Appendix F

Acoustic Assessment Report 2016

aurecon

M1 Pacific Motorway Intersection upgrade at Weakleys Drive and John Renshaw Drive

Acoustic Assessment Report

Roads and Maritime Services

18 September 2016
Revision: 4
Reference: 249492

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1 Introduction

1.1 Proposal overview

Roads and Maritime Services (Roads and Maritime) propose to upgrade the M1 Pacific Motorway, Weakleys Drive and John Renshaw Drive intersection at Beresfield, New South Wales (NSW). In response to identified existing and projected traffic constraints, Roads and Maritime proposes to replace the existing roundabout with traffic lights (the proposal).

The revised concept design (option 3B) (**Figure 1**) as provided by Roads and Maritime on 1 February 2016 forms the basis of the Review of Environmental Factors (REF) and this acoustic assessment.

The M1 Pacific Motorway is an important link in the National Land Transport Network and Sydney to Brisbane Corridor. Located at the northern end of the M1 Pacific Motorway, the proposal links the M1 Pacific Motorway and the A1 Pacific Highway. The proposal also provides connections between the M1 Pacific Motorway, New England Highway and local industrial and commercial areas.

The existing two lane roundabout is used by about 4000 vehicles per hour in peak periods and cannot effectively cater for the current level of demand. This results in delays, queuing and increased travel times.

The proposal is needed to improve traffic flow, travel times and safety for motorists.

Within this proposal, provision has been made for equipment laydown, stockpile and plant parking areas that would be located in the north–western, south–western and south–eastern corners of the intersection. These equipment laydown areas may also operate as satellite construction compounds to a main compound. A construction compound outside of these areas is not included in this assessment.

Figure 1: Overview of the proposal

1.2 Proposal objectives

The objectives of the proposal include:

- Improve freight efficiency and commuter movement at the intersection targeting Level of Service Delivery in 2029 on the National Land Transport Network (assuming the M1 to Raymond Terrace Link is operating).
- Improve overall safety for road users by reducing crash rates. This objective is measured in crash rates per million vehicle kilometres travelled (MVKT).
- Compatible with future M1 to Raymond Terrace Link design.
- Best value for money over a 10 year project life.
- Minimise the impacts to the existing environment.

1.3 Purpose and scope of this acoustic assessment

1.3.1 Reference documents

Construction and operation noise assessments and this report have been prepared primarily in accordance with the following documents:

- Office of Environment and Heritage (OEH) (formally DECCW and EPA) documents:
  - Interim Construction Noise Guideline, 2009 (ICNG).
  - NSW Road Noise Policy, 2011 (RNP).
  - Industrial Noise Policy, 2000 (INP).
  - Environmental Criteria for Road Traffic Noise, 1999 (ECRTN).
  - Assessing Vibration: A Technical Guideline, 2006.
- Roads and Maritime documents:
  - Noise Criteria Guideline, 2015 (NCG).
  - Noise Mitigation Guidelines, 2015 (NMG).
  - Environmental Noise Management Manual, 2001 (ENMM).
  - Procedure – Preparing an operational Traffic and Construction Noise and Vibration Assessment report, 2014.
- Transport for NSW, *Construction Noise Strategy*, 2013 (CNS).
- WHO GCN 1999. World Health Organization, *Guideline for Community Noise*, 1999 (GCN).
- Australian Standards:
  - AS 1055.1-1997, Acoustics - Description and measurement of environmental noise - General procedures, 1997.
  - AS 2436-2010, Guide to noise and vibration control on construction, demolition and maintenance sites, 2010.
- BS6472:1992, British Standard, Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80Hz), 1992.
- DIN4150-3 (1999-02). German Standard, Structural Vibration Part 3 – ‘Effects of vibration on structures, 1999.
- Hyder – M1 Pacific Motorway Intersection Upgrade at Weakleys Drive & John Renshaw Drive Traffic Modelling on Strategic Concept Design, Prepared for Roads and Maritime, May 2015.

1.3.2 Construction noise

This report is prepared in order to understand the potential impacts arising from the construction of the proposal and to identify and recommend mitigation measures as appropriate. The quantitative assessment method described in ICNG has been followed to assess construction noise impact.

Construction noise criteria (Management Level) for sensitive receivers would be developed based on the ICNG stipulated criteria for non-residential receivers and onsite background noise (Rating Background Level) monitoring.

Construction noise impact would consider construction timing, operating hours of sensitive receivers, method of construction to be used, construction vehicles, relative distances of construction work from noise sensitive receivers, construction management level (noise goal), and barrier effects due to intervening industrial buildings and terrain.

1.3.3 Operational noise

The proposal is classified as minor works in the NCG as the installation of traffic control devices does not increase the traffic growth within the locality. The minor works criteria applies the existing road criteria where the minor works increase noise levels by more than 2 dBA relative to the existing noise levels at the worst affected receiver.

The RNP and NCG outlines that traffic noise monitoring should be undertaken at a distance of 600 metres from the centre line of the outermost traffic lane on each side of the subject roads for the proposal. The NCG states that for minor works the 600 metre noise catchment may not be required and as the nearest residential property to the proposal is about 1200 metres away traffic noise monitoring and an operational noise model is not required to assess operational noise for residential properties.

There are two sensitive receivers within the study area (see **Section 2.3**) and noise monitoring was carried out at their locations to determine the potential noise impact expected from the proposal compared with the criteria referenced from the NCG.

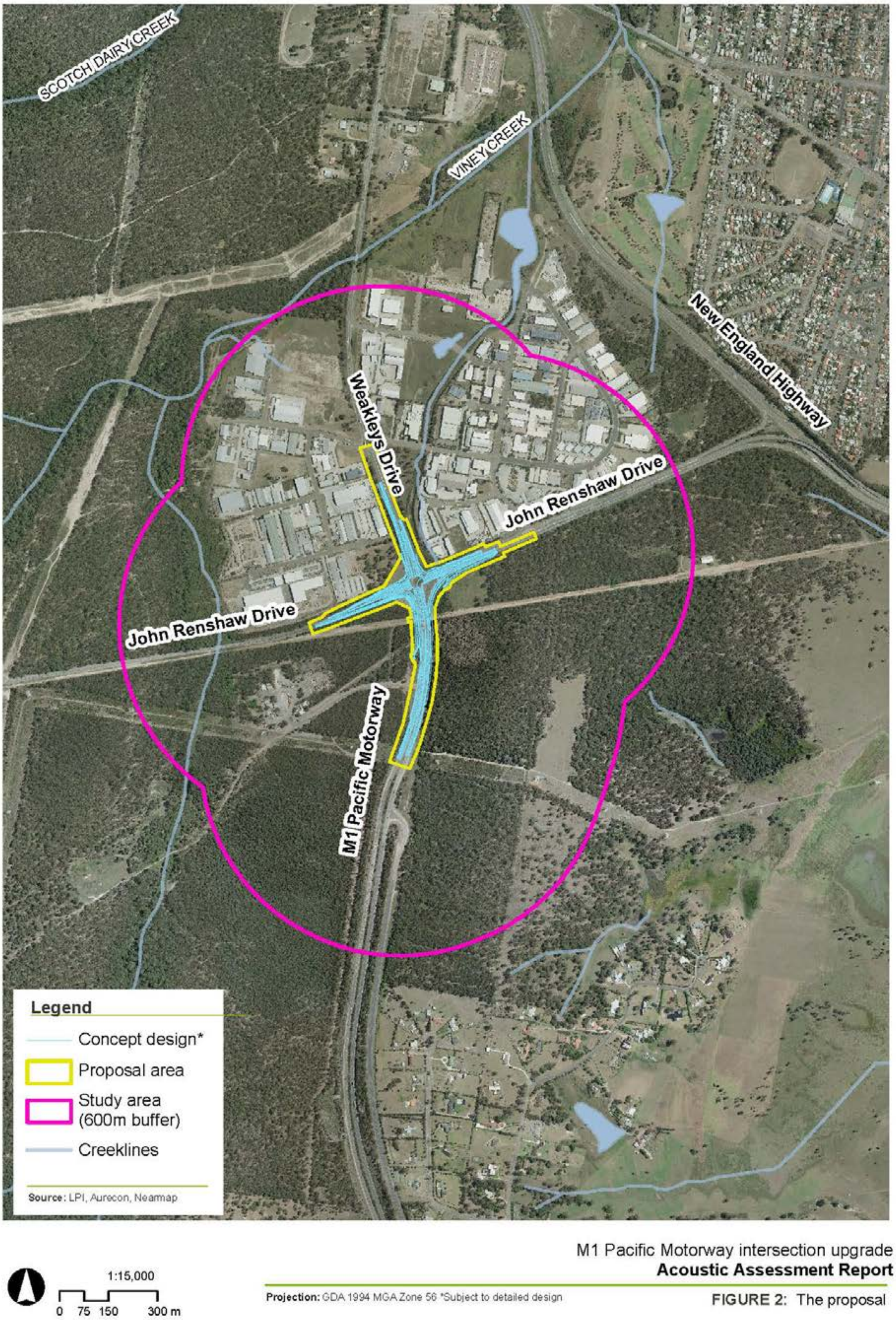
2 Proposal description

2.1 The proposal

The proposal involves the upgrade of the intersection at Beresfield by replacing the existing roundabout with a signalised intersection. **Figure 2** shows the proposed layout and concept design drawings for the proposal. The concept design would be further refined during the detailed design process. The main features of the proposal include:

- A traffic light controlled intersection with two through lanes on all approaches
- Additional turning lanes on all approaches including two right turn lanes from the M1 Pacific Motorway to increase flow for traffic turning right onto John Renshaw Drive
- Two northbound lanes on Weakleys Drive from the traffic lights to Enterprise Drive
- Improved intersection geometry and safety on M1 Pacific Motorway and Weakleys Drive approaches
- Upgrading the existing left slip lane to the M1 Pacific Motorway southbound to a larger curve radius to improve safety
- An additional left turn lane from John Renshaw Drive (westbound) to the M1 Pacific Motorway (southbound) to manage periods of peak holiday southbound traffic and incidents that close the southbound slip lane
- The two southbound through lanes on the M1 Pacific Motorway merge just to the south of the intersection to form one lane and the slip lane continues in its own lane. These conditions remain the same as the existing layout
- Extension of existing drainage culverts under the slip lane from John Renshaw Drive (westbound) to the M1 Pacific Motorway (southbound) and an existing culvert under Weakleys Drive. These culvert extensions would be required to allow road widening work
- Additional drainage, lighting, signage, barriers, fencing and landscaping work
- Installation of Intelligent Traffic Systems (ITS)
- Ancillary works such as stockpiling and construction work areas
- Utility relocations via trenching and underboring the existing road pavement
- Closing the informal car park located in the south–western corner of the existing intersection which operates as a Driver Reviver site during peak holiday periods. This would accommodate proposed road widening work
- Closing the oversize over mass truck stop bay on the M1 Pacific Motorway (southbound). This would increase the radius of the left turn lane from the M1 Pacific Motorway to John Renshaw Drive (westbound)
- Removal of redundant Variable Message Signs (VMS) that do not meet current standards on the M1 Pacific Motorway (northbound) and eastern section of John Renshaw Drive (westbound)
- Clearing of State listed EEC Lower Hunter Spotted Gum - Ironbark Forest in the Sydney Basin Bioregion and individuals of the threatened Callistemon linearifolius (Netted Bottle Brush) to allow for proposed road widening and construction works.

Figure 2: The proposal



2.2 Proposed study area

The study area for the proposal has been determined as outlined in the NCG. For the purposes of the construction noise assessment, the study area extends 600 metres from the proposal area (as shown in **Figure 1**). The proposal area includes laydown areas and temporary stockpile areas but does not include a construction compound.

The location of the construction compound has not yet been determined and therefore is not considered in this acoustic assessment. However, due to the industrial nature of most of the surrounding areas, the acoustic impact of such a facility is unlikely to result in an unacceptable levels of noise. This would need to be confirmed as part of the site compound approval process.

2.3 Noise sensitive receivers

Based on the analysis of aerial imagery and confirmed by site inspection, the study area is predominantly commercial/ industrial premises to the north and north-west of the roundabout and undeveloped vegetation to the south. The closest residential property is about 1200 metres to the south-east/ east of the proposal.

Based on the definition in the RNP and the ICNG there are several noise sensitive receivers within the study area. These are listed in **Table 1** and shown on **Figure 3**.

Operating hours of sensitive noise receivers is an important factor and has been taken into account in the assessment. These sensitive noise receivers are generally non-operational during night time (10pm – 7am).

Noise sensitive receivers R3, R4 and R5 are a mix of commercial and light industrial properties. For this assessment a worst case has been adopted by using the commercial criteria.

Table 1 | Noise sensitive receivers

Receiver ID	Receiver type	Address	Minimum distance between proposal and receiver (metres)
R1	Christian City Church Place of Worship	1/1 Pippita Close, Beresfield NSW 2322	215
R2	Christian Outreach Centre Place of Worship	14 Enterprise Drive, Beresfield, NSW 2322	175
R3	Business Centre Hunter Commercial / light industrial (including residential construction company, tractor, truck and car repair and sales businesses.),	9/21 Babilla Close, Beresfield NSW 2322	45
R4	Group of commercial / light industrial centre (including truck, bus and material moving repairs and sales companies.)	Toyota Material Handling, 7 Kullara Close Beresfield, NSW 2322	40
R5	Group of commercial / light industrial centre (Including hire company, records storage and construction machine repair and manufacturer.)	Coates Hire, 15 Kullara Close, Beresfield, NSW 2322 Minister Beresfield, 30 Kullara Close Beresfield, NSW 2322	20

3 Existing environment

3.1 Noise monitoring methodology

The following noise monitoring was conducted on 21/04/2016 between 10am till 3pm to gain an understanding of the existing daytime traffic noise and background noise. The locations are shown on **Figure 3**.

- Three unattended (about 2-3 hours) noise monitoring tests were located at:
  - UA-1: Inside the Christian City Church located at 1/1 Pippita Close (worship area). Two tests were done at this location.
  - UA-2: Eastern end of Kullara Close.
  - UA-3: South-western end of 17 Babilla Close.
- Five attended 15 minute noise monitoring tests were located at:
  - A-1: Outside Christian City Church.
  - A-2: South-western end of 17 Babilla Close.
  - A-3: South-western end of Kinta Drive.
  - A-4: BP Service Station, south-eastern end of Kinta Drive.
  - A-5: Eastern end of Kullara Close on the edge of John Renshaw Drive.

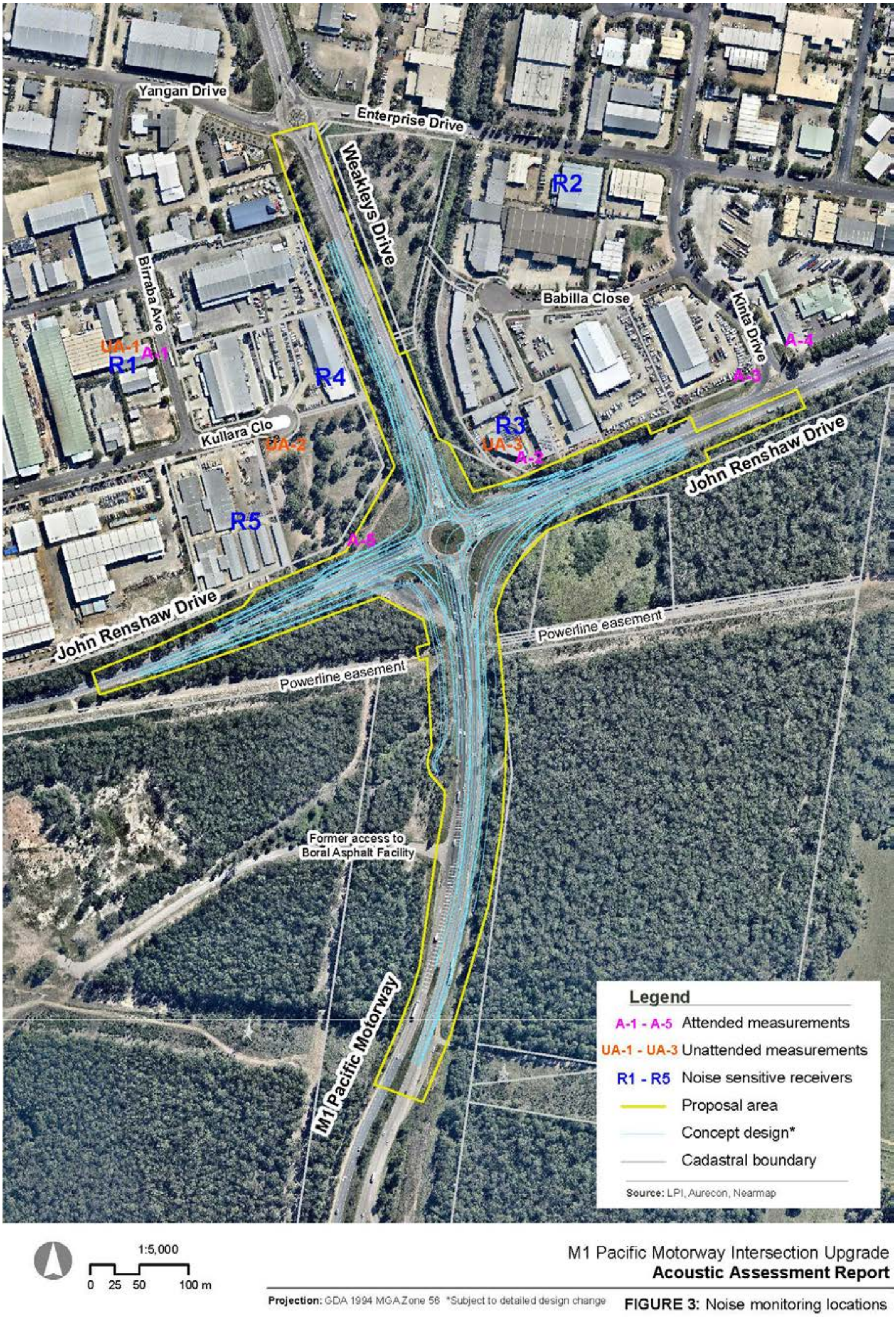
During measurements at A-2, A-3 and A4 simultaneous manual traffic counts were done.

Noise measurements and assessments have been undertaken in accordance with the ENMM, INP, ICNG and Australian Standard 1055.1-1997.

The statistical attended noise measurements including the averaged A-weighted noise levels (L_{Aeq}), maximum A-weighted noise levels (L_{Amax}) and statistical A-weighted LA90 and LA10 noise levels were conducted using a Larson Davis 831 Type 1 sound level meter equipped with a LD PRM831 pre-amplifier and a PCB 377B02 ½" microphone. The microphone was set to 'A' frequency weighting, 'F' time weighting, and was fitted with an approved windshield.

Measurements were typically taken at a height of 1.2 metres and at least 3.5 metres from any reflecting structure other than the ground. The measurement period at each location was 15 minutes. A Larson Davis CAL200 was utilised to calibrate the sound level meter before and after each series of measurements with no significant calibration drift noted.

Figure 3: Noise monitoring locations



3.2 Equipment

Table 2 shows the equipment used for all the measurements undertaken on site.

Table 2 | Sound pressure level measurement equipment

Equipment	Make	Model	Serial No.	Type	Last Calibration	Calibration Due
Sound Level Meter	LD	831	0001595	1	19.08.2014	19/08/2016
Noise logger 1	LD	LXT	1718	1	1/09/2014	1/09/2016
Noise logger 2	LD	LXT	1719	1	26/08/2015	26/08/2017
Noise logger 3	RION	NL-21	00709529	2	29/09/2014	29/09/2016
Calibrator	LD	CAL200	6345	-	10/02/2016	10/02/2017

3.3 Results

Table 3 shows the results from the attended and unattended noise monitoring. Background noise at each of the measurement locations were influenced predominantly by road traffic on Weakleys Drive and M1 Pacific Motorway comprising of heavy and light vehicles.

Table 3 | Results of environmental noise monitoring

Location	Start time	Period	Measured sound Pressure Level, dB(A)					Traffic count (Vehicles)
			$L_{Aeq, 15min}$	$L_{A10, 15min}$	$L_{A90, 15min}$	$L_{Amax, 15min}$	$L_{Amin, 15min}$	
UA-1 – Inside (5 min test)	10:30am	Day	31	33	27	46	25	n/a
UA-1 – Inside	10:25am	Day	42	35	27	73	24	n/a
UA-2	10:46am	Day	58	60	53	72	50	n/a
UA-3	11:15am	Day	71	74	64	87	54.3	336 (55 Heavy)
A-1 Outside	10:37am	Day	60	63	46	80	43	Traffic on Kullara Close
A-2	11:13am	Day	71	75	64	86	58	336 (55 Heavy)
A-4 BP Station	11:33am	Day	70	72	62	81	55	348 (54 Heavy)
A-3 Kinta Drive	11:50am	Day	75	79	66	91	56	377 (57 Heavy)
A-5	This site was unsafe to access and no measurements were taken.							

4 Criteria

4.1 Construction noise management level

The following section presents the noise management levels for different land uses in accordance with the ICNG.

4.1.1 Recommended standard hours

The recommended standard hours identified in the ICNG for construction work are shown in Table 4. These hours are not mandatory. The likely noise impacts and the ability to undertake works during the recommended standard hours should be considered when scheduling work.

Table 4 | Recommended standard hours for construction work

Work Type	Recommended standard hours of work
Normal construction	Monday to Friday 7.00 am to 6.00 pm
	Saturday 8.00 am to 1.00 pm
	No work on Sundays or public holidays

4.1.2 Airborne noise for residences

People's reaction to noise from construction would depend on the time of day that works are undertaken. Night time works has the potential to disturb sleep. Noise from work during evenings, Saturday afternoons, Sundays and public holidays can also interrupt certain leisure activities.

The rating background level (RBL) is used when determining the management level. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). **Table 5** from the ICNG presents the relevant criteria for the residential noise sensitive receivers however the nearest receivers are about 1200 metres from the proposal.

Table 5 | Residential - Construction noise management level

<table>
<tr><th>Time of day</th><th>Management level LAeq (15 min) [1]</th><th>How to apply</th></tr>
<tr><td rowspan="2">Recommended standard hours:

Monday to Friday
7 am to 6 pm

Saturday
8 am to 1 pm

No work on Sundays or public holidays</td><td>Noise affected (RBL + 10 dB)</td><td>The noise affected level represents the point above which there may be some community reaction to noise.
▪ Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level.
▪ The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.</td></tr>
<tr><td>Highly noise affected 75 dBA</td><td>The highly noise affected level represents the point above which there may be strong community reaction to noise.
▪ Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account:
1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences).
2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.</td></tr>
<tr><td>Outside recommended standard hours</td><td>Noise affected (RBL + 5 dB)</td><td>▪ A strong justification would typically be required for works outside the recommended standard hours.
▪ The proponent should apply all feasible and reasonable work practices to meet the noise affected level.
▪ Where all feasible and reasonable practices have been applied and noise is more than 5 dB (A) above the noise affected level, the proponent should negotiate with the community.</td></tr>
</table>

4.1.3 Non-residential sensitive noise receptors

Table 6 from the ICNG presents the noise management levels at the boundary of non-residential receivers surrounding the site applies when properties are being used.

Table 6 | Non-residential construction noise management levels

Land use	Noise management level LAeq (15min) dBA
Places of worship	45 (Internal) 55 (External)[2]
Industrial	75
Commercial	70

[1] Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence. Based on the guidance of the World Health Organization (WHO) the difference between internal noise levels and external noise levels is around 15dB with windows open for adequate ventilation.

[2] A conservative estimate of the difference between internal and external noise levels is 10 dB as per ICNG.

4.2 Operational noise level

The NCG establishes criteria for three project types, with this project falling under Minor works. The Pacific Highway is termed as a Freeway and Weakleys Drive/ John Renshaw Drive are considered as Arterial roads as per the definition in RNP.

Target noise abatement levels for existing roads near minor works (freeway/ arterial road type) is given below in **Table 7** (NCG, 2014).

Table 7 | Target noise abatement levels for existing roads near minor works

Existing road category	Target noise level dBA Day (7am – 10pm)	Target noise level dBA Night (10pm – 7am)
Freeway/ Arterial/ sub-arterial road	$L_{Aeq\ (15hour)}$ 60 (external)	$L_{Aeq\ (9hour)}$ 55 (external)

Road traffic noise criteria for non-residential land uses affected by proposed road projects and traffic generating developments is shown in **Table 8** (NCG, 2014).

Table 8 | Road traffic noise assessment criteria for noise sensitive receivers

Noise sensitive receivers	Target noise level dBA Day (7am – 10pm)	Target noise level dBA Night (10pm – 7am)
Places of worship	$L_{Aeq\ (1\ hour)}$ 40 (internal)	$L_{Aeq\ (1\ hour)}$ 40 (internal)

Due to the high external ambient noise level and the types of Industrial and commercial properties surrounding the site, they are excluded from the operational assessment as they are not considered noise sensitive receivers in the RNP.

As outlined in **Section 1.3.3** due to residential properties being located more than 600 metres away from the site they have been excluded from the assessment.

In summary the noise assessment criteria for places of worship are:

- Internal noise criteria of $L_{Aeq\ 1hour}$ 40 dBA (internal) which equates to $L_{Aeq\ 1hour}$ 50 dBA (external) with windows closed.
- If the increase of total noise (built and no built condition) by more than 2dBA for minor works near an existing road, then apply the Target noise abatement levels.
- Target noise abatement levels for existing road is L_{Aeq} period 60 dBA in the day and 55 dBA at night) at the boundary of the sensitive receiver.

4.3 Sleep disturbance

Sleep disturbance, due to road traffic noise, has been the subject of numerous research studies. The main noise characteristics that influence sleep disturbance are the number of noisy events heard distinctly above the background level, the emergence of these events and the highest noise level (RNP). Sleep disturbance criteria are generally considered as the assessment of any noise likely to occur during the night time. The two most relevant documents to define the sleep disturbance criteria are the RNP and GCN.

In the RNP, OEH reviewed current research on sleep disturbance and concluded that the range of results was so diverse that there was insufficient evidence and therefore it was not reasonable to issue a new noise criteria for sleep disturbance.

From research, the RNP recognised that current sleep disturbance criterion of an LA1 (1 minute) not exceeding the LA90 (15 minute) by more than 15 dBA is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, OEH would continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.

The detailed analysis should cover the maximum noise level or LA1, (1 minute), that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night time period. Some guidance on possible impact is contained in the review of research results in the appendices to the ECRTN.

The L_{A1}, (1 minute) descriptor is meant to represent a maximum noise level measured under 'fast' time response, however analysis based on either L_{A1}, (1 minute) or L_A, (Max) would also be accepted. If the above screening criterion of L_{A90}, (15 minute) + 15 dBA is exceeded further review of the noise source is recommended.

The WHO has published guidelines which make reference to a number of studies on sleep disturbance. The general conclusions provided in the GCN suggest that for continuous noise, the sound pressure level should not exceed 30 dBA indoors, and for intermittent noise sources (short term or transient noise events), maximum levels (L_{Amax}) should not exceed 45 dBA internally for more than 10-15 times per night.

The sleep disturbance criteria is outlined in **Table 9** and the conclusions made in the RNP are as follows:

- Maximum internal noise levels below 50-55 dBA are unlikely to cause awakening reactions.
- One or two events per night with maximum internal noise levels of 65-70 dBA are not likely to affect health and well-being significantly.

Table 9 | Sleep disturbance criteria

Item	ECCW RNP 2011 - Maximum Internal noise level dBA	WHO GCN 1999 - LAmax dBA
Noise criteria	50 - 55	L_{A90} + 15 dBA

4.4 Vibration criteria

4.4.1 Human comfort

OEH developed, *Assessing vibration: A Technical Guideline* in February 2006 to aid in protecting people from vibration levels above preferred and maximum values felt inside buildings. The guideline does not however address vibration induced damage to structures or building contents or structure-borne noise effects. Vibration and its associated effects with regards to human comfort are usually classified as continuous, impulsive or intermittent as follows:

- Continuous vibration occurs uninterrupted for a defined period (usually throughout day time and/or night time). This type of vibration is assessed on the basis of weighted rms (Root Mean Square) acceleration values presented in the guideline.
- Impulsive vibration is a rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration. It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds. Impulsive vibration is assessed on the basis of weighted rms acceleration values presented in the guideline.
- Intermittent vibration can be defined as interrupted periods of continuous or repeated periods of impulsive vibration or continuous vibration that varies significantly in magnitude. It may originate from impulse sources or repetitive sources or sources which operate intermittently, but which would produce continuous vibration. This type of vibration is assessed on the basis of vibration dose value.

- Construction activity typically consists of all three types of vibration, depending on the construction equipment and operations being undertaken.

4.4.1.1 Continuous and impulsive vibration

The maximum allowable magnitudes of building vibration provided in the Technical Guideline with respect to human response are shown in **Table 10**.

Table 10 | Criteria for exposure to continuous and impulsive vibration with respect to human comfort

Location	Assessment period	Preferred Peak velocity (mm/s)	Maximum Peak velocity (mm/s)
Continuous vibration			
Residences	Day time	0.28	0.56
	Night time	0.20	0.40
Offices, schools, educational institutions and places of worship	Day time or Night time	0.56	1.1
Workshops	Day time or Night time	1.1	2.2
Impulsive vibration			
Residences	Day time	8.6	17.0
	Night time	2.8	5.6
Offices, schools, educational institutions and places of worship	Day time or Night time	18.0	36.0
Workshops	Day time or Night time	18.0	36.0

4.4.1.2 Intermittent vibration

Disturbance caused by intermittent vibration would depend on its duration as well as its magnitude. This method involves the calculation of a Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of bursts of intermittent vibration. Various studies have shown that VDV assessment methods far more accurately assess the level of disturbance than methods which assess the vibration magnitude only.

The VDV is the fourth root of the integral of the fourth power of vibration with respect to time. The VDV represents an 'amount' of vibration. In assessing the VDVs, criteria detailed in BS6472:1992 *Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80Hz*' are used, however the base values and multiples are converted into VDVs assuming constant levels over a 15 hour day and a 9 hour night. The resulting VDV criteria are shown in **Table 11**.

Table 11 | Acceptable vibration dose values for intermittent vibration (m/s1.75)

Location	Time Period	**Low Probability of Disturbance** ($m/s^{1.75}$)
Residential	Day (7:00am – 10:00pm)	0.2 - 0.4
	Night (10:00pm – 7:00am)	0.13 - 0.26

4.4.2 Structural damage

Vibration generated by operation and construction activities can travel though the ground and cause nearby building structures to vibrate. This may cause damage to the building structure ranging from minor hairline cracking to major structural cracking.

The German Standard DIN4150-3 *Structural Vibration Part 3 – Effects of vibration on structures* is used to assess the structural damage on residential/ commercial and heritage buildings. **Table 12** outlines the frequency-dependant vibrational criteria for residential and commercial properties.

Table 12 | Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration

Type of Structure	Guideline values for velocity in mm/s			
	Vibration at the foundation at a frequency of			Vibration at horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and building of similar design and/or occupancy	5	5 to 15	15 to 20	15

At frequencies above 100Hz, the values given in column 50Hz to 100 Hz in the table above may be used as minimum values. Construction activities typically occur between 10Hz to 50Hz based on previous measurements conducted by Aurecon at construction sites.

5 Assessment

5.1 Construction methodology

Table 13 lists the expected details of construction works to be carried out for the proposal.

Table 13 | Construction itinerary and assumptions

Item	Description	Details
Duration of construction activities	About 9 months	2 months of services relocation/ early works, 7 months for actual works
Day evening and night time operations[3]	■ Day time: ■ Evening time: ■ Night time:	■ Relocation of services, Earthworks associated with lane widening ■ No works planned ■ Majority of work, ie milling, small construction and asphalting (within existing road lanes and islands)
Construction hours	■ Day: ■ Night:	■ Standard construction hours ■ 10 pm to 5 am (7 days a week)
Stages of work	■ Early works: ■ Earthworks: ■ Milling: ■ Small construction: ■ Asphalting:	■ Relocation of services ■ Clearing of vegetation, removal of unsuitable material, placing and compaction of material followed by asphalting associated with lane widening ■ Existing asphalt and breaking up to median concrete ■ Drainage structures, street lighting, ITS, temporary and permanent barriers, landscape/ urban design ■ Vast majority of work
Any specific noisy activity during night time	Reverse beeping	Reverse beeping for excavators, milling, asphalt laying/ compaction
Percentage of time Equipment operational during worst case 15 minute duration	Varies between 100% - 25%	-
Barrier attenuation from intervening buildings for receivers R1 and R2	3 dBA attenuation	-

[3] As per NSW Industrial Noise Policy, day (7am – 6pm), Evening (6pm – 10pm), night (10pm – 7am)

Table 14 indicates the expected construction equipment, time of day equipment would be used and the typical Sound Power Levels of each. Typical construction equipment noise levels have been primarily obtained from AS 2436 – 2010, *Guide to noise and vibration control on construction, demolition and maintenance sites*. Other equipment may be used, however it is anticipated that they would produce similar noise emissions.

Table 14 | Construction equipment

Construction item	Description	Equipment used	Sound Power Level dBA
Early works	Relocation of services D	1 x 10-20 tonne excavator 2 x delivery trucks 1 x horizontal borer	107 108 108
Main works	Earthworks D	2 x 10-20 tonne excavator 6 x delivery trucks 1 x grader 1 x compactor	107 108 110 113
	Milling and breaking up median N	1 x milling machine 3 x delivery trucks 1 x road sweeper 2 x jackhammers 1 x 20-30 tonne excavator	116 108 75 121 110
	Small construction D&N	1 x 10-20 tonne excavator 2 x delivery trucks 1 x mobile crane	107 108 104
	Asphalting N	2 x asphalt machines 8 x delivery trucks 2 x vibratory rollers 2 x road sweeper	111 108 108 75

Note: D - Day time works, N – Night time works

5.2 Construction noise prediction

The noise level from the various construction stages has been calculated based on the theoretical maximum cumulative noise impact. The magnitude of the noise during the construction phase of the proposal would vary and depend on the:

- Type and size of construction equipment used onsite.
- Number of equipment operating.
- Intensity and location of the activities onsite.
- Traffic changes due to traffic control management, workforce movements and delivery of materials.

It should be noted that the predicted levels in this section are worst case for each of the above construction items listed in **Table 14** and include adjustments for annoying activities outlined in the ICNG. The prediction methodology takes into account individual items of equipment operating simultaneously as well as the percentage of time (100 per cent for this prediction) each item of equipment in use during a 15 minute period.

In order to provide a conservative estimate, the assessment assumes that each item of equipment would be operating at maximum capacity and considers the distance between the equipment in operation and the assessment location to be the minimum distance between the proposal and the nearest sensitive receiver (see **Table 1** for distance). Screening provided by buildings and topography has been taken into account for the two church (R1 and R2) receivers.

The magnitude of the noise emissions during the construction of the project may vary and would depend on the number of machines operating, the intensity and exact working location of the equipment. It would be unlikely for all of the plant and equipment to be running simultaneously in the same location; and the nature of activities onsite is expected to vary during the course of construction.

The predicted levels in **Table 15** provides a theoretical maximum cumulative (worst case) noise impact. **Table 15** also presents a summary of the construction noise predictions in accordance with AS 2436-2010.

Table 15 | Predicted construction noise impacts at noise sensitive receivers (without any noise mitigation measures)

Activity/ Stage	Mobile plant/ equipment	Predicted noise levels (worst Case) $L_{Aeq\ 15min}$ dBA				
Receiver locations*		R1	R2	R3	R4	R5
Noise Management Levels (Day & Night) dBA		55	55	70	70	70
Relocation of services D&N	10t Excavator	48	50	65	66	72
	Delivery truck	49	51	66	67	73
	Horizontal borer	49	51	66	67	73
	Cumulative noise level	53	55	70	71	77
Earthworks D	10t Excavator	48	50	65	66	72
	Delivery truck	49	51	66	67	73
	Grader	51	53	68	69	75
	Compactor	54	56	71	72	78
	Cumulative noise level	57	59	74	75	81
Milling and breaking up median N	Milling (pavement)	58	60	75	76	82
	Delivery truck	49	51	66	67	73
	Road sweeper	14	16	31	32	38
	Jackhammer	57	59	74	75	81
	20t Excavator	51	53	68	69	75
	Truck	49	51	66	67	73
	Cumulative noise level	62	64	78	79	85
Small construction D&N	10t Excavator	48	50	65	66	72
	Delivery truck	49	51	66	67	73
	Mobile crane	45	47	62	63	69
	Cumulative noise level	53	54	69	70	76
Asphalting N	Asphalt rotomill	52	54	69	70	76
	Delivery truck	49	51	66	67	73
	Vibratory roller	47	49	64	65	71
	Road sweeper	14	16	31	32	38
	Cumulative noise level	55	57	71	72	78

Note: Values in red cells exceed the construction management level. D - Day time works. N – Night time works.

Table 15 shows that construction noise management levels are exceeded for some activities at all locations. Most of the works would be conducted during night time however the earthworks would be conducted mostly during the day time. All the sensitive receivers in close proximity to the works would be non-operational during night time therefore it is expected that most of the noise impacts from the proposal would not impact any sensitive receivers during night time.

Earthworks may exceed the noise management levels at noise sensitive receivers during the day. If exceeded, community reaction to noise during the recommended standard construction hours is likely to occur. In order to minimise the likelihood of adverse reaction to construction noise, the standard noise mitigation measures outlined in **Section 6** should be undertaken to achieve the predicted noise levels in **Table 16**.

It should be noted that noise exceedances outside of standard working hours, as shown in the yellow highlighted squares below are considered compliant as sensitive receivers would be non-operational during night time construction works.

Table 16 | Predicted construction noise impacts at noise sensitive receivers (with standard noise mitigation measures)

Activity/ Stage	Mobile plant/ equipment	Predicted noise levels (worst Case) $L_{Aeq\ 15min}$ dBA				
Receiver locations*		R1	R2	R3	R4	R5
Noise Management Levels (Day/ Night) dBA		55	55	70	70	70
Relocation of services D&N	10t Excavator	44	46	60	61	67
	Delivery truck	45	47	61	62	68
	Horizontal borer	45	47	61	62	68
	Cumulative noise level	49	51	65	66	72
Earthworks D	10t Excavator	44	46	60	61	67
	Delivery truck	45	47	61	62	68
	Grader	47	49	63	64	70
	Compactor	50	52	66	67	73
	Cumulative noise level	53	55	69	70	76
Milling and breaking up median N	Milling (Pavement)	54	56	70	71	77
	Delivery Truck	45	47	61	62	68
	Road sweeper	10	12	26	27	33
	Jackhammer	53	55	69	70	76
	20t Excavator	47	49	63	64	70
	Cumulative noise level	58	60	73	74	80
Small construction D&N	10t Excavator	44	46	60	61	67
	Delivery truck	45	47	61	62	68
	Mobile Crane	41	43	57	58	64
	Cumulative noise level	49	50	64	65	71
Asphalting N	Asphalt rotomill	48	50	64	65	71
	Delivery Truck	45	47	61	62	68
	Vibratory roller	43	45	59	60	66
	Road sweeper	10	12	26	27	33
	Cumulative noise level	51	53	66	67	73

Note: Values in yellow exceed the construction management level during non-standard hours but the sensitive receivers would be non-operational during night time and therefore are compliant.
D - Day time works. N – Night time works.

Noise impact at the sensitive receiver boundary of R5 may exceed the noise management levels during the day time earthworks, relocation of services and small construction works. Refer to Section 6.2 for additional noise mitigation measures in accordance with Transport for NSW's (TfNSW) Construction Noise Strategy. However the existing noise levels near R5 (Commercial / light industrial properties) measured between 58 dBA (UA-2) and 71 dBA (UA-3), therefore it is unlikely that temporary construction noise impacts from these day works would cause significant adverse effects on the people working inside the facility.

5.3 Operational noise prediction

The current ambient noises within the study area are dominated by road traffic and industrial source noises. Current traffic data volumes are summarised in **Table 17** and have been sourced from two documents:

- Roads and Maritime 2004 Annual Average Daily Traffic (AADT) data report.
- Hyder, M1 Pacific Motorway Intersection Upgrade at Weakleys Drive & John Renshaw Drive Traffic Modelling on Strategic Concept Design, Report No. AA006517, Prepared for RMS, May 2015).
- The Hyder analysis documents the results of an assessment for 2019 and 2029 based on natural two per cent growth trend and has predicted a traffic reduction through the M1/ Weakleys Drive intersection in the order of 20 per cent after 2029 (assuming that the M1 to Raymond Terrace Link (M12RT) is constructed.

M1/Weakleys Drive intersection is currently used by 15 per cent heavy vehicles in AM (7 – 8am) and eight per cent in PM peaks (4 – 5pm).

Table 17 | Traffic AADT 2004 to 2029

Roads	Vehicles per hour (Peak)				
	2004 Existing (RMS)	**2014 Existing (Hyder)**	**2019 Without proposed M12RT[4] (Hyder)**	**2029 Without proposed M12RT (Hyder)**	**2029 With proposed M12RT (Hyder)**
M1 Pacific Motorway (Black Hill)	33,000/ 24 = 1375	AM – 2550 PM - 2837	AM – 2690 PM - 2990	AM – 3060 PM - 3370	AM – 2490 PM - 2720
Weakleys Drive	19,750/24 = 823	AM – 3526 PM - 3853	AM – 3910 PM - 4240	AM – 4560 PM - 5100	AM – 3570 PM - 3880
John Renshaw Drive	28,020/24 = 1168				

Note: AM – represents 7:00am - 8:00am peak traffic conditions PM – represents 4:00pm - 5:00pm peak traffic conditions

5.3.1 Scenarios

Various scenarios for calculating the traffic noise potential impact (present/ future) from natural traffic growth were undertaken and shown in **Table 18**. The traffic noise scenarios that were calculated included the year of opening (2019) and predictions for 10 years after opening (2029).

Table 18 | Prediction scenarios

Scenarios	Year	M1 Weakleys Drive/ John Renshaw	Proposed M12RT Link project
Case 1	2014	Existing scenario based on the traffic counts conducted by Hyder Consulting.	Not assumed
Case 2	2019	Predicted future scenario of opening of M1 Weakleys Drive/ John Renshaw Drive upgrade	Not assumed
Case 3	2029	Predicted future scenario 10 years after opening of M1 Weakleys Drive/ John Renshaw Drive upgrade	Not assumed
Case 4	2029		Assumed

[4] M12RT Link (M1 Pacific Motorway to Raymond Terrace upgrade) was modelled according to the Concept Design documented in the F3 Freeway to Raymond Terrace Upgrade Pacific Highway – Concept design Submissions Report (RMS, December 2010). The analysis indicated that proposed M12RT link would reduce peak hour flows at the M1/ Weakleys Drive intersection in the order of 1,000 Vehicles (in 2019) to 1,200 (in 2029) respectively.

Calculation of traffic noise was undertaken using Calculation of Road Traffic Noise (CoRTN) method. The CoRTN calculation takes into account various parameters summarised in **Table 19**.

Table 19 | Model parameters

Model parameters	Description
Traffic volume	Refer to **Table 17**
Traffic speed (Average)	40km/h[5]
Percentage of heavy vehicles	15% AM, 8% PM
Type of road surface	Asphalt (dense grade type)
Road gradient	None
Ground absorption	100% hard ground
Receiver location height	1.5 metres above external ground level
Receiver distance from the road edge (R2)	175 metres
Shielding from ground topography and intervening structures	yes (as per the current site conditions)

Results of the traffic noise impact in accordance with CoRTN is summarised in **Table 20**.

Table 20 | Traffic noise impact prediction in accordance with CoRTN for Christian Outreach Centre

Scenarios	LA10 (1hr) AM	LA10 (1hr) PM	LAeq (1hr)[6] AM	LAeq (1hr)[7]PM
Case 1 (2014)	39	37.8	36	34.8
Case 2 (2019)	39.5	38.3	36.5	35.3
Case 3 (2029)	40.2	39.1	37.2	36.1
Case 4 (2029)	39.1	37.9	36.1	34.9

It is evident from **Table 20** that the noise impact from natural traffic growth during a worst case scenario (Peak traffic conditions) would be well below the stipulated criteria of $L_{Aeq\ 1hr}$ 55 dBA at the external façade of the Christian Outreach Centre (R2). Increase of total noise (2014/ 2029 scenario) as per the CoRTN predictions is 1.2 dBA (AM) and 1.3 dBA (PM) which is less than 2 dBA. Therefore operational noise increase would be from natural traffic growth, not the proposal, and at the boundary of the most sensitive receiver the proposal would comply with the RNP stipulated criteria.

5.3.2 Features of interrupted versus free flowing traffic

Traffic noise is among the most extensively studied fields of noise pollution based on the level of influence traffic has on people irrespective of them living in urban, suburban or rural areas. Various noise prediction models have been developed to assess and predict noise propagation from road networks for free-flowing traffic conditions and road intersections. Noise predictions for intersections are not easy to assess due to complexity of traffic dynamics when the vehicle approaches/ exit the intersection.

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[5] Average speeds for vehicles approaching a roundabout is a complex phenomenon which depends on the peak traffic flow and exiting traffic in the roundabout. As a conservative approach we have assumed an average speed of 40 km/h for all vehicles approaching/ exiting the roundabout during peak traffic flow.

[6] Based on the previous traffic noise measurements there has been a 3 dBA difference between observed between L_{A10} and L_{Aeq} results, where L_{Aeq} being the lower quantity.

[7] Based on the previous traffic noise measurements there has been a 3 dBA difference between observed between L_{A10} and L_{Aeq} results, where L_{Aeq} being the lower quantity.

Based on previous studies/ projects on operational road noise near intersections and the paper presented by Aurecon at the international acoustic conference Inter.noise2014 (Melbourne) *Noise modelling of road intersections*, there was evidence of 2 - 4 dBA increase at the edge of the road (this level difference can change based on specific site conditions including design speeds, road type, etc)[8] observed near an intersection (roundabout) which was changed to signalised intersection keeping the traffic count the same. The difference in noise was mainly attributed to non-stopping vehicles going straight at high velocity during green light and stop/ go vehicles trapped into queues approaching the roundabout.

The closest noise sensitive receiver for this project is about 175 metres from proposal with some intervening industrial/ commercial buildings which could act as noise barriers. Therefore the noise increase at the boundary of the churches (R1/R2) may increase by less than 2 dBA due to the proposal changing the existing intersection into a signalized intersection.

5.4 Vibration assessment

Sydney Trains Environmental Management System – Construction and Maintenance Noise and Vibration Management guideline(Jan 2014) provides estimates of vibration levels of construction equipment and safe distance for operating the equipment near a sensitive property summarised in **Table 21** below.

Table 21 | Safe working distances for typical equipment

Plant	Rating/ description	Cosmetic damage (m)		Human response (m)
		Residential	Industrial	
Vibratory Roller	< 50kN (Typically 1-2T)	5	2	15-20
	< 100kN (Typically 2-4T)	6	2	20
	< 200kN (Typically 4-6T)	12	3	40
	< 300kN (Typically 7-13T)	15	4	100
	> 300kN (Typically 13-18T)	20	6	100
	> 300kN (> 18T)	25	8	100
Small Hydraulic Hammer	(300kg – 5-12T excavator)	2	<1	7
Medium Hydraulic Hammer	(900kg – 12-18T excavator)	7	2	23
Large Hydraulic Hammer	(1,600kg – 18-34T excavator)	22	7	73
Hydraulic Jacking Rig	-	1.5	<1	Avoid contact with structure
Vibratory Rig	50kJ per cycle	30	8	100
	10kJ per cycle	15	3.5	100
Pile Boring	≤ 800mm	2	<1	N/A
Jackhammer	Handheld	1m nominal	<1	Avoid contact with structure

The German Standard DIN4150-3 (**Table 12**) provides the vibration criteria at the foundation of a building at various frequency ranges to prevent damage to structures.

[8] CoRTN Chart 4 (Correction for mean traffic speed V and percentage heavy vehicles, p) also provides guidance on change in noise level with the change in vehicular speeds.

The nearest industrial property (R5) is located 20 metres from the proposal construction site, and no adverse vibration impacts are expected on the property based on the safe distances for typical equipment mentioned above.

It is important to note that the levels in **Table 12** are considered conservative, ie vibration levels that exceed the limits would not necessarily translate into structural damage. Most commonly specified “safe” structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure.

5.5 Sleep disturbance assessment

As there are no residential properties within the study area (within 600 metres), there is no requirement for sleep disturbance assessment for this project.

6 Recommendations

The NMG outlines the approach Roads and Maritime takes to the evaluation, selection and design of feasible and reasonable noise mitigation measures. Noise impacts and mitigation measures are evaluated at various stages of a proposal to inform the approval and design process.

Below are some of the noise management measures that would be employed for minimising construction noise and vibration at the nearest sensitive receivers. Work practices that minimise noise levels on site and provide for proper communication with the community are generally the most effective at managing noise.

6.1 Construction safeguards and mitigation measures

The safeguards and management measures for construction activities are listed in **Table 22**.

Table 22 | Safeguards and management measure for construction noise and vibration issues

Impact	Environmental safeguard	Responsibility	Timing	Standard / additional safeguard
Noise and vibration	A Noise and Vibration Management Plan (NVMP) will be prepared and implemented as part of the CEMP. The NVMP will generally follow the approach in the *Interim Construction Noise Guideline* (ICNG) (DECC, 2009) and identify: • All potential significant noise and vibration generating activities associated with the activity. • Feasible and reasonable mitigation measures to be implemented, taking into account Beyond the Pavement: urban design policy, process and principles (Roads and Maritime, 2014). • A monitoring program to assess performance against relevant noise and vibration criteria. • Arrangements for consultation with affected neighbours and sensitive receivers, including notification and complaint handling procedures. • Contingency measures to be implemented in the event of non-compliance with noise and vibration criteria.	Contractor	Detailed design / pre-construction	Core standard safeguard NV1 Section 4.6 of QA G36 Environment Protection
Impacts on sensitive receivers – Path controls	Stationary noise sources should be enclosed or shielded where feasible and reasonable whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of AS 2436:2010 lists materials suitable for shielding	Contractor	Construction	Standard safeguard
Site induction	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All project specific and relevant standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on high noise generating activities • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures.	Contactor	Construction	Standard safeguard
Behavioural practices	• No swearing or unnecessary shouting or loud stereos/radios on site. • No dropping of materials from height, throwing of metal items and slamming of doors.	Contactor	Construction	Standard safeguard

Equipment Selection	• Use only the necessary size and power. • Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. • Ensure vehicles are fitted with a maintained Original Equipment Manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard. • Ensure plant including the silencer is well maintained.	Contactor	Pre-construction/ Construction	Standard safeguard
Plant noise levels	• The noise levels of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the criteria in Appendix H of the RMS Construction Noise and Vibration Guideline (2016). • Implement a noise monitoring audit program to ensure equipment remains within the more stringent of the manufacturers specifications or Appendix H.	Contactor	Construction	Standard safeguard
Rental plant and equipment.	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in Table 2 of the RMS Construction Noise and Vibration Guideline (2016).	Contactor	Construction	Standard safeguard
Use and siting of plant.	• The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. • Plant used intermittently to be throttled down or shut down. • Noise-emitting plant to be directed away from sensitive receivers. • Only have necessary equipment on site.	Contactor	Construction	Standard safeguard
Plan worksites and activities to minimise noise and vibration.	• Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site. • Where additional activities or plant may only result in a marginal noise increase and speed up works, consider limiting duration of impact by concentrating noisy activities at one location and move to another as quickly as possible.	Contactor	Construction	Standard safeguard
Non-tonal and ambient sensitive reversing alarms	• Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. • Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.	Contactor	Construction	Standard safeguard

Minimise disturbance arising from delivery of goods to construction sites.	• Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. • Select site access points and roads as far as possible away from sensitive receivers. • Dedicated loading/unloading areas to be shielded if close to sensitive receivers. • Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible. • Avoid or minimise these movements during the day where possible.	Contactor	Construction	Standard safeguard
Plan worksites and activities to minimise noise and vibration.	Very noisy activities should be scheduled for night working hours. If the activities cannot be undertaken during the night, if feasible the activities should be started after 4pm.	Contactor	Construction	Additional safeguard
Impacts on sensitive receivers – Notification	All noise sensitive receivers likely to be affected will be notified at least five (5) days prior to commencement of any works associated with the activity that may have an adverse noise impact. The notification could be provided as a letterbox drop, phone call or individual briefing. The notification will provide details of: • The project. • The construction period and construction hours. • Contact information for project management staff. • Complaint and incident reporting. • How to obtain further information. Have a documented complaints process, including an escalation procedure so that if a complainant is not satisfied there is a clear path to follow.	Contactor	Construction	Additional safeguard

6.2 Additional noise mitigation measures

Section 8 of the Transport for NSW's (TfNSW) Construction Noise Strategy outlines additional mitigation measures in circumstances where noise management levels are still exceeded after the application of standard noise mitigation measures shown in sections above.

Table 23 | Additional noise mitigation measures for airborne construction noise

Time period	Mitigation measures: $L_{eq, 15 min}$ noise level above background (RBL) Qualitative assessment of noise levels			
	0-10 dBA Noticeable	10-20 dBA Clearly audible	20-30 dBA Moderately intrusive	>30 dBA Highly intrusive
Standard: Mon – Fri (7am – 6pm) Sat (8am – 1pm)	-	-	LB, M	LB, M
OOHW Period 1: Mon – Fri (6pm – 10pm) Sat (7am – 8am, 1pm –10pm) Sun/PH (8am – 6pm)	-	LB	LB, M	M, IB, LB, PC, SN, RO
OOHW[9] Period 2: Mon – Fri (10pm – 7am) Sat (10pm – 8am) Sun/PH (6pm – 7am)	LB	LB, M	M, IB, LB, PC, SN	AA, M, IB, LB, PC, SN

Notes: AA – Alternative accommodation, M – monitoring, IB – Individual briefings, LB – letter box drops, RO – project specific respite offer, PC – phone calls, SN – specific notification.

Implementation of the mitigation measures for all activities (about 5-10dBA reduction) resulted in reduced levels at the boundary of sensitive receivers. These are assessed against the measured background noise levels (RBL) to identify which additional mitigation measures to apply. Table 24 outlines the additional noise mitigation measures required in the vicinity of the worst case sensitive receivers in accordance with the TfNSW Construction Noise Strategy.

Table 24 | Additional noise mitigation measures to be implemented

Sensitive receiver	Type	Additional mitigation measures	When	Activity	Applicable receivers/ activity
R5	Commercial/ Industrial	Letter box drops	Standard hours	Relocation of services, Earthworks, Small construction works	Coates Hire, 15 Kullara Close, Beresfield, NSW 2322 Minister Beresfield, 30 Kullara Close Beresfield, NSW 2322

[9] Out Of Hours Work

7 Conclusion

This acoustic report presents assessment of the construction and operational noise and vibration associated with the proposed M1 Weakleys Drive John Renshaw Drive upgrade works.

Based on the noise assessment, the predicted construction noise impact for all the stages of work for the proposal would comply with the stipulated noise criteria as per DECC ICNG after employing standard mitigation measures at all sensitive receivers except at R5 (Commercial / light industrial properties). Therefore it is advised that the additional mitigation measures identified in Section 6.2 be undertaken during the works to minimise the effect on R5.

There is a very low risk of the vibration impact criteria being exceeded during the construction works and therefore no specific mitigation measures are required.

Operational noise due to both the natural traffic growth increase to 2029 and the change of the intersection into a signalised intersection would comply with the stipulated noise criteria in accordance with RNP at all sensitive receivers. There is no requirement for any noise mitigation measures for operational noise control.

Appendix A
Glossary of terms

Sound Pressure Level (Lp) – Sound or noise is the sensation produced at the ear by very small fluctuations in atmospheric pressure. The human ear responds to changes in sound pressure over a very wide range (from 20 microPascals to 60 Pascals). A scale that compresses this range to a more manageable size and that is best matched to subjective response is the logarithmic scale, rather than a linear scale.

Sound Pressure Level (Lp) is defined as:

$$L_P = 10\log_{10}\left(\frac{p^2}{p_{ref}^2}\right) dB$$

In the above equation, *p* is the sound pressure fluctuation (above or below atmospheric pressure), and p_{ref} is 20 microPascals (2 x 10^{-5} Pa), the approximate threshold of hearing. To avoid a scale which is too compressed, a factor of 10 is included, giving rise to the decibel, or dB for short.

A-Weighted Decibel (dB(A)) & Loudness – The overall level of a sound is usually expressed as dB(A), instead of dB. The sound is measured using an A-weighted filter, which is incorporated into the sound level meter. The filter is used to approximate the response of the human ear. It reduces the significance of lower frequencies and very high frequencies, thereby increasing the importance of mid-frequencies (500Hz to 4kHz), and being a good measure of the “loudness” of a sound.

A change of 1 to 2dB(A) is difficult to detect, whilst a change of 3 to 5dB(A) corresponds to a small but noticeable change. A 10dB(A) change corresponds to a doubling or halving in apparent loudness.

C-Weighted Decibel (dB(C)) – In some circumstances, the sound pressure level is expressed as C-Weighted decibels, instead of the more common A-Weighted. The C-Weighting filter is designed to replicate the response of the human ear above 85 dB, and places a greater weighting on low frequency noise.

L_{Aeq} is the time averaged A-weighted sound pressure level for the interval, as defined in AS1055.1. It is generally described as the equivalent continuous A-weighted sound pressure level that has the same mean square pressure level as a sound that varies over time. It can be considered as the average sound pressure level over the measurement period.

L_{Ceq} is the time averaged C-weighted sound pressure level for a time interval, as defined in AS1055.1. It is generally described as the equivalent continuous C-weighted sound pressure level that has the same mean square pressure level as a sound that varies over time. It can be considered as the average sound pressure level over the measurement period.

L_{An} is the sound level, which, for a specified time interval, in relation to an investigation of a noise, means the A-weighted sound pressure level that is equalled or exceeded for n% of the interval. Commonly used percentages are 1, 10, 90 & 99%.

L_{Cpk} is the peak C-weighted sound pressure level for a time interval.

$L_{Cmax,T}$ is the average maximum C-weighted sound pressure level, which, for the specified time interval, means the C-weighted sound pressure level during the interval obtained by using the fast time weighting and arithmetically averaging the maximum sound levels of the noise during the interval. Under certain conditions the 10th percentile noise level, $L_{C10,T}$, can represent the average maximum C-weighted sound pressure level.

Octave frequency bands allow a representation of the spectrum associated with a particular noise. They are an octave wide, meaning that the highest frequency in the band is just twice the lowest frequency, with all intermediate frequencies included and all other frequencies excluded. Each octave band is described by its centre frequency.

Maximum Exposure Time (Hours) is the maximum possible time a person can be safely exposed to a specific noise level (L_{Aeq}).

Appendix B
Calculation sheets

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