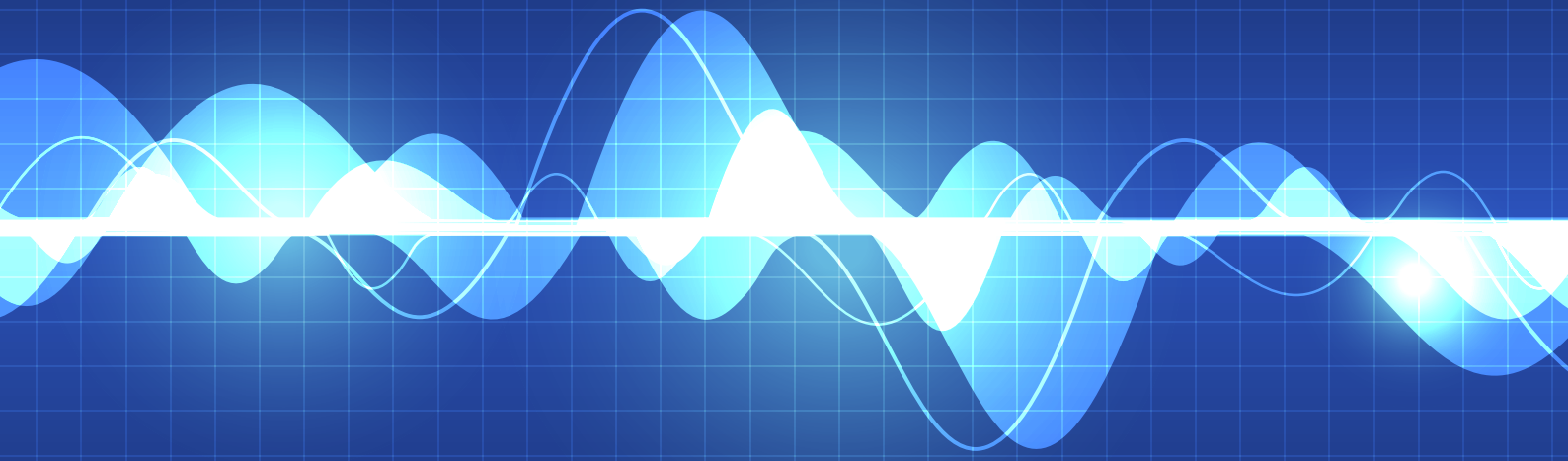
APPENDIX G

NOISE AND VIBRATION IMPACT ASSESSMENT

Proposed Segment Factory

Noise and Vibration Impact Assessment

Prepared for Snowy Hydro Limited
September 2019



EMM
creating opportunities

Proposed Segment Factory

Noise and Vibration Impact Assessment

Report Number

J17188 RP2

Client

Snowy Hydro Limited

Date

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Version

v1 Final

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Executive Summary

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%. Snowy 2.0 would 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 (SSI) and critical State significant infrastructure (CSSI) by the NSW Minister for Planning under Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). CSSI is infrastructure that is deemed by the NSW Minister for Planning to be essential for the State for economic, environmental or social reasons. An application for CSSI must be accompanied by an environmental impact statement (EIS).

Separate applications are being submitted by Snowy Hydro for different phases of Snowy 2.0, including Exploratory Works for Snowy 2.0 (the Exploratory Works) and Snowy 2.0 Main Works (the Main Works).

The first phase of Snowy 2.0, the Exploratory Works (Application Number SSI 9208), includes an exploratory tunnel and portal and other exploratory and construction activities primarily in the Lobs Hole area of the Kosciuszko National Park (KNP). Exploratory Works has been assessed in a separate EIS and is subject to an approval issued by the NSW Minister for Planning on 7 February 2019. Construction for Exploratory Works has already commenced.

The second phase of Snowy 2.0, the Snowy 2.0 Main Works (Application Number SSI-9687), covers the major construction elements of Snowy 2.0, including permanent infrastructure (such as the underground power station, power waterways, access tunnels, chambers and shafts), temporary construction infrastructure (such as construction adits, construction compounds and accommodation), management and storage of extracted rock material and establishing supporting infrastructure (such as road upgrades and extensions, water and sewage treatment infrastructure, and the provision of construction power). Snowy 2.0 Main Works also includes the operation of Snowy 2.0. The EIS for Snowy 2.0 Main Works is currently being prepared.

A separate application has also been submitted for a proposed factory that would manufacture precast concrete segments that would line the tunnels being excavated for Snowy 2.0 (Application Number SSI 10034). This Noise and Vibration Impact Assessment (NVIA) supports the EIS for the proposed segment factory.

On 26 June 2019, Snowy Hydro referred the proposed segment factory (Reference Number 2019/8481) to the Commonwealth Minister for the Environment under the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). On 13 August 2019, the proposed segment factory was determined by the Acting Assistant Secretary Assessments and Waste Branch of the Commonwealth Department of the Environment and Energy (DEE), as delegate to the Minister, to be 'not a controlled action' and therefore does not require further assessment or approval under the EPBC Act.

The tunnels for Snowy 2.0, including the exploratory tunnel for Exploratory Works and underground tunnels linking Tantangara and Talbingo reservoirs for the Main Works, would be excavated, for the most part, using tunnel boring machines (TBMs) and would be lined using precast concrete segments. These segments are proposed to be manufactured at the proposed segment factory to be located on the south-eastern side of Polo Flat (the site), which is an industrial area located to the east of Cooma.

The proposed segment factory would contain a building for the casting and curing of the segments, uncovered storage areas for raw materials and segments, vehicle parking areas and associated offices and workshops. Main inputs for the segments include aggregate, sand, cement and rebar steel. Primary outputs include the segments which would be transported to the TBM launch sites for Exploratory Works and Main Works within KNP.

The factory would operate over a period of about 3.5 years utilising a workforce of about 125 people. It would be operational 24 hours a day, seven days a week.

The site of the proposed segment factory is located on the south-eastern side of Polo Flat, predominantly on the southern part of the land owned by Snowy Hydro. The site is located to the east of Polo Flat Road and to the north of Carlaminda Road.

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

- NSW Department of Environment Climate Change (DECC) 2009, *The Interim Construction Noise Guideline* (ICNG);
- NSW Environment Protection Authority (EPA) 2017, *NSW Noise Policy for Industry* (NPfI);
- NSW Department of Environment Climate Change and Water (DECCW) 2011, *Road Noise Policy* (RNP) and associated application notes;
- Australian and New Zealand Environment Council 1990, Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration;
- Department of Environment and Conservation (DEC) NSW 2006*, Assessing Vibration: a technical guideline*; and
- German Standard DIN 4150 Part 2 1975.

Operational noise associated with the segment factory has confirmed compliance with NPfI requirements for all industrial assessment locations and most residential assessment locations with the exception of R16 during the evening and night. A residual negligible exceedance of 2dB has been predicted for R16 after the implementation of all feasible and reasonable mitigation measures. Compliance is predicted at all industrial assessment locations.

Intermittent night activities are predicted to satisfy the sleep disturbance screening criteria of L_{Amax} 52 dBA as defined in the NSW NPfI (EPA 2017) for all residential assessment locations.

Construction noise levels from the project are predicted to satisfy ICNG noise management levels (NMLs) at the majority of assessment locations, with exception of R15, R16 and R17 where exceedances of 2-7 dB are predicted for daytime out of hours work periods during on Saturday and Sunday.

Given the limited construction period outside of standard construction hours (ie Saturday morning from 7 am to 8 am and Saturday afternoon from 1 pm to 5 pm) and given this period is during the day, the exceedance of the NMLs at the residences at Carlaminda Road is unlikely to result in significant impact. Nonetheless, residents will be notified prior to works commencing. Noise monitoring during the initial stages of construction will be undertaken to determine actual construction noise levels. If this initial monitoring identifies exceedances, the proponent will:

- identify feasible and reasonable mitigation measures that reduce construction noise levels to NMLs where practical; or
- consider construction during ICNG standard hours only.

The above will be determined depending on the measured level of exceedance and the availability of feasible and reasonable noise mitigation and management measures.

The potential for road traffic noise impacts on public roads due to project traffic has been assessed in accordance with the NSW Road Noise Policy (EPA 2011). In summary, road traffic noise levels are generally predicted to satisfy RNP assessment requirements. Potential for a 0.4 dB exceedance of the RNP baseline and <2 dB allowance criterion for night-time traffic is predicted for Snowy Mountains Highway (south) and Polo Flat Road (north), whilst an exceedance of 1.2 dB of the RNP <2 dB allowance criterion is predicted for Monaro Highway (north).

These exceedances relate to a discrete period of 2-3 months at peak traffic generation and include an additional 20% allowance factor applied to the project traffic volumes. For the majority of the project life outside of the peak period, average heavy vehicle (HV) volumes are typically 50% lower and would result in compliance with RNP assessment requirements.

At the completion of construction of Snowy 2.0, the proposed segment factory would be decommissioned which would include removal of all plant and equipment.

Snowy Hydro would retain the main structures such as the precast building, workshops and offices and seek to use these for an alternative industrial use.

It is envisaged that Snowy Hydro would submit a DA to SMRC for an alternative use of the site.

In summary, with the management and mitigation measures listed in Chapter 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
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.
CSSI	Critical State significant infrastructure.
Day period	Monday-Saturday: 7 am to 6 pm, on Sundays and public holidays: 8 am to 6 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.
DEE	Commonwealth Department of Environment and Energy EP&A Act NSW *Environmental Planning and Assessment Act 1979.*
Evening period	Monday-Sunday: 6 pm to 10 pm EIS Environmental impact statement FGJV Future Generation Joint Venture 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.
KNP	Kosciuszko National Park.
L1	The noise level exceeded for 1% of the time.
L10	The noise level which is exceeded 10% of the time. It is roughly equivalent to the average of maximum noise level.
L90	The noise level that is exceeded 90% of the time. Commonly referred to as the background noise level.
Leq	The energy average noise from a source. This is the equivalent continuous sound pressure level over a given period. The Leq(15min) descriptor refers to a Leq noise level measured over a 15-minute period.
Linear peak	The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.
Lmax	The maximum sound pressure level received during a measuring interval.
NEM	National Electricity Market Night period Monday-Saturday: 10 pm to 7 am, on Sundays and public holidays: 10 pm to 8 am.
NPfI	Noise Policy for Industry NVIA Noise and vibration impact assessment.
Project area	The area required to access and build project infrastructure, operation of precast segment factory.
PNTL	The project-noise trigger level (PNTL) 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.

Project and technical terms

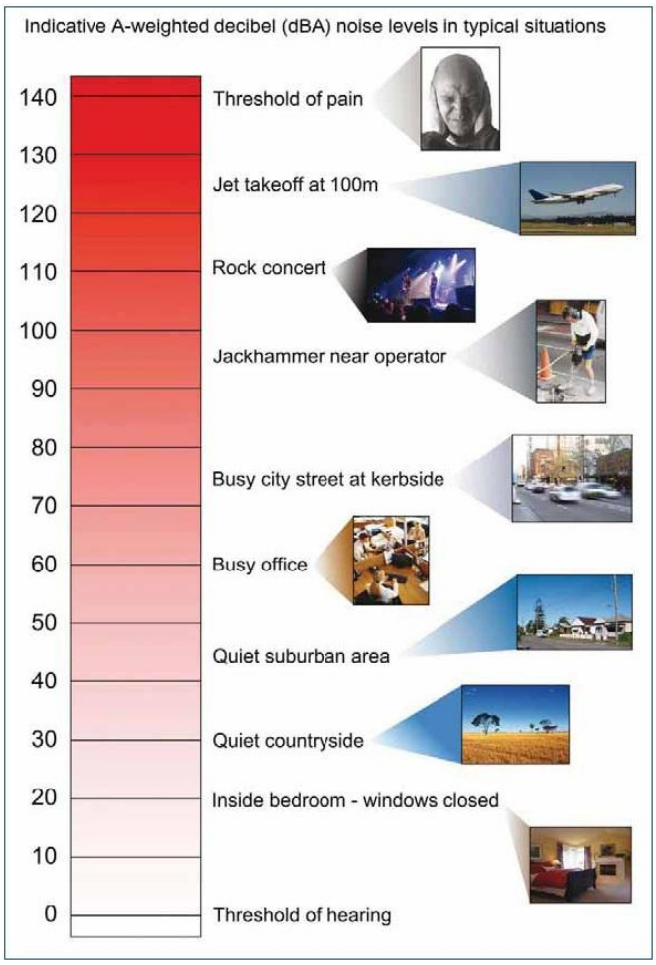
Term	Meaning
RBL	The rating background level (RBL) is an overall single value background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the average background levels.
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.
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.
SSI	State significant infrastructure TBM Tunnel boring machine 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 Snowy 2.0

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

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

Separate applications are being submitted by Snowy Hydro for different phases of Snowy 2.0, including Exploratory Works for Snowy 2.0 (the Exploratory Works) and Snowy 2.0 Main Works (the Main Works).

The first phase of Snowy 2.0, the Exploratory Works (Application Number SSI 9208), includes an exploratory tunnel and portal and other exploratory and construction activities primarily in the Lobs Hole area of the Kosciuszko National Park (KNP). Exploratory Works has been assessed in a separate EIS and is subject to an approval issued by the former NSW Minister for Planning on 7 February 2019. Construction for Exploratory Works has already commenced.

The second phase of Snowy 2.0, the Snowy 2.0 Main Works (Application Number SSI 9687), covers the major construction elements of Snowy 2.0, including permanent infrastructure (such as the underground power station, power waterways, access tunnels, chambers and shafts), temporary construction infrastructure (such as construction adits, construction compounds and accommodation), management and storage of extracted rock material and establishing supporting infrastructure (such as road upgrades and extensions, water and sewage treatment infrastructure, and the provision of construction power). Snowy 2.0 Main Works also includes the operation of Snowy 2.0. The EIS for Snowy 2.0 Main Works was submitted to the NSW Department of Planning, Industry and Environment (DPIE) in September 2019.

A separate application has also been submitted for a proposed factory that would manufacture precast concrete segments that would line the tunnels being excavated for Snowy 2.0 (Application Number SSI 10034). This Noise and Vibration Impact Assessment (NVIA) supports the EIS for the proposed segment factory.

On 26 June 2019, Snowy Hydro referred the proposed segment factory (Reference Number 2019/8481) to the Commonwealth Minister for the Environment under the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). On 13 August 2019, the proposed segment factory was determined by the Acting Assistant Secretary Assessments and Waste Branch of the Commonwealth Department of the Environment and Energy (DEE), as delegate to the Minister, to be 'not a controlled action' and therefore does not require further assessment or approval under the EPBC Act.

1.2 The proposed segment factory

The tunnels for Snowy 2.0, including the exploratory tunnel for Exploratory Works and underground tunnels linking Tantangara and Talbingo reservoirs for the Main Works, would be excavated, for the most part, using tunnel boring machines (TBMs) and would be lined using precast concrete segments. These segments are proposed to be manufactured at the proposed segment factory to be located on the south-eastern side of Polo Flat (the site), which is an industrial area located to the east of Cooma.

The proposed segment factory would contain a building for the casting and curing of the segments, uncovered storage areas for raw materials and segments, vehicle parking areas and associated offices and workshops.

Main inputs for the segments include aggregate, sand, cement and rebar steel. Primary outputs include the segments which would be transported to the TBM launch sites for Exploratory Works and Main Works within KNP.

The construction phase of the proposed segment factory would last about five months utilising a workforce of about 30 people. Construction would take place six days a week (from Monday to Saturday) and for 10 hours per day.

The factory would operate over a period of about 3.5 years utilising a workforce of about 125 people. It would be operational 24 hours a day, seven days a week.

The proposed segment factory would be constructed and operated by Future Generation Joint Venture (FGJV) which has been contracted by Snowy Hydro to construct Snowy 2.0.

At the completion of the construction of Snowy 2.0, the proposed segment factory would be decommissioned.

Further details of the proposed segment factory are provided in Chapter 2 of this report.

1.3 Location of the site

The site of the proposed segment factory is located on the south-eastern side of Polo Flat, predominantly on the southern part of the land owned by Snowy Hydro. The site is located to the east of Polo Flat Road and to the north of Carlaminda Road.

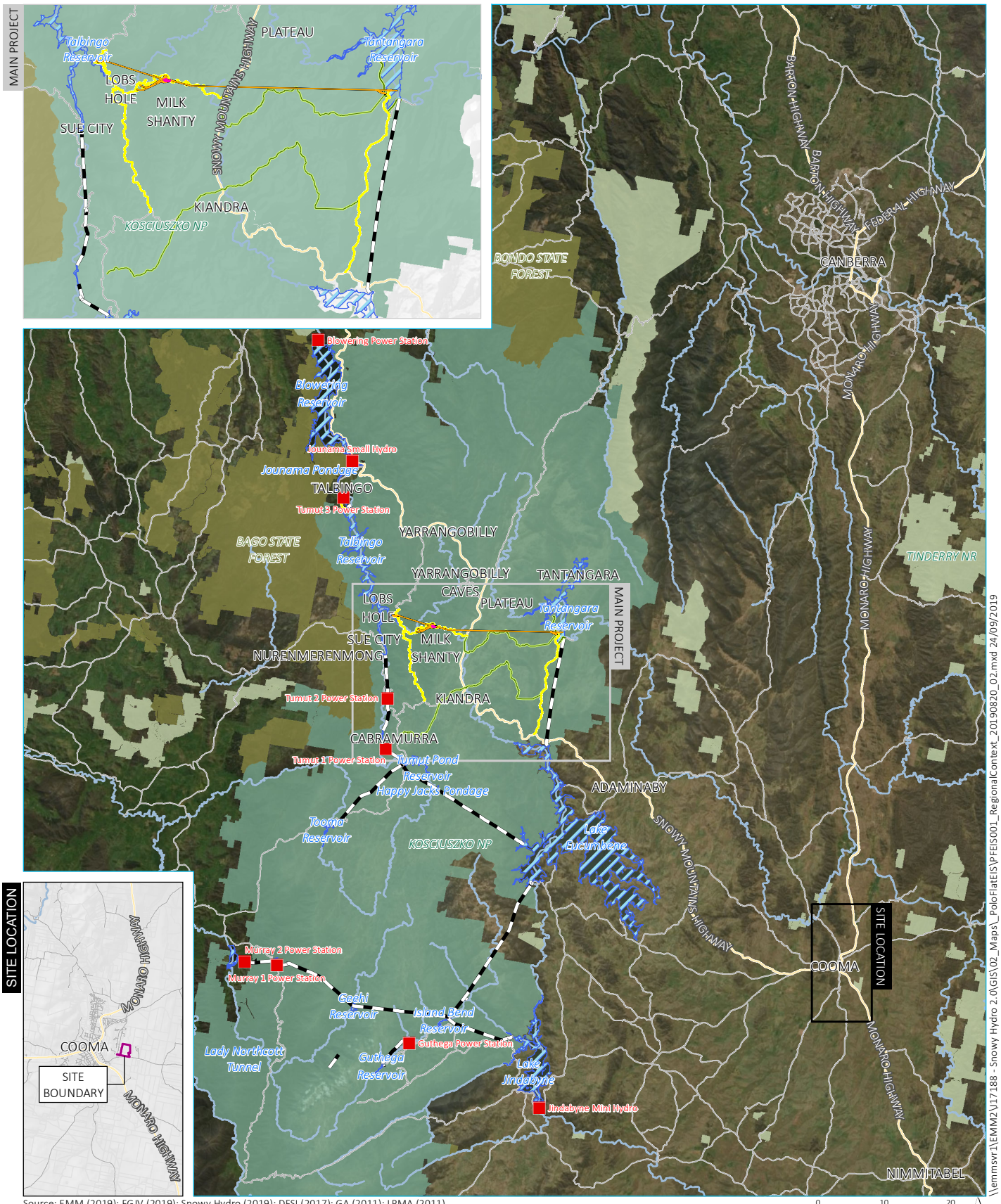
Figure 1.1 shows the location of the site in a regional context and Figure 1.2 shows the site in its local context.

The site contains the following land parcels:

- southern part of Lot 14 in Deposited Plan (DP) 250029 – also known as 9 Polo Flat Road, Polo Flat;
- Lot 3 in DP 238762 – also known as 33 Carlaminda Road, Polo Flat; and
- an unmade road corridor, directly south of the aforementioned lots.

Except for a few buildings located on the southern part of Lot 3 in DP 238762, the site is vacant and dominated by grassland. A third order watercourse flows in a north-westerly direction through the middle of the site.

Lot 14 in DP 250029 is a large parcel of land which contains a private airfield predominantly located in the middle and northern part of the land. This airfield was originally established in 1921 and further developed in the late 1950s and 1960s to service the Snowy Scheme. It became the base for the Snowy Mountains Hydro-electric Authority's (the predecessor to Snowy Hydro) flying unit and aircraft. The land was sold by Snowy Hydro in 1998 where it continued use as a private airfield. Snowy Hydro purchased the land again in early 2019.



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

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KEY

Site boundary

Snowy 2.0 project elements
- Utilities
- Tunnels, portals, intakes
- Power station
- Permanent roads and surface infrastructure

Existing Snowy Scheme
- Existing power station
- Existing pipeline tunnel
- Scheme storage

- Main road
- Local road or track
- Watercourse
- Kosciuszko National Park
- NPWS reserve
- State forest

Location of the project area

Snowy 2.0
Noise and Vibration Impact Assessment
Proposed Segment Factory
Figure 1.1

snowy 2.0

EMM creating opportunities

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

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KEY

- Site boundary
- Rail line
- Main road
- Local road or track
- Watercourse
- Cadastral boundary
- NPWS reserve

Site location in local context

Snowy 2.0
Noise and Vibration Impact Assessment
Proposed Segment Factory
Figure 1.2

snowy 2.0

EMM creating opportunities

The site is surrounded by industrial development to the west and predominantly rural land to the south and east. To the north of the site is the remainder of Lot 14 in DP 250029 which contains the private airfield, and other industrial development. Snowy Hydro's private airfield contains a main north-south aligned runway, hangers and offices. It also contains an above ground fuel tank for the refuelling of planes and helicopters.

Lot 3 in DP 238762 contains a communications tower which ceased use (ie transmission) in August 2019.

There is an isolated industrial operation containing a residence located about 150 metres (m) to the south-east of the site, and an abattoir located about 350 m to the east.

The nearest residence is a rural residence located about 450 m to the south-south-east of the site. The nearest residences within Cooma are located about 1 km to the west of the site.

1.4 Proponent

Snowy Hydro is the proponent for the proposed segment factory. 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.

As previously stated, the proposed segment factory would be constructed and operated by FGJV which has been contracted by Snowy Hydro to construct Snowy 2.0.

1.5 Purpose of this report

This NVIA supports the EIS for the proposed segment factory. It documents the existing noise environment, applicable impact assessment criteria, source of noise and vibration, noise modelling of operational and construction activities including traffic and assessment of predicted impacts relative to criteria.

This NVIA consists of the following sections:

- a description of the local setting and surrounds of the site;
- a description of the existing environment, specifically:
  - existing noise environment; and
  - meteorology and climate;
- a list of plant and equipment adopted for noise modelling of construction and operation of the proposed segment factory;
- noise modelling of operational and construction noise emissions including adverse meteorological scenarios;
- assessment of road traffic noise as a result of project related vehicles on public roads; and
- an overview of compliance, noise mitigation measures residual impacts where relevant.

The NVIA has been prepared in general accordance with the guidelines specified in:

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

1.6 Assessment guidelines and requirements

This NVIA has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs), issued by DPIE (Department of Planning, Industry and Environment) on 31 July 2019.

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 and information request

Requirement	Section addressed
Construction, operational, decommissioning and road noise impacts of the project	Section 6
Vibration impacts of the project	Section 6

1.7 Other relevant reports

This NVIA has been prepared with reference to other technical reports that were prepared as part of the Snowy 2.0 Proposed Segment Factory – Polo Flat EIS. The other relevant reports referenced in this NVIA are listed below:

- Surface water assessment (EMM 2019) – appended to the EIS.
- Traffic and Transport Assessment Report (SCT 2019) – appended to the EIS.

2 Project description

2.1 Introduction

It is proposed to construct and operate a factory on the site to supply precast concrete segments that would line the tunnels for Snowy 2.0.

The construction phase of the proposed segment factory would last about five months utilising a workforce of about 30 people. The operational phase would last about 3.5 years utilising a workforce of about 125 people.

The proposed segment factory would be decommissioned at the completion of operations.

2.2 Construction

2.2.1 Main activities

The following main activities would be undertaken for the construction of the proposed segment factory:

- demolition and removal of buildings and decommissioned telecommunications tower on the southern part of site;
- clearing, removal of topsoil and vegetation (topsoil excavated would be stockpiled on site for later use if deemed suitable);
- undertaking earthworks to establish level surfaces;
- establishment of primary access road;
- installation of site services (power, water and communications);
- establishment of site surfaces (ie concrete, asphalt and cement soil); and
- construction of site facilities and buildings, including precast building, concrete batching plant (CBP), workshops, offices, parking areas, storage areas and associated facilities.

2.2.2 Earthworks

Excavation will be carried out at the site to provide level surfaces, establish the access road and create the required trenches for drainage.

Where possible excavated material would be reused on site for filling and compaction (including benching areas of the site where required). Where there is a deficit of excavated material, additional material would be sourced from local quarries.

2.2.3 Traffic movements

Construction vehicle movements will comprise construction worker's light vehicles and heavy vehicles transporting equipment, building and construction materials, waste, and fill material if required.

2.2.4 Construction timeframe and hours

The construction phase of the proposed segment factory would last about five months (estimated to commence in March 2020 subject to obtaining the required approvals). Construction would be undertaken from Monday to Saturday for 10 hours per day. Access to the site would generally start at 6 am for pre-starts and toolbox talks, and construction would commence at 7 am.

2.2.5 Workforce

A workforce of about 30 people would be required to construct the proposed segment factory.

2.3 Operations

2.3.1 General

The segments would be produced by casting concrete (made in the CBP) in reusable steel moulds which would then be cured in a chamber. Following curing, the segments would be temporarily stored onsite before being transported to the TBM launch sites within KNP.

The casting and curing would be undertaken in the precast building. Storage of the segments would predominantly be undertaken in uncovered storage areas.

Main inputs for the segments include aggregate, sand, cement, water and steel rebar.

Approximately 130,500 segments would be manufactured over the operational period.

2.3.2 Site layout

The layout of the proposed segment factory is shown in Figure 2.1. Details of the site layout are provided below.

i General layout

The CBP and precast building (which contains a casting room and curing chamber) would be located at the southern end of the site. Open storage areas would be located predominantly to the north of the building on the northern part of the site.

Site offices and workshops would be located in the south-western corner of the site.

ii Ingress and egress

Vehicle ingress and egress to the site would be provided on a new access road which would connect to Polo Flat Road. The access road would be constructed on an existing informal service road located in the unmade road corridor immediately north of Carlaminda Road.

iii Raw materials storage

Cement silos, and aggregate and sand storage areas for the CBP would be located adjacent to the CBP. Storage would be sized to hold approximately three days production.

Other raw materials include steel rebar and concrete admixtures which would be stored in, or adjacent to, the precast building.

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

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KEY

- Site boundary
- Indicative site layout
- Local road or track
- Cadastral boundary
- Precast yard, concrete plant, aggregates area, precast warehouse, segment storage
- Bus stop and parking
- Offices, guard house and first aid
- Mechanical and plant workshop with parking
- Trailer parking
- Storage area
- Emergency storage area
- Detention basin
- Drainage

Proposed site layout

Snowy 2.0
Noise and Vibration Impact Assessment
Proposed Segment Factory
Figure 2.1

snowy 2.0

EMM creating opportunities

iv Parking

Two large parking areas are proposed in the south-western corner of the site, and to the north of the precast building. Parking in the south western area would be used for light vehicles, trucks and buses. Parking to the north of the precast building would be used for trucks.

v Drainage

A diversion drain would be constructed around the eastern perimeter of the site to divert water from the third order watercourse. The drain diversion would be constructed to match the general width and depth of the existing watercourse.

A detention basin would be provided to the north of the site to collect surface flows. Overflows from the detention basin would be directed into the diversion drain.

2.3.3 Utility connections

The proposed segment factory would be connected to utility mains, including communications, electricity, water, wastewater and gas.

2.3.4 Segment inputs

As previously stated, main inputs for the precast concrete segments include aggregate, sand, cement and steel rebar. These main inputs would likely be sourced from locations in proximity to site and/or from quarries near Canberra.

In addition to these main inputs, several accessories are also required to produce the segments, such as reinforcement cages, steel fibres, gaskets and inserts. These inputs would likely be sourced locally or from Canberra.

2.3.5 Segment transport

Following casting, curing and storage, the segments would be transported to the TBM launch sites within KNP.

2.3.6 Traffic movements

Operational vehicle movements will comprise light vehicles (worker's vehicles and service vehicles) and heavy vehicles required for the transportation of the main inputs for the segments and for the transportation of the segments from the site to the TBM launch sites within KNP.

2.3.7 Staff and manpower

A workforce of about 125 people would be required to operate the proposed precast segment factory. As many local workers as possible would be sourced from the Snowy Mountains Regional LGA and surrounding localities.

2.3.8 Hours of operation

It is proposed to operate the proposed segment factory 24 hours a day, seven days a week. It is estimated that the factory would operate for a period of about 3.5 years.

2.4 Decommissioning

As previously stated, the proposed segment factory would be decommissioned at the completion of construction of Snowy 2.0 which would include removal of all plant and equipment. Snowy Hydro would retain the main structures such as the precast building, workshops and offices and seek to use these for an alternative industrial use.

It is envisaged that Snowy Hydro would submit a separate application for approval for an alternative use of the site prior to the decommissioning phase of the project.

2.5 Key aspects relevant to noise and vibration

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

- construction noise to nearest noise sensitive assessment locations;
- construction vibration from plant and equipment;
- operational noise from the proposed segment factory including sleep disturbance and cumulative noise; and
- road traffic noise on public roads due to project related traffic.

3 Existing environment

Polo Flat Industrial Area accommodates a variety of commercial and industrial uses including workshops and fabrication, wrecking yards, service station, bulk storage, building materials and concrete batching plant. To the east of the site is Monbeef meat processing facility with associated feedlots, whilst a cattle saleyard is to the south on the corner of Saleyards Road and Monaro Highway.

It is understood that the majority of the existing uses within the industrial area are daytime operation only. The Monbeef facility and saleyards operate 24/7 on a campaign basis. That is a period of intensive activity followed by a period of no activity. This is confirmed in the results of the background noise monitoring summarised in Section 3.2.

3.1 Noise and vibration assessment locations

The nearest representative noise sensitive locations to the proposed segment factory have been identified for the purpose of assessing potential noise and vibration impacts. These locations were selected to represent the range and extent of noise impacts from the site. 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. No schools, child-care centres, hospitals or similar uses are located within 1,500 m of the segment factory.

Table 3.1 Noise assessment locations

ID	Address	Classification	Easting	Northing
R1	14 Warra Street, Cooma	Residential	693057	5989409
R2[1]	10 Carlaminda Road, Polo Flat	Industrial	692758	5987347
R3	103 Bombala Street, Cooma	Residential	691580	5987112
R4	57 Bradley Street, Cooma	Residential	691813	5987775
R5	91 Baron Street, Cooma	Residential	691954	5987213
R6	82 Baron Street, Cooma	Residential	691964	5987291
R7	1 Albert Street, Cooma	Residential	691849	5987414
R8	63 Bradley Street, Cooma	Residential	691798	5987683
R9	1 Short Street, Cooma	Residential	691842	5988048
R10	3 Monaro Highway, Cooma	Residential	691871	5988605
R11	57 Yareen Road, Cooma	Residential	692242	5989152
R12	32 Woolalla Street, Cooma	Residential	692664	5989240
R13	12 Windarra Place, Cooma	Residential	692910	5989259
R14	4 Yamba Crescent, Cooma	Residential	693189	5989323
R15	130 Carlaminda Road, Cooma	Residential	693910	5987127
R16	112 Carlaminda Road Cooma	Residential	693796	5987246
R17	140 Carlaminda Road Cooma	Residential	693796	5987246
R18[1]	112 Carlaminda Road Cooma	Industrial	693796	5987246
R19[1]	112 Carlaminda Road Cooma	Industrial	693796	5987246
R20[1]	112 Carlaminda Road Cooma	Industrial	693796	5987246

Note: 1. Industrial site (IN1) with residence – residences are prohibited in IN1 zoning Cooma-Monaro Local Environmental Plan 2013. These residences were approved by Snowy Monaro Regional Council.

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

0 250 500 m

GDA 1994 MGA Zone 55

N

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KEY

- Site boundary
- Indicative site layout
- Rail line
- Main road
- Local road or track
- Watercourse
- Assessment location
- Monitoring location
- Precast yard, concrete plant, aggregates area, precast warehouse, segment storage
- Bus stop and parking
- Offices, guard house and first aid
- Mechanical and plant workshop with parking
- Trailer parking
- Storage area
- Emergency storage area
- Detention basin
- Drainage

Noise monitoring and assessment locations

Snowy 2.0
Noise and Vibration Impact Assessment
Proposed Segment Factory
Figure 3.1

snowy 2.0

EMM creating opportunities

3.2 Background noise survey

In order to establish the existing ambient noise environment of the area, unattended noise surveys and operator-attended aural observations were conducted at monitoring locations as guided by the procedures described in Australian Standard AS 1055-1997 - *Acoustics - Description and Measurement of Environmental Noise*.

Noise monitoring was conducted at four noise monitoring locations considered to be representative of the range of noise levels likely to be experienced by residential assessment locations in the vicinity of the site. The logger locations were selected after inspection of the site and its surrounds, giving due consideration to other noise sources which may influence the readings (eg domestic air-conditioners), the proximity of assessment locations to the site, security issues for the noise monitoring device and gaining permission for access from the residents or landowners.

The monitoring locations selected are presented in Table 3.2 and shown in (Figure 3.1).

Table 3.2 Noise monitoring locations

ID	Address	Instrumentation
NM1	14 Warra Street, Cooma	SVAN 957 S/N 27552
NM2	The site - southern boundary	SVAN 955 S/N 15223
NM3	103 Bombala Street, Cooma	SVAN 955 S/N 28808
NM4	57 Bradley Street, Cooma	SVAN 957 S/N 14566

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

A summary of existing background and ambient noise levels is given in Table 3.3. Results are provided for each day in Annexure A.

Table 3.3 Summary of existing background and ambient noise

Monitoring location	Period[1]	Rating background level (RBL)[2], dBA	Measured $L_{Aeq, period}$ noise level[3], dBA
NM1 – 14 Warra Street, Cooma	Day	35 (30)	47
	Evening	30 (25)	49
	Night	30 (<20)	43
NM2 – The site - southern boundary	Day	35 (32)	50
	Evening	30 (28)	44
	Night	30 (22)	39
NM3 – 103 Bombala Street, Cooma[4]	Day	44	61
	Evening	33	56
	Night	30 (25)	51

Table 3.3 Summary of existing background and ambient noise

Monitoring location	Period[1]	Rating background level (RBL)[2], dBA	Measured $L_{Aeq, period}$ noise level[3], dBA
NM4 – 57 Bradley Street, Cooma	Day	35 (31)	52
	Evening	30 (29)	53
	Night	30 (<20)	40

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

2. The RBL is an NPfI term and is used to represent the background noise level. In accordance with the NPfI, minimum thresholds were adopted given measured values were lower. Measured noise levels are provided in brackets () where relevant.

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

4. Noise monitoring location selected for measuring road traffic noise and for L_{A90} for assessment locations exposed to high traffic volumes.

For the review and assessment of road traffic noise levels, Table 3.4 provides a summary of the measured day $L_{Aeq,15hr}$ and night $L_{Aeq,9hr}$ noise levels for measurement locations NM3.

Table 3.1 Summary of existing traffic noise levels

Monitoring location	Measured $L_{Aeq,15hr}$ Noise Level, dB	Measured $L_{Aeq,9hr}$ Noise Level, dB
NM3 – 103 Bombala Street, Cooma	60	51

3.3 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 metres per second (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 assessment locations 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.

3.3.1 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 project's Air Quality consultant (EMM) (using CALMET), with input from the Australian Bureau of Meteorology's (BoM) automatic weather station (AWS) at Cooma Airport for the year 2017 with outputs presented in Table 3.5. Analysis identified that wind was not a feature of the area, in accordance with the NPfI procedures wind was not incorporated into the noise modelling.

Table 3.2 Percentage occurrence of wind speeds between 0.5 to 3 m/s (vector at 22.5° intervals), Cooma Airport from January 2017 to January 2018

Direction	Day				Evening				Night			
	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer	Winter	Autumn	Spring	Summer
N	2.7%	3.4%	1.9%	2.7%	4.5%	4.7%	3.8%	3.8%	3.3%	4.7%	7.6%	7.9%
NNE	3.1%	4.6%	2.9%	2.6%	3.4%	5.8%	6.3%	5.1%	3.7%	5.8%	9.4%	9.0%
NE	3.2%	5.0%	3.0%	2.4%	2.7%	7.2%	6.6%	5.1%	3.3%	6.5%	9.7%	9.4%
ENE	3.1%	5.2%	3.0%	2.2%	1.9%	8.2%	6.4%	5.5%	2.8%	6.5%	9.2%	9.6%
E	2.8%	4.8%	2.8%	1.6%	1.1%	7.0%	5.8%	5.0%	1.9%	4.5%	6.4%	5.5%
ESE	2.4%	4.1%	2.4%	1.0%	1.2%	6.9%	5.5%	5.5%	2.1%	4.3%	4.7%	4.6%
SE	2.8%	3.9%	1.8%	1.3%	3.7%	8.2%	2.5%	4.1%	3.6%	7.3%	3.5%	4.7%
SSE	3.6%	3.6%	2.2%	1.4%	6.7%	7.9%	2.7%	3.2%	7.6%	10.2%	4.8%	5.8%
S	4.2%	3.5%	2.2%	1.5%	7.4%	7.1%	2.8%	2.7%	8.5%	10.3%	5.2%	5.5%
SSW	4.3%	3.3%	2.0%	1.6%	8.2%	7.0%	2.9%	3.2%	9.3%	10.3%	5.3%	5.9%
SW	4.2%	3.0%	1.8%	1.7%	9.3%	6.4%	3.1%	3.9%	9.7%	9.8%	5.3%	5.8%
WSW	3.2%	2.0%	1.4%	1.6%	7.8%	4.0%	3.4%	4.9%	7.6%	5.4%	4.1%	4.7%
W	2.4%	1.6%	0.8%	1.7%	5.5%	3.2%	2.9%	5.1%	3.8%	2.1%	2.5%	3.1%
WNW	1.7%	1.5%	0.7%	1.8%	5.7%	2.8%	2.9%	5.5%	3.4%	1.5%	2.2%	3.3%
NW	1.6%	1.8%	0.9%	2.0%	5.4%	2.9%	3.4%	5.3%	3.2%	1.8%	3.0%	3.3%
NNW	2.0%	2.3%	1.2%	2.3%	5.3%	4.0%	3.5%	4.9%	3.4%	3.8%	5.7%	7.2%

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

3.3.2 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. It is noted that for the purpose of determining presence of temperature inversion conditions, the NPfI defines 'night-time' to be the period from 6 pm to 7 am and hence encompasses evening and night noise assessment period. Operation of the proposed segment factory would occur 24/7 so the effect of temperature inversions on noise levels needs to be considered.

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

Table 3.6 provides a summary of the Pasquill atmospheric stability categories (or a measure of temperature gradients) for evening and night. The analysis is based on data calculated the project's Air Quality consultant (EMM) (using CALMET), with input from the BoM AWS at Cooma Airport for the year 2017.

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

Table 3.3 Percentage occurrence of Pasquill stability categories

Pasquill stability category	Percentage occurrence (night[1] period)				
	Annual	Summer	Autumn	Winter	Spring
A	0%	0%	0%	0%	0%
B	1%	2%	0%	0%	1%
C	4%	9%	2%	0%	7%
D	28%	28%	26%	24%	32%
E	10%	8%	9%	13%	10%
F	57%	54%	63%	63%	50%

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

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

4 Assessment criteria

4.1 Operational noise

Following the construction and commissioning of proposed segment factory there will be noise emissions from plant and equipment associated with the operation of the factory for production of precast concrete segments to supply construction of the tunnels for Snowy 2.0.

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

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

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

4.1.1 Intrusiveness noise levels

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

The NPfI (Table 2.2 notes) states:

> For isolated residences within an industrial zone as defined in a local environment plan (LEP) the industrial amenity level is usually applied.

Isolated residences (R2, R18, R19 and R20) exist within the industrial area (IN1) as defined under Cooma- Monaro LEP 2013[1] despite being a prohibited use. These isolated residences are located on or adjacent to active industrial sites. The application of the NPfI results in the amenity criterion of 70 dB(A) $L_{eq,period}$ for these assessment locations.

Table 4.1 presents the intrusiveness noise levels determined for the site based on the adopted RBLs. Where assessment locations have been grouped together in the following tables, it has been assumed that the ambient noise environment at these assessment locations is similar.

Table 4.1 Project intrusiveness noise levels

Residential assessment location[1]	Assessment period[2]	Adopted RBL, dBA	Project intrusiveness noise level (RBL + 5 dB), $L_{Aeq,15min}$, dB
R1, R4-R9 and R11-R17	Day	35	40
	Evening	30	35
	Night	30	35
R3 and R10	Day	44	49
	Evening	33	38
	Night	30	35

Notes: 1. Residential assessment locations only.

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

4.1.2 Amenity noise levels

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

To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, the project amenity noise level for a new industrial development is the recommended amenity noise level (outlined in Table 2.2 of the NPfI) minus 5 dB. It is noted that this approach is based on a receiver being impacted by multiple industrial sites (or noise sources).

Residential areas potentially affected from operational noise are located to the south-east, west and north of the site. The project amenity noise level for residential assessment locations are presented in Table 4.2.

Table 4.2 Project amenity noise levels

Residential assessment location	Time period[1]	Indicative area	Project amenity noise level[2] dB, $L_{Aeq,period}$
R1, R4-R9 and R11-R14	Day	Suburban	50
	Evening		40
	Night		35
R3 and R10	Day	Suburban	50
	Evening		40
	Night		35
R15-R17	Day	Rural	45
	Evening		40
	Night		35
R2, R18-R20	Day	Industrial	70
	Evening		
	Night		

Source: NPfI (EPA 2017)

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

2. Project amenity noise level is Amenity noise level (Table 2.2 of NPfI) -5dB in accordance with NPfI Section 2.4.2.

4.1.3 Project noise trigger level

The project noise trigger level (PNTL) is the lower of the calculated intrusiveness or amenity noise levels. Taking account of the measured background noise levels, project intrusive noise levels and project amenity levels for residential assessment locations, a summary of the project noise trigger levels (PNTL) for the assessment of operational noise from the proposed segment factory is presented in Table 4.3.

Table 4.3 Project noise trigger levels

Residential assessment location	Assessment period[1]	Intrusiveness noise level, $L_{Aeq,15min}$, dB	Amenity noise level[2], $L_{Aeq,15min}$, dB	PNTL[3], $L_{Aeq,15min}$, dB
R1, R4-R9 and R11-R14	Day	40	53	40
	Evening	35	43	35
	Night	35	38	35
R3 and R10	Day	49	53	49
	Evening	38	43	38
	Night	35	38	35
R15-R17	Day	40	48	40
	Evening	35	43	35
	Night	35	38	35
R2, R18-R20	When in use	n/a	73	73

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

2. Project amenity LAeq,15min noise level is the recommended amenity noise level LAeq,period +3 dB as per the NPfI.

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

4.2 Mitigating noise

Where the PNTLs are predicted to be exceeded, all feasible and reasonable mitigation are to be considered for the project to reduce noise levels towards the PNTLs before any residual impacts are determined and addressed. Feasible and reasonable measures are discussed in Section 5.3.

The significance of the residual noise impacts are generally based around the human perception to changes in noise levels as explained in the glossary of the acoustic terms. For example, a change in noise level of 1 to 2 dB is typically indiscernible to the human ear. The characterisation of a residual noise impact of 0 to 2 dB above the PNTL is therefore considered negligible. This characterisation of residual noise impacts is outlined further in Table 4.4.

Table 4.4 Significance of residual noise impacts

If the predicted noise level minus the project noise trigger level is:	And the total cumulative industrial noise level is:	Then the significance of the residual noise level is:
≤ 2 dB	Not applicable	Negligible
≥ 3 but ≤5 dB	< recommended amenity noise level or > recommended amenity noise level, but the increase in total cumulative industrial noise level resulting from development is ≤1 dB	be Marginal
≥ 3 but ≤5 dB	> recommended amenity noise level and the increase in total cumulative industrial noise level resulting from the development is >1dB	Moderate
> 5 dB	≤ recommended amenity noise level	Moderate
> 5 dB	> recommended amenity noise level	Significant

Source: NPfI (NSW Government, 2017)

4.3 Sleep disturbance

The NPfI suggests that a detailed maximum noise level event assessment should be undertaken where operation or 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 numerous 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 (ie EPA) 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 4.5 provides the noise level event screening criteria for the residential assessment locations.

Table 4.5 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

4.4 Construction noise

The ICNG (DECC 2009) has been jointly developed by NSW Government agencies, including the NSW Environment Protection Authority (EPA) and Department of Planning (DoP). 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), as follows:

- Monday to Friday 7 am to 6 pm;
- Saturday 8 am to 1 pm; and
- no construction work is to take place on Sundays or public holidays.

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

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

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

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

4.4.1 Construction noise management levels

Table 4.6 provides ICNG noise management levels (NML) which apply to residential assessment locations.

Table 4.6 ICNG construction noise management levels for residences

Time of day	NML $L_{Aeq,15min}$	Application
Recommended standard hours: Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 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.
	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 4.7 summarises the ICNG recommendations and provides NML for other land uses.

Table 4.7 ICNG noise levels at other land use

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 project construction NMLs for recommended standard and out of hour periods are presented in Table 4.8 for all assessment locations. However, it is acknowledged that construction of the proposed segment factory would be during daytime hours only.

Table 4.8 Construction noise management levels – all assessment locations

Assessment location	Period	Adopted RBL[1]	NML $L_{Aeq,15min}$, dB
Residential assessment locations: R1, R4-R9 and R11-R17	Day (standard ICNG hours)	35	45
	Evening (out of hours)	30	35
	Night (out of hours)	30	35
Residential assessment locations: R3 and R10	Day (standard ICNG hours)	44	54
	Evening (out of hours)	33	38
	Night (out of hours)	30	35
Industrial premises including R2, R18-R20	When in use	n/a	75
Offices, retail outlets	When in use	n/a	70

Note: 1. The RBLs adopted from Table 3.3.

4.5 Construction vibration

4.5.1 Human perception of vibration

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

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

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2 1975. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in Table 4.9.

Table 4.9 suggests that people will just be able to feel floor vibration at levels of approximately 0.15 millimetres per second (mm/s) and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

Table 4.9 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 Hertz (Hz) to 80 Hz.

i Assessing vibration - a technical guideline

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

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

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in Table 4.10.

Table 4.10 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.

Continuous vibration associate with compaction of fill on the site is most relevant to the construction of the proposed segment factory.

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 4.11.

Table 4.11 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.

4.5.2 Structural vibration

i Australian Standard AS 2187.2 – 2006

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

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

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg 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 4.12 and graphically in Figure 4.1.

Table 4.12 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 4.12 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 4.12 may need to be reduced by up to 50%.

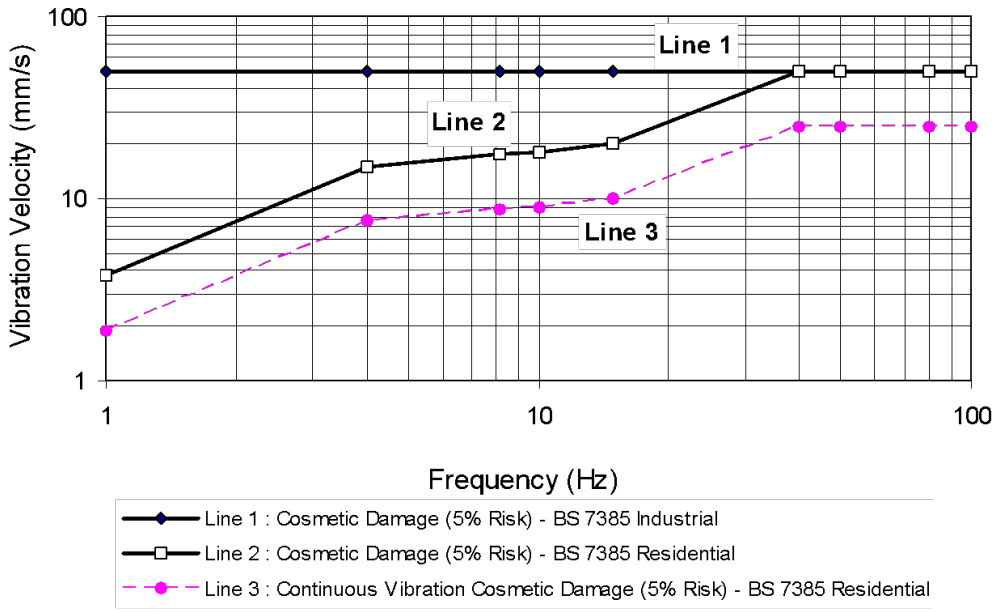


Figure 4.1 Graph of transient vibration guide values for cosmetic damage

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 4.12 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 4.12.

It is noteworthy that in addition to the guide values nominated in Table 4.12 the standard states that:

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

ii German Standard DIN 4150-3:1999

The German Standard DIN 4150 - Part 3: 1999, provides the strictest guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, or maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 4.13 and shown graphically in Figure 4.2.

For residential and commercial type structures, the standard recommends safe limits as low as 5 mm/s and 20 mm/s respectively. These limits increase with frequency values above 10 Hz. The operational frequency of construction plant typically ranges between 10 Hz to 30 Hz, and hence according to DIN 4150, the safe vibration guide limit range for dwellings is 5 to 15 mm/s. For reinforced commercial type buildings, the limit is as low as 20 mm/s, while for heritage or sensitive structures the lower limit is 3 mm/s.

Table 4.13 Structural damage guideline values of vibration velocity – DIN4150

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

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

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

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

As indicated by the guide levels from DIN 4150 in Table 4.13, high frequency vibration has less potential to cause damage than lower frequencies. Furthermore, the “point source” nature of vibration from plant causes the vibratory disturbances to arrive at different parts of nearby large structures in an out-of-phase manner, thereby reducing its potential to excite in-phase motion of the low order modes of vibration in such structures.

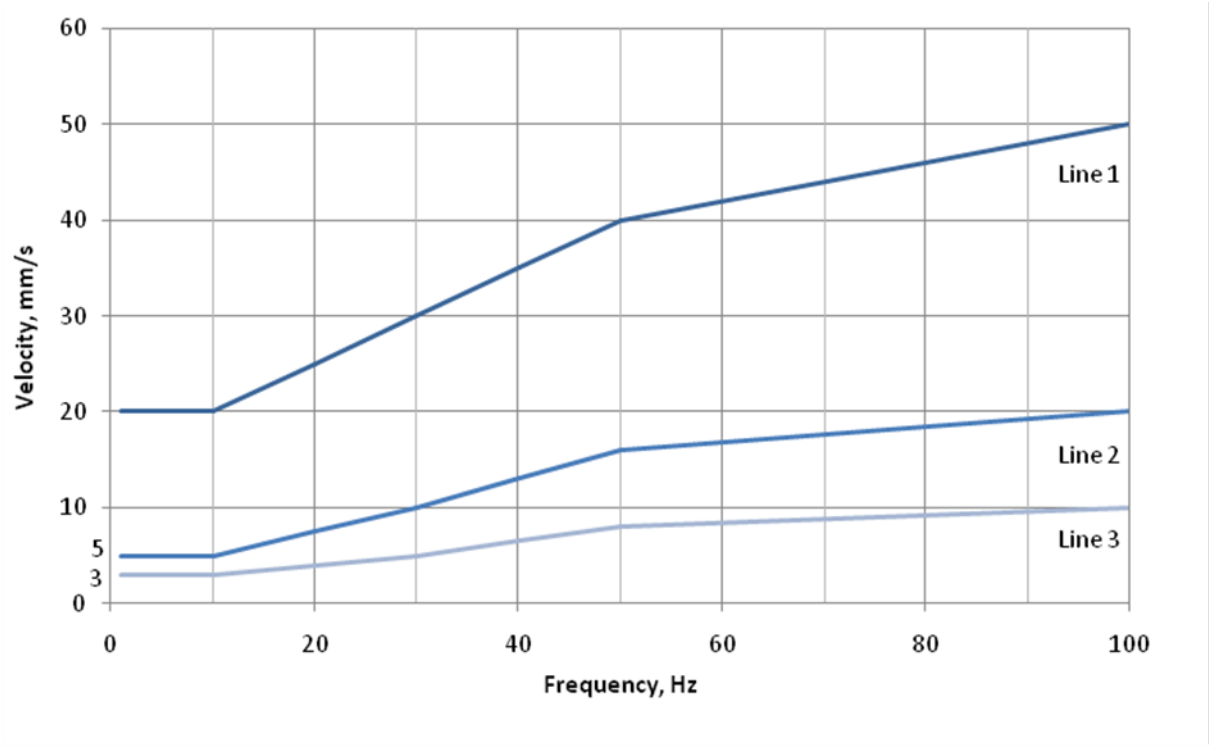


Figure 4.1 DIN4150 structural damage guideline values of vibration velocity

The potential effect of vibration on particular structures can vary depending on many factors including their existing structural integrity and use.

4.5.3 Project specific assessment criteria

Assessment of potential for cosmetic damage associated with construction activities of residential and commercial buildings, heritage structures, infrastructure items and transmission lines has adopted the criteria established in BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2* be used as they are “applicable to Australian conditions”.

4.5.4 Road traffic noise

Construction and operational traffic require assessment for potential noise impacts. The principle guidance to assess the impact of the road traffic noise on assessment locations is in the RNP. Table 4.14 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 proposed segment factory.

Table 4.1 Road traffic noise assessment criteria for residential land uses

Road category	Type of project/development	Assessment criteria – dBA	
		Day (7 am to 10 pm)	Night (10 pm to 7 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)

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 an increase of up to 2 dB.

In addition to meeting the assessment criteria in Table 4.14 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 4.15 should be considered for mitigation.

Table 4.2 Road traffic relative increase criteria for residential land uses

Road category	Type of project/development	Total traffic noise level increase – dBA	
		Day (7 am to 10 pm)	Night (10 pm to 7 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)

Appendix B of the RNP, states that noise levels shall be rounded to the nearest integer, whilst difference between two noise levels are to be rounded to a single decimal place.

5 Assessment method

5.1 Noise modelling

This section presents the methods and base parameters used to model operational and construction noise and vibration emissions from the proposed segment factory.

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

The model was populated with 3-D topography of the project area and surrounding area, extending out past nearest assessment locations. Plant and equipment representing the range of proposed construction and operation scenarios was placed at locations which would represent worse case noise levels throughout the construction and operational scenarios.

5.2 Operations noise

5.2.1 Design drawings

The acoustic assessment has been based on design drawings (5 August 2019) and details listed below:

- Snowy 2.0 Polo Flat Air Field, Precast Yard Site, Site Locality Plan, Sheet 1 Rev A;
- Snowy 2.0 Polo Flat Air Field, Precast Yard Site, Site Layout Plan, Sheet 2 Rev A;
- Snowy 2.0 Polo Flat Air Field, Conceptual - Precast Yard Site, Plan and Sections, Sheet 6 Rev A; and
- Snowy 2.0 Method Statement Precast Yard, SH2.0-RFT-CS2.11-MS27.

5.2.2 Plant and equipment

Plant and equipment and associated sound power levels considered for operations is presented in Table 5.1 and Figure 5.1. The list is based on information provided by FGJV and review of similar facilities. Plant and equipment associated with the operation of the segment factory comprises both fixed and mobile noise sources. Plant and equipment presented in Table 5.1 incorporate fixed and mobile plant sound power levels (Lw) and typically operating external to the building and internal noise levels for space averaged internal sound pressure levels. The noise model has taken account of the total surface area (m^2) of the buildings and noise reduction across building facades / roof and open doors.

The sound power levels assigned to each item have been sourced from an EMM measurement database of similar equipment, Department of Environment, Food and Rural Affairs (DEFRA) 2005, *Update of Noise Database for Prediction of Noise on Construction and Open Sites*, manufacturer data and other equivalent facilities.

Table 5.1 Operational plant and equipment

Description	No. of items	Sound power level ($L_{Aeq,15min}$) dBA
External		
Front End Loader (CAT 972H, Hyundai HL770 7A or equivalent)[1]	1	105
Fork-Lift (Hyundai 250D-9 or equivalent)[2]	4	103
Low loader[1]	1	103
Boiler[1]	2	85
Semi-Trailer[1]	2	103
Low Loader[1]	1	103
Cement delivery (compressor) [1]	Vehicle - adjacent silos	104
Internal		
Insulated Concrete batching Plant (e.g. Perth)[1,3]	building	91^
Office/Warehouse[1]	building	70*
Segment manufacturing[4]	building	78*
Segment curing[4]	building	75*
Metal fabrication – rebar cages[1]	building	80*

Notes: ^ external noise level of insulated concrete batching plant (consistent with EMM audits of similar facilities)
* space averaged internal sound pressure level

1. EMM database audit measurements
2. Sydney Metro City & Southwest – TSE Works – Construction Noise and Vibration Impact Statement Marrickville Construction Site – Renzo Tonin Associates 2018
3. FGJV data Perth (Forrestfield Airport Link Precast / Segment Facility) – external level adjusted for surface area (m^2) of building for Transport for London – Silvertown Tunnel – Environmental Appraisal of Precast Concrete (PCC) Segment Manufacturing Plant 2017

Noise from the segment factory operational plant and equipment considers the following:

- operating sound power level of plant calculated for a number of items running simultaneously;
- reduction in noise levels from building fabric (model has assumed all segment factory buildings including roof be constructed of minimum 0.6mm BMT sheet metal within internal lining of 100 mm medium to heavy duty fibreglass or rockwool building blanket);
- closed doors to manufacturing buildings during evening and night operations;
- continuous 24/7 operation of batching plant and segment factory; and
- prediction of noise levels at the identified assessment locations.

Preliminary noise modelling of the factory identified the potential for exceedances of PNTLs at a number of residential assessment locations. Noise exceedances were a result of noise sources including:

- FEL servicing CBP and raw materials bunkers and load hopper;
- truck manoeuvring area;

- trucks traversing site including low loader and segment transfer to site (KNP);
- utilisation of fork trucks servicing:
    - main northern storage area;
    - temporary storage adjacent building (north); and
    - temporary storage area adjacent building (south-east).

Where exceedance of PNTLs have been identified for a project, Section 3.1 of the NPfI requires the proponent to consider all feasible and reasonable mitigation measures to reduce noise levels.

5.3 Feasible and reasonable noise mitigation

5.3.1 Overview

A noise mitigation measure is considered feasible if it can be engineered and is practical to build and/or implement, given project constraints such as safety, maintenance and reliability requirements.

Reasonableness relates to the application of judgement in arriving at a decision, taking into account if the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the mitigation measure.

The following factors have been considered when evaluating the available noise mitigation options:

- Noise impacts:
    - existing and future noise levels, and projected changes in noise levels;
    - the amount by which the NPfI triggers are exceeded;
- Noise mitigation benefits:
    - amount of noise reduction expected;
    - number of people likely to benefit;
- Cost-effectiveness of noise mitigation:
    - total cost of mitigation measures (including capital and maintenance);
    - ongoing operational and maintenance cost borne by the community (eg running air conditioners if closing dwelling windows is required to improve noise);
- Community views:
    - aesthetic considerations; and
    - views of all potentially affected areas determined through community consultation.

5.3.2 Assessment of mitigation

Consideration of the feasibility and reasonableness of additional noise mitigation measures has been undertaken with reference to the guidance provided in Section 3.4 of the NPfI. Assessment location R16 was identified as the main location for noise mitigation.

Operational noise sources contributing to the exceedance of the PNTLs were principally associated with external activities including:

- FEL operating on the northern side of the building feeding the CBP hopper with raw materials;
- fork trucks transferring segments from segment curing building to the north and south-east temporary storage areas;
- low loader movements for transfer of segments to KNP.

Mitigation options targeting these noise sources have been considered as provided in Table 5.2. Mitigation strategies have been considered in the following hierarchical approach:

1. control of noise at the source;
2. once the feasible and reasonable controls at the source are exhausted, controlling the transmission of noise; and
3. once source and transmission feasible and reasonable controls are exhausted, considering mitigation measures at the noise-sensitive receivers.

A key measure not outlined above is the application of land-use controls, that is separating noise generating development from other sensitive uses. This approach avoids conflict of noise and sensitive land-use and potential cost of short-term mitigation measures. The implementation of land use controls could also incorporate measures that restrict the operation of specific sites during more sensitive time periods like evening and night, when considering impacts at residential assessment locations.

Table 5.2 Mitigation decision-making matrix

Mitigation option	Feasible?	Reasonable?	Justification for adopting / disregarding and expected noise benefit
At-source controls			
Option 1 Only operate segment factory and storage during day hours	No	No	This would significantly restrict production capacity for the site and lead to segment supply issues and delays to the construction of the Snowy 2.0 tunnel. A significant lead time for segment production would be required to stockpile sufficient segments to not impact on tunnel construction. Benefits: Compliance with PNTLs at all assessment locations. No sleep disturbance impacts.

Table 5.2 Mitigation decision-making matrix

Mitigation option	Feasible?	Reasonable?	Justification for adopting / disregarding and expected noise benefit
Option 2 Prohibit evening and night external fork and truck movements. Production fully operational. Restrict truck routes western and northern side of building only	No	No	Production rates of segments would need to reduce due to limited storage in building, leading to significant extension in Snowy 2.0 construction duration. Unreasonable impacts on overall project and extended duration of noise exposure for assessment locations. Benefits: Compliance with PNTLs at all assessment locations. No sleep disturbance impacts.
Option 3 Reduction in utilisation of fork trucks operating externally in evening / night hours	Yes	Yes	Benefits: Reduction in noise contribution from fork trucks Residual exceedance of 3-4 dB of PNTL at R16 and considered marginal.
Option 4 Reconfigure raw materials storage and load hopper area to western side of CBP AND Reduction in utilisation of fork trucks operating externally in evening / night hours AND Truck / trailer storage north of building	Yes	Yes	Will require a redesign of layout but utilises building structure to provide acoustic shielding to assessment locations R15, R16 and R17 from CBP and FEL activities. Benefits: Reduction in noise contribution from FEL operation to feed CBP by 5-7 dB. Overall noise reductions of 3-4 dB to R16 with residual exceedance of 2 dB of PNTL and considered negligible.
Control transmission of noise			
Option 5 Provision of blade wall (5m high above hardstand) extending north on the eastern alignment of the segment building OR Acoustic wall (5m high above hardstand) on eastern site boundary	Yes	No	Cost very high and has potential flow on effects in terms of surface water flows and increased disturbance footprint. Benefits: Reduction in noise contribution from external activities including fork trucks, low loader and FEL serving CBP by 5-7 dB. Overall noise reductions of 3-4 dB to R16 with residual exceedance of 2 dB of PNTL and considered negligible.
Mitigation at the receptor			
Receptor mitigation	Yes	No	Potential for at receiver mitigation, however this should only be considered after the above two approaches have been exhausted and residual noise impacts are greater than 2 dB. Not required if Option 4 adopted.

The operational scenarios presented in Table 5.3 were adopted following consideration of feasible and reasonable options outlined in Table 5.2 and the implementation of Option 4 mitigation comprising the reconfigured load hopper and raw materials bunkers on the western side of the CBP and reduced fork truck utilisation.

Noise from plant and equipment (Table 5.1) was considered in conjunction with the day and evening / night scenarios and equipment utilisation outlined in Table 5.3 and shown graphically in Figure 5.1.

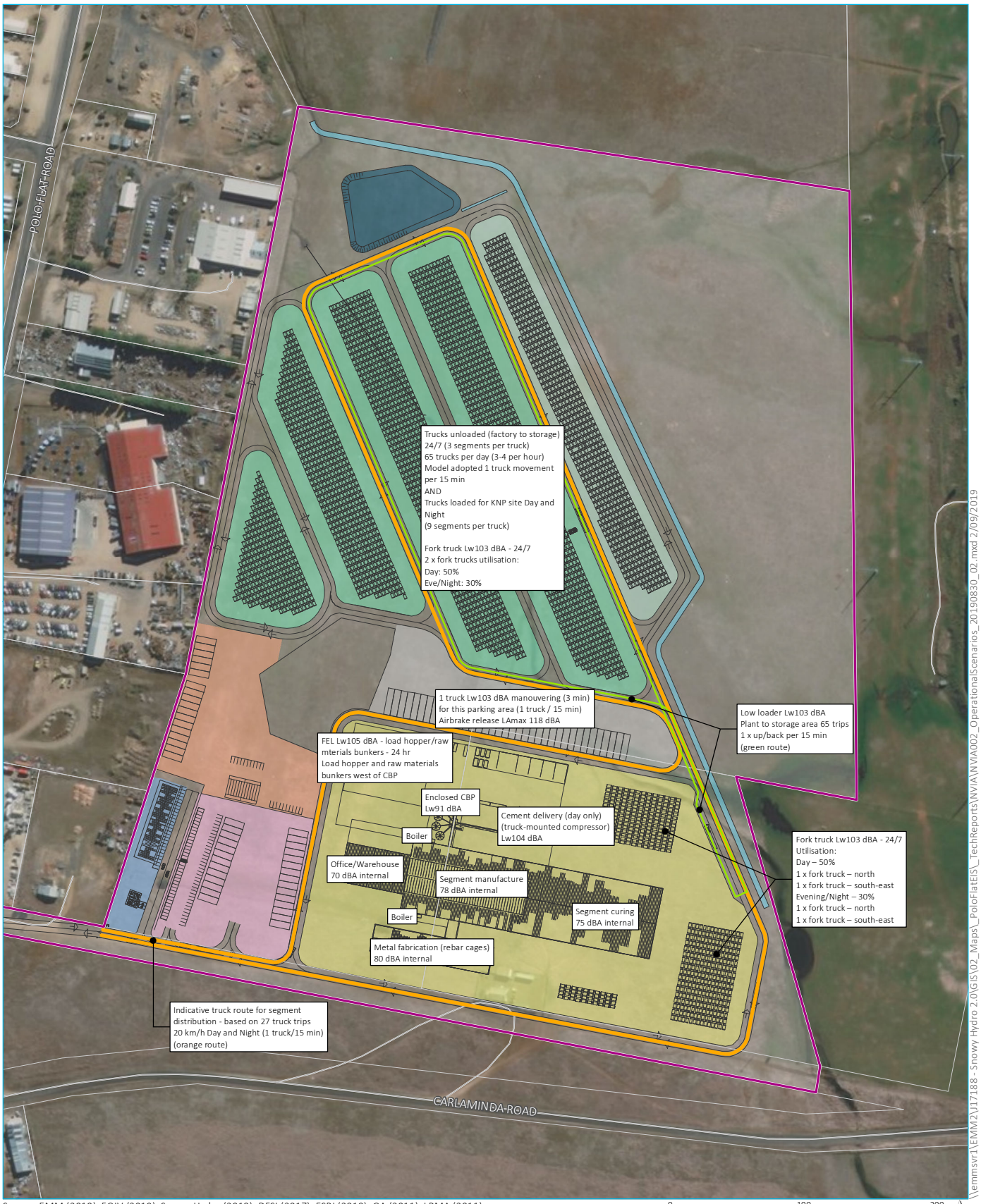
Table 5.3 Operational scenarios

Scenario	Description	Utilisation (%)/15min
Day	Front End Loader (x1):	
	• aggregate pile	70
	• load hopper and storage bunkers	30
	Fork-Lift (x4):	
	• 2 x fork trucks in northern storage area	50
	• 1 x fork truck loading low loader (north)	50
	• 1 x fork truck stacking segments (south-east)	50
	Low loader:	
	• Loaded on northern side of building	30
	• Traversing through northern storage	30
	Insulated Concrete batching Plant - building	100
	Boiler (x2) – adjacent building	100
	Semi-Trailer (x1):	
	• Distribution of precast segments - route through site	50[1]
	• Trailer parking	20
	Low Loader -route from north side of building to storage area	25[1]
	Office/Warehouse - building	100
	Segment manufacturing - building	100
	Segment curing - building	100
	Metal fabrication – rebar cages - building	100
	Cement delivery (compressor) – west of cement silos	100
Evening / Night	Front End Loader (x1) – CBP area:	
	• aggregate pile	30
	• load hopper and storage bunkers	70
	Fork-Lift (x4):	
	• 2 x fork trucks in northern storage area	30
	• 1 x fork truck loading low loader (north)	30
	• 1 x fork truck stacking segments (south-east)	30
	Low loader:	
	• Loaded on northern side of building	25[1]
	• Traversing through northern storage	25[1]
	Insulated Concrete batching Plant - building	100
	Boiler (x2) – adjacent building	100
	Semi-Trailer (x2):	
	• Distribution of precast segments - route through site	50[1]
	• Trailer parking	20

Table 5.3 Operational scenarios

Scenario	Description	Utilisation (%)/15min
	Low Loader -route from north or east side of building to storage area	25[1]
	Office/Warehouse - building	100
	Segment manufacturing - building	100
	Segment curing - building	100
	Metal fabrication – rebar cages - building	100
	Cement delivery (compressor) – west of cement silos	100

Note: 1. Accounting for length of route through site and 20km/h travel speed.



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

0 100 200 m

GDA 1994 MGA Zone 55

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KEY

- Site boundary
- Indicative site layout
- Local road or track
- Cadastral boundary
- Truck route for transfer of segments to storage
- Truck route for segment distribution
- Precast yard, concrete plant, aggregates area, precast warehouse, segment storage
- Bus stop and parking
- Offices, guard house and first aid
- Mechanical and plant workshop with parking
- Trailer parking
- Storage area
- Emergency storage area
- Detention basin
- Drainage

Operational scenarios

Snowy 2.0
Noise and Vibration Impact Assessment
Proposed Segment Factory
Figure 5.1

snowy 2.0

EMM creating opportunities

i Night-time maximum noise level events and sleep disturbance

Operation of the segment factory is proposed to be 24/7, hence assessment of intermittent noise and potential for sleep disturbance at residential assessment locations is required under the NPfI. For the purpose of assessing sleep disturbance, a worse case sound power level of 118 dBA L_{Amax} (based on EMM measurements) has been considered for the assessment of airbrake release for trucks on site.

Areas on the site with the greatest potential for this activity to occur are the trailer parking area on the northwest of the site as shown on Figure 5.1, however for assessment purposes potential activities were considered at multiple locations throughout the northern segment storage area, low loader on eastern side of segment building, trailer parking area and bus / trailer parking at site entry / exit.

5.3.3 Noise predictions

i Single point predictions

Noise predictions to assessment locations identified in Table 3.1 and Figure 3.1 considered source noise levels outlined in Table 5.1 and the scenario assumptions for day and evening/night operation outlined in Table 5.3 and Figure 5.1 to predict the overall $L_{Aeq,15min}$ noise contributions.

ii Noise contours

Further to the above approach and acknowledging adjacent industrial land uses and other residential areas to the north, south and west of the site, noise contours have been generated for the day and evening/night operational activities to determine the potential extent of noise exposure.

5.3.4 Noise enhancing meteorology

Noise modelling was conducted using Brüel & Kjær Predictor noise modelling software. The model utilised international standard ISO 9613-2:1996 'Acoustics – Attenuation of sound during propagation outdoors'. As per Section 1 of the standard:

> The method predicts the equivalent continuous A-weighted sound pressure level (as described in parts 1 to 3 of ISO 1996) under meteorological conditions favourable to propagation from sources of known sound emission.
>
> These conditions are for downwind propagation, as specified in 5.4.3.3 of ISO 1996-2:1987 or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.

A summary of modelling conditions for which noise predictions have been provided are shown in Table 5.4.

Table 5.4 Conditions adopted in the model

Assessment condition	Period	Temperature	Wind speed (m/s)[1]	Relative humidity	Stability class
ISO9613	Day	10°C	2	70%	n/a
	Evening/Night	0°C	2	90%	F[2]

Notes: 1. Downwind conditions in accordance with ISO9613 algorithm – Section 5 and 8.
2. Moderate inversion as defined in NPfI.

5.4 Construction noise

5.4.1 Times

Construction of the segment factory would be during daytime hours only and has an envisaged duration of up to five months. Key stages in construction of the site will include:

- bulk earthworks, filling, compaction and drainage;
- concrete hardstand for factory building and surrounds, concrete or asphalt site roadways and stabilised pavement for main northern segment storage area; and
- building erection and commissioning.

5.4.2 Equipment sound power levels

i Continuous

Equipment sound power levels have been taken from the Department of Environment, Food and Rural Affairs (DEFRA) 2005, *Update of Noise Database for Prediction of Noise on Construction and Open Sites*, where available. Otherwise data was sourced from an EMM database of similar equipment which is based on measurements at other construction sites.

Acoustically significant fixed and mobile equipment items were considered in the model for the site with 100% utilisation based on information provided by FGJV. A review of the supplied information confirmed that bulk earthworks and hardstand construction had potential for the greatest noise impact. A summary of the cumulative sound power level (Lw) for the schedule of plant is presented in Table 5.5. The model considered the cumulative plant and equipment sound power level as an area source across the site providing a potential worse-case scenario. This approach accounts for construction phases, compaction and concrete, occurring simultaneously, whilst allowing some flexibility in specific locations of individual activities.

Table 5.5 Construction equipment sound power levels

Description	No. of items	Sound power level, dB (per single item)
Agitator Truck	3	108
Bobcat 543 Skid Steer	1	95
Crane 100t	1	112
Dozer CAT D6	2	112
Excavator 12t (0.21-0.76m^3)	1	110
Excavator CAT 345	1	107
Franna Crane 25tn	1	98
Roller 16t smooth drum	1	101
Truck & Dog	1	103
Wheeled Compactor	1	110
Low Loader	1	103
Total	14	119

Notes: Plant schedule for construction provided by FGJV.

ii Night-time maximum noise level events and sleep disturbance

Construction activities are not proposed during the ICNG night-time hours of 10 pm to 7 am. Therefore, intermittent noise and assessment of the sleep disturbance at residential assessment locations has not been considered further for construction activities.

5.4.3 Noise predictions

i Single point predictions

In order to assess a potential worse-case construction scenario, the assessment has considered the identified plant and equipment in Table 5.5 operating continuously over a 15 minute period. Construction noise levels were predicted to the assessment locations listed in Table 3.1 and identified in Figure 3.1.

ii Noise contours

Further to the above approach and acknowledging adjacent industrial land uses and other residential areas to the north, south and west of the site, noise contours have been generated for the day to evaluate noise exposure surrounding the site.

5.4.4 Noise enhancing meteorology

Construction is proposed to occur during day hours only. A review of prevailing meteorological conditions for the site (Section 3.3) confirmed that wind was not a feature of the area, notwithstanding modelling of construction noise considered standard ISO9613 weather conditions.

5.5 Construction vibration

5.5.1 Mobile plant and equipment

Safe working distances for typical items of vibration intensive plant are listed in Table 5.6. 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 5.6 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (BS 6472)
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
Vibratory Rollers	<50kN (Typically 1-2 tonnes)	5 m	15 to 20 m
	<100kN (Typically 2-4 tonnes)	6 m	20 m
	<200kN (Typically 4-6 tonnes)	12 m	40 m
	<300kN (Typically 7-13 tonnes)	15 m	100 m
	>300kN (Typically 13-18 tonnes)	20 m	100 m
	>300kN (>18 tonnes)	25 m	100 m

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

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

The safe working distances presented in Table 5.6 are indicative and will vary depending on the 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.

5.6 Road traffic noise

The Calculation of Road Traffic Noise (CoRTN) and US EPA Federal Highways (FHWA) methods were considered in the assessment of road traffic noise. Where traffic flows were low (<200 vehicles per hour) the FHWA procedures were adopted as it is more sensitive to low traffic volumes. Where traffic volumes were greater than 200 vehicles per hour the CoRTN methodology was adopted. A summary of the road sections and assessment methodology is provided in Table 5.7 and identified in Figure 5.1.

Table 5.7 Road segments considered in noise assessment

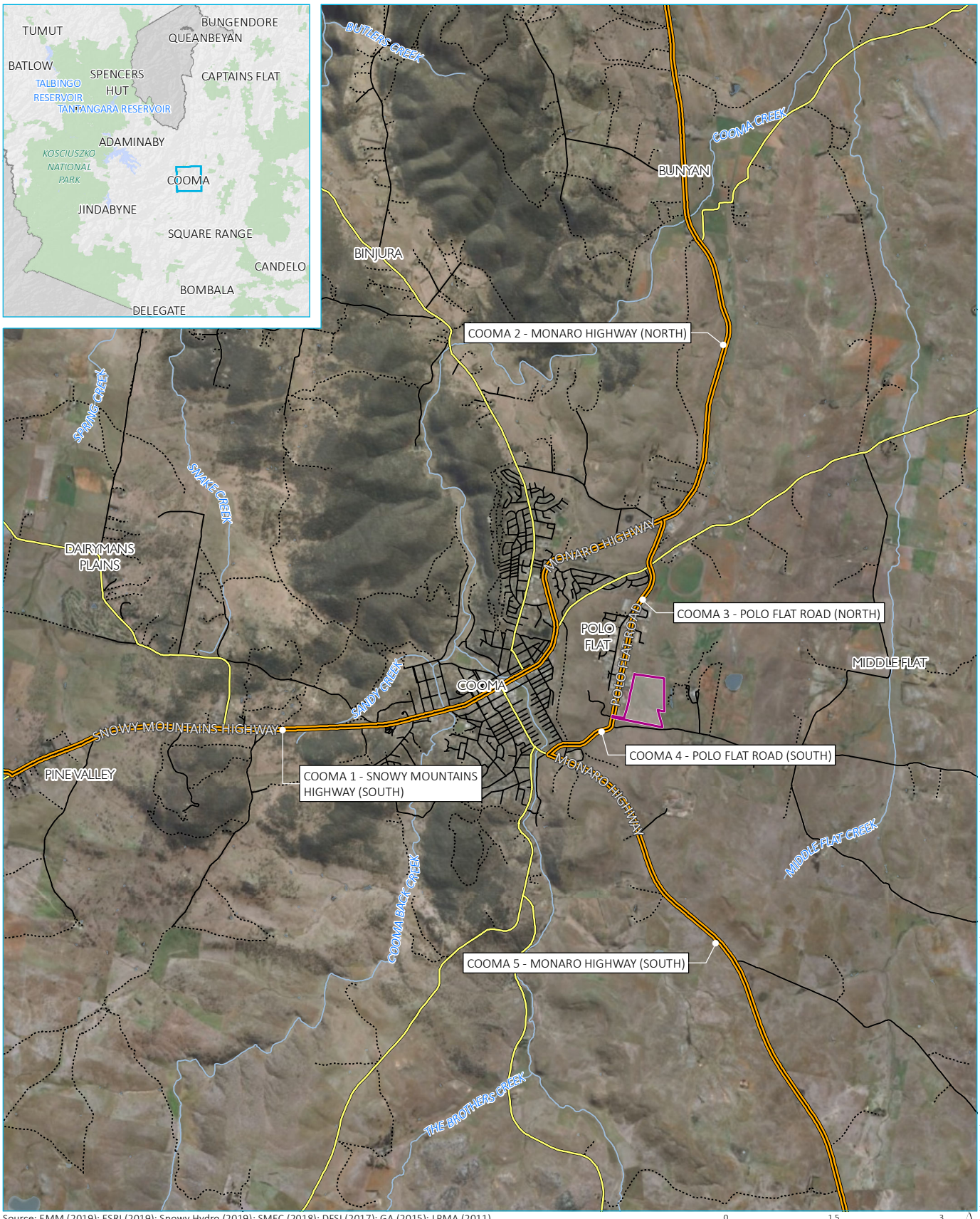
ID	Road segment / name	AADT	Assessment methodology
Cooma 1	Snowy Mountains Highway (south)	4847	CoRTN / FHWA[1]
Cooma 2	Monaro Highway (north)	6395	CoRTN / FHWA[1]
Cooma 3	Polo Flat Road (north)	1862	FHWA
Cooma 4	Polo Flat Road (south)	2169	FHWA
Cooma 5	Monaro Highway (south)	2495	FHWA

Note: 1. FHWA adopted to night traffic assessment due to low traffic volumes.

Road traffic movements associated with construction and operation of segment factory have been referenced from the Traffic Impact Assessment (SCT 2019) and adapted to suit RNP assessment requirements (Section 4.5.3).

Road traffic noise levels from the project have been assessed by calculating existing and existing plus project traffic at representative residential assessment locations using FHWA and CoRTN methods. The following assumptions have been adopted:

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



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

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KEY

- Site boundary
- Assessed road segment
- Main road
- Local road
- Vehicular track
- Named watercourse
- Waterbody

Assessed road segments

Snowy 2.0
Noise and Vibration Impact Assessment
Proposed Segment Factory
Figure 5.2

snowy 2.0

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6 Impact assessment

6.1 Operational noise

6.1.1 Single point predictions

In accordance with procedures outlined in Section 5.3.3 prediction of single point operational noise levels are provided in Table 6.1 for day and evening / night periods. The levels presented for each assessment location represents the energy-average noise level over a 15 minute period and assumes all plant operating concurrently in accordance with scenarios outlined in Table 5.3 under ISO9613 noise enhancing conditions.

Table 6.1 Predicted operational noise levels – ISO9613

Assessment location	Classification	Period	PNTL, dB	Predicted noise level, dB $L_{Aeq,15min}$
R1	Residential	Day	40	27
		Evening/Night	35	25
R2[1]	Industrial	Day	70	44
		Evening/Night		43
R3	Residential	Day	48	26
		Evening/Night	35	25
R4	Residential	Day	40	26
		Evening/Night	35	24
R5	Residential	Day	40	27
		Evening/Night	35	26
R6	Residential	Day	40	26
		Evening/Night	35	25
R7	Residential	Day	40	25
		Evening/Night	35	23
R8	Residential	Day	40	25
		Evening/Night	35	23
R9	Residential	Day	40	25
		Evening/Night	35	23
R10	Residential	Day	48	27
		Evening/Night	35	26
R11	Residential	Day	40	26
		Evening/Night	35	25
R12	Residential	Day	40	27
		Evening/Night	35	26
R13	Residential	Day	40	30
		Evening/Night	35	29

Table 6.1 Predicted operational noise levels – ISO9613

Assessment location	Classification	Period	PNTL, dB	Predicted noise level, dB $L_{Aeq,15min}$
R14	Residential	Day	40	29
		Evening/Night	35	27
R15	Residential	Day	40	36
		Evening/Night	35	34
R16	Residential	Day	40	39
		Evening/Night	35	**37**
R17	Residential	Day	40	35
		Evening/Night	35	33
R18[1]	Industrial	Day	70	38
		Evening/Night		36
R19[1]	Industrial	Day	70	31
		Evening/Night		30
R20[1]	Industrial	Day	70	31
		Evening/Night		30

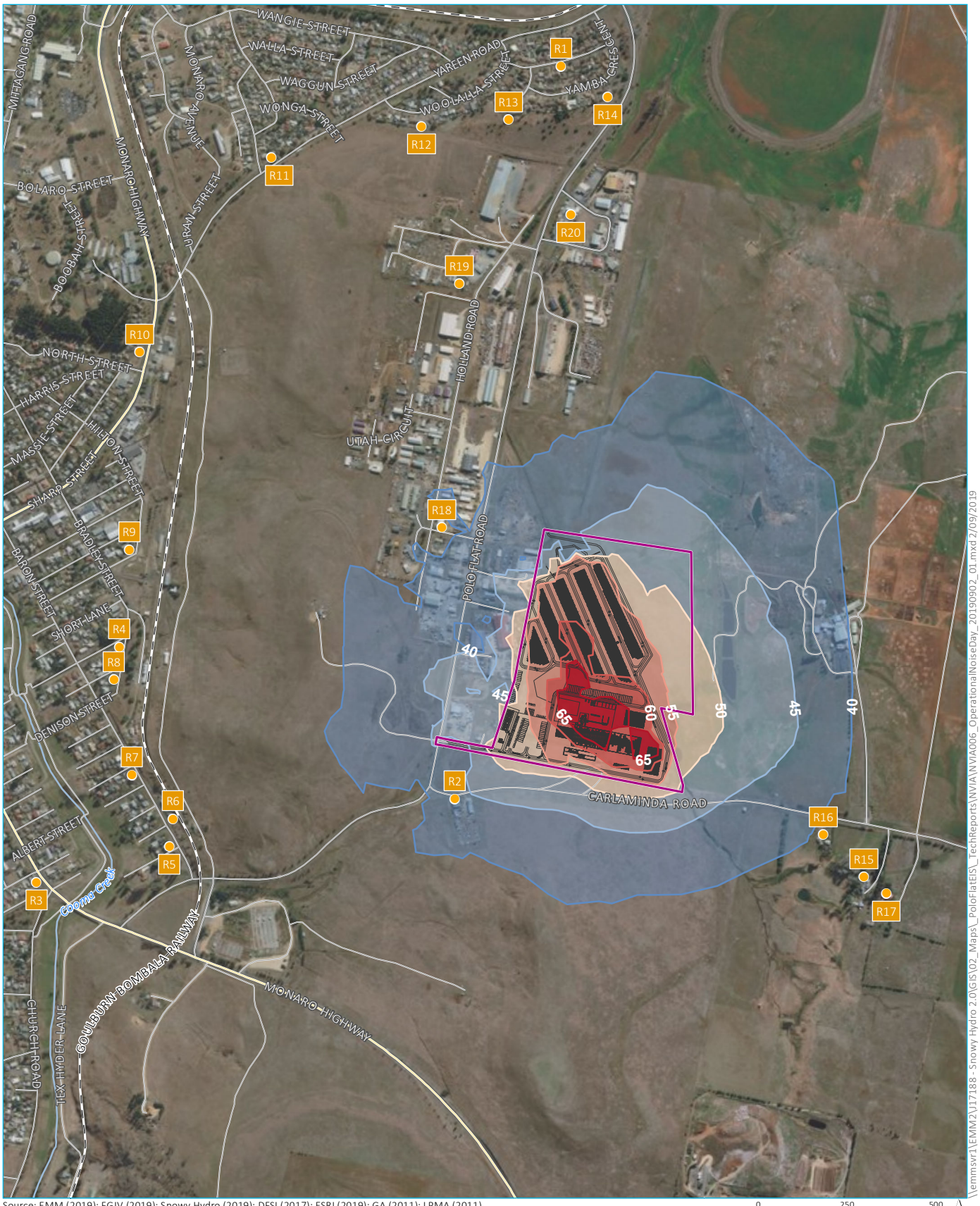
Notes: 1. Industrial site (IN1) with residence – residences are prohibited in IN1 zoning Cooma-Monaro Local Environmental Plan 2013. These residences were approved by Snowy Monaro Regional Council.

2. Exceedances of PNTL shown in **bold**.

Noise modelling has demonstrated the PNTLs are satisfied at all assessment locations during day operations. Exceedance of 2 dB of the PNTL has been identified for R16 during evening / night operations. Under the definitions under Section 4.2 of NPfI a 2 dB exceedance would be considered 'negligible', would not be discernible by the average listener and therefore would not warrant receiver-based treatments or controls.

6.1.2 Contours

Predicted $L_{Aeq,15min}$ noise contours representing day and evening/night operations are provided in Figure 6.1 and Figure 6.2 respectively. The figures represent the predicted operational noise levels during ISO9613 conditions for day and noise enhancing for evening/night.



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

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KEY

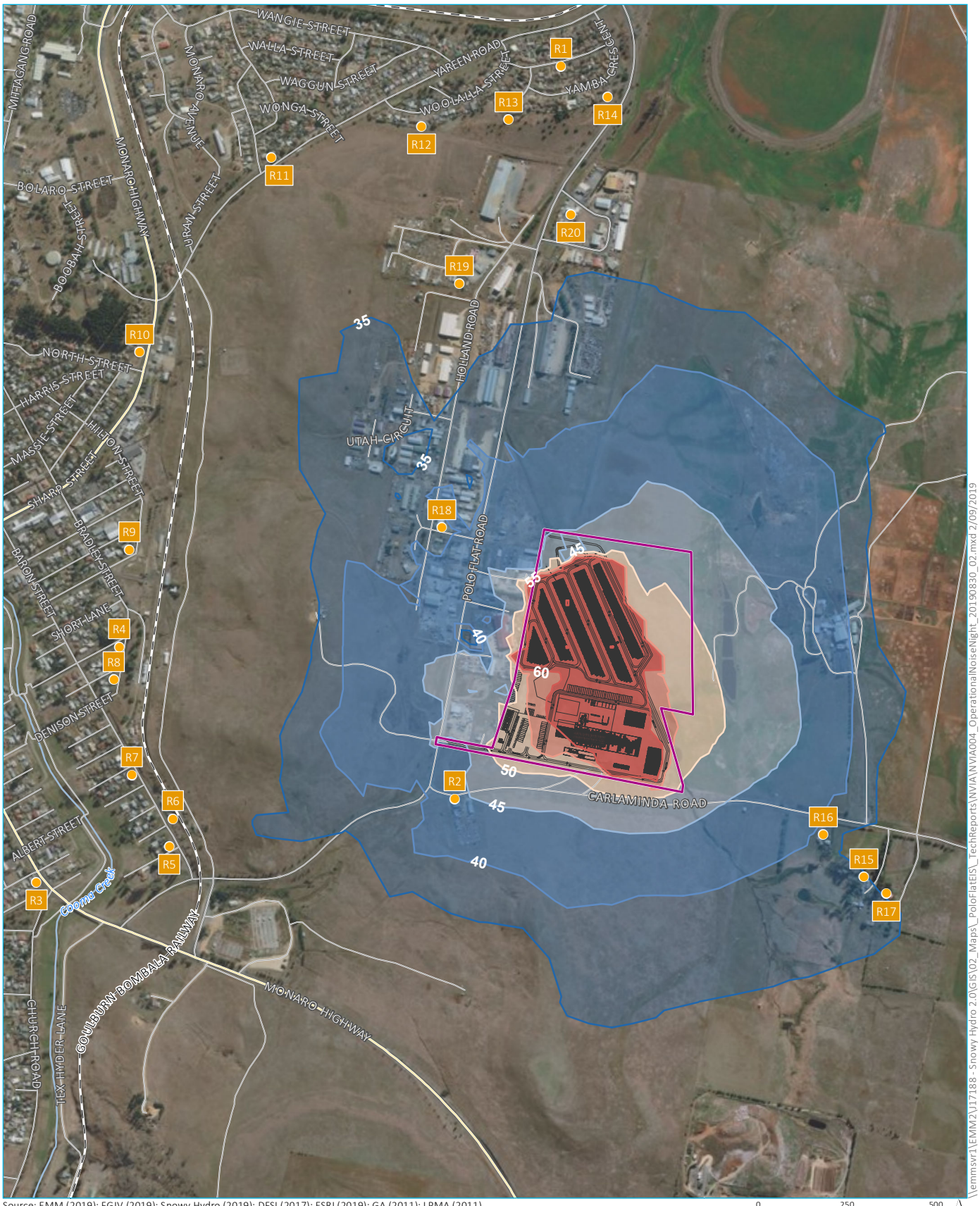
Site boundary	Noise level contour	Noise level contour range
Indicative site layout	40 dB(A)	40 - 44 dB(A)
Assessment location	45 dB(A)	45 - 49 dB(A)
Rail line	50 dB(A)	50 - 54 dB(A)
Main road	55 dB(A)	55 - 59 dB(A)
Local road or track	60 dB(A)	60 - 64 dB(A)
Watercourse	65 dB(A)	65 + dB(A)

Operational noise contours, day, ISO9613

Snowy 2.0
Noise and Vibration Impact Assessment
Proposed Segment Factory
Figure 6.1

snowy 2.0

EMM creating opportunities



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

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KEY

Site boundary	Noise level contour	Noise level contour range
Indicative site layout	35 dB(A)	35 - 39 dB(A)
Assessment location	40 dB(A)	40 - 44 dB(A)
Rail line	45 dB(A)	45 - 49 dB(A)
Main road	50 dB(A)	50 - 54 dB(A)
Local road or track	55 dB(A)	55 - 59 dB(A)
Watercourse	60 dB(A)	60 - 64 dB(A)

Operational noise contours, evening/night, ISO9613

Snowy 2.0
Noise and Vibration Impact Assessment
Proposed Segment Factory
Figure 6.2

snowy 2.0

EMM creating opportunities

6.1.3 Intermittent noise events

Modelling of intermittent L_{Amax} noise events at night considered a typical worse case event of truck airbrake release and a source sound power level of 118 dBA. Potential for these events were considered at staggered locations along the east, north and western areas of the site and predicted to the identified assessment locations. The results of the predictions under calm and noise enhancement conditions are presented in Table 6.2.

Table 6.2 Predicted intermittent noise levels – ISO9613

Assessment location	Classification	Period	Screening Level, dB	Predicted intermittent noise level, dB L_{Amax}
R1	Residential	Night	52	38
R2[1]	Industrial	Night	n/a	57
R3	Residential	Night	52	37
R4	Residential	Night	52	35
R5	Residential	Night	52	36
R6	Residential	Night	52	34
R7	Residential	Night	52	36
R8	Residential	Night	52	35
R9	Residential	Night	52	37
R10	Residential	Night	52	38
R11	Residential	Night	52	37
R12	Residential	Night	52	37
R13	Residential	Night	52	41
R14	Residential	Night	52	39
R15	Residential	Night	52	47
R16	Residential	Night	52	50
R17	Residential	Night	52	44
R18[1]	Industrial	Night	n/a	54
R19[1]	Industrial	Night	n/a	43
R20[1]	Industrial	Night	n/a	45

Notes: 1. Industrial site (IN1) with residence – residences are prohibited in IN1 zoning Cooma-Monaro Local Environmental Plan 2013. These residences were approved by Snowy Monaro Regional Council.

2. Exceedances of PNTL shown in **bold**

Results of modelling confirm compliance with the sleep disturbance screening level of 52 dBA for all residential assessment locations.

6.2 Construction noise

6.2.1 Single point predictions

In accordance with procedures outlined in Section 5.4.3, prediction of construction noise levels are provided in Table 6.1 for standard and out of hours (OOH) day periods under ISO9613 conditions. 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 7.

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

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

Table 6.3 Predicted construction noise levels

Assessment location	Classification	Period	Noise affected NML, dB	Highly noise affected NML, dB	Predicted construction noise level, dB $L_{Aeq,15min}$	Compliance with NML
R1	Residential	Standard	45	75	32	Yes
		OOH	40	n/a		
R2[1]	Industrial	Any period	75	n/a	52	Yes
R3	Residential	Standard	54	75	32	Yes
		OOH	49	n/a		
R4	Residential	Standard	45	75	31	Yes
		OOH	40	n/a		
R5	Residential	Standard	45	75	33	Yes
		OOH	40	n/a		
R6	Residential	Standard	45	75	31	Yes
		OOH	40	n/a		
R7	Residential	Standard	45	75	29	Yes
		OOH	40	n/a		
R8	Residential	Standard	45	75	31	Yes
		OOH	40	n/a		
R9	Residential	Standard	45	75	30	Yes
		OOH	40	n/a		

Table 6.3 Predicted construction noise levels

Assessment location	Classification	Period	Noise affected NML, dB	Highly noise affected NML, dB	Predicted construction noise level, dB $L_{Aeq,15min}$	Compliance with NML
R10	Residential	Standard	54	75	33	Yes
		OOH	49	n/a		
R11	Residential	Standard	45	75	32	Yes
		OOH	40	n/a		
R12	Residential	Standard	45	75	32	Yes
		OOH	40	n/a		
R13	Residential	Standard	45	75	35	Yes
		OOH	40	n/a		
R14	Residential	Standard	45	75	33	Yes
		OOH	40	n/a		
R15	Residential	Standard	45	75	44	Yes
		OOH	40	n/a		No (+4dB)
R16	Residential	Standard	45	75	47	No (+2dB)
		OOH	40	n/a		No (+7dB)
R17	Residential	Standard	45	75	42	Yes
		OOH	40	n/a		No (+2dB)
R18[1]	Industrial	Any period	75	n/a	45	Yes
R19[1]	Industrial	Any period	75	n/a	37	Yes
R20[1]	Industrial	Any period	75	n/a	37	Yes

Notes: 1. Industrial site (IN1) with residence R2 – residences are prohibited in IN1 zoning Cooma-Monaro Local Environmental Plan 2013.
2. Exceedances of PNTL shown in bold.
3. Standard hours (7am to 6pm Monday to Friday, 8am to 1pm Saturday and no work on Sunday or public holidays.
4. OOH – out of hours (Day – 1pm to 6pm Saturday, Sunday and public holidays).

Construction noise levels satisfy NMLs at all assessment locations for standard day construction hours with exception of R16 112 Carlaminda Road, Cooma where an exceedance of 2 dB is predicted. Construction noise levels are predicted to exceed NMLs for Day OOH at three assessment locations:

- R15 +2dB
- R16 +7dB
- R17 +2dB

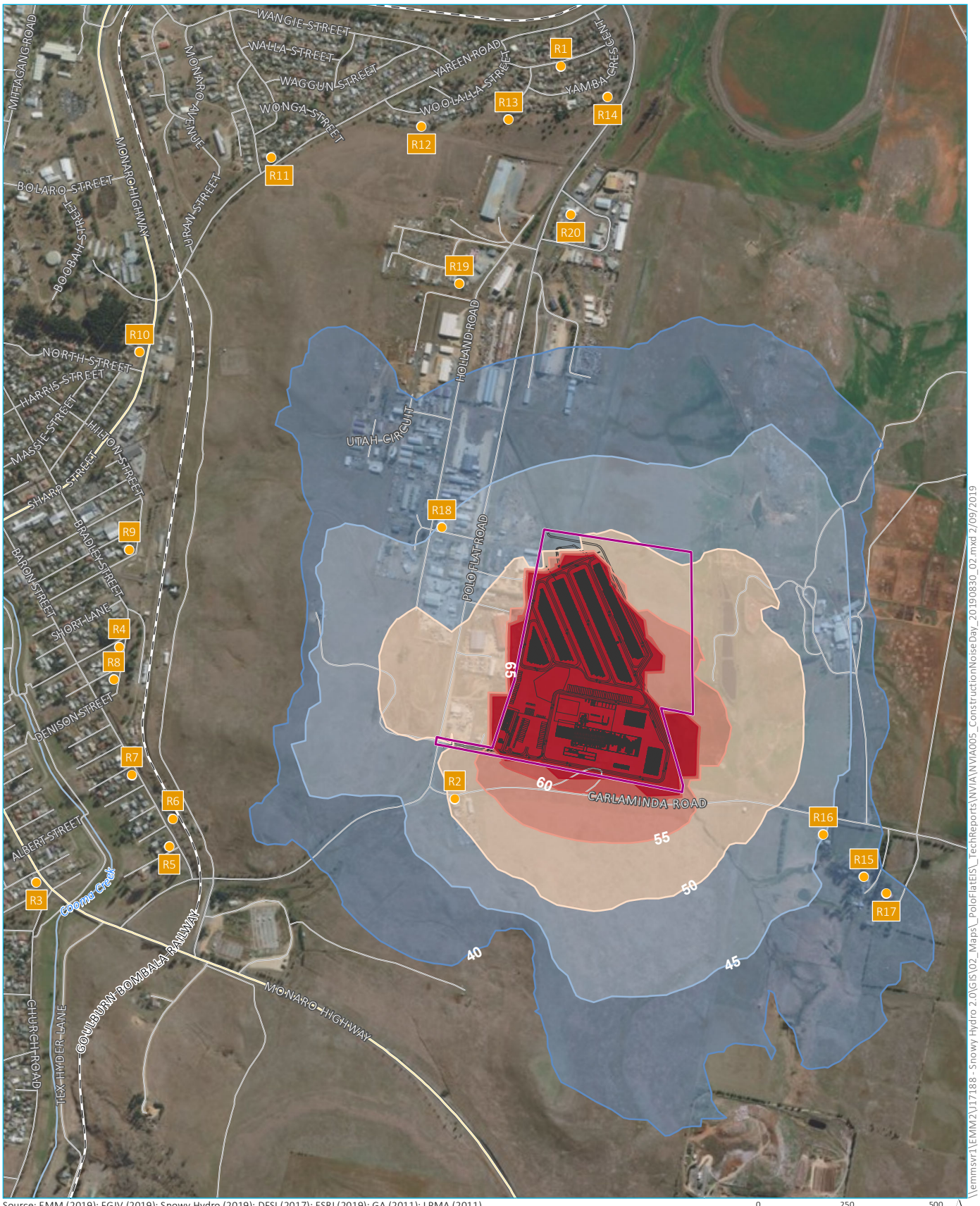
Given the limited construction period outside of standard construction hours (ie Saturday morning from 7 am to 8 am and Saturday afternoon from 1 pm to 5 pm) and given this period is during the day, the exceedance of the NMLs at the residences at Carlaminda Road is unlikely to result in significant impact. Nonetheless, residents will be notified prior to works commencing. 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 where practical; and
- consider construction during ICNG standard hours only.

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.

6.2.2 Contours

Predicted $L_{Aeq,15minute}$ noise contours representing the worse-case noise level footprint from the project construction is provided in Figure 6.3. The figure represents the predicted construction noise levels under ISO9613 noise enhancing conditions.



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

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KEY

	Noise level contour	Noise level contour range
Site boundary		
Indicative site layout	40 dB(A)	40 - 44 dB(A)
Assessment location	45 dB(A)	45 - 49 dB(A)
Rail line	50 dB(A)	50 - 54 dB(A)
Main road	55 dB(A)	55 - 59 dB(A)
Local road or track	60 dB(A)	60 - 64 dB(A)
Watercourse	65 dB(A)	65 + dB(A)

Construction noise contours, day, ISO9613

Snowy 2.0
Noise and Vibration Impact Assessment
Proposed Segment Factory
Figure 6.3

snowy 2.0

EMM creating opportunities

6.3 Construction vibration

In relation to human comfort response, the safe working distances in Table 5.6 relate to continuous vibration and apply to residential assessment locations. 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 (R2) is located within the industrial area and approximately 180 metres to the closest proposed construction activities. This assessment location is beyond the safe working distances for human response (Table 2.7). 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 5.6, if construction is within 25 m of sensitive structures, then work practices should be reviewed so that the safe working distance in Table 5.6 are followed.

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

6.4 Road traffic noise

Road traffic noise level predictions for peak generation day and night are provided in Table 6.4 and Table 6.5, respectively. Traffic volumes were provided by FGJV to represent the peak generation of light (LV) and heavy vehicles (HV) associated with the segment factory including raw materials for segment production, employees and distribution of manufactured segments to KNP for construction of Snowy 2.0. Volumes were distributed 80% day (7am to 10pm) and 20% night (10pm to 7am) in accordance with FGJV expectations. It is noted that peak volumes incorporate an additional 20% allowance safety factor adopted by FGJV.

Table 6.4 Road traffic noise calculations, Day (7am to 10pm)

ID	Approximate distance from nearest carriageway	Road segments	Existing movements[1]			Existing plus project movements			Noise level increase due to the Project, $L_{Aeq,15hour}$
			Total	%HV	Calculated level, $L_{Aeq,15hour}$	Total	%HV	Predicted level, $L_{Aeq,15hour}$	
Cooma 1	20m	Snowy Mountains Highway (south)	4648	12	62.5	5131	17	63.0	0.5
Cooma 2	14m	Monaro Highway (north)	6150	23	66.4	6674	26	66.7	0.3
Cooma 3[2]	14m	Polo Flat Road (north)	1744	43	67.4	2103	45	68.4	1.0
Cooma 4[2,3]	60m	Polo Flat Road (south)	2041	49	59.4	2375	44	59.8	0.2
Cooma 5[2,4]	240m	Monaro Highway (south)	2391	39	53.5	2493	40	53.9	0.3

Notes:
1. Existing movements are based on 2018/2019 long-term road traffic counts. Refer TIA (SCT 2018/2019) for detail.
2. Cooma 3, Cooma 4 and Cooma 5 utilise FHWA prediction methodology due to low traffic volumes (<200vehicle/hr).
3. Closest house for this road segment is on Dangelong Lane.
4. 100km/h zone south of Cooma between Saleyards Road and Schmidt Quarry – closest house.

Assessment of day ($L_{Aeq,15hour}$) traffic predictions confirm compliance with the <2dB allowance criterion for all road segments likely to be used by vehicles associated with the segment factory.

Table 6.5 Road traffic noise calculations, Night (10pm to 7am)

ID	Approximate distance from nearest carriageway	Road segment	Existing movements[1]			Existing plus project movements			Noise level increase due to the Project, $L_{Aeq,9hour}$
			Total	%HV	Calculated level, $L_{Aeq,9hour}$	Total	%HV	Predicted level, $L_{Aeq,9hou}$	
Cooma 1	20m	Snowy Mountains Highway (south)	196	14	49.9	319	34	55.4	5.5[6]
Cooma 2	14m	Monaro Highway (north)	239	30	55.9	372	40	59.1	3.2[6]
Cooma 3[2]	14m	Polo Flat Road (north)	118	55	59.0	208	55	61.4	2.4[6]
Cooma 4[2,3]	60m	Polo Flat Road (south)	128	59	50.3	211	43	51.2	0.9
Cooma 5[2,4]	240m	Monaro Highway (south)	104	45	42.7	130	48	43.9	1.2

Notes:
1. Existing movements are based on 2018/2019 long-term road traffic counts. Refer TIA (SCT 2018/2019) for detail.
2. Cooma 3, Cooma 4 and Cooma 5 utilise FHWA prediction methodology due to low traffic volumes (<200vehicle/hr).
3. Closest house for this road segment is on Dangelong Lane.
4. 100km/h zone south of Cooma between Saleyards Road and Schmidt Quarry – closest house.
5. Greater than 2dB increase, however less than baseline NSW, RNP criteria of $L_{Aeq,9hr}$ 55dBA.
6. Exceedance of +2dB increase and baseline NSW, RNP criteria of $L_{Aeq,9hr}$ 55dBA.

Assessment of night ($L_{Aeq,9hour}$) traffic predictions confirm compliance with the <2 dB allowance criterion for Polo Flat Road (south) and Monaro Highway (south).

For Snowy Mountains Highway (south) and Polo Flat Road (north) the predicted increase in road traffic noise levels is 5.5 dB and 2.4 dB respectively, resulting in an exceedance of RNP requirements given existing traffic noises level are above the baseline criterion of 55 dB(A). The 0.4 dB exceedance of baseline criterion of 55 dBA for Snowy Mountains Highway (south) and 0.4 dB exceedance of <2 dB allowance criterion for Polo Flat Road (north) occurs during proposed peak traffic generation only. Similarly, for Monaro Highway (north) an exceedance of 1.2 dB of the <2 dB allowance criterion is predicted for the closest residence during the peak traffic generation period comprising up to 9 HV movements per hour.

Peak traffic volumes represent a snapshot in time for the Snowy 2.0 project to assess the worse-case scenario and incorporates an additional 20% allowance as a safety margin as adopted by FGJV. Peak volumes are anticipated for a discrete period of 2-3 months. For the majority of the project life outside of this peak period, average daily volumes are typically 30% lower for LV and 50% lower for HV and would comply with the RNP requirements. For more detail refer to Traffic Impact Assessment – Proposed segment factory – Polo Flat (SCT, 2019).

6.5 Decommissioning

At the completion of construction of Snowy 2.0, the proposed segment factory would be decommissioned including removal of all plant and equipment. Future use of the Polo Flat site is currently unknown however Snowy Hydro would retain the main structures such as the precast building, hardstand areas, workshops and offices and seek to use these for an alternative industrial use under a separate development application.

Decommissioning activities are expected to be limited to removal of plant and equipment during standard day hours in accordance with the ICNG. Noise from these activities would be less than levels predicted for construction activities (Section 6.2) and are not anticipated to result in any adverse noise impacts at the identified assessment locations.

Vehicle movements associated with decommissioning activities would be significantly lower than that generated by the segment factory and satisfy RNP requirements.

7 Management of impacts

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

Table 7.1 Environmental management measures for noise and vibration

Impact	Ref #	Environmental management measures
Operational Noise	NV1	An environmental management plan (EMP) will be prepared to manage environmental impacts during the construction and operational phase of the project. For operations, the EMP will address noise management and mitigation options (where required) prior to commencement of operations. The EMP will describe how operational noise levels will be managed where predicted noise levels above the PNTLs have been identified. The EMP would address noise mitigation and management to reduce operational noise levels at the potentially most affected assessment location based on the findings of this assessment as a minimum. The EMP will outline a procedure to: • measure operational noise levels at early stages during commissioning or within 3 months of operation to validate the predicted operational noise levels. • re-evaluate the predicted operational noise levels at assessment locations, and where required review noise management, mitigation measures and site management to reduce levels where required. This may include (but is not limited to): – limiting specific site operations within identified site areas during the evening and night-time period; – selecting quieter equipment or reduced equipment fleet; and – measuring operational 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 PNTLs is identified. Affected landholders should be consulted prior to commencement of operation where an exceedance of PNTLs has been predicted and should be notified of proposed mitigation measures that will be used to manage operational noise levels.

Table 7.1 Environmental management measures for noise and vibration

Impact	Ref #	Environmental management measures
Construction Noise	NV2	The EMP will also address noise and vibration management and mitigation options (where required) prior to construction. For construction, the EMP will detail how construction noise and vibration impacts will be minimised and managed. The EMP will describe how construction noise levels will be managed where predicted noise levels above the NMLs have been identified. The EMP would address noise mitigation and management to reduce construction noise levels at the potentially most affected assessment locations based on the findings of this assessment as a minimum. The EMP 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 to NMLs where practical. This may include (but is not limited to): – selecting quieter equipment or reduced equipment fleet; – measuring construction noise levels at assessment locations, if relevant, and implementing further noise management and mitigation; and – feasible and reasonable measures where an exceedance of NMLs is identified.

8 Conclusion

This NVIA has been prepared to support the EIS for a precast segment factory at Polo Flat. 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 feasibly and reasonably avoided.

Operational noise associated with the segment factory has confirmed compliance with NPfI requirements for most residential assessment locations with the exception of R16 during the evening and night. A residual negligible exceedance of 2 dB has been predicted for R16 after the implementation of all feasible and reasonable mitigation measures. Compliance is predicted at all industrial assessment locations.

Intermittent night activities are predicted to satisfy the sleep disturbance screening criteria of L_{Amax} 52 dBA as defined in the NSW NPfI (EPA 2017) for all residential assessment locations.

Construction noise levels from the project are predicted to satisfy ICNG NMLs at the majority of assessment locations, with exception of R15, R16 and R17 where exceedances of 2-7 dB are predicted for daytime out of hours work periods during on Saturday and Sunday.

Given the limited construction period outside of standard construction hours (ie Saturday morning from 7 am to 8 am and Saturday afternoon from 1 pm to 5 pm) and given this period is during the day, the exceedance of the NMLs at the residences at Carlaminda Road is unlikely to result in significant impact. Nonetheless, residents will be notified prior to works commencing. Noise monitoring during the initial stages of construction will be undertaken to determine if actual construction noise levels are above NMLs. If this initial testing identifies exceedances, the proponent will:

- identify feasible and reasonable mitigation measures that reduce construction noise levels to NMLs where practical; or
- consider construction during ICNG standard hours only; or

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

The 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 (residence in industrial zoned land) which is more than 180 m away from construction activities. The assessment location is well outside of the safe working distances required to maintain acceptable human response and structural vibration levels. Vibration impacts from construction at residential assessment locations are therefore highly unlikely.

The safe working distances for cosmetic damage should be monitored throughout the construction process. If construction is within 25 m of sensitive structures, then work practices should be reviewed so that the safe working distances presented in Table 5.6 are followed.

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 generally predicted to satisfy RNP assessment requirements. Potential for a 0.4 dB exceedance of the RNP baseline and <2 dB allowance criterion for night-time traffic is predicted for Snowy Mountains Highway (south) and Polo Flat Road (north), whilst an exceedance of 1.2 dB of the RNP <2 dB allowance criterion is predicted for Monaro Highway (north).

These exceedances relate to a discrete period of 2-3 months at peak traffic generation and include an additional 20% allowance factor applied by FGJV to project traffic volumes. For the majority of the project life outside of the peak period, average HV volumes are typically 50% lower and would result in compliance with RNP assessment requirements.

At the completion of construction of Snowy 2.0, the proposed segment factory would be decommissioned which would include removal of all plant and equipment.

Snowy Hydro would retain the main structures such as the precast building, workshops and offices and seek to use these for an alternative industrial use.

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

References

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

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

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

Department of Environment, Food and Rural Affairs (DEFRA – United Kingdom) 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 (United Kingdom)
D&B	drill and blast
DP&E	Department of Planning and Environment
EPA	Environmental Protection Authority
EIS	environmental impact statement
EMM	EMM Consulting Pty Limited
FGJV	Future Generation Joint Venture
FHWA	US EPA Federal Highways
GWh	gigawatt hours
HV	heavy vehicle
ICNG	Interim Construction Noise Guideline
LGAs	local government areas
LV	light vehicle
MAT	Main Access Tunnel
MW	megawatts
NATA	National Association of Testing Authorities
NPfI	Noise Policy for Industry
NML	noise management level
NVIA	Noise and vibration impact assessment
OOH	out of hours
PHES	Pumped Hydro-Electric Storage
PPV	peak particle velocity
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
PNTL	project noise trigger level
RBL	rating background level
RNP	Road Noise Policy
RMS	root mean square
SHL	Snowy Hydro Limited
SEARs	Secretary's environmental assessment requirements
SSI	State significant infrastructure
VDV	vibration dose value

Annexure A

Long-term unattended noise monitoring results

A.1 Long-term unattended noise monitoring results

Table A.1 Background noise monitoring summary, NM1 14 Warra Street, Cooma

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Monday, 18-03-19	0	21	<20
Tuesday, 19-03-19	30	21	<20
Wednesday, 20-03-19	30	22	<20
Thursday, 21-03-19	30	25	<20
Friday, 22-03-19	32	28	<20
Saturday, 23-03-19	29	28	<20
Sunday, 24-03-19	32	31	0
Rating Background Level (RBL)[1]	35	30 (25)	30 (<20)

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.

Table A.2 Background noise monitoring summary, NM2 – Polo Flat (site) – southern boundary

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Monday, 18-03-19	0	25	<20
Tuesday, 19-03-19	32	28	28
Wednesday, 20-03-19	32	28	25
Thursday, 21-03-19	31	26	21
Friday, 22-03-19	34	30	22
Saturday, 23-03-19	0	0	0
Rating Background Level (RBL)[1]	35	30 (28)	30 (22)

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.

Table A.3 Background noise monitoring summary, NM3 – 103 Bombala Street, Cooma

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Monday, 18-03-19	0	27	22
Tuesday, 19-03-19	43	43	34
Wednesday, 20-03-19	44	39	30
Thursday, 21-03-19	43	31	25
Friday, 22-03-19	44	33	22
Saturday, 23-03-19	0	0	0
Rating Background Level (RBL)[1]	44	33	30 (25)

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.

Table A.4 Background noise monitoring summary, NM4 – 57 Bradley Street, Cooma

Date	ABL Day[2]	ABL Evening[2]	ABL Night[2]
Monday, 18-03-19	0	21	<20
Tuesday, 19-03-19	33	29	<20
Wednesday, 20-03-19	32	21	<20
Thursday, 21-03-19	29	22	<20
Friday, 22-03-19	30	29	<20
Saturday, 23-03-19	28	30	<20
Sunday, 24-03-19	33	30	0
Rating Background Level (RBL)[1]	35	30 (29)	30 (<20)

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.