Sydney Harbour Bridge Cycleway Northern Access

Noise and Vibration Impact Assessment

S210904RP1 Revision E

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Document Information

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Revision Table

Report revision	Date	Description	Author	Reviewer
0	19 April 2022	First Draft	Andrew Parker	Raymond Sim
A	26 April 2022	Second Draft	Andrew Parker	Raymond Sim
B	12 October 2022	Third Draft – address Transport's comments	Andrew Parker	Raymond Sim
C	17 October 2022	Fourth Draft – update construction scenarios	Andrew Parker	Raymond Sim
D	2 November 2022	Fifth Draft – address Transport's comments	Andrew Parker	Raymond Sim
E	15 November 2022	Sixth Draft – update proposal boundary in figure	Andrew Parker	Raymond Sim

Glossary

'A' Weighted	A spectrum adaption that is applied to measured noise levels to approximate human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	'A' Weighted sound level in dB.
Feasible and reasonable	Consideration of best practice noise and vibration mitigation measures taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. Feasible relates to engineering considerations and what is practical to build. Reasonable relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community views and nature and extent of potential improvements.
Frequency	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low.
Hz	Hertz—units of frequency.
L_{A10}	A-weighted energy noise level present for 10% of the 15 minute interval. Commonly referred to the average maximum noise level.
L_{A90}	A-weighted energy noise level exceeded for 90% of time (background level). The average minimum background sound level (in the absence of the source under consideration)
L_{Aeq}	Equivalent Noise Level— A-weighted energy averaged noise level over the measurement time.
$L_{Aeq,\ (15\ min)}$	A-weighted energy averaged noise level over a 15-minute period. Used in the EPA Interim Construction Noise Guideline (ICNG).
$L_{Aeq,\ (15\ hour)}$	A-weighted energy averaged noise level over the 15-hour daytime period from 7 am to 10 pm. Used in the EPA Road Noise Policy (RNP).
$L_{Aeq,\ (9\ hour)}$	A-weighted energy averaged noise level over the 9-hour night-time period from 10 pm to 7 am. Used in the EPA Road Noise Policy (RNP).
L_{Amax}	A-weighted maximum recorded noise level.
millimetres per second	Millimetres per second—unit of vibration velocity.
metres per second$^{1.75}$	Units of vibration dose value (VDV).
Noise Catchment Area (NCA)	Noise Catchment Areas are groupings of receivers within the study area that are associated for the purposes of assessment and reporting. Receivers are grouped based on common noise exposure to construction works.
Noise Management Level (NML)	Construction noise management level. Where the construction noise levels are above the NML, additional consideration of feasible and reasonable noise mitigation is required.
OOH	Out of Hours

OOHW	Out of Hours Works
Peak Particle Velocity (PPV)	The maximum speed of a particle in a particular component direction due to vibration during a measurement.
Rating Background Level (RBL)	The Rating Background Level for each period is the median value of the average background values for the period over all of the days measured. There is an RBL value for each period (day, evening and night).
Vibration	Refers to the oscillation of an object back and forth, normally the ground.
Vibration Dose Value (VDV)	A measure used to assess the level of vibration over a defined time period, such as a day, evening or night. Often used for the assessment of intermittent construction vibration that may rise and fall across a day.

Table of Contents

1 Introduction

Transport for NSW (Transport) proposes to upgrade the existing cycleway connection between the Sydney Harbour Bridge Cycleway and the bike network in Milsons Point. The cycleway connection would interface with a new cycle path along Alfred Street South (the proposal).

The proposal is located on Cammeraygal land and is in Milsons Point, within the North Sydney Local Government Area (LGA). The proposal is bounded by Middlemiss Street to the north, the Sydney Harbour Bridge to the east, Fitzroy Street to the south and Alfred Street South to the west.

The proposal would consist of a three-metre-wide elevated linear bike ramp that extends 200 metres from Bradfield Park North, near Burton Street, interfacing with the Sydney Harbour Bridge Cycleway south of the existing stair access. The ramp would connect to a new cycle path which would extend along the east side of Alfred Street South, between Middlemiss Street and Burton Street, and include a new street crossing on Alfred Street South. The two-way cycle path would be 2.5 metres wide and connect to the existing bike network in Milsons Point.

The location of the proposal is provided in Figure 1.

Resonate Consultants Pty Ltd has been engaged to prepare a noise and vibration impact assessment to be included in a Review of Environmental Factors (REF) for the proposal.

1.1 Purpose of this report

The purpose of this noise and vibration assessment report is to:

- Characterise the existing acoustic environment within the proposal boundary (Section 2)
- Establish appropriate construction noise and vibration assessment criteria (Section 3)
- Predict and assess construction noise and vibration levels against the criteria (Section 4)
- Determine reasonable and feasible construction noise and vibration mitigation measures (Section 5)
- Present a qualitative assessment of potential operational noise impacts that may result from the proposal (Section 6)
- Potential construction vibration related impacts on the Nationally and State Heritage Listed Sydney Harbour Bridge and the State Heritage Listed Milsons Point Railway Station Group are included within this report (Section 4.4.3).

1.2 Proposal description

- A design-led approach to the integration of new cycling infrastructure with its existing important open space and heritage setting
- A new elevated linear bike ramp, with deck about three metres wide and about 200 metres in length between the Sydney Harbour Bridge Cycleway and Bradfield Park North including:
  - Steel ramp structure with deck incorporating Designing with Country motifs, and balustrade with integrated lighting
  - Precast columns carefully sited within Bradfield Park North and Central
  - Provision of a bike riders rest area next to the Sydney Harbour Bridge Cycleway connection
  - A gathering space , lighting and cycle path within Bradfield Park North connecting the elevated linear bike ramp and the proposed Alfred Street South cycle path
- Alfred Street South pedestrian and cycle path upgrade including:
  - New 2.5-metre-wide two-way cycle path on Alfred Street South from the ramp landing, linking to the existing bike network in Middlemiss Street. The cycle path would be located on the east side of Alfred Street South between the ramp landing and the new street crossing at 110 Alfred Street South. On the

west side of Alfred Street South the cycle path would be located between the new crossing and Lavender Street
- Replacement of the existing pedestrian refuge crossing at the north end of Alfred Street South with a pedestrian and bike rider crossing located near 110 Alfred Street South and an upgrade to the pedestrian crossing at Lavender Street
- Low speed shared path and verge widening on the north side of Lavender Street
- Adjustments to the Lavender Street roundabout
- New street tree planting, shrub planting and footpath paving
- Relocation of the existing bus stop on Alfred Street South near Lavender Street, about 60 metres to the south of its current location
- Permanent removal of up to 15 parking spaces along Alfred Street South.

The proposal, would also include, but not be limited to:

- Kerb and pavement work, and line marking
- Drainage and utility adjustments
- Street furniture adjustments
- Changes to street parking, parking meter locations and regulatory signage
- Minor lighting upgrades to Bradfield Park North and in other locations where required to meet safe lighting standards.

Construction of the proposal would take around 18 months and, subject to planning approval, is expected to commence mid-2023.

Figure 1 provides an overview of the proposal, including:

- The proposal boundary which represents the maximum extent of the site
- The potential ancillary facility site.

Sydney Harbour Bridge Northern Cycleway

FIGURE 1
The Proposal

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- Potential Ancillary Site
- Proposal
- Proposal Boundary

Resonate

2 Existing Acoustic Environment

2.1 Site description and sensitive receivers

The proposal boundary is located along the western side of the Sydney Harbour Bridge curtilage adjacent to Alfred Street South, Milsons Point. The site boundary extends from Fitzroy Street in the south to Lavender Street in the north. The immediate surrounding area contains various noise and vibration sensitive receivers, including residential and commercial buildings, places of worship, educational facilities and recreation areas as shown in Figure 2.

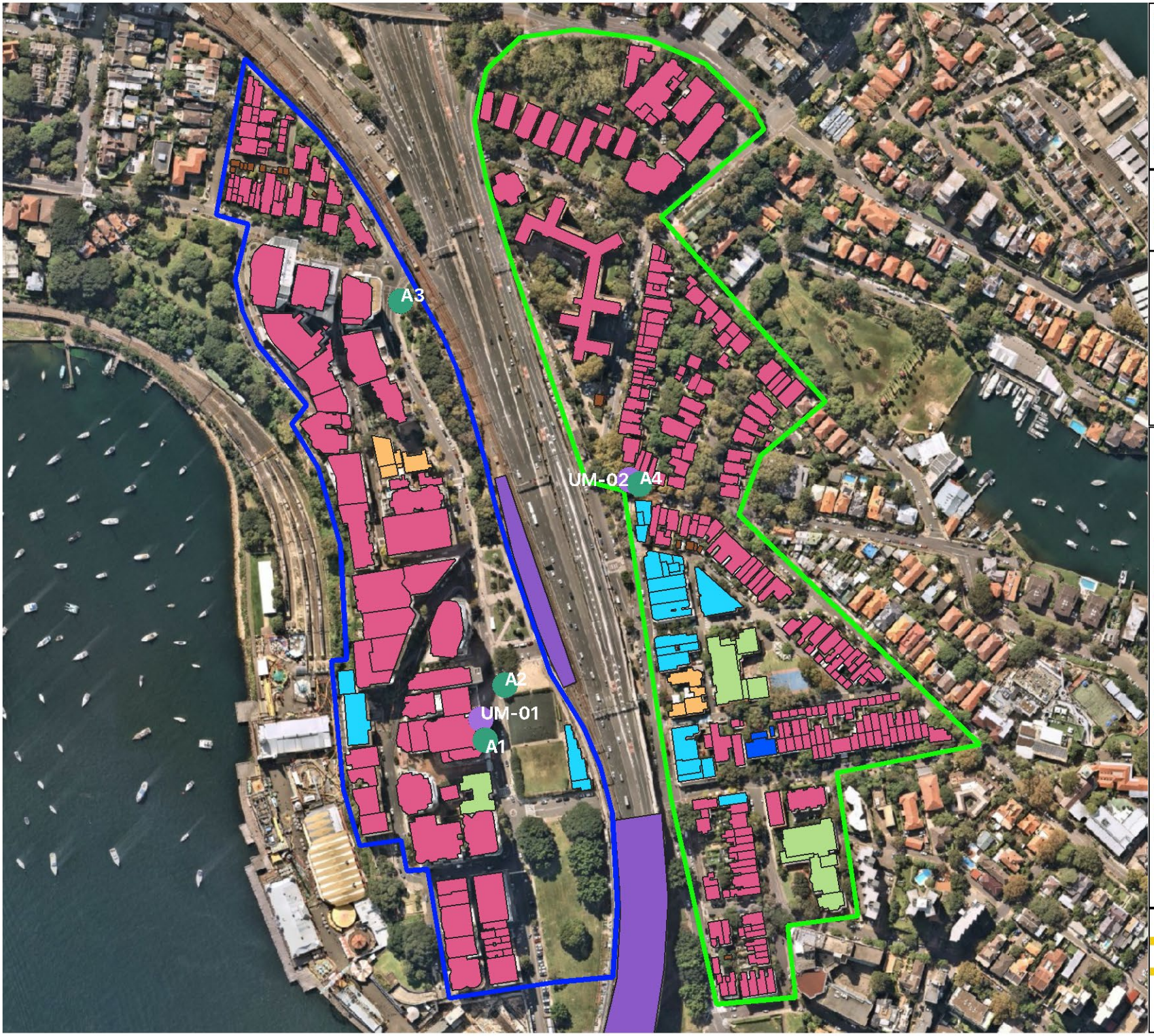
Details of the non-residential and non-commercial receivers identified in the study area are shown in Table 1.

Table 1 Non-residential and non-commercial sensitive receivers

Noise Catchment Area	Description	Address	Type of Receiver
01	The Chinese Christian Church	100 Alfred Street South, Milsons Point	Place of Worship
01	Nightingale Nursing	48 Alfred Street South	Aged Care Facility
01	Senses ELC Childcare Centre	48-50 Alfred St S, Milsons Point	Educational Facility
02	James Milson Retirement	4 Clark Road	Aged Care Facility
02	The Bridge Church	5/7-9 Broughton Street, Kirribilli	Place of Worship
02	St Aloysius' College Junior School	29 Broughton Street, Kirribilli	Educational Facility
02	Kirribilli Neighbourhood Centre	16-18 Fitzroy Street, Kirribilli	Community Centre
02	St Aloysius' College	47 Upper Pitt Street, Kirribilli	Educational Facility

2.2 Noise Catchment Areas (NCAs)

Two NCAs have been identified for the purpose of assessing potential construction noise impacts. The NCAs have been determined on the basis of the measured rating background levels (RBLs), as described in Section 2.3 and further validated by short-term measurement as described in Section 2.3.3. The NCAs are shown in Figure 2. NCA01 incorporates the sensitive receivers to the west of the proposal and NCA02 incorporates the sensitive receivers to the east of the proposal.



Sydney Harbour Bridge Northern Cycleway

FIGURE 2
Noise Survey Locations & Surrounding Receivers

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- Unattended Monitoring
- Attended Measurements
- NCA01
- NCA02

Surrounding Receivers

- Commercial
- Educational Facility
- Place of Worship
- Residential
- Shed/Garage
- Heritage Structure
- Community Centre

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2.3 Noise monitoring

Noise monitoring surveys were conducted between February and March 2022 to establish prevailing ambient noise levels to allow for the formulation of construction noise criteria. The locations of these monitoring locations are shown in Figure 2. A photograph and additional description of each noise monitoring location are provided in Appendix A.

2.3.1 Unattended noise monitoring

The purpose of unattended noise measurements is to obtain the L_{Aeq} and L_{A90} prevailing noise levels for sensitive receivers located near the proposed construction works areas. These measurements were undertaken for a minimum period of one week of unaffected weather.

Unattended noise monitoring was conducted at two locations:

- UM-01: 52 Alfred Street South, Milsons Point (Level 4 balcony)
- UM-02: 26 Willoughby Street, Kirribilli.

These locations were selected on the basis of their proximity to the proposal and to appropriately represent the existing background noise levels in the surrounding area.

The equipment used for monitoring were Rion NL-21 sound level meters. These meters were configured to capture L_{Aeq} and L_{A90} measurements for each 15-minute window over the logging period. All instruments carry current National Association of Testing Authorities (NATA) calibration certification. Calibration was checked before and after logging and the level of drift was less than 0.5 dB in all cases.

It is a requirement the NSW EPA Noise Policy for Industry (NPfI) that noise data is captured during periods of favourable weather conditions avoiding adverse impacts of wind and rain on background noise levels. In order to assess weather conditions for the measurement period, half-hourly weather data was obtained from the Bureau of Meteorology (BOM) weather observation station IDN60801 at Sydney Observatory Hill.

Noise data has been excluded from the processed results if:

- Rain was observed during a measurement period, and/or
- Wind speed exceeded 5 m/s (18 km/h) at the measurement height of 1.5 m above ground. Wind data obtained from the BOM is presented as the value at 10 m above ground, and a correction factor for the purpose of estimating wind speed at 1.5 m above ground has been applied.

The methodology to formulate a correction factor has been derived[1]. The correction multiplier for the measured wind speed at 10 m is derived by the following formula:

$$W_{1.5} = W_{10} \times \left(\frac{M_{1.5,cat}}{M_{10,cat}} \right)$$

where:

$W_{1.5}$ = Wind speed at height of 1.5 m
W_{10} = Wind speed at height of 10 m
$M_{1.5,cat}$ = AS 1170 multiplier for receiver height of 1.5 m and terrain category
$M_{10,cat}$ = AS 1170 multiplier for receiver height of 10 m and terrain category

[1] Gowen, T., Karantonis, P. & Rofail, T. (2004), *Converting Bureau of Meteorology wind speed data to local wind speeds at 1.5m above ground level*, Proceedings of ACOUSTICS 2004

2.3.2 Unattended noise monitoring results

As noted above, the results of the noise monitoring have been analysed to exclude noise from adverse weather events, to establish representative existing noise conditions for each NCA and for each assessment period (daytime, evening and night-time). A summary of results from unattended noise surveys are presented in Table 2. The Rating Background Level (RBL) and overall average noise level (L_{Aeq}) are provided for each assessment period, being:

- The RBL for each period is the median value of the average background values for the period over all of the days measured.
- The L_{Aeq} or equivalent noise level is the energy averaged noise level over the measurement period.

Table 2 Unattended noise survey results summary (2022)

ID	Location	Noise Level, dB(A)					
		Day (7 am to 6 pm)		Evening (6 pm to 10 pm)		Night (10 pm to 7 am)	
		RBL	L_{eq}	RBL	L_{eq}	RBL	L_{eq}
UM-01 (2022)	52 Alfred Street South, Milsons Point (Level 4 balcony)	61	66	60	65	48	60
UM-02 (2022)	26 Willoughby Street, Kirribilli	56	67	54	65	44	60

Previous unattended noise monitoring was carried out between March and April 2018 within the proposal boundary This data was collected to inform a construction noise assessment for early geotechnical works. The details of the previous noise monitoring survey were detailed in Resonate Report S16656RP2A, dated 20 April 2018. A summary of the relevant RBL and L_{Aeq} noise levels is presented in Table 3.

Table 3 Unattended noise survey results summary (2018)

ID	Location	Noise Level, dB(A)					
		Day (7 am to 6 pm)		Evening (6 pm to 10 pm)		Night (10 pm to 7 am)	
		RBL	L_{eq}	RBL	L_{eq}	RBL	L_{eq}
UM-01 (2018)	100 Alfred Street South, Milsons Point	57	60	56	59	44	56
UM-02 (2018)	26 Willoughby Street, Kirribilli	56	63	56	62	45	57

The previous unattended noise monitoring was carried out at similar locations to those adopted for the 2022 monitoring. However, the location on the western side of the proposal boundary was located at ground-level at 100 Alfred Street South, approximately 200 m to the south of the location selected for the 2022 monitoring.

The noise monitoring results were found to be similar on the eastern side of the proposal boundary (NCA01), with RBLs within 1 dB to 2 dB for the respective assessment periods. The noise monitoring results for the western side of the proposal boundary (NCA02) were found to be lower in 2018 than in 2022. This is likely due to the noise logger being located at a slight elevation for the 2022 survey, which is considered to be more representative of the majority of receivers on the western side of the proposal which are predominantly multi-story buildings.

For conservatism, the construction noise management levels have been based on the 2018 noise measurement data for the noise sensitive receivers located on the western side of the proposal boundary (NCA01).

2.3.3 Attended noise monitoring

Supplementary operator-attended noise monitoring was conducted to capture further information relating to the prevailing ambient noise environment. Table 4 provides a summary of the attended measurements.

Table 4 Operator-attended short-term noise measurement results

ID	Location	Measurement period	L_{eq} dB(A)	L_{max} dB(A)	L_{90} dB(A)
A1	52 Alfred Street South, Milsons Point (Level 4 balcony)	25/03/2022 11:04 – 11:19	66	76	64
A2	Opposite 70-72 Alfred Street South, Milsons Point	11/03/2022 16:23 – 16:38	64	73	60
A3	Opposite 126 Alfred Street South, Milsons Point	11/03/2022 16:01 – 16:16	67	86	62
A4	26 Willoughby Street, Kirribilli (First Floor balcony)	9/02/2022 10:06 – 10:21	63	77	57

The operator attended noise measurement results showed good correlation to the unattended noise monitoring results for the daytime period. Ambient noise levels were observed to be lower on the eastern side of the proposal boundary, likely due to the monitoring location being set lower relative to the Warringah Freeway.

The noise measurement results on the western side of the proposal boundary were reasonably consistent with the unattended noise monitoring, noting these measurements were not taken concurrently. Furthermore, the lowest measured L_{A90} noise level aligned with the daytime and evening RBLs determined from the unattended noise monitoring at 52 Alfred Street, Milsons Point. This demonstrates that we can have confidence that the RBLs established are appropriate for use in this assessment.

During the attended measurements and initial site survey, the following prevailing noise environment was observed:

- On both sides of Warringha Freeway – background noise environment is typical of an urban ‘hum’ dominated by traffic noise from Warringha Freeway
- On the west side (Alfred Street South side) - intermittent road traffic noise from Alfred Street South and train noise from Milsons Point train station
- On the east side (Alfred Street South side) - intermittent road traffic noise from Broughton Street and train noise from Milsons Point train station.

3 Construction Noise and Vibration Criteria

3.1 Construction noise criteria

3.1.1 Interim Construction Noise Guideline (DECC)

The *Interim Construction Noise Guideline* (ICNG), prepared by the NSW Department of Environment & Climate Change (DECC) and released in 2009, details construction noise assessment criteria and calls for the application of feasible and reasonable measures to mitigate construction noise and vibration. The ICNG has been used for the assessment of construction noise and vibration.

The ICNG defines various working hours for which different construction noise assessment procedures apply. Standard working hours, during which the majority of construction work will occur, are:

- 7 am to 6 pm, Monday to Friday
- 8 am to 1 pm, Saturday
- No work on Sundays or public holidays.

Any works outside of these hours would be classified as Out of Hours Works (OOHW).

The ICNG also prescribes noise management levels (NMLs) depending on the time that construction work is to be carried out. These NMLs should be achieved at noise sensitive locations where it is feasible and reasonable to do so.

3.1.2 Construction Noise and Vibration Guideline (Roads and Maritime)

The Roads and Maritime Construction Noise and Vibration Guideline (CNVG) defines time periods to which construction activity should be limited, where feasible and reasonable to do so. These working hours are set out in Table 5.

Table 5 CNVG construction hours

Activity	Working hours		
	Monday to Friday	Saturday	Sunday & Public Holiday
Standard construction	7 am to 6 pm	8 am to 1 pm	No work
Construction activities with impulsive or tonal noise emissions	8 am to 5 pm	9 am to 1 pm	No work
Blasting	9 am to 5 pm	9 am to 1 pm	No blasting

The CNVG also outlines the method for identification of all feasible and reasonable mitigation measures most relevant to the proposal.

3.2 Noise management levels

The ICNG outlines a methodology for determining NMLs for construction work based on classification of potentially noise affected receiver land use type.

3.2.1 Residential and aged care land uses

Table 6 presents the NMLs for residential and aged care receivers for both standard working hours and periods outside of the standard working hours. The NMLs apply at the property boundary most exposed to construction noise.

If the residence is more than 30 metres from the boundary, the NML applies to the most noise affected position within 30 metres of the residence.

Table 6 Noise Management Levels for residential land uses (ICNG)

Time of day	Noise Management Level, $L_{Aeq(15\text{-}minute)}$	How to apply
Standard hours: 7 am to 6 pm, Monday to Friday 8 am to 1 pm, Saturday	**Noise affected** RBL +10 dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. Actions: • Where the predicted or measured construction noise level exceeds the noise-affected level, all feasible and reasonable work practices should be applied to meet the noise affected level. • All residents potentially impacted by the works should be informed of the nature of the works, the expected noise levels and duration, and provided with site contact details.
	Highly noise affected (HNA) >= 75 dB(A)	The HNA level represents the point above which there may be strong community reaction to noise. Actions: • Where construction noise is predicted or measured to be above this level, the relevant authority may require respite periods that restrict the hours that the very noisy activities can occur. • Respite activities would be determined taking into account times identified by the community when they are less sensitive to noise, and if the community is prepared to accept a longer period of construction to accommodate respite periods.
Out of Hours Work (OOHW)	**Noise affected** RBL +5 dB(A)	A strong justification typically required for these works. Actions: • All feasible and reasonable work practices should be adopted. • Where all feasible and reasonable work practices have been adopted and noise level is more than 5 dB(A) above the NML, negotiation should be undertaken with the community.

3.2.2 Other sensitive land uses

The ICNG also establishes NMLs for other sensitive land uses. Table 7 summarises the NMLs for those other sensitive land uses identified for the project.

Table 7 Noise Management Levels for other land uses (ICNG)

Land use	Noise Management Level, $L_{Aeq(15\text{-}minute)}$[1]
Classrooms at schools and other educational institutions	Internal noise level – 45 dB(A)
Places of worship	Internal noise level – 45 dB(A)

Land use	Noise Management Level, $L_{Aeq(15\text{-}minute)}$[1]
Active recreation areas (characterised by sporting activities and activities that generate their own noise or focus for participants, making them less sensitive to external noise intrusion).	External noise level – 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion (i.e. reading and meditation).	External noise level – 60 dB(A)
Community centres	Dependent on the intended use. Refer to the recommended 'maximum' internal levels by AS/NZS 2107:2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors*.

(1) Applies when premises are in use.

As shown in Table 7, the ICNG recommends internal NMLs for certain receiver types. It is considered more practical from an assessment perspective to establish external NMLs for all receivers. It has been assumed that most receivers would have open windows in order to maximise natural ventilation. Typically, a facade insertion loss performance of 10 dB may be achieved where windows are open. For this reason, a NML of $L_{Aeq(15\text{-}minute)}$ 55 dB has been established for educational and place of worship land uses.

3.2.3 Commercial and industrial premises

The ICNG recommends NMLs for commercial and industrial land uses that are applicable during the time of day for which they are occupied. The external noise levels recommended are:

- industrial premises – external $L_{Aeq(15\text{-}minute)}$ 75 dB
- commercial premises – external $L_{Aeq(15\text{-}minute)}$ 70 dB
- other businesses that may be very sensitive to noise where the noise level is project specific.

3.2.4 Sleep disturbance

The ICNG requires that a quantitative assessment be used where works are planned to extend over than two consecutive nights that includes consideration of the maximum noise level, and the extent and the number of times that the maximum noise level exceeds the RBL. Limited Out of Hours Works are proposed and would likely extend for more than two consecutive nights.

The CNVG considers night works exceeding an external L_{Amax} sound pressure level at a receiver of 65 dB to potentially impact upon occupant sleep amenity. This criterion has been factored into the analysis of potential airborne noise impacts that may be generated by the proposal.

3.2.5 Ground-borne noise

Ground-borne noise will not be a controlling factor with respect to construction noise impacts. Due to the offset distances to nearby residential receivers, air-borne noise levels would exceed the ground-borne noise levels. As such a detailed ground-borne noise assessment is not required for this proposal.

3.2.6 Construction traffic noise

The EPA's *Interim Construction Noise Guideline* (ICNG) refers to the *NSW Road Noise Policy* (RNP) for the assessment of construction traffic on public roads.

For Transport projects an initial screening test should first be applied by evaluating whether noise levels will increase by more than 2 dB(A) due to construction traffic or a temporary reroute due to a road closure. Where increases are 2 dB(A) or less then no further assessment is required.

Where noise levels increase by more than 2 dB(A) (2.1 dB(A)) further assessment is required using Roads and Maritime's (RMS) *Noise Criteria Guideline* (NCG). This documents Transport's approach to implementing the RNP. Consideration should also be given under the NCG as to whether the construction traffic or temporary reroute triggers new road criteria due to changes in road category.

Noise mitigation should be considered using mitigation measures detailed in Appendices B and C of the RMS's *Construction Noise and Vibration Guideline*. Since noise from construction traffic is non-permanent, guidance to feasible and reasonable noise mitigation differs from operational traffic noise.

3.2.7 Project specific Noise Management Levels

NMLs for the identified sensitive receivers have been determined based on the measured RBL summarised in Section 2.2 and the ICNG methodology in Table 6. The NMLs relevant to this assessment are presented in Table 8.

Table 8 NMLs for sensitive land uses

Land use	Noise Catchment Area (NCA)	Noise Management Level, $L_{Aeq(15\text{-minute})}$			
		Day (Standard Hours)	Day (OOHW)	Evening	Night
Residential	01	67	62	61	49
Residential	02	66	61	61	49
Classrooms[1]	All	55 (external – when in use)			
Places of worship[1]	All	55 (external – when in use)			
Community Centre	All	55 (external – when in use)			
Active recreation	All	65 (external – when in use)			
Passive recreation	All	60 (external – when in use)			
Commercial	All	70			
Industrial	All	75			

(1) Typically, a facade insertion loss performance of 10 dB may be achieved where windows are open. For this reason, an external NML of $L_{Aeq(15\text{-minute})}$ 55 dB has been established for educational and place of worship land uses.

(2) The Kirribilli Neighbour Centre is typically used as function centre. Hence, the AS/NZS 2107:2016 recommended internal noise level of 45 dB(A) for function areas has been used established the external NML.

3.3 Construction vibration criteria

Ground vibration generated by construction can have a range of effects on buildings and building occupants, with the main effects generally classified as:

- Human disturbance – disturbance to building occupants: vibration which inconveniences or interferes with the activities of the occupants or users of the building
- Effects on building structures – vibration that may compromise the condition of the building structure itself including the potential impacts on structures of heritage significance including the Nationally and State Heritage Listed Sydney Harbour Bridge and the State Heritage Listed Milsons Point Railway Station Group.

In general, vibration criteria for human disturbance are more stringent than vibration criteria for effects on building contents and building structural damage. Building occupants will normally feel vibration readily at levels well below those that may cause a risk of cosmetic or structural damage to a structure. However, it may not always be practical to achieve the human comfort criteria. Furthermore, unnecessary restriction of construction activities can prolong construction works longer than necessary, potentially resulting in other undesirable effects for the local community.

Construction vibration criteria have been adopted from the following sources:

- Cosmetic and structural damage to buildings: German Standard DIN 4150-3, 1999, Structural Vibration – Part 3: Effects of vibration on structures
- British Standard BS 7385 Part 2-1993 *Evaluation and Measurement for Vibration in Buildings*
- *Assessing Vibration: a technical guideline* (DEC, 2006).

3.3.1 Cosmetic and structural damage

The DIN 4150-3 structural and cosmetic damage assessment criteria for different types of buildings are presented in Table 9. The criteria are specified as Peak Particle Velocity (PPV) levels measured in any direction at or adjacent to the building foundation.

DIN 4150-3 states that exposing buildings to vibration levels higher than that recommended in Table 9 would not necessarily result in damage. Rather it recommends these values as maximum levels of short-term construction vibration at which experience has shown that damage that reduces the serviceability of structures will not occur due to vibration effects.

DIN 4150-3 is considered to be suitable for the assessment of both structural and cosmetic damage as it considers a reduction in serviceability of the structure is deemed to have occurred if:

- Cracks form in plastered surfaces of walls.
- Existing cracks in the building are enlarged.
- Partitions become detached from loadbearing walls or floors.

Table 9 DIN 4150-3 vibration cosmetic and structural damage criteria

Line	Structure type	Peak Particle Velocity (PPV) mm/s			
		Foundation of structure			Vibration at horizontal plane of highest floor at all frequencies
		< 10 Hz	10-50 Hz	50-100 Hz	
1	Buildings used for commercial, industrial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwelling and buildings of similar design and/or use	5	5 to 15	15 to 20	15

Line	Structure type	Peak Particle Velocity (PPV) mm/s			
		Foundation of structure			Vibration at horizontal plane of highest floor at all frequencies
		< 10 Hz	10-50 Hz	50-100 Hz	
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in rows 1 and 2, and are of great intrinsic value (e.g. heritage-listed buildings)	3	3 to 8	8 to 10	8

The guideline values from BS7385 relating to cosmetic damage from transient vibration are reproduced in Table 10.

Table 10 Transient vibration guide values for cosmetic damage (BS7385)

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		Frequency range	
		4-15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
(3) Values referred to are at the base of the building.			
(4) For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.			

DIN4150 and BS7385 state that exceedances of the guidance values do not necessarily mean that damage will occur, but that more detailed analysis may be required in order to quantify the site specific relationship between vibration levels, strain and the potential for damage. If required, the additional analysis may include more detailed vibration, strain or displacement measurements combined with engineering analysis.

BS7385 also states that *a building of historical value should not (unless it is structural unsound) be assumed to be more vibration sensitive*.

The most stringent 3 mm/s criterion from Line 3 of Table 9 has been adopted for heritage structures in this assessment.

3.3.2 Human comfort

The ICNG recommends that vibration from construction works be assessed under *Assessing Vibration – a technical guideline* (Vibration Guideline). The vibration assessment criteria defined in this guideline are for human comfort and represent goals that, where predicted or measured to be exceeded, require the application of all feasible and reasonable mitigation measures. Where the maximum value cannot be feasibly and reasonably achieved, the operator would need to negotiate directly with the affected community.

The Vibration Guideline defines vibration assessment criteria for continuous, impulsive and intermittent vibration. Vibration can be classified according to the following definitions:

- Continuous vibration: continues uninterrupted for a defined period. Applies to continuous construction activity such as tunnel boring machinery.
- Impulsive vibration: rapid build-up to a vibration peak followed by a damped decay or the sudden application of several cycles of vibration at approximately the same magnitude providing that the duration is short. Applies to very occasional construction activities that create distinct events such as the occasional dropping of heavy equipment.
- Intermittent vibration: interrupted periods of continuous vibration (such as a drill) or repeated periods of impulsive vibration (such as a pile driver).
- The majority of construction works as part of the proposal would be expected to be intermittent in nature with the potential for some impulsive activities (e.g. demolition works).

Table 11 presents the management levels for continuous and impulsive vibration at different land uses. The management levels specified are as overall unweighted Root-Mean-Square vibration velocity levels (V_{rms}). The Guideline specifies the management levels as suitable for vibration sources predominantly in the frequency range 8-80 Hz as would be expected for construction vibration.

Table 11 Daytime V_{rms} management levels for continuous and impulsive vibration

Receiver	Continuous vibration V_{rms}, mm/s		Impulsive vibration V_{rms}, mm/s	
	Preferred	Maximum	Preferred	Maximum
Residences – daytime	0.2	0.4	6	12
Residences – night-time	0.14	0.28	2	4
Offices, schools, place of worship	0.4	0.8	13	26
Workshops	0.8	1.6	13	26

For intermittent vibration, the Vibration Dose Value (VDV) is used as the metric for assessment as it accounts for the duration of the source, which will occur intermittently over the assessment period. The VDV management levels at different land uses for intermittent vibration sources are presented in Table 12.

Table 12 VDV management levels for intermittent vibration

Receiver	VDV – Intermittent vibration, $m/s^{1.75}$	
	Preferred	Maximum
Residences – daytime	0.2	0.4
Residences – night-time	0.13	0.26
Offices, schools, places of worship	0.4	0.8
Workshops	0.8	1.6

4 Construction Noise and Vibration Assessment

4.1 Construction noise assessment methodology

In order to quantify noise emissions from the proposed construction works, noise modelling software (SoundPLAN v8.2, ISO 9613 prediction algorithm) has been used to predict the $L_{Aeq(15\text{-}minute)}$ noise levels at nearby receivers. The calculations include the source noise levels of the anticipated equipment, the location of selection of nearby sensitive receivers, the number of plant items likely to be operating at any given time and the distance between the equipment and the receivers.

The typical noise levels used for the purposes of this assessment are based on previous measurements conducted by Resonate and on data from Roads and Maritime's Construction Noise and Vibration Guideline. The predicted noise level results are presented as a summary of the noise impacts for each of the construction phases.

In practice, the noise levels would vary due to the fact that plant would move around the worksites and would not all be operating concurrently. As such, noise levels are likely to be lower than the worst-case noise levels presented for notable periods of time during the works.

The ICNG states that where construction works are planned to extend over more than two consecutive nights, the impact assessment should cover the maximum noise level from the proposed works.

4.1.1 Construction scenarios, duration and equipment sound power levels

A summary of the sound power levels used for the construction noise assessment is provided in Table 13 below. All scenarios described are anticipated to occur during standard construction hours. A limited amount of Out of Hours Works (OOHW) is anticipated and is described in Section 4.1.2.

Table 13 Assumed construction sound power levels

Construction Scenario	Duration	Plant item	Typical Sound Power Level dB(A)	Number	Operating time (% of typical 15-minute assessment period	Estimated Sound Power Level dB(A)
CS1 – Site Establishment	Approximately 1 month	Truck	103	1	50%	100
		Concrete saw[1]	123	1	25%	117
		Concrete mixer	109	1	25%	103
		Total $L_{Aeq(15minute)}$				**117**
CS2 – Ramp Construction	Approximately 12 months	Large delivery truck (road truck)	109	1	50%	106
		Mobile cranes	113	1	25%	107
		Cherry picker (EWP)	97	1	25%	91
		Scissor lift	98	1	25%	92
		Welders	110	1	50%	107

Construction Scenario	Duration	Plant item	Typical Sound Power Level dB(A)	Number	Operating time (% of typical 15-minute assessment period	Estimated Sound Power Level dB(A)
		Excavator	110	1	50%	107
		Piling rig (bored)	112	1	50%	109
		Jackhammers[1]	118	1	50%	115
		Total $L_{Aeq(15minute)}$ **Total L_{Amax}** (based on mobile crane for OOHW)				**118** **116**
CS3 – Groundwork, cycleway and landscaping	Approximately 12 months	Trucks	103	1	50%	100
		Excavators	110	1	50%	107
		Concrete pourer (concrete pump)	109	1	25%	103
		Forklifts	85	1	50%	82
		Jackhammers[1]	118	1	50%	115
		Concrete saw[1]	123	1	25%	117
		Total $L_{Aeq(15minute)}$ **Total L_{Amax}** (based on concrete saw for OOHW)				**120** **130**
CS4 - Demobilisation	Approximately 4 months	Trucks	103	1	50%	100
		Power tools (rattle gun)	104	1	50%	101
		Total $L_{Aeq(15minute)}$				**104**
CS5 - Ancillary Site	Duration of construction	Trucks	103	1	50%	100
		Total $L_{Aeq(15minute)}$				**100**

(1) Plant item includes a 5 dB annoyance penalty in accordance with the requirements of the NPfI.

4.1.2 Out of Hours Works

The activities that are required to be undertaken outside of normal construction hours during the night-time period due to operational road and rail user safety are described in Table 14.

Table 14 Out of Hours Works Description

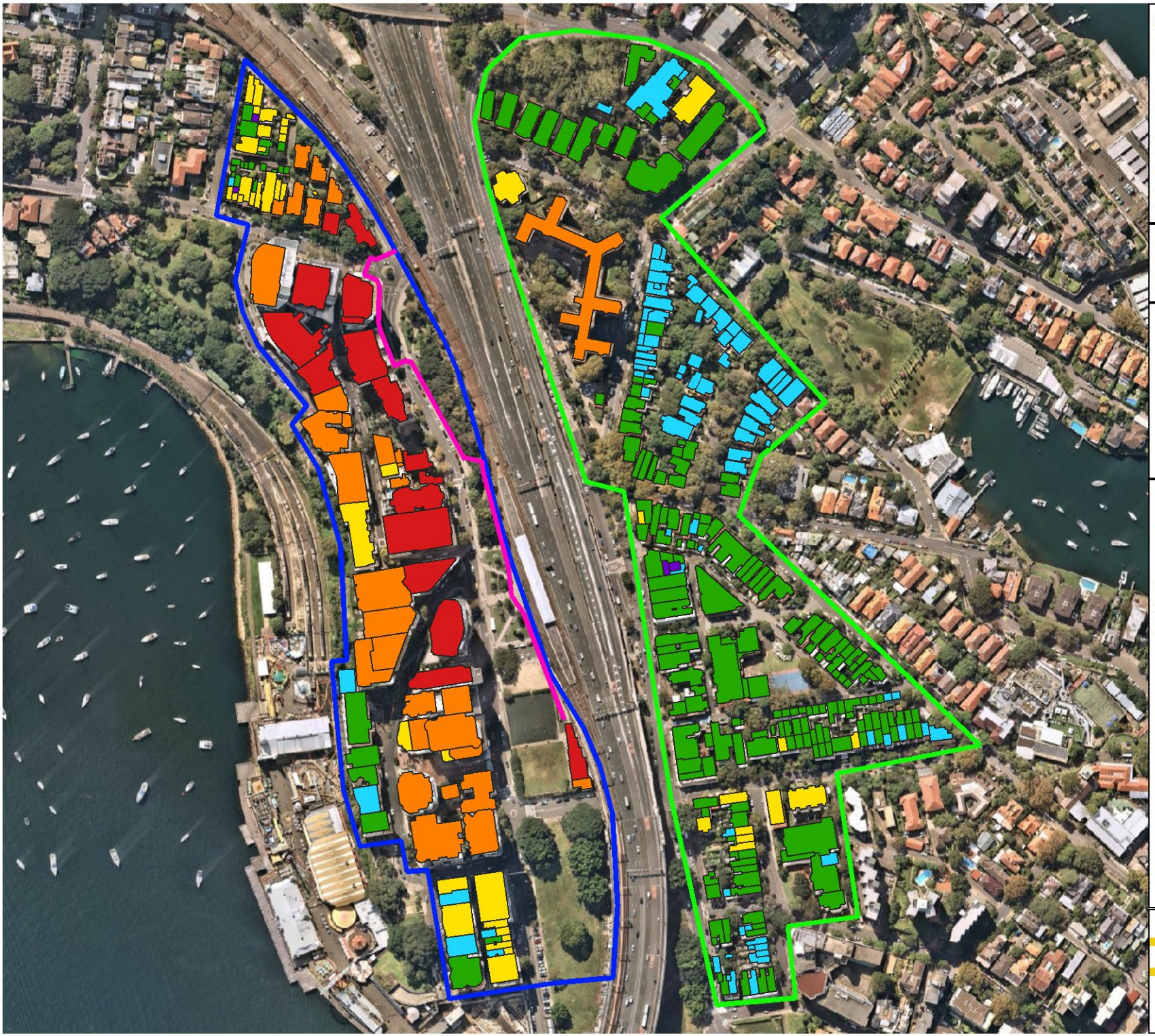
Construction Activity	Description	Construction Plant and Equipment
Ramp works	Prefabricated bridge sections will be delivered at night and stored on Burton Street on low bed loaders, articulated and flatbed trucks between 12.00am and 4.00am. Some sections of the ramp will be dropped into place with cranage at night between 10.00pm and 4.00am Monday to Thursday when trains are not operational and when pedestrians and bike riders' numbers are low. The duration of this activity would occur over around two months. Night works would be limited where possible and may occur non-consecutively depending on wind or other environmental conditions which may affect the ability to lift panels safely.	Construction plant and equipment will be as per Construction Scenario CS2 – Ramp Construction as described in Table 13, with the exception of jackhammers and bored piling rigs, which would not be used during OOHW.
Adjustments to the Lavender Street roundabout and civil works along Alfred Street	The adjustment to pedestrian crossing and roundabout works on Lavender Street and civil works along Alfred Street would be completed out of hours on either a weekend and or weeknights between the end of the PM peak and beginning of the AM peak.	Construction plant and equipment will be as per Construction Scenario CS3 – Groundwork, cycleway and landscaping as described in Table 13. Concrete saw has been assessed for OOHW to provide a conservative assessment. However, it is anticipated that concrete saw would rarely be used during OOHW, and if it is being used, it will only be used for a very brief period of time.

4.2 Predicted noise levels

Construction noise heat maps have been prepared to present the potential noise impacts that may result from the construction of the proposal. The worst case construction scenario for standard and night-time OOHW are presented in Figure 3 and Figure 4 respectively.

Heat maps for all construction scenarios are presented in Appendix C. The heat maps show buildings shaded according to the maximum noise level predicted on the most potentially impacted façade and floor when the works are occurring at the worst-case 'noise source to receiver' orientation.

The most sensitive land use has been used for assessment purposes where a building has multiple uses (for example a predominantly residential building with a ground-floor commercial usage is assessed is shown as residential. In practice, construction activities would move around the proposal construction footprint with noise levels rising and falling in intensity. Appendix D presents NML exceedance heat maps for each construction scenario that correspond to the levels of additional mitigation measures described in Table 29 and Table 30 as required by the CNVG.



Sydney Harbour Bridge Northern Cycleway

FIGURE 3
Predicted Worst Case Standard Hours Construction (CS3 Groundwork, Cycleway & Landscaping)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- CS3 - Works Locations

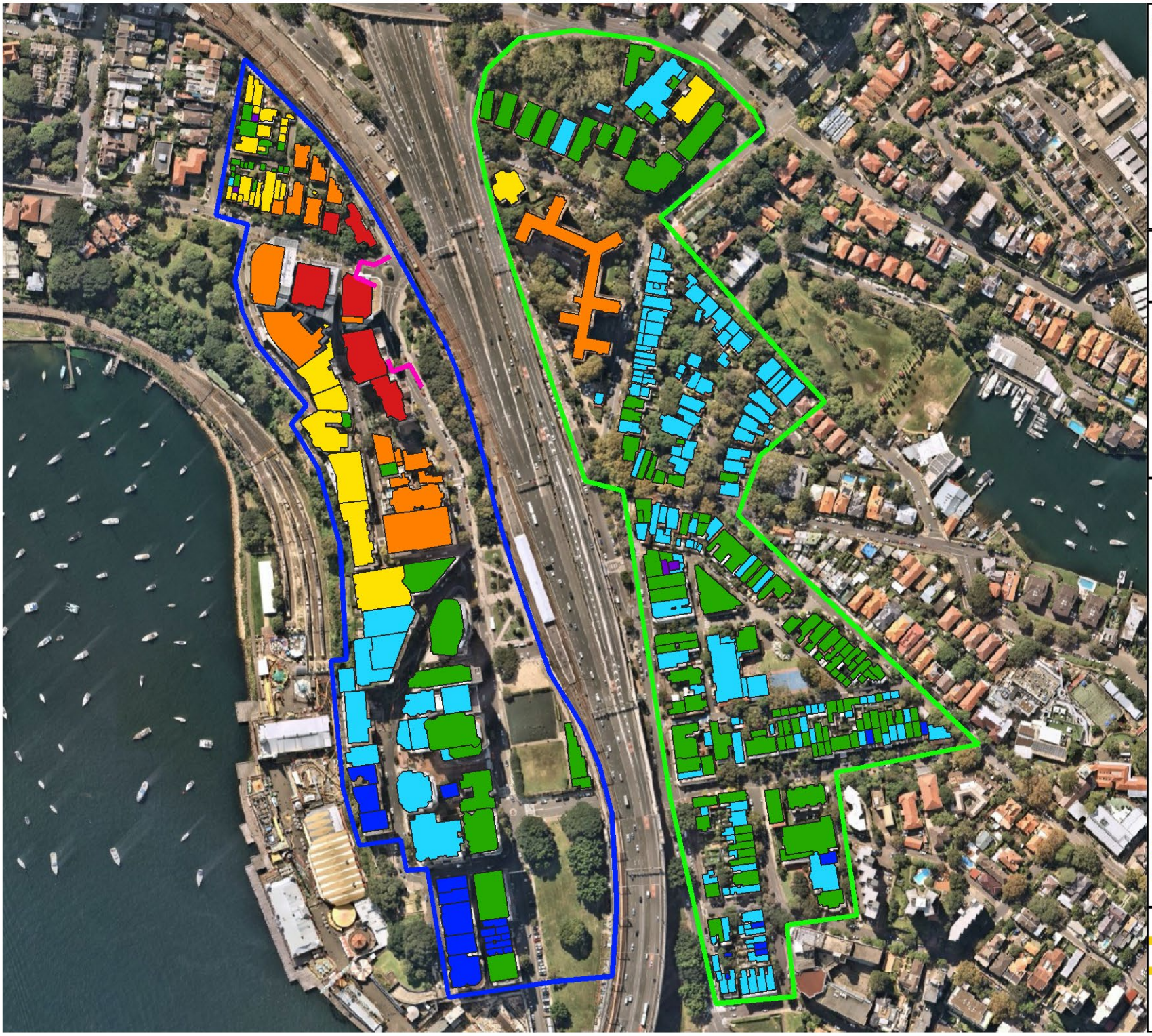
Noise Catchment Area

- NCA01
- NCA02

Predicted Noise Levels dB(A)

- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- > 80

Resonate



Sydney Harbour Bridge Northern Cycleway

FIGURE 4
Predicted Worst Case OOH (Night-time) Construction (CS3 Cycleway Works)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- CS3: Cycleway Works Location

Predicted Noise Levels dB(A)

- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- > 80

Noise Catchment Area

- NCA01
- NCA02

Resonate

4.3 Discussion of predicted noise levels

4.3.1 NCA01 (West of proposal)

Standard Construction Hours

The predicted construction noise levels within NCA01 typically range between 47 dB(A) and 89 dB(A) with the highest noise level predicted to be up to 105 dB(A). The highest noise level is predicted when a concrete saw is used during ground works on the footpath within 1m to 2m of 110 to 118 Alfred Street South. These works would not occur for an extended duration noting that these works work would gradually move along Alfred Street South avoiding an extended duration of high noise levels outside any one sensitive receiver location.

The highest noise levels are predicted when ground works occur directly adjacent to receivers located on Alfred Street South between Burton Street and Lavender Street. NML exceedances would typically range between 0 dB and 22 dB and these would be classified as being in the noticeable to highly intrusive range. Predicted NML exceedances and subjective classification for each potentially affected receiver adjacent to the proposed works are presented in Appendix D.

The worst case noise impacts from most construction activities, except ramp works, on multi-storey buildings are typically on lower level receivers as these works are carried out at ground level in proximity to these receivers.

The worst case noise impacts from ramp works on multi-storey buildings are typically the receivers on Levels 4 and 5. This is because ramp works would be carried out at an elevation similar to the railway tracks.

The highest noise levels would not occur at the same receiver locations for different works. This is because different works would occur at different locations throughout the proposal boundary. Furthermore, the predicted noise levels are considered worst case and would not occur continuously for the duration of construction. Additional mitigation measures in the form of verification noise measurements and community notifications would be implemented to confirm predictions and inform the local community of what can be expected during specific phases of work.

Table 15 presents the number of residential receivers in NCA01 that either achieves or exceeds the NML by up to 10 dB, between 10 to 20 dB or by 20 dB or more for each construction scenario during standard daytime construction hours.

Table 15 Number of Residential Building NML exceedances

Construction Scenario	Noise Management Level Exceedance Category (CNVG)			
	NML Noticeable	NML +10 dB(A) Clearly audible	NML +10 to 20 dB(A) Moderately intrusive	NML +20 dB(A) Highly intrusive
CS1	78	9	4	0
CS2	72	16	3	0
CS3	43	26	17	5
CS4	88	3	0	0

Based on Table 15, there are a number of residential buildings in NCA01 that are predicted to exceed the NML and would potentially require standard hours additional mitigation measures. Additional mitigation measures are provided based on the extent of NML exceedance where residual impacts are predicted after the standard mitigation measures (detailed in Section 5.1) have been applied. Predicted NML exceedances and subjective classification for each potentially affected receiver adjacent to the proposed works are presented in Appendix D. The subjective classification

of NML exceedances align with the additional mitigation measures detailed in Section 5.2. The number of residential buildings per construction scenario that may be eligible for additional standard hours mitigation measures is summarised below. It should be noted that the majority of buildings located on the western side of the proposal boundary are multi-story and so a single building may have multiple potentially affected apartments or commercial tenancies

- Construction CS1 – up to 4 residential buildings would potentially require additional mitigation measures as there are 4 residential buildings predicted to exceed the NML between 10 and 20 dB and 5 residential receivers predicted to exceed the NML by 20 dB or more.
- Construction CS2 – up to 3 residential buildings would potentially require additional mitigation measures as there are 6 residential buildings predicted to exceed the NML between 10 and 20 dB.
- Construction CS3 – up to 17 residential buildings would potentially require additional mitigation measures as there are 16 residential buildings predicted to exceed the NML between 10 to 20 dB and 5 residential receivers predicted to exceed the NML by 20 dB or more.
- Construction CS4 – no residential buildings would require additional mitigation measures.

Table 16 presents the number of commercial buildings in NCA01 that either achieves the NML or exceed the NML by up to 10 dB, between 10 to 20 dB or by 20 dB or more for each construction scenario during standard daytime construction hours.

Table 16 Number of Commercial Building NML exceedances

Construction Scenario	Noise Management Level Exceedance Category (CNVG)			
	NML Noticeable	NML +10 dB(A) Clearly audible	NML +10 to 20 dB(A) Moderately intrusive	NML +20 dB(A) Highly intrusive
CS1	2	1	0	1
CS2	3	0	0	1
CS3	2	1	0	1
CS4	3	0	1	0

Based on Table 16, there are a number of commercial buildings in NCA01 that are predicted to exceed the NML and would potentially require standard hours additional mitigation measures. Additional mitigation measures are provided based on the extent of NML exceedance where residual impacts are predicted after the standard mitigation measures (detailed in Section 5.1) have been applied. Predicted NML exceedances and subjective classification for each potentially affected receiver adjacent to the proposed works are presented in Appendix D. The subjective classification of NML exceedances align with the additional mitigation measures detailed in Section 5.2. The number of residential buildings per construction scenario that may be eligible for additional standard hours mitigation measures is summarised below. It should be noted that the majority of buildings located on the western side of the proposal boundary are multi-story and so a single building may have multiple potentially affected apartments or commercial tenancies.

- Construction CS1 – up to 1 commercial building would potentially require additional mitigation measures as there is 1 commercial building predicted to exceed the NML by 20 dB or more.
- Construction CS2 – up to 1 commercial building would potentially require additional mitigation measures as there is 1 commercial building predicted to exceed the NML by 20 dB or more.
- Construction CS3 – up to 1 commercial building would potentially require additional mitigation measures as there is 1 commercial building predicted to exceed the NML by 20 dB or more.
- Construction CS4 – up to 1 commercial building would potentially require additional mitigation measures as there is 1 commercial building predicted to exceed the NML between 10 to 20 dB.

Table 17 presents the NML exceedances predicted at the place of worship and educational facility in NCA01 for each construction scenario during standard daytime construction hours.

Table 17 Places of Worship and Educational NML Exceedances

Receiver	Receiver Type	NML Exceedance per Construction Scenario – dB(A)			
		CS1	CS2	CS3	CS4
The Chinese Christian Church	Place of Worship	0	24	31	0
Senses ELC	Educational	11	15	20	11

Based on Table 17, the construction scenarios where standard hours additional mitigation measures (in accordance with Table 29) would likely be required for all construction scenarios CS1 to CS4.

Out of Hours Works (Night-time)

The predicted construction noise levels within this noise catchment area typically range between 32 dB(A) and 76 dB(A) with the highest noise level predicted to be up to 92 dB(A) for ramp works and 105 dB(A) for cycleway works.

The highest noise levels are predicted for when a jackhammer or concrete saw is used during cycleway works in close proximity to receivers located near the corner of Alfred Street South and Lavender Street. NML exceedances range between 0 dB and 56 dB are predicted and these would be classified as being in the noticeable to highly intrusive range. These works are required to be conducted outside of standard construction hours for road safety reasons.

Predicted NML exceedances and subjective classification for each potentially affected receiver adjacent to the proposed works are presented in Appendix D. The subjective classification of NML exceedances align with the additional mitigation measures detailed in Table 29 and Table 30.

The highest noise levels would not occur for long durations noting that the works would gradually move from location to location within the proposal boundary and works would not occur for a long duration directly adjacent to a particular receiver location. Furthermore, night-time works are scheduled for a very short duration in the context of the overall construction program. Night-time works is currently envisaged and would not be conducted in one continuous block. Additional noise mitigation measures would be applied to further mitigate noise impacts and would include community notifications, verification monitoring to confirm predictions and respite periods. Respite equipment (such as noise cancelling headphones or white noise machines) or alternative accommodation may be considered on a case by case basis, if required, and if identified as part of the Construction Environment Management Plan and Construction Noise and Vibration Management sub-plan.

Table 18 presents the number of residential buildings in NCA01 that either achieves the NML or exceed the NML by 5 dB, between 5 to 15 dB, between 15 to 25 dB or by 25 dB or more for each construction scenario during out of hours (OOH) construction.

Table 18 Number of Residential Building NML exceedances

Construction Scenario	Noise Management Level Exceedance Category (CNVG)				
	NML	NML +5 dB(A) Noticeable	NML +5 to 15 dB(A) Clearly audible	NML +15 to 25 dB(A) Moderately intrusive	NML +25 dB(A) Highly intrusive
CS2	30	10	26	16	9
CS3	29	5	19	27	11

Based on Table 18, there are a number of residential buildings in NCA01 that are predicted to exceed the night-time NML and would potentially require out of hours additional mitigation measures. Additional mitigation measures are provided based on the extent of NML exceedance where residual impacts are predicted after the standard mitigation measures (detailed in Section 5.1) have been applied. Predicted NML exceedances and subjective classification for each potentially affected receiver adjacent to the proposed works are presented in Appendix D. The subjective classification of NML exceedances align with the additional mitigation measures detailed in Section 5.2. The number of residential buildings per construction scenario that may be eligible for additional out of hours mitigation measures is summarised below. It should be noted that the majority of buildings located on the western side of the proposal boundary are multi-story and so a single building may have multiple potentially affected apartments or commercial tenancies.

- Construction CS2 – up to 61 residential buildings would potentially require additional mitigation measures as there are 10 residential buildings predicted to exceed the NML by up to 5 dB, 26 residential buildings predicted to exceed the NML between 5 and 15 dB, 16 residential buildings predicted to exceed the NML between 15 to 25 dB and 9 residential buildings predicted to exceed the NML by 25 dB or more.
- Construction CS3 – up to 62 residential buildings would potentially require additional mitigation measures as there are 5 residential buildings predicted to exceed the NML by up to 5 dB, 19 residential buildings predicted to exceed the NML between 5 and 15 dB, 27 residential buildings predicted to exceed the NML between 15 to 25 dB and 11 residential buildings predicted to exceed the NML by 25 dB or more.

Table 19 presents the number of commercial buildings in NCA01 that either achieves the NML or exceed the NML by 5 dB, between 5 to 15 dB, between 15 to 25 dB or by 25 dB or more for each construction scenario during OOH construction.

Table 19 Number of Commercial Building NML exceedances

Construction Scenario	Noise Management Level Exceedance Category (CNVG)				
	NML	NML +5 dB(A) Noticeable	NML +5 to 15 dB(A) Clearly audible	NML +15 to 25 dB(A) Moderately intrusive	NML +25 dB(A) Highly intrusive
CS2	3	0	0	1	0
CS3	4	0	0	0	0

Based on Table 19, there are number of commercial buildings in NCA01 that that are predicted to exceed the night-time NML and would potentially require out of hours additional mitigation measures if the buildings are in operation. Additional mitigation measures are provided based on the extent of NML exceedance where residual impacts are predicted after the standard mitigation measures (detailed in Section 5.1) have been applied. Predicted NML exceedances and subjective classification for each potentially affected receiver adjacent to the proposed works are presented in Appendix D. The subjective classification of NML exceedances align with the additional mitigation measures detailed in Section 5.2. The number of residential buildings per construction scenario that may be eligible for additional standard hours mitigation measures is summarised below. It should be noted that the majority of

buildings located on the western side of the proposal boundary are multi-story and so a single building may have multiple potentially affected apartments or commercial tenancies.

- Construction CS2 – up to 1 commercial building would potentially require additional mitigation measures as there is 1 commercial building predicted to exceed the NML between 15 to 25 dB.
- Construction CS3 – no commercial buildings would require additional mitigation measures.

Table 20 presents the NML exceedances predicted at the place of worship and educational facility in NCA01 for each construction scenario during night-time OOH construction.

Table 20 Places of Worship and Educational NML Exceedances

Receiver	Receiver Type	NML Exceedance per Construction Scenario – dB(A)			
		CS1	CS2	CS3	CS4
The Chinese Christian Church	Place of Worship	-	24	22	-
Senses ELC	Educational	-	15	0	-

Based on Table 20, the construction scenarios where OOH additional mitigation measures (in accordance with Table 29) would likely be required are as follows:

- Construction CS2
- Construction CS3

4.3.2 NCA02 (East of proposal)

Standard Construction Hours

The predicted construction noise levels within this noise catchment area typically range between 42 dB(A) and 62 dB(A) with the highest noise level predicted to be up to 76 dB(A). The highest noise level is predicted for when cycleway works occur to the north of the proposal boundary that have direct line of sight to sensitive receivers on the eastern side of the Warringah Freeway. NML exceedances would typically range between 0 dB and 5 dB. The highest noise levels would not occur for long durations noting that the undergrounding works are linear in nature and would not occur for a long duration directly adjacent to a particular receiver location. The buildings to the east of the proposal boundary are predominantly one to two storeys in height.

Table 21 presents the number of residential buildings in NCA02 that either achieves the NML or exceed the NML by up to 10 dB, between 10 to 20 dB or by 20 dB or more for each construction scenario during standard daytime construction hours.

Table 21 Number of Residential Building NML exceedances

Construction Scenario	Noise Management Level Exceedance Category (CNVG)			
	NML Noticeable	NML +10 dB(A) Clearly audible	NML +10 to 20 dB(A) Moderately intrusive	NML >20 dB(A) Highly intrusive
CS1	222	0	0	0
CS2	221	1	0	0
CS3	221	1	0	0
CS4	222	0	0	0

Based on Table 21, there will be no residential buildings in NCA02 that would require standard hours additional mitigation measures (in accordance with Table 29) for any construction scenarios.

Table 22 presents the number of commercial buildings in NCA02 that either achieves the NML or exceed the NML by up to 10 dB, between 10 to 20 dB or by 20 dB or more for each construction scenario during standard daytime construction hours.

Table 22 Number of Commercial Building NML exceedances

Construction Scenario	Noise Management Level Exceedance Category (CNVG)			
	NML Noticeable	NML +10 dB(A) Clearly audible	NML +10 to 20 dB(A) Moderately intrusive	NML >20 dB(A) Highly intrusive
CS1	19	0	0	0
CS2	19	0	0	0
CS3	19	0	0	0
CS4	19	0	0	0

Based on Table 22, there would be no commercial buildings in NCA02 that would require standard hours additional mitigation measures (in accordance with Table 29) for any construction scenarios.

Table 23 presents the NML exceedances predicted at the place of worship and educational facility in NCA02 for each construction scenario during standard daytime construction hours.

Table 23 Places of Worship and Educational NML Exceedances

Receiver	Receiver Type	NML Exceedance per Construction Scenario – dB(A)			
		CS1	CS2	CS3	CS4
The Bridge Church	Place of Worship	0	0	1	0
St Aloysius' College Junior School	Educational Facility	0	1	5	0
Kirribilli Neighbourhood Centre	Community Centre	0	0	4	0
St Aloysius' College	Educational Facility	0	0	5	0

- Based on Table 23, standard hours additional mitigation measures (in accordance with Table 29) would not be required at any place of worship or educational facility for any construction scenarios.

Out of Hours Works (Night-time)

The predicted construction noise levels within this noise catchment area typically range between 32 dB(A) and 52 dB(A) with the highest noise level predicted to be up to 71 dB(A) for cycleway works. The highest noise level is predicted for when CS3 groundwork, cycleway and landscaping works occur to the north of the proposal boundary that have direct line of sight to sensitive receivers on the eastern side of the Warringah Freeway. Night-time OOH NML exceedances would typically range between 0 dB and 22 dB are predicted. The highest noise levels would not occur for long durations noting that the works are typically linear in nature and would not occur for a long duration directly adjacent to a particular receiver location. Furthermore, night-time works are only scheduled for a very short duration in the context of the overall construction program.

Table 24 presents the number of residential buildings in NCA02 that either achieves the NML or exceed the NML by 5 dB, between 5 to 15 dB, between 15 to 25 dB or by 25 dB or more for each construction scenario during night-time OOH construction.

Table 24 Number of Residential Building NML exceedances

Construction Scenario	Noise Management Level Exceedance Category (CNVG)				
	NML	NML +5 dB(A) Noticeable	NML +5 to 15 dB(A) Clearly audible	NML +15 to 25 dB(A) Moderately intrusive	NML +25 dB(A) Highly intrusive
CS2	156	52	13	1	0
CS3	107	77	36	1	0

Based on Table 24, the number of residential buildings in NCA02 that would potentially require night-time OOH additional mitigation measures (in accordance with Table 29) during each construction scenarios is as follows:

- Construction CS2 – up to 66 residential buildings would potentially require additional mitigation measures as there are 52 residential buildings predicted to exceed the NML by up to 5 dB, 13 residential buildings predicted to exceed the NML between 5 and 15 dB and 1 residential building predicted to exceed the NML between 15 to 25 dB.
- Construction CS3 – up to 114 residential buildings would potentially require additional mitigation measures as there are 77 residential buildings predicted to exceed the NML by up to 5 dB, 36 residential buildings predicted to exceed the NML between 5 and 15 dB and 1 residential building predicted to exceed the NML between 15 to 25 dB.

Table 25 presents the number of commercial buildings in NCA02 that either achieves the NML or exceed the NML by 5 dB, between 5 to 15 dB, between 15 to 25 dB or by 25 dB or more for each construction scenario during night-time OOH construction.

Table 25 Number of Commercial Building NML exceedances

Construction Scenario	Noise Management Level Exceedance Category (CNVG)				
	NML	NML +5 dB(A) Noticeable	NML +5 to 15 dB(A) Clearly audible	NML +15 to 25 dB(A) Moderately intrusive	NML +25 dB(A) Highly intrusive
CS2	19	0	0	0	0
CS3	19	0	0	0	0

Based on Table 25, there would be no commercial buildings in NCA02 that would require OOH additional mitigation measures (in accordance with Table 29) for any construction scenarios.

Table 26 presents the NML exceedances predicted at the place of worship and educational facilities in NCA02 for each construction scenario during night-time OOH construction.

Table 26 Places of Worship and Educational NML Exceedances

Receiver	Receiver Type	NML Exceedance per Construction Scenario – dB(A)			
		CS1	CS2	CS3	CS4
The Bridge Church	Place of Worship	-	0	0	-
St Aloysius' College Junior School	Educational Facility	-	1	1	-
Kirribilli Neighbourhood Centre	Community Centre	-	0	1	-
St Aloysius' College	Educational Facility	-	0	0	-

Based on Table 26, the construction scenarios where night-time OOH additional mitigation measures (in accordance with Table 29) would likely be required during:

- Construction CS2 at St Aloysius College Junior School only, and only when in use during night-time OOH construction.
- Construction CS3 at St Aloysius College Junior School and Kirribilli Neighbour Centre only, and only when in use during night-time OOH construction.

4.3.3 Sleep disturbance

A map showing the locations at which maximum noise levels in excess of 65 dB(A) are predicted is provided in Figure 5. It should be noted that extensive night-time works are not expected to occur and the potential for sleep disturbance would be considered in determining reasonable and feasible noise mitigation measures during construction. The nights of work may not be consecutive.

Sydney Harbour Bridge Northern Cycleway

FIGURE 5
Predicted Sleep Disturbance Exceedances of CS2.1 Ramp Construction and CS3.1 Cycleway Works (OOHW)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- CS2.1 & CS3.1 - Works Locations

Sleep Disturbance Exceedance

- > 65 dB(A)

Noise Catchment Area

- NCA01
- NCA02

Resonate

4.3.4 CS05 Ancillary site

The ancillary site is predicted to comply with the standard hours NMLs at all locations with the exception of the commercial receiver located directly adjacent where an exceedance of up to 9 dB(A) is predicted. No additional mitigation measures are required for the operation of the ancillary site during standard hours.

Access to the ancillary site may be required for the brief periods of out of hours works associated with ramp and roundabout construction. Noise impacts and associated noise mitigation requirements would typically be controlled by the works. However, when assessed in isolation, up to 18 buildings to the west of the proposal boundary are predicted to exceed the night-time NML. The NML exceedances range between 0 dB and 17 dB. Additional out of hours mitigation measures would be applied on the basis of the predicted NML exceedances as described in Section 5.2.

4.4 Construction vibration

4.4.1 Minimum working distances

Minimum working distances for typical vibration intensive construction equipment are provided in the CNVG and are shown in Table 27. The minimum working distances are for both cosmetic damage (from BS 7385 and DIN 4150) and human comfort (from the NSW EPA Assessing Vibration: a technical guideline). They are calculated from empirical data which suggests that where work is further from receivers than the quoted minimum distances then impacts are not considered likely. The minimum working distances apply to addressing the risk of cosmetic (minor – easily reparable) damage of typical buildings under typical geotechnical conditions.

Where vibration intensive works are required to be undertaken within the specified minimum working distances, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied.

In relation to human comfort, the minimum working distances relate to continuous vibration. For most construction activities, vibration emissions would be intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods may be allowed.

Table 27 presents the recommended minimum working distances for vibration intensive plant.

Table 27 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Minimum Working Distance – Cosmetic Damage[1] (BS7385)	Minimum Working Distance – Human Response (OH&E Guideline)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m

Plant Item	Rating/Description	Minimum Working Distance – Cosmetic Damage[1] (BS7385)	Minimum Working Distance – Human Response (OH&E Guideline)
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Handheld	1 m (nominal)	2 m

4.4.2 Vibration intensive activities

The currently anticipated schedule of plant to be used to construct the proposal includes the following vibration intensive plant and associated minimum working distances based on typical structures in sound structural condition:

- Pile boring (four metre minimum distance for human response, two metre minimum distance for cosmetic damage)
- Jackhammer (two metre minimum distance for human response, one metre minimum distance for cosmetic damage)

There are no structures located outside of the proposal construction footprint that fall within the minimum working distances for pile boring and jackhammers. It is unlikely that structures located outside of the proposal construction footprint would be adversely impact by construction vibration.

4.4.3 Heritage structures located within the proposal construction footprint

The Nationally and State Heritage Listed Sydney Harbour Bridge and the State Heritage Listed Milsons Point Railway Station Group are located within the minimum working distances for pile boring and jackhammers. This relates to the construction of the piers that would support the bicycle ramp and connection of the ramp to the existing cycleway located on the Sydney Harbour Bridge approach span.

BS7385 states that a building of historical value should not (unless it is structural unsound) be assumed to be more vibration sensitive, and therefore, compliance with the minimum distances provided in Table 27, is likely to result in low risk of cosmetic damage to the nominated structures.

Notwithstanding the above, minimum working distances base on the nominated 3 mm/s criterion for heritage structures have been estimated. These distances have been estimated for the nominated vibration intensive plant items on the basis of empirical vibration data as follows:

- Pile boring (four metres for heritage structures)
- Jackhammer (two metres for heritage structures)

Work may occur within the established minimum working distances for the following activities. Working within the minimum working distances may present a risk of cosmetic or structural damage to the Sydney Harbour Bridge approach spans and the Milsons Point Railway Station.

- The pile boring required as part of the ramp pier construction.
- The removal of a section of the Sydney Harbour Bridge parapet to enable the connection between the newly built ramp and the existing cycleway on the bridge.

Therefore, the following additional management measures are recommended in order to minimise the risk of damage to these structures:

- Conduct a pre-construction dilapidation survey and monitor the condition of the structures throughout construction.
- Conduct vibration monitoring during construction to confirm vibration levels and minimum working distances.
- Conduct a more detailed vibration measurement investigation in order to determine the sensitivity of the structure in question to ground-borne vibration. This would only be required in specific cases where a structure was deemed to have a particular sensitivity to vibration.

4.5 Construction traffic noise

An estimation of the anticipated noise level contribution of construction traffic on local roads has been conducted using the TfNSW Construction Noise Estimator Tool. The following indicative construction road traffic has been assumed on the local access roads to the proposal boundary including Alfred Street South:

- Cycleway works
  - Five two-way light vehicle movements per day.
  - Two two-way heavy vehicle movements per day.
- Ramp works
  - Ten two-way light vehicle movements per day.
  - Ten two-way heavy vehicle movements per day.

The following has been determined:

- Daytime
  - A typical $L_{Aeq(15\ hour)}$ noise level contribution of 55 dB(A) has been predicted for a typical receiver offset distance of 6 m from the Alfred Street South.
  - An existing $L_{Aeq(15hour)}$ noise level of 68 dB(A) was measured as part of the noise logging survey at a receiver facing Alfred Street South.
  - A total combined noise level of 68 dB(A) is predicted with a noise level increase of less than 2 dB.
- Night-time
  - A typical $L_{Aeq(9\ hour)}$ noise level contribution of 57 dB(A) has been predicted for a typical receiver offset distance of 6 m from the Alfred Street South.
  - An existing $L_{Aeq(9hour)}$ noise level of 62 dB(A) was measured as part of the noise logging survey at a receiver facing Alfred Street South.
  - A total combined noise level of 63 dB(A) is predicted with a noise level increase of less than 2 dB.

The assessment has shown that construction traffic is not expected to result in a noticeable increase in traffic noise (i.e. more than a 2.0 dB increase in existing traffic noise). Measures to mitigate construction traffic noise are not therefore proposed.

5 Construction Noise and Vibration Mitigation

5.1 Standard mitigation measures

Construction noise and vibration criteria exceedances are predicted at several identified sensitive receivers for various construction activities associated with the proposal. Efforts should be made to implement all feasible and reasonable mitigation measures in order to minimise the impacts of construction noise and vibration.

Appendix B of the CNVG and Table 28 below present a detailed table of standard noise mitigation measures. The CNVG states that the standard mitigation measures should be implemented on all construction projects. The standard mitigation measures include items such as:

- Community consultation or notification
- Site inductions and staff training
- Preparation of work specific construction noise and vibration management plans
- Validation noise and vibration measurements
- Selection of the quietest available plant and equipment
- Scheduling of noise and vibration intensive work
- Use of temporary noise barrier / enclosure and/or planning work to use natural topographical shielding
- Dilapidation surveys and vibration monitoring.

Table 28 Standard noise mitigation measures applicable to the proposal (CNVG)

Action required	Applies to:	Details
Management measures		
Implementation of any project specific mitigation measures required.	Airborne noise.	Implementation of any project specific mitigation measures required (see Table 32).
Implement community consultation or notification measures	Airborne noise. Ground-borne noise & vibration.	• Notification detailing work activities, dates and hours, impacts and mitigation measures, indication of work schedule over the night-time period, any operational noise benefits from the works (where applicable) and contact telephone number. • Website (If required). • Contact telephone number for community. • Email distribution list (if required). • Community drop-in session (if required by approval conditions).
Site inductions	Airborne noise. Ground-borne noise & vibration.	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • all project specific and relevant standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise generating activities • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures • site opening/closing times (including deliveries) • environmental incident procedures.

Action required	Applies to:	Details
Behavioural practices	Airborne noise.	• No swearing or unnecessary shouting or loud stereos/radios on site. • No dropping of materials from height, throwing of metal items and slamming of doors.
Verification	Airborne noise Ground-borne noise and vibration.	Where specified under Appendix C of the CNVG, a noise verification program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Attended vibration measurements	Ground-borne vibration	Where required, attended vibration measurements should be undertaken at the commencement of vibration generating activities to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Update Construction Environmental Management Plans	Airborne noise. Ground-borne noise and vibration.	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies.
Building condition surveys	Vibration	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to commencement of activities with the potential to cause property damage.
Source controls		
Construction hours and scheduling	Airborne noise. Ground-borne noise and vibration.	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period during normal hours and out-of-hours works	Airborne noise. Ground-borne noise and vibration.	Please refer to Table 29 for more details on the following respite measures: • Respite Offers (RO) • Respite Period 1 (R1) • Respite Period 2 (R2) • Duration Respite (DR)
Equipment selection	Airborne noise. Ground-borne noise and vibration.	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits. Ensure plant including the silencer is well maintained.
Plant noise levels	Airborne noise.	The noise levels of plants and equipment must have operating Sound Power or Sound Pressure Levels compliant with the criteria in Appendix H of the CNVG.
Rental plant and equipment	Airborne noise.	The noise levels of plant and equipment items are to be considered in rental decisions and, in any case, cannot be used on site unless compliant with the criteria in Table 2 of the CNVG.

Action required	Applies to:	Details
Use and siting of plant	Airborne noise.	• The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. • Plant used intermittently to be throttled down or shut down. • Noise-emitting plant to be directed away from sensitive receivers. • Only have necessary equipment on site.
Plan worksites and activities to minimise noise and vibration	Airborne noise. Ground-borne vibration.	• Locate compounds away from sensitive receivers and discourage access from local roads. • Plan traffic flows, parking and loading/unloading areas to minimise reversing movements within the site. • Where additional activities or plant may only result in a marginal noise increase and speed up works, consider limiting duration of impact by concentrating noisy activities at one location and move to another as quickly as possible. • Very noisy activities should be scheduled for normal working hours. If the work cannot be undertaken during the day, it should be completed before 11.00 pm. • Where practicable, work should be scheduled to avoid major student examination periods when students are studying for examinations, whether at an institution or within a residence, such as before or during Higher School Certificate and at the end of higher education semesters. • If programmed night work is postponed the work should be re-programmed and the approaches in the CNVG apply again.
Reduced equipment power	Airborne noise. Ground-borne vibration.	Use only the necessary size and power.
Non-tonal and ambient sensitive reversing alarms	Airborne noise.	• Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. • Consider the use of ambient sensitive alarms that adjust output to the ambient noise level.
Minimise disturbance arising from delivery of goods to construction sites	Airborne noise.	• Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. • Select site access points and roads as far as possible from sensitive receivers. • Dedicated loading/unloading areas to be shielded if close to sensitive receivers. • Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible. • Avoid or minimise these out of hours movements where possible.

Action required	Applies to:	Details
Engine compression brakes	Construction vehicles.	• Limit the use of engine compression brakes at night and in residential areas. • Ensure vehicles are fitted with a maintained Original Equipment Manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.
Path controls		
Shield stationary noise sources such as pumps, compressors, fans, etc.	Airborne noise.	Stationary noise sources should be enclosed or shielded where feasible and reasonable whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of AS 2436:2010 lists materials suitable for shielding.
Shield sensitive receivers form noisy activities	Airborne noise.	Use of structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.
Receptor controls		
Structural surveys and vibration monitoring	Ground-borne vibration.	• Pre-construction surveys of the structural integrity of vibration sensitive buildings may be warranted. • At locations where there are high-risk receptors, vibration monitoring should be conducted during the activities causing vibration.

5.2 Additional mitigation measures

The CNVG recommends additional mitigation measures where all feasible and reasonable efforts cannot achieve the NMLs and maximum vibration levels for the proposed works.

Detailed construction noise and vibration impact assessments will be prepared during the construction phase based on detailed programming information. The detailed assessments will identify the specific additional mitigation measures required for the work in question based on the requirements of the CNVG.

Appendix D presents NML exceedance heat maps that correspond to the levels of additional mitigation measures described in Table 29 and Table 30.

For standard hours works additional mitigation measures include controls such as:

- Widespread community consultation via letterbox drops
- Verification monitoring
- Phone calls and respite offers for highly noise affected receivers.

For Out of Hours works additional mitigation measures include controls such as:

- Widespread community consultation via letterbox drops, phone calls and one-on-one briefings,
- Verification monitoring
- Respite offers which involves scheduling of work to provide specific receivers with a break from continuous construction work,
- Respite equipment (such as noise cancelling headphones or white noise machines) or alternative accommodation may be considered on a case by case basis, if required, and if identified as part of the Construction Environment Management Plan and Construction Noise and Vibration Management sub-plan

Guidelines to the additional mitigation measures are described in detail as follows:

- Table 29 details the additional mitigation measures for airborne noise impacts
- Table 30 details the additional mitigation measures for ground-borne vibration impacts.

Table 29 CNVG additional mitigation measures (airborne noise)

Construction hours	dB(A) above RBL	dB(A) above NML	Additional mitigation measure type		Mitigation Levels
All periods >75 dB(A)			Notification Verification	Phone calls Respite offer	> 75 dB(A)
Standard: Mon-Fri (7am – 6pm), Sat (8am – 1pm) Sun/Public Holiday (Nil)					
Noticeable	5 to 10	0	-		NML
Clearly Audible	10 to 20	<10	-		NML
Moderately Intrusive	20 to 30	10 to 20	Notification Verification		NML+10
Highly Intrusive	>30	>20	Notification Verification		NML+20
OOHW Period 1: Mon-Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Public Holiday (8am – 6pm)					
Noticeable	5 to 10	< 5	-		NML
Clearly Audible	10 to 20	5 to 15	Notification Respite Period 1	Duration Respite	NML+5
Moderately Intrusive	20 to 30	15 to 25	Verification Notification	Respite Period 1 Duration Respite	NML+15
Highly Intrusive	> 30	> 25	Verification Individual briefings Notification Respite Period 1	Duration Respite Phone calls Specific notifications	NML+25
OOHW Period 2: Mon-Fri (10pm – 7am) Sat (10 pm – 8am) Sun/Public Holiday (6pm – 7am)					
Noticeable	5 to 10	< 5	Notification		NML
Clearly Audible	10 to 20	5 to 15	Verification Notification	Respite Period 2 Duration Respite	NML+5
Moderately Intrusive	20 to 30	15 to 25	Verification Individual briefings Notification Phone calls	Specific notifications Respite Period 2 Duration Respite	NML+15
Highly Intrusive	> 30	> 25	Alternative Accommodation Verification Individual Briefings Notification	Phone calls Specific notifications Respite Period 2 Duration Respite	NML+25

Table 30 CNVG additional mitigation measures (vibration)

Construction hours	Additional mitigation measure type		Apply to:
Standard: Mon-Fri (7am – 6pm), Sat (8am – 1pm) Sun/Public Holiday (Nil)			
Predicted vibration levels exceeds maximum levels	Verification Notification	Respite Offer	All
OOHW Period 1: Mon-Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Public Holiday (8am – 6pm)			
Predicted vibration levels exceeds maximum levels	Verification Individual Briefings Notification Respite Offer	Phone calls Respite Offer Specific notifications	All
OOHW Period 2: Mon-Fri (10pm – 7am) Sat (10 pm – 8am) Sun/Public Holiday (6pm – 7am)			
Predicted vibration levels exceeds maximum levels	Alternative Accommodation Verification Individual Briefings Notification	Phone calls Respite Offer Specific notifications	All

5.2.1 Detailed description of CNVG additional mitigation measures

Table 31 provides a detailed description of each category of additional mitigation measures outlined in Table 29 and Table 30 above.

Table 31 Description of CNVG additional mitigation measures

Mitigation measure	Abbreviation	Description
Notification	N	Advanced warning of works and potential disruptors can assist in reducing the impact on the community. The notification may consist of a letterbox drop (or equivalent) detailing work activities, time periods over which these will occur, impacts and mitigation measures. Notification should be a minimum of 5 working days prior to the start of works. The approval conditions for projects may also specify requirements for notification to the community about works that may impact on them.
Specific Notifications	SN	Specific notifications are letterbox dropped (or equivalent) to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. The specific notification provides additional information when relevant and informative to more highly affected receivers than covered in general letterbox drops. The exact conditions under which specific notifications would proceed are defined in the relevant Additional Mitigation Measures (Table 29 to Table 30). This form of communication is used to support periodic notifications, or to advertise unscheduled works.

Mitigation measure	Abbreviation	Description
Phone Calls	PC	Phone calls detailing relevant information made to identified/affected stakeholders within seven calendar days of proposed work. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs. Where the resident cannot be telephoned then an alternative form of engagement should be used.
Individual Briefings	IB	Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Project representatives would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project. Where the resident cannot be met with individually then an alternative form of engagement should be used.
Respite Offers	RO	Respite Offers should be considered made where there are high noise and vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed 3 hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers. The purpose of such an offer is to provide residents with respite from an ongoing impact. This measure is evaluated on a project-by-project basis, and may not be applicable to all projects.
Respite Period 1	R1	Out-of-hours construction noise in out of hours period 1 shall be limited to no more than three consecutive evenings per week except where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and no more than 6 evenings per month.
Respite Period 2	R2	Night time construction noise in out-of-hours period 2 shall be limited to two consecutive nights except for where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and 6 nights per month. Where possible, high noise generating works shall be completed before 11 pm.
Duration Respite	DR	Respite offers and respite periods 1 and 2 may be counterproductive in reducing the impact on the community for longer duration projects. In this instance and where it can be strongly justified it may be beneficial to increase the work duration, number of evenings or nights worked through Duration Respite so that the project can be completed more quickly. The project team should engage with the community where noise levels are expected to exceed the NML to demonstrate support for Duration Respite. Where there are few receivers above the NML each of these receivers should be visited to discuss the project to gain support for Duration Respite.

Mitigation measure	Abbreviation	Description
Alternative Accommodation	AA	Alternative accommodation options may be offered to residents living in close proximity to construction works that are likely to experience highly intrusive noise levels (Tables C1-C3). The specifics of the offer will be identified on a project-by-project basis. Additional aspects for consideration shall include whether the highly intrusive activities occur throughout the night or before midnight.
Verification	V	Please see Appendix F for more details about verification of Noise and Vibration levels as part of routine checks of noise levels or following reasonable complaints. This verification should include measurement of the background noise level and construction noise. Note this is not required for projects less than three weeks unless to assist in managing complaints.

5.3 Project specific mitigation measures

The additional mitigation measures generally relate to receiver-based actions such as notifications, measurements and briefings. Therefore, a further table of activity specific source related controls to be implemented, where reasonable and feasible, are presented in Table 32.

Table 32 Project specific mitigation measures

Mitigation action	Responsibility
Minimise the use of reversing alarms via one-way traffic management	Site supervisor
Erect a temporary noise barrier between the work areas and nearest sensitive receivers where reasonable and feasible to do so	Site supervisor
Complete work during daytime and evening periods where possible	Site supervisor
Erect a temporary noise barrier / enclosure around concrete saws, jackhammers and other high noise generating plant items where required for OOHW	Site supervisor

5.4 Vibration mitigation

- The potential impacts from vibration are to be considered in the site-specific Construction Noise and Vibration Management Plans, to be developed during the detailed design phase when more information is available on the schedule for the works and the equipment to be used.
- The safe working distances should be maintained as per Table 27, with distances between works and sensitive receivers maximised wherever possible.
- All plant should be properly maintained.
- Low vibration alternatives for plant should be implemented where possible.
- Plant that have high and low vibration operating settings should be run on the lowest effective vibration setting.
- Vehicle movements along uneven surfaces should be restricted to minimum speed adjacent to vibration sensitive receivers.
- The vibration sensitivity of nearby structures should be reviewed with respect to structural integrity (particularly those of heritage significance) and/or vibration monitoring be conducted at commencement of construction.
- Consider demarcating areas of heritage significance, irrespective of sensitivity, such that the risk of accidental damage is minimised. An example of this may be where works abutting the existing retaining walls on the Sydney Harbour Bridge approach.

6 Operational Noise Assessment

According to Section 5.5 of Transport's Noise Criteria Guideline (2022), 'minor works' are defined as work that is primarily intended to improve safety, including minor straightening of curves, installing traffic control devices, intersection widening and turning bay extensions or making minor road realignments. The proposed road upgrades as part of the cycleway is not considered 'redeveloped' or 'new' as its main purpose is not to increase road traffic flow volumes. It is therefore reasonable to assume that the proposal would be defined as 'minor works' as according to the guideline.

Noise emissions from cyclists on the upgraded cycleway will be minimal and unlikely to adversely impact on surrounding noise sensitive receivers.

A qualitative desktop review of a potential road traffic noise level increase has been conducted with regard to source-receiver distance and traffic volume sensitivity.

6.1 Distance sensitivity

The distance between roads and cycleway altered by the proposal as relative to the nearest noise sensitive receivers is not anticipated to change and therefore operational road traffic and cyclist related noise levels are not expected to change as a result of the proposal. The proposed cycleway ramp which connects cyclists traveling from the SHB to the ground level cycleway would result in minimal noise emissions. Therefore, the change in elevation of the cycleway would not adversely impact on surrounding noise sensitive receivers..

6.2 Traffic flow sensitivity

The proposal would not result in an increase of road traffic volumes, classification or speed, and therefore road traffic noise levels are unlikely to change as a result of this proposal.

6.3 Summary

No further assessment of operational road traffic or cyclist noise is warranted on the basis of the qualitative review described above.

7 Conclusion

Resonate has conducted a noise and vibration assessment for works associated with the Sydney Harbour Bridge Northern Access Cycleway project.

Due to the locality of the proposal boundary, several potentially affected noise and vibration sensitive receivers have been identified including the Nationally and State Heritage Listed Sydney Harbour Bridge and the State Heritage Listed Milsons Point Railway Station Group.

Unattended and attended background noise monitoring was completed to characterise the prevailing environmental noise within the proposal boundary. Project specific construction noise and vibration assessment criteria have been established on this basis.

Predicted construction noise levels have been assessed against the established criteria and the proposed cycleway design and construction methodology. Residual construction noise criteria exceedances are predicted after all standard mitigation measures have been applied. The residual criteria exceedances may be considered noticeable to highly intrusive depending on the relative location of sensitive receivers to the works and whether the works are occurring during standard hours or out of hours. Additional feasible and reasonable mitigation measures are likely to be required including community notifications ,verification monitoring, phone calls, respite offers (triggered where NMLs are exceeded by 15 dB during the evening period or by 5 dB during the night-time period). Alternative accommodation for highly noise affected receivers during night-time works may be considered.

The additional mitigation measures aim to reduce impacts through informing the community of potential impacts, providing breaks in construction works to manage construction noise fatigue and in certain cases providing short-term alternative accommodation during periods of high impact out of works.

The range of criteria exceedances indicates that preference should be given to conduct work during the daytime where feasible and reasonable to do so, and where possible schedule noise intensive work outside of the night-time period in order to minimise the risk of sleep disturbance.

Assessment of potential construction vibration impacts indicated that exceedances of cosmetic damage and human comfort criteria are unlikely on the basis that most sensitive receiver locations are situated outside of the relevant minimum working distances. Pile boring and the use of jackhammers may occur within minimum working distances established for the Sydney Harbour Bridge and the Milsons Point Railway Station Group which presents a potential risk of cosmetic or structural damage. Additional mitigation measures have been recommended in order to mitigate the potential risk of damage to these structures. These include vibration monitoring and dilapidation surveys.

A qualitative review of the potential operational noise impacts of the project has been conducted. It was found that there was unlikely to be significant changes to the operational noise environment due to the proposal and no additional mitigation measures are proposed.

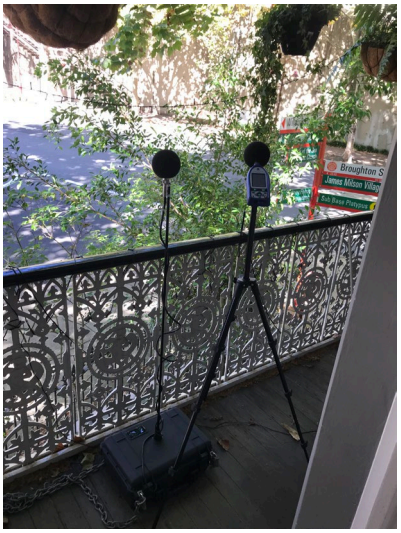
This document may be subject to review pending finalised design input and construction methodology and timing from Transport for NSW.

Appendix A – Noise Measurement Location Descriptions

Location/description	UM-01 (22) unattended / A1 attended 52 Alfred Street South, Milsons Point (Level 4 balcony)	
Measurement details	1/3 octave Z-weighted	
Duration	16 days (unattended) / 15 minutes (attended)	
Weather conditions	Sunny, moderate to strong intermittent breeze.	
Noise observations	• Direct line of sight to Willoughby Street, Broughton Street. • Predominantly road traffic noise on Broughton Street. • Some wind noise from trees at ground level. • Intermittent noise from wildlife (birds). • Nearby train passes.	

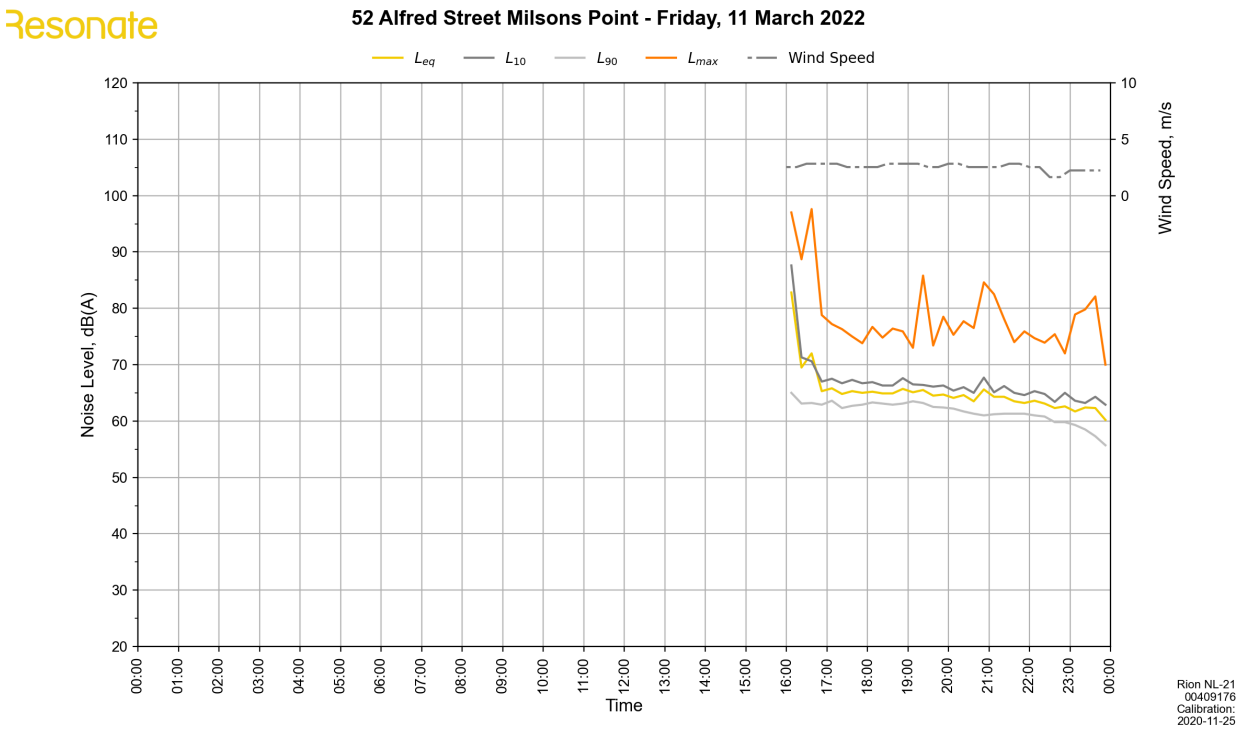
Location/description	A2 attended Opposite 70-72 Alfred Street, Milsons Point	
Measurement details	1/3 octave Z-weighted	
Duration	15 minutes	
Weather conditions	Sunny, light to moderate breeze.	
Noise observations	• Direct line of sight to Alfred Street. • Predominantly road traffic noise on Alfred Street. • Some wind noise from trees. • Intermittent noise from wildlife (birds) • Nearby train passes.	

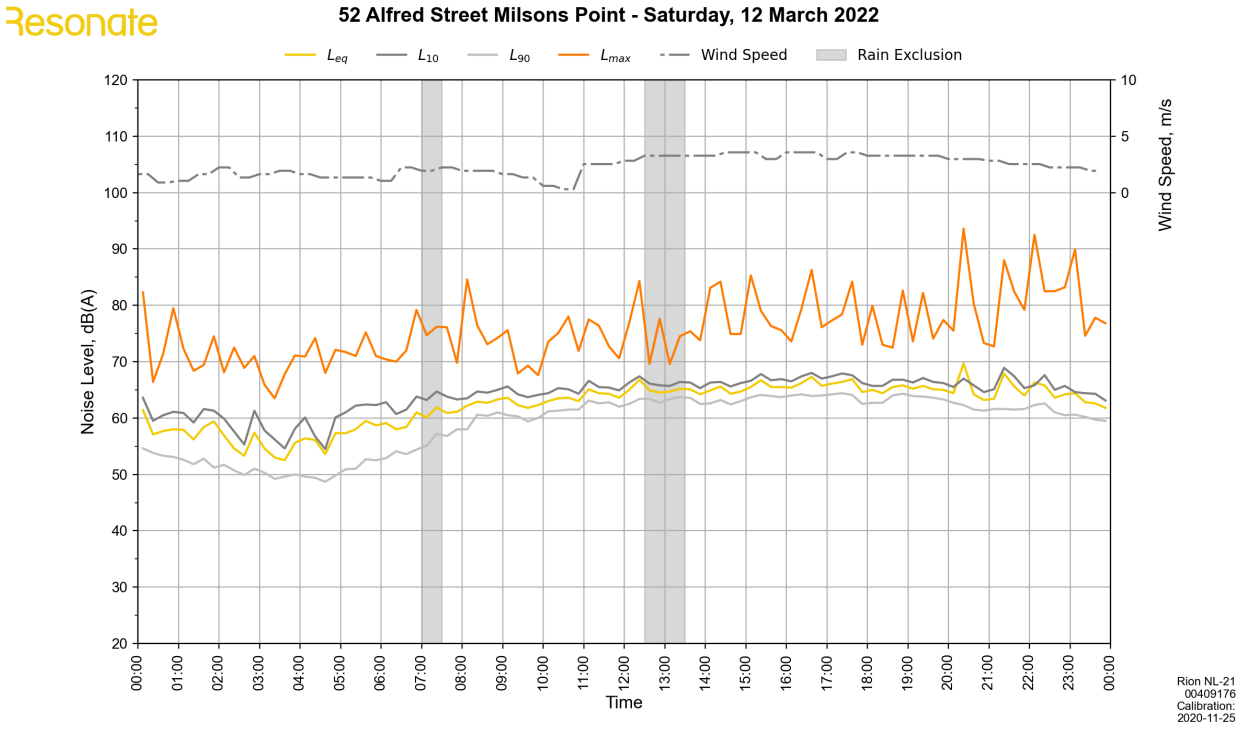
Location/description	A3 attended Opposite 126 Alfred Street, Milsons Point	
Measurement details	1/3 octave Z-weighted	
Duration	15 minutes	
Weather conditions	Sunny, light to moderate breeze.	
Noise observations	• Direct line of sight to Alfred Street. • Predominantly road traffic noise on Alfred Street. • Some wind noise from trees. • Intermittent noise from wildlife (birds). • Nearby train passes.	

Location/description	UM-02 (22) unattended / A4 attended 26 Willoughby Street, Kirribilli (First Floor balcony)	
Measurement details	1/3 octave Z-weighted	
Duration	16 days (unattended) / 15 minutes (attended)	
Weather conditions	Sunny, light breeze.	
Noise observations	• Direct line of sight to Willoughby Street, Broughton Street. • Predominantly road traffic noise on Broughton Street. • Some wind noise from trees at ground level.	

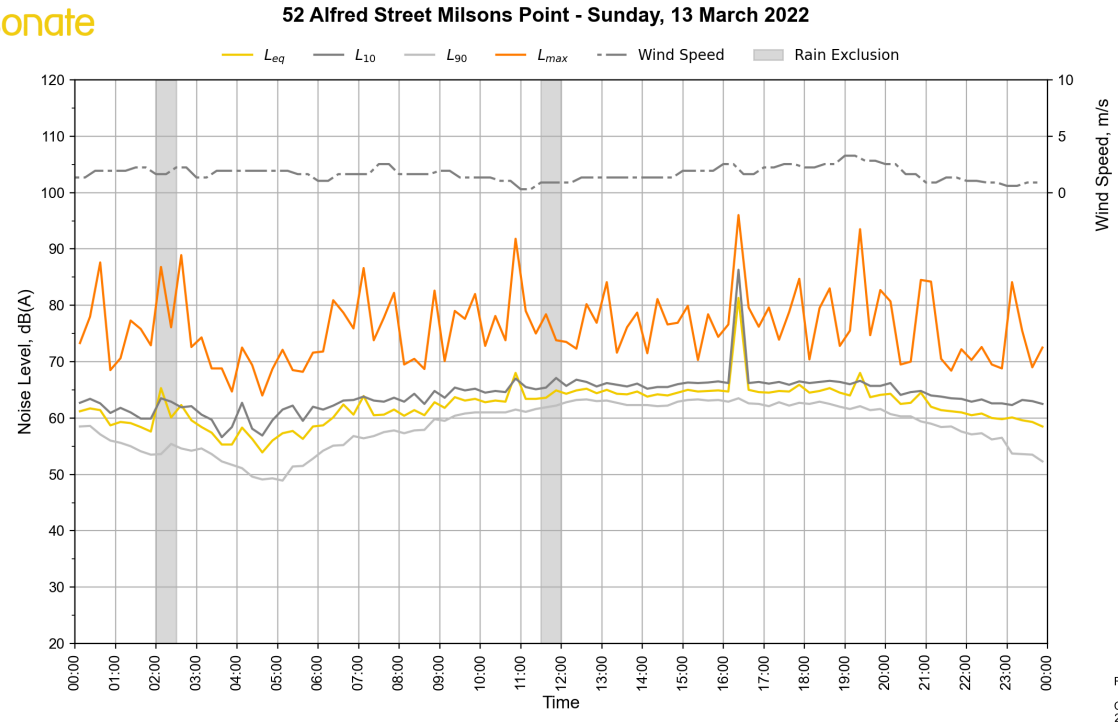
Appendix B – Unattended Noise Measurement Data

UM-02 (22) 52 Alfred Street South, Milsons Point (Level 4 balcony)

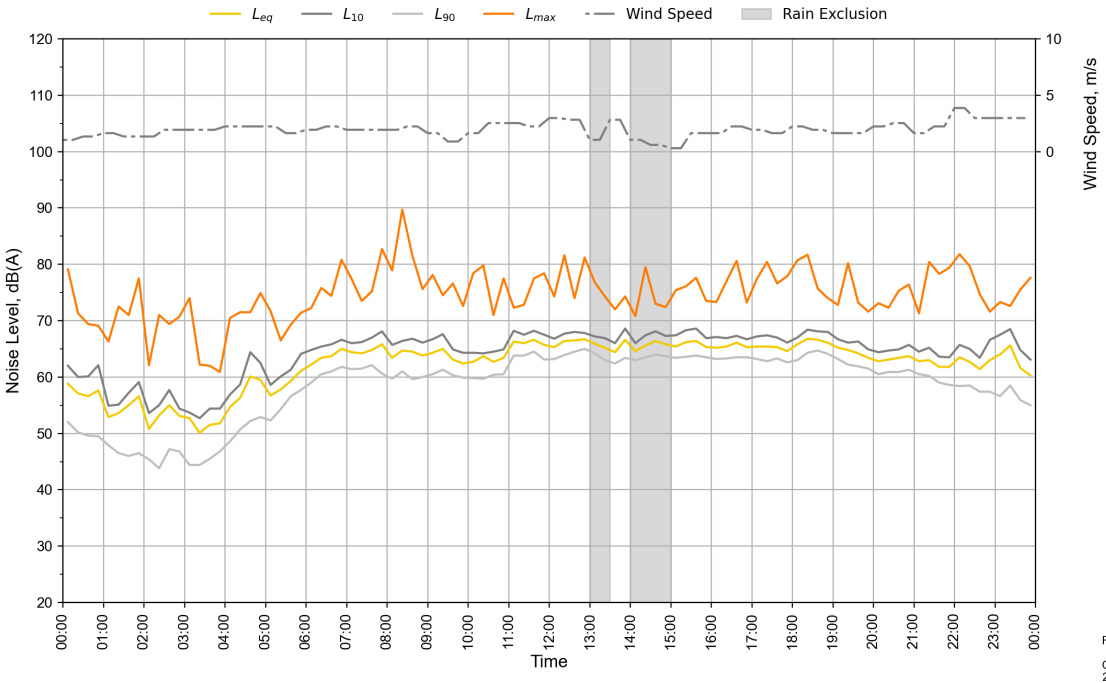




Resonate

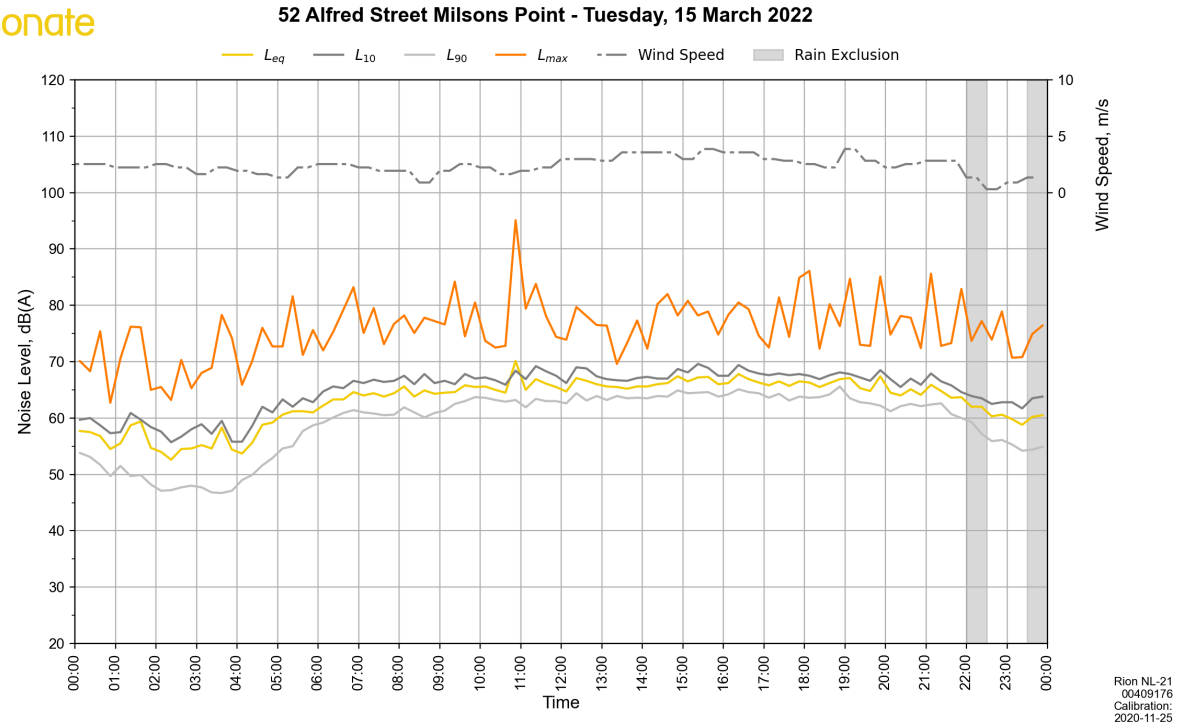


Resonate

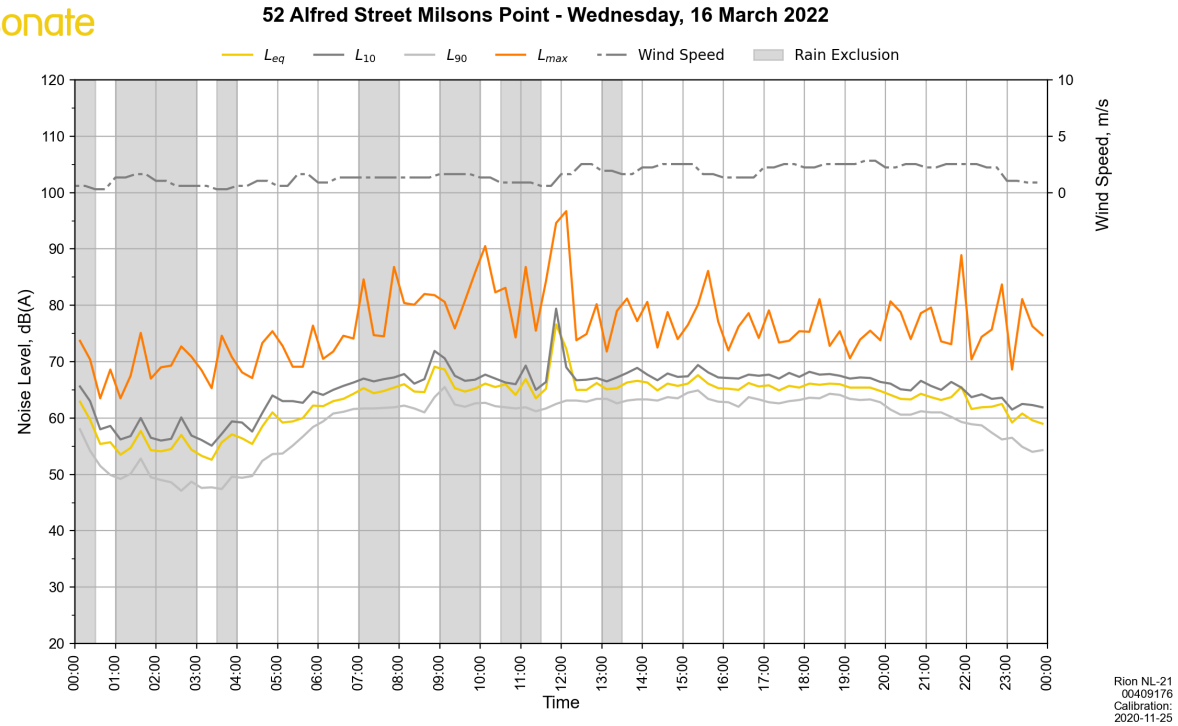


Resonate

Resonate

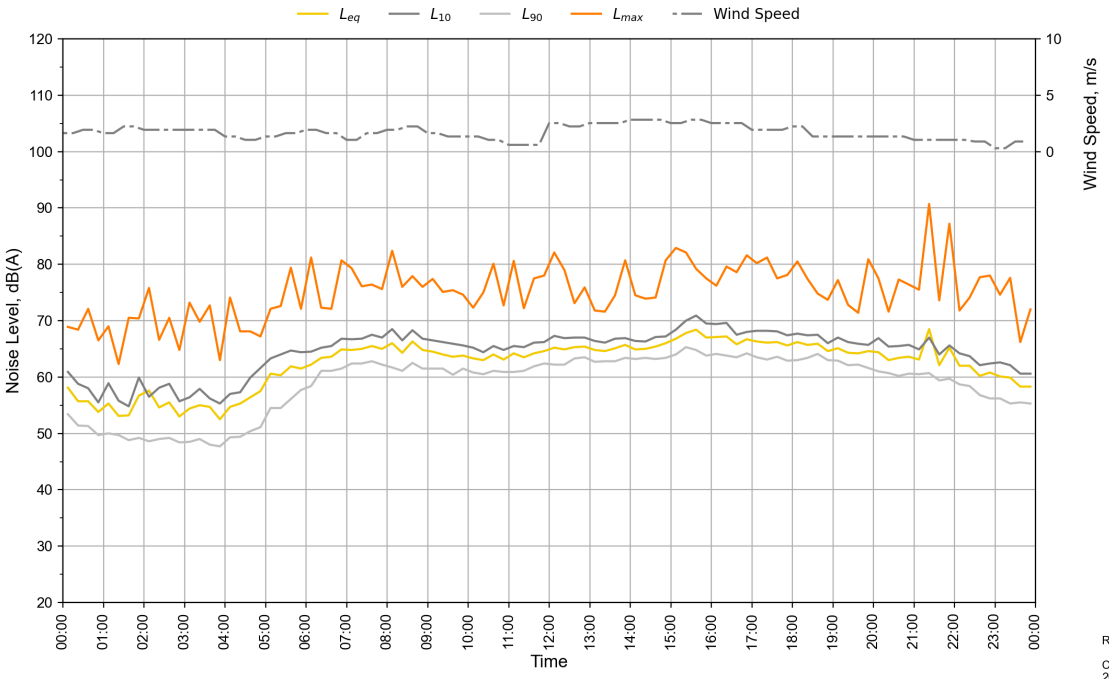


Resonate



Resonate

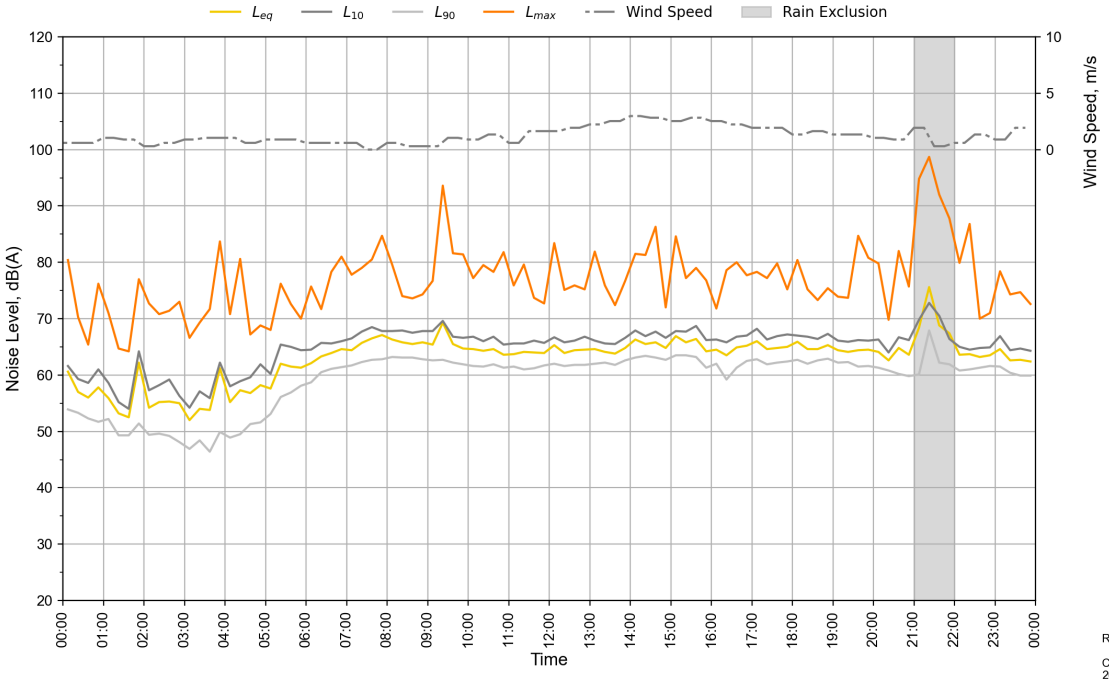
52 Alfred Street Milsons Point - Thursday, 17 March 2022



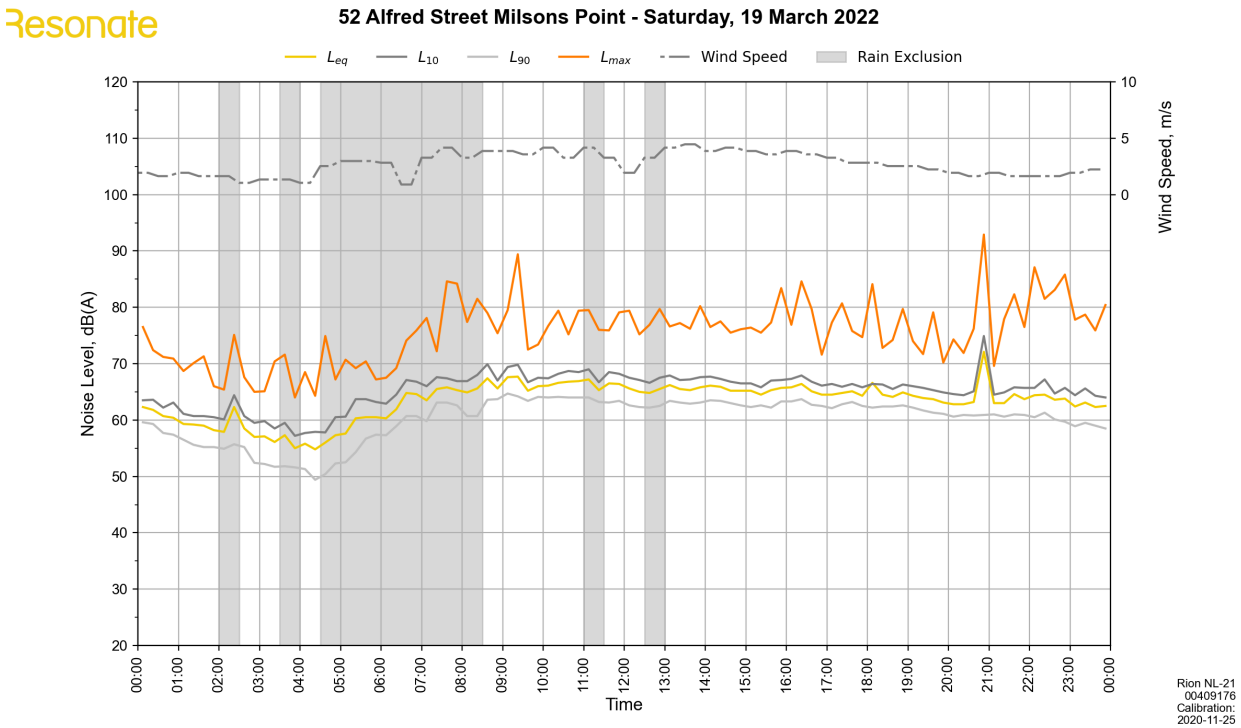
Rion NL-21
00409176
Calibration:
2020-11-25

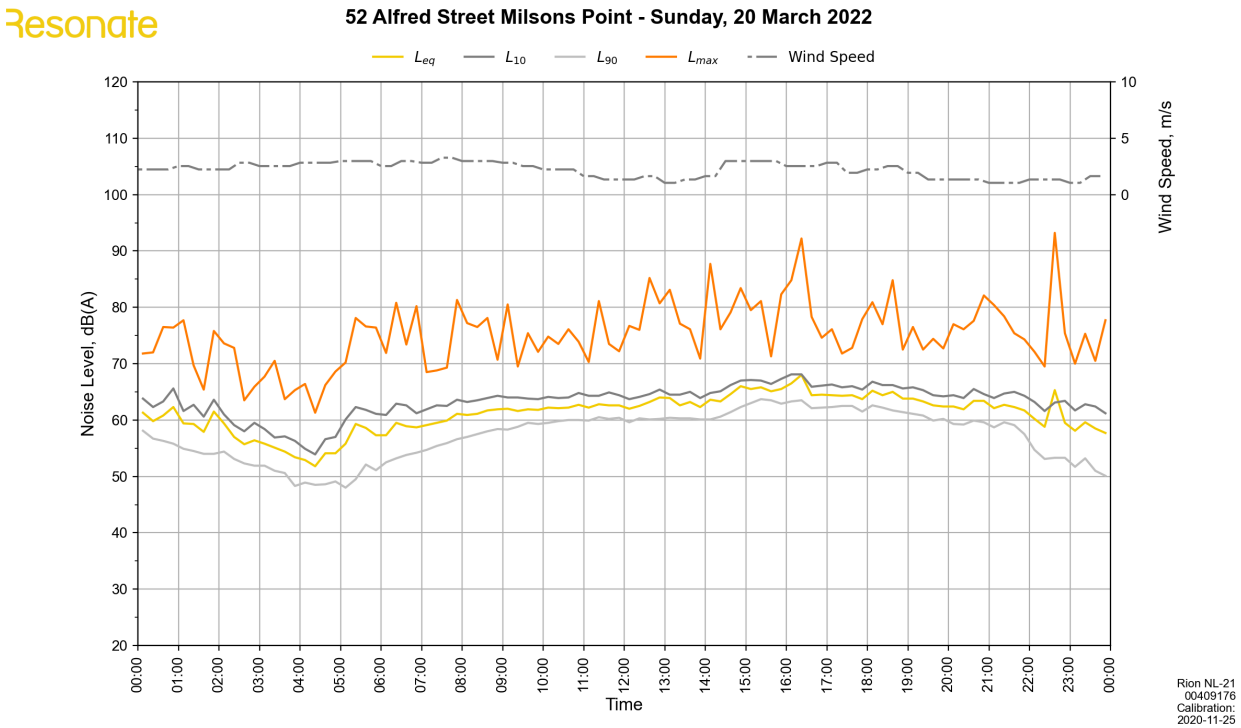
Resonate

52 Alfred Street Milsons Point - Friday, 18 March 2022

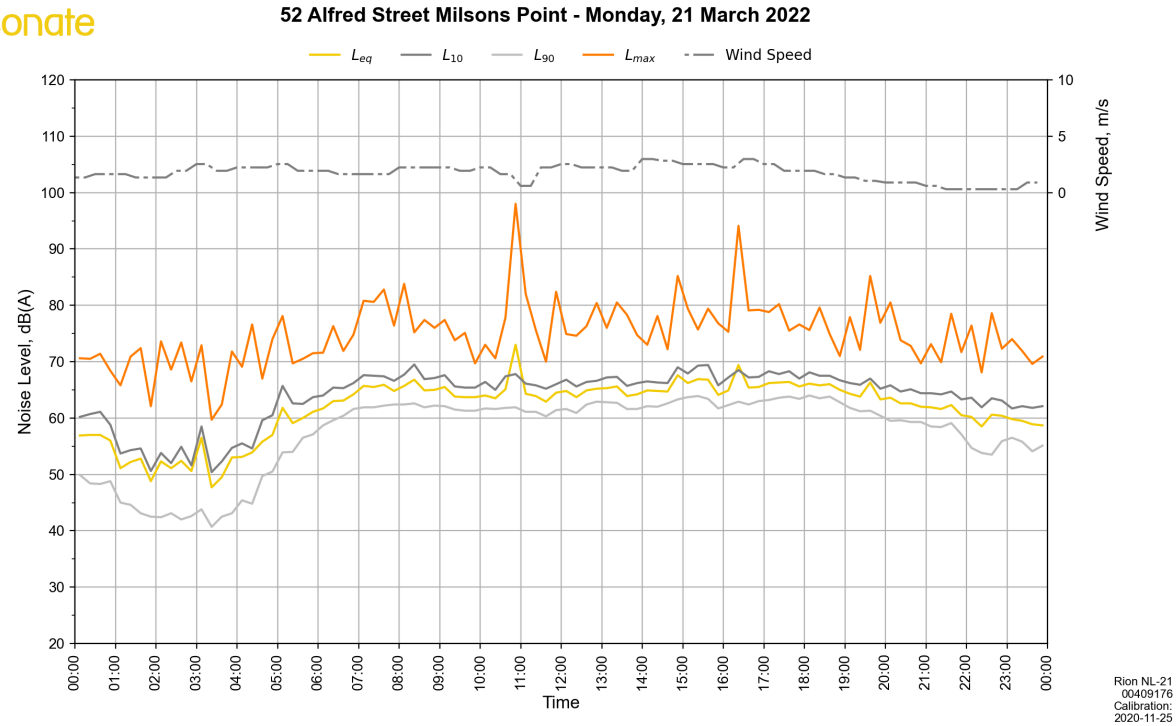


Rion NL-21
00409176
Calibration:
2020-11-25

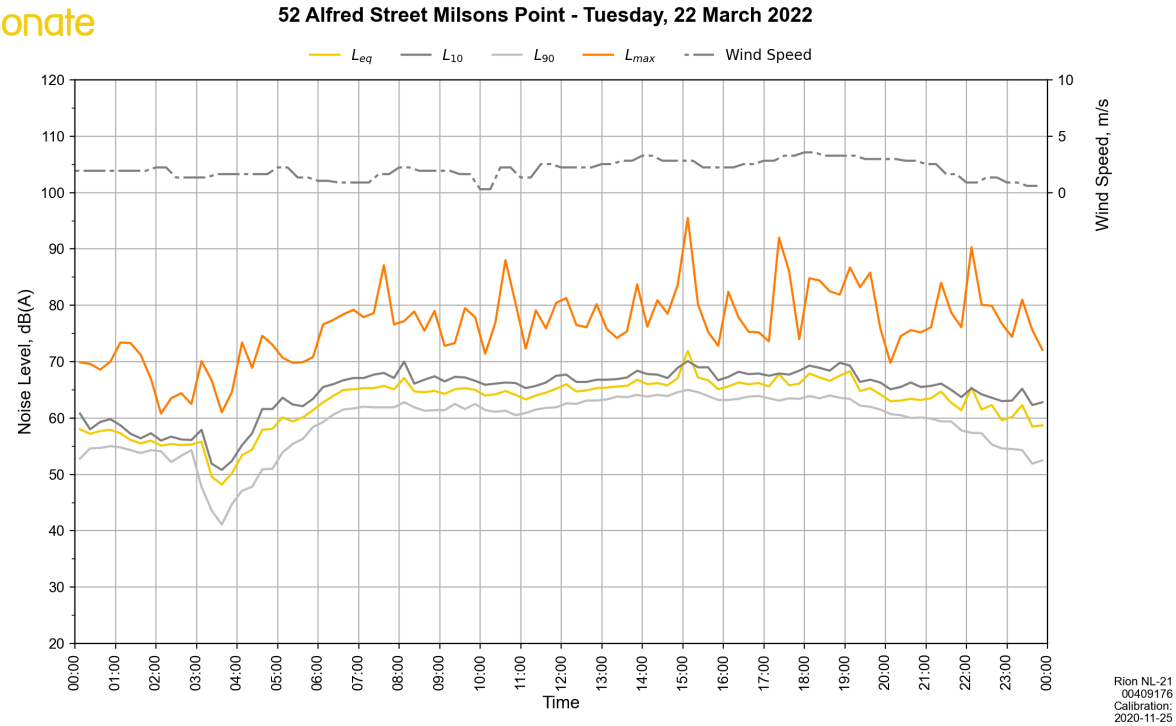

Resonate
52 Alfred Street Milsons Point - Saturday, 19 March 2022
L_{eq} L_{10} L_{90} L_{max} Wind Speed Rain Exclusion
Noise Level, dB(A)
Wind Speed, m/s
Time
Rion NL-21
00409176
Calibration:
2020-11-25


Resonate
52 Alfred Street Milsons Point - Sunday, 20 March 2022
L_{eq} L_{10} L_{90} L_{max} Wind Speed
Noise Level, dB(A)
Wind Speed, m/s
Time
Rion NL-21
00409176
Calibration:
2020-11-25

Resonate

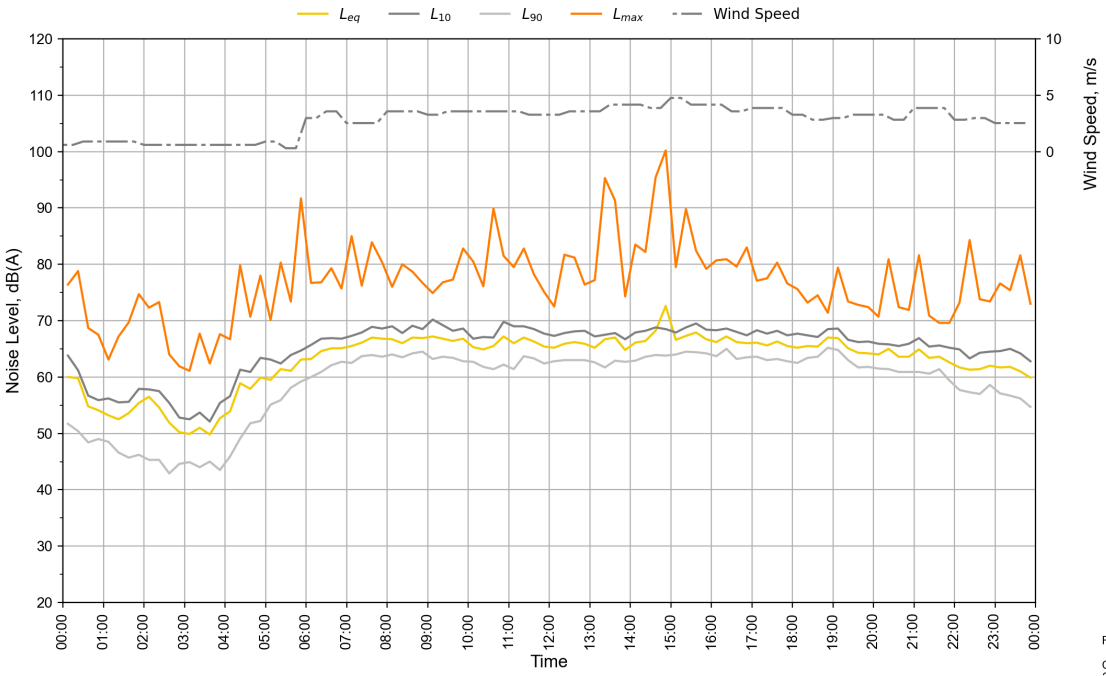


Resonate



Resonate

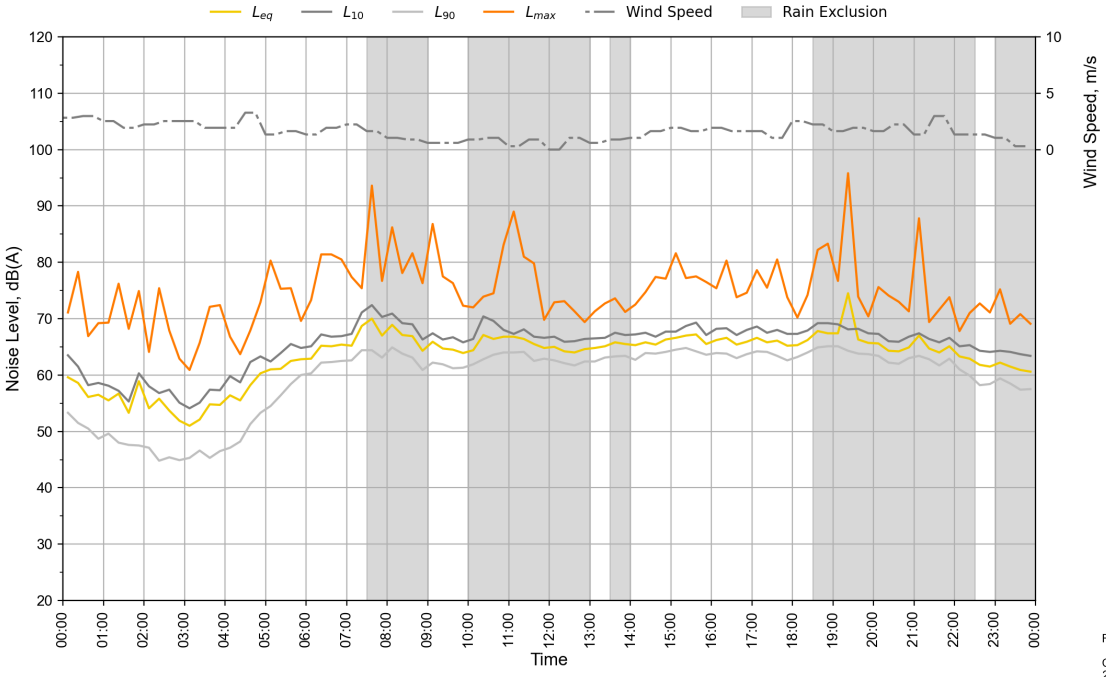
52 Alfred Street Milsons Point - Wednesday, 23 March 2022



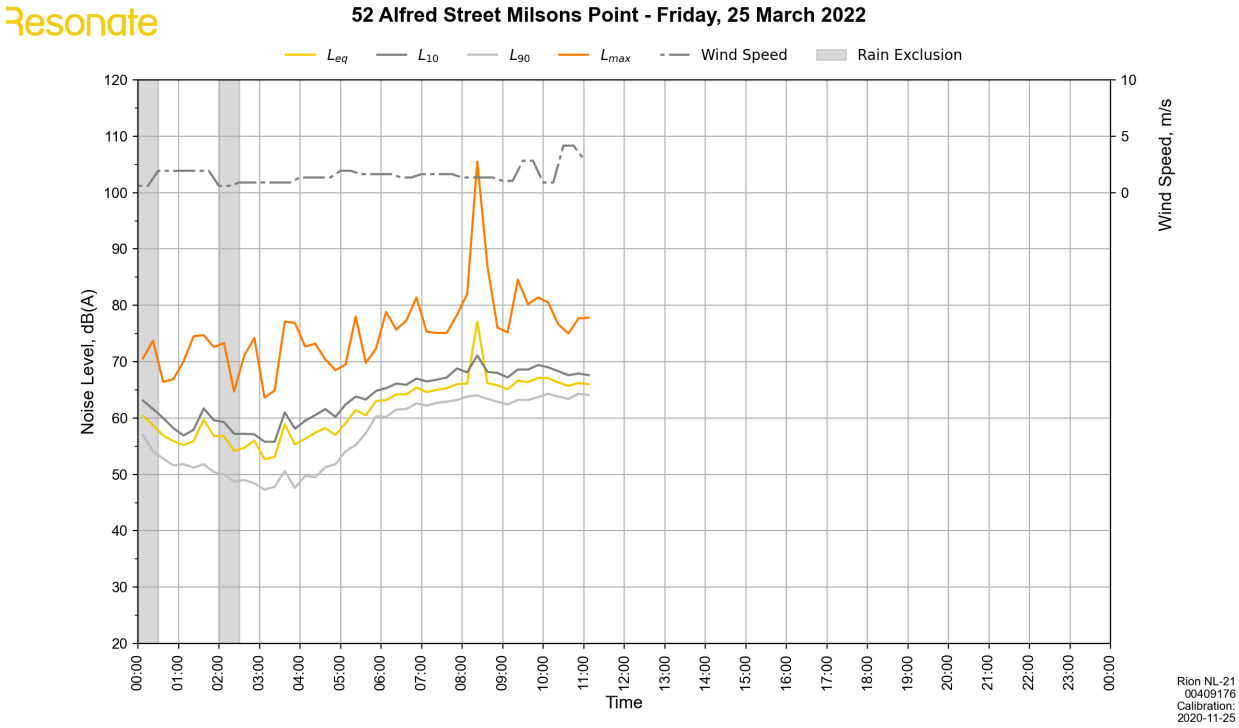
Rion NL-21
00409176
Calibration:
2020-11-25

Resonate

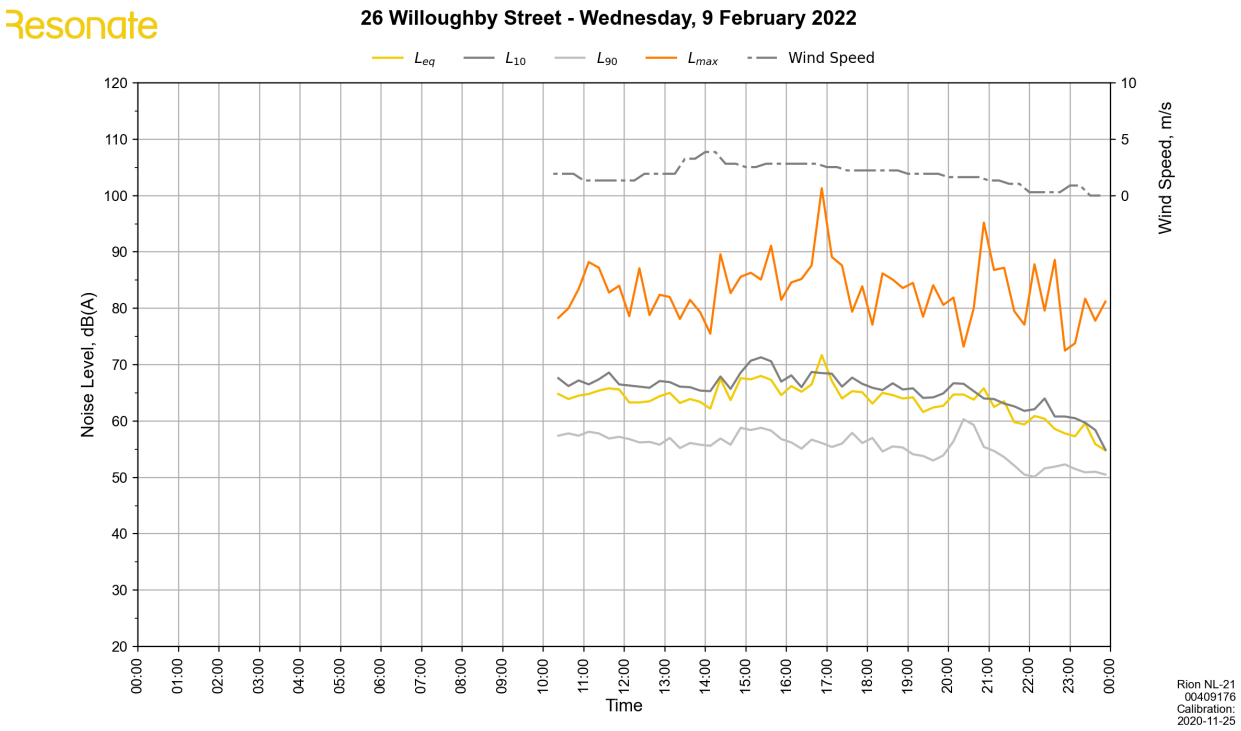
52 Alfred Street Milsons Point - Thursday, 24 March 2022

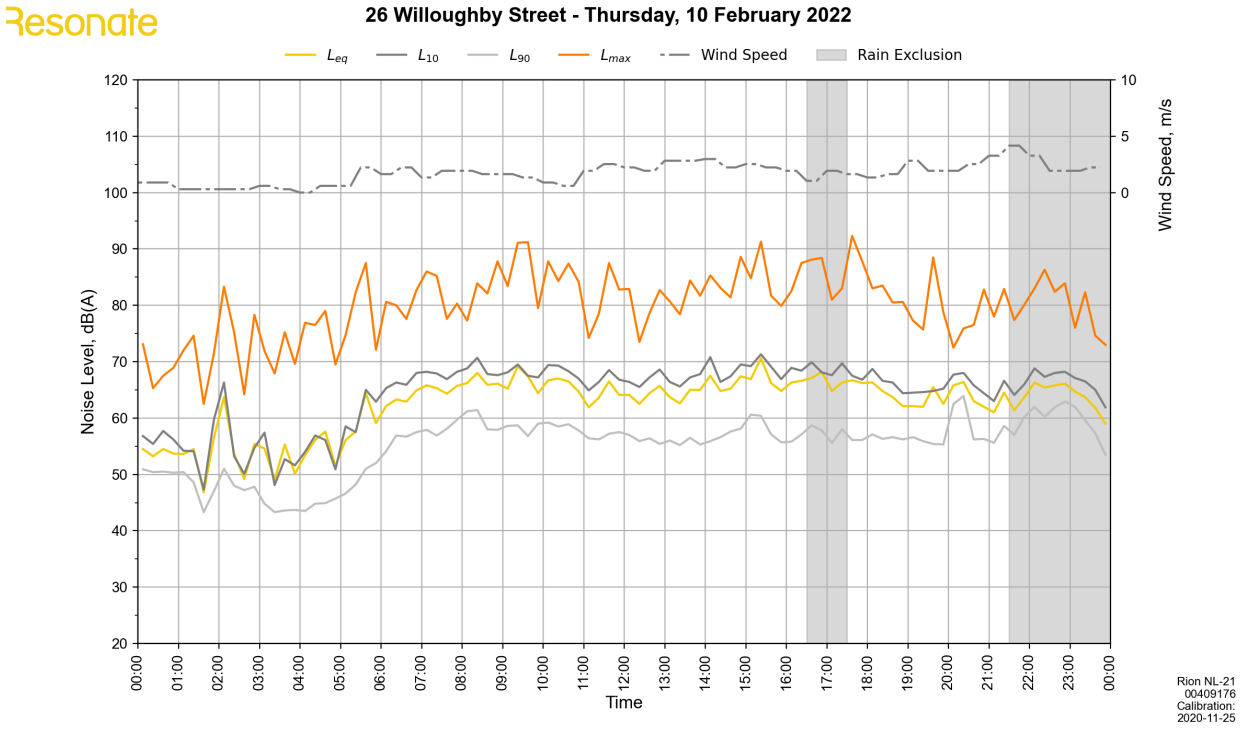


Rion NL-21
00409176
Calibration:
2020-11-25

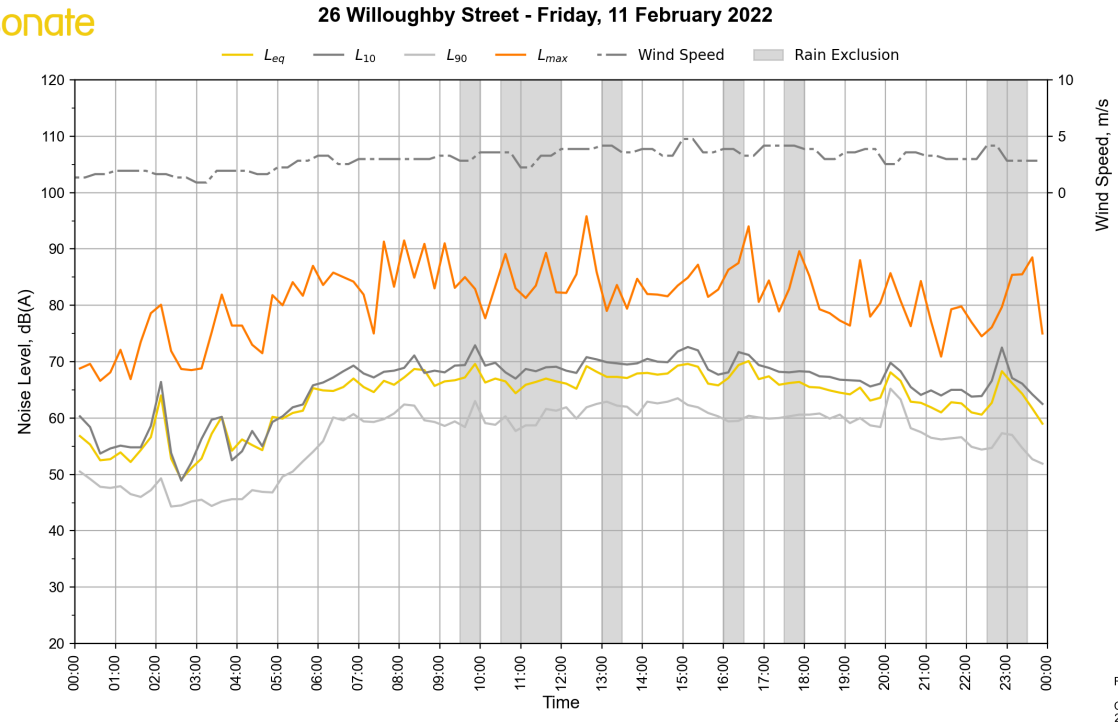

Resonate
52 Alfred Street Milsons Point - Friday, 25 March 2022
L_{eq}
L_{10}
L_{90}
L_{max}
Wind Speed
Rain Exclusion
Noise Level, dB(A)
Wind Speed, m/s
Time
Rion NL-21
00409176
Calibration:
2020-11-25

UM-02 (22) 26 Willoughby Street, Kirribilli

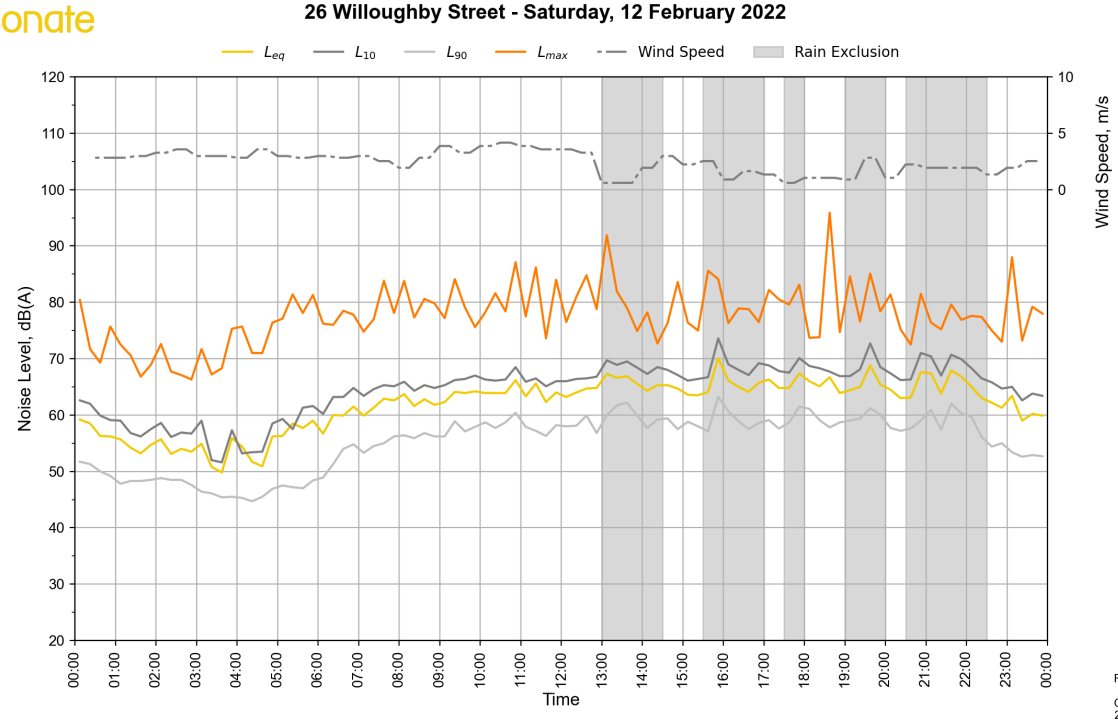




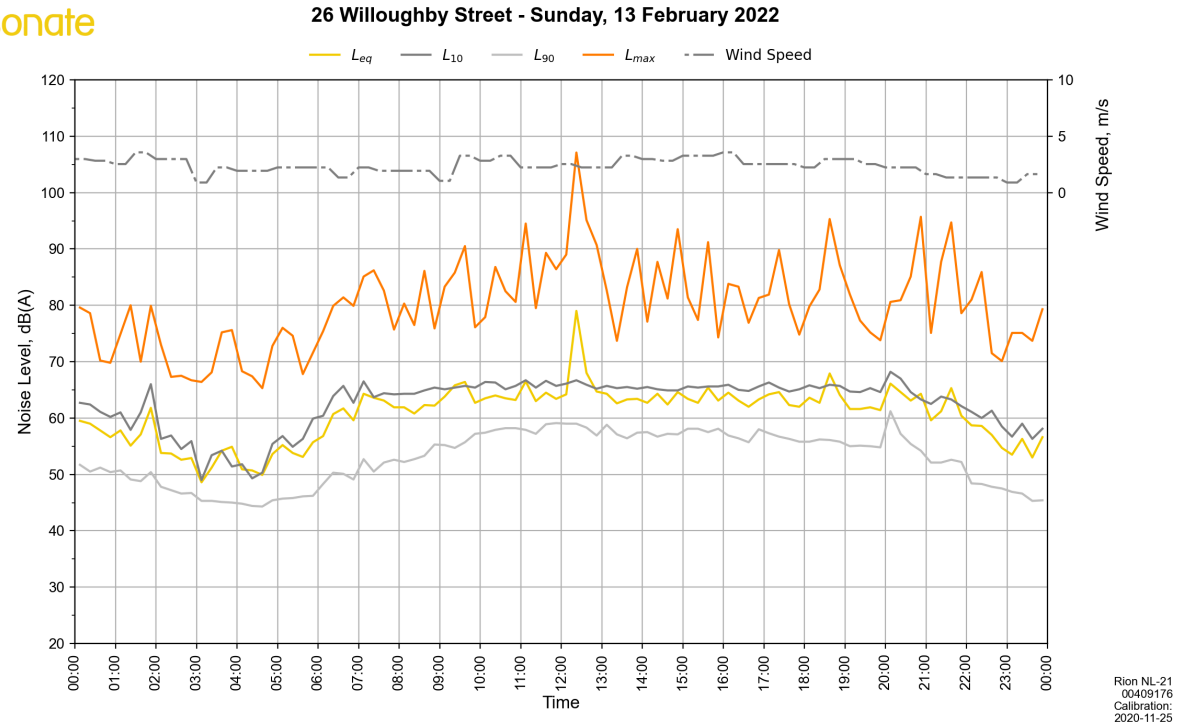
Resonate



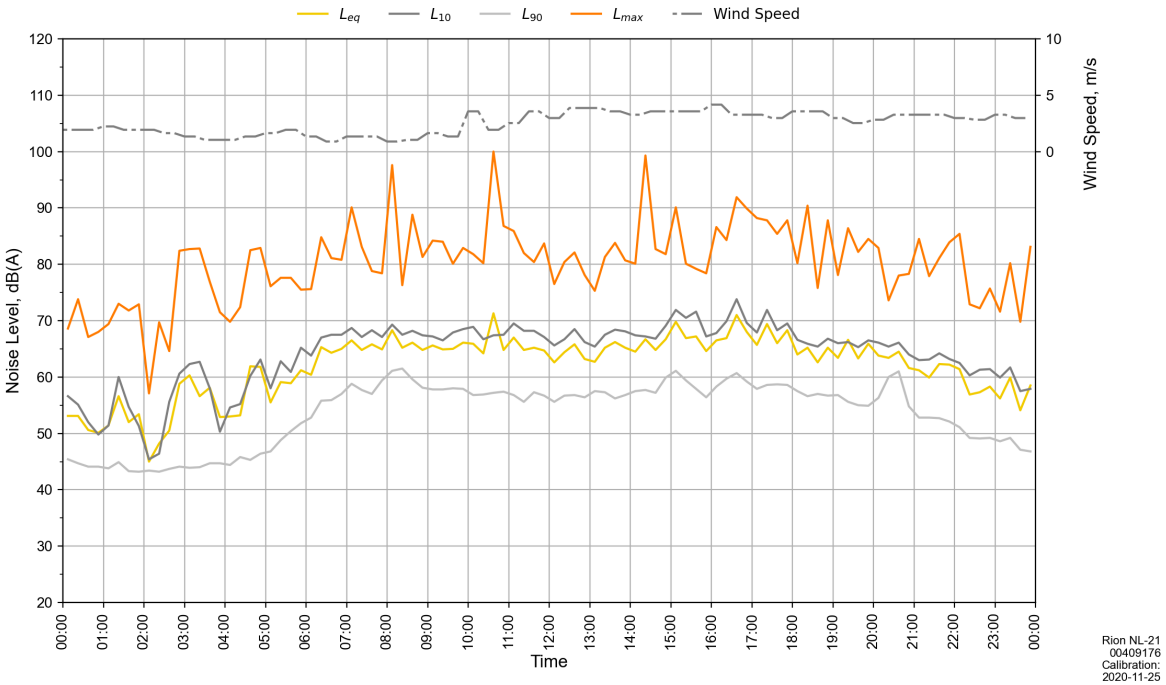
Resonate



Resonate

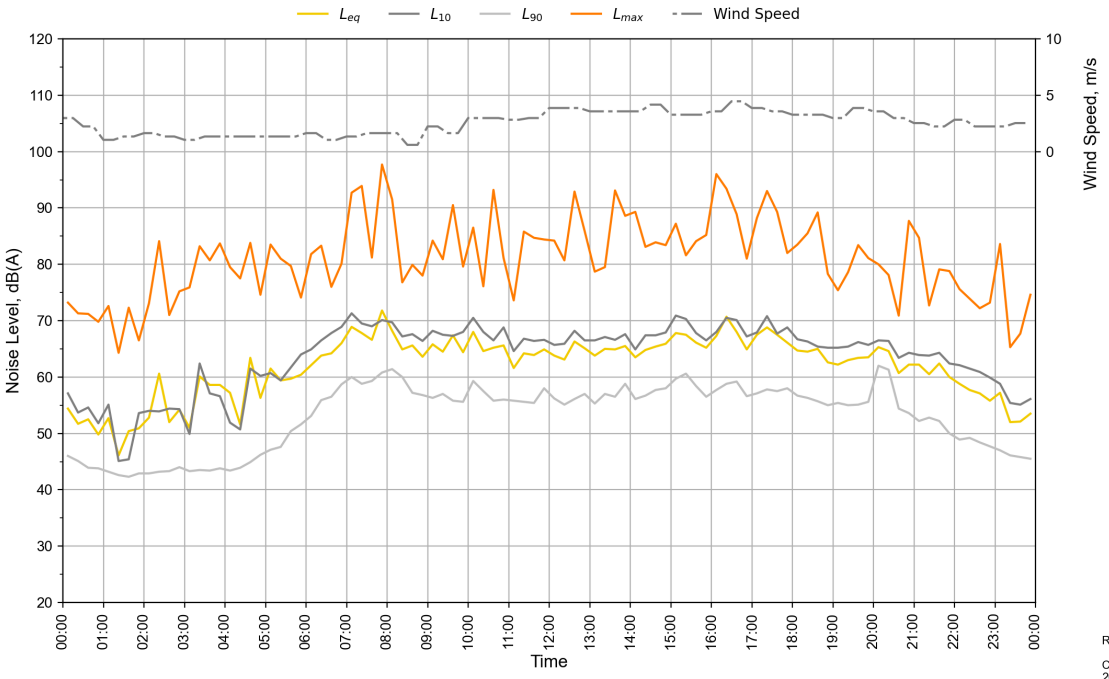


Resonate



Resonate

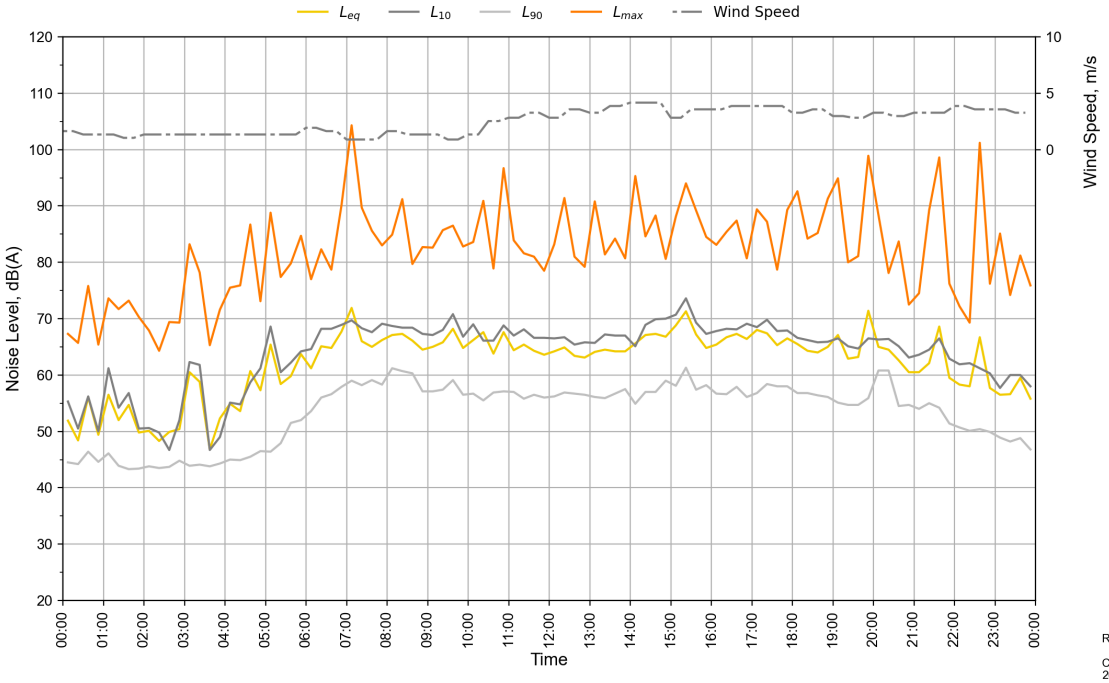
26 Willoughby Street - Tuesday, 15 February 2022



Rion NL-21
00409176
Calibration:
2020-11-25

Resonate

26 Willoughby Street - Wednesday, 16 February 2022

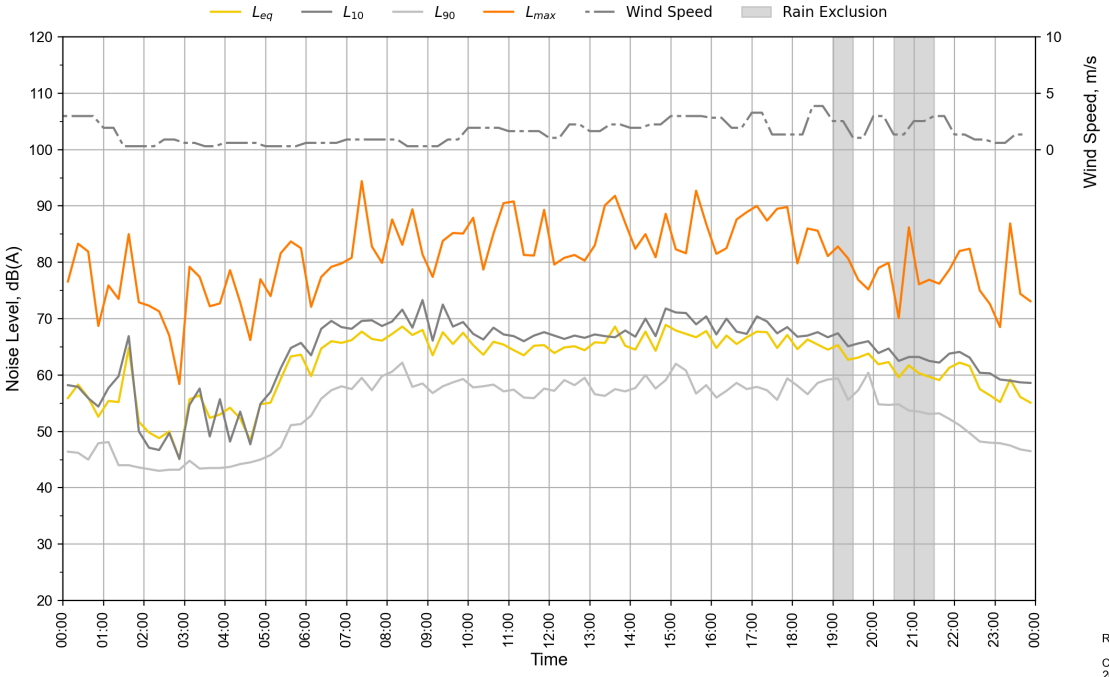


Rion NL-21
00409176
Calibration:
2020-11-25

Resonate

Resonate

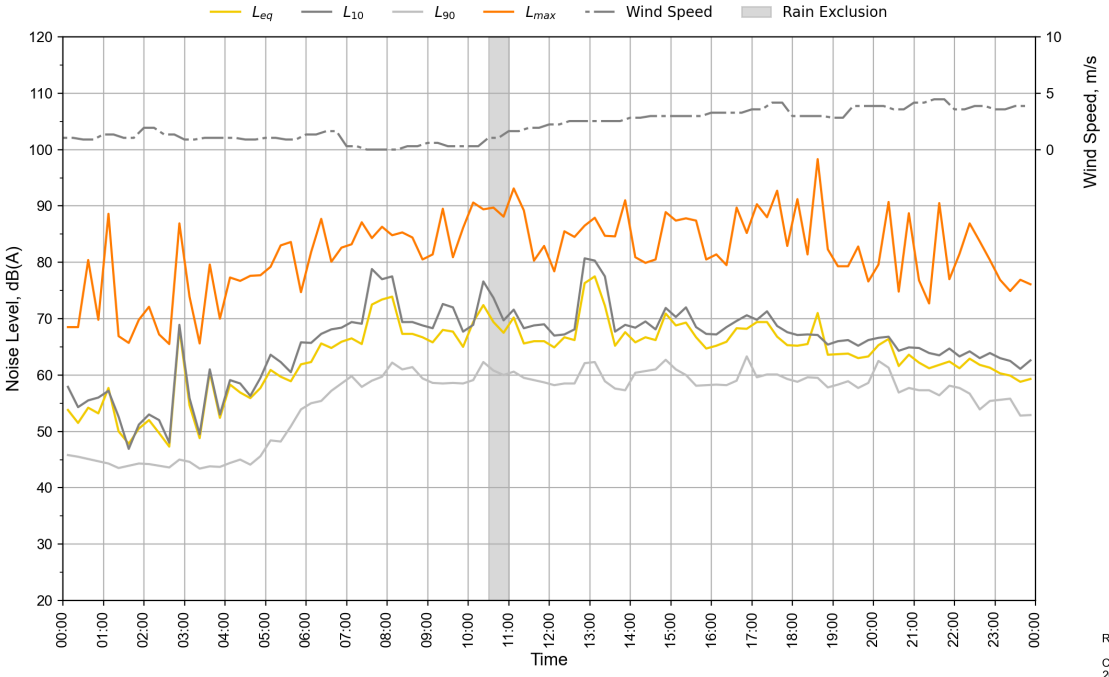
26 Willoughby Street - Thursday, 17 February 2022



Rion NL-21
00409176
Calibration:
2020-11-25

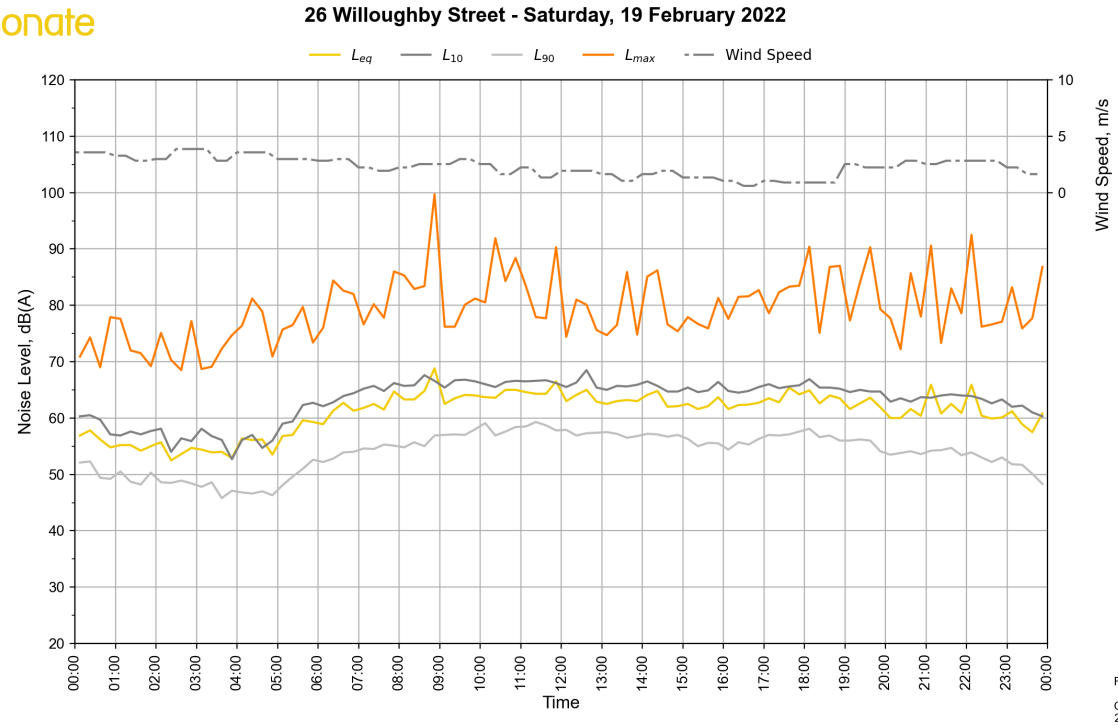
Resonate

26 Willoughby Street - Friday, 18 February 2022



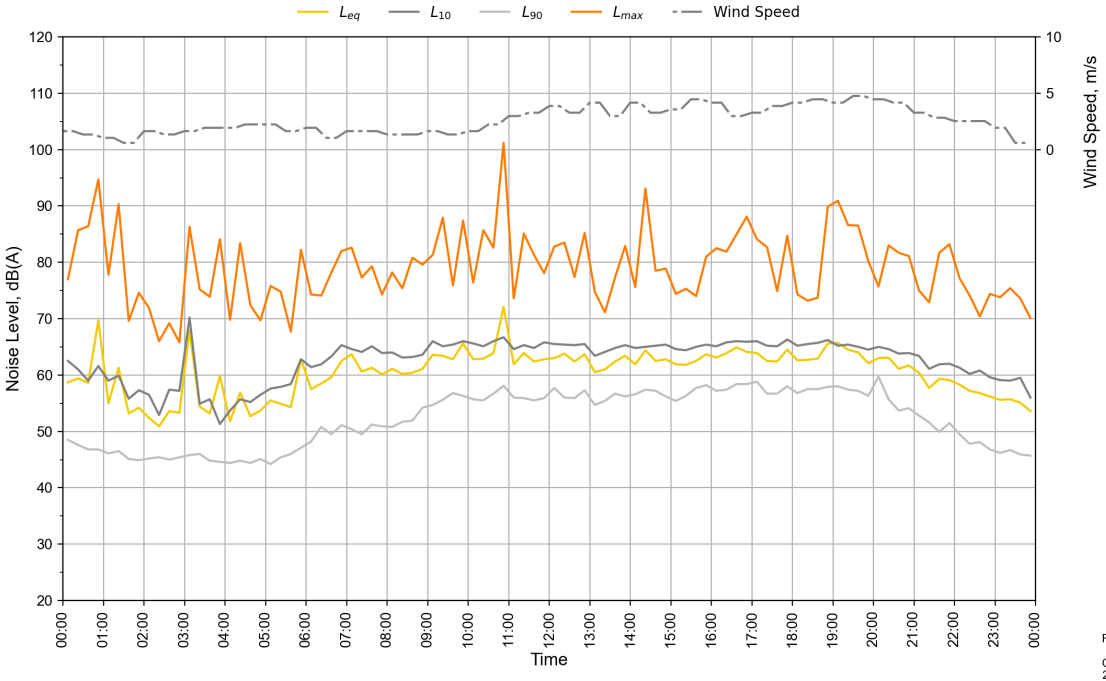
Rion NL-21
00409176
Calibration:
2020-11-25

Resonate



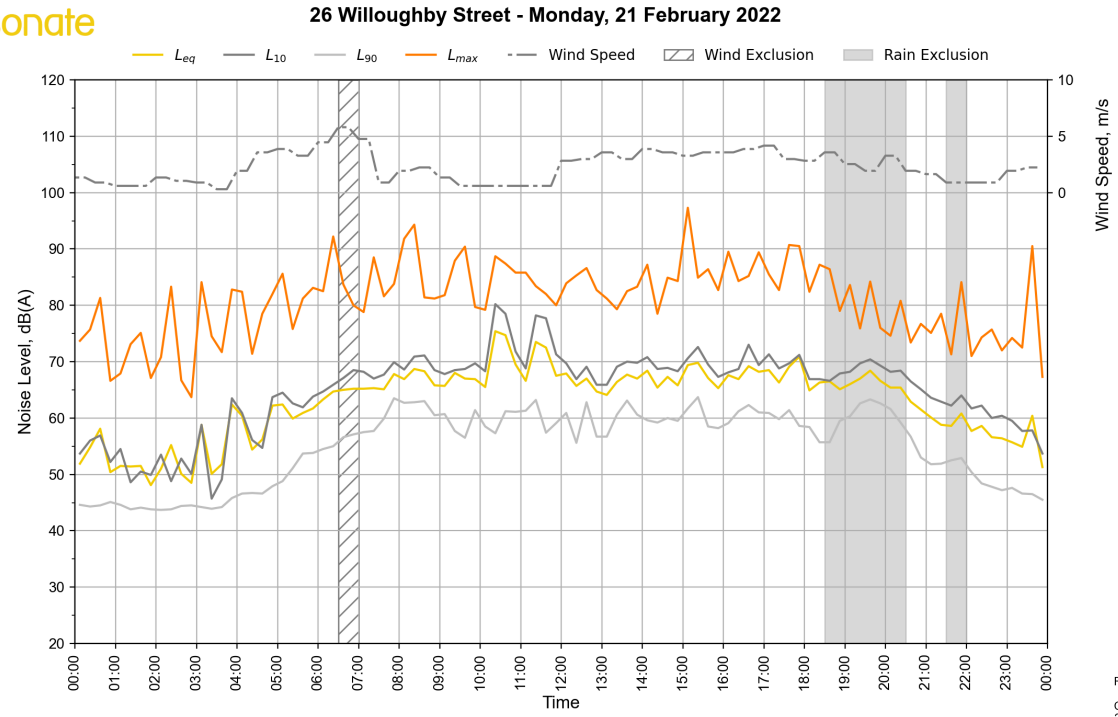
Rion NL-21
00409176
Calibration:
2020-11-25

Resonate

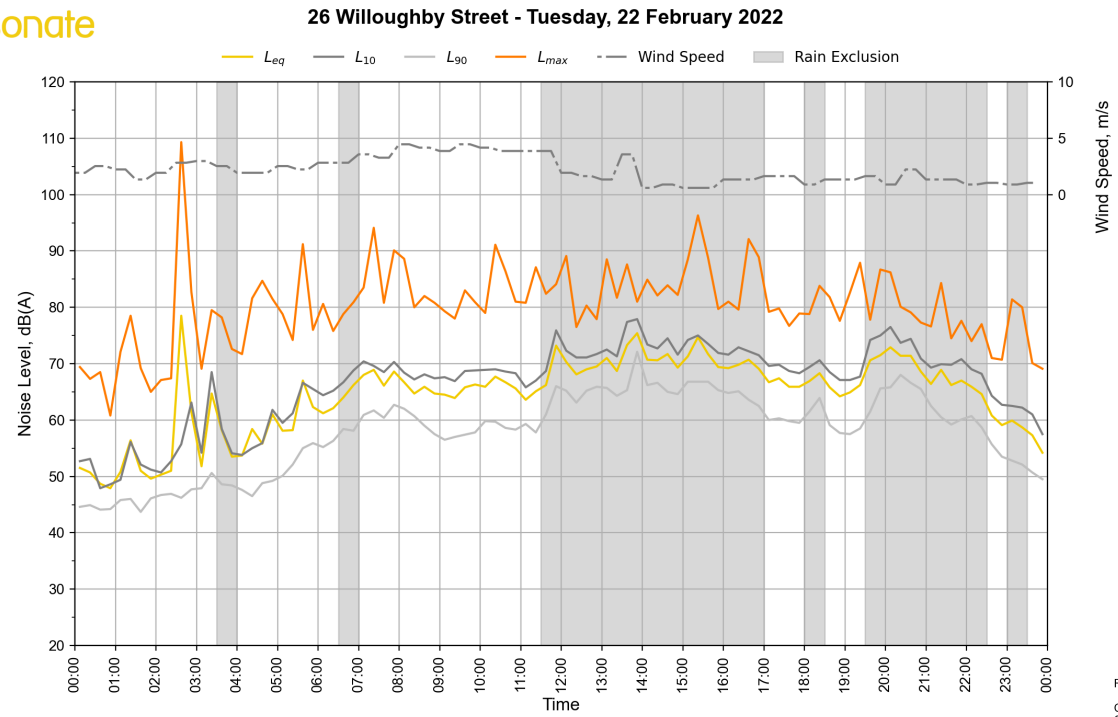


Rion NL-21
00409176
Calibration:
2020-11-25

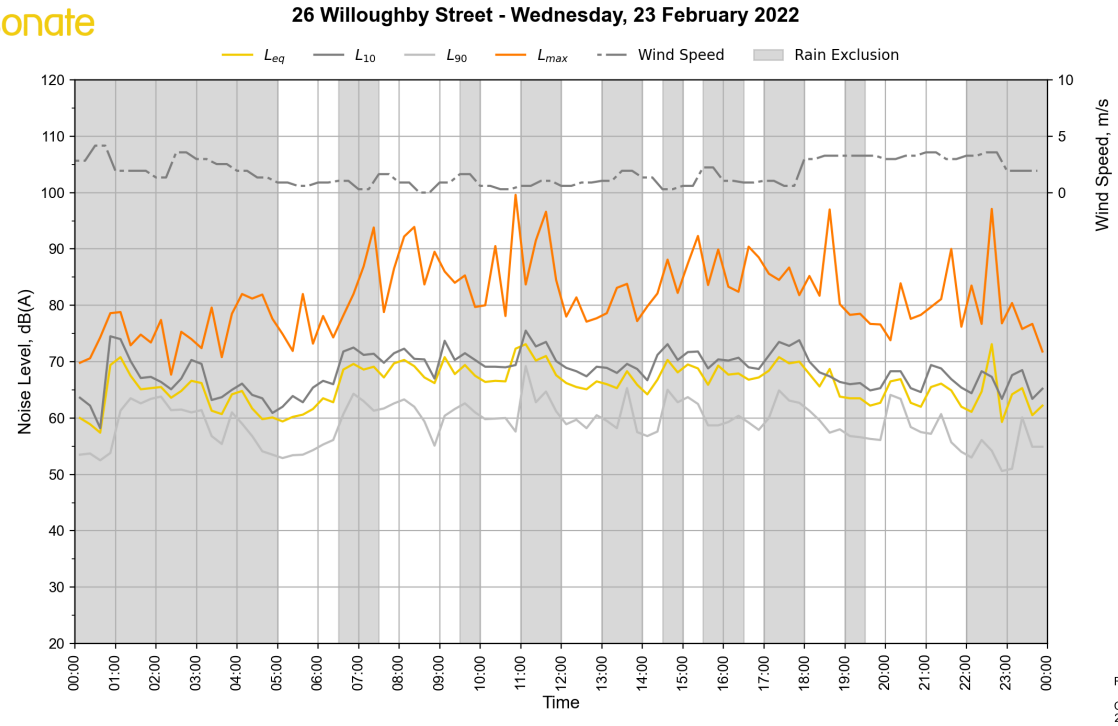
Resonate



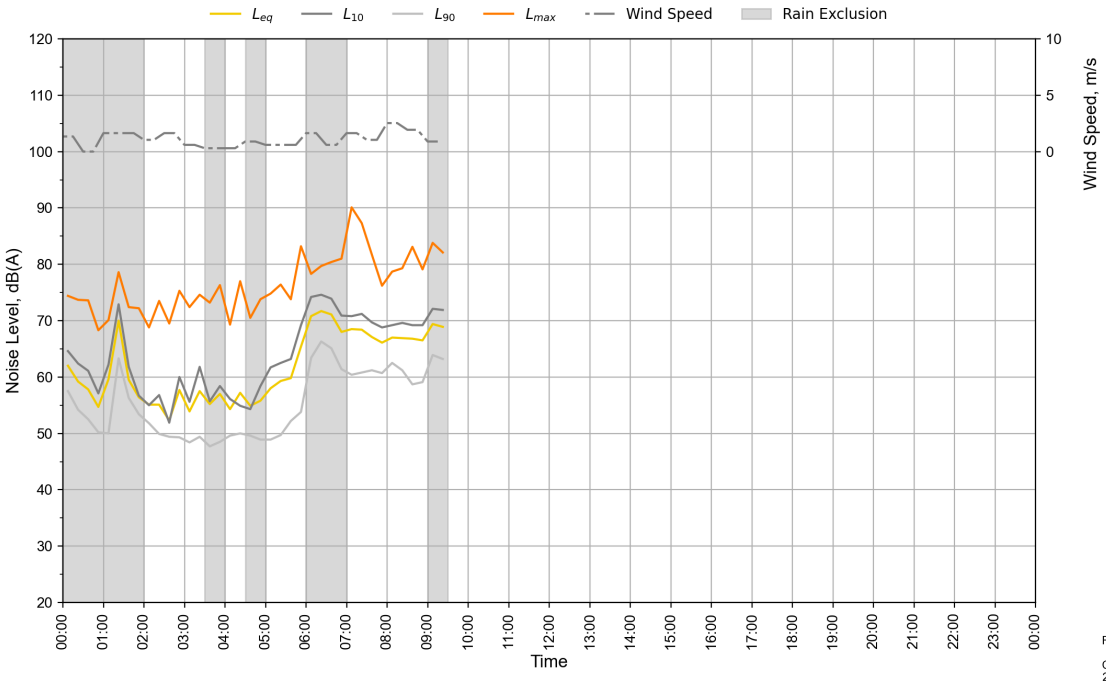
Resonate



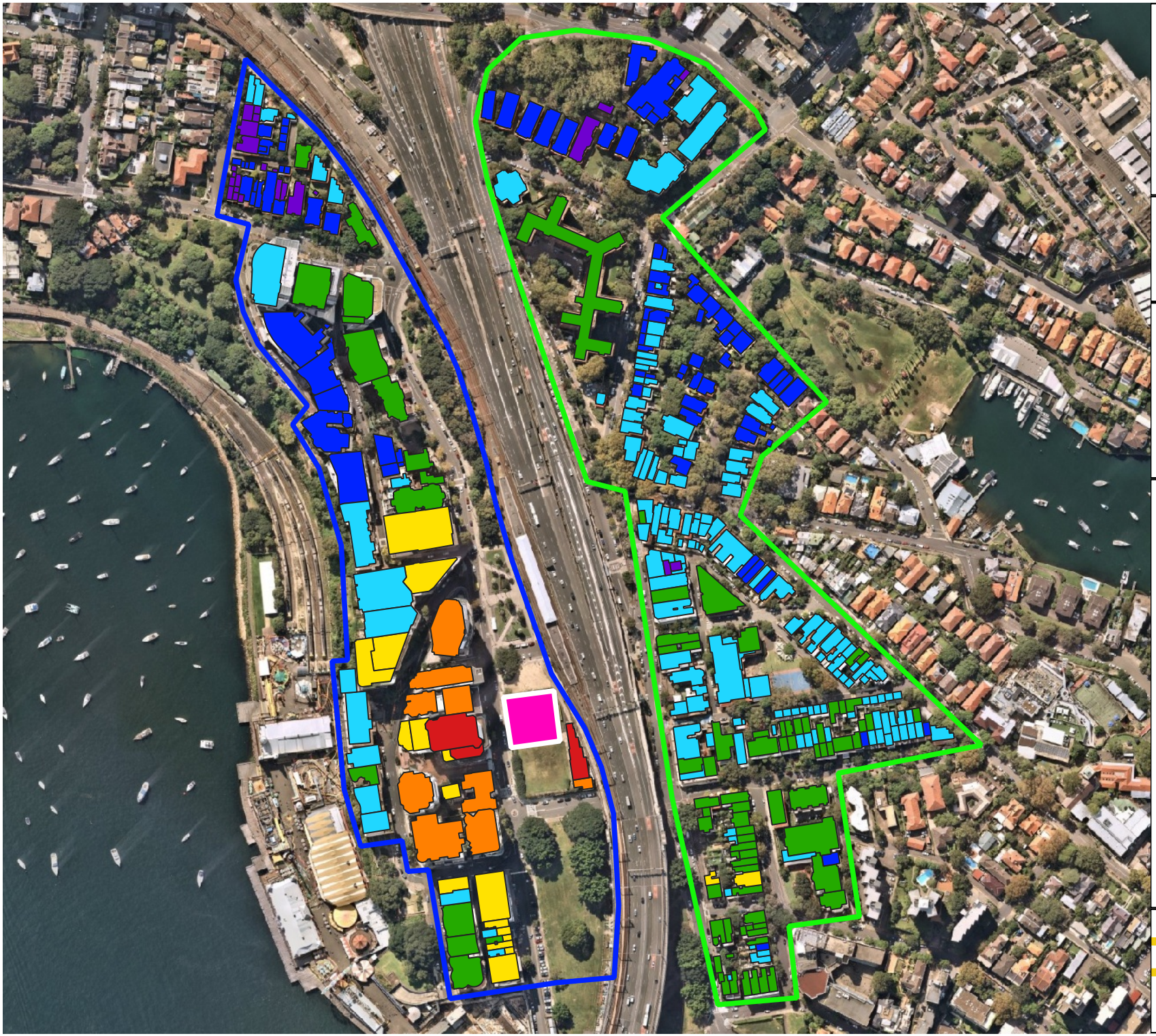
Resonate



Resonate



Appendix C – Predicted Noise Levels



Sydney Harbour Bridge Northern Cycleway

APPENDIX C1
Predicted Noise Levels of CS1 Site Establishment (Standard Hours Works)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- CS1: Site Establishment Location

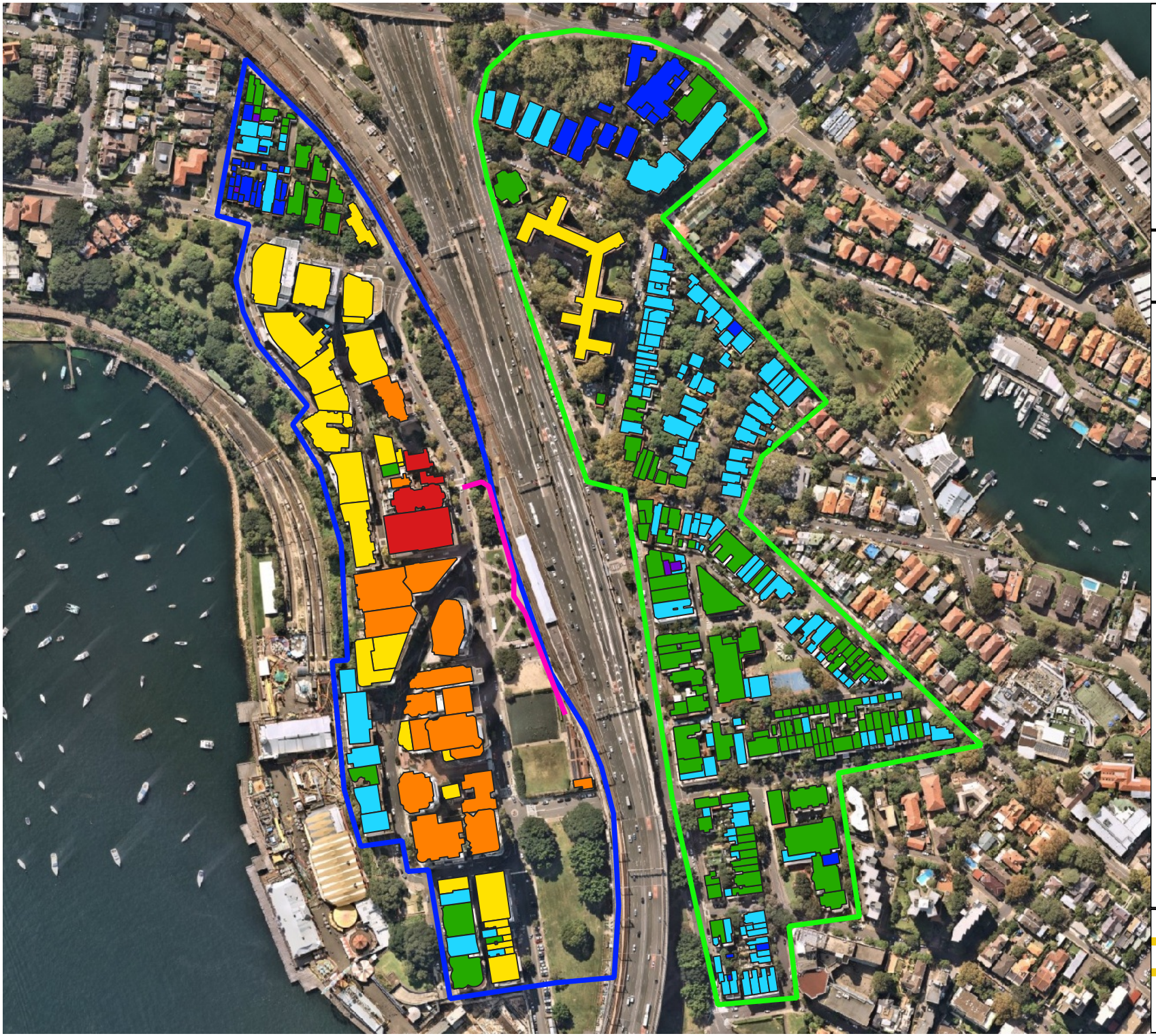
Predicted Noise Levels dB(A)

- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- > 80

Noise Catchment Area

- NCA01
- NCA02

Resonate



Sydney Harbour Bridge Northern Cycleway

APPENDIX C2
Predicted Noise Levels of CS2 Ramp Construction (Standard Hours Works & OOHW)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

CS2: Ramp Construction Location

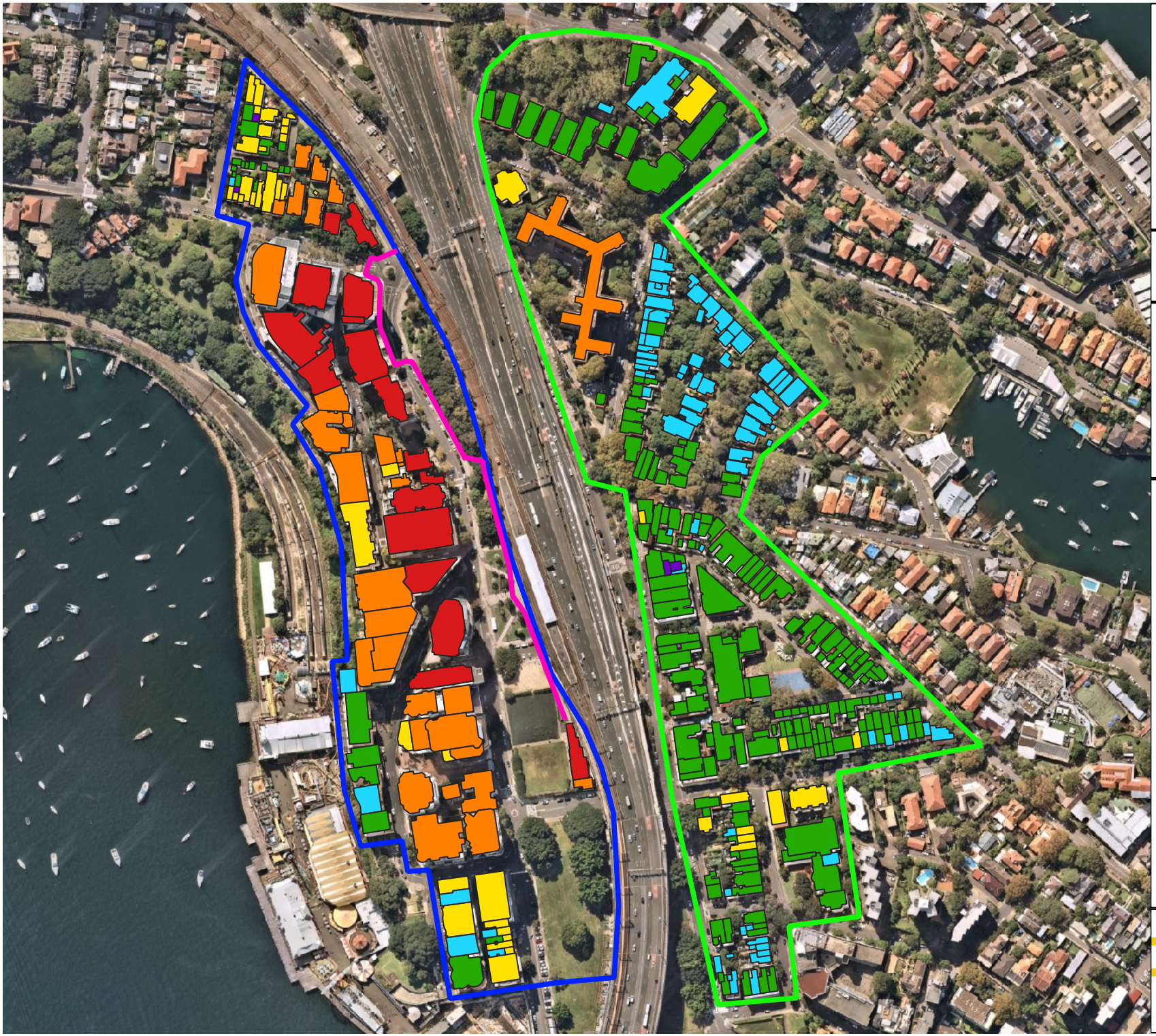
Predicted Noise Levels dB(A)

- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- > 80

Noise Catchment Area

- NCA01
- NCA02

Resonate



Sydney Harbour Bridge Northern Cycleway

APPENDIX C3
Predicted Noise Levels of CS3 Groundworks, Cycleway Works & Landscaping (Standard Hours Works)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

CS3: Works Location

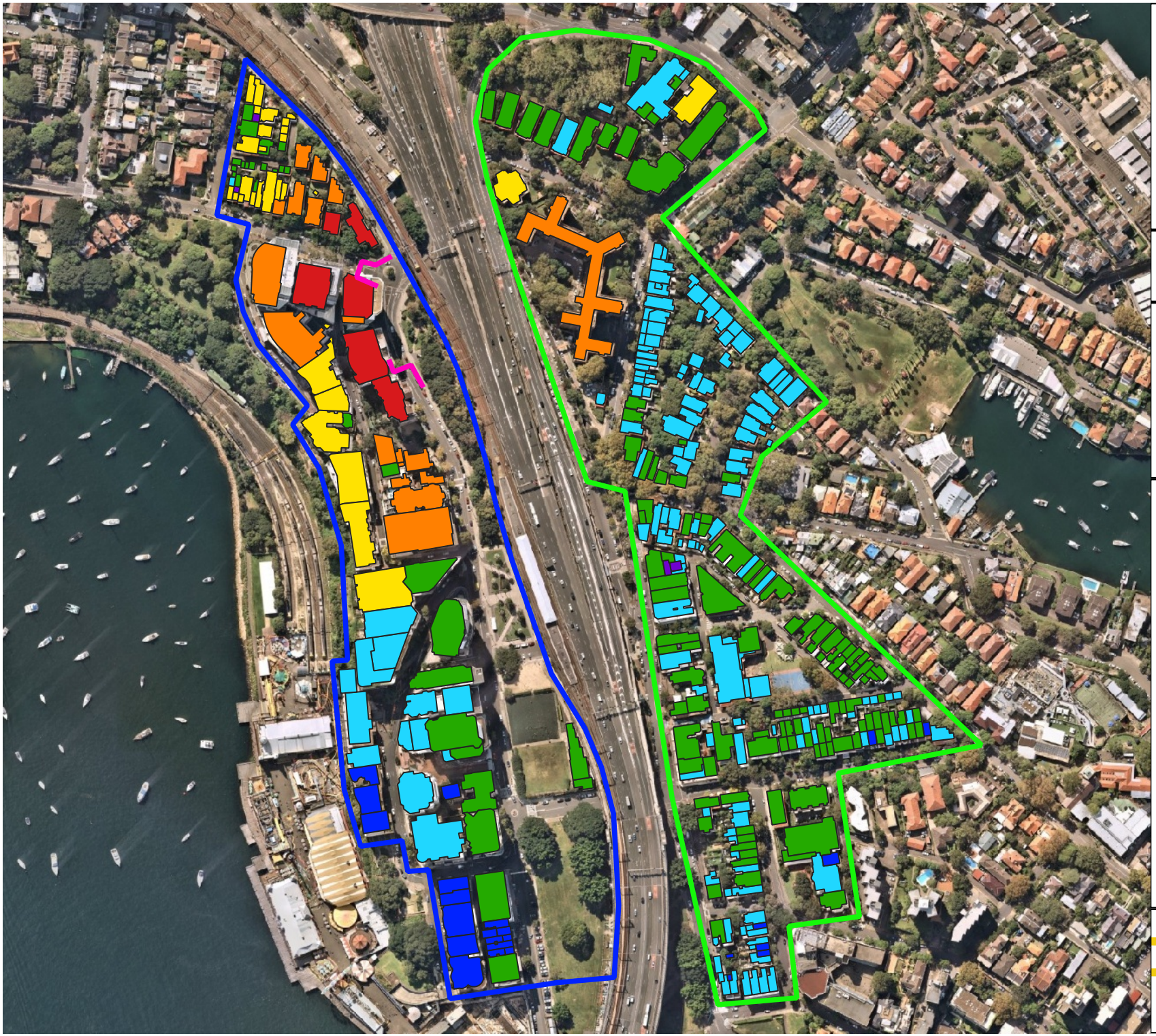
Predicted Noise Levels dB(A)

- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- > 80

Noise Catchment Area

- NCA01
- NCA02

Resonate



Sydney Harbour Bridge Northern Cycleway

APPENDIX C3.1 Predicted Noise Levels of CS3.1 Cycleway Works (OOHW)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- CS3.1: Cycleway Works Location

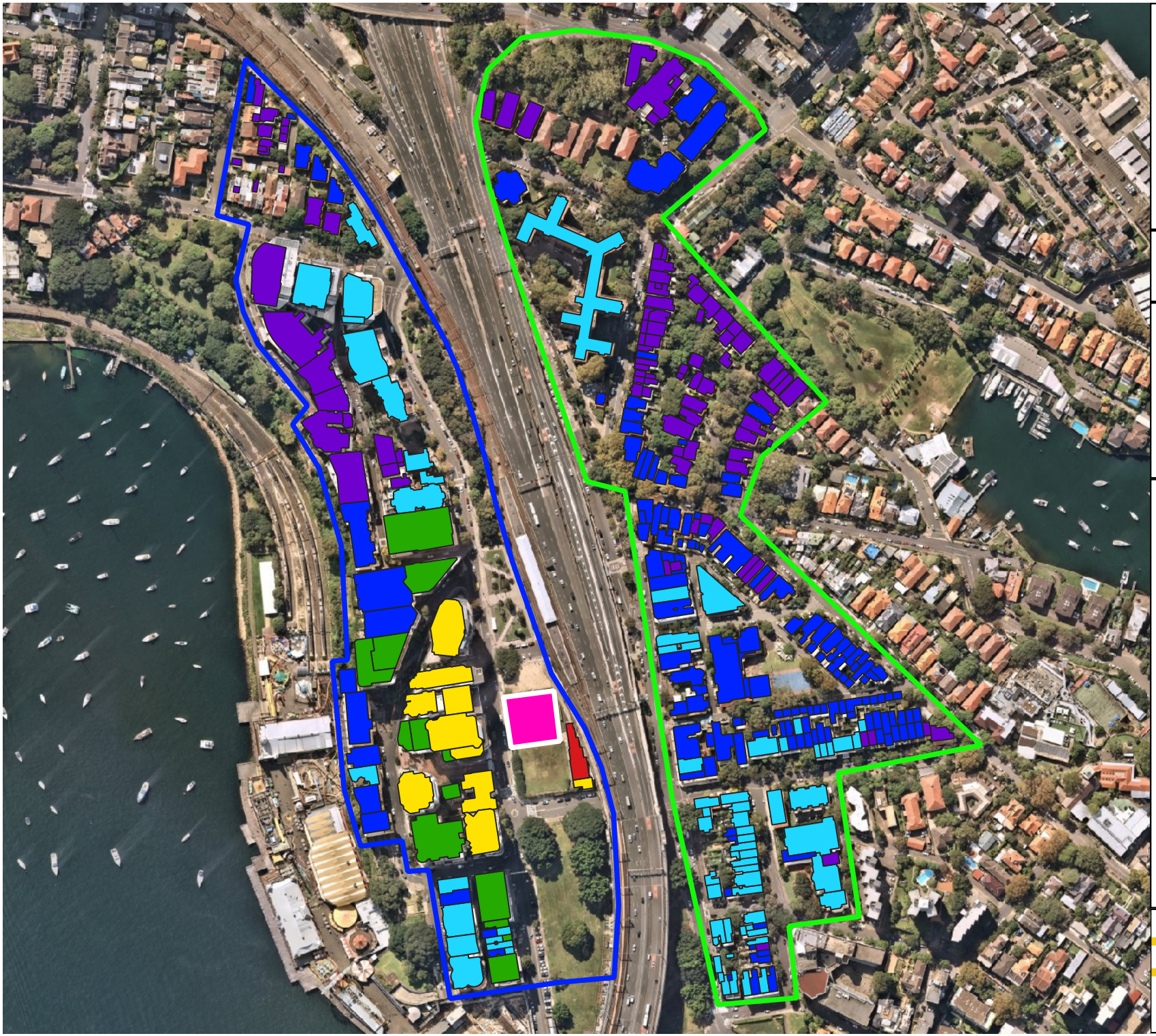
Predicted Noise Levels dB(A)

- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- > 80

Noise Catchment Area

- NCA01
- NCA02

Resonate



Sydney Harbour Bridge Northern Cycleway

APPENDIX C4
Predicted Noise Levels of CS4 Demobilisation (Standard Hours Works)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

CS4: Demobilisation Location

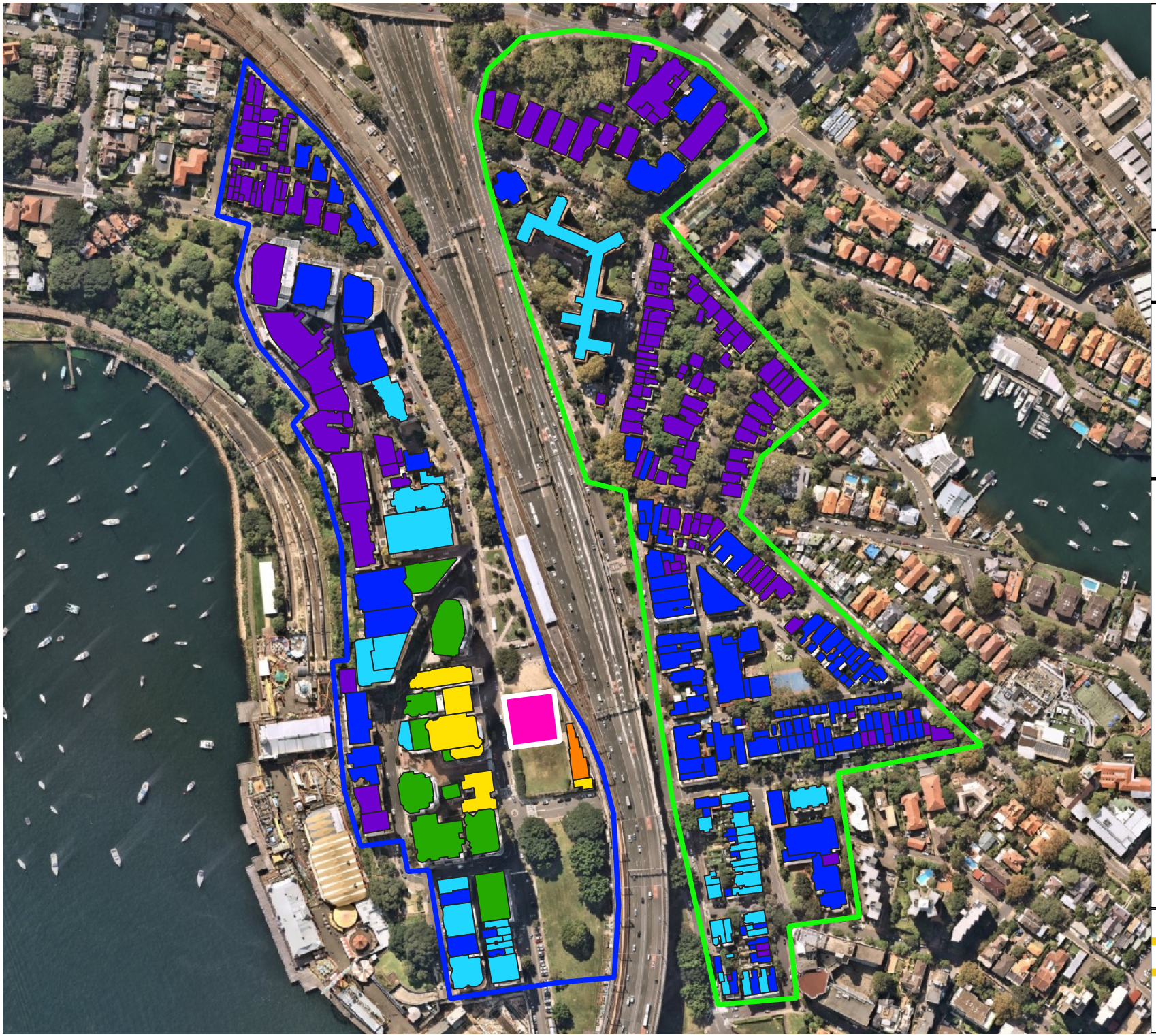
Predicted Noise Levels dB(A)

- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- > 80

Noise Catchment Area

- NCA01
- NCA02

Resonate



Sydney Harbour Bridge Northern Cycleway

APPENDIX C5
Predicted Noise Levels of CS5 Ancillary Facility (Standard Hours Works)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- CS5: Ancillary Facility Location

Predicted Noise Levels dB(A)

- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- > 80

Noise Catchment Area

- NCA01
- NCA02

Resonate

Appendix D – NML Exceedance and Additional Noise Mitigation Maps

Sydney Harbour Bridge Northern Cycleway

APPENDIX D1
Predicted NML Exceedances of CS1 Site Establishment (Standard Hours Works)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

CS1 - Site Establishment

Predicted NML Exceedances dB(A)

- 0 (Noticeable)
- < 10 (Clearly Audible)
- 10 - 20 (Moderately Audible)
- > 20 (Highly Intrusive)

Noise Catchment Area

- NCA01
- NCA02

Resonate

Sydney Harbour Bridge Northern Cycleway

APPENDIX D2
Predicted NML Exceedances of CS2 Ramp Construction Works (Standard Hours Works)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- CS2 - Ramp Construction Location

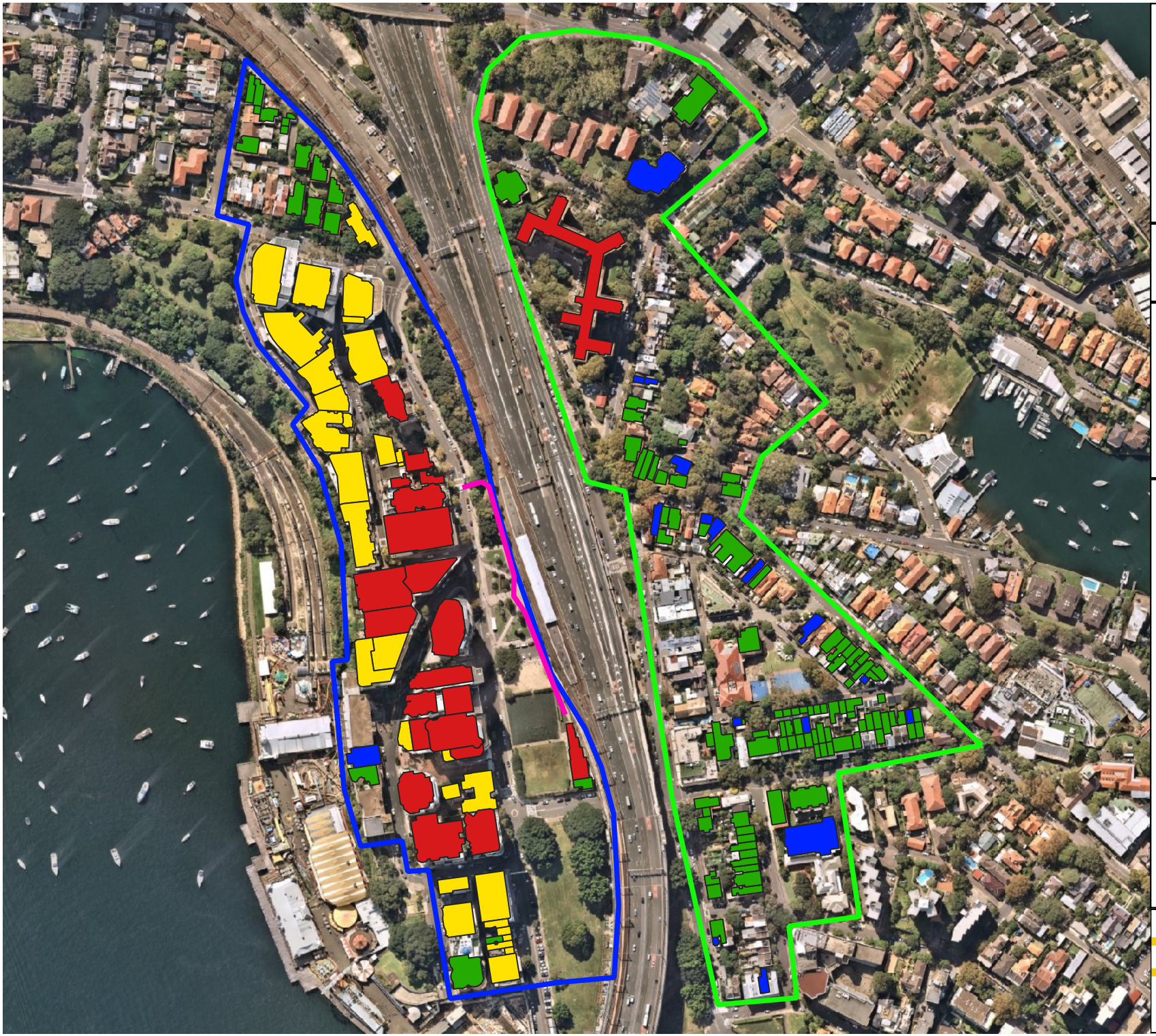
Predicted NML Exceedances dB(A)

- 0 (Noticeable)
- < 10 (Clearly Audible)
- 10 - 20 (Moderately Audible)
- > 20 (Highly Intrusive)

Noise Catchment Area

- NCA01
- NCA02

Resonate



Sydney Harbour Bridge Northern Cycleway

APPENDIX D2.1
Predicted NML Exceedances of CS2.1 Ramp Construction Works (OOHW)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

CS2 - Ramp Construction Location

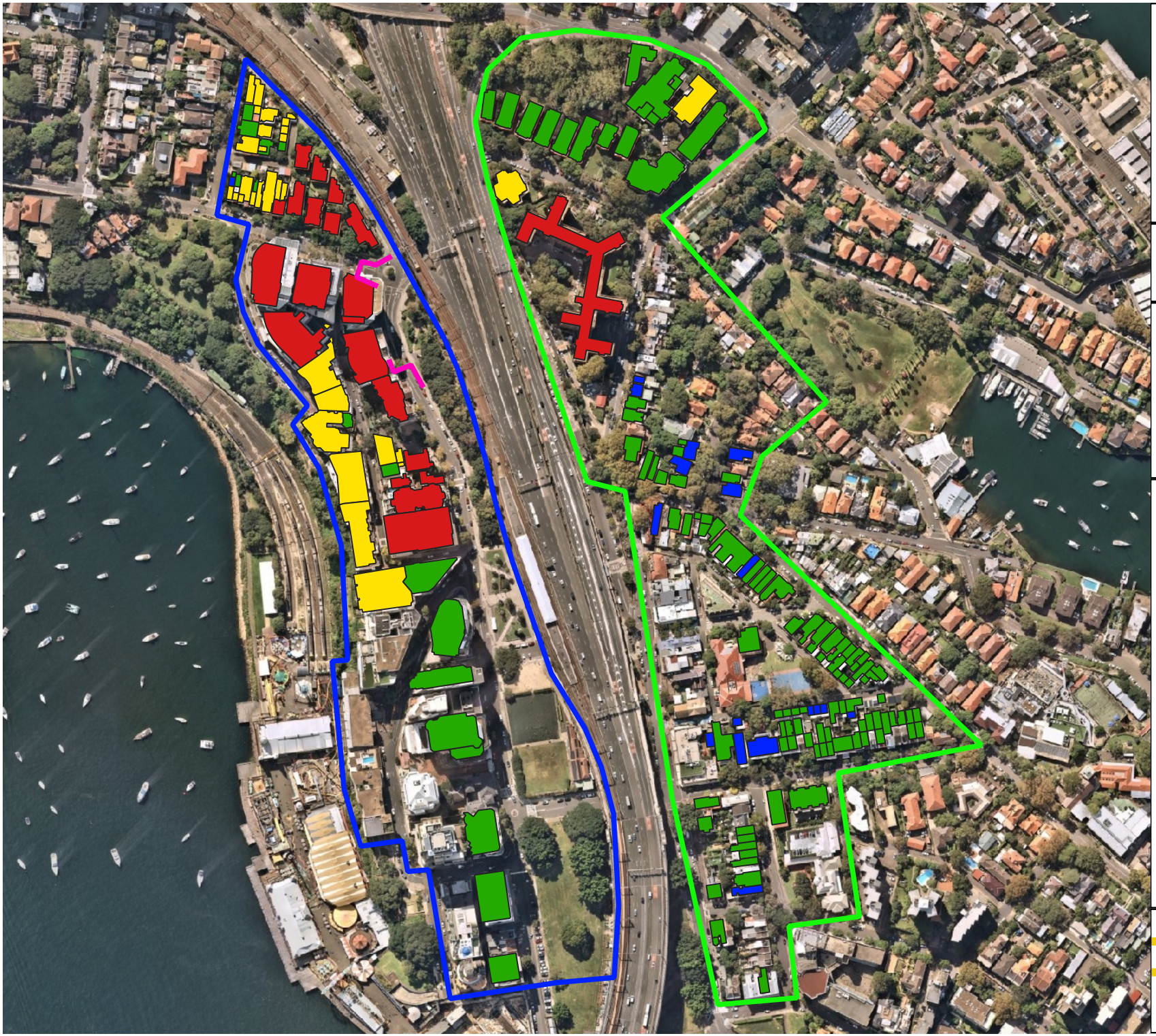
Predicted OOH NML Exceedances dB(A)

- < 5 (Noticeable)
- 5 - 15 (Clearly Audible)
- 15 - 25 (Moderately Audible)
- > 25 (Highly Intrusive)

Noise Catchment Area

- NCA01
- NCA02

Resonate



Sydney Harbour Bridge Northern Cycleway

APPENDIX D3.1
Predicted NML Exceedances of CS3.1 Cycleway Works (OOHW)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- CS3.1 - Cycleway Works Location

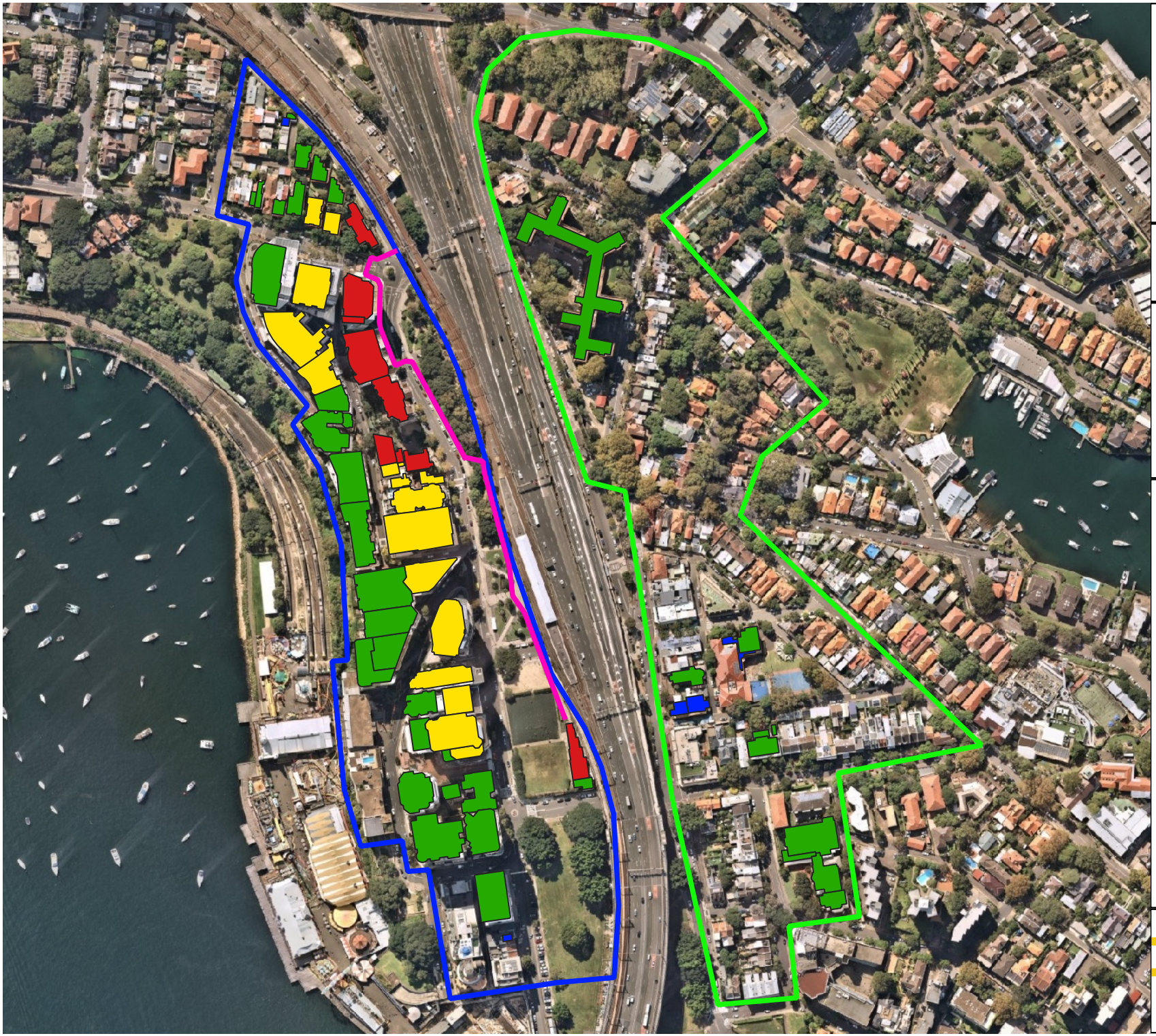
Predicted OOH NML Exceedances dB(A)

- < 5 (Noticeable)
- 5 - 15 (Clearly Audible)
- 15 - 25 (Moderately Audible)
- > 25 (Highly Intrusive)

Noise Catchment Area

- NCA01
- NCA02

Resonate



Sydney Harbour Bridge Northern Cycleway

APPENDIX D3
Predicted NML Exceedances of CS3 Groundworks, Cycleway Works & Landscaping (Standard Hours Works)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

CS3 - Works Location

Predicted NML Exceedances dB(A)

- 0 (Noticeable)
- < 10 (Clearly Audible)
- 10 - 20 (Moderately Audible)
- > 20 (Highly Intrusive)

Noise Catchment Area

- NCA01
- NCA02

Resonate

Sydney Harbour Bridge Northern Cycleway

APPENDIX D5
Predicted NML Exceedances of CS5 Ancillary Facility (Standard Hours Works)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- CS6 - Ancillary Facility Location

Predicted NML Exceedances dB(A)

- 0 (Noticeable)
- < 10 (Clearly Audible)
- 10 - 20 (Moderately Audible)
- > 20 (Highly Intrusive)

Noise Catchment Area

- NCA01
- NCA02

Resonate

Sydney Harbour Bridge Northern Cycleway

APPENDIX D4
Predicted NML Exceedances of CS4 Demobilisation (Standard Hours Works)

Date: 2 November 2022
Client: Transport for NSW
Prepared by: RS

N

Datum GDA 94, Projection MGA ZONE 56

0 50 100 150 200 m

Legend

- CS4 - Demobilisation Location

Predicted NML Exceedances dB(A)

- 0 (Noticeable)
- < 10 (Clearly Audible)
- 10 - 20 (Moderately Audible)
- > 20 (Highly Intrusive)

Noise Catchment Area

- NCA01
- NCA02

Resonate