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NOISE ASSESSMENT AND REVIEW OF EIS FOR NORTHCONNEX PROJECT

Independent Review

8 December 2014

Department of Planning & Environment

TG979-01F01 (r5) NorthConnex Review_NOISE

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Contents

List of tables

List of figures

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1 Introduction

Renzo Tonin & Associates was requested to undertake an independent peer review of the Noise and Vibration Impact Assessment prepared for the NorthConnex Environmental Impact Statement (EIS). The noise and vibration assessment for the Project was prepared by AECOM and is included in Appendix F of the EIS also prepared by AECOM.

It is noted that Renzo Tonin & Associates work to date has been limited to a desktop review of information. Independent modelling and assessment of impacts has not been carried out.

The following documents were reviewed:

- NorthConnex Technical Working Paper: Noise and Vibration (EIS-NV), 13 June 2014, AECOM (ref: 20140613_Noise_and_Vibration_Technical_Paper_V3_RMS.docx)
- NorthConnex Environmental Impact Statement (EIS), July 2014, AECOM

This review is largely limited to the Technical Working Paper: Noise and Vibration (EIS-NV) as the EIS largely summarises its contents. This review predominately outlines where the noise and vibration report is considered deficient in its assessment of impacts.

The review has been structured as follows:

- Scope of Study;
- Review of EIS-NV assessment methodology and approach, including:
  - Noise monitoring and assessment locations;
  - Application of acoustic criteria based on relevant NSW guidelines;
  - Approach to noise modelling methodology based on relevant NSW guidelines;
- Analysis of the EIS-NV outcomes, with reference to applicable legislation, guidelines and comparable projects, namely:
  - Review of Operational Noise Impact Assessment;
  - Review of Construction Noise Impact Assessment;
- EIS-NV mitigation and management review, which will investigate the appropriateness and effectiveness of management and mitigation measures recommended for the project;
- Recommended actions and draft conditions of approval.

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 Scope of Study

2.1 Project Overview

The project entails the construction and operation of a multi-lane tolled motorway linking the M1 Pacific Motorway at Wahroonga to the Hills M2 Motorway at West Pennant Hills in northern Sydney (the Project). Key features of the Project are:

- Twin motorway tunnels up to around nine kilometres in length with two lanes in each direction.
- A northern interchange with the M1 Pacific Motorway and Pennant Hills Road, including sections of tunnel for on-ramps and off-ramps, which also facilitate access to and from the Pacific Highway.
- A southern interchange with the Hills M2 Motorway and Pennant Hills Road, including sections of tunnel for on-ramps and off-ramps.
- Integration works with the Hills M2 Motorway including alterations to the eastbound carriageway to accommodate traffic leaving the Hills M2 Motorway to connect to the project travelling northbound and the provision of a new westbound lane on the Hills M2 Motorway extending through to the Windsor Road off-ramps.
- Tie-in works with the M1 Pacific Motorway extending to the north of Edgeworth David Avenue.
- A motorway operations complex located near the southern interchange on the corner of Eaton Road and Pennant Hills Road that includes operation and maintenance facilities.
- Two tunnel support facilities incorporating emergency smoke extraction outlets and substations.
- Ancillary facilities for motorway operation, such as electronic tolling facilities, signage, ventilation systems and fire and life safety systems including emergency evacuation infrastructure.
- Modifications to service utilities and associated works at surface roads near the two interchanges and operational ancillary facilities.
- Modifications to local roads, including widening of Eaton Road near the southern interchange, West Pennant Hills, and repositioning of the Hewitt Avenue cul-de-sac near the northern interchange.
- Ancillary temporary construction facilities and temporary works to facilitate the construction of the project.

2.2 Study Area Extent

Figures showing the extent of the EIS Noise Catchment Areas (NCAs), monitoring locations, construction compounds, tunnel ramps, tunnel portals and surface works are provided in Appendix B.

3 Assessment Methodology and Approach

3.1 Baseline Noise Monitoring and Assessment Locations

The EIS-NV divided the NorthConnex Project area into 16 Noise Catchment Areas (NCAs), representing areas of similar ambient and background noise environment. Ambient noise monitoring was undertaken at 23 locations as part of the EIS. The NCAs and representative monitoring locations are shown in Figure B1 to B5 in Appendix B.

3.1.1 Noise Catchment Areas (NCAs)

The NCAs adopted within the EIS-NV are large, particularly for the Northern and Southern Interchange works. For a Project with a large Study area this is a reasonable approach. However, one of the shortcomings is that it generalises the ambient noise environment across the NCA based on a single monitoring location, which may not represent the whole catchment. For example, in a NCA adjacent to a major arterial road, typically receivers within the first two of rows of houses are exposed to higher noise levels than receivers further away from the arterial road. A noise monitoring location within the first two rows of houses would provide representative noise levels for this part of the catchment, but then assumes that these potentially higher noise levels also represent the part of the NCA that is further from the road.

The NCAs defined for NorthConnex do not appear to take into consideration the changes in the noise environment around the Project area, in particular in relation to the existing noise sources in the area, such as the M1 Pacific Motorway, Pacific Highway, Pennant Hills Road, North Shore Rail Line and the M2 Motorway.

3.1.2 Selection of Noise Monitoring Locations

Baseline noise monitoring was carried out as part of the EIS-NV in order to obtain:

- Representative Background Levels (RBLs) for the purpose of setting criteria to assess construction and operational noise impact;
- Existing road traffic noise levels, to allow the validation and calibration of the road traffic noise model.

Baseline monitoring requirements differ in order to satisfy these two objectives. Noise monitoring to determine the Rating Background Level (RBL) should be carried out in accordance with the NSW Industrial Noise Policy ('the INP', Environment Protection Authority 2000). Appendix B of the INP recommends that the microphone be located 1.2 to 1.5 m above the ground and, where practicable, at least 3 to 5 m from walls, buildings and other reflecting surfaces.

Procedures for monitoring road traffic noise are described in Appendix B of the NSW Road Noise Policy ('the RNP', Department of Environment, Climate Change and Water 2011). In accordance with the RNP (p17), road traffic noise should be measured:

- at 1 m from the facade of an existing building (facade affected measurement);
- at least 15 metres from any wall, building or other reflecting pavement surfaces on the opposite side of the roadway, and at least 3.5 metres from any wall, building or other pavement surface, behind or at the sides of the measurement point which would reflect the sound (free field measurement).

Background noise levels should be at the potentially worst affected location. This may not be the closest location to the noise source being assessed. Conversely, traffic noise levels should be measured at 1 m from the facade of a building close to the road to acquire a good signal to noise ratio. For this reason a single monitoring location is not always suitable in acquiring RBLs and existing traffic noise levels, in particular where the NCAs are very large (see Section 3.1.1 above).

The EIS-NV assumes that a single monitoring location in each of the NCAs is adequate. For NCAs 1, 2, 3, 6, 7 and 8 the single noise monitoring location is on one side of the existing arterial road (either M1, Pennant Hills Rd or M2), to represent a NCA that stretches up to 1 km on either side of the arterial Rd.

The representative noise monitoring locations are all located in close proximity to major roads, with the exception of NL07 and NL10. This implies that the purpose of these monitoring locations is to calibrate the traffic noise model rather than acquire background noise levels. The results within Table 58 of the EIS-NV generally support this as there is a good correlation between measured and modelled traffic noise levels, with the exception of NL14. As such, monitoring for the purpose of obtaining RBLs near construction and stationary operational noise sources, in particular where receiver areas are not directly affected by road traffic noise, is recommended.

3.2 Methods of baseline monitoring and collation of baseline data

Ambient noise monitoring was undertaken at 23 locations within the period 27 November to 19 December 2013.

3.2.1 Baseline Monitoring Requirements

Baseline monitoring requirements differ depending on the purpose of the monitoring data, as outlined following:

- Road traffic noise monitoring:
  - The RNP prefers a minimum of seven consecutive monitoring days. In addition to this, from our experience on similar RMS projects, RMS' preference is for a minimum of 5 weekdays and 2 weekend days of monitoring to ensure a representative 7-day sample.
- Background noise monitoring to determine the RBL:
  - The INP recommends monitoring of background noise and meteorological conditions continuously for each day of the week the proposed development will be operating and over the proposed operating hours. The Interim Construction Noise Guideline ('the

ICNG', Department of Environment and Climate Change 2009) references the INP in relation to background noise monitoring.

- With regard to the NorthConnex Project, fixed facilities will operate up to 24 hours per day, 7 days per week and construction activity may occur up to 24 hours per day, 7 days per week. Therefore, noise monitoring should be carried out over a minimum 7 days.

- Meteorological conditions:
  - The INP recommends that ideally a weather monitor that continuously monitors wind and rainfall be positioned within 5 m of the noise monitoring equipment, to assist in determining the effect of weather on the noise monitor. However, weather conditions may be represented by a single weather station within a 30 km radius of the noise monitor and in the same topographical basin.

3.2.2 Review of the Noise Monitoring in EIS-NV

3.2.2.1 Noise Monitoring

Review of the noise monitoring summary in Table 5 of the EIS-NV indicates that data generally collected was collected over a minimum of 7 days, including 5 weekdays and 2 weekend days. The exception to this are:

- Location NL19, where less than 4 complete week days and less than 2 complete weekend days were monitored;
- Locations NL20, NL21 and NL22, where less than 5 complete week days were monitored.

In addition, it is not clear that noise monitoring data has been excluded in accordance with Figure B.1 of the INP. Where data for an assessment period is defines as invalid, in accordance with the data exclusion rule, it is not clear whether or not this data has been discarded, which may result in more incomplete datasets with regard to the minimum 7 days of monitoring. If data has been used despite the exclusion rule, no justification for the use of the data has been provided.

The noise monitoring summary in Section 2.4 of the EIS-NV does not adequately describe the noise monitoring locations used in the assessment in terms of the following:

- Location of the noise monitoring (i.e. free field or facade affected location);
- Height of noise monitoring microphone to ground level/ floor level;
- Description of the existing ambient environment (i.e. is the noise environment dominated by traffic, natural sounds etc.).

Noise monitoring was carried out over two separate monitoring periods. During the second monitoring period a 'control' noise logger was re-established at NL18. The difference in the reported noise levels at NL-18 are summarised in the table below.

Noise Logging Location	Measurement Period	Rating Background Level dB(A)[1]			Ambient noise level dB(A)[2]	
		Day	Evening	Night	Day	Night
NL18A	10 – 18 December 2013	49	44	37	55	50
NL18B	27 November - 8 December 2013	52	49	41	59	54
Difference	*(Period B-A)*	*+3*	*+5*	*+4*	*+4*	*+4*

Notes: 1. Day represents the period 7am to 6pm, Evening 6pm to 10pm and Night 10pm to 7am

2. Day $L_{Aeq(15hr)}$ represents the period 7am to 10pm and Night $L_{Aeq(9hr)}$ represents the period 10pm to 7am

The measured noise levels are consistently lower during the second monitoring period. The reason for the difference in noise levels is not discussed in the EIS-NV. The second monitoring period was during the last week of the school term for 2013, when it is likely that traffic volumes have reduced significantly. However, NL18's proximity to bushland increases the possibility of extraneous environmental noise contributing to the difference in measured noise levels. Review of the noise logger graphs indicates that there are large amounts of data excluded from the second monitoring period. In addition, there are gaps in the monitoring data, making the data set incomplete and technically invalid (i.e. less than 7 days of valid data).

The EIS-NV reports a difference in the ambient (traffic) noise levels of 3.6 dB(A) during the day and 4.6 dB(A) at night between the first and second monitoring periods. This difference was applied to all measured traffic noise levels in the second monitoring period (i.e. to locations NL17, NL19, NL20, NL21, NL22 and NL23), reported in Table 58 of the EIS-NV. This is not considered to be an appropriate methodology, in particular in light of the reduced data set for the second monitoring period.

Further to the above, noise monitoring at Location NL16 was conducted during the second measurement period. However, Table 58 of the EIS-NV shows that the ambient (traffic) noise levels for NL16 have not been adjusted to account for the 3.6 dB(A) daytime and 4.6 dB(A) night-time difference between the two measurement periods. The processing of data from the second monitoring period should be consistent, or justification for the inconsistency should be provided.

3.2.2.2 Traffic Counting

The EIS-NV states that initially noise logging was undertaken in the vicinity of the northern and southern interchanges only, with traffic counting in this area undertaken simultaneously at nine locations. Transurban also provided traffic volume data for the M2 Motorway. The report indicates that the traffic counter locations are illustrated in Appendix C however this has been omitted from the figures. Furthermore, the EIS-NV should state which locations simultaneous traffic counting was conducted at.

Simultaneous traffic counting should have been undertaken adjacent to NL18 during both the first and second monitoring periods. The traffic count data would assist to confirm that the acquired difference of 3.6 dB(A) during the day and 4.6 dB(A) at night between the two monitoring periods was in fact from traffic and not from a non-traffic noise source. Note that the level of difference between the two monitoring periods is so significant in level that it would require more than halving traffic volumes on the M2 Motorway for the difference to be attributable to traffic alone.

Location NL18 is located along the M2 Motorway. It is understood that Transurban provided traffic volume data for the M2 Motorway for the first monitoring period (although it is not clear where this was measured). Data for the second monitoring period should also be provided.

3.2.2.3 Meteorology

Meteorological data was taken from the Bureau of Meteorology (BOM) Automatic Weather Station (AWS) at Terry Hills. Wind data at the Terry Hills AWS is measured at a height of 10 m above ground level. This approach is generally acceptable, except that wind is normally measured by BOM meteorological stations at a height of 10 m above ground level, where it tends to have greater speeds than at 1.2-1.5 m above ground level, the preferred microphone height (Australian Standard AS1170.2). The EIS-NV does not indicate whether wind speed has been adjusted for the reduced height of the microphone. Whilst this approach is generally conservative in terms of excluding wind affected data, it may mean that data has been excluded unnecessarily, which may impact the application of the INP's data exclusion rule noted above.

The EIS-NV does not provide any justification for using the Terry Hills AWS. Whilst the Terry Hills AWS is within 30 km of the Project location and broadly within the Sydney Basin, it is located approximately 7 km from the coast compared with the Project at 15-20 km from the coast. The Sydney Olympic Park AWS, which is approximately the same distance from the Project may have been more representative of the Project meteorological conditions and should also have been considered.

4 Operational Noise Impact Assessment

4.1 Operational Traffic Noise

4.1.1 Application of Acoustic Criteria

The EIS-NV appropriately references the EPA's NSW Road Noise Policy (RNP, NSW Department of Environment, Climate Change and Water 2011) and the Roads and Maritimes' Environmental Noise Management Manual (ENMM, NSW Roads and Traffic Authority 2001). According to the ENMM, the EIS appropriately applies the RNP's 'redeveloped road' to receivers along the M1 Pacific Motorway, Pacific Highway and Pennant Hills Road.

4.1.2 Noise Modelling Approach

4.1.2.1 Road Traffic Noise Model

The EIS-NV states that road traffic noise levels were calculated using SoundPLAN software, which implements the Calculation of Road Traffic Noise (CoRTN) algorithm. Furthermore, noise modelling was completed for the existing year (2013), the year of opening (2019) and 10 years after opening (2029). Both the 'Build' and 'No Build' options were modelled for 2019 and 2029. This modelling approach is consistent with the RNP and ENMM requirements and current best practice.

4.1.2.2 Noise Modelling Parameters

The noise modelling parameters used to model road traffic noise are summarised in Table 57 of the EIS-NV. The parameters adopted are generally considered to be satisfactory, with the following exceptions:

- Australian Conditions Corrections

  It is often considered appropriate to apply corrections for Australian conditions to the Day $L_{Aeq,15hr}$ and / or Night $L_{Aeq,9hr}$ predictions [Australian Road Research Board (ARRB) Transport Research (Saunders et al 1983) and referred to in Austroads Research Report (ARR) 2002, 'An Approach to the Validation of Road Traffic Noise Models')]. RMS's preferred approach is that these corrections should be applied to the Day period only (not Night).

  Correction Factors have been adopted for the noise model with no reference to the source of the corrections. For the **Northern Interchange** correction factors of -1.4 dB and -1.1 dB for the day and night respectively were applied as these '*were found to most accurately correlate with the measured noise levels for the northern interchange*'. At the **Southern Interchange** a correction factor of -1.7 dB for the day and night were utilised.

  At NL11 (near the Southern Interchange) a correction factor of -1.7 dB was applied during the night-time but not during the daytime. This is inconsistent with the application of corrections for this assessment and conflicts with RMS's preference for applying corrections (see above).

- Model Calibration

  The noise model was calibrated against the measured existing (2013) traffic noise levels (Section 5.1.3 of the EIS-NV). The model was generally found to be within the acceptable calibration allowance of ±2 dB(A), however due to the inconsistencies noted above, the model calibration should be redone.

- A safety factor has not been applied to the modelled noise levels. It is generally good acoustic practice to apply a safety factor to a road traffic noise model where the risk of non-compliance may have significant consequences, as might be expected in densely populated and urbanised areas.

- Road Surface Corrections

  The existing road surface on the M1 Motorway including ramps is open-graded asphalt (OGA). For calibration purposes OGA corrections of -3.0 dB(A) for light vehicles and -4.9 dB(A) for heavy vehicles has been applied for the northbound carriageway. The EIS-NV states the southbound carriageway has a deteriorated surface and a correction of +2.0 dB(A) was applied to both the light vehicle and heavy vehicle type emissions. More information is required as to how the OGA corrections for the M1 southbound carriageway were derived.

  The EIS_NV has assumed that the road surface on the M1 Motorway southbound carriageway would be re-surfaced for the 'No Build' scenario for the Opening and Design years. The 'Build' scenario maintains OGA on the main carriageways for the M1 Motorway and Stone-Mastic Asphalt (SMA) for the portal ramps.

  For existing, 'No Build' and 'Build' scenarios the road surface on the Hills M2 Motorway is OGA, using corrections of -3.0 dB(A) for light vehicles and -4.9 dB(A) for heavy vehicles. The Hills M2 Motorway / Pennant Hills Road interchange on and off-ramps have been modelled as DGA, using standard DGA corrections for all scenarios. The EIS-NV does not state what pavement type has been used for Pennant Hills Rd.

  Ramp portals for the northern and southern interchanges have been modelled with stone Mastic Asphalt (SMA), using corrections of -2.2 dB(A) for light vehicles and -4.3 dB(A) for heavy vehicles which is in accordance with the ENMM.

  With regard to pavement corrections it should be clarified whether the corrections were applied equally for each vehicle emission string (car exhaust/engine; car/truck tyre noise; truck engines and truck exhaust) or just for the car/truck tyre noise emission string.

  EIS assessment has assumed that the road surface on the M1 Motorway southbound carriageway would be re-surfaced for the 'No Build' scenario for the Opening and Design years. The 'Build' scenario maintains OGA on the main carriageways for the M1 Motorway and Stone-Mastic Asphalt (SMA) for the portal ramps.

- Tunnel Portal Noise

  The EIS-NV states that portal noise from road traffic within the main tunnels has been modelled using SoundPLAN's tunnel algorithm (EIS-NV section 5.1.6). This approach is reasonable, however it is not clear from the EIS-NV how portal noise affects the overall predicted road traffic noise levels. More information is required with regard to the portal correction used in the noise assessment. Note that road traffic noise contours may have shown influences from portal noise impacts, making the effect of overall traffic noise more obvious.

4.1.3 Noise Impact Assessment

The Study area, based on the Roads and Maritime Services (RMS) advice, was based on an area considered to be where the project adds no more than 2.0 dB(A) to the total noise level, rather than 600 metres either side of the Project road as is recommended in the RNP. RT&A agree that a study area 600 metres on each side of the Project in urban environments can be excessive for a few reasons including acoustic shielding from buildings and other structures in close proximity to the Project road and the influence of other ambient noise on the environment further from the Project road. However, it is not clear how the study area was derived and the boundary of the study area has not been defined within the EIS. Furthermore, the study areas do not relate to the NCAs identified in the EIS-NV, which are extensive and up to 1 km from the Project boundary.

The RTA's ENMM requires a traffic noise assessment for road upgrades to include, as a minimum, noise contours, generally for intervals of 5 dB(A), clearly identified with the contour value (ENMM, p172). Appendix J of the EIS-NV presents tabulated operational noise results for the Project. No noise contours for road traffic noise are presented in the EIS-NV. This is considered to be a significant deficiency in the EIS-NV.

In addition to the above, our review of the EIS-NV found the following in relation to the assessment of operational road traffic noise:

- Noise affected receiver heights were not identified in the EIS-NV. It is not clear whether second storey premises have been accounted for. It is not clear if the property treatments identified within Table 59 and 60 of the EIS are applicable to the ground floor and/or first floor of multi-storey dwellings. This may affect the outcomes of the noise barrier assessment.
- The EIS maximum noise level assessment has only considered existing maximum noise levels at the M1 and M2 portals. Maximum noise levels associated with Pennant Hills Rd portals at the northern and southern interchanges have not been considered. The number of maximum noise level events is likely to increase as trucks engage their engine brakes as they descend into the portals. More detailed assessment of maximum noise level impacts associated with the Northern Interchange should be provided.

4.1.4 Management and Mitigation Measures

4.1.4.1 Northern Interchange Proposed Mitigation and Effectiveness

Noise barrier analysis was conducted in accordance with Practice Note (iv) of the ENMM. A summary of the 'assessed' barrier, 'target' barrier and recommended barrier heights is reproduced from the EIS in the table below.

Table 4.1: Noise Barrier Assessment Summary

Noise Barrier	Target Barrier Height (m)	Assessed Barrier Height (m)	Recommended Barrier Height (m)
NWM1NB02	>8	3.0	Existing barrier height
NWM1NB04	>8	3.5	Existing barrier height
NWM1SB02	>8	3.5	Existing barrier height
NWM1SB04	>8	3.5	3.5

Our review of the EIS-NV found the following in relation to the proposed mitigation and effectiveness:

- NCAs used for the purpose of assessing cost-effectiveness of noise barriers are not clearly identified in the EIS-NV.
- The EIS-NV states that existing noise barriers on the M1 Pacific Motorway range from 2.5 metres to 5.5 metres in height. The EIS also states that where 'existing barrier height' has been recommended, the RL of the top of the new noise barrier should be no lower than the top the existing noise barriers which is reasonable. It is recommended that the RL of the existing noise barriers should be based on multiple points along the length of the barrier(s) and not be based on the average RL of the barrier.
- A reasonable and feasible noise barrier analysis has not been conducted for Lucinda Avenue properties located north east of the on and off-ramp portals. The EIS has recommended five (5) closely grouped Lucinda Avenue properties (IDs 1617, 1626, 1648, 1656 & 1661) for At-property treatment within Table 59 of the EIS. In accordance with ENMM Practice Note (iv) a reasonable and feasible noise barrier analysis should be conducted for this area as part of the EIS submission.
- The EIS-NV needs to provide more information to ensure the receivers affected by the Northern Interchange where noise barriers are to be replaced are provided with replacement noise barriers of at least the equivalent performance of the existing barriers.
- Architectural treatment is recommended for 82 Properties near the Northern Interchange.

4.1.4.2 Southern Interchange and Hills M2 Motorway Integration Proposed Mitigation and Effectiveness

Noise barrier analysis was conducted in accordance with Practice Note (iv) of the ENMM. A summary of the 'assessed' barrier, 'target' barrier and recommended barrier heights is reproduced from the EIS in the table below.

Table 4.2: Noise Barrier Assessment Summary

Noise Barrier	Target Barrier Height (m)	Assessed Barrier Height (m)	Recommended Barrier Height (m)
NWM2EB01	>8	3.0	Existing barrier height
NWM2WB01	>8	5.0	5.0
NWM2WB04	>8	4.0	Existing barrier height
NWM2WB06	>8	5.0	Existing barrier height
NWM2WB07	>8	5.0	Existing barrier height
NWM2WB08	>8	4.5	Existing barrier height

Our review of the EIS-NV found the following in relation to the proposed mitigation and effectiveness:

- NCAs used for the purpose of assessing cost effectiveness of noise barriers are not clearly identified in the EIS-NV.
- The EIS-NV states that existing noise barriers on the Hills M2 Motorway range from 2.5 metres to 8.0 metres in height. The EIS also states that where 'existing barrier height' has been recommended, the top (RL) of the new noise barrier should be no lower than the top (RL) the existing noise barriers which is reasonable. It is recommended that the RL of the existing noise barriers should be based on multiple points along the length of the barrier(s) and not be based on the average RL of the barrier.
- Barrier NWM2WB02 is displayed as an assessed barrier within Figure 3 of Appendix K of the EIS-NV. However a noise barrier assessment analysis for NWM2WB02 in accordance with Practice Note (iv) of the ENMM is not included within Appendix K of the EIS-NV. NWM2WB02 is also not included within Table 77 of the EIS-NV.

4.2 Operational Fixed Noise Sources

Operational fixed noise sources associated with the project include the:

- Northern and Southern Ventilation Facilities;
- Northern and Southern tunnel portals;
- Motorway Operations Complex;
- Trelawney St and Wilson Rd Tunnel Support Facilities; and
- Coral Tree Drive Switching Station.

4.2.1 Application of Acoustic Criteria

Section 3.5.2 of the EIS-NV appropriately establishes the acoustic criteria for the Project's fixed facilities identified above in accordance with the NSW INP. The EIS-NV identifies the intrusive and amenity noise criteria for each NCA potentially affected by the Project's fixed facilities. These NCAs have been defined by the EIS-NV as 'Urban' noise amenity areas, in accordance with the INP. The INP (p18) defines 'Urban' as an area with an acoustic environment that:

- is dominated by 'urban hum' or industrial source noise
- has through traffic with characteristically heavy and continuous traffic flows during peak periods
- is near commercial districts or industrial districts
- has any combination of the above,

  where 'urban hum' means the aggregate sound of many unidentifiable, mostly traffic-related sound sources.

The area surrounding the Project typically fits the above definition.

The Project Specific Environmental Noise Levels (ENLs) for the relevant NCAs have been determined as the more stringent of the intrusive and amenity criteria for each assessment period, in accordance with the INP. These are reproduced from the EIS-NV in Table 4.3 below. In addition, the sleep disturbance screening criteria for fixed noise sources have been determined in accordance with the relevant EPA guideline document and are also reproduced from the EIS-NV in Table 4.3 below.

As the facilities are operational 24 hours per day, the strictest criterion has been aptly adopted for each NCA (typically the night period) for the purpose of assessment, identified by the bold text in the table below.

Table 4.3: Project Specific Environmental Noise Levels (ENLs)

Applicable Facility	NCA	Project Specific ENLs dB(A)			
		Day[1]	Evening[2]	Night[2]	Sleep
Motorway operations complex, Southern Interchange Portals, Southern Ventilation Facility and Coral Tree Drive switching station	NCA08	49	49	**44**	54
	NCA09	53	50	**49**	59
	NCA10	49	45	**41**	51
Wilson Rd Tunnel Support Facility	NCA07	46	43	**35**	45
Trelawney Rd Tunnel Support Facility	NCA06	52	50	**44**	54
Northern interchange Portals (M1 Pacific Motorway on and off-ramp)	NCA04	56	50	**45**	56
Northern ventilation facility and Northern interchange Portals (main alignment north and southbound)	NCA02	61	50	**45**	58
	NCA03	58	50	**45**	56

Notes 1. $L_{Aeq(15min)}$ Intrusiveness criterion, dB(A)
2. $L_{Aeq(9\ hour)}$ Amenity criterion, dB(A)

Applicable Facility	NCA	Project Specific ENLs dB(A)			
		Day[1]	Evening[2]	Night[2]	Sleep

Notes 1. $L_{Aeq(15min)}$ Intrusiveness criterion, dB(A)
2. $L_{Aeq(9\ hour)}$ Amenity criterion, dB(A)

Following review of the EIS-NV we make the following comments with regard to application of the noise criteria for operational fixed noise sources.

- For NCA09, the more stringent night-time amenity criterion of 45 dB(A) should have been adopted rather than 49 dB(A), which is based on the intrusiveness criteria. Note that this should have negligible impact on the assessment as the night-time amenity criterion of 45 dB(A) was adopted for residential receivers within NCA10. The residential receivers within NCA10 are in closer proximity to all fixed operational noise sources than the receivers within NCA09.
- For NCA02, the marginally more stringent daytime amenity criterion of 60 dB(A) should have been adopted rather than 61 dB(A), which is based on the intrusiveness criteria. However this would have negligible impact on the assessment as the night period is the determining period with regard to assessment of impact and design of noise mitigation measures.
- The sleep disturbance screening criteria for NCA03 was not included in the Summary of Environmental Noise Criteria Table 25 of EIS-NV. It was included within Table 12 of EIS-NV, which summarises the construction noise criteria.
- The remaining criteria for NCA02, NCA03, NCA04, NCA06, NCA07, NCA08, NCA09 and NCA10 have been correctly applied.
- Note that based on Section 2.2.3 of the INP there is argument for the application of an amenity criterion of $L_{Aeq,\ period(traffic)}$ minus 10 dB(A). This would result in slightly higher Project Specific criteria for some periods. In this regard the EIS is conservative.
- The large NCAs defined in the EIS-NV assume a single noise monitoring location to be representative of background levels across the NCA (see Section 3.1 above for more detail). This may have resulted in higher ENLs for some receivers in the NCA, particularly during the critical night period.

4.2.2 Noise Modelling Approach

4.2.2.1 Operational Noise Model

There is no discussion in the EIS-NV as to what noise model has been used to predict operational fixed facility noise, what modelling assumptions have been used with regard to topography, ground absorption, shielding/ mitigation from site etc. Note that this information was included in Section 4.2 of the EIS-NV in relation to construction noise modelling and prediction. This information should be confirmed (if applicable) in the operational fixed facilities assessment.

Noise levels from fixed facilities have been predicted to a single receiver in each NCA, identified as the 'worst affected' receiver.

4.2.2.2 Source Noise Levels

In accordance with the NSW INP, noise impact from fixed facilities has been appropriately assessed under neutral (calm and isothermal conditions) and adverse conditions (wind and temperature inversion). Furthermore, three likely operational scenarios have been assessed:

- Normal traffic conditions;
- Low speed / congested conditions; and
- Emergency conditions (typically not regulated but assessed as good practice).

Source noise levels for the following sources have been reviewed and compared to data in our noise database and library files:

- Ventilation facilities equipment sound power levels (Table 62 of EIS-NV);
- Ventilation facilities attenuator insertion loss (Table 63 of EIS-NV);
- Substation Transformer sound power level (Table 64 of EIS-NV);
- Portal Jet fan sound power levels and assessed sound power levels at portal openings (Table 65 and Table 66 of EIS-NV);
- Tunnel support facilities fan sound power levels (Table 67 of EIS-NV); and
- Tunnel support facilities attenuator insertion loss (Table 68 of EIS-NV).

Review of the source noise levels found they were comparable to source data used for similar facilities. The exception to this is that the EIS-NV assumes that the substation transformers would not contain any 'annoying characteristics' (as described in the INP). Although it's unlikely with small transformers, it is good practice to apply a penalty for tonal noise emissions unless real data is available to confirm otherwise.

While discussed in the EIS-NV , source noise levels for the Motorway Control Centre, namely door/ boot slamming, people talking and car accelerating, have not been provided in the report. In addition, likely number of occurrences and time of occurrence have not been included. Due to the close proximity of residential receivers in Hillside Place, Eaton Road and Karloon Road to the Motorway Control Centre, and understanding of the level of activity at the Motorway Control Centre is required to ensure than noise impacts are adequately mitigated.

4.2.3 Noise Impact Assessment

Our review of the EIS-NV assessment has assumed that the noise predictions at the most affected receivers have been based on the correct fixed operational noise sources but are labelled incorrectly within Tables 69 to 73 of the EIS-NV.

4.2.3.1 Noise Assessment Locations

Our review of the EIS-NV found the following in relation to the noise assessment locations adopted for the project:

- Predicted noise levels were appropriately assessed at the most affected boundary or 30 metres from the residential building at the receiver location, in accordance with the INP.
- The noise assessment receiver location 1740 Pacific Highway, Wahroonga is not definitive, a unit number should be provided. The assessment receiver locations 101 Trelawney Road, Thornleigh and 82 Gum Grove Place, West Pennant Hills do not appear to exist. The assessment receiver location 131 Pennant Hills Road, Pennant Hills is located several kilometres from the Wilson Rd Tunnel Support Facility.
- There are five (5) assessment receiver locations representing NCA10 but no receiver assessment points representing NCA08 and NCA09. Assessment receiver locations representing NCA08 and NCA09 should be added to the EIS-NV. Note that this should have negligible impact on the assessment as the residential receivers within NCA10 are in closer proximity to all fixed operational noise sources and have a lower night-time criteria than the receivers within NCA08 and NCA09. Nonetheless the information should be provided for completeness.
- There is no discussion in the EIS-NV as to why noise levels have been predicted to a single receiver location for selected NCAs. It is not clear from the review that receivers representing 'the most affected receiver' for individual fixed noise sources within Tables 69 to 73 of EIS-NV are in fact the most affected receiver. For example, 32 Coral Tree Drive, Carlingford is the assessment point for the main alignment southern tunnel portal but is located greater than 500m away. Further, 10 Hillside Place, West Pennant Hills is the assessment point for the off-ramp onto Pennant Hills Road but is located at a distance of 350m.
- It is also not clear whether cumulative noise from 'normal' and 'congested low speed traffic' operation of all fixed facilities has been considered in the assessment.

4.2.3.2 Northern and Southern Tunnel Portals

Our review of the EIS-NV found the following in relation to the assessment of jet fan noise from the Northern and Southern Tunnel Portals:

- Portal noise from the M1 Pacific Motorway on and off-ramps (NCA04) and the main alignment (NCA02 & NCA03) were assessed against the INP and were predicted to be well below the most stringent night-time criterion for all weather conditions.

- Portal noise from the M2 Motorway on and off-ramps and the main alignment (NCA10) were assessed against the INP and were predicted to be below the most stringent night-time criterion for all weather conditions.
- The EIS-NV states that noise emissions from the operation of the jet fans would not contain any "annoying characteristics", such as prominent tonal components and dominant low-frequency content (as described in the INP). It is not clear whether an assessment to identify any "annoying characteristics" has been undertaken. However, since the make and model of the jet fans within the EIS-NV are indicative only, it is reasonable that an assessment to identify any "annoying characterises" will be undertaken for the detailed design stage.
- There was no investigation of potential sleep disturbance impacts from the jet fan noise. It is understood that mechanical ventilation is unlikely to cause sleep disturbance issues, however for completeness this should be noted in the report.

4.2.3.3 Northern and Southern Ventilation Facilities

Our review of the EIS-NV found the following in relation to the noise assessment of the operation of the Northern and Southern Ventilation Facilities:

- The EIS-NV assessed the Northern and Southern Ventilation Facilities against three (3) operational scenarios, 'Normal operation', 'Congested and low speed traffic operation' and Emergency conditions' for three (3) different weather conditions, 'neutral weather conditions', 'F class inversions' and '3m/s source to receiver wind speeds'.
  - For the Northern Ventilation Facility in all cases the predicted noise level was less than $L_{Aeq\ (15min)}$ 30 dB(A) and well below the most stringent night-time criterion.
  - For the Southern Ventilation Facility in all cases the predicted noise level was equal or lower than $L_{Aeq\ (15min)}$ 41 dB(A) and just below or equal to most stringent night-time criterion.
  - The prediction methodology and approach are comparable to tunnel ventilation predictions previously carried out by RT&A for other projects.
- For clarity, noise predictions from Ventilation Facilities and Tunnel Portals should be separated and then combined to produce a cumulative noise level at the most affected receiver.
- Clarity is sort to explain why predictions at the location identified as '82 Gum Grove Place, West Pennant Hills' decrease by 6 dB(A) for congested and low speed traffic operation. Note: the address '82 Gum Grove Place' does not exist as noted in Section 4.2.3.1 above.
- The EIS-NV states that noise emissions from the operation of the ventilation fans would not contain any "annoying characteristics", such as prominent tonal components and dominant low-frequency content (as described in the INP). It is not clear whether an assessment to identify any "annoying characteristics" has been undertaken. However, since the make and model of the ventilation fans within the EIS-NV are indicative only, it is reasonable that an

assessment to identify any "annoying characterises" will be undertaken for the detailed design stage.

- There was no investigation of potential sleep disturbance impacts from the Ventilation Facilities. It is understood that mechanical ventilation is unlikely to cause sleep disturbance issues, however for completeness this should be noted in the report.

4.2.3.4 Motorway Operations Complex

Our review of the EIS-NV found the following in relation to the assessment of the Motorway Operations Complex:

- The EIS-NV assessed the Motorway Operations Complex Northern under 'Normal operation', for three (3) different weather conditions, 'neutral weather conditions', 'F class inversions' and '3m/s source to receiver wind speeds'. For the Motorway Operations Complex in all cases the predicted noise level was well below the most stringent night-time criterion. These predictions are indicative to what RT&A have previously predicted and is considered suitable.
- There was no investigation of potential sleep disturbance impacts from the Motorway Operations Complex. It is understood that mechanical ventilation is unlikely to cause sleep disturbance issues, however there may be sleep disturbance impacts associated with the car park and entry/ exit from the site if the facility is accessed at night. This should be confirmed.

4.2.3.5 Trelawney St and Wilson Rd Tunnel Support Facilities

Our review of the EIS-NV found the following in relation to the assessment of the operation of the smoke extraction outlets at the Trelawney St and Wilson Rd Tunnel Support Facilities which will operate concurrently with the Northern and Southern Ventilation Facilities during low speed or congested traffic conditions:

- The EIS-NV assessed the Tunnel Support Facilities against two (2) operational scenarios, 'Congested and low speed traffic operation' and Emergency conditions' for three (3) different weather conditions, 'neutral weather conditions', 'F class inversions' and '3m/s source to receiver wind speeds'. For the Trelawney St and Wilson Rd Tunnel Support Facilities in all cases the predicted noise level was well below the most stringent night-time criterion. The predictions for Wilson Rd Facility are comparative to previous RT&A predictions. However, the predictions appear low at the Trelawney Rd Facility.
- The EIS-NV states that noise emissions from the operation of the tunnel support facility fans would not contain any "annoying characteristics", such as prominent tonal components and dominant low-frequency content (as described in the INP). It is not clear whether an assessment to identify any "annoying characterises" has been undertaken. However, since the make and model of the tunnel support facility fans within the EIS-NV are indicative only, it is reasonable that an assessment to identify any "annoying characterises" will be undertaken for the detailed design stage.

- There was no investigation of potential sleep disturbance impacts from the operation of the smoke extraction outlets. It is understood that mechanical ventilation is unlikely to cause sleep disturbance issues, however for completeness this should be noted in the report.

4.2.3.6 Coral Tree Drive Switching Station

Our review of the EIS-NV found the following in relation to the assessment of the Coral Tree Drive Switching Station:

- The EIS-NV assessed the Coral Tree Drive Switching Station under 'Normal operation' for three (3) different weather conditions, 'neutral weather conditions', 'F class inversions' and '3m/s source to receiver wind speeds'. For the Coral Tree Drive Switching Station in all cases the predicted noise level was less than $L_{Aeq\ (15min)}$ 30 dB(A) and well below the most stringent night-time criterion. These predictions are indicative to what RT&A have previously predicted and is considered suitable.
- There was no investigation of potential sleep disturbance impacts from the Coral Tree Drive Switching Station. It is understood that switch gear is unlikely to cause sleep disturbance issues, however for completeness this should be noted in the report.

4.2.4 Management and Mitigation Measures

The EIS-NV identified the following noise management and mitigation measures for the operational fixed noise sources:

- High performance attenuators (see Table 63) are recommended for the intake and discharge sides of the ventilation fans. These are similar to attenuators RT&A have previously adopted for tunnel ventilation projects and will reduce fan noise emissions significantly.
- High performance attenuators (see Table 68) are recommended for the tunnel support facility fans. Again, this is similar to attenuators RT&A have previously adopted and will reduce fan noise emissions significantly. It is noted however that the EIS-NV does not stipulate whether these attenuators will be for the intake and/ or discharge sides of the fans.
- In regard to the construction of the ventilation buildings the EIS states:

  The assessment assumes that the building fabric (ie walls, roof, doors, louvers, etc) housing the ventilation equipment will reduce the noise emission from the building to be at least 10 dB(A) less than the contribution from the outlets. The final noise emission from the building fabric may change subject to the detailed design but in any case when considered in combination with the noise from the outlets will be controlled to satisfy the appropriate noise criteria.

  RT&A agree that there is sufficient scope to design the building fabric that will house the ventilation equipment to achieve the noise criteria.
- In regard to the construction of the Motorway Control Centre RT&A agree that there is sufficient scope to design the building fabric and treat building heating and ventilation and

air-conditioning services (HVAC) with standard engineering solutions during the detailed design stage. More information is required to satisfy the review that operational noise from the Motorway Control Centre, including sleep disturbance impacts, can be adequately mitigated.

- As noted in Section 4.2.3, additional information regarding cumulative noise impact from the fixed facilities is required to satisfy the review that operational noise can been adequately mitigated.
- Airborne noise emission from the operational fixed noise sources are shown to comply with the Project's ENLs at the identified nearest affected receivers. Care will need to be taken when installing fans, substations, HVAC and supporting structure to ensure ground-borne noise is not an issue.
- Potential impact and possible changes to noise mitigation requirements will need to be reviewed once additional noise monitoring has been completed, as recommended above.

5 Construction Noise and Vibration

5.1.1 Application of Acoustic Criteria

The EIS appropriately references and applies the NSW Interim Construction Noise Guideline (ICNG, NSW Department of Environment and Climate Change 2009) for the assessment of airborne and ground-borne construction noise. Sleep disturbance screening and sleep disturbance awakening criteria have also been established, in accordance with the ICNG, with reference to the Environmental Criteria for Road Traffic Noise (ECRTN, NSW EPA 1999).

With regard to airborne noise, the large NCAs defined in the EIS-NV assume a single noise monitoring location to be representative of background levels across the NCA (see Section 3.1.1 above for more detail). This may have resulted in high Construction Noise Management Levels (NMLs) for some receivers in the NCA, particularly during the critical night period.

In addition, the EIS-NV applies a criterion for construction traffic movements on public roads generated during the construction phase of an increase in existing road traffic noise levels of no more than 2 dB(A). This is an acceptable approach.

Table 5.1 following presents the representative catchments, noise monitoring locations and associated Noise Management Levels (NMLs), reproduced from the EIS-NV. Table 5.1 also summarises the nearest construction compound and construction work area and operational noise source to each NCA along with the approximate distance to the nearest residence within the NCA. Also identified are the shortfalls in the EIS-NV with regard to the baseline noise monitoring.

The EIS-NV aptly assesses vibration impact against the relevant guidelines for NSW, being:

- Structural damage - German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (DIN 4150); and
- Human comfort - Assessing Vibration: A Technical Guideline (AVATG, NSW Department of Environment and Conservation 2006).

Criteria for assessing impact from blasting have been established in the EIS-NV based on:

- Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration, Australian and New Zealand Environment Conservation Council (ANZECC) 1990; and
- Australian Standard 2187.2-2006 Explosives - Storage and Use Part 2: Use of Explosives - Appendix J.

This approach is in line with best practice.

Table 5.1: EIS Noise Catchment Areas, Assessment Locations, Noise Management Levels and Project Noise Sources

NCA	Monitoring Location	Period	RBL, dB(A)[1]	Construction NML, dB(A)[2]	Nearest Construction Compound / work site to NCA & approx. distance to nearest residence[3]	Comment on Monitoring Location
NCA01	NL01	Day	56	66	Junction Road compound (<20m) Northern Ventilation Facility (400m) Surface Works (30m); Ramp (190m); Tunnel Portal (400m)	Monitoring closer to receivers located east of the Junction Rd Compound would have been more appropriate. However, since NL01 is located at a similar distance from the M1, RBLs are satisfactory for east of M1 setting construction NMLs. Additional monitoring should be carried out west of M1.
		Evening	52	57		
		Night	45	50		
NCA02	NL02	Day	56	66	Bareena Avenue compound (<20m) Northern Ventilation Facility (40m) Surface Works (<20m); Ramp (<20m); Tunnel Portal (30m)	Monitoring closer to receivers located west of Bareena Avenue Compound would have been more appropriate. However, since NL02 is located at a similar distance from the M1, RBLs are satisfactory for setting NMLs and ENLs for residences in the first row of houses from M1. Additional monitoring required to obtain RBLs for areas shielded from the M1. Additional monitoring should also be carried out east of M1.
		Evening	54	59		
		Night	43	48		
NCA03	NL03	Day	53	63	Bareena Avenue compound (30m) Northern Interchange compound (260m) Northern Ventilation Facility (90m) Surface Works (220m); Ramp (<20m); Tunnel Portal (<20m)	Given the Tunnel Ramps and Tunnel Portal are the closest noise sources to NCA03, NL03 is considered an appropriate location. The RBLs measured at NL03 are comparable to noise data previously collected by RT&A. Note: there was an equipment failure at NL04. Additional monitoring to be carried out at NL04.
		Evening	50	55		
		Night	41	46		
NCA04	NL05	Day	51	61	Northern Interchange compound (adjacent) Surface Works (<20m); Ramp (<20m); Tunnel Portal (40m)	NL05 is appropriate to establish NMLs and ENLs for the Northern Interchange Compound, Surface Works, Tunnel Ramps and Tunnel Portals. In addition a conservative approach has been adopted by assigning NL05 to represent NCA04, as opposed to NL06 which was also measured within NCA04. However, previous RT&A noise level monitoring data suggests that background noise levels at receivers located south of the Northern Interchange Compound are significantly lower than those measured at NL05. Additional monitoring should also be carried out to determine appropriate NMLs south of the compound, in particular as the Northern Interchange Compound is to provide tunnel support and 24 hour operations are proposed. Further, additional monitoring should be carried out on the north-western side of the M1 to confirm existing traffic noise levels in this area.
		Evening	47	52		
		Night	41	46		
NCA05	NL07	Day	41	51	Northern Interchange compound (170m) Pennant Hills Rd Surface Works (<20m) Ramp (90m); Tunnel Portal (210m)	NL07 is considered an appropriate location to represent NCA05. In addition, a conservative approach has been adopted by assigning NL07 to represent NCA05 as opposed to NL08 which was also measured within NCA05. Lower day, evening and night background noise levels were measured at NL07.
		Evening	40	45		
		Night	35	40		

NCA	Monitoring Location	Period	RBL, dB(A)[1]	Construction NML, dB(A)[2]	Nearest Construction Compound / work site to NCA & approx. distance to nearest residence[3]	Comment on Monitoring Location
NCA06	NL09	Day	47	57	Trelawney St Tunnel Support compound (adjacent) Pioneer Ave Compound (100m)	NL09 is appropriate to establish NMLs for the Trelawney St Compound. However, additional monitoring should also be carried out to determine appropriate NMLs at receivers east of the compound that are shielded from traffic noise from Pennant Hill Rd and local Rds. This is critical as the Trelawney St Compound is to provide tunnel support and 24 hour operations are proposed. Additional monitoring required to confirm the RBLs for the nearest residential receivers to Pioneer Ave Compound. The RBLs at receivers on Sefton Rd maybe particular low.
		Evening	47	52		
		Night	39	44		
NCA07	NL10	Day	41	51	Wilson Rd Tunnel Support compound (adjacent)	NL10 is appropriate to establish NMLs for the Wilson Rd Compound. NL10 represents receivers that are shielded from Pennant Hills Rd traffic noise. Additional monitoring to confirm the RBLs for residential receivers located on Pennant Hills Rd would be useful.
		Evening	38	43		
		Night	30	35		
NCA08	NL13	Day	44	54	Southern Interchange Compound (<20m) Motorway Control Centre (30m) Southern Ventilation Facility (320m) Ramp (50m); Tunnel Portal (50m); Surface Works (<20m)	NL13 is considered an appropriate location to represent residents that are relatively exposed to Pennant Hills Rd. This is because an adjacent undeveloped parcel of land lies between NL13 and Pennant Hills Rd. Additional monitoring required to confirm the RBLs for areas shielded from Pennant Hills Rd. Additional monitoring should also be carried out east of Pennant Hills Rd.
		Evening	44	49		
		Night	39	44		
NCA09	NL15	Day	48	58	Southern Interchange Compound (180m) Motorway Control Centre (500m) Southern Ventilation Facility (190m) Ramp (180m); Tunnel Portal (180m); Surface Works (30m)	NL15 is considered an appropriate location to set NMLs and ENLs for residences in the first row of houses from Pennant Hills Road. Additional monitoring required to confirm the RBLs for areas shielded from Pennant Hills Rd and the M2.
		Evening	48	53		
		Night	44	49		
NCA10	NL16	Day	44	54	Southern Interchange Compound (adjacent) Coral Tree Drive Compound (20m) Motorway Control Centre (50m) Southern Ventilation Facility (60m) Ramp (30m); Tunnel Portal (60m); Surface Works (<20m)	NL16 is appropriate to establish NMLs and ENLs for residences in the first row of houses from the M2. In addition a conservative approach has been adopted by assigning NL16 to represent NCA10, as opposed to NL14 which was also measured within NCA10. Additional monitoring required to confirm the RBLs for areas shielded from the M2.
		Evening	40	45		
		Night	36	41		

NCA	Monitoring Location	Period	RBL, dB(A) [1]	Construction NML, dB(A) [2]	Nearest Construction Compound / work site to NCA & approx. distance to nearest residence [3]	Comment on Monitoring Location
NCA11	NL17	Day	51	61	Yale Close Compound (460m) Motorway Control Centre (>500m) Southern Ventilation Facility (>500m) Ramp (180m); Tunnel Portal (480m); Surface Works (<20m)	NL17 is appropriate to establish NMLs and ENLs for residences in the first row of houses from the M2. In addition a conservative approach has been adopted by assigning NL17 to represent NCA11, as opposed to NL18 which was also measured within NCA11. Additional monitoring required to confirm the RBLs for areas shielded from the M2.
		Evening	46	51		
		Night	37	42		
NCA12	NL21	Day	39	49	Yale Close Compound (20m) Barclay Rd Compound (120m) Surface Works (30m)	NL21 is appropriate to establish NMLs for residences in the first row of houses from the M2. In addition a conservative approach has been adopted by assigning NL21 to represent NCA12, as opposed to NL19 which was also measured within NCA12. Additional monitoring required to confirm the RBLs for areas shielded from the M2.
		Evening	39	44		
		Night	33	38		
NCA13	NL20	Day	49	59	Barclay Rd Compound (90m) Surface Works (<20m)	NL20 is considered an appropriate location to set NMLs for residences in the first row of houses from the M2. Additional monitoring required to confirm the RBLs for areas shielded from the M2.
		Evening	44	49		
		Night	33	38		
NCA14	NL22	Day	53	63	Barclay Rd Compound (30m) Darling Mills Compound (250m) Surface Works (30m)	NL22 is considered an appropriate location to set NMLs for residences in the first row of houses from the M2. Additional monitoring required to confirm the RBLs for areas shielded from the M2.
		Evening	47	52		
		Night	35	40		
NCA15	NL23	Day	53	63	Darling Mills Compound (150m) Windsor Rd Compound (240m) Surface Works (30m)	NL23 is considered an appropriate location to set NMLs for residences in the first row of houses from the M2. Additional monitoring required to confirm the RBLs for areas shielded from the M2. Additional monitoring should also be carried out north of the M2.
		Evening	48	53		
		Night	38	43		
NCA16	NL23	Day	53	63	Windsor Rd Compound (30m)	NL23 has not been conducted within NC16. Additional monitoring required within NCA16 to confirm the RBLs for areas shielded from the M2 and Windsor Rd.
		Evening	48	53		
		Night	38	43		

Notes:
1. Rating Background Level (RBL)
2. Construction Noise Managment Level (NML)
3. Distance in brackets is indicative only, based on Figures 1 and 3 and Appendix C within the EIS Noise and Vibration Technical Working Paper and Chapter 5 of the EIS

5.1.2 Noise Modelling Approach

5.1.2.1 Noise Model

The EIS-NV states that airborne noise from construction activities have been predicted at nearby residences using SoundPLAN noise modelling software v7.0, incorporating the CONCAWE algorithm, ground topography, buildings and structures and the representative construction noise sources detailed in the report. Neutral (calm and isothermal) weather conditions were assumed for all construction scenarios, which is a reasonable approach for construction noise.

The noise model assumes:

- No temporary barriers have been included in the assessment for construction activities along the M1 Pacific Motorway and Hills M2 Motorway;
- 3 metre high barriers have been assumed on the perimeter of ancillary construction compounds where residential development is located adjacent to the compound;
- Acoustic sheds (with an insertion loss of 25 dB) have been included at the compounds providing tunnel launch access and support;
- Noise from equipment located underground was considered not acoustically significant and was not included in the airborne noise modelling.

The above approach is considered reasonable.

Excavation of the main tunnel alignments and sections of the on and off-ramps will be undertaken using a number of Roadheaders and surface miners. The number of Roadheaders and the location of their deployment are not stipulated within the EIS. Excavation of cross passages will be undertaken using small Roadheaders, excavators with rock hammers and/or drilling and blasting. Ground-borne noise has been predicted based on previous measurements of tunnelling activities from Roadheaders in Sydney, using methods in accordance with ISO14837: Mechanical vibration – Ground-borne noise and vibration arising from rail systems, which is a reasonable approach.

5.1.2.2 Source Noise Levels

The Sound Power Levels (SWLs) adopted for construction equipment are identified in Table 28, Table 29 and Table 30 of the EIS-NV. It was noted that SWLs were taken from Australian Standard AS2436-2010 and DEFRA, which are credible data sources, however the source noise levels for some plant items appear to be low.

Table 5.2 following compares the SWLs reported in the EIS-NV to those commonly adopted by RT&A for similar construction projects.

Table 5.2: Comparison of EIS-NV and RT&A Construction Equipment Sound Power Levels, dB(A)

Item of Equipment	EIS SWLs	RT&A SWLs	Difference RT&A - EIS
Delivery truck	98	108	10
Truck and dog	98	108	10
25t Articulated dump truck	98	108	10
Jack hammer	108	113	5
30t Excavator w/Hammer	112	119	7
Concrete saw	110	118	8
Bored pilling rig	103	110	7
Jumbo drill	110	120	10
Rockbolting rig	115	120	5
Skid steer loaders	104	107-110	3-6

Table 5.2 above identified that the EIS-NV adopted noise levels are potentially 10 dB(A) lower than typical sound power levels adopted by RT&A for similar construction noise assessments. For example, the EIS-NV adopted SWL of L_{Aeq} 98 dB(A) for delivery trucks, truck and dogs and articulated dump trucks, which cannot be sourced within Australian Standard AS2436-2010 and/or DEFRA. It is not clear from the EIS whether this is a time-weighted sound power level or not.

The EIS-NV proposes 24 hour spoil truck movements to/ from the tunnel support sites (Southern Interchange compound; Wilson Road compound; Trelawney Road compound; and Northern Interchange compound). The low SWLs adopted for delivery trucks, truck and dogs and articulated dump trucks are of concern as the EIS-NV could be significantly under predicting noise impacts, by an order of 10 dB(A), in particular during the night period. Further justification and explanation of the EIS-NV noise source data is required.

5.1.3 Noise Impact Assessment

5.1.3.1 Airborne Construction Noise

Further to the above, our review of the EIS-NV found the following in relation to the airborne construction noise assessment:

- It is not clear whether a penalty has been applied to noise sources identified in the ICNG (p16) as having particularly annoying characteristics, including jackhammering, rock hammering or rockbreaking. Confirmation of this is required.
- The number of spoil truck movements occurring during the day, evening and night has not been quantified in the EIS, nor has the number of trucks such as concrete trucks (only the number of articulated trucks) that will operate underground. This makes it difficult to gain an understanding of potential impacts at night as predicted noise contours show significant exceedance of the night NMLs. Heavy vehicle movements on site will potentially generate sleep disturbance impacts from braking on site, especially at the entry/ exit to the site. Further review is required.

- Review of the EIS-NV found that the excavation methodology for the construction of the tunnels near portals has not been provided and may not have been assessed. Further information is required as due to the close proximity of these works to residential receivers, this stage of construction may cause significant noise impact especially if there are rockbreakers / rockhammers or similarly noisy plant involved in these operations.
- The EIS-NV relies on site access and egress points being located away from residences and other sensitive land uses, where feasible and reasonable. Heavy vehicle movements outside of standard construction hours associated with tunnel support works (spoil removal, concrete delivery and other truck movements) would only occur via access and egress directly to and from Pennant Hills Road or the M1 Pacific Motorway and would only occur at the southern interchange compound, Wilson Road compound, Trelawney Street compound and the northern interchange compound. From the site layout drawings provided in the EIS-NV, this is not clear for the Southern Interchange site.

As expected during the daytime there are a significant number of receivers where NMLs are exceeded for the construction compounds. Also, for many of the construction stages there is predicted to be a number of highly noise affected receivers predicted. A summary of the exceedances for construction works is summarised in Table 5.3.

Table 5.3: EIS Receiver Exceedance Summary for Construction

Construction Operation and Stage	Range of Total Number of Receivers where NMLs are exceeded for works stages	Range of Total Number of Highly Noise Affected Receivers for works stages
Southern Interchange (road works) and Hills M2 Motorway integration works – Table 31 of EIS	281-445	4-27
Northern Interchange (road works) and M1 Pacific Motorway tie-in works – Table 32 of EIS	134-171	26-60
Darling Mills Creek, Barclay Road and Yale Close construction compounds – Table 33 of EIS	87	4
Southern interchange compound – Table 34 of EIS	6-121	0-21
Coral Tree Drive switching station – Table 35 of EIS	38-41	1-2
Wilson Road compound – Table 36 of EIS	96-185	0-18
Trelawney Street compound – Table 37 of EIS	24-79	0-14
Pioneer Avenue construction compound – Table 38 of EIS	7	0
Northern Interchange Construction Compound - Table 39 of EIS	37-60	0-12
Bareena Avenue Construction Compound - Table 40 of EIS	16-28	1-9
Junction Road Construction Compound - Table 41 of EIS	22	7

Note: Highly noise affected is considered to be ≥ 75 dB(A)

- No highly noise affected receivers are predicted to occur for the tunnel support stage of the tunnel support sites (Southern Interchange compound; Wilson Road compound; Trelawney Road compound; and Northern Interchange compound), which is of importance since this stage will occur over numerous years. Nonetheless there are still significant numbers of

exceedances for these sites, which will essentially be operating as short term industrial type sites, potentially operating 24 hours per day, 7 days per week for the duration of the works.

- The out of hours work for the evening period has not been predicted within the EIS only out of hours work for the night-time. This leads to the conclusion that operations (i.e. number of truck movements) are not differentiated between evening and night.
- Night-time exceedance of the NML from the tunnel support sites is summarised in Table 43 of EIS. Whilst there are no 'highly noise affected' receivers [where noise levels exceed 75 dB(A)], there is predicted to be:
  - 53 exceedances for the Southern Interchange compound;
  - 119 exceedances at the Wilson Road compound;
  - 37 exceedances at the Trelawney Street compound; and
  - 8 exceedances for the Northern Interchange compound.

  This is a significant number of receivers that will be long term noise affected during the night period. The EIS-NV does not specify what operations cause the exceedances, how many truck off-site truck movements are proposed and why increasing the perimeter barrier heights or adopting other on-site management strategies was not investigated. Further information regarding how these impacts will be managed and mitigated is required to give some confidence that this is a workable operation.
- The EIS indicates that no temporary barriers have been included in the assessment for construction activities along the M1 Pacific Motorway and Hills M2 Motorway, including where permanent noise barriers would be demolished and / or relocated. Further clarification is required to confirm whether existing noise walls earmarked for replacement have been included in the construction noise assessment. Where possible, new noise walls should be constructed prior to or as soon as practical upon the commencement of construction.

5.1.3.2 Ground-borne Construction Noise Assessment

The EIS-NV predicted maximum Ground borne noise (GBN) exceedances of up to 5 dB(A) at 28 receivers during the evening period and up to 10 dB(A) at 90 receivers during the night period.

The EIS states that with a Roadheader progression rate of 7 metres per day it is likely that ground-borne noise would be discernible for up to five (5) days at each affected receiver with exceedances occurring for up to two days. Furthermore, Roadheader progression rates would reduce to 2 – 5 metres per day around the portals, which may increase the duration of exposure for receivers in these areas. The Roadheader progression rate is reasonable but the duration of exceedances in the EIS appears low especially where the Roadheader is operating in close proximity to noise sensitive properties. Further information to justify the extent of impacts is required.

There is some reservation about the GBN predictions. They are satisfactory for the EIS stage but will need to be more comprehensive for the detailed design stage, to ensure impacts are adequately quantified and receivers appropriately notified prior to tunnelling.

Excavators with rock hammers will be used in unison with Roadheaders to excavate the cross passages. Ground borne noise associated with rock hammers is typically higher than that associated with Roadheaders. The EIS does not provide any predictions associated with cross passages. It is recommended that these predictions be undertaken preferably as part of the EIS process and only if not possible then as part of project design.

5.1.3.3 Construction Vibration Assessment

The EIS-NV does not provide an assessment for construction surface works, including potential impacts from heavy vehicles. The EIS-NV only provides indicative safe working distances for vibration intensive plant. With regard to heritage properties, the EIS-NV notes that '*More stringent conditions may apply to heritage or other sensitive structures. Any heritage property would need to be considered on a case by case basis*'. This is not unreasonable, given the limited information available regarding construction methodology at the EIS stage.

The EIS vibration assessment for tunnelling activities relates only to human comfort. The EIS states that structural damage would not be exceeded by tunnelling activities. From our review of the information available in the EIS and EIS-NV, the risk of structural damage from Roadheader tunnelling is low. This would need to be confirmed during the detailed design stage of the Project, in particular in relation to excavation of the cross passages, and should predicted levels approach the relevant building damage limits then smaller and / or alternative rockbreakers / rockhammers may need to be used.

5.1.3.4 Blasting

Blasting is identified several times throughout the EIS-NV as a means of excavation, including excavation of the cross passages. There is however no assessment of potential blast impact in the EIS-NV.

5.1.3.5 Construction Road Traffic Noise

Construction road traffic noise has been reviewed and assessed in terms of relative increase to existing traffic noise during peak and off-peak periods. The approach adopted is thorough and consistent with best practise. No further information is required in relation to construction road traffic noise.

5.1.4 Management and Mitigation Measures

5.1.4.1 Airborne Construction Noise

- The EIS states that 3 metre barriers have been assumed on the perimeter of ancillary construction compounds where residential development is located adjacent to the construction compound. It is recommended that further consideration of the noise benefits

of increasing the height of compound perimeter barriers be explored to address the high number of exceedances predicted within the EIS-NV.

- The EIS states acoustic sheds have been assumed to have an insertion loss of 25 dB which is reasonable. The EIS also states that acoustic sheds will cover all tunnelling operations and loading of trucks with tunnel spoil. This is a reasonable approach but it is envisaged that in order to accommodate 24 hour operations that sheds may have to be extended to cover all on-site truck movements and/or perimeter barrier heights increased.

5.1.4.2 Ground-borne Construction Noise

The EIS does not specify any specific mitigation measures related to ground borne noise. The Construction Noise and Vibration Management Plan (CNVMP) will need to provide details and protocols for the management of ground-borne noise impact, including provision of alternative accommodation where required.

5.1.4.3 Construction Vibration

The EIS does not specify any specific mitigation measures related to surface and tunnel vibration other than safe working distances for vibration intensive plant. The Construction Noise and Vibration Management Plan (CNVMP) will need to provide details and protocols for minimising the risk of vibration impacts from construction activity.

6 EIS-NV Gap Analysis

This section presents a 'gap analysis' or summary of the outstanding items identified and described earlier in this report addressing each of the following main areas:

- Baseline Noise Monitoring & Assessment Locations
- Operational Traffic Noise
- Operational Fixed Facilities
- Construction Noise and Vibration

6.1 Baseline Noise Monitoring & Assessment Locations

1. NCAs defined in the EIS-NV should be further subdivided to ensure that each catchment represents a similar acoustic environment.
2. Additional noise monitoring should be carried out to determine RBLs and existing traffic noise levels for the revised NCAs.
3. Description of the noise monitoring location (i.e. free field or facade affected etc.) should be provided.
4. Details of the ambient noise environment observed at each noise monitoring location should be provided to assist in understanding the purpose of the measurement and its proposed use in the noise assessment.
5. Additional long-term noise monitoring should be carried out at locations NL 19, NL20, NL21 and NL22, or further justification should be provided for the incomplete datasets provided in the EIS-NV.
6. Confirmation of the application of the INP's data exclusion rule should be provided and/ or justification for when data has not been discarded in strict accordance with this rule.
7. Traffic counter locations and the traffic count monitoring period should be identified in the report.
8. Review of meteorological data, confirmation of wind height used and justification of the use of the Terry Hills AWS data is required.
9. Traffic data for the M2 Motorway should be provided by Transurban (if available) covering the second noise monitoring period (10-18 December 2013) to enable comparison of traffic volumes for the two assessment periods.

6.2 Operational Traffic Noise

10. Detail should be provided to clarify how the study area was derived [i.e. how was it calculated that the Project adds no more than 2.0 dB(A) to the total noise level] and the boundary of the study area should be defined.

11. Operational daytime $L_{Aeq,15hr}$ and night-time $L_{Aeq,9hr}$ traffic noise contours should be provided.

12. Detail should be provided to clarify what receiver heights were assessed as part of the operational assessment. Confirmation is required as to whether this affects the outcomes of the noise barrier assessment.

13. More information is required as to how the open graded asphalt (OGA) corrections for the M1 southbound carriageway were derived.

14. The pavement type used for Pennant Hills Rd should be confirmed.

15. With regard to pavement corrections it should be clarified whether the corrections were applied equally for each vehicle emission string (car exhaust/engine; car/truck tyre noise; truck engines and truck exhaust) or just for the car/truck tyre noise emission string.

16. It is not clear why the southbound carriageway of the M1 Motorway has assumed to be resurfaced with open graded asphalt (OGA) for the 'No Build' Opening year and Design year scenarios. This would imply that the resurfacing is not project related and has perhaps already been undertaken post-EIS noise monitoring (i.e. after December 2013).

17. Details should be provided to clarify whether ARRB corrections or any other calibration corrections and safety factors have been applied to operational traffic noise predictions.

18. More information is required with regard to the portal correction used in noise assessment.

19. A reasonable and feasible noise barrier analysis in accordance with ENMM Practice Note (iv) should be conducted for Lucinda Avenue properties (including IDs 1617, 1626, 1648, 1656 & 1661) which are located north-east of the on and off-ramp portals. Furthermore, a noise barrier assessment analysis for NWM2WB02 in accordance with Practice Note (iv) of the ENMM is not included within Appendix K of the EIS-NV. NWM2WB02 is also not included within Table 77 of the EIS-NV.

20. The EIS-NV needs to provide more information to ensure the receivers where noise barriers are to be replaced are provided with replacement noise barriers of at least the equivalent performance of the existing noise barriers.

21. A cumulative noise assessment should be included in the EIS to address operational foxed facilities noise (i.e. noise from Northern/ Southern Ventilation Facility, portal noise, Motorway Operations Complex) and operational traffic noise.

22. Details should be provided to clarify whether the property treatments identified within Table 59 of the EIS are applicable to the ground floor and/or first floor of multi-storey dwellings.

23. The EIS-NV should include a commitment to provide a road surface with similar acoustic performance to OGA when the road is resurfaced in future.

6.3 Operational Fixed Facilities

24. The Industrial Noise Assessment (fixed facilities), Section 5.2 of the EIS-NV, needs to be re-assessed. Some receiver assessment points do not exist, do not represent NCAs correctly and are not the nearest sensitive receiver(s) to individual fixed noise sources.

25. Operational $L_{Aeq,}$ noise contours representing noise impacts from the operation of fixed facilities should be provided to confirm the predicted cumulative noise impacts.

26. Further information should be provided regarding the Ventilation Facilities and tunnel portal jet fans and a review of potential sleep disturbance from the operation of the Ventilation facilities. For example, noise predictions from Ventilation Facilities and Tunnel Portals should be separated and then combined to produce a cumulative noise level at the most affected receiver. Further clarity is sort why predictions at 82 Gum Grove Place, West Pennant Hills decrease by 6 dB(A) for congested and low speed traffic operation.

27. A sleep disturbance impact assessment for the Northern and Southern Ventilation Facilities, jet fan noise, Motorway Operations Complex, Trelawney St and Wilson Rd Tunnel Support Facilities and Coral Tree Drive Switching Station needs to be undertaken.

28. The large NCAs defined in the EIS-NV assume a single noise monitoring location to be representative of background levels across the NCA (see Section 3.1 above for more detail). This may have resulted in higher ENLs for some receivers in the NCA, particularly during the critical night period.

29. The noise modelling approach used for the assessment of operational fixed facilities should be confirmed.

30. A more detailed investigation of potential impacts from activity at the Motorway Control Centre is required to ensure than noise impacts are adequately mitigated.

31. A sleep disturbance impact assessment for the Northern and Southern Ventilation Facilities, jet fan noise, Motorway Operations Complex, Trelawney St and Wilson Rd Tunnel Support Facilities and Coral Tree Drive Switching Station needs to be undertaken.

32. Approximate distances from the most affected receivers within Table to the individual fixed operation noise sources should be noted in the EIS-NV.

33. Additional information regarding cumulative noise impact from the fixed facilities is required to satisfy the review that operational noise can been adequately mitigated.

34. Any conditions of approval for the Project must include clear objectives in relation to mechanical plant to ensure noise emission from the sites are effectively managed.

35. Potential impact and possible changes to noise mitigation requirements will need to be reviewed once additional noise monitoring has been completed, as recommended above.

6.4 Construction Noise and Vibration

36. The literature source of the sound power level (SWL) of 98 L_{Aeq} dB(A) adopted for delivery trucks, truck and dogs and articulated dump trucks should be stated. Justification should be provided as to why this seeming low SWL is applicable.

37. Confirmation is required as to whether a penalty has been applied to noise sources identified in the ICNG (p16) as having particularly annoying characteristics, including jackhammering, rock hammering or rockbreaking.

38. The number of spoil truck movements proposed to occur during the daytime, evening and night-time for the Northern Interchange compound should be quantified. The number of spoil truck movements which have been assumed for the construction noise predictions should be clearly stated. Deciphering the data within the construction road traffic noise assessment, section 4.3 of the EIS, shouldn't have to be relied on to acquire this information.

39. A review of on-site heavy vehicle movements associated with the tunnel support compounds outside of standard construction hours required to identify potential impacts and confirm that proposed compound mitigation and shed structure will satisfactorily mitigate noise. Review of the EIS-NV found that it has not been provided.

40. Further information is required regarding the excavation methodology for the construction of the tunnels near portals. Due to the close proximity of these works to residential receivers, this stage of construction may cause significant noise impacts.

41. It is not clear in the EIS-NV whether existing noise walls earmarked for replacement have been included in the construction noise assessment. There should be a commitment in the EIS-NV that where possible, new noise walls should be constructed prior to or as soon as practical after the commencement of construction.

42. Further consideration of the noise benefits of increasing the height of compound perimeter barriers to be explored to address the high level of construction noise impacts predicted within the EIS-NV.

43. There are significant exceedances for these tunnelling support sites, which will essentially be operating as short term industrial type sites, potentially operating 24 hours per day, 7 days per week for the duration of the works. The EIS-NV does not specify what operations cause the exceedances, how many truck off-site truck movements are proposed and why increasing the perimeter barrier heights or adopting other on-site management strategies was not investigated. Further information regarding how these impacts will be managed and mitigated is required to give some confidence that this is a workable operation.

44. Further information to justify the extent of impacts from ground borne noise is required. Ground borne noise associated with rock hammers is typically higher than that associated

with Roadheaders. The EIS does not provide any predictions associated with cross passages. Confirmation is required as to whether this has been considered as part of the EIS-NV. It is recommended that these predictions be undertaken as part of the EIS process and only if not possible then as part of project design.

45. If blasting is considered to be a viable option for excavation of the tunnel, it should be further considered at this EIS stage to allow adequate provision for management of impacts in the Conditions of Approval for the Project.

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APPENDIX A Glossary of terminology

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

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
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.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
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, when extraneous noise is removed. 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 L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 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 115dB Limit of sound permitted in industry 120dB Deafening
dB(A)	A-weighted decibels. The ear is not as effective in hearing low frequency sounds as it is 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 switched on is denoted as dB(A). Practically all noise is measured using the A filter.
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.
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.
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.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.

L_{90}	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).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
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 pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
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.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Map of Study Area

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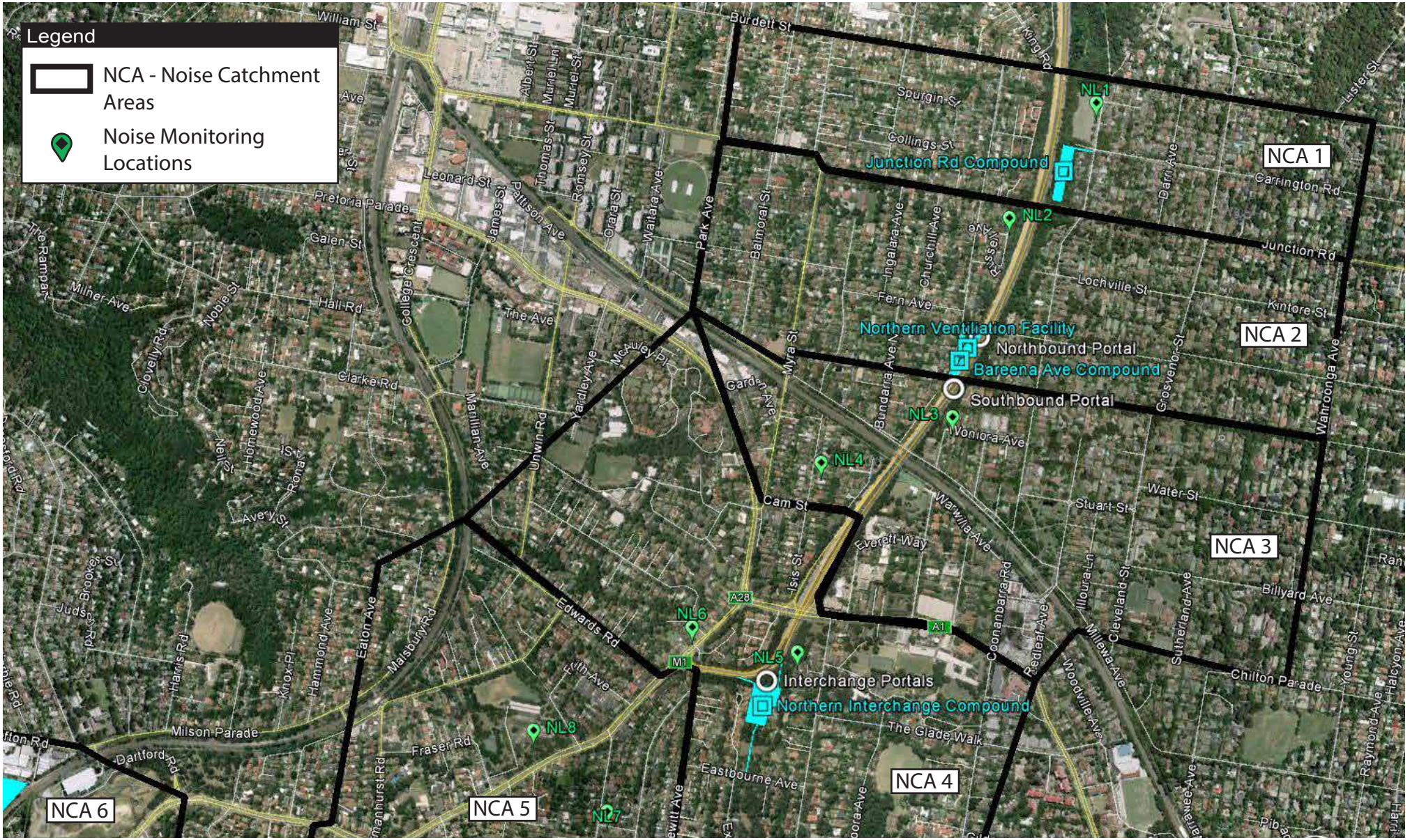

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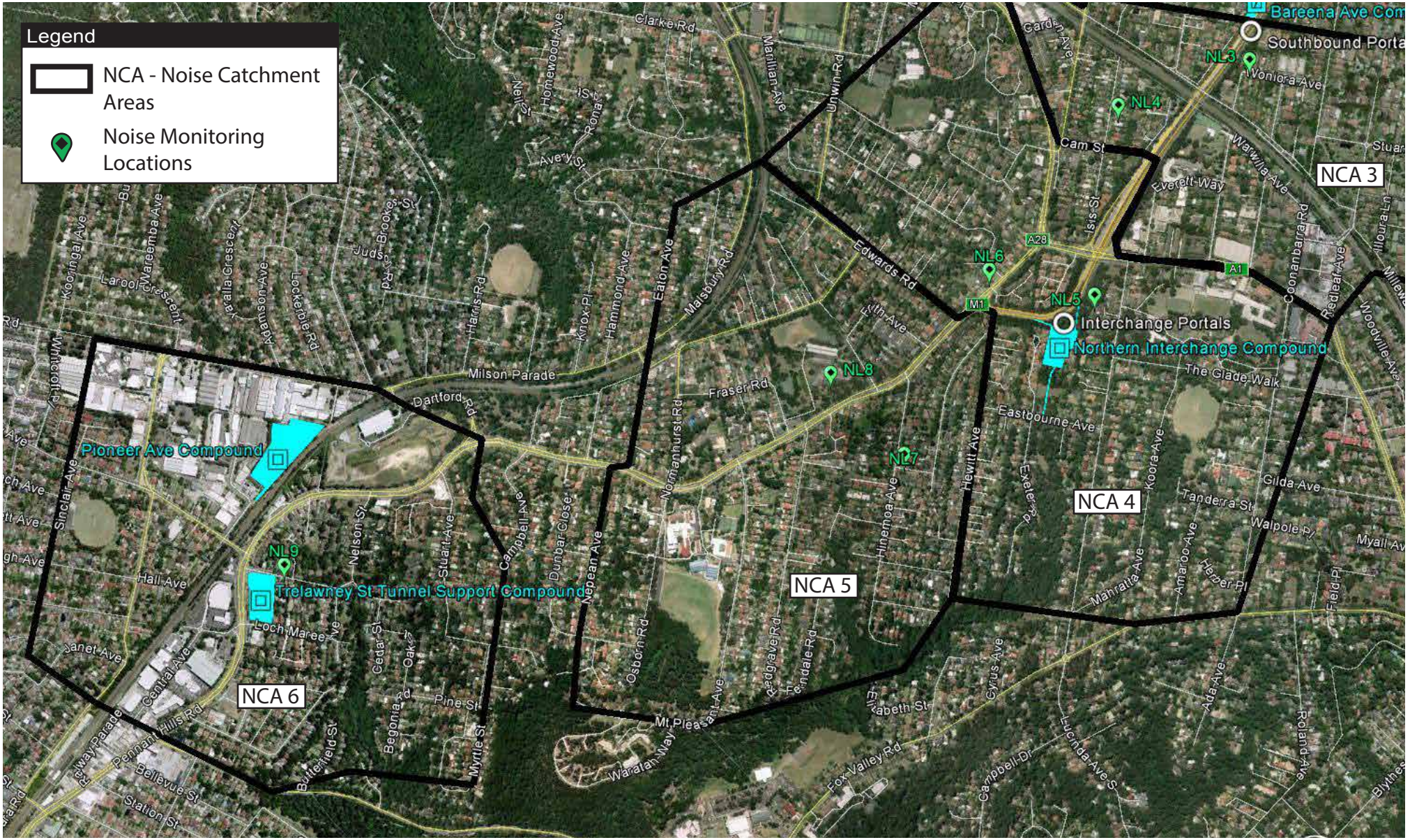
NORTH CONNEX EIS REVIEW - NOISE MONITORING LOCATIONS

Project: TG979-01

Date: 20-08-2014

Ref: TG979-01-F01(r0)

Scale: NTS



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NORTH CONNEX EIS REVIEW - NOISE MONITORING LOCATIONS

Project: TG979-01

Date: 20-08-2014

Ref: TG979-01-F02(r0)

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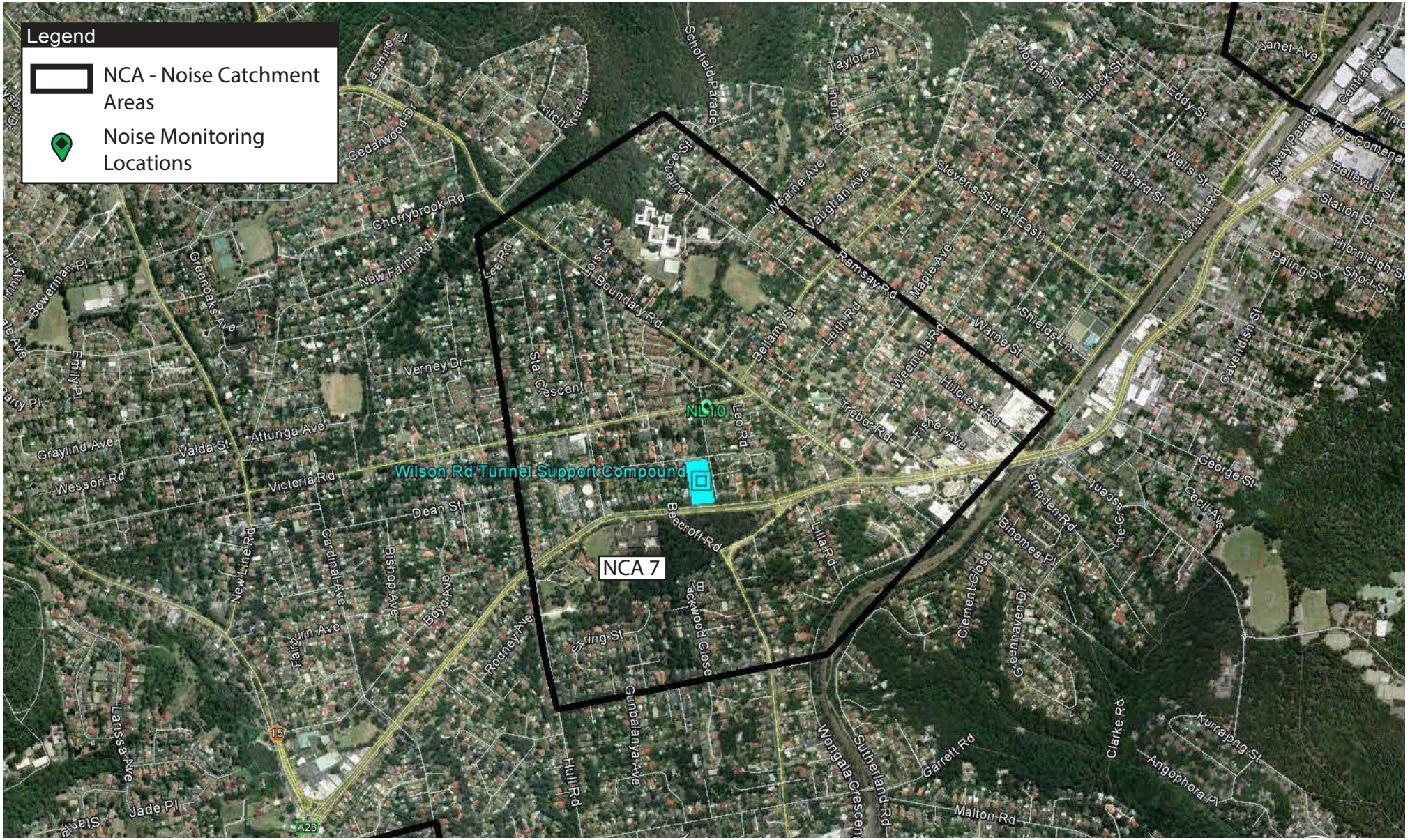

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NORTH CONNEX EIS REVIEW - NOISE MONITORING LOCATIONS

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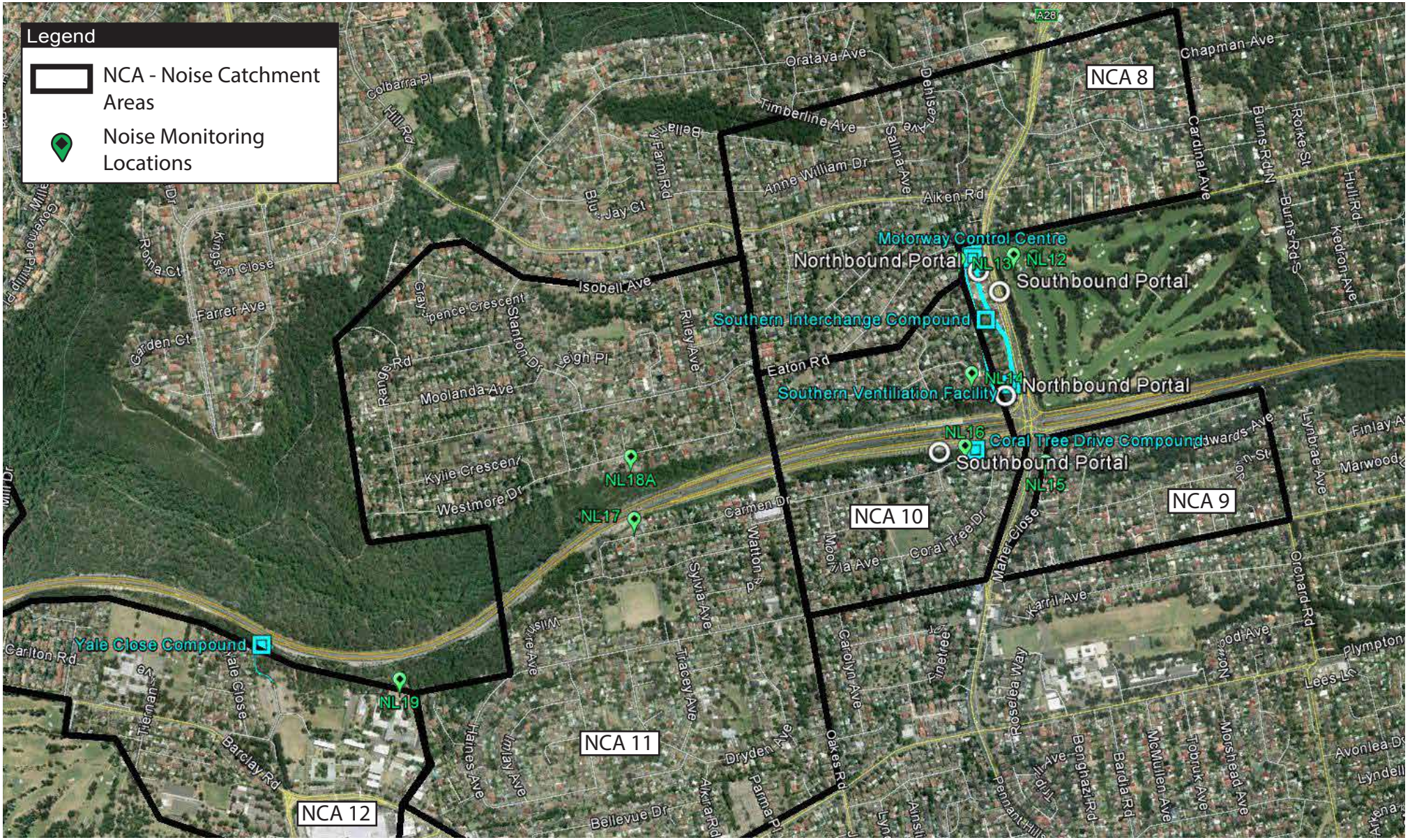

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NORTH CONNEX EIS REVIEW - NOISE MONITORING LOCATIONS

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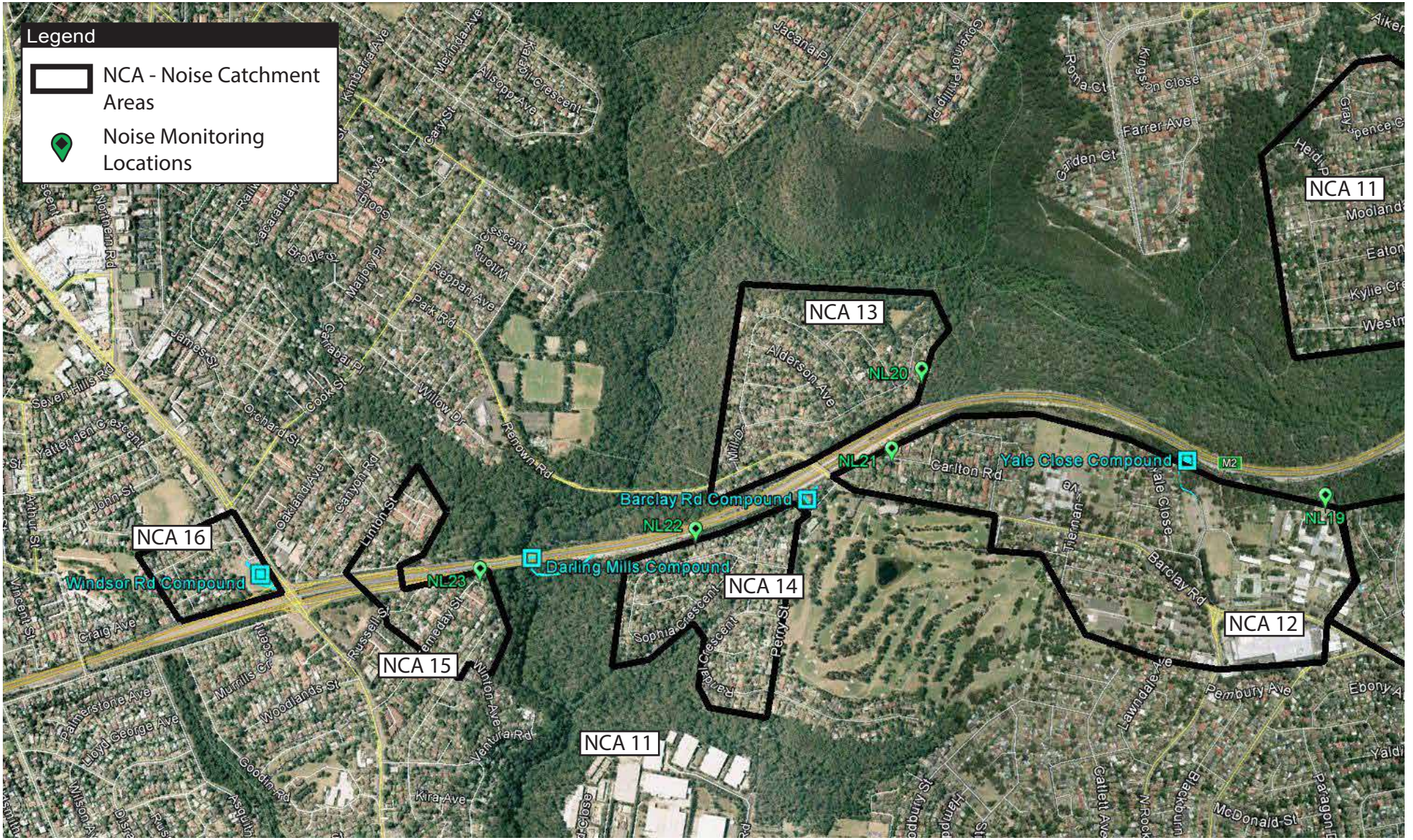

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NORTH CONNEX EIS REVIEW - NOISE MONITORING LOCATIONS

Project:	Date:	Ref:	Scale:
TG979-01	20-08-2014	TG979-01-F05(r0)	NTS

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APPENDIX C Recommended Draft Conditions

C.1 Noise and Vibration

1. Prior to the commencement of construction, complete a detailed land use survey to identify potentially critical areas that are sensitive to construction vibration, construction ground-borne noise and operational noise impacts. Noise Catchment Areas (NCAs) identified in the EIS should be redefined to ensure that each catchment represents a similar acoustic environment. Additional noise monitoring should be carried out to determine rating background levels and existing traffic noise levels for the redefined NCAs. Furthermore, additional long-term noise monitoring shall be carried out at locations NL 19, NL20, NL21 and NL22 (as identified in the EIS).

   Where monitoring is being carried out for the purpose of measuring existing road traffic noise levels, concurrent traffic classification counting shall be carried out.

   A Survey Report shall be prepared summarising the results of the land use survey and identifying the redefined NCAs. Noise monitoring and traffic count data will also be presented in the report, including documentation of the monitoring locations and a brief description of the ambient environment at each monitoring location.

C.2 Construction

C.2.1 Construction Hours

2. Construction activities associated with NorthConnex shall be undertaken during the following standard construction hours:
   a. 7:00am to 6:00pm Mondays to Fridays, inclusive; and
   b. 8:00am to 1:00pm Saturdays;
   c. at no time on Sundays or public holidays.
3. Notwithstanding draft condition 2, tunnelling and associated activities may be undertaken 24-hours, seven days per week. This draft condition does not relate to any other activities associated with NorthConnex, including works associated with the viaduct.
4. Except as permitted by an EPL, activities resulting in impulsive or tonal noise emissions shall only be undertaken:
   a. between the hours of 8:00 am to 5:00 pm Monday to Friday;
   b. between the hours of 8:00 am to 1:00 pm Saturday; and
   c. in continuous blocks not exceeding three hours each with a minimum respite from those activities and works of not less than one hour between each block.

For the purposes of this draft condition 'continuous' includes any period during which there is less than a one hour respite between ceasing and recommencing any of the work the subject of this draft condition.

5. Notwithstanding draft conditions 2 to 4, construction activities outside of the prescribed construction hours may be undertaken in any of the following circumstances:

   a. construction works that generate air-borne noise that is:

      i. no more than 5 dB(A) above rating background level at any residence in accordance with the *Interim Construction Noise Guideline* (DECC, 2009);

      ii. no more than the noise management levels specified in Table 3 of the *Interim Construction Noise Guideline* (DECC, 2009) at other sensitive receivers;

   b. construction works that generate continuous or impulsive vibration values, measured at the most affected residence, that are no more than those for human exposure to vibration, specified for residences in Table 2.2 of *Assessing Vibration: a technical guideline* (DEC, 2006);

   c. works that generate intermittent vibration values, measured at the most affected residence, that are no more than those for human exposure to vibration, specified for residences in Table 2.4 of *Assessing Vibration: a technical guideline* (DEC, 2006);

   d. where a negotiated agreement has been reached with affected receivers, where the prescribed noise and vibration levels cannot be achieved;

   e. for the delivery of materials required outside these hours by the NSW Police Force or other authorities for safety reasons;

   f. where it is required in an emergency to avoid the loss of lives, property and/or to prevent environmental harm; and

   g. works approved through an EPL, including for works identified in an out of hours procedure.

6. Blasting associated with the project shall only be undertaken during the following hours:

   a. 9:00 am to 5:00 pm, Monday to Friday, inclusive;

   b. 9:00 am to 1:00 pm Saturday; and

   c. at no time on Sunday or on a public holiday.

   This condition does not apply in the event of a direction from police or other relevant authority for safety or emergency reasons to avoid loss of life, property loss and/or to prevent environmental harm.

7. In relation to construction hours, including for standard and out of hours activities, NorthConnex shall be constructed to comply with an EPL applying to NorthConnex, including all relevant noise mitigation and management measures. In the event of a dispute between the Proponent (including its contractors) and the EPA, in relation to construction hours, either party may refer the matter to the Director-General for resolution.

C.2.2 Construction Noise and Vibration

8. NorthConnex shall be constructed with the aim of achieving the construction noise management levels detailed in the *Interim Construction Noise Guideline* (DECC, 2009). All feasible and reasonable noise mitigation measures shall be implemented and any activities that could exceed the construction noise management levels shall be identified and managed in accordance with the Construction Noise and Vibration Management Plan (draft condition 19).

   Note: The *Interim Construction Noise Guideline* identifies 'particularly annoying' activities that require the addition of 5dB(A) to the predicted level before comparing to the construction Noise Management Levels.

9. NorthConnex construction traffic movements on public roads shall aim to generate an increase in existing road traffic noise levels of no more than 2 dB(A). All feasible and reasonable noise mitigation and management measures shall be implemented and any activities that could exceed the construction noise management levels shall be identified and managed in accordance with the Construction Noise and Vibration Management Plan (draft condition 19).

10. NorthConnex shall be constructed with the aim of achieving the following construction vibration goals:

    a. for structural damage, the vibration limits set out in the German Standard *DIN 4150-3: Structural Vibration - effects of vibration on structures*; and

    b. for human exposure, the acceptable vibration values set out in the *Assessing Vibration: A Technical Guideline* (DEC, 2006).

    Where vibration levels exceed the acceptable vibration dose values, feasible and reasonable mitigation measures shall be considered.

11. Airblast overpressure generated by blasting associated with NorthConnex shall not exceed the criteria specified in Table C.1 when measured at the most affected residence or other sensitive receiver.

Table C.1: Airblast Overpressure Criteria

Airblast overpressure (dB(Lin Peak))	Allowable exceedance
115	5% of total number of blasts over a 12 month period
120	0%

12. Ground vibration generated by blasting associated with NorthConnex shall be limited for human comfort to the criteria specified in Table C.2 when measured at the most affected residence or other sensitive receiver.

Table C.2: Ground Vibration Limits for Human Comfort (AS 2187.2)

Receiver	Type of blasting operations	Peak component particle velocity (mm/s)
Sensitive site*	Operations lasting longer than 12 months or more than 20 blasts	5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive site*	Operations lasting for less than 12 months or less than 20 blasts	10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	25 mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

Notes: *A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people.

The recommendations in Table J4.5(A) are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions.

13. The blasting criteria identified in draft condition 11 and/ or 12 do not apply where the Proponent has a written agreement with the relevant landowner to exceed the criteria identified in draft condition 11 and/ or 12 and the Director-General has approved the terms of the written agreement. In obtaining the Director-General approval for any such agreement, the Proponent shall submit to the Director General:

    a. details of the proposed blasting program and justification for the proposed increase to blasting criteria including alternatives considered (where relevant);

    b. an assessment of the environmental impacts of the increased blast limits on the surrounding environment and most affected residences or other sensitive receivers including, but not limited to noise, vibration and air quality and any risk to surrounding utilities, services or other structures;

    c. details of the blast management, mitigation and monitoring procedures to be implemented; and

    d. details of consultation undertaken and agreement reached with the relevant landowners (including a copy of the agreement in relation to increased blasting limits).

    The following exclusions apply to the application of this draft condition:

    e. any agreements reached may be terminated by the landowner at any time should concerns about the increased blasting limits be unresolved;

    f. the blasting limit agreed to under any agreement can at no time exceed a maximum Peak Particle Velocity vibration level of 25 mm/s or maximum Airblast Overpressure level of 125 dBL; and

g. the provisions under this draft condition 13 (to increase applicable blast criteria in agreement with the relevant landowners) do not apply where the property is a heritage property.

14. For any section of construction where blasting is proposed, a series of initial trials at reduced scale shall be conducted prior to production blasting to determine site-specific blast response characteristics and to define allowable blast sizes to meet the airblast overpressure and ground vibration limits in this approval.

15. Wherever feasible and reasonable, piling activities shall be undertaken using quieter alternative methods than impact or percussion piling, such as bored piles or vibrated piles.

16. The Proponent shall conduct vibration testing and monitoring to identify minimum working distances to retained heritage items to prevent cosmetic damage to these items. In the event that the vibration testing and monitoring shows that the preferred values for vibration are likely to be exceeded, the Proponent shall review the construction methodology and, if necessary, implement additional reasonable and feasible mitigation measures, unless otherwise agreed to by the Director-General.

17. The Proponent shall consult with potentially-affected community, religious, educational institutions and vibration-sensitive businesses and critical working areas (such as theatres, laboratories and operating theatres) to ensure that noise generating construction works in the vicinity of the receivers are not timetabled during sensitive periods, unless appropriate other arrangements are made.

18. During construction, Proponents of other construction works in the vicinity of NorthConnex shall be consulted and reasonable steps taken to coordinate works to minimise impacts on, and maximise respite for, affected sensitive receivers.

19. As part of the Construction Environmental Management Plan for NorthConnex the Proponent shall prepare and implement a Construction Noise and Vibration Management Plan to detail how construction noise and vibration impacts will be minimised and managed. The Plan shall be consistent with the guidelines contained in the *Interim Construction Noise Guidelines* (DECC, 2009). The plan shall be developed in consultation with the EPA and shall include, but not be limited to:

    a. Identification of the work areas, site compounds and access points;

    b. identification of sensitive receivers and relevant construction noise and vibration goals applicable to NorthConnex and stipulated in the draft conditions above;

    c. details of construction activities and an indicative schedule for construction works, including the identification of key noise and/or vibration generating construction activities (based on representative construction scenarios, including at ancillary facilities) that have the potential to generate noise and/or vibration impacts on surrounding sensitive receivers, particularly residential areas;

d. identification of feasible and reasonable measures proposed to be implemented to minimise and manage construction noise impacts (including construction traffic noise impacts), including, but not limited to, acoustic enclosures, erection of noise walls (hoardings), respite periods and the limiting of truck movements during night periods;

e. identification of feasible and reasonable procedures and mitigation measures to ensure relevant vibration and blasting criteria are achieved, including suitable blast program, applicable buffer distances for vibration intensive works, use of low-vibration generating equipment/ vibration dampeners or alternative construction methodology, and pre- and post- construction dilapidation surveys of sensitive structures where blasting and/ or vibration is likely to result in damage to buildings and structures (including surveys being undertaken immediately following a monitored exceedance of the criteria);

f. details of tunnelling and associated activities described in draft condition 3, including associated impacts, management and mitigation measures;

g. if blasting is required, an assessment of the potential noise and vibration impacts, and a strategy to minimise and manage those impacts, including preparation of an appropriate community information program;

h. a description of how the effectiveness of mitigation and management measures would be monitored during the proposed works, clearly indicating how often this monitoring would be conducted, the locations where monitoring would take place, how the results of this monitoring would be recorded and reported, and, if any exceedance is detected, how any noncompliance would be rectified; and

i. mechanisms for the monitoring, review and amendment of this plan.

C.3 Operational Noise and Vibration

20. The Proponent shall design and operate NorthConnex with the objective of not exceeding the requirements of the *NSW Road Noise Policy* (DECCW, 2011).

    For the purpose of this draft condition, existing development includes all development that at the date of this approval, has been carried out in the vicinity of NorthConnex and any such development approved prior to the determination of NorthConnex, but only to the extent that the location of sensitive receivers is known.

21. The Proponent shall design and operate all fixed facilities, including the Northern and Southern tunnel portals; Northern and Southern Ventilation Facilities; the Motorway Operations Complex; the Trelawney Street and Wilson Road Ventilation Facilities and the Coral Tree Drive Switching Station, with the objective of not exceeding the requirements of the *NSW Industrial Noise Policy* (EPA, 2000) and the *Sleep Disturbance Application Note to the Industrial Noise Policy* (DEC, 2007). The Proponent shall apply mitigation at existing receivers where the noise requirements cannot be achieved.

For the purpose of assessment of noise targets specified under this draft condition, noise from the development shall be:

a. measured at the most affected point on or within the site boundary at the most sensitive locations to determine compliance with $L_{Aeq,T}$ noise limits;

b. measured in the free field at least three to five metres from any vertical reflecting surface in line with the worst-affected dwelling facade to determine compliance with L_{Amax} noise limits; and

c. subject to the modification factors provided in Section 4 of the *NSW Industrial Noise Policy* (EPA, 2000), where applicable.

Notwithstanding, should direct measurement of noise from the fixed facilities be impractical, the Proponent may employ an alternative noise assessment method deemed acceptable by the EPA [refer to Section 11 of the NSW *Industrial Noise Policy* (EPA, 2000)]. Details of such an alternative noise assessment method accepted by the EPA shall be submitted to the Director-General prior to the implementation of the assessment method.

22. The Proponent shall design and operate NorthConnex with the objective, where reasonable and feasible, of not exceeding the vibration goals for human exposure for existing receivers, as presented in *Assessing Vibration: A Technical Guideline* (DECC, 2006).

23. The Proponent shall prepare an Operational Noise and Vibration Review (ONVR) to confirm noise and vibration control measures that would be implemented for the project. The Operational Noise and Vibration Review shall be prepared in consultation with the Department, the EPA, relevant Councils, Sydney Trains, NSW Trains, Freight & Regional Development and the community and shall:

a. identify the appropriate operational noise and vibration objectives and levels for adjoining development, including existing sensitive receivers;

b. confirm the operational noise predictions of NorthConnex based on the final design. This operational noise assessment shall be based on an appropriately calibrated noise model (which has incorporated additional noise monitoring and concurrent traffic counting, where necessary for calibration purposes). The assessment shall specifically include verification of noise levels at all fixed facilities, based on additional noise monitoring undertaken at appropriately identified noise catchment areas surrounding these facilities;

c. predict the operational noise and vibration impacts at adjoining development based on the final design of the project, including operational daytime $L_{Aeq,15hr}$ and night-time $L_{Aeq,9hr}$ traffic noise contours;

d. examine all reasonable and feasible noise and vibration mitigation measures identify specific physical and other mitigation measures for controlling noise and vibration at the source and at the receiver (if relevant) including location, type and timing for the erection of permanent noise barriers and/or other noise mitigation measures;

e. include a consultation strategy to seek feedback from directly affected property owners (including educational institutions) on the noise and vibration mitigation measures; and

f. procedures for operational noise and vibration complaints management, including investigation and monitoring (subject to complainant agreement).

The ONVR is to be independently verified by a noise and vibration expert. The scope of the verification exercise undertaken by the noise and vibration expert is to be developed by the Proponent in consultation with EPA. The verification will be undertaken at the Proponent's expense and the independent expert shall be approved by the Director-General. The ONVR and independent review is to be submitted to the Director-General for approval prior to the commencement of construction of physical noise mitigation structures, unless otherwise agreed to by the Director-General.

The Proponent shall implement the identified noise and vibration control measures and make the ONVR publicly available.

24. The Proponent shall undertake a noise and vibration compliance assessment to confirm the predictions of the noise assessment referred to in the Operational Noise and Vibration Review (draft condition 23). The noise and vibration compliance assessment shall be developed in consultation with EPA and undertaken within twelve months of the commencement of operation of NorthConnex, or as otherwise agreed by the Director-General. The assessment shall include, but not necessarily be limited to:

a. noise and vibration monitoring and compliance assessment, to assess compliance with draft condition 20, 21 and 22 and the ONVR;

b. methodology for the assessment;

c. details of any complaints received relating to operational noise and vibration impacts;

d. any required recalibration of the noise and vibration model taking into account considerations such as land use change (if applicable);

e. an assessment of the performance and effectiveness of the applied noise and vibration mitigation measures; and

f. identification, if required, of further noise and vibration mitigation measures to meet the draft conditions 20, 21 and 22 and the objectives of the ONVR.

A Noise and Vibration Compliance Assessment Report providing the results of the assessment shall be submitted to the Director General and the EPA within 60 days of its completion. If the assessment indicates an exceedance of any of the draft conditions 20, 21 and 22 and/or the objectives of the ONVR, the Proponent shall implement further feasible and reasonable measures (where required) to mitigate these exceedances in consultation with affected property owners.

APPENDIX D Response to Gap Analysis

Table D.1 – Response to Gap Analysis

Gap Item	NorthConnex Response	Final Review
Baseline Noise Monitoring & Assessment Locations		
1. NCAs defined in the EIS-NV should be further subdivided to ensure that each catchment represents a similar acoustic environment.	The noise catchment areas identified and applied to the project are considered to be sufficient in terms of number and extent for the purpose of conducting an appropriately level of noise impact assessment.	Receivers close to arterial roads (within first 2 rows of houses) have higher background and ambient levels than those further back. Some EIS NCAs extend across multiple arterial or sub-arterial roads and a broad topographical area. E.g NCA 7is crossed by Pennant Hills Road, Beecroft Road and Boundary Road. NCAs 4 and 5 straddle Pennant Hills Road, which essentially runs along the top of a ridgeline. NCAs should be refined during the Detailed Design process and incorporated into the ONVR (see Draft Condition 2).
2. Additional noise monitoring should be carried out to determine RBLs and existing traffic noise levels for the revised NCAs.	Noise monitoring would be conducted at the commencement of construction activities and periodically during the construction program (refer to mitigation measure NV17 in Table 7-186 of the environmental impact statement). This monitoring would be used to confirm rating background levels at the commencement of construction and to monitor noise compliance over time.	Additional monitoring locations would be required to ensure existing acoustic environment is adequately captured. E.g. NCA 7 – noise monitoring should (as a minimum) be on either side of Pennant Hills Road; NCA 4 – noise monitoring should also be carried out at the back of the compound area, in Eastbourne Ave or Kingsley Close, where it is more shielded from M1 Motorway. The noise monitoring program should be refined during the Detailed Design process and incorporated into the ONVR (see Draft Condition 2).
3. Description of the noise monitoring location (i.e. free field or facade affected etc.) should be provided.	Noise monitoring locations are shown in Appendix C of the Technical Working Paper: Noise and Vibration (Appendix F of the environmental impact statement). Depending on the exact siting, some of these locations were façade affected. These monitoring locations have been façade corrected where necessary in accordance with the Road Noise Policy (DECCW, 2011).	RMS guidelines (including the ENMM) require that details of the noise monitoring location be documented in the report. This should include a brief description of the ambient environment, documentation of the location of the monitors, including distance to the nearest road, sensitive receivers the monitoring location represents etc. The detail should be provided in the Detailed Design and incorporated into the ONVR (see Draft Condition 2).

Gap Item	NorthConnex Response	Final Review
4. Details of the ambient noise environment observed at each noise monitoring location should be provided to assist in understanding the purpose of the measurement and its proposed use in the noise assessment.	Loggers NL2, NL3, NL5, NL6, NL8, NL11 to NL23 were used for calibration of the road traffic noise model. The noise environment at these locations was predominantly road traffic noise. Loggers NL1, NL2, NL5, NL9, NL10, NL16, NL21 to NL23 were considered to represent the noise environment at the noise sensitive receivers most likely to be affected by construction noise.	As noted above, this detail should be provided for each monitoring location in the Detailed Design and incorporated into the ONVR (see Draft Condition 2).
5. Additional long-term noise monitoring should be carried out at locations NL 19, NL20, NL21 and NL22, or further justification should be provided for the incomplete datasets provided in the EIS-NV.	Section 5.1.3 of the EIS-NV provides a discussion on the existing road traffic noise model, including the calibration of the model. This discussion concludes that the noise model calibrates well and within acceptable accuracies. Additionally, the ambient noise environment at all locations used for the road traffic noise model was consistently dominated by road traffic noise. As such, the logging results are considered appropriate for the purposes of the assessment.	RMS guidelines (including the ENMM) recommend a minimum of 7 valid days of monitoring. This should be addressed as part of the Detailed Design monitoring program and incorporated into the ONVR (see Draft Condition 2).
6. Confirmation of the application of the INP's data exclusion rule should be provided and/ or justification for when data has not been discarded in strict accordance with this rule.	All data exclusion was in accordance with the data exclusion rule from the Industrial Noise Policy (EPA, 2000).	Review of the monitoring data indicates that application of the Data Exclusion Rule in Figure B.1 of the INP would result in exclusion of further days from the monitoring period. Justification for inclusion of these days should be provided or additional monitoring carried out to satisfy the requirements. This should be addressed as part of the Detailed Design monitoring program and incorporated into the ONVR (see Draft Condition 2).
7. Traffic counter locations and the traffic count monitoring period should be identified in the report.	Traffic count locations are shown in Figure 5-2 of the Technical Working Paper: Traffic and Transport (Appendix E of the environmental impact statement) along with further details of those traffic counts. The traffic counts were conducted concurrently with noise monitoring.	No comment.
8. Review of meteorological data, confirmation of wind height used and justification of the use of the Terry Hills AWS data is required.	The Terry Hills weather station was considered to be the most appropriate for use as it is located in an area with similar topography and is relatively close to the project area. In accordance with the EPA and Roads and Maritime procedures which uses a conservative approval, the wind height was not adjusted.	Review of other, potentially closer weather stations (e.g. Sydney Olympic Park) should be included in the Detailed Design monitoring program and incorporated into the ONVR.

Gap Item	NorthConnex Response	Final Review
9. Traffic data for the M2 Motorway should be provided by Transurban (if available) covering the second noise monitoring period (10-18 December 2013) to enable comparison of traffic volumes for the two assessment periods.	A control logger was also deployed at location NL18. The controlling noise source at this location is the Hills M2 Motorway. Additionally, the only changing variable at this location is traffic flows and it was therefore possible to determine the change in traffic flows through routine calculations based on the change in noise levels. As there is no opportunity to enter or exit the Hills M2 Motorway along the section of the integration works, the extrapolated traffic volumes were able to be applied to all monitoring locations during the second logging period.	The rationale for this approach is reasonable, however the difference in monitored noise levels is of the order of 4 to 5 dB(A). If this is solely as a result of traffic on the M2 Hills Motorway, this equates to a difference of roughly 3 times the traffic volume between the two monitoring periods The two monitoring periods were within two weeks of each other and within the State school term period (i.e. not during a holiday traffic period.) This approach is flawed. Additional traffic monitoring (with concurrent traffic count data) will be required for the detailed design and should be incorporated into the ONVR (see Draft Condition 2).
Operational Traffic Noise		
10. Detail should be provided to clarify how the study area was derived [i.e. how was it calculated that the Project adds no more than 2.0 dB(A) to the total noise level] and the boundary of the study area should be defined.	For the southern interchange and the Hills M2 Motorway integration works, the entire 600 metre catchment area of the 'envelop method' referred to in the NSW Road Noise Policy (DECCW, 2011) has been modelled and assessed. For the northern interchange and M1 Pacific Motorway tie-in, the noise impact assessment study area has been reduced from the 600 metres area by applying the 'highly urban' area approach. This approach has been adopted to address other significant sources of noise in this area, including major roads (such as the Pacific Highway) and railway lines.	Noted. It is recommended that the process of defining the study area be more transparent for the detailed design stage. The study area should be shown in the ONVR (see Draft Condition 23).
11. Operational daytime $L_{Aeq,15hr}$ and night-time $L_{Aeq,9hr}$ traffic noise contours should be provided.	Provision of operation traffic contours are not a requirement of the Road Noise Policy (DECCW, 2011) or the Director-General's environmental assessment requirements for the project. They have not been included in the environmental impact statement because they are not as accurate as façade calculations and in some circumstances can be misleading. Noise levels at individual receiver locations have been provided to community members on request.	Agreed that noise contours are not as accurate as façade calculations. Also agree that noise contours do not change the outcome of the noise assessment. However, an EIS is a public document prepared to inform stakeholders of the impacts and assist in the decision making process with regard to a proposal. In this regard, noise contours are far more effective in than tabulated results. RMS guidelines (including the ENMM) recommend noise contours be included in a road traffic noise assessment report. Noise contours or an alternative graphical representation of operational traffic noise be included in the ONVR (see Draft Condition 23).

Gap Item	NorthConnex Response	Final Review
12. Detail should be provided to clarify what receiver heights were assessed as part of the operational assessment. Confirmation is required as to whether this affects the outcomes of the noise barrier assessment.	Receiver calculation heights were assessed at 2.4 metres above ground for the first floor and then at 1.5 metre increments for each additional floor. All levels of multilevel residential buildings have been considered. As such, this does not affect the outcomes of the noise barrier assessment.	This approach does not make sense and does not appear to follow the RNP or ENMM guidance. The RNP advises that the criteria apply at: • 1.5 m above floor level; • For multi-level buildings, the two floors of the building that are most exposed to traffic noise. Assessment locations need to be clearly defined in the detailed design process and included in the ONVR.
13. More information is required as to how the open graded asphalt (OGA) corrections for the M1 southbound carriageway were derived.	Existing pavement corrections have been derived based on a combination of site measurements and calculations. Future pavement corrections have been obtained from the Environmental Noise Management Manual (RTA, 2001).	The pavement corrections applied, based on ENMM are optimistic and do not take into consideration the likely degradation of the road surface over time. This should be reviewed at detailed design and the pavement corrections clearly stated in the modelling assumptions outlined in the ONVR.
14. The pavement type used for Pennant Hills Rd should be confirmed.	The pavement type on Pennant Hills Road, and used within the road traffic noise model for Pennant Hills Road, is Dense Graded Asphalt (DGA).	Noted. All pavement types/ corrections should be clearly stated in the modelling assumptions outlined in the ONVR.
15. With regard to pavement corrections it should be clarified whether the corrections were applied equally for each vehicle emission string (car exhaust/engine; car/truck tyre noise; truck engines and truck exhaust) or just for the car/truck tyre noise emission string.	Pavement corrections have been appropriately applied to the road/ tyre interface only.	Noted. All pavement types/ corrections should be clearly stated in the modelling assumptions outlined in the ONVR.
16. It is not clear why the southbound carriageway of the M1 Motorway has assumed to be resurfaced with open graded asphalt (OGA) for the 'No Build' Opening year and Design year scenarios. This would imply that the resurfacing is not project related and has perhaps already been undertaken post-EIS noise monitoring (i.e. after December 2013).	This conclusion is correct. Resurfacing of the M1 Pacific Motorway with Open Graded Asphalt was undertaken around one month after noise monitoring was completed for the environmental impact statement.	Noted.
17. Details should be provided to clarify whether ARRB corrections or any other calibration corrections and safety factors have been applied to operational traffic noise predictions.	The standard ARRB correction has not been used; rather, specific corrections have been derived from the measured and modelled noise levels. A safety factor has not been applied, however it is noted that the model was calibrated to provide a conservative approach (ie on average the predicted road traffic noise levels are slightly higher than the measured road traffic noise levels).	Noted. Calibration of the noise model must be clearly described and justified in the ONVR (see Draft Condition 23).

Gap Item	NorthConnex Response	Final Review
18. More information is required with regard to the portal correction used in noise assessment.	The portal noise assessment has been conducted using SoundPLAN's implementation of the Nord2000 standard. This standard considers portal dimensions, sound absorption of the tunnel and the road traffic noise sources. Inputs to this modelling have included the portal dimensions and the assumption of a smooth concrete surface in relation to absorption. This is a conservative assumption.	Noted.
19. A reasonable and feasible noise barrier analysis in accordance with ENMM Practice Note (iv) should be conducted for Lucinda Avenue properties (including IDs 1617, 1626, 1648, 1656 & 1661) which are located north-east of the on and off-ramp portals. Furthermore, a noise barrier assessment analysis for NWM2WB02 in accordance with Practice Note (iv) of the ENMM is not included within Appendix K of the EIS-NV. NWM2WB02 is also not included within Table 77 of the EIS-NV.	In this location, five properties have been identified as exceeding the relevant traffic noise assessment thresholds as derived from the RNP. … The provision of an operational noise barrier in this location is not considered feasible or reasonable because any noise barrier in this location would need to be located at the top of the cutting to be effective. This would result in potential for significant visual and overshadowing impacts to residential properties. … Consideration has been given to potential at-property acoustic treatments. Five properties have been identified as being eligible for consideration of at-property acoustic treatments.	The justification for not further considering a noise barrier at this location is insufficient. During the detailed design phase, a detailed analysis most reasonable and feasible noise mitigation solution should be provided, in accordance with the ENMM. The outcomes of the analysis should be included in ONVR (see Draft Condition 23).
20. The EIS-NV needs to provide more information to ensure the receivers where noise barriers are to be replaced are provided with replacement noise barriers of at least the equivalent performance of the existing noise barriers.	Noise barriers have been recommended in accordance with the RNP and the ENMM. Section 7.1 of the EIS-NV states that: "the top of the new noise barrier should be no lower than the top of the existing noise barrier (that is, the reduced level (RL) of the top of the existing barrier must be maintained)." The performance would therefore be at the least equivalent." **Noise barriers that are relocated/ replaced would provide equivalent or better noise attenuation performance as existing noise barriers, consistent with RMS policy.**	This commitment should be clearly described in the ONVR.

Gap Item	NorthConnex Response	Final Review
21. A cumulative noise assessment should be included in the EIS to address operational fixed facilities noise (i.e. noise from Northern/ Southern Ventilation Facility, portal noise, Motorway Operations Complex) and operational traffic noise.	There is no requirement to assess combined noise from fixed facilities and road traffic. Additionally, there are no criteria against which to assess this potential cumulative impact. Regardless, the assessed worst-case noise levels from the northern ventilation facility and the portal jet fans combined is 29 dB(A). The traffic noise levels in this area are in the order of 55 to 65 dB(A). As such, there would not be a cumulative noise impact from the combination of these two sources. Traffic noise would be dominant in this location, with negligible contribution from the ventilation facility and jet fan noise from the tunnel portals.	Noted.
22. Details should be provided to clarify whether the property treatments identified within Table 59 of the EIS are applicable to the ground floor and/or first floor of multi-storey dwellings.	The noise impact assessment has considered all façades and floors for each relevant affected building. Further analysis of traffic noise impacts and mitigation would be conducted during detailed design of the project. The aim of this analysis would be to identify further feasible and reasonable noise mitigation measures that could be applied to reduce noise impacts, if necessary.	Noted. The outcomes of the detail noise mitigation design for NorthConnex should be fully described and justified, as applicable to the ground floor and/or first floor of multi-storey dwellings, in the ONVR (see Draft Condition 23).
23. The EIS-NV should include a commitment to provide a road surface with similar acoustic performance to OGA when the road is resurfaced in future.	The existing road surface on the M1 Pacific Motorway is open grade asphalt. The proposed surface for the M1 Pacific Motorway (excluding the portal ramps) is also open graded asphalt. This design pavement would be maintained in the future.	Noted. The ONMR should confirm maintenance of the pavement to equivalent or better than OGA.
Operational Fixed Facilities		
24. The Industrial Noise Assessment (fixed facilities), Section 5.2 of the EIS-NV, needs to be re-assessed. Some receiver assessment points do not exist, do not represent NCAs correctly and are not the nearest sensitive receiver(s) to individual fixed noise sources.	The assessment of fixed facilities was completed based on the most affected sensitive receivers; however there were some typographical errors in the report. The consolidated amended list of most affected receivers was provided in the response document.	Noted. The consolidated amended list of most affected receivers should be included in the ONVR, updated to meet the relevant detailed design requirements.
25. Operational $L_{Aeq,}$ noise contours representing noise impacts from the operation of fixed facilities should be provided to confirm the predicted cumulative noise impacts.	Provision of operation traffic contours are not a requirement of the RNP or the Director-General's environmental assessment requirements for the project. They have not been included in the environmental impact statement because they are not as accurate as façade calculations and in some circumstances can be misleading. Noise levels at individual receiver locations have been provided to community members on request.	Fixed facilities are assessed to the INP. As noted for Item 11 above, an EIS is a public document prepared to inform stakeholders of the impacts and assist in the decision making process with regard to a proposal. In this regard, noise contours are far more effective in than tabulated results. Noise contours or an alternative graphical representation of operational fixed facility noise should be included in the ONVR (see Draft Condition 23).

Gap Item	NorthConnex Response	Final Review
26. Further information should be provided regarding the Ventilation Facilities and tunnel portal jet fans and a review of potential sleep disturbance from the operation of the Ventilation facilities. For example, noise predictions from Ventilation Facilities and Tunnel Portals should be separated and then combined to produce a cumulative noise level at the most affected receiver. Further clarity is sort why predictions at 82 Gum Grove Place, West Pennant Hills decrease by 6 dB(A) for congested and low speed traffic operation.	Noise from the operation of the project's ventilation facilities and tunnel portal jet fans would be steady and consistent, and as such, the LAeq and LA1 noise levels from the facilities would be within 2-3 dB(A) of each other. Under the worst case weather conditions and during low speed or emergency conditions when the facility would be operating at its maximum capacity, noise from the facility would be 29 dB(A), compared with the applicable noise criterion of 45 dB(A). As such, complying with the LAeq noise criterion would also ensure compliance with the sleep disturbance criterion for surrounding receivers. Similarly for the southern ventilation facility (including jet fan noise from the southern portals), compliance with the 41 dB(A) operational criterion at surrounding receivers would also ensure compliance with the sleep disturbance criterion. The noise levels presented as part of the assessment of fixed facilities are cumulative noise levels from multiple fixed facilities where appropriate (for example, the operation of the ventilation outlet and the portals). This is considered to be appropriate as these will operate concurrently in practice. Additionally, as the cumulative noise level result in compliance with the applicable criteria there is no requirement to investigate the noise levels from individual sources to inform mitigation measures. The reduction by 6 dB(A) from the 'normal operation' scenario to the 'congested and low speed traffic operation' scenario is a typographical error. The noise levels should be consistent with the noise levels from the 'normal operation' scenario. This noise level will continue to comply with the applicable criteria and, as such, the outcomes of the assessment are not affected.	Noted. Details to be included in the ONVR (see Draft Condition 21).
27. A sleep disturbance impact assessment for the Northern and Southern Ventilation Facilities, jet fan noise, Motorway Operations Complex, Trelawney St and Wilson Rd Tunnel Support Facilities and Coral Tree Drive Switching Station needs to be undertaken.	Noise from the operation of the fixed facilities would be steady and consistent, and as such, the LAeq and LA1 noise levels from the facilities would be within 2-3 dB(A) of each other. As the LA1 noise levels would not appreciably exceed the LAeq noise levels and the noise levels are also significantly lower than the existing traffic noise in the area, the potential for sleep disturbance impacts is considered to be negligible.	Noted. Details to be included in the ONVR (see Draft Condition 21 and 23).

Gap Item	NorthConnex Response	Final Review
28. The large NCAs defined in the EIS-NV assume a single noise monitoring location to be representative of background levels across the NCA (see Section 3.1 above for more detail). This may have resulted in higher ENLs for some receivers in the NCA, particularly during the critical night period.	Noise loggers have been located in areas representative of the most affected receivers. As the ambient noise environment is controlled by the existing motorways and other major roads, noise levels would not be expected to change appreciably along the NCA, although they may change with distance from controlling noise source. Areas which may have lower background noise levels would also have significantly lower predicted noise levels due to the distance from the controlling motorway noise source. Noise monitoring was undertaken in accordance with RMS and EPA requirements.	See items 1. And 2. Above. The noise monitoring program should be refined during the Detailed Design process and incorporated into the ONVR (see Draft Condition 2).
29. The noise modelling approach used for the assessment of operational fixed facilities should be confirmed.	The noise modelling approach for the fixed facilities is described in detail in Section 5.2 of the EIS-NV. This includes consideration of the sound power levels of listed equipment, such as fans and transformers, under different operating conditions.	There is no discussion in the EIS-NV as to what noise model has been used to predict operational fixed facility noise, what modelling assumptions have been used with regard to topography, ground absorption, shielding/ mitigation from site etc. Note that this information was included in Section 4.2 of the EIS-NV in relation to construction noise modelling and prediction. This information should be confirmed (if applicable) in the ONVR (see Draft Condition 23).
30. A more detailed investigation of potential impacts from activity at the Motorway Control Centre is required to ensure than noise impacts are adequately mitigated.	Section 5.2 of the Technical Working Paper: Noise and Vibration (Appendix F of the environmental impact statement) provides a detailed assessment of potential operational noise impacts from the motorway control centre incorporating all known parameters at this stage of the project. Further analysis would be undertaken at the detailed design stage of the project which would inform further consideration of feasible and reasonable noise mitigation measures.	There was no investigation of potential sleep disturbance impacts from the Motorway Operations Complex. It is understood that mechanical ventilation is unlikely to cause sleep disturbance issues, however there may be sleep disturbance impacts associated with the car park and entry/ exit from the site if the facility is accessed at night. This should be confirmed in the ONVR (see Draft Condition 21 and 23).
31. A sleep disturbance impact assessment for the Northern and Southern Ventilation Facilities, jet fan noise, Motorway Operations Complex, Trelawney St and Wilson Rd Tunnel Support Facilities and Coral Tree Drive Switching Station needs to be undertaken.	Noise from the operation of the fixed facilities would be steady and consistent, and as such, the LAeq and LA1 noise levels from the facilities would be within 2-3 dB(A) of each other. As the LA1 noise levels would not appreciably exceed the LAeq noise levels and the noise levels are also significantly lower than the existing traffic noise in the area, the potential for sleep disturbance impacts is considered to be negligible.	Noted, with the exception of the Motorway Operations Complex (see Item 30. above). This should be confirmed in the ONVR (see Draft Condition 21 and 23).
32. Approximate distances from the most affected receivers within Table to the individual fixed operation noise sources should be noted in the EIS-NV.	The assessment of fixed facilities was completed based on the most affected sensitive receivers, however there were some typographical errors in the report. The consolidated amended list of most affected receivers is provided in the Response report.	Noted.

Gap Item	NorthConnex Response	Final Review
33. Additional information regarding cumulative noise impact from the fixed facilities is required to satisfy the review that operational noise can be adequately mitigated.	The predicted noise levels from the fixed facilities are significantly lower than the predicted road traffic noise levels. Based on this assessment there is no anticipated to be any cumulative impacts at nearby receivers from the operation of these facilities and road traffic noise. Further analysis would be undertaken at the detailed design stage of the project which would inform further consideration of feasible and reasonable noise mitigation measures.	Noted. This commitment should be confirmed in the ONVR.
34. Any conditions of approval for the Project must include clear objectives in relation to mechanical plant to ensure noise emission from the sites are effectively managed.	Noted.	See Draft Condition 21 and 23).
35. Potential impact and possible changes to noise mitigation requirements will need to be reviewed once additional noise monitoring has been completed, as recommended above.	Further analysis would be undertaken at the detailed design stage of the project which would inform further consideration of feasible and reasonable noise mitigation measures. As noted above, the monitoring undertaken in considered to be appropriate.	Noted. This should be confirmed in detailed design and the ONVR (see Draft Condition 2).
Construction Noise and Vibration		
36. The literature source of the sound power level (SWL) of 98 L_{Aeq} dB(A) adopted for delivery trucks, truck and dogs and articulated dump trucks should be stated. Justification should be provided as to why this seeming low SWL is applicable.	The sound power levels have been taken from experience on similar projects considering the proposed operations and are consistent with those provided in the UK Department for Environment Food and Rural Affairs (DEFRA) Update of Noise Database for Prediction of Noise on Construction and Open Sites (2005).	The SWL for trucks in the DEFRA database varies from 89 L_{Aeq} dB(A) for a small concrete mixer to 116 L_{Aeq} dB(A) for a 25t articulated dump truck, depending on the activity being undertaken. RT&A typically adopt a SWL 108 L_{Aeq} dB(A) for truck and dogs/ delivery trucks. The truck source level of SWL 98 L_{Aeq} dB(A) in the EIS-NV is considered low. This source and other sources in the EIS, in particular $L_{A1,1min}$ noise sources, should be confirmed in the detailed construction noise assessment and design and CNVMP.
37. Confirmation is required as to whether a penalty has been applied to noise sources identified in the ICNG (p16) as having particularly annoying characteristics, including jackhammering, rock hammering or rockbreaking.	Where appropriate, annoying characteristics have been included in the assessed construction activities. The potential for annoying noise characteristics would be taken into account as part of the detailed design and construction planning for the project, with appropriate mitigation and management measures reflected in the Construction Noise and Vibration Management Plan.	Noted. This should be confirmed in detailed construction design and CNVMP.

Gap Item	NorthConnex Response	Final Review
38. The number of spoil truck movements proposed to occur during the daytime, evening and night-time for the Northern Interchange compound should be quantified. The number of spoil truck movements which have been assumed for the construction noise predictions should be clearly stated. Deciphering the data within the construction road traffic noise assessment, section 4.3 of the EIS, shouldn't have to be relied on to acquire this information.	Total light and heavy vehicle numbers are clearly indicated in Section 4.3 of the EIS-NV. Vehicle numbers are listed for each affected road and grouped by construction site for two scenarios: • All spoil haulage to the north. • All spoil haulage to the south. Vehicles numbers have been listed for the AM and PM peak periods, as well as for two periods outside of standard construction hours (late night and early morning). The information provided is sufficient to inform the construction traffic noise impact assessment and to interpret the assessment's inputs, assumptions and outcomes. In response to issues raised in submissions, haulage routes associated with the southern interchange compound (C5), the Trelawney Street compound (C7) and the northern interchange compound (C9) have been reviewed and revised. Further details of these changes are provided in Section 7.4 of the Submissions and Total light and heavy vehicle numbers are clearly indicated in Section 4.3 of the EIS-NV. Vehicle numbers are listed for each affected road and grouped by construction site for two scenarios: • All spoil haulage to the north. • All spoil haulage to the south. Vehicles numbers have been listed for the AM and PM peak periods, as well as for two periods outside of standard construction hours (late night and early morning). The information provided is sufficient to inform the construction traffic noise impact assessment and to interpret the assessment's inputs, assumptions and outcomes.	The detailed construction assessment and design will need to address all surface OOHW, including on-site truck movements, site entry and egress points, truck breaking and reversing on site. This will need to be assessed from both an annoyance/ amenity and sleep disturbance perspective. Where practicable, all night time truck haul routes should be kept of 'local ' roads and on arterial and sub-arterial roads, to limit the potential for impact during the critical night period. This will be addressed in the detailed construction design (see Draft Condition 8 and 9).
39. A review of on-site heavy vehicle movements associated with the tunnel support compounds outside of standard construction hours required to identify potential impacts and confirm that proposed compound mitigation and shed structure will satisfactorily mitigate noise. Review of the EIS-NV found that it has not been provided.	The construction noise impact assessment presented in Section 4 of the Technical Working Paper: Noise and Vibration (Appendix F of the environmental impact statement) includes assessment of site establishment and earthworks at each construction compound. This scenario is expected to have a significantly higher impact than on-site heavy vehicle movements, and is therefore considered an appropriate worst-case construction noise impact scenario. More information would be provided in the CNVMP.	See comments to Item 38 above. This will be addressed in the detailed construction design (Draft Condition 9, 10 and 19).

Gap Item	NorthConnex Response	Final Review
40. Further information is required regarding the excavation methodology for the construction of the tunnels near portals. Due to the close proximity of these works to residential receivers, this stage of construction may cause significant noise impacts.	A Construction Noise and Vibration Management Plan(s) would be prepared during the detailed design stage of the project when construction practices are developed by the construction contractor. The plan(s) would include more specific details about the construction methodology and associated noise and vibration impacts. Further discussion of construction noise and vibration management measures is provided in Section 2.11 of the Submissions and Preferred Infrastructure Report.	Noted. This will be addressed in the detailed construction design.
41. It is not clear in the EIS-NV whether existing noise walls earmarked for replacement have been included in the construction noise assessment. There should be a commitment in the EIS-NV that where possible, new noise walls should be constructed prior to or as soon as practical after the commencement of construction.	Noise barriers that are earmarked for replacement have not been included in the construction noise assessment. This provides a conservative assumption for the purpose of the construction noise impact assessment, as potential impacts have not taken into account the potential presence of relocated noise barriers as an early mitigation measure for construction noise. Where feasible and reasonable, the relocation and/ or replacement of noise barriers would be prioritised for implementation during the early phases of construction as an effective noise mitigation measure.	Where practicable, noise barriers and at-property treatments should be implemented prior to the commencement of or early in the construction stage to provide noise mitigation from construction works. This commitment should be clearly stated in the detailed construction design.
42. Further consideration of the noise benefits of increasing the height of compound perimeter barriers to be explored to address the high level of construction noise impacts predicted within the EIS-NV.	Feasible and reasonable noise mitigation and management measures have been identified in accordance with the Interim Construction Noise Guideline (DECC, 2009). Further discussion of construction noise mitigation and management measures is provided in Section 2.11 of the Submissions and Preferred Infrastructure Report. Site specific mitigation and management measures would be detailed in the Construction Noise and Vibration Management Plan(s) for the project which would be developed during the detailed design stage.	Detailed assessment of construction noise and vibration impact will need to be completed during the design development phase of the Project. The assessment will need to review all noise mitigation options identified in the EIS-NV, with particular attention to reasonable/ feasible noise barriers and acoustic sheds for 24 hour construction sites. This will be addressed in the detailed construction design, Construction Noise Management Plan and subsequent impact statements to address the different worksites/ stages of the Project see Draft Condition 19)..

Gap Item	NorthConnex Response	Final Review
43. There are significant exceedances for these tunnelling support sites, which will essentially be operating as short term industrial type sites, potentially operating 24 hours per day, 7 days per week for the duration of the works. The EIS-NV does not specify what operations cause the exceedances, how many truck off-site truck movements are proposed and why increasing the perimeter barrier heights or adopting other on-site management strategies was not investigated. Further information regarding how these impacts will be managed and mitigated is required to give some confidence that this is a workable operation.	Section 2.11 of the Submissions and Preferred Infrastructure Report provides a refinement of the construction noise and vibration assessment to better understand the magnitude of the noise exceedances. This section also provides additional information regarding site specific individual mitigation measures for certain noise level exceedances. Further consideration of physical and procedural noise mitigation would be undertaken during the development of the Construction Noise and Vibration Management Plan.	See Final Review comments for Items 38, 39 and 42 above.
44. Further information to justify the extent of impacts from ground borne noise is required. Ground borne noise associated with rock hammers is typically higher than that associated with Roadheaders. The EIS does not provide any predictions associated with cross passages. Confirmation is required as to whether this has been considered as part of the EIS-NV. It is recommended that these predictions be undertaken as part of the EIS process and only if not possible then as part of project design.	The exact location of rock hammering activities and cross passages is not available at this stage of the project. The use of rock hammers would be subject to detailed design and the nature of the geology encountered during the works. The potential impacts from the use of rock hammers would be considered during the detailed design and construction planning. This would include consideration of the magnitude of the impact, the duration of the impacts, and the potential use of alternative methods or smaller equipment to reduce potential impacts. Section 2.11 of the Submissions and Preferred Infrastructure Report provides a refinement of the construction noise and vibration assessment to better understand the magnitude of the noise exceedances. This section also provides additional information regarding site specific individual mitigation measures for certain noise level exceedances, including exceedances of ground-borne noise levels.	More comprehensive GBN and vibration modelling is required for the detailed design stage, to ensure impacts are adequately quantified and receivers appropriately notified prior to tunnelling. (see Draft Condition 19).
45. If blasting is considered to be a viable option for excavation of the tunnel, it should be further considered at this EIS stage to allow adequate provision for management of impacts in the Conditions of Approval for the Project.	As indicated in the EIS-NV, it is not possible to conclusively determine the extent of blasting that may be required during construction of the NorthConnex project. It is expected that the need for blasting is very low. In reality is unlikely to be required. However, there is a residual risk that geological conditions may be encountered during tunnelling that required limited use of blasting. For transparency and completeness, the potential for blasting is identified in the EIS-NV despite it being considered unlikely.	Detailed assessment of blasting impact is required for the detailed design stage, where blasting is identified as a potential construction method. (see Draft Condition 11, 12, 13 and 14).

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