ACOUSTICS AND AIR

MERRYLANDS COMMUTER CAR PARKS

REF - NOISE & VIBRATION IMPACT ASSESSMENT

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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.

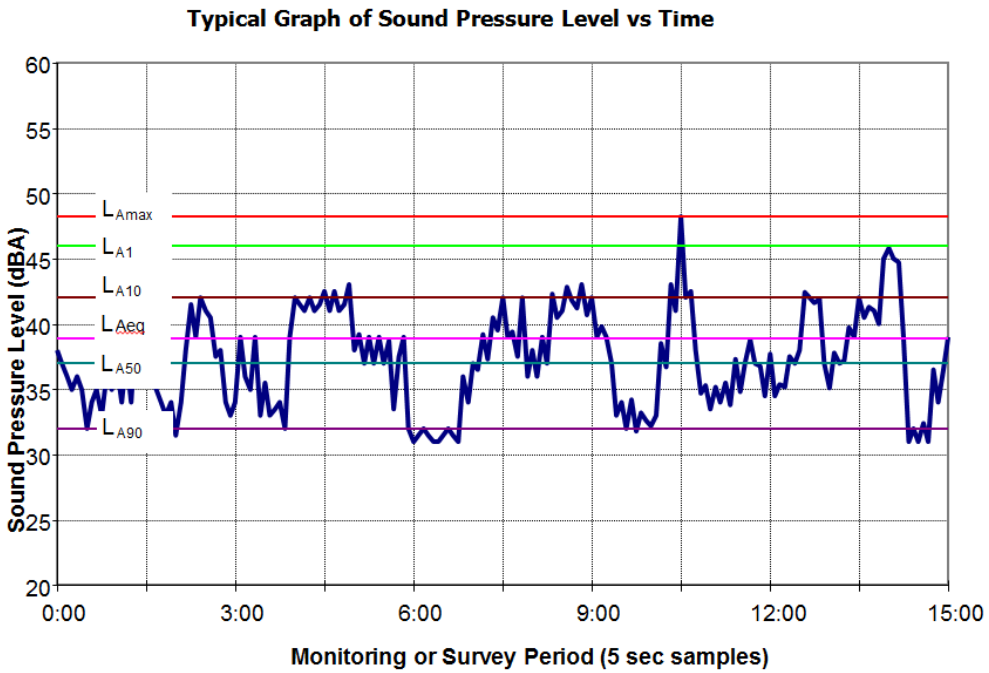
L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

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.



GLOSSARY OF VIBRATION TERMS

Displacement – A vector quantity that specifies the change of position of a body or particle with respect to a reference frame.

Velocity – A vector quantity that specifies the time derivative of displacement.

Acceleration – Acceleration is rate of change of velocity with time usually along a specified axis, usually expressed in m/s^2

Hertz (Hz) – Units in which frequency is expressed. Synonymous with cycles per second.

Decibel – Ratios of identical quantities are expressed in decibel or decibel or dB units. The number of dB is "ratiod" against some standard or reference value in terms of the base 10 logarithm of that ratio. In measuring acoustic or vibration power (as in PSD or ASD of random vibration), the number of dB = 10 log10 P/P_o. P_o, the reference level, equals 0 dB. In measuring the more common voltage-like quantities such as acceleration, the number of dB = 20 log10 E/E_o E_o, the reference level, equals 0 dB.

Peak – Extreme value of a varying quantity, measured from the zero or mean value. Also, a maximum spectral value.

Peak-to-peak value – The algebraic difference between extreme values (as D = 2X).

Duration - Of a shock pulse is how long it lasts. Time is usually measured between instants when the amplitude is greater than 10% of the peak value.

Amplitude – The magnitude of variation (in a changing quantity) from its zero value. Always modify it with an adjective such as **peak, RMS, average**, etc. May refer to displacement, velocity, acceleration.

Crest factor – *Of an oscillating quantity.* The ratio of the peak value to the r.m.s. value.

VDV – The Vibration Dose Value is the accumulation of energy measured over a given time period, proportional to the root mean quad of acceleration. This is usually measured in each of the three axes of motion. In most cases, vibration tends to be higher in the Z (vertical) axis. This is measured with units of $m/s^{1.75}$.

PPV – Peak Particle Velocity is the instantaneous peak of the resultant vector sum of all three axes of motion. Results are expressed in terms of velocity normally mm/s.

Peak Acceleration – This is the peak acceleration level measured in each of the three axes of motion. In some cases, this can also be combined in a vector sum. This is measured in m/s^2.

Accelerometer – A sensor or transducer or pickup for converting acceleration to an electrical signal. Two common types are piezoresistive and piezoelectric.

Charge amplifier – An amplifier which converts a charge input signal (as from an accelerometer) into an output voltage; a charge-to-voltage converter.

Geophone – A sensor or transducer or pickup for converting velocity to an electrical signal.

1 INTRODUCTION

Transport for NSW (TfNSW) proposes to build a new commuter car park as part of the NSW Government's Transport Access Program (TAP). KMH commissioned Wilkinson Murray on behalf of TfNSW to carry out a noise and vibration assessment as part of a Review of Environmental Factors (REF) for the proposed commuter car parks at Merrylands. This report presents a noise and vibration assessment of the proposed commuter car parks at Merrylands, which involves two sites defined as Site 1 and Site 2. The report covers noise and vibration emission from both on-site parking area operations and construction of the proposed development. The use of the car parks by light vehicles would generate a negligible vibrational impact during its operational phase; hence, operational vibration does not form part of this assessment.

The proposed car park for Site 1 would be built to enable additional car park levels in the future if required. This report does not assess the potential noise impact associated with the additional car park levels. Should TfNSW confirm the additional car park levels, a separate assessment and planning approval would be required when this occurred.

2 DESCRIPTION OF THE PROPOSAL

The key features of the Proposal are summarised as follows:

- The proposed commuter car park at Site 1 involves the construction of 3 additional part levels over the existing council/commuter car park adjacent to the Merrylands Station. The existing car park provides 155 car spaces whilst the proposed car park would provide 220 car spaces. The Site would include:

    i. construction of a 3 additional part levels over the existing council/commuter car park structure with sufficient height to provide access to existing easements including: a ground level above the existing lower ground level and a mid-lower ground level and mid upper ground level adjacent the existing lower ground level.

    ii. The mid upper ground level will be 5.2m above the existing lower ground level and align with the existing structures at the bus interchange.

    iii. provision of approximately 220 parking spaces (65 new) including six accessible car parking spaces in accordance with DDA requirements

    iv. vehicular exit and entrance from Terminal Place (as current) with a new ramp leading to the mid upper ground level

    v. provision of a new lift from the car park to the Merrylands Station entry plaza

    vi. partial removal and relocation of a metal fence along the railway adjacent to rail tracks

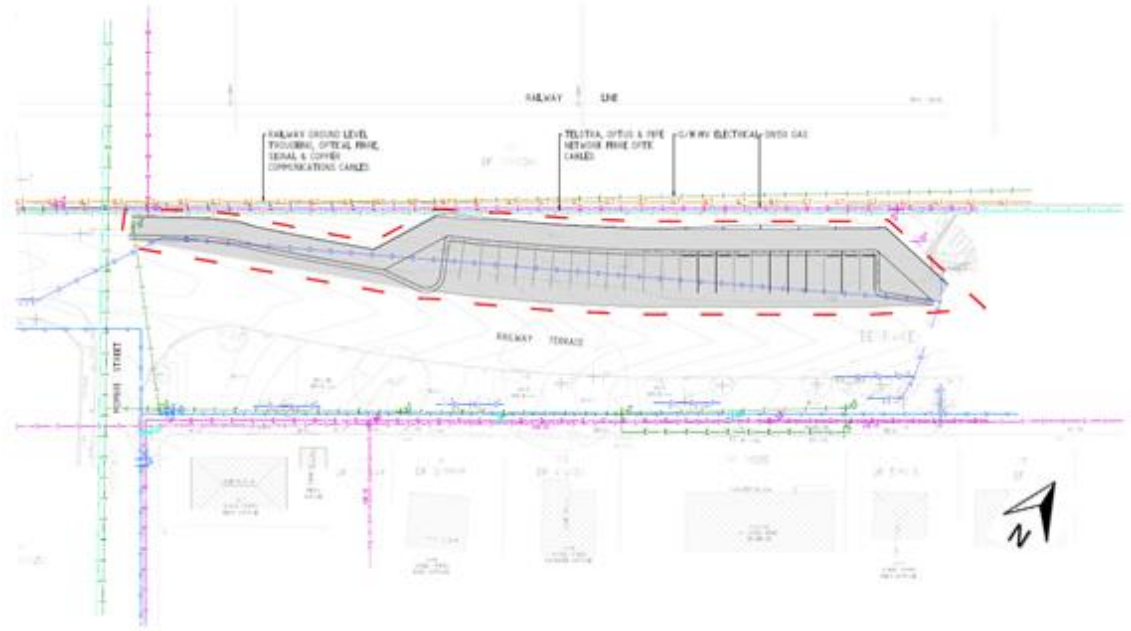
    vii. partial removal of an existing pedestrian ramp to be converted into a landscaped area

- The proposed commuter car park Site 2 is situated approximately 210 metres east of the station. This part of the proposal provides for 24 on-street car parking spaces.

The proposed layout is shown in Figure 2-1 and Figure 2-2.

Figure 2-1 Car Park Layout Site 1 – Lower Ground Floor

Figure 2-2 Car Park Layout Site 2



3 SITE DESCRIPTION

The sites of the proposed car parks are shown in Figure 3-1. The figure also shows the nearest noise-sensitive receivers (red circles) and monitoring locations (green circles). Areas shaded in orange show receivers that can be assumed to be represented by the selected noise-sensitive receivers. The receiver addresses are listed in Table 3-1.

The following land uses surround the proposed car parks.

Site 1

- There are commercial premises to the north and west of the car park at Site 1. Receiver R1 has been identified as the most affected commercial receiver in the area. The façade of this building is located at approximately 35 metres from the northern boundary of the car park.
- Residential receivers surrounding the car park at Site 1 are located to the east and south of the site. These are multi-storey apartment buildings. The residential receiver that is potentially most affected by the noise from the proposed car park is Receiver R2, 104 Railway Terrace, Merrylands. The façade of this apartment building is approximately 42 metres from the eastern boundary of the site.

Site 2

- Site 2 is surrounded by residential premises in all directions. The receivers that are potentially most affected by the noise from the proposed car park are residences located to the east and north-west, represented by Receivers R3 and R4 respectively.

Figure 3-1 Proposed Car Park, Receivers & Monitoring Locations

Table 3-1 Receivers near Car Parks – Site 1

Receiver	Type	Distance to Site Boundary (m)	Address	Comments
R1	Commercial	35	224-240 Pitt Street, Merrylands	1-storey structure
R2	Residence	42	104 Railway Terrace, Merrylands	7-storey building

Table 3-2 Receivers near Car Parks – Site 2

Receiver	Type	Distance to Site Boundary (m)	Address	Comments
R3	Residence	26	62-64 Railway Terrace, Granville	3-storey building
R4	Residence	56	42-50 Brickworks Drive, Holroyd	7-storey building

In addition, a heritage building located at Merrylands Station has been assessed against the building damage criteria during construction works. Figure 3-2 shows the location of this building.

Figure 3-2 Heritage Building at Merrylands Station

4 OPERATIONAL NOISE CRITERIA

Noise goals are based on the NSW Environment Protection Authority (EPA) *Industrial Noise Policy* (INP). The *INP*, while specifically aimed at large and complex industrial activities, defines a number of terms such as 'intrusiveness' and can be used to provide guidance to councils on assessing and measuring noise.

The *INP* defines time periods as follows:

- **Day** is defined as 7.00am to 6.00pm, Monday to Saturday and 8.00am to 6.00pm Sundays and Public Holidays
- **Evenings** is defined as 6.00pm to 10.00pm, Monday to Sunday and Public Holidays
- **Night** is defined as 10.00pm to 7.00am, Monday to Saturday and 10.00pm to 8.00am Sundays and Public Holidays.

In addition, the *INP* recognises that there will often be situations that require different assessment periods, including when early morning (6am – 7am) operations are proposed. In this case, it may be unduly stringent to assess such operations against the nighttime criteria, particularly when existing background noise levels rise steadily throughout this time. Consequently, more appropriate noise criteria may be adopted on a case-by-case basis. A similar approach applies for operations between 6pm and 7pm. These non-standard time periods are referred to as "shoulder periods".

4.1 Intrusiveness Criterion

The intrusiveness criterion of the *INP* is that noise from a site should not exceed the background noise level plus 5dBA when measured over a 15-minute period ($L_{Aeq,15\ min}$).

The background level is described by the Rating Background Noise Level (RBL),which is determined from measurement of L_{A90} noise levels, in the absence of noise from the source. Noise measurements are discussed in Section 4.4.

4.2 Amenity Criterion

The *INP* also provides amenity noise goals, which set maximum limits in addition to the intrusiveness criterion. The purpose of amenity criteria is to prevent noise levels increasing indefinitely with each successive development, which could occur if only the intrusiveness criteria was utilised.

4.2.1 Residences

This area would be considered suburban, and the "acceptable" amenity criteria are 55, 45 and 40dBA for daytime, evening and nighttime respectively. Maximum criteria are 5dBA higher for all periods. These values apply to noise over an entire day, evening or night period. Because usage of a commuter car park is concentrated in peak periods, intrusiveness criteria, which are calculated over 15-minute periods, are in this case more stringent than amenity criteria.

4.2.2 Non Residential Receivers

Commercial premises are recommended to comply with an amenity criterion of 65 dBA $L_{Aeq.Period}$ for the daytime period.

4.3 Sleep Disturbance

In order to minimise the risk of sleep disturbance during night time operation at this site (between 10.00pm and 7.00am), sleep disturbance criteria have been set which take into account short-term transient noise events that may result from car park activities.

For screening purposes, the EPA recommends that sleep disturbance be assessed as the emergence of the L_{Amax} noise level above the background noise level. An appropriate screening criterion for sleep disturbance is determined to be that the L_{Amax} level should not exceed 15dBA above the RBL for the nighttime period. In the event that exceedances of this criterion are predicted, sleep disturbance does not necessarily result, but the EPA recommends a more thorough approach be investigated.

4.4 Background Noise Levels

4.4.1 Monitoring Locations

Detailed attended short-term noise monitoring was undertaken at:

- **MM1**: commercial premises located at 244 Pitt Street, Merrylands to the west of Site 1. Day-time measurements were carried out
- **MM2**: residence located at 48 Railway Terrace, Granville to the east of Site 2. Both daytime and night time measurements were carried out.

In addition, long-term unattended noise monitoring was performed at:

- **MM2**: between 2 and 7 March 2016. The noise logger was left in the front yard of the property.
- As construction works are currently taking place to the east of Site 1, long-term noise monitoring was not conducted in this area.

The resultant data is considered representative of the background and equivalent sound pressure levels for areas surrounding both car parks, and is therefore suitable for use in this noise impact assessment. The noise monitoring locations are shown in Figure 3-1.

4.4.2 Noise Logger Description

The noise monitoring equipment used consists of a Bruel & Kjaer 2250 Sound Level Meter (attended noise monitoring) and one ARL Ngara Environmental Noise Logger (unattended noise monitoring). These were set to A-weighted, fast response, continuously monitoring over 15minute sampling periods. The environmental noise loggers are capable of remotely monitoring and storing noise level descriptors for later detailed analysis. The equipment calibration was checked before and after the survey and no significant drift was noted.

The equipment has been calibrated at a NATA approved laboratory within the last two years in accordance with Australian standards and Wilkinson Murray's internal QS procedures. Current

certificates for all devices have been issued.

The logger determines L_{A1}, L_{A10}, L_{A90} and L_{Aeq} levels of the ambient noise. L_{A1}, L_{A10} and L_{A90} are the levels exceeded for 1%, 10% and 90% of the sample time respectively (see Glossary of Acoustic Terms for definitions). The L_{A1} is indicative of maximum noise levels due to individual noise events such as the occasional pass-by of a heavy vehicle. This is used for the assessment of sleep disturbance. The L_{A90} level is normally taken as the background noise level during the relevant period. Appropriate exclusions were made for occasions of rain or high wind as required by the *INP*. Detailed results from noise monitoring are shown in graphical form in Appendix A.

Table 4-1 summarises the primary noise descriptors recorded during the attended noise monitoring. Distant traffic, breeze and noise from crickets were found to be the primary noise contributors at both locations, and no existing industrial noise was audible.

The measured RBLs, based on long-term monitoring at location MM2, are given in Table 4-2. The table gives the RBLs for standard periods, daytime, evening and nighttime, as well as the shoulder periods from 6.00am to 7.00am and 6.00pm to 7.00pm for weekdays.

Table 4-1 Measured Rating Background Levels, dBA

Monitoring Location	Time	L_{A90}	L_{Aeq}	Comments
MM1	Day 12.46om to 1.01pm	54	66	Background noise levels were dominated by distant traffic.
MM2	Day 3.00pm to 3.15pm	45	55	Background noise levels were dominated by distant traffic and breeze.
MM2	Night 4.13am to 4.28am	38	63	Background noise levels were dominated by crickets and industrial noise was inaudible.

Table 4-2 Measured Rating Background Levels, dBA

Monitoring Location	Daytime (7am-6pm)	Evening (6pm-10pm)	Night Time (10pm-7am)	Early Morning Shoulder (6am-7am) Weekday	Early Evening Shoulder (6pm-7pm) Weekday
MM2	43	48	42	47	48

4.5 Operational Noise Criteria

Intrusiveness criteria for noise from operation of the car park at residential receivers are given in Table 4-3. The following should be noted.

- In the absence of long-term measurement data close to location R2, measurements at location MM2 have been used to define daytime and shoulder period criteria. These are considered to be conservatively low, as daytime L_{A90} levels measured at location MM1 from

short-term measurements are higher than the measured RBL at location MM2; and

- If noise compliance is achieved during the daytime periods, noise levels would readily comply with the evening and night time criteria. This is due to the minimal movements expected in the carpark between 7.00pm and 6.00am.

Table 4-3 Intrusiveness Criteria (Site 1), $L_{Aeq,15min}$, dBA

Receiver	Daytime (7am-6pm)	Early Morning Shoulder (6am-7am) Weekday	Early Evening Shoulder (6pm-7pm) Weekday
R2	48	52	53

Table 4-4 Intrusiveness Criteria (Site 2), $L_{Aeq,15min}$, dBA

Receiver	Daytime (7am-6pm)	Early Morning Shoulder (6am-7am) Weekday	Early Evening Shoulder (6pm-7pm) Weekday
R3, R4	48	52	53

The applicable criterion for the commercial receiver R1 is 65 dBA $L_{Aeq.Period}$ for the daytime period.

4.6 Sleep Disturbance Criteria

The screening criteria for sleep disturbance due to short-term noise are shown in Table 4-5.

Table 4-5 Sleep Disturbance Screening Criteria (Site 1), L_{Amax} dBA

Receiver	Night Time (10pm-6am) RBL+15dBA	Early Morning Shoulder (6am-7am) Weekday RBL+15dBA
R2	57	62

Table 4-6 Sleep Disturbance Screening Criteria (Site 2), L_{Amax} dBA

Receiver	Night Time (10pm-6am) RBL+15dBA	Early Morning Shoulder (6am-7am) Weekday RBL+15dBA
R3, R4	57	62

Sleep disturbance criteria is not applied to commercial premises and as such, R1 is excluded.

5 OPERATIONAL NOISE ASSESSMENT

5.1 Noise Prediction Method

Noise emissions were predicted using the SoundPlan v7.4 noise modelling software, which takes into account such attenuation factors as: geometric spreading, shielding by barriers and topography, and atmospheric absorption.

The source noise levels for emissions from the car park were based on detailed measurements performed at Revesby commuter car park where simultaneous traffic counts and noise measurements were undertaken. The noise measurements carried out at Revesby have been adjusted to expected traffic volumes at Merrylands.

Mechanical ventilation would be required for the Communications Room given the nature of the partially enclosed car park. Dependent on final design, it is also possible that natural ventilation would need to be supplemented with mechanical ventilation. Any mechanical plant to be placed on site has not been considered in this assessment as data is not available at this stage. This would be considered in the detailed design of the car park.

5.2 Part A- Site 1

5.2.1 Vehicle Movements

Noise emission from the car park is proportional to the number of vehicle movements at any time.

The following assumptions are made for movements during peak periods, based on the conservative assumption that all spaces at the site would be occupied:

- *50% entering the car park between 6.00am – 7.00am and other 50% entering the car park between 7.00am – 8.00am*
- *50% leaving the car park between 5.00pm – 6.00pm and other 50% leaving the car park between 6.00pm – 7.00pm*
- *Between around 7.00pm and 6.00am movements would be minimal.*

The proposed number of car spaces for Site 1 is shown in Table 5-1.

Table 5-1 Distribution of Car Spaces for Site 1

Level	Available spaces	Car Movements peak hour	Car Movements 15-minute period
Lower Ground	163	82	20.5
Ground Level	57	29	7
Total	220	111	27.5

Assuming that the car arrivals are evenly spread throughout the hour, the worst-case scenario

for assessment is by comparison of the worst-case flow to the criterion based on the lowest background noise readings. If noise compliance is achieved during this period, compliance would also be achieved at all other periods.

5.2.2 Predicted Noise Levels from Vehicles

The predicted noise levels for operations during the peak hour are given in Table 5-2. The predicted noise levels comply with noise criteria at all times.

Table 5-2 Predicted Operational Noise Levels, $L_{Aeq,15min}$, dBA – Peak Hour – Site 1

Receiver	Address	Predicted Noise Level	Criteria Early Morning Shoulder (6am-7am)	Criteria Daytime (7am-6pm)	Criteria Early Evening Shoulder (6pm-7pm)
R2	104 Railway Terrace, Merrylands	44	52	48	53

The amenity assessment to commercial receiver R1 is based on the total noise through the daytime period. Most noise emissions from the car park occur during the peak traffic periods, so the noise emission in the worst-case hours will be higher than the overall noise during the day, evening or night periods. Noise levels at commercial receiver R1 were predicted to be $L_{Aeq, 15min}$ of 40dBA. As this noise level represents the worst case scenario for a 15-minute period, compliance with the amenity criteria of 65 dBA at any time period would be readily achieved.

5.2.3 Sleep Disturbance Assessment

The typical maximum noise level associated with patrons in the car park including doors closing, engine starting and car accelerating is a level of 70dBA at 7m (Sound Power Level 95dBA).

The predicted maximum noise levels at relevant receivers are given in Table 5-3. These comply with screening noise criteria for sleep disturbance between 10pm and 7am.

Table 5-3 Sleep Disturbance Predicted Levels, L_{Amax} dBA – Site 1

Receiver	Address	Predicted Noise Level	Criteria - Night time (10pm-6am) RBL+15dBA	Criteria - Early Morning Shoulder (6am-7am) RBL+15dBA
R2	104 Railway Terrace, Merrylands	54	57	62

5.3 Part B- Site 2

5.3.1 Vehicle Movements

Noise emission from the car park is proportional to the number of vehicle movements at any time.

The following assumptions are made for movements during peak periods, based on the conservative assumption that all spaces at the site would be occupied:

- *50% entering the car park between 6.00am – 7.00am and other 50% entering the car park between 7.00am – 8.00am*
- *50% leaving the car park between 5.00pm – 6.00pm and other 50% leaving the car park between 6.00pm – 7.00pm*
- *Between around 7.00pm and 6.00am movements would be minimal.*

The proposed number of car spaces for Site 2 is shown in Table 5-4.

Table 5-4 Distribution of Car Spaces for Site 2

Level	Available Spaces	Car Movements Peak Hour	Car Movements 15-minute Period
Ground Level / Total	24	12	3

Assuming that the car arrivals are evenly spread throughout the hour, the worst-case scenario for assessment is by comparison of the worst-case flow to the criterion based on the lowest background noise readings. If noise compliance is achieved during this period, compliance would also be achieved at all other periods.

5.3.2 Predicted Noise Levels from Vehicles

The predicted noise levels for operations during the peak hour are given in Table 5-5. The predicted noise levels comply with noise criteria at all times.

Table 5-5 Predicted Operational Noise Levels, $L_{Aeq,15min}$, dBA – Peak Hour – Site 2

Receiver	Address	Predicted Noise Level	Criteria Early Morning Shoulder (6am-7am)	Criteria Daytime (7am-6pm)	Criteria Early Evening Shoulder (6pm-7pm)
R3	62-62 Railway Terrace, Granville	38	52	48	53
R4	42-50 Brickworks Drive, Holroyd	32	52	48	53

5.3.3 Sleep Disturbance Assessment

The typical maximum noise level associated with patrons in the car park including doors closing,

engine starting and car accelerating is a level of 70dBA at 7m (Sound Power Level 95dBA).

The predicted maximum noise levels at relevant receivers are given in Table 5-6. These comply with screening noise criteria for sleep disturbance between 10pm and 7am.

Table 5-6 Sleep Disturbance Predicted Levels, L_{Amax} dBA -Site 2

Receiver	Address	Predicted Noise Level	Criteria Night time (10pm-6am) RBL+15dBA	Criteria Early Morning Shoulder (6am-7am) RBL+15dBA
R3	62-62 Railway Terrace, Granville	57	57	62
R4	42-50 Brickworks Drive, Holroyd	51	57	62

5.4 Noise Mitigation Measures

Noise mitigation measures are not strictly required for operational noise from vehicle movements, as noise compliance is predicted at all considered receivers.

The following mitigation measures are recommended for operational noise at Site 1:

- any mechanical ventilation or equipment identified during detailed design should be selected in order to achieve the acceptable noise levels identified in the *INP*
- noise monitoring at receiver R2 and R3 within 3 months of operations commencing to assess compliance with applicable noise criteria in the *INP*.

6 CONSTRUCTION NOISE

6.1 EPA Construction Noise Goals

The assessment of construction noise impact follows the procedures of NSW EPA *Interim Construction Noise Guideline* (ICNG). The *ICNG* is used in this report to set Noise Management Levels (NML). While the *ICNG* also discusses mitigation of construction noise, TfNSW has published its *Construction Noise Strategy* (CNS),which deals with mitigation of construction noise specific to its own projects.

6.1.1 Standard Hours of Work

The NSW EPA *Interim Construction Noise Guideline* (ICNG) recommends that as far as practicable, construction activities should be undertaken between the following hours:

Recommended standard hours of work

- Monday to Friday - 7.00am to 6.00pm
- Saturday - 8.00am to 1.00pm

- No work on Sundays or Public Holidays.

6.1.2 *ICNG* Noise Goals

The *ICNG* recognises, however, that by necessity construction works must sometimes be undertaken outside of the standard recommended hours. More stringent noise goals apply during out-of-hours works.

ICNG noise goals are detailed in Table 6-1.

Table 6-1 Noise Goals using Quantitative Assessment

Time of Day	Management Level $L_{Aeq,(15min)}$ *	How to Apply
Recommended Standard Hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or Public Holidays	Noise affected RBL + 10dBA	• The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. • 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.
Recommended Standard Hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or Public Holidays	Highly noise affected 75dBA	• 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 proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. • If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside Standard Hours	Noise affected RBL + 5dB	• 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 5dBA above the noise affected level, the proponent should negotiate with the community.

Table 6-2 and Table 6-3 presents the relevant construction noise criteria for residential receivers for all time periods.

Table 6-2 Construction Noise Management Levels (Site 1), $L_{Aeq,15min}$ dBA

Receiver	Daytime (7am-6pm)	Evening (6pm-10pm)	Night (10pm-7am)
R2	53	53	47

Table 6-3 Construction Noise Management Levels (Site 2), $L_{Aeq,15min}$ dBA

Receiver	Daytime (7am-6pm)	Evening (6pm-10pm)	Night (10pm-7am)
R3, R4	53	53	47

6.1.3 Noise Management Levels at Non-Residential Receivers

No non-residential noise sensitive receivers, such as schools or childcare centres, have been identified in the vicinity of Site 2.

The *ICNG* has the following recommended NMLs for commercial and industrial premises:

- Industrial premises: external $L_{Aeq,15min}$ 75dBA; and
- Offices, retail outlets: external $L_{Aeq,15min}$ 70dBA.

6.2 Transport for NSW Construction Noise Strategy

The Transport for NSW *Construction Noise Strategy* (*CNS*) recognises the potential for a project's construction noise and vibration levels to exceed the objectives. The *CNS* outlines a number of standard mitigation measures that should be implemented at all construction sites. If these do not reduce noise to the objective levels (in this case the NMLs specified in Table 6-2), a range of additional mitigation measures may be implemented. The additional mitigation measures are listed in Table 6-4.

The application of any mitigation measure depends on the level of noise above the RBL (not the NML) and the period of the day when construction is to take place, as listed in Table 6-5.

"Out-of-hours work" (OOHW), is any work which takes place outside the standard construction work hours.

Table 6-4 Additional Mitigation Measures (Table 4 of *CNS*)

Measure	Abbreviation
Alternative accommodation	AA
Monitoring	M
Individual briefings	IB
Letterbox drops	LB
Project specific respite offer	RO
Phone calls	PC
Specific notifications	SN

Table 6-5 Airborne Construction Noise Management (Table 5 of *CNS*) – Mitigation Measures - LAeq,15min noise level above background level (RBL)- Qualitative

Time Period		0 to 10 dBA (Noticeable)	10 to 20 dBA (Clearly Audible)	20 to 30 dBA (Moderately Intrusive)	>30 dBA (Highly Intrusive)
Standard	Mon-Fri (7am-6pm) Sat (8am-1pm) Sun/Pub Hol (Nil)	-	-	LB,M	LB, M
OOHW Period 1	Mon-Fri (6pm-10pm) Sat (7am-8am) & (1pm-10pm) Sun/Pub Hol (8am-6pm)	-	LB	M, LB	M, IB, LB, PC, SN
OOHW Period 2	Mon-Fri (10pm-7am) Sat (10pm-8am) Sun/Pub Hol (6pm-7am)	LB	M, LB	M, IB, LB, PC, SN	AA, M, IB, LB, PC, SN

6.3 Construction Zone

The construction works areas are shown in Figure 6-1 and Figure 6-2.

Figure 6-1 Construction Zone Car Pak Site 1

Figure 6-2 Construction Zone Car Park Site 2

6.4 Noise Levels for Equipment

Table 6-6 is taken from the *CNS* and lists the maximum allowable noise levels for equipment to be used on site. The *CNS* states "Plant and equipment with SWLs higher than those presented in the table would be deemed to be emitting an excessive level of noise and should not be permitted to operate on construction sites." To predict the noise emission from the site, the maximum levels listed in Table 6-6 were used to calculate the total noise emission from Site operations.

Table 6-6 Maximum Allowable Noise Levels (*CNS* Table 2 unless noted)

Equipment	Maximum Allowable Noise Level, dBA – L_{Amax} Sound Power Level L_w	Maximum Allowable Noise Level, dBA – L_{Amax} Sound Pressure Level at 7m
Excavator Hammer	122	97
Excavator (approx. 3 tonne)	90	65
Excavator (approx. 6 tonne)	95	70
Excavator (approx. 10 tonne)	100	75
Excavator (approx. 20 tonne)	105	80
Excavator (approx. 30 tonne)	110	85
Skidsteer Loaders (approx. 1/2 tonne)	107	82
Skidsteer Loaders (approx. 1 tonne)	110	85
Backhoe/FE Loader	111	86
Dump Truck (approx. 15 tonne)	108	83
Concrete Truck	112	87
Concrete Pump	109	84
Concrete Vibrator	105	80
Bored Piling Rig	110	85

Equipment	**Maximum Allowable Noise Level, dBA – L_{Amax}** Sound Power Level L_w	**Maximum Allowable Noise Level, dBA – L_{Amax}** Sound Pressure Level at 7m
Scraper	110	85
Grader	110	85
Vibratory Roller (approx. 10 tonne)	114	89
Vibratory Pile Driver	121	96
Impact Piling Rig	134	109
Compressor (approx. 600 CFM)	100	75
Compressor (approx. 1500 CFM)	105	80
Concrete Saw	118	93
Jackhammer	113	88
Generator	104	79
Lighting Tower	80	55
Flood Lights	90	65
Cherry Picker	102	77
Mobile Crane	110	85

6.6 PART A – Site 1

6.6.1 Description of Construction Method

The proposed construction activities are identified in Table 6-7 and Table 6-8. This phasing is indicative, based on the current preliminary design, and may change once the detailed design methodology is finalised. It is also dependent on the contractor's preferred methodology, program and sequencing of the work in consultation with TfNSW. Non-standard working hours may be required to maintain station and bus operations. Activities identified in Table 6-7 and Table 6-8 have been considered during day and evening time periods. Activities likely to take place during the night have been displayed in Table 6-8.

Table 6-7 Indicative Construction Staging & Equipment - Site 1

Phase	Activities	Plant & Equipment
1	Establishment of site compound (erect fencing, tree protection zones, site offices, amenities and plant/material storage areas etc.)	• Trucks • Generator • Bobcat • Hand tools
2	Removal of vegetation	• Mulcher • Chainsaw • Bobcat • Trucks • Hand tools
3	Demolition of existing structure and site clearing Located within proposed car park boundary	• Bobcat • Jackhammer • Dozer • Excavator (Breaker) • Grader • Truck (10 tonne) • Concrete Saw • Excavator (20 tonne) • Generator • Auger Drill Rig • Hand tools
4	Relocation of services and preparation of substructure Located within proposed car park boundary	• Excavator (20 tonne) • Truck (10 tonne) • Wacker Rammer • Hand tools

Phase	Activities	Plant & Equipment
5	Construct floor slabs, columns and walls Located within proposed car park boundary	• Jackhammer • Generator • CFA Rig • Truck (HIBA) • Concrete Pump • Concrete Truck / Agitator • Hand tools
6	Installation of lifts Installation of fixtures, fittings, lighting, CCTV cameras etc.	-
7	Construction of external cladding Located around proposed car park boundary	• Jackhammer • Truck (10 tonne) • Hand tools
8	Installation of bicycle racks, wayfinding signage, landscaping etc	• Truck 1 (10 tonne) • Core Drill • Hand tools
9	Construction of external road works and footpaths Located around proposed car park boundary	• Concrete pump • Concrete Truck / agitator • Paving Machine • Grader • Excavator (20 tonne) • Truck (10 tonne) • Mobile Crane (100 tonne) • Grinder 4” • Hand tools

Table 6-8 Indicative construction staging and equipment for night time period (if required)

Phase	Activities	Plant and equipment
A	Lifting of lift into position	• 200 tonne crane • Concrete pump & concrete trucks • Trucks • Scissor lift • Manitou • Franna crane • Balloon wheel dumpies • Hi rail

Phase	Activities	Plant and equipment
		• Hand tools • Lighting towers (for night works)
B	Construction of stairs, anti-throw screens or canopies	• Trucks • Grinder • Generator • Crane • Scissor lift • Rattle gun • Hand tools Lighting towers (for night works)

6.6.2 Proposed Working Hours

Where possible, works required for the Proposal would be undertaken during standard (NSW) Environment Protection Authority (EPA) construction hours, which are as follows:

- 7.00am to 6.00pm Monday to Friday
- 8.00am to 1.00pm Saturdays
- No work on Sundays or public holidays.

However, to ensure the continued operation of the railway station and bus interchange, certain works may need to occur outside standard hours, and may include night works.

6.6.3 Duration of Construction

Subject to approval, construction of the Proposal is expected to commence in late 2016 and take approximately 12 months to complete.

6.6.4 Construction Noise Assessment

Table 6-9, Table 6-10, Table 6-11 and Table 6-12 provide the predicted noise level from each activity to the two representative receivers. A range of noise levels is quoted to indicate the typical loudest noise level that would be experienced when the construction site is nearest to the receiver, and a typical noise level that would occur during the construction stage. For each receiver, the table also lists the exceedance of the NML.

During standard hours and outside standard hours excluding the night time period, noise levels at all considered residential receivers are predicted to exceed the NML, by up to 29dB at receiver R2. Noise levels would exceed the "highly impacted" level of 75dBA for activities such as removal of vegetation, demolition of existing structure and road works.

In addition, construction works carried out during the night are predicted to exceed the NML at all considered receivers.

Management of noise exceedances is discussed Section 6.6.5.

Table 6-9 Construction Noise Predicted Levels ($L_{Aeq,15min}$ dBA) & Exceedance of NML (dB) During Standard Hours – Site 1 (R1 – NML 70dBA)

Phase	Activities	L_w# dBA	Noise Range	Exceedance
1	Establishment of site compound	110	64-71	0-1
2	Removal of vegetation	116	70-77	0-7
3	Demolition of existing structure and site clearing	122	76-83	6-13
4	Relocation of services and preparation of substructure	111	65-72	0-2
5	Construct floor slabs, columns and walls	113	67-74	0-4
6	Installation of lifts, fixtures, fittings, lighting, CCTV cameras etc.	*	*	*
7	Construction of external cladding	114	68-75	0-5
8	Installation of bicycle racks, wayfinding signage, landscaping etc	108	62-69	0-0
9	Construction of external road works and footpaths	117	69-78	0-8

Note: # indicates representative sound power level for all equipment to be used during the respective phase.
shaded cell indicates noise level exceed 75dBA.
* Phase 6 has been excluded from this table as it would generate a minor noise impact at all receivers.

Table 6-10 Construction Noise Predicted Levels ($L_{Aeq,15min}$ dBA) & Exceedance of NML (dB) During Standard Hours – Site 1 (R2 – NML 53dBA)

Phase	Activities	L_w# dBA	Noise Range	Exceedance
1	Establishment of site compound	110	66-70	13-17
2	Removal of vegetation	116	72-76	19-23
3	Demolition of existing structure and site clearing	122	78-82	25-29
4	Relocation of services and preparation of substructure	111	67-71	14-18
5	Construct floor slabs, columns and walls	113	69-73	16-20

Phase	Activities	L_w# dBA	Noise Range	Exceedance
6	Installation of lifts, fixtures, fittings, lighting, CCTV cameras etc.	*	*	*
7	Construction of external cladding	114	70-74	17-21
8	Installation of bicycle racks, wayfinding signage, landscaping etc	108	64-68	11-15
9	Construction of external road works and footpaths	117	67-74	14-21

Note: # indicates representative sound power level for all equipment to be used during the respective phase.
shaded cell indicates noise level exceed 75dBA.
* Phase 6 has been excluded from this table as it would generate a minor noise impact at all receivers.

Table 6-11 Construction Noise Predicted Levels ($L_{Aeq,15min}$ dBA) & Exceedance of NML (dB) Outside Standard Hours Excluding Night – Site 1

Phase	Activities	L_w# dBA	R1 – NML 70dBA Noise Range	R1 – NML 70dBA Exceedance	R2 – NML 53dBA Noise Range	R2 – NML 53dBA Exceedance
1	Establishment of site compound	110	64-71	0-1	66-70	13-17
2	Removal of vegetation	116	70-77	0-7	72-76	19-23
3	Demolition of existing structure and site clearing	122	76-83	6-13	78-82	25-29
4	Relocation of services and preparation of substructure	111	65-72	0-2	67-71	14-18
5	Construct floor slabs, columns and walls	113	67-74	0-4	69-73	16-20
6	Installation of lifts, fixtures, fittings, lighting, CCTV cameras etc.	*	*	*	*	*
7	Construction of external cladding	114	68-75	0-5	70-74	17-21
8	Installation of bicycle racks, wayfinding signage, landscaping etc	108	62-69	0-0	64-68	11-15
9	Construction of external road works and footpaths	117	69-78	0-8	67-74	14-21

Note: # indicates representative sound power level for all equipment to be used during the respective phase.
shaded cell indicates noise level exceed 75dBA.
* Phase 6 has been excluded from this table as it would generate a minor noise impact at all receivers.

Table 6-12 Construction Noise Predicted Levels ($L_{Aeq,15min}$ dBA) & Exceedance of NML (dB) During Night – Site 1

Phase	Activities	L_w# dBA	R1 – NML 70dBA Noise Range	R1 – NML 70dBA Exceedance	R2 – NML 47dBA Noise Range	R2 – NML 47dBA Exceedance
A	Lifting of lift into position	116	70-77	0-7	72-76	25-29
B	Construction of stairs, anti-throw screens or canopies	112	66-73	0-3	68-72	21-25

Note: # indicates representative sound power level for all equipment to be used during the respective phase. shaded cell indicates noise level exceed 75dBA.

6.6.5 Construction Noise Mitigation & Management at Residences

Table 6-13, Table 6-14 and Table 6-15 show the additional mitigation measures (AMM) for receiver R2. For standard hours work, the *CNS* would recommend letterbox drops (LB) to potentially affected residents, and monitoring (M) for all operations, as noise levels would exceed the RBL by more than 20dB.

For non-standard hours, receiver R2 should also be considered for individual briefing (IB), phone calls (PC) and specific notifications (SN) during demolition of existing structure and site clearing. In addition to the previous recommendations, receiver R2 exposed to noise generated by night time works should be considered for alternative accommodation (AA) and project specific respite offers (RO) in accordance with Table 6-15.

Table 6-13 Construction Noise Predicted Levels ($L_{Aeq,15min}$ dBA), Exceedance of RBL (dB) & Additional Mitigation Measures (AMM) During Standard Time Period – Site 1

Phase	Activities	$L_{w\#}$ dBA	R2 – RBL 43dBA Noise Range	R2 – RBL 43dBA Exceedance	R2 – RBL 43dBA AMM**
1	Establishment of site compound	110	66-70	23-27	LB,M
2	Removal of vegetation	116	72-76	29-33	LB,M
3	Demolition of existing structure and site clearing	122	78-82	35-39	LB,M
4	Relocation of services and preparation of substructure	111	67-71	24-28	LB,M
5	Construct floor slabs, columns and walls	113	69-73	26-30	LB,M
6	Installation of lifts, fixtures, fittings, lighting, CCTV cameras etc.	*	*	*	*

Phase	Activities	$L_{w\#}$ dBA	R2 – RBL 43dBA Noise Range	R2 – RBL 43dBA Exceedance	R2 – RBL 43dBA AMM**
7	Construction of external cladding	114	70-74	27-31	LB,M
8	Installation of bicycle racks, wayfinding signage, landscaping etc	108	64-68	21-25	LB,M
9	Construction of external road works and footpaths	117	67-74	24-31	LB,M

Note: # indicates representative sound power level for all equipment to be used during the respective phase.
* Phase 6 has been excluded from this table as it would generate a minor noise impact at all receivers.
** Refer to Table 6-4

Table 6-14 Construction Noise Predicted Levels ($L_{Aeq,15min}$ dBA), Exceedance of RBL (dB) & Additional Mitigation Measures (AMM) During OOHW Period 1 – Site 1

Phase	Activities	$L_{w\#}$ dBA	R2 – RBL 48dBA Noise Range	R2 – RBL 48dBA Exceedance	R2 – RBL 48dBA AMM**
1	Establishment of site compound	110	66-70	18-22	LB,M
2	Removal of vegetation	116	72-76	24-28	LB,M
3	Demolition of existing structure and site clearing	122	78-82	30-34	LB,M,IB,PC,SN
4	Relocation of services and preparation of substructure	111	67-71	19-23	LB,M
5	Construct floor slabs, columns and walls	113	69-73	21-25	LB,M
6	Installation of lifts, fixtures, fittings, lighting, CCTV cameras etc.	*	*	*	*
7	Construction of external cladding	114	70-74	22-26	LB,M
8	Installation of bicycle racks, wayfinding signage, landscaping etc	108	64-68	16-20	LB
9	Construction of external road works and footpaths	117	67-74	19-26	LB,M

Note: # indicates representative sound power level for all equipment to be used during the respective phase.
* Phase 6 has been excluded from this table as it would generate a minor noise impact at all receivers.
** Refer to Table 6-4

Table 6-15 Construction Noise Predicted Levels ($L_{Aeq,15min}$ dBA), Exceedance of RBL (dB) & Additional Mitigation Measures (AMM) During OOHW Period 2 – Site 1

Phase	Activities	$L_{w\#}$ dBA	R2 – RBL 42dBA Noise Range	R2 – RBL 42dBA Exceedance	R2 – RBL 42dBA AMM**
A	Lifting of lift into position	116	72-76	30-34	LB,M,AA,IB,PC,SN
B	Construction of stairs, anti-throw screens or canopies	112	68-72	26-30	LB,M,IB,PC,SN

Note: # indicates representative sound power level for all equipment to be used during the respective phase.
** Refer to Table 6-4

6.6.6 Management at Non-Residential Receivers

The noise management levels from the *CNS* are the same as for the *ICNG* quoted in Section 0. The *CNS* states:

> *The proponent should assess construction noise levels for the project, and consult with occupants of commercial and industrial premises prior to lodging an application where required. During construction, the proponent should regularly update the occupants of the commercial and industrial premises regarding noise levels and hours of work.*

Noise levels could exceed 70dBA at receiver R1 during the majority of the phases of construction works. As required by the *CNS*, it is recommended that neighbouring business be regularly updated with the construction schedule.

6.7 PART B – Site 2

6.7.1 Description of Construction Method

The proposed construction activities are identified in Table 6-16. This phasing is indicative, based on the current preliminary design, and may change once the detailed design methodology is finalised. It is also dependent on the contractor's preferred methodology, program and sequencing of the work in consultation with TfNSW. Activities identified in Table 6-16 have been considered during day time periods.

Table 6-16 Indicative Construction Staging & Equipment - Site 2

Phase	Activities	Plant & Equipment
1	Establishment of site compound (erect fencing, tree protection zones, site offices, amenities and plant/material storage areas etc)	• Trucks • Generator • Bobcat • Hand tools
2	Removal of vegetation – (turf)	• Bobcat

Phase	Activities	Plant & Equipment
		• Trucks • Hand tools
3	Demolition of kerb line and footpath	• Bobcat • Jackhammer • Dozer • Grader • Truck (10 tonne) • Wacker Rammer • Hand tools
4	Services relocation	• Truck • Dozer • Wacker Rammer • Hand tools
5	Construction of asphalt paving and footpath	• Generator • Roller • Bobcat • Truck • Concrete pump • Concrete truck/Agitator • Hand tools
6	Installation of CCTV cameras and lighting	• Hand tools
7	Installation of wayfinding signage	• Core drill • Truck • Hand tools

6.7.2 Proposed Working Hours

Where possible, works required for the Proposal would be undertaken during standard (NSW) Environment Protection Authority (EPA) construction hours, which are as follows:

- 7.00am to 6.00pm Monday to Friday
- 8.00am to 1.00pm Saturdays
- No work on Sundays or public holidays.

6.7.3 Duration of Construction

Subject to approval, construction of the Proposal is expected to commence in late 2016 and take approximately 2 months to complete.

6.7.4 Construction Noise Assessment

Table 6-17 and Table 6-17 provide the predicted noise level from each activity to the two representative receivers. A range of noise levels is quoted to indicate the typical loudest noise level that would be experienced when the construction site is nearest to the receiver, and a typical noise level that would occur during the construction stage. For each receiver, the table also lists the exceedance of the NML.

During standard hours, noise levels at all considered residential receivers are predicted to exceed the NML, by up to 28dB at receiver R3 and by up to 21dB at receiver R4. Noise levels would exceed the "highly impacted" level of 75dBA at receiver R3 for activities associated with demolition of kerb line and footpath, services relocation and construction of asphalt paving and footpath. Receiver R4 is slightly less impacted as it is further from Site 2 and would not be exposed to noise levels above 75dBA.

It is important to note that due to the nature of the construction activities, these works would take approximately 2 months to complete. On this basis, noise exceedances would occur for short periods only.

Management of noise exceedances is discussed Section 6.7.5.

Table 6-17 Construction Noise Predicted Levels ($L_{Aeq,15min}$ dBA) & Exceedance of NML (dB) During Standard Hours – Site 2

Phase	Activities	L_w# dBA	R3 – NML 53dBA Noise Range	R3 – NML 53dBA Exceedance	R4 – NML 53dBA Noise Range	R4 – NML 53dBA Exceedance
1	Establishment of site compound	110	68-74	15-21	63-67	10-14
2	Removal of vegetation	109	67-73	14-20	62-66	9-13
3	Demolition of kerb line and footpath	117	75-81	22-28	70-74	17-21
4	Services relocation	115	73-79	20-26	68-72	15-19
5	Construction of asphalt paving and footpath	111	69-76	16-23	64-66	11-13
6	Installation of CCTV cameras and lighting	*	*	*	*	*
7	Installation of wayfinding signage	100	58-64	5-11	53-57	0-4

Note: # indicates representative sound power level for all equipment to be used during the respective phase.
shaded cell indicates noise level exceed 75dBA.
* Phase 6 has been excluded from this table as it would generate a minor noise impact at all receivers

6.7.5 Construction Noise Mitigation & Management at Residences

Table 6-18 shows the additional mitigation measures (AMM) for receivers R3 and R4. For

standard hours work, the *CNS* would recommend letterbox drops (LB) to potentially affected residents, and monitoring (M) for all operations, as noise levels would exceed the RBL by more than 20dB.

Table 6-18 Construction Noise Predicted Levels ($L_{Aeq,15min}$ dBA), Exceedance of RBL (dB) & Additional Mitigation Measures (AMM) During Standard Time Period – Site 2

Phase	Activities	$L_{w\#}$ dBA	R3 – RBL 43dBA Noise Range	R3 – RBL 43dBA Exceedance	R3 – RBL 43dBA AMM**	R3 – RBL 43dBA Noise Range	R3 – RBL 43dBA Exceedance	R3 – RBL 43dBA AMM**
1	Establishment of site compound	110	68-74	25-31	LB,M	63-67	20-24	LB,M
2	Removal of vegetation	109	67-73	24-30	LB,M	62-66	19-23	LB,M
3	Demolition of kerb line and footpath	117	75-81	32-38	LB,M	70-74	27-31	LB,M
4	Services relocation	115	73-79	30-36	LB,M	68-72	25-29	LB,M
5	Construction of asphalt paving and footpath	111	69-76	26-33	LB,M	64-66	21-23	LB,M
6	Installation of CCTV cameras and lighting	*	*	*	*	*	*	*
7	Installation of wayfinding signage	100	58-64	15-21	LB,M	53-57	10-14	-

Note: # indicates representative sound power level for all equipment to be used during the respective phase.
* Phase 6 has been excluded from this table as it would generate a minor noise impact at all receivers.
** Refer to Table 6-4

6.8 Indicative notification areas

Figure 6-3 shows the indicative area where a letterbox drop would be recommended for standard hours work.

Figure 6-3 Indicative notification areas

6.9 Additional Work Practices Associated with Noise Impacts

In addition to the recommendation listed in section 6.6.5, 6.6.6 and 6.7.5, the following work practices should be implemented for Site 1 and Site 2 in order to minimise noise levels.

- Work is to be scheduled during standard construction hours where feasible and reasonable.
- Where feasible, the use of jackhammers, grinders and demolition saws should be confined to standard hours or should be scheduled to be carried out early in the evening or night period.
- Provide periods of respite from the use of demolition saws and jackhammers. Respite periods should be defined by those periods where the community is less sensitive to noise such as avoiding early morning and late afternoon.
- Orientate generators, concrete trucks and concrete pumps away from sensitive receivers.
- Utilise vehicles, obstacles and stockpiles on site to provide shielding to receivers, especially for static noise sources: generators, lighting towers, mobile cranes and the piling rig.

- Use equipment that has noise levels equal to or less than the sound power levels in Table 6-6.

To minimise the potential for sleep disturbance, where night works are proposed to be undertaken, the following controls should be implemented where feasible and reasonable:

- Avoid conducting noise intensive night works for more than two consecutive nights.
- Schedule noise intensive activities such as concrete sawing, grinding or jackhammering to before 10pm.
- Schedule activities which are likely to cause maximum noise events such as deliveries, moving material or equipment, compacting and demolition works to avoid the night time period (10pm to 7am).
- Avoid dropping tools or materials from height, striking materials, dragging materials or making metal on metal contact.
- Educate workers on the importance of minimising noise and avoid creating short duration high noise level events.
- Inform surrounding residents by mail of planned works prior to the works commencing. Construction Vibration

6.10 Construction Vibration Criteria

Impacts from vibration can be considered both in terms of effects on building occupants (human comfort) and the effects on the building structure (building damage). Of these considerations, the human comfort limits are the most stringent. Therefore, for occupied buildings, if compliance with human comfort limits is achieved, it will follow that compliance will be achieved with the building damage objectives.

6.10.1 Human Comfort

The EPA's *Assessing Vibration: A Technical Guideline* provides acceptable values for continuous and impulsive vibration in the range 1-80Hz. Both preferred and maximum vibration limits are defined for various locations and are shown in Table 6-19.

Table 6-19 Preferred & Maximum Peak Particle Velocity (PPV) Values for Continuous Vibration

Location	Assessment Period[1]	Preferred Values	Maximum Values
Critical areas	Day or Night Time	0.14	0.28
Receivers	Daytime	0.28	0.56
Receivers	Night Time	0.20	0.40
Offices, schools, educational institutions and places of worship	Day or Night Time	0.56	1.1
Workshops	Day or Night time	1.1	2.2

Note: 1. Daytime is 7.00am to 10.00pm and Night Time is 10.00pm to 7.00am.

Table 6-20 Preferred & Maximum Peak Particle Velocity (PPV) Values for Impulsive Vibration

Location	Assessment Period1	Preferred Values	Maximum Values
Critical areas	Day or Night Time	0.14	0.28
Receivers	Daytime	8.6	17.0
Receivers	Night Time	2.8	5.6
Offices, schools, educational institutions and places of worship	Day or Night Time	18.0	36.0
Workshops	Day or Night Time	18.0	36.0

Note: 1. Daytime is 7.00am to 10.00pm and Night Time is 10.00pm to 7.00am.

These limits relate to a long-term (15 hours for daytime), continuous exposure to vibration sources.

6.10.2 Building Damage

For assessment of the potential for vibration to cause building damage, British Standard BS 7385 and German Standard DIN 4150-3 are used. The *CNS* recommends the limits from BS 7385 Part 2, 1993, which are summarised in Table 6-21.

Table 6-21 Transient Vibration Guide Values for Cosmetic Damage

Type of Building	Peak component particle velocity infrequency range of predominant pulse	
	4-15Hz	15Hz & above
Reinforced or framed structures Industrial & heavy commercial buildings	50mm/s at 4Hz & above	
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15hHz increasing to 50mm/s at 40Hz & above

The German Standard DIN 4150 (Table 1) shows guideline values for short term vibration for commercial buildings, houses and heritage buildings which are dependent on the frequency of vibration. The recommended vibration level for sensitive heritage buildings ranges from 3 to 10mm/s, and 5 to 20mm/s for dwellings.

6.11 Source Vibration Levels

Table 6-22 provides some estimated vibration levels at a range of distances from the various construction activities. At a distance of 30m, some activities by larger plant items would exceed the criterion for human comfort, however, no activity would cause vibration likely to cause building damage.

Mitigation of vibration impacts is discussed in Section 6.13

Table 6-22 Typical Vibration Emission Levels from Construction Plant

Activity	PPV Vibration Level (mm/s) at 10m Distance	PPV Vibration Level (mm/s) 20m at Distance	PPV Vibration Level (mm/s) at 30m Distance
Concrete Sawing	0.5	0.3	0.2
4-10 Tonne Vibratory Roller (High)	2.0-2.4	0.4-1.2	0.2-0.8
Hydraulic Hammer (30t)	3	1.5	1.0

6.12 Vibration Levels at Receivers

6.12.1 Human Comfort

For works other than those requiring vibratory rollers or hydraulic hammers, the vibration is predicted to be below the criteria for human comfort at all receivers.

For work using a hydraulic hammer or vibratory roller, work may cause vibration levels exceeding the criterion for continuous vibration at residential receivers only (the lowest criterion is 0.28mm/s for daytime continuous and 0.20mm/s for night time continuous). In general, any work near a receiver would be temporary and intermittent. Even if the vibration level is above the criterion for continuous vibration, it may not exceed the criterion for intermittent vibration. This will depend on the duration of the activity and the number of repetitions through the work period.

However, the use of smaller equipment can reduce predicted vibration levels to within human comfort criteria even for continuous vibration. This is discussed in Section 6.13.

Monitoring is recommended at receiver R3 if hydraulic hammers or vibratory rollers are to be used in this area to ensure limits for human comfort are not exceeded.

6.12.2 Building Damage

Vibration levels are predicted to be below the criteria for building damage at all residential receivers and commercial receivers. However, the heritage building located at Merrylands Station could potentially experience vibration levels in exceedance of the criterion for building damage, depending on the equipment to be used and their distance to the community centre.

6.13 Construction Vibration Mitigation & Management

Table 3 of the *CNS*, reproduced as Table 6-23, shows the safe working distance for various construction machinery.

The *CNS* lists standard vibration mitigation measures which must be implemented at all sites. Where there is a potential for an exceedance of the vibration limits, the *CNS* has a table of additional mitigation measures, which is reproduced in

Table 6-24. At the proposed construction sites, all activities would be further from any residential and commercial structure than the distances listed in the column headed "Cosmetic Damage". This confirms the conclusion above that vibration levels resulting from this proposal would not result in damage to buildings. Regarding Merrylands Station, special attention should be given to any construction works to be undertaken within 10m from the façade of any buildings. If hydraulic hammers or vibratory rollers are to be used in this area, vibration monitoring should be undertaken. In addition, the following plant items must be used:

- vibratory roller no greater than 50 kN (typically 1-2 tonnes) and small hydraulic hammer no greater than (300kg – 5-12t excavator).

Regarding "Human Response" the use of some items listed in column headed "Plant Item" might exceed the criteria for human comfort. Based on the "safe working distance", the following equipment is recommended:

- Site 1: vibratory roller no greater than 200 kN (typically 4-6 tonnes) and medium hydraulic hammer no greater than (900kg – 12-18t excavator).
- Site 2: vibratory roller no greater than 100 kN (typically 2-4 tonnes) and medium hydraulic hammer no greater than (900kg – 12-18t excavator) if required.

With the above equipment, predicted vibration levels remain below the criteria for human comfort. If it proves impractical to use this equipment, the measures listed in

Table 6-24 should be implemented.

Table 6-23 Recommendations for Safe Working Distances for Vibration-Intensive Plant (*CNS* Table 3)

Plant Item	Rating / Description	Safe Working Distance Cosmetic Damage (BS 7385)	Safe Working Distance Human Response (OH&E Vibration Guideline)
Vibratory Roller	< 50 kN (typically 1-2 tonnes)	5m	15m – 20m
Vibratory Roller	< 100 kN (typically 2-4 tonnes)	6m	20m
Vibratory Roller	< 200 kN (typically 4-6 tonnes)	12m	40m
Vibratory Roller	< 300 kN (typically 7-13 tonnes)	15m	100m
Vibratory Roller	> 300 kN (typically 13-18 tonnes)	20m	100m
Vibratory Roller	> 300 kN (> 18 tonnes)	25m	100m
Small Hydraulic Hammer	(300kg – 5-12t Excavator)	2m	7m
Medium Hydraulic Hammer	(900kg – 12-18t Excavator)	7m	23m
Large Hydraulic Hammer	(1,600kg – 18-34t Excavator)	22m	73m
Vibratory Pile Driver	Sheet piles	2m – 20m	20m
Pile Boring	≤ 800mm	2m (nominal)	n/a
Jackhammer	Hand held	1m (nominal)	Avoid contact with structure

Table 6-24 Additional Mitigation Measures – Ground-borne vibration (*CNS* Table7)

Time Period		Mitigation Measures* Predicted Vibration Levels exceed Maximum Levels
Standard	Mon-Fri (7am-6pm) Sat (8am-1pm) Sun/Pub Hol (Nil)	M, LB, RP
OOHW Period 1	Mon-Fri (6pm-10pm) Sat (7am-8am) & (1pm-10pm) Sun/Pub Hol (8am-6pm)	M, IB, LB, RO, PC, RP, SN
OOHW Period 2	Mon-Fri (10pm-7am) Sat (10pm-8am) Sun/Pub Hol (6pm-7am)	AA, M, IB, LB, PC, RP, SN

Note: * Refer to Table 6-4

6.14 Additional Work Practices Associated with Vibration Impacts

In addition to the recommendation listed above, the following work practices should be implemented at Site 1 and Site 2 in order to minimise the risk of vibration impacts:

- Condition surveys of heritage buildings are to be undertaken in order to assess potential for increased susceptibility to building damage from vibration.
- Where possible, the use of less vibration intensive methods of construction or equipment should be considered where possible to reduce the potential for cosmetic damage.
- All equipment should be maintained and operated in an efficient manner, in accordance with manufacturer's specifications, to reduce the potential for adverse vibration impacts.
- Ensure that safe working distances provided in Table 6-23 are complied with.
- Site-specific safe working distances are to be established on-site prior to the vibration generating works commencing.
- If vibration intensive equipment is to be used within the safe working distances, attended vibration measurements are to be undertaken when work commences to determine site specific safe working distances.
- Vibration intensive work should not proceed within the safe working distances unless a permanent vibration monitoring system is installed approximately one metre from the building footprint, to warn operators (via flashing light, audible alarm, SMS etc.) when vibration levels are approaching the peak particle velocity trigger levels.
- Avoid direct contact with structures when using jackhammers or bored piling equipment. SUMMARY OF MITIGATION MEASURES

Noise

Site 1 – Construction

- apply additional mitigation measures at Receiver 2 in accordance with this Noise and Vibration Impact Assessment (Table 6-11, 6-12 and 6-13) and the CNS
- regularly update neighbouring business with the construction schedule
- complete letter box drop notification to potentially impacted receivers in accordance with this Noise and Vibration Impact Assessment (Figure 6-3)
- implement best practice work practices in accordance with this Noise and Vibration Impact Assessment (Section 6.9)

Site 2 – Construction

- Apply additional mitigation measures at Receiver 3 and 4 in accordance with this Noise and Vibration Impact Assessment (Table 6-17) and the CNS
- Complete letter box drop notification to potentially impacted receivers in accordance with this Noise and Vibration Impact Assessment (Figure 6-3)
- Implement best practice work practices in accordance with this Noise and Vibration Impact Assessment (Section 6.9)

Site 1 and Site 2 - Operational

- any mechanical ventilation or equipment identified during detailed design should be selected in order to achieve the acceptable noise levels identified in the *INP*
- noise monitoring at receiver R2 and R3 within 3 months of operations commencing to assess compliance with applicable noise criteria in the *INP*.

Vibration

Site 1 – Construction

- apply safe working distances in accordance with this Noise and Vibraiton Impact Assessment (Table 7-5) and the CNS
- apply standard mitigation measures in accordance with this Noise and Vibraiton Impact Assessment (Table 7-6) and the CNS
- use vibratory roller no greater than 200 kN (typically 4-6 tonnes) and medium hydraulic hammer no greater than (900kg – 12-18t excavator).
- When working within 10m of the façade of Merrylands Station or when using hydraulic hammers or vibratory rollers
    - complete vibration monitoring for works
    - use vibratory roller no greater than 50 kN (typically 1-2 tonnes) and small hydraulic hammer no greater than (300kg – 5-12t excavator).
- implement best practice work practices in accordance with this Noise and Vibration Impact Assessment (Section 7.5)

Site 2 – Construction

- apply safe working distances in accordance with this Noise and Vibration Impact Assessment (Table 7-5) and the CNS
- apply standard mitigation measures in accordance with this Noise and Vibration Impact Assessment (Table 7-6) and the CNS
- use vibratory roller no greater than 100 kN (typically 2-4 tonnes) and medium hydraulic hammer no greater than (900kg – 12-18t excavator) if required.
- implement best practice work practices in accordance with this Noise and Vibration Impact Assessment (Section 7.5)

7 CONCLUSION

A noise assessment of the proposed car parks and associated works at Merrylands was carried out. The assessment covers operational and construction aspects of the Proposal.

Noise emission from vehicle movements in the car park is predicted to comply with criteria of the NSW *Industrial Noise Policy* (INP) at all times. Should mechanical ventilation be required, the total noise generated on-site should not exceed the background noise level plus 5dBA when measured over a 15-minute period ($L_{Aeq,15\ min}$).

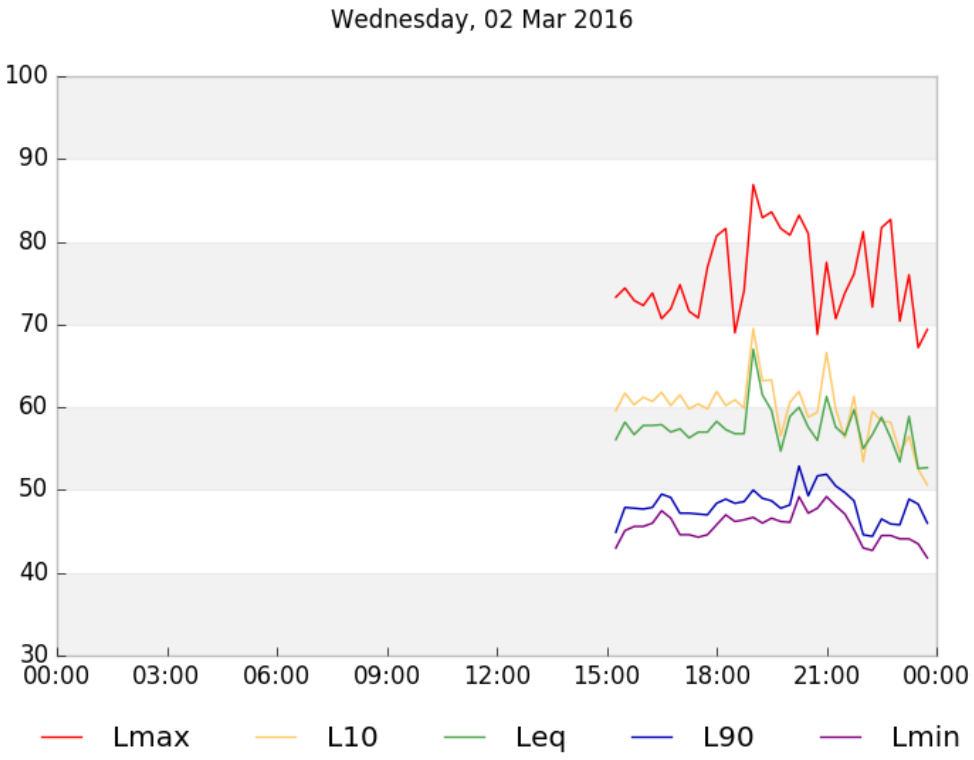
Construction noise and vibration has been assessed and indicative additional mitigation measures as specified in the *Construction Noise Strategy* are outlined. As construction may be carried out both during standard and non-standard hours, any additional mitigation measures required depend on the activities and time period of operation.

The additional mitigation measures are primarily aimed at pro-active engagement with affected residents and building occupants. Additional mitigation measures that may be applicable include letterbox drops, noise monitoring, individual briefings, phone calls, specific notifications, proposal specific respite offers and alternative accommodation. Specific additional mitigation measures would be identified for affected receivers at the CNVMP stage of the project.

Vibration management will ensure appropriate limits will be achieved. In particular, monitoring is recommended at residential receiver R3 and Merrylands Station if hydraulic hammers or vibratory rollers are to be used in these areas. In addition, recommendations regarding equipment to be used on-site are listed in the body of this report.

APPENDIX A

NOISE MEASUREMENT RESULTS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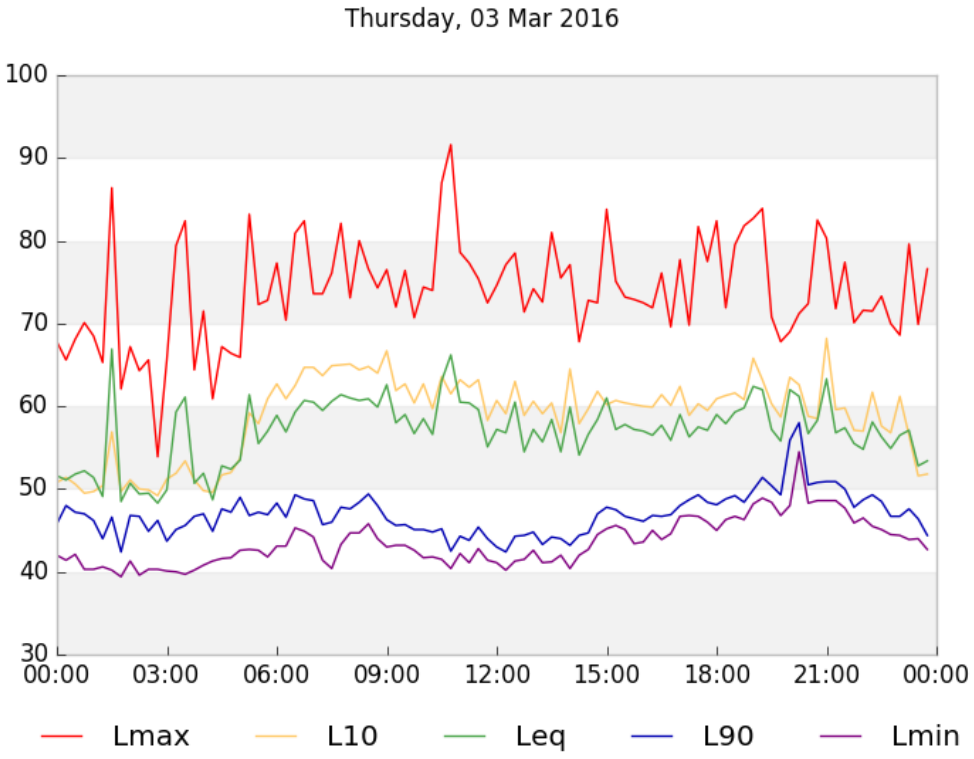
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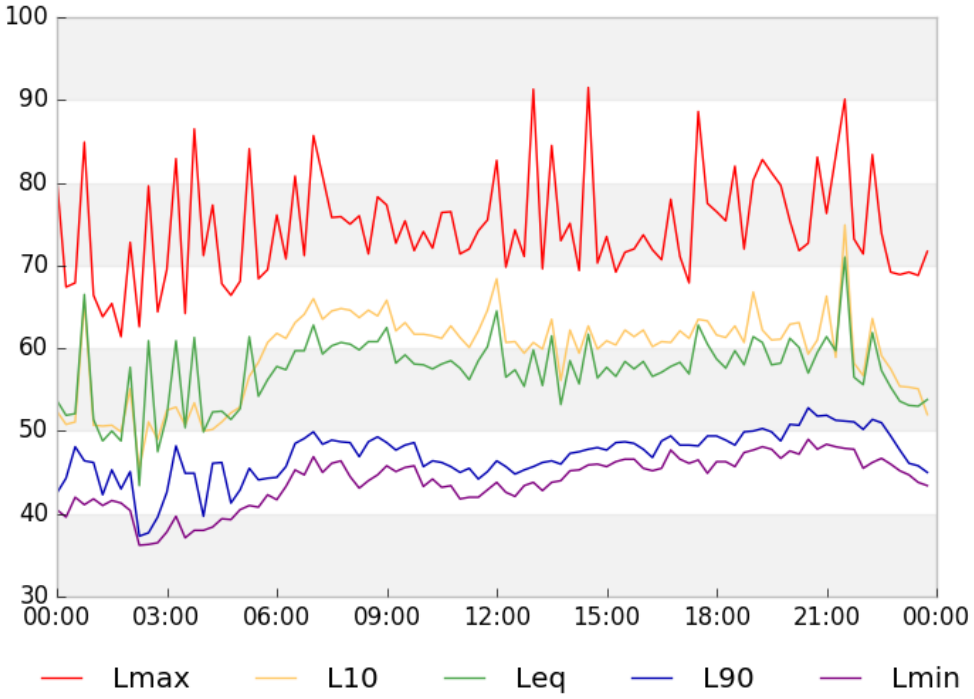

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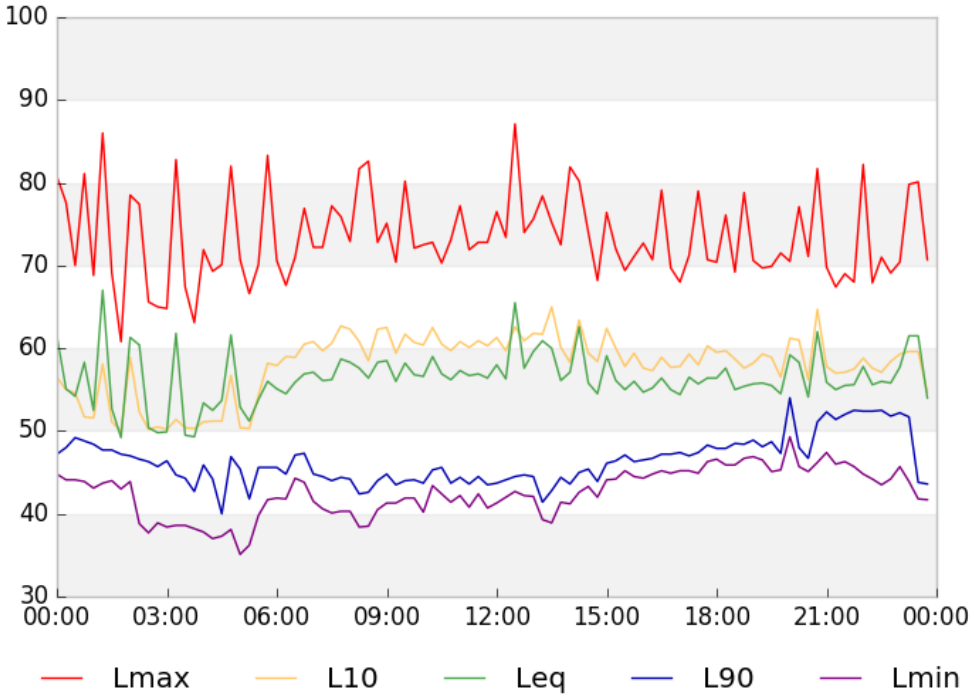

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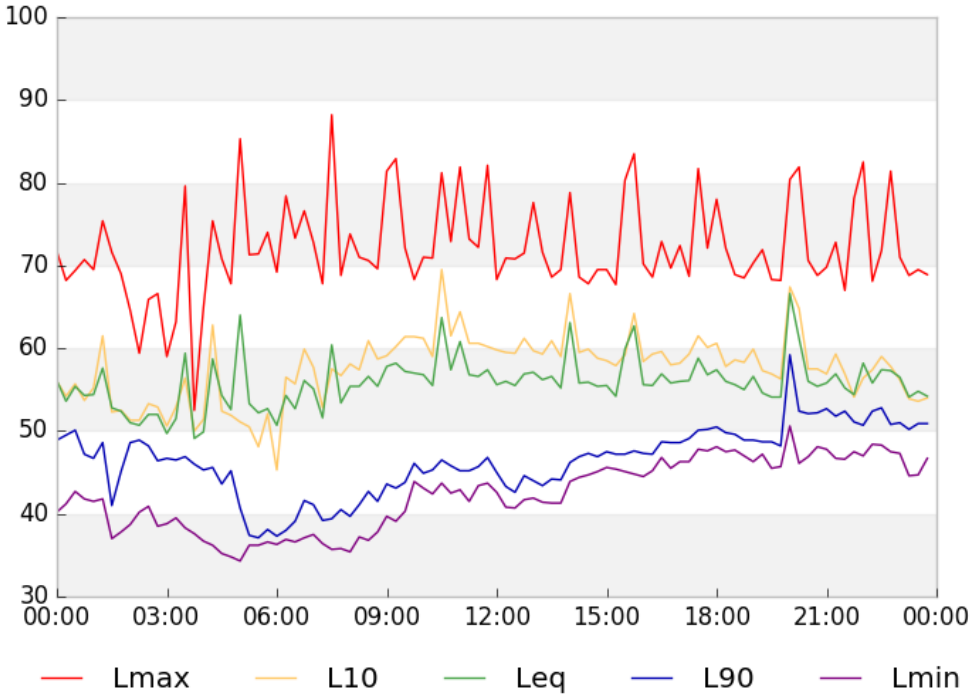

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