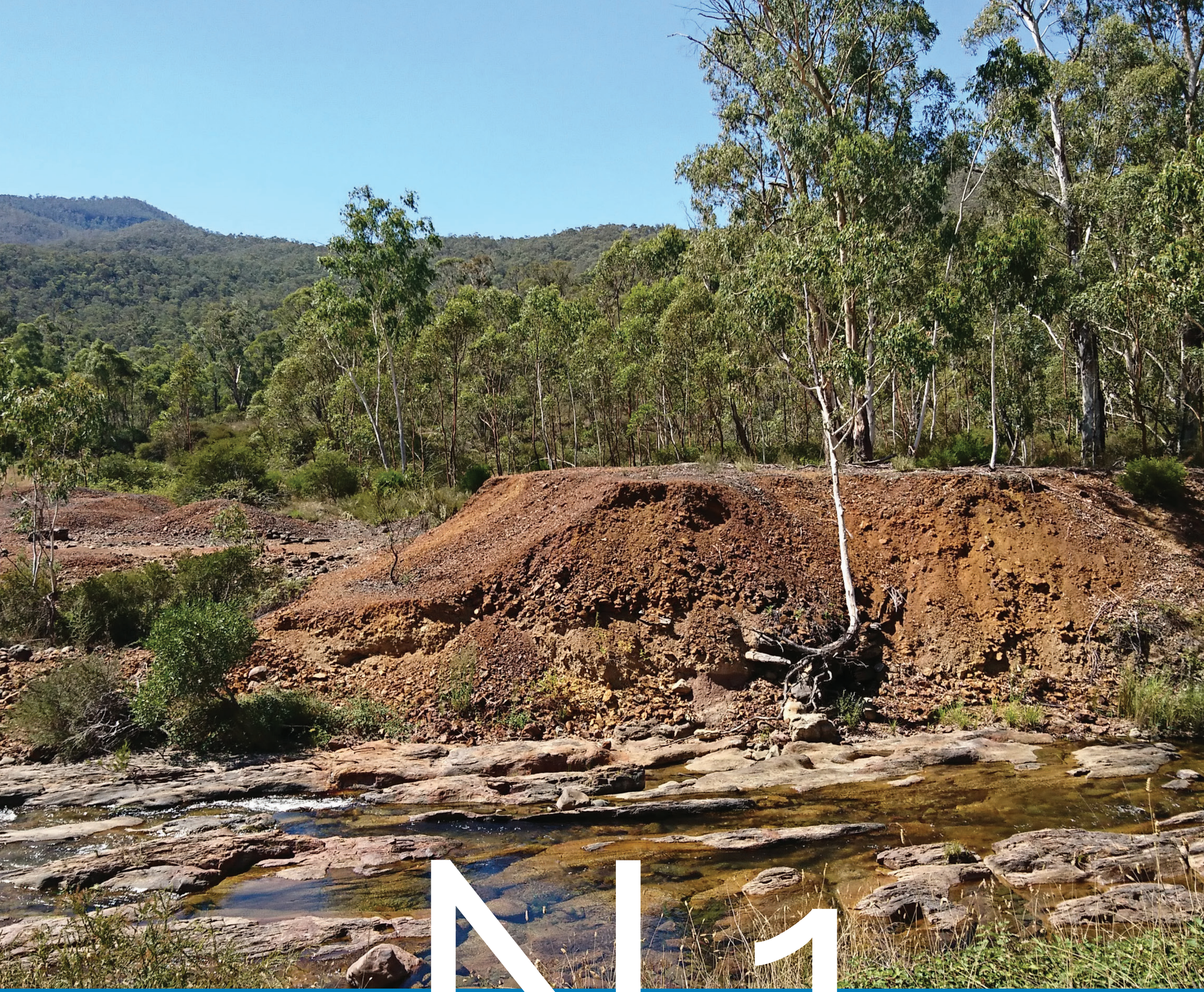

APPENDIX N.1

CONTAMINATION ASSESSMENT

Contamination Assessment

Snowy 2.0 Main Works

Prepared for Snowy Hydro Limited
September 2019

creating opportunities

Contamination Assessment

Snowy 2.0 Main Works

Report Number

J17188 RP#1

Client

Snowy Hydro Limited

Date

13 September 2019

Version

v1 Draft

Prepared by	Approved by
Nina Baulch	**Anthony Davis**
Senior Hydrogeologist	Associate Director
13 September 2019	13 September 2019

Executive Summary

ES1 Introduction

Snowy Hydro Limited (Snowy Hydro) proposes to develop Snowy 2.0, a large-scale pumped hydro-electric storage and generation project which would increase hydro-electric capacity within the existing Snowy Mountains Hydro-electric Scheme (Snowy Scheme).

This contamination assessment has been prepared to accompany an application and supporting EIS for the second phase of Snowy 2.0, which is to be known as the **Snowy 2.0 Main Works**, hereafter referred to as the project. This phase of the project covers the major construction elements of Snowy 2.0, including permanent infrastructure, temporary construction infrastructure management, storage of extracted rock material and establishment of supporting infrastructure.

ES2 Contamination assessment objectives

The objectives of this contamination assessment are to:

- Identify areas of known or potentially contaminated land, including land disturbed by historical mining activities, that may be encountered during the construction of the project;
- Identify areas of naturally occurring asbestos (NOA) and potentially acid forming (PAF) rock that may be encountered or impacted during the construction of the project;
- Provide a qualitative assessment of ecological and human health risks posed by the above in the context of the construction and operation of the project;
- Outline and describe the following requirements for the project:
  - further investigations to be undertaken;
  - management measures for the identification, handling, transport and disposal of contaminated materials including NOA, PAF rock, contaminated soil and water; and
- Address the Secretary's Environmental Assessment Requirements (SEARs) for the project relevant to contaminated land.

ES3 Scope

To inform the EIS and address the SEARs, the following scope of work was completed:

- Preliminary screening review of project background/historical information;
- Inspection of the project footprint to assist with the identification of potential on and off-site sources of contamination and to understand the general condition of the project footprint;
- Review and evaluation of desktop information, including previous contamination reports, relevant to identified areas of contamination concern within the project footprint; and

- Assessment of the potential impacts of the project and identification of the need for further assessment and/or management measures where required.

To achieve the desired performance outcome, which is to ensure that risks arising from the disturbance of land and disposal of excavated rock are minimised, the following methodology has been adopted:

- Identification of potential or known contamination in the project footprint by assessing the existing environment, including review and assessment of relevant reports, soil and surface water investigation data;

- Assessment of the potential contamination impacts of the project during construction and operation phases; and

- Identification and description of mitigation measures to manage potential or known soil, excavated rock, surface water and groundwater contamination during construction and operation.

During the preparation of this report, the entire study area has been assessed, including surface works, ancillary facilities and subsurface works (tunnelling). Emphasis was given to those areas where construction activities could impact soil, surface water and groundwater which may require remediation and/or management during the construction and operation of the project.

ES4 Key findings

This technical working paper has identified several areas and contaminants of concern which require management during the construction and operation of the Snowy 2.0 project. Existing contamination issues are primarily related to historical mining activities, particularly at Lobs Hole, which have adversely impacted the quality of soil and surface water at some limited locations within the project footprint.

There is also a potential that project construction activities such as blasting and tunnel boring could intersect NOA and PAF rock which has the potential to impact soil, surface water and groundwater if not managed appropriately.

ES5 Construction impacts and mitigation measures

A CEMP would be prepared for the project. The CEMP would include management measures for areas within the project footprint identified as being potentially contaminated. As part of the CEMP, an EMMP (including waste management plans) and an AMP would be prepared to manage PAF rock and NOA during construction.

Areas within the project footprint that have been assessed as low risk do not require further assessment or remediation and would be managed through the implementation of the CEMP. Sites which are assessed as potentially containing soil, mine waste, surface water or groundwater contamination that could pose a medium or high risk to human or ecological receptors during construction of the project may require further intrusive site investigation.

The following sites would require the completion of targeted site investigations, to inform the appropriate management of contamination during the intrusive construction program:

- Lobs Hole where there is a potential for construction disturbance to encounter NOA, PAF rock or residual contamination associated with historical mining activities;

- Marica where there is a potential for NOA and PAF rock to be encountered during construction;

- Tantangara Reservoir where there is a potential for residual contamination associated with historic quarrying activities;

- All contamination investigations must be undertaken by a suitably qualified and experienced person in accordance with guidelines made or approved under the *Contaminated Land Management Act 1997* (NSW);

- Subject to the outcomes of the additional investigations, Remediation Action Plan (RAPs) may be required and implemented if site remediation is warranted prior to construction;

- The CEMP would incorporate an unexpected finds procedure. The CEMP prepared for implementation during the project and should encompass all construction activities associated with the project. The plan should accurately reflect the conditions likely to be encountered during construction at various locations within the project footprint; and

- A construction soil and water management plan must be prepared for implementation during construction of the project.

ES6 Operation impacts and mitigation measures

Following the completion of construction works, additional site investigations may be required to confirm the suitability of remaining project land proposed to be rehabilitated in accordance with the rehabilitation plan and to minimise the potential for residual contamination from land-based stockpiling of material potentially containing NOA and PAF rock. If residual contamination is identified, remediation works would be undertaken in accordance with an approved RAP.

The following would be undertaken and implemented prior to the operational phase of the project:

- A NSW EPA Accredited Site Auditor would be engaged to review all contamination reports and evaluate the suitability of a site for a specified use as part of the project; and

- An Operational Environmental Management Plan (OEMP) must be prepared to manage potential environmental impacts during the operational phases of the project.

ES7 Conclusions

Based on the findings of this contamination assessment, there is potential for localised areas of soil, mine waste, surface water and groundwater contamination associated with historically contaminating land uses to be encountered during construction, and further assessment is warranted in some instances. NOA and PAF rock are also likely to be encountered during tunnelling and associated construction activities that will require management to minimise potential risks to human health and the environment.

Following adoption of the mitigation and management measures outlined herein, which have been recommended to be implemented during the construction and operational phases of the project, the desired performance outcome, which is to ensure that risks arising from the disturbance and excavation of land and disposal of are minimised, would be satisfactorily achieved.

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Glossary

Project and technical terms

Term	Definition
Accommodation camp	Area used for temporary housing and facilities for construction personnel
Acidic	With a low pH, typically lower than pH 6
Adit	A horizontal passage leading into an underground structure (eg mine or tunnel) for the purposes of access or drainage
Amphiboles	Silicate minerals which occur commonly in igneous and metamorphic rocks, often forming needle like crystals
Anoxic	Depleted of oxygen
Asbestos	Silicate minerals, grouped into six classes, that are composed of long and thin fibrous crystals
Asbestiform	Mineral crystal habit with an extremely fibrous form, with high tensile strength and flexible, long and thin crystals that readily separate
Barge access infrastructure	A ramp and associated facilities to allow the loading and unloading of barge(s) on Talbingo Reservoir
Bioregion	An ecologically and geographically defined area
Colluvium	Sediment transported by weakly selective, non-fluvial (riverine) processes, including slope wash
Devonian	A sub era of the Palaeozoic, approximately 419 to 359 million years ago
Exploratory tunnel	A 3.1 km tunnel to the cavern of the proposed Machine Hall for the purposes of understanding geotechnical and underground conditions
Exploratory Works	A program of exploratory works for Snowy 2.0, subject of this EIS and as described in Section 2
Facultative	Occurring optionally in response to circumstance, rather than a dependent relationship
Fault zone	A land volume containing many faults, which are discontinuity surfaces across which there has been displacement
Fold belt	A large scale group of related folds, being a curved or angular shape of an originally planar surface, typically forming an orogenic belt
Igneous rock	A rock formed by the solidification of molten or partially molten volcanic material
Intrusion	An igneous rock that has been forced between or through existing formations
Karst	Topography formed by the dissolution of calcium carbonate rich soluble rocks (ie limestones)
Kinetic test	Measurement of the change in rock leachate chemistry/composition
Lachlan Fold Belt	Major geological subdivision located between central NSW and central Victoria
Leachate	The product resulting from the process of leaching, whereby solid constituents including soluble minerals are displaced from soil by a liquid (typically water) percolating through the subsurface profile
Lobs Hole	A former settlement location within Kosciuszko National Park, and primary location of Exploratory Works
Lobs Hole Mine	The site of a former copper mine circa 1908, located at Lobs Hole
Lobs Hole Ravine Road	The main access road to Lobs Hole
Mafic	An igneous rock or silicate mineral rich in magnesium and iron, including amphibole
Metalliferous	Metal rich

Project and technical terms

Term	Definition
Metamorphism	The process by which rocks are changed by the solid state application of heat, pressure and fluids, excluding weathering
Metasedimentary	A sedimentary rock that has undergone metamorphism
Middle Bay Road	The access road from the accommodation camp to the Middle Bay barge ramp. An extension to Middle Bay Road is proposed as part of Exploratory Works.
Mine Trail Road	The access road from the intersection with Lower Lobs Hole Ravine Road and the portal construction pad. An extension to Mine Trail Road is proposed as part of Exploratory Works.
Neutralisation	A chemical reaction involving and acid and a base react quantitatively
Ordovician	A sub era of the Palaeozoic, approximately 485 to 444 million years ago
Orogenic	The cyclicity involved with the process of creation of a mountain belt by tectonic activity
Oxic	In the presence of oxygen
Pleistocene	The first epoch of the Quaternary Period, 1 50 2.4 million years ago
Portal	Location of surface connection with the exploratory tunnel
Portal construction pad	Area used for construction for the exploratory tunnel and portal, including ancillary facilities, laydown and storage, and environmental controls
Precipitation	Reaction that refers to the formation of insoluble salt(s)
Project area	The area required to access and build project infrastructure, including surface and tunnel components of the project
Quaternary	The most recent geological period, 1.64 million years ago to present time
Ravine	A deep narrow valley with steep sides
Regolith	Superficial layer of loose, unconsolidated material overlying bedrock over much of the land surface
Rock emplacement area	Land area identified for the placement and storage of from Exploratory Works
Sedimentary	Rock formed by the consolidation of sediment
Silurian	A period of the Palaeozoic, 439-408 million years ago
Snowy 2.0	A pumped-hydro expansion of the Snowy Scheme that will link the two existing reservoirs of Tantangara and Talbingo through underground tunnels, and include a new underground power station with pumping capabilities.
Spillway	Structure used to provide the controlled release of flows from Talbingo Dam into the reservoir
Talbingo barge ramp	Location of barge access infrastructure at the northern end of Talbingo Reservoir
Tertiary	An interval of geological time in the Cenozoic Era approximately 66 to 2.6 million years ago
Thrust	A reverse fault with a low angle of dip, whereby older strata is displaced horizontally over newer strata
Ultramafic	A rock containing >90% ferromagnesium (mafic) minerals

Acronyms

List of Acronyms

Term	Definition
ACM	Asbestos containing material
ACT	Australian Capital Territory
AMD	Acid mine drainage
ANC	Acid neutralising capacity
ANZECC	Australian and New Zealand Environment and Conservation Council
AMP	Asbestos management plan
AS	Australian Standard
ASS	Acid sulfate soils
CEMP	Construction environmental management plan
Ch	Chainage
CLM Act	Contaminated Land Management Act 1997 (NSW)
CoPC	Contaminants of potential concern
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSM	Conceptual site model
DDT	Dichlorodiphenyltrichloroethane
DQI	Data quality indicators
DQO	Data quality objectives
EC	Electrical conductivity
EDS	Energy dispersive spectroscopy
EHC Act	Environmentally Hazardous Chemicals Act 1985 (NSW)
EIL	Ecological investigation level
EIS	Environmental impact statement
EMM	EMM Consulting Pty Ltd
EPA	Environment Protection Authority
EP Act	Environment Protection Act 1997 (ACT)
EPL	Environment Protection Licence
ESL	Ecological screening level
FutureGen	FutureGen Joint Venture
HIL	Health investigation level
HSL	Health screening level
KNP	Kosciuszko National Park
LFB	Lachlan Fold Belt

List of Acronyms

Term	Definition
LPF	Long Plain Fault
mbgl	metres below ground level
MPA	Maximum potential acidity
NAF	Non acid forming
NAG	Net acid generation
NEPC	National Environment Protection Council
NEPM	National Environmental Protection (Assessment of Site Contamination) Measure, as amended (2013)
NMD	Neutral metalliferous drainage
NOA	Naturally occurring asbestos
NPWS	National Parks and Wildlife Service (NSW)
NSW	New South Wales
PAF	Potential acid forming
PAF-LC	Potential acid forming – low capacity
PFAS	Per- and polyfluoroalkyl substances
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
SAQP	Sampling analysis and quality control plan
SEM	Scanning electron microscopy
SHL	Snowy Hydro Limited
SMEC	SMEC Holdings Limited
TMB	Tunnel boring machine
URS	URS Corporation
UST	Underground storage tank
VENM	Virgin excavated natural material

1 Introduction

Snowy Hydro Limited (Snowy Hydro) proposes to develop Snowy 2.0, a large-scale pumped hydro-electric storage and generation project which would increase hydro-electric capacity within the existing Snowy Mountains Hydro-electric Scheme (Snowy Scheme). Snowy 2.0 is the largest committed renewable energy project in Australia and is critical to underpinning system security and reliability as Australia transitions to a decarbonised economy. Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and a new hydro-electric power station will be built underground.

Snowy 2.0 has been declared to be State significant infrastructure (SSI) and critical State significant infrastructure (CSSI) by the former NSW Minister for Planning under Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and is defined as CSSI in clause 9 of Schedule 5 of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP). CSSI is infrastructure that is deemed by the NSW Minister to be essential for the State for economic, environmental or social reasons. An application for CSSI must be accompanied by an environmental impact statement (EIS).

Separate applications are being submitted by Snowy Hydro for different stages of Snowy 2.0 under Part 5, Division 5.2 of the EP&A Act. This includes the preceding first stage of Snowy 2.0, Exploratory Works for Snowy 2.0 (the Exploratory Works) and the stage subject of this current application, Snowy 2.0 Main Works (the Main Works). In addition, an application under Part 5, Division 5.2 of the EP&A Act is also being submitted by Snowy Hydro for a segment factory that will make tunnel segments for both the Exploratory Works and Main Works stages of Snowy 2.0.

The first stage of Snowy 2.0, the Exploratory Works, includes an exploratory tunnel and portal and other exploratory and construction activities primarily in the Lobs Hole area of the Kosciuszko National Park (KNP). The Exploratory Works were approved by the former NSW Minister for Planning on 7 February 2019 as a separate project application to DPIE (SSI 9208).

This contamination assessment has been prepared to accompany an application and supporting EIS for the **Snowy 2.0 Main Works**. As the title suggests, this stage of the project covers the major construction elements of Snowy 2.0, including permanent infrastructure (such as the underground power station, power waterways, access tunnels, chambers and shafts), temporary construction infrastructure (such as construction adits, construction compounds and accommodation), management and storage of material and establishing supporting infrastructure (such as road upgrades and extensions, water and sewage treatment infrastructure, and the provision of construction power). Snowy 2.0 Main Works also includes the operation of Snowy 2.0.

Snowy 2.0 Main Works is shown in Figure 1.1. If approved, the Snowy 2.0 Main Works would commence before completion of Exploratory Works.

The Snowy 2.0 Main Works do not include the transmission works proposed by TransGrid (TransGrid 2018) that provide connection between the cableyard and the NEM. These transmission works will provide the ability for Snowy 2.0 (and other generators) to efficiently and reliably transmit additional renewable energy to major load centres during periods of peak demand, as well as enable a supply of renewable energy to pump water from Talbingo Reservoir to Tantangara Reservoir during periods of low demand. While the upgrade works to the wider transmission network and connection between the cableyard and the network form part of the CSSI declaration for Snowy 2.0 and Transmission Project, they do not form part of this application and will be subject to separate application and approval processes, managed by TransGrid. This project is known as the HumeLink and is part of AEMO's Integrated System Plan.

With respect to the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), on 30 October 2018 Snowy Hydro referred the Snowy 2.0 Main Works to the Commonwealth Department of the Environment and Energy (DEE) and, on a precautionary basis, nominated that Snowy 2.0 Main Works has potential to have a significant impact on MNES and the environment generally.

On 5 December 2018, Snowy 2.0 Main Works were deemed a controlled action by the Assistant Secretary of the DEE. It was also determined that potential impacts of the project will be assessed by accredited assessment under Part 5, Division 5.2 of the EP&A Act. This accredited process will enable the NSW Department of Planning, Industry and Environment (DPIE) to manage the assessment of Snowy 2.0 Main Works, including the issuing of the assessment requirements for the EIS. Once the assessment has been completed, the Commonwealth Minister for the Environment will make a determination under the EPBC Act.

1.1 Project location

Snowy 2.0 Main Works are within the Australian Alps, in southern NSW, about mid-way between Canberra and Albury. Snowy 2.0 Main Works is within both the Snowy Valleys and Snowy Monaro Regional local government areas (LGAs).

The nearest large towns to Snowy 2.0 Main Works are Cooma and Tumut. Cooma is located about 50 kilometres (km) south east of the project area (or 70 km by road from Providence Portal at the southern edge of the project area), and Tumut is located about 35 km north west of the project areas (or 45 km by road from Tumut 3 power station at the northern edge of the project area). Other townships near the project area include Talbingo, Cabramurra, Adaminaby and Tumbarumba. Talbingo and Cabramurra were built for the original Snowy Scheme workers and their families, while Adaminaby was relocated in 1957 to make way for the establishment of Lake Eucumbene.

The location of Snowy 2.0 Main Works with respect to the region is shown in Figure 2.1.

The pumped hydro-electric scheme elements of Snowy 2.0 Main Works are mostly underground between the southern ends of Tantangara and Talbingo reservoirs, a straight-line distance of 27 km. Surface works will also occur at locations on and between the two reservoirs. Key locations for surface works include:

- **Tantangara Reservoir** - at a full supply level (FSL) of about 1,229 metres (m) to Australian Height Datum (AHD), Tantangara Reservoir will be the upper reservoir for Snowy 2.0 and include the headrace tunnel and intake structure. The site will also be used for a temporary construction compound, accommodation camp and other temporary ancillary activities;

- **Marica** - this site will be used primarily for construction including construction of vertical shafts to the underground power station (ventilation shaft) and headrace tunnel (surge shaft), and a temporary accommodation camp;

- **Lobs Hole** - the site will be used primarily for construction but will also become the main entrance to the power station during operation. Lobs Hole will provide access to the Exploratory Works tunnel, which will be refitted to become the main access tunnel (MAT), as well as the location of the emergency egress, cable and ventilation tunnel (ECVT), portal, associated services and accommodation camp; and

- **Talbingo Reservoir** - at a FSL of about 546 m AHD, Talbingo Reservoir will be the lower reservoir for Snowy 2.0 and will include the tailrace tunnel and water intake structure. The site will also be used for temporary construction compounds and other temporary ancillary activities.

Works will also be required within the two reservoirs for the placement of excavated rock and surplus cut material. Supporting infrastructure will include establishing or upgrading access tracks and roads and electricity connections to construction sites.

Most of the proposed pumped hydro-electric and temporary construction elements and most of the supporting infrastructure for Snowy 2.0 Main Works are located within the boundaries of KNP, although the disturbance footprint for the project during construction is less than 0.25% of the total KNP area. Some of the supporting infrastructure and construction sites and activities (including sections of road upgrade, power and communications infrastructure) extends beyond the national park boundaries. These sections of infrastructure are primarily located to the east and south of Tantangara Reservoir. One temporary construction site is located beyond the national park along the Snowy Mountains Highway about 3 km east of Providence Portal (referred to as Rock Forest).

The project is described in more detail in Chapter 2.

1.1.1 Project area

The project area for Snowy 2.0 Main Works has been identified and includes all the elements of the project, including all construction and operational elements. The project area is shown on Figure 1.2.

. Key features of the project area are:

- the water bodies of Tantangara and Talbingo reservoirs, covering areas of 19.4 square kilometres (km^2) and 21.2 km^2 respectively. The reservoirs provide the water to be utilised in Snowy 2.0;
- major watercourses including the Yarrangobilly, Eucumbene and Murrumbidgee rivers and some of their tributaries;
- KNP, within which the majority of the project area is located. Within the project area, KNP is characterised by two key zones: upper slopes and inverted treelines in the west of the project area (referred to as the 'ravine') and associated subalpine treeless flats and valleys in the east of the project area (referred to as the 'plateau'); and
- farm land southeast of KNP at Rock Forest.

The project area is interspersed with built infrastructure including recreational sites and facilities, main roads as well as unsealed access tracks, hiking trails, farm land, electricity infrastructure, and infrastructure associated with the Snowy Scheme.

1.1.2 Contamination assessment study area

This contamination assessment focuses on works within the project disturbance area, but also extends below the ground surface to incorporate consideration of tunnelling and subsurface disturbance activities associated with the construction and operation of the project, herein referred to as the study area. While project disturbance boundaries represent the physical extent of where project infrastructure may be located, or construction works undertaken, it does not mean that this entire area would be physically disturbed or that indirect impacts would not be experienced beyond this area.

The study area for this contamination assessment comprises (Table 1.1):

- the proposed tunnel alignment and underground power station, and associated subsurface infrastructure, including portals, access tunnels, ventilation shafts and adits;
- temporary surface construction areas including construction and laydown areas, and accommodation camps;
- access roads and the cable yard; and

- temporary and permanent excavated rock disposal locations.

The study area is shown in Figures 2.2 to 2.6.

1.2 Proponent

Snowy Hydro is the proponent for the Snowy 2.0 Main Works. Snowy Hydro is an integrated energy business – generating energy, providing price risk management products for wholesale customers and delivering energy to homes and businesses. Snowy Hydro is the fourth largest energy retailer in the NEM and is Australia's leading provider of peak, renewable energy.

1.3 Purpose of this report

This contamination assessment supports the EIS for the Snowy 2.0 Main Works. It documents the contamination assessment methods and results, the initiatives built into the project design to avoid and minimise impacts to human health and the environment, and the mitigation, and management measures, proposed to address any contamination impacts.

The specific objectives of this assessment are to inform the EIS and address the Secretary's Environment Assessment Requirements (SEARs) by:

- Completing desktop preliminary site investigation works to inform the understanding of contamination conditions within the project footprint;
- Identifying potential areas and contaminants of concern within the project footprint;
- Assessing the potential for contamination to be present within the project footprint;
- Providing a preliminary qualitative assessment, and desktop review of available quantitative data, in relation to contamination risk posed during construction and operation of the project;
- Assessing where further investigation should be undertaken, or appropriate management procedures should be implemented for the construction and operational phases of the project; and
- Assessing whether the land may be contaminated and if so, whether remediation may be required including confirmation that future assessment and/or remediation would be undertaken in accordance with the current guidelines.

1.3.1 Assessment guidelines and requirements

This contamination assessment has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) for Snowy 2.0 Main Works, issued on 31 July 2019, as well as relevant government assessment requirements, guidelines and policies, and in consultation with the relevant government agencies.

The SEARs must be addressed in the EIS. Table 1.1 lists the matters relevant to this assessment and where they are addressed in this report.

Table 1.1 Relevant matters raised in SEARs

Requirement	Section addressed
Potential impacts associated with the use of hydrocarbons and chemicals	Section 8.1.4 Section 8.1.5 Section 9
Dealing with the spoil generated by the project	Section 8 Section 9
Disturbing land associated with previous mining activities	Section 4.4.2 Section 6.4 Section 8.1.3 Section 8.1.5 Section 9
Encountering any naturally occurring asbestos	Section 4.4.1 Section 6.2 Section 6.3 Section 8.1.1 Section 8.1.5 Section 9

To inform preparation of the SEARs, the DPIE invited relevant government agencies to advise on matters to be addressed in the EIS. These matters were taken into account by the Secretary for DPIE when preparing the SEARs.

1.4 Related projects

There are three other projects related to Snowy 2.0 Main Works, they are:

- Snowy 2.0 Exploratory Works (SSI-9208) – a Snowy Hydro project with Minister's approval;
- Snowy 2.0 Transmission Connect Project (SSI-9717) – a project proposed by TransGrid; and
- Snowy 2.0 – Segment Factory (SSI-10034) – a project proposed by Snowy Hydro.

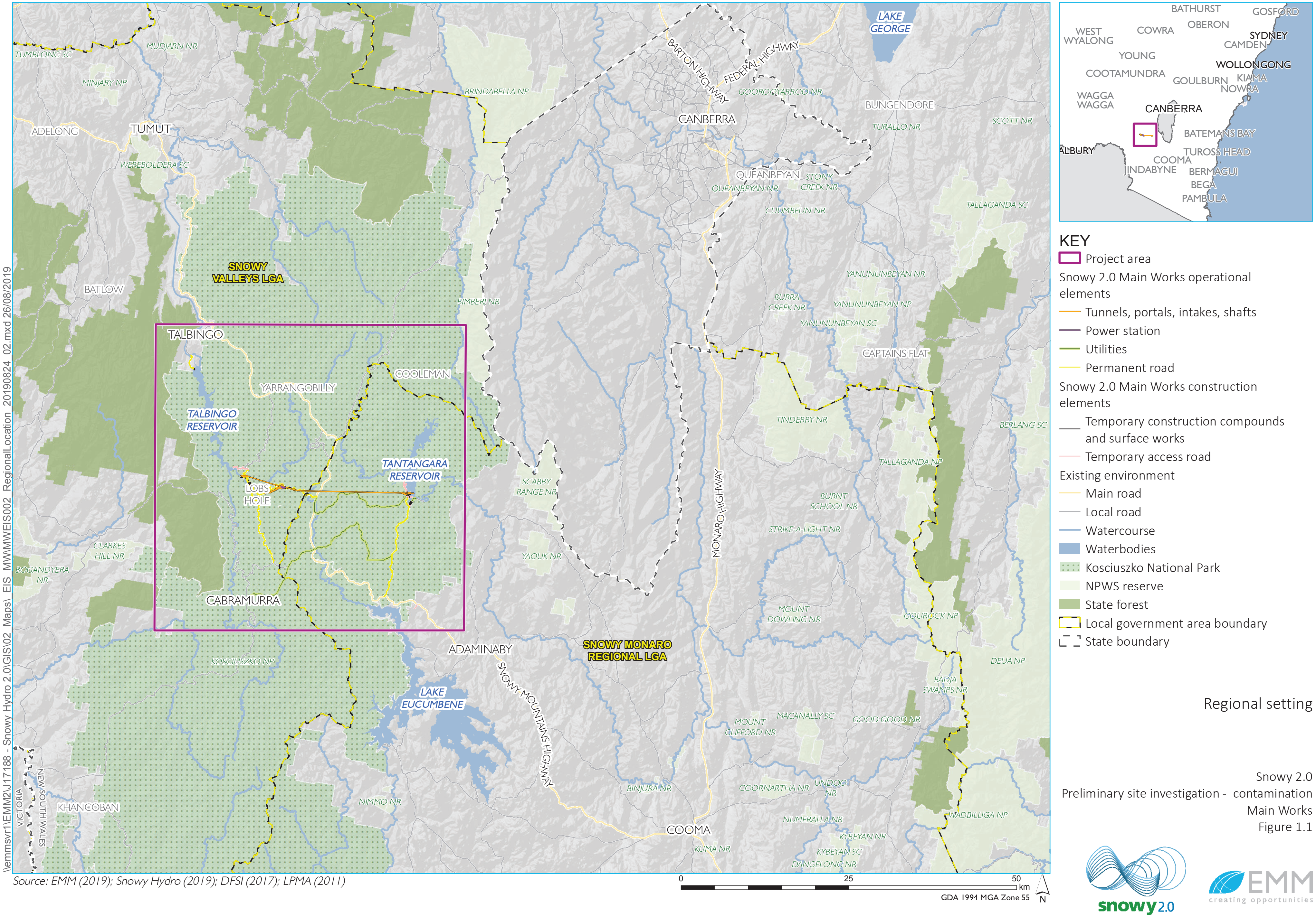
While these projects form part of the CSSI declaration for Snowy 2.0, they do not form part of Snowy Hydro's application for Snowy 2.0 Main Works. These related projects are subject to separate application and approval processes. Staged submission and separate approval is appropriate for a project of this magnitude, due to its complexity and funding and procurement processes. However, cumulative impacts have been considered in this report where relevant.

1.5 Other relevant reports

This contamination assessment has been prepared with reference to other technical reports that were prepared as part of the Snowy 2.0 Main Works EIS. The other relevant reports referenced in this contamination assessment are listed below.

- Biodiversity development assessment (EMM 2019) – Appended to the EIS;
- Groundwater assessment (EMM 2019) – Appended to the EIS;
- Soils and land assessment (EMM 2019) –Appended to the EIS; and

- Surface water assessment (EMM 2019) – Appended to the EIS.

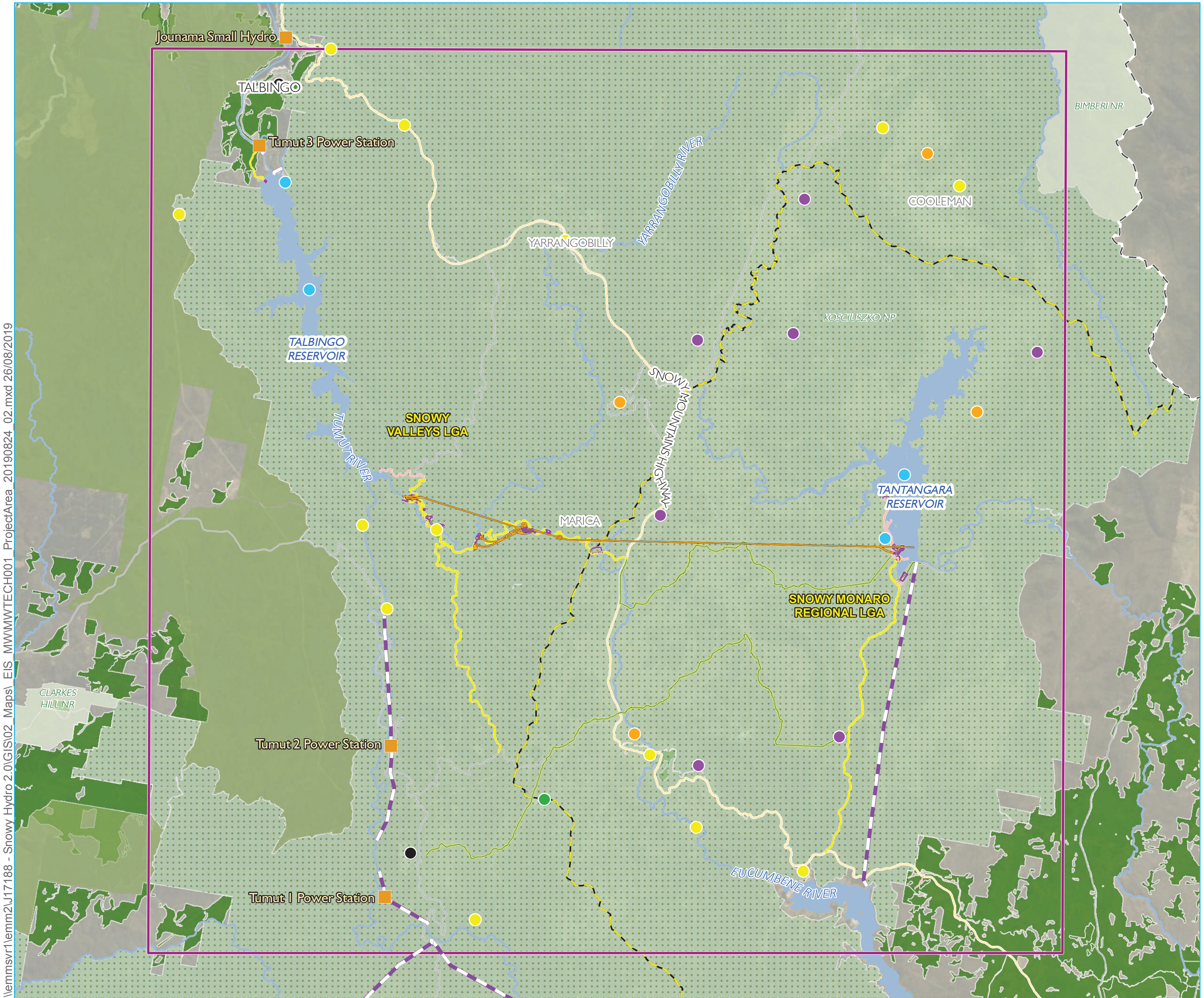


Regional setting

Snowy 2.0
Preliminary site investigation - contamination
Main Works
Figure 1.1

snowy 2.0

EMM
creating opportunities



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

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GDA 1994 MGA Zone 55

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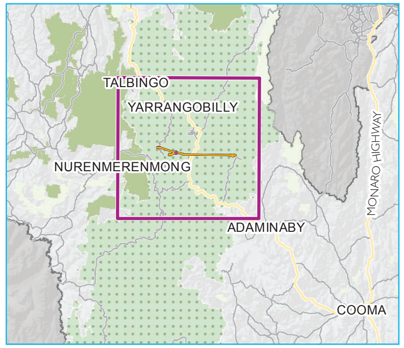

KEY

Existing Snowy Scheme
- Power station

Pipeline tunnel
- Snowy Tumut pipeline tunnel
- Project area

Recreational use areas
- Camping
- Camping - horses permitted
- Fishing and boating
- Place of interest
- Ski resort
- Township

Snowy 2.0 Main Works operational elements
- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements
- Temporary construction compounds and surface works
- Temporary access road

Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies
- Kosciuszko National Park
- NPWS reserve
- State forest
- Grazing
- Local government area boundary
- State boundary

Snowy 2.0 project area

Snowy 2.0
Preliminary site investigation - contamination
Main Works
Figure 1.2

snowy 2.0

EMM creating opportunities

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2 Description of the project

This chapter provides a summary of the Snowy 2.0 Main Works project. It outlines the functional infrastructure required to operate Snowy 2.0, as well as the key construction elements and activities required to build it. A more comprehensive detailed description of the project is provided in Chapter 2 (Project description) of the EIS, which has been relied upon for the basis of this technical assessment.

2.1 Overview of Snowy 2.0

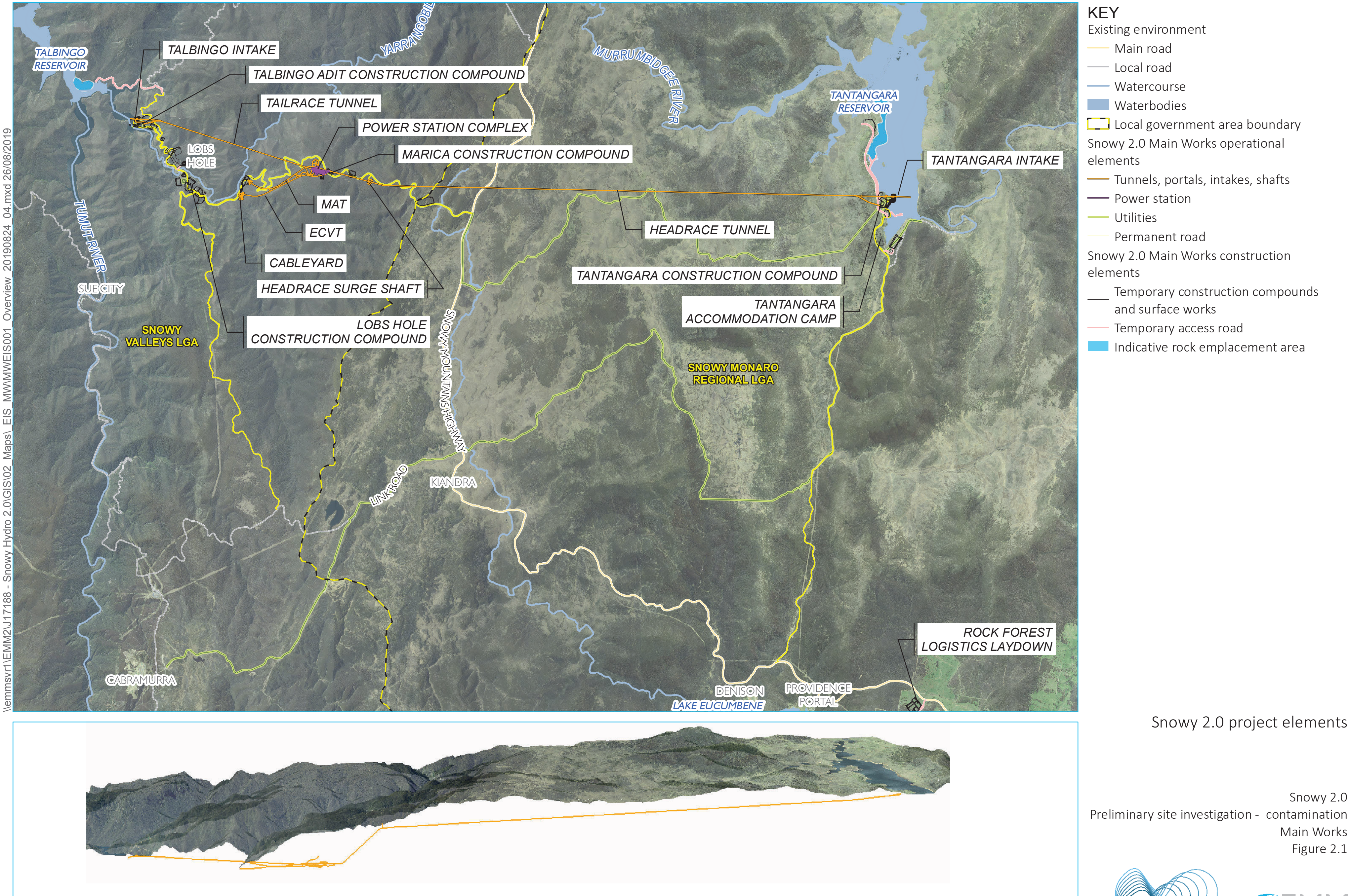
Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and a new hydro-electric power station will be built underground. An overview of Snowy 2.0 is shown on Figure 2.1, and the key project elements of Snowy 2.0 are summarised in Table 2.1.

Table 2.1 Overview of Snowy 2.0 Main Works

Project element	Summary of the project
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.
Permanent infrastructure	Snowy 2.0 infrastructure to be built and operated for the life of the assets include the: • intake and gate structures and surface buildings at Tantangara and Talbingo reservoirs; • power waterway tunnels primarily comprising the headrace tunnel, headrace surge structure, inclined pressure tunnel, pressure pipelines, tailrace surge tank and tailrace tunnel; • underground power station complex comprising the machine hall, transformer hall, ventilation shaft and minor connecting tunnels; • access tunnels (and tunnel portals) to the underground power station comprising the main access tunnel (MAT) and emergency egress, communication, and ventilation tunnel (ECVT); • establishment of a portal building and helipad at the MAT portal; • communication, water and power supply including the continued use of the Lobs Hole substation; • cable yard adjacent to the ECVT portal to facilitate the connection of Snowy 2.0 to the NEM; • access roads and permanent bridge structures needed for the operation and maintenance of Snowy 2.0 infrastructure; and • fish control structures on Tantangara Creek and near Tantangara Reservoir wall.
Temporary infrastructure	Temporary infrastructure required during the construction phase of Snowy 2.0 Main Works are: • construction compounds, laydown, ancillary facilities and helipads; • accommodation camps for construction workforce; • construction portals and adits to facilitate tunnelling activities; • barge launch ramps; • water and wastewater management infrastructure (treatment plants and pipelines); • communication and power supply; and • temporary access roads.
Disturbance area	The disturbance area is the extent of construction works required to build Snowy 2.0. The maximum disturbance area is about 1,680 hectares (ha), less than 0.25% of the total area of KNP. Parts of the disturbance area will be rehabilitated and landformed and other parts will be retained permanently for operation (operational footprint).

Table 2.1 Overview of Snowy 2.0 Main Works

Project element	Summary of the project
Operational footprint	The operational footprint is the area required for permanent infrastructure to operate Snowy 2.0. The maximum operational footprint is about 99 ha. This is 0.01% of the total area of KNP.
Tunnelling and excavation method	The primary tunnelling method for the power waterway is by tunnel boring machine (TBM), with portals and adits using drill and blast methods. Excavation for other underground caverns, chambers and shafts will be via combinations of drill and blast, blind sink, and/or raise bore techniques.
management	will be generated as a result of tunnelling activities and earthworks. The material produced through these activities will be stockpiled and either reused by the contractor (or NPWS), placed permanently within Tantangara or Talbingo reservoirs, used in final land forming and rehabilitation of construction pads in Lobs Hole, or transported offsite.
Construction water and wastewater management	Water supply for construction will be from the two existing reservoirs (Talbingo and Tantangara) and reticulated via buried pipelines (along access roads). Raw water will be treated as necessary wherever potable water is required (eg at accommodation camps). Water to be discharged (comprising process water, wastewater and stormwater) will be treated before discharge to the two existing reservoirs (Talbingo and Tantangara) as follows: • treated process water will be reused onsite where possible to reduce the amount of discharge to reservoirs, however excess treated water will be discharged to the reservoirs; • collected sewage will be treated at sewage treatment plants to meet the specified discharge limits before discharge and/or disposal; and • stormwater will be captured and reused as much as possible.
Rehabilitation	Rehabilitation of areas disturbed during construction including reshaping to natural appearing landforms or returning to pre-disturbance condition, as agreed with NPWS and determined by the rehabilitation strategy. This includes construction areas at Lobs Hole which comprise surplus cut materials that are required for the construction. Areas to be used by Snowy Hydro in the long-term may be re-shaped and rehabilitated to maintain access and operational capabilities (eg intakes and portal entrances).
Construction workforce	The construction workforce for the project is expected to peak at around 2,000 personnel.
Operational life	The operational life of the project is estimated to be 100 years.
Operational workforce	The operational workforce is expected to be 8-16 staff, with fluctuations of additional workforce required during major maintenance activities.
Hours of operation	Construction of Snowy 2.0 will be 24/7 and 365 days per year. Operation of Snowy 2.0 will be 24/7 and 365 days per year.
Capital investment value	Estimated to be $4.6 billion.



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

Snowy 2.0 project elements

Snowy 2.0
Preliminary site investigation - contamination
Main Works
Figure 2.1

snowy 2.0

EMM creating opportunities

2.2 Construction of Snowy 2.0

A number of construction activities will be carried out concurrently, and across a number of different sites. Specific details on these activities as well as an indicative schedule of construction activities is provided in Chapter 2 (Project description) of the EIS. This section summarises the key construction elements of the project.

Table 2.2 provides an overview of the construction elements, their purpose and location within the Project area.

Table 2.2 Snowy 2.0 construction elements

Construction element	Purpose	Location
Construction sites	Due to the remoteness of Snowy 2.0, construction sites are generally needed to: • Provide ancillary facilities such as concrete batching plants, mixing plants and on-site manufacturing; • Store machinery, equipment and materials to be used in construction; • Provide access to underground construction sites; and • Provide onsite accommodation for the construction workforce.	Each construction site needed for Snowy 2.0 is shown on Figures 2.2 to Figure 2.6.
Substations and power connection	One substation is required to provide permanent power to Snowy 2.0, at Lobs Hole. This substation is proposed as part of a modification to the Exploratory Works with a capacity of 80 mega volt amp (MVA). It will continue to be used for Main Works, however requires the establishment of further power supply cables to provide power to the work sites and TBM at Tantangara, as well as Talbingo, in particular to power the TBMs via the MAT, ECVT, Talbingo and Tantangara portals.	The supporting high voltage cable route mostly follows access roads to each of the work sites, using a combination of aerial and buried arrangements.
Communications system	Communications infrastructure will connect infrastructure at Tantangara and Talbingo reservoirs to the existing communications system at the Tumut 3 power station (via the submarine communications cable in Talbingo Reservoir established during Exploratory Works) and to Snowy Hydro's existing communications infrastructure at Cabramurra.	The cable will be trenched and buried in conduits within access roads. Crossing of watercourses and other environmentally sensitive areas will be carried out in a manner that minimises environmental impacts where possible, such as bridging or underboring.
Water and waste water servicing	Drinking water will be provided via water treatment plants located at accommodation camps. Water for treatment will be sourced from the nearest reservoir. There are three main wastewater streams that require some form of treatment before discharging to the environment, including: • Tunnel seepage and construction wastewater (process water); • Domestic sewer (wastewater); and • Construction site stormwater (stormwater).	Utility pipelines generally follow access roads. Water treatment plants (drinking water) will be needed for the accommodation camps and will be located in proximity. Waste water treatment plants will similarly be located near accommodation camps. Process water treatment plants will be at construction compounds and adits where needed to manage tunnel seepage and water during construction.

Table 2.2 Snowy 2.0 construction elements

Construction element	Purpose	Location
Temporary and permanent access roads	Access road works are required to: • provide for the transport of excavated material between the tunnel portals and the excavated rock emplacement areas; • accommodate the transport of oversized loads as required; and • facilitate the safe movement of plant, equipment, materials and construction workers into and out of construction sites. The access road upgrades and establishment requirements are shown on Figure 2.2 to Figure 2.6. These roads will be used throughout construction including use of deliveries to and from site and the external road network. Some additional temporary roads will also be required within the footprint to reach excavation fronts such as various elevations of the intakes excavation or higher benches along the permanent roads.	The access road upgrades and establishment requirements are shown across the project area. Main access and haulage to site will be via Snowy Mountains Highway, Link Road and Lobs Hole Ravine Road (for access to Lobs Hole), and via Snowy Mountains Highway and Tantangara Road (for access to Tantangara Reservoir) (see Figure 2.1).
Contamination management	Approximately 9 million m^3 (unbulked) of excavated material will be generated by construction and require management. The strategy for management of contamination will aim to maximise beneficial reuse of materials for construction activities. Beneficial re-use of excavated material may include use for road base, construction pad establishment, selected fill and tunnel backfill and rock armour as part of site establishment for construction. Excess excavated material that cannot be re-used during construction will be disposed of within Talbingo and Tantangara reservoirs, used in permanent rehabilitation of construction pads to be left in situ in Lobs Hole, or transported for on-land disposal if required.	Placement areas are shown on Figure 2.2 and Figure 2.6.
Barge launch facilities	Barge launch facilities on Talbingo Reservoir will have already been established during Exploratory Works for the placement of the submarine communications cable and will continued to be used for Main Works for construction works associated with the Talbingo intake structure. The Main Works will require the establishment of barge launch facilities on Tantangara Reservoir to enable these similar works (removal of the intake plug).	Barge launch sites are shown on Figure 2.2 and Figure 2.6.
Construction workforce	The construction workforce will be accommodated entirely on site, typically with a FIFO/DIDO roster. Private vehicles will generally not be permitted and the workforce bused to and from site.	Access to site will be via Snowy Mountains Highway

The key areas of construction are shown on Figure 2.2 to Figure 2.6 and can be described across the following locations:

- Talbingo Reservoir – Talbingo Reservoir provides the lower reservoir for the pumped hydro-electric project and will include the tailrace tunnel and water intake structure. The site will also be used for temporary construction compounds and other temporary ancillary activities;

- Lobs Hole – this site will be used primarily for construction (including construction of the MAT and ECVT portals and tunnels to the underground power station and the headrace tunnel (and headrace tunnel surge shaft), underground tailrace surge shaft and a temporary accommodation camp);

- Marica – the site will be used primarily for construction to excavate the ventilation shaft to the underground power station as well as for the excavation and construction of the headrace surge shaft;

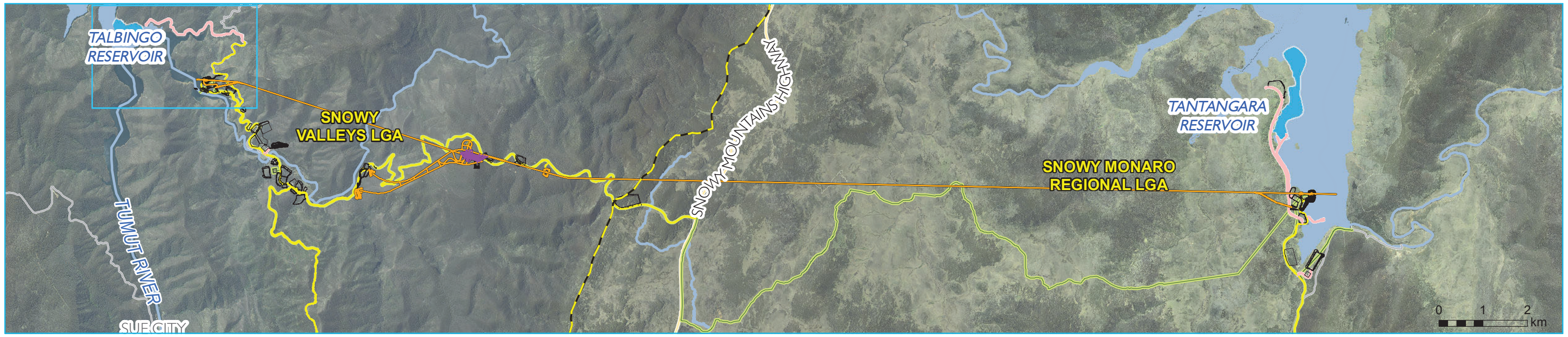
- Plateau – the land area between Snowy Mountains Highway and Tantangara Reservoir is referred to as the Plateau. The Plateau will be used to access and construct a utility corridor and construct a fish weir on Tantangara Creek;

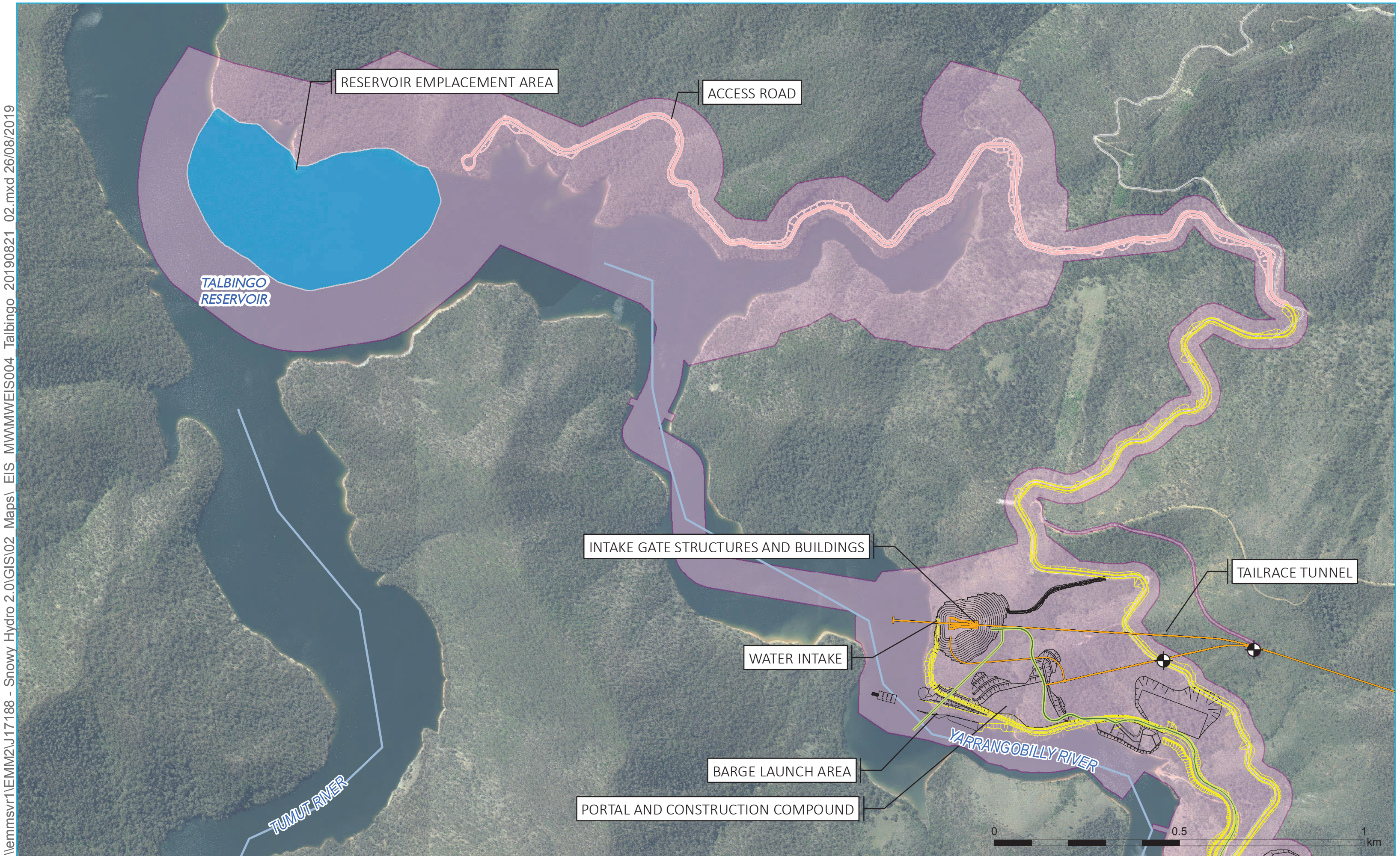
- Tantangara Reservoir – Tantangara Reservoir will be the upper reservoir for the pumped hydro project and include the headrace tunnel and intake structure. The site will also be used for a temporary construction compound, accommodation camp and other temporary ancillary activities; and

- Rock Forest – a site to be used temporarily for logistics and staging during construction. It is located beyond the KNP along the Snowy Mountains Highway about 3 km east of Providence Portal.

During the construction phase, all work sites will be restricted access and closed to the public. This includes existing road access to Lobs Hole via Lobs Hole Ravine Road. Restrictions to water-based access and activities will also be implemented for public safety and to allow safe construction of the intakes within the reservoirs. Access to Tantangara Reservoir via Tantangara Road will be strictly subject to compliance with the safety requirements established by the contractor.

A key construction element for the project is the excavation and tunnelling for underground infrastructure including the power station, power waterway (headrace and tailrace tunnels) and associated shafts. The primary methods of excavation are shown in Figure 2.7 with further detail on construction methods provided at Appendix D of the EIS.





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

GDA 1994 MGA Zone 55

N

KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements

- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Indicative rock emplacement area
- Disturbance area*

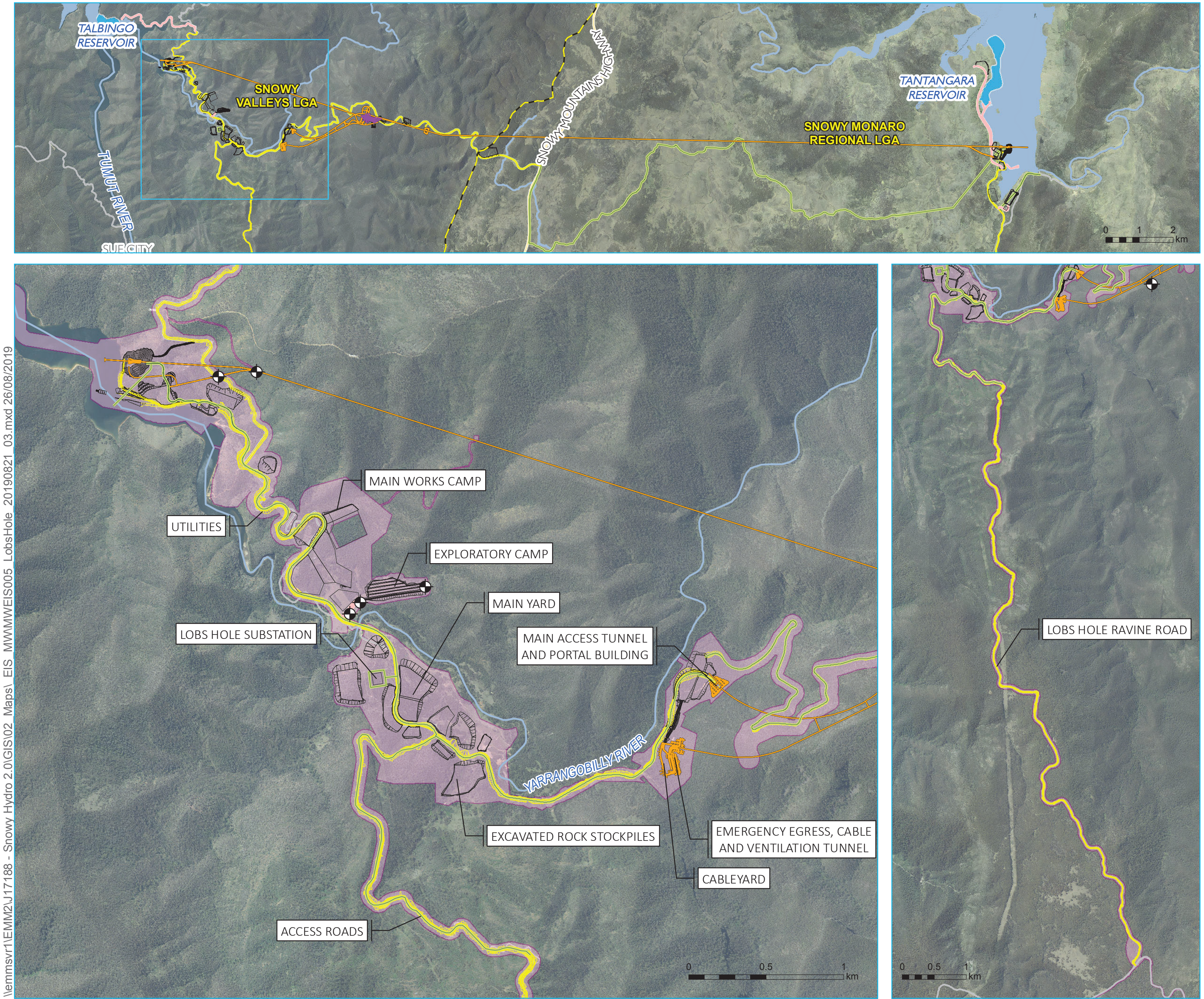
Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

Talbingo Reservoir - project elements, purpose and description

Snowy 2.0
Preliminary site investigation - contamination
Main Works
Figure 2.2

snowy 2.0

EMM creating opportunities



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

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GDA 1994 MGA Zone 55

KEY

Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

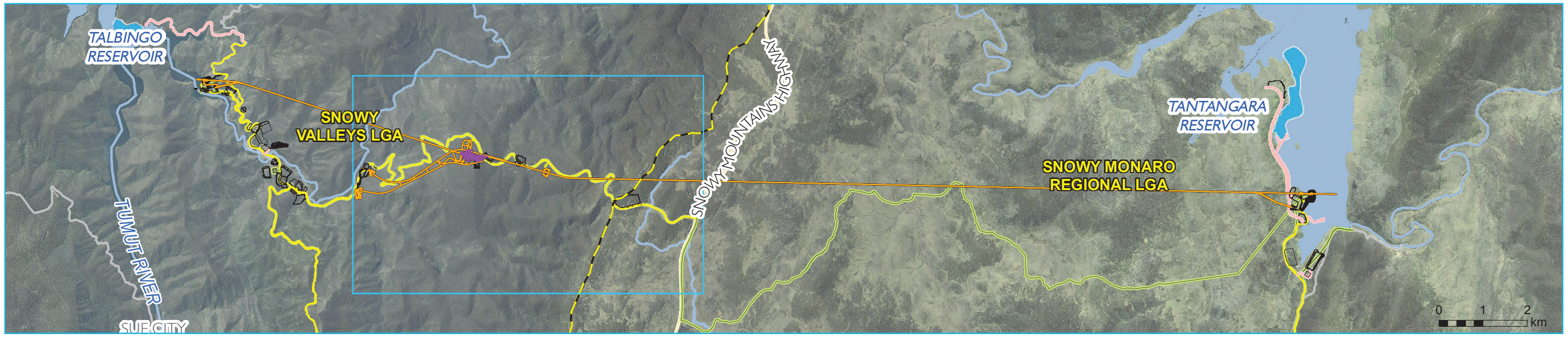
Snowy 2.0 Main Works operational elements
- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

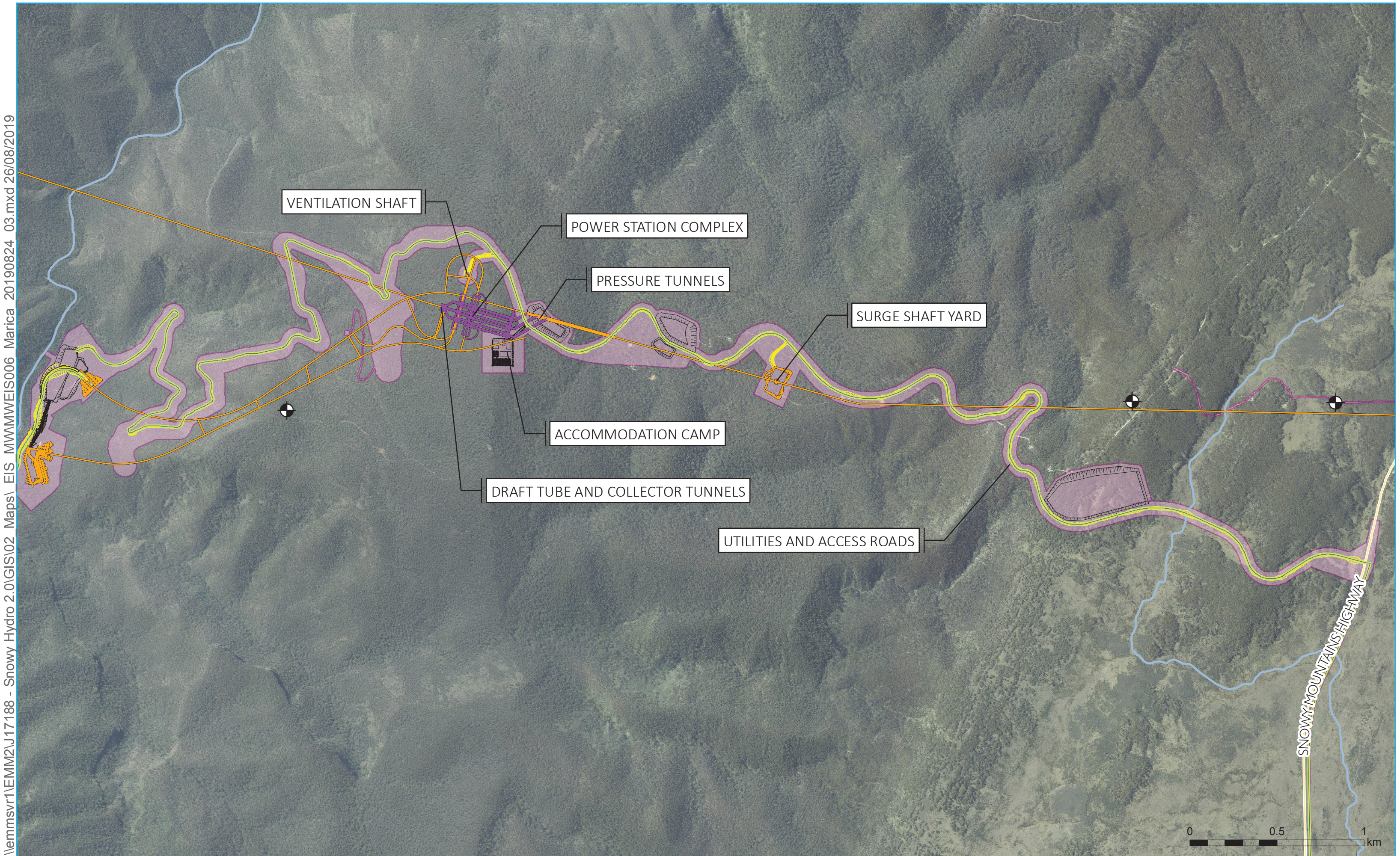
Snowy 2.0 Main Works construction elements
- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Indicative rock emplacement area
- Disturbance area*

Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

Lobs Hole - project elements, purpose and description

Snowy 2.0
Preliminary site investigation - contamination
Main Works
Figure 2.3





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

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KEY

Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements
- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements
- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Indicative rock emplacement area
- Disturbance area*

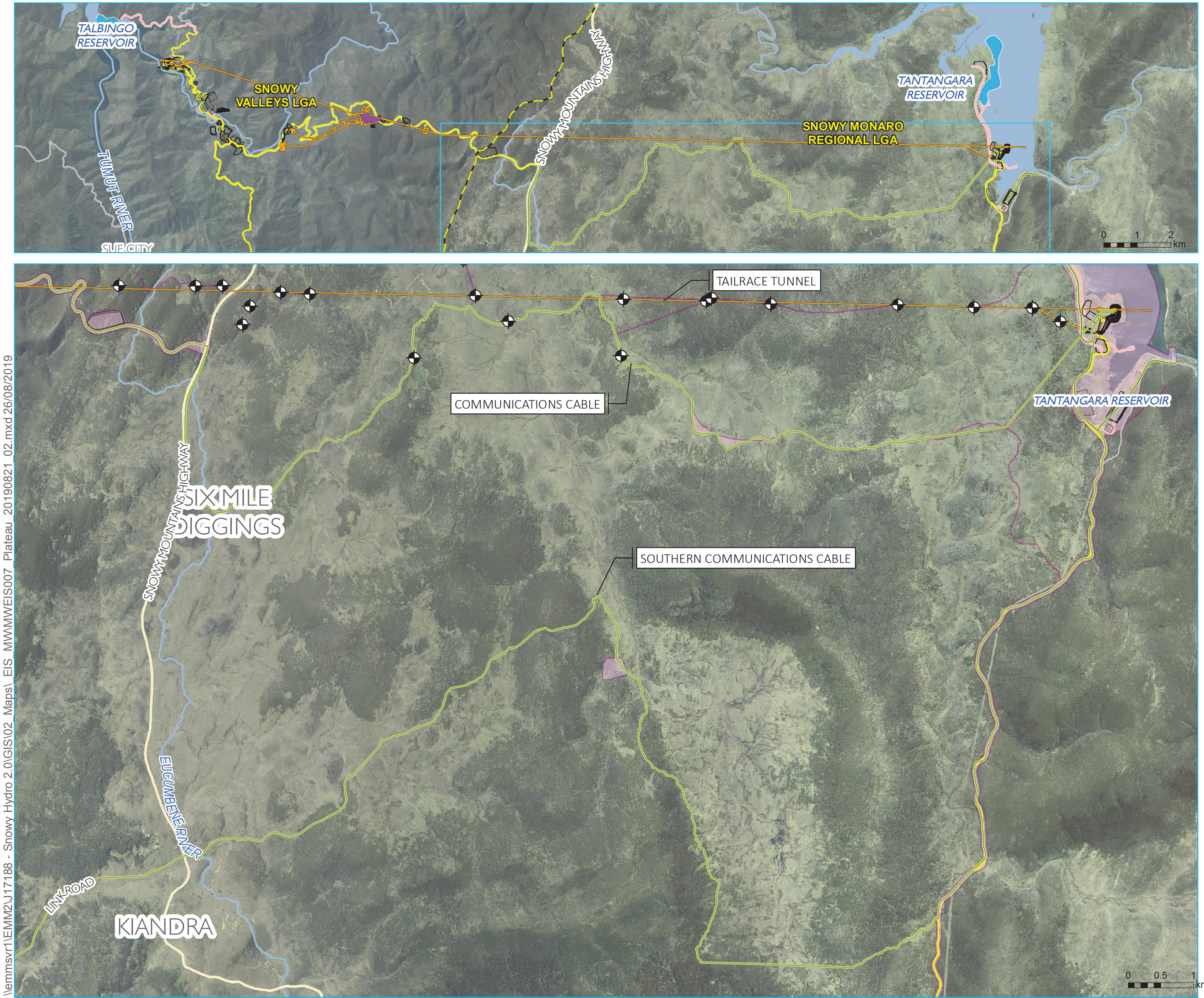
Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

Marica - project elements, purpose and description

Snowy 2.0
Preliminary site investigation - contamination
Main Works
Figure 2.4

snowy 2.0

EMM
creating opportunities



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

GDA 1994 MGA Zone 55

N

KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements

- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Indicative rock emplacement area
- Disturbance area*

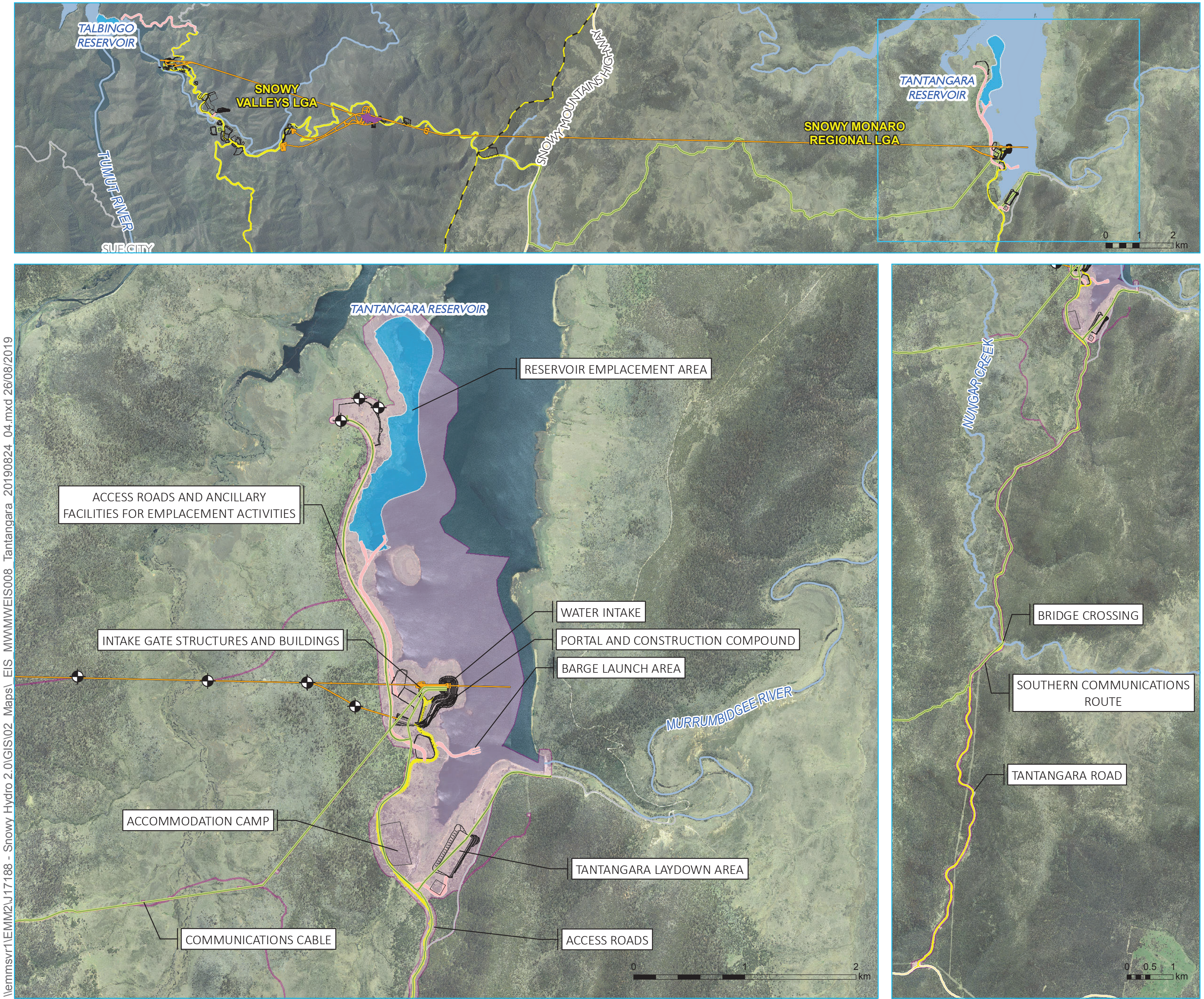
Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

Plateau - project elements, purpose and description

Snowy 2.0
Preliminary site investigation - contamination
Main Works
Figure 2.5

snowy 2.0

EMM
creating opportunities



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

GDA 1994 MGA Zone 55

N

KEY

Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements
- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements
- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Indicative rock emplacement area
- Disturbance area*

Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

Tantangara Reservoir - project elements, purpose and description

Snowy 2.0
Preliminary site investigation - contamination
Main Works
Figure 2.6

snowy 2.0

EMM creating opportunities

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

GDA 1994 MGA Zone 55

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KEY

Existing environment

- Main road
- Local road
- Watercourse

Snowy 2.0 operational elements

- Tunnels, portals, intakes, shafts
- Utilities
- Permanent road

Snowy 2.0 contruction elements

- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Disturbance area*

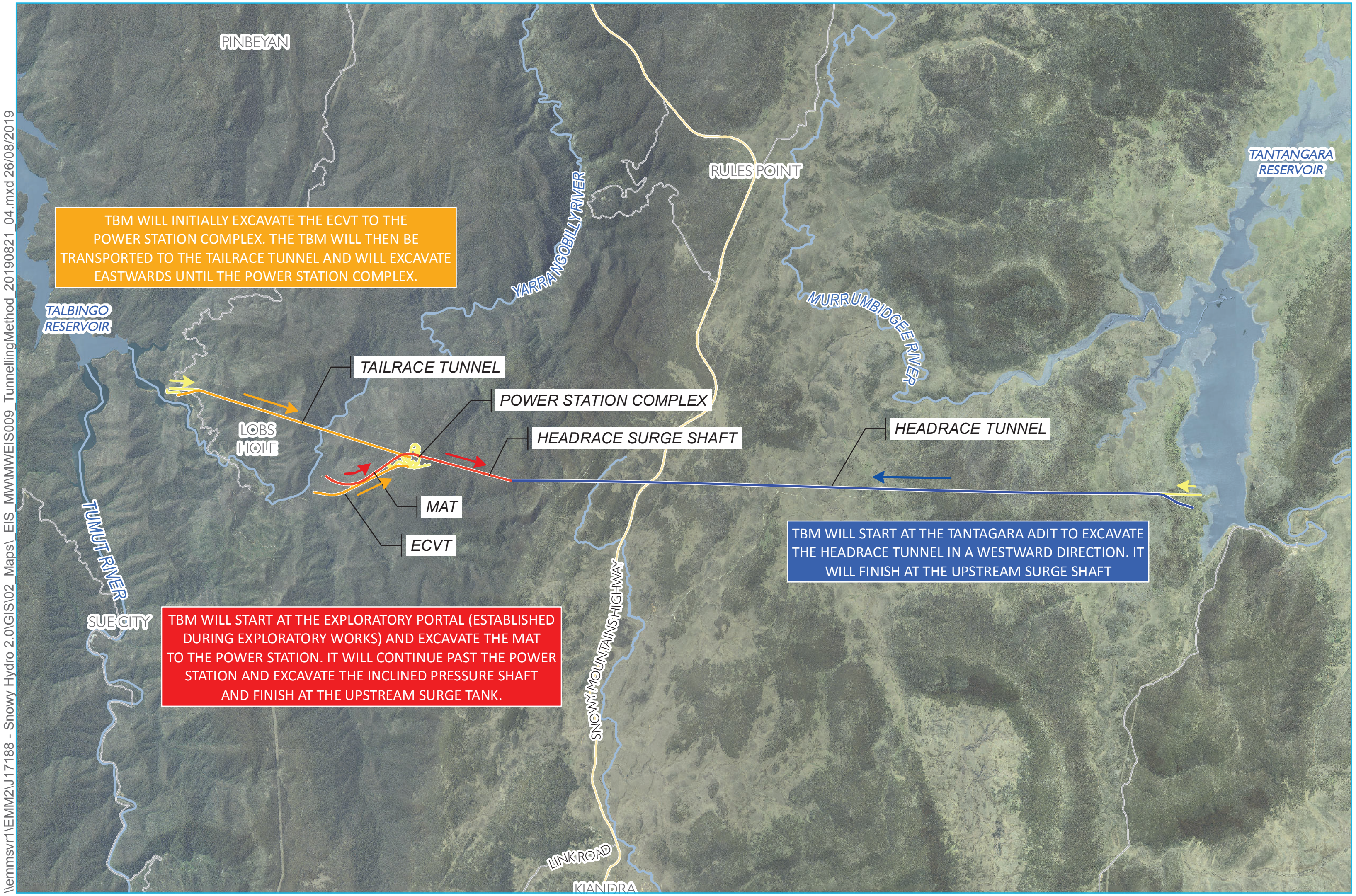
Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

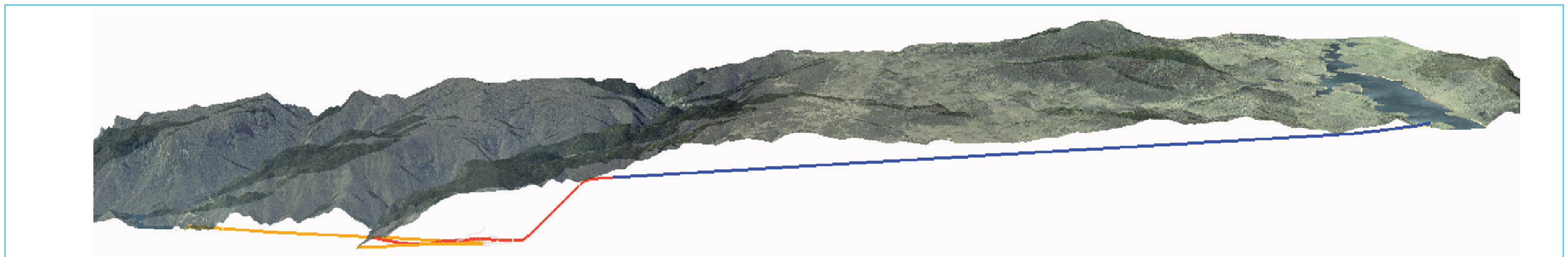
Rock Forest - project elements, purpose and description

Snowy 2.0
Preliminary site investigation - contamination
Main Works
Figure 2.7

snowy 2.0

EMM creating opportunities





KEY
Tunnelling method
Drill and blast
TBM 1
TBM 2
TBM 3
Tunnelling direction
Existing environment
Main road
Local road
Watercourse
Waterbodies

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

0 2.5 5 km
GDA 1994 MGA Zone 55
N

Primary excavation methods – drill and blast and tunnel boring machine

Snowy 2.0
Preliminary site investigation - contamination
Main Works
Figure 2.8

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2.3 Operation of Snowy 2.0

2.3.1 Scheme operation and reservoir management

Snowy 2.0 would operate within the northern Snowy-Tumut Development, connecting the existing Tantangara and Talbingo reservoirs.

Tantangara Reservoir currently has the following operational functions within the Snowy Scheme:

- collects releases from the Murrumbidgee River and the Goodradigbee River Aqueduct;
- provides a means for storage and diversion of water to Lake Eucumbene via the Murrumbidgee-Eucumbene Tunnel; and
- provides environmental releases through the Tantangara Reservoir river outlet gates to the Murrumbidgee River.

Talbingo Reservoir currently has the following operational functions:

- collects releases from Tumut 2 power station;
- collects releases from the Yarrangobilly and Tumut rivers;
- acts as head storage for water pumped up from Jounama Pondage; and
- acts as head storage for generation at Tumut 3 power station.

Due to its historic relationship to both the upstream Tumut 2 power station and downstream Tumut 3 power station, Talbingo Reservoir has had more operational functions than Tantangara Reservoir in the current Snowy Scheme.

Following the commencement of the operation of Snowy 2.0, both Tantangara and Talbingo reservoirs will have increased operational functions. Tantangara Reservoir will have the additional operational functions of acting as a head storage for generation from the Snowy 2.0 power station and also acting as a storage for water pumped up from Talbingo Reservoir. Talbingo Reservoir will have the additional operational function of acting as a tail storage from Snowy 2.0 generation.

As a result of the operation of Snowy 2.0, the water level in Tantangara Reservoir will be more variable than historically. Notwithstanding this, operations will not affect release obligations under the Snowy Water Licence nor will it involve any change to the currently imposed Full Supply Levels (FSLs). No additional land will be affected by virtue of the inundation of the reservoirs through Snowy 2.0 operations. Water storages will continue to be held wholly within the footprint of the existing FSLs.

2.3.2 Permanent access

Permanent access to Snowy 2.0 infrastructure is required. During operation, a number of service roads established during construction will be used to access surface infrastructure including the power station's ventilation shaft, water intake structures and gates, and the headrace tunnel surge shaft. Permanent access tunnels (the MAT and ECVT) will be used to enter and exit the power station. For some roads, permanent access by Snowy Hydro will require restricted public access arrangements.

2.3.3 Maintenance requirements

Maintenance activities required for Snowy 2.0 will be integrated with the maintenance of the existing Snowy Scheme. Maintenance activities that will be required include:

- maintenance of equipment and systems within the power station complex, intake structures, gates and control buildings;
- maintenance of access roads (vegetation clearing, pavement works, snow clearing);
- dewatering of the tailrace and headrace tunnel (estimated at once every 15 to 50 years, or as required); and
- maintenance of electricity infrastructure (cables, cable yard, cable tunnel).

2.4 Rehabilitation and final land use

A Rehabilitation Strategy has been prepared for Snowy 2.0 Main Works and appended to the EIS.

It is proposed that all areas not retained for permanent infrastructure will be revegetated and rehabilitated. At Lobs Hole, final landform design and planning has been undertaken to identify opportunities for the reuse of excavated material in rehabilitation to provide landforms which complement the surrounding topography in the KNP.

Given that most of Snowy 2.0 Main Works is within the boundaries of the KNP, Snowy Hydro will liaise closely with NPWS to determine the extent of decommissioning of temporary construction facilities and rehabilitation activities to be undertaken following the construction of Snowy 2.0 Main Works.

3 Assessment methodology

3.1 Policy and guidelines

The relevant legislation and policies for contaminated land in NSW that have been considered during the preparation of this report include:

- *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*;
- *Contaminated Land Management Act 1997* (CLM Act);
- *Protection of the Environment Operations Act 1997* (POEO Act) and regulations under the POEO Act relevant to this report include:
  - *Protection of the Environment Operations Legislation Amendment (Waste) Regulation 2018*
- *Environmentally Hazardous Chemicals Act 1985* (EHC Act).
- State Environment Planning Policy No 55 – Remediation of Land (SEPP 55)

The following guidelines relevant to the assessment of potentially contaminated land in NSW that have been considered during the preparation of this report include:

- National Environment Protection Council (NEPC) 1999, *National Environment Protection (Assessment of Site Contamination) Measure* 2019 (ASC NEPM 2013);
- NSW Environment Protection Authority (NSW EPA) 2015, *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*;
- NSW Department of Environment and Conservation (DEC) 2006, *Guidelines for the Site Auditor Scheme* (2nd Edition);
- NSW Department of Urban Affairs and Planning (DUAP) and NSW EPA 1998, *Managing Land Contamination, Planning Guidelines SEPP 55-Remediation of Land*;
- NSW DEC 2007, *Guidelines for the Assessment and Management of Groundwater Contamination*;
- NSW Office of Environment and Heritage (OEH) 2011, *Guidelines for Consultants Reporting on Contaminated sites*; and
- Australian and New Zealand and Australian State and Territory Governments (ANZAST), 2018 *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

3.2 Investigation methodology

The construction of the Snowy 2.0 tunnels and supporting infrastructure works would result in the disturbance and excavation of surface and subsurface soils and rock. Surface disturbance would also occur as a result of construction activities associated with the development of construction sites, substations, water and waste water servicing, temporary and permanent access roads, transport and storage of excavated rock, the development of barge launch facilities and construction of accommodation for the project work force. Groundwater will also be encountered during construction.

The following methodology was adopted to assess the study area in relation to existing and potential contamination:

1. Identification of potential or known soil, surface water and groundwater contamination in the project footprint by assessing the existing environment, including review and assessment of previous reports and soil and groundwater investigation data relevant to the project

2. Assessment of the potential contamination impacts of the project during construction and operation

3. Identification and description of mitigation measures to manage potential or known soil and groundwater contamination during construction and operation

The methodologies for the following are outlined in Section 3.2.1 and include:

- Assessment of the existing environment for the project footprint; and

- Preliminary qualitative risk assessment for the potential construction and operational impacts.

3.2.1 Methodology for assessing the project footprint

The following methodology was adopted as part of the preparation of this desktop contamination assessment:

- Assessment of the environmental setting of the areas of the park to be impacted by the project, including geology maps and NSW Trade & Investment, Division of Resources & Energy naturally occurring asbestos (NOA) maps;

- Review of site history assessment and data review to identify historical activities that may cause contamination of the site;

- Review of the current land use and historical land use (using aerial imagery from 1950's onwards) to identify areas of historical potentially contaminating land sources;

- Review of NSW EPA records relating to contamination, including:

  - contaminated sites notified to the NSW EPA under Section 60 of the CLM Act 1997;

  - contaminated sites currently or formerly regulated by the NSW EPA (Record of Notices);

  - environment protection licenses issued by NSW EPA;

  - former gasworks sites;

  - EPA Per- and Poly-Fluoroalkyl Substances (PFAS) investigation program; and

- sites listed on the National Waste Management site database.

- Review of relevant assessment reports:
  - GHD 2018, *Geotechnical Factual Report;*
  - SMEC 2019, *Naturally Occurring Asbestos and Other Hazardous Mineral Fibres*;
  - URS 2015, *Lobs Hole Site Investigation and Remediation Assessment;*
  - EMM 2018b, *Phase 1 Contamination Assessment, Exploratory Works for Snowy 2.0;*
  - EMM 2018c, *Soil and Land Assessment, Exploratory Works for Snowy 2.0;*
  - SHL 2019, *Targeted Contamination Investigation on Mine Trail Ch 50-450;*
  - SMEC 2018, *Contamination Investigation Interpretive Report – Exploratory Surface Works – Roads Ravine Road and Mine Trail;*
  - SMEC 2019, *Acid Metalliferous Drainage, Issue E;*
  - CSIRO 2018, *Snowy 2.0 P1: Comprehensive Geochemistry Examination;*
  - CSIRO 2019a, *Snowy 2.0 P2: Environmental Risk Characterisation of Rock Materials;* and
  - CSIRO 2019b, *Snowy 2.0 Assignment P4: Environmental Characterisation of Spoil Interactions with and Potential Impacts on Reservoir Waters and Sediments.*
- A site inspection to identify potential sources and areas of site contamination; and
- The preparation of a report detailing the findings of the assessment.

Following review of the existing information, the potential areas and contaminants of concern were identified and a preliminary conceptual site model (CSM) and qualitative risk assessment was undertaken to inform the need for further investigations, management and mitigation measures for the project (refer to Section 9).

3.3 Conceptual site model and qualitative risk assessment

Potentially contaminated material (i.e. soil, rock, sediment) has the potential to adversely impact human health and ecological receptors if not managed appropriately. A CSM is used to present and assess the linkage between potential contamination sources, exposure pathways[1], and receptors. As detailed in the ASC NEPM (2013), the development of a CSM is a key component of contaminated site assessments and provides the framework for identifying how potential receptors may be exposed to contamination.

A risk is considered to be posed to a receptor when the pathway between the receptor and a contamination source is 'complete' and the contamination is present at concentrations that could have a negative impact on the health of the receptor. Where there is no or insufficient quantitative analytical data to assess whether concentrations of contamination pose a risk, a qualitative risk assessment is used.

[1] An exposure pathway is the link from the source of contamination to the exposed population or environment eg direct contact, inhalation or ingestion by human receptors, transport in wind or groundwater migration (NEPC 1999).

To assess the relative risk of existing and potential contamination during project construction and operation, a qualitative risk assessment was undertaken for the study area (as defined in Section 1.1.2). The methodology for the risk assessment is detailed in Table 3.1.

Table 3.1 Preliminary qualitative risk assessment methodology

Construction	Operation
Identification of areas and contaminants of concern	
Identified using the methodology outlined in Section 3.3	
Likelihood of contamination to be present and likely extent of impacts	
Identified by review of information presented in section 5.2.	
Potential migration pathways	
• Dust generation • Excavation and disposal or reuse of soils • Extraction and disposal or reuse of groundwater from dewatering or drainage • Migration of groundwater via preferential pathways • Surface water erosion.	• Extraction of groundwater in drainage systems • Migration of groundwater via preferential pathways • Surface water erosion.
Potential receptors	
• Project construction workers and visitors • Surrounding land users such as the general public and nearby residents and commercial workers • Receiving water bodies.	• Intrusive maintenance workers • Future site users of final land use such as commercial, open space or residential • Ecological receptors • Receiving water bodies.
Potential exposure pathways	
• Direct contact, ingestion or inhalation by human receptors • Uptake by aquatic flora and intake by aquatic fauna.	• Direct contact, ingestion or inhalation by human receptors and fauna • Uptake by terrestrial and aquatic flora and intake by aquatic fauna.

To identify the risk rating, the preliminary qualitative contamination risk assessment matrix in Table 3.2 was used. The matrix included in Table 3.2 was used to assign the risk in assuming the absence of appropriate controls and mitigation measures. This site conceptual model and risk assessment is included in Annexure A.

Table 3.2 Preliminary qualitative risk assessment matrix

Consequence	Likelihood of soil or groundwater contamination to be present				
	Very unlikely to be present at concentrations above the relevant assessment criteria and limited in extent	Potentially present at concentrations above the relevant assessment criteria and limited in extent	Potentially present at concentrations above the relevant assessment criteria and widespread	Most likely present at concentrations above the relevant assessment criteria and widespread	Known to be present at concentrations above the relevant assessment criteria and widespread
No or unlikely exposure pathway for human or ecological receptor's either now or during or post construction*	Low	Low	Low	Medium	Medium
Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction*	Low	Medium	Medium	High	High
Exposure pathway for human or ecological receptors present and are complete either now, during or post construction*	Medium	Medium	High	High	High

Notes: * without implementation of appropriate controls or remediation as recommended in the management of construction and operational impacts – Section 9

4 Existing environment

4.1 Heritage

Understanding previous occupation and land use of the site is informed by the assessment of historic cultural heritage (NSW Archaeology 2019). The assessment identified a rich history beginning with thousands of years of active use of the area by Aboriginal peoples. The early-European settlers arrived in the 1820s and the established pastoralism and summer grazing in the 1830s. Of interest from a land contamination perspective is the previous mining activity that included the gold rush at Kiandra in 1859-60, the copper mining and processing activities at Lobs Hole (also known as Ravine) as well as gold mining activities at Gooandra and Tantangara. Other activities include the early scientific exploration, promotion of tourism and the construction of the Snowy Mountains Scheme during the 20th Century. Other lesser known activities in the high country include timber harvesting and milling and Eucalyptus oil distilling.

4.2 Climate

The study area has an alpine climate that is characterised by cool summers and cold, damp, and snowy winters. The highest and most consistent rainfall occurs in winter to early spring, with rainfall depths increasing with elevation. Summer and autumn are generally drier and experience greater variation in monthly rainfall depths. Summer rainfall is generally of higher intensity and of shorter duration than winter rainfall.

Climate data for the study area has been sourced from regional Bureau of Meteorology (BoM) and Snowy Hydro rainfall gauges, and climate maps that are also produced by BoM. A summary of climate data for the ravine (including Talbingo, Lobs Hole and Marica) and plateau (including plateau and Tantangara) is provided in Table 4.1. A more detailed description of the study area climate is provided in the water characterisation report (Annexure A).

Table 4.1 Climate summary

	Ravine	Plateau
Temperature[1]		
Mean annual maximum	21.3 °C	12.6 °C
Mean annual minimum	9.1 °C	5.1 °C
Annual rainfall[2]		
Highest	1,315 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	

Notes: 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 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).

4.3 Soils

The soils of the study area reflect the extreme climatic gradient across the ravine and plateau, and complex geology on which the soils have formed. Climatic conditions have a more dominant role in soil formation across the alpine and subalpine areas of the plateau compared to the low-lying areas of the ravine where the study area is located (550 - 1200 mAHD). The range of geologies present has led to a wide variety of soils forming across the study area including Kandosols, Tenosols, Rudosols, Dermosols, Chromosols, Vertosols, Ferrosols and Organosols. Refer to the soils and land assessment (EIS Appendix P.2) for further details.

4.4 Geology

The geology of the broader assessment area comprises Ordovician to Devonian granites, volcanics, and metamorphosed sedimentary sequences that have formed faulted, stepped ranges at the point where the South Eastern Highlands (part of the Lachlan Fold Belt) in NSW transition west into Victoria (NPWS 2003) NSW (Stuart-Smith 1991). There are eight karst areas in KNP, all of which are developed in Silurian or Devonian limestones. Volcanic activity associated with periods of uplift during the Tertiary period also resulted in the formation of basalts which form some of the ridgelines to the east of the study area. Shallow and outcropping Ordovician to Devonian rocks are regionally extensively weathered, consisting of a mixture of colluviums, regolith, and weathered basement rocks.

In the Pleistocene, the cold climate superimposed glacial features on the landscape (NPWS 2003). The Australian Alps Bioregion was the only part of the mainland to have been affected by Pleistocene glaciation and contains a variety of unique glacial and periglacial landforms above 1,100 m altitude (NPWS 2003). Overlying these older geological units, a regionally extensive weathered zone exists. Geological units are shown conceptually in Figure 4.1.

The various rock types have developed during multiple orogenic periods. These orogenic periods are associated with extensive faulting and have formed major structural features throughout the area (Wyborn et al 1990). The area between Talbingo and Tantangara reservoirs is structurally deformed, with numerous folds and several major faults associated with the north-south trending Long Plain Fault. Long Plain Fault (LPF) forms the western boundary of the Tantangara Block and the plateau. The fault trends in a north-northeast direction over a distance of more than 200 km, from the Upper Murray River to west of the Brindabella Ranges near Canberra. Near the study area, the LPF dips eastwards at 50–60 degrees (SMEC 2019c).

Refer to the surface water assessment (Appendix L to the EIS)

4.4.1 Naturally occurring asbestos

A review of the distribution of NOA within NSW was undertaken by the Geological Survey of NSW (NSW Trade & Investment 2015). Known sites of NOA were mapped; the mapping identified the majority of NSW (99.17%) has very little or no potential for NOA. The mapping project was initiated by the risk associated with the inhalation of asbestos fibres, which can cause chronic disease characterised by scarring of lung tissue and long-term breathing complications. Asbestos is listed as a category 1 carcinogen by world health authorities (NSW Resources & Geoscience 2018).

NOA includes silicate, inorganic mineral fibres of the serpentine and amphibole mineral group that are typically fine fibrous aggregates of high tensile strength and flexibility that readily separate. NOA can be both asbestiform and non-asbestiform; two different types of mineral fibrous forms. There are six main asbestos minerals reported by NSW Trade & Investment (2015), these include: actinolite, amosite, anthophyllite, chrysotile, crocidolite and tremolite. NOA does not present in a predictable distribution, rather concentrations often occur as veins or nuggets (SMEC 2019b).

A high potential for NOA is reported in the ultramafic and mafic igneous rocks underlying the KNP (NSW Trade & Investment 2015). Asbestos fibres are commonly produced by shearing stresses (ie faulting and folding) during deformation of ultramafic rocks. High potential areas have been assessed as having the highest potential for asbestiform minerals. The distribution of asbestos in a high area is most likely to be widespread and large accumulations of asbestos are possible. However, asbestiform minerals will mostly only constitute a small proportion of the rock overall (< 0.1%). Medium potential areas include theoretically less favourable rock types such as sandstones which could include ultramafic material, as well as areas of poor outcrop where ultramafic rocks are physically resistant and subtly emergent.

Ultramafic rocks are typically dark in colour, and are rich in magnesium and iron relative to silica and potassium. Mafic rocks having undergone certain metamorphosis can also host asbestos minerals. Historical amphibole mineral sightings in Boraig Group and Ravine Beds formations near Yarrangobilly River date back to investigations from 1950s (SMEC 2019b).

4.4.2 Potentially acid forming rock

Acid generation is caused by the exposure of sulfide minerals, most commonly iron sulfide (pyrite, FeS_2), to oxygen (from air) and water. The oxidation of pyrite to produce sulfuric acid and ferric hydroxide ($Fe(OH)_3$, orange precipitate) occurs as follows:

$$FeS_2 + 3.75O_2 + 3.5H_2O \leftrightarrow Fe(OH)_{3(s)} + 2SO_4^{2-} + 4H^+$$

According to this reaction, the maximum potential acidity (MPA) of a sample containing 1 % sulfur as pyrite would generate 30.6 kg H_2SO4/t. The amount and rate of acid generation is determined by the interaction and overall balance of the acid generation and neutralization components. As acidic water migrates through a site, it will react with minerals in the surrounding rock material, potentially dissolving metals and salts. The acid will be progressively neutralised at the expense of the increasing concentration of metals (COA 2016)).

Sometimes the dissolution of carbonate minerals (eg calcite) can neutralise acidic drainage. This neutralisation process can lead to the precipitation of metals (eg aluminium, copper) as the pH increases removing them from the drainage. However, at near neutral pH, concentrations of elements such as arsenic, cadmium, manganese, and zinc can remain elevated resulting in neutral metalliferous drainage (COA 2016). Where acidic drainage is completely neutralised by carbonate and the resulting leachate contains no significant residual concentrations of metals, the potential exists for saline drainage with elevated concentrations of magnesium, calcium and sulfate (COA 2016).

The generation of Acid Mine Drainage (AMD) has the potential to occur from excavated rock resulting from tunnelling, during construction and placement. To understand the potential risk of AMD on the project, previous investigation reports have been reviewed and summarised in Section 6.4.

4.5 Hydrology

The entire study area lies within the Murrumbidgee River catchment. The Murrumbidgee River is a regulated system and has 14 dams and eight large weirs, designed to support primarily environmental receivers, power generation and irrigation. Most of the study area is located between Talbingo and Tantangara reservoirs. Tantangara Reservoir, on the Murrumbidgee River, is approximately 14 km long and has a surface area of approximately 21.2 km^2. The Yarrangobilly River is a major regional watercourse that flows into Talbingo Reservoir.

Talbingo Reservoir is approximately 25 km long and has a surface area of approximately 19.4 km^2.

Watercourses across the study area vary according to soil type, geology, topography, elevation and climate and range from small ephemeral watercourses to regional rivers with perennial flow regimes. There are headwater streams (swampy meadows, steep headwater streams and discontinuous channel) and trunk streams (confined, and partially and unconfined). The hydrologic regime is strongly influenced by seasonal changes to climate. Flow in watercourses occurs due to the following processes quickflow, following intense rainfall; interflow, lateral movement of water through the unsaturated zone or shallow perched saturated zone that returns to surface and flows toward stream channels; and baseflow, water discharged from the shallow groundwater system. Refer to the water characterisation report (Annexure A to water assessment) in Appendix L of the EIS and groundwater assessment in Groundwater assessment in Appendix L of the EIS for further details.

4.6 Hydrogeology

Most of the study area is located between Talbingo and Tantangara Reservoirs, within the Tumut (ravine) and Tantangara (plateau) structural blocks. The two structural blocks are separated by the north-south trending LPF, forming distinct geological terrains and associated groundwater systems. Refer to water characterisation report (Annexure A to water assessment) for further details.

The groundwater units within the study area are defined as:

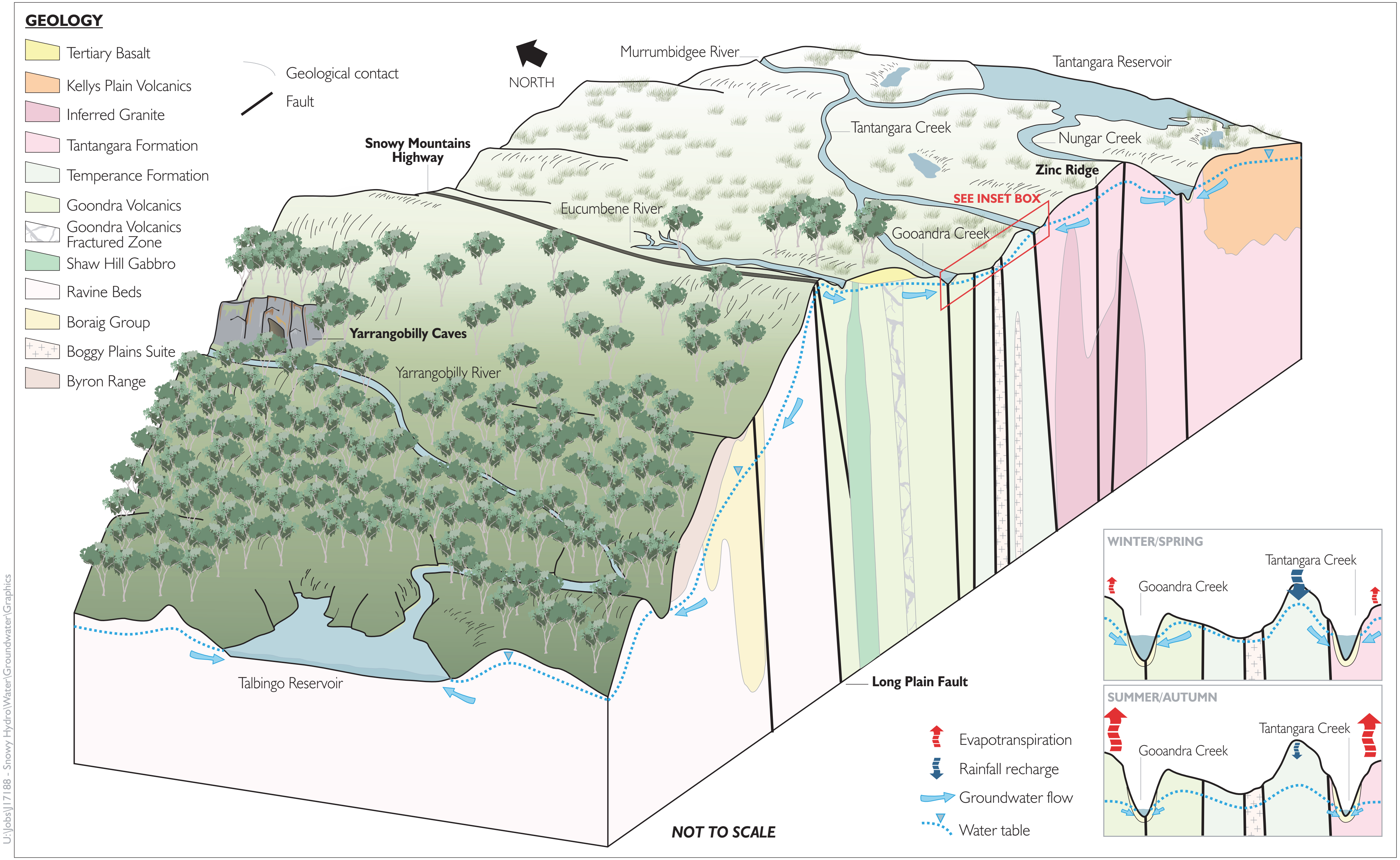
- localised highly permeable shallow groundwater system associated with the thin basalt caps present across the plateau area;
- low permeability fractured rock groundwater system associated with the weathered and oxidised shallow component of the geology across the plateau area; and
- low permeability regional fractured rock groundwater system associated with the volcanic and metasedimentary rock across the plateau and ravine areas.

In addition, localised groundwater systems can be associated with unconsolidated Quaternary alluvium and colluvium deposited in major creeks and river valleys and in depressions across the plateau and ravine areas.

The fractured rock unit, associated with the volcanic and metasedimentary rock, is the main hydrogeological unit in the study area. The unit is accessed by various environmental users, including alpine bog/fen vegetation, deep rooted Eucalypt species and gaining creeks and rivers. There are no recorded landholder bores located within the study area.

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 significant rainfall events. Discharge occurs via: drainage to surface water, evaporation from the water table, transpiration from overlying groundwater dependent ecosystems, drainage to springs and regional groundwater flow. Groundwater flow is shown conceptually in Figure 4.1.

Groundwater dependent ecosystems can occur where the depth to groundwater is less than 2 mbgl. These communities have an obligate/dependent relationship with groundwater (Sorev et al 2012) and intercept the shallow and/or regional groundwater systems. Other potential GDEs have a facultative dependence on groundwater. These communities occur where groundwater levels are greater than 5 mbgl.



EMM creating opportunities

snowy2.0

Snowy 2.0 conceptual geological block diagram

Snowy 2.0
Contamination Assessment
Figure 4.1

4.7 Ecology

The alps are home to unique cold climate adapted plants and animals—from alpine daisies to snow gums, and from mountain pygmy possums to migratory Bogong moths. The seasonal presence of snow, sets the Australian Alps apart from most other places on mainland Australia. Seasonal changes include in summer displays of alpine wildflowers, the glacial and periglacial landforms, the extensive subalpine grasslands and snow gum woodlands, and the swift flowing alpine streams are all rare, if not unique, features in Australia.

The total project footprint supports 985.06 ha of native vegetation communities including grassy woodlands, grasslands, dry sclerophyll forests, wet sclerophyll forests, alpine complex and very minor areas of freshwater wetlands with montane bogs and fens. Dominant vegetation communities are grassy woodlands including plant community type 1224 – Sub-alpine dry grasslands and heathlands of valley slopes, southern South Eastern Highlands Bioregion and Australian Alps Bioregion and plant community type 1196 - Snow Gum - Mountain Gum shrubby open forest of montane areas, South Eastern Highlands Bioregion and Australian Alps Bioregion.

The vegetation at the study areas comprises:

- Talbingo Reservoir: there has been some clearing and disturbance associated with the construction of the dam wall and Tumut 3 power station in the northern end.
- Marica: vegetation comprises tall montane forests with large trees and a shrubby understorey.
- Lobs Hole: weed invasion is minimal, and largely limited to road edges. In some areas disturbance due to past land use is evident and significant, while in other areas there is minimal disturbance. The lower section of Lobs Hole Ravine Road there are dry sclerophyll forests with a shrubby to grassy understorey.
- Plateau: there is a mix of dry grassy plains in cold air depressions, ringed by grassy woodlands of Black Sally and Snow Gum. In drainage lines dry grasslands give way to wet grasslands. In this area disturbance is limited to historical land use, along with impacts from recreational use such as horse-riding. Impacts from feral horses are prevalent in the grassy plains and along drainage lines.
- Tantangara: vegetation within the southern end of Tantangara consists of grassy woodlands and grasslands, moderately disturbed as a result of fire damage, historical clearing, weed invasion and heavy recreational use. Feral horses are also prolific in this area.
- Rock Forest: is predominantly derived grasslands as a result of historical clearing and grazing. Vegetation within Rock Forest, bordering the KNP, consists of medium to high quality vegetation.

Refer to the biodiversity development assessment report (Appendix N.1 to the EIS) for more information.

5 Site history

5.1 Historical aerial imagery

Aerial photographs from the 1950s, when the records commenced, have been reviewed. Given the land use in the last 70 years (ie Kosciuszko State Park later named Kosciuszko National Park), very little infrastructure or significant changes are noted in the photographs, other than the construction of the initial Snowy Hydro Scheme. The aerial photographs are summarised in Table 5.1. The relevant aerial photographs are provided as figures in Annexure B.

Table 5.1 Review of historical aerial imagery

Year	Description
Talbingo Reservoir	
1950s	The study area has no developments and is heavily vegetated; Talbingo Dam does not yet exist. Bare vegetation patches adjacent to the original course of the Yarrangobilly River are visible. There is one access track in the northern end to the Yarrangobilly River.
Lobs Hole	
1961	The study area is sparsely developed. Scarring (bare vegetation patches) in the Lobs Hole Mine operation areas are visible. Few access tracks run into and out of the area. The transmission line corridor, south of Ravine, is visible. The original course of the Yarrangobilly and Tumut Rivers is observed. The remnants of the Washington Hotel are visible in the footprint of the former village of Ravine.
1998	The Lobs Mine area appears similar to the previous photo. Both the northern and southern transmission line corridors are visible. Talbingo Reservoir is encroaching through the Tumut River floodplain.
2018	No significant changes in land use or features noted.
Marica	
1961	Wallaces Creek Trail is visible on the western extent of the image. The area is otherwise dominated by remnant vegetation with little evidence of disturbance.
1998	No significant changes in land use or features noted.
2019	No significant changes in land use or features noted.
Plateau	
1961	The Snowy Mountains Highway transects the from north to south and the utilities corridor is visible parallel to the highway. Some remnant vegetation has been cleared. Otherwise there is little evidence of disturbance or impacts.
1976	No significant changes in land use or features noted.
1985	No significant changes in land use or features noted.
1998	No significant changes in land use or features noted.
2019	No significant changes in land use or features noted.
Tantangara Reservoir	
1950s	There are no developments or infrastructure. The Murrumbidgee River has not been dammed, ie Tantangara Dam does not exist. There is a significant lack of vegetation cover adjacent to the Murrumbidgee River.
1961	Access tracks run into and out of the area. The dam is visible at the southern extent of the reservoir. Scarring and impacts from its construction can be seen in the southern extent of the image. The quarry at Tantangara is visible on the southern edge of the 1961 photo.
1998	The reservoir levels are significantly lower than the 1961 levels. Some vegetation appears to have regrown in various areas impacted by the dams construction. Additional tracks are visible along the western shores of the reservoir. The quarry extent has expanded slightly.

Table 5.1 Review of historical aerial imagery

Year	Description
2018	The reservoirs water levels are similar to those observed in the 1961 photo. No significant changes in land use or features noted other than access tracks in the intake area are more pronounced.
Rock Forest	
1963	Site has been partially cleared for agricultural use, some remnant vegetation remains. A homestead is located to the north-east of the site, and KNP to the west. The remainder of the surrounding land is partially cleared agricultural land.
1970	No significant changes in land use or features noted.
1979	A track has been cleared in the south-western corner and a dam has been constructed in the southern end of the site. Widespread evidence of flooding.
1985	A dam has been constructed in the northern end of the site, and some vegetation clearing has also occurred in the northern end of the site.
1994	A small dam near the eastern front gate. Stockyard has been built near the front gate.
2001	No significant changes in land use or features noted.
2018	Dam near the eastern front gate is not filled, small depression only.

5.2 Overview of project area history

5.2.1 Talbingo Reservoir

Talbingo Reservoir was formed by the damming of the Tumut River for the Snowy Mountains Scheme and was constructed between 1968 and 1971. Before the dams construction, the area comprised a densely vegetated valley. Evidence of the forested area can be seen throughout the shallow zones, with submerged trees a key visual feature of the reservoir.

5.2.2 Lobs Hole

Lobs Hole, formerly known as the Village of Ravine, is situated in a ravine along the Yarrangobilly River. The area was transformed in the early 1800s as a thoroughfare for the movement of stock, prospecting, grazing, horse breeding, settlement, refuge from the winters of Kiandra, horticulture, gardening and agriculture, copper mining and processing. The area was also a popular recreational destination for Snowy Scheme workers, during and after the scheme's construction between 1949 and 1974 (NSW Archaeology 2019).

While active, the village buildings of Lobs Hole included a school, a butcher shop, a blacksmith's workshop, a police station, a hotel and boarding houses. The town reached a maximum population of approximately 500 by 1917. The population of the town dwindled in the 1920s, the Washington Hotel was partially demolished, and the school burned down in 1928 (Boot 2001). Remnants of the Washington Hotel and other minor building foundations and associated archaeological deposits remain.

Mining of copper at the Lobs Hole Copper Mine began in 1865. Most of the early works (ie prior to 1900) at the mine were done on the surface. Shafts were eventually sunk between 15 and 45.7 mbgl but were repeatedly flooded given the close proximity to the Yarrangobilly River. In 1900 the Lobs Hole Copper Mine company was formally established, and the original mine was further expanded underground. Surface works included a draw-lift pump on the main shaft, a dam, a water race (to prevent flooding of the mine), 30 horsepower hydraulic plant and a reverberatory furnace (NSW Archaeology 2019). The reverberatory furnace (ie a smelter) was added to operations in 1909 to enrich and concentrate the mined ore. It was later blown up in the 1950s.

The Alpine Copper-Mining Company was registered in 1900 and was established on the northern bank of the Yarrangobilly river, opposite the Lobs Hole Copper Mine. Two other groups also took up leases about this time to the north-east and west of Lobs Hole. These mines were smaller in comparison to the original mine and lasted only 10 years. Mining continued intermittently at the Lobs Hole Copper Mine until 1917 (NSW Archaeology 2019). At the time of closure, the mine consisted of a total of six shafts, two adits, and several waste rock stockpiles, much of which is still observable on the site today.

The Lobs Hole mining complexes are identified as a geoheritage site in the KNP Geodiversity action plan (OEH 2012) and as a heritage item on the NPWS Historical Heritage Information Management System. The footprint of the Lobs Hole mine covers an area of approximately 3 ha, with all features within close proximity to the Main Works disturbance area, with the exception of adit south being situated within Lick Hole Gully.

Prior to Snowy 2.0 project activity, the Lobs Hole/Ravine area was accessible to the public for recreational four-wheel driving use and for use as a campground. Public access to the area is now not permissible.

5.2.3 Marica

The Marica area is part of the Kiandra plateau which has been used since the early 1800s for summer grazing, with some gold mining activity in the 1850s. Following the initial reports of gold at Kiandra in 1854, large numbers of prospectors quickly moved to the area. However, the Kiandra gold rush peaked in 1860 and lasted only one year. Relevant to the study area is historical gold mining activities which were undertaken along Eucumbene River. Little permanent structures were erected at the mine sites, with miners either camping or staying in Kiandra (NSW Archaeology 2019).

5.2.4 Plateau

The Plateau area was used for intermittent pastoral grazing and farming from the 1830s. Presently there are the remnants of one hut, Roadmans Hut (NSW Archaeology 2019). Gold mining activities along Gooandra and Tantangara Creeks, similar to Eucumbene River, peaked in the 1860s. NSW Archaeology (2019) report some shafts were dug in search of quartz and gold, however there is little evidence of these presently, suggesting they were shallow features.

5.2.5 Tantangara Reservoir

The area of Tantangara is dominated by Tantangara Dam and the main access to the reservoir, Tantangara Road. The western edges of the Reservoir are a popular spot for recreational four-wheel driving use, fishing and for camping. Tantangara has been used for summer grazing, mining and more recently the construction of the dam and its associated infrastructure.

There is a former quarry located 1.5 km southwest of Tantangara Dam. This quarry was established during construction of the Tantangara Dam wall for aggregate supply during the original Snowy Scheme. Percival (2019) reports that about 25 m of fresh massive dark bluish quartz-feldspar porphyry, typical of the Kellys Plain Volcanics, is exposed in this quarry.

There are some areas within the project proximity that include historical waste materials associated with the drill and blast tunnelling from the former snowy scheme. These waste materials often include construction debris (metal and concrete) and were often disposed adjacent to water courses. Rehabilitation efforts have occurred since their deposition, with works mostly including flattening, the control of total suspended solids release into water systems and an attempt to revegetate the batters.

5.2.6 Rock Forest

A table detailing the historical land ownership is included in Annexure C. The Russell family have been the predominant landowners and have used the site for agriculture since 1964. The site was previously Crown land, with clearing undertaken between 1911 to 1985 to support non intensive livestock.

5.3 Potential historical contaminating activities

There are recorded previous land uses and activities relating to mining and quarrying in some study areas. This includes former copper mining and processing operations at Lobs Hole and quarrying at Tantangara Reservoir. The former Snowy Scheme comprised tunnelling activities, dam construction, equipment storage and operation of construction camps. These activities predominantly did not occur in the current study areas, although there is potential for unreported contamination. Other activities relating to vegetation clearing, agricultural land use and historic settlements could also have implications for potential site contamination.

6 Desktop contamination assessment

A review of known previous investigations at the site was undertaken in conjunction with information provided from searches of relevant environmental databases.

6.1 Contamination registers

A desktop review of contamination registers was undertaken for the site and is detailed in Table 6.1

Table 6.1 Desktop contamination assessment

Register	Description	Date assessment undertaken	Result
NSW EPA contaminated land: record of notices	NSW EPA's Contaminated Land Public Record register (under Section 58 of the CLM Act 1997) lists sites for which the EPA has issued regulatory notices under the CLM Act. The register includes the details of current and former regulatory notices issued.	20 March 2019	No records for the site
NSW EPA contaminated land: sites notified	NSW EPA's register of contaminated sites notified to the EPA under Section 60 of the CLM Act, provides an indication of the management status of that particular site. Under Section 60 of the CLM Act, properties must be registered with EPA if there is reason to suspect the land is contaminated, and one or more of the notification triggers in the Duty to Report guidelines exist at the site. Upon receipt of a Section 60 notification, the EPA assesses the contamination status of the site to determine whether the contamination is significant enough to warrant regulation by the EPA.	Database dated 15 April 2019	No records for the site
NSW EPA: environment protection licences (EPLs)	The NSW Protection of the Environment Operations Act (POEO Act) 1997 requires EPLs, issued by the EPA, to be held by owners or operators of premises where the activities being undertaken are potentially contaminating activities listed in Schedule 1 of the POEO Act. An EPL typically includes conditions that relate to pollution prevention, monitoring and reporting.	5 August 2019	10515 – electricity generation 21226 – Lobs Hole Exploratory Works
NSW EPA: former gasworks register	The NSW EPA maintains a register of former gasworks as the operation of gasworks has left a legacy of soil and groundwater contamination. The major contaminants include tars, oils, hydrocarbon sludges, spent oxide wastes, ash and ammoniacal recovery wastes.	20 March 2019	No records for the site
National waste management site database	The National Waste Management Database (upgraded) presents the spatial locations of Australia's known landfills, waste transfer stations and a large number of waste reprocessing facilities. The data are a compilation of Australian, jurisdictional government, council and industry databases.	Database dated November 2018	No records for the site
NSW EPA PFAS (per-and poly-fluoroalkyl substances) Investigation Program	NSW EPA has a state-wide PFAS investigation program to identify the use and impacts of legacy PFAS, a group of manufactured chemicals that are fire retardant, waterproof and stain-resistant that are very stable and can bioaccumulate.	20 March 2019	No records for the site

Table 6.1 Desktop contamination assessment

Register	Description	Date assessment undertaken	Result
Acid sulfate soils mapping	Acid sulfate soils (ASS) are acidic (pH<4) soil horizons or layers resulting from the aeration of soil rich in iron sulfides, primarily pyrite (Department of Land and Water Conservation, 1998). Drainage or excavation of these soils aerates these previously waterlogged soils and the pyrite is oxidised into sulfuric acid.	20 March 2019	Project area is unlikely to contain acid sulfate soils, however PAF has been identified within the project study area

6.2 Naturally occurring asbestos

Field testing of topsoil, drilling mud and core samples within the study area has been undertaken as part of previous investigations (detailed below) to understand the likelihood and distribution of NOA. Testing has focused predominantly on the tunnel alignment as well as areas where surface excavations or ground disturbance are proposed.

6.2.1 GHD (2018) Geotechnical Factual Report

GHD (2018) undertook a geotechnical drilling program along the tunnel alignment. A total of seven drilling mud and 14 rock core samples were analysed using stereo microscopy and polarised light microscopy (AS4964) for asbestos identification.

One positive fibrous result was detected from a rock core sample (BH3108) at a depth of 381.6 mbgl. This sample was from the Gooandra Volcanics and is believed to be above the tunnel alignment. This core was then analysed using SEM and EDS, which showed over 100 countable fibres in 100 image fields. The elemental composition of the fibre was indicative of actinolite.

A layout of the boreholes along the tunnel alignment is shown in Figure 6.1. Sampling analytical results are outlined in Figure 6.2.

6.2.2 SMEC (2018) Contamination Investigation Interpretive Report – Exploratory Surface Works Roads - Ravine Road and Mine Trail

As part of the Exploratory Works investigations, a targeted surface contamination investigation was undertaken at selected locations to assess NOA risk during road construction. Road upgrades, along 26 km of roads, and 2 km of new road will be built along these roads.

Samples were collected from 24 test pits, at 500 m - 600 m intervals along Lobs Hole Ravine Road (14.9 km) and Mine Trail (2.6 km) at depths between 0 - 0.1 mbgl. No NOA was identified in the samples analysed. Samples were also collected from seven test pits, at approximate 200 m intervals along Mine Trail, between 0 - 0.1 mbgl. No NOA was identified in the samples analysed. Sampling locations are outlined in Figure 6.3.

6.2.3 SMEC (2019b) Naturally Occurring Asbestos and Other Hazardous Mineral Fibres

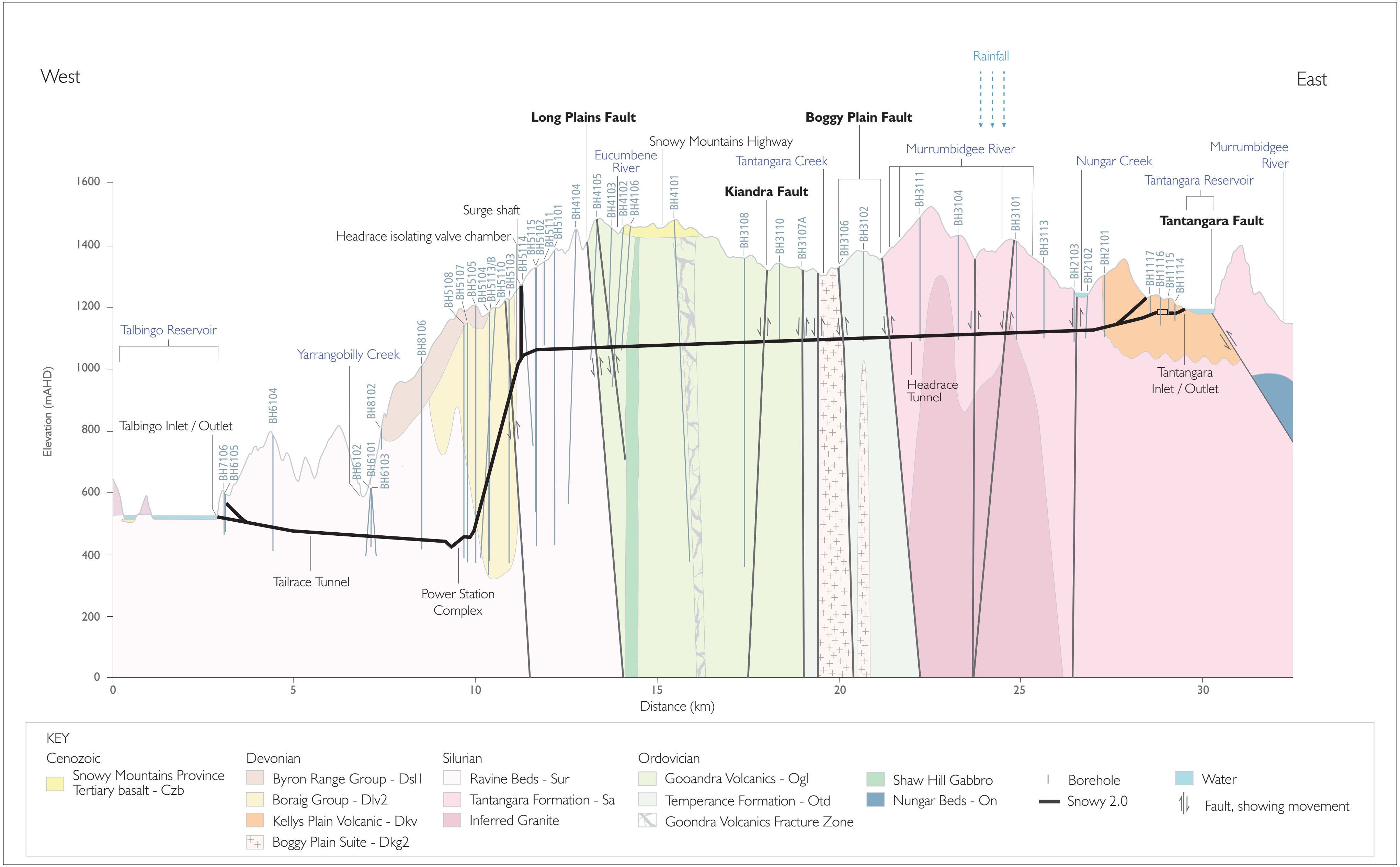
During 2018 and 2019 top soil and rock core samples were collected from the study area and selectively analysed for mineral fibres by SMEC. Topsoil samples were collected from within the Gooandra Volcanics, and rock core samples were collected from 16 locations along the tunnel alignment as shown in Figure 6.1 and Figure 6.2.

No asbestos fibres were detected in the topsoil samples analysed. A total of 348 rock core samples underwent analysis by AS4946, 44 samples were analysed by X-ray diffraction, and 7 samples were analysed by SEM and EDS. A total of 71 samples from 4 boreholes had a positive result, ie the presence of either asbestiform or non-asbestiform fibres. Mineral fibres were detected between 19 and 1,158 mbgl. A summary of the results from the four bores is provided:

- BH3106: 9 particles with fibrous characteristics of tremolite-actinolite mineralogy were reported from one sample from 149-149.33 mbgl. 6 fibres met the fibre sizing definition and were considered NOA. This sample was from the Boggy Plain Suite.
- BH3108: more than 100 countable fibres indicative of actinolite asbestiform fibres were from one sample (391.59 mbgl). This sample was from the Gooandra Volcanics.
- BH4101: more than 100 countable fibres indicative of actinolite asbestiform and non-asbestiform fibres were recorded from two samples (302.5-302.6 and 761.6-761.7 mbgl). 10 countable actinolite asbestiform and non-asbestiform fibres were recorded in 100 images from one sample 778-778.6 mbgl. These samples were from the Gooandra Volcanics.
- BH4106: 10 particles from two samples (124.75-125.0 and 198.1-198.4 mbgl) with mineralogy of tremolite-actinolite met the fibre sizing definition and were considered NOA. These samples were collected from the Shaw Hill Gabbro.

Core samples from 40 boreholes underwent petrography analysis. Amphibole and/or actinolite/tremolite minerals were detected in 14 samples from 4 bores (BH3102, BH3106, BH4101 and BH4106). Fibrous and bladed crystals were identified in 4 of these 14 samples, however assessment against the definition of NOA was not undertaken. These samples were from the Boggy Plain Suite, Temperance Formation and Gooandra Volcanics formations.

While asbestiform fibres were only confirmed in one sample from the tunnel alignment, it was noted there was a potential for NOA to be present as the full lateral extent of the tunnel alignment has not been assessed.

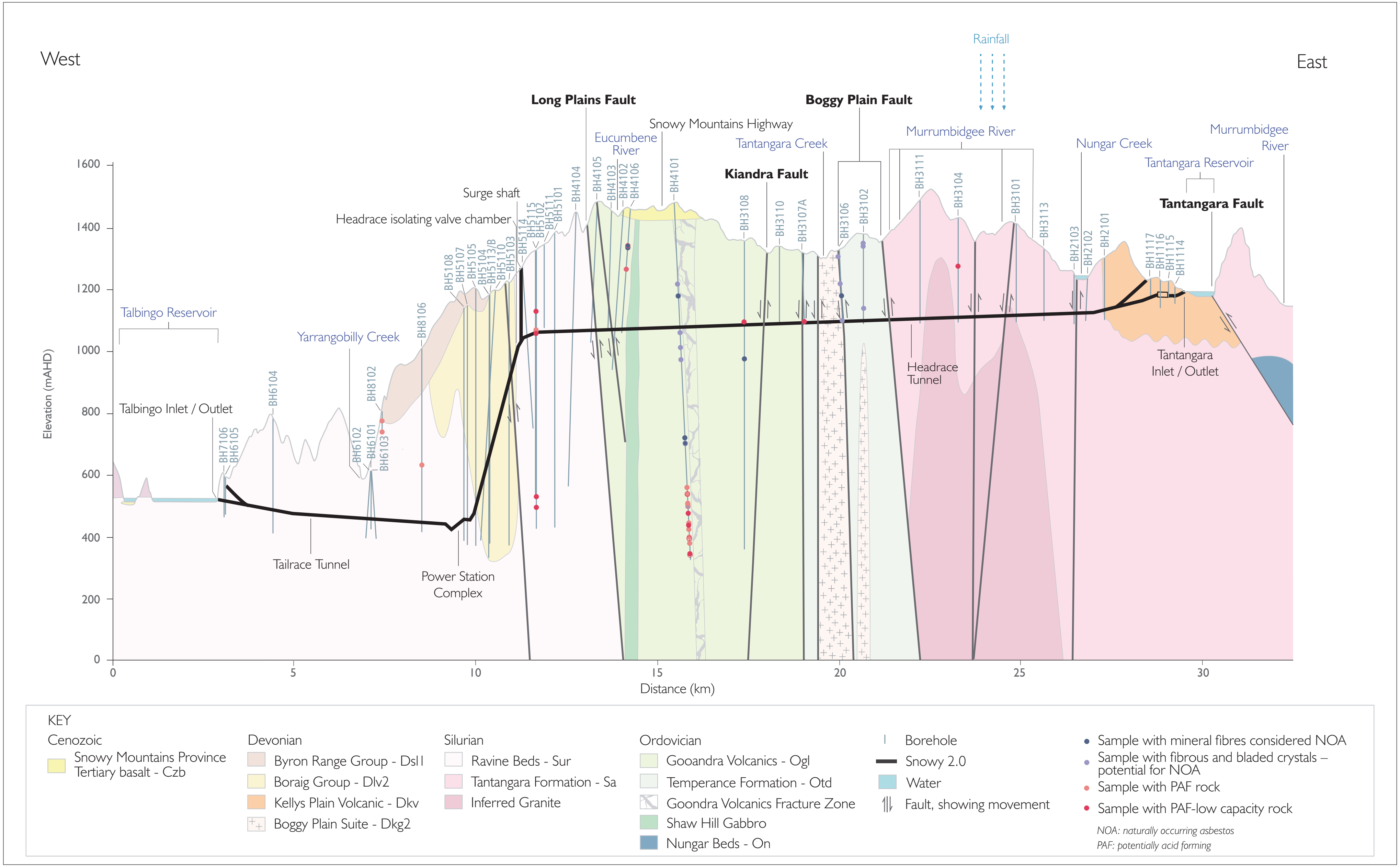


SMEC tunnel alignment borehole locations

Snowy 2.0

Contamination Assessment

Figure 6.1



SMEC tunnel alignment borehole sampling results for NOA and PAF

Snowy 2.0
Contamination Assessment
Figure 6.2

6.3 NOA hazard classification

SMEC (2019b) assessed the likelihood of intersecting NOA along the proposed tunnel alignment. This is presented in Table 6.2.

Table 6.2 NOA hazard classification

Ranking	NOA hazard classification	Geological units
Unlikely: excluded from potentially containing asbestiform minerals	0	Tertiary Basalt, Byron Range Group, Kelleys Plain Volcanics, Peppercorn Formation, Ravine Beds, Tantangara Formation, Adaminaby Beds, Bolton Beds, Tumut Ponds Beds, Mountain Creek Volcanics, Rough Creek Tonalite, Green Hills Granodorite, Kings Cross Formation, Quaternary Alluvial Terrance Deposits, McLaughlines Flat Granodiorite, Abercrombie Formation, Gang Monzogranite
Possible: possible presence of asbestiform minerals	1	Boraig Group, Boggy Plain Suite
Likely: rock formations known to contain asbestiform minerals	2	Boraig Group/Ravine Beds contact area, Tumut Ponds Serpentinite, Temperance Formation
Confirmed: asbestiform confirmed in the formations tested	3	Gooandra Volcanics, Shaw Hill Gabbro, Boggy Plain Suite intrusions

Source: SMEC 2019b

Further information about the geological units with confirmed NOA is provided below (SMEC 2019b):

- Boggy Plain Suite is a complex igneous intrusive rock system. Petrographic reports from one borehole indicate 3-12% amphibole with some alteration to actinolite.
- Gooandra Volcanics comprises deep marine extrusive volcanics that have been extensively deformed and affected by low grade metamorphism. There is pronounced foliation that dips mostly to the west, actinolite is aligned with this foliation. Actinolite was identified in the range of <1-28% of the core sample rock mass. Testing has confirmed NOA east of Long Plain Fault within the Gooandra Volcanics and is yet to confirm the presence of NOA west of the Gilmore Fault Zone (Figure 8.1).

Shaw Hill Gabbro comprises a range of mafic to ultramafic rock intruded into the Gooandra Volcanics. Amphibole in the form of actinolite comprised up to 5% of the core rock sample.

6.4 Acid mine drainage

6.4.1 Existing acid mine drainage

i URS (2015) Lobs Hole Site Investigation and Remediation Assessment

URS (2015) undertook a soil, sediment and water quality sampling event at Lobs Hole, around the old copper mine, in 2014. The objective of the investigation was to identify point sources of metal contamination associated with the former mine and determine if contaminants were migrating off-site.

The soil assessment included the sampling of test pits (excavated using a shovel) to a maximum of 0.5 mbgl across the site targeting soils in the vicinity of shafts and processing areas, tailings, adits, a slag pile and background areas. Several areas of copper staining were observed, in addition to acidic stagnant water bodies adjacent to the Lobs Hole Shaft and Processing Area.

Of the 18 samples analysed, eight exceeded the NEPM Human Health Investigation Level (HIL) C - Recreational guidelines for arsenic (NEPM 2013). These eight samples were collected from the shaft and processing area, tailings north and tailings south. The sample locations are within proximity to the proposed construction footprint area (with the exception of tailings north). Laboratory results also reported potentially acid forming (high capacity) material in the waste rock piles and stockpile areas (shaft and processing area), however. Moderate metal/metalloid leachate concentrations were also reported.

Elevated concentrations of arsenic, copper, lead, mercury, nickel and zinc were measured in sediment samples collected between the shaft and processing area and Yarrangobilly River, exceeding the adopted *Guidelines for Fresh and Marine Water Quality* (ANZECC 2000). An exceedance of arsenic, copper, mercury and nickel was also detected in the vicinity of the southern tailings stockpile, with the sample from Yarrangobilly River exceeding the ANZECC 2000 criteria for copper and nickel.

Water quality samples for laboratory analysis were collected at four locations along the Yarrangobilly River. The reported results indicated neutral to slightly alkaline pH conditions, with total copper, dissolved copper and zinc concentrations exceeding ANZECC (2000) and the *Australian Drinking Water Guidelines* (2011) guidelines in two o the four locations sampled. The highest concentrations were measured near the shaft and processing area. No exceedances were detected in the Yarrangobilly River surface water sampled 700 m down gradient from mining areas.

The investigation conducted at Lobs Hole identified soil, sediment and surface water contamination associated with historical mine activities. This contamination was identified to have impacted the sediment and water quality in the nearby Yarrangobilly River; however, concentrations of contaminants of potential concern (CoPC) were below the adopted criteria at a distance of 700 m down gradient (west) of the mine.

ii EMM (2018) Phase 1 Contamination Assessment (including Appendix D Memorandum), Exploratory Works for Snowy 2.0

EMM undertook a desktop based contaminated land assessment in 2018, as part of the exploratory works for Snowy 2.0, which included review of AMD data relevant to the former copper mine at Lobs Hole. The objective of the investigation was to identify potential areas and contaminants of concern to inform the Exploratory Works program. The former Lobs Hole copper mine was identified as a potential AMD risk to the project.

As part of the Exploratory Works contamination assessment, EMM collected ten shallow soil samples (between approximately 0.2 – 0.5 mbgl) across Lobs Hole Valley (Figure 6.3). The results of the soil analysis were compared to the NEPM Health investigation and screening levels considering HIL/HSL B (applicable to residential sites with minimal soil) and HIL/HSL C (applicable to public open spaces). All metal and hydrocarbon concentrations were below the adopted criteria except for some exceedances of Ecological Investigation Levels (EILs) for metals (arsenic, copper, zinc and nickel), summarised as follows:

- Copper: Samples exceeding the EIL were observed within the accommodation camp area, adit south and the mine.
- Nickel: samples exceeded the EIL at seven locations across the investigation area.
- Arsenic: samples exceeded the EIL at one location in the vicinity of adit south.
- Zinc: samples exceeded the EIL at three locations; near the accommodation camp, in an open area along Mine Trail, and at adit south.

One waste rock sample was assessed for AMD, with an uncertain classification reported, requiring further investigation to determine whether it is non acid forming (NAF) or PAF.

iii SMEC (2018) Contamination Investigation Interpretive Report – Exploratory Surface Works - Ravine Road and Mine Train and SHL (2019) *Targeted Contamination Investigation on Mine Trail Ch 50-450*

As part of the Exploratory Works a targeted surface contamination investigation along Lobs Hole Ravine Road and Mine Trail was undertaken by SMEC in 2018 to assess metal and hydrocarbon concentrations in soil and the potential for AMD to be encountered during road upgrade and construction works. One sample with PAF characteristics was identified along Mine Trail between Chainage (Ch) 200 and 300.

Additional soil samples were collected by SHL (2019) from six locations along Mine Trail between Ch 50-450 at depths of 0.1 - 0.2 mbgl. This sampling was undertaken to further characterise potential contamination within this Chainage which was previously identified by SMEC (2018). All metals, metal leachate, and hydrocarbon concentrations were less than the adopted criteria, and no PAF material was identified.

iv CSIRO 2018, Snowy 2.0 P1: Comprehensive Geochemistry Examination

CSIRO undertook detailed geochemical and mineralogical characterisation of drill core and lab samples from the Snowy 2.0 Exploratory Works drilling program (comprising 290 samples obtained from 37 boreholes). This data was obtained to inform the understanding of the chemical composition and mineralogy of rocks requiring excavation as part of the Snowy 2.0 scheme, as well as understanding the potential environmental impacts of handling and disposing of .

Results indicated that the Ravine Beds and Gooandra Volcanics contain elevated sulfur concentrations. The Ravine Beds contain a 35 m apparent thickness shale unit containing approximately 1.5% sulfur, and the Gooandra Volcanics has a unit of unconstrained thickness with up to 4% sulfur. In other lithologies sulfide minerals occur but represent a volumetrically minor (<1%) component of the rocks sampled.

v CSIRO 2019, Snowy 2.0 P2: Environmental Risk Characterisation of Rock Materials

CSIRO also undertook a risk characterisation of rock material to assess reactivity, leachability and the potential environmental consequences of placement both on land and subaqueously in reservoirs. Geochemical composition assessment, hand specimen analysis and regional geology examination were used to define seven geological zones for assessment in P2: Ravine Group; Byron/Boraig Group; Shaw Hill Gabbro; Gooandra Volcanics; Peppercorn/Tantangara/Temperance Formations; Kellys Plain Volcanics; and Felsic/Granite/Gneiss/Ignimbrite. A further classification involved a comparison with the Post-Archaen Australian Shale to assist in the selection of a Baseline Group and an Enriched Group for each of the seven zones. The Enriched Group most commonly exhibited elevated sulfur and trace elements (including metals and metalloids) compared to the Baseline Group.

As part of the risk characterisation, 115 samples were investigated for acid-base accounting (for AMD assessment) and leachate analysis using the Australian Standard Leaching Procedure (ASLP). Approximately 23% of samples were classified as having a net acid-generation (NAG) capacity, with acid neutralising capacity (ANC) in excess of maximum potential acidity (MPA) for all samples analysed, with 93% of samples nominally classified as very low risk. Leaching tests indicated that no samples had acidic pH and all samples reported low leachable salt concnetration. A relative risk rating based on mean ANC and MPA indicated that the greatest potential for acid generation is from the Gooandra Volcanics, Byron/Boraig Groups and Peppercorn/Tantangara/Temperance groups. It is noted the leaching assessment concentrated on the conditions associated with subaqueous disposal of excavated rock and did not fully consider conditions associated with the land placement of material and/or tunnel seepage.

Talbingo Reservoir water of neutral pH and low dissolved salts and nutrient concentrations was used for leachate testing under oxic, anoxic and acidic conditions. The oxic and anoxic conditions were designed to simulate the sub-aqueous storage of excavated rock in reservoirs where it will be exposed to varying redox conditions dependent on placement in the reservoirs. The weak acid conditions relate to the rock material being exposed to ambient air that will oxidise minerals such as sulfur. It is noted the excavated rock will initially be stored on land stockpiles, and there is some uncertainty regarding how much of the rock material will react with oxygen and how oxygen will affect the leachates geochemical properties.

For oxic leachates there is a similar mean pH of approximately 9 and low electrical conductivity (EC) for both Baseline and Enriched Groups, with substantially higher concentrations of calcium, sulfur, antimony and selenium in the Enriched Group leachates. For the anoxic leachates there is a similar mean EC and pH two units lower than oxic leachates, with higher mean concentrations of Barium and sulfur in the Enriched Group leachates. The dilute acid leachates yield a higher EC but similar pH to the oxic leachates, indicating a substantial buffering capacity. There are substantially higher mean concentrations in the Enriched Group leachates of aluminium, antimony arsenic, barium, cadmium, chloride, manganese, selenium, sulfur and total nitrogen.

It was concluded that the relative rates of acidity versus alkalinity 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. Additional kinetic/leachate testing was recommended to better predict leachate quality from land placed material, tunnel wall and subaqueously placed material respectively, during construction and over time.

vi SMEC (2019a) Acid Metalliferous Drainage, Issue E

The objective of the SMEC (2019a) investigation was to identify potential AMD forming rock from across the tunnel extent, with a desktop review followed by the geochemical sampling and analysis. The investigation collected and analysed 434 rock core samples from 40 boreholes for static AMD tests, with elemental analysis undertaken for 75 samples from 6 boreholes. Sulfur speciation was carried out for 116 samples from 10 boreholes.

Rock samples were collected from depths between 16.0 mbgl (BH7101) and 1,139.5 mbgl (BH4101, below the proposed tunnel depth). A layout of the boreholes along the tunnel alignment is shown in Figure 6.1, with the sampling results outlined in Figure 6.2.

The AMD sampling included targeted, random and systematic sampling of rock core from lithologies at the proposed underground features including tunnel alignment and power station cavern. Significant enrichments of total sulfur were observed in samples from the Gooandra Volcanics and Ravine Beds. Elevated enrichments were also observed in the Tantangara and Temperance Formations.

Based on static AMD analysis of 434 samples from 40 boreholes, it was determined that AMD materials were highly variable, likely due to the tendency of pyrite to occur in veins and seams of the analysed rock cores. PAF material is confirmed within the Tantangara (one sample as PAF-Low Capacity [LC]), Temperance (one sample as PAF-LC), Gooandra Volcanics (nine samples as PAF-LC, 13 samples as PAF) and Ravine Beds (four samples as PAF-LC, 7 samples as PAF) formations. It was concluded the host rock appears to have considerable ANC which can be utilised to manage excavated rock, through may be less available for the management of tunnel seepage.

6.4.2 AMD hazard classification

The potential for AMD impacts is dependent on the total sulfur content (which forms the maximum potential acidity) and the neutralising capacity of the material. However, as acidic water migrates it reacts with minerals in the surrounding rock, potentially dissolving a range of metals and salts. The acid leachate could be progressively neutralised at the expense of increasing concentrations of metals. Shallow soil samples collected at the former Lobs Hole copper mine were classified as PAF. Deeper rock along the tunnel alignment was also identified as PAF. SMEC (2019a) determined the likelihood of intersecting AMD in the targeted geological units and the AMD hazard classification. This is presented in Table 6.3.

Table 6.3 Likelihood of encountering AMD

Ranking	AMD hazard classification	Geological units
Unlikely: certain exclusion of formations potentially containing PAF	0	Tertiary Basalt, Byron Range Group, Kelley's Plain Volcanics, Peppercorn Formation, Boggy Plain Suite intrusions, Adaminaby Beds, Bolton Beds
Possible: possible presence of rock formation potentially containing PAF	1	Boraig Group, Shaw Hill Gabbro
Likely: rock formations potentially containing PAF – PAF not already detected	2	
Confirmed: PAF confirmed in the formations tested	3	Gooandra Volcanics, Ravine Beds, Tantangara Formation[1], Temperance Formation[1]

Note: 1 One sample was reported as PAF-LC

Source SMEC 2019a

7 Site walk over

Site inspections of the main study areas have been conducted as part of the Exploratory Works and Main Works assessments. The purpose of the site inspections was to identify potential contamination sources, or visible evidence of contamination, and to observe current landforms and site conditions. Site photos from the walk over are included in Annexure D.

7.1 Talbingo Reservoir

A site inspection of the northern and southern ends of the Talbingo Reservoir was conducted on 12 and 13 March 2018. This was undertaken as part of Exploratory Works; there have been no recent works or activities in the area. The northern end of the Reservoir is currently used as a spillway and public boat ramp. Public toilets, picnic tables, and a public swimming area are also located at the spillway. No evidence of actual or potential contamination or contaminating activities was noted.

During the site inspection, extra piping for culvert upgrades and metal fencing were observed along the existing access roads. The inspection of the existing roadways did not identify any significant contamination sources, clear evidence of vegetation stress, or observations of any present contamination (ie no odours, staining or material fragments).

The proposed intake area and rock emplacement areas proposed along the northern shores of Middle Bay were not accessed. These areas have not been disturbed (or have minimal historical disturbance) and are not developed.

7.2 Lobs Hole

A site inspection of Lobs Hole was conducted on 12 and 13 March 2018. Copper mining was undertaken in the eastern portion of Lobs Hole between 1874 and 1916 (Boot 2001). The footprint of the Lobs Hole mine covers an area of approximately 3 ha, with all features located in proximity to the Main Works disturbance area, except for adit south, which is located within Lick Hole Gully and remains open; URS (2015) noted that surface water appears to drain from the adit to the north along Lick Hole Gully. Capped shafts and processing areas remain around Lobs Hole, along with waste rock stockpiles. Waste rock material is spread around an area less than 300 m^2 around adit south. Processed copper slag from the former copper mine site was observed underlying the road surface and in drainage lines near Lobs Hole. Directly parallel to sections of the Yarrangobilly River there are signs of acid and mineral leachate between the waste material and the river.

Downstream, Snowy Hydro maintains a hydrometric and meteorological monitoring station along the river. There is also unvegetated, exposed ground around Lobs Hole that is used for camping; with associated small fire pits and minor rubbish.

7.2.1 Ravine town site

The site of the former town of Ravine is situated in the western portion of Lobs Hole. Few visible remnants of the village remain in the valley; with most of the building construction materials having been removed. The foundation of the former Washington Hotel was observed as well as other minor building foundations, waste brick and scrap metals and 'cultural plantings' (ie orchard trees). Access tracks, evidence of open fires, and minor rubbish associated with the use of the areas as a public campground were evident, however, no evidence of actual or potential contamination or contaminating activities was noted.

7.3 Marica

A walk over of Marica was not undertaken; there are no known developments and this area comprises dense remnant vegetation that posed a constraint to access.

7.4 Plateau

A walk over of Plateau was not undertaken; there are no known developments or infrastructure excluding the Snowy Mountains Highway.

7.5 Tantangara Reservoir

A walk over of the southern end of Tantangara Reservoir was undertaken on 22 April 2019. Tantangara Reservoir is used by the public, however there are no public facilities such as toilets or a boat ramp. Access tracks and evidence of open fires associated with public use was observed but no evidence or sources of contamination were observed. The former entry to Tantangara quarry was visible to the south of the Reservoir adjacent to Kellys Plain Creek. The quarry face was approximately 5 m in height and 2 m wide, with additional disturbance at the base of the quarry.

7.6 Rock Forest

A walk over of Rock Forest was undertaken on 13 March 2019. Several used tyres, an abandoned vehicle, a dead cow and an old drum were observed (Appendix E). It is noted the observed waste objects could be removed and disposed offsite and are not considered to present an ongoing contamination risk. Section 143 of the POEO Act requires that *special waste* comprising tyres must be transported (and tracked) to a designated landfill that can lawfully accept it for disposal. General and animal waste can be disposed of at a licensed facility. There was no visual evidence of sheep dips or other potentially contaminating activities or infrastructure identified during the walkover. An interview was conducted with the landowner (Tim Russell), which is provided in Annexure E.

8 Assessment of potential impacts

8.1 Construction impacts

Construction phase impacts relate to the tunnelling and associated surface disturbance impacts associated with the construction of the project.

It is estimated that up to 9,000,000 m^3 (banked) of excavated rock would be excavated during construction of the project. Excavated material would be transported to disposal/reuse sites following confirmation of suitability for the proposed land use. Opportunities to reuse excavated rock generated by the project within the study area would be investigated further during detailed design and construction planning. could potentially be reused in permanent works including portals, roads, pads and for land forming/rehabilitation works. Based on the review of the existing environment, construction works may encounter areas of NOA, PAF rock and AMD impacts associated with historical mine waste.

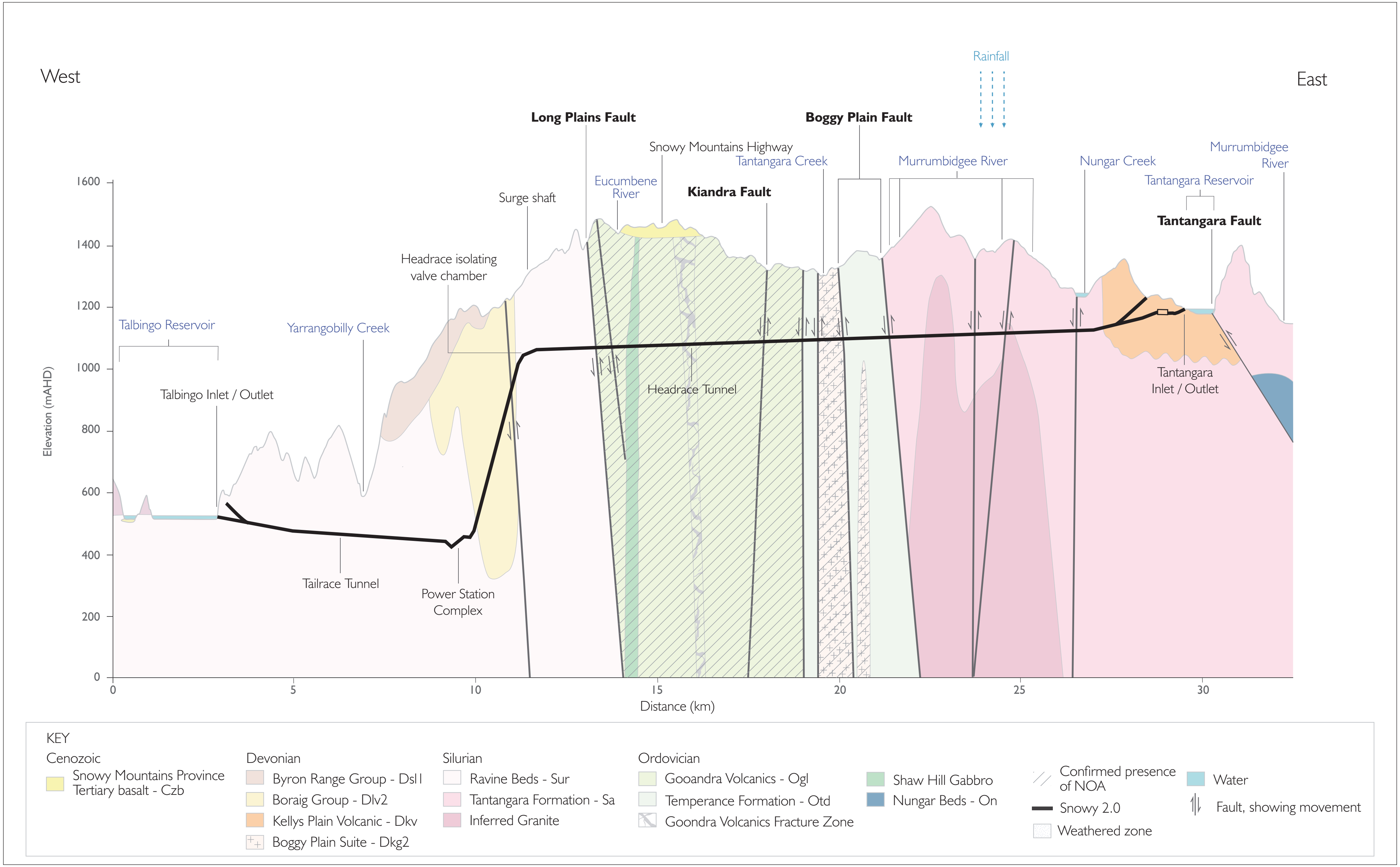
8.1.1 Naturally occurring asbestos

Field investigations have confirmed the presence of NOA, predominantly consisting of tremolite-actinolite and actinolite fibres, within geological units proposed to be intersected by tunnelling activities and ground disturbance works. Specifically, NOA has been reported in the Gooandra Volcanics, Boggy Plain Suite and Shaw Hill Gabbro units, although the distribution of mineral fibres is complex and non-uniform. The confirmed presence of NOA in the Gooandra Volcanics is consistent with the NSW Resources & Geoscience (2018) NOA mapping.

In an undisturbed state the presence of NOA is generally well bound in the crystalline fabric of the host rock and does not present a risk to human health. However, the inhalation of airborne mineral asbestos fibres presents a potential human health risk where asbestos bearing rocks are disturbed in a manner likely to release respirable fibres. While the overall risk of exposure to NOA is generally considered to be low throughout the study area (SMEC 2019b), there are two instances where excavation and tunnelling works will be undertaken in areas with a confirmed presence of NOA in the geological formation, which could result in the mobilisation of asbestos fibres. This includes:

- Two sections of the headrace tunnel: a 5.55 km section and a 0.54 km section, as shown in Figure 8.1; and
- Surface excavation works, including road upgrades and construction areas, as well as the instillation of a utility line at Plateau and Marica.

NOA impacts could also result if impacted excavated rock is improperly stockpiled or managed, temporarily or permanently.



West-east schematic cross-section showing confirmed presence of NOA

Snowy 2.0

Contamination Assessment

Figure 8.1

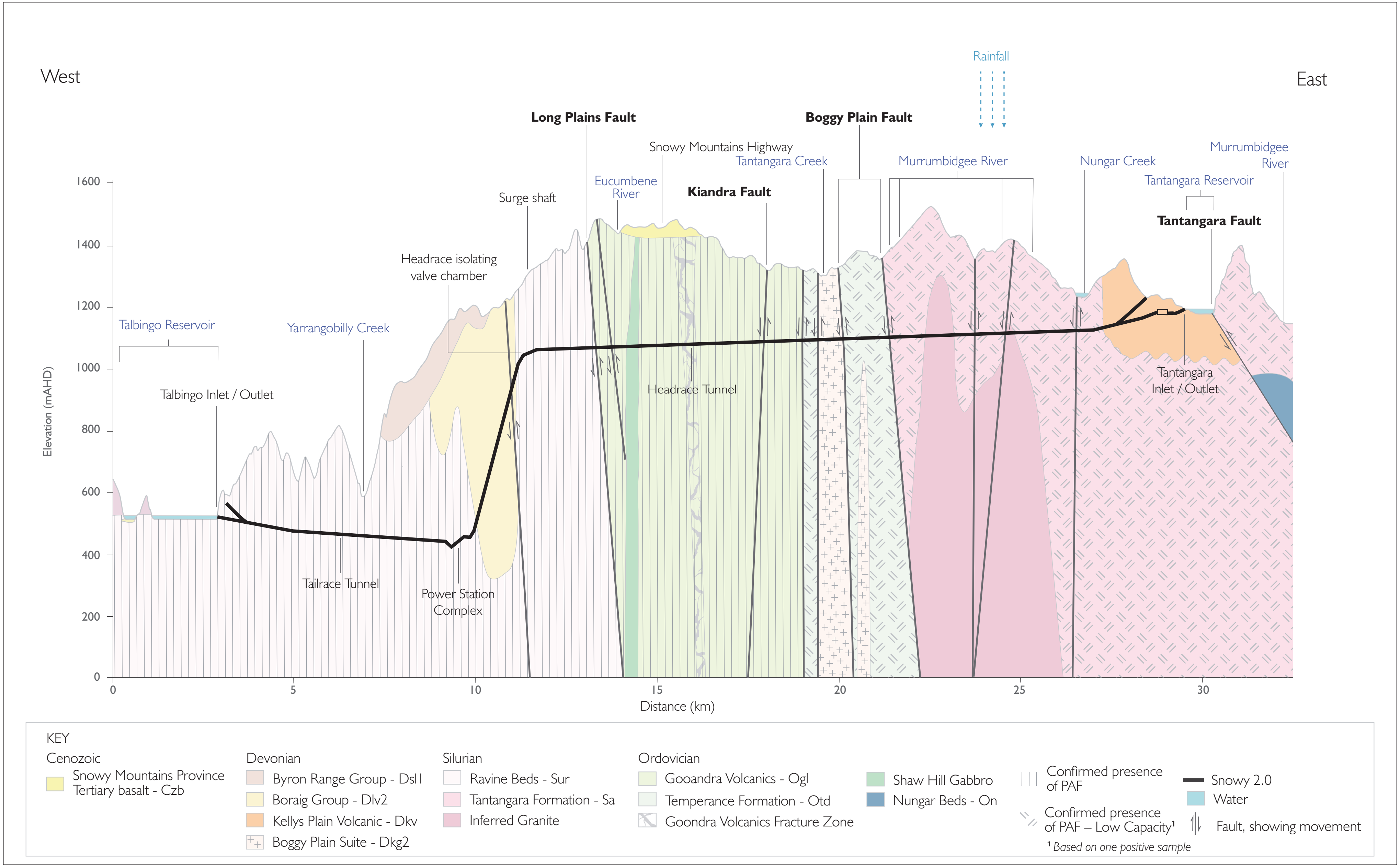
8.1.2 Acid metalliferous drainage

Localised AMD impacts exist at Lobs Hole; a construction compound and the main entrance to the power station is proposed at Lobs Hole. URS (2015) identified areas that have been impacted by AMD in waste material, located between the redundant Lobs Hole mine shaft and processing area, and the Yarrangobilly River. Results from sediment samples collected between the former Lobs Hole copper mine and Yarrangobilly River identified off-site migration of these impacts with potential impacts to nearby sensitive environmental receptors less than 700 m downstream.

Surface excavation works, including road upgrades and construction areas, as well as tunnel boring will intersect areas with confirmed potential for PAF rock. Along the tunnel alignment it was determined that AMD materials were highly variable due to the tendency of pyrite to occur in veins and seams. The host rock has ANC which can be utilised to manage excavated rock but may be less available for the management of tunnel seepage. PAF material is confirmed within the Tantangara (one sample was PAF-LC), Temperance (one sample was PAF-LC), Gooandra Volcanics and Ravine Beds formations.

The potential AMD impacts via the generation of acidic leachate from the improper storage of excavated PAF rock poses a risk to predominantly ecological receptors and project infrastructure (through corrosion). If excavated PAF rock and/or material already impacted by AMD is improperly stockpiled or managed there could be localised impacts, with wider-scale impacts if leachate migrates via surface water and/or groundwater.

SMEC (2019a) concluded that the relative rates of acidity versus alkalinity 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.

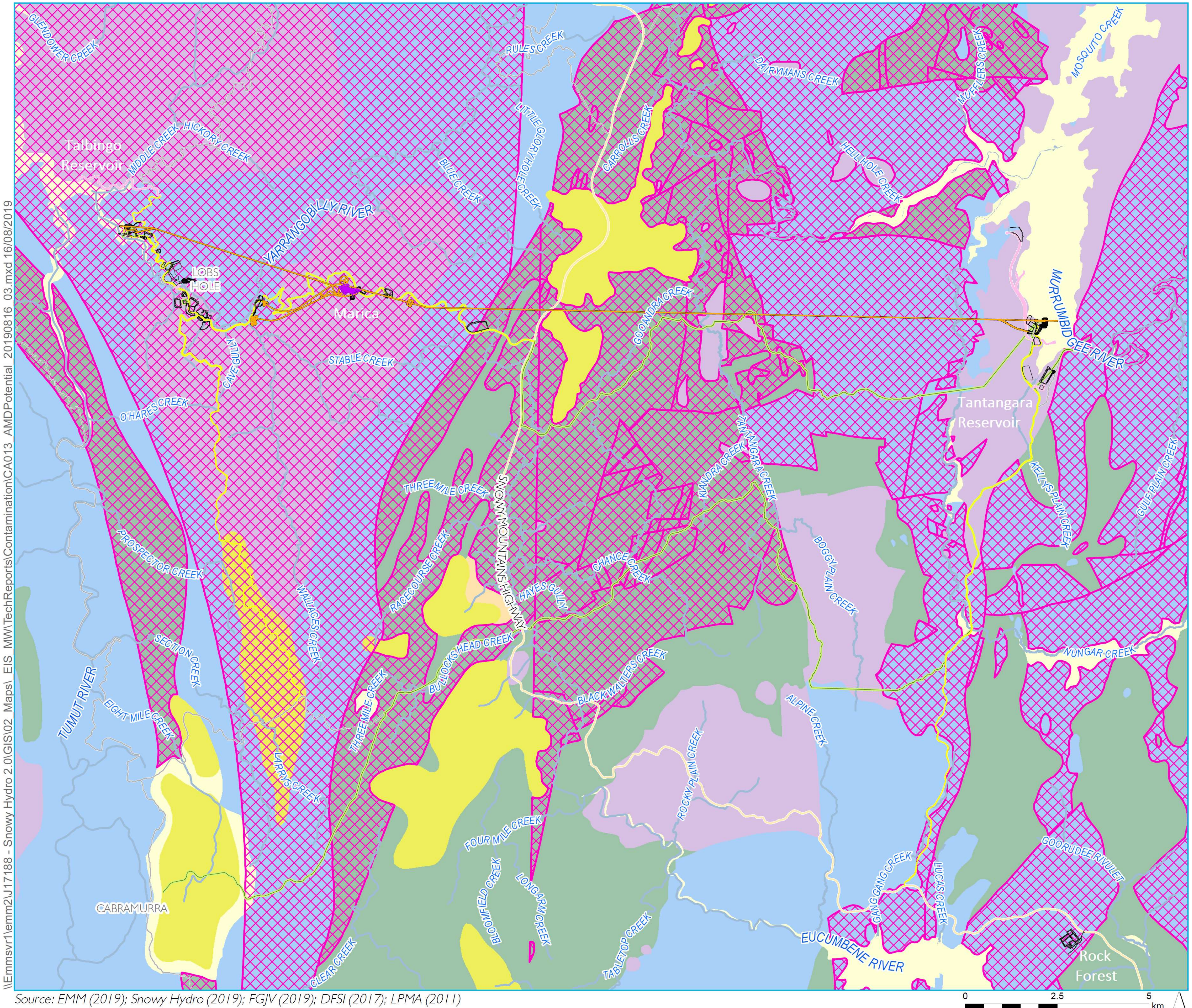


West-east schematic cross-section showing confirmed presence of PAF

Snowy 2.0

Contamination Assessment

Figure 8.2



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

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KEY

Confirmed formations with potential acid-forming rock
- Gooandra Volcanics, Ravine Beds, Tantangara Formation, Temperance Formation

Snowy 2.0 operational elements
- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 construction elements
- Temporary construction compounds and surface works
- Temporary access road

Existing environment
- Main road
- Local road
- Watercourse

Geology (250k) by period
- Cainozoic
- Quaternary
- Tertiary
- Devonian
- Silurian
- Ordovician

AMD potential at surface

Snowy 2.0
Contamination report
Main Works
Figure 8.3

8.1.3 Impacts from existing sources of potential contamination

Construction activities which require consideration of potential contamination primarily related to excavation and tunnelling works (via blasting, tunnel boring and surface works), and may include the following:

- tunnelling excavation;
- transfer of excavated rock materials;
- temporary and permanent stockpiling of excavated rock on land;
- establishment of site offices, amenities and temporary infrastructure;
- laydown and storage of materials;
- delivery of materials, plant and equipment;
- construction of temporary accommodation;
- utility works;
- drainage works;
- road construction;
- construction of permanent operational infrastructure; and
- excavating, filling and rehabilitation of disturbed areas to the final approved landform.

If not managed appropriately, there would potentially be complete pathways from the contamination source (where present) to the receptor for the following, if appropriate controls were not implemented:

- direct contact, inhalation and ingestion risk to project workers either during tunnelling or temporary and permanent stockpiling of NOA impacted excavated rock;
- exposure of ecological receptors, including downgradient surface water bodies such as Yarrangobilly River, to AMD cause by excavated PAF rock via transport of contaminated sediment and leachate via overland flow;
- exposure of human and ecological receptors to elevated concentrations of metals associated with historical mining activities and the presence of residual mine spoil;

8.1.4 Impacts to the environment from project activities during construction

There is the potential for exposure of human and ecological receptors to contamination as a result of the inappropriate management of waste, including potential leaks and spills from equipment and plant generated by construction activities); Typical examples would include spills of hydrocarbons while refuelling or lubricants used by machinery, and generation of solid construction waste or liquid waste during tunnelling. If managed appropriately, all potential impacts to human and environmental health can be minimised.

The permanent subaqueous storage of excavated rock and associated possible risks are considered in the reservoir modelling and subaqueous spoil placement assessment (RHDHV 2019).

The generation, treatment and management of waste water, including surface water runoff from construction areas, separation of water types, intercepted water captured during tunnelling and water generated from water treatment plants is discussed in the *Water Assessment* (EMM 2019).

8.1.5 Preliminary conceptual site model

The preliminary CSM and risk assessment for the construction works is presented in Annexure A. This CSM has been used to identify existing known sources and areas of contamination, associated potential impacts to human health and ecological receptors and to identify exposure source, pathway and receptor linkages. Areas of low, medium and high risk identified are also identified (Annexure A). The methodology to assign these risk ratings is described in Section 3.4. Typical receptors during the construction phase include project construction workers, surrounding human users of the park (although access will be restricted from work areas), and ecological receptors.

Sections of the study area were assessed as negligible risk where no current or historical contaminating activities or CoPC were identified. Sections of the study area were assessed as low or medium contamination risk where historical and current potentially contaminating land uses were located. A single area at Lobs Hole (proposed excavated stockpile area) was assessed as high contamination risk where the study area intersects known contaminated land.

An overview of the potential sources and areas of CoPC during the project construction phase is included in Table 8.1. A tabulated and schematic conceptual site model overview is provided for each project area in Appendix A.

Table 8.1 Potential sources and areas of CoPC during construction

Construction activity and area	CoPC and sources
Talbingo Reservoir	
Surface excavation and tunnelling works	• PAF rock disturbance and acidic water neutralisation – heavy metals
Construction/maintenance works	• Machinery storage and refuelling – petroleum hydrocarbons • Wastewater generation and discharge to Talbingo Reservoir – heavy metals, hydrocarbons (see *Surface Water Assessment* in Appendix L of the EIS) • Temporary and permanent land based stockpiling of contaminated /fill – heavy metals, NOA • Transport of contaminated materials by vehicles along access roads – spills and dust generation – heavy metals, NOA • Backfilling construction area for rehabilitation (post construction) – heavy metals, NOA
Lobs Hole	
Surface excavation and tunnelling works	• Former copper mine near main construction compound (within proposed stockpiling area) – heavy metals • Former buildings near proposed main construction compound – heavy metals • PAF rock disturbance and acidic water neutralisation – heavy metals • Low NOA potential within a small section of Lobs Hole Ravine Road – near Prospector Creek. Low-medium potential NOA within a section of Link Road near Three Mile Dam, Mt Selwyn and Kiandra – asbestos
Construction/maintenance works	• Machinery storage and refuelling – petroleum hydrocarbons • Wastewater generation and treatment plants – heavy metals, hydrocarbons (see *Water Assessment*) • Stockpiling of contaminated /fill – heavy metals, asbestos • Transport of contaminated materials by vehicles along access roads – spills and dust generation – heavy metals, asbestos • Backfilling construction area for rehabilitation (post construction) – heavy metals, asbestos
Marica	
Surface excavation and tunnelling works	• PAF rock disturbance and acidic water neutralisation – heavy metals
Construction/maintenance works	• Wastewater generation and treatment plants – heavy metals, hydrocarbons (see *Water Assessment*) • Transport of contaminated materials by vehicles along access roads – spills and dust generation – heavy metals, asbestos • Backfilling construction area for rehabilitation (post construction) – heavy metals, asbestos

Table 8.1 Potential sources and areas of CoPC during construction

Construction activity and area	CoPC and sources
Plateau	
Surface excavation and tunnelling works	• PAF rock disturbance and acidic water neutralisation – heavy metals • Medium potential for NOA to be encountered within the tunnel alignment within the Tantangara Block geological domain, west of Tantangara Creek – asbestos • Medium potential for NOA along communication cable routes – Gooandra Trail, west of Tantangara Creek – asbestos
Tantangara Reservoir	
Surface excavation and tunnelling works	• Accommodation camp near former quarry – heavy metals • Potential former buildings – heavy metals
Construction/maintenance works	• Machinery storage and refuelling – petroleum hydrocarbons • Wastewater generation and discharge to Tantangara Reservoir – heavy metals, hydrocarbons (see *Water Assessment*) • Stockpiling of contaminated /fill – heavy metals, asbestos • Transport of contaminated by vehicles along access roads – spills and dust generation – heavy metals, asbestos • Backfilling construction area for rehabilitation (post construction) – heavy metals, asbestos
Rock Forest	
Surface excavation works	• Agricultural land use including potential former uncontrolled fill – asbestos, hydrocarbons, heavy metals, pesticides/herbicides
Construction/maintenance works	• Machinery storage and refuelling – petroleum hydrocarbons • Stockpiling of fill – heavy metals • Transport of contaminated by vehicles along access roads – spills and dust generation – heavy metals, asbestos • Potential leaking from subaqueous storage/containment cell – heavy metals • Backfilling construction area for rehabilitation (post construction) – heavy metals, asbestos

8.2 Operational impacts

8.2.1 Impacts from existing potential sources of contamination during operation

Potential impacts from existing contamination during operation of the project are primarily associated with the production of AMD from PAF rock and exposure to NOA from permanently placed on land stockpiles. If management and capping protocols are not implemented and/or managed appropriately, this could create a pathway for water infiltration and subsequent generation of AMD. Improper stockpile management could also liberate NOA. Adoption of appropriate sampling, monitoring and containment protocols would be required to be developed and implemented to manage the risks posed by AMD and NOA in above ground (ie permanent landform) and below ground (adits) storage locations.

8.2.2 Impacts to the environment from project activities during operation

For the purposes of this contamination assessment, identified operational impacts primarily relate to the potential contamination of soil, surface water and groundwater arising from maintenance incidents, leaks and spills associated with the operation of the project. To manage spills and leaks associated during the operation of the project, spill containment facilities would be in permanent operational facilities where there is a risk of impact from spills. Site management activities would be documented in an Operational Environmental Management Plan (OEMP) prepared to inform the operation of the project.

9 Environmental management and mitigation measures

9.1 Management objectives

The objectives of the contamination management approach are to:

- demonstrate that the construction works will be undertaken in accordance with relevant requirements of the CLM Act, POEO Act and EHC Act;
- prevent significant impacts to project workers and surrounding human receptors from the disturbance of NOA contaminated excavated rock;
- prevent significant impacts to surrounding watercourses and aquatic ecological receptors from the excavation of PAF impacted excavated rock;
- formally record the actions taken to identify and control exposure to workplace hazardous substances, as well as their use and transport; and
- ensure, from a contamination perspective, the study area is restored to a suitable condition consistent with the agreed future land use domains as identified by the rehabilitation strategy for the project.

9.2 Management of impacts

The environmental management and mitigation measures to be undertaken during the project to manage potential contamination issues and achieve the management objectives and outcomes are presented in Table 9.1.

Table 9.1 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
1	Assessment of excavation areas / construction surface disturbance area	Soil and investigations will be undertaken along all proposed medium or high-risk surface construction disturbance areas, which have not been characterised, (refer Table A.1) in order to: • assess the presence of existing contamination and risks posed to project workers and the environment, so that appropriate controls can be implemented during construction; • chemically classify the soil and / or excavated for CoPC, including NOA, either in-situ or at designated sites, to confirm suitability for re-use / disposal as part of the project or off-site disposal to licensed landfill or re-use facility in accordance with the applicable land use criteria, Waste Classification Guidelines (NSW EPA, 2014) or applicable Resource Recovery Exemption and order, where required; and • assess for the presence of PAF rock and AMD, so appropriate management plans can be prepared and implemented. A Sampling, Analysis and Quality Plan (SAQP) will be prepared to inform the scope of investigations in accordance with the NEPM (ASC NEPM 2013). The SAQP will detail: • data quality objectives (DQOs) and data quality indicators (DQIs); • justification of the number, density and location of sampling locations based on the potential for contamination, excavation extents and quantities requiring off-site disposal; • the sampling locations would target areas of concern and provide coverage of the construction disturbance areas; • analytical suite and schedule, including contaminants of concern; • assessment criteria for on-site reuse or off-site disposal, if required (waste classification); and • sampling and laboratory methodologies, field and laboratory quality assurance and control. Following the completion of the investigations a report will be prepared for each construction disturbance area providing conclusions on site suitability, material characterisation and recommendations for health and environmental controls during construction. Where the presence of contamination is considered low risk, site inspections will be undertaken for each construction disturbance area to manage identified risks during construction. The investigations will include limited sampling to identify and assess contamination in surface soil, surface water (where applicable) and excavated rock. A baseline report will be prepared for each construction disturbance area. Where contamination is identified, a site-specific management plan will be implemented prior to inform the management of asbestos or chemical contamination in soil while the construction area is in use. Following demobilisation of the construction disturbance area a post–construction report would be prepared for each construction location. The post-construction report would confirm the land is fit for purpose and confirm if remedial works are required to clean up contamination from the project works to ensure compliance with the land domains in accordance with the project land rehabilitation strategy.	Construction

Table 9.1 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
2	Contaminated soil and water management during construction	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. The CEMP would: • detail requirements for safety controls including the following where required: – air monitoring; – exclusion zones and decontamination; – excavation ventilation; – dust suppression and containment; – odour suppression and monitoring; – personnel protective equipment; and – training and supervision. • detail requirements for environmental controls including the following: – erosion and sediment control; – management of surface water runoff around the excavation/tunnelling areas and prevention of surface water entering excavations; – stockpile management procedures for segregating materials and preventing cross contamination of clean material (VENM or ENM) with contaminated material including both natural (eg PAF rock and NOA) and anthropogenic sources of contamination; and – materials tracking and records. Sediment and erosion mitigation measures that will be implemented are detailed in Chapter 8 of the EIS.	Construction

Table 9.1 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
3	Asbestos management	A site-specific asbestos management plan (AMP) is required under Part 8.4 of the NSW Work Health and Safety Regulation 2017 where there is potential for NOA to be encountered. This will relate to works that would intersect, excavate or otherwise encounter areas with potential, likely and confirmed NOA. Snowy 2.0 would be required to ensure human exposure to NOA is below the guideline limits outlined in Workplace Exposure Standards for Airborne Contaminants (Safe Work Australia 2018). It is noted that NOA is not proposed to be transported offsite and would be reused/managed as part of the project. Specific protocols will be stipulated for separation, monitoring, validation and clearance of asbestos. The AMP and associated Standard Work Procedures will satisfy the relevant requirements of: • Work Health and Safety Regulation 2017; and • the Safe Work Australia Asbestos Codes of Practice and Guidance Notes. All persons performing the works will be required to undertake a suitable risk assessment and develop a Safe Work Method Statement (SWMS) for all work activities prior to commencing work in potential or actual asbestos impacted areas. In the event that non naturally occurring asbestos containing material (ACM) is identified (eg in historic building structures or materials) which require offsite disposal, the material would be segregated, managed and disposed of as Special Waste and transported and disposed in accordance with Protection of the Environment Operations (Waste) Regulation (2014). Where more than 100 kg of asbestos waste or more than 10 square metres of asbestos sheeting is transported, the NSW EPA online tool WasteLocate will be used. The handling and disposal of asbestos waste will be tracked and recorded.	Construction

Table 9.1 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
4	PAF/NOA Rock management	An Excavated Material Management Plan (EMMP) would be developed which would include: • procedures for handling, sampling and testing, classification, storage and disposal/placement of excavated rock to ensure that excavated material is appropriately managed; • monitoring required to mitigate potential impacts from the placement of excavated rock material; • A clear, effective and trackable mechanism for implementing mitigation measures; • Allowances for the treatment and separate placement of some PAF/NOA material in dedicated permanent emplacements in accordance with excavated rock management strategies for the Project; • Allowances for the treatment of tunnel drainage containing AMD components for excavations in Possible, Likely and Confirmed AMD hazard areas. • A process for the identification/characterisation/quantification of PAF/NOA material and activity specific risk assessments; • A continued excavated material characterisation program would be developed which will allow for adequate assessment of NOA, acid metalliferous drainage (AMD)/neutral metalliferous drainage (NMD)/saline drainage (SD) material, and reduce the risk of material being misclassified as 'benign' and being managed inappropriately, and may include: – Geochemical kinetic testing of each key lithology or alteration type identified to have an actual (PAF, Potentially acid-forming—low capacity (PAF-LC)), or potential (uncertain) AMD risk; – Sequential NAG testing, where TS >1% is reported in any single addition NAG tests (even where classification of the sample indicates NAF); – CRS testing, where is reported equal to or greater than 0.3% in single addition NAG tests; – Creation of a graphical or statistical analysis of AMD sample distribution to identify any critical information gaps, and develop a block model for potentially AMD forming material in the Possible to Confirmed Criticality Assessment areas; and – Any laboratory analysis be compared to/correlated with XRF core scans conducted by CSIRO and previous laboratory X ray diffraction (XRD), acid based accounting (ABA), and net acid generating (NAG) tests and management responses to mitigate identified risks associated with potentially AMD forming material.	Construction

Table 9.1 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
5	waste management and transport	As part of the EMMP, waste management plans would include procedures for handling and storing excavated rock and/or stockpiled materials, including potentially or known contaminated soil/fill in accordance with the protection of the environment operations (POEO) Act. Material which has been assessed as not suitable for reuse on land or for subaqueous disposal or cannot be otherwise reused or managed (eg via encapsulation or treatment) will be appropriately characterised prior to offsite disposal. The following material handling requirements will be implemented for trucks transporting materials off-site: • Where required, a licensed transporter will be used to transport material to an appropriately licensed disposal location or waste facility; • all truck loads will be filled to the correct level and not over filled; • trucks carrying spoil materials will be covered prior to exiting the work site and would remain covered until authorised to unload at the receiving destination; • trucks transporting saturated materials will be fitted with seals to ensure that the movement of potentially saturated materials is undertaken appropriately. The integrity of the seals would be inspected and tested at regular intervals as prescribed in the CEMP; • if construction materials are tracked or spilt, leaks and spills will be cleaned up in a manner that prevent contamination of land and waterways; and • all truckloads and waste material contents and volumes will be described and tracked, and a register completed to reconcile and check material has been lawfully and appropriately disposed in accordance with project approvals and relevant legislation. Temporary excavated rock stockpiles may be stored at select locations within the project footprint. All stockpiled material will be tracked in accordance with protocols outlined within the CEMP for material tracking.	Construction
6	Assessment of imported Virgin Excavated Natural Material (VENM)	Prior to the importation of any virgin excavated natural material (VENM) during construction, the VENM source(s) will be identified and assessed against the definition of VENM in the Waste Classification Guidelines (NSW EPA 2014) and POEO Act. The VENM source(s) will be assessed by an appropriately qualified contaminated land consultant, which will entail: • identifying whether the current and past activities at the source site that had potential to contaminate the land, whether PAF is present and that the site is not within an area mapped as containing NOA; and • undertaking chemical assessment to ascertain that the material is not contaminated, where required. • The NSW EPA VENM certificate will be completed and signed by the consultant (or supplier) and provided to FutureGen prior to importation and use of the VENM.	Construction

Table 9.1 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
7	Unexpected finds	An unexpected finds procedure will be included in the CEMP. An unexpected find is potential contamination that was not previously identified during this contamination assessment or other investigations conducted for the project. Project workers will be trained in identifying the following: • soil that appears to be contaminated based on visual and olfactory (odour) assessment; • NOA or other ACM (ie either bonded or friable asbestos); • Groundwater or surface water that appears to be contaminated based on visual and olfactory (odour) assessment (including sheens or abnormal discolouration on the water surface, free phase liquids such as petroleum fuel etc.); • drums or USTs or other potentially contaminating infrastructure (such as historical building structures potentially containing hazardous materials); and • fill containing wastes (e.g. residual mine waste and tailings, NOA, refuse). In the event of an unexpected contamination find: • excavation works will temporarily be suspended at the location of the unexpected find, the environment manager contacted and the area of concern appropriately isolated; • the area will be inspected by a contaminated land consultant and if required, appropriate sampling and analysis would be undertaken, the sampling activities will be documented in a report; and • workplace health and safety and environmental protection requirements will be reviewed, depending on the type of unexpected finds encountered.	Construction and operation
8	OEMP	• An OEMP would be developed to manage potential impacts to the surrounding environment during operation. The OEMP would be a 'live' document with the capacity to be updated if conditions are different to those expected and would include provision for the management of leaks and spills which may occur during operation of the project.	Operation

9.2.1 Further investigations

Areas within the project footprint that have been assessed as low risk do not require further assessment or remediation and would be managed by the implementation of the CEMP. Sites which are assessed as potentially containing soil, excavated rock, surface water or groundwater contamination that will be disturbed by the project and could pose an unacceptable risk to human or ecological receptors during construction of the project would be further investigated by completing intrusive site investigations prior to the commencement of construction.

The site investigation(s) would be designed in accordance with NSW EPA (1995) *Sampling Design Guidelines* and in accordance with the relevant guidelines listed in Section 3.1. The contractors consultant would prepare a SAQP, which would be reviewed by an appointed independent NSW EPA accredited site auditor prior to commencement of the site investigation. The final site investigation report would also be reviewed by the appointed independent NSW EPA accredited site auditor.

Protocols for the sampling, analysis, monitoring and management of excavated rock and other potentially contaminated materials would be developed and provided in the CEMP, AMP and EMMP prepared for the project.

9.2.2 Remediation

Sites within the study area which are assessed as containing soil, surface water or groundwater contamination either as a result of existing contamination or contamination caused by the project, that poses an unacceptable risk to human or ecological receptors and will be disturbed by the project would be remediated.

Sites requiring remediation would have a RAP developed prior to the commencement of construction. The RAP would be prepared by a suitably qualified and experienced contaminated lands consultant and independently audited by a NSW EPA accredited site auditor.

Where there is currently insufficient data to prepare a Remedial Action Plan (RAP), sites assessed as either medium or high risk would have a site investigation undertaken.

Remediation and validation activities would be completed by a contaminated lands consultant, independent to the construction contractor. A validation report would be prepared by the consultant and reviewed by the appointed independent NSW EPA accredited site auditor.

The RAPs would be prepared in accordance with the relevant legislation and guidelines listed in Section 3.1.

The need for remediation would be undertaken by considering the risks of undertaking the works. If the risks posed to the environment and human health is greater than the contamination remaining in-situ, then the need for active remediation would be reconsidered and alternative management options such as capping investigated. The RAPs would include the assessment of sustainable remediation options and consideration of the *Waste Avoidance and Resource Recovery Act 2001 (NSW)*.

10 Conclusions

10.1 Key findings

This technical working paper has identified a number of areas and contaminants of concern which require management during the construction and operation of the Snowy 2.0 project. Existing contamination issues are primarily related to historical mining activities, particularly at Lobs Hole, which have adversely impacted the quality of soil and surface water at some limited locations within the project footprint.

There is also a potential that project construction activities such as blasting and tunnel boring could intersect NOA and PAF rock which has the potential to impact excavated rock, surface soil, surface water and groundwater if not managed appropriately.

10.2 Construction impacts and mitigation measures

A CEMP would be prepared for the project. The CEMP would include management measures for areas within the project footprint identified as being potentially contaminated. As part of the CEMP, an EMMP (including waste management plans) and an AMP would be prepared to manage PAF rock and NOA during construction.

Areas within the project footprint that have been assessed as low risk do not require further assessment or remediation and would be managed through the implementation of the CEMP. Sites which are assessed as potentially containing soil, , surface water or groundwater contamination that could pose a medium or high risk to human or ecological receptors during construction of the project would require further intrusive site investigation.

The following sites would require the completion of targeted site investigations, to inform the appropriate management of contamination during the intrusive construction program:

- Lobs Hole where there is a potential for construction disturbance to encounter NOA, PAF rock or residual contamination associated with historical mining activities;
- Marica where there is a potential for NOA and PAF rock to be encountered during construction;
- Tantangara Reservoir where there is a potential to for residual contamination associated with historic quarrying activities;
- All contamination investigations must be undertaken by a suitably qualified and experienced person in accordance with guidelines made or approved under the *Contaminated Land Management Act 1997* (NSW);
- Subject to the outcomes of the additional investigations, Remediation Action Plan (RAPs) may be required and implemented in the event that site remediation is warranted prior to construction;
- The CEMP would incorporate an unexpected finds procedure. The CEMP prepared for implementation during the project and should encompass all construction activities associated with the project. The plan should accurately reflect the conditions likely to be encountered during construction at various locations within the project footprint; and
- A construction soil and water management plan must be prepared for implementation during construction of the project.

10.3 Operation impacts and mitigation measures

Following the completion of construction works, additional site investigations would be required to confirm the suitability of remaining project land proposed to be rehabilitated in accordance with the rehabilitation plan and to minimise the potential for residual contamination from land based stockpiling of excavated rock potentially containing NOA and PAF rock. In the event that residual contamination is identified, remediation works would be undertaken in accordance with an approved RAP.

The following would be undertaken and implemented prior to the operational phase of the project:

- A NSW EPA Accredited Site Auditor would be engaged to review all contamination reports and evaluate the suitability of a site for a specified use as part of the project; and

- An OEMP must be prepared to manage potential environmental impacts during the operational phases of the project.

10.4 Conclusions

Based on the findings of this contamination assessment, there is potential for localised areas of soil, mine waste and surface water contamination associated with historically contaminating land uses to be encountered during construction, and further assessment is warranted in some instances. NOA and PAF rock are also likely to be encountered during tunnelling and associated construction activities that will require management to minimise potential risks to human health and the environment.

Following adoption of the mitigation and management measures outlined herein, which have been recommended to be implemented during the construction and operational phases of the project, the desired performance outcome, which is to ensure that contamination risks arising from the disturbance and excavation of land and disposal of are minimised, would be satisfactorily achieved.

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