ACOUSTICS AND AIR

NUNDAH BANK

NOISE AND VIBRATION COMPLIANCE MONITORING

REPORT NO. 10073-N
VERSION B

DECEMBER 2013

PREPARED FOR

AUSTRALIAN RAIL TRACK CORPORATION
20 NEWTON STREET
BROADMEADOW NSW 2292

WILKINSON MURRAY

DOCUMENT CONTROL

Version	Status	Date	Prepared By	Reviewed By
A	Draft	8 January 2014	Luke Warren	Adam Bioletti
B	Final	22 January 2014	Luke Warren	-

Note

All materials specified by Wilkinson Murray Pty Limited have been selected solely on the basis of acoustic performance. Any other properties of these materials, such as fire rating, chemical properties etc. should be checked with the suppliers or other specialised bodies for fitness for a given purpose. The information contained in this document produced by Wilkinson Murray is solely for the use of the client identified on the front page of this report. Our client becomes the owner of this document upon full payment of our **Tax Invoice** for its provision. This document must not be used for any purposes other than those of the document's owner. Wilkinson Murray undertakes no duty to or accepts any responsibility to any third party who may rely upon this document.

Quality Assurance

We are committed to and have implemented AS/NZS ISO 9001:2008 "Quality Management Systems – Requirements". This management system has been externally certified and Licence No. QEC 13457 has been issued.

Certified System
Quality
ISO 9001
SAI GLOBAL

AAAC

This firm is a member firm of the Association of Australian Acoustical Consultants and the work here reported has been carried out in accordance with the terms of that membership.

Association of Australian Acoustical Consultants

Celebrating 50 Years in 2012

Wilkinson Murray is an independent firm established in 1962, originally as Carr & Wilkinson. In 1976 Barry Murray joined founding partner Roger Wilkinson and the firm adopted the name which remains today. From a successful operation in Australia, Wilkinson Murray expanded its reach into Asia by opening a Hong Kong office early in 2006. 2010 saw the introduction of our Queensland office and 2011 the introduction of our Orange office to service a growing client base in these regions. From these offices, Wilkinson Murray services the entire Asia-Pacific region.

50 YEARS 1962–2012

TABLE OF CONTENTS

GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

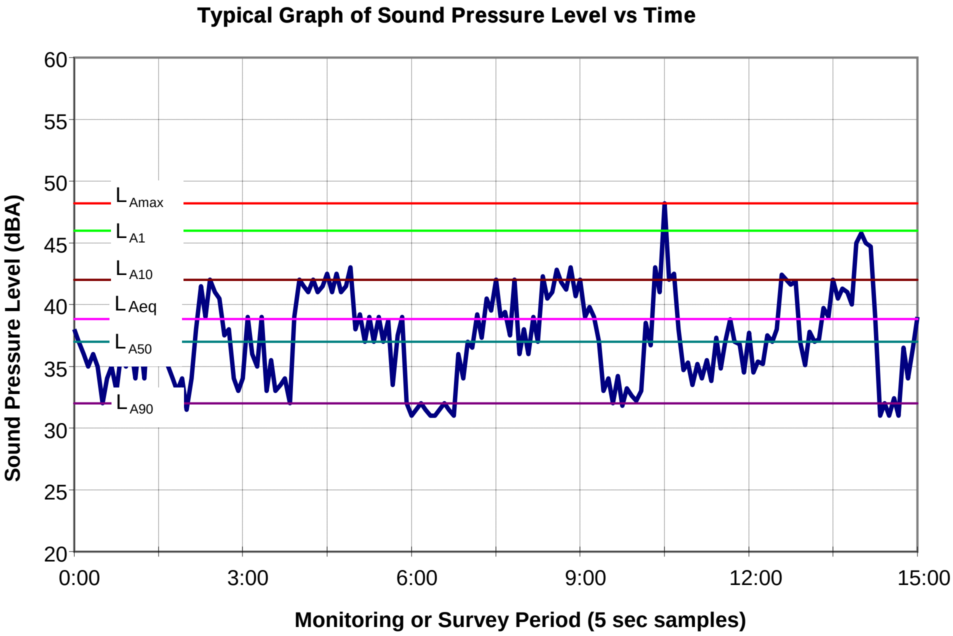
L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.



1 INTRODUCTION

Wilkinson Murray has undertaken operational noise and vibration monitoring of the Nundah Bank Third Track Project to address the Ministers Condition of Approval (MCoA) (Conditions D2,D3,D4 and D5).

Condition D2 of the Project's approval conditions requires compliance with the following criteria.

The Proponent shall design and operate the project with the objective of not exceeding the airborne and ground-borne noise trigger levels associated with the project at sensitive receivers as presented in the Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects (DECC and DoP, 2007).

Condition D3 of the Project's approval conditions requires the following.

The Proponent shall design and operate the project with the objective of not exceeding, at receivers, the vibration goals for human exposure as presented in Assessing Vibration: A Technical Guideline (DECC, 2006) and German Standard DIN 4150 for structural vibration impacts.

Condition D4 of the Project's approval conditions requires the following.

"The Proponent shall undertake noise and vibration compliance monitoring and assessment to confirm compliance with the goals and limits identified in condition D2 and D3. The monitoring and assessment shall be undertaken in consultation with the OEH and the Department and will:

a) identify sensitive receivers within the immediate proximity of the project,

b) identify noise and vibration goals at sensitive receivers consistent with the requirements of condition D2 and D3;

c) identify a monitoring and assessment methodology, including representative monitoring locations; and

d) consider complaints received relating to operational noise and vibration impacts.

The noise and vibration monitoring and assessment shall be undertaken prior to the commencement of operations, 1 and 5 years from the commencement of operations."

The process of compliance monitoring involves the comparison of "with Project" and "without Project" rail noise levels at sensitive receivers. Effectively comparisons will be made at two intervals, consistent with the approval conditions stated above: at one year post-commencement of operations and at five years post-commencement of operations.

This report details operational noise monitoring at one year post-commencement of operations.

2 SITE DESCRIPTION

The Project is located in a rural area north of Singleton. The site location is shown in Figure 2-1.

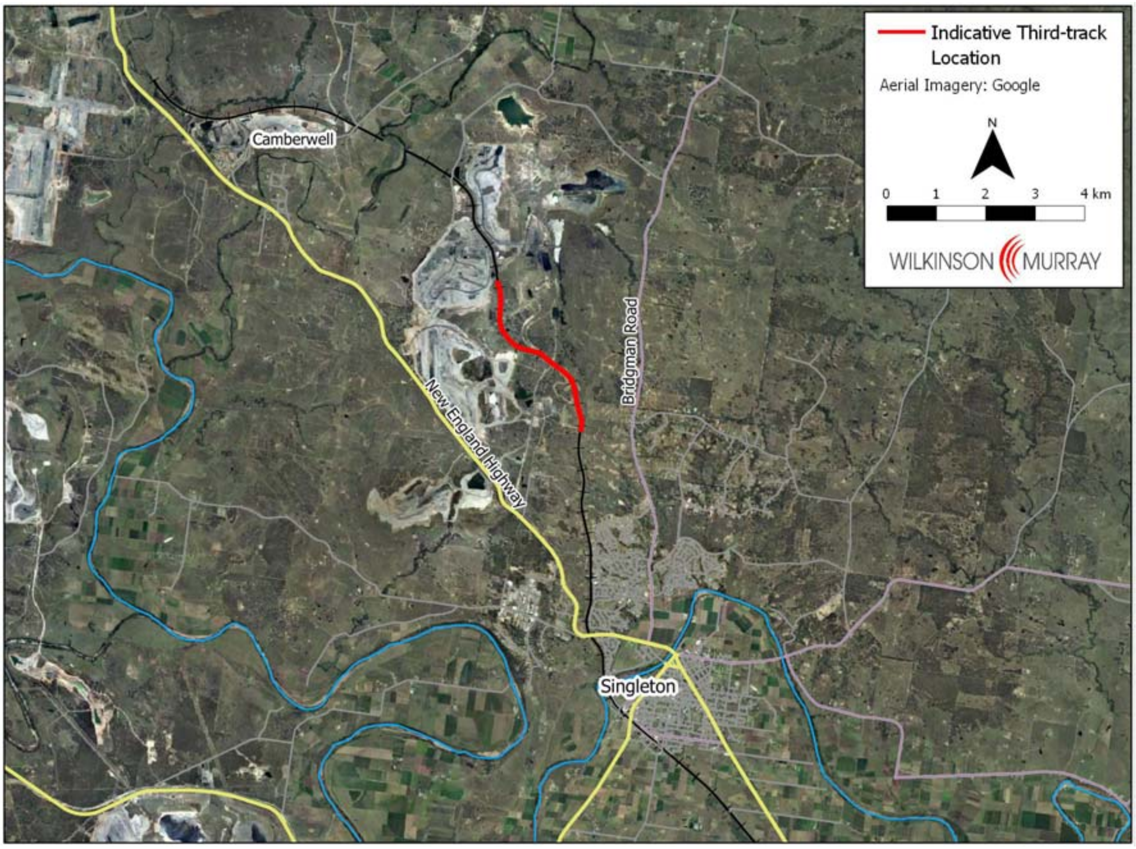
The site surrounds are generally rural in nature with few residential receivers surrounding the rail corridor. The area surrounding the Project also includes the Rix's Creek Coal Mine to the west, and its associated infrastructure.

The nearest two receivers as identified in the pre-construction monitoring have been considered in this assessment, these are:

- 427 Bridgman Road – Access to 427 Bridgman Road was not available, so the noise logger was installed at the adjacent property 411 Bridgman Rd.
- Dulwich House, Falbrook.

In addition to the above receiver locations, noise monitoring was also undertaken at a control location - Location A – approximately 140m setback from the rail line. This location is consistent with the control location at which monitoring was undertaken as part of the Project's EA.

Figure 2-1 Project Location



2.1 Rail Traffic

Table 2-1 shows current and estimated future numbers of train operations on the line [Source: Table 3-1 *EA Noise and Vibration Assessment*].

Table 2-1 Current and Future Train Numbers [Source: 2013 PHOENIX data supplied by ARTC for logging period / 2018 Prediction Table 3-1 *EA Noise and Vibration Assessment*]

Train Type	Train pass-bys per 24 hours					
	2013			2018		
	Day 7am-10pm	Night 10pm-7am	Total 24-hour	Day 7am-10pm	Night 10pm-7am	Total 24-hour
Freight (Coal and non-coal)	63	44	107	128	76	204
Passenger	8	2	10	8	2	6
Total	**71**	**46**	**117**	**132**	**78**	**210**

3 NOISE & VIBRATION CRITERIA

3.1 Operational Noise Criteria

The EA determined applicable criteria in accordance with the NSW Environment Protection Agency (EPA, formerly known as the Office of Environment and Heritage) *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects* [*IGANRIP*] (2007). These criteria are summarised in Table 3-1.

Table 3-1 Airborne Rail Traffic Noise Trigger Levels for Residential Land Uses
[Source: Extract of Table 1 of the DECCW's *IGANRIP*]

Type of Development	Day (7am – 10pm)	Night (10pm – 7am)	Comment
Redevelopment of existing rail line	Development increases existing rail noise levels **and** resulting rail noise levels exceed:		These numbers represent external levels of noise that trigger the need for an assessment of the potential noise impacts from a rail infrastructure project.
	65 $L_{Aeq(15hr)}$ 85 L_{Amax}	60 $L_{Aeq(9hr)}$ 85 L_{Amax}	An 'increase' in existing rail noise levels is taken to be an increase of 2 dBA or more in L_{Aeq} in any hour or an increase of 3 dBA or more in L_{Amax}.

The definition of an 'increase' of existing rail levels in Table 3-1 is not completely clear in IGANRIP, particularly in the case where the number of movements is likely to increase due to developments not associated with the proposal. However in undertaking this assessment, guidance has been taken from the NSW Rail Infrastructure Noise Guideline (RING) which succeeds IGANRIP.

RING confirms that the determination of the 'increase' due to the development is to be made by comparing noise levels of like times both with and without the development.

IGANRIP states that the trigger levels apply to the time immediately after opening and also at a time up to 10 years in the future.

As the trains are distributed evenly throughout the 24 hour period, the $L_{Aeq,period}$ increase has been assumed to be synonymous with the $L_{Aeq,1hr}$ increase and as such the $L_{Aeq,1hr}$ is not considered separately. This directive was given by ARTC and is consistent with the *RING*.

Note that this interpretation differs from that adopted in the Project's EA. We consider that this interpretation supersedes that which was adopted in the EA and subsequently this will be adopted in this and future compliance monitoring/assessments associated with the Project. We note also that the Project's conditions of approval are not explicit in this regard, nor do they condition the criteria detailed in the EA. Therefore it is considered that the decision to apply the most recent (and believed correct) interpretation of *IGANRIP* is not in opposition to the Project's conditions of approval.

3.1 Operational Vibration Criteria

When assessing vibration there are two components that require consideration:

- human exposure to vibration; and
- the potential for building damage from vibration.

3.1.1 Human Exposure to Vibration

The EPA's *Assessing Vibration: A Technical Guideline* provides guidance for assessing human exposure to vibration. The publication is based on British Standard BS 6472:1992. Vibration from train passbys is intermittent vibration and is best assessed by the Vibration Dose Value (VDV) which is based on the *weighted* root mean quartic (rmq) acceleration. Research has shown that the VDV can be adequately approximated by the estimated vibration dose value (eVDV) for vibration exhibiting a crest factor (the ratio between peak and rms acceleration) below 6. Typically, train vibration has a crest factor well below 6 and thus the eVDV is a suitable assessment parameter.

BS 6472:1992 provides the following advice on the probability of adverse comment resulting from various values of eVDV.

Table 3-2 Probability of Adverse Comment Resulting from VDV in Residences
[Source: Table 7, Appendix A, BS 6472:1992]

Period	Low Probability of Adverse Comment	Adverse Comment Possible	Adverse Comment Probable
Day (7am – 10pm)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Night (10pm – 7am)	0.13	0.26	0.51

For operational vibration, the EA adopted values expected to have a low probability of adverse comment as vibration goals.

3.1.2 Building Damage from Vibration

The EA adopted vibration criteria described by DIN 4150 for the evaluation of the potential for building damage from vibration. Table 3-3 summarises the goal levels specified in DIN 4150.

With regard to these levels DIN 4150 states:

"Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible. Exceeding [these] *values does not necessarily lead to damage; should they be significantly exceeded, however, further investigations are necessary."*

Table 3-3 Guideline Values for Vibration Velocity to be used when Evaluating the Effects of Short-Term Vibration on Structures
[Source: Table 1, DIN 4150-3:1999]

Type of Structure	Guideline Values for Velocity – PPV (mm/s)		
	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
Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20
Structures that, because of their particular sensitivity to vibration, cannot be classified under either of the other classifications and of great intrinsic value	3	3 to 8	8 to 10

For train passbys the vibration is typically in the frequency range of 31.5 – 100 Hz and is dependant on speed, wheel condition and rail condition. Because the dominant frequency of vibration cannot be determined with certainty, the EA adopted a goal level 5 mm/s for the nearest residences.

4 MEASURED NOISE AND VIBRATION LEVELS

Unattended noise and vibration measurements were undertaken between Thursday, 12th December 2013 and Thursday, 19th December 2013. Weather conditions were favourable for environmental noise logging throughout the measurement period with nil rain recorded and low wind speeds observed at Singleton and Cessnock airport.

4.1 Measurement Locations

Noise and vibration monitoring was undertaken at 3 locations:

- R1 – 411 Bridgman Rd (adjacent to 427 Bridgman Road at similar setback to rail line.)
- R2 – Dulwich House, Falbrook
- Monitoring Location A (calibration location at 140m setback from rail line)

Measurement Locations are shown in Figure 4-1.

4.2 General Measurement Procedure

The following describes the general measurement procedure undertaken.

1) Unattended noise monitoring utilised an environmental noise logger with audio recording capability. The noise logger recorded one-tenth of a second A-weighted and C-weighted SPLs with “FAST” time weighting, and a digital recording of real-time audio saved in (lossless) wav file format for the duration of the monitoring.
2) Microphones were positioned in free-field locations at mid-window height of the uppermost storey.
3) Unattended vibration monitoring utilised equipment that stored the PPV vibration level every 1 to 6 seconds.
4) Detailed analysis of the unattended monitoring data was undertaken following collection of the equipment and using a semi-automated processing methodology developed by Wilkinson Murray. The analysis involved:
   (a) the automatic identification of possible train events based on the characteristic noise level history of rail events. Wav files corresponding to identified events were also extracted during this stage;
   (b) visual inspection of 30-minute SPL-history plots to confirm that all apparent rail events had been identified;
   (c) aural verification that each of the identified events were from rail operations. Those events that were identified as being extraneous were eliminated from further analysis;
   (d) aural analysis of rail events to identify relative contributions from rail sources (e.g. rolling noise, gearbox whine, locomotive engine/exhaust, wheel squeal etc.).
   (e) reanalysis of events identified as containing extraneous noise such as horns, traffic or birds. For analysis, periods containing extraneous noise were excluded (see Appendix B for screenshots of the exclusion process);

(f) calculation of noise parameters relevant to rail operations – being L_{AFmax} from the one-tenth second SPL-history;

(g) calculation of rail noise summary descriptors $L_{Aeq,day}$, $L_{Aeq,night}$ and the 95th Percentile L_{AFmax};

(h) analysis of vibration data by an automated routine, with identified events confirmed against those aurally identified in the noise analysis; and

(i) calculation of rail vibration summary descriptors.

A key feature of the above system is that sound pressure levels and wav file audio are recorded for the duration of the measurement period, and not only when events are triggered by a predetermined sound pressure level. This process results in far greater quality of data, especially in elevated ambient noise environments, because trigger levels are not required to be determined during installation, thus negating the loss of data due to incorrectly set triggers and/or a variable ambient noise environment

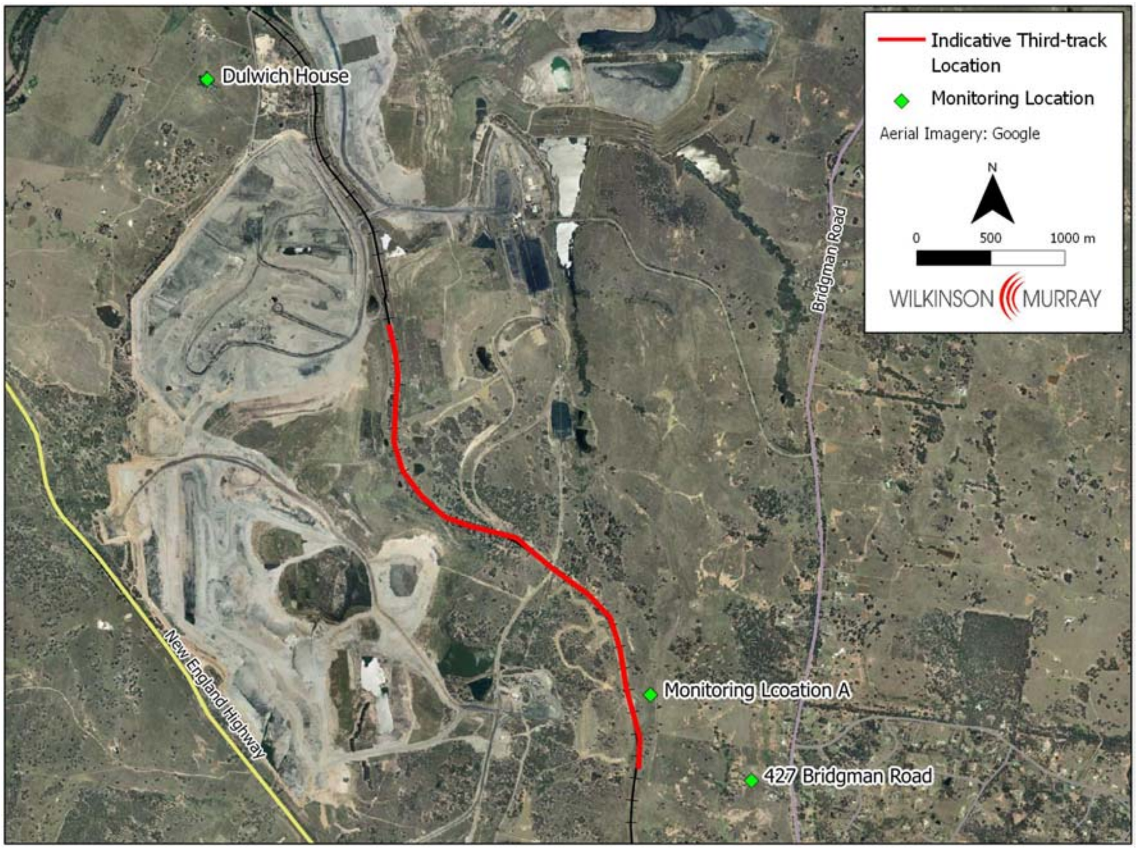
4.3 Measurement Equipment

The noise monitoring equipment used for these measurements consisted of three ARL Ngara environmental noise loggers set to A-weighted, fast response, continuously monitoring over 15-minute sampling periods. This equipment is capable of remotely monitoring and storing one-tenth second noise levels for later detailed analysis. The equipment calibration was checked before and after the survey and no significant drift occurred.

The noise loggers also recorded the sound level every one-tenth of a second as well as recording audio files at high quality. This time-history of sound pressure level allows individual rail events to be identified.

A Texcel ETM vibration monitor was set to record maximum peak particle velocity (PPV) in each of the three orthogonal axes (x, y and z) every minute and was located at Location A, installed adjacent to the noise logger.

Figure 4-1 Measurement Locations – Location A, 427 Bridgman Road and Dulwich House



4.4 Results

A summary of the measured rail noise descriptors are presented in

Table 4-1. Results are presented exclusively for the residential receivers .

Up to 820 trains were measured during the seven day study, averaging 117 per 24hr period. This is far greater than the rail traffic observed in previous monitoring of the Project, however it is consistent with forecasts which were used in the EA.

Train Movements at 411 Bridgman Road (indicative logging location of 427 Bridgman Rd) were audible at times, but difficult to measure above ambient noise levels with the exception of L_{Amax} levels from some locomotives. This is consistent with previous pre- and post-construction noise measurements at this location.

Note that monitoring at 411 Bridgman Road was interrupted by a resident because the monitor had been mistakenly placed on their land. As such the monitoring at this location commenced approximately 1 day after the other two locations. Given the difficulty in measuring train events at this location, and the subsequent limited reliance on results from this location, the reduced dataset is not considered to have influenced the outcome of this assessment.

As the measurements were undertaken in free-field locations, a façade correction of +2.5dB has been applied.

Table 4-1 Summary of Measured Train Events Day $L_{Aeq,15hr}$ – dBA

Location ID	Pre-operation (February 2013) Measured Level	1-year Post-completion (December 2013) Measured Level	*IGANRIP* Trigger Level	*IGANRIP* Trigger
R1	N/M[1]	N/M[1]	>65dBA and >2 dB 'increase'	-
R2	41.6[1]	49.8[1]		NO

Notes: 1. L_{Aeq} level over the measurement period.
2. L_{Aeq} from rail events could not be determined at R1 due to ambient noise.
3. N/M = not measurable.

Table 4-2 Summary of Measured Train Events Night $L_{Aeq,9hr}$ – dBA

Location ID	Pre-operation (February 2013) Measured Level	1-year Post-completion (December 2013) Measured Level	*IGANRIP* Trigger Level	*IGANRIP* Trigger
R1	N/M[1]	N/M[1]	>60dBA and >2 dB 'increase'	-
R2	46.0[1]	52.3[1]		NO

Notes: 1. L_{Aeq} level over the measurement period.
2. L_{Aeq} from rail events could not be determined at R1 due to ambient noise.
3. N/M = not measurable.

Table 4-3 Summary of Measured Train Events Day L_{AMax} – dBA

Location ID	Pre-operation (February 2013) Measured Level	1-year Post-completion (December 2013) Measured Level	*IGANRIP* Trigger Level	*IGANRIP* Trigger
R1 [2]	64.6	63.7	>85dBA and >3 dB 'increase'	NO
R2	81.0	79.9		NO

Notes: 1. L95% L_{Amax} over the measurement period.

Table 4-4 Summary of Measured Train Events L_{AE} – dBA

Location ID	1-year Post-completion (December 2013) Measured Level	Pre-operation (February 2013) Measured Level	Pre-construction (2010) Measured Level	Increase
R1	N/M	N/M	N/M	-
R2	80.8	79.9	N/M	NO
Loc. A [3]	85.0	88.8	89.3	NO

Notes: 1. Energy Average L_{AE} level over the measurement period
2. N/M = not measureable; L_{AE} from rail events could not be determined at R1 due to ambient noise.
3. Free-field L_{AE} is presented at Location A.

The measured $L_{Aeq,day}$, $L_{Aeq,night}$, and L_{Amax} noise levels were all below 'base' *IGANRIP* triggers. Thus compliance was demonstrated at both receivers.

4.5 Measured Vibration Levels

The vibration monitor recorded the peak particle velocity (PPV) in each of the three orthogonal axes. To simplify the analysis the maximum component (i.e. the greatest magnitude PPV on any of the three axes) was calculated and is reported. This is considered to be representative of the maximum resultant PPV.

Measured vibration levels at Location A from rail movements were below 0.2mm/s indicating that they were well within both structural damage and human comfort levels.

Based on results of vibration monitoring during previous studies, which showed that rail vibration was undetectable at the R1 and R2, vibration monitoring was undertaken at Location A only.

5 CONCLUSION

Wilkinson Murray has undertaken operational noise and vibration monitoring adjacent to the Nundah Bank Rail Project to satisfy the 1-year compliance monitoring requirements of the Consent Conditions.

This report details this monitoring and provides results. Measured noise levels were within the *IGANRIP* base trigger levels that were determined in the EA, and therefore compliance with this criterion has been achieved.

Measured vibration levels were consistent with previous measurements. As such we have concluded that vibration levels are well within the 'Goal Levels' that were adopted for assessing potential building damage and protecting human comfort at the nearest residence.

Operational compliance with the noise and vibration criteria presented in the Ministers Condition of Approval (MCoA) (Conditions D2, D3, D4 and D5) has been demonstrated as a result of this monitoring.

We note that the MCoA requires post-completion operational noise monitoring at a period 5 year after commencement. Measured rail noise levels have been well below criteria in each of the past assessments. Unless rail traffic increases by more than 300% it is unlikely that rail noise levels would approach criteria in the next 4 years. As such it is our judgement that further operational noise monitoring offers little benefit to the Project or the community. Therefore further monitoring should only be considered in the event of complaints relating to rail noise from the Project, if a substantial growth in rail traffic is experienced or if strict compliance with the MCoA are required.