portion of the Lachlan Fold Belt (LFB) of NSW. The LFB comprises a suite of Ordovician to Devonian sedimentary, igneous and metamorphic rocks that have developed during multiple orogenic periods.

The geology between Talbingo and Tantangara reservoirs is structurally deformed with numerous folds and several major faults associated with the north-south trending Long Plain Fault (LPF) zone. The terrains are separated by an escarpment caused by movement on the LPF zone.

There are eight karst areas in KNP, all of which are developed in Silurian or Devonian limestones. These include Yarrangobilly Caves, a known groundwater dependent ecosystem (GDE) and karst area, and Coolemans Plain karst area; both are recognised in the KNP Plan of Management (DEC 2014) for their cultural and natural significance. This complex geology, in association with topography, has resulted in a diverse soil landscape. Soils vary significantly in relation to altitude, temperature and rainfall.

Rock Forest is characterised as Silurian and Ordovician geology and is within the Lachlan Fold Belt.

3.4. Climate

The project area has an alpine climate that is characterised by cool summers and cold, damp, and snowy winters. The highest and most consistent precipitation occurs in winter to early spring, with precipitation amounts increasing with elevation. Summer and autumn are generally drier and experience greater variation in monthly rainfall. Summer rainfall is generally of higher intensity and of shorter duration than in winter. Climate data for the project area has been sourced from regional Bureau of Meteorology (BoM) and Snowy Hydro rainfall gauges, as well as climate maps produced by BoM. A summary of climate data for the ravine and plateau areas is provided in Table 3-1. Precipitation comprises rainfall and snowfall, however, the term rainfall has been used throughout the water assessment to maintain consistency with other sections of the Main Works EIS.

Table 3-1: Climate Summary

Parameter	Ravine area	Plateau area
Temperature[1]		
Mean annual maximum	21.3 C	12.6 C
Mean annual minimum	9.1 C	5.1 C
Annual rainfall[2]		
Highest	1315 mm/year	1,902 mm/year
Median	878 mm/year	1,158 mm/year
Lowest	382 mm/year	525 mm/year
Mean Class A pan evaporation[3]		
Annual	1,256 mm/year	
Lowest monthly	27 mm/month	
Highest monthly	206 mm/month	

1. Representative temperature for the ravine and plateau have been sourced from Snowy Hydro operated Talbingo gauge and BoM operated Cabramurra SMHEA AWS (72161) gauge.
2. Representative rainfall for the ravine and plateau areas have been sourced from Snowy Hydro operated Ravine gauge and BoM operated Yarrangobilly Caves (72141) gauge.
3. Representative pan evaporation sourced from Climate Atlas maps (BoM website).

3.5. Rainfall

The 10th, 50th and 90th percentile monthly rainfall have been calculated by BoM from the Yarrangobilly Caves (72142) gauge records and are presented in Figure 3-1. Mean monthly pan evaporation sourced from the BoM website are also shown in Figure 3-1. The trends shown indicate that a soil moisture deficit is likely to occur from December to March, when monthly evaporation exceeds the 90th percentile rainfall.

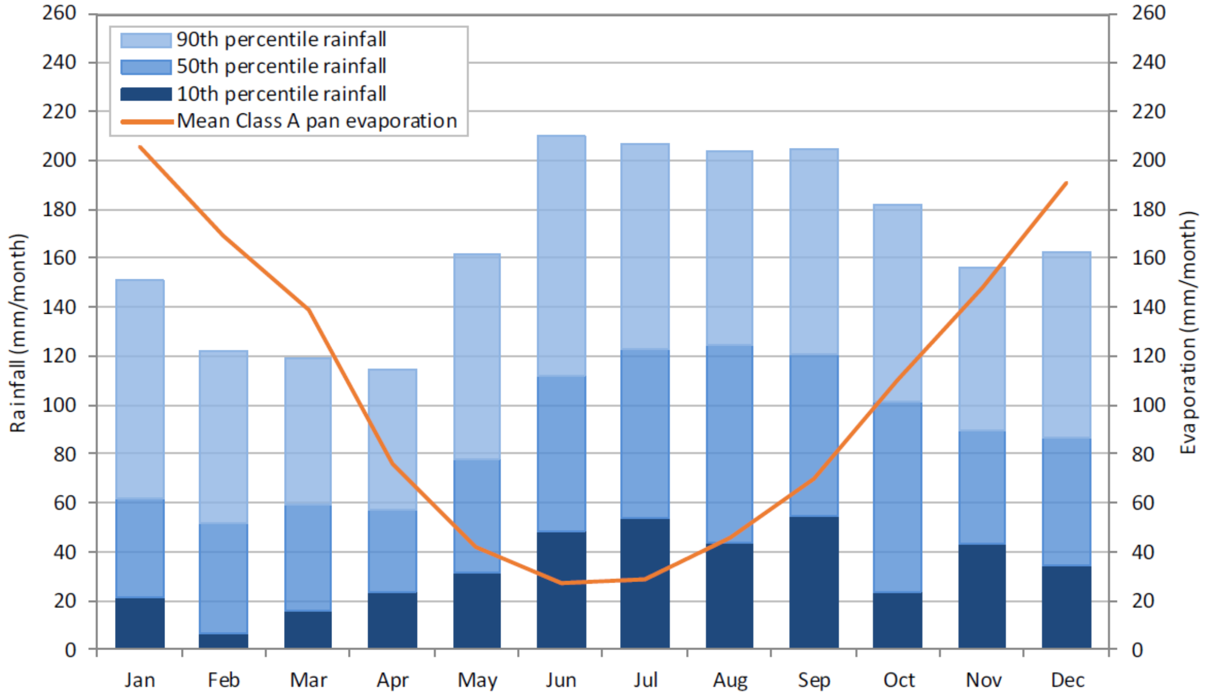

Figure 3-1: Monthly rainfall variability (BoM: 72141) and mean monthly pan evaporation (EMM, 2019)

Monthly rainfall totals recorded at Yarrangobilly Caves (BoM station 72141) from 1999 to March 2019 are shown in Figure 3-2. The deviation of rainfall totals over the previous 12-month period have been calculated and compared to annualised monthly average rainfall to identify and characterise periods of extended dry and wet conditions. A positive value relates to wetter than average conditions while a negative value relates to drier than average conditions. These deficits and excess in rainfall can also correspond to long-term groundwater level and streamflow trends. The trends in Figure 3-2 indicate that:

- Below average rainfall occurred between mid-2002 to late 2003, mid-2004 to early 2005, mid-2006 to late 2010, early 2013 to mid-2016 and mid-2017 to mid-2019. The most significant below average rainfall conditions occurred between mid-2006 and late 2010.
- Above average rainfall occurred between 1999 and mid-2002, April 2005 to May 2006, late 2010 to early 2013 and mid-2016 to mid-2017.

It is noted that data collected for the EIS during 2018 and early 2019 were collected during drier than average conditions.

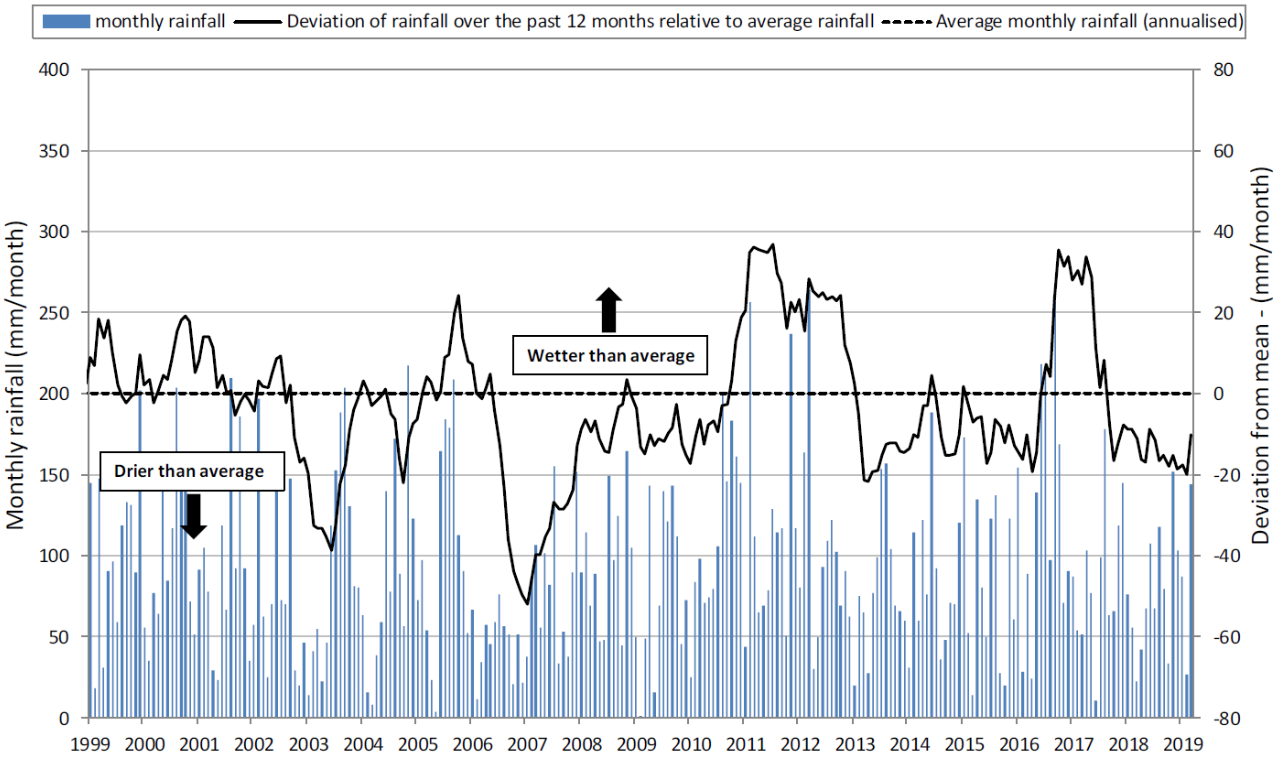

Figure 3-2: Yarrangobilly Caves (BoM: 72141) rainfall over the 1999 to 2019 period (EMM, 2019)

3.6. Soils

3.6.1. Plateau

Climate in these alpine and subalpine areas has a dominant role in soil formation leading to the development of one soil group, the Alpine Humus Soil, across all parent geological materials (e.g. volcanic, sediment and metamorphic) (NPWS 2004). Kandosols are the most common soil type from the site data, forming on a range of geologies. Rudosols/Tenosols are the second most common soil type and are most likely to be Alpine Humus Soils with high organic or peaty layers in the profile. Dermosols (on a range of geologies) and Chromosols (on granites and sediments) were also relatively common. Other soil types include Ferrosols (on basic igneous geologies), Hydrosols, and Organosols (in drainage depressions or alluvial areas).

The plateau soils are likely to have high organic matter content and are generally moderately to strongly acidic likely reflecting a highly leached environment. Soils are not likely to be sodic or magnesic. Topsoil erodibility is likely to be low to moderate depending on the organic matter content. The subsoils are generally non-dispersible ranging from loams to clays. Some subsoils are likely to have relatively low coherence particularly for lighter textures (i.e. loams) or coarser sandy soils.

The erosion hazard of the soils in this area is moderate to very high with the affects of cold climate, shallow soils, highly organic soils and steep slopes increasing the erosion hazard of the soils.

Alpine and subalpine soils with very high organic layers such as the Alpine Humus Soils (most commonly Tenosols) and bog and fen peats (usually Organosols) are fragile soils that are difficult to return to their natural state once disturbed. They are fragile due in part to the restricted growing season of the alpine and subalpine regions, but also due to the very fragile nature of some systems, particularly alpine snowpatch vegetation and the Alpine Sphagnum Bogs and Associated Fens ecological community.

3.6.2. Ravine

Ravine soils are generally sandy or silty clay loams that are neutral to strongly acid depending on the parent material. Depending on depth, the soils are generally either Kandosols or Rudosols/Tenosols. Occasionally the lithology of these sediments may result in different soils (e.g. Dermosols or Ferrosols in limestone or more clay rich layers).

There are relatively minor areas of clayey alluvium of Dermosols and Vertosols associated with the Yarrangobilly River. There are also deeper Kandosol and Ferrosol soils on more gently sloping basic and intermediate volcanics towards the top of Ravine Road.

The topsoils generally have moderate to low erodibility with moderate to high organic matter contents. The subsoils are loams to light clays and have a moderate erodibility and range from non-dispersible to showing some dispersion following remoulding. The majority of the soils have only weak structure, low coherence, and moderate to very high class of erosion hazard due to the steep long slopes and shallow soils of the ravine.

The soils analysed from the Exploratory Works soil survey (EMM 2018b) did not contain any samples that were sodic or magnesic. The NSW Office of Environment and Heritage site data noted one dispersive soil (Sodosol - Yarrangobilly survey site 81), 2.3 km to the north-west of the footprint on rhyolite in a drainage depression. There are seven other sites in the same geology which are Tenosols or Kandosols. Based on the landforms of the project footprint with this geology, Sodosols may potentially occur, but are unlikely.

3.6.3. Rock Forest

Rock Forest is located on the lower to mid-slopes of gently undulating to undulating rises of sandstone. The soils are likely to be Kandosols and Dermosols that have moderately deep gradational profiles of clay loam over light clays.

The topsoils generally have moderate to low erodibility with possible highly organic layers. The subsoils have a moderate erodibility. The Kandosols have massive to weak structure throughout and are likely to have low coherence. The Dermosols do not have low coherence in the subsoil and are likely to be slightly less erodible due to their better structure. The soils are moderately to strongly acidic likely to reflect a highly leached environment. Soils are not likely to be sodic or magnesic.

The erosion hazard is moderate to high due to the climatic conditions of the area (snow and limited growing season), the possible highly organic topsoils, low coherence of Kandosols, and the gently undulating to undulating slopes.

3.7. Reservoirs

3.7.1. Tantangara Reservoir

Tantangara Reservoir is an existing reservoir that forms part of the Snowy Scheme and construction of the dam was completed in 1960. The reservoir is approximately 14 km long and has a surface area of approximately 21.2 km^2 (at full supply level).

The reservoir captures runoff from the head waters of the Murrumbidgee River and flows diverted from Goodradigbee River via the Goodradigbee aqueduct. Water is transferred to Lake Eucumbene via the Murrumbidgee to Eucumbene tunnel. Water from Lake Eucumbene is transferred to both the Tumut and Murry schemes. Tantangara Reservoir also provides environmental releases to the Murrumbidgee River.

A summary of key operating levels, storage volumes, tunnel discharge capacities and flood peak water levels are provided in Table 3-2

Table 3-2: Tantangara Reservoir overview (EIS Appendix J Annexure A, EMM)

Characteristic	Value
Full supply level (FSL)	1,228.7 m AHD
Minimum operating level (MOL)	1,205.8 m AHD
Operating range (FSL-MOL)	22.9 m
Spillway crest	1,228.7 m AHD
Active storage (within operating range)	240 GL
Gross storage	254 GL
Murrumbidgee – Eucumbene tunnel peak discharge	22 m^3/s
Murrumbidgee – environmental release	Annual targets range from 0 to 40 GL/year, with a long-term average of 20 GL/year.
Peak water level – 2% AEP	1,230.1 m AHD
Peak water level – 1% AEP	1,230.3 m AHD
Peak water level – PMF	1,236.3 m AHD

3.7.2. Talbingo Reservoir

Talbingo Reservoir is an existing reservoir on the Tumut River that forms part of the Snowy Scheme. Construction of Talbingo Reservoir was completed in 1971. The reservoir is approximately 25 km long and has a surface area of approximately 19.4 km^2 (at spillway crest).

Water is released from the reservoir through the Tumut 3 power station into Jounama Pondage, which releases water into Blowering Reservoir. Blowering Reservoir is operated by Water NSW and releases water into the Tumut River to supply a variety of consumptive users but primarily large irrigation schemes such as that run by Murrumbidgee Irrigation. The Tumut 3 power station also pumps water from Jounama Pondage back into Talbingo Reservoir.

A summary of key operating levels, storage volumes, tunnel discharge capacities and flood peak water levels are provided in Table 3-3

Table 3-3: Talbingo Reservoir overview (EIS Appendix J Annexure A, EMM)

Characteristic	Value
Full supply level (FSL)	543.2 m AHD
Minimum operating level (MOL)	534.4 m AHD
Operating range (FSL-MOL)	8.8 m
Spillway crest	544.7 m AHD
Active storage (within operating range)	239 GL
Gross storage	921 GL
Tumut 3 discharge (maximum)	1,133 m^3/s
Tumut 3 pump back rate (maximum)	300 m^3/s
Peak water level – 2% AEP	545.8 m AHD
Peak water level – 1% AEP	546.1 m AHD
Peak water level – PMF	552.1 m AHD

3.8. Water Courses

All water courses are defined as receiving baseflow from groundwater (gaining streams). The key watercourses are described below for the ravine (Figure 3-3), plateau (Figure 3-4) and Rock Forest

(Figure 3-5). The ravine watercourses generally flow to the Talbingo Reservoir and the Plateau watercourses generally flow into the Tantangara Reservoir.

3.8.1. Ravine

Within the ravine, the Yarrangobilly River is the major regional watercourse that flows into Talbingo Reservoir, downstream of Lobs Hole. Its catchment has an area of 271 km2 that is wholly within the KNP. The Yarrangobilly River has a number of tributaries within the ravine, including Wallaces Creek, Stable Creek, Sheep Station Creek and Highground Creek. The majority of annual stream flow occurs in late winter and early spring, which is typical for rivers in the Australian Alps. The following watercourses occur within the ravine zone:

- Yarrangobilly River
- Tumut River
- Wallaces Creek
- Stable Creek
- Cave Gully
- Lick Hole Gully
- Sheep station Creek
- Highground Creek; and
- Watercourses 1 through to 7.

3.8.2. Plateau

The plateau is within the upper reaches of the Murrumbidgee and Eucumbene River catchments, wholly within the KNP. The headwaters of the Eucumbene River are in the western plateau, and the river flows in a southerly direction to Lake Eucumbene. The Murrumbidgee River flows from north of the plateau in a south easterly direction into Tantangara Reservoir.

A number of perennial waterways are present across the plateau, that either flow north into the Murrumbidgee River or directly into Tantangara Reservoir, including Gooandra Creek, Tantangara Creek, Nungar Creek and Kellys Plain Creek. The following watercourses occur within the Plateau zone:

- Eucumbene River;
- Murrumbidgee River;
- Tantangara Creek;
- Gooandra Creek;
- Nungar Creek; and
- Kellys Plain Creek.

3.8.3. Rock Forest

Rock Forest is in the headwaters of the Goorudee Rivulet catchment, outside of the KNP and is nearby to two watercourses, being Camerons Creek and an unnamed 3rd order watercourse.

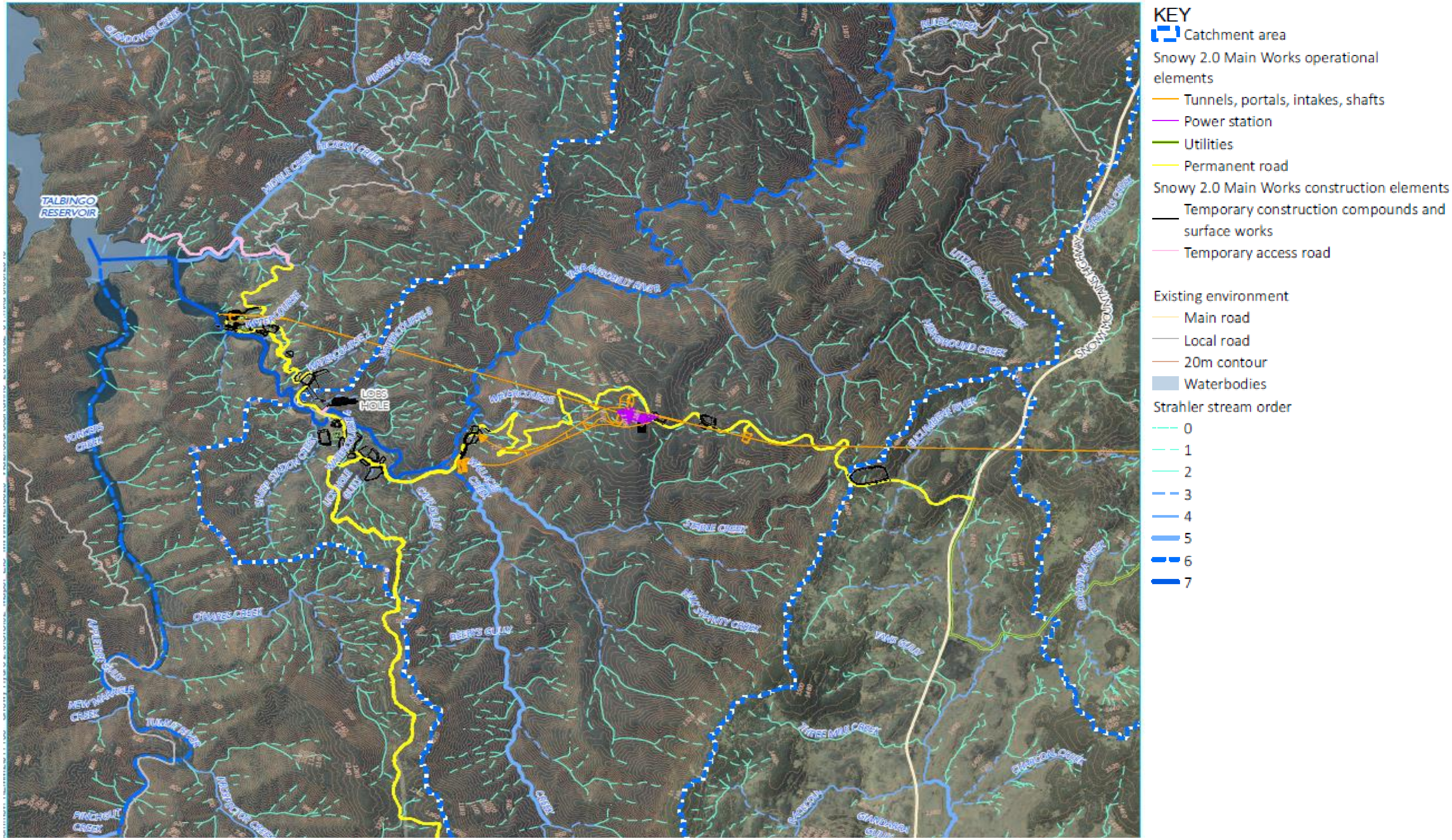

Figure 3-3: Watercourses - Ravine

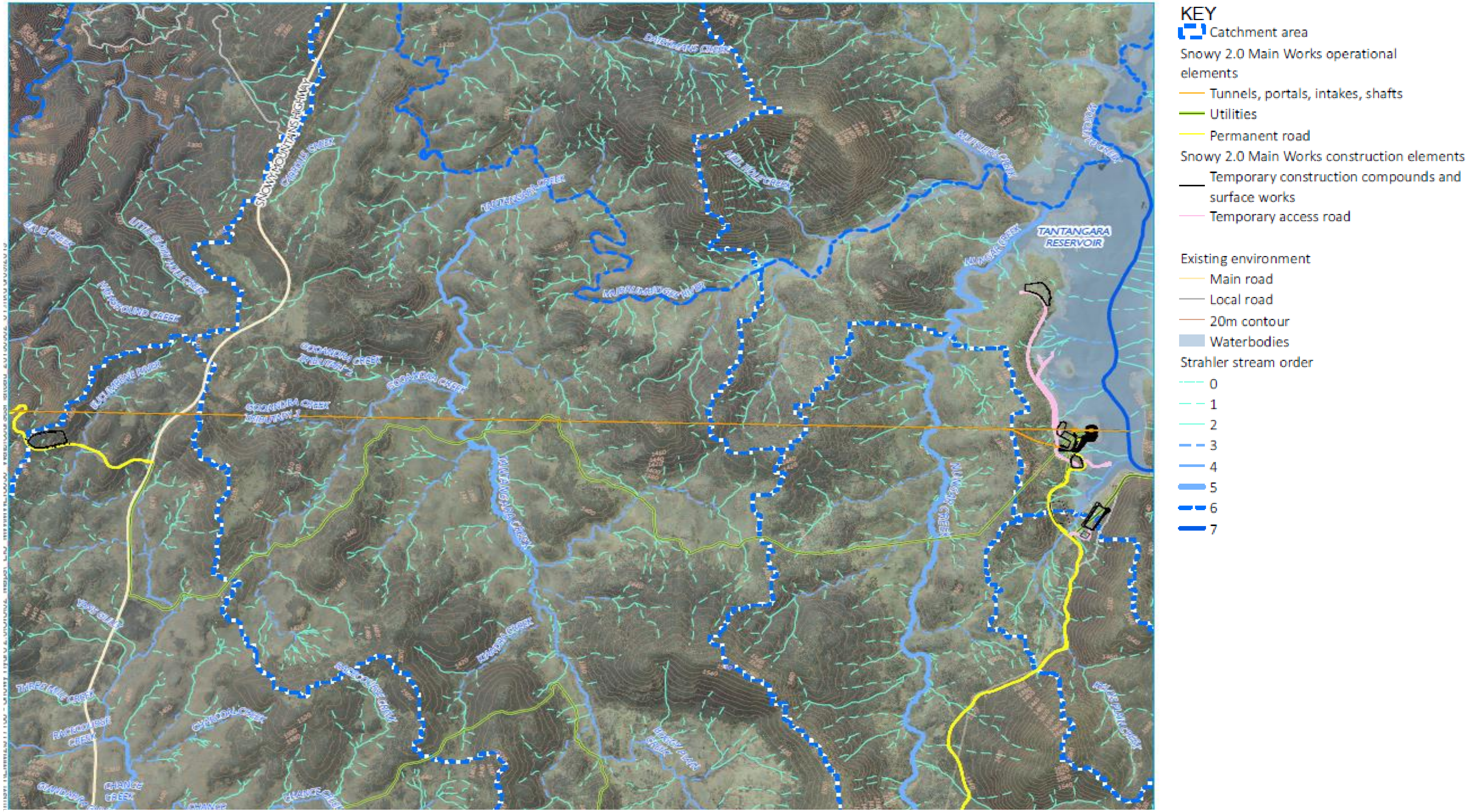

Figure 3-4: Watercourses - Plateau

Figure 3-5: Watercourses - Rock Forest

3.9. Existing Water Quality

Baseline monitoring of reservoir and watercourses was undertaken for the preparation of the Main Works EIS. This section details the findings identified in the Water Characterisation Report (EIS Appendix J Annexure A). Percentiles of baseline water quality data for the reservoirs and water courses are provided in the Surface Water Monitoring Program (Appendix A).

During the Main Works EIS application, significant bushfires occurred within the Project area. This has led to a reduction in ground cover and increase in burnt ash material within and adjacent to the construction envelope. It is likely that, for some time, the existing pre-fire baseline data that has been gathered and discussed in the sections below will differ to the post-fire water quality. This has been confirmed by the Exploratory Works surface water monitoring program, which has found increases in a number of parameters since the fires, such as turbidity and electrical conductivity.

3.9.1. Reservoirs

3.9.1.1. Tantangara Reservoir

Baseline monitoring was undertaken over the March 2018 to February 2019 period. The program comprised sampling from nine locations within the reservoir. Water quality characteristics from this monitoring period are described as follows:

- pH ranges between 6.6 and 8.0, with one lower and upper bound exceedance occurring;
- low levels of suspended solids and low turbidity;
- carbonate and salinity vary seasonally, with higher levels occurring in summer/autumn;
- oxidised nitrogen and ammonia occasionally exceeded WQO values in summer/autumn;
- total phosphorus frequently exceeded WQO values in summer/autumn and winter/spring while reactive phosphorus occasionally exceeded WQO values;
- all dissolved metal concentrations were below WQO values except for:
  - aluminium concentrations exceeded WQO values on a frequent basis;
  - copper, iron and zinc exceeded WQO values on a frequent basis during summer/autumn; and
  - chromium (total), cobalt and lead exceeded WQO values on an occasional basis during summer/autumn.

It is noted that all of the copper exceedances and the zinc exceedances occurred during March 2018 sampling, where 100% of samples exceeded the WQO values. Different analysis methods (consistent with the methods applied more broadly to EIS sampling) were applied to subsequent sampling (post-March 2018).

- reservoir water quality during and following wet weather conditions is poorly understood. There is potential for elevated turbidity, nutrients and some metals to occur near watercourse inflow locations for several weeks following a substantial runoff event.

3.9.1.2. Talbingo Reservoir

Baseline monitoring was undertaken over the March 2018 to February 2019 period. The program comprised sampling from ten locations within the reservoir. Water quality characteristics from this monitoring period are described as follows:

- pH ranges between 6.3 and 8.2, with occasional lower and upper bound exceedances;
- low concentrations of suspended solids and low turbidity;
- carbonate and salinity vary seasonally, with higher levels occurring in summer/autumn,

correlating with the higher salinity of streamflow over summer and autumn months;

- oxidised nitrogen concentrations exceeded WQO values frequently in winter/spring and occasionally in summer/autumn. This is the opposite trend to the Yarrangobilly River, where exceedances occurred more often in summer/autumn;
- ammonia concentrations frequently exceed WQO values during winter/spring, corelating with the elevated oxidised nitrogen;
- total phosphorus concentrations exceed WQO values in all summer/autumn samples and in approximately 25% of winter/spring samples;
- all dissolved metal concentrations were below WQO values except for:
  - copper and zinc concentrations exceeded WQO values frequently in summer/autumn and occasionally in winter/spring; and
  - chromium (total) and lead concentrations occasionally exceeded WQO values in summer/autumn.
- It is noted that all but one of the copper and zinc exceedances occurred during March 2018 sampling, where 80% of samples exceeded the WQO values. Different analysis methods (consistent with the methods applied more broadly to EIS sampling) were applied to subsequent sampling (post-March 2018).
- Reservoir water quality during and following wet weather conditions is poorly understood. There is potential for elevated turbidity, nutrients and some metals to occur near watercourse inflow locations for several weeks following a substantial runoff event.

3.9.2. Watercourses

3.9.2.1. Plateau

Water quality characteristics for the plateau watercourses are described as follows:

- The Murrumbidgee and Eucumbene rivers, Tantangara, Gooandra, Nungar and Kellys Plain creeks have similar water quality during dry weather conditions, key characteristics include:
  - pH that generally ranges between 6.2 and 8.5, with occasional lower and upper bound exceedances;
  - carbonate and salinity vary seasonally, with higher levels occurring in summer/autumn; and
  - low concentrations of suspended solids and low turbidity.
  - total and reactive phosphorus concentrations are generally below WQO values; and
  - aluminium concentrations exceed the WQO value on a frequent basis. Copper, iron and zinc concentrations exceed WQO values on an occasional basis
- The water quality of minor watercourses in the vicinity of the proposed surface works near Tantangara Reservoir is generally poorer than larger watercourses, with elevated suspended sediment, nutrients and some metals (aluminium and iron).
- The water quality during wet weather conditions is poorly understood. It is expected that concentrations of suspended sediment and some metals may be higher than dry weather concentrations. Wet weather sampling is proposed prior to commencement of works.

3.9.2.2. Ravine

Water quality characteristics for the ravine watercourses are described as follows:

- Yarrangobilly River and Wallaces Creek have similar water quality during dry weather conditions. Key characteristics include:

- pH ranges between 6.2 to 8.5, with occasional lower and upper bound exceedances;
  - low concentrations of suspended solids and low turbidity;
  - carbonate and salinity vary seasonally, with higher levels occurring in summer/autumn;
  - oxidised nitrogen concentrations exceed WQO values frequently in summer/autumn and occasionally in winter/spring;
  - total and reactive phosphorus concentrations are generally below WQO values; and
  - aluminium concentrations in the Yarrangobilly River exceed WQO values frequently in winter/spring and occasionally in summer/autumn. Copper concentrations in Wallaces Creek exceed WQO values occasionally.
- The water quality during dry weather conditions in minor watercourses in Lobs Hole is generally poorer than larger watercourses, with elevated suspended sediment, nutrients and some metals (aluminium and copper). Former mine workings including shafts and spoil piles are located adjacent to the Yarrangobilly River channel and immediate areas. These works are remnant from copper mines that operated intermittently from the late 1800s to early 1900s. Seeps from flooded underground workings are known to discharge directly into the river and are known to have acid mine drainage characteristics (very low pH and high dissolved metal concentrations). The rate of discharge is poorly understood.
- The water quality in Lick Hole Gully generally has higher concentrations of electrical conductivity, total hardness and some dissolved metals compared to the other ravine water courses as it is predominantly groundwater fed, and is often dry during summer/autumn conditions.
- The understanding of water quality during wet weather conditions is informed by data from monitoring undertaken in March and May 2019 following moderate rainfall. Receiving water quality during wet weather conditions is generally poorer relative to baseflow conditions with higher turbidity, lower pH, higher nutrients and potential for non-trivial concentrations of some metals such as aluminium and copper.
- Runoff samples were collected from existing disturbed areas in Lobs Hole such as access tracks and remnant copper mining areas in March and May 2019. Existing disturbed area runoff is characterised as being mildly acidic, having very high suspended sediment and turbidity levels, high total nitrogen and total phosphorous, and very high aluminium and copper concentrations. During wet weather conditions (when runoff is occurring to local watercourses in Lobs Hole), the water quality in the Yarrangobilly River is expected to be degraded as it passes through Lobs Hole.

3.10. Flood Characteristics

Existing flooding characteristics are identified in the Flood Risk Assessment (EIS Appendix J, Annexure C) and summarised below:

- Existing flood characteristics for the Lobs Hole area indicate that:
  - for the lower magnitude flood events such as the 20% and the 5% AEP event, flooding is predominantly confined to the channel and immediate floodplain areas;
  - full inundation of the floodplain occurs in the 1% AEP and greater magnitude events;
  - for all events except the probable maximum flood (PMF), most of the flow conveyance occurs within the channel and immediate floodplain areas.
- Existing flood characteristics for Kelly Plain Creek indicate that:
  - floodwaters generally follow the alignment of Kelly Plain Creek for all event up to the PMF, with no major breakouts or flow diversions;

- peak flood levels in the lower reaches of Kelly Plain Creek are influenced by reservoir water levels

- Existing flood characteristics for Rock Forest indicate that floodwaters generally follow the alignment of watercourses for all event up to the PMF, with no major breakouts or flow diversions; and
- Reservoir flood peak water levels are presented in Table 3-2 and Table 3-3.

4. WATER ASPECTS AND IMPACTS

4.1. Construction Activities

An environmental aspect is an element of an organisation's activities, products, or services that has or may have an impact on the environment (ISO 14001 Environmental management systems). The relationship of aspects and impacts is one of cause and effect.

Key aspects of the project that may result in impacts to surface water impacts are identified in Table 4-1 (Column 1). The extent of these impacts will depend on the nature, extent and magnitude of construction activities and their interaction with the natural environment (Column 2). This is further exacerbated by environmental factors (Column 3).

The aspects and impacts relevant to water for construction are summarised in Table 4-1.

Table 4-1: Project aspects and impacts relevant to surface water

Environmental Aspects (Construction activities that may impact surface water)	Environmental Impacts	Environmental Factors (Conditions)
• Vegetation clearing • Topsoil stripping • Bulk earthworks • Stockpiling • Water use and extraction • Dewatering • Subaqueous placement / excavated rock placement • Dredging activities • Storage of fuels and chemicals • Accidental leaks and spills • Works on waterfront land and instream works • In reservoir works (i.e. removal of intake rock plug) • Drilling and piling • On-site water management (run off from construction areas)	• Sediment-laden runoff entering waterways • Contamination of stormwater runoff due to construction activities (including accidental spills) • Changes to flow regime from new infrastructure • Water quality impacts associated with the discharge of treated process water and wastewater (sewage) to Talbingo and Tantangara reservoirs • Water quality impacts including sediment impacts associated with dredging, drilling, blasting and subaqueous placement works.	• **Soil type** – more erodible soil types have an increased soil erosion potential; • **Soil moisture** – increased soil moisture decreases soil mobilisation; • **Rainfal**l – heavy rainfall increases soil entrainment • **Extent of vegetation cover** – vegetation assists in stabilising soils and reduces the ability for erosion. The presence of acid forming and acid neutralising materials. Existing soil and water contamination • **Sensitivity of aquatic environments** – Dispersion of contaminants is increased when working within aquatic environments

4.2. Impacts

4.2.1. Overview

The Main Works RTS revised Water Management Report (RTS Appendix J) was prepared to assess the impact of Main Works on the environment. The assessment identified that residual surface water impacts would occur with the implementation of practical controls to avoid or mitigate impacts. These residual impacts are described in the following sections.

4.2.2. Watercourses

Key sources of contaminants to watercourses include:

- direct stormwater runoff from disturbed areas;
- stormwater overflows from sediment basins; and

- sub-surface seepage from excavated rock stockpiles and final landforms .

Potential changes to water quality in the Yarrangobilly River, the upper Eucumbene River and Kellys Plain Creek have been assessed using a conceptual stormwater discharge model. Table 4-2 provides a summary of the estimated disturbance durations and profiles and potential magnitude of changes to receiving water quality during construction.

Potential changes to water quality are described using categories that represent varying magnitudes of change relative to the relevant default NSW Water Quality Objective values.

Table 4-2 Summary of potential changes to watercourse water quality during construction (EMM, 2020)

Watercourse	Construction phase 1 (Initial 15 months of construction program)	Construction phase 2 (Majority of construction program)
Percentage of time no change to receiving water quality is expected		
Yarrangobilly River 2[1]	85%	85%
Upper Eucumbene River	72%	81%
Kellys Plain Creek 3[2]	81%	76%
Percentage of time concentrations of suspended solids, nutrients or metals in receiving waters may increase by between 0 to 10% of WQO values[3]		
Yarrangobilly River 2[1]	7%	12%
Upper Eucumbene River[3]	10%	8%
Kellys Plain Creek 3[2]	2%	8%
Percentage of time concentrations of suspended solids, nutrients or metals in receiving waters may increase by between 10 to 50% of WQO values[3]		
Yarrangobilly River 2[1]	6%	3%
Upper Eucumbene River	10%	8%
Kellys Plain Creek 3[2]	2%	8%
Percentage of time concentrations of suspended solids, nutrients or metals in receiving waters may increase by between 50 to 100% of WQO values[3]		
Yarrangobilly River 2[1]	1%	0%
Upper Eucumbene River	4%	2%
Kellys Plain Creek 3[2]	3%	%
Percentage of time concentrations of suspended solids, nutrients or metals in receiving waters may increase by more than 100% of WQO values[3]		
Yarrangobilly River 2[2]	1%	0%
Upper Eucumbene River	5%	1%
Kellys Plain Creek 3[2]	12%	5%

1. Results for Yarrangobilly River include discharge from disturbance areas adjacent to the Yarrangobilly River arm of Talbingo Reservoir.
2. Results for Kellys Plain Creek include discharge from disturbance areas to the north of Kellys Plain Creek that also drain into the southern portion of Tantangara Reservoir
3. WQO values refer to the Water Quality Objective values established in the water assessment

4.2.3. Reservoirs

Key sources of contaminants to the reservoirs include:

- inflows from watercourses potentially impacted by the construction environmental aspects;

- treated wastewater and process water discharges;
- surface runoff and sub-surface seepage from excavated rock stockpiles and final landforms (including subaqueous placement of excavated rock into Talbingo reservoir); and
- dredging, drilling and blasting operations.

The revised Water Management Report (RTS Appendix J) (RTS Appendix J) identified that the combination of stormwater discharges and controlled discharges of treated wastewater and process water during the construction phase of the project would have potential to increase the ambient salinity levels and nutrient concentrations of reservoir waters.

Table 4-3 provides estimates of the change in median ambient salinity levels (as indicated by electrical conductivity) and total nitrogen and phosphorus concentrations in Tantangara Reservoir and the Yarrangobilly River arm of Talbingo Reservoir. It is noted that:

- a mixing zone assessment was undertaken by Royal HaskoningDHV (RTS Appendix J Attachment F) to determine the near-field dilutions associated with process and wastewater discharges to Tantangara and Talbingo reservoirs and estimate the size of mixing zone required to dilute key analytes (electrical conductivity, total nitrogen and total phosphorus) to ambient water quality conditions
- higher concentration increases may occur near treated wastewater and process water discharge locations. However, the spatial extent of higher concentrations (also referred to as a mixing zone) is predicted to be less than 10 m from the outfall location for most of the discharge scenarios modelled, due to the high level of treatment and the small amount of dilution required; and
- additional changes to reservoir water quality may occur due to spoil management activities.

The magnitude of water quality change associated with treated wastewater and process water discharge and subaqueous spoil placement is expected to be greater:

- in summer/autumn due to lower seasonal streamflow into the reservoir; and
- during drought conditions due to lower streamflow into the reservoir.

No material changes to the greater Talbingo Reservoir or downstream waterways is expected due to mixing with the significant year-round discharge from Tumut 2 power station that enters Talbingo Reservoir via the Tumut River.

Table 4-3 Summary of potential changes to reservoir water quality during construction (EMM, 2020)

	Units	Summer / Autumn (Drought)[1]	Summer / Autumn (Typical)	Winter / Spring (Typical)
Tantangara Reservoir				
Construction phase 1 – Initial 15 months of construction program				
Salinity (as indicated by EC)	µS/cm	22 to 22	22 to 22	14 to 14
Total Nitrogen	mg/L	0.20 to 0.22	0.20 to 0.21	0.11 to 0.11
Total Phosphorus	mg/L	0.03 to 0.03	0.03 to 0.03	0.01 to 0.01
Construction phase 2 – Majority of construction program				
Salinity (as indicated by EC)	µS/cm	22 to 28	22 to 24	14 to 14
Total Nitrogen	mg/L	0.20 to 0.23	0.20 to 0.21	0.11 to 0.11
Total Phosphorus	mg/L	0.03 to 0.03	0.03 to 0.03	0.01 to 0.01
Yarrangobilly River arm of Talbingo Reservoir				

	Units	Summer / Autumn (Drought)[1]	Summer / Autumn (Typical)	Winter / Spring (Typical)
Construction phase 1 – Initial 15 months of construction program				
Salinity (as indicated by EC)	µS/cm	27 to 27	27 to 27	22 to 22
Total Nitrogen	mg/L	0.20 to 0.24	0.20 to 0.21	0.12 to 0.12
Total Phosphorus	mg/L	0.03 to 0.04	0.03 to 0.03	0.01 to 0.01
Construction phase 2 – Initial 15 months of construction program				
Salinity (as indicated by EC)	µS/cm	27 to 35	27 to 29	22 to 23
Total Nitrogen	mg/L	0.20 to 0.25	0.20 to 0.21	0.12 to 0.12
Total Phosphorus	mg/L	0.03 to 0.04	0.03 to 0.03	0.01 to 0.01

The predicted values for total nitrogen and total phosphorus make no allowance for decay and assimilation are there conservative. Ambient values refer to typical or median values.
1. Calculations based on reservoir inflows and calculated stormwater discharges for the 2006/2007 summer/autumn period.

4.2.4. Flooding

The key flood impact mechanisms are associated with:

- locating temporary and/or permanent surface infrastructure on flood prone land (i.e. land susceptible to flooding by the PMF), including instream works and works on the adjacent floodplain; and
- placement of excavated material in the Talbingo reservoirs, which may reduce the volume of reservoir storage available during flood events

Table 4-4 provides a summary of flood impacts during construction, as described in the Main Works EIS Flood Risk Assessment (EIS Appendix J Annexure C)

Table 4-4: Summary of construction flood impacts (EIS Appendix J Annexure C)

Project area	Location	Summary
Ravine	Talbingo Reservoir	No significant change to flooding characteristics for Talbingo Reservoir is anticipated as the volume of excavated material to be placed in the reservoir is very small in comparison to the existing storage.
	Lobs Hole	Whilst the spatial extent and magnitude of impacts is extensive throughout Lobs Hole, in particular for floods of 1% AEP and above, these impacts are not anticipated to impact on existing infrastructure or other areas of significance, and the design of temporary works can accommodate the changed flooding characteristics.
Plateau	Tantangara Reservoir	No significant change to flooding characteristics for Tantangara.
	Kellys Plain Creek	Temporary surface infrastructure in the vicinity of Kellys Plain Creek largely avoids flood prone land and therefore will not significantly impact on existing flooding characteristics. Minor increases to peak flood levels are expected to occur from the proposed upgraded road crossing of this watercourse, however these impacts will be localised are not anticipated to impact on infrastructure or other areas of significance.
Rock Forest	Rock Forest	Temporary surface infrastructure associated with the proposed logistic yard at Rock Forest largely avoids flood prone land and therefore will not impact on existing flooding characteristics.

Evacuation and flood response will be undertaken in accordance with Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090).

4.3. Environmental Risk Assessment

The environmental aspects and impacts for water are further considered within Appendix A3 of the EMS. This includes a risk assessment process. The risk assessment is based on (1) the likelihood of an impact occurring as a result of the aspect; and (2) the consequences of the impact if the event occurred. These risks as well as any regulatory requirement (see Section 0) form the basis for the management measures committed to in Section 5

5. SURFACE WATER MANAGEMENT

Surface water impacts during construction will be avoided, minimised or managed through the development and implementation of management measures and the approval (SSI 9687). Snowy Hydro and Future Generation aim to prevent or minimise adverse impacts during construction. The overarching management measures to be implemented during construction are described in the following sections and comprehensively listed in Table 5-3.

The principles of surface water management are to:

- provide targeted training and education;
- minimise the extent and duration of disturbance;
- monitor weather conditions and modify work programs accordingly;
- segregate clean and dirty water including clean water diversions as early as possible;
- control stormwater flows onto, through and from the following locations:
  - excavated rock emplacement areas;
  - topsoil and subsoil stockpiles;
  - disturbed areas (i.e. roads);
- capture, contain and reuse process water as much as practicable in order to avoid release into the surrounding water environments. Surplus process water will be treated and discharged to reservoirs;
- minimise soil erosion;
- maximise sediment retention on site;
- capture, contain, treat and discharge wastewater to reservoirs;
- regularly inspect and maintain controls in working order;
- monitor the site and respond appropriately;
- prepare and maintain documents; and
- report outcomes and impacts.

5.1. Stormwater

Potential erosion and sedimentation impact will be predicted and in-turn managed through the development of Erosion and Sediment Control Plans (ESCP). ESCPs will be developed per specific location. ESCPs will be applicable for the following works:

- vegetation clearing and initial site establishment;
- construction and operation of unsealed access roads;
- construction and operation of accommodation camps, laydown and portal areas;
- construction and operation of stockpiles areas and emplacement areas;
- construction of permanent infrastructure
- construction of instream works (i.e. barge infrastructure, culverts, bridges)
- construction of the communications cable;
- construction of the services pipeline, dewatering pipes and discharge outlets; and
- construction and operation of ancillary facilities including chemical storage and workshops.

These plans will be designed by a suitably qualified person in consultation with construction personnel and the Project Soil Conservationist to guide staff on the appropriate controls for specific work stages. The ESCPs will be updated as required based on the progression of new areas of ground disturbance and changing site conditions.

The Environment team, through site inspections and consultation with construction personnel, will manage updates of the ESCPs.

The Project will implement the following stormwater control and treatment options;

- controls be designed and bench-marked against Main Works RTS predicted stormwater discharge characteristics, as identified in the Surface Water Monitoring Program (Annexure A)
- erosion and sediment controls will be installed and maintained to manage impacts to receiving environments including areas that do and do not trigger the need for sediment basins in compliance with the Blue Book (Landcom 2004);
    - clean water diversions will be installed around disturbance areas and designed and inspected to convey water and minimise scour impacts to adjoining watercourses;
    - sediment basins will be installed with a design rainfall depth of 85th percentile 5-day rainfall event with consideration given to increasing basin size at locations where sufficient space is available and / or topography does not constrain the basin size (i.e. construction pads, accommodation camps) (see section 5.1.1);
    - some work areas will be stabilised between the initial disturbance / works and prior to decommissioning to remove the reliance on sediment basins during this period;
    - additional controls will be applied for both erosion control and sediment control to reduce reliance on the sediment basins
    - standpipes will be considered at operational (wetland) basins; at long-term (>12 months) sediment basins; and at high-risk short-term sediment basins.;
    - sprinkler irrigation systems will be installed at each basin, on the spoil emplacement pads, in areas of rehabilitation and at the crushing and screening plant.
- the following dewatering hierarchy will apply to captured stormwater in sediment basins:
    - maximise water reuse on site (i.e. use basin water in water carts, dust suppression)
    - irrigation dewatering methods to adjacent lands within the construction envelope (further described in section 5.1.2)
    - active discharge based on risk assessment, where storage, reuse or irrigation options are not appropriate; and
- locating stockpiles away from waterways and severe flood areas where possible;

These measures will be planned, designed and detailed in progressive ESCPs as described above. Review and modifications of these options possible on the basis of evolving design and construction elements. Any proposed changes will be discussed with the relevant stakeholders.

5.1.1. Design rainfall depths

Design rainfall depths for the Project are identified in Table 5-1 below.

Table 5-1: Design rainfall depths (Main Works EIS Appendix J.2 Annexure A (EMM), 2020)

Catchment	Description	85th percentile, 5-day rainfall (mm)	90th percentile, 5-day rainfall (mm)	95th percentile, 5-day rainfall (mm)
Yarrangobilly River	Surface works at Lobs Hole and Marica	28.1	35.6	49.0
Upper Eucumbene River	Surface works between Marica and the Snowy Mountain Highway	35.2	43.4	56.9
Tantangara construction compound	Surface works adjacent to the southern portion of Tantangara Reservoir	30.5	37.0	51.0
Goorudee Rivulet	Surface works at Rock Forest	20.0	25.7	36.1

5.1.2. Stormwater irrigation

The use of irrigation for stormwater management will take into consideration relevant aspects of Managing urban stormwater: harvesting and reuse (NSW DEC 2004) and the Australian Guidelines for Water Recycling – Stormwater Harvesting and Reuse (NRMMC/EPHC/NHMRC 2009). Although guidance documents focus on urban, open-space irrigation of stormwater, they provide a useful guide and some information for irrigation in non-urban, vegetated areas.

Factors which will considered when setting up the irrigation system will include (but not be limited to):

- slope
- landform
- soil characteristics; and
- available soil water holding capacity.

Sprinkler irrigation systems will generally consist of irrigation mains and laterals, tall risers, and high angle, long throw range sprinkler heads. Irrigation will be used in conjunction with stormwater harvesting for dust suppression to de-water and empty sedimentation basins between rain events.

Irrigation areas will generally be located up- or cross-catchment of the sediment basins, away from watercourses, and to the other side of “no go” fencing, away from work areas and other disturbed areas (so as to minimise further sediment-laden runoff). Irrigation will not be directed to sensitive environmental habitats such as the 50 m buffer zones of Wallace and Yarrangobilly creeks.

Irrigation will occur within the construction envelope and seek to occur in vegetated areas (as opposed to cleared areas) to enable increased infiltration. Irrigation will be scheduled and monitored to minimise the risk of over-irrigating or excessive pooling and runoff of water.

5.2. Flooding

The key flood impact mechanisms associated with construction are:

- locating temporary and/or permanent surface infrastructure on flood prone land (i.e. land susceptible to flooding by the Probable Maximum Flood (PMF)), including instream works and works on the adjacent floodplain; and
- placement of excavated material in reservoirs, which may reduce the volume of reservoir storage available during flood events.

Detailed design of both temporary and permanent works includes consideration of existing flooding conditions and impacts, including flood modelling where necessary, to support future detailed design of both temporary and permanent works.

Stockpiles will be located where they are not exposed to concentrated of flood flow. Flood flow is defined as the 20% Annual Exceedance Probability (AEP) flood event. Details regarding the placement of excavated material is contained within the Spoil Management Plan (S2-FGJV-ENV-PLN-0019).

Flood emergency response will be undertaken in accordance with Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090). This includes protocols for evacuation to areas outside the flood prone land and protocols for storage of plant, equipment and materials in flood prone areas commensurate with the frequency of inundation.

5.3. Water treatment plants

Water treatment plants (WTP) are proposed to be installed and utilised at:

- tunnel portals for tunnel process water treatment (i.e. groundwater management)
- accommodation camps for wastewater (i.e. sewage) treatment; and
- accommodation camps for potable water consumption;

In accordance with EPL condition E1, detailed design reports and a commissioning report for the process water treatment plant and wastewater treatment plan will be submitted to the EPA. The following sections provide an overview of the water treatment plants.

5.3.1. Process water treatment plant

Three process water treatment plants are proposed. These will be located at the Talbingo Main Access Tunnel (MAT) portal, Talbingo emergency egress, cabling and ventilation tunnel (ECVT) and the Tantangara portal. An additional process water treatment plant may be established during construction of the surge shaft.

The process water WTPs will be connected to a drainage system comprised of sumps and pipelines from the tunnel to the WTP at the portal surface. This process water will be treated to the water quality discharge criteria in the Project's EPL and be re-used on site either in the tunnel or on the surface (refer to WMP Section 4.2). Excess treated water that cannot be utilised on site will be discharged via pipe into either Talbingo or Tantangara reservoirs.

The process water WTP systems have been designed for emergency scenarios and include the following contingency measures:

- the plants will be designed to minimise the risk of failure. For example:
  - the plants will be designed to work in stages. Therefore, if a stage of the plant fails, the treatment plant will continue to work in reduced capacity conditions without stopping the entire operation of the treatment plant;

  - treatment plants will have a contingency period during which the plant is able to hold process waters. The holding capacity is dependent on the size of the plant;
- process waters can be transferred to nearby plant (i.e. the MAT portal treatment plant can transfer waters to the ECVT treatment plant);
- water supply can be reduced decreasing the volume of process water which requires treatment;
- if the problem is occurring after the process water treatment plant, process water can be directed to the mainstream line for reuse in the tunnel boring machines. The main line will operate with three pumps (two working and one standby) to ensure continued operation of the main line;
- using the clean water storage tanks – there will be tanks distributed within the tunnel. In a time of emergency, these tanks would be emptied of clean water and used as the emergency storage; and
- discharging back into the tunnel so that the water can be recollected in sumps and treated again once the plant is operational.

Process water treatment plants will be located at tunnel portals. Hence, only treated water will be discharged to reservoirs. Any ruptures or leaks upstream of the water treatment plants will be captured in the tunnel portal water management system.

5.3.2. Wastewater treatment plants

Multiple wastewater treatment plants are proposed. These will be located at the Main camp, Marica camp, Tantangara camp and Exploratory works camp.

The sanitary sewer system will collect wastewater from showers, kitchens, laundries and toilets. The collected sewage will then be treated at the sewage treatment plants before being pumped into the combined surplus treated process water and wastewater trunk services main which will discharge via a diffuser outlet into the reservoirs.

5.3.3. Potable water treatment plants

Potable water treatment plants are proposed at Tantangara and Talbingo. The potable water treatment plants will produce potable water from both Talbingo and Tantangara Reservoirs. The water will be used for the accommodation camps, concrete production and other construction requirements where technical specifications demand high quality water.

5.3.4. Operation of the discharge points

A combined water stream of surplus treated process water and treated wastewater will discharge to the Talbingo Reservoir and Tantangara Reservoir at licenced discharge points. Surplus process water will be reused onsite, either in the tunnel or on the surface in the first instance, and where it cannot be reused, discharged to the reservoirs. No surplus process water will be discharged to stormwater basins.

A specific plan for the operation of the discharge points is included in Annexure F. All measures are included in Table 5-3 of the SWMP.

5.4. Chemical control and spill management

Chemicals will be stored and managed in a manner that is consistent with the CoA and REMMs. Details of these requirements and the manner with which they will be complied is detailed in Annexure C of this Plan as the Spill Management Procedure.

Chemical transport, handling and storage controls are detailed in the Chemical, Hazardous and Fibrous Material Management Plan (S2-FGJV-ENV-PLN-0004). Designated chemical storage areas will be established on the Project including appropriate bunding consistent with Storing and handling of liquids: Environmental protection participant's manual (DECC NSW2007).

Response to incidents will be managed in accordance with Section 7 of the EMS.

5.5. Road Works

Key road works and upgrades for the Project are detailed in the Transport Management Plan.

Roads surfaces will be constructed and maintained with aggregate material to reduce soil loss rates and water quality risks. The use of material that presents elevated water quality risks relative to other material available for road construction and maintenance will be avoided.

Where practical access roads will grade to table drains that are designed and constructed to have non-erosive hydraulic capacity for the 10% AEP event. Transverse (or cross drainage) will be constructed to have the following non-erosive hydraulic capacities:

- primary roads – 1% AEP event;
- maintenance roads – 2% AEP event; and
- temporary access roads – 10% AEP event

Any existing access tracks that will no longer be required following the construction of the new access roads will be rehabilitated in accordance with the Rehabilitation Management Plan.

5.6. Accommodation Camps

Four accommodation camps will be built and used, including the:

- Lobs Hole exploratory accommodation camp and Main Works accommodation camp;
- Marica accommodation camp; and
- Tantangara accommodation camp.

The sanitary sewer system will collect wastewater from showers, kitchens, laundries and toilets. The collected sewage will then be treated at the sewage treatment plants before being pumped into the trunk services main that will discharge via a diffuser outlet into the reservoirs.

Stormwater will be managed through the implementation of clean water diversions, vegetated swales, and sedimentation or biofiltration basins, consistent with Section 5.1.

5.7. Works on waterfront land and instream works

The *Water Management Act 2000* defines waterfront land as the bed of any river, lake or estuary and any land within 40 m of a riverbank, lake shore or estuary mean high water mark. Instream works refer to modifications or enhancements to a watercourse. All instream works or development within 40 metres of any watercourse will be undertaken generally in accordance with the requirements in the *Guidelines for Controlled Activities on Waterfront Land.*

Table 5-2 describes proposed instream works and other works on waterfront land, along with the overarching management approach.

Table 5-2: Works on waterfront land

Type	Description	Management approach
Fish weir (undertaken by SHL)	A fish weir is proposed in the upper reaches of Tantangara Creek to protect the Tantangara Galaxias from the threat of potential migration of the larger Climbing Galaxia.	Undertaken by SHL and to be addressed in a separate SHL document or framework.

Type	Description	Management approach
Permanent watercourse diversions	Any watercourse that traverses the project disturbance area may be permanently diverted.	Any watercourse that will be permanently diverted around permanent infrastructure will: • be a piped and/or surface drainage system; • be designed and constructed to have non-erosive hydraulic capacity and be structurally sound for the 1% AEP event; and • have adequate scour protection at the system inlets and outlets. During detailed design a risk assessment will be undertaken to identify risks associated with by-pass flows that may occur as a result of system blockage or an event greater than the design event. Watercourses will be rehabilitated in accordance with Rehabilitation Management Plan.
Temporary watercourse diversions	Any watercourse that traverses the project disturbance area may be temporarily diverted.	Where practical, any watercourse that will be temporarily diverted will; • be a piped and/or surface drainage system; • be designed and constructed to have non-erosive hydraulic capacity and be structurally sound for a design event (that will be established by a rick assessment); and • have adequate scour protection at the system inlets and outlets. A risk assessment will be undertaken to identify risks associated with by-pass flows that may occur as a result of system blockage or an event greater than the design event. Watercourses will be rehabilitated in accordance with Rehabilitation Management Plan.
Watercourse crossings (Bridge, access, culvert and services)	Culvert and bridge crossings of watercourses are proposed at numerous locations within the project disturbance area. Service crossings of watercourses are proposed at numerous locations within the project disturbance area.	Watercourse crossings where feasible and reasonable, will be consistent with the Guidelines for Controlled Activities Watercourse Crossings (NRAR, 2018), *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge, 2003), *Policy and Guidelines for Fish Friendly Waterway Crossings* (NSW Fisheries, February 2004), and *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI Fisheries, 2013). All culverts and bridges will be designed by a suitably qualified professional in accordance with the relevant Austroads Guidelines. All service crossings will be designed by a suitably qualified professional in accordance with best practice methods.
Works within 40m of a watercourse	Disturbance may occur on any land within the project disturbance area that is within 40 m of a watercourse or reservoir.	ESCPs are to dictate the specific controls to be used on waterfront land. Typical measures include: • monitoring weather forecasts and taking appropriate action prior; • minimising the extent of work and the amount of time disturbance where possible; • isolating work areas from natural flows where possible; • stockpiles to be located outside of the waterfront area; • use of temporary ground covers in areas of concentrated flow to minimise erosion of exposed soils during rainfall; and • completing and stabilising works as quickly as possible after works are complete.

5.8. Dredging

This SWMP will be revised and submitted to DPIE prior to dredging.

5.9. Intake structures

This SWMP will be updated and submitted to DPIE, prior to major sub-surface water works in Talbingo Reservoir and Tantangara Reservoir.

Major sub-surface water works includes dredging, channel extraction or underwater blasting for construction of the intake structures.

5.10. Temporary spoil stockpiles

Temporary spoil stockpiles will be managed by ESCPs (refer Section 5.1) in accordance with the relevant requirements in the *Managing Urban Stormwater: Soils and Construction guidance series*, as detailed in the Spoil Management Plan (S2-FGJV-ENV-PLN-0019) - Annexure C (Stockpiling Procedure).

5.11. Permanent spoil emplacement areas

Management of the permanent spoil emplacement areas is detailed in the Spoil Management Plan (S2-FGJV-ENV-PLN-0019). This SWMP will be updated and submitted to DPIE, prior to in-reservoir emplacement.

5.12. Operation of the power station and associated infrastructure

Operation of the Snowy 2.0 Project, including dewatering of the tailrace tunnel during operations will be detailed through a separate Snowy Hydro framework or document.

5.13. Management Measures Summary

A range of environmental requirements and control measures are identified in the Main Works and Exploratory Works Submissions Reports and the Infrastructure Approval. Safeguards and management measures will be implemented to avoid, minimise or manage impacts on water.

Specific safeguards and management measures to address surface water impacts of the project are identified in Table 5-3.

Table 5-3: Surface water management measures

ID	Measure / Requirement	When to implement	Responsibility*	Source document**	Area
General					
SW01	Training will be provided to all project personnel, including relevant sub-contractors on surface water and soil management practices, and the requirements from this plan through inductions, toolboxes and targeted training.	Pre-construction and construction	Contractor – EM, EC	MW CoA 30(m) MW CoA 31(c)	All
SW02	Unless authorised otherwise by an environment protection licence the requirements of Section 120 of the POEO Act will be complied with.	Pre-construction and construction	Contractor – All	MW CoA 29	All
Stormwater management					
SW03	Works will minimise erosion and the generation and dispersion of sediment using suitable controls in accordance with the relevant requirements in the *Managing Urban Stormwater: Soils and Construction guidance series*	Construction	Contractor – CM, S, SS	MW CoA 30(f) EW REMM SOIL02	All
SW04	An Erosion and Sediment Control Plan (ESCP) will be prepared for each construction area. Each ESCP will: • apply the methods and principles provided in Managing Urban Stormwater: Soils and Construction: – Volume 1 – Soils and construction (Landcom 2004); and/or – Volume 2A – Installation of services (DECC 2008); and/or – Volume 2C – Unsealed roads (DECC 2008);	Construction	Contractor – CM, EM, EC	MW CoA 30(c) MW REMM WM04 MW RWMM WM1.2.1 MW RWMM WM1.3.1 MW RWMM WM2.5.2 EW REMM SOIL02	All
SW05	Suitably qualified erosion and sediment control professional(s) will be commissioned to: • oversee the development of ESCPs; • inspect and audit controls; • train relevant staff; and • provide advice regarding erosion and sediment control.	Construction	Contractor – EM, EC	MW REMM WM05 MW RWMM WM1.2.3 MW RWMM WM1.3.3	All
SW06	Stormwater management systems will be benchmarked to Main Works RTS predicted stormwater discharge quality characteristics.	Construction	Contractor – EM, EC	MW RWMM WM2.2.4	All

ID	Measure / Requirement	When to implement	Responsibility*	Source document**	Area
SW07	Where practical, clean water will be diverted around or through construction areas. Runoff from clean water areas that cannot be diverted will be accounted for in the design of surface water management systems.	Pre-construction and construction	Contractor – CM, S, SS	MW CoA 30(b) MW REMM WM03 MW RWMM W1.1.1 EW REMM WM5.3	All
SW08	Clean water diversions will be designed to minimise potential scour impacts in adjoining watercourses.	Pre-construction and construction	Contractor – DM	MW CoA 30(c) MW RWMM WM1.1.2	All
SW09	Works will be programmed to minimise the extent and duration of disturbance to vegetation where practicable. This will include minimising the time between clearing and site establishment earthworks, initial earthworks and commencement of subsequent ground stabilisation activities	Pre-construction and construction	Contractor – CM, S, SS	Blue Book	All
SW10	All slopes that have been cut and/or filled as part of the construction works shall be appropriately stabilised in accordance with erosion and sediment control and other relevant sub plans. Stabilisation including rehabilitation will be undertaken progressively where practicable.	Construction	Contractor – CM, DM, S, SS	EW REMM WM2.4	All
SW11	Stockpiles will be managed in accordance with the Spoil Management Plan (S2-FGJV-ENV-PLN-0019)	Construction	Contractor – CM, S, SS	MW CoA 7	All
SW12	New landforms will maximise surface drainage to the natural environment	Construction	Contractor – DM	REMM REHAB02	All
SW13	Sediment basins will be designed and constructed in accordance with the methods recommended in Managing Urban Stormwater: Soils and Construction: Volume 1 (Landcom 2004) and Volume 2D (DECC 2008). Sediment basins will have adequate capacity for at least a 5 day 85th percentile rainfall event. Consideration shall be given to increasing basin size at locations where sufficient space is available and / or topography does not constrain the basin size.	Pre-construction and construction	Contractor – DM	Blue Book MW RWMM WM1.3.1 MW RWMM WM2.3.3 MW RWMM WM2.5.2	All
SW14	The following dewatering hierarchy will be used when stormwater is captured in sediment basins: • maximise water reuse on site (e.g. dust suppression and material preparation) • irrigation dewatering methods to adjacent lands within the construction envelope • active discharge based on risk assessment, where reuse and irrigation options are not appropriate	Construction	Contractor – CM, S, SS	MW CoA 30(a)	All

ID	Measure / Requirement	When to implement	Responsibility*	Source document**	Area
SW15	Sprinkler irrigation systems shall be installed at each basin, on the spoil emplacement pads, in areas of rehabilitation and at the crushing and screening plant	Construction	Contractor – CM, S, SS	Project Requirement	All
SW16	Standpipes will be considered at operational (wetland) basins; at long-term (>12 months) sediment basins; and at high-risk short-term sediment basins.	Construction	Contractor – DM, CM	Project Requirement	All
SW17	Regular inspection and maintenance of (as required) erosion and sediment controls and chemical storage will be undertaken	Construction	Contractor – S, SS, EC	Blue Book / Project Requirement	All
Flooding					
SW18	Further consideration of flooding conditions and impacts, including flood modelling where necessary, will be undertaken to support future detailed design of both temporary and permanent works.	Construction	Contractor – DM	MW CoA 30 (d) MW REMM WM13	All
SW19	Where possible, stockpiles will be located where they are not exposed to concentrated of flood flow. Flood flow is defined as the 20% Annual Exceedance Probability (AEP) flood event.	Construction	Contractor – DM, CM	MW CoA 30 (d) EW REMM WM_2.3	All
SW20	Emergency flood response will be managed in accordance with the Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090).	Construction	Contractor – All	MW REMM WM14	All
SW21	Protocols will be developed for use and storage of plant, equipment and materials in flood prone areas commensurate with the frequency of inundation	Construction	Contractor – CM	EW REMM M1.13	All
Process water management					
SW22	A process water management system will be established to manage water during construction; and to supply water to construction activities. All surplus process water will be treated to meet the water quality specifications in Annexure A of this Plan and unless an environmental protection licence authorises otherwise, in compliance with Section 120 of the POEO Act. Process water discharges to watercourses will be avoided.	Construction	Contractor – DM	MW CoA 29 MW CoA 30(j) MW REMM WM10 MW RWMM WM2.7.1 MW RWMM WM2.7.6 EW REMM WM6.1	Talbingo Tantangara
SW23	A detailed design report and a commissioning report for the process water treatment plant will be submitted to the EPA in accordance with EPL 21266 Condition E1.	Construction	Contractor – DM, EM	EPL 21266 Condition E1	Talbingo Tantangara

ID	Measure / Requirement	When to implement	Responsibility*	Source document**	Area
SW24	The process water system will be designed and constructed to minimise stormwater ingress into the system to reduce the volume of water that requires management.	Construction	Contractor – DM	MW RWMM WM2.7.2 EW REMM WM621	Talbingo Tantangara
SW25	Where practical, the storage and handling of chemicals that have potential to contaminate the process water system will be undertaken in bunded areas.	Construction	Contractor – SS	MW RWMM WM2.7.3	All
SW26	The process water system will be designed to include the following system contingency measures: • water treatment plants will be designed to minimise the risk of complete failure by staging treatment plants (i.e. a treatment plant may include two or more treatment systems in parallel) and providing contingency storage. • water supply to TBMs will be temporarily decreased to reduce the volume of process water that is required to be dewatered from tunnel sumps. • where possible, process water will be transferred to a nearby treatment plant. • where practical and safe to do so, surplus process water will be stored in underground sumps. • the clean water storage tanks can be emptied and utilised to store untreated process water • process water treatment plants will be located at tunnel portals. Hence, only treated water will be reticulated to reservoirs. Any ruptures or leaks upstream of the water treatment plants will be captured in the tunnel portal water management system.	Construction	Contractor – DM	MW RWMM WM2.7.5	Talbingo Tantangara
SW27	All treated surplus process water will be discharged to Tantangara and Talbingo reservoirs via diffuser arrangements. Low velocity discharges will be avoided. Discharges to watercourses will be avoided.	Construction	Contractor – DM	MW CoA 30(k) MW RWMM WM2.7.7	Talbingo Tantangara
SW28	Surplus treated process water will not be discharged to the stormwater basins on site	Construction	Contractor – DM	MW CoA 30(l)	Talbingo Tantangara
SW29	Where practical, plant and equipment washdown will be undertaken in designated washdown bays or areas. Washdown water will be captured, treated and reused to minimise or avoid discharge to reservoirs.	Construction	Contractor – SS	MW RWMM WM2.7.4	All
Wastewater					

ID	Measure / Requirement	When to implement	Responsibility*	Source document**	Area
SW30	A wastewater management system will be established to manage effluent and grey water from construction compounds and accommodation camps. All wastewater will be treated to meet the water quality specifications provided in in Annexure A of this Plan and unless an environmental protection licence authorises otherwise, in compliance with Section 120 of the POEO Act. Wastewater discharges to watercourses will be avoided. The wastewater (sewage) system will include emergency storage of untreated wastewater. The storage volume will be calculated at detailed design based on analysis of response times from regional waste management contractors to provide emergency trucking and offsite disposal options. All wastewater treatment plants will be designed to operate during winter when sub-zero temperatures can persist for extended periods of time.	Construction	Contractor – DM	MW CoA 29 MW CoA 30(j) MW REMM WM09 MW RWMM WM2.9.5 EW REMM WM7.5 EW REMM WM7.4	Talbingo/Lobs Holes Tantangara Marica
SW31	Detailed design report and a commissioning report for the wastewater treatment plant will be submitted to the EPA.	Construction	Contractor – DM, EM	EPL 21266 Condition E1	Talbingo Tantangara
SW32	The sewer system will be designed to restrict stormwater ingress into the wastewater system.	Construction	Contractor – DM	EW REMM WM7.1	Talbingo Tantangara
SW33	All wastewater produced (i.e. from showers, kitchens, laundries and toilets) will be directed to a wastewater treatment plant. All reticulation and storages will be designed to restrict stormwater and groundwater ingress into the wastewater system.	Construction	Contractor – DM	MW RWMM WM2.9.1 MW RWMM WM2.9.4	Talbingo/Lobs Holes Tantangara Marica
SW34	Water efficient fittings will be used to minimise wastewater loads.	Construction	Contractor – DM	MW RWMM WM2.9.2 EW REMM WM7.2	All
SW35	Treated wastewater will be discharged to Talbingo and Tantangara reservoirs via diffuser arrangements. Low velocity discharges will be avoided. Discharges to watercourses will be avoided.	Construction	Contractor – DM	MW CoA 30(k) MW RWMM WM2.9.7	Talbingo Tantangara
Chemical control and spill management					
SW36	Emergency response to spills of oils and fuel etc will be managed in accordance with the Spill Response Procedure included in Annexure C of this plan.	Construction	Contractor – All	MW CoA 30(n) MW RWMM WM1.3.2 MW RWMM WM1.2.2 EW REMM WAT01	All

ID	Measure / Requirement	When to implement	Responsibility*	Source document**	Area
SW37	Construction vehicles and mechanical plant will be regularly maintained and checked for leakage of fuel and /or oils.	Construction	Contractor – All	MW CoA 30(n) MW RWMM WM1.3.2 MW RWMM WM1.2.2 EW REMM WAT01	All
SW38	Where possible, refuelling and maintenance of vehicles and mechanical plant will be undertaken at least 50m away from watercourses. A risk assessment that outlines suitable controls will be undertaken in the event that refuelling or maintenance is constrained to within 50m from a watercourse.	Construction	Contractor – S, SS, EC	EW REMM WAT01	All
SW39	Where practical, activities that have potential to contaminate stormwater runoff will be isolated from the stormwater system by covering (i.e. by a building or roof) and/or bunding.	Construction	Contractor – S, SS	MW CoA 30(n) MW RWMM WM2.3.1 EW REMM WM5.2	All
SW40	Emergency spill kits will be kept onsite. The spill kit must be appropriately sized for the volume of substances in use. All staff would be made aware of the location of the spill kit and trained in its use.	Construction	Contractor – CM, S, SS, EC	EW REMM WAT01	All
SW41	Fuels and chemicals will be stored in bunded areas to prevent chemical spills or leakages in accordance with the relevant Australian Standards including: • ASNZS 4452:1997 The storage and handling of toxic substances, • AS1940 – 2017 The storage and handling of flammable and combustible liquids, and • Areas to be used for long-term storage and handling (i.e. those at a site compound or dedicated fuel storage area) of hydrocarbons and chemicals will be enclosed with concrete bunds or other suitably sealed bunding.	Construction	Contractor – S, SS,	MW CoA 30(n) MW CoA 30(p) ASNZS 4452:1997 AS1940 – 2017 EW REMM WAT01	All
Access Roads					
SW42	Any existing access tracks that will no longer be required following the construction of the new access roads will be rehabilitated in accordance with the Rehabilitation Management Plan.	Construction	Contractor – CM, S, SS	MW RWMM WM2.4.1	All
SW43	All cut and fill batters will be stabilised as soon as practical following construction.	Construction	Contractor – S, SS	MW RWMM WM2.4.2	All
SW44	Roads surfaces will be constructed and maintained with aggregate material to reduce soil loss rates and water quality risks. The use of material that presents elevated water quality risks relative to other material available for road construction and maintenance will be avoided where practicable.	Construction	Contractor – CM	MW RWMM WM2.4.3	All

ID	Measure / Requirement	When to implement	Responsibility*	Source document**	Area
SW45	Where practical access roads will grade to table drains that are designed and constructed to have non-erosive hydraulic capacity for the 10% AEP event. Transverse (or cross drainage) will be constructed to have the following non-erosive hydraulic capacities: • Primary roads – 1% AEP event; • Maintenance roads – 2% AEP event; and • Temporary access roads – 10% AEP event.	Construction	Contractor – DM	MW RWMM WM2.4.4	All
SW46	Temporary roads will be rehabilitated as soon as they are no longer needed.	Construction	Contractor – CM	MW RWMM WM2.4.6	All
Accommodation Camps					
SW47	Where practical, the following source controls for the accommodation camps will be applied: • the storage and handling of chemicals that have potential to contaminate the stormwater system will be undertaken in bunded areas. Any liquid waste stream will be disposed to an appropriate facility; • landscaped areas will be predominately vegetated with endemic native vegetation; and • runoff from road and other hardstand areas will be treated in vegetated swales.	Construction	Contractor – DM	MW RWMM WM2.2.1	Lobs Hole Marica Tantangara
SW48	Runoff from accommodation camps will be managed by drainage systems that have a 20% AEP capacity. Overland flow paths will be provided as required.	Construction	Contractor – DM	MW RWMM WM2.2.2	Lobs Hole Marica Tantangara
SW49	Runoff from accommodation camps will be treated in either sedimentation or bioretention basins (also referred to as raingardens). The most appropriate control will be established at detailed design with consideration of topography, soil conditions and other relevant factors.	Construction	Contractor – DM	MW RWMM WM2.2.3	Lobs Hole Marica Tantangara
SW50	Low phosphorus products shall be used for washing activities controlled by site management (i.e. laundry services and mess hall) and encouraged (via training) for general use.	Construction	Contractor – CM, EM, EC	MW RWMM WM2.9.3 EW REMM WM7.3	Lobs Hole Marica Tantangara
Works on waterfront land and instream works (watercourse diversions and crossings)					
SW51	Unless permitted by this approval, avoid carrying out of any development within 40 metres of any watercourse	Construction	Contractor – CM	MW CoA 30(h)	All

ID	Measure / Requirement	When to implement	Responsibility*	Source document**	Area
SW52	All instream works or development within 40 metres of any watercourse will be undertaken generally in accordance with the requirements in the *Guidelines for Controlled Activities on Waterfront Land*	Construction	Contractor – CM, S, SS	MW CoA 30(i)	All
SW53	The temporary bridges at Yarrangobilly River and Wallaces Creek where feasible and reasonable, will be consistent with the Guidelines for Controlled Activities Watercourse Crossings (NRAR, 2018), *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge, 2003), *Policy and Guidelines for Fish Friendly Waterway Crossings* (NSW Fisheries, February 2004), and *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI Fisheries, 2013). The permanent bridges at Yarrangobilly River and at Wallaces Creek will be designed and constructed to comply with the *Policy and Guidelines for Fish Habitat Conservation - Update 2013* (DPI 2013) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge 2003) and Guidelines for Controlled activities on Waterfront Land (NRAR, 2018).	Construction	Contractor – DM	EW CoA 39 EW CoA 40	All
SW54	ESCPs are to dictate the specific controls to be used on waterfront land. Typical measures include: • monitoring weather forecasts and taking appropriate action prior; • minimising the extent of work and the amount of time disturbance where possible; • isolating work areas from natural flows where possible; • stockpiles to be located outside of the waterfront area; • use of temporary ground covers in areas of concentrated flow to minimise erosion of exposed soils during rainfall; and • completing and stabilising works as quickly as possible after works are complete.	Construction	Contractor – CM, S, SS, EC	MW REMM WM04	All
SW55	The disturbance area and extent to which soil and vegetation within the riparian zone are disturbed will be minimised where practicable.	Construction	Contractor – S, SS	Project Requirement	All
SW56	Direct access to the rivers and creeks by construction vehicles and mechanical plant will be minimised and permitted only within the limits of clearing and designated areas of disturbance	Construction	Contractor – S, SS	Project Requirement	All
SW57	Erosion control matting or other practical methods will be used in the riparian zone to minimise sediment entering the river channel and provision of protection against scouring and erosion of the river bed.	Construction	Contractor – CM, S, SS	MW CoA 30(g)	All

ID	Measure / Requirement	When to implement	Responsibility*	Source document**	Area
SW58	Any watercourse that will be permanently diverted around permanent infrastructure will: • be a piped and/or surface drainage system; • be designed and constructed to have non-erosive hydraulic capacity and be structurally sound for the 1% AEP event; and • have adequate scour protection at the system inlets and outlets. A risk assessment will be undertaken to identify risks associated with by-pass flows that may occur as a result of system blockage or an event greater than the design event.	Construction	Contractor – DM	MW RWMM WM3.1.1 MW CoA 30(g)	All
SW59	Where practical, any watercourse that will be temporarily diverted will; • be a piped and/or surface drainage system; • be designed and constructed to have non-erosive hydraulic capacity and be structurally sound for a design event (that will be established by a rick assessment); and • have adequate scour protection at the system inlets and outlets. A risk assessment will be undertaken to identify risks associated with by-pass flows that may occur as a result of system blockage or an event greater than the design event.	Construction	Contractor – CM	MW RWMM WM2.1.1 MW CoA 30(g)	All
SW60	Where practical, temporary watercourse diversions will seek to avoid increasing flow rates in adjoining watercourses	Construction	Contractor – CM	MW REMM WM2.1.2 MW CoA 30(g)	All
SW61	Where practical, the permanent diversion of drainage lines or watercourses using contour drains will be avoided	Construction	Contractor – DM	EW REMM WM1.4	All
SW62	All culverts, bridges and service crossings will be designed by a suitably qualified professional in accordance with the relevant Austroads Guidelines or best practice methods.	Construction	Contractor – DM	MW REMM WM Instream works 1 and 2	All
SW63	Watercourses will be rehabilitated / reinstated in accordance with Rehabilitation Management Plan	Construction	Contractor SHL	MW RWMM WM2.1.3 MW REMM WM3.1.2	All
Stockpiling					
SW64	Temporary spoil stockpiles will be managed by ESCPs in accordance with the relevant requirements in the Managing Urban Stormwater: Soils and Construction guidance series and in accordance with the Stockpiling Procedure (Annexure C of the Spoil Management Plan)	Construction	Contractor – S, SS	MW CoA 7 EW REMM CON02	All

ID	Measure / Requirement	When to implement	Responsibility*	Source document**	Area
Design and construction of the intake structures					
SW65	This SWMP will be updated and submitted to DPIE prior to the construction of the intake structure.	Construction	Contractor – EM	CoA 30(g) Project Requirement	Talbingo Tantangara
SW66	The specifications and locations of the proposed environmental measures for the plug removal within the reservoirs will be determined as part of detailed design, including the installation of silt curtains. They will be designed such that water quality criteria is agreed with the regulators, with the application of a mixing zone if required.	Construction	Contractor SHL	MW REMM WM11	Talbingo Tantangara
SW67	Investigations to minimise the disturbance of bed sediments due to water flows during commissioning will be undertaken as part of detailed design. Potential measures to minimise the disturbance of bed sediments include: • investigate mitigated design measures; • dredging sediments from the potential disturbance zones and placing them in another part of the reservoir; and/or • armouring the sediments in the potential disturbance zones.	Construction	SHL	MW REMM WM12	Talbingo Tantangara
Monitoring					
SW68	A Surface Water Monitoring Program has been developed and is included in this plan. The Surface Water Monitoring Program (Annexure A) establishes monitoring requirements to assess the quality of discharge and receiving waters	Construction	Contractor – EM, EC	MW REMM WM02 EW REMM ECO15	All
SW69	Surface water extraction will be monitored and tracked against water access licence limits.	Construction	Contractor – CM, EC	Water Access Licence	Talbingo Tantangara
SW70	Rainfall forecasts will be monitored daily and the works planned, and the site works managed to minimise the potential impact of heavy rainfall and flood events. Prior to heavy rain events erosion and sediment controls will be reviewed and improved where necessary to minimise impacts.	Construction	Contractor – S, SS, EC	Blue Book Good Practice	All
SW71	Erosion and sediment controls including clean water diversions will be inspected at least weekly (with maintenance and/or modifications made as necessary). Inspections and/or maintenance during wet-weather may be increased where necessary.	Construction	Contractor – SS, EC	Blue Book Good Practice	All
SW72	A Trigger Action Response Plan provides detail of the response actions that will be implemented in the event of an exceedance. This plan will be implemented.	Pre-construction and construction	Contractor – All	MW CoA 31(c)	All

** Responisbility*	*Regardless of the allocation of responsibilities within this plan, the responsible party is to be assigned in accordance with the Contract*
***Source Documents*	*1. MW RWMM – Main Works Revised Water Management Measure (Main Works RTS Appendix J Appendix C)* *2. MW REMM – Main Work Revised Environmental Management Measures (Main Works RTS Appendix C)* *3. CoA – Condition of Approval (SSI 9687)* *4. EW REMM – Exploratory Works Revised Environmental Management Measures (Exploratory Works RTS Chapter 8)*
Responsibility abbreviations	*CM – Construction Manager, DM – Design Manager, EM – Environmental Manager, EC – Environmental Coordinator, S – Superintendent, SS – Supervisor, All – All personnel including subcontractors*

5.14. Risk and Contingency

The key risk to the successful implementation of measures identified in Table 5-3 have been categorised based on the management measure stream. Table 5-4 outlines these risks and discusses contingency measures to reduce these risks.

Table 5-4: Contingency overview

Management measure stream	Risk	Contingency
Stormwater management	• stormwater management systems / controls not meeting predicted stormwater discharge quality characteristics. • sediment basins frequently over-topping • inadequate diversion of clean water or inclusion within system capacity • inadequate dewatering of captured stormwater	• design reviews • undertake monitoring in accordance with SWMP Annexure A. Implement TARP to identify investigate the exceedance mechanism • prior to heavy rain events, review erosion and sediment controls will be reviewed and make improvements where necessary to minimise impacts • seek advice from suitably qualified erosion and sediment control professional
Flooding	• flood areas not considered during detailed design	• design reviews • flood mapping extents to be reviewed during temporary and permanent designs • Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090)
Process and intercepted water management	• process water treatment plant does not meet water quality design specifications • process water treatment plant performance reduction or failure	• design reviews • contingency measures for emergency scenarios are identified in Section 5.3.1. Only surplus treated water will be discharged to reservoirs. • continuous in-line monitoring of WTPs • undertake monitoring in accordance with SWMP Annexure A. Implement TARP to identify and remediate the exceedance mechanism
Wastewater	• wastewater treatment plant does not meet water quality specifications • wastewater treatment plant performance reduction or failure	• design reviews • wastewater system will include emergency storage of untreated wastewater. The storage volume will be calculated at detailed design based on analysis of response times from regional waste management contractors to provide emergency trucking and offsite disposal options. • all wastewater treatment plants will be designed to operate during winter when sub-zero temperatures can persist for extended periods of time. • continuous in-line monitoring of WTPs • undertake monitoring in accordance with SWMP Annexure A. Implement TARP to identify and remediate the exceedance mechanism

Management measure stream	Risk	Contingency
Chemical control and spill management	• insufficient spill controls materials (i.e. absorbent pads, spill socks, etc) • inadequate size of chemical storage area	• undertake spill response equipment inspections to confirm that spill kits are adequately stocked and distributed • conduct training / toolboxes on response to spills (i.e. Annexure C spill procedure) • inclusion of designated chemical storage areas through design for proposed storage quantities
Access Roads	• stormwater management systems / controls not meeting predicted stormwater discharge quality characteristics	• design reviews • undertake monitoring in accordance with SWMP Annexure A. Implement TARP to identify and remediate the exceedance mechanism
Accommodation Camps	• stormwater management systems / controls not meeting predicted stormwater discharge quality characteristics	• design reviews • undertake monitoring in accordance with SWMP Annexure A. Implement TARP to identify investigate the exceedance mechanism
Works on waterfront land and instream works (watercourse diversions and crossings)	• weather, including flooding • inadequate staging of works	• design reviews • all culverts, bridges and service crossings will be designed by a suitably qualified professional in accordance with the relevant Austroads Guidelines or best practice methods • review and plan works according to weather • seek advice from suitably qualified erosion and sediment control professional • undertake monitoring in accordance with SWMP Annexure A. Implement TARP to identify investigate the exceedance mechanism
Dredging	• in-effective or damaged silt curtain	• undertake monitoring in accordance with SWMP Annexure A. Implement TARP to identify and remediate the exceedance mechanism • silt curtain to remain in place until after completion of the works (when water quality sampling demonstrates that it is acceptable to do so)
Stockpiling / spoil emplacement	• stormwater management systems / controls not meeting predicted stormwater discharge quality characteristics. • sediment basins frequently over-topping • inadequate diversion of clean water or inclusion within system capacity	• design reviews • undertake monitoring in accordance with SWMP Annexure A. Implement TARP to identify investigate the exceedance mechanism • prior to heavy rain events, review erosion and sediment controls will be reviewed and make improvements where necessary to minimise impacts • seek advice from suitably qualified erosion and sediment control professional

Management measure stream	Risk	Contingency
Monitoring	• monitoring site access restrictions due to weather / safety issues • deficiencies in data management / quality assurance • monitoring program inadequate to detect water quality changes and sources / extents of events	• approved surface water monitoring program • monitoring, analysis and management of water quality data undertaken by trained professionals and according to relevant guidelines • calibration records • TARP training to be undertaken • periodic review of monitoring program to ensure effectiveness

6. COMPLIANCE MANAGEMENT

6.1. Roles and Responsibilities

Future Generation's organisational structure and overall roles and responsibilities are outlined in Section 4 of the EMS. Specific responsibilities for the implementation of mitigation measures are detailed in Section 5 of this SWMP. Regardless of the allocation of responsibilities within this plan, the responsible party is to be assigned in accordance with the Contract.

6.2. Inspection

Inspection of water management measures will be undertaken regularly during construction in the form of weekly environmental inspections and rainfall inspections. All inspections will be internally recorded.

Any opportunities for improvement identified through the inspection process will be recorded in an inspection report (minor issues) in accordance with Section 8 of the EMS or an incident report completed in accordance with Section 7 of the EMS. Findings from inspection and incident report(s) will be reported to relevant agencies where required.

6.3. Monitoring

A surface water quality monitoring program (Annexure A) has been prepared in accordance with CoA 31 and REMM WM01, and will be implemented during construction. The monitoring aspects of the program are summarised in Table 6-1.

Table 6-1: Surface Water Monitoring Overview

Monitoring Aspect	Objective
Routine receiving surface water quality monitoring Event based wet weather overtopping water quality monitoring	• inform and assess the performance of management processes/measures that seek to minimise the Project's impact on surface water quality • help determine source and extent of any water quality changes • collect baseline data to characterise water quality and determine site specific values
Streamflow monitoring Note: Details of this monitoring will be included in a future update to this SWMP.	• inform and assess the performance of management processes/measures that seek to minimise the Project's impact on streamflow

The program is an extension of the Exploratory Works monitoring program and EPL 21266, with a major focus on detection of change in water quality of watercourses and the reservoirs associated with the Main Works activities across all site areas (i.e. Talbingo Reservoir, Lobs Hole, Marica, Plateau, Tantangara Reservoir and Rock Forest).

The surface water monitoring program has been staged, such that initial monitoring focuses on current and impending construction activities, with further monitoring details to be added based on the timing of specific significant construction activities in the specific sites areas (e.g. sub-aqueous rock emplacement for Talbingo Reservoir, dredging/blasting in Talbingo and Tantangara reservoirs and tunnelling under the Plateau, refer to 1.7). Reporting of monitoring results will be in accordance with the details in Section 6.7.

Surface water extraction from the reservoirs will be monitored and tracked against the Water Access Licence, as identified in Section 5 of the WMP.

6.4. Trigger Action Response Plan

6.4.1. Purpose

The purpose of a Trigger Action Response Plan (TARP) is to detail a standardised, response procedure in the event WQO or discharge characteristics are exceeded during a monitoring event for surface water quality monitoring. The TARPs aim to:

- identify the potential cause of the water quality variation;
- identify the extent of water quality variation, via supplementary monitoring if necessary
- identify and implement potential management measures to minimise continuation of the water quality variation;
- perform due diligence when variation is identified; and
- meet CoA and REMMs requirements for trigger response.

6.4.2. Objective

TARPs that have been prepared for the following situations:

- TARP-1: monthly routine monitoring identifies receiving water quality exceedance against the relevant WQOs; and
- TARP-2: if stormwater controls (i.e. sediment basins) overtop. Stormwater controls be will be bench-marked against predicted stormwater discharge characteristics and the relevant WQOs.

Table 6-2 provides an overview of the TARPs. All TARPs are provided in Annexure B.

Table 6-2: Overview of Trigger Action Response Plans

TARP Type	Trigger	Objective
TARP 1 – Receiving water monitoring exceedance	If a WQO / latest monthly SSTV is exceeded in receiving waters.	To identify (where possible) if the exceedance is naturally occurring or due to construction
TARP 2 – Stormwater overtopping event	If stormwater controls overtop	To identify the source (where possible) of each exceedance. To establish actions to either improve water management or further investigate the exceedance mechanism.

At all times during construction, Future Generation will lead the initiation of TARPs and implementation of corrective measures.

6.4.3. Limitation

The following limitations apply for the TARPs:

- response to basic monitoring (see Annexure A) can be immediately implemented within 24 hours of the monitoring event however response to comprehensive monitoring (see Annexure A) cannot be immediately implemented at the time of the monitoring event due to the delay in receiving laboratory results. Considering this, it is deemed appropriate that response actions based on comprehensive monitoring will be undertaken as soon as reasonable. A greater depth of understanding of water quality impacts and impact mechanisms can be gained from comprehensive monitoring. This information can then be applied to establish specific improvements to the water management system, and is also valuable for reporting purposes.

6.5. Training

All site personnel will undergo site induction training relating to water management issues. The induction training will address elements including:

- minimisation of water quality impacts to surface water; and
- procedures required for reuse and discharge of water including incident response.

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

- discharge quality parameters; and
- erosion and sediment control implementation.

Further details regarding the staff induction and training are outlined in Section 5 of the EMS.

6.6. Auditing

Audits will be undertaken to assess the effectiveness of water management measures, and overall compliance with this SWMP. Audit requirements are detailed in Section 8.3 of the EMS.

6.7. Reporting

Future Generation will report to Snowy Hydro and other agencies as detailed in Table 6-3 on water management aspects related to the Project. During construction, surface water monitoring data will be collected, tabulated and assessed against thresholds.

Table 6-3: Reporting requirements relevant to surface water

Report	Requirement	Recipient
Reporting		
Weekly inspection	EMS Requirement Weekly inspection report undertaken by environmental advisor which includes aspects relevant to the management of water	FGJV Internal Record
Incident Report (related to water)	Infrastructure Approval Schedule 4, CoA 6 The Proponent must notify the Department and NPWS via the Major Projects Portal immediately after it becomes aware of an incident on site. This notice must set out the location and nature of the incident.	Depending on the type and severity of the incident this may include notification to the Department and NPWS in writing for incidents defined under the conditions of approval, notification to the NPWS where required under the Deed of Agreement of Lease and notification to the EPA for pollution related incidents. Snowy Hydro will notify DPIE in writing immediately after they become aware of the incident on site.
	EPL 21266 Incident reports to be provided to EPA in accordance with EPL notification of environmental harm and written report requirements.	
EPL Monitoring Reports and Annual Returns	EPL 21266 EPL monitoring reports will be prepared in accordance with the requirements of the EPL. An EPL Annual Return will be prepared in respect of each EPL reporting period (typically 12 months)	EPA

Report	Requirement	Recipient
Environmental Water Report (every 3 months)	Infrastructure Approval Schedule 3, CoA 31(c)(d) Commentary on the performance of the monitoring programs within the surface water management plan will be documented in the quarterly environmental water report. Any incidents and key environmental issues will be documented.	Publicly available on project website
Other Aspects		
Updates to this WMP	Section 1.8 of this WMP This SWMP will be updated prior to the commencement of the following activities: • dredging, channel extraction or underwater blasting • in-reservoir emplacement works • construction works in the third year for the purposes of determining need / location of streamflow monitoring sites • Snowy 2.0 operations (a separate SHL document or framework may be prepared)	Proposed future updates to this WMP will be provided to EPA, NPWS, Water Group, NRAR and NSW DPI.

ANNEXURE A – SURFACE WATER MONITORING PROGRAM

S2-FGJV-ENV-PLN-0017

SNOWY 2.0 MAIN WORKS – SURFACE WATER MONITORING PROGRAM

Approval Record			
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Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:29:31 +10'00'

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	29.11.2019	Initial draft for SHL review
B	2.06.2020	Revised to address Infrastructure Approval
C	15.06.2020	Revised to address SHL comments. For consultation.
D	25.06.2020	Revised to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments

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1. INTRODUCTION

1.1. Context

This Surface Water Monitoring Program (Program) forms part of the Surface Water Management Plan (SWMP), Water Management Plan (WMP) and Environmental Management Strategy (EMS) for construction of Snowy 2.0 Main Works (the Project).

The Program addresses the requirements of the Minister's Conditions of Approval (CoA) as approved on 21 May 2020, the Main Works Snowy 2.0 Environmental Impact Statement (EIS), the revised environmental management measures (REMM) within the Snowy 2.0 Main Works - Preferred Infrastructure Report and Response to Submissions (EMM 2020), and all applicable guidance and legislation

1.2. Scope

The scope of this Program is to describe how Future Generation will monitor the extent and nature of potential impacts to surface water during construction of the Project. Operational monitoring and operation measures do not fall within the scope of the construction phase and therefore are not included in the processes contained within the Program. Groundwater monitoring is also out of scope for the Program and is covered in detail in the Groundwater Management Plan.

The Program provides details on the following elements:

- performance criteria and their assessment;
- type and frequency of monitoring;
- analytes to be monitored; and
- surface water monitoring sites.

This Program has been developed based on the level of risk, informed by the the RTS Revised Water Management Report (EMM, 2020) and as such is predominantly focused on surface water quality.

As the Main Works EIS Flood Risk Assessment (EMM, 2019) identified, the key residual flood risk during construction will be the effective evacuation of the construction workforce in the event of a major flood occurring. Precautionary measures (such as weather monitoring) and evacuation procedures will be undertaken in accordance with the Natural Hazard Management Plan (S2-FGJV-ENV-PLN-0090). Given the EIS assessment, this Program has not identified flood criteria for remedial action.

Streamflow is maintained by discharges from the groundwater system (i.e. baseflow) and quickflow will only occur following significant rainfall events. As there is a long lead time before any impacts are predicted to streamflow and that it is likely that these impacts will be indiscernible in the observed data considering the interannual variability in flow, the need and location for streamflow monitoring sites and criteria will be reviewed based on additional groundwater monitoring data (refer Section 1.4).

1.3. Purpose and objectives

This Program has been prepared in accordance with schedule 3, condition 31 and REMM WM01 and will be implemented during construction of Main Works. The purpose of the monitoring program is to provide data and information to feed into management processes that seek to minimise the Project's impact on surface water.

The objectives of the Program are to:

- monitor surface water quality at a range of locations such that any water quality impacts attributable to the Project can be identified;
- where a change in water quality is detected and exceeds relevant criteria, collect data to help identify the source of the change (via Trigger Action Response Plans);
- continue to collect baseline data (upstream of disturbance areas and in unimpacted disturbance areas) to characterise background water quality for project areas where site-specific WQOs are needed; and
- regularly inspect Project aspects that have the potential to impact on surface water quality and maintaining these elements where required.

1.4. Staging

This Program contains monitoring details for surface water at the following sites:

- Lobs Hole;
- Marica;
- Plateau;
- Rock Forest;
- Talbingo; and
- Tantangara.

Some distinct work activities require greater detail prior to commencement. Consequently, this Program will be updated and submitted to DPIE prior to the commencement of specific activities as detailed in Table 1-1

Table 1-1: Activities that require update to the SWMP

Activities	Timing
Dredging, channel extraction or underwater blasting	This Program will be updated for approval prior to dredging, channel extraction or underwater blasting.
Permanent in-reservoir emplacement areas	This Program will be updated prior to in-reservoir emplacement and will include verification monitoring.
Construction works in the third year for the purposes of determining need/location streamflow monitoring sites	This Program will be updated in the third year of construction to determine the need for surface water flow monitoring sites and if necessary, suitable locations to monitor potential streamflow impacts (based on additional groundwater monitoring data / revised drawdown predictions).
Operation of Snowy 2.0 Project, including dewatering of the tailrace tunnel during operations.	Operation will be addressed through a separate Snowy Hydro framework or document.

1.5. Responsibility

Future Generation’s organisational structure and overall roles and responsibilities are outlined in Section 4 of the EMS.

1.6. Consultation

In accordance with schedule 3, condition 31 of the Infrastructure Approval and revised environmental management measure (REMM) WM01, the WMP (which includes this SWMP) is to be prepared in consultation with;

- NSW Environment Protection Agency (EPA);
- National Parks and Wildlife Services (NPWS);
- NSW Department of Industry – Water (Water Group);
- Natural Resources Access Regulator (NRAR); and
- NSW Department of Primary Industries (NSW DPI)

In accordance with condition 18 of the Commonwealth approval, the WMP (including this SWMP) is also to be prepared in consultation with the DAWE.

A summary of the consultation undertaken is included in the SWMP.

2. PERFORMANCE CRITERIA

Two types of performance criteria are applied to assess water quality – water quality objectives and discharge criteria. Water quality objectives are applied to receiving waterbodies, and are described in section 2.1. Discharge characteristics are applied to discharge waters prior to and/or during their discharge to receiving waters, and are described in section 0 for treated waste water and process water discharges and section 2.2.2 for stormwater discharges.

2.1. Water quality objectives

Waterbodies potentially impacted by Snowy 2.0 Main Works are within the 'Murrumbidgee River and Lake George catchment'. Tantangara and Talbingo reservoirs and watercourses within the Lobs Hole, Marica and Plateau areas are classified as 'streams affected by the Snowy Scheme'. Watercourses within Rock Forest are classified as 'uncontrolled streams'.

The approach for assigning Water Quality Objectives (WQOs) for watercourses and reservoirs is based on the *NSW Water Quality and River Flow Objectives* (DECCW 2006) and is presented in Table 2-1. The approach and default WQOs provided in DECCW (2006) are based on the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000). WQOs are assigned based on the type of waterbody and existing ecosystem condition. The approach is essentially the same as that recommended in the recently updated Guidelines for Fresh and Marine Water Quality (ANZG 2018); however, reference to ANZECC/ARMCANZ (2000) has been retained because the updated Guidelines (ANZG 2018) have not yet been formally captured by water quality policy in NSW.

The DECCW (2006) approach encourages the derivation of local, or site-specific, trigger values (SSTVs) to use as WQOs in preference to the default WQOs. Although baseline water quality datasets for sites on Yarrangobilly River and Talbingo Reservoir are approaching or have met the minimum requirement (monthly data for 24 months) for deriving SSTVs, the ability to derive SSTVs in the near-term is compromised due to the following two issues: (i) insufficient data for wet weather water quality; and (ii) the impact that the January 2020 bushfire has had on local ambient water quality. Bushires are known to impact water quality and such impacts have been observed in the Yarrangobilly River since the 2020 bushfire. A brief review of the potential impacts of bushfires on water quality is provided in Attachment A. Until sufficient representative data can be obtained, it would not be appropriate to derive SSTVs. Hence, until SSTVs can be derived, the default WQOs presented in Table 2-2: continue to be applied to characterise and assess receiving water quality during construction phase. The default WQOs are consistent with those presented in the Snowy 2.0 Main Works revised Water Management Report (Appendix J of EMM 2020).

Despite the current baseline data limitations, the ability to derive SSTVs will continue to be reviewed. When limitations are overcome, SSTVs shall be developed and presented in a future update to this SWMP. Regardless of whether WQO or SSTV are in place, the management approach to surface water shall remain consistent with management principles and management measures identified in Section 5 of the SWMP.

Table 2-1: Summary of approach for assigning water quality objectives (from Main Works EIS, Appendix J)

Waterbody type	Project area	Ecosystem condition	Ecosystem condition justification	Proposed WQO approach	Default WQOs
Watercourses	Lobs Hole	High conservation	• Watercourses are located within KNP. • A number of watercourses provide relatively undisturbed aquatic and riparian habitat – non-native species of fish (brown trout and rainbow trout) are abundant, but there are climbing galaxias, Murray crayfish and other native species in the river.	Physical and chemical stressors – no change to natural variability	Default trigger values for upland rivers in South Eastern Australia
	Marica			Toxicant trigger values for the protection of 99% of aquatic species	Toxicant trigger values for the protection of 99% of freshwater aquatic species
	Plateau				
	Rock Forest	Slightly–moderately disturbed	• The area adjacent to, and downstream of Main Works has been predominantly cleared for grazing. • Instream farm dams located upstream of Rock Forest have modified flow regimes within the primary watercourses.	Physical and chemical stressors – some change to natural variability acceptable	Default trigger values for upland rivers in South Eastern Australia
				Toxicant trigger values for slightly to moderately disturbed ecosystems	Toxicant trigger values for slightly to moderately disturbed ecosystems
Reservoirs	Tantangara Reservoir	Slightly–moderately disturbed	• The reservoirs are artificial waterbodies created by flooding natural river valleys in the 1960s to 1970s. • Water levels in the reservoirs are not natural, being controlled for electricity generation as part of the Snowy Scheme. • The reservoirs support low biodiversity, consistent with their relatively recent construction and its largely homogeneous bed habitat.	Physical and chemical stressors – some change to natural variability acceptable	Default trigger values for freshwater lakes and reservoirs in South Eastern Australia
	Talbingo Reservoir			Toxicant trigger values for slightly to moderately disturbed ecosystems	Toxicant trigger values for slightly to moderately disturbed ecosystems

Table 2-2: Water quality objectives for receiving waters (source: Appendix J of EMM 2020)

Category	Analyte	Unit	Water quality objective	
			Watercourses	Talbingo and Tantangara Reservoirs
Physico-chemical Properties	pH		6.5-8.0[1]	6.5-8.0[1]
	Electrical conductivity (EC)	µS/cm	30-350[1]	20-30[1]
	Turbidity	NTU	2-25[1]	1-20[1]
	Dissolved oxygen (DO)	%	90-110[1]	90-110[1]
	Suspended solids	mg/l	No objective	No objective
	Total hardness (as $CaCO_3$)	mg/l	No objective	No objective
Nutrients	Total ammonia (NH_4^+)	mg/l	0.013[1]	0.010[1]
	Oxidised Nitrogen (NO_x)	mg/l	0.015[1]	0.010[1]
	Total Nitrogen (TN)	mg/l	0.25[1]	0.35[1]
	Total kjeldahl nitrogen	mg/l	No objective	No objective
	Filterable Reactive phosphorus (FRP)	mg/l	0.015[1]	0.005[1]
	Total Phosphorus (TP)	mg/l	0.02[1]	0.01[1]
Inorganics (dissolved)	Cyanide	mg/l	0.004	0.007
Metals and metalloids (dissolved)[2]	Aluminium (Al)	mg/l	0.027	0.055
	Arsenic (As)[4]	mg/l	0.005	0.013
	Total Chromium (Cr)[5]	mg/l	0.0001	0.001
	Copper (Cu)	mg/l	0.0010	0.0014
	Manganese (Mn)	mg/l	1.2	1.9
	Nickel (Ni)	mg/l	0.008	0.011
	Lead (Pb)	mg/l	0.001	0.0034
	Silver (Ag)	mg/l	0.00002	0.00005
	Zinc (Zn)	mg/l	0.0024	0.008
	Iron (Fe) [3]	mg/l	0.3	0.3

Note 1. *The WQOs for physico-chemical properties and nutrients refer to the trigger values for physical and chemical stressors in south-east Australia (for upland rivers or freshwater lakes and reservoirs), as reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).*

2. *The WQOs for metals amd metalloids are based on the trigger values for 99% or 95% species protection from ANZECC/ARMCANZ (2000), applied according to the approach outlined in Table 2-1*
3. *WQO is based on a low reliability trigger value.*
4. *For As (V).*
5. *For Cr (VI).*

2.2. Discharge characteristics

2.2.1. Treated wastewater and process water

Licensed sampling locations in accordance with the Project EPL 21266 will exist in both Talbingo and Tantangara reservoirs for the effluent waste streams from the wastewater and process water treatment plants. These two waste streams will be combined prior to discharge to the receiving environments such that there will be only one discharge point in each reservoir.

Predicted discharge characteristics for the combined waste discharge stream prior to it being discharged are shown in Table 2-3. These characteristics are based on the water quality of the combined waste streams estimated for the treated process water and wastewater mixing zone assessment (Attachment F of the revised Water Management Report in EMM 2020). They reflect the median water quality values reported in Tables 4.9 and 5.1 of the revised Water Management Report in EMM (2020), adjusted to account for the relative proportions of each of the waste streams contributing to the combined discharge.

The reported discharge characteristics will be updated at the appropriate time if detailed design specifications indicate different characteristics, noting that specifications need to be such that the WQOs will be met in the receiving environment wherever possible. Updating of the discharge characteristics will be done in consultation with Snowy Hydro and regulators.

Beyond the discharge point to the reservoirs, the effect of the combined (treated) waste stream on receiving water quality will be monitored against the WQOs in Table 2-2: at the relevant receiving water monitoring locations (see section 3.2).

Table 2-3: Predicted major water quality characteristics of combined treated wastewater and process water discharge (source: Appendix J of EMM 2020)

Analyte	Units	Discharge characteristics[1]		Comments
		Talbingo	Tantangara	
Electrical conductivity	µS/cm	700	168	The treatment processes will not remove dissolved solids. Hence, water salinity will not be reduced by the treatment process.
pH	-	6.5-8.5	6.5-8.5	Alkalinity and pH will be adjusted as part of the treatment processes
Turbidity	NTU	<25	<25	Suspended solids and turbidity will be substantially reduced as part of treatment processes
Total nitrogen	mg-N/L	0.27	0.25	Nutrients will be substantially reduced by the treatment processes.
Total phosphorus	mg-P/L	0.03	0.02	

Note 1. Values represent an average of the likely medians for treated wastewater and process water, weighted according to the proportional volume of each discharge contributing to the combined discharge, as reported in Attachment F of the revised Water Management Report (EMM 2020).

2.2.2. Stormwater discharges

Stormwater includes water in sediment basins or in swale drains and other erosion and sediment control structures in locations where sediment basin are unable to be installed (e.g. access roads in steep terrain). The predicted discharge characteristics of stormwater are shown in Table 2-4.

The Snowy 2.0 Main Works revised Water Management Report (Appendix J of EMM 2020) listed predicted discharge water quality for at least six different Main Works activities (referred to in the RTS as Water Management Categories), such as Phase 1 Minor works and Major works and

Phase 2 accommodation camps, construction pads, access roads and large temporary stockpiles. Predicted water quality for these activities varied for some of the analytes, however, a number of these activities will often co-occur and will drain to common sediment basins. Therefore, it is not possible to specifically assess stormwater discharge water quality for each of the different types of activities. Consequently, the discharge characteristics specified for Phase 1 Minor works and Major works have been adopted (Table 2-4), which encompass the range of discharge characteristics for the other specific Main Works activities.

The rationale for selection of the predicted discharge characteristics is detailed in the revised Water Management Report (Appendix J of EMM 2020; see Table A.4). Briefly, the predicted discharge characteristics were based on three rounds of wet weather monitoring of runoff from existing disturbed areas (existing access tracks and areas disturbed by historic construction and mining activities) undertaken as part of the Snowy 2.0 baseline monitoring. A total of 30 disturbed area runoff samples and 20 receiving water samples were collected across Lobs Hole, Marica and Tantangara compound. The water quality treatment benefits of the proposed stormwater management measures, including results from laboratory jar tests, were also taken into account when predicting discharge characteristics. The predicted discharge characteristics will be validated against actual stormwater quality monitoring data and updated as necessary (see section

Stormwater captured as part of erosion and sediment controls will primarily be managed via re-use on site (e.g. for dust suppression, irrigation to natural vegetation and rehabilitated areas) in order to minimise the need to discharge to receiving waters. Discharges from sediment basins may occur under the following situations: (i) passive discharge (i.e. via overflow) during a rainfall event that exceeds the sediment basin design capacity, and (ii) active discharge (i.e. via pumping) under a discharge permit, for example, where a significant rainfall event is imminent, other water management measures are insufficient to maintain basin capacity, and the basin water quality is deemed of sufficient quality to discharge. In the event of passive or (approved) active basin discharges, TARP-2 will be invoked. Briefly, if the stormwater reaches receiving waters, the discharge water at the overflow location will be monitored for pH and turbidity and compared to the discharge characteristics shown in Table 2-4. If one or both of these parameters is exceeded, all the analytes listed In Table 2-4 will be measured, while receiving water quality upstream and downstream of the stormwater discharge will be measured and monitored against the WQOs in Table 2-2:, at the nearest upstream and downstream receiving water monitoring sites, allowing for a sufficient mixing zone prior to the downstream site.

The water quality (pH and turbidity) of over-topping stormwater will be compared with the discharge characteristics to assess whether the controls are achieving the predicted water quality. Due to a general lack of significant rainfall events during the Exploratory Works, there have been limited opportunities to undertake this comparison. Hence, this process will continue during the Main Works period until sufficient data exist for an appropriate validation to be undertaken. The aim is to ensure that stormwater discharge characteristics are well understood and that the erosion and sediment controls are sufficient to ensure that discharge quality is such that WQOs are met in the receiving environment wherever possible. These refinements to discharge characteristics, along with any recommendations will be included in updates to the SWMP.

Table 2-4 Predicted discharge quality characteristics of stormwater (source: Appendix J of EMM 2020) [1]

Analyte	Units	Discharge characteristics [1]	
		Likely range [2]	Likely median [3]
pH	-	4.0 – 8.0	4.5
Turbidity	NTU	100 – 1000	250
Suspended sediment	mg/L	25 - 300	50
Electrical conductivity (EC)	µS/cm	No values provided	
Total nitrogen (TN)	mg/L	0.1 – 5.0	0.8
Total phosphorus (TP)	mg/L	0.01 – 1.0	0.15
Oil and Grease	mg/L	No visible oil and grease	
Dissolved aluminium [4,5,6]	µg/L	0 – 50 x WQO	10 x WQO
Dissolved copper [4,5,6]	µg/L	0 – 500 x WQO	7 x WQO
Other dissolved metals	mg/L	WQOs occasionally exceed	< WQOs

Note

1. *The values presented capture the range of predicted stormwater qualities from across a range of Main Works activities, including Phase 1 minor works and major works and Phase 2 works such as access roads, construction pads and accommodation camps to support construction activities.*
2. *Likely range refers to the estimated range of concentrations that could occur during typical discharge conditions. Attachment A of the revised Water Management Report (EMM 2020) describes the supporting information and assumptions that were applied to establishing these values.*
3. *Likely median refers to a conservative estimate of typical or median values in discharge from a project level water management category. Attachment A of the revised Water Management Report (EMM 2020) describes the supporting information and assumptions that were applied to establishing these values.*
4. *Aluminium and copper are the metals most likely to be elevated above WQOs, due to naturally elevated levels in soils in some areas.*
5. *Default trigger values for 99% level of species protection apply as WQOs. Refer to Table 2-2 for relevant values.*
6. *Concentrations of metals/metalloids refer to laboratory analysis of a 0.45 µm field filtered sample. Some of the metal concentration may be mineral or organic bound and may have lower ecotoxicology risks than similar concentrations of dissolved metals.*

3. MONITORING PROGRAM DETAILS

3.1. Sampling framework

Surface water monitoring for discharges and receiving waters will be undertaken based on the framework defined in Table 3-1. The sampling framework comprises a combination of waterbody type, sampling frequency/event type and analysis suite. Sample collection will comply with the NSW EPA's Approved Methods for the Sampling and Interpretation of Results of Water Pollutants in NSW.

Table 3-2 describes proposed sampling analytes and analysis methods. Each monitoring event will record the date, time, weather conditions, location, visual appearance of water, recent rainfall and the sampling field readings based on monitoring type. It is noted that receiving waterway water monitoring will be located more than 10m from any discharge location to ensure monitoring is undertaken outside of any mixing zone.

Table 3-1: Surface water monitoring sampling framework

Waterbody type	
Discharge water	Discharges from sediment basins and wastewater and process water treatment plants
Receiving water	Watercourses and reservoirs
Sampling frequency / event type [1]	
Continuous	Monitoring equipment installed long-term within a waterway with data collected at available intervals from the commencement of construction
Daily	Monitoring undertaken on a daily basis
Weekly	Monitoring undertaken on a weekly basis,
Monthly	Monitoring undertaken on a monthly basis
TARP-1	Monitoring undertaken as part of TARP-1 (see Section 6), in response to exceedances of receiving water quality against relevant WQOs (Table 2-2).
TARP-2	Monitoring undertaken as part of TARP-2 (see Section 6), in response to over-topping/discharge of stormwater from sediment basins.
Analysis suite	
Visual	Site observations as shown in Table 3-2. Turnaround time: same day.
Basic	Site observations and the basic water quality parameters shown in Table 3-2, via in situ measurement. Turnaround time: same day.
Comprehensive	The comprehensive water quality parameters shown in Table 3-2, via a combination of in situ measurement and field grab samples with laboratory analysis. Turnaround time: same day for in situ; within 2 weeks for laboratory analysis.

Note 1. All sampling will be subject to work health and safety assessments to ensure worker safety at all times.

Table 3-2: Proposed sampling analytes and analysis method for surface water monitoring

Category	Monitoring analytes	Analysis method
Visual		
Visual inspection	Gross water quality indicators – e.g. visible oil and grease, turbidity plumes Management measures – e.g. erosion and sediment controls, downstream drainage and clean water diversion	Visual inspection
Basic		
Visual inspection	Visible oil and grease	Visual inspection
Physico-chemical Properties	pH, electrical conductivity and turbidity	Measured in situ using a hand-held water quality meter and/or in situ water quality probes
Comprehensive		
Visual inspection	Visible oil and grease	Visual inspection
Physico-chemical Properties	pH, electrical conductivity, turbidity, dissolved oxygen, temperature and redox potential	To be measured using a portable water quality meter in the field
	Total suspended solids, total hardness	Analysis to be undertaken by a NATA certified laboratory
Nutrients	Total nitrogen, ammonia, oxidised nitrogen and total kjeldahl nitrogen Total phosphorus and reactive phosphorus	
Metals (dissolved)	Al, As, Ag, Cr (total), Cu, Fe, Mn, Ni, Pb and Zn	
Non-metallic inorganics	Cyanide	

3.2. Surface water monitoring sites

Monitoring will be undertaken in accordance with EPL 21266, supplemented for Main Works activities where necessary. Proposed monitoring sites have been identified and listed according to the following Main Works activity areas:

- Talbingo Reservoir;
- Lobs Hole;
- Marica;
- Plateau;
- Tantangara Reservoir; and
- Rock Forest.

The monitoring program is based on assessing water quality associated with current or imminent construction activities, and will be staged such that additional monitoring sites and details will be added in advance of the commencement of additional activities (e.g. sub-aqueous rock emplacement, dredging, blasting). The exact location of some sites may need to be finalised or slightly adjusted, at a time closer to commencement of Main Works construction activities once disturbance areas and discharge locations are better delineated, or for safe access reasons. All changes and additions to the monitoring sites during construction would be approved by Snowy Hydro and EPA prior to implementation, and updated in subsequent revisions of the water quality monitoring program and EPL 21266.

Baseline water quality was assessed as part of the Main Works EIS and, to a lesser extent, since the EIS, with the characterisation of these data provided in Attachment B. The monitoring site network includes some sites for continued collection of baseline water quality data in order to inform TARP processes (i.e. for identifying sources of water quality exceedances). Although baseline data collection specifically for the purposes of deriving site-specific WQOs has not been incorporated in the monitoring program, site-specific WQOs may be proposed for implementation when and where there are sufficient representative data to do so.

The monitoring site network includes sites to be included in EPL 21266 (EPL sites) as well as investigation sites to be monitored as part of Trigger Action Response Plan (TARP) investigations (see Section 6). TARP-1 sites will be sampled in the event of an exceedance of a WQO during routine monthly sampling, while TARP-2 sites will be sampled in the event that a sediment basin is over-topping or needs to be discharged and the discharge water is or will reach the watercourse. TARP sites are used to help identify the source of an exceedance as well as the spatial extent of an exceedance (see Section 6).

3.2.1. Talbingo Reservoir

Monitoring in Talbingo Reservoir is for the purpose of water quality change detection associated with various construction activities occurring in and also upstream of Talbingo Reservoir (e.g. rock emplacement areas, barge launch area, Talbingo intake, water treatment plants, accommodation camp, access roads). The key water quality issues are treated wastewater and process water discharge, runoff and seepage from the excavated rock emplacement area, stormwater discharges and disturbances from in-reservoir blasting and dredging. The present version of the monitoring program does not include details of monitoring to detect water quality changes associated with construction activities such as underwater blasting and the excavated rock emplacement, and will be updated with such details as the commencement of these activities draws closer and detailed design is known.

3.2.1.1. Receiving waters

The receiving water monitoring sites include the sites from EPL 21266 and a new site, but may be subject to change once finer details of on-site water management for Main Works activities are known. Related to this, monitoring sites will be added at a later date to monitor specific in-reservoir works such as sub-aqueous rock emplacement, and underwater blasting.

Receiving water monitoring site descriptions are provided in Table 3-3 and shown in Figure 3-1.

Table 3-3: Receiving water monitoring site details, Talbingo Reservoir

Site ID [1]	Previous site ID	Site Description	Site type and purpose	Sampling details		Comments
				Frequency/ Event type	Analysis suite	
10	RW_6	Talbingo Reservoir upstream of treated process water / wastewater discharge outlet, and site works for water intake and barge launch area	EPL site. Control site for treated process water / wastewater discharge outlet and site works for water intake and barge launch area Impact site for construction works upstream in Yarrangobilly River	Monthly	Comprehensive	To be sampled below the surface of the reservoir away from the land edge. *This site may need to be relocated further upstream if it is too close site works in this area.*
11	RW_7	Talbingo Reservoir downstream of treated process water / wastewater discharge outlet, and site works for water intake and barge launch area	EPL site. Impact site for treated process water / wastewater discharge outlet and site works for water intake and barge launch area	Monthly	Comprehensive	To be sampled below the surface of the reservoir away from the land edge. *This site may need to be relocated if it is too close to the construction works for the water intake and associated infrastructure.*
TBC [2]	TAL_19	Southern end of the reservoir, Yarrangobilly River inlet, upstream of main rock emplacement area	TARP site. Investigation site for determining downstream extent of impact if exceedance at Site 11	TARP-1 [3]	Comprehensive	To be sampled below the surface of the reservoir away from the land edge.

Note 1. *Wherever possible, the Site ID for EPL sites corresponds to the EPL 21266 site number. These may be subject to change due to variations to the EPL.*
2. *TBC: Site ID to be confirmed.*
3. *TARP-1 monitoring initiated in response to WQO exceedances at Site 11.*

3.2.1.2. Discharge waters

Treated wastewater and process water

The site description for the Talbingo Reservoir wastewater and process water treatment plants combined discharge water (pre-discharge) is provided in Table 3-4. The sampling details relate to post-commissioning operation of the treatment plants. In total, there will be multiple wastewater treatment plants and two process water treatment plants for which treated water will be discharged via the Talbingo treated water outfall. During commissioning, water quality analysis will be undertaken for the combined treated water stream to verify that the discharge characteristics are met.

A discrete verification monitoring program will be undertaken following commissioning of the Talbingo treated wastewater and process water discharge outlet. The purpose of this program will be to validate the modelled mizing zone estimates from the mixing zone assessment (Attachment F of the revised Water Management Report in EMM 2020). Further details are provided in section 4.2.1.

Table 3-4: Treated wastewater and process water discharge monitoring site details for Talbingo Reservoir treatment plants[1]

Site ID [2]	Previous site ID	Site Description	Site type and purpose	Sampling details		Comments
				Frequency/ Event type	Analysis suite	
TBC [3]	-	Proposed licensed point for combined streams from Talbingo Reservoir Process Water and Wastewater Treatment plants	EPL site. To verify and monitor water quality characteristics of treated water discharge.	Daily Monthly	Basic Comprehensive	

Note
1. *See section 4.2.1 for details of verification monitoring program sites.*
2. *Wherever possible, the Site ID for EPL sites corresponds to the EPL 21266 site number. These may be subject to change due to variations to the EPL.*
3. *TBC: Site ID to be confirmed with EPA and to align with EPL.*

Stormwater

Stormwater discharge monitoring sites associated with sediment basins will be identified once sediment basin location has been finalised. Once constructed, sediment basins will be subject to monitoring in accordance with TARP-2 (see Section 6).

3.2.2. Lobs Hole

Monitoring in Lobs Hole is for the purpose of water quality change detection associated with various construction activities occurring along the Yarrangobilly River (e.g. portal pad, accommodation camp, temporary rock stockpiles, rock emplacement areas, access roads). Where necessary, monitoring sites are included in tributaries of Yarrangobilly River. For the Yarrangobilly River, the key water quality issue is that of stormwater discharges from sediment basins. Apart from the permanent stream gauge at Yarrangobilly Caves, streamflow will not be monitored in the Yarrangobilly River as the RTS found that no streamflow impacts were predicted to occur as a result of Main Works activities (see Appendices I and J of EMM 2020).

3.2.2.1. Receiving waters

Receiving water monitoring sites are based on the sites specified in EPL 21266, but have been rationalised as described in Attachment C. They may be subject to further change once finer details of on-site water management for Main Works activities are known. The site rationalisation was based on a number of factors, including duplication, proximity to key Main Works features and efficiency (e.g. sampling some tributary sites as part of TARP investigations only).

Receiving water monitoring site descriptions are provided in Table 3-5 and shown in Figure 3-2. Whilst the current upstream-most site, EPL-5, is upstream, of all Exploratory Works activities, it will not be upstream of all Main Works activities, due to potential stormwater runoff from Marica entering Yarrangobilly River upstream of this site. Consequently, a new site may be needed; however, the feasibility of this needs to consider access and safety issues.

3.2.2.2. Discharge waters

Stormwater discharge monitoring sites associated with sediment basins will be identified once sediment basin location has been finalised. Once constructed, sediment basins will be subject to monitoring in accordance with TARP-2 (see Section 6).

Table 3-5: Receiving water monitoring site details, Lobs Hole

Site ID [1]	Previous site ID	Site Description	Site type and purpose	Sampling details	
				Frequency/ Event type[2]	Analysis suite
Weather station					
Rainfall gauge	n/a	Lobs Hole		Continuous	Record date, time, weather conditions, location, rainfall volume.
Yarrangonilly River and tributiaries					
5	RW_1	Upstream of Portal Pad disturbance area	EPL site. Control/reference site for construction activities in Lobs Hole. Also acts as a TARP site for determining upstream receiving water quality in event of sediment basin over-topping.	Monthly TARP-2	Comprehensive Comprehensive
6	RW_2	Wallaces Creek, upstream of the confluence with Yarrangobilly River	EPL site. Impact site for construction activities in Lobs Hole. Also acts as a TARP site for determining receiving water quality in event of sediment basin over-topping.	Monthly TARP-2	Comprehensive Comprehensive
7	RW_3	Wallaces Creek, downstream of Stable Creek confluence	TARP site. Investigation site for determining source of exceedance at Site 6	TARP-1	Comprehensive
8	RW_4	Yarrangobilly River, downstream of Eastern Emplacement stockpile disturbance area	EPL site. Impact site for construction activities in Lobs Hole. Also acts as a TARP site for determining receiving water quality in event of sediment basin over-topping.	Monthly TARP-2	Comprehensive Comprehensive
9	RW_5	Yarrangobilly River, downstream of Accommodation Camp disturbance area	EPL site. Impact site for construction activities in Lobs Hole. Also acts as a TARP site for determining receiving water quality in event of sediment basin over-topping.	Monthly TARP-2	Comprehensive Comprehensive
12	RW_8	Downstream of Portal Pad disturbance area and sedimentation basin discharge	EPL site. Impact site for construction activities in Lobs Hole. Also acts as a TARP site for determining receiving water quality in event of sediment basin over-topping.	Monthly TARP-2	Comprehensive Comprehensive
13	RW_9	Yarrangobilly River tributary, downstream of the Accommodation camp and new road	TARP site. Investigation site for determining source of exceedance at Site 9.	TARP-1	Comprehensive

Site ID [1]	Previous site ID	Site Description	Site type and purpose	Sampling details	
				Frequency/ Event type[2]	Analysis suite
14	RW_10	Yarrangobilly River, downstream of Roads Construction area	EPL site. Impact site for construction activities in Lobs Hole. Also acts as a TARP site for determining receiving water quality in event of sediment basin over-topping.	Monthly TARP-2	Comprehensive Comprehensive
15	RW_11	Adjacent to remnant mine workings	EPL site. Impact site for construction activities in Lobs Hole. Also acts as a TARP site	Monthly TARP-1	Comprehensive Comprehensive
16	RW_12	Yarrangobilly River, upstream Accommodation Camp and downstream of Western Emplacement Stockpile disturbance area at Camp Bridge	EPL site. Impact site for construction activities in Lobs Hole. Also acts as a TARP site for determining receiving water quality in event of sediment basin over-topping.	Monthly TARP-2	Comprehensive Comprehensive
17	RW_13	Lick Hole Gully, upstream of Eastern Emplacement stockpile disturbance area	TARP site. Investigation site for determining source of exceedance at Site 18.	TARP-1	Comprehensive
18	RW_14	Lick Hole Gully, downstream of Eastern Emplacement stockpile disturbance area	TARP site. Investigation site for determining source of exceedance at Site 8.	TARP-1	Comprehensive
22	RW-18	Watercourse 3, upstream of Accommodation Camp disturbance area	TARP site. Investigation site for determining source of exceedance at Site 13.	TARP-1	Comprehensive

Note 1. Wherever possible, the Site ID for EPL: sites corresponds to the EPL 21266 site number. These may be subject to change due to variations to the EPL.

2. If TARP-2 monitoring is required, it will occur only at sites immediately upstream and downstream of relevant stormwater discharges associated with Main Works construction areas (see section 2.2.2).

3.2.3. Marica

Monitoring at Marica is for the purpose of water quality change detection associated with various construction activities occurring along the Marica trail (e.g. accommodation camp, temporary rock stockpiles). The key water quality issue is that of stormwater runoff from disturbed areas.

3.2.3.1. Receiving waters

Apart from the Eucumbene River to the east there are no permanent watercourses along the Marica trail, with the area characterised by undefined ephemeral drainage lines that feed into Yarrangobilly River or Highground Creek to the north and Stable Creek to the south. Consequently, it is not possible to identify receiving water monitoring sites for the majority of the area. However, the eastern-most temporary rock stockpile on the Marica Trail drains into the Eucumbene River on the Plateau. Consequently, sites on the Eucumbene River have been selected to detect any water quality impacts associated with runoff from this structure.

Receiving water monitoring site descriptions are provided in Table 3-6 and shown in Figure 3-3.

Table 3-6 Receiving water monitoring site details, Marica

Site ID	Previous site ID	Site Description	Site type and purpose	Sampling details		Comments
				Frequency/ Event type[2]	Analysis suite	
TBC [1]	PL_SW_006	Eucumbene River upstream of Snowy Mountains Highway and drainage line from large temporary stockpile	EPL site. Control/reference site for drainage from large temporary stockpile. Also acts as a TARP site for determining upstream receiving water quality in event of sediment basin over-topping.	Monthly TARP-2	Comprehensive Comprehensive	
TBC	PL_SW_003	Eucumbene River at Snowy Mountains Highway, downstream of drainage line from large temporary stockpile	EPL site. Impact site for drainage from large temporary stockpile. Also acts as a TARP site for determining receiving water quality in event of sediment basin over-topping.	Monthly TARP-2	Comprehensive	

Note 1. TBC: Site ID to be confirmed with EPA and to align with EPL.
2. If TARP-2 monitoring is required, it will occur only at sites immediately upstream and downstream of relevant stormwater discharges associated with Main Works construction areas (see section 2.2.2).

3.2.3.2. Discharge waters

The terrain is typically too steep to enable the use of sediment basins as the primary control, so stormwater runoff from disturbed areas will be controlled primarily via structures such as swale drains, berms, check dams and sediment traps. Sediment basins may be installed in some areas (e.g. accommodation camp, rock stockpiles) subject to the detailed design process and erosion and sediment control plan.

Water quality monitoring at Marica will be in accordance with with TARP-2 (see Section 6), but will also focus on opportunistic basic monitoring of wet weather runoff waters in swale drains, check dams, sediment basins (if present) and drainage lines.

3.2.4. Plateau

Monitoring on the Plateau is primarily for the purpose of water quality and/or streamflow change detection associated with potential drawdown of groundwater due to tunnelling and associated activities that could affect water quality (e.g. access roads, communications table – see below).

3.2.4.1. Receiving waters

The groundwater modelling for the Main Works RTS predicted that any baseflow impacts on Gooandra Creek and Eucumbene River on the Plateau will not occur for 4-5 years. As there is a long lead time before any impacts are predicted to streamflow and that it is likely that these impacts will be indiscernible in the observed data considering the interannual variability in flow, the need and location for streamflow monitoring sites will be reviewed based on additional groundwater monitoring data (refer Section 1.4).

Monitoring of water quality at perennial watercourse crossings during the laying of the communications cable from the Snowy Mountains Highway to Tantangara Reservoir, and any significant works to access roads, will be undertaken as necessary as the works progress. Temporary monitoring sites will be established upstream and downstream of the works for approximately four weeks before, during and four weeks after works within the vicinity of a watercourse. For this period, basic water quality suite will be measured weekly and/or after significant rainfall events in the catchments.

3.2.4.2. Discharge waters

As there will be little surface works on the Plateau apart from the communications cable, sediment basins to manage stormwater will not be required and, hence, no stormwater discharge monitoring is proposed.

3.2.5. Tantangara Reservoir

Monitoring at Tantangara Reservoir is primarily related to water quality change detection associated with various construction activities occurring along the shoreline and in the reservoir (e.g. accommodation camp, portal, barge launch area, access roads, Tantangara intake, rock emplacement area). The key water quality issues are stormwater discharges, treated wastewater and process water discharge, runoff and seepage from the excavated rock emplacement area, and disturbances from in-reservoir blasting. In addition, there are potential surface water quality and streamflow impacts in the area to the immediate west of the reservoir as a result of potential drawdown of groundwater due to tunnelling and associated activities. The present version of the monitoring program does not include details of monitoring to detect water quality changes associated with construction activities such asunderwater blasting and the excavated rock emplacement, and will be updated with such details as the commencement of these activities draws closer and detailed design is known.

3.2.5.1. Receiving waters

The receiving water monitoring sites include a combination of sites from previous baseline monitoring programs and new sites, but may be subject to change once finer details of on-site water management for Main Works activities are known; for example, once the exact location of the treated process water and wastewater discharge outfall is known. Monitoring sites will be added to monitor specific in-reservoir works such as dredging, blasting and borehole drilling.

Receiving water monitoring site descriptions are provided in Table 3-7 and shown in Figure 3-4

Table 3-7 Receiving water monitoring site details, Tantangara Reservoir

Site ID	Previous site ID	Site Description	Site type and purpose	Sampling details		Comments
				Frequency/ Event type	Analysis suite	
TBC[1]	TAN_09	Middle portion of the reservoir, upstream of rock emplacement area	EPL site. Control/reference site for construction works at Tantangara Reservoir.	Monthly	Comprehensive	Upstream baseline site.
TBC	TAN_01	Southern end of reservoir, adjacent to dam wall	EPL site. Impact site for construction works at Tantangara Reservoir.	Monthly	Comprehensive	
TBC	TanS_SW_002	Murrumbidgee River, at bridge crossing ~1.2 km downstream of Tantangara dam	TARP site. Investigation site for determining downstream extent of exceedance at Site TAN_01.	TARP-1	Comprehensive	TARP site in the event of an exceedance at TAN_01 coinciding with water release at the dam wall.

Site ID	Previous site ID	Site Description	Site type and purpose	Sampling details		Comments
				Frequency/ Event type	Analysis suite	
TBC	Tan_SW_001	Kelly Plains Creek downstream of accommodation camp and laydown area	EPL site. Impact site for construction works at Tantangara Reservoir	Monthly	Comprehensive	
TBC	New site 2	Kellys Plain Creek, upstream of accommodation camp and laydown area	EPL site. Control/reference site for construction works at Tantangara Reservoir.	Monthly	Comprehensive	Upstream baseline site.

Note 1. TBC: Site ID to be confirmed with EPA and to align with EPL where relevant.

3.2.5.2. Discharge waters

Treated wastewater and process water

The site description for the Tantangara Reservoir wastewater and process water treatment plants combined discharge water is provided in Table 3-8. The sampling details relate to post-commissioning operation of the treatment plants. In total, there will be multiple wastewater treatment plant and one process water treatment plant for which treated water will be discharged via the Talbingo trated water outfall. During commissioning, water quality analysis will be undertaken for the combined treated water stream to verify that the discharge characteristics are met.

A discrete verification monitoring program will be undertaken following commissioning of the Tantangara treated wastewater and process water discharge outlet. The purpose of this program will be to validate the modelled mizing zone estimates from the mixing zone assessment (Attachment F of the revised Water Management Report in EMM 2020). Further details are provided in section 4.2.1.

Table 3-8: Treated wastewater and process water discharge monitoring site details for Tantangara Reservoir treatment plants[1]

Site ID	Previous site ID	Site Description	Site type and purpose	Sampling details		Comments
				Frequency/ Event type	Analysis suite	
TBC [2]	-	Proposed licensed point for combined streams from Tantangara Reservoir Process Water and Wastewater Treatment plants	EPL site. To verify and monitor water quality characteristics of treated water discharge.	Daily Monthly	Basic Comprehensive	

Note 1. See section 4.2.1 for details of verification monitoring program sites.
2. TBC: Site ID to be confirmed with EPA and to align with EPL.

Stormwater

Stormwater discharge monitoring sites associated with sediment basins will be identified once sediment basin location has been finalised. Once constructed, sediment basins will be subject to monitoring in accordance with TARP-2 (see Section 6).

3.2.6. Rock Forest

Monitoring at Rock Forest is related to water quality change detection associated with the rock emplacement area and logistics laydown area. The key water quality issue is stormwater runoff from these areas.

3.2.6.1. Receiving waters

Receiving water monitoring sites have been tentatively identified but may be subject to change once finer details of on-site water management are known. For example, additional monthly or TARP monitoring sites may need to be added to assess and identify the source of water quality changes.

Receiving water monitoring site descriptions are provided in Table 3-9 and shown in Figure 3-5.

3.2.6.2. Discharge waters

Stormwater discharge monitoring sites associated with sediment basins will be identified once sediment basin location has been finalised. Once constructed, sediment basins will be subject to monitoring in accordance with TARP-2 (see Section 6).

Table 3-9 Monitoring site details, Rock Forest

Site ID	Previous site ID	Site Description	Site type and purpose	Sampling details	
				Frequency/ Event type	Analysis suite
TBC [1]	New	Camerons Creek, upstream of Rock Forest	EPL site. Control/reference site (i.e. upstream baseline site) for drainage from rock emplacement area. Also acts as a TARP site for determining upstream receiving water quality in event of sediment basin over-topping.	Monthly TARP-2	Comprehensive Comprehensive
TBC	New	Camerons Creek, downstream of rock emplacement area, laydown area and small tributary with dam	EPL site. Impact site for drainage from rock emplacement area. Also acts as a TARP site for determining receiving water quality in event of sediment basin over-topping.	Monthly TARP-2	Comprehensive Comprehensive

Note 1. TBC: Site ID to be confirmed with EPA and to align with EPL.

3.2.7. Other works

Other works include the southern communications cable and roadworks along Lobs Hole-Ravine Road. Monitoring of water quality at perennial watercourse crossings during roadworks and the laying of the southern communications cable from the Snowy Mountains Highway to Tantangara Reservoir, will be undertaken as necessary as the works progress. Temporary monitoring sites will be established upstream and downstream of the works for approximately four weeks before, during and four weeks after works within the vicinity of a watercourse. For this period, the basic water quality suite will be measured weekly and/or after significant rainfall events in the catchments.

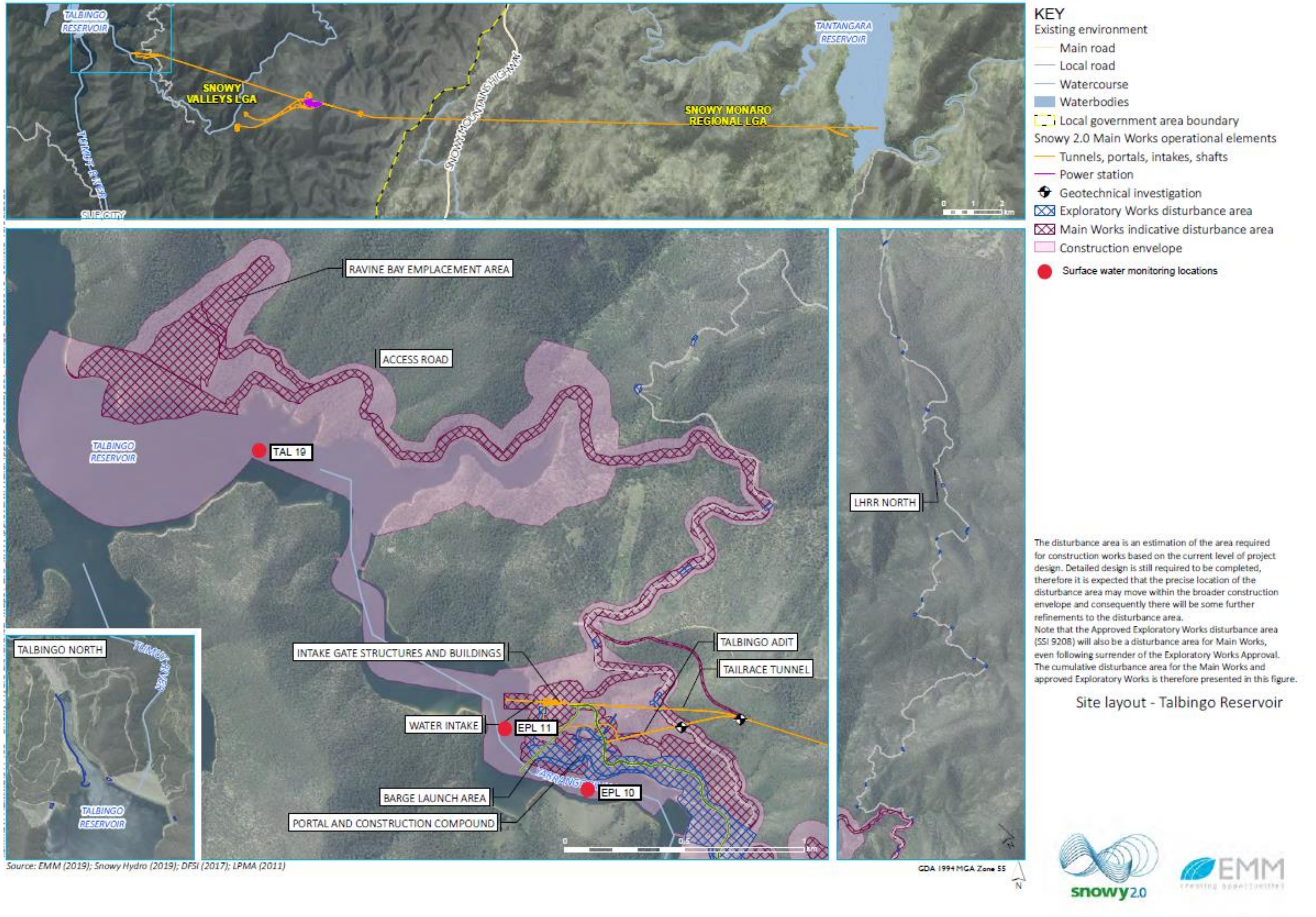

Figure 3-1: Surface water monitoring sites for Talbingo Reservoir

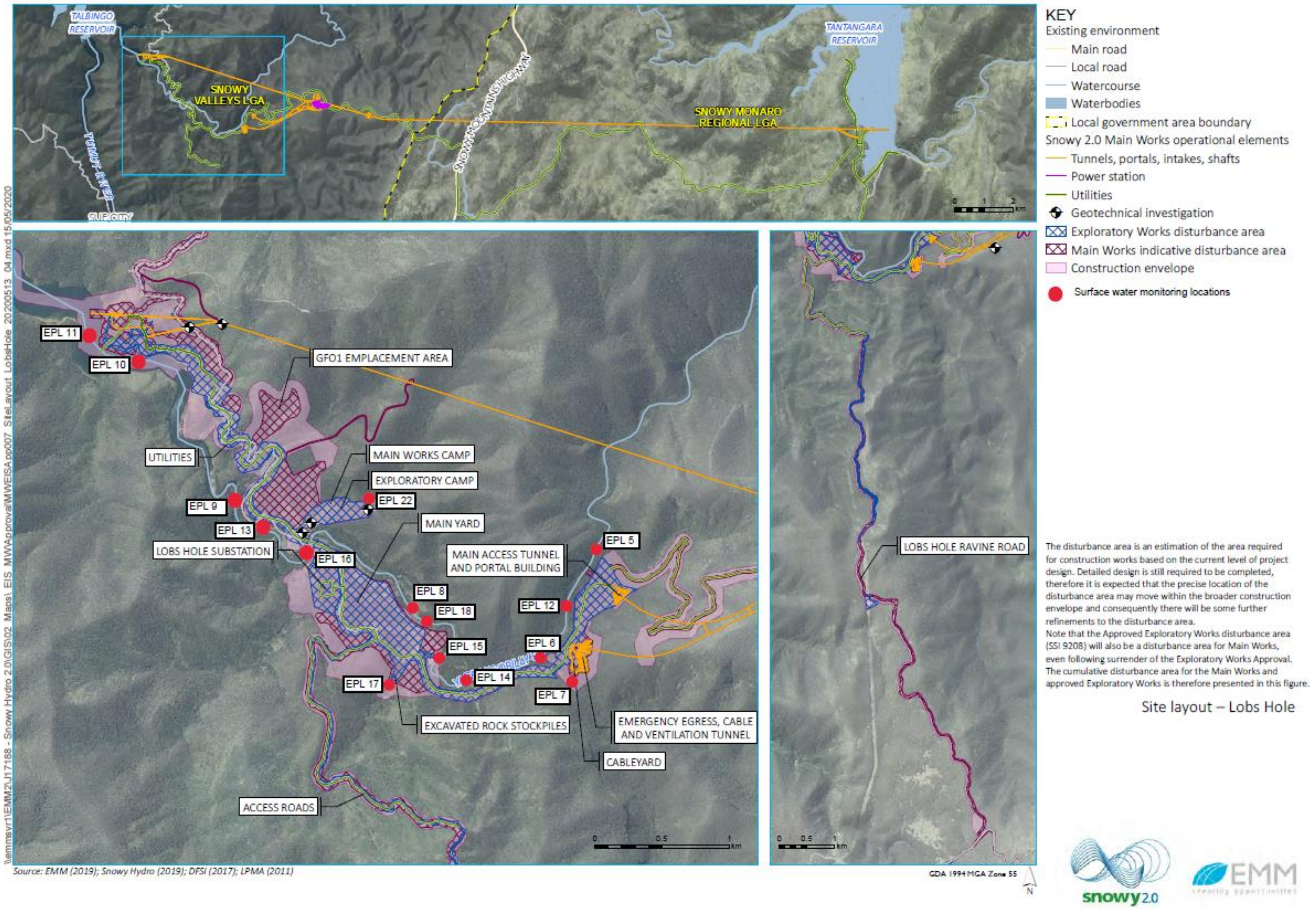

Figure 3-2: Surface water monitoring sites for Lobs Hole

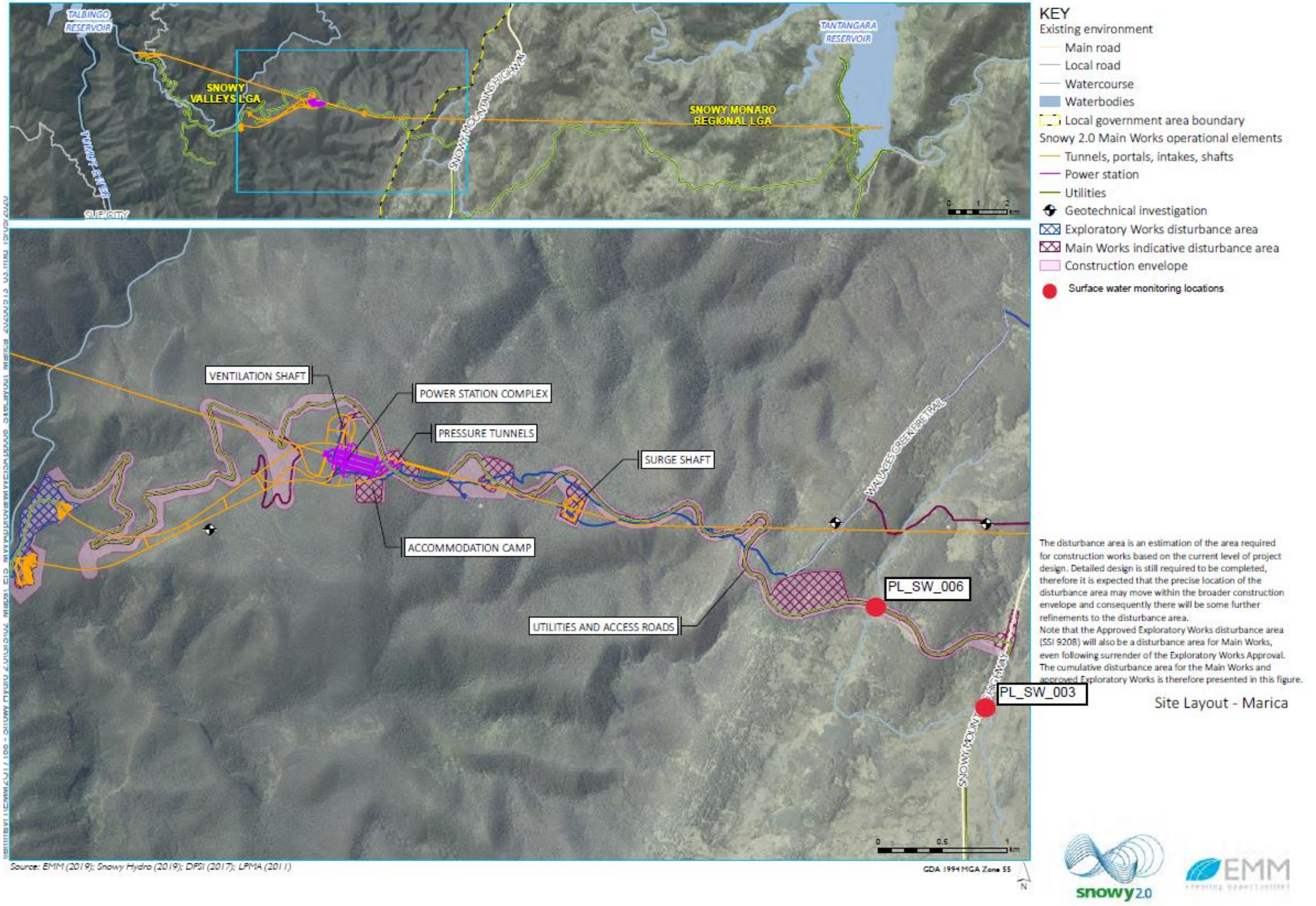

Figure 3-3: Surface water monitoring sites for Marica

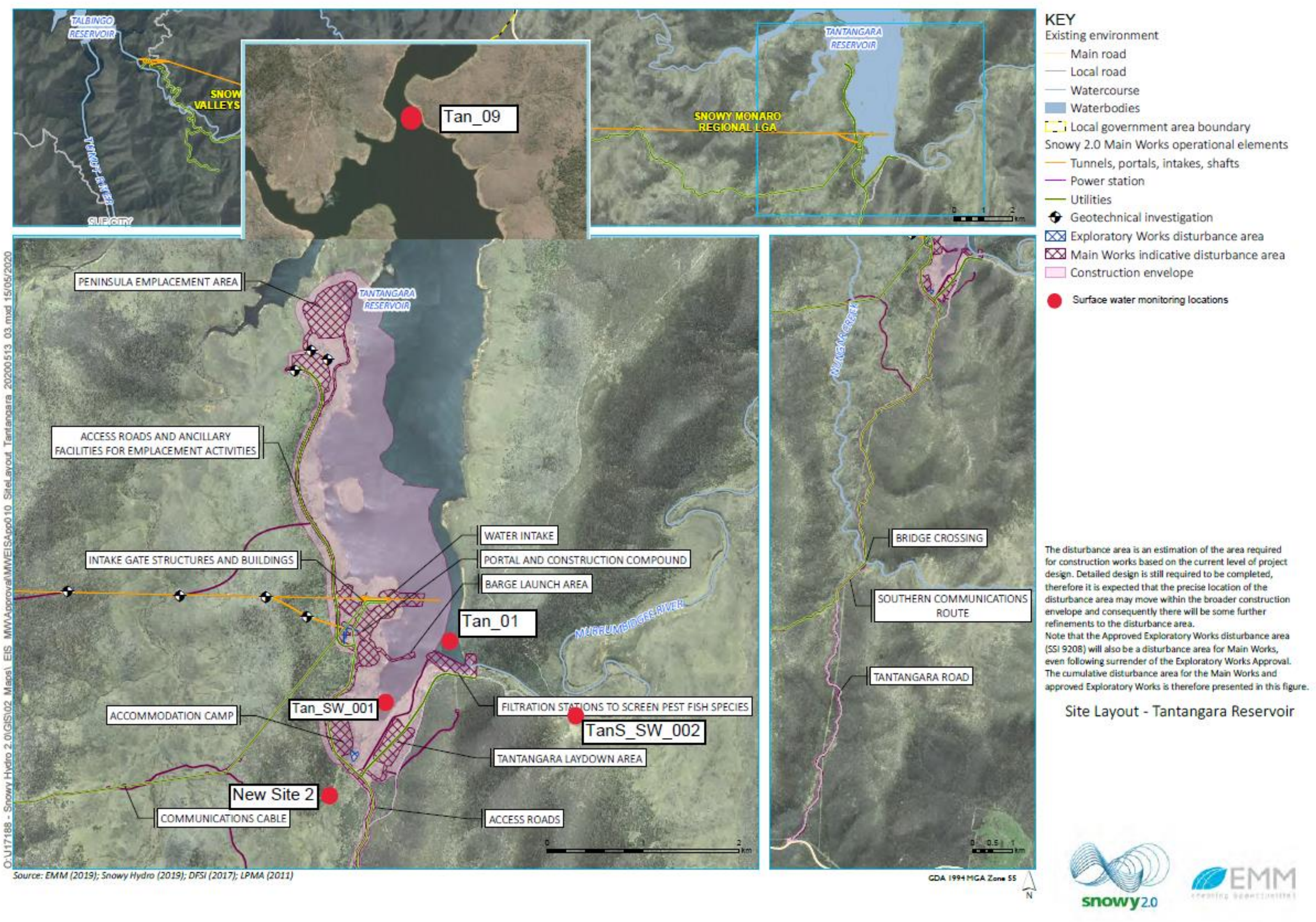

Figure 3-4: Surface water monitoring sites for Tantangara Reservoir

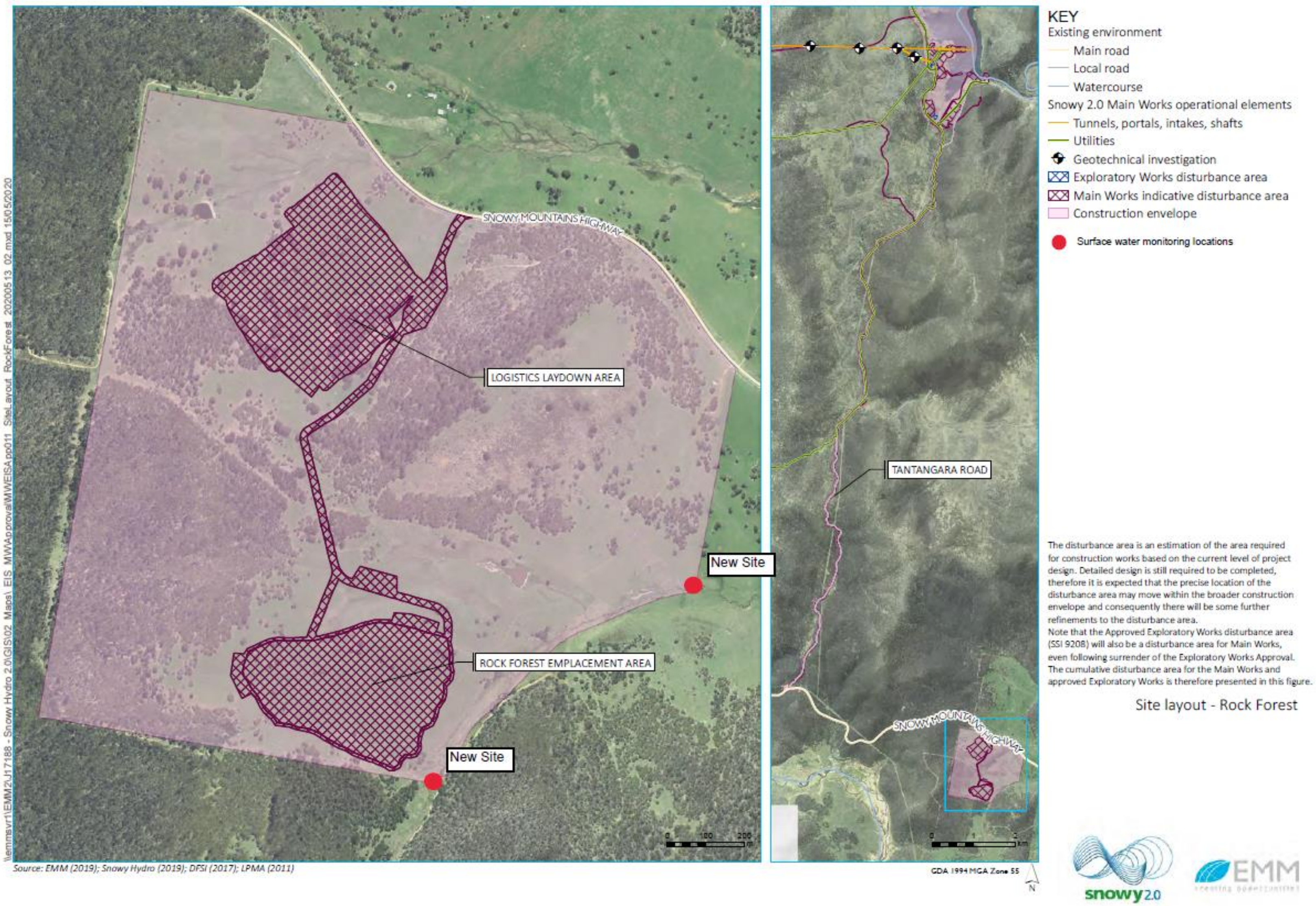

Figure 3-5: Surface water monitoring sites for Rock Forest

4. ASSESSMENT OF WATER QUALITY

Assessment of relevant performance criteria for discharges (from sediment basins and process water and wastewater treatment plants) and receiving water sites are described below. Reporting of water quality data, analyses and TARPS will be in accordance with EPL21266.

4.1. Receiving waters

Receiving water monitoring results will be compared with the relevant WQOs as presented in Table 2-2:. Exceedances of WQOs at receiving water sites that are located downstream of any Main Works activities will trigger TARP-1 (see Section 6). The results of the comparisons and any associated TARPS will be reported to EPA as part of standard reporting, and will be used to better understand and refine the water management approach, as necessary.

As noted in Section 2.1, it may not be not possible at this stage to derive SSTVs using baseline water quality data due to the impact on water quality of the January 2020 bushfire, although the need for and ability to derive SSTVs will continue to be reviewed during Main Works construction activities. In needing to continue to use default WQOs, it is known that the baseline water quality data collected to date (Attachment B) has shown that natural background concentrations of several analytes exceed their default WQOs either on a frequent or occasional basis. The baseline dataset, which can be considered to include the data collected during the Exploratory Works phase prior to significant rainfall events in February 2020 (given the water quality during Exploratory Works had, to this point, not differed to that collected prior to the commencement of Exploratory Works), has been predominatly collected during baseflow conditions, however, there are an increasing amount of data for wet weather conditions.

During wet weather conditions, streams flows will predominantly comprise surface water runoff (rather than groundwater fed base flow) and may have different water chemistry. As sediment-laden runoff from existing access tracks and other disturbed areas (non-construction related) is known to occur in Lobs Hole and will also occur in other Main Works construction areas, it is likely that turbidity levels may exceed WQOs in some minor watercourses and potentially the Yarrangobilly River. Also, elevated concentrations of phosphorus and some metals can be associated with sediment-laden runoff and may, therefore, also exceed WQOs. Hence, regular exceedances of some analytes are expected to occur due to natural or non-anthropogenic catchment processes that are not associated with Main Works.

4.2. Discharge waters

Monitoring of combined treated wastewater and process water streams prior to discharge will be compared with the discharge characteristics presented in Table 2-3. Also, the combined discharge water quality data will be able to be compared with water quality monitoring data collected as part of the operation of the individual water treatment plants. This comparison would form part of a TARP for the combined treated wastewater and process water discharge, to inform the source of any exceedances of the combined discharge characterisatics.

Monitoring of stormwater discharges from non-licenced discharge points (typically, sediment basins) will be in accordance with TARP-2 (see Section 6). The results of the comparisons and any associated TARPS will be reported to EPA as part of standard reporting, and will be used to better understand and refine the water management approach, as necessary. The discharge water quality data may also be used for receiving water TARP-1 investigations, to help identify sources of WQO exceedances.

4.2.1. Verification monitoring program for treated wastewater and process water discharge

Verification monitoring programs will be undertaken for the treated wastewater and process water discharge points in both Talbingo and Tantangara reservoirs in accordance with the EPL. The purpose of these programs will be to validate the modelled mizing zone estimates from the mixing zone assessment (Attachment F of the revised Water Management Report in EMM 2020). The mixing zone assessment found that dilutions to meet target water quality were generally achieved within 10s of metres of the outfall, but that for some ambient conditions, the mixing zone could be between 50 and 100 m.

The verification monitoring program will commence approximately 2 weeks prior to the discharge of treated water to the reservoirs, and will consist of weekly sampling for 6 weeks (i.e. 2 weeks pre-discharge, 4 weeks post-discharge) followed by monthly sampling for a further period of 11 months, for a combined duration of one year. Each time an additional treatment plant is commissioned and connected to the trunk services mains outfall, an additional set of weekly sampling for 2 weeks will be undertaken (unless the period coincides with a monthly sampling period, in which case only one additional weekly sampling event will be undertaken). All samples will be subject to comprehensive analysis. The monitoring results will be compared with the modelling predictions based on the relevant environmental and discharge conditions (i.e. reservoir level and flow rate, degree of stratification, and treated effluent composition and discharge rate). The initial 4x weekly and subsequent 2x weekly sampling frequencies will provide assurances that the outfall is consistently meeting WQOs within the modelled mixing zone (i.e. typically <10 m but depending on conditions, up to 100 m) shortly after commencement of discharge or addition of another treatment plant. The monthly sampling over 11 months will enable further validation of the modelling at a range of environmental conditions, such as winds, reservoir water level, flow rate and stratification.

Verification monitoring sites will be established at 10 m, 50 m and 100 m downstream of the outfalls in both Talbingo and Tantangara reservoirs. A control site at approximately 50–100 m upstream of each of the outfalls will also be established (i.e. 4 verification monitoring sites per outfall). Final site locations will be determined once the exact locations of the outfalls are known.

The number of sites and frequency of sampling may be revised depending on results. For example, if monitoring under worst case conditions demonstrates that acceptable dilution is achieved within 10 m, it may be appropriate to remove one or both of the 50 m and 100 m sites. Additionally, if monitoring over a period less than the proposed one year covers the necessary range of environmental conditions and verifies the modelling predictions, it may be appropriate to reduce the frequency or duration of the program.

Any changes to the details of the verification monitoring program in the EPL will be reflected in subsequent updates to the Surface Water Management Plan.

5. REVIEW AND RESPONSE

Monitoring will be undertaken using a combination of methods and will require varying levels of processing and review before it can be used to inform assessment and decision making. Monitoring data collected in situ (i.e. via portable field meters) are generally available same day, enabling rapid responses to identified exceedances. Monitoring data from samples sent for laboratory analysis are generally available within two weeks of sampling and, hence, such data are unable to be used to inform rapid responses. However, the data from laboratory analyses can be used to inform a detailed understanding of water quality impacts and impact mechanisms, which can then be applied to establish targeted improvements to the water management system.

As discussed in Section 2.1, baseline monitoring to date has only characterised water quality during baseflow and after, but not during, wet weather events. There is also potential for exceedances of additional analytes during wet weather conditions. Hence, regular exceedances of some analytes are expected to occur due to natural catchment processes that are not associated with Main Works. Subsequently, TARPs have been developed to investigate and identify the source of each exceedance and, if necessary, establish actions to either improve water management or further investigate the exceedance (see section 6).

The water quality monitoring program will be periodically reviewed. It is noted that additional or varied/reduced monitoring sites, frequencies and analytes may be warranted following detailed design and during construction as risk requires or where it can be demonstrated that negligible risk remains. Changes to the frequencies, parameters and development of SSTVs would be approved by Snowy Hydro prior to amendment and updated in subsequent revisions of the water quality monitoring program and SWMP. Snowy Hydro will refer any such changes to the regulator.

Additional requirements and responsibilities in relation to inspections are documented in Section 8 of the EMS.

6. TRIGGER ACTION RESPONSE PLANS

Trigger Action Response Plans (TARPs) have been developed to enable appropriate investigations and management responses to WQO exceedances. They detail a standardised response procedure in the event that a WQOs is exceeded during a monitoring event for surface water quality monitoring.

TARPs have been developed for the following situations:

- TARP-1: monthly routine monitoring identifies receveiving water quality exceedance against the relevant WQOs (Table 2-2); and
- TARP-2: if stormwater controls (i.e. sediment basins) overtop. Stormwater controls be will be bench-marked against predicted stormwater discharge characteristics (Table 2-4) and the relevant WQOs (Table 2-2)

The TARP processes are described in more detail in the Section 6.3 of the SWMP (Section 6.3), while all TARPs are provided in Annexure B of the SWMP.

7. REPORTING

Future Generation will report to Snowy Hydro and other agencies on surface water management aspects related to the Project. During construction, surface water monitoring data will be collected, tabulated and assessed against thresholds. Reporting will occur in accordance with Section 6.7 of the SWMP.

8. REFERENCES

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ATTACHMENT A – OVERVIEW OF THE IMPACTS OF BUSHFIRES ON WATER QUALITY

Overview of the impacts of bushfires on water quality

Background

Severe bushfires in the Kosciuszko National Park in January 2020 prompted the Proponent of the Snowy 2.0 Project, Snowy Hydro Limited (SHL), and its Contractor, Future Generation Joint Venture (FGJV), to ask how such fires can affect water quality in order to inform water quality management and monitoring programs for the construction delivery of the Snowy 2.0 Project. This attachment provides a brief overview of the impact of high severity/ intensity bushfires on water quality.

Limited albeit informative research on the impact of bushfires on water quality has been undertaken over the past 20+ years. Relatively recent comprehensive reviews on the topic have been undertaken by Smith *et al.* (2011) and Tulau (2015), both of which focused on south-eastern Australia. The summary provided herein draws largely from these reviews. The key issues can be categorised in terms of (i) the factors that contribute to water quality impacts following fire, and (ii) the nature of water quality impacts.

Factors that contribute to water quality impacts following fire

Key factors that contribute to water quality impacts following fire are the fire regime (including severity and intensity) and rainfall. Associated with these are a number of processes can cause water quality impacts following fire. Some key aspects include:

- Fire can affect the quantity and quality of water produced at the catchment scale by the destruction or modification of vegetation, litter and the organic horizons of soils, and by altering certain physical characteristics of the soil that are related to runoff-infiltration characteristics;
- The magnitude and distribution of rainfall soon after fire, and before vegetation cover is re-established, is a key driver of post-fire erosion and water quality impacts;
- As a result of various processes, runoff from land to waterways generally increases post-fire, and can persist for ~2-10 years. The higher the burn severity, the higher the immediate post-fire increase in runoff and stream flows. More severe fires may also induce changes in various physical properties of the soil (e.g. soil structure, porosity and infiltration, water holding capacity) that affect soil erodibility and infiltration-runoff ratios.
- Consistent with the above-mentioned increase in, and timeframe of, increased runoff, erosion rates increase post-fire and generally take up to a decade or more to return to near pre-disturbance conditions. In the medium- to longer-term, and as the vegetation begins to re-grow and establish, the hydrological effects can start to move in the opposite direction, whereby catchment flows are reduced to below pre-fire levels due to high water requirements of the growing vegetation. However, this response may not occur in all landscapes, and will be dependent on numerous biophysical factors, including fire severity/intensity, vegetation type and its response to fire, and the rainfall zone.
- Debris flows, which are a fast-moving mass of unconsolidated, saturated debris, are thought to be a significant contributor to water quality impacts post-fire, particularly in severely burnt, steep upland catchments following high intensity rainfall events.
- Fire can change the levels of chemical constituents in soils and may make some constituents more readily available for transport into waterways. For example, ash represents a concentrated and readily mobilised and transported source of soluble

inorganic material, including nutrients, major ions and trace elements. Ash can represent a significant source of contaminants to waterways, especially in the first-year post-fire.

- Burning of riparian zones can result in increased runoff and associated sediment and contaminant transport into waterways, increased streambank erosion, as well as increased light penetration and associated increased water temperatures of waterways.
- Use of large quantities of fire retardant/suppressant, which typically contains high levels of phosphorus and/or nitrogen, can add an additional nutrient burden to waterways, although this may still be minor relative to that contributed by the burnt catchment.
- In relation to water quality impacts within reservoirs, the extent of post-fire water quality changes will reflect the type and magnitude of pollutant loads entering the reservoir relative to its capacity to attenuate impacts. Some studies have shown significant and prolonged (up to two year) water quality impacts in reservoirs, while others have shown negligible to minor impacts, post-fire.

Nature of water quality impacts

The increased runoff and stream flows experienced post-fire increases the potential for movement of sediment and any associated nutrients and other elements (e.g. major ions, trace elements). Sediment may be derived from increased erosion of hillslopes or scouring of gullies, drainage lines and stream banks. Poor water quality has the potential to affect numerous environmental values (e.g. human consumption, recreation, cultural and spiritual, agriculture, aquatic ecosystems, industrial use), although impacts to aquatic ecosystems are the primary focus of this overview. Key contaminants of concern to waterways post-fire are briefly discussed, below

Suspended sediment

Suspended sediment loads immediately post-fire (i.e. up to one year) are highly variable, and range from just over 1x to more than 1000x higher than pre-fire loads. The magnitude of change is dependent on fire extent and severity, post-fire rainfall patterns, erosion processes, topography, sources of suspended sediment and scale effects. Intense summer storms represent the most significant events of concern for suspended sediment inputs to waterways post-fire. The increases in suspended loads are generally reflected in increased concentrations. Maximum values typically occur briefly, during stormflow events, but elevated levels may persist for longer timescales due to increased erodibility of the landscape as well as increases in stores of sediment within the waterway, which can be remobilised by subsequent flow events. The length of time that such remobilisation and associated water quality impacts can occur depends on the extent of sediment stored in the waterway as well as the pattern of rainfall and associated streamflows. Increased suspended sediment and turbidity can be measurable and prolonged more than 100 km downstream of burnt areas. Sediment will deposit in low flow zones and standing waterbodies such as reservoirs, which can result in smothering effects and altered bathymetry. Suspended sediment (and organic matter) associated with post-fire debris flows may also contribute to reduced dissolved oxygen levels in waterways.

Nutrients

As with suspended sediment, bushfires tend to increase nitrogen and phosphorus inputs to waterways, including reservoirs, with the extent of increase being highly variable, and largely linked to a similar set of factors as for suspended sediment, as well as the vegetation type. The timing of nutrient inputs is also variable, and probably largely linked to rainfall regime and various catchment processes. The key contributing sources of nitrogen and phosphorus to waterways after severe fire are likely to be suspended sediment, ash and dissolved in runoff water. In standing water or low flow environments, including reservoirs, increased nutrient concentrations, combined with potentially higher temperatures, can result in nuisance plant growth, including algal and cyanobacterial (blue-green algae) blooms. Notably, and as with many other chemical constituents, significant amounts of nitrogen, phosphorus and organic matter present in the vegetation and soil may be lost to the atmosphere, via combustion and volatilisation, depending on fire intensity.

There are few Australian data on the effect of bushfires on organic carbon in waterways. The data that exist, as well as data from North America indicate that increases may be observed but are generally minor. Organic carbon inputs to waterways appear to depend on the magnitude and timing of storm events after fire, and may be highest in burnt forest environments susceptible to large increases in overland flow and erosion (e.g. steep terrain). Fire severity is known to affect terrestrial organic carbon levels and, therefore, may also affect aquatic organic carbon levels. Higher severity fires result in volatilisation of most of the organic matter, whereas lower severity fires leave behind significant organic matter (e.g. leaves) that can be washed into waterways and facilitate microbial activity, potentially leading to anoxic conditions with associated consequences (e.g. mobilisation of metals such as manganese and iron, fish kills, effects on macroinvertebrates). However, organic matter can also ameliorate toxicity of metals and, as such, may have a beneficial effect in the waterways.

Trace elements

Trace elements are mobilised following the combustion of organic matter (vegetation, soil organic matter) and heating of soil. The limited information on effects of bushfires on trace elements suggests that metal and metalloid loads and concentrations can be increased post-fire. For the Snowy 2.0 Project, this could mean even higher background concentrations of aluminium and copper (and other metals) in local watercourses and the reservoirs. The legacy copper mining areas may become an even greater source of copper (and other metals) to the waterways given the likely increased erodibility of the soils. However, higher stream discharge due to increased runoff can also dilute the concentration of contaminants if the contaminants are supply limited.

Other contaminants

There are insufficient data on the effects of bushfires on major ions concentrations in waterways. Although some North American data exist, they are from conifer forests and may bear no relevance to native south-east Australian forests. However, it is plausible that salts from soils and vegetation would be mobilised following fire and be transported to waterways.

High severity fires can result in the natural production of pyrogenic compounds such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo-ρ-dioxins and dibenzofurans (PCDD/Fs) and polychlorinated biphenyls (PCBs). Limited data from overseas suggests that such compounds can be elevated post-fire, but return to background levels after relatively short periods (i.e. months). However, there appears to be no data for Australia.

As noted above, fire retardants/suppressants can introduce nutrients and other chemicals into aquatic ecosystems. There are limited data on their significance to post-fire water quality. Boulton et al. (2003) found that the use of fire suppressants could result in short-term increases in nitrogen and phosphorus concentrations, but that this did not result in significant impacts to aquatic macroinvertebrate communities. The impact of fire retardants/suppressants on water quality is likely to be minor relative to the other impacts of bushfires on water quality, but still warrants recognition.

References

Boulton AJ, Moss GL & Smithyman D 2003. Short-term effects of aerially-applied fire-suppressant foams on water chemistry and macroinvertebrate in streams after natural wild-fire on Kangaroo Island, South Australia. *Hydrobiologia* 498, 177-189.

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Tulau MJ 2015. Fire and Soils. A review of the potential impacts of different fire regimes on soil erosion and sedimentation, nutrient and carbon cycling, and impacts on water quantity and quality. State of NSW and Office of Environment and Heritage, Sydney, NSW.

ATTACHMENT B – BASELINE WATER QUALITY DATA AND STREAMFLOW

EMM, 2019. Water Characterisation Report (Annexure A to Water Assessment). Snowy 2.0 Main Works Environmental Impact Statement.

Baseline water quality data

D.1 Departures from water quality objectives

Table D.1 Departures from WQOs – plateau

Watercourse	analyte	Summer/autumn dry weather conditions			Winter/spring dry weather conditions			Wet weather conditions		
		Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances
Murrumbidgee River	Dissolved oxygen	✓		15/14	✓		16/14		No data available	
	pH	✓		18/5		✓	20/3			
	Ammonia		✓	18/2		✓	21/2			
	Oxidised nitrogen	✓		17/9	✓		21/7			
	Total nitrogen	✓		18/4		✓	21/2			
	Total phosphorus		✓	18/1		✓	21/1			
	Aluminium	✓		16/14	✓		21/21			
	Arsenic			16/0		✓	21/1			
	Iron	✓		16/6		✓	21/3			
	Zinc			16/0		✓	21/3			
Eucumbene River	Dissolved oxygen	✓		11/11	✓		13/11		No data available	
	pH		✓	14/1	✓		17/4			
	Ammonia			14/0		✓	18/3			
	Oxidised nitrogen	✓		14/9	✓		18/7			
	Total nitrogen		✓	14/1			18/0			
	Total phosphorus		✓	14/2		✓	18/1			
	Aluminium	✓		14/4	✓		18/5			
	Boron		✓	14/1			18/0			
	Copper		✓	14/1			18/0			

Table D.1 Departures from WQOs – plateau

Watercourse	analyte	Summer/autumn dry weather conditions			Winter/spring dry weather conditions			Wet weather conditions		
		Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances
	Zinc			14/0		✓	18/3			
Tantangara Creek	Dissolved oxygen	✓		11/9	✓		11/10		No data available	
	pH		✓	13/2	✓		15/6			
	Ammonia			13/0	✓		15/5			
	Oxidised nitrogen	✓		13/9	✓		15/5			
	Total nitrogen	✓		13/3			15/0			
	Total phosphorus		✓	13/1		✓	15/2			
	Aluminium	✓		12/10	✓		15/12			
	Boron		✓	12/1			15/0			
	Copper			12/0		✓	15/2			
	Zinc			12/0		✓	15/2			
Gooandra Creek	Dissolved oxygen	✓		5/4	✓		6/5		No data available	
	pH	✓		6/2	✓		8/4			
	Ammonia			6/0	✓		8/2			
	Oxidised nitrogen	✓		5/2	✓		8/3			
	Total nitrogen			6/0		✓	8/1			
	Total phosphorus			6/0		✓	8/1			
	Aluminium	✓		5/1	✓		8/3			
	Chromium (total)	✓		5/1		✓	8/1			

Table D.1 Departures from WQOs – plateau

Watercourse	analyte	Summer/autumn dry weather conditions			Winter/spring dry weather conditions			Wet weather conditions		
		Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances
	Copper			5/0		✓	8/1			
	Zinc	✓		5/1	✓		8/2			
Nungar Creek	Dissolved oxygen	✓		3/3	✓		4/4		No data available	
	pH	✓		4/1		✓	6/1			
	Oxidised nitrogen	✓		4/2		✓	7/1			
	Total nitrogen			4/0		✓	7/1			
	Total phosphorus			4/0		✓	7/1			
	Aluminium	✓		4/3	✓		7/6			
	Copper	✓		4/1			7/0			
	Iron	✓		4/1			7/0			
Kellys Plain Creek	Dissolved oxygen	✓		5/5	✓		6/5	✓		1/1
	pH	✓		6/2		✓	8/1			1/0
	Ammonia			6/0		✓	9/1			1/0
	Oxidised nitrogen	✓		6/5	✓		9/6			1/0
	Total nitrogen		✓	6/1	✓		9/2			1/0
	Total phosphorus		✓	6/1		✓	9/1			1/0
	Aluminium	✓		6/6	✓		9/8	✓		1/1
	Copper		✓	6/1		✓	9/1	✓		1/1
	Iron			6/0		✓	9/1			1/0

Table D.1 Departures from WQOs – plateau

Watercourse	analyte	Summer/autumn dry weather conditions			Winter/spring dry weather conditions			Wet weather conditions		
		Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances
	Zinc			6/0	✓		9/3			1/0
Minor watercourses	Dissolved oxygen	✓		13/13	✓		11/11		No data available	
	pH	✓		17/5	✓		21/7			
	Turbidity		✓	16/2		✓	19/3			
	Ammonia	✓		19/4		✓	25/4			
	Oxidised nitrogen	✓		18/15	✓		25/17			
	Total nitrogen	✓		19/13	✓		25/11			
	Reactive phosphorus		✓	16/1			25/0			
	Total phosphorus	✓		19/14	✓		25/11			
	Aluminium	✓		16/12	✓		25/20			
	Arsenic			16/0		✓	25/2			
	Chromium (total)		✓	16/1			25/0			
	Copper		✓	16/3		✓	25/2			
	Iron	✓		16/7	✓		25/6			
	Zinc			16/0	✓		25/8			

Notes: 1. Exceedances are described as frequent if the WQO value was exceeded in 20% or more of samples.
2. Exceedances are described as occasional if the WQO value was exceeded in at least one sample, but in less than 20% of samples.

Table D.2 Departures from WQOs – ravine

		Summer/autumn dry weather conditions			Winter/spring dry weather conditions			Wet weather conditions		
Watercourse	**analyte**	**Frequent exceedance[1]**	**Occasional exceedance[2]**	**# Samples/ exceedances**	**Frequent exceedance[1]**	**Occasional exceedance[2]**	**# Samples/ exceedances**	**Frequent exceedance[1]**	**Occasional exceedance[2]**	**# Samples/ exceedances**
Yarrangobilly River	Dissolved oxygen	✓		27/22	✓		31/21	✓		5/4
	pH	✓		27/15	✓		31/11	✓		5/1
	Turbidity			23/0			21/0			5/1
	Ammonia		✓	27/2	✓		30/7			5/0
	Oxidised nitrogen	✓		23/14	✓		31/11	✓		5/1
	Total nitrogen		✓	27/1			30/0	✓		5/2
	Reactive phosphorus			20/0		✓	31/1			5/0
	Total phosphorus		✓	27/1		✓	30/1	✓		5/2
	Aluminium	✓		20/5	✓		30/19			5/0
	Chromium (total)		✓	20/1		✓	30/1			5/0
	Copper			20/0		✓	30/2	✓		5/5
	Zinc			20/0	✓		30/7	✓		5/2
Wallaces Creek	Dissolved oxygen	✓		8/7	✓		10/7		No data available	
	pH	✓		9/2		✓	10/1			
	Turbidity			7/0		✓	7/1			
	Ammonia			9/0		✓	10/1			
	Oxidised nitrogen	✓		6/3	✓		10/3			
	Total nitrogen			9/0		✓	10/1			

Table D.2 Departures from WQOs – ravine

Watercourse	analyte	Summer/autumn dry weather conditions			Winter/spring dry weather conditions			Wet weather conditions		
		Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances
	Reactive phosphorus			6/0	✓		10/2			
	Copper		✓	6/1	✓		10/2			
	Zinc		✓	6/1		✓	10/3			
Lick Hole Gully	Dissolved oxygen	✓		1/1	✓		5/5	✓		1/1
	Electrical conductivity	✓		1/1	✓		5/5	✓		1/1
	Turbidity	✓		1/1	✓		3/1			1/0
	Ammonia			1/0	✓		5/2			1/0
	Oxidised nitrogen			1/0	✓		5/2			1/0
	Total nitrogen	✓		1/1			5/0			1/0
	Total phosphorus	✓		1/1	✓		5/1			1/0
	Arsenic			1/0	✓		5/1			1/0
	Copper	✓		1/1	✓		5/5	✓		1/1
	Zinc			1/0	✓		5/1	✓		1/1
Minor watercourses	Dissolved oxygen	✓		3/3	✓		7/7	✓		2/2
	pH	✓		3/1		✓	7/1			2/0
	Ammonia			3/0	✓		7/3			2/0
	Total nitrogen			3/0		✓	7/1	✓		2/2
	Total phosphorus	✓		3/2		✓	7/1	✓		2/1

Table D.2 Departures from WQOs – ravine

Watercourse	analyte	Summer/autumn dry weather conditions			Winter/spring dry weather conditions			Wet weather conditions		
		Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances
	Aluminium			3/0		✓	7/1	✓		2/2
	Arsenic			3/0		✓	7/1			2/0

Notes: 1. Exceedances are described as frequent if the WQO value was exceeded in 20% or more of samples.
2. Exceedances are described as occasional if the WQO value was exceeded in at least one sample, but in less than 20% of samples.

Table D.3 Departures from WQOs – Lobs Hole runoff

Waterbody	analyte	March 2019 Frequent exceedance[1]	March 2019 Occasional exceedance[2]	March 2019 # Samples/ exceedances	May 2019 Frequent exceedance[1]	May 2019 Occasional exceedance[2]	May 2019 # Samples/ exceedances
Runoff	Dissolved oxygen	✓		10/10	✓		8/8
	pH	✓		10/8	✓		8/5
	Turbidity	✓		10/10	✓		8/8
	Ammonia	✓		10/5		✓	8/1
	Oxidised nitrogen	✓		10/8	✓		8/6
	Total nitrogen	✓		10/10	✓		8/8
	Reactive phosphorus	✓		10/3			8/0
	Total phosphorus	✓		10/10	✓		8/8
	Aluminium	✓		10/10	✓		8/8
	Arsenic	✓		10/3	✓		8/2
	Chromium (total)			10/0		✓	8/1
	Cobalt			10/0		✓	8/1
	Copper	✓		10/9	✓		8/4
	Iron	✓		10/4	✓		8/3
	Lead		✓	10/1		✓	8/1
	Zinc	✓		10/2	✓		8/3

Notes: 1. Exceedances are described as frequent if the WQO value was exceeded in 20% or more of samples.
2. Exceedances are described as occasional if the WQO value was exceeded in at least one sample, but in less than 20% of samples.

Table D.4 Departures from WQOs – Rock Forest

Watercourse	analyte	Summer/autumn dry weather conditions			Winter/spring dry weather conditions			Wet weather conditions		
		Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances
Camerons Creek	Dissolved oxygen	✓		2/2	✓		1/1	✓		1/1
	Turbidity	✓		3/1			1/0			1/0
	Ammonia	✓		3/3	✓		1/1			1/0
	Oxidised nitrogen	✓		3/3			1/0			1/0
	Total nitrogen	✓		3/3	✓		1/1	✓		1/1
	Reactive phosphorus	✓		3/1			1/0			1/0
	Total phosphorus	✓		3/3	✓		1/1	✓		1/1
	Aluminium	✓		3/3	✓		1/1	✓		1/1
	Copper	✓		3/1			1/0	✓		1/1
	Iron	✓		3/3			1/0	✓		1/1

Notes: 1. Exceedances are described as frequent if the WQO value was exceeded in 20% or more of samples.
2. Exceedances are described as occasional if the WQO value was exceeded in at least one sample, but in less than 20% of samples.

Table D.5 Departures from WQOs – Talbingo Reservoir

Waterbody	analyte	Summer/autumn dry weather conditions			Winter/spring dry weather conditions		
		Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances
Talbingo Reservoir	Electrical conductivity	✓		23/9	✓		36/11
	pH		✓	23/4	✓		36/14
	Ammonia			23/0	✓		28/20
	Oxidised nitrogen		✓	23/4	✓		28/23
	Total nitrogen			23/0		✓	28/1
	Reactive phosphorus			23/1		✓	28/1
	Total phosphorus	✓		8/8	✓		28/7
	Chromium (total)		✓	23/4			36/0
	Copper	✓		23/10		✓	36/1
	Lead		✓	23/1			36/0
	Zinc	✓		23/12		✓	36/1

Notes: 1. Exceedances are described as frequent if the WQO value was exceeded in 20% or more of samples.
2. Exceedances are described as occasional if the WQO value was exceeded in at least one sample, but in less than 20% of samples.

Table D.6 Departures from WQOs – Tantangara Reservoir

Waterbody	analyte	Summer/autumn dry weather conditions			Winter/spring dry weather conditions		
		Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances	Frequent exceedance[1]	Occasional exceedance[2]	# Samples/ exceedances
Tantangara Reservoir	Dissolved oxygen	✓		8/3			12/0
	pH		✓	23/1		✓	27/1
	Ammonia		✓	22/3			19/0
	Oxidised nitrogen		✓	22/3			19/0
	Total nitrogen		✓	22/3			19/0
	Reactive phosphorus		✓	22/2		✓	19/1
	Total phosphorus	✓		8/8	✓		19/7
	Aluminium	✓		23/8	✓		27/27
	Chromium (total)		✓	23/2			27/0
	Cobalt		✓	23/1			27/0
	Copper	✓		23/15			27/0
	Iron	✓		23/19			27/0
	Lead		✓	23/2			27/0
	Zinc	✓		23/15			27/0

Notes: 1. Exceedances are described as frequent if the WQO value was exceeded in 20% or more of samples.
2. Exceedances are described as occasional if the WQO value was exceeded in at least one sample, but in less than 20% of samples.

D.2 Summary tables

D.2.1 Watercourses

i Plateau

Table D.7 Baseline water quality results summary: Murrumbidgee River (PL_SW_005, PN_SW_002, TanS_SW_002)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	18/0	14.3	17.4	23.1	21/0	5.6	9.2	19.5	-	-	-	-
Dissolved oxygen	%	90-110[1]	15/14	**54**	**75**	**85**	16/14	**13**	**65**	**87**	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	18/0	26	32	36	21/0	14	26	33	-	-	-	-
pH	-	6.5-8.0[1]	18/5	6.7	7.5	**8.3**	20/3	6.6	7.3	**8.0**	-	-	-	-
Oxidising and reducing potential	-	-	18/0	-6	120	155	19/0	40	106	164	-	-	-	-
Turbidity	NTU	2-25[1]	14/0	2.1	3.9	6.5	16/0	1.5	2.6	6.3	-	-	-	-
Analytical results – general														
Suspended solids	mg/L	-	18/0	<5	<5	7	21/0	<5	<5	7	-	-	-	-
Total hardness (as $CaCO_3$)	mg/L	-	16/0	4	9	11	21/0	<1	5	9	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	2/0	15	16	16	-	-	-	-	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	18/2	<0.01	<0.01	**0.02**	21/2	<0.01	<0.01	0.01	-	-	-	-
Oxidised nitrogen	mg/L	0.015	17/9	<0.01	**0.02**	**0.05**	21/7	<0.01	<0.01	**0.03**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	17/0	<0.1	0.1	0.2	21/0	<0.1	0.1	0.2	-	-	-	-
Total nitrogen	mg/L	0.25	18/4	<0.1	0.10	**0.30**	21/2	<0.1	0.1	0.2	-	-	-	-
Reactive phosphorus	mg/L	0.015	16/0	<0.01	<0.01	<0.01	21/0	<0.01	<0.01	<0.01	-	-	-	-
Total phosphorus	mg/L	0.020	18/1	<0.01	<0.01	0.02	21/1	<0.01	<0.01	0.01	-	-	-	-

Table D.7 Baseline water quality results summary: Murrumbidgee River (PL_SW_005, PN_SW_002, TanS_SW_002)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	16/0	2	2	4	20/0	1	2	3	-	-	-	-
Dissolved organic carbon	mg/L	-	16/0	2	2	3	21/0	2	2	5	-	-	-	-
Analytical results – inorganics														
Cyanide	mg/L	0.004	12/0	<0.004	<0.004	<0.004	12/0	<0.004	<0.004	<0.004	-	-	-	-
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	16/14	0.03	**0.05**	**0.10**	21/21	**0.04**	**0.06**	**0.10**	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	16/0	<0.001	<0.001	<0.001	21/1	<0.001	<0.001	<0.001	-	-	-	-
Barium (Ba)	mg/L	-	16/0	0.006	0.008	0.011	21/0	0.005	0.008	0.011	-	-	-	-
Beryllium (Be)	mg/L	-	16/0	<0.001	<0.001	<0.001	21/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.09	16/0	<0.05	<0.05	<0.05	21/0	<0.05	<0.05	<0.05	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	16/0	<0.0001	<0.0001	<0.0001	21/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Total chromium (Cr)	mg/L	0.00001[3,6]	16/0	<0.001	<0.001	<0.001	21/0	<0.001	<0.001	<0.001	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	16/0	<0.001	<0.001	<0.001	21/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)	mg/L	0.001	16/0	<0.001	<0.001	<0.001	21/0	<0.001	<0.001	0.001	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	16/6	0.08	0.13	**0.44**	21/3	0.05	0.12	**0.40**	-	-	-	-
Lead (Pb)	mg/L	0.001	16/0	<0.001	<0.001	<0.001	21/0	<0.001	<0.001	<0.001	-	-	-	-
Manganese (Mn)	mg/L	1.2	16/0	0.002	0.006	0.040	21/0	0.002	0.004	0.026	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	16/0	<0.0001	<0.0001	<0.0001	21/0	<0.0001	<0.0001	<0.0001	-	-	-	-

Table D.7 Baseline water quality results summary: Murrumbidgee River (PL_SW_005, PN_SW_002, TanS_SW_002)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.008	16/0	<0.001	<0.001	<0.001	21/0	<0.001	<0.001	<0.001	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	16/0	<0.01	<0.01	<0.01	21/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	16/0	<0.001	<0.001	<0.001	21/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	16/0	<0.01	<0.01	<0.01	21/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	16/0	<0.005	<0.005	<0.005	21/3	<0.005	<0.005	**0.006**	-	-	-	-

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.8 Baseline water quality results summary: Eucumbene River (PL_SW_003, PL_SW_006, PL_SW_007)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	14/0	9.8	13.3	22.3	18/0	5.4	9.6	13.9	-	-	-	-
Dissolved oxygen	%	90-110[1]	11/11	**69**	**81**	**87**	13/11	**39**	**69**	105	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	14/0	36	38	41	18/0	19	30	37	-	-	-	-
pH	-	6.5-8.0[1]	14/1	6.6	7.3	7.7	17/4	**6.4**	7.4	7.8	-	-	-	-
Oxidising and reducing potential	-	-	14/0	-14	80	116	17/0	63	99	173	-	-	-	-
Turbidity	NTU	2-25[1]	12/0	1.1	1.5	2.5	16/0	1.0	1.5	3.2	-	-	-	-
Analytical results – general														
Suspended solids	mg/L	-	14/0	<5	<5	5	18/0	<5	<5	8	-	-	-	-
Total hardness (as $CaCO_3$)	mg/L	-	14/0	9	12	16	18/0	4	9	12	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-									-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	14/0	<0.01	<0.01	<0.01	18/3	<0.01	<0.01	**0.03**	-	-	-	-
Oxidised nitrogen	mg/L	0.015	14/9	0.01	**0.03**	**0.05**	18/7	<0.01	0.01	**0.05**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	14/0	<0.1	<0.1	<0.1	18/0	<0.1	<0.1	<0.1	-	-	-	-
Total nitrogen	mg/L	0.25	14/1	<0.1	<0.1	<0.1	18/0	<0.1	<0.1	<0.1	-	-	-	-
Reactive phosphorus	mg/L	0.015	14/0	<0.01	<0.01	<0.01	18/0	<0.01	<0.01	<0.01	-	-	-	-
Total phosphorus	mg/L	0.020	14/2	<0.01	<0.01	**0.04**	18/1	<0.01	<0.01	0.01	-	-	-	-

Table D.8 Baseline water quality results summary: Eucumbene River (PL_SW_003, PL_SW_006, PL_SW_007)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	14/0	<1	<1	2	18/0	<1	1	2	-	-	-	-
Dissolved organic carbon	mg/L	-	14/0	<1	1	2	18/0	<1	1	3	-	-	-	-
Analytical results – inorganics														
Cyanide	mg/L	0.004	12/0	<0.004	<0.004	<0.004	12/0	<0.004	<0.004	<0.004	-	-	-	-
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	14/4	0.01	0.02	**0.03**	18/5	0.01	0.02	**0.03**	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	14/0	<0.001	<0.001	<0.001	18/0	<0.001	<0.001	<0.001	-	-	-	-
Barium (Ba)	mg/L	-	14/0	0.002	0.003	0.004	18/0	0.002	0.003	0.008	-	-	-	-
Beryllium (Be)	mg/L	-	14/0	<0.001	<0.001	<0.001	18/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.09	14/1	<0.05	<0.05	<0.05	18/0	<0.05	<0.05	<0.05	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	14/0	<0.0001	<0.0001	<0.0001	18/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Total chromium (Cr)	mg/L	0.00001[3,6]	14/0	<0.001	<0.001	<0.001	18/0	<0.001	<0.001	<0.001	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	14/0	<0.001	<0.001	<0.001	18/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)	mg/L	0.001	14/1	<0.001	<0.001	0.001	18/0	<0.001	<0.001	0.001	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	14/0	<0.05	0.06	0.09	18/0	<0.05	<0.05	0.05	-	-	-	-
Lead (Pb)	mg/L	0.001	14/0	<0.001	<0.001	<0.001	18/0	<0.001	<0.001	<0.001	-	-	-	-
Manganese (Mn)	mg/L	1.2	14/0	0.002	0.004	0.006	18/0	<0.001	0.002	0.004	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	14/0	<0.0001	<0.0001	<0.0001	18/0	<0.0001	<0.0001	<0.0001	-	-	-	-

Table D.8 Baseline water quality results summary: Eucumbene River (PL_SW_003, PL_SW_006, PL_SW_007)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.008	14/0	<0.001	<0.001	<0.001	18/0	<0.001	<0.001	<0.001	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	14/0	<0.01	<0.01	<0.01	18/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	14/0	<0.001	<0.001	<0.001	18/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	14/0	<0.01	<0.01	<0.01	18/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	14/0	<0.005	<0.005	<0.005	18/3	<0.005	<0.005	**0.006**	-	-	-	-

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.9 Baseline water quality results summary: Tantangara Creek (PL_SW_002, PL_SW_004, PL_SW_009)

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	13/0	9.5	14.2	21.9	15/0	4.6	10.3	19.0	-	-	-	-
Dissolved oxygen	%	90-110[1]	11/9	**32**	**76**	90	11/10	**43**	**66**	**90**	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	13/0	33	37	46	15/0	16	32	44	-	-	-	-
pH	-	6.5-8.0[1]	13/2	7.1	7.4	7.9	15/6	**6.2**	7.1	7.8	-	-	-	-
Oxidising and reducing potential	-	-	13/0	6	115	153	15/0	81	122	191	-	-	-	-
Turbidity	NTU	2-25[1]	9/0	1.0	2.4	5.4	13/0	1.4	2.1	8.8	-	-	-	-
Analytical results – general														
Suspended solids	mg/L	-	13/0	<5	<5	7	15/0	<5	<5	10	-	-	-	-
Total hardness (as $CaCO_3$)	mg/L	-	12/0	7	12	12	15/0	2	5	9	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	1/0	17	17	17					-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	13/0	<0.01	<0.01	<0.01	15/5	<0.01	<0.01	**0.03**	-	-	-	-
Oxidised nitrogen	mg/L	0.015	13/9	<0.01	**0.03**	**0.05**	15/5	<0.01	<0.01	**0.05**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	13/0	<0.1	<0.1	0.3	15/0	<0.1	0.1	0.2	-	-	-	-
Total nitrogen	mg/L	0.25	13/3	<0.1	<0.1	**0.3**	15/0	<0.1	0.1	0.2	-	-	-	-
Reactive phosphorus	mg/L	0.015	12/0	<0.01	<0.01	<0.01	15/0	<0.01	<0.01	<0.01	-	-	-	-
Total phosphorus	mg/L	0.020	13/1	<0.01	<0.01	0.02	15/2	<0.01	<0.01	**0.03**	-	-	-	-

Table D.9 Baseline water quality results summary: Tantangara Creek (PL_SW_002, PL_SW_004, PL_SW_009)

	Unit	WQO value[1]	Summer/autumn dry weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	Winter/spring dry weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	Wet weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	12/0	1	2	4	15/0	1	2	3	-	-	-	-
Dissolved organic carbon	mg/L	-	12/0	<1	2	2	15/0	1	2	4	-	-	-	-
Analytical results – inorganics														
Cyanide	mg/L	0.004	8/0	<0.004	<0.004	<0.004	8/0	<0.004	<0.004	<0.004	-	-	-	-
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	12/10	0.02	**0.03**	**0.05**	15/12	0.02	**0.04**	**0.05**	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	12/0	<0.001	<0.001	<0.001	15/0	<0.001	<0.001	<0.001	-	-	-	-
Barium (Ba)	mg/L	-	12/0	0.004	0.005	0.006	15/0	0.004	0.005	0.008	-	-	-	-
Beryllium (Be)	mg/L	-	12/0	<0.001	<0.001	<0.001	15/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.09	12/1	<0.05	<0.05	<0.05	15/0	<0.05	<0.05	<0.05	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	12/0	<0.0001	<0.0001	<0.0001	15/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Total chromium (Cr)	mg/L	0.00001[3,6]	12/0	<0.001	<0.001	<0.001	15/0	<0.001	<0.001	<0.001	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	12/0	<0.001	<0.001	<0.001	15/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)	mg/L	0.001	12/0	<0.001	<0.001	<0.001	15/2	<0.001	<0.001	**0.002**	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	12/0	0.07	0.10	0.14	15/0	<0.05	0.10	0.14	-	-	-	-
Lead (Pb)	mg/L	0.001	12/0	<0.001	<0.001	<0.001	15/0	<0.001	<0.001	<0.001	-	-	-	-
Manganese (Mn)	mg/L	1.2	12/0	0.002	0.002	0.003	15/0	0.001	0.003	0.005	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	12/0	<0.0001	<0.0001	<0.0001	15/0	<0.0001	<0.0001	<0.0001	-	-	-	-

Table D.9 Baseline water quality results summary: Tantangara Creek (PL_SW_002, PL_SW_004, PL_SW_009)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.008	12/0	<0.001	<0.001	<0.001	15/0	<0.001	<0.001	<0.001	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	12/0	<0.01	<0.01	<0.01	15/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	12/0	<0.001	<0.001	<0.001	15/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	12/0	<0.01	<0.01	<0.01	15/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	12/0	<0.005	<0.005	<0.005	15/2	<0.005	<0.005	**0.005**	-	-	-	-

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.10 Baseline water quality results summary: Gooandra Creek (PL_SW_001)

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	6/0	8.6	12.5	21.9	8/0	2.2	8.0	16.8	-	-	-	-
Dissolved oxygen	%	90-110[1]	5/4	**67**	**78**	105	6/5	**36**	**70**	104	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	6/0	33	35	68	8/0	14	37	50	-	-	-	-
pH	-	6.5-8.0[1]	6/2	7.0	7.7	**10.9**	8/4	**6.0**	7.3	**8.9**	-	-	-	-
Oxidising and reducing potential	-	-	6/0	-25	126	189	8/0	14	81	237	-	-	-	-
Turbidity	NTU	2-25[1]	4/0	1.4	1.8	2.6	7/0	0.7	1.9	12.5	-	-	-	-
Analytical results – general														
Suspended solids	mg/L	-	6/0	<2[8]	<5[8]	5	8/0	<5	<5	22	-	-	-	-
Total hardness (as $CaCO_3$)	mg/L	-	5/0	5	10	12	8/0	5	5	12	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	1/0	17	17	17	-	-	-	-	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	6/0	<0.01[8]	<0.01[8]	<0.1[8]	8/2	<0.01	<0.01	**0.03**	-	-	-	-
Oxidised nitrogen	mg/L	0.015	5/2	<0.01	0.01	**0.04**	8/3	<0.01	<0.01	**0.05**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	5/0	<0.1	<0.1	<0.1	8/0	<0.1	<0.1	0.3	-	-	-	-
Total nitrogen	mg/L	0.25	6/0	<0.1	<0.1	0.1	8/1	<0.1	<0.1	**0.3**	-	-	-	-
Reactive phosphorus	mg/L	0.015	5/0	<0.01	<0.01	<0.01	8/0	<0.01	<0.01	<0.01	-	-	-	-
Total phosphorus	mg/L	0.020	6/0	<0.01	<0.01	0.01	8/1	<0.01	<0.01	**0.05**	-	-	-	-

Table D.10 Baseline water quality results summary: Gooandra Creek (PL_SW_001)

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	5/0	<1	<1	3	8/0	<1	1	2	-	-	-	-
Dissolved organic carbon	mg/L	-	5/0	<1	<1	2	8/0	<1	2	8	-	-	-	-
Analytical results – inorganics														
Cyanide	mg/L	0.004	4/0	<0.004	<0.004	<0.004	4/0	<0.004	<0.004	<0.004	-	-	-	-
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	5/1	<0.01	0.02	**0.03**	8/3	0.01	0.02	**0.06**	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	5/0	<0.001	<0.001	<0.001	8/0	<0.001	<0.001	<0.001	-	-	-	-
Barium (Ba)	mg/L	-	5/0	0.004	0.004	0.006	8/0	0.003	0.004	0.014	-	-	-	-
Beryllium (Be)	mg/L	-	5/0	<0.001	<0.001	<0.001	8/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.09	5/0	<0.05	<0.05	<0.05	8/0	<0.05	<0.05	<0.05	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	5/0	<0.0001	<0.0001	<0.0001	8/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Total chromium (Cr)	mg/L	0.00001[3,6]	5/1	<0.001	<0.001	**0.002**	8/1	<0.001	<0.001	**0.002**	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	5/0	<0.001	<0.001	<0.001	8/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)	mg/L	0.001	5/0	<0.001	<0.001	0.001	8/1	<0.001	<0.001	**0.002**	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	5/0	<0.05	<0.05	0.08	8/0	<0.05	0.06	0.08	-	-	-	-
Lead (Pb)	mg/L	0.001	5/0	<0.001	<0.001	<0.001	8/0	<0.001	<0.001	<0.001	-	-	-	-
Manganese (Mn)	mg/L	1.2	5/0	<0.001	0.002	0.002	8/0	<0.001	0.002	0.002	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	5/0	<0.0001	<0.0001	<0.0001	8/0	<0.0001	<0.0001	<0.0001	-	-	-	-

Table D.10 Baseline water quality results summary: Gooandra Creek (PL_SW_001)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.008	5/0	<0.001	<0.001	<0.001	8/0	<0.001	<0.001	0.002	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	5/0	<0.01	<0.01	<0.01	8/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	5/0	<0.001	<0.001	<0.001	8/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	5/0	<0.01	<0.01	<0.01	8/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	5/1	<0.005	<0.005	**0.012**	8/2	<0.005	<0.005	**0.007**	-	-	-	-

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
8. Where more than one LOR has been used in the reporting of an analyte, the lowest and highest LOR are considered in calculating 10th percentile, median and 90th percentile values.
Bold denotes WQO value is exceeded.

Table D.11 Baseline water quality results summary: Nungar Creek (TanR_SW_001)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	4/0	14.2	16.4	27.8	7/0	5.5	12.0	20.1	-	-	-	-
Dissolved oxygen	%	90-110[1]	3/3	**62**	**66**	**66**	4/4	**11**	**42**	**75**	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	4/0	24	27	43	7/0	11	21	30	-	-	-	-
pH	-	6.5-8.0[1]	4/1	**6.1**	7.4	7.9	6/1	**5.8**	6.8	7.4	-	-	-	-
Oxidising and reducing potential	-	-	4/0	60	88	106	7/0	88	119	185	-	-	-	-
Turbidity	NTU	2-25[1]	3/0	2.1	3.3	3.3	5/0	1.9	2.6	4.7	-	-	-	-
Analytical results – general														
Suspended solids	mg/L	-	4/0	<5	6	32	7/0	<5	<5	12	-	-	-	-
Total hardness (as $CaCO_3$)	mg/L	-	4/0	<1	7	16	7/0	<1	<1	12	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-									-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	4/0	<0.01	<0.01	0.01	7/0	<0.01	<0.01	0.01	-	-	-	-
Oxidised nitrogen	mg/L	0.015	4/2	<0.01	**0.03**	**0.06**	7/1	<0.01	<0.01	**0.03**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	4/0	<0.1	<0.1	0.1	7/0	<0.1	<0.1	0.4	-	-	-	-
Total nitrogen	mg/L	0.25	4/0	<0.1	<0.1	0.1	7/1	<0.1	<0.1	**0.4**	-	-	-	-
Reactive phosphorus	mg/L	0.015	4/0	<0.01	<0.01	<0.01	7/0	<0.01	<0.01	<0.01	-	-	-	-
Total phosphorus	mg/L	0.020	4/0	<0.01	<0.01	<0.01	7/1	<0.01	0.01	**0.03**	-	-	-	-

Table D.11 Baseline water quality results summary: Nungar Creek (TanR_SW_001)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	4/0	1	2	18	7/0	1	2	3	-	-	-	-
Dissolved organic carbon	mg/L	-	4/0	1	2	2	7/0	1	2	5	-	-	-	-
Analytical results – inorganics														
Cyanide	mg/L	0.004	3/0	<0.004	<0.004	<0.004	4/0	<0.004	<0.004	<0.004	-	-	-	-
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	4/3	0.02	**0.05**	**0.07**	7/6	0.01	**0.05**	**0.06**	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	4/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Barium (Ba)	mg/L	-	4/0	0.009	0.010	0.011	7/0	0.001	0.010	0.030	-	-	-	-
Beryllium (Be)	mg/L	-	4/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.09	4/0	<0.05	<0.05	<0.05	7/0	<0.05	<0.05	<0.05	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	4/0	<0.0001	<0.0001	<0.0001	7/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Total chromium (Cr)	mg/L	0.00001[3,6]	4/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	4/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)	mg/L	0.001	4/1	<0.001	<0.001	**0.005**	7/0	<0.001	<0.001	<0.001	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	4/1	0.18	0.22	**0.33**	7/0	<0.05	0.14	0.21	-	-	-	-
Lead (Pb)	mg/L	0.001	4/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Manganese (Mn)	mg/L	1.2	4/0	0.007	0.008	0.012	7/0	<0.001	0.004	0.007	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	4/0	<0.0001	<0.0001	<0.0001	7/0	<0.0001	<0.0001	<0.0001	-	-	-	-

Table D.11 Baseline water quality results summary: Nungar Creek (TanR_SW_001)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.008	4/0	<0.001	<0.001	0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	4/0	<0.01	<0.01	<0.01	7/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	4/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	4/0	<0.01	<0.01	<0.01	7/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	4/0	<0.005	<0.005	<0.005	7/0	<0.005	<0.005	<0.005	-	-	-	-

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.12 Baseline water quality results summary: Kellys Plain Creek (TanS_SW_001)

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	6/0	13.7	16.4	23.2	9/0	1.1	7.8	18.8	1/0	9.8	9.8	9.8
Dissolved oxygen	%	90-110[1]	5/5	**67**	**84**	**88**	6/5	**1**	**58**	102	1/1	**72**	**72**	**72**
Electrical conductivity	µS/cm	30-350[1]	6/0	30	33	37	9/0	20	29	37	1/0	40	40	40
pH	-	6.5-8.0[1]	6/2	**6.0**	7.2	**8.5**	8/1	**6.4**	7.3	7.7	1/0	7.3	7.3	7.3
Oxidising and reducing potential	-	-	6/0	41	90	145	9/0	87	114	212	1/0	174	174	174
Turbidity	NTU	2-25[1]	4/0	2.2	2.8	14.7	6/0	1.8	2.4	6.8	1/0	3.7	3.7	3.7
Analytical results – general														
Suspended solids	mg/L	-	6/0	<5	<5	34	9/0	<5	<5	24	1/0	7	7	7
Total hardness (as $CaCO_3$)	mg/L	-	6/0	2	9	13	9/0	<1	7	13	1/0	9	9	9
Total alkalinity (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	6/0	<0.01	<0.01	<0.01	9/1	<0.01	<0.01	**0.05**	1/0	<0.01	<0.01	<0.01
Oxidised nitrogen	mg/L	0.015	6/5	<0.01	**0.03**	**0.06**	9/6	<0.01	**0.02**	**0.06**	1/0	0.01	0.01	0.01
Total kjeldahl nitrogen	mg/L	-	6/0	<0.1	<0.1	0.4	9/0	<0.1	<0.1	0.3	1/0	0.1	0.1	0.1
Total nitrogen	mg/L	0.25	6/1	<0.1	<0.1	**0.5**	9/2	<0.1	<0.1	**0.3**	1/0	0.1	0.1	0.1
Reactive phosphorus	mg/L	0.015	6/0	<0.01	<0.01	<0.01	9/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01
Total phosphorus	mg/L	0.020	6/1	<0.01	0.01	**0.04**	9/1	<0.01	<0.01	**0.03**	1/0	0.02	0.02	0.02

Table D.12 Baseline water quality results summary: Kellys Plain Creek (TanS_SW_001)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	6/0	1	2	6	9/0	<1	2	16	1/0	3	3	3
Dissolved organic carbon	mg/L	-	6/0	1	2	5	9/0	1	2	4	1/0	3	3	3
Analytical results – inorganics														
Cyanide	mg/L	0.004	4/0	<0.004	<0.004	<0.004	4/0	<0.004	<0.004	<0.004	1/0	<0.004	<0.004	<0.004
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	6/6	**0.03**	**0.04**	**0.11**	9/8	0.02	**0.05**	**0.44**	1/1	**0.04**	**0.04**	**0.04**
Arsenic (As)	mg/L	0.0008[2,6]	6/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Barium (Ba)	mg/L	-	6/0	0.010	0.011	0.014	9/0	0.009	0.010	0.026	1/0	0.014	0.014	0.014
Beryllium (Be)	mg/L	-	6/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Boron (B)	mg/L	0.09	6/0	<0.05	<0.05	<0.05	9/0	<0.05	<0.05	<0.05	1/0	<0.05	<0.05	<0.05
Cadmium (Cd)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	9/0	<0.0001	<0.0001	<0.0001	1/0	<0.0001	<0.0001	<0.0001
Total chromium (Cr)	mg/L	0.00001[3,6]	6/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Cobalt (Co)	mg/L	0.0014[4]	6/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Copper (Cu)	mg/L	0.001	6/1	<0.001	<0.001	**0.002**	9/1	<0.001	<0.001	**0.002**	1/1	**0.003**	**0.003**	**0.003**
Iron (Fe)	mg/L	0.3[4]	6/0	0.10	0.10	0.20	9/1	<0.05	0.06	**0.31**	1/0	0.10	0.10	0.10
Lead (Pb)	mg/L	0.001	6/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.2	6/0	0.002	0.003	0.008	9/0	0.002	0.002	0.021	1/0	0.004	0.004	0.004
Mercury (Hg)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	9/0	<0.0001	<0.0001	<0.0001	1/0	<0.0001	<0.0001	<0.0001

Table D.12 Baseline water quality results summary: Kellys Plain Creek (TanS_SW_001)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.008	6/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001	1/0	0.003	0.003	0.003
Selenium (Se)	mg/L	0.005[6]	6/0	<0.01	<0.01	<0.01	9/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	6/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	6/0	<0.01	<0.01	<0.01	9/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	6/0	<0.005	<0.005	<0.005	9/3	<0.005	<0.005	**0.007**	1/0	<0.005	<0.005	<0.005

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.13 Baseline water quality results summary: Minor watercourses (PL_SW_008, TanN_SW_001, TanS_SW_003, TanS_SW_004, TanS_SW_005, TanS_SW_006)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	17/0	12.7	16.0	21.7	25/0	6.7	11.6	21.8	-	-	-	-
Dissolved oxygen	%	90-110[1]	13/13	**62**	**75**	**88**	11/11	**0**	**54**	**82**	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	17/0	31	52	77	25/0	20	39	65	-	-	-	-
pH	-	6.5-8.0[1]	17/5	**5.9**	6.7	7.8	21/7	**5.9**	6.9	7.6	-	-	-	-
Oxidising and reducing potential	-	-	17/0	53	92	149	25/0	89	119	203	-	-	-	-
Turbidity	NTU	2-25[1]	16/2	1.2	8.1	**32.9**	19/3	0.9	4.9	**32.4**	-	-	-	-
Analytical results – general														
Suspended solids	mg/L	-	19/0	7	33	60	25/0	<5	12	75	-	-	-	-
Total hardness (as $CaCO_3$)	mg/L	-	16/0	2	10	27	25/0	2	9	25	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	3/0	14	26	31					-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	19/4	<0.01	<0.01	**0.03**	25/4	<0.01	<0.01	**0.02**	-	-	-	-
Oxidised nitrogen	mg/L	0.015	18/15	<0.01	**0.03**	**0.14**	25/17	<0.01	**0.03**	**0.09**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	18/0	<0.1	0.3	1.4	25/0	<0.1	0.2	0.5	-	-	-	-
Total nitrogen	mg/L	0.25	19/13	<0.1	**0.30**	**1.48**	25/11	<0.1	0.2	**0.5**	-	-	-	-
Reactive phosphorus	mg/L	0.015	16/1	<0.01	<0.01	0.01	25/0	<0.01	<0.01	<0.01	-	-	-	-

Table D.13 Baseline water quality results summary: Minor watercourses (PL_SW_008, TanN_SW_001, TanS_SW_003, TanS_SW_004, TanS_SW_005, TanS_SW_006)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	**WQO value[1]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**
Total phosphorus	mg/L	0.020	19/14	0.01	**0.05**	**0.26**	25/11	<0.01	0.02	**0.13**	-	-	-	-
Total organic carbon	mg/L	-	16/0	2	3	6	25/0	<1	2	6	-	-	-	-
Dissolved organic carbon	mg/L	-	16/0	<1	3	6	25/0	<1	2	7	-	-	-	-
Analytical results – inorganics														
Cyanide	mg/L	0.004	16/0	<0.004	<0.004	<0.004	18/0	<0.004	<0.004	<0.004	-	-	-	-
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	16/12	<0.01	**0.05**	**0.18**	25/20	0.01	**0.07**	**0.16**	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	16/0	<0.001	<0.001	<0.001	25/2	<0.001	<0.001	<0.001	-	-	-	-
Barium (Ba)	mg/L	-	16/0	0.002	0.013	0.024	25/0	0.002	0.015	0.028	-	-	-	-
Beryllium (Be)	mg/L	-	16/0	<0.001	<0.001	<0.001	25/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.09	16/0	<0.05	<0.05	<0.05	25/0	<0.05	<0.05	<0.05	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	16/0	<0.0001	<0.0001	<0.0001	25/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Total chromium (Cr)	mg/L	0.00001[3,6]	16/1	<0.001	<0.001	<0.001	25/0	<0.001	<0.001	<0.001	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	16/0	<0.001	<0.001	<0.001	25/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)	mg/L	0.001	16/3	<0.001	<0.001	**0.003**	25/2	<0.001	<0.001	0.001	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	16/7	<0.05	0.11	**0.84**	25/6	<0.05	0.14	**0.36**	-	-	-	-
Lead (Pb)	mg/L	0.001	16/0	<0.001	<0.001	<0.001	25/0	<0.001	<0.001	<0.001	-	-	-	-

Table D.13 Baseline water quality results summary: Minor watercourses (PL_SW_008, TanN_SW_001, TanS_SW_003, TanS_SW_004, TanS_SW_005, TanS_SW_006)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Manganese (Mn)	mg/L	1.2	16/0	<0.001	0.009	0.053	25/0	<0.001	0.012	0.036	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	16/0	<0.0001	<0.0001	<0.0001	25/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Nickel (Ni)	mg/L	0.008	16/0	<0.001	<0.001	<0.001	25/0	<0.001	<0.001	<0.001	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	16/0	<0.01	<0.01	<0.01	25/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	16/0	<0.001	<0.001	<0.001	25/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	16/0	<0.01	<0.01	<0.01	25/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	16/0	<0.005	<0.005	<0.005	25/8	<0.005	<0.005	**0.007**	-	-	-	-

Notes:
1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.

Bold denotes WQO value is exceeded.

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Table D.14 Baseline water quality results summary: Yarrangobilly River (PN_SW_001, LH_SW_004, LH_SW_006, LH_SW_007)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	27/0	13.4	20.9	23.6	31/0	4.0	9.3	18.7	5/0	14.5	15.8	17.8
Dissolved oxygen	%	90-110[1]	27/22	**39**	**78**	93	31/21	**2**	**77**	112	5/4	**0**	**61**	92
Electrical conductivity	µS/cm	30-350[1]	27/0	66	160	187	31/0	26	70	109	5/0	89	116	155
pH	-	6.5-8.0[1]	27/15	7.5	**8.0**	**8.5**	31/11	7.1	7.8	**8.2**	5/1	**6.2**	7.3	7.9
Oxidising and reducing potential	-	-	27/0	-20	108	149	27/0	51	164	210	5/0	78	96	157
Turbidity	NTU	2-25[1]	23/0	0.0	0.4	1.7	21/0	0.8	1.6	4.4	5/1	6.4	13.7	**42.1**
Analytical results – general														
Suspended solids	mg/L	-	27/0	<2[8]	<5[8]	5	31/0	<5	<5	<5	5/0	<5	10	148
Total hardness (as $CaCO_3$)	mg/L	-	20/0	22	75	88	31/0	7	32	53	5/0	43	51	78
Total alkalinity (as $CaCO_3$)	mg/L	-	7/0	29	86	109	1/0	16	16	16	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	27/2	<0.01[8]	<0.01[8]	<0.1[8]	30/7	<0.01	<0.01	**0.02**	5/0	<0.01	<0.01	<0.01
Oxidised nitrogen	mg/L	0.015	23/14	<0.01	**0.02**	**0.05**	31/11	<0.01	<0.01	**0.03**	5/1	<0.01	<0.01	**0.03**
Total kjeldahl nitrogen	mg/L	-	23/0	<0.1	<0.1	<0.1	30/0	<0.1	<0.1	0.1	5/0	<0.1	0.1	2.1
Total nitrogen	mg/L	0.25	27/1	<0.1	<0.1	0.1	30/0	<0.1	<0.1	0.1	5/2	<0.1	0.1	**2.1**
Reactive phosphorus	mg/L	0.015	20/0	<0.01	<0.01	<0.01	31/1	<0.01	<0.01	<0.01	5/0	<0.01	<0.01	<0.01
Total phosphorus	mg/L	0.020	27/1	<0.01	<0.01	0.01	30/1	<0.01	<0.01	0.01	5/2	<0.01	0.02	**0.20**

Table D.14 Baseline water quality results summary: Yarrangobilly River (PN_SW_001, LH_SW_004, LH_SW_006, LH_SW_007)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	20/0	1	2	7	30/0	<1	2	3	5/0	2	2	4
Dissolved organic carbon	mg/L	-	20/0	<1	2	2	30/0	1	2	5	5/0	2	3	4
Analytical results – inorganics														
Cyanide	mg/L	0.004	16/0	<0.004	<0.004	<0.004	16/0	<0.004	<0.004	<0.004	5/0	<0.004	<0.004	<0.004
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	20/5	<0.01	<0.01	**0.04**	30/19	0.01	**0.03**	**0.11**	5/0	<0.01	<0.01	0.01
Arsenic (As)	mg/L	0.0008[2,6]	20/0	<0.001	<0.001	<0.001	30/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001
Barium (Ba)	mg/L	-	20/0	0.018	0.026	0.036	30/0	0.011	0.016	0.026	5/0	0.013	0.024	0.029
Beryllium (Be)	mg/L	-	20/0	<0.001	<0.001	<0.001	30/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001
Boron (B)	mg/L	0.09	20/0	<0.05	<0.05	<0.05	30/0	<0.05	<0.05	<0.05	5/0	<0.05	<0.05	<0.05
Cadmium (Cd)	mg/L	0.00006[6]	20/0	<0.0001	<0.0001	<0.0001	30/0	<0.0001	<0.0001	<0.0001	5/0	<0.0001	<0.0001	<0.0001
Total chromium (Cr)	mg/L	0.00001[3,6]	20/1	<0.001	<0.001	<0.001	30/1	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001
Cobalt (Co)	mg/L	0.0014[4]	20/0	<0.001	<0.001	<0.001	30/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001
Copper (Cu)	mg/L	0.001	20/0	<0.001	<0.001	<0.001	30/2	<0.001	<0.001	0.001	5/5	**0.002**	**0.006**	**0.027**
Iron (Fe)	mg/L	0.3[4]	20/0	<0.05	<0.05	0.08	30/0	<0.05	<0.05	0.07	5/0	<0.05	<0.05	<0.05
Lead (Pb)	mg/L	0.001	20/0	<0.001	<0.001	<0.001	30/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.2	20/0	<0.001	0.002	0.002	30/0	<0.001	0.001	0.002	5/0	0.002	0.004	0.006
Mercury (Hg)	mg/L	0.00006[6]	20/0	<0.0001	<0.0001	<0.0001	30/0	<0.0001	<0.0001	<0.0001	5/0	<0.0001	<0.0001	<0.0001

Table D.14 Baseline water quality results summary: Yarrangobilly River (PN_SW_001, LH_SW_004, LH_SW_006, LH_SW_007)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.008	20/0	<0.001	<0.001	<0.001	30/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001
Selenium (Se)	mg/L	0.005[6]	20/0	<0.01	<0.01	<0.01	30/0	<0.01	<0.01	<0.01	5/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	20/0	<0.001	<0.001	<0.001	30/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	20/0	<0.01	<0.01	<0.01	30/0	<0.01	<0.01	<0.01	5/0	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	20/0	<0.005	<0.005	<0.005	30/7	<0.005	<0.005	**0.006**	5/2	<0.005	<0.005	**0.006**

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
8. Where more than one LOR has been used in the reporting of an analyte, the lowest and highest LOR are considered in calculating 10th percentile, median and 90th percentile values.
Bold denotes WQO value is exceeded.

Table D.15 Baseline water quality results summary: Wallaces Creek (LH_SW_001, LH_SW_002, LH_SW_003)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	9/0	13.0	14.6	19.4	10/0	3.5	6.4	13.6	-	-	-	-
Dissolved oxygen	%	90-110[1]	8/7	**72**	**80**	92	10/7	**62**	**77**	105	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	9/0	65	163	185	10/0	36	64	89	-	-	-	-
pH	-	6.5-8.0[1]	9/2	**6.2**	7.5	**8.4**	10/1	6.8	7.8	8.0	-	-	-	-
Oxidising and reducing potential	-	-	9/0	12	101	167	9/0	-19	170	210	-	-	-	-
Turbidity	NTU	2-25[1]	7/0	0.2	0.4	0.7	7/1	0.1	1.3	**152.0**	-	-	-	-
Analytical results – general														
Suspended solids	mg/L	-	9/0	<2[8]	<5[8]	5	10/0	<5	<5	<5	-	-	-	-
Total hardness (as $CaCO_3$)	mg/L	-	6/0	42	67	94	10/0	16	28	55	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	3/0	38	99	104	-	-	-	-	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	9/0	<0.01[8]	<0.01[8]	<0.1[8]	10/1	<0.01	<0.01	0.01	-	-	-	-
Oxidised nitrogen	mg/L	0.015	6/3	<0.01	0.02	**0.04**	10/3	<0.01	<0.01	**0.02**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	6/0	<0.1	<0.1	<0.1	10/0	<0.1	<0.1	0.1	-	-	-	-
Total nitrogen	mg/L	0.25	9/0	<0.05[8]	<0.1[8]	0.15	10/1	<0.1	<0.1	0.1	-	-	-	-
Reactive phosphorus	mg/L	0.015	6/0	<0.01	<0.01	<0.01	10/2	<0.01	<0.01	**0.02**	-	-	-	-
Total phosphorus	mg/L	0.020	9/0	<0.01	0.01	0.02	10/0	<0.01	<0.01	0.02	-	-	-	-

Table D.15 Baseline water quality results summary: Wallaces Creek (LH_SW_001, LH_SW_002, LH_SW_003)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	6/0	<1	2	25	10/0	<1	1	2	-	-	-	-
Dissolved organic carbon	mg/L	-	6/0	1	1	2	10/0	1	2	4	-	-	-	-
Analytical results – inorganics														
Cyanide	mg/L	0.004	4/0	<0.004	<0.004	<0.004	4/0	<0.004	<0.004	<0.004	-	-	-	-
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	6/0	<0.01	<0.01	<0.01	10/0	<0.01	<0.01	0.02	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	6/0	<0.001	<0.001	<0.001	10/0	<0.001	<0.001	<0.001	-	-	-	-
Barium (Ba)	mg/L	-	6/0	0.060	0.082	0.106	10/0	0.029	0.044	0.057	-	-	-	-
Beryllium (Be)	mg/L	-	6/0	<0.001	<0.001	<0.001	10/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.09	6/0	<0.05	<0.05	<0.05	10/0	<0.05	<0.05	<0.05	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	10/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Total chromium (Cr)	mg/L	0.00001[3,6]	6/0	<0.001	<0.001	<0.001	10/0	<0.001	<0.001	<0.001	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	6/0	<0.001	<0.001	<0.001	10/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)	mg/L	0.001	6/1	<0.001	<0.001	**0.003**	10/2	<0.001	<0.001	**0.002**	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	6/0	<0.05	<0.05	<0.05	10/0	<0.05	<0.05	0.06	-	-	-	-
Lead (Pb)	mg/L	0.001	6/0	<0.001	<0.001	<0.001	10/0	<0.001	<0.001	<0.001	-	-	-	-
Manganese (Mn)	mg/L	1.2	6/0	0.001	0.002	0.002	10/0	<0.001	<0.001	0.001	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	10/0	<0.0001	<0.0001	<0.0001	-	-	-	-

Table D.15 Baseline water quality results summary: Wallaces Creek (LH_SW_001, LH_SW_002, LH_SW_003)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	**WQO value[1]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**
Nickel (Ni)	mg/L	0.008	6/0	<0.001	<0.001	0.001	10/0	<0.001	<0.001	<0.001	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	6/0	<0.01	<0.01	<0.01	10/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	6/0	<0.001	<0.001	<0.001	10/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	6/0	<0.01	<0.01	<0.01	10/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	6/1	<0.005	<0.005	**0.006**	10/3	<0.005	<0.005	**0.008**	-	-	-	-

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
8. Where more than one LOR has been used in the reporting of an analyte, the lowest and highest LOR are considered in calculating 10th percentile, median and 90th percentile values.
Bold denotes WQO value is exceeded.

Table D.16 Baseline water quality results summary: Tumut River (TalS_SW_001)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	6/0	12.7	17.2	21.6	7/0	4.5	7.7	18.0	-	-	-	-
Dissolved oxygen	%	90-110[1]	6/6	**58**	**72**	**89**	7/5	**52**	**81**	160	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	6/0	86	99	118	7/0	36	68	157	-	-	-	-
pH	-	6.5-8.0[1]	6/1	6.6	7.7	**9.5**	7/1	**5.6**	7.4	7.8	-	-	-	-
Oxidising and reducing potential	-	-	6/0	96	148	193	6/0	84	154	217	-	-	-	-
Turbidity	NTU	2-25[1]	5/0	0.2	0.8	1.1	6/0	0.4	4.0	13.9	-	-	-	-
Analytical results – general														
Suspended solids	mg/L	-	6/0	<2[8]	<5[8]	6	7/0	<5	<5	23	-	-	-	-
Total hardness (as $CaCO_3$)	mg/L	-	5/0	30	32	32	7/0	12	21	27	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	1/0	46	46	46	-	-	-	-	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	6/0	<0.01	<0.01	**0.10**	7/3	<0.01	<0.01	**0.02**	-	-	-	-
Oxidised nitrogen	mg/L	0.015	5/3	<0.01	**0.02**	**0.03**	7/2	<0.01	<0.01	**0.04**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	5/0	<0.1	<0.1	0.2	7/0	<0.1	<0.1	0.3	-	-	-	-
Total nitrogen	mg/L	0.25	6/0	<0.1	<0.1	0.2	7/1	<0.1	<0.1	**0.3**	-	-	-	-
Reactive phosphorus	mg/L	0.015	5/0	<0.01	<0.01	<0.01	7/0	<0.01	<0.01	<0.01	-	-	-	-
Total phosphorus	mg/L	0.020	6/0	<0.01	<0.01	0.01	7/1	<0.01	<0.01	**0.05**	-	-	-	-

Table D.16 Baseline water quality results summary: Tumut River (TalS_SW_001)

	Unit	WQO value[1]	Summer/autumn dry weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	Winter/spring dry weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	Wet weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	5/0	1	2	2	7/0	1	2	6	-	-	-	-
Dissolved organic carbon	mg/L	-	5/0	1	2	2	7/0	1	3	4	-	-	-	-
Analytical results – inorganics														
Cyanide	mg/L	0.004	4/0	<0.004	<0.004	<0.004	4/0	<0.004	<0.004	<0.004	-	-	-	-
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	5/0	<0.01	0.01	0.02	7/6	0.02	**0.03**	**0.11**	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	5/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Barium (Ba)	mg/L	-	5/0	0.006	0.008	0.010	7/0	0.006	0.008	0.017	-	-	-	-
Beryllium (Be)	mg/L	-	5/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.09	5/0	<0.05	<0.05	<0.05	7/0	<0.05	<0.05	<0.05	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	5/0	<0.0001	<0.0001	<0.0001	7/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Total chromium (Cr)	mg/L	0.00001[3,6]	5/0	<0.001	<0.001	<0.001	7/1	<0.001	<0.001	**0.001**	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	5/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)	mg/L	0.001	5/0	<0.001	<0.001	0.001	7/0	<0.001	<0.001	0.001	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	5/0	0.08	0.11	0.15	7/0	<0.05	0.08	0.17	-	-	-	-
Lead (Pb)	mg/L	0.001	5/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Manganese (Mn)	mg/L	1.2	5/0	0.004	0.008	0.012	7/0	0.002	0.003	0.007	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	5/0	<0.0001	<0.0001	<0.0001	7/0	<0.0001	<0.0001	<0.0001	-	-	-	-

Table D.16 Baseline water quality results summary: Tumut River (TalS_SW_001)

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.008	5/0	<0.001	<0.001	0.001	7/0	<0.001	<0.001	0.001	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	5/0	<0.01	<0.01	<0.01	7/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	5/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	5/0	<0.01	<0.01	<0.01	7/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	5/0	<0.005	<0.005	<0.005	7/3	<0.005	<0.005	**0.007**	-	-	-	-

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
8. Where more than one LOR has been used in the reporting of an analyte, the lowest and highest LOR are considered in calculating 10th percentile, median and 90th percentile values.
Bold denotes WQO value is exceeded.

Table D.17 Baseline water quality results summary: Lick Hole Gully (LH_SW_005)

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	1/0	16.9	16.9	16.9	5/0	8.6	13.2	13.9	1/0	16.7	16.7	16.7
Dissolved oxygen	%	90-110[1]	1/1	**60**	**60**	**60**	5/5	**48**	**62**	**70**	1/1	**1**	**1**	**1**
Electrical conductivity	µS/cm	30-350[1]	1/1	**801**	**801**	**801**	5/5	**403**	**640**	**814**	1/1	**783**	**783**	**783**
pH	-	6.5-8.0[1]	1/0	7.8	7.8	7.8	5/0	7.1	7.5	7.8	1/0	6.8	6.8	6.8
Oxidising and reducing potential	-	-	1/0	136	136	136	4/0	131	159	221	1/0	116	116	116
Turbidity	NTU	2-25[1]	1/1	**198.0**	**198.0**	**198.0**	3/1	0.4	3.4	**73.4**	1/0	0.7	0.7	0.7
Analytical results – general														
Suspended solids	mg/L	-	1/0	172	172	172	5/0	<5	12	168	1/0	5	5	5
Total hardness (as $CaCO_3$)	mg/L	-	1/0	474	474	474	5/0	305	310	497	1/0	402	402	402
Total alkalinity (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	1/0	<0.01	<0.01	<0.01	5/2	<0.01	<0.01	**0.02**	1/0	<0.01	<0.01	<0.01
Oxidised nitrogen	mg/L	0.015	1/0	<0.01	<0.01	<0.01	5/2	<0.01	0.01	**0.11**	1/0	<0.01	<0.01	<0.01
Total kjeldahl nitrogen	mg/L	-	1/0	0.4	0.4	0.4	5/0	<0.1	<0.1	0.2	1/0	0.2	0.2	0.2
Total nitrogen	mg/L	0.25	1/1	**0.4**	**0.4**	**0.4**	5/0	<0.1	0.1	0.2	1/0	0.2	0.2	0.2
Reactive phosphorus	mg/L	0.015	1/0	<0.01	<0.01	<0.01	5/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01
Total phosphorus	mg/L	0.020	1/1	**0.16**	**0.16**	**0.16**	5/1	<0.01	<0.01	**0.08**	1/0	<0.01	<0.01	<0.01

Table D.17 Baseline water quality results summary: Lick Hole Gully (LH_SW_005)

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	1/0	3	3	3	5/0	<1	1	2	1/0	3	3	3
Dissolved organic carbon	mg/L	-	1/0	3	3	3	5/0	<1	2	5	1/0	5	5	5
Analytical results – inorganics														
Cyanide	mg/L	0.004	1/0	<0.004	<0.004	<0.004	3/0	<0.004	<0.004	<0.004	1/0	<0.004	<0.004	<0.004
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	1/0	<0.01	<0.01	<0.01	5/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01
Arsenic (As)	mg/L	0.0008[2,6]	1/0	<0.001	<0.001	<0.001	5/1	<0.001	<0.001	**0.001**	1/0	<0.001	<0.001	<0.001
Barium (Ba)	mg/L	-	1/0	0.153	0.153	0.153	5/0	0.108	0.116	0.128	1/0	0.113	0.113	0.113
Beryllium (Be)	mg/L	-	1/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Boron (B)	mg/L	0.09	1/0	<0.05	<0.05	<0.05	5/0	<0.05	<0.05	<0.05	1/0	<0.05	<0.05	<0.05
Cadmium (Cd)	mg/L	0.00006[6]	1/0	<0.0001	<0.0001	<0.0001	5/0	<0.0001	<0.0001	<0.0001	1/0	<0.0001	<0.0001	<0.0001
Total chromium (Cr)	mg/L	0.00001[3,6]	1/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Cobalt (Co)	mg/L	0.0014[4]	1/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Copper (Cu)	mg/L	0.001	1/1	**0.011**	**0.011**	**0.011**	5/5	**0.002**	**0.003**	**0.008**	1/1	**0.010**	**0.010**	**0.010**
Iron (Fe)	mg/L	0.3[4]	1/0	<0.05	<0.05	<0.05	5/0	<0.05	<0.05	<0.05	1/0	<0.05	<0.05	<0.05
Lead (Pb)	mg/L	0.001	1/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.2	1/0	0.009	0.009	0.009	5/0	0.002	0.002	0.015	1/0	0.002	0.002	0.002
Mercury (Hg)	mg/L	0.00006[6]	1/0	<0.0001	<0.0001	<0.0001	5/0	<0.0001	<0.0001	<0.0001	1/0	<0.0001	<0.0001	<0.0001

Table D.17 Baseline water quality results summary: Lick Hole Gully (LH_SW_005)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.008	1/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	0.002	1/0	0.002	0.002	0.002
Selenium (Se)	mg/L	0.005[6]	1/0	<0.01	<0.01	<0.01	5/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	1/0	<0.001	<0.001	<0.001	5/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	1/0	<0.01	<0.01	<0.01	5/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	1/0	<0.005	<0.005	<0.005	5/1	<0.005	<0.005	**0.006**	1/1	**0.006**	**0.006**	**0.006**

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.18 Baseline water quality results summary: Minor watercourses (LH_SW_008, LH_SW_009)

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	3/0	12.4	14.0	21.3	7/0	8.4	11.1	20.5	2/0	14.0	14.3	14.5
Dissolved oxygen	%	90-110[1]	3/3	**39**	**39**	**45**	7/7	**35**	**63**	**75**	2/2	**57**	**58**	**59**
Electrical conductivity	µS/cm	30-350[1]	3/0	79	87	107	7/0	42	63	83	2/0	70	72	74
pH	-	6.5-8.0[1]	3/1	6.7	7.8	**8.3**	7/1	**6.5**	7.1	7.9	2/0	7.1	7.4	7.7
Oxidising and reducing potential	-	-	3/0	113	118	162	6/0	151	179	223	2/0	165	169	173
Turbidity	NTU	2-25[1]	3/0	0.1	0.4	1.0	7/0	0.2	0.9	5.7	2/0	5.2	5.7	6.3
Analytical results – general														
Suspended solids	mg/L	-	3/0	<5	<5	5	7/0	<5	<5	8	2/0	<5	<5	<5
Total hardness (as $CaCO_3$)	mg/L	-	3/0	35	39	45	7/0	21	28	39	2/0	28	29	30
Total alkalinity (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	3/0	<0.01	<0.01	<0.01	7/3	<0.01	0.01	**0.03**	2/0	<0.01	<0.01	<0.01
Oxidised nitrogen	mg/L	0.015	3/0	<0.01	<0.01	<0.01	7/0	<0.01	<0.01	0.01	2/0	<0.01	<0.01	<0.01
Total kjeldahl nitrogen	mg/L	-	3/0	<0.1	<0.1	<0.1	7/0	<0.1	<0.1	2.4	2/0	0.3	0.3	0.3
Total nitrogen	mg/L	0.25	3/0	<0.1	<0.1	<0.1	7/1	<0.1	<0.1	**2.4**	2/2	**0.3**	**0.3**	**0.3**
Reactive phosphorus	mg/L	0.015	3/0	<0.01	<0.01	<0.01	7/0	<0.01	<0.01	<0.01	2/0	<0.01	<0.01	<0.01
Total phosphorus	mg/L	0.020	3/2	<0.01	**0.04**	**0.06**	7/1	<0.01	<0.01	**1.12**	2/1	0.02	**0.03**	**0.03**

Table D.18 Baseline water quality results summary: Minor watercourses (LH_SW_008, LH_SW_009)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	3/0	<1	<1	1	7/0	<1	<1	2	2/0	7	8	8
Dissolved organic carbon	mg/L	-	3/0	1	1	1	7/0	<1	2	5	2/0	7	8	8
Analytical results – inorganics														
Cyanide	mg/L	0.004	3/0	<0.004	<0.004	<0.004	5/0	<0.004	<0.004	<0.004	2/0	<0.004	<0.004	<0.004
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	3/0	<0.01	<0.01	<0.01	7/1	<0.01	0.02	**0.10**	2/2	**0.10**	**0.14**	**0.17**
Arsenic (As)	mg/L	0.0008[2,6]	3/0	<0.001	<0.001	<0.001	7/1	<0.001	<0.001	**0.002**	2/0	<0.001	<0.001	<0.001
Barium (Ba)	mg/L	-	3/0	0.014	0.015	0.020	7/0	0.010	0.011	0.017	2/0	0.012	0.013	0.013
Beryllium (Be)	mg/L	-	3/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	2/0	<0.001	<0.001	<0.001
Boron (B)	mg/L	0.09	3/0	<0.05	<0.05	<0.05	7/0	<0.05	<0.05	<0.05	2/0	<0.05	<0.05	<0.05
Cadmium (Cd)	mg/L	0.00006[6]	3/0	<0.0001	<0.0001	<0.0001	7/0	<0.0001	<0.0001	<0.0001	2/0	<0.0001	<0.0001	<0.0001
Total chromium (Cr)	mg/L	0.00001[3,6]	3/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	2/0	<0.001	<0.001	<0.001
Cobalt (Co)	mg/L	0.0014[4]	3/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	2/0	<0.001	<0.001	<0.001
Copper (Cu)	mg/L	0.001	3/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	0.001	2/0	<0.001	<0.001	<0.001
Iron (Fe)	mg/L	0.3[4]	3/0	<0.05	<0.05	<0.05	7/0	<0.05	<0.05	0.06	2/0	0.14	0.18	0.21
Lead (Pb)	mg/L	0.001	3/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	2/0	<0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.2	3/0	<0.001	<0.001	0.020	7/0	<0.001	<0.001	0.001	2/0	0.002	0.002	0.002
Mercury (Hg)	mg/L	0.00006[6]	3/0	<0.0001	<0.0001	<0.0001	7/0	<0.0001	<0.0001	<0.0001	2/0	<0.0001	<0.0001	<0.0001

Table D.18 Baseline water quality results summary: Minor watercourses (LH_SW_008, LH_SW_009)

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.008	3/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	0.002	2/0	<0.001	<0.001	<0.001
Selenium (Se)	mg/L	0.005[6]	3/0	<0.01	<0.01	<0.01	7/0	<0.01	<0.01	<0.01	2/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	3/0	<0.001	<0.001	<0.001	7/0	<0.001	<0.001	<0.001	2/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	3/0	<0.01	<0.01	<0.01	7/0	<0.01	<0.01	<0.01	2/0	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	3/0	<0.005	<0.005	<0.005	7/0	<0.005	<0.005	<0.005	2/0	<0.005	<0.005	<0.005

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.19 Baseline water quality results summary: Wet weather sampling (March 2019)

			Receiving water		Access track					Mine workings	Access track			
	Unit	WQO value[1]	LH_WW_006	LH_WW_007	WW_1	WW_2	WW_3	WW_4	WW_5	WW_6	WW_7	WW_8	WW_9	WW_10
Field Parameters														
Temperature	°C	-	17.8	17.1	17.4	17.3	16.8	16.3	16.7	17.5	18.0	18.9	18.5	18.0
Dissolved oxygen	%	90-110	**82**	92	**81**	**74**	**83**	**72**	**81**	**71**	**80**	**68**	**74**	**87**
Electrical conductivity	µS/cm	30-350	155	154	10	33	12	17	53	24	20	10	19	78
pH	-	6.5-8.0	6.9	**6.2**	**5.9**	**5.2**	**5.0**	**5.3**	7.4	**6.1**	**6.0**	**5.6**	7.4	**6.1**
Oxidising and reducing potential	-	-	78	96	115	159	159	132	71	168	137	124	66	145
Turbidity	NTU	2-25	17	14	**3311**	**1216**	**4229**	**925**	**974**	**186**	**1993**	**1370**	**1336**	**2232**
Analytical results – general														
Suspended solids	mg/L	-	<5	10	1200	379	1200	605	705	77	436	184	390	1340
Total hardness (as $CaCO_3$)	mg/L	-	76	78	<1	5	<1	<1	22	<1	<1	<1	2	34
Total alkalinity (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	<0.01	<0.01	0.01	<0.01	**0.04**	<0.01	**0.04**	**0.08**	<0.01	**0.02**	0.01	**0.02**
Oxidised nitrogen	mg/L	0.015	**0.03**	0.01	**0.03**	<0.01	**0.14**	**0.02**	**0.18**	**0.40**	<0.01	**0.07**	**0.06**	**0.22**

Table D.19 Baseline water quality results summary: Wet weather sampling (March 2019)

			Receiving water			Access track					Mine workings		Access track		
	Unit	WQO value[1]	LH_WW_006	LH_WW_007	WW_1	WW_2	WW_3	WW_4	WW_5	WW_6	WW_7	WW_8	WW_9	WW_10
Total kjeldahl nitrogen	mg/L	-	<0.1	<0.1	3.1	1.3	2.9	2.6	6.7	1.1	2.0	1.6	2.7	5.3
Total nitrogen	mg/L	0.25	<0.1	<0.1	**3.1**	**1.3**	**3.0**	**2.6**	**6.9**	**1.5**	**2.0**	**1.7**	**2.8**	**5.5**
Reactive phosphorus	mg/L	0.015	<0.01	<0.01	0.01	**0.02**	<0.01	<0.01	**0.11**	**0.03**	<0.01	<0.01	<0.01	<0.01
Total phosphorus	mg/L	0.020	<0.01	<0.01	**0.71**	**0.41**	**0.86**	**0.30**	**1.10**	**0.22**	**0.73**	**0.52**	**0.82**	**0.97**
Total organic carbon	mg/L	-	2	2	16	28	15	25	14	7	30	11	15	16
Dissolved organic carbon	mg/L	-	4	3	16	24	10	19	8	8	24	8	13	17
Analytical results – inorganics														
Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.027	<0.01	0.01	**0.23**	**0.42**	**0.22**	**0.64**	**0.33**	**0.38**	**2.85**	**0.27**	**0.22**	**0.57**
Arsenic (As)	mg/L	0.0008[2,5]	<0.001	<0.001	<0.001	**0.001**	<0.001	<0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	**0.001**
Barium (Ba)	mg/L	-	0.029	0.029	0.005	0.056	0.016	0.02	0.011	0.027	0.031	0.006	0.042	0.019
Beryllium (Be)	mg/L	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron (B)	mg/L	0.09	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium (Cd)	mg/L	0.00006[5]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total chromium (Cr)	mg/L	0.00001[3,5]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table D.19 Baseline water quality results summary: Wet weather sampling (March 2019)

			Receiving water		Access track					Mine workings	Access track			
	Unit	**WQO value[1]**	**LH_WW_006**	**LH_WW_007**	**WW_1**	**WW_2**	**WW_3**	**WW_4**	**WW_5**	**WW_6**	**WW_7**	**WW_8**	**WW_9**	**WW_10**
Cobalt (Co)	mg/L	0.0014[4]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001
Copper (Cu)	mg/L	0.001	**0.008**	**0.027**	<0.001	**0.531**	**0.037**	**0.006**	**0.008**	**0.381**	**0.02**	**0.002**	**0.003**	**0.159**
Iron (Fe)	mg/L	0.3[4]	<0.05	<0.05	0.08	**0.31**	0.11	**0.36**	0.2	0.2	**0.33**	0.25	0.12	**0.65**
Lead (Pb)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.002**	0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.2	0.004	0.006	0.055	0.14	0.026	0.111	0.008	0.065	0.106	0.081	0.248	0.046
Mercury (Hg)	mg/L	0.00006[5]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel (Ni)	mg/L	0.008	<0.001	<0.001	<0.001	0.003	<0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	<0.001
Selenium (Se)	mg/L	0.005[5]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[5]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,5]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[5]	<0.005	**0.005**	<0.005	<0.005	<0.005	**0.007**	<0.005	**0.014**	<0.005	<0.005	<0.005	<0.005

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
6. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.20 Baseline water quality results summary: Wet weather sampling (May 2019)

			Receiving water						Access track							
	Unit	**WQO value[1]**	**LH_SW_004**	**LH_SW_005**	**LH_SW_006**	**LH_SW_007**	**LH_SW_008**	**LH_SW_009**	**WW_11**	**WW_12**	**WW_13**	**WW_14**	**WW_15**	**WW_16**	**WW_17**	**WW_18**
Field Parameters																
Temperature	°C	-	15.7	16.7	14.5	15.8	14.0	14.5	19.4	15.6	16.1	18.0	16.5	15.3	17.0	19.4
Dissolved oxygen	%	90-110	**0**	**1**	**61**	**32**	**59**	**57**	**53**	**33**	**46**	**53**	**0**	**33**	**4**	**0**
Electrical conductivity	µS/cm	30-350	89	**783**	116	103	70	74	8	34	26	16	35	39	76	13
pH	-	6.5-8.0	7.3	6.8	7.9	7.5	7.7	7.1	7.3	**4.7**	7.1	8.0	**4.1**	**5.8**	**5.7**	**5.6**
Oxidising and reducing potential	-	-	107	116	157	90	165	173	139	219	166	142	260	176	187	167
Turbidity	NTU	2-25	**42**	**1**	6	**7**	5	6	**1431**	**110**	**1553**	**519**	**34**	**643**	**125**	**132**
Analytical results – general																
Suspended solids	mg/L	-	148	5	6	24	<5	<5	464	120	458	2720	20	304	154	111
Total hardness (as $CaCO_3$)	mg/L	-	43	402	51	43	28	30	<1	5	5	<1	2	5	27	<1
Total alkalinity (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Analytical results – nutrients																
Ammonia	mg/L	0.013	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.04**	<0.01	<0.01	<0.01	<0.01
Oxidised nitrogen	mg/L	0.015	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.24**	<0.01	<0.01	**0.97**	**0.95**	**0.09**	**1.60**	**0.11**
Total kjeldahl nitrogen	mg/L	-	2.1	0.2	0.1	0.5	0.3	0.3	0.9	0.6	3.3	6.7	0.6	0.8	1.2	1.2
Total nitrogen	mg/L	0.25	**2.1**	0.2	0.1	**0.5**	**0.3**	**0.3**	**1.1**	**0.6**	**3.3**	**7.7**	**1.6**	**0.9**	**2.8**	**1.3**

Table D.20 Baseline water quality results summary: Wet weather sampling (May 2019)

			Receiving water						Access track							
	Unit	WQO value[1]	LH_SW_ 004	LH_SW_ 005	LH_SW_ 006	LH_SW_ 007	LH_SW_ 008	LH_SW_ 009	WW_11	WW_12	WW_13	WW_14	WW_15	WW_16	WW_17	WW_18
Reactive phosphorus	mg/L	0.015	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Total phosphorus	mg/L	0.020	**0.2**	<0.01	0.02	**0.03**	0.02	**0.03**	**0.59**	**0.26**	**1.04**	**2.64**	**0.08**	**0.28**	**0.20**	**0.14**
Total organic carbon	mg/L	-	4	3	2	3	7	8	2	11	14	5	5	8	8	7
Dissolved organic carbon	mg/L	-	4	5	2	3	7	8	6	10	12	4	5	9	9	7
Analytical results – inorganics																
Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Analytical results – metals (dissolved)																
Aluminium (Al)	mg/L	0.027	0.01	<0.01	<0.01	<0.01	**0.1**	**0.17**	**0.13**	**0.67**	**1.07**	**0.06**	**0.31**	**0.15**	**0.07**	**0.46**
Arsenic (As)	mg/L	0.0008[2,5]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**
Barium (Ba)	mg/L	-	0.013	0.113	0.024	0.02	0.012	0.013	<0.001	0.056	0.016	0.007	0.044	0.029	0.053	0.009
Beryllium (Be)	mg/L	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron (B)	mg/L	0.09	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium (Cd)	mg/L	0.00006[5]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total chromium (Cr)	mg/L	0.00001[3,5]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt (Co)	mg/L	0.0014[4]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.002**	<0.001	<0.001	<0.001
Copper (Cu)	mg/L	0.001	**0.003**	**0.01**	**0.006**	**0.002**	<0.001	<0.001	<0.001	**0.319**	**0.004**	<0.001	**0.665**	<0.001	**0.003**	<0.001
Iron (Fe)	mg/L	0.3[4]	<0.05	<0.05	<0.05	<0.05	0.14	0.21	0.06	**0.6**	**0.88**	<0.05	0.13	0.06	0.08	**0.35**
Lead (Pb)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001

Table D.20 Baseline water quality results summary: Wet weather sampling (May 2019)

			Receiving water						Access track							
	Unit	**WQO value[1]**	**LH_SW_ 004**	**LH_SW_ 005**	**LH_SW_ 006**	**LH_SW_ 007**	**LH_SW_ 008**	**LH_SW_ 009**	**WW_11**	**WW_12**	**WW_13**	**WW_14**	**WW_15**	**WW_16**	**WW_17**	**WW_18**
Manganese (Mn)	mg/L	1.2	0.004	0.002	0.002	0.002	0.002	0.002	<0.001	0.074	0.09	0.025	0.095	0.061	0.029	0.007
Mercury (Hg)	mg/L	0.00006[5]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel (Ni)	mg/L	0.008	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	0.002	<0.001	0.001	<0.001	<0.001	<0.001
Selenium (Se)	mg/L	0.005[5]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[5]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,5]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[5]	**0.006**	**0.006**	<0.005	<0.005	<0.005	<0.005	<0.005	**0.007**	**0.009**	<0.005	**0.012**	<0.005	<0.005	<0.005

Notes:
1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for the protection of 99% of aquatic species.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
6. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.

Bold denotes WQO value is exceeded.

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Table D.21 Baseline water quality results summary: Camerons Creek (TRL_SW_001)

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	3/0	10.8	14.9	21.0	1/0	10.9	10.9	10.9	1/0	13.6	13.6	13.6
Dissolved oxygen	%	90-110[1]	2/2	**60**	**60**	**61**	1/1	**31**	**31**	**31**	1/1	**60**	**60**	**60**
Electrical conductivity	µS/cm	30-350[1]	3/0	60	65	124	1/0	67	67	67	1/0	68	68	68
pH	-	6.5-8.0[1]	3/0	6.6	6.9	7.0	1/0	6.6	6.6	6.6	1/0	7.0	7.0	7.0
Oxidising and reducing potential	-	-	3/0	25	49	134	1/0	172	172	172	1/0	156	156	156
Turbidity	NTU	2-25[1]	3/1	1.3	13.2	**38.2**	1/0	14.4	14.4	14.4	1/0	14.0	14.0	14.0
Analytical results – general														
Suspended solids	mg/L	-	3/0	6	6	37	1/0	13	13	13	1/0	7	7	7
Total hardness (as $CaCO_3$)	mg/L	-	3/0	13	17	30	1/0	11	11	11	1/0	13	13	13
Total alkalinity (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.013	3/3	**0.05**	**0.19**	**0.20**	1/1	**0.06**	**0.06**	**0.06**	1/0	<0.01	<0.01	<0.01
Oxidised nitrogen	mg/L	0.015	3/3	**0.03**	**0.07**	**0.09**	1/0	<0.01	<0.01	<0.01	1/0	0.01	0.01	0.01
Total kjeldahl nitrogen	mg/L	-	3/0	0.8	0.8	1.2	1/0	0.6	0.6	0.6	1/0	0.8	0.8	0.8
Total nitrogen	mg/L	0.25	3/3	**0.8**	**0.9**	**1.3**	1/1	**0.6**	**0.6**	**0.6**	1/1	**0.8**	**0.8**	**0.8**
Reactive phosphorus	mg/L	0.015	3/1	<0.01	0.01	**0.04**	1/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01
Total phosphorus	mg/L	0.020	3/3	**0.07**	**0.08**	**0.09**	1/1	**0.25**	**0.25**	**0.25**	1/1	**0.05**	**0.05**	**0.05**

Table D.21 Baseline water quality results summary: Camerons Creek (TRL_SW_001)

	Unit	WQO value[1]	Summer/autumn dry weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	Winter/spring dry weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	Wet weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	3/0	6	6	8	1/0	4	4	4	1/0	9	9	9
Dissolved organic carbon	mg/L	-	3/0	5	6	8	1/0	4	4	4	1/0	10	10	10
Analytical results – inorganics														
Cyanide	mg/L	0.007	3/0	<0.004	<0.004	<0.004	1/0	<0.004	<0.004	<0.004	1/0	<0.004	<0.004	<0.004
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.055	3/3	**0.19**	**0.24**	**0.26**	1/1	**0.18**	**0.18**	**0.18**	1/1	**0.13**	**0.13**	**0.13**
Arsenic (As)	mg/L	0.013[2]	3/0	0.001	0.002	0.002	1/0	0.001	0.001	0.001	1/0	<0.001	<0.001	<0.001
Barium (Ba)	mg/L	-	3/0	0.010	0.011	0.018	1/0	0.003	0.003	0.003	1/0	0.012	0.012	0.012
Beryllium (Be)	mg/L	-	3/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Boron (B)	mg/L	0.37	3/0	<0.05	<0.05	<0.05	1/0	<0.05	<0.05	<0.05	1/0	<0.05	<0.05	<0.05
Cadmium (Cd)	mg/L	0.0002[6]	3/0	<0.0001	<0.0001	<0.0001	1/0	<0.0001	<0.0001	<0.0001	1/0	<0.0001	<0.0001	<0.0001
Total chromium (Cr)	mg/L	0.001[3,6]	3/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Cobalt (Co)	mg/L	0.0014[4]	3/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Copper (Cu)	mg/L	0.0014	3/1	<0.001	0.001	**0.002**	1/0	<0.001	<0.001	<0.001	1/1	**0.004**	**0.004**	**0.004**
Iron (Fe)	mg/L	0.3[4]	3/3	**0.47**	**0.70**	**1.27**	1/0	0.28	0.28	0.28	1/1	**0.39**	**0.39**	**0.39**
Lead (Pb)	mg/L	0.0034	3/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.9	3/0	0.014	0.017	0.090	1/0	0.006	0.006	0.006	1/0	0.013	0.013	0.013
Mercury (Hg)	mg/L	0.00006[6]	3/0	<0.0001	<0.0001	<0.0001	1/0	<0.0001	<0.0001	<0.0001	1/0	<0.0001	<0.0001	<0.0001

Table D.21 Baseline water quality results summary: Camerons Creek (TRL_SW_001)

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.011	3/0	0.001	0.001	0.002	1/0	<0.001	<0.001	<0.001	1/0	0.003	0.003	0.003
Selenium (Se)	mg/L	0.005[6]	3/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00005[6]	3/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001	1/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	3/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01	1/0	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.008[6]	3/0	<0.005	<0.005	<0.005	1/0	<0.005	<0.005	<0.005	1/0	0.008	0.008	0.008

Notes:
1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for slightly – moderately disturbed ecosystems.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.

Bold denotes WQO value is exceeded.

D.2.2 Reservoirs

Table D.22 Baseline water quality results summary: Talbingo Reservoir

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	23/0	8.6	18.1	27.5	36/0	6.3	12.2	21.2	-	-	-	-
Dissolved oxygen	%	90-110[1]	8/0	99	101	107	12/0	99	100	103	-	-	-	-
Electrical conductivity	µS/cm	20-30[1]	23/9	18	27	**41**	36/11	13	22	**35**	-	-	-	-
pH	-	6.5-8.0[1]	23/4	**6.3**	7.0	8.0	36/14	7.7	8.0	**8.2**	-	-	-	-
Oxidising and reducing potential	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	1-20[1]	8/0	1.0	1.4	1.5	12/0	1.0	1.1	1.3	-	-	-	-
Analytical results – general														
Suspended solids	mg/L	-	23/0	<1	2	5	36/0	<1	<1	5	-	-	-	-
Total hardness (as $CaCO_3$)	mg/L	-	15/0	6	7	10	24/0	5	5	12	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	15/0	<20	<20	<20	24/0	9	10	14	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.01	23/0	<0.005	<0.01	<0.01	28/20	<0.005	**0.015**	**0.027**	-	-	-	-
Oxidised nitrogen	mg/L	0.01	23/4	<0.002	<0.05	**0.058**	28/23	<0.002	**0.027**	**0.044**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	23/0	<0.2	<0.2	0.20	28/0	0.07	0.09	0.23	-	-	-	-
Total nitrogen	mg/L	0.35	23/0	<0.2	<0.2	0.20	28/1	0.11	0.12	0.23	-	-	-	-
Reactive phosphorus	mg/L	0.005	23/1	<0.05	<0.05	**0.050**	28/1	0.002	0.002	0.003	-	-	-	-
Total phosphorus	mg/L	0.01	8/8	**0.017**	**0.026**	**0.039**	28/7	0.010	0.010	**0.020**	-	-	-	-

Table D.22 Baseline water quality results summary: Talbingo Reservoir

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	15/0	<5	<5	<5	24/0	1	1	2	-	-	-	-
Dissolved organic carbon	mg/L	-	15/0	<5	<5	<5	24/0	1	2	2	-	-	-	-
Analytical results – inorganics														
Cyanide	mg/L	0.007	-	-	-	-	-	-	-	-	-	-	-	-
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.055	23/0	<0.01	<0.05	0.05	36/0	<0.01	0.01	0.03	-	-	-	-
Arsenic (As)	mg/L	0.013[2]	23/0	<0.001	<0.001	0.001	36/0	<0.001	<0.001	<0.001	-	-	-	-
Barium (Ba)	mg/L	-	23/0	<0.02	<0.02	0.020	36/0	0.005	0.007	0.013	-	-	-	-
Beryllium (Be)	mg/L	-	23/0	<0.001	<0.001	<0.001	36/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.37	23/0	<0.05	<0.05	<0.05	36/0	<0.05	<0.05	<0.05	-	-	-	-
Cadmium (Cd)	mg/L	0.0002	23/0	<0.0001	<0.0002	<0.0002	36/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Total chromium (Cr)	mg/L	0.001[3]	23/4	<0.001	<0.001	**0.002**	36/0	<0.001	<0.001	<0.001	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	23/0	<0.001	<0.001	<0.001	36/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)[9]	mg/L	0.0014	23/10	<0.001	<0.001	**0.046**	36/1	<0.001	<0.001	<0.001	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	23/0	<0.05	<0.05	<0.05	36/0	<0.05	<0.05	<0.05	-	-	-	-
Lead (Pb)	mg/L	0.0034	23/1	<0.001	<0.001	0.003	36/0	<0.001	<0.001	<0.001	-	-	-	-
Manganese (Mn)	mg/L	1.9	23/0	<0.001	<0.005	<0.005	36/0	<0.001	<0.001	0.003	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	23/0	<0.0001	<0.0001	<0.0001	36/0	<0.0001	<0.0001	<0.0001	-	-	-	-

Table D.22 Baseline water quality results summary: Talbingo Reservoir

			Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.011	23/0	<0.001	<0.001	0.004	36/0	<0.001	<0.001	<0.001	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	23/0	<0.001	<0.001	<0.01	36/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00005	23/0	<0.001	<0.005	<0.005	36/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	23/0	<0.005	<0.005	<0.01	36/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)[9]	mg/L	0.008	23/12	<0.005	**0.010**	**0.058**	36/1	<0.005	<0.005	<0.005	-	-	-	-

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (freshwater lakes and reservoirs) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for slightly – moderately disturbed ecosystems.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
8. Where more than one LOR has been used in the reporting of an analyte, the lowest and highest LOR are considered in calculating 10th percentile, median and 90th percentile values.
9. It is noted that all but one of the copper exceedances and two of the zinc exceedances occurred during March 2018 sampling, where 80% of samples exceeded the WQO values. Different analysis methods (consistent with the methods applied more broadly to EIS sampling) were applied to subsequent sampling.
Bold denotes WQO value is exceeded.

Table D.23 Baseline water quality results summary: Tantangara Reservoir

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters														
Temperature	°C	-	23/0	17.5	17.7	23.1	27/0	8.5	10.1	16.7	-	-	-	-
Dissolved oxygen	%	90-110[1]	8/3	**86**	91	92	12/0	90	94	96	-	-	-	-
Electrical conductivity	µS/cm	20-30[1]	23/0	22	22	26	27/0	13	14	23	-	-	-	-
pH	-	6.5-8.0[1]	23/1	6.6	6.7	7.6	27/1	7.4	7.8	8.0	-	-	-	-
Oxidising and reducing potential	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	1-20[1]	8/0	1.9	2.4	3.0	12/0	1.1	1.6	2.0	-	-	-	-
Analytical results – general														
Suspended solids	mg/L	-	23/0	<1	4	6	27/0	<1[8]	<5[8]	5	-	-	-	-
Total hardness (as $CaCO_3$)	mg/L	-	15/0	<5	5	6	15/0	2	2	2	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	15/0	<20	<20	<20	15/0	8	8	8	-	-	-	-
Analytical results – nutrients														
Ammonia	mg/L	0.01	22/3	<0.005[8]	<0.01[8]	**0.019**	19/0	<0.005	<0.005	0.006	-	-	-	-
Oxidised nitrogen	mg/L	0.01	22/3	<0.002[8]	<0.05[8]	**0.050**	19/0	<0.002	0.004	0.007	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	22/0	<0.2	0.20	0.39	19/0	0.10	0.11	0.30	-	-	-	-
Total nitrogen	mg/L	0.35	22/3	<0.2	0.20	**0.39**	19/0	0.10	0.11	0.30	-	-	-	-
Reactive phosphorus	mg/L	0.005	22/2	<0.001[8]	<0.05[8]	**0.050**	19/1	<0.001	<0.001	0.002	-	-	-	-
Total phosphorus	mg/L	0.01	8/8	**0.024**	**0.028**	**0.042**	19/7	0.008	0.009	**0.020**	-	-	-	-

Table D.23 Baseline water quality results summary: Tantangara Reservoir

	Unit	WQO value[1]	Summer/autumn dry weather conditions				Winter/spring dry weather conditions				Wet weather conditions			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total organic carbon	mg/L	-	15/0	<5	<5	<5	15/0	2	2	2	-	-	-	-
Dissolved organic carbon	mg/L	-	15/0	<5	<5	<5	15/0	2	2	2	-	-	-	-
Analytical results – inorganics														
Cyanide	mg/L	**0.007**	-	-	-	-	-	-	-	-	-	-	-	-
Analytical results – metals (dissolved)														
Aluminium (Al)	mg/L	0.055	23/8	<0.05	0.05	**0.13**	27/27	**0.06**	**0.07**	**0.08**	-	-	-	-
Arsenic (As)	mg/L	0.013[2]	23/0	<0.001	<0.001	0.001	27/0	<0.001	<0.001	<0.001	-	-	-	-
Barium (Ba)	mg/L	-	23/0	<0.02	<0.02	0.020	27/0	0.007	0.007	0.008	-	-	-	-
Beryllium (Be)	mg/L	-	23/0	<0.001	<0.001	<0.001	27/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.37	23/0	<0.05	<0.05	<0.05	27/0	<0.05	<0.05	<0.05	-	-	-	-
Cadmium (Cd)	mg/L	0.0002	23/0	<0.0001[8]	<0.0002[8]	<0.0002[8]	27/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Total chromium (Cr)	mg/L	0.001[3]	23/2	<0.001	<0.001	0.001	27/0	<0.001	<0.001	<0.001	-	-	-	-
Cobalt (Co)	mg/L	**0.0014[4]**	23/1	<0.001	<0.001	<0.001	27/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)[9]	mg/L	0.0014	23/15	<0.001	**0.015**	**0.053**	27/0	<0.001	<0.001	<0.001	-	-	-	-
Iron (Fe)	mg/L	**0.3[4]**	23/19	0.26	**0.57**	**0.70**	27/0	0.18	0.19	0.20	-	-	-	-
Lead (Pb)	mg/L	0.0034	23/2	<0.001	0.001	0.003	27/0	<0.001	<0.001	<0.001	-	-	-	-
Manganese (Mn)	mg/L	1.9	23/0	0.001	0.019	0.043	27/0	<0.001	0.003	0.008	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	23/0	<0.0001	<0.0001	<0.0001	27/0	<0.0001	<0.0001	<0.0001	-	-	-	-

Table D.23 Baseline water quality results summary: Tantangara Reservoir

	Unit	WQO value[1]	Summer/autumn dry weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	Winter/spring dry weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	Wet weather conditions # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Nickel (Ni)	mg/L	0.011	23/0	<0.001	0.002	0.004	27/0	<0.001	<0.001	<0.001	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	23/0	<0.001[8]	<0.001[8]	<0.01[8]	27/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00005	23/0	<0.001[8]	<0.005[8]	<0.005[8]	27/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	23/0	<0.005[8]	<0.005[8]	<0.01[8]	27/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)[9]	mg/L	0.008	23/15	<0.005	**0.018**	**0.081**	27/0	<0.005	<0.005	<0.005	-	-	-	-

Notes:
1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (freshwater lakes and reservoirs) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000). Toxicant trigger values are for slightly – moderately disturbed ecosystems.
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (LOR) (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for turbidity and electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
8. Where more than one LOR has been used in the reporting of an analyte, the lowest and highest LOR are considered in calculating 10th percentile, median and 90th percentile values.
9. It is noted that all but one of the copper exceedances and two of the zinc exceedances occurred during March 2018 sampling, where 80% of samples exceeded the WQO values. Different analysis methods (consistent with the methods applied more broadly to EIS sampling) were applied to subsequent sampling.

Bold denotes WQO value is exceeded.

The following streamflow statistics have been extracted from the Snowy 2.0 Main Works EIS Appendix J Annexure A Water Characterisation Report.

Table 1: Annual streamflow statistics - plateau (EMM, 2019)

	Murrumbidgee River (410535)		Eucumbene River (222522)	
	Annual runoff	Runoff coefficient[1]	Annual runoff	Runoff coefficient[2]
Gauge record[3]	1978 - 2019		1978 - 2019	
Minimum	20 GL/year	15% of rainfall	26 GL/year	23% of rainfall
10th percentile	88 GL/year	38% of rainfall	102 GL/year	41% of rainfall
50th percentile	126 GL/year	49% of rainfall	137 GL/year	56% of rainfall
Average	144 GL/year	50% of rainfall	148 GL/year	57% of rainfall
90th percentile	210 GL/year	63% of rainfall	214 GL/year	75% of rainfall
Maximum	236 GL/year	76% of rainfall	232 GL/year	90% of rainfall

Notes: 1. The runoff coefficient has been calculated using rainfall from the Yarrangobilly Caves (72141) rainfall record, adjusted to reflect median rainfall contours in each catchment.

2. The runoff coefficient has been calculated using rainfall from the Cabramurra (72161) rainfall record, adjusted to reflect median rainfall contours in each catchment.

3. Record period based on the record available in electronic format. Earlier data may be available in non-electronic format.

Table 2: Annual streamflow statistics - ravine (EMM, 2019)

	Yarrangobilly River (410574)		Wallaces Creek (410507)		Brownleys Back Creek (600577)	
	Annual runoff	Runoff coefficient[1]	Annual runoff	Runoff coefficient[1]	Annual runoff	Runoff coefficient[1]
Record[2]	1985 – 2019		1982 - 1999		1984 - 2019	
Minimum	15 GL/year	10% of rainfall	8 GL/year	20% of rainfall	3 GL/year	14% of rainfall
10th percentile	58 GL/year	21% of rainfall	9 GL/year	22% of rainfall	8 GL/year	20% of rainfall
50th percentile	99 GL/year	31% of rainfall	20 GL/year	41% of rainfall	17 GL/year	34% of rainfall
Average	115 GL/year	32% of rainfall	19 GL/year	37% of rainfall	20 GL/year	36% of rainfall
90th percentile	184 GL/year	47% of rainfall	28 GL/year	48% of rainfall	31 GL/year	54% of rainfall
Maximum	235 GL/year	53% of rainfall	32 GL/year	59% of rainfall	38 GL/year	62% of rainfall

Notes: 1. The runoff coefficient has been calculated using rainfall from the Yarrangobilly Caves (72141) rainfall record, adjusted to reflect mean rainfall contours.

2. Record period based on the record available in electronic format. Earlier data may be available in non-electronic format.

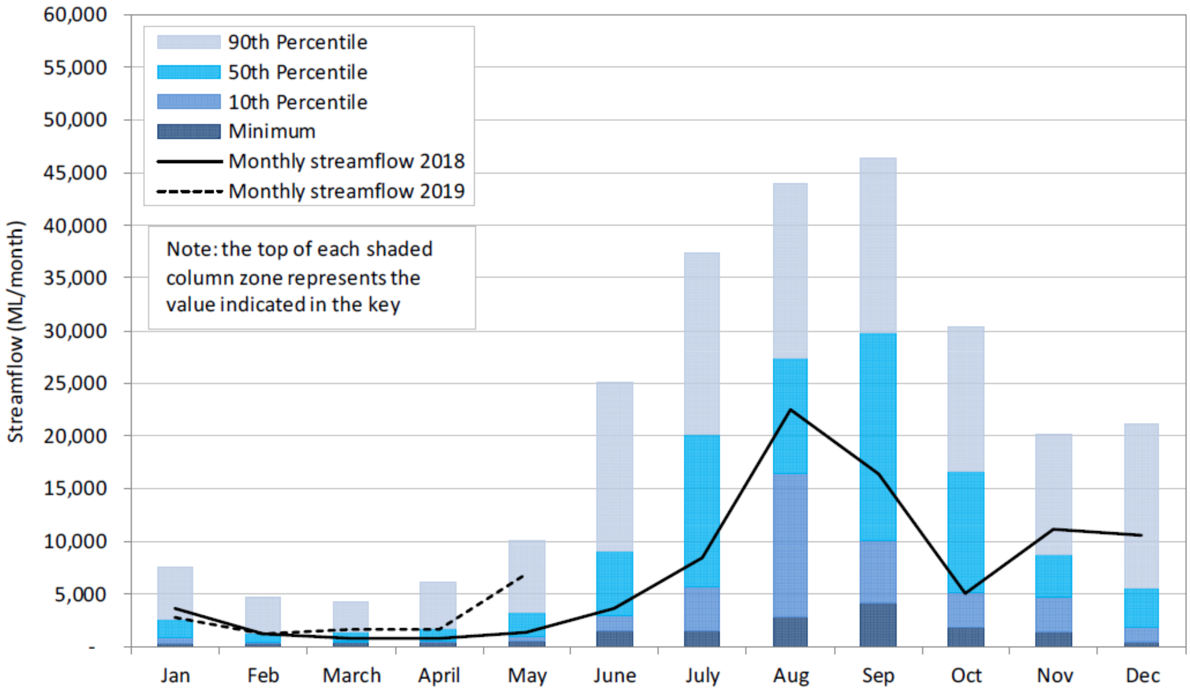


Figure 1: Monthly streamflow statistics (1978 to 2019) (Murrumbidgee River – 410535) (EMM, 2019)

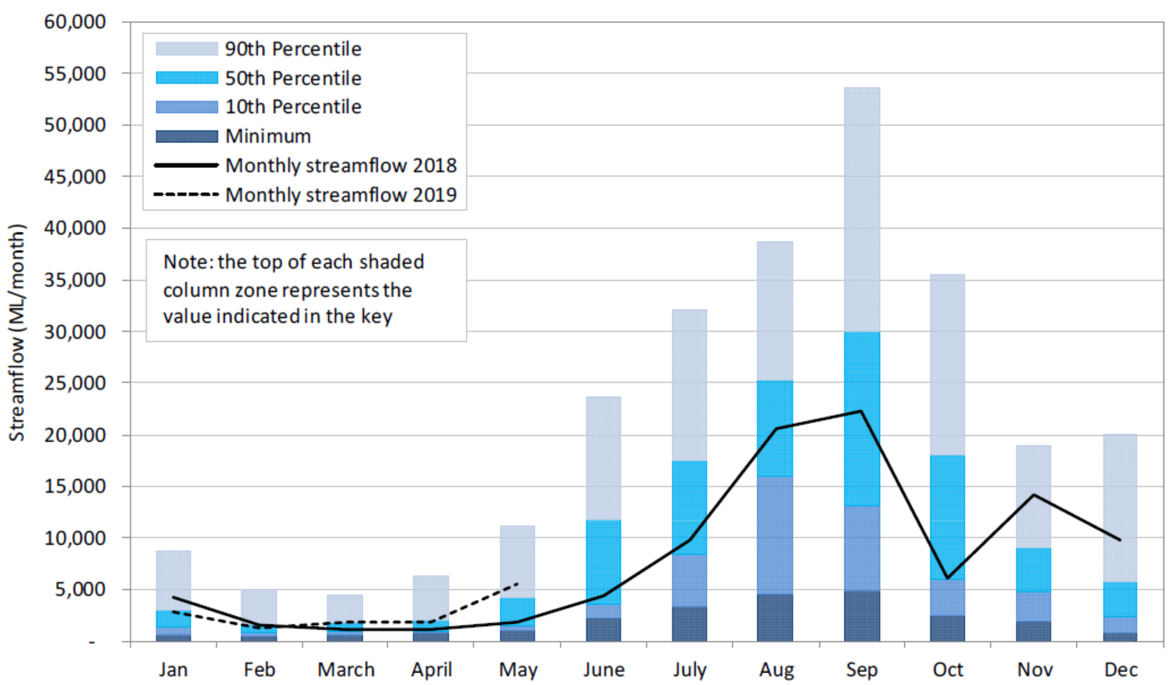


Figure 2: Monthly streamflow statistics (1978 to 2019) (Eucumbene River – 222522) (EMM, 2019)

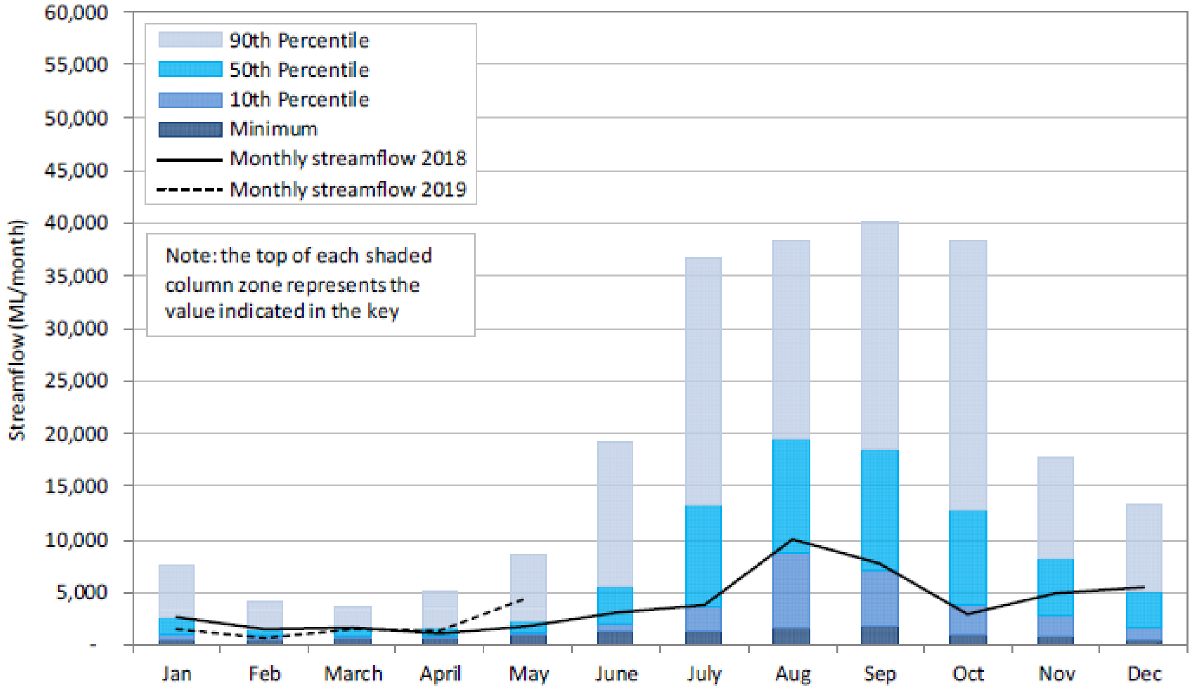


Figure 3: Monthly streamflow statistics (1978 to 2019) (Yarrangobilly River – 410535) (EMM, 2019)

ATTACHMENT C – RATIONALISATION OF EPL 21266 MONITORING LOCATIONS

Rationalisation of existing EPL 21266 monitoring locations

Monitoring locations specified in EPL 21266 were reviewed and rationalised based on the following criteria:

- **Site duplication:** this was assessed based on the need for the monitoring site network to capture key inputs to Yarrangobilly River, specifically, significant tributaries and sediment basin overflow points. In this sense, having two sites between two significant inputs was considered to be duplicative and unnecessary. Where relevant, water quality data from the Exploratory Works monitoring program were assessed and compared; and
- **Resolution for identifying sources:** The level of resolution was assessed in relation to the ability of the monitoring network to identify sources of contaminants to Yarrangobilly River in the event an exceedance occurred in Yarrangobilly River.

The outcomes of this assessment are detailed in Table C.1 and its supporting figures.

Table C.1 Basis for rationalisation of existing EPL monitoring sites in Lobs Hole

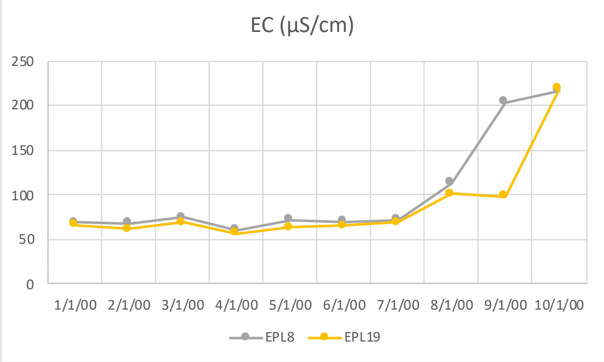
EPL site no. (SHL site no.)	EPL site description	Proposed change	Rationale
5 (RW-1)	Yarrangobilly River, upstream of the exploratory tunnel and construction pad	NO CHANGE	
12 (RW-8)	Yarrangobilly River, immediately downstream of portal pad	NO CHANGE	
7 (RW-3)	Wallaces Creek, upstream of Yarrangobilly River and Wallaces Creek confluence	Change from a routine (monthly and wet weather) site to a TARP site, such that it is only sampled if the next downstream site, EPL-6, records a basic water quality exceedance.	• There is no need to sample this upstream site if no exceedance is recorded at EPL-6.
6 (RW-2)	Wallaces Creek, upstream of Yarrangobilly River and Wallaces Creek confluence	NO CHANGE	
14 (RW-10)	Yarrangobilly River, downstream of road construction	NO CHANGE	
15 (RW-11)	Yarrangobilly River, downstream of road construction areas	NO CHANGE	
17 (RW-13)	Lick Hole Gully, upstream of Mine Trail Road	Change from a routine (monthly and wet weather) site to a TARP site, such that it is only sampled if the next downstream site, EPL-18, records a basic water quality exceedance.	• There is no need to sample this upstream site if no exceedance is recorded at EPL-18.
18 (RW-14)	Lick Hole Gully, upstream of the confluence with the Yarrangobilly River	Change from a routine (monthly and wet weather) site to a TARP site, such that it is only sampled if the next downstream site, EPL-8, records a basic water quality exceedance. Also, move site back up into Lick Hole Gully, as it was recently moved into Yarrangobilly Creek at the confluence with Lick Hole Gully.	• There is no need to sample this upstream site if no exceedance is recorded at EPL-8. • The site acts as an indicator of water quality coming out of Lick Hole Gully, so needs to be located in Lick Hole Gully.
8 (RW-4)	Yarrangobilly River, downstream of Lick Hole Gully	NO CHANGE	

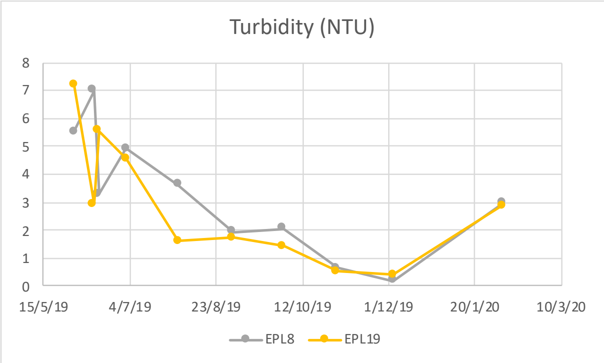
EPL site no. (SHL site no.)	EPL site description	Proposed change	Rationale
19	Yarrangobilly River, adjacent to Western Emplacement Area	Remove site from monitoring program	• EPL19 is considered to represent duplication in the monitoring site network because there are no significant inputs to Yarrangobilly River, including sediment basin overflow points, between EPL19 and EPL8. Downstream of EPL19, there is a sediment basin overflow point, the influence of which will be captured by the next downstream site, EPL16. • EPL19 and EPL8 share similar water quality, as shown in Figures C.1 and C.2. There is one exception for copper in April 2020, where the concentration at EPL19 was higher than EPL8, and similar to EPL15 for the same sampling period. The cause of this is currently being investigated. Pending the outcome of the investigation of the anomalous copper result, the current view is that there is no need to retain EPL19 in the Main Works monitoring program as it is duplicative of EPL8.
16 (RW-12)	Yarrangobilly River, downstream of road construction areas	NO CHANGE	
22 (RW-18)	Yarrangobilly River tributary (Watercourse 3), upstream of accommodation camp	Change from a routine (monthly and wet weather) site to a TARP site, such that it is only sampled if the downstream site, EPL-13, records a basic water quality exceedance.	• There is no need to sample this upstream site if no exceedance is recorded at EPL-13.

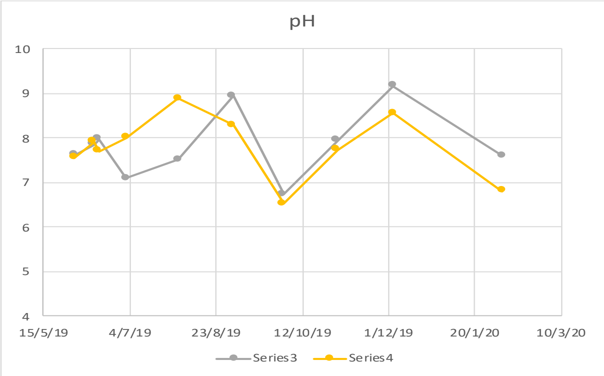
EPL site no. (SHL site no.)	EPL site description	Proposed change	Rationale
23 (RW-19)	Yarrangobilly River tributary (Watercourse 3), downstream of accommodation camp	Remove site from monitoring program	• EPL23 represents one of three sites (along with EPL22 and EPL13) within Watercourse 3, which is a tributary of Yarrangobilly River on which the main accommodation camp will be constructed. EPL22 is located upstream of the accommodation camp, EPL23 is located approximately where the accommodation camp will be constructed (i.e. unlikely to be fully downstream of the camp) and EPL13 is located downstream of the accommodation camp, near the confluence with Yarrangobilly River. The main construction-related activity in the Watercourse 3 catchment is the accommodation camp. Consequently, in terms of identifying construction-related sources of contaminants within Watercourse 3 in the event that an exceedance is measured in Yarrangobilly River downstream of the confluence of this tributary, there is a need for only one site upstream of the camp and one site downstream of the camp. • It is appropriate to remove EPL23 from the monitoring program because (i) an upstream and a downstream site for the accommodation camp will still exist, (ii) EPL23 is unlikely to be fully downstream of the camp site making it inappropriate as a downstream site, and (iii) current design plans suggest that the part of the watercourse in which EPL23 is located may need to be diverted as a part of the camp's construction and operation and, hence, this monitoring site may be lost as a result.
13 (RW-9)	Yarrangobilly River tributary (Watercourse 3), downstream of accommodation camp and new road	Change from a routine (monthly and wet weather) site to a TARP site, such that it is only sampled if the downstream site, EPL-9, records a basic water quality exceedance.	• There is no need to sample this upstream site if no exceedance is recorded at EPL-9.
9 (RW-5)	Yarrangobilly River, downstream of the accommodation camp and upstream of Talbingo Reservoir	NO CHANGE	

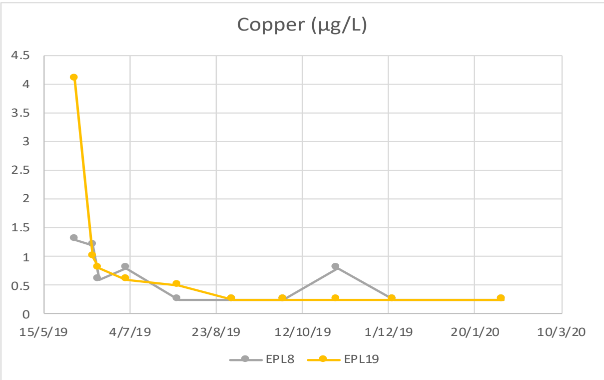
EPL site no. (SHL site no.)	EPL site description	Proposed change	Rationale
24 (RW-20)	Yarrangobilly River tributary (Watercourse 2), directly downstream of road	Remove site from monitoring program	• EPL24 was incorporated in the Exploratory Works monitoring program to monitor potential effects of Exploratory Works road construction on water quality in Watercourse 2. However, this road has since been constructed and the area stabilised, and the area will not be a source of contaminants to the stream. Consequently, EPL24 will not be relevant as an indicator of construction-related water quality impacts during Main Works, and we do not propose to retain this site in the Main Works monitoring program.

June 2019 – February 2020

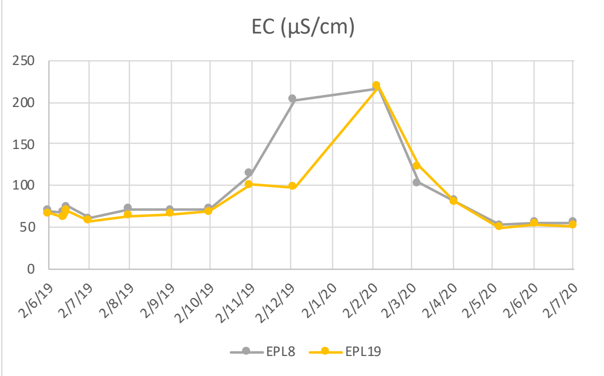


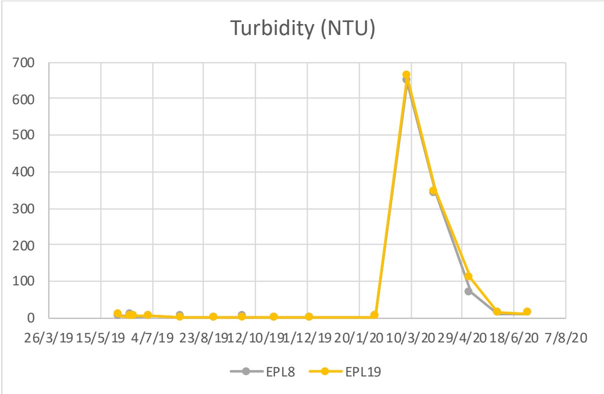


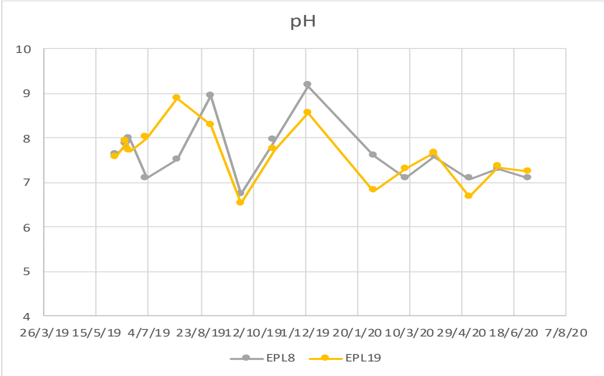


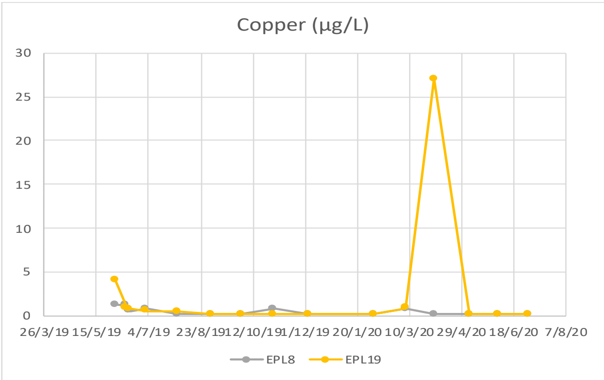


June 2019 – July 2020









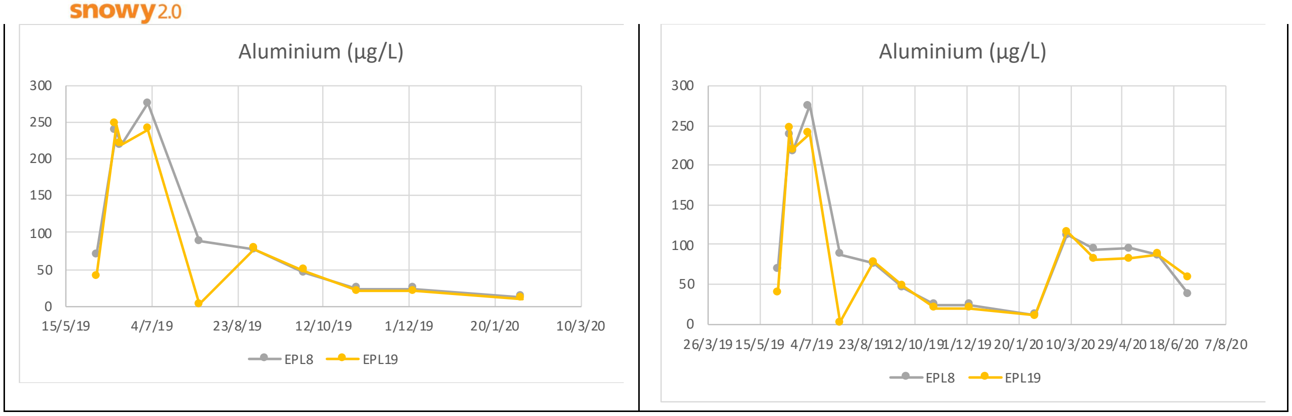


Figure C.1 Summary monthly water quality for EPL8 and EPL19 (data from Exploratory Works monitoring program). The data from June 2019 to Feb 2002 are shown in order to improve the resolution ofn the plots prior to the post-bushfire rainfall events that resulted in significant water quality impacts (see Attachment A).

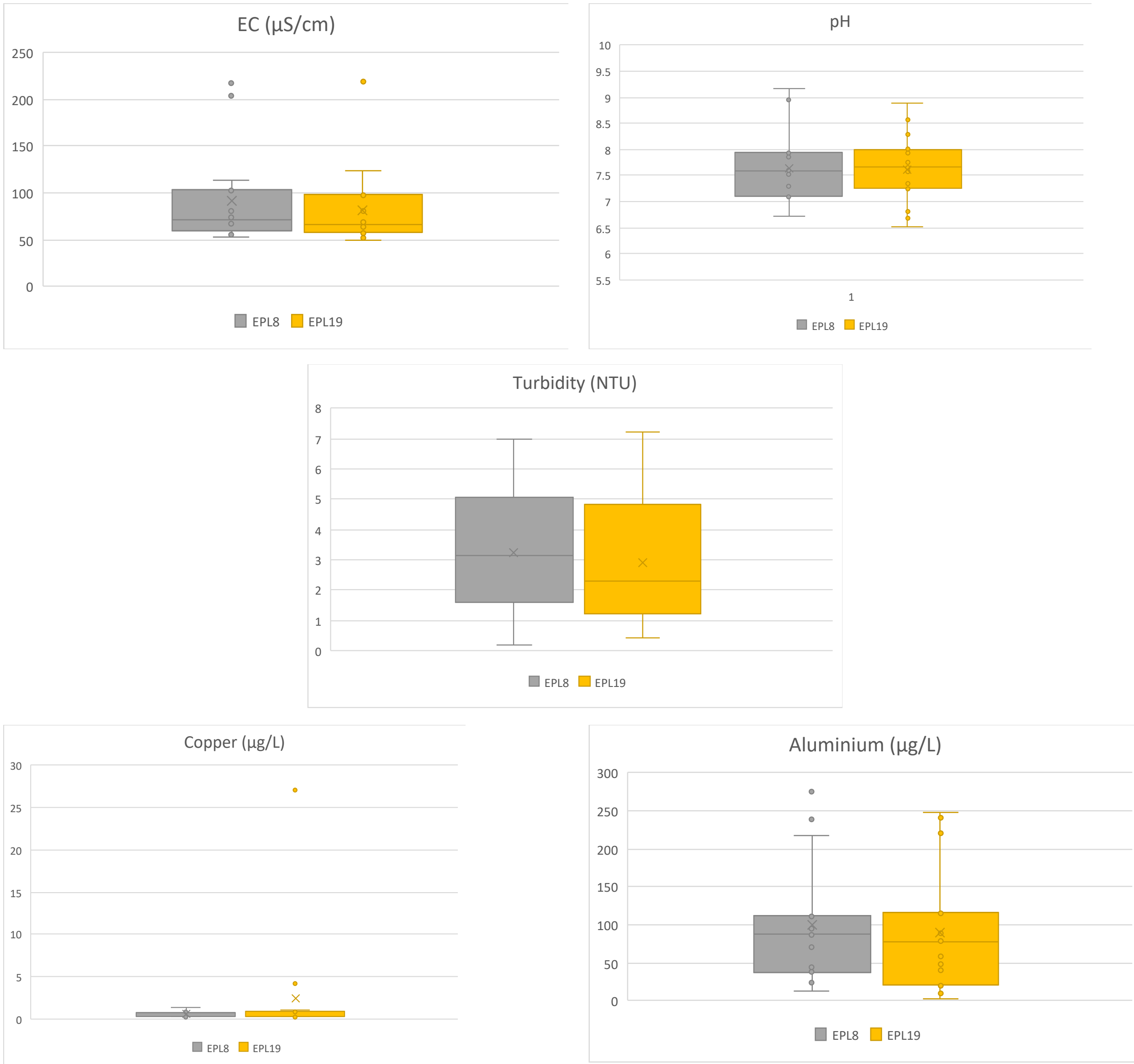


Figure C.2 Water quality box plots for EPL8 and EPL19 (monthly data from Exploratory Works monitoring program, June 2019 to July 2020).

ANNEXURE B – TRIGGER ACTION RESPONSE PLAN

S2-FGJV-ENV-PLN-0145

SNOWY 2.0 MAIN WORKS – SURFACE WATER TRIGGER ACTION RESPONSE PLAN 1

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Environmental Consultant	S. Mitchell	
Reviewed by	Environmental Manager	L. Coetzee	
Verified by	HSE Manager	J. Weir	John Weir
Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:30:43 +10'00'

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	29.11.2019	Initial draft for SHL review
B	29.05.2020	Revised to address Infrastructure Approval
C	15.06.2020	Revised to address SHL comments. For consultation.
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments

Trigger Action Response Plan 1 –
Receiving Waters Monitoring Exceedance

Trigger action response plan initiation

- Exceedance identified during / following comprehensive routine monthly monitoring. This TARP process is to be followed until a grey box has been reached.

Monitoring details

- In-situ (Basic) and Comprehensive monitoring to be undertaken:
  - Monthly for baseflow conditions (12 monitoring events per year)
  - During/after wet weather events (as required by TARP 2)
  - Monitoring to occur at all locations identified in the Surface Water Monitoring Plan / EPL
- Monitoring includes a full range of physio-chemical parameters, nutrients and metals
- Monitoring results available around 2 weeks after monitoring.

Trigger action response plan objective

- To identify (where possible) if the exceedance is naturally occurring or due to construction activities
- To establish actions to either improve water management or further investigate the exceedance mechanism (if required)
- To meet EPL Environmental Monitoring Report requirements

Exceedance(s) of one or more analytes identified at a receiving water monitoring location.

Note if exceedance is a metal, undertake adjustment (i.e. Is the post hardness adjustment above the WQO value?)

Does a similar exceedance(s) occur in any receiving water that is upstream of all disturbed work areas associated with construction?

YES

Exceedance is unlikely to be associated with construction. **Report monitoring results in monthly water quality report and in accordance with EPL**

NO

Review point of discharge monitoring and inspection results. Is there any evidence that exceedance is due to construction directly upstream of this monitoring location?

YES

Source of exceedance identified. Potential incident*

Investigate root causes and identify measures to minimise discharge. Review controls and construction area to identify opportunities for improvement to meet discharge predictions. Report identified actions in accordance with EPL.

Report monitoring results in monthly water quality report and in accordance with EPL.

NO

Are water quality controls and treatment systems functioning to specifications / as designed prior to during monitoring

NO

YES

Has a similar exceedance occurred at this location in at least 1 of the last 3 monitoring rounds?

NO

Exceedance is to be noted in a database for consideration in future monitoring rounds. A risk assessment will be undertaken based on the nature, extent and magnitude to determine the need for immediate further investigation. **Report monitoring results in monthly water quality report and in accordance with EPL.**

YES

Further actions are required to identify the source of the exceedance and potential improvements to the water management system.

Report monitoring results in monthly water quality report and in accordance with EPL.

Investigate the source of the exceedance and potential improvements to the water management system that can be made to reduce the risk of the exceedance reoccurring. The scope of the investigation will depend on the extent and nature of the exceedance. Report identified actions in accordance with EPL.

* In the event of the occurrence of an incident, the Future Generation Environment Manager will immediately inform SHL who will contact DPIE, NPWS and EPA in accordance with the requirements of Schedule 4 Condition 6 of the Infrastructure Approval and the EPL (21266)

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FUTURE GENERATION

S2-FGJV-ENV-PLN-0146

SNOWY 2.0 MAIN WORKS – SURFACE WATER TRIGGER ACTION RESPONSE PLAN 2

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Environmental Consultant	S. Mitchell	SMitchell
Reviewed by	Environmental Manager	L. Coetzee	LCoetzee
Verified by	HSE Manager	J. Weir	John Weir
Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:31:09 +10'00'

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	29.11.2019	Initial draft for SHL review
B	29.05.2020	Revised to address Infrastructure Approval
C	15.06.2020	Revised to address SHL comments. For consultation.
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments

Trigger Action Response Plan 2 –
Stormwater Overtopping Event

Trigger action response plan initiation

- Sediment basin / control overtopping event during / following rainfall event
- Irrigation event causing surface flow to waterway
- This TARP process is to be followed until a grey box has been reached.

Monitoring details

- Monitoring to be undertaken when overtopping event is first identified and conditions are safe to permit monitoring. Monitoring is required once per overtopping event at the following locations:
  - Within basin or at point of discharge (if discharge occurring elsewhere); and
  - Downstream and upstream of discharge location beyond mixing zone or at nearest EPL monitoring point
- Monitoring includes visual inspection and measurement of pH, electrical conductivity and turbidity using an in-situ data logger or portable water quality meter.

Trigger action response plan objective

- To identify (where possible) if the exceedance is naturally occurring or due to construction activities
- To establish actions to either improve water management or further investigate the exceedance mechanism (if required)
- To meet EPL reporting requirements

Are controls overtopping?

NO

Record on wet weather inspection sheet and monitor daily

YES

Did waters make it to receiving waterway?

NO

Record on wet weather inspection sheet and monitor daily

YES

Notify SHL, EPA and NPWS of overtopping event.
Conduct monitoring using hand held probe.
Conduct monitoring within basin, and upstream and downstream of discharge location at safest location (i.e. beyond mixing zone or nearest EPL monitoring point).
Are results compliant with predicted discharge characteristics (likely range) and receiving water quality objectives?

YES

Report monitoring results in monthly water quality report and in accordance with EPL.

NO

Potential exceedances include exceedance of pH, electrical conductivity or turbidity WQOs or visible signs of sedimentation, turbid water or floating hydrocarbons.

Undertake laboratory samples.

Follow both arrows.

2 week waiting period

Review laboratory samples. Is there exceedance(s) of one or more analytes identified at a receiving water monitoring locations.

Note if exceedance is a metal, undertake adjustment (i.e. Is the post hardness adjustment above the WQO value?

YES

Follow **TARP 1 - Receiving Waters Comprehensive Monitoring Exceedance**

CONTINUE

Review site controls.

Are water quality controls functioning to specifications / as designed?

NO

Possible incident* Review if other non construction related factors are also contributing to exceedance.

Report monitoring results / incident in accordance with EPL and report in monthly water quality report.

Investigate root causes and identify measures to minimise discharge. Review sediment basin and construction area to identify opportunities for improvement to meet discharge predictions. Report identified actions in accordance with EPL.

EXTERNAL FACTORS

YES

Is downstream exceedance similar to upstream exceedance? Or Is similar exceedance known to occur on a frequent or occasional basis (refer to EIS baseline sampling data)?

YES

Exceedance unlikely to be associated with construction.

Report monitoring results in accordance with EPL and report in monthly water quality report.

NO

Has a similar exceedance occurred at this location in at least 1 of the last 3 monitoring rounds?

NO

Exceedance is to be noted as an unexplained exceedance for consideration in future monitoring results.

Report monitoring results in accordance with EPL and report in monthly water quality report.

YES

Report monitoring results in accordance with EPL.

Report reoccurring exceedance in monthly water quality report

Increase the frequency of monitoring and inspection events at the monitoring location of the exceedance in future basic water quality monitoring rounds and repeat TARP if results demonstrate that TARP is triggered

* In the event of the occurrence of an incident, the Future Generation Environment Manager will immediately inform SHL who will contact DPIE, NPWS and EPA in accordance with the requirements of Schedule 4 Condition 6 of the Infrastructure Approval and the EPL (21266)

ANNEXURE C – SPILL RESPONSE PROCEDURE

S2-FGJV-ENV-PRO-0039

SNOWY 2.0 MAIN WORKS - SPILL RESPONSE PROCEDURE

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Environmental Consultant	S. Mitchell	SMitchell
Reviewed by	Environmental Advisor	K. Meulenbroeks	
Verified by	Environment Manager	L Coetzee	LCoetzee
Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:30:20 +10'00'

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	24.02.2020	First Draft
B	29.05.2020	Revised to address Infrastructure Approval
C	10.06.2020	Revised to address SHL comments. For consultation
D	19.09.2020	Final

Introduction

This procedure has been developed and will be implemented in accordance with the requirements of the Environmental Management Strategy (EMS) and corresponding approval requirements.

Objective

The objective of this procedure is to:

- detail the requirements for managing, containing and cleaning-up spills on-site including but not limited to chemical, fuel or oil spills or leaks that originate from the project work area that have the potential to contamination soil and or water;
- to aid in minimising the emergency response time and in-turn minimise the potential impact to the environment; and
- meet the requirements in schedule 3, condition 30 of the Infrastructure Approval.

In the event of a spill the emergency response procedure provided on the following page will be implemented. All spills will be reported to the appropriate officer and immediately deploying spill containment and/ or absorption kits to restrict its spread.

Control Measures

Preventative Spill Measures

In order to minimise the potential environmental impacts to water and soil from spills the following will be undertaken by Future Generation:

- training in use of spill containment materials, their locations and spill response will be undertaken proactively as required particularly for personnel who are working within or near to aquatic environments such as dredging works;
- minimising vehicle and plant accessibility to waterways by maintaining the 50-metre exclusion zone around Yarrangobilly River (excluding some areas such as required water crossings);
- where possible, refuelling, washing and maintenance of vehicles and mechanical plant will occur at least 50 metres from waterbodies;
- plant and equipment will undergo regular checks and subsequent repair for potential leakages or worn hydraulic hoses;
- all chemicals including fuels and oils will be stored when not in use in bunded areas; and
- all chemicals and hydrocarbons will be stored and handled as per manufacturer's instructions;

Regular inspection of chemical storage and usage will be undertaken to assess compliance of the above measures.

Reactive Spill Measures

This includes response to any spills during the following activities which have a higher likelihood or consequence of spill occurrence:

- vegetation clearing and stripping of soils;
- refuelling, wash down and or maintenance of plant and equipment including marine equipment used for in reservoir geotechnical investigations;

- operation of equipment that require fuel, chemicals, lubricants or similar including pumps and water treatment plants;
- working within particularly sensitive environments including marine dredging, subaqueous material placement, in reservoir geotechnical investigation, waterway crossings or diversions.

The impacts of the spill should be isolated and the Emergency Spill Response Flowchart implemented.

Spill containment material such as those listed in Table C 1 referred to as 'spill kits' will be kept, stocked on site at any location where there is significant risk/consequence of a spill including at refuelling areas, workshops, chemical storage and within the vicinity of waterways including on all marine vessels at all times.

The spill kits will be appropriately sized according to the volume of chemicals and fuels being stored or used as well as based on the potential for proliferation such as silt curtain lengths based on dredging extent (as required). All staff would be made aware of the location of the spill kit and trained in its use. Table C 1 provides examples of appropriate application of material types.

The Environment Team is available for assistance and advice in purchasing the correct spill containment materials. Spill kit inspections and required restocking and are to be undertaken on regular intervals such as during weekly site inspections in accordance with the EMS.

Table C 1: Spill containment materials

Name	Description
Hydrophobic booms	• Used to contain and absorb floating contaminants typically in aquatic environments including hydrocarbons. • Consider the need to install floating booms before starting works if there is potential for contamination in a waterbody • If the booms alone cannot absorb the contaminant then consider using absorbent material such as granules to soak up the spilled liquid on land or deploy additional surrounding booms or silt curtains when within a waterway
Silt curtains	• Used to minimise impacts due to contaminants within waterbody including sediments • Consider the need to install silt curtain(s) and the extent of the curtain(s) prior to commencing ground disturbance works including dredging in or near waterbodies • If one curtain alone cannot contain the contaminant then consider deploying additional curtains around the outer perimeter
Pads, Pillows and socks	• Used to clean-up (absorb) small to medium liquid spills on land rather than containing. Thin absorbent mats place over spills. Cushion shaped products containing absorbent fibres, used directly under a leak or drip. Absorbent socks placed at the low point of a spill • Consider the need to have a spill kit containing these at the source of the activity and extras in-stock on site • If these materials are not enough to clean-up the spill, consider using absorbent granular materials or equivalent
Drain Covers	• Used to filter or absorb contaminants as they enter a drainage system. Covers such as drain wardens placed over stormwater inlets and pit grates to filter sediments and, when installed with hydrophobic pillow, absorb hydrocarbons prior to entering to stormwater system • Covers should be installed within the pit/drain prior to works commencing. Consider regular checks and cleaning of drain covers to extend its life. • Consider installation of physical bunding, diversions away from drains or plastic pit gel covers if drain covers are frequently becoming laden with contaminant(s)

Name	Description
Sorbents	• Used to clean-up, sorbents are materials that soak up the spill such as saw dust and peat mixture. Spread the sorbent over the contaminant after control materials have been applied. Recover the contaminant/sorbent mixture using shovels/excavator bucket or similar • Sorbents can be used from small to large spills • Consider if a large quantity of sorbent needs to be used then manual recovery may be a more suitable method
Manual Recovery	• Used to physically remove the contaminant either by excavating the contaminant and adjacent soil on land or vacuum truck removal for contaminant and adjacent liquid/sludge in waterbodies • Control materials should be installed prior to manual recovery to prevent spread during recovery task
Drip trays and washout bunds	• Used to contain incidental leaks during plant and equipment maintenance and equipment washout post activities such as concrete works • Containers should be maintained and liquids/sludge collected should be regular removed appropriately • Consider if these containers are not sufficient to contain leaks/washout then construction of permanent bunding may be suitable

Incident management

Incidents are managed in accordance with the Section 7 of the EMS and the Pollution Incident Response Management Plan (PIRMP). The investigation will include a review of events leading up to the incident and a review of what improved practices may be required.

In the event of the occurrence of an incident as defined under the Infrastructure Approval, the Future Generation Environment Manager will immediately inform Snowy Hydro (verbally) who will contact Department of Planning, Industry and Environment in accordance with the requirements of Schedule 4, Condition 5 of the Infrastructure Approval.

Corrective actions will be implemented to reflect the root cause of the event. This may include:

- additional spill response training; and
- installation of physical barriers or diversions;

In accordance with Part 5.7 the *Protection of the Environment Operations Act 1997*, the Environment Manager or Project Director will enact the Pollution Incident Response Management Plan (PIRMP) should the incident be deemed to have:

- resulted in actual or potential for material environmental harm, or
- the associated clean-up costs exceed $10,000.

EMERGENCY SPILL RESPONSE FLOWCHART

ASSESS SAFETY

- Is it safe to take action?
- What is the source of the spill and can it be stopped, shutdown or controlled?
- Consult the Safety Data Sheet - What PPE and emergency equipment is required?
- Are there any other hazards that need to be controlled? E.g. ignition sources
- Do I need further assistance? For large spills beyond capacity of work crew to contain or hazardous substances, call 000 and request NSW Fire and Rescue HAZMAT

Yes, it is safe | **No, it is unsafe**

ASSESS SAFETY

- Report the event to the site supervisor.
- Site supervisor to evaluate the area and make the area safe if possible
- Site supervisor to notify the Safety Team and evacuate personnel if required
- Safety Manager or Project Director to contact emergency services if the spill is of a hazardous nature or not manageable with site resources

CONTAIN

- Site personnel to stop the flow of the spilt material eg. shutting down equipment, re-erecting containers, applying spill controls
- Divert the spill away from waterways and/or drains into or towards a contained, safe area
- If the spill enters a waterway and/or drain install physical barriers or similar at the furthest lowest extent to stop the spill from moving further within the drain/waterway

REPORT

- Site personnel to immediately report the spill to the relevant supervisor
- Supervision personnel to immediately report the spill to the Environment Team
- Provide brief details of the event, where is it, what is it, how much is there, emergency response provided or other related information

CLEAN UP

- Clean up the spill by applying clean-up spill kit materials
- Do not hose away spills into the drains or waterways
- If necessary cover spills during rain events to avoid spread and further contamination
- Clean up all contaminated material, soils and water and dispose of appropriately

DISPOSE

- Contaminated materials will be disposed of offsite at licensed waste disposal facility. This includes the absorbent material, and impacted soil used for clean-up
- Burning of contaminated waste material on site is not permitted

INVESTIGATE, REPORT & LESSONS LEARNT

- Report to relevant stakeholders such as Snowy Hydro Limited, DPIE, NPWS and EPA as required by CoA, EPL and EMS
- The environmental team will investigate the event to determine the root cause
- Implement lessons learnt to reduce the potential for reoccurrence
- Restock spill kits as soon as possible after the incident

NOTES:

- At all times ensure the safety of yourself and others whilst implementing this procedure. Wear appropriate PPE prior to making any contact with the spilt material.
- Spill controls include temporary earth bunds, spill pads, oil booms, silt curtains and absorbent granular material. Details are provided in Table C-1 of the Spill Management Procedure.
- Responsible persons includes personnel involved in the cause of the event, witnesses to the event, supervision, Environment Team, construction personnel in emergency response

Figure C 1: Emergency Spill Response Flow Chart

ANNEXURE D – IN-RESERVOIR GEOTECHNICAL WORKS

Geotechnical works

Process for in-reservoir and on land drilling

The below details provide information relating to the proposed procedure for undertaking geotechnical works both on the reservoir (in-reservoir) and on land. These measures are detailed and therefore may need to be modified to address any site specific requirements as they arise.

Environmental Clearance

Prior to commencing work activities, the project will ensure approvals and systems developed during the planning stages are complete.

Environmental inspections will be undertaken in accordance with EMS requirements, prior to establishment to identify acceptable clearing routes.

Track and Pad Preparation

The FGJV Permit to clear will be obtained where clearing is required.

The method to for track and pad establishment will include:

- pre-establishment vegetation inspections by the ecologists in accordance with EMS and Biodiversity Management Plan (BMP);
- disturbance boundary and / or clearing limits to be delineated with flagging in accordance with the Pre-clearing Procedure in Appendix C of the BMP;
- clearing of vegetation in approved locations and drill pads to occur using forestry mulcher, chainsaws and excavator crew;
- removed cover and woody debris / branches, to be pushed to the edges of the access track and drill pad sites for later use during site rehabilitation;
- placement of geofabric, track mats and / or gravel at track depression to maintain safe access and minimise impact on gully soils;
- installation of required sediments control measures along the tracks and around the drill pad sites;
- install track signage to allow UHF call up and communication protocol;
- minor earthworks and importation of sheeting gravel to level and stabilise drill sites;

The water supply infrastructure currently in place at Marica Track will be extended to supply new boreholes.

Water supply for drill sites outside of Marica track will generally consist of direct supply to on-site storage tanks using water carts.

Mobilisation of Drilling Equipment

The following points provide a summary of the key activities associated with mobilising equipment to site;

- drill rigs will be floated to the laydown areas where they will be taken to site using existing and constructed access trails. Laydown areas identified for use during mobilisation include:
  - Coppermine and Marica Laydown (for work on Marica Track);
  - Tantangara Quarry (for work near Talbingo);
  - Lobs Hole (for work near Talbingo Intake);

- Tantangara Foreshores (for overwater work in Tantangara);
- O'Hares Rest (for overwater work in Talbingo);

- drilling support equipment including rods, pumps, water tanks, mud tanks, spill kits, site compound, lighting, mobile generators and other equipment necessary for the operation of the drill rig will also be mobilised to laydowns and transferred to site pads accordingly;
- access (by personnel and for delivery and removal of equipment etc) will be via the existing and newly established tracks and the Snowy Mountains Highway.

Vehicle hygiene for all new plant, machinery and vehicles will be checked prior to accessing the site for the first time as per the Weed and Pest Inspection Form.

For all plant and machinery coming directly from the Tantangara area known to contain the invasive weed species Ox Eye Daisy specific wash-down will occur prior to re-entering the National Park to ensure the removal of seeds and potential seed-harbouring material.

Where possible, all ancillary equipment and personnel will be mobilised to site using light / tracked vehicles.

Drilling Activities and Downhole Testing

Drilling activities, including borehole establishment and in situ testing and will typically include the following:

1. Excavate surface sump at drill collar and line with suitable plastic liner to seal collar.
2. Install HW casing to suitable depth and seal in place with gypset or similar.
3. Core drilling of boreholes using triple tube coring methods. Most boreholes will be starting with PQ-3, size hole, then telescope to HQ-3 and where necessary to NQ-3.
4. Drill mud management - Containment of excess drilling fluids and cuttings in above-ground re-circulation tanks, excess fluids would be stored in portable industrial bulk containers (IBCs).
5. Clean water flushing of boreholes upon reaching target depths.
6. In situ down hole testing as required:
   - In-situ Stress Test via overcore (IST)
   - Dilatometer testing
   - Hydro-fracture and hydro-jacking pressure testing
   - Drill Stem permeability testing (DST)
7. Clean water flushing of boreholes upon reaching target depths.
8. Downhole borehole survey using acoustic teleview cameras and probes.
9. Survey of the as-built borehole location using GPS or suitable survey techniques.
10. Ongoing maintenance of the equipment and site as required.

An indicative site layout for the drill sites is shown below in Figure 1 and Figure 2.

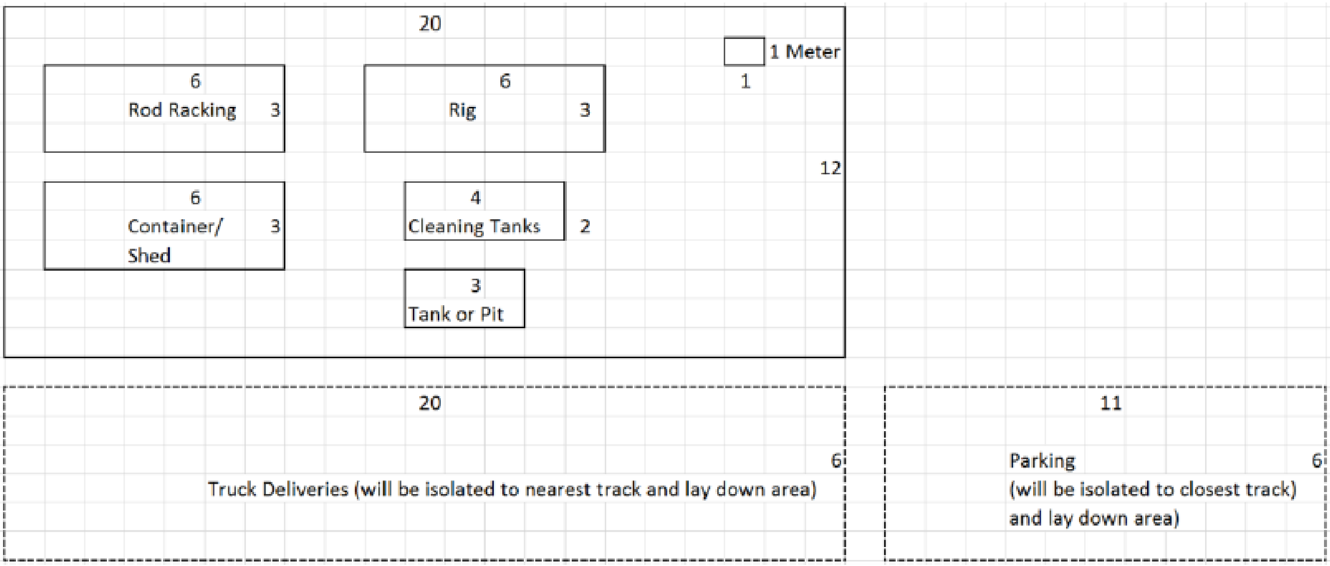

Figure 1 Indicative site layout

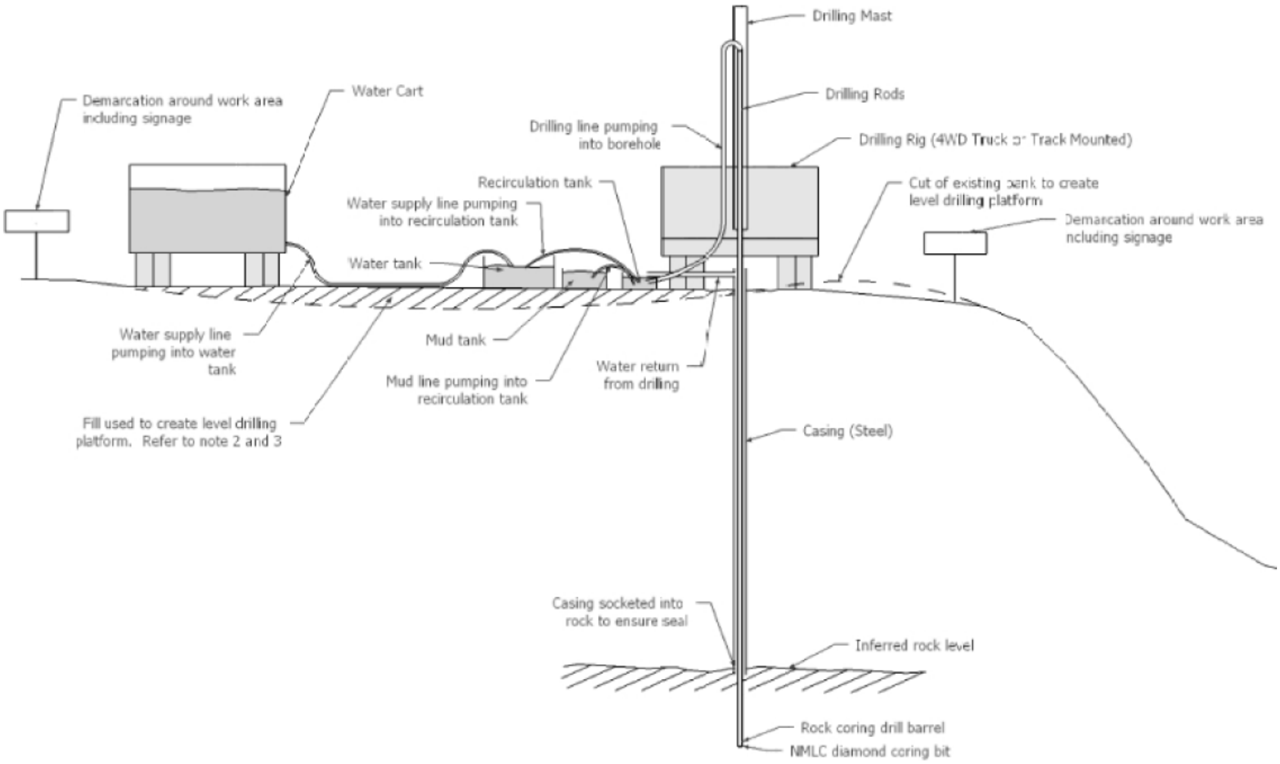

Figure 2 Indicative site layout (cross-section)

Auxiliary Support Services

Water Supply

Drilling activities require consistent fresh water supply circulate drilling muds through the borehole to return rock cuttings.

Water will be supplied using water carts by extraction and transfer to Marica tank farm, or directly to the drill sites.

Core Sample Transport

Removal of drill core (contained in light steel core trays) and other equipment will be undertaken as required on a daily basis. Transport of core trays will be done using a dedicated core transfer team in 4WD utes.

Drill Mud and Waste Disposal

Excess drilling muds and all drilling waste will be collected from drill sites using vacuum tankers and transferred to a holding facility. From this the waste will be disposed at a suitably licensed (NSW EPA) waste management facility in accordance with the NSW EPA *Waste Classification Guidelines* (2014).

Borehole Instrumentation and Decommissioning

Following successful completion of borehole drilling and in situ testing and sampling, the following borehole decommissioning activities will occur:

for boreholes with nominated VWP logging instrumentation, a series of grout tubes, sensors and cabling will be hung inside the borehole. The borehole will be grouted using displacement grouting techniques, and the sensor cables will be wired to a data logger box for completion;

for boreholes with no instrumentation to be installed, the borehole will be decommissioned by grouting in accordance with Minimum Construction Requirements for Water Bores in Australia.

Equipment Demobilisation

On completion of drilling activities and borehole installations and decommissioning, all equipment used during the works will be demobilised staged in the same laydown areas used during mobilisation.

Track and Pad Rehabilitation

Drill sites where any ground disturbance or clearing have occurred will be rehabilitated in accordance with Exploratory Works Modification 1 requirements, unless further approvals supersede Modification 1 requirements; i.e.. The tracks or pads are planned to be used for future approved works.

The drill pads will be rehabilitated in accordance with the following principles:

- successful rehabilitation is based on the principle of “No Bare Ground” after rehabilitation works have been carried out;
- implementation of strict vehicle hygiene protocol, such as washing down of equipment and vehicle wash bays before entering KNP;
- utilisation of cleared or mulched vegetation in the rehabilitation activities.

The approach to rehabilitation will aim to use existing ecological resources at the sites and to minimise the use of additional materials such as seed, tubestock and mulch. This approach to rehabilitation was used throughout the Feasibility stage geotechnical investigation program and has been undertaken successfully to date.

Following completion of all site activities, a visual inspection of the site by Snowy Hydro and NPWS personnel will be undertaken to ensure that the location of the drilling activities has been reinstated to an acceptable standard.

Overwater drilling

Overwater drilling activities, including in situ testing and borehole decommissioning are to include the following activities.

- mobilise and secure ‘jack up’ or floating barge to reservoir floor using concrete anchors that will be removed at completion of work;
- install a small anchor on the shore line or to deployed concrete anchor blocks to allow stabilisation of the barge;
- drill boreholes using auger and rotary wash bore drilling techniques through soils and weathered rock including collection of disturbed samples;
- rock core drilling using triple tube diamond coring techniques to the nominated target depth at each borehole location;
- during drilling works excess drilling fluids and cuttings will be captured in re-circulation tanks at the borehole location. Any excess fluids would be stored in portable IBC containers and disposed to NSW EPA licensed facility;
- in situ permeability testing using water pressure tests;
- clean water flushing of boreholes upon reaching target depths;
- downhole borehole survey using acoustic teleview cameras and gyronometers;
- coordinate survey of the as-built borehole location using GPS or suitable survey techniques.

At all times while the barge is moored it will comply with NSW Maritime safety requirements to ensure it is visible for other waterway users and will not pose a hazard to the public. A cross-sectional plan showing indicative site layout and operations of water based (barge) drilling is provided in Figure 3.

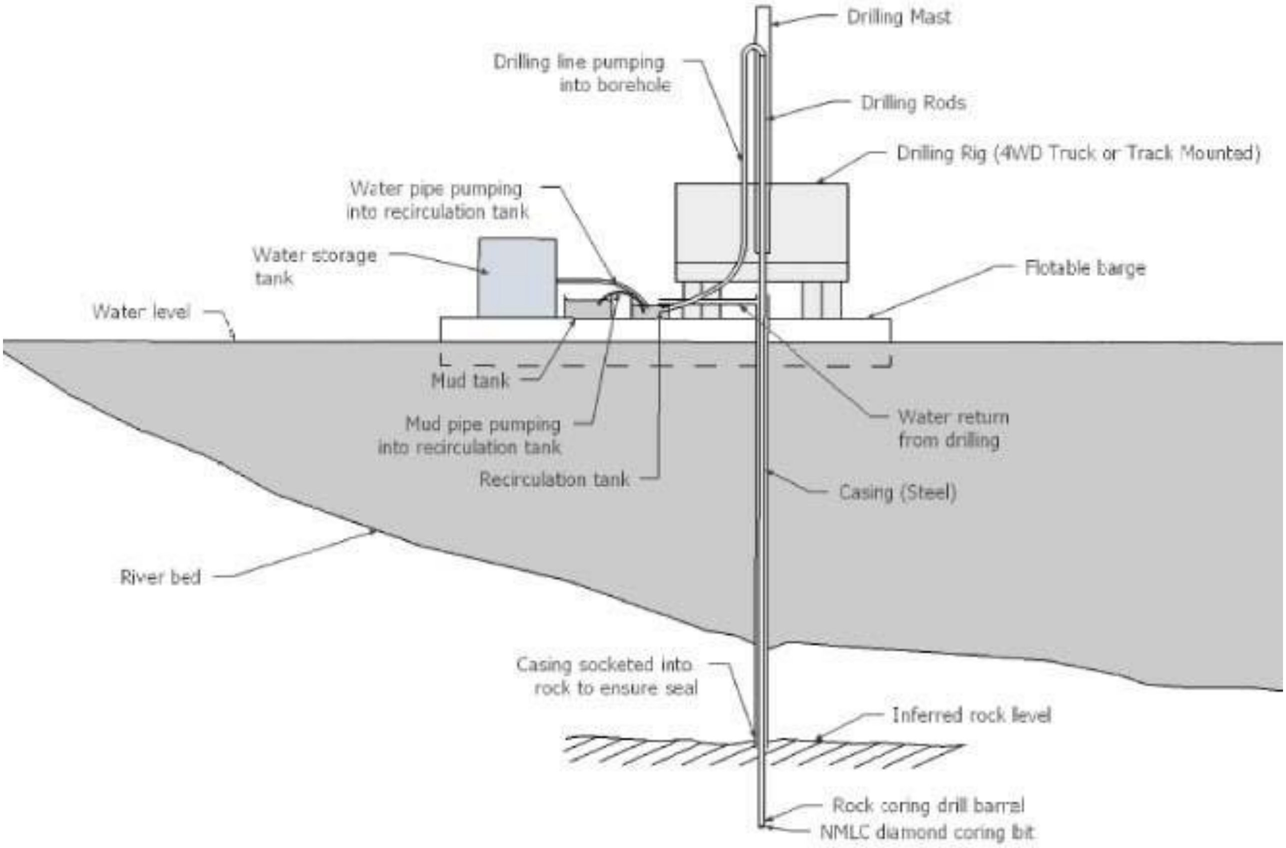

Figure 3 Typical barge geotechnical drilling set-up (cross section)

In-reservoir refuelling

During geotechnical works, some geotechnical drilling will be required to occur on Tantangara and Talbingo Reservoirs. The geotechnical drills will be based on barges and refuelling will be required to enable the works to occur.

The following steps are recommended to occur prior to and during refuelling.

Prior to refuelling

- Lock or shut all valves or taps which are not required to be used during refuelling.
- Ensure that spill kits are available on the barge and are suitably stocked.
- Ensure that personnel are aware of how to utilise the spill kit.
- Ensure that any safety requirements are met (as a priority).
- Ensure that relevant MSDSs are available for use (either in soft or hard copy).
- Where possible, locate machinery as close as possible to the refuelling point.
- Where located on the barge, ensure that any scuppers or drains are blocked.

During refuelling

- Carefully deploy the fuel hose.
- Lock shut all valves or taps which are not required for use.
- Where refuelled by fuel truck from shore, the vessel / barge being refuelled is positioned as close as possible to the quay/crane pad.

- Carefully deploy the fuel hose.
- Allowances must be made for the relative movement of the barge.
- Ensure spill kits and fire extinguishers are suitably positioned for each refuelling situation.
- Install a watch system on board both the vessel and the shore to watch for leaks and spills.
- Terminate the fuel transfer system immediately if a leak or spill occurs.
- Any spills are to be reported in accordance with the Spill Response Procedure (Annexure C).

ANNEXURE E – EXPLORATORY WORKS CONDITIONS OF APPROVAL (SSI-9208)

Table E1 details the conditions from the Exploratory Works Infrastructure Approval which are relevant to surface water and demonstrates where these conditions are addressed or are no longer relevant.

Table E1: Exploratory Works conditions of approval relevant to surface water (SSI 9208)

Condition	Requirement	Where addressed
Sch 3, Cond 32	Unless an environment protection licence authorises otherwise, the Proponent must comply with Section 120 of the POEO Act. *Note: Section 120 of the POEO Act makes it an offence to pollute any waters.*	SWMP - Table 5-3: SW02, SW22, SW30 WMP - Appendix B (GMP)
Sch 3, Cond 33	The Proponent must: (a) minimise the use of clean water on site; (b) maximise the diversion of clean water runoff around the approved disturbance areas on site; (c) minimise the flow rates from any clean water runoff diversions to adjoining watercourses; (d) minimise any soil erosion associated with the development; (e) ensure all chemical and hydrocarbon products are stored on site in bunded areas in accordance with the relevant Australian Standards.	SWMP – Section 5.1, Section 5.4. Table 5-3:SW03 to SW17
Sch 3, Cond 34	Prior to carrying out any construction, unless the Planning Secretary agrees otherwise, the Proponent must prepare a Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must: (a) include a Surface Water Management Plan with:	This Plan
	• detailed baseline data on surface water flows and quality in the watercourses that could potentially be affected by the development;	SWMP – Annexure A Attachment A
	• a program to augment the baseline data during the development;	SWMP – Annexure A
	• a description of the measures that would be implemented to minimise the impacts of: – any subaqueous emplacement; – the dredging within Talbingo Reservoir; – the barge infrastructure; – the water intake; – the water treatment pipes and outlets; – any in-stream works; – stockpiles; – eastern emplacement area; – western emplacement area; – construction portal; – accommodation camp; – Lobs Hole substation; – road upgrades, and in particular the road works in the vicinity of the Yarrangobilly River; – chemical and hydrocarbon storage.	SWMP – Section 5

Condition	Requirement	Where addressed
	• surface water assessment criteria, including trigger levels for investigating any potentially adverse surface water impacts of the development;	SWMP – Annexure A
	• a description of the measures that would be implemented to minimise the surface water impacts of the development, and comply with the performance measures in Condition 33 above;	SWMP – Section 5
	• a program to monitor and report on the surface water impacts of the development including water monitoring locations, analytes and sampling frequency for each monitoring location;	SWMP – Annexure A
	• a program to monitor and report on the surface water impacts of the development;	SWMP – Annexure A and Section 6.7
	• a plan to respond to any exceedances of the surface water trigger levels and/or assessment criteria and mitigate and/or offset any adverse surface water impacts of the development;	SWMP – Annexure C
Sch 3, Cond 39	The Proponent must: (a) ensure the temporary bridges over Wallace Creek and the Yarrangobilly River incorporate, to the greatest extent practicable, the requirements: • *Guidelines for Controlled activities on Waterfront Land (NRAR, 2018)*; and • *Policy and Guidelines for Fish Habitat Conservation* (DPI 2013) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (NSW Fisheries 2003); (b) remove temporary bridges as soon as practicable after the construction of the permanent bridges, and rehabilitate the land to the satisfaction of the NPWS; (c) consider scheduling to minimise in stream works between October to January, the migratory period of the Macquarie Perch (*Macquaria australasica*).	Section 5.7 Note that this scope of works has been completed
Sch 3, Cond 40	The Proponent must: (a) ensure that permanent bridges over Wallace creek and the Yarrangobilly River are designed and constructed to comply with the relevant requirements of the: • *Guidelines for Controlled activities on Waterfront Land* (NRAR, 2018); and • *Policy and Guidelines for Fish Habitat Conservation* (DPI 2013) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (NSW Fisheries 2003); (b) ensure that the permanent bridges over Wallace creek and the Yarrangobilly River are designed and constructed to comply with the relevant requirements of the relevant Austroads Standards (such as elevating them above the 1% AEP flood level); (c) minimise in stream works between October to January, the migratory period of the Macquarie Perch (*Macquaria australasica*).	Section 5.7 Note that this scope of works has been completed

ANNEXURE F – OPERATION OF THE DISCHARGE POINTS

snowy 2.0

SALINI IMPREGILO • CLOUGH • LANE

FUTURE GENERATION

S2-FGJV-ENV-PRO-0034

SNOWY 2.0 MAIN WORKS - OPERATION OF THE DISCHARGE POINTS

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Environmental Consultant	S. Mitchell	SMitchell
Reviewed by	Environmental Manager	L. Coetzee	LCoetzee
Verified by	HSE Manager	J. Weir	John Weir
Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:31:35 +10'00'

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	06.08.2020	For inclusion in SMWP
B	19.09.2020	Final

Introduction

This specific plan has been developed as part of the SWMP and outlines the measures for the operation of the discharge points.

Objective

The objective of this specific plan is to:

- detail the requirements for managing the discharge points in Talbingo and Tantangara reservoirs; and
- meet the requirements in schedule 3, condition 30(k) and 31(c) of the Infrastructure Approval.

Context

Licensed discharge locations in accordance with the Project EPL 21266 will exist in both Talbingo and Tantangara reservoirs for the effluent waste streams from the wastewater and process water treatment plants. These two waste streams will be treated and combined prior to discharge to the receiving environments such that there will be only one discharge point in each reservoir.

A mixing zone assessment was undertaken by Royal HaskoningDHV (RTS Appendix J Attachment F) to determine the near-field dilutions associated with process and wastewater discharges to Tantangara and Talbingo reservoirs and estimate the size of mixing zone required to dilute key analytes (electrical conductivity, total nitrogen and total phosphorus) to ambient water quality conditions.

The mixing zone assessment found that dilutions to meet target water quality were achieved within 10s of metres of the outfall, but that for some ambient conditions the mixing zone could be between 50 and 100 m. The assessment also identified that the magnitude of water quality change associated with treated wastewater and process water discharge and subaqueous spoil placement is expected to be greater:

- in summer/autumn due to lower seasonal streamflow into the reservoir; and
- during drought conditions due to lower streamflow into the reservoir.

Control Measures

This section identifies the measures that will be implemented to minimise surface water impacts and achieve the outcomes of the RTS mixing zone assessment. All measures are included in Table 5-3 of the SWMP (SW22 to SW35, SW68 and SW72).

Preventative Measures

Water is treated to discharge specifications

Predicted discharge characteristics for the combined waste discharge stream prior to it being discharged are shown in Table F-1. These characteristics are based on the water quality of the combined waste streams estimated for the treated process water and wastewater mixing zone assessment (Attachment F of the revised Water Management Report in EMM 2020). They reflect the median water quality values reported in Tables 4.9 and 5.1 of the revised Water Management Report in EMM (2020), adjusted to account for the relative proportions of each of the waste streams contributing to the combined discharge.

The reported discharge characteristics will be updated at the appropriate time if detailed design specifications indicate different characteristics, noting that specifications need to be such that the WQOs will be met in the receiving environment wherever possible. Updating of the discharge characteristics will be done in consultation with Snowy Hydro and regulators.

Table F-1: Predicted major water quality characteristics of combined treated wastewater and process water discharge (source: Appendix J of EMM 2020)

Analyte	Units	Discharge characteristics[1]		Comments
		Talbingo	Tantangara	
Electrical conductivity	µS/cm	700	168	The treatment processes will not remove dissolved solids. Hence, water salinity will not be reduced by the treatment process.
pH	-	6.5-8.5	6.5-8.5	Alkalinity and pH will be adjusted as part of the treatment processes
Turbidity	NTU	<25	<25	Suspended solids and turbidity will be substantially reduced as part of treatment processes
Total nitrogen	mg-N/L	0.27	0.25	Nutrients will be substantially reduced by the treatment processes.
Total phosphorus	mg-P/L	0.03	0.02	

Note 1. Values represent an average of the likely medians for treated wastewater and process water, weighted according to the proportional volume of each discharge contributing to the combined discharge, as reported in Attachment F of the revised Water Management Report (EMM 2020).

Where in-line sensors (typically pH and turbidity) or monitoring identify WTPs performance drift outside of the required discharge characteristics, 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, re-used on site (e.g. dust suppression) or disposed offsite at an appropriate licenced liquid waste facility.

In accordance with EPL 21266, detailed design reports will be prepared and submitted to the EPA prior to the installation of Water Treatment Plants. These detailed design reports will include details of the nominated plant treatment processes, technologies, and systems that will be used to target the discharge characteristics.

Discharge Outlet

The location of the combined treated wastewater and process water discharge outlets in Talbingo and Tantangara Reservoirs are shown in Figure F-1. The Talbingo outfall location is located below the minimum operating levels (MOL), whilst the Tantangara outfall location will operate close to MOL, consistent with the mixing zone assessment assumptions (RTS Appendix J Attachment F).

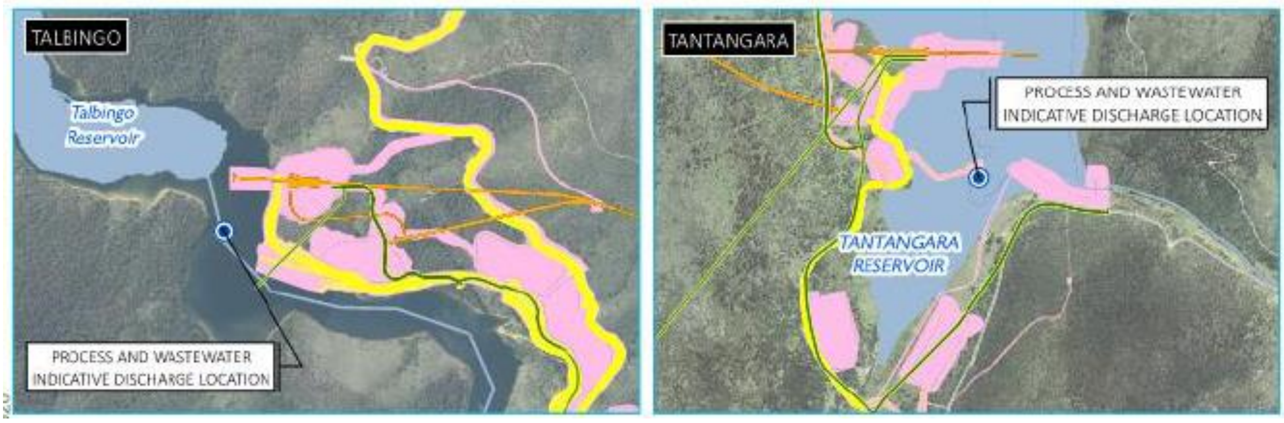

Figure F-1: Reservoir discharge outlets

To enhance the mixing efficiency of the combined treated discharge with reservoir water, an outfall diffuser outlet will be used which contains port (or diffuser) holes that are angled upwards into the water column. This arrangement is shown in Figure F-2 and will minimise the potential for the reservoir bed to inhibit mixing.

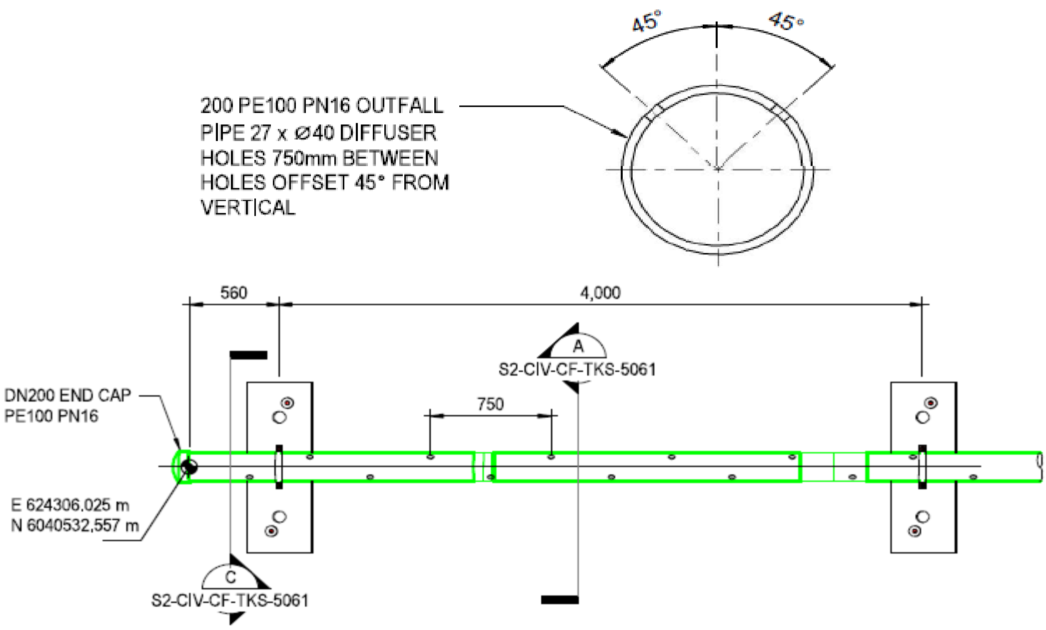

Figure F-2: Discharge outfall configuration

As dilution increases with plume velocity from the diffuser outlet, discharge velocity of the treated combined water will be controlled such that low velocity discharges are avoided. Treated wastewater and process water will be held in storage prior to the final release into the reservoirs. Pumps will be initiated to direct the treated water to the diffuser outlets and configured to avoid low discharge velocity.

Reactive Measures

Discharge and Verification Monitoring

As identified in Section 3.2 of the Surface Water Monitoring Program (SWMP Annexure A):

- treated discharge waters will be monitored daily (basic parameters) and monthly (comprehensive parameters) to validate discharge characteristics; and
- a discrete verification monitoring program will be undertaken to verify that WQOs are consistently met at the edge of the near-field mixing zone for the discharge point

In the event that monitoring identifies an exceedance, TARP 1 (Receiving Water Comprehensive Monitoring Exceedance) in SWMP Annexure B will be iniatated.

Incident management

Incidents are managed in accordance with the Section 7 of the EMS and the Pollution Incident Response Management Plan (PIRMP). The investigation will include a review of events leading up to the incident and a review of what improved practices may be required.

In the event of the occurrence of an incident as defined under the Infrastructure Approval, the Future Generation Environment Manager will immediately inform Snowy Hydro (verbally) who will contact Department of Planning, Industry and Environment, NPWS and EPA in accordance with the requirements of Schedule 4, Condition 6 of the Infrastructure Approval and EPL 21266.

Corrective actions will be implemented to reflect the root cause of the event.

In accordance with Part 5.7 the *Protection of the Environment Operations Act 1997*, the Environment Manager or Project Director will enact the Pollution Incident Response Management Plan (PIRMP) should the incident be deemed to have:

- resulted in actual or potential for material environmental harm, or
- the associated clean-up costs exceed $10,000.

APPENDIX B – GROUNDWATER MANAGEMENT PLAN

S2-FGJV-ENV-PLN-0012

SNOWY 2.0 MAIN WORKS – GROUNDWATER MANAGEMENT PLAN

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Principal Hydrogeologist	R. Cresswell	
Reviewed by	Environment Consultant	S. Mitchell	SMitchell
Verified by	Environmental Manager	L. Coetzee	Coetzee
Approved by	Project Director	A. Betti	

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	29.11.2019	Initial draft for SHL review
B	22.05.2020	Update to reflect conditions of approval and revised environmental management measures
C	15.06.2020	Revised to address SHL comments. For consultation.
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments
G	15.10.2020	Revised to address NRAR clarification

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ABBREVIATIONS, ACROYNMS, INITIALISMS AND DEFINITIONS

Acronym	Definition
AFL	Agreement for Lease
AHD	Australian Height Datum
AIP	*Aquifer Interference Policy*
CoA	*Infrastructure Conditions of Approval (SSI 9687)*
Construction envelope	The maximum extent within which the disturbance area corridor can move to allow the final siting of infrastructure through the detailed design process
DAWE	Commonwealth Department of Agriculture, Water and the Environment
Disturbance footprint	The disturbance footprint as described in the PIR-RTS is the indicative corridor inside the larger construction envelope, where construction works required to build Snowy 2.0 can be carried out.
DOI	Department of Industry
DPIE	NSW Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
EMS	Environmental Management Strategy
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPL	Environmental Protection Licence
Exploratory Works	The development of an exploratory tunnel and associated infrastructure described in the Environmental Impact Statement for the Snowy 2.0 Exploratory Works (CSSI 9208) dated July 2018, and modified by the: • *Submissions Report* dated October 2018 and additional information provided to the Department on 17 October 2018, 19 November 2018 and 23 January 2019; • *Modification Report* dated 6 June 2019 and associated Submissions Report dated 2 September 2019 and amendment letter date 4 October 2019; and • *Modification Report* dated 17 October 2019 and associated Submissions Report dated 10 January 2020
Future Generation	Future Generation Joint Venture
Future Generation-PMS	Project Management System
GDE	Groundwater Dependent Ecosystem – ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain the communities of plants and animals, ecological processes they support, and ecosystem services they provide.
GMP	Groundwater Management Plan (S2-FGJV-ENV-PLN-0012) (This Plan)
IBRA	Interim Biogeographic Regionalisation for Australia
Incident	An occurrence or set of circumstances that causes or threatens to cause material harm and which may or may not be or cause a non-compliance
Kosciusko National Park	A National Park protected under the *National Parks and Wildlife Act 1974* (NSW) and managed by NSW National Parks and Wildlife Service. It covers an area of 673,543 hectares and forms part of Australia's only Alpine area
KNP	Kosciusko National Park

Acronym	Definition
Lobs Hole site	The development in the vicinity of Lobs Hole, including the GFO1 emplacement area; construction facilities (Main Yard), including workers' accommodation camp and temporary spoil emplacement areas; Main Access Tunnel and Emergency Cable and Ventilation Tunnel portals; and ancillary infrastructure including access roads, substation, cableyard and utilities.
LFB	Lachlan Fold Belt
LPF	Long Plain Fault
Main Works	The development of an underground power station and associated infrastructure described in the Environmental Impact Statement for the Snowy 2.0 Main Works (CSSI 9687) dated September 2019, and modified by the: • *Preferred Infrastructure Report and Response to Submissions – Snowy 2.0 Main Works*, dated February 2020; and • Additional information provided to the Department by EMM on 24 March 2020 and 7 April 2020
Marica site	The development in the vicinity of Marica, including the headrace surge shaft; ventilation shaft; construction facility workers' camp; and ancillary infrastructure including access roads and utilities.
MDB	Murray-Darling Basin
NSW DPI	The NSW Department of Primary Industries within Regional NSW
NPWS	National Park and Wildlife Services
NRAR	NSW Natural Resources Access Regulator
Plateau site	The development in the vicinity of the Plateau, including the instream barrier in Tantangara Creek and ancillary infrastructure including access roads and utilities.
Plateau area	The plateau area; located to the east of the Snowy Mountains Highway and spanning the area between the highway and Tantangara Reservoir, is typical of elevated alpine environments, dominated by low energy streams, gentle rolling hills and mostly flat floodplains. The plateau area includes the Plateau and Tantangara work site.
POEO Act	*Protection of the Environment Operations Act 1997*
POEO Regulation	*Protection of the Environment (General) Regulation 2009*
Project	Snowy 2.0 Main Works
Project area	The project area is the broader region within which Snowy 2.0 will be built and operated, and the extent within which direct impacts from Snowy 2.0 Main Works are anticipated. The project area does not represent a footprint for the construction works, but rather indicates an area that was investigated during environmental assessments.
Ravine area	The ravine area; located mostly to the west of the Snowy Mountains Highway, is characterised by deep gorges and steep sloping ridges, the product of incision from river flow, historic glaciation and structural movement. The ravine area includes the Talbingo, Lobs Hole and Marica work sites.
REMM	Revised Environmental Management Measures
Rock Forest site	The development on the Rock Forest property, including the Rock Forest emplacement area, logistics laydown area and ancillary infrastructure including access roads.
SC	South Coast
Submissions Report or RTS	*Main Works Preferred Infrastructure Report and Response to Submissions*
SHC Act	Snowy Hydro Corporatisation Act 1997
SHL	Snowy Hydro Limited

Acronym	Definition
SSI	State Significant Infrastructure under EP&A Act (Infrastructure Approval 9687)
SWMP	Surface Water Management Plan (S2-FGJV-ENV-PLN-0011) (Appendix A)
Talbingo Reservoir site	The development in and around the Talbingo Reservoir, including the Ravine Bay emplacement area; development at Middle Bay, including the water intake and associated structures, barge launch ramp, and construction facilities; and ancillary infrastructure, including access roads and utilities.
Tantangara Reservoir site	The development in and around the Tantangara Reservoir, including the Tantangara emplacement area; water intake and associated infrastructure; barge launch infrastructure; construction and laydown facilities, including workers' camp; fish screens; and ancillary infrastructure, including access roads and utilities.
TARP	Trigger Action Response Plan
TBM	Tunnel boring machine
VWP	Vibrating wire piezometer – a deep, sealed bore that records groundwater pressure
WAL	Water Access Licence
Water Group	The Water Group within the Department
WM Act	*Water Management Act 2000*
WM Regulation	*Water Management (General) Regulation 2011*
WMP	Water Management Plan (S2-FGJV-ENV-PLN-0010)
WSP	Water Sharing Plan
WTP	Water Treatment Plant

1. INTRODUCTION

1.1. Project Description

1.1.1. Overview

Snowy Hydro Limited (Snowy Hydro) is constructing a pumped hydro-electric expansion of the Snowy Mountains Hydro-electric Scheme (Snowy Scheme), called Snowy 2.0. Snowy 2.0 will be built by the delivery of two projects: Exploratory Works (which has commenced) and Snowy 2.0 Main Works.

Snowy 2.0 is a pumped hydro-electric project that will link the existing Tantangara and Talbingo Reservoirs through a series of new underground tunnels and a hydro-electric power station. Most of the project's facilities will be built underground, with approximately 27 kilometres of concrete-lined tunnels constructed to link the two reservoirs and a further 20 kilometres of tunnels required to support the facility. Intake and outlet structures will be built at both Tantangara and Talbingo Reservoirs.

Snowy 2.0 will increase the generation capacity of the Snowy Scheme by an additional 2,000 MW, and at full capacity will provide approximately 350,000 MWh of large-scale energy storage to the National Electricity Market (NEM). This will be enough to ensure the stability and reliability of the NEM, even during prolonged periods of adverse weather conditions.

Salini Impregilo, Clough and Lane have formed the Future Generation Joint Venture (Future Generation) and have been engaged to deliver both Stage 2 of Exploratory Works and Snowy 2.0 Main Works.

1.1.2. Construction Activities and Program

The Snowy 2.0 Main Works Project includes, but is not limited to, construction of the following:

- pre-construction preparatory activities including dilapidation studies, survey, investigations, access, etc;
- exploratory works including:
  - an exploratory tunnel to the site of the underground power station;
  - horizontal and test drilling;
  - a portal construction pad;
  - an accommodation camp;
  - barge access infrastructure;
- an underground pumped hydro-electric power station complex;
- water intake structures at Tantangara and Talbingo Reservoirs;
- power waterway tunnels, chambers and shafts;
- access tunnels;
- new and upgraded roads to allow ongoing access and maintenance;
- power, water and communication infrastructure, including:
  - a cable yard to facilitate connection between the NEM electricity transmission network and Snowy 2.0;

    - permanent auxiliary power connection;
    - permanent communication cables;
    - permanent water supply to the underground power station; and
- post-construction revegetation and rehabilitation.

The Snowy 2.0 construction program is summarised in Figure 1-1

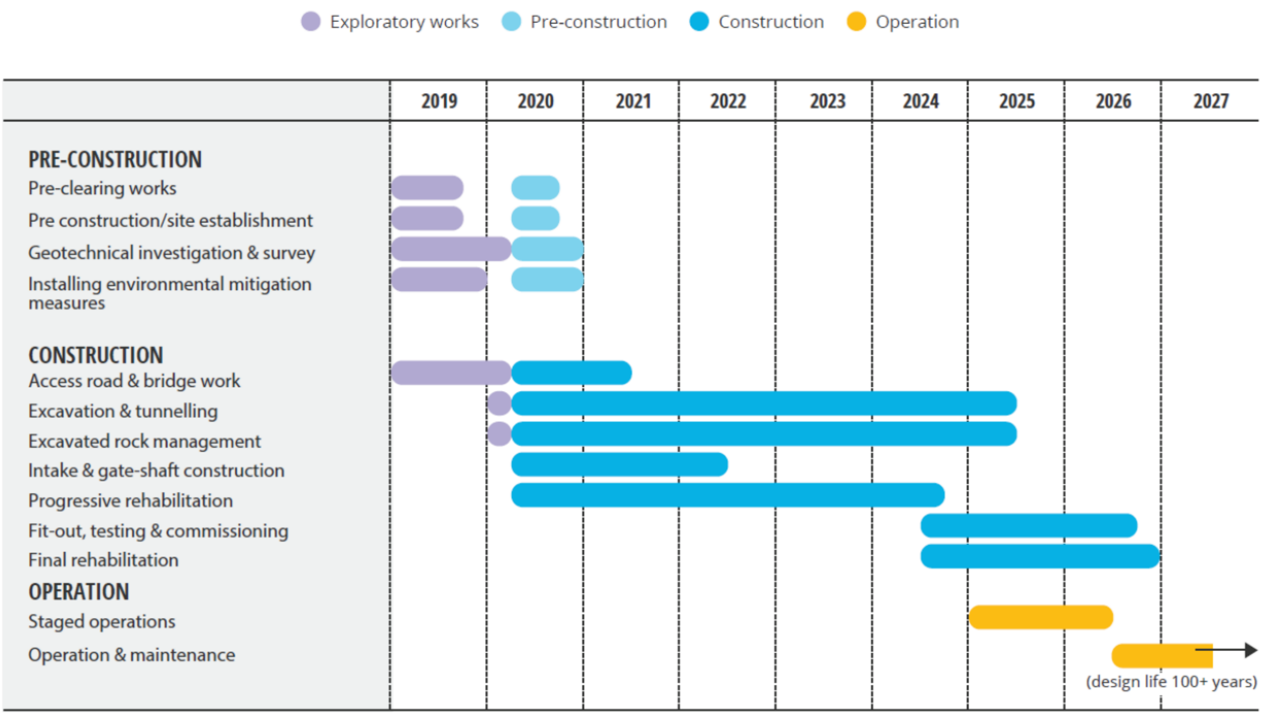

Figure 1-1: Timing of Snowy 2.0

The Snowy 2.0 Main Works Project includes numerous work sites as shown in Figure 1-2. Specifically, these are designated:

- Talbingo;
- Lobs Hole;
- Lobs Hole Ravine Road;
- Marica;
- Plateau (from Snowy Mountains Highway to Tantangara);
- Tantangara; and
- Rock Forest.

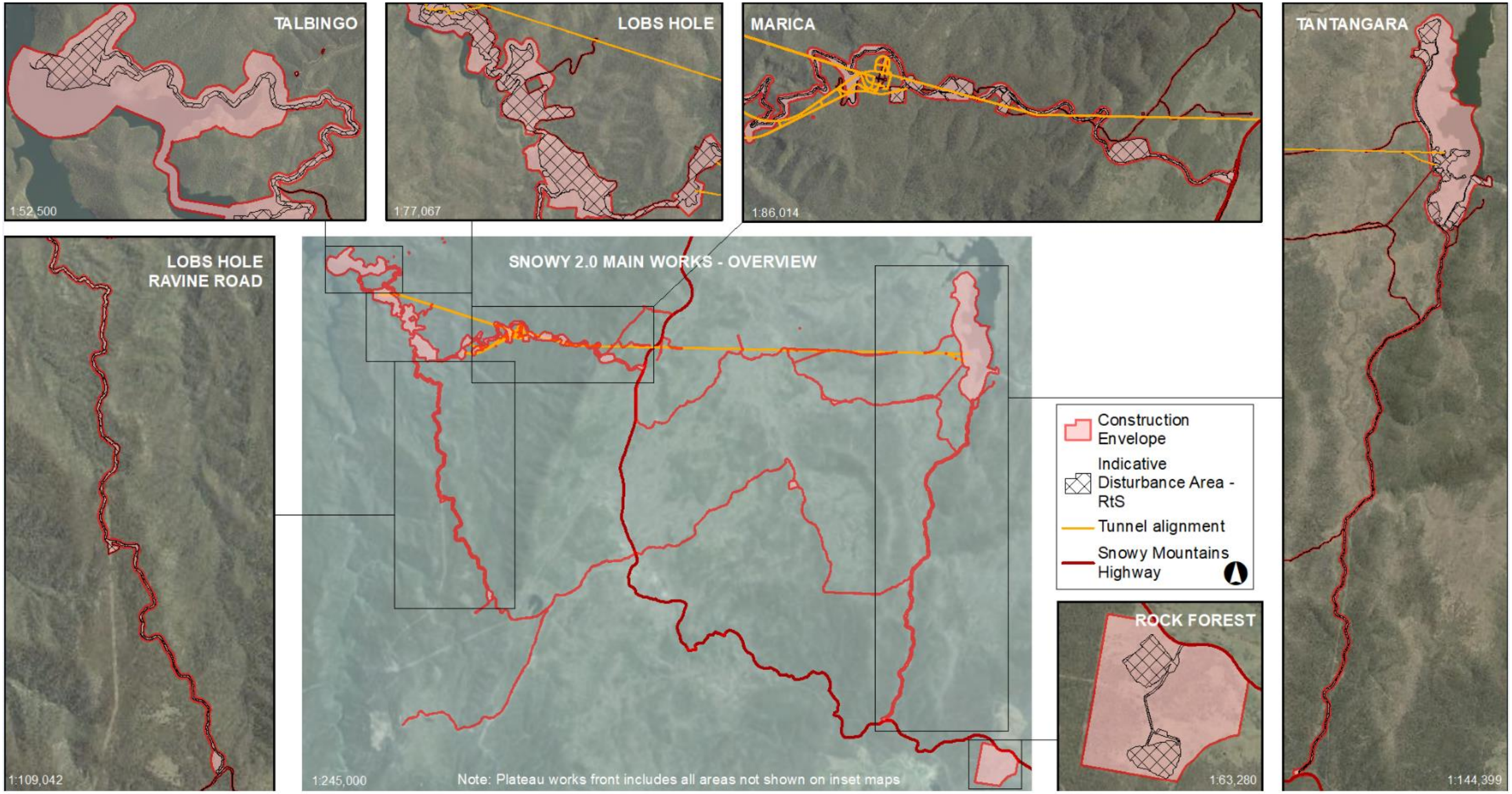

Figure 1-2: Snowy 2.0 Main Works work site

1.2. Project Approval

On 7 March 2018 the NSW Minister for Planning declared Snowy 2.0 to be State significant infrastructure (SSI) and critical State significant infrastructure (CSSI) under the *Environmental Planning and Assessment Act 1979* (EP&A Act) on the basis that it is critical to the State for environmental, economic or social reasons.

An environmental impact statement for the first stage of Snowy 2.0, the *Environmental Impact Statement Exploratory Works for Snowy 2.0* (Exploratory Work EIS) was submitted to the then Department of Planning and Environment in July 2018 and publicly exhibited between 23 July 2018 and 20 August 2018. Approval for the first stage of Snowy 2.0 was granted for Exploratory Works by the Minister for Planning on 7 February 2019. In accordance with section 5.25 of the EP&A Act, the infrastructure approval for the Exploratory Works was modified on 2 December 2019 and on 27 March 2020.

An environmental impact statement for the second stage of Snowy 2.0, the Snowy 2.0 Main Works – Environmental Impact Statement (Main Work EIS) was submitted to Department of Planning, Industry and Environment (DPIE) in September 2019 and was publicly exhibited between 26 September 2019 and 7 November 2019. A total of 222 submissions were received during the public exhibition period, including 10 from government agencies, 30 from special interest groups and 182 from the general public. In February 2020, the response to submissions (RTS or Submission Report) was issued to DPIE to address the public and agency submissions (*Snowy 2.0 Main Works - Preferred Infrastructure Report and Response to Submissions, February 2020*).

Following consideration of the Main Works EIS and RTS, approval was granted by the Minister for Planning and Public Spaces on 20 May 2020, through issue of Infrastructure Approval SSI 9687.

Further to the Infrastructure Approval, the Main Works RTS include revised environmental management measures (REMMs) within Appendix C which will also be implemented for the Project.

In addition to the State approval, a referral (EPBC 2018/8322) was prepared and lodged with the Commonwealth Department of Energy and Environment (DoEE – *now* Department of Agriculture, Water and the Environment; DAWE) under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Commonwealth Minister's delegate determined on 5 December 2018 that Snowy 2.0 Main Works is a "controlled action" under the EPBC Act. The EPBC Act referral decision determined that the project will be assessed by accredited assessment under Part 5, Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979*

1.3. Disturbance area

A key refinement following public exhibition of the Main Works EIS was a change to and clarification of disturbance area terminology. The revised disturbance area terminology as per the SSI-9687 Instrument, RTS and this Plan is outlined in Table 1-1, with an example of the terminology shown for Lobs Hole Ravine Road in Figure 1-3.

Table 1-1: Disturbance area terminology

Term	Definition	Reasoning
Project area	The project area is the broader region within which Snowy 2.0 will be built and operated, and the extent within which direct impacts from Snowy 2.0 Main Works are anticipated.	The project area does not represent a footprint for the construction works, but rather indicates an area that was investigated during environmental assessments.
Construction envelope	The envelope within which the disturbance area of the development may be located.	As detailed design continues, final siting of the infrastructure (i.e. the disturbance area) may move within the assessed construction envelope subject to recommended environmental management measures and provided it does not exceed the limits defined by the construction envelope.
Disturbance area	The area within the construction envelope where development may be carried out; the precise location of the disturbance area will be fixed within the construction envelope following final design.	

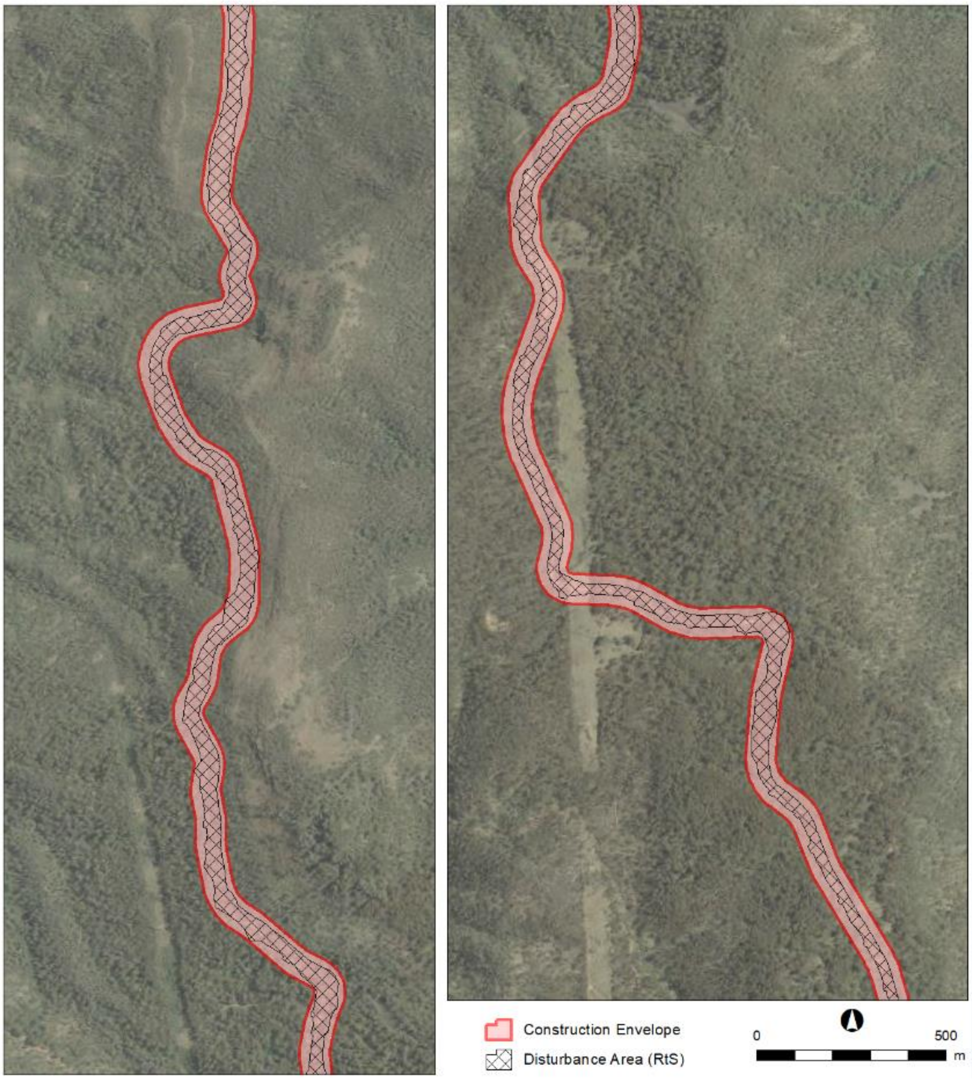

Figure 1-3: Disturbance area and construction envelope

1.4. Works within the Construction Envelope

Where project works are required to occur in locations outside of the disturbance boundary, Future Generation will review the proposed area of clearing against the limits included within condition 5 of schedule 2. The review will be undertaken to ensure that the maximum disturbance area and maximum native vegetation clearing remains within the total areas nominated within the condition. These area limits are included within Table 1-2.

All vegetation clearing which occurs on the project will be monitored regularly to record the extent of clearing which has occurred, and to ensure that the clearing limits are not exceeded.

Table 1-2: Maximum disturbance area and native vegetation clearing

Matter	Exploratory Works	Main Works	Total
Maximum Disturbance Area	126 ha	504 ha	630 ha
Maximum Native Vegetation Clearing	107 ha	425 ha	532 ha

1.5. Environmental Management System

The overall environmental management system for the Project is described in the Environmental Management Strategy (EMS). The EMS forms part of the Project Management System (Future Generation-PMS) and will include any requirements specified in the contract documents, where appropriate. All Future Generation-PMS procedures will support, interface or directly relate to the development and execution of the plan.

The management plans and post-approval documents for the project include those listed within Figure 1-4.

This Groundwater Management Plan (GMP or Plan) (S2-FGJV-ENV-PLN-0012) is an appendix to the Water Management Plan (WMP) (S2-FGJV-ENV-PLN-0010) which has been prepared for the Snowy 2.0 Main Works project, and supersedes the existing Stage 1 and Stage 2 Exploratory Works Water Management Plan. It does not address the operational phase of the project.

This Plan forms part of Future Generation's environmental management framework.

An overview of the WMP structure relative to the elements of water management is shown in Figure 1-5.

This Plan aims to transfer the relevant requirements of the Approval documents into a management plan which can be practically applied on the Project site

snowy 2.0

Future Generation
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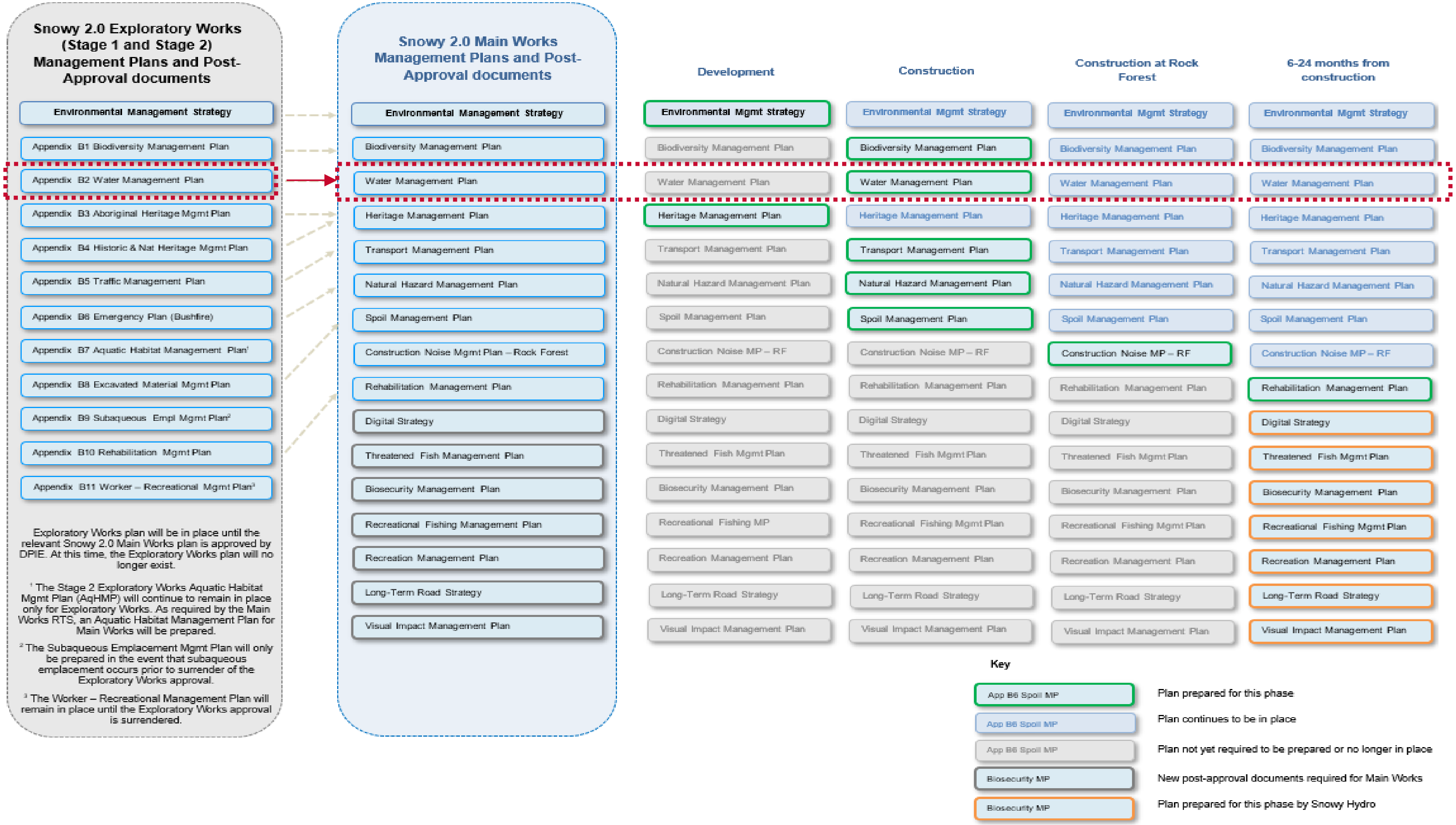

Figure 1-4: Management plans and post-approval documents with the WMP indicated

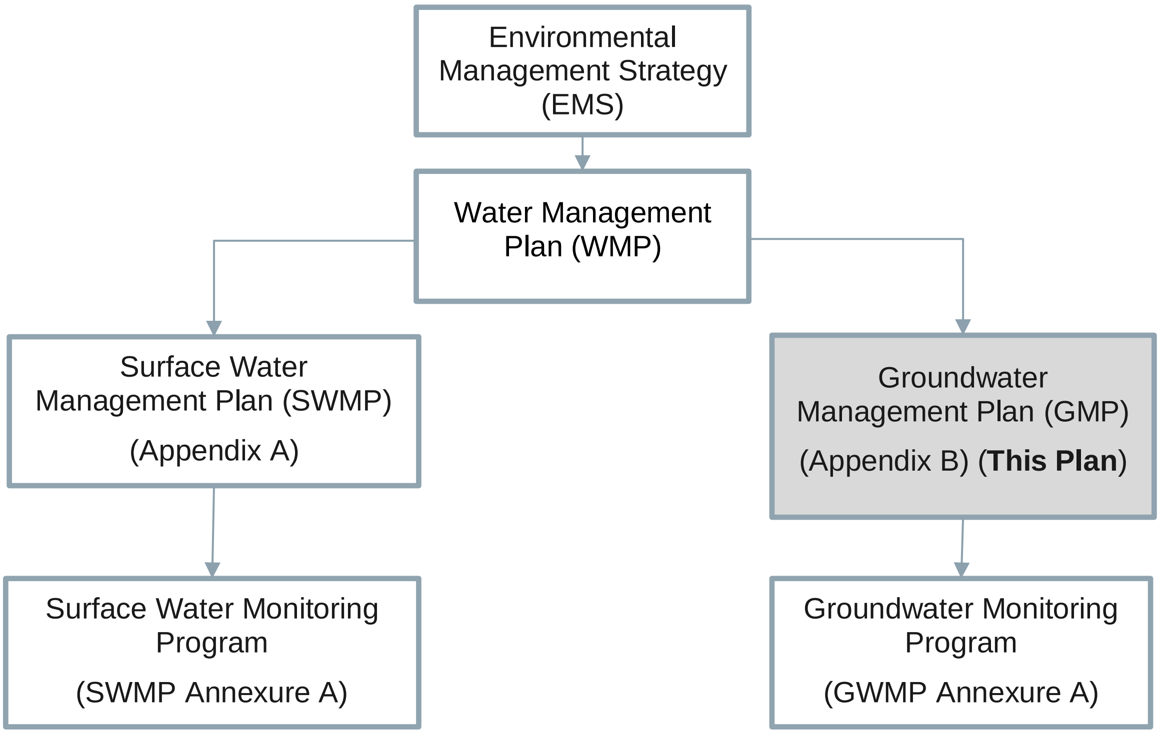

Figure 1-5: Water Management Plan Structure

1.6. Purpose and objective of this plan

The purpose of this Plan is to address the construction environmental management requirements as they relate to groundwater as detailed in the:

- Infrastructure Approval (SSI 9687) (Approval) issued for Snowy 2.0 Main Works on 21 May 2020;
- *Main Works Snowy 2.0 - Environmental Impact Statement;*
- revised environmental management measures (REMMs) within the Main Works RTS;
- the Infrastructure Approval (SSI 9208) issued for Snowy 2.0 Exploratory Works on 7 February 2019 and modified on 2 December 2019 and 27 March 2020
- *Exploratory Works for Snowy 2.0 - Environmental Impact Statement*;
- *Exploratory Works for Snowy 2.0 – Modification 1 Assessment Report;*
- *Exploratory Works for Snowy 2.0 – Modification 2 Assessment Report;*
- REMMs within the Exploratory Works RTS, Exploratory Works Modification 1 RTS, and Exploratory Works Modification 2 RTS; and
- Environmental Protection License (EPL) 21266 (*as varied 8th April, 2020*).

The key objective of this Plan is to detail management measures and inform site procedures for implementation so that groundwater impacts are minimised and within the scope permitted by the Infrastructure Approval. To achieve this, Snowy Hydro and Future Generation will implement:

- appropriate measures to address relevant conditions of approval and REMMs listed within the Submissions Report, as detailed within Section 2 of this Plan;

- appropriate measures during construction to manage and protect groundwater;
- a groundwater monitoring program during construction to assess the effectiveness of the groundwater management controls and impacts on the receiving environment; and
- corrective actions and contingency measures during construction when triggered.

Specific on-site management measures identified in this plan will be incorporated into site documents where relevant. These site-specific documents will be prepared for construction activities and will detail the management measures which are to be implemented on the ground. Construction personnel will be required to undertake works in accordance with the mitigation measures identified in the site-specific documents.

1.7. Staging

Some distinct activities require greater detail prior to commencement. Consequently, this Plan will be updated, in consultation with relevant government agencies, and submitted to DPIE prior to the commencement of specific activities as detailed in Table 1-3.

Table 1-3: Activities that require update to this GMP

Activities	Timing
Operation of Snowy 2.0 Project, including dewatering of the tailrace tunnel during operations.	Operation will be addressed through a separate Snowy Hydro framework or document.

1.8. Plan Preparation

In accordance with schedule 3, condition 31 of the Approval, the GMP has been prepared by a suitably qualified and experienced person. This plan was prepared by Dr Richard Cresswell, Eco Logical Australia.

1.9. Consultation

In accordance with schedule 3, condition 31 of the Infrastructure Approval, the WMP (which includes this GMP) is prepared in consultation with:

- NSW Environment Protection Agency (EPA)
- National Parks and Wildlife Services (NPWS)
- NSW Department of Planning, Industry and Environment – Water (DPIE – Water Group)
- Natural Resources Access Regulator (NRAR), and
- NSW Department of Primary Industries within Regional Australia (NSW DPI).

In accordance with condition 18 of the Commonwealth approval, the WMP (including this GMP) is also to be prepared in consultation with the DAWE.

Agency briefings for the WMP were held on 30 April 2020 and 7 May 2020 with EPA, NPWS, Water Group, NSW DPI and the Biodiversity and Conservation Division (BCD).

On 15th June 2020 the plan was issued to stakeholder agencies for review and comment. Comments from consultation have been incorporated into this plan where appropriate. Response to the comments have been provided back to the stakeholder agencies. Consultation is summarised in Table 1-4.

Table 1-4: Consultation undertaken for this plan

Date	Consultation	Outcomes
26/03/2020	Water Group	Agency briefing (online PowerPoint) and discussion of previous meetings held with SHL during RTS assessment.
30/04/2020	EPA, NPWS, NSW DPI, BCD, DPIE Water Group	Agency briefing (online PowerPoint) providing overview of document structure and surface water management approach.
07/05/2020	EPA, NPWS, BCD, DPIE Water Group	Agency briefing (online PowerPoint) providing overview of the development of the surface water monitoring program and groundwater monitoring program.
15/06/2020	NPWS, EPA, Water Group, NRAR, NSW DPI	GMP (revision C) including monitoring program issued to stakeholders for review and comment
08/07/2020	DAWE	Agency briefing (online PowerPoint) providing overview of document structure and water management approach.
03/08/2020	NRAR, Water Group	Amendment to groundwater monitoring network.
24/08/2020	DAWE	General clarifications on WMP

A separate document is proposed to be provided to DPIE and DAWE which details the consultation process, along with Future Generation responses to stakeholder comments and how feedback has been implemented during the action.

1.9.1. Ongoing Consultation

Future Generation will consult with stakeholders identified in schedule 3, condition 31 of the Infrastructure Approval for updates to this WMP.

Where additional monitoring infrastructure is proposed outside the construction envelope. Future Generation will review environmental constraints and consult with relevant stakeholders (i.e. NPWS for monitoring infrastructure within the KNP).

2. ENVIRONMENTAL REQUIREMENTS

2.1. Legislation

Legislation relevant to groundwater management includes:

- *Environmental Planning and Assessment Act 1979* (EP&A Act);
- *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation);
- *Protection of the Environment Operations Act 1997* (POEO Act);
- Protection of the Environment (General) Regulation 2009 (POEO General Regulation);
- *Water Management Act 2000* (WM Act);
- *Water Management Amendment Act 2014* (WMA Act);
- Water Management (General) Regulation 2011 (WM General Regulation);
- Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources (2012);
- Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources (2011);
- Water Sharing Plan for the South Coast Groundwater Sources (2016); and
- *Snowy Hydro Corporatisation Act 1997* (SHC Act).

Relevant provisions of the above legislation are explained in the register of legal and other requirements included in Appendix A1 of the EMS.

2.2. Conditions of Approval

Table 2-1 details the COA that are relevant to groundwater and demonstrates where these conditions are addressed

Table 2-1: Conditions of approval relevant to groundwater

CoA	Requirement	Where addressed
Schedule 3		
15	**Potential Additional Offsets – Alpine Sphagnum Bogs and Associated Fens** The Proponent must ensure that the development does not cause any exceedances of the following performance measures in the Alpine Sphagnum Bogs and Associated Fens above the Gooandra Volcanics and Kellys Plains Volcanics: (a) negligible change to the shallow groundwater regime supporting the bogs and associated fens when compared to a suitable control site; and (b) negligible change in the ecosystem functionality of the bogs and associated fens.	GMP – Section 7.2.3 and Annexure A Section 2.5.1

CoA	Requirement	Where addressed
16	If the Planning Secretary determines that the development has caused exceedances of the performance measures in condition 15 above, the Proponent must pay additional funds to the NPWS within 3 months of the determination to offset the groundwater-related impacts of the development on the Alpine Sphagnum Bogs and Associated Fens. The Planning Secretary will determine the amount of funds the proponent must pay following consultation with the NPWS, DAWE and the Proponent; and having regard to: (a) The significance of the impacts on the bogs and associated fens; (b) The relevant values from the Biodiversity Offset Payment calculator; and (c) The likely cost of carrying out the conservation actions required to offset these impacts on the bogs and associate fens. *Note: These funds will be added to the funds paid under condition 12 (Biodiversity Offset Payments) and managed in accordance with the notes under that condition.*	Biodiversity Management Plan (S2-FGJ-ENV-PLN-0008)
28	**Water Supply** The Proponent must ensure it has sufficient water for each stage of the development; and if necessary, adjust the scale of development on site to match its available water supply. *Note: Under the Water Management Act 2000, the Proponent must obtain the necessary water licences for the development.*	WMP – Section 2.5.3 SWMP – Section 2.5.3 GMP – Section 2.5.3
29	**Water Pollution** Unless an environment protection licence authorises otherwise, the Proponent must comply with Section 120 of the POEO Act. *Note: Section 120 of the POEO Act makes it an offence to pollute any waters*	SWMP – Table 5-3: SW02, SW22, SW30 GMP – Table 5-1: GW03
30	**Water Mitigation Requirements** The Proponent must:	
	(e) minimise groundwater take from the Gooandra Volcanics and Kellys Plain Volcanics using pre and post grouting of the tunnel, to minimise the loss of stream flows in the waterways above these geological formations, including Gooandra Creek and the headwaters of the Eucumbene River;	GMP – Section 5.1 and Table 5-1: GW04 and GW05
	(o) minimise the groundwater quality impacts of the development, particularly through the design of the temporary and permanent spoil emplacement areas and all water storages on site;	GMP – Section 5.4 and Table 5-1: GW09 Spoil Management Plan (S2-FGJV-PLN-0019)
31	**Water Management Plan** Prior to the commencement of construction, the Proponent must prepare a Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must:	WMP
	(d) include a Groundwater Management Plan with: • detailed baseline data on groundwater levels, yield and quality on the aquifers that could be affected by the development, and a program to augment this baseline data over time;	This Plan GMP – Annexure A Attachment A
	• a program to validate and calibrate the groundwater model for the development as new information is collected;	GMP – Section 8.2 and Table 5-1: GW12
	• detailed criteria for determining the groundwater impacts of the development, including criteria for triggering remedial action (if necessary)	GMP – Section 6.4
	• a description of the measures that would be implemented to comply with the management requirements in condition 30 above;	GMP – Section 5 and Table 5-1

CoA	Requirement	Where addressed
	• a program to monitor and report on: – groundwater inflows to the tunnel; – water take from the groundwater bores and connected water sources; – the impacts of the development on: o regional and local (including alluvial) aquifers; o base flow to surface water sources;	GMP – Section 6.8 and Annexure A Section 2
38	The Proponent must implement the approved Water Management Plan for the development.	The Water Management Plan will be implemented for the development.
Schedule 4		
5	The Proponent may undertake monitoring outside the construction envelope of the development provided this monitoring is required under the conditions of this approval and authorised under an approved management plan.	WMP – Section 6.3.1

2.3. Revised Environmental Management Measures

During preparation of the Exploratory Works and Main Works Submission Reports, Revised Environmental Management Measures (REMMs) were developed and are included in Appendix C of the Main Works RTS and Section 8 of the Exploratory Works RTS.

The Main Works and Exploratory Works REMMs relevant to groundwater are listed in Table 2-2 and Table 2-3. In accordance with CSSI 9687, schedule 2, CoA 3, if there is any inconsistency between the Exploratory Works and Main Works documents, the most recent document will prevail to the extent of the inconsistency (i.e. Main Works).

Table 2-2: Main Works revised environmental management measures relevant to groundwater

Impact	Reference	Environmental Management Measures	Where addressed
General	WM01	A Water Management Plan will be developed for Snowy 2.0 Main Works that includes:	WMP
		• proposed mitigation and management measures for all construction water management categories;	WMP – Section 4.1 SWMP – Table 5-3 (All measures) GMP – Table 5-1 (All measures)
		• a surface and groundwater monitoring program;	GMP – Annexure A SWMP – Annexure A
		• water quality trigger action response plan;	GMP – Section 7, Annexure B, Annexure C, Annexure D SWMP – Section 6.4, Annexure B
		• reporting requirements;	WMP – Section 6.6 SWMP – Section 6.7 GMP – Section 6.8
		• corrective actions;	GMP – Section 7 SWMP – Section 6
		• contingencies; and	GMP – Table 5-1: GW13 SWMP – Section 5.3.1, Section 5.14 and Section 6.4
		• responsibilities for all management measures.	GMP – Table 5-1 SWMP – Table 5-3
General	WM02	A water monitoring program will be developed as part of the water management plan to monitor quality and quantity impacts to surface water, groundwater and reservoirs. The water monitoring program will incorporate and update the existing monitoring network and detail monitoring frequencies and water quality constituents.	GMP – Annexure A SWMP – Annexure A
Groundwater modelling	WM06	The groundwater model developed for Snowy 2.0 Main Works will be validated and, if necessary, recalibrated to new groundwater monitoring data as the monitoring record increases throughout construction. It is recommended that assessment of the monitoring record and groundwater affecting activities, along with model updates, be undertaken at least annually throughout construction and into operation until it is evident that the update frequency can be reduced.	GMP – Section 8.2
Groundwater inflow / drawdown	WM07	Where discrete high flow features are intercepted, pre-grouting and secondary grouting from the tunnel boring machines (TBMs) may be undertaken to enable tunnel construction.	GMP – Section 5.1.4, Section 5.1.5 and Table 5-1: GW05
Impacts to GDEs	ECO3	A GDE monitoring program will be implemented to assess actual impacts against predicted. If actual impacts are greater than predicted, adaptive management will be implemented.	GMP – Section 3.9, Section 4.2.4, Section 7.2.3 and Annexure A

Table 2-3: Exploratory Works revised environmental management measures relevant to groundwater

Impact	Reference	Requirement	Where addressed
Leaching/ running into groundwater/ creeks	WAT01	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including: • minimising direct access to the river by construction vehicles and mechanical plant; • regular inspection of construction vehicles and mechanical plant for leakage of fuel and /or oils; • establishing a bunded area for storage of fuel and oils; • refuelling and maintenance of vehicles and mechanical plant at least 50 m from watercourses; • avoiding as far as possible re-fuelling, washing and maintenance of land-based vehicles and plant within 50 m of watercourses; • reporting spillages to the appropriate officer and immediately deploying spill containment and / or absorption kits as required to restrict its spread; • vehicles, vessels and plant would be properly maintained and regularly inspected for fluid leaks; • emergency spill kits will be kept onsite, at refuelling areas and on all vessels at all times during the Exploratory Works. The spill kit will be appropriately sized for the volume of substances on the vessel. All staff would be made aware of the location of the spill kit and trained in its use; • if any hydrocarbon spills were to occur during soil stripping, the impact will be isolated and clean-up procedures implemented; • areas to be used for long-term storage and handling of hydrocarbons and chemicals will be enclosed with concrete bunds; • chemicals will be handled and stored as per manufacturer's instructions; and • below ground, refuelling will be undertaken in dry, enclosed, bunded areas;	GMP - Section 5, Table 5-1: GW02, GW06, GW07, GW08 SWMP - Section 5.4, Table 5-3: SW36, SW37, SW38, SW39, SW40 and SW41, Annexure C (Spill Response Procedure)
Surface and groundwater	WAT02	A Surface and Groundwater Monitoring Program will be developed and implemented to monitor the effectiveness of water quality controls. The program will include:	GMP – Annexure A SWMP – Annexure A
		• establish monitoring locations to provide suitable baseline and detection monitoring of surface and groundwater parameters;	GMP – Annexure A SWMP – Annexure A
		• monitor groundwater inflows indirectly through the process water system and groundwater levels as well as groundwater quality during construction; and	GMP – Annexure A
		• set out annual monitoring requirements for Yarrangobilly Caves and plant community types potentially reliant on groundwater.	GMP – Annexure A Biodiversity Management Plan (S2-FGJ-ENV-PLN-0008)
	WAT03	Areas of groundwater inflow will be shotcreted or sealed by other methods to minimise further ingress.	GMP – Section 5.1.4, Section 5.1.5 and Table 5-1: GW05
		If groundwater is intercepted and reductions to groundwater inflows to watercourses predicted, then groundwater should be discharged to waterways. This	GMP – Section 5.3 and Table 5-1: GW13

Impact	Reference	Requirement	Where addressed
		would occur following appropriate treatment of discharge water.	
Borehole drilling	M1.6	During borehole drilling slurries used will be of appropriate grade and composition such that it poses no threat to groundwater quality should it infiltrate intersected aquifers.	GMP – Table 5-1: GW08

2.4. EPBC Approval

The EPBC Act approval for Snowy 2.0 Main Works was granted by DAWE in 2020. This approval was provided for the impact of the Snowy 2.0 Main Works Project on national heritage values of a national heritage place (Sections 15B and 15C of the EPBC Act), listed threatened species and communities (Section 18, Section 18A of the EPBC Act) and listed migratory species (Section 20, Section 20A of the EPBC Act).

Table 2-4 details the EPBC Act Approval conditions which are relevant to water and demonstrates where these conditions are addressed.

Table 2-4: Commonwealth conditions of approval relevant to water

Condition	Requirement	Where addressed
17	To minimise impacts on water resources, the approval holder must comply with conditions 30 – 32 of the NSW approval relating to water management	Refer to Table 2-1
18	The approval holder must prepare the Water Management Plan required by condition 31 of the NSW approval in consultation with the Department, before it is approved by the NSW Planning Secretary	Section 1.7
19	The Water Management Plan must include provisions to make monitoring data (excluding sensitive ecological data) available as part of the monitoring, evaluation and reporting programs required by condition 31c and 31d of the NSW approval	Section 6.8
20	Once the Water Management Plan is approved by the NSW Planning Secretary, the approval holder must implement the plan for the duration of the approval, unless otherwise agreed by the Minister in writing.	This SWMP will be implemented for the development Refer to Section 6.

2.5. Licences and Permits

2.5.1. Environment Protection Licence

Environment Protection Licence (EPL) (No. 21266) was issued as part of the Exploratory Works phase for extractive activities and includes requirements for groundwater protection. The present boundary for the Exploratory Works EPL is proposed to be expanded to encompasses both Exploratory Works and Main Works activities with the governing scheduled activity to become Electricity Generation.

The groundwater requirements in the current Project EPL (No. 21266, dated as variation 8th April, 2020; Notice Number 1592566) will be adhered to and includes groundwater monitoring. Future groundwater monitoring requirements of the EPL may differ to that detailed within this Plan, in the event of variations to the EPL. Differences may include changes to the monitoring locations; changes to the frequency of monitoring, or changes to the parameters which are required to be monitored.

Should differences arise, the monitoring requirements of the active EPL will take precedence.

2.5.2. Agreement for Lease

Snowy Hydro Limited have established an Agreement for Lease (AFL) with NPWS. A Construction Lease and Works Access Licence will be established with NPWS in order to carry the works in accordance with Main Works, Exploratory Works, CSSI 9687 and the approved management plans.

2.5.3. Water Access Licencing

Section 60A of the *Water Management Act 2000* requires that a water access licence be obtained to extract water from a water source.

Section 21 and schedule 4 of the *Water Management (General) Regulation 2018* does, however, provide exemptions for the requirement to obtain water access licences. These exemptions include: water extracted for the use as dust suppression by a public authority (clause 5); certain aquifer interference activities (i.e. pump testing a bore; or monitoring) requiring up to 3 ML of groundwater from a groundwater source (clause 7) and operation of a hydro-electric power station for the purpose of generating hydro-electric power (clause 11).

Water access licences would therefore not be required if Snowy Hydro, as the licence holder, is using the water for dust suppression, or for certain aquifer interference activities (i.e. pump testing a bore; or monitoring) with less than 3ML of groundwater take in a water year.

Any other water required for construction purposes requires a water access licence. This includes extraction for:

- interception activities (i.e. intercepted groundwater during tunnelling);
- potable uses for human consumption associated with the accommodation camp; and
- process water, via the services pipeline from Talbingo and Tantangara Reservoirs, for tunnelling and construction activities.

The Project will intercept two groundwater sources (see Figure 2-1): Lachlan Fold Belt Murray Darling Basin (LFB MDB) groundwater source and the Lachlan Fold Belt South Coast (LFB SC) groundwater source.

Snowy Hydro have secured two groundwater access licences (WAL42408, WAL42960) and a surface water specific purpose access licence (WAL42407) for the Exploratory Works Project. These three licences allow for direct and indirect take of water from the LFB MDB) groundwater source and direct take from the Upper Tumut water source (i.e. from Talbingo Reservoir).

Snowy Hydro are in the process of finalising groundwater licences via Controlled Allocation Order for additional share entitlement from the LFB MDB groundwater source (RO13-19-093), the LFB South Coast groundwater source (RO13-19-192) and a surface water specific purpose access licence (to take water from Tantangara Reservoir) for the Main Works Project. The additional allocation covers the peak predicted annual take modelled for both Main Works and Exploratory Works.

These Water Access Licenses are being processed by the Natural Resources Access Regulator (NRAR) and registration with NSW Land Registry Services (LRS) has commenced. Actual take will be reported to NRAR on an annual basis in accordance with licence conditions.

Table 2-5 summarises the licencing arrangements.

Table 2-5: Water access licences

Water Access Licence	Project	Water source	Share (ML)
WAL42407– Specific Purpose Access Licence	Exploratory Works	Upper Tumut water source	227
WAL42408 – Groundwater Licence	Exploratory Works	Lachlan Fold Belt MDB	0
WAL42960 – Groundwater Licence	Exploratory Works	Lachlan Fold Belt MDB	354
RO13-19-093 – via Controlled Allocation	Main Works	Lachlan Fold Belt MDB	3,375
RO1-19-092 – via Controlled Allocation	Main Works	Lachlan Fold Belt South Coast	1,722
Specific Purpose Access Licence (under application)	Main Works	Tantangara Water Source	In progress

2.6. Guidelines and standards

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

- Australian & New Zealand Guidelines for Fresh & Marine Water Quality (ANZG, 2018)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000);
- Australian Drinking Water Guidelines (Natural Resource Management Ministerial Council (NRMMC), 2011);
- Groundwater Dependent Ecosystems Risk Assessment Guidelines (NOW 2012d);
- NSW State Groundwater Quantity Management Policy (2001 (unpublished));
- NSW State Groundwater Quality Protection Policy (DLWC 1998);
- NSW State Groundwater Dependent Ecosystem Policy (DLWC 2002);
- Australian Groundwater Modelling Guidelines (National Water Commission 2012);
- National Water Quality Management Strategy Guidelines for Groundwater Quality Protection in Australia (NWQMS 2013);
- Department of Primary Industries Guidelines for Controlled Activities (2012);
- Environment Protection Authority (EPA): Approved methods for Sampling and Analysis of Water Pollutants in NSW (EPA 2004);
- Department of Planning and Environment (DPR): Guideline for riparian corridors on waterfront land (DPE 2012);
- Department of Water and Energy (DWE): NSW Water Extraction Monitoring Policy (DWE 2007); and
- NSW Office of Water (NoW) NSW Aquifer Interference Policy (NoW 2012).

Other reference documents include:

- *Snowy 2.0 Environmental Impact Statement Volume 3, Appendix J, Water Assessment Annexure A, September 2019;*
- *Snowy 2.0 Main Works - Preferred Infrastructure Report and Response to Submissions,* Appendix I, *Revised Water Modelling Report, February 2020;* and
- *Snowy 2.0 Main Works - Preferred Infrastructure Report and Response to Submissions,* Appendix J, *Revised Water Management Report*, February 2020

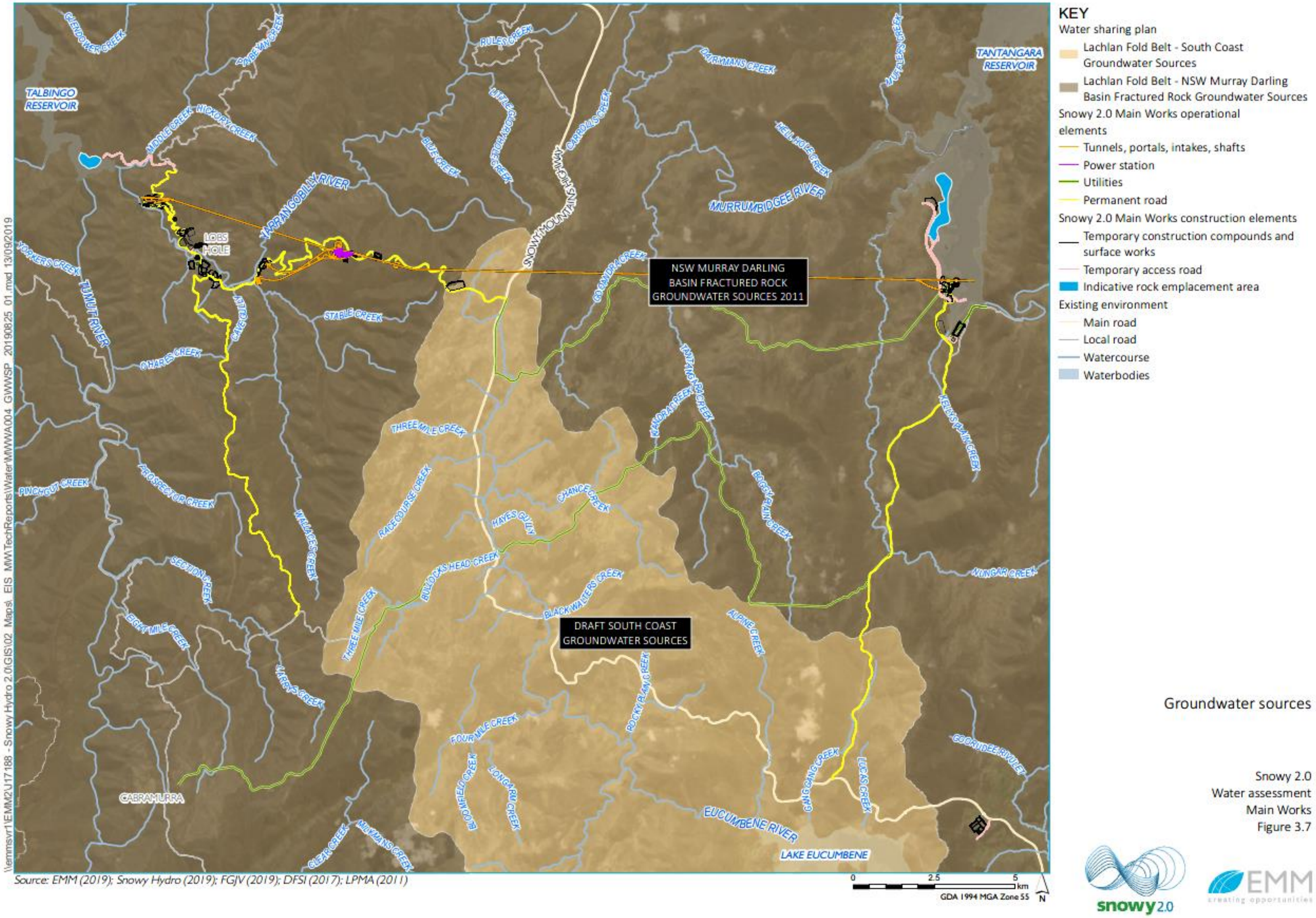

Figure 2-1: Groundwater sources intercepted by the Main Works

3. EXISTING ENVIRONMENT

The following section identifies the factors influencing groundwater within the Project area and has been summarised from the following EIS documents to provide pertinent detail relating to the Project:

- Main Works EIS Section 6.2 (Water) and Section 6.5 (Land);
- Main Works EIS Appendix J (Water assessment); and
- Main Works EIS Appendix O.1 (Palaeozoic Geodiversity Assessment) and Appendix O.2 (Cenozoic Geodiversity Assessment).

Hydrogeology across the project area has been informed by a groundwater monitoring network, designed specifically to investigate the hydrogeological conditions of the project area; developed as part of the EIS approval.

3.1. Topography and Landscape

The Snowy 2.0 Project is mostly located within the KNP and spans the NSW Western Slopes, South Eastern Highlands and Australian Alps Interim Biogeographic Regionalisation for Australia (IBRA) regions. The geomorphic history of the project area is complex and has resulted in a landscape of disrupted drainage patterns, swampy basins and erosion surfaces (Snowy Hydro 2017). This complexity is seen in the diverse landforms present in the area, ranging from valleys to mountain ranges. For the most part, the project area can be broken into two distinctive terrains: the incised ravine area and the plateau area.

The ravine area is located mostly to the west of the Snowy Mountains Highway and is characterised by deep gorges and steep sloping ridges. It is the product of incision from river flow, historic glaciation and structural movement. The ravine area includes the Talbingo, Lobs Hole, Lobs Hole Ravine Road and Marica work sites.

The plateau area is located to the east of the Snowy Mountains Highway and spans the area between the highway and Tantangara Reservoir. This area is typical of elevated alpine environments, dominated by low energy streams, gentle rolling hills and mostly flat floodplains. The plateau area includes the Plateau and Tantangara work sites.

The landscape varies from 545m AHD in the Ravine area (Lobs Hole) leading up the valleys (Marica/ Plateau zones) to the plateau topped Tantangara zone at 1524m AHD.

The Rock Forest work site is located on farm land outside the KNP; 13 km to the south of Tantangara Reservoir. No underground nor significant excavations are proposed at this site, hence there will be no impacts to groundwater and this area is not considered further for groundwater management.

3.2. Climate

The project area has an alpine climate characterised by cool summers and cold, damp and snowy winters. The highest and most consistent precipitation occurs during winter to early spring, with precipitation amounts increasing with elevation. Summer and autumn are generally drier and experience greater inter-annual variation in monthly rainfall. Summer rainfall is generally of higher intensity and of shorter duration than that in winter. Climate data for the project area has been sourced from regional Bureau of Meteorology (BoM) and Snowy Hydro rainfall gauges, as well as climate maps produced by BoM.

A summary of climate data for the ravine and plateau areas is provided in Table 3-1. Precipitation comprises rainfall and snowfall; the term rainfall has been used throughout the water assessment to maintain consistency with other sections of the Main Works EIS.

Table 3-1: Climate Summary

Parameter	Ravine area	Plateau area
Temperature[1]		
Mean annual maximum	21.3 C	12.6 C
Mean annual minimum	9.1 C	5.1 C
Annual rainfall[2]		
Highest	1315 mm/year	1,902 mm/year
Median	878 mm/year	1,158 mm/year
Lowest	382 mm/year	525 mm/year
Mean Class A pan evaporation[3]		
Annual	1,256 mm/year	
Lowest monthly	27 mm/month	
Highest monthly	206 mm/month	

1. Representative temperature for the ravine and plateau have been sourced from Snowy Hydro operated Talbingo gauge and BoM operated Cabramurra SMHEA AWS (72161) gauge.
2. Representative rainfall for the ravine and plateau areas have been sourced from Snowy Hydro operated Ravine gauge and BoM operated Yarrangobilly Caves (72141) gauge.
3. Representative pan evaporation sourced from Climate Atlas maps (BoM website).

3.3. Rainfall

The 10th, 50th and 90th percentile monthly rainfall have been calculated by BoM from the closest reliable weather station with adequate temporal records cited at Yarrangobilly Caves (Station No. 72142) and are presented in Figure 3-1. Mean monthly pan evaporation sourced from the BoM website are also shown in Figure 3-1. The long-term record indicates that rainfall generally significantly exceeds evaporation over the winter months (May to October) and recharge to shallow systems might be expected during this period. A soil moisture deficit is likely to occur from December to March, when monthly evaporation exceeds the 90th percentile rainfall and these months are likely to result in seasonal drops in connected water tables.

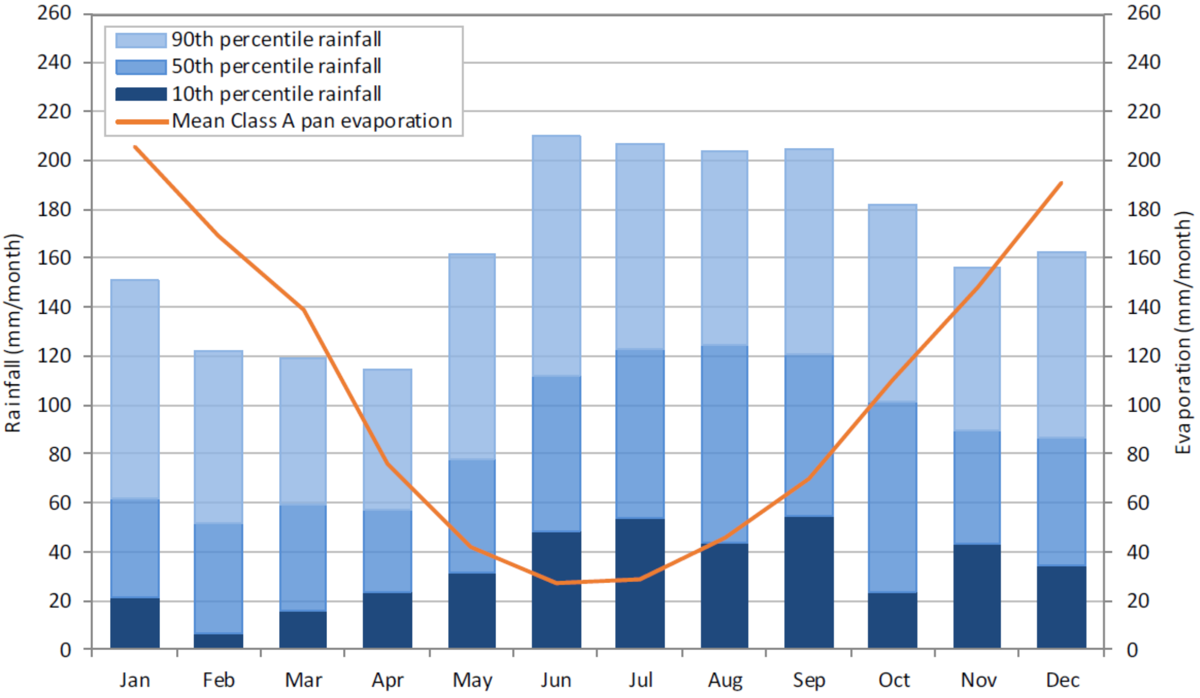

Figure 3-1: Monthly rainfall variability (BoM: 72141) and mean monthly pan evaporation

Long-term monthly rainfall totals recorded at Yarrangobilly Caves (BoM station 72141) from 1999 to March 2019 are shown in Figure 3-2. The deviation of rainfall totals over the previous 12-month period have been calculated and compared to annualised monthly average rainfall to identify and characterise periods of extended dry and wet conditions.

The horizontal line in Figure 3-2 marks the distinction between positive and negative rainfall deviation values. Positive or increasing values relate to wetter than average conditions while negative or falling values relate to drier than average conditions. These deficits and excess in rainfall can also correspond to long-term groundwater level and streamflow trends, with actual conditions reliant on the antecedent conditions of the soil profile. The trends in Figure 3-2 indicate that:

- Below average rainfall occurred between mid-2002 to late 2003, mid-2004 to early 2005, mid-2006 to late 2010, early 2013 to mid-2016 and mid-2017 to mid-2019. The most significant below average rainfall conditions occurred between mid-2006 and late 2010.
- Above average rainfall occurred between 1999 and mid-2002, April 2005 to May 2006, late 2010 to early 2013 and mid-2016 to mid-2017.

The cyclic and seasonal variability is critical in the evaluation of groundwater dependent ecosystem (GDE) functionality and provides context for baseline data collected during the EIS period.

It is noted that data collected for this EIS during 2018 and early 2019 was collected during drier than average conditions.

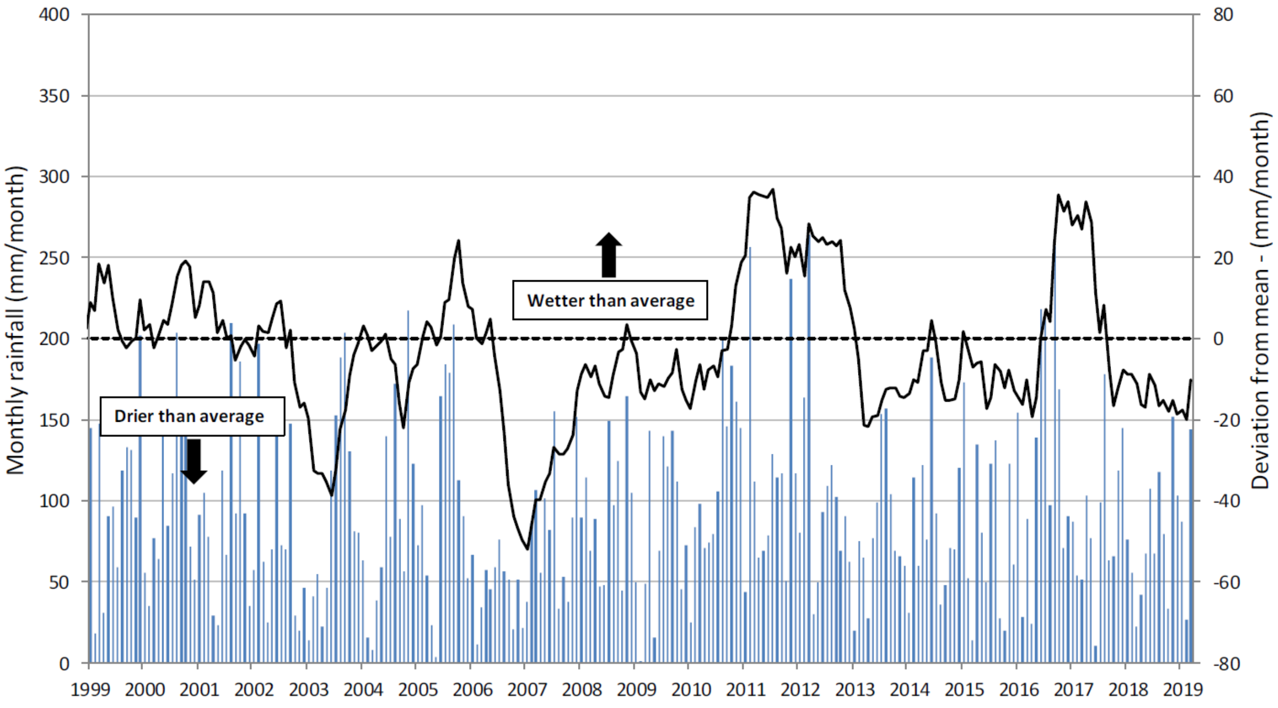

Figure 3-2: Long-term Yarrangobilly Caves (BoM: 72141) rainfall record

3.4. Bushfire

In January 2020, during the Main Works EIS application, significant bushfires occurred within the Project area and northern section of Kosciuszko National Park. The project site at Lobs Hole was severely impacted with much of the groundcover and trees burned, leaving the catchment area with bare soil and no ground protection. Other parts of the Main Works project area including the Plateau, Marica and Tantangara were also impacted by the bushfire to varying degrees.

The bushfires have led to a reduction in ground cover and increase in burnt ash material within and adjacent to the construction envelope. It is likely that, for some time, the existing pre-fire baseline water data that has been gathered and discussed in the Surface Water Management Plan (Appendix A) and Groundwater Management Plan (Appendix B) will differ to the post-fire water quality.

3.5. Geology

The Project area is located within the south-eastern portion of the Lachlan Fold Belt (LFB) of NSW. The LFB comprises a suite of Ordovician to Devonian sedimentary, igneous and metamorphic rocks that have been laid down, compacted and deformed across multiple orogenic periods (Figure 3-3).

The geology between Talbingo and Tantangara reservoirs is structurally deformed with numerous tight folds and several major faults. The region is associated with a strong north-south axial trend and strike which has a dominant control on topography and sub-surface groundwater movement.

The project intercepts two major structural blocks. These two structural blocks form distinct geological terrains: the dominantly Silurian Tumut Block in the west (the incised Ravine area), and the dominantly Ordovician Tantangara Block in the east (the raised Plateau area). The terrains are geologically and topographically separated by an escarpment caused by movement on the Long Plain Fault (LPF).

The key geological formations for each block are listed in Table 3-2 and illustrated schematically in Figure 3-3.

Table 3-2: Key geological formations

Plateau	Ravine
Tertiary Basalt, Kellys Plain Volcanics, Boggy Plain Suite, Peppercorn Formation, Tantangara Formation, Temperance Formation, Shaw Hill Gabbro and the Gooandra Volcanics	Boraig Group, Byron Range Group, Ravine Beds and Yarrangobilly Limestone. Within the Tantangara Block

Also of note, there are eight karst areas in Kosciusko National Park (KNP), all of which are developed in Silurian or Devonian limestones. These include Yarrangobilly Caves, a known GDE and karst area, and Coolemans Plain karst area. Both are recognised in the KNP Plan of Management (DEC 2014) for their cultural and natural significance.

This complex geology, and resulting topography, has resulted in a diverse soil landscape. Soils vary significantly in relation to altitude, temperature and rainfall. In particular, development of relatively fragile Alpine Humus Soils on the Plateau, across all geological materials, is recognised for the Alpine Shagnum Bogs and Associated Fens ecological communities that they support.

The EIS identified two high-risk geological formations: the Gooandra Volcanics and Kellys Plain Volcanics, both of which are located in the Plateau structural block, the Gooandra to the west adjacent to the escarpment and Kellys Plain to the east adjacent to Tantangara Reservoir. These formations have demonstrated (through pumping tests) vertical hydraulic connections between shallow and deeper horizons within each geological unit.

The Ravine area can be further delimited into the eastern and western units, with units becoming more calcareous to the west. This has implications on the groundwater transmissivity and water quality as summarised in Sections 3.6 and Section 3.11.

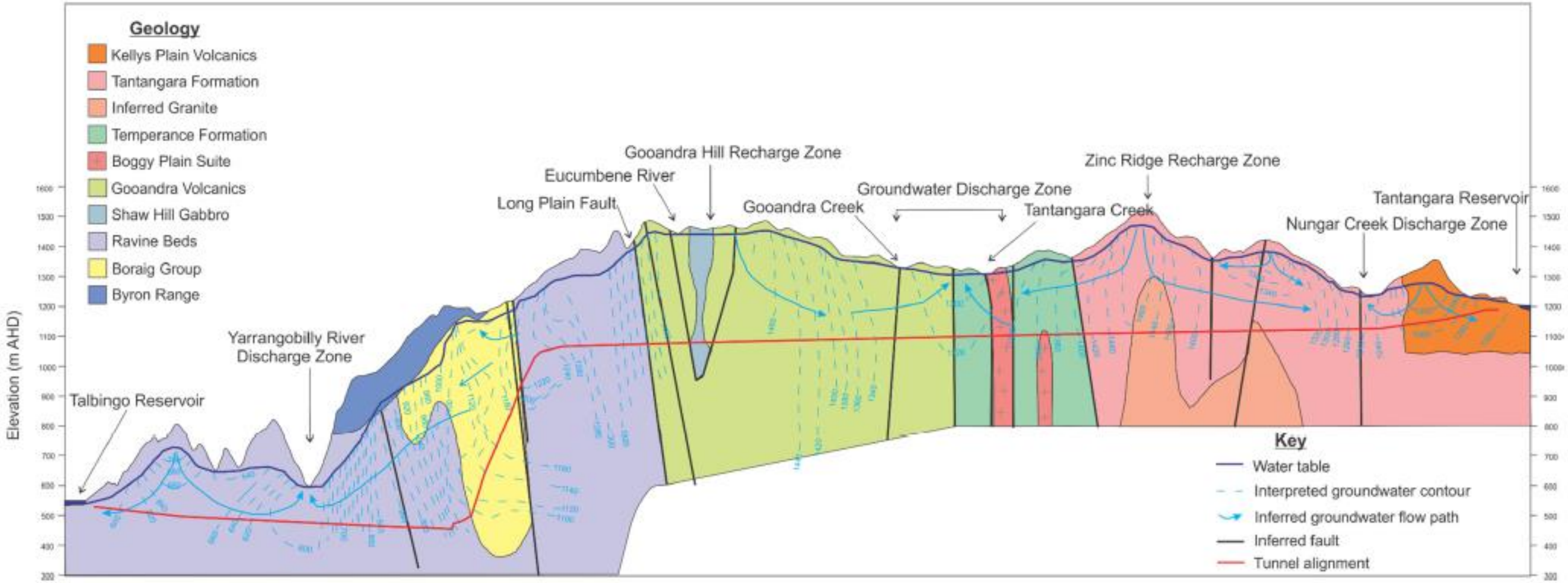

Figure 3-3: Interpreted groundwater recharge, discharge and flow patterns along the tunnel alignment

3.6. Hydrogeology and groundwater units

As defined above, most of the project area is located between the Talbingo and Tantangara reservoirs, within the Tumut (Ravine) and Tantangara (Plateau) structural blocks.

The groundwater-bearing units within the project area are defined as:

- a localised highly permeable shallow groundwater system associated with the thin basalt caps present across the Plateau area;
- a low permeability fractured rock groundwater system associated with the weathered and oxidised shallow component of the geology across the Plateau area;
- a low permeability regional fractured rock groundwater system associated with the volcanic and metasedimentary rocks across the Plateau and Ravine areas.

The hydrogeological units of the project thus transgress the geological units and may be defined as:

- Alluvium, colluvium and surficial weathered rock: These shallow units are generally highly transmissive and are recharged by moderate to high rainfall events; flooding in alluvial areas and from snow melt.
- Shallow, weathered fractured rock: These units have low to moderate permeability and are recharged by moderate to high rainfall events and snow melt when saturated soil moisture conditions are exceeded.
- Deep, fractured rock: Permeability is generally lowest in the central section of the plateau and higher in the east and western areas of the plateau. These units are recharged by infiltration of rainfall migrating through shallow groundwater systems. Groundwater flow can be downward in recharge areas and upward in discharge areas.

Localised groundwater systems are also associated with unconsolidated Quaternary alluvium and colluvium deposited along major creeks and river valleys, and in depressions across the Plateau and Ravine areas.

The deeper fractured volcanic and metasedimentary rocks form the main hydrogeological units in the project area. The groundwater in these units is accessed by various environmental users, including alpine bog/fen vegetation and deep-rooted Eucalypt species. Where it discharges it provides baseflow to gaining creeks and rivers. Groundwater within the fractured rock unit is generally fresh but low yielding when accessed by bores.

The volcanics intercepted by the project across the western Plateau area have been extensively deformed through structural movement and exhibit enhanced secondary porosity and vertical connection.

The metasedimentary units located across the remainder of the Plateau area (mostly closer to Tantangara Reservoir) and within the Ravine area are generally more massive with reduced permeabilities.

3.7. Groundwater recharge, discharge and flow

An overview of groundwater recharge, flow and discharge processes are outlined in Table 3-3.

Table 3-3: Summary of groundwater processes in the Project area

Parameter	Plateau	Ravine
Groundwater recharge	Groundwater recharge is predominantly from rainfall and snowmelt. Recharge is higher when the soil and weathered rock is saturated which generally occurs during winter and spring or after significant rainfall events.	The ravine groundwater system is largely recharged by rainfall and through flooding of the Yarrangobilly River (and storages), and the lateral movement of groundwater from higher elevations, such as from the plateau and elevated Ravine Bed outcrops.
Groundwater flow	Groundwater flow processes include: • groundwater flow within the colluvium/alluvium (when saturated) via primary porosity and within the shallow and deeper fractured rock via secondary porosity (i.e. fractures, joints and bedding planes); • regional groundwater flow towards the east, influenced by stratigraphy, dip of the strata, faulting, fractures and topography; • downward gradients mostly observed between shallow and deeper groundwater systems in recharge areas and upward gradients in discharge areas; • steeper vertical gradients where creeks/rivers are incised and escarpments occur.	Groundwater flow processes include: • groundwater flow away from the Long Plain Fault (LPF), which represents a regional high point and is considered a flow boundary with regional groundwater flow from the LPF moving east to the plateau and west to the ravine. • the bulk of groundwater movement and permeability in the shallow and deep groundwater systems determined by secondary (fracture) porosity, while permeability in the alluvium and colluvium is predominately via primary (matrix) porosity. • localised groundwater flow and direction largely controlled by stratigraphy, dip of the strata, faulting, fractures and topography.
Groundwater discharge	Groundwater discharge processes include: • drainage to surface water (as baseflow to tributaries); • evaporation from the water table where it is shallow (as seeps, springs and escarpments); • evapotranspiration from overlying GDEs (such as some alpine bogs and fens) and vegetation intercepting shallow groundwater systems; • regional groundwater throughflow toward Tantangara Reservoir in the east.	Groundwater discharge processes include: • drainage to the Yarrangobilly River and its tributaries; • evapotranspiration from overlying vegetation intercepting shallow groundwater systems; • seepage/springs and evaporation along escarpments; • regional groundwater throughflow toward Talbingo Reservoir.

3.8. Extractive Water Users

There are no registered groundwater users within the project area nor within 20 km of the Project area boundary.

3.9. Groundwater Dependent Ecosystems

3.9.1. High Priority GDE

The relevant water sharing plans do not identify any High Priority GDEs within the Project area. High priority GDEs are defined as those with high ecological value as determined in the relevant Water Sharing Plans.

The nearest High Priority GDE is the Yarrangobilly Caves which is located approximately 5 km north of the nearest infrastructure feature of the Project and is listed in the Water Sharing Plan (WSP) for the LFB Murray Darling Basin (MDB) Fractured Rock groundwater source.

3.9.2. Type 1 (Sub-surface) GDE (Stygofauna)

A stygofauna assessment by Macquarie University (2019) was undertaken as part of the RTS assessment and identified a total of five specimens, from two families, likely to be obligate (fully groundwater-dependent) stygofauna representatives, from one of the 11 fractured rock sites (TMB02A) and two of the five Alpine bog and fen sites (GH01, GH02). A further 80 specimens from five groups, with potential to be obligate stygofauna representatives, were collected from four of the 11 fractured rock sites and four of the five Alpine bog and fen sites

Limited stygofauna studies have been undertaken within fractured rock aquifers of the region, thus there is limited data for comparison. The stygofauna found in the aquifers in the Snowy 2.0 Project area are noted to be similar to those encountered in other fractured rock systems in NSW.

3.9.3. Type 2 (Aquatic) GDE

Aquatic GDEs are dependent on baseflow in non-perennial rivers and creeks. Across the Project region, all rivers comprise both runoff and baseflow components as shallow groundwater tables are consistently above creek bed elevations. All creeks are therefore considered to support Type 2 GDEs. In particular, PCT 300 occurs along drainage lines on mid-slopes across the Project area and PCTs 285, 299 and 302 occur in riparian zones and gullies (Figure 3-4) where there is likely to be some near-surface expression of groundwater (Main Works EIS, Appendix M.1-01 – Part A9)

3.9.4. Type 3 (Terrestrial) GDE

Terrestrial GDEs include vegetation that accesses groundwater to maintain ecosystem function. These are classified according to their proportional (temporal) dependence on groundwater. This classification is conceptually described and shown in Figure 3-5.

Plant communities with varying degrees of groundwater dependence within the project area are listed in Table 3-4 and shown in Figure 3-5.

Table 3-4: Terrestrial GDE

Groundwater dependence	Mapped plant community type (PCT)
Entirely/obligate dependence on groundwater	• PCT 637 - Alpine and sub-alpine peatlands, damp herbfields and fens, South Eastern Highlands Bioregion and Australian Alps Bioregion; • PCT 1225 - Sub-alpine grasslands of valley floors, southern South Eastern Highlands Bioregion and Australian Alps Bioregion.
Facultative – proportional dependence on groundwater	• PCT 285 - Broad-leaved Sally grass - sedge woodland on valley flats and swamps in the NSW South Western Slopes Bioregion and adjoining South Eastern Highlands Bioregion; • PCT 299 - Riparian Ribbon Gum - Robertsons Peppermint - Apple Box riverine very tall open forest of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion; and

Groundwater dependence	Mapped plant community type (PCT)
	• PCT 302 - Riparian Blakely's Red Gum - Broad-leaved Sally woodland - tea-tree - bottlebrush - wattle shrubland wetland of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion.
Facultative – opportunistic dependence on groundwater	• PCT 300 - Ribbon Gum - Narrow-leaved (Robertsons) Peppermint montane fern - grass tall open forest on deep clay loam soils in the upper NSW South Western Slopes Bioregion and western Kosciuszko escarpment; • PCT 303 - Black Sally grassy low woodland in valleys in the upper slopes sub-region of the NSW South Western Slopes Bioregion and western South Eastern Highlands Bioregion; and • PCT 679 - Black Sallee - Snow Gum low woodland of montane valleys, South Eastern Highlands Bioregion and Australian Alps Bioregion.

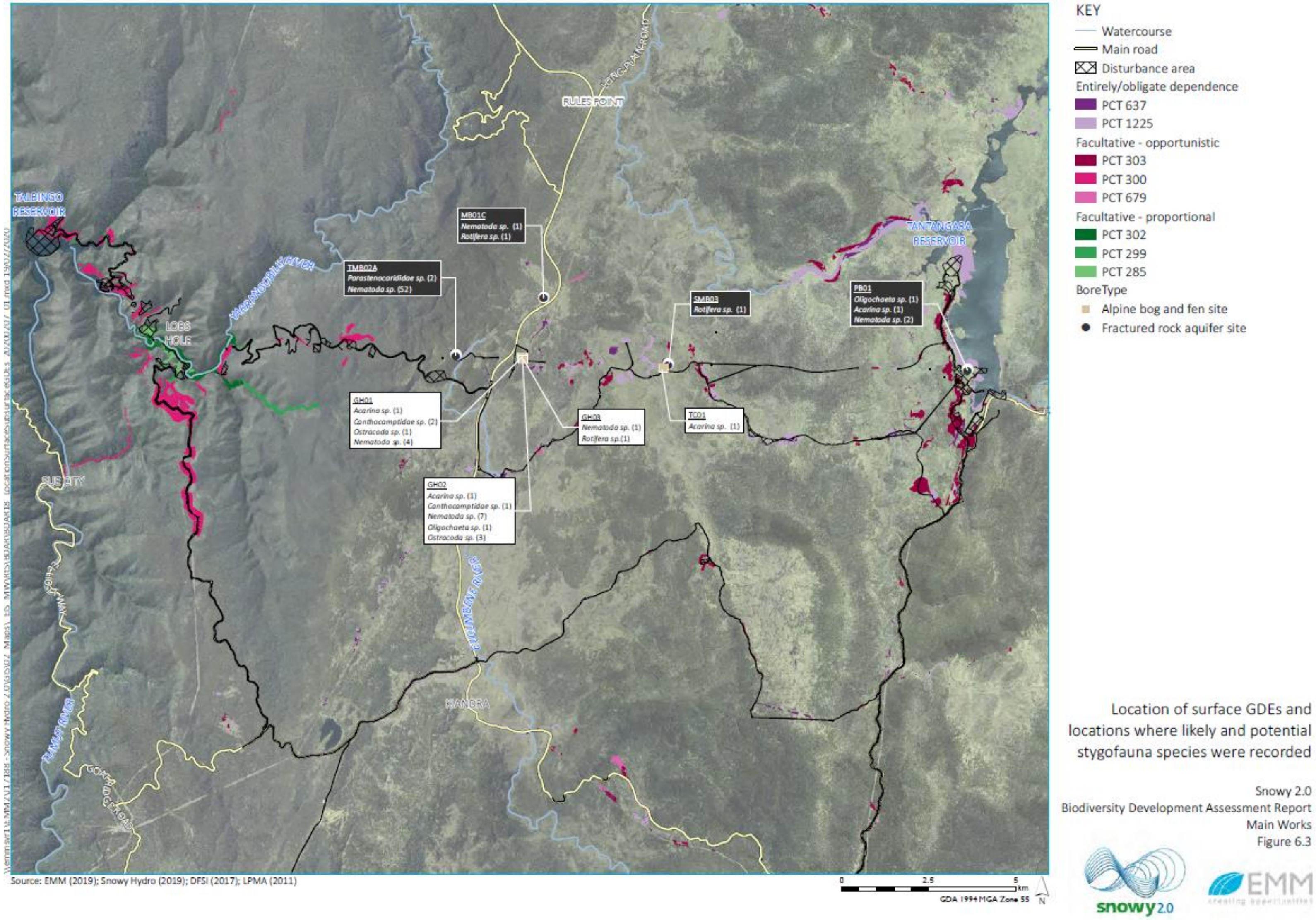

Figure 3-4: Location of terrestrial GDEs

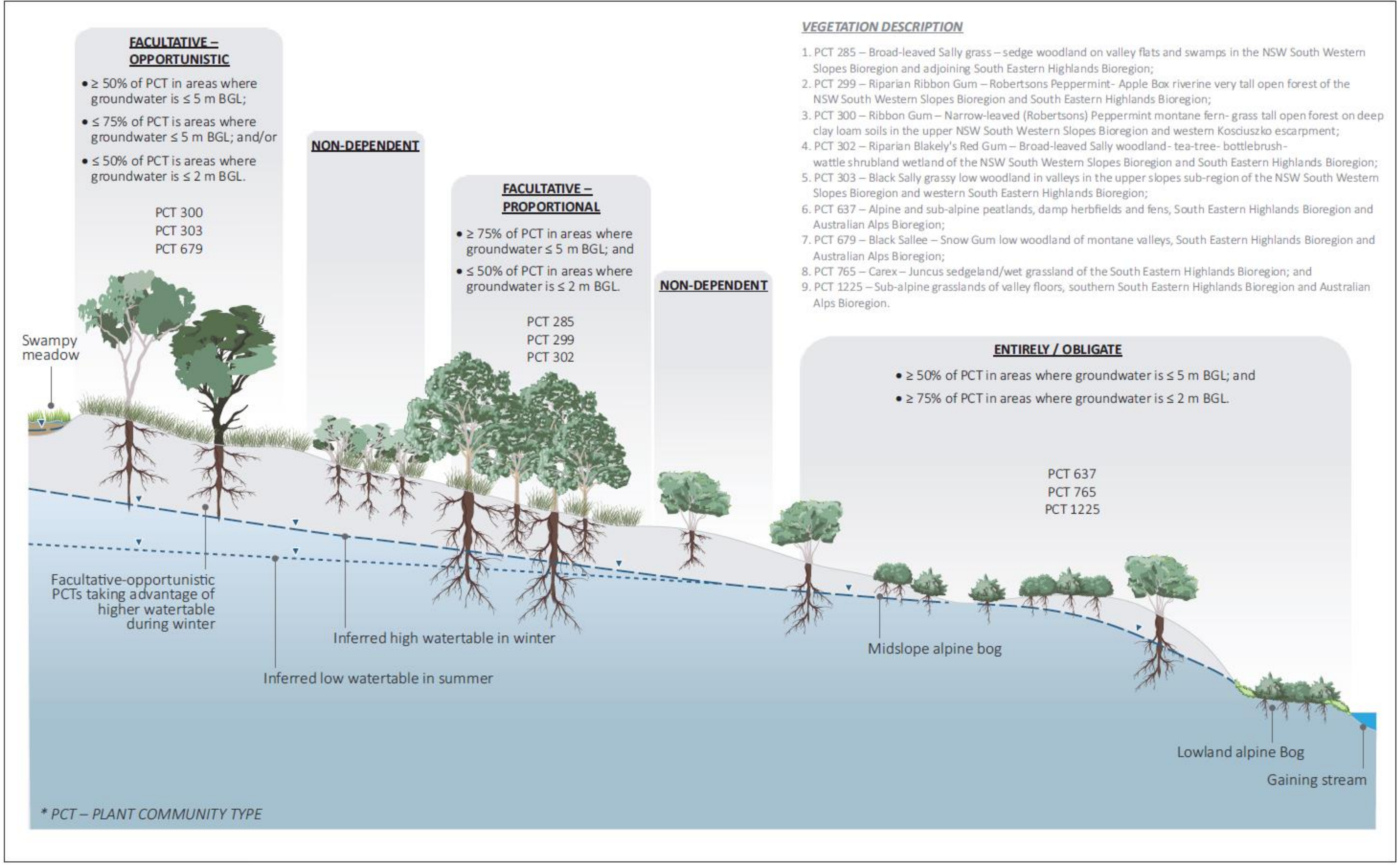

Figure 3-5: Conceptual diagram for Terrestrial GDEs

3.10. Groundwater Levels and Flow

3.10.1. Plateau

Groundwater levels within the plateau are influenced by the relief and generally mirror the topography. Groundwater levels are above the creek beds and therefore groundwater provides baseflow to all streams (gaining streams).

Along the proposed headrace tunnel transect, groundwater levels vary from approximately 1,470 m AHD in the elevated areas adjacent to the LPF in the west, to approximately 1,170 m AHD in the lower elevated area near Tantangara Creek. Overall, groundwater levels observed along the proposed tunnel alignment indicate that groundwater flow direction is generally west to east from the LPF.

Groundwater levels within monitoring bores and deduced from water pressures measured in the vibrating wire piezometers (VWPs) have generally shown fluctuations of less than 10 m during the monitoring period. Groundwater levels within the Gooandra Volcanics, Tertiary basalt, Tantangara Formation, Temperance Formation, Boraig Group, Kellys Plain Volcanics and Boggy Plain Suite generally show a moderate to strong response to rainfall events.

Vertical leakage within the Gooandra Volcanics, Tantangara Formation and Temperance Formation is variable and potentially complex with the direction of vertical leakage (i.e. upwards versus downwards) varying with location and depth within these units, but demonstrating connectivity between the shallow weathered rocks and deeper fractured rocks of the same formations.

Differences between groundwater levels within the Tertiary basalt and underlying Gooandra Volcanics suggests that the Tertiary basalt aquifer is a perched aquifer system.

Further detail regarding groundwater levels and flow within the plateau area is provided in Section 9.2.1 of the EIS water characterisation report.

3.10.2. Ravine

Groundwater levels within the ravine are influenced by the steep relief that exists across the area and generally mirrors the topography. In monitored locations within the project area, groundwater levels are above creeks and streams, therefore suggesting creeks and streams are gaining systems.

Along the proposed headrace tunnel transect, groundwater levels within the Ravine Beds vary from approximately 1,325 m AHD in the topographically elevated terrain adjacent to the LPF in the east, to approximately 570 m AHD in the topographically lower terrain near Lobs Hole. Groundwater flow direction is generally from east to west, with the LPF area acting as a groundwater divide between the ravine and plateau areas.

Groundwater levels within monitoring bores and VWPs have generally shown fluctuations of less than 10 m during the monitoring period. Groundwater levels within the ravine do not typically show an obvious response to rainfall events or flow events within the Yarrangobilly River.

Vertical leakage within the Ravine Beds is downwards with groundwater in the upper horizons of the unit recharging the deeper horizons.

Nested monitoring bores within the Boraig Group have similar groundwater elevation and trends which suggests that the top 70 m or so of Boraig Group sediments are hydraulically connected.

Groundwater levels within the Ravine Beds and Boraig Group show similar elevations and trends at one nested location (TMB01A/TMB02B) which suggests that there may be some degree of hydraulic connection between the Boraig Group and Ravine Beds at this location.

Further discussion on groundwater levels and flow within the ravine area is provided in Section 9.3.1 of the EIS water characterisation report.

3.11. Hydraulic properties

Hydraulic tests were completed to provide site-specific information on the hydraulic properties of the plateau and ravine groundwater systems. Hydraulic properties have been estimated for most of the geological formations intercepted by the tunnel alignment. Derived hydraulic properties allow estimation of groundwater ingress to the tunnel and are used in the groundwater numerical modelling to estimate potential impacts to groundwater systems and hence to groundwater-dependent users and ecosystems. Details are provided in the Water Characterisation Reports (EIS, Appendix J).

3.11.1. Plateau

Hydraulic properties within the plateau are summarised as follows:

- estimated horizontal hydraulic conductivity in the Gooandra Volcanics (mean = 0.01 m/day) are generally higher when compared to the other geological units;
- pumping tests conducted at bores installed within the Gooandra Volcanics and Kellys Plain Volcanics demonstrated vertical hydraulic connection between shallow and deeper horizons within these geological units, with vertical hydraulic conductivities comparable to horizontal hydraulic conductivities (0.01 m/day);
- pumping tests conducted at bores installed within the Temperance Formation and Boggy Plain Suite demonstrated no apparent vertical hydraulic connection between shallow and deeper horizons within these geological units and low horizontal hydraulic conductivities (10^{-5} – 10^{-7} m/day); and
- horizontal hydraulic conductivity is generally decreasing with increasing depth in all the geological units tested.

A summary of hydraulic properties for the plateau region are outlined in Table 9.1 of the EIS Water Characterisation report.

3.11.2. Ravine

Hydraulic properties within the ravine are summarised as follows:

- estimated horizontal hydraulic conductivity in the Ravine Beds West (10^{-3} m/day) are generally higher when compared to the Ravine Beds East (10-4 m/day);
- a pumping test conducted within the Ravine Beds West demonstrated a low to moderate degree of vertical hydraulic connection (10^{-4} m/day) between shallow and deeper horizons within this geological unit; and
- horizontal hydraulic conductivity generally decreases with increasing depth in all the geological units tested.

A summary of hydraulic properties for the ravine region are outlined in Table 9.3 of the EIS Water Characterisation report.

3.12. Groundwater Quality

Aquifer chemistry monitoring results to date are included in the Baseline Data presented as an Attachment to the Groundwater Monitoring Plan (Annexure A) and is summarised in Table 3-5 and below.

Table 3-5: Summary of baseline aquifer chemistry within the Project area

Parameter	Plateau	Ravine
Total dissolved solids (TDS)	Ranges from 14 mg/L (Gooandra Volcanics) to 1,610 mg/L (Temperance Formation)	Ranges from 52 mg/L (Boraig Group) to 1,540 mg/L (Ravine Beds West);
pH	Ranges from 3.5 to 13.0. pH is generally lowest in the bogs and fens and highest within the Kellys Plain Volcanics	Ranges from 4.7 to 8.1. pH is generally highest in the Ravine Beds West when compared to the other monitored geological units.
Major ions	Bicarbonate concentrations in all geological units are generally higher than other major ions with a maximum of 205 mg/L in the Temperance Formation. Calcium, magnesium, chloride, sodium and sulphate are generally less than 100 mg/L.	Bicarbonate concentrations in all geological units are generally higher than other major ions with a maximum of 1,170 mg/L in the Ravine Beds West. Calcium, magnesium, chloride, sodium and sulphate are generally less than 100 mg/L
Metals	Metal concentrations are generally low across all bores, though with aluminium, arsenic, chromium, copper and zinc measured above water quality objectives. Median values remain at or close to the objective concentrations. Concentrations decrease towards the east and only copper and zinc register above WQO levels in the Kellys Plain Volcanics. Iron can be high in the shallow groundwaters supporting the plateau bogs and fens.	Metal concentrations are low (close to or below limits of detection) across all bores, though slight exceedances of water quality objectives are occasionally recorded for most analysed metals except manganese, with zinc, aluminium, arsenic and iron commonly recorded at levels above detection limits. In the west, aluminium, arsenic and boron are observed at elevated levels. Aluminium and iron are commonly reported at levels greater than 1 ppm in the alluvium and colluvium sediments along the river valleys.

In comparison with the water quality objectives (WQOs) for SE Australian Upland Rivers (*see* Section 6.4.1.3), the plateau aquifers' baseline water chemistry indicated:

- samples collected from all plateau aquifers exceeded dissolved oxygen, ammonia, oxidised nitrogen, total nitrogen, total phosphorous and copper WQOs;
- samples collected from most formations (Gooandra Volcanics, Temperance Formation, Boggy Plain Suite, Tantangara Formation, Tertiary Basalt) also exceeded several metals including aluminium, arsenic, boron, chromium, cobalt, copper, iron, lead, vanadium and zinc WQOs;
- the Kellys Plain Volcanics only had one metal exceedance (copper);
- the shallow aquifers associated with Bogs and Fens also had low pH (<6).

In comparison with the WQOs, the ravine aquifers' baseline water chemistry indicated:

- samples collected from all bores exceeded dissolved oxygen, electrical conductivity, ammonia, oxidised nitrogen, total nitrogen, total or reactive phosphorus and several metals including aluminium, arsenic, boron, chromium, cobalt, copper, iron, nickel and zinc WQOs.

4. WATER ASPECTS AND IMPACTS

4.1. Construction Activities

An environmental aspect is an element of an organisation's activities, products, or services that has or may have an impact on the environment (ISO 14001 Environmental management systems). The relationship of aspects and impacts is one of cause and effect.

Key aspects of the Project that may result in impacts to groundwater impacts are identified in Table 4-1 (Column 1). The extent of these impacts will depend on the nature, extent and magnitude of construction activities and their interaction with the natural environment (Column 2). This is further exacerbated by environmental factors (Column 3).

Table 4-1: Project aspects and impacts relevant to groundwater

Environmental Aspects (Construction activities that may impact water)	Environmental Impacts	Environmental Factors (Conditions)
• Tunnelling (causing inflows) • Surface excavations intercepting the groundwater table • Water use and extraction • Dewatering (Discharge of groundwater to surface water, minimising recharge availability) • Refuelling and chemical handling	• Reduction in groundwater availability (quantity) • Reduction (drawdown) in groundwater levels • Reduced groundwater availability for groundwater dependent ecosystems (GDEs) • Groundwater contamination • Reduction in baseflow from groundwater to waterways	• Existing groundwater levels • Existing groundwater fluxes • Existing baseflow dependency • Geology type • Seasonal fluctuations • Existing groundwater quality

4.2. Impacts

4.2.1. Overview

The following predicted impacts are considered conservative due to the design scenario assumptions (i.e. modelling assuming unmitigated tunnel inflows) and the adoption of conservative hydraulic parameters (using relevant limits of field measurements). Therefore, it is considered that the actual tunnel ingress (and subsequent groundwater impacts) will be lower than predicted due to mitigation and management measures already proposed during construction (e.g. pre-grouting and post-grouting of key areas).

The RTS summarised the groundwater impacts as:

- Localised and regional drawdown of groundwater tables, resulting in potential impacts on:
  - Biodiversity, including GDEs, subterranean fauna and aquatic fauna
  - Baseflow to surface water features
- Changes to groundwater quality; and
- Cumulative impacts from any compounding local and regional impacts.

4.2.2. Numerical groundwater modelling

The regional numerical groundwater flow model, referred to as SH4.0, was developed for the Main Works EIS and was based on an unlined, unmitigated (i.e. no grouting) tunnelling scenario. This was done to provide a worst-case (conservative) prediction of potential impacts.

Subsequent to the Main Works EIS, refinement of the inputs into the regional groundwater model have been undertaken to better represent a more realistic outcome. These refinements have focussed on representing the predicted permeability characteristics of the concrete lining (i.e. how much groundwater inflow is expected through the segmented concrete lining of the tunnels) and better estimation of likely groundwater inflows for the immediate 15 m of tunnel construction (termed the 'face' of the TBM) prior to segmental lining installation. The representation of the inflow at the face of the TBM, a constrained inflow rate through the segmental lining (as opposed to the unconstrained inflows represented in the EIS), and the subsequent remodelling exercise, has resulted in a predicted reduction to the groundwater inflows, water table drawdown and related impacts at surface when compared to those modelled for the EIS. The revised Modelling Report submitted as part of the RTS provides further details on all updated inputs, scenarios modelled, and the scenario chosen for the reassessment of predicted impacts.

It should be noted that the hydraulic parameters of the rock to be excavated by the project has been estimated using appropriate hydrogeological techniques and pumping test methods at the groundwater bore locations. Groundwater flow in fractured rock is highly heterogeneous, however, and actual local scale and overall groundwater inflow to excavations will only be realised once the project commences and actual groundwater ingress to the tunnels are measured. The inherently fractured nature of the host rocks introduces a finite uncertainty in the modelling exercise and this will influence the intensity and duration of any impacts. The regional scale of the numerical modelling does not permit local-scale features to influence instantaneous flow and field assessment will be required to facilitate appropriate mitigation strategies when increased ingress zones are encountered.

4.2.3. Groundwater inflows

Relevant to the revised impacts, the EIS predicted that total inflows into all tunnel excavations during construction would peak at 160 L/s and reduce to approximately 85 L/s during operation. Modelling undertaken during the RTS and incorporating conservative mitigation strategies now predicts a peak during construction of 62 L/s, stabilising at 45 L/s during operation (RTS Appendix I – Revised Water Modelling Report (EMM,2020)). This modelled reduction in groundwater inflow has reduced the magnitude and extent of groundwater drawdown and associated impacts and this is summarised below in Section 4.2.4.

The revised modelling identifies a peak inflow to the tunnels during the quarter of 1 March 2024 focussed on the head race tunnel. This is the longest project component and is also excavated through the two deep rock units with the highest estimated hydraulic conductivity: the Kellys Plain Volcanics and the Gooandra Volcanics (the latter including the associated Gooandra Volcanics Fracture Zone and Shaw Hill Gabbro). Long-term inflow to the headrace tunnel is predicted to reduce during operation and stabilise at around 35 L/s (RTS Appendix I – Revised Water Modelling Report (EMM,2020)).

Considering potential average, wet and dry climate scenarios, groundwater inflows to all excavations peak at 1,874 ML, 1,952 ML and 1,835 ML on an annual basis for the average, wet and dry climate scenarios modelled, respectively, as summarised in Table 4-2.

SHL hold sufficient water access licences to account for these levels of inflow (Section 2.5.3), hence management measures are focussed on minimising environmental impacts to groundwater, specifically with respect to potential for groundwater drawdown and changes to groundwater quality.

Table 4-2: Predicted annual inflows to all excavations (RTS model) during the Main Works period

Year ending	Dry climate (ML)	Wet climate (ML)	Average climate (ML)
1 June 2019	0	0	0
1 June 2020	3	3	3
1 June 2021	392	395	393
1 June 2022	1212	1259	1212
1 June 2023	1456	1503	1475
1 June 2024	1835	1952	1874
1 June 2025	1398*	1488*	1800*

* Simulation ends 1 March 2025 and volume is for previous 9 months only

4.2.4. Groundwater level decrease

4.2.4.1. Groundwater drawdown

Groundwater flow into the excavations will result in groundwater hydraulic head drawdown developing over time. Groundwater drawdown of the water table is predicted to occur primarily near the Tantangara adit, and in the vicinity of the Gooandra Volcanics geological unit (near Gooandra Creek and the Snowy Mountains Highway). Groundwater modelling undertaken as part of the Response to Submissions (EMM, 2020) also predicts scattered pockets of water table drawdown within the Yarrangobilly River catchment. No change in groundwater level, however, was predicted at the Yarrangobilly Caves.

Predicted drawdown after 5 years of construction (for the Base Case parameterisation; EMM, 2020) is shown in Figure 4-1.

Calculated as the difference between a “null scenario” that simulates only transient climate stresses and a model run simulating construction of Snowy 2.0, the groundwater model predicted the following drawdown:

- After one year of construction almost no drawdown is predicted.
- After two years of construction a drawdown footprint is predicted near the western edge of Tantangara Reservoir, associated with the construction and excavation of the headrace tunnel. The model simulates the geological unit (Kellys Plain Volcanics) intercepted by the project at this location to have a much higher permeability (consistent with values estimated from field assessments) when compared with the majority of the model domain. A small drawdown footprint (0.5m) is also predicted around the main access tunnel for the power station.
- After three and four years of construction the drawdown footprint associated with the Kellys Plain Volcanics is predicted to expand and increase in magnitude immediately above the headrace tunnel to over 50 m. Small pockets of minor drawdown are predicted above other parts of the project with a more significant region of drawdown predicted to be growing above the headrace tunnel in the Gooandra Volcanics region (generally 2 - 5 m).
- After five years of construction the footprint of the Kellys Plain Volcanics drawdown is predicted to further expand, along with the region of drawdown above the headrace tunnel in the Gooandra Volcanics region, which is predicted to reach magnitudes of greater than 10 m.
- Groundwater levels at the Yarrangobilly Caves are not predicted to be impacted during any part of the construction.

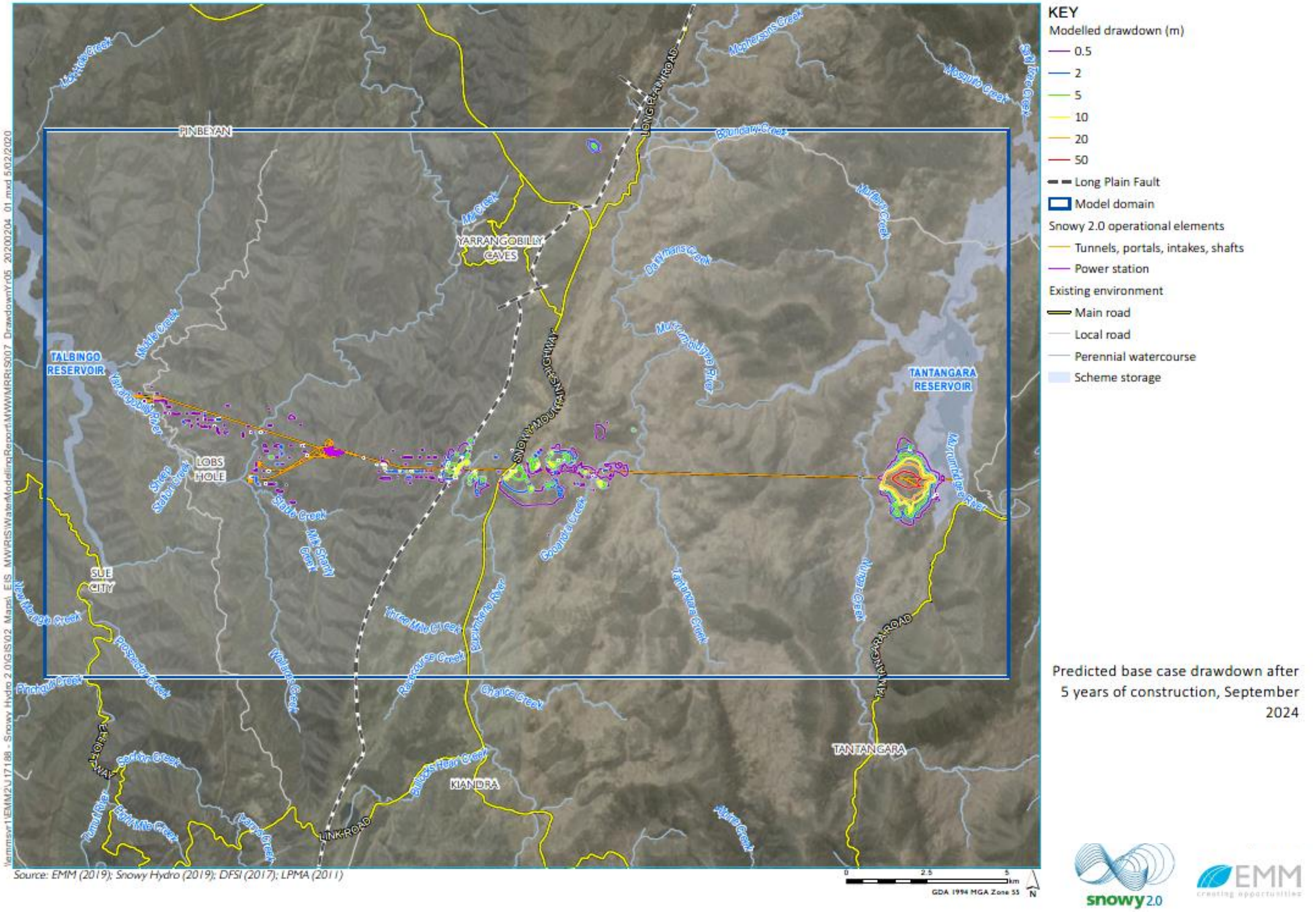

Figure 4-1: Predicted drawdown after 5 years of construction

4.2.4.2. Subsurface (Type 1) GDE: Loss of aquifer habitat

Aquifer habitat (i.e. where stygofauna may be present) is predicted to be affected. Specifically, the predicted impact to fractured-rock aquifers will likely result in drawdown, reducing the extent of habitat available to stygofauna. It is likely that predicted impacts will be restricted to an area on the Plateau bounded by Tantangara Creek in the east and the boundary of the Gooandra Volcanics in the west. Drawdown of less than 20 m is considered unlikely to have a significant effect on many stygofauna species given the ability of these species to relocate within the saturated zone. Thus, drawdown of up to 5 m would be unlikely to have any significant effect.

The stygofauna assessment by Macquarie University (2019) suggests the overall predicted impact to stygofauna will be low across the region. Species identified are not considered endemic to the local area and regionally species diversity will not be impacted.

Of note, no impact is predicted at or near the Yarrangobilly Caves or associated ecosystems.

4.2.4.3. Surface (Type 2) GDE: Reduced surface water baseflow

As a result of water table drawdown, the groundwater model predicted that localised baseflow discharges to creeks and rivers would be seen in the catchments upstream of Tantangara Reservoir, Lake Eucumbene, and Talbingo Reservoir. While inflows to the excavations are predicted to peak in the final year of construction, impacts to baseflow are predicted to develop more slowly, with peak impacts occurring several decades after the completion of construction. Long-term peak baseflow reductions are predicted to approximately match the long-term inflow rate to the power waterway.

Baseflow reduction due to tunnelling and excavation works during the construction period was predicted in Gooandra Creek and the headwaters of the Eucumbene River. The timing of the baseflow reduction will depend on the project schedule, as drawdown impacts are predicted to peak after the tunnel excavation reaches the Gooandra Volcanics, which occur in the vicinity of Gooandra Creek and the Eucumbene River headwaters. If no delays to schedule occur, Gooandra Creek baseflow reduction could begin during year 4 of construction, and Eucumbene River baseflow reductions could begin in year 5 of construction. Impacts were predicted to be still developing at the end of the construction period. No impacts to baseflow due to tunnel excavation were predicted within creek catchments other than Gooandra Creek and the Eucumbene River north of the Snowy Highway (EMM, 2020). Baseflow reductions predicted by the groundwater model during project construction are predicted to balance the ingress of groundwater to the excavated tunnels (Table 4-2), but with an approximately 3-5 year lag (Figure 4-2).

The baseflow reduction in Gooandra Creek during the excavation of the power waterway is expected to cause no discernible changes to streamflow through winter months. During March–April in the final two years of excavation there is a potential that baseflow reduction may result in reduced flow within the Gooandra Creek catchment if those construction years coincide with dry climate conditions.

Within the Eucumbene River, baseflow reduction during the construction period is expected to cause no discernible changes to streamflow.

Inflows to the tunnel excavation are predicted to increase markedly during the groundwater model year 2023 (construction year 4), rising to approximately 60 L/s when the tunnel encounters the Gooandra Volcanics before stabilising during 2024. Through the final quarter of construction, the baseflow impacts within the Gooandra and Eucumbene catchments were estimated to be in the order of 10 L/s, significantly less than the tunnel inflows. Impacts to baseflow within the Gooandra Creek catchment and within the Eucumbene River catchment upstream of Gooandra Track were predicted to increase over the final years of the construction period, reflecting a lag between the greatest tunnel inflow and the greatest baseflow impacts. The peak change in baseflow is expected to occur following completion of the project.

Specifically, during construction and in the areas directly overlying the tunnel alignment the model predicted that:

- Baseflow to Gooandra Creek may decline by up to 6%, beginning in year 4 of construction; and
- Baseflow to the Eucumbene River may decline by up to 1%, beginning in year 5 of construction, with impacts centred on the uppermost 1.5 km of the Eucumbene River headwaters.

The surface water catchment model was used to investigate the effect of these baseflow reductions on the streamflow regimes downstream of the impacted catchments, and showed that:

- Gooandra Creek will potentially change from a perennial streamflow regime to marginally ephemeral, as days with less than 0.1 ML/day streamflow at the downstream end of the creek increase from 0% to 2%; and
- North of the Snowy Highway the Eucumbene River could also become ephemeral, as days with less than 0.1 ML/day streamflow at this location increase from 0% to approximately 5-7%.

It is expected that the quickflow component of streamflow (surface runoff in response to rainfall) will not be affected by groundwater drawdown and baseflow reduction. In each catchment, the modelled impact reduced with distance downstream as flows from catchment areas unaffected by the project entered the creek system.

Figure 4-2: Baseflow reduction predicted by the groundwater model during project construction

Groundwater-dependent riparian vegetation (Type 2 GDEs), consisting of species adapted to mesic/hydric soils, are located along sections of creeks and waterways where groundwater is expressing at the surface providing baseflow. It is unlikely that drawdown of less than 5 m will impact on these areas, as some groundwater will continue to be expressed at the surface. In addition, not all groundwater will be diverted to regional aquifers, with an unknown proportion continuing to supply baseflow to these GDEs, maintaining biological integrity. Groundwater-dependent riparian vegetation is predicted to be at moderate risk of predicted impact due to groundwater drawdown.

The small impacts to baseflow, as described above, will be indiscernible in the observed data considering the interannual variability in flow in the Gooandra and Eucumbene Creeks.

Assessment of baseflow will be triggered following trigger of the groundwater level TARP (Section 7).

4.2.4.4. Surface (Type 3) GDE: Lowering of water tables

The predicted impacts to surface GDEs was determined by calculating the area of each GDE that occurs within the groundwater drawdown areas predicted by the model. It is noted that the current version of the model (SH4.0) still retains a large degree of conservativism, such that the predicted impacts are expected to exceed actual impacts given the current state of knowledge. Future iterations of the numerical model, as further relevant data is collected, will refine our understanding and the potential impact extent. The current modelling identified the following potential impacts to surface (Type 3) GDEs:

- PCTs 302, 299 and 679 may experience predicted impacts to less than 3 ha of the community, and/or may experience groundwater drawdown of less than 5 m. These GDEs are considered to be at a low risk of impacts.
- PCT 303 may experience predicted impacts to 24.70 ha of the community, representing 6% of the 409 ha of the community mapped in the survey area, while PCT 300 may experience drawdown to 6.38 ha of the community, representing 2% of the 270 ha of the community mapped in the survey area. In addition, 14.02 ha of PCT303 and 3.71 ha of PCT 300 may experience drawdown of less than 2 m, and will be unlikely to have any noticeable effect on the ability of these communities to access groundwater during periods of stress, and is therefore unlikely to result in any significant changes in the biological integrity of the GDEs. It is predicted these GDE are at low risk of impact.
- PCT 1225 may experience drawdown of >0.5 m to 10.27 ha of the community. Drawdown of more than 0.5 m may have some impact given the entirely/obligate dependence of this community on groundwater. While there is a high risk of predicted impact to some portion of the community, as defined in Serov et al. (2012), the predicted drawdown may impact on 3% of the 312 ha of this PCT mapped across the survey area, and larger patches of the community will be maintained on major watercourses such as Tantangara Creek and Nungar Creek. Overall impacts to community are expected to be low.
- PCT 637, aligned with the Alpine bogs and fens, may experience drawdown of >0.5 m to 6.93 ha of the community. This community is entirely/obligate dependent on groundwater and has a large number of hydric and mesic species that do not occur outside of this or other allied communities. The 6.93 ha that may be subject to drawdown represents 8% of the 86 ha mapped within the survey area, 0.08% of the mapped extent of the community in the Snowy Mountains (OEH 2012b) and 0.06% of the 11,100-ha mapped at a national scale (TSSC 2009). While there is a high risk of predicted impact to some portion of the community, as defined in Serov et al. (2012), the overall risk to the community and listed community is considered low.

The predicted impacts to these surface GDEs was determined through the RTS Numerical Modelling (Appendix G: Revised Biodiversity Development Assessment Report) and is presented in Table 4-3.

Table 4-3: Potentially impacted terrestrial GDEs and potential area subject to drawdown

Mapped plant community type (PCT)	GW dependency	0.5m	plus 2-5m	plus 5-20m	Plus >20m	Total
PCT 1225 - Sub-alpine grasslands of valley floors, southern South Eastern Highlands Bioregion and Australian Alps Bioregion	Entirely - obligate	9.96	0.3	0	0	10.27

Mapped plant community type (PCT)	GW dependency	0.5m	plus 2-5m	plus 5-20m	Plus >20m	Total
PCT 637 - Alpine and sub-alpine peatlands, damp herbfields and fens, South Eastern Highlands Bioregion and Australian Alps Bioregion	Entirely - obligate	6.03	0.85	.05	0	6.93
PCT 302 - Riparian Blakely's Red Gum - Broad-leaved Sally woodland - tea-tree - bottlebrush - wattle shrubland wetland of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion	Facultative - proportional	0.71	0	0	0	0.71
PCT 299 - Riparian Ribbon Gum - Robertsons Peppermint - Apple Box riverine very tall open forest of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion	Facultative - proportional	0.96	0.82	0.12	0	1.89
PCT 679 - Black Sallee - Snow Gum low woodland of montane valleys, South Eastern Highlands Bioregion and Australian Alps Bioregion	Facultative - opportunistic	0	0.02	0	0	0.02
PCT 303 - Black Sally grassy low woodland in valleys in the upper slopes sub-region of the NSW South Western Slopes Bioregion and western South Eastern Highlands Bioregion	Facultative - opportunistic	14.02	5.73	4.95	0	24.7
PCT 300 - Ribbon Gum - Narrow-leaved (Robertsons) Peppermint montane fern - grass tall open forest on deep clay loam soils in the upper NSW South Western Slopes Bioregion and western Kosciuszko escarpment	Facultative - opportunistic	3.71	2.17	0.49	0	6.38

Whilst potential predicted impacts are considered to be low for all plant communities, the obligate dependency of ecosystem plant community types 1225 and 637 (Alpine Bogs and Associated Fens) requires specific recognition and focus during monitoring and impact assessment and inclusion in trigger action response plans (Section 7).

4.2.5. Groundwater quality

4.2.5.1. Spills and contamination

There is the potential for the project construction works to cause contamination to the groundwater resource. This predominately encompasses either spills of hazardous materials/chemicals and/or the generation of solid or liquid waste. Examples of this include spills of hydrocarbons while refuelling or lubricants used by machinery, and generation of solid construction waste or liquid waste during tunnelling. All scenarios have the potential to impact human and environmental health depending on the type of contaminant if not managed accordingly.

Protocols for the management of contaminated soil and water during construction will be included in a construction environmental management plan (CEMP) for all construction works.

Soil investigations will also be undertaken along all proposed medium and high-risk construction disturbance areas to identify the presence of any existing contamination and assess the risks posed to the groundwater environment. Management of soil and excavation waste will be undertaken through the Spoil Management Plan.

4.2.5.2. Acid Mine Drainage

As summarised in the Main Works EIS, it was concluded that the relative rates of acidity (i.e. PAF) versus alkalinity (i.e. ANC) generation in geological formations at the site are uncertain and require further investigation, and that for many of the formations there remains insufficient information on the compositional variation.

There is potential for Acid Mine Drainage (AMD) impacts via the generation of acidic leachate from improper temporary or permanent storage of excavated PAF rock and this poses a risk to localised and wider (regional scale) groundwater environment.

To manage this risk, it is proposed that any excavated material is managed in accordance with the Spoil Management Plan (SMP). On-going monitoring in the vicinity of major excavations will recognise any changes to water quality and trigger an appropriate response.

4.3. Environmental Risk Assessment

The environmental aspects and impacts for water are further considered within Appendix A3 of the EMS. This includes a risk assessment process. The risk assessment is based on (1) the likelihood of an impact occurring as a result of the aspect; and (2) the consequences of the impact if the event occurred. These risks as well as any regulatory requirement form the basis for the groundwater mitigation measures committed to in this GMP in Section 5, below.

5. GROUNDWATER MANAGEMENT MEASURES

A range of environmental requirements and control measures are identified in the Main Works EIS, RTS and the Infrastructure Approval. Safeguards and management measures will be implemented to avoid, minimise or manage impacts on groundwater.

Potential impacts to groundwater may be divided into those potential impacts relating directly to groundwater inflows to the tunnels and other excavation works and to those potential impacts indirectly caused by those groundwater inflows, that is, impacts to the environmental function of groundwater. The former may be distinguished as part of the process water cycle; the latter as part of the natural water cycle.

A conceptual overview of the water distribution network that relates to process water is provided in Figure 5-1. Minimising risks to the natural groundwater environment critically requires minimisation of groundwater ingress to tunnels to acceptable levels. Specific safeguards and management measures to address potential groundwater impacts from the project are identified in Table 5-1. As control of groundwater inflow is the principle method to reduce potential groundwater impacts, the major components of groundwater management may thus be described in relation to the operation of the tunnel boring machine; the drill and blast excavations of the access tunnels; the excavation of the large transformer cavern and treatment of removed groundwater via water treatment plants.

5.1. Tunnel boring machine method

The tunnels for Snowy 2.0 Main Works will be excavated with a circular cross-section using three tunnel boring machines (TBMs). Each TBM will be fully equipped to perform excavation, ventilation, lining and removal of excavated material.

Groundwater will enter the tunnel during construction. The volume and flux of ingress will directly determine the potential for drawdown of water levels in the vicinity of the project corridor, including the potential to cause drawdown of groundwater near the surface. To mitigate impacts a number of controls have been identified that will reduce the actual ingress of water to the tunnels. Specifically, developing a planned excavation sequence; forward surveys of rock condition; pre- and post-grouting of the rocks as determined through the surveys; use of segmental lining for the tunnel and continuous inflow monitoring will facilitate reduced inflows to the tunnel and reduce the potential drawdown impacts.

5.1.1. Excavation sequencing

Excavation sequencing is the process of managing the order that the excavation occurs to ensure critical sections remain open for the least amount of time possible.

Early identification of critical sections of highly permeable or vertically connected formations was undertaken during assessment of the EIS. This process identified that the Gooandra Volcanics had a higher hydraulic conductivity than other geological units in the project area.

The construction program has therefore been planned such that the Gooandra Volcanics region shall be excavated late in the construction program so that the excavation would remain open for the shortest period of time.

5.1.2. Forward investigations

Surveys will be conducted ahead of each TBM to identify potentially critical areas with poor rock conditions or high fracturing intensity. Each TBM will be equipped with devices to perform the following surveys:

- geophysical seismic reflection surveys;
- geoelectrical surveys; and

- systematic probe core retrieval ahead of the advancing tunnel face.

5.1.3. Segmental lining

Each TBM will be equipped to install the segmental lining for the tunnel using the universal ring method. The ring will be 2m wide, composed of nine pre-cast concrete segments which form each ring (eight segments, one 'large size' key-segment) and which have no bolts along the longitudinal joints. One drainage relief hole will be provided in each segment to guarantee a 'drainage effect' and water pressure re-equilibrium.

This segmental lining will reduce permeability, assisting to:

- achieve acceptable head loss in the conduit;
- prevent hydraulic jacking; and
- prevent excessive leakage by seepage.

5.1.4. Pre-grouting

Pre-grouting will be conducted to reduce the hydraulic conductivity of the rock mass (minimise groundwater inflow) and improve the stability of the excavation face. This is undertaken ahead of the excavation face and will generally be carried out by:

- drilling and testing a probe hole;
- drilling and installing a crown of groutable pipes;
- injecting grout through the pipes; and
- drilling a verification probe hole.

Probe holes are drilled up to 40 m in front of the working face. Water flow through the initial holes is measured and a decision is made on the need to grout.

The number and location of the holes will depend on rock mass condition and, in cases of work performed by a TBM, on the specific configuration of the excavation head.

The grouting of soil or rock masses with cement slurries or chemical mixtures to improve their mechanical and hydraulic properties is a well-established practice in engineering.

Verification of the grout effectiveness is made by comparing inflow rates in the original probe hole to those in verification holes.

5.1.5. Post-grouting

Post-grouting may also be used to further consolidate the surrounding rock and/or prevent water ingress if required. Tunnel water inflow will be measured using in-line monitoring of flow along the constructed tunnel and will inform the decision on the need to grout.

Post grouting entails drilling sets of holes perpendicular to the tunnel, in a fan of 9 holes around the tunnel. The holes are generally drilled at an even spacing from a jumbo with hydraulic top hammer. Mechanical packers are installed and connected to a pump via hoses. Grout is then injected to reduce the total permeability of the rock mass.

5.1.6. Inflow monitoring

Groundwater inflow into the tunnels will be monitored during construction and compared to model predictions. Tunnel water inflow will be measured in the tunnel via in-line flow meters. Tunnel inflow monitoring, water treatment plant (WTP) discharges and Project water inputs re-cycled back into the tunnel will all be monitored and used to determine a simple water balance to estimate local groundwater extracted during construction. Monitoring will be undertaken at the indicated locations shown in Figure 5-1. Thus:

Groundwater inflow = WTP discharge (*flow meter C*) – Project water inputs (*flow meter E*)

Groundwater extraction will be reported on an annual basis in accordance with licence requirements (as described in Section 2.5.3).

5.2. Drill and blast operations

Access tunnels and the large cavern for the transformers will be excavated using drill and blast techniques. These excavations are not planned to be lined and high initial inflows will reduce as groundwater tables are drawn down to the invert levels. Inflows will be directed to sumps and pumped to the closest WTP for processing before entering the surface water stream, or re-cycled for use in the excavation process. The latter includes dust-suppression, cooling and cleaning.

Ingress monitoring will be undertaken as for the tunnels.

5.3. Water Treatment Plants

All groundwater encountered during tunnelling will be drawn to the surface where it will be treated via a water treatment plant (WTP).

WTPs are proposed to be installed and utilised at:

- tunnel portals for tunnel process water treatment (i.e. groundwater management);
- accommodation camps for wastewater (i.e. sewage) treatment; and
- accommodation camps for potable water consumption.

A detailed description of each of these WTPs streams is provided in the Surface Water Management Plan.

Process WTPs are specifically proposed to manage and treat intercepted groundwater from the main tunnels. That is, to collect water associated with each TBM. The process WTPs will be located at the Talbingo Main Access Tunnel (MAT) portal, Talbingo emergency egress, cabling and ventilation tunnel (ECVT) and the Tantangara portal.

The process water WTPs will be connected to a drainage system comprised of sumps and pipelines from each tunnel to the WTP at the portal surface. This process water will be treated to the water quality discharge criteria in the Project's EPL and be re-used on site or within the tunnel. Excess treated water that cannot be utilised on site or within the tunnel will be managed as surface water under the Surface Water Management Plan (SWMP).

5.4. Spoil Emplacement

The Spoil Management Plan (S2-FGJV-PLN-0019) identifies spoil management process and measures for temporary and permanent spoil emplacement areas, including measures for natural occurring asbestos (NOA) and acid and metalliferous drainage (AMD).

NOA will be placed in designated encapsulation cells at the Tantangara emplacement area. In cell formations, the NOA will be placed over an inert foundation layer and contained with a geosynthetic textile wrapping.

AMD refers to potential for rock to be potentially acid forming (PAF) through exposure of sulfide minerals. In relation to groundwater quality, the key controls that will be applied to each PAF treatment area include:

- seepage from the treatment area will be collected in a sediment basin downstream of the treatment emplacement area. Collected water will either be irrigated to the treatment (to promote evaporation) or treated in the process water treatment plant. Discharge of seepage water to the environment will be avoided. The sizing of the basins are subject to final design, and are dependent on disturbed ground extent and the utilisation of other erosion and sediment controls. The basin and all erosion and sediment controls will be designed and operated in compliance with mitigation measures in the SWMP;
- a barrier system will be installed under the stockpiles to prevent seepage from entering underlying soils and groundwater; and
- neutralised PAF material can, once validated, be safely disposed of like any other spoil

Further detail on spoil management and design is provided in the Spoil Management Plan (S2-FGJV-PLN-0019).

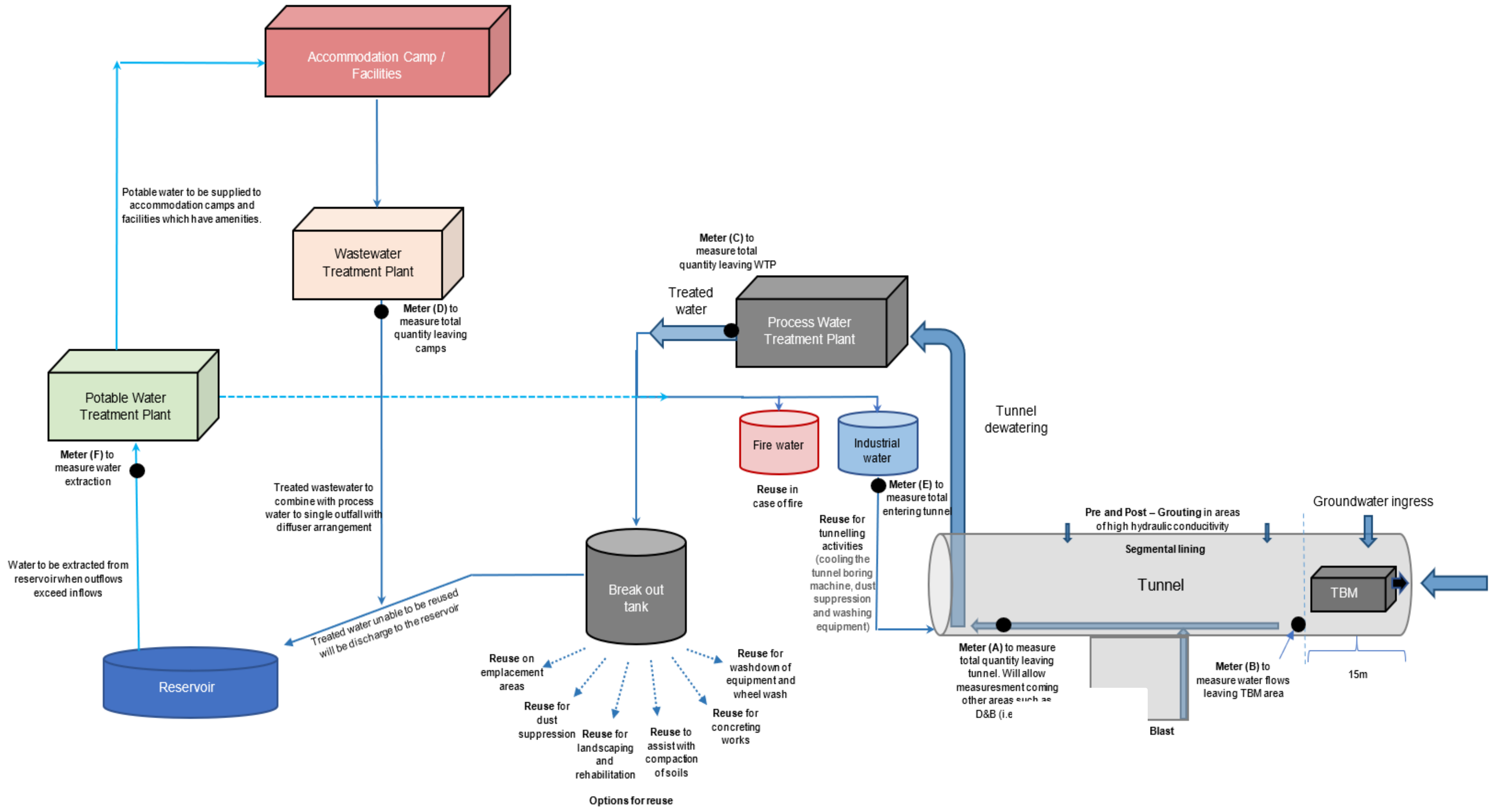

Figure 5-1: Conceptual process water management system

Table 5-1: Groundwater management measures

ID	Measure / Requirement	When to implement	Responsibility*	Source document**
General				
GW01	Training will be provided to all project personnel, including relevant subcontractors on groundwater management through inductions, toolboxes and targeted training.	Pre-construction and Construction	Contractor – EM, EC	Best Practice
Procedures and plans				
GW02	Spills and emergency response will be managed in accordance with the Emergency spill response procedure included in the Surface Water Management Plan (Appendix A of the Water Management Plan)	Construction	Contractor – All	MW REMM WM01
Groundwater management				
GW03	Groundwater discharged to reservoirs will be in accordance with the Surface Water Management Plan and unless an environmental protection licence authorises otherwise, in compliance with Section 120 of the POEO Act.	Construction	Contractor – All	CoA 29
GW04	The construction program shall be planned such that the Gooandra Volcanics region will be excavated late in the construction program.	Construction	Contractor – CM	CoA 30(e)
GW05	Where discrete high flow features are intercepted such as the Gooandra Volcanics and Kelly Plain Volcanics, pre-grouting and / or post-grouting will be undertaken to enable tunnel construction and minimise further ingress.	Construction	Contractor – CM, DM, S	CoA 30(e) MW REMM WM07 EW REMM WAT03
Groundwater contamination				
GW06	Emergency spill kits will be readily available at key construction sites across the project and workers trained in their use.	Construction	Contractor – EM, EC, CM, S	MW REMM WM01
GW07	Storage and handling of chemicals, fuels and oils will be as per manufacturer's instructions in bunded, storage areas.	Construction	Contractor – All	MW REMM WM01
GW08	During borehole drilling, slurries used will be of appropriate grade and composition such that it poses no threat to groundwater quality should it infiltrate intersected aquifers	Construction	Contractor – CM	EW REMM M1.6
GW09	Temporary and permanent emplacement areas will be managed in accordance with the Spoil Management Plan	Construction	Contractor – DM, CM, S, SS	MW CoA 30(o)
Monitoring and model validation				

ID	Measure / Requirement	When to implement	Responsibility*	Source document**
GW10	Groundwater monitoring will be undertaken in accordance with the Groundwater monitoring program (Annexure A of this Groundwater Management Plan)	Construction	Contractor – EM, EC	CoA 31(d) MW REMM WM01 MW REMM WM02 EW REMM WAT02
GW11	Groundwater level monitoring will be undertaken in accordance with the Groundwater monitoring program (Annexure A of this Groundwater Management Plan) to provide early warning for impacts beyond those assessed for: • baseflow connected waterways; • the local groundwater flow system; • local depressurisation of groundwater resources; and • groundwater dependant ecosystems. The trigger actions response plans (TARPs) will be initiated in the event that a trigger value banding is exceeded (refer to Section 7.2 of this Groundwater Management Plan)	Construction	Contractor – EM, EC	CoA 31(d) MW REMM WM01 MW REMM WM02
GW12	The groundwater model developed for Snowy 2.0 Main Works will be validated and, if necessary, recalibrated to new groundwater monitoring data as the monitoring record increases throughout construction. Review will be undertaken annually during construction and include review of the monitoring data collection frequency, in consultation with NRAR and DPIE-Water Group.	Construction	SHL	CoA 31(d) MW REMM WM06 NPWS / DPIE consultation comment on reviewing monitoring frequency
GW13	Groundwater extraction will be monitored and tracked against water access iicence limits.	Construction	Contractor – EM, EC	Water Access Licene
GW14	Adaptive management will be implemented for groundwater monitoring, including review, analysis and modification of mitigation measures if they are shown to be ineffective.	Construction	Contractor SHL	MW REMM WM01 (TARP)

** Responsibility* — *Regardless of the allocation of responsibilities within this plan, the responsible party is to be assigned in accordance with the Contract*

***Source Documents*
1. *MW RWMM – Main Works Revised Water Management Measure (Main Works RTS Appendix J Appendix C)*
2. *CoA – Condition of Approval (SSI 9687)*
3. *EW REMM – Exploratory Works Revised Environmental Management Measures (Exploratory Works RTS Chapter 8)*

Responsibility abbreviations — *CM – Construction Manager, DM – Design Manager, EM – Environmental Manager, EC – Environmental Coordinator, S – Superintendent, SS – Supervisor, All – All personnel including subcontractors*

6. COMPLIANCE MANAGEMENT

6.1. Roles and Responsibilities

Future Generation's organisational structure and overall roles and responsibilities are outlined in Section 4 of the EMS. Specific responsibilities for the implementation of mitigation measures are detailed in Section 5 of the GMP. Regardless of the allocation of responsibilities within this plan, the responsible party is to be assigned in accordance with the Contract.

6.2. Licenses and permits

Licenses and permits relevant to groundwater extraction were summarised in Section 2.5.3.

6.3. Monitoring and Inspections

6.3.1. Groundwater monitoring program

A groundwater monitoring program has been developed to monitor potential impacts to groundwater during construction of the Project to ensure compliance with this management plan. The program is an extension of the EIS baseline monitoring.

Details of the groundwater monitoring program, including detailed inspection criteria, are provided in the accompanying Groundwater Monitoring Program (the Program – Annexure A).

The Main Works monitoring program differs in fundamental ways to that developed for the Exploratory Works. Thus, whilst the Exploratory Works groundwater monitoring program was designed to provide baseline data and understanding of ambient groundwater conditions across the Project area, the Main Works monitoring program is designed to provide early warning of potential risks to assets and guidance on protection and any mitigation measures for any impacted assets. Groundwater-dependent assets critically include the Alpine Bogs and Associated Fens which are iconic ecosystems across the Plateau region.

The Main Works monitoring program will provide an extension to the Exploratory Works program and where the Exploratory Works program is considered incomplete (for example, where less than 24 months of baseline data have been collected), the Exploratory Works program will continue before switching to the Main Works program.

The objectives of the Main Work Monitoring Program are to:

- identify and quantify changes to groundwater quality and groundwater level or pressure;
- assess compliance with relevant consent and license conditions and other monitoring requirements including prescribed targets for the Project; and
- assess and modify where required the effectiveness of water mitigation measures;

The Program provides detailed inspection criteria including:

- groundwater monitoring locations;
- parameters/analytes to be monitored;
- type of monitoring;
- frequency of monitoring, and
- monitoring methodology.

Groundwater monitoring is reviewed to determine whether any actions are required due to inconsistencies between monitored and predicted data. The groundwater monitoring process measures are outlined in Table 6-1, which provides reference to the relevant trigger, action, response plan for water levels, quality and usage.

Table 6-1: Groundwater process measures

Performance measure	Monitoring sites	Frequency	Trigger	Objectives	Management Measures
Groundwater quality monitoring	Groundwater bores designated as water quality sites in the Groundwater Monitoring Plan	Quarterly groundwater quality sampling	If a parameter exceeds the nominated water quality triggers for two consecutive monitoring events	To identify (where possible) if the exceedance is naturally occurring or due to construction	Implement Groundwater Quality TARP
Groundwater level monitoring: Piezometers	Groundwater bores designated as water level sites in the Groundwater Monitoring Plan, including: Conventional bores; Vibrating wire piezometers;	Daily – 6 hourly Data collected quarterly*	If the 7 day moving average exceeds the month's established trigger level by 1 standard deviation at the impacted bore		Implement Groundwater Level TARP
Groundwater level monitoring: Standpipes	Standpipes and drive-point piezometers	Daily – 6 hourly Data collected quarterly*	If the 7 day moving average exceeds the 80th percentile level at the impacted standpipe during the months of May to October, inclusive		Implement Level 3 investigation as described under the Groundwater Level TARP
Groundwater inflow rate monitoring	As indicated in Figure 5-1	Daily – continuous collection reported as daily flux	Monthly inflow volumes exceed modelled values for three consecutive months and cumulative inflows exceed cumulative modelled inflows	To ensure the water take is within licence limits To limit the volume of groundwater take and consequent drawdown	Implement Groundwater Usage TARP

** The Project is investigating opportunities for telemetric monitoring of monitoring data. No drawdown is predicted for the first few years of the project (see Section 4.2.4) hence existing data loggers will be downloaded manually quarterly until telemetry is in place. Monitoring frequency will be continuously reviewed and data compared to model predictions, and frequency of data collection will be adapted to ensure potential significant trigger events are detected early (i.e. particularly when Tunnelling commences in high risk areas). Data collection will also be reviewed annually during groundwater model review as identified in Table 5-1: GW12.*

6.4. Trigger Levels and Methodology

All groundwater data collected prior to the commencement of construction will be used as reference baseline data against which to compare monitoring data collected during construction at all locations detailed in the monitoring program (Annexure A). Groundwater triggers have been developed in line with recommendations under the NSW Aquifer Interference Policy (NOW, 2012) and based on baseline data collection for a minimum of two years to capture a full seasonal cycle twice at an appropriate frequency and scale commensurate with the Project. This is also reflected in the provisions of the Environmental Protection Licence (Section 2.5.1).

Where baseline data has not been collected for a minimum of two years, collection will continue at that site until a baseline can be established.

6.4.1. Groundwater triggers

Four levels of groundwater trigger can be described, dependent on the level of impact observed. Thus, Level 1 (indicator) triggers are those that might be expected to occur due to the activities and which do not result in undue, or significant, stress to the system. Unpredicted triggers may correspond to sites where impacts indicate a precursor to a greater future impact and can be considered as early warning (Level 2) triggers. Level 3 triggers mark a requirement for additional investigations and possibly mitigation and are considered threshold triggers, beyond which an unpredicted or unacceptable impact can be confidently assigned.

It should be determined whether the observed impact is due to the activities or to natural external effects, and Level 2 triggers would generally instigate additional monitoring and potentially additional modelling and model re-calibration.

An additional (Level 4, or limit) trigger may also be set indicating a level at which remediation measures become mandatory.

Different triggers are set for different parameters and require specific monitoring requirements as described below (Table 6-2). Baseline conditions will be used to determine site specific trigger values (SSTVs) for water level and quality at each target measuring point. That is, for each bore and at each depth if multiple depth samplers are in place.

Table 6-2: Groundwater trigger levels

Trigger Level	Description	Groundwater Level Impact	Groundwater Quality Impact
1	Indicator triggers – levels of expected maximum response for the Project	No impacts beyond that predicted in the RtS (refer Annexure A – Groundwater Monitoring Program Attachment A and B)	No impacts beyond that predicted in the RtS (refer Annexure A – Groundwater Monitoring Program Attachment A and B)
2	Early Warning triggers – increased monitoring and assessment	Drawdown greater than predicted for the RtS or in exceedance of SSTVs (refer Annexure A – Groundwater Monitoring Program Attachment A and B)	No impacts beyond that predicted in the RtS or in exceedance of SSTVs (refer Annexure A – Groundwater Monitoring Program Attachment A and B)
3	Threshold triggers – additional investigations (including modelling) and possible mitigation implemented	Drawdown continues to exceed predicted values	Water quality may exceed baseline trigger values
4	Limit triggers – mitigation actions to be implemented	Drawdown reaches a critical approved level that requires immediate mitigation	Water quality at risk of change to beneficial use

Different triggers are set for different parameters and require specific monitoring requirements as described below.

6.4.1.1. Groundwater extraction triggers

Groundwater usage in NSW is regulated according to the financial year, also referred to as the water year. Metering equipment will be installed within the tunnel to monitor tunnel inflows. Readings will be undertaken manually (the Project are investigating opportunities for electronic monitoring) on an ongoing basis throughout construction (i.e. weekly) and recorded in a project water register.

Comparison between groundwater ingress volumes and predicted groundwater inflow, as modelled in the numerical groundwater model, will be undertaken throughout the year to ensure groundwater extraction are within permitted volumes of take from respective water sources. Actual water take will be reported to NRAR on an annual basis in accordance with water access licence conditions.

If cumulative water extraction exceeds cumulative water production published in the EIS (and subsequent Response to Submissions), review of the groundwater modelling predictions will be undertaken and assessment made of the implications on groundwater levels and pressures.

6.4.1.2. Groundwater level triggers

Groundwater level triggers will be set for two primary purposes:

1. Monitoring for project impacts (model validation) and to refine numerical model calibration
2. Monitor for asset protection.

Thus the former constitute the monitoring of the piezometer network to assess any changes in aquifer behaviour; the latter provides a means to assess potential and real impacts to groundwater dependent ecosystems.

Groundwater level triggers for each piezometer will be set as the cumulative predicted drawdown at each water level monitoring site. Predicted drawdown will be calculated from the baseline levels and updated monthly to reflect actual observed drawdowns. Monitoring will continue from the baseline program, using the existing monitoring infrastructure (using loggers and telemetry where available).

Groundwater level triggers will be updated to the date of the previous month's collected data. If the 7-day moving average of the recently collected data exceeds the previous month's trigger level by 1 standard deviation for more than 30 days, an exceedance has occurred and investigation into the exceedance to discern whether it is a natural, anthropogenic or Main Works-related exceedance is required. If the exceedance is deemed to be seasonal and/or climatically driven, the recently collected data will be incorporated into the data set and the water level triggers updated for comparison for the following monitoring event. If the exceedance is deemed to be related to Main Works, the groundwater level trigger is set at the previous month's trigger level to assess the extent of impacts thereafter.

If the exceedance is less than the predicted drawdown as defined through the SSTVs, then monitoring will continue with the revised trigger level. If the exceedance is greater than predicted, a Level 2 trigger investigation is initiated.

Groundwater Level 1 triggers are assigned where modelling has predicted a significant (>2m) impact at the bore's location due to Main Works activities as well as at baseline sites for comparison. These trigger levels have been extracted from the groundwater model and form the basis of assessment (*see* Section 7.2.1). Exceedance of Level 1 triggers instigate additional water level and/or pressure measurement and assessment and may initiate water quality sampling and assessment based on previous baseline response to water levels and potential changes to water chemistry.

Subsequently, Level 2 trigger levels are assigned to additional locations and if these levels are exceeded further investigations are carried out, including additional monitoring (level and water quality) and potentially re-assessment of conceptualisations and modelling.

If Level 3 triggers are exceeded, these indicate values at which mitigation actions should be initiated and would be contingent on recommendations from DPIE Water following expert advice.

Continued drawdown may trigger a Level 4 (threshold) response and mandatory mitigation actions.

Groundwater level triggers at GDE sites (shallow standpipes) will only be assessed against trigger values from Autumn through to Spring (May through to October) as baseline assessment has demonstrated that drying of these sites is a normal occurrence through the summer months and constitutes normal ecosystem function.

6.4.1.3. Groundwater quality triggers

Baseline collection of groundwater quality (Annexure A Attachment A) has identified two critical aspects that influence the efficacy of water quality sampling:

1. Water quality objectives are only exceeded by a constrained sub-set of analytes across all groundwaters, with most groundwaters exhibiting nutrient and metal concentrations close to, or below, limits of detection.
2. Analytes that present above WQOs exhibit similar levels (concentrations) across most groundwater units. That is, there is a broadly homogeneous (and good) water quality across the region, particularly across the Plateau, though increasing salinity is observed towards the western Ravine Beds in the Ravine area.

Combined, these characteristics mean that (i) water quality does not provide a good marker for interaquifer connectivity, nor exchange, and (ii) there is minimal risk from inter-aquifer exchange induced by changing groundwater flow regimes between geological formations as a result of the Main Works.

Further, baseline monitoring has identified significant apparent intra-sample variability, in large part due to the inherently low levels of most analytes, but also reflecting the high inter-connectedness between shallow and deep units and response to recharge events across the region. Monthly sampling at the EPL sites indicates a water quality dependency on water levels, likely reflecting the variable recharge in response to the variable rainfall across the area. This is more evident for shallow sites, but all sites show significant temporal variability in salinity and major ions that reflect climatic inputs.

These characteristics have implications on the optimal frequency of sampling and relevance of analysed parameters. Thus, water quality changes can be ascribed to correspond to significant water level changes and water levels can reasonably act as proxy for stable water quality if levels do not change beyond those observed during the baseline collection period.

Significant changes to water levels, as indicated by exceedance of Level 1 water level triggers (as described above) would trigger water quality sampling at indicative sites to check for water quality impacts. As water quality variables either do not vary significantly with time, or may show a seasonal pattern, quarterly sampling is proposed for this initial phase of analysis. Quarterly sampling would achieve comparable confidence in water quality characteristics as monthly sampling with most analytes currently analysed being very unlikely to change with time or under any perceived potential impacts.

If water quality trigger values are triggered at this restricted (Level 2) network, this would trigger additional sites to be monitored and Level 3 triggers assigned to all analytes at these bores. Repeated exceedance would instigate investigation and assessment of the causes for the triggers.

For most parameters, ANZECC trigger values have been used as the foundation for determining appropriate water quality targets (and hence triggers) to be adopted for groundwater monitoring during construction. These same default trigger values were also applied in the Main Works EIS during assessment of baseline groundwater quality, where relevant.

The following default WQO values have been adopted for the purposes of this GMP:

- physical and chemical stressors – default trigger values for upland rivers in South Eastern Australia that are reported in ANZECC/ARMCANZ (2000); and
- toxicant trigger values for the protection of 99% of freshwater aquatic species that are provided in ANZECC/ARMCANZ (2000).

In setting the groundwater quality trigger values for this plan, results from the EIS baseline monitoring were also reviewed to identify those sites where consistent exceedances were recorded against the ANZECC values. At these locations, Site-Specific Trigger Values (SSTV) will be adopted in place of the default ANZECC trigger value.

Site-specific triggers rely on a temporal trend that is sufficiently long to determine consistent variability through time. Thus, a distribution of values equally distributed around a mean value allows the determination of the standard deviation of data around that mean value. If a consistent baseline can be established, deviation from normally expected variation can be assessed by considering the number of sequential data points that exceed the normal variability in the data. Using this “control chart” approach, a trigger event may be defined when:

- A single data point exceeds the mean plus 3 standard deviations, or
- Two consecutive data points are greater than the mean plus 2 standard deviations, or
- Five successive data points are greater than the mean plus 1 standard deviation.

An example of this type of analysis is shown in Figure 6-1.

For parameters that display a skewed distribution, such as those at the limits of detection or which are impacted by systematic external events (e.g. periodic recharge from a freshwater source), it is appropriate to use equivalent percentiles to assess a trigger event. In this case, a trigger event is defined when:

- One data point exceeds the 99.87th percentile
- Two consecutive data points exceed the 97.73rd percentile, or
- Five successive data points exceed the 84.14th percentile.

This methodology is illustrated in Figure 6-2.

Where continued monitoring demonstrates a shift in variability under baseline conditions (i.e. can be demonstrated to not be due to the Project), these values will be modified to reflect the changing conditions.

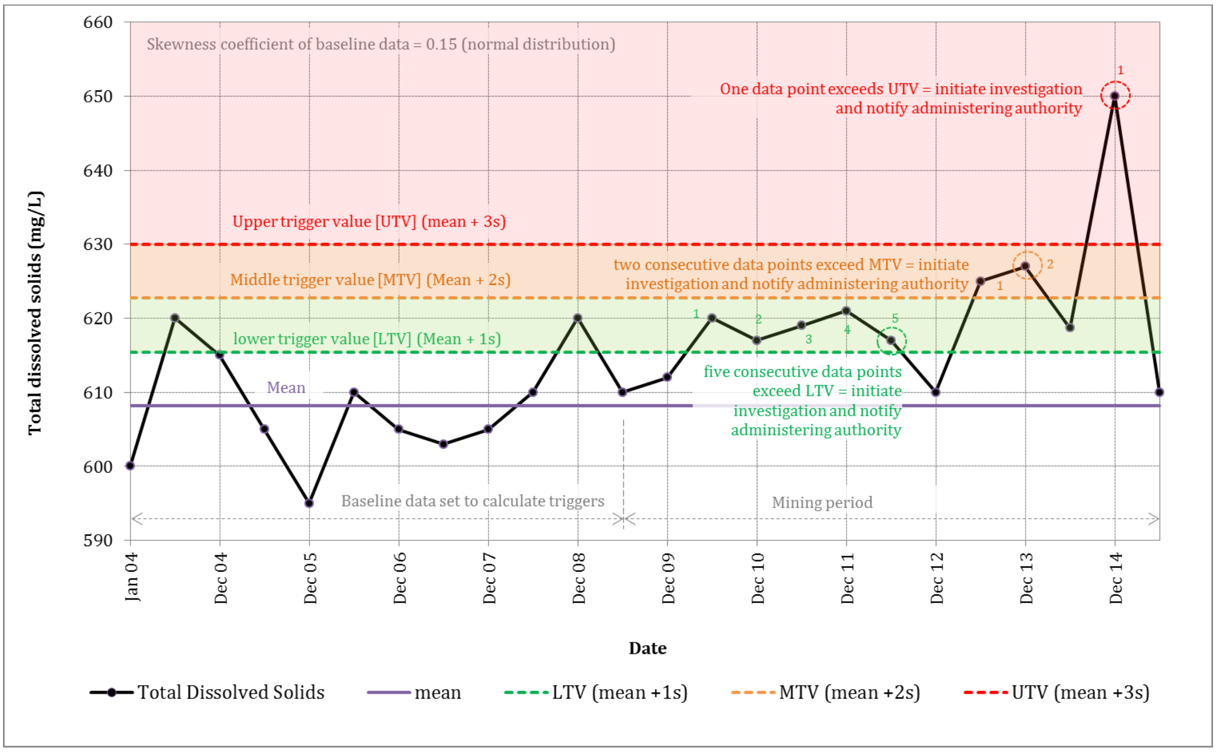

Figure 6-1: Example of a control chart for Total Dissolved Solids that had a normal baseline distribution

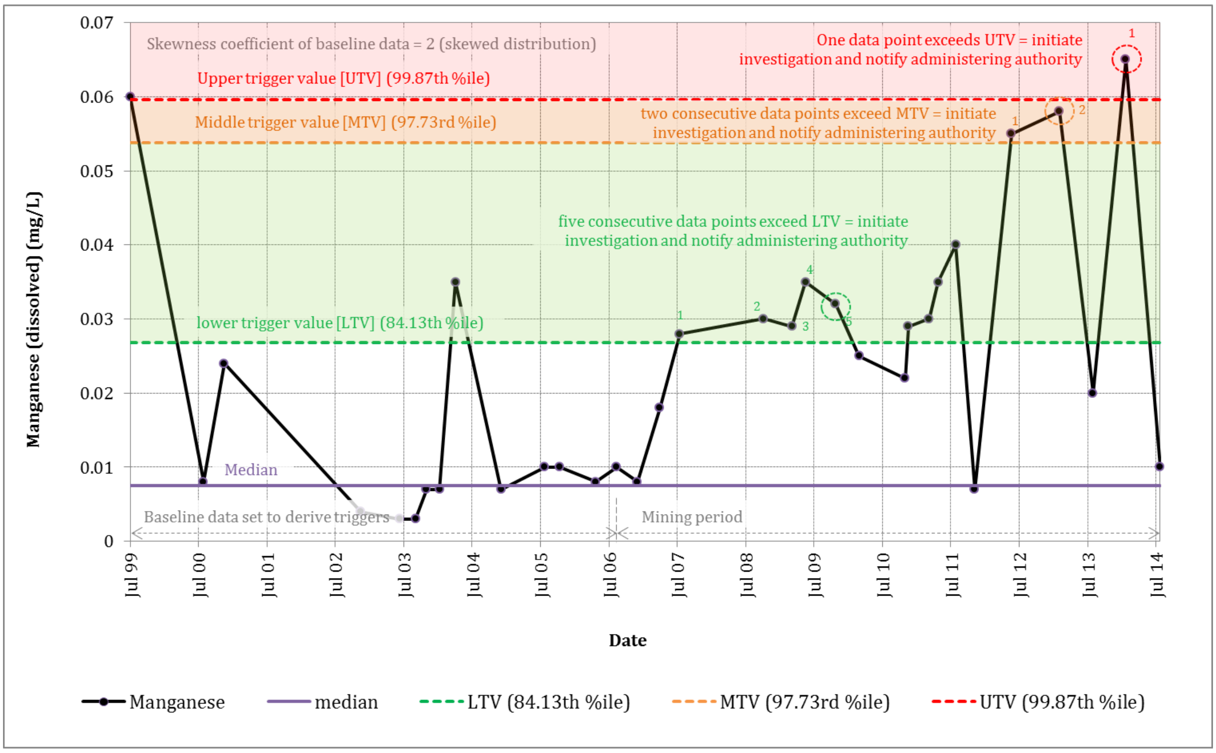

Figure 6-2: Example of a control for manganese showing a skewed baseline concentration distribution

The proposed default ANZECC target values will be adopted where appropriate across the network and are summarised in Table 6-3. The sites for which SSTVs will be identified are indicated with *SSTV* in Table 6-3 and values for SSTVs are provided by bore in the Groundwater Monitoring Program (Annexure A).

Throughout Main Works, should consistent exceedances be observed above these values and shown to not be the result of Main Works activities, a revision of this GMP will be undertaken and trigger values will be revised. If the exceedances are believed to be related to Main Works, investigation into the exceedances are required (*see* Section 7.2, *below*).

6.4.1.4. Water quality – a note on pH

The pH of waters is an indicator of the concentration of hydrogen ions. The scale is logarithmic, with values less than 7 indicating acidic waters and greater than 7 being basic. Baseline values of pH measured in groundwater samples from the monitoring network are reported in Attachment D of the Water Assessment for the EIS (EMM, 2019). The report contains statistics summarising the pH range in each geological formation. Based on the field values, pH of the groundwater typically falls within the 6.5 to 8.0 range specified as the water quality objective (WQO) value.

The control chart methodology used for salinity is not appropriate for pH as the log scale results in control lines that are too closely spaced relative to natural variability. The baseline groundwater monitoring shows pH values are commonly between pH 6 and pH 9. These values are therefore adopted as upper and lower trigger thresholds. Where results are higher than the threshold of pH 9 or lower than pH 6 then the decision tree process shown graphically in Figure 7-2 is undertaken.

It should also be noted that the upper annulus[1] of groundwater monitoring bores is commonly sealed using a grout slurry of cement and bentonite to prevent ingress of surface water. Occasionally this slurry can impact upon groundwater pH immediately around the borehole. This unintended outcome can often result groundwater samples with greater than pH 9 (and up to pH 12) for a significant period of time. If investigations determine the grout seal around any boreholes has raised pH around the boreholes it will not trigger DPIE review as there is no regional impact from the small volumes of cement[2] used in the sealing process.

[1] The volume between the outside of the borehole and the outside of the PVC bore casing
[2] Dependent on bore depth but commonly less than $1m^3$

Table 6-3: ANZECC groundwater quality trigger values and formations and parametes requiring site specific trigger values (SSTVs)

	Unit	Gooandra Volcanics	Temperence Formation	Boggy Plain Suite	Tantangara Formation	Kellys Plain Volcanics	Tertiary basalt	Plateau bogs/fens	Ravine Beds East	Ravine Beds West	Boraig Group	Yarrangobilly Caves
Field Parameters												
Dissolved oxygen	% saturation	*No Water Quality Objective Value*										
Electrical conductivity	µS/cm	30-350	SSTV	30-350	30-350	30-350	30-350	30-350	30-350	*SSTV*	30-350	30-350
pH	-	6.5-8.0	6.5-8.0	6.5-8.0	6.5-8.0	6.5-8.0	6.5-8.0	*SSTV*	6.5-8.0	6.5-8.0	6.5-8.0	6.5-8.0
Oxidation Reduction Potential	mV	*No Water Quality Objective Value*										
Turbidity	NTU	*No Water Quality Objective Value*										
Analytical results – nutrients												
Total nitrogen	mg/L	0.25	0.25	*SSTV*	0.25	0.25	0.25	*SSTV*	0.25	0.25	0.25	0.25
Reactive phosphorus	mg/L	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Analytical results – metals (dissolved)												
Aluminium (Al)	mg/L	0.027	0.027	*SSTV*	0.027	0.027	0.027	*SSTV*	0.027	0.027	0.027	*SSTV*
Copper (Cu)	mg/L	*SSTV*	*SSTV*	*SSTV*	0.001	0.001	*SSTV*	0.001	0.001	0.001	*SSTV*	*SSTV*
Iron (Fe)	mg/L	0.34	0.34	0.34	0.34	0.34	0.34	*SSTV*	0.34	0.34	0.34	0.34
Lead (Pb)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese (Mn)	mg/L	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Nickel (Ni)	mg/L	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Silver (Ag)	mg/L	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026
Zinc (Zn)	mg/L	*SSTV*	*SSTV*	*SSTV*	0.00246	0.00246	*SSTV*	*SSTV*	0.00246	0.00246	*SSTV*	0.002

SSTV Site specific trigger values to be calculated based on long-term statistical analysis – *see* Annexure A: Groundwater Monitoring Program

6.5. Training

All site personnel will undergo site induction training relating to groundwater management 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 water management. Examples of training topics include:

- discharge quality parameters;
- groundwater monitoring methodology and protocols;
- groundwater dependent ecosystems;
- incident response; and
- spill management and reporting

Further details regarding the staff induction and training are outlined in Section 5 of the EMS.

6.6. Incident management

Incidents are managed in accordance with the Section 7 of the EMS and the Pollution Incident Response Management Plan (PIRMP). The investigation will include a review of events leading up to the incident and implement improved practices as required.

The Secretary and other relevant agencies will be notified of incidents in accordance with Section 7 of the EMS. Depending on the type and severity of the incident this may include notification to the Department and NPWS in writing for incidents defined under the conditions of approval, notification to the NPWS where required under the Deed of Agreement of Lease and notification to the EPA for pollution related incidents. Snowy Hydro would notify DPIE in writing immediately after they become aware of the incident on site.

6.7. Auditing

Audits will be undertaken to assess the effectiveness of water management measures and overall compliance with this GMP. Audit requirements are detailed in Section 8.3 of the EMS.

6.8. Reporting

Future Generation will report to Snowy Hydro and other agencies as detailed in Table 6-4 on groundwater management aspects related to the Project. During construction, groundwater monitoring data will be collected, tabulated and assessed against thresholds.

Table 6-4: Reporting requirements relevant to groundwater

Report	Requirement	Recipient
Reporting		
Weekly inspection	EMS Requirement Weekly inspection report undertaken by environmental advisor which includes aspects relevant to the management of water	FGJV Internal Record

Report	Requirement	Recipient
Incident Report (related to water)	<u>Infrastructure Approval Schedule 4, CoA 6</u> The Proponent must notify the Department and NPWS via the Major Projects Portal immediately after it becomes aware of an incident on site. This notice must set out the location and nature of the incident. <u>EPL 21266</u> Incident reports to be provided to EPA in accordance with EPL notification of environmental harm and written report requirements.	Depending on the type and severity of the incident this may include notification to the Department and NPWS in writing for incidents defined under the conditions of approval, notification to the NPWS where required under the Deed of Agreement of Lease and notification to the EPA for pollution related incidents. Snowy Hydro will notify DPIE in writing immediately after they become aware of the incident on site.
EPL Monitoring Reports and Annual Review/Returns	<u>EPL 21266</u> EPL monitoring reports will be prepared in accordance with the requirements of the EPL. An EPL Annual Review/Return will be prepared in respect of each EPL reporting period (typically 12 months)	EPA
Water Access Licence Report (annual)	<u>Water Access Licence</u> Actual water take will be reported to NRAR on an annual basis in accordance with water access licence conditions.	NRAR
Environmental Water Report (every 3 months)	<u>Infrastructure Approval Schedule 3, CoA 31(c)(d)</u> Commentary on the performance of the groundwater monitoring program (including rainfall data and tunnelling progress) will be documented in the quarterly environmental water report. Any incidents and key environmental issues will be documented.	Publicly available on project website
Other Aspects		
Site Water Balance	<u>Infrastructure Approval Schedule 3, CoA 31(b)</u> Yearly calendar revision of the Site Water Balance will be undertaken and where updates are identified, the revised Balance will be updated and included in a future revision of this WMP.	Proposed future updates to this WMP will be provided to EPA, NPWS, Water Group, NRAR and NSW DPI.
Groundwater model validation	<u>Infrastructure Approval Schedule 3, CoA 31(d)</u> Yearly calendar groundwater model review, validation and recalibration/update (as required/dictated by monitoring results) (undertaken by SHL).	The review will be submitted to NRAR, and the revised model will be submitted to the relevant agencies on completion.
Updates to this WMP	<u>Section 1.7 of this WMP</u> This WMP will be updated prior to the commencement of the following activities: • dredging, channel extraction or underwater blasting • in-reservoir emplacement works • construction works in the third year for the purposes of determining need / location of streamflow monitoring sites • Snowy 2.0 operations (a separate SHL document or framework may be prepared)	Proposed future updates to this WMP will be provided to EPA, NPWS, Water Group, NRAR and NSW DPI.

7. TRIGGER ACTION REPONSE PLANS

This section details the Trigger Action Response Plans (TARP) that has been developed for appropriate groundwater variation response. TARPs allow for prompt identification of unpredicted impacts and guide the implementation of additional management measures and corrective actions should adverse conditions arise that are attributable to construction.

Monitoring will be undertaken using a combination of methods and will require varying levels of processing and review before collected data can be used to inform assessment and decision making.

7.1. Adaptive management

Monitoring results obtained during construction will be subject to monitoring, analysis of results, review of mitigation measures (where exceedances are identified) and updates to measures and trigger values where required.

Additional or varied monitoring locations may be warranted following detailed design and during construction. Where a well becomes inoperable, damaged or within the disturbance footprint, the Environmental Manager will identify a suitable replacement in consultation with a suitably qualified hydrogeologist. Changes to monitoring locations and parameters would be approved by SHL in consultation with relevant agencies, and via EPL variation where required. Any relocation or addition of monitoring locations would trigger updating of the monitoring plan.

On-going monitoring results will inform future re-assessment of the numerical groundwater model. If a modelling up-date indicates increased drawdown over time at any location this may trigger additional montoring in the vicinity of the predicted drawdown area. The monitoring program (Annexure A) is designed to continue logging data at the majority of sites, with a retricted suite of sites used for instantaneous assessment. If any changes in excess of the predicted drawdown is registered, this would trigger expansion of the assessment suite of sites and will inform potential locations for additional monitoring sites.

7.2. Trigger Action Response Plans

In addition to the general principles described above (Section 6.4.1) for assessment of groundwater triggers, trigger action response plans (TARPs) have been developed to further investigate potential impacts to groundwater during construction of the Project.

The groundwater TARPs include:

- TARP 1 groundwater level (Annexure B)
- TARP 2 groundwater quality (Annexure C)
- TARP 3 groundwater ingress (Annexure D).

The purpose of the groundwater TARPs are to detail a standardised response procedure in the event that a trigger value banding is exceeded during a monitoring event for groundwater quantity, quality, pressures and/or levels. As groundwater take (in the form of discharged tunnel inflows) is a condition of approval, a groundwater ingress TARP is also developed.

The objectives of the TARPs are as follows:

- undertake supplementary monitoring to confirm and establish the extent of water quality or level variation;
- identify the potential cause(s) of the water quality or level variation, if possible;
- identify and implement appropriate mitigation measures to minimise on-going trigger of the water quality or level variation, if possible;

- perform due diligence when any variation is triggered; and
- meet CoA and REMMs requirements for trigger response.

7.2.1. Groundwater dependent ecosystems

Groundwater dependent ecosystems are critical assets to be protected during construction. The fundamental cause for any impacts to GDEs will be reduced access to groundwater driven by water level drop during the winter months. For this reason, potential impacts to GDEs is monitored through direct monitoring at targeted GDE locations via shallow standpipes as well as indirect monitoring via comparison of regional water levels with predicted drawdowns from the numerical modelling.

Critically, the Alpine Bogs and Associated Fens of the Plateau area have been shown during the baseline assessment (Annexure A Attachment A) to tolerate substantial groundwater drawdown during the summer months, with soil profiles drying out (e.g. Figure 7-1). Ecosystem function does not appear to be impacted by this drying, provided winter rainfall and/or subsequent spring snow-melt return groundwater levels to the surface or near surface. Thus, the critical period for high water levels (and groundwater-dependence) runs from May to October with reduced water tables outside this period expected and hence should not trigger a response.

GDE triggers, therefore, are only applicable for the critical periods between May and October.

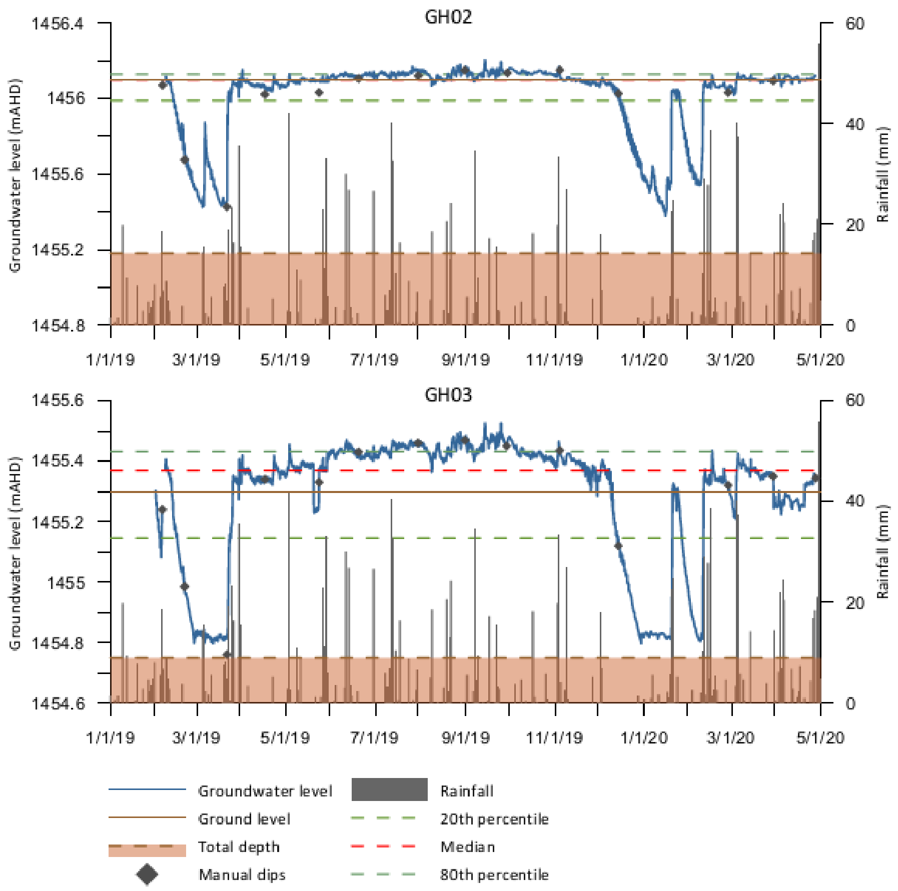

Figure 7-1: Typical water table response in the vicinity of an Alpine Bog (Gooandra Hill Bog)

7.2.2. Trigger Process

Figure 7-2 illustrates the investigation process to be followed when water level or quality results exceed values as described in Section 6.4 and itemised in the Groundwater Monitoring Program (Annexure A). The process requires review of all factors that can influence groundwater levels and quality including climatic conditions, any changes in geological conceptualisation and other physical constraints and operational conditions with the purpose to identify if there is a unique influence that has resulted in the change or if it is a result of multiple factors.

The TARP process is staged such that an initial monitored result is assessed against the relevant trigger values for that site (Stage 1). If the value exceeds the trigger value for groundwater inflow, groundwater level or groundwater quality indicators, the initial response (Stage 2) is to organise an additional measurement of that parameters at the site.

Confirmation of the initial results (Stage 3) triggers assessment by the site environmental officer for external factors, including natural or climatic variability (e.g. prolonged drought or excessive rainfall) (Stage 4) or changed site conditions (e.g. changed rate of TBM progress) (Stage 5).

If no external drivers can be identified, the potential for a construction impact is assessed (Stage 6). If it is determined that a construction activity may be responsible, or if no reason can be determined, an external third-party reviewer is engaged to repeat the assessment and make recommendations (Stage 7).

If the external reviewer has reason to believe the trigger was as a response of construction activities (or cannot determine the cause), the DPIE and NPWS will be notified (Stage 8) and further discussions undertaken to assess whether additional monitoring and/or mitigation is required. Notification to the DPIE and NPWS would occur within seven (7) days of the initial recognition of a trigger exceedance.

The external, third-party, reviewer will establish the appropriate level of trigger warning (Stage 9) based on the following principles:

1. Indicator Triggers are not considered detrimental to the environment and may reflect predicted impacts expected from the level of tunnel ingress and consequent drawdown. They may initiate an increased monitoring frequency and focus attention to potentially impacted bores. These triggers may also be set to provide verification for modelling results, typically with the use of Sentinel Bores that are expected to be impacted by construction as predicted by the numerical groundwater modelling.

2. Early Warning Triggers alert that levels or quality are trending towards potential impacts to specified assets and instigate additional statistical analysis of the data to verify trends and relationships across the network.

3. Threshold Triggers instigate mitigation activities. A detrimental trend is identified and potential for impact realised.

4. Trigger Limits can also be set for some parameters (for example, metal levels, extreme drawdown) that determine that a breach of Approval Conditions has occurred (i.e. CoA 29). Significant mitigation activities are activated.

If it is determined that a threshold trigger has been exceeded the external reviewer will provide a report to DPIE and NPWS within 30 days of the initial notification of a triggered exceedance (Stage 10). SHL will negotiate appropriate mitigation actions with DPIE and undertake any additional works within agreed timeframes.

The three groundwater TARPs outlined in Annexure B, Annexure C and Annexure D provide the basis for the corresponding trigger warning levels and consequent mitigation actions and response.

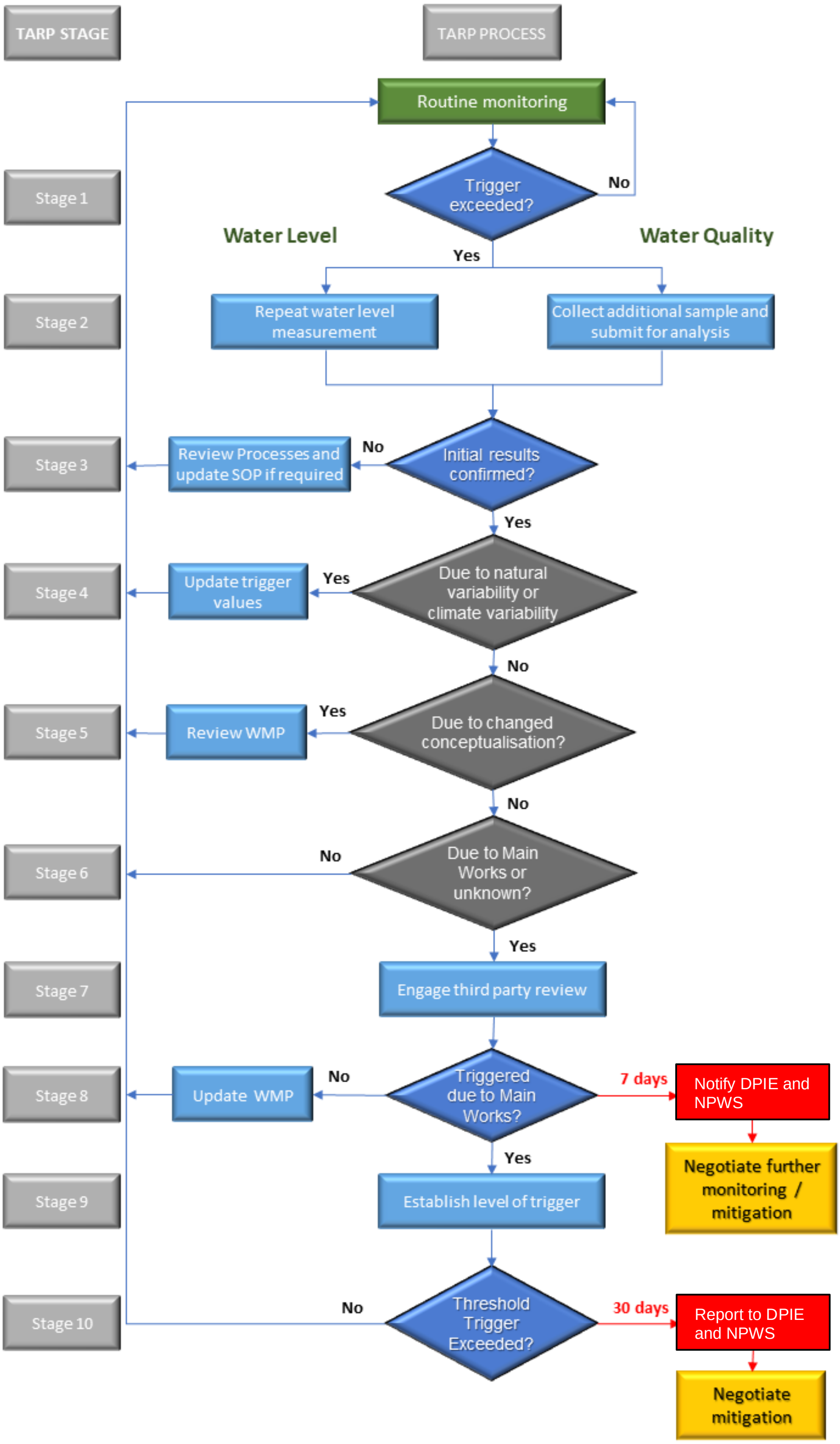

Figure 7-2: Decision tree for analysis of all trigger exceedances

The results of the trigger investigations will be reported in each Annual Review as described in Section 6.8. Consequent identified changes to baseline data or trigger levels that are not deemed a result of Main Works will trigger an update of the GMP and groundwater monitoring plan.

7.2.3. Alpine Bog and Associated Fen triggers

Shallow bores installed at identified Type 3 GDE locations (Alpine Bog and Associated Fens) have recorded shallow groundwater level variations and ecosystem health at twelve sites across the Plateau at Bullocks Hill Bog, Gooandra Hill Bog, Nungar Creek Bog and Tantangara Creek Bog. All sites record water levels in the top metre of the profile and seasonal variability demonstrates that these features dry during the summer and saturate during the winter (Annexure A). Water level variability in excess of a metre can occur between seasons, though this is generally limited by surficial discharge. All sites are characterised by six months (May to October) with water levels at or near the ground surface. Water level drawdown below the 80th percentile during these months would be considered a change (i.e. greater than a negligible change, as per CoA 15A) in the shallow groundwater regime and would trigger a Level 3 investigation as described under the groundwater level TARP (Annexure B).

The specific process at GDE sites requires consideration of biodiversity offsets if a trigger is deemed to be irreversible and the GDE function is compromised. Thus an additional trigger process is introduced that transfers responsibility of biodiversity considerations to the Biodiversity Management Plan and consideration of potential off-sets. This process is outlined in Figure 7-3.

GDE monitoring sites have been (or will be) established at a combination of: (i) identified GDEs within the predicted area of drawdown; (ii) identified GDEs outside the predicted area of drawdown, but along the tunnel alignment, and (iii) identified GDEs outside the predicted area of drawdown and at a significant distance from the project alignment. These would record shallow watertables at sites that are expected to be impacted; unlikely to be impacted and very unlikely to be impacted (baseline), respectively.

In the unlikely event that impacts are greater than predicted (Section 4.2.4), additional monitoring sites will be considered in consultation with DPIE and NPWS (Section 7.2.2 Step 8).

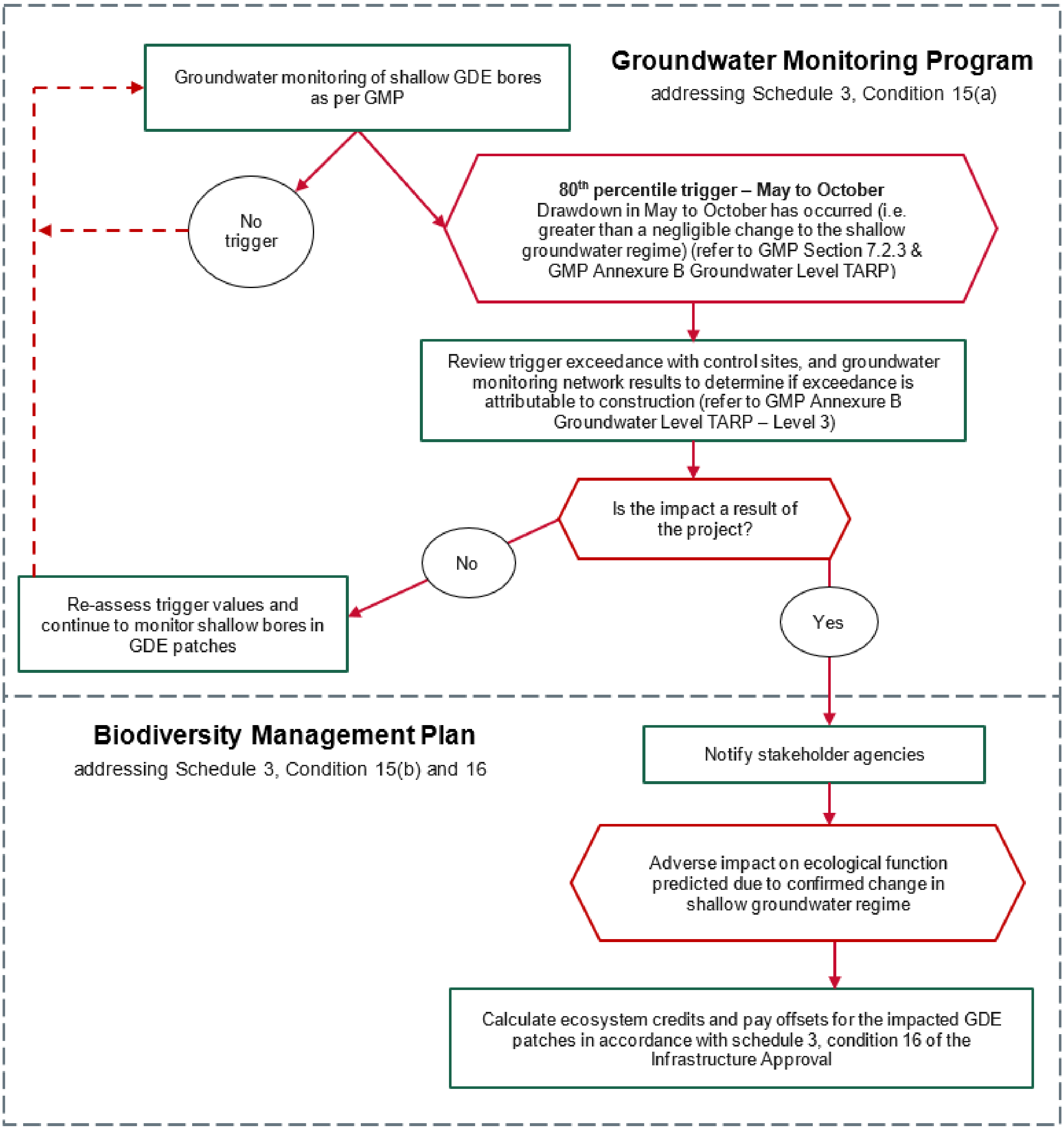

Figure 7-3: Linkage between Groundwater Level TARP and Biodiversity Management Plan

8. REVIEW AND IMPROVEMENT

8.1. Continuous improvement

This plan will be subject to continuous improvement through regular evaluation of environmental management performance against the policies, objectives and targets outlined in this plan and the project EMS in order to identify opportunities for improvement.

This review and improvement process will be designed to:

- Assess performance of the environmental management system through comparisons with objectives and targets;
- Identify opportunities for improving practices and processes;
- Determine the cause or causes of non-conformances or exceedance events;
- Develop and implement a plan of corrective and preventative action to address any non-compliances;
- Verify the effectiveness of the corrective and preventative actions; and
- Document any changes in procedures resulting from process improvement

8.2. Groundwater Model Validation

The SH4.0 model (and linked surface water SOURCE model) will be kept as a live groundwater management tool throughout construction. It will be validated and, if necessary, recalibrated to new groundwater monitoring data as the monitoring record increases.

Of particular benefit to ongoing validation of the model will be the inclusion of measured groundwater responses at the commencement of excavations and as works progress. Dewatering of excavations provides a much greater stress on the groundwater system than climate-driven stresses, and this information will enable greater accuracy in the prediction of impacts to the system.

Monitoring data will be reviewed throughout the construction period to provide validation of the groundwater model and potential requirements to increase, or decrease, the number of sampling locations and/or the analytical suites.

The review to recalibrate and update the groundwater model, and associated monitoring data collection frequency will be will be undertaken during each Annual Reporting cycle, in consultation with NRAR and DPIE Water Group.

The revised model will be submitted to the relevant agencies on completion, or as required by the REMMs and Conditions of Approval.

8.3. Groundwater Management Plan Revision

Throughout construction, there may be a need to update or revise this Plan. This may be in response to updates of the groundwater model, other elements of the project EMS or due to an update to the EPL. Plan updates will occur on an as needed basis, with conditions approved through the EPL taking precedence until any changes to the GMP are approved.

Amendments to this plan will be in accordance with the delegations outlined in the EMS. A copy of the updated plan and changes will be distributed to all relevant stakeholders in accordance with the approved document control procedure.

9. REFERENCES

ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra, ACT, Australia. Viewed [viewed 08/04/2020], [https://www.waterquality.gov.au/anz-guidelines].

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EMM, 2020. Modelling Report. Annexure I to Main Works Preferred Infrastructure Report and Response to Submissions

Groundwater Dependent Ecosystems Risk Assessment Guidelines (NOW 2012d);

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Australian Groundwater Modelling Guidelines (National Water Commission 2012);

National Water Quality Management Strategy Guidelines for Groundwater Quality Protection in Australia (NWQMS 2013);

Department of Primary Industries Guidelines for Controlled Activities (2012); and

Environment Protection Authority (EPA): Approved methods for Sampling and Analysis of Water Pollutants in NSW (EPA 2004).

Department of Planning and Environment (DPR): Guideline for riparian corridors on waterfront land (DPE 2012)

Department of Water and Energy (DWE): NSW Water Extraction Monitoring Policy (DWE 2007); and

NSW Office of Water (NoW) NSW Aquifer Interference Policy (NoW 2012).

ANNEXURE A – GROUNDWATER MONITORING PROGRAM

S2-FGJV-ENV-PLN-0108

SNOWY 2.0 MAIN WORKS – GROUNDWATER MONITORING PROGRAM

Approval Record			
Document preparation, review and approval		Name in print	Signature
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Verified by	Environmental Manager	L. Coetzee	
Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:31:58 +10'00'

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	13.03.2020	Initial draft
B	22.05.2020	Update to reflect conditions of approval and revised environmental management measures
C	15.06.2020	Revised to address SHL comments. For consultation
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments

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1. INTRODUCTION

1.1. Context

This Groundwater Monitoring Program (Program) forms part of the Groundwater Management Plan (GMP), Water Management Plan (WMP) and Environmental Management Strategy (EMS) for construction of Snowy 2.0 (the Project).

The Program addresses the requirements of the Minister's Conditions of Approval (CoA) as approved on 21 May 2020; the Main Works Snowy 2.0 Environmental Impact Statement (EIS); the revised environmental management measures (REMMs) within the Snowy 2.0 Main Works and Exploratory Works Response to Submissions; Environmental Protection Licence (EPL) 21266, as well as all applicable guidance and legislation as described in the Groundwater Management Plan to which this is appended.

1.2. Scope

The scope of this Program is to describe how Future Generation propose to monitor the extent and nature of potential impacts to groundwater and dependent uses and ecosystems during construction of the Project. Operational monitoring and operation measures do not fall within the scope of the construction phase and therefore are not considered within this Program.

This Program provides detailed inspection criteria and responsibilities including:

- groundwater monitoring locations;
- parameters/analytes to be monitored;
- types of monitoring;
- frequency of monitoring,
- monitoring methodology; and
- data management, model verification and ownership.

1.3. Purpose and objectives

This groundwater monitoring program has been developed to monitor potential impacts to groundwater (and consequent potential impacts to groundwater dependent users, including ecosystems) during construction (Main Works) of the Project.

The objectives of the program are to:

- quantify groundwater inflow volumes to tunnels
- assess any changes to groundwater levels/pressures
- assess any changes to water quality of different groundwater aquifers
- assess groundwater conditions against nominated trigger values
- help identify, and monitor the response of, any actions required in the event of trigger value exceedances;
- assess the effectiveness of groundwater mitigation measures;
- assure compliance with relevant consent and licencing conditions and other monitoring requirements, as prescribed for the Project; and

- provide additional data for groundwater numerical modelling verification, validation and re-calibration, as required.

This Program is based on the baseline monitoring program established during the assessment of the Project EIS (EMM, 2019) and continued through baseline monitoring reports (EMM, 2020). Baseline data is provided as Attachment A to this Program.

1.4. Consultation

In accordance with schedule 3, condition 31 of the Infrastructure Approval and Main Works REMM WM01, the WMP (which includes the GMP) is to be prepared in consultation with:

- NSW Environment Protection Agency (EPA);
- National Parks and Wildlife Services (NPWS);
- Department of Planning, Industry and Environment – Water group (DPIE – Water Group);
- Natural Resources Access Regulator (NRAR); and
- NSW Department of Primary Industries (NSW DPI).

In accordance with condition 18 of the Commonwealth approval, the WMP (including the GMP) is also to be prepared in consultation with the DAWE.

The Program is proposing to utilise bores from the existing baseline monitoring network established by Snowy Hydro Limited (Snowy Hydro) during the Exploratory Works. Snowy Hydro developed this network in consultation with DPIE-Water with the objective of providing good coverage along the Project alignment across all hydrostratigrahic units and under the diverse geological conditions.

A summary of consultation undertaken during the development of the GMP and GWMP is included in Section 1.7 of the GMP.

1.5. Relationships to other documents

The overall environmental management system for the Project is described in the Environmental Management Strategy (EMS).

This Groundwater Monitoring Program forms part of Future Generation's environmental management framework as described in the EMS. An overview of the Groundwater Monitoring Program relative to the elements of water management is provided in the Groundwater Management Plan (S2-FGJV-ENV-PLN-0012).

This Program provides groundwater level and quality monitoring relevant to protection of groundwater-dependent ecosystems (GDEs). Additional monitoring and mitigation measures for ecosystems are outlined in the Biodiversity Management Plan (S2-FGJV-ENV-PLN-0008).

This Groundwater Monitoring Program monitors groundwater water levels that inform the calibration of numerical groundwater modelling that includes changes to baseflow caused by changes in groundwater levels and pressures.

1.6. Overview

Groundwater monitoring to be undertaken is summarised in Table 1-1.

Table 1-1: Groundwater monitoring

Characteristic	Proposed sampling	Frequency of sampling
Groundwater level	Groundwater Level - Direct-read data loggers	Six-hourly
Groundwater quality - general	Water quality lab samples from the suite	Quarterly, or as required by the EPL or TARPs
Compliance with groundwater extraction licence approval	Volume - Measured extraction volume (i.e. Groundwater inflow to the tunnels (and subsequent discharge via the Project WTPs).	As required by the extraction licence
Tunnel inflow monitoring	Inflow volume measurements	Dependent on tunneling program

Where a well becomes inoperable, damaged or within the works footprint, the Future Generation environment team, in consultation with Snowy Hydro and relevant agencies, will identify a suitable replacement in consultation with a suitably qualified hydrogeologist.

1.7. Physical environment

The existing physical environment is described in Section 3 of the WMP and Section 3 of the GMP and summarised below.

The Snowy 2.0 Project spans the NSW Western Slopes, South Eastern Highlands and Australian Alps Interim Biogeographic Regionalisation for Australia (IBRA) regions characterised as diverse landforms of limestone, granite and basalt valleys and mountain ranges. These landscapes vary from 545m AHD in the Lobs Hole zone leading up the valleys (Marica/ Plateau zones) to the plateau topped Tantangara zone at 1524m AHD. The Ravine area is characterised by deep gorges and steep sloping ridges. The plateau area is typical of elevated alpine environments, dominated by low energy streams, gentle rolling hills and mostly flat floodplains.

The Project area is located within the south-eastern portion of the Lachlan Fold Belt (LFB) of NSW. The LFB comprises a suite of Ordovician to Devonian sedimentary, igneous and metamorphic rocks that have been laid down, compacted and deformed across multiple orogenic periods.

The geology between Talbingo and Tantangara reservoirs is structurally deformed with numerous folds and several major faults associated with the north-south trending Long Plain Fault (LPF) zone.

The project intercepts two major geological structural blocks. These two structural blocks form distinct geological terrains: the dominantly Silurian Tumut Block in the west (the incised ravine area), and the dominantly Ordovician Tantangara Block in the east (the plateau). The terrains are separated by an escarpment caused by movement on the LPF (Figure 1-1).

The EIS identified two high risk geological formations, the Gooandra Volcanics and Kellys Plain Volcanics, both of which are located in the Plateau structural block (Figure 1-1). These formations demonstrated (through pumping tests) vertical hydraulic connections between shallow and deeper horizons within these geological units. A summary of hydraulic properties for the plateau and ravines regions are summarised in Section 3 of the GMP.

This monitoring plan aims to provide groundwater information on each of the identified geological units and specifically to provide information that informs the groundwater interpretations and supports further development of the groundwater model and protection of groundwater dependent users and ecosystems.

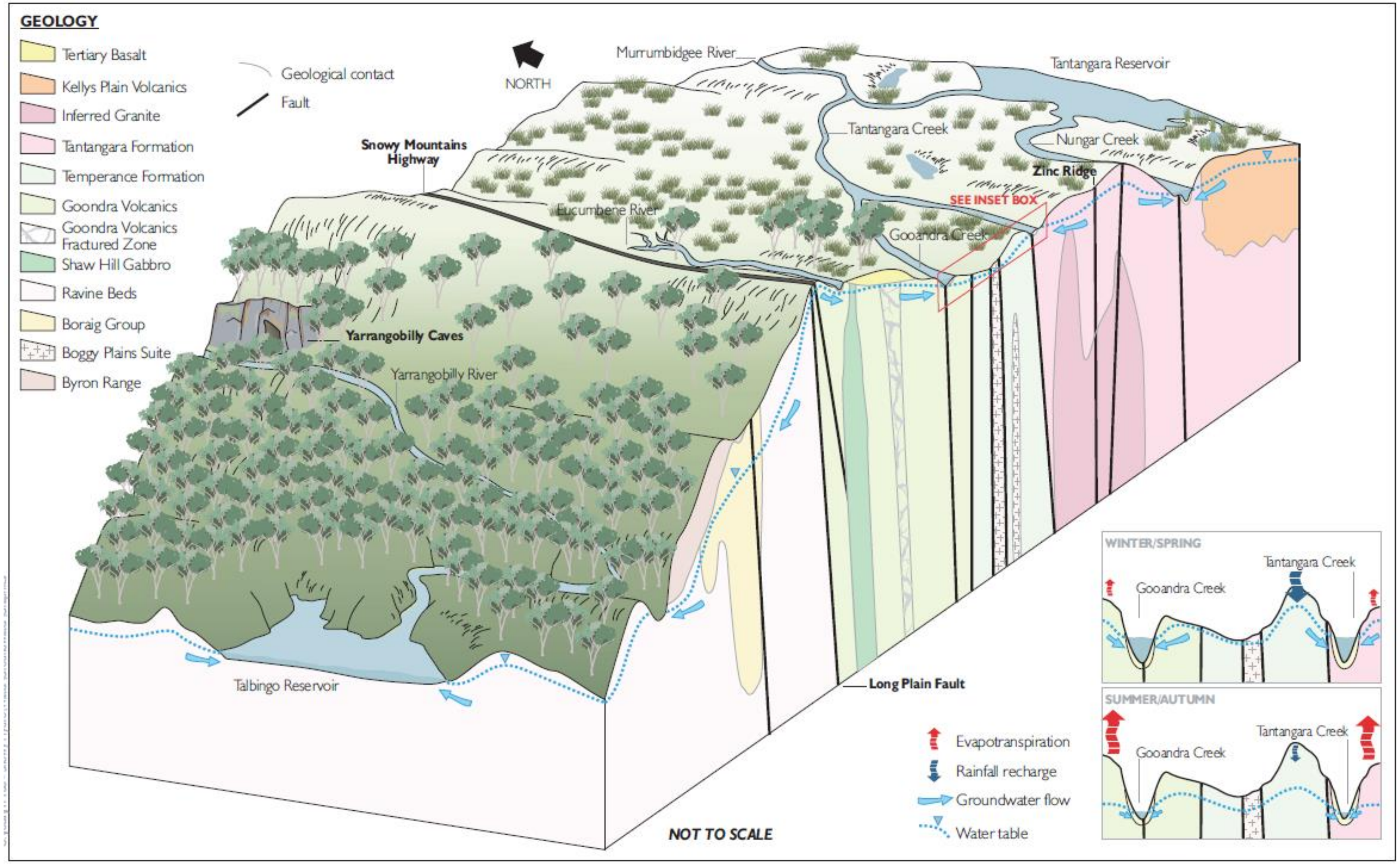


Figure 1-1: Schematic geological block diagram of the Project area showing key groundwater interactions

2. GROUNDWATER MONITORING PRINCIPLES AND DESIGN

2.1. Key Principles

To meet the objectives identified in Section 1.3, the groundwater monitoring program has been developed specifically to:

- verify the groundwater model (i.e. validate the predicted drawdown);
- monitor in areas predicted to be at high risk of groundwater drawdown, including the Kellys Plain Volcanics and Gooandra Volcanics geological formations; and
- monitor impacts to groundwater dependent ecosystems.

The following key principles were adopted:

- identification of key receptors to monitor (to ensure protection);
- use of the existing baseline network to understand natural variations and fluctuations;
- use of compliance groundwater bores north and south of the tunnel alignment in high risk areas to validate the predicted model impacts extents (the distance from the alignment was chosen to confirm the absence of impact in areas that were modelled to have no impact);
- addition of lagging indicator groundwater bores within areas of predicted impacts to verify modelled predicted impacts and provide warning for further investigation, and
- addition of shallow bores to evaluate and protect GDEs from impacts.

2.2. Network Design

For the EIS, EMM designed and implemented a dedicated project baseline groundwater monitoring network to investigate groundwater conditions in the project area. The network was developed in consultation with DPIE-Water (formerly DoI Water). The network and baseline data were reported in the EIS (Appendices J.2 and J.3).

The Project baseline groundwater monitoring network within the project area was completed over four drilling campaigns and consists of conventional groundwater monitoring bores, test production bores, vibrating wire piezometers (VWPs) and shallow drive points/auger holes. Monitoring bores, VWPs and drive points/auger holes were positioned to provide spatial coverage, investigate the major geologies and groundwater environments, and monitor potentially sensitive features. The monitoring network also consists of both background (regional) monitoring locations and targeted (local) monitoring locations along the alignment of the key proposed project features. Numerous nested sites were developed to provide information on surficial to deep connectivity along the alignment to inform the conceptualisation of the numerical groundwater model.

This Project baseline groundwater monitoring network has been adopted as the basis of the construction monitoring network. Sites have been rationalised, however, to focus on potentially high-risk areas and assets and the sampling program revised where justifiable to reduce monitoring frequency and hence impacts to the local landscape caused by intensive sampling campaigns. Critically, the numerical groundwater modelling has identified locations where additional monitoring is required, or may provide critical information to inform future iterations of the model. Hence, additional monitoring locations have been selected, guided by the key principles discussed in Section 2.1.

The Main Works monitoring network is identified in Section 2.3.

2.3. Monitoring Network

The current groundwater monitoring infrastructure for Main Works includes 98 bore constructions listed in Table 2-1. These are listed for each bore type and from west to east. Locations are shown in Figure 2-1 and Figure 2-2. The current infrastructure consists of:

- Forty-eight (48) conventional groundwater monitoring bores at 39 locations. At some locations multiple monitoring bores are installed next to one another to varying depths (nested bores). These bores are suitable for both water level and water quality sampling.
- Eight (8) test production bores used to assess indicative groundwater yields and quality at the proposed tunnel depth.
- Two (2) production bores at Lobs Hole which are used as auxiliary water supply sources.
- Four (4) shallow drive point piezometers and 12 swamp monitoring bores.
- Twenty-four (24) VWP locations with 61 depth sensors.

An additional fourteen (14) sites have been selected as part of an expanded network to monitor groundwater at GDEs and investigate groundwater conditions away from the tunnel alignment (see Section 2.4). That is, to the north and south of the existing network to assess groundwater connectivity along strike from the existing network. The focus will be on the high-risk zones of the Gooandra Volcanics and Kellys Plain Volcanics.

Table 2-1: Baseline groundwater monitoring network

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Conventional monitoring bores					
Ravine Beds West	BH7106	613	154.1	141.1–153.1	Siltstone
	BH8101	610	68.4	53.4–65.4	Siltstone
	BH8102	608	68.6	53.6–65.6	Siltstone
	BH8105	621	58.9	43.9–55.9	Siltstone
	BH8108	629	60	45.0–57.0	Siltstone
	RSMB1	561	30	27.0–30.0	Siltstone/sandstone
	RSMB2	570	30	27.0–30.0	Siltstone/sandstone
	RSMB3	593	30	27.0–30.0	Siltstone/sandstone
	TMB01B	582	72	63.0–69.0	Siltstone
	TMB05A	603	21	12.0–18.0	Weathered Siltstone
	TMB05B	603	77	68.0–74.0	Siltstone
Boraig Group	BH5105	1,199	108.2	97.0–109.0	Ignimbrite
	BH7104	584	92.2	80.2–89.2	Ignimbrite
	MB06A	1,145	14	9.0–12.0	Weathered volcanic
	MB06B	1,145	72	64.0–70.0	Volcanic
	TMB01A	581	14	11.0–14.0	Ignimbrite
Ravine Beds East	MB12B	1,331	180	149.0–179.0	Siltstone
	MB12A	1,330	36	26.0–35.0	Weathered siltstone

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Tertiary basalt	MB01B	1,464	7.5	5.3–6.8	Basalt
Gooandra Volcanics	BH3110	1,346	178.9	165.9–177.9	Diorite
	MB01C	1,464	52	45.0–51.0	Basalt
	MB02	1,387	150	141.0–147.0	Chloritic schist
	MB03	1,373	101	92.0–98.0	Chloritic schist
	MB11A	1,485	7.5	17.0–23.0	Weathered basalt
	SMB04	1,342	180	170.0–179.0	Chloritic schist
	SMB05	1,342	50	40.0–49.0	Basalt
	TMB02A	1,470	15	11.0–14.0	Weathered basalt
	TMB02B	1,472	200	191.0–197.0	Chloritic schist
	TMB03A	1,478	34	29.5–32.5	Weathered basalt
	TMB03B	1,478	150	141.0–147.0	Chloritic schist
	TMB04	1,346	200	191.0–197.0	Basalt
Temperance Formation	BH3102	1,383	91	82.0–88.0	Sandstone
	MB04A	1,330	30	23.0–29.0	Basalt
	MB04B	1,330	102.5	93.5–99.5	Chloritic schist
	MB07A	1,265	15	10.0–13.0	Weathered siltstone
	MB07B	1,265	60	51.0–57.0	Sandstone
	MB13A	1,382	60	50.0–59.0	Weathered siltstone
	MB13B	1,382	190	169.0–189.0	Siltstone
Temperance Formation /Boggy Plain Suite	SMB03	1,335	50	40.0–49.0	Sandstone
Boggy Plain Suite	SMB02	1,335	195	182.0–194.0	Sandstone
Tantangara Formation	BH2103	1,264	103.3	94.3–100.3	Sandstone
	BH3101	1,418	85.6	76.6–82.6	Sandstone
	MB08A	1,435	30	20.0–29.0	Weathered siltstone
	MB08B	1,436	298	277.0–297.0	Sandstone
Kellys Plain Volcanics	BH1115	1,231	55	42.0–51.0	Dacite
	BH1116	1,234	93.1	80.5–89.5	Dacite
	BH1117	1,241	65	51.9–60.9	Dacite
	BH2101	1,314	169.9	154.6–166.6	Siltstone
Test production bores					
Ravine Beds West	PB05	614	100	50.0–100.0	Siltstone
Ravine Beds East	PB09	1,330	300	200.0–300.0	Siltstone

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Gooandra Volcanics	PB04	1,341	200	185.0–200.0	Chloritic schist
	TMB03C	1,478	250	237.0–249.0	Chloritic schist
Temperance Formation	PB10	1,382	230	210.0–230.0	Chloritic schist
Boggy Plain Suite	PB03	1,336	215	200.0–215.0	Granite
Tantangara Formation	PB06	1,436	318	298.0–318.0	Sandstone
Kellys Plain Volcanics	PB01	1,231	60	30.0–60.0	Dacite
Production bores					
Ravine Beds West[3]	EWPB1	563	96	36.0–42.0, 54.0–60.0, 90.0–96.0	Siltstone/sandstone
	EWPB3	560	60	24.0–42.0, 48.0–54.0	Siltstone/sandstone
Vibrating wire peizometers				Vertical sensor depth (m BGL)	
Ravine Beds West	BH6103	602	220	218.7, 131.2	Siltstone/sandstone
Boraig Group /Ravine Beds East	BH5104A	1187	840	673.3, 475.3, 376.3	Siltstone/sandstone
	BH5103	1272	882	765.0, 562.0, 352.0	Mixed sediments
Ravine Beds East	BH8106	1096	673	669.0, 431.0	Siltstone/sandstone
	BH5108	1141	764	666.0, 431.0, 380.3	Siltstone
	BH5107	1163	774	737.5, 554.5, 381.4	Siltstone/sandstone
	BH5110	1196	799	687.5, 435.4, 267.3	Mixed sediments
	BH5114	1287	532	491.9, 359.0, 208.5	Siltstone
	BH5115	1330	789	292.0, 192.0	Siltstone
	BH5102	1329	949	818.8, 619.1, 419.4	Siltstone/sandstone
	BH5111	1351	272	232.4, 180.7, 116.5	Siltstone/sandstone
	BH5101A	1390	1011	248.0	Siltstone
	BH4104	1484	917	628.4, 506.6	Siltstone
Gooandra Volcanics	BH4103	1471	388	335.6, 232.2, 139.5	Metatuff, Tuff, Gneiss
	BH4102	1460	534	455.6, 374.3, 246.3	Gneiss, Phyllite
	BH4101	1479	1100	883.9, 729.6, 542.5	Meta-rhyolite
	BH3108	1369	998	620.0, 342.0, 250.0	Schist
	BH3111	1502	406	354.6, 252.5, 120.5	Meta-siltstone/sandstone
Temperance Formation /Gooandra Volcanics	BH3107A	1325	237	200.2, 133.5	Siltstone/sandstone

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Temperance Formation/Boggy Plain Suite	BH3106	1335	247	194.3, 150.1	Pyroxenite, Diorite
Tantangara Formation	BH3104	1436	339	287.0, 174.0, 72.9	Siltstone/sandstone
	BH3113	1334	234	184.8, 94.9	Meta-siltstone/sandstone
	BH2102	1246	145	107.2, 41.8	Meta-siltstone/sandstone
Drive point piezometers and narrow diameter piezometers					
Gooandra Hill Bog[2]	GH01	1,456	1	0.5–1.0	Alluvium/colluvium
	GH02	1,456	0.9	0.5–0.9	Alluvium/colluvium
	GH03	1,455	0.6	0.3–0.6	Alluvium/colluvium
Tantangara Creek Bog[2]	TC01	1,324	1	0.6–1.0	Alluvium/colluvium
	TC02	1,322	1.1	0.7–1.1	Alluvium/colluvium
	TC03	1,321	0.8	0.5–0.8	Alluvium/colluvium
Bullocks Hill Bog[2]	BP1	1,366	1.8	1.5–1.8	Alluvium/colluvium
	BP2	1,364	1.8	1.5–1.8	Alluvium/colluvium
	BP3	1,364	1.8	1.5–1.8	Alluvium/colluvium
	BP4	1,363	1.8	1.5–1.8	Alluvium/colluvium
	BH01	1,351	0.4	0.2–0.4	Alluvium/colluvium
	BH02	1,352	0.9	0.6–0.9	Alluvium/colluvium
	BH03	1,350	0.7	0.5–0.7	Alluvium/colluvium
Nungar Creek Bog/Fen[2]	NC01	1,237	0.8	0.5–0.8	Alluvium/colluvium
	NC02	1,237	1.1	0.8–1.1	Alluvium/colluvium
	NC03	1,237	1.0	0.7–1.0	Alluvium/colluvium

Notes: 1. m AHD = metres Australian Height Datum.
2. Interpreted surficial formation.
3. monitoring bores used for production only, no testing completed.

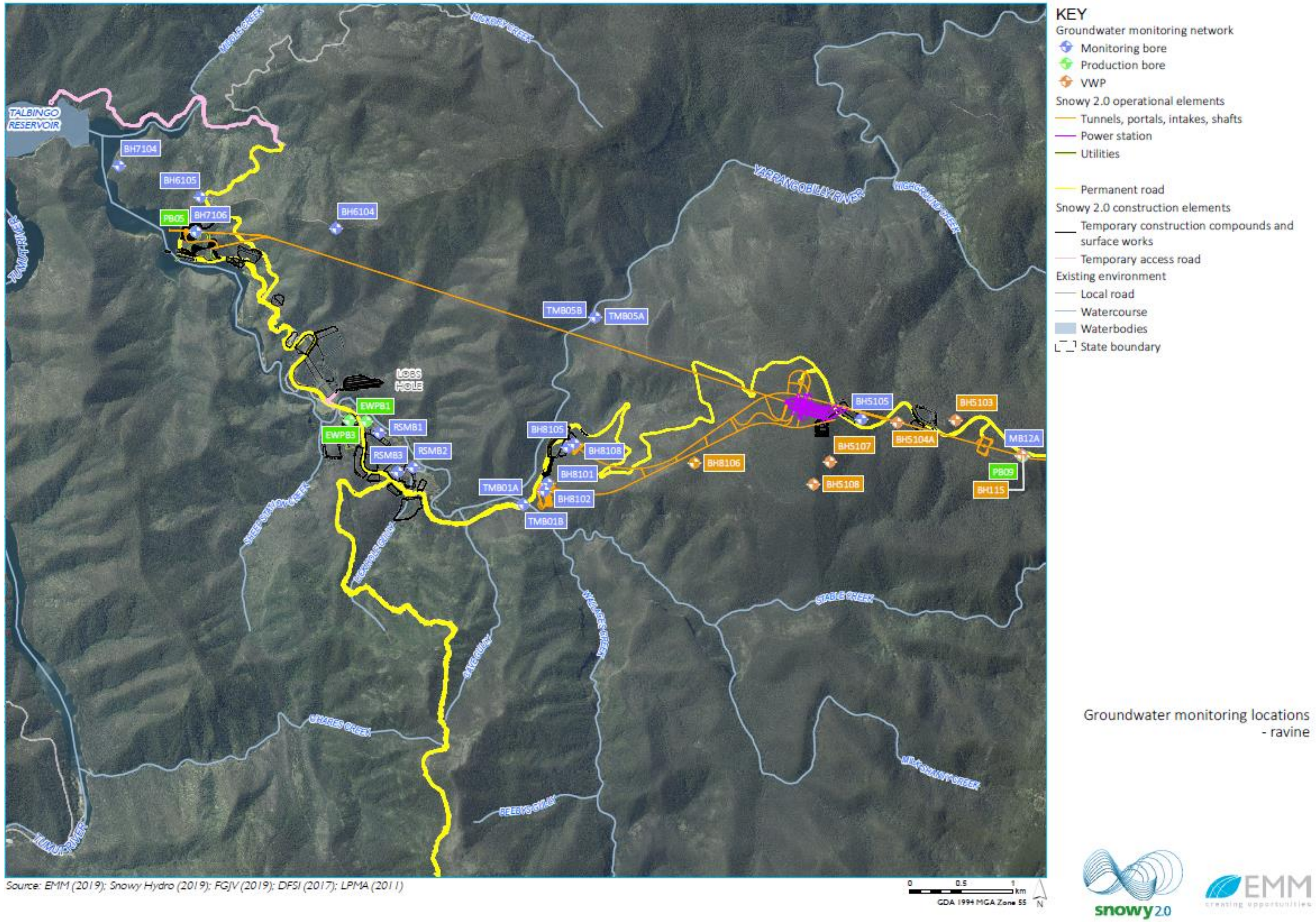


Figure 2-1: Groundwater monitoring locations - Ravine

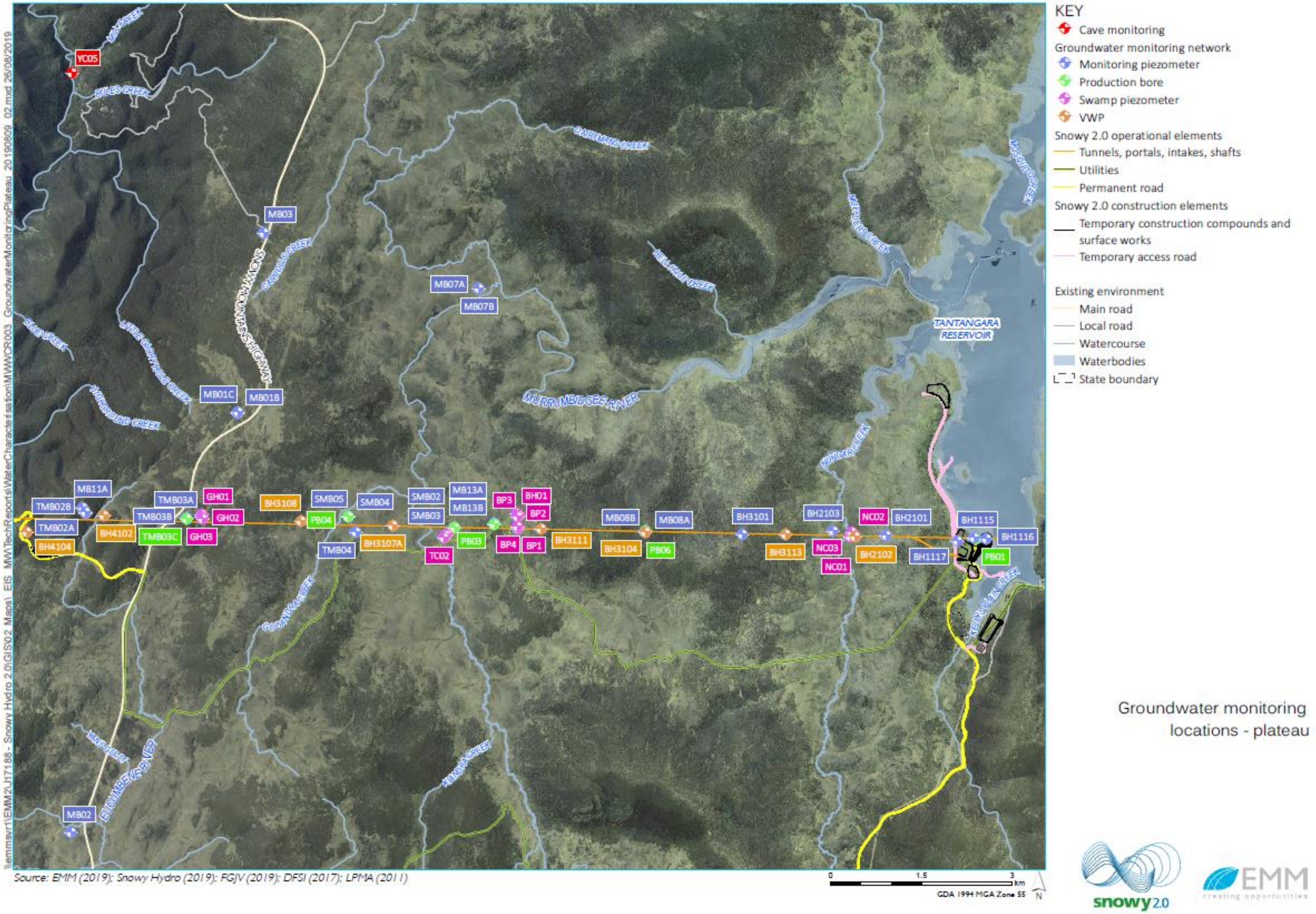


Figure 2-2: Groundwater monitoring locations - Plateau

2.4. Risk Prioritisation

Numerical groundwater modelling (model version SH4.0) for the EIS and subsequently revised for the RTS (EMM, 2020) has indicated that there are areas at risk from drawdown induced by construction activities. Risk is primarily related to drawdown in water levels in shallow groundwater systems that provide support for identified GDEs. This is predicted to particularly occur in groundwater associated with the Gooandra Volcanics and the Kellys Plain Volcanics on the Plateau as well as (to a lesser consequence) within all Ravine units. Predicted peak maximum drawdown across the region is shown in Figure 2-3 and critical areas above the Gooandra Volcanics and Kellys Plain Volcanics are expanded in Figure 2-4.

These higher risk areas are recognised in the Conditions of Approval (COA).

Specifically, Schedule 3, Clause 30(e) requires the Proponent to:

"*minimise groundwater take from the Gooandra Volcanics and Kellys Plain Volcanics using pre and post grouting of the tunnel, to minimise the loss of stream flows in the waterways above these geological formations, including Gooandra Creek and the headwaters of the Eucumbene River".*

Further, Schedule 3, Clause 15 refers to the Alpine Sphagnum Bogs and Associated Fens:

"*The Proponent must ensure that the development does not cause any exceedances of the following performance measures in the Alpine Sphagnum Bogs and Associated Fens above the Gooandra Volcanics and Kellys Plain Volcanics:*

(a) Negligible change to the shallow groundwater regime supporting the bogs and associated fens when compared to a suitable control site; and

(b) Negligible change in the ecosystem functionality of the bogs and associated fens."

The existing network includes sites that co-locate with recognised GDEs (PCT 637) (Figure 2-4). These sites have been used to define baseline conditions for bogs and associated fens across the Plateau region. These sites will be augmented by an additional 15 monitoring sites (Table 2-2) to those presented in the EIS that have been proposed in consultation with DPIE-Water and will constitute the next round of drilling and bore development (note these will be progressively installed upon approval of this GMP). A combination of deep and shallow bores will be constructed to monitor water pressure changes that are expected during the tunnel construction and to monitor shallow levels that may be impacted by the deeper water drawdown specifically in the vicinity of the potentially impacted Alpine Sphagnum Bogs and Associated Fens (Figure 2-5).

Sites will include at least one location where the bog is predicted to be impacted, as well as sites that are not. As described in Section 7.2.3 in the GMP, shallow bores installed at identified Type 3 GDE locations (Alpine Sphagnum Bog and Associated Fens: PCT 637 at Bullocks Hill Bog (bores BH01, BH02, BH03), Gooandra Hill Bog (GH1, GH02, GH03), Nungar Creek Bog (NC01, NC02, NC03) and Tantangara Creek Bog (TC01, TC02, TC03) have recorded significant shallow groundwater level variations across the Plateau area. All sites record water levels with a strong seasonal variability indicating that these features dry during the summer months and saturate during the winter (*see bore water level baseline results in* Attachment A). Water level variability in excess of a metre can occur between seasons, though variability of only a few tens of centimetres is also recorded, with all sites characterised by six months (May to October) with water levels at or near the ground surface.

Recovery of the water table to ground levels each year maintains ecosystem function, hence water level drawdown below the 80th percentile during these months can be used as a trigger for further action (*see* GMP Section 7.2.1).

Shallow bores will thus monitor the shallow surficial water table that interacts directly with the GDE. The local deeper bores will provide data to verify the predictions from the numerical modelling and are designed to penetrate to the level of the tunnel invert.

Additional monitoring locations will be progressively installed upon approval of this GMP. The exact location of each bores will be confirmed on-site and final survey locations included in a revision to the GMP where required. Three monitoring bores are proposed each bog site and two bores for the nested bored.

Table 2-2: Additional monitoring locations

Target formation	Bore ID	Bore Type	Ground level (m AHD)[1]	Total depth (m BGL)	Rationale
Gooandra Volcanics	RtS_BH1A	Conventional monitoring bore (nested)	1,392	50	Model validation
Gooandra Volcanics	RtS_BH1B	Conventional monitoring bore (nested)	1,392	316	Model validation
Gooandra Volcanics	RtS_BH2A	Conventional monitoring bore (nested)	1,395	50	Model validation
Gooandra Volcanics	RtS_BH2B	Conventional monitoring bore (nested)	1,395	314	Model validation
Gooandra Volcanics	RtS_BH3A	Conventional monitoring bore (nested)	1,431	50	Model validation
Gooandra Volcanics	RtS_BH3B	Conventional monitoring bore (nested)	1,431	344	Model validation
Gooandra Volcanics	RtS_BH4A	Conventional monitoring bore (nested)	1,397	50,	Model validation
Gooandra Volcanics	RtS_BH4B	Conventional monitoring bore (nested)	1,397	308	Model validation
Gooandra Volcanics	RtS_BH5	Shallow piezometer	1,398	<1	GDE monitoring
Gooandra Volcanics	RtS_BH6	Shallow piezometer	1,449	<1	GDE monitoring
Kellys Plain Volcanics	RtS_BH7A	Shallow piezometer	1,231	<1	Model validation
Kellys Plain Volcanics	RtS_BH7B	Conventional monitoring bore (nested)	1,231	49	Model validation
Kellys Plain Volcanics	RtS_BH8A	Shallow piezometer	1,225	<1	Model validation
Kellys Plain Volcanics	RtS_BH8B	Conventional monitoring bore (nested)	1,225	65	Model validation
Gooandra Volcanics	RtS_BH9	Shallow piezometer	1,459	<1	GDE monitoring
Gooandra Volcanics	RtS_BH10	Shallow piezometer	1,421	<1	GDE monitoring
Gooandra Volcanics	RtS_BH11	Shallow piezometer	1,354	<1	GDE monitoring
Gooandra Volcanics	RtS_BH12	Shallow piezometer	1,317	<1	GDE monitoring
Kellys Plain Volcanics	RtS_BH13	Shallow piezometer	1,269	<1	GDE monitoring

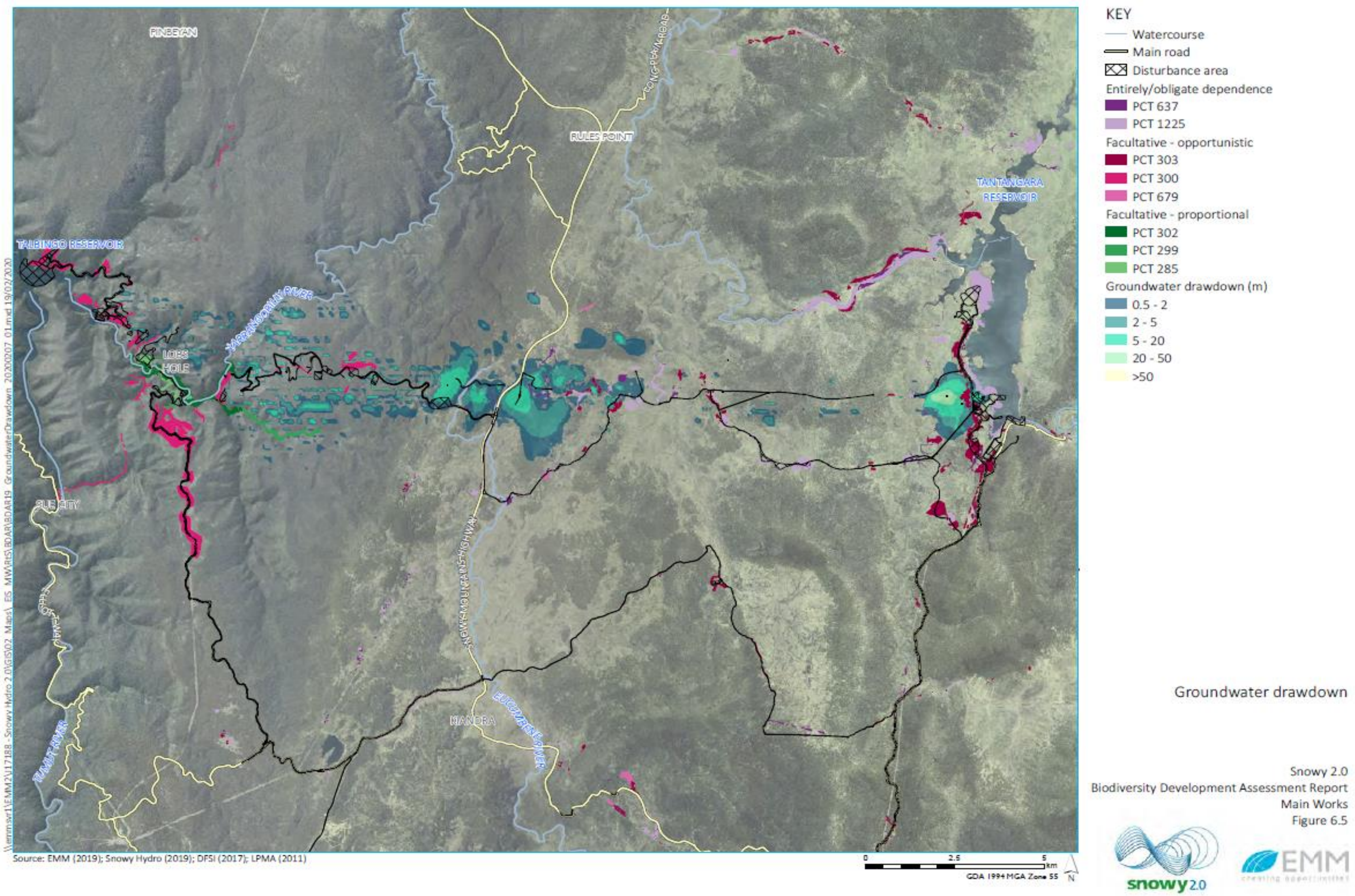


Figure 2-3: Modelled peak drawdown (model version SH4.0, RTS) in relation to potential GDEs

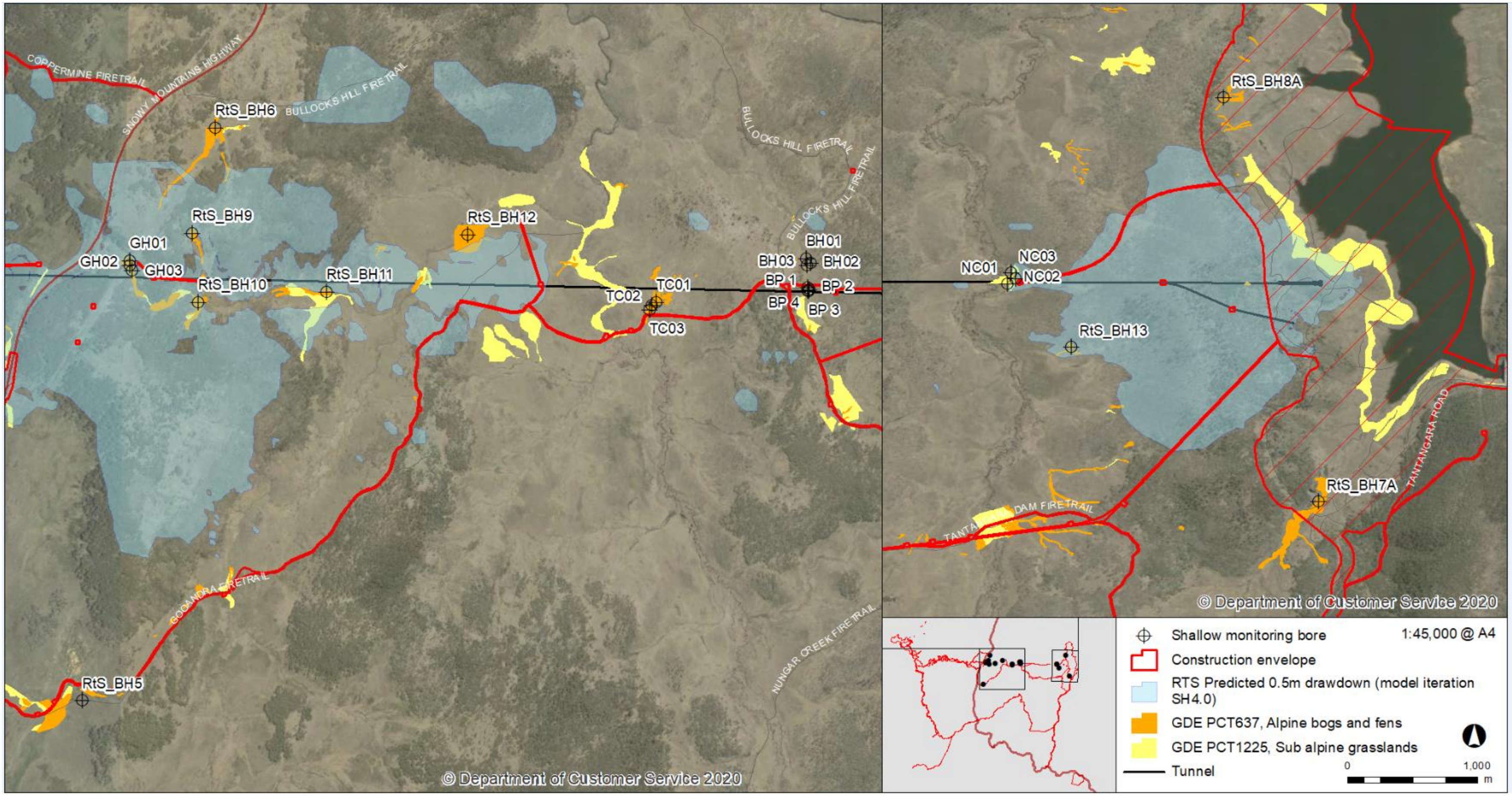


Figure 2-4: Existing and new shallow standpipes to monitor groundwater dependent ecosystem water levels

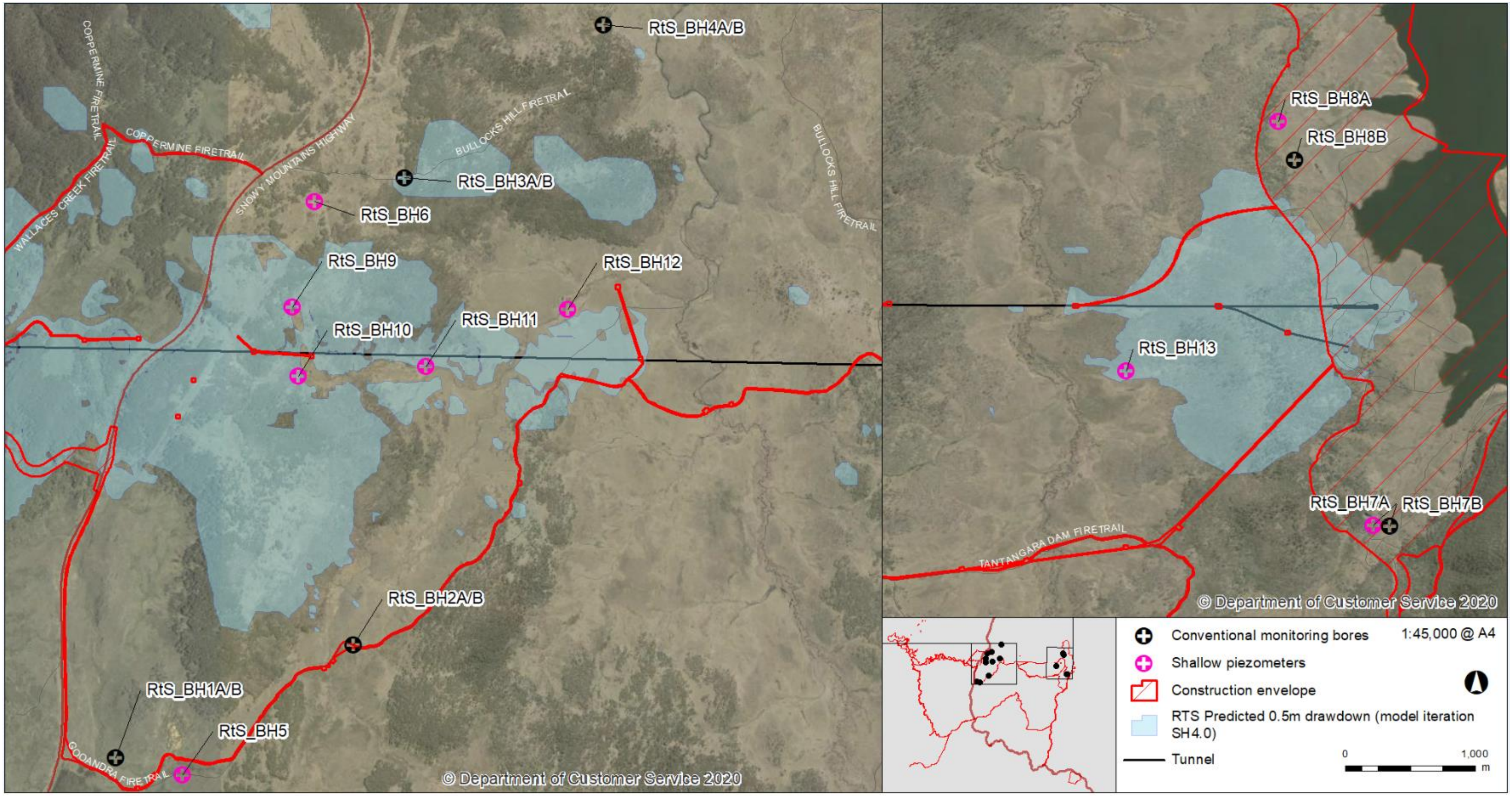


Figure 2-5: Additional groundwater monitoring locations in high risk drawdown areas

2.5. Groundwater levels

Dataloggers will be maintained from the Main Works baseline groundwater monitoring network phase (or installed in the additional monitoring locations) to provide continuous water level data collection. Dataloggers will be programmed to record at 6 hour intervals. A restricted suite of bores will be used as Indicator Trigger (Level 1) sites that will be analysed quarterly.

Monitoring frequency will be continuously reviewed and data compared to model predictions, and frequency of data collection will be adapted to ensure potential significant trigger events are detected early (i.e. particularly when Tunnelling commences in high risk areas). The Project is investigating opportunities for telemetric monitoring of monitoring data. No drawdown is predicted for the first few years of the project (see Section 4.2.4 of GMP) hence existing data loggers will be downloaded manually quarterly until telemetry is in place. Monitoring data collection frequency will also be reviewed during the annual review of the groundwater model, in consultation with NRAR and DPIE Water.

These Indicator Trigger (Level 1) sites have been selected to provide a balanced assessment of water level response from the Project and are listed in Table 2-3, and shown in Figure 2-9, Figure 2-10 and Figure 2-11.

Table 2-3: Level 1 routine monitoring bores

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Conventional monitoring bores					
Ravine Beds West	BH8101 (EPL 3)	610	68.4	53.4–65.4	Siltstone
	RSMB2	570	30	27.0–30.0	Siltstone/sandstone
	RSMB6 (EPL 1)	581	15	11-14	Siltstone
	RSMB7 (EPL 2)	581	45	38-44	Siltstone
	RSMB8 (EPL 25)	583	15	11-14	Siltstone
	RSMB9 (EPL 4)	583	45	38-44	Siltstone
Ravine Beds East	MB12B	1,330	36	26.0–35.0	Weathered siltstone
Gooandra Volcanics	BH3110	1,346	178.9	165.9–177.9	Diorite
	MB01C	1,464	52	45.0–51.0	Basalt
	MB11A	1,485	7.5	17.0–23.0	Weathered basalt
	SMB04	1,342	180	170.0–179.0	Chloritic schist
	SMB05	1,342	50	40.0–49.0	Basalt
	TMB02A	1,470	15	11.0–14.0	Weathered basalt
	TMB02B	1,472	200	191.0–197.0	Chloritic schist
	TMB03A	1,478	34	29.5–32.5	Weathered basalt
	TMB03B	1,478	150	141.0–147.0	Chloritic schist
	TMB04	1,346	200	191.0–197.0	Basalt
Temperance Formation	MB04A	1,330	30	23.0–29.0	Basalt
Kellys Plain Volcanics	BH1117	1,241	65	51.9–60.9	Dacite
	BH2101	1,314	169.9	154.6–166.6	Siltstone

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Test production bores					
Ravine Beds West	PB05	614	100	50.0–100.0	Siltstone
Gooandra Volcanics	PB04	1,341	200	185.0–200.0	Chloritic schist
	TMB03C	1,478	250	237.0–249.0	Chloritic schist
Kellys Plain Volcanics	PB01	1,231	60	30.0–60.0	Dacite
Vibrating wire piezometers					
Ravine Beds East	BH8106	1096	673	669.0, 431.0	Siltstone/sandstone
Gooandra Volcanics	BH4103	1471	388	335.6,232.2, 139.5	Metatuff, Tuff, Gneiss
	BH4102	1460	534	455.6, 374.3, 246.3	Gneiss, Phyllite
	BH4101	1479	1100	883.9, 729.6, 542.5	Meta-rhyolite
Temperance Formation / Gooandra Volcanics	BH3107A	1325	237	200.2, 133.5	Siltstone/sandstone
Drive point piezometers and narrow diameter piezometers					
Gooandra Hill Bog	GH01	1,456	1	0.5–1.0	Alluvium/colluvium
	GH02	1,456	0.9	0.5–0.9	Alluvium/colluvium
	GH03	1,455	0.6	0.3–0.6	Alluvium/colluvium
Tantangara Creek Bog	TC01	1,324	1	0.6–1.0	Alluvium/colluvium
	TC02	1,322	1.1	0.7–1.1	Alluvium/colluvium
	TC03	1,321	0.8	0.5–0.8	Alluvium/colluvium
Bullocks Hill Bog	BP1	1,366	1.8	1.5–1.8	Alluvium/colluvium
	BP2	1,364	1.8	1.5–1.8	Alluvium/colluvium
	BP3	1,364	1.8	1.5–1.8	Alluvium/colluvium
	BP4	1,363	1.8	1.5–1.8	Alluvium/colluvium
	BH01	1,351	0.4	0.2–0.4	Alluvium/colluvium
	BH02	1,352	0.9	0.6–0.9	Alluvium/colluvium
	BH03	1,350	0.7	0.5–0.7	Alluvium/colluvium
Nungar Creek Bog/Fen	NC01	1,237	0.8	0.5–0.8	Alluvium/colluvium
	NC02	1,237	1.1	0.8–1.1	Alluvium/colluvium
	NC03	1,237	1.0	0.7–1.0	Alluvium/colluvium
Additional monitoring locations to be progressively installed upon approval of this GMP					
Gooandra Volcanics	RtS_BH1A	1,392	50	TBC	TBC
	RtS_BH1B	1,392	316	TBC	TBC
	RtS_BH2A	1,395	50	TBC	TBC
	RtS_BH2B	1,395	314	TBC	TBC
	RtS_BH3A	1,431	50	TBC	TBC
	RtS_BH3B	1,431	344	TBC	TBC
	RtS_BH4A	1,397	50	TBC	TBC

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
	RtS_BH4B	1,397	308	TBC	TBC
	RtS_BH5	1,398	<1	TBC	Alluvium/colluvium
	RtS_BH6	1,449	<1	TBC	Alluvium/colluvium
	RtS_BH9	TBC	<1	TBC	Alluvium/colluvium
	RtS_BH10	TBC	<1	TBC	Alluvium/colluvium
	RtS_BH11	TBC	<1	TBC	Alluvium/colluvium
	RtS_BH12	TBC	<1	TBC	Alluvium/colluvium
Kellys Plain Volcanics	RtS_BH7A	1,231	<1	TBC	Alluvium/colluvium
	RtS_BH7B	1,231	49	TBC	TBC
	RtS_BH8A	1,225	<1	TBC	Alluvium/colluvium
	RtS_BH8B	1,225	65	TBC	TBC
	RtS_BH13	1,269	<1	TBC	Alluvium/colluvium

Groundwater level changes will be compared to predicted level changes from the numerical modelling as presented in Appendix B. A summary of predicted water level or pressure changes due to the Project is presented in Figure 2-6.

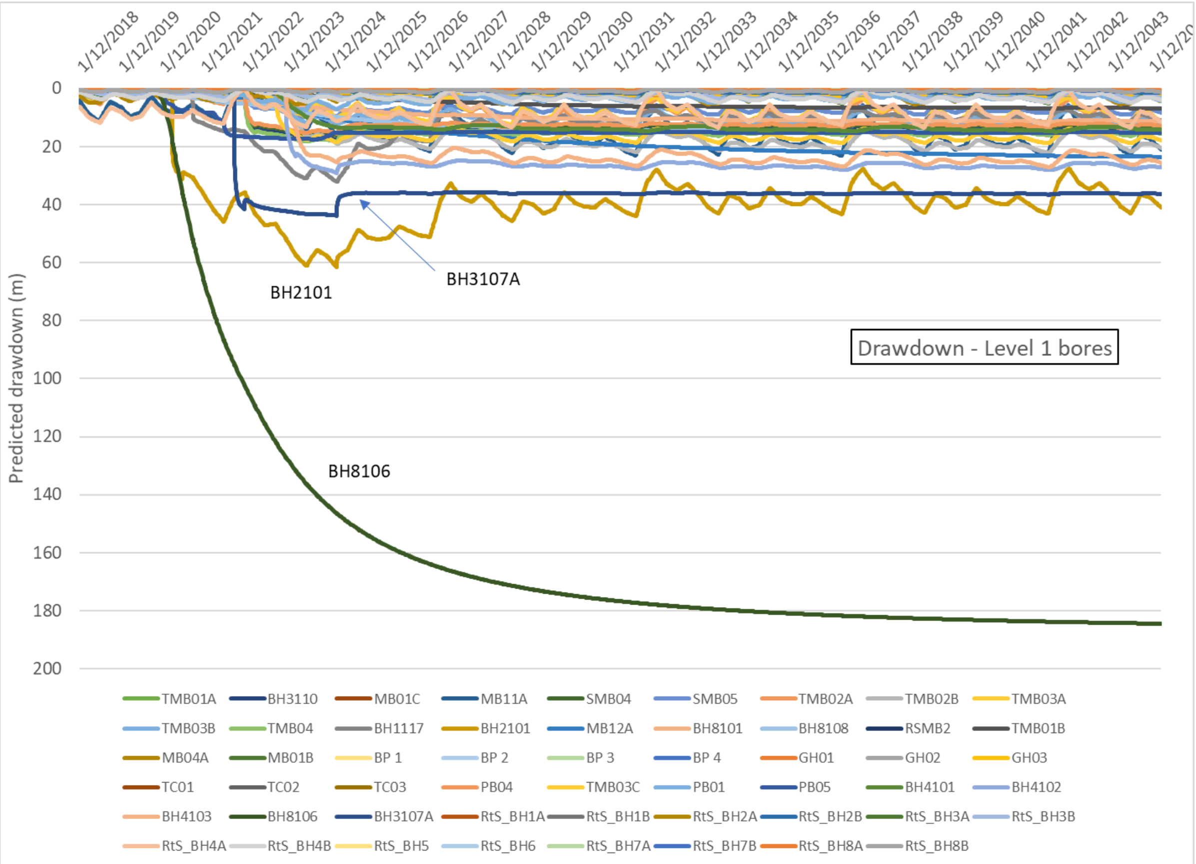


Figure 2-6: Predicted water level or pressure change for designated Level 1 monitoring bores

Groundwater level data will be compared to local rainfall records to assess any trends. Seasonal and climatic fluctuations considered within the RTS groundwater model (EMM 2020) will facilitate this assessment and comparison between groundwater level decrease and the predicted drawdown from the Project.

The assessment will determine whether the observed decrease is attributable to the Project and, if so, whether it aligns with approved predictions. Data analysis is described in Section 3.2 and monitoring reports will be produced quarterly (Section 3.6), including data summary reports presenting tabulated groundwater monitoring data collected during the reporting period.

If drawdown is identified outside of model predictions, management actions outlined in the GMP (i.e. Trigger Action Response Plan) will be initiated including (but not limited to) a review of baseline groundwater level and quality data in the relevant and surrounding monitoring bores as well as an assessment of groundwater inflow rates into the tunnel.

Drawdown in excess of that predicted will trigger data collection from an expanded bore network and will trigger water quality sampling (Section 2.6) at selected bores to confirm that no material change has occurred relative to the existing water quality conditions.

A sub-set of bores used in the baseline assessment have not been recording data for more than 24 months. Figure 2-7 and Figure 2-8 illustrate the monitoring periods for each bore. Those with less than 24 months' data will continue to be collected.

2.5.1. Groundwater dependent ecosystems

Shallow groundwater levels in standpipes located at known GDEs will be compared to the 80th percentile between the months of May and October. If drawdown is identified beyond trigger levels in areas of these GDEs during this period, actions outlined in the Groundwater level Trigger Action Response Plan (TARP) will be initiated.

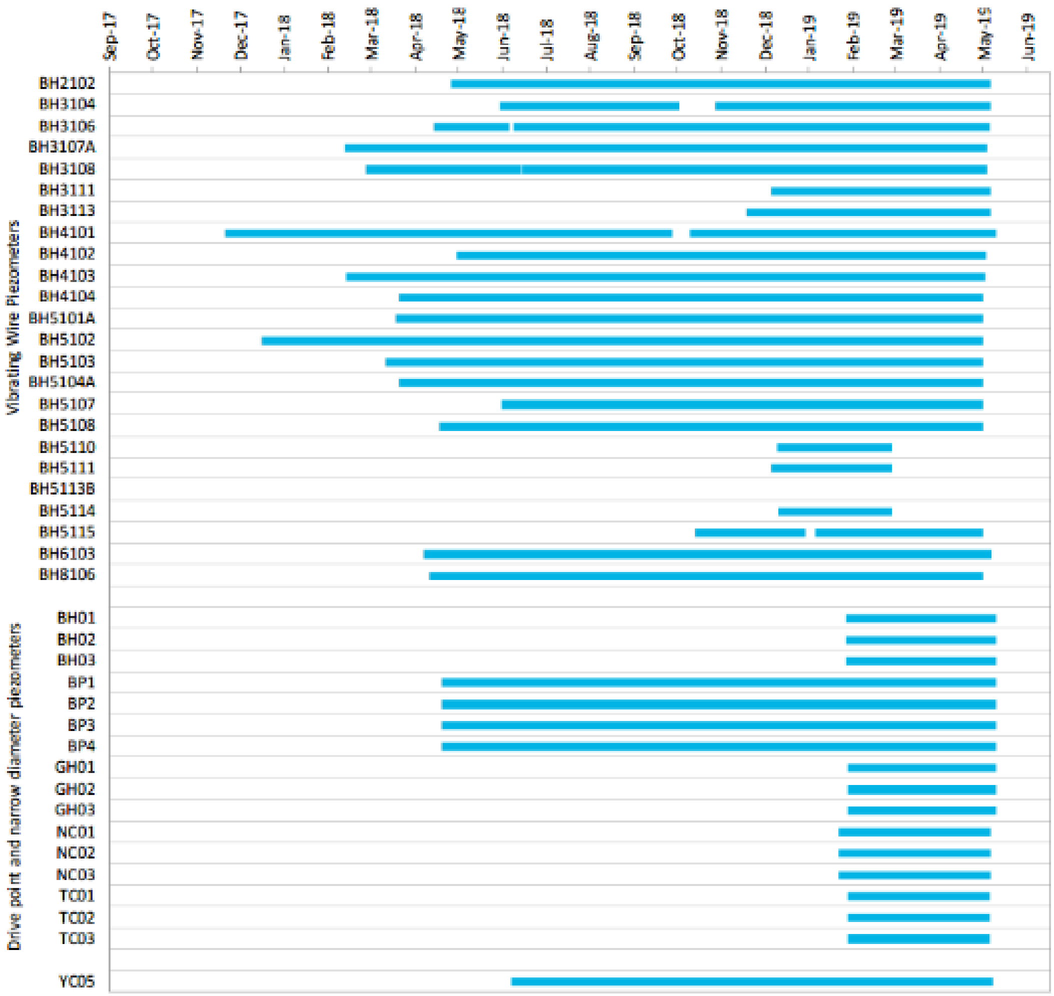


Figure 2-7: Monitoring period for the vibrating wire piezometers (*Note: monitoring has continued, refer to Attachment A)*

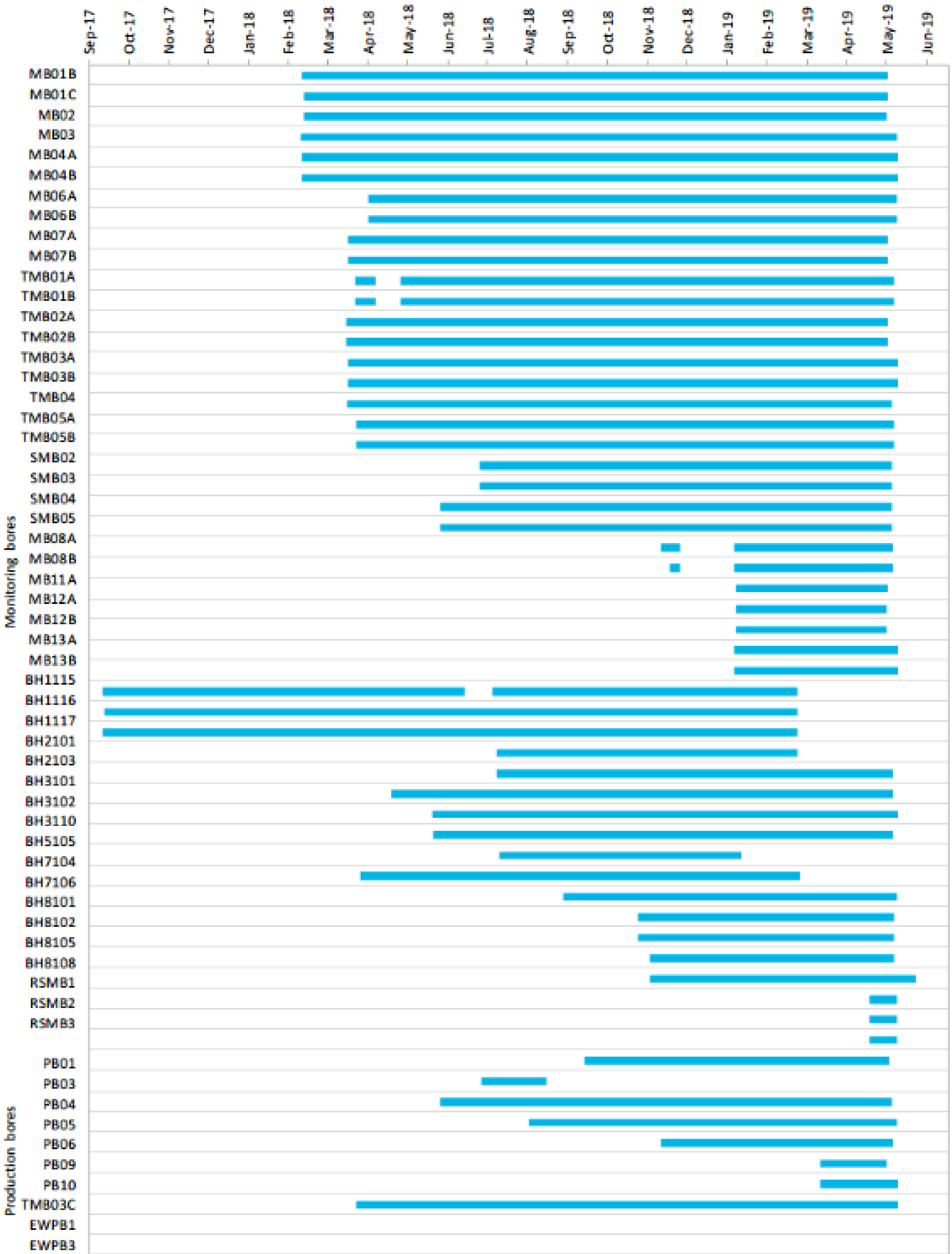


Figure 2-8: Monitoring period for the conventional monitoring bores (*Note: monitoring has continued to date, refer to Attachment A)*

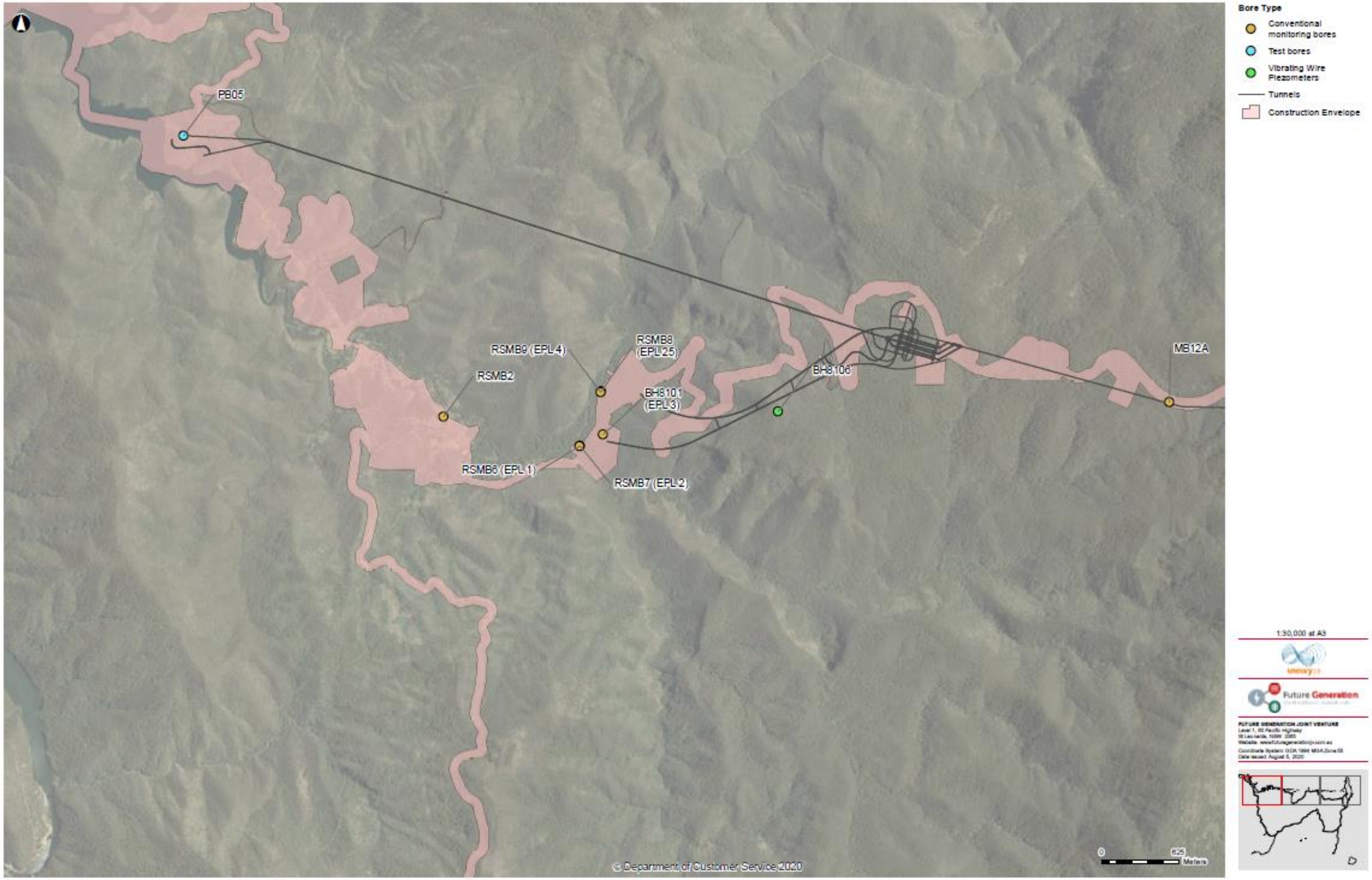


Figure 2-9: Level 1 groundwater monitoring bores (Western section)

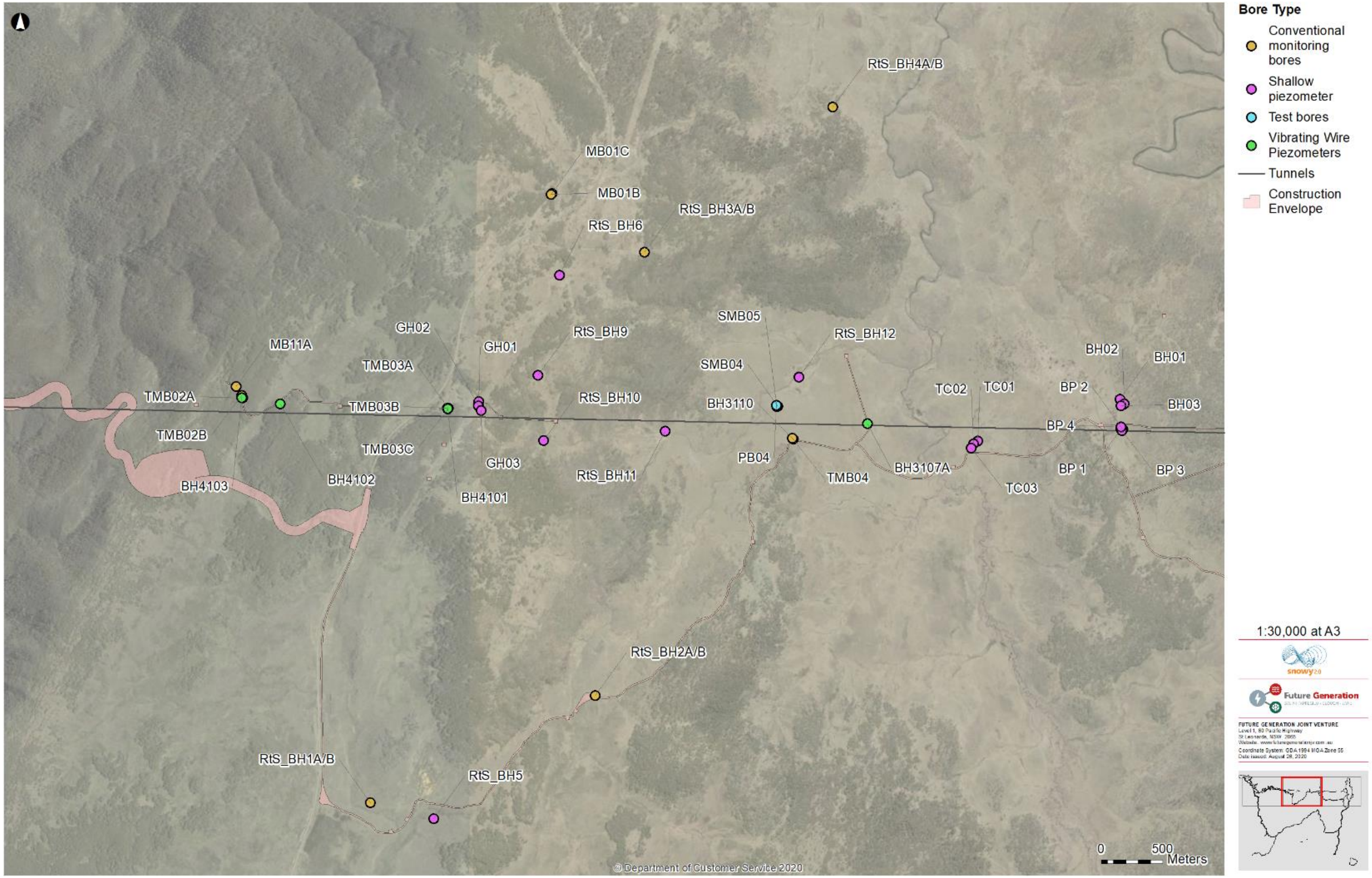


Figure 2-10: Level 1 groundwater monitoring bores (Central section)

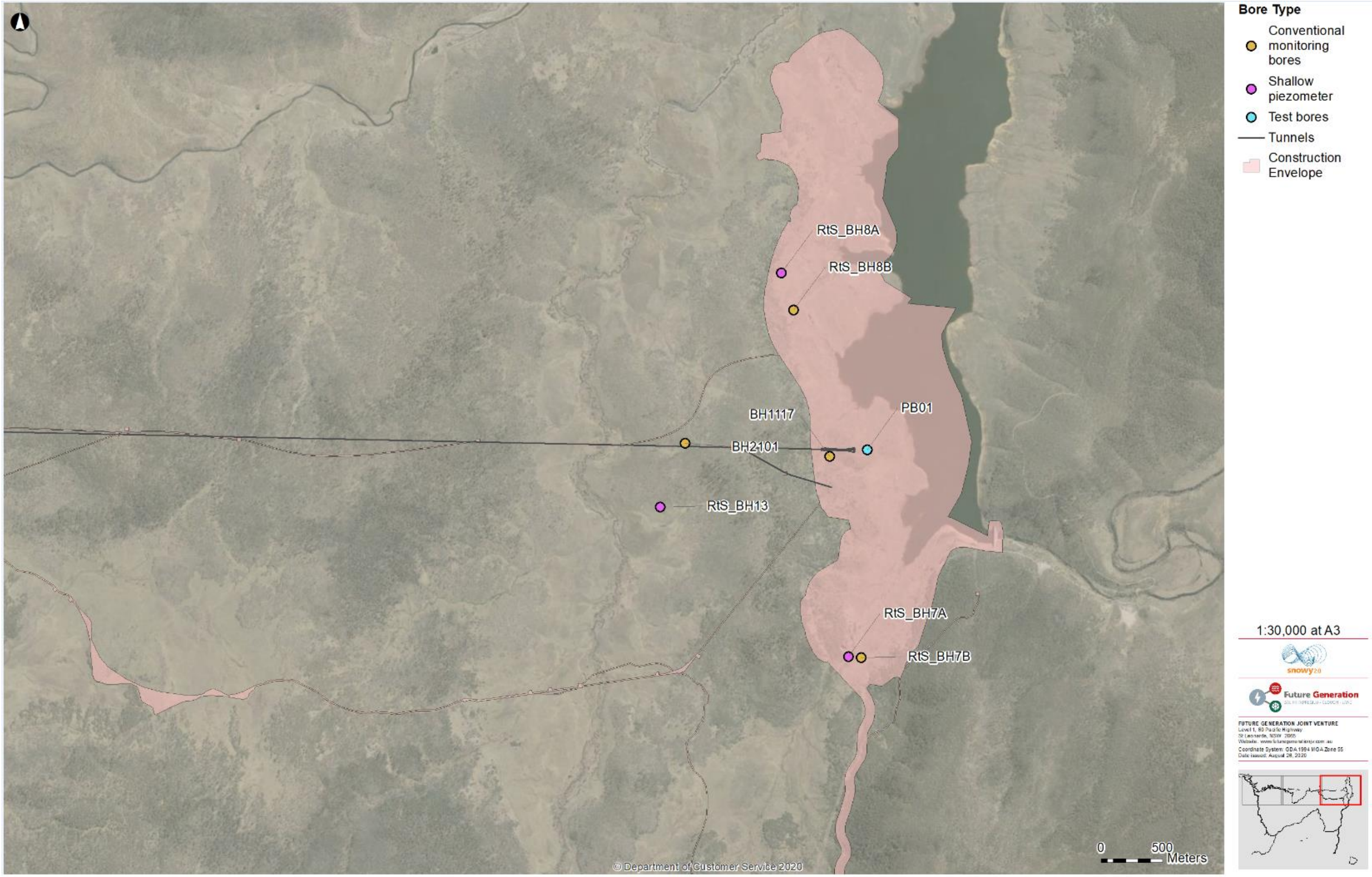


Figure 2-11: Level 1 groundwater monitoring bores (Eastern section)

2.6. Groundwater quality

Only those bores designated under the current EPL 21266 will be routinely analysed for water quality (current EPL 1, EPL 2, EPL 3, EPL 4 and EPL 25). Baseline assessment has demonstrated that water quality can be affected by seasonal changes, but these can be directly associated with water level changes. For this reason, it is proposed that sampling frequency be reduced to quarterly sampling at these EPL 21266 sites.

The sympathetic response of water quality to significant water level change also allows a significant reduction in routine sampling, such that water level changes associated with Level 1 bores can be used to guide whether water quality sampling is required, or not.

If a Level 1 water level trigger occurs, a round of water quality sampling is initiated at the triggered bore (unless the trigger occurs at a VWP site where water quality cannot be sampled) and immediate surrounding bores. Water quality analysis will indicate whether any change from baseline conditions has occurred. Sampling will be undertaken quarterly and if no change is detected after one year the bore reverts to a Level 1 condition (i.e. no further sampling).

A review after the first 12 months of construction of the monitoring program will be completed to determine the efficiency of the monitoring program and any required changes.

Parameters to be analysed will include those specified in the EPL (Table 2-4), as well as any additional parameters analysed as part of the standard suite that embraces the stipulated parameters. Thus, total aluminium, copper, iron, lead, manganese and zinc will also be analysed.

Field analysis of physico-chemical parameters (EC, pH, DO, NTU) will be compared to laboratory results to provide additional quality control.

Table 2-4: Parameters to be monitred

Pollutant	Units of measure	Units of measure	Frequency	Sampling method
Aluminium (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Copper (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Dissolved Oxygen (DO)	Percent saturation	% sat	quartlery	Representative sample
Electrical conductivity (EC)	Microsiemens per centimetre	µS/cm	quartlery	Representative sample
Iron (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Lead (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Manganese (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Nickel (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Nitrogen (total)	micrograms per litre	µg/L	quartlery	Representative sample
Oxidation Reducton Potential (ORP)	millivolts	mV	quartlery	Representative sample
pH	pH	pH	quartlery	Representative sample
Reactive Phosphorous	micrograms per litre	µg/L	quartlery	Representative sample
Silver (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Turbidity	Nephelometric turbidity units	NTU	quartlery	Representative sample
Zinc (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample

2.7. Baseflow

Groundwater discharge to surface water as creek baseflow will be monitored through assessment of multiple line of evidence as direct analysis is problematic, being variable both in time and space. Thus, numerical modelling (Response to Submissions, Appendix I) has simulated annual baseflow to rivers and creeks across the Project area and identified reaches of Stable Creek, Eucumbene Creek and Gooandra Creek that may undergo baseflow loss during the latter stages (post year 3) of construction of the Main Works and during operation. Combined losses to creeks feeding Yarrangobilly River may result in a 2.5% loss in baseflow at the stream gauge (station 410574) in the long term (steady state), but less than 1% loss over the first 10 years. No impact is predicted at the Murrumbidgee gauging station (410535). Loss therefore will not be discernable at the existing stream gauges for many years. Alternate sites (at creek crossings adjacent to existing or planned shallow groundwater bore installations) on the Eucumbene and Gooandra Creeks will be instrumented with pressure transducers and manual flow readings will be undertaken during routine sampling rounds to provide a proxy for continuous creek flow volumes. These records will be assessed for baseflow using a combination of:

- analysis of stream flow at the surface water gauging stations compared to simulated flow at the creek crossings;
- use of suitable hydrograph filters (e.g. Lyne & Hollick, 1979) at established stream gauge sites subsequent to each month’s data collection;
- calculation of baseflow indices (BFI) using rainfall, stream and groundwater salinities at the designated streamflow sampling sites and adjacent shallow groundwater bores, and
- consideration of groundwater hydrographs and rainfall conditions.

An example of baseflow separation is provided at Figure 2-12 (reproduced from the Main Works EIS; Appendix J – Annexure A) which demonstrates a manual estimation of baseflow through comparison of streamflow with groundwater levels at a relevant shallow bore.

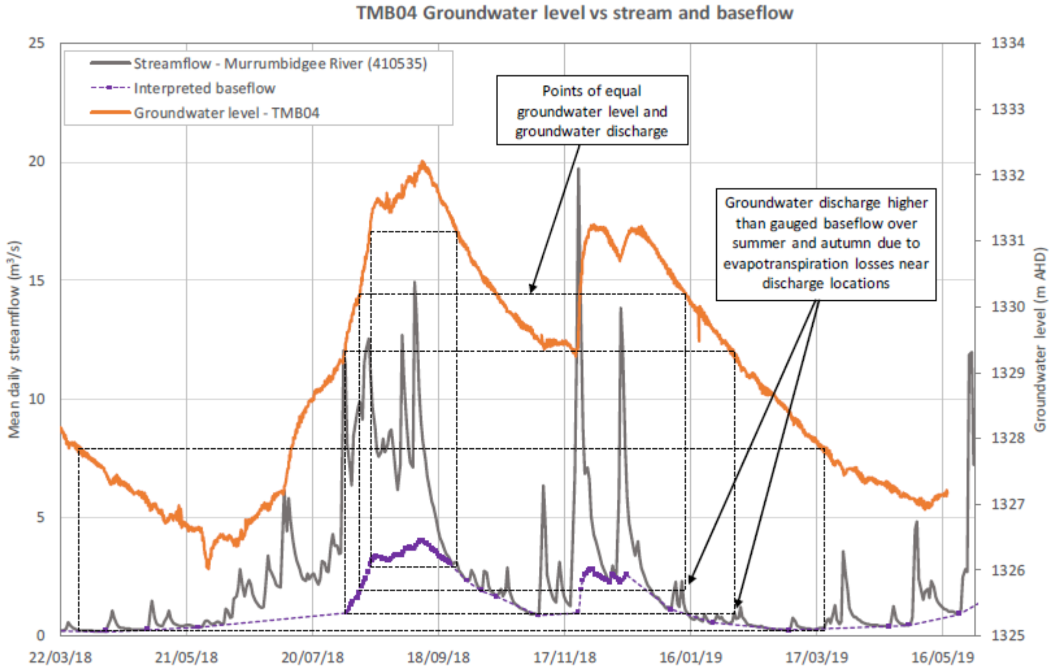


Figure 2-12 Manual baseflow separation at the gauging station (410535) on the Murrumbidgee River

Any calculated baseflow reduction greater than that predicted from the numerical groundwater modelling for the RTS (Appendix I – Part 3, Table J.1) will constitute a trigger to the Groundwater Level TARP as described in the GMP (Section 7.2.2; GMP Table 7.1).

2.8. Tunnel inflow

During construction, groundwater will be intersected and managed by capturing the water that enters the tunnels or by restricting inflow through pre grouting and / or post grouting.

Groundwater inflow into the tunnels will be monitored during construction and compared to model groundwater ingress predictions and water access licencing. The groundwater model will be updated as required based on the results of monitoring, and proposed management measures to minimise potential groundwater impacts adjusted accordingly.

2.8.1. Groundwater extraction

The groundwater sources that will be will intercepted include the Lachlan Fold Belt Murray Darling Basin (MDB) groundwater source and the Lachlan Fold Belt South Coast groundwater source. Tunnel inflow monitoring, WTP discharges and Project water inputs back into the tunnel will be monitored and used in a simple water balance approach to estimate groundwater extracted during construction. A conceptual diagram is presented in Figure 2-13 and is also described in Section 5 of the Water Management Plan

Groundwater inflow = WTP discharge (flow meter C) – Project water inputs (flow meter E)

Groundwater extraction will be monitored throughout the year throughout the year to ensure groundwater extraction is within permitted volumes of take from respective water sources and reported on an annual basis in accordance with licence requirements (described in Section 2.4.3 of the Groundwater Management Plan).

2.9. Water treatment plant monitoring

Groundwater captured during construction of the Project will be treated at process water treatment plants. The water from the treatment plants will be tested and either reused or discharged in accordance with the Surface Water Management Plan. Discharge volumes will be continuously monitored at the WTPs via calibrated flow meters, which will enable the daily measurement of the amount of water discharged from the WTPs.

Detail of the water treatment management system is provided in Section 5 of the Surface Water Management Plan.

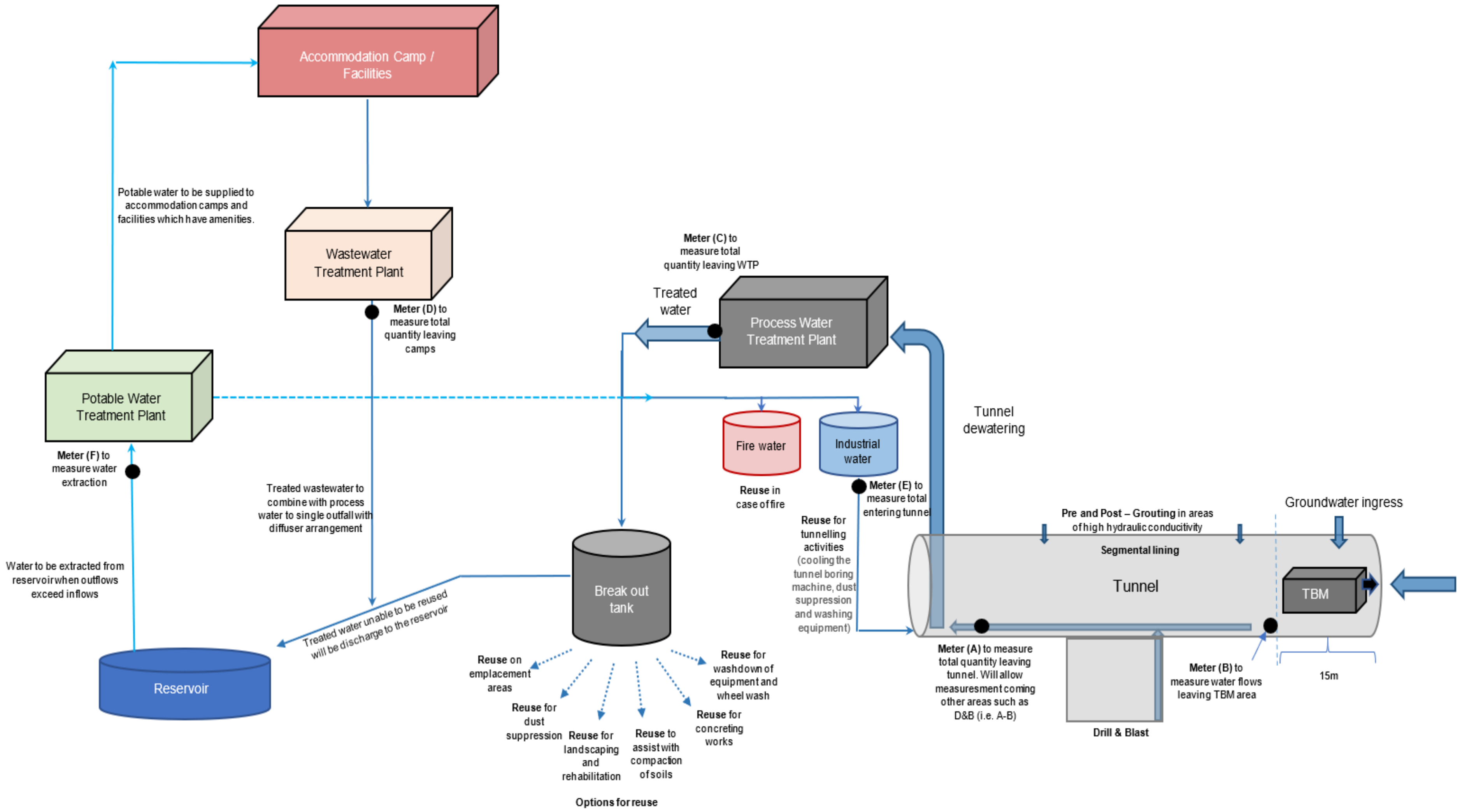


Figure 2-13: Groundwater movement

3. REVIEW AND RESPONSE

3.1. Responsibility

Sampling and testing of the groundwater monitoring network will be coordinated by Future Generation. Sample data collected by Future Generation will be analysed, investigated and reported. At all times during construction, Future Generation will be responsible for initiation of the Trigger Action Response Plans (Section 6.5 of the GMP).

3.2. Data Analysis

Results from the construction monitoring program will be compared against default criteria, the site-specific trigger values (SSTV) and groundwater modelling predictions.

Monitoring results of groundwater level will involve recorded data being compensated for barometric pressure and converted to a groundwater level measurement. Groundwater level data will be compared to local rainfall records to assess trends for reporting in Annual Reports.

Monitoring results for both groundwater levels and groundwater quality will be compared against SSTVs and reported in the monitoring reports. If results trigger a response, management actions will be implemented (Section 3.5), as required, should an initial review determine a potential impact outside of approved predictions.

The monitoring results for groundwater level and groundwater quality will be used to inform the groundwater model updates increasing the confidence level in model predictions with respect to groundwater inflow, drawdown, and aquifer chemistry. Where required the groundwater model will be calibrated to monitoring results and predictions updated.

3.3. Quality Assurance

During each sampling and reporting round, calibration and quality assurance will be carried out relevant to the data being collected as outlined in Table 3-1, below.

Table 3-1 Groundwater sampling, calibration and quality assurance procedures

Measure	Calibration process	Quality Assurance
Groundwater quality monitoring	All field analysis equipment to be calibrated prior to the field campaign and at a frequency recommended by the supplier. NATA Accredited Laboratories used for analyses.	Chain-of-command documentation to be created for each sampling campaign. Data storage and recovery procedures to follow best practice.
Groundwater level monitoring	Monthly check for data drift and aberrations (spikes, missing data) and comparison to adjacent bores for continuity and consistency.	Calibration statistics provided with reports. Long-term trends plotted and provided with each report.
Groundwater inflow rate monitoring	Cross-checking of metered and manual estimates of flow in tunnels. Data redundancy in metering through input/output checks and multiple water balance associations.	Daily recording of tunneling water production documented with tunnelling processes and activities (e.g. grouting schedules). Monthly reporting and cross-checking of groundwater take and surface water processing.

3.4. Adaptive Management

Monitoring results obtained during construction will be subject to monitoring, analysis of results, review of mitigation measures (where exceedances are identified) and updates to measures and trigger values where required.

An adaptive management approach is taken that applies observed data to influence mitigation response and system understanding. Thus, the groundwater monitoring network will record actual groundwater levels and groundwater take (via bore sensors and tunnel discharge meters, respectively) which will be used to validate and verify or re-calibrate the numerical groundwater model. Revised predicted drawdowns can then be predicted with increasing confidence and the extents of potential impacts revised accordingly.

3.5. Trigger Action Response Plan

The purpose of a TARP is to detail a standardised response procedure in the event that a trigger value is exceeded during a monitoring event for groundwater quality and/or availability (level) and/or inflow monitoring.

This allows for the prompt identification of unpredicted impacts and guide the implementation additional management measures and corrective actions should adverse conditions arise attributable to construction.

The TARP applies to all current and future groundwater monitoring locations.

The TARP response procedure is detailed Section 6.4 of the Groundwater Management Plan.

As outlined in Section 3.3, above, groundwater levels and quality will be routinely monitored across the network at bores identified for monitoring at different levels of impact. Trigger levels for pH, salinity, dissolved metals and water level for each target location have been developed using baseline data (EMM, 2019), that if exceeded will trigger investigation into the cause. In addition to these trigger thresholds the GWMP includes a trigger action response plan (TARP) that provides a process for investigation into trigger events.

3.6. Trigger values

Preference under the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) is given to site specific guidelines determined through a comprehensive assessment of baseline data for a minimum period of two years (24 months). To date, a sub-set of bores has provided data for groundwater levels extending back to October 2017. The majority of bores have provided data since autumn 2018, with some bores only recording data since the last drilling campaign in April 2019 (EMM, 2019a). Consequently, bores that have not recorded at least 24 months data will continue to be monitored monthly until 24 months is achieved.

Those bores designated as Level 1 bores will continue to be assess for water level change on a quarterly basis. Water levels will be compared to numerical modelling results. Where measured water levels are lower than those predicted from subtraction of the predicted drawdown for the Base Case from the previous month's level, this will constitute a trigger event. Measured drawdown less than predicted will constitute a Level 1 (indicator) trigger value that does not illicit a response, except where the bore is located at a GDE, whereby drawdown greater than the 80th percentile during the winter months (May to October) will constitute a trigger event.

Tables of indicative drawdown values with time at each monitoring location are provided in Attachment B. These values should be incrementally subtracted from the relative previous month's average measured value as part of the monitoring program.

Water quality trigger values are as stipulated in Table 6-3 in the GMP, except where site-specific trigger values have been set. These are recorded in Attachment C to this Groundwater Monitoring Program.

3.7. Reporting

Future Generation will report to Snowy Hydro and other agencies on ground water monitoring aspects related to the Project. During construction, ground water monitoring data will be collected, tabulated and assessed against thresholds. Reporting will occur in accordance with Section 6.8 of the GMP.

4. REFERENCES

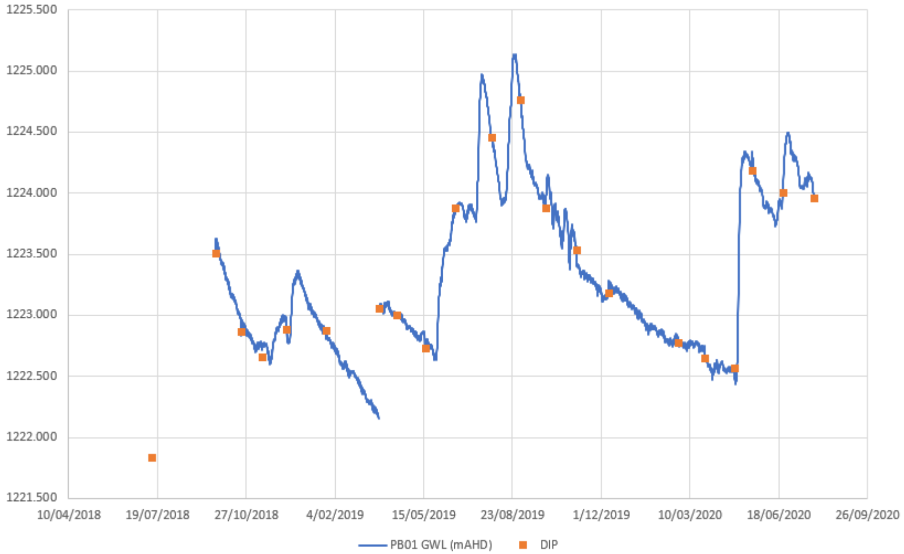
ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra, ACT, Australia. Viewed [viewed 08/04/2020], [https://www.waterquality.gov.au/anz-guidelines].

EMM, 2019. Appendix J.1: Water Assessment for the Snowy 2.0 Main Works EIS (report #J17188 RP#86)

EMM, 2020. Modelling Report. Annexure I to Main Works Preferred Infrastructure Report and Response to Submissions

Lyne, V. & Hollick, M. 1979, “Stochastic timevariable rainfall-runoff modelling”, *Proceedings of the Hydrology and Water Resources Symposium*, Perth, 10-12 September, Institution of Engineers National Conference Publication, No. 79/10, pp. 89–92.

ATTACHMENT A – BASELINE LEVELS AND GROUNDWATER QUALITY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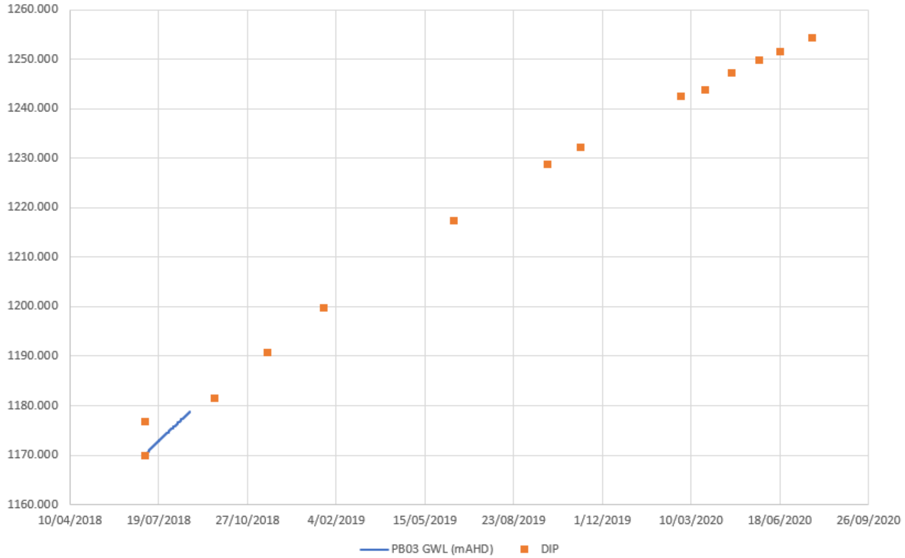
DIP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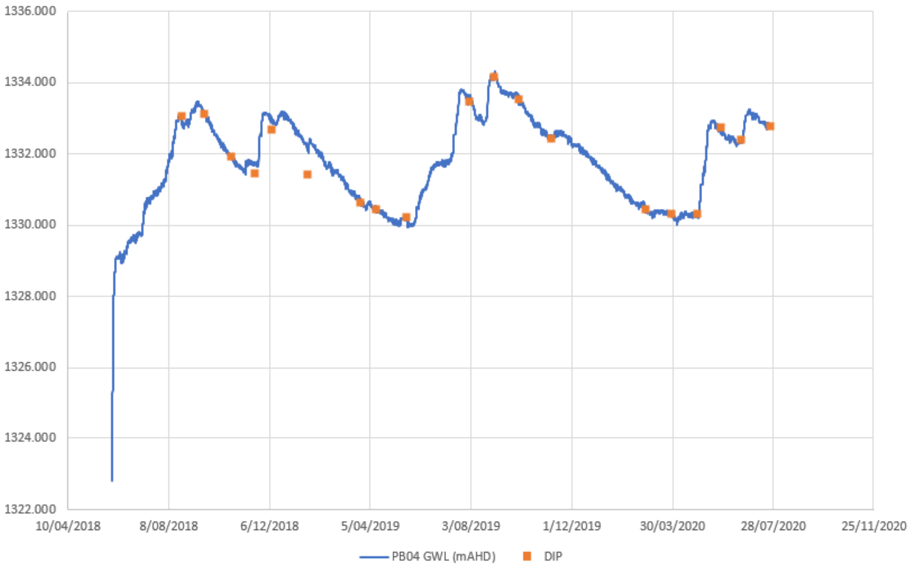
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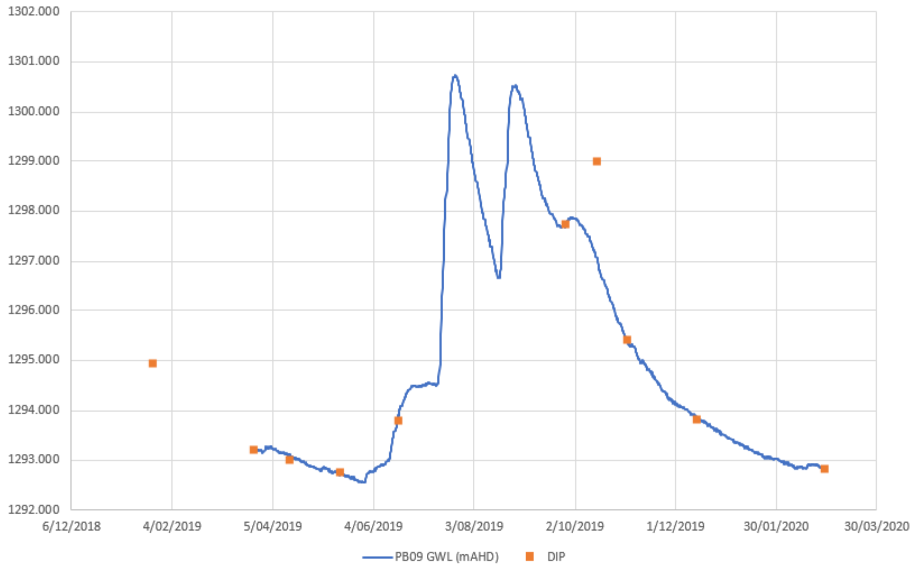
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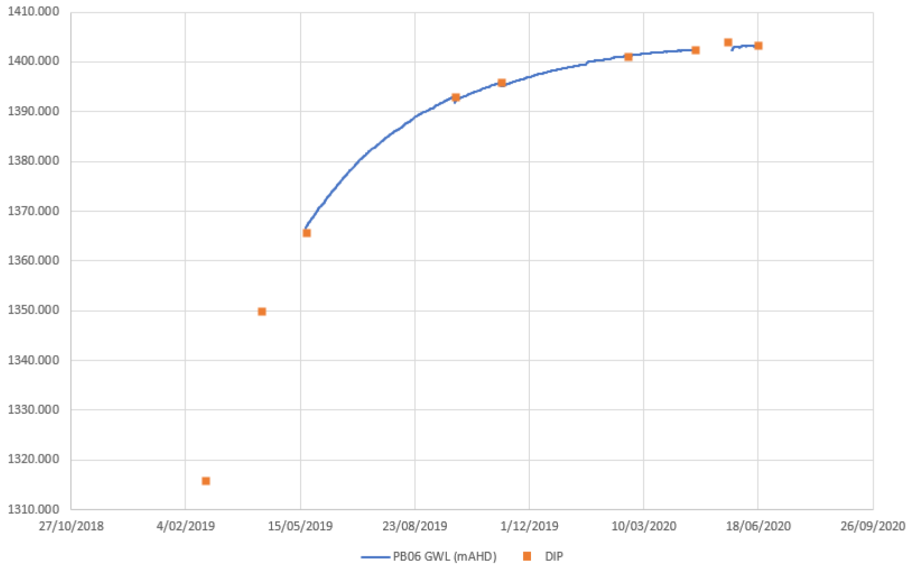

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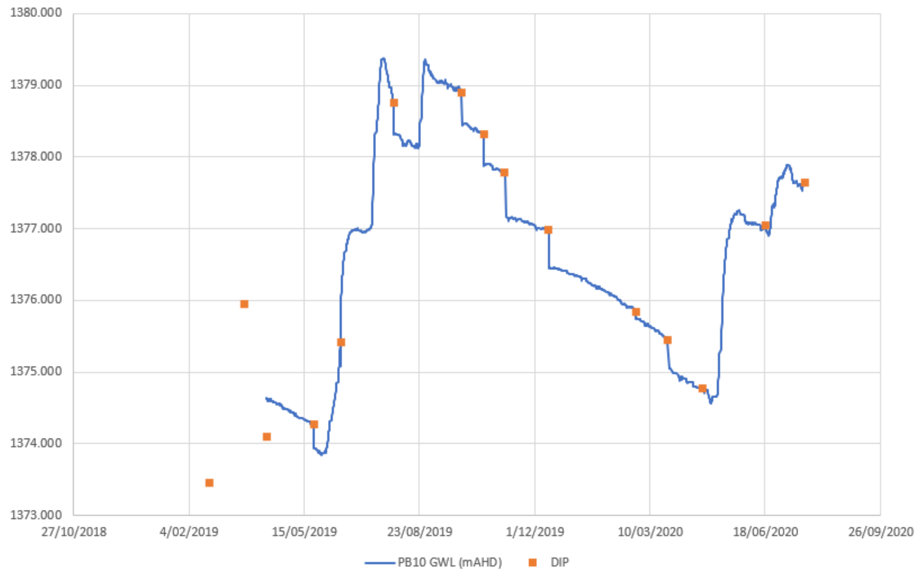

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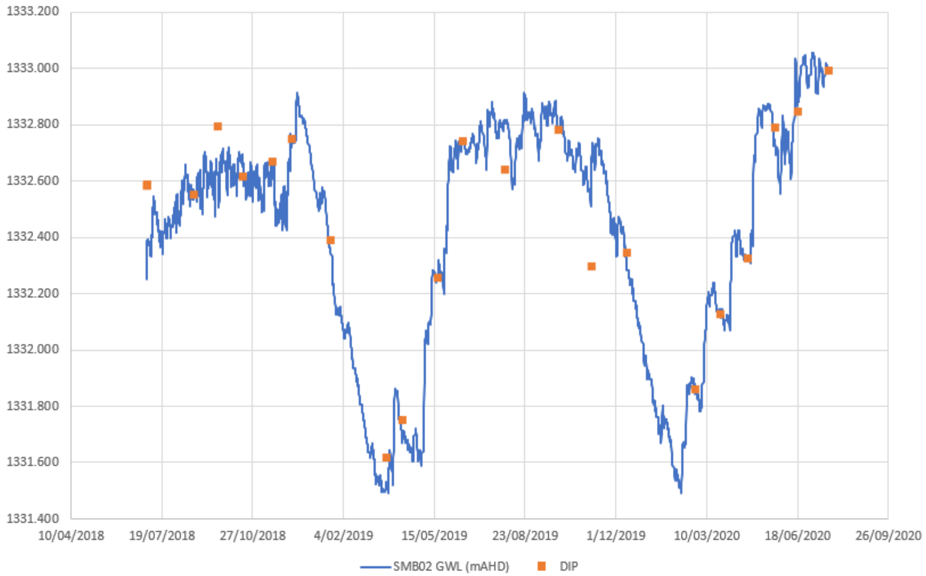
PB10 GWL (mAHD)
DIP



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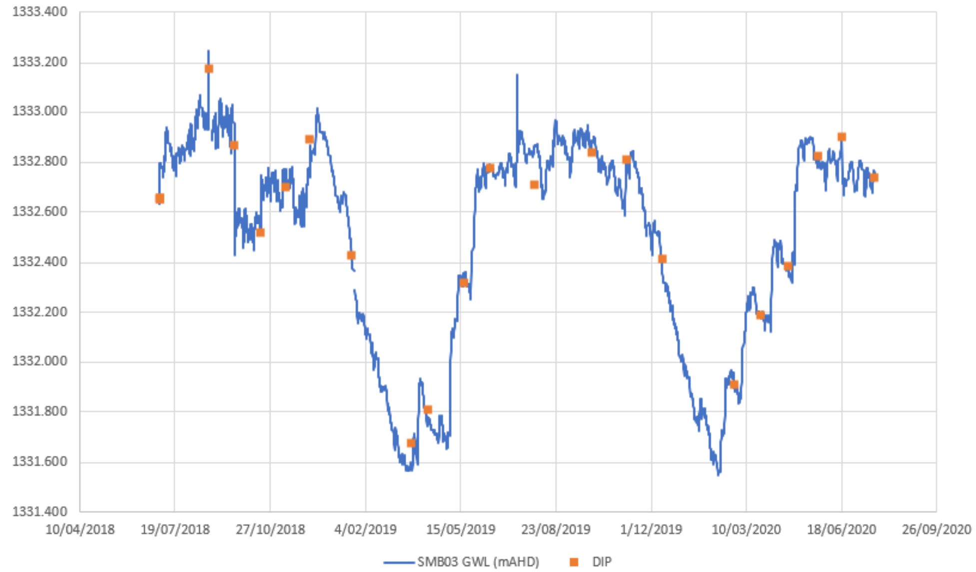
18/06/2020
26/09/2020
SMB02 GWL (mAHD)
DIP



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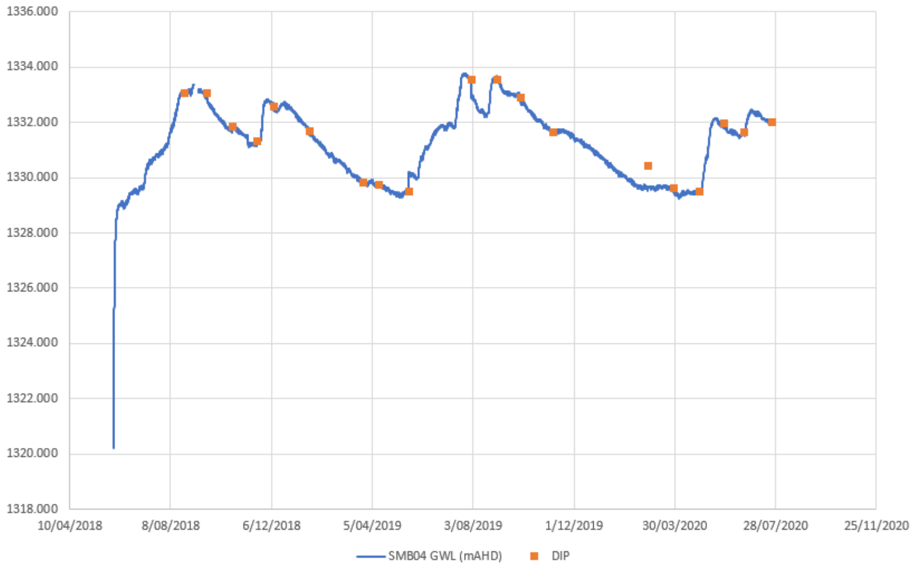
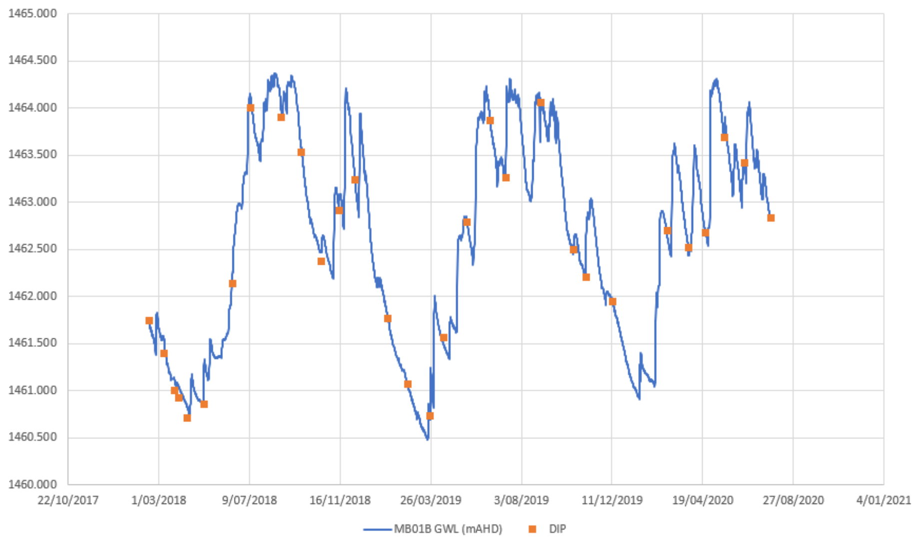
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
SMB03 GWL (mAHD)
DIP

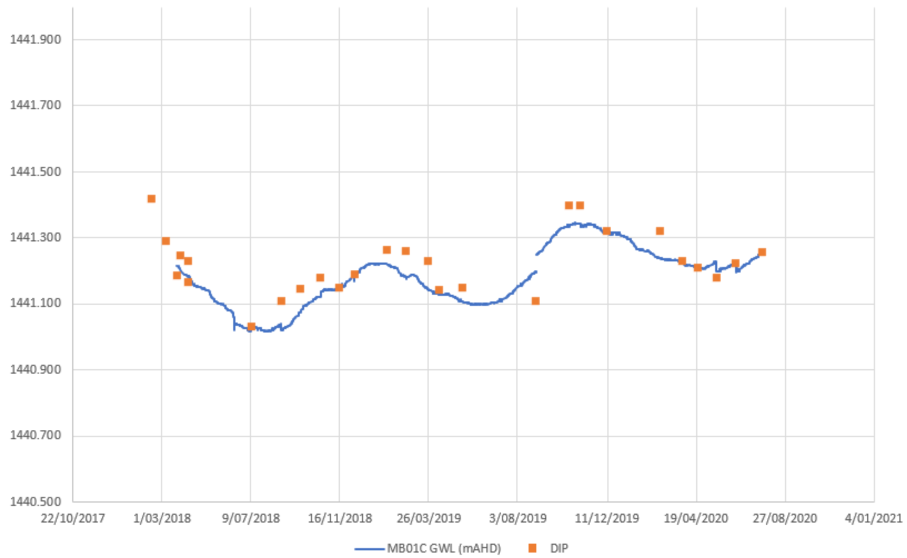


SMB04 GWL (mAHD)
DIP

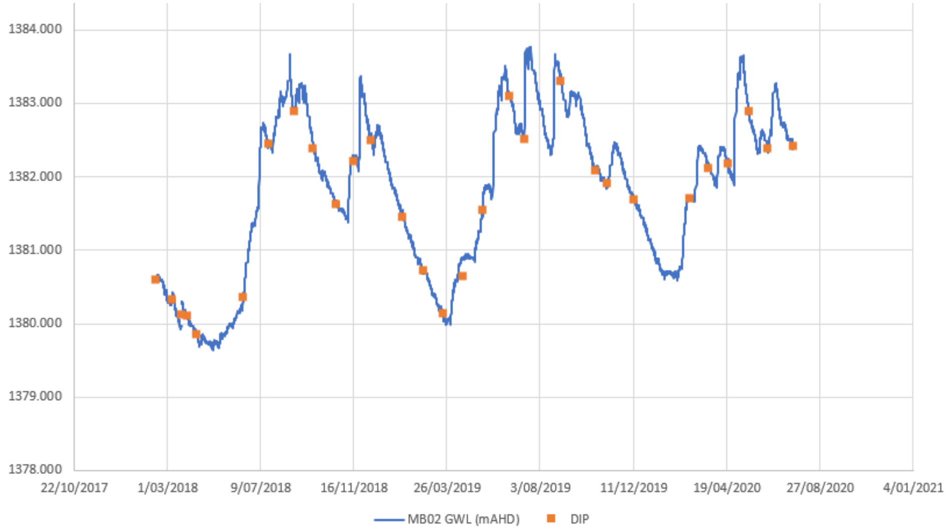
SMB05 GWL (mAHD)
DIP



MB01B GWL (mAHD)
DIP



MB01C GWL (mAHD)
DIP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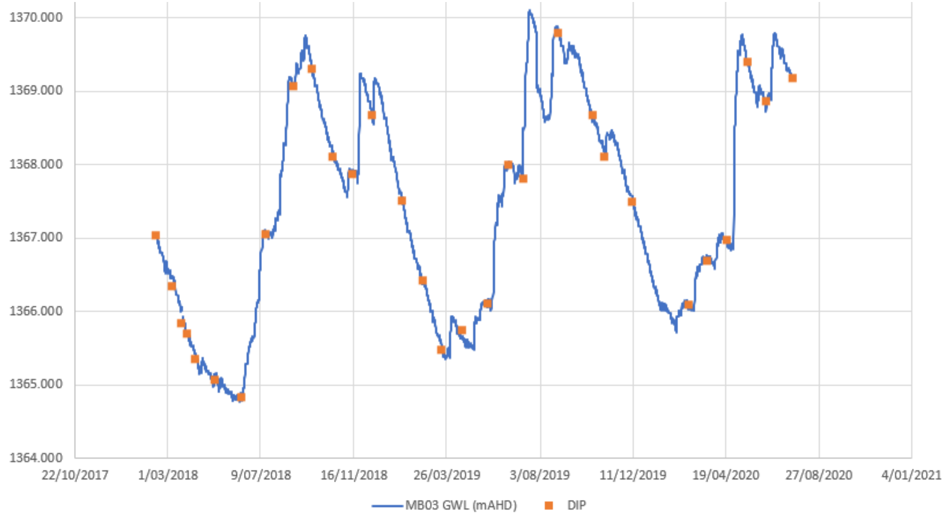
19/04/2020
27/08/2020
4/01/2021
MB02 GWL (mAHD)
DIP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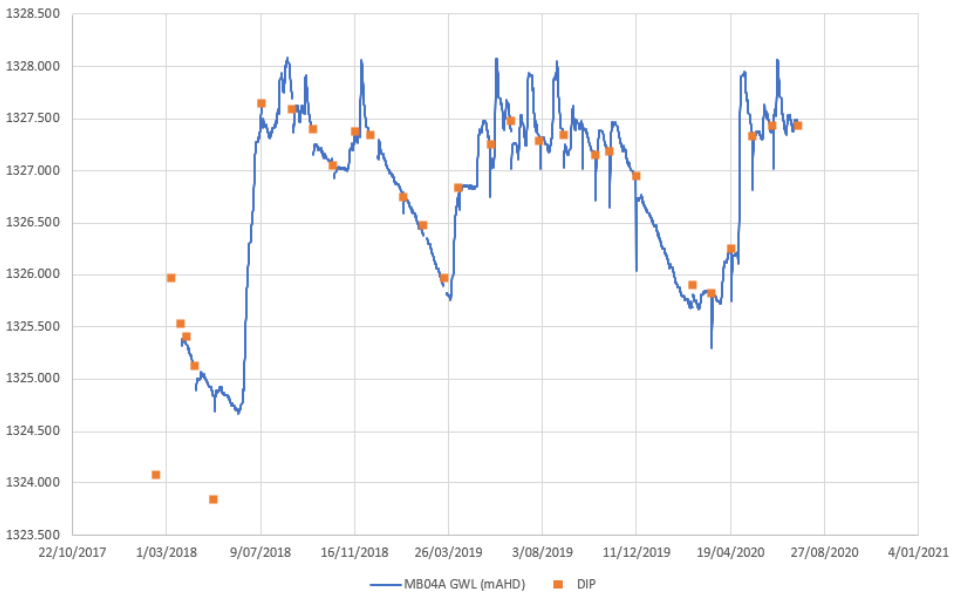
MB03 GWL (mAHD)
DIP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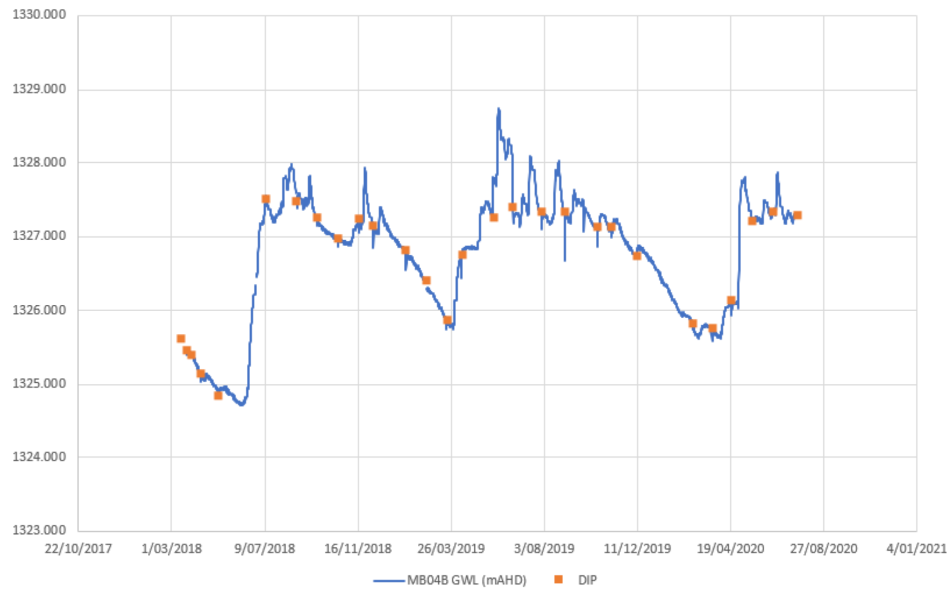
MB04A GWL (mAHD)
DIP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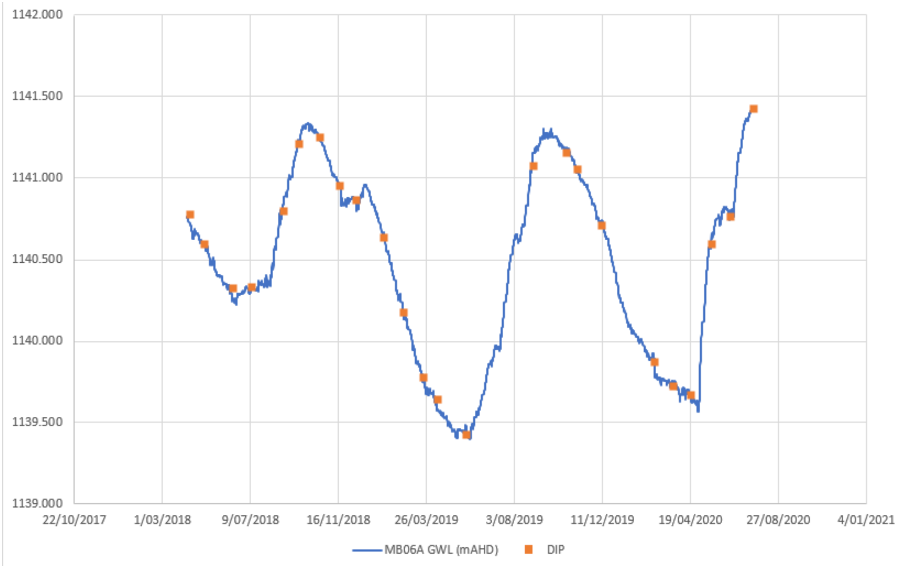
MB04B GWL (mAHD)
DIP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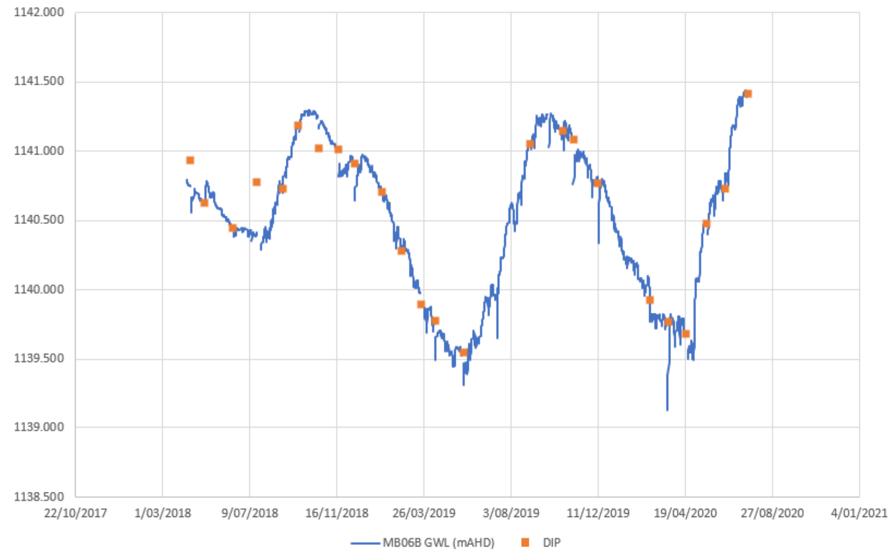
MB06A GWL (mAHD)
DIP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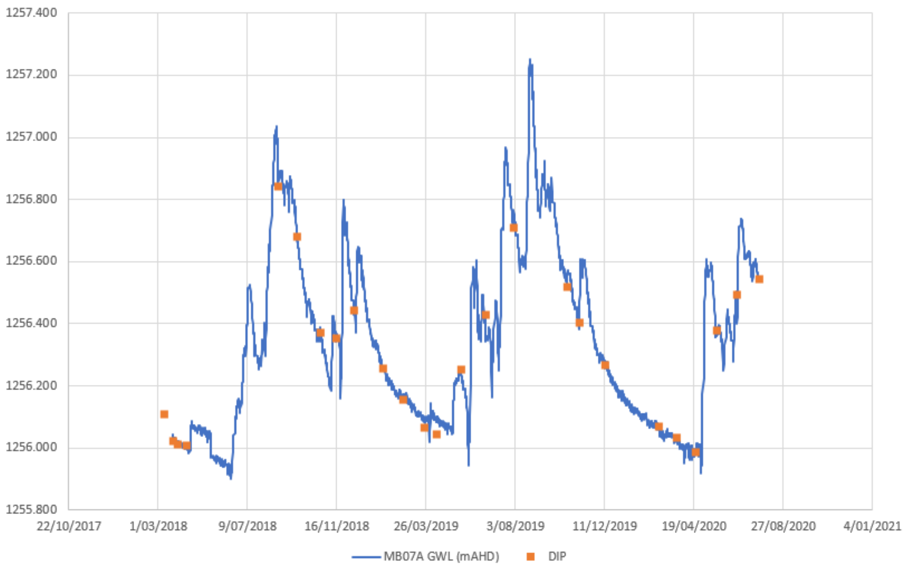
MB06B GWL (mAHD)
DIP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11/12/2019
19/04/2020
27/08/2020
4/01/2021
MB07A GWL (mAHD)
DIP


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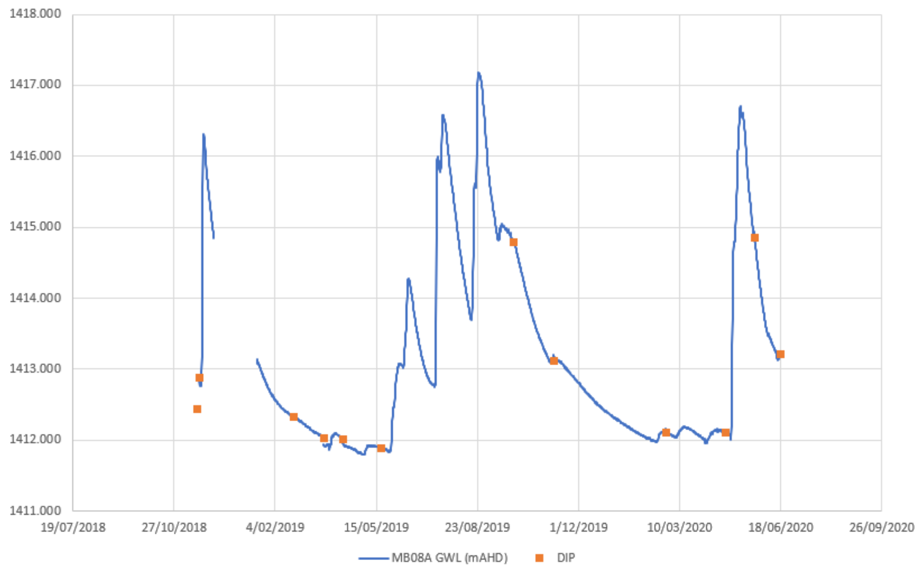
MB07B GWL (mAHD)
DIP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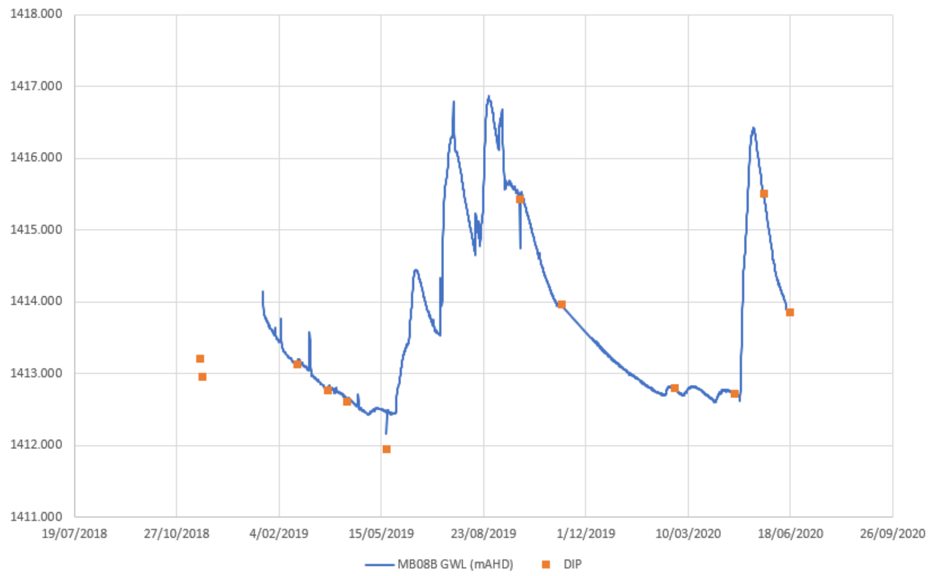
26/09/2020
MB08A GWL (mAHD)
DIP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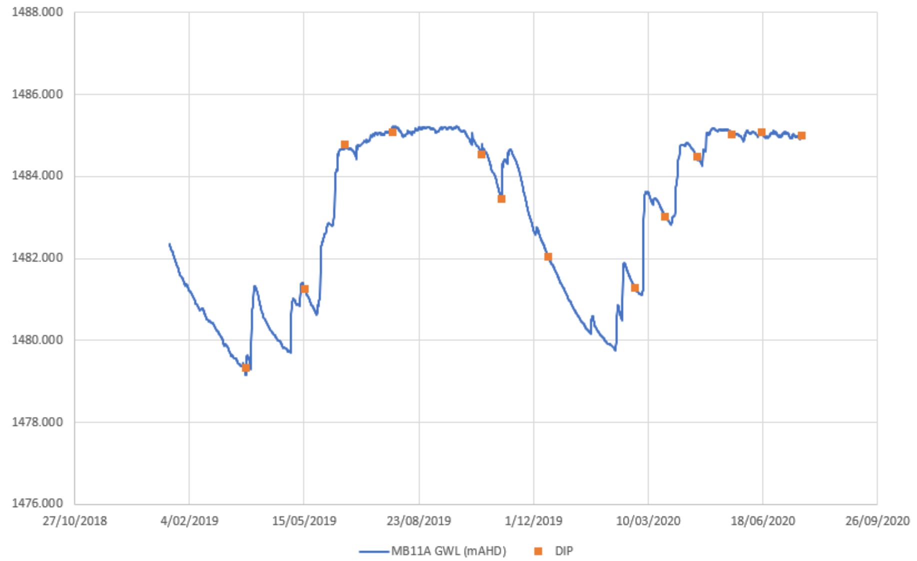
26/09/2020
MB08B GWL (mAHD)
DIP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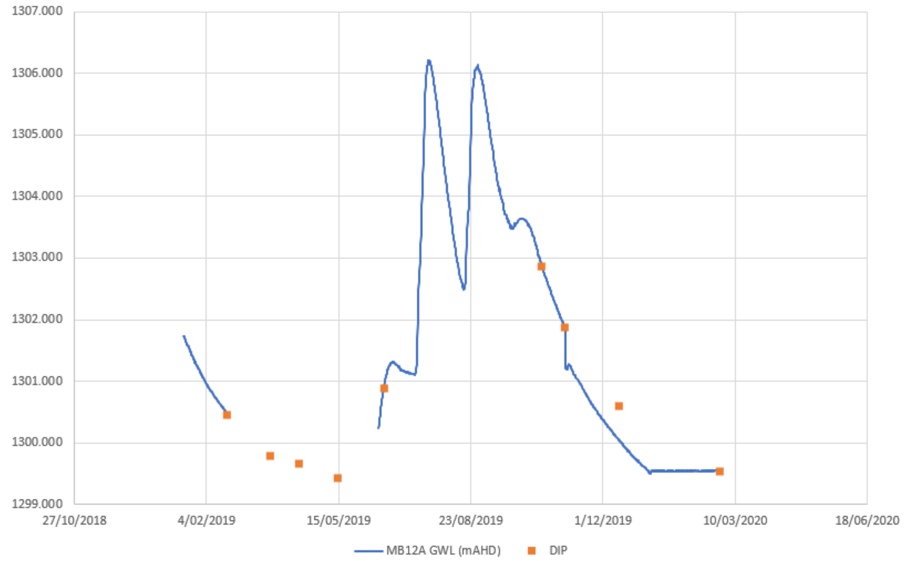
26/09/2020
MB11A GWL (mAHD)
DIP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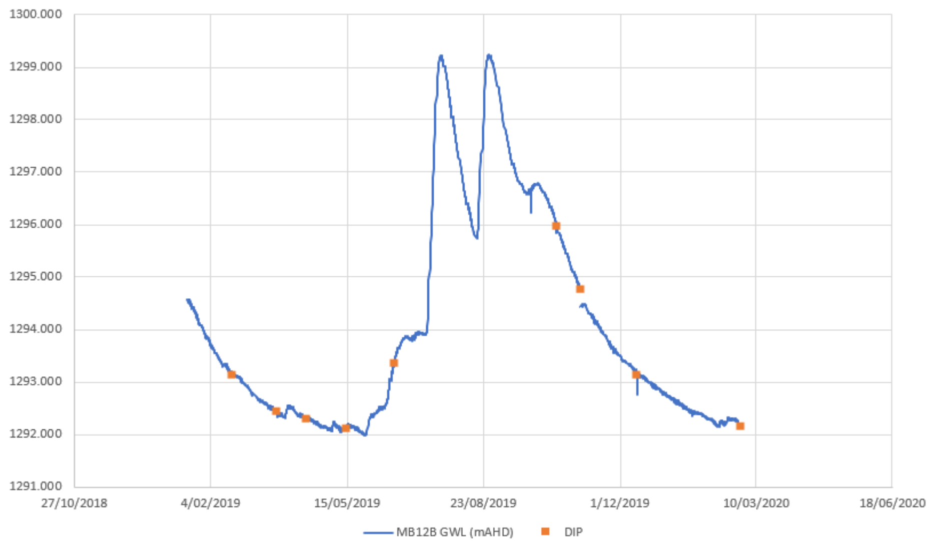
23/08/2019
1/12/2019
10/03/2020
18/06/2020
MB12A GWL (mAHD)
DIP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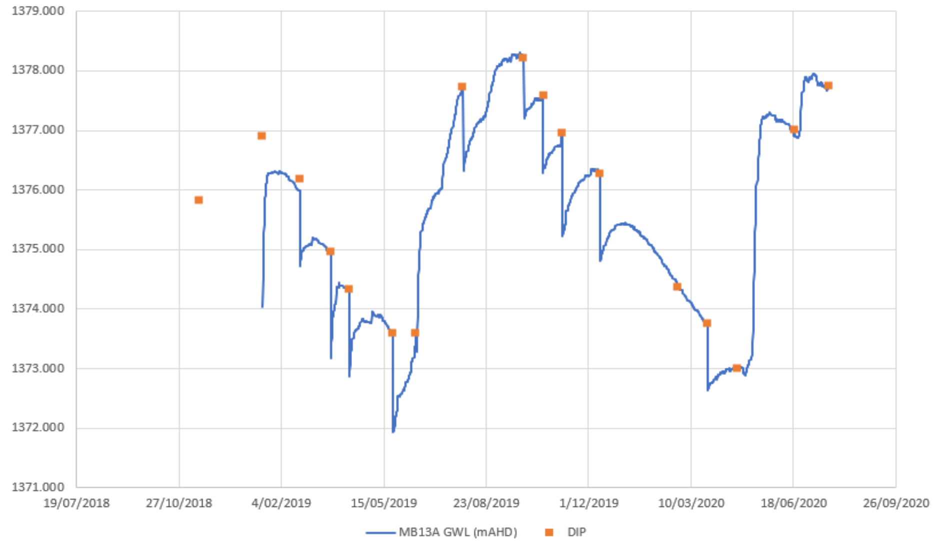
MB12B GWL (mAHD)
DIP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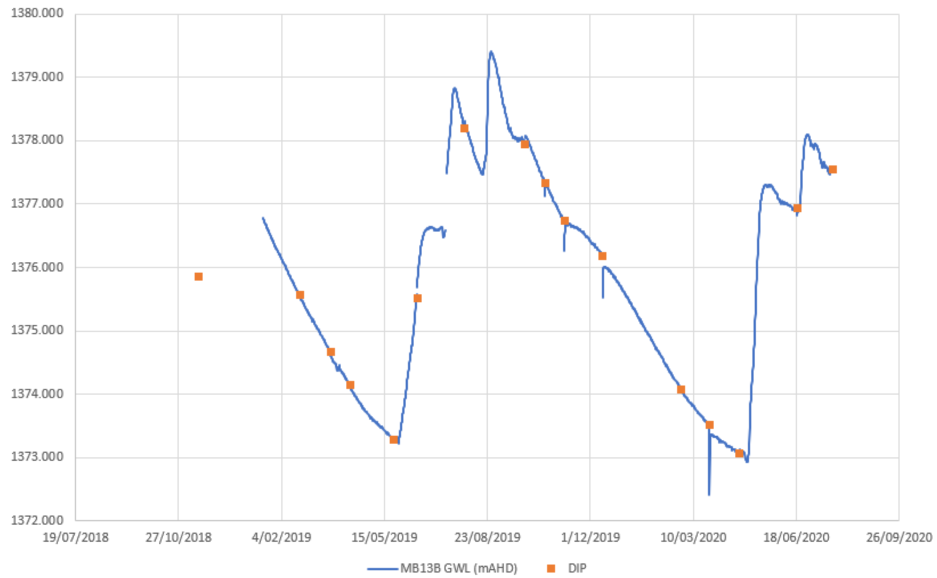
MB13A GWL (mAHD)
DIP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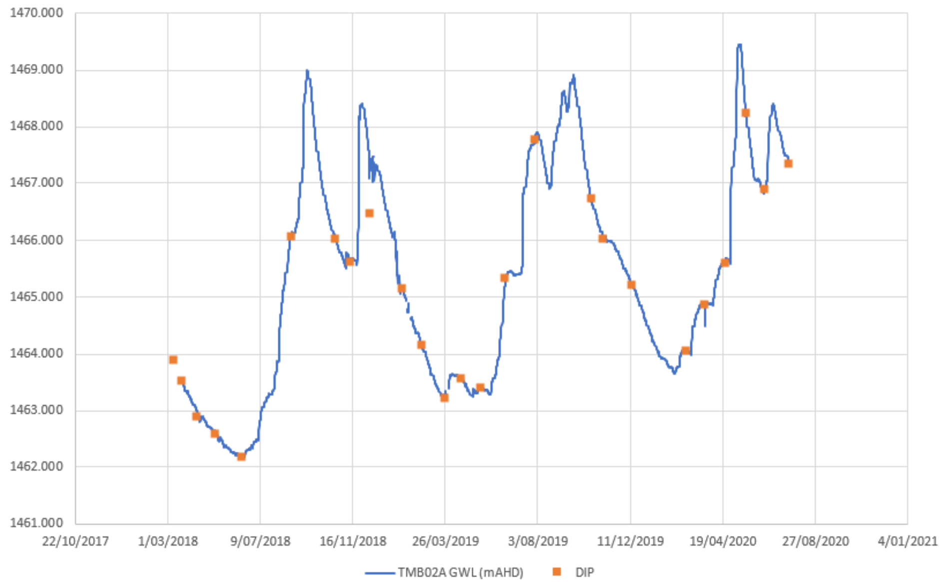
MB13B GWL (mAHD)
DIP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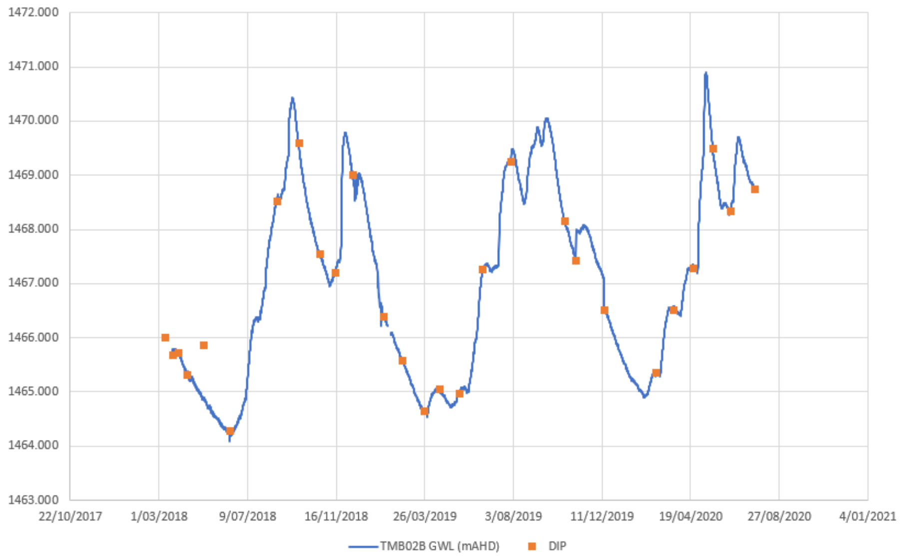
19/04/2020
27/08/2020
4/01/2021
TMB02A GWL (mAHD)
DIP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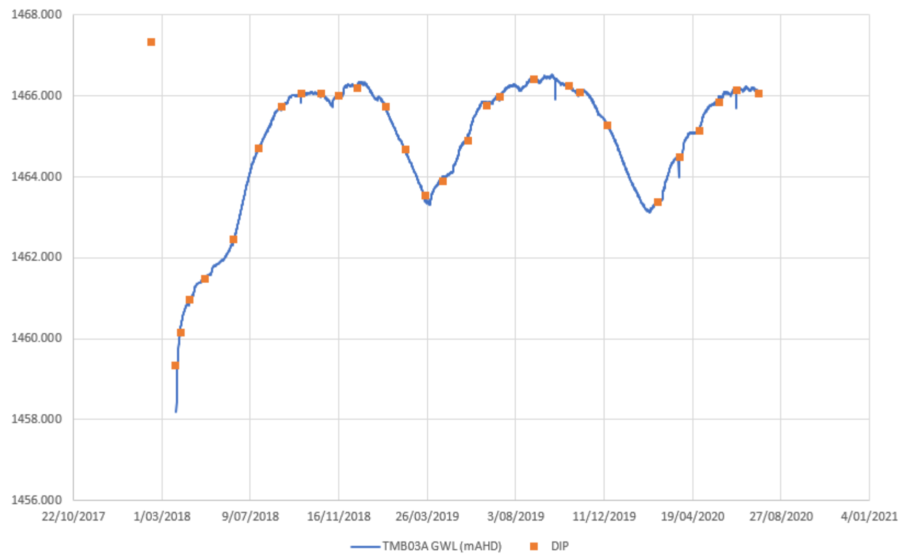
TMB02B GWL (mAHD)
DIP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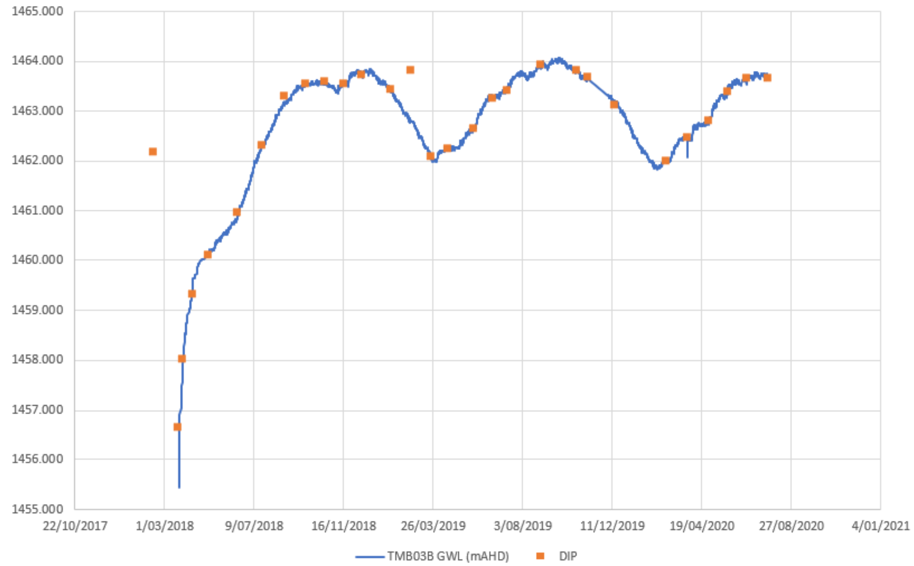
19/04/2020
27/08/2020
4/01/2021
TMB03A GWL (mAHD)
DIP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1/03/2018
9/07/2018
16/11/2018
26/03/2019
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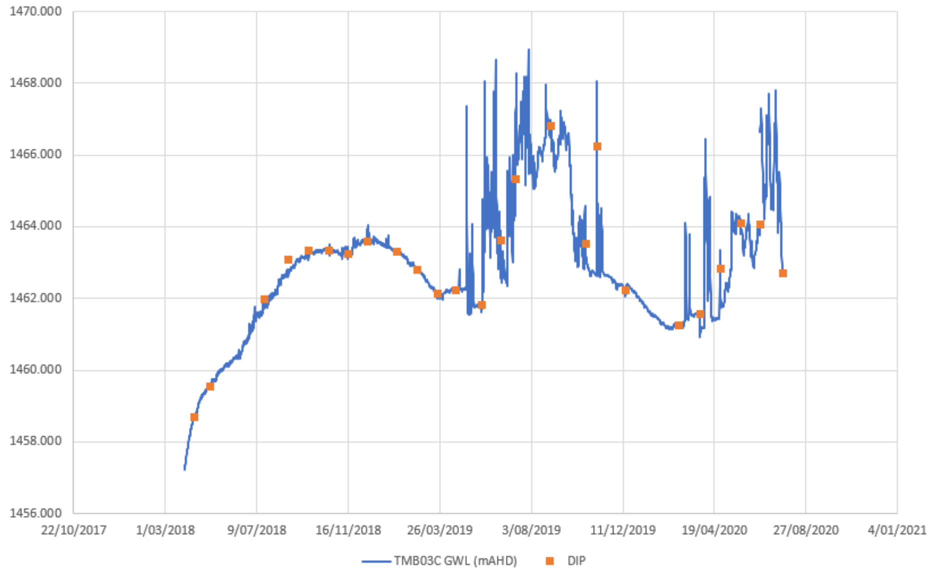
19/04/2020
27/08/2020
4/01/2021
TMB03B GWL (mAHD)
DIP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26/03/2019
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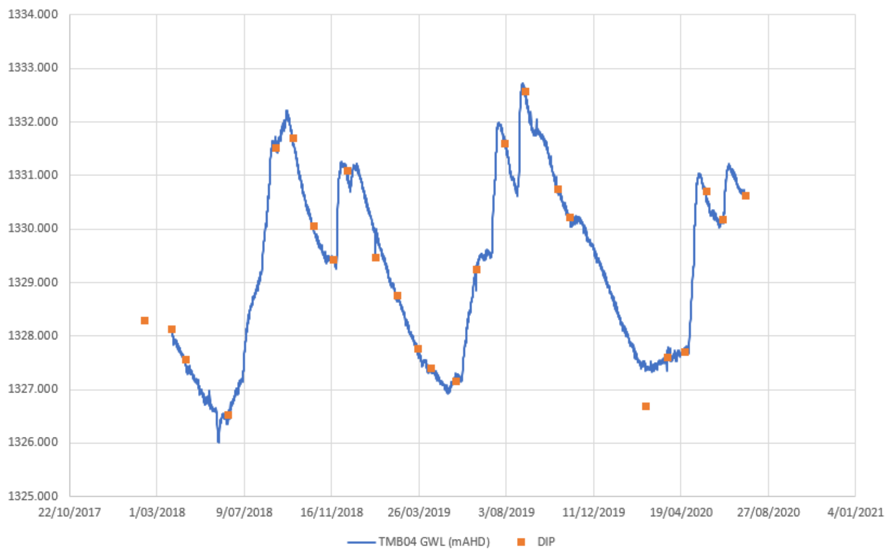
27/08/2020
4/01/2021
TMB03C GWL (mAHD)
DIP



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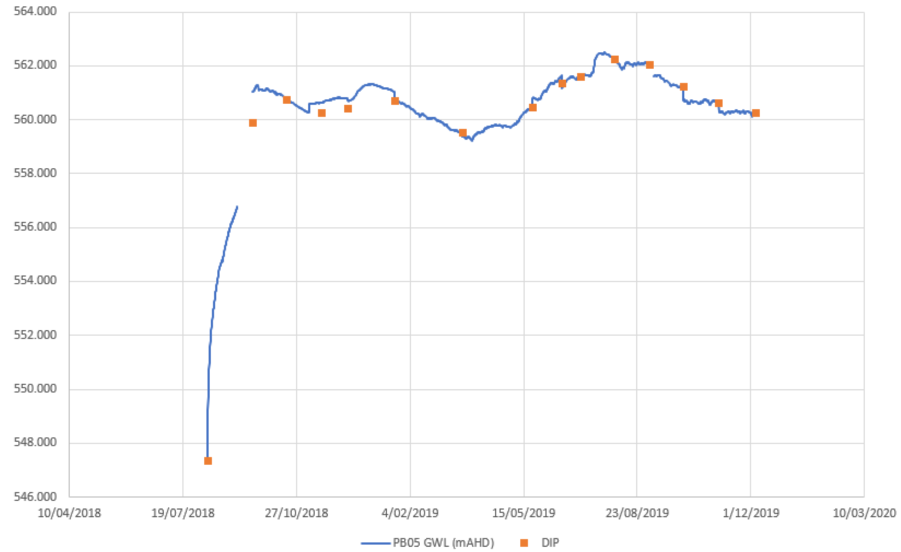
TMB04 GWL (mAHD)
DIP



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10/04/2018
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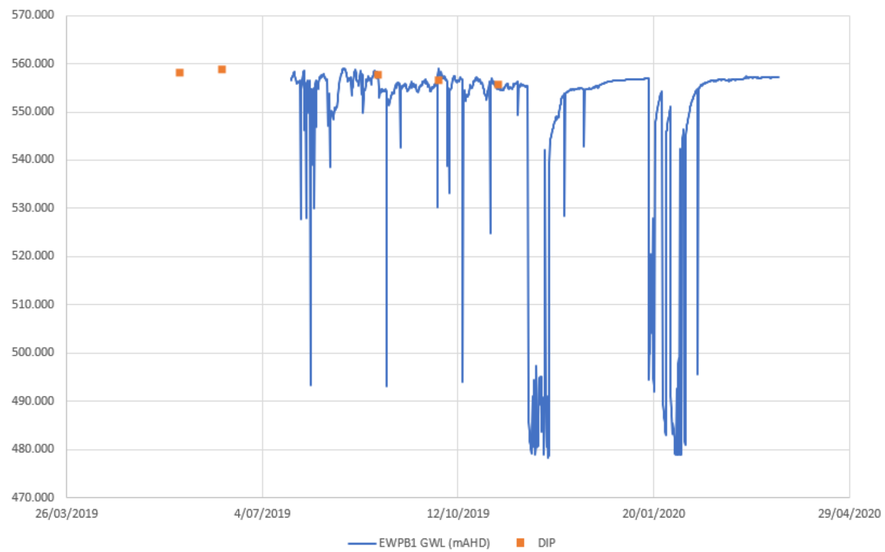
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
PB05 GWL (mAHD)
DIP



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490.000
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4/07/2019
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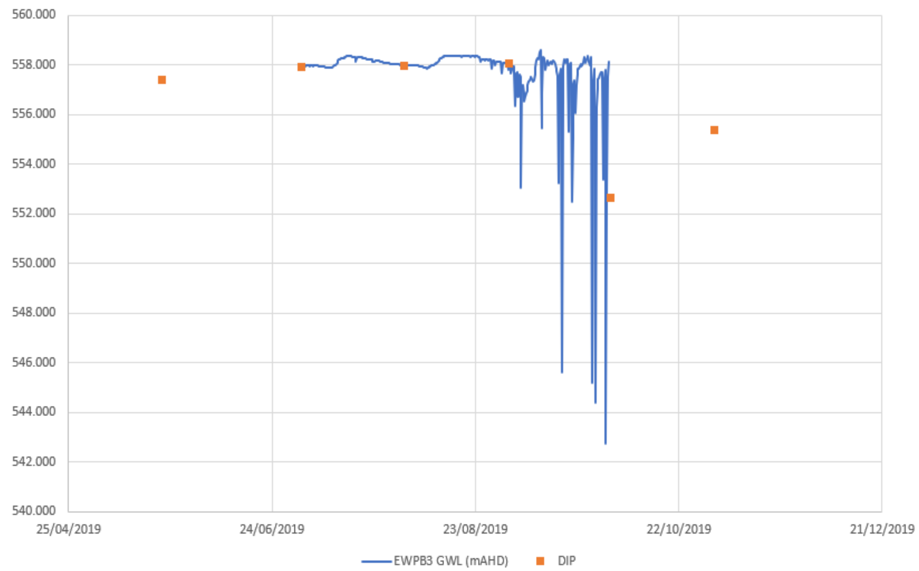
29/04/2020
EWPB1 GWL (mAHD)
DIP



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25/04/2019
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22/10/2019
21/12/2019
EWPB3 GWL (mAHD)
DIP


577.600
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1/12/2019
30/03/2020
28/07/2020
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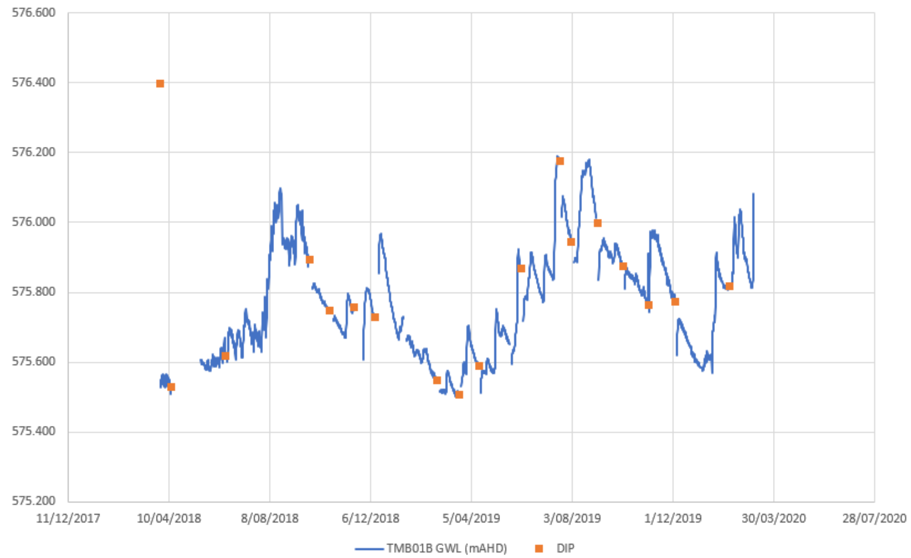
DIP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575.200
11/12/2017
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8/08/2018
6/12/2018
5/04/2019
3/08/2019
1/12/2019
30/03/2020
28/07/2020
TMB01B GWL (mAHD)
DIP


600.000
599.800
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599.000
598.800
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22/10/2017
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11/12/2019
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TMB05A GWL (mAHD)
DIP


600.500
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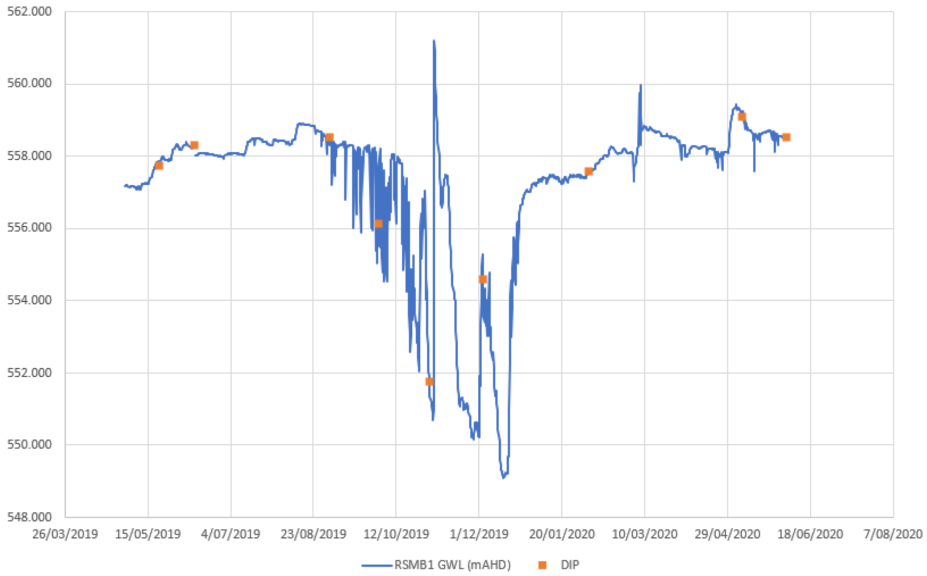
TMB05B GWL (mAHD)
DIP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23/08/2019
12/10/2019
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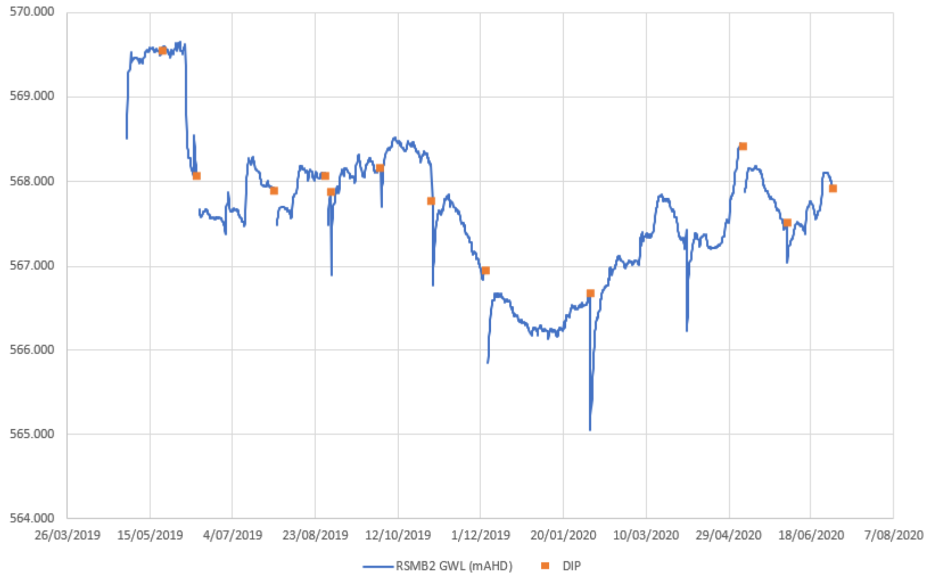
10/03/2020
29/04/2020
18/06/2020
7/08/2020
RSMB1 GWL (mAHD)
DIP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12/10/2019
1/12/2019
20/01/2020
10/03/2020
29/04/2020
18/06/2020
7/08/2020
RSMB2 GWL (mAHD)
DIP


574.600
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573.000
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26/03/2019
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4/07/2019
23/08/2019
12/10/2019
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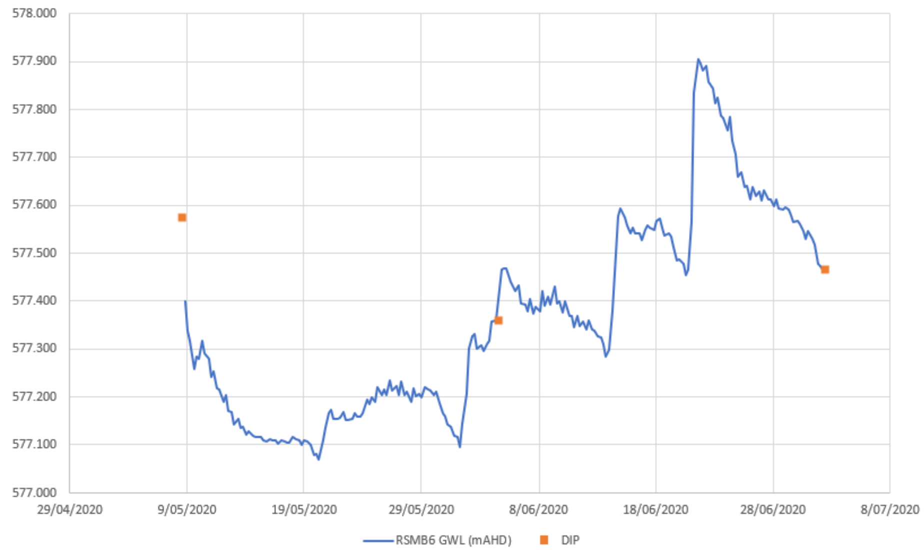
10/03/2020
29/04/2020
18/06/2020
7/08/2020
RSMB3 GWL (mAHD)
DIP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29/04/2020
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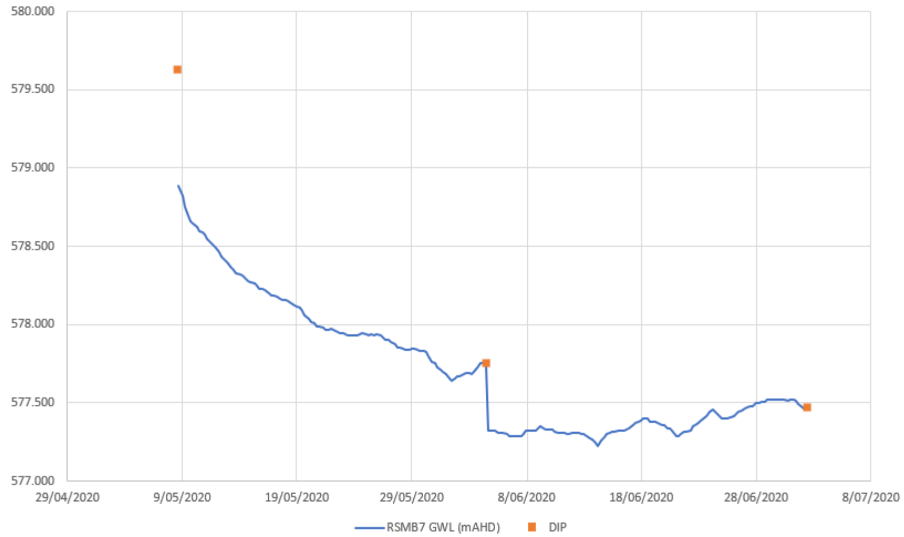
RSMB6 GWL (mAHD)
DIP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29/04/2020
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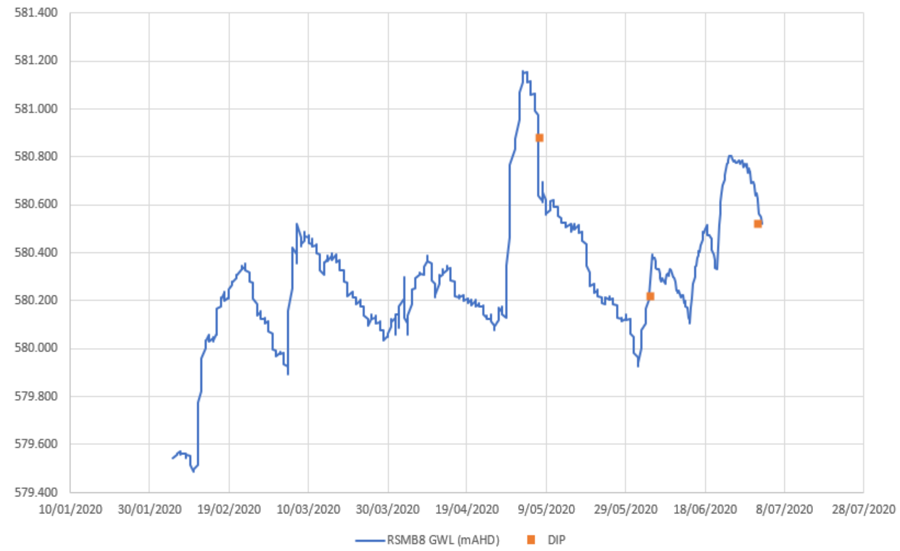
RSMB7 GWL (mAHD)
DIP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579.400
10/01/2020
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10/03/2020
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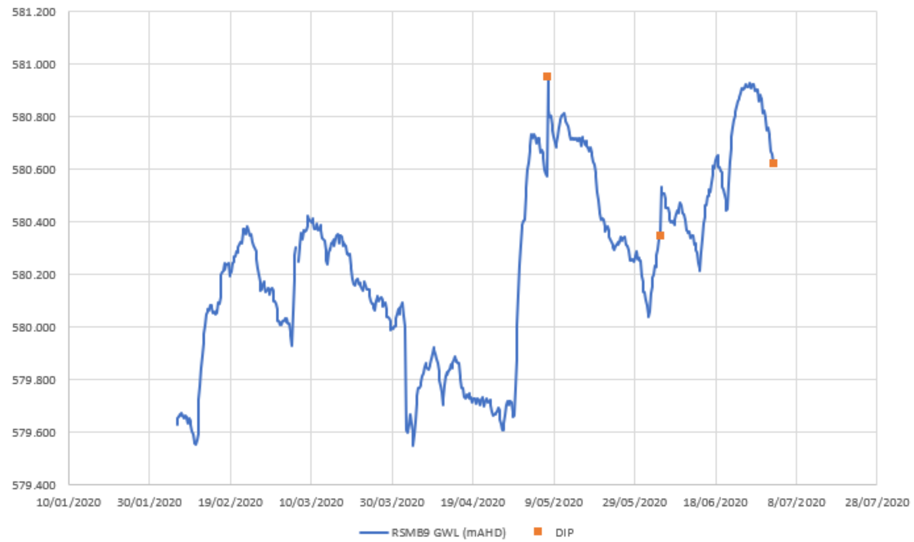
28/07/2020
RSMB8 GWL (mAHD)
DIP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579.600
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10/01/2020
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19/02/2020
10/03/2020
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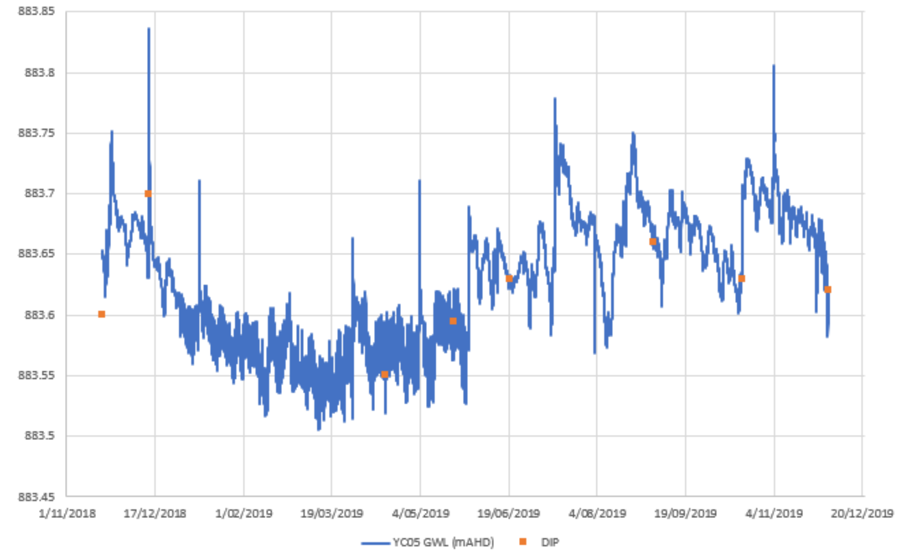
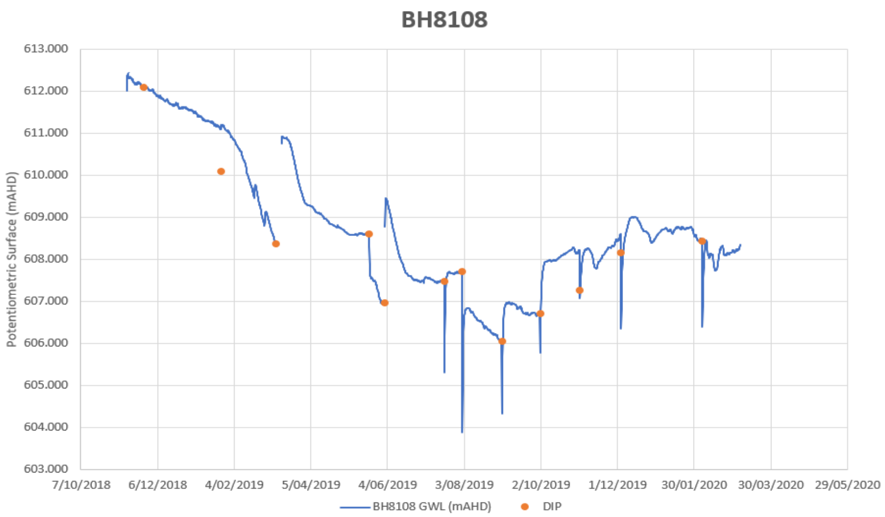
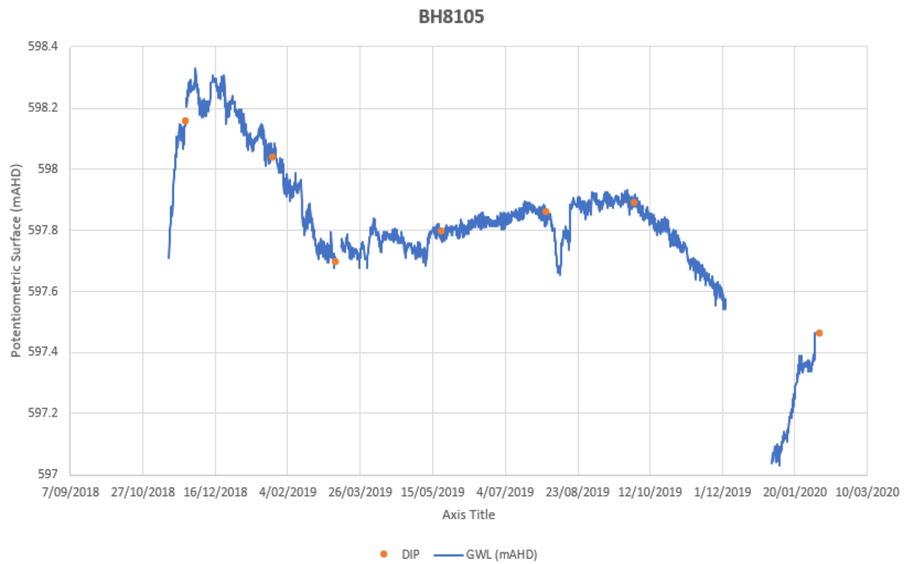
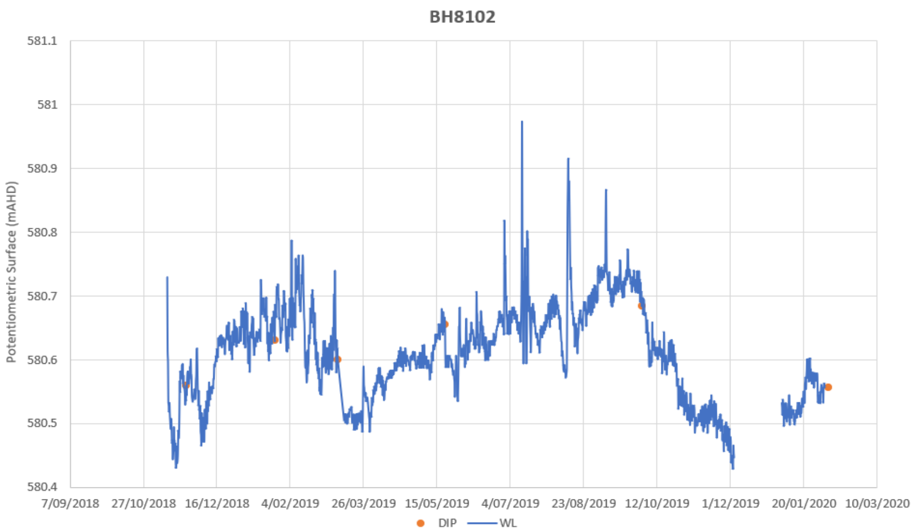
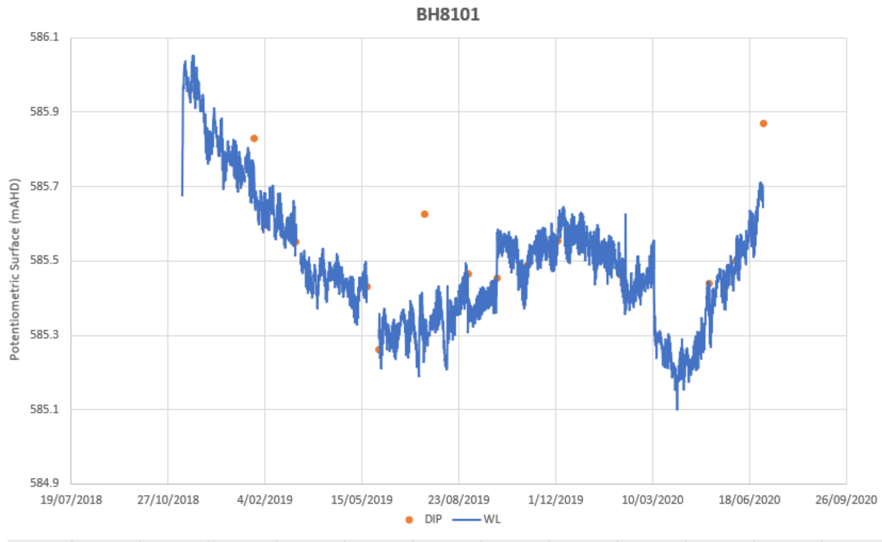
19/04/2020
9/05/2020
29/05/2020
18/06/2020
8/07/2020
28/07/2020
RSMB9 GWL (mAHD)
DIP

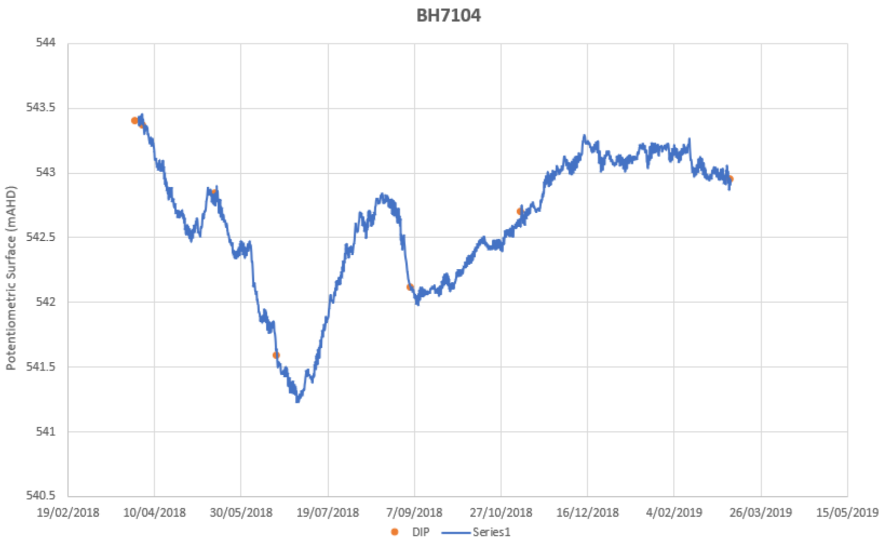

883.85
883.8
883.75
883.7
883.65
883.6
883.55
883.5
883.45
1/11/2018
17/12/2018
1/02/2019
19/03/2019
4/05/2019
19/06/2019
4/08/2019
19/09/2019
4/11/2019
20/12/2019
YC05 GWL (mAHD)
DIP

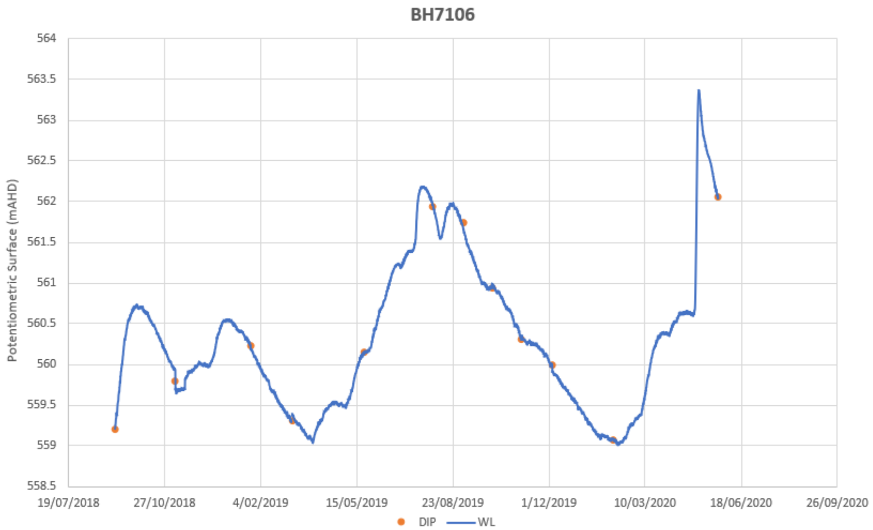

BH8108
Potentiometric Surface (mAHD)
613.000
612.000
611.000
610.000
609.000
608.000
607.000
606.000
605.000
604.000
603.000
7/10/2018
6/12/2018
4/02/2019
5/04/2019
4/06/2019
3/08/2019
2/10/2019
1/12/2019
30/01/2020
30/03/2020
29/05/2020
BH8108 GWL (mAHD)
DIP

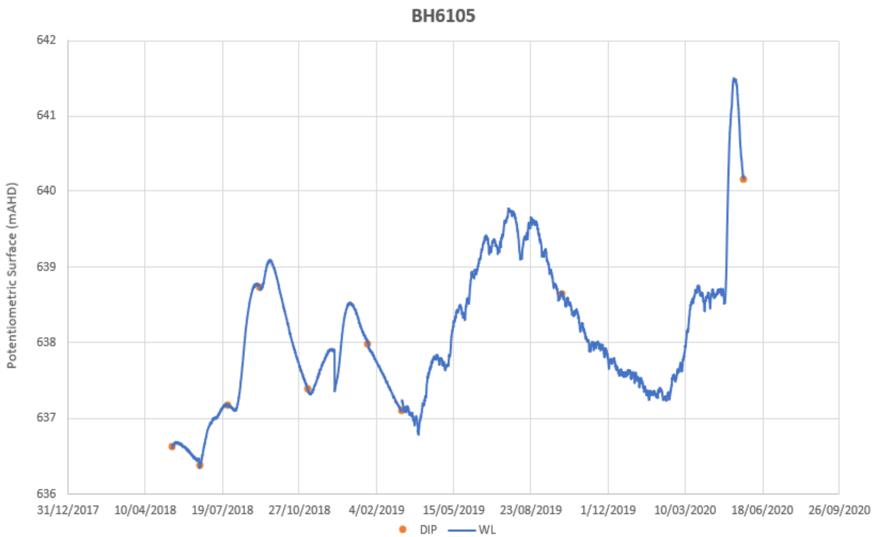

BH8105
Potentiometric Surface (mAHD)
598.4
598.2
598
597.8
597.6
597.4
597.2
597
7/09/2018
27/10/2018
16/12/2018
4/02/2019
26/03/2019
15/05/2019
4/07/2019
23/08/2019
12/10/2019
1/12/2019
20/01/2020
10/03/2020
Axis Title
DIP
GWL (mAHD)


BH8102
Potentiometric Surface (mAHD)
581.1
581
580.9
580.8
580.7
580.6
580.5
580.4
7/09/2018
27/10/2018
16/12/2018
4/02/2019
26/03/2019
15/05/2019
4/07/2019
23/08/2019
12/10/2019
1/12/2019
20/01/2020
10/03/2020
DIP
WL

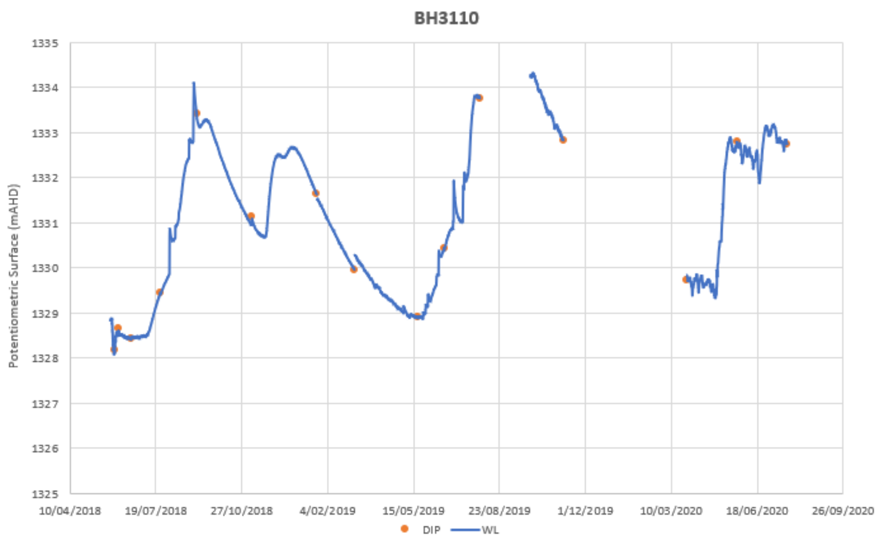

BH8101
Potentiometric Surface (mAHD)
586.1
585.9
585.7
585.5
585.3
585.1
584.9
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
DIP
WL

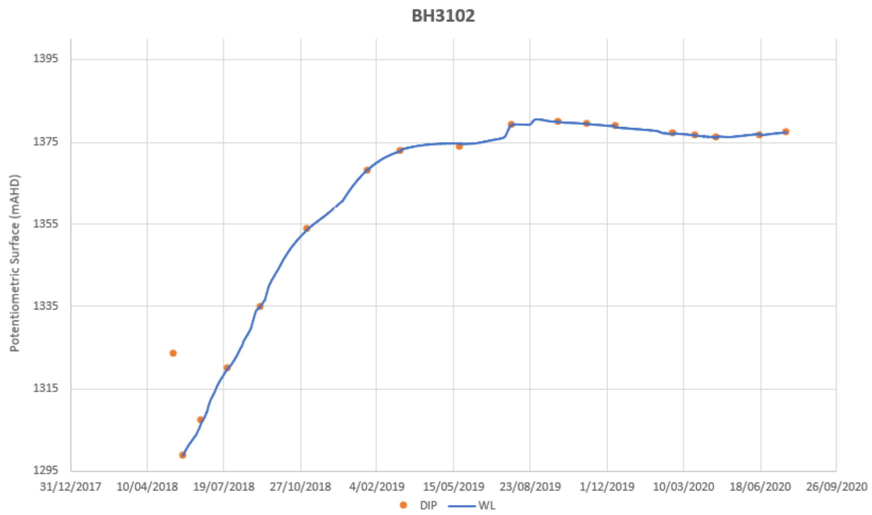

BH7104
Potentiometric Surface (mAHD)
DIP
Series1

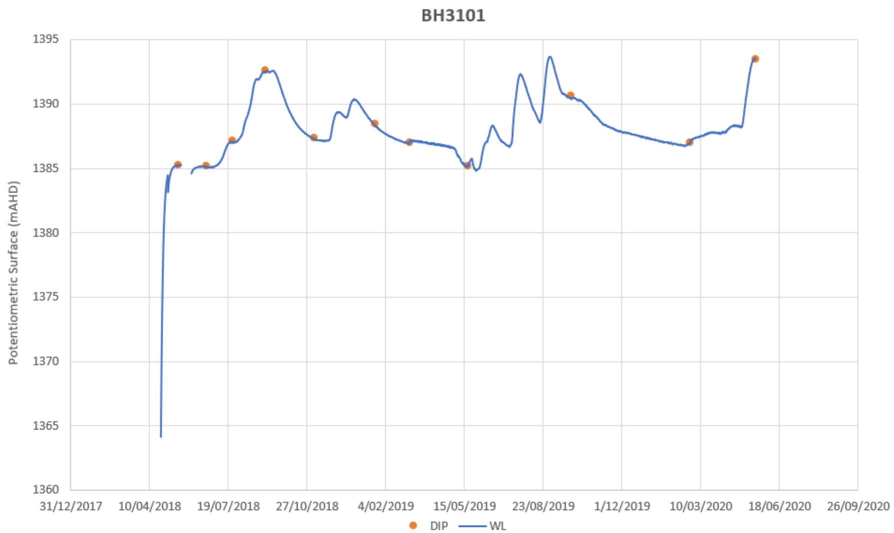

BH7106
Potentiometric Surface (mAHD)
DIP
WL


BH6105
Potentiometric Surface (mAHD)
DIP
WL

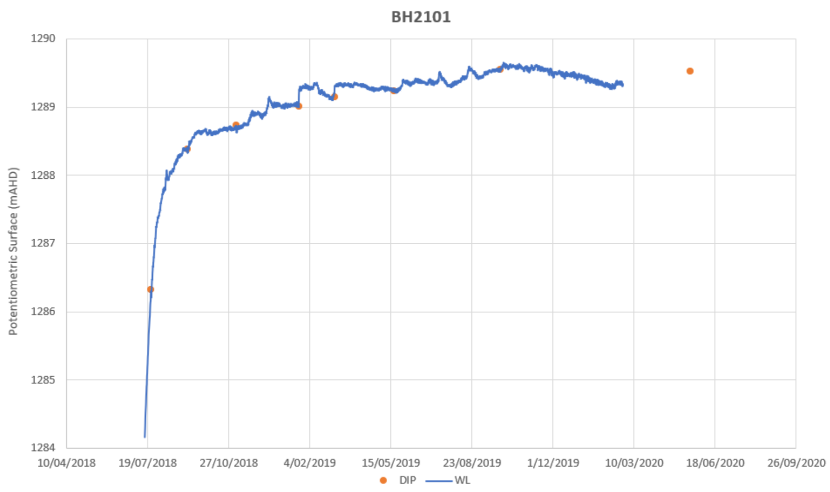

BH6104
Potentiometric Surface (mAHD)
DIP
WL

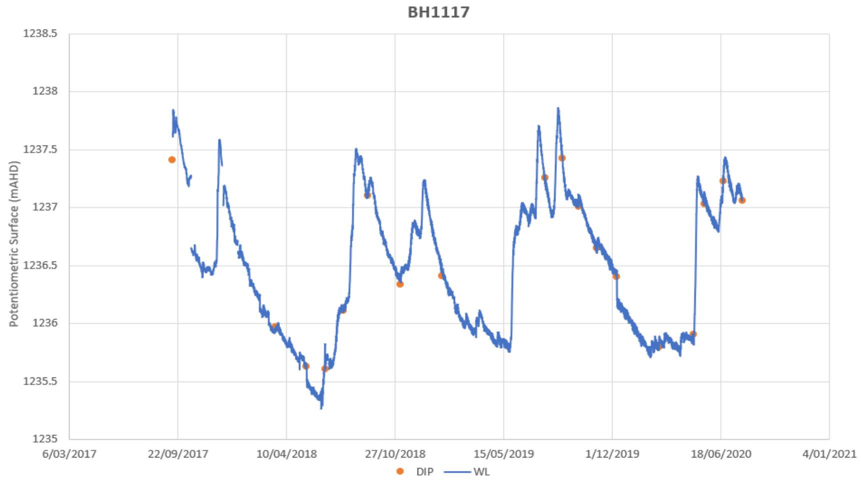

BH3110
Potentiometric Surface (mAHD)
1335
1334
1333
1332
1331
1330
1329
1328
1327
1326
1325
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
DIP
WL


BH3102
Potentiometric Surface (mAHD)
1395
1375
1355
1335
1315
1295
31/12/2017
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
DIP
WL

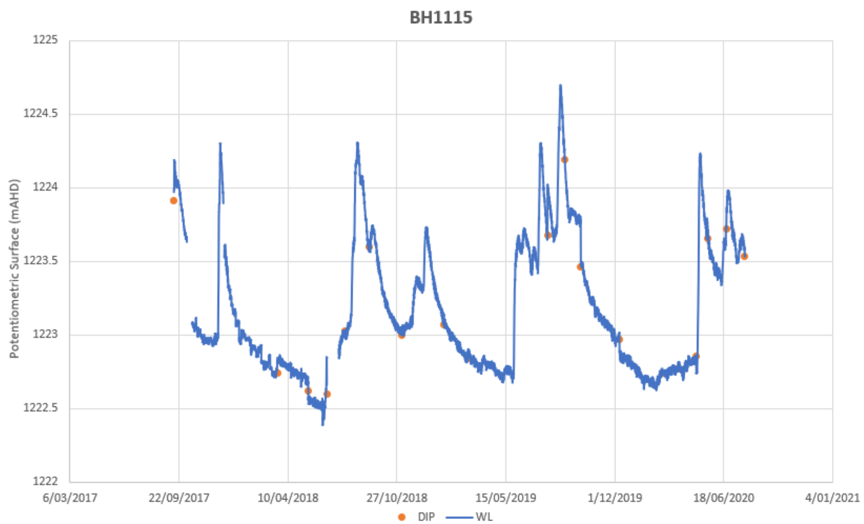

BH3101
Potentiometric Surface (mAHD)
1395
1390
1385
1380
1375
1370
1365
1360
31/12/2017
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
DIP
WL

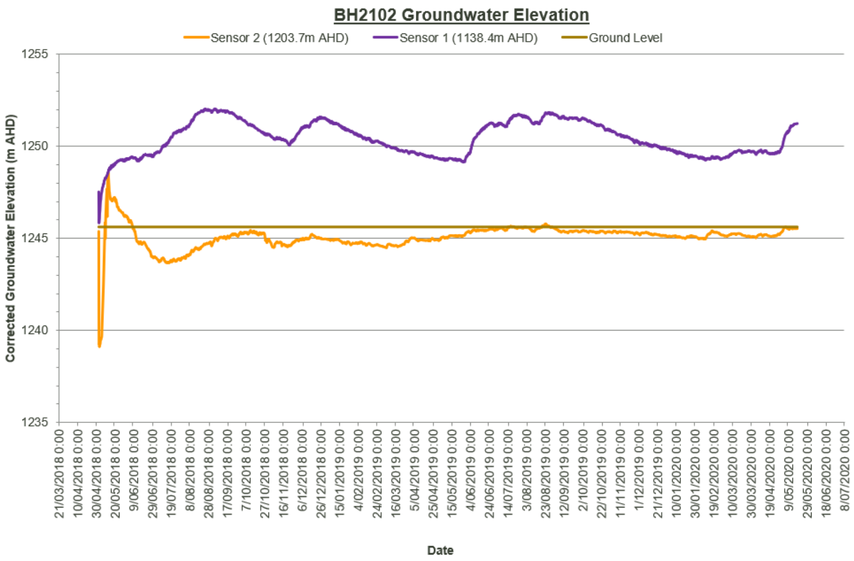

BH2103
Potentiometric Surface (mAHD)
1248
1247.5
1247
1246.5
1246
1245.5
1245
1244.5
1244
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
DIP
WL

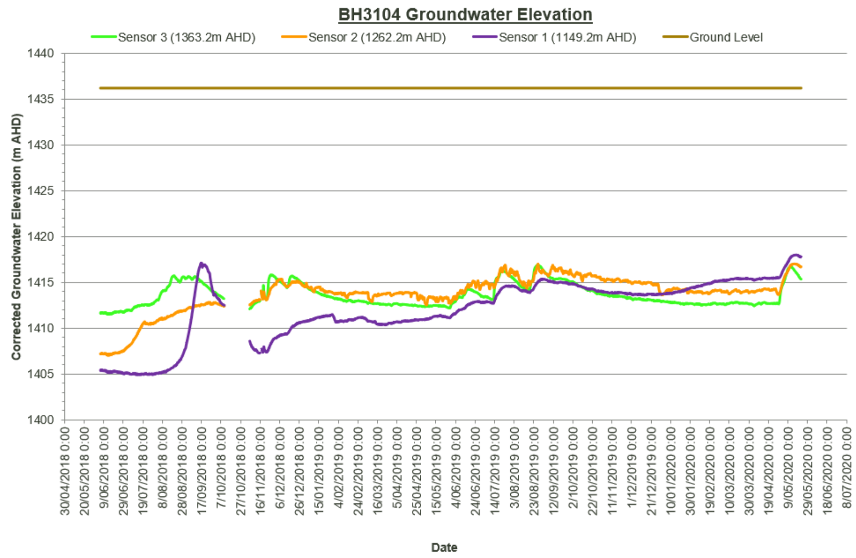

BH2101
Potentiometric Surface (mAHD)
1290
1289
1288
1287
1286
1285
1284
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
DIP
WL

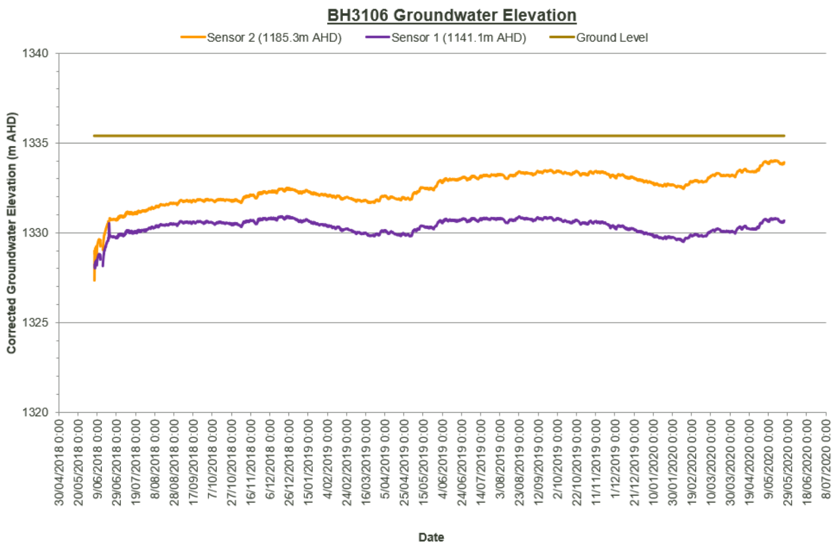

BH1117
Potentiometric Surface (mAHD)
1238.5
1238
1237.5
1237
1236.5
1236
1235.5
1235
6/03/2017
22/09/2017
10/04/2018
27/10/2018
15/05/2019
1/12/2019
18/06/2020
4/01/2021
DIP
WL

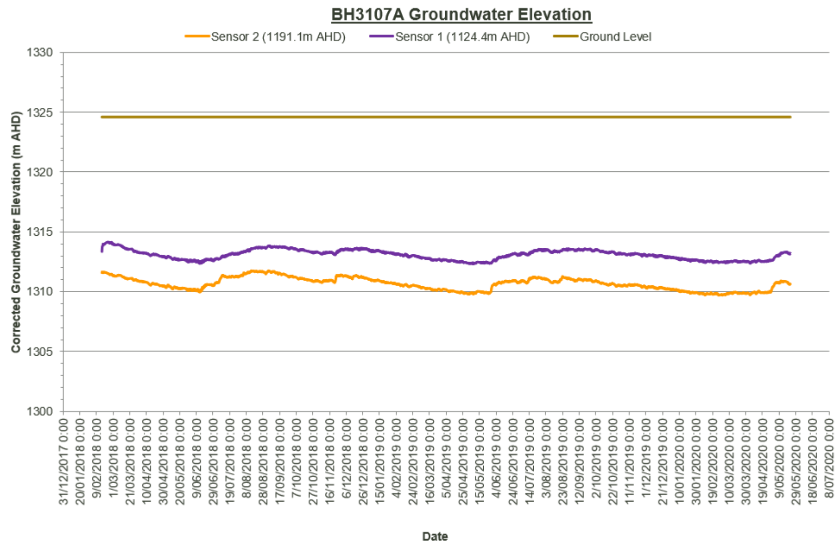

BH1116
Potentiometric Surface (mAHD)
1225
1224.5
1224
1223.5
1223
1222.5
1222
1221.5
1221
1220.5
1220
6/03/2017
22/09/2017
10/04/2018
27/10/2018
15/05/2019
1/12/2019
18/06/2020
4/01/2021
DIP
WL

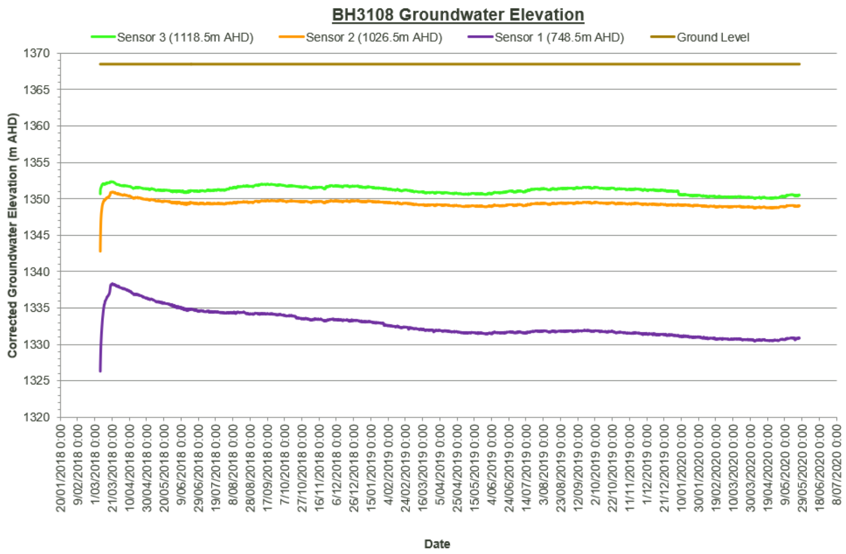

BH1115
Potentiometric Surface (mAHD)
1225
1224.5
1224
1223.5
1223
1222.5
1222
6/03/2017
22/09/2017
10/04/2018
27/10/2018
15/05/2019
1/12/2019
18/06/2020
4/01/2021
DIP
WL

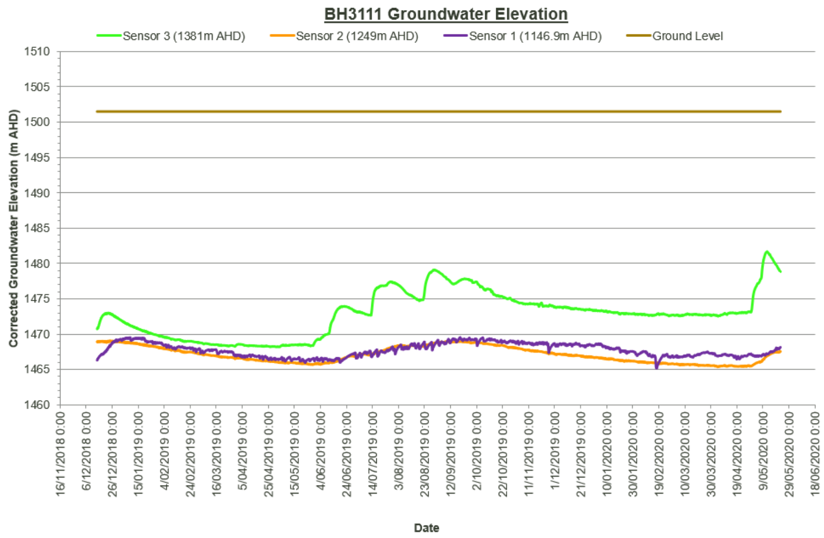

BH2102 Groundwater Elevation
Sensor 2 (1203.7m AHD)
Sensor 1 (1138.4m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

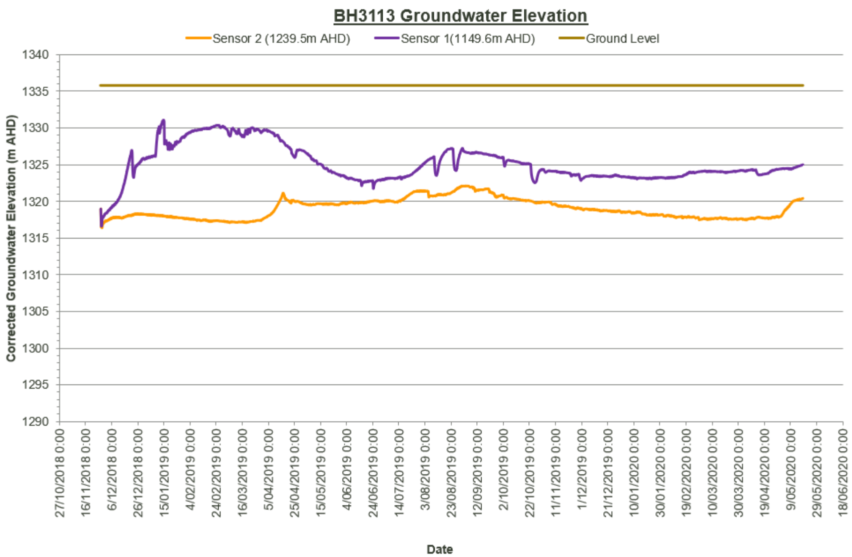

BH3104 Groundwater Elevation
Sensor 3 (1363.2m AHD)
Sensor 2 (1262.2m AHD)
Sensor 1 (1149.2m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

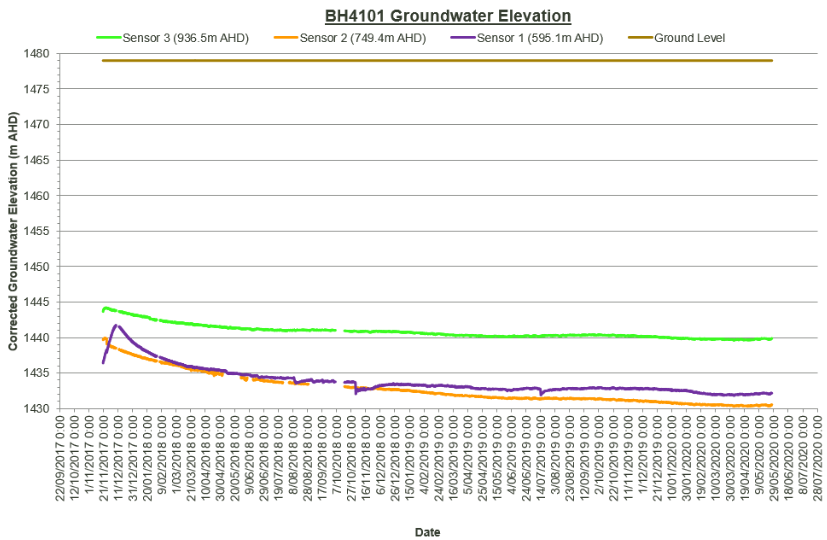

BH3106 Groundwater Elevation
Sensor 2 (1185.3m AHD)
Sensor 1 (1141.1m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

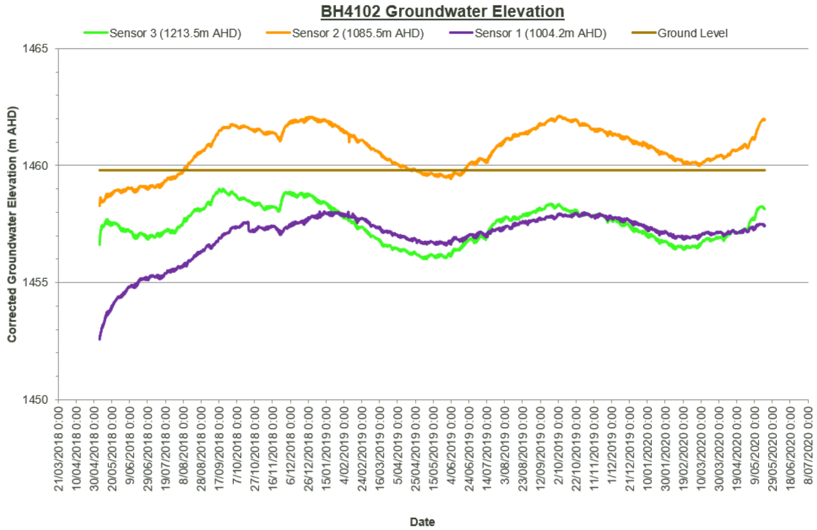

BH3107A Groundwater Elevation
Sensor 2 (1191.1m AHD)
Sensor 1 (1124.4m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

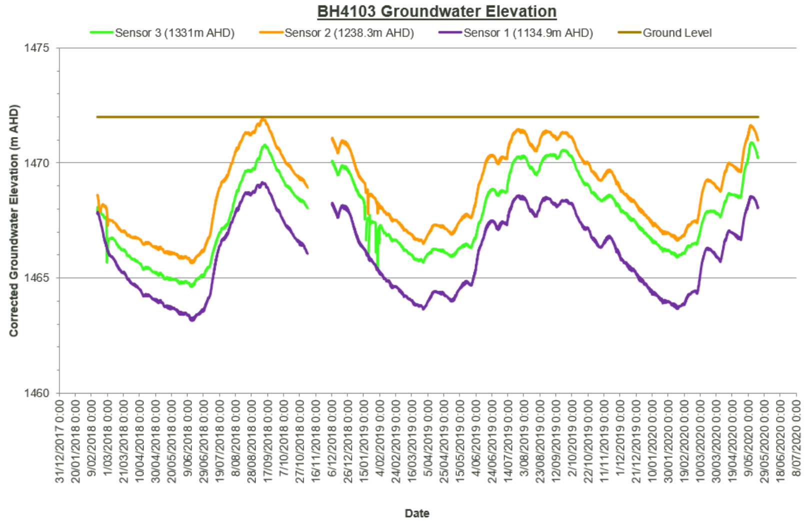

BH3108 Groundwater Elevation
Sensor 3 (1118.5m AHD)
Sensor 2 (1026.5m AHD)
Sensor 1 (748.5m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1370
1365
1360
1355
1350
1345
1340
1335
1330
1325
1320
Date

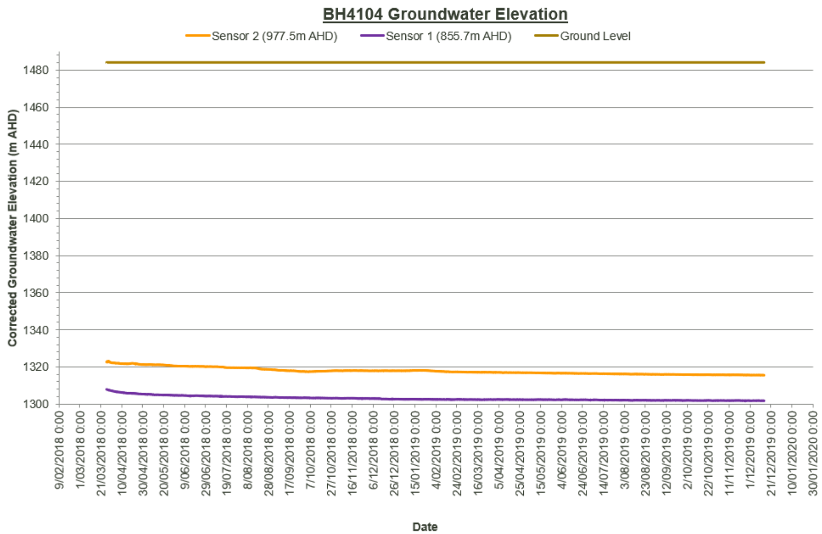

BH3111 Groundwater Elevation
Sensor 3 (1381m AHD)
Sensor 2 (1249m AHD)
Sensor 1 (1146.9m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1510
1505
1500
1495
1490
1485
1480
1475
1470
1465
1460
Date

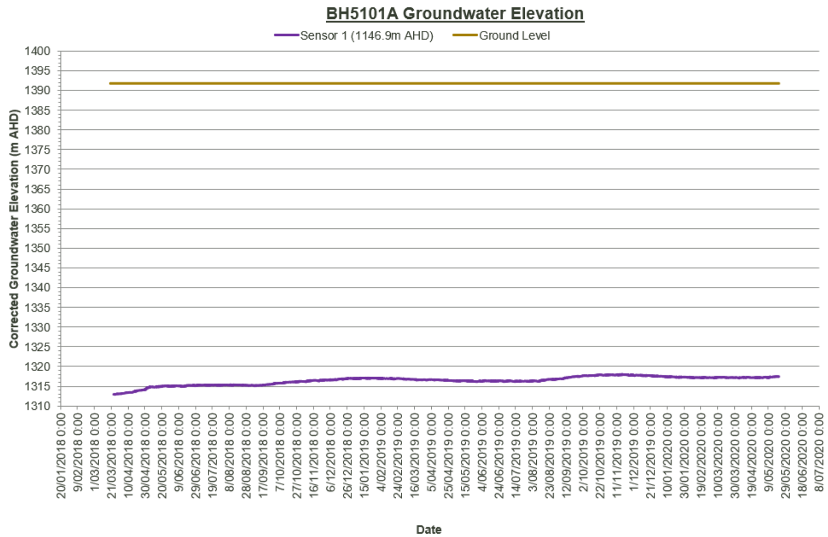

BH3113 Groundwater Elevation
Sensor 2 (1239.5m AHD)
Sensor 1(1149.6m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1340
1335
1330
1325
1320
1315
1310
1305
1300
1295
1290
Date

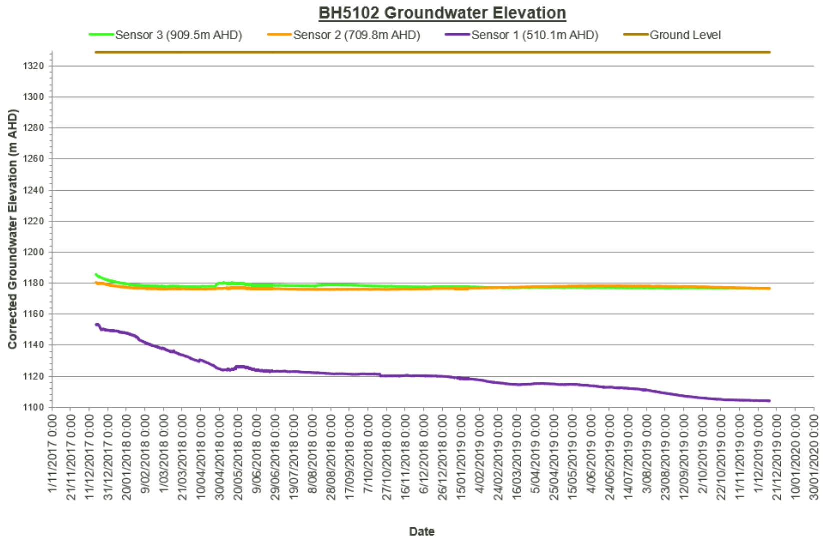

BH4101 Groundwater Elevation
Sensor 3 (936.5m AHD)
Sensor 2 (749.4m AHD)
Sensor 1 (595.1m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1480
1475
1470
1465
1460
1455
1450
1445
1440
1435
1430
Date

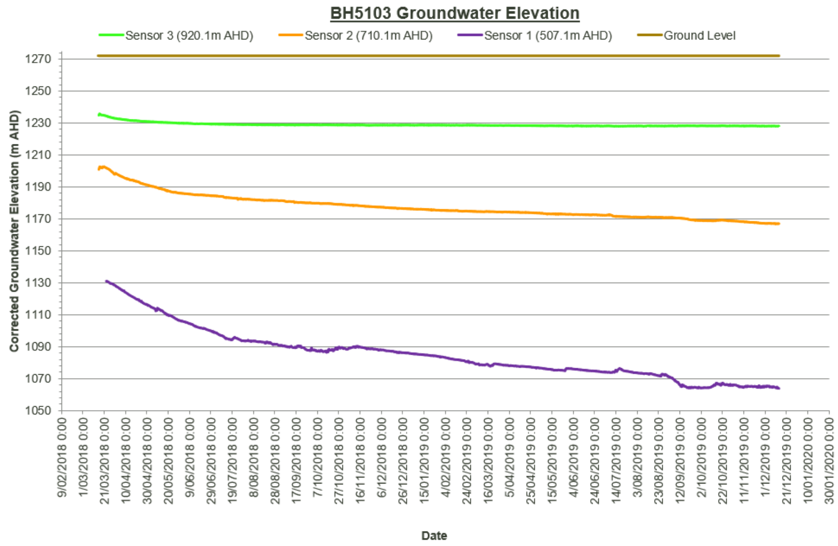

BH4102 Groundwater Elevation
Sensor 3 (1213.5m AHD)
Sensor 2 (1085.5m AHD)
Sensor 1 (1004.2m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1465
1460
1455
1450
Date

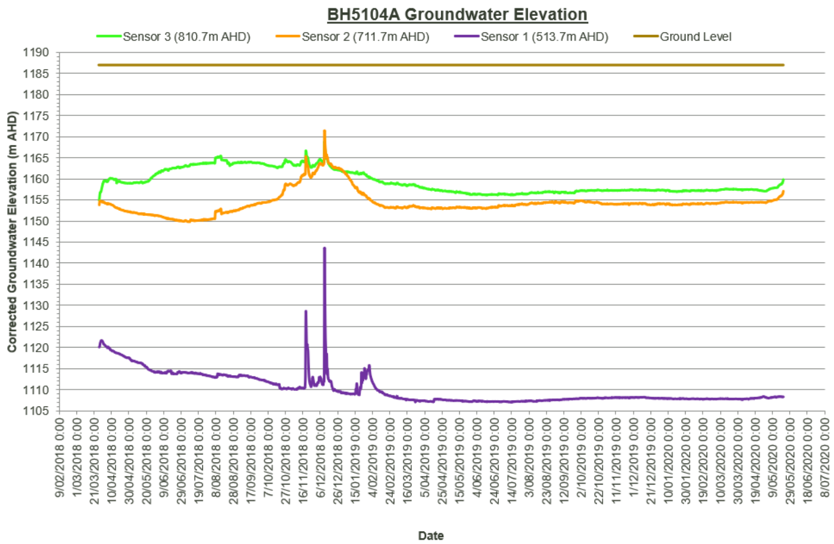

BH4103 Groundwater Elevation
Sensor 3 (1331m AHD)
Sensor 2 (1238.3m AHD)
Sensor 1 (1134.9m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1475
1470
1465
1460
Date

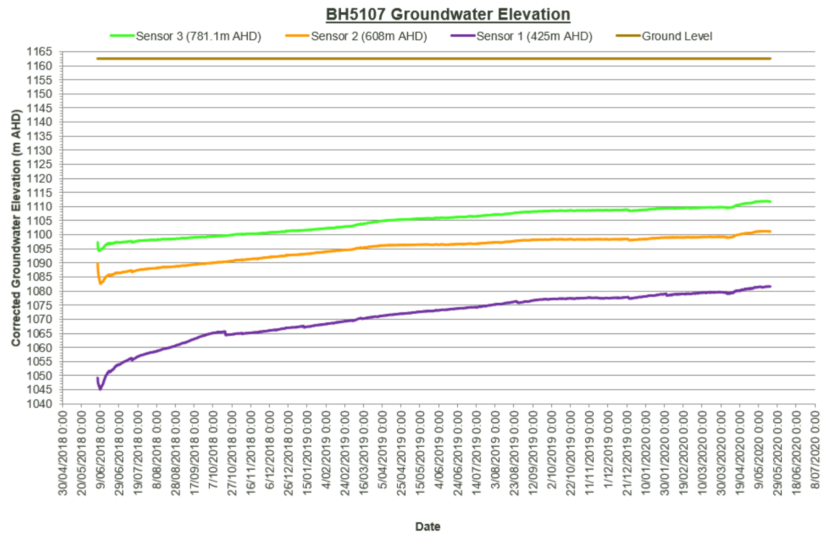

BH4104 Groundwater Elevation
Sensor 2 (977.5m AHD)
Sensor 1 (855.7m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
Date

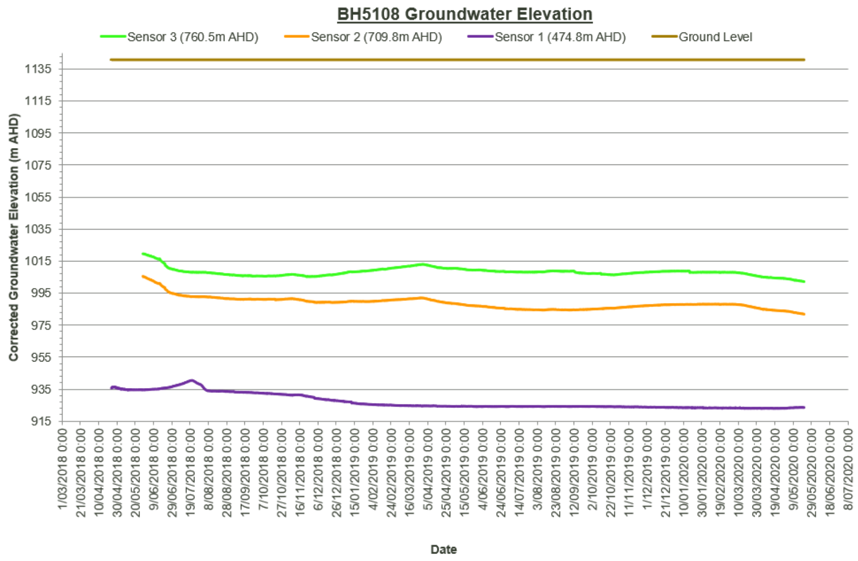

BH5101A Groundwater Elevation
Sensor 1 (1146.9m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1400
1390
1380
1370
1360
1350
1340
1330
1320
1310
Date

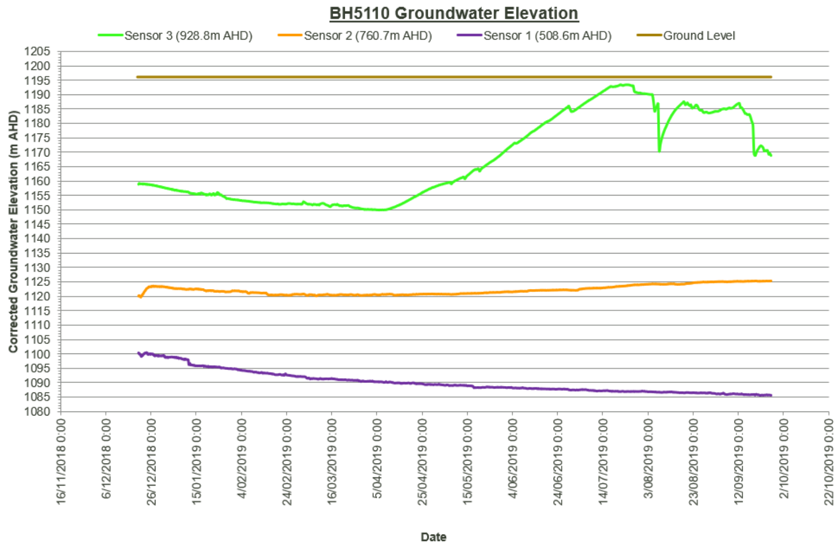

BH5102 Groundwater Elevation
Sensor 3 (909.5m AHD)
Sensor 2 (709.8m AHD)
Sensor 1 (510.1m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

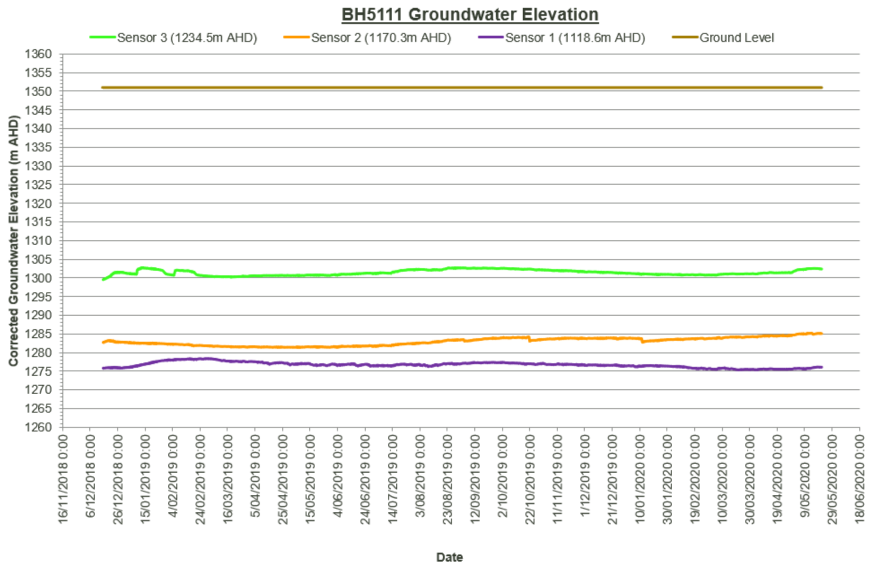

BH5103 Groundwater Elevation
Sensor 3 (920.1m AHD)
Sensor 2 (710.1m AHD)
Sensor 1 (507.1m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

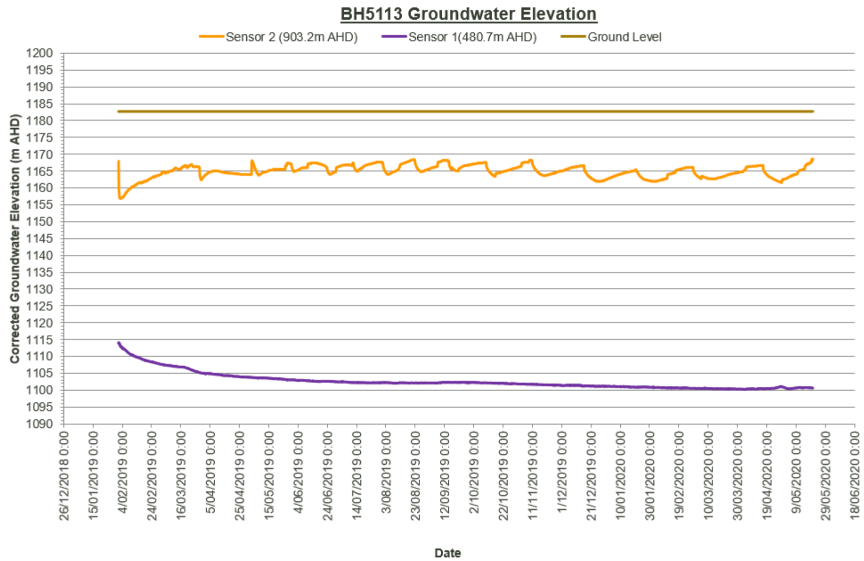

BH5104A Groundwater Elevation
Sensor 3 (810.7m AHD)
Sensor 2 (711.7m AHD)
Sensor 1 (513.7m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

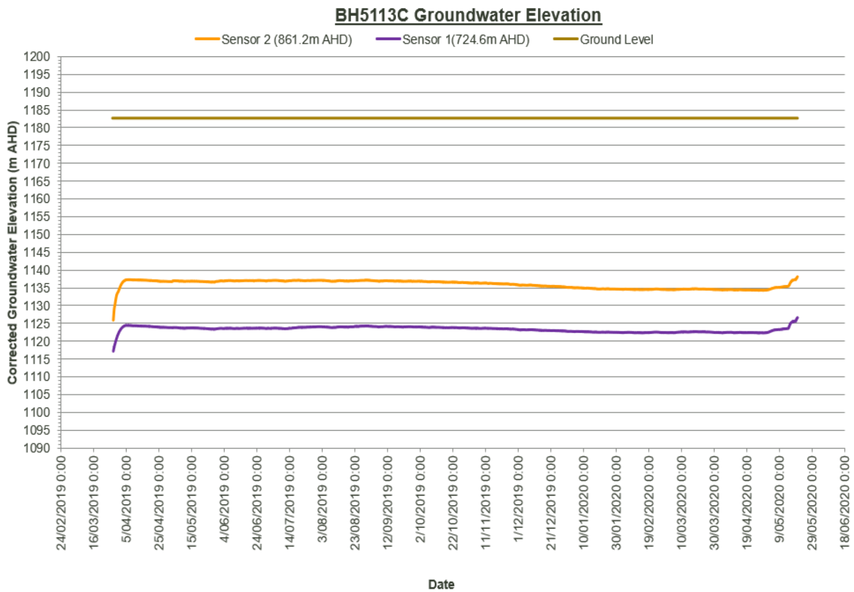

BH5107 Groundwater Elevation
Sensor 3 (781.1m AHD)
Sensor 2 (608m AHD)
Sensor 1 (425m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

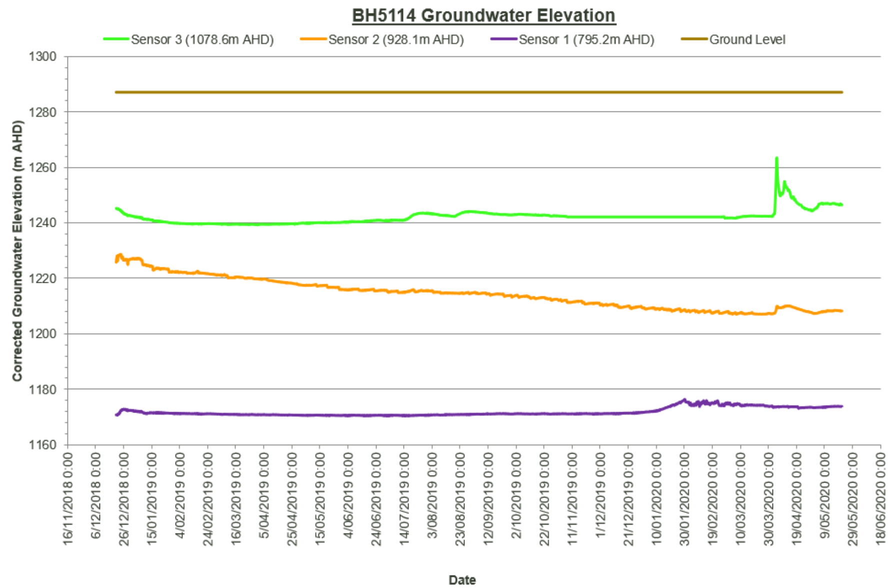

BH5108 Groundwater Elevation
Sensor 3 (760.5m AHD)
Sensor 2 (709.8m AHD)
Sensor 1 (474.8m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

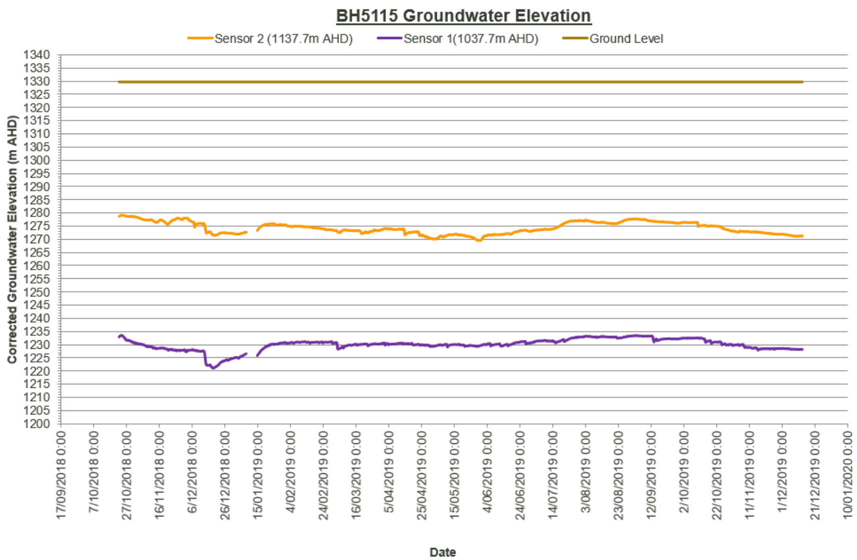

BH5110 Groundwater Elevation
Sensor 3 (928.8m AHD)
Sensor 2 (760.7m AHD)
Sensor 1 (508.6m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

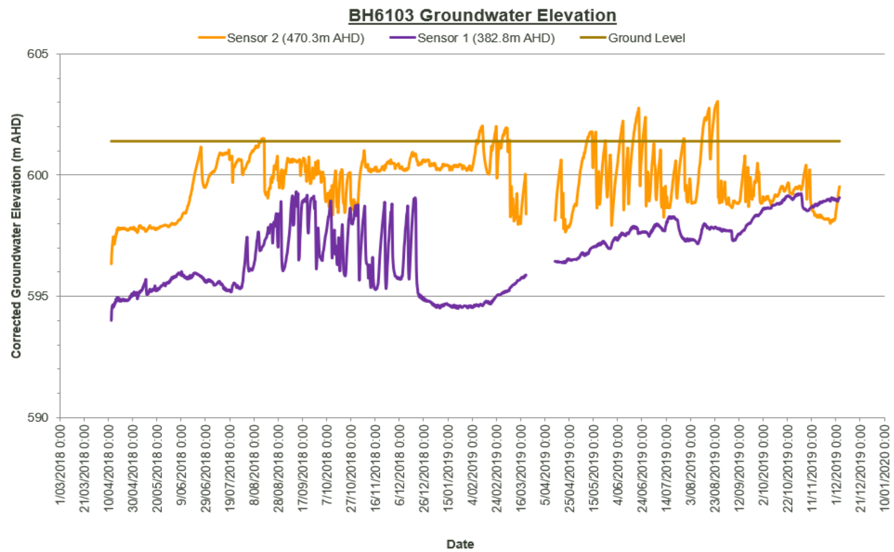

BH5111 Groundwater Elevation
Sensor 3 (1234.5m AHD)
Sensor 2 (1170.3m AHD)
Sensor 1 (1118.6m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

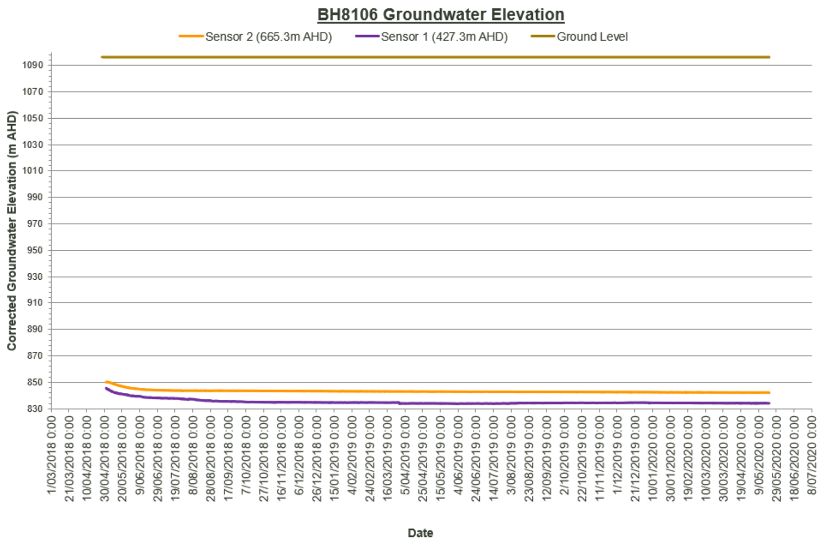

BH5113 Groundwater Elevation
Sensor 2 (903.2m AHD)
Sensor 1(480.7m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date


BH5113C Groundwater Elevation
Sensor 2 (861.2m AHD)
Sensor 1(724.6m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

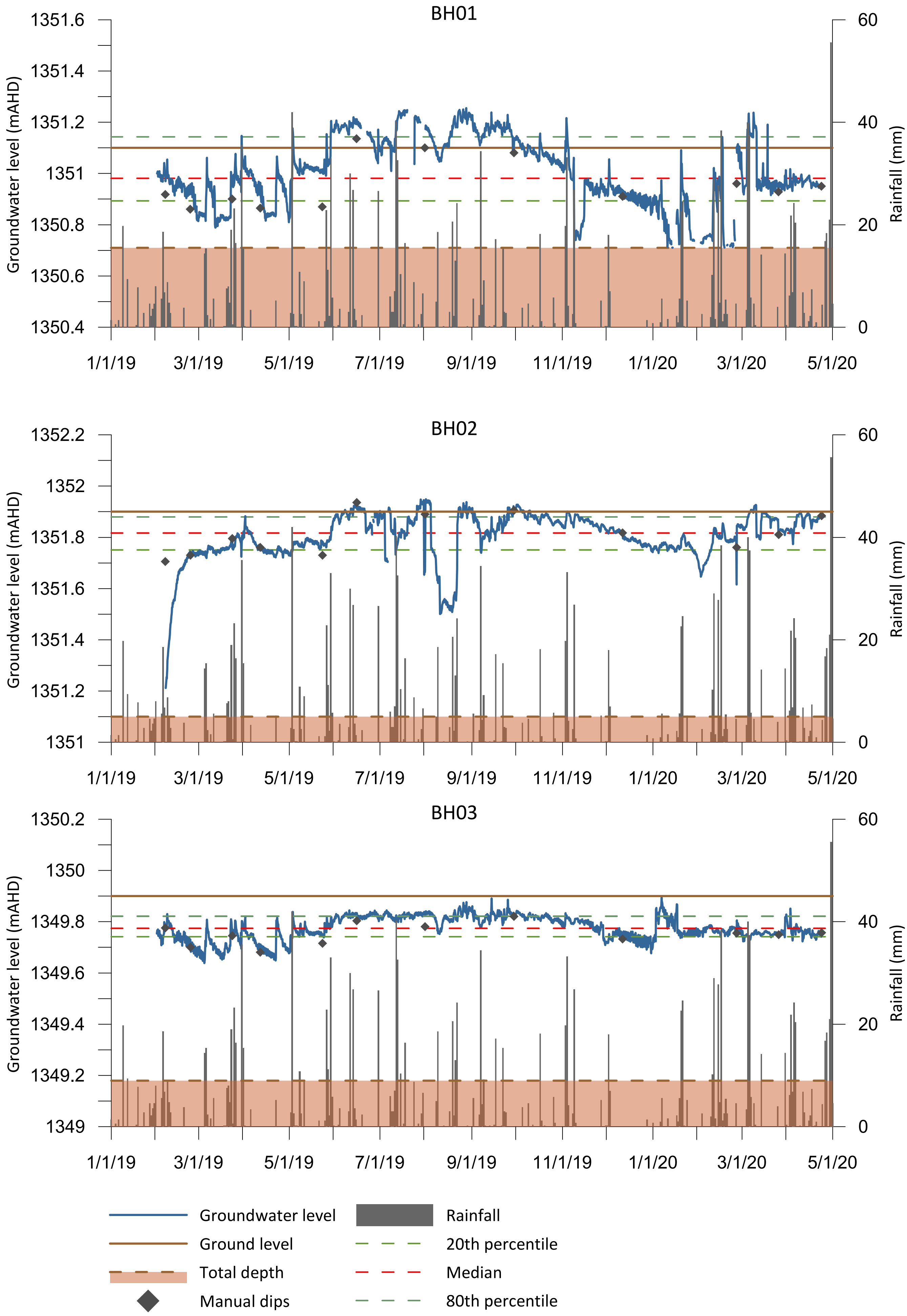

BH5114 Groundwater Elevation
Sensor 3 (1078.6m AHD)
Sensor 2 (928.1m AHD)
Sensor 1 (795.2m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date


BH5115 Groundwater Elevation
Sensor 2 (1137.7m AHD)
Sensor 1(1037.7m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

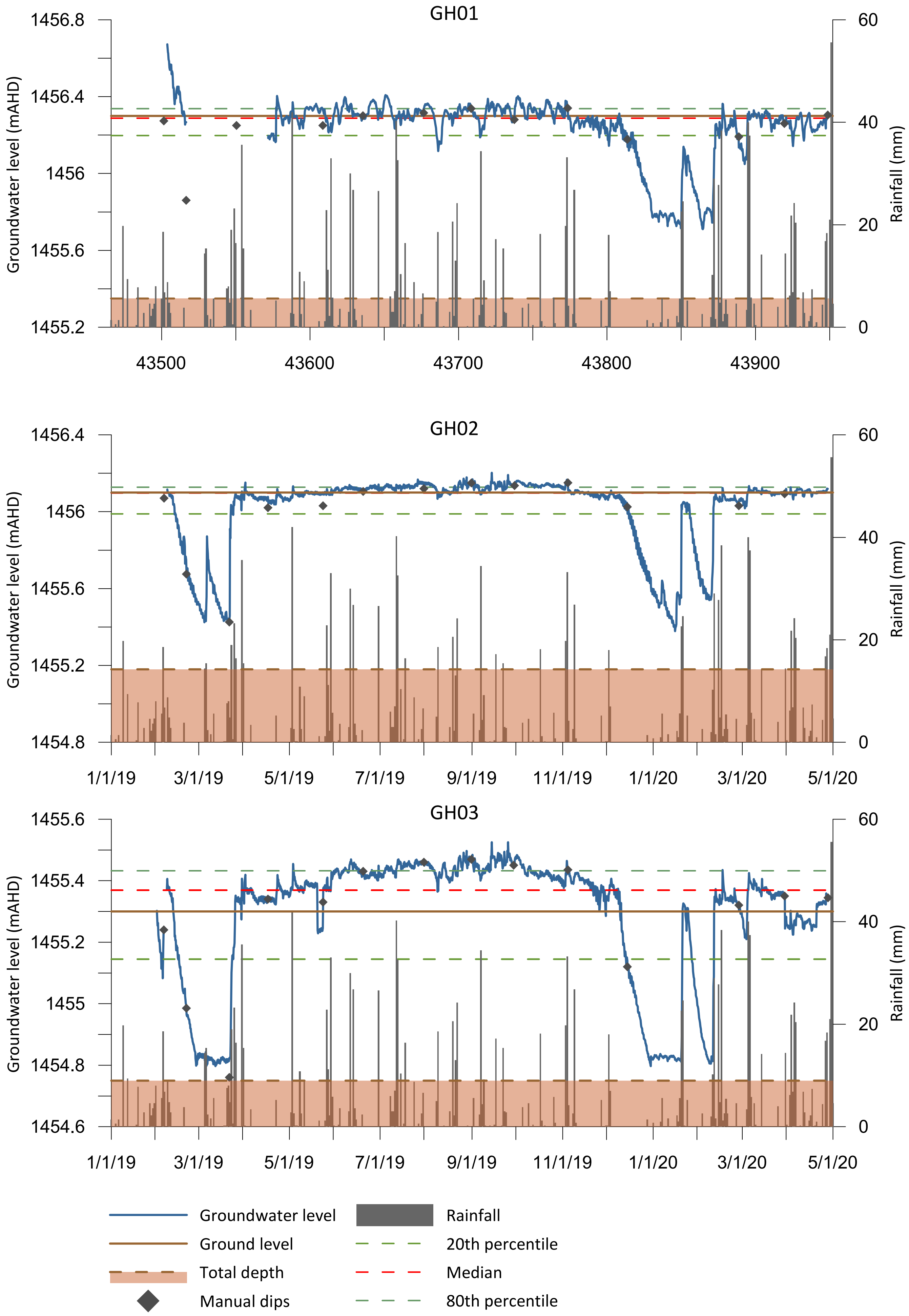

BH6103 Groundwater Elevation
Sensor 2 (470.3m AHD)
Sensor 1 (382.8m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date



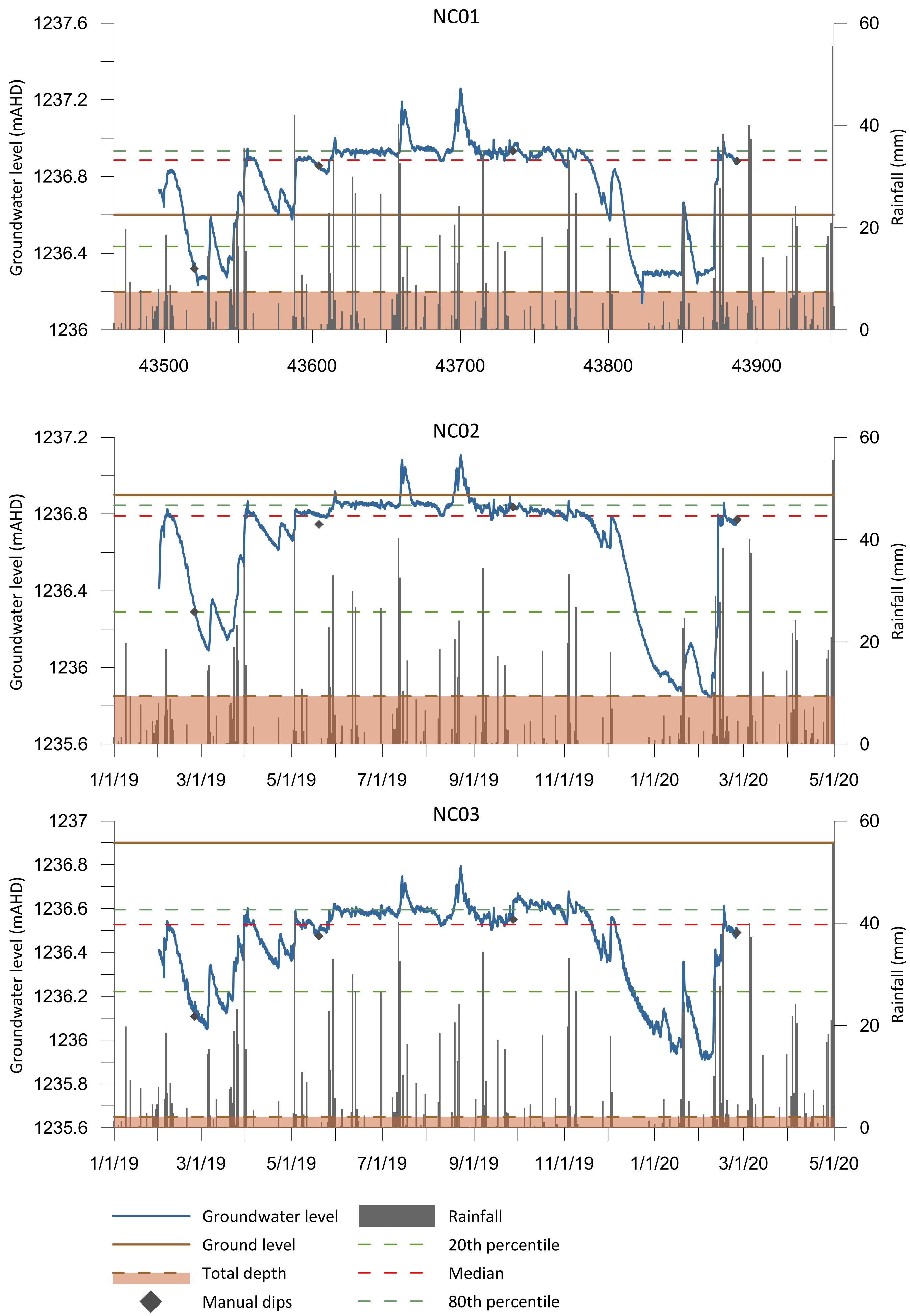
BH8106 Groundwater Elevation
Sensor 2 (665.3m AHD)
Sensor 1 (427.3m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

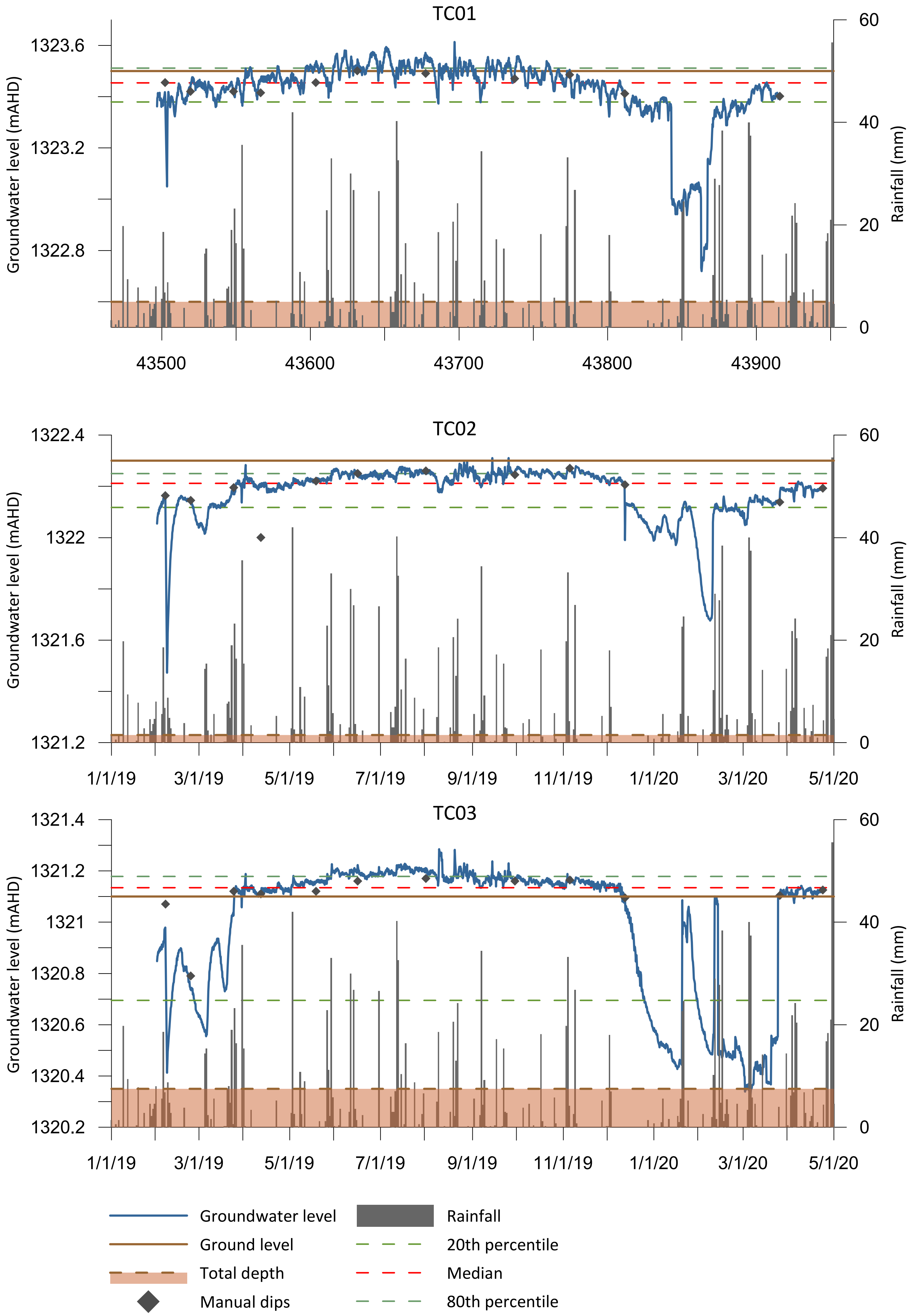


BH01
1351.6
1351.4
1351.2
1351
1350.8
1350.6
1350.4
Groundwater level (mAHD)
60
40
20
0
Rainfall (mm)
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
BH02
1352.2
1352
1351.8
1351.6
1351.4
1351.2
1351
BH03
1350.2
1350
1349.8
1349.6
1349.4
1349.2
1349
Groundwater level
Ground level
Total depth
Manual dips
Rainfall
20th percentile
Median
80th percentile



GH01
Groundwater level (mAHD)
Rainfall (mm)
1456.8
1456.4
1456
1455.6
1455.2
60
40
20
0
43500
43600
43700
43800
43900
GH02
Groundwater level (mAHD)
Rainfall (mm)
1456.4
1456
1455.6
1455.2
1454.8
60
40
20
0
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
GH03
Groundwater level (mAHD)
Rainfall (mm)
1455.6
1455.4
1455.2
1455
1454.8
1454.6
60
40
20
0
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
Groundwater level
Rainfall
Ground level
20th percentile
Total depth
Median
Manual dips
80th percentile


NC01
Groundwater level (mAHD)
Rainfall (mm)
1237.6
1237.2
1236.8
1236.4
1236
60
40
20
0
43500
43600
43700
43800
43900
NC02
Groundwater level (mAHD)
Rainfall (mm)
1237.2
1236.8
1236.4
1236
1235.6
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
NC03
Groundwater level (mAHD)
Rainfall (mm)
1237
1236.8
1236.6
1236.4
1236.2
1236
1235.8
1235.6
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
Groundwater level
Ground level
Total depth
Manual dips
Rainfall
20th percentile
Median
80th percentile


TC01
Groundwater level (mAHD)
Rainfall (mm)
1323.6
1323.2
1322.8
60
40
20
0
43500
43600
43700
43800
43900
TC02
1322.4
1322
1321.6
1321.2
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
TC03
1321.4
1321.2
1321
1320.8
1320.6
1320.4
1320.2
Groundwater level
Ground level
Total depth
Manual dips
Rainfall
20th percentile
Median
80th percentile

Baseline EIS Groundwater Quality

i Plateau

Table D.24 Baseline water quality results summary: Gooandra Volcanics and Temperance Formation

			Gooandra Volcanics (MB01C, MB02, MB03, MB11A, PB04, SMB04, SMB05, TMB02A, TMB02B, TMB03A, TMB03B, TMB03C, TMB04)				Temperance Formation (MB04A, MB04B, MB07A, MB07B MB13A, MB13B, SMB03, PB10)			
	Unit	**WQO value[1]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**
Field Parameters										
Temperature	°C	-	142/0	8.0	9.4	12.7	74/0	8.7	10.2	12.7
Dissolved oxygen	%	90-110[1]	96/95	**2**	**33**	**77**	48/47	**1**	**14**	**66**
Electrical conductivity	µS/cm	30-350[1]	142/0	41	103	175	74/43	96	**420**	**1566**
pH	-	6.5-8.0[1]	139/0	5.8	7.1	8.4	72/0	6.5	7.8	8.6
Oxidising and reducing potential	-	-	142/0	-174	82	176	74/0	-227	-79	139
TDS	NTU	-	128/0	28	67	114	67/0	66	321	827
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	93/0	13	36	64	54/0	35	89	321
Bicarbonate (as CaCO3)	mg/L	-	143/0	25	49	78	73/0	16	61	138
Carbonate (as $CaCO_3$)	mg/L	-	143/0	<1	<1	<1	73/0	<1	<1	<1
Hydroxide (as $CaCO_3$)	mg/L	-	143/0	<1	<1	<1	73/0	<1	<1	<1
Total alkalinity (as $CaCO_3$)	mg/L	-	143/0	25	49	78	73/0	18	64	147
Analytical results – nutrients										
Ammonia	mg/L	0.013	146/44	<0.01	<0.01	**0.04**	75/35	<0.01	0.01	**0.07**
Oxidised nitrogen	mg/L	0.015	147/78	<0.01	**0.02**	**0.22**	75/37	<0.01	0.01	**0.27**
Total kjeldahl nitrogen	mg/L	-	146/0	<0.1	<0.1	0.2	75/0	<0.1	<0.1	0.4

Table D.24 Baseline water quality results summary: Gooandra Volcanics and Temperance Formation

	Unit	WQO value[1]	Gooandra Volcanics (MB01C, MB02, MB03, MB11A, PB04, SMB04, SMB05, TMB02A, TMB02B, TMB03A, TMB03B, TMB03C, TMB04)				Temperance Formation (MB04A, MB04B, MB07A, MB07B MB13A, MB13B, SMB03, PB10)			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total nitrogen	mg/L	0.25	146/18	<0.1	<0.1	**0.4**	75/17	<0.1	0.1	**0.6**
Reactive phosphorus	mg/L	0.015	93/16	<0.01	<0.01	**0.02**	53/13	<0.01	<0.01	**0.02**
Total phosphorus	mg/L	0.020	146/66	<0.01	0.02	**0.12**	75/41	<0.01	**0.03**	**0.19**
Analytical results – major ions										
Calcium	mg/L	-	143/0	4	12	20	73/0	8	25	117
Chloride	mg/L	-	143/0	<1	<1	2	73/0	<1	6	45
Magnesium	mg/L	-	143/0	<1	2	5	73/0	1	4	7
Sodium	mg/L	-	143/0	2	6	9	73/0	4	30	112
Potassium	mg/L	-	143/0	<1	<1	2	73/0	<1	2	9
Sulphate	mg/L	-	143/0	<1	3	14	73/0	7	82	363
Cyanide	mg/L	0.004	88/0	<0.004	<0.004	<0.004	51/0	<0.004	<0.004	<0.004
Fluoride	mg/L	2.4	143/0	<0.1	<0.1	0.2	73/0	<0.1	0.4	0.7
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	92/7	<0.01	<0.01	0.02	53/14	<0.01	0.01	**0.13**
Arsenic (As)	mg/L	0.0008[2,6]	146/68	<0.001	<0.001	**0.007**	75/32	<0.001	<0.001	**0.028**
Barium (Ba)	mg/L	-	92/0	0.004	0.015	0.026	53/0	0.005	0.036	0.141
Beryllium (Be)	mg/L	-	92/0	<0.001	<0.001	<0.001	53/0	<0.001	<0.001	<0.001

Table D.24 Baseline water quality results summary: Gooandra Volcanics and Temperance Formation

			Gooandra Volcanics (MB01C, MB02, MB03, MB11A, PB04, SMB04, SMB05, TMB02A, TMB02B, TMB03A, TMB03B, TMB03C, TMB04)				Temperance Formation (MB04A, MB04B, MB07A, MB07B MB13A, MB13B, SMB03, PB10)			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Boron (B)	mg/L	0.09	92/1	<0.05	<0.05	<0.05	53/4	<0.05	<0.05	0.09
Cadmium (Cd)	mg/L	0.00006[6]	146/1	<0.0001	<0.0001	<0.0001	75/0	<0.0001	<0.0001	<0.0001
Total chromium (Cr)	mg/L	0.00001[3,6]	146/11	<0.001	<0.001	<0.001	75/5	<0.001	<0.001	<0.001
Cobalt (Co)	mg/L	0.0014[4]	92/0	<0.001	<0.001	<0.001	53/0	<0.001	<0.001	<0.001
Copper (Cu)	mg/L	0.001	146/83	<0.001	**0.002**	**0.011**	75/38	<0.001	**0.002**	**0.010**
Iron (Fe)	mg/L	0.3[4]	92/21	<0.05	<0.05	**1.58**	53/11	<0.05	0.05	**1.40**
Lead (Pb)	mg/L	0.001	146/4	<0.001	<0.001	<0.001	75/3	<0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.2	92/0	<0.001	0.015	0.291	53/0	<0.001	0.093	0.189
Mercury (Hg)	mg/L	0.00006[6]	146/1	<0.0001	<0.0001	<0.0001	75/1	<0.0001	<0.0001	<0.0001
Nickel (Ni)	mg/L	0.008	146/7	<0.001	<0.001	0.005	75/4	<0.001	<0.001	0.004
Selenium (Se)	mg/L	0.005[6]	92/0	<0.01	<0.01	<0.01	53/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	92/0	<0.001	<0.001	<0.001	53/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	92/0	<0.01	<0.01	<0.01	53/1	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	146/86	<0.005	**0.006**	**0.015**	75/45	<0.005	**0.006**	**0.037**

Notes:
1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.

5. If less than 10 samples are available, the minimum value is reported instead of the 10^{th} percentile value and the maximum value is reported instead of the 90^{th} percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.25 Baseline water quality results summary: Boggy Plain Suite and Tantangara Formation

			Boggy Plain Suite (SMB02)				Tantangara Formation (MB08A, MB08B, PB06)			
	Unit	**WQO value[1]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**
Field Parameters										
Temperature	°C	-	6/0	5.0	12.8	25.8	9/0	10.4	11.3	13.8
Dissolved oxygen	%	90-110[1]	6/6	**0**	**50**	**84**	4/4	**2**	**6**	**55**
Electrical conductivity	µS/cm	30-350[1]	6/0	173	197	225	9/0	118	246	300
pH	-	6.5-8.0[1]	6/0	7.3	7.7	8.3	9/0	6.7	7.8	8.8
Oxidising and reducing potential	-	-	6/0	-85	85	131	9/0	-249	-186	74
TDS	NTU	-	6/0	112	128	148	8/0	77	163	196
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	4/0	68	76	83	9/0	41	81	86
Bicarbonate (as CaCO3)	mg/L	-	6/0	76	87	94	9/0	52	107	114
Carbonate (as $CaCO_3$)	mg/L	-	6/0	<1	<1	<1	9/0	<1	<1	16
Hydroxide (as $CaCO_3$)	mg/L	-	6/0	<1	<1	<1	9/0	<1	<1	<1
Total alkalinity (as $CaCO_3$)	mg/L	-	6/0	76	87	94	9/0	52	107	130
Analytical results – nutrients										
Ammonia	mg/L	0.013	6/1	<0.01	<0.01	**0.02**	9/2	<0.01	<0.01	**0.03**
Oxidised nitrogen	mg/L	0.015	6/3	<0.01	**0.03**	**0.44**	9/2	<0.01	<0.01	**0.02**
Total kjeldahl nitrogen	mg/L	-	6/0	<0.1	0.3	0.4	9/0	<0.1	<0.1	6.4
Total nitrogen	mg/L	0.25	6/4	<0.1	**0.3**	**0.8**	9/2	<0.1	<0.1	**6.4**

Table D.25 Baseline water quality results summary: Boggy Plain Suite and Tantangara Formation

	Unit	WQO value[1]	Boggy Plain Suite (SMB02) # Samples/ exceedances[7]	Boggy Plain Suite (SMB02) Min/10P[5]	Boggy Plain Suite (SMB02) Median	Boggy Plain Suite (SMB02) Max/90P[5]	Tantangara Formation (MB08A, MB08B, PB06) # Samples/ exceedances[7]	Tantangara Formation (MB08A, MB08B, PB06) Min/10P[5]	Tantangara Formation (MB08A, MB08B, PB06) Median	Tantangara Formation (MB08A, MB08B, PB06) Max/90P[5]
Reactive phosphorus	mg/L	0.015	4/0	<0.01	<0.01	<0.01	9/4	<0.01	0.01	**0.02**
Total phosphorus	mg/L	0.020	6/3	<0.01	**0.03**	**0.07**	9/5	<0.01	**0.03**	**15.20**
Analytical results – major ions										
Calcium	mg/L	-	6/0	21	25	30	9/0	10	16	18
Chloride	mg/L	-	6/0	1	2	5	9/0	<1	2	3
Magnesium	mg/L	-	6/0	2	2	2	9/0	4	10	10
Sodium	mg/L	-	6/0	10	10	14	9/0	4	31	47
Potassium	mg/L	-	6/0	<1	<1	4	9/0	<1	4	6
Sulphate	mg/L	-	6/0	6	7	16	9/0	<1	30	39
Cyanide	mg/L	0.004	4/0	<0.004	<0.004	<0.004	9/0	<0.004	<0.004	<0.004
Fluoride	mg/L	2.4	6/0	0.3	0.3	0.4	9/0	<0.1	0.4	0.5
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	4/4	**0.03**	**0.05**	**0.10**	9/2	<0.01	0.01	**0.58**
Arsenic (As)	mg/L	0.0008[2,6]	6/0	<0.001	<0.001	<0.001	9/7	<0.001	**0.004**	**0.016**
Barium (Ba)	mg/L	-	4/0	0.013	0.018	0.021	9/0	0.033	0.448	1.020
Beryllium (Be)	mg/L	-	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001
Boron (B)	mg/L	0.09	4/0	<0.05	<0.05	<0.05	9/0	<0.05	<0.05	<0.05
Cadmium (Cd)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	9/0	<0.0001	<0.0001	<0.0001

Table D.25 Baseline water quality results summary: Boggy Plain Suite and Tantangara Formation

			Boggy Plain Suite (SMB02)				Tantangara Formation (MB08A, MB08B, PB06)			
	Unit	**WQO value[1]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**
Total chromium (Cr)	mg/L	0.00001[3,6]	6/3	<0.001	<0.001	**0.002**	9/1	<0.001	<0.001	**0.001**
Cobalt (Co)	mg/L	0.0014[4]	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	0.001
Copper (Cu)	mg/L	0.001	6/5	<0.001	**0.003**	**0.006**	9/3	<0.001	<0.001	**0.005**
Iron (Fe)	mg/L	0.3[4]	4/0	<0.05	0.06	0.10	9/1	<0.05	0.10	**0.57**
Lead (Pb)	mg/L	0.001	6/0	<0.001	<0.001	<0.001	9/1	<0.001	<0.001	**0.002**
Manganese (Mn)	mg/L	1.2	4/0	0.002	0.004	0.007	9/0	0.009	0.145	0.388
Mercury (Hg)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	9/0	<0.0001	<0.0001	<0.0001
Nickel (Ni)	mg/L	0.008	6/0	<0.001	<0.001	0.001	9/0	<0.001	<0.001	0.002
Selenium (Se)	mg/L	0.005[6]	4/0	<0.01	<0.01	<0.01	9/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	4/0	<0.01	<0.01	<0.01	9/0	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	6/6	**0.016**	**0.042**	**0.071**	9/4	<0.005	<0.005	**0.104**

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10^{th} percentile value and the maximum value is reported instead of the 90^{th} percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.26 Baseline water quality results summary: Kellys Plain Volcanics and Tertiary basalt

			Kellys Plain Volcanics (PB01)				Tertiary basalt (MB01B)			
	Unit	**WQO value[1]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**
Field Parameters										
Temperature	°C	-	6/0	10.4	13.8	16.0	16/0	8.6	9.1	12.3
Dissolved oxygen	%	90-110[1]	5/5	**1**	**19**	**29**	12/12	**29**	**49**	**66**
Electrical conductivity	µS/cm	30-350[1]	6/0	97	146	165	16/0	47	82	176
pH	-	6.5-8.0[1]	5/0	8.3	9.1	9.9	16/0	5.4	5.8	7.9
Oxidising and reducing potential	-	-	6/0	-105	78	205	16/0	44	116	177
TDS	NTU	-	5/0	81	96	107	13/0	31	52	104
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	4/0	50	55	60	9/0	18	36	114
Bicarbonate (as CaCO3)	mg/L	-	6/0	39	63	77	15/0	22	39	63
Carbonate (as $CaCO_3$)	mg/L	-	6/0	<1	10	18	15/0	<1	<1	<1
Hydroxide (as $CaCO_3$)	mg/L	-	6/0	<1	<1	<1	15/0	<1	<1	<1
Total alkalinity (as $CaCO_3$)	mg/L	-	6/0	55	72	83	15/0	22	39	63
Analytical results – nutrients										
Ammonia	mg/L	0.013	6/3	<0.01	**0.02**	**0.08**	16/5	<0.01	<0.01	**0.09**
Oxidised nitrogen	mg/L	0.015	6/4	<0.01	**0.02**	**0.06**	16/13	<0.01	**0.04**	**0.17**
Total kjeldahl nitrogen	mg/L	-	6/0	<0.1	<0.1	0.2	16/0	<0.1	<0.1	0.6
Total nitrogen	mg/L	0.25	6/0	<0.1	<0.1	0.2	16/4	<0.1	<0.1	**0.6**

Table D.26 Baseline water quality results summary: Kellys Plain Volcanics and Tertiary basalt

			Kellys Plain Volcanics (PB01)				Tertiary basalt (MB01B)			
	Unit	**WQO value[1]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**
Reactive phosphorus	mg/L	0.015	4/0	<0.01	<0.01	<0.01	9/2	<0.01	<0.01	**0.06**
Total phosphorus	mg/L	0.020	6/3	<0.01	**0.04**	**0.25**	16/16	**0.08**	**0.62**	**1.85**
Analytical results – major ions										
Calcium	mg/L	-	6/0	8	11	13	15/0	4	8	19
Chloride	mg/L	-	6/0	<1	1	5	15/0	<1	<1	1
Magnesium	mg/L	-	6/0	4	7	8	15/0	1	2	3
Sodium	mg/L	-	6/0	9	11	11	15/0	1	1	4
Potassium	mg/L	-	6/0	<1	<1	1	15/0	<1	<1	3
Sulphate	mg/L	-	6/0	<1	9	10	15/0	<1	2	10
Cyanide	mg/L	0.004	4/0	<0.004	<0.004	<0.004	8/0	<0.004	<0.004	<0.004
Fluoride	mg/L	2.4	6/0	<0.1	<0.1	0.2	15/0	<0.1	<0.1	<0.1
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	4/0	<0.01	<0.01	<0.01	9/1	<0.01	0.01	**0.08**
Arsenic (As)	mg/L	0.0008[2,6]	6/0	<0.001	<0.001	<0.001	16/2	<0.001	<0.001	**0.002**
Barium (Ba)	mg/L	-	4/0	0.016	0.038	0.056	9/0	0.011	0.026	2.390
Beryllium (Be)	mg/L	-	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001
Boron (B)	mg/L	0.09	4/0	<0.05	<0.05	<0.05	9/1	<0.05	<0.05	**1.06**
Cadmium (Cd)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	16/0	<0.0001	<0.0001	<0.0001

Table D.26 Baseline water quality results summary: Kellys Plain Volcanics and Tertiary basalt

			Kellys Plain Volcanics (PB01)				Tertiary basalt (MB01B)			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total chromium (Cr)	mg/L	0.00001[3,6]	6/0	<0.001	<0.001	<0.001	16/3	<0.001	<0.001	**0.002**
Cobalt (Co)	mg/L	0.0014[4]	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	0.001
Copper (Cu)	mg/L	0.001	6/1	<0.001	0.001	**0.002**	16/15	**0.003**	**0.010**	**0.024**
Iron (Fe)	mg/L	0.3[4]	4/0	<0.05	<0.05	0.13	9/0	<0.05	<0.05	0.21
Lead (Pb)	mg/L	0.001	6/0	<0.001	<0.001	<0.001	16/1	<0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.2	4/0	0.019	0.022	0.038	9/0	0.004	0.012	0.137
Mercury (Hg)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	16/0	<0.0001	<0.0001	<0.0001
Nickel (Ni)	mg/L	0.008	6/0	<0.001	<0.001	0.001	16/0	<0.001	0.001	0.003
Selenium (Se)	mg/L	0.005[6]	4/0	<0.01	<0.01	<0.01	9/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	4/0	<0.01	<0.01	<0.01	9/0	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	6/0	<0.005	<0.005	<0.005	16/10	<0.005	**0.006**	**0.012**

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.27 Baseline water quality results summary: Plateau bogs/fens

	Unit	WQO value[1]	Plateau bogs/fens (BH01, BH02, BH03, GH01, GH02, GH03, TC01, TC02, TC03)							
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters										
Temperature	°C	-	9/0	16.4	17.6	24.3	-	-	-	-
Dissolved oxygen	%	90-110[1]	9/9	**0**	**13**	**22**	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	9/0	42	103	343	-	-	-	-
pH	-	6.5-8.0[1]	9/8	**4.2**	**5.7**	6.7	-	-	-	-
Oxidising and reducing potential	-	-	9/0	-135	-4	145	-	-	-	-
TDS	NTU	-	9/0	27	67	223	-	-	-	-
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	8/0	2	8	90	-	-	-	-
Bicarbonate (as CaCO3)	mg/L	-	7/0	11	31	101	-	-	-	-
Carbonate (as $CaCO_3$)	mg/L	-	7/0	<1	<1	<1	-	-	-	-
Hydroxide (as $CaCO_3$)	mg/L	-	7/0	<1	<1	<1	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	7/0	11	31	101	-	-	-	-
Analytical results – nutrients										
Ammonia	mg/L	0.013	8/8	**0.02**	**0.11**	**0.54**	-	-	-	-
Oxidised nitrogen	mg/L	0.015	8/5	<0.01	**0.06**	**0.33**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	8/0	<0.1	3.8	421.0	-	-	-	-
Total nitrogen	mg/L	0.25	8/7	<0.1	**4.0**	**421.0**	-	-	-	-

Table D.27 Baseline water quality results summary: Plateau bogs/fens

	Unit	WQO value[1]	Plateau bogs/fens (BH01, BH02, BH03, GH01, GH02, GH03, TC01, TC02, TC03)							
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Reactive phosphorus	mg/L	0.015	8/1	<0.01	<0.01	**0.02**	-	-	-	-
Total phosphorus	mg/L	0.020	8/8	**0.09**	**1.73**	**74.20**	-	-	-	-
Analytical results – major ions										
Calcium	mg/L	-	8/0	1	2	26	-	-	-	-
Chloride	mg/L	-	8/0	<1	4	6	-	-	-	-
Magnesium	mg/L	-	8/0	<1	<1	6	-	-	-	-
Sodium	mg/L	-	8/0	2	7	28	-	-	-	-
Potassium	mg/L	-	8/0	<1	<1	2	-	-	-	-
Sulphate	mg/L	-	8/0	1	9	36	-	-	-	-
Cyanide	mg/L	0.004	8/0	<0.004[8]	<0.004[8]	<0.4[8]	-	-	-	-
Fluoride	mg/L	2.4	8/0	<0.1[8]	<0.1[8]	<1[8]	-	-	-	-
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	8/6	<0.01	**0.15**	**8.63**	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	8/0	<0.001	<0.001	<0.01[8]	-	-	-	-
Barium (Ba)	mg/L	-	8/0	0.012	0.017	1.370	-	-	-	-
Beryllium (Be)	mg/L	-	8/0	<0.001	<0.001	<0.01[8]	-	-	-	-
Boron (B)	mg/L	0.09	8/1	<0.05	<0.05	**0.93**	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	8/0	<0.0001	<0.0001	<0.001[8]	-	-	-	-

Table D.27 Baseline water quality results summary: Plateau bogs/fens

	Unit	WQO value[1]	Plateau bogs/fens (BH01, BH02, BH03, GH01, GH02, GH03, TC01, TC02, TC03)							
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total chromium (Cr)	mg/L	0.00001[3,6]	8/2	<0.001	<0.001	**0.010**	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	8/3	<0.001	**0.002**	**0.010**	-	-	-	-
Copper (Cu)	mg/L	0.001	8/2	<0.001	<0.001	**0.010**	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	8/5	<0.05	**0.75**	**2.41**	-	-	-	-
Lead (Pb)	mg/L	0.001	8/0	<0.001	<0.001	<0.01[8]	-	-	-	-
Manganese (Mn)	mg/L	1.2	8/0	0.008	0.039	0.399	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	8/0	<0.0001	<0.0001	<0.001[8]	-	-	-	-
Nickel (Ni)	mg/L	0.008	8/0	<0.001	<0.001	**0.010**	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	8/0	<0.01	<0.01	<0.1[8]	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	8/0	<0.001	<0.001	<0.01[8]	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	8/1	<0.01	<0.01	**0.10**	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	8/5	<0.005	**0.009**	**0.479**	-	-	-	-

Notes:
1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
8. Where more than one LOR has been used in the reporting of an analyte, the lowest and highest LOR are considered in calculating 10th percentile, median and 90th percentile values.

Bold denotes WQO value is exceeded.

ii Ravine

Table D.28 Baseline water quality results summary: Ravine Beds

	Unit	WQO value[1]	Ravine Beds East (MB12A, MB12B, PB09) # Samples/ exceedances[7]	Ravine Beds East Min/10P[5]	Ravine Beds East Median	Ravine Beds East Max/90P[5]	Ravine Beds West (PB05, BH8101, BH8102, EWPB1, EWPB3, TMB01B, TMB05A, TMB05B) # Samples/ exceedances[7]	Ravine Beds West Min/10P[5]	Ravine Beds West Median	Ravine Beds West Max/90P[5]
Field Parameters										
Temperature	°C	-	14/0	10.5	12.3	13.7	33/0	13.1	15.7	21.0
Dissolved oxygen	%	90-110[1]	6/6	**0**	**7**	**15**	26/25	**0**	**5**	**74**
Electrical conductivity	µS/cm	30-350[1]	14/4	137	223	**647**	33/28	196	**677**	**2342**
pH	-	6.5-8.0[1]	14/0	5.3	6.9	7.6	33/0	7.4	7.7	9.2
Oxidising and reducing potential	-	-	14/0	-243	-103	123	33/0	-198	-153	108
TDS	NTU	-	12/0	91	145	406	32/0	139	442	1524
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	14/0	65	76	156	27/0	29	99	166
Bicarbonate (as CaCO3)	mg/L	-	14/0	61	80	192	34/0	82	278	1002
Carbonate (as $CaCO_3$)	mg/L	-	14/0	<1	<1	<1	34/0	<1	<1	52
Hydroxide (as $CaCO_3$)	mg/L	-	14/0	<1	<1	<1	34/0	<1	<1	<1
Total alkalinity (as $CaCO_3$)	mg/L	-	14/0	61	80	192	34/0	82	325	1002
Analytical results – nutrients										
Ammonia	mg/L	0.013	14/2	<0.01	<0.01	**0.02**	34/29	0.01	**0.21**	**0.25**
Oxidised nitrogen	mg/L	0.015	14/5	<0.01	<0.01	**0.02**	34/19	<0.01	**0.02**	**0.26**
Total kjeldahl nitrogen	mg/L	-	14/0	<0.1	<0.1	1.6	34/0	<0.1	0.2	0.4

Table D.28 Baseline water quality results summary: Ravine Beds

			Ravine Beds East (MB12A, MB12B, PB09)				Ravine Beds West (PB05, BH8101, BH8102, EWPB1, EWPB3, TMB01B, TMB05A, TMB05B)			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total nitrogen	mg/L	0.25	14/4	<0.1	<0.1	**1.6**	34/13	<0.1	0.2	**0.6**
Reactive phosphorus	mg/L	0.015	14/0	<0.01	<0.01	0.01	27/10	<0.01	<0.01	**0.05**
Total phosphorus	mg/L	0.020	14/6	<0.01	0.02	**0.56**	34/19	<0.01	**0.03**	**0.19**
Analytical results – major ions										
Calcium	mg/L	-	14/0	14	16	48	34/0	5	19	25
Chloride	mg/L	-	14/0	<1	1	12	34/0	1	12	191
Magnesium	mg/L	-	14/0	7	8	10	34/0	4	10	21
Sodium	mg/L	-	14/0	2	7	87	34/0	9	154	516
Potassium	mg/L	-	14/0	<1	<1	2	34/0	2	5	12
Sulphate	mg/L	-	14/0	<1	4	139	34/0	3	9	23
Cyanide	mg/L	0.004	14/0	<0.004	<0.004	<0.004	26/0	<0.004	<0.004	<0.004
Fluoride	mg/L	2.4	14/0	<0.1	<0.1	0.1	34/12	0.2	1.8	**4.0**
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	14/0	<0.01	<0.01	<0.01	26/7	<0.01	0.01	**0.04**
Arsenic (As)	mg/L	0.0008[2,6]	14/5	<0.001	<0.001	**0.005**	34/28	<0.001	**0.004**	**0.037**
Barium (Ba)	mg/L	-	14/0	0.029	0.040	0.057	26/0	0.059	0.408	7.410
Beryllium (Be)	mg/L	-	14/0	<0.001	<0.001	<0.001	26/0	<0.001	<0.001	<0.001

Table D.28 Baseline water quality results summary: Ravine Beds

	Unit	WQO value[1]	Ravine Beds East (MB12A, MB12B, PB09) # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	Ravine Beds West (PB05, BH8101, BH8102, EWPB1, EWPB3, TMB01B, TMB05A, TMB05B) # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Boron (B)	mg/L	0.09	14/0	<0.05	<0.05	<0.05	26/20	<0.05	**0.48**	**1.54**
Cadmium (Cd)	mg/L	0.00006[6]	14/1	<0.0001	<0.0001	<0.0001	34/0	<0.0001	<0.0001	<0.0001
Total chromium (Cr)	mg/L	0.00001[3,6]	14/0	<0.001	<0.001	<0.001	34/7	<0.001	<0.001	**0.002**
Cobalt (Co)	mg/L	0.0014[4]	14/2	<0.001	<0.001	**0.002**	26/6	<0.001	<0.001	**0.002**
Copper (Cu)	mg/L	0.001	14/5	<0.001	<0.001	**0.038**	34/7	<0.001	<0.001	**0.003**
Iron (Fe)	mg/L	0.3[4]	14/4	<0.05	0.06	**26.64**	26/2	<0.05	0.12	0.25
Lead (Pb)	mg/L	0.001	14/0	<0.001	<0.001	<0.001	34/0	<0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.2	14/0	0.079	0.250	0.432	26/0	0.005	0.064	0.158
Mercury (Hg)	mg/L	0.00006[6]	14/0	<0.0001	<0.0001	<0.0001	34/0	<0.0001	<0.0001	<0.0001
Nickel (Ni)	mg/L	0.008	14/4	<0.001	0.003	**0.016**	34/2	<0.001	0.001	0.007
Selenium (Se)	mg/L	0.005[6]	14/0	<0.01	<0.01	<0.01	26/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	14/0	<0.001	<0.001	<0.001	26/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	14/0	<0.01	<0.01	<0.01	26/0	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	14/6	<0.005	<0.005	**0.027**	34/15	<0.005	<0.005	**0.012**

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.

5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.29 Baseline water quality results summary: Boraig Group

			Boraig Group (MB06A, MB06B, TMB01A)							
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters										
Temperature	°C	-	37/0	10.4	11.2	14.9	-	-	-	-
Dissolved oxygen	%	90-110[1]	28/28	**1**	**19**	**47**	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	37/15	92	265	**395**	-	-	-	-
pH	-	6.5-8.0[1]	37/0	5.7	6.7	7.7	-	-	-	-
Oxidising and reducing potential	-	-	37/0	-158	15	178	-	-	-	-
TDS	NTU	-	35/0	63	228	257	-	-	-	-
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	25/0	35	51	126	-	-	-	-
Bicarbonate (as CaCO3)	mg/L	-	39/0	51	92	166	-	-	-	-
Carbonate (as $CaCO_3$)	mg/L	-	39/0	<1	<1	<1	-	-	-	-
Hydroxide (as $CaCO_3$)	mg/L	-	39/0	<1	<1	<1	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	39/0	51	92	166	-	-	-	-
Analytical results – nutrients										
Ammonia	mg/L	0.013	38/14	<0.01	<0.01	**0.04**	-	-	-	-
Oxidised nitrogen	mg/L	0.015	39/12	<0.01	<0.01	**0.03**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	38/0	<0.1	<0.1	0.2	-	-	-	-
Total nitrogen	mg/L	0.25	38/4	<0.1	<0.1	0.2	-	-	-	-

Table D.29 Baseline water quality results summary: Boraig Group

	Unit	WQO value[1]	Boraig Group (MB06A, MB06B, TMB01A) # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Reactive phosphorus	mg/L	0.015	25/0	<0.01	<0.01	0.01	-	-	-	-
Total phosphorus	mg/L	0.020	38/22	<0.01	**0.03**	**0.26**	-	-	-	-
Analytical results – major ions										
Calcium	mg/L	-	39/0	8	15	35	-	-	-	-
Chloride	mg/L	-	39/0	1	7	11	-	-	-	-
Magnesium	mg/L	-	39/0	2	4	9	-	-	-	-
Sodium	mg/L	-	39/0	2	30	69	-	-	-	-
Potassium	mg/L	-	39/0	<1	2	2	-	-	-	-
Sulphate	mg/L	-	39/0	<1	12	76	-	-	-	-
Cyanide	mg/L	0.004	24/0	<0.004	<0.004	<0.004	-	-	-	-
Fluoride	mg/L	2.4	39/0	<0.1	0.1	1.4	-	-	-	-
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	24/1	<0.01	<0.01	0.02	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	37/13	<0.001	<0.001	**0.005**	-	-	-	-
Barium (Ba)	mg/L	-	24/0	0.080	0.106	0.812	-	-	-	-
Beryllium (Be)	mg/L	-	24/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.09	24/8	<0.05	<0.05	**0.29**	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	37/0	<0.0001	<0.0001	<0.0001	-	-	-	-

Table D.29 Baseline water quality results summary: Boraig Group

	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
			Boraig Group (MB06A, MB06B, TMB01A)							
Total chromium (Cr)	mg/L	0.00001[3,6]	37/14	<0.001	<0.001	**0.002**	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	24/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)	mg/L	0.001	37/19	<0.001	**0.002**	**0.005**	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	24/7	<0.05	0.08	**0.57**	-	-	-	-
Lead (Pb)	mg/L	0.001	37/0	<0.001	<0.001	<0.001	-	-	-	-
Manganese (Mn)	mg/L	1.2	24/0	0.010	0.026	0.178	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	37/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Nickel (Ni)	mg/L	0.008	37/14	<0.001	0.003	**0.024**	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	24/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	24/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	24/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	37/27	<0.005	**0.007**	**0.025**	-	-	-	-

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

ATTACHMENT B – SITE SPECIFIC GROUNDWATER LEVEL TRIGGERS

The Groundwater Level SSTV are based on the RTS groundwater model predicted drawdown. A nominal start date of 1st June 2020 has been chosen and this should be adjusted once the actual date of start is determined. Figure B-1, below, includes a 2 year pre-construction period, with the corresponding Table B-1 providing the predicted drawdown from the nominal start of construction.

Drawdown values should be adjusted to reflect the observed drawdown. For example, if drawdown over a given month differs by more than one standard deviation from the predicted drawdown in that month, then the following month's predicted drawdown should be determined relative to the revised level and not to the original level. This prevents unnecessary multiple activation of triggers resulting from inaccurate absolute levels determined in the modelling process.

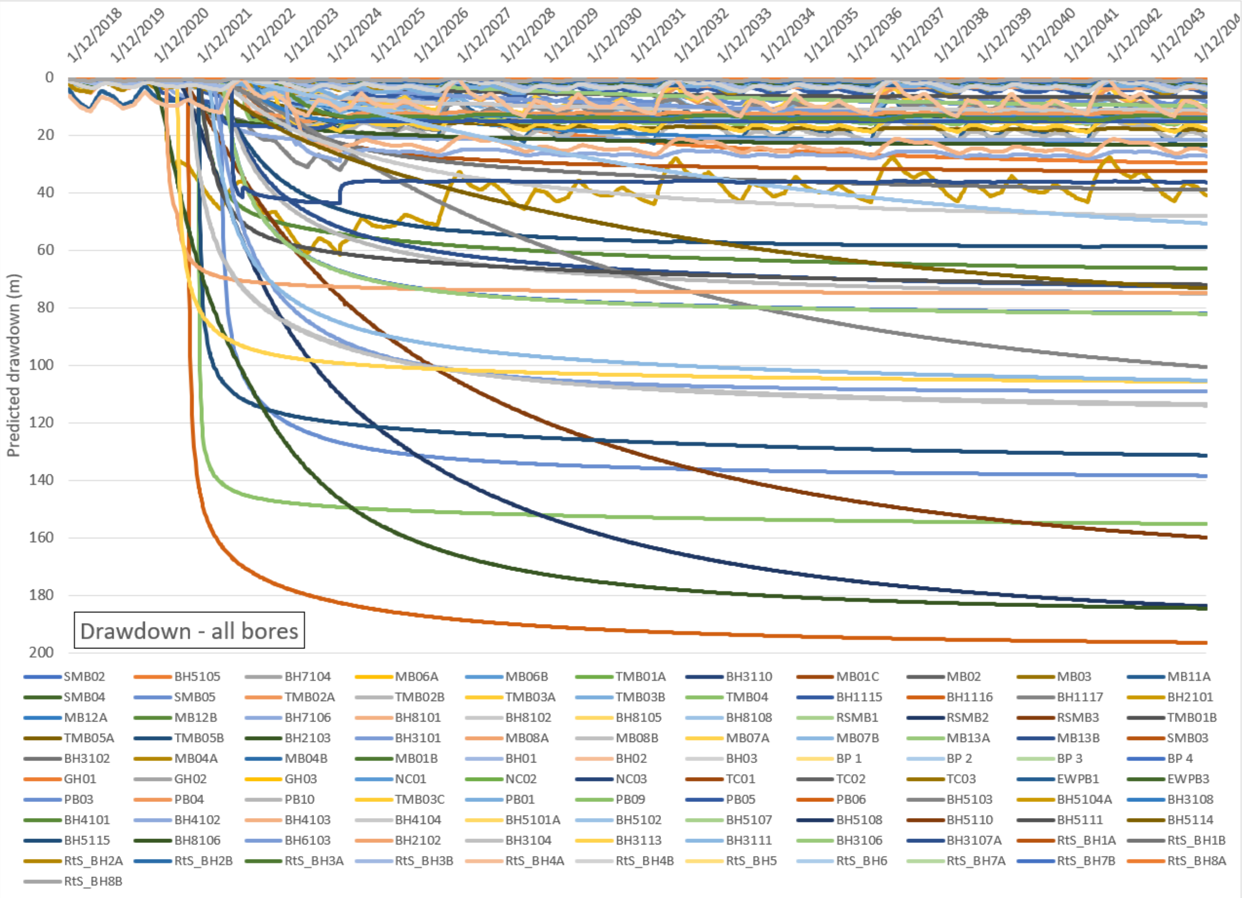


Figure B 1: Predicted drawdown for all bores from the start of construction

ATTACHMENT C – SITE SPECIFIC GROUNDWATER QUALITY TRIGGERS

Table C-1 summarises the groundwater quality trigger values at baseline water quality monitoring sites. Groundwater quality SSTVs are restricted to those bores and parameters that were routinely greater than ANZECC guidelines and where a minimum of 24 samples were collected. SSTVs are determined at the 84th percentile values of the baseline data collected. These bores / parameters with SSTVs are shaded. Unshaded cells have adopted Water Quality Objectives, however it is noted that baseline records often indicate natural exceedances of these Water Quality Objectives

Table C-1: Groundwater quality triggers

Target formation	Bore ID	# of Samples[1]	EC	pH	TN	RP	Al	Cu	Fe	Pb	Mn	Ni	Ag	Zn
Ravine Beds West	BH8101 (EPL 3)	14	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	BH8108[2]	8	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	RSMB1	7	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	RSMB2	11	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	RSMB3	8	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	TMB01B[3]	19	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	TMB05A	13	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	TMB05B	13	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	PB05	13	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	EWPB1	8	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	EWPB3	7	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Boraig Group	MB06A	29	30-350	6.5-8.0	0.25	0.015	0.027	0.01	0.34	0.001	1.2	0.008	0.000026	0.02
	MB06B	28	30-350	6.5-8.0	0.25	0.015	0.027	0.006	0.34	0.001	1.2	0.008	0.000026	0.02
	TMB01A[4]	22	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.000026
Ravine Beds East	MB12B	11	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	MB12A	11	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Tertiary basalt	MB01B	34	30-350	6.5-8.0	0.25	0.015	0.027	0.022	0.34	0.001	1.2	0.008	0.000026	0.012
Gooandra Volcanics	MB01C	29	30-350	6.5-8.0	0.25	0.015	0.027	0.008	0.34	0.001	1.2	0.008	0.000026	0.011
	MB02	28	30-350	6.5-8.0	0.25	0.015	0.027	0.021	0.34	0.001	1.2	0.008	0.000026	0.013
	MB03	31	30-350	6.5-8.0	0.25	0.015	0.027	0.004	0.34	0.001	1.2	0.008	0.000026	0.009
	MB11A	17	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.000026
	SMB04	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.000026
	SMB05	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.000026
	TMB02A	29	30-350	6.5-8.0	0.25	0.015	0.027	0.029	0.34	0.001	1.2	0.008	0.000026	0.011
	TMB02B	26	30-350	6.5-8.0	0.25	0.015	0.027	0.009	0.34	0.001	1.2	0.008	0.000026	0.014
	TMB03A	28	30-350	6.5-8.0	0.25	0.015	0.027	0.008	0.34	0.001	1.2	0.008	0.000026	0.017

Target formation	Bore ID	# of Samples[1]	EC	pH	TN	RP	Al	Cu	Fe	Pb	Mn	Ni	Ag	Zn
	TMB03B	30	30-350	6.5-8.0	0.25	0.015	0.027	0.006	0.34	0.001	1.2	0.008	0.000026	0.015
	TMB04	27	30-350	6.5-8.0	0.25	0.015	0.027	0.018	0.34	0.001	1.2	0.008	0.000026	0.008
	PB04	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.000026
Temperance Formation	MB04A	29	30-895	6.5-8.0	0.25	0.015	0.027	0.019	0.34	0.001	1.2	0.008	0.000026	0.032
	MB04B	29	30-598	6.5-8.0	0.25	0.015	0.027	0.007	0.34	0.001	1.2	0.008	0.000026	0.008
	MB07A	26	30-350	6.5-8.0	0.25	0.015	0.027	0.011	0.34	0.001	1.2	0.008	0.000026	0.007
	MB07B	24	30-563	6.5-8.0	0.25	0.015	0.027	0.017	0.34	0.001	1.2	0.008	0.000026	0.039
	MB13A	15	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	MB13B	15	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	PB10	12	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Boggy Plain Suite	SMB03	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	SMB02	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Tantangara Formation	MB08A	5	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	MB08B	9	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	PB06	4	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Kellys Plain Volcanics	PB01	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Gooandra Hill Bog	GH01	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	GH02	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	GH03	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Tantangara Creek Bog	TC01	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	TC02	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	TC03	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Bullocks Hill Bog	BH01	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	BH02	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	BH03	2	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Yarrangobilly Caves	YC05	21	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246

[1] Up until and including July 2020. [2] BH8108 was originally EPL 4, but has since been decommissioned. EPL 4 is now RSMB8.
[3] TMB01B was originally EPL2, but has since been decommissioned. EPL 2 is now RSMB7. [4] TMB01A was originally EPL1, but has since been decommissioned. EPL 1 is now RSMB6.

ANNEXURE B – GROUNDWATER TARP 1 GROUNDWATER LEVEL

S2-FGJV-ENV-PLN-0147

SNOWY 2.0 MAIN WORKS – GROUNDWATER TARP 1 GROUNDWATER LEVEL

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Principal Hydrogeologist	R. Cresswell	
Reviewed by	Environmental Consultant	S. Mitchell	SMitchell
Verified by	Environment Manager	L. Coetzee	LCoetzee
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Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	29.11.2019	Initial draft for SHL review
B	29.05.2020	Revised to address Infrastructure Approval
C	15.06.2020	Revised to address SHL comments. For consultation.
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments

This groundwater level TARP identified in Table B-1 should be read in conjunction with Section 7.2 of the GMP.

Table B-1: Groundwater level TARP

Trigger Level	Trigger	Action	Response
Level 1 (Indicator)	Groundwater level measurements within trigger limits	Continue to monitor levels in accordance with monitoring plan	No response required
Level 2 (Early warning)	Water level records are trending towards an exceedance, but within predicted levels	Continue to monitor levels in accordance with monitoring plan	Conduct preliminary review of activities occurring in vicinity of subject bore(s), including groundwater usage (i.e. Groundwater Usage TARP)
Level 3a (Exceedance of Threshold Trigger level)	Groundwater level measurements trigger investigation	Determine suitably qualified person[1] to conduct review Review impacts in accordance with decision tree	Report results of trigger investigation to SHL. If trigger exceedance is determined to be attributable to construction, proceed to Level 3b. If trigger response is determined not to be attributable to construction, review trigger levels and up-date monitoring plan. Report results in Annual Review
Level 3b (Exceedance identified as related to construction activities)	Groundwater level triggers due to construction activities	Engage suitably qualified person to prepare report and identify potential for impacts on a receptor	Notify DPIE and NPWS within seven days of the trigger investigation report (Level 3a Report) Provide DPIE and NPWS with a trigger exceedance report within 30 days of notification. Identify mitigation actions or revisions to trigger levels in consultation with DPIE.
Level 4 (Limit Trigger denotes Impact on receptor)	Water level drawdown impacts on a receptor (GDE)	Activate mitigation measures[2] to remediate impact to receptor	Initiate investigation into reasons for impact on receptor including assessment of environmental harm Take actions recommended by investigation.

1 In some circumstances SHL or Future Generation staff may have sufficient experience to conduct the investigation. In other circumstances a specialist may be required.

2 Mitigation measures as developed at Level 3b

ANNEXURE C – GROUNDWATER TARP 2 GROUNDWATER QUALITY

S2-FGJV-ENV-PLN-0148

SNOWY 2.0 MAIN WORKS – GROUNDWATER TARP 2 GROUNDWATER QUALITY

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Principal Hydrogeologist	R. Cresswell	
Reviewed by	Environmental Consultant	S. Mitchell	
Verified by	Environment Manager	L. Coetzee	
Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:33:10 +10'00'

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Rev.	Date	Description of modifications / revisions
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D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments

This groundwater quality TARP identified in Table C-1 should be read in conjunction with Section 7.2 of the GMP.

Table C-1: Groundwater quality TARP

Level	Trigger	Action	Response
Level 1 (Indicator)	Groundwater quality measurements within trigger limits	Continue to monitor water quality parameters in accordance with monitoring plan	No response required
Level 2 (Early warning)	Rainfall events create significant runoff and recharge	Ensure salinity measurements are occurring in appropriate bores	Review monitoring records to identify influence of rainfall runoff on groundwater salinity
Level 3a (Exceedance of Threshold Trigger level)	Groundwater quality measurements trigger investigation	Engage suitably qualified person[1] to conduct review Review if the exceedance is representative of known EIS baseline/ pre-construction exceedances (GMP Annexure A Attachment A) Review impacts in accordance with decision tree	Report results of trigger investigation to SHL. If trigger exceedance is determined to be attributable to construction, proceed to Level 3b. If trigger response is determined not to be attributable to construction, review trigger levels and up-date monitoring plan. Report results in Annual Review.
Level 3b (Exceedance identified as related to construction activities)	Groundwater quality triggers due construction activities	Engage suitably qualified person to prepare report and identify potential for impacts on a receptor	Notify DPIE and NPWS within seven days of the trigger investigation report (Level 3a Report) Provide DPIE and NPWS with a trigger exceedance report within 30 days of notification. Identify mitigation actions or revisions to trigger levels in consultation with DPIE.
Level 4 (Limit Trigger denotes Impact on receptor)	Water quality changes impacts on a receptor (GDE)	Activate mitigation measures to remediate impact to receptor[2]	Initiate investigation into reasons for impact on receptor, including assessment of environmental harm Take actions recommended by investigation

1 In some circumstances SHL or Future Generation staff may have sufficient experience to conduct the investigation. In other circumstances a specialist may be required.
2 Mitigation measures as developed at Level 3b

ANNEXURE D – GROUNDWATER TARP 3 GROUNDWATER INGRESS

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SNOWY 2.0 MAIN WORKS – GROUNDWATER TARP 3 GROUNDWATER INGRESS

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Document preparation, review and approval		Name in print	Signature
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Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:33:35 +10'00'

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Rev.	Date	Description of modifications / revisions
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B	29.05.2020	Revised to address Infrastructure Approval
C	15.06.2020	Revised to address SHL comments. For consultation.
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments

This groundwater ingress TARP identified in Table D-1 should be read in conjunction with Section 7.2 of the GMP.

Table D-1: Groundwater ingress TARP

Level	Trigger	Action	Response
Level 1 (Indicator)	Groundwater take within license allocation	Continue to monitor levels in accordance with monitoring plan	No response required
Level 2 (Early warning)	Groundwater use trending to exceeding 80% of allocation	Identify major contributor to water usage and feasible actions to prevent usage exceeding allocation	Conduct preliminary review of groundwater usage, recent groundwater level monitoring results (i.e. Groundwater Level TARP) and determine drivers for identified trend and potential for recurrence Identify availability of additional water from relevant water source on the water market Investigate water ingress reduction measures Review recent groundwater level monitoring
Level 3a (Exceedance of Threshold Trigger level)	Groundwater usage exceeds 80% of allocation	Implement actions identified above if forecast indicates usage will exceed 100% of allocation	Report results in Annual Review. Initiate purchase of additional water entitlements if reduction measures are unsuccessful.
Level 3b (Exceedance identified as related to Main Works activities)	Groundwater modelling predicts usage will exceed 100% of allocation in the future	Initiate purchase of additional water from relevant water source on the water market	Report results in Annual Review.
Level 4 (Limit Trigger denotes Impact on receptor)	Water usage exceeds 100% of allocation	Formalise purchase water entitlements to account for exceedance	Initiate investigation into reasons for exceedance and report reports in Annual Review Notify NRAR/DPIE Water Group and provide report on reasons for exceedance Take actions recommended by investigation to prevent recurrence

ANNEXURE E – EXPLORATORY WORKS CONSOLIDATED CONDITIONS OF APPROVAL (SSI-9208)

Table B 1 details the conditions from the Exploratory Works Infrastructure Approval which are relevant to groundwater and demonstrates where these conditions are addressed or are no longer relevant.

Table B 1: Exploratory Works conditions of approval relevant to ground water (SS9208)

Condition	Requirement	Where addressed
Sch 3, Cond 31	The Proponent must ensure that it has sufficient water for all stages of the development; and if necessary, stage the development to match its available water supply. *Note: Under the Water Management Act 2000, the Proponent must obtain the necessary water licences for the development.*	GMP - Section 2.5.3
Sch 3, Cond 32	Unless an environment protection licence authorises otherwise, the Proponent must comply with Section 120 of the POEO Act. *Note: Section 120 of the POEO Act makes it an offence to pollute any waters.*	WMP - Appendix A (SWMP) GMP - Section 5
Sch 3, Cond 34	Prior to carrying out any construction, unless the Planning Secretary agrees otherwise, the Proponent must prepare a Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must: (e) include a Groundwater Management Plan with:	This Plan
	• detailed baseline data on groundwater levels, yield and quality on the aquifers that could be affected by the development;	GMP – Annexure A Attachment A (Baseline Groundwater Quality and Levels)
	• a program to augment the baseline data during the development;	GMP – Annexure A (Groundwater Monitoring Program)
	• groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts;	GMP – Section 6.4
	• a description of the measures that would be implemented to minimise the groundwater impacts of the development	GMP - Section 5
	• a program to monitor and report on: ○ groundwater inflows to the tunnel, including inflows to relevant water sources; ○ groundwater takes from the groundwater bore ○ the impacts of the development on: ▪ regional and local (including alluvial) aquifers; ▪ groundwater dependent ecosystems, stygofauna and riparian vegetation; and ▪ base flow to surface water sources;	GMP – Annexure A (Groundwater Monitoring Program) GMP – Section 6.8
	• a plan to respond to any exceedances of the trigger levels and/or assessment criteria and mitigate and/or offset any adverse groundwater impacts of the development.	GMP – Section 7

APPENDIX C – EXPLORATORY WORKS CONSOLIDATED CONDITIONS OF APPROVAL (SSI-9208)

Table C 1 details the conditions from the Exploratory Works Infrastructure Approval which are relevant to water and demonstrates where these conditions are addressed or are no longer relevant.

Table C 1: Exploratory Works conditions of approval relevant to water (SSI 9208)

Condition	Requirement	Where addressed
Sch 3, Cond 31	The Proponent must ensure that it has sufficient water for all stages of the development; and if necessary, stage the development to match its available water supply. *Note: Under the Water Management Act 2000, the Proponent must obtain the necessary water licences for the development.*	WMP - Section 2.5.3
Sch 3, Cond 32	Unless an environment protection licence authorises otherwise, the Proponent must comply with Section 120 of the POEO Act. *Note: Section 120 of the POEO Act makes it an offence to pollute any waters.*	WMP - Appendix A (SWMP) WMP - Appendix B (GMP)
Sch 3, Cond 33	The Proponent must: (a) minimise the use of clean water on site; (b) maximise the diversion of clean water runoff around the approved disturbance areas on site; (c) minimise the flow rates from any clean water runoff diversions to adjoining watercourses; (d) minimise any soil erosion associated with the development; (e) ensure all chemical and hydrocarbon products are stored on site in bunded areas in accordance with the relevant Australian Standards.	WMP - Appendix A (SWMP) WMP - Appendix B (GMP)
Sch 3, Cond 34	Prior to carrying out any construction, unless the Planning Secretary agrees otherwise, the Proponent must prepare a Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must:	This Plan
	(a) be prepared in consultation with the EPA, NPWS, DoI Water and DPI - Fisheries by a suitably qualified and experienced person/s whose appointment has been approved by the Planning Secretary;	A Water Management Plan was prepared for both Stage 1 and Stage 2 of Exploratory Works in consultation with the EPA, NPWS, DoI Water and DPI – Fisheries. Consultation undertaken for this Main Works Water Management Plan is identified in Section 1.9
	(b) include a Site Water Balance for the development and a program to review and update the site water balance each calendar year;	WMP – Section 5
	(c) include a Surface Water Management Plan with: • detailed baseline data on surface water flows and quality in the watercourses that could potentially be affected by the development; • a program to augment the baseline data during the development; • a description of the measures that would be implemented to minimise the impacts of:	WMP - Appendix A (SWMP)

Condition	Requirement	Where addressed
	– any subaqueous emplacement; – the dredging within Talbingo Reservoir; – the barge infrastructure; – the water intake; – the water treatment pipes and outlets; – any in-stream works; – stockpiles; – eastern emplacement area; – western emplacement area; – construction portal; – accommodation camp; – Lobs Hole substation; – road upgrades, and in particular the road works in the vicinity of the Yarrangobilly River; – chemical and hydrocarbon storage. • surface water assessment criteria, including trigger levels for investigating any potentially adverse surface water impacts of the development; • a description of the measures that would be implemented to minimise the surface water impacts of the development, and comply with the performance measures in Condition 33 above; • a program to monitor and report on the surface water impacts of the development including water monitoring locations, analytes and sampling frequency for each monitoring location; • a program to monitor and report on the surface water impacts of the development • a plan to respond to any exceedances of the surface water trigger levels and/or assessment criteria and mitigate and/or offset any adverse surface water impacts of the development;	
	(d) include a Dredging Management Plan with: • a description of the measures that would be implemented to minimise the generation and dispersion of sediments outside the identified works zone during dredging; • monitoring at representative locations to determine the extent of suspended sediment concentrations and any other potential pollutants dispersed by dredging; • a plan to respond to any exceedances of the surface water trigger levels and/or assessment criteria and mitigate and/or offset any adverse surface water impacts of the development;	A Dredging Management Plan will be prepared for exploratory works prior to the undertaking of any dredging for exploratory works.
	(e) include a Groundwater Management Plan with: • detailed baseline data on groundwater levels, yield and quality on the aquifers that could be affected by the development; • a program to augment the baseline data during the development;	WMP - Appendix B (GMP)

Condition	Requirement	Where addressed
	• groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts; • a description of the measures that would be implemented to minimise the groundwater impacts of the development • a program to monitor and report on: • groundwater inflows to the tunnel, including inflows to relevant water sources; • groundwater takes from the groundwater bore • the impacts of the development on: • regional and local (including alluvial) aquifers; • groundwater dependent ecosystems, stygofauna and riparian vegetation; and • base flow to surface water sources; • a plan to respond to any exceedances of the trigger levels and/or assessment criteria and mitigate and/or offset any adverse groundwater impacts of the development.	
Sch 3, Cond 35	The Proponent must implement the approved Water Management Plan for the development.	This WMP will be implemented for the development.
Sch 3, Cond 39	The Proponent must: (a) ensure the temporary bridges over Wallace Creek and the Yarrangobilly River incorporate, to the greatest extent practicable, the requirements: • *Guidelines for Controlled activities on Waterfront Land (NRAR, 2018)*; and • *Policy and Guidelines for Fish Habitat Conservation* (DPI 2013) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (NSW Fisheries 2003); (b) remove temporary bridges as soon as practicable after the construction of the permanent bridges, and rehabilitate the land to the satisfaction of the NPWS; (c) consider scheduling to minimise in stream works between October to January, the migratory period of the Macquarie Perch (*Macquaria australasica*).	WMP - Appendix A (SWMP)
Sch 3, Cond 40	The Proponent must: (a) ensure that permanent bridges over Wallace creek and the Yarrangobilly River are designed and constructed to comply with the relevant requirements of the: • *Guidelines for Controlled activities on Waterfront Land* (NRAR, 2018); and • *Policy and Guidelines for Fish Habitat Conservation* (DPI 2013) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (NSW Fisheries 2003); (b) ensure that the permanent bridges over Wallace creek and the Yarrangobilly River are designed and constructed to comply with the relevant requirements of the relevant Austroads Standards (such as elevating them above the 1% AEP flood level);	WMP - Appendix A (SWMP)

Condition	Requirement	Where addressed
	(c) minimise in stream works between October to January, the migratory period of the Macquarie Perch (*Macquaria australasica*).	