WestConnex M4-M5 Link

Rozelle Interchange – Modification: Iron Cove ventilation underground

Modification report

Appendix D

Noise and vibration

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Roads and Maritime Services

WestConnex - M4-M5 Link

Iron Cove Ventilation Underground Modification Report

Modification report

Appendix D Noise and Vibration

November 2019

Prepared for

Roads and Maritime Services

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Glossary of terms and abbreviations

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Airborne noise	Noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise source and receiver.
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
A-weighting	A filter applied to the sound recording made by a microphone to approximate the response of the human ear.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the LA90 noise level if measured as an overall level or an L90 noise level when measured in octave or third-octave bands.
Barrier (Noise)	A natural or constructed physical barrier which impedes the propagation of sound and includes fences, walls, earth mounds or berms and buildings.
Decibel [dB]	The units of sound measurement. The following are examples of the decibel readings of everyday sounds: 0dB The faintest sound we can hear, defined as 20 micro Pascal 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 110dB Operating a chainsaw or jackhammer 120dB Deafening

dB(A)	A-weighted decibel. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the “A” filter. A sound level measured with this filter is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz) but is less effective outside these frequencies. The dB(C) level is not widely used but has some applications.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Ground-borne noise	Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
INP	NSW Industrial Noise Policy, EPA 1999
ICL	Iron Cove Link civil site
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
Intrusive noise	Refers to noise that intrudes above the background level by more than 5 dB(A).
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L10(1hr)	The L10 level measured over a 1 hour period.
L10(18hr)	The arithmetic average of the L10(1hr) levels for the 18 hour period between 6am and 12 midnight on a normal working day.

L90	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq or Leq	The “equivalent noise level” is the summation of noise events and integrated over a selected period of time, which would produce the same energy as a fluctuating sound level. When A-weighted, this is written as the LAeq.
LAeq(1hr)	The LAeq noise level for a one-hour period. In the context of the NSW EPA’s Road Noise Policy it represents the highest tenth percentile hourly A-weighted Leq during the period 7am to 10pm, or 10pm to 7am (whichever is relevant).
LAeq(8hr)	The LAeq noise level for the period 10pm to 6am.
LAeq(9hr)	The LAeq noise level for the period 10pm to 7am.
LAeq(15hr)	The LAeq noise level for the period 7am to 10pm.
LAeq (24hr)	The LAeq noise level during a 24 hour period, usually from midnight to midnight.
Lmax	The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmax.
Lmin	The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmin.
Microphone	An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.
NCA	Noise Catchment Area. An area of study within which the noise environment is substantially constant.
Noise	Unwanted sound
RRY	Rozelle Railyards civil and Tunnel Site
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 pico watt.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone referenced to 20 mico Pascal.
Spoil	Soil or materials arising from excavation activities.

1 Introduction

Renzo Tonin & Associates was engaged by John Holland CPB Contractors Joint Venture (the Contractor) to prepare a noise and vibration assessment of the proposed modification to the ventilation ancillary facilities at Iron Cove Link during the construction and operational phases.

1.1 Summary description of proposed modification

The EIS described an electrical substation and ventilation exhaust facility located in separate buildings on the surface, that together would comprise the Iron Cove Motorway Operations Complex 4 (MOC 4) (see Figure 1).

The proposed modification would relocate MOC4 underground, including the electrical substation and ventilation facilities. A switch room, high voltage regulators, an alternative Operational Motorway Control System (OMCS) room and a separate stair access leading down to the ventilation tunnel would be required on the surface (see Figure 2). The combined switch room and high voltage regulator structure would be about 6 metres wide and 30 metres long, with a height of up to 8 metres. The L-shaped OMCS room would be approximately 9 metres wide by 9 metres long and 5 metres high. A small above ground structure in the vicinity of Callan Street about 2 metres wide, 6 metres long and 3 metres high would contain an access door and a stairway. The ventilation outlet will remain above ground in the same location illustrated in the EIS.

Figure 1 Operational Iron Cove configuration shown in EIS

Figure 2 Operational Surface layout at Iron Cove under the proposed modification

The following points provide an overview of the proposed ventilation tunnel and caverns:

Construction of a ventilation tunnel about 340 metres in length that connects the Iron Cove Link tunnel, at an underground location between Cambridge and Waterloo Streets, with the Iron Cove cut and cover structure near Callan Street. This ventilation tunnel would be on average about seven metres high and about 10 metres wide. The depth of the ventilation tunnel would vary from about eight metres (from ground level to tunnel crown) at its shallowest to about 25 metres (from ground level to tunnel crown) at its deepest.

The ventilation tunnel would include two caverns for the housing of ventilation equipment and the electrical substation:

- The ventilation cavern would contain four ventilation fans laid horizontally, with associated attenuators and dampers. The dimensions of the exhaust fan cavern would be about 25 metres wide, 15 metres high and 70 metres long
- The cavern containing the electrical substation would be parallel to the cavern containing the ventilation. The dimensions of the substation cavern would be about 20 metres wide, 10 metres high and 65 metres long.

A five-metre wide and 20-metre long access tunnel, to facilitate personnel access from the exhaust fan cavern into the substation cavern.

The Iron Cove cut and cover area would include a side access for the vent tunnel to connect to the cut and cover about 7 metres wide and 17 metres long. This area would also accommodate the access stairs to the surface.

The alignment of proposed new ventilation tunnel and caverns at Iron Cove is shown in Figure 3. The approved Iron Cove Link road tunnels are shown in orange.

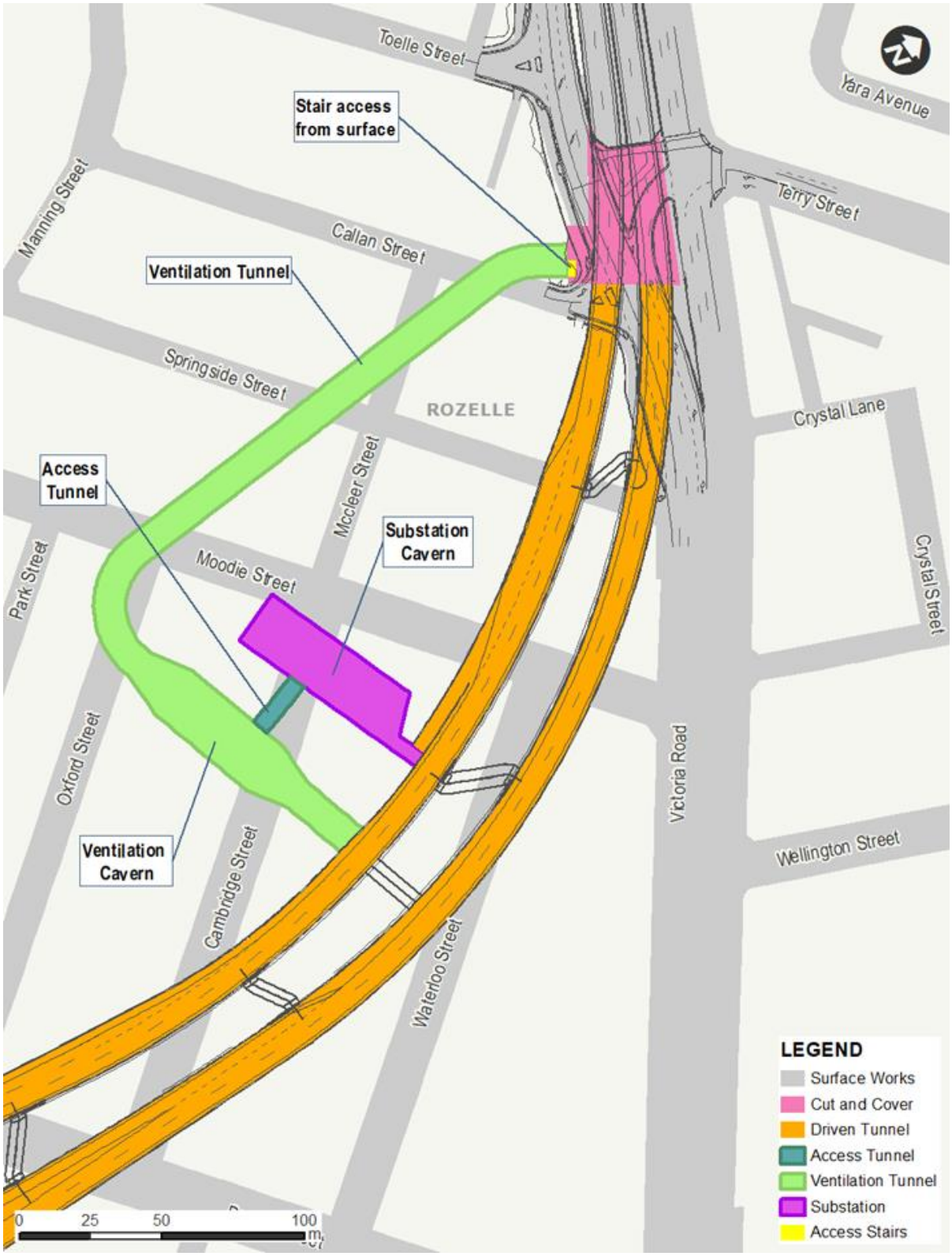


Figure 3 Proposed ICL Ventilation Ancillary Facilities – underground layout

1.2 Key aspects of the proposed modification relevant to this assessment

1.2.1 Ventilation tunnel and caverns excavation

The proposed ventilation tunnel and caverns would be constructed in hard rock (i.e. Hawksbury sandstone) and would be excavated as described in Section 6.4.2 of the EIS, in summary (Figure 4):

- Excavation of top section (top heading – see figure below) of the ventilation tunnel would be carried out using roadheaders
- The lower section (bench – see figure below) of the ventilation tunnel would be excavated using a combination of rock-breakers, and roadheaders
- Ground support, including rock bolting and shotcrete, would be installed as the tunnelling face is advanced along the ventilation tunnel.

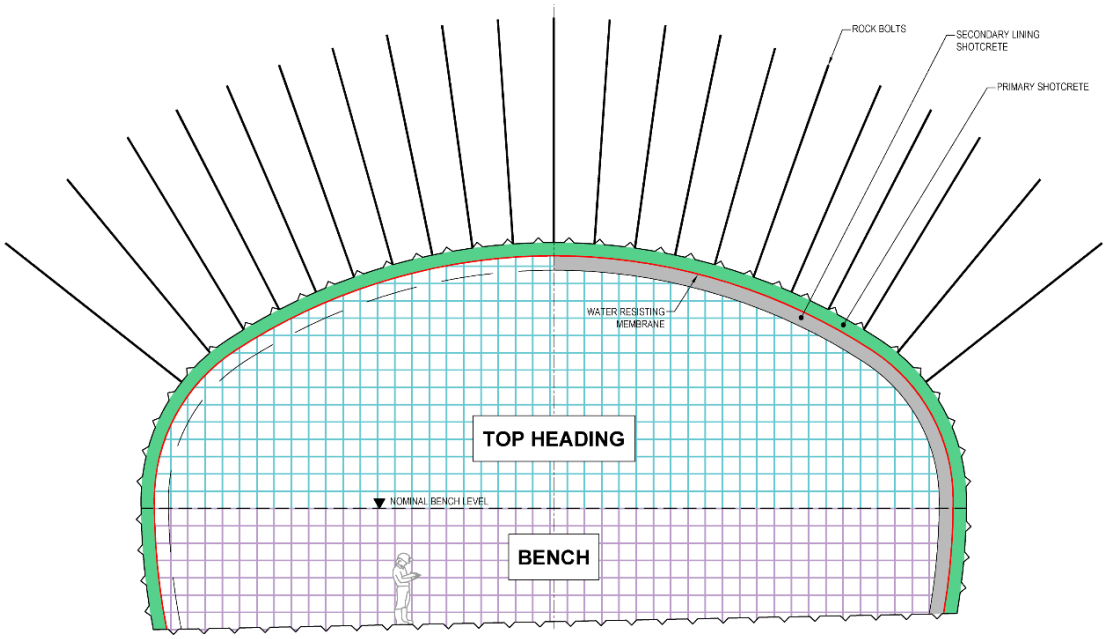


Figure 4 Ventilation tunnel section

As per the EIS, tunnelling will occur 24 hours a day, up to seven days a week. Reasonable and feasible methods to reduce potential impacts, such as using surface miners and/or blasting, would be further considered during detailed construction planning. Blasting would only be considered where the blast could be designed to comply with current guidelines, as set out in a Blast Management Strategy that would be prepared in accordance with Planning Approval Conditions E96 to E100.

All plant, equipment and materials required to construct the proposed new ventilation tunnel and caverns would be supported from the Iron Cove civil site (C8), with the potential for some tunnelling to be supported from the Rozelle civil and tunnel site (C5) later in the program. The programs for the tunnel support site options to be used to construct the proposed ventilation tunnel and caverns are different:

- Iron Cove civil site (C8) – tunnelling works at the Iron Cove cut and cover have been scheduled to occur over about 15 months between about Q3 2020 and the end of 2021
- Rozelle civil and tunnel site (C5) – excavation of the ventilation tunnel and caverns would occur from about Q2 2021 if required.

The proposed new Iron Cove ventilation tunnel and caverns can be easily accessed from within the Iron Cove cut and cover using a single roadheader.

Any tunnelling of the proposed new ventilation tunnel and caverns supported from the Rozelle civil and tunnelling site (C5) would be commenced from within the Iron Cove Link Tunnel once it is excavated. This would not require the installation of any additional temporary surface support infrastructure at the Rozelle civil and tunnelling site (C5).

This assessment has been completed assuming the worst-case impacts of all deliveries and spoil transportation occurring from both these sites

As the proposed new ventilation tunnel and cavern works would be supported from the Iron Cove civil site (C8) but could also use the Rozelle civil and tunnel site (C5), this assessment has been completed assuming the worst case impacts of all deliveries and spoil transportation occurring from either sites. It is noted that the new ventilation tunnel and cavern excavation works would not commence from the Rozelle civil and tunnel site (C5) until the mainline tunnels are completed, so operations at the Rozelle civil and tunnel site (C5) would not change from the peak impact scenario assessed in the EIS.

1.2.2 Permanent surface works

The proposed modification substantially reduces the extent of permanent surface works required at Iron Cove. The EIS described an electrical substation and ventilation exhaust facility located in separate buildings on the surface, that together would comprise Motorway Operations Complex 4 (MOC 4). The proposed modification would relocate Motorway Operations Complex (MOC4) underground, including the electrical substation and ventilation facilities. The ventilation outlet will remain above ground in the same location. Under the proposed modification only a switch room, high voltage regulators, an alternative Operational Motorway Control System (OMCS) room and a stair access requires construction above surface level to the west of Victoria Road between Callen and Toelle Streets.

Construction of switch room, high voltage regulators, the alternative OMCS room and stair access would entail minor excavation, foundation preparation, drainage works, concrete works and structural works as well as mechanical and electrical fit out. Commissioning of the entire project will begin at Iron Cove Link and the alternative OMCS room would also be used to support commissioning and testing of motorway systems to ensure they are safe and meet required specifications.

The M4-M5 Link EIS, Appendix J, Table 5-89 identifies the total duration of surface work construction of MOC4 to be 144 weeks. This modification reduces the surface work construction time to about 40 weeks for the construction of the surface buildings to be located to the west of Victoria Road.

1.2.3 Tunnelling support from Iron Cove civil site (C8)

Tunnelling would commence once the southern half of the cut and cover structure has been constructed. It is anticipated that one roadheader would be used to excavate the rock beneath the cut and cover structure in order to gain access to the tunnel portal located under the cut and cover structure. This rock would ordinarily be excavated using large excavators with rock breakers as part of surface construction works. Using a roadheader for this work would reduce noise and vibration impacts on the surrounding community.

Once the rock beneath the cut and cover structure has been removed, the chamber beneath the roof of the cut and cover structure would be temporarily converted into a spoil shed. A temporary shed wall and roller door would be installed at the western end of the cut and cover structure, and this wall combined with the concrete roof of the cut and cover structure would assist with reducing noise emission from the spoil shed during tunnelling. A generator, dust collector, water treatment plant and ventilation fans would be installed within the dive structure and/or inside the spoil shed as appropriate to support the tunnelling works. An indicative site layout is provided in Figure 5.

Spoil from tunnelling would be loaded into off-road trucks at the tunnel face. Tunnel spoil would be transported and stockpiled in the dive structure area and loaded into trucks for off-site disposal during standard construction hours. Spoil generated outside standard construction hours would be transported from the tunnel face and stockpiled in the enclosed cut and cover structure, to be loaded into truck and dogs and/or single tippers during standard hours for disposal off-site.

Concrete deliveries would be required 24 hours a day during tunnelling for tunnel ground support and concrete lining works. Typically, there would be 6 shotcrete deliveries by agitator trucks per day, with 2 concrete deliveries in the evening (6:00 pm to 10:00 pm) and typically 1 concrete delivery truck at night (10:00 pm to 7:00 am).

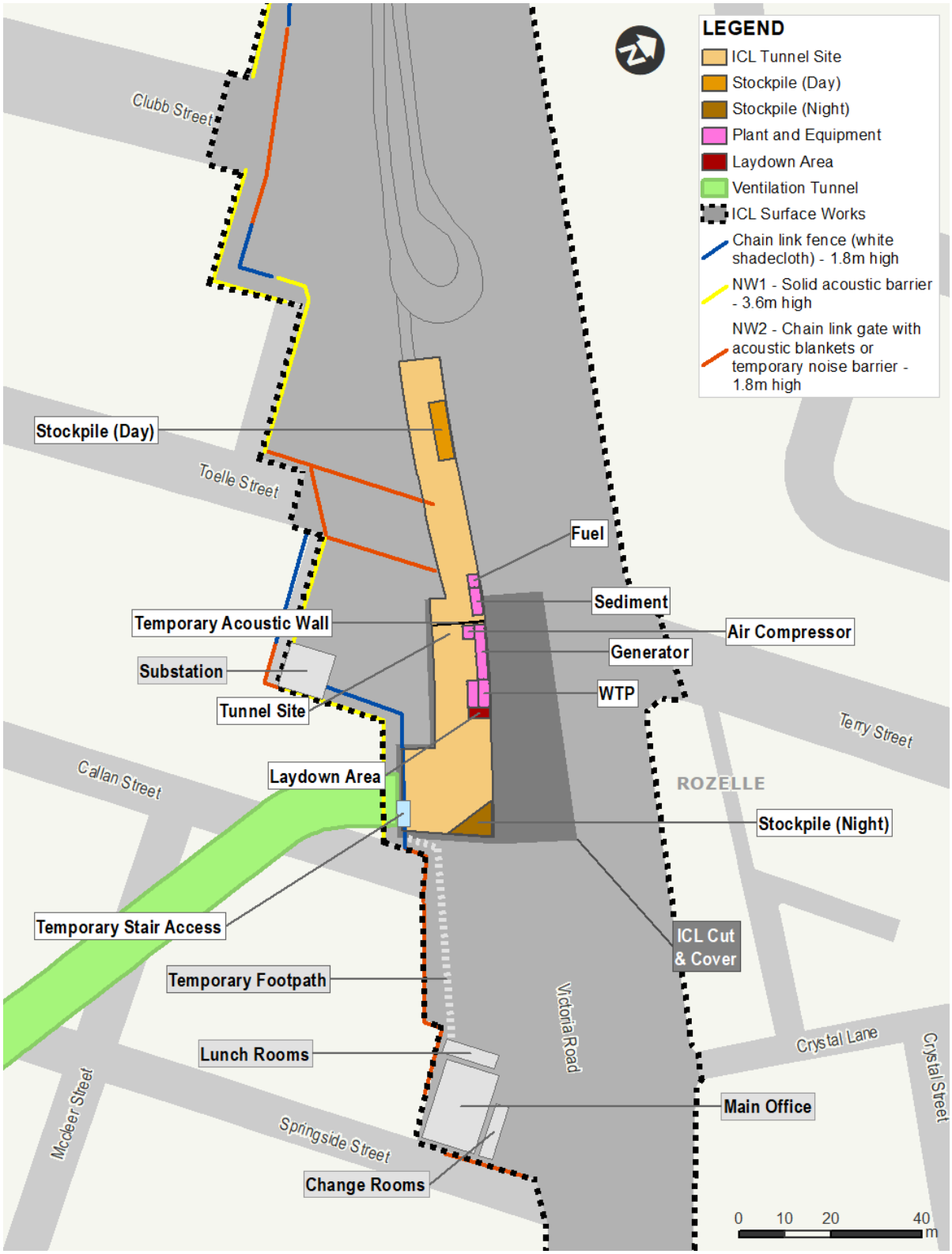


Figure 5 Proposed ICL tunnel support site indicative layout

The surface civil compound facilities at the Iron Cove civil works site (C8) including crib rooms and amenities would be co-used by the tunnelling workforce and supervision. Light vehicles and delivery vehicles would access the Iron Cove civil works site (C8) and the enclosed cut and cover structure regularly to support tunnelling operations.

1.2.4 Tunnelling support from Rozelle civil and tunnel site (C5)

Any tunnelling of the proposed modification that is supported from the Rozelle civil and tunnel site (C5) would not change the site layout or construction operations. All spoil would be transferred to one of the acoustic sheds at this worksite. At this worksite, spoil handling and haulage would occur 24 hours a day, seven days a week.

1.2.5 Changes to locations of operational noise sources

As described in Section 1.1, the EIS described an electrical substation and ventilation exhaust facility located in separate buildings to be located on the southern side of the realigned Victoria Road. The electrical substation would be located on the corner of Victoria Road and Callan Street, while the ventilation facilities would be located between Callan Street and Springside Street. A ventilation outlet would be located in the middle of the widened Victoria Road carriageway connected via tunnel to the above-ground ventilation facility.

As part of the proposed modification, both the ventilation equipment and electrical substation would be relocated to underground caverns. Above-ground structures located on the southern side of Victoria Road would be limited to a switch room, high voltage regulators, an OMCS room and a stair access leading down to the ventilation tunnel. These facilities would be located between Toelle Street and Callan Street. The ventilation outlet would remain in the middle of the widened Victoria Road carriageway.

The switch room would house equipment, such as electrical meters, which would be used to monitor the operation of the substation and ventilation facilities. The combined switch room and high voltage regulator structure would be about 6 metres wide and 30 metres long, with a height of up to 8 metres. This structure would be adjacent to the Victoria Road Shared User Path on the eastern side of the intersection of Victoria Road and Toelle Street. Within the same area would be the smaller 'L'- shaped OMCS room with a footprint of approximately 9 metres wide by 9 metres long and 5 metres high.

A small above ground structure in the vicinity of Callan Street, about two metres wide, six metres long and three metres high would contain an access door and a stairway. The staircase would provide an alternative safe maintenance and emergency access to and from the ventilation tunnels from the surface, with the main access from within the road tunnels.

Dedicated parking would be provided for operations and maintenance personnel with access off Clubb Street and within the switch room site with access off Toelle Street.

1.3 Quality assurance

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on *Australian Standard / NZS ISO 9001*. Appendix A contains a glossary of acoustic terms used in this report.

2 Compliance with SEARs

SEARS (Noise & Vibration)	Construction	Operation
The construction and operational noise and vibration assessments must be quantitative assessments. The assessments must identify any sensitive receivers not previously affected by the modified activities and those where the level of impact is predicted to increase.	Yes, quantitative assessment in Section 4	Yes, quantitative assessment in Section 5
The assessment of sleep disturbance must assess the predicted number of awakening events.	Yes, compliance with NMLs so no predicted awakening events (Section 4.2.1)	Yes, compliance with sleep disturbance screening criteria shown so no predicted awakening events (Section 0)
If blasting is proposed, the assessment must demonstrate that blast impacts are capable of complying with current guidelines.	Section 1.2.1	N/A
Assessment of construction and operational noise and vibration impacts including sleep disturbance associated with the proposed modification. This assessment must be in accordance with relevant NSW noise and vibration guidelines and potential noise and vibration mitigation measures should be identified.	Yes, all sections	Yes, all sections
The assessment of operational noise should focus on the relocation and use of the proposed modified ventilation facility and compare the results of this assessment to the existing baseline and approved project.	N/A	Yes, Section 5.1 and 5.4 assesses relocation of vent facility
The assessment of construction noise and vibration impacts must address:		N/A
1. the nature of construction activities (including transport, tonal or impulsive noise-generating works as relevant);	Section 3.1	
2. the likely intensity and duration of potential noise and vibration impacts (both air and ground-borne);	Section 3.1	
3. confirmation of works occurring within and outside standard construction hours, including estimated duration and timing, predicted levels, exceedances and number of potentially affected receivers and justification for the activity in terms of the Interim Construction Noise Guideline (DECCW, 2009);	Section 3.1 and Section 4	
4. figures consistent with the EIS illustrating the existing, previously assessed and predicted noise levels related to the modification; and	Figures and tables presented consistent with EIS	

SEARS (Noise & Vibration)	Construction	Operation
5. a cumulative noise and vibration assessment of other M4-M5 Link works proposed at Iron Cove where potential impacts are likely to differ from those that were previously assessed under the EIS for SSI 7485.	Section 4.2.1	
Assess potential construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	Yes, construction noise and vibration assessed to relevant NSW noise and vibration guidelines. Assessment methodology outlined in Section 3.1.	Yes, operational noise assessed to INP which is consistent with Approval Condition E92(d). Assessment methodology outlined in Section 3.2.

3 Methodology

3.1 Construction noise and vibration assessment methodology

3.1.1 Excavation of the ventilation tunnel and caverns

Ground-borne noise (GBN) levels that may be experienced in buildings during tunnel excavation depends on the minimum slant distance from the tunnel ground geology (e.g. Hawksbury sandstone, Ashfield shale), building foundation-to-footing interaction, receiving room dimensions and reverberation times - see Figure 6).

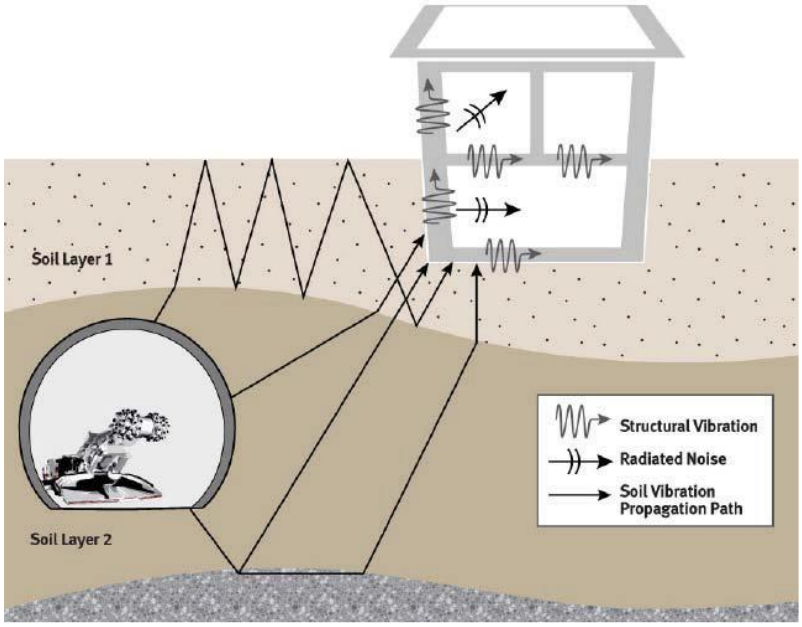


Figure 6 Ground-borne noise generation in buildings on surface during tunnelling excavation (source: Cross River Rail, EIS Chapter 16)

An empirical algorithm for roadheader excavation was used in the EIS based on previous measurements in the region of Sydney, where the geology primarily consists of sandstone rock. Figure 7 presents indicative ground-borne noise levels for road-headers as a function of the distance between plant and the receiver.

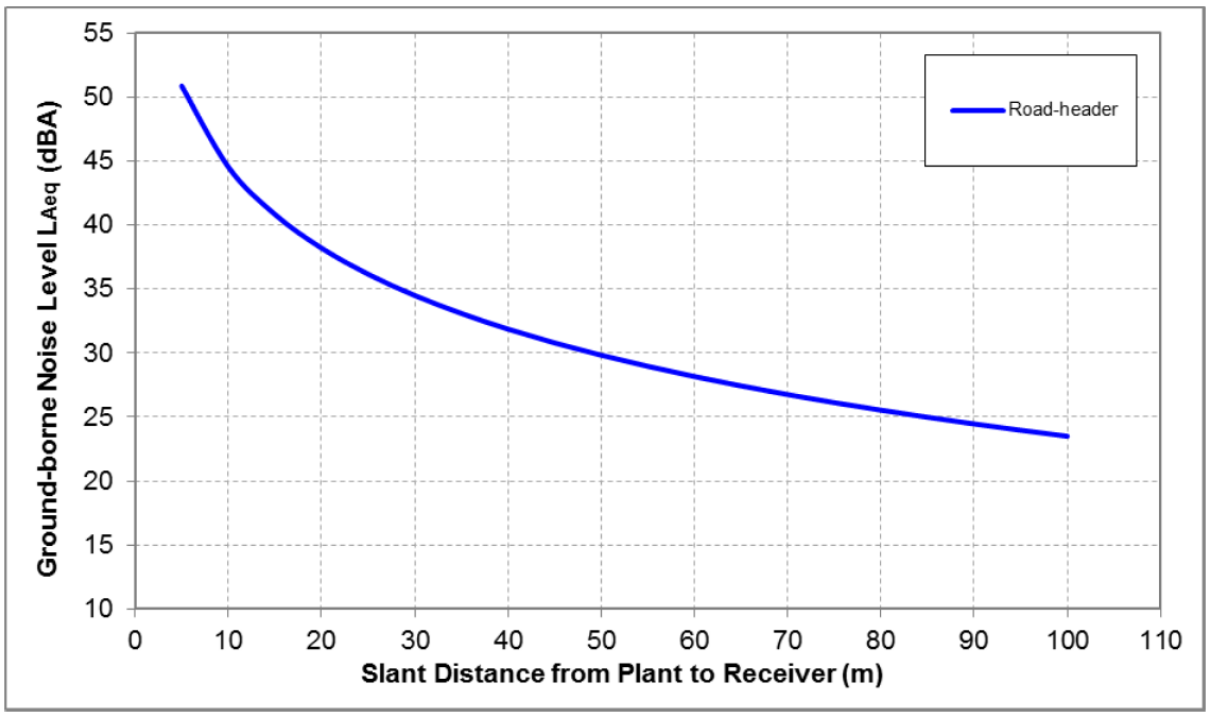


Figure 7 EIS indicative ground-borne noise levels from road-headers (Source: M4-M5 Link EIS, Appendix J, Figure 4-2)

The algorithm was used to predict ground-borne noise levels inside sensitive receiver buildings near the ventilation tunnels. The predicted noise levels were compared with the evening Ground-borne Noise Management Level (GBNML) of 40dB(A) and night-time GBNML of 35 dB(A). GBNMLs are only applicable when ground-borne noise levels are higher than airborne noise levels. The ground-borne noise levels are therefore for evening and night-time periods only, as the objectives aim to protect the amenity and sleep of people when they are at home.

The assessment of potential construction vibration impacts during roadheader tunnelling excavation was based on the minimum working distances established for cosmetic damage presented in M4-M5 Link EIS, Appendix J, Table 4-12.

The methodology used to assess ground-borne noise and vibration impacts of the proposed modification was the same as the assessment process used in the EIS. GBN predictions were based on the empirical algorithm presented in the M4-M5 Link EIS, APPENDIX J, Figure 4-2. Construction vibration impacts were based on the minimum working distances established for cosmetic damage presented in M4-M5 Link EIS, Appendix J, Table 4-12.

For the construction ground-borne noise and vibration assessment, it is noted that Appendix J of the EIS does not consider ventilation tunnels at Iron Cove, therefore a direct comparison could not be undertaken to compare impacts with the EIS design.

3.1.2 Tunnel support works from Iron Cove cut and cover

As described in Section 1.2.3, all plant and equipment required to support tunnelling from the Iron Cove cut and cover site (EIS C8) would access the tunnel from the cut and cover structure, which would be temporarily converted into a spoil shed. Table 1 lists additional plant and equipment that would be utilised at the Iron Cove Link cut and cover site to support tunnelling activities.

Table 1 Tunnel support plant and equipment - Iron Cove Link (ICL)

Activity	Plant/equipment	Worst case item in same location		Sound power level (dB(A))	Location of plant
		Day	**OOH**		
Cut and cover tunnel support (ventilation tunnels and caverns)	Roadheader	1	1	111	In tunnel
	Wheeled loader	1	-	104 (muffled)	Outside shed to load spoil trucks
	Dump trucks	4 per hour	4 per hour	106	In dive structure1/'shed'/ tunnel
	Generator and air compressor	1	1	105	In 'shed'/ dive structure2
	Shotcrete rig	1	1	104	In tunnel
	Drilling/bolting rig	1	1	125	In tunnel
	Excavator with bucket/ Muffled Wheeled Loader	1	1	104	In dive structure1/'shed'
	Dust collector	1	1	104	In shed/ tunnel
	Ventilation fans	1	1	105	In 'shed'
	Water treatment plant	1	1	100	In 'shed'/ dive structure2
	Light vehicles and delivery vehicles	4 per hour	4 per hour	89	On and off site
	Spoil trucks and deliveries	30 per day	-	108	On and off site Loaded in dive
	Concrete agitator	6 per day	Up to 3 (total)	106	On and off site. Concrete pours inside shed

Notes: 1. Daytime (standard hours) only

2. Inside acoustic enclosure, details to be confirmed at detailed design

Work hours for construction of the ventilation tunnel and caverns from within the Iron Cove cut and cover would be in accordance with those prescribed by the Planning Approval Condition E70, which allow tunnelling activities and tunnel fit out works to occur 24 hours a day, seven days a week.

The following daily traffic volumes are anticipated during peak construction activities involving spoil load out and concrete works to support tunnelling from Iron Cove. Typically:

- 30 light vehicles per day
- 30 spoil truck and trailers per day during standard daytime hours in accordance with Conditions E68 and E69
- Six shotcrete deliveries by agitator trucks per day, with 2 concrete deliveries in the evening (6 pm to 10 pm) and typically 1 truck at night (10 pm to 7 am)
- Six additional rigid heavy vehicles per day (including other deliveries and garbage removal)
- Total around 42 heavy vehicle movements per day.

There are a number of opportunities to incorporate noise mitigation into the Iron Cove tunnel support site design including the following standard construction features, in accordance with the M4-M5 Link EIS and Planning Approval:

- Site hoarding/ noise barriers – temporary acoustic hoarding/barriers (1.8 metres to 3.6 metre high) would be installed around the site perimeter (see Figure 5) to mitigate noise from civil works associated with the cut and cover. This temporary barrier, which will be construction regardless of the proposed modification, is included in this noise assessment
- Acoustic shed – the chamber beneath the roof of the cut and cover structure would be temporarily converted into a spoil shed by installing a temporary wall with roller door at the western end of the cut and cover structure. The roller door would be open during standard construction hours and closed outside standard construction hours. Initial investigation considered different wall constructions with the performance ratings set out in Table 2. Given the acoustic benefits of the Wavebar this has been incorporated into the wall design to minimise noise impacts on surrounding receivers
- At-receiver mitigation in the form of at-property treatment in accordance with PPA Condition E87. Properties that must be offered at-receiver mitigation are identified in Appendix D of the PPA and include receivers along the EIS Iron Cove civil works site (EIS C8). This at-property treatment, which will be implemented regardless of the proposed modification, is included in this noise assessment. At-property mitigation is only included as a final mitigation measure, as all other reasonable and feasible mitigation measures have been reviewed and adopted in the design of the Iron Cove Link tunnel support site.

Table 2 Acoustic shed performance – ICL tunnel support

Indicative shed construction	Octave band transmission loss dB						
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**
Single skin steel 1 x 0.48 mm BMT corrugated steel	7	9	13	18	22	19	20
Single skin steel + Wavebar 0.48mm thick sheet metal, 1 x 10kg Wavebar, 50mm thick insulation (perforated foil face)	14	18	20	28	38	43	50

3.1.3 Tunnel support works from Rozelle civil and tunnel site

As described in Section 1.2.4, should tunnelling be supported from the Rozelle site all plant and equipment required to construct the ventilation tunnel would access the tunnel from the Rozelle civil and tunnel site (C5) and progress towards to the Iron Cove civil worksite. There would be therefore a minor increase in spoil trucks and deliveries at RRY worksite associated with the proposed modification. However, support of excavation works associated with the proposed modification are not predicted to overlap with peak construction activities associated with the overall Rozelle Interchange Project scheduled to occur in about March 2021. Impacts of the peak construction support have been already included in the assessment of the operation of the Rozelle civil and tunnel site (C5) and suitable mitigation measures have been identified.

3.1.4 Permanent surface works

As described in Section 1.2.2, the proposed modification substantially reduces the extent of permanent surface works required at Iron Cove (C8). The construction of the switch room, high voltage regulator (HV regulator) bays, Operational Motorway Control System (OMCS) room and stair access would entail minor excavation, drainage works, foundation preparation, concrete works, and structural works as well as mechanical and electrical fit out.

The associated construction activities are presented in M4-M5 Link EIS, Appendix J, Table 5-89 under the work activity ICL-14 (i.e. ventilation station and substation). The airborne noise assessment for the construction of the facility (scenario ICL-14) was based on three typical items of plant (mobile crane, concrete trucks/agitator and concrete pump) that would likely be used for construction. Table 5-92 identifies that the plant/equipment for the work activity ICL-14, reproduced in Table 3.

Table 3 EIS construction plant/equipment schedule (Source: M4-M5 Link EIS, Appendix J)

Worksite	Works ID	Activity	Plant/equipment	Sound power level (dB(A))
Iron Cove Link (ICL)	ICL-14	Ventilation station and substation	Mobile crane	101
			Concrete truck/agitator	106
			Concrete pump	106

The technical assessment was undertaken in accordance with the assessment process documented in the EIS.

3.1.5 Construction hours

Construction of the project would be carried out during 'Standard Construction Hours' where practicable. Standard Construction Hours are defined in the ICNG and shown in Figure 8..

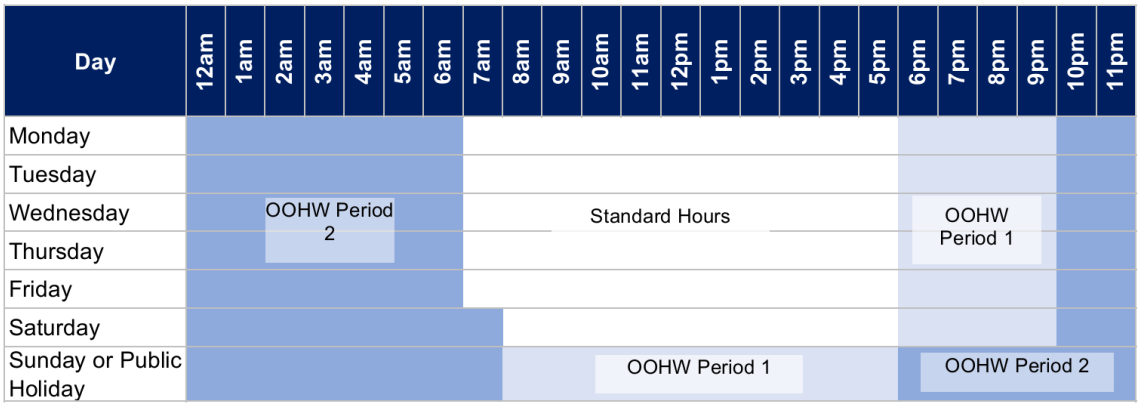


Figure 8 Construction hours

Works hours for the M4-M5 Link project are outlined in Planning Approval Conditions E68 and E69. Planning Approval Condition E68 allows works to be undertaken during standard construction hours as outlined in the ICNG, while Condition E69 allows works to be undertaken between 1:00 pm and 6:00 pm on Saturdays. Daytime works for this proposed modification would be undertaken during these hours.

Planning Approval Condition E70 permits the following works to be undertaken 24 hours a day, seven days a week:

- tunnelling activities excluding cut and cover tunnelling
- haulage of spoil and delivery of material
- works within an acoustic shed and
- tunnel fit out works.

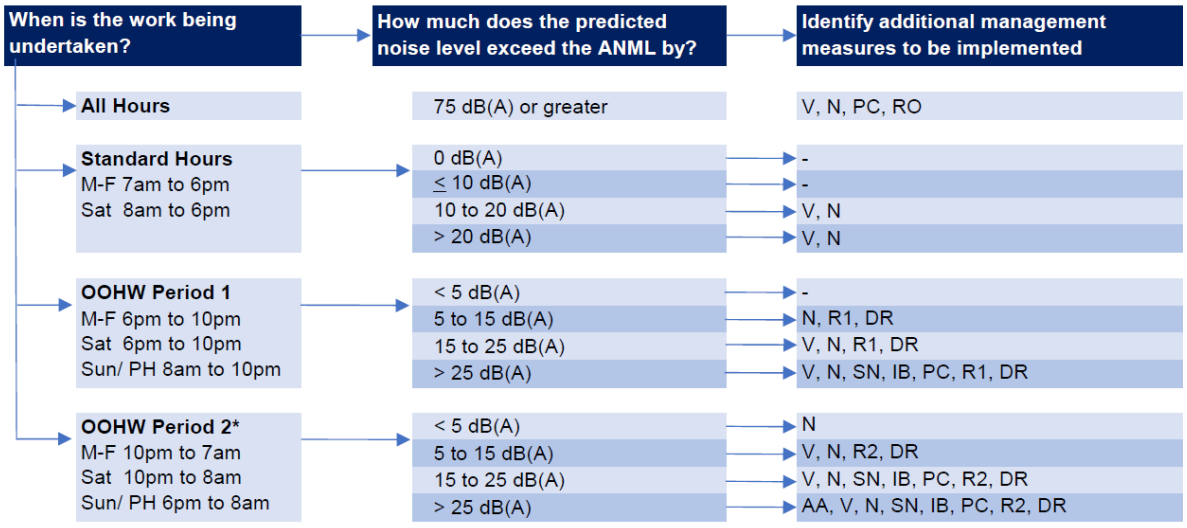
3.1.6 Additional construction mitigation

Section 4.6.1 of the M4-M5 Link EIS, Appendix J identifies standard mitigation measures for construction activities likely to result in adverse noise or vibration impact based on the Roads and Maritime Construction Noise and Vibration Guideline (CNVG). Standard mitigation measures have been considered in this modification assessment, consistent with the EIS. Also consistent with the M4-M5 Link EIS, Appendix J, Section 4.6.2 and in accordance with Infrastructure Approval Condition E81, the following key mitigation measures have been developed based on the Roads and Maritime Construction Noise and Vibration Guideline (CNVG) and detailed in the Construction Noise and Vibration Management Plan (CNVMP):

- Validation of predicted noise/vibration levels at the nearest receiver buildings to the construction works

- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these would occur, impacts and mitigation measures
- Specific notifications, which provide additional information when relevant and informative to more highly affected receivers than covered in general letterbox drops
- Phone calls, which detail relevant information to identified/affected stakeholders and provide personalised contact, tailored advice and the opportunity to comment on the proposed work.
- Individual briefings, which inform stakeholders about the impacts of high noise activities and mitigation measures and provide personalised contact, tailored advice and the opportunity to comment on the proposed work
- Duration respite, which refers to the increase of the duration of specific works (i.e. number of evenings or nights) so that the entire Project can be completed more quickly; this additional mitigation measure would be considered in consultation with the receivers
- Respite periods may be offered to the affected residents during works where the predicted noise/ vibration is above the management levels as noted in Figure 9, Figure 10 and Figure 11
- Alternative accommodation (or other negotiated respite offers when alternative accommodation is not suitable for the resident) would also be considered where predicted noise/ vibration is above the management levels for more than two consecutive nights.

Figure 9, Figure 10 and Figure 11 detail the above-mentioned additional mitigation measures for the all assessment periods (i.e. day, evening and night) for airborne noise, ground-borne noise and vibration respectively. Where feasible and reasonable, this approach would be implemented.



Notes: Use the abbreviation codes in the table above to confirm management measures required

* Where OOHW occur in the evening/night shoulder period (10pm to 12am) or the night/morning shoulder period (5am to 7am) apply additional airborne mitigation measures from the OOHW Period 2, excluding AA.

N = Notification (should be issued a minimum of five working days prior to the start of works)

SN = Specific notifications (issued no later than seven calendar days ahead of construction activities)

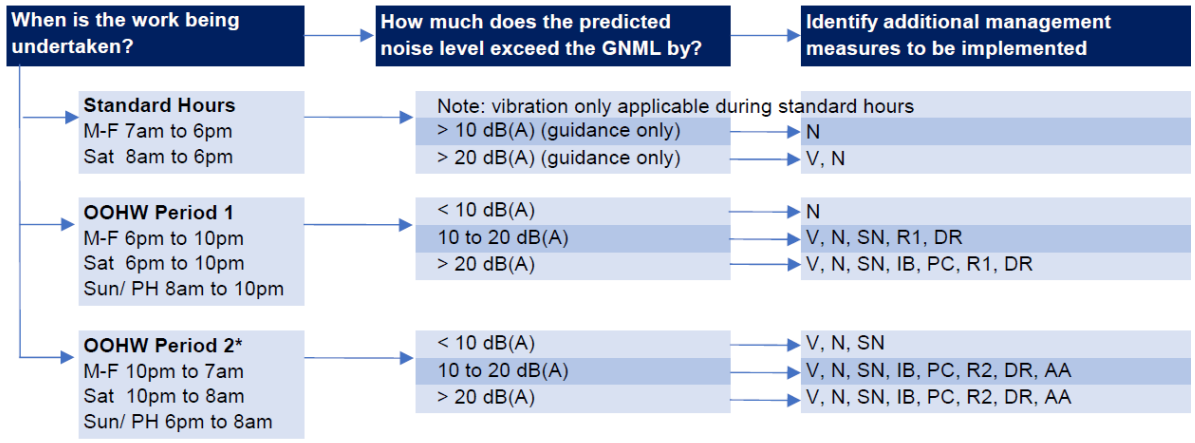
IB = Individual briefing PC = Phone Call

AA = Alternative accommodation** RO = Project specific respite offer R1 = Respite period 1

V = Verification of predicted noise DR = Duration respite R2 = Respite period 2

** Where construction activity impacts receiver for more than two consecutive nights. AA is not applicable to shoulder periods.

Figure 9 Triggers for additional mitigation measures – airborne noise



Notes: Use the abbreviation codes in the table above to confirm management measures required

* Where OOHW occur in the evening/night shoulder period (10pm to 12am) or the night/morning shoulder period (5am to 7am) apply additional airborne mitigation measures from the OOHW Period 2, excluding AA.

N = Notification (should be issued a minimum of five working days prior to the start of works)

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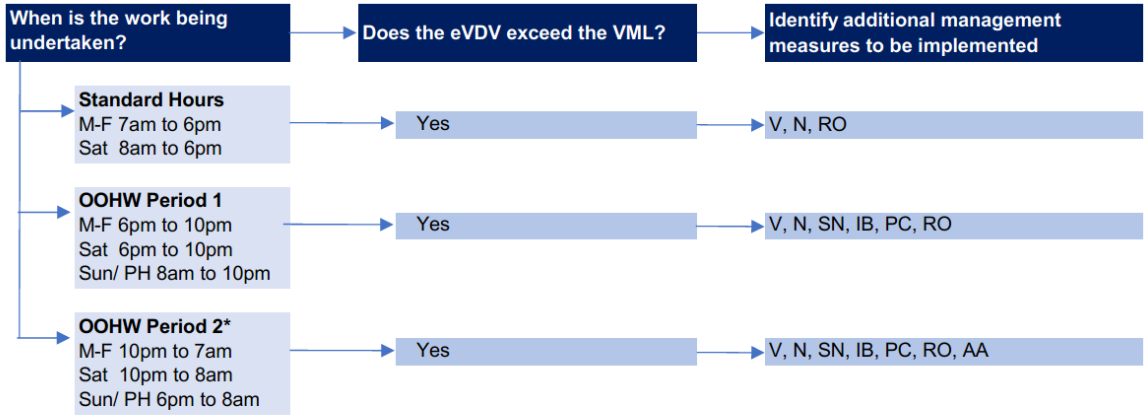
IB = Individual briefing PC = Phone Call

AA = Alternative accommodation** RO = Project specific respite offer R1 = Respite period 1

V = Verification of predicted noise DR = Duration respite R2 = Respite period 2

** Where construction activity impacts receiver for more than two consecutive nights. AA is not applicable to shoulder periods.

Figure 10 Triggers for additional mitigation measures – ground-borne noise



Notes: Use the abbreviation codes in the table above to confirm management measures required

* Where OOHW occur in the evening/night shoulder period (10pm to 12am) or the night/morning shoulder period (5am to 7am) apply additional airborne mitigation measures from the OOHW Period 2, excluding AA.

N = Notification (should be issued a minimum of five working days prior to the start of works)

SN = Specific notifications (issued no later than seven calendar days ahead of construction activities)

IB = Individual briefing PC = Phone Call

AA = Alternative accommodation** RO = Project specific respite offer R1 = Respite period 1

V = Verification of predicted noise DR = Duration respite R2 = Respite period 2

** Where construction activity impacts receiver for more than two consecutive nights. AA is not applicable to shoulder periods.

Figure 11 Triggers for additional mitigation measures – vibration

3.2 Operational noise and vibration assessment

Operational noise and vibration impact from the ventilation facilities, including MOC4 were assessed as part of the M4-M5 Link EIS, Appendix J. The M4-M5 Link EIS, Appendix J (Section 4.9.1) assumes an indicative sound power level of 105dB(A) at the top of the ventilation outlet, which assumes appropriate attenuators have been installed on the outlet side of the fans. Based on this noise source level the EIS predicted non-compliances at receivers in NCA 33 by up to 12dB(A).

The proposed modification assessment is based on further development of the detailed design and has determined appropriate attenuator requirements to meet the noise criteria at all relevant Noise Catchment Areas (NCAs). The following methodology was used to predict operational noise levels from the ventilation outlet, the location of which remains unchanged under the proposed modification:

- Assume ventilation fan source noise level of 123dB(A) per fan, based on further development of the detailed design
- Install four fans -three duty fans in operation as a worst case, with one fan on standby;
- Conduct noise modelling to determine acoustic losses through the proposed new ventilation tunnel between fan cavern and outlet (approx. 245m of tunnel)
- Apply attenuator insertion loss for a 5-metre acoustic attenuator based on test data available from similar previous projects
- Apply a 5-dB penalty to account for the possibility of low-frequency noise generated by the fan
- Apply +3 dB noise modelling engineering margin
- Apply the final calculated sound power level at ventilation outlet and use 3D noise modelling software to predict noise levels to nearest and most affected receivers
- Compare predicted noise levels against the noise criteria from EIS.

Operational noise from the HV regulators has been considered by modelling regulator noise and considering noise reduction from the blockwork walls around the regulators. The residences adjacent to the HV regulators in Callan Street would be essentially first row receivers once the new alignment of Victoria Road is completed. Existing noise levels of typical first row receivers were established by recent additional noise monitoring at the rear of 1B Byrnes Street in March 2019. The measured night-time RBL was 43dB(A), and the existing night-time LAeq ambient level was 60dB(A). Therefore, the controlling intrusive noise criteria for these receivers is 43 + 5 = 48dB(A). The total noise from the ventilation outlet plus the HV regulators therefore should not exceed 48dB(A).

The detailed assessment of operational noise is in Section 5. Operational noise mitigation measures would be confirmed in the Operational Noise and Vibration Review to be prepared in accordance with Planning Approval Condition E92.

4 Construction noise and vibration assessment

4.1 Tunnelling excavation of the ventilation tunnel and caverns

4.1.1 Predicted ground-borne noise levels

Table 4 presents a summary of the number of residential receivers where predicted ground-borne noise (GBN) levels are above the evening GBNML of 40 dB(A) and night-time GBNML of 35 dB(A) in each NCA ground-borne noise affected as a result of the ventilation tunnel excavation works. Note that GBN from excavation of the ventilation tunnel and cavern will be the same whether the tunnels are excavated from the Iron Cove civil site (C8) or the Rozelle civil and tunnel site (C5).

Table 4 Worst predicted ground-borne noise levels during excavation of the ventilation tunnel and caverns

NCA	Worst-case ground-borne noise level at a residential receiver (dB(A) LAeq,15min)	Number of residential receivers predicted to be within		
		35-40 dB(A)	**40-45dB(A)**	**>45 dB(A)**
NCA31	<35	0	0	0
NCA32	39	21	0	0
NCA33	47	40	14	3
NCA34	<35	0	0	0
NCA35	<35	0	0	0
NCA36	<35	0	0	0
Total number per GBN intervals		61	14	3
Total number		78		
Percentage (%) of total		78%	18%	4%

As shown in Table 4 and Figure 12 residential properties along the ventilation tunnel alignment are expected to be above the night-time GBNML in NCA33 and NCA32. Residential receivers are not expected to be GBN affected at night (from 10 pm to 7 am) in NCA31, NCA34, NCA35 and NCA36. There are 78 residential receivers along the ventilation tunnel alignment who are expected to experience maximum GBN levels above the night-time GBNML of 35dB(A) during roadheader excavation works. However, more than two thirds of these receivers (i.e. 78%) are predicted to be exposed to maximum GBN levels between 35 and 40 dB(A). Only a small portion of these receivers (i.e. 18%) is expected to be between 40 and 45 dB(A). Finally, only three receivers in NCA33 are predicted to be more than 45 dB(A). The maximum GBN level is predicted to be 47 dB(A).

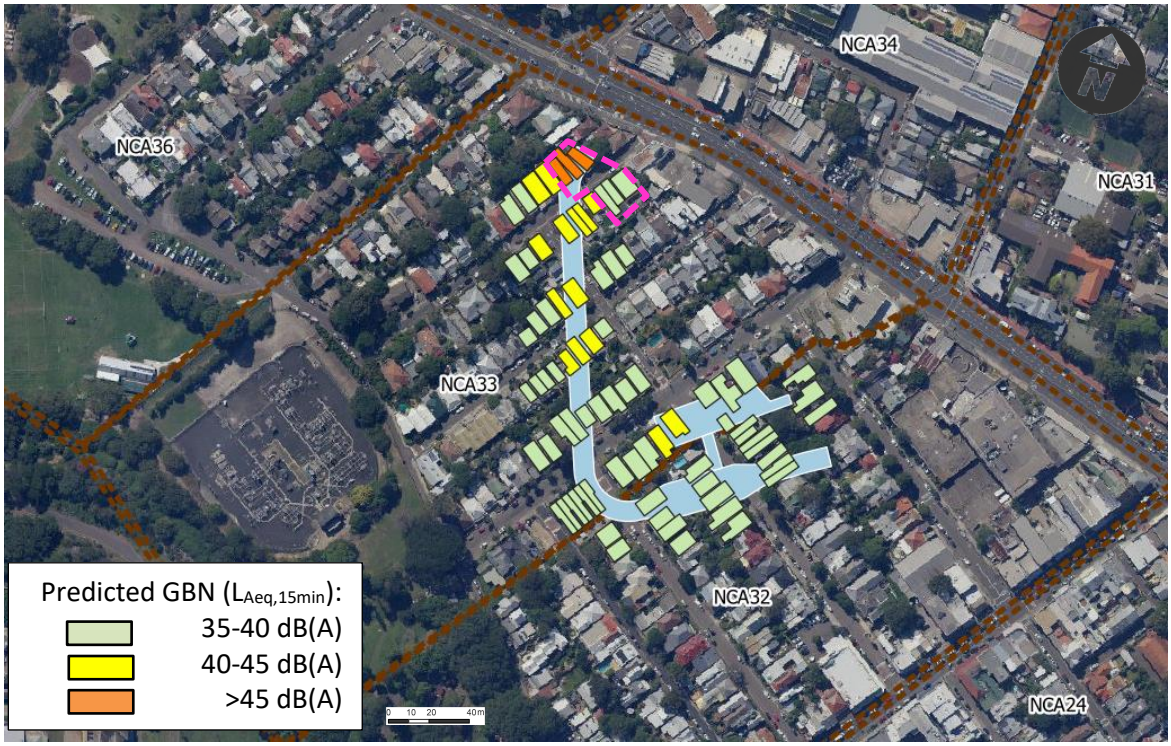


Figure 12 Maximum predicted GBN levels (ventilation tunnels in light blue). Properties within dashed pink area will also receive GBN from Iron Cove link tunnel excavation.

Figure 12 identifies residential properties where GBN levels from the ventilation tunnel excavation are expected to be above the night-time GBNML of 35 dB(A) as properties coloured green, yellow and orange. Residential properties where GBN levels are expected to be above the evening GBNML of 40 dB(A) are also shown as properties coloured yellow and orange. Properties not highlighted are not predicted to be ground-borne noise affected by the proposed modification.

These GBN affected receivers are in addition to the receivers already identified in the M4-M5 Link EIS, APPENDIX J, Table 5-148 during mainline tunnel excavation works. It is noted that Appendix J of the EIS does not consider ventilation tunnels at Iron Cove, therefore a direct comparison could not be undertaken to compare impacts with the EIS design. There are six properties identified within the pink dotted line in Figure 12 where ground-borne noise from the mainline tunnel excavation is predicted to be above the night GBNML of 35 dB(A) but below the evening GBNML of 40 dB(A), based on information provided in the M4-M5 Link EIS Annexure I.

The EIS noted that at residential locations greater than 30 metres from the nearest tunnel (taking into account the tunnel depth and the horizontal distance), exceedances of the ground-borne NML of 35 dB(A) during night-time periods are unlikely.

Figure 13 shows approximate tunnel depths (from ground elevation to the tunnel ground) for the ventilation tunnels at the Iron Cove Link site.

Figure 13 Approximate tunnel depths below existing ground elevation

As indicated in the EIS, the GBN predictions presented in Figure 12 represent the worst-case scenario when roadheader excavation works are directly underneath the receivers. At each receiver, noise levels will vary during the construction period based on the position of the roadheaders along the tunnel and caverns. This concept is described in M4-M5 Link EIS, Appendix J, Figure 5-34 and reproduced in Figure 14 below.

As can be noted from Figure 13 and Figure 14 considering an advance rate for the roadheader works of approximately 20m per week, the worst-case GBN impacted receivers along the ventilation tunnel alignment are expected to be above night-time GBN management levels for a relatively short period of time (i.e. approximately 2-3 weeks for each roadheader pass). However, it should also be noted that due to the roadheader excavation constraints, the top heading of a tunnel is generally divided in two sections (or “tunnel faces”), whilst the top heading of a cavern is usually excavated in three sections. These sections are not excavated at the same time and as such the road header would pass under properties above the tunnel more than once. Residential receivers above the tunnels would likely be exposed to two roadheader passes, whilst receivers above the caverns would likely be exposed to three roadheader passes.

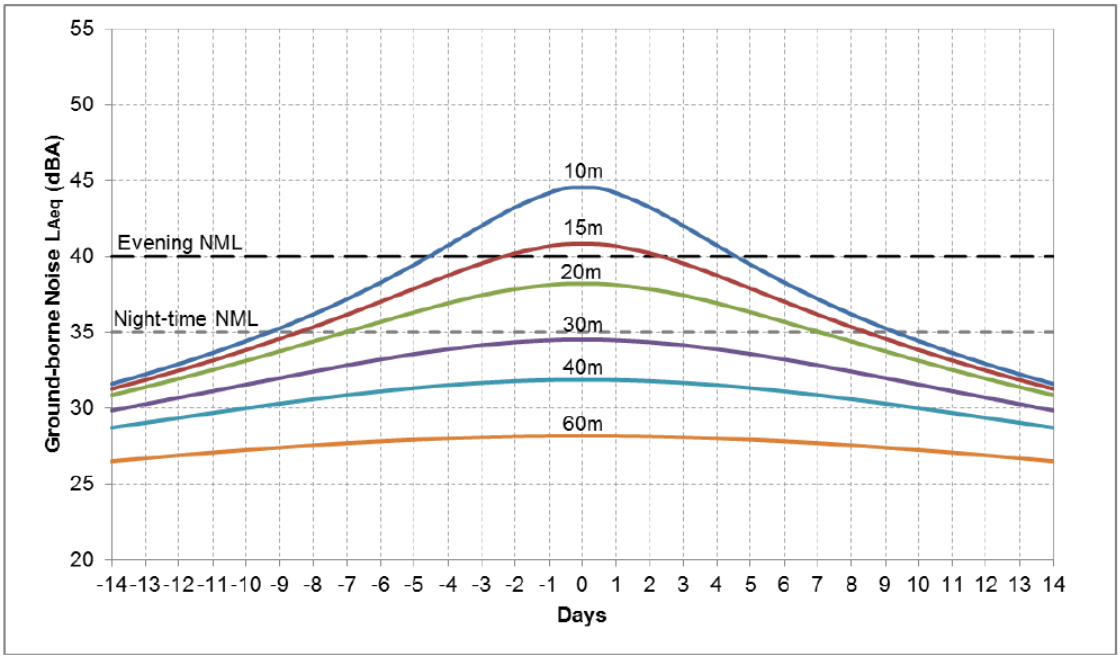


Figure 14 Ground-borne noise levels at slant distances from road-heading (progress = 20m/week) (Source: M4-M5 Link EIS, Appendix J, Figure 5-34)

The staging of the top heading excavation depends on the depth below existing ground. It is likely that the top heading of tunnels with low cover may be excavated in one stage (or 'full face"), requiring the roadheader to pass only once under the properties. As tunnel depth increases the staging of the top heading could be introduced to a maximum of two sections for the ventilation tunnel and up to three for the ventilation cavern as stated in paragraph above.

Predicted ground-borne noise levels from rock-breaker tunnel excavation (i.e. bench excavation) are likely to be above the evening and night-time GBNMLs of 40dB(A) and 35dB(A) respectively, where residential receivers are located above the tunnel alignment. Rock hammer excavation works are proposed to be undertaken during the daytime period only. Alternative low vibration excavation techniques such as roadheader and surface miner excavation would be considered whenever practicable.

4.1.2 Predicted ground-borne vibration

The recommended minimum working distances during roadheader excavation works are presented in Table 5 and are based on the M4-M5 Link EIS, Appendix J, Table 4-12.

Table 5 Recommended minimum working distances (Source: M4-M5 Link EIS, Appendix J, Table 4-12)

Plant item	Work activity	Minimum working distance			
		Cosmetic damage			Human responses[1]
		Residential and light commercial[1]	Group 2 (typical)[2,3]	Group 3 (structural unsound)[2,4]	
Roadheader	Tunnelling excavation	2 m	3 m	5 m	7 m

Notes: 1. Criteria referenced from Roads and Maritime CNVG

2. Criteria referenced from DIN 4150

3. Residential buildings and buildings of similar design and/or occupancy

4. Structures with particular sensitivity to vibration and with great intrinsic value (e.g. listed buildings).

Table 6 presents the number of buildings within minimum working distances established for structural damage and for human annoyance during roadheader excavation.

Table 6 Number of buildings within minimum working distances

Work scenario	NCA	Number of buildings within minimum working distance			
		Cosmetic damage			**Human responses**
		Residential and light commercial	**Group 2 (typical)**	**Group 3 (structural unsound) ***	
Tunnelling works (roadheader)	NCA31	0	0	0	0
	NCA32	0	0	0	0
	NCA33	0	0	0	0
	NCA34	0	0	0	0
	NCA35	0	0	0	0
	NCA36	0	0	0	0

Notes: * This group identifies Heritage listed items only and represents a screening test applicable where a historic item is deemed to be sensitive to damage from vibration

As can be noted from Table 6 no sensitive receivers are located within the minimum working distances established for cosmetic damage and for human annoyance during roadheader tunnelling excavation.

It should be noted that ground-borne vibration levels from tunnelling works at or below the threshold of human perception would generally result in noise levels above the ground-borne noise management levels for residential and commercial premises. In fact, the Environmental Impact Statement for Sydney Metro City & South West Project notes that “People tend to “hear” vibration (i.e. regenerated noise) before they feel vibration”1. Therefore, management and mitigation measures triggered by the exceedance of ground-borne noise management levels would appropriately address and manage potential vibration impacts.

Nevertheless, potential vibration impacts and associated feasible and reasonable mitigation and management measures would be managed in accordance with the processes set out in the Construction Noise and Vibration Management Plan prepared in accordance with Planning Approval Condition C4(b).

4.1.3 Mitigation and management

In accordance with the Planning Approval Condition E82:

“*Mitigation measures must be applied when the following residential ground-borne noise levels are exceeded:*

- *Evening (6:00 pm to 10:00 pm) – internal LAeq(15min): 40dB(A*
- *Night (10:00 pm to 7:00 am) – internal LAeq(15min): 35dB(A).*

1 Sydney Metro, 2016, Environmental Impact Statement for the Sydney Metro City & South West project (Chapter 10)

The mitigation measures must be outlined in the Construction Noise and Vibration Management Sub-plan, including in any Out-Of-Hours Work Protocol, required by Condition E77."

Appropriate measures to reduce the potential for ground-borne noise impact would be identified in accordance with the processes set out Construction Noise and Vibration Management Plan prepared in accordance with Planning Approval Condition C4(b). All feasible and reasonable mitigation and management measures would be considered and implemented in order to minimise and manage potential noise impacts.

Additional mitigation and management measures, as outlined in Section 3.1.6 would also be adopted.

4.2 Tunnel support works from Iron Cove cut and cover

4.2.1 Predicted airborne noise levels

A summary of the predicted noise levels in each of the NCAs from the tunnel support activities at the Iron Cove Link cut and cover site are presented in Table 7 based on the assumptions outlined in Section 3.1.2. For comparison, predicted noise levels from the EIS Iron Cove civil works site (EIS C8) based on the EIS construction noise assessment scenario ICL-11 and ICL-12.

Table 7 EIS and contractor comparison – predicted worst case noise levels for ICL (residential)

NCA	EIS NML	Predicted $L_{Aeq(15\ minute)}$ noise levels (dB(A))		
		EIS ICL-111	**EIS ICL-121**	**Contractor – ICL Tunnel Support**
Daytime				**Single skin with Wavebar**
NCA30	71	49	50	<30
NCA31	73	55	60	<30
NCA32	73	59	80	36
NCA33	54	72	75	51
NCA34	75	69	69	53
NCA35	75	80	75	66
NCA36	54	84	79	53
NCA38	55	53	48	<30
Evening				
NCA30	65	-	50	<30
NCA31	63	-	60	<30
NCA32	63	-	80	<30
NCA33	45	-	75	42
NCA34	65	-	69	36
NCA35	65	-	75	57
NCA36	45	-	79	41
NCA38	45	-	48	<30
Night				
NCA30	49	-	50	<30
NCA31	48	-	60	<30
NCA32	48	-	80	<30
NCA33	36	-	75	42
NCA34	51	-	69	36
NCA35	51	-	75	57
NCA36	39	-	79	41
NCA38	40	-	48	<30

Notes: 1. Source: M4-M5 Link EIS, APPENDIX J, Table 5-93, Table 5-94 and Table 5-95
Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 7 shows that predicted noise levels from the contractor Iron Cove tunnel support site are more than 10 dB(A) below predicted noise levels from the EIS Iron Cove civil site. Therefore, cumulative noise from the addition of noise generated by the tunnel support site to the noise from civil works would be negligible.

Table 8 compares the number of receivers above night-time EIS Noise Management Levels (NMLs) for the EIS Iron Cove civil works site (EIS C8) and the contractor Iron Cove tunnel support site, with noise mitigation measures in place. Comparison of the number of receivers above the evening EIS NMLs have not been included in Table 8 as this presents the worst case impact for the construction works. Note that ICL-11 occurs during the daytime only.

Table 8 EIS and contractor comparison – number of receivers above EIS NMLs for ICL cut and cover

Activity ID (from EIS)	Activity	Time period	Number of receivers above EIS NMLs (with mitigation*)					
			EIS1			**Contractor**		
			1 to 10 dB(A)	**11 to 20 dB(A)**	**>20 dB(A)**	**1 to 10 dB(A)**	**11 to 20 dB(A)**	**>20 dB(A)**
ICL-11	Earthworks general and drainage	Day	119	38	3	-	-	-
ICL-12	Concrete works	Day	92	17	4	-	-	-
ICL-12	Concrete works	Night	158	149	87	-	-	-
N/A	Cut and cover tunnel support	Day	-	-	-	0	0	0
N/A	Cut and cover tunnel support (Single skin Wavebar wall)	Night	-	-	-	0	0	0

Notes: Source: M4-M5 Link EIS, APPENDIX J, Table 5-98
*Mitigation includes at-property treatments identified in PPA Condition E87 (see Section 4.2.3).

Table 7 reflects that predicted noise from the civil construction works under the EIS are significantly above the NML at the nearest receivers during the day and where works are required during the evening and night. Impacts will be managed through a combination of standard and additional mitigation and management measures as outlined in Section 3.1.6. In addition, Planning Approval Condition E79 requires consultation with affected receivers to assist in determining site-specific mitigation measures.

By comparison, predicted noise levels from the tunnel support works at the Iron Cove Link cut and cover site would be below NMLs at all receivers during the day. At night-time, with a single skin with Wavebar shed wall construction at the end of the cut and cover structure, no receivers are predicted to be above the NML at night.

The likelihood of sleep disturbance impact is assessed as low as the site will be mitigated and managed to comply with the NMLs at night.

4.2.2 Predicted traffic noise impacts

As noted in Section 3.1.2, the daily traffic volumes anticipated during peak tunnel support activities are:

- Day period (7:00 am to 10:00 pm), 30 light vehicles and typically 40 heavy vehicles per day
- Night period (10:00 pm to 7:00 am), typically 1 heavy vehicle (concrete delivery) at night.

The addition of the above construction traffic to the existing traffic on Victoria Road would not be discernible and is not further addressed in this report.

4.2.3 Mitigation and management

Construction noise impacts will be managed as outlined in sections 3.1.2, 3.1.5 and 3.1.6.

A detailed construction noise and vibration impact assessment will be prepared for the proposed activities at the Iron Cove site in accordance with the approved Construction Noise and Vibration Management Plan (CVNMP) to document the outputs of detailed noise and vibration modelling and confirm the optimum suite of noise and vibration mitigation measures.

4.2.4 Predicted vibration

Vibration impacts from cut and cover excavation have been addressed and are consistent with the M4-M5 Link EIS, APPENDIX J. There are no vibration significant plant associated with the tunnel support activities. Vibration impact from tunnel support activities is assessed as low, with the risk of disturbance to nearby receivers considered low to negligible.

4.3 Permanent surface works

4.3.1 Predicted airborne noise levels

Based on the assumptions made in the M4-M5 Link EIS, construction of the switch room, HV regulator bays, alternative Operational Motorway Control System (OMCS) room and stair access would be during the daytime (standard hours) only and airborne construction noise generated from within the site would be similar. Predicted worst case noise levels from the construction of MOC4 are presented in Table 9 for the EIS design and the proposed modification.

Table 9 EIS and contractor comparison – predicted worst case noise levels for ICL-14 (daytime - residential)

NCA	EIS NML	Worst-case predicted LAeq (15 minute) noise levels (dB(A)) for ICL-14	
		EIS1	**Contractor**
NCA30	71	41	39
NCA31	73	46	40
NCA32	73	52	45
NCA33	54	71	62
NCA34	75	60	57
NCA35	75	64	62
NCA36	54	54	54
NCA38	55	37	39

Notes: 1. Source: M4-M5 Link EIS, APPENDIX J, Table 5-93
Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Due to the substantially reduced extent of the permanent surface works, there are fewer potentially noise affected receivers compared to the EIS. Furthermore, the proposed modification would reduce the duration of airborne noise impact from construction of the permanent surface works from 144 weeks down to about 40 weeks. The outcomes are summarised in Table 10 below.

Table 10 EIS and contractor comparison – number of receivers above EIS NMLs for ICL-14 (daytime)

Activity ID (from EIS)	Activity	Estimated duration		Number of receivers above EIS NMLs (with mitigation)					
				EIS[1]			Contractor		
		EIS1	Contract-or	1 to 10 dB(A)	11 to 20 dB(A)	>20 dB(A)	1 to 10 dB(A)	11 to 20 dB(A)	>20 dB(A)
ICL-14	Ventilation station and substation	144 weeks	40 weeks	24	4	-	11	-	-

Notes: 1. Source: M4-M5 Link EIS, APPENDIX J, Table 5-98

Construction noise impacts will be managed as outlined in sections 3.1.5 and 3.1.6.

4.3.2 Predicted vibration

There are no vibration significant plant associated with the construction of MOC4 permanent surface works. Vibration impact is assessed as low, with the risk of disturbance to nearby receivers considered low to negligible.

5 Operational noise and vibration assessment

5.1 Predicted operational noise levels

In the EIS, noise emissions from fixed facilities in the Iron Cove area are predicted to exceed the criteria by up to 12 dB(A) at the most-affected receivers either side of Callan Street. The EIS proposed that noise generating operational equipment would be reviewed at the detailed design stage of the Project when specific plant selection is finalised, and appropriate noise control measures determined to ensure compliance with relevant operational noise criteria.

Under the proposed modification the ventilation equipment would be located underground in tunnels and caverns instead of in the MOC4 ventilation building. Locating equipment underground reduces potential noise impacts as noise breakout through ventilation building walls, roof, doors etc is no longer an issue as the above ground building has been replaced with an underground cavern. Similarly, for the substation, transformer noise and building services, noise impact is reduced as the substation is also located underground.

There is potential for noise emission from the above ground ventilation outlet. This has been reviewed as part of the development of the detailed design, including review of the fan selections and attenuator selections. The review considered the location of the ventilation fans underground. From the detailed design development, a source sound power level of 123dB(A) was assumed, with three fans in operation (one fan on standby). It was determined that to achieve the night-time design criteria of 45dB(A) at residential receivers in Noise Catchment Area (NCA) 33, an acoustic attenuator capable of achieving 35dB(A) noise reduction would need to be installed on the outlet side of the fans. Acoustic losses along the long tunnel between the underground fan room and the exhaust outlet assist in reducing noise emissions at the outlet.

Table 11 compares the EIS predicted operational noise levels for Iron Cove against the proposed modification.

Table 11 Operational noise levels at the closest residential receivers – Iron Cove fixed facilities

Receiver	NCA	Criteria	EIS predicted operational noise levels, dB(A)	Proposed modification predicted operational noise levels, dB(A)
Closest residential receivers	NCA33	45	57	44
	NCA34	45	40	40
	NCA35	45	42	38
	NCA36	45	39	41

The criteria of 45dB(A) in Table 11 is consistent with the EIS and was established according to the NSW Industrial Noise Policy (INP), based on the night-time amenity criteria for residences in urban areas.

The proposed attenuator on the outlet side of the fans has been selected such that the non-compliance predicted at NCA33 in the EIS has been mitigated. Compliance is now predicted at all surrounding NCAs. Although noise levels at the closest receiver in NCA36 are expected to be 2 dB higher than in the EIS, compliance with the noise criteria of 45dB(A) is still achieved. Therefore, noise impacts at the closest receivers associated with the operation of the Iron Cove fixed facilities are consistent with or less than the EIS.

Noise emissions from either the ventilation fan cavern or the substation cavern will be treated at the source by appropriate acoustic treatment of door openings and louvres to the caverns.

5.2 Operational noise from HV regulators

While under the proposed modification a switch room, high voltage regulators, an alternative Operational Motorway Control System (OMCS) room and a separate stair access leading down to the ventilation tunnel would be required on the surface, the only element of this surface infrastructure which required noise assessment are the high voltage regulators (HV regulators).

The HV regulators are electrical transformers with operational noise levels expected to be approximately 65dB(A) at 1m, which would be confirmed during procurement. The regulators would be surrounded by core-filled blockwork on all sides.

There are also On Load Tap Changers (OLTC) attached to the regulators that operate for periods of 10-15 seconds at a time, and usually occur during peak hours of tunnel operation as more load is required. This operation generates noise levels of approximately 72dB(A) at 1m over this short duration. If OLTC operation occurred for 15 seconds within a 15-minute assessment period, this would add approximately 1dBA to the total HV regulator plus OLTC noise emission.

The nearest residential receivers are on the north side of Callan Street, and share a common boundary with the site. Most receivers are single storey dwellings, however there is one dwelling with a recent double storey addition.

Based on a HV regulator noise level of 65dB(A) at 1m, + 1dB(A) for OLTC, 8dB(A) distance loss, and 10dB(A) reduction from the blockwork walls, noise levels could be up to 48dB(A) at ground level receivers. At first floor receivers noise levels may be up to approximately 53dB(A). A low-frequency annoyance penalty has not been applied for regulator noise as this noise emission would not emerge enough above the ambient traffic noise levels (around 60dB(A)) to trigger the application of this penalty under the Industrial Noise Policy (NSW Environment Protection Authority 2000) procedures.

The aim is to mitigate HV regulator noise to 45dB(A), so that the combination of HV regulator noise and ventilation outlet noise would not exceed 48dB(A) at any nearby property.

During the night-time when electrical loads are low, the predicted noise levels may be 3dB(A) less than those shown for full load, in which case ground level receivers would be 45dB(A) and would comply. Some additional noise mitigation may be required for the first-floor receiver.

The following additional noise mitigation measures would be considered during the detailed design so that the combination of HV regulator noise and ventilation outlet noise would comply at nearby properties:

During the procurement process for the HV regulators, the aim would be to procure equipment less than 65dB(A) at full load, and less than 62dB(A) at typical night-time loads.

Blockwork walls around the transformers would be as high as practical (minimum 4m high), particularly on southern and eastern sides to maximise noise reductions.

If additional noise reduction is required, installing a partial pitched roof would be investigated. A full roof is not practical due to cooling requirements.

If further reduction is required, the underside of the pitched roof and the inner face of the walls would be lined with acoustic absorption material where practical.

Operational noise mitigation measures would be confirmed in the Operational Noise and Vibration Review to be prepared in accordance with Planning Approval Condition E92.

5.3 Predicted operational vibration levels

Operational vibration impacts are predicted to be negligible for the following reasons:

- The majority of operational sources are relocated underground as part of this proposed modification and there are relatively large distances to buildings at the surface. Figure 13 demonstrates the depth of the ventilation and substation tunnels/ caverns
- Ventilation fans would be installed with appropriate vibration isolation mounts such that vibration is not transmitted from the fan cavern to the surrounds
- The substation is also relocated underground, and substations do not generally contain plant or machinery that generates significant levels of vibration
- The HV regulators and OLTC do generate any significant levels of vibration during operation.

5.4 Change in traffic noise levels

Modelling for traffic noise levels in the EIS did not include the ventilation facility between Springside Street and Callan Street or the substation between Callan Street and Toelle Street. This conservative approach to traffic noise modelling reflects the uncertainty related to the detailed design of operational infrastructure. As these surface operational buildings did not influence the EIS traffic noise model, the proposed removal of the ventilation facility will have no impact on the traffic noise predictions. The proposed construction of operational buildings between Callan Street and Toelle Street will provide some traffic noise shielding to residents adjacent to these structures, potentially improving operational traffic noise relative to the EIS predictions.

All properties impacted by traffic noise would be mitigated in accordance with the RMS Noise Mitigation Guideline as part of the operation noise and vibration review required by the Planning Approval.

5.5 Sleep disturbance from operation

The operational noise sources are generally fairly constant noise sources and are unlikely to cause sleep disturbance as will be mitigated to meet the INP criteria. Electrical switching equipment is wholly contained within the switch room and are therefore not expected to be an issue. The item that has the most potential to cause sleep disturbance is the On Load Tap Changer (OLTC), which is attached to the HV regulator and located inside the concrete blockwork walls. The OLTC operates for periods of 10 -15 seconds at a time. This operation generates noise levels of approximately 72dB(A) at 1m.

Based on 8dB(A) distance loss and 10dB(A) reduction from the blockwork walls, maximum noise levels from this operation could be up to 54dB(A) at the nearest receivers.

The INP does not contain sleep disturbance criteria. Taking guidance from the Noise Policy for Industry (EPA, 2017), sleep disturbance screening criteria is either LAFmax 52dB(A), or the prevailing RBL plus 15dB, whichever is the greater.

Based on a night-time RBL of 43dB(A), the sleep disturbance screening criteria is 43 + 15 = 58dB(A). As the predicted maximum noise level of 54dB(A) is below the screening criteria of 58dB(A), sleep disturbance impacts are unlikely.

6 Conclusion

Renzo Tonin & Associates was engaged by the Contractor to prepare a noise and vibration assessment of the proposed modification to the ventilation ancillary facilities at Iron Cove Link during the construction and operational phases. The findings of this noise and vibration assessments are summarised below.

6.1 Construction noise and vibration

6.1.1 Tunnelling of underground ventilation tunnel and caverns

There are 78 residential properties where ground-borne noise (GBN) levels are predicted to be above the night-time GBNML in Noise Catchment Area (NCA) 33 and NCA32. However, more than two thirds of these receivers (i.e. 78%) are predicted to be exposed to maximum ground borne noise (GBN) levels between 35 and 40 dBA. Only a small portion of these receivers (i.e. 18%) is expected to be between 40 and 45 dBA. Finally, only three receivers in NCA33 are predicted to be more than 45 dBA. The maximum GBN level is predicted to be 47 dBA. These GBN affected receivers are in addition to the receivers already identified in the M4-M5 Link EIS, APPENDIX J, Table 5-148 during mainline tunnel excavation works. Due to the advance rate of roadheader works, this impact is expected to be relatively short-term in duration (i.e. approximately 2-3 weeks per roadheader pass).

In accordance with Planning Approval Condition E82, mitigation measures would be implemented when predicted GBN levels are above relevant GBN management levels in accordance with the approved Construction Noise and Vibration Management Plan (CVNMP). The proposed new ventilation tunnel and caverns would equate to a total length of about 425 metres. This calculation is based on a length of about 340 metres for the ventilation tunnel alignment and the ventilation fan cavern, 65 metres for the substation cavern and about 20 metres of access tunnel connecting the two caverns. It is important to note that Rozelle Interchange (which is Stage 2 of the M4-M5 Link Project) includes excavation of approximately 23 kilometres of tunnels and that the proposed modification is limited to the construction of about 425 metres of additional tunnels and caverns, which represents a very small increase in the extent of tunnelling and associated construction ground-borne noise impacts.

No sensitive receivers are located within minimum working distances for roadheader during tunnelling works for the proposed ventilation tunnels, therefore the risk of disturbance due to vibration from roadheader excavation works is considered low.

6.1.2 Tunnel support construction works

All plant, equipment and materials required to construct the proposed new ventilation tunnel and caverns would be supported from the Iron Cove civil site, with the potential for some tunnelling to be supported from the Rozelle civil and tunnel site later in the construction program. As the proposed new ventilation tunnel and cavern works would be supported from the Iron Cove Link civil site but could also use the Rozelle civil and tunnel site, this assessment has been completed assuming the worst-case impacts of all deliveries and spoil transportation occurring from either site.

The Iron Cove civil site within the cut and cover - there would be no properties affected by construction noise associated with the tunnel support site operation. As tunnel support would be a 24-hour operation, noise impacts at night were also predicted and found to be below the noise management level (NML) at receivers nearby the worksite. A detailed construction noise and vibration assessment will be prepared for the proposed activities at the Iron Cove Link site in accordance with the approved CNVMP to document the outputs of detailed noise and vibration modelling and confirm the optimum suite of noise and vibration mitigation measures

Rozelle civil and tunnel site - should tunnelling be supported from Rozelle civil and tunnel site there would be a minor increase in spoil trucks and deliveries due to the proposed modification. However, support of excavation works associated with the proposed modification would not overlap with peak construction activities associated with the overall Project which are scheduled to occur in March 2021. Impacts of the peak construction support has been already included in the assessment of the operation of the Rozelle civil and tunnel site and suitable mitigation measures have been identified. As such, the

slight increase in spoil trucks and deliveries at Rozelle civil and tunnel site worksite would not require additional mitigation measures.

It is important to note that the above tunnel support options represent two worst case scenarios with all tunnel support either via the Iron Cove civil site or the Rozelle civil and tunnel site. Construction noise impacts associated with these worst cases are similar to the EIS results indicating either option is acceptable. It is likely that the additional tunnelling required under the proposed modification would be completed predominately from the Iron Cove civil site with some tunnelling also supported from the Rozelle civil and tunnel site later in the programme.

6.1.3 Permanent surface construction works

Construction airborne noise: the proposed modification would result in a shorter duration of surface works than the EIS concept design and greatly reduced scope of works at Iron Cove as only a switch room, high voltage regulator (HV regulator) bays, Operational Motorway Control System (OMCS) room and stair access need to be built. Potential construction noise and vibration impacts would be managed in accordance with the processes set out in the CNVMP prepared in accordance with Planning Approval Condition C4(b).

6.2 Operational noise and vibration

The proposed relocation of the ventilation fans and substation underground would have a long-term acoustic benefit by reducing the operational noise impacts compared to the EIS. The predicted noise exceedance at NCA33 identified in the EIS would be avoided through selection of appropriate noise attenuators and noise compliance would be achieved at all surrounding NCAs.

The assessment completed in this report has demonstrated that the operation of the HV regulators would comply with the required noise criteria, subject to the implementation of mitigation measures. Mitigation measures for the HV regulators at surface have been identified and would be confirmed during detailed design so that the combination of HV regulator noise and ventilation outlet noise would comply at nearby properties.

Noise impacts from the operation of the Iron Cove fixed facilities are consistent with or less than the potential impacts identified in the EIS. Operational noise mitigation measures would be confirmed in the Operational Noise and Vibration Review to be prepared in accordance with Planning Approval Condition E92.