ACOUSTICS AND AIR

SYDNEY ZOO

NOISE AND VIBRATION IMPACT ASSESSMENT

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PREPARED FOR

SYDNEY ZOO
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WAVERLEY NSW 2041

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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.

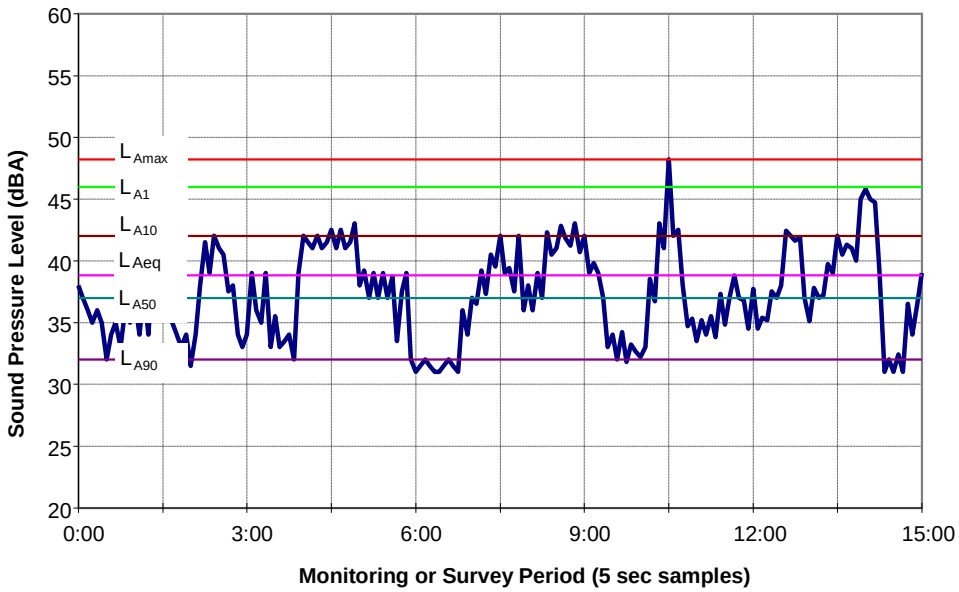
L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

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.

Typical Graph of Sound Pressure Level vs Time



1 INTRODUCTION

1.1 Project Background

Sydney Zoo is seeking approval under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the construction of a zoo (Sydney Zoo) within the Bungarribee Precinct in the Western Sydney Parklands.

The project was declared to be State Significant Development (SSD). Assessment and approval is being pursued in accordance with the EP&A Act. The Secretary's Environmental Assessment Requirements (SEARs) for the project have been issued and set out the environmental assessment requirements for the project.

This Noise and Vibration Impact Assessment (NVIA) has been prepared to address the relevant SEARs in relation to the preparation of the Environmental Impact Statement (EIS) for the project, and was conducted in general accordance with the following NSW Government guidelines:

- *NSW Industrial Noise Policy* (EPA, 2000);
- *Noise Guide for Local Government* (EPA, 2013);
- *NSW Road Noise Policy* (DECCW, 2011); and,
- *Interim Construction Noise Guideline* (DECC, 2009).

Given the substantial setback distances to nearby receivers it is considered that a vibration assessment is not warranted and therefore not considered further in this assessment.

1.2 The Project

The proposed development of Sydney Zoo will include:

- Animal exhibits across several enclosures of varying design for a range of native and exotic animals.
- Back-of-house buildings for exhibits.
- Main entrance building comprising entry/exit, and gift shop.
- Restaurant and café.
- Kiosks and amenities.
- Show arena.
- Picnic areas and gardens.
- Wetlands and waterways.
- Service building containing:
  - Administration areas;
  - Curatorial and food preparation areas; and,
  - Veterinarian space.
- Service yard with maintenance shelter.
- Main car park for approximately 475 vehicles, with an overflow car park for approximately 800 vehicles, accessed via an internal road connecting to the Great Western Highway.
- Bus parking.

Construction of the project is expected to take approximately 8 – 12 months to complete.

2 SITE DESCRIPTION

2.1 Site Location

The site is located approximately 33 kilometres west of the Sydney Central Business District, and approximately 15 kilometres east of Penrith. It falls within the Western Sydney Parklands, and is in close proximity to the Great Western Highway, M4 Western Motorway, and Westlink M7, providing excellent access to both the state and regional road network and surrounding parkland areas.

The project site is 16.5 hectares in size, and irregular in shape. Access will be from the Great Western Highway, approximately 75 metres from the southern border of the project site.

The site location is shown in Figure 2-1.

Figure 2-1 Site Location

2.2 Surrounding Land Use and Sensitive Receivers

To the north of the site is the residential suburb of Bungarribee, approximately 700 metres away, with separation via Bungarribee Creek which meanders through the parklands. Numerous sensitive receivers are located in this area.

The Arndell Park industrial estate is to the east of the site. This estate contains a large number of industrial businesses, none of which are identified as sensitive receivers in this assessment.

To the south, across the Great Western Highway, sit additional industrial development in Huntingwood, again with a mixture of industrial and warehouse type businesses. A number of isolated residential dwellings are located to the south of the site, the nearest of which is Lot 1 Great Western Highway (R1), approximately 250 metres away.

Westlink M7 Motorway is to the west of the site, providing a strong border to the parklands. A portion of the suburb of Eastern Creek is located to the west of the site and contains sensitive residential receivers and the Eastern Creek Primary School within approximately 800 metres of the site.

The nearest sensitive receivers identified for this assessment are presented in Table 2-1 and shown in Figure 2-2.

Table 2-1 Sensitive Receivers

Receiver / Catchment	Distance (m)
Bungarribee Residential	> 700
Lot 1 Great Western Highway, Eastern Creek (R1)	250
Eastern Creek Residential	> 800
Eastern Creek Primary School (S1)	750

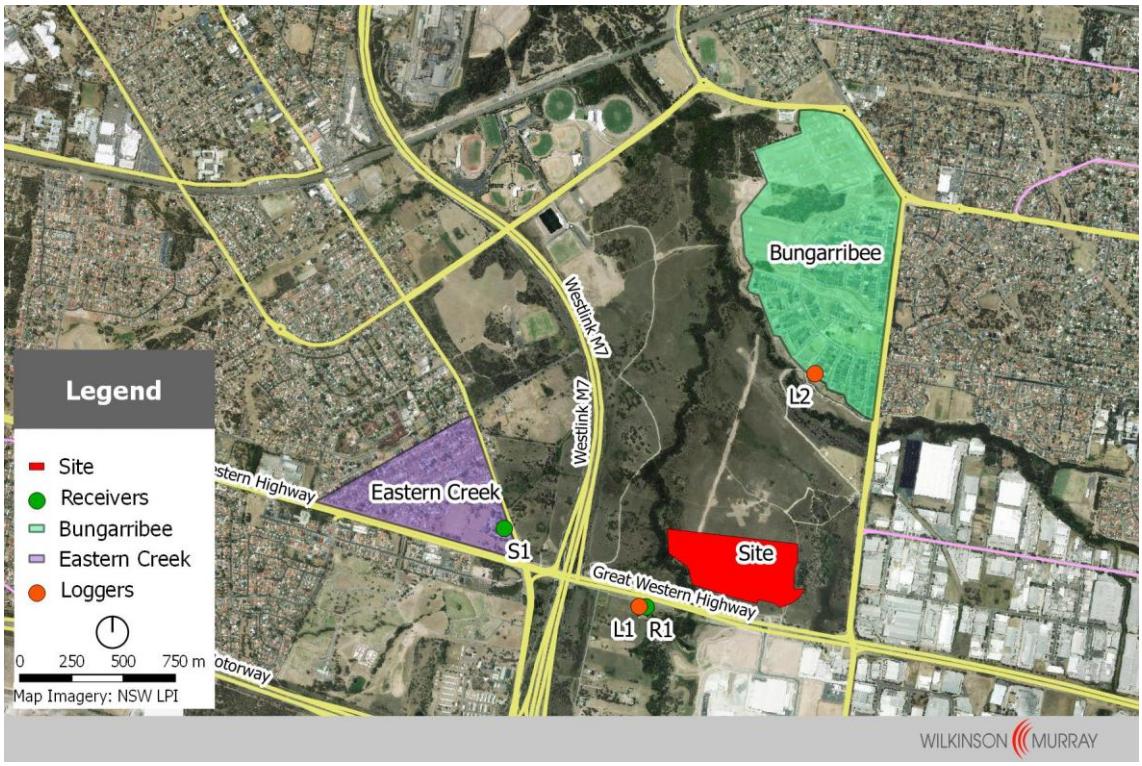
Figure 2-2 Sensitive Receivers

3 EXISTING NOISE ENVIRONMENT

To establish existing noise levels in the areas surrounding the development, unattended noise monitoring was conducted between 15 and 24 September 2015. Noise monitoring was conducted at 715 Great Western Highway, Eastern Creek (L1) and 26 Velocity Parade, Bungarribee (L2). The monitoring locations are presented in Figure 3-1.

Monitoring location L1 is considered representative of several isolated residences situated adjacent to the Great Western Highway, of which R1 is considered the most affected. Monitoring location L2 is considered representative of the nearest sensitive receivers to the north of the project site in Bungarribee, and to the west of the project site in Eastern Creek.

Figure 3-1 Noise monitoring locations



The noise monitoring equipment used for these measurements consisted of environmental noise loggers set to A-weighted, fast response. This equipment is 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.

From the background noise levels (L_{A90}) the Rating Background Levels (RBLs) were determined using the methodology recommended in the NSW *Industrial Noise Policy*.

The existing ambient noise levels are presented in Table 3-1. Daily plots of the noise logger data are presented in Appendix A.

Table 3-1 Existing ambient noise levels

Monitoring location	Represented receivers	Time period	Noise Levels (dBA)	
			RBL	L_{Aeq}
L1	Bungarribbee, Eastern Creek	Day (7:00am – 6:00pm)	46	54
		Evening (6:00pm – 10:00pm)	45	51
		Night (10:00pm – 7:00am)	45	52
L2	R1	Day (7:00am – 6:00pm)	52	59
		Evening (6:00pm – 10:00pm)	51	58
		Night (10:00pm – 7:00am)	48	58

The dominate noise source during the measurement period was from the existing traffic noise associated with M7 and Great Western Highway.

4 NOISE AND VIBRATION CRITERIA

4.1 Operational Noise Criteria

The NSW *Industrial Noise Policy* (INP) provides the framework for establishing noise criteria and assessing impacts from sources of industrial noise. This policy seeks to promote environmental well-being through preventing and minimising noise.

There are two noise criteria which should be satisfied under the INP. The first being the "intrusiveness" criterion which assesses the likelihood of noise being intrusive above the ambient noise level. The intrusiveness criterion applies for residential receivers only.

The second noise criterion, known as the "amenity" criterion, ensures the total industrial noise from all sources in the area does not rise above a maximum acceptable level.

The INP stipulates that intrusiveness and amenity criteria are determined for the daytime (7:00am 6:00pm), evening (6:00pm 10:00pm) and night time (10:00pm 7:00am) periods, as relevant. The determined criteria apply at the most affected point on or within the receiver property boundary.

4.1.1 INP Intrusiveness Criteria

The intrusiveness criterion requires that the L_{Aeq} noise level from the source being assessed, when measured over 15 minutes, should not exceed the Rating Background Noise Level (RBL) by more than 5 dBA.

Based on the established background noise levels, Table 4-1 summarises the intrusiveness noise criteria which apply to the identified receivers.

Table 4-1 Project specific intrusiveness criteria

Receiver	$L_{Aeq,15min}$ Intrusiveness Criterion (dBA)		
	Day*	Evening*	Night*
Bungarribee, Eastern Creek	46+5 = 51	45+5 = 50	45+5 = 50
R1	52+5 = 57	51+5 = 56	48+5 = 53

* Day = 7:00am – 6:00pm, Evening = 6:00pm – 10:00pm, Night = 10:00pm – 7:00am

4.1.2 INP Amenity Criteria

The amenity criterion sets a limit on the total noise level from *all industrial noise sources* affecting a receiver. Different criteria apply for different types of receiver (e.g. residence, school classroom); different areas (e.g. rural, suburban); and different time periods, namely daytime (7:00am-6:00pm), evening (6:00pm-10:00pm) and night time (10:00pm-7:00am).

The noise level to be compared with this criterion is the L_{Aeq} noise level, measured over the time period in question, due to all industrial noise sources, but excluding non-industrial sources such as transportation.

Where a new noise source is proposed in an area with negligible existing industrial noise, the amenity criterion for that source may be taken as being equal to the overall amenity criterion. However, if there is significant existing industrial noise, the amenity criterion for any new source must be set at a lower value. If existing industrial noise already exceeds the relevant amenity criterion, noise from any new source must be set well below the overall criterion to ensure that any increase in noise levels is negligible. Methods for determining a source-specific amenity criterion where there is existing industrial noise are set out in the *INP*.

The INP amenity criteria are shown in Table 4-2.

Table 4-2 Amenity Criteria

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended $L_{Aeq, period}$ Noise Level, (dBA)	
			Acceptable	Recommended Maximum
Residence	Rural	Day	50	55
		Evening	45	50
		Night	40	45
	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
	Urban	Day	60	65
		Evening	50	55
		Night	45	50
School classroom – internal	All	Noisiest 1-hour period when in use	35	40
Hospital Ward				
Internal	All	Noisiest 1-hour	35	40
External	All	Noisiest 1-hour	50	55
Place of Worship – internal	All	When in use	40	45
Passive recreation area (e.g. National park)	All	When in use	50	55
Active recreation area (e.g. playground, golf course)	All	When in use	55	60
Commercial premises	All	When in use	65	70
Industrial premises	All	When in use	70	75

The INP classifies all sensitive residential receivers identified in this assessment as "urban".

The land use surrounding the project site and sensitive receivers features a number of industrial developments. However during site visits, industrial noise was not audible at sensitive receiver locations. This is primarily due to the significant levels of transportation noise in the area. It is estimated that the existing levels of industrial noise at receivers in Bungarribee and in the vicinity of R1 is less than 40 dBA. Due to the increased separation from industrial land use, the existing levels of industrial noise in Eastern Creek are estimated to be less than 35 dBA.

The amenity criteria for sensitive residential receivers in proximity to the project have been adjusted, in accordance with the INP, to account for the existing levels of industrial noise, and are presented in Table 4-3.

Table 4-3 Project Specific Amenity Criteria for Residential Receivers

Receiver	Time Period	Amenity Criteria (dBA – $L_{Aeq, period}$)
Bungarribee, Eastern Creek	Day (7:00am – 6:00pm)	60
	Evening (6:00pm – 10:00pm)	50
	Night (10:00pm – 7:00am)	43
R1	Day (7:00am – 6:00pm)	60
	Evening (6:00pm – 10:00pm)	50
	Night (10:00pm – 7:00am)	45

The INP amenity criteria for schools are defined as acceptable internal noise levels. For the purpose of assessment, these internal noise levels have been converted to allowable external noise levels based on the assumption that noise levels are typically attenuated by approximately 10 dBA when pass from outside to inside. Therefore the $L_{Aeq, period}$ criteria for S1 is 45 dBA, and applies when the school classrooms are in use.

4.1.3 Project-Specific Noise Levels

To simplify operational noise assessments, it is desirable to establish a single set of criteria for the relevant assessment periods. These criteria are referred to as the Project Specific Noise Levels (PSNL) and are equal to the most stringent of the established intrusiveness and amenity criteria for each assessment period.

Since $L_{Aeq, 15min}$ noise levels are higher than $L_{Aeq, period}$ noise levels, care must be taken when establishing PSNL. For example, $L_{Aeq, 15min}$ noise levels from this project would be approximately 5 dBA higher than $L_{Aeq, period}$ noise levels at the most affected receivers. Therefore, the evening intrusiveness criterion of 50 dBA applicable at residential receivers in Bungarribee and Eastern Creek is significantly more stringent than the corresponding evening amenity criterion of 50 dBA.

To achieve simplicity in the assessment, while retaining a conservative approach, the PSNL have been established by taking the numerical values of the established amenity criteria, and applying them as $L_{Aeq, 15min}$ criteria. Table 4-4 presents the INP criteria for this project, along with the PSNL.

Table 4-4 INP Criteria and Project Specific Noise Levels

Receiver	Time Period	Criteria (dBA)		PSNL ($L_{Aeq, 15min}$)
		Intrusiveness ($L_{Aeq, 15min}$)	Amenity ($L_{Aeq, period}$)	
Bungarribee, Eastern Creek	Day (7:00am – 6:00pm)	51	60	51
	Evening (6:00pm – 10:00pm)	50	50	50
	Night (10:00pm – 7:00am)	50	43	43
R1	Day (7:00am – 6:00pm)	57	60	57
	Evening (6:00pm – 10:00pm)	56	50	50
	Night (10:00pm – 7:00am)	53	45	45
S1	Busiest 1 hour (when in use)	n/a	45	45

It is worth noting that another advantage of establishing PSNL using the $L_{Aeq, 15min}$ noise descriptor is the additional ease of confirming compliance with the criteria since noise compliance measurements conducted in accordance with the INP are done so using the $L_{Aeq, 15min}$ descriptor.

4.2 Sleep Disturbance Screening Levels

With respect to operational noise at night time (10.00pm-7.00am), it is possible for events of short duration, but high intensity to cause sleep disturbance; without significantly affecting $L_{Aeq, 15min}$ noise levels.

The EPA's *Noise Guide for Local Government (NGLG)* notes that:

> *"Currently, there is no definitive guideline to indicate a noise level that causes sleep disturbance and more research is needed to better define this relationship. Where likely disturbance to sleep is being assessed, a screening test can be applied that indicated the potential for this to occur.*
>
> *For example, this could be where the subject noise exceeds the background noise level by more than 15 dBA. The most appropriate descriptors for a source relating to sleep disturbance would be $L_{A1, 1 minute}$ (the level exceeded for 1% of the specified time period of 1 minute) or L_{Amax} (the maximum level during the specified time period) with measurement outside the bedroom window."*

Based on the above advice, sleep disturbance screening levels have been established for the receiver catchment areas and are shown in Table 4-5.

Sleep disturbance screening levels are established for residential receivers only.

Table 4-5 Sleep Disturbance Screening Levels

Receiver Catchment	Night Time (10:00pm-7:00am) RBL (dBA)	Sleep Disturbance Screening Level (dBA - $L_{A1,1min}$ / L_{Amax})
Bungarribee	45	60
Eastern Creek	45	60
R1	48	63

4.3 Traffic Noise Criteria

The *NSW Road Noise Policy* (RNP) provides guidance on assessing road traffic noise impacts from traffic generating developments. The RNP road traffic noise assessment criteria for residential land uses are presented in Table 4-6.

In addition to the criteria in Table 4-6, the RNP advises that in cases where existing levels of road traffic noise exceed the applicable criteria, and that a development has the potential to increase road traffic noise levels; an increase of up to 2 dBA represents a minor impact that is considered barely perceptible to the average person.

Table 4-6 Road traffic noise criteria for residential land uses

Road Category	Type of project/land use	Assessment Criteria - dBA	
		Day (7am – 10pm)	Night (10pm – 7am)
Freeway/ arterial/ sub-arterial roads	Existing residences affected by noise from **new** freeway/arterial/sub-arterial road corridors	$L_{Aeq,\ 15\ hour}$ 55 (external)	$L_{Aeq,\ 9\ hour}$ 50 (external)
	Existing residences affected by noise from **redevelopment** of existing freeway/arterial/sub-arterial roads	$L_{Aeq,\ 15\ hour}$ 60 (external)	$L_{Aeq,\ 9\ hour}$ 55 (external)
	Existing residences affected by **additional traffic** on existing freeway/arterial/sub-arterial roads generated by land use developments		
Local roads	Existing residences affected by noise from **new** local road corridors	$L_{Aeq,\ 1\ hour}$ 55 (external)	$L_{Aeq,\ 1\ hour}$ 50 (external)
	Existing residences affected by noise from **redevelopment** of existing local roads		
	Existing residences affected by **additional traffic** on existing local roads generated by land use developments		

Note: Land use developers must meet internal noise goals in the Infrastructure SEPP (Department of Planning NSW 2007) for sensitive developments near busy roads.

Nearby residences most affected by traffic generated by the project are located along the Great Western Highway and along Doonside Road. In accordance with the RNP, both the Great Western Highway and Doonside Road fall into to the Freeway/arterial/sub-arterial road category.

4.4 Construction Noise Criteria

The NSW EPA's *Interim Construction Noise Guidelines (ICNG)* recommends noise management levels (NML) to reduce the likelihood of noise impacts arising from construction activities. The ICNG NML for residential receivers are shown in Table 4-7.

Table 4-7 ICNG Noise Management Levels for residential receivers

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 + 10 dBA	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 meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences; • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• 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 5dB(A) above the noise affected level, the proponent should negotiate with the community.

The ICNG recommends an internal noise level of 45 dBA as an appropriate NML for school classrooms. Consistent with the approach taken in Section 4.1, the internal NML of 45 dBA for school classrooms has been converted to an external NML of 55 dBA.

It is expected that all construction activities will be conducted within standard construction hours. Based on the RBLs in Table 3-1, the construction noise management levels for this project are presented in Table 4-8.

Table 4-8 Project specific construction NML

Receiver	Acceptable $L_{Aeq, 15min}$ Noise Level (Standard daytime construction hours)
Bungarribee, Eastern Creek	56
R1	62
S1	55

5 ASSESSMENT OF IMPACTS

5.1 Noise Modelling Methodology and Assumptions

5.1.1 Noise Prediction Software

To predict the potential noise impacts from the operation and construction of the project an acoustic model, implementing the CONCAWE algorithms, has been prepared using the CadnaA environmental noise modelling software. Factors addressed in the noise model are:

- Equipment noise emissions and locations;
- Shielding from structures;
- Noise attenuation due to geometric spreading;
- Ground absorption;
- Atmospheric absorption; and,
- Meteorological effects including wind and temperature inversions.

The opening hours of the zoo are limited to daytime and evening hours only, and noise enhancement from temperature inversions during these time periods is considered unlikely. However during the summer months, easterly breezes during the afternoon and evening are very common. Accordingly, adverse meteorological conditions included in the assessment during 'opening hours' comprise a 3 m/s source to receiver wind for R1 and other receivers to the east in Eastern Creek.

Temperature inversions are likely during winter nights. Therefore for the 'after hours' assessment, during the night time period, the default parameters recognised by the INP to represent adverse meteorological conditions for noise propagation have been applied, as follows:

Moderate (F-class stability category) inversions:

- 3°/100 m temperature inversion strength; and
- 2 m/s wind blowing in the direction from source to receiver

5.2 Operational Noise Impacts

The following section identifies equipment and activities, associated with the operation of the development, which are likely to generate significant noise emissions and presents the predicted noise levels at nearby receivers.

The assessment of potential operational noise impacts will investigate separately, the noise emissions from the project site while it is open to the public, referred to as 'opening hours', and during the 'after hours' period. The opening hours of the zoo would typically be 9:00am – 6:00pm, but would extend to 10:00pm during the peak summer period.

5.2.1 Sources of Operational Noise

Significant sources of operational noise have been identified from information from the client, and from recent observations in the area surrounding Taronga Park Zoo.

Observations of the noise environment at sensitive receivers near the Taronga Park Zoo during Thursday 1 October and Friday 2 October revealed that traffic noise on the surrounding road network dominated the ambient noise environment. Noise sources from Taronga Park Zoo that were audible comprised patrons, mechanical plant and animals.

Noise from patrons and mechanical plant would be expected to contribute to $L_{Aeq,\ 15min}$ noise levels outside of periods of peak traffic flows. Despite being occasionally audible, animal noise is considered unlikely to influence $L_{Aeq,\ 15min}$ noise levels at sensitive receivers near Taronga Park Zoo.

With consideration of the Taronga Park Zoo observations and taking into account the existing noise environment, the most significant sources of operational noise identified for the proposed Sydney Zoo are:

- Mechanical plant, specifically air conditioning units and exhaust fans;
- Carpark movements;
- Mobile plant, such as delivery trucks; and,
- Patron noise, specifically children.

Detailed design of all mechanical plant to be installed on the site has not been completed. However for assessment purposes, it has been assumed that air conditioning units would be installed in the administration and gift shop buildings and that exhaust fans would be installed at the restaurant. It has been conservatively assumed that mechanical plant items would be installed on the rooftops of these buildings, without parapets.

A number of pumps, associated with the moats and lagoons, would be required, and would be installed in pits or plant rooms. Pumps would not contribute significantly to operational noise emissions while the zoo is open to the public, but since the pumps would operate on a 24/7 basis, they would be a significant source of site noise emissions during the night time. It is assumed that approximately 20 pumps would be installed on the site.

According to the Transport Impact Assessment for the project, prepared by GTA Consultants, the peak activity in the carpark would be 543 vehicle movements per hour. During a worst case 15 minute period, it is assumed that 150 vehicle movements would occur in the carpark.

Deliveries of food and beverage, animals and feed, and collection of waste would involve trucks accessing the perimeter road. It is assumed that up to two deliveries could occur in a 15 minute period.

The client has advised that the peak anticipated number of visitors to the Zoo at any time would be 8,000 people, and it is assumed that 75% of patrons would be children. For assessment purposes it is assumed that all children would be talking loudly.

The key operational noise sources included in the assessment are summarised in Table 5-1. The quoted sound power level for pumps has been corrected, with a 10 dBA reduction, to account for the fact that they would be installed in pits or plant rooms. This correction is considered to be conservative.

Table 5-1 Operational Noise Sources

Source	Quantity	Sound Power Level (dBA)	
		Per Item	Total
Air conditioning units	1 per building (admin, main)	100[1]	103
Exhaust Fan	1 (restaurant)	95[1]	95
Carpark	150 movements	63[1]	85
Trucks	2	103[1]	106
Children	600	72[2]	100
Pumps	20	80[1]	93

1. Wilkinson Murray Measurements
2. AAAC Technical Guideline, Child Care Centre Noise Assessment

5.2.2 Predicted Operational Noise Levels at Nearby Receivers

Noise levels at sensitive receivers have been predicted as outlined above for the opening hours and after hours periods, and are presented in Table 5-2 and Table 5-3, respectively.

Table 5-2 Predicted $L_{Aeq,\ 15min}$ Noise Levels – Opening Hours

Receiver	Predicted $L_{Aeq,\ 15min}$ Noise Level (dBA)		Criterion		Complies?
	Calm Meteorological Conditions	Adverse Meteorological Conditions	Daytime	Evening	
Bungarribee	28	28	51	50	Yes
Eastern Creek	25	29	51	50	Yes
R1	37	40	57	50	Yes
S1	26	30	45	n/a	Yes

Table 5-3 Predicted $L_{Aeq,\ 15min}$ Noise Levels – After Hours

Receiver	Predicted $L_{Aeq,\ 15min}$ Noise Level (dBA)		Criterion Night Time	Complies?
	Calm Meteorological Conditions	Adverse Meteorological Conditions		
Bungarribee	<25	<25	40	Yes
Eastern Creek	<25	<25	40	Yes
R1	<25	<25	40	Yes
S1	<25	<25	n/a	n/a

Review of Table 5-2 and Table 5-3 indicate that the predicted operational noise levels at nearby receivers comply with the established criteria at all times day.

Contour plots of the predicted noise levels during opening hours for calm and adverse meteorological conditions are presented in Figure 5-1 and Figure 5-2, respectively.

5.2.3 Cumulative Operational Noise Impacts

An assessment of cumulative noise in accordance with the INP requires that the $L_{Aeq,\ period}$ noise levels from the development are added to the existing levels of industrial noise at sensitive receivers, and assessed against the applicable amenity criteria.

Table 5-4 presents a conservative cumulative assessment for the project whereby the predicted $L_{Aeq,\ 15min}$ noise levels from the project during adverse meteorological conditions are added to the existing levels of industrial noise, as presented in Section 4.1.2, and assessed against the relevant amenity criteria for each receiver.

Table 5-4 Cumulative Industrial Noise Levels

Receiver	Time	$L_{Aeq,\ period}$ Noise Levels			Criteria	Complies?
		Existing	From Project	Cumulative		
Bungarribee	Day	40	28	40	60	Yes
	Evening	40	28	40	50	Yes
	Night	40	25	40	45	Yes
Eastern Creek	Day	35	29	36	60	Yes
	Evening	35	29	36	50	Yes
	Night	35	25	35	45	Yes
R1	Day	40	40	43	60	Yes
	Evening	40	40	43	50	Yes
	Night	40	25	40	45	Yes
S1	Day	35	30	36	45	Yes

Review of Table 5-4 indicates that cumulative industrial noise levels at sensitive receivers comply with the relevant INP amenity criteria.

Figure 5-1 Operational Noise Contours – Opening Hours, Calm Meteorology

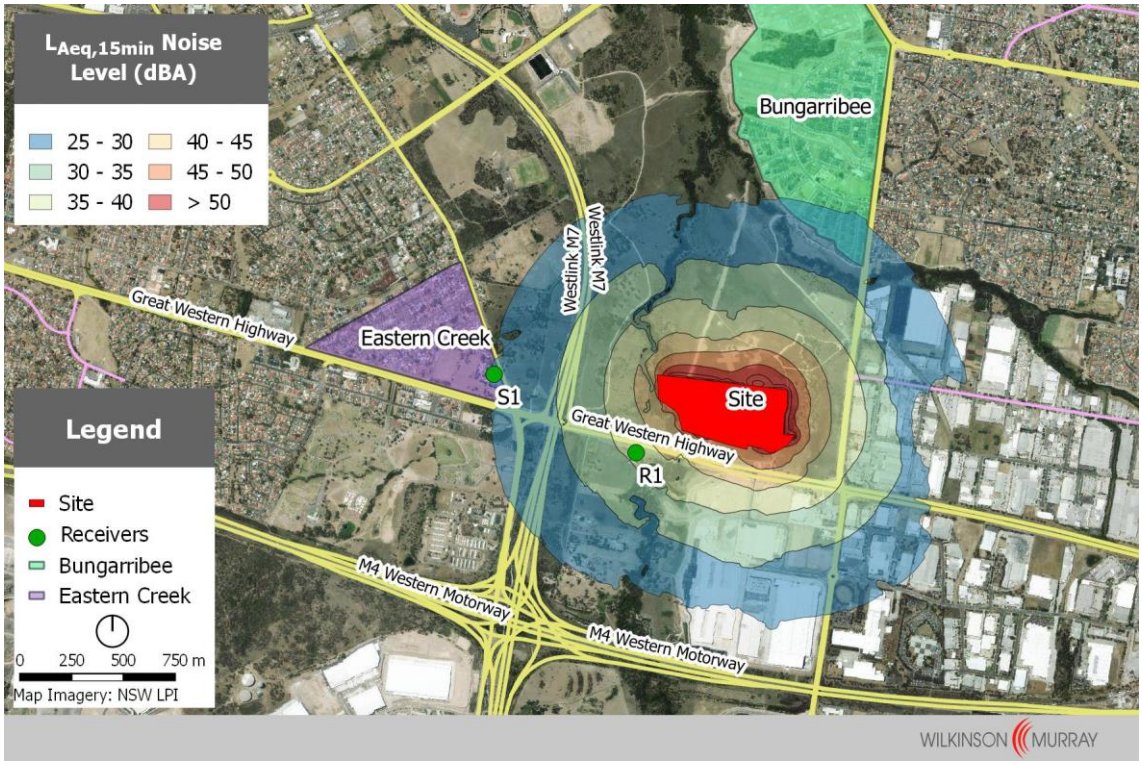
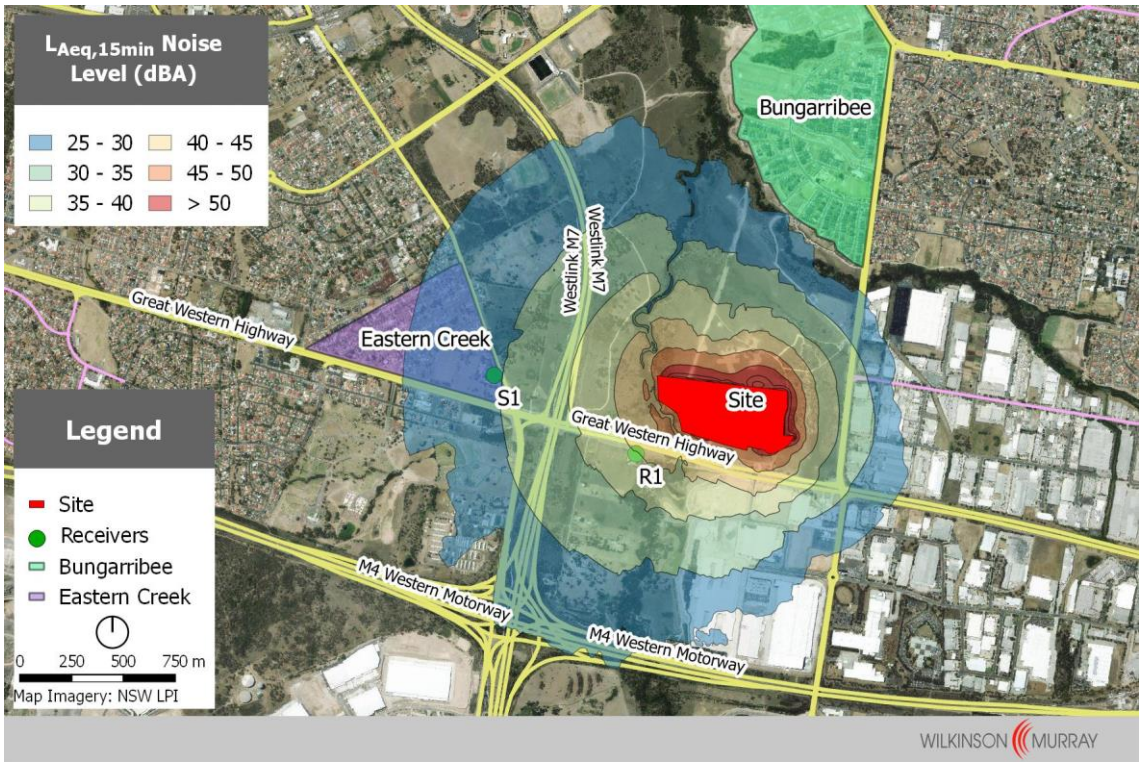


Figure 5-2 Operational Noise Contours – Opening Hours, Adverse Meteorology



5.3 Sleep Disturbance Impacts

Transient noise events associated with the operation of the project which have the greatest potential to cause sleep disturbance impacts are roaring lions.

Based on available research (Klemuk et al, 2011) L_{Amax} noise levels from roaring lions can reach up to 114 dBA at 1 meter. This corresponds to an L_{Amax} sound power level of 122 dBA.

L_{Amax} noise levels at sensitive residential receivers associated with lions roaring in their enclosure, located in the north west portion of the site, were predicted during both calm and adverse meteorological conditions. These results are presented in Table 5-5.

Table 5-5 Predicted L_{Amax} Noise Levels at Sensitive Receivers

Receiver	Predicted L_{Amax} Noise Level (dBA)		Screening Level	Complies?
	Calm Meteorological Conditions	Adverse Meteorological Conditions		
Bungarribee	33	38	60	Yes
Eastern Creek	38	43	60	Yes
R1	50	54	63	Yes

Review of Table 5-5 indicates that the predicted L_{Amax} noise levels at sensitive residential receivers due to lions roaring comply with the established screening levels. Accordingly, sleep disturbance impacts are unlikely.

5.4 Traffic Noise Impacts

Nearby residences most affected by traffic generated by the project are located along the Great Western Highway, between the project site and the Westlink M7 Interchange, and along Doonside Road, north of the Great Western Highway.

According to the Transport Impact Assessment for the project, prepared by GTA Consultants, the project will generate approximately 5,000 vehicle movements on the busiest days, with 50% of vehicles accessing the site from the Great Western Highway, west of the site, and 10% via Doonside Road.

It is assumed that all traffic movements generated by the project will occur during the daytime period. The daytime period for traffic noise assessments is 7:00am – 10:00pm.

The annual average daily traffic (AADT) volumes along the Great Western Highway and Doonside Road are approximately 42,500 and 27,000 vehicles per day, and it is assumed that heavy vehicles make up 10% of the total volume along both roads. The speed limits along these roads, in the vicinity of the most affected receivers are 80 km/h and 70km/h, respectively.

5.4.1 Traffic Noise Prediction Methodology

Traffic noise levels have been predicted using the *Calculation of Road Traffic Noise (CORTN)* model developed by the Welsh Office of the UK Department of Transport, 1988. The *CORTN* method calculates the $L_{A10,18hr}$ noise level and takes into account the following factors:

- Traffic flow volumes
- Average vehicle speed
- Percentage of heavy vehicles
- Gradient of road
- Type of road pavement
- Distance from receiver location to road
- Shielding from barriers / building and intervening topography
- Reflections from barriers / buildings
- Angle of view
- Building facade reflection correction
- Ground absorption

This procedure has been modified to permit calculation of 15 hour and nine hour L_{A10} levels which have then been converted to L_{Aeq} levels using the US Federal Highway Administration (FHWA) procedure.

5.4.2 Predicted Road Traffic Noise Levels at Nearby Receivers

The predicted increases in traffic noise levels at residential receivers along the Great Western Highway and along Doonside Road are presented in Table 5-6.

Table 5-6 Predicted Road Traffic Noise Levels

Road	Without Project	With Project	Increase
	Day ($L_{Aeq,\ 15hour}$ dBA)	Day ($L_{Aeq,\ 15hour}$ dBA)	
Great Western Highway	65.3	65.6	0.3
Doonside Road	64.1	64.2	0.1

Review of Table 5-6 indicates that the existing $L_{Aeq,\ 15hour}$ traffic noise levels at the most affected receivers along both the Great Western Highway and Doonside Road are above the RNP criterion, and that the predicted increases in traffic noise levels due to the project are well below 2 dB. In accordance with the RNP, no further assessment of reasonable and feasible mitigation is required.

5.5 Construction Noise Impacts

The following section identifies equipment and activities, associated with the construction of the development, which are likely to generate significant noise emissions and presents the predicted noise levels at nearby receivers.

The assessment of construction noise will investigate the worst case construction noise emissions from the project site. The highest construction noise emissions from the site will occur during the bulk earthworks phase, which is planned to last for 3 – 4 months. Construction activities during bulk earthworks and all other phases are planned to occur during the following standard construction hours:

- Monday to Friday - 7:00am to 6:00pm
- Saturdays – 8:00am to 1:00pm
- Sundays and Public Holidays - no work

5.5.1 Construction Plant and Noise Source Levels

Sound Power Levels (SWLs) associated with typical construction plant to be used during the bulk earthworks phase are identified in Table 5-7. These SWLs have recently been measured at other similar construction sites. The table gives both Sound Power Level and Sound Pressure Levels (SPL) at 7m for the equipment. Sound Power Level is independent of measurement position.

Table 5-7 Typical Construction Plant Sound Levels – dBA

Plant	Sound Power Level	Sound Pressure Level at 7m
Bulldozer	119	94
Excavator	107	81
Dump Truck	112	87
Front End Loader	110	85
Scraper	119	94
Grader	109	84
Roller	102	77
Water Cart	109	84
Compactor	112	87
Truck & Dog	103	78

5.5.2 Predicted Construction Noise Levels at Nearby Receivers

The ICNG requires predicted noise levels at receivers to be based on 15-minute periods. The modelling assumes a "typical worst-case" scenario whereby all the plant is running continuously. As such, the modelling represents likely noise levels that would occur during intensive periods of construction. Therefore, the presented noise levels can be considered in the upper range of noise levels that can be expected at surrounding receivers when the various construction scenarios occur.

The predicted worst case $L_{Aeq, 15min}$ noise levels at nearby receivers during the bulk earthworks are presented in Table 5-8.

Table 5-8 Predicted Construction Noise Levels at Nearby Receivers

Receiver	Predicted Noise Level	NML	Exceedance
Bungarribee	36	56	0
Eastern Creek	38	56	0
R1	49	62	0
S1	39	55	0

Review of Table 5-8 indicates that $L_{Aeq, 15min}$ construction noise levels comply with the established NML at all receivers during the bulk earthworks phase. Since construction noise emissions during bulk earthworks are expected to be significantly higher than during other construction phases, it is considered unlikely that construction noise levels associated with the project would exceed the NML at any stage.

6 CONCLUSION

A Noise and Vibration Impact Assessment (NVIA) has been conducted for the proposed Sydney Zoo Development.

Potential noise and vibration impacts associated with the development have been assessed consistent with the Secretary's Environmental Assessment Requirements issued for the project. The assessment investigates potential impact associated with operations, construction and traffic, and has been conducted in general accordance with relevant NSW Government guidelines.

The predicted levels of operational, road, and construction noise comply with established goals at all nearby receivers.

L_{Amax} noise levels at night time due to roaring lions are well below the established sleep disturbance screening levels.

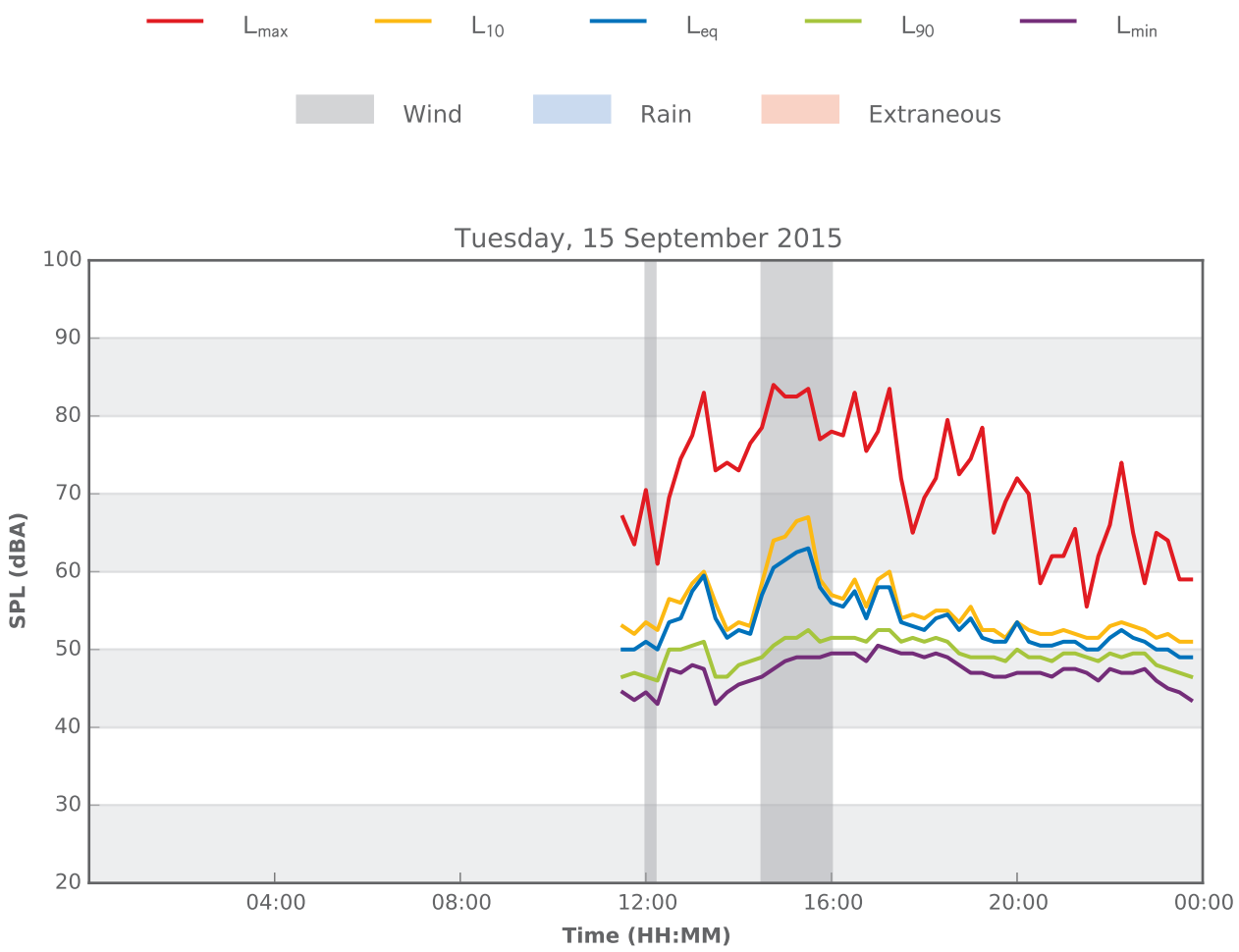
Cumulative noise levels due to the project and existing industrial sources have been assessed against the INP amenity criteria and are predicted to comply at all receivers.

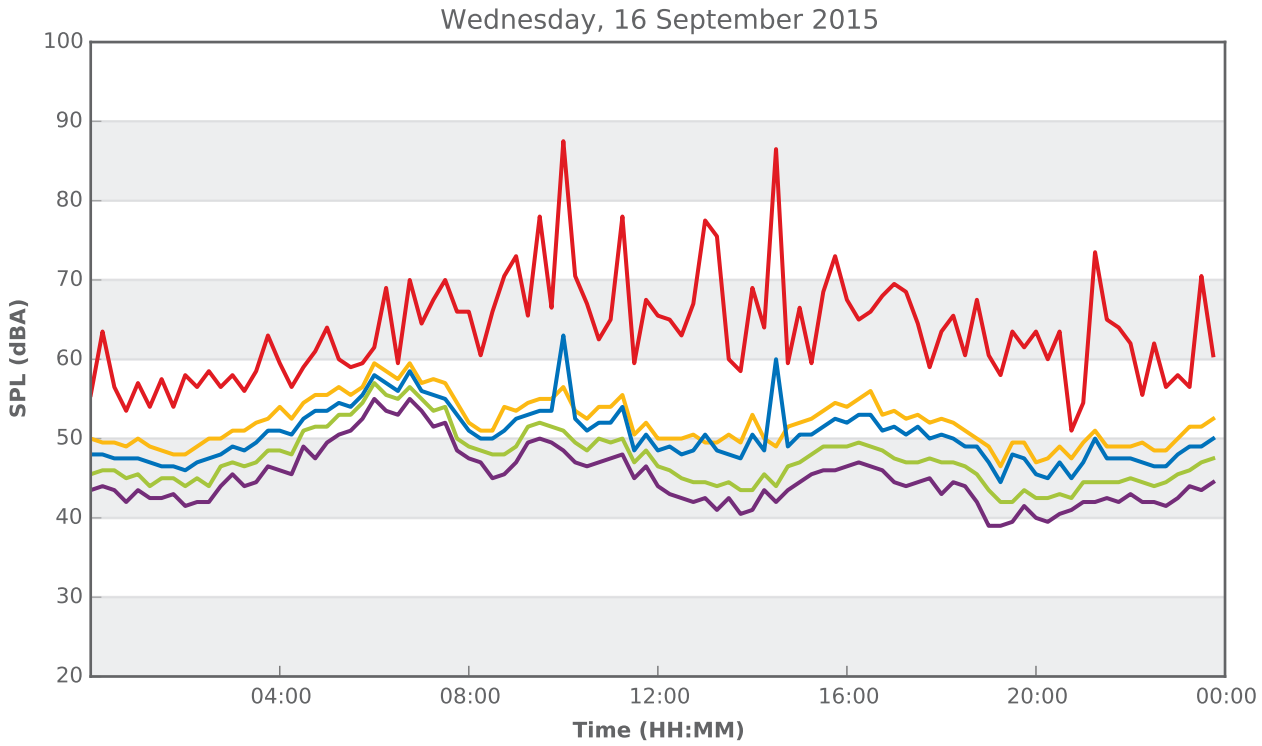
Given the substantial setback distances to nearby receivers, any ground vibrations arising due to construction activities would be unnoticeable at these locations and significantly below the relevant guideline criteria for human comfort and structural damage.

APPENDIX A

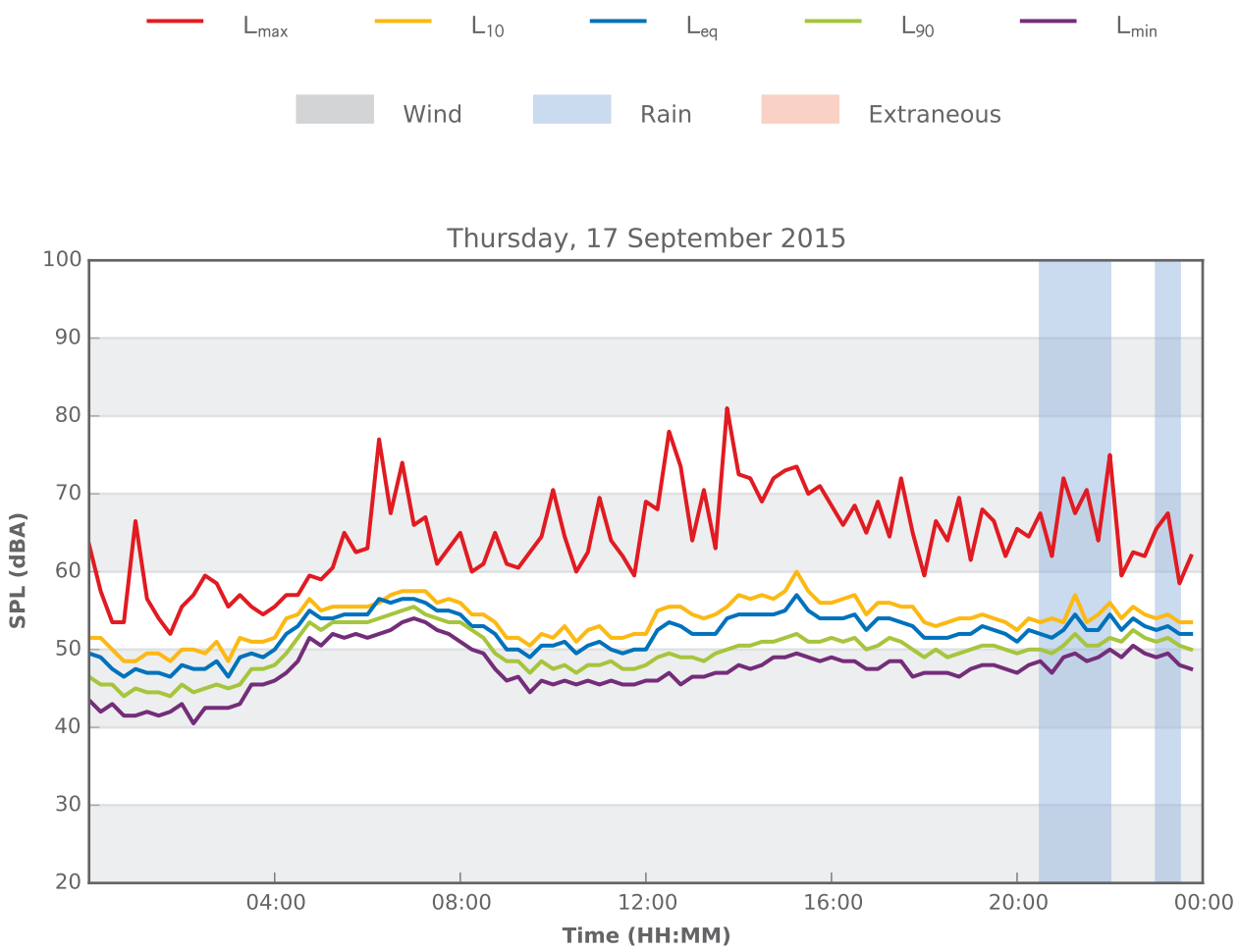
NOISE MEASUREMENT RESULTS

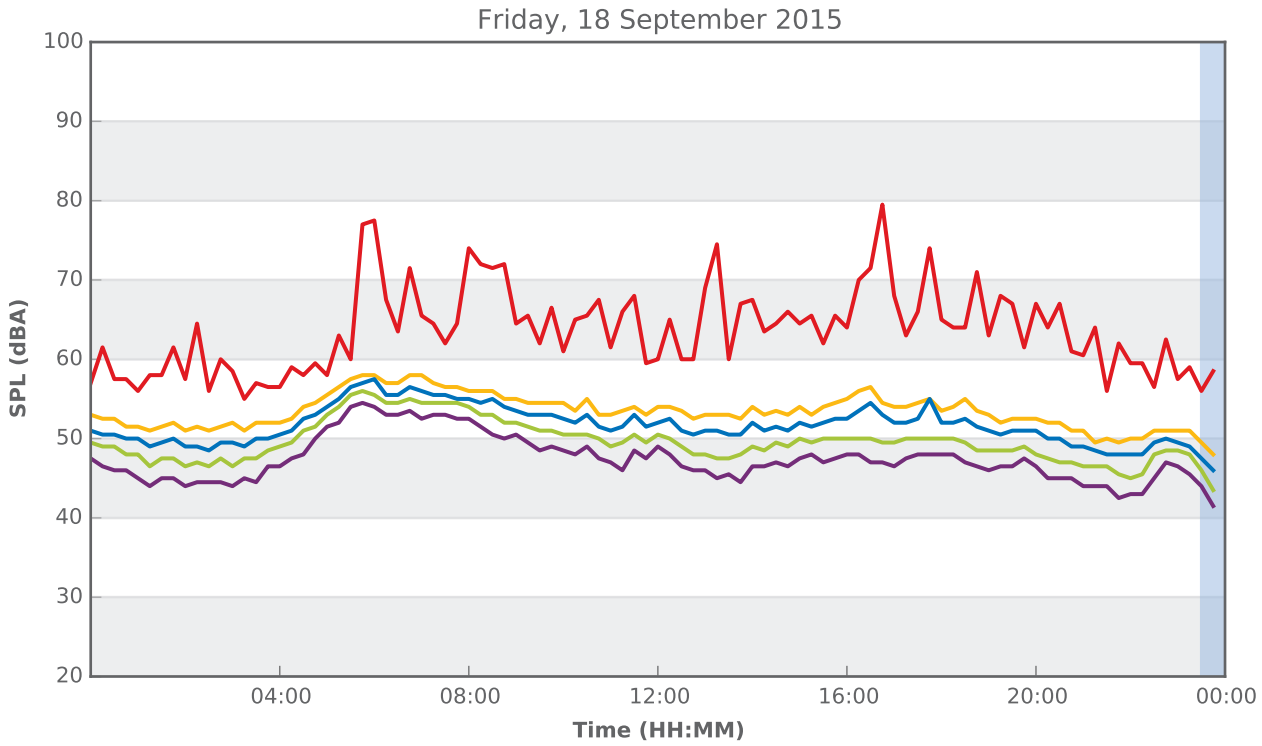
26 Velocity Parade, Bungarribee



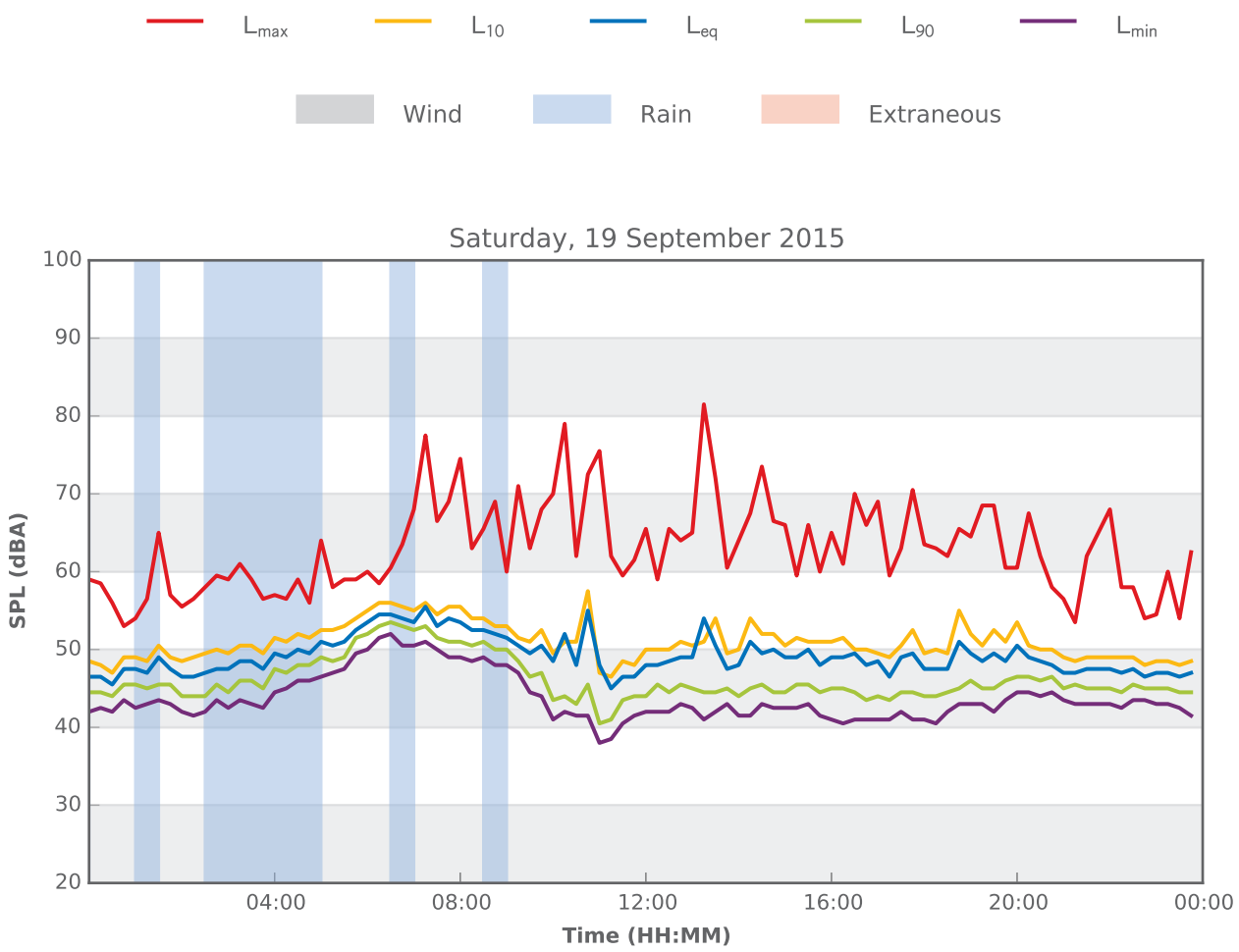


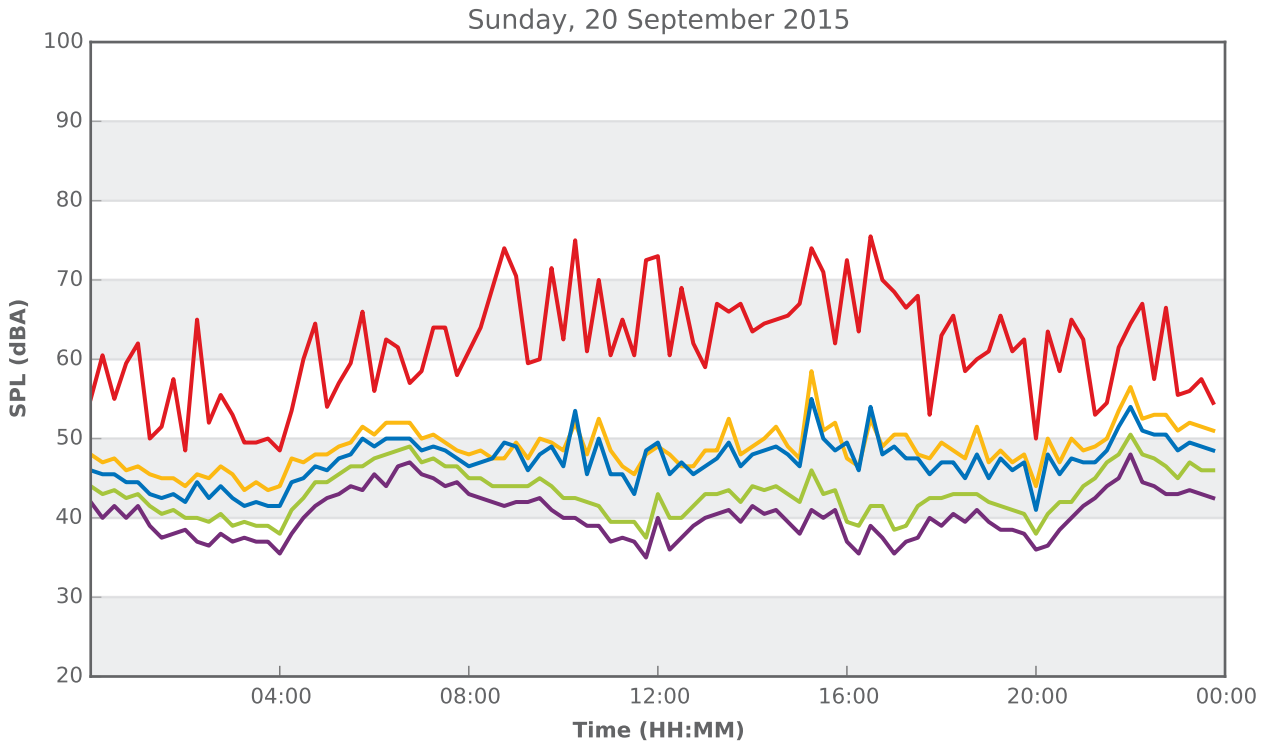
26 Velocity Parade, Bungarribee



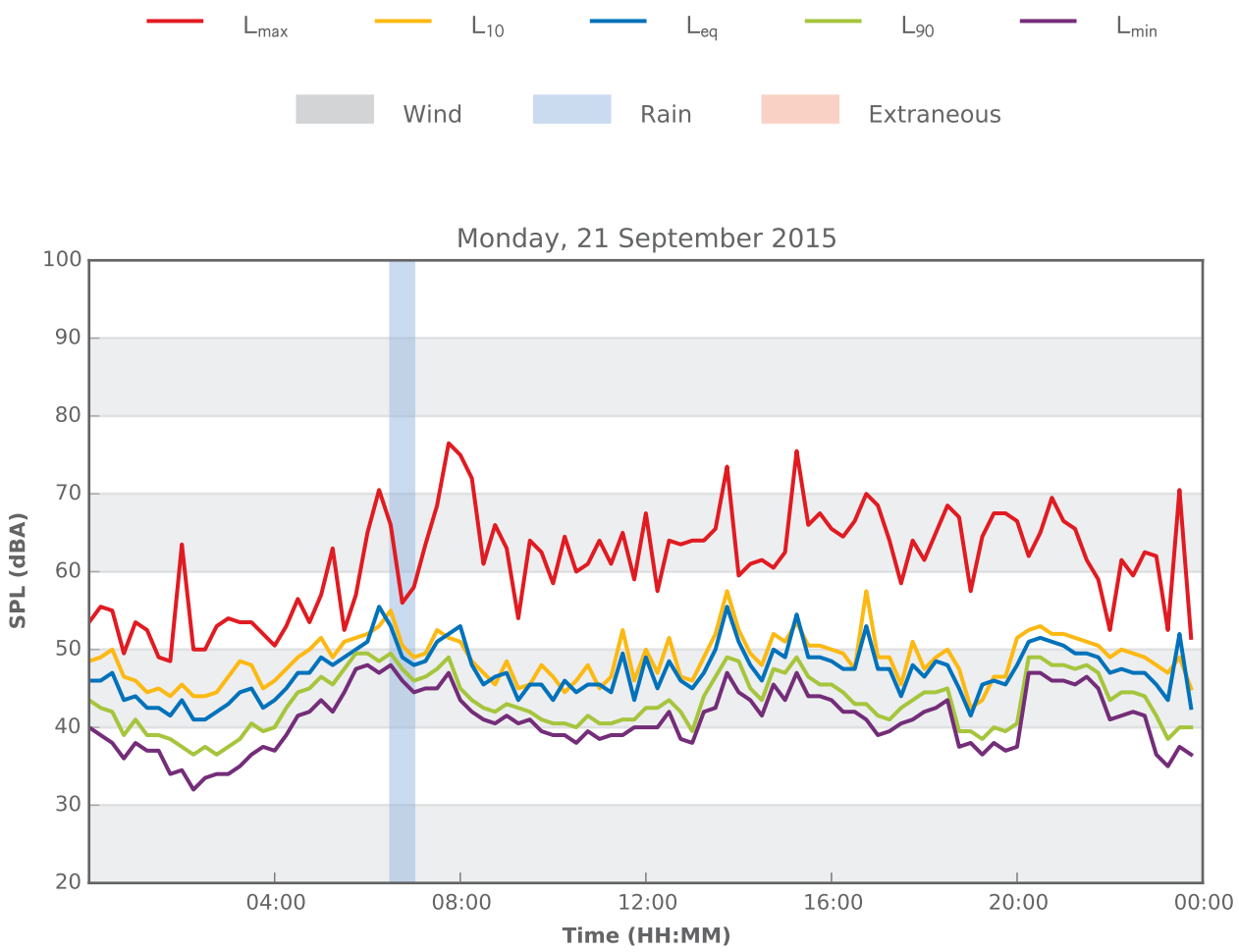


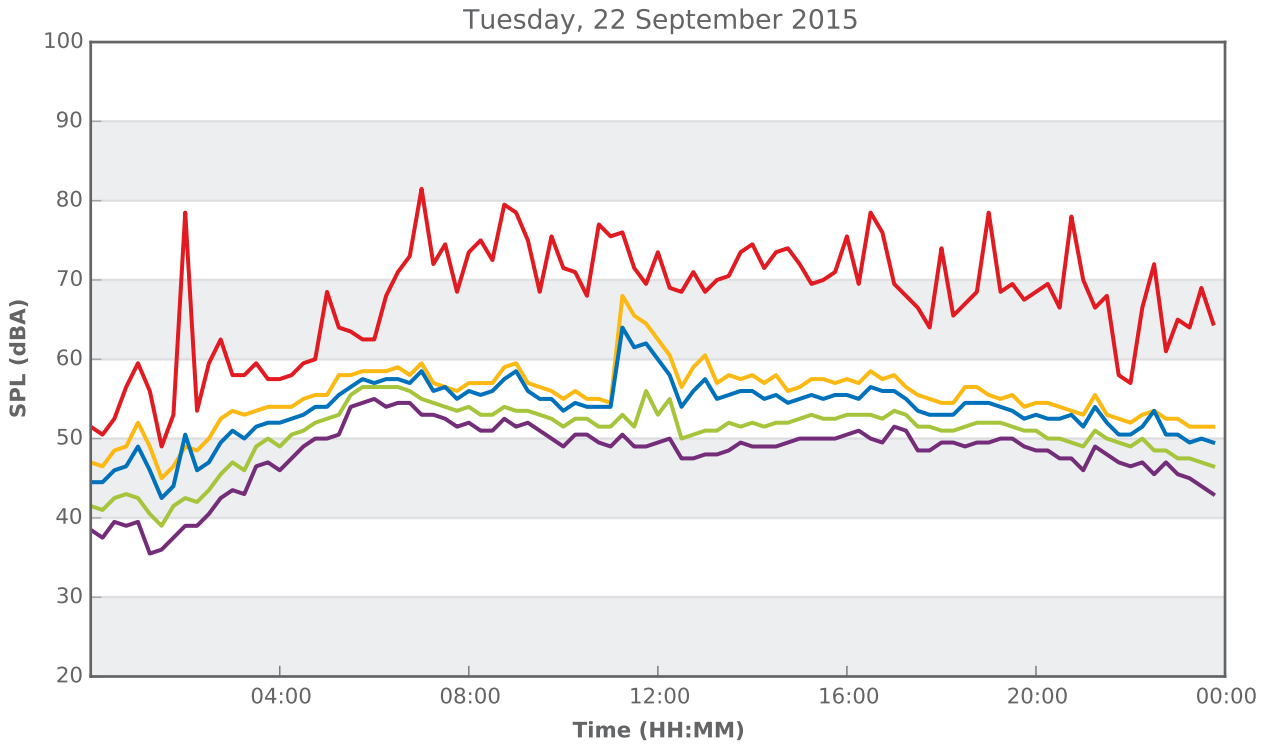
26 Velocity Parade, Bungarribee



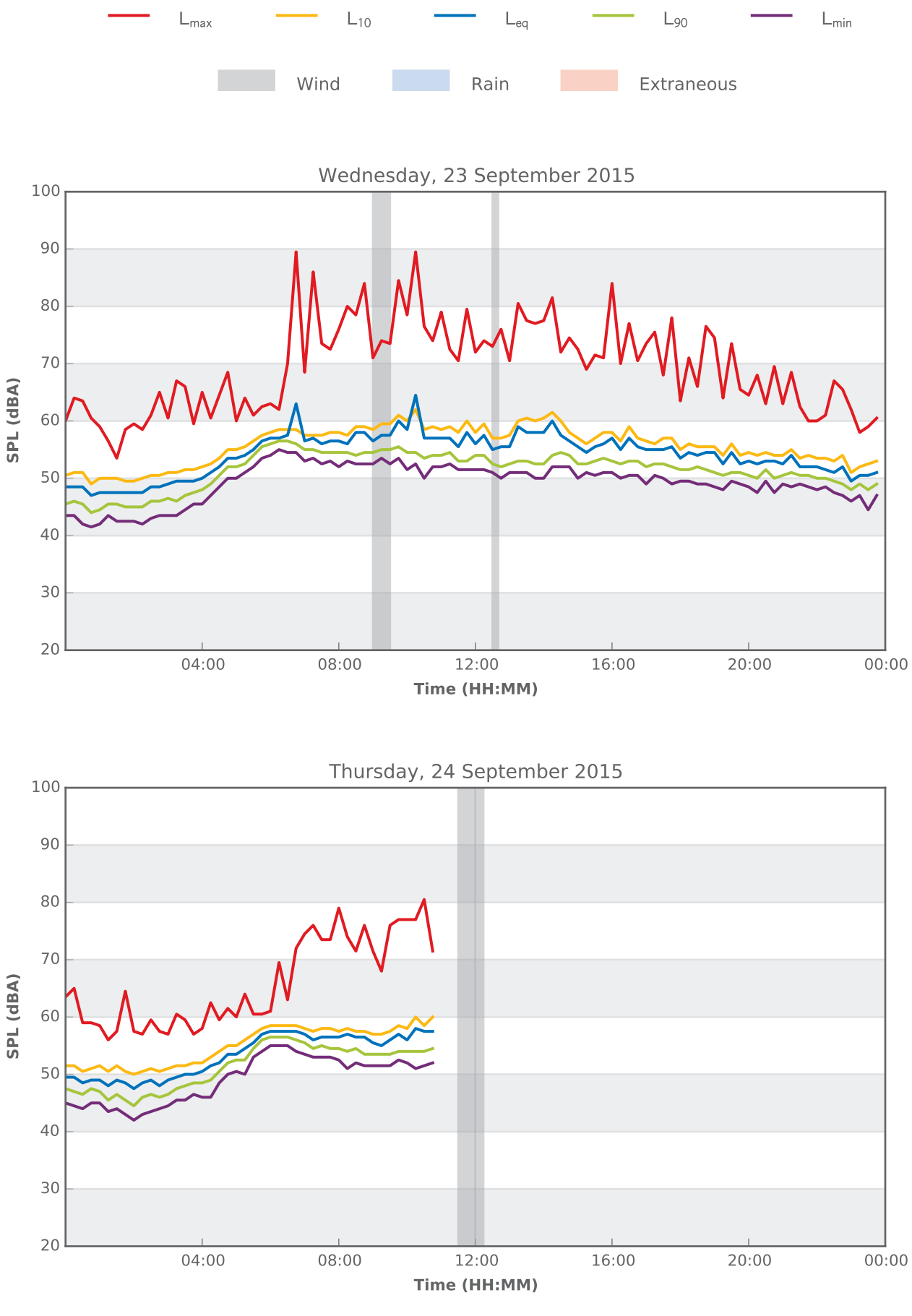


26 Velocity Parade, Bungarribee





26 Velocity Parade, Bungarribee



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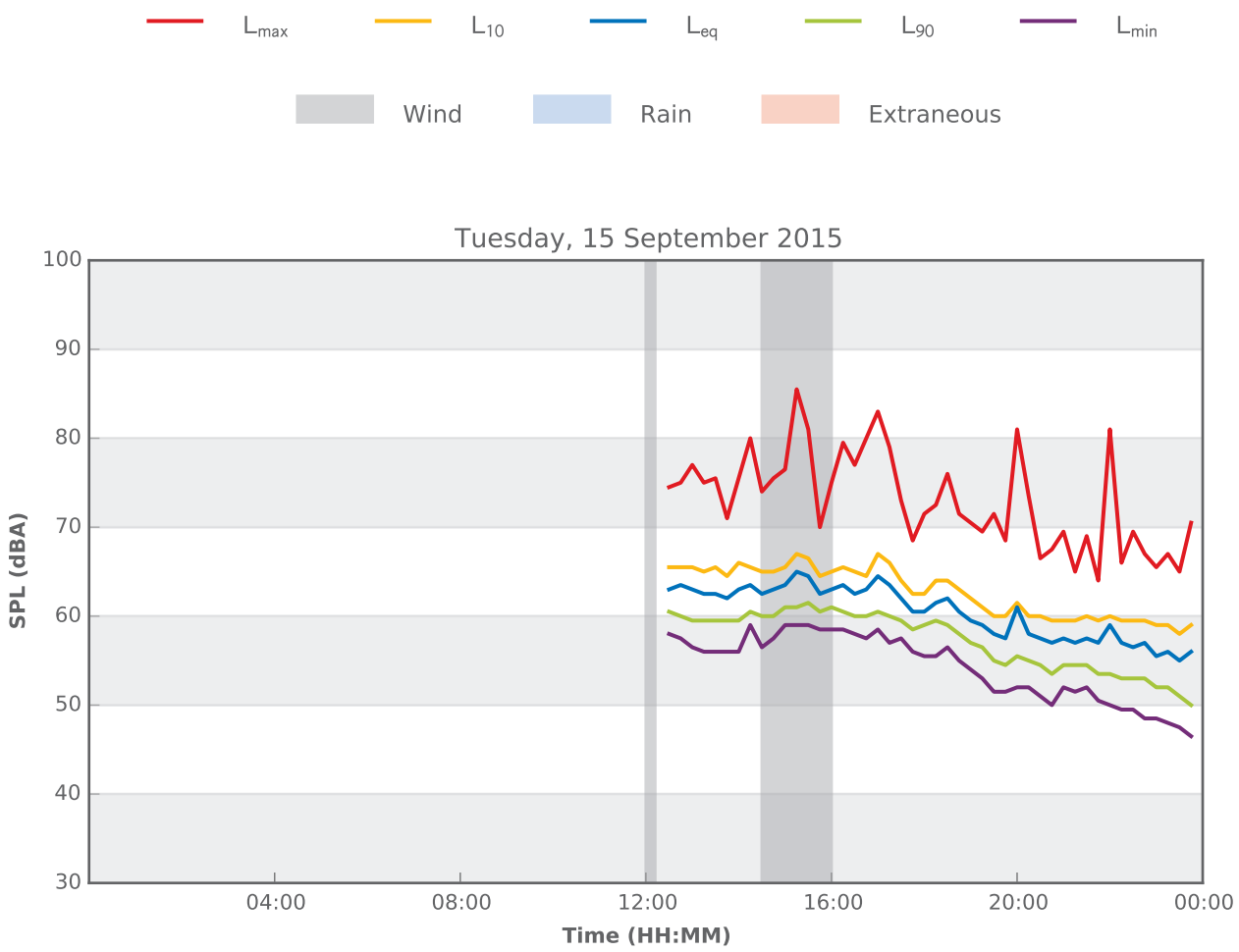

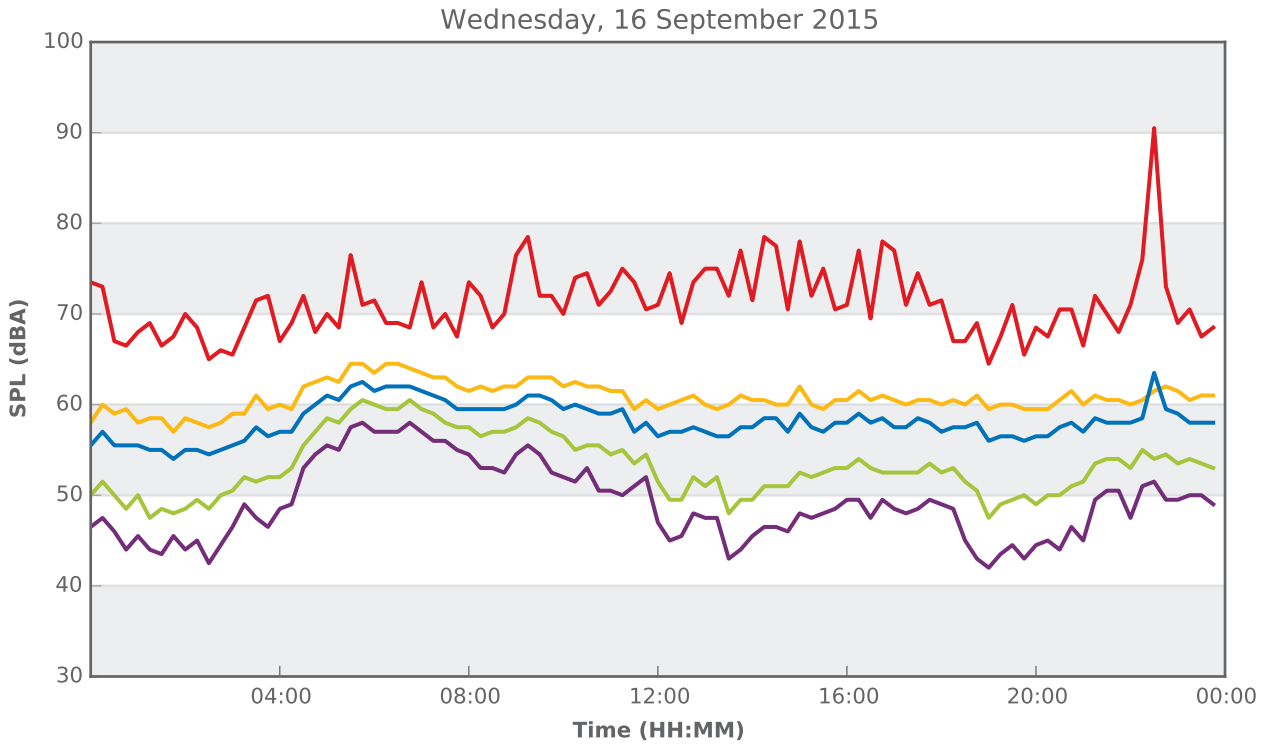

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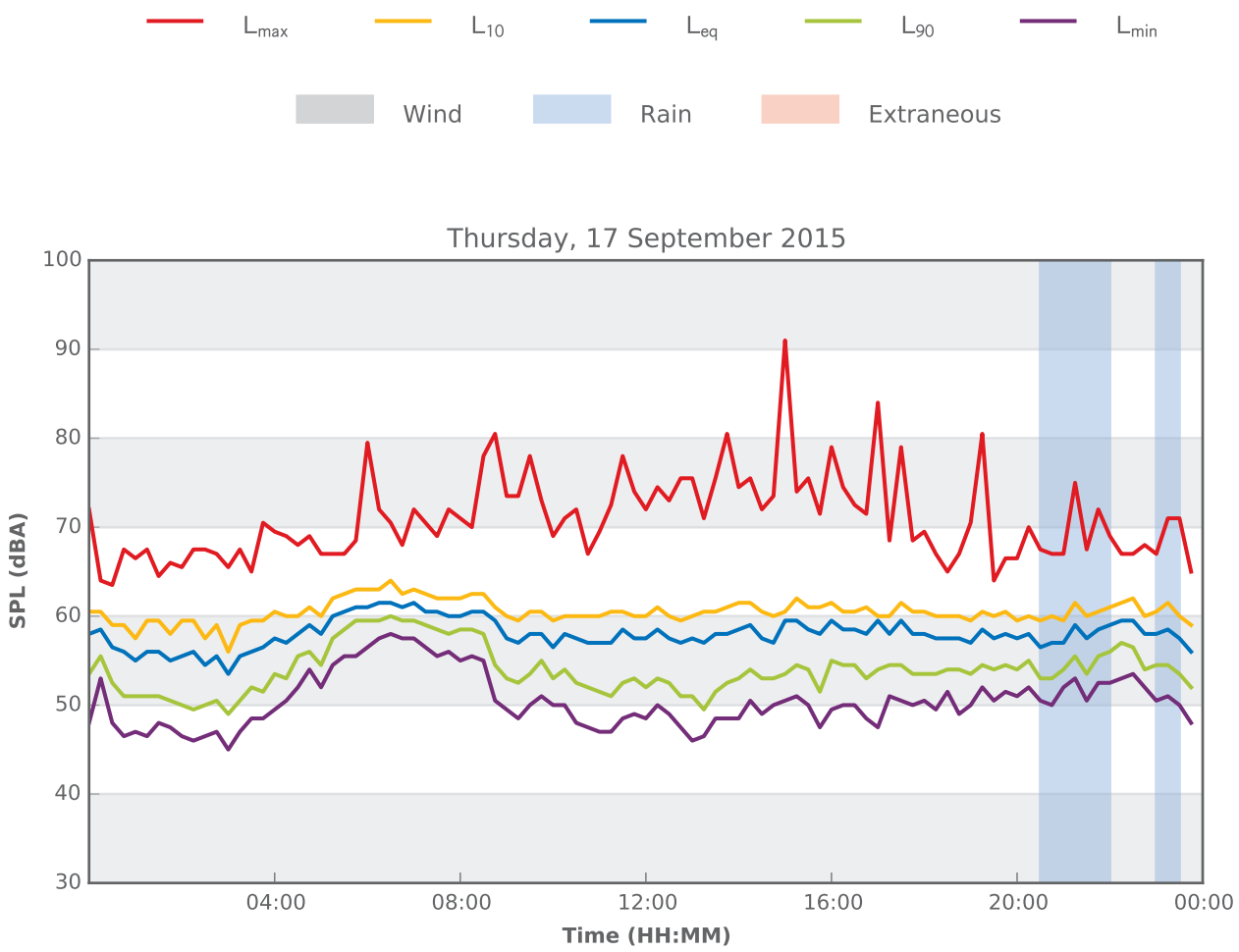

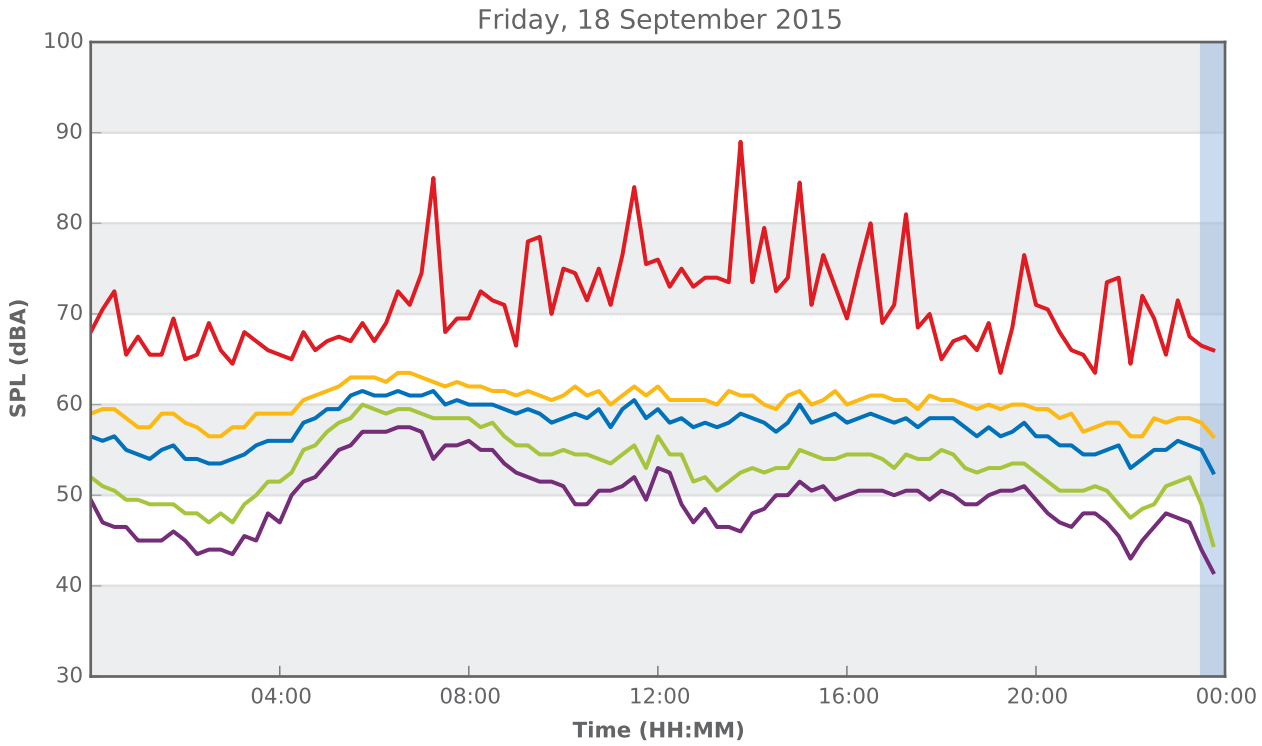

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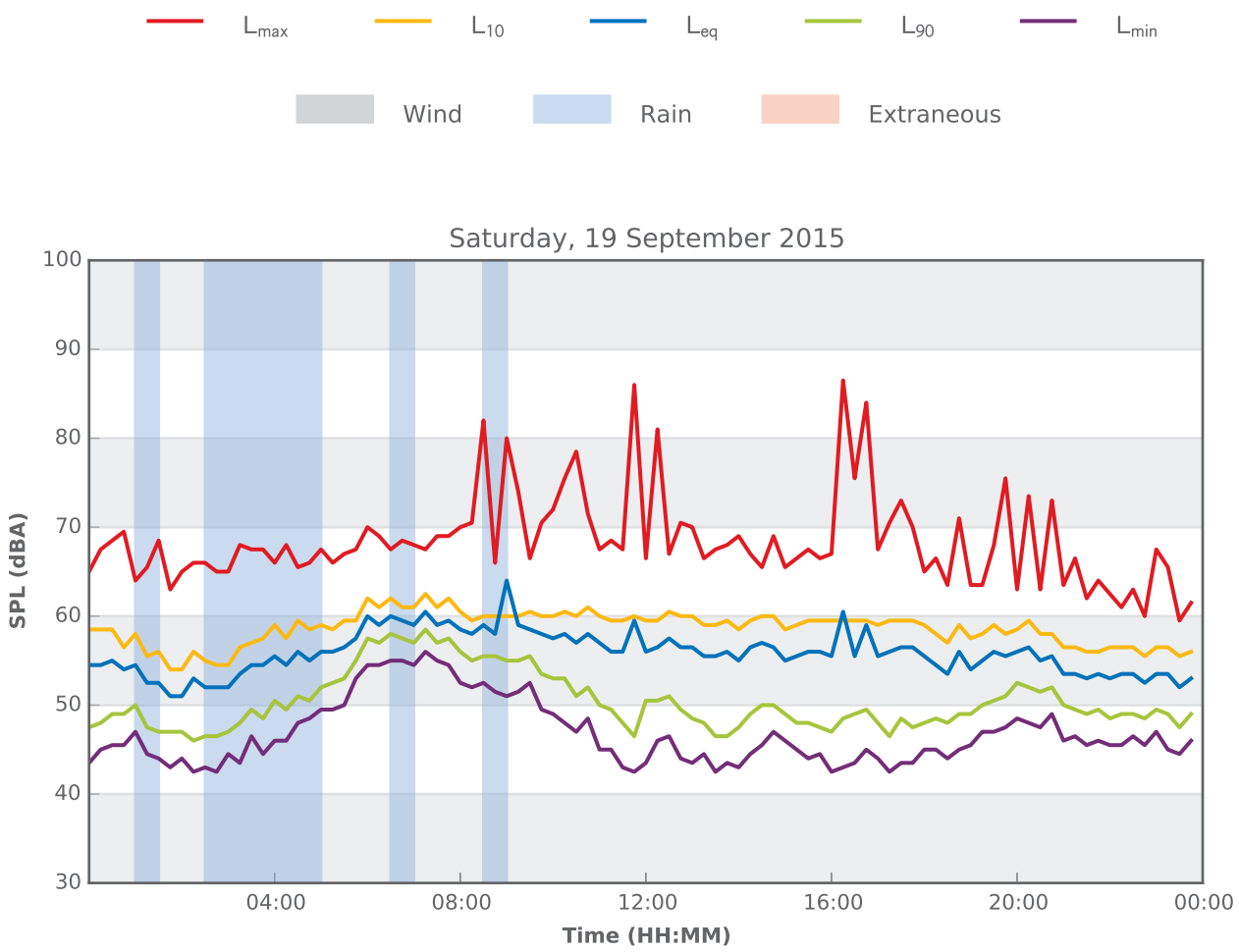

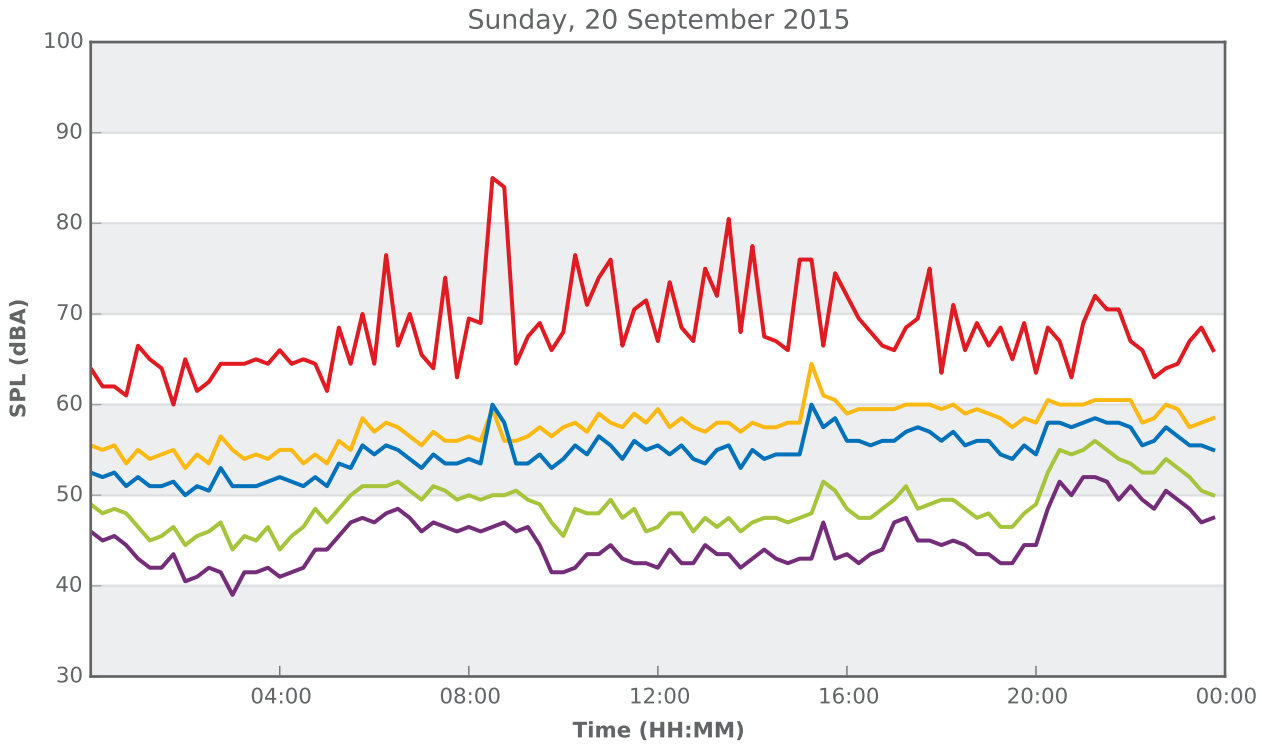

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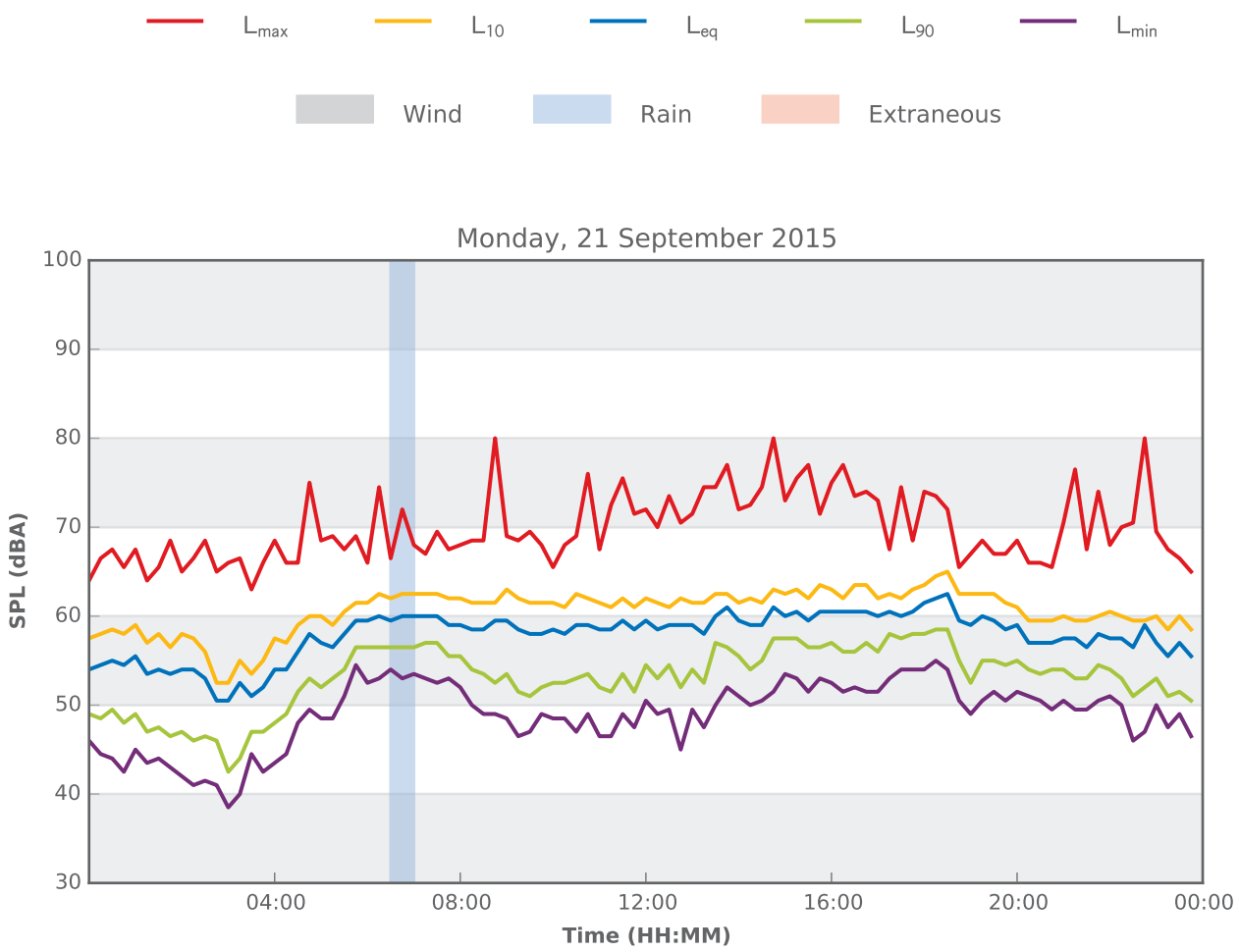

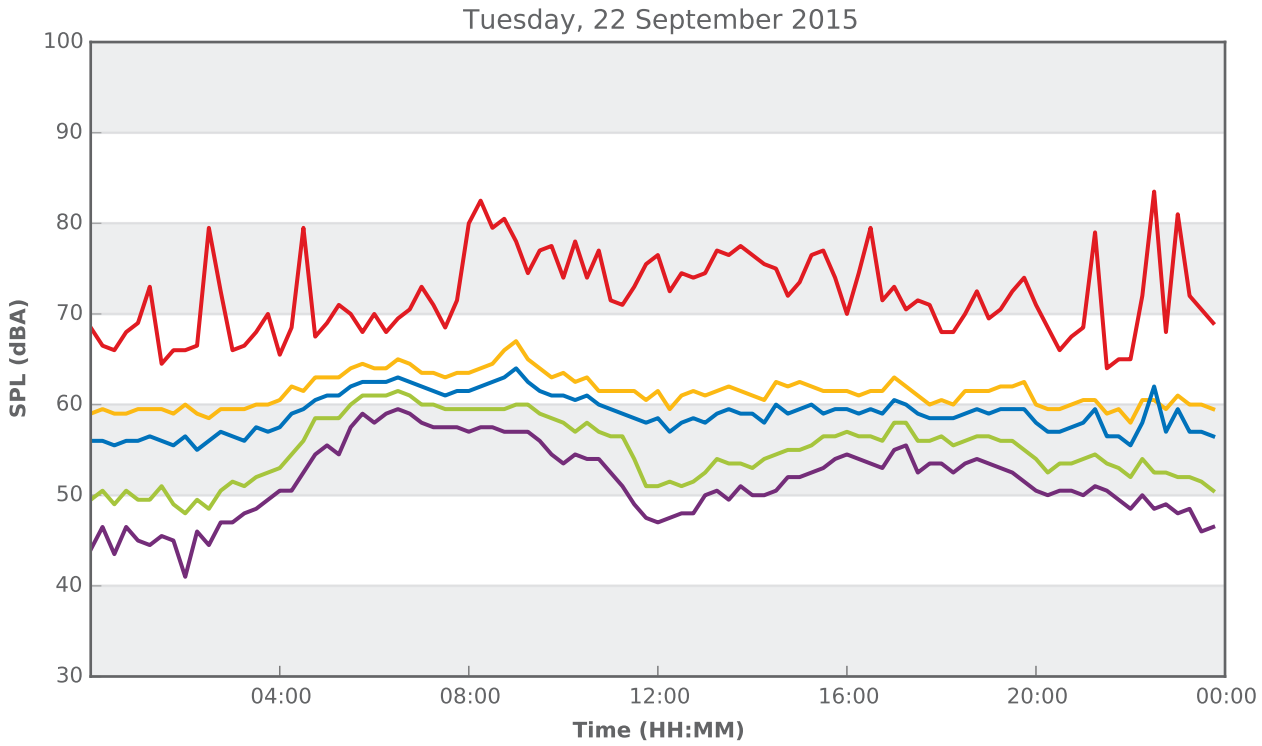

715 Great Western Highway, Eastern Creek