Prepared for
Transport for New South Wales
ABN: 18 804 239 602

Transport Access Program 3: Waitara Station Upgrade

Noise and Vibration Impact Assessment

25 Mar 2022
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Client: Transport for New South Wales

ABN: 18 804 239 602

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Abbreviations

Term	Meaning
AADT	Annual Average Daily Traffic
CEMP	Construction Environmental Management Plan
CNVMP	Construction Noise and Vibration Management Plan
CTMP	Construction Traffic Management Plan
dB	Decibel
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
EMS	Environmental Management System
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EP&A Regulation	Environmental Planning and Assessment Regulation 2000 (NSW)
EPI	Environmental Planning Instrument
EPL	Environment Protection Licence
ESD	Ecologically Sustainable Development (refer to Definitions)
Heritage Act	*Heritage Act 1977* (NSW)
ICNG	*Interim Construction Noise Guideline* (Department of Environment and Climate Change, 2009).
Infrastructure SEPP	*State Environmental Planning Policy (Infrastructure) 2007 (NSW)*
LEP	Local Environmental Plan
LGA	Local Government Area
NCA	Noise Catchment Areas
NML	Noise Management Level
NPfI	*Noise Policy for Industry* (Environment Protection Authority, 2017)
NSW	New South Wales
OEH	NSW Office of the Environment and Heritage
OOHW	Out of Hours Work
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
RBL	Rating Background Level
REF	Review of Environmental Factors
SEPP	State Environmental Planning Policy
SHR	State Heritage Register
SSE	Station Services Equipment
Transport	Transport for NSW
TMP	Traffic Management Plan
VDV	Vibration Dose Values

1.0 Introduction

1.1 Background information

Transport for NSW (Transport) is the government agency responsible for the delivery of major transport infrastructure projects in NSW and is the proponent for the Waitara Station Upgrade (the Proposal).

The Proposal is part of the Transport Access Program which is a NSW Government initiative to provide a better experience for public transport customers by delivering accessible, modern, secure and integrated transport infrastructure across NSW.

AECOM Australia Pty Ltd (AECOM) has been commissioned by Transport to undertake a Noise and Vibration Impact Assessment of the construction and operation of the Proposal. Construction of the Waitara Station Upgrade is expected to commence in mid 2022 and take up to 18 months to complete. The construction work would primarily be undertaken during standard hours. Some work may need to occur outside standard hours and would include night work and work during routine rail shutdowns, which are scheduled closures that would occur regardless of the Proposal when part of the rail network is temporarily closed, and trains are not operating.

1.2 Scope

The scope of this Noise and Vibration Impact Assessment is to:

- establish the existing background noise levels in the vicinity of the Proposal
- establish construction noise management levels and vibration limits that would apply to the Proposal
- predict environmental noise and vibration levels at nearby residential and other sensitive receivers due to the Proposal
- predict noise levels from additional off-site construction traffic generated by the Proposal
- recommend mitigation measures, where necessary, to reduce and manage noise and vibration impacts from the Proposal to comply with established construction noise management levels and vibration limits
- consider noise from the operation of the upgraded Waitara Station.

1.3 Proposed work

The key elements of the Proposal are summarised as follows:

- construction of a new pedestrian underpass at the northern end of the platform to provide a new accessible station entrance
- installation of two new lifts at the new northern station entrance including a lift from the commuter car park to the underpass and a lift from the underpass to the platform, including associated landings, canopies and support structures
- construction of new platform stairs and associated canopy to provide access from the new pedestrian underpass to the station platform
- construction of a new northern station entrance including a lift entrance and entrance stairs from the commuter car park off Waitara Avenue, and an eastern entrance from Alexandria Parade
- construction of an accessible pedestrian footpath on Alexandria Parade connecting to a new pedestrian crossing on Alexandria Parade
- provision of seating and wheelchair spaces at the two boarding assistance zones (BAZ) and installation of one canopy on the station platform
- modifications to the station building to provide additional Station Services Equipment (SSE)

- reconfiguration of the existing toilet facilities in the station building to provide a new family accessible toilet and new unisex ambulant toilet
- modifications to the commuter car park including relocation of the turning circle, relocation of two accessible parking spaces and provision of kiss and ride bays
- modifications to the parking on Alexandria Parade to provide a new station entrance including provision of two new accessible parking spaces adjacent to the new station entrance
- ancillary work including platform stabilisation and regrading, station power supply upgrade, protection and relocation of existing services and utilities, installation of new services and utilities, new or reinstatement of Tactile Ground Surface Indicators (tactiles) where required, handrails and fencing, new ticketing facilities including additional Opal card readers, improvement to station communication systems (including CCTV cameras) and wayfinding signage.

Figure 1 shows the key elements of the Proposal. Further construction details are provided in Section 5.1 of this report and a detailed description of the Proposal is provided in Chapter 3 of the *Waitara Station Upgrade Review of Environmental Factors* (AECOM, 2022).

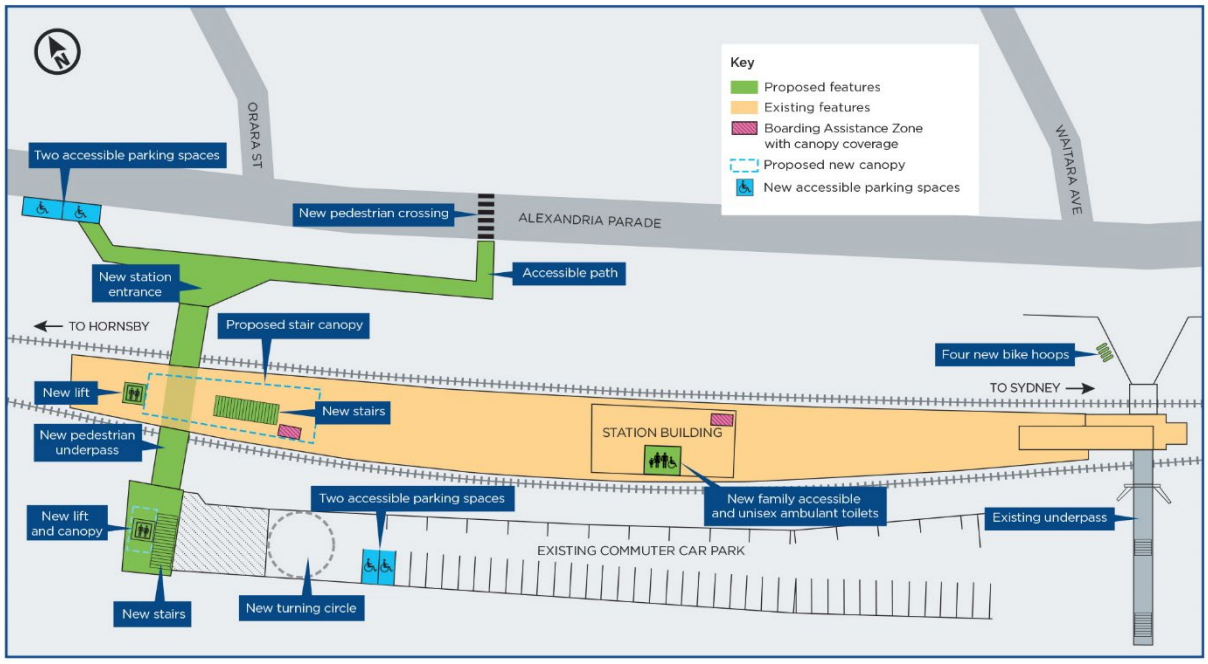


Figure 1 Key elements of the Proposal

1.4 Policies and guidelines

The following policies and guidelines are relevant for this assessment:

- *Interim Construction Noise Guideline* (ICNG), Department of Environment and Climate Change, 2009
- *Assessing Vibration: A Technical Guideline* (AVATG), Department of Environment and Conservation, 2006
- *NSW Road Noise Policy* (RNP), Department of Environment, Climate Change and Water, 2011
- *Noise Policy for Industry* (NPfI), Environment Protection Authority (EPA), 2017
- *Construction Noise and Vibration Strategy* (CNVS), Transport for NSW, 2019
- Australian Standard AS 2436-2010, *Guide to noise and vibration control on construction, demolition and maintenance sites*, 2010

- Australian Standard AS 1055-2018 – *Acoustics—Description and measurement of environmental noise*, 2018
- British Standard 7385: Part 2 1993 - *Evaluation and Measurement of Vibration in Buildings*, 1993
- British Standard 6472: Part 1 2008 - *Evaluation of Human Exposure to Vibration in Buildings*, 2008
- British Standard 5228: Part 1 2009 - *Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 1: Noise*
- DIN Standard 4150: Part 3 1999 - *Structural Vibration in Buildings - Effects on Structures*, 1999
- International Standard ISO 9613-2:1996 - *Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation.*

Definitions for acoustic terminology used within this report can be found in Appendix A.

2.0 Existing acoustic environment

2.1 Site description

Waitara Station is located within a mainly residential suburban environment. The closest residential receivers are located on Alexandria Parade, Waitara to the north of the station. Commercial receivers are also located adjacent to the Proposal along Pacific Highway south of the station. The station and its surrounding environment are shown in Figure 2 and the location of the compound sites to facilitate construction work are shown in Figure 4.

Pacific Highway, which runs to the south of the station, and Alexandria Parade, which runs north of the station, are considered arterial and sub-arterial roads respectively as per categories within the RNP.

2.1.1 Representative receivers

To provide a comprehensive assessment, 22 representative residential receivers surrounding the Proposal have been selected to represent the potential noise impacts associated with the Proposal in accordance with the ICNG. These receivers are listed in Table 1 and shown in **Figure** 3. Residences located closest to the Proposal within each street block were selected as representative of the potentially worst affected receivers.

Receivers predominantly comprise residential properties, to the east of the railway line, located within the suburb of Waitara and extend the length of the Proposal along Alexandria Parade. The residential receivers to the north-west of Waitara Station are generally multi-storey apartment buildings, whilst the receivers to the north-east comprise one and two storey buildings.

Receivers are generally commercial between the railway line and the Pacific Highway. To the west of the Pacific Highway receivers are generally residential, being predominantly seniors housing with some commercial and educational receivers.

Impacts were also assessed at representative non-residential sensitive receivers as listed in Table 2.

Table 1 Representative receiver addresses – residential

Receiver ID	Noise Catchment Area (NCA)	Receiver address	Building type	Approximate distance to Proposal in metres
R1	2	14 Waitara Avenue, Waitara	Multi-storey	48
R2	2	11 Orara Street, Waitara	Multi-storey	76
R3	1	2 McAuley Place, Waitara	Detached	95
R4	1	8 McAuley Place, Waitara	Detached	155
R5	1	65 Pacific Highway, Waitara	Multi-storey	157
R6	2	57 Alexandria Parade, Waitara	Detached	168
R7	1	108 McAuley Place, Wahroonga	Townhouse	218
R8	2	15 Yardley Avenue, Waitara	Detached	234
R9	2	18 Park Avenue, Waitara	Multi-storey	245
R10	2	3 Thomas Street, Hornsby	Multi-storey	254
R11	2	45 Waitara Avenue, Waitara	Multi-storey	316
R12	2	67 Alexandria Parade, Waitara	Detached	334
R13	2	27 Yardley Avenue, Waitara	Detached	362
R14	2	26 Balmoral Street, Waitara	Detached	377
R15	1	2C Carden Avenue, Wahroonga	Townhouse	387
R16	2	40 Park Avenue, Waitara	Multi-storey	423
R17	2	7 Edgeworth David Avenue, Hornsby	Multi-storey	427
R18	2	3 Clarke Road, Waitara	Detached	450
R19	2	46 Balmoral Street, Waitara	Detached	456
R20	2	28 Myra Street, Wahroonga	Detached	486
R21	1	12B Woolcott Avenue, Wahroonga	Detached	490
R22	2	4 Myra Street Wahroonga	Detached	491

Table 2 Representative receiver addresses – non-residential

Receiver ID	Receiver address	Approximate distance to Proposal in metres
N1	Volvo Car Dealer, Waitara	25
N2	Magpies Leagues Club, Waitara	36
N3	Hornsby Mazda, Waitara	54
N4	Waitara Seventh-day Adventist Church, Waitara	131
N5	PCYC Hornsby, Hornsby	181
N6	Barker College, Hornsby	221
N7	Bars N Racks Sydney (auto parts shop), Hornsby	251
N8	Centacare Children's Services Waitara, Waitara	253
N9	Edgeworth Medical Centre, Hornsby	344
N10	Explore & Develop Childcare Centre, Waitara	371
N11	Wallarobba Arts and Cultural Centre, Hornsby	464
N12	St Leo's Catholic College, Wahroonga	477
N13	Westfield Hornsby	515

2.1.2 Noise catchment areas

To assist in determining noise criteria for the receivers surrounding the Proposal, two noise catchment areas (NCAs) were identified. The noise environment at each of the residential receivers within each NCA is considered to be similar. The NCAs are shown in Figure 2 and the applicable NCA for the representative residential receivers are identified in Table 1. NCA 1 includes receivers adjacent to the Pacific Highway for a distance of up to around 250 metres and generally has a higher background noise level associated with traffic movements on the Pacific Highway. NCA 2 includes receivers beyond this distance from the Pacific Highway and receivers on the northern side of the station which generally have a lower (and similar) background noise level being further away from the Pacific Highway.

2.1.3 Heritage items

The Waitara Railway Station Group is a listed local heritage item on the Transport Asset Holding Entity (TAHE) Section 170 Heritage and Conservation Register, having significance at a local level of a station that represents a good example of early twentieth century station design. The platform building, island platform and underpass (subway) are particularly representative of structures built between 1909 and 1917.

There are two heritage items located within 100 metres of Waitara Station. The first is a series of Box Brush tree plantings that form a streetscape along Alexandria Parade, on the eastern side of the station. The second is a shop located at 32 Alexandria Parade, around 50 metres from Waitara Station.

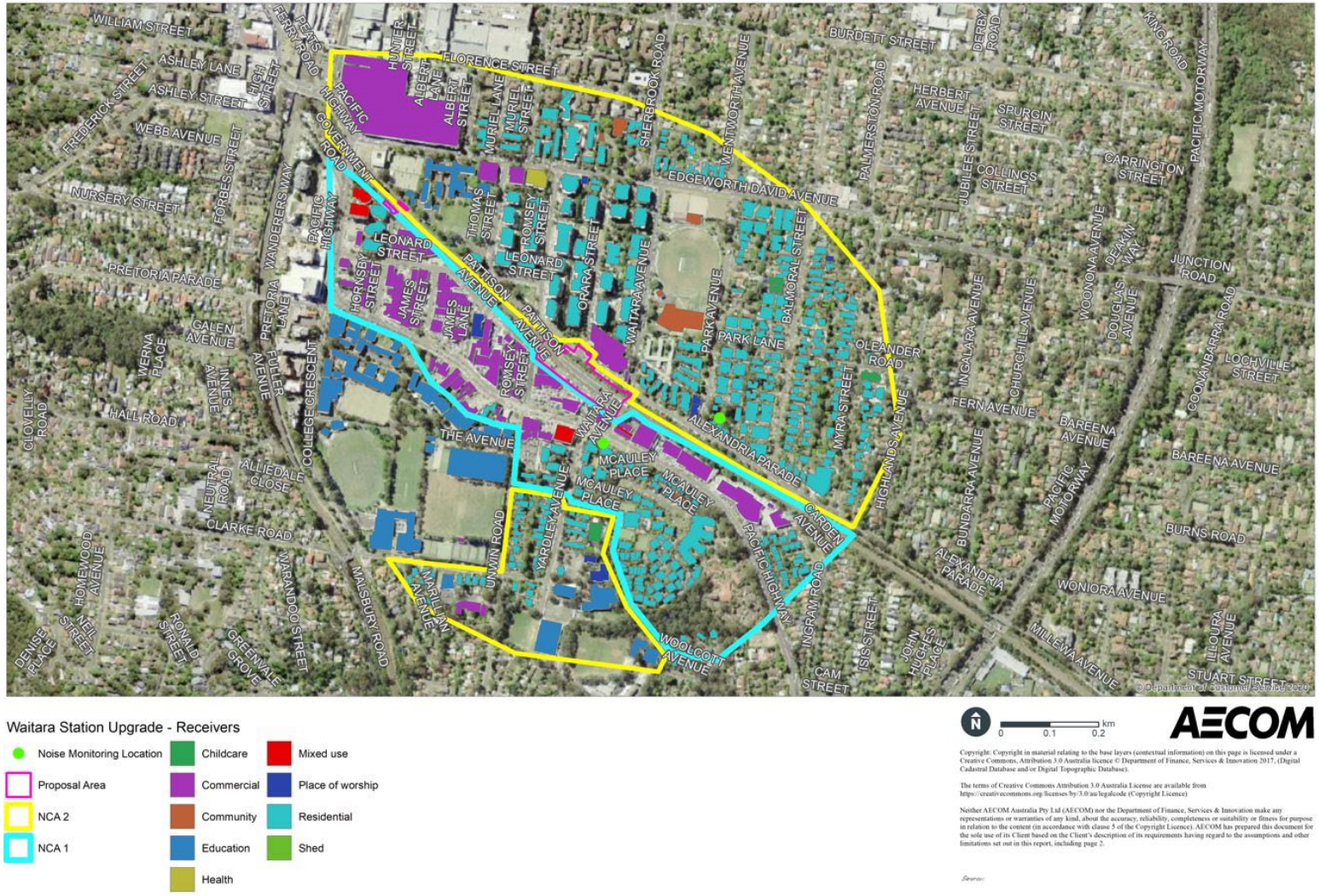
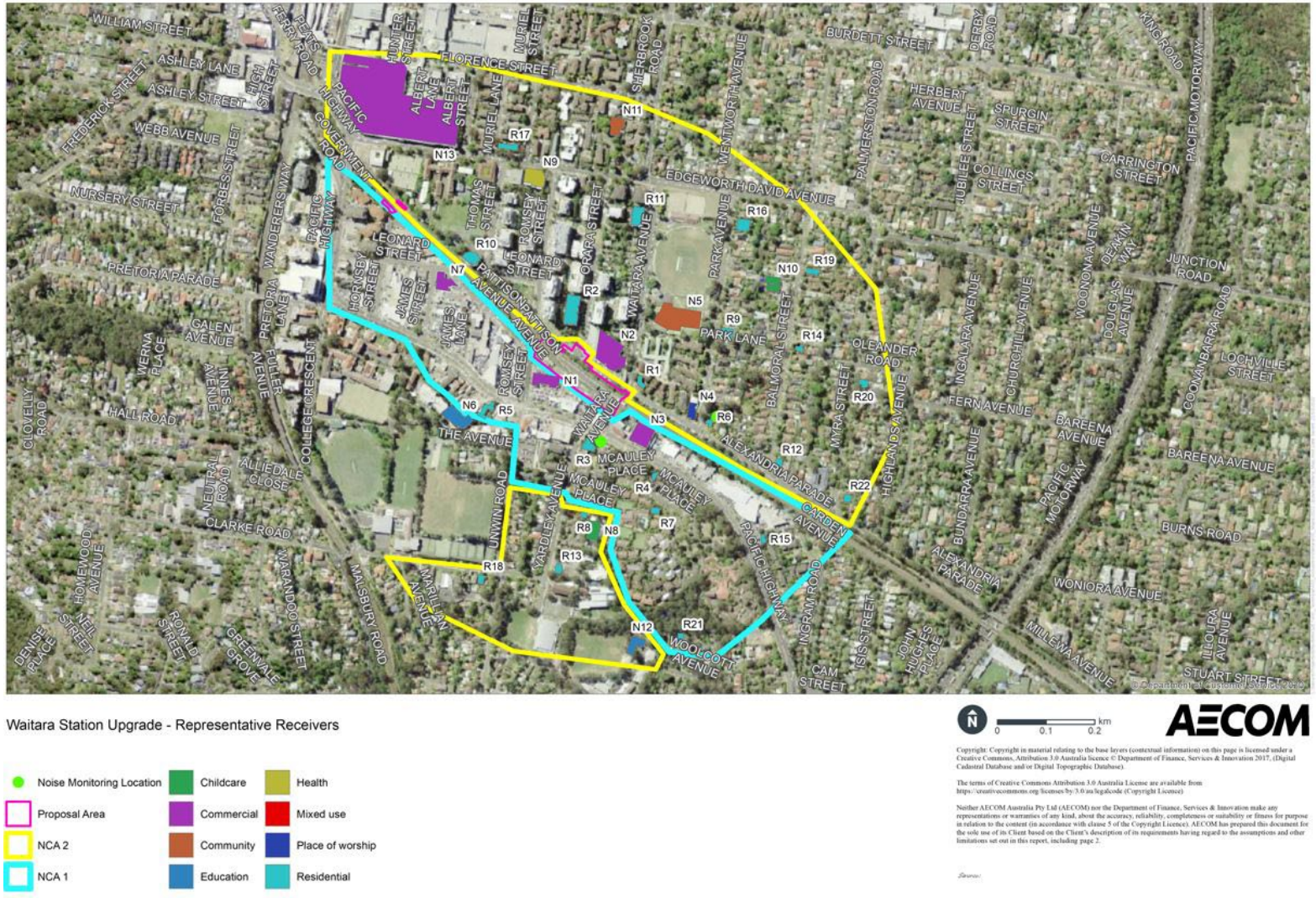


Figure 2 Noise and vibration receivers, NCAs and logger locations



Waitara Station Upgrade - Representative Receivers

- Noise Monitoring Location
- Proposal Area
- NCA 2
- NCA 1
- Childcare
- Commercial
- Community
- Education
- Health
- Mixed use
- Place of worship
- Residential

Figure 3 Representative receiver locations

Figure 4 Location of compound sites

2.2 Noise measurement methodology

Long term unattended and short term attended measurements were undertaken to establish the existing ambient and background noise environment at potentially affected receivers. The locations of the two noise loggers are shown in Figure 2.

2.2.1 Unattended noise measurement methodology

Long term unattended noise monitoring was conducted between 14 and 23 October 2020 at 2 McAuley Place (logger 1), and between 23 October and 3 November 2020 at 59 Alexandria Parade (logger 2). The noise loggers were placed at the locations indicated in Table 3 and shown in Figure 2. These locations were considered representative of the NCAs. The noise loggers were calibrated prior to and after the monitoring period with a drift in calibration not exceeding ± 0.5 dB. Within the time period since the noise monitoring was undertaken, no changes have occurred in the area that would significantly alter the acoustic environment, therefore the measured noise levels are considered to be representative of the current acoustic environment for the purposes of assessment.

All the acoustic instrumentation employed during the noise measurements comply with the requirements of "*AS IEC 61672.1-2004 Electroacoustics - Sound level meters - Specifications*" and were within their current National Association of Testing Authorities, Australia (NATA) certified in-calibration period (i.e. calibration in the last two years).

Table 3 Noise monitoring details

NCA	Logger	Location	Model	Serial number
1	1	2 McAuley Place, Waitara	ARL 315	15299444
2	2	59 Alexandria Parade, Waitara	Svan 977	45417

The noise environment at each of the residential receivers within an NCA is considered to have a similar noise environment to the unattended monitoring location within that NCA. As such each of these residential receivers is assigned the same background noise level and construction noise management level.

In accordance with the NPfI, noise monitoring affected by adverse weather conditions or extraneous noise events should be excluded from the monitoring data. The NPfI advises that data may be affected where adverse weather, such as wind speeds higher than five m/s or rain, occurs. Weather data was acquired from the Bureau of Meteorology's Terrey Hills weather station (station number 066059) located around 12 kilometres north of the Proposal.

The logger measured noise levels over the sample period and then determined L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels of the noise environment. The L_{A1}, L_{A10} and L_{A90} noise levels are the levels exceeded for 1%, 10% and 90% of the measurement period respectively. The L_{A90} is taken as the background level. The L_{A1} is indicative of the maximum noise levels due to individual noise events such as the pass-by of a heavy vehicle. The L_{Aeq} level is the equivalent continuous sound level and has the same sound energy over the sample period as the actual noise environment with fluctuating sound levels.

The L_{A90} noise levels were analysed to determine a single assessment background level (ABL) for each day, evening and night period in accordance with the NPfI for each monitoring location. The ABL is established by determining the lowest ten-percentile level of the L_{A90} noise data acquired over each period of interest. Table 4 presents individual ABLs for each day's assessment periods. The background noise level or rating background level (RBL) representing the day, evening and night-time assessment periods is based on the median of individual ABLs determined over the entire monitoring period.

2.2.2 Attended noise measurement methodology

Attended noise measurements were conducted at logger locations 1 and 2 on 14 October 2020. The measurements were conducted over a 15 minute period for each location. Weather conditions were sunny on the day of monitoring, with no wind.

Attended noise measurements were conducted using a Brüel & Kjær Type 2270 sound level meter. The sound level meter used is designated as a Type 1 instrument and has accuracy suitable for laboratory

and field use. The sound level meter was calibrated before and after the measurements with a no drift in calibration exceeding ±0.5 dB.

All the acoustic instrumentation employed during the noise measurements comply with the requirements of "*AS IEC 61672.1-2004 Electroacoustics - Sound level meters - Specifications*" and were within their current National Association of Testing Authorities, Australia (NATA) certified in-calibration period (i.e. calibration in the last two years).

2.3 Noise measurement results

2.3.1 Unattended noise measurement results

Table 4 presents the existing overall representative L_{Aeq} ambient noise level and the background L_{A90} noise levels for the day, evening and night-time periods, in accordance with the NPfL. The overall representative L_{Aeq} noise levels were determined by logarithmically averaging each assessment period for the entire monitoring period.

The results for each day and the graphical noise logging results are presented in Appendix B.

Table 4 Existing background (L_{A90}) and ambient (L_{Aeq}) noise levels

Location	Rating background level, L_{A90}, dB(A)			Ambient L_{Aeq} noise levels, dB(A)		
	Day[1]	Evening[1]	Night[1]	Day[1]	Evening[1]	Night[1]
NCA 1	52	47	38	65	64	61
NCA 2	38	34	32	71	67	66

Notes:

1. *Day is defined as 7:00 am to 6:00 pm, Monday to Saturday and 8:00 am to 6:00 pm Sundays & Public Holidays. Evening is defined as 6:00 pm to 10:00 pm, Monday to Sunday & Public Holidays. Night is defined as 10:00 pm to 7:00 am, Monday to Saturday and 10:00 pm to 8:00 am Sundays & Public Holidays.*

2.3.2 Attended noise measurements

The results of the attended noise monitoring are presented in Table 5.

Table 5 Attended noise measurements

Logger	Date	Time	L_{Aeq} dB(A)	L_{A90} dB(A)	Comments
1	14/10/2020	9:18am	68	53	Noise environment dominated by road traffic noise on Pacific Highway Truck pass-by 78 dB(A) Bus braking 66 dB(A) Local vehicle traffic 62 dB(A) Birds chirping (42 dB(A)) and mild breeze noise contributes to the noise environment
2	14/10/2020	9:42am	59	46	Noise environment dominated by road traffic noise on Alexandria Parade and Pacific Highway in background Train pass-by 63 dB(A) Local vehicle traffic 60 dB(A) Birds chirping (50 dB(A)) and mild breeze noise contributes to the noise environment

2.4 Existing noise environment summary

The acoustic environment is dominated by road traffic noise at both logging locations with natural sounds in the background. Intermittent rail noise is also audible. These characteristics are typical of a suburban environment.

3.0 Construction noise and vibration criteria

3.1 Construction activity noise criteria

3.1.1 Interim Construction Noise Guideline

The ICNG is the principal guideline for the assessment and management of construction noise in NSW. As the proposed work is expected to continue for a period of more than three weeks and is within relatively close proximity to noise sensitive receivers, a quantitative assessment, based on 'reasonable' worst case work packages, has been carried out for this work.

Noise levels resulting from construction activities are predicted at nearby noise sensitive receivers using environmental noise modelling software and compared to the noise management levels (NML), derived in accordance with the ICNG.

Where an exceedance of the NMLs is predicted, the ICNG recommends certain measures be implemented to minimise adverse impacts.

The construction NMLs for the residential and other sensitive land uses are detailed in Table 6, Table 7 and Table 8.

Table 6 ***Interim Construction Noise Guideline*** **Residential noise management levels**

Time of day	NML, $L_{Aeq,15min}$, dB(A)[1]	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise: • where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level • the proponent should also inform all potentially impacted residents of the nature of work to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise: • where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for work near schools, or mid-morning or mid-afternoon for work near residences 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• a strong justification would typically be required for work outside the recommended standard hours • the proponent should apply all feasible and reasonable work practices to meet the noise affected level • where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community • the ICNG provides guidance on negotiating agreements.

Notes:

1. *Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metres above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.*

The ICNG defines what is considered to be feasible and reasonable as follows:

- *"Feasible*

  A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements.

- *Reasonable*

  Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure."

Table 7 presents the NMLs applicable to residential receivers nearby to the Proposal.

Table 7 Construction noise management levels – Residential receivers

Noise catchment area	Period	RBL, L_{A90} dB(A)	Standard hours noise management levels, $L_{Aeq,15min}$, dB(A)		Out of hours noise management levels, $L_{Aeq,15min}$, dB(A)
1	Day	52	62	75 (highly noise affected level)	57
	Evening	47	N/A		52
	Night	38	N/A		43
2	Day	38	48	75 (highly noise affected level)	43
	Evening	34	N/A		39
	Night	32	N/A		37

Table 8 presents the NMLs applicable to other noise sensitive receivers such as educational facilities and places of worship and to commercial receivers.

Table 8 Construction noise management levels – Other receivers

Land use	Noise management levels, $L_{Aeq,15min}$ (applies when properties are in use)
Place of worship	55 dB(A)[1]
Classroom at schools and other educations institutions	55 dB(A) [1]
Hospital wards and operating theatres	55 dB(A) [1]
Community Hall	55 dB(A)[1]
Commercial premises (including offices, retail outlets)	70 dB(A)
Industrial	75 dB(A)

Notes:

1. *This external management level is based upon a 45 dB(A) internal noise management level and a 10 dB reduction from outside to inside through an open window.*

3.1.2 Sleep disturbance criteria

The ICNG requires a sleep disturbance analysis where construction work is planned to extend over more than two consecutive nights. The L_{A1} noise levels and number of expected L_{A1} noise events should be predicted in order to determine the likelihood of potential sleep disturbance.

The EPA recommends that to minimise the risk of sleep disturbance during the night-time period (10.00 pm to 7.00 am), the $L_{A1(1\ min),}$ noise level outside a bedroom window should not exceed the $L_{A90\ (15\ minute)}$ background noise level by more than 15 dB. If this screening criterion is found to be exceeded then a more detailed analysis must be undertaken and include the extent that the maximum noise level exceeds the background noise level and the number of times this is likely to happen during the night-time period.

Sleep disturbance research presented in the RNP concludes that *'Maximum internal noise levels below 50-55 dB(A) are unlikely to cause awakening reactions'*. Therefore, given that an open window provides approximately 10 dB in noise attenuation from outside to inside, external noise levels of 60-65 dB(A) are unlikely to result in awakening reactions.

Based on the measured background noise levels during the night, the sleep disturbance criteria for the nearest noise sensitive residential receivers are presented in Table 9.

Table 9 Sleep disturbance criteria

Noise catchment area	Background noise level (L_{A90}), dB(A)	Sleep disturbance criteria, $L_{A1(1\ minute)}$, dB(A) (external)	
		Screening level	Awakening reaction
1	38	53	60 – 65
2	32	47	60 – 65

3.2 Construction traffic noise criteria

To assess noise impacts from construction traffic an initial screening test should be undertaken to evaluate whether existing road traffic noise levels would increase by more than 2 dB(A), in line with the RNP. Where the predicted noise increase is 2 dB(A) or less, then no further assessment is required. However, where the predicted noise level increase is greater than 2 dB(A), and the predicted road traffic noise level exceeds the road category specific criterion then noise mitigation should be considered for those receivers affected. The RNP does not require assessment of noise impact to commercial or industrial receivers.

Pacific Highway and Alexandria Parade provide the main road access to Waitara Station. These roads are classified as arterial and sub-arterial respectively and are listed in Table 10. The external noise criteria are applied one metre from the external facade of an affected building.

Table 10 Roads used by construction traffic

Road	Type	Residential receivers	Estimated AADT[1]
Pacific Highway	Arterial	Yes	>50,000
Alexandria Parade	Sub-arterial	Yes	>5,000

Notes:

1. *Annual average daily traffic*

3.3 Construction vibration criteria

The relevant standards/guidelines for the assessment of construction vibration are summarised in Table 11.

Table 11 Standards/guidelines used for assessing construction vibration

Item	Standard/guideline
Structural damage	Heritage structures – *German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures* (DIN 4150) Non-heritage structures – *Evaluation and Measurement for Vibration in Buildings Part 2,* (British Standard (BS) 7385:Part 2-1993) (BS 7385)
Human comfort (tactile vibration)	*Assessing Vibration: A Technical Guideline* (AVATG)[1]

Notes:

1. *This document is based upon the guidelines contained in British Standard 6472:1992, "Evaluation of human exposure to vibration in buildings (1-80 Hz)". This British Standard was superseded in 2008 with BS 6472-1:2008 "Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting" and the 1992 version of the Standard was withdrawn. Although a new version of BS 6472 has been published, the EPA still requires vibration to be assessed in accordance with the 1992 version of the Standard at this point in time.*

Vibration, at levels high enough, has the potential to cause damage to structures and disrupt human comfort. Vibration and its associated effects are usually classified as continuous, impulsive or intermittent as follows:

- continuous vibration continues uninterrupted for a defined period and includes sources such as machinery and continuous construction activities
- impulsive vibration is a rapid build up to a peak followed by a damped decay. It may consist of several cycles at around the same amplitude, with durations of typically less than two seconds and no more than three occurrences in an assessment period. This may include occasional dropping of heavy equipment or loading activities
- intermittent vibration occurs where there are interrupted periods of continuous vibration, repeated periods of impulsive vibration or continuous vibration that varies significantly in magnitude. This may include intermittent construction activity, impact pile driving, jack hammers.

3.3.1 Structural damage

At present, no Australian Standards exist for the assessment of building damage caused by vibration. DIN 4150 and BS 7385-2 provide recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are presented in Table 12 and Table 13. DIN 4150 states that buildings exposed to higher levels of vibration than recommended limits would not necessarily result in damage. Structural damage criteria for heritage items have been taken from DIN 4150, whilst criteria for commercial/residential items have been taken from BS 7385-2.

Table 12 DIN 4150: Structural damage safe limits for building vibration

Group	Type of structure	At foundation Less than 10 Hz	At foundation 10 Hz to 50 Hz	At foundation 50 Hz to 100 Hz[1]	Vibration at the horizontal plane of the highest floor for all frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20 mm/s	20 to 40 mm/s	40 to 50 mm/s	40 mm/s
2	Dwellings and buildings of similar design and/or use	5 mm/s	5 to 15 mm/s	15 to 20 mm/s	15 mm/s
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (eg buildings that are under a preservation order/heritage listed)	3 mm/s	3 to 8 mm/s	8 to 10 mm/s	8 mm/s

Notes:

1. *At frequencies above 100 Hz, the values given in this column may be used as minimum values*

Table 13 BS 7385-2: Transient vibration guide values for cosmetic damage

Group	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 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

3.3.2 Human comfort

The assessment of intermittent vibration outlined in the AVATG is based on Vibration Dose Values (VDVs). The VDV accumulates the vibration energy received over the daytime and night-time periods.

Maximum and preferred VDVs for intermittent vibration arising from construction activities are listed in Table 14. The VDV criteria are based on the likelihood that a person would be annoyed by the level of vibration over the entire assessment period.

Table 14 Preferred and maximum vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Daytime [1] Preferred	Daytime Max	Night time Preferred	Night time Max
Residences	0.2	0.4	0.13	0.26
Offices, schools, educational institutions, commercial premises and places of worship	0.4	0.8	0.4	0.8
Workshops or factory environments	0.8	1.6	0.8	1.6

Notes:
1. Daytime is defined as 7:00 am to 10:00 pm. Night-time is defined as 10:00 pm to 7:00 am

4.0 Operational noise criteria

The Proposal includes changes to the station and supporting infrastructure only and does not include changes to rail movements. As a result, operational noise is to be assessed under the NPfI.

4.1 Noise Policy for Industry

The NPfI provides guidance in relation to acceptable noise limits for industrial noise emissions, which includes, but is not limited to, noise emissions from mechanical plant.

The assessment procedure in the NPfI has two components:

- controlling **intrusive** noise impacts in the short term for residences
- maintaining noise level **amenity** for residences and other land uses.

Both components are assessed at the boundary of the noise sensitive receiver site, or if the site boundary is more than 30 metres from the noise sensitive building, a distance of 30 metres from the noise sensitive building.

4.1.1 Intrusive noise impacts

The NPfI states that the noise from any single noise source should not be greatly above the prevailing background noise level. Industrial noise sources are generally considered acceptable if the A-weighted equivalent continuous sound pressure level of noise from the source, measured over a 15 minute period ($L_{Aeq,15\ min}$) does not exceed the RBL by more than 5 dB(A) for the period under consideration. This is termed the Intrusiveness Criterion.

The RBL is the background noise level to be used for assessment purposes and is determined by the methods given in the NPfI.

The RBL and the respective intrusive criteria for the day, evening and night periods are provided in Table 15.

Table 15 Intrusive criteria

Location	Period	RBL (L_{A90}), dB(A)	Intrusive criteria (RBL+5), dB(A)
NCA1 Residential receivers	Day	52	57
	Evening	47	52
	Night	38	43
NCA2 Residential receivers	Day	38	43
	Evening	34	39
	Night	32	37

4.1.2 Protecting amenity

To limit continuing increase in noise levels, the maximum ambient noise level within an area from all industrial noise sources should not normally exceed the recommended noise levels specified in the NPfI. That is the noise level should not exceed the level appropriate for the particular locality and land use. This is often termed the “background creep” or “amenity criterion”.

The project amenity level for a project is equal to the ‘recommended amenity level’ minus 5 dB. The project amenity level is then converted to a 15 minute period by adding 3 dB. The amenity criteria applicable the Proposal are provided in Table 16.

Table 16 Amenity criteria

Type of receiver	Indicative noise amenity area	Time of day	Recommended amenity noise level, dB(A)	Project amenity noise level, dB(A)	
			$L_{Aeq\ (period)}$	$L_{Aeq\ (period)}$	$L_{Aeq\ (15\ minute)}$
NCA 1 and 2 Residential receivers	Suburban	Day	55	50	53
		Evening	45	40	43
		Night	40	35	38
School classroom	All	Noisiest 1-hour period when in use	45[1]	45	48
Place of worship	All	When in use	50[1]	50	53
Active recreation area	All	When in use	55	55	58
Commercial premises	All	When in use	65	65	68

Notes:

1. External noise levels are based upon a 10 dB reduction from outside to inside through an open window.

4.1.3 Environmental noise emission criteria summary

A summary of the Proposal specific noise levels is presented in Table 17 below in accordance with the NPfI. These criteria apply to environmental noise emissions from any plant installed as part of the Proposal and for residential receivers represent the lower of the intrusive and amenity criteria.

Table 17 Summary of environmental noise emission criteria

Location	Time of day	Project specific noise levels criteria[1] L_{Aeq}, dB(A)
NCA 1	Day	57
	Evening	48
	Night	43
NCA 2	Day	43
	Evening	39
	Night	37
School classroom	Noisiest 1-hour period when in use	48
Place of worship	When in use	53
Active recreation area	When in use	58
Commercial premises	When in use	68

Notes:

1. Project noise trigger levels represent the lower of the intrusive and amenity criteria.

5.0 Construction noise assessment

5.1 Work packages and scheduling

In consultation with Transport, eight distinct work packages, each consisting of a number of construction activities, have been assumed for the Proposal. These would be confirmed by the construction contractor prior to construction commencing and further assessment would be undertaken if required. These work packages are described in Table 18. All work packages have been assessed with the exception of Work package 8 – Demobilisation, testing and commissioning as it is expected to be a relatively low noise impact activity.

Noise from activities within the construction compounds has been assumed to be minor in comparison to the noise generated by the worst case work packages assessed.

Out-of-hours work would likely be required during around six rail shutdowns over the 18 month construction period and during some night-time periods to minimise traffic impacts and allow for work which requires track access. It should be noted that night-time construction work during rail shutdown periods would not take place over more than two consecutive nights. This would provide some respite periods during weekdays between work.

Table 18 Construction assessment work packages and scheduling

Work package	Activities	Scheduling
1. Site establishment and enabling work	• survey investigations including examining geophysical, hydrological and contamination conditions • dilapidation surveys identifying and recording the condition and location of buildings, structures and services (including investigation of the crane location) • temporary relocation of services required for construction • establishment of site compound (i.e. erect fencing, site offices, amenities and plant/material storage areas) • establishment of temporary facilities as required (e.g. hoarding, scaffolding, formwork, establishing crane and piling pads, temporary toilets)	Standard hours
2. New pedestrian underpass	• vegetation removal where required • installation of piling on the platform as well as under and between the railway track for the new pedestrian underpass • removal of railway tracks and sleepers and excavation of platform and railway tracks to provide for the new pedestrian underpass • installation of retaining headwalls and roof slabs • underpass excavation from both sides of the station using small excavator and bobcat to loosen material and progressively remove spoil offsite • installation of structural walls progressively during pedestrian underpass excavation • structural and waterproofing work • pedestrian underpass finishing (including installation of the ceiling, wall finishes, floor tiling and installation of services within the retaining walls)	Standard hours, out of hours and rail shutdown periods

Work package	Activities	Scheduling
3. New northern station entrances	• construction of new entrance stairs and lift access area from the commuter car park • pavement re-grading and kerb landing and treatments around the new lift and entrance stairs from the commuter car park	Standard hours, out of hours and rail shutdown periods
4. New lifts, stairs and platform upgrades	• excavation and installation of piling on the platform for the new platform stairs • removal of excavated material through the new pedestrian underpass during rail shutdowns • installation of formwork and shotcrete roofing to cover the excavated area • construction and installation of lifts, including shaft foundations, the roof, louvres and screens • construction of new platform stairs, including walls, non-slip stair edging, handrails and screens • construction weather protection canopies at the lift landings, including drainage downpipes connecting to the commuter car park • platform regrading to achieve compliant gradients • installation of BAZ seating and wheelchair spaces and an additional canopy • installation of fixtures, tactiles as required, lighting, signage and CCTV cameras	Standard hours, out of hours and rail shutdown periods
5. Station building reconfiguration work	• reconfiguration of the existing station building to provide a family accessible toilet and a unisex ambulant toilet • modifications to the station building to provide additional SSE	Standard hours, out of hours and rail shutdown periods

Work package	Activities	Scheduling
6. Interchange works	• construction of a new accessible pedestrian footpath between the new pedestrian crossing on Alexandria Parade and the new station entrance • construction of a new pedestrian crossing on Alexandria Parade • reconfiguration of existing parking spaces to provide two accessible parking spaces on Alexandria Parade • provision of new bicycle hoops at the existing station entrance on Alexandria Parade • reconfiguration of car parking spaces to provide two accessible parking spaces and two kiss and ride bays in the commuter car park • relocation of the current turning circle in the commuter car park • line-marking and signage for the reconfigured accessible parking spaces and kiss and ride bays on both sides of the station • installation of wayfinding signage and other statutory/regulatory signage • fencing adjustments	Standard hours and out of hours
7. Service and utilities upgrade work	• installation of the new substation, transformer and new IMSB room • installation of two new underground to overhead poles • diversion of the existing 11kV overhead cables via the new poles to the new substation • installation of electrical services beneath the railway track via underbore • installation of new drainage infrastructure on the eastern side of the railway track to connect to a new drainage system	Standard hours and out of hours
8. Demobilisation, testing and commissioning	• dismantling of existing site compound/hoarding areas • testing electrical, communications and signalling components	Standard hours

5.2 Construction sources

Noise sources and their respective L_{Aeq} sound power levels for each work package are shown in Table 19. These sound power levels are typical values taken from data provided in Australian Standard AS2436-2010 and BS5228: Part 1 2009 *Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 1: Noise* and assume equipment is modern and in good working order.

Table 19 Equipment sound power levels per construction work package

Equipment	Sound Power Level, dB(A)	Work package
Bobcat	104	1, 2, 3, 4, 5, 6, 7
Generator	101	1, 7
Crane trucks (semi-trailer and tipper)	104	1, 7
Hand tools	94	1, 3, 5, 6, 7
Lighting tower	77	1, 7
Power tools	94	1, 7
Excavator with auger	103[1]	1
400T crane	106	2, 4
Air compressor	109	2, 4
Water truck	104	2, 4
Small excavator (3-15T)	98[1]	2, 4
5-12T bored piling rig	115[1]	2, 4
6m^3 concrete mixer	105	2, 4
Hi rail dump truck	105	2, 4
Concrete pumps	106	2, 3, 4
Trucks (semi-trailer and 15T tipper)	98	2, 3, 4, 6
25T franna crane	93	2, 4, 5
Posi track	103	2, 4
Telehandler	93	2, 4
Hiab	104	2, 4
15T tipper truck	98	2, 4
10m^3 skip truck	108	2, 4
2T compaction roller	105	2, 4
Drill rig	107	2
Welding tools	101	3, 5, 6
Jack hammer	108	3, 5, 6
Concrete truck	106	3, 5, 6
Concrete saw	110[1]	3, 5, 6
100T crane	99	3, 6
Sucker truck	108	7

Notes:

1. *Sound powers are time weighted (i.e. expected utilisation percentage per 15 minute period) in accordance with the following:*
    a. *Excavator – 33%*
    b. *Bored piling rig – 75%*
    c. *Concrete saw – 33%*

5.3 Modelling and conditions

In order to assess noise impacts from the site during construction, a noise model was created to represent 'reasonable' worst periods of upgrade work.

The construction of the Proposal has been modelled in SoundPLAN Version 8.0. The following features were included in the noise model:

- ground topography
- ground absorption and reflection
- buildings (residential and commercial)
- receivers (shown in Figure 2)
- construction noise sources (listed in Table 19).

Noise emissions from the construction sites have been modelled using an implementation of the ISO 9613 propagation algorithm with neutral metrological conditions.

It can be expected that there may be differences between predicted and measured noise levels due to variations in instantaneous operating conditions, plant in operation during the measurement and also the location of the plant equipment. The acoustic shielding calculated in the model due to fixed building structures would also vary as the construction equipment moves around the site.

5.4 Construction noise assessment

The identified representative residential and non-residential receivers have been assessed against the standard hours and out-of-hours night-time NMLs. The level of impact may change depending on the final construction methodology and further assessment would be undertaken if required.

During construction it is likely that all equipment would not be operating simultaneously at all times and in the one location, which would result in reduced noise levels compared with those predicted. As each construction work package would be occurring discretely, a cumulative noise impact is unlikely. However cumulative noise impacts may occur as a result of other construction work in the area. This may cause an increase of up to 3 dB(A) of the highest noise level predicted for any construction stage. This is based on the combination of the highest noise levels from this Proposal and other construction work nearby.

Mitigation measures have been specified in Section 5.8 which may reduce the impact of these exceedances on receivers.

There would be intermittent use of the rail corridor during rail possessions between the compound/ancillary sites and the station to transport plant and material. This would involve heavy vehicles or hi-rail plant using the hi-rail ramp to access the track. Noise from these movements would be similar in nature to the existing Sydney Trains rail movements passing through and stopping at Waitara Station, however there are typically no Sydney Trains rail movements in this area during the period 1:00 am to 3:45 am. Nonetheless, the vehicle and plant movements are unlikely to impact nearby residents given their similarity to existing rail movements.

Noise results are presented graphically in Appendix C.

5.4.1 Summary of impacts during standard hours at residential receivers

Results show construction noise levels are predicted to exceed the NMLs during standard hours for all assessed construction work packages at the closest representative receivers (R1 and R2), as shown in grey in Table 20. The largest numbers of exceedances occur during Work package 5 – Station building reconfiguration work, however the highest noise levels are experienced during Work package 2 – New pedestrian underpass at R2, which may be 'highly affected' at times (i.e. a construction noise level of 75 dB(A) or greater).

Table 20 Predicted L_{Aeq} noise impacts at representative residential receivers for each work package during standard hours, dB(A)

Receiver ID[2]	NCA[2]	Distance, metres	Standard hours NML, dB(A)	Highly affected noise level, dB(A)	Work Package[3]						
					1	2	3	4	5	6	7
R1	2	48	48	75	52	61	56	62	67	59	60
R2	2	76	48	75	64	76	71	74	64	73	68
R3	1	95	62	75	39	61	56	62	65	57	52
R4	1	155	62	75	36	46	40	48	51	46	37
R5	1	157	62	75	41	46	40	46	57	40	37
R6	2	168	48	75	43	51	39	52	55	49	39
R7	1	218	62	75	29	42	36	45	48	40	33
R8	2	234	48	75	22	31	26	30	30	27	23
R9	2	245	48	75	45	56	49	56	56	48	47
R10	2	254	48	75	54	59	53	59	54	52	50
R11	2	316	48	75	31	39	33	41	50	32	29
R12	2	334	48	75	22	33	28	33	32	27	26
R13	2	362	48	75	24	40	34	34	42	34	32
R14	2	377	48	75	24	35	22	35	36	30	27
R15	1	387	62	75	38	49	43	49	48	44	40
R16	2	423	48	75	27	34	28	36	51	27	25
R17	2	427	48	75	47	37	27	38	31	28	24
R18	2	450	48	75	30	30	25	34	30	28	24
R19	2	456	48	75	36	32	26	49	45	45	23
R20	2	486	48	75	37	47	43	48	46	42	40
R21	1	490	62	75	26	34	29	37	35	31	26
R22	2	491	48	75	39	46	39	47	44	43	36

Notes:

1. *Items shaded in grey indicate the predicted noise levels at this receiver during this work stage exceed the daytime NMLs. Items in red indicate the receiver is highly noise affected during this work stage.*
2. *Addresses of receiver and noise catchment areas are provided in Table 1*
3. *Details of work packages provided in Table 18*

5.4.2 Summary of impacts during night work at residential receivers

Results show construction noise levels are predicted to exceed the NMLs during night work for all assessed construction work packages at most representative receivers, as shown in grey in Table 21.

The highest noise levels are experienced during Work package – 2, 4 and 5. Overall, there are exceedances at receivers R1 to R7, R9 to R11, R13, R15 to R17, R19, R20 and R22. Noise levels at receivers R1 and R2 are predicted to exceed the NMLs by more than 25 dB(A) at times. However, these exceedances would be limited to the rail shutdown periods and some night work. In addition, night work would not be undertaken for more than two consecutive nights.

Table 21 Predicted L_{Aeq} noise impacts at representative residential receivers for each work package outside standard hours, dB(A)

Receiver ID[2]	NCA[2]	Distance (metres)	Night time NML, (dB(A))	Work Package[3]					
				2	3	4	5	6	7
R1	2	48	37	61	56	62	67	59	60
R2	2	76	37	76	71	74	64	73	68
R3	1	95	43	61	56	62	65	57	52
R4	1	155	43	46	40	48	51	46	37
R5	1	157	43	46	40	46	57	40	37
R6	2	168	37	51	39	52	55	49	39
R7	1	218	43	42	36	45	48	40	33
R8	2	234	37	31	26	30	30	27	23
R9	2	245	37	56	49	56	56	48	47
R10	2	254	37	59	53	59	54	52	50
R11	2	316	37	39	33	41	50	32	29
R12	2	334	37	33	28	33	32	27	26
R13	2	362	37	40	34	34	42	34	32
R14	2	377	37	35	22	35	36	30	27
R15	1	387	43	49	43	49	48	44	40
R16	2	423	37	34	28	36	51	27	25
R17	2	427	37	37	27	38	31	28	24
R18	2	450	37	30	25	34	30	28	24
R19	2	456	37	32	26	49	45	45	23
R20	2	486	37	47	43	48	46	42	40
R21	1	490	43	34	29	37	35	31	26
R22	2	491	37	46	39	47	44	43	36

Notes:

1. *Items shaded in grey indicate the predicted noise levels at this receiver during this work stage exceed the night-time NML*
2. *Addresses of receiver and noise catchment areas are provided in Table 1*
3. *Details of work packages provided in Table 18*

5.4.3 Summary of impacts to non-residential receivers

Three non-residential receivers are predicted to be exposed to noise levels which exceed the NMLs as shaded in grey in Table 22. These are the Volvo Car Dealer (N1) (Work package 1 – 4, 6), Magpies Leagues Club Waitara (N2) (Work package 2 to 5), and PCYC Hornsby (N5) (Work package 4 and 5). Key noisy activities include the use of concrete saws, jack hammers and bored piling. For receiver N1 an exceedance of up to 16 dB(A) is predicted for Work Package 4 which would be of limited duration. It is also noted that the predicted noise levels are based on all equipment operating at once and at the closest location to each receiver, therefore noise levels would be less for significant periods of time.

Table 22 Predicted noise impacts at representative non-residential receivers, dB(A)

Receiver ID[2]	Distance (metres)	NML (dB(A))	Work Package[3]						
			1	2	3	4	5	6	7
N1	25	70	79	82	71	86	67	74	68
N2	36	70	57	76	71	76	74	79	69
N3	54	70	48	57	45	58	63	57	47
N4	131	55	33	41	34	43	49	36	34
N5	181	55	46	50	45	57	62	50	38
N6	221	55	35	42	36	42	45	39	33
N7	251	70	50	57	50	55	50	49	48
N8	253	55	20	35	30	31	37	33	27
N9	344	55	45	38	28	38	33	31	25
N10	371	55	37	31	26	51	49	44	23
N11	464	55	34	50	45	50	41	44	42
N12	477	55	25	33	27	36	34	31	25
N13	515	70	54	48	33	48	36	42	30

Notes:

1. *Items shaded in grey indicate predicted noise levels at this receiver during this work stage exceed the NML*
2. *Addresses of receiver are provided in Table 2*
3. *Details of work packages provided in Table 18*

5.5 Sleep disturbance assessment

A sleep disturbance assessment was undertaken to assess work potentially required during the night-time period (e.g. during weekend rail shutdown periods). Appendix C presents the predicted maximum $L_{A1(1min)}$ noise level contours. Based on the predicted noise level, the awakening reaction criterion of 65 dB(A) is predicted to be exceeded at residential receivers along Yardley Avenue, Waitara Avenue, Orara Street, and Alexandria Parade during Work packages 2 to 5. In addition, the awakening reaction may be exceeded at residential receivers along Leonard Street during Work package 1 and Orara Street during Work package 7.

The predicted construction $L_{A1(1min)}$ noise levels presented in Appendix C are external noise levels. The typical outdoor to indoor noise reductions provided by most standard dwellings (i.e. without acoustical treatment) is generally accepted as being 10 dB with windows slightly open and a minimum of 20 dB with windows closed. Therefore, by closing their windows during noisy activities residents can potentially attenuate external noise levels by 20 dB to below the sleep awakening criterion.

In addition, the predicted construction noise levels are typically the worst case noise levels, therefore the majority of the actual $L_{A1(1min)}$ noise levels are likely to be less than those predicted.

Construction activities would be undertaken during the daytime where feasible.

5.6 Construction traffic assessment

The numbers of construction vehicles have been estimated by Transport for a rail shutdown period to be up to 45 heavy vehicles and 40 light vehicles per shift for travel to and from the Proposal area. For a normal week day, up to 25 heavy vehicles and 30 light vehicles are expected. Vehicles would access the site primarily via Alexandria Parade, and some vehicles would access the site from Romsey Street, Pattison Avenue and Leonard Street.

Due to existing numbers of traffic on Alexandria Parade, Romsey Street, Pattison Avenue and Leonard Street the relatively small numbers of construction traffic would likely not increase road traffic noise by more than 2 dB. This would comply with the RNP criteria.

To minimise the construction traffic noise levels and reduce the risk of negative impacts occurring, construction traffic management should be considered as part of the Noise and Vibration Management Plan.

5.7 Construction vibration assessment

Vibration intensive work may include the use of the following items of equipment:

- jackhammer
- bored piling rig.

The minimum working distances of these items of equipment from off-site receivers are shown in Table 23 which is based on recommendations of the Transport CNVS. If these minimum working distances are complied with, no adverse impacts from vibration intensive work are likely in terms of human response or cosmetic damage.

If vibration intensive work is required within these minimum working distances, mitigation measures to control excessive vibration would be implemented as outlined in Section 5.8.

Table 23 Minimum working distances of vibration intensive equipment to be used during the Proposal

Plant	Rating/ Description	Cosmetic	Damage	Human response
		Heritage	Residential/commercial	
Jackhammer	Handheld	1 metre (nominal)	1 metre (nominal)	Avoid contact with structure
Bored piling	≤ 800 millimetres	4 metres	2 metres	N/A

It is noted that the heritage items noted in Section 2.1.3 are located well outside the minimum working distances in Table 23 above, with the exception of the Waitara Railway Station Group (on-site receiver). Vibration intensive work would likely be required within the minimum working distances of the significant heritage elements associated with the station (such as the ticket booths and station building). If vibration intensive works are required within these minimum working distances, mitigation measures to control excessive vibration would be implemented as outlined in Section 5.8.

5.8 Construction mitigation measures

5.8.1 Construction Noise and Vibration Management Plan

A Construction Noise and Vibration Management Plan (CNVMP) should be developed for the Proposal and implemented prior to commencement of construction activities. The CNVMP should include all feasible and reasonable safeguards to manage the noise emissions from the site and manage any complaints which may occur due to construction noise or vibration. The CNVMP should include, as a minimum, the following:

- identification of nearby residences and other sensitive land uses
- description of approved hours of work

- description and identification of all construction activities, including work areas, equipment and duration
- description of what work practices (generic and specific) would be applied to minimise noise and vibration
- a complaints handling process
- noise and vibration monitoring procedures, including for heritage structures
- overview of community consultation required for identified high impact work.

Construction work should be planned and carried out during standard construction hours wherever possible. Given the relatively minor noise and vibration impacts of the Proposal, the standard and additional mitigation measures outlined in the Transport Construction Noise and Vibration Strategy are considered appropriate to manage potential impacts. Table 24 presents a summary of the standard mitigation measures contained within the CNVS which should be considered as mitigation measures as part of the CNVMP.

Table 24 Transport *Construction Noise and Vibration Strategy* standard mitigation measures

Action required	Safeguard details
Management measures	
Implement stakeholder consultation measures	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities, would be delivered to sensitive receivers at least 7 days prior to commencement of relevant work.
Site inductions	All employees, contractors and subcontractors would receive an environmental induction.
Behavioural practices	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.
Noise monitoring	A noise monitoring program would be implemented to assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities at the commencement of activities and periodically during the construction program as the work progress. The program would be developed in accordance with the CNVMP and any approval/licence conditions. The results would be reviewed to determine if additional mitigation measures are required. All measurements would be undertaken in accordance with Australian Standard *1055.2018 – Acoustics – Description and measurement of environmental noise.*

Action required	Safeguard details
Source controls	
Construction hours and scheduling	Where feasible and reasonable, construction would be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels would be scheduled during less sensitive time periods as far as practicable. This would include the use of demolition saws, coring machines, grinders, impact drills and jackhammers.
Construction respite period	Noise with special audible characteristics and vibration generating activities (including jack hammering) would only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a 1 hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work would be undertaken in the same NCA over any 7-day period, unless otherwise approved by the relevant authority.
Equipment selection	Quieter and less vibration emitting construction methods would be used where feasible and reasonable (e.g. rubber wheeled instead of steel tracked plant). Equipment would be regularly inspected and maintained to ensure it is in good working order.
Maximum noise levels	The noise levels of plant and equipment would have operating sound power or sound pressure levels that would meet the predicted noise levels.
Rental plant and equipment	Noise emissions would be considered as part of the selection process.
Use and siting of plant	Simultaneous operation of noisy plant within discernible range of a sensitive receiver would be avoided. The offset distance between noisy plant and adjacent sensitive receivers would be maximised. Plant used intermittently would be throttled down or shut down. Plant and vehicles would be turned off when not in use. Noise-emitting plant would be directed away from sensitive receivers where reasonable and feasible.
Plan work site and activities to minimise noise and vibration	Traffic flow, parking and loading/unloading areas would be planned to minimise reversing movements within the site. Truck drivers would be advised of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (i.e. minimising the use of engine brakes, and no extended periods of engine idling).
Non-tonal reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) would be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.

Action required	Safeguard details
Minimise disturbance arising from delivery of goods to construction sites	Loading and unloading of materials/deliveries would occur as far as possible from sensitive receivers. Site access points and roads would be selected as far as possible away from sensitive receivers. Dedicated loading/unloading areas would be shielded if close to sensitive receivers. Delivery vehicles would be fitted with straps rather than chains for unloading, wherever possible.
Silencers on Mobile Plant	Where possible, noise from mobile plant would be reduced through additional fittings including: • Residential grade mufflers • Silencing air parking brake engagement.
Construction Related Traffic	Vehicle movements would be routed away from sensitive receivers and scheduled during less sensitive times. The speed of vehicles would be limited and the use of engine compression brakes would be minimised. On-site storage capacity would be maximised to reduce the need for truck movements during sensitive times.
Vibration minimum working distances	If vibration intensive equipment is to be used within the minimum working distances for cosmetic damage, as presented in Table 23, then attended vibration measurements would be undertaken when work commences, to determine “site specific minimum working distances”. The minimum working distances for cosmetic damage from Table 23 are generally considered to be conservative. Working within them would not necessarily result in damage however as factors such as work practices and intervening structures can affect vibration levels. In addition, vibration intensive work would not proceed within the site specific minimum working distances unless a permanent vibration monitoring system is installed approximately one metre from the building footprint, to warn operators (e.g. via flashing light, audible alarm, SMS) when vibration levels are approaching the peak particle velocity objective. It is also advisable to carry out building condition surveys of sensitive historical structures before construction work begins.
Path controls	
Shield stationary noise sources such as pumps, compressors, fans etc.	Stationary noise sources would be enclosed or shielded to the greatest extent possible whilst ensuring that the occupational health and safety of workers is maintained.
Shield sensitive receivers from noisy activities	Structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) would be used.

5.8.2 Community consultation and complaints handling

All residents and sensitive receivers impacted by noise levels from the Proposal where noise levels are expected to exceed the noise management level should be consulted prior to the commencement of the particular activity, with the highest consideration given to those that are predicted to be most affected as a result of the work.

The information provided to the residents would include:

- programmed times and locations of construction work
- the hours of proposed work
- construction noise and vibration impact predictions
- construction noise and vibration mitigation measures being implemented on site.

Community consultation regarding construction noise and vibration would be detailed in a Community Liaison Plan for the construction of the Proposal and would include a 24 hour hotline and complaints management process.

5.8.3 Transport for NSW Construction Noise and Vibration Strategy - Additional mitigation measures

Transport's CNVS provides practical guidance on how to minimise, to the fullest extent practicable, the impacts on the community from airborne noise, ground-borne noise and vibration generated during the construction of Transport's projects. This is managed through the application of all feasible and reasonable mitigation measures. Where exceedances are still expected to occur after standard mitigation measures have been applied, the CNVS recommends the implementation of additional mitigation measures. These mitigation measures are specified within the CNVS and presented in Table 25.

The provision of additional mitigation is based on the predicted exceedances above RBLs and when the exceedances occur, which is related to a receiver's perception of the noise. From Table 24 it can be seen that the consideration of a receiver's perception of construction noise ranges from 'noticeable' to 'highly intrusive'. The RBLs can be found in Table 7, and Appendix C shows the location of impacted receivers and degree of noise exceedance predicted (to determine which mitigation measures should be applied to which receiver).

Table 25 Additional mitigation measures matrix

Time period		Action level[1](mitigation measures)[2]				
		0 10 dB(A) Noticeable	>10 20 dB(A) Clearly audible	20 30 dB(A) Moderately intrusive	>30 dB(A) Highly intrusive	≥75 dB(A)
Standard	Weekday (7am-6pm) Saturday (8am-1pm) Sun/Pub Hol (Nil)	-	-	PN, V	PN, V	PN, V SN
Out-of-Hours Work Period 1	Weekday (6pm-10pm) Saturday (7-8am) & (1-10pm) Sun/Pub Hol (8am-6pm)	-	PN, RP[3], DR[3]	PN, V, SN, RO, RP[3], DR[3]	PN, V, SN, RO, RP[3] DR[3]	N/A
Out-of-Hours Work Period 2	Weekday (10pm-7am) Saturday (10pm-8am) Sun/Pub Hol (6pm-7am)	PN	PN, V, SN, RO[4], RP[3], DR[3]	PN, V, SN, RO[4], RP[3] DR[3]	PN, V, SN, RO[4], RP[3] DR[3], AA	N/A

Notes:

1. Action level is $L_{Aeq(15\ minute)}$ noise level above background (RBL) - qualitative assessment of noise levels

2. The following abbreviations have been used (refer to Table 26 for further details):

PN: Project notification
V: Verification monitoring
SN: Specific notification
RP: Respite period
DR: Duration Respite
RO: Project specific respite offer
AA: Alternative accommodation

3. Respite periods and duration reduction are not applicable when work are carried out during OOHW Period 1 Day only (i.e. Saturday 6:00 am-7:00 am and 1:00 pm-6:00 pm, Sundays/Public Holidays 8:00 am-6:00 pm)

4. Respite offers during OOHW Period 2 are only applicable for evening periods (i.e. Sundays/Public Holidays 6pm-10pm), and may not be required if a respite offer has already been made for the immediately preceding OOHW Period 1

Table 26 outlines the additional mitigation measures, as outlined in the CNVS.

Table 26 Description of additional mitigation measures

Abbreviation	Mitigation measure	Explanation
PN	Periodic notification	A notification entitled 'Project Update', 'Construction Update' or 'Community Update' or similar is produced and distributed to stakeholders via letterbox drop and distributed to the Project postal and/or email mailing lists. The same information would be published on Transport's website. Periodic notifications provide an overview of current and upcoming work across the Project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions can assist in reducing the impact on stakeholders. The approval conditions for projects specify requirements for notification to sensitive receivers where work may impact on them. Content and length is determined on a project-by-project basis and must be approved by Transport prior to distribution. Most projects distribute notifications on a monthly basis.
V	Verification	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver or a nominated representative location. Monitoring can be in the form of either unattended logging or operator attended surveys. The purpose of monitoring is to confirm that: Attended noise monitoring is to be undertaken as follows: • construction noise and vibration from the Project are consistent with the predictions in the noise assessment • mitigation and management of construction noise and vibration is appropriate for receivers affected by the work. Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required.

Abbreviation	Mitigation measure	Explanation
SN	Specific notifications	Specific notifications are in the form of a personalised letter, or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Letters may be letterbox dropped or hand distributed. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that would be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the Project. Specific notifications are used to support periodic notifications, or to advertise unscheduled work and must be approved by Transport prior to implementation/distribution.
RO	Respite offers	The purpose of a respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre-purchased tickets for activities, restaurants or similar.
AA	Alternative accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction work that are likely to incur unreasonably high impacts. Alternative accommodation would be determined on a case-by-case basis and should provide a like-for-life replacement for permanent residents, including provisions for pets, where reasonable and feasible.
RP	Respite period	OOHW during evening and night periods would be restricted so that receivers are impacted for no more than three consecutive evenings and no more than two consecutive nights in the same NCA in any one week, except where this is a Duration Reduction. A minimum respite period of four evenings/five nights shall be implemented between periods of evening and/or night work. Strong justification must be provided where it is not feasible and reasonable to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by Transport through the OOHW Approval Protocol.
DR	Duration Reduction	Where Respite Periods are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through an overall Duration Reduction to minimise the duration of the activity. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with Project Community Engagement Representatives.

6.0 Operational noise

Additional operational equipment at the station would include a new pedestrian underpass, two new lifts and new family accessible and ambulant toilet facilities which would not produce significant noise emissions. Additional car parking is not proposed as part of the Proposal. As such, the operational noise environment is expected to remain largely unchanged. Standard noise controls such as appropriate selection of mechanical plant would reduce any impacts. If required, operational noise emissions shall be addressed during the detailed design phase in order to comply with operational noise criteria as per the NPfI. Operational noise criteria are presented in Section 4.0.

7.0 Conclusions

A construction and operational Noise and Vibration Impact Assessment has been completed for the Proposal. Nearby noise and vibration sensitive receivers were identified. Attended and unattended noise measurements were completed to characterise the existing noise environment. The measured noise levels were used to establish operational noise criteria and construction noise management levels.

The Proposal is expected to commence construction in mid-2022 and take up to 18 months to complete. Construction would be undertaken during both standard construction hours and out-of-hours however would primarily be undertaken during standard hours. Some work may need to occur outside standard hours and would include night work and work during routine rail shutdowns, which are scheduled closures that would occur regardless of the Proposal when part of the rail network is temporarily closed, and trains are not operating.

Construction work packages have been developed in consultation with Transport and the proposed equipment has been detailed within this report. Eight distinct work packages were identified and seven were used in a computer-based noise model to determine the potential changes to noise levels. Construction noise impacts were assessed at 22 representative residential receivers surrounding the Proposal. Impacts were also assessed at 13 representative nearby non-residential sensitive receivers.

7.1 Construction noise

The predicted construction noise levels exceed the construction NMLs for all scenarios at the closest residential and non-residential receivers. Noise exceedances are generally unavoidable given the proposed work and proximity to receivers, notwithstanding the implementation of feasible and reasonable noise mitigation measures. The largest impacts would be experienced by residents along Alexandria Parade. During standard hours, one residential receiver (R2) is predicted to be 'highly affected' during the new pedestrian underpass works (Work package 2).

During night-time work noise levels at several receivers are predicted to exceed the NMLs including R1 to R7, R9 to R11, R13, R15 to R17, R19, R20 and R22. Noise levels at receivers R1 and R2 are predicted to exceed the NMLs by more than 25 dB(A) at times. However, these exceedances would be limited to the rail shutdown periods and some night work. In addition, night work would not be undertaken for more than two consecutive nights.

Recommendations to mitigate construction noise impacts have been provided in Section 5.8.

7.2 Sleep disturbance assessment

A sleep disturbance assessment was undertaken to assess work potentially required during the night-time period (e.g. during weekend rail shutdown periods). Appendix C presents the predicted maximum $L_{A1(1min)}$ noise level contours. Based on the predicted noise levels, the awakening reaction criterion of 65 dB(A) is predicted to be exceeded at residential receivers along Yardley Avenue, Waitara Avenue, Orara Street, and Alexandria Parade during Work packages 2 to 4. In addition, the awakening reaction may be exceeded at residential receivers along Leonard Street during Work package 1 and Orara Street during Work package 7.

The predicted construction $L_{A1(1min)}$ noise levels presented in Appendix C are external noise levels. The typical outdoor to indoor noise reductions provided by most standard dwellings (i.e without acoustical treatment) is generally accepted as being 10 dB with windows slightly open and a minimum of 20 dB with windows closed. Therefore, by closing their windows during noisy activities residents can potentially attenuate external noise levels by 20 dB which would result in internal noise levels which are less than the sleep awakening criterion. In addition, the predicted construction noise levels are typically the worst case noise levels, therefore the majority of the actual $L_{A1(1min)}$ noise levels are likely to be less than those predicted.

Implementation of mitigation measures outlined in Section 5.8 would aim to minimise and manage noise impacts where possible. Mitigation measures have been recommended in line with Transport's CNVS in order to minimise and manage the impact of construction noise on nearby noise sensitive receivers. Construction activities would be undertaken during the daytime where feasible.

7.3 Construction vibration

Minimum working distances to nearby structures have been recommended for nominated plant. If the minimum working distances are maintained, then no adverse impact from the vibration intensive work is likely in terms of human response or cosmetic damage. It is unlikely that work would be undertaken within the minimum working distances for heritage, commercial and residential receivers during the proposed vibration intensive work, with the exception of heritage items at the station itself. Should work be required within the minimum working distances, the recommended additional mitigation measures would be implemented.

7.4 Operation

During the operation of the Proposal, there may be minor changes to the existing noise levels due to the operation of the new lifts, however these are not considered to be significant. As such, the operational noise environment is expected to remain largely unchanged. If required, operational noise emissions shall be addressed during the detailed design phase in order to comply with operational noise criteria as per the NPfI.

Appendix A

Acoustic Terminology

Appendix A Acoustic Terminology

The following is a brief description of acoustic terminology used in this report.

Sound power level	The total sound emitted by a source.
Sound pressure level	The amount of sound at a specified point.
Decibel [dB]	The measurement unit of sound.
A Weighted decibels [dB(A)]	The A weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1kHz and 4 kHz) which the human ear is most sensitive to and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A).
Decibel scale	The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A 3 dB increase in the sound pressure level corresponds to a doubling in the sound energy. A 10 dB increase in the sound pressure level corresponds to a perceived doubling in volume. Examples of decibel levels of common sounds are as follows:

0dB(A)	Threshold of human hearing
30dB(A)	A quiet country park
40dB(A)	Whisper in a library
50dB(A)	Open office space
70dB(A)	Inside a car on a freeway
80dB(A)	Outboard motor
90dB(A)	Heavy truck pass-by
100dB(A)	Jackhammer/Subway train
110 dB(A)	Rock Concert
115dB(A)	Limit of sound permitted in industry
120dB(A)	747 take off at 250 metres

Frequency [f]	The repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high pitched sound and a low frequency to a low pitched sound.
Equivalent continuous sound level [L_{eq}]	The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy.
L_{max}	The maximum sound pressure level measured over the measurement period.
L_{min}	The minimum sound pressure level measured over the measurement period.
L_{10}	The sound pressure level exceeded for 10% of the measurement period. For 10% of the measurement period it was louder than the L_{10}.

L_{90}	The sound pressure level exceeded for 90% of the measurement period. For 90% of the measurement period it was louder than the L_{90}.
Ambient noise	The all-encompassing noise at a point composed of sound from all sources near and far.
Background noise	The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The L_{90} sound pressure level is used to quantify background noise.
Traffic noise	The total noise resulting from road traffic. The L_{eq} sound pressure level is used to quantify traffic noise.
Day	The period from 0700 to 1800 h Monday to Saturday and 0800 to 1800 h Sundays and Public Holidays.
Evening	The period from 1800 to 2200 h Monday to Sunday and Public Holidays.
Night	The period from 2200 to 0700 h Monday to Saturday and 2200 to 0800 h Sundays and Public Holidays.
Noise catchment area [NCA]	The noise environment at each of the sensitive receivers within a noise catchment area is considered to be similar to the unattended monitoring location within that NCA.
Assessment background level [ABL]	The overall background level for each day, evening and night period for **each day** of the noise monitoring.
Rating background level [RBL]	The overall background level for each day, evening and night period for the **entire length** of noise monitoring.

*Definitions of a number of terms have been adapted from Australian Standard AS1633:1985 *"Acoustics – Glossary of terms and related symbols"*, the EPA's *Noise Policy for Industry* and the EPA's *Road Noise Policy*.

Appendix B

Noise Logging

Noise Logger Report

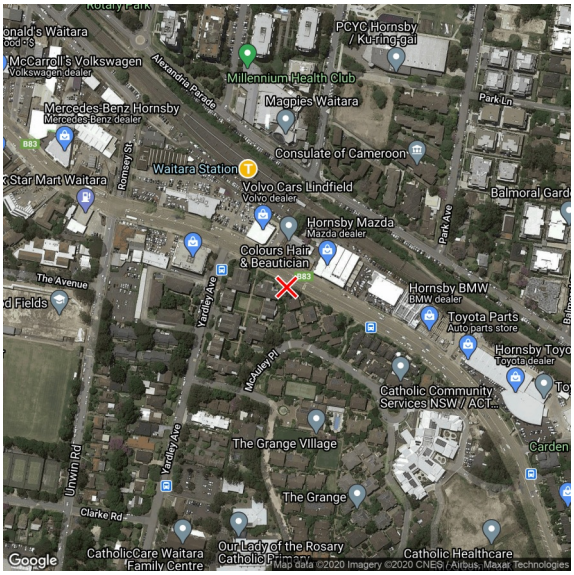
2 McAuley Place, Waitara

Item	Information
Logger Type	ARL315
Serial number	15-299-444
Address	2 McAuley Place, Waitara
Location	2 McAuley Place, Waitara
Facade / Free Field	Free Field
Environment	Sunny with a light breeze. Birds chirping occasionally (42 dB(A)), vehicle pass by (62 dB(A)), bus pass by (66 dB(A)) and trucks pass by (78 dB(A))

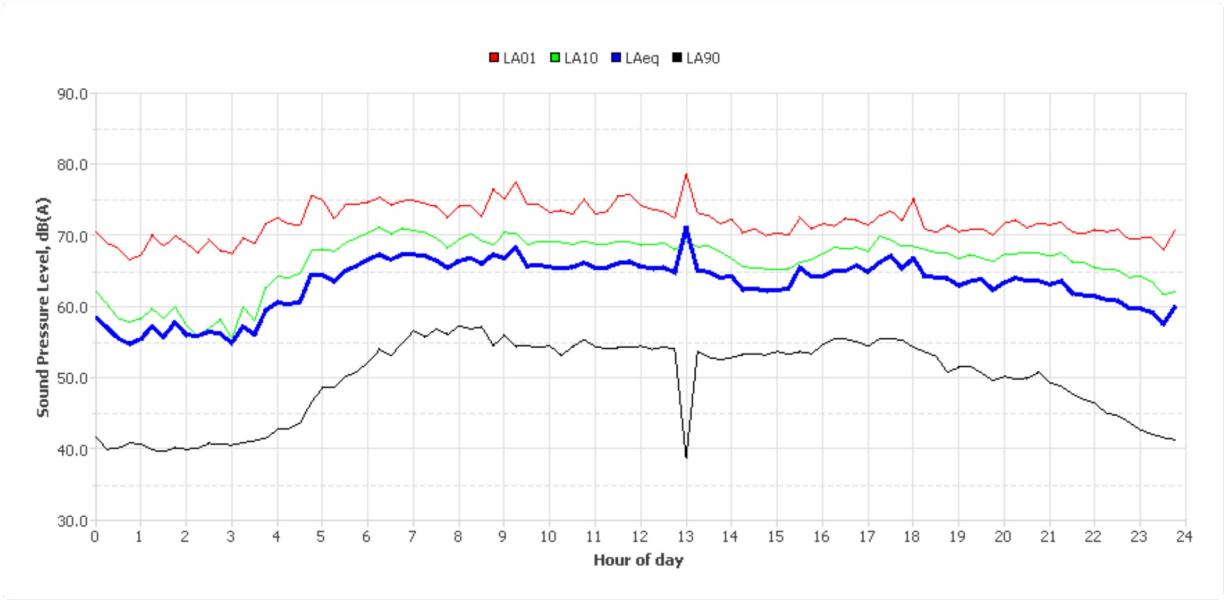
Measured noise levels

Logging Date	L_{Aeq} Day	Eve	Night	ABL Day	Eve	Night	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Wed Oct 14 2020	63	61	56	-	42	-	63	56
Thu Oct 15 2020	64	62	60	50	45	35	64	60
Fri Oct 16 2020	66	65	60	55	46	37	66	60
Sat Oct 17 2020	65	64	61	51	47	36	65	61
Sun Oct 18 2020	65	64	60	49	48	39	65	60
Mon Oct 19 2020	67	64	62	53	45	39	66	62
Tue Oct 20 2020	67	65	63	53	48	37	66	63
Wed Oct 21 2020	65	64	62	52	47	40	64	62
Thu Oct 22 2020	65	63	62	-	48	40	65	62
Fri Oct 23 2020	66	-	62	-	-	-	66	62
Summary	**65**	**64**	**61**	**52**	**47**	**38**	**65**	**61**

Note: Results denoted with '-' do not contain enough valid data for a value to be calculated. The data has been excluded either manually or automatically as a result of adverse weather conditions.

Logger Location	Logger Deployment Photo
	

Typical Day



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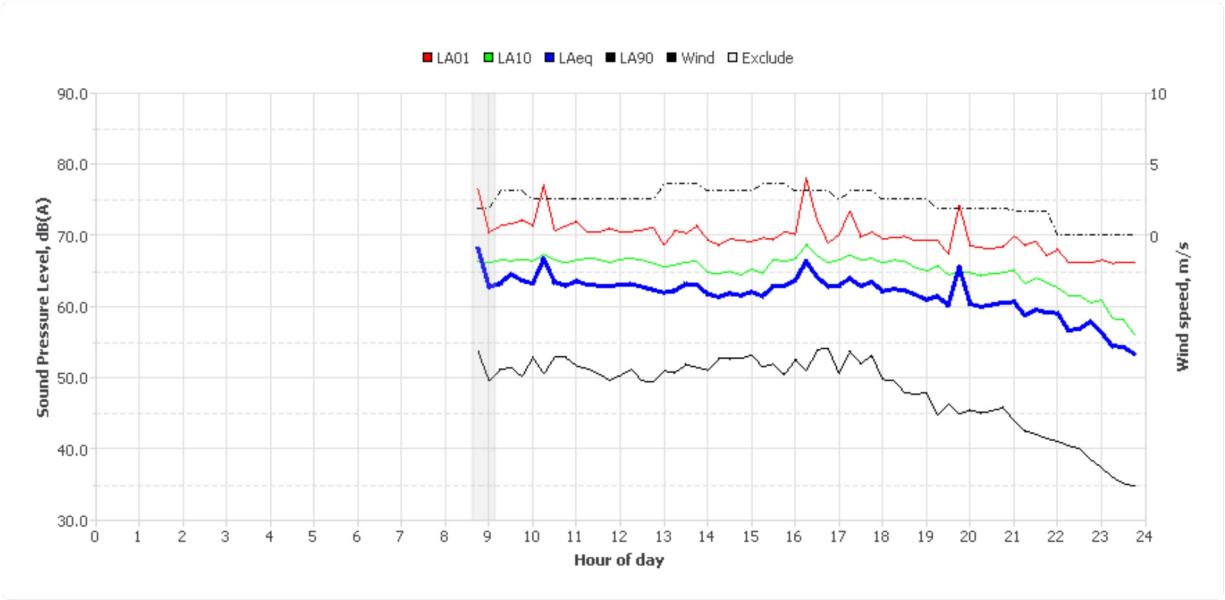

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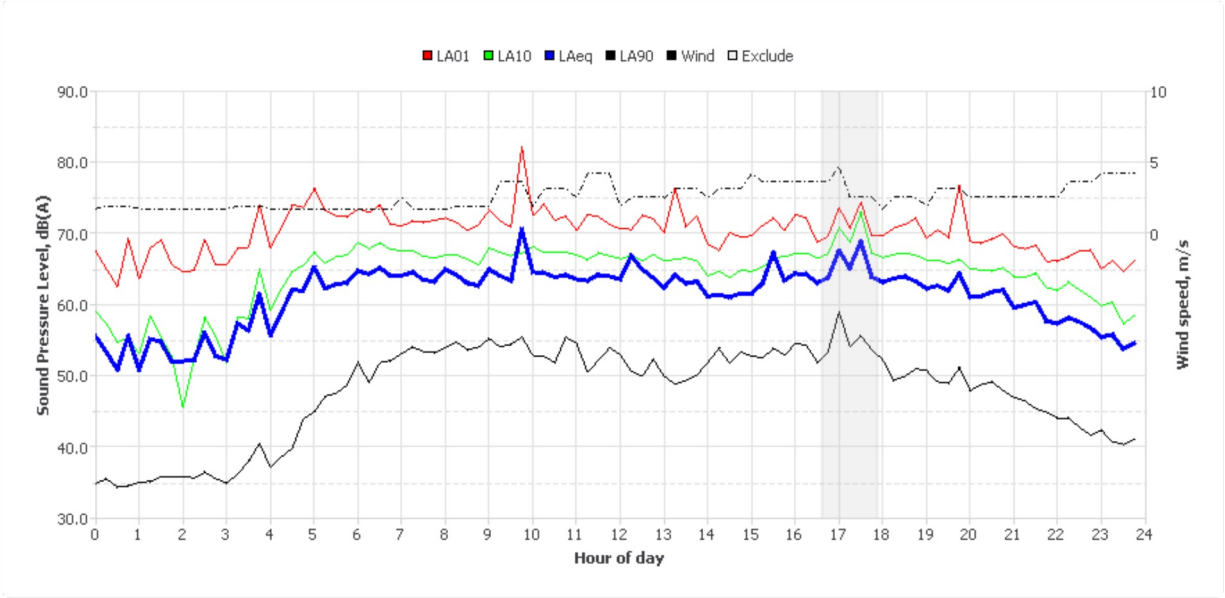

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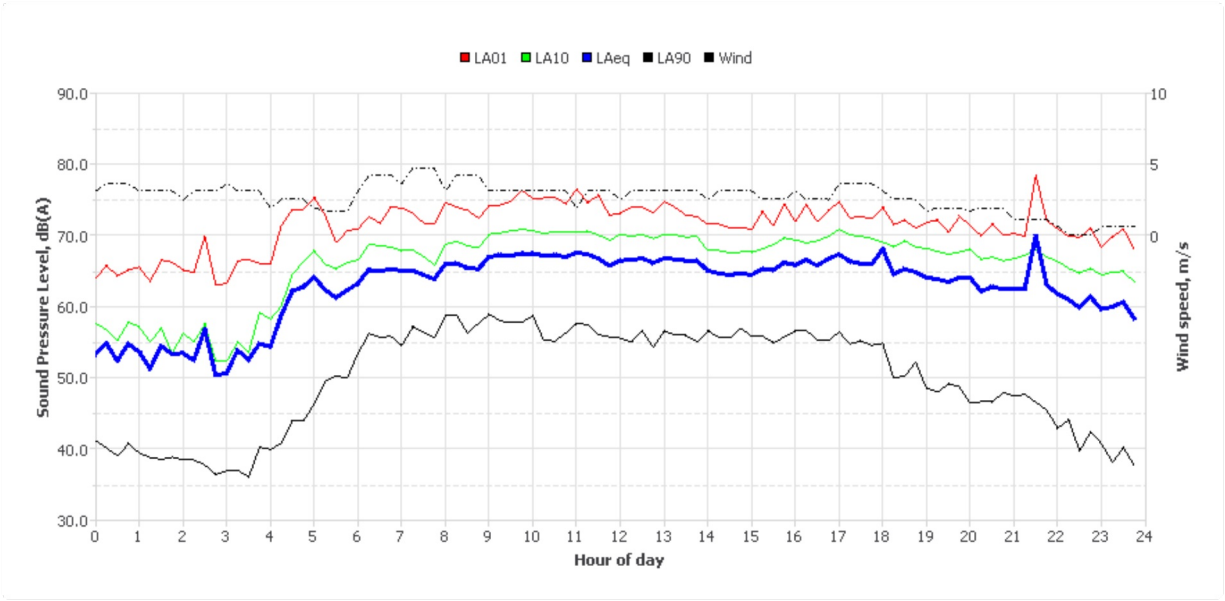

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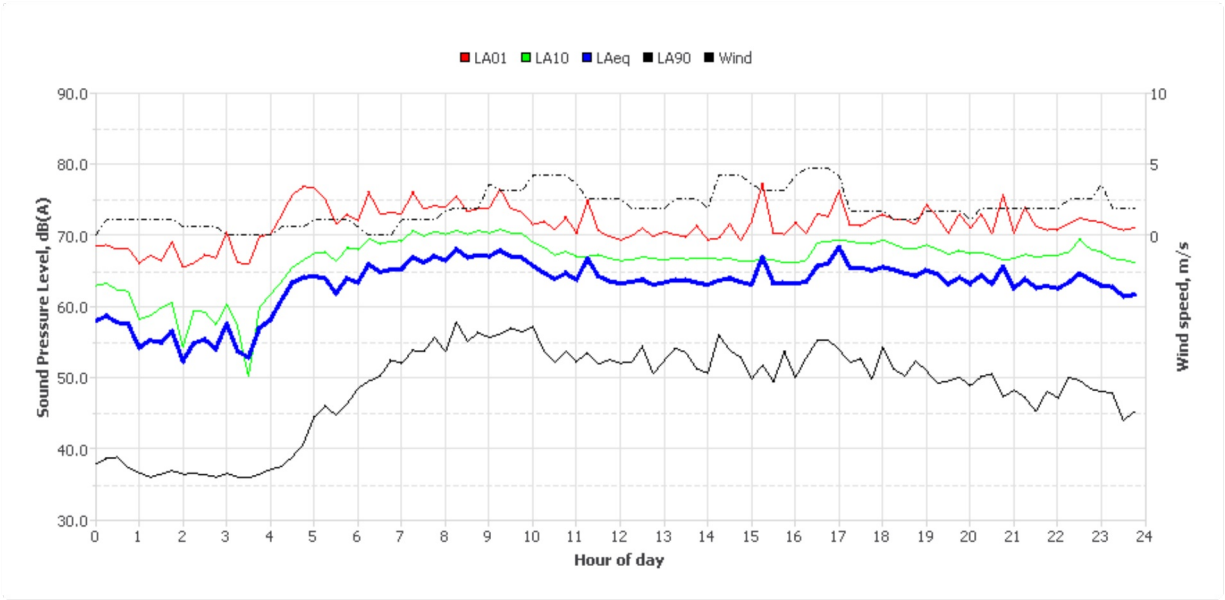

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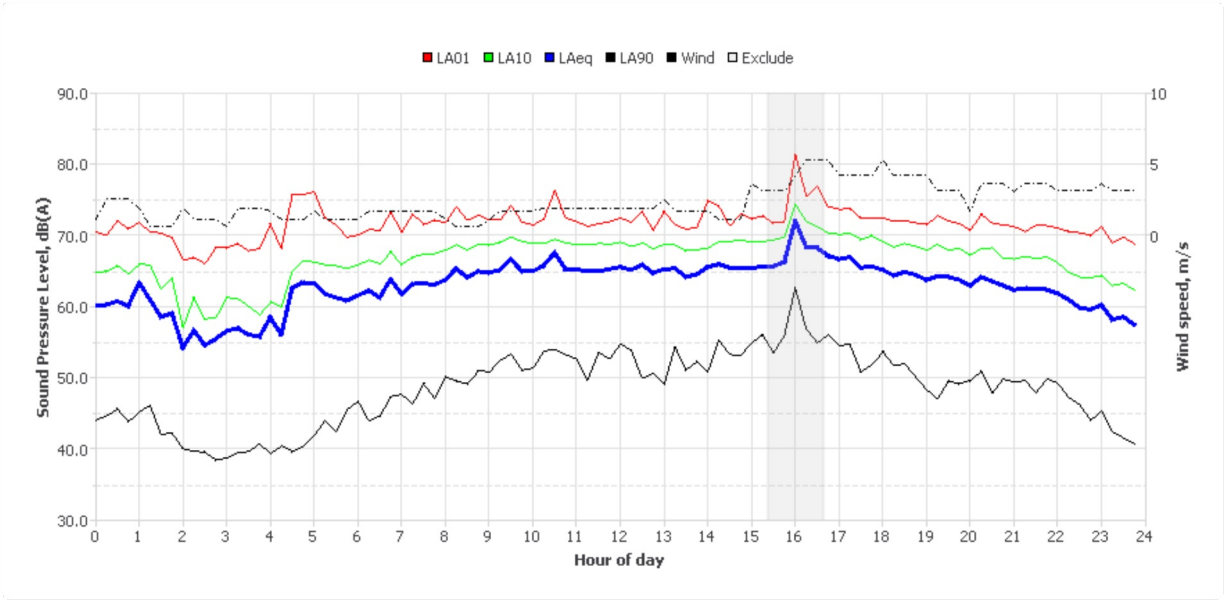

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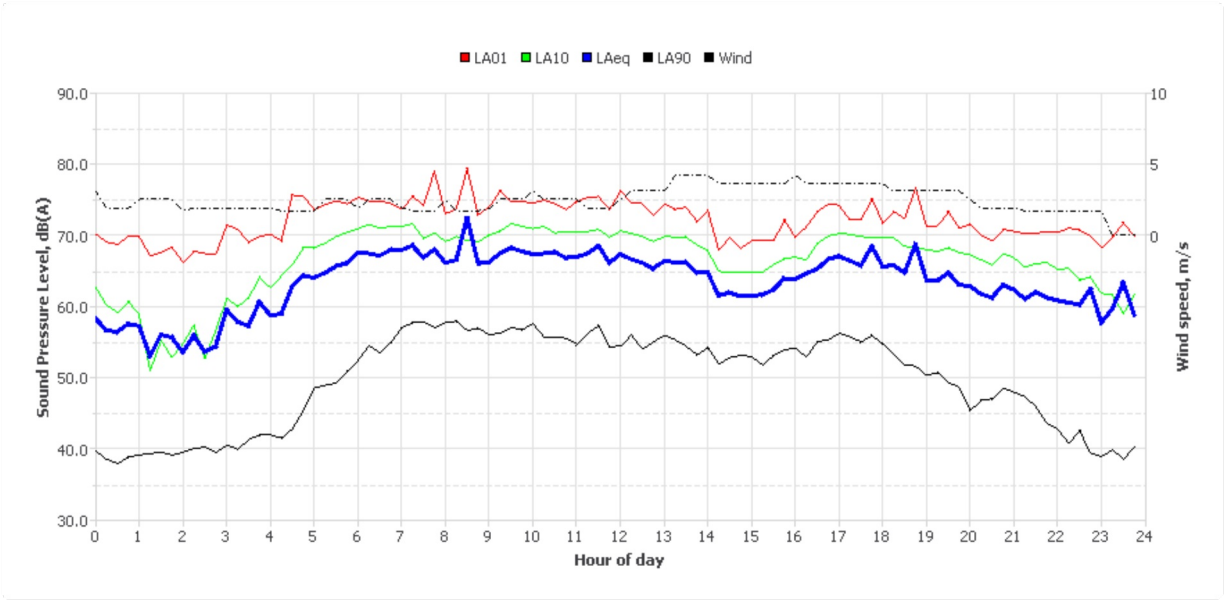

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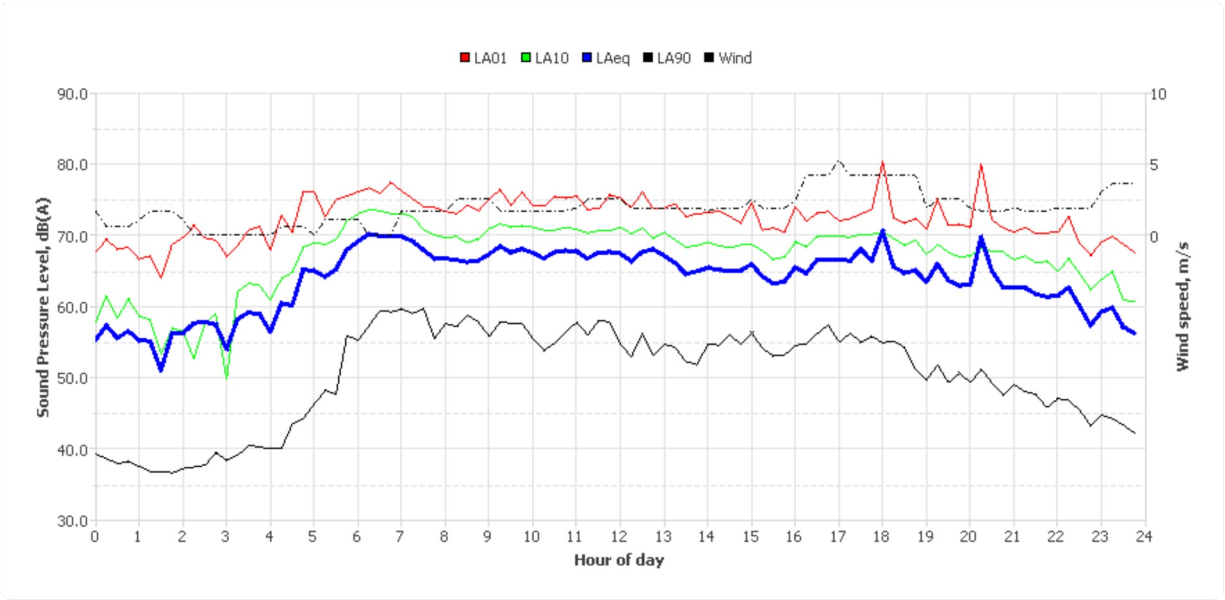

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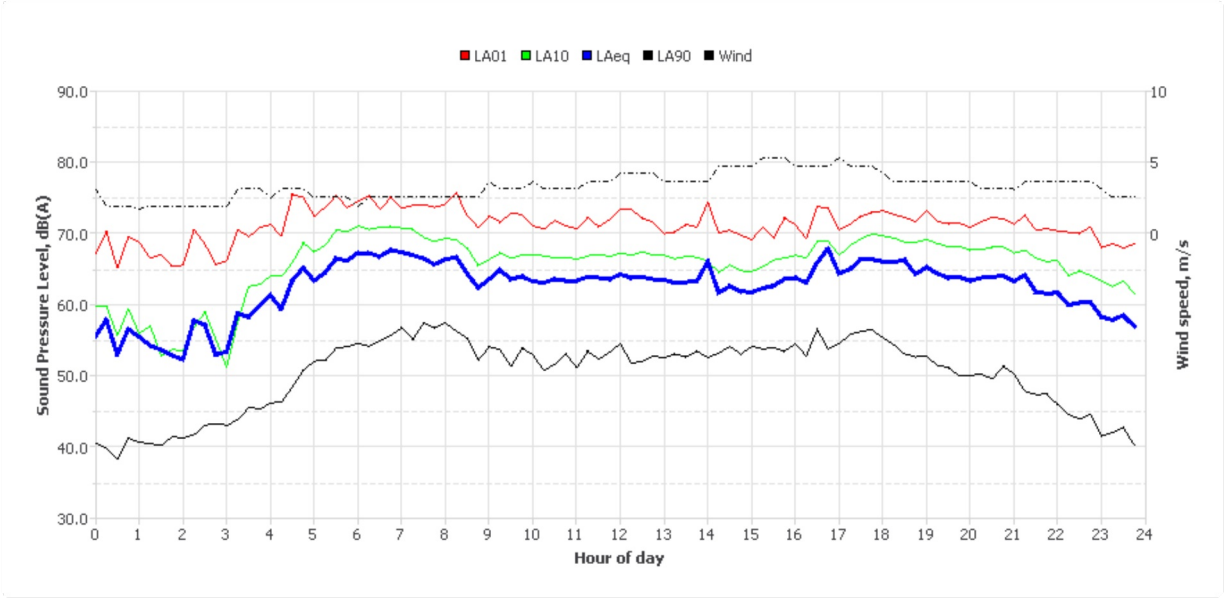

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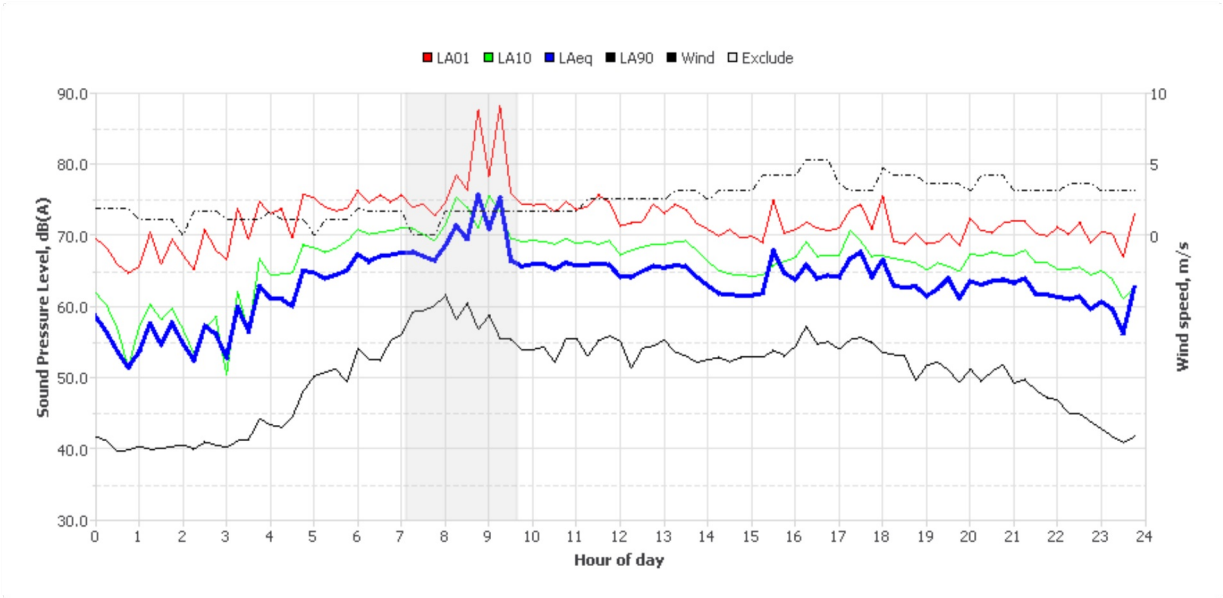

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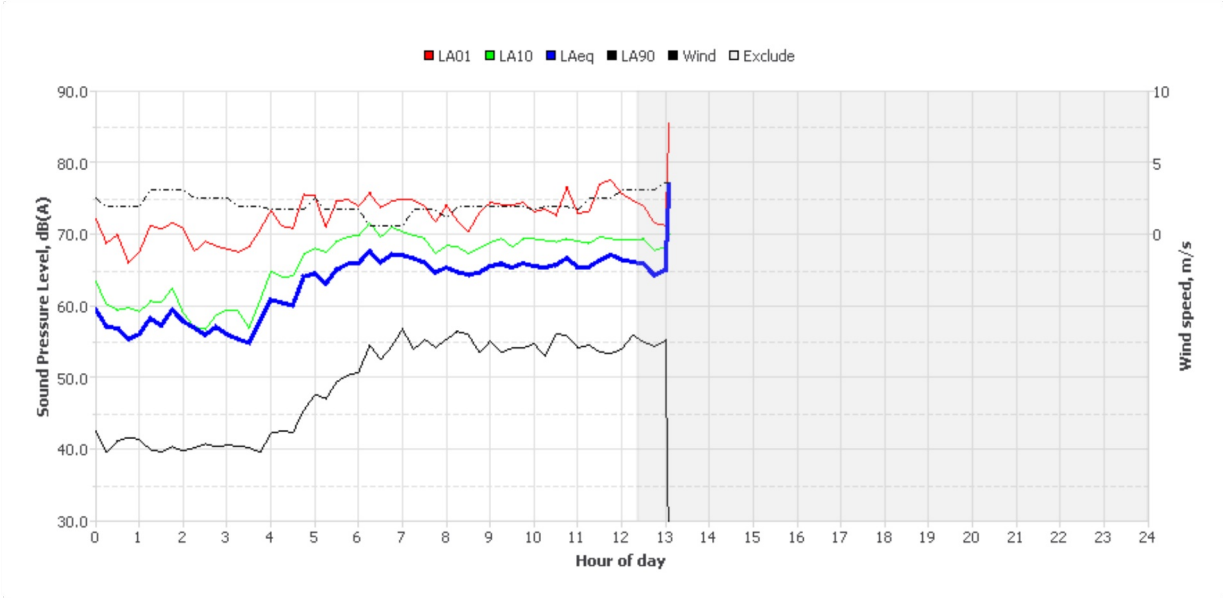


Noise Logger Report

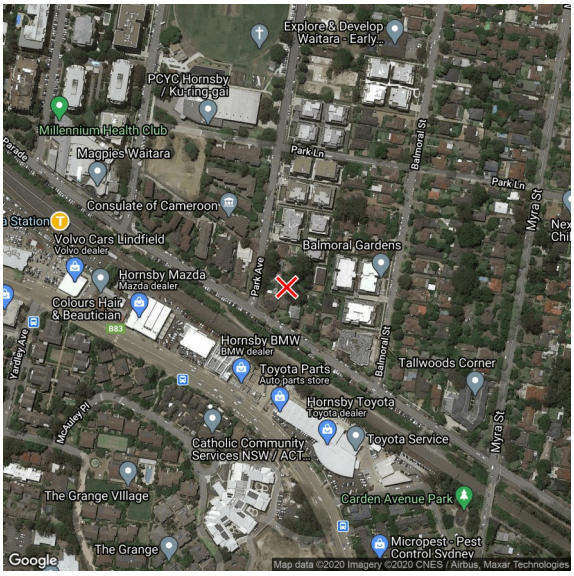
59 Alexandria Parade, Waitara

Item	Information
Logger Type	Svan 977
Serial number	45417
Address	59 Alexandria Parade, Waitara
Location	59 Alexandria Parade, Waitara
Facade / Free Field	Free Field
Environment	Cloudy, rain at times, birds chirping (50dB(A)), vehicle pass by (60.1dB(A))

Measured noise levels

Logging Date	L_{Aeq} Day	Eve	Night	ABL Day	Eve	Night	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Fri Oct 23 2020	52	50	44	-	41	-	51	44
Sat Oct 24 2020	53	-	53	-	-	24	53	53
Sun Oct 25 2020	-	-	30	-	-	-	-	30
Mon Oct 26 2020	-	-	48	-	-	-	-	48
Tue Oct 27 2020	-	-	55	-	-	-	-	55
Wed Oct 28 2020	-	-	84	-	-	-	-	84
Thu Oct 29 2020	56	50	49	-	-	-	55	49
Fri Oct 30 2020	53	49	47	41	-	33	52	47
Sat Oct 31 2020	52	48	43	40	-	-	51	43
Sun Nov 1 2020	52	52	48	-	-	32	52	48
Mon Nov 2 2020	54	51	47	44	-	34	53	47
Tue Nov 3 2020	53	-	49	-	-	-	53	49
Summary	**53**	**50**	**73**	**41**	**41**	**32**	**53**	**73**

Note: Results denoted with '-' do not contain enough valid data for a value to be calculated. The data has been excluded either manually or automatically as a result of adverse weather conditions.

Logger Location	Logger Deployment Photo
	

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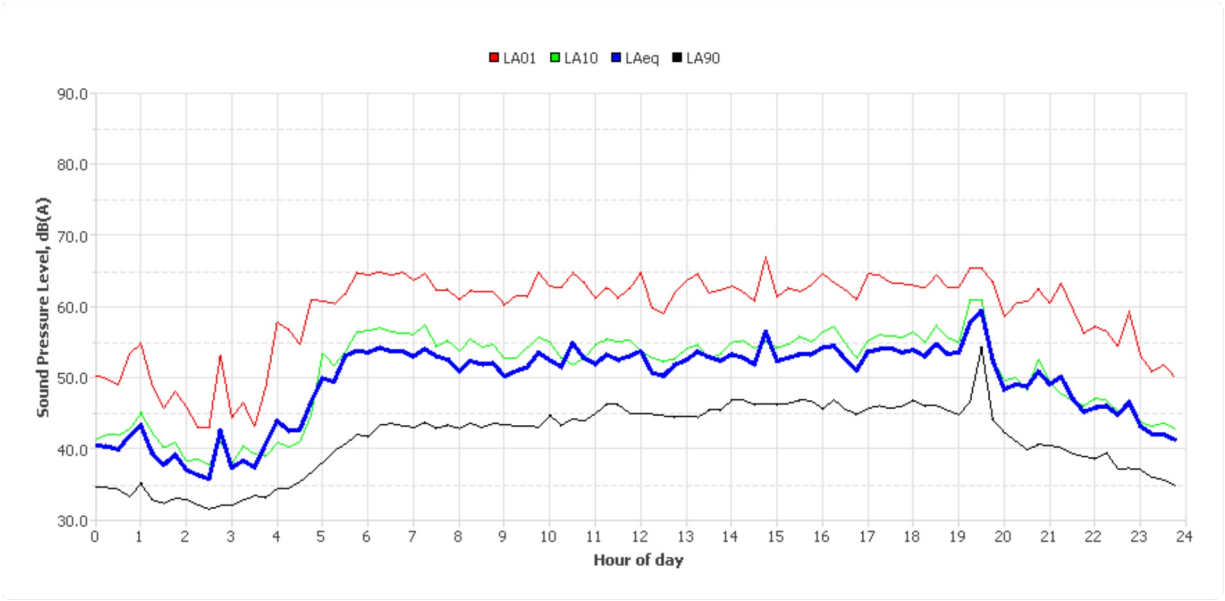

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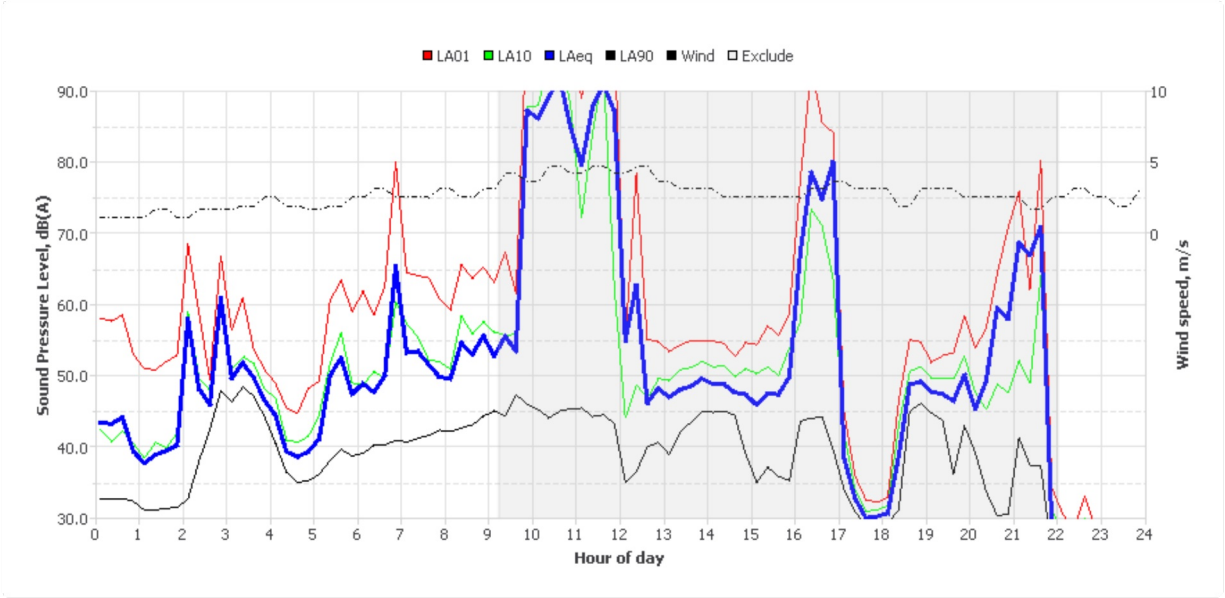

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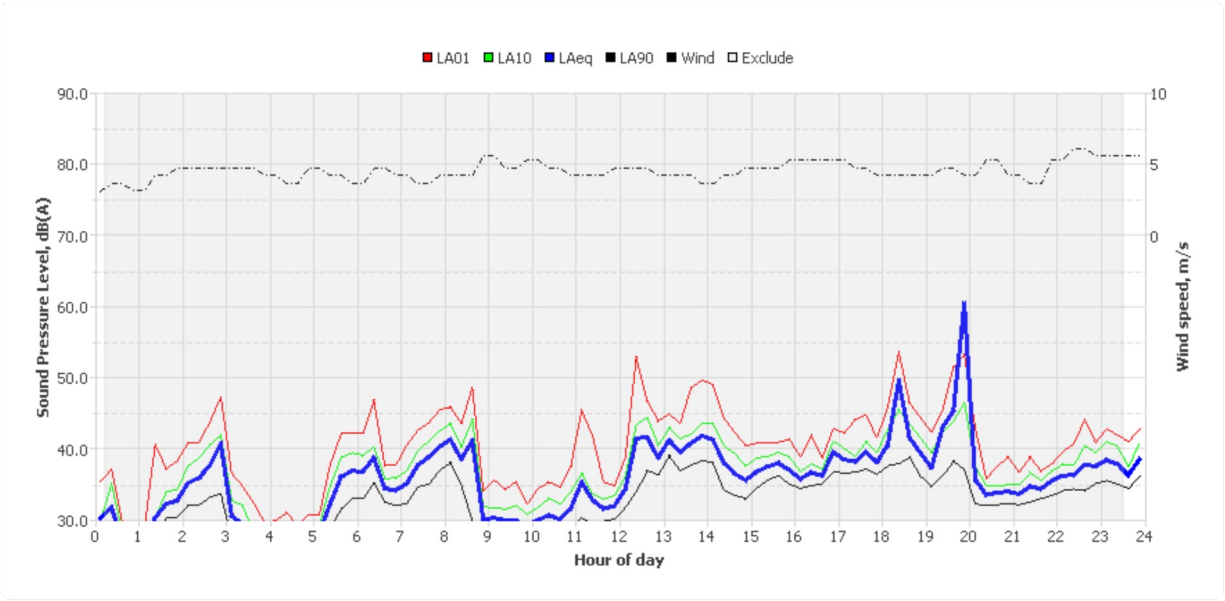

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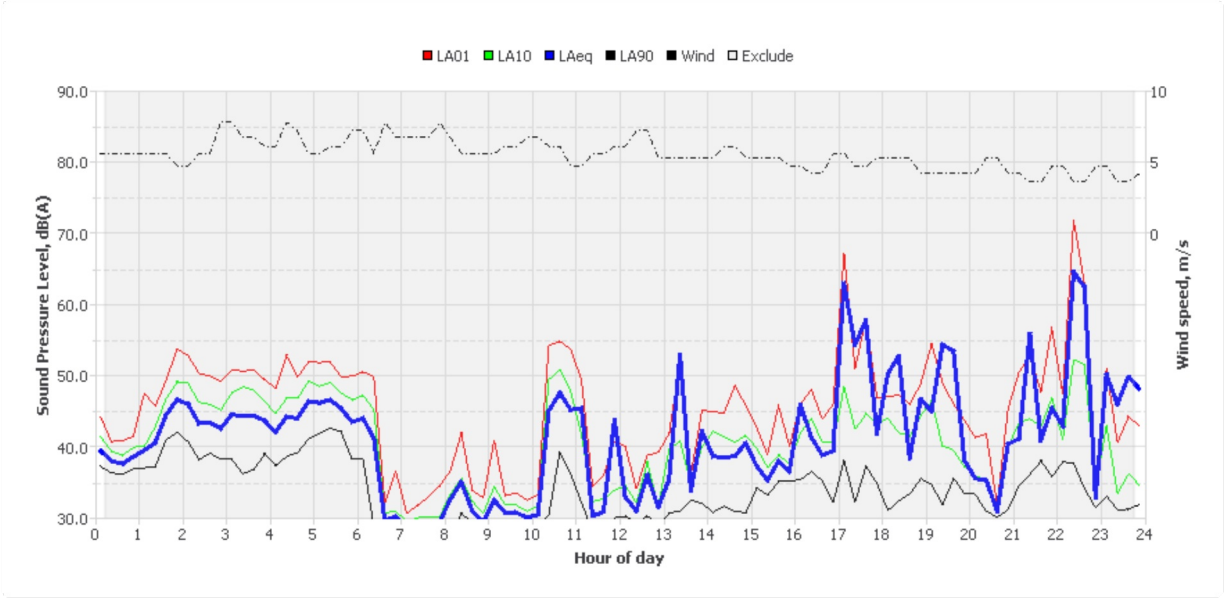

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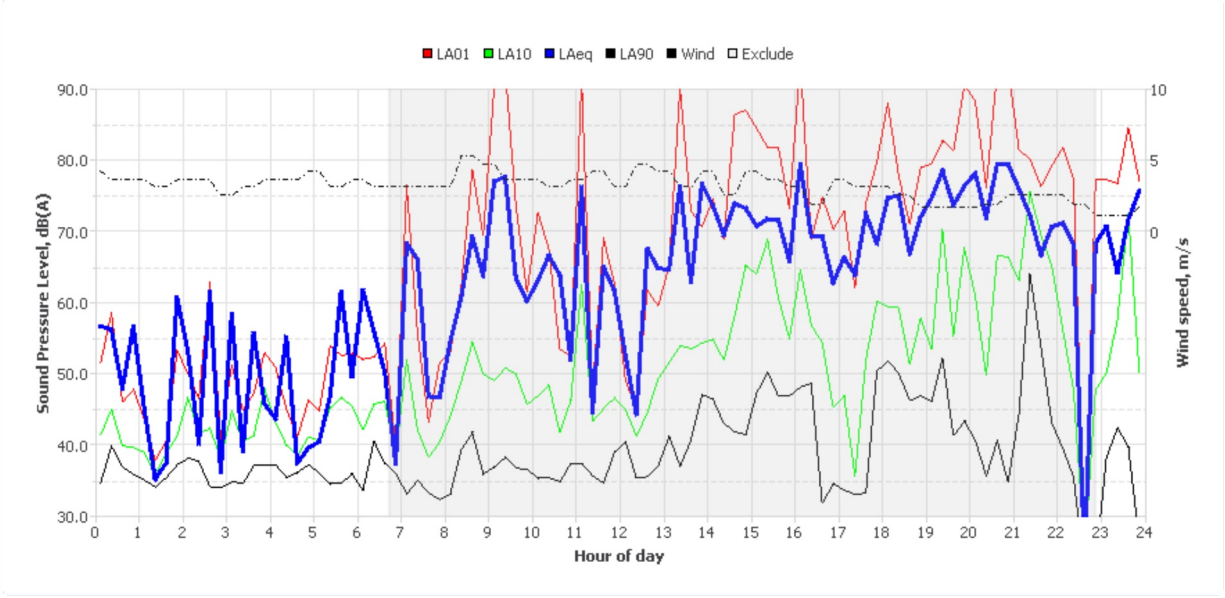

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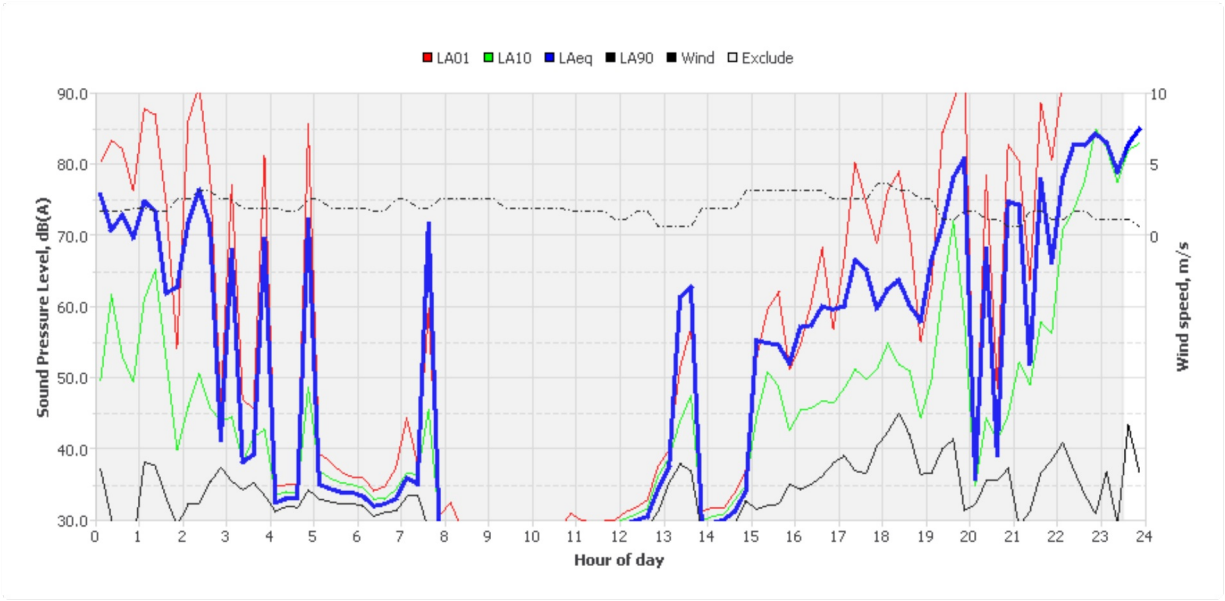

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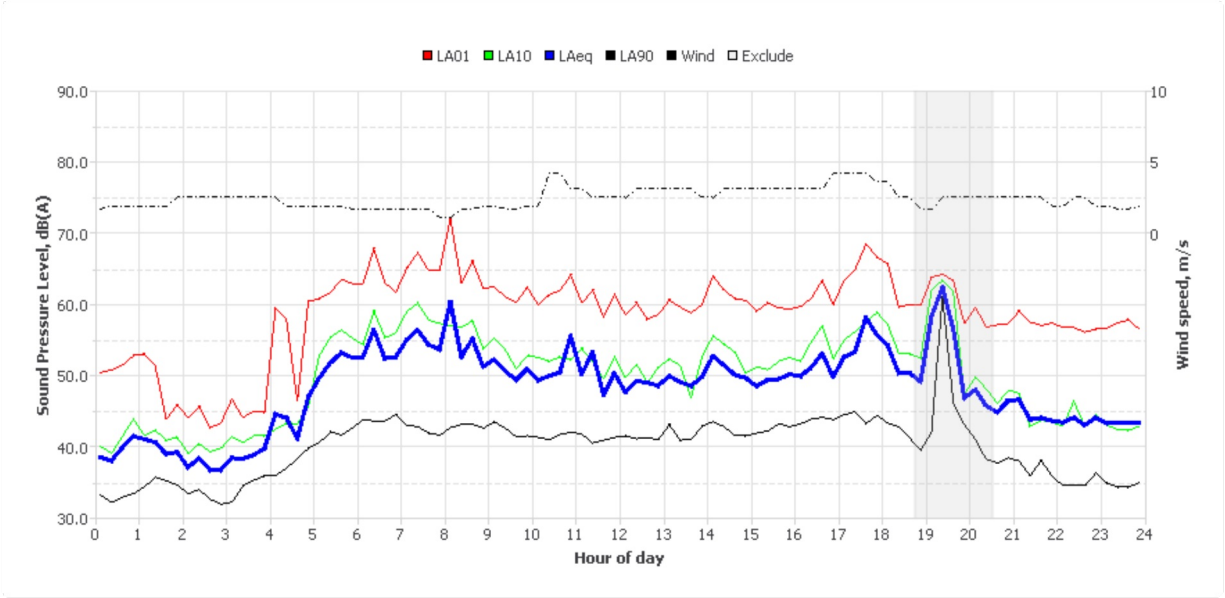

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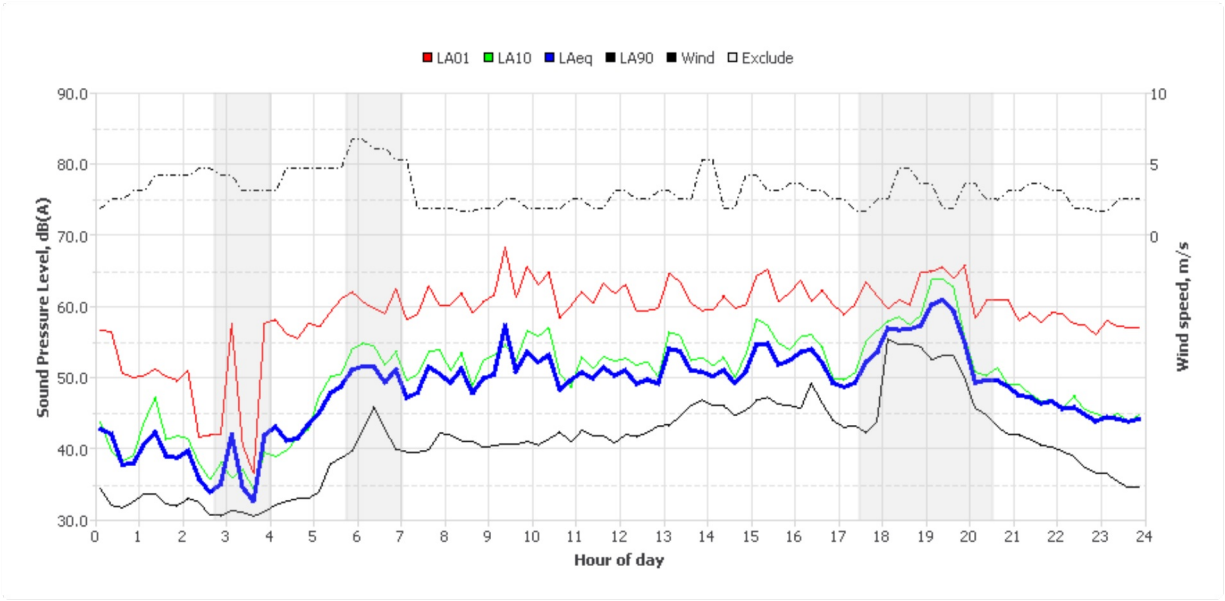

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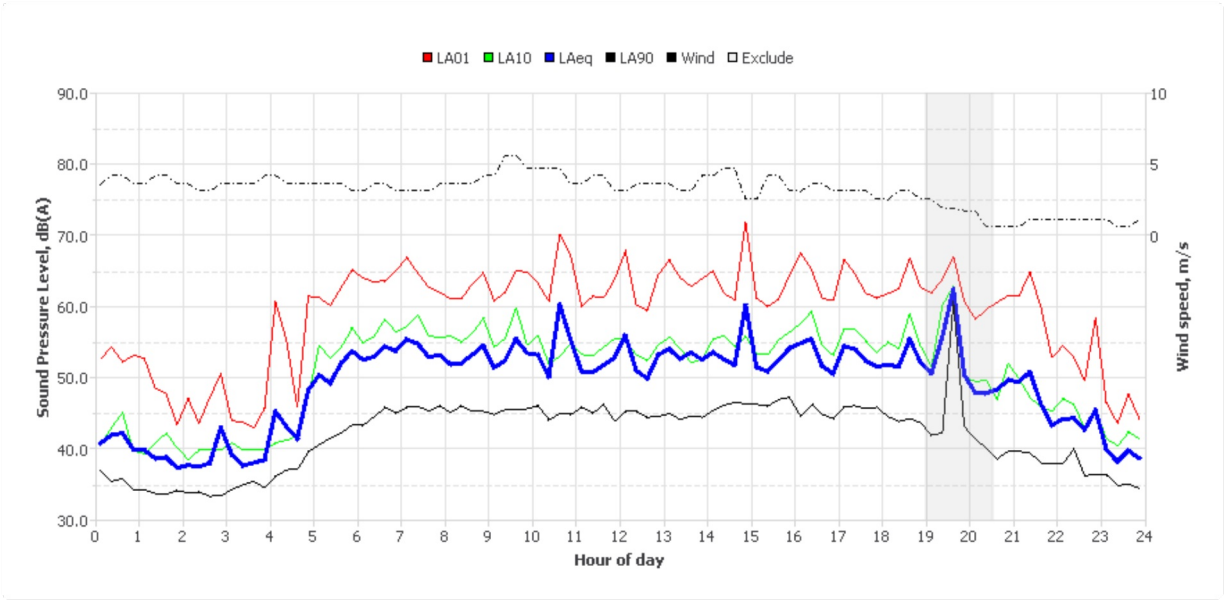
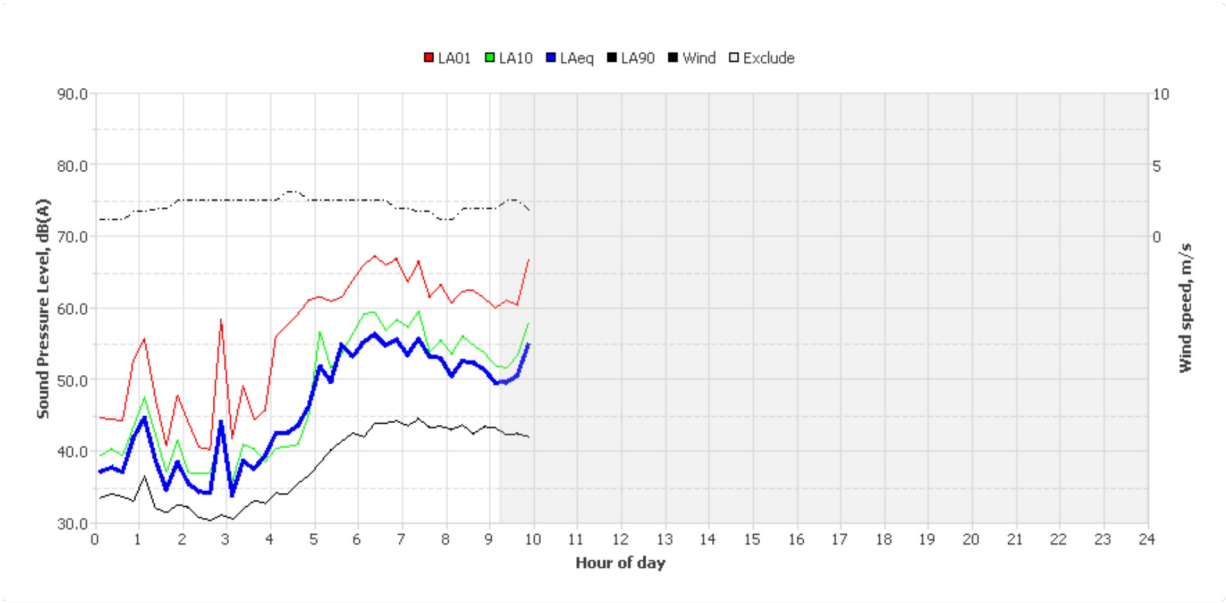
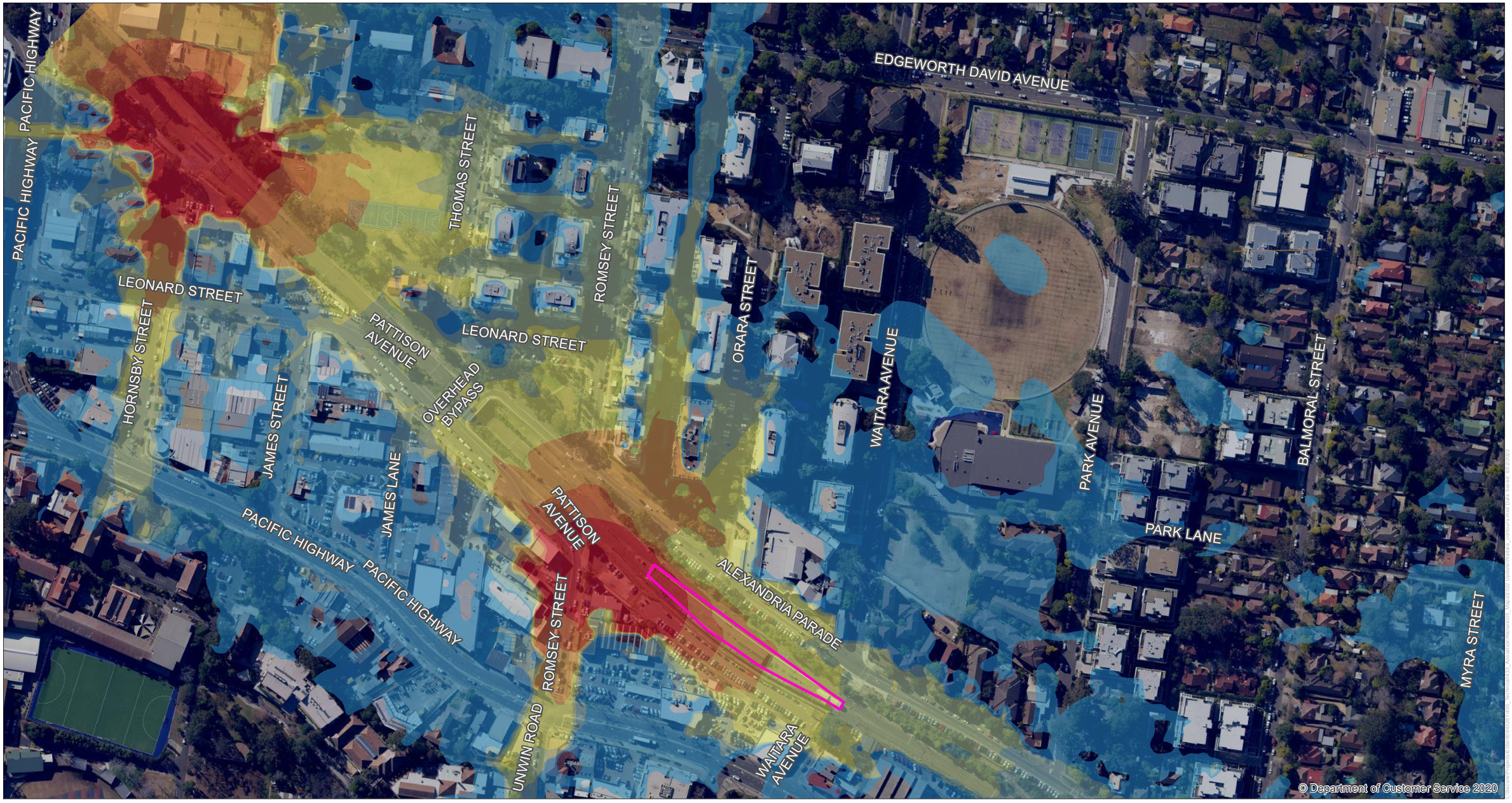


Tuesday, 03 Nov 2020



Appendix C

Predicted Noise Contours - Construction



Site establishment and enabling works - L_{Aeq} (dB(A))

L_{Aeq} (dB(A)) Proposal

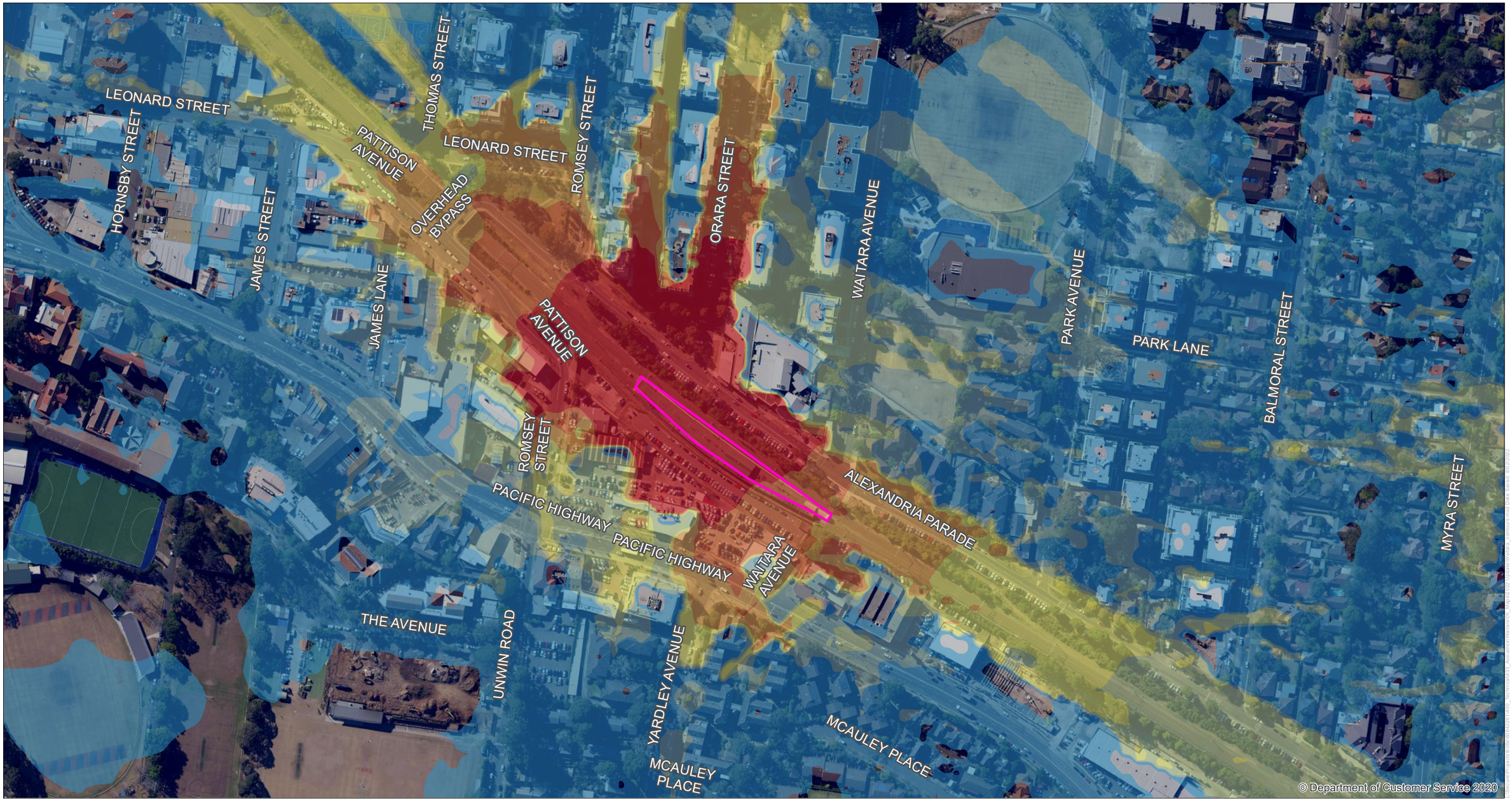
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



New pedastrian underpass - L_{Aeq} (dB(A))

L_{Aeq} (dB(A)) Proposal

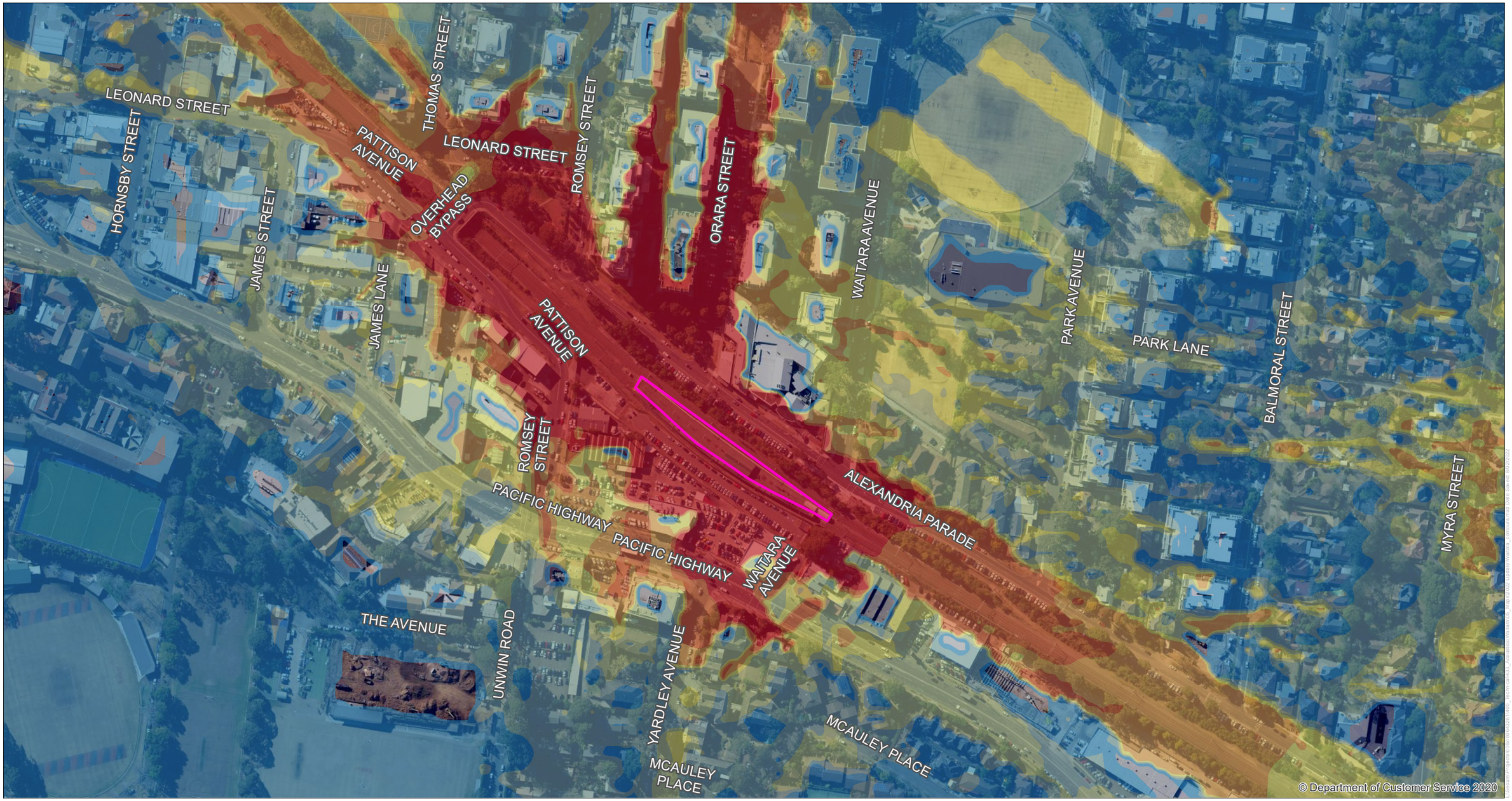
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



New pederstrian underpass - $L_{A1(1min)}$ (dB(A))

$L_{A1(1min)}$ (dB(A))

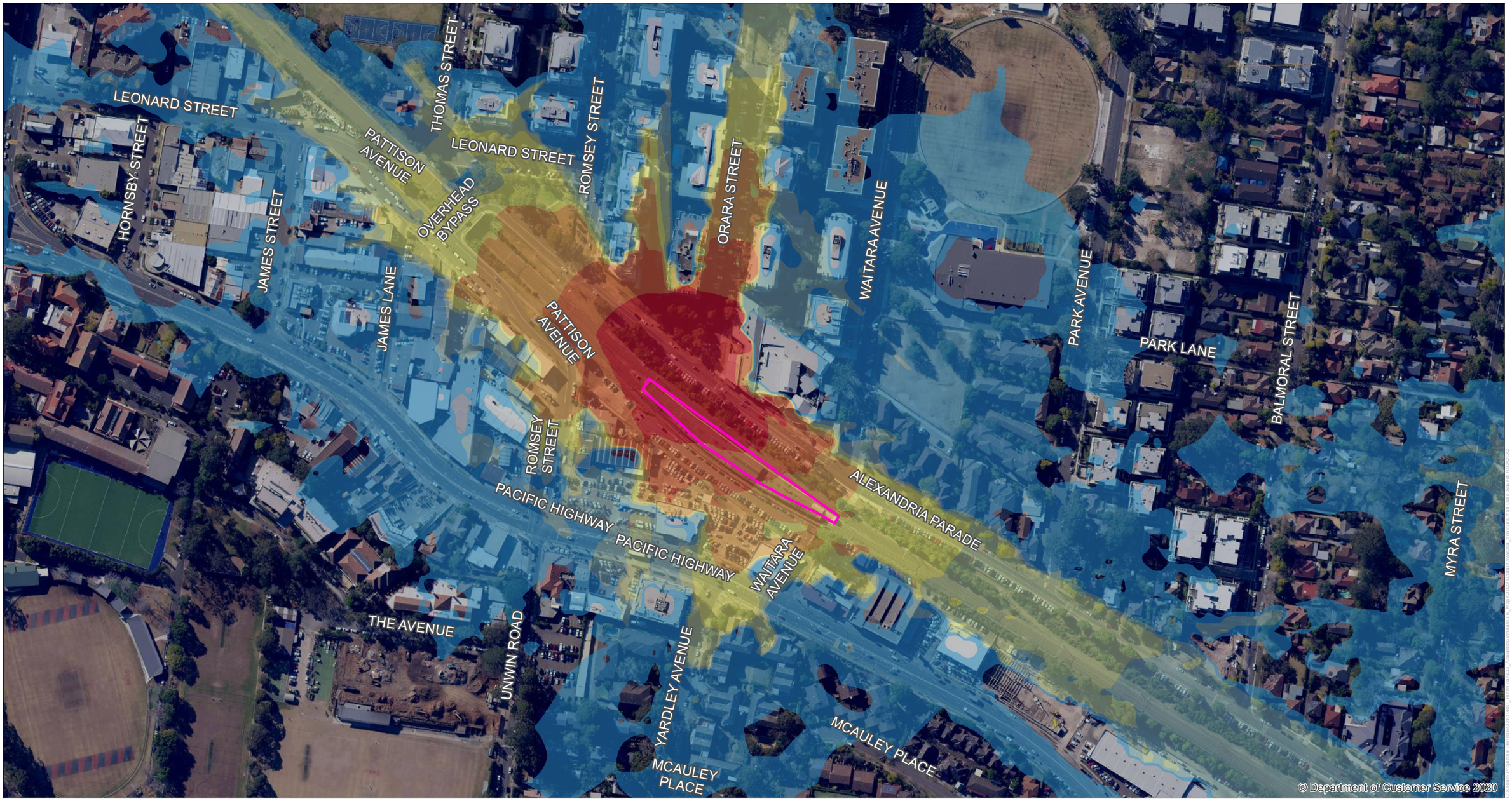
- Proposal
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



New station entrance - L_{Aeq} (dB(A))

L_{Aeq} (dB(A)) Proposal

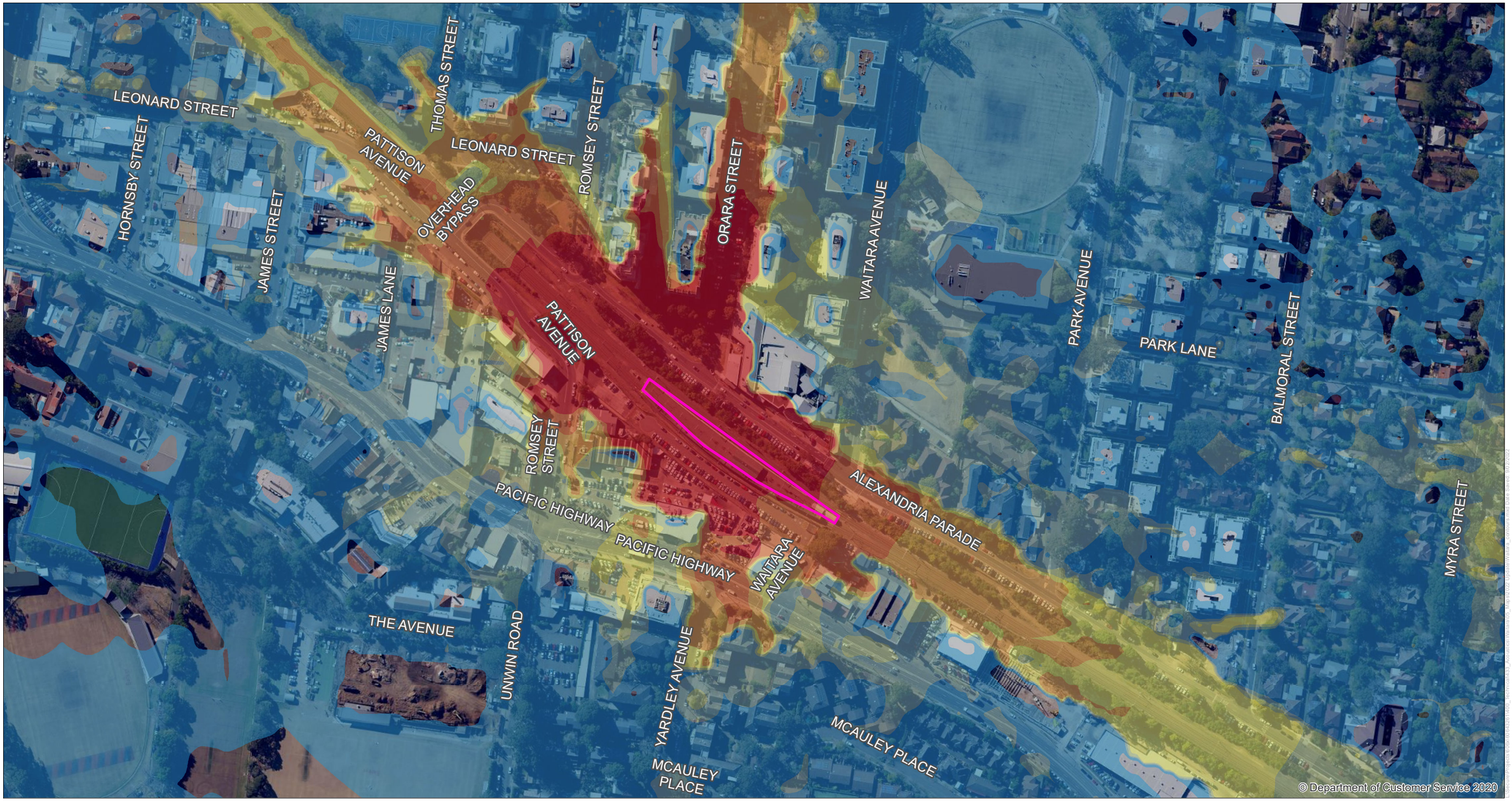
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



New station entrance - $L_{A1(1min)}$ (dB(A))

L_{Aeq} (dB(A))

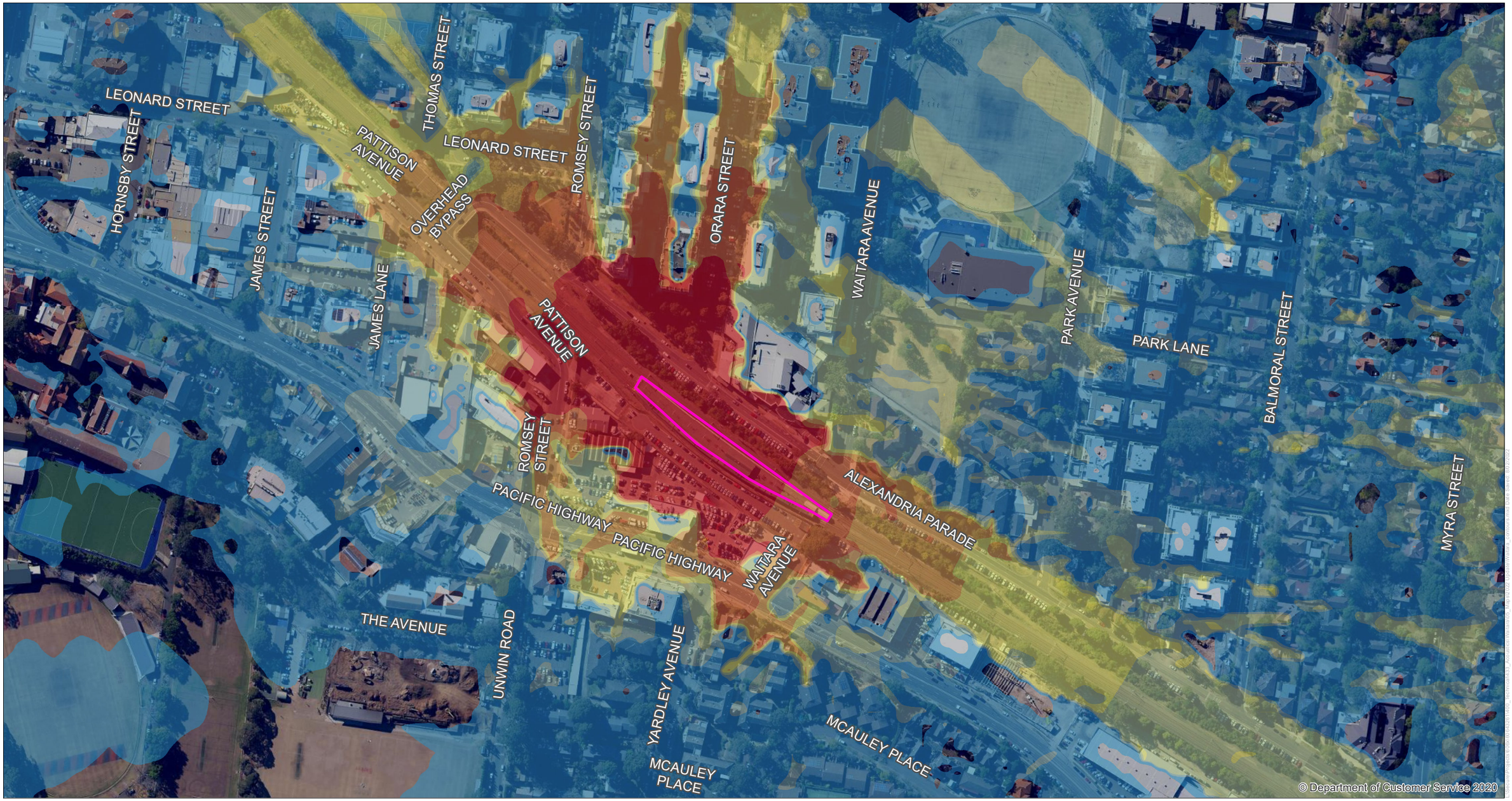
- Proposal
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



Lifts, platform staircase and platform upgrades - L_{Aeq} (dB(A))

L_{Aeq} (dB(A)) Proposal

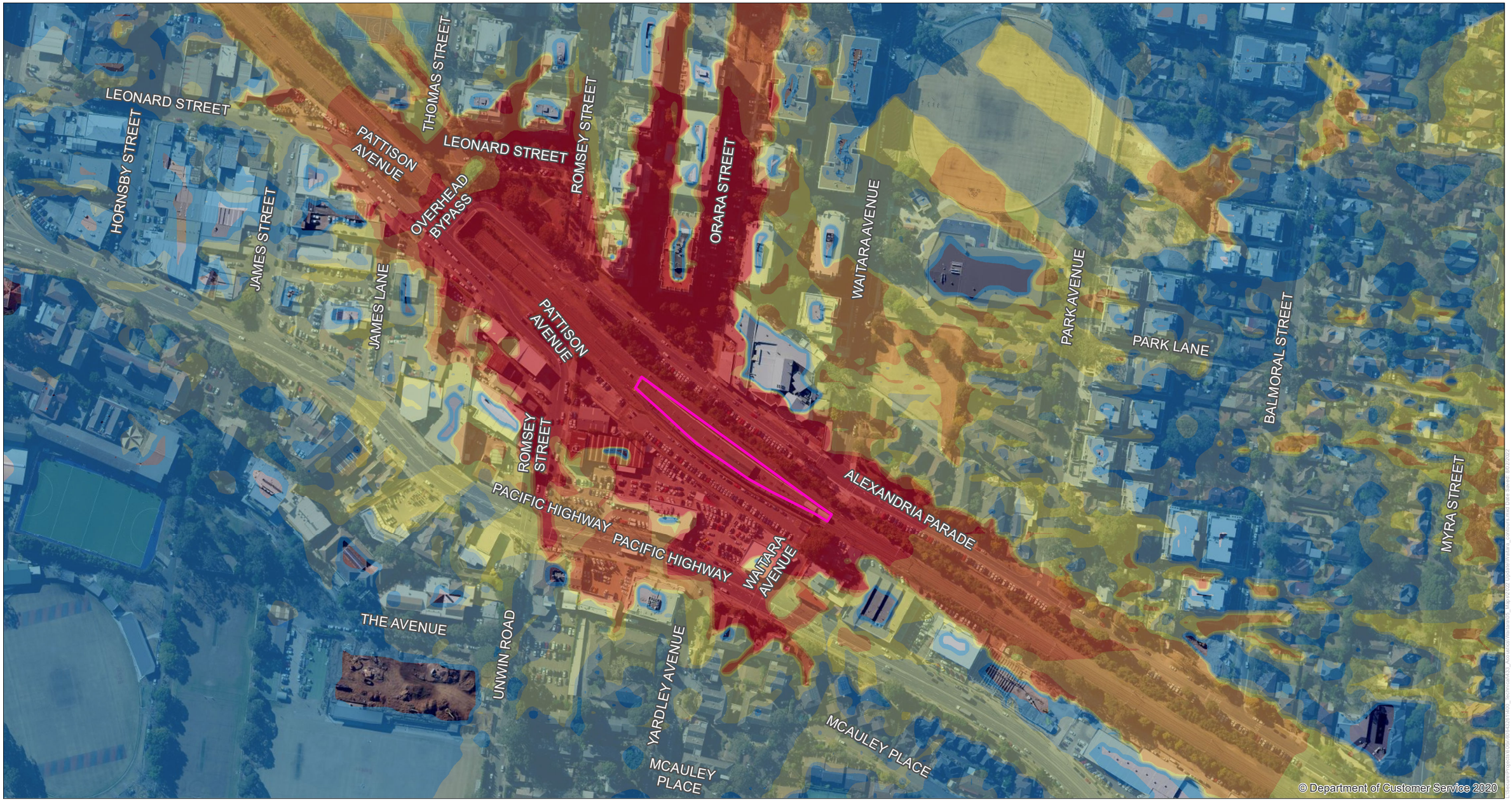
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



Lifts, platform staircase and platform upgrades - $L_{A1(1min)}$ (dB(A))

$L_{A1(1min)}$ (dB(A))

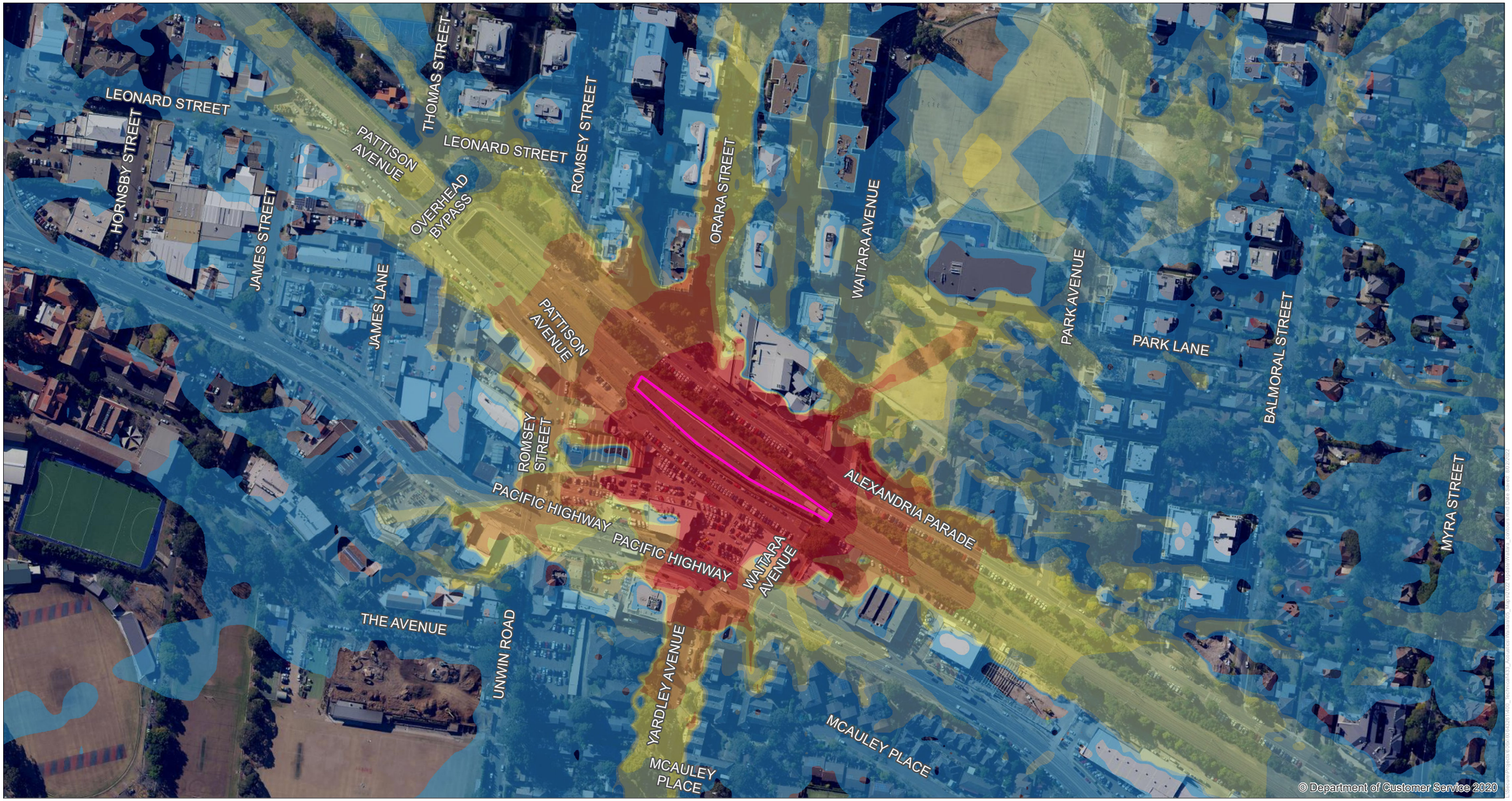
- Proposal
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



Station building reconfiguration works - L_{Aeq} (dB(A))

L_{Aeq} (dB(A)) Proposal

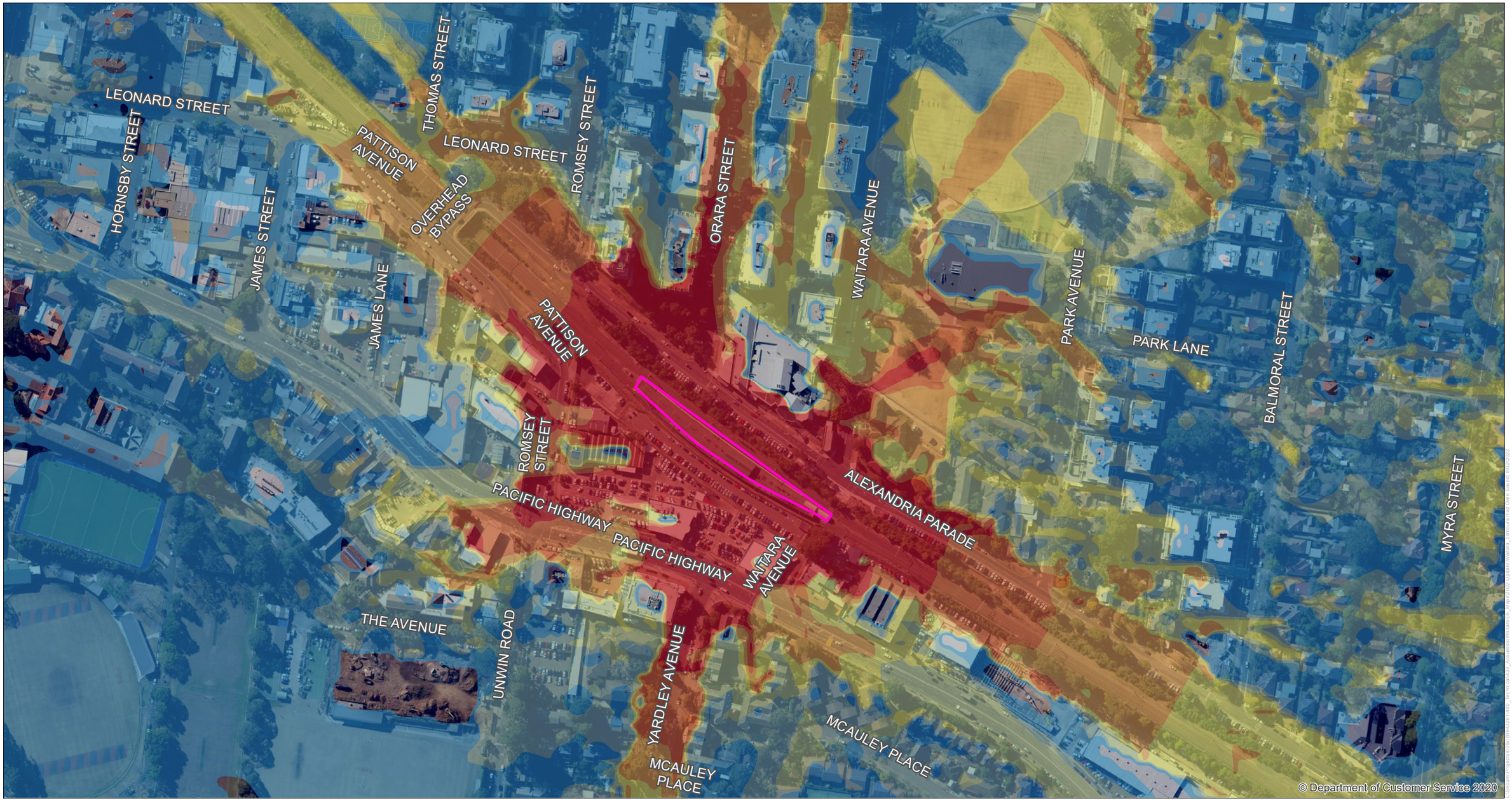
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



Station building reconfiguration works - $L_{A1(1min)}$ (dB(A))

$L_{A1(1min)}$ (dB(A)) Proposal

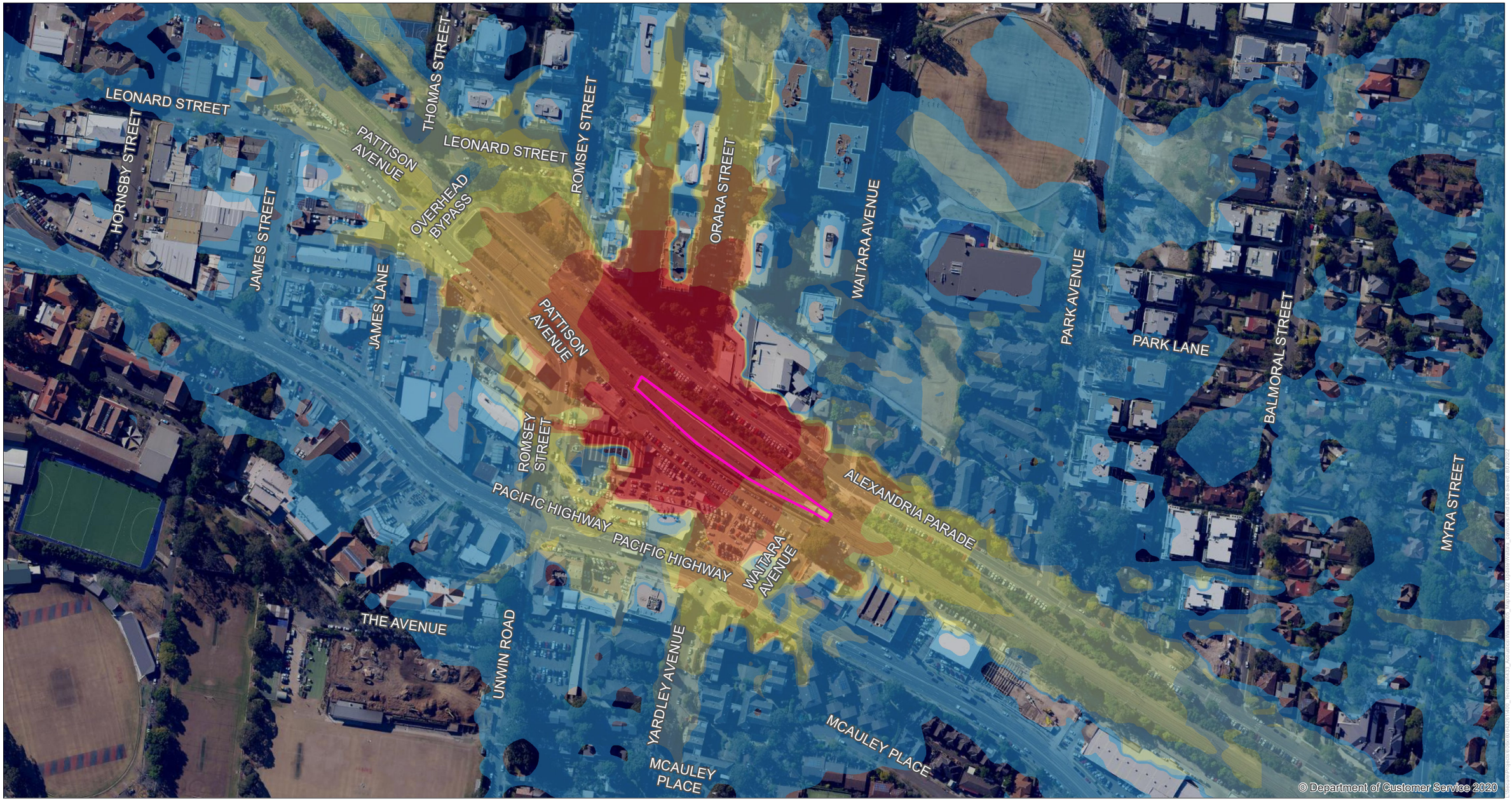
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



Interchange works - L_{Aeq} (dB(A))

L_{Aeq} (dB(A)) Proposal

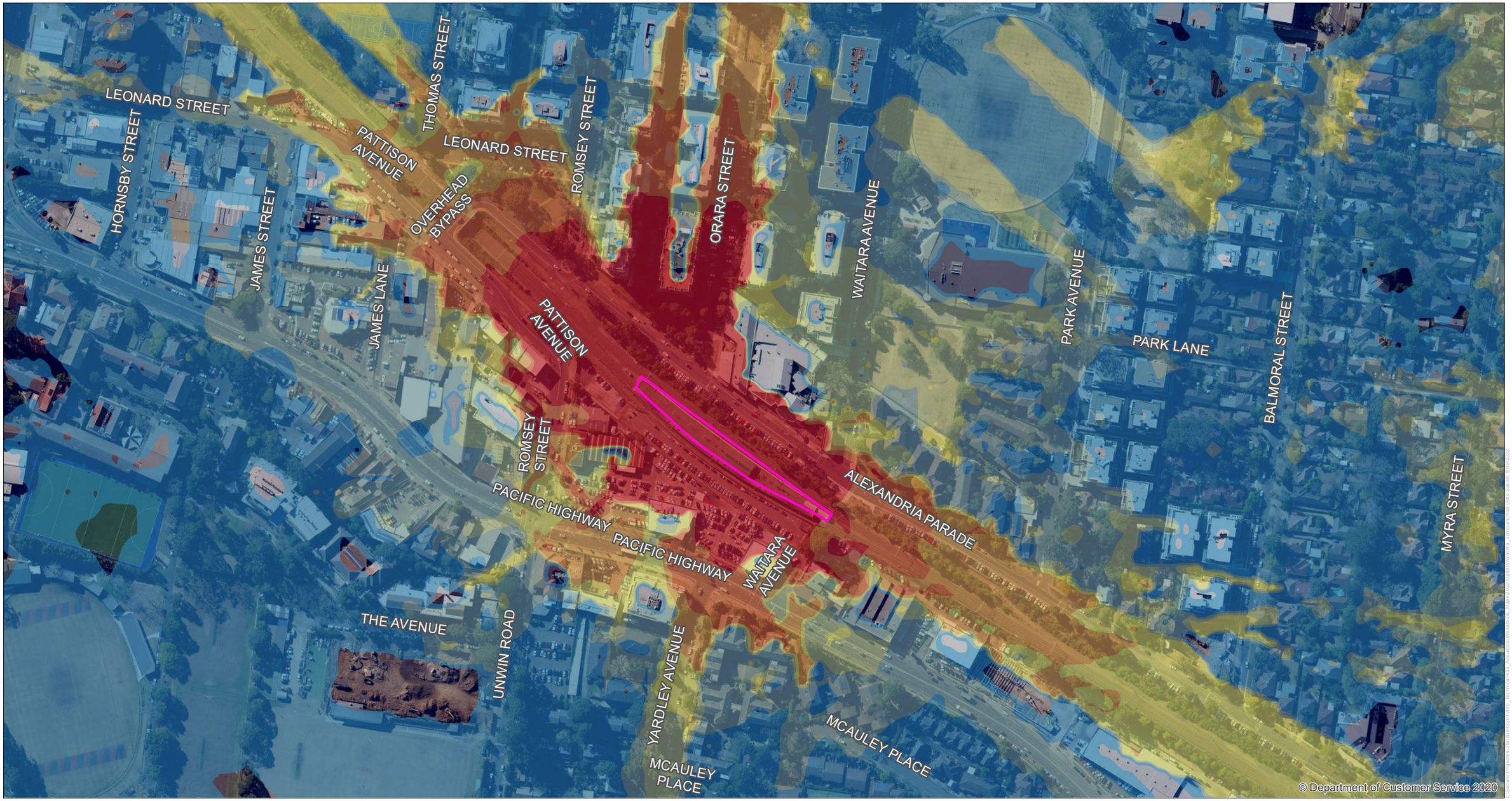
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



Interchange works - $L_{A1(1min)}$ (dB(A))

$L_{A1(1min)}$ (dB(A))

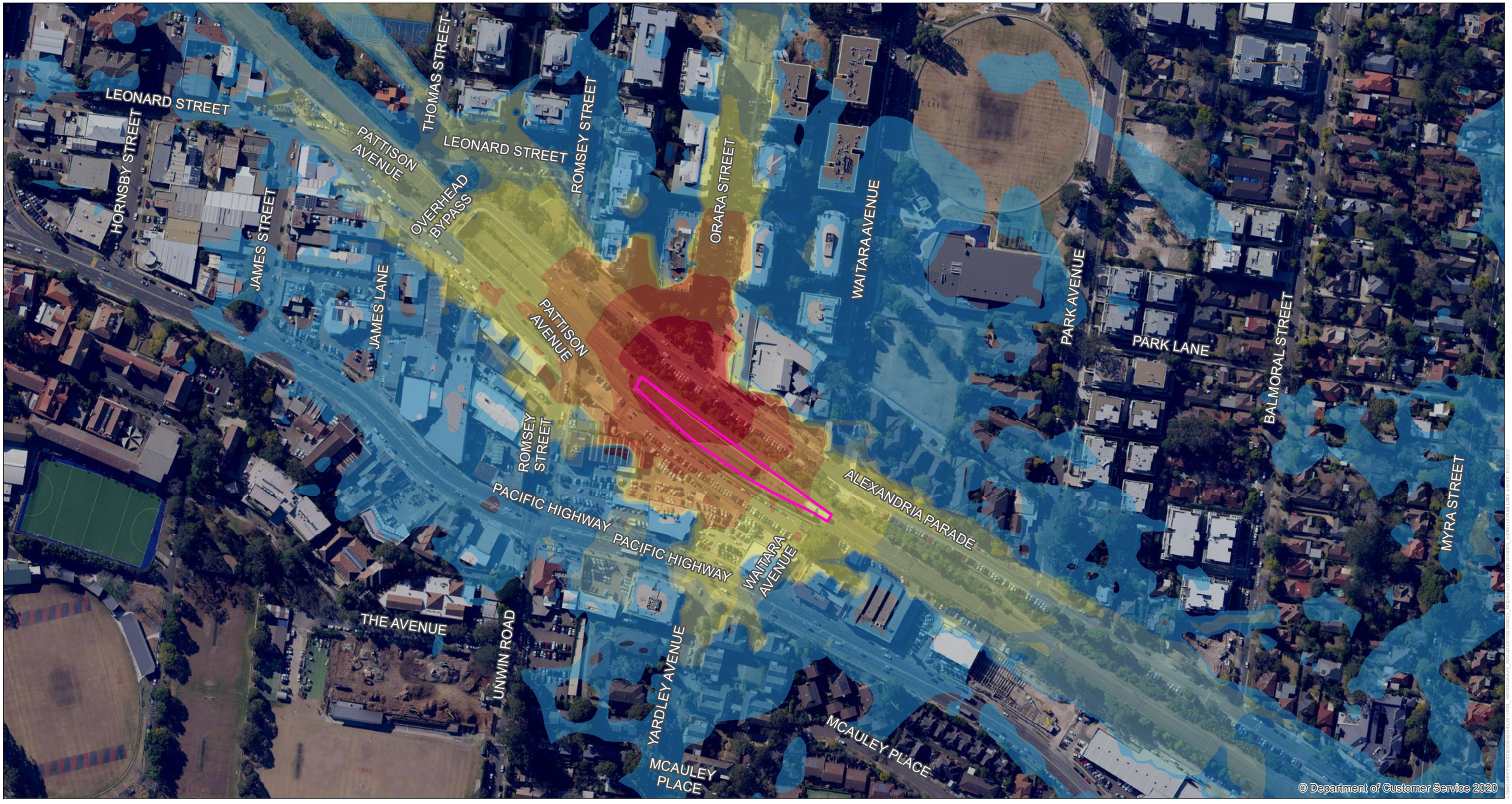
- Proposal
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



Service and utilities upgrade works - L_{Aeq} (dB(A))

L_{Aeq} (dB(A)) Proposal

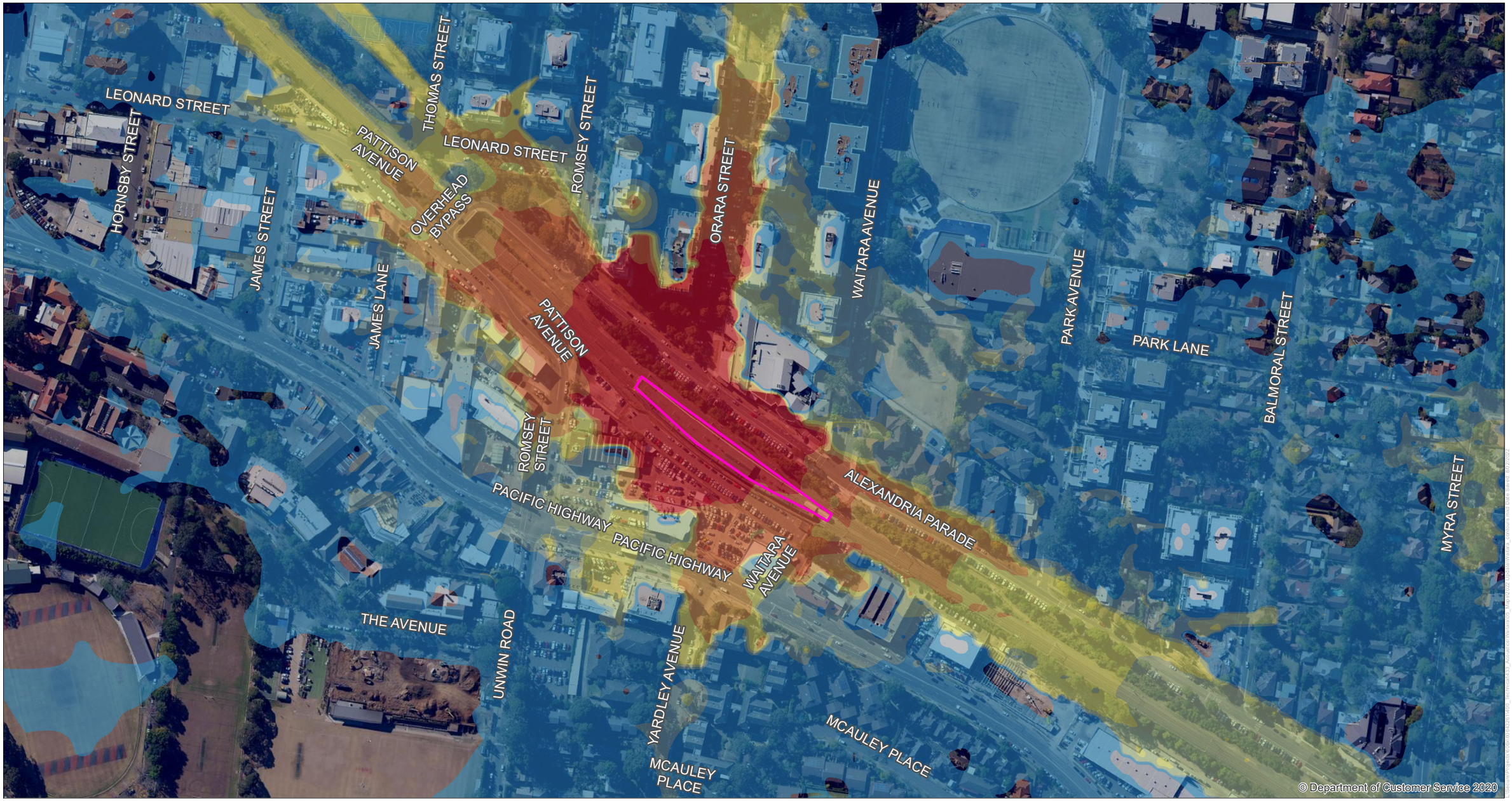
- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source:



Service and utilities upgrade works - $L_{A1(1min)}$ (dB(A))

$L_{A1(1min)}$ (dB(A)) Proposal

- 37 - 41
- 42 - 46
- 47 - 51
- 52 - 56
- 57 - 61
- 62 - 66
- > 67

N

0 0.045 0.09 km

AECOM

Source: