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MOOREBANK INTERMODAL TERMINAL PROJECT

Best Practice Wagon Report (Condition G6B)

5 November 2019

QUBE Holdings

TJ741-04F02 (r10) Best Practice Wagon Report.docx

Document details

Detail	Reference
Doc reference:	TJ741-04F02 (r10) Best Practice Wagon Report.docx
Prepared for:	QUBE Holdings
Address:	Level 27, 45 Clarence Street Sydney NSW 2000
Attention:	[redacted]

Document control

Date	Revision history	Non-issued revision	Issued revision	Prepared	Instructed	Authorised
22.11.2018	Preliminary draft for discussion	-	0	[redacted]		
15.02.2019	Revised draft	-	1	[redacted]		
04.04.2019	Final draft including bogie benchmarking study and additional details relating to ECP braking	-	2	[redacted]		
08.04.2019	Final draft for consultation	3	4	[redacted]		
15.04.2019	Final for consultation	-	5	[redacted]		
16.04.2019	Additional QUBE comments	-	6	[redacted]		
28.05.2019	Update based on TfNSW comments	-	7	[redacted]		
19.06.2019	Final	-	8	[redacted]		
16.07.2019	Update based on DPE Comments	-	9	[redacted]		
05.11.2019	Update to section 2.5	-	10	[redacted]		

Contents

1 Introduction

The Moorebank Intermodal Terminal (IMT) involves the development of intermodal freight terminal facilities at Moorebank in south-west Sydney, linked by rail to Port Botany and the interstate rail network. The Project includes the IMT, a rail link connecting the IMT to the Southern Sydney Freight Line (SSFL) and road entry and exit points along Moorebank Avenue.

An Environmental Impact Statement (EIS) for the IMT was prepared and exhibited in 2014. Following the preparation of a Submissions Report and a Supplementary Response to Submissions Report in 2015, the project was approved by the NSW Planning Assessment Commission in 2016. Construction works commenced in 2017.

The final approval for the Moorebank IMT[1] includes conditions which relate to operational noise from freight trains. Renzo Tonin & Associates was engaged by QUBE to provide specialist acoustic advice relating to Condition G6b, which is copied verbatim below:

> *G6. Port shuttle operations must use:*
>
> *b) Wagons that incorporate available best practice noise technologies, such as "one-piece" freight bogies or three-piece freight bogies fitted with cross-bracing or steering arms; and permanently coupled 'multi-pack' steering wagons using Electronically Controlled Pneumatic (ECP) braking with a wire based distributed power system (or better practice technology). Prior to the commencement of operation, the Applicant must submit a report to the Secretary for consideration and approval that has been prepared in consultation with TfNSW and the EPA that justifies the technology proposed and how it meets the objective of best practice noise technologies.*

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.

[1] State Significant Development (SSD) Approval 6766. Revised Conditions of Consent issued from the Land and Environment Court, 2018 (https://majorprojects.accelo.com/public/998577dee30a161b8647d256fe5bcd69/Court%20decision%20-%20MPE%20Stage%201%20Consent.pdf accessed 21/5/2019)

2 Wagons that incorporate available best practice noise and emission technologies

This section relates to available best practice noise technologies for wagons and provides justification on how best practice is proposed to be implemented on the Moorebank IMT project.

2.1 Background information on curve squeal

According to Ref 2, *"In NSW, curve squeal generated from freight operation has been the greatest source of complaints associated with freight rail operations making up approximately two thirds of all freight rail noise-related complaints received by Transport for NSW"*.

Curve squeal is a highly tonal noise that sometimes occurs when rolling stock navigates sharp (small radius) curves. The likelihood of curve squeal occurring increases with smaller curve radii and longer wheelbases. According to Ref 3, curve squeal does not normally occur when the curve radius R > 100b (with b the bogie wheelbase). For typical one-piece bogies or three-piece bogies with good steering characteristics, this translates to a curve radius of around 200 m. Other studies (e.g. Ref 4) indicate that curve squeal may occur on bogies with poor steering characteristics at larger curve radii (up to 600 m).

The proposed rail link between the SSFL and the IMT includes several curves. The location of these curves and radii are provided on the site map in Appendix B. The risk of curve squeal is greatest for the 160 m radius curve between the rail link and the southbound connection with the SSFL.

As part of TfNSW's Strategic Noise Action Program (SNAP), a systematic approach to the management of freight noise in NSW included a comprehensive study which examined the cause of squeal noise on small radius curves[5]. The study included the installation of a noise monitor and Angle of Attack (AoA) monitoring system on a 300 m radius curve on the Main North Line at Beecroft. Over a three year period, from 04/2013 to 04/2016, a dataset including more than 1,000,000 wheel passes were measured and analysed. Of these many wheel passes, 2,490 severe squeal events (noise levels greater than 120 dB(A) at 1.2 m from the near rail) were detected[6]. A summary of the key findings from the TfNSW study is provided below:

- Squeal is associated with specific classes of freight wagons, and that these wagons constitute only around 5 % of the total vehicle fleet. Specifically, the bogies on these classes of wagons are unable to rotate under the wagon body to negotiate curves, causing the side frames to

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[2] Jiang, J., Hanson, D. & Dowdell, B. Acoust Aust (2015) 43: 233. *At-Source Control of Freight Rail Noise: A Case Study* https://doi.org/10.1007/s40857-015-0026-3

[3] Thompson, D.: *Railway Noise and Vibration: Mechanisms, Modelling and Means of Control*. Elsevier, Oxford (2009)

[4] Basutu, L., Hanson, D. & Schulten, C. Acoust Aust (2015) *Modelling Curve Gain in NSW*

[5] Hanson, D., Jiang, J., Dowdell B. & Dwight, R. Internoise 2014, *Curve Squeal: Causes, Treatments and Results*

[6] Jiang J., Hanson D., Dowdell B. (2018) *Wheel Squeal: Insights from Wayside Condition Monitoring*. In: Anderson D. et al. (eds) Noise and Vibration Mitigation for Rail Transportation Systems. Notes on Numerical Fluid Mechanics and Multidisciplinary Design, vol 139. Springer, Cham

warp and thereby imposing a high AoA. Curve squeal is always associated with abnormal bogie steering behaviour whereas bogies that steer properly generally do not squeal.

- Squeal from freight wagons is caused by the warping of three piece bogies due to an inability of the bogie bolster to rotate to negotiate the curve. Rotation can be improved by reducing the friction at the centre plate, either through lubrication or a wear liner. A more effective strategy is to eliminate warping of three piece bogies altogether through the use of cross bracing or steering arms, and many wagons operating on the NSW network already include these features. Generally, wagons with cross bracing, steering arms or rigid frames do not generate curve squeal.

- Centre plates of coal wagons in NSW often employ polymer liners to reduce wear, but intermodal wagons typically have unlubricated, steel-on-steel centre plates. The effectiveness of polymer liners in addressing bolster rotation issues was proven through a trial conducted in 2014 by TfNSW and a national freight operator (Ref 5). Following the implementation of polymer liners, no wheels returned a positive AoA and no wheels squealed. Based on subsequent discussions with TfNSW[7], more recent measurement results show that wagons fitted with polymer liners still generate high AoA. TfNSW is working with operators to implement additional measures on wagons fitted with polymer liners to ensure they comply with the AoA performance requirements in Ref 8.

- There was no or extremely low incidence of severe squeal when the AoA was less than 10 mrad (10 milliradian). Squeal incidence increased linearly with increasing AoA in the range from 10 to 35 mrad, and then experienced a more rapidly increase when the AoA exceeded around 35 mrad (Ref 5).

2.2 ASA wagon bogie steering requirements

Section 2.7.1 of Asset Standards Authority Standard T HR RS 00400 ST[8] provides details in relation to the mandatory requirements for bogie AoA and steering performance. Section 2.7.1 of the ASA Standard is copied verbatim below:

> *Wagon steering performance is assessed in terms of the angle of attack (AoA) of the wheelset when the bogie traverses curves. The AoA presented by the wheelsets of any freight bogie, measured at any wayside system on the RailCorp network, shall remain within acceptable limits throughout the service life of the bogie. This includes when the bogie is new and overhauled and when the bogie is at its wear limits.*
>
> *Acceptable AoA is defined as being less than a value given by the following equation:*

[7] E-mail correspondence with TfNSW, 8/5/2019

[8] Transport for NSW Asses Standards Authority T HR RS 00400 ST *RSU 400 Series – Minimum Operating Standards for Rolling Stock – Freight Vehicle Specific Interface Requirements* Version 2.0 dated 24 August 2017

AoA = 2.5 x Bwb / R

Where, AoA is angle of attack (Rad), Bwb is bogie wheel base (m) and R is radius of track curvature (m)

Note: At the Beecroft AoA detector on the Up Main North at 26.675 km (310 m radius curve), for a typical freight bogie, this corresponds to an acceptable AoA of <15 mrad.

This limit will be applied from 01 January 2018. Any wagon that exceeds the AoA limit at any wayside detection system on the RailCorp network from this date shall be held in breach and TfNSW will issue a notification of breach to the operator.

The operator shall, within 12 months from the day TfNSW has notified the breach to the operator, either:

- *Rectify the performance of the wagon; or,*
- *Submit a plan to rectify the performance of the wagon to the satisfaction of the Lead Rolling Stock Engineer, ASA. The timeline for rectification shall be no longer than the next scheduled overhaul of the bogies on the wagon.*

If the operator fails to satisfy these requirements, then the affected wagon shall not be operated on the RailCorp Network until its steering performance has been rectified to the satisfaction of the Lead Rolling Stock Engineer, ASA.

ASA reserve the right to restrict wagons from entering, or returning to service, onto the RailCorp Network, where the performance of the wagon's steering is clearly noncompliant, or any corrective actions and assurance is ambiguous.

TfNSW shall provide AoA performance data from wayside systems on the RailCorp Network to freight operators in a timely manner sufficient to allow these operators to monitor the performance of their fleets and to ensure compliance with the AoA performance requirements.

From the ASA standard, it can be seen that the maximum AoA threshold of 15 mrad is similar to the 10 mrad value identified in the TfNSW studies referred to in the previous section, which resulted in no or extremely low incidence of severe squeal.

2.3 Benchmarking Study of Intermodal Wagon Bogies

A benchmarking study was undertaken by Interfleet on behalf of Transport for NSW Freight and Regional Development (2015)[9]. The purpose of the study was to *"determine the best practice that*

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[9] *TfNSW Intermodal Wagon Bogies - Benchmarking Study* - Task No: TA3605/001, Interfleet 6 August 2015

current state of the art can offer, such that the wagons steer properly with low wheel wear, operate at 115km/h without hunting and possess a low whole of life cost".

Further, *"The goal of identifying the benchmark is to provide a target for future procurement and inform standards governing the operation of intermodal traffic in New South Wales"*.

The study examined bogies that are currently used in Australia, Europe, North America and China. One conclusion of the study was that bogies developed for the European market (single piece bogies) are considered to represent too great a shift for the Australian market.

Three-piece bogies are the most common bogie type in North America, South America, Russia, China, India, Australia and much of Africa. Standard three piece bogies without cross bracing steer poorly and generally squeal around small radius curves. This is due to combination of poor rotation and low warp stiffness.

Cross braced three-piece bogies address the key limitations of standard three piece bogies. The cross-bracing permits wheelsets to adjust position in curves, but significantly reduce warping of the frame, improving curving and prolonging wheel and track life. However, curving performance is not as good as steering bogies such as the Scheffel and AR-1.

The study concludes: *"The Scheffel and self steering bogies, such as the AR-1, have been identified as setting the benchmark for curving performance in intermodal bogies. Whilst not possessing the exceptionally high curving capability of the Scheffel bogies, cross braced bogies with their marginal capital cost increase over a standard three piece bogie, and high levels of operational performance, represent a compelling compromise. Hence, this study has determined, both offer performance levels to which intermodal bogies should be expected to meet."*

2.4 Electronically Controlled Pneumatic (ECP) braking

We understand that electronically controlled pneumatic (ECP) braking systems are a current best-practice braking system that allows trains to operate at higher average speeds and carry heavier loads whilst still operating within safety limits[10]. ECP braking uses electronic signals to activate the brake mechanisms throughout the entire train simultaneously, rather than mechanically and progressively down the train.

Ref 2 suggests the use of ECP braking systems as a possible solution to reduce brake squeal and wagon bunching / stretching by ensuring more even brake applications. In relation to the use of ECP braking systems to reduce brake squeal, no measured or otherwise proven evidence has been found in the

[10] Energy Exchange (EX) website - *Electronically controlled pneumatic brakes*, https://www.eex.gov.au/resource/potential-energy-efficiency-opportunities-in-the-australian-road-and-rail-sectors/electronically-controlled-pneumatic-brakes, accessed 22/11/2018

literature to support this proposition. ECP braking systems however may be beneficial in reducing wagon / bunching noise in areas where freight trains accelerate or brake.

The Asset Standards Authority TOC Manual[11] refers to the use of ECP equipped trains. Information in the TOC Manual indicates that ECP braking systems are currently used exclusively on permanently coupled coal wagons, with no current examples of container wagon usage. QUBE has further advised that the use of ECP braking systems is not feasible or reasonable for the following reasons:

- The existing brake equipment on the QUBE wagon fleet is incompatible with ECP systems. Fitting ECP brakes to the existing QUBE wagon fleet would be cost prohibitive. Wagons would need to be removed from service, stripped of all their brake componentry and fitted with the ECP system, wiring and fixtures. The high capital cost of equipment and labour to strip, then fit new systems is not considered reasonable.

- SIMTA is required and committed to operate the MPE Stage 1 Project as a non-discriminatory open access terminal. That means the Import and Export (IMEX) terminal could be accessed by any rail operator within the existing fleet of locomotives and wagons used by the industry. No other operators employ a fleet with ECP-equipped container wagons. It is not feasible or reasonable to require all operators to require the implementation of ECP braking systems.

- Since no existing container wagons in NSW utilise ECP braking systems, the concept of this technology representing "best practice", as required by Condition G6b, isn't a reality.

Given that there is no established link between brake noise and ECP equipped trains, and that ECP braking is not currently employed on container wagons, the use of ECP braking systems for Moorebank IMT trains is not considered feasible or reasonable at this point in time.

2.5 Moorebank IMT commitments to use of best practice freight wagons

The IMT Facility to be developed for the Moorebank East Precinct East (MPE) Stage 1 Project is to be operated by SIMTA. SIMTA has national experience in logistics delivery, property management, and a strong commitment to stakeholder engagement. SIMTA is wholly owned by QUBE Holdings.

SIMTA is required and committed to operate the MPE Stage 1 Project as a non-discriminatory open access terminal. That means the Import and Export (IMEX) terminal could be accessed by any rail operator within the existing fleet of port shuttle locomotives and wagons used by the industry. Therefore, while SIMTA cannot directly influence the technology used by the existing fleet, they can impose reasonable and feasible performance benchmarks for noise emissions for port shuttle locomotives and wagons that enter the IMEX terminal. It is SIMTA's intention to continuously improve, through benchmarking, the environmental performance of port shuttle locomotives and wagons which use the IMEX terminal. This continuous improvement will be based on industry benchmarking to ensure

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[11] Train Operating Conditions (TOC) Manual – General Instructions, Report TS TOC.1 : 2018 issue 3, Version 14.0 12 December 2018

that both a non-discriminatory access arrangement and best practice can be achieved. The benchmarking process will provide reasonable time for the rail operator to ensure that their fleet intended to use the IMEX terminal meet the imposed standard that will be set by SIMTA as the minimum benchmark, from a published date. It was not possible to complete a detailed review of the fleet for the timing of this report as the specific operators intending to use the IMEX terminal for port shuttle operations have not yet been identified. SIMTA has advised that the following wagon and bogie types are likely to be used for port shuttle wagons:

- SQEF (three-piece bogies with cross-bracing)
- SQEY (three-piece bogies with cross-bracing)
- CQBY (three-piece bogies with cross-bracing)
- CQZY (three-piece bogies with cross-bracing)
- LQAY (three-piece bogies with steering arms)

In relation to curve squeal noise, all of these wagons include three-piece bogies with cross-bracing or steering arms. On this basis, these bogies are considered to represent best practice (refer Section 2.3) and are expected to have good steering characteristics around curved track sections with a low risk of curve squeal.

The following commitments are made to reduce the noise impacts from the Rail Link and at other locations on the network:

- The wagon types to be used for port shuttle wagons are three-piece bogies with cross-bracing or steering arms. These bogies represent current best practice, with a low risk of curve squeal at locations with small curve radii.

- Moorebank IMT will only contract to rail service providers who are able to demonstrate that best practice rolling stock (wagons) are being utilised. This will include wagon types designs that are proven to consistently generate low AoA values at TfNSW wayside detection sites in accordance with ASA Standard T HR RS 00400 ST.

- In accordance with approval condition G7, a rail noise monitoring system will be installed on the rail link between the SSFL and the IMT at the commencement of operation to continuously monitor the noise from rail operations on the rail link. The system will capture the noise from each individual train passby. If the noise monitoring system identifies wagons with squeal or high noise emissions, this information will be fed into the Rail Noise Management Plan. Details of the noise monitoring system and Rail Noise Management Plan will be provided in a separate report.

- In accordance with approval condition G7A, a wayside AoA monitoring system will be installed on the rail link at the commencement of operation to continuously monitor the AoA to the rail of rolling stock wheels. G7A will also include knowledge sharing to allow for operators to actively manage their fleet into IMEX and for SIMTA to actively monitor operators compliance with its commitment to best practice. Details of the proposed AoA monitoring system will be provided in a separate report. If the noise monitoring system identifies wagons with a high

AoA, this information will be fed into the Rail Noise Management Plan. Details of the Rail Noise Management Plan will be provided in a separate report.

- ECP braking is not currently used by operators of port shuttle operations. When the container freight industry transitions to technologies that are recognised as more advanced than current best practice for port shuttle rolling stock, either voluntarily or under new regulation imposed by NSW rail and environmental regulators, the development and its operator would welcome such a transition.

- SIMTA will notify operators of any non-compliances with the established AoA or noise limits and impose reasonable and feasible performance benchmarks.

    - Rollingstock Fault Reporting and Maintenance will be performed in accordance with QUBE Standard PCE-185.

    - Train Inspection Procedures will be performed in accordance with QUBE Standard PCE-212.

3 Conclusion

This report has been prepared to address the requirements of Moorebank IMT Approval Condition G6b, which relates to the use of best practice technologies to reduce environmental noise from intermodal freight wagons.

The study provides a review of curve squeal noise and the key design parameters that influence whether bogies are likely to squeal or not when negotiating small radius curves. Investigations by TfNSW and others conclude that squeal noise is primarily related to bogies which have a low warp stiffness and or/poor rotation (approximately 5 % of the total vehicle fleet). At locations with small curve radii, bogies with a low warp stiffness and or/poor rotation have high Angles of Attack (AoA), in the range of 10-15 milliradian or more. This can cause squeal, which is the greatest source of noise complaints relating to freight rail operations in NSW.

Asset Standards Authority Standard T HR RS 00400 ST provides details relating to the mandatory requirements for bogie AoA and steering performance. If a wagon exceeds the AoA limit, operators are notified and are required to rectify non-compliances within specified timeframes.

A best practice review was undertaken by Interfleet in 2015 to *"determine the best practice that current state of the art can offer, such that the wagons steer properly with low wheel wear, operate at 115km/h without hunting and possess a low whole of life cost"*. The study noted that Standard three piece bogies without cross bracing steer poorly and often squeal around small radius curves. On the other hand, Scheffel bogies, self-steering bogies (AR-1) and three-piece bogies with cross-bracing are considered to represent best practice, steer well around curves and do not squeal.

The use of Electronically Controlled Pneumatic (ECP) braking on wagons was investigated as a possible solution to reduce brake squeal, but no evidence was found to support this proposition. Given no established link between brake noise and ECP equipped trains, and that ECP braking is not currently employed on container wagons in NSW, the use of ECP braking systems for Moorebank IMT trains is not considered feasible or reasonable at this point in time. Since no existing container wagons in NSW utilise ECP braking systems, the concept of this technology representing "best practice", as required by Condition G6b, isn't a reality.

Wagons likely to utilise the Moorebank IMT comprise bogie designs that are consistent with best practice. On this basis, the risk of curve squeal is considered low. SIMTA will minimise the potential for poor performing wagons to enter the site where possible.

Other measures that SIMTA will implement to minimise the risk of curve squeal include the installation of an AoA and permanent noise monitoring systems on the rail link. These will monitor the AoA and noise from all trains accessing the IMT. SIMTA will notify operators of any non-compliances with the established AoA or noise limits and impose reasonable and feasible performance benchmarks.

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.
AoA	Angle of Attack - As the wheels on a bogie negotiate a tight curve, the leading wheelset typically presents an Angle-of-Attack (AoA) to the rail. The AoA of a leading wheelset with good steering performance can be calculated from AoA = wheelbase (m) / curve radius (m). AoA is normally measured in milliradian (mrad).
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 A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the “A” filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
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.
Wheelbase	The wheelbase is the distance between the centres of the front and rear wheels on a 2-axle bogie.

APPENDIX B Site map showing location of rail link, curve radii and nearest noise-sensitive receivers

Main South Rail Line + Southern Sydney Freight Line
Moorebank Intermodal Terminal
NCA3 (L11)
Radius 276m
IMT Rail Link
Radius 160m
Radius 244m
Radius 245m
Radius 200m
Radius 200m
Radius 200m
Moorebank Ave Bridge
NCA1
Glenfield Waste Facility
Turnouts 2 lines / 1 line
East Hills Rail Line
NCA4
NCA1 – 19 Wallcliffe Court, Wattle Grove
NCA3 - L11 Glenfield Farm
NCA4 – 30 Goodenough St, Glenfield