APPENDIX T

NOISE AND VIBRATION ASSESSMENT


Noise and vibration assessment

Exploratory Works for Snowy 2.0

Prepared for Snowy Hydro Limited
July 2017




snowy 2.0

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Noise and Vibration Assessment

Final

Report J17188RP1 | Prepared for Snowy Hydro Limited | 13 July 2018

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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). This would be achieved by establishing a new underground hydro-electric power station that would increase the generation capacity of the Snowy Scheme by almost 50%, providing an additional 2,000 megawatts (MW) generating capacity, and providing approximately 350 gigawatt hours (GWh) of storage available to the National Electricity Market (NEM) at any one time, which is critical to ensuring system security as Australia transitions to a decarbonised NEM. Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and hydro-electric power station.

Snowy 2.0 has been declared to be Critical State Significant Infrastructure (CSSI) by the NSW Minister for Planning under the provisions of the 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. The application for Exploratory Works is the first application for Snowy 2.0.

The purpose of the Exploratory Works for Snowy 2.0 is primarily to gain a greater understanding of the conditions at the proposed location of the power station, approximately 850 metres (m) below ground level. Understanding factors such as rock conditions (such as stress conditions) and ground temperature is essential to confirm the suitability of the site for the underground power station.

The Exploratory Works comprise:

- establishment of an exploratory tunnel to the site of the underground power station for Snowy 2.0;
- establishment of a portal construction pad;
- excavated rock management, including subaqueous rock placement;
- establishment of an accommodation camp;
- road establishment and upgrades providing access and haulage routes during Exploratory Works;
- establishment of barge access infrastructure to enable access and transport by barge on Talbingo reservoir; and
- establishment of services infrastructure such as diesel-generated power and communication.

This noise and vibration impact assessment (NVIA) supports the EIS for the Exploratory 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 noise and vibration 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);
- Australian and New Zealand Environment Council 1990, *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration;* and
- 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*".

Construction noise levels from the project are predicted satisfy ICNG noise management levels (NMLs) at all assessment locations, with the exception of R2 where a 2 dB and 5 dB exceedance is predicted during out of hour work periods during calm and adverse weather conditions, respectively. The predicted exceedance at location R2 is generated by Spillway Road construction for a small portion of the road alignment. Road construction for the entire Spillway Road alignment is scheduled to occur for six weeks. The time spent in this zone and therefore the duration of noise levels above the NMLs will therefore be less.

The proponent will notify this resident R2 of Spillway Road construction works and the potential noise impacts. Noise monitoring during the initial stages of construction will be undertaken to determine if actual construction noise levels are above NMLs. If NMLs are exceeded, the proponent will:

- identify feasible and reasonable mitigation measures that reduce construction noise levels to at or below NMLs;
- limit road construction within the zone marked on Figure 6.1 to ICNG standard hours only; or
- enter into a negotiated agreement with the property owner.

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.

No sleep disturbance impacts as defined in the NSW NPfI (EPA 2017) due to night-time construction are 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 R2 which is more than 400 m away from Spillway Road construction. This places this assessment location 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 this report are followed. This includes structures associated with the existing Snowy Hydro scheme, such as Talbingo dam and spillway. 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.

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 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 73 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 48 dBL_{peak} which is below the sleep disturbance screening criteria of 52 dBA, L_{max}. 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 Talbingo. Notwithstanding, blast practices will be reviewed and modified during the night period if higher airblast levels are generated that cause adverse impacts on residents.

Five vibration assessment locations with recorded heritage significance fall within the required offset distances presented in this report. Blast practices should be reviewed when blasting occurs in the vicinity of these 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. 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.

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.

Very little evidence is available in literature on the direct impacts that noise and vibration has on fauna. However, it is likely that if levels are suitable for humans, they would also for a large extent be tolerable by fauna. It is also understood the construction will be avoided in areas with recorded pygmy possum population which will minimise potential for noise and vibration exposure on this species. More information on this is available in the ecological assessment of the EIS.

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

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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: 7.00 am to 6.00 pm, on Sundays and public holidays: 8.00 am to 6.00 pm.
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.
Exploratory tunnel	A 3.1 km tunnel to the cavern of the proposed Machine Hall for the purposes of understanding geotechnical and underground conditions
Exploratory Works	A program of exploratory works for Snowy 2.0, subject of this EIS and as described in Section 2.
Exploratory Works avoidance footprint	Areas excluded from clearing and ground disturbance due to sensitive environmental constraints
Exploratory Works disturbance footprint	The area subject to clearing and ground disturbance
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
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 an Leq noise level measured over a 15minute period.

Project and technical terms

Term	Meaning
Linear peak	The peak level of an event is normally measured using a microphone in the same manner as linear noise (i.e. 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 is proposed as part of Exploratory Works.
Miles Franklin Drive	Existing road leading to Spillway Road, for access to the Talbingo barge ramp
Mine Trail Road	The access road from the intersection with Lower Lobs Hole Ravine Road and the portal construction pad. An extension to Mine Trail Road is proposed as part of Exploratory Works.
Night period	Monday-Saturday: 10.00 pm to 7.00 am, on Sundays and public holidays: 10.00 pm to 8.00 am.
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
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
Study area	Define if appropriate for the technical study (ie. Is different to the Exploratory Works project area)
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.
Talbingo barge ramp	Location of barge access infrastructure at the northern end of Talbingo Reservoir

Project and technical terms

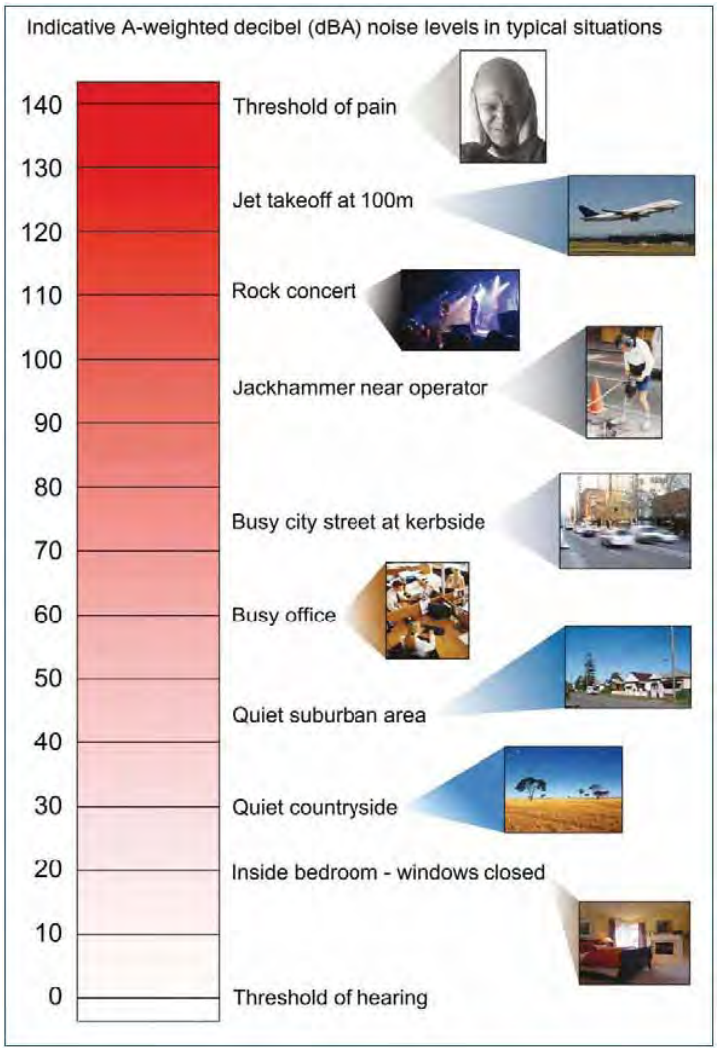
Term	Meaning
PSNL	The project-noise trigger level (PSNL) is criteria for a particular industrial noise source or industry. The PSNL is the lower of either the intrusive noise criteria or amenity noise criteria.
RBL	The rating background level (RBL) is an overall single value background level representing 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.
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.
Temperature inversion	A meteorological condition where the atmospheric temperature increases with altitude.

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).*

Common sources of noise with levels

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). This would be achieved by establishing a new underground hydro-electric power station that would increase the generation capacity of the Snowy Scheme by almost 50%, providing an additional 2,000 megawatts (MW) generating capacity, and providing approximately 350,000 megawatt hours (MWh) of storage available to the National Electricity Market (NEM) at any one time, which is critical to ensuring system security as Australia transitions to a decarbonised NEM. Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and hydro-electric power station.

Snowy 2.0 has been declared to be State significant infrastructure and critical State significant infrastructure (CSSI) by the NSW Minister for Planning under the provisions of the 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 technical assessment has been prepared to support an EIS for Exploratory Works to undertake investigative works to gather important technical and environmental information for the main Snowy 2.0 project. The main project will be subject of a separate application and EIS next year.

The purpose of Exploratory Works for Snowy 2.0 is primarily to gain a greater understanding of the conditions at the proposed location of the power station, approximately 850 metres (m) below ground level. Understanding factors such as rock conditions (such as stress conditions) and ground temperature is essential to inform decisions about the precise location of the power station cavern and confirm the cavern construction methods.

Exploratory Works comprises:

- an exploratory tunnel to the site of the underground power station for Snowy 2.0;
- horizontal and other test drilling, investigations and analysis in situ at the proposed cavern location and associated areas, and around the portal construction pad, access roads and excavated rock management areas all within the disturbance footprint;
- a portal construction pad for the exploratory tunnel;
- an accommodation camp for the Exploratory Works construction workforce;
- road works and upgrades providing access and haulage routes during Exploratory Works;
- barge access infrastructure, to enable access and transport by barge on Talbingo reservoir;
- excavated rock management, including subaqueous placement within Talbingo Reservoir;
- services infrastructure such as diesel-generated power, water and communications; and
- post-construction revegetation and rehabilitation, management and monitoring.

1.2 Purpose of this report

This noise and vibration impact assessment (NVIA) supports the EIS for Exploratory 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 noise and vibration 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);
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- German Standard DIN 4150 Part 2 1975; and
- Australian Standard AS 2187.2 - 2006 "*Explosives* - Storage *and Use - Use of Explosives*".

1.3 Location of Exploratory Works

Snowy 2.0 and Exploratory Works are within the Australian Alps, in southern NSW. The regional location of Exploratory Works is shown on Figure 1.1. Snowy 2.0 is within both the Snowy Valleys and Snowy Monaro Regional local government areas (LGAs), however Exploratory Works is entirely within the Snowy Valleys LGA. The majority of Snowy 2.0 and Exploratory Works are within Kosciuszko National Park (KNP). The area in which Exploratory Works will be undertaken is referred to herein as the project area, and includes all of the surface and subsurface elements further discussed in Section 2.1.

Exploratory Works is predominantly in the Ravine region of the KNP. This region is between Talbingo Reservoir to the north-west and the Snowy Mountains Highway to the east, which connects Adaminaby and Cooma in the south-east to Talbingo and Tumut to the north-west of the KNP. Talbingo Reservoir is an existing reservoir that forms part of the Snowy Scheme. The reservoir, approximately 50 kilometres (km) north-west of Adaminaby and approximately 30 km east-north-east of Tumbarumba, is popular for recreational activities such as boating, fishing, water skiing and canoeing.

The nearest large towns to Exploratory Works are Cooma and Tumut. Cooma is approximately one hour and forty five minutes drive (95 km) south-east of Lobs Hole. Tumut is approximately half an hour (45 km) north of Talbingo. There are several communities and townships near the project area including Talbingo, Tumbarumba, Batlow, Cabramurra and Adaminaby. Talbingo and Cabramurra were built for the original Snowy Scheme workers and their families. Adaminaby was relocated to alongside the Snowy Mountains Highway from its original location (now known as Old Adaminaby) in 1957 due to the construction of Lake Eucumbene. Talbingo and Adaminaby provide a base for users of the Selwyn Snow Resort in winter. Cabramurra was modernised and rebuilt in the early 1970s and is owned and operated by Snowy Hydro. It is still used to accommodate Snowy Scheme employees and contractors. Properties within Talbingo are now predominantly privately owned. Snowy Hydro now only owns 21 properties within the town.

Other attractions and places of interest in the vicinity of the 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.

The project area is shown on Figure 1.2 and comprises:

- **Lobs Hole:** Lobs Hole will accommodate the excavated rock emplacement areas, an accommodation camp as well as associated infrastructure, roads and laydown areas close to the portal of the exploratory tunnel and portal construction pad at a site east of the Yarrangobilly River;

- **Talbingo Reservoir:** installation of barge access infrastructure near the existing Talbingo Spillway, at the northern end of the Talbingo Reservoir, and also at Middle Bay, at the southern end of the reservoir, near the Lobs Hole facilities, and installation of a submarine cable from the Tumut 3 power station to Middle Bay, providing communications to the portal construction pad and accommodation camp. A program of subaqueous rock placement is also proposed;

- **Mine Trail Road** will be upgraded and extended to allow the transport of excavated rock from the exploratory tunnel to sites at Lobs Hole that will be used to manage excavated material, as well as for the transport of machinery and construction equipment and for the use of general construction traffic; and

- several sections of **Lobs Hole Ravine Road** will be upgraded in a manner that protects the identified environmental constraints present near the current alignment.

The project is described in more detail in Chapter 2.

1.4 Proponent

Snowy Hydro is the proponent for Exploratory 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.

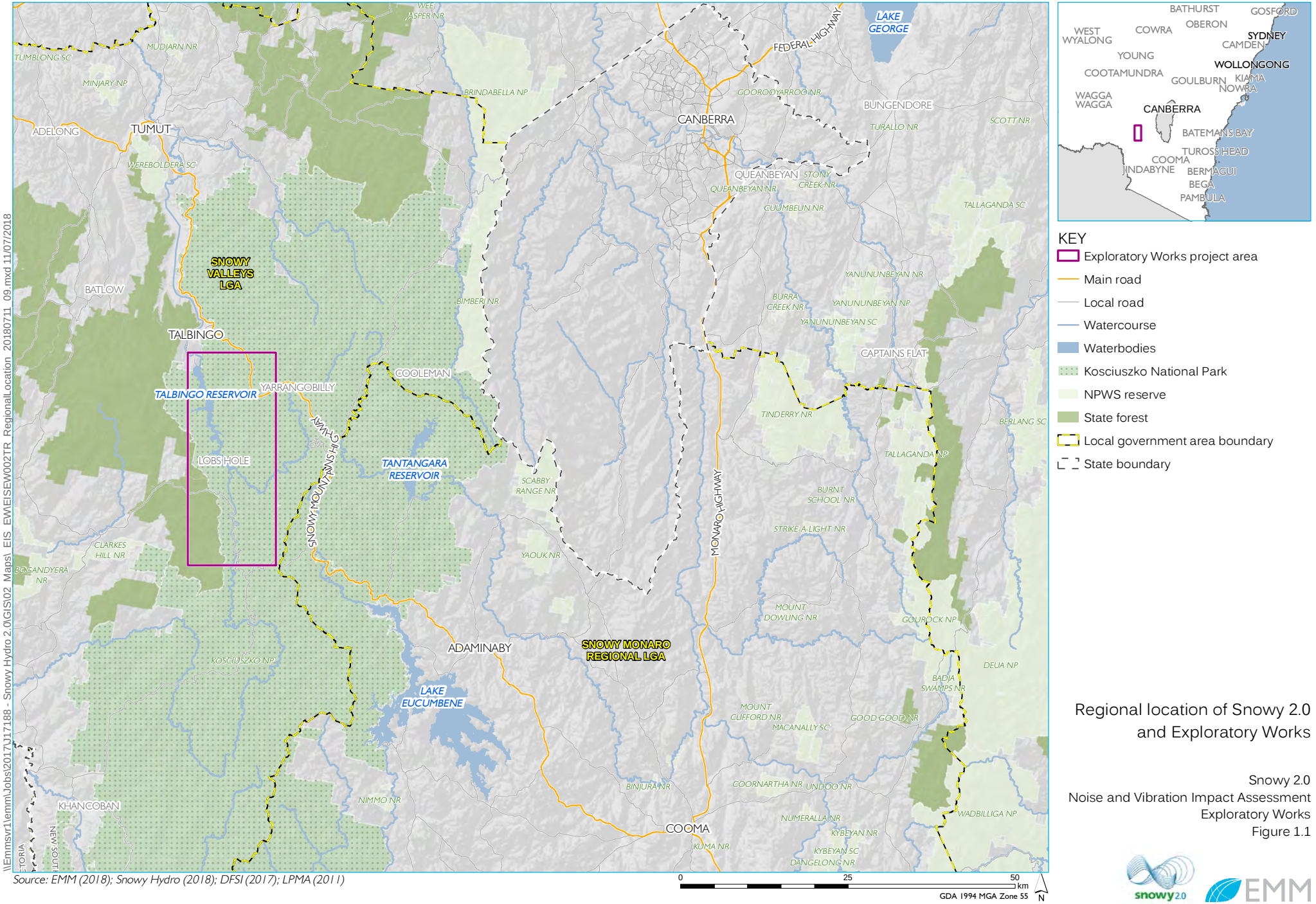
1.5 Assessment guidelines and requirements

This noise and vibration impact assessment has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) for Exploratory Works, issued on 17 May 2018 and revised on 20 June 2018, as well as relevant governmental 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 the construction noise, road noise and vibration impacts of the project	Section 6.



KEY

- Exploratory Works project area
- Main road
- Local road
- Watercourse
- Waterbodies
- Kosciuszko National Park
- NPWS reserve
- State forest
- Local government area boundary
- State boundary

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Source: EMM (2018); Snowy Hydro (2018); DFSI (2017); LPMA (2011)

Regional location of Snowy 2.0 and Exploratory Works

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 1.1

Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); DFSI (2017); LPMA (2011)

0 2.5 5 km

N

GDA 1994 MGA Zone 55

KEY

- Exploratory tunnel
- Access road upgrade
- Access road extension
- Communications cable
- Main road
- Local road
- Major watercourse
- On land rock management
- Subaqueous excavated rock placement
- Disturbance footprint
- Avoidance footprint

Exploratory Works project area

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 1.2

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2 Project description

2.1 Overview

Exploratory Works comprises construction associated with geotechnical exploration for the underground power station for Snowy 2.0. The Exploratory Works elements are shown on Figure 2.1 and involve:

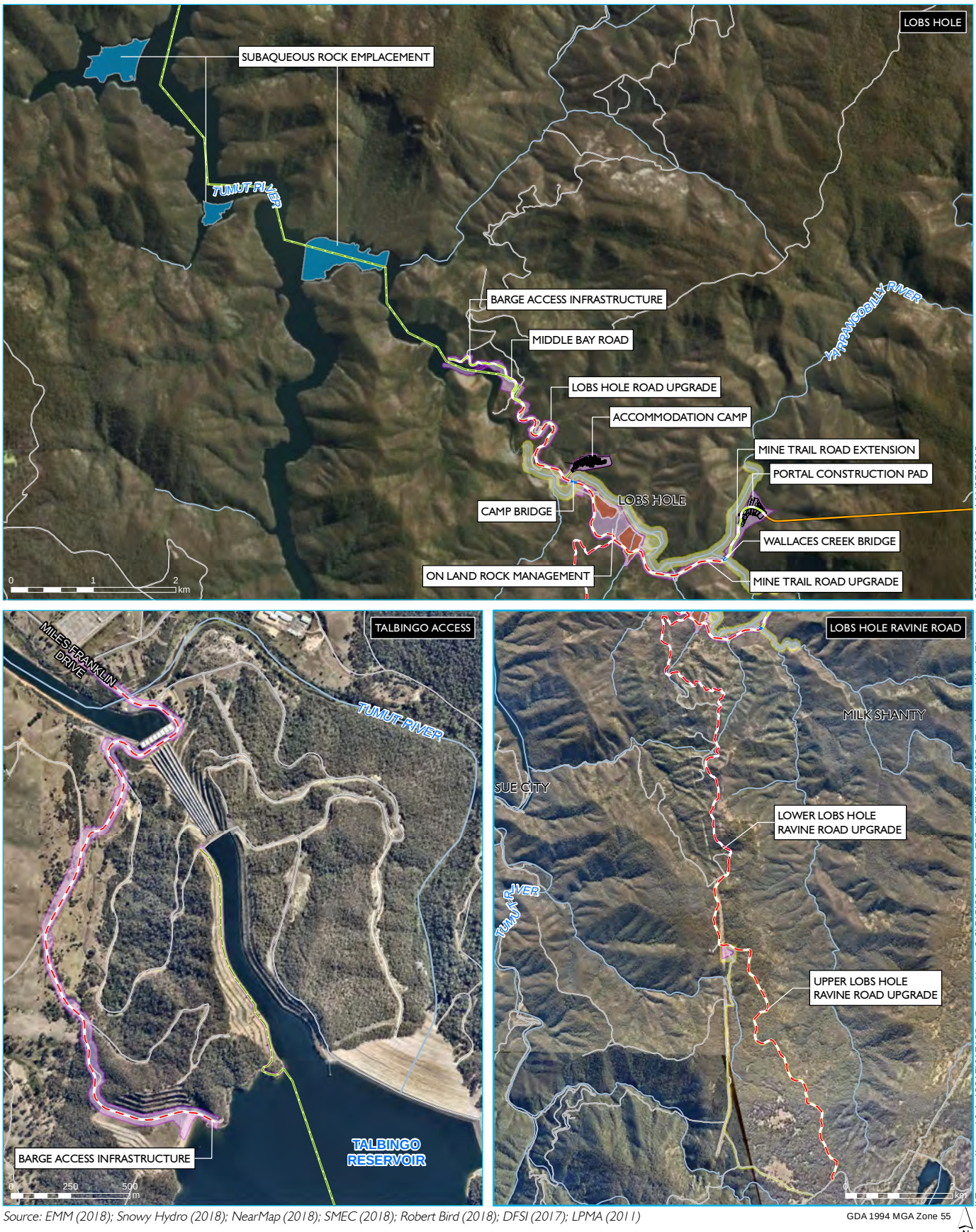
- establishment of an exploratory tunnel to the site of the underground power station for Snowy 2.0;
- horizontal and other test drilling, investigations and analysis in situ at the proposed cavern location and associated areas, and around the portal construction pad, access roads and excavated rock management areas all within the disturbance footprint;
- establishment of a portal construction pad for the exploratory tunnel;
- establishment of an accommodation camp for the Exploratory Works construction workforce;
- road works and upgrades providing access and haulage routes during Exploratory Works;
- establishment of barge access infrastructure, to enable access and transport by barge on Talbingo reservoir;
- excavated rock management, including subaqueous placement within Talbingo Reservoir;
- establishment of services infrastructure such as diesel-generated power, water and communications; and
- post-construction revegetation and rehabilitation, management and monitoring.

2.2 Exploratory tunnel

An exploratory tunnel of approximately 3.1 km is proposed to provide early access to the location of the largest cavern for the underground power station. This will enable exploratory drilling and help optimise the location of the cavern which, in turn, will optimise the design of Snowy 2.0.

The exploratory tunnel is proposed in the north-east section of Lobs Hole and will extend in an east-west direction with the portal construction pad to be outside the western end of the tunnel at a site east of the Yarrangobilly River, as shown on Figure 2.2.

The location of the proposed exploratory tunnel and portal construction pad is shown in Figure 2.2. The exploratory tunnel will be excavated by drill and blast methods and have an 8 x 8 m D-Shaped cross section, as shown on Figure 2.3.



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Source: EMM (2018); Snowy Hydro (2018); NearMap (2018); SMEC (2018); Robert Bird (2018); DFSI (2017); LPMA (2011)

GDA 1994 MGA Zone 55

N

KEY

- Exploratory tunnel
- Access road upgrade
- Access road extension
- Permanent bridge
- Portal construction pad and accommodation camp conceptual layout
- Communications cable
- Local road or track
- Watercourse
- On land rock management
- Subaqueous rock emplacement area
- Disturbance footprint
- Avoidance footprint

Exploratory Works elements

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 2.1

snowy 2.0 EMM

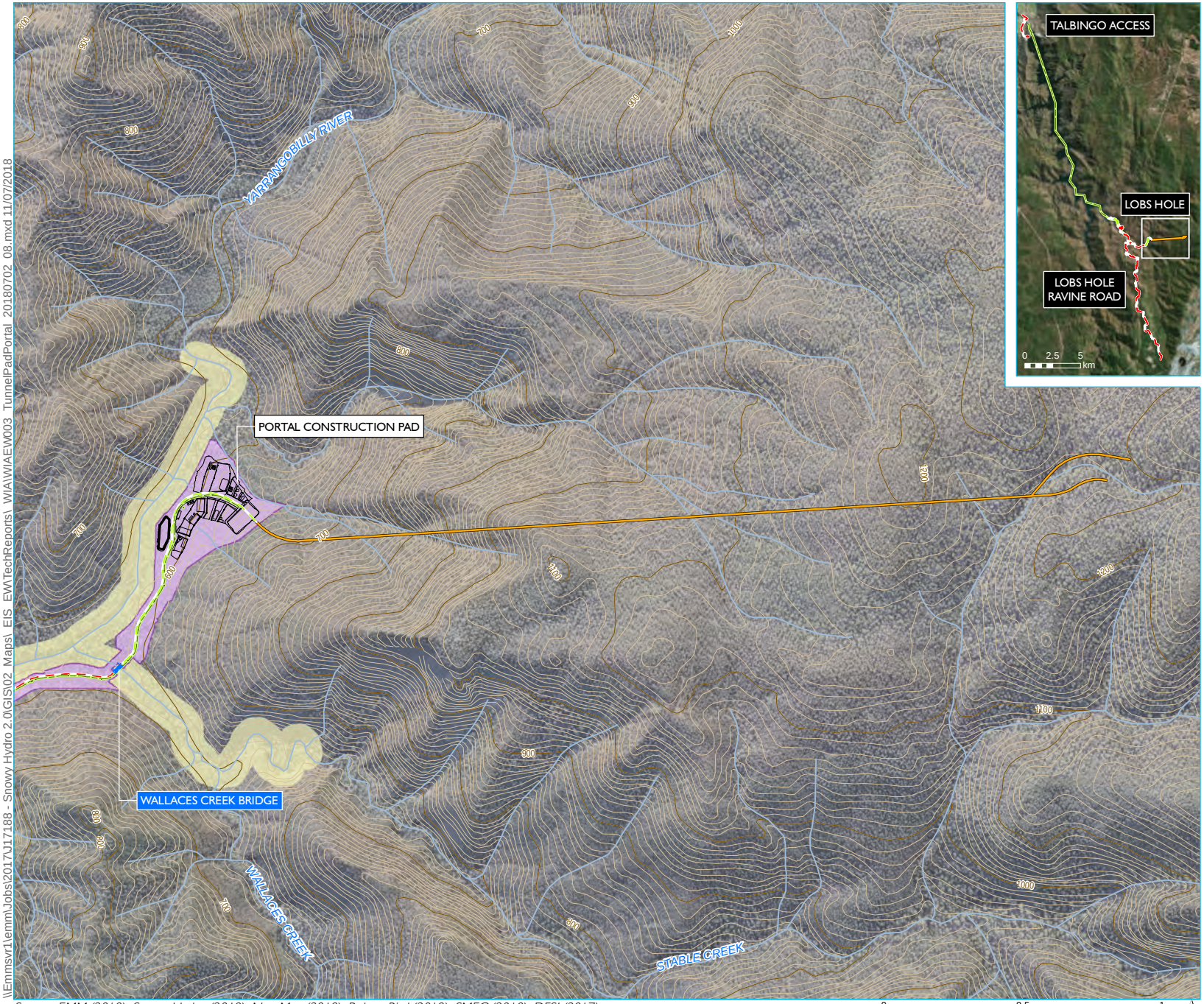
The drill and blast excavation process will be repeated cyclically throughout the tunnelling works, involving:

- marking up and drilling blast holes in a predetermined pattern in the working face of the tunnel;
- loading the blast holes with explosives, attaching detonators and connecting the holes into a blast sequence, and detonating the blast;
- ventilating the tunnel to remove blast fumes and dust;
- removing blasted rock;
- scaling and wash down of the tunnel roof and walls to remove loosened pieces of rock;
- geological mapping of the exposed rock faces and classification of the conditions to determine suitable ground support systems for installation;
- installing ground support; and
- advancing construction ventilation ducting and other utilities including power, water, compressed air and communications.

The exploratory tunnel will be shotcrete-lined with permanent anchor support, and incorporate a groundwater management system. The exploratory tunnel shape and dimensions are designed to allow two-lane traffic for the removal of excavated material, along with additional space for ventilation and drainage of groundwater inflows. Groundwater intersected during tunnelling will be contained and transferred to the portal for treatment and management. Areas identified during forward probing with the potential for high groundwater flows may require management through a detailed grouting program or similar.

The tunnel portal will be established at the western end of the exploratory tunnel and provide access and utilities to the exploratory tunnel during construction. The portal will house power, communications, ventilation and water infrastructure. The portal will also provide a safe and stable entrance to the exploratory tunnel.

It is anticipated that the exploratory tunnel will be adapted for multiple functions during construction of the subsequent stages of the Snowy 2.0 project. The exploratory tunnel will also eventually be utilized to form the main access tunnel (MAT) to the underground power station during the operational phase of Snowy 2.0, should it proceed.



\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02 Maps\ EIS EWTechReports\ WIA\WIAEW003 TunnelPadPortal 20180702 08.mxd 11/07/2018

Source: EMM (2018); Snowy Hydro (2018); NearMap (2018); Robert Bird (2018); SMEC (2018); DFSI (2017)

Exploratory tunnel location

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 2.2

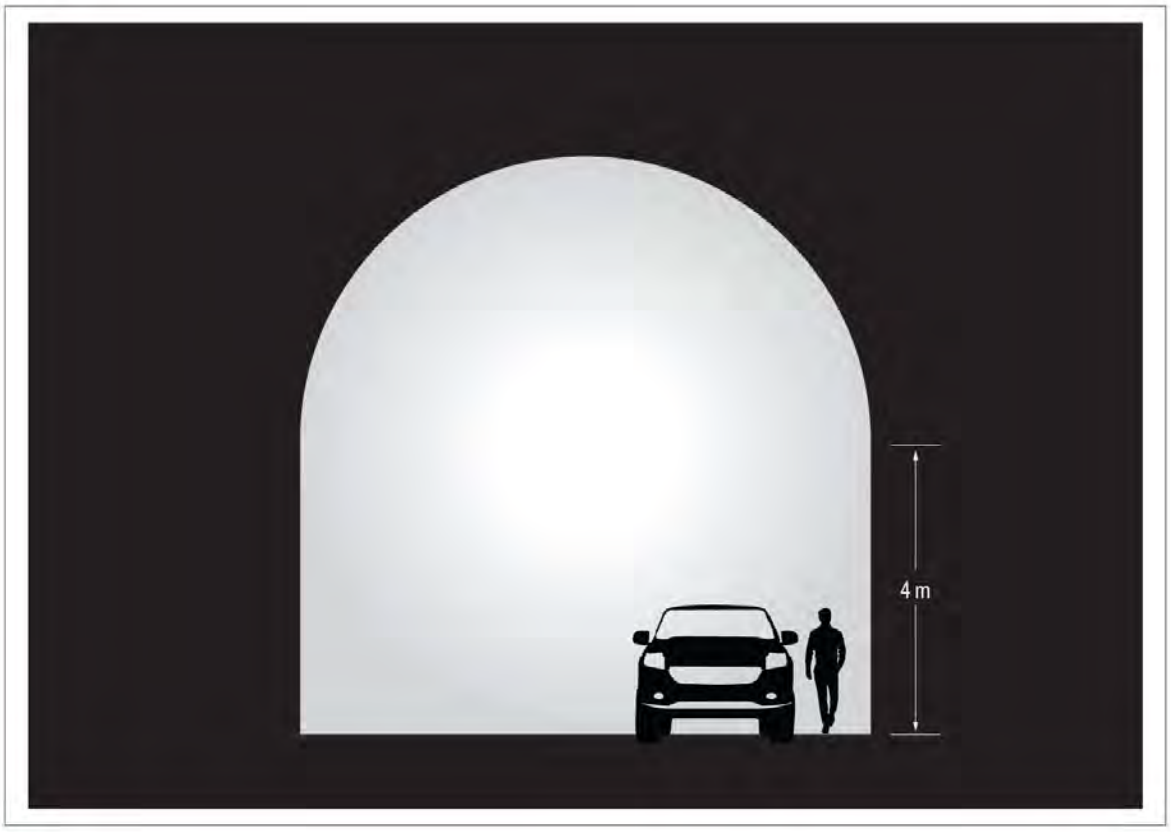
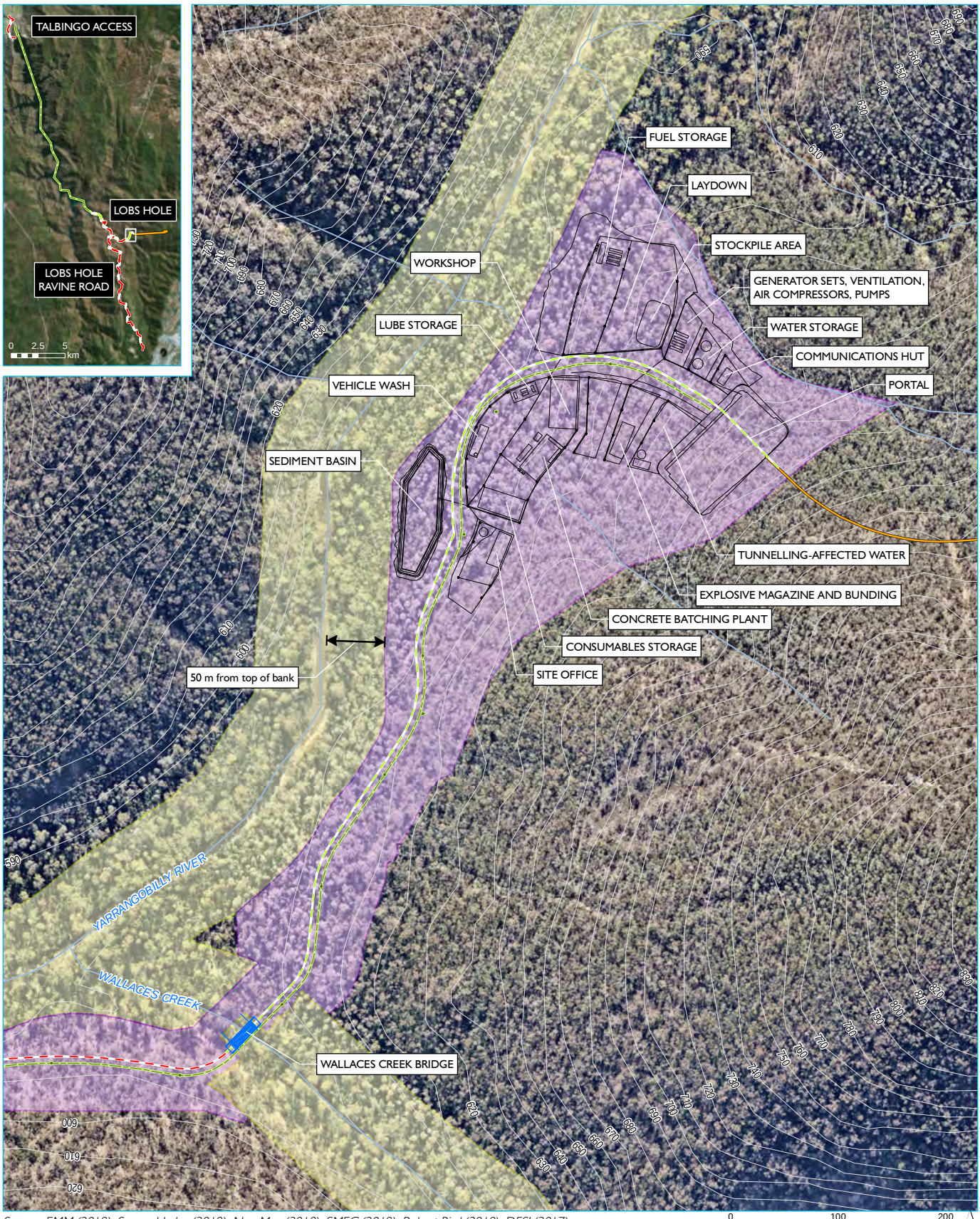


Figure 2.3 Exploratory tunnel indicative cross section

2.3 Portal construction pad

A portal construction pad for the exploratory tunnel will provide a secure area for construction activities. Infrastructure at the portal construction pad, shown in Figure 2.4, will primarily support tunnelling activities and include a concrete batching plant and associated stockpiles, site offices, maintenance workshops, construction support infrastructure, car parking, equipment laydown areas. Stockpile areas will allow for around two to three months supply of concrete aggregate and sand for the concrete batching plant to ensure that the construction schedule for the proposed access road works do not interfere with the exploratory tunnel excavation schedule. A temporary excavated rock stockpile area is also required to stockpile material excavated during tunnel construction prior to its transfer to the larger excavated material emplacement areas.

The portal construction pad will be at the western end of the exploratory tunnel. The portal construction pad will be excavated to provide a level construction area with a near vertical face for the construction of the portal and tunnelling. The area required for the portal construction pad is approximately 100,000 m^2.



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Source: EMM (2018); Snowy Hydro (2018); NearMap (2018); SMEC (2018); Robert Bird (2018); DFSI (2017)

0 100 200 m
GDA 1994 MGA Zone 55

N

KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable
- Watercourse
- Contour (10m)
- Disturbance footprint
- Avoidance footprint

Conceptual layout – portal construction pad

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 2.4

2.4 Excavated rock management

It is estimated that approximately 750,000 m^3 of bulked materials will be excavated, mostly from the exploratory tunnel and portal construction pad with additional quantities from road upgrade works. Subject to geochemical testing of the rock material, excavated rock will be placed either on land or subaqueously within Talbingo Reservoir.

2.4.1 On land placement

Excavated materials will be placed in one of two rock emplacement areas at Lobs Hole as shown on Figure 2.5.

The strategy for excavated rock management is for excavated material to be emplaced at two areas with the final placement of excavated material to be determined at a later date.

Consultation with NPWS throughout the design process has identified an opportunity for the eastern emplacement area to form a permanent landform that enables greater recreational use of Lobs Hole following the completion of Snowy 2.0's construction. It is envisaged that the excavated rock emplacement area will provide, in the long-term, a relatively flat final landform suitable for camping and basic recreational facilities to be confirmed in consultation with NPWS.

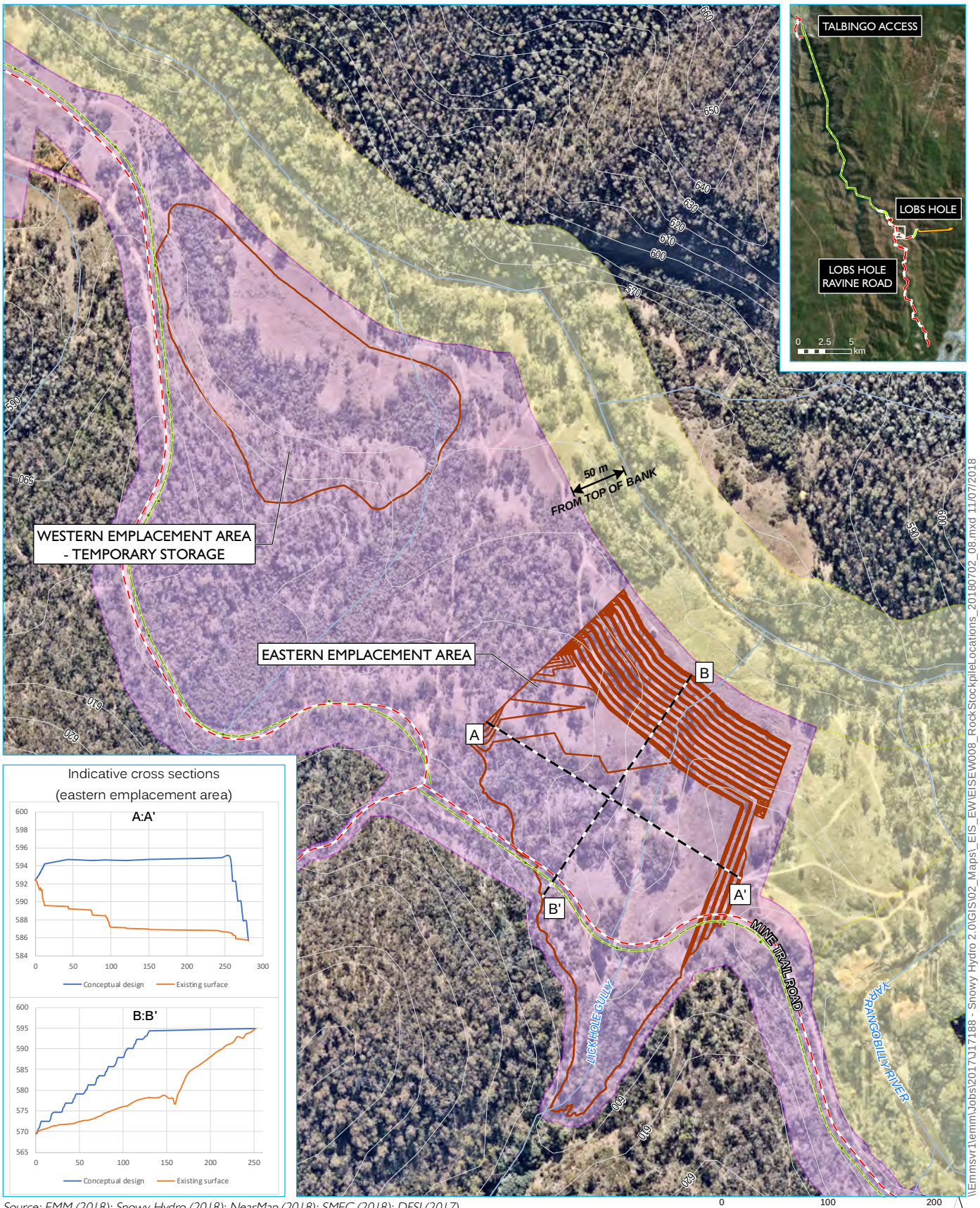
The eastern emplacement area has a capacity of up to 600,000 m^3 of material. It will be approximately 25 m maximum depth and will be benched down to the northern edge of the emplacement which is setback 50 m from the Yarrangobilly River.

The western emplacement area will be used to store excavated material should it not be able to be placed within the eastern emplacement area. It is envisaged this emplacement area will be used to store excavated materials suitable for re-use within the construction of Exploratory Works or for use by NPWS in KNP maintenance activities. All remaining material placed in this emplacement area will be removed following the completion of Exploratory Works.

The guiding principles for the design, construction method and management of emplacement areas undertaken for Exploratory Works have been as follows:

- reducing potential for acid rock drainage from the excavated rock emplacement area entering the Yarrangobilly River or forming groundwater recharge;
- avoid known environmental constraints; and
- manage existing surface water flows from Lick Hole Gully.

The design and management of the emplacement areas have not yet been finalised due to the need for further investigations to determine the likely geochemical characteristics of the excavated material. Following further investigation and prior to construction of Exploratory Works a management plan will be prepared and implemented.



Indicative cross sections (eastern emplacement area)

Source: EMM (2018); Snowy Hydro (2018); NearMap (2018); SMEC (2018); DFSI (2017)

KEY

- Cross-section
- Exploratory tunnel
- Access road upgrade
- Access road extension
- Communications cable
- On land rock management
- Watercourse
- Contour (10m)
- Disturbance footprint
- Avoidance footprint

Conceptual layout – excavated material emplacement areas

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 2.5

\\Emmsvr1\emmJobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EW\EISEW008_RockStockpileLocations_20180702_08.mxd 11/07/2018

2.4.2 Subaqueous placement

An intial program for the placement of excavated rock within Talbingo Reservoir also forms part of Exploratory Works. The program will be implemented in an appropriate section of Talbingo Reservoir in accordance with a detailed management plan based on an engineering method informed through the materials' geochemistry and reservoir's characteristics. The purpose of the program is to confirm the suitability of the emplacement method for future excavated rock material from the construction of Snowy 2.0, should it proceed.

The rock for subaqueous placement will be taken from the excavated rock emplacement areas as described above. Testing of the rock would be conducted during excavation to assess geochemical properties. Any rock assessed as unsuitable for subaqueous placement based on the prior geochemical and leachability testing would be separately stockpiled and not used in the program. Suitable (ie non-reactive material) would be transported and loaded to barge, for placement at the deposition area. Suitable placement locations have been identified for Exploratory Works and are shown indicatively on Figure 2.6.

All placement within the reservoir would occur within silt curtains and would be subject to a detailed monitoring regime including survey monitoring of pre-placement and post-placement bathymetry, local and remote background water quality monitoring during placement with a structured management response to monitoring results in the event of an exceedance of established triggers. The management, mitigation and monitoring measures would be refined following the ongoing investigations.

2.5 Accommodation camp

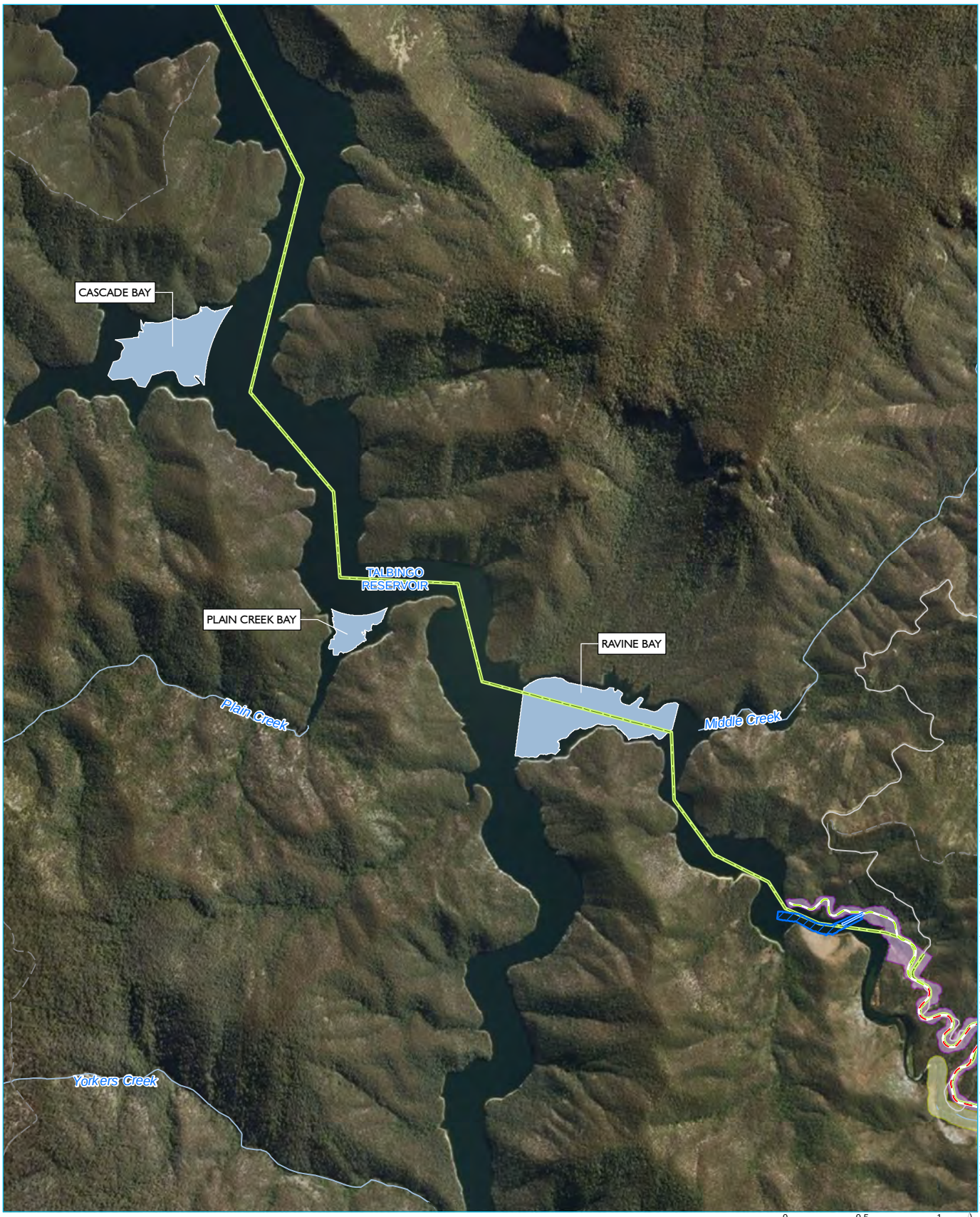
An accommodation camp is proposed to provide accommodation and supporting services for workers in close proximity to the exploratory tunnel. The accommodation camp layout is shown on Figure 2.7 and includes ensuite rooms surrounding central facilities including a kitchen, tavern, gym, admin office, laundry, maintenance building, sewage and water treatment plants and parking that will service the Exploratory Works workforce. The accommodation camp access road will connect to the north side of Lobs Hole Road at Lobs Hole. The conceptual layout of the accommodation camp is shown on Figure 2.7.

2.6 Road and access provisions

Existing road and access will need to be upgraded to a suitable standard to:

- provide for the transport of excavated rock material between the exploratory tunnel 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 staff to the portal construction pad.

Given the topographic constraints of the area, the standard of the existing roads and the environmental values associated with KNP, the option of barging larger and oversized loads to the site is available. This is discussed further at Section 2.7.



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

0 0.5 1 km
GDA 1994 MGA Zone 55

N

T:\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EW\EISEW034_IndicativeExcavatedMaterialPlacement_20180702_07.mxd 11/07/2018

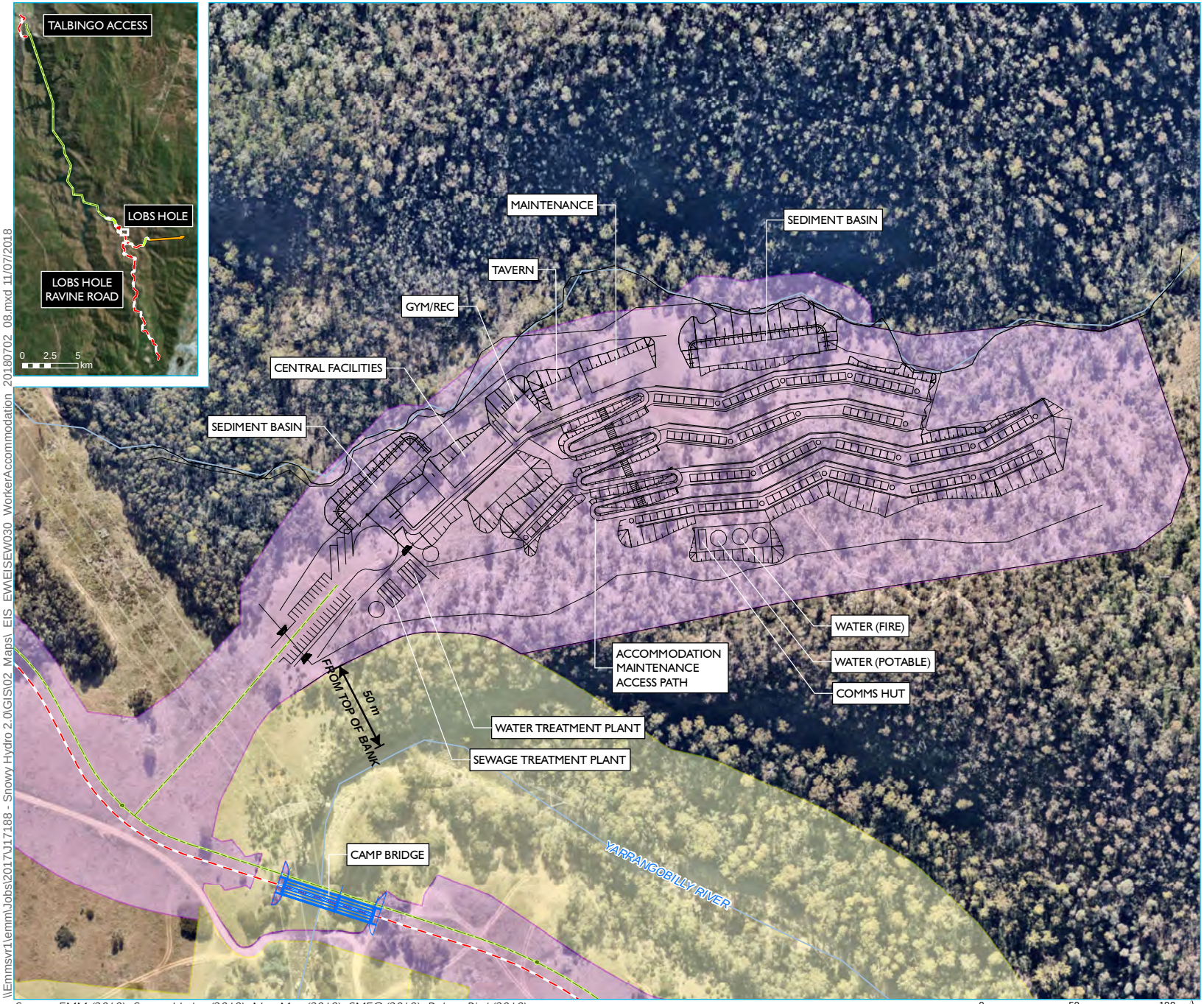
KEY

- Access road upgrade
- Access road extension
- Communications cable
- Subaqueous rock emplacement
- Major watercourse
- Local road
- Track
- Middle Bay barge access
- Disturbance area - barge infrastructure
- Disturbance footprint
- Avoidance footprint

Subaqueous excavated rock placement

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 2.6

snowy 2.0 EMM



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Source: EMM (2018); Snowy Hydro (2018); NearMap (2018); SMEC (2018); Robert Bird (2018)

Conceptual layout – accommodation camp

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 2.7

2.6.1 Access road works

The access road upgrades will be designed based on access for a truck and dog trailer. The proposed road works are shown in Figure 2.8 and described in Table 2.1. It is expected that the majority of materials and equipment will travel along the Snowy Mountains Highway, Link Road and Lobs Hole Ravine Road, with some required to travel on Miles Franklin Drive via Talbingo to Talbingo Dam Wall and be transferred via a barge to site. The primary haul routes for construction material on site are provided in Figure 2.9. Where existing roads are replaced by new access roads or road upgrades, the existing roads will be removed and rehabilitated in line with the rehabilitation strategy for Exploratory Works.

Table 2.1 Access road works summary

Roadwork area	Overview
Upper Lobs Hole Ravine Road upgrade	Minor upgrades to 7.5 km section of existing road. Only single lane access will be provided. No cut and fill earthworks or vegetation clearing will be undertaken.
Lower Lobs Hole Ravine Road upgrade	Upgrades to 6 km section of existing road involving cut and fill earthworks in some sections. Only single lane access will be provided.
Lobs Hole Road upgrade	Upgrade to 7.3 km section of existing road providing two-way access.
Mine Trail Road upgrade	Upgrade to 2.2 km section of existing track to two-way access.
Mine Trail Road extension	Establishment of a new two-way road providing access to the exploratory tunnel portal.
Middle Bay Road	Establishment of a new two-way road to the proposed Middle Bay barge ramp.
Spillway Road	Upgrade of a 3 km section of existing road to provide two-way access to the proposed Spillway barge ramp.

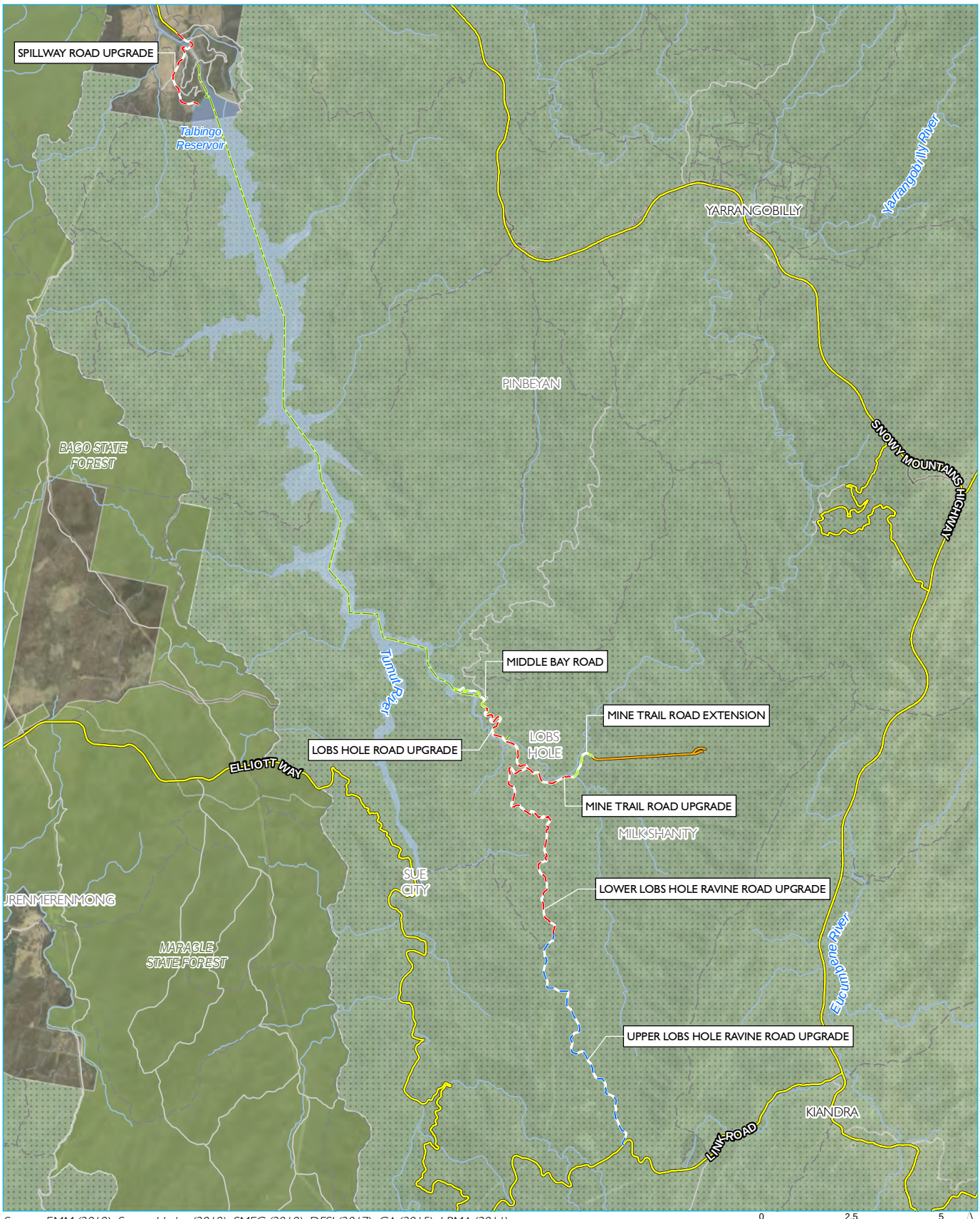
While no cut and fill earthworks or vegetation clearing is proposed along Upper Lobs Hole Ravine Road, a laydown area is proposed within and adjacent to the existing transmission line easement. This area will be used to store materials required for the road works to the lower section of Lobs Hole Ravine Road.

2.6.2 Watercourse crossings

Bridge construction will be required at two locations as described in Table 2.2. The locations of proposed bridge works are shown in Figure 2.9.

Table 2.2 Watercourse crossing summary

Bridge works area	Overview
Camp bridge	An existing crossing on Yarrangobilly River will be used as a temporary crossing while a new permanent bridge is built as part of Lobs Hole Road upgrade. The existing crossing will require the crossing level to be raised with rocks to facilitate vehicle passage. The rocks used to raise the crossing level will be removed and the crossing no longer used once the permanent bridge has been constructed. The new bridge (Camp Bridge) will be a permanent crossing and used for both Exploratory Works and Snowy 2.0 main works, should it proceed.
Wallaces Creek bridge	Establishment of a new permanent bridge at Wallaces Creek as part of the Mine Trail Road extension. Establishment of this bridge will require an initial temporary pre-fabricated 'Bailey bridge' to be constructed, which will be removed before the end of Exploratory Works.



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

0 2.5 5 km
GDA 1994 MGA Zone 55

N

KEY

- Access road upgrade - without widening
- Access road upgrade - with widening
- Access road extension
- Exploratory tunnel
- Communications cable
- Main road
- Local road
- Vehicular track
- Perennial watercourse
- Scheme storage
- Kosciuszko National Park
- State forest

Access road upgrades and establishment

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 2.8

snowy 2.0 EMM

\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02 Maps\ EIS EWEISEW005 ExcavatedRockHaulRoute 20180702 10.mxd 11/07/2018

Source: EMM (2018); Snowy Hydro (2018); NearMap (2018); SMEC (2018); Robert Bird (2018); DFSI (2017)

Excavated material haul route

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 2.9

The design for permanent bridges at both crossings will consist of steel girders with a composite deck. This is the most common type of permanent bridge constructed in and around the existing Snowy Scheme. Lightweight steel girders are easy to transport and will therefore allow for efficiencies in the construction schedule and permit the use of smaller-scale lifting equipment at the construction site.

2.7 Barge access infrastructure

To provide an alternative to road access, a barge option is proposed, not only for bulky and heavy equipments but for materials and also in case of emergency. During Exploratory Works, barges will be loaded at the northern barge ramp (Talbingo barge ramp), travel about 18 km along Talbingo Reservoir and be unloaded at the southern barge ramp (Middle Bay barge ramp) before returning to the north. Some loads may also be transported in the reverse direction.

Barge access infrastructure will comprise two dedicated barge ramps at Middle Bay and Talbingo Spillway, with a slope of approximately 1 vertical to 10 horizontal (1V: 10H) at each location. A navigation channel is also required adjacent to the Middle Bay barge ramp. Construction will involve:

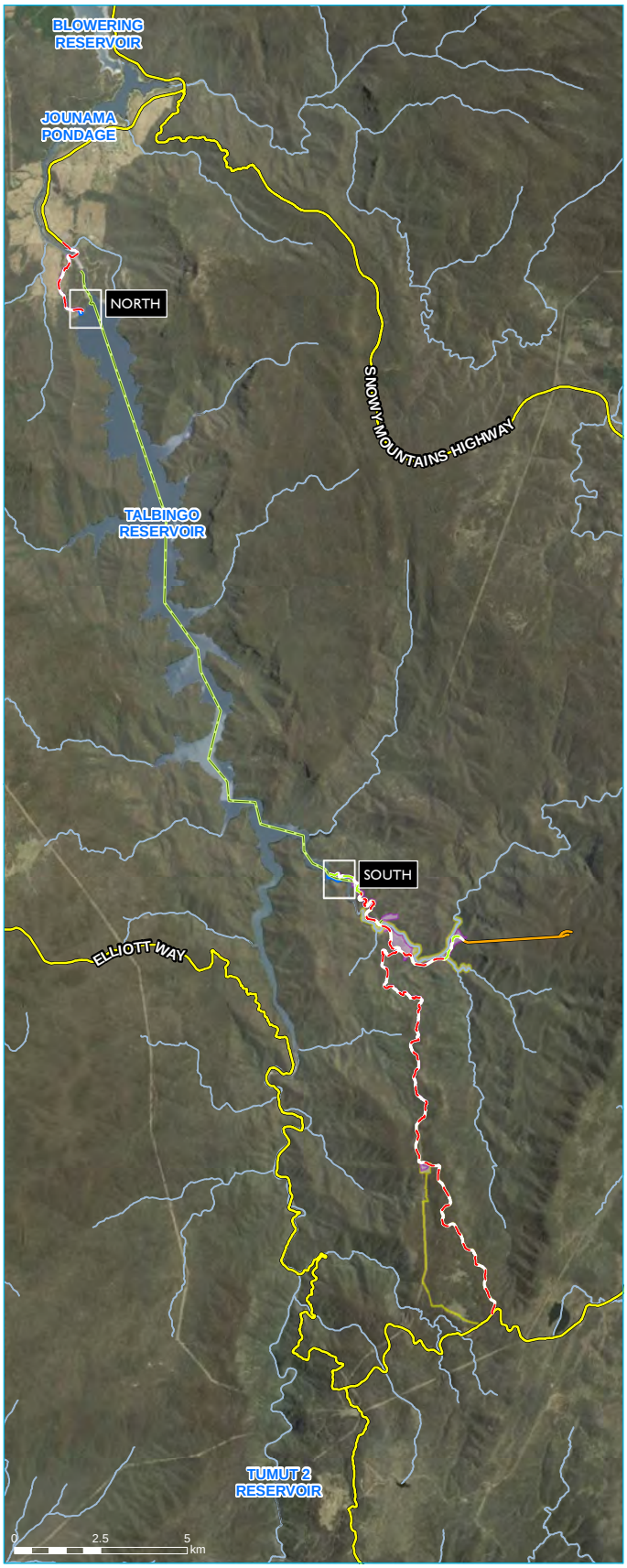
- geophysical and geotechnical investigation of the barge access area to inform detailed design;
- site establishment and excavation of barge access area;
- installation of precast concrete panels at the ramp location;
- installation of bollards for mooring lines;
- removal of trees and debris to establish a navigation channel allowing barge access; and
- minor dredging to allow barge access at the reservoir minimum operating level.

To facilitate construction, laydown areas are proposed adjacent to the Middle Bay barge ramp and adjacent to the water inlet pipeline. Laydown will also be used within the footprint of the Talbingo barge ramp.

Dredged material will be placed as part of the subaqueous placement program or within one of the designated on land rock emplacement areas. The infrastructure proposed for the Talbingo Spillway barge ramp and Middle Bay barge ramp is provided in Figure 2.10.

2.8 Services and infrastructure

Exploratory Works will require additional power and communication infrastructure. Water services are also needed and include a water services pipeline and water and waste water (sewage) treatment facilities. A summary of services required is provided at Table 2.3.



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Source: EMM (2018); Snowy Hydro (2018); NearMap (2018); SMEC (2018); DFSI (2017); LPMA (2011)

GDA 1994 MGA Zone 55

N

KEY

- Exploratory tunnel
- Access road upgrade
- Access road extension
- Communications cable
- Main road
- Local road or track
- Perennial watercourse
- Middle Bay barge access
- Disturbance area - barge infrastructure
- Disturbance footprint
- Avoidance footprint

Barge access locations

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 2.10

Table 2.3 Summary of services and infrastructure

Services infrastructure	Description
Power	Power will be provided at the portal construction pad and accommodation camp by diesel generators, with fuel storage provided at the portal construction pad.
Communication	Communication will be provided via fibre optic link. The fibre optic service has been designed to incorporate a submarine cable from Tumut 3 power station across Talbingo Reservoir to Middle Bay, and then via a buried conduit within the access roads to the accommodation camp and the portal construction pad.
Water and waste water (sewage)	A water services pipeline is proposed for the supply and discharge of water for Exploratory Works which will pump water between Talbingo Reservoir and the exploratory tunnel portal, portal construction pad and accommodation camp.
	A package water treatment plant is proposed at the accommodation camp to provide potable water to the accommodation camp and portal construction pad facilities and will be treated to a standard that complies with the Australian Drinking Water Guidelines. The accommodation camp water supply will be pumped via the water pipeline from Talbingo Reservoir at Middle Bay.
	A package waste water (sewage) treatment plant (STP) is proposed at the accommodation camp for Exploratory Works waste water. The STP will produce effluent quality comparable to standard for inland treatment facilities in the region (eg Cabramurra). Following treatment waste water will be discharged to Talbingo reservoir via the water services pipeline connecting the accommodation camp to Talbingo Reservoir.
	Waste water from the exploratory tunnel and concrete batching plant will be either re-used on site or sent to the waste water treatment plant for treatment prior to discharge.

2.9 Construction and schedule

2.9.1 Geotechnical investigation

To assist the design development for the portal construction pad, accommodation camp, Middle Bay Road, Spillway Road, and Lobs Hole Ravine Road, further survey of ground conditions is required. A program of geotechnical investigations including geophysical survey, construction of test pits, and borehole drilling within the disturbance footprint, will be undertaken as part of construction activities. Excavation of test pits in areas where information on relatively shallow subsurface profiles is required, or where bulk sampling is required for laboratory testing. Borehole drilling is required to facilitate the detailed design of cuttings, bridge foundations, retaining wall foundations, and drainage structures.

2.9.2 Construction activities

A disturbance footprint has been identified for Exploratory Works. The extent of the disturbance footprint is shown on Figure 2.1 and shows the area required for construction, including the buildings and structures, portal construction pad, road widening and bridges, laydown areas, and rock emplacement areas. Typical construction activities that will occur within the footprint are summarised in Table 2.4.

Table 2.4 Construction activities

Activity	Typical method
Geophysical and geotechnical investigation	Geophysical surveys will generally involve: • laying a geophone cable at the required location and establishing seismic holes; • blasting of explosives within seismic holes; and • in-reservoir geophysics surveys will use an air gun as the seismic source. Geotechnical surveys will generally involve: • establishing a drill pad including clearing and setup of environmental controls where required; • drilling a borehole to required depth using a tracked or truck mounted drill rig; and • installing piezometers where required for future monitoring program. Geophysical and geotechnical investigation within Talbingo Reservoir will be carried out using barges and subject to environmental controls.
Site establishment for portal construction pad, accommodation camp, rock placement areas and laydown areas	Site establishment will generally involve: • identifying and flagging areas that are to be avoided during the Exploratory Works period; • clearing of vegetation within the disturbance footprint, typically using chainsaws, bulldozers and excavators; • civil earthworks to create a stable and level area suitable for establishment. This will involve a cut and fill approach where required to minimise the requirement for imported material; • installing site drainage, soil erosion and other permanent environmental controls where required; • surface finishing, compacting only existing material where possible, or importing additional material. Where suitable, this material will be sourced locally (eg from upgrade works to Lobs Hole Ravine Road); and • set up and commissioning of supporting infrastructure, including survey marks.
Road works	Upgrades of existing tracks (no widening) will generally involve: • identifying and flagging areas that are to be avoided during the Exploratory Works period; and • removing high points, infilling scours, levelling of rutting, and compacting surfaces. Extension or widening of existing tracks will generally involve: • identifying and flagging areas that are to be avoided during the Exploratory Works period; • installing site drainage, soil erosion and other permanent environmental controls where required; • clearing and earthworks within the disturbance footprint; and • placing road pavement material on the roadway.
Bridge works	Establishment of permanent bridges will generally involve: • installing erosion and sedimentation controls around watercourses and installing scour protection as required; • establishing temporary diversions within the watercourse where required, including work to maintain fish passage; • establishing temporary bridges to facilitate permanent bridge construction; • constructing permanent bridges including piling, establishment of abutments and piers; and • removal and rehabilitation of temporary bridges and diversions.
Barge access works	Establishment of barge access infrastructure will generally involve: • installing sediment controls; • excavating and dredging of barge ramp area and navigation channel; • installing precast concrete planks and bollards; and • set up and commissioning of supporting infrastructure.

Table 2.4 Construction activities

Activity	Typical method
Exploratory tunnel construction	The drill and blast excavation process will be repeated cyclically throughout the tunnelling works, involving: • marking up and drilling blast holes in a predetermined pattern in the working face of the tunnel; • loading the blast holes with explosives, attaching detonators and connecting the holes into a blast sequence, and detonating the blast; • ventilating the tunnel to remove blast fumes and dust; • removing blasted rock; • scaling and wash down of the tunnel roof and walls to remove loosened pieces of rock; • geological mapping of the exposed rock faces and classification of the conditions to determine suitable ground support systems for installation; • installing ground support; and • advancing construction ventilation ducting and other utilities including power, water, compressed air and communications.

2.9.3 Ancillary construction areas

Ancillary facilities and laydown areas have been identified within the conceptual layout for the portal construction pad and accommodation camp. A number of other indicative construction and laydown areas have also been identified to support Exploratory Works. A summary of these sites are:

- Upper Lobs Hole Ravine Road laydown area;
- rock emplacement area laydown, storage and ancillary uses;
- barge access infrastructure laydown areas at Talbingo and Middle Bay; and
- other minor laydown areas as needed during site establishment of watercourse crossings.

All laydown areas are within the disturbance footprint identified for Exploratory Works.

In addition, an area near Camp Bridge has been identified to be used for a plant nursery and organic stockpile area.

2.9.4 Construction workforce requirements

i Staffing levels

It is currently expected that workforce for Exploratory Works will be approximately 200 people in total at peak construction. Workers are anticipated to work a 'swing' shift, for example two weeks on and one week off. These workers will be accommodated within the accommodation camp at Lobs Hole when rostered on.

The majority of the workforce will work on a fly-in fly-out and drive-in drive-out basis. It is expected that the majority of workers will fly in and out of either Cooma Airport or Canberra Airport and then travel to site via bus.

During construction of the accommodation camp, workers will be accommodated at Cabramurra. Some workers may also be accommodated at Snowy Hydro existing accommodation units at Talbingo during construction of the Talbingo barge ramp. No accommodation will be required outside of Cabramurra, the construction accommodation camp or Talbingo for the Exploratory Works workforce.

ii Hours of operation

It is expected that construction of the exploratory tunnel and haulage of rock material between the tunnel and excavated rock stockpile locations at Lobs Hole will be 24 hours a day, seven days a week for the duration of the tunnel drilling and blasting operation. Other construction activities, including the establishment works, road and infrastructure works, will normally work a 12 hour day, seven days a week.

The transport of materials along the haul route from Snowy Mountains Highway, Link Road and Upper Lobs Hole Ravine Road will only occur during day time hours (except during emergency), to avoid impacts to threatened species (Smoky Mouse). Transport by barge will be 24 hours a day, seven days a week.

2.9.5 Timing and staging

Exploratory Works are expected to take about 34 months, with the exploratory tunnel expected to be completed by late 2021.

It is expected that the construction works will be completed largely in parallel. However, road and access works are expected to be completed within the first six months from commencement. The proposed staging of construction activities are highlighted in Figure 2.11.

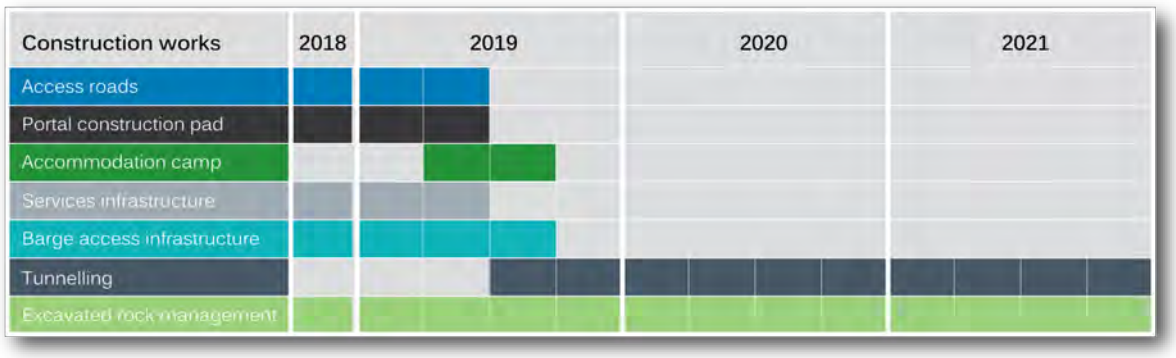


Figure 2.11 Indicative timing of Exploratory Works elements

2.10 Site rehabilitation

All Exploratory Works align with components of the main works for Snowy 2.0. However, should Snowy 2.0 not be approved or not progress, the project area will need to be rehabilitated, and project elements decommissioned in consultation with NPWS. Anticipated rehabilitation activities are summarised in Table 2.5.

Table 2.5 Planned Exploratory Works rehabilitation activities

Exploratory Works element	Indicative rehabilitation activities
Exploratory tunnel	Tunnel to remain open, and allowed to flood in lower portion provided groundwater impacts are negated.
Exploratory tunnel portal area	Permanent portal facade to be constructed, portal to be sealed from entry.
Portal construction pad and associated infrastructure	To be demobilised and all infrastructure removed. Site to be revegetated and returned to "original state".
Excavated rock emplacement areas	Emplaced excavated rock in the western emplacement area to be removed offsite and area to be revegetated and returned to "original state". The eastern emplacement area could remain in-situ and the landform rehabilitated as agreed with NPWS.
Accommodation camp	To be demobilised and all infrastructure removed. Site to be revegetated and returned to "original state".
Road access works	No remediation required as works are to be designed to be permanent.
Barge access infrastructure	No remediation works required as wharf and loading ramps are designed as permanent. Wharf can be removed if desired.
Services and infrastructure	To be demobilised and all infrastructure removed. Site to be revegetated and returned to "original state".

2.11 Decommissioning

Should Snowy 2.0 not proceed following the commencement or completion of Exploratory Works, elements constructed are able to be decommissioned and areas rehabilitated. Given works are within KNP, Snow Hydro will liaise closely with NPWS to determine the extent of decommissioning and types of rehabilitation to be undertaken. This approach will be taken to ensure that decommissioning allows for integration with future planned recreational use of these areas and to maintain the values of KNP.

2.12 Key aspects relevant to noise and vibration

Potential noise and vibration impacts have been identified for the proposed Exploratory Works and associated activities. This identification process has considered the proposed project activities and the types of potential impacts at noise and vibration sensitive receivers. The following aspects are considered relevant to this assessment:

- potential construction noise impacts on nearest noise sensitive receivers such as residents in Talbingo and recreation parks, camping grounds and tourist destinations in Kosciuszko National Park (KNP);
- potential blast vibration and overpressure impacts at residences;
- potential vibration impacts from blasting and from construction plant and equipment on existing infrastructure (eg roads and dams) and historic and aboriginal heritage items; and
- potential road traffic noise impacts on public roads due to project related traffic.

3 Existing environment

3.1 Site description

Snowy 2.0 is within both the Snowy Valleys and Snowy Monaro Regional local government areas (LGAs), and parts of the Snowy 2.0 project and the Exploratory Works are within KNP. The Exploratory Works would predominantly be in the Ravine region of the KNP. This region is between Talbingo Reservoir to the north-west and the Snowy Mountains Highway to the east which connects Adaminaby and Cooma in the south-east to Talbingo and Tumut to the north-west of the KNP. Talbingo Reservoir is an existing reservoir that forms part of the Snowy Scheme. The reservoir, approximately 50 km north-west of Adaminaby and approximately 30 km east-north-east of the township of Tumbarumba, is popular for recreational activities such as fishing, water skiing and canoeing.

The majority of the project area is within the KNP with the predominant land use being a conservation area (OEH 2011). The only element of the Exploratory Works occurring outside the KNP is the proposed barge access infrastructure at the north end of Talbingo reservoir. The western wharf location and access road upgrades at the north end of Talbingo reservoir are on land owned by Snowy Hydro near the Tumut 3 power station. The existing land uses at these locations are river and drainage system, tree and shrub cover, grazing and conservation area (OEH 2011).

The nearest large towns to the Exploratory Works would be Cooma and Tumut. Cooma is approximately 95 km south-east of Talbingo Reservoir. Tumut is approximately 45 km north of Talbingo Reservoir. There are several communities and smaller townships near the Exploratory Works project area including Talbingo, Tumbarumba, Batlow, Cabramurra and Adaminaby. Talbingo and Cabramurra were originally built for the original Snowy Scheme workers and their families. Adaminaby was relocated to alongside the Snowy Mountains Highway from its original location (now known as Old Adaminaby) in 1957 due to the construction of Lake Eucumbene. Talbingo and Adaminaby provide a base for users of the Selwyn Snow Resort in winter. Cabramurra was modernised and rebuilt in the early 1970s and is owned and operated by Snowy Hydro. It is still used to accommodate Snowy Scheme employees and contractors.

Other attractions and places of interest in the vicinity of the Exploratory 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 Exploratory 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.

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 camp ground and rest area	Passive recreation	623443	6035053
A6	Old Kiandra	Passive recreation	635905	6028711
A7	Selwyn Ski resort	Active recreation	631364	6025420
R2	Buddong Cottage	Residential	616339	6058255
R3	563-571 Murray Jackson Drive	Residential	616128	6059648
A8	Talbingo reservoir rest area	Passive recreation	619502	6051134
R4	Talbingo town	Residential	617997	6061517
A9	Yarrangobilly campground	Passive recreation	635163	6045458
R5	Talbingo Town#	Residential	617383	6061614
R6	6560 Snowy Mountains Highway#	Residential	650414	6021798
R7	6076 Snowy Mountains Highway#	Residential	653506	6018950
R8	6078 Snowy Mountains Highway#	Residential	652944	6018961
R9	6074 Snowy Mountains Highway#	Residential	653314	6018430
A10	Yarrangobilly Caves	Passive recreation	636019	6044413
R10	Yarrangobilly Village	Residential	634841	6045443
R11	Private properties at Nurrenmerenmong	Residential	615307	6040979
A11	Three Mile Campground	Passive recreation	630753	6027410

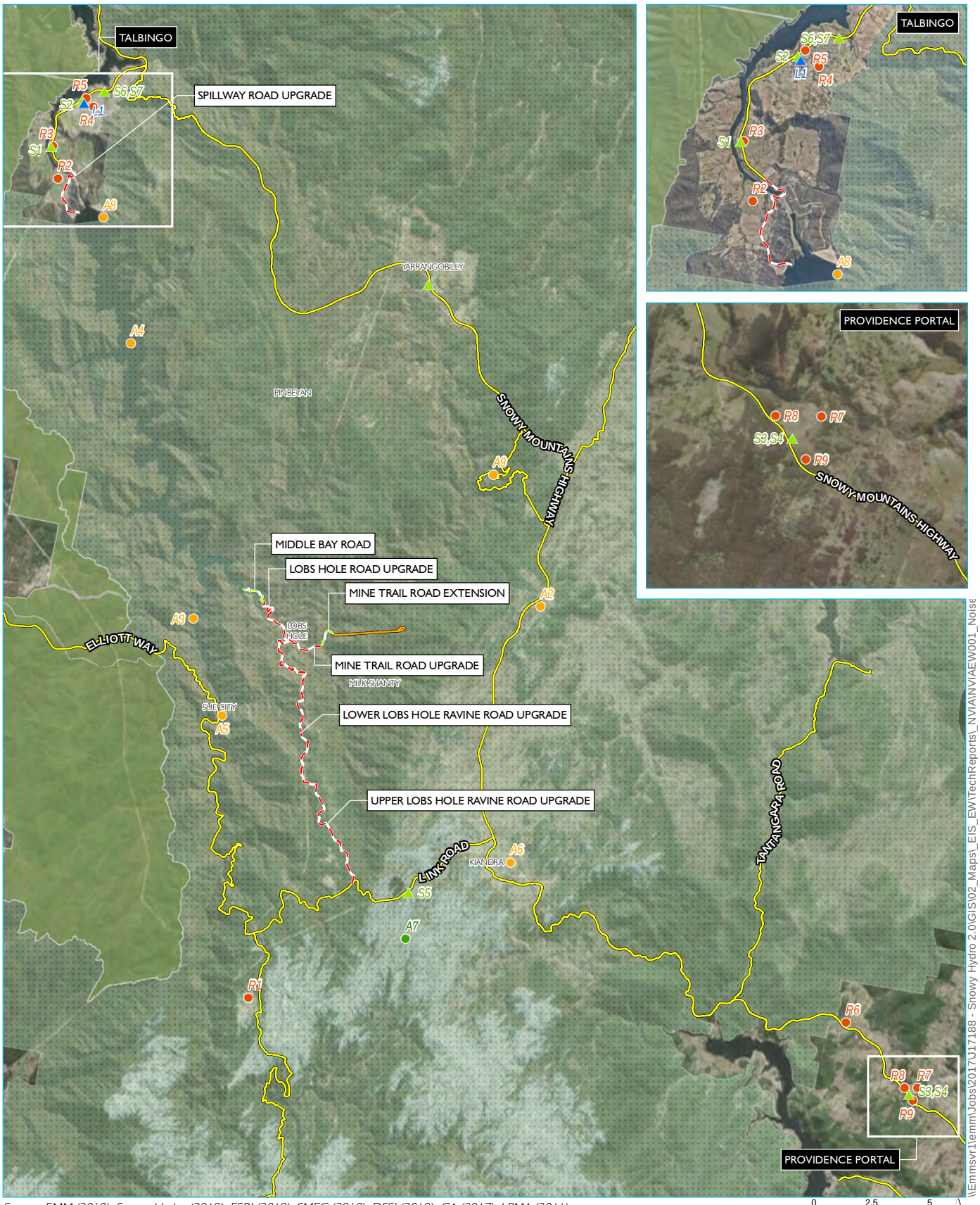
** Owned by the proponent*

 # Road traffic noise assessed only

The majority of assessment locations identified in the region of the Exploratory Works are passive and active recreation areas. These include recreation areas such as Yarrangobilly campground (to the north), Bullocks Hill campground (to the east), Selwyn Ski resort (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 Exploratory Works road traffic noise are residences and camp grounds in the vicinity of Miles Franklin Drive, Talbingo, and on the Snowy Mountains Highway between Cooma and Talbingo. Other assessment locations in the vicinity of The Link Road, between the Snowy Mountains Highway and Lobs Hole Ravine Road, may also be affected by road traffic noise. These assessment locations are shown in Figure 3.1.

The assessment locations potentially most exposed to construction vibration from the exploratory works are Aboriginal and European heritage sites in and around Lobs Hole Ravine, Yarrangobilly Caves as well as electricity transmission line pylons in the vicinity of the exploratory works area. These assessment locations are shown in Figure 3.2.



\\Emmsvr1\emmJobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EW\TechReports_NVIA\NVIAEW001_Noise

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

0 2.5 5 km
GDA 1994 MGA Zone 55

N

KEY

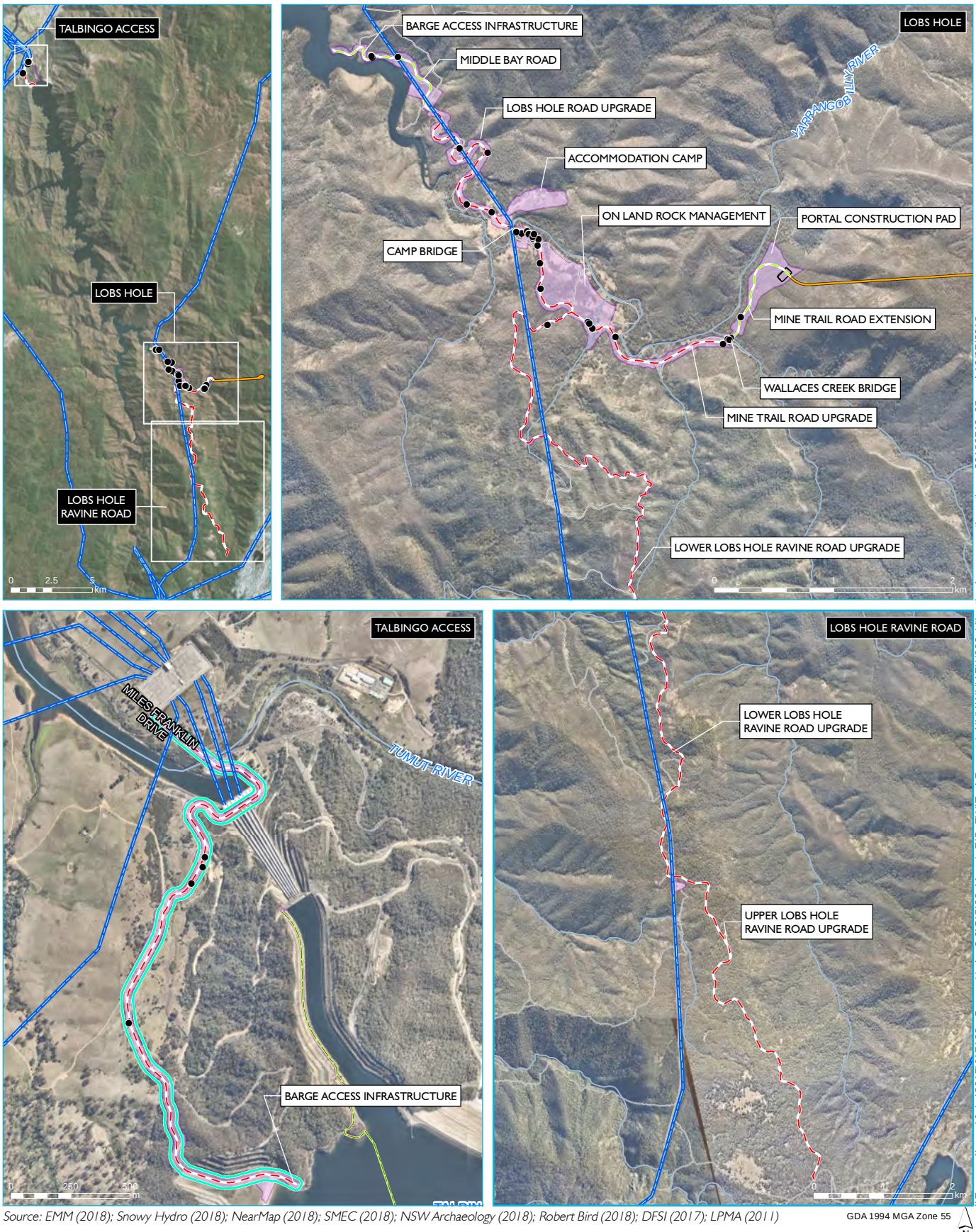
- Exploratory tunnel
- Access road upgrade
- Access road extension
- Main road
- Kosciuszko National Park
- State forest
- Attended noise monitoring location
- Unattended noise monitoring location

Receptors

- Passive recreation
- Active recreation
- Residential

Noise monitoring and assessment locations

Snowy 2.0
Noise and Vibration Impact Assessment
Exploratory Works
Figure 3.1



Source: EMM (2018); Snowy Hydro (2018); NearMap (2018); SMEC (2018); NSW Archaeology (2018); Robert Bird (2018); DFSI (2017); LPMA (2011)

GDA 1994 MGA Zone 55

KEY

- Access road upgrade
- Access road extension
- Exploratory tunnel
- Main road
- Local road or track
- Watercourse
- Disturbance footprint
- Vibration assessment location
- Heritage site
- Electricity transmission line

Vibration assessment locations

Snowy 2.0
Noise and vibration impact assessment
Exploratory Works
Figure 3.2

3.3 Background noise survey

In order to establish the existing ambient noise environment of the area, both unattended and short-term operator-attended noise surveys were conducted at the monitoring locations in general accordance with the procedures described in Australian Standard AS 1055-1997 - *Acoustics - Description and Measurement of Environmental Noise*. One noise logger was placed in the yard of a residence in 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. Operator-attended noise monitoring was undertaken at the logger location and several other locations, as shown in Figure 3.1, to gain an understanding of the existing acoustical environment, particularly in relation to existing noise from road traffic.

The unattended measurements were carried out using 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).

The noise logger was 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 measurements. 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.

A summary of existing background and ambient noise levels is given in Table 3.2. Results are provided for each day in Appendix A.

Table 3.2 Summary of existing background and ambient noise

Monitoring location	Period	Rating Background Level[1] (RBL), dB	Measured $L_{Aeq, period}$ Noise Level[2], dB
L1 – Brownlie Court, Talbingo	Day	35	48
	Evening	30	47
	Night	30	35

Notes: *1. 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.*

2. The energy averaged noise level over the measurement period and representative of general ambient noise.

3. 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, Morning Shoulder: 5 am to 7 am

EMM completed attended noise measurements on 19 and 20 March and 4 April 2018 at a number of locations (Figure 3.1), to identify noise sources contributing to the ambient noise environment.

Operator attended measurements were conducted using Brüel & Kjær Type 2250 integrating sound level meters (serial numbers 2759405 and 3008201, respectively) to both quantify and qualify the existing noise sources. Field calibration of the instrument was completed using a Brüel & Kjær type 4230 calibrator. Meteorological conditions throughout the survey period were relatively calm and clear with no winds above 5 m/s and no rain.

A summary of results of the attended noise monitoring is provided in Table 3.3.

Table 3.3 Summary of attended noise measurements

ID	Location	Date	Start time	Duration	Measured noise level dB			Comments
					L_{Aeq}	L_{A90}	L_{Amax}	
L1	Brownlie Court, Talbingo logger location (150m from Miles Franklin Drive)	19/3/18	16:45	15 minutes	43	32	69	Bird noise very frequent. Wind in foliage frequent. Car passby (1xLight Vehicle (LV)) briefly audible. Traffic negligible.
S1	Talbingo (roadside) West of Whitty Street (10m from Miles Franklin Drive)	19/3/18	17:30	15 minutes	47	36	70	Insects consistently audible and dominant. Bird noise very frequent. Livestock almost constant. Wind in foliage occasional. Tractor on property audible for approximately 2.5 minutes.. No traffic passbys on Miles Franklin Drive.
S2	Roadside of logger location (35m from Miles Franklin Drive)	19/3/18	18:00	15 minutes	44	31	67	Wind in trees constant. Bird noise frequent. Insects just audible. Plane above audible on two occasions. Car passby on Ware St (3m away). Car audible turning on Lampe Street from Miles Franklin Drive. No traffic passbys on Miles Franklin Drive.
S3	Snowy Mountain Hwy roadside (55m from Snowy Mountains Highway)	19/3/18	18:45	60 minutes	42	31	69	Nearby creek and insects consistently audible. Bird noise occasional. Traffic passbys (2xLV and 1xHeavy vehicle (HV)) with compression braking. Van arriving at camping ground and generator from nearby camper van occasionally audible.
S4	Snowy Mountain Hwy roadside (50m from Snowy Mountains Highway)	20/3/18	07:48	60 minutes	52	32	79	Traffic on Snowy Mountains Highway (26xLV and 1xHV). Bird noise frequent. Traffic passbys (x5) on Snowy Mountain Alpine cottages access road.
S5	Selwyn snowfields resort (75m from The Link Road)	20/3/18	09:47	60 minutes	47	29	73	Traffic on Link Road (24xLV and 3xHV). Planes (x6) and helicopter (x1) audible. Bird noise frequent. Pedestrians briefly audible. Traffic passbys on Selwyn snowfields resort access road (x6).
S6	Talbingo (roadside) East of Bridle Street (10m from Miles Franklin Drive)	4/4/18	13:45	60 minutes	43	23	68	Traffic on Miles Franklin Drive (29xLV and 3xMotorbikes (M)). Helicopters occasionally audible. Bird noise intermittent. Pedestrians briefly audible.
S7	Talbingo (roadside) East of Bridle Street (10m from Miles Franklin Drive)	4/4/18	16:30	60 minutes	43	24	69	Traffic on Miles Franklin Drive (21xLV 2xHV, and 1xM). Bird noise intermittent. Pedestrians briefly audible.

The ambient noise environment in Talbingo was found to be typical of a rural area with natural noise sources (birds and insects), human activity, domestic pets (dog barks) and occasional local car movements noted in the acoustical environment. Road traffic volumes were relatively low as per notes provided in Table 3.3.

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 the by Air Quality specialist on the project (using CALMET) for the exploratory works site during 2017 (one calendar year), with input from the BoM Cabramurra Snowy Hydro Limited (SHL) automatic weather station. The analysis identified that no wind directions were found to be a feature of the area, as per the NPfI. Table 3.4 provides a summary of the wind vector review. Nonetheless, the NPfI noise enhancing weather parameters were conservatively adopted in the assessment.

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

Direction	Day				Evening				Night			
	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer
N	6.5%	5.6%	3.1%	7.5%	1.1%	2.6%	3.4%	2.4%	1.1%	3.3%	4.5%	4.6%
NNE	3.0%	2.4%	1.9%	4.0%	0.0%	0.3%	1.1%	1.3%	0.0%	0.1%	1.0%	1.4%
NE	1.0%	0.6%	1.0%	2.1%	0.0%	0.3%	0.7%	1.3%	0.0%	0.0%	0.4%	0.1%
ENE	0.8%	0.5%	0.7%	1.0%	0.0%	0.1%	0.3%	1.0%	0.0%	0.0%	0.1%	0.0%
E	0.9%	0.9%	0.9%	0.8%	0.0%	0.0%	0.4%	0.6%	0.0%	0.0%	0.1%	0.1%
ESE	1.5%	1.7%	1.1%	0.6%	0.0%	0.0%	1.1%	0.7%	0.1%	0.0%	0.4%	0.3%
SE	2.1%	2.9%	1.2%	0.5%	2.3%	1.2%	2.3%	1.3%	1.6%	1.9%	2.5%	2.2%
SSE	2.8%	4.3%	1.2%	0.9%	6.1%	4.2%	3.6%	2.8%	3.6%	4.7%	5.7%	4.6%
S	3.6%	5.2%	1.4%	1.2%	8.3%	6.8%	4.3%	4.6%	4.8%	6.0%	7.8%	5.4%
SSW	4.2%	6.2%	1.9%	1.6%	9.5%	8.3%	4.4%	6.1%	6.2%	6.6%	8.3%	5.9%
SW	5.6%	8.4%	3.5%	2.1%	8.6%	8.0%	4.4%	8.3%	6.3%	5.0%	6.8%	5.3%
WSW	9.7%	12.3%	6.8%	3.0%	9.1%	9.0%	5.9%	11.4%	8.1%	6.3%	5.9%	7.5%
W	14.1%	15.8%	9.1%	5.9%	11.5%	12.4%	9.5%	13.3%	11.2%	12.1%	8.9%	12.7%
WNW	16.4%	17.2%	9.5%	9.1%	11.4%	13.2%	11.0%	12.8%	10.9%	14.8%	11.5%	15.3%
NW	16.4%	15.6%	8.8%	10.8%	10.1%	12.2%	10.2%	10.0%	9.3%	14.6%	11.5%	15.3%
NNW	11.9%	10.4%	5.8%	10.5%	5.7%	8.4%	7.8%	5.7%	5.4%	10.5%	9.5%	10.8%

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 surrounding 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. Some construction will occur at night so the affect 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 3.5 provides a summary of the Pasquill atmospheric stability categories (or a measure of temperature gradients). The analysis is based on data calculated by Air Quality specialist on the project (using CALMET) for the exploratory works site during 2017 (one calendar year), with input from the BoM Cabramurra SHL automatic weather station.

Noise enhancement due to temperature inversions occurs when the atmosphere is relatively stable which corresponds with atmospheric stability class category F and G. It can be seen that 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 3.5 Percentage occurrence of Pasquill stability categories

Pasquill stability category	Percentage occurrence (night period)				
	Annual	**Summer**	**Autumn**	**Winter**	**Spring**
A	0.0%	0.0%	0.0%	0.0%	0.0%
B	0.3%	0.7%	0.0%	0.0%	0.7%
C	1.8%	3.5%	0.4%	0.0%	3.2%
D	47.4%	48.7%	45.7%	44.0%	51.4%
E	24.2%	26.1%	24.5%	21.2%	24.9%
F and G	26.3%	21.0%	29.3%	**34.9%**	19.8%

Notes: 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 complaints handling procedure.

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

Table 4.1 ICNG construction noise management levels for residential land uses

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 for residential land uses

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: 1. 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); 2. 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

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 Exploratory 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 4.2 will also be applied to residential assessment locations for any construction activity during the morning shoulder and any other part of 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
	Evening (out of hours)	30	35
	Night (out of hours) inc 'shoulder'	30	35
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)
Hospital wards and operating theatres	When in use	n/a	45 (internal)
Places of worship	When in use	n/a	45 (internal)
Active recreation areas	When in use	n/a	65
Passive recreation areas	When in use	n/a	60

Notes: 1.The RBLs adopted from Table 3.2.

4.2 Sleep disturbance

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 residential assessment locations.

Table 4.4 Sleep disturbance screening criteria at residences

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

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. Table 4.5 presents the road noise assessment criteria for residential land uses (ie assessment locations), reproduced from Table 3 of the RNP for road categories relevant to the Exploratory Works.

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	-	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. 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.
Open space (passive use)	$L_{eq,15hr}$ 55 (external) when in use	-	

4.4 Construction vibration

4.4.1 Human comfort

i General discussion on 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.

ii 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.

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 Buildings

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 mineral extraction or construction excavation), piling, ground treatments (e.g. compaction), construction equipment, tunnelling, road and rail 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 4.1.

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.

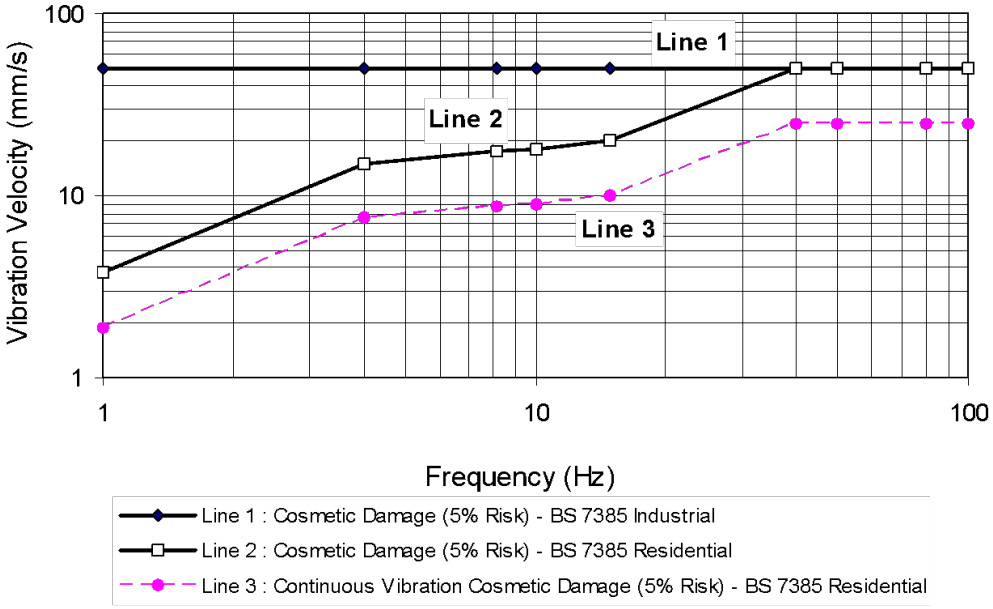


Figure 4.1 Graph of transient vibration guide values for cosmetic damage

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 Other vibration-sensitive items

AS2187 states that:

> A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

Hence, buildings of historical significance would be assessed with reference to the criteria outlined above with reference to BS7385 unless identified otherwise by a structural engineer as requiring more stringent criteria.

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.

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). It is noted that this criteria applies 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 are provided in Table 4.12.

Table 4.12 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 4.4.2 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.

5 Assessment method

5.1 Construction noise

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

Construction noise levels from Exploratory Works were predicted using a computer generated model using Brüel & Kjær Predictor Version 11 software (the model). The model calculates tot al 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:

- the establishment of an exploratory tunnel to the site of the underground power station for Snowy 2.0 and portal;
- the establishment of a portal construction pad;
- excavated rock management;
- the establishment of an accommodation camp;
- road establishment and upgrades providing access to the proposed construction areas;
- establishment of barge access infrastructure on Talbingo reservoir; and
- supporting power and communication.

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

5.1.1 Construction times

The following activities are proposed 24 hours, 7 days per week:

- exploratory tunnel works and haulage of rock material between the tunnel and rock emplacement areas at Lobs Hole. This may include up to one blast between the hours of 10pm and 7am;
- concrete batching at the tunnel portal compound; and
- generator and wastewater treatment plant operation.

All other construction activities will be contained within daylight hours which will typically be 6am to 6pm.

5.1.2 Equipment sound power levels

i Continuous

Acoustically significant fixed and mobile equipment items considered in the model are provided for day, evening and night construction in Table 5.1. Equipment sound power levels have been from the taken 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.

Table 5.1 Construction equipment sound power levels and periods of operation

Activity	Equipment item	Quantity	Sound power level, dB, $L_{Aeq,15min}$		Day	Eve	Night
			Per equipment item	Per activity			
Transport of equipment and material	Heavy vehicle (deliveries)*	2	103	106	☐	☐	☐
Site clearing/ stripping	Excavator (20t)	3	110	122	☐	☐	☐
	Rock breaker (medium)	1	117				
	Dozer (D10)*	1	116				
	Roller	1	103				
	40t ADT composite	4	107				
	Heavy vehicle (truck and dog)*	2	103				
Site establishment	Generator	2	102	115	☐	☐	☐
	Concrete truck (agitator)	1	108				
	Heavy vehicle (deliveries)*	2	103				
	Watercart	2	109				
	Bobcat	1	95				
	Hand tools	1	101				
	Crane 15t Mobile	1	98				
Camp/Office Construction	Generator	2	102	117	☐	☐	☐
	Concrete truck (agitator)	2	108				
	Heavy vehicle (deliveries)*	2	103				
	Watercart	2	109				
	EWP	2	94				
	Telehandler	1	107				
	Upright trench rammer	1	108				
	Light tower	2	93				
	Bobcat	1	95				
	Hand tools	4	101				
	Crane 50t Mobile	1	104				
	Crane 15t Mobile	1	98				
Bridge construction	Crane 15t Mobile	1	98	115	☐	☐	☐
	Crane 50t Mobile	1	104				

Table 5.1 Construction equipment sound power levels and periods of operation

Activity	Equipment item	Quantity	Sound power level, dB, $L_{Aeq,15min}$		Day	Eve	Night
			Per equipment item	Per activity			
	Concrete truck (agitator)	1	108				
	Concrete Pump	1	106				
	Piling rig	1	112				
	Heavy vehicle (deliveries)*	2	103				
Bulk Earthworks	Excavator (20t)	4	110	121	☐	☐	☐
	Dozer (D10)*	1	116				
	Roller	1	103				
	40t ADT composite	6	107				
	Heavy vehicle (truck and dog)*	2	103				
Pavements	Excavator (20t)	1	110	117	☐	☐	☐
	Bitumen/asphalt laying truck	1	112				
	40t ADT composite	4	107				
	Heavy vehicle (truck and dog)*	2	103				
Wharf construction	Piling rig	1	112	112	☐	☐	☐
	Crane 15t Mobile (8hrs)	1	98				
Tunnel works (Drill & Blast)	Drill (Jumbo 3 Boom)	2	114	119	☐	☐	☐
	Concrete truck (agitator)	1	108				
	Shotcrete robot/pump	2	106				
	Grout pump	1	106				
	Compressor	2	103				
	Generator	2	102				
Pipeline works	Excavator (20t)	2	110	116	☐	☐	☐
	Haul truck	2	108				
	Hand tools	1	101				
	Upright trench rammer	1	108				
	Crane 15t Mobile	1	98				
Transportation of excavated material	Front end loader	1	104	114	☐	☐	☐
	Excavator (20t)	2	110				
	Heavy vehicles (truck and dog)*	2	103				

Note: Rounding may result in totals for 'per activity' being distorted up or down by 1dB

**Sound power level taken from an EMM measurement database.*

ii Night-time maximum noise level events and sleep disturbance

Construction activity will occur between the ICNG night-time hours of 10pm to 7am. 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.

Table 5.2 Maximum noise from intermittent sources

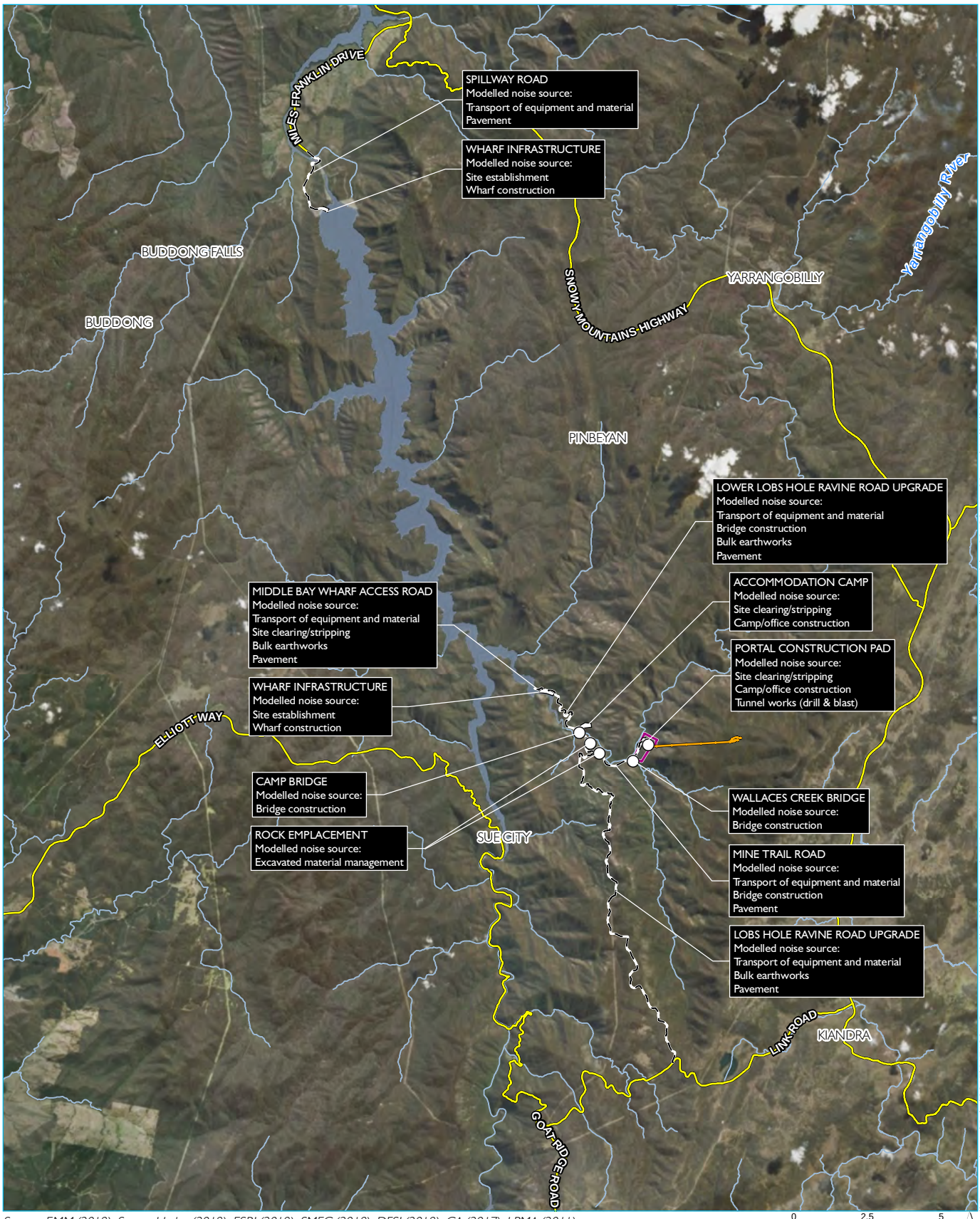
Activity	Equipment item most likely to generate maximum noise level	Adopted sound power level, dB L_{Amax}
Transport of equipment and material	Heavy vehicle (deliveries)	113
Site clearing/stripping	Rock breaker (medium)	120
Site establishment	Watercart passby	114
Camp/Office Construction	Watercart passby	114
Bridge construction	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

5.1.3 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 April/May 2019 period was identified to be the most active with most areas across the early works project area having operating plant and equipment. This period also provides a fair representation of worst case construction noise levels at assessment locations identified in Figure 3.1, given their location with respect to the active construction areas. Therefore, this period was adopted as a snap-shot in time to represent worst case construction noise levels from the project at identified assessment locations.

Figure 5.1 presents the proposed activities during the April/May 2019 and the location at which the construction activities will occur.



\\Emmsvr1\emmJobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EW\TechReports_NV\AINV\AEW004_ModelledActivity_20180711_02.mxd 11/07/2018

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

0 2.5 5 km
GDA 1994 MGA Zone 55

N

KEY

- Portal construction pad
- Exploration tunnel
- Main road
- Perennial watercourse
- Scheme storage

Modelled noise source

- Point source
- Access road
- Area

Modelled construction activity locations

Snowy 2.0
Noise and vibration impact assessment
Exploratory Works
Figure 5.1

snowy 2.0 EMM

Table 5.3 Single point noise level prediction construction scenario

April/May 2019 – construction activity	Location								
	Wharf	Accommodation camp	Portal construction pad	Middle Bay Road	Mine Trail Road	Lobs Hole Ravine Road	Talbingo Access Road	Pipeline	Lobs Hole
Transport of equipment and material				▯	▯	▯	▯		
Site clearing/stripping		▯	▯	▯					
Site establishment	▯								
Camp, office and support services (including services infrastructure) construction		▯	▯						
Bridge construction					▯	▯			
Bulk Earthworks				▯		▯			
Pavements				▯	▯	▯	▯		
Wharf construction	▯								
Tunnel works (Drill & Blast)			▯					▯	
Pipeline works									▯

For each activity at each location, all equipment has been assumed to operate concurrently and continuously for the 15 minute assessment period. This approach is conservative, given this is unlikely to be the practice in reality.

ii Noise contours – worst case construction noise footprint

It is acknowledged that the project area is vast and there is potential for other noise sensitive assessment locations to be identified as Exploratory Works continues. To account for this and to identify the risk of potential construction noise impacts, noise contours have been generated for Exploratory Works.

The fundamental 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. For example, there is no south wharf construction for the April/May 2019 scenario and therefore this activity is not captured in single point noise level predictions. It has however been included in noise contours to show the potential outer envelope from all possible construction activity across the early works schedule.

5.1.4 Noise enhancing meteorology

A summary of calm and noise enhancing weather conditions for which noise predictions have been provided are shown in Table 5.4.

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

Table 5.4 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 5.5. 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 5.5 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (BS 6472)
Vibratory Roller	<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
	<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
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

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

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

The safe working distances presented in Table 5.5 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 Drill and Blast (D&B) construction method will be used for the excavation of the portal, exploratory tunnel, and the cavern for the Machine Hall D&B will also be used for small sections of road where granite has been identified.

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.

5.3 Road traffic noise

The US EPA Federal Highways (FHWA) method was used to predict noise levels at the nearest assessment locations for additional traffic from construction of Exploratory Works. This method is more suited to relatively low traffic flows (ie less than 200 vehicles per hour) which is most typical of roads that the project will use.

Road traffic movements associated with construction of Exploratory Works have been referenced from the Snowy 2.0 Exploratory Works Traffic Impact Assessment (SCT 2018) and adapted to suit RNP assessment requirements (Table 5.6).

Nearest residential assessment location potentially affected by project related traffic are located on Miles Franklin Drive, Talbingo and Snowy Mountains Highway to the east of the project area (Figure 3.2). To assess road traffic noise at these assessment locations it has been assumed that the majority (95%) of project related traffic will use the Snowy Mountains Highway approach from the east. The remaining 5% will utilised the northern route through Talbingo Town down to Talbingo Reservoir.

Table 5.6 Project related road traffic movements on public roads

Period	Light vehicle movements	Heavy vehicle movements	Total vehicle movements
Day (7.00 am to 10.00 pm)	4	44	48
Night (10.00 pm to 7.00 am)	0	0	0

Notes: The volumes adopted are the annual average of the worst case day in each month. A movement refers to one single passby event (eg 4 movements could mean two vehicles in and two vehicles out, or 4 vehicles in or 4 vehicles out)

6 Impact assessment

6.1 Construction noise

6.1.1 Single point predictions

Predicted single point construction noise levels 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 management plan as discussed further in Section 6.2.

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 access construction noise levels

Assessment location	Classification	Period	Noise affected NML, dB	Highly noise affected NML, dB	Predicted construction noise level, dB $L_{Aeq,15min}$		Level above noise affected NML, dB $L_{Aeq,15min}$	
					Calm	Noise-enhancing	Calm	Noise-enhancing
A1	Passive recreation	Standard	60	n/a	<30	<30	0	0
		OOH	60	n/a	<30	<30	0	0
A2	Passive recreation	Standard	60	n/a	<30	<30	0	0
		OOH	60	n/a	<30	<30	0	0
R1[1]	Residential	Standard	40	75	<30	<30	0	0
		OOH	35	n/a	<30	<30	0	0
A3	Passive recreation	Standard	60	n/a	<30	<30	0	0
		OOH	60	n/a	<30	<30	0	0
A4	Passive recreation	Standard	60	n/a	<30	<30	0	0
		OOH	60	n/a	<30	<30	0	0
A5	Passive recreation	Standard	60	n/a	<30	<30	0	0
		OOH	60	n/a	<30	<30	0	0
A6	Passive recreation	Standard	60	n/a	<30	<30	0	0
		OOH	60	n/a	<30	<30	0	0

Table 6.2 Predicted access construction noise levels

Assessment location	Classification	Period	Noise affected NML, dB	Highly noise affected NML, dB	Predicted construction noise level, dB $L_{Aeq,15min}$		Level above noise affected NML, dB $L_{Aeq,15min}$	
					Calm	Noise-enhancing	Calm	Noise-enhancing
A7	Passive recreation	Standard	60	n/a	<30	<30	0	0
		OOH	60	n/a	<30	<30	0	0
R2	Residential	Standard	40	75	37	40	0	0
		OOH	35	n/a	37	40	**2**	**5**
R3	Residential	Standard	40	75	30	33	0	0
		OOH	35	n/a	30	33	0	0
A8	Passive recreation	Standard	60	n/a	44	47	0	0
		OOH	60	n/a	44	47	0	0
R4	Residential	Standard	40	75	<30	<30	0	0
		OOH	35	n/a	<30	<30	0	0
A9	Passive recreation	Standard	60	n/a	<30	<30	0	0
		OOH	60	n/a	<30	<30	0	0

Notes: 1. Property owned by the proponent however has been conservatively assessed as a residential receiver.

There is potential for all construction activity as indicated in Figure 5.1 to occur in the 6am to 7am shoulder period. This period falls within the OOH night period of 10pm to 7am. Therefore, predicted noise levels in Table 6.1 are the same for standard and OOH periods for calm and noise-enhancing weather conditions.

Typically however, construction outside of daylight hours which will mostly fall within the evening (6pm to 10pm) and night (10pm to 7am) periods will be limited to excavation of the portal and transportation of excavated material to the rock emplacement area. Construction noise levels during these times will be less than those predicted for the OOH period in Table 6.1.

To that end, construction noise levels satisfy NMLs at all assessment locations with the exception of R2 where a 2 dB and 5 dB exceedance is predicted for the OOH period during calm and adverse weather conditions, respectively. The predicted exceedance at location R2 is generated by Spillway Road construction when works are in the zone indicated in Figure 6.2. Road construction for the entire Spillway Road alignment is scheduled to occur for six weeks. The time spent in this zone and therefore the duration of noise levels above the NMLs will therefore be less.

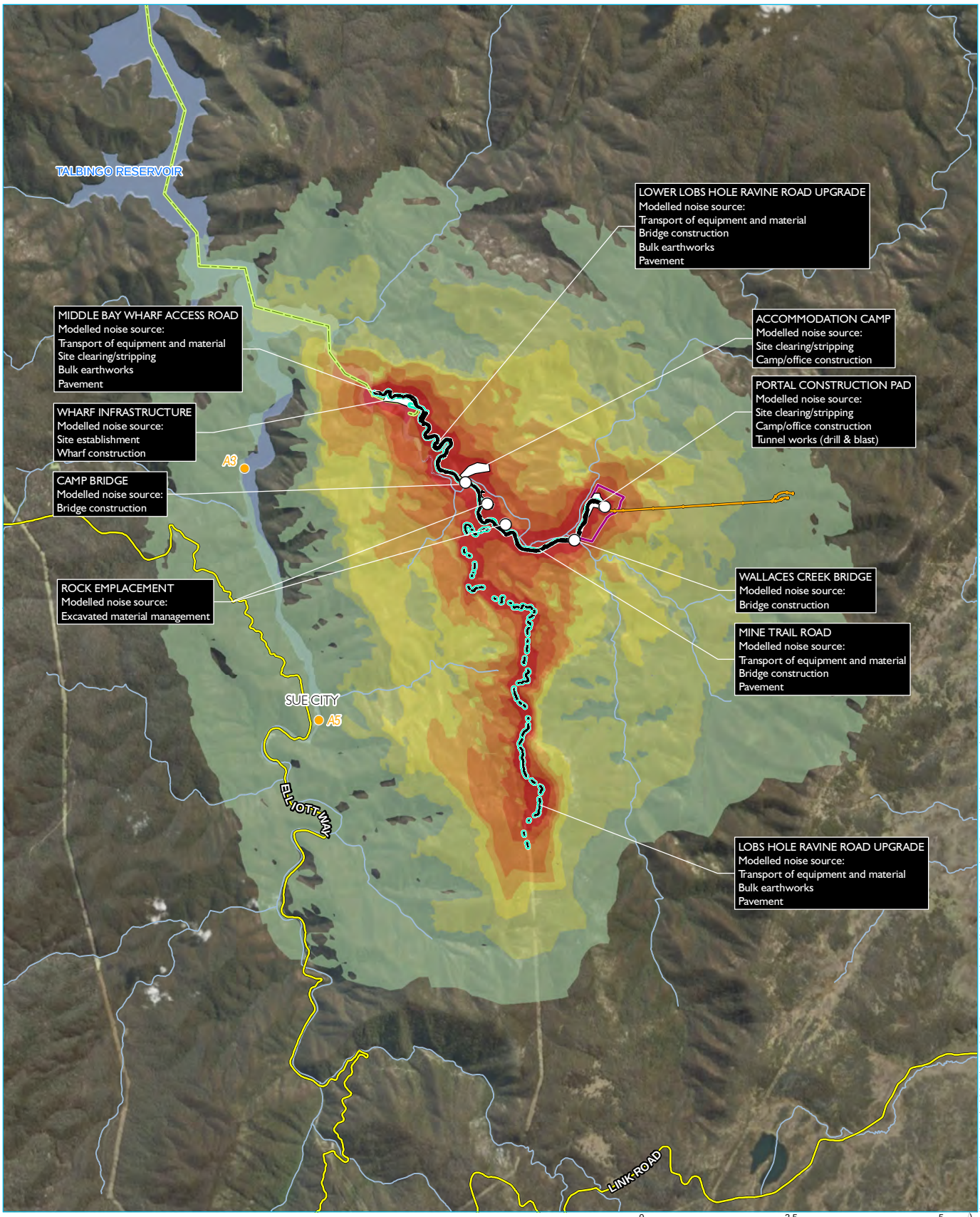
The proponent will notify this resident of Spillway Road construction works and the potential noise impacts. Noise monitoring during the initial stages of construction will be undertaken to determine if actual construction noise levels are above NMLs. If NMLs are exceeded, the proponent will:

- identify feasible and reasonable mitigation measures that reduce construction noise levels to at or below NMLs;
- limit road construction within the zone marked on Figure 6.2 to ICNG standard hours only; or
- enter into a negotiated agreement with the property owner.

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 and Figure 6.2. The figures represent the predicted construction noise levels during worst case meteorological conditions presented in Table 5.6 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.



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

0 2.5 5 km

GDA 1994 MGA Zone 55

N

KEY

- Portal construction pad
- Exploration tunnel
- Communications cable
- Main road
- Perennial watercourse
- Potential granite blasting emission zone
- Scheme storage

Modelled noise source

- Point source
- Access road
- Area

Receptors

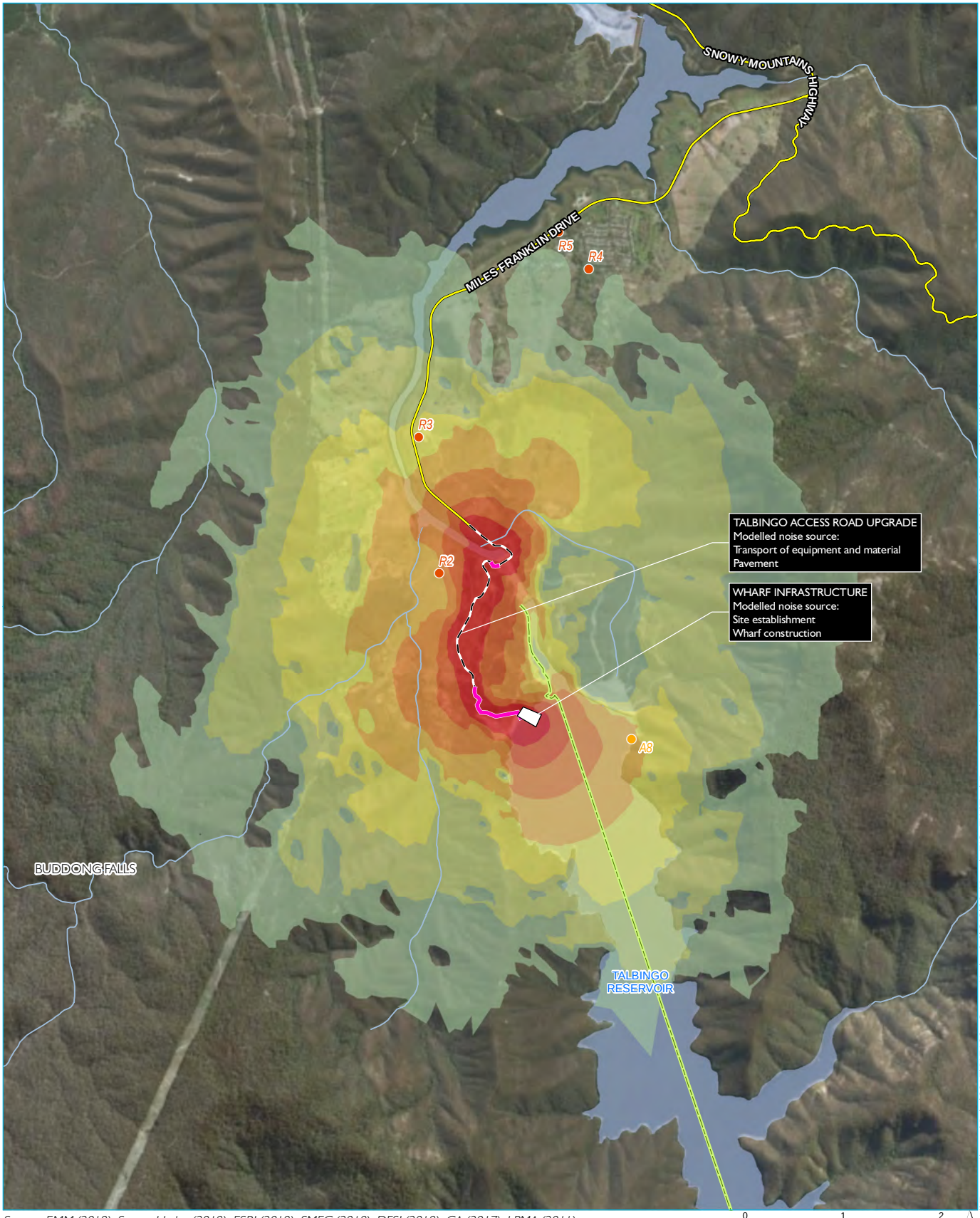
- Passive recreation

Noise contours - dB $L_{Aeq15min}$

- 35-39
- 40-44
- 45-49
- 50-54
- 55-59
- 60-64
- >65

Outer envelope construction noise contours, day and night - Lobs Hole

Snowy 2.0
Noise and vibration impact assessment
Exploratory Works
Figure 6.1



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

0 1 2 km
GDA 1994 MGA Zone 55

N

KEY

- Communications cable
- Main road
- Perennial watercourse
- Scheme storage
- Access road
- Area

Receptors

- Passive recreation
- Residential
- Spillway Road construction zone
- – OOH NML exceedance predicted at R2

Noise contours - dB

- 35-39
- 40-44
- 45-49
- 50-54
- 55-59
- 60-64
- >65

Outer envelope construction noise contours, day and night - Talbingo

Snowy 2.0
Noise and vibration impact assessment
Exploratory Works
Figure 6.2

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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	40	47
R3	40	52	33	41
R4	40	52	<30	49

Notes: 1. Residential properties are owned by the proponent however have been assessed as a residential receiver

Predicted noise levels from the project satisfy sleep disturbance criteria at all assessment locations.

6.3 Construction vibration

In relation to human comfort response, the safe working distances in Table 5.5 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 R2 which is more than 400 m away from Spillway Road construction. This places this assessment location well outside of the safe working distances for human response. 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 5.5, if construction is within 25 m of sensitive structures, then work practices should be reviewed so that the safe working distance in Table 5.5 are followed. This includes structures associated with the existing Snowy Hydro scheme, such as Talbingo dam and spillway.

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.

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

- Exploratory tunnel excavation - representative MIC of up to 40kg and a K factor of 1140 (for average rock).

Table 6.3 provides the offset distance required to vibration sensitive receivers which would satisfy vibration criteria for both road construction and tunnel excavation.

Table 6.3 Minimum offset distances required to satisfy blast criteria

Activity	Representative MIC (kg)	Receiver type	Criteria		Offset distance required to satisfy criteria – road, m	
			Ground vibration (PPV)	Air blast, $L_{Lin,peak}$, 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.

In addition to construction blasting for road construction and tunnel excavation, seismic surveys are proposed in early construction phases. These surveys will detonate a small a 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. 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 with the worst case blast offsets provided in Table 6.3. Adverse blasting impacts from the seismic survey on land are therefore highly unlikely.

Some seismic surveys are proposed in water bodies and therefore the potential for marine fauna impacts has been raised as a potential risk. These impacts have been addressed in aquatic ecology assessment (Appendix H).

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 and tunnel excavation. Therefore, blast impacts on residential receivers are considered highly unlikely.

There is the potential for 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 73 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 48 dBL_{peak} which is below the sleep disturbance screening criteria of 52 dBA, L_{max}. 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 Talbingo.

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 6.3 maps the blast offset distances presented in Table 6.3 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 6.3. Details of these items are also listed in Table 6.4.

Table 6.4 Vibration assessment locations in blast offset zones

ID	Description	Easting	Northing
R28	Pise ruin	625907	6038986
R78	Pine tree	626550	6038172
R118	Cemetry	625668	6039652
R28	Pise ruin	625907	6038986
R72	Stone furnace	626171	6038205

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.

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.

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 methods. The following assumptions have been adopted:

- the speed limit for Miles Franklin Drive and Snowy Mountains Highway is 60 km/h and 100 km/h, respectively;
- 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 2.5 dB facade reflection has been added to predicted noise levels.

Road traffic noise level predictions are provided in Table 6.5

Table 6.5 Road traffic noise calculations, 15 hour day period

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, $L_{Aeq,15hou}$	
R5[2]	30m	Miles Franklin Drive	506	9%	51.4 dB	508	9%	51.6 dB	0.2 dB
R3[2]	50m	Miles Franklin Drive	218	9%	46.4 dB	220	10%	46.8 dB	0.2 dB
R8[3]	60m	Snowy Mountains Highway	1219	10%	56.9 dB	1265	13%	57.9 dB	1 dB

Notes: *1. Existing movements are based on 2018 long-term road traffic counts. Refer TIA (SCT 2018) for detail.*

2. Based on 5% of all project movements

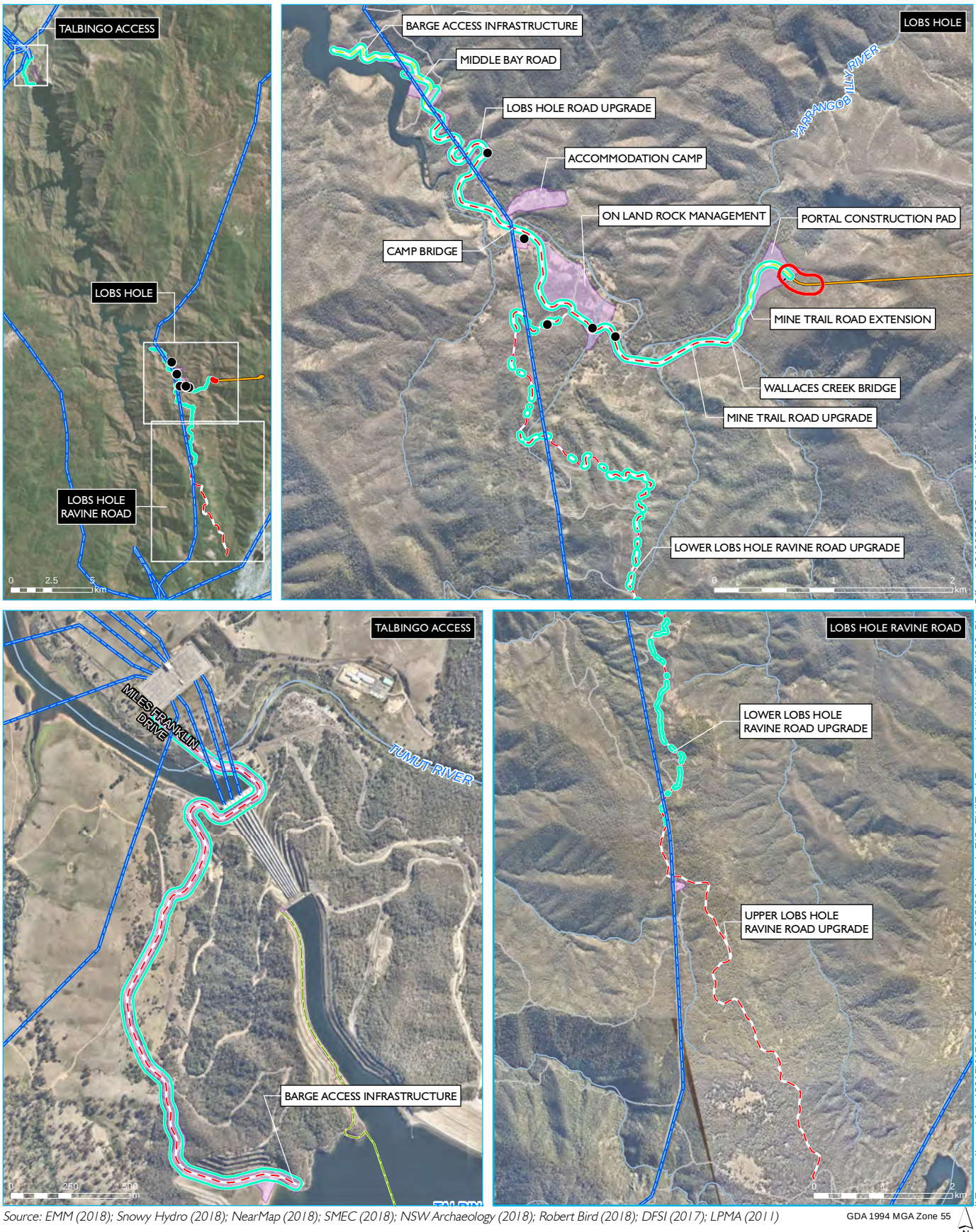
3. Based on 95% of all project movements

Existing and existing plus project road traffic noise levels are predicted to satisfy the RNP daytime criteria of 60 dB, $L_{Aeq,15hour}$. Further, the predicted noise level increase due to project traffic is less than 2 dB at all assessment location.

In summary, road traffic noise levels are predicted to satisfy RNP assessment requirements.

6.6 Noise and vibration impacts on fauna

Very little evidence is available in literature on the direct impacts that noise and vibration has on fauna. However, it is likely that if levels are suitable for humans, they would also for a large extent be tolerable by fauna. It is also understood the construction will be avoided in areas with recorded pygmy possum population which will minimise potential for noise and vibration exposure on this species. More information on this is available in the ecological assessment of the EIS.



\\Emmsvr1\emmJobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EW\TechReports_NV\AIN\AEW006_BlastOffset_20180712_05.mxd 12/07/2018

Source: EMM (2018); Snowy Hydro (2018); NearMap (2018); SMEC (2018); NSW Archaeology (2018); Robert Bird (2018); DFSI (2017); LPMA (2011)

GDA 1994 MGA Zone 55

N

KEY

- Access road upgrade
- Access road extension
- Exploratory tunnel
- Main road
- Local road or track
- Watercourse
- Disturbance footprint

Blast offset zones

- Tunnel portal entry blast emission zone
- Potential granite blasting emission zone

Vibration monitoring location

- Heritage site
- Electricity transmission line

Blast offset distances to achieve ground vibration criteria

Snowy 2.0
Noise and vibration impact assessment
Exploratory Works
Figure 6.3

snowy 2.0 EMM

7 Management of impacts

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

Table 7.1 Environmental management measures for noise and vibration

Impact	Ref #	Environmental management measures
Noise	N1	A construction environmental management plan (CEMP) that will address noise and vibration management and mitigation options (where required) will be completed prior to construction. The main objective of the CEMP noise and vibration sub-plan would be to manage construction activities to meet ICNG NMLs and applicable vibration criteria across the project. The CEMP will describe how construction noise levels will be managed where predicted noise levels above the NMLs have been identified. The CEMP would address noise mitigation and management to reduce construction noise levels at the potentially most affected assessment location based on the findings of this assessment as a minimum. The CEMP 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 noise management and mitigation measures to reduce levels below the NMLs. 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 • entering into 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 and, the assessment has shown that privately owned residences are not predicted to be impacted.

Impact	Ref #	Environmental management measures
Vibration	V1	A construction vibration management plan will be prepared which will include as a minimum: • identification of nearby residences and sensitive land uses; • 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 6.4. 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. 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 (noting that no more than one blast will occur during the night period). A survey of heritage items and other potential vibration sensitive receivers should be undertaken in the blast offset zone identified around the tunnel excavation portal. The charge used for the water body seismic survey should be selected with regard to aquatic fauna. Additional information on the potential impacts of noise on fauna is provided in the ecological assessment of the EIS.

8 Conclusion

This NVIA has been prepared to support the EIS for the Exploratory 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 the exception of R2 where a 2 dB and 5 dB exceedance is predicted during out of hour work periods during calm and adverse weather conditions, respectively. The predicted exceedance at location R2 is generated by Spillway Road construction for a small portion of the road alignment shown in Figure 6.1. Road construction for the entire Spillway Road alignment is scheduled to occur for six weeks. The time spent in the zone presented in Figure 6.2 and therefore the duration of noise levels above the NMLs will therefore be less.

The proponent will notify this resident R2 of Spillway Road construction works and the potential noise impacts. Noise monitoring during the initial stages of construction will be undertaken to determine if actual construction noise levels are above NMLs. If NMLs are exceeded, the proponent will:

- identify feasible and reasonable mitigation measures that reduce construction noise levels to at or below NMLs;
- limit road construction within the zone marked on Figure 6.1 to ICNG standard hours only; or
- enter into a negotiated agreement with the property owner.

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.

No sleep disturbance impacts as defined in the NSW NPfI (EPA 2017) due to night-time construction are 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 R2 which is more than 400 m away from Spillway Road construction. This places this assessment location 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 5.5 are followed. This includes structures associated with the existing Snowy Hydro scheme, such as Talbingo dam and spillway. 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.

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 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 in Talbingo is significant and would provide a high level of air blast attenuation. For example, the predicted airblast level based on an MIC of 40 kg and distance attenuation only is 73 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 48 dBL_{peak} which is below the sleep disturbance screening criteria of 52 dBA, L_{max}. 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 Talbingo. Notwithstanding, blast practices will be reviewed and modified during the night period if higher airblast levels are generated that cause adverse impacts on residents.

Five vibration assessment locations with recorded heritage significance fall within the required offset distances presented in this report. Blast practices should be reviewed when blasting occurs in the vicinity of these 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.

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.

Very little evidence is available in literature on the direct impacts that noise and vibration has on fauna. However, it is likely that if levels are suitable for humans, they would also for a large extent be tolerable by fauna. It is also understood the construction will be avoided in areas with recorded pygmy possum population which will minimise potential for noise and vibration exposure on this species. More information on this is available in the ecological assessment of the EIS.

In summary, with the management and mitigation measures listed in Section 7 in place, noise and vibration emissions from the project are 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*

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
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
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
VDV	Vibration dose value

Appendix A

Long-term unattended noise monitoring results

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

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Monday, 19-03-18	0	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	0	0
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.*

2. A "0" indicates insufficient data samples due to adverse weather or other extraneous effects.