

391-423 Pacific Highway, Crows Nest NSW

DA Acoustic Assessment

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1 INTRODUCTION

Acoustic Logic (AL) have been engaged to conduct an acoustic assessment of potential noise and vibration impacts associated with the proposed mixed-use development at 391-423 Pacific Highway, 3-15 Falcon Street and 8 Alexander Street, Crows Nest, known as the Five Ways Triangle Site.

This document addresses noise impacts associated with the following:

- Noise intrusion to the project site from Pacific Highway, Falcon Street and Alexander Street
- Noise intrusion to the project site from operational noise from surrounding commercial buildings
- Future vibration impacts from proposed Sydney Metro tunnels
- Preliminary construction noise and vibration impacts, and
- Noise emissions from mechanical plant to service the project site (in principle).

AL have utilised the following documents and regulations in the noise assessment of the development:

- North Sydney Council *North Sydney Development Control Plan 2013 (As amended 4 May 2023)*
- NSW Department of Planning *State Environmental Planning Policy Transport & Infrastructure (SEPPT&I) 2021*
- NSW Department of Planning *Developments near Rail Corridors or Busy Roads – Interim Guideline (DNRCBR) 2008*
- NSW Environment Protection Authority (EPA) *Noise Policy for Industry (NPI) 2017*

This assessment has been conducted based on the architectural drawings for DA submission, prepared by Turner (project No. 19073, dated January 2024).

2 SITE DESCRIPTION

The proposed mixed-use development comprises 188 apartments, commercial & retails and associated basement parking. Details are presented below:

- 7 levels of basement, which contains car and bike parking, end of trip storage areas and base building services areas (i.e., substation, pump rooms, waste areas and plant)
- Ground floor contains basement entry, retail tenancies, commercial and residential lobbies
- Mezzanine, Levels 1 to 2 are commercial, level 3 is podium
- Remainder of the levels are residential apartments up to level 21.

A site survey has been carried out by this office regarding the existing acoustic environment around the proposed development, which has detailed below:

- Existing commercial site to the north across Falcon Street, to the southwest across Pacific Highway, to the east across Alexander Street
- Pacific Highway along the south western boundary
- Alexander Street along the eastern boundary, and
- Falcon Street along the northern boundary of the site.

In addition to above, the site is projected to be affected by the Sydney Metro Tunnel (under construction) which will run underneath basement along the north-eastern boundaries of the site.

The nearest noise receivers around the site include:

- **C1:** Commercial Receiver 1 – Multi-storey commercial buildings to the north of the site across Falcon Street at 8-10 Falcon Street, 1-3 Willoughby Road, Crows Nest
- **C2:** Commercial Receiver 2 – Multi-storey commercial buildings to the north east of the site across Falcon Street at 12-16 Falcon Street, Crows Nest
- **C3:** Commercial Receiver 3 – Multi-storey commercial building to the east of the site across Alexander Street, at 11-15 Alexander Street & 17-21 Falcon Street, Crows Nest
- **C4:** Commercial Receiver 4 – Multi-storey commercial building to the east of the site across Alexander Street, at 5-12 Alexander Street, Crows Nest
- **C5:** Commercial Receiver 5 – Multi-storey commercial building located to the southern corner of the site across Alexander Street, at 385-387 Alexander Street, Crows Nest
- **C6:** Commercial Receiver 6 – Multi-storey commercial buildings to the south west of the site across Pacific Hwy at 270-306 Pacific Hwy, Crows Nest
- **R1:** Residential Receiver 1 – Shop top Housing to the east of the site at 9 Alexander Street, Crows Nest
- **R2:** Residential Receiver 2 – Residential development to the far south across Pacific Hwy at 246-258 Pacific Hwy, Crows Nest

A site map, measurement description and surrounding receivers are presented in Figure 2-1 below.



Figure 2-1 – Project Site (Source from: Six Map NSW)

3 NOISE DESCRIPTORS

Ambient noise constantly varies in level from moment to moment, so it is not possible to accurately determine prevailing noise conditions by measuring a single, instantaneous noise level.

To quantify ambient noise, a 15-minute measurement interval is typically utilised. Noise levels are monitored continuously during this period, and then statistical and integrating techniques are used to characterise the noise being measured.

The principal measurement parameters obtained from the data are:

L_{eq} - represents the average noise energy during a measurement period. This parameter is derived by integrating the noise levels measured over the measurement period. L_{eq} is important in the assessment of noise impact as it closely corresponds with how humans perceive the loudness of time-varying noise sources (such as traffic noise).

L₉₀ – This is commonly used as a measure of the background noise level as it represents the noise level heard in the typical, quiet periods during the measurement interval. The L₉₀ parameter is used to set noise emission criteria for potentially intrusive noise sources since the disturbance caused by a noise source will depend on how audible it is above the pre-existing noise environment, particularly during quiet periods, as represented by the L₉₀ level.

L₁₀ is used in some guidelines to measure noise produced by an intrusive noise source since it represents the average of the loudest noise levels produced at the source. Typically, this is used to assess noise from licenced venues.

L_{max} is the highest noise level produced during a noise event and is typically used to assess sleep arousal impacts from short term noise events during the night. It is also used to assess internal noise levels resulting from aircraft and railway ground vibration induced noise.

L₁ is sometimes used in place of L_{max} to represent a typical noise level from a number of high-level, short-term noise events.

4 ENVIRONMENTAL NOISE SURVEY

4.1 MEASUREMENT LOCATION

Detailed locations for all measurements have been summarised below.

4.1.1 Unattended Noise Monitoring

Two unattended noise monitors were placed in the existing building at the site. The noise monitor locations are:

- Southwestern boundary at Level 1 awning, facing Pacific Hwy, and
- Northern boundary at Level 3 window, facing Falcon Street

Refer to Figure 2-1 for detailed location.

4.1.2 Attended Noise Measurements

Attended noise measurements were taken around the project site at the following locations:

- Northern site boundary at ground level, facing Falcon Street
- Southwestern boundary at ground level, facing Pacific Hwy
- Eastern boundary at ground level, facing Alexander Street
- Northern boundary at level 3 window, facing Falcon Street

Refer to Figure 2-1 for detailed location. All measurements had 180° view of each relevant road.

4.2 MEASUREMENT PERIOD

Unattended noise monitoring was conducted from Thursday 13th of April 2023 to Monday 24th of April 2023. Attended noise measurements were undertaken between the hours of 1 pm and 3 pm on Thursday 13th of April 2023.

4.3 MEASUREMENT EQUIPMENT

Unattended noise monitoring was conducted using two Acoustic Research Laboratories Pty Ltd noise loggers. The loggers were set to A-weighted fast response mode and were programmed to store 15-minute statistical noise levels throughout the monitoring period. The equipment was calibrated at the start and end of the monitoring period using a Rion NC-74 calibrator. No significant drifts were noted.

Attended noise measurements were conducted using a Norsonic 140 Sound Analyser. The analyser was set to fast response and calibrated before and after the measurements using a Norsonic Sound Calibrator type 1251. No significant drift was noted.

4.4 MEASURED RATING BACKGROUND NOISE LEVELS

Measured background noise levels for the project site and immediate surroundings are presented below.

Table 4-1 – Rating Background Noise Level: Facing Pacific Hwy

Location	Time of day	Rating Background Noise Level dB(A) _{L90}
Western boundary of Level 1 awning Facing Pacific Hwy 391-423 Pacific Highway, Crows Nest NSW	Day (7 am – 6 pm)	59
	Evening (6 pm – 10 pm)	55
	Night (10 pm – 7 am)	44

Table 4-2 – Rating Background Noise Level: Facing Falcon Street

Location	Time of day	Rating Background Noise Level dB(A) _{L90}
Northern boundary at Level 3 Facing Falcon Street 391-423 Pacific Highway, Crows Nest NSW	Day (7 am – 6 pm)	58
	Evening (6 pm – 10 pm)	55
	Night (10 pm – 7 am)	40

On review of the monitoring data, the measured L₉₀ noise levels during high wind speed days do not increase background noise levels significantly as periods with little to no wind. This demonstrates that even though wind speeds measured at Sydney Observatory Hill (the closest weather station) exceed EPA guidelines, either:

- The wind speed on site at this time was significantly lower than at Observatory Hill (which is likely given Observatory Hill is located in a very exposed area) and/or
- The wind on site was not sufficiently consistent to increase background noise levels compared to calm periods.

Therefore, only periods of adverse weather that were determined to have affected the noise data have been eliminated when determining the rating background noise level at the site, which is presented above.

4.5 SUMMARISED TRAFFIC NOISE LEVELS

Results of unattended and attended noise measurements have been summarised below for each location.

Table 4-3 – Summarised Traffic Noise Levels (L_{Aeq} (period))

Location	Time of Day	Noise Level – L_{Aeq} (period)
Western boundary of Level 1 awning Facing Pacific Hwy 391-423 Pacific Highway, Crows Nest NSW	Daytime 7 am – 10 pm	68 dB(A) L_{Aeq} (15hr) 69 dB(A) L_{Aeq} (1hr)
	Night-time 10 pm – 7 am	63 dB(A) L_{Aeq} (9hr) 68 dB(A) L_{Aeq} (1hr)
Northern boundary at Level 3 Facing Falcon Street 391-423 Pacific Highway, Crows Nest NSW	Daytime 7 am – 10 pm	65 dB(A) L_{Aeq} (15hr) 67 dB(A) L_{Aeq} (1hr)
	Night-time 10 pm – 7 am	61 dB(A) L_{Aeq} (9hr) 65 dB(A) L_{Aeq} (1hr)

5 EXTERNAL NOISE INTRUSION ASSESSMENT

Site survey indicates that the major external noise sources around project site are from traffic movements along Pacific Hwy, Falcon Street and Alexander Street adjacent to the western, northern, and eastern boundary of the site.

Noise intrusion from the source will be assessed in accordance with criteria nominated in Section 5.1 of this report.

5.1 NOISE INTRUSION CRITERIA

A noise intrusion assessment has been conducted based on the requirements of the following acoustic noise criteria and standards:

- North Sydney Council *North Sydney Development Control Plan 2013 (As amended 4 May 2023)*
- NSW Department of Planning *State Environmental Planning Policy Transport & Infrastructure (SEPPT&I) 2021*
- NSW Department of Planning *Developments near Rail Corridors or Busy Roads – Interim Guideline (DNRCBR) 2008*

5.1.1 North Sydney Development Control Plan 2013

2.3.9 Acoustic privacy

Control

P2 New dwellings shall be designed and constructed to comply with the criteria specified in Table B-2.6 for all noise intrusion from external noise sources (including mechanical services noise from within the development itself), with windows and doors closed:

TABLE B 2.6: Acoustic Amenity		
Internal Space	Time period	Max 1hr noise level (LAeq 1Hour)
<i>Living Areas</i>	<i>Day or Night</i>	<i>≤40dBA</i>
<i>Sleeping Areas</i>	<i>Day or Night</i>	<i>≤35dBA</i>

P12 Development comprising places of public worship, hospitals, educational facilities or child care centres or containing residential uses on land which is on or is within 100m of a railway corridor, a road corridor for a freeway, a tollway, a transit way or any other road with an annual average daily traffic volume of more than 40,000 vehicles (based on the traffic volume data published on the website of the RMS) must consider the requirements of the DoP's Development Near Rail Corridors and Busy Roads – Interim Guideline (19 December 2008) in accordance with cl.87(2) and cl.102(2) of SEPP (Infrastructure) 2007. An acoustic report may be required to be prepared to demonstrate compliance with this Guideline and the acoustic requirements within cl.87(3) and cl.102(3) of the SEPP (Infrastructure) 2007

It is also note that SEPP (Infrastructure) 2007 referenced in the DCP has been superseded. State guidance becoming mandatory under clause 2.100 of the SEPPT&I 2021 for development near rail and clause 2.120 for development near busy roads. The definition of busy road is also changed to AADT more than 20,000 vehicles and a noise descriptor of $L_{eq(Period)}$ should be applied for assessment. It is noted that Map 16 of the traffic volume maps for the SEPPT&I 2021 on RTA website identifies Pacific Hwy as AADT>40,000 and Falcon Street as AADT>20,000. Hence, clause 2.120 will need to be satisfied.

5.1.2 SEPPT&I 2021

RMS Map No. 16 of the traffic volume maps referenced by the SEPPT&I 2021 on RTA website (see below), classifies Pacific Hwy and the section of Falcon Street where the development is located adjacent to as a road where a noise intrusion assessment is mandatory under clause 2.120 of the SEPPT&I 2021. See RMS average annual daily road traffic volume map number 16 and the approximate location of the site below.



Figure 5-1 RMS map No. 16 and approximate location of proposed development

Clause 2.120 of the SEPPT&I 2021 states the following with regard to the impact of traffic noise on residential development.

2.120 Impact of road noise or vibration on non-road development

(1) This section applies to development for any of the following purposes that is on land in or adjacent to the road corridor for a freeway, a tollway or a transitway or any other road with an annual average daily traffic volume of more than 20,000 vehicles (based on the traffic volume data published on the website of TfNSW) and that the consent authority considers is likely to be adversely affected by road noise or vibration—

(a) residential accommodation...

(3) If the development is for the purposes of residential accommodation, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded—

(a) in any bedroom in the residential accommodation—35 dB(A) at any time between 10 pm and 7 am,

(b) anywhere else in the residential accommodation (other than a garage, kitchen, bathroom or hallway)—40 dB(A) at any time.

5.1.3 DNRCBR

The DNRCBR outlines how to apply SEPPT&I clause 2.120. Section 3.5 of the NSW Department of Planning's 'Development near Rail Corridors and Busy Roads (Interim Guideline)' states:

"The following provides an overall summary of the assessment procedure to meet the requirements of clauses 87 and 102 of the Infrastructure SEPP. The procedure covers noise at developments for both Road and Rail.

- *If the development is for the purpose of a building for residential use, the consent authority must be satisfied that appropriate measures will be taken to ensure that the following L_{Aeq} levels are not exceeded:*
 - *in any bedroom in the building: 35 dB(A) at any time 10 pm-7 am*
 - *anywhere else in the building (other than a garage, kitchen, bathroom or hallway): 40 dB(A) at any time."*

AL notes that the Infrastructure SEPP has been superseded by the SEPPT&I clause 2.120 of the previous section.

The guideline also provides guidance on the assessment of natural ventilation. The allowable internal noise goal is permitted to be 10 dB(A) higher than when the windows are closed (i.e. – allowable level in bedrooms becomes 45 dB(A), and 50 dB(A) in living rooms). Where noise levels would exceed this, the NSW Planning guideline recommends that an alternative ventilation system be provided, such that adequate ventilation may be achieved whilst still meeting internal noise goals. We note that where the 'open window/door' scenario cannot be achieved, this does not necessarily mean that there cannot be operable elements on these façades, only that internal noise level requirements will only be met when they are closed.

5.1.4 Summarised External Noise Intrusion Criteria

The internal noise criteria adopted for each internal space is therefore summarised below based on the relevant State, Council and Australian Standard requirements.

Table 5-1 – Summarised Internal Noise Criteria

Space /Activity Type	Internal Noise Requirement dB(A) L_{Aeq} (period)
Sleeping Areas	35 dB L_{Aeq} (9 hour) (SEPPT&I 2021)
Living Areas	40 dB L_{Aeq} (15 hour) (SEPPT&I 2021)

5.2 COMPLYING CONSTRUCTIONS

Assessment of façade requirements to achieve required indoor noise levels has been undertaken. Dimensions of rooms, setbacks from roadways, window openings and floor areas have been used.

5.2.1 Glazed Windows and Doors

The following constructions comply with the project noise objectives. Aluminium framed/sliding glass doors and windows will be satisfactory provided they meet the following criteria. All external windows and doors listed are required to be fitted with Q-Ion type acoustic seals. **(Mohair Seals are unacceptable)**.

Thicker glazing may be required for structural, safety or other purposes. Where it is required to use thicker glazing than scheduled, this will also be acoustically acceptable. The complying constructions are detailed in Table 5-2.

Table 5-2 – Complying Glazing Construction

Facades	Space	Glazing Thickness	Acoustic Seals
All facades	Living room	6.38 mm laminated	Yes
	Bedroom	6.38 mm laminated	Yes

It is recommended that only window systems having test results indicating compliance with the required ratings obtained in a certified laboratory be used where windows with acoustic seals have been recommended.

In addition to complying with the minimum scheduled glazing thickness, the R_w rating of the glazing fitted into open-able frames and fixed into the building opening should not be lower than the values listed in Table 5-3 for all areas. Where nominated, this will require the use of acoustic seals around the full perimeter of open-able frames and the frame will need to be sealed into the building opening using a flexible sealant.

Table 5-3 – Minimum R_w of Glazing Assembly (with Acoustic Seals)

Glazing Assembly	Minimum R_w of Installed Window
4 mm Float	27
6.38 mm Laminated	31

Note: Façade constructions to be reviewed at CC stage based on construction drawings. The glazing types listed above are indicative and for authority approvals purposes only

5.2.2 External Roof/Ceiling Construction

External roof construction will be constructed from concrete elements, this proposed structure will not require any further acoustic upgrading. **In the event that any penetrations are required thru the external skin, an acoustic sealant should be used to minimise all gaps.**

5.2.3 External Wall Construction

External wall construction will be constructed from masonry elements. For masonry walls, acoustic upgrading is not required. There should not be vents on the internal skin of external walls. In the event that any penetrations are required through the external skin, an acoustic sealant should be used to minimise all gaps.

5.2.4 Ventilation Assessment

NSW Department of Planning's *Development near Busy Roads and Rail Corridors - Interim Guideline* dictates that:

"If internal noise levels with windows or doors open exceed the criteria by more than 10 dB(A), the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia."

With windows open, the allowable internal noise goal is permitted to be 10 dB(A) higher than when the windows are closed (i.e. – allowable level in bedrooms becomes 45 dB(A) $L_{eq(9\text{ hr})}$ and 50 dB(A) $L_{eq(\text{anytime})}$ in living rooms) if the NSW planning methodology is implemented.

A SoundPlan noise model of the proposed mixed development was developed to predict façade noise levels result from traffic noise. The traffic noise sources were calibrated based on unattended monitoring data and attended measured spectrums. Details of the modelling results are attached in Appendix Four – SoundPlan Modelling Results.

Where external noise levels are predicted to exceed the windows open criteria (being daytime 60 dB(A) for living room facade and nighttime 55 dB(A) for bedroom facade), additional acoustic treatment/additional ventilation strategy that meets the objectives of the DNRCBR would need to be employed.

The following conclusion can be drawn in terms of natural ventilation:

- All bedrooms and living rooms with façade facing Alexander Street will be able to achieve designed internal noise levels with windows or doors open.
- Bedrooms rooms and living rooms on L4 – L13 with façade facing Pacific Highway will not be able to achieve internal noise levels with windows or doors open. Specific spaces should refer to SoundPlan results presented in Appendix Four, where façade noise levels exceed 55dB(A) for night-time and 60dB(A) for daytime. Bedrooms and living rooms with façade facing Pacific Highway on other levels will be able to achieve internal noise levels with windows or doors open.
- Bedrooms rooms on L4 – L13 and living rooms on L4 – L11 with façade facing Falcon Street will not be able to achieve internal noise levels with windows or doors open. Specific spaces should refer to SoundPlan results presented in Appendix Four, where façade noise levels exceed 55dB(A) for night-time and 60dB(A) for daytime. Bedrooms and living rooms with façade facing Falcon Street on other levels will be able to achieve internal noise levels with windows or doors open.

A detailed mark up for spaces that will/will not be able to achieve natural ventilation has been presented in Appendix Three – Ventilation Mark Up.

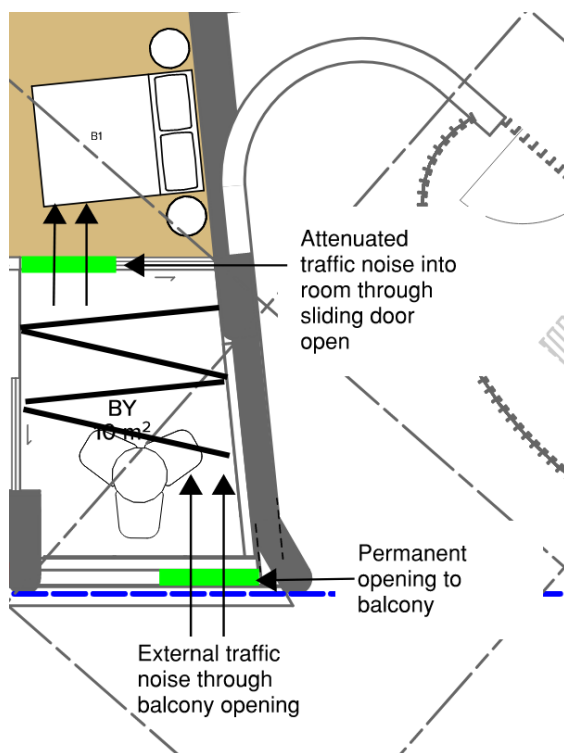
Acoustic treatments for those spaces could include the following:

1. Acoustically Treated Balcony Soffit

Spaces that directly connected to a balcony will be able to achieve natural ventilation by installing acoustic absorptive materials on the balcony soffit with two options below:

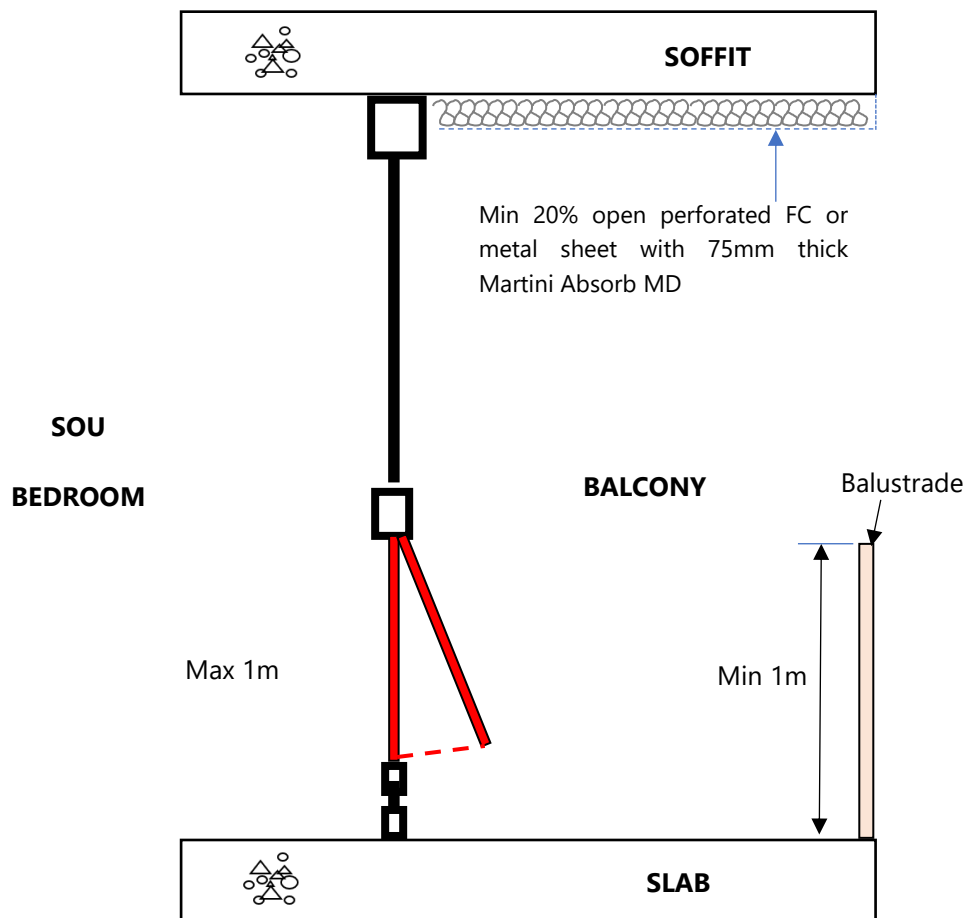
Option 1- Staggered Opening Scheme

Further acoustic attenuation can be achieved by implementing the staggered opening scheme. This is to achieve additional acoustic attenuation by increasing the distance the noise has to travel to enter the rooms (i.e. opening on the sliding door locates away from the opening of the balcony). The proposed ventilation system is indicated as below:



Option 2- Awning Windows with Absorptive Ceiling

The following drawing provides indicative details for absorptive ceiling and low awning windows.

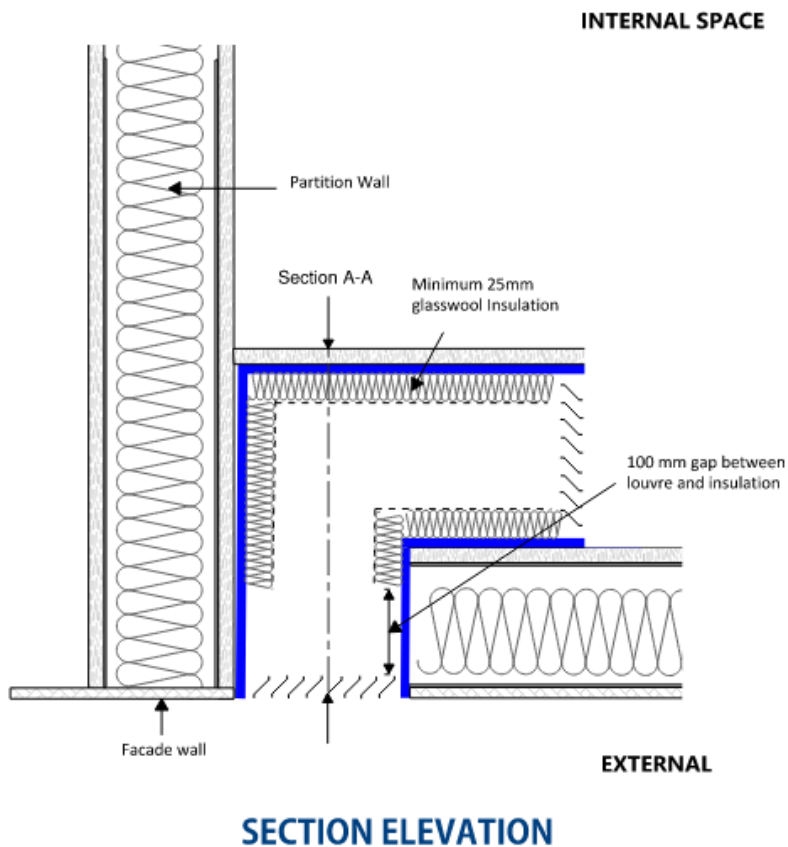


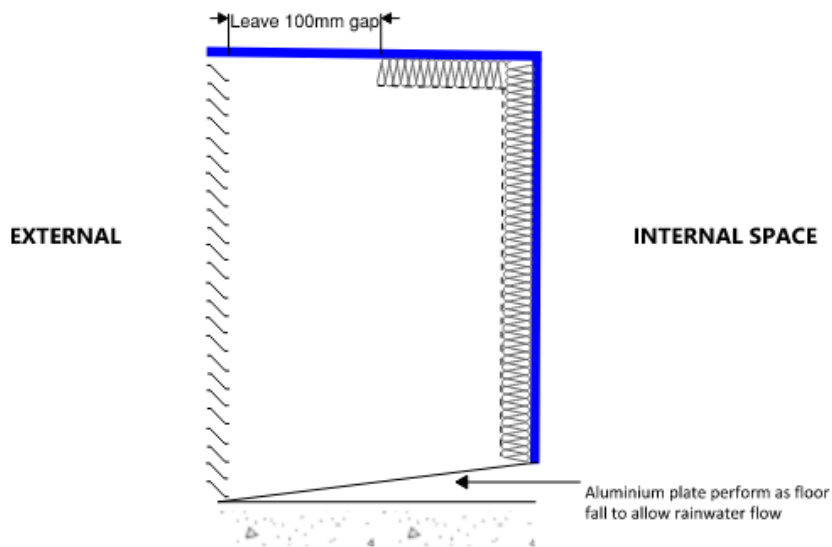
2. Acoustically treated trickle ventilation system

Alternative solutions for spaces that do not have access to balcony will be able to achieve natural ventilation by installing proper acoustic trickle ventilation systems. This detail will be determined based on discussion with mechanical consultant.

3. Acoustic plenums

Alternatively, vertical or horizontal plenums can be employed to spaces that requires additional acoustic treatment to comply with internal noise criteria while achieving natural ventilation. This option is the most restrictive with regard to spatial requirements within units. The indicative detail for vertical plenum is below:





SECTION A-A

Using the above strategies, natural ventilation of the apartments (while achieving the “naturally ventilated” noise levels) will be achievable in all the proposed dwellings. Progressive advice as to specific treatments will be provided during the detailed design process as apartment layouts and designs are finalised.

Any supplementary ventilation system proposed to be installed should be acoustically designed to ensure that the acoustic performance of the acoustic treatments outlined above is not reduced and does not exceed Council criteria for noise emission to nearby properties. A mechanical engineer is to confirm if supplementary ventilation (to meet Australian Standard AS1668.2 requirements) will be required to these rooms.

5.2.4.1 Noise Intrusion from Central Void to Apartments Via Louvred Windows

Concerns have been raised by the State Design Review Panel (SDRP) about noise intrusion from the central void to apartments via louvred windows next to the entry door. There are no statutory requirements for noise emission from the use of communal open space/ people walking in the corridor to the proposed residential units. An indicative assessment predicts the following:

- 10 patrons using the communal open spaces on level 3 with 1 in 2 people speaking at a raised noise level with a sound power level of 78 dB(A) (Cushing et al) predicts internal noise levels within the living room via louvred windows open of around 37dB(A).
- 65 patrons using the communal open spaces on level 3 with 1 in 2 people speaking at a normal noise level with a sound power level of 70 dB(A) (Cushing et al) predicts internal noise levels within the living room via louvred windows open of around 37dB(A).

All predicted scenarios are within the designed criteria of living areas (40dB(A)) and provide comfort that the amenity of the residents can be easily controlled.

6 SYDNEY METRO INDUCED VIBRATION ASSESSMENT

6.1 PROJECT CRITERIA

This section of the report nominates criteria applicable to nearby receivers which will be impacted by the future the operation of the Sydney Metro Chatswood to Sydenham tunnel adjacent to the project site. The following guidelines and standards have been referenced:

- British Standard BS 7385:1990 Part 2 *Evaluation and measurement for vibration in buildings – part 2*
- Australian Standard AS2670:1990 *Vibration and Shock – Guide to the evaluation of human exposure to whole body vibration*
- NSW EPA *Assessing Vibration: A Technical Guideline*, and
- NSW Department of Planning *Developments near Rail Corridors or Busy Roads – Interim Guideline*.

6.1.1 Ground Borne Noise

Development located adjacent to railway lines must be assessed in accordance with Clause 2.100 of the SEPPT&I 2021. It is noted that the requirements of this standard are achieved when assessed in accordance with the NSW Department of Planning DNRCBR. The section relevant to ground borne noise is as follows:

Where buildings are constructed over or adjacent to land over tunnels, ground borne noise may be present without the normal masking effect of airborne noise. In such cases, residential buildings should be designed so that the 95th percentile of train pass-bys complies with a ground borne L_{max} noise limit of 40dBA (daytime) or 35dBA (night-time) measured using the “slow” response time setting on a sound level meter.

Table 6-1 – Internal Railway Noise Level Criteria for Ground Borne Noise

Location	Time of Day	Internal Ground Borne Noise Criteria dB(A)L _{max} (SLOW)
Living and sleeping areas	Day (7am-10pm)	40
	Night (10pm-7am)	35

6.1.2 Tactile Vibration

Human comfort is typically assessed with reference to the British Standard BS 7385 Part 2 1993 or Australian Standard AS 2670.2 1990.

The NSW Planning Interim Guideline references the NSW EPA *Assessing Vibration- A technical guideline* which recommends that habitable rooms should comply with the criteria therein which is in line with the requirements of British Standard BS 6472:1992 "Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)".

British Standard BS 6472:1992 "Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)" is recommended by the RIC's and SRA's Interim Guidelines for Councils "Consideration of rail noise and vibration in the planning process" as this standard includes guidance for the assessment of human response to building vibration including intermittent vibrations such as that caused by trains.

Human response to vibration has been shown to be biased at particular frequencies, which are related to the orientation of the person. This standard provides curves of equal annoyance for various orientations. These curves are applied as correction filters such that an overall weighted acceleration level is obtained. As the orientation of the resident is unknown or varying the weighting filter used is based on the combined base curve as given in ISO 2631 & Australian Standard 2670 "Evaluation of Human Exposure to Vibration and Shock in Buildings (1 to 80Hz)" which represent the worst case of the X, Y and Z axes. Filtered measurements are made in all three co-ordinate axes and the highest value axis used.

This standard assesses the annoyance of intermittent vibration by using the Vibration Dose Value (VDV). Alternatively the VDV may be estimated by the eVDV which is derived by a simpler calculation using an empirical factor. The VDV or eVDV is calculated for the two periods of the day being the 'Daytime' (6am-10pm) and 'Night time' (10pm-6am). The overall value is then compared to the levels in Table 6-2. For this project the aim will be for a low probability of adverse comment.

Table 6-2 – Vibration Dose Values (m/s^{1.75}) above which various degrees of adverse comment may be expected in residential buildings

Place	Low Probability of adverse comment	Adverse comment possible	Adverse comment probable
Residential buildings 16hr day (Daytime)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8hr night (Night time)	0.13	0.26	0.51

6.2 SYDNEY METRO IMPACT ASSESSMENT

6.2.1 Preliminary Ground Borne Noise Assessment Based on EIS Technical Paper

Operational noise and vibration levels expected to be generated by the Sydney Metro Chatswood to Sydenham line are detailed in the SLR document *Sydney Metro Chatswood to Sydenham Technical Paper 2: Noise and Vibration* (Report Number 610.14718R1, V1.0, dated 28th April 2016). The report details the expected acoustic impacts on existing properties along the proposed rail line, including existing properties at 391-423 Pacific Highway, Crows Nest. Both tactile vibration and structure borne noise are considered as part of the technical paper.

391-423 Pacific Highway, Crows Nest is located approximately 0.5km south of Crows Nest Station relative to the track chainage. Figure 6-1 and Figure 6-2 indicate the predicted ground borne noise and vibration respectively.

Figure 40 Predicted Ground-borne Noise Levels - Residential Receivers

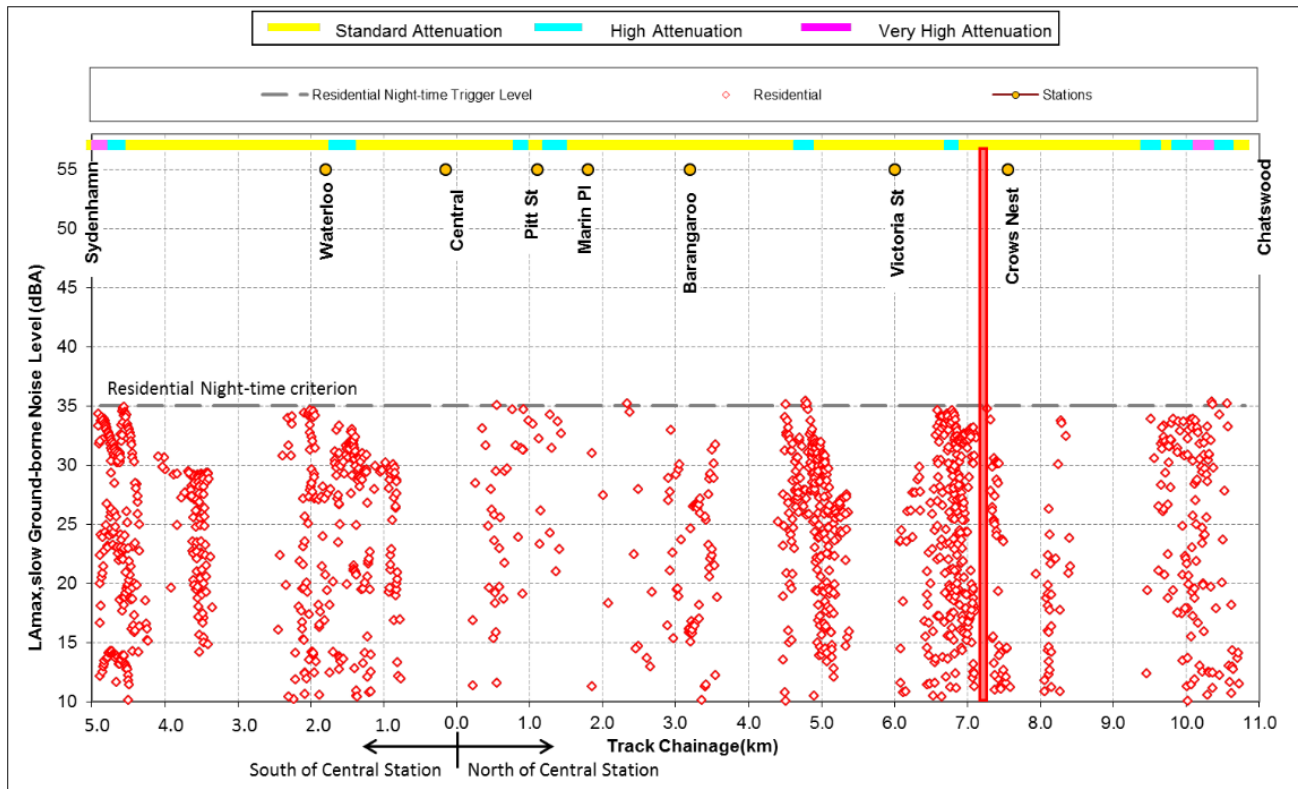


Figure 6-1 – Predicted Operational Ground-borne Noise Levels Induced by Metro

Figure 34 Predicted Ground-borne Vibration Levels (Proposed Track Form)

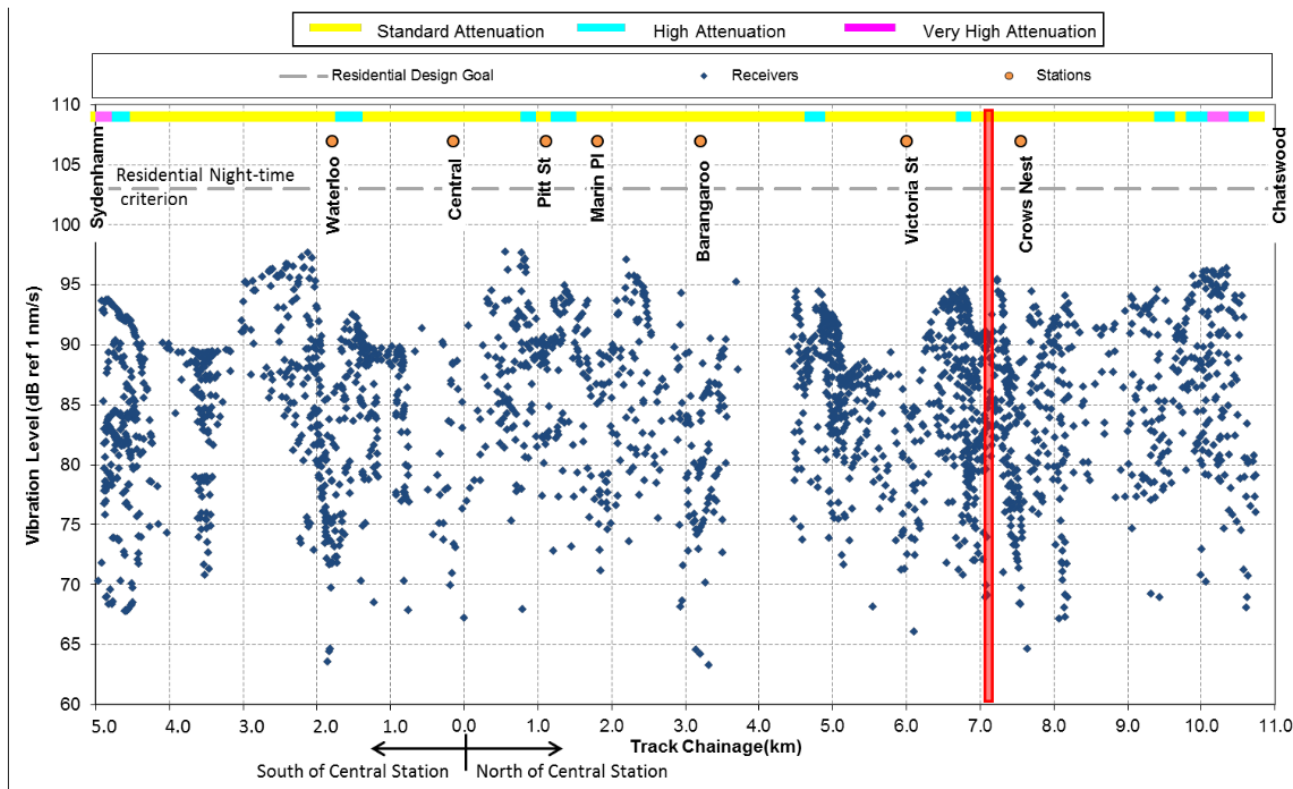


Figure 6-2 – Predicted Operational Vibration induced by Metro

Operational ground borne noise and vibration levels shown in Figure 6-1 and Figure 6-2 indicate that both rail induced noise and vibration meet the project requirements, namely, $35L_{Amax(slow)}$ for residential night time ground borne noise criteria and $103dB_v$ (0.14mm/s) for residential night time vibration criteria.

We also note that the predictions detailed in the SLR report assume the noise/vibration level on the ground floor of each residence, however in this case there are 5 additional levels (ground level, mezzanine level and level 1-2 Commercial and Level 3 podium) prior to the first level containing residential apartments. As vibration travels up the building, there will be additional attenuation, further reducing the impact of future occupants.

6.2.2 Detailed Ground Borne Noise Prediction

This section has been prepared in response to the following Sydney Metro’s Request for Additional Information (dated 18 June 2024):

4. *The Acoustic Assessment dated 12/03/24 (EIS Appendix 28) is to be updated to account for the reduced distance to the Sydney Metro - City & Southwest tunnel.*

Detailed ground borne noise prediction has been conducted in this section following steps presented in the EIS report.

6.2.2.1 Source Vibration Levels Calculation

The first step for vibration level prediction is to select the reference source vibration levels. According to the *EIS report*, standard attenuation will be used for the tunnel track below the project site, hence the following relevant reference source vibration will be used. The noise levels are measured on tunnel wall at 80 km/h reference speed.

Table 6-3 – Reference Sound Vibration Levels – Standard Attenuation Track

Vibration Levels	1/3 Octave Bands (Hz) – L _{max, slow 95%}															
	10	12	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315
dB _v re 1nm/s	77	78	78	77	80	86	86	86	85	84	84	89	86	82	79	78

Then, the source vibration levels are aligned based on the track radii at the project location. No correction has been applied for track radii given the EIS report does not specify any tight radius curves around the project site between Victoria Cross station and Crows Nest station.

A speed adjustment has been applied to the vibration levels based on the following equation and the speed profile of the metro shown in Figure 6-3. Given the project site is located approximately 0.5km south of Crows Nest Station, an averaged value of 90 km/h is hence adopted as indicated in the speed profile. Hence, a 1 dB adjustment is applied based on the equation:

$$V(\text{speed adjusted}) = V(\text{reference}) + 20 \log_{10}\left(\frac{\text{speed}}{80}\right)$$

Figure 31 Speed Profile

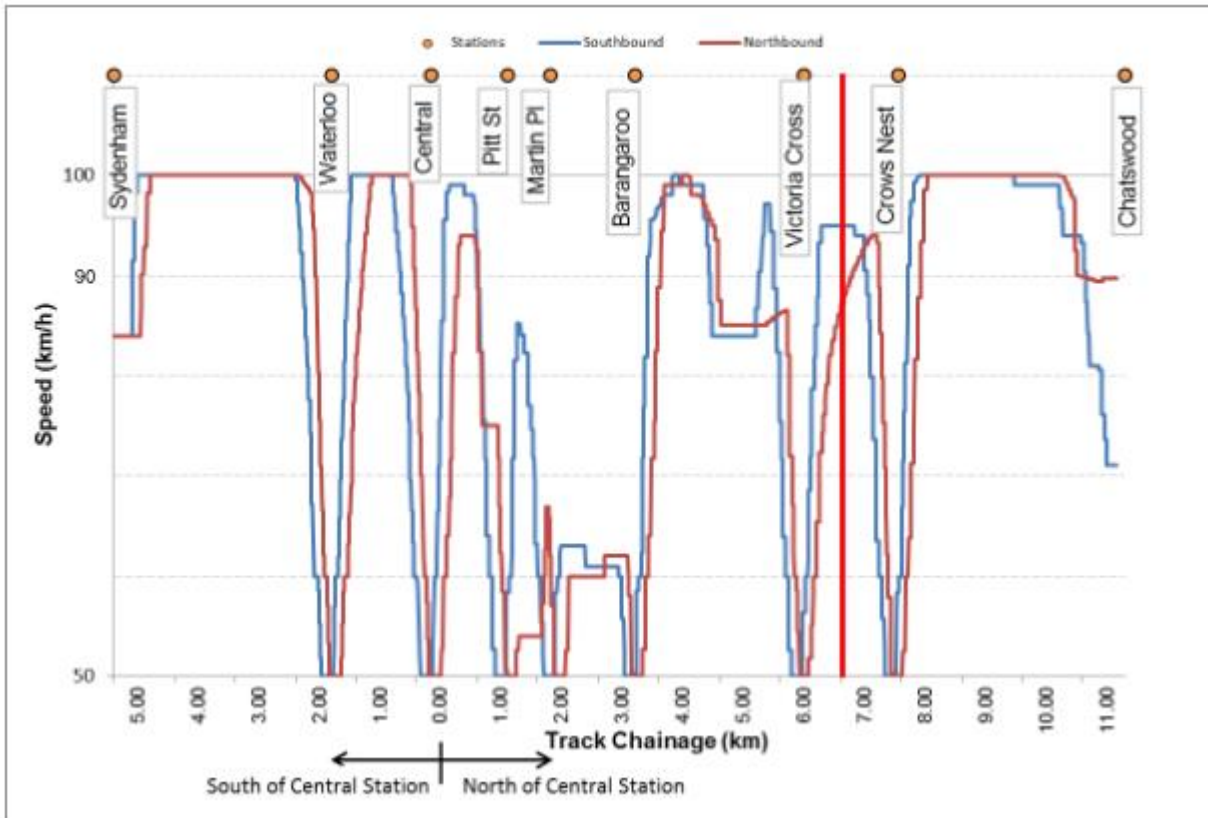


Figure 6-3 – Speed Profile (Sourced from SLR EIS report)

Furthermore, a 5dB safety factor has been applied to the predictions to accommodate any specific site factors (e.g abnormal building construction methods or fairly close distance between tunnel and development). The resulting vibration levels for metro tunnel at the building footing of the project site is hence presented below. The prediction presented in the following sections will be performed in octave bands between 31.5Hz – 250Hz.

Table 6-4 – Source Vibration Levels at Project Site

Vibration Levels	1/3 Octave Bands (Hz) – L _{max, slow 95%}															
	10	12	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315
dB _v re 1nm/s	83	84	84	83	86	92	92	92	91	90	90	95	92	88	85	84
Vibration Levels	Octave Bands (Hz) – L _{max, slow 95%}															
	dB _v re 1nm/s	-				31.5			63			125			250	
	-				96			96			98			91		

6.2.2.2 Vibration Attenuation During Propagation

This section details the vibration attenuation predictions for the transmission of vibration from tunnel to the proposed new development at 391-423 Pacific Highway, Crows Nest.

First of all, the vibration attenuation due to geometric spreading is considered. In response to Sydney Metro’s comments, prediction will be conducted considering the tunnel vibration transmission through the closeded building façade at southeastern conner at basement level. Hence, vibration propagated to the subject wall at the building base is calculated based on the following formula:

$$V(\text{spreading}) = 10 \log_{10}\left(\frac{2}{\text{distance}}\right)$$

in which $V(\text{spreading})$ is the change in vibration levels (dB). 2 is the distance between the central of rail track and tunnel wall (source vibration measurement location). distance is the distance between point source and the receiver location, which is approximately 14 m as indicted in the below drawing. Therefore, a 8.5 dB reduction is applied for each frequency band.

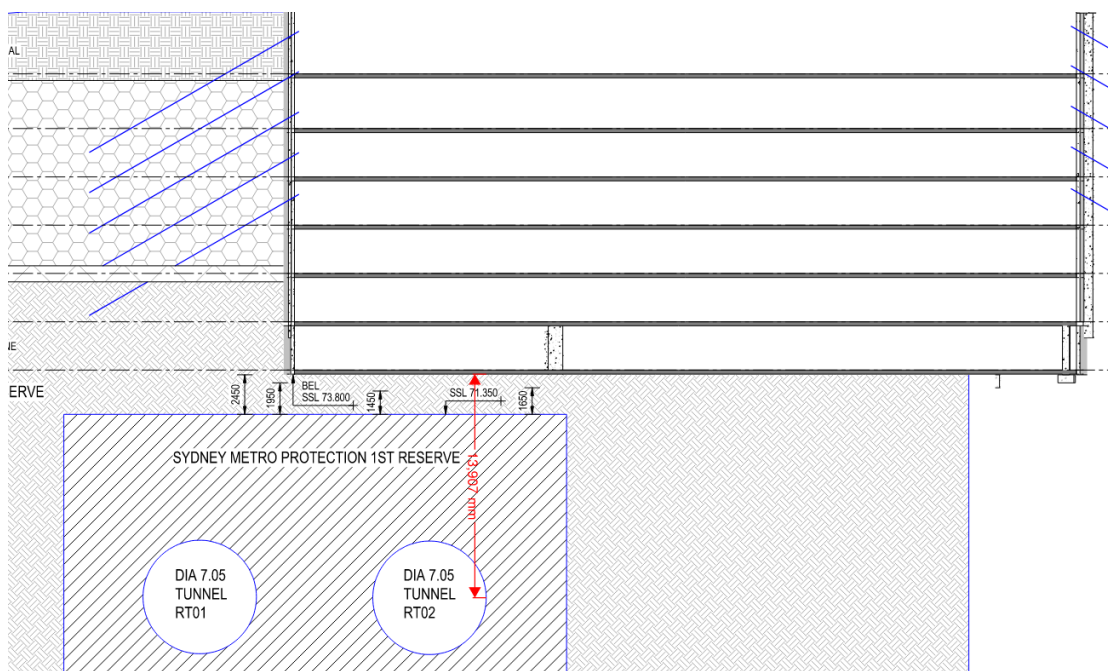


Figure 6-4 – Distance Between Metro Tunnel and the Building Foundations

Then vibration attenuation due to material damping is estimated. The excess attenuation curve for Sydney Hawkesbury sandstone is applied for the project site. The following attenuation values at octave bands are obtained from the below curve with a distance of 14 m.

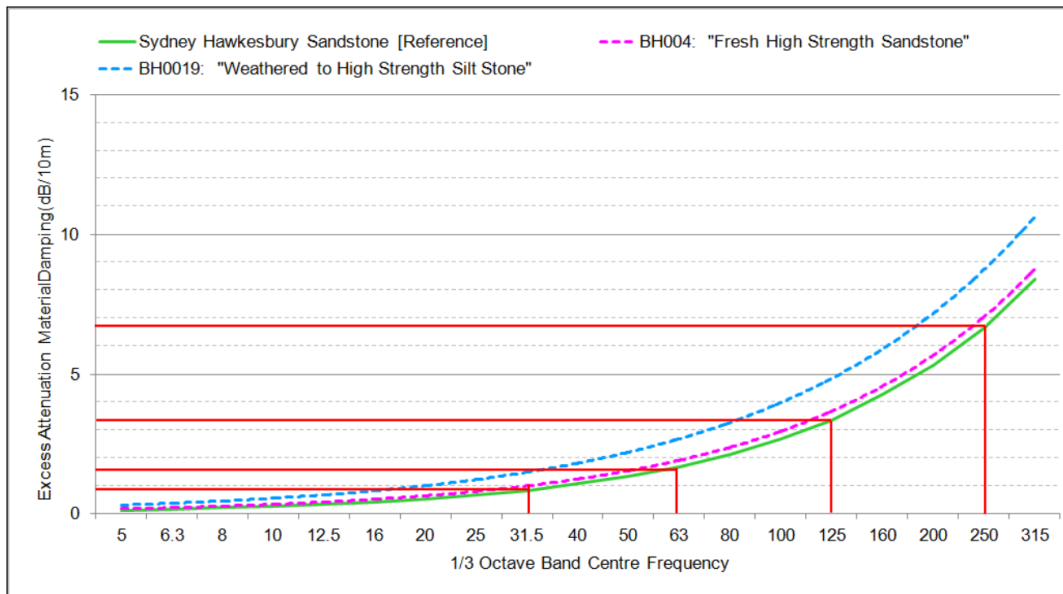


Figure 5 – Material Damping Induced Excess Attenuation

The excess attenuation damping values in 1/1 octave bands are extrapolated below:

Table 6-5 – Excess Attenuation Due to Material Damping at Project Site

Vibration attenuation	Octave Bands (Hz)			
	31.5	63	125	250
dB	1.26	2.52	4.48	9.38

6.2.2.3 Propagation of Vibration within Buildings

This section discusses vibration levels travel from the footing of the building to the first residential floor at ground level.

It is noted that no coupling loss values is applied to the project site as the footing for the proposed development does not have any interface effect with the ground.

For vibration propagates inside the building, the following floor to floor loss values are adopted: The ground-borne noise and vibration levels attenuate by approximately 2 dB per floor for the first four floors and by approximately 1 dB per floor thereafter.

Table 6-6 – Vibration Loss Due to Transmission Between Floors

Vibration attenuation between floors	Vibration Loss (dB) in Octave Bands (Hz)			
	31.5	63	125	250
Each floor for the First 4 floors (dB)	2	2	3	3
Each floor for Further floors (dB)	1	1	1	1
Project building from basement 7 to ground level	12	12	16	16

Low frequency vibration can be amplified within buildings by resonances in floors and walls. Based on information discussed by Nelson (1987), the amplification spectra presented in Table 26 has been adopted. Nelson (1987) indicates that amplification values found in practice are typically within ± 3 dB of these values. Slightly lower values are assumed for the ground-borne noise calculations as the use of the full floor amplification values can result in over estimation of the resultant noise levels.

Table 6-7 – Floor Resonance Amplification for Ground Borne Noise

Amplification between floors	Vibration Loss (dB) in Octave Bands (Hz)			
	31.5	63	125	250
dB	7	5.7	4.1	1.4

6.2.2.4 Conversion between Velocity Levels and Ground – Borne Noise Levels

According to the book titled “Measurement & Assessment of Groundborne Noise & Vibration”, authored by the Association of Noise Consultants (ANC 2001), the relationship between ground borne noise levels and vibration velocity levels is established as follows:

$$L_p = L_v - 27,$$

where: L_p is the L_{Amax} sound pressure level

L_v is the A weighted, L_{max} velocity level, in dB re 1×10^{-9} m/s

Note: In Section 4.1.2 of the latest version of the ANC Guideline (second edition 2012), the authors suggest that:

“... the conversion from the rms vibration velocity to the sound pressure level may overstate the sound pressure level by 5 dB and that the measured data supported a correction of -32 rather than -27 dB.”

However, for this assessment, a conservative correction factor of -27 is used for this project instead of -32 which was used in EIS report.

6.2.2.5 Prediction of Vibration Levels & Ground – Borne Noise Levels

Based on the information and methodology discussed in the sections above, ground-borne noise levels have been predicted for the nearest residential areas located at ground floor level at the project site. The predicted levels are summarised in Table 6-8 and Table 6-9. The predicted ground-borne noise levels utilise the measured L_{Amax} vibration levels from the suburban train with the highest levels of vibration.

Table 6-8 – Summary of Predicted Vibration Velocity Level on Lower Ground

Location	Predicted LASmax Velocity Level (dB re 1x10 ⁻⁹ m/s) A Weighted Level (including floor amplification)				Overall dBv	Criteria dBv	Complies?
	31.5	63	125	250			
Ground Level	81	79	73	58	83	103	Yes

Table 6-9 – Summary of Predicted Ground Borne Noise Level on Lower Ground

Location	Predicted LASmax Velocity Level (dB re 1x10 ⁻⁶ m/s) A Weighted Level				Overall dB(A)	Criteria dB(A) L _{max(slow)}	Complies?
	31.5	63	125	250			
Ground Level	54	52	46	31	32	35	Yes

Based on the information presented in the above, predicted ground-borne noise levels are below the criteria for residential spaces. Vibration isolation treatment of the structure is **therefore not required**.

7 NOISE EMISSION CRITERIA

The noise emission from the project site shall comply with the requirements of the following documents:

- North Sydney Council *North Sydney Development Control Plan 2013 (As amended 4 May 2023)*, and
- NSW Environmental Protection Authority (EPA) *Noise Policy for Industry (NPI) 2017*.

7.1 NORTH SYDNEY COUNCIL NORTH SYDNEY DEVELOPMENT CONTROL PLAN 2013

Section 2 Commercial & Mixed use development of the North Sydney DCP has proposed the following noise emission criteria:

2.3.2 Noise

Provisions

- P1 *Noise emission associated with the operation of non-residential premises or non-residential components of a building must not exceed the maximum 1 hour noise levels (LAeq 1 Hour) specified in Table B-2.3.*

TABLE B-2.3 –Noise Emission Limits			
Day	Time Period		Max 1 hour noise level (LAeq 1 Hour)
	Week	Time	
Weekday	Day	7am – 6pm	60 dBA
	Evening	6pm – 10pm	50 dBA
	Night	10pm – 7am	45 dBA
Weekend	Day	8am – 7pm	60 dBA
	Evening	7pm – 10pm	50 dBA
	Night	10pm – 8am	45 dBA

Notes: LAeq (1hour) readings are to be measured during the noisiest 1 hour period between Day – 7/8am to 6/7pm, Evening – 6/7pm – 10pm and Night – 10pm to 7/8am.

- P2 *In terms of determining the maximum noise levels as required by P1 above, the measurement is to be taken at the property boundary of the nearest residential premises. Within a mixed use development, the boundary is taken to be nearest floor ceiling or wall to a residential dwelling on the site.*
- P3 *Despite P1 above, the noise emission associated with the operation of non-residential premises or non-residential components of a building must not exceed 5 dBA above the background maximum 1 hour noise level (LAeq 1 Hour) during the day and evening and not exceeding the background level at night when measured at the boundary of the property.*
- P4 *Council may require the submission of an Acoustic Report to ensure compliance with P1 above.*
- P5 *Plant and machinery should incorporate noise reduction measures to minimise their impacts.*
- P8 *Developments must comply with EPA Noise Policy for Industry 2017 in particular the modification required for acceptable noise level (ANL).*

7.2 NSW EPA NOISE POLICY FOR INDUSTRY (NPI) 2017

The EPA NPI has two criteria which both are required to be satisfied, namely Intrusiveness and amenity. The NPI sets out acceptable noise levels for various localities. The policy indicates four categories to assess the appropriate noise level at a site. They are rural, suburban, urban and urban/industrial interface. Under the policy the nearest residential receivers would be assessed against the urban criteria.

Noise levels are to be assessed at the property boundary or nearby dwelling, or at the balcony or façade of an apartment.

7.2.1 Intrusiveness Criterion

The guideline is intended to limit the audibility of noise emissions at residential receivers and requires that noise emissions measured using the L_{eq} descriptor not exceed the background noise level by more than 5dB(A). Where applicable, the intrusive noise level should be penalised (increased) to account for any annoying characteristics such as tonality.

Background noise levels adopted are presented in Section 5. Noise emissions from the site should comply with the noise levels presented below when measured at nearby property boundary.

Table 7-1 – NPfl Intrusiveness Criteria

Receiver	Time of day	Background Noise Level dB(A) L_{90}	Intrusiveness Criteria Background + 5dB(A)
Receiver R1	Day	58	63
	Evening	55	60
	Night	40	45
Receiver R2	Day	59	64
	Evening	55	60
	Night	44	49

7.2.2 Project Amenity Criterion

The guideline is intended to limit the absolute noise level from all noise sources to a level that is consistent with the general environment.

The EPA's NPI sets out acceptable noise levels for various localities. The recommended noise amenity area is based upon the measured background noise levels at the sensitive receiver. Based on the measured background noise levels detailed in Section 4.4, the Noise Policy for Industry suggests the adoption of the 'urban' categorisation.

The NPI requires project amenity noise levels to be calculated in the following manner:

$$L_{Aeq,15min} = \text{Recommended Amenity Noise Level} - 5 \text{ dB(A)} + 3 \text{ dB(A)}$$

The amenity levels appropriate for the receivers surrounding the site are presented in Table 7-2.

Table 7-2 – NPfI Project Amenity Noise Levels

Type of Receiver	Time of day	Recommended Noise Level dB(A) $L_{eq}(\text{period})$	Project Amenity Noise Level dB(A) $L_{eq}(15 \text{ minute})$
Residential – urban	Day	60	58
	Evening	50	48
	Night	45	43
Commercial	When in use	65	63

The NSW EPA Noise Policy for Industry (2017) defines:

- Day as the period from 7 am to 6 pm Monday to Saturday and 8 am to 6 pm Sundays and Public Holidays.
- Evening as the period from 6 pm to 10 pm.
- Night as the period from 10 pm to 7 am Monday to Saturday and 10 pm to 8 am Sundays and Public Holidays.

7.2.3 Sleep Arousal Criteria

The Noise Policy for Industry recommends the following noise limits to mitigate sleeping disturbance:

Where the subject development / premises night -time noise levels at a residential location exceed:

- $L_{eq,15min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- L_{Fmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater,

a detailed maximum noise level even assessment should be undertaken.

Table 7-3 – Sleep Arousal Criteria for Residential Receivers

Receiver	Rating Background Noise Level (Night) dB(A) L_{90}	Emergence Level
Residential Receiver R1	40 dB(A) L_{90} Night (10pm – 7am)	45 dB(A) $L_{eq, 15min}$; 55 dB(A) L_{Fmax}
Residential Receiver R2	44 dB(A) L_{90} Night (10pm – 7am)	49 dB(A) $L_{eq, 15min}$; 59 dB(A) L_{Fmax}

7.3 SUMMARISED NOISE EMISSION CRITERIA

Table 7-4 – EPA NPI Noise Emission Criteria for Residential Receivers

Receiver	Time Period	Assessment Background Noise Level dB(A) _{L90}	Project Amenity Criteria dB(A) _{L_{eq}}	Intrusiveness Criteria _{L_{eq}(15min)}	North Sydney DCP (Max 1 hour)	NPI Criteria for Sleep Disturbance
R1	Day	58	58	63	60	N/A
	Evening	55	48	60	50	N/A
	Night	40	43	45	45	45 dB(A)_{L_{eq}, 15min} 55 dB(A)_{L_{Fmax}}
R2	Day	59	58	64	60	N/A
	Evening	55	48	60	50	N/A
	Night	44	43	49	45	49 dB(A)_{L_{eq}, 15min} 59 dB(A)_{L_{Fmax}}

The project noise trigger levels are indicated by the bolded values in the table above.

Table 7-5 – EPA NPI Noise Emission Criteria for Commercial Receivers

Time Period	Project Amenity Criteria dB(A) _{L_{eq} (15min)}
When in use	63

8 NOISE EMISSION ASSESSMENT

8.1 MECHANICAL PLANT NOISE

Detailed plant selection has not been undertaken at this stage, as plant selections have not been determined. However, a preliminary noise emission assessment of major plant items has been conducted in this section with indicative placement of plantroom on podium level/roof level of the site.

- 2 off smoke exhaust plantrooms are proposed to be located on level 3. Preliminary analysis indicates that smoke exhaust fan with an outlet source sound power level of 90 dB(A) is capable of complying with the noise emission requirements detailed in Section 7.3, due to distance attenuation between noise source and receiver, as well as barrier effects provided by the balcony.
- 2 off Water cooled chillers located within the water cooled chiller plantroom on mezzanine level to the eastern boundary of the site. Analysis indicates that with chillers a source sound power level of approximately 96dB will be able to comply with the noise emission requirements detailed in Section 7.3 with the following treatments:
 - Chillers are to run 50% speed during night time (10:00 pm – 7:00 am).
 - Install 300sp acoustic louvres with the following minimum insertion loss:

Hz	63	125	250	500	1k	2k	4k	8k
Insertion loss	2	4	5	11	14	17	18	16

- 2 off cooling towers located within the roof top plantroom to the northern boundary of the site. Analysis indicates that with chillers a source sound power level of approximately 96dB will be able to comply with the noise emission requirements detailed in Section 7.3 with the following treatments:
 - Chillers are to run 60% speed during night time (10:00 pm – 7:00 am).
 - Install minimum 2.3m height acoustic barrier along northern roof boundary.
 - Install 300sp acoustic louvres with the following minimum insertion loss:

Hz	63	125	250	500	1k	2k	4k	8k
Insertion loss	2	4	5	11	14	17	18	16

- Smaller fans and other ancillary items will be readily able to achieve the noise emission requirements for the site. Satisfactory levels will be achievable through appropriate plant selection, location and if necessary, standard acoustic treatments such as duct lining, acoustic silencers and enclosures.

Detailed acoustic review should be undertaken at CC stage to determine acoustic treatments to control noise emissions to satisfactory levels. Noise emissions from all mechanical services plant to the closest residential receiver should comply with the noise emission criteria in Section 7.

8.2 NOISE FROM FUTURE COMMERCIAL/RETAIL TENANCIES

Residential apartments are proposed to be located above or adjacent to lower level commercial/retail use spaces within the development. We note the following:

- General retail outlets are expected to have a minimal impact on proposed residential uses.
- Licensed tenancies (especially those which are proposed to operate during the night time period) will have a higher potential acoustic impact, pending their capacity and siting.
- Noise from internal spaces are typically controlled through management controls to ensure internal noise levels are not excessive, and to ensure the façade is not open during noise sensitive periods of the day (i.e. after 10pm, and before 7am).
- In the event any tenancies were to incorporate liquor licensing or an outdoor dining area, this would likely be subject to a separate approval, at which time the proposal would need to demonstrate compliance with the relevant noise emission criteria. With respect to noise transmission through the floor slab (internal/internal noise transmission), the construction of an appropriate ceiling may be required, depending on the level of noise expected to be generated by the proposed use.

8.3 NOISE FROM THE LOADING DOCK AND CARPARK

The entrance/exit of the loading dock and carpark is located on Alexander Street with line of sight to the western façade of the residential receiver **R1**. Operational noise levels from the proposed loading dock/carpark facilities are predicted and assessed against the NSW EPA *Noise Policy for Industry* criteria detailed in Section 7.3 based on information provided in the *Traffic Impact Assessment Report* by JMT Consulting dated 27 October 2023.

Operational noise emissions are predicted based on the following source noise levels.

Table 8-1 – Average (L_{eq}) Source Noise Levels

Noise Source	Sound Power Level
Medium Rigid Vehicle slowly manoeuvring at up to 10km/h	100dB(A) L_{eq}
Small Rigid Vehicle slowly manoeuvring at up to 10km/h	90dB(A) L_{eq}
Car/Van travelling at up to 10km/h	84dB(A) L_{eq}

Based on the information above, predicted noise levels from loading dock noise emissions are summarised below:

Table 8-2 – Predicted Cumulative Noise Levels from the Use of Loading Dock/Carpark

Receiver	Predicted Noise Level $dB(A)L_{eq(15min)}^{(1,2)}$	Criteria Noise Level $dB(A)L_{eq(15min)}$	Complies
Nearest shop top housing R1 – Level 2 Western Façade with line of sight to the Carpark Entrance	41	NSW EPA Project Criteria: 58 (Daytime) 48 (Evening) 43 (Night)	Yes

Table Notes:

1. *Based on up to 1 medium truck, 1 small truck, and up to 20 car in any given 15min period. Each vehicle is assumed to travel at 10km/h, and have their engines on for up to 1 minute while manoeuvring within the loading dock.*
2. *Above assessment is based on assumption that carpark entry is open. If required, further attenuation will be provided with the roller shutter being installed and closed during loading.*

Note that the above assessment is based on all available bays within the loading dock being occupied in a single 15-minute period, which would represent a worst-case scenario. In practice, it is unlikely that this intensity of use would be realised or even practicable, and so the actual noise impact to surrounding receivers would be reduced. Notwithstanding, the above demonstrates the ability of the loading to meet noise emission requirements, even when used intensively.

9 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

9.1 CONSTRUCTION NOISE MANAGEMENT LEVELS

Noise associated of construction activities on the site will be assessed in accordance with the NSW DECC *Interim Construction Noise Guideline* (ICNG, 2009).

The “quantitative” assessment procedure, as outlined in the Interim Construction Noise Guideline (ICNG) will be used. The quantitative assessment method requires: Determination of noise generation goals (based on ambient noise monitoring); Prediction of operational noise levels at nearby development; and if necessary, recommendation of noise controls strategies in the event that compliance with noise emission goals is not possible.

DECC guidelines adopt differing strategies for noise control depending on the predicted noise level at the nearest residences:

- “Noise affected” level. Where construction noise is predicted to exceed the “noise affected” level at a nearby residence, the proponent should take reasonable/feasible work practices to ensure compliance with the “noise affected level”. For residential properties, the “noise affected” level occurs when construction noise exceeds ambient levels by more than 10dB(A) $L_{eq(15min)}$.
- “Highly noise affected level”. Where noise emissions are such that nearby properties are “highly noise affected”, noise controls such as respite periods should be considered. For residential properties, the “highly noise affected” level occurs when construction noise exceeds 75dB(A) $L_{eq(15min)}$ at nearby residences.

A summary of the above recommended noise levels from the ICNG is presented below.

Table 9-1 – Noise Management Levels at Residential Receiver

Receiver	“Noise Affected” Level - dB(A) $L_{eq(15min)}$	“Highly Noise Affected” Level - dB(A) $L_{eq(15min)}$
R1	68(BG+10) externally at façade	75
R2	69(BG+10) externally at façade	

Where noise from the construction works is above the “noise affected” level, the proponent should apply any feasible and reasonable work practices to minimise noise. The “noise affected level is representative of a level where there may be some community reaction to noise.

If noise emissions are likely to exceed 75 dB(A) $L_{eq(15min)}$ “highly noise affected” at the boundary of surrounding affected residential receivers, the receiver is deemed to be “highly noise affected”. The “highly noise affected” level is representative of a level where strong community reaction to noise is expected. Introduction of management controls such as scheduling of noisy periods, or respite periods is then recommended.

Section 4.1.2 and 4.1.3 of the EPA Interim Construction Noise Guideline also nominates management levels for other sensitive land uses (other than residences). Criteria relevant to this assessment is detailed below;

Table 9-2 – Noise Management Levels at Commercial Boundaries

Location	“Noise Affected” Level – dB(A) $L_{eq(15min)}$ Standard Hours
Surrounding Commercial Receivers C1-C6	70 externally at façade

9.2 CONSTRUCTION VIBRATION OBJECTIVES

Vibration associated with demolition and excavation activities on the site will be assessed in conjunction with the following guidelines:

For human exposure to vibration - Department of Environment and Conservation *NSW Assessing Vibration: A Technical Guideline* (Feb 2006) is based on the guidelines contained in BS 6472:1992 *Guide to Evaluate Human Exposure to Vibration in Buildings (1Hz to 80Hz)* for low probability of adverse comment.

For structural damage vibration - German Standard DIN 4150-3 *Structural Vibration: Effects of Vibration on Structures*.

9.2.1 Assessing Amenity (Human Comfort Guidelines)

The NSW EPA's *Assessing Vibration – a technical guideline* is based on the guidelines contained in British Standard BS 6472-1992 '*Guide to Evaluate Human Exposure to Vibration Buildings (1Hz to 80Hz)*'. This guideline provides procedures for assessing tactile vibration and regenerated noise within potentially affected buildings.

The recommendations of this guideline should be adopted to assess and manage vibration from the site during construction. Where vibration exceeds, or is likely to exceed, the recommended levels then an assessment of reasonable and feasible methods for the management of vibration should be undertaken.

Table 9-3 – BS 6472 Vibration Criteria

		RMS acceleration (m/s ²)		RMS velocity (mm/s)		Peak velocity (mm/s)	
Place	Time	Preferred	Maximum	Preferred	Maximum	Preferred	Maximum
Continuous Vibration							
Residences	Daytime	0.01	0.02	0.2	0.4	0.28	0.56
Offices	Day or night-time	0.02	0.04	0.4	0.8	0.56	1.1
Workshops		0.04	0.08	0.8	1.6	1.1	2.2
Impulsive Vibration							
Residences	Daytime	0.3	0.6	6.0	12.0	8.6	17.0
Offices	Day or night-time	0.64	1.28	13	26	18	36
Workshops		0.64	1.23	13	26	18	36

Note 1: Continuous vibration relates to vibration that continues uninterrupted for a defined period (usually throughout the daytime or night-time), e.g. continuous construction or maintenance activity. (DECC, 2009).

Note 2: Impulsive vibration relate to vibration that builds up rapidly to a peak followed by a damped decay and that may or may not involve several cycles of vibration (depending on frequency and damping), with up to three occurrences in an assessment period, e.g. occasional loading and unloading, or dropping of heavy equipment. (DECC, 2009).

9.2.2 Structure Borne Vibration (Damage Criteria)

German Standard DIN 4150-3 (1999-02) provides a guideline for acceptable levels of vibration velocity in building foundations, to assess the effects of vibration on structures. The table gives guidance on the maximum accepted values of velocity at the foundation and in the plane of the highest floor of various types of buildings, to prevent any structural damage.

The table below lists the peak particle velocity, which is the maximum absolute value of the velocity signals for the three orthogonal components. This is measured as a maximum value of any of the three orthogonal component particle velocities when measured at the foundation, and the maximum levels measured in the x- and y-horizontal directions in the plane of the floor of the uppermost storey.

Table 9-4 – DIN 4150-3 (1999-02) Safe Limits for Building Vibration

TYPE OF STRUCTURE		PEAK PARTICLE VELOCITY (mms ⁻¹)			
		At Foundation at a Frequency of			Plane of Floor of Uppermost Storey
		< 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used in commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

9.3 CONSTRUCTION NOISE EMISSION ASSESSMENT

The proposal is to demolish the existing commercial blocks at 391-423 Pacific Highway, Crows Nest and build a new mixed used building with 7 levels basement carpark. An indicative construction scope is summarised as following:

- Demolition Stage: Demolish existing commercial blocks
- Excavation Stage: Excavate and piling for 7 basement levels, and
- Construction Stage: Construct new buildings with 21 levels

It is envisaged that construction scope and staging would be further refined in subsequent stages of the development approval and documented (along with additional impacts or considerations) within a Construction Environment Management Plan.

9.3.1 Source Noise Data

In this section, typical equipment/processes anticipated to be used during the construction of the project site are outlined in the table below with A-weighted sound power levels. The equipment list is prepared based on our experience with similar projects. Typically, the most significant sources of noise or vibration generated during a construction project will be demolition and excavation.

Table 9-5 – Sound Power Levels of Equipment

Equipment /Process	Typical Sound Power Level dB(A)	Duty
Excavator with Bucket Attachment	107	100%
Forklift	106	100%
Medium Rigid Trucks	100	100%
Powered Hand Tools (Electric)	102	75%
Piling Rig	112	100%
Electric Tower Crane	113	50%
Concrete Pump Truck	108	100%

The noise levels presented in the above table are derived from the following sources, namely:

- On-site measurements.
- Table A1 of Australian Standard 2436-2010.
- Data held by this office from other similar studies.

Noise levels take into account correction factors (for tonality, intermittency where necessary).

9.3.2 Methodology

Noise from the loudest typical construction activities for all stages of works have been predicted to the nearest most affected sensitive receivers.

Predictions take into account:

- The distance between the noise source and the receiver.
- The screening effect provided by any building structure or building shell, if applicable. In particular, noise from works proposed during the fit-out stages when the building shell will screen these activities from the surrounding sensitive receivers.

Recommended standard hours for construction work presented in Section 2.2 of the NSW DECC Interim Construction Noise Guideline (ICNG, 2009) has been adopted for this project.

9.3.3 Predicted Noise Levels

Maximum noise impacts from the construction equipment listed above have been predicted to the nearest noise receivers and presented below. Given the size of the site predicted noise levels will change significantly depending on where the noise source is located. As such, a noise level range has been presented, giving expected noise levels for activities 'farthest from' to 'nearest to' the receiver.

Table 9-6 – Predicted Construction Noise Levels – R1 & R2

Activity	R1	R2
Excavator with Bucket Attachment	59-73	58-68
Forklift	58-72	57-67
Medium Rigid Trucks	58-66	51-62
Powered Hand Tools (Electric)	53-67	52-62
Piling Rig	64-78	63-73
Electric Tower Crane	62-74	61-71
Concrete Pump Truck	60-74	59-70
NML	68	69
HNML	75	75
Comments	Exceeds NML when conducting activities close to the site boundary but generally below HNML. Exceeds HNML when using piling rig close to site boundary	Exceeds NML when using piling rig, crane and concrete pump when close to the site boundary but below HNML for all the activities

Table 9-7 – Predicted Construction Noise Levels – C1

Activity	C1	C2	C3-C4	C5	C6
Excavator with Bucket Attachment	60-66	59-63	59-68	57-63	58-63
Forklift	59-65	58-62	58-67	56-62	57-62
Medium Rigid Trucks	53-59	52-61	58-61	50-56	51-57
Powered Hand Tools (Electric)	54-60	53-57	53-62	51-57	52-57
Piling Rig	65-71	64-68	64-71	62-68	63-68
Electric Tower Crane	63-69	62-70	62-69	60-66	61-66
Concrete Pump Truck	61-67	60-64	60-69	58-64	59-65
NML	70				
Comments	Slightly exceeds NML when using piling rig at the site boundary	Below NML for all the activities	Slightly exceeds NML when using piling rig at the site boundary	Below NML for all the activities	

9.4 GENERAL DISCUSSION

Noise

- Noise impacts on nearby development will be dependent on the activity and where on the site the activity is undertaken. Excavation works (e.g., use of piling rig) tend to be the loudest typical activity. Work close to the site boundaries will have the greatest impact on nearby receivers.

Initial analysis indicates:

- Demolition stage: Primary noise emissions occur when using excavator, with equipment items typically having sound power levels of approximately 107 dB(A)_{Leq(15min)}. Predicted noise levels at residential receivers **R1** and **R2** will not exceed the HNML but will generally exceed NML when work is conducted close to the receiver. Predicted noise levels at commercial receivers during this stage will generally comply with NML 70dB(A). It is also note that existing commercial block will potentially provide additional attenuations during this stage.
- Excavation stage: Primary noise emissions occur when using piling rig, with equipment items typically having sound power levels of approximately 112 dB(A)_{Leq(15min)}. Predicted noise levels at residential receivers **R1** will not exceed the HNML but will generally exceed NML when work is conducted close to the receiver. Predicted noise level at **R2**, however, is slightly over the HNML when work is conducted close to the eastern boundary. Predicted noise levels at commercial receivers C1, C3-C4 will slightly exceed the NML when piling is conducted at site boundary.
- Construction stage: Predicted noise levels at all residential receivers will not exceed the HNML but will generally exceed NML when work is conducted close to the receiver.

Noise impacts can be minimised using the following:

- Selection of equipment and process.
- Location of static plant.
- Use of screens or enclosures and erection of hoarding (typically only feasible for static plant).
- Scheduling of noisy activities and provision of respite periods.

Detailed construction noise planning is typically undertaken after engagement of a builder and a construction program is prepared (i.e. – after DA stage) and therefore, detailed planning is not possible at this stage.

In light of the above, we recommend:

- During preparation of the construction program (CC stage), acoustic review of proposed construction activities and plant/methods should be undertaken to identify work items likely to exceed Noise Management Levels.
- For those activities likely to generate high noise levels, the analysis should identify where on the site are the areas likely to result in high noise levels. This will then assist in determining the likely time period for which high noise levels will occur.
- Identify feasible acoustic controls or management techniques (use of screens, scheduling of noisy works, notification of adjoining land users, respite periods) when excessive levels may occur.
- For activities where acoustic controls and management techniques still cannot guarantee compliant noise levels, implement a notification process whereby nearby development is made aware of the time and duration of noise intensive construction processes.

Through adoption of the above, noise impacts on nearby development can be suitably managed to prevent excessive impact.

Vibration

The highest levels of vibration are likely to be produced when excavation activities are undertaken with the use of piling rig. This activity would only produce a moderate level of vibration close to the work site. Given the closest residential receiver is approximately 20m away from the site (R1), the impact at the surrounding properties is moderate considering amenity and structure damage.

A separate *Construction Vibration Management Plan* (Ref: 20230371.2/2108A/R0/PF, dated 21/02/2023) has been prepared for Metro Tunnel below the project site.

Where required, vibration monitors may be installed at critical locations to determine any impact. Ongoing review and assessment of vibration impact will be conducted throughout the construction process to determine appropriate vibration levels. The specific location and quantity of vibration monitors to monitor residential houses are to be determined in consultation with the builder and structural engineer.

10 NOISE AND VIBRATION MANAGEMENT AND CONTROL

Notwithstanding that the assessment indicates noise and vibration emissions will generally comply with the noise and vibration management levels, emissions should be minimised as part of best practice endeavours, and contingency measures should be put into place to respond to complaints or if it is found the processes needed to complete the tasks vary from those envisaged in this assessment.

The recommended measures are provided below.

10.1 NOISE AND VIBRATION MONITORING, REPORTING AND RESPONSE PROCEDURES

Given the relatively low level of impact predicted, monitoring would only be required in response to complaints, if the processes needed to complete the tasks vary from those envisaged in this assessment, or if works outside of standard hours are proposed.

Noise and vibration monitoring may either consist of manned and/or unmanned measurements. Active monitoring may be undertaken during the construction work phase of the project if required in the event complaints are received from neighbours.

In the event that complaints are received from neighbours the following process should be considered:

1. Assessing impacts and determining the offending plant/equipment/process.
2. Locating the plant/equipment/process further away from the affected receiver(s) if possible.
3. Implementing additional acoustic treatment in the form of localised barriers, silencers etc.
4. Selecting alternative equipment/processes.

Where monitoring is required and indicates exceedances of the predicted noise impacts immediate action should be taken to identify any further controls as required to reduce noise emissions so that the noise limits are complied with. Monitoring of the activities following the implementation of these additional controls will be undertaken to confirm compliance.

10.1.1 Reporting Requirements

The following is an example of reporting which may be kept on site:

1. A register of complaints received/communication with the local community shall be maintained and kept on site with information as detailed below.
2. Where noise/vibration complaints require noise/vibration monitoring, results from monitoring shall be retained on site at all times.
3. Any noise exceedances occurring including, the actions taken and results of follow up monitoring.
4. A report detailing complaints received and actions taken shall be presented.
5. All monitoring and reporting shall be conducted in conjunction with the conditions of consent.

10.1.2 Response Procedures

Complaints associated with noise and vibration generated by site activities shall be recorded on a Noise Complaint Form. The person(s) responsible for complaint handling and contact details for receiving of complaints shall be established on site prior to construction works commencing. A sign shall be displayed at the site indicating the site manager and the general public and their contact telephone number.

If a noise complaint is received the complaint should be recorded on a Noise Complaint Form. The complaint form may list:

- The name and address of the complainant (if provided).
- The time and date the complaint was received.
- The nature of the complaint and the time and date the noise was heard.
- The name of the employee who received the complaint.
- Actions taken to investigate the complaint, and a summary of the results of the investigation.
- Indicate what operations were occurring on site at the time of the complaint.
- Required remedial action, if required
- Validation of the remedial action.
- Summary of feedback to the complainant.

The flow chart that follows illustrate the process followed to assess construction activities prior to the start of work on site and well as the ongoing investigation into noise during the construction period.

10.2 GENERAL NOISE CONTROL METHODS

The determination of appropriate additional noise control measures will be dependent on the particular activities and the construction equipment and plant identified as requiring future acoustic treatments to those already identified in this report. This section provides an outline of available methods which have previously been used on similar construction sites and may be possible on this site.

10.2.1 Selection of Alternate Appliance or Process

Where a particular activity or plant and equipment is found to generate noise levels that exceed the management levels, it may be possible to select an alternative approach or plant and equipment. For example, the use of excavator mounted hydraulic hammers of the site may potentially generate high levels of noise. By carrying this activity by using concrete saws or smaller plant here practical, construction noise levels and/or length of exposure to construction noise levels may be reduced.

10.2.2 Acoustic Barriers

The placement of barriers at the source is generally only effective for static plant. Placing barriers at the source cannot effectively attenuate equipment which is on the move or working in rough or undulating terrain.

The degree of noise reduction provided by barriers is dependent on the amount by which the line of sight can be blocked by the barrier. If the receiver is totally shielded from the noise source reductions of up to 15 dB(A) can be affected. Where only partial obstruction of line of sight occurs, noise reductions of 5 to 8 dB(A) may be achieved. Where the barrier does not obstruct line of sight, generally no noise reduction will occur.

Barriers are used to provide shielding and do not act as an enclosure. The material they are constructed from should have a noise reduction performance which is approximately 10dB(A) greater than the maximum reduction provided by the barrier screening. In this case, the use of a material such as 15mm plywood (or equivalent material) would be acceptable for the barriers.

10.2.3 Silencing Devices

Where construction methodologies or plant and equipment permit, investigate the use of silencing devices. These may take the form of engine shrouding, or special industrial silencers fitted to exhausts, for example.

10.2.4 Treatment of Specific Equipment

In certain cases, it may be possible to specially treat a piece of equipment to dramatically reduce the sound levels emitted.

10.2.5 Establishment of Site Practices

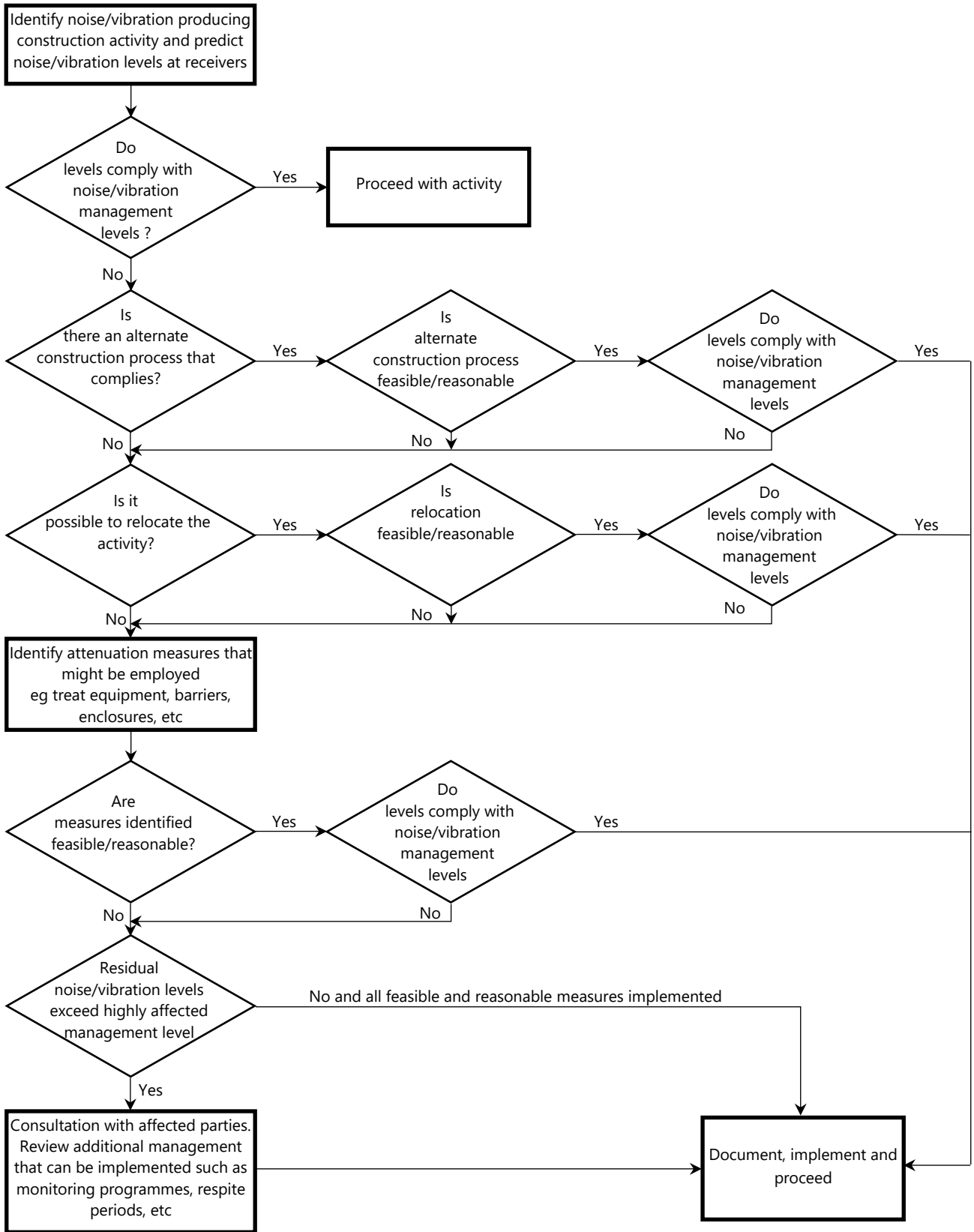
This involves the formulation of work practices to reduce noise generation. This includes investigating the possibility of locating fixed plant items as far as possible from residents as well as rotating plant and activities to provide respite to receivers.

10.2.6 Notification

Notification of affected receivers of the progress of works, particularly when short-term activities likely to create higher noise levels occur, can in many cases minimise community reaction.

11 CONTROL OF CONSTRUCTION NOISE AND VIBRATION – PROCEDURAL STEPS

The flow chart presented below illustrates the process that will be followed in assessing construction activities.



12 CONCLUSION

This report presents an acoustic assessment of noise impacts associated with the proposed mixed-use development located at 391-423 Pacific Highway, Crows Nest NSW. Based on the information provided above we conclude the following:

Provided that the treatments set out in Section 5.2 of this report are adopted, internal noise levels for the development will comply with the acoustic requirements of the following documents:

- North Sydney Council *North Sydney Development Control Plan 2013 (As amended 4 May 2023)*
- NSW Department of Planning *State Environmental Planning Policy Transport & Infrastructure (SEPPT&I) 2021*
- NSW Department of Planning *Developments near Rail Corridors or Busy Roads – Interim Guideline (DNRCBR) 2008*

Sydney Metro tunnel induced ground borne noise and vibration has been assessed against the following criteria:

- British Standard BS 7385:1990 Part 2 *Evaluation and measurement for vibration in buildings – part 2*
- Australian Standard AS2670:1990 *Vibration and Shock – Guide to the evaluation of human exposure to whole body vibration*
- NSW EPA *Assessing Vibration: A Technical Guideline*, and
- NSW Department of Planning *Developments near Rail Corridors or Busy Roads – Interim Guideline*.

External noise emissions criteria have been setup in this report to satisfy the requirements from the following documents:

- North Sydney Council *North Sydney Development Control Plan 2013 (As amended 4 May 2023)*, and
- NSW Environmental Protection Authority (EPA) *Noise Policy for Industry (NPI) 2017*.

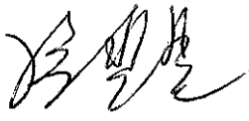
Once detailed location and selections of all proposed mechanical plant are known, an acoustic review should be undertaken to ensure compliance with the above. This should be undertaken during CC stage.

Construction noise and vibration management impacts have been established and preliminarily assessed in this report. A full construction noise and vibration management plan can be prepared in CC Stage ensuring compliance with the following:

- NSW DECC *Interim Construction Noise Guideline (ICNG, 2009)*.
- German Standard DIN 4150-3 (1999-02) *Structural Vibration – Effects of Vibration on Structures*
- Department of Environment and Conservation NSW *Assessing Vibration: A Technical Guideline (Feb 2006)*, and

Please contact us should you have any further queries.

Yours faithfully,

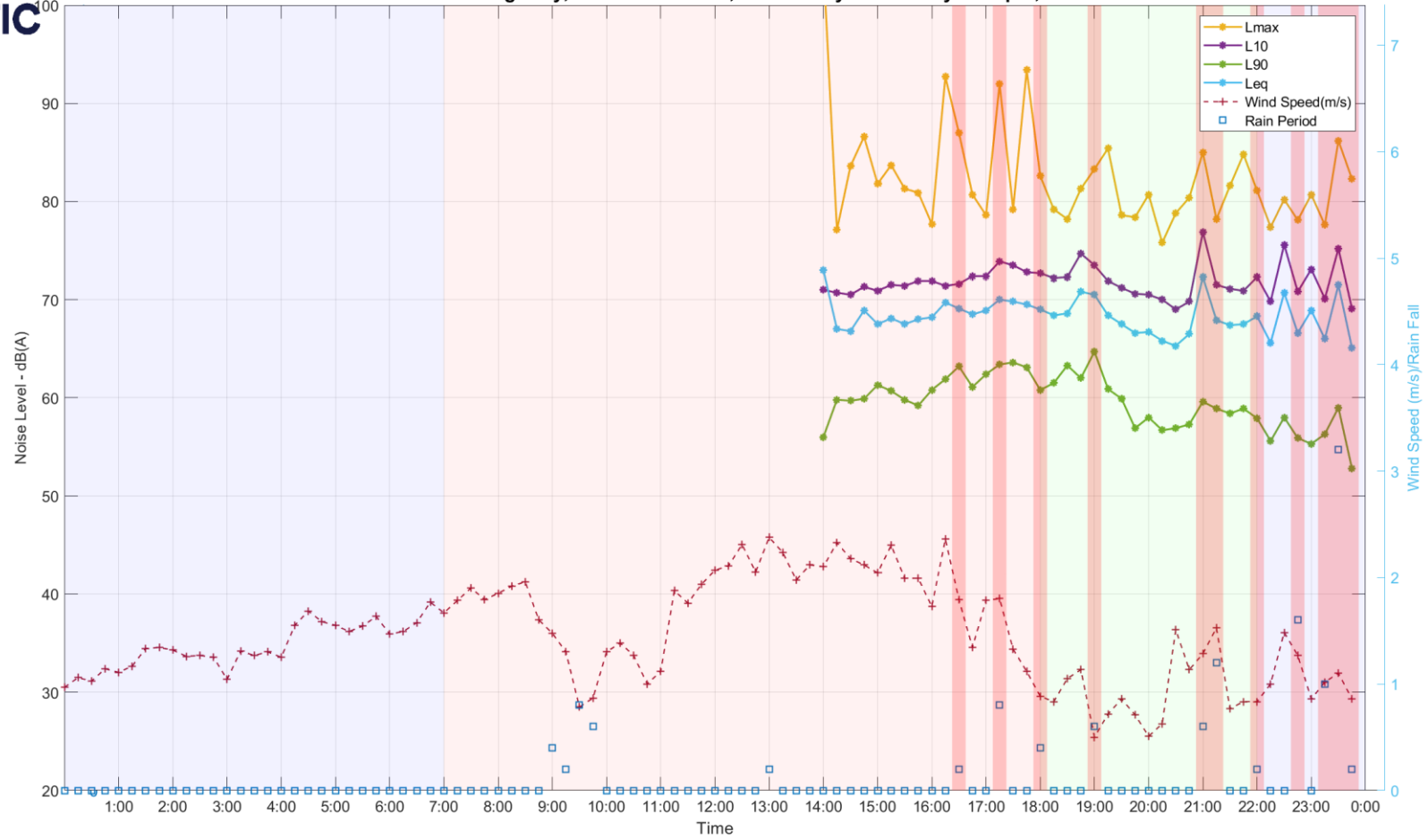
A handwritten signature in black ink, appearing to be 'PeiPei Feng', written in a cursive style.

Acoustic Logic Pty Ltd
PeiPei Feng

APPENDIX ONE – NOISE MONITORING DATA AT L1 AWNING FACING PACIFIC HWY

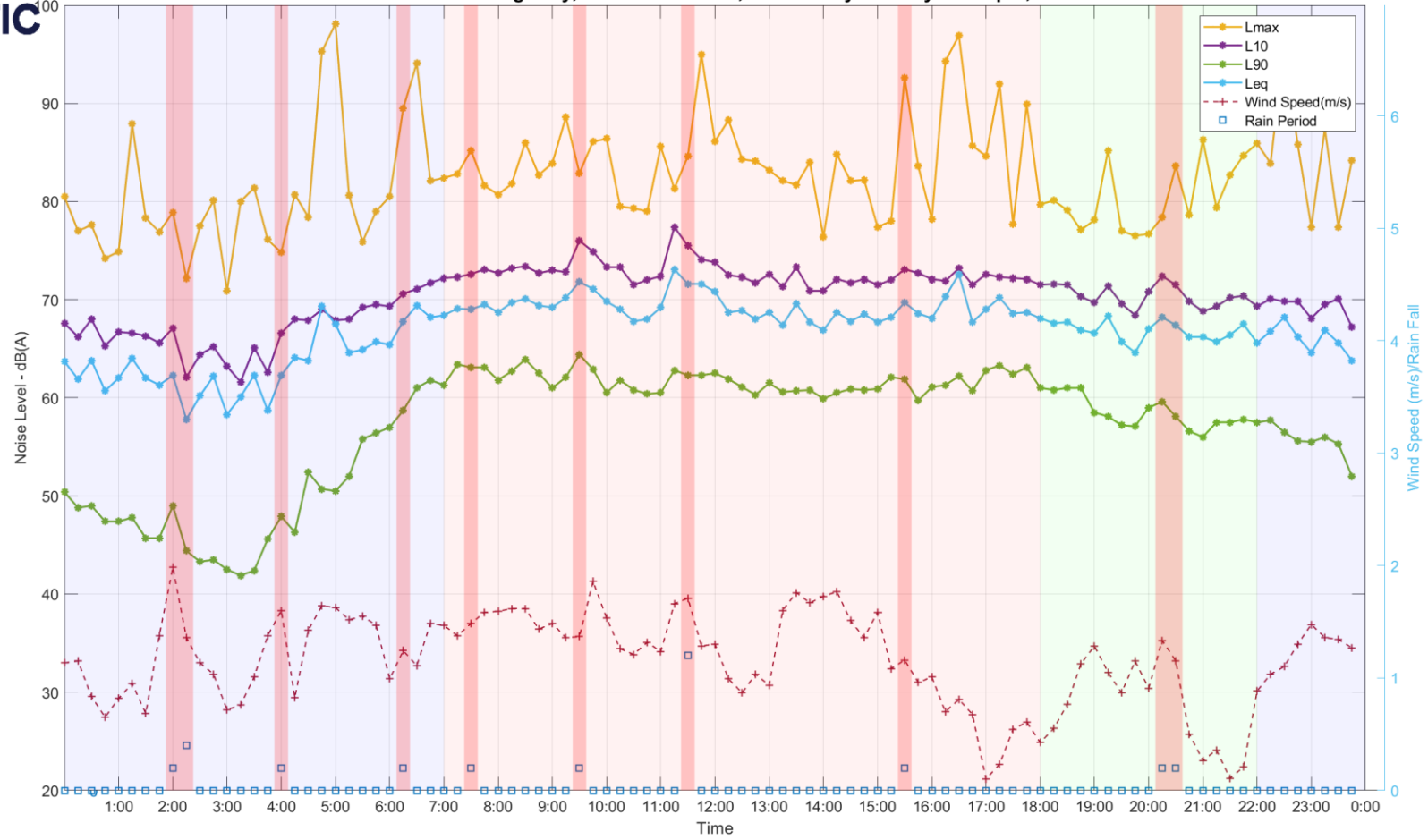


391-423 Pacific Highway, Crows Nest NSW, Pacific Hwy : Thursday 13 April, 2023



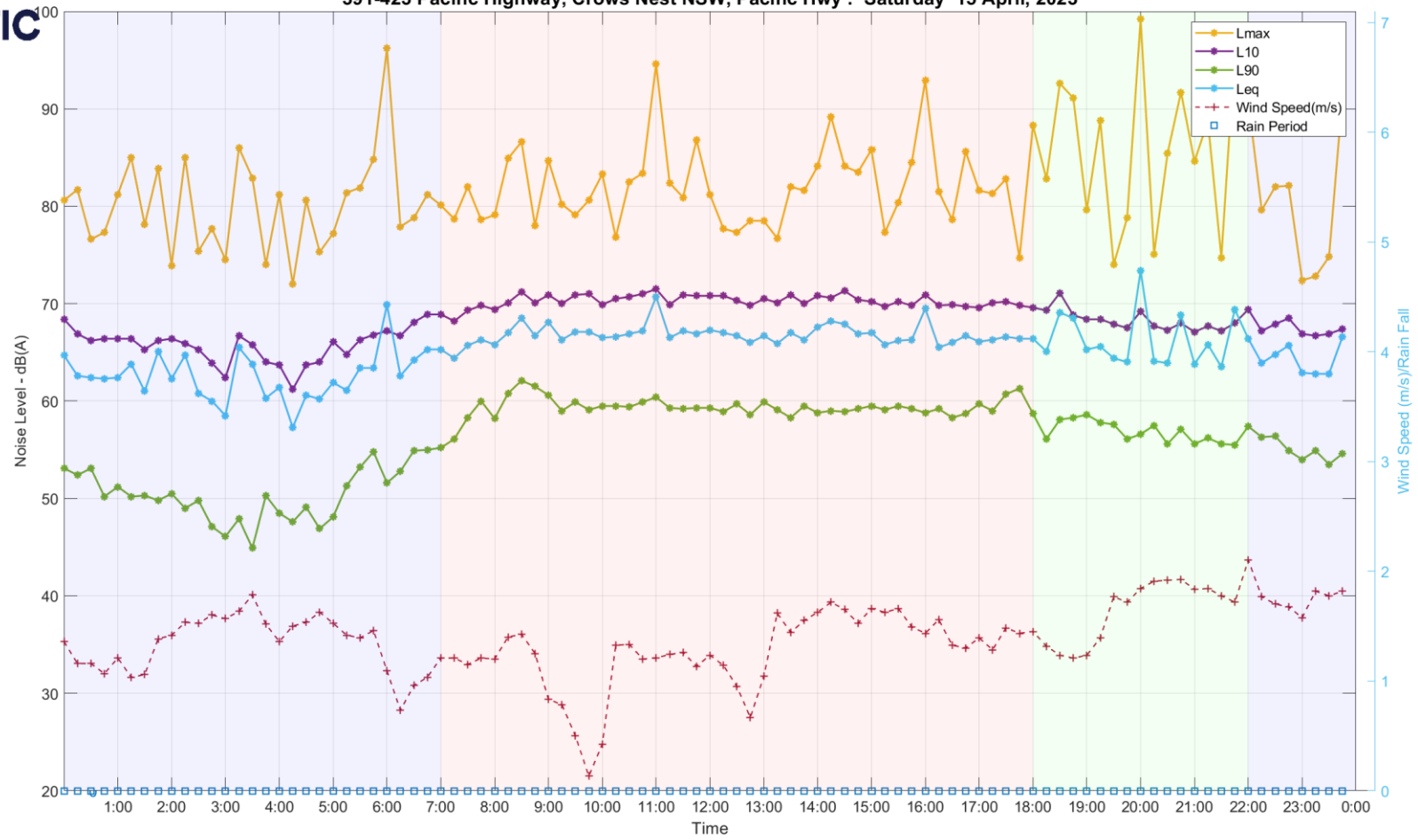


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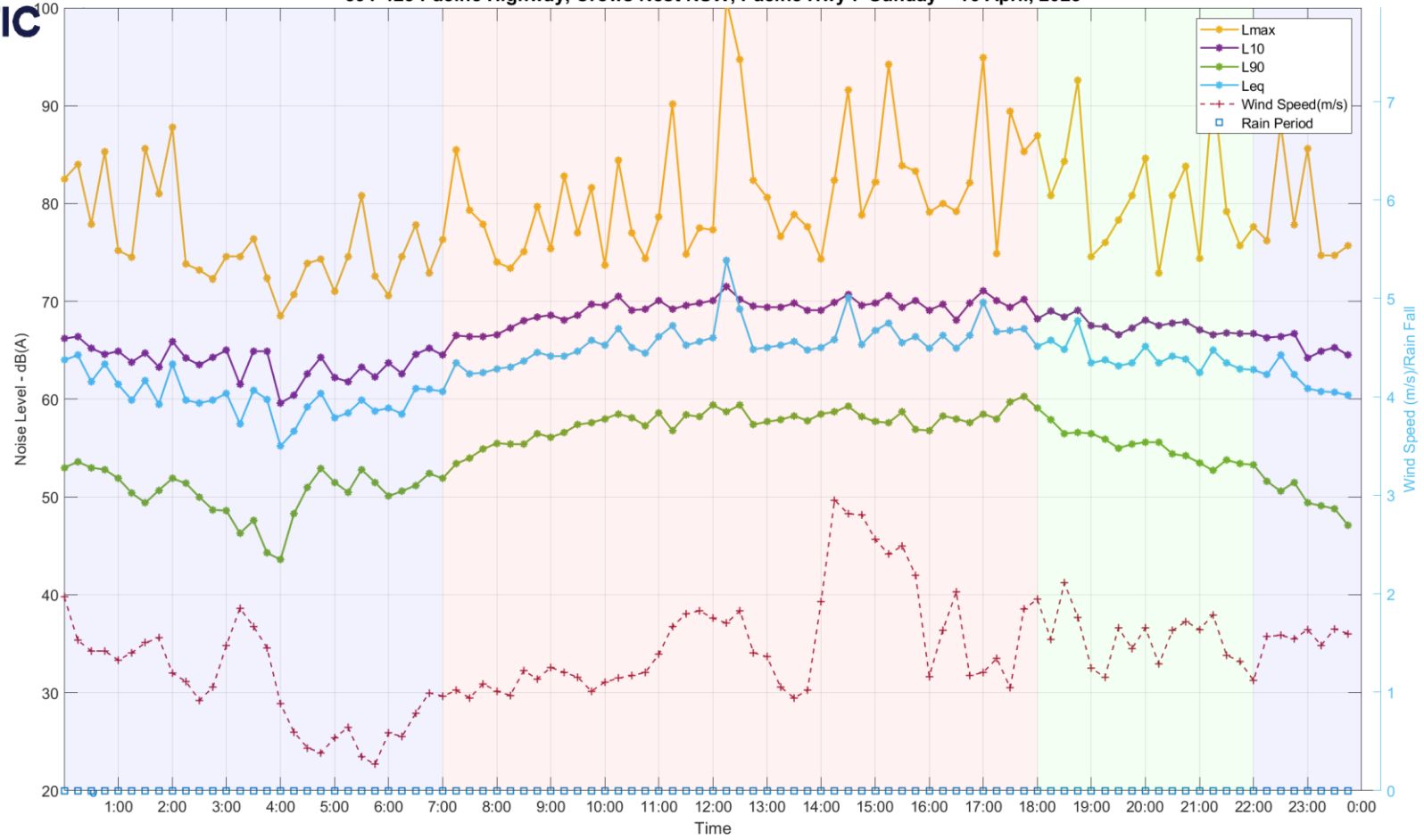




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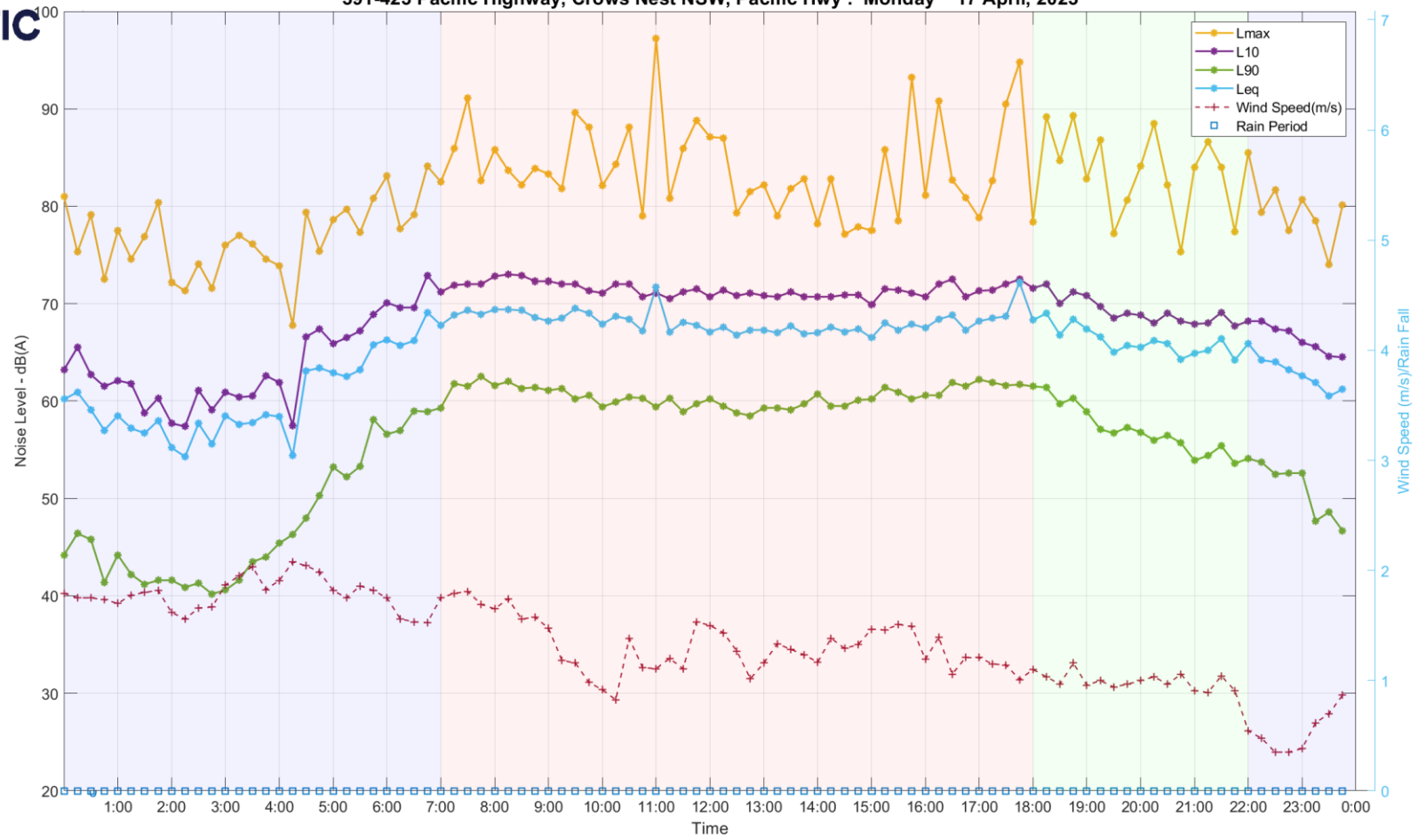


391-423 Pacific Highway, Crows Nest NSW, Pacific Hwy : Sunday 16 April, 2023

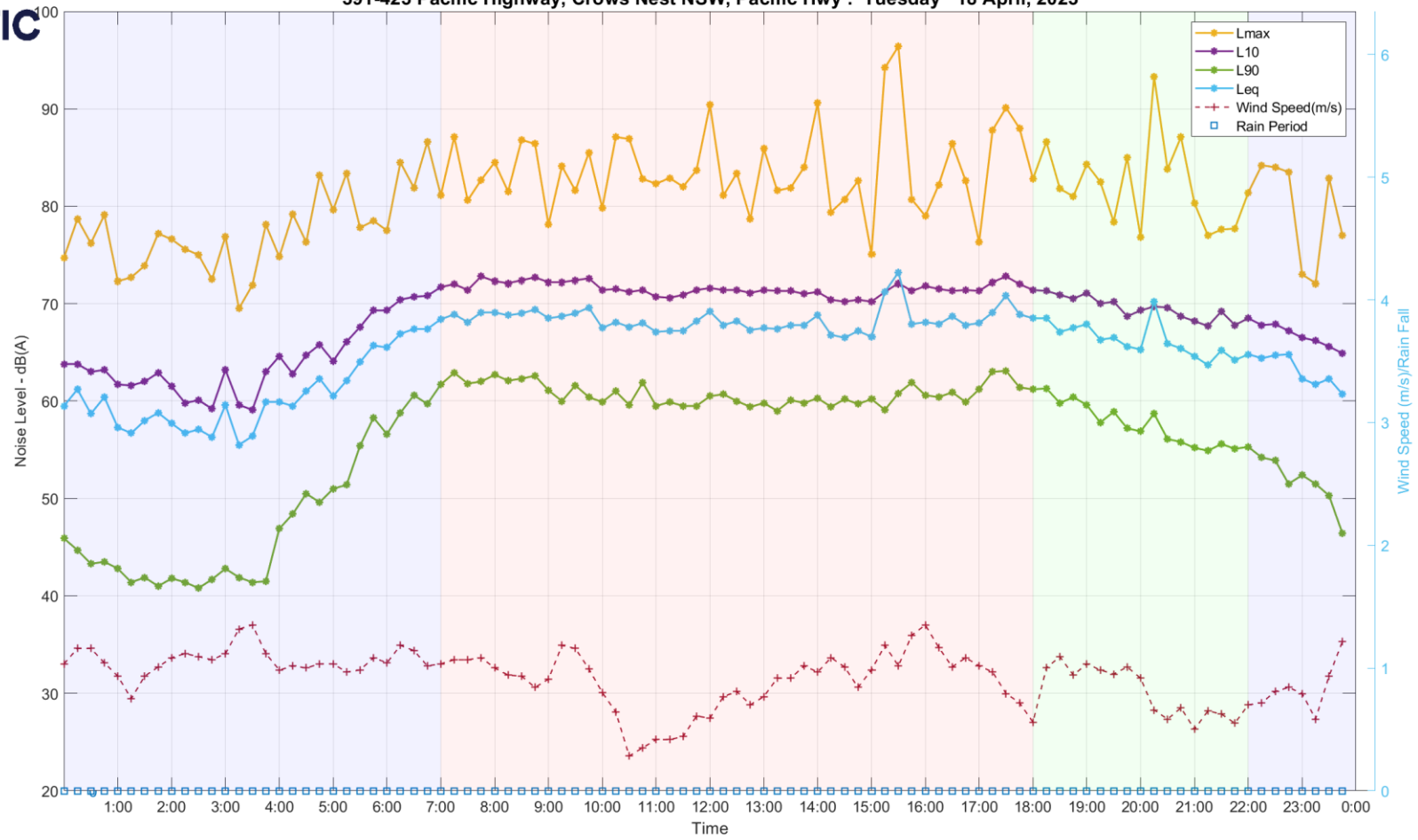




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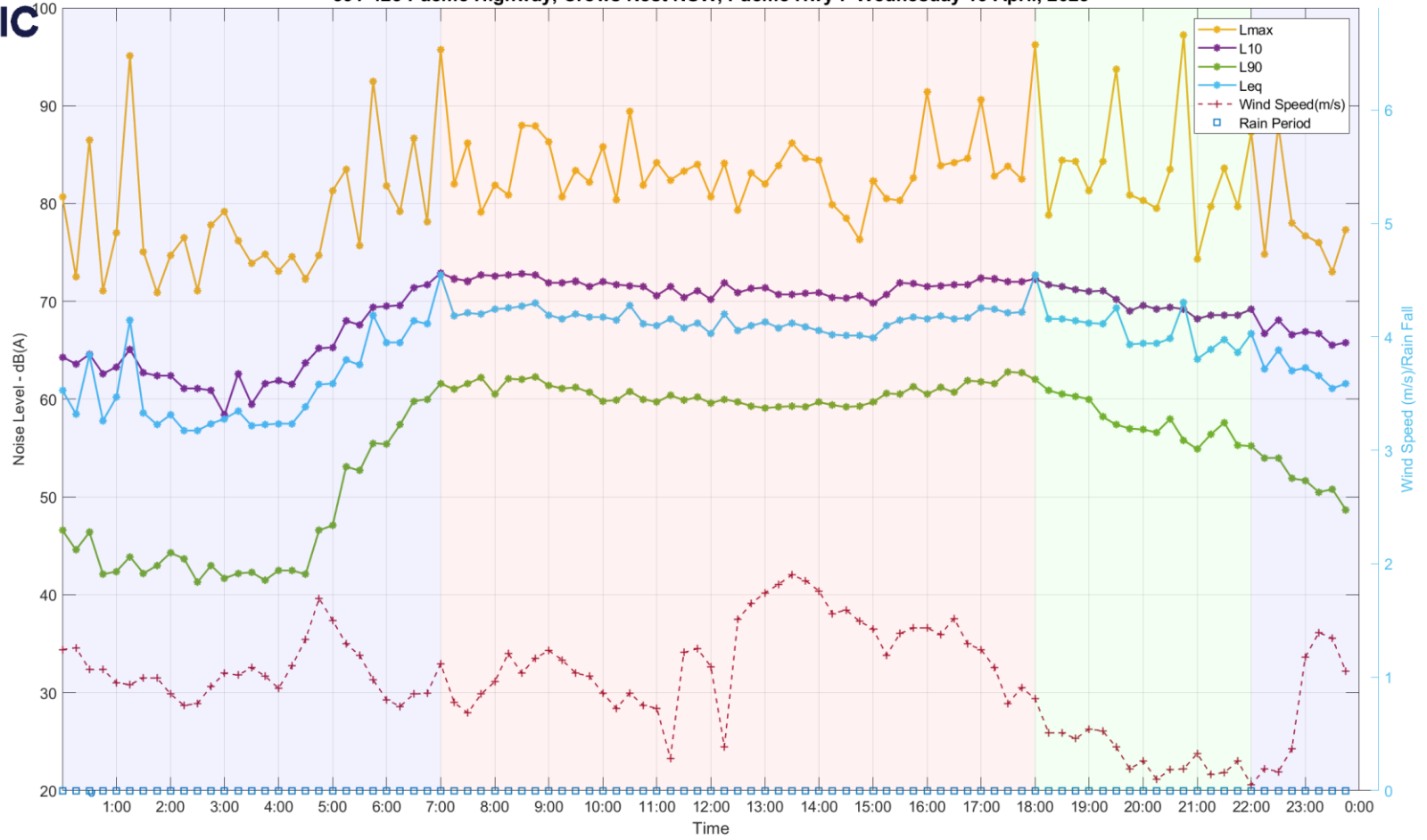


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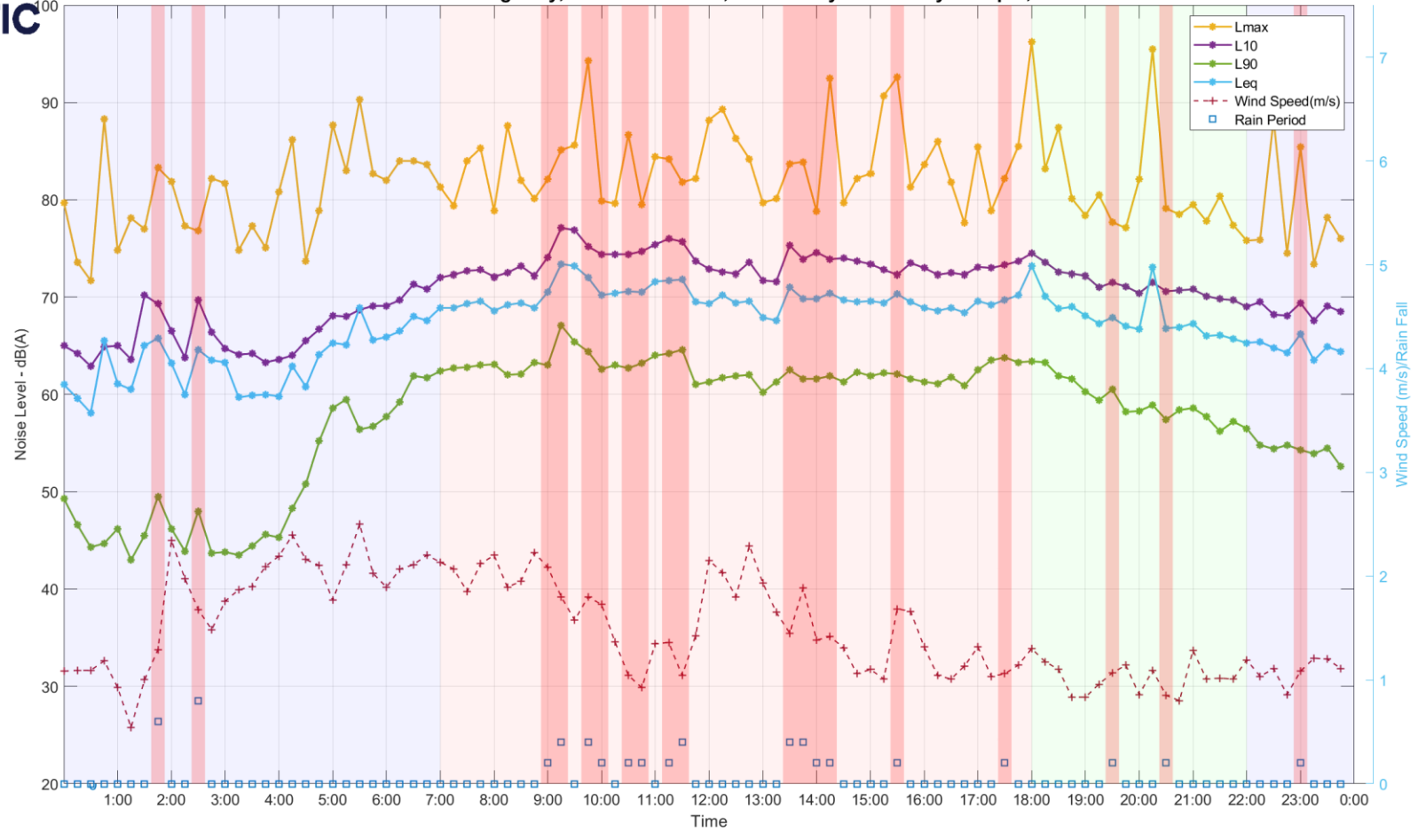




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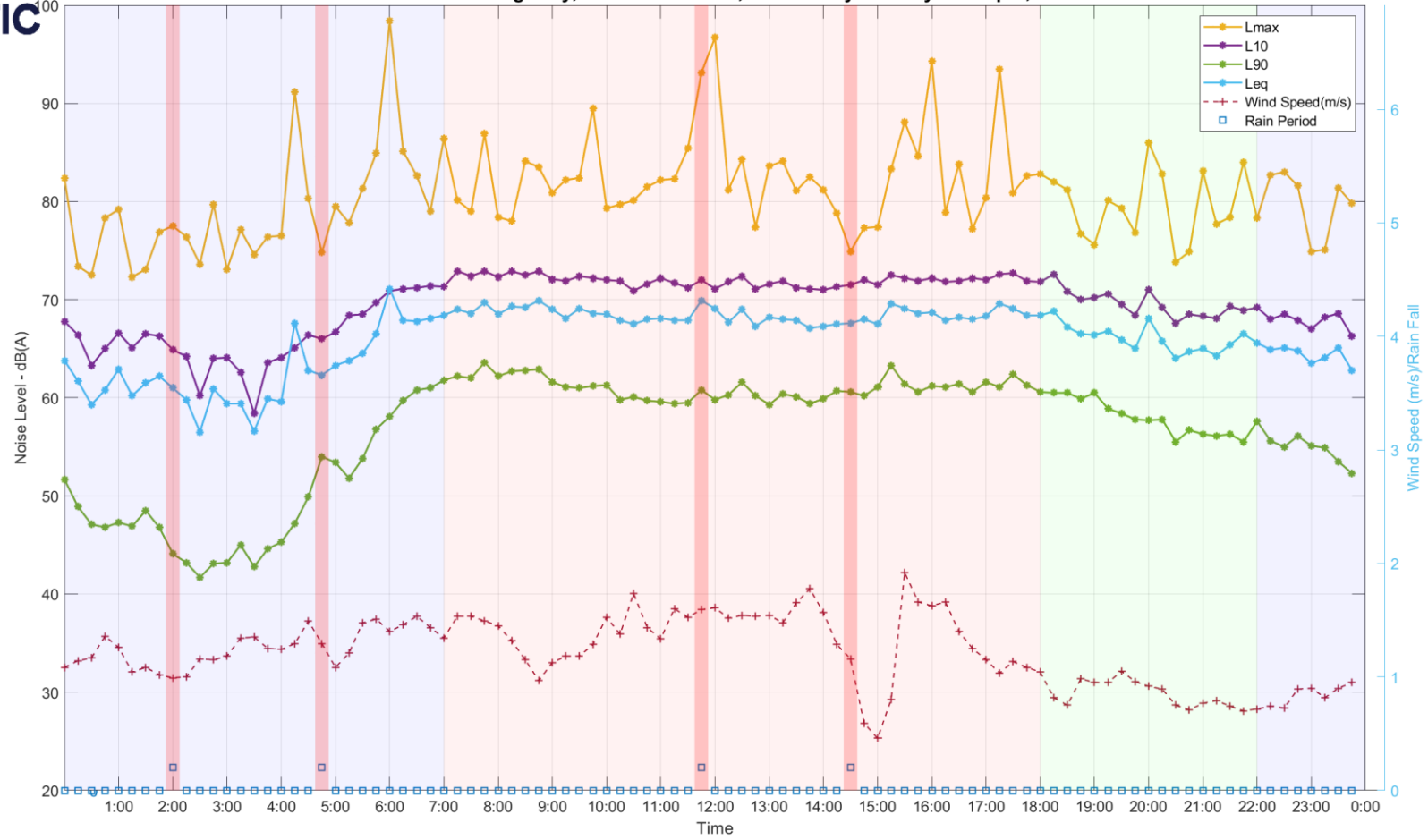


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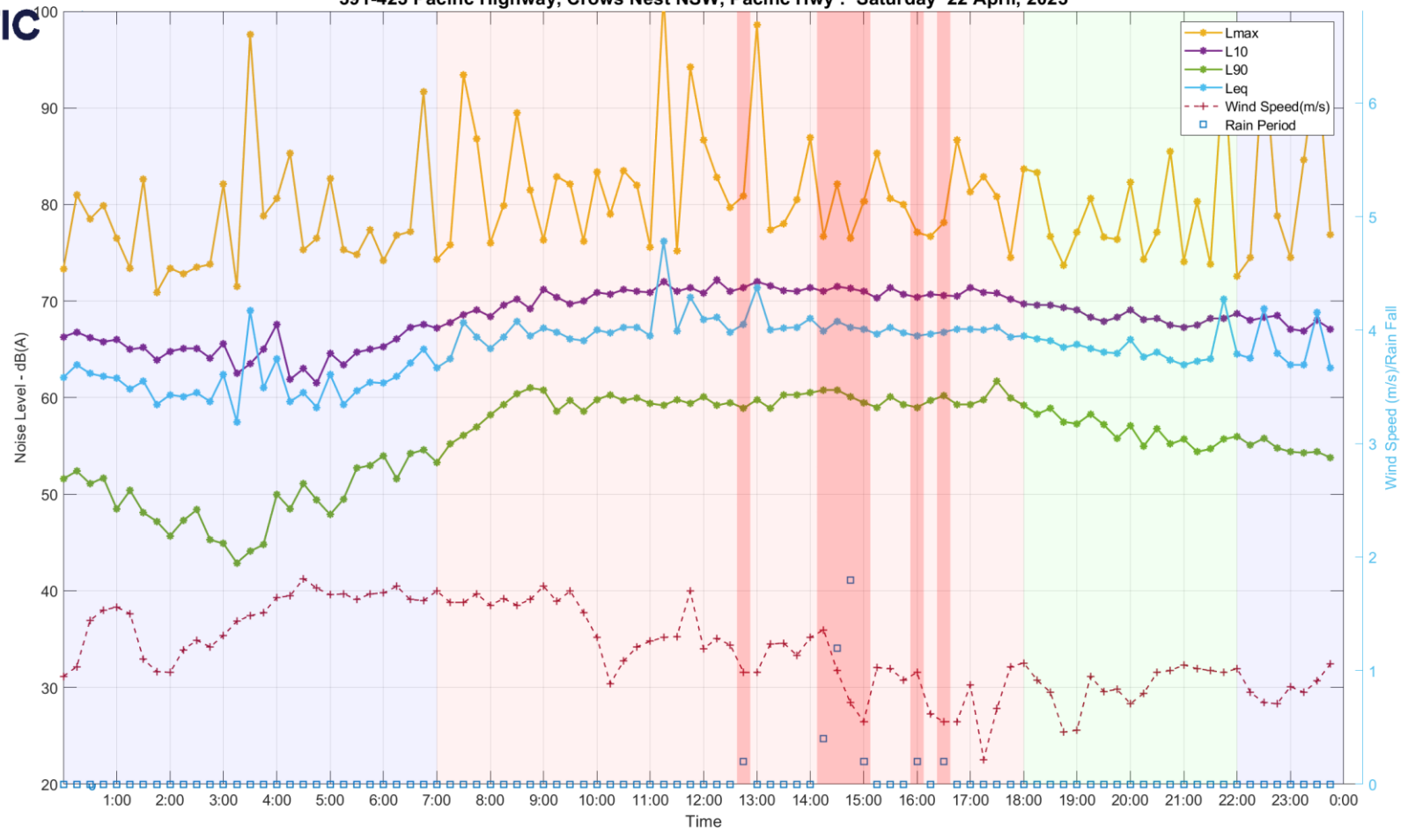


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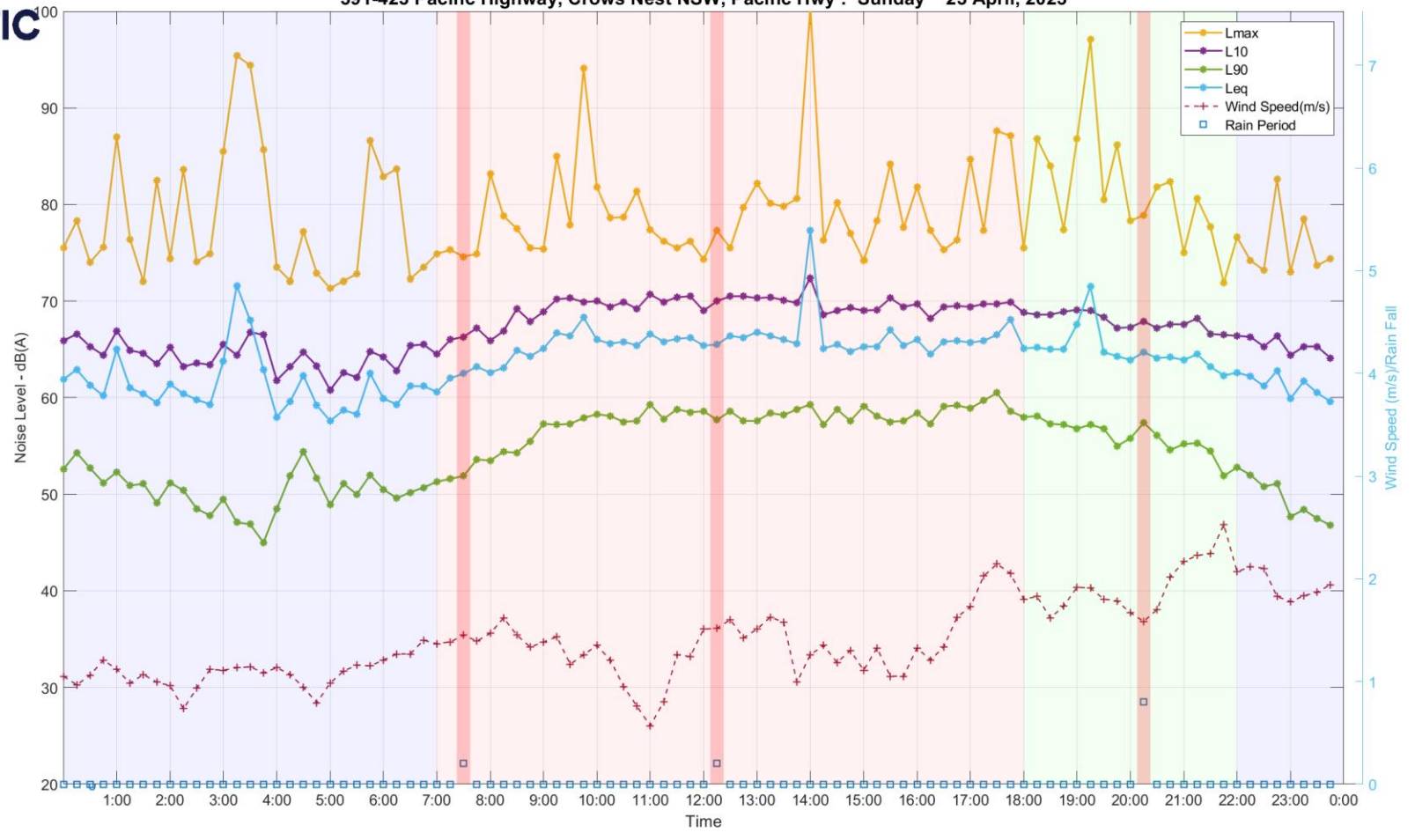


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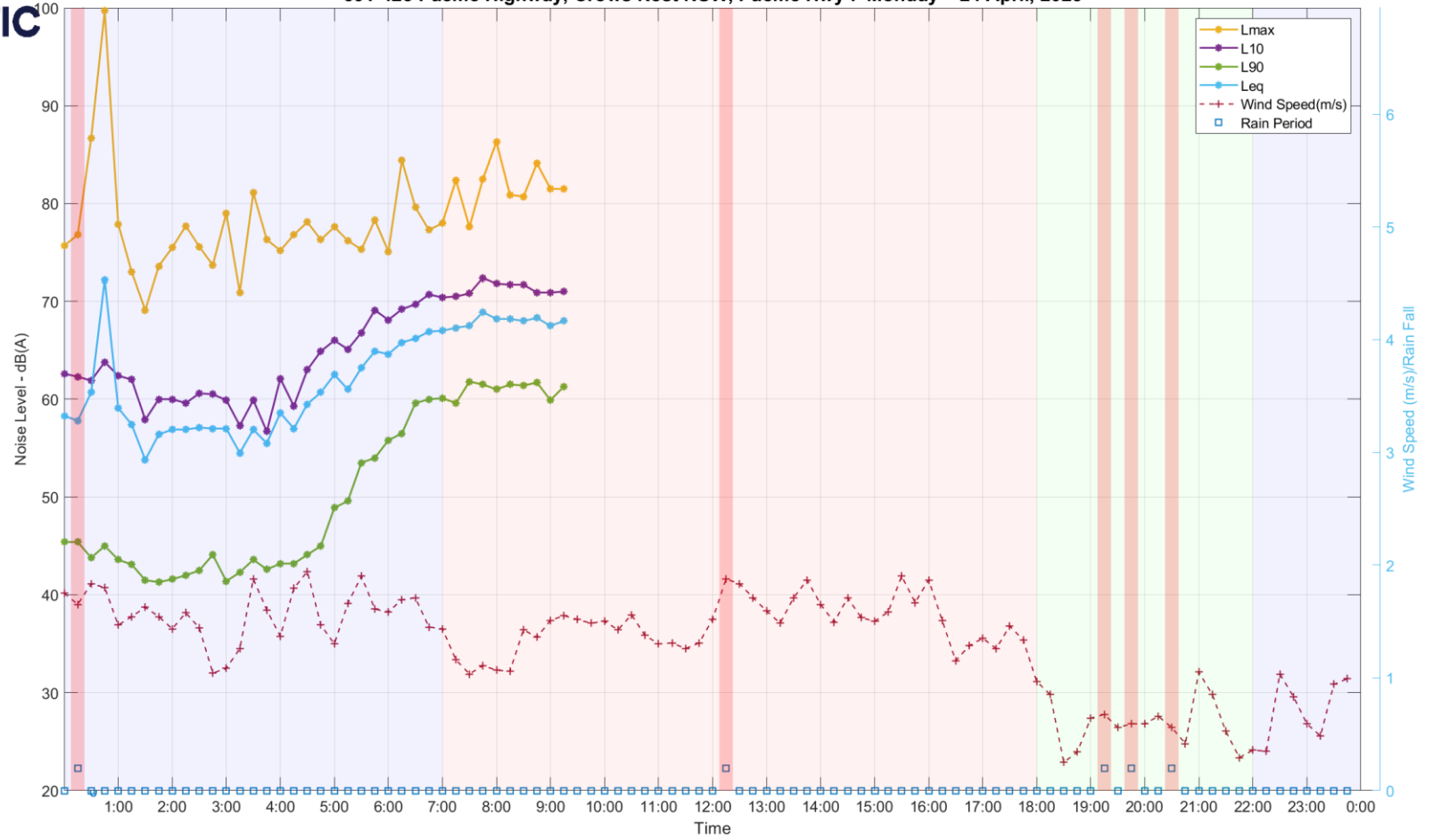


391-423 Pacific Highway, Crows Nest NSW, Pacific Hwy : Sunday 23 April, 2023





391-423 Pacific Highway, Crows Nest NSW, Pacific Hwy : Monday 24 April, 2023

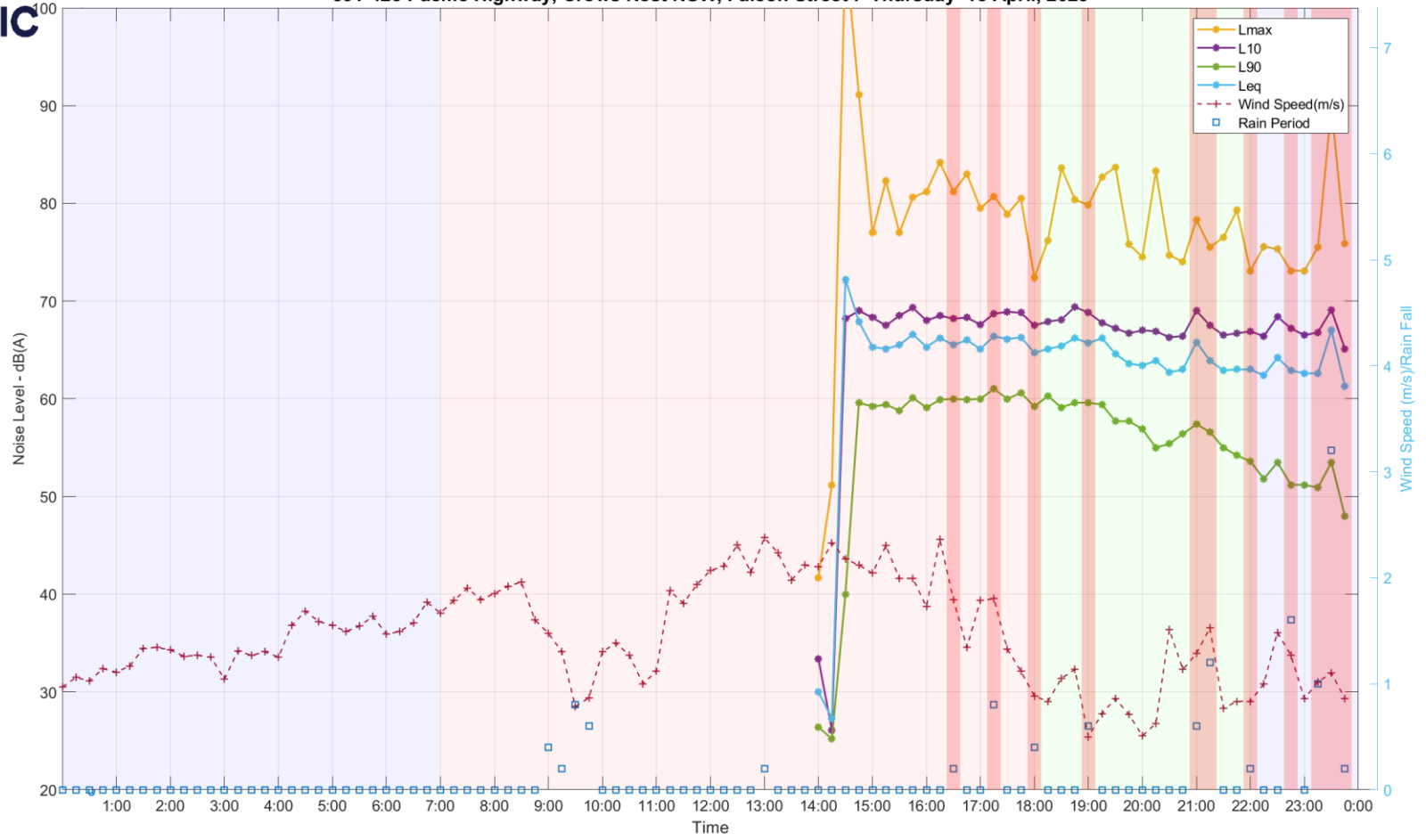


Wind Speed is corrected using factor 0.3000 based on logger location

APPENDIX TWO – NOISE MONITORING DATA AT L3 FACING FALCON STREET

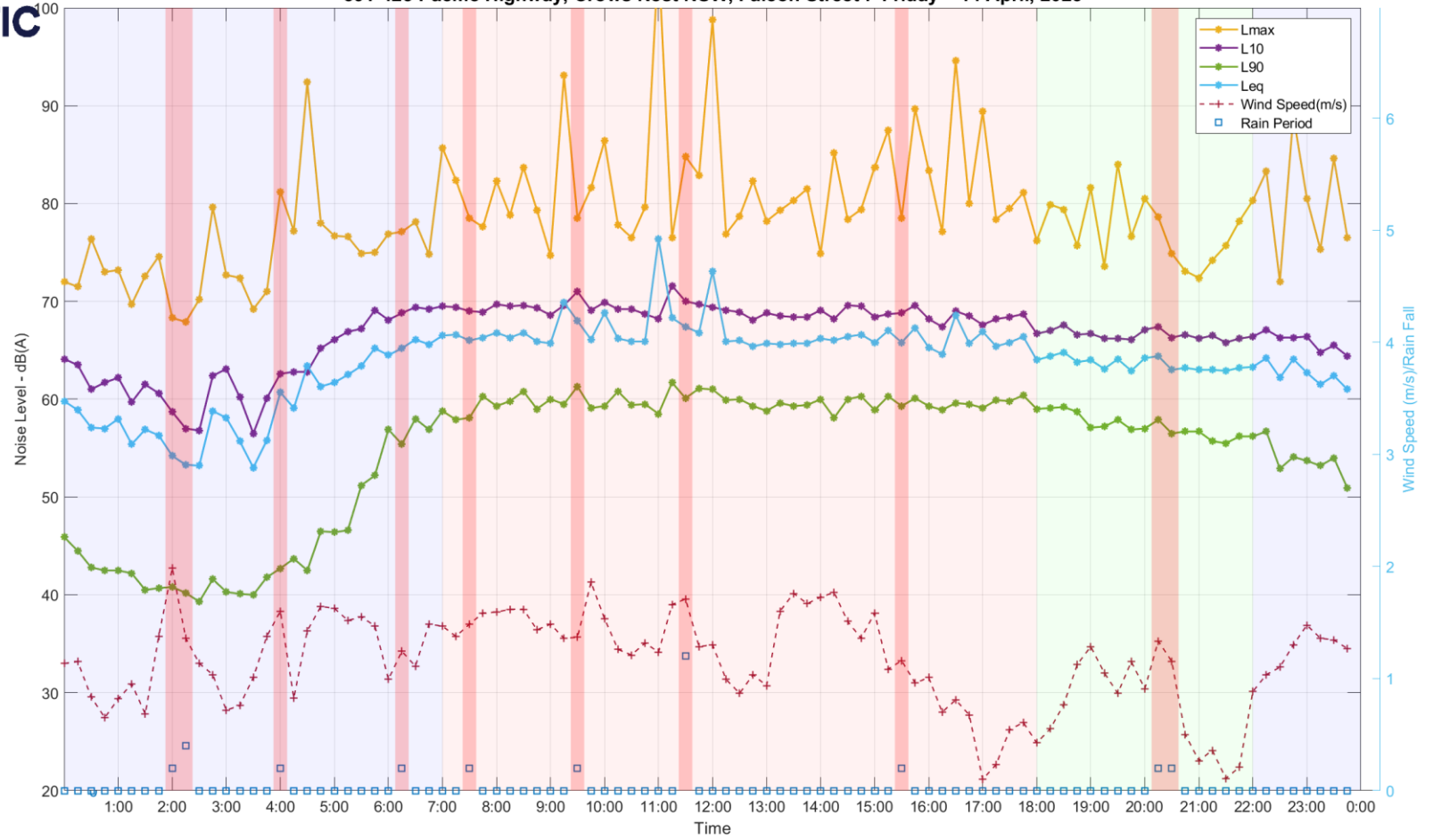


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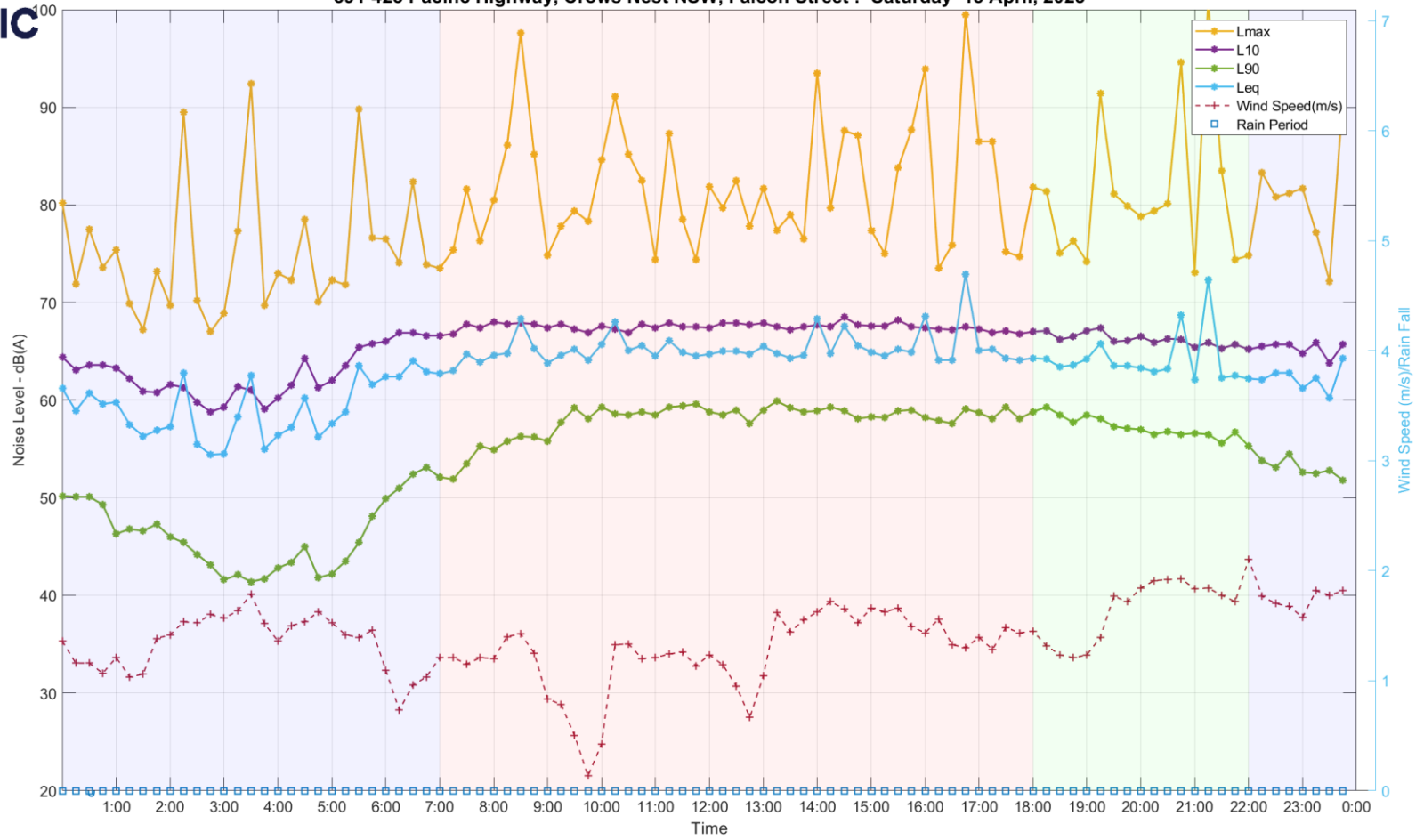


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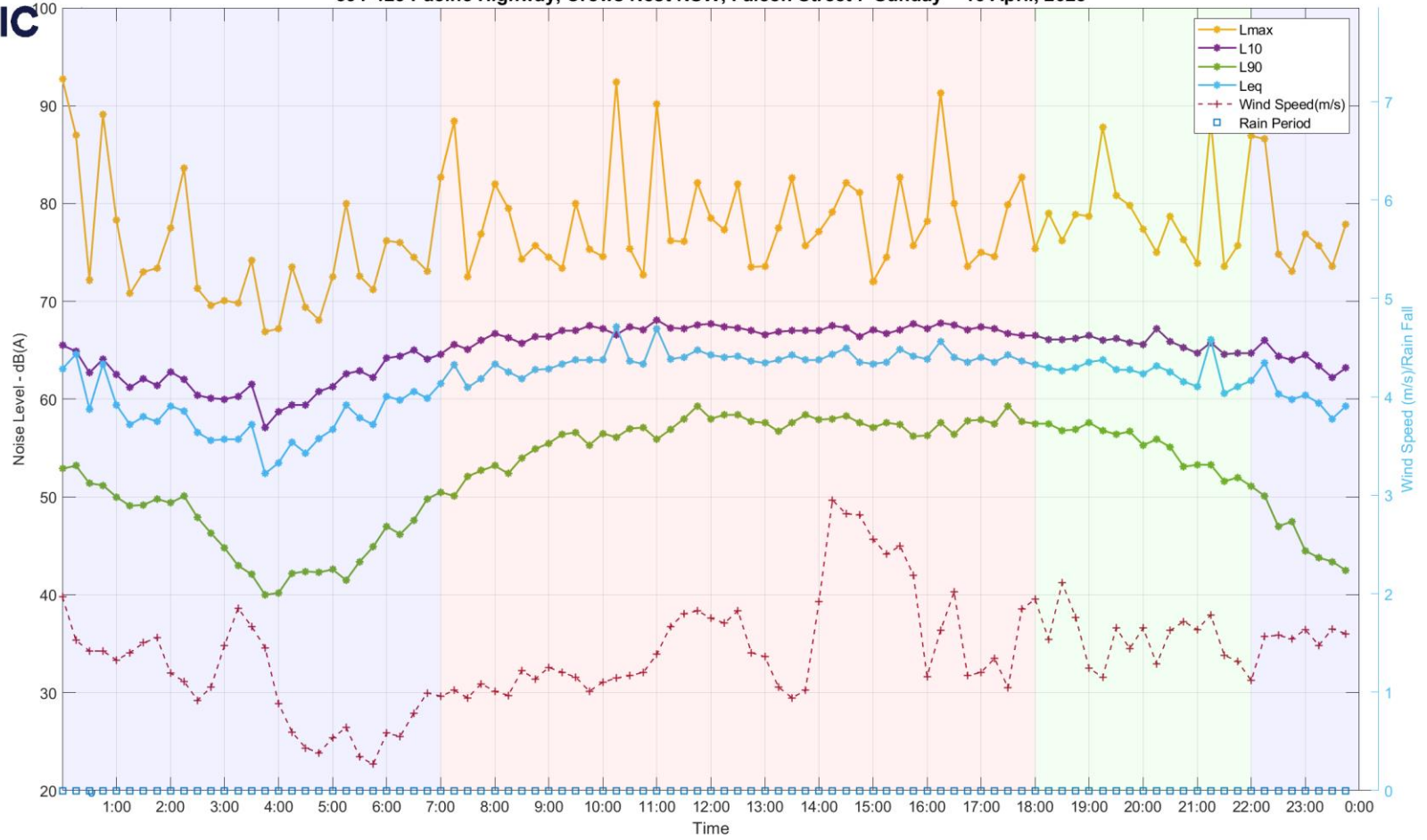




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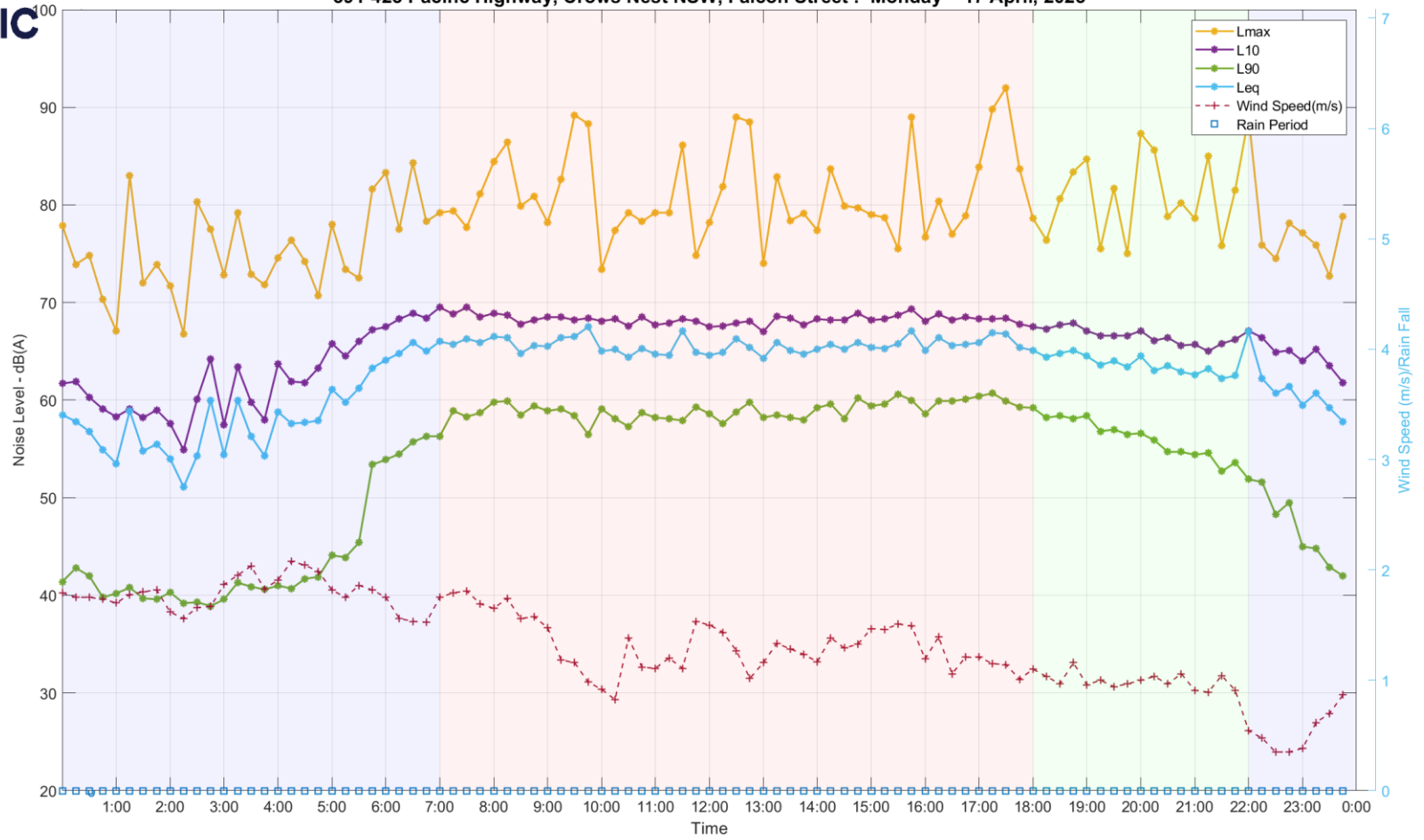


391-423 Pacific Highway, Crows Nest NSW, Falcon Street : Sunday 16 April, 2023



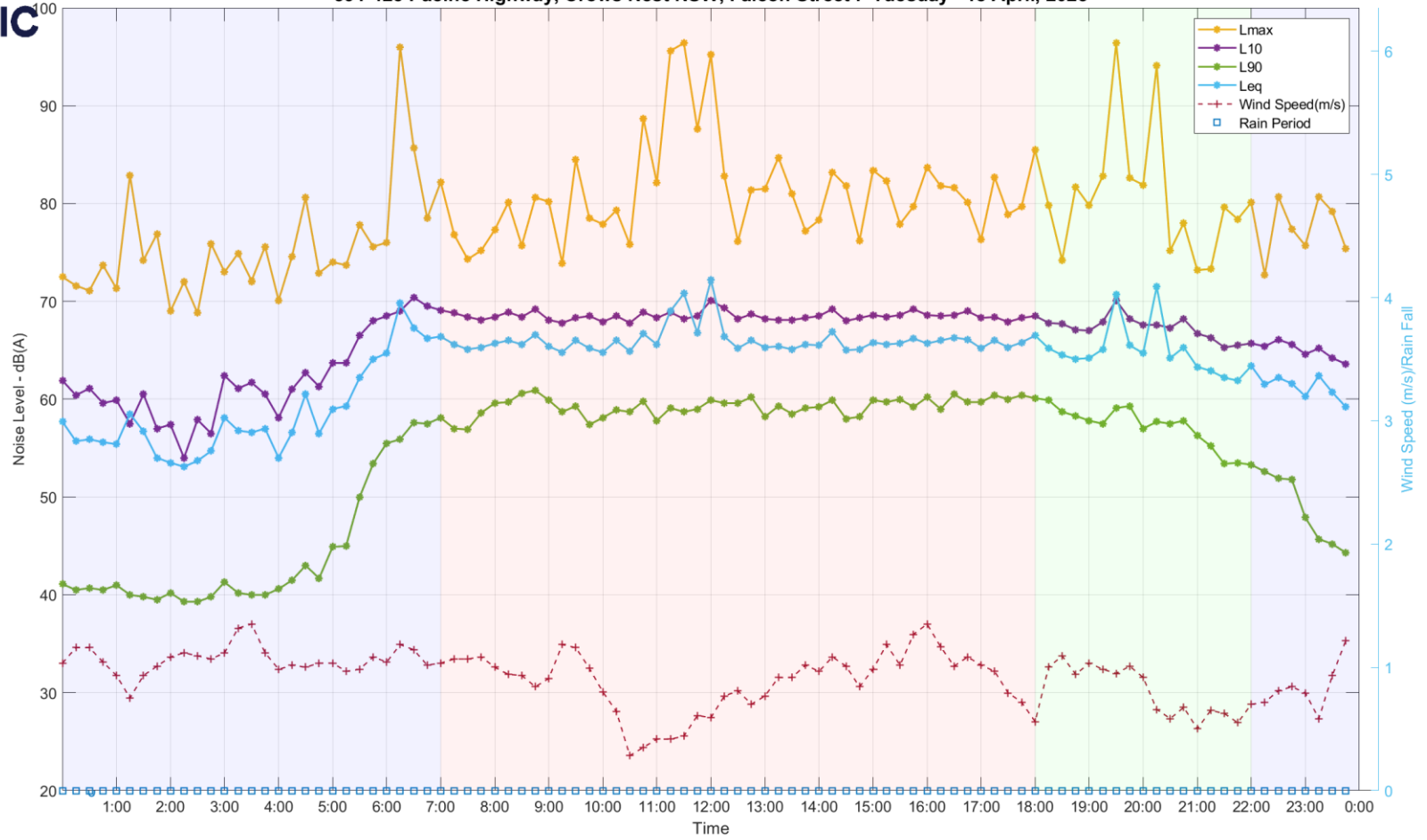


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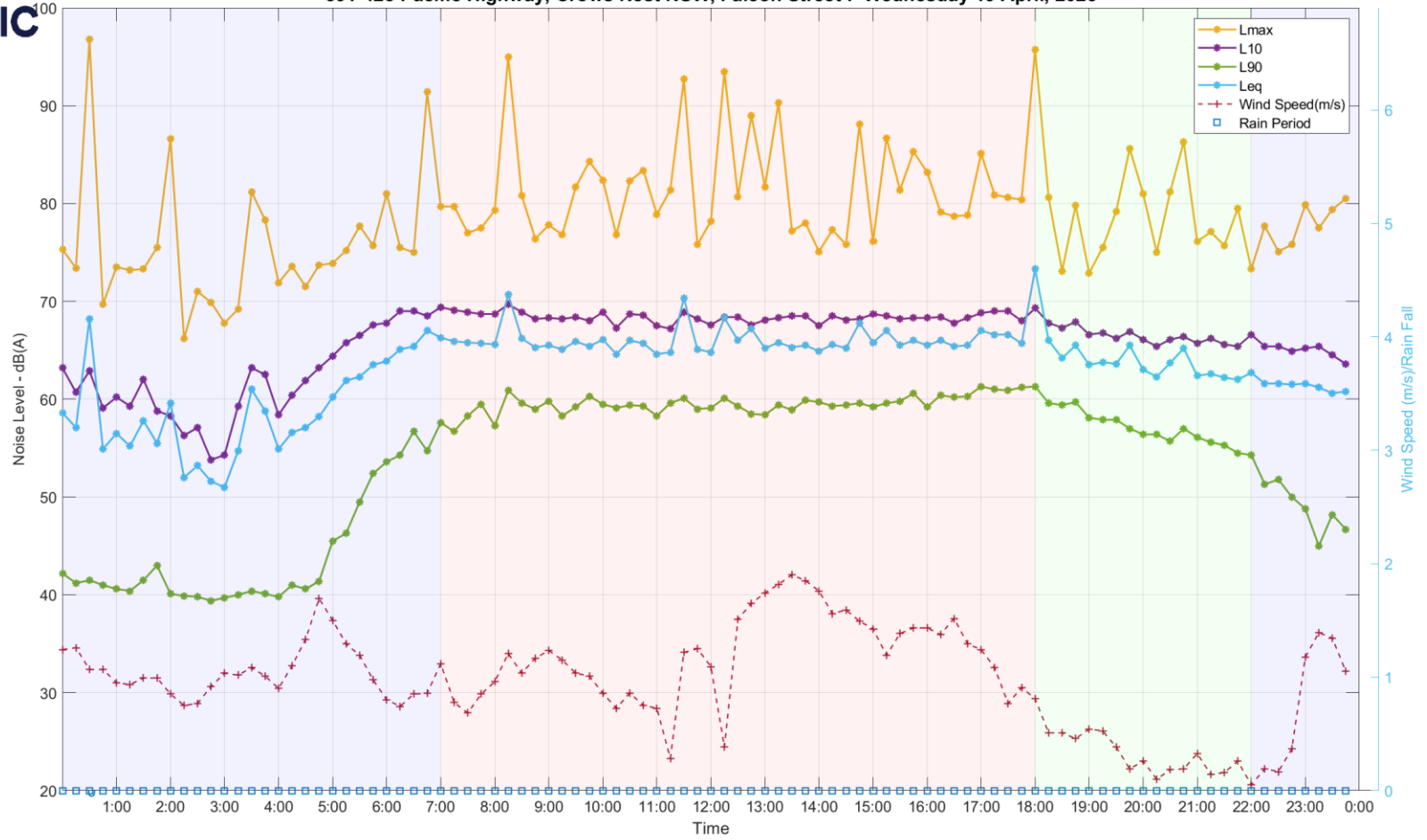


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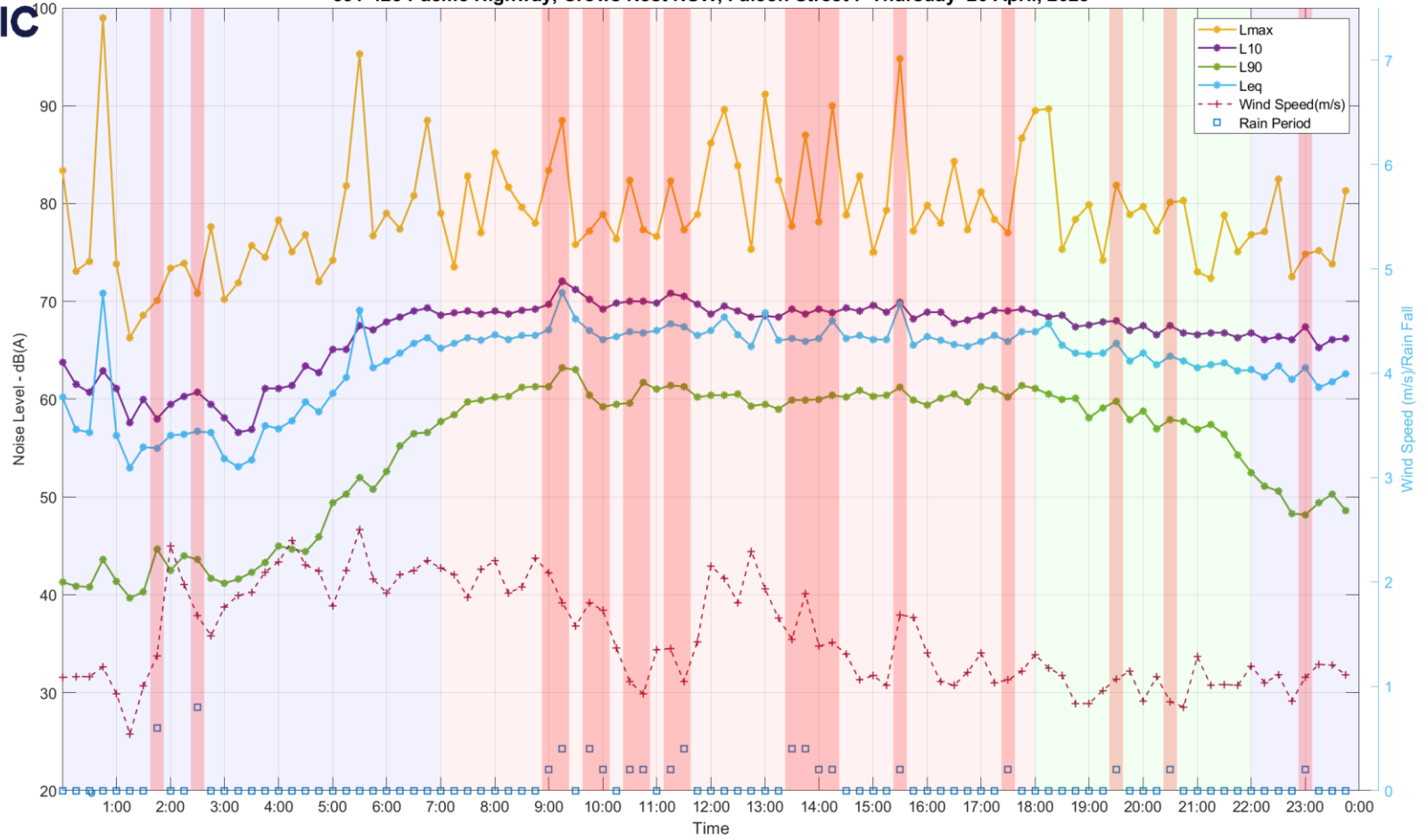




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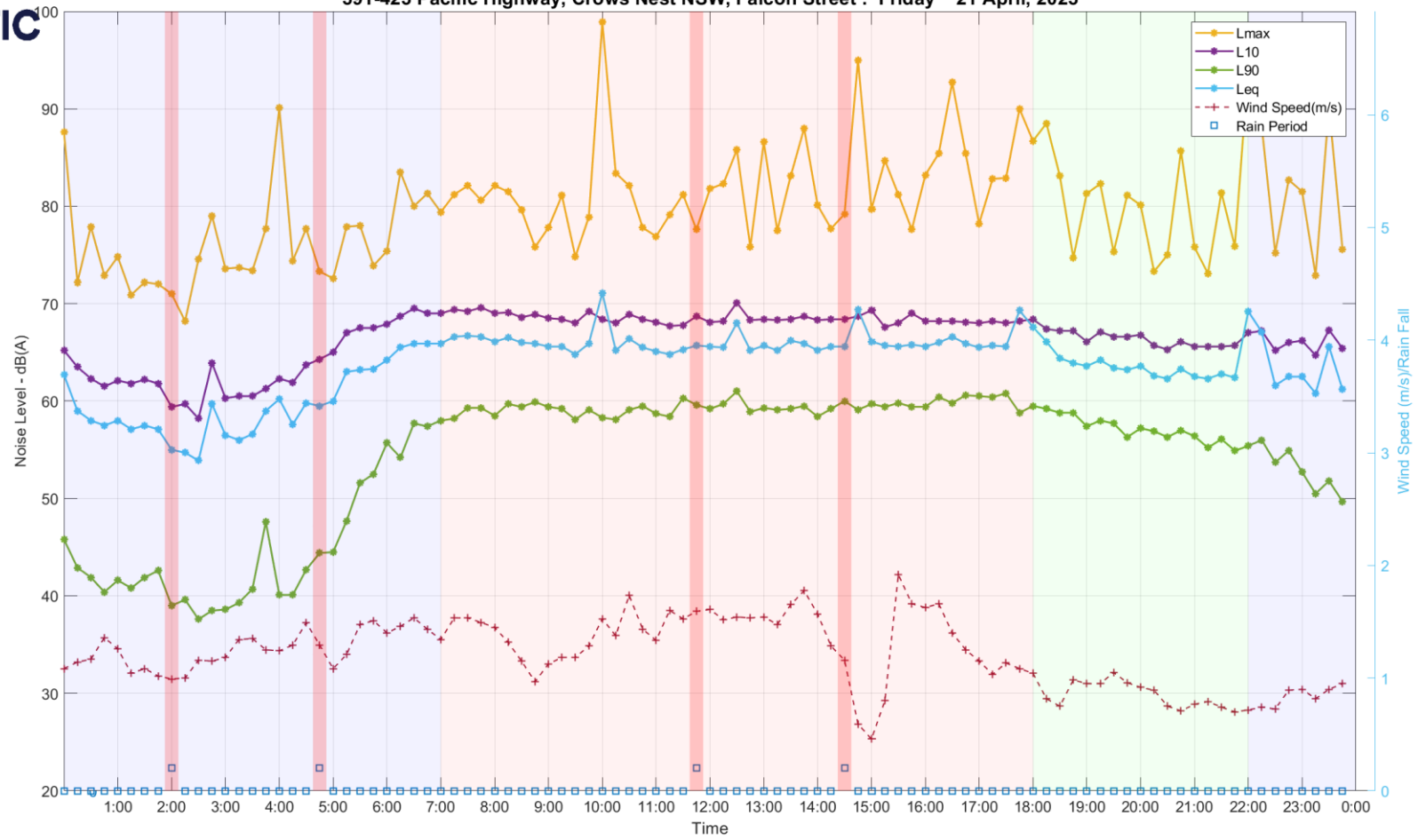


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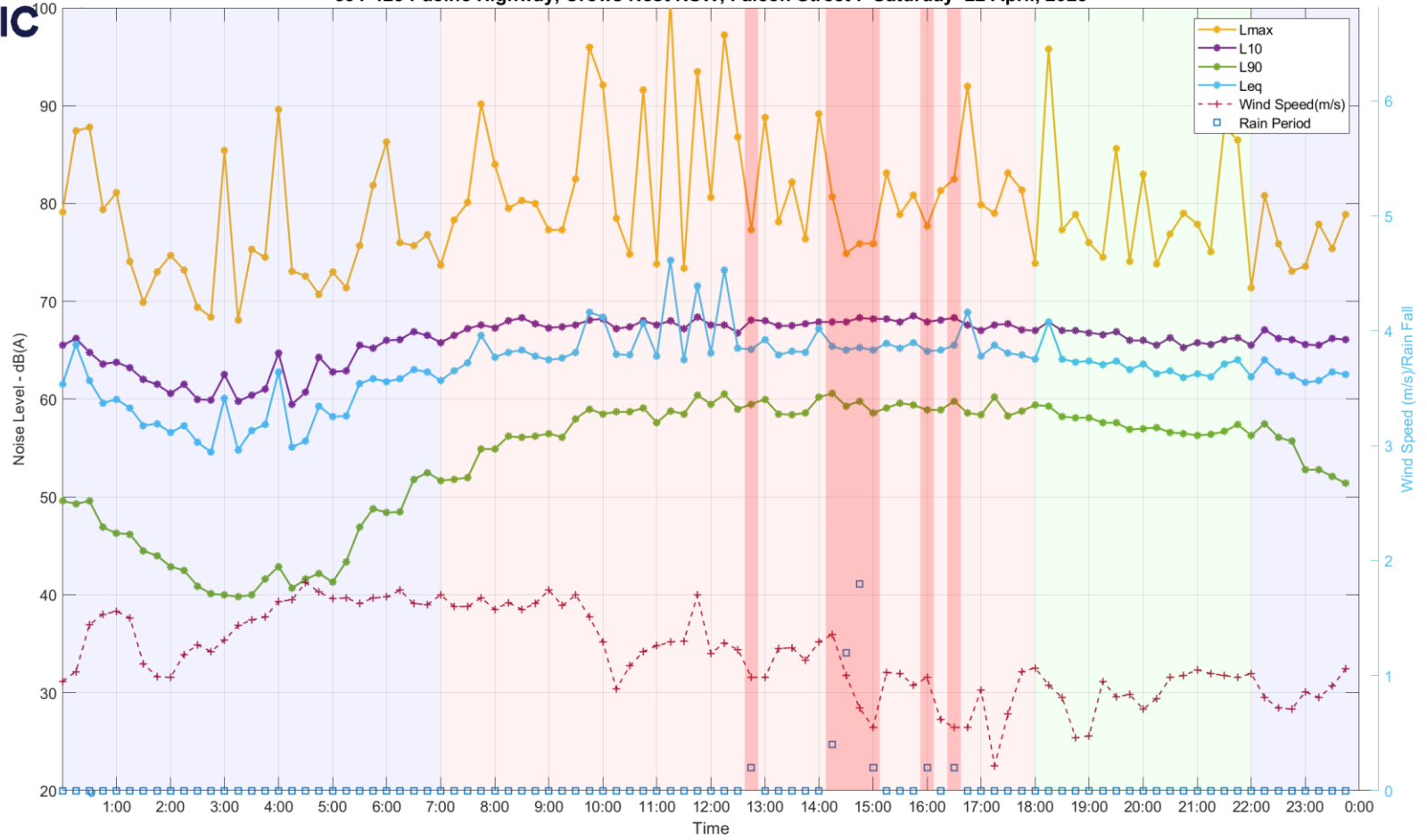


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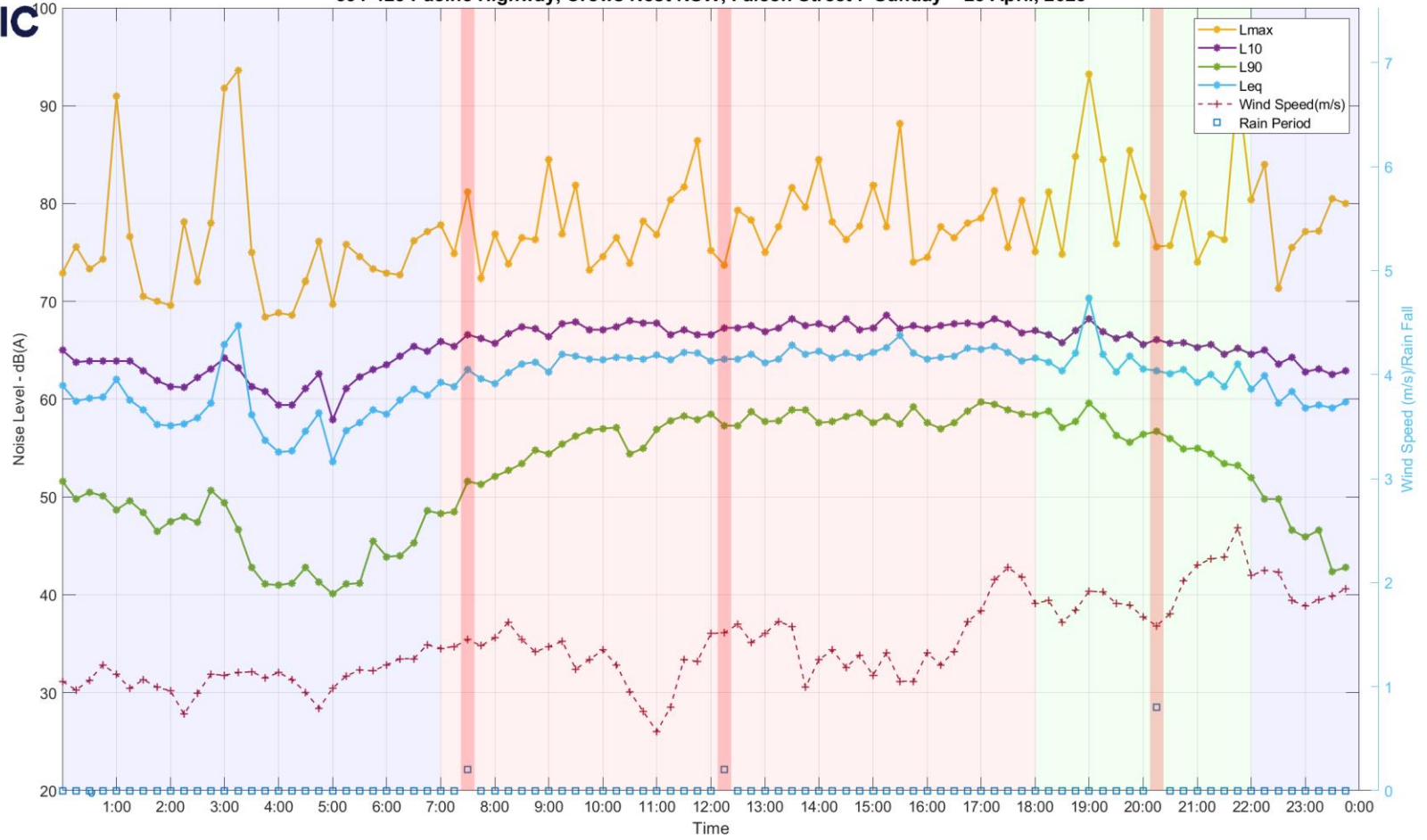


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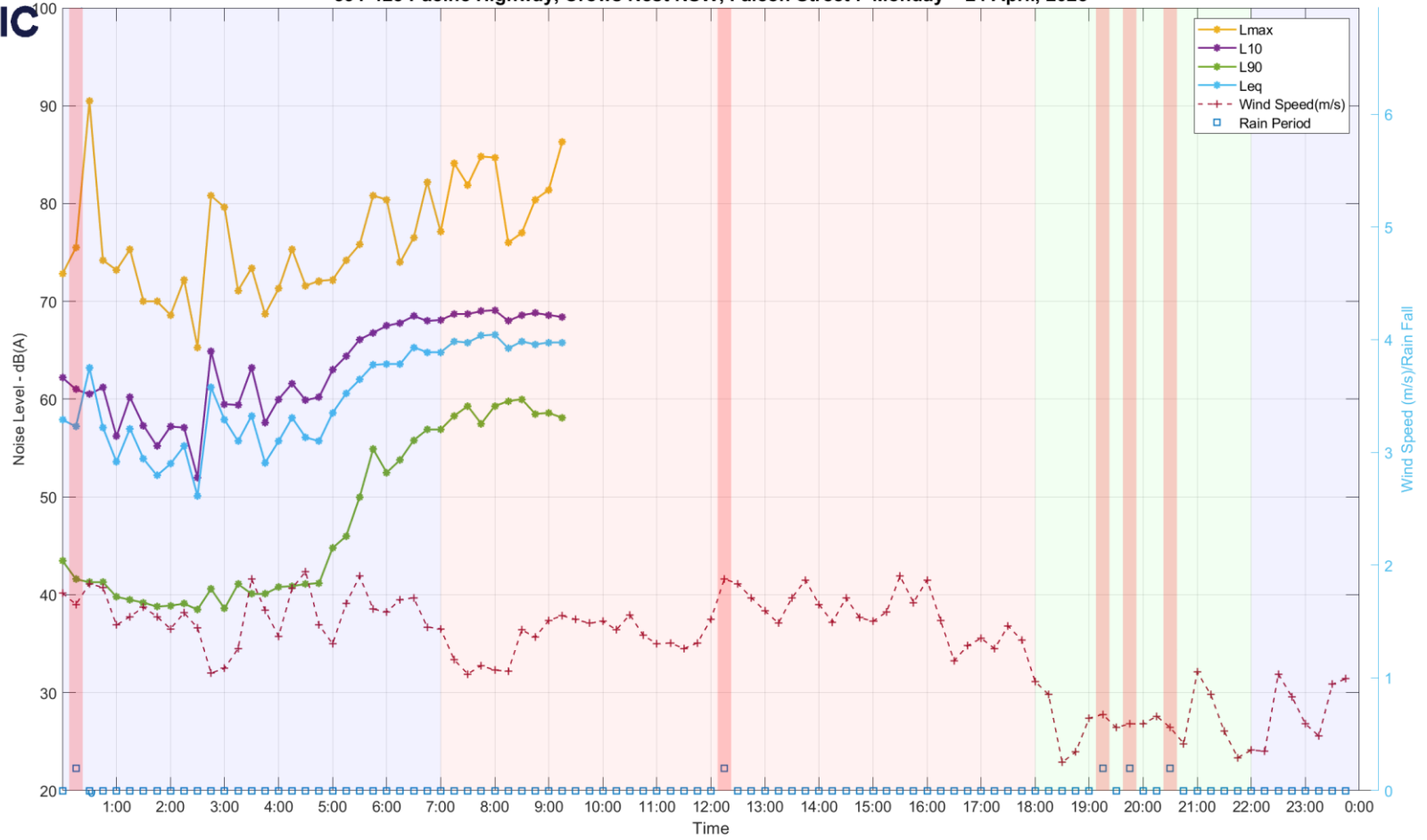


391-423 Pacific Highway, Crows Nest NSW, Falcon Street : Sunday 23 April, 2023





391-423 Pacific Highway, Crows Nest NSW, Falcon Street : Monday 24 April, 2023



Wind Speed is corrected using factor 0.3000 based on logger location

APPENDIX THREE – VENTILATION MARK UP



- Natural Ventilation
- Alternative Ventilation

Level 03



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 Delcorp
 Level 3 161 Redfern Street Redfern NSW
 2016

Rev	Date	Approved by	Revision Notes
A	11.09.23	KR	For Coordination
B	22.09.23	KR	For Coordination
C	28.09.23	KR	For Coordination
D	06.10.23	KR	For Coordination
E	16.10.23	KR	For Coordination
F	23.10.23	KR	For Review
G	03.11.23	KR	For Review

Project Title
 Fiveways Crows Nest
 391/423 Pacific Hwy Crows Nest NSW 2065 Australia

Drawing Title
 GA Plans
 Level 03

Scale
 1:200 @A1, 50% @A3

Project No. 19073
Drawn by WC, CN, KR
Rev G

For Information DA-110-030

TURNER

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- Natural Ventilation
- Alternative Ventilation

Level 04 - Level 11



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A	08.10.23	KR	For Coordination
B	16.10.23	KR	For Coordination
C	23.10.23	KR	For Review
D	03.11.23	KR	For Review

Project Title
 Fiveways Crows Nest
 391/423 Pacific Hwy Crows Nest NSW 2065 Australia

Drawing Title
 GA Plans
 Level 04

Scale	Project No.	Drawn by	North
1:200 @A1, 50% @A3	19073	WC, CN, KR	↗
For Information	DA-110-040	Rev	D

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- Natural Ventilation
- Alternative Ventilation

Level 12 - Level 13



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 2016

Rev	Date	Approved by	Revision Notes
A	08.10.23	KR	For Coordination
B	16.10.23	KR	For Coordination
C	23.10.23	KR	For Review
D	03.11.23	KR	For Review

Project Title
 Fiveways Crows Nest
 391/423 Pacific Hwy Crows Nest NSW 2065 Australia

Drawing Title
 GA Plans
 Level 12

Scale
 1:200 @A1, 50% @A3

Project No. 19073
Drawn by WC, CN, KR
Rev D

For Information DA-110-120

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- Natural Ventilation
- Alternative Ventilation

Level 14- Level 21



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Rev	Date	Approved by	Revision Notes
A	11.09.23	KR	For Coordination
B	22.09.23	KR	For Coordination
C	28.09.23	KR	For Coordination
D	06.10.23	KR	For Coordination
E	16.10.23	KR	For Coordination
F	23.10.23	KR	For Review
G	03.11.23	KR	For Review

Project Title
 Fiveways Crows Nest
 391/423 Pacific Hwy Crows Nest NSW 2065 Australia

Drawing Title
 GA Plans
 Level 14

Scale
 1:200 @A1, 50% @A3

Project No.
 19073

Drawn by
 WC, CN, KR

Rev
 G

For Information
 DA-110-140

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APPENDIX FOUR – SOUNDPLAN MODELLING RESULTS

Crows Nest, NSW

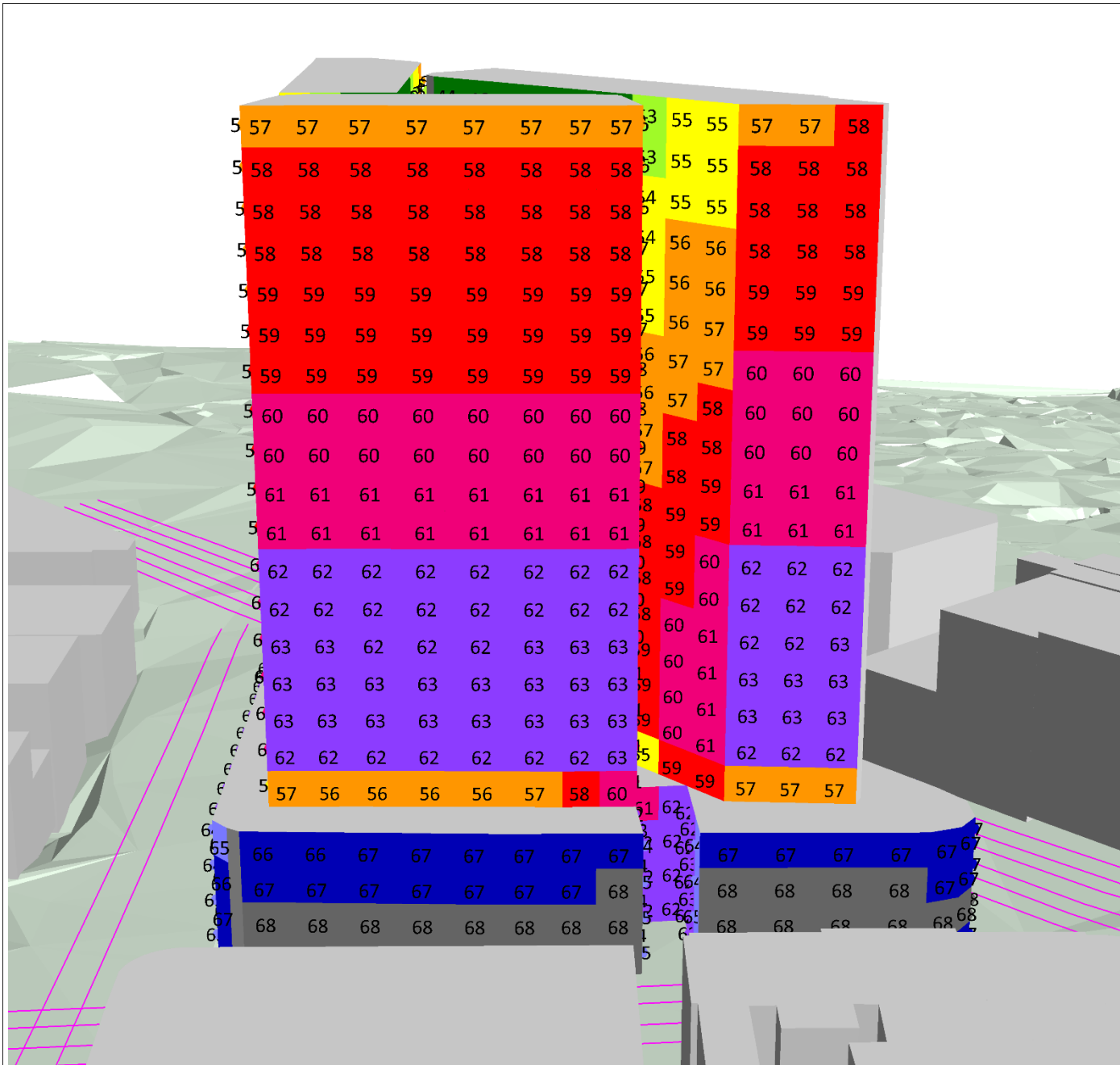
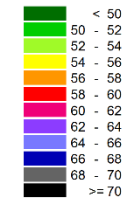
Facade Noise Prediction

Facade facing Falcon Street
Daytime Leq(15hr)

Prepared by: P. Feng
Date: 15/12/2023

Noise Level

L_{eq}
in dB(A)



Crows Nest, NSW

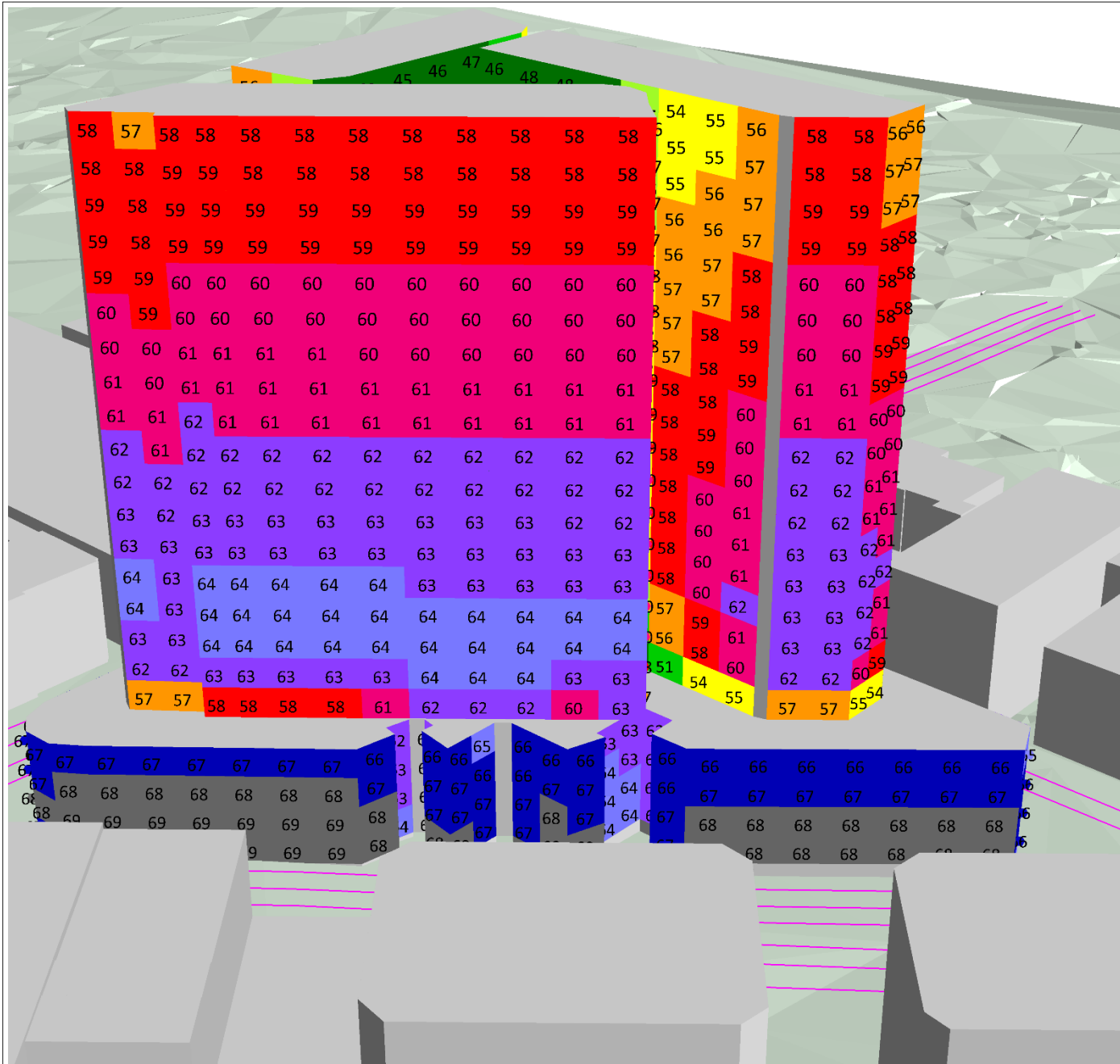
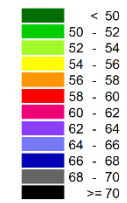
Facade Noise Prediction

Facade facing Pacific Hwy
Daytime Leq(15hr)

Prepared by: P. Feng
Date: 15/12/2023

Noise Level

L_{eq}
in dB(A)



Crows Nest, NSW

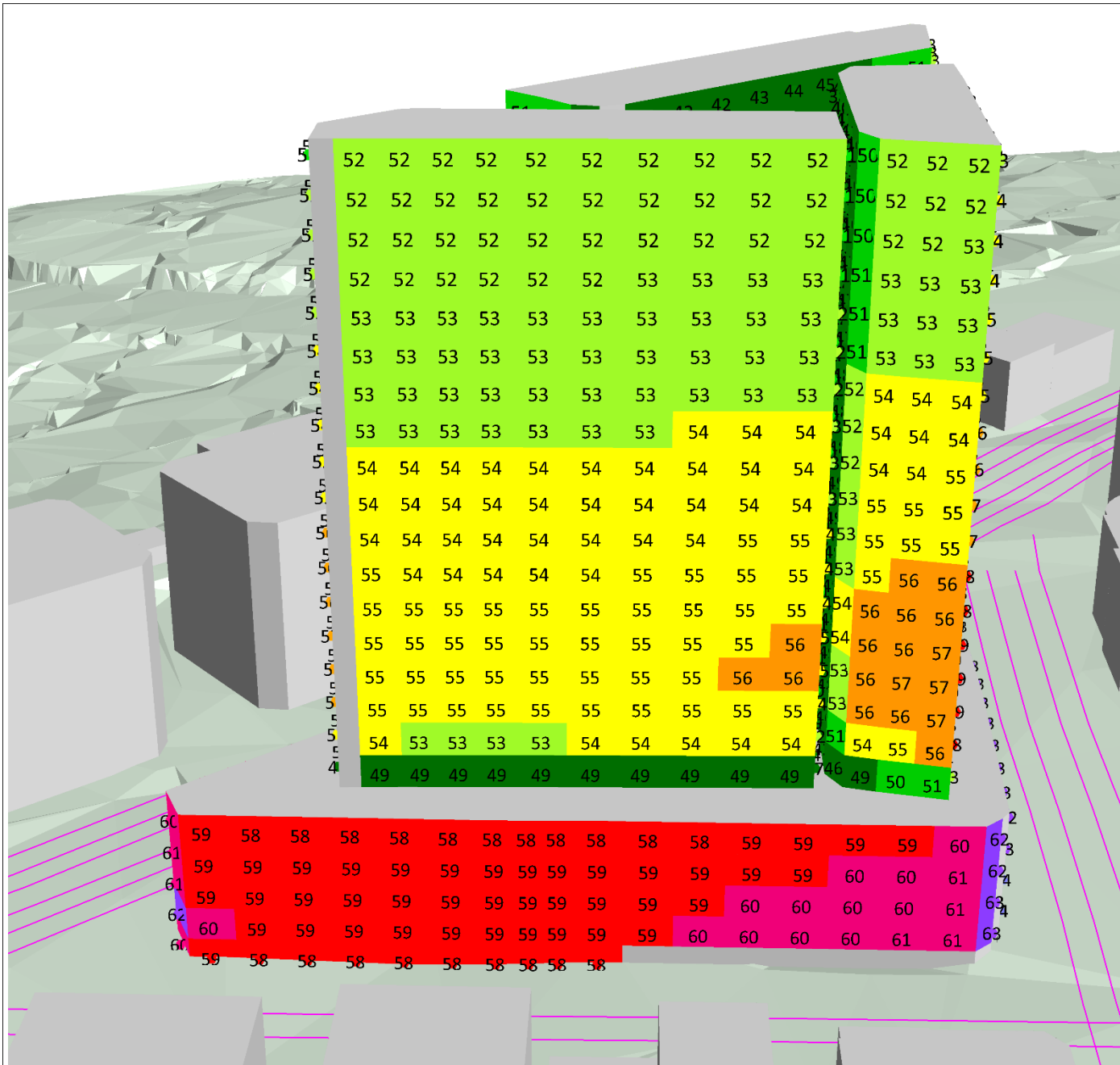
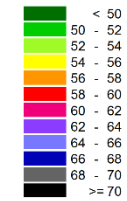
Facade Noise Prediction

Facade facing Alexander Street
Nighttime Leq(9hr)

Prepared by: P. Feng
Date: 15/12/2023

Noise Level

L_{eq}
in dB(A)



Crows Nest, NSW

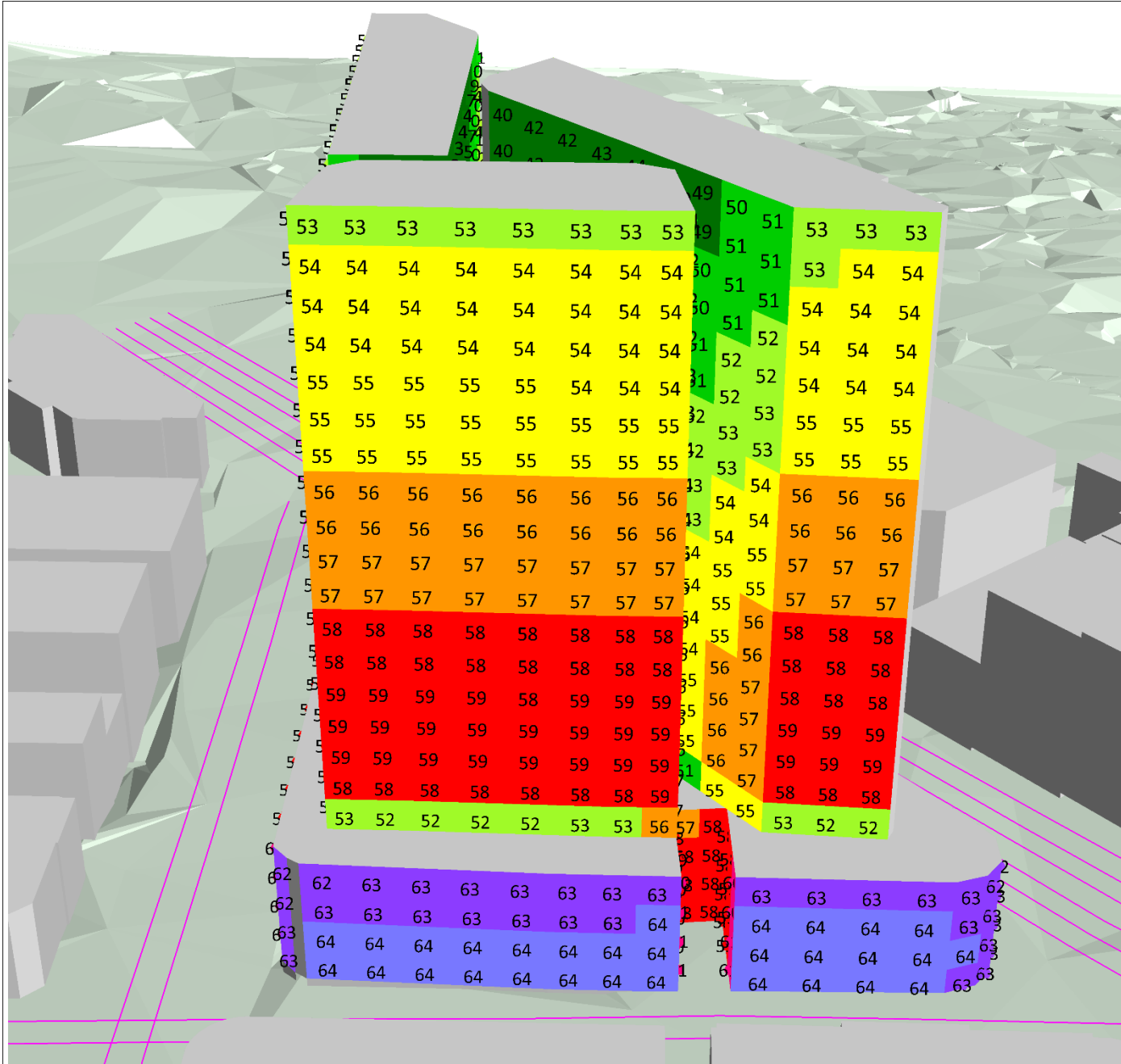
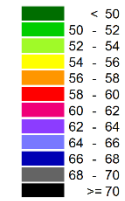
Facade Noise Prediction

Facade facing Falcon Street
Nighttime Leq(9hr)

Prepared by: P. Feng
Date: 15/12/2023

Noise Level

Leq
in dB(A)



Crows Nest, NSW

Facade Noise Prediction

Facade facing Pacific Hwy
Nighttime Leq(9hr)

Prepared by: P. Feng
Date: 15/12/2023

Noise Level

L_{eq}
in dB(A)

