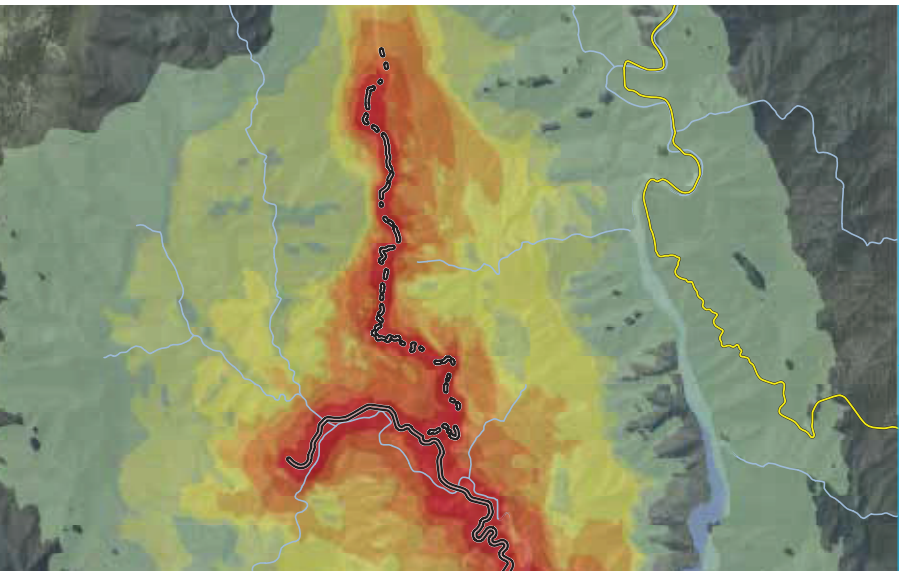
APPENDIX R

NOISE AND VIBRATION IMPACT ASSESSMENT

Noise and Vibration Impact

Snowy 2.0 Main Works

Prepared for Snowy Hydro Limited
September 2019



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Noise and Vibration Impact Assessment

Snowy 2.0 Main Works

Report Number

J17188 RP#92

Client

Snowy Hydro Limited

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Executive Summary

Snowy Hydro Limited (Snowy Hydro) proposes to develop Snowy 2.0, a large-scale Pumped Hydro-Electric Storage (PHES) 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 critical State significant infrastructure (CSSI) by the NSW Minister for Planning under the provisions of the former NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and is defined in Clause 9 of Schedule 5 of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP). Separate applications and Environmental Impact Statements (EIS) for different phases of Snowy 2.0 are being submitted under Part 5, Division 5.2 of the EP&A Act. This Noise and Vibration Impact Assessment (NVIA) excludes impacts associated with the previous phase of Snowy 2.0 known as the Exploratory Works (EW) phase, which has already been separately assessed and approved by the Minister on [insert details].

The following key design elements are proposed as part of Snowy 2.0 Main Works as they are needed for the operation of Snowy 2.0, and are referred to as operational infrastructure:

- an underground pumped hydro-electric power station complex;
- water intake structures at Tantangara and Talbingo reservoirs;
- power waterway tunnels, chambers and shafts;
- access tunnels;
- new and upgraded roads to allow ongoing access and maintenance; and
- power and communication infrastructure, including:
    - a cable yard to facilitate connection between the NEM electricity transmission network and Snowy 2.0;
    - permanent auxiliary power connection; and
    - permanent communication cables.

To build the permanent infrastructure required for Snowy 2.0, several construction elements are needed. The construction elements proposed as part of Snowy 2.0 Main Works include:

- construction compounds, portals, stockpile areas, yards, maintenance and laydown areas to provide areas for plant and equipment, and storage of construction materials, at Talbingo Reservoir, Lobs Hole, Marica, and Tantangara Reservoir;
- access tunnels and adits to support main tunnelling activities and construction of the underground power station complex;
- a construction logistics site at Rock Forest;

- site-based accommodation camps to house the temporary workforce at Lobs Hole, Marica and Tantangara;
- road establishment and other access improvements and upgrades to allow access to construction sites;
- management of excavated rock from tunnelling and excavation activities, including:
  - permanent storage of excavated rock within Talbingo and Tantangara reservoirs;
  - temporary and/or permanent on-land storage within the KNP and temporary and/or permanent storage outside of KNP;
- temporary water supply for water required by construction activities;
- temporary water and wastewater treatment facilities where needed to manage the above sites and construction activities;
- continued use of the Lobs Hole substation for construction power (note that this component is subject to a modification to the current Exploratory Works for Snowy 2.0 approval requesting its construction and operation for the Exploratory Works phase of Snowy 2.0); and
- continued access to Talbingo Reservoir by barge (established during Exploratory Works for Snowy 2.0) and establishment of barge access at Tantangara Reservoir for construction of the intake.

A project area for Snowy 2.0 Main Works has been identified that includes the elements of the project, including all construction and operational elements. Some construction activities associated with Snowy 2.0 Main Works may also be undertaken outside of the project area. Once Snowy 2.0 Main Works are completed, temporary construction elements (such as construction compounds, accommodation camps and excavated rock stockpiles) will be removed and on-going rehabilitation and revegetation programs implemented.

Operation of Snowy 2.0 will involve the transfer of water through a series of newly established power waterway tunnels and the underground power station to provide for energy generation, as well as large scale energy storage. Energy will be generated when water is transferred from Tantangara Reservoir, through the headrace tunnel into the underground power station, before being transferred to Talbingo Reservoir through the tailrace tunnel. Storage of energy will be possible by pumping water back through the tailrace tunnel, from Talbingo Reservoir up to Tantangara Reservoir, where it can be used again for energy generation when needed.

This noise and vibration impact assessment (NVIA) supports the EIS for the Main Works. It documents the NVIA methods and results, the initiatives built into the project design to avoid and minimise associated impacts, and the mitigation and management measures proposed to address any residual impacts not able to be avoided.

This assessment has been prepared following the appropriate guidelines, policies and industry requirements, as follows:

- NSW Department of Environment Climate Change (DECC) 2009, *The Interim Construction Noise Guideline* (ICNG);
- NSW Environment Protection Authority (EPA) 2017, *NSW Noise Policy for Industry* (NPfI);
- NSW Department of Environment Climate Change and Water (DECCW) 2011, *Road Noise Policy* (RNP) and associated application notes;

- Australian and New Zealand Environment Council 1990, *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration;*
- Department of Environment and Conservation (DEC) NSW 2006*, Assessing Vibration: a technical guideline*;
- German Standard DIN 4150 Part 2 1975; and
- Australian Standard AS 2187.2 - 2006 "*Explosives* - Storage *and Use - Use of Explosives*".

To facilitate Snowy 2.0 Main Works the following roads will require upgrading:

- Tantangara Camp Road;
- Tantangara Road;
- Quarry Trail;
- Marica Trail;
- Marica West Trail;
- Middle Bay Road, Ravine Bay Road;
- Camp Road; and
- Talbingo Intake Road

Construction noise levels from the project are predicted to satisfy ICNG noise management levels (NMLs) at all assessment locations, with the exception of a residential dwelling associated with a rural property being R6 6560 Snowy Mountains Highway, Adaminaby where exceedances of 11-14 dB are predicted during standard and out of hours work periods during calm and adverse weather conditions, respectively.

The proponent will notify R6 6560 Snowy Mountains Highway, Adaminaby of the potential noise impacts and discuss options for mitigating impacts. Noise monitoring during the initial stages of construction comprising bulk earthworks and use of the Rock Forest logistics site will be undertaken to determine if actual construction noise levels are above NMLs. If this initial testing identifies exceedances, the proponent will adopt the following steps:

- identify feasible and reasonable mitigation measures that reduce construction noise levels as far as practicable to NMLs;
- restrict use of the Rock Forest site to ICNG standard hours only where feasible;
- consider Section 7.2.2 of the ICNG and option of a negotiated agreement with the property owner/s identified to be impacted that may include:
    - at receiver mitigation;
    - relocation;
    - compensation.

No sleep disturbance impacts as defined in the NSW NPfI (EPA 2017) from night-time construction are predicted at any residence with the exception of R6 6560 Snowy Mountains Highway, Adaminaby where an exceedance of 6 dB is predicted.

The potential for vibration impacts on residents and vibration sensitive structures near construction has been assessed. The nearest residence to construction activity is assessment location R6 6560 Snowy Mountains Highway, Adaminaby which is more than 300m away from Rock Forest construction and logistics camp. This assessment location is beyond the safe working distances required to maintain acceptable human response and structural vibration levels. Vibration impacts from construction at residences are therefore highly unlikely.

The safe working distances for cosmetic damage should be monitored throughout the construction process. If construction is within 25 m of sensitive structures, then work practices should be reviewed so that the safe working distances presented in this report are followed. This includes structures associated with the existing Snowy Hydro scheme, such as Talbingo dam and spillway, Tantangara Dam and heritage items. If safe working distances need to be encroached, real time vibration monitoring with audible and visual alarms should be considered at vibration sensitive structures so actual vibration levels can be monitored and managed appropriately.

Five vibration assessment locations with recorded heritage significance fall within the required safe working distances presented in this report. Methodology should be reviewed when construction occurs in the vicinity of these items. This may include limiting the size of plant and equipment for excavation, compaction or removal of rock or re-assessing the significance and/or the sensitivity of these items to vibration prior to construction commencing in the area.

A quantitative blast assessment has been undertaken to calculate blast ground vibration and overpressure offset distances required to achieve acceptable emissions at sensitive receiver locations. Residential receivers surrounding the project are well outside required blast offset distances from road construction, intake, portal and early stage tunnel excavation. Therefore, blast impacts on residential receivers are considered highly unlikely.

Blasting will occur each night for early stage tunnel excavation, adit construction, tunnels linking intake and adits, power house cavern and intakes. The ANZEC blasting guideline recommends that blasting be conducted during the day period (9am to 5pm Monday to Saturday) to avoid potential impacts during the more sensitive evening and night periods.

The ANZEC guideline goes on to state that restrictions on the time and frequency of blasting would not apply if the effects are not perceived at noise sensitive sites. Furthermore, ANZEC states that in some circumstances, blasts may not be able to comply with emission level, time and frequency requirements. In these instances, environmental authorities would apply appropriate controls based on individual project circumstances.

For the project, the distance and intervening topography between the blast location and nearest residences is significant and would provide a high level of air blast attenuation. For example, the predicted air blast level at Talbingo based on an MIC of 40 kg and distance attenuation only is <64 dBL_{peak}. Based on guidance provided in AS 2187.2-2006 on the typical difference in dBL and dBA levels from airblasts, this would approximately equate to a level of <39 dBA, L_{max} which is below the sleep disturbance screening criteria of 52 dBA, L_{max}. Furthermore, studies by Aloui, Bleuzen Essefi and Abbed, 2016[1] on airblast overpressure from blasting in open-cut mines confirmed that the dominant frequency for the peak airblast was typically less than 10Hz, below the audible spectrum of normal human hearing (20Hz to 20kHz). Given this, the proposed blast frequency and the controlled blast parameters typical of the proposed construction method, it is unlikely that emissions would cause impact at nearest residences in Nurenmerenmong or any other residential assessment location. Notwithstanding, blast practices will be reviewed and modified during the night period if higher airblast levels are generated that cause adverse impacts on residents.

1 Ground Vibrations and Air Blast Effects Induced by Blasting in Open Pit Mines: Case of Metlaoui Mining Basin, Southwestern Tunisia, Journal of Geology & Geophysics 2016

Heritage items within the blast offset zone surrounding the portal excavation should also be identified. If vibration sensitive items are identified within this offset, blast practices should be managed accordingly when in the vicinity.

The potential for road traffic noise impacts on public roads due to project traffic has been assessed in accordance with relevant NSW Road Noise Policy (EPA 2011). In summary, road traffic noise levels are predicted to satisfy RNP assessment requirements. Potential for a 0.4 dB exceedance of the RNP baseline criteria for night-time traffic is predicted for Snowy Mountains Highway (south), whilst an exceedance of 1.2 dB of the RNP <2 dB allowance criterion is predicted for Monaro Highway (north) at night. These exceedances relate to a discrete period of 2-3 months at peak traffic generation and include an additional 20% allowance factor applied by FGJV to project traffic volumes. For the majority of the project life outside of the peak period, average HV volumes are typically 50% lower and would result in compliance with RNP assessment requirements.

Very little evidence is available in literature on the direct impacts that noise and vibration have on fauna. However, it is likely that if levels are suitable for humans, they would also for a large extent be tolerable by fauna. Further discussion is provided in Section 6.6. Construction and traffic noise impacts to fauna are considered in the Biodiversity Development Assessment Report (EMM 2019)

Assessment of operational noise associated with the project has confirmed compliance with NPfI requirements for all residential assessment locations and the amenity criteria for passive recreation within KNP at a reference distance of 50m from the project permanent infrastructure.

In summary, with the management and mitigation measures listed in Section 7 in place, noise and vibration emissions from the project are generally predicted to satisfy relevant guidelines, standards and policies.

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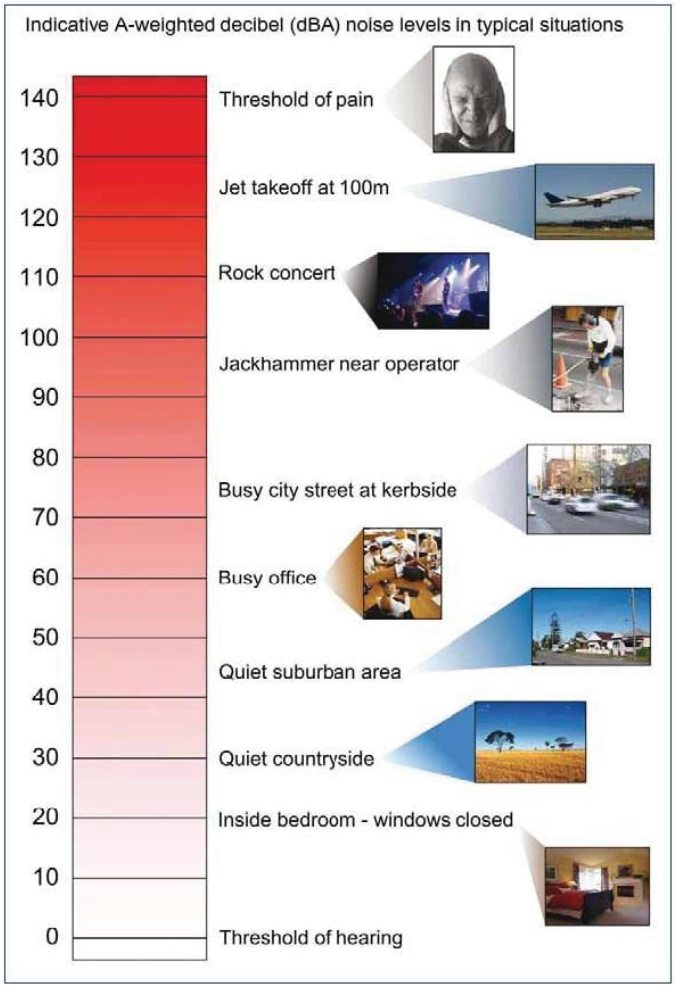
Common noise levels

The table below gives an indication as to what an average person perceives about changes in noise levels. Examples of common noise levels encountered on a daily basis are provided in the figure below.

Perceived change in noise

Change in sound level (dB)	Perceived change in noise
3	just perceptible
5	noticeable difference
10	twice (or half) as loud
15	large change
20	four times as loud (or quarter) as loud



Source: Road Noise Policy (DECCW 2011).

1 Introduction

1.1 The project

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 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 Noise and vibration impact assessment (NVIA) 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 excavated rock 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 1.2. 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 (DoEE) 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 DoEE. 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.

1.2 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 1.1.

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.

1.2.1 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.

1.3 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.

1.4 Purpose of this report

This Noise and Vibration Impact Assessment (NVIA) supports the EIS for the Snowy 2.0 Main Works. It documents the existing noise environment, applicable impact assessment criteria, source of noise and vibration, noise modelling of construction and operational activities and assessment of predicted impacts relative to criteria.

This NVIA consists of the following sections:

- a description of the local setting and surrounds of the project;
- a description of the existing environment, specifically:
  - existing noise environment; and
  - the meteorology and climate;
- a list of plant and equipment adopted for noise modelling of construction for Snowy 2.0 Main Works;
- a list envisaged plant and equipment for noise modelling of operational noise from Snowy 2.0;
- noise modelling and assessment of construction and operational noise emissions including adverse meteorological scenarios;
- assessment of blasting associated with road works, portals, early stage tunnelling activities and intakes;
- assessment of road traffic noise as a result of project related vehicles on public roads;
- an overview of compliance, noise mitigation measures residual impacts where relevant.

This assessment has been prepared following the appropriate guidelines, policies and industry requirements, as follows:

- NSW Department of Environment Climate Change (DECC) 2009, *The Interim Construction Noise Guideline* (ICNG);
- NSW Environment Protection Authority (EPA) 2017, *NSW Noise Policy for Industry* (NPfI);
- NSW Department of Environment Climate Change and Water (DECCW) 2011, *Road Noise Policy* (RNP) and associated application notes;
- Australian and New Zealand Environment Council 1990, *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration;*

- Department of Environment and Conservation (DEC) NSW 2006, *Assessing Vibration: a technical guideline*;
- German Standard DIN 4150 Part 2 1975; and
- Australian Standard AS 2187.2 - 2006 "*Explosives* - Storage *and Use - Use of Explosives*".

1.4.1 Assessment guidelines and requirements

This NVIA 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
Assessment of construction, operational and road noise impacts of the project	Chapter 6

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

1.5 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.

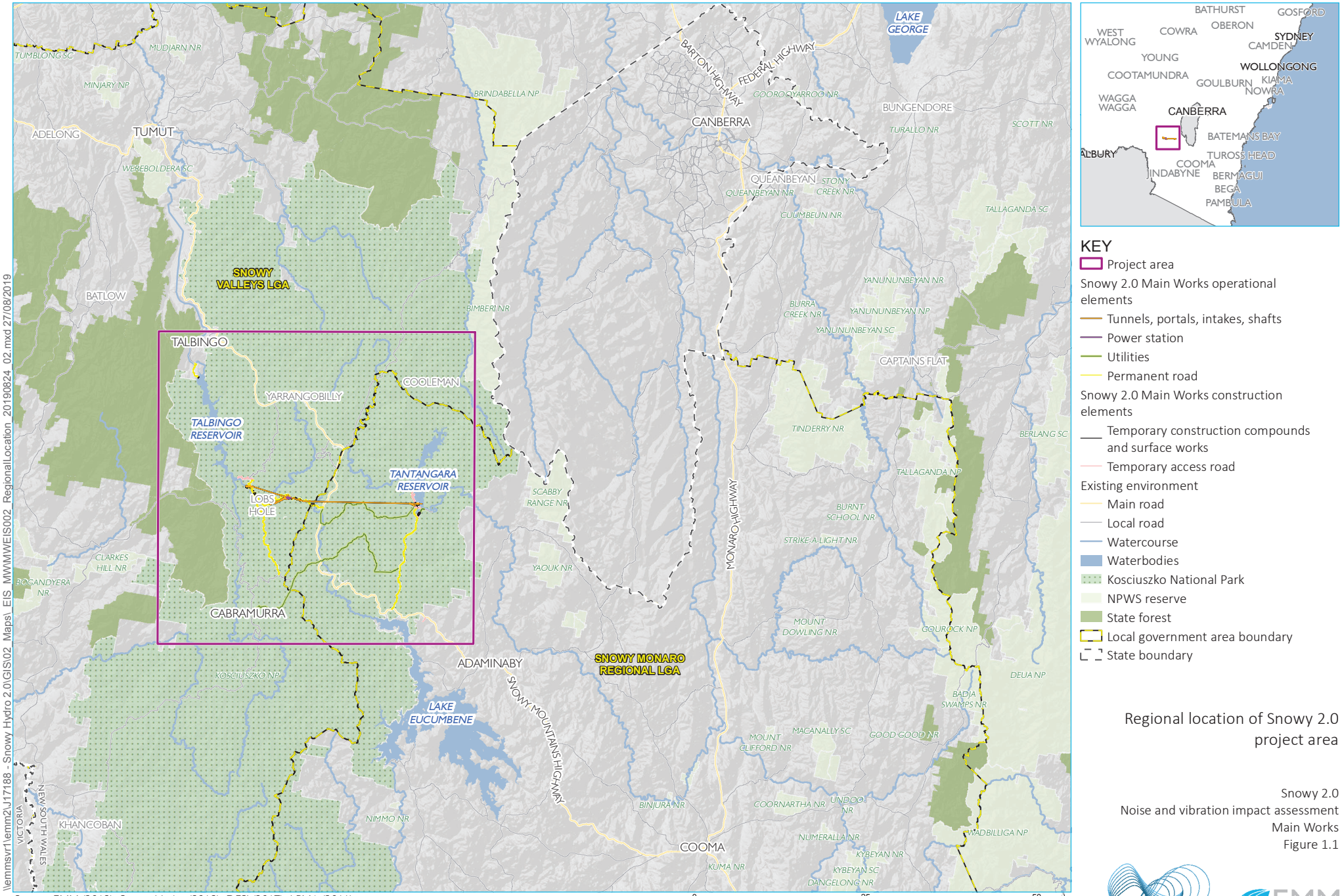
While these projects form part of the CSSI declaration for Snowy 2.0 and Transmission Project, they do not form part of Snowy Hydro's application for Snowy 2.0 Main Works. These related projects are subject to separate application and approval processes. However, cumulative impacts have been considered in this report where relevant.

1.6 Other relevant reports

This NVIA 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 NVIA are listed below.

- Air Quality Impact Assessment (EMM 2019) – Appended to the EIS;
- Biodiversity development assessment (EMM 2019) – Appended to the EIS;
- Cenozoic Geodiversity Report (Troedson 2019) – Appended to the EIS;
- Historic cultural heritage assessment (NSW Archaeology 2019) – Appended to the EIS; and

- Traffic and Transport Assessment Report (SCT 2019) – Appended to the EIS.



KEY

- Project area

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
- Local government area boundary
- State boundary

Regional location of Snowy 2.0 project area

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 1.1

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

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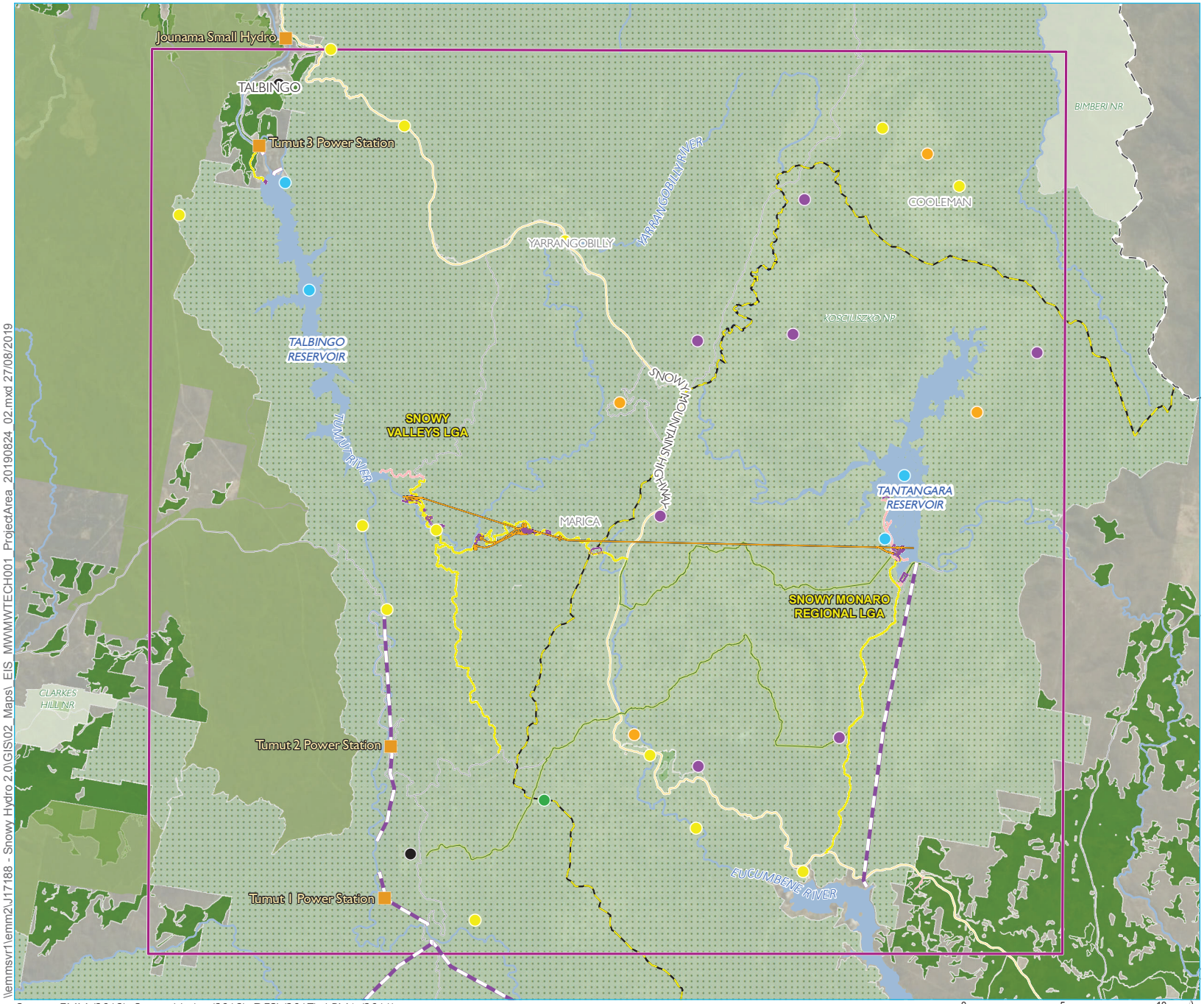

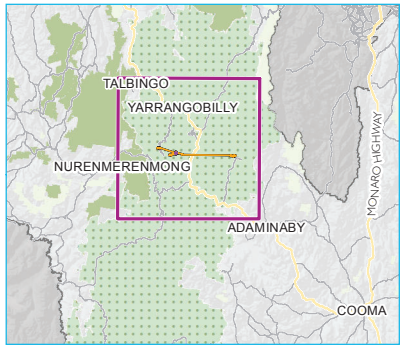

KEY

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

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

Snowy 2.0
Noise and vibration impact assessment
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

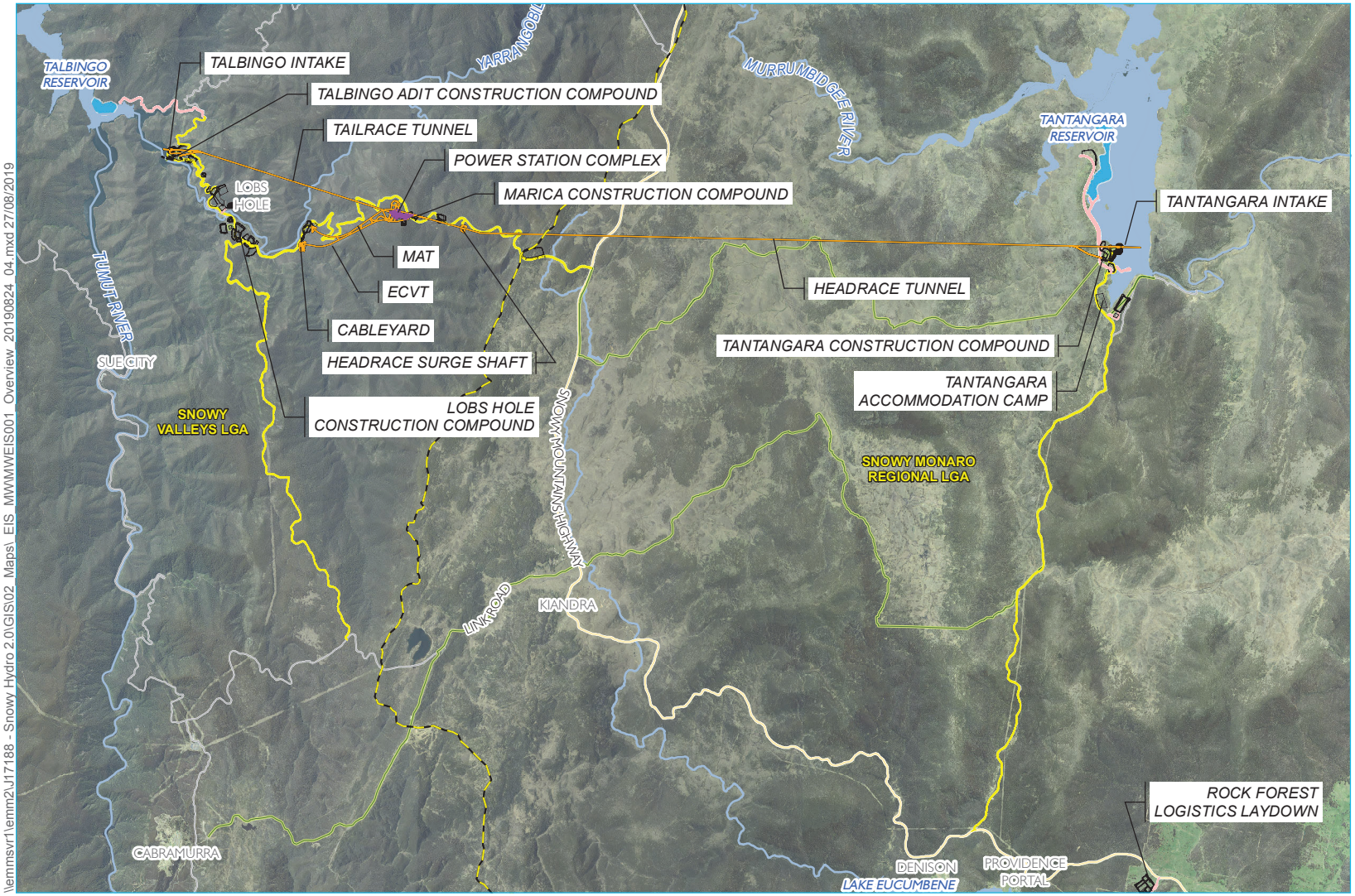
Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and a new hydro-electric power station will be built underground. An overview of Snowy 2.0 is shown on Figure 2.1, and the key project elements of Snowy 2.0 are summarised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

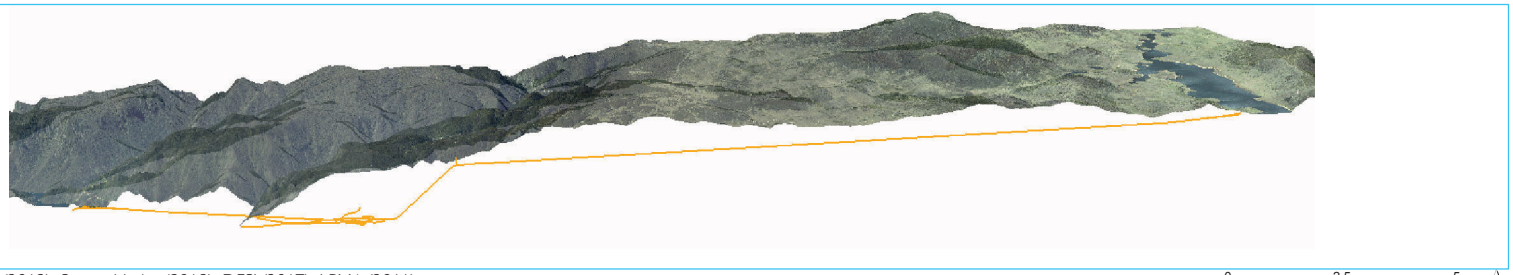
Table 2.1 Overview of Snowy 2.0 Main Works

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 the 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.
Excavated rock management	Excavated rock 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.





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
- Indicative rock emplacement area

Main Works project area

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

0 2.5 5 km

GDA 1994 MGA Zone 55

N

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 2.1

snowy 2.0

EMM creating opportunities

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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

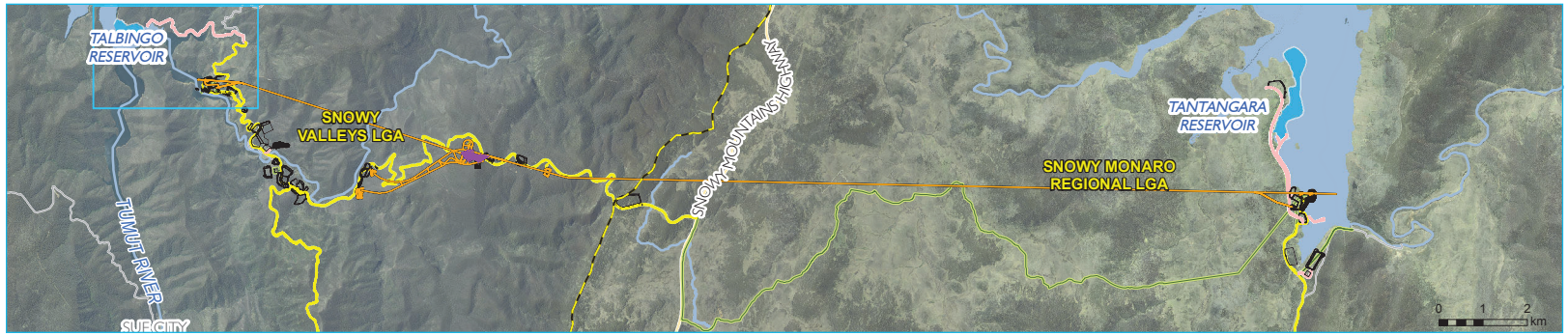
Construction element	Purpose	Location
Temporary and permanent access roads	Access road works are required to: • provide for the transport of excavated material between the tunnel portals and the excavated rock emplacement areas; • accommodate the transport of oversized loads as required; and • facilitate 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).
Excavated rock management	Approximately 9 million m^3 (unbulked) of excavated material will be generated by construction and require management. The strategy for management of excavated rock 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

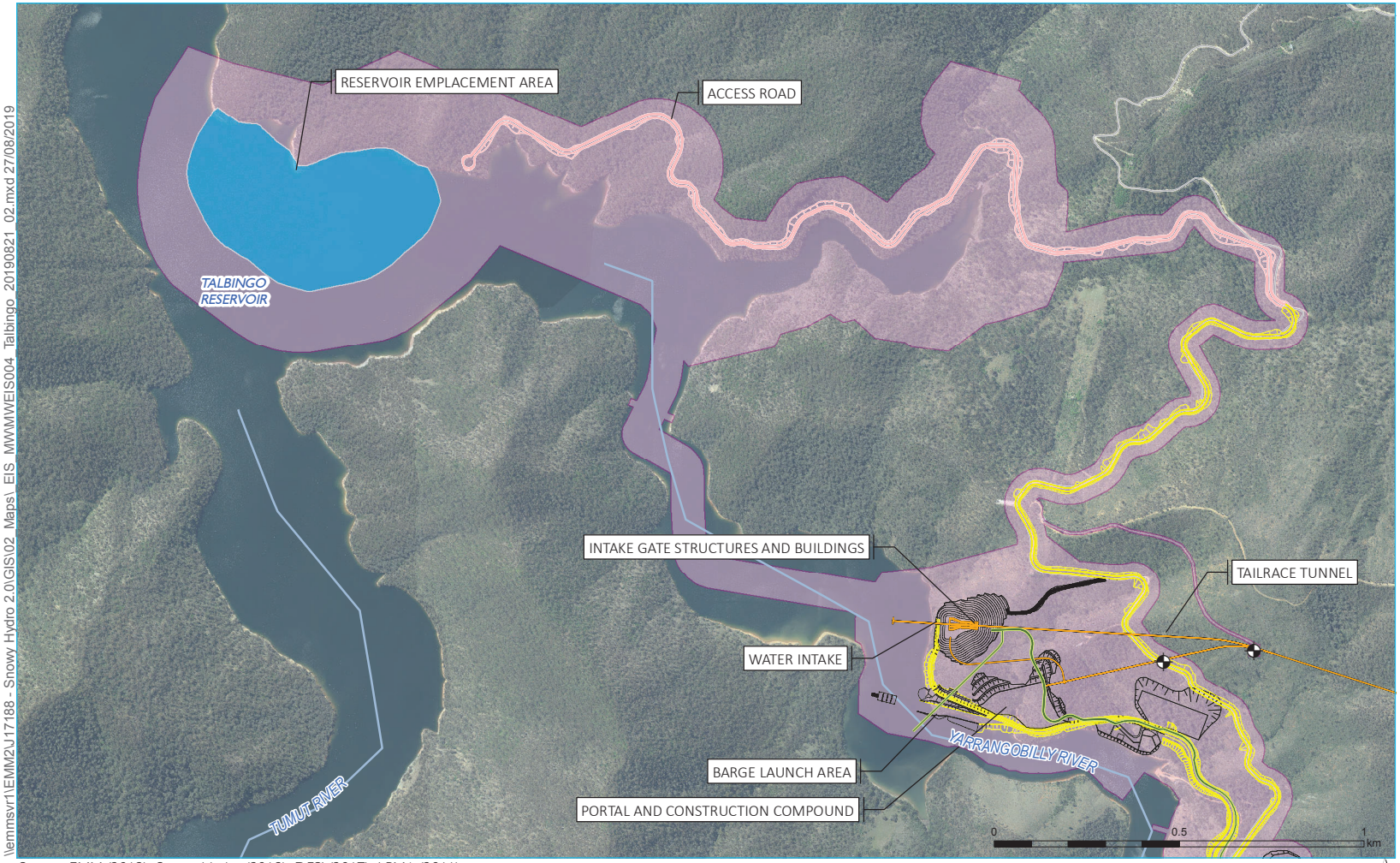
The key areas of construction are shown on Figure 2.2 to Figure 2.7 and can be described across the following locations:

- 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 2.8 with further detail on construction methods provided at Appendix D of the EIS.





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.

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

GDA 1994 MGA Zone 55

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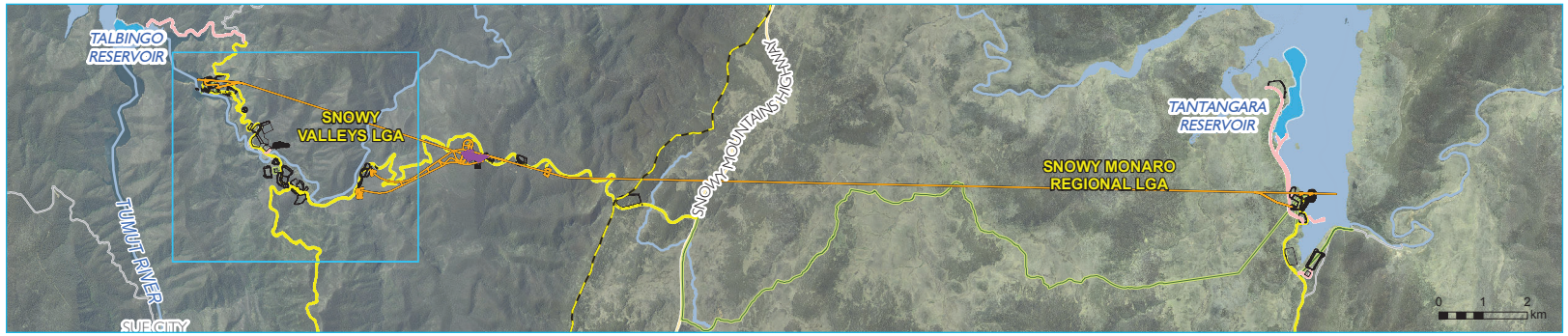
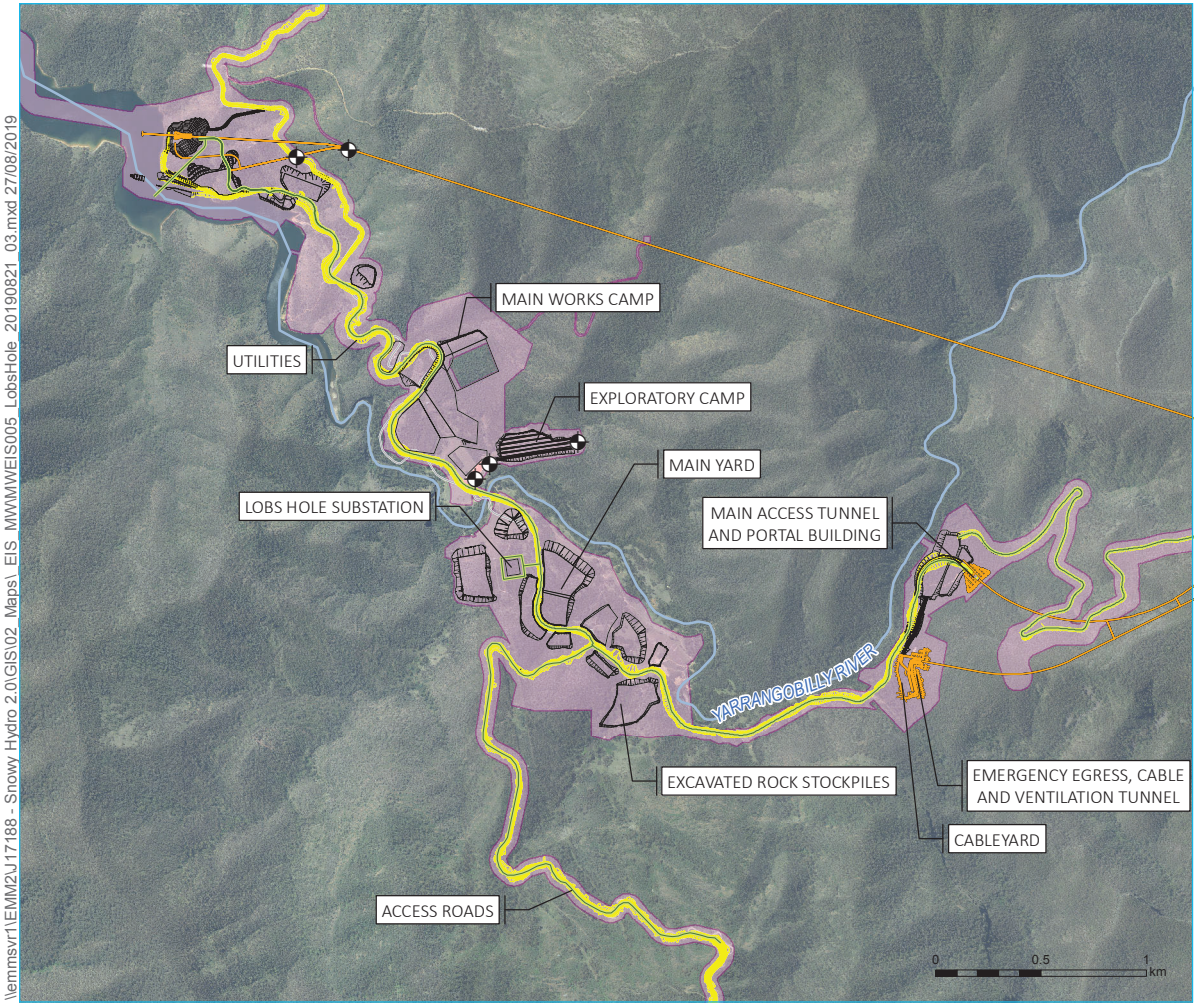
Talbingo Reservoir - project elements, purpose and description

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 2.2

snowy 2.0

EMM creating opportunities





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.

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

GDA 1994 MGA Zone 55

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Lobs Hole - project elements, purpose and description

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 2.3

snowy 2.0

EMM creating opportunities

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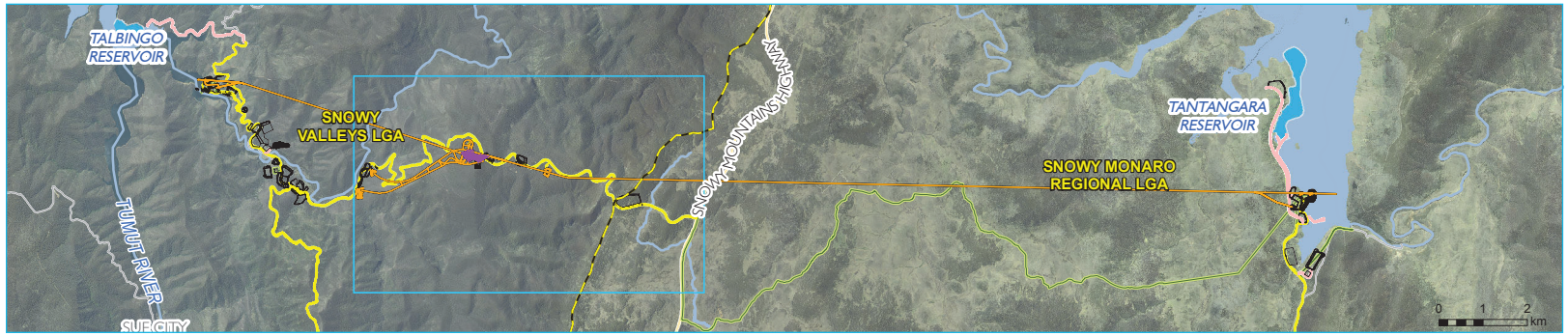

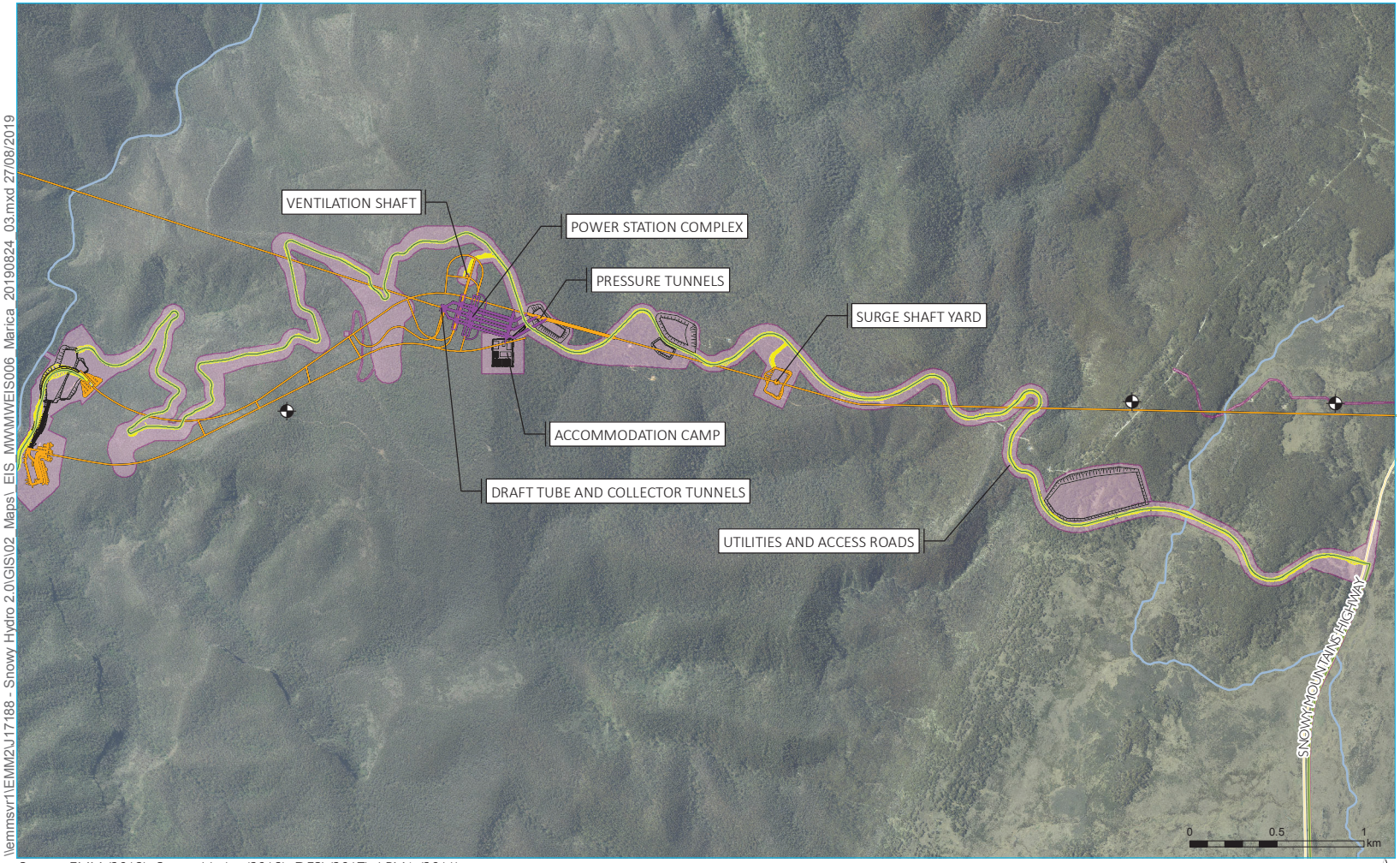

KEY

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
Noise and vibration impact assessment
Main Works
Figure 2.4

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

GDA 1994 MGA Zone 55

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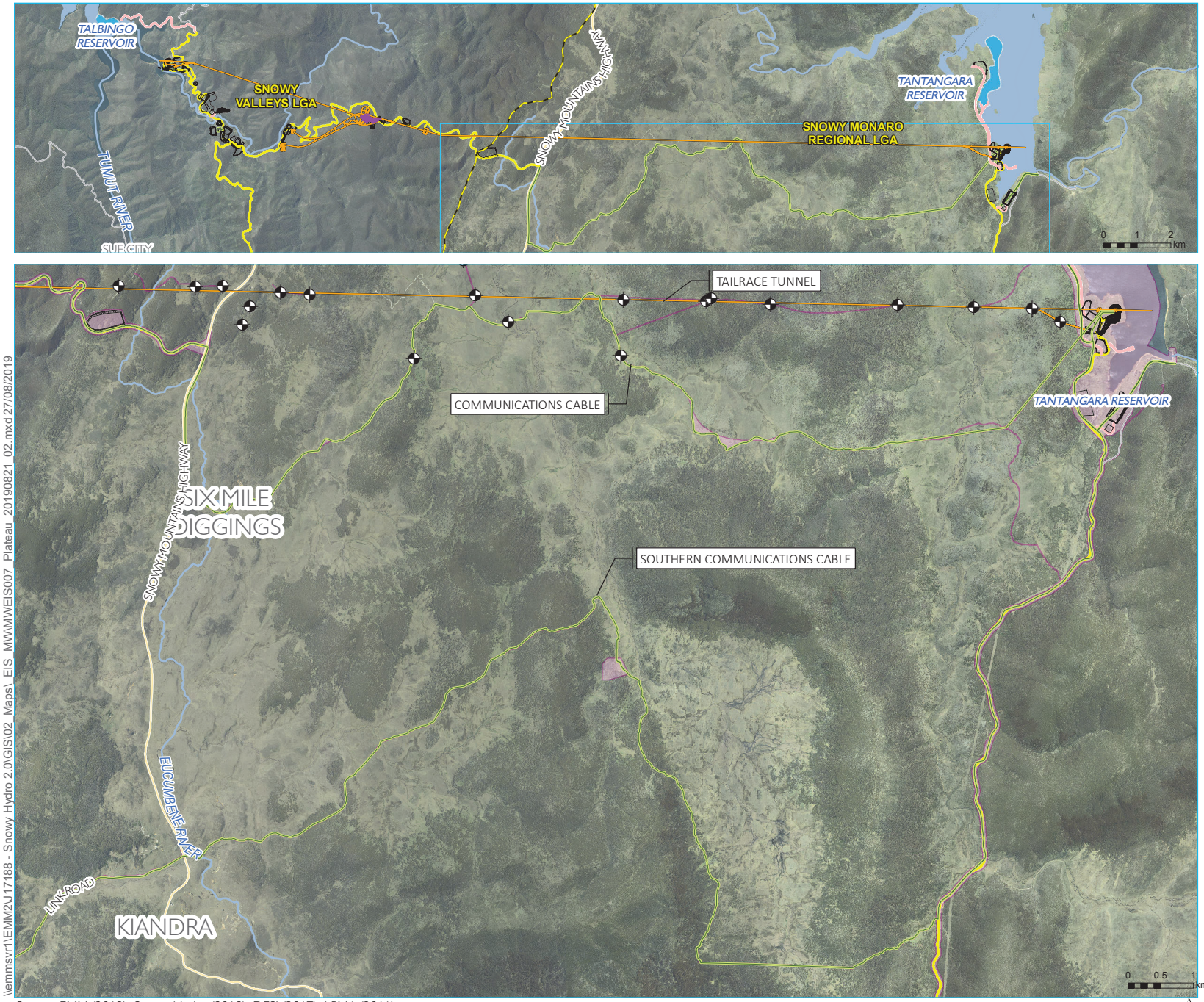

KEY

Existing environment

- Main road
- Local road
- Watercourse
- 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.

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

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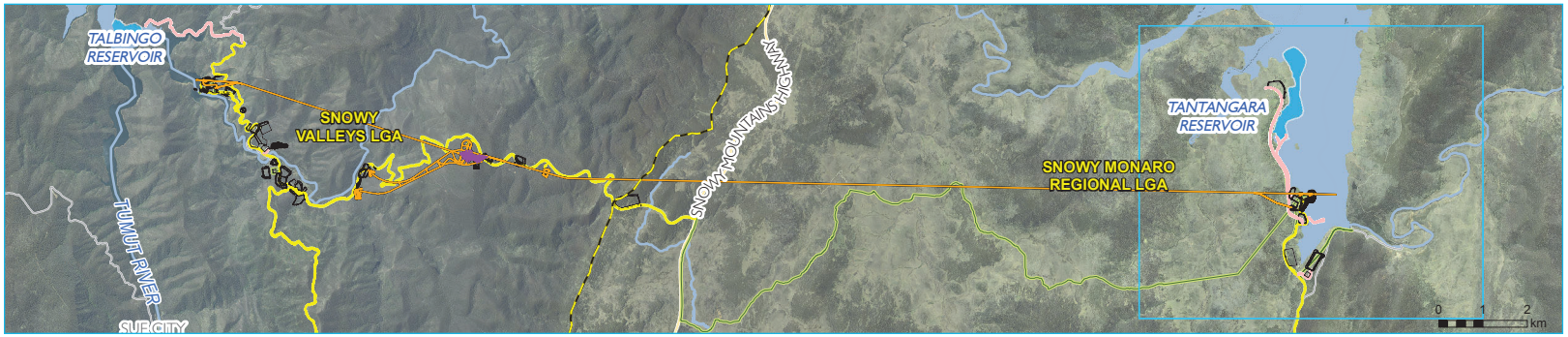
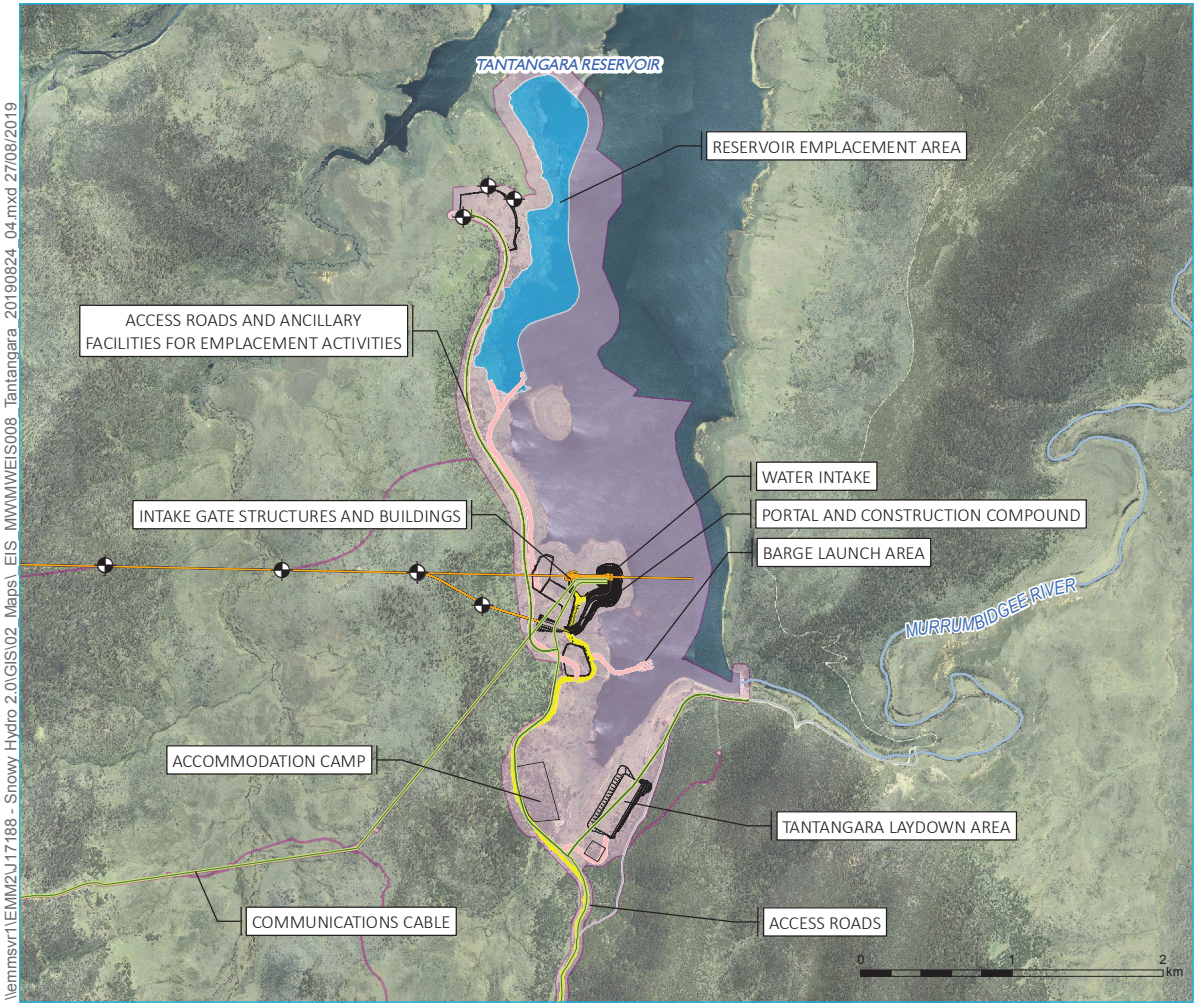
Plateau - project elements, purpose and description

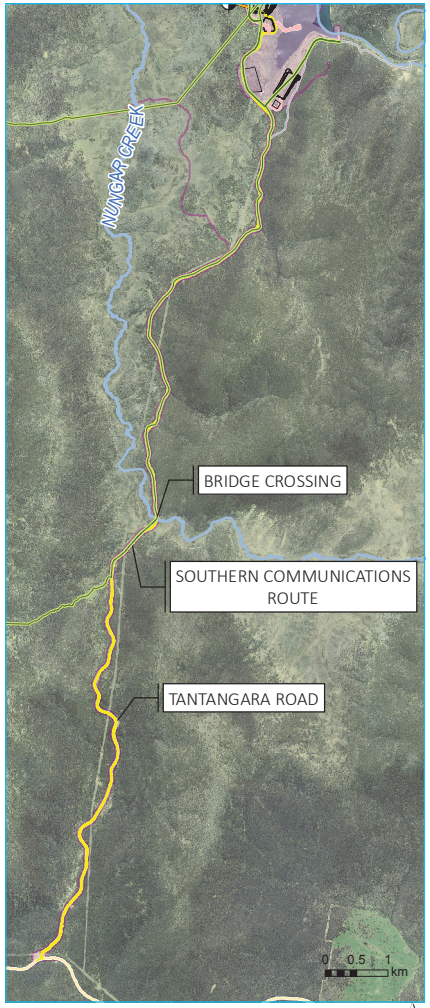
Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 2.5

snowy 2.0

EMM creating opportunities







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.

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

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Tantangara Reservoir - project elements, purpose and description

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 2.6

snowy 2.0

EMM creating opportunities

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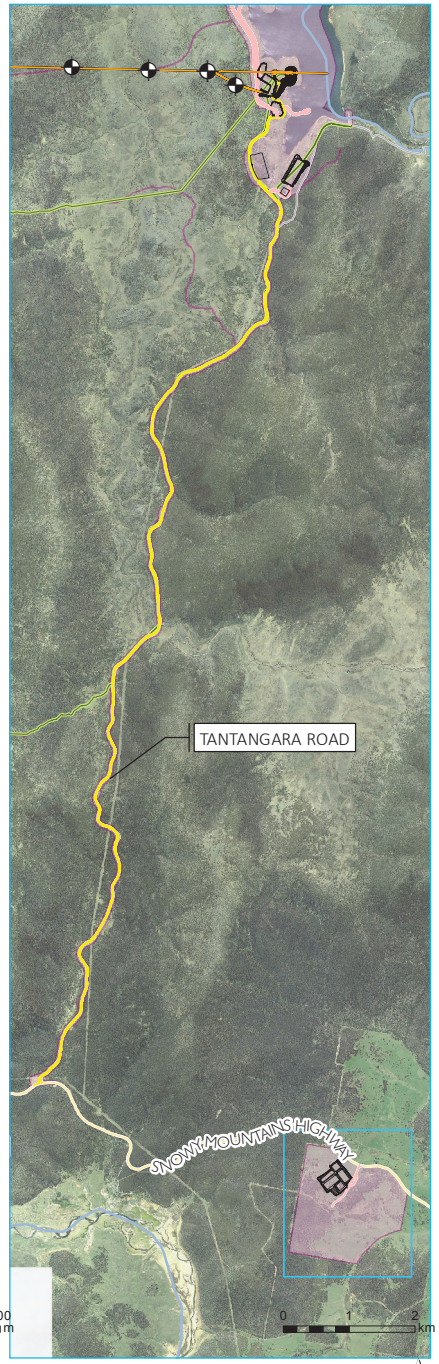

KEY

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.

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

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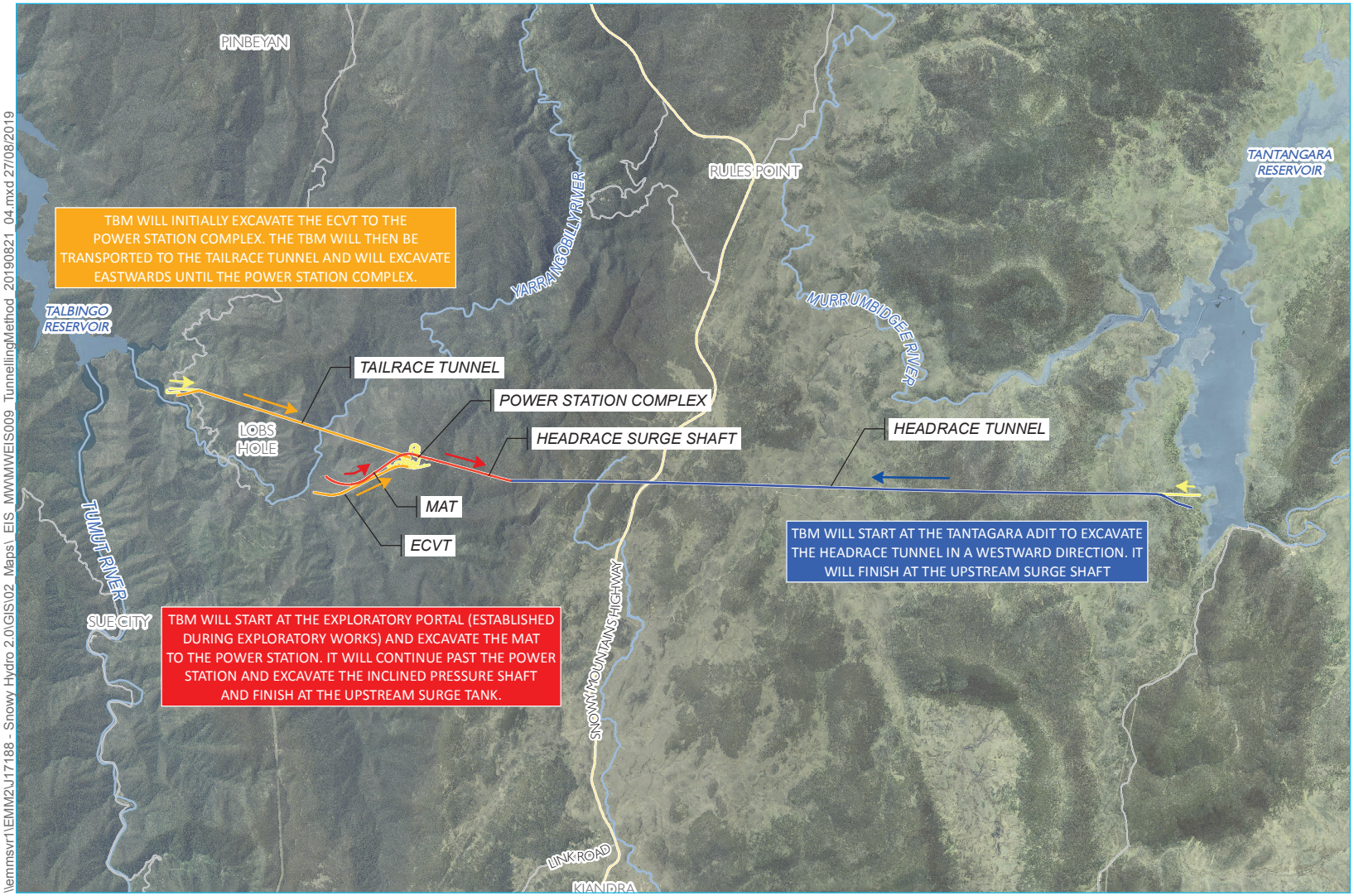
Rock Forest - project elements, purpose and description

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 2.7

snowy 2.0

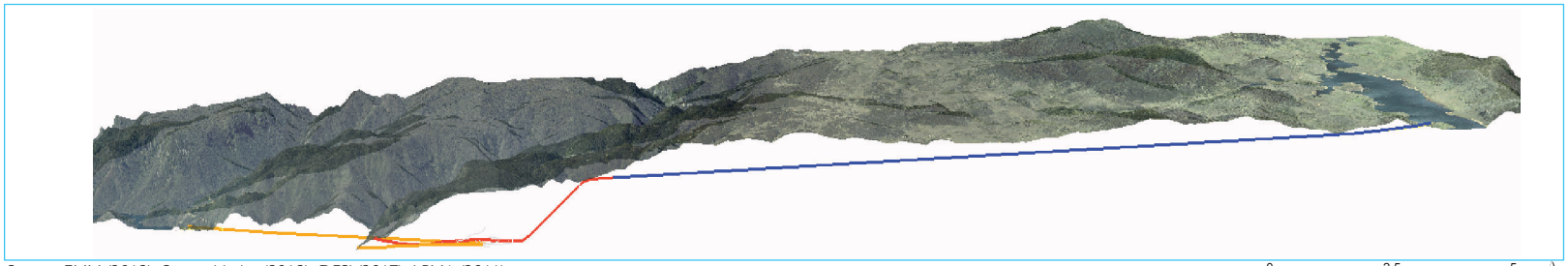
EMM creating opportunities



KEY

Tunnelling method
- Drill and blast
- TBM 1
- TBM 2
- TBM 3
- Tunnelling direction

Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies



Primary excavation methods – drill and blast and tunnel boring machine

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

0 2.5 5 km

GDA 1994 MGA Zone 55

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Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 2.8

snowy 2.0

EMM creating opportunities

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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 Existing environment

3.1 Site description

Snowy 2.0 Main Works is located in the Australian Alps in southern NSW, about mid-way between Canberra and Albury. Snowy 2.0 Main Works will be in 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 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 with respect to the region is shown in Figure 1.2.

The pumped hydro-electric scheme elements of Snowy 2.0 Main Works are located mostly underground between the southern ends of Talbingo and Tantangara 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 an elevation of about 1,222 m AHD, 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;

- **Marica** - this site will be used primarily for construction (including vertical shafts to the underground power station, access to the power waterway tunnel and temporary construction compounds);

- **Lobs Hole** - the site is located at and where the Exploratory Works tunnel 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 and associated services. The area will continue to be used to facilitate construction and accommodate workers; and

- **Talbingo Reservoir** - at a full supply level of about 546 m AHD, 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.

Associated aquatic and sub-aqueous works will also be required within the two reservoirs comprising the placement of extracted rock. Supporting infrastructure will include establishing or upgrading access tracks and roads and electricity connections to construction sites.

All 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. Some of the supporting infrastructure (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.

A logistics area for construction laydown or other similar activities has been identified at Rock Forest (6193 Snowy Mountains Highway, Adaminaby) and considered in this NVIA.

Other attractions and places of interest in the vicinity of the Main Works project area include Selwyn Snow Resort, the Yarrangobilly Caves complex and Kiandra. Kiandra has special significance as the first place in Australia where recreational skiing was undertaken and is also an old gold rush town.

3.2 Noise and vibration assessment locations

The nearest representative noise sensitive locations to the Main Works have been identified for the purpose of assessing potential noise and vibration impacts. Details are provided in Table 3.1 and their locations are shown in Figure 3.1. They are referred to in this report as assessment locations.

The majority of assessment locations identified in the region of the Main Works are passive and active recreation areas. These include recreation areas such as Yarrangobilly campground (to the north), Bullocks Hill campground (to the north), Currango Homestead (to the north-east), Wares Yards campground (to the south), Rocky Plain campground (to the south), Old Kiandra Goldfields (to the south), Selwyn Snow Resort (to the south), Three Mile campground (to the south), Coonara Point and O'Hares rest area (to the west) and Talbingo reservoir (to the northwest). These assessment locations are shown in Figure 3.1.

The assessment locations most likely to be affected by Main Works road traffic noise are residences and campgrounds in the vicinity of the Snowy Mountains Highway between Cooma and Talbingo. Other assessment locations in the vicinity of The Link Road (Cabramurra Road), between the Snowy Mountains Highway and Lobs Hole Ravine Road, may also be affected by road traffic noise. These assessment locations are also shown in Figure 3.1.

Table 3.1 Noise assessment locations

ID	Description	Classification	Easting	Northing
A1	Buddong Falls	Passive recreation	612949	6054947
A2	Bullocks Hill campground	Passive recreation	637207	6039763
R1*	Cabramurra town	Residential	624617	6022721
A3	Coonara Point rest area	Passive recreation	622202	6039251
A4	Fishing	Passive recreation	618305	6056565
A5	O'Hares campground and rest area	Passive recreation	623443	6035053
A6	Old Kiandra	Passive recreation	635905	6028711
A7	Selwyn Snow Resort	Active recreation	631364	6025420
R2	Buddong Cottage	Residential	616339	6058255
R3	563-571 Murray Jackson Drive	Residential	616128	6059648
A8	Talbingo reservoir	Passive recreation	619502	6051134
R4	Talbingo town	Residential	617997	6061517
A9	Yarrangobilly Village	Commercial^	634825	6045448
R5	Talbingo Town#	Residential	617383	6061614
R6	6560 Snowy Mountains Highway#	Residential	650414	6021793
R7	6065 Snowy Mountains Highway	Residential	653068	6017700
R8	6067 Snowy Mountains Highway	Residential	652785	6018304
R9	6069 Snowy Mountains Highway	Residential	652758	6018605
R10	6074 Snowy Mountains Highway#	Residential	653301	6018452
R11	6076 Snowy Mountains Highway#	Residential	653413	6018914
R12	6078 Snowy Mountains Highway#	Residential	652937	6018962

Table 3.1 Noise assessment locations

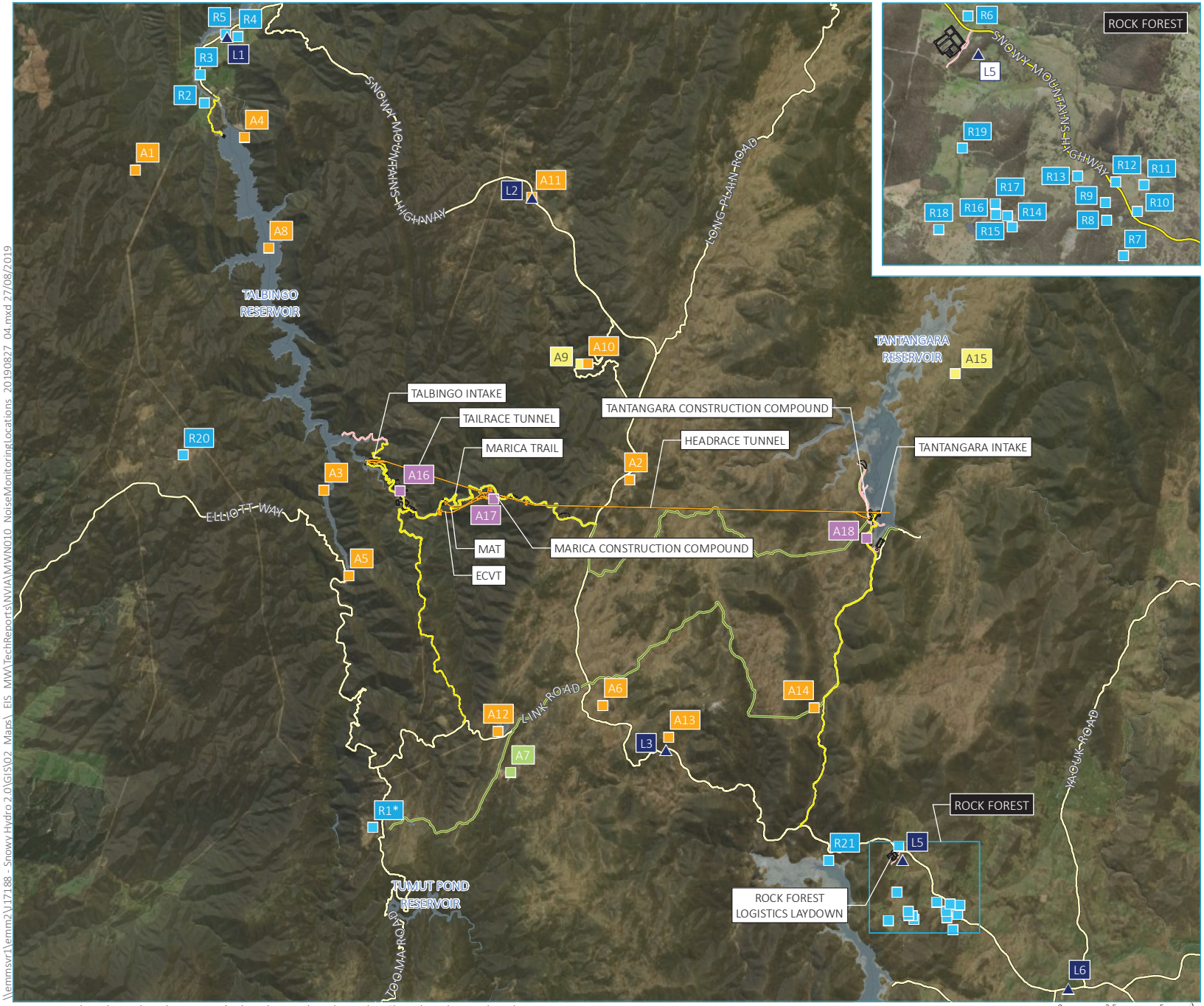
ID	Description	Classification	Easting	Northing
R13	Rock Forest, 6193 Snowy Mountains Highway	Residential	652289	6019054
R14	4/DP1002302 Snowy Mountains Highway, Adaminaby	Residential	651167	6018200
R15	Lot 3 Snowy Mountains Highway, Adaminaby	Residential	651093	6018384
R16	Lot 2 Snowy Mountains Highway, Adaminaby	Residential	650893	6018404
R17	1/DP100230, Snowy Mountains Highway, Adaminaby	Residential	650879	6018592
R18	6225 Snowy Mountains Highway, Adaminaby	Residential	649917	6018153
R19	10/DP48756 Snowy Mountains Highway, Adaminaby	Residential	650325	6019535
A10	Yarrangobilly Caves	Passive recreation	635163	6045458
A11	Yarrangobilly Village campground	Passive Recreation	632425	6053636
R20	Private properties at Nurrenmerenmong	Residential	615307	6040979
A12	Three Mile Dam campground	Passive recreation	630757	6027446
A13	Rocky Plain Campground	Passive Recreation	639142	6027130
A14	Wares Yards Campground	Passive Recreation	646262	6028591
R21	Providence Portal	Residential	646991	6021120
A15	Currango Homestead	Commercial^	653200	6044983
A16	Snowy 2.0 Lobs Hole Accommodation	n/a*	625947	6039216
A17	Snowy 2.0 Marica Accommodation	n/a*	630540	6038820
A18	Snowy 2.0 Tantangara Accommodation	n/a*	648840	6036903

Notes: * Owned by the proponent

Road traffic noise assessed only

^ Commercial property operated by National Parks and Wildlife Service (NPWS) and assessed as internal noise levels in accordance with AS/NZS 2107:2016.

* Not applicable – accommodation camp as part of Snowy 2.0 construction works



KEY

- Noise monitoring location

Noise assessment location

- Residential
- Commercial
- Passive recreation
- Active recreation
- Project accommodation

Snowy 2.0 operational elements

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

Snowy 2.0 contruction elements

- Temporary construction compounds and surface works
- Temporary access road
- Utilities

Existing environment

- Main road
- Waterbody

Source: EMM (2019); ESRI (2019); Snowy Hydro (2019); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

0 2.5 5 km

GDA 1994 MGA Zone 55

N

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Noise monitoring and assessment locations

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 3.1

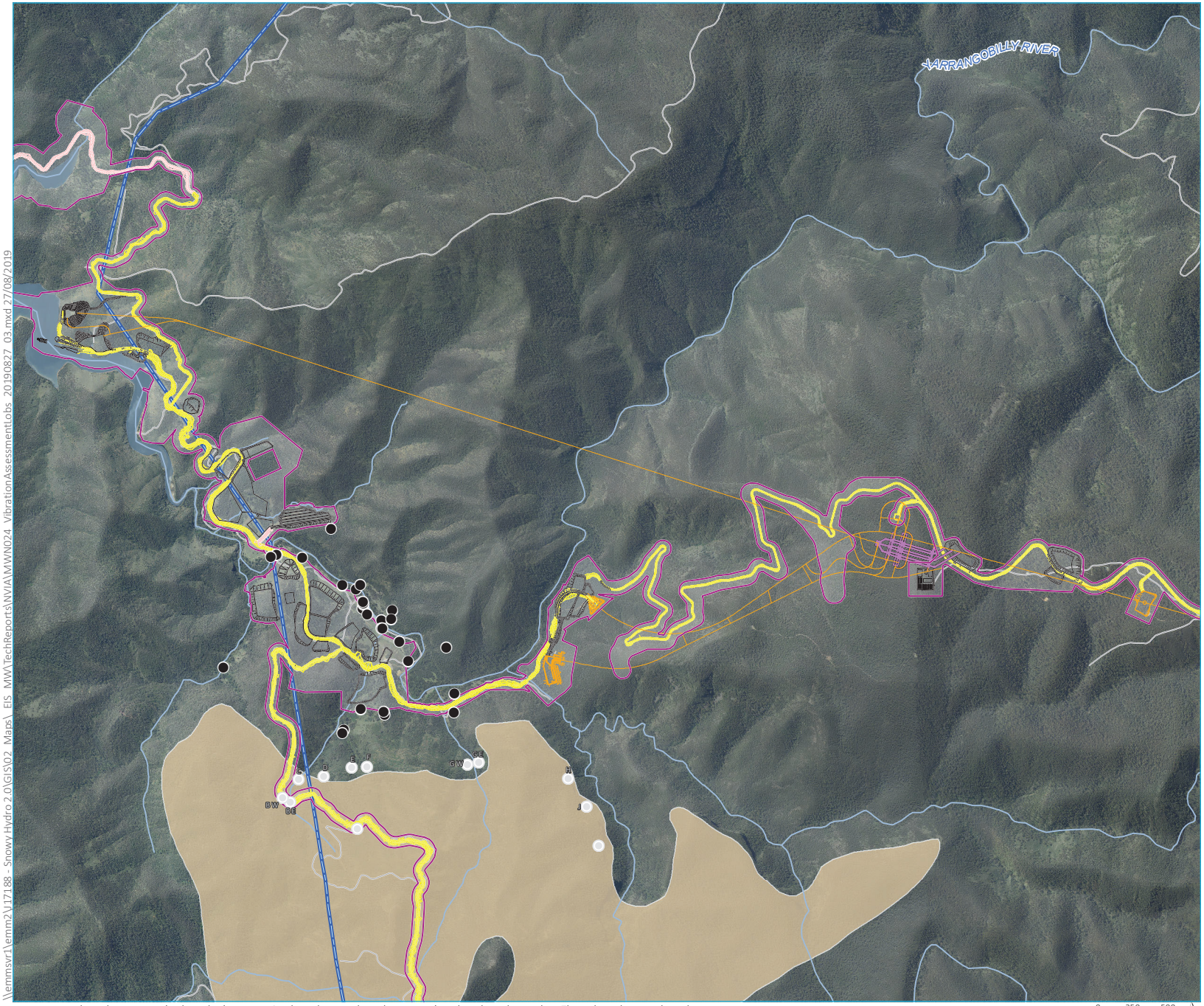
snowy 2.0

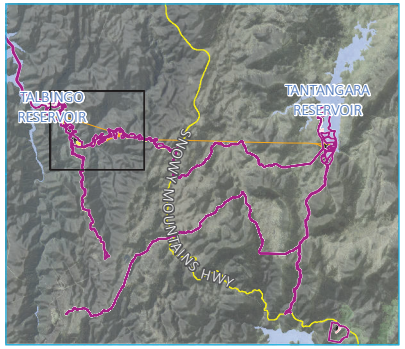
EMM creating opportunities

The assessment locations potentially most exposed to construction vibration from the Main Works are Aboriginal and European heritage sites in and around Lobs Hole Ravine, Yarrangobilly Caves, Yarrangobilly and Ravine Karst systems, Tantangara Dam wall, historic huts as identified by Kosciuszko Huts Association (KHA) as well as electricity transmission line pylons in the vicinity of the main works area. These assessment locations are shown in Figure 3.2 and Figure 3.3. The ECVT and portal are approximately 240 m north of the Ravine Karst system, whilst the existing alignment of Lobs Hole Ravine Road traverses the Ravine Karst structure.

Tufa outcrops that have been identified in the Cenozoic Geodiversity Report (Troedson 2019) as being significant and warrant assessment (Figure 3.2). It is acknowledged that Tufa A, B east and B west are presently directly impacted by the existing alignment of Lobs Hole Ravine Road. Tufa C to G have been identified as high value cliff-edge tufa and have been considered in Section 6. Tufa is a variety of limestone formed when carbonate minerals precipitate out of ambient temperature water.

The Yarrangobilly Karst area is located more than six kilometres from the construction and tunnelling works and considering the distance separation would not be expected to receive any noise or vibration impacts. If noise and vibration impacts are managed to the closest assessment locations, locations further away from the construction site would also be managed.





KEY

- Main Works disturbance footprint

Vibration assessment location

- Historic heritage site
- Tufa location

Snowy 2.0 Main Works operational elements

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

Snowy 2.0 Main Works construction elements

- Temporary construction compounds and surface works
- Temporary access road

Existing environment

- Local road or track
- Electricity transmission lines
- Watercourse
- Waterbody
- Ravine Karst Areas

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); NSW Archaeology (2018); DFSI (2017); GA (2015); LPMA (2011)

0 250 500 m

GDA 1994 MGA Zone 55

N

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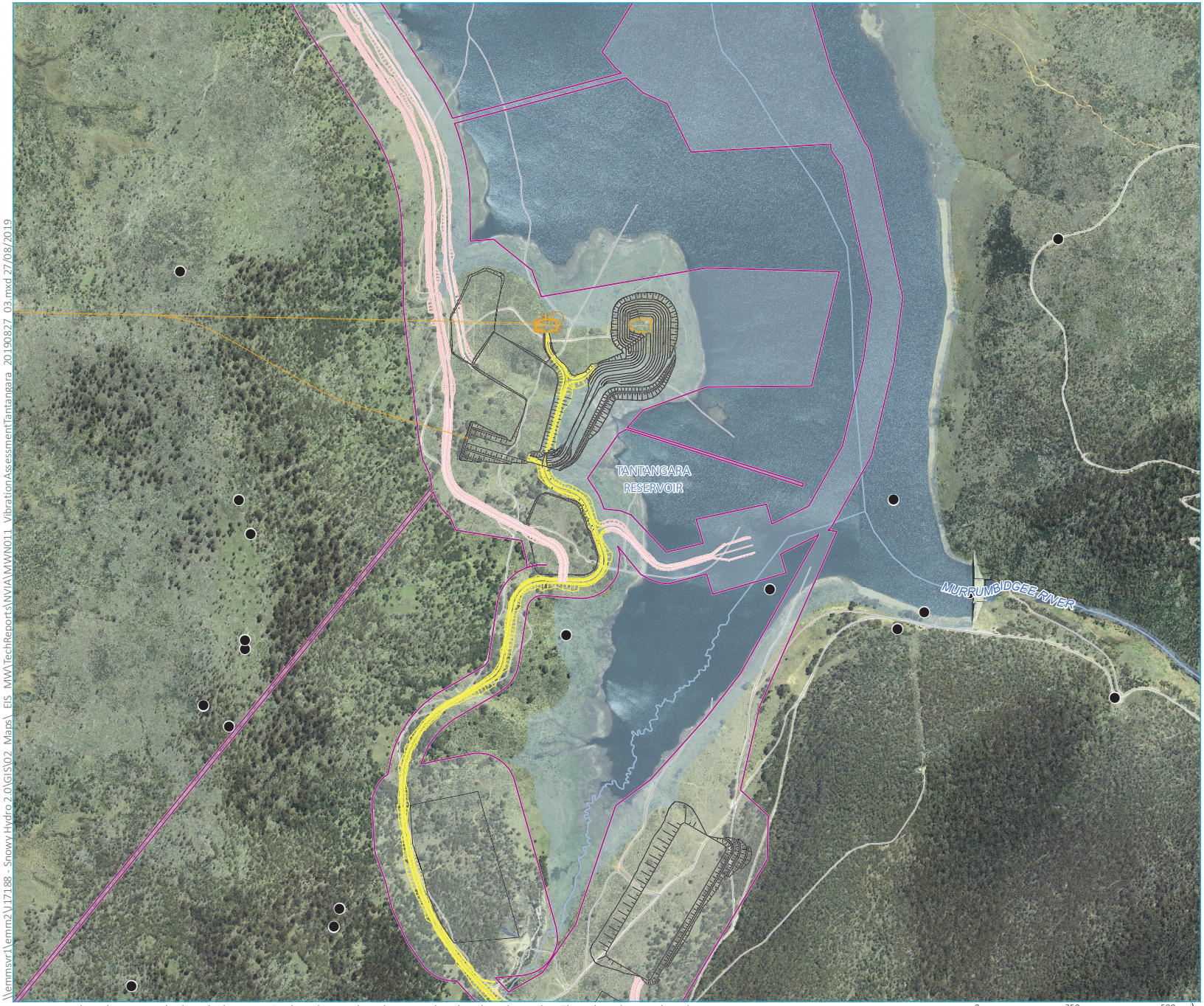
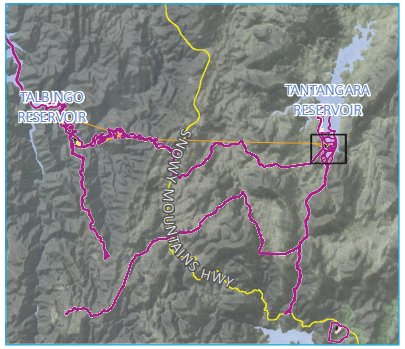
Vibration assessment locations - Lobs Hole to Marica

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 3.2

snowy 2.0

EMM creating opportunities





KEY

- Main Works disturbance footprint
- Vibration assessment location
- Historic heritage site

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Permanent road

Snowy 2.0 Main Works construction elements

- Temporary construction compounds and surface works
- Temporary access road

Existing environment

- Local road or track
- Watercourse
- Waterbody

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); NSW Archaeology (2018); DFSI (2017); GA (2015); LPMA (2011)

0 250 500 m

GDA 1994 MGA Zone 55

N

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Vibration assessment locations - Tantangara

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 3.3

snowy 2.0

EMM
creating opportunities

3.3 Background noise survey

3.3.1 Ambient noise environment

In order to establish the existing ambient noise environment of the area, both unattended and short-term operator-attended noise surveys were conducted as part of the noise assessment for the Exploratory Works EIS at the monitoring locations in general accordance with the procedures described in Australian Standard AS 1055-1997 - *Acoustics - Description and Measurement of Environmental Noise*.

To determine ambient noise levels in Talbingo, a noise logger was placed in the yard of a residence at Brownlie Court, Talbingo (L1). The location of the unattended noise monitoring was representative of the Talbingo residential assessment locations and was selected after inspection of the site and its surrounds, giving due consideration to other noise sources which may influence the readings (eg domestic air-conditioners), the proximity of assessment locations to the site, security issues for the noise monitoring device and gaining permission for access from the residents or landowners.

The unattended monitoring was carried out using an Acoustic Research Laboratories (ARL) Ngara environmental noise logger (serial number 8780F0). The noise logger was in place from 19 March to 4 April 2018 (17 days).

Supplementary long-term unattended monitoring was conducted at an additional five locations from 15 to 30 November 2018 (15 days) and 18 to 25 March 2019 to further establish the acoustic environment of the study area and determine road traffic noise levels in the vicinity of potential traffic routes for the Project (Figure 3.1).

The instrumentation utilised for the additional monitoring comprised ARL EL316, SVAN 977, ARL EL316, ARL Ngara and SVAN 959 environmental noise loggers (S/N 16-207-030, 59682, 16-306-036, 878113 and 11225) respectively. The additional locations were:

- Snowy Mountains Highway at Yarrangobilly Village Campground (L2);
- Snowy Mountains Highway at Sawyers Hut (L3);
- Tooma Road, Tooma (L4);
- 'Rock Forest' 6193 Snowy Mountains Highway, Adaminaby (L5); and
- Snowy Mountains Highway, Adaminaby (L6).

The noise loggers were programmed to record statistical noise level indices continuously in 15 minute intervals, including the L_{Amax}, L_{A1}, L_{A10}, L_{A50}, L_{A90}, L_{A99}, L_{Amin} and the L_{Aeq}. Calibration of all instrumentation was checked prior to and following monitoring. Drift in calibration did not exceed ±0.5 dB. All equipment carried appropriate and current National Association of Testing Authorities (NATA) (or manufacturer) calibration certificates.

The majority of the study area is located within the KNP, which is uninhabited with ambient noise levels controlled by natural elements. The monitoring results confirmed background noise levels during the day and night typically <30 dBA. The ICNG procedures for determining background noise levels refers to the NSW Industrial Noise Policy (INP), the INP has since been superseded by NSW Noise Policy for Industry (NPfI). Section 2.3 and Fact Sheet A of the NPfI stipulates where measured day background noise levels are <35 dBA and evening / night are <30 dBA, then the background noise levels for assessment purposes shall be set at 35 dBA day and 30 dBA evening / night respectively.

A summary of existing background and ambient noise levels at the measurement locations is given in Table 3.2. Results are provided for each day in Annexure A.

Table 3.2 Summary of existing background and ambient noise

Monitoring location (period)	Period[1]	Rating Background Level (RBL)[2], dBA	Measured $L_{Aeq, period}$ Noise Level[3], dBA
L1 – Brownlie Court, Talbingo (R) 19/3/18 - 4/4/18	Day	28 (35)	48
	Evening	29 (30)	47
	Night	23 (30)	35
L2 – Yarrangobilly Village Campground, Snowy Mountains Highway (PR) 15/11/18 - 30/11/19	Day	31 (35)	53
	Evening	31 (30)	45
	Night	32 (30)	41
L3 – Sawyers Hut (PR), Snowy Mountains Highway 15/11/18 - 30/11/19	Day	26 (35)	54
	Evening	25 (30)	49
	Night	24 (30)	46
L4 – Tooma Road, Tooma (R) 15/11/18 - 30/11/19	Day	25 (35)	57
	Evening	24 (30)	51
	Night	23 (30)	53
L5 – Rock Forest, Adaminaby[2,4] (R) 18/4/19 - 25/4/19	Day	34 (35)	41
	Evening	*<30* (30)	-
	Night	*<30* (30)	-
L6– Snowy Mountains Highway, Adaminaby (R) 15/11/18 - 30/11/19	Day	26 (35)	58
	Evening	21 (30)	53
	Night	21 (30)	47

1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Night: 10 pm to 7 am, Sunday to Friday and 10 pm to 8 am Saturday and public holidays.
2. The RBL is an NPfI term and is used to represent the background noise level. In accordance with the NPfI, minimum thresholds were adopted given measured values were lower.
3. The energy averaged noise level over the measurement period and representative of general ambient noise.
4. Limited data was available for Rock Forest due to battery failure, however a review of the data confirmed Day background L_{A90} noise levels less than 30 dBA accordingly the NPfI, minimum thresholds were adopted.
5. Threshold RBLs are presented in brackets () in accordance with the procedures of the NPfI.
6. (R) – residential, (PR) passive recreation

3.3.2 Road traffic noise

For the review and assessment of road traffic noise levels, Table 3.3 provides a summary of the measured day $L_{Aeq,15hr}$ and night $L_{Aeq,9hr}$ noise levels for measurement locations L2 to L4 inclusive. It is noted that the existing road network typically carries low traffic volumes, hence measured L_{Aeq} levels may also be influenced by other activities including natural elements, localised noise sources and intermittent human activities.

Table 3.3 Summary of existing traffic noise levels

Monitoring location	Measured Day $L_{Aeq,15hr}$ Noise Level, dB	Measured Night $L_{Aeq,9hr}$ Noise Level, dB
L2 – Snowy Mountains Highway, Yarrangobilly Village Campground	52	41
L3 – Snowy Mountains Highway, Sawyers Hut	54	46
L6 – Snowy Mountains Highway, Adaminaby	57	47

3.4 Meteorology

The NPfI (EPA 2017) requires assessment of noise under standard and noise enhancing weather conditions. The NPfI defines these as follows:

- **Standard meteorological conditions:** defined by stability categories A through to D with wind speeds up to 0.5 m/s at 10 m above ground level (AGL) for day, evening and night periods.

- **Noise-enhancing meteorological condition:** defined by stability categories A through to D with light winds (up to 3 m/s at 10 m AGL) for the day and evening periods; and stability categories A through to D with light winds (up to 3 m/s at 10 m AGL) and/or stability category F with winds up to 2 m/s at 10 m AGL.

The NPfI specifies the following two options to consider meteorological effects:

1. Adopt the noise-enhancing meteorological conditions for all assessment periods for noise impact assessment purposes without an assessment of how often these conditions occur – a conservative approach that considers source-to-receiver wind vectors for all receivers and F class temperature inversions with wind speeds up to 2 m/s at night; or

2. Determine the significance of noise-enhancing conditions. This involves assessing the significance of temperature inversions (F and G class stability categories) for the night-time period and the significance of light winds up to and including 3 m/s for all assessment periods during stability categories other than E, F or G. Significance is based on a threshold of occurrence of 30% determined in accordance with the provisions in this policy. Where noise-enhancing meteorological conditions occur for less than 30% of the time, standard meteorological conditions may be adopted for the assessment.

3.4.1 Winds

The NPfI recommends consideration of wind effects if they are “significant”. The NPfI defines “significant” as the presence of source-to-receiver wind speed (measured at 10 m above ground level) of 3 m/s or less, occurring for 30% of the time in any assessment period and season.

This is further clarified by defining source-to-receiver wind direction as being the directional component of wind. The NPfI states that where wind is identified to be a significant feature of the area then assessment of noise impacts should consider the highest wind speed below 3 m/s, which is considered to prevail for at least 30% of the time.

A thorough review of the vector components of hourly wind data was undertaken for data calculated by the project’s Air Quality consultant (EMM) (using CALMET) for the Snowy 2.0 study area during 2017 (one calendar year). Hourly average meteorological data from the BoM Cabramurra SMHEA AWS and project-related stations at Tantangara Dam, Cabramurra Airstrip and Talbingo were used as observations in the TAPM modelling. Data from the BoM Cabramurra SMHEA AWS and Tantangara Dam were used in the CALMET modelling. The analysis incorporated wind vectors 45 degrees either side of the stated wind direction and identified that no wind directions were found to be a feature of the area, as per the NPfI. Table 3.4, Table 3.5 and Table 3.6 provide a summary of the wind vector review for the respective areas of Lobs Hole, Marica and Tantangara reservoir. Nonetheless, consistent with assessment for Exploratory Works, noise enhancing winds were conservatively adopted for the assessment.

Table 3.4 **Percentage occurrence of wind speeds between 0.5 to 3 m/s (vector at 22.5° intervals), Lobs Hole from January 2017 to January 2018**

Direction	Day				Evening				Night			
	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer
N	8.7%	7.4%	8.9%	4.7%	13.4%	7.1%	7.9%	8.1%	10.5%	6.0%	6.4%	6.1%
NNE	7.0%	7.9%	8.3%	3.8%	11.0%	6.8%	6.0%	7.4%	7.6%	5.2%	4.5%	6.1%
NE	5.5%	7.5%	7.4%	3.2%	7.6%	7.0%	4.8%	6.8%	6.2%	5.1%	4.2%	5.9%
ENE	4.3%	6.9%	5.7%	2.5%	6.3%	6.7%	4.0%	6.2%	4.8%	4.5%	3.8%	5.6%
E	3.5%	5.8%	3.2%	1.7%	4.5%	6.1%	2.9%	4.8%	3.7%	3.7%	3.0%	4.9%
ESE	1.8%	4.3%	1.4%	1.0%	0.3%	2.1%	1.1%	2.4%	0.5%	0.7%	1.2%	1.5%
SE	1.0%	3.0%	0.5%	0.8%	0.1%	0.6%	0.4%	0.7%	0.3%	0.2%	0.2%	0.2%
SSE	0.8%	2.3%	0.3%	0.4%	0.0%	0.0%	0.1%	0.3%	0.0%	0.0%	0.0%	0.0%
S	1.6%	1.8%	0.6%	0.8%	0.0%	0.0%	0.3%	0.2%	0.0%	0.0%	0.0%	0.0%
SSW	2.3%	2.2%	1.5%	2.0%	0.0%	0.0%	0.2%	0.6%	0.0%	0.0%	0.0%	0.0%
SW	5.4%	3.6%	3.9%	3.4%	0.0%	0.0%	0.3%	1.2%	0.0%	0.0%	0.3%	0.2%
WSW	7.6%	4.4%	5.7%	4.9%	0.0%	0.0%	0.5%	2.2%	0.1%	0.3%	0.7%	0.3%
W	10.0%	5.2%	7.0%	6.0%	2.7%	1.8%	3.1%	4.5%	3.2%	1.6%	3.6%	1.7%
WNW	11.1%	6.1%	8.1%	6.6%	6.2%	2.3%	4.4%	5.5%	4.8%	1.9%	4.0%	2.0%
NW	11.3%	6.3%	8.8%	6.1%	7.5%	2.5%	5.1%	5.8%	6.3%	2.5%	4.4%	2.3%
NNW	9.3%	6.6%	8.9%	5.5%	9.3%	3.2%	6.2%	6.6%	7.4%	3.3%	5.0%	2.9%

Notes: 1. Based on data calculated (using CALMET) for the exploratory works site for Calendar Year 2017.

Table 3.5 **Percentage occurrence of wind speeds between 0.5 to 3 m/s (vector at 22.5° intervals), Marica data from January 2017 to January 2018**

Direction	Day				Evening				Night			
	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer
N	3.2%	5.4%	6.8%	3.5%	3.2%	0.3%	1.6%	1.9%	2.8%	0.5%	1.0%	0.9%
NNE	2.3%	5.5%	6.3%	3.0%	3.8%	1.0%	2.6%	2.8%	3.2%	1.1%	2.3%	1.6%
NE	2.5%	5.3%	5.2%	2.8%	6.1%	2.5%	4.5%	3.9%	5.4%	2.2%	3.7%	3.2%
ENE	3.0%	6.2%	3.8%	2.7%	7.5%	3.0%	5.1%	4.8%	6.1%	3.1%	4.4%	4.4%
E	3.2%	6.3%	2.6%	2.2%	7.7%	4.0%	5.7%	5.6%	6.1%	3.3%	4.8%	5.0%
ESE	3.3%	5.9%	1.6%	1.9%	7.1%	4.7%	6.0%	6.2%	5.8%	3.9%	5.2%	4.9%
SE	3.9%	5.3%	0.8%	1.4%	10.2%	5.2%	7.3%	6.2%	8.5%	4.1%	5.3%	5.1%
SSE	3.6%	4.8%	0.6%	0.8%	8.0%	4.0%	5.7%	5.3%	6.5%	3.1%	4.0%	3.4%
S	4.2%	3.6%	0.7%	0.7%	7.5%	3.6%	5.5%	4.9%	6.2%	2.4%	3.9%	2.6%

Table 3.5 Percentage occurrence of wind speeds between 0.5 to 3 m/s (vector at 22.5° intervals), Marica data from January 2017 to January 2018

Direction	Day				Evening				Night			
	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer
SSW	5.7%	4.2%	1.3%	1.5%	6.6%	3.1%	5.8%	4.5%	6.1%	2.5%	4.4%	2.0%
SW	7.1%	4.6%	2.9%	2.1%	5.6%	2.4%	4.1%	3.7%	4.9%	1.8%	3.3%	1.9%
WSW	8.0%	4.5%	4.2%	2.9%	1.8%	1.3%	1.8%	3.0%	1.8%	1.0%	1.9%	1.1%
W	8.6%	5.1%	5.4%	3.9%	1.6%	1.0%	1.5%	2.9%	1.6%	1.0%	1.8%	1.0%
WNW	7.9%	5.8%	6.5%	4.4%	0.8%	0.9%	1.1%	2.3%	1.1%	0.8%	1.2%	0.7%
NW	6.2%	5.4%	7.5%	4.0%	0.7%	0.4%	0.0%	1.8%	0.9%	0.2%	0.2%	0.5%
NNW	4.6%	5.0%	7.2%	3.9%	1.5%	0.1%	0.2%	1.6%	1.4%	0.2%	0.2%	0.6%

Notes: 1. Based on data calculated (using CALMET) for the exploratory works site for Calendar Year 2017.

Table 3.6 Percentage occurrence of wind speeds between 0.5 to 3 m/s (vector at 22.5° intervals), Tantangara reservoir data from January 2017 to January 2018

Direction	Day				Evening				Night			
	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer
N	6.6%	7.9%	9.3%	8.0%	3.7%	2.3%	3.9%	3.3%	3.2%	2.4%	2.2%	2.8%
NNE	4.4%	6.9%	7.9%	5.7%	2.1%	1.5%	4.1%	3.6%	2.2%	2.1%	1.9%	2.7%
NE	1.9%	5.5%	6.2%	4.0%	0.9%	1.8%	4.1%	3.4%	0.3%	1.6%	1.9%	2.6%
ENE	1.0%	3.7%	4.0%	3.1%	0.3%	2.0%	4.0%	2.5%	0.1%	1.2%	1.8%	1.8%
E	1.0%	3.2%	2.2%	2.4%	0.5%	2.9%	4.7%	3.3%	0.5%	1.9%	2.2%	2.7%
ESE	1.4%	4.2%	2.2%	2.2%	1.0%	5.7%	5.3%	4.4%	1.9%	4.0%	2.9%	4.3%
SE	3.0%	6.0%	2.6%	2.5%	5.1%	10.3%	6.6%	6.4%	5.2%	8.9%	5.8%	6.2%
SSE	4.8%	7.3%	3.7%	3.3%	9.7%	14.4%	9.6%	10.9%	10.3%	13.4%	9.8%	10.0%
S	8.6%	8.8%	5.5%	5.6%	13.5%	16.2%	12.6%	15.2%	14.0%	14.9%	11.9%	11.9%
SSW	10.2%	9.0%	6.6%	7.2%	16.2%	15.9%	12.2%	14.5%	15.3%	14.6%	11.9%	11.5%
SW	10.7%	8.0%	6.7%	8.0%	16.6%	12.9%	11.4%	13.2%	14.6%	12.3%	11.3%	10.1%
WSW	10.3%	6.6%	6.8%	10.0%	13.2%	8.8%	9.9%	10.8%	12.1%	7.8%	8.5%	8.1%
W	10.8%	6.1%	7.0%	11.3%	10.1%	5.3%	6.6%	6.3%	8.0%	3.8%	4.8%	4.4%
WNW	9.2%	6.1%	6.8%	10.6%	7.5%	2.8%	3.5%	2.1%	6.1%	2.6%	2.5%	2.3%
NW	8.5%	7.1%	7.7%	9.7%	5.2%	2.3%	3.3%	2.5%	4.6%	2.4%	2.3%	2.7%
NNW	7.6%	7.8%	9.2%	9.7%	4.1%	2.4%	3.4%	2.7%	4.0%	2.7%	1.9%	2.9%

Notes: 1. Based on data calculated (using CALMET) for the exploratory works site for Calendar Year 2017.

3.4.2 Temperature inversions

Temperature inversions (ie where atmospheric temperature increases with altitude) typically occur during the night-time period in the winter months and can also increase site noise levels at assessment locations. As per the NPfI, temperature inversions are to be assessed when they are found to occur for 30% of the time (about two nights per week) or greater during the winter months. Construction will occur at night so the effect of temperature inversions on noise levels needs to be considered.

Drainage flow winds (ie localised cold air travelling in a direction of decreasing altitude) can occur during temperature inversion conditions. The increase of noise levels caused by a drainage flow wind needs consideration if a development (ie noise source) is at a higher altitude to surrounding assessment locations, and where there is no intervening topography. Noise sources are typically at a similar elevation to surrounding assessment locations or there is intervening topography separating site and surrounding properties. The potential for source to receptor drainage flow winds to occur is therefore not considered relevant.

Table 3.7 provides a summary of the Pasquill atmospheric stability categories (or a measure of temperature gradients). The analysis is based on data calculated by the project's Air Quality consultant (EMM) (using CALMET) for the Snowy 2.0 during 2017 (one calendar year), with input as for the wind analysis. A summary of the results for the key project areas are presented in Table 3.7.

Noise enhancement due to temperature inversions occurs when the atmosphere is relatively stable which corresponds with atmospheric stability class category F and G. The occurrence of "F" atmospheric stability class conditions (ie temperature gradients of 1.5°C to less than 4°C per 100m elevation) trigger the NPfI assessment requirement (ie equal or greater than 30%).

Table 3.7 Percentage occurrence of Pasquill stability categories

Pasquill stability category	Percentage occurrence (night[1] period)				
	Annual	Summer	Autumn	Winter	Spring
			Lobs Hole		
A	0%	0%	0%	0%	0%
B	1%	2%	0%	0%	1%
C	3%	5%	0%	0%	5%
D	22%	23%	20%	18%	26%
E	49%	54%	54%	40%	45%
F	**26%**	**16%**	**26%**	**42%**	**23%**
			Marica		
A	0%	0%	0%	0%	0%
B	1%	2%	0%	0%	1%
C	3%	6%	0%	0%	5%
D	47%	41%	58%	39%	49%
E	29%	33%	29%	29%	22%
F	**21%**	**18%**	**13%**	**32%**	**23%**
			Tantangara reservoir		
A	0%	0%	0%	0%	0%
B	1%	3%	0%	0%	2%
C	7%	13%	3%	0%	11%
D	22%	16%	32%	21%	19%
E	8%	4%	5%	15%	6%
F	**63%**	**65%**	**60%**	**63%**	**62%**

Notes: 1. NPfI defined 'night' for assessment of temperature inversion conditions as sunset to sunrise - that is 6.00pm to 7.00am

The results indicate that ‘F’ class temperature inversions are a feature of the area as they occur for more than 30% of the time during the winter and therefore have been considered in the assessment.

4 Assessment criteria

4.1 Construction noise

The Interim Construction Noise Guideline (ICNG) (DECC 2009) has been jointly developed by NSW Government agencies including the EPA and DPE. The objectives of the guideline relevant to the planning process are to promote a clear understanding of ways to identify and minimise noise from construction and to identify 'feasible' and 'reasonable' work practices. The guideline recommends standard construction hours where noise from construction activities is audible at residential premises (ie assessment locations):

- Monday to Friday 7.00 am to 6.00 pm;
- Saturday 8.00 am to 1.00 pm; and
- no construction work is to take place on Sundays or public holidays.

The ICNG acknowledges that works outside standard hours may be necessary, however, justification should be provided to the relevant authorities.

The ICNG provides two methodologies to assess construction noise emissions. The first is a quantitative approach, which is suited to major construction projects with typical durations of more than three weeks. This method requires noise emission predictions from construction activities at the nearest assessment locations and assessment against ICNG recommended noise levels.

The second is a qualitative approach, which is a simplified assessment process that relies more on noise management strategies. This method is suited to short-term infrastructure and maintenance projects of less than three weeks.

This assessment has adopted a quantitative approach. The qualitative aspects of the assessment include identification of assessment locations, description of works involved including predicted noise levels and proposed management measures that include a complaint's handling procedure developed as part of a construction environmental management noise and vibration plan.

4.1.1 Construction noise management levels

Table 4.1provides ICNG noise management levels (NML) which apply to residential assessment locations.

Table 4.1 ICNG construction noise management levels at residences

Time of day	Management level $L_{Aeq(15\text{-}min)}$	Application
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm, Saturday 8.00 am to 1.00 pm, No work on Sundays or public holidays	Noise-affected RBL + 10 dB	The noise-affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{eq(15\text{-}min)}$ is greater than the noise-affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Table 4.1 ICNG construction noise management levels at residences

Time of day	Management level $L_{Aeq(15\text{-}min)}$	Application
	Highly noise affected 75 dBA	The highly noise-affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: – times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences); and – if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise-affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise-affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see Section 7.2.2 of the ICNG.

Source: ICNG (EPA, 2009).

Table 4.2 summarises the ICNG recommendations and provides NML for other land uses.

Table 4.2 ICNG noise levels at other land uses

Land use	Management level, $L_{Aeq,15\ minute}$
Industrial premises	External noise level 75 dB (when in use)
Offices, retail outlets	External noise level 70 dB (when in use)
Classrooms at schools and other educational institutions	Internal noise level 45 dB (when in use)
Hospital wards and operating theatres	Internal noise level 45 dB (when in use)
Places of worship	Internal noise level 45 dB (when in use)
Active recreation areas	External noise level 65 dB (when in use)
Passive recreation areas	External noise level 60 dB (when in use)

Source: ICNG (DECC, 2009).

The Main Works project construction NMLs for recommended standard and out of hour periods are presented in Table 4.3 for all assessment locations. It is noted the sleep disturbance criteria in Section 4.4 will also be applied to residential assessment locations for any construction activity during the night-time period.

Table 4.3 Construction noise management levels – all assessment locations

Assessment location	Period	Adopted RBL[1]	NML $L_{Aeq,15min}$, dB
All residential assessment locations	Day (standard ICNG hours)	35	45
	Day (out of hours)	35	40
	Evening (out of hours)	30	35
	Night (out of hours)	30	35
Commercial property ^	Day	n/a	50
	Out of hours	n/a	45
Industrial premises	When in use	n/a	75
Offices, retail outlets	When in use	n/a	70
Classrooms at schools and other educational institutions	When in use	n/a	45 (internal) 55 (external)[3]
Hospital wards and operating theatres	When in use	n/a	45 (internal) 55 (external)[3]
Places of worship	When in use	n/a	45 (internal) 55 (external)[3]
Active recreation areas	When in use	n/a	65
Passive recreation areas	When in use	n/a	60

1. The RBLs adopted from Table 3.2
2. ^ Commercial property operated by NPWS and assessed in accordance with AS/NZS 2107:2016, eg 35dBA internal (night-time), becomes 45dBA external accounting for windows open for ventilation.
3. External criteria equivalent to internal criteria plus 10dB.

It is acknowledged that accommodation is provided in the area comprising Yarrangobilly Village at location A9 depicted in Figure 3.1. These properties are owned by the Commonwealth Government (ie NPWS) and for the purposes of assessing noise, operate as a commercial entity, including the accommodation facility. Under the definitions of the Interim Construction Noise Guideline (ICNG) commercial assessment locations include temporary accommodation (such as caravan parks and camping grounds) and leads to a target external NML of 70 dBA. For comparison purposes the ICNG recommends a target external NML of 60 dBA for passive recreation. A more conservative approach would be to assess this location as a hotel type receiver having internal noise targets as per the appropriate AS2107 category. This leads to an internal target noise level of 35 dBA and equivalent external noise level of 45 dBA. This approach was documented in the Response to Submissions for Exploratory Works and has been adopted for Main Works assessment.

4.2 Sleep disturbance

For assessment of potential sleep disturbance the ICNG refers to the requirements of the Environmental Criteria for Road Traffic Noise (ECRTN) EPA 1999. The ECRTN referenced a criteria of $L_{A1,1min}$ noise level not to exceed the background L_{A90} level by more than 15dB. The ECRTN was superseded by NSW Road Noise Policy (RNP) EPA 2011 and similarly refers to a range of studies on sleep disturbance and a $L_{A1,1min}$ or L_{Amax} level not more than 15dB above the background L_{A90} level.

The NPfI was released in October 2017 and represents current EPA policy and best practice on assessing potential for sleep disturbance for residences.

The NPfI suggests that a detailed maximum noise level event assessment should be undertaken where construction night-time noise levels at a residential location exceed:

- $L_{Aeq,15\ minute}$ 40 dB or the prevailing RBL plus 5 dB (whichever is the greater); and/or

- L_{Amax} 52 dB or the prevailing RBL plus 15 dB (whichever is the greater).

Guidance regarding potential for sleep disturbance is also provided in the RNP. The RNP calls upon a number of studies that have been conducted into the effect of maximum noise levels on sleep. The RNP acknowledges that, at the current level of understanding, it is not possible to establish absolute noise level criteria that would correlate to an acceptable level of sleep disturbance. However, the RNP provides the following conclusions from the research on sleep disturbance:

- maximum internal noise levels (L_{Amax}) below 50 to 55 dB are unlikely to awaken people from sleep; and
- one or two noise events per night, with maximum internal noise levels (L_{Amax}) of 65 to 70 dB, are not likely to affect health and wellbeing significantly.

It is commonly accepted by acoustic practitioners and regulatory bodies that a facade including a partially open window will reduce external noise levels by 10 dB. Therefore, external noise levels in the order of 60 to 65 dB calculated at the facade of a residence is unlikely to awaken people according to the RNP.

If noise levels over the screening criteria are identified, then additional analysis would consider factors such as:

- how often the events would occur;
- the time the events would occur;
- whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods); and
- current scientific literature available regarding the impact of maximum noise level events at night.

Table 4.4 provides the noise level event screening criteria for the permanent residential assessment locations.

Table 4.4 Sleep disturbance screening criteria at residences[1]

Assessment location	Adopted Night RBL, dB	Night-time maximum noise level event screening criteria, dB	
		$L_{Aeq,15\ minute}$	L_{Amax}
All residential assessment locations	30	40	52

Notes: 1. Does not apply to project related accommodation, commercial or passive recreation

4.3 Road traffic noise

Construction traffic requires assessment for potential noise impact. The principle guidance to assess the impact of the road traffic noise on assessment locations is in the NSW RNP.

4.3.1 Road traffic noise criteria

The road traffic noise assessment criteria for residential land uses (ie assessment locations) for traffic associated with Main Works is presented in Table 4.5, reproduced from Table 3 of the RNP for relevant road categories.

Table 4.5 Road traffic noise assessment criteria for residential land uses

Road Category	Type of project/development	Assessment criteria – dBA	
		Day (7:00 am to 10:00 pm)	Night (10:00 pm to 7:00 am)
Freeway/arterial/sub-arterial roads	Existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments.	$L_{eq,15hr}$ 60 (external)	$L_{eq,9hr}$ 55 (external)
Local Roads	Existing residences affected by additional traffic on existing local roads generated by land use developments.	$L_{eq,1hr}$ 55 (external)	$L_{eq,1hr}$ 50 (external)

Additionally, the RNP states that where existing road traffic noise criteria are already exceeded, any additional increase in total traffic noise level should be limited to +2 dB.

In addition to meeting the assessment criteria (Table 4.5), any significant increase in total traffic noise at the relevant residential assessment locations must be considered. Residential assessment locations experiencing increases in total traffic noise levels above those presented in Table 4.6 should be considered for mitigation.

Table 4.6 Road traffic relative increase criteria for residential land uses

Road Category	Type of project/development	Total traffic noise level increase – dBA	
		Day (7:00 am to 10:00 pm)	Night (10:00 pm to 7:00 am)
Freeway/arterial/sub-arterial roads and transit ways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road.	Existing traffic $L_{eq(15\text{-}hr)}$+12 dB (external)	Existing traffic $L_{eq(9\text{-}hr)}$+ 12 dB (external)

Road traffic noise criteria for other land uses relevant to the project are provided in Table 4.7. These criteria apply to all road categories.

Table 4.7 Road traffic noise assessment criteria for non-residential land uses

Existing sensitive land use	Assessment criteria – dBA		Additional considerations
	Day (7:00 am to 10:00 pm)	Night (10:00 pm to 7:00 am)	
Open space (active use)	$L_{eq,15hr}$ 60 (external) when in use	n/a	Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion.
Open space (passive use)	$L_{eq,15hr}$ 55 (external) when in use	n/a	Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. playing chess, reading. In determining whether areas are used for active or passive recreation, the type of activity that occurs in that area and its sensitivity to noise intrusion should be established. For areas where there may be a mix of passive and active recreation, e.g. school playgrounds, the more stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses.

4.4 Construction vibration

4.4.1 Human perception of vibration

Humans can detect vibration levels which are well below those causing any risk of damage to a building or its contents.

The actual perception of motion or vibration may not in itself be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2 1975. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in Table 4.8.

Table 4.8 Peak vibration levels and human perception of motion

Approximate vibration level	Degree of perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hz to 80 Hz.

Table 4.8 suggests that people will just be able to feel floor vibration at levels of approximately 0.15 mm/s and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

i Assessing vibration - a technical guideline

Environmental Noise Management – Assessing Vibration: a technical guideline (DEC 2006) (the guideline) is based on BS 6472 – 2008, Evaluation of human exposure to vibration in buildings (1-80Hz).

The guideline presents preferred and maximum vibration values for the use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration values below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are still beyond the maximum value, it is recommended that the operator negotiate directly with the affected community.

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in Table 4.9.

Table 4.9 Examples of types of vibration

Continuous Vibration	Impulsive Vibration	Intermittent Vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZEC (1990).	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer these would be assessed against impulsive vibration criteria.

Impulsive and intermittent vibration is most relevant to the project as discussed herein. Continuous vibration associated with operation of tunnel boring machine (TBM) would not be detectable at assessment locations given tunnel alignment, tunnel depth and distance separating assessment locations from tunnelling works. Furthermore, the level of vibration generated by TBMs is significantly lower than that generated by large vibratory roller considered in the assessment.

Intermittent vibration (as defined in Section 2.1 of the guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time.

Intermittent vibration is representative of heavy vehicle pass-bys and construction activities such as impact hammering, rolling or general excavation work.

Section 2.4 of the guideline provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted rms (root mean square) acceleration levels over the frequency range 1 Hz to 80 Hz. To calculate VDV the following formula is used (refer to Section 2.4.1 of the guideline):

$$VDV = \left[\int_0^T a^4(t)dt\right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, *a (t)* is the frequency-weighted rms of acceleration in m/s^2 and *T* is the total period of the day (in seconds) during which vibration may occur.

The acceptable VDV for intermittent vibration are reproduced in Table 4.10.

Table 4.10 Acceptable vibration dose values for intermittent vibration

Location	Daytime		Night-time	
	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$
Critical Areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes: 1. Daytime is 7 am to 10 pm and night-time is 10 pm to 7 am.
2. These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. The guideline recommends that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

Impulsive vibration as defined in Table 4.9 can be caused by blasting which is discussed further in Section 4.5 and otherwise not applicable to the other construction activities associated with the project.

4.4.2 Structural vibration

i Australian Standard AS 2187.2 - 2006

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187.2 - 2006 "*Explosives - Storage and Use - Use of Explosives*" recommends that the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *"Evaluation and measurement for vibration in buildings Part 2*" be used as they are "applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to manage minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 4.11 and graphically in Figure 4.2.

Table 4.11 Transient vibration guide values - minimal risk of cosmetic damage

Line[1]	Type of Building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s	50 mm/s
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Notes: Refers to the "Line" in Figure 4.1

The standard notes that the guide values in Table 4.11 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 4.11 may need to be reduced by up to 50%.

Some construction or tunnelling activities (for example) are considered to have the potential to cause dynamic loading in some structures and therefore transient values in Table 4.11 have been reduced by 50% for assessment purposes, with a vibration screening criteria set at 7.5 mm/s.

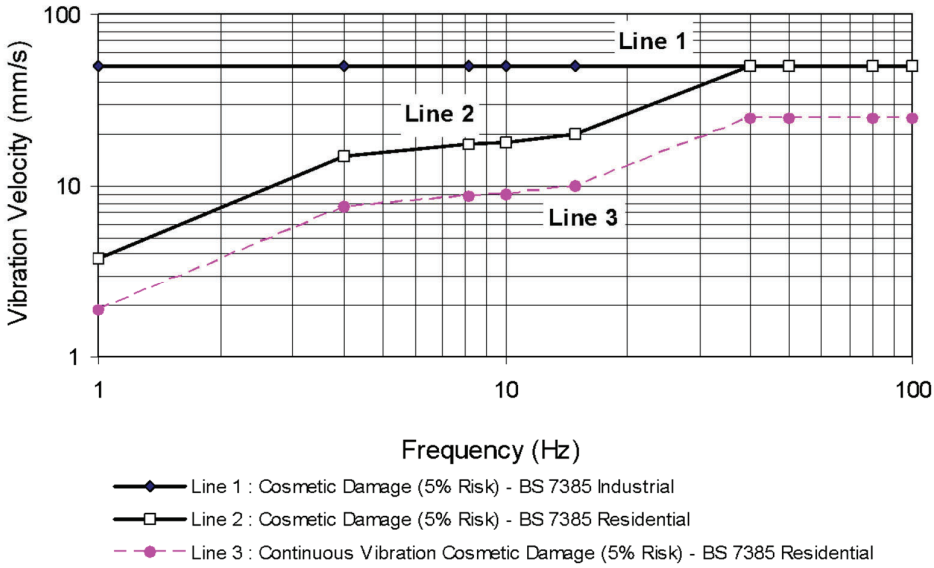


Figure 4.1 Graph of transient vibration guide values for cosmetic damage

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz (as shown in Figure 4.1).

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 4.11 should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measurements should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in Table 4.11.

It is noteworthy that in addition to the guide values nominated in Table 4.11, the standard states that:

Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK.

ii German Standard DIN 4150-3:2016

The German Standard DIN 4150 - Part 3: 2016, provides the strictest guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, or maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 4.12 and shown graphically in Figure 4.2.

For residential and commercial type structures, the standard recommends safe limits as low as 5mm/s and 20mm/s respectively. These limits increase with frequency values above 10Hz. The operational frequency of construction plant typically ranges between 10Hz to 30Hz, and hence according to DIN4150, the safe vibration guide limit range for dwellings is 5 to 15 mm/s. For reinforced commercial type buildings, the limit is as low as 20mm/s, while for heritage or sensitive structures the lower limit is 3 mm/s.

Table 4.12 Structural damage guideline values of vibration velocity – DIN4150

Line*	Type of Structure	Vibration Velocity in mm/s			
		At Foundation at a Frequency of			Plane of Floor of Uppermost Storey
		1Hz to 10Hz	10Hz to 50 Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	5 to 20	15
3	Structures that because of their particular sensitivity to vibration do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Notes: 1. "Line*" refers to curves in Figure 1 of DIN4150.
2. For frequencies above 100Hz the higher values in the 50Hz to 100Hz column should be used.

These levels are "safe limits", for which damage due to vibration effects is unlikely to occur. "Damage" is defined in DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

Should such damage be observed without vibration levels exceeding the "safe limits" then it is likely to be attributable to other causes. DIN 4150 also states that when vibration levels higher than the "safe limits" are present, it does not necessarily follow that damage will occur.

As indicated by the guide levels from DIN 4150 in Table 4.12, high frequency vibration has less potential to cause damage than lower frequencies. Furthermore, the "point source" nature of vibration from plant causes the vibratory disturbances to arrive at different parts of nearby large structures in an out-of-phase manner, thereby reducing its potential to excite in-phase motion of the low order modes of vibration in such structures.

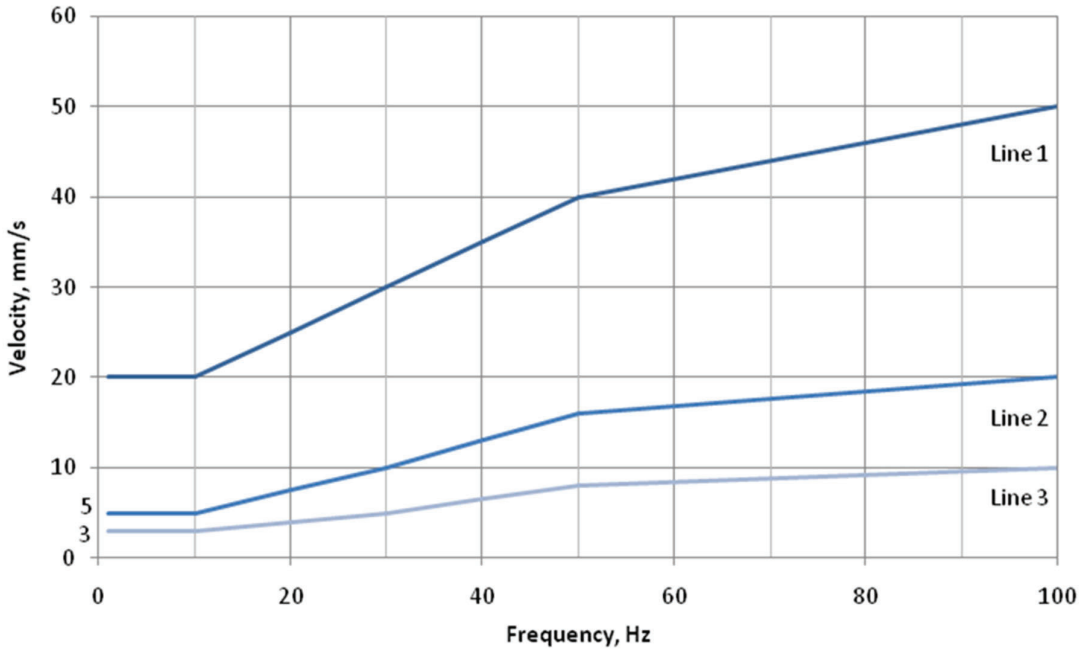


Figure 4.2 DIN4150 structural damage guideline values of vibration velocity

Vibration sensitive items relevant to the project are shown in Figure 3.2.

The potential effect of vibration on particular structures can vary depending on many factors including their existing structural integrity and use. Criteria in the order of 20–100mm/s are typically applied by regulatory authorities to other infrastructure items including tunnels, rock structures and transmission lines.

DIN 4150-3:2016 Vibrations in Buildings Part 3: Effects on Structures (Section 5.2) provides guideline values for evaluating the effect of short-term vibration on structural components and underground structures. Based on the guideline values, the recommended short-term vibration assessment criteria to ensure minimal risk of damage are presented in Table 4.13.

Table 4.13 Guideline Values for Vibration - Effects of Short-Term Vibration on Buried Structures

Structure Type	Short-Term Vibration PCPV[1] Criteria
Steel, welded	100mm/s
Vitrified clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80mm/s
Masonry, plastic	50mm/s

Notes: 1. Vibration Peak Component Particle Velocity - PCPV (mm/s).

4.4.3 Assessment criteria

Assessment of potential for structural damage associated with construction activities of residential buildings, heritage structures, infrastructure items, rock structure and transmission lines has adopted the criteria established in German Standard DIN 4150 - Part 3: 2016.

4.5 Construction blasting

The limits adopted by the EPA for blasting are provided in the Australian and New Zealand Environment Council (ANZEC) guidelines *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration* (ANZEC 1990). The criteria apply to residences only with the aim to minimise annoyance and discomfort.

The blasting limits address two main effects of blasting:

- air blast noise overpressure; and
- ground vibration.

4.5.1 Air blast

The recommended maximum vibration level for air blast is 115 dB linear peak. The vibration level of 115 dB may be exceeded on up to 5% of the total number of blasts over 12 months. However, the level should not exceed 120 dB linear peak at any time.

4.5.2 Ground vibration

Peak particle velocity (PPV) from ground vibration should not exceed 5 mm/s for more than 5% of the total number of blasts over 12 months. However, the maximum level should not exceed 10 mm/s at any time. A summary of blast limits is provided in Table 4.14.

Table 4.14 Air blast overpressure and ground vibration limits

Blasting	Criteria	Allowable exceedance
Air blast overpressure	115 dB($L_{Lin,peak}$)	5% of the total number of blasts over 12 months
	120 dB($L_{Lin,peak}$)	0%
Ground vibration	5 mm/s (PPV)	5% of the total number of blasts over 12 months
	10 mm/s (PPV)	0%

To assess the potential impact of damage to buildings and other structures from blasting vibration the criteria outlined in Section 4.4.3 would be utilised.

4.5.3 Times and frequency of blasting

ANZEC recommends blasting should generally only be permitted 9am to 5pm Monday to Saturday and should be generally controlled to one blast per day. Blasting should not take place on Sundays or Public Holidays.

Notwithstanding the above, the restrictions and times and frequency of blasting do not apply to premises where the effects of blasting are not perceived at noise sensitive sites.

4.6 Operational noise

Following the construction and commissioning of Snowy 2.0 Main Works there is the potential for noise emissions from plant and equipment (transformers, pumps, HVAC, etc.) associated with the operation of the facilities.

Noise from industrial operations or processes (eg onsite truck movements or material processing, etc.) in NSW is regulated by the local council, DPIE and/or the EPA, and generally have a licence and/or development consent conditions stipulating noise limits. These limits are typically derived from project specific trigger or operational noise levels predicted at assessment locations. They are based on EPA guidelines (ie NPfI or previous Industrial Noise Policy) or noise levels that can be achieved by a specific site following the application of all reasonable and feasible noise mitigation.

The objectives of noise trigger levels for industry established in accordance with the NSW Noise Policy for Industry (NPfI) are to protect the community from excessive intrusive noise and preserve amenity for specific land uses. It should be noted that the audibility of a noise source does not necessarily equate to disturbance at an assessment location.

To ensure these objectives are met, the EPA provides project specific noise trigger levels, namely intrusiveness and amenity.

4.6.1 Intrusiveness noise levels

The intrusiveness noise levels require that $L_{Aeq,15min}$ noise levels from the site during the relevant operational periods do not exceed the RBL by more than 5 dB. It is noted that intrusiveness noise levels are only applicable at residential assessment locations.

Table 4.15 presents the intrusiveness noise levels determined based on the adopted RBLs.

Table 4.15 Project intrusiveness noise levels

Assessment location[1]	Assessment period[2]	Adopted RBL, dBA	Project intrusiveness noise level (RBL + 5 dB), $L_{Aeq,15min}$, dBA
All residential receivers	Day	35	40
	Evening	30	35
	Night	30	35

1. Residential assessment locations only.
2. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Morning shoulder: 6 am to 7 am Monday to Saturday, 6 am to 8 am Sundays and public holidays; Night: remaining periods.

4.6.2 Project amenity noise levels

The assessment of amenity is based on noise levels specific to the land use. The noise levels relate only to industrial noise and exclude road or rail traffic noise. Where the measured existing industrial noise approaches recommended amenity noise levels, it needs to be demonstrated that noise levels from new industry will not contribute to existing industrial noise such that amenity noise levels are exceeded.

To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, the project amenity noise level for a new industrial development is the recommended amenity noise level (outlined in Table 2.2 of the NPfI) minus 5 dB. It is noted that this approach is based on a receiver being impacted by three or four individual industrial sites (or noise sources). This approach has not been adopted for operational noise from Snowy 2.0 as there are no existing or future noise sources with the potential to result in cumulative noise.

There are no residential assessment locations in the vicinity of sites likely to generate noise from the operation of Snowy 2.0, notwithstanding the criteria for residential assessment locations has been incorporated for completeness. Receptors potentially exposed to operational noise are associated with passive recreational use within KNP. The project amenity noise level for the passive recreational areas and residential assessment locations is presented in Table 4.16.

Table 4.16 Project amenity noise levels

Assessment location	Indicative area	Time period[1]	Project amenity noise level dB, $L_{Aeq,period}$
Passive recreation area	All	When in use	50
Residential	Rural	Day	50
		Evening	45
		Night	40

Source: NPfI (EPA 2017).

Notes: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Night: 10 pm to 7 am Monday to Saturday; 10 pm to 8 am Sundays and public holidays.

4.6.3 Project noise trigger level

The project noise trigger level (PNTL) is the lower of the calculated intrusiveness or amenity noise levels. Considering that the only assessment locations potentially affected by noise from the operation of Snowy 2.0 is passive recreation within KNP, the PNTL is 50 dBA $L_{Aeq,period}$ or 53 dBA $L_{Aeq,15minute}$ by adopting the NPfI default correction between 'period' to 15-minute.

A summary of the project noise trigger levels (PNTL) for assessment of operational noise from Snowy 2.0 is presented in Table 4.17.

Table 4.17 Project noise trigger levels

Assessment location	Assessment period[1]	Intrusiveness noise level, $L_{Aeq,15min}$, dB	Amenity noise level[2], $L_{Aeq,15min}$, dB	PNTL[3], $L_{Aeq,15min}$, dB
Residential	Day	40	53	40
	Evening	35	48	35
	Night	35	43	35
Dedicated camping areas, huts and passive recreation areas	When in use	-	53	53

Notes: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Morning shoulder: 6 am to 7 am Monday to Saturday, 6 am to 8 am Sundays and public holidays; Night: remaining periods.

2. Project amenity $L_{Aeq,15min}$ noise level is the recommended amenity noise level $L_{Aeq,period}$ +3 dB as per the NPfI.

3. PNTL is the lower of the calculated intrusiveness or amenity noise levels.

In assessing amenity noise levels at passive recreational areas, the noise level is to be assessed at the most-affected point within the area that is reasonably expected to be used by people, for example, picnic areas or walking tracks.

5 Assessment methods

5.1 Construction noise

This section presents the methods and base parameters used to model construction noise and vibration emissions from proposed Main Works.

Construction noise levels from Main Works were predicted using a computer-generated model using Brüel & Kjær Predictor software (the model). The model calculates total noise levels at assessment locations from concurrent operation of multiple noise sources. It considers factors that influence noise propagation such as the lateral and vertical location of plant, source-to-receptor distances, ground effects, atmospheric absorption, topography of the site and surrounding area and applicable meteorological conditions.

The model was populated with 3-D topography of the project area and surrounding area, extending out to nearest assessment locations. Construction plant and equipment representing the range of proposed construction scenarios was placed at locations which would represent worst case noise levels throughout the early works construction program.

Generally, the following construction activities were modelled and assessed:

- Phase 1 - site establishment and bulk excavation / earth works;
- Phase 2 - construction activities typical for approximately six years;
- Phase 3 - rehabilitation works;
- road establishment and upgrades providing access to the proposed construction areas;
- spoil haulage on Middle Bay Road and Marica Trail;
- construction related traffic; and
- supporting power and communication.

The method for assessing blast noise (airblast overpressure) and vibration from construction is provided in Section 5.2.2

5.1.1 Construction times

Initial site establishment works and bulk earthworks to setup construction camps and portals would typically be constructed during daylight hours.

The main construction activities and blasting are proposed 24 hours, 7 days per week and include:

- tunnel excavation and haulage of rock material between the tunnel portals and rock emplacement areas at Middle Bay and Tantangara;
- blasting during initial intake, portal establishment and early phases of tunnelling;
- concrete batching plants at the tunnel compounds;
- mobile plant at the various construction camps;

- fixed plant at accommodation camps – Lobs Hole, Marica and Tantangara; and
- generator, wastewater treatment plant, ventilation and other support ancillary infrastructure operation.

Rehabilitation of construction camps and accommodation camps will be contained within daylight hours which will typically be 6am to 6pm.

5.1.2 Construction locations

The key construction camps and construction locations (Figure 1.2) considered in the noise assessment are as follows:

- ECVT portal and cable yard;
- Lobs Hole main camp;
- Lobs Hole Ravine Road;
- Main yard;
- Marica camp, vent shaft and surge shaft;
- Marica Trail and Snowy Mountains Highway;
- MAT portal;
- Talbingo intake and spillway;
- Talbingo spoil disposal (east and west) including Middle Bay Road;
- Tantangara camp, intake and portal;
- Tantangara spoil disposal; and
- Rock Forest logistics camp.

5.1.3 Equipment sound power levels

i Continuous

Equipment sound power levels have been taken from the Department of Environment, Food and Rural Affairs (DEFRA) 2005, *Update of Noise Database for Prediction of Noise on Construction and Open Sites*, where available. Otherwise data was sourced from an EMM database of similar equipment which is based on measurements at other construction sites as indicated. A detailed summary of the plant and equipment supplied by the construction contractor FGJV for each construction camp and phase of construction is provided in Annexure B. Acoustically significant fixed and mobile equipment items were considered in the model for each construction camp/area and adopted typical worst-case scenarios and utilisation. A summary of the cumulative sound power level (Lw) for each component is presented in Table 5.1 acknowledging that multiple activities may occur simultaneously.

Table 5.1 Construction phase and equipment sound power levels

Construction camp / area	Sound power level, dB, $L_{Aeq,15min}$		
	Phase 1 Site establishment and bulk earthworks	Phase 2 Main construction works	Phase 3 Rehabilitation
ECVT portal and cable yard	119	125	115
Main camp	118	115	118
Lobs Hole Ravine Road	126	123	124
Main yard	123	125	121
Marica camp and vent shaft	118	115	118
Marica surge shaft	122	126	121
Marica Trail and Snowy Mountains Highway	110	110	110
MAT portal	119	126	116
Talbingo spoil disposal (east and west) including Middle Bay Road	119	119	119
Talbingo intake	122	126	122
Talbingo portal	119	125	116
Tantangara camp	118	112	118
Tantangara intake	123	124	115
Tantangara portal	122	127	121
Tantangara spoil disposal	118	119	119
Rock Forest logistics camp	118	107	117

Notes: 1. Refer to Annexure B for full list of plan and equipment and sound power levels (Lw)

ii Night-time maximum noise level events and sleep disturbance

Construction activities will occur between the ICNG night-time hours of 10 pm to 7 am. Therefore, intermittent noises, such as loading/unloading of materials, equipment start-up alarms or other similar construction activity have been assessed against the sleep disturbance criteria at residential assessment locations.

Maximum (L_{max}) equipment sound power levels adopted to assess sleep disturbance from each activity are presented in Table 5.2. Equipment sound power levels have been taken from an EMM database of similar equipment which is based on measurements at other construction sites and consistent with Exploratory Works.

Table 5.2 Maximum noise from intermittent sources

Activity	Equipment item most likely to generate maximum noise level	Adopted sound power level, dB L_{Amax}
Transport of equipment and material	Heavy vehicle (deliveries)	113
Site clearing/stripping	Rock breaker (medium)	120
Site establishment	Watercart pass by	114
Camp/Office Construction	Watercart pass by	114
Bridge construction	Bored piling rig	117
Bulk Earthworks	Excavator (20t)	116
Pavements	Bitumen/asphalt laying truck	120
Wharf construction	Piling rig	117
Tunnel works (Drill & Blast)	Drill (Jumbo 3 Boom)	119
Pipeline works	Excavator (20t)	116
Transportation of excavated material	Excavator (20t)	116

5.1.4 Scenarios

i Single point predictions – worst case "snap-shot" in time

Periods of potential worst-case construction noise levels were identified by reviewing the proposed construction schedule with activities listed in Table 5.1. The assessment has considered the identified plant and equipment operating simultaneously within the defined construction camp / areas in order to predict the overall $L_{Aeq,15min}$ noise contributions. Construction noise levels were predicted to the assessment locations listed in Table 3.1 identified in Figure 3.1.

Site preparation / bulk excavation and rehabilitation works would typically be conducted during daytime hours, however the main construction work activities are proposed 24/7 and has the potential to result in the greatest noise impacts.

Due to the complex nature of the project, extensive work force and staging at each construction camp / area the assessment has adopted an outer envelope approach, with all plant operating for each area simultaneously in order to identify the zone of affectation from construction works. This approach is conservative and unlikely to occur in practice. A review of Table 5.1 confirmed Phase 2 main construction works typically resulted in the highest cumulative sound power level from each camp/area with the exception of Rock Forest, accordingly the assessment has adopted these source noise levels on the assumption that it represents the worst-case. Noise contributions from site / establishment and rehabilitation activities would typically be lower and of a shorter duration.

ii Noise contours – worst case construction noise footprint

Further to the above approach and acknowledging the extent of the project area, there is potential for other noise sensitive assessment locations to be identified as further investigations continue and works proceed. To account for this and to identify the risk of potential construction noise impacts, noise contours have been generated for a worst-case construction scenario. The modelling has adopted construction sites at peak activities and simultaneous road upgrades to determine an outer envelope of potential construction noise footprint.

The difference between the two prediction methods is that the single point predictions represent a possible worst-case point in time. The contours represent the outer envelope from all activity across the entire construction period.

5.1.5 Noise enhancing meteorology

A summary of calm and noise enhancing weather conditions for which noise predictions have been provided are shown in Table 5.3.

A conservative approach has been adopted, whereby worst-case noise enhancing meteorological conditions have been adopted for all time periods.

Table 5.3 Meteorology adopted in the model

Assessment condition	Period	Temperature	Wind speed (m/s)	Relative humidity	Stability class
Calm	Day	10°C	n/a	70%	n/a
	Evening/Night	0°C	n/a	90%	n/a
Noise enhancing winds	Day	10°C	3 m/s in all directions	70%	n/a
	Evening/Night	0°C	3 m/s in all directions	90%	n/a
'F' class temperature inversion	Night	0°C	0 or 2 m/s in all directions	90%	F

5.2 Construction vibration

5.2.1 Mobile plant and equipment

Safe working distances for typical items of vibration intensive plant are listed in Table 5.4. The safe working distances are quoted for both "Cosmetic Damage" (refer British Standard BS 7385) and "Human Comfort" (refer British Standard BS 6472-1).

Table 5.4 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (BS 6472)
Tunnel Boring Machine[1]	6-8m diameter	2-5 m	7m
Small hydraulic hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium hydraulic hammer	(900 kg - 12 to 18t excavator)	7 m	23 m
Large hydraulic hammer	(1600 kg - 18 to 34t excavator)	22 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand-held	1 m (nominal)	Avoid contact with structure
Vibratory Rollers	<50kN (Typically 1-2 tonnes)	5 m	15 to 20 m
	<100kN (Typically 2-4 tonnes)	6 m	20 m
	<200kN (Typically 4-6 tonnes)	12 m	40 m

Table 5.4 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (BS 6472)
	<300kN (Typically 7-13 tonnes)	15 m	100 m
	>300kN (Typically 13-18 tonnes)	20 m	100 m
	>300kN (>18 tonnes)	25 m	100 m

Source: From Transport Infrastructure Development Corporation Construction's Construction Noise Strategy (Rail Projects), November 2007 – based on residential building.

Safe work distances relate to continuous vibration. For most construction activity, vibration emissions are intermittent in nature. The safe working distances are therefore conservative.

TBM level adopted based on road header data as reported in SLR Environment Effect Statement –North East Link Project. North East Link. Surface noise and vibration impact assessment – 640.11671-R01-FINAL

The safe working distances presented in Table 5.4 are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

The safe working distances have been used to assess the potential for contraction vibration impacts based on proposed construction activities.

5.2.2 Blasting

A review of the Tender Design Report prepared by FGJV C3.1 – 1.1 (Report Ref: SG-MG02J-REP-0001) confirmed drill and blast (D&B) construction method will be required in a number of locations within the project, in conjunction with utilisation of tunnel boring machines (TBMs). Locations identified were:

- intake and portal construction at Talbingo and Tantangara;
- ECVT portal;
- powerhouse cavern including collector tunnels, manifolds, penstocks, gallery, surge shaft chamber and draft tubes;
- early phases of tunnel construction before commencement with TBMs including:
  - 800 m between the Talbingo intake and adit;
  - 1,000 m between the Tantangara intake and adit;
  - 300 m for the MAT portal;
  - removal of final 'plugs' and channel construction at Talbingo and Tantangara; and
  - additional blasting may be required for small sections of road where granite has been identified.

Blasting will occur 24/7 for works carried out underground and in the headrace tunnel surge shaft.

Indicative vibration levels from D&B have been predicted using the guidance given in AS2187-2-2006: Explosives – Storage and Use Part 2: Use of Explosives and formulae provided in Imperial Chemical Industries (ICI) Explosives Blasting Guide (ICI Technical Services 1995). The ICI formula has been shown to be conservative in calculating overpressure and vibration.

The method considers charge mass delay (kg) or maximum instantaneous charge, constants relating to rock properties and distance to calculate ground vibration and over pressure levels.

Removal of rock for intake channel and final plugs at Talbingo and Tantangara reservoirs will be required. Current work method statements propose a mix of methodologies comprising:

- drill and blast (dry) to remove a portion of the rock plugs on the dry side of the excavation area;
- drill and blast (wet) underwater to break down remaining rock and removal by dredging machine or barge mounted excavator; and
- long-arm excavator on barge to remove bigger boulders (acknowledging potential depth limitations), that are late crushed on site before being transported to spoil disposal areas.

5.3 Road traffic noise

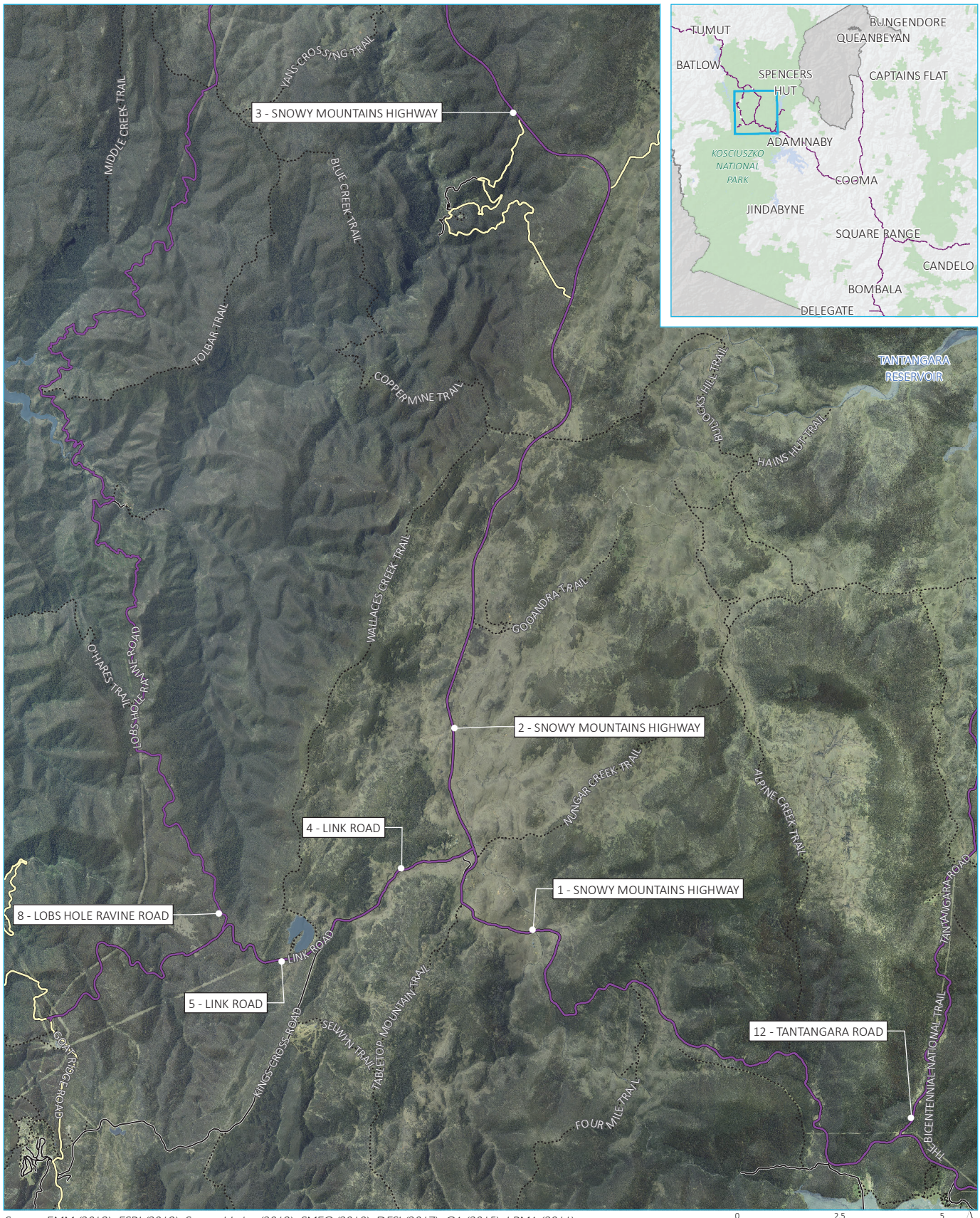
The Calculation of Road Traffic Noise (CoRTN) and the US EPA Federal Highways (FHWA) methods were considered in the assessment of road traffic noise. Where traffic flows were low (<200 vehicles per hour) the assessment of construction traffic adopted the FHWA procedures that is more sensitive to low traffic volumes. Where traffic volumes were greater than 200 vehicles per hour the CoRTN methodology was adopted. A summary of the road sections assessed and methodology adopted is provided in Table 5.5 and identified in Figure 5.1.

Table 5.5 Road segments

ID	Road segment / name	AADT	Assessment methodology
1	Snowy Mountains Highway[1]	596	FHWA
2	Snowy Mountains Highway[2]	515	FHWA
3	Snowy Mountains Highway[3]	455	FHWA
4	Link Road	360	FHWA
5	Link Road	228	FHWA
8	Lobs Hole Ravine Road	21	FHWA
12	Tantangara Road	45	FHWA
Cooma 1	Snowy Mountains Highway (south)	4847	CoRTN / FHWA[4]
Cooma 2	Monaro Highway (north)	6395	CoRTN / FHWA[4]

1. SMH Between Adaminaby and Link Road
2. SMH between Link Road and Long Plain Road
3. SMH between Long Plain Road and Talbingo
4. FHWA adopted to night traffic assessment due to low traffic volumes

Road traffic movements associated with construction of Main Works have been referenced from the Snowy 2.0 Main Works Traffic Impact Assessment (SCT 2019) and adapted to suit RNP assessment requirements (Section 4.3).



Source: EMM (2019); ESRI (2019); Snowy Hydro (2019); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

0 2.5 5 km

GDA 1994 MGA Zone 55

N

KEY

- Assessed road segment
- Main road
- Local road
- Vehicular track
- Waterbody

Road segments
- Snowy Mountains

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 5.1

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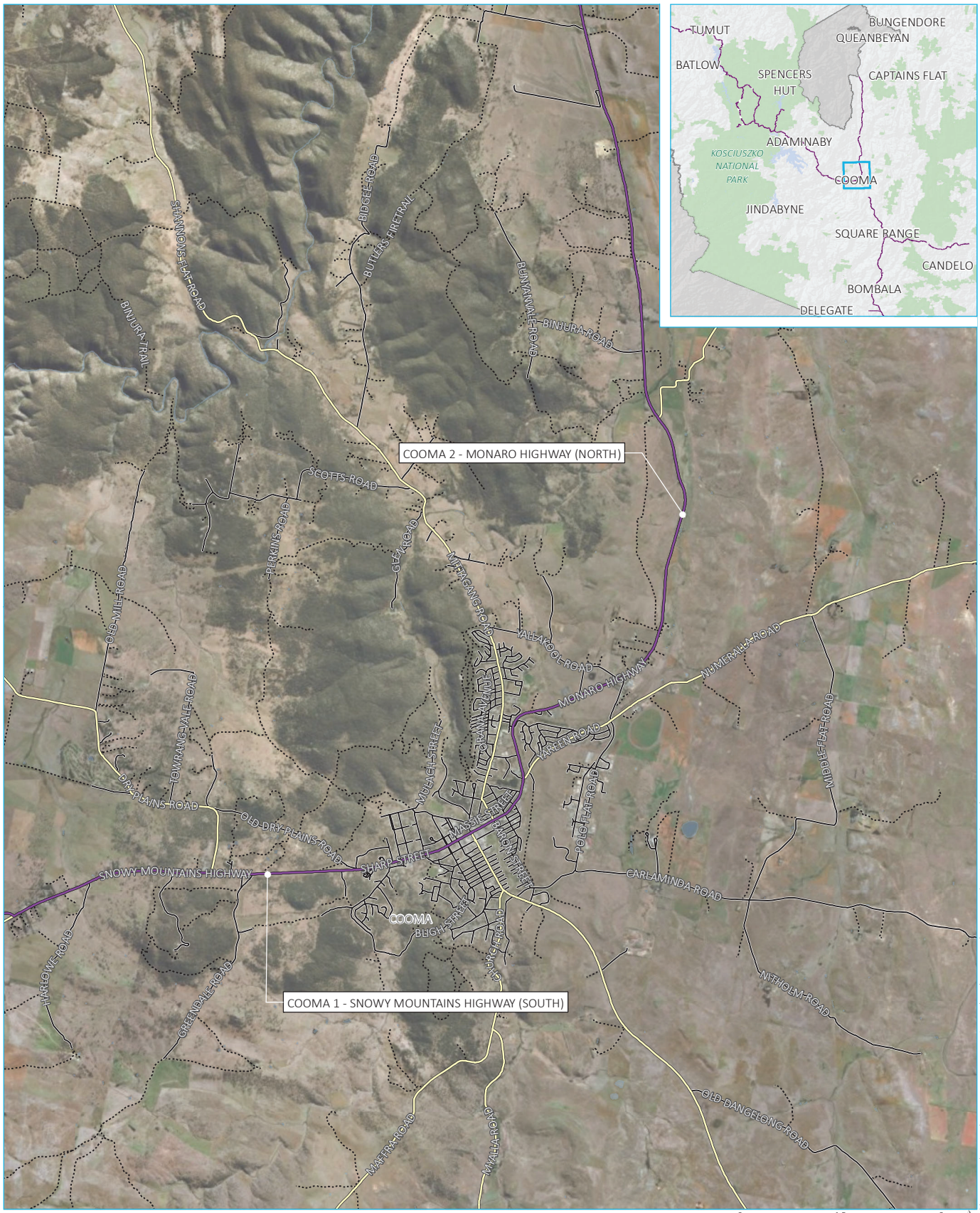


Source: EMM (2019); ESRI (2019); Snowy Hydro (2019); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

KEY

- Assessed road segment
- Main road
- Local road
- Vehicular track
- Waterbody

Road segments - Cooma

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 5.2

snowy 2.0

EMM creating opportunities

5.4 Operational plant and equipment

5.4.1 Design information

Operational plant and equipment design and specifications were not available during the preparation of this NVIA, however preliminary design details were contained and extracted from the Tender Design Report prepared by FGJV C3.1 – 1.1 (Report Ref: SG-MG02J-REP-0001).

Additional information was provided by SHL – Project Engineers on the envisaged requirements for the operational components of Snowy 2.0. Preliminary selections for the various components are presented in Table 5.6.

Table 5.6 Operational plant and equipment

Site	Item	Description	No. of items	Sound power level (Lw) dBA
MAT Portal	diesel generator^	2.25 MVA	3	107
	ventilation*	unknown[1]	2	72
	potable water pump*	small (0.7l/s)	1	75
ECVT portal	exhaust fans*	200kw (300m3/s)	3	110
	dry type transformer*	750kVa	1	73
Cable Yard	diesel generator^	2.25 MVA	3	107
	ventilation GIS building*	unknown	2	72
Talbingo Gate Structure	ventilation*	unknown	2	72
Talbingo Surface Building (adjacent gate)	diesel generator*	100kVA	1	93
	ventilation*	unknown[1]	2	72
Tantangara Gate Structure	ventilation*	unknown[1]	2	72
Tantangara Surface Building (adjacent gate)	diesel generator^	100kVA	1	93
	dry type transformer*	100kVA	1	73
	ventilation*	unknown[1]	2	72
Marica Ventilation Shaft (plant would be located subterranean in power hall)	diesel generator^	750kVA	1	100
	supply fans*	200kw (300m3/s)	3	110
	dry type transformer*	750kVa	1	73

Notes: ^ monthly testing (1 hour) and emergency back-up scenario

* continuous or quasi continuous operation

1. data a typical ventilation exhaust fan (0.71kW, 450mm dia) – light duty

Operational requirements from SHL confirmed buildings accommodating the diesel generators, ventilation fans and other mechanical plant would be designed to comply with an internal noise level of L_{Aeq} 80 dBA. For noise modelling a space averaged internal noise level of 80 dBA was adopted in conjunction with surface areas of envisaged buildings with a nominal dimension of 40 m x 20 m x 4.5 m and constructed with masonry walls and metal roof. The composite transmission loss for the generator buildings adopted in the noise model is presented in and adjusted to account for surface areas of building components.

Table 5.7 Transmission loss – roof and wall transmission loss

Component	Insertion loss (dB)							
	63	125	250	500	1K	2K	4K	Rw + Ctr
Building roof[1]	6	12	16	21	27	30	40	23
Building walls[2]	34	36	32	38	46	51	56	40

1. Metal deck roof min. 0.4mm BMT over Anticon foil faced building blanket (100mm)
2. 190mm hollow concrete blockwork (760kg/m^3)

The main source of operational noise from Snowy 2.0 is associated with the power hall cavern ventilation. Current design incorporates three supply fans within the cavern and three exhaust fans at the MAT portal. Additional booster fans and condensers are proposed within the power hall cavern, however they would ultimately be connected to the atmosphere through the main supply (Marica) and exhaust (MAT) ventilation system.

In the absence of fan specifications, modelling of operational noise from the main ventilation system considered a typical profile for a 200kW fan outlined in Table 5.8.

Table 5.8 Ventilation fan data

Site	Location	Quantity (D+S)[1]	Sound Power Level per fan - in duct (dBA)								
			63	125	250	500	1K	2K	4K	8K	SWL dBA
Marica Vent Shaft	Power hall cavern	3 (2+1)	105	113	110	108	105	100	96	91	110
MAT Portal	In tunnel or external building adjacent	3 (2+1)	105	113	110	108	105	100	96	91	110

Notes: 1. D – Duty S – Standby

In order to satisfy the project noise trigger level (PNTL) for passive recreation under the requirements of the NPfI, noise mitigation is anticipated. In the absence of detailed design of the ventilation system, assessment has adopted the insertion loss for supply and exhaust attenuation outlined in Table 5.9.

Table 5.9 Attenuator data

Site	Location	Insertion loss (dB)							
		63	125	250	500	1K	2K	4K	8K
Marica Vent Shaft	Power hall cavern	19	29	30	36	34	32	28	25
MAT Portal	In tunnel or external building adjacent	19	29	30	36	34	32	28	25

During the detailed design phase both internal noise and environmental noise to KNP would require detailed acoustic review to ensure project noise trigger levels and occupational noise requirements are satisfied.

6 Impact assessment

6.1 Construction noise

6.1.1 Single point predictions

In accordance with procedures outlined in Section 5.1.4 prediction of single point construction noise levels for Phase 2 construction are provided in Table 6.1 for standard and out of hours (OOH) periods. The level presented for each assessment location represents the energy-average noise level over a 15 minute period and assumes all plant operating concurrently. The predicted exceedance of the ICNG noise affected NML at each assessment location is also provided.

The proponent will manage construction noise levels where exceedances of NMLs have been identified. The construction noise management methods will be detailed in a construction noise and vibration management plan (CNVMP) as discussed further in Section 7.

The ICNG recommends the following where NMLs are predicted to be exceeded:

- application of feasible and reasonable work practices to minimise noise;
- inform potentially impacted residents of the nature of the works to be carried out, expected noise levels and duration and relevant contact details; and
- negotiation with the community where noise from work outside standard hours is predicted to exceed the relevant NML by more than 5 dB.

Table 6.1 Predicted construction noise levels – Phase 2

Assessment location	Classification	Period	Noise affected NML, dB	Highly noise affected NML, dB	Predicted construction noise level, dB $L_{Aeq,15min}$			
					Calm		Noise-enhancing	
					Day	Evening/Night	Day	Evening/Night
A1	Passive recreation	When in use	60	n/a	<30	<30	<30	<30
A2	Passive recreation	When in use	60	n/a	<30	<30	<30	<30
R1[1]	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
A3	Passive recreation	When in use	60	n/a	36	36	38	38
A4	Passive recreation	When in use	60	n/a	50	50	53	53
A5	Passive recreation	When in use	60	n/a	33	33	34	34
A6	Passive recreation	When in use	60	n/a	<30	<30	<30	<30
A7	Passive recreation	When in use	60	n/a	<30	<30	<30	<30

Table 6.1 Predicted construction noise levels – Phase 2

Assessment location	Classification	Period	Noise affected NML, dB	Highly noise affected NML, dB	Predicted construction noise level, dB $L_{Aeq,15min}$			
					Calm		Noise-enhancing	
					Day	Evening/Night	Day	Evening/Night
R2	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R3	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
A8	Passive recreation	When in use	60	n/a	<30	<30	<30	<30
R4	Residential	Standard	60	n/a	<30	<30	<30	<30
		OOH						
A9	Commercial^	Standard	50	75	<30	<30	<30	<30
		OOH	45	n/a				
R5	Residential	Standard	40	n/a	<30	<30	<30	<30
		OOH	35	n/a				
R6	Residential	Standard	40	75	**51**	**44**	**54**	**46**
		OOH	35	n/a				
R7	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R8	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R9	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R10	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R11	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R12	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R13	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R14	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R15	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R16	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R17	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				

Table 6.1 Predicted construction noise levels – Phase 2

Assessment location	Classification	Period	Noise affected NML, dB	Highly noise affected NML, dB	Predicted construction noise level, dB $L_{Aeq,15min}$			
					Calm		Noise-enhancing	
					Day	Evening/Night	Day	Evening/Night
R18	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
R19	Residential	Standard	40	75	<30	<30	31	<30
		OOH	35	n/a				
A10	Passive recreation	When in use	60	n/a	<30	<30	<30	<30
A11	Passive recreation	When in use	60	n/a	<30	<30	<30	<30
R20	Passive recreation	When in use	60	n/a	<30	<30	<30	<30
A12	Passive recreation	When in use	60	n/a	<30	<30	<30	<30
A13	Passive recreation	When in use	60	n/a	<30	<30	<30	<30
A14	Passive recreation	When in use	60	n/a	35	31	37	33
R21	Residential	Standard	40	75	<30	<30	<30	<30
		OOH	35	n/a				
A15	Commercial^	Day	50	75	<30	<30	<30	<30
		Eve/Night	45	n/a				
A16	*n/a**	*When in use*	*50 (60)*	*75*	*55*	*55*	*58*	*57*
				n/a				
A17	*n/a**	*When in use*	*50 (60)*	*75*	*57*	*55*	*59*	*58*
				n/a				
A18	*n/a**	*When in use*	*50 (60)*	*75*	*55*	*53*	*57*	*55*
				n/a				

1. Property owned by the proponent however has been conservatively assessed as a residential receiver.
2. ^ Commercial property operated by NPWS and assessed in accordance with AS/NZS 2107:2016, eg 35 dBA internal (night-time), becomes 45 dBA external accounting for windows open for ventilation.
3. ** Not applicable – accommodation camp as part of Snowy 2.0 construction works – 50dBA adopted external for internal level of 40 dBA naturally ventilated (Provision of alternative ventilation and windows closed would increase allowance for external exposure to 60 dBA)*

The main construction activities including spoil haulage will occur 24/7. Therefore, predicted noise levels in Table 6.1 are the same for standard and OOH periods for calm and noise-enhancing weather conditions.

Construction noise levels satisfy NMLs at all assessment locations with exception of R6 6560 Snowy Mountains Highway, Adaminaby where exceedance of 11-14 dB is predicted for the day and OOH periods during calm and adverse weather conditions, respectively. The predicted exceedance at location R6 is generated by site establishment/bulk earthworks, logistics activities and rehabilitation at Rock Forest logistics site.

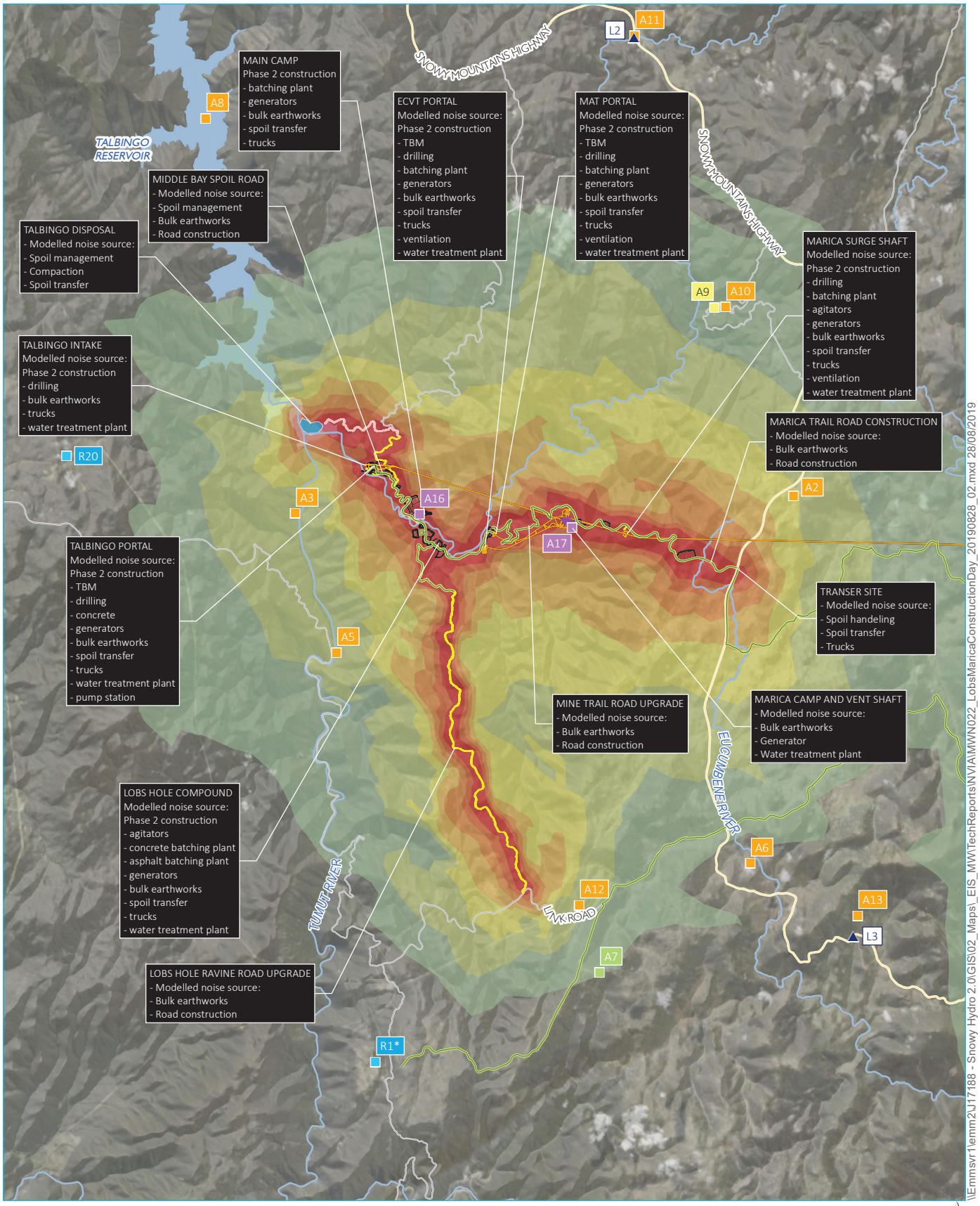
The proponent will notify the owner/occupier of R6 6560 Snowy Mountains Highway, Adaminaby of Rock Forest construction works and the potential noise impacts and discuss options for mitigating impacts. Noise monitoring during the initial stages of construction will be undertaken to determine if actual construction noise levels are above NMLs. If this initial testing identifies exceedances, the proponent will:

- identify feasible and reasonable mitigation measures that reduce construction noise levels as far as practicable to NMLs;
- restrict use of the Rock Forest site to ICNG standard hours only where feasible;
- consider Section 7.2.2 of the ICNG and option of a negotiated agreement with the property owner/s identified to be impacted that may include:
    - at receiver mitigation;
    - relocation;
    - compensation.

The above will be determined depending on the measured level of exceedance and the availability of feasible and reasonable noise mitigation and management measures. This is discussed further in Section 7.

6.1.2 Contours

Predicted $L_{Aeq,15minute}$ noise contours representing the worst-case noise level footprint from the project construction are provided in Figure 6.1, Figure 6.2, Figure 6.3 and Figure 6.4. The figures represent the predicted construction noise levels during worst case meteorological conditions presented in Table 5.3 for day and night periods, respectively. It should be noted that contours are not as precise as single point calculations in Table 6.1. This is because contours are based on noise levels interpolated over a calculated noise prediction grid. The interpolation of contours between grid points can lead to a slightly different result than single point calculations at specific points. The single point assessment locations in Table 6.1 are shown only where they fall within the presented noise contours.



Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); GA (2015); LPMA (2011)

0 2.5 5 km

N

GDA 1994 MGA Zone 55

KEY

Noise monitoring location

Noise assessment location
- Residential
- Commercial^
- Passive recreation
- Active recreation
- Project accommodation

Noise contours - dB $L_{Aeq15min}$
- 35-39
- 40-44
- 45-49
- 50-54
- 55-59
- 60-64
- >65

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
- Indicative rock emplacement area

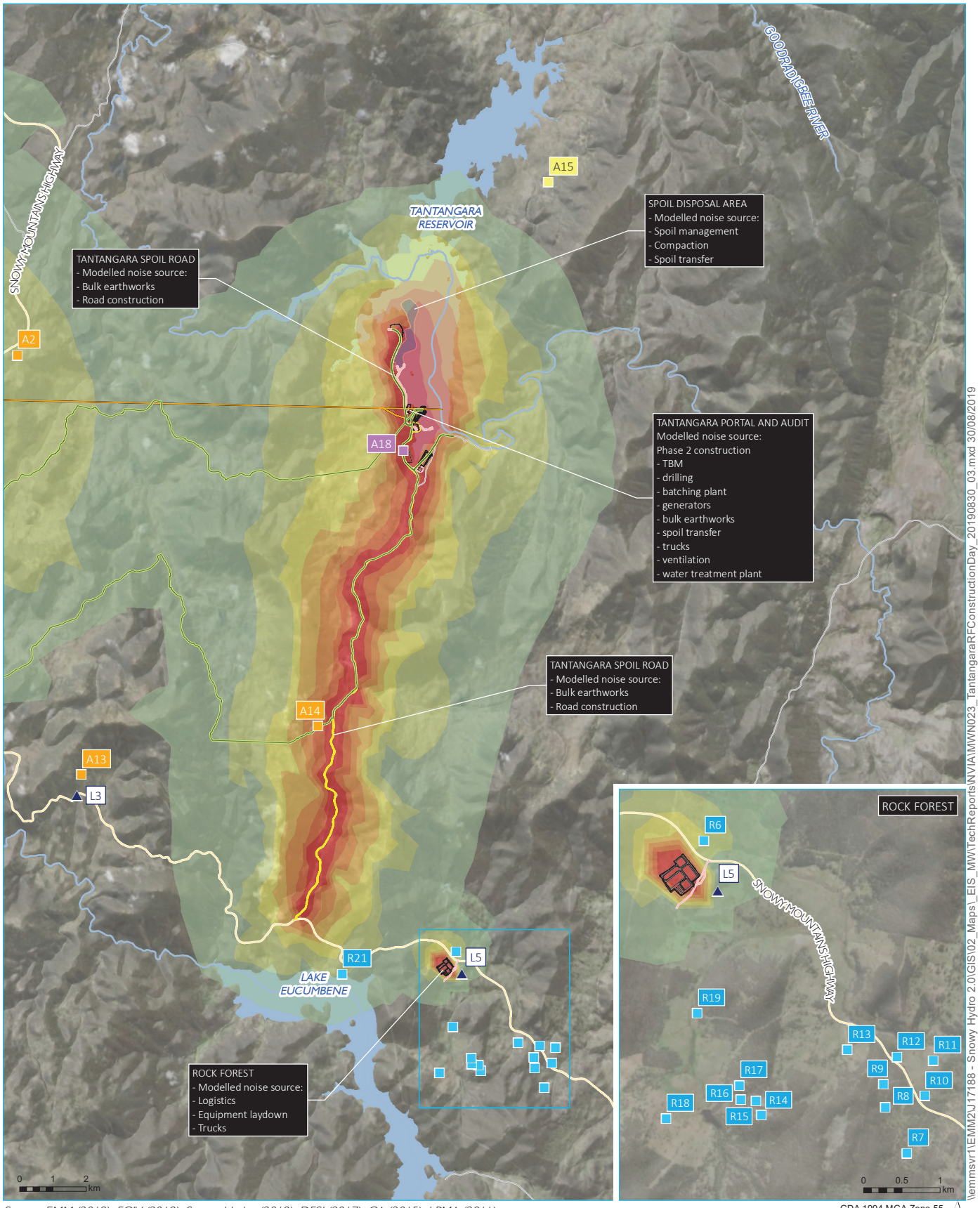
Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies

Outer envelope construction noise contours, day, noise enhancing weather – Lobs Hole to Marica

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 6.1

snowy 2.0

EMM creating opportunities



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Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); GA (2015); LPMA (2011)

GDA 1994 MGA Zone 55

N

KEY

- Noise monitoring location

Noise assessment location
- Residential
- Commercial^
- Passive recreation
- Project accommodation

Noise contours - dB $_{LAeq15min}$
- 35-39
- 40-44
- 45-49
- 50-54
- 55-59
- 60-64
- >65

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

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

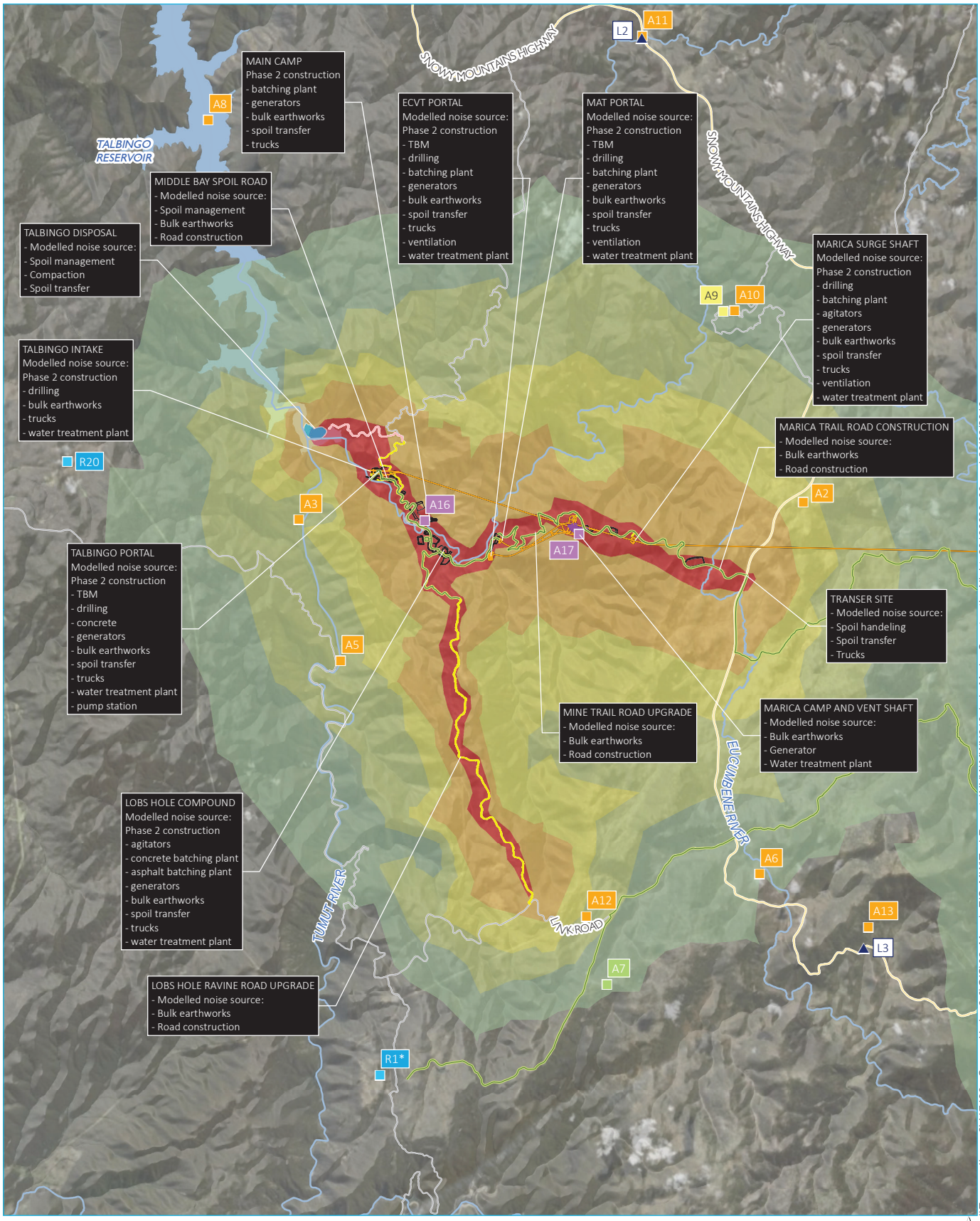
Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies

Outer envelope construction noise contours, day, noise enhancing weather – Marica to Tantangara

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 6.2

snowy 2.0

EMM creating opportunities



Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); GA (2015); LPMA (2011)

0 2.5 5 km

N

GDA 1994 MGA Zone 55

KEY

- Noise monitoring location

Noise assessment location
- Residential
- Commercial^
- Passive recreation
- Active recreation
- Project accommodation

Noise contours - dB $L_{Aeq15min}$
- 35-39
- 40-44
- 45-49
- 50-54
- 55-59
- 60-64
- >65

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
- Indicative rock emplacement area

Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies

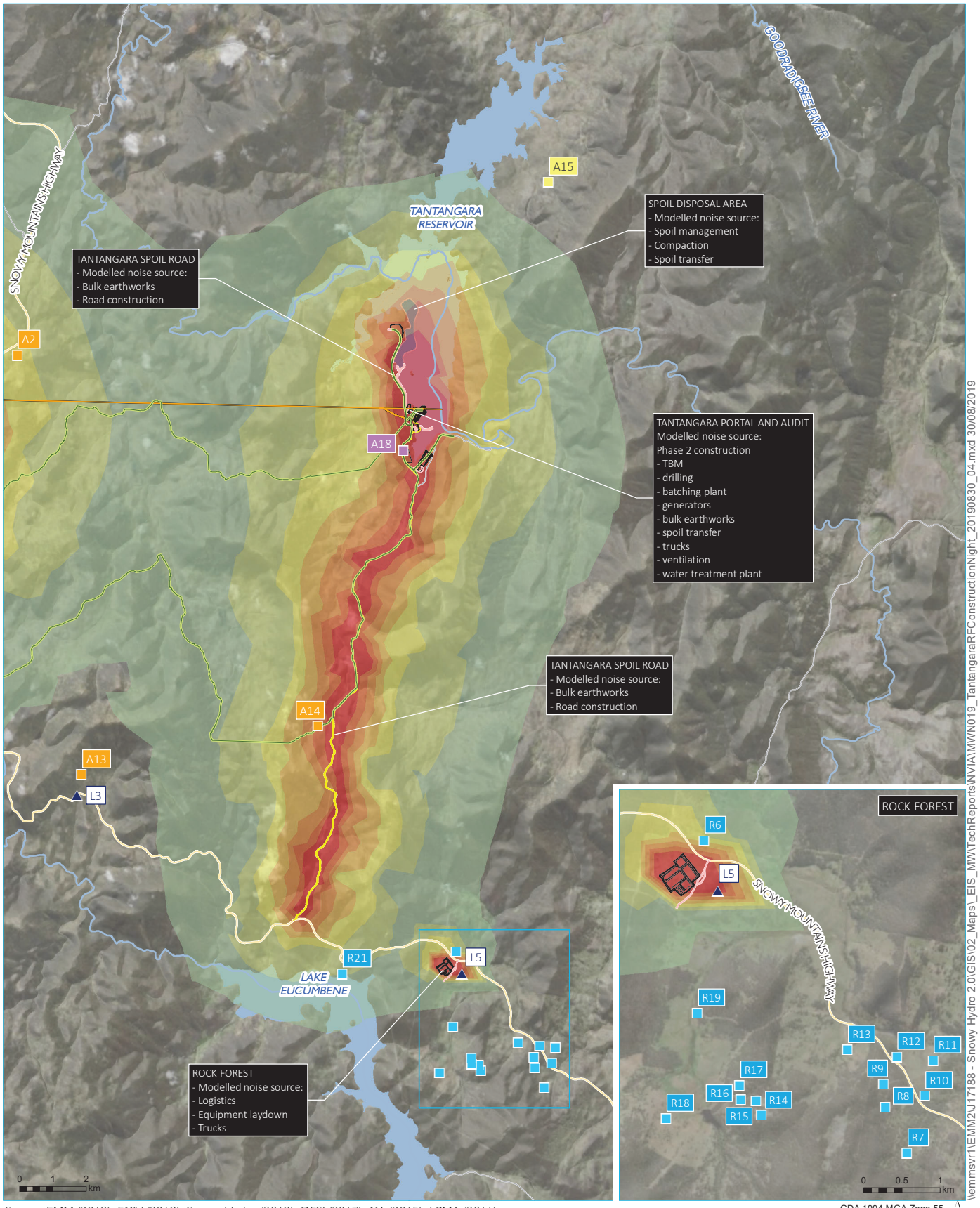
Outer envelope construction noise contours, night, noise enhancing weather – Lobs Hole to Marica

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 6.3

snowy 2.0

EMM creating opportunities

\\Emmsvr1\emm2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\NVIA\MWN018_LobsMaricaConstructionNight_20190828_03.mxd 28/08/2019



\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\NVIA\MWN019_TantangaraRFConstructionNight_20190830_04.mxd 30/08/2019

Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); GA (2015); LPMA (2011)

GDA 1994 MGA Zone 55

N

KEY

- Noise monitoring location

Noise assessment location
- Residential
- Commercial^
- Passive recreation
- Project accommodation

Noise contours - dB $_{LAeq15min}$
- 35-39
- 40-44
- 45-49
- 50-54
- 55-59
- 60-64
- >65

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

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

Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies

Outer envelope construction noise contours, night, noise enhancing weather – Marica to Tantangara

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 6.4

snowy 2.0

EMM creating opportunities

6.2 Sleep disturbance

Predicted maximum noise levels from project construction at residential assessment locations during adverse weather are provided in Table 6.2.

Table 6.2 Predicted maximum noise levels at residential assessment locations

Assessment location	Sleep disturbance screening criteria, dB		Predicted construction noise level, adverse weather, dB	
	$L_{Aeq,15\ minute}$	L_{Amax}	$L_{Aeq,15\ minute}$	L_{Amax}
R1[1]	40	52	<30	<30
R2	40	52	<30	<30
R3	40	52	<30	<30
R4	40	52	<30	<30
R5	40	52	<30	<30
R6[2]	40	52	**46**	**58**
R7	40	52	<30	<30
R8	40	52	<30	<30
R9	40	52	<30	<30
R10	40	52	<30	<30
R11	40	52	<30	<30
R12	40	52	<30	<30
R13	40	52	<30	<30
R14	40	52	<30	<30
R15	40	52	<30	<30
R16	40	52	<30	<30
R17	40	52	<30	<30
R18	40	52	<30	<30
R19	40	52	<30	30
R20	40	52	<30	<30
R21	40	52	<30	<30

Notes: 1. Residential properties are owned by the proponent however have been assessed as a residential receiver
2. Mitigation measures to be negotiated with owner as limited opportunity for onsite control of noise

Predicted noise levels from the project satisfy sleep disturbance screening criteria at all assessment locations with the exception of R6 6560 Snowy Mountains Highway, Adaminaby where exceedances of 5-6 dB are predicted. The proponent would consult with the affected landowner / occupier and appropriate mitigation measures would be agreed and implemented.

6.3 Construction vibration

In relation to human comfort response, the safe working distances in Table 5.4 relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed, as discussed in BS 6472-1.

The nearest residence to construction activity is assessment location R6 which is more than 300 m away from the Rock Forest construction site. This assessment location is beyond the safe working distances for human response considerations. Vibration impacts from construction at residential assessment locations are therefore highly unlikely.

The safe working distances for cosmetic damage should be monitored throughout the construction process. Based on the safe working distances guide in Table 5.4, if construction is within 25 m of sensitive structures, then work practices should be reviewed so that the safe working distance in Table 5.4 are followed. This includes structures associated with the existing Snowy Hydro scheme, such as Talbingo dam and spillway, Ravine Karst areas, Tufa and heritage structures.

Five vibration assessment locations with recorded heritage significance fall within the required safe working distances presented in this report. Methodology should be reviewed when construction occurs in the vicinity of these items (Table 6.3). This may include limiting the size of plant and equipment for excavation, compaction or removal of rock or re-assessing the significance and/or the sensitivity of these items to vibration prior to construction commencing in the area.

Table 6.3 Vibration assessment locations in safe working distance

ID	Description	Easting	Northing
R20	Washington Hotel	625925	6038961
R28	Pisé ruin	625907	6038986
R72	Stone furnace	626171	6038205
R78	Pine tree	626550	6038172
R118	Cemetery	625668	6039652

If safe working distances need to be encroached, real time vibration monitoring with audible and visual alarms should be considered at vibration sensitive structures so actual vibration levels can be monitored and managed appropriately in real-time.

6.4 Blasting

A quantitative blast assessment has been undertaken to calculate blast ground vibration and overpressure based on conservative empirical prediction formula provided in the ICI guideline. The following parameters were adopted:

- road excavation - representative MIC of 8kg and a K factor of 500 (for hard or highly structured rock); and
- intake, portal and early tunnel excavation - representative MIC of up to 40 kg and a K factor of 1140 (for average rock).

A summary of the offset distance required to satisfy blast vibration criteria for both road construction, portals, power house cavern and early stage tunnel excavation is provided in Table 6.4.

Table 6.4 Minimum offset distances required to satisfy blast criteria

Activity	Representative MIC (kg)	Receiver type	Criteria		Offset distance required to satisfy criteria – m	
			Ground vibration (PPV)	Airblast, $L_{Lin,peak}$, dB	Ground vibration	Air blast
Road construction	8kg	Residential	5 mm/s	115	50	225
		Rock structures/transmissions lines/heritage structures	20 mm/s	n/a	21	n/a
Tunnel excavation	40kg	Residential	5 mm/s	115	190	370
		Rock structures/transmissions lines/heritage structures	20 mm/s	n/a	80	n/a

Notes: 1. Airblast overpressure is the limiting factor for residential receivers with respect to blast emissions.

All rock structures / transmission lines / and heritage structures in the vicinity of the proposed blasting areas are confirmed to be located outside the minimum calculated offset distances outlined in Table 6.4.

As part of the ongoing construction and monitoring of rock, seismic surveys may be required. These surveys will detonate a relatively small charge in the ground using a seismic airgun. Vibration levels will be measured at a series of points from the charge detonation to assist in identifying potential seismic faults to inform the tunnelling construction team. The charge quantum is relatively small and is only required to generate a vibration signal in the survey zone to facilitate measurement of a vibration level. Based on preliminary survey design advice, the charge is approximately equivalent to an MIC of 100g. This charge is highly insignificant in comparison to the MICs proposed for road construction and tunnel excavation. It was determined from proposed seismic survey locations that the potential vibration and airblast emission would be contained within the worst-case blast offsets provided in Table 6.4. [further detail required from Snowy – but not a concern]

Detailed methodology for blasting associated with the intake and channel structures including frequency of blasts and MICs are still under development.

In the absence of specific wet drill and blast details, a number of key environmental controls are proposed for consideration, including:

- incorporation of silt curtains;
- preparation and implementation of underwater blast management procedure including detailed review of blast design[2]:
  - evaluate the need to use explosives. If practical alternatives are available and not excessively expensive, require their use;
  - plan the blasting program to minimise the total weight of explosive charges per shot and the number of shots for the project;

2 The Underwater Effects of Underwater Explosions with Methods to Mitigate Impacts, T.M Keevin and G.H Hempen. US Army Corps of Engineers. August 1997

- use angular stemming material of sufficient length in drill holes to reduce energy dispersal to the aquatic environment;

- subdivide the charge, using detonating caps with delays or delay connectors with detonating cord, to reduce total pressure. Avoid the use of submerged detonation cord;

- use decking when possible in lengthy drill holes to reduce total pressure;

- for seismic exploration use non-explosive sources when possible or use linear charges for open water shots or buried charges;

- use shaped charges to focus the blast energy when submerged surface charges are necessary, reducing energy released to the aquatic environment;

- in terms of addressing potential biological impacts of fish, consideration of:

    - season of explosive use and interactions with major migration periods, spawning seasons, spawning beds, or larval drift;

    - where there is concern with migrating fish, there is potential to use sampling techniques (eg hydroacoustics) to avoid impacting large congregations; and

    - use non-explosive scare techniques to move fish from the immediate blast zone.

6.4.1 Summary – residential receivers

Residential receivers surrounding the project are well outside the blast offset distances required to maintain acceptable emission levels from road construction, portal and early stage tunnel excavation. Therefore, blast impacts on residential receivers are considered highly unlikely.

There is the potential for at least one blast to occur each night. The ANZEC blasting guideline recommends that blasting be conducted during the day period (9 am to 5 pm Monday to Saturday) to avoid potential impacts during the more sensitive evening and night periods.

The ANZEC guideline goes on to state that restrictions on the time and frequency of blasting would not apply if the effects are not perceived at noise sensitive sites. Furthermore, ANZEC states that in some circumstances, blasts may not be able to comply with emission level, time and frequency requirements. In these instances, environmental authorities would apply appropriate controls based on individual project circumstances.

For the project, the distance and intervening topography between the blast location and nearest residences is significant and would provide a high level of air blast attenuation. For example, the predicted airblast level at Talbingo based on an MIC of 40 kg and distance attenuation only is <64 dBL_{peak}. Based on guidance provided in AS 2187.2-2006 on the typical difference in dBL and dBA levels from airblasts, this would approximately equate to a level of 39 dBA, L_{max} which is below the sleep disturbance screening criteria of 52 dBA, L_{max}. Furthermore, studies by Aloui, Bleuzen Essefi and Abbed, 2016[3] on airblast overpressure from blasting in open cut mines confirmed that the dominant frequency for the peak airblast was typically less than 10Hz, below the audible spectrum of normal human hearing (20Hz to 20kHz). Given this, the proposed blast frequency and the controlled blast parameters typical of the proposed construction method, it is unlikely that emissions would cause impact at nearest residences at Nurenmerenmong or any other residential assessment location.

3 Ground Vibrations and Air Blast Effects Induced by Blasting in Open Pit Mines: Case of Metlaoui Mining Basin, Southwestern Tunisia, Journal of Geology & Geophysics 2016

Although highly unlikely, blast practices will be reviewed and modified during the night period if higher airblast levels are generated that cause adverse impacts on residents.

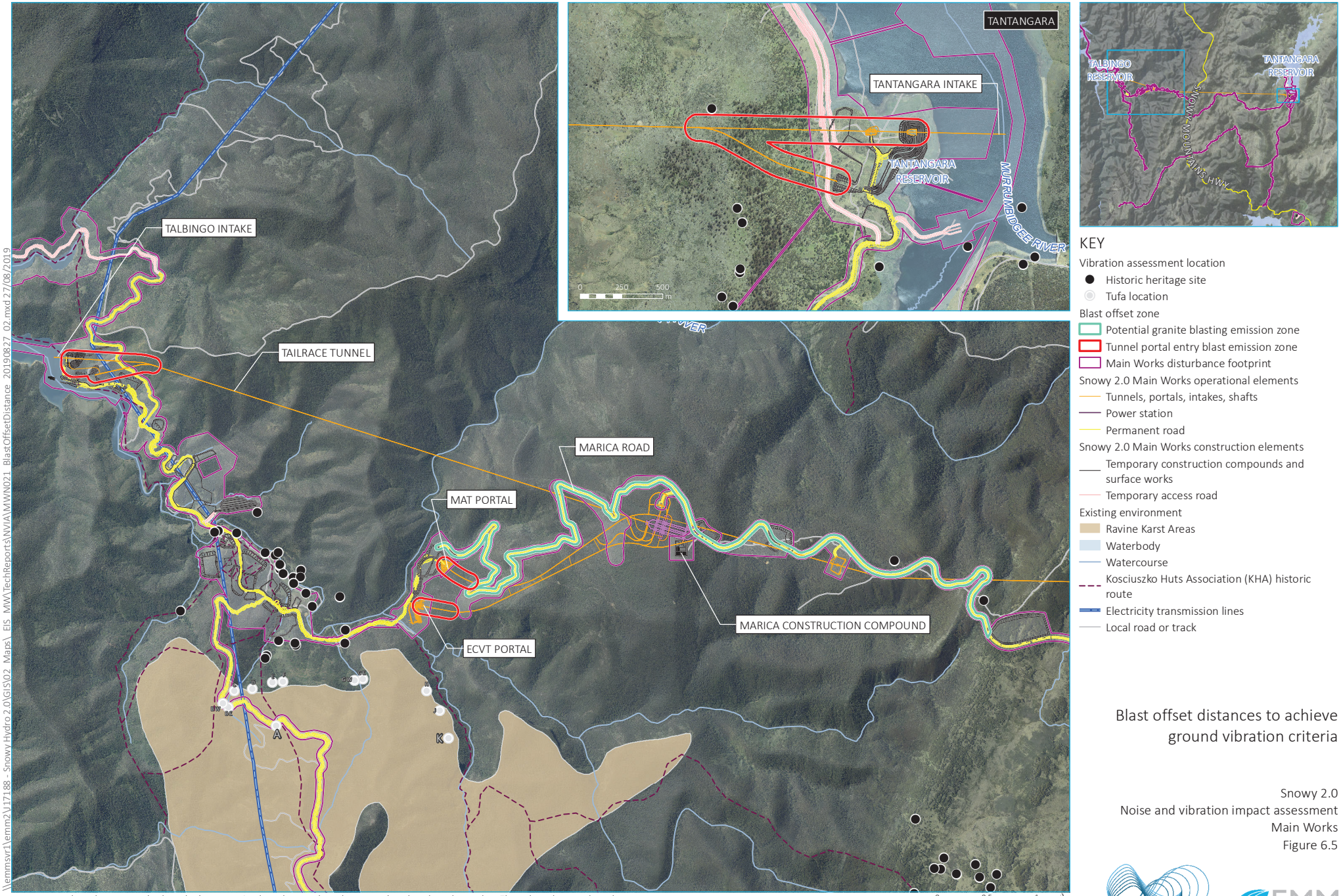
6.4.2 Summary – non-residential vibration sensitive receivers

Figure 6.5 maps the blast offset distances presented in Table 6.4 required to maintain acceptable PPV levels in relation to identified non-residential vibration sensitive receivers. Several vibration assessment locations fall within the required offset distances as shown in Figure 6.5. Details of these items are also listed in Table 6.3.

Notwithstanding the limitations to MIC's imposed by the proximity of heritage items, blasting activities would adopt the limits of Australian Standard AS 2187.2 – 2006 "Explosives - Storage and Use - Use of Explosives" that recommends frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 "Evaluation and measurement for vibration in buildings Part 2" be used as they are "applicable to Australian conditions". Appropriate engineering investigations and advice will be part of the management process of ensuring heritage and Karst areas are not impacted. A review of BS 7385 Section 7.5.5 also notes that structures below ground are known to sustain higher levels of vibration and are very resistant to damage unless in very poor condition.

Casaday and Lehmann (1967) studied animal installations to observe animal behaviour when subjected to sonic booms (Responses of Farm Animals to Sonic Booms). Animals observed included up to 10,000 beef cattle, 100 horses, 150 sheep and 320 dairy cattle. During the test period sonic booms were scheduled at varying intervals during the morning, Monday to Friday of each week.

Study outcomes indicated that reactions of the sheep and horses exposed to sonic booms were minimal in terms of change in behaviour. Similarly, dairy cattle were typically unaffected by sonic booms (125dB to 136dB). Less than 20% of booms produced even a mild reaction, as confirmed by a pause in eating, raising of heads, or mild startle effects. Production of milk was unaffected during the study, as evidenced by total and individual milk yield. The researchers summarised that the occasional abnormal behavioural changes observed were well within the range of activity variation to be expected of a group of animals. Changes were defined as horses jumping up and galloping, dairy cattle bellowing, and increased activity by beef cattle (Casaday and Lehmann, 1967). The lowest airblast overpressure exposure adopted in the study was 125dB and considered conservative in the assessment of livestock impacts.



KEY

Vibration assessment location
- Historic heritage site
- Tufa location

Blast offset zone
- Potential granite blasting emission zone
- Tunnel portal entry blast emission zone
- Main Works disturbance footprint

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

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

Existing environment
- Ravine Karst Areas
- Waterbody
- Watercourse
- Kosciuszko Huts Association (KHA) historic route
- Electricity transmission lines
- Local road or track

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); NSW Archaeology (2018); DFSI (2017); GA (2015); LPMA (2011)

\\emmsvr1\emm2\J171\88 - Snowy Hydro 2.0\GIS\02 Maps\ EIS MW\TechReports\NVIA\MWN021 BlastOffsetDistance 20190827 02.mxd 27/08/2019

Blast offset distances to achieve ground vibration criteria

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 6.5

snowy 2.0

EMM creating opportunities

Blast practices should be reviewed when blasting occurs in the vicinity of significant heritage items. This may include limiting the MIC or re-assessing the significance and/or the sensitivity of these items to vibration prior to construction commencing in the area. The Tufa deposits identified as A, B East and B West are already directly impacted by the existing road alignment of Lobs Hole Ravine Road.

In addition, heritage items within the blast offset zone surrounding the portal excavation should also be identified. If vibration sensitive items are identified within this offset, blast practices should be managed accordingly when in the vicinity.

A number of specific areas of significance have been identified in the Heritage study (EMM 2019) relating to a rock shelter at Tantangara, and exposed cliff-edge Tufa deposits identified in Cenozoic Geodiversity Report (Troedson 2019) and are considered high value and worthy of protection. These areas are summarised in Table 6.5 and are located well outside of blast offset zones. However, if work methods and locations change, these areas should be considered and assessed to ensure no adverse impacts.

Table 6.5 Vibration sensitive sites

ID	Description	Easting	Northing
Tufa C	Tufa cliff-edge deposit	626065	6037370
Tufa D	Tufa cliff-edge deposit	626246	6037394
Tufa E	Tufa cliff-edge deposit	626449	6037455
Tufa F	Tufa cliff-edge deposit	626556	6037462
Tufa G West	Tufa cliff-edge deposit	627277	6037479
Tufa G East	Tufa cliff-edge deposit	627361	6037492
57-4-0277	Rock shelter	648158	6039501

6.5 Road traffic noise

Road traffic noise levels from the project have been assessed by calculating existing and existing plus project traffic at representative residential assessment locations using FHWA and CoRTN methods. Traffic volumes were provided by FGJV to represent the peak generation of light (LV) and heavy vehicles (HV) associated with the construction of Snowy 2.0. Volumes were distributed 80% day (7am to 10pm) and 20% night (10pm to 7am) in accordance with FGJV operations. The following assumptions were adopted:

- speed limit for Snowy Mountains Highway:
  - 60 km/h through Adaminaby and Cooma townships; and
  - 100 km/h outside of townships, respectively;
- speed limit for Monaro Highway within Cooma township 60 km/h;
- speed limit for Link Road 80 km/h;
- speed limit for Lobs Hole Ravine Road 60 km/h;
- there are no buildings or other intervening objects that will act like a noise barrier between the road and the noise assessment point; and
- a facade reflection has been added to predicted noise levels as appropriate for each calculation method.

Road traffic noise level predictions for day and night are provided in Table 6.6 and Table 6.7, respectively.

Table 6.6 Road traffic noise calculations, Day (7am to 10pm)

ID	Approximate distance from nearest carriageway	Road	Existing movements[1]			Existing plus project movements			Noise level increase due to the Project, $L_{Aeq,15hour}$
			Total	%HV	Predicted level, $L_{Aeq,15hour}$	Total	%HV	Predicted level, $L_{Aeq,15hou}$	
1	75m - KNP	Snowy Mountains Highway	579	10	47.6	927	36	54.1	6.5[2]
	180m to A1				44.5			51.0	6.5[3]
	45m to Snowy mountains Motel, Adaminaby				49.6			56.6	6.9[3]
2	75m - KNP	Snowy Mountains Highway	495	15	48.1	615	26	51.1	3.0[2]
3	75m - KNP	Snowy Mountains Highway	440	14	47.5	510	22	49.7	2.2[2]
4	75m - KNP	Link Road	346	12	44.4	759	48	52.9	8.5[2]
5	75m - KNP	Link Road	224	10	41.8	298	20	45.3	3.5[2]
8	75m - KNP	Lobs Hole Ravine Road	21	14	30.6	715	89	53.4	49.6[2]
12	75m - KNP	Tantangara Road	44	14	33.2	365	71	49.1	15.9[2]
Cooma 1	20m	Snowy Mountains Highway (south)	4648	12	62.5	5131	17	63.0	0.5
Cooma 2	14m	Monaro Highway (north)	6150	23	66.4	6674	26	66.7	0.3

1. Existing movements are based on 2018/2019 long-term road traffic counts. Refer TIA (SCT 2018/2019) for detail.
2. Greater than 2dB increase, however less than baseline NSW, RNP criteria of LAeq 55 dBA when in use for passive recreation
3. Greater than 2dB increase, however less than baseline NSW, RNP criteria of LAeq,15hr 60 dBA

Table 6.7 Road traffic noise calculations, Night (10pm to 7am)

ID	Approximate distance from nearest carriageway	Road	Existing movements[1]			Existing plus project movements			Noise level increase due to the Project, $L_{Aeq,15hour}$
			Total	%HV	Predicted level, $L_{Aeq,9hour}$	Total	%HV	Predicted level, $L_{Aeq,9hou}$	
1	75m - KNP	Snowy Mountains Highway	16	37	38.9	104	72	49.6	10.7[2]
	180m to A1				35.7			46.4	10.7[3]
	45m to Snowy mountains Motel, Adaminaby				41.3			52.2	10.9[3]
2	75m - KNP	Snowy Mountains Highway	19	32	39.0	49	57	45.4	6.4
3	75m - KNP	Snowy Mountains Highway	13	46	38.8	31	62	43.7	4.9
4	75m - KNP	Link Road	14	7	30.8	117	70	48.6	17.8
5	75m - KNP	Link Road	6	17	30.0	24	40	39.5	9.5
8	75m - KNP	Lobs Hole Ravine Road	0	0	-	173	91	53.4	53.4
12	75m - KNP	Tantangara Road	1	0	-	81	78	45.2	45.2
Cooma 1	20m	Snowy Mountains Highway (south)	196	14	49.9	319	34	55.4	5.5[4]
Cooma 2	14m	Monaro Highway (north)	239	30	55.9	372	40	59.1	3.2[4]

1. Existing movements are based on 2018/2019 long-term road traffic counts. Refer TIA (SCT 2018/2019) for detail.
2. Greater than 2dB increase, however less than baseline NSW, RNP criteria of LAeq 55 dBA when in use for passive recreation
3. Greater than 2dB increase, however less than baseline NSW, RNP criteria of LAeq,9hr 55 dBA
4. Greater than 2dB increase, and greater than baseline NSW, RNP criteria of LAeq,9hr 55 dBA

Road traffic noise levels will increase as a result of the project, however the existing plus project traffic noise levels are typically less than the RNP baseline criteria for residences of 60 dB, $L_{Aeq,15hour}$ day and 55 dB, $L_{Aeq,9hour}$ night, and 55 dBA for passive recreation. Further, the predicted noise level increase due to project traffic generally satisfies the <2 dB RNP allowance criterion where applicable.

Potential for a 0.4 dB exceedance of the RNP baseline criteria for night-time traffic is predicted for Snowy Mountains Highway (south), whilst an exceedance of 1.2 dB of the RNP <2 dB allowance criterion is predicted for Monaro Highway (north) at night. These exceedances relate to a discrete period of 2-3 months at peak traffic generation and include an additional 20% allowance factor applied by FGJV to project traffic volumes. For the majority of the project life outside of the peak period, average HV volumes are typically 50% lower and would result in compliance with RNP assessment requirements.

For more detail refer to Traffic and Transport Impact Assessment – Snowy 2.0 – Main Works (Appendix Q).

6.6 Noise and vibration impacts on fauna

Very little evidence is available in literature on the direct impacts that noise and vibration have on fauna. The Australian Academy of Science provided a review of research into noise and the environment[4]. The review included consideration of flying species, land species and marine species. The focus is largely on continuous noise from urban environments including roads and industrial sites, whilst consideration of marine species focuses on impacts of shipping and low frequency noise on the navigation of sea mammals. Indications confirm high noise levels can affect the calling of birds and communication, sometimes resulting in change in nesting areas, with noisy areas being repopulated by a more noise tolerant species of bird. However, the actual level of noise where this occurs is unclear. In terms of land species, studies have indicated high noise areas can affect the ability of frogs to communicate and breed.

There are no current government policies or guidelines that recommend thresholds or criteria in relation to fauna. High noise levels may lead some species avoiding noisy areas, potentially resulting in the fragmentation of species habitat. Radle[5] (2007) states that typically terrestrial fauna will avoid any industrial plant or construction area where noise or vibration presents an annoyance to them. Additionally, many animals react to new noise initially as a potential threat, but quickly 'learn' that the noise is not associated with a threat (Radle, 2007).

In general, increased activity levels are likely to result in reduced fauna activity around work areas and heavily trafficked road segments including Lobs Hole Ravine Road, Middle Bay Road, Marica Road, Link Road, Snowy Mountains Highway within KNP and Tantangara spoil haulage route. Noise will be generated by the Project through operation of machinery, plant, vehicles, and blasting. Construction and operational noise will be in areas largely untouched by direct human impacts and disturbance. Fauna species that occur in the vicinity of construction sites and main traffic routes are expected to leave the immediate area of noise impact. It would be anticipated that following completion of Snowy 2.0 construction, fauna could return to the previous habitat.

However, it is likely that if levels are suitable for humans, they would also for a large extent be tolerable by fauna. However, it is likely that if levels are suitable for humans, they would also for a large extent be tolerable by fauna. Further discussion is provided in Section 6.6. Construction and traffic noise impacts to fauna are considered in the Biodiversity Development Assessment Report (EMM 2019)

6.7 Operational noise

6.7.1 Assessment procedure

Noise from Snowy 2.0 operational plant and equipment were assessed considering the following:

- operating sound power level of plant calculated for number of items running simultaneously;
- reduction in noise levels along airpaths including bends, duct dimensions, duct length and directivity for fans and subterranean plant areas;
- insertion loss of proposed attenuator selections (if required);
- consideration of low frequency noise components from all plant and equipment; and
- prediction of noise levels to a reference offset for passive recreation area and dedicated camping or huts areas identified in KNP in vicinity of facilities.

4 Noise pollution and the environment. Dr Kirsten Parris and Associate Professor Robert McCauley. Australian Academy of Science 2016

5 The effect of noise on wildlife: A literature review. Autumn. Lyd Radle 2007

Noise from plant and equipment associated with these facilities was considered and includes air conditioning condensers, exhaust and supply fans, transformers, pumps, natural ventilation openings for buildings, water treatment plant and vent shaft.

6.7.2 Operational noise modelling

Operational noise levels from Snowy 2.0 were predicted using a computer-generated model using Brüel & Kjær Predictor software (the model). The model calculates total noise levels at assessment locations from concurrent operation of multiple noise sources. It considers factors that influence noise propagation such as the lateral and vertical location of plant, source-to-receptor distances, ground effects, atmospheric absorption, topography of the site and surrounding area and applicable meteorological conditions.

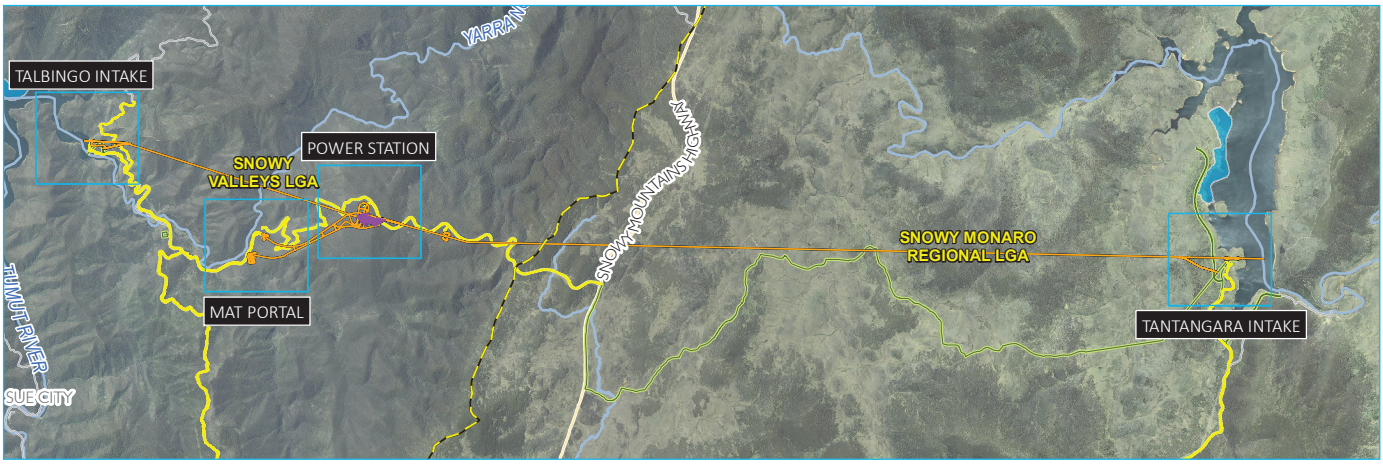
The model was populated with 3-D topography of the project and surrounding area, extending out to nearest assessment locations. Operational plant established from preliminary plant and equipment design (Section 5.4.1).

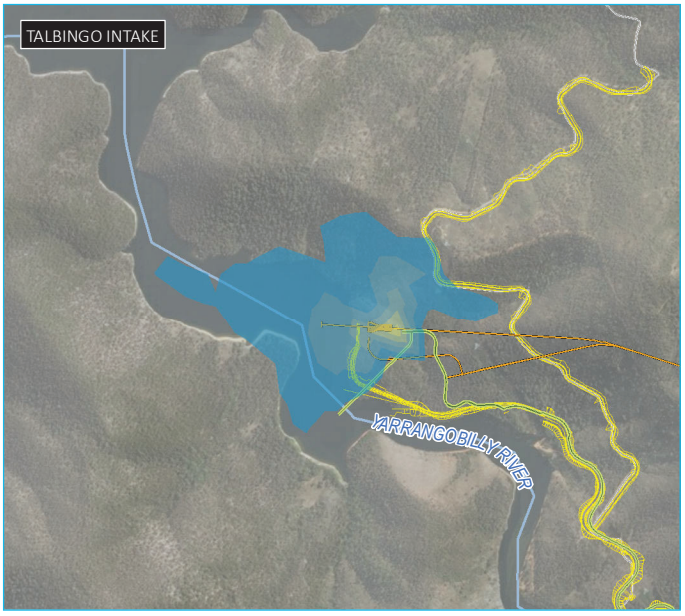
6.7.3 Predicted noise levels

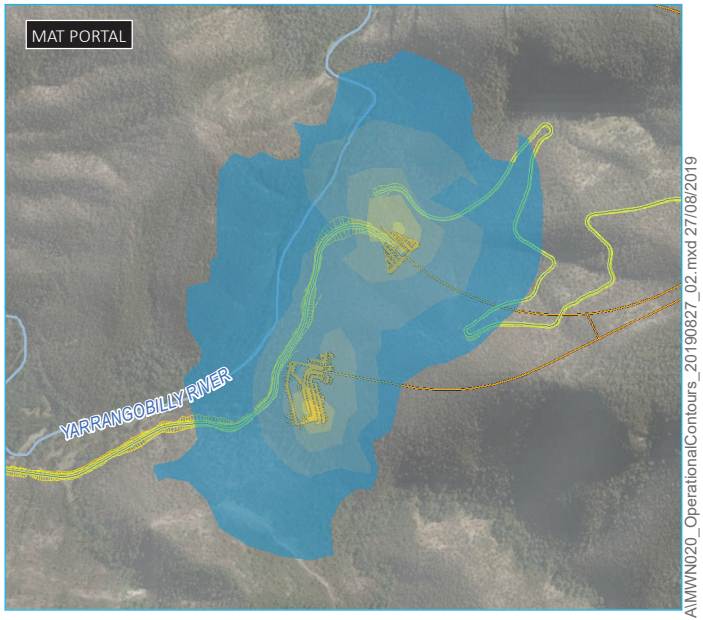
No residential assessment locations are located within the vicinity (<1000m) of the operational sites associated with Snowy 2.0, accordingly the model has considered noise contours and determined a minimum offset area to confirm compliance with the NPfI amenity goal $L_{Aeq,period}$ 50 dBA or 53 dBA $L_{Aeq,15min}$ for passive recreation.

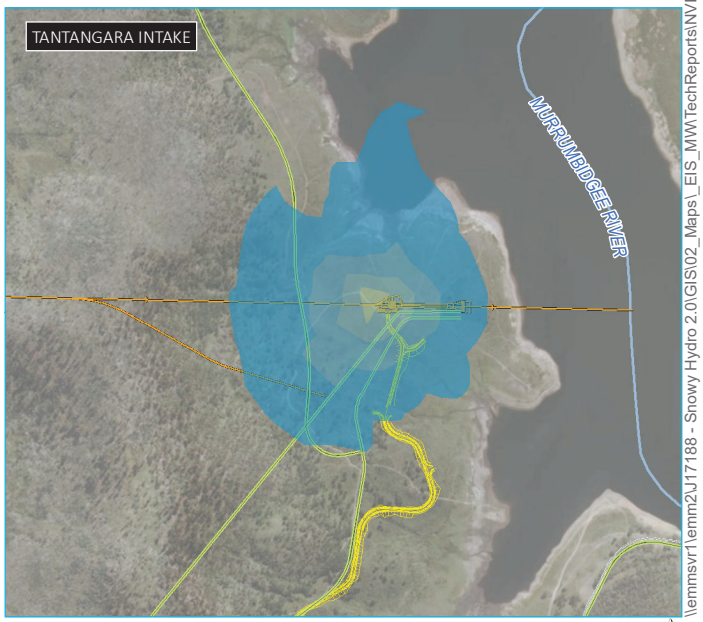
Predicted $L_{Aeq,15minute}$ noise contours representing the worst-case noise level footprint from Snowy 2.0 are provided in Figure 6.6. Modelling has indicated that at a setback of 50m the operation of the facilities are predicted to comply with the recommended NPfI amenity level for passive recreation. Additionally, the contours demonstrate that noise from the operation of Snowy 2.0 facilities would be less than 30 dBA at Lobs Hole campground and other camping areas within the vicinity of Talbingo intake, the ECVT and MAT portals, Marica vent shaft and Tantangara intake.

It is acknowledged that an L_{Aeq} noise level of 50 dBA could be very noticeable to dedicated camping areas and huts within KNP given measured baseline noise levels. Accordingly, noise levels predicted for camping areas and huts identified in the vicinity of the operational facilities will also be viewed in the context of the residential intrusiveness noise levels of L_{Aeq} 40 dBA during the day and 35 dBA for evening and night.









Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); GA (2015); LPMA (2011)

0 0.25 0.5 km

N

GDA 1994 MGA Zone 55

KEY

▲ Noise monitoring location

Noise contours - dB $_{LAeq15min}$

- 20-24
- 25-29
- 30-34
- 35-39
- 40-44

Snowy 2.0 operational elements

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

Existing environment

- Main road
- Local road

Watercourse

Outer envelope operational noise contours, 24/7, noise enhancing weather

Snowy 2.0
Noise and vibration impact assessment
Main Works
Figure 6.6

snowy 2.0

EMM creating opportunities

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7 Management of impacts

Environmental management measures for noise and vibration are provided in Table 7.1.

Table 7.1 Environmental management measures for noise and vibration

Impact	Ref #	Environmental management measures
Construction Noise	N1	A construction noise and vibration management plan (CNVMP) that will address noise and vibration management and mitigation options (where required) will be prepared prior to construction. The CNVMP will detail how construction noise and vibration impacts will be minimised and managed. The CNVMP will describe how construction noise levels will be managed where predicted noise levels above the NMLs have been identified. The CNVMP will outline a procedure to: • Measure construction noise levels at early stages to validate the predicted construction noise levels. • Re-evaluate the predicted construction noise levels at assessment locations, and where required review feasible and reasonable noise management and mitigation measures to reduce levels as close to NMLs as possible. This may include (but is not limited to): – limiting construction within a certain distance of assessment locations during the evening and night-time period; – selecting quieter equipment or reduced equipment fleet; – measuring construction noise levels at assessment locations, especially during the evening and night-time period, if relevant, and implementing further noise management and mitigation measures where an exceedance of NMLs is identified; or – consider Section 7.2.2 of the ICNG and option of a negotiated agreement with affected landholders. Affected landholders should be consulted prior to and during construction where an exceedance of NMLs has been predicted and should be notified of proposed mitigation measures that will be used to manage construction noise levels to below ICNG NMLs where practicable. To that end, the assessment has shown that privately owned residences are not predicted to be impacted.

Table 7.1 Environmental management measures for noise and vibration

Impact	Ref #	Environmental management measures
Vibration	V1	A construction noise and vibration management plan (CNVMP) will be prepared which will include as a minimum: • identification of nearby residences and sensitive land uses as per Figure 3.1; • a description of approved hours of work and what work will be undertaken; • a description of what work practices will be applied to minimise vibration; • a description of the complaints handling process; and • a description of monitoring that is required. If the safe working distances in Section 5.5 are encroached vibration monitoring will be carried out at nearby heritage or infrastructure structures. If required, the monitoring system will be fitted with an auditory and visual alarm that triggers when vibration levels reach the nominated criteria. This would indicate if and when alternate work practices should be adopted (such as decrease vibratory intensity, alternate equipment selection, etc). Blast practices should be reviewed when blasting occurs in the vicinity of significant heritage items listed in Table 6.3. This may include limiting the MIC or re-assessing the significant and/or the sensitivity of these items to vibration prior to construction commencing in the area. A Blasting Management Plan will be prepared and include specific details to address the potential for wet drill and blast activities at Talbingo and Tantangara intakes to ensure potential impacts are managed. Guidance on measures is provided in Section 6.4. The potential for blast impacts on residents during the night period is considered highly unlikely given the distance and topography separation between construction and nearest residents in Talbingo. Notwithstanding, blast practices will be constantly reviewed and adapted if complaints are received from residents due to night blasting. A condition survey of heritage items and other potential vibration sensitive receivers identified in Table 6.5 should be undertaken in the blast offset zone identified around the tunnel excavation portal.
Operational Noise	N2	All operational plant and equipment including ventilation, pumps, generators, transformers, VSD or other plant associated with the operation of Snowy 2.0 shall be subject to detailed acoustic review prior to final specification. Design shall be assessed against the requirements of the NPfI and consider the amenity criteria for passive recreation. Building and equipment shall be designed to satisfy the Snowy Hydro design limits of L_{Aeq} 80 dBA internal.

8 Conclusion

This NVIA has been prepared to support the EIS for Snowy 2.0 Main Works. It has documented the methods and results, the initiatives built into the project design to avoid and minimise associated impacts, and the mitigation and management measures proposed to address any residual impacts not able to be avoided.

Construction noise levels from the project are predicted to satisfy ICNG NMLs at all assessment locations, with exception of R6 where a 11-14 dB exceedance is predicted during out of hour work periods during under adverse weather conditions. The predicted exceedance at location R6 is a result of bulk earthworks and night logistics activities at Rock Forest.

The proponent will notify this resident R6 6560 Snowy Mountains Highway, Adaminaby of construction works and the potential noise impacts and discuss options for mitigating impacts. Noise monitoring during the initial stages of construction will be undertaken to determine if actual construction noise levels are above NMLs. If this initial testing identifies exceedances, the proponent will:

- identify feasible and reasonable mitigation measures that reduce construction noise levels to NMLs where practical;
- limit construction to ICNG standard hours only; or
- consider Section 7.2.2 of the ICNG and option of a negotiated agreement enter into a negotiated agreement with the property owner that may include:
    - at receiver mitigation;
    - relocation;
    - compensation.

The above will be determined depending on the measured level of exceedance and the availability of feasible and reasonable noise mitigation and management measures. This is discussed further in Section 7.

The NVIA has identified potential for sleep disturbance as defined in the NSW NPfI (EPA 2017) due to night-time logistics activities associated with construction at Rock Forest at R6 6560 Snowy Mountains Highway, Adaminaby. In addressing potential exceedance of NMLs at this assessment location, sleep disturbance impacts would also be addressed.

The potential for vibration impacts on residents and vibration sensitive structures near construction has been assessed. The nearest residence to construction activity is assessment location R6 which is more than 300 m away from Rock Forest construction. The assessment location is well outside of the safe working distances required to maintain acceptable human response and structural vibration levels. Vibration impacts from construction at residential assessment locations are therefore highly unlikely.

The safe working distances for cosmetic damage should be monitored throughout the construction process. If construction is within 25 m of sensitive structures, then work practices should be reviewed so that the safe working distances presented in Table 5.4 are followed. This includes structures associated with the existing Snowy Hydro scheme, such as Talbingo dam and spillway, heritage items and identified Tufa outcrops. If safe working distances need to be encroached, real time vibration monitoring with audible and visual alarms should be undertaken at vibration sensitive structures so actual vibration levels can be monitored and managed appropriately.

Five vibration assessment locations with recorded heritage significance fall within the required safe working distances presented in this report. Methodology should be reviewed when construction occurs in the vicinity of these items. This may include limiting the size of plant and equipment for excavation, compaction or removal of rock or re-assessing the significance and/or the sensitivity of these items to vibration prior to construction commencing in the area.

A quantitative blast assessment has been undertaken to calculate blast ground vibration and overpressure offset distances required to achieve acceptable emissions at sensitive receiver locations. Residential receivers surrounding the project are well outside required blast offset distances from road construction and tunnel excavation. Therefore, blast impacts on residential receivers are considered highly unlikely.

There is the potential for at least one blast to occur each night for tunnel excavation. The ANZEC blasting guideline recommends that blasting be conducted during the day period (9am to 5pm Monday to Saturday) to avoid potential impacts during the more sensitive evening and night periods.

The ANZEC guideline goes on to state that restrictions on the time and frequency of blasting would not apply if the effects are not perceived at noise sensitive sites. Furthermore, ANZEC states that in some circumstances, blasts may not be able to comply with emission level, time and frequency requirements. In these instances, environmental authorities would apply appropriate controls based on individual project circumstances.

For the project, the distance and intervening topography between the blast location and nearest residences is significant and would provide a high level of air blast attenuation. For example, the predicted airblast level at Talbingo based on an MIC of 40 kg and distance attenuation only is <64 dBL_{peak}. Based on guidance provided in AS 2187.2-2006 on the typical difference in dBL and dBA levels from airblasts, this would approximately equate to a level of 39 dBA, L_{max} which is below the sleep disturbance screening criteria of 52 dBA, L_{max}. Furthermore, studies by Aloui, Bleuzen Essefi and Abbed, 2016[6] on airblast overpressure from blasting in open-cut mines confirmed that the dominant frequency for the peak airblast was typically less than 10Hz, below the audible spectrum of normal human hearing (20Hz to 20kHz). Given this, the proposed blast frequency and the controlled blast parameters typical of the proposed construction method, it is unlikely that emissions would cause impact at nearest residences at Nurenmerenmong or any other residential assessment location.

Removal of the final rock plugs and channel construction may require wet drill and blast methodology. Detailed design of methods is not determined however recommendations are provided in Section 6.4 to manage any potential impacts.

Heritage items within the blast offset zone surrounding the portal excavation should also be identified. If vibration sensitive items are identified within this offset, blast practices should be managed accordingly when in the vicinity.

The potential for road traffic noise impacts on public roads due to project traffic has been assessed in accordance with relevant NSW Road Noise Policy (EPA 2011). In summary, road traffic noise levels are predicted to satisfy RNP assessment requirements. Potential for a 0.4 dB exceedance of the RNP baseline criteria for night-time traffic is predicted for Snowy Mountains Highway (south), whilst an exceedance of 1.2 dB of the RNP <2 dB allowance criterion is predicted for Monaro Highway (north) at night. These exceedances relate to a discrete period of 2-3 months at peak traffic generation and include an additional 20% allowance factor applied by FGJV to project traffic volumes. For the majority of the project life outside of the peak period, average HV volumes are typically 50% lower and would result in compliance with RNP assessment requirements.

6 Ground Vibrations and Air Blast Effects Induced by Blasting in Open Pit Mines: Case of Metlaoui Mining Basin, Southwestern Tunisia, Journal of Geology & Geophysics 2016

Very little evidence is available in literature on the direct impacts that noise and vibration have on fauna. However, it is likely that if levels are suitable for humans, they would also for a large extent be tolerable by fauna. Further discussion is provided in Section 6.6. Construction and traffic noise impacts to fauna are considered in the Biodiversity Development Assessment Report (EMM 2019)

Assessment of operational noise associated with the project has confirmed compliance with NPfI requirements for all residential assessment locations and the amenity criteria for passive recreation within KNP at a reference distance of 50m from the project permanent infrastructure.

With the effective management and incorporation of mitigation measures listed in Section 7 in place, noise and vibration emissions from the project are generally predicted to satisfy relevant guidelines, standards and policies.

References

NSW Environment Protection Authority (EPA) 2017, *NSW Noise Policy for Industry* (INP)

NSW Department of Environment Climate Change and Water (DECCW) 2011, *Road Noise Policy* (RNP)

NSW Environmental Protection Authority (EPA) 2009, *The Interim Construction Noise Guideline* (ICNG)

Department of Environment and Conservation NSW 2006, *Assessing Vibration: a technical guideline*

BS 6472 – 2008 *"Evaluation of human exposure to vibration in buildings (1-80Hz)"*

German Standard DIN 4150 Part 2 1975

Australian Standard AS 2187.2 - 2006 "*Explosives* - Storage *and Use - Use of Explosives*"

BS 7385 Part 2-1993 *"Evaluation and measurement for vibration in buildings Part 2*"

Australian and New Zealand Environment Council 1990, *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration*

Department of Environment, Food and Rural Affairs (DEFRA) 2005, *Update of Noise Database for Prediction of Noise on Construction and Open Sites*

Glossary

Project and technical terms

Term	Meaning
Accommodation camp	Area used for temporary housing and facilities for construction personnel
ABL	The assessment background level (ABL) is defined in the INP as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured L90 statistical noise levels.
Amenity noise criteria	The amenity noise criteria relate to existing industrial noise. Where industrial noise approaches base amenity noise criteria, then noise levels from new industries need to demonstrate that they will not be an additional contributor to existing industrial noise. See Section 3.1.2 for more detail.
Barge access infrastructure	A ramp and associated facilities to allow the loading and unloading of barge(s) on Talbingo Reservoir
Camp bridge	The permanent bridge structure across Yarrangobilly River
Day period	Monday-Saturday: 7.00am to 6.00pm, on Sundays and public holidays: 8.00am to 6.00pm.
dBA	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
dBC	Noise is measured in units called decibels (dB). There are several scales for describing noise, with the 'C-weighted' scale typically used to assess low frequency noise.
Evening period	Monday-Saturday: 6.00 pm to 10.00 pm, on Sundays and public holidays
Intrusive noise criteria	The intrusive noise criteria refers to noise that intrudes above the background level by more than 5 dB. The intrusiveness criterion is described in detail in Section 3.1.1.
Lobs Hole	A former settlement location within Kosciuszko National Park, and primary location of Exploratory Works and Main 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
Lower Lobs Hole Ravine Road	The section of Lobs Hole Ravine Road from Link Road to where it crosses the transmission easement
L1	The noise level exceeded for 1% of the time.
L10	The noise level which is exceeded 10% of the time. It is roughly equivalent to the average of maximum noise level.
L90	The noise level that is exceeded 90% of the time. Commonly referred to as the background noise level.
Leq	The energy average noise from a source. This is the equivalent continuous sound pressure level over a given period. The Leq(15min) descriptor refers to a Leq noise level measured over a 15-minute period.
Linear peak	The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.
Lmax	The maximum sound pressure level received during a measuring interval.
Middle Bay barge ramp	Location of barge access infrastructure at the southern end of Talbingo Reservoir
Middle Bay Road	The access road from the accommodation camp to the Middle Bay barge ramp. An extension to Middle Bay Road was proposed as part of Exploratory Works this road will be expanded to accommodate spoil disposal vehicle requirements

Project and technical terms

Term	Meaning
Mine Trail Road	The access road from the intersection with Lower Lobs Hole Ravine Road and the portal construction pad. This road will be expanded to accommodate spoil disposal vehicle requirements
Night period	Monday-Saturday: 10.00 pm to 7.00 am, on Sundays and public holidays: 10.00 pm to 8.00 am.
NVIA	Noise and vibration impact assessment.
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
Project area	The area required to access and build project infrastructure, including surface and tunnel components of the project
PSNL	The project-noise trigger level (PSNL) is criteria for a particular industrial noise source or industry. The PSNL is the lower of either the intrusive noise criteria or amenity noise criteria.
Rock emplacement area	Land area identified for the placement and storage of excavated rock from Exploratory Works
Rock Forest	Logistics site to the east of KNP to be utilised as a temporary storage and marshalling are for Main Works
RBL	The rating background level (RBL) is an overall single value background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the average background levels.
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
Spillway Road	The access road to Talbingo barge ramp
Sound power level (Lw)	A measure of the total power radiated by a source. The sound power of a source is a fundamental property of the source and is independent of the surrounding environment.
Study area	Area of Snowy 2.0 Main Works comprising the key areas of: • Lobs Hole • Marica • Plateau • Tantangara Reservoir • Rock Forest
Temperature inversion	A meteorological condition where the atmospheric temperature increases with altitude.

Abbreviations

Abbreviation	Term
ARL	Acoustic Research Laboratories
AGL	above ground level
ANZEC	Australian and New Zealand Environment Council
ABL	Assessment background level
BoM	Bureau of Meteorology
CSSI	critical State significant infrastructure
CEMP	Construction Environmental Management Plan
DECC	Department of Environment and Climate Change
DEC	Department of Environment and Conservation
DEFRA	Department of Environment, Food and Rural Affairs
D&B	drill and blast
DP&E	Department of Planning and Environment
EPA	Environmental Protection Authority
EIS	environmental impact statement
EMM	EMM Consulting Pty Limited
FGJV	Future Generation Joint Venture
FHWA	US EPA Federal Highways
GWh	gigawatt hours
HV	heavy vehicle
ICNG	Interim Construction Noise Guideline
LGAs	local government areas
LV	light vehicle
MAT	Main Access Tunnel
MW	megawatts
NATA	National Association of Testing Authorities
NPfI	Noise Policy for Industry
NML	noise management level
NVIA	Noise and vibration impact assessment
OOH	out of hours
PHES	Pumped Hydro-Electric Storage
PPV	peak particle velocity
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
PNTL	project noise trigger level
RBL	rating background level
RNP	Road Noise Policy
RMS	root mean square
SHL	Snowy Hydro Limited
SEARs	Secretary's environmental assessment requirements
SSI	State significant infrastructure
VDV	vibration dose value

Annexure A

Long term unattended noise monitoring results

A.1 Long-term unattended noise monitoring results

Table A.1 Background noise monitoring summary, L1 - Brownlie Court, Talbingo

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Monday, 19-03-18	-	26	22
Tuesday, 20-03-18	27	30	31
Wednesday, 21-03-18	36	30	26
Thursday, 22-03-18	31	29	23
Friday, 23-03-18	27	28	25
Saturday, 24-03-18	28	32	28
Sunday, 25-03-18	29	28	27
Monday, 26-03-18	30	22	21
Tuesday, 27-03-18	26	29	22
Wednesday, 28-03-18	26	28	24
Thursday, 29-03-18	27	29	23
Friday, 30-03-18	30	31	22
Saturday, 31-03-18	30	31	22
Sunday, 01-04-18	29	28	22
Monday, 02-04-18	28	28	21
Tuesday, 03-04-18	26	27	21
Wednesday, 04-04-18	27	-	-
Rating Background Level (RBL)[1]	35 (28)	30 (29)	30 (23)

Notes: 1. Adopted RBL is as per NPfI minimum background threshold. Actual RBL shown in brackets.

Table A.2 Background noise monitoring summary, L2 - Yarrangobilly Village Campground, Snowy Mountains Highway

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Thursday, 15-11-18	-	31	29
Friday, 16-11-18	30	31	30
Saturday, 17-11-18	28	28	29
Sunday, 18-11-18	29	29	30
Monday, 19-11-18	28	29	29
Tuesday, 20-11-18	28	28	28
Wednesday, 21-11-18	34	36	34
Thursday, 22-11-18	33	38	39
Friday, 23-11-18	40	38	37
Saturday, 24-11-18	36	36	32
Sunday, 25-11-18	33	32	33
Monday, 26-11-18	31	34	33
Tuesday, 27-11-18	31	30	31

Table A.2 Background noise monitoring summary, L2 - Yarrangobilly Village Campground, Snowy Mountains Highway

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Wednesday, 28-11-18	32	32	34
Thursday, 29-11-18	-	-	-
Rating Background Level (RBL)[1]	35 (31)	31	32

Notes: 1. Adopted RBL is as per NPfI minimum background threshold. Actual RBL shown in brackets.

Table A.3 Background noise monitoring summary, L3 - Sawyer's Hut, Snowy Mountains Highway

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Thursday, 15-11-18	-	25	23
Friday, 16-11-18	25	23	24
Saturday, 17-11-18	27	26	23
Sunday, 18-11-18	25	23	23
Monday, 19-11-18	25	23	24
Tuesday, 20-11-18	25	23	24
Wednesday, 21-11-18	34	24	25
Thursday, 22-11-18	30	38	33
Friday, 23-11-18	36	33	27
Saturday, 24-11-18	26	26	25
Sunday, 25-11-18	27	26	27
Monday, 26-11-18	25	24	25
Tuesday, 27-11-18	24	24	24
Wednesday, 28-11-18	30	29	27
Thursday, 29-11-18	26	-	-
Rating Background Level (RBL)[1]	35 (26)	30 (25)	30 (24)

Notes: 1. Adopted RBL is as per NPfI minimum background threshold. Actual RBL shown in brackets.

Table A.4 Background noise monitoring summary, L4 - Tooma Road, Tooma

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Friday, 16-11-18	-	23	25
Saturday, 17-11-18	25	23	25
Sunday, 18-11-18	24	23	24
Monday, 19-11-18	26	23	22
Tuesday, 20-11-18	24	23	26
Wednesday, 21-11-18	29	26	28
Thursday, 22-11-18	31	35	32
Friday, 23-11-18	45	47	22
Saturday, 24-11-18	26	25	21
Sunday, 25-11-18	24	22	21
Monday, 26-11-18	24	25	22
Tuesday, 27-11-18	23	24	23
Wednesday, 28-11-18	25	23	21
Thursday, 29-11-18	23	23	23
Friday, 30-11-18	26	24	23
Saturday, 01-12-18	27	27	30
Sunday, 02-12-18	38	27	22
Monday, 03-12-18	28	25	24
Tuesday, 04-12-18	0	-	-
Rating Background Level (RBL)[1]	35 (25)	30 (24)	30 (23)

Notes: 1. Adopted RBL is as per NPfI minimum background threshold. Actual RBL shown in brackets.

Table A.5 Background noise monitoring summary, L5 - Rock Forest

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Tuesday, 19-03-19	34	-	-
Rating Background Level (RBL)[1]	35 (34)	(30)	(30)

Notes: 1. Adopted RBL is as per NPfI minimum background threshold. Actual RBL shown in brackets.
Equipment failure resulted in limited data, however a review of available data and other noise monitoring locations in similar areas confirmed minimum background noise levels

Table A.6 Background noise monitoring summary, L6 - Snowy Mountains Highway, Adaminaby

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Thursday, 15-11-18	0	22	22
Friday, 16-11-18	28	23	21
Saturday, 17-11-18	28	25	21
Sunday, 18-11-18	27	26	17
Monday, 19-11-18	25	21	21
Tuesday, 20-11-18	29	21	21
Wednesday, 21-11-18	31	20	21
Thursday, 22-11-18	30	28	27
Friday, 23-11-18	39	25	21
Saturday, 24-11-18	29	23	23
Sunday, 25-11-18	25	25	16
Monday, 26-11-18	24	21	20
Tuesday, 27-11-18	24	20	22
Wednesday, 28-11-18	32	23	22
Thursday, 29-11-18	24	0	0
Rating Background Level (RBL)[1]	35 (26)	30 (21)	30 (21)

Notes: 1. Adopted RBL is as per NPfI minimum background threshold. Actual RBL shown in brackets.
2. A "0" indicates insufficient data samples due to adverse weather or other extraneous effects.

Annexure B

Construction plant and equipment

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
ECVT Portal and cable yard				
150kVA Generators		1		102
4WD Utility, Dual Cab	1	1	1	76
5t Telehandlers		1		107
Acetylene Storage		1		n/a
Air Poker 75mm		1		101
Bobcat 543 Skid Steer	1	1	1	95
Cable Rollers		1	1	n/a
Cable Sock		1		n/a
Cable Stand		1		n/a
CAT 740 ADT	1	1	1	107
Compressors		1		103
Compressors system		1		103
Concrete & Shotcrete pumps		1		106
Concrete distribution boom		1		106
Concrete Saw		1		121
Crib and ablutions		1		63
DC12 Roller 12t (Flat drum)	1	1	1	103
Dozer CAT D6	1	1	1	111
Drills, Impact Hammer	1	1		101
Dumper 2t Thwaites 4000	1	1	1	105
Electrical Compressor / Air Receiver		1		103
Excavator CAT 345	1	1	1	107
External and tunnel lighting		1		n/a
First Aid and Rescue Equipment	1	1	1	n/a
Flex-drive Vibrator		1		101
Fork Lift 25tn		1		107
Formwork		1		n/a

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Fuel Farms/bowsers	1	1		79
Fuel trucks		1	1	96
Gantry cranes		1		92
Grease/Oil/Lube Storage		1		n/a
Grouting Plant 30m3/hr		1		106
Grouting pumps		1		106
HV TBM Distribution Substation		1		72
HV/LV Transformer Substation		1		82
Jumbo 1 boom or equivalent track drill		1		114
Jumbo 2 booms		1		114
Jumbo 3 booms		1		114
Low Loader Float	1	1	1	103
Mucking conveyors		1		n/a
Oil Separator		1		n/a
Oxygen Storage		1		n/a
Power Float		1		102
Power Plant (Generator)		1		102
Power supply for electrical tools		1		102
Rock Breakers	1	1		117
Segment Storage Area		1		n/a
Service trucks	1	1	1	96
Shaeff		1		99
Shotcrete Pump		1		106
Shotcrete Robot		1		106
Site offices		1		63
Specialist Demolition Equipment		1		108
TBM		1		95
Tipper Trucks	1	1	1	96
Triple Gas Monitor		1		n/a
Truck & Dog	1	1	1	103
Ventilation Units		1		93

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Vertical Belt Storage		1		n/a
Wastewater treatment plant		1		103
Water Blasters		2		80
Water Cooling Tower System		1		97
Water heater plant		1		85
Water Tanks		1		n/a
Welding Set Generators (20kVA)		1		102
Workshop trucks	1	1	1	96
		Exploratory/Main Camp		
22 Seat Bus	1	1		94
2WD Utility	1	1	1	76
CAT 740 ADT	1	1	1	107
Crane 120T Mobile		1		112
Dozer CAT D8	1		1	116
Excavator 21t (0.66-1.57m3)	1		1	110
Excavator CAT 330	1		1	99
Excavator CAT 345	1		1	107
Exploratory Camp at Lobs Hole - Phase 1		1		n/a
Exploratory Camp at Lobs Hole - Phase 2		1		n/a
Fly Camp at Lobs Hole		1		n/a
Franna Crane 25tn		2		98
Grader CAT 12/14M	1	1	1	104
Main Camp at Lobs Hole		1		n/a
Medical Facility - Main		1		n/a
Mini Excavators	1		1	99
Roller 16tn smooth drum	1	1	1	103
Site offices in Exploratory Camp - Phase 1		1		n/a
Site offices in Exploratory Camp - Phase 2		1		n/a
Site offices in Fly Camp		1		n/a

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Site offices in Main Camp		1		n/a
Wastewater treatment plant		2		103
		Lobs Hole Ravine Road		
22 Seat Bus	1	1		94
7 Ton Truck, flat top tray	1	1	1	103
Air Poker 75mm		2		101
Barber Greene 879 Asphalt Paver		1		112
Bobcat 543 Skid Steer	2	2	2	95
Compressors		2		103
Conc Skip 1m3 - Lever		1		n/a
Crane 120T Mobile		1		112
Crib and ablutions		1		63
DC12 Roller 12t (Flat drum)	2	2	2	103
Dozer CAT D4	2		2	116
Dozer CAT D6	2		2	111
Dozer CAT D8	2		2	116
Drills, Impact Hammer	2	2	2	101
Excavator 21t (n/a.66-1.57m3)	2		2	110
Excavator CAT 345	1		1	107
First Aid and Rescue Equipment	1	1	1	n/a
Flex-drive Vibrator		2		101
Formwork		1		n/a
Franna Crane 25tn		1		98
Fuel trucks		2	2	96
Grader CAT 12/14M	2	2	2	104
Hiab Crane Trucks		1		103
Light. Tower 5m 4 X 500 w c/w mast, 16h tank		1		93
Low Loader Float	1	1	1	103
Mini Excavators	2		2	99
Padfoot Roller	2	2	2	103

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Pile Hammer	2	2		112
Pneumatic Roller	2	2	2	103
Potable Concrete Mixer (n/a.5m3)		1		n/a
Rock Breakers	2	2		117
Sand Sprayer / De-iceing Equipment		1		n/a
Semi Trailers	1	1	1	103
Service trucks	2	2	2	96
Site offices		1		63
Snow Plough	1	1	1	109
Stand Pipe		1		n/a
Submersible Pumps		1		93
Tipper Trucks	2	2	2	96
Truck & Dog	2	2	2	103
Water Blasters		2		80
Water Bowser (TRUCK)		1	1	109
Welding Set Generators (20kVA)		2		102
Workshop trucks	2	2	2	96
		Main Yards		
150kVA Generators		1		102
22 Seat Bus		1		94
2WD Utility	1	1	1	76
4WD Utility, Dual Cab	2	2	2	76
4WD Utility, Single Cab	1	1	1	76
54 Seat MAN Coach Bus	1	1	1	94
5t Telehandlers		1		107
75kVA Generators		1		102
Aggregate storage area – with heaters		1		n/a
Agi Trucks	1	1		108
Air Poker 75mm		1		101
Ambulance	1	1	1	96
Asphalt batch plant		1		115

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Bobcat 543 Skid Steer	1	1	1	95
Cable Rollers		1	1	n/a
Cable Sock		1		n/a
Cable Stand		1		n/a
Compressors		1		103
Compressors system		1		103
Concrete Batching plant		1		115
Concrete Pump: Mobile		1		106
Crane 120T Mobile		1		112
Crib and ablutions		2		63
Dozer CAT D4	1	1	1	116
Dozer CAT D6	1	1	1	111
Dozer CAT D8	1	1	1	116
Drills, Impact Hammer	1			101
Excavator 12t (n/a.21-n/a.76m3)	1	1	1	110
Excavator 21t (n/a.66-1.57m3)	1	1	1	110
Excavator CAT 345	1	1	1	107
External and tunnel lighting		1		n/a
Fire Trucks	1	1	1	103
First Aid and Rescue Equipment	1	1	1	n/a
Flex-drive Vibrator		1		101
Formwork		1		n/a
Franna Crane 25tn		1		98
Fuel Farms/bowsers		1		79
Fuel trucks	1	1	1	96
Gantry cranes		1		92
Grader CAT 12/14M	1	1	1	104
JCB 525 2.5T 4WD Telesco		1		107
Joinery		1		101
Low Loader Float	1	1	1	103
Medical Facility - Satellite		1		n/a

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Mobile Crushing and Screening Plant		1		114
Power Float		1		102
Power supply for electrical tools		1		102
Precast Yard (to be confirmed if it will be on site or in Cooma/Tumut)		1		75
Reinforcement bending yard		1		n/a
Rock Breakers	1			117
Service trucks	1	1	1	96
Site offices		1		63
Snow Plough	1	1	1	109
Steel Yard		1		101
Testing Laboratory (Concrete and Geotechnical)		1		108
Tipper Trucks	1	1	1	96
Wastewater treatment plant		1		103
Water heater plant		1		85
Welding Set Generators (20kVA)		1		102
Workshop - Main		1		101
Workshop trucks	1	1	1	96
Marica Camp and vent shaft				
CAT 740 ADT	1	1	1	107
Crane 120T Mobile		1		112
Dozer CAT D8	1		1	116
Excavator 21t (n/a.66-1.57m3)	1		1	110
Excavator CAT 330	1		1	99
Excavator CAT 345	1		1	107
Franna Crane 25tn		1		98
Grader CAT 12/14M	1	1	1	104
Marica Camp for Surge Shaft Personnel		1		n/a

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Medical Facility - Main		1		n/a
Mini Excavators	1		1	99
Roller 16tn smooth drum	1	1	1	103
Site offices in Marica Camp		1		63
Wastewater treatment plant		1		103
Generator (800MVa)		1		102
		Marica Surge Shaft		
150kVA Generators		1		102
22 Seat Bus	1	1		94
4WD Utility, Dual Cab	1	1	1	76
4WD Utility, Single Cab	1	1	1	76
54 Seat MAN Coach Bus	1	1		94
5t Telehandlers		1		107
75kVA Generators		1		102
Aggregate storage area – with heaters		1		n/a
Agi Trucks	1	1		108
Air Poker 75mm		1		101
Ambulance	1	1	1	96
Blasting Storage Magazine		1		n/a
Bobcat 543 Skid Steer	1	1	1	95
Cable Rollers		1	1	n/a
Cable Sock		1		n/a
Cable Stand		1		n/a
Compressors		1		103
Compressors system		1		103
Concrete & Shotcrete pumps		1		106
Concrete Batching plant		1		115
Concrete Saw		1		121
Crane 120T Mobile		1		112
Crib and ablutions		1		63
Dozer CAT D4	1	1	1	116

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Dozer CAT D6	1	1	1	111
Dozer CAT D8	1	1	1	116
Drills, Impact Hammer	1	1	1	101
Electrical Compressor / Air Receiver		1		103
Excavator CAT 345	1	1	1	107
Explosive trucks		1		96
Fire Trucks		1	1	103
First Aid and Rescue Equipment	1	1	1	n/a
Flex-drive Vibrator		1		101
Formwork		1		n/a
Franna Crane 25tn		1		98
Fuel Farms/bowsers		1		79
Fuel trucks		1	1	96
Gantry cranes		1		92
Grader CAT 12/14M	1	1	1	104
Grouting Plant 30m3/hr		1		106
Grouting pumps		1		106
JCB 525 2.5T 4WD Telesco		1		107
Jumbo 2 booms		1		114
Low Loader Float	1	1	1	103
Mobile Crushing and Screening Plant		1		114
Power Plant (Generator)		1		102
Power supply for electrical tools		1		102
Raw Water treatment plant		1		87
Reinforcement bending yard		1		n/a
Rock Breakers	1	1		117
Service trucks	1	1	1	96
Shotcrete Pump		1		106
Shotcrete Robot		1		106

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Site offices		1		63
Snow Plough	1	1	1	109
Specialist Demolition Equipment		1		108
Tipper Trucks	1	1	1	96
Triple Gas Monitor		1		n/a
Truck & Dog	1	1	1	103
Ventilation Units		1		93
Wastewater treatment plant		1		103
Water Blasters		2		80
Water heater plant		1		85
Water Pumping station		1		87
Welding Set Generators (20kVA)		1		102
Workshop - Satellite		1		n/a
Workshop trucks	1	1	1	96
Lighting		1		93
Marica Trail / Snowy Mountains Highway transfer site				
30T ADT	1	1	1	107
CAT 330 Excavator	1	1	1	99
CAT 980 Loader	1	1	1	104
Truck & Dog	1	1	1	103
MAT Portal				
150kVA Generators		1		102
4WD Utility, Dual Cab	1	1	1	76
5t Telehandlers		1		107
Acetylene Storage		1		n/a
Aggregate storage area – with heaters		1		n/a
Agi Trucks	1	1	1	108
Air Poker 75mm		1		101
Blasting Storage Magazine		1		n/a
Bobcat 543 Skid Steer	1	1	1	95
Cable Rollers		1	1	n/a

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Cable Sock		1		n/a
Cable Stand		1		n/a
CAT 740 ADT	1	1	1	107
Compressors		1		103
Compressors system		1		103
Concrete & Shotcrete pumps		1		106
Concrete Batching plant		1		115
Concrete distribution boom		1		106
Concrete Saw		1		121
Crib and ablutions		1		63
DC12 Roller 12t (Flat drum)	1	1	1	103
Dozer CAT D6	1	1	1	111
Drills, Impact Hammer	1	1	1	101
Dumper 2t Thwaites 4000	1	1	1	105
Electrical Compressor / Air Receiver		1		103
Excavator CAT 345	1	1	1	107
Explosive trucks		1	1	96
External and tunnel lighting		1		n/a
First Aid and Rescue Equipment	1	1	1	n/a
Flex-drive Vibrator		1		101
Fork Lift 25tn		1		107
Formwork		1		n/a
Franna Crane 25tn		1		98
Fuel Farms/bowsers		1		79
Fuel trucks		1	1	96
Gantry cranes		1		92
Grease/Oil/Lube Storage		1		n/a
Grouting Plant 30m3/hr		1		106
Grouting pumps		1		106

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Horizontal Belt Storage		1		n/a
HV TBM Distribution Substation		1		72
HV/LV Transformer Substation		1		82
Jumbo 1 boom or equivalent track drill		1		114
Jumbo 2 booms		1		114
Jumbo 3 booms		1		114
Low Loader Float	1	1	1	103
Medical Facility - Satellite		1		n/a
Mobile Crushing and Screening Plant		1		114
Mucking conveyors		1		n/a
Oil Separator		1		n/a
Oxygen Storage		1		n/a
Power Float		1		102
Power Plant (Generator)		1		102
Power supply for electrical tools		1		102
Rock Breakers	1	1		117
Segment Storage Area		1		n/a
Service trucks	1	1	1	96
Shaeff		1		99
Shotcrete Pump		1		106
Shotcrete Robot		1		106
Site offices		1		63
Specialist Demolition Equipment		1		108
TBM		1		95
Tipper Trucks	1	1	1	96
Triple Gas Monitor		1		n/a
Truck & Dog	1	1	1	103
Ventilation Units		1		93
Wastewater treatment plant		1		103

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Water Blasters		2		80
Water Cooling Tower System		1		97
Water heater plant		1		85
Water Tanks		1		n/a
Welding Set Generators (20kVA)		1		102
Workshop - Satellite		1		n/a
Workshop trucks	1	1	1	96
		Rock Forest Logistics		
Trucks	1	5	1	107
CAT 740 ADT	1		1	107
Dozer CAT D8	1		1	116
Excavator 21t (n/a.66-1.57m3)	1		1	110
Excavator CAT 330	1			99
Excavator CAT 345	1			107
Franna Crane 25tn		1		98
Fuel Farms/bowsers		1		79
Grader CAT 12/14M	1			104
Roller 16tn smooth drum	1			103
Site Office		1		63
Telehandler 5t Manitou MLT-X 960		1		107
Weighbridge		1		n/a
		Talbingo Intake		
150kVA Generators		1		102
4WD Utility, Dual Cab	1	1	1	76
5t Telehandlers		1		107
Air Poker 75mm		1		101
Blasting Barge		1		111
Blasting Storage Magazine		1		n/a
Bobcat 543 Skid Steer	1	1	1	95
Cable Rollers		1	1	n/a
Cable Sock		1		n/a

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Cable Stand		1		n/a
CAT 740 ADT	1	1	1	107
Compressors		1		103
Concrete distribution boom		1		106
Concrete Pump: Mobile		1		106
Concrete Saw		1		121
Crib and ablutions		1		63
Dozer CAT D10	1	1	1	113
Dozer CAT D11	1	1	1	116
Dozer CAT D6	1	1	1	111
Dredging Barge		1		111
Drills, Impact Hammer	1	1		101
Dumb Barge		1		111
Dumper 2t Thwaites 4000	1	1	1	105
Electrical Compressor / Air Receiver		1		103
Excavator CAT 345	1		1	107
Excavator CAT 365	1		1	107
Explosive trucks		1	1	96
First Aid and Rescue Equipment	1	1	1	n/a
Flex-drive Vibrator		1		101
Formwork		1		n/a
Fuel trucks		1	1	96
Grouting pumps		1		106
Jumbo 2 booms		1		114
Low Loader Float	1	1	1	103
Power Float		1		102
Rock Breakers	1	1	1	117
Service trucks	1	1	1	96
Shotcrete Pump		1		106
Shotcrete Robot		1		106
Specialist Demolition Equipment		1		108

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Tipper Trucks	1	1	1	96
Tower Crane		1		104
Triple Gas Monitor		1		n/a
Truck & Dog	1	1	1	103
Wastewater treatment plant		1		103
Water Blasters		1		80
Welding Set Generators (20kVA)		1		102
Workshop trucks	1	1	1	96
		Talbingo Portal		
150kVA Generators		2		102
2WD Utility	1	1	1	76
4WD Utility, Dual Cab	1	1	1	76
4WD Utility, Single Cab	1	1	1	76
5t Telehandlers		1		107
Acetylene Storage		1		n/a
Air Poker 75mm		1		101
Barge / conveyors / washing bays for spoil management		1		111
Bobcat 543 Skid Steer	1	1	1	95
Cable Rollers		1	1	n/a
Cable Sock		1		n/a
Cable Stand		1		n/a
CAT 740 ADT	1	1	1	107
Compressors		1		103
Compressors system		1		103
Concrete & Shotcrete pumps		1		106
Concrete Saw		1		121
Crane 120T Mobile		1		112
Crib and ablutions		1		63
DC12 Roller 12t (Flat drum)	1	1	1	103
Dozer CAT D6	1	1	1	111

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Drills, Impact Hammer	1	1	1	101
Dumper 2t Thwaites 4000	1	1	1	105
Electrical Compressor / Air Receiver		1		103
Excavator CAT 345	1	1	1	107
External and tunnel lighting		1		n/a
First Aid and Rescue Equipment	1	1	1	n/a
Flex-drive Vibrator		1		101
Fork Lift 25tn		1		107
Formwork		1		n/a
Fuel Farms/bowsers		1		79
Fuel trucks		1	1	96
Grease/Oil/Lube Storage		1		n/a
Grouting Plant 30m3/hr		1		106
Grouting pumps		1		106
HV TBM Distribution Substation		1		72
HV/LV Transformer Substation	1			82
Jumbo 2 booms		1		114
Low Loader Float	1	1	1	103
Mobile Crushing and Screening Plant		1		114
Oil Separator		1		n/a
Oxygen Storage		1		n/a
Power Float		1		102
Power Plant (Generator)		1		102
Raw Water treatment plant		1		87
Rock Breakers	1	1		117
Segment Storage Area		1		n/a
Service trucks	1	1	1	96
Shotcrete Pump		1		106
Shotcrete Robot		1		106

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Site offices		1		63
Specialist Demolition Equipment		1		108
TBM		1		95
Tipper Trucks	1	1	1	96
Triple Gas Monitor		1		n/a
Truck & Dog	1	1	1	103
Ventilation Units		1		93
Vertical Belt Storage		1		n/a
Wastewater treatment plant		1		103
Water Blasters		1		80
Water Cooling Tower System		1		97
Water heater plant		1		85
Water Pumping station		1		87
Water Tanks		1		n/a
Weighbridge		1		n/a
Welding Set Generators (20kVA)		1		102
Wheel Wash		1		n/a
Workshop trucks	1	1	1	96
Talbingo Spoil Disposal (East)				
CAT 740 ADT	1	1	1	107
CAT 825C Compactor	1	1	1	116
Dozer CAT D10	1	1	1	113
Grader CAT 12/14M	1	1	1	104
Site offices	1	1		63
Water Bowser (TRUCK)	1	1	1	109
Workboats	1	1		111
Talbingo Spoil Disposal (West)				
CAT 740 ADT	1	1	1	107
CAT 825C Compactor	1	1	1	116
Dozer CAT D10	1	1	1	113
Grader CAT 12/14M	1	1	1	104

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Site offices	1	1		63
Water Bowser (TRUCK)	1	1	1	109
Workboats	1	1		111
		Tantangara Camp		
22 Seat Bus	1	1	1	94
CAT 740 ADT	1	1	1	107
Concrete Pump: Mobile		1		106
Crane 120T Mobile		1		112
Dozer CAT D8	1		1	116
Excavator 21t (n/a.66-1.57m3)	1		1	110
Excavator CAT 330	1		1	99
Excavator CAT 345	1		1	107
Franna Crane 25tn		1		98
Grader CAT 12/14M	1	1	1	104
Medical Facility - Main		1		n/a
Mini Excavators	1		1	99
Roller 16tn smooth drum	1	1	1	103
Site offices in Tantangara Camp		1		63
Tantangara Camp for Main Works HRT		1		63
Wastewater treatment plant		1		103
		Tantangara Intake		
150kVA Generators		1		102
4WD Utility, Dual Cab	1	1		76
5t Telehandlers		1		107
Air Poker 75mm		1		101
Blasting Barge	1	1		111
Blasting Storage Magazine	1			n/a
Bobcat 543 Skid Steer	1	1	1	95
Cable Rollers		1		n/a
Cable Sock		1		n/a
Cable Stand		1		n/a

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
CAT 740 ADT	1	1	1	107
Compressors		1		103
Concrete distribution boom		1		106
Concrete Pump: Mobile		1		106
Concrete Saw		1		121
Crib and ablutions	1	1		63
Dozer CAT D10	1			113
Dozer CAT D11	1			116
Dozer CAT D6	1		1	111
Dredging Barge	1	1		111
Drills, Impact Hammer	1	1		101
Dumb Barge	1	1		111
Dumper 2t Thwaites 4000	1			105
Electrical Compressor / Air Receiver	1	1	1	103
Excavator CAT 345	1		1	107
Excavator CAT 365	1			107
Explosive trucks	1	1		96
First Aid and Rescue Equipment	1	1	1	n/a
Flex-drive Vibrator		1		101
Formwork		1		n/a
Fuel trucks	1	1	1	96
Grouting pumps		1		106
Jumbo 2 booms		1		114
Low Loader Float	1	1	1	103
Power Float		1		102
Rock Breakers	1			117
Service trucks	1	1	1	96
Shotcrete Pump		1		106
Shotcrete Robot		1		106
Specialist Demolition Equipment		1		108
Tipper Trucks	1	1	1	96

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Tower Crane		1		104
Triple Gas Monitor		1		n/a
Truck & Dog	1	1	1	103
Wastewater treatment plant	1	1		103
Water Blasters		1		80
Welding Set Generators (20kVA)		1		102
Workshop trucks	1	1	1	96
		Tantangara Portal		
150kVA Generators		1		102
2WD Utility	1	1	1	76
4WD Utility, Dual Cab	1	1	1	76
4WD Utility, Single Cab	1	1	1	76
54 Seat MAN Coach Bus		1		94
5t Telehandlers		1		107
Acetylene Storage		1		n/a
Aggregate storage area – with heaters		1		n/a
Agi Trucks	1	1	1	108
Air Poker 75mm		1		101
Ambulance	1	1	1	96
Asphalt batch plant		1		115
Barge / conveyors / washing bays for spoil management		1		111
Blasting Barge		1		111
Blasting Storage Magazine		1		n/a
Bobcat 543 Skid Steer	1	1	1	95
Cable Rollers		1	1	n/a
Cable Sock		1		n/a
Cable Stand		1		n/a
CAT 740 ADT	2	2	2	107
Compressors		1		103
Compressors system		1		103

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Concrete & Shotcrete pumps		1		106
Concrete Batching plant		1		115
Concrete distribution boom		1		106
Concrete Pump: Mobile		1		106
Concrete Saw		1		121
Crane 120T Mobile		1		112
Crib and ablutions		1		63
Dozer CAT D10	1	1	1	113
Dozer CAT D11	1	1	1	116
Dozer CAT D6	1	1	1	111
Dredging Barge		1		111
Drills, Impact Hammer	1	1	1	101
Dumb Barge		1		111
Dumper 2t Thwaites 4000	1	1	1	105
Electrical Compressor / Air Receiver		1		103
Excavator CAT 345	1	1	1	107
Excavator CAT 365	1	1	1	107
Explosive trucks		1	1	96
External and tunnel lighting		1		n/a
Fire Trucks		1	1	103
First Aid and Rescue Equipment	1	1	1	n/a
Flex-drive Vibrator		1		101
Fork Lift 25tn		1		107
Formwork		1		n/a
Franna Crane 25tn		1		98
Fuel Farms/bowsers		1		79
Fuel trucks		1	1	96
Grease/Oil/Lube Storage		1		n/a
Grouting Plant 30m3/hr		1		106
Grouting pumps		1		106

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
HV TBM Distribution Substation		1		72
HV/LV Transformer Substation		1		82
Jumbo 2 booms		1		114
Low Loader Float	1	1	1	103
Mobile Crushing and Screening Plant		1		114
Mucking conveyors		1		n/a
Oil Separator		1		n/a
Oxygen Storage		1		n/a
Power Float		1		102
Power Plant (Generator)		1		102
Power supply for electrical tools		1		102
Raw Water treatment plant		1		87
Reinforcement bending yard		1		n/a
Rock Breakers	1	1		117
Segment Storage Area		1		n/a
Service trucks	1	1	1	96
Shotcrete Pump		1		106
Shotcrete Robot		1		106
Site offices		1		63
Slurry Treatment Plant		1		87
Snow Plough	1	1	1	109
Specialist Demolition Equipment		1		108
TBM		1		95
Tipper Trucks	1	1	1	96
Tower Crane		1		104
Triple Gas Monitor		1		n/a
Truck & Dog	1	1	1	103
Ventilation Units		1		93
Vertical Belt Storage		1		n/a

Table B.1 Plant and equipment schedule

Description	Phase 1: Bulk earth works	Phase 2: Construction	Phase 3: Rehabilitation	Sound Power Level (dBA) per item
Warehouse		1		n/a
Wastewater treatment plant		1		103
Water Blasters		2		80
Water Cooling Tower System		1		97
Water heater plant		1		85
Water Pumping station		1		87
Water Tanks		1		n/a
Weighbridge		1		n/a
Welding Set Generators (20kVA)		1		102
Wheel Wash		1		n/a
Workboats		1		111
Workshop - Satellite		1		n/a
Workshop trucks	1	1	1	96
		Tantangara Spoil Disposal		
CAT 740 ADT	1	1	1	107
CAT 825C Compactor	1	1	1	116
Dozer CAT D10	1	1	1	113
Grader CAT 12/14M	1	1	1	104
Water Bowser (TRUCK)		1	1	109