Infrastructure New South Wales

Stadium Australia Redevelopment

SSDA - Noise and Vibration Assessment

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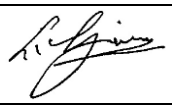
		Signature			
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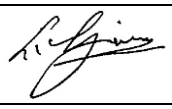
		Signature			
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1 Introduction

This report supports a State Significant Development (SSD) Development Application (DA) for the refurbishment of Stadium Australia, which is submitted to the Minister for Planning pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). Infrastructure NSW is the proponent of the SSD DA.

A list of referenced documents is provided in Section 7.

A glossary of the acoustic terminology used in this report has been included in Appendix A.

1.1 Background

Stadium Australia opened in 1999 for the 2000 Sydney Olympic and Paralympic Games and, at the time, was the largest Olympic Stadium ever built and the second largest stadium in Australia. In March 2018, the NSW Premier announced plans to refurbish Stadium Australia to address deficiencies with the existing infrastructure and ensure that the stadium retains its status as a premier venue within a network of stadia and events infrastructure in NSW.

The NSW Stadia Strategy 2012 provides a vision for the future of stadia within NSW, prioritising investment to achieve the optimal mix of venues to meet community needs and to ensure a vibrant sports and event environment in NSW. A key action of the strategy includes developing Tier 1 stadia and their precincts covering transport, integrated ticketing, spectator experience, facilities for players, media, corporate and restaurant and entertainment provision. Stadium Australis is one of three Tier 1 stadia within NSW, the others being Sydney Football Stadium and the Sydney Cricket Ground.

To qualify for Tier 1 status, a stadium is required to include:

- seating capacity greater than 40,000;
- regularly host international sporting events;
- offer extensive corporate facilities, including suites, open-air corporate boxes and other function/dining facilities; and
- be the home ground for sporting teams playing in national competitions.

The refurbishment of Stadium Australia will address deficiencies in the existing infrastructure and improve facilities to be in line with contemporary Australian venue standards. The works ensure the stadium remains a modern, globally competitive venue that achieves the requirements for a Tier 1 stadium. The refurbishment of Stadium Australia addresses the following project objectives:

- transform the stadium into a ‘fan favourite’ destination for experiencing and enjoying sports and entertainment events;
- maximise the direct and indirect economic, social and cultural benefits to NSW from the project, including securing major, economically beneficial events within NSW to ensure the economic sustainability of the stadium into the future;

- deliver a multi-use contemporary rectangular venue that meets the needs of patrons, hirers and other users for rugby, football, concerts and other new forms of entertainment, and reaffirms the status of the stadium as Australia's largest purpose-built rectangular venue in Australia;
- improve the facility's sensitivity to the environmental conditions of the site by providing a roof which provides cover to 100% of seats (to the drip line);
- provide new and refurbished corporate areas, members areas and general admission areas to enhance the patron experience;
- promote universal accessibility, safety and security such that the stadium is welcoming, inclusive and safe for all stadium users, including persons requiring universal access;
- promote environmental sustainability and embrace a whole of life approach to operations and maintenance; and
- achieve a high standard of design and reinforce the Stadium's status and identity within the NSW stadia network, and more broadly, nationally and internationally.

1.2 Site description

The site is located at 15 Edwin Flack Avenue within Sydney Olympic Park. It is bound by Edwin Flack Avenue to the west, Dawn Fraser Avenue to the south, Olympic Boulevard to the east and Qudos Bank Arena to the north. The site is located within the City of Parramatta Local Government Area.

The site is legally described as Lot 4000 in DP 1004512 and part of Lot 4001 in DP 1004512. In 2017, the Minister for Sport assigned Venues NSW as the trustee of Stadium Australia under the *Sporting Venues Authorities Act 2008*.

In a broader context, the site forms part of Sydney Olympic Park which is a sporting and economic centre in metropolitan Sydney that covers 680 hectares. Sydney Olympic Park comprises a range of sports and entertainment venues, parklands, and commercial, retail and residential developments. It benefits from convenient access to Homebush Bay Drive, Parramatta Road and the M4 Western Motorway, as well as Olympic Park railway station. The Parramatta Light Rail Stage 2 and Sydney Metro West will also significantly increase accessibility.

The locational context of the Site is shown in Figure 1, whilst the site boundaries and existing site features are shown in Figure 2.

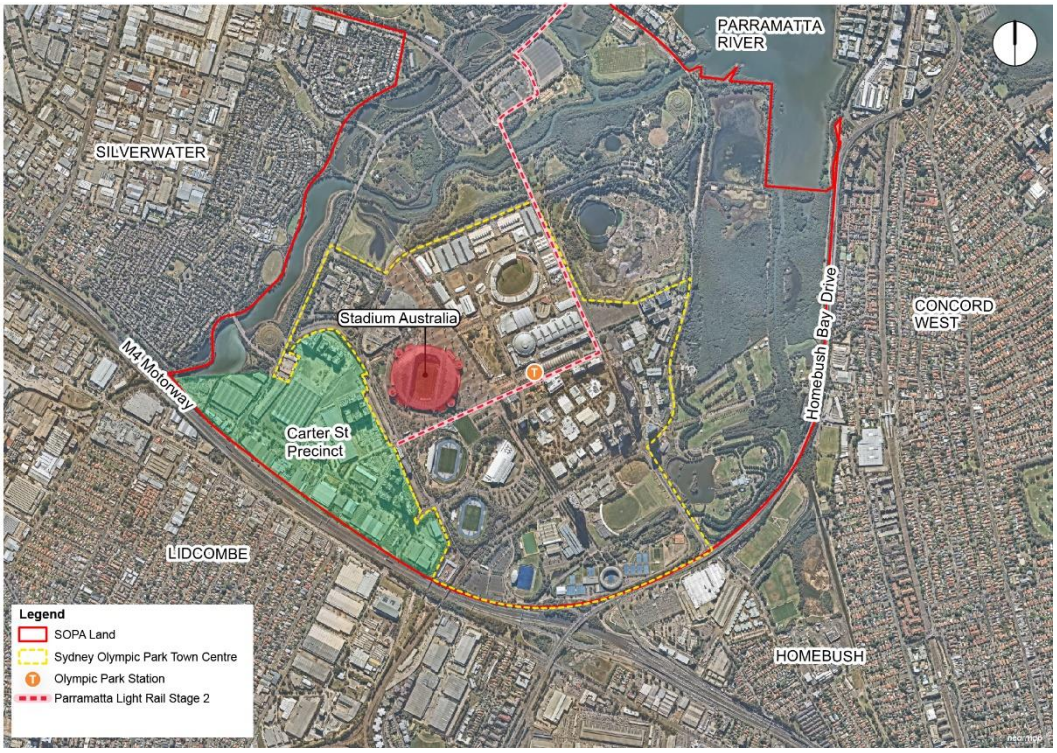


Figure 1: Regional site context

Figure 2: Site area and local context

1.3 Overview of proposed development

In March 2018 the NSW Government announced its commitment to refurbish the existing Stadium Australia and retain its status as a premier venue within a network of stadia and events infrastructure in NSW. This comprises the following:

- Reconfiguring the field of play to a permanent rectangular configuration.
- Redeveloping the lower and middle seating bowl to locate seating closer to the field and increase the pitch (steepness) of the seating bowl, which has the effect of reducing the capacity to approximately 70,000 seats (plus up to 20,000 persons on the field during concerts).
- Providing 100% drip-line roof coverage to all permanent seats by replacing the northern and southern sections of the roof and extending the existing eastern and western sections of the roof.
- Providing a new northern and southern public stadium entrance, including a new stadium facade and double-height concourse
- Renewing the food and beverage concessions, bathrooms, team facilities including new gender neutral changerooms, members and corporate facilities, press and broadcast facilities, and back of house areas.
- Providing new signage, high-definition video replay screens, LED lighting, and other functional improvements.
- Retaining the public domain areas surrounding the stadium that deliver a range of publicly accessible, event and operational areas, with minor works for tree removal.

Part of the existing stadium forecourt will be used as a construction compound during the construction phase and reinstated following the completion of works and prior to commencement of stadium operations.

Figure 3: Indicative photomontage of proposed stadium

1.4 Acoustic assessment requirements

This report addresses the following acoustic assessment requirements as below.

- The Department of Planning, Industry and Environment (DPIE) issued Secretary's Environmental Assessment Requirements (SEARs) to the applicant for the preparation of an Environmental Impact Statement for the proposed development. This report has been prepared having regard to the relevant SEARs as follows:

Table 1: SSD 10342 – Schedule 2 general requirements

SEAR key issue.	Acoustic aspect	Report section
17. Noise and Vibration The EIS shall include a noise and vibration assessment prepared in accordance with the relevant EPA guidelines. This assessment must consider construction and operational noise impacts on nearby noise sensitive receivers and outline proposed noise mitigation and monitoring issues. Operational noise impacts include crowd noise, amplified sound, pyrotechnics and mechanical services.	Construction and operational noise	Section 3 and 4

Key Issues of the SEARs also references the following policies relevant to acoustics:

- *Interim Construction Noise Guideline*, DECC 2009 (ICNG) [1]; and
- *Development Near Rail Corridors and Busy Roads – Interim Guideline, Department of Planning 2008 (DNRCBR)* [2].

It is noted that DNRCBR [2] is not relevant to the subject development, as it relates to the assessment of noise from rail and road traffic on residential uses, places of worship, hospitals, and educational establishments or childcare centres.

1.5 Scope of acoustic assessment

This acoustic assessment report addresses construction noise and vibration impacts associated with the demolition and construction of the redevelopment, and changes to event noise levels which are anticipated as a result of the proposed stadium.

No changes to the everyday operation of the stadium are proposed, nor additional external mechanical plant, therefore no assessment of operational noise emissions other than event noise emissions is considered necessary.

No additional acoustic treatment for non-event operational noise is recommended as part of the redevelopment works.

2 Existing acoustic environment

The Stadium Australia site is located within the Sydney Olympic Park (SOP) Precinct, bounded to the north, east and south by surrounding venues within the SOP Precinct such as Qudos Bank Arena, Sydney Olympic Sports Halls, Cathy Freeman Park and Sydney Olympic Park Aquatic and Athletic Centres, as well as various other sporting and entertainment venues, hotels and residences. To the south-east of the site, beyond Edwin Flack Avenue, lies the Carter Street Precinct which comprises residential, commercial and industrial premises. Further south beyond the Carter Street Precinct, approximately 600 metres south of the proposed SAR is the Western Motorway which generally controls background noise levels on site.

The main noise sources in the local environment are:

- Intermittent road traffic along roads within the SOP Precinct, including Edwin Flack Avenue, Dawn Fraser Avenue and Olympic Boulevard
- Constant road traffic along the Western Motorway
- Activity at surrounding venues, such as sporting or concert events, training, rehearsals, cultural events.
- Local community and pedestrian activity
- Nearby commercial venues
- Construction from on-going Precinct development and redevelopment
- Natural surrounds
- Aircraft

The above sources generally vary in level over the day.

Events have been a feature of the area since being redeveloped for the 2000 Olympics.

2.1 Surrounding land-use

Maps showing the location of the site and the surroundings are included in Section 1.2 above.

Residential zones are located within the Carter Street Precinct to the south and south-east, further south beyond the Western Motorway and Parramatta Road in Lidcombe, and to the west in Newington and Silverwater.

It should be noted that the development of the areas surrounding the existing ANZ Stadium has introduced several noise sensitive receivers including residential developments close to the Stadium, such as the Carter Street Precinct and residential towers within the Sydney Olympic Park precinct. It is noted the Carter Street DCP and SOPA Master Plan include specific planning requirements for new residential and other sensitive receivers to ensure that buildings are designed to mitigate against the effects of event noise and to ensure that property owners and residents are aware of the potential for noise generation associated with events.

Non-residential premises also surround the site, with scattered child cares, places of worship, educational facilities and various sporting and entertainment venues located in the SOP Precinct and the surrounding suburbs.

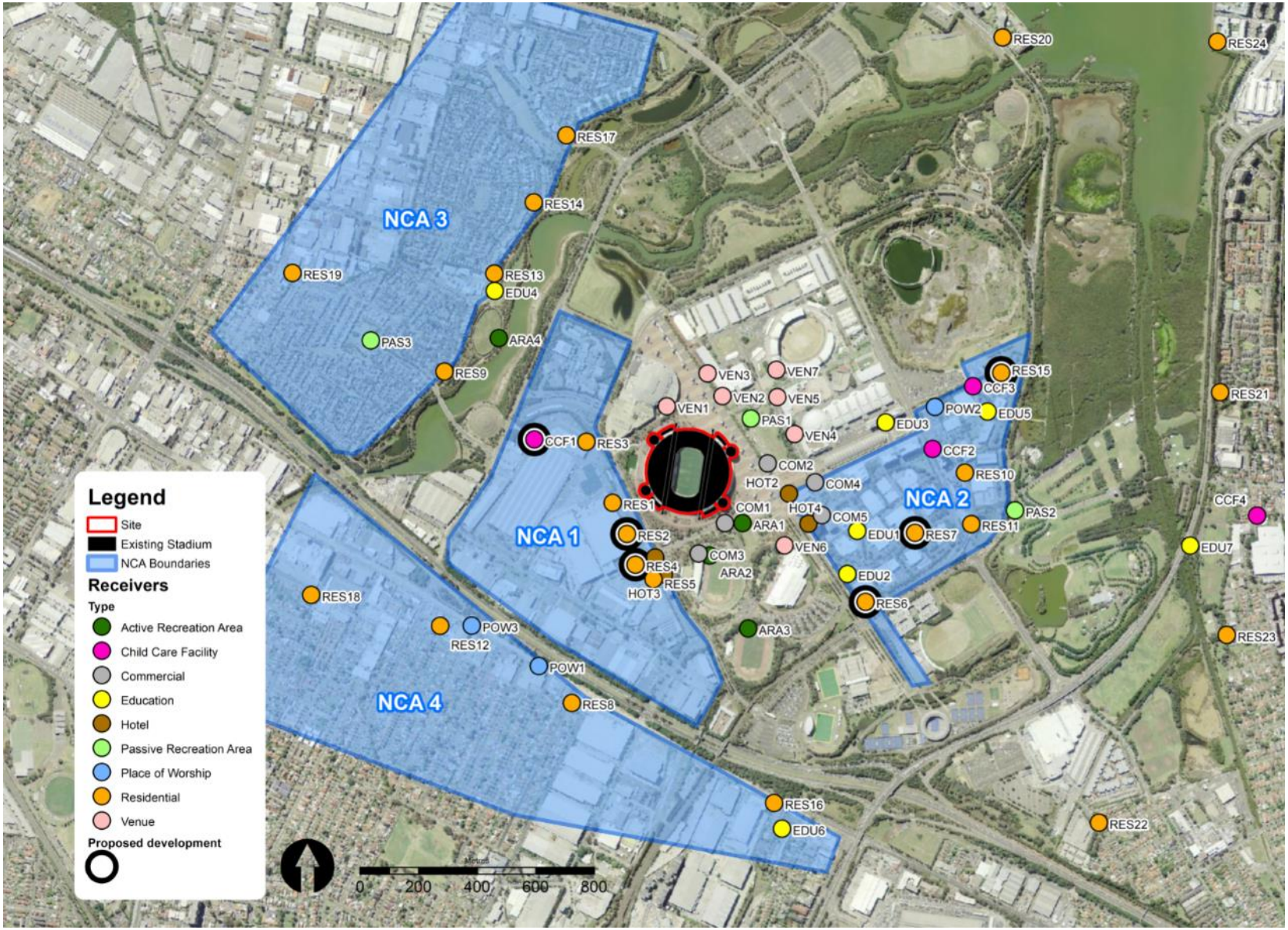


Figure 4: Assessment locations and NCAs

Residential receivers located within similar environments and with comparable relationship to surrounding noise sources have been grouped into Noise Catchment Areas (NCAs), also shown in Figure 4 and described in Table 2.

Table 2: NCAs and description

NCA	Description	Noise environment
NCA 1	Sydney Olympic Park Precinct	Generally controlled by local intermittent road traffic, local activity and natural surrounds
NCA 2	Carter Street Precinct	Background controlled by road traffic along Western Motorway, ambient levels controlled by local road traffic and surrounding local activity from industrial premises, venues or commercial premises.
NCA 3	Newington and Silverwater	Generally controlled by local intermittent road traffic, local activity and natural surrounds
NCA 4	Lidcombe	Background controlled by road traffic along Western Motorway, ambient levels controlled by local road traffic.

NCA boundaries have been determined from site observations and attended measurements, which are detailed in Appendix B.

2.2 Assessment locations

The reasonably most-affected residences have been identified in each NCA have been identified and are presented in Table 3. While noise predictions have been carried out to each receiver, for clarity, the assessment of residential receivers presented in this report is isolated to the reasonably most-affected receivers.

Table 3: Reasonably most-affected residential receivers

Receiver ID	Address	No. of floors	NCA	Proposed development[1]
RES1	5 Uhrig Road, Lidcombe (Existing)	15	1	
RES2	5 Uhrig Road, Lidcombe (Proposed)	15	1	Yes
RES3	YMCI Homebush Gardens Zones 3A & 3B, Olympic Park	13	1	
RES4	7 Carter Street, Lidcombe (Proposed)	22	1	Yes
RES5	7 Carter Street, Lidcombe (Existing)	12	1	
RES6	Cnr Sarah Durack Avenue and Olympic Boulevard	38	2	Yes
RES7	2 Figtree Drive, Olympic Park	30	2	Yes
RES8	72 Gallipoli Street, Lidcombe	1	4	
RES9	2 Elvstrom Avenue, Newington	2	3	
RES10	100 Bennelong Parkway, Olympic Park	7	2	
RES11	88 Bennelong Parkway, Olympic Park	36	2	
RES12	137 Delhi Street, Lidcombe	1	4	
RES13	3 Heidelberg Avenue, Newington	3	3	

Receiver ID	Address	No. of floors	NCA	Proposed development[1]
RES14	24 Nurmi Avenue, Newington	2	3	
RES15	2 Murray Rose Avenue, Olympic Park	16	2	Yes
RES16	3 Telopea Rd, Homebush West	1	4	
RES17	1 Sandpiper Crescent, Newington	4	3	
RES18	1 Hastings Street, Lidcombe	1	4	
RES19	91 Wetherill, Silverwater	1	3	
RES20	27 Bennelong Parkway, Wentworth Point	10	- [2]	
RES21	21 Cole Crescent, Liberty Grove	1	- [2]	
RES22	29 Wentworth Rd North, Homebush	1	- [2]	
RES23	22 Conway Avenue, Concord West	1	- [2]	
RES24	11 Lewis Avenue, Rhodes	4	- [2]	

Notes:

1. Approved future development identified and included as receiver.

2. Receivers are beyond 1.5 kilometres from the site, therefore construction noise levels are not expected to affect these receivers. Since construction Noise Management Levels are not required, no NCA is assigned for these receivers.

A list of all non-residential noise sensitive receivers within the study area is presented in Table 4.

Table 4: Non-residential receivers

Receiver ID	Name	Address	No. of floors	Proposed development[1]
Active Recreation Area				
ARA1	NSWRL Rugby Field	12 Dawn Fraser Avenue, Olympic Park	1	
ARA2	Sydney Olympic Park Athletic Centre	Edwin Flack Avenue, Olympic Park	3	
ARA3	Warm Up Arena	Edwin Flack Avenue, Olympic Park	1	
ARA4	Haslams Field	Louise Savage Pathway, Newington	1	
Child Care				
CCF1	Ovation Quarter Childcare (Building 3D)	Carter St Precinct	14	Yes
CCF2	Woodstock Childcare	11 Australia Avenue, Olympic Park	25	
CCF3	Mini Masterminds	4 Murray Rose Avenue, Olympic Park	6	
CCF4	Only About Children	31B George Street, Concord West	1	
Commercial				
COM1	NSWRL Centre of Excellence	14 Dawn Fraser Avenue, Olympic Park	5	
COM2	Yulang Pub	Olympic Boulevard, Olympic Park	1	
COM3	Sydney Olympic Park Athletic Centre	Edwin Flack Avenue, Olympic Park	2	
COM4	Paralympics Australia	1 Herb Elliot Avenue, Olympic Park	2	
COM5	UBT Marketing	10 Herb Elliot Avenue, Olympic Park	8	
Educational Facilities				
EDU1	SP Jain School of Global Management	5 Figtree Drive, Olympic Park	3	
EDU2	Kirana Colleges	8 Figtree Drive, Olympic Park	4	
EDU3	Western Sydney University	8 Australia Avenue, Olympic Park	6	
EDU4	Newington Public School	Newington Boulevard, Newington	1	
EDU5	Aus. Coll. of Phys. Edu. & Sweet Peas Early Learn.	10 Parkview Drive, Olympic Park	4	
EDU6	Message School	43/14-26 Telopea Avenue, Homebush West	1	

Receiver ID	Name	Address	No. of floors	Proposed development[1]
EDU7	Victoria Avenue Public School	64 Victoria Avenue, Concord West	3	
Hotels				
HOT1	Paddington Town Hall	249 Oxford Street, Paddington	2	
HOT2	Novotel Sydney Olympic Park	11 Olympic Boulevard, Olympic Park	20	
HOT3	Quest Apartments	6 Edwin Flack Avenue, Olympic Park	8	
HOT4	Pullman Hotel	9 Olympic Boulevard, Olympic Park	19	
Passive Recreation Area				
PAS1	Cathy Freeman Park	Cnr Olympic Boulevard & Grand Parade, Olympic Park	1	
PAS2	Bicentennial Park	Australia Avenue, Olympic Park	1	
PAS3	Blankers Koen Park	Newington Boulevard, Newington	1	
Place of Worship				
POW1	St Francis of Assisi Catholic Church	64 Gordon Street, Paddington	3	
POW2	St Mattias Anglican Church	471-475 Oxford Street, Paddington	2	
POW3	Paddington Uniting Church	395 Oxford Street, Paddington	2	
Venues				
VEN1	Qudos Bank Arena	19 Edwin Flack Avenue, Olympic Park	6	
VEN2	Sydney Olympic Park Sports Halls	Grand Parade, Olympic Park	3	
VEN3	Paddington Pavillion	Grand Parade, Olympic Park	3	
VEN4	Sydney Showground	1 Showground Rd, Olympic Park	5	
VEN5	Exhibition Hall 5	1 Showground Rd, Olympic Park	3	

Notes:

1. Approved future developments identified and included as receivers.

2.3 Measurement of existing noise levels

Criteria for the assessment of construction noise are usually derived from the existing noise environment of an area, excluding noise from the subject development.

It should be noted that, since no changes to existing operations are proposed as part of the redevelopment, no assessment of non-event operations is required, hence no operational noise criteria have been developed as part of this assessment.

2.3.1 Noise measurement locations

Noise measurements are ideally carried out at the nearest or most potentially affected locations surrounding a development. An alternative, representative location should be established in the case of access restrictions or if a safe and secure location cannot be identified. Furthermore, representative locations may be established in the case of multiple receivers as it is usually impractical to carry out measurements at all locations surrounding a site.

The short-term and long-term measurement locations are outlined in Table 5 and shown in Figure 5.

Table 5: Measurement summary

ID	NCA	Measurement location	Measurement type	Comment on location suitability
Meas. 1A	1	Bus terminal along Edwin Flack Avenue, Olympic Park	Long and short term	Short-term measurement was conducted to verify previous long-term measurements conducted by EMM Consulting. Considered representative of reasonably most-affected residences in NCA 1.
Meas. 1B	1	Corner of Old Hill Link & Edwin Flack Avenue, Olympic Park	Short term	Conducted to confirm noise levels at 1A the northern end of NCA 1 were comparable and therefore represented by those at the logging location at 1B.
Meas. 2	2	Corner of Dawn Fraser Ave & Olympic Boulevard	Long and short term	Short-term measurement was conducted to verify previous long-term measurements conducted by Cundall. Considered representative of reasonably most-affected residences in NCA 2.
Meas. 3	3	12 Devitt Avenue, Newington	Long and short term	Considered representative of reasonably most-affected residences in NCA 3.
Meas. 4	4	54 Ostend Street	Long and short term	Considered representative of reasonably most-affected residences in NCA 4.

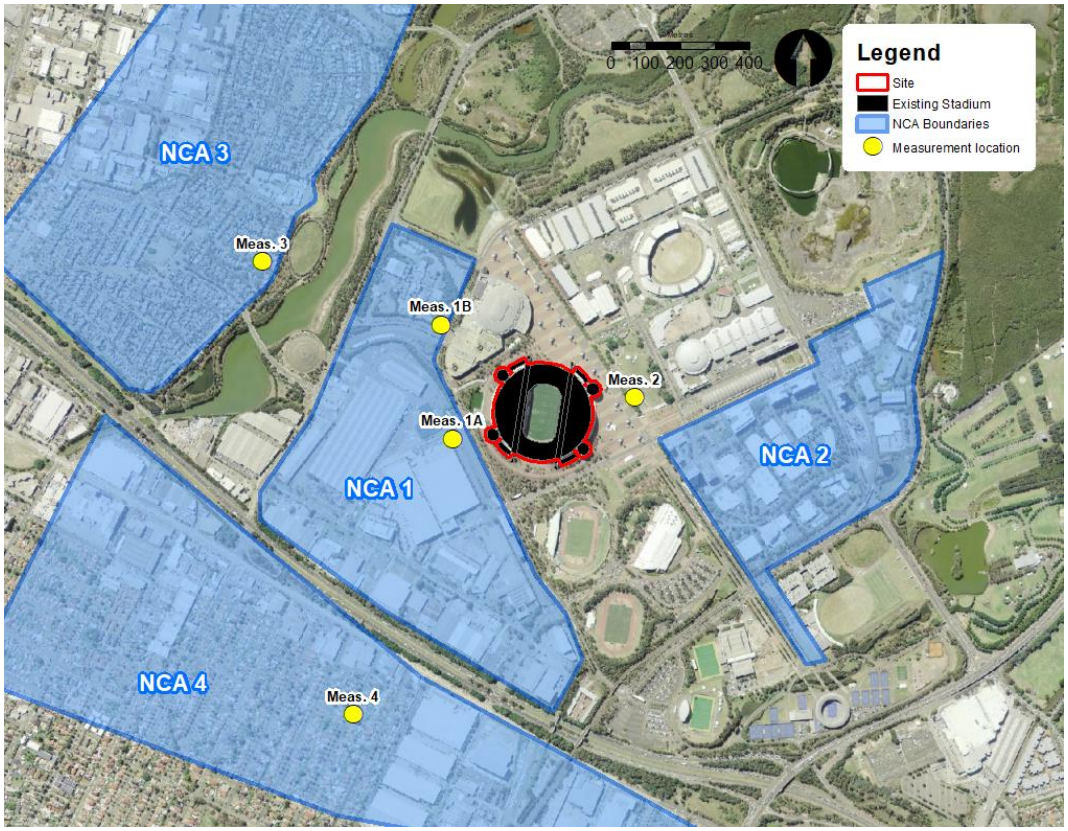


Figure 5: Measurement locations and NCAs

2.3.2 Long-term unattended noise measurement results

presents the overall single RBLs and representative ambient L_{eq} noise levels for each assessment period, determined in accordance with the NPI.

Table 6: Long-term noise monitoring results

ID	NCA	Location	Time period	RBLs, dBL_{A90}	Ambient $dBL_{Aeq(period)}$
Meas. 1A	NCA 1	Edwin Flack Avenue Bus Terminal (5 Uhrig Road)	Day	47	56
			Evening	44	- [1]
			Night	40	48
Meas. 2	NCA 2	Corner of Dawn Fraser Ave & Olympic Boulevard	Day	53	61
			Evening	49	59
			Night	46	55
Meas. 3	NCA 3	12 Devitt Avenue, Newington	Day	42	58
			Evening	43	52
			Night[1]	41	49
Meas. 4	NCA 4	54 Ostend Street, Lidcombe	Day	41	59
			Evening	45	54
			Night	39	52

ID	NCA	Location	Time period	RBLs, dBL_{A90}	Ambient $dBL_{Aeq(period)}$

Note:
1. Unavailable, not required for assessment.

Measurement samples affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the procedures outlined in Appendix B of the NPI [3].

Data was provided by the Bureau of Meteorology (BOM) collection station at Sydney Olympic Park. Wind speed data was adjusted to account for the difference in measurement height and surrounding environment between the BOM weather station (measured 10 m above ground) and the microphone location based on Table C.1 of ISO 4354:2009 '*Wind actions on structures'*.

2.3.3 Short-term attended noise measurement results

Short-term operator attended noise measurements were conducted on Thursday, 1 August 2019 by Arup at each logger location. Noise measurements were conducted over a 15-minute period. Weather conditions were warm, still and clear during measurements.

presents the measured L_{90} and L_{eq} noise levels for at each measurement locations, determined in accordance with the NPI.

Table 7: Short-term noise monitoring results

ID	Location	Date / Time	dBL_{Aeq}	dBL_{A90}	dBL_{Amax}	Description of noise environment
Meas. 1A	Corner of Quest at Olympic Park	01 Aug 2019 13:13	62	51	78	Local road traffic Construction noise from Meriton Retreat Activity from SOP Natural surrounds
Meas. 1B	Corner of Old Hill Link & Edwin Flack Avenue, Olympic Park	01 Aug 2019 12:41	66	56	89	Local road traffic Delivery trucks (including reversing alarm) Industrial noise from water treatment facility Aircraft.
Meas. 2	Corner of Dawn Fraser Ave & Olympic Boulevard, Olympic Park	01 Aug 2019 13:39	60	55	78	Local road traffic Community noise (restaurant sounds) Natural surrounds
Meas. 3	12 Devitt Avenue, Newington	01 Aug 2019 12:09	58	51	74	Local road traffic Community noise (Leafblower, car washing) Aircraft. Natural surrounds

ID	Location	Date / Time	dBL_{Aeq}	dBL_{A90}	dBL_{Amax}	Description of noise environment
Meas. 4	54 Ostend Street, Lidcombe	01 Aug 2019 14:59	57	43	82	Local road traffic Road traffic along Western Motorway

A full set of measurement results is presented in Appendix B.

3 Construction noise and vibration

This report addresses the noise and vibration associated with demolition and construction works for the Stadium Australia Redevelopment (SAR).

3.1 Construction noise criteria

The ICNG provides recommended noise levels for airborne construction noise at sensitive land uses. The guideline provides construction management noise levels above which all 'feasible and reasonable' work practices should be applied to minimise the construction noise impact. The ICNG works on the principle of a 'screening' criterion – if predicted or measured construction noise exceeds the ICNG levels then the construction activity must implement all 'feasible and reasonable' work practices to reduce noise levels.

The ICNG sets out management levels for noise at noise sensitive receivers, and how they are to be applied. These management noise levels for residential receivers are reproduced below, in Table 8 and other sensitive receivers in Table 9 below.

Table 8: Construction noise management levels at residential receivers

Time of day	**Management level** [1] **$L_{Aeq\ (15\ min)}$**	**How to apply**
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10dB	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 works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the 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 works near schools, or mid-morning or mid-afternoon for works near residences 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Time of day	Management level [1] $L_{Aeq\ (15\ min)}$	How to apply
Outside recommended standard hours[2]	Noise affected RBL + 5dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dBA above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

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

2 – See Table for definition of outside standard hours definitions

Table 9: Construction noise management levels at other noise sensitive land uses

Land use	Where objective applies	Noise Management level $L_{Aeq(15\ min)}$[1]
Passive recreation areas	External noise level	60 dBA
Active recreation areas	External noise level	65 dBA
Educational institutions	Internal noise level	45 dBA
Place of worship	Internal noise level	45 dBA
Commercial premises	External noise level	70 dBA

1 - Noise management levels apply when properties are in use.

3.1.1 Project construction noise targets

Construction noise criteria are set based on noise catchment areas relative to proposed construction works. These catchment areas are defined for the project in Section 2.1.

Measured noise data obtained at the logger location most representative of each noise catchment area has been used to derive appropriate noise management levels for the project. These are summarised in Table 10.

Table 10: Residential Noise Management Levels during intended working hours, $dBL_{Aeq\ 15minute}$

Location	NCA	Highly noise affected	Noise Management Level
Standard construction hours			
R1	1	75	57
R2	1	75	57
R3	1	75	57
R4	1	75	57
R5	1	75	57
R6	2	75	63
R7	2	75	63
R8	4	75	51
R9	3	75	52
R10	2	75	63
R11	2	75	63
R12	4	75	51
R13	3	75	52
R14	3	75	52
R15	2	75	63
R16	4	75	51
R17	3	75	52
R18	4	75	51
R19	3	75	52

Noise Management Levels for non-residential receivers are presented in Table 11.

Table 11: Non-residential Noise Management Levels during intended working hours

Usage	Rec. ID	Name	Time period	Assess. location	NML, $dBL_{Aeq\ 15minute}$
Active Recreation Area	ARA1	NSWRL Rugby Field	When in use	External	65
	ARA2	Sydney Olympic Park Athletic Centre	When in use	External	65
	ARA3	Warm Up Arena	When in use	External	65
	ARA4	Haslams Field	When in use	External	65

Usage	Rec. ID	Name	Time period	Assess. location	NML, $dBL_{Aeq\ 15minute}$
Child Care[1]	CCF1	Ovation Quarter Childcare (Building 3D)	When in use	Internal	45
	CCF2	Woodstock Childcare	When in use	Internal	45
	CCF3	Mini Masterminds	When in use	Internal	45
	CCF4	Only About Children	When in use	Internal	45
Commercial	COM1	NSWRL Centre of Excellence	When in use	External	70
	COM2	Yulang Pub	When in use	External	70
	COM3	Sydney Olympic Park Athletic Centre	When in use	External	70
	COM4	Paralympics Australia	When in use	External	70
	COM5	UBT Marketing	When in use	External	70
Educational Facilities	EDU1	SP Jain School of Global Management	When in use	Internal	45
	EDU2	Kirana Colleges	When in use	Internal	45
	EDU3	Western Sydney University	When in use	Internal	45
	EDU4	Newington Public School	When in use	Internal	45
	EDU5	Aus. Coll. of Phys. Edu. & Sweet Peas Early Learn.	When in use	Internal	45
	EDU6	Message School	When in use	Internal	45
	EDU7	Victoria Avenue Public School	When in use	Internal	45
Hotels[2]	HOT1	Paddington Town Hall	When in use	External	70
	HOT2	Novotel Sydney Olympic Park	When in use	External	70
	HOT3	Quest Apartments	When in use	External	70
	HOT4	Pullman Hotel	When in use	External	70
Passive Recreation Area	PAS1	Cathy Freeman Park	When in use	External	60
	PAS2	Bicentennial Park	When in use	External	60
	PAS3	Blankers Koen Park	When in use	External	60
Place of Worship	POW1	St Francis of Assisi Catholic Church	When in use	Internal	45
	POW2	St Mattias Anglican Church	When in use	Internal	45
	POW3	Paddington Uniting Church	When in use	Internal	45
Venues[2]	VEN1	Qudos Bank Arena	When in use	External	70
	VEN2	Sydney Olympic Park Sports Halls	When in use	External	70
	VEN3	Paddington Pavillion	When in use	External	70
	VEN4	Sydney Showground	When in use	External	70
	VEN5	Exhibition Hall 5	When in use	External	70
	VEN6	Sydney Olympic Park Aquatic Centre	When in use	External	70

Usage	Rec. ID	Name	Time period	Assess. location	NML, $dBL_{Aeq\ 15minute}$
	VEN7	Giants Stadium	When in use	External	70

Notes:

1. Child Care Facilities' NMLs have been based on school classrooms to reflect the children's sensitivity to noise during rest periods.
2. Hotels' and Venues' NMLs have been based on commercial premises.

3.2 Construction traffic criteria

Increased traffic generated on the surrounding road network due to either construction activities or by the operation of the SAR is assessed in accordance with the NSW Road Noise Policy (RNP). Table 3 of the RNP which sets out the assessment criteria for particular types of project, road category and land use, shown in Table 12 below.

Table 12: Road traffic criteria for traffic generating development - residential receivers

Road category	Type of project / land use	Assessment criteria – dB(A)	
		Day (7:00am-10:00pm)	Night (10:00pm-7:00am)
Freeway/arterial/sub-arterial roads - Moore Park Road	Existing residences affected by additional traffic on existing freeways / arterial / sub-arterial roads generated by land use developments	$L_{Aeq,(15\ hour)}$ 60 (external)	$L_{Aeq,(9\ hour)}$ 55 (external)

Notes: These criteria are for assessment against façade corrected noise levels when measured in front of a building façade.

Regarding the application of the assessment, the RNP states:

> *In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.*

3.3 Construction vibration criteria

Vibration criteria for construction works are established in the following sections. Vibration management measures have been recommended in Section 3.6.

3.3.1 Human comfort

The NSW EPA's *Assessing Vibration – A Technical Guideline* [4] provides vibration criteria for maintaining human comfort within different space uses. The guideline recommends 'preferred' and 'maximum' weighted vibration levels for both continuous vibration sources, such as steady road traffic and continuous construction activity, and for impulsive vibration sources. The weighting curves are obtained from BS 6472-1:2008 [5].

For intermittent sources (e.g. passing heavy vehicles, impact pile driving, intermittent construction), the guideline uses the vibration dose value (VDV) metric to assess human comfort effects of vibration. VDV considers both the magnitude of vibration events and

the number of instances of the vibration event. Intermittent events that occur less than 3 times in an assessment period (either day, 7 am to 10 pm, or night, 10 pm to 7 am) are counted as 'impulsive' sources for the purposes of assessment.

As noted in the Guideline, situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances, such as a construction or excavation projects. Notwithstanding, the recommended vibration limits for maintaining human comfort in residences and other relevant receiver types are given for continuous/impulsive and intermittent vibration in Table 13 and Table 14 respectively.

Table 13: Preferred and maximum weighted root-mean-square (rms) values for continuous and impulsive vibration acceleration (m/s²) 1-80 Hz

Location	Period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous Vibration					
Critical areas[1]	Day- or Night-time	0.005	0.0036	0.01	0.0072
Residences	Daytime 0700-2200h	0.010	0.0071	0.020	0.014
	Night-time 2200-0700h	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.020	0.014	0.040	0.028
Impulsive Vibration					
Critical areas[1]	Day- or Night-time	0.005	0.0036	0.01	0.0072
Residences	Daytime 0700-2200h	0.30	0.21	0.60	0.42
	Night-time 2200-0700h	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.64	0.46	1.28	0.92

1. Criteria for sensitive areas are only indicative, and have been provided as guidance to acceptable vibration levels for the use of sensitive equipment, eg. camera equipment at Fox Studios.

Table 14: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Daytime 0700-2200 h		Night-time 2200-0700 h	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas[1]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80

1. Criteria for sensitive areas are only indicative, and there may be a need to assess intermittent vibration against impulsive or continuous criteria.

3.3.2 Building damage

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with British Standard 7385 Part 2-1993 and/or German Standard DIN4150-3. British Standard 7385 Part 1: 1990, defines different levels of structural damage as:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition, the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

Table 1 of BS7385-2 sets limits for the protection against cosmetic damage, however the following guidance on minor and major damage is provided in Section 7.4.2 of the Standard:

> *7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1 (reproduced below).*

Table 1 — Transient vibration guide values for cosmetic damage

Line (see Figure 1)	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 commerical 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

NOTE 1 Values referred to are at the base of the building (see **6.3**).

NOTE 2 For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

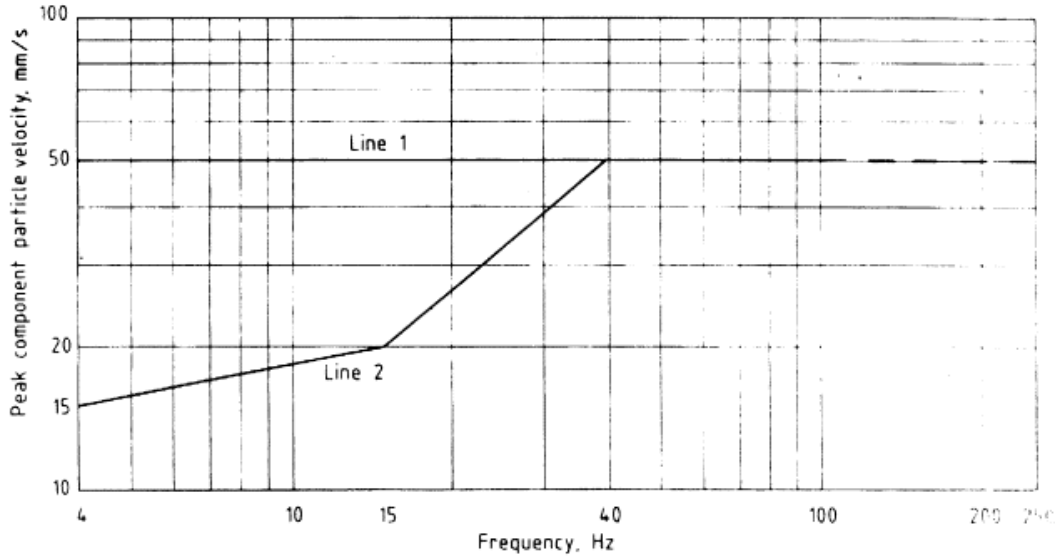


Figure 1 — Transient vibration guide values for cosmetic damage

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.

Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values.

Within DIN4150-3, damage is defined as "any permanent effect of vibration that reduces the serviceability of a structure or one of its components" (p.2). The Standard also outlines:

"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if

- *cracks form in plastered surfaces of walls;*
- *existing cracks in the building are enlarged;*
- *partitions become detached from loadbearing walls or floors.*

These effects are deemed 'minor damage." (DIN4150.3, 1990, p.3)

While the DIN Standard defines the above damage as 'minor', the description aligns with BS7385 cosmetic damage, rather than referring to structural failures.

British Standard BS7835-2

BS7385-2 [6] is based on peak particle velocity and specifies damage criteria for frequencies within the range 4–250 Hz, and a maximum displacement value below 4 Hz is recommended. Table 14 sets out the BS7385 criteria for cosmetic, minor and major damage. Regarding heritage buildings, British Standard 7385 Part 2 (1993, p.5) notes that "a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive".

Table 15: BS 7385-2 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s1		
			4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
		Minor[2]	100		
		Major[2]	200		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

Notes

1 - Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

2 - Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

All levels relate to transient vibrations in low-rise buildings. Continuous vibration can give rise to dynamic magnifications that may require levels to be reduced by up to 50%.

German Standard DIN 4150-3

German Standard DIN 4150 - Part 3 'Structural vibration in buildings - Effects on Structure' (DIN 4150-3) [7] are generally recognised to be conservative. DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The criteria are presented in Table 16.

Table 16: DIN 4150-3 structural damage criteria

Group	Type of structure	Vibration velocity, mm/s			
		At foundation at frequency of			Plane of floor uppermost storey
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order)	3	3 to 8	8 to 10	8

3.3.3 Buried services

DIN 4150-2:1999 [7] sets out guideline values for vibration effects on buried pipework and reproduced in Table 17 below.

Table 17: Guideline values for short-term vibration impacts on buried pipework

Pipe material	Guideline values for vibration velocity measured on the pipe, mm/s
Steel (including welded pipes)	100
Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
Masonry, plastic	50

Note:

For gas and water supply pipes within 2m of buildings, the levels given above should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.

In addition, specific limits for vibration affecting high-pressure gas pipelines is provided in the UK National Grid's Specification for Safe Working in the Vicinity of National Grid High Pressure Gas Pipelines and Associated Installations – Requirements for Third Parties (report T/SP/SSW/22, UK National Grid, Rev 10/06, October 2006). This specification states that no piling is allowed within 15 m of a pipeline without an assessment of the vibration levels at the pipeline. The PPV at the pipeline is limited to a maximum level of 75 mm/s, and where PPV is predicted to exceed 50 mm/sec the ground vibration is required to be monitored.

Other services that may be encountered include electrical cables and telecommunication services such as fibre optic cables. While these may sustain vibration velocity levels from between 50 mm/s and 100 mm/s, the connected services such as transformers and switchgear may not. Where encountered, site specific vibration assessment in consultation with the utility provider should be carried out.

3.3.4 Heritage structures

Heritage structures which have been identified in the vicinity of the Stadium Australia project site include the Olympic Cauldron, State Abbattoirs and the Newington Armament Depot and Nature Reserve. The distance of these heritage structures from the project site is provided in Table 18.

Table 18: Distance of heritage structures from project site

Heritage Item	Distance from site
Olympic Cauldron	100m
State Abbattoirs	280m
Newington Armament Depot & Nature Reserve	1,400m

Regarding heritage buildings, BS7385-2 notes that '*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*'. As all three sites are considered to be structurally sound, these heritage structures are not considered to be more vibration sensitive than other surrounding structures. Further, based on the proposed

construction equipment and the distance of the heritage items from the project site, vibration is not anticipated to be an issue for all three heritage structures.

3.4 Construction noise assessment

3.4.1 Hours of works

General construction works will be undertaken within the hours outlined in Table 19, in accordance with ICNG standard hours of construction.

Table 19: Preferred Hours of Construction

Day	Proposed construction hours
Monday to Friday	7.00 am to 6:00 pm
Saturdays	8.00 am to 1:00 pm
Sundays or Public Holidays	No construction

In some cases, after-hours permits may be sought from the relevant authorities where special requirements exist, for example oversized deliveries.

3.4.2 Activities

Proposed construction equipment and activities to be used for redevelopment works have been provided by Aver and are summarised in Table 20.

The locations of equipment have been based on the locations of the construction works in and around the stadium. Demolition works of the northern and southern stands may take place separately or concurrently, and each possible scenario have been modelled separately.

Equipment sound power levels have been determined by reference to AS2436 [8], DEFRA [9], and Arup's measurement database. The equipment below has been assumed to operate concurrently and continuously over a full 15-minute period (a typical worst-case assumption).

Table 20: Construction equipment usage and associated sound power levels (L_w)

Approx. duration	Description of works in sub-stage	Equipment	Total number of units on site	No. operating within worst case 15-min	Sound Power dBL_{eq} (15min)
Phase 1 – Deconstruction/Demolition of North and South Stands					
5-6 months		Boom lift	8	4	113
		Scissor lift	4	2	101
		Crane 100T/200T	3	2	116
		Excavator 40T	1	1	115
		Excavator with bucket and hammers	1	1	120
		Semi tipper	4	2	116

Approx. duration	Description of works in sub-stage	Equipment	Total number of units on site	No. operating within worst case 15-min	Sound Power dBL_{eq} (15min)
		Semi trailer	4	2	110
Phase 2 – Stadium Roof Construction					
24 months		Boom lift	12	6	115
		Scissor lift	8	4	104
		Crane 100T/200T/400T	6	3	118
		Piling rig	2	1	116
		Semi tipper	4	2	116
		Semi trailer	4	2	110

3.4.3 Assessment methodology

Noise emissions from construction activities associated with the SFSR have been assessed to criteria outlined in Section 3.1.

Noise emissions have been modelled using SoundPlan 8 in accordance with ISO9613-2 algorithms. The model included:

- Construction noise sources listed in Section 3.4.1;
- Stadium Australia and surrounding buildings;
- Receivers listed in Table 3; and
- Ground terrain and absorption.

Noise emissions have been modelled on the following conservative assumptions:

- Equipment, staging and durations are based on information provided by Aver. A review of predicted emissions should be conducted when final construction details are available as part of the development of a Construction Noise and Vibration Management Plan.
- The equipment Table 20 have been assumed to operate concurrently and continuously over a full 15-minute period

3.4.4 Noise prediction results

Predicted construction noise levels at surrounding receivers are presented in Table 21, along with the relevant NML for the intended working hours, as presented in Table 10.

Graphical representations of construction noise emission are presented in Appendix C.

Table 21: Predicted construction noise levels, $dBL_{Aeq\ (15\ min)}$

Receiver	NML	Phase of works			
		Phase 1 – Deconstruction/Demolition of North and South Stands			Phase 2 – Stadium Roof Construction
		Works at northern end of stadium	Works at southern end of stadium	Concurrent works at northern and southern end of stadium	
		Highest predicted noise levels[1]			
Residential receivers					
RES1	57	54	70	67	54
RES2 - proposed	57	58	72	69	62
RES3	57	60	59	59	46
RES4 - proposed	57	58	68	65	61
RES5	57	57	65	63	60
RES6 - proposed	63	53	56	55	50
RES7 - proposed	63	51	50	50	43
RES8	51	35	41	40	41
RES9	52	44	45	45	35
RES10	63	48	33	45	31
RES11	63	49	47	48	41
RES12	51	35	36	36	33
RES13	52	48	46	47	44
RES14	52	48	45	47	46
RES15 - proposed	63	51	47	49	43
RES16	51	43	47	45	44
RES17	52	50	45	48	47
RES18	51	31	29	30	28
RES19	52	35	38	36	26
Non-residential receivers					
ARA1	65	48	64	61	48
ARA2	65	40	58	55	51
ARA3	65	40	49	47	48
ARA4	65	44	44	44	38
CCF1 - proposed	55[2]	51	54	53	41
CCF2	55[2]	51	48	50	42
CCF3	55[2]	51	47	50	42
CCF4	55[2]	34	28	32	21
COM1	70	45	72	69	54
COM2	70	60	51	57	46

Receiver	NML	Phase of works			
		Phase 1 – Deconstruction/Demolition of North and South Stands			Phase 2 – Stadium Roof Construction
		Works at northern end of stadium	Works at southern end of stadium	Concurrent works at northern and southern end of stadium	
		Highest predicted noise levels[1]			
COM3	70	57	69	66	61
COM4	70	55	53	54	42
COM5	70	53	55	54	40
EDU1	55[2]	47	45	46	34
EDU2	55[2]	48	49	49	41
EDU3	55[2]	50	48	49	40
EDU4	55[2]	47	47	47	43
EDU5	55[2]	43	43	43	30
EDU6	55[2]	42	46	44	44
EDU7	55[2]	39	28	36	28
HOT1	70	59	71	68	62
HOT2	70	58	62	60	48
HOT3	70	58	67	65	61
HOT4	70	54	58	56	46
PAS1	60	65	44	62	54
PAS2	60	29	30	29	27
PAS3	60	44	43	44	35
POW1	55[2]	37	42	40	39
POW2	55[2]	50	47	49	39
POW3	55[2]	37	38	37	36
VEN1	70	76	54	72	64
VEN2	70	71	57	68	62
VEN3	70	68	58	66	62
VEN4	70	62	51	59	48
VEN5	70	61	45	58	52

Notes:

1 - Noise levels shaded in grey indicate an exceedance of noise limit

2 – A 10dB correction due to attenuation through an open window has been applied to internal NMLs to derive external NMLs

Results indicate that exceedances may occur at the nearest residential receivers located within the Carter Street Precinct, including both proposed and existing developments at 5 Uhrig Road and 7 Carter Street, Lidcombe. Although proposed developments at these

locations have been approved, these premises may not be occupied prior to the commencement of construction.

It should be noted that no residences are predicted to be 'highly affected' during any stage of works, i.e. experience noise levels of $L_{Aeq(15minute)}$ 75 dBA or above.

The highest levels are predicted during use of equipment such as the excavators with hammers and cranes. These items are typically used over short durations and therefore may not be in operation concurrently as assumed in the predictions. Therefore, the noise levels predicted in Table 21 are expected to represent a conservative worst-case 15-minute period of each construction stage. In practice, noise levels during each stage are expected to be lower than that predicted.

Minor exceedances of 2 dB or less are predicted at the COM1 - NSW Rugby League Centre of Excellence and HOT1 - Ibis Hotel Olympic Park, and exceedances of up to 5 dB are predicted at PAS1 – Cathy Freeman Park. No significant disturbance to the operation of these premises are anticipated as a result of the predicted noise levels.

Some exceedances are of up to 6 dB are predicted at VEN1 – Qudos Bank Arena, and although it is unlikely noise ingress into the venue will generate significant disturbances to activities taking place inside, liaison with operators of this venue is recommended to minimise the impacts of construction noise on events hosted at the venue.

As noise predictions are conservative with respect to number of concurrent operating plant and durations, significant disturbance is not expected at other non-residential receivers.

Construction noise mitigation and management measures are discussed in Section 3.7.

3.5 Construction traffic assessment

Construction vehicles will be used for deliveries and to remove waste from the site, with the proposed access points to the site located at:

- Edwin Flack Avenue – construction vehicles to access site via the existing basement access next to P1 Car Park, travelling east along Edwin Flack Avenue with worst affected residential receivers located along Edwin Flack Avenue, including YMCI Homebush Gardens and 5 Uhrig Road.
- Dawn Fraser Avenue – construction vehicles accessing the site from the south will enter via Dawn Fraser Avenue, with worst affected existing residential receiver located at 7 Carter Street.

Edwin Flack Avenue and Dawn Fraser Avenue are considered Local Roads in accordance with the Road Noise Policy [10], as they '*provide vehicular access to abutting property and surrounding streets*'. Proposed construction traffic routes and most potentially affected receivers, both residential, are presented in Figure 6.

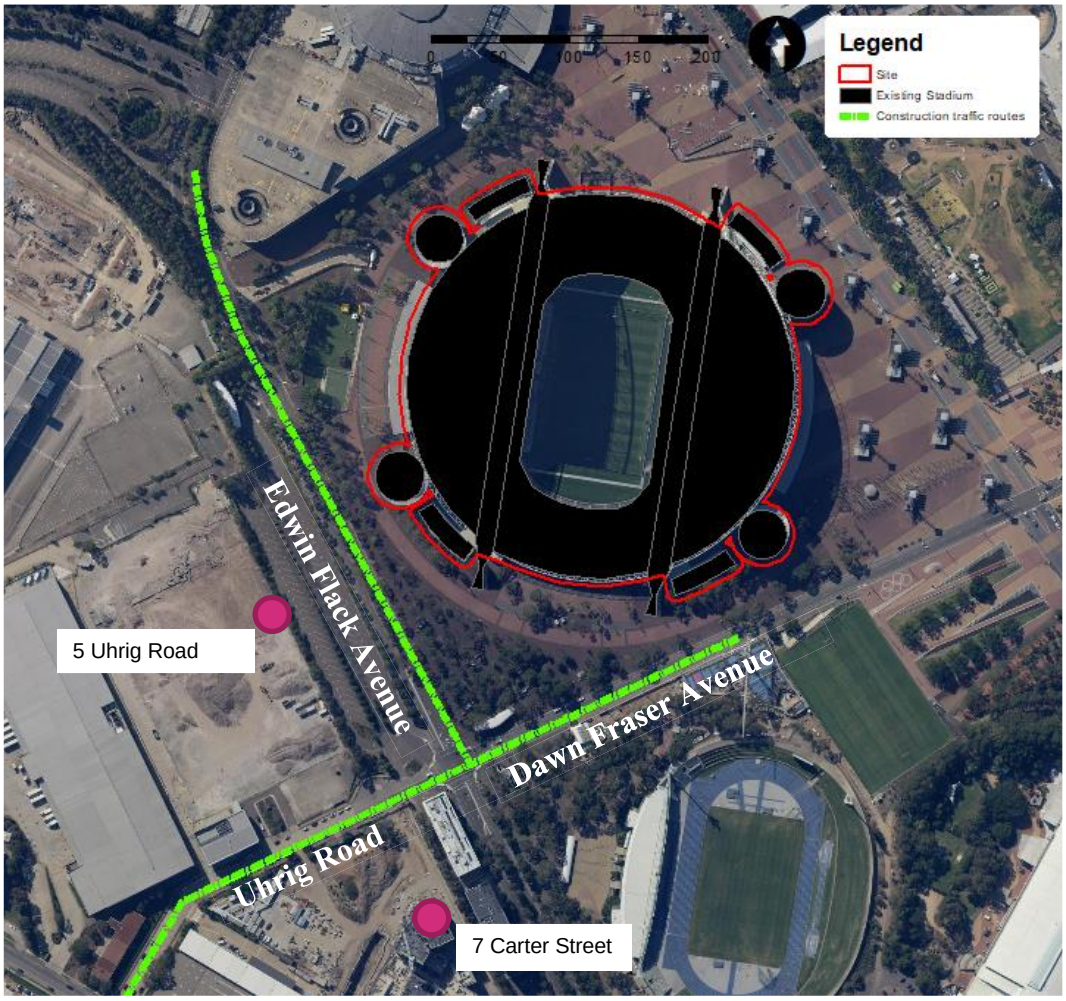


Figure 6: Construction traffic routes and worst affected residences.

Construction traffic vehicles are anticipated to comprise the following.

Demolition:

- 40-50 heavy vehicles
- 50 light vehicles for workers, arriving at AM peak hour and leaving at PM peak hour. It is noted that a reduction of 120 light vehicles for current permanent staff is also anticipated, arriving at AM peak hour and leaving at PM peak hour. An overall decrease of 70 light vehicles during the AM and PM peak hours is therefore anticipated.

Construction:

- 40-60 heavy vehicles
- 200 light vehicles for workers, arriving at AM peak hour and leaving at PM peak hour. It is noted that a reduction of 120 light vehicles for current permanent staff is also anticipated, arriving at AM peak hour and leaving at PM peak hour. An overall increase of 80 light vehicles during the AM and PM peak hours is therefore anticipated.

100% of trucks could utilise either Edwin Flack Avenue or Dawn Fraser Avenue on any given day.

Regarding the assessment of potential impact and consideration of mitigation and management measures, the RNP [10] states:

> *In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.*

Existing traffic volumes were provided by JMT traffic planning consultants. The assessment of construction related traffic noise is presented in Table 22.

Table 22: Construction traffic assessment

Traffic route	Most potentially affected residential receiver	Existing 15hr traffic volumes[1]	Daily construction movements[2]		Predicted increase in road traffic noise, $L_{Aeq(15hour)}$	Criteria	Comply
			Heavy vehicles	Light vehicles			
Edwin Flack Avenue	5 Uhrig Road	3,300	80-120	160	1.9 dB	< 2 dB	Yes
Dawn Fraser Avenue	7 Carter Street	3,626	80-120	160	1.7 dB	< 2 dB	Yes

Notes:

1. Based on 8% heavy vehicle proportion
2. Based on worst case scenario construction works

Considering the existing traffic numbers along Edwin Flack Avenue and Dawn Fraser Avenue, the additional construction traffic created by construction works is predicted to increase the $L_{Aeq(15\ hour)}$ noise levels by 1.9 dB at 5 Uhrig Road and 1.7 dB at 7 Carter Street. This is less than the 2 dB 'minor impact' criteria, and therefore represents an insignificant effect on the ambient noise environment.

3.6 Construction vibration assessment

As no significant vibration intensive activities are proposed as part of the construction works, the likelihood of adverse impacts due to the proposed construction activities is low.

Given the large distances between other receivers and the demolition works, vibration damage is not considered a significant risk for surrounding receivers. No adverse vibration impact, either in terms of cosmetic damage or human comfort, are expected to occur at receiver buildings due to their distance from the subject works.

Consideration should be given to excavation works taking place in the vicinity of the heritage listed sites, described in Section 3.3.4, however it is noted that these structures are considered structurally sound, therefore these heritage structures are not considered to be more vibration sensitive than other surrounding structures.

The following guidance provides recommended minimum working distances for vibration intensive plant. These are based on international standards and guidance and reproduced in Table 23 below for reference.

Table 23: Recommended minimum working distances for vibration intensive plant

Plant Item	Rating / Description	Minimum working distance	
		Cosmetic damage (BS 7385)	Human response (OH&E Vibration Guideline)
Small rock breaker	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium rock breaker	(900 kg – 12 to 18t excavator)	7 m	23 m
Large rock breaker	(1600 kg – 18 to 34t excavator)	22 m	73 m

The minimum working distances presented are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

Mitigation will need to be considered where sensitive receivers are located closer to the construction work zone than these minimum working distances. It is noted that focus is on mitigating cosmetic damage.

The contractor will be required to manage vibration as well as noise and make use of best practice in the management of vibration using simple and practicable techniques such equipment selection and as avoiding dropping heavy items.

Where vibration intensive works are required within the minimum working distances outlined in Table 23, vibration monitoring at the nearest potential affected building should be considered, where real-time alerts can be generated when measured vibration levels exceed criteria.

3.7 Construction noise mitigation measures

The contractor will have a key role in managing the noise and vibration levels during the works to reduce noise and vibration as far as is reasonably practicable. This will include:

Table 24: Construction noise mitigation measures

Item	Detail
Noise and vibration management plan	A Construction Noise and Vibration Management Plan shall be prepared prior to the issuing of a Construction Certificate. This will specify the actual plant to be used and will include updated estimates of the likely levels of noise and the scheduling of activities.
Staffing	Appointing a named member of the site staff who will act as the Responsible Person with respect to noise and vibration; Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise; Ensuring good work practices are adopted to avoid issues such as noise from dropped items, noise from communication radios is kept as low as is practicable; Avoid the use of radios or stereos outdoors; and Avoid shouting and minimise talking loudly and slamming vehicle doors.

Item	Detail
Plant and equipment	Where possible stationary equipment should be located behind structures such as demountable buildings or stockpiles to maximise shielding to receivers; Consider using electric / hydraulic equipment where possible Using the smallest equipment as is practical All plant and equipment used on site must be: • maintained in a proper and efficient condition; and • operated in a proper and efficient manner. Turn off all vehicles, plant and equipment when not in use Ensuring that the Responsible Person checks the conditions of the powered equipment used on site daily to ensure plant is properly maintained and that noise is kept as low as practicable.
Scheduling	Ensure that the Responsible Person controls the working hours on site to ensure that work is only done during the acceptable periods (7am to 6pm on weekdays and 8am to 1pm on Saturdays. No work on Sundays or public holidays)
Work site training	'Toolbox talks' will be held at regular intervals with the contractor workers, including discussion of noise and vibration mitigation, monitoring and assessment. These topics will also be covered under induction processes. Operate two way radios at the minimum effective volume, and avoid shouting or whistling at the site. Identification of all reasonable and feasible noise mitigation methods will be conducted by the Responsible Person on a daily basis during noisy works. The Responsible Person will have the authority to modify work practices in response to complaints, where this is considered appropriate.
Scheduling	High noise activities will be programmed to occur during the daytime hours wherever possible and will be scheduled with due consideration to the nearest sensitive receivers. For approved out-of-hours work (refer Section 3.4.1), noisy activities should be scheduled early in the night to minimise the impact on adjacent residents. Limit number of consecutive nights receivers are impacted
Community liaison	Ensuring that the Responsible Person keeps the local community advised on expected activities and coordinates scheduling and locations of noisy works around any critical user events where practicable. This shall include face to face meetings with nearby receivers if requested and a letter box drop, and shall include close liaison with neighbours during construction, including Qudos Bank Arena. Maintaining appropriate records of complaints to include timing, reported issues, actions taken and measures to be included for on-going works. The complaints log will need to be filed with the Responsible Person.
Reversing alarms	The use of audible movement alarms of a type that would minimise noise impacts on surrounding noise sensitive receivers must be implemented. Where practicable, broadband, non-tonal reversing alarms should be utilised on site equipment. Ensure that the difference in volume between the reversing warning devices and the base machine noise level (at maximum governed speed under no load at any given test location) is minimised (in accordance with International Standard ISO9533:1989), and ensure that warning devices are no more than 5 dB above the Australian Standard level;

Item	Detail
Material handling	Avoid dropping equipment/materials from a height or into trucks. Where practicable, use sound dampening material to cover the surfaces on to which any materials must be dropped.
Equipment Location	Site noisy equipment away from noise-sensitive areas. Plant known to emit noise strongly in one direction is to be orientated so that the noise is directed away from noise-sensitive areas. Locate site access roads and site compounds as far away as possible from noise sensitive receptors. Plan truck movements to avoid residential streets where possible.

4 Event noise

This section addresses noise emission associated with events at Stadium Australia, which include regular sporting events and irregular concerts and cultural events, such as the Bengali New Year's Festival and the Royal Edenborough Military Tattoo.

4.1 Comparison of existing ANZ Stadium and proposed Stadium Australia

The existing ANZ Stadium is a multi-purpose sporting and entertainment venue which hosts a range of events throughout the year.

Table 25: ANZ Stadium

Description	**Current ANZ Stadium**	**Proposed Stadium Australia**
Capacity	83,500	70,000
Field shape	Oval	Rectangular
Event time restrictions	7:00am to 11:00pm	No change

The proposed Stadium Australia will reconfigure the lower and middle seating bowl bringing the seating closer to the field and increasing the pitch of the seating bowl. This reduces the capacity from 83,500 to approximately 70,000 seats. Further, roof coverage will be provided to all permanent seats by replacing the northern and southern sections of the roof and extending the existing eastern and western sections. These changes are anticipated to reduce the noise emission to the surrounding environment, while enhancing the acoustic atmosphere within the Stadium.

Like the current stadium operation, the most significant noise sources emanating from the new stadium are expected to include:

- Music and announcements from sound amplification systems during sporting, concert and other entertainment events; and,
- Crowd noise during sporting, concert and other entertainment events.

A comparison of the noise emission from the existing ANZ Stadium and the proposed Stadium Australia development has been carried out. 3D renderings of the existing ANZ Stadium and proposed Stadium Australia noise models are shown in Figure 7 below.

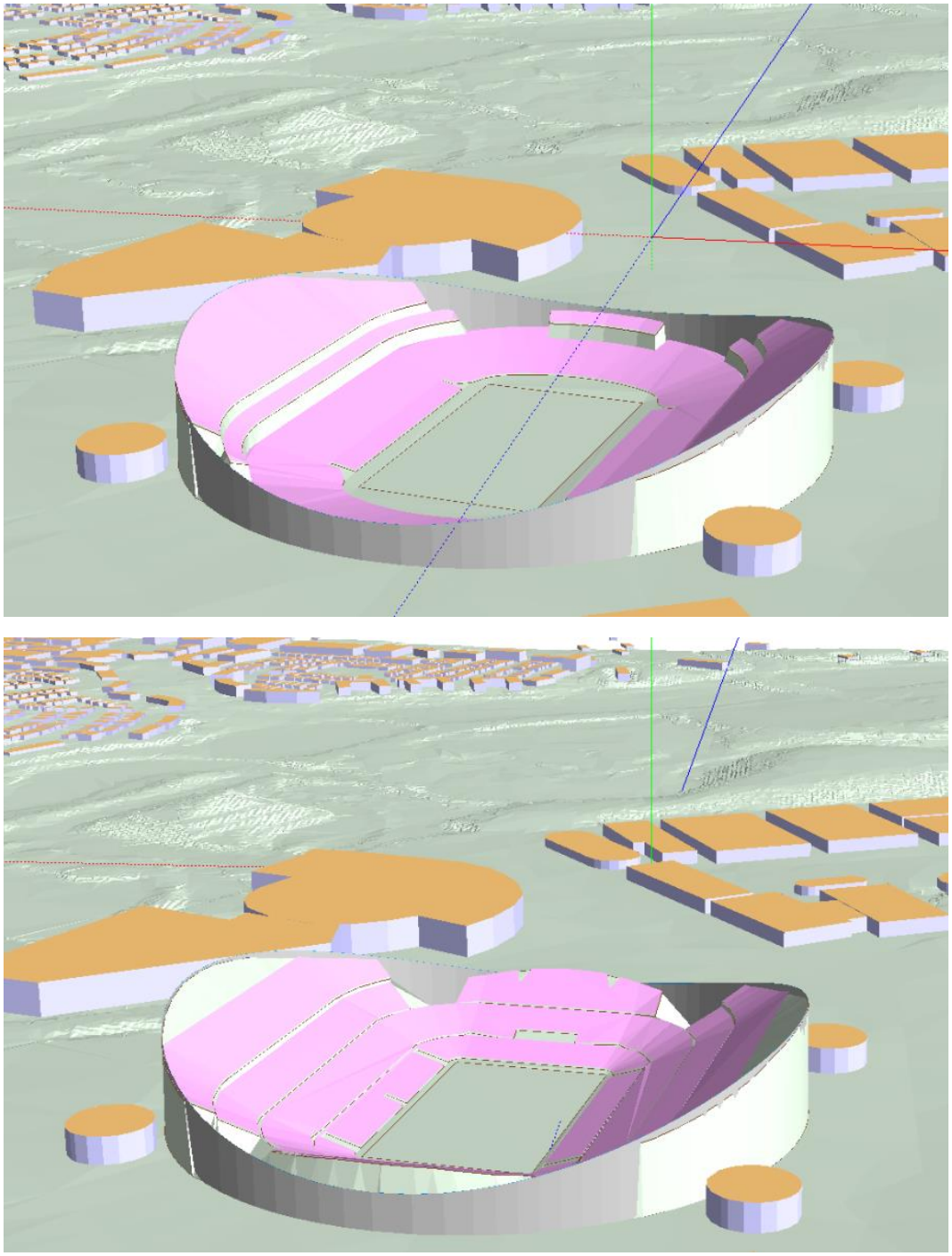


Figure 7: Renderings of existing ANZ Stadium noise model (above) and proposed Stadium Australia noise model (below). Note the higher tiered seating at the north and south stands and the lower tiered seating on the east and west stands.

4.2 Modelling methodology

Noise emissions have been modelled using SoundPlan 8 using the Concawe algorithm, which is considered appropriate for this scenario with nearest receivers located over 100 metres of the noise sources, with some nominated assessment locations located over 1 kilometre away.

Both the existing ANZ Stadium and the proposed redeveloped Stadium Australia were modelled to provide a comparison of existing vs. proposed noise levels.

The evaluation of the proposal is in terms of predicted changes in noise level emission, as the application does not seek modification of the existing operations. Assessment has been carried out to residential receivers only, however the locations are representative of other non-residential receivers.

The noise models included:

- Event noise sources, including;
  - Crowd noise sources as area sources covering the entire tiered seating areas;
  - Concert sound systems as point sources;
- Both the existing ANZ Stadium and the proposed Stadium Australia in two scenarios
- Surrounding buildings;
- Residential receivers listed in Table 3; and
- Ground terrain and absorption.

A 3D rendering of the noise models are presented in Figure 7.

4.3 Results

Table 26 presents the predicted noise levels at existing ANZ Stadium and proposed Stadium Australia at the worst affected residential receivers.

Noise level difference contours showing predicted changes in noise levels due to the redevelopment are presented in Appendix E.

Table 26: Existing ANZ Stadium and proposed Stadium Australia comparison of concert event noise emissions- $dBL_{eq15min}$

Representative receiver	Change in noise level from existing ANZ Stadium to proposed Stadium Australia, dB	
	Concert events	Sporting events
RES1	0	0
RES2	0	-1
RES3	-1	-1
RES4	0	-2
RES5	0	-1
RES6	0	-1
RES7	0	0
RES8	0	0
RES9	-1	-2
RES10	1	2
RES11	0	-2
RES12	0	-3

Representative receiver	Change in noise level from existing ANZ Stadium to proposed Stadium Australia, dB	
	Concert events	Sporting events
RES13	-3	-3
RES14	-1	-2
RES15	-1	-2
RES16	0	-1
RES17	-1	-1
RES18	-1	-2
RES19	-2	-3
RES20	-1	-1
RES21	-2	-3
RES22	-2	-2
RES23	1	1
RES24	-1	-1
Median	**-0.5**	**-1.0**
Mean	**-0.6**	**-1.3**

The assessment indicates that the proposed modifications of Stadium Australia should not increase noise emissions, with generally minor reductions in noise levels being predicted at the majority of receivers in the concert and sporting event scenarios (up to 3 dB).

Reductions are largely attributed to the slightly higher tiered seating proposed at the northern and southern ends of the stadium, which will slightly increase the shielding of receivers. A minor reduction of less than 1 dB for sporting events and a negligible reduction for concert events is attributed to the reduction in seating capacity.

4.4 Discussion

The acoustic assessment reveals no increases in noise emissions are predicted as a result the redevelopment works, with minor reductions being predicted at the majority of surrounding residences. Predicted reductions are attributed to the higher tiered seating which will increase shielding of receivers from event activities within the stadium, as well as an overall reduction in seating capacity, which will marginally decrease crowd noise during events.

In general, changes in noise levels are predicted to be insignificant (i.e. 2 dB or less), with noise levels at some receivers predicted to reduce by more than 2 dB. No additional acoustic treatment is considered necessary for event noise.

5 Summary of mitigation measures

A summary of recommended mitigation measures are presented in Table 27.

Table 27: Recommended noise mitigation and management measures

Item	Item	Detail
Construction noise and vibration		
1	Noise and vibration management plan	A Construction Noise and Vibration Management Plan shall be prepared prior to the issuing of a Construction Certificate. This will specify the actual plant to be used and will include updated estimates of the likely levels of noise and the scheduling of activities.
2	Staffing	Appointing a named member of the site staff who will act as the Responsible Person with respect to noise and vibration; Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise; Ensuring good work practices are adopted to avoid issues such as noise from dropped items, noise from communication radios is kept as low as is practicable; Avoid the use of radios or stereos outdoors; and Avoid shouting and minimise talking loudly and slamming vehicle doors.
3	Plant and equipment	Where possible stationary equipment should be located behind structures such as demountable buildings or stockpiles to maximise shielding to receivers; Consider using electric / hydraulic equipment where possible Using the smallest equipment as is practical All plant and equipment used on site must be: • maintained in a proper and efficient condition; and • operated in a proper and efficient manner. Turn off all vehicles, plant and equipment when not in use Ensuring that the Responsible Person checks the conditions of the powered equipment used on site daily to ensure plant is properly maintained and that noise is kept as low as practicable.
4	Scheduling	Ensure that the Responsible Person controls the working hours on site to ensure that work is only done during the acceptable periods (7am to 6pm on weekdays and 8am to 1pm on Saturdays. No work on Sundays or public holidays)
5	Work site training	'Toolbox talks' will be held at regular intervals with the contractor workers, including discussion of noise and vibration mitigation, monitoring and assessment. These topics will also be covered under induction processes. Operate two way radios at the minimum effective volume, and avoid shouting or whistling at the site. Identification of all reasonable and feasible noise mitigation methods will be conducted by the Responsible Person on a daily basis during noisy works. The Responsible Person will have the authority to modify work practices in response to complaints, where this is considered appropriate.

Item	Item	Detail
6	Scheduling	High noise activities will be programmed to occur during the daytime hours wherever possible and will be scheduled with due consideration to the nearest sensitive receivers. For approved out-of-hours work (refer Section 3.4.1), noisy activities should be scheduled early in the night to minimise the impact on adjacent residents. Limit number of consecutive nights receivers are impacted
7	Community liaison	Ensuring that the Responsible Person keeps the local community advised on expected activities and coordinates scheduling and locations of noisy works around any critical user events where practicable. This shall include face to face meetings with nearby receivers if requested and a letter box drop, and shall include close liaison with neighbours during construction, including Qudos Bank Arena. Maintaining appropriate records of complaints to include timing, reported issues, actions taken and measures to be included for on-going works. The complaints log will need to be filed with the Responsible Person.
8	Reversing alarms	The use of audible movement alarms of a type that would minimise noise impacts on surrounding noise sensitive receivers must be implemented. Where practicable, broadband, non-tonal reversing alarms should be utilised on site equipment. Ensure that the difference in volume between the reversing warning devices and the base machine noise level (at maximum governed speed under no load at any given test location) is minimised (in accordance with International Standard ISO9533:1989), and ensure that warning devices are no more than 5 dB above the Australian Standard level;
9	Material handling	Avoid dropping equipment/materials from a height or into trucks. Where practicable, use sound dampening material to cover the surfaces on to which any materials must be dropped.
10	Equipment Location	Site noisy equipment away from noise-sensitive areas. Plant known to emit noise strongly in one direction is to be orientated so that the noise is directed away from noise-sensitive areas. Locate site access roads and site compounds as far away as possible from noise sensitive receptors. Plan truck movements to avoid residential streets where possible.
No operational or event mitigation measures		

6 Conclusion

Based on the assessments detailed above, it is concluded that the development will not have any significant additional operational noise impacts on the nearby noise sensitive receivers or the environment around the development site.

Some disturbances due to construction noise are anticipated and mitigation measures have been recommended. No significant construction vibration impacts are anticipated.

No increases in event noise impacts are predicted as a result of the redevelopment.

The assessment has covered the following issues and concluded:

6.1 Construction noise

Noise generated from the demolition and construction phases of stadium redevelopment works have been predicted at surrounding noise sensitive receivers. This has been informed by guidance from the project Construction Consultant.

The most significant noise impacts are predicted during stadium demolition works, where the use of equipment such as the hammers and cranes are predicted to generate noise impacts above construction NMLs.

No residential receivers are predicted be ‘highly affected’ during proposed works,

The likelihood of adverse vibration impacts as a result of proposed construction works is low. Nonetheless, mitigation should be considered where vibration intensive works are required closer than ‘safe working distances’ to sensitive receivers, presented in Table 23.

Detailed recommendations are given for the control of construction noise for the periods where exceedances are predicted of relevant Noise Management Levels. The construction contractor is required to prepare a detailed Construction Noise and Vibration Management Sub Plan which reviews the modelled construction details and noise and vibration impacts presented in Section 3.

6.2 Event noise

As no changes to the type, scale or frequency of events to take place at Stadium Australia are proposed and no significant modifications to the existing façade of the stadium are proposed, no increases in event noise are predicted. Minor reductions in overall noise emissions from concert events and sporting events are predicted as a result of higher tiered seating, resulting in more shielding from event noise within the stadium, and an overall reduction in seating capacity.

It is noted the Carter Street DCP and SOPA Master Plan include specific planning requirements for new residential and other sensitive receivers to ensure that buildings are designed to mitigate against the effects of event noise and to ensure that property owners and residents are aware of the potential for noise generation associated with events.

No additional acoustic treatment for event noise mitigation are considered necessary.

7 References

[1] Department of Environment and Climate Change NSW, “Interim Construction Noise Guideline,” Department of Environment and Climate Change NSW, Sydney, 2009.

[2] Department of Planning NSW, “Development Near Rail Corridors and Busy Roads – Interim Guideline,” Department of Planning NSW, Sydney, 2008.

[3] NSW Environment Protection Authority, “NSW Noise Policy for Industry,” NSW Environment Protection Authority , Sydney, 2017.

[4] Department of Environment and Conservation (NSW), “Assessing Vibration: A technical guideline,” Department of Environment and Conservation (NSW), Sydney, 2006.

[5] British Standards, “BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting,” British Standards, 2008.

[6] British Standards, “BS 7385-1:1990 - Evaluation and measurement for vibration in buildings. Guide for measurement of vibrations and evaluation of their effects on buildings,” British Standards, 1990.

[7] German Institute for Standardisation, “DIN 4150 - Part 3 'Structural vibration in buildings - Effects on Structure',” German Institute for Standardisation, 1999.

[8] Standards Australia, “AS 2436-2010 - Guide to noise and vibration control on construction, demolition and maintenance sites,” Standards Australia, 2010.

[9] Department for Environment Food and Rural Affairs, “Update of noise database for prediction of noise on construction and open sites,” Department for Environment Food and Rural Affairs, 2006.

[10] Department of Environment, Climate Change and Water NSW, “NSW Road Noise Policy,” NSW Environmental Protection Authority, Sydney, 2011.

[11] Environmental Resources Management Australia, “Sydney Cricket Ground and Allianz Stadium - Noise Management Plan,” Environmental Resources Management Australia, Sydney, 2017.

[12] Infrastructure NSW, “Methodology Statement - Working Near Busby’s Bore,” Infrastructure NSW, Sydney, 2018.

[13] Arup, “2018-06-05 - AC01-v5_SFSR_Noise and Vibration Impact Assessment,” Arup, Sydney, 2018.

[14] M. f. U. A. a. Planning, “Stadium Australia - Development Approval Conditions,” Department of Urban Affairs and Planning, Sydney, September 1996.

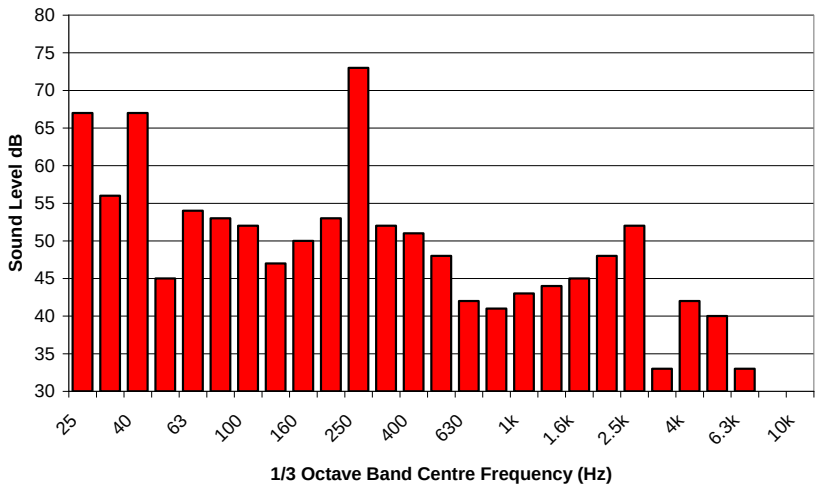
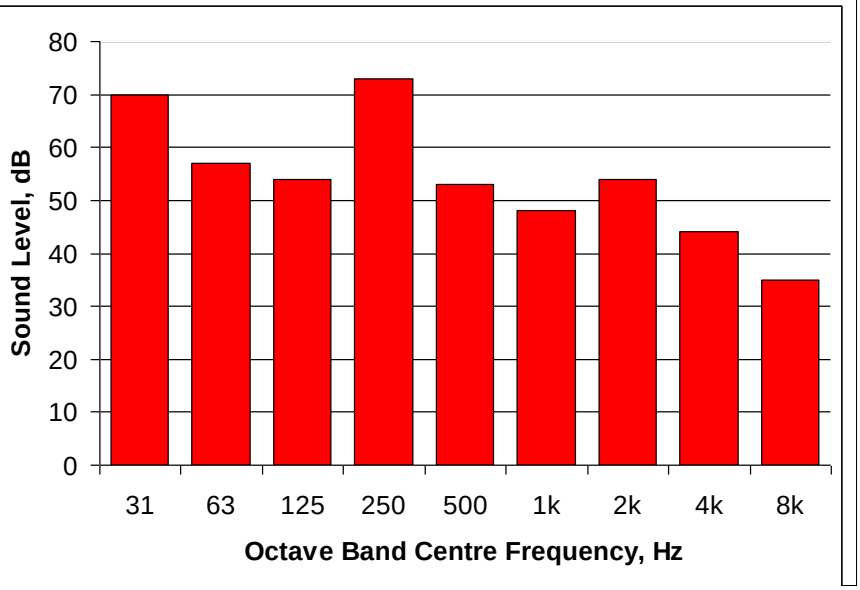
[15] A. Stadium, “Sydney Olympic Park Noise Management Plan for ANZ Stadium,” ANZ Stadium, Sydney, August 2008.

Appendix A

Acoustic Glossary

Term	Definition
Ambient Noise Level	The ambient noise level is the overall noise level measured at a location from multiple noise sources. When assessing noise from a particular development, the ambient noise level is defined as the remaining noise level in the absence of the specific noise source being investigated. For example, if a fan located on a city building is being investigated, the ambient noise level is the noise level from all other sources without the fan running. This would include sources such as traffic, birds, people talking and other nearby fans on other buildings.
Background Noise Level	The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects. **Assessment Background Level (ABL)** A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background LA90 noise levels – i.e. the measured background noise is above the ABL 90% of the time. **Rating Background Level (RBL / min $L_{A90,1hour}$)** A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey. This parameter is denoted RBL in NSW, and min $L_{A90,1hour}$ in QLD.
Decibel	The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressure levels, which would be unwieldy if presented on a linear scale. Therefore, a logarithmic scale, the decibel (dB) scale, is used to describe sound levels. An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.
dBA	dBA denotes a single-number sound pressure level that includes a frequency weighting (“A-weighting”) to reflect the subjective loudness of the sound level. The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dBA.

<table>
<tr><th>Term</th><th>Definition</th></tr>
<tr><td></td><td>Some typical dBA levels are shown below.
<table>
<tr><th>Sound Pressure Level dBA</th><th>Example</th></tr>
<tr><td>130</td><td>Human threshold of pain</td></tr>
<tr><td>120</td><td>Jet aircraft take-off at 100 m</td></tr>
<tr><td>110</td><td>Chain saw at 1 m</td></tr>
<tr><td>100</td><td>Inside nightclub</td></tr>
<tr><td>90</td><td>Heavy trucks at 5 m</td></tr>
<tr><td>80</td><td>Kerbside of busy street</td></tr>
<tr><td>70</td><td>Loud stereo in living room</td></tr>
<tr><td>60</td><td>Office or restaurant with people present</td></tr>
<tr><td>50</td><td>Domestic fan heater at 1m</td></tr>
<tr><td>40</td><td>Living room (without TV, stereo, etc.)</td></tr>
<tr><td>30</td><td>Background noise in a theatre</td></tr>
<tr><td>20</td><td>Remote rural area on still night</td></tr>
<tr><td>10</td><td>Acoustic laboratory test chamber</td></tr>
<tr><td>0</td><td>Threshold of hearing</td></tr>
</table></td></tr>
<tr><td>L_1</td><td>The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.
Mathematically, the L_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB $L_{A1,15min}$ is a sound level of 87 dBA or higher for 1% of the 15 minute measurement period.</td></tr>
<tr><td>L_{10}</td><td>The L_{10} statistical level is often used as the “average maximum” level of a sound level that varies with time.
Mathematically, the L_{10} level is the sound level exceeded for 10% of the measurement duration. L_{10} is often used for road traffic noise assessment. As an example, 63 dB $L_{A10,18hr}$ is a sound level of 63 dBA or higher for 10% of the 18 hour measurement period.</td></tr>
<tr><td>L_{90}</td><td>The L_{90} statistical level is often used as the “average minimum” or “background” level of a sound level that varies with time.
Mathematically, L_{90} is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB $L_{A90,15min}$ is a sound level of 45 dBA or higher for 90% of the 15 minute measurement period.</td></tr>
<tr><td>L_{eq}</td><td>The ‘equivalent continuous sound level’, Leq, is used to describe the level of a time-varying sound or vibration measurement.
Leq is often used as the “average” level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dBA weighting is applied, the level is denoted dB LAeq. Often the measurement duration is quoted, thus LAeq,15 min represents the dBA weighted energy-average level of a 15 minute measurement.</td></tr>
</table>

Term	Definition
L_{max}	The Lmax statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time. Mathematically, Lmax is the highest value recorded during the measurement period. As an example, 94 dB LAmax is a highest value of 94 dBA during the measurement period. Since Lmax is often caused by an instantaneous event, Lmax levels often vary significantly between measurements.
Frequency	Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as "pitch". Sounds towards the lower end of the human hearing frequency range are perceived as "bass" or "low-pitched" and sounds with a higher frequency are perceived as "treble" or "high pitched".  

Term	Definition
Peak Particle Velocity (PPV)	Peak Particle Velocity (PPV) is the highest velocity of a particle (such as part of a building structure) as it vibrates. Most sound level meters measure *root mean squared* (RMS) values; it is common to approximate the PPV based on an RMS measurement. PPV is commonly used as a vibration criterion, and is often interpreted as a PPV based on the L_{max} or $L_{max,spec}$ index.
Sound Power and Sound Pressure	The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.
Vibration	Waves in a solid material are called "vibration", as opposed to similar waves in air, which are called "sound" or "noise". If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage. A vibrating structure (eg a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space. Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s^2) or else using a decibel scale.

Appendix B

Measurement Methodology and Results

B1 Noise monitoring

B1.1 Equipment

Unattended and attended monitoring was carried out using the following equipment:

Monitoring	Measurement location	Equipment/model	Serial No.	SLM Type
Unattended long-term	Meas. 1	Conducted by EMM		
	Meas. 2	Conducted by Cundall		
	Meas. 3	Ngara (ARL)	878 07f	Class 1
	Meas. 4	Ngara (ARL)	878 0D0	Class 1

Notes: All meters comply with AS IEC 61672.1 2004 “Electroacoustics - Sound Level Meters” and designated either Class 1 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Class 4231 calibrator. No significant drift in calibration was observed.

B1.2 Long-term unattended noise measurement results

Long-term noise monitoring was carried out from Thursday, 1 August 2019 to Sunday, 11 August 2019 by Arup, Tuesday, 18 June 2017 to Tuesday, 25 June 2017 by Cundall, and Thursday, 12 May 2016 to Tuesday, 24 May 2016 by EMM. Monitoring was conducted in accordance with Appendix B1 of the NPI [3]. The NPI separates the 24-hour day into three different time periods – day, evening and night, as detailed below in Table 28.

Table 28: Standard NPI time periods

Period	Day of Week	Time period
Day	Monday-Saturday Sunday, Public Holidays	7:00 am-6:00 pm 8:00 am-6:00 pm
Evening	Monday-Sunday	6:00 pm -10:00 pm
Night	Monday-Saturday Sunday, Public Holidays	10:00 pm -7:00 am 10:00 pm -8:00 am

The long-term noise level-vs-time graphs of the data are included in Appendix C.

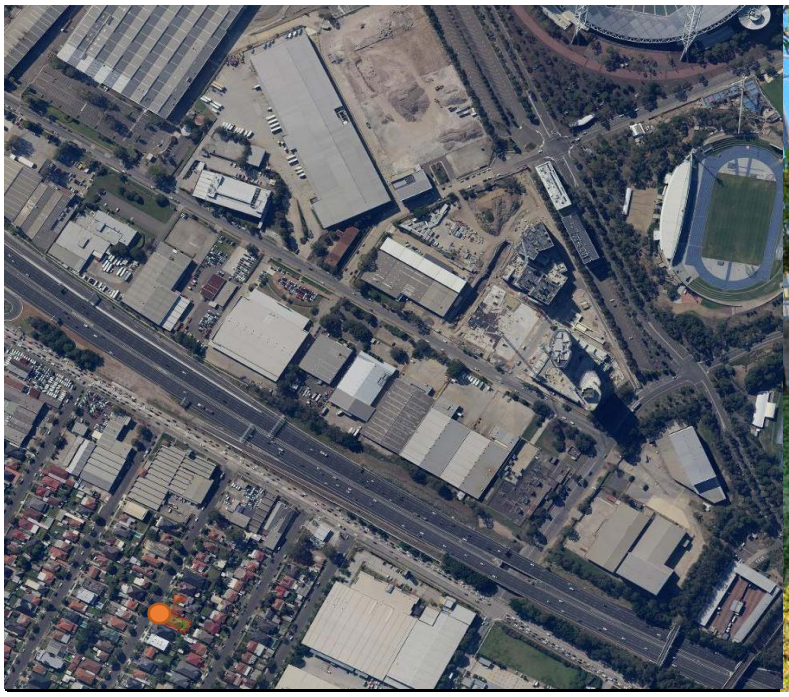
Appendix C

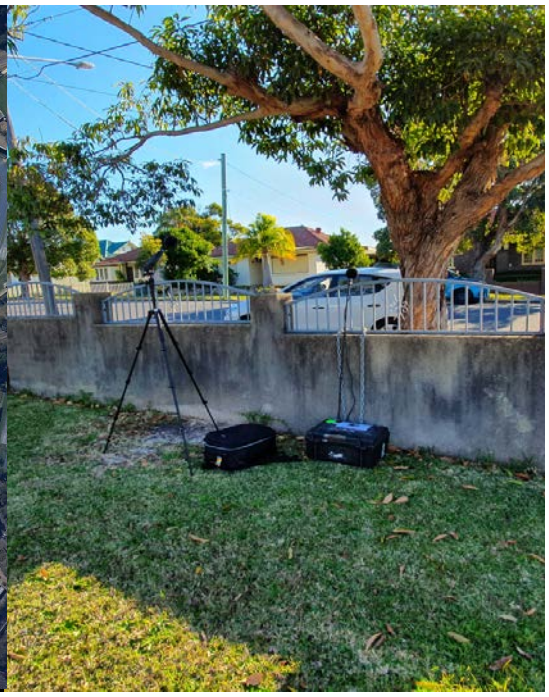
Long-term Noise Monitoring Graphs

ARUP

54 Ostend Street, Lidcombe (Free Field)

Additional detail:





Background and ambient noise monitoring results - NSW 'Industrial Noise Policy', 2000

	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Thursday-01-August-2019		46	38		56	51
Friday-02-August-2019	41	45	40	57	54	50
Saturday-03-August-2019	41	41	35	56	53	49
Sunday-04-August-2019	39	40	36	56	51	49
Monday-05-August-2019	42	44	39	62	54	52
Tuesday-06-August-2019	42	47	41	59	54	53
Wednesday-07-August-2019	39	47	42	59	54	55
Thursday-08-August-2019	47	45		58	55	
Friday-09-August-2019						
Representative Weekday[5]	**42**	**45**	**40**	**59**	**54**	**52**
Representative Weekend[5]	**40**	**40**	**36**	**56**	**52**	**49**
Representative Week[5]	**41**	**45**	**39**	**59**	**54**	**52**

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road / Rail noise monitoring results

	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
Date	**Day[1]**	**Night[2]**	**Day**	**Night**
Thursday-01-August-2019	56	51	57	56
Friday-02-August-2019	56	50	58	54
Saturday-03-August-2019	56	48	57	53

Sunday-04-August-2019	55	49	57	55
Monday-05-August-2019	61	52	62	57
Tuesday-06-August-2019	58	53	61	59
Wednesday-07-August-2019	58	55	58	63
Thursday-08-August-2019	58	51	60	53
Friday-09-August-2019				
Representative Weekday[3]	**58**	**52**	**60**	**58**
Representative Weekend[3]	**55**	**49**	**57**	**54**
Representative Week[3]	**58**	**52**	**59**	**58**

Notes:

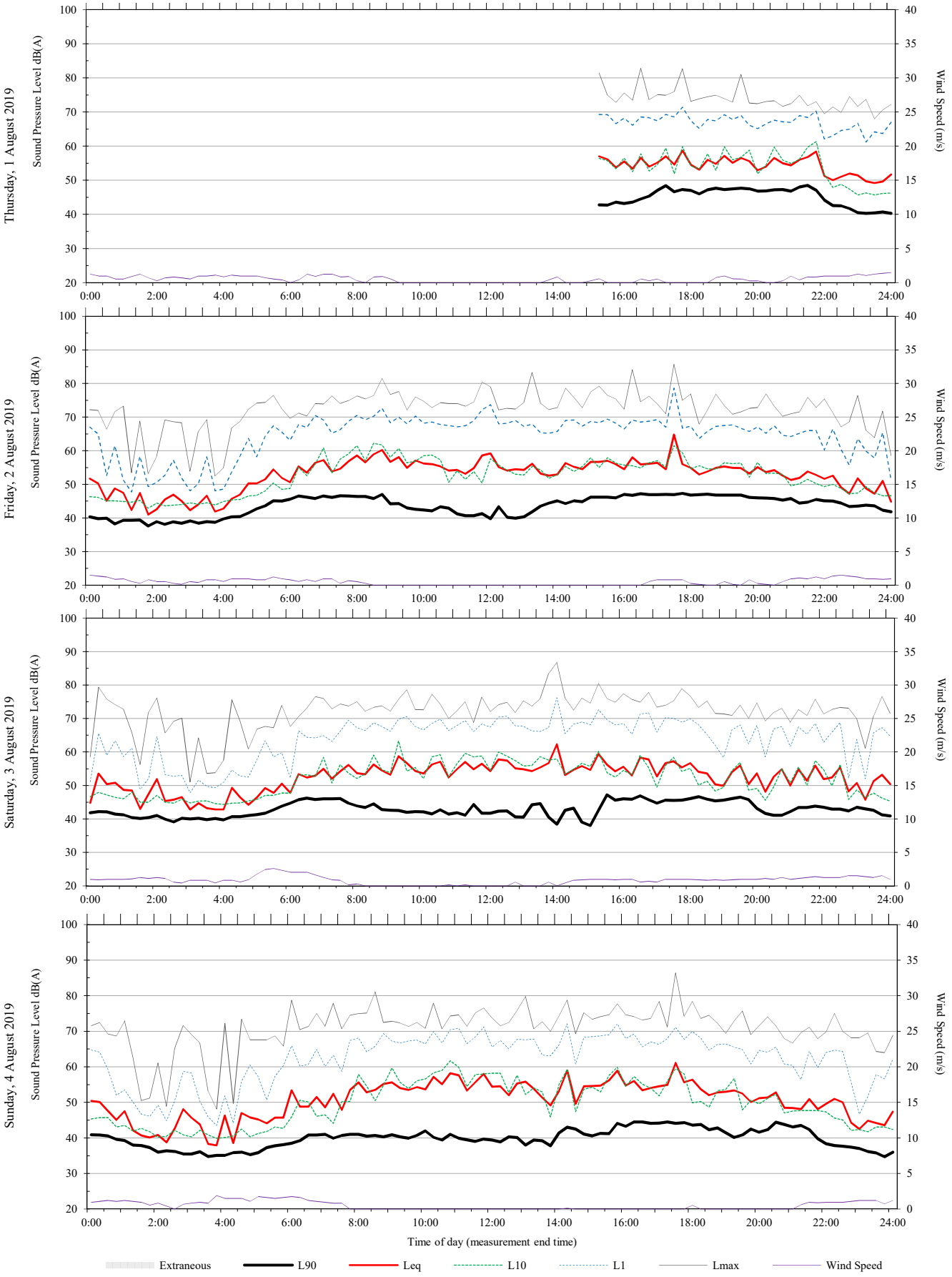
1. Day is 7:00am to 10:00pm

2. Night is 10:00pm to 7:00am

3. Logarithmic average of daily L_{Aeq}

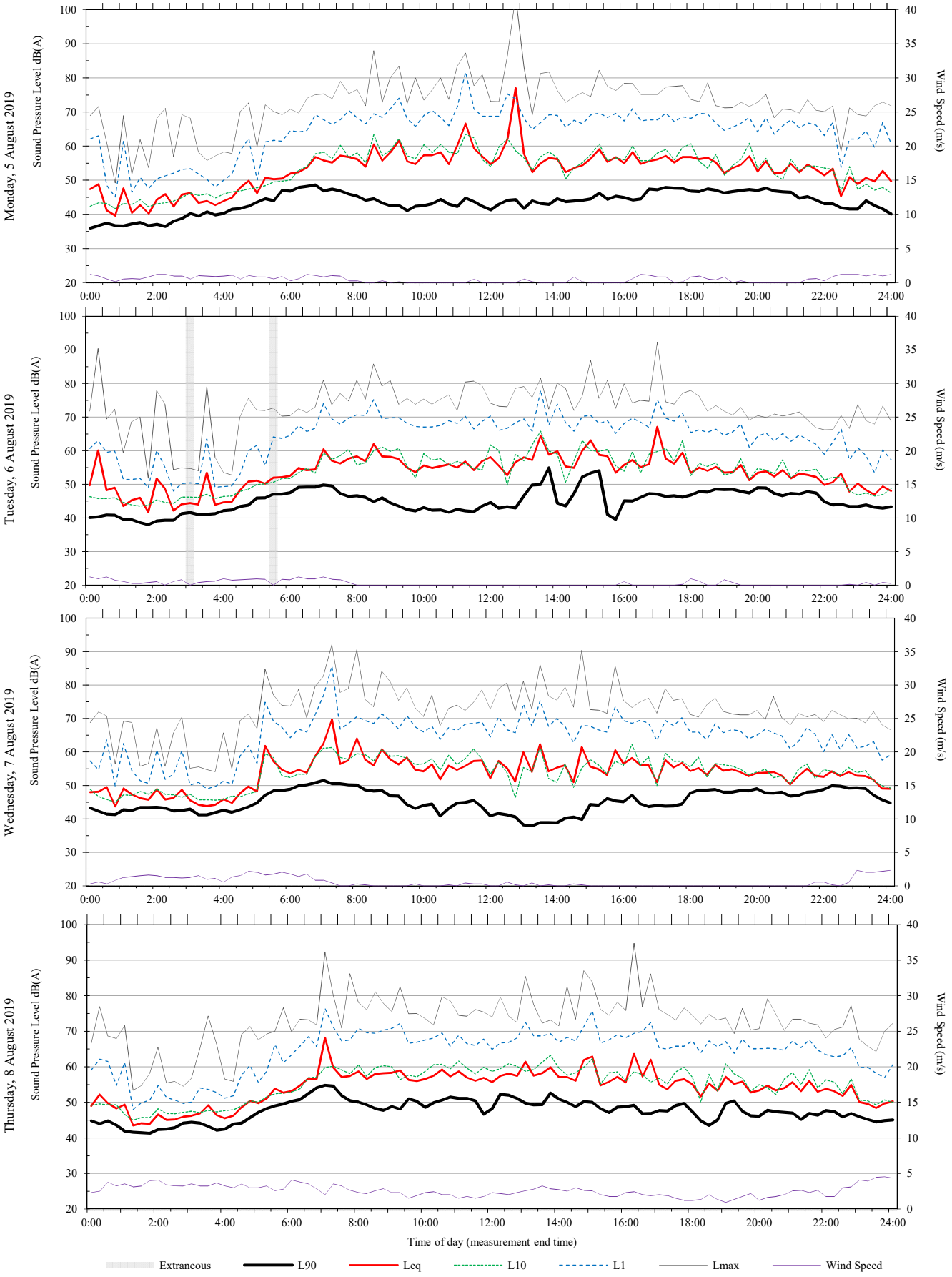
Unattended monitoring: 54 Ostend Street, Lidcombe (Free Field)

ARUP



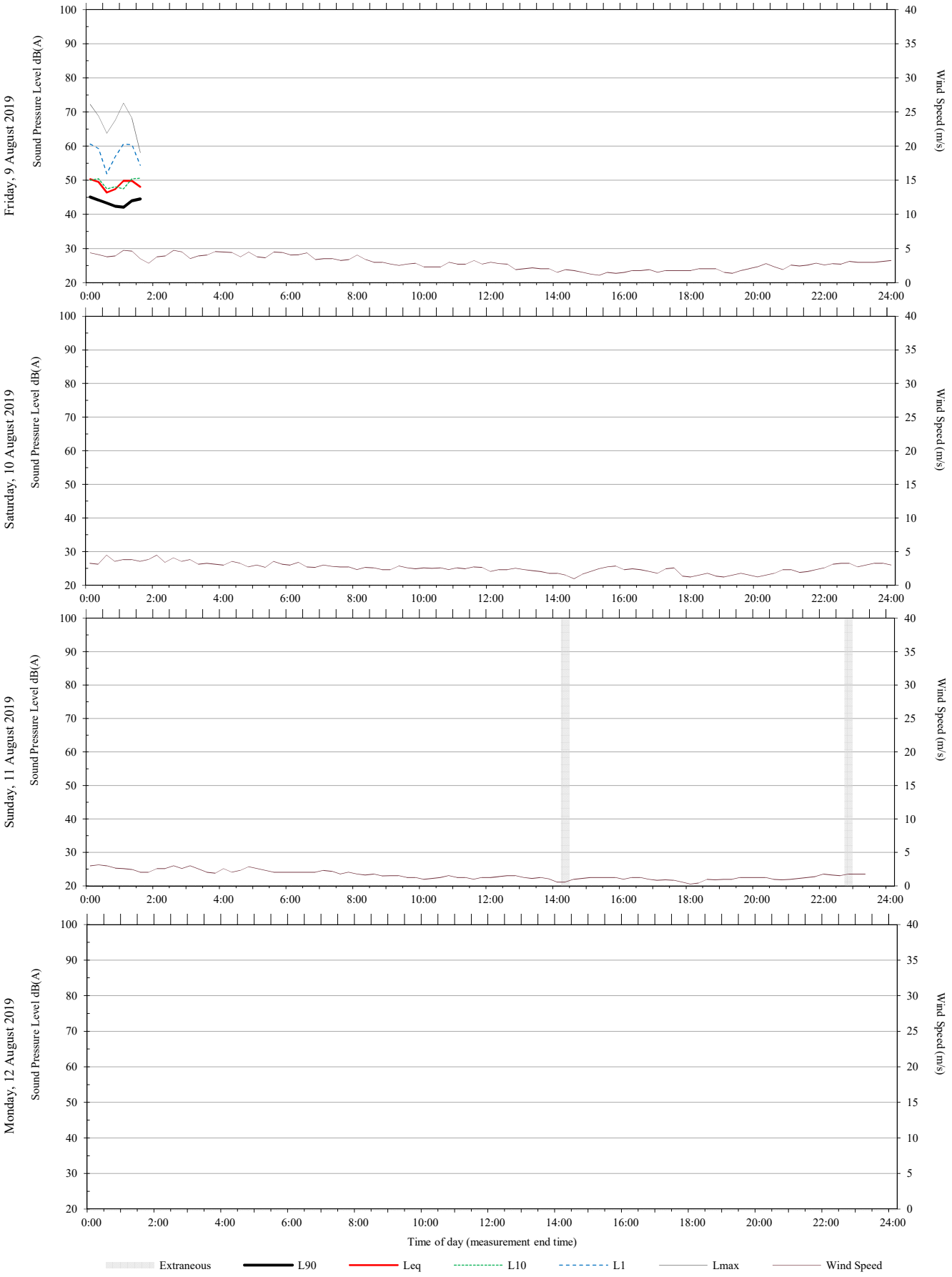
Unattended monitoring: 54 Ostend Street, Lidcombe (Free Field)

ARUP



Unattended monitoring: 54 Ostend Street, Lidcombe (Free Field)

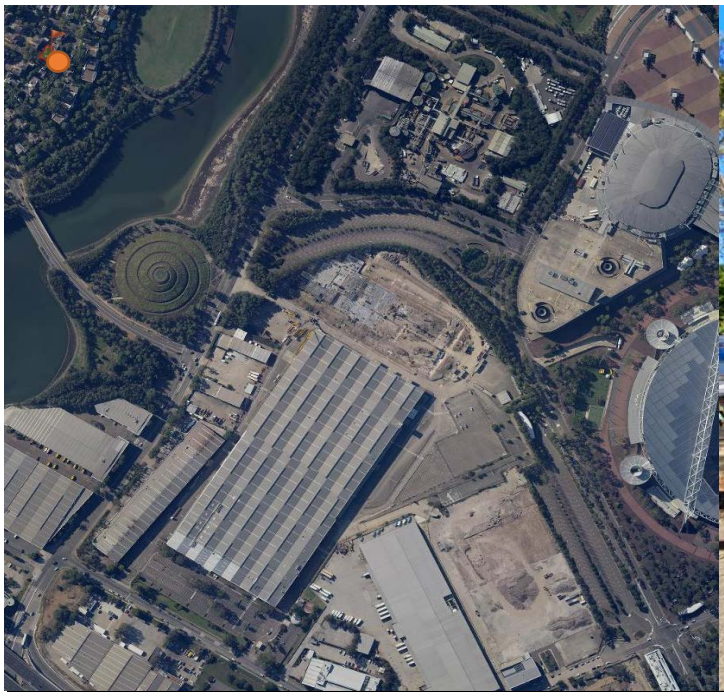
ARUP



ARUP

12 Devitt Avenue, Newington (Free Field)

Additional detail:



Background and ambient noise monitoring results - NSW 'Industrial Noise Policy', 2000

	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Thursday-01-August-2019		42	41		54	48
Friday-02-August-2019	42	42	41	57	47	47
Saturday-03-August-2019	41	43	38	53	50	48
Sunday-04-August-2019	41	39	38	57	49	47
Monday-05-August-2019	41	42	42	59	50	49
Tuesday-06-August-2019	40	44	43	57	51	50
Wednesday-07-August-2019	42	45	44	58	51	51
Thursday-08-August-2019	47	45	41	58	53	51
Friday-09-August-2019	49	45	39	61	54	49
Saturday-10-August-2019	47	45	39	59	53	49
Sunday-11-August-2019	45	43	40	55	53	49
Monday-12-August-2019						
Representative Weekday[5]	**42**	**44**	**41**	**59**	**52**	**49**
Representative Weekend[5]	**43**	**43**	**39**	**57**	**52**	**48**
Representative Week[5]	**42**	**43**	**41**	**58**	**52**	**49**

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road / Rail noise monitoring results

	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
Date	**Day[1]**	**Night[2]**	**Day**	**Night**

Thursday-01-August-2019	59	48	65	56
Friday-02-August-2019	56	47	59	54
Saturday-03-August-2019	53	47	55	52
Sunday-04-August-2019	56	47	58	54
Monday-05-August-2019	58	49	61	54
Tuesday-06-August-2019	56	50	58	55
Wednesday-07-August-2019	57	51	56	57
Thursday-08-August-2019	58	51	60	56
Friday-09-August-2019	60	49	62	54
Saturday-10-August-2019	58	48	0	55
Sunday-11-August-2019	55	49	57	55
Monday-12-August-2019	58		62	
Representative Weekday[3]	**58**	**49**	**61**	**55**
Representative Weekend[3]	**56**	**48**	**55**	**54**
Representative Week[3]	**57**	**49**	**60**	**55**

Notes:

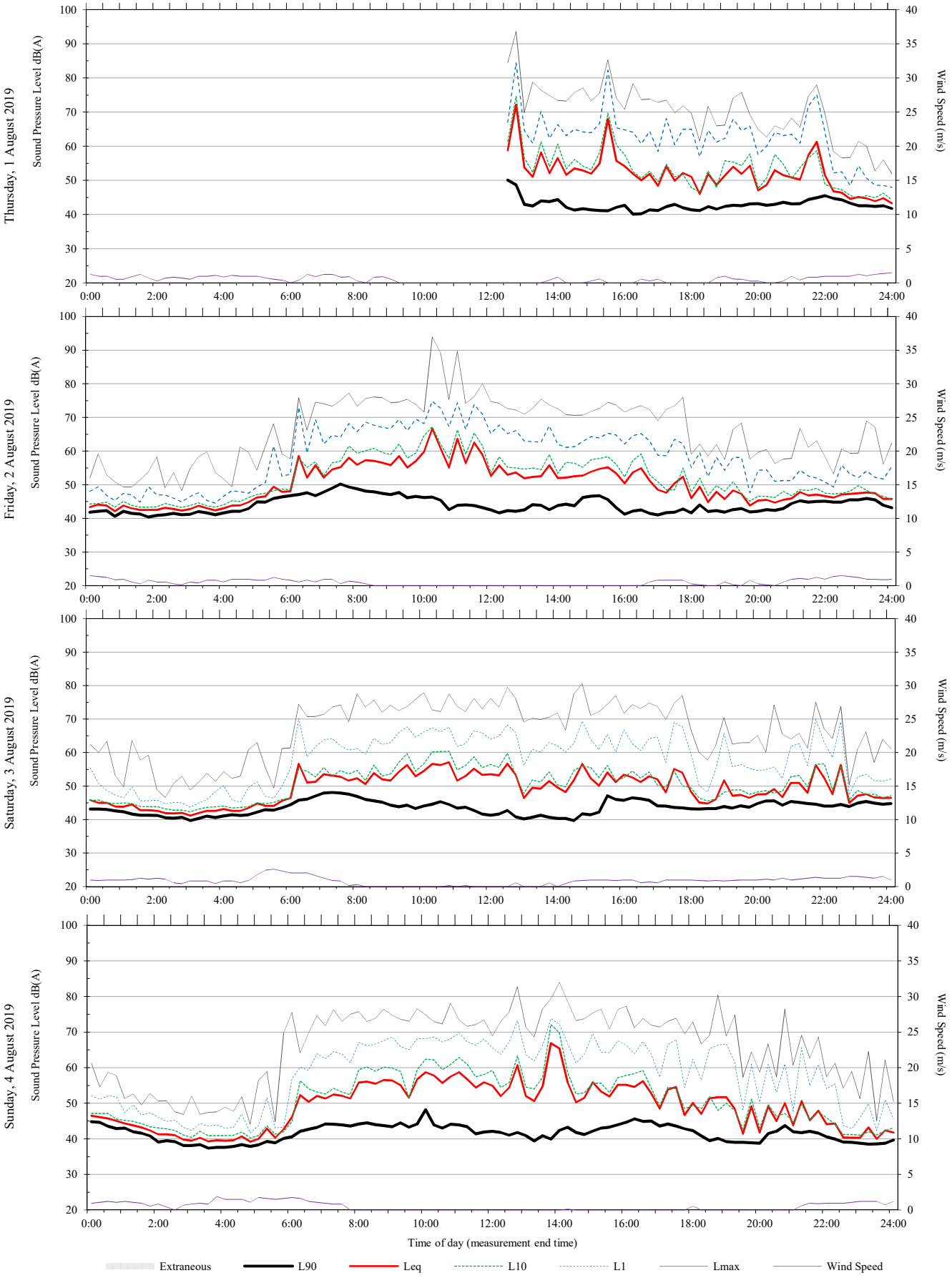
1. Day is 7:00am to 10:00pm

2. Night is 10:00pm to 7:00am

3. Logarithmic average of daily L_{Aeq}

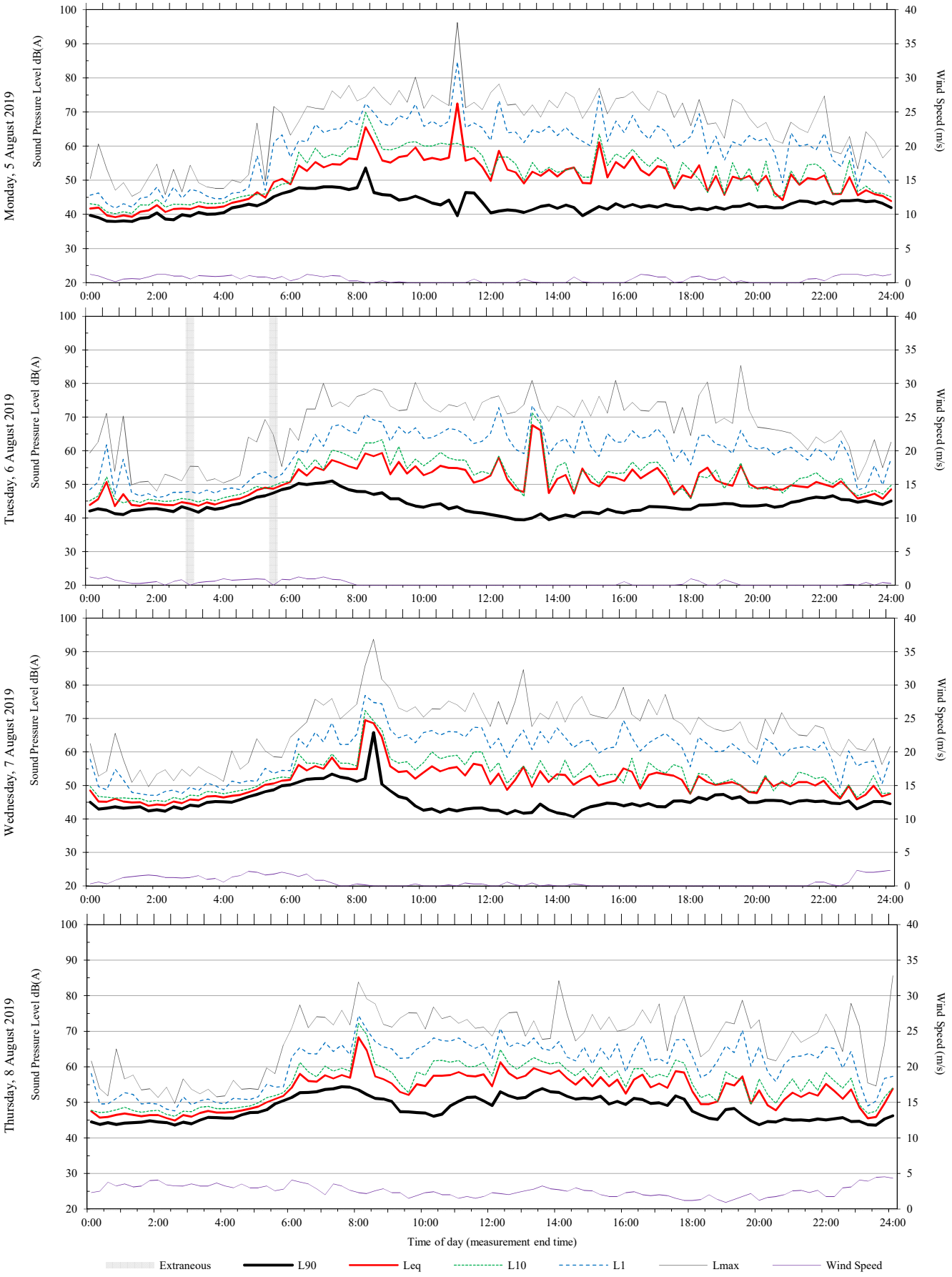
Unattended monitoring: 12 Devitt Avenue, Newington (Free Field)

ARUP



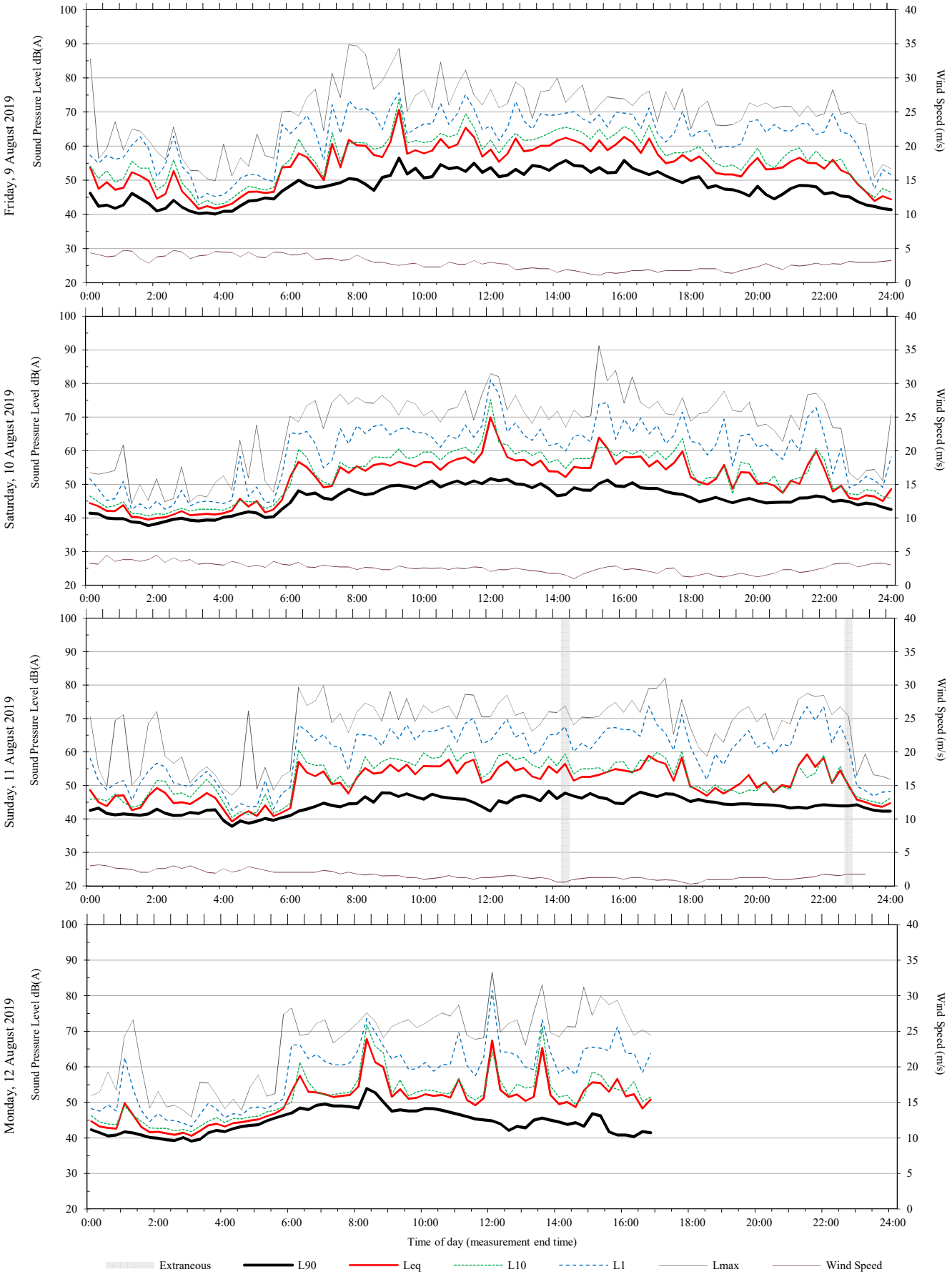
Unattended monitoring: 12 Devitt Avenue, Newington (Free Field)

ARUP



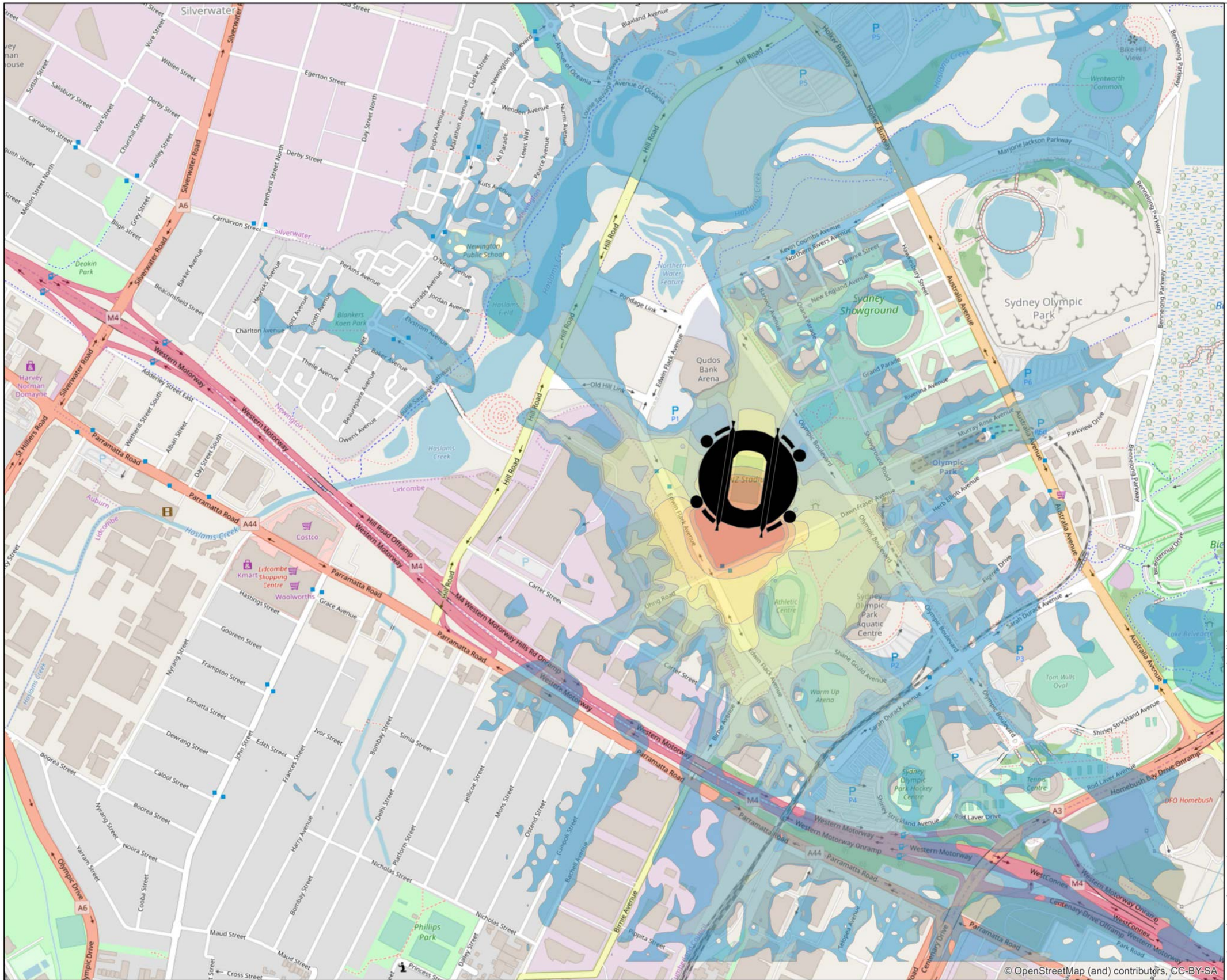
Unattended monitoring: 12 Devitt Avenue, Newington (Free Field)

ARUP



Appendix D

Construction Noise Contour Maps



Legend

Object

- Existing Stadium

Sound Pressure Level dBL$_{Aeq(15min)}$

- 40
- 45
- 50
- 55
- 60
- 65
- 70
- 75
- 80
- 85

Issue	Date	By	Chkd	Appd
D1	23/08/2019	TGM	MS	MS

Metres

0 100 200 300 400

ARUP

Level 5. 151 Clarence Street
Sydney, NSW 2000
Tel +61 (2) 9320 9320
www.arup.com

Client

Infrastructure NSW

Job Title

Stadium Australia Redevelopment

Drawing Title

Demolition Noise Contours - Southern Works

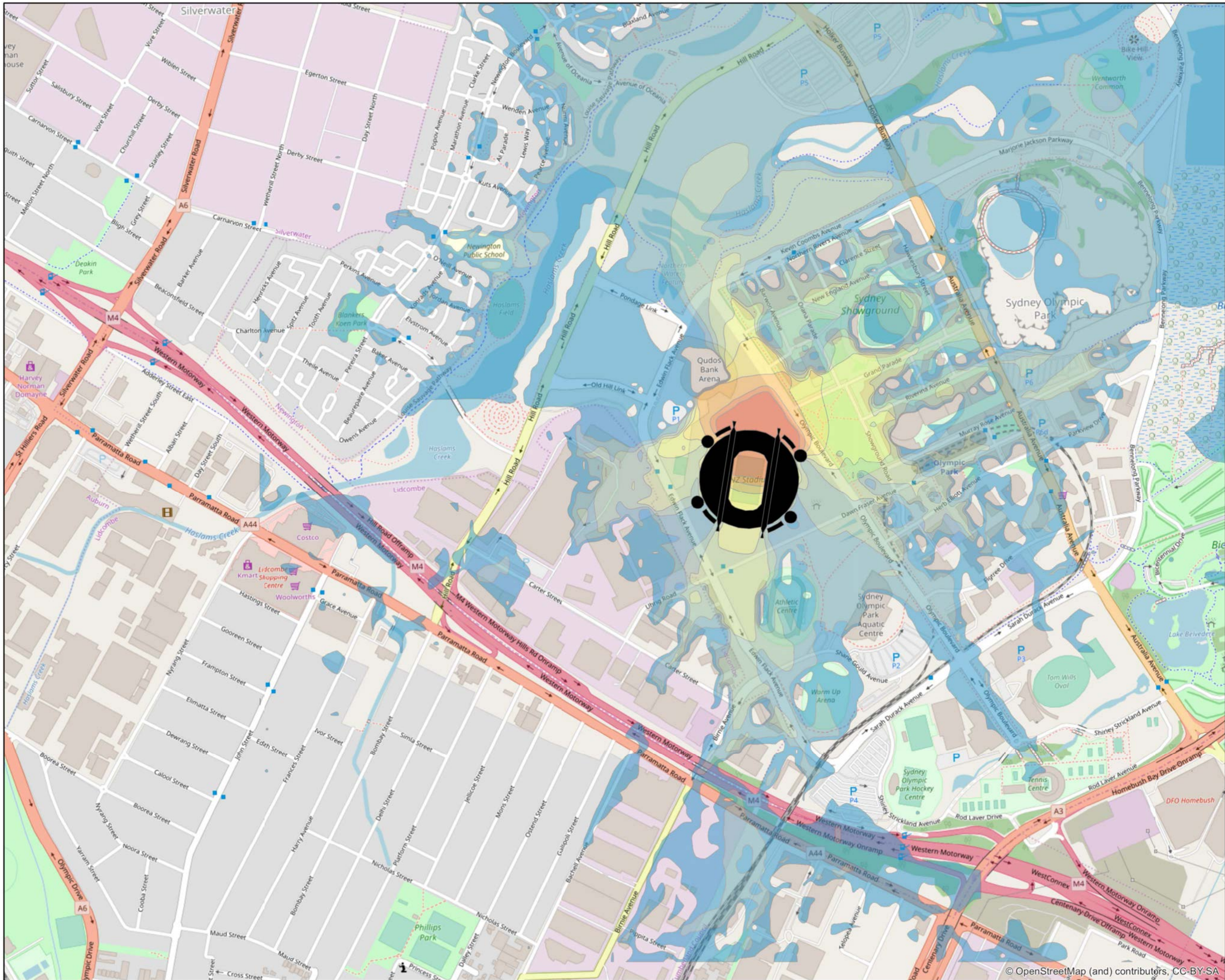
Scale at A3	Drawing Status
1:10,000	**Draft**

Coordinate System

GDA 1994 MGA Zone 56

Job No	Drawing No
270719-00	**001**

J:\270000\270719-00 ANZ Stadium Acoustic\Work\Internal\4_GIS\2_MXDs\ANZ Stadium_Contour Maps.mxd



Legend

Object

Existing Stadium

Sound Pressure Level dBL$_{Aeq(15min)}$

- 40
- 45
- 50
- 55
- 60
- 65
- 70
- 75
- 80
- 85

D1	23/08/2019	TGM	MS	MS
Issue	Date	By	Chkd	Appd

Metres
0 100 200 300 400

ARUP

Level 5, 151 Clarence Street
Sydney, NSW 2000
Tel +61 (2) 9320 9320
www.arup.com

Client
Infrastructure NSW

Job Title
Stadium Australia Redevelopment

Drawing Title
Demolition Noise Contours - Northern Works

Scale at A3
1:10,000

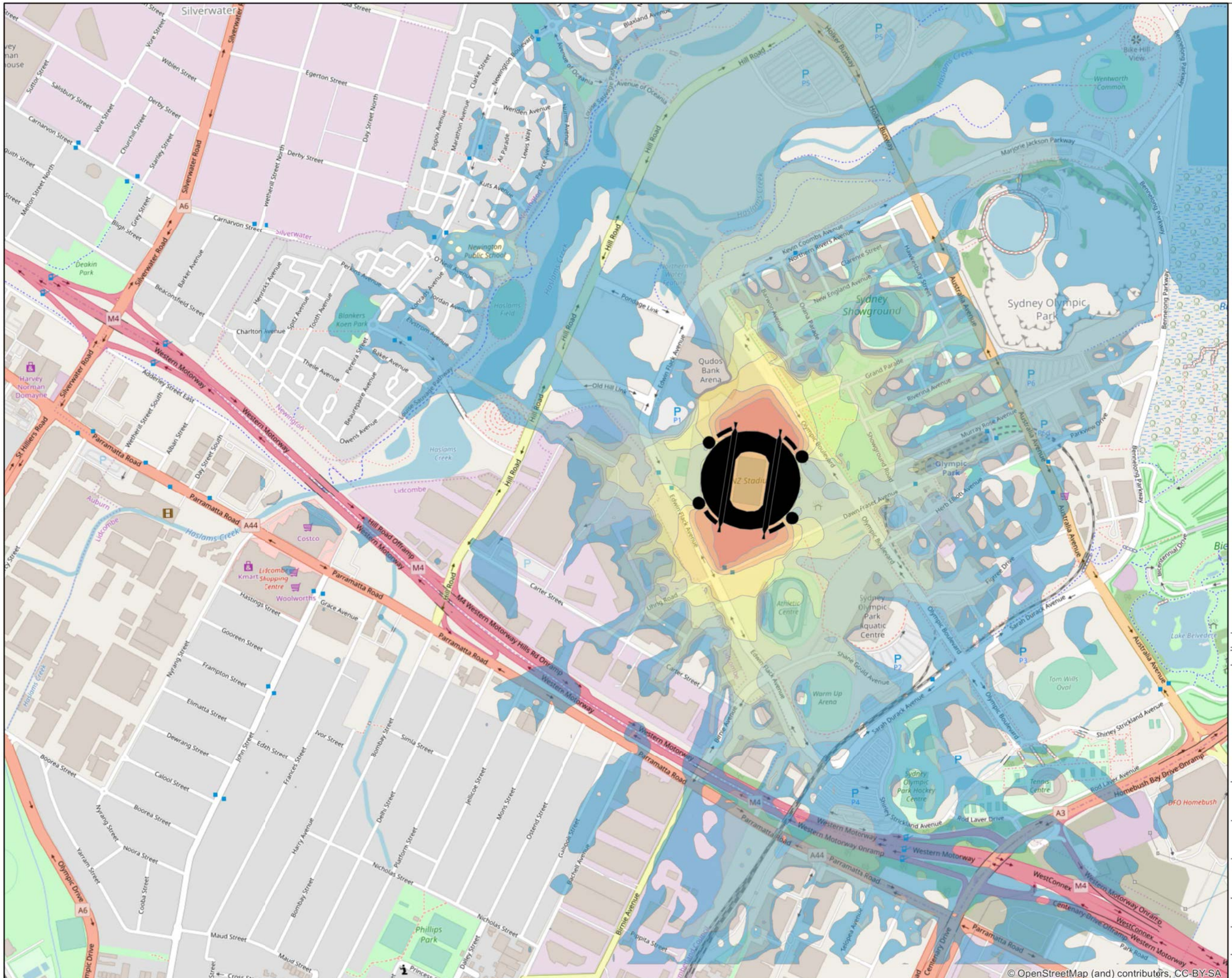
Drawing Status
Draft

Coordinate System
GDA 1994 MGA Zone 56

Job No
270719-00

Drawing No
001

J:\270000\270719-00 ANZ Stadium Acoustic\Work\Internal\4_GIS\2_MXDs\ANZ Stadium_Contour Maps.mxd



Legend

Object

Existing Stadium

Sound Pressure Level dBL$_{Aeq(15min)}$

- 40
- 45
- 50
- 55
- 60
- 65
- 70
- 75
- 80
- 85

Issue	Date	By	Chkd	Appd
D1	23/08/2019	TGM	MS	MS

Metres

0 100 200 300 400

ARUP

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Client

Infrastructure NSW

Job Title

Stadium Australia Redevelopment

Drawing Title

Demolition Noise Contours - Concurrent North and South Works

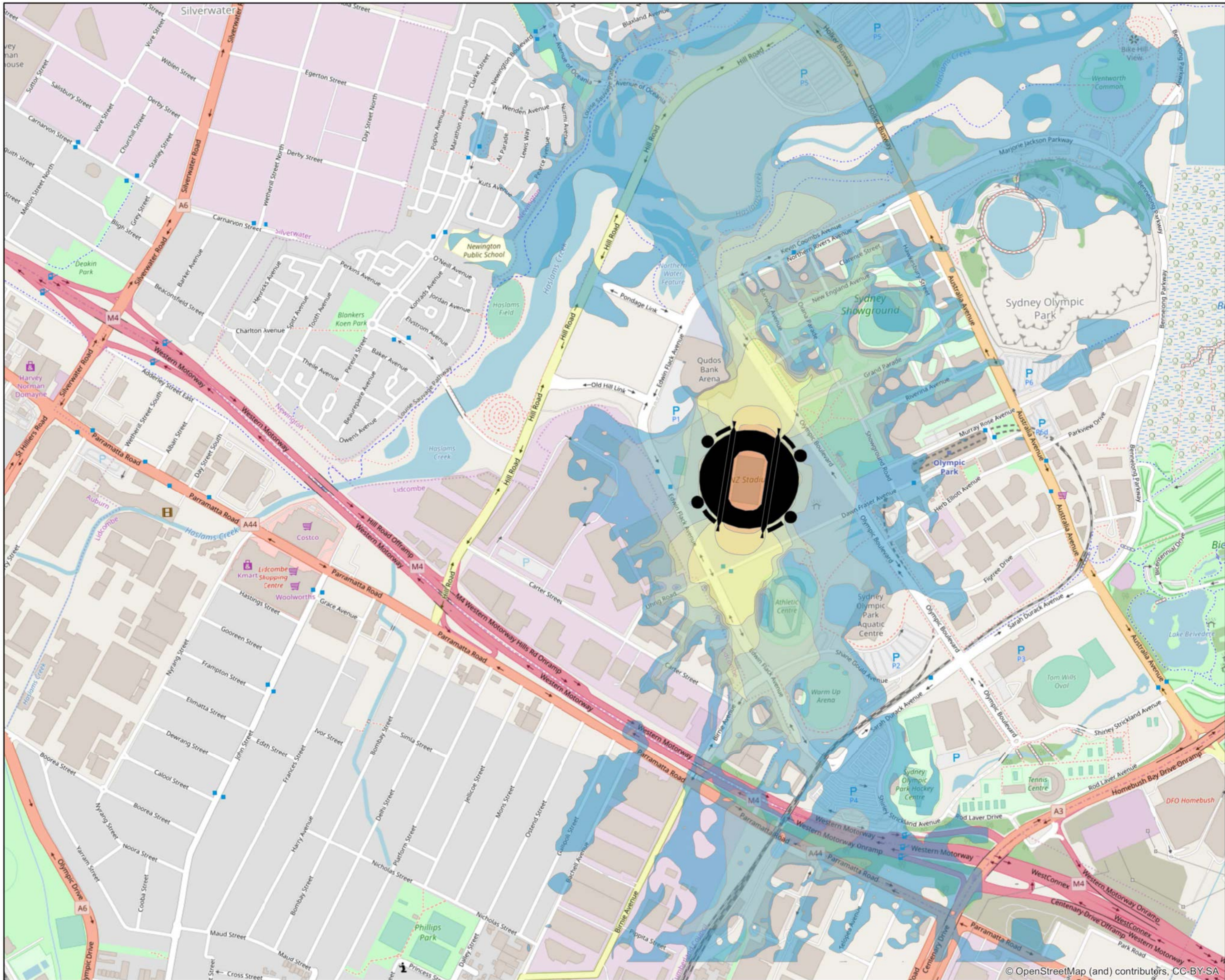
Scale at A3	Drawing Status
1:10,000	**Draft**

Coordinate System

GDA 1994 MGA Zone 56

Job No	Drawing No
270719-00	**001**

J:\270000\270719-00 ANZ Stadium Acoustic\Work\Internal\4_GIS\2_MXDs\ANZ Stadium_Contour Maps.mxd



Legend

Object

Existing Stadium

Sound Pressure Level dBL$_{Aeq(15min)}$

- 40
- 45
- 50
- 55
- 60
- 65
- 70
- 75
- 80
- 85

D1	23/08/2019	TGM	MS	MS
Issue	Date	By	Chkd	Appd

Metres

0 100 200 300 400

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Client
Infrastructure NSW

Job Title
Stadium Australia Redevelopment

Drawing Title
ConstructionNoise Contours - Stadium Works

Scale at A3
1:10,000

Drawing Status
Draft

Coordinate System
GDA 1994 MGA Zone 56

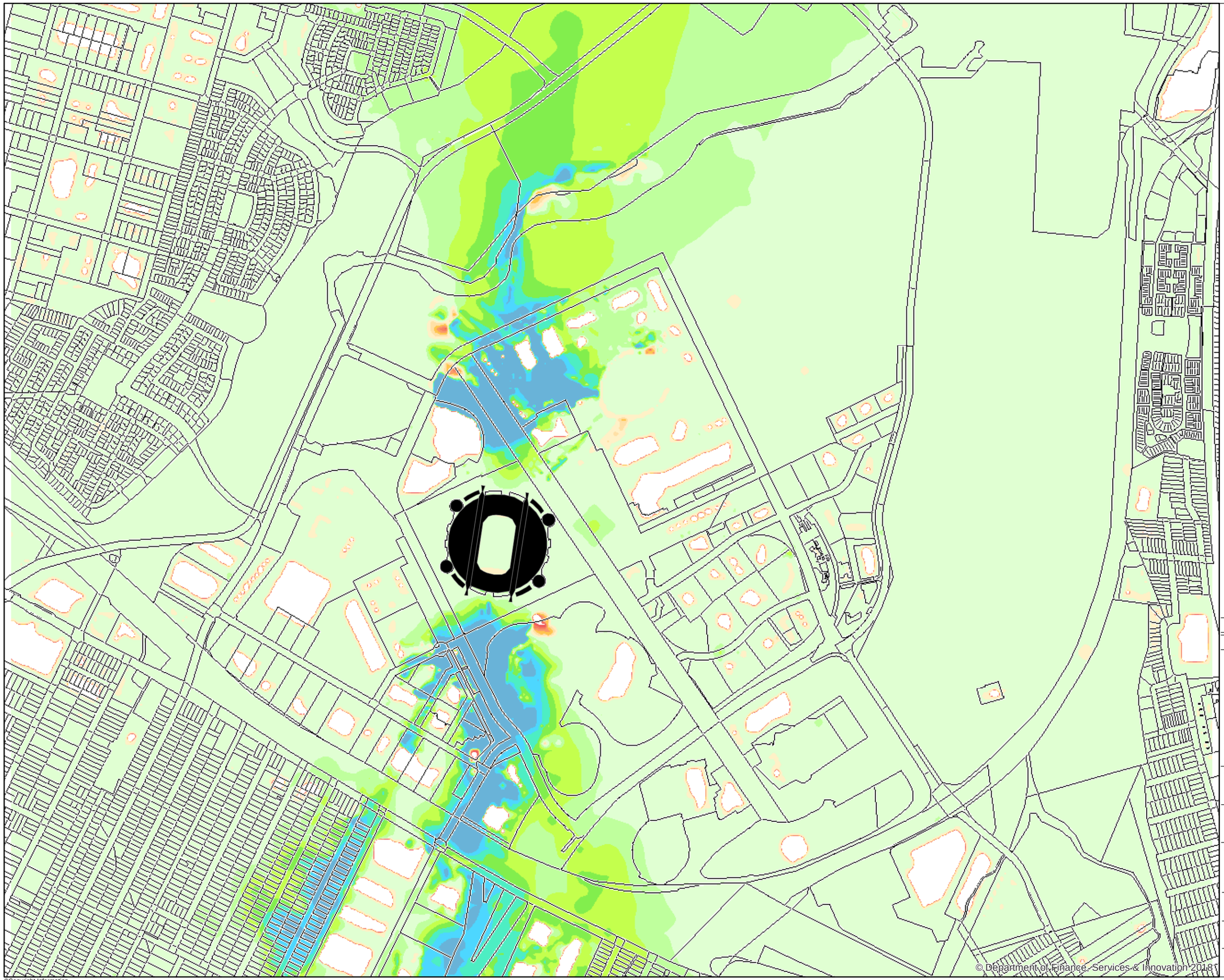
Job No
270719-00

Drawing No
001

J:\270000\270719-00 ANZ Stadium Acoustic\Work\Internal\4_GIS\2_MXDs\ANZ Stadium_Contour Maps.mxd

Appendix E

Event Noise Difference Contour Maps



Legend

Object

Existing Stadium

Event Noise Decrease (dB)

6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6

Issue	Date	By	Chkd	Appd
D1	2/09/2019	TGM	MS	MS

Metres

0 100 200 300 400

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Client

Infrastructure NSW

Job Title

Stadium Australia Redevelopment

Drawing Title

Event Noise Contours - Existing minus Proposed Concert Event

Scale at A3	Drawing Status
1:10,000	**Issue**

Coordinate System

GDA 1994 MGA Zone 56

Job No	Drawing No
270719-00	**001**

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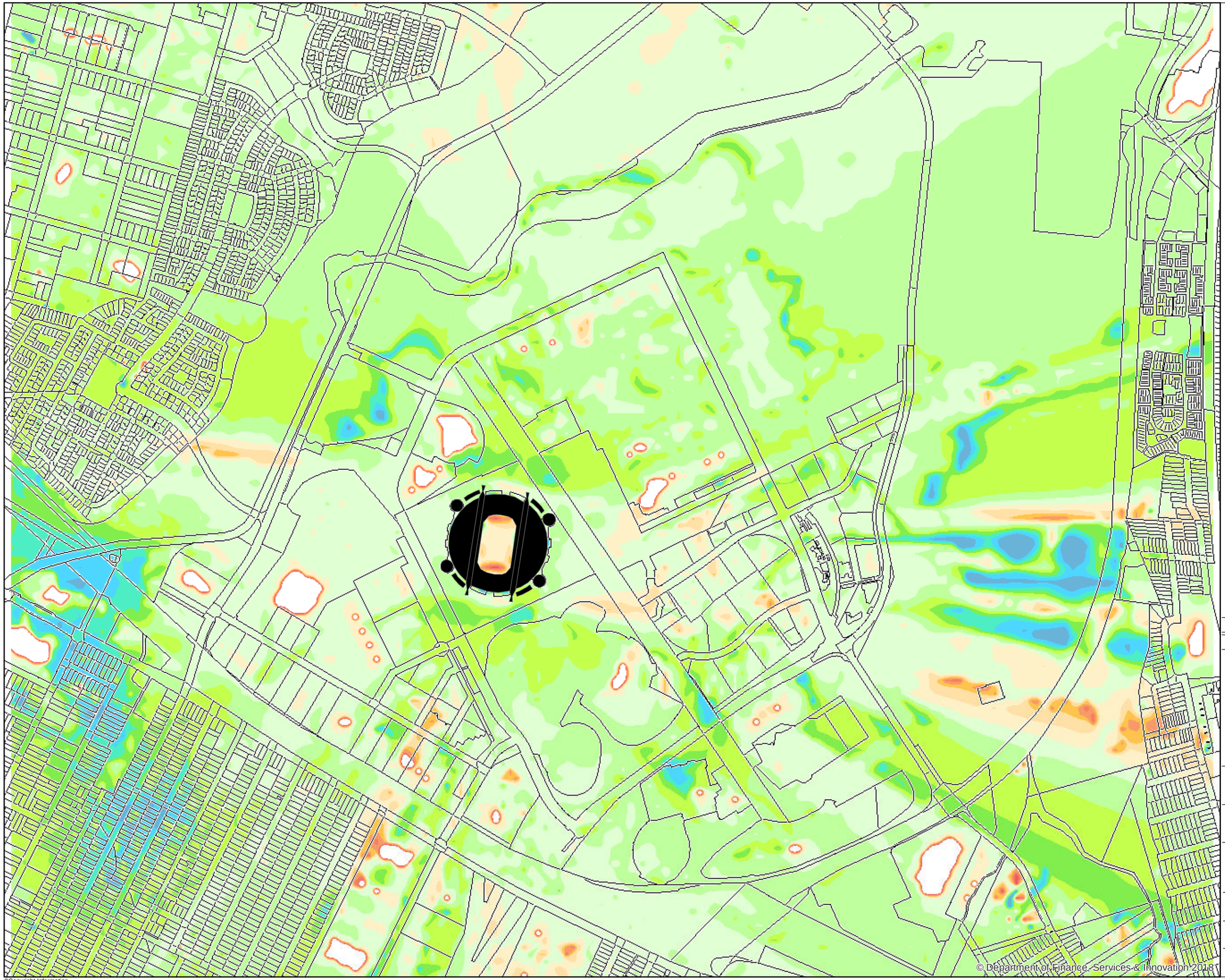

Legend

Object

Existing Stadium

Event Noise Decrease (dB)

6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6

Issue	Date	By	Chkd	Appd
D1	2/09/2019	TGM	MS	MS

Metres

0 100 200 300 400

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Client

Infrastructure NSW

Job Title

Stadium Australia Redevelopment

Drawing Title

Event Noise Contours - Existing minus Proposed Sports Event

Scale at A3	Drawing Status
1:10,000	**Issue**

Coordinate System

GDA 1994 MGA Zone 56

Job No	Drawing No
270719-00	**001**

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