Transport
Roads & Maritime
Services

ADDITIONAL CROSSING OF THE CLARENCE RIVER AT GRAFTON

Appendix F – Technical Paper: Noise and vibration assessment

AUGUST 2014

Contents

Appendices

1 Introduction

Roads and Maritime Services (Roads and Maritime) is seeking approval for a new bridge over the Clarence River at Grafton (the project).

The project involves constructing a new bridge linking Grafton and South Grafton about 70 metres downstream of the existing bridge, and upgrading parts of the road network in Grafton and South Grafton to connect the new bridge to the existing road network.

Arup has been engaged by Roads and Maritime to undertake an assessment of the noise and vibration impacts associated with the construction and operation of the project.

The project is being assessed under Part 5.1 of the *Environmental Planning and Assessment Act 1979*. The Director General's Requirements (DGRs) for the project that relate to noise and vibration are as follows:

Noise and Vibration – *including but not limited to:*

- *An assessment of the noise impacts of the project during operation, consistent with the Road Noise Policy (Environment Protection Authority, 2011). The assessment must include specific consideration of impacts to receivers (dwellings, child care centres, educational establishments, hospitals, motels, nursing homes, or places of worship), as relevant and identify reasonable and feasible mitigation measures;*
- *An assessment of construction noise and vibration impacts, consistent with the Interim Construction Noise Guideline (Department of Environment, Climate Change and Water, 2009) and Assessing Vibration: a technical guideline (Department of Environment and Conservation, 2006).*

This noise and vibration assessment supports the environmental impact statement (EIS) for the project and provides an assessment of the noise and vibration impacts from the construction and operation of the Project. It also provides an assessment of feasible and reasonable noise and vibration mitigation measures.

A summary of acoustic terminology is provided in Appendix A.

2 Project description

The main components of the Grafton Bridge project are:

- Construction of a new bridge over the Clarence River about 70 metres downstream (east) of the existing road and rail bridge, comprising two traffic lanes.
- Construction of a new road to link the new bridge with Iolanthe Street in South Grafton.
- Construction of a new road to link the new bridge with Pound Street in Grafton.
- An approach viaduct, about 64 metres long, on the South Grafton side of the Clarence River and 29 metres long on the Grafton side.
- Upgrades to the road network in South Grafton to connect the new bridge to the existing road network, including:
  - Widening Iolanthe Street to four lanes
  - Widening the Gwydir Highway to four lanes between Bent Street and the Pacific Highway
  - Realigning the existing Pacific Highway to join Iolanthe Street near Through Street
  - Providing a new roundabout at the intersection of the Pacific Highway and Gwydir Highway
  - Providing a new roundabout at the intersection of Through Street and Iolanthe Street
  - Limiting Spring Street and the Old Pacific Highway to left in and left out only where they meet Iolanthe Street
  - Realigning Butters Lane.
- Upgrades to the road network in Grafton to connect the new bridge to the existing road network, including:
  - Widening Pound Street to four lanes between Villiers Street and the approach to the new bridge
  - Providing traffic signals at the intersection at Pound Street and Clarence Street
  - Closing Kent Street where it is crossed by the bridge approach road
  - Realigning and lowering Greaves Street beneath the new bridge
  - Realigning Bridge Street to join directly to the southern part of Pound Street (east of the new bridge approach). There would be no direct connection between Pound Street south and the new bridge approach
  - Widening Clarence Street to provide formal car park spaces
  - Minor modifications to the existing Dobie Street and Villiers Street roundabout.
- Replacement of the existing three span concrete arch rail viaduct which crosses Pound Street in Grafton with a single span steel truss bridge.

- Construction of a pedestrian and cycle path to provide connectivity between Grafton, South Grafton and the new bridge.
- Provision of two signalised pedestrian crossings in South Grafton to improve safety for pedestrians crossing Iolanthe Street and Gwydir Highway.
- Construction of new pedestrian links to connect the new bridge with the existing bridge.
- Provision of designated car park spaces in Pound Street and Clarence Street, including some off street parking, to maintain a similar number of existing car park spaces currently available in those two street.
- Flood mitigation works, which include raising the height of sections of the existing levee upstream from the new bridge in Grafton and South Grafton.
- Construction of a stormwater detention basin and pump station in Grafton to manage local flooding.
- Public utilities adjustment.
- Ancillary facilities required for the construction of the project, including some or all of the following: site compounds, concrete batching plant, pre-cast facilities, and stockpile areas for materials and temporary storage of spoil and mulch.

3 Existing ambient noise and vibration environment

There are a range of ambient noise environments in the Grafton area including rural and urban environments depending on proximity to the town centres. The main contributors to ambient noise in the Grafton area are:

- Road traffic noise, including heavy vehicles, along the main arterial roads in and around Grafton
- General road traffic in and around the city centre
- Passenger and freight rail activity along the Northern Railway Line
- Rural industry and machinery
- Local insect and animal noise.

3.1 Noise sensitive land uses relevant to the project

Residential and non-residential noise sensitive land uses relevant to the project are presented in Figure 1 and Figure 2.

The majority of receivers relevant to the project are residential with a small number of non-residential open space and educational (TAFE and Aboriginal pre-school) land uses adjacent to the project area.

Typical land use characteristics within each noise catchment area are shown in Table 1.

Table 1: Typical land use characteristics within each noise catchment area (NCA)

Noise Catchment Area	Typical land uses within catchment
NCA 1	This area is predominantly commercial and industrial with a few residential single storey detached dwellings.
NCA 2	This is a residential area consisting predominantly of single storey and high-set detached dwellings and aged care facilities.
NCA 3	This area is a mixture of residential single storey and high-set detached dwellings and an area owned by the Catholic Church consisting of some two storey buildings used for a range of purposes such as education, places of worship and residential.
NCA 4	This area is largely made up of the TAFE and residential single storey and high-set detached dwellings.
NCA 5	This is a residential area consisting predominantly of single storey and high-set detached dwellings and the Gummyaney Pre-School.
NCA 6	This is a residential area consisting predominantly of single storey and high-set detached dwellings.
NCA 7	This area is predominantly rural with a few isolated residential dwellings.
NCA 8	This area is a mixture of rural land, commercial properties such as a petrol station and public open spaces.

Noise Catchment Area	Typical land uses within catchment
NCA 9	This area is a mixture of residential single storey and high-set detached dwellings, the main South Grafton commercial precinct, other commercial and industrial areas and rural land.
NCA 10	This area is predominantly rural with a few isolated residential dwellings.
NCA 11	This area is predominantly rural with a few isolated residential dwellings. It also includes part of Junction Hill which is predominantly residential.
NCA 12	This area is a mixture of residential single storey and high-set detached dwellings, some industrial areas and the Grafton racecourse.
NCA 13	This area is a mixture of residential single storey and high-set detached dwellings, the main Grafton commercial precinct, the TAFE and an area owned by the Catholic Church consisting of two storey buildings used for a range of purposes such as education, places of worship and residential.
NCA 14	This is a residential area consisting predominantly of single storey and high-set detached dwellings.

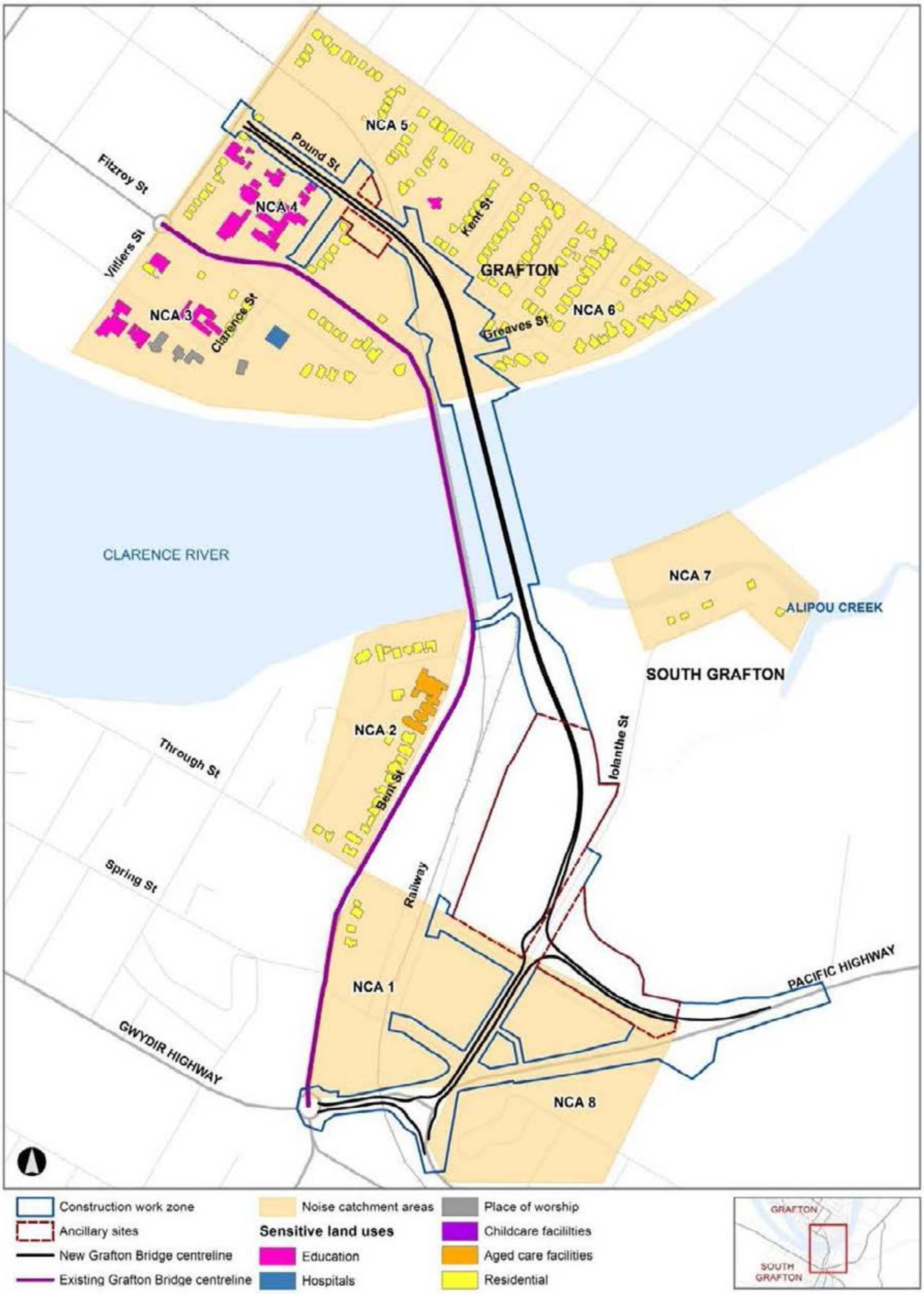

Figure 1: Noise sensitive land uses relevant to the project

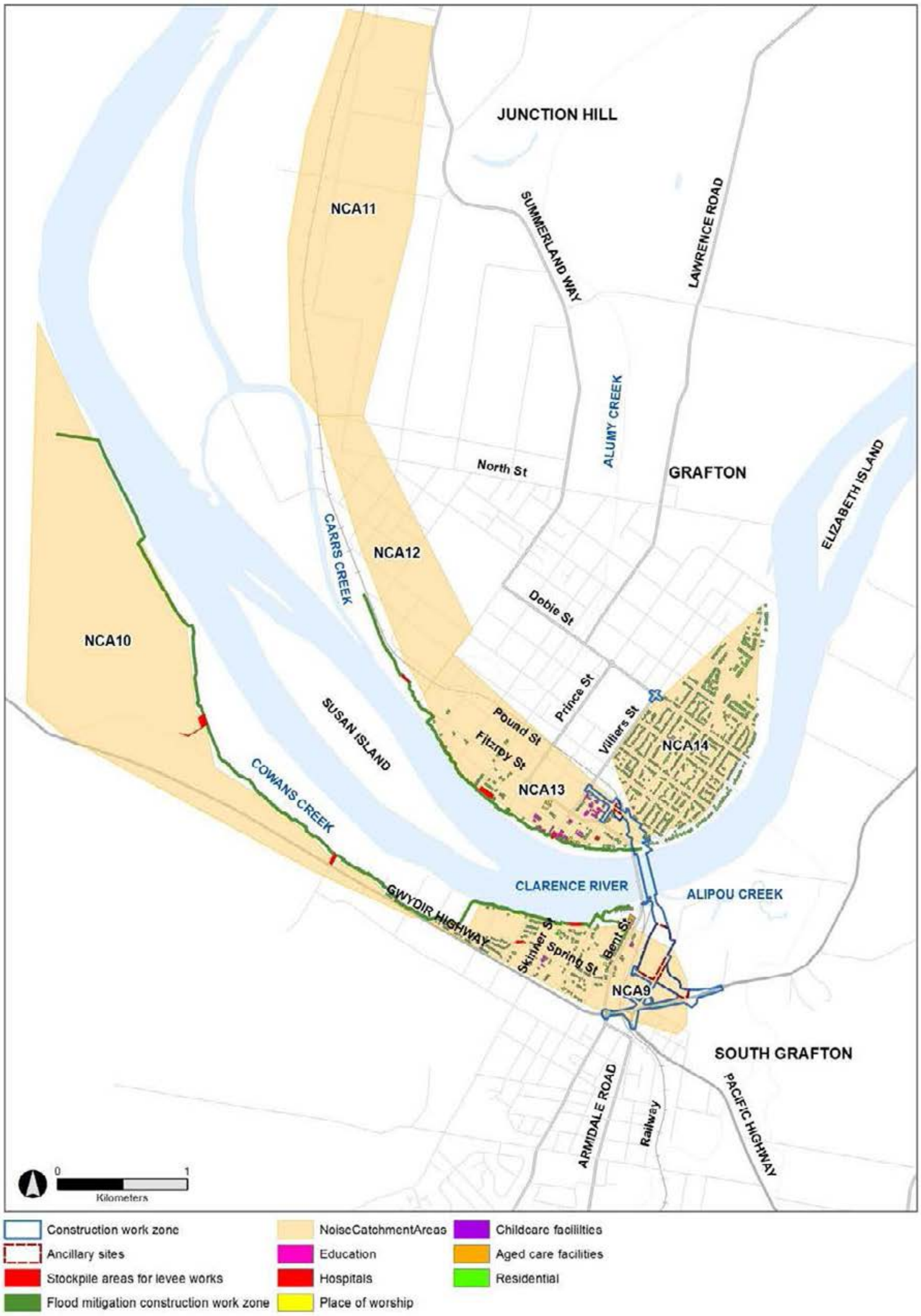

Figure 2: Noise sensitive land uses relevant to the project – flood mitigation works

3.2 Noise surveys

An extensive noise survey of the Grafton area was undertaken in order to benchmark the existing acoustic environment. This survey incorporates noise data collected during various stages of the project in 2010, 2011 and 2013 and is discussed further in the following sections. A map showing the noise monitoring locations is provided in Figure 3, with further details provided in Appendix B.

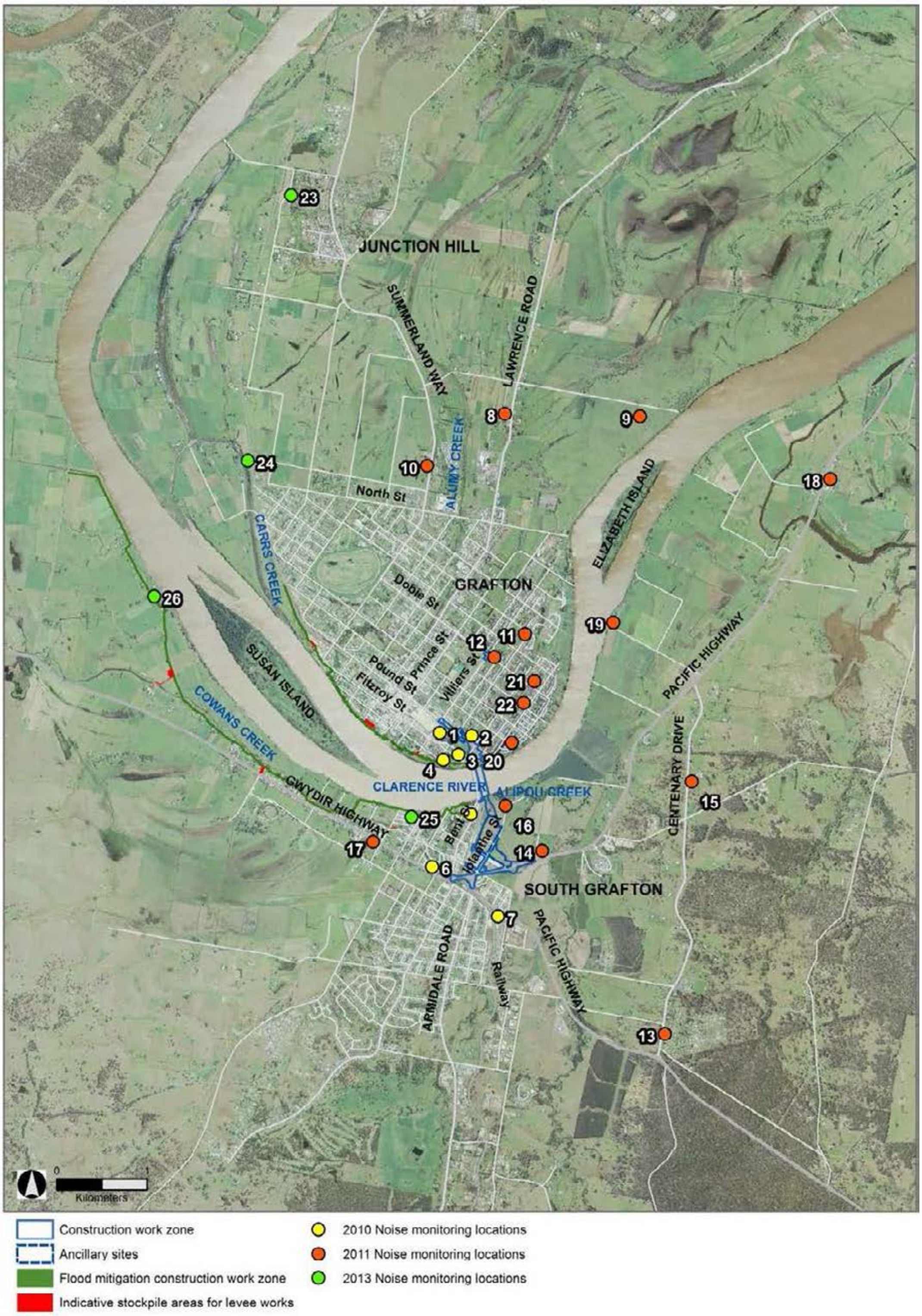

Figure 3: Noise monitoring locations

3.2.1 August 2010 survey

A noise survey was conducted by Arup between Monday 9 and Thursday 19 August 2010. Noise monitoring during this survey was concentrated in the areas near to the existing bridge. The noise levels measured during this survey were validated against the road traffic data obtained at the time.

3.2.2 September 2011 survey

Additional noise monitoring was undertaken by Arup from Thursday 15 September to Wednesday 21 September, 2011 for the wider Grafton area to supplement the August 2010 survey. The noise survey areas were selected based on the different characteristic acoustic environments that exist in the Grafton and South Grafton areas.

The following representative locations were selected for noise monitoring:

- 'Rural' ambient noise environment: characterised as being remote from urban centres and existing road traffic noise.
- 'Urban' ambient noise environment: characterised by proximity to the town centre. Expected to have local traffic flows with low percentage of heavy vehicles.
- Existing arterial road noise affected: locations aligning existing arterial roads. Expected to have a higher percentage of heavy vehicles than local roads.

Based on this methodology, a total of 15 noise monitoring locations were selected, to supplement the data collected in 2010.

3.2.3 October 2013 survey

Additional noise logging was undertaken from Thursday 17 October to Friday 25 October 2013 by Arup at 4 locations upstream of the existing bridge. The purpose of this monitoring was to quantify the existing ambient noise environment at locations where construction noise impacts from the raising of the levee may be experienced.

3.2.4 Unattended noise monitoring

3.2.4.1 Noise monitoring locations

A total of 26 locations were used for unattended noise monitoring. Noise loggers were placed at a height of 1.5 m above the ground at the receiver locations. Wherever appropriate and possible, noise loggers were located within 1 m of the building facade, in accordance with best practice and RMS guidelines[1].

[1] RMS Procedure: Preparing an Operational Traffic and Construction Noise and Vibration Assessment Report – July 2011

A brief description of each logger location along with site photographs identifying the noise logger position is provided in Appendix B.

3.2.4.2 Instrumentation

Equipment used for the continuous unattended noise surveys included RTA Technology Type 1 Noise Loggers and ARL Ngara and EL-31X Type 1 noise loggers carrying current calibration certificates. Details of logger types and serial numbers can be found below in Table 1.

Calibration of the loggers was checked prior to and following measurements using a Brüel & Kjær Sound Level Calibrator Type 4231 with no significant drift in calibration being recorded. The sample time interval was set at 15 minutes and the meter time constant set to "Fast".

Table 2: Unattended noise logger locations, types and serial numbers

	Reference Location	Address	Logger Type	Serial Number
2010 Noise Survey	1	Villiers Street, near TAFE, Grafton	RTA-04	008
	2	Gummyaney Pre-School, 30 Pound Street, Grafton	RTA-02	050
	3	8 Fitzroy Street, Grafton	RTA-04	010
	4	St. Mary's Church, Clarence Street	EL-316	15-299-419
	5	12 Bent Street, Grafton Aged Care Home, South Grafton	EL-315	15-299-422
	6	8 Beatson Street, South Grafton	RTA-04	009
	7	España Hotel, Schwinghammer Street, South Grafton	RTA-02	049
2011 Noise Survey	8	245 Lawrence Road, Great Marlow	RTA -02	050
	9	86 Great Marlow Road, Great Marlow	RTA -02	049
	10	591 Summerland Way, Carrs Creek	RTA -02	009
	11	Cnr Hoof and Clarence Streets, Grafton	Ngara	87809E
	12	94 Dobie Street, Grafton	RTA -04	010
	13	81 Edward Ogilvie Drive, Clarenza	Ngara	87802E
	14	Pacific Highway near Alipou Creek	Ngara	87807F
	15	326 Centenary Drive, Clarenza	Ngara	878079
	16	Cnr Iolanthe Street & Butters Lane, South Grafton	Ngara	878060
	17	146-148 Ryan Street, South Grafton	Ngara	878000
	18	5 School Drive, Swan Creek	Ngara	878080
	19	Riverbank at end of Meona Lane, off Pacific Highway.	Ngara	878007
	20*	4 Bacon Street, Grafton	RTA -02	035
	21*	40 Dobie Street, Grafton	RTA -02	016

	Reference Location	Address	Logger Type	Serial Number
	22*	22 Fry Street, Grafton	Ngara	878061
2013 Noise Survey	23	320 Back Lane, Junction Hill	RTA-04	008
	24*	235 Carr Street, Grafton	Ngara	878107
	25	98 Through Street, South Grafton	RTA-04	010
	26	Maclennan's Lane, Waterview	Ngara	8780D1

*4 of the noise loggers were omitted from the noise study due to either of the following:

- Noise Logger failure (i.e. no data being recorded); or
- Significant amounts of spurious data being recorded across the entire measurement period.

3.2.4.3 Weather data

Continuous weather data was obtained from the Bureau of Meteorology's (BOM) nearby weather stations at Grafton Airport and Grafton Agricultural Research Station. This data was reviewed to identify periods of adverse weather during the unattended noise logging surveys. Adverse weather has the potential to influence recorded noise levels and provide inaccurate results.

Where appropriate, periods of high winds and/or rain were excluded from the analysis. Other extraneous noise events were also excluded from the analysis as required (e.g. farm machinery, local animal noise).

3.2.4.4 Road traffic counts

Road traffic counts were undertaken by Austraffic at the noise logging locations aligning the existing road corridors. Traffic counts were conducted concurrently with noise logging throughout the entire noise monitoring period, with the exception of the 2013 measurements which were undertaken for the assessment of the levee construction works. Traffic modelling parameters are discussed further in Section 6.2.

The traffic data was recorded to correlate measured ambient noise data with the expected contribution from road traffic based on recorded traffic volumes. This validation process is discussed further in Section 6.4.

3.2.4.5 Noise logging results

The unattended noise logging results were processed in accordance with the:

- NSW Road Noise Policy[2] (RNP)
- NSW Industrial Noise Policy[3] (INP)

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[2] NSW Department of Environment Climate Change & Water – *NSW Road Noise Policy* (July 2011)
[3] NSW Environment Protection Authority – *Industrial Noise Policy* (Jan 2000)

These processed results were used as the basis for deriving noise criteria for the project in Section 4 of this report. A summary of processed measured noise levels for each logger location is provided in Table 2.

Instances where logger data returned erroneous or spurious results have been identified and omitted from the data presented. It should be noted that this process was done separately to derive appropriate road traffic and ambient background noise criteria.

Attended noise measurements were used in favour of unattended noise logging data to derive road traffic noise levels where it was deemed on-site that other significant ambient noise sources extraneous to road traffic noise impacts would be measured. These instances are marked with an asterisk in Table 2.

For the noise logger location of the Gummyaney Pre School, 30 Pound Street, attended measurements were used instead of noise logger data because of the logger's close proximity to the train line passing through Grafton. The train line is a significant noise source that is not modelled. An attended measurement that did not capture train noise was used to calibrate the model at this location.

For the noise logger location of 8 Fitzroy Street an attended measurement was used instead of noise logger data. This is due to the logger's close proximity to the residence's kitchen and a number of dogs and birds kept on the property, all of which would have produced significant noise that has not been modelled.

For the noise logger location at the TAFE, Fitzroy Street, attended measurements on Villiers Street within line of sight of the TAFE noise logger were used instead of noise logger data. This was due to the shielded position of the noise logger on the TAFE premises.

Instances of noise logger battery failure or malfunction are marked with a dash.

24 hour graphs of measured acoustic metrics are also provided for reference in Appendix C for the entire monitoring period.

Table 3: Unattended noise logger results

	Reference Location	Address	Measured Noise Level (dB)							
			Road Traffic Noise		Ambient Background Noise					
			Day-time average	Night-time average	Day-time 0700-1800		Evening 1800-2200		Night-time 2200-0700	
			$L_{Aeq, 15 hour}$	$L_{Aeq, 9 hour}$	$L_{Aeq(period)}$	RBL	$L_{Aeq(period)}$	RBL	$L_{Aeq(period)}$	RBL
2010 Noise Survey	1	Villiers Street, near TAFE, Grafton	66*	58*	55	48	51	42	48	35
	2	Gummyaney Pre School, 30 Pound Street, Grafton	53*	43	55	44	54	39	54	35
	3	8 Fitzroy Street, Grafton	59*	53	61	53	61	41	53	31
	4	St. Mary's Church, Clarence Street, Grafton	53	47	54	46	50	43	48	32
	5	12 Bent Street, Grafton Aged Care Home, South Grafton	68	59	66	59	63	46	60	36
	6	8 Beatson Street, South Grafton	56	49	56	45	52	39	49	32
	7	España Hotel, Schwinghammer Street, South Grafton	66	66	66	53	67	46	66	42
2011 Noise Survey	8	245 Lawrence Road, Great Marlow	58	51	59	38	56	36	51	34
	9	86 Great Marlow Road, Great Marlow	66	45	67	30	50	32	45	31
	10	591 Summerland Way, Carrs Creek	65	59	65	44	61	34	59	28
	11	Cnr Hoof and Clarence Streets, Grafton	49	45	50	35	47	35	45	32
	12	94 Dobie Street, Grafton	58	51	-	-	-	-	-	-
	13	81 Edward Ogilvie Drive, Clarenza	60	56	60	43	58	42	56	35
	14	Pacific Highway near Alipou Creek	71	70	71	49	71	48	70	41
	15	326 Centenary Drive, Clarenza	50	49	50	33	49	35	33	36
	16	Cnr Iolanthe Street & Butters Lane,	52	49	53	39	49	42	49	37

	Reference Location	Address	Measured Noise Level (dB)							
			Road Traffic Noise		Ambient Background Noise					
			Day-time average $L_{Aeq, 15 hour}$	Night-time average $L_{Aeq, 9 hour}$	Day-time 0700-1800		Evening 1800-2200		Night-time 2200-0700	
					$L_{Aeq(period)}$	RBL	$L_{Aeq(period)}$	RBL	$L_{Aeq(period)}$	RBL
		South Grafton								
	17	146-148 Ryan Street, South Grafton	63	56	64	45	60	40	56	29
	18	5 School Drive, Swan Creek	69	68	69	43	69	42	68	32
	19	Riverbank at end of Meona Lane, off Pacific Highway.	64	47	66	35	46	38	47	35
	20	4 Bacon Street, Grafton	-	-	72	37	76	39	76	34
	21	40 Dobie Street, Grafton	-	-	57	35	-	-	-	-
	22	22 Fry Street, Grafton	-	-	-	-	-	-	-	-
2013 Noise Survey	23	320 Back Lane, Junction Hill	-	-	50	29	52	36	52	35
	24	235 Carr Street, Grafton	-	-	-	-	-	-	-	-
	25	98 Through Street, South Grafton	-	-	55	40	54	37	48	34
	26	Maclennan's Lane, Waterview	-	-	54	30	66	41	47	37

* Fifteen minute attended measurements employed

It should be noted that the ambient noise levels measured at locations 23 and 26, which are rural locations, were observed to be quieter during the day than the evening and night periods. This is not uncommon for rural locations, however it has potential ramifications on the criteria derived.

3.2.5 Attended noise measurements

Operator attended noise monitoring was also conducted at each noise logger location during both the day and night-time periods. This was undertaken to record more detailed spectral noise data that assists in observing and analysing the prevailing ambient noise environment. Noise spectrum measurements break the overall noise level down into its individual frequency components, this assists in identifying the different types of noise sources within a measurement. For example, an aeroplane fly over is dominated by low frequency noise and may appear different to a train passing by or mechanical machinery.

A summary of measured noise spectra is provided in Appendix D. Comments on the noise environment at each measurement location are provided in Appendix B.

3.3 Existing vibration

There are no significant existing sources of vibration affecting the project area, and vibration levels from existing traffic is well below levels that are either perceptible to humans or could potentially cause damage to sensitive structures. Therefore no detailed vibration survey has been undertaken.

4 Assessment criteria

Noise and vibration assessment criteria for highway developments are addressed in a range of policies and standards, and apply to both the construction stage and operation of the highway.

Noise from the construction stage of the project is required to be addressed in accordance with the NSW Interim Construction Noise Guideline (ICNG), while vibration from construction works will be assessed against the NSW DECs Assessing Vibration guideline and various national and international standards.

The primary operational noise assessment criteria are provided in the NSW Road Noise Policy[2] (RNP). These assessment criteria are used to identify receivers where noise mitigation should be considered. In considering whether noise mitigation at the assessment locations is feasible and reasonable, the RTA Environmental Noise Management Manual[4] (ENMM) provides additional guidance.

In addition, since the project will include the replacement of the Pound Street railway viaduct in Grafton, it is also necessary to consider the potential for changes to operational railway noise. Guidelines for railway noise assessment criteria are provided in the NSW Rail Infrastructure Noise Guideline[5] (RING).

Noise from fixed infrastructure, such as the proposed pumping station to manage local flooding, is required to be addressed in accordance with the NSW Industrial Noise Policy[3] (INP).

The various noise and vibration assessment criteria are explained in more detail below.

4.1 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 3. Noise levels apply at the worst affected property boundary of the residence, at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residences, the noise levels apply at the most noise-affected point within 30 m of the residence.

[4] NSW Road Traffic Authority – *Environmental Noise Management Manual* (Dec 2001)
[5] NSW Environment Protection Authority – *Rail Infrastructure Noise Guideline* (May 2013)

Table 4: ICNG management levels for airborne construction noise at residences

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

For work within standard construction hours, if after implementing all ‘feasible and reasonable’ noise levels the site still exceeds the noise affected level, the ICNG does not require any further action – since there is no further scope for noise mitigation.

For out-of-hours work, the ICNG uses a noise level 5 dB above the noise-affected level as a threshold where the proponent should negotiate with the community.

Although the ICNG does not use this terminology, in this report, the term ‘highly-noise affected level’ has been used to refer to this level (i.e. 5 dBA above the noise affected level for out-of-hours work) for brevity.

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 6.1 and have been separated out into proposed road and flood mitigation works.

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 4.

Table 5: ICNG screening criteria and sleep disturbance criteria for residential receivers per noise catchment area

Construction Works	Noise Catchment Area	Noise Logger Reference	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance Criteria (L_{Amax})
Road works	1	8 Beatson Street, South Grafton	Day (standard hours)	55	75	-
			Day (outside hours)	50	55	-
			Evening	44	49	-
			Night	37	42	47
	2	12 Bent Street, South Grafton	Day (standard hours)	69	75	-
			Day (outside hours)	64	69	-
			Evening	51	56	-
			Night	41	46	51
	3	8 Fitzroy Street, Grafton	Day (standard hours)	63	75	-
			Day (outside hours)	58	63	-
			Evening	46	51	-
			Night	36	41	46
	4	29 Villiers Street, Grafton	Day (standard hours)	58	75	-
			Day (outside hours)	53	58	-
			Evening	47	52	-
			Night	40	45	50
	5	30 Pound Street, Grafton	Day (standard hours)	54	75	-

Construction Works	Noise Catchment Area	Noise Logger Reference	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance Criteria (L_{Amax})
			Day (outside hours)	49	54	-
			Evening	44	49	-
			Night	40	45	50
	6	30 Pound Street, Grafton	Day (standard hours)	54	75	-
			Day (outside hours)	49	54	-
			Evening	44	49	-
			Night	40	45	50
	7	Cnr Iolanthe Street & Butters Lane, South Grafton	Day (standard hours)	49	75	-
			Day (outside hours)	44	49	-
			Evening	47	52	-
			Night	42	47	52
	8	Pacific Highway near Allipou Creek	Day (standard hours)	59	75	-
			Day (outside hours)	54	59	-
			Evening	53	58	-
			Night	46	51	56
Flood mitigation works	9	12 Bent Street, South Grafton	Day (standard hours)	69	75	-
			Day (outside hours)	64	69	-
			Evening	51	56	-
			Night	41	46	51
	10*	Maclennan's Lane, Waterview	Day (standard hours)	40	75	-
			Day (outside hours)	35	40	-
			Evening	46	51	-

Construction Works	Noise Catchment Area	Noise Logger Reference	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance Criteria (L_{Amax})
			Night	42	47	52
	11*	320 Back Lane, Junction Hill	Day (standard hours)	39	75	-
			Day (outside hours)	34	39	-
			Evening	41	46	-
			Night	40	45	50
	12*	320 Back Lane, Junction Hill	Day (standard hours)	39	75	-
			Day (outside hours)	34	39	-
			Evening	41	46	-
			Night	40	45	50
	13	8 Fitzroy Street, Grafton	Day (standard hours)	63	75	-
			Day (outside hours)	58	63	-
			Evening	46	51	-
			Night	36	41	46
	14	30 Pound Street, Grafton	Day (standard hours)	54	75	-
			Day (outside hours)	49	54	-
			Evening	44	49	-
			Night	40	45	50

* Since the existing ambient noise level in these rural locations is higher during the evening and night periods, it is recommended that the least onerous of all periods be adopted as the limiting criterion to ensure that overly onerous criteria are not assigned to the Project.

The ICNG also gives recommended management measures for commercial premises. For commercial premises that are not very sensitive to noise, such as offices or retail outlets, an external $L_{Aeq,15minute}$ noise limit of 70 dBA is recommended.

The ICNG also provides recommended noise levels for sensitive land uses other than residential receivers. These recommended limits are reproduced below in Table 5.

Table 6: Recommended construction noise limits for non-residential sensitive receivers

Sensitive Land Use	Management level, $L_{Aeq,15min}$ (applies when properties are being used)
Classrooms at schools and other educational institutions.	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB(A)
Community centres	Internal noise levels 45 dB(A) (based on the Maximum internal noise level for Reading Areas in public libraries in AS2107)

4.2 Construction vibration criteria

4.2.1 Human comfort and amenity

The NSW EPA's Assessing Vibration Guideline (Department of Environment and Conservation NSW, February 2006) 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[6].

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 takes into account 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.

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 6 and Table 7 respectively.

[6] British Standard BS 6472 - *Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)*

Table 7: Preferred and maximum weighted root-mean-square (rms) values for continuous and impulsive vibration acceleration (m/s²) 1-80 Hz

Location	Assessment Period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous Vibration					
Residences	Daytime 0700-2200	0.010	0.0071	0.020	0.014
	Night-time 2200-0700	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					
Residences	Daytime 0700-2200	0.30	0.21	0.60	0.42
	Night-time 2200-0700	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

Table 8: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Daytime 0700-2200		Night-time 2200-0700	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
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

4.2.2 Building damage

With regards to the potential for vibration to cause structural damage to buildings, BS7385: Part 2: 1993[7] was developed from an extensive review of UK data, relevant national and international documents and other published data, which yielded very few cases of vibration-induced damage. This standard contains the most up-to-date research on vibration damage in structures. Part 2 of the standard gives specific guidance on the levels of vibration below which building structures are considered to be at minimal risk.

Limits on the foundations of the building as proposed in the Standard are listed in Table 8.

[7] British Standard BS 7385:2 – *Evaluation and measurement for vibration in buildings- Part 2: Guide to damage levels from goundborne vibration* (1993)

Table 9 Transient vibration guide values for cosmetic damage

Category	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 @ 4 Hz and above	
2) Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s @ 4 Hz increasing to 20 mm/s @ 15 Hz	20 mm/s @ 15 Hz increasing to 50 mm/s @ 40 Hz and above

DIN 4150: Part 3: 1999[8] also gives guidelines for short-term and steady state structural vibration for varying types of structure. The limits for short-term vibration in buildings of varying sensitivity are given in Table 9.

Table 10: Guideline Values of Vibration Velocity, v_i, for Evaluating the Effects of Short-term Vibration

	Vibration Velocity, vi, in mm/s			
	Foundation			**Plane of floor of uppermost full storey**
Structural type	1 to 10 Hz	10 to 50 Hz	50 to 100 Hz	Frequency mixture
Commercial, Industrial or Similar	20	20 to 40	40 to 50	40
Dwellings or Similar	5	5 to 15	15 to 20	15
Particularly Sensitive	3	3 to 8	8 to 10	8

The guidelines state that:

> *"Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible. Exceeding the values in table [17] does not necessarily lead to damage; should they be significantly exceeded, however, further investigations are necessary."*

The most stringent limit recommended in the German Standard is 3 mm/s. This criterion is applicable to particularly sensitive constructions such as heritage structures.

4.3 Road noise assessment criteria

The RNP provides road traffic noise criteria for both residential and other non-residential noise sensitive receivers. The RNP provides both absolute noise level limits, dependent upon road category, and limits to control the relative increase in road traffic noise.

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[8] German Standard DIN 4150:3 – *Structural vibration, Part 3: Effects of vibration on structures* (1999)

It should be noted that the road traffic noise criteria are provided as guidelines and are 'non-mandatory'. They provide target noise levels that it is desired to meet where it is *feasible and reasonable* to do so. The policy document states that in some instances this may be achievable only through long-term strategies such as improved planning; design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles; greater use of public transport; and alternative methods of freight haulage.

In particular, Practice Note IV of the ENMM provides detailed guidance on "selecting and designing 'feasible and reasonable' treatment options for road traffic noise".

The following sections provide a summary of project specific acoustic criteria for noise sensitive receiver types and land uses as stipulated in the RNP.

4.3.1 Residential receivers

Table 10 is an excerpt from the RNP Section 2.3.1 Noise assessment criteria – residential land uses, summarising noise criteria for residential receivers relevant to this project.

Table 11: Road traffic noise assessment criteria for residential land uses

Road Category	**Type of Project/Land Use**	**Assessment Criteria (dB)**	
		Day 0700 – 2200 hours	**Night 2200 – 0700 hours**
Freeway / arterial / sub-arterial roads	1. Existing residences affected by noise from new freeway / arterial / sub-arterial road corridors	$L_{Aeq, 15 hour}$ 55 (external)	$L_{Aeq, 9 hour}$ 50 (external)
Freeway / arterial / sub-arterial roads	2. Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads	$L_{Aeq, 15 hour}$ 60 (external)	$L_{Aeq, 9 hour}$ 55 (external)

The ENMM defines road development types as being 'new' or 'redeveloped' based on several criteria. In general, the definition relates to whether the relevant façade of a receiver has an existing road traffic noise exposure. The ENMM defines an existing road traffic noise exposure in Practice Note (i) as:

> *'A site is defined as having an "existing road traffic noise exposure" if the prevailing noise level from the existing road alignment(s) under consideration is equal to or greater than 55 dB(A) $L_{Aeq\ (15hr)}$ (day) or 50 dB(A) $L_{Aeq\ (9hr)}$ (night). The noise level contours corresponding to these day and night noise levels define the "noise catchment" for an existing road. In areas outside these contours, road traffic is unlikely to be a significant noise source.'*

4.3.2 Relative increase criteria

Table 11 is an excerpt from the RNP Section 2.4 Relative increase criteria, stipulating the allowable increase above existing traffic noise for residential receivers. These criteria are to be assessed in addition to those mentioned above.

Table 12: Relative increase criteria for residential land uses

Road Category	Type of Project/Land Use	Assessment Criteria (dB)	
		Day 0700 – 2200 hours	**Night 2200 – 0700 hours**
Freeway / arterial / sub-arterial roads	New road corridor / redevelopment of existing road / land use development with the potential to generate additional traffic on existing road	Existing Traffic $L_{Aeq,\ 15\ hour}$ + 12 (external)	Existing Traffic $L_{Aeq,\ 9\ hour}$ + 12 (external)

As defined in the Section 2.5.3 of the RNP, the 'existing' traffic noise level refers to the level from all road categories which would occur for the relevant 'no build' option. ('No build' refers to the scenario where no additional crossing or approach roads are constructed.) Where the existing $L_{Aeq,\ period}$ road traffic noise level is found to be less than 30 dB(A), it is deemed to be 30 dB(A).

4.3.3 Other sensitive land uses

Table 12 is an excerpt from the RNP Section 2.3.2 Noise assessment criteria – other non-residential land uses, summarising noise criteria for other noise sensitive receivers relevant to this project.

Table 13: Road traffic noise assessment criteria for non-residential land uses

Existing Sensitive Land Use	Assessment Criteria (dB)		Additional Considerations
	Day 0700 – 2200 hours	**Night 2200 – 0700 hours**	
1. School Classrooms	$L_{Aeq,\ 1\ hour}$ 40 (internal)	-	In the case of buildings used for education or health care, noise level criteria for spaces other than classrooms and wards may be obtained by interpolation from the 'maximum' levels shown in Australian Standard 2107:2000 (Standards Australia 2000)
2. Hospital Wards	$L_{Aeq,\ 1\ hour}$ 35 (internal)	$L_{Aeq,\ 1\ hour}$ 35 (internal)	

Existing Sensitive Land Use	Assessment Criteria (dB)		Additional Considerations
	Day 0700 – 2200 hours	**Night 2200 – 0700 hours**	
3. Places of Worship	$L_{Aeq,\ 1\ hour}$ 40 (internal)	$L_{Aeq,\ 1\ hour}$ 40 (internal)	The criteria for places of worship are internal, i.e. the inside of the building. Areas outside the place of worship, such as a churchyard or cemetery, may also be a place of worship. Therefore, in determining appropriate criteria for such external areas, it should be established what in these areas may be affected by road traffic noise. For example, if there is a church car park between a church and the road, compliance with the internal criteria inside the church may be sufficient. If, however, there are areas between the church and the road where outdoor services may take place such as weddings and funerals, external criteria for these areas are appropriate. As issues such as speech intelligibility may be a consideration in these cases, the passive recreation criteria (see point 5) may be applied.
4. Open Space (Active Use)	$L_{Aeq,\ 15\ hour}$ 60 (external) When in Use	-	Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion. Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. playing chess, reading. In determining whether areas are used for active or passive recreation the type of activity that occurs in that area and its sensitivity to noise intrusion should be established. For areas where there may be a mix of passive and active recreation, e.g. school playgrounds, the more stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses.
5. Open Space (Passive Use)	$L_{Aeq,\ 15\ hour}$ 55 (external) When in Use	-	

Existing Sensitive Land Use	Assessment Criteria (dB)		Additional Considerations
	Day 0700 – 2200 hours	**Night 2200 – 0700 hours**	
8. Childcare Facilities	Sleeping Rooms $L_{Aeq,\ 1\ hour}$ 35 (internal) Indoor Play Areas $L_{Aeq,\ 1\ hour}$ 40 (internal) Outdoor Play Areas $L_{Aeq,\ 1\ hour}$ 55 (external)	-	Multi-purpose spaces, e.g. shared indoor play/sleeping rooms should meet the lower of the respective criteria. Measurements for sleeping rooms should be taken during designated sleeping times for the facility, or if these are not known, during the highest hourly traffic noise level during the opening hours of the facility.
9. Aged Care Facilities	-	-	Residential land use noise assessment criteria should be applied to these facilities.

The RNP stipulates internal noise objectives for the majority of sensitive land uses (e.g. schools, hospitals, churches, etc). Given the variability of building construction, it is not practical to accurately assess the impact on internal noise levels.

Corresponding external criteria for sensitive land uses were used for the assessment, defined as being 10 dB above those stipulated as internal noise criteria. This is considered to be representative of expected attenuation through a typical open window.

4.3.4 Acute noise levels

In addition to the RNP criteria, the ENMM identifies a category of highly affected noise sensitive receivers as ‘acute’. This category applies to receivers that are predicted to experience noise levels greater than or equal to 65 $dBL_{Aeq,\ 15\ hour}$ (daytime) and 60 $dBL_{Aeq,\ 9\ hour}$ (night-time), as a result of existing or future road traffic noise. A detailed assessment of noise mitigation in accordance with ENMM Practice Note IV is warranted for receiver locations identified as being ‘acute’.

For the purposes of this assessment, residential receivers and other sensitive land uses that are subject a noise level increase or decrease, and exceed the ‘acute’ noise levels, are considered for treatment where the dominant noise is due to the project.

4.3.5 Maximum noise level assessment

The ENMM provides an assessment methodology to assess the potential for sleep disturbance due to maximum noise level events associated with road traffic. For assessment purposes, at locations where traffic noise is continuous rather than intermittent, the ENMM employs a methodology to assess these impacts based on the emergence of the L_{Amax} over the $L_{Aeq,\ 1\ hour}$ noise level.

A maximum noise pass-by event is defined as the emergence of the L_{Amax} noise level above the $L_{Aeq,\ 1\ hour}$ noise level by 15 dB(A) or more, ie:

$$L_{Amax} \geq L_{Aeq,\ 1\ hour} + 15\ dB(A)$$

The ENMM goes on to say:

> *This maximum noise assessment should be used as a tool to help prioritise and rank mitigation strategies, but should not be applied as a decisive criterion in itself.*

The RNP further states the following:

> *From the research on sleep disturbance to date it can be concluded that:*
>
> - *Maximum internal noise levels below 50-55 dB(A) are unlikely to awaken people from sleep*
> - *One or two noise events per night, with maximum internal noise levels of 65-70 dB(A), are not likely to affect health and wellbeing significantly.*

Following the same rationale as presented in Section 4.3.3, the corresponding external assessment guideline is taken to be 10 dB higher than the maximum internal noise levels presented above.

4.4 Rail noise infrastructure guideline (RING)

It will be necessary to replace the existing rail viaduct at Pound Street in order to provide sufficient vertical clearance for the proposed upgrade of Pound Street. This has the potential to alter rail noise impacts on nearby sensitive receivers.

The RING provides rail noise criteria for both residential and other non-residential noise sensitive receivers. The RING provides both absolute noise level limits and limits to control the relative increase in rail noise.

4.4.1 Airborne noise

Table 13 and Table 14 are excerpts from the RING Section 2.3 – Airborne noise trigger levels for heavy rail, summarising airborne noise trigger levels for residential and other sensitive land uses respectively as relevant to this study. These railway noise levels trigger the need for an assessment of potential noise mitigation measures to reduce noise levels from a rail infrastructure project.

Table 14: Airborne rail noise trigger levels for residential land uses

Type of Development	Noise Trigger Levels dB(A) (External)	
	Day **0700 – 2200 hours**	**Night** **2200 – 0700 hours**
Redevelopment of existing rail line	Development increases existing $L_{Aeq(period)}$ rail noise levels by 2dB or more, or existing L_{Amax} rail noise levels by 3 dB or more and predicted rail noise levels exceed:	
	65 $L_{Aeq(15h)}$ OR 85 L_{AFmax}	60 $L_{Aeq(15h)}$ OR 85 L_{AFmax}

Table 15: Airborne rail noise trigger levels for sensitive land uses other than residential

Other Sensitive Land Uses	Noise Trigger Levels dB(A) (when in use)
	Redevelopment of Existing Rail Line
	Development increases existing rail noise levels by 2dB(A) or more in L_{Aeq} for that period and resulting rail noise levels exceed:
Schools, educational institutions and child care centres	45 $L_{Aeq(1h)}$ internal
Places of worship	45 $L_{Aeq(1h)}$ internal
Hospital wards	40 $L_{Aeq(1h)}$ internal
Hospitals other uses	65 $L_{Aeq(1h)}$ external
Open space – passive use (e.g. parkland, bush reserves)	65 $L_{Aeq(15h)}$ external
Open space – active use (e.g. sports field, golf course)	65 $L_{Aeq(15h)}$ external

4.4.2 Groundborne noise

Table 15 is an excerpt from the RING Section 2.5 – Groundborne noise trigger levels, summarising groundborne noise trigger levels for residential and other sensitive land uses.

Table 16: Groundborne noise trigger levels for heavy rail projects

Sensitive Land Use	Time of Day	Internal Noise Trigger Levels dB(A)
		Development increases existing rail noise levels by 3 dB(A) or more and resulting rail noise levels exceed:
Residential	Day (7am-10pm)	40 L_{ASmax}
	Night (10pm-7am)	35 L_{ASmax}
Schools, educational institutions, places of worship	When in use	40-45 L_{ASmax}

4.5 Industrial noise policy (INP)

As noted in Section 2, an industrial flood pump station is proposed to extract water from the detention basin and convey it to the Clarence River to allow flood-free access to the new bridge in 20-year average recurrence interval event floods. The pump station would be used when the Pound Street approach road in vicinity to the railway viaduct is impacted by flooding from a local rain event and the Grafton levee system gates are closed as a result of a river flood. At the current stage of the project, the proposed pump station is to be located on the northern river bank in between the existing and proposed river crossing alignments (Refer to Figure 7).

The INP provides industrial noise criteria for both residential and non-residential noise sensitive receivers. The assessment procedure for industrial noise sources as per INP guidance has two components:

- Controlling intrusive noise impacts in the short term for residences
- Maintaining noise level amenity for particular land uses for residences and other land uses.

4.5.1 Intrusive criteria

For assessing intrusiveness, the existing ambient noise level needs to be measured. The intrusiveness criterion essentially means that the equivalent continuous noise level (L_{Aeq}) of new industrial noise sources should not be more than 5 dBA above the measured Rated Background Level (RBL), over any 15 minute period.

4.5.2 Amenity criteria

In addition to the intrusive criteria, the INP also has provision for maintaining noise level amenity for particular area types. The cumulative effect of noise from existing and proposed industrial noise sources needs to be considered in assessing this impact. The existing noise level from industry is measured. If it approaches a predefined value based on area type, then noise levels from new industrial noise sources need to be designed so that the cumulative effect does not produce total noise levels that would significantly exceed the criterion.

4.5.3 Area classification

The INP classifies the noise environment of the subject area as 'suburban'. The INP characterises the 'Suburban' noise environment as an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristics:

- Decreasing noise levels in the evening period (1800-2200); and/or
- Evening ambient noise levels defined by the natural environment and infrequent human activity.

4.5.4 Modifying factor corrections

The INP has provision for modifying assessment criteria based on frequency and duration. Table 16 is an excerpt from the INP Section 4 – Modifying factor adjustments, summarising applicable industrial noise emission criteria adjustments based on duration.

Table 17: INP noise criteria modifying factor corrections for duration

Duration of Noise (one event in any 24 hour period)	**Increase in acceptable noise level at receiver, dB(A)**	
	Day 0700 – 2200 hours	Night 2200 – 0700 hours
1.0 to 2.5 hours	2	Nil
15 minutes to 1 hour	5	Nil
6 minutes to 15 minutes	7	2
1.5 minutes to 6 minutes	15	5
Less than 1.5 minutes	20	10

Given that the pump station is intended to be used in the event of a localised flood on Pound Street, the noise impacts from operation are likely to be limited to maintenance testing. It is assumed that this will occur for a maximum of 1 hour in any given 24 hour period. An adjustment of +5 dB(A) to industrial noise criteria is therefore proposed to daytime assessment criteria.

4.5.5 Limiting noise criteria

The most representative noise logging location for deriving appropriate industrial noise criteria is 8 Fitzroy Street (Logger Reference #18). Having defined the area type, the processed results of the unattended noise monitoring at this location have been used to generate project specific noise criteria. These are summarised in Table 17 and include the +5dB modifying factor for both daytime and evening periods but not the night-time period. The more stringent of the two industrial noise criteria have been bolded for each time period. This will be the limiting criterion for that period.

Table 18: INP noise emission criteria for new industrial plant

Time of Day	**Intrusive Criteria dB$L_{Aeq(15minute)}$**	**Amenity Criteria dB$L_{Aeq(Period)}$**
Day (0700-1800)	63	**56**
Evening (1800-2200)	**51**	56
Night (2200-0700)	**36**	43

5 Construction noise and vibration assessment

This section assesses the noise and vibration impacts of the project during construction.

At this stage of the project, the precise locations and type of equipment used to construct the bridge and associated roadwork is not known in detail. Therefore it is not possible to provide a detailed or accurate prediction of the construction noise and vibration impacts. This section therefore provides an overview of the proposed construction timing, activities, ancillary facilities and working hours, and identifies where the key construction works will occur. It identifies the key construction activities which have the potential to result in noise and vibration impacts on the community. It provides a broad assessment of which areas may be impacted by construction noise levels above the construction noise criteria developed in Section 4.1, and what mitigation measures could be adopted to help control construction noise.

It should be noted that the construction contractor would refine construction methods during detailed design, and be required to prepare a more detailed construction noise and vibration management plan as part of the construction process.

5.1 Noise catchment areas

This assessment has considered noise catchment areas in Grafton and South Grafton, as well as areas adjacent to the proposed levee works. The broad noise catchment areas considered in this assessment are shown in Figure 4 and Figure 5 respectively.

Residential and non-residential noise sensitive land uses relevant to the project are presented in Section 3.1.

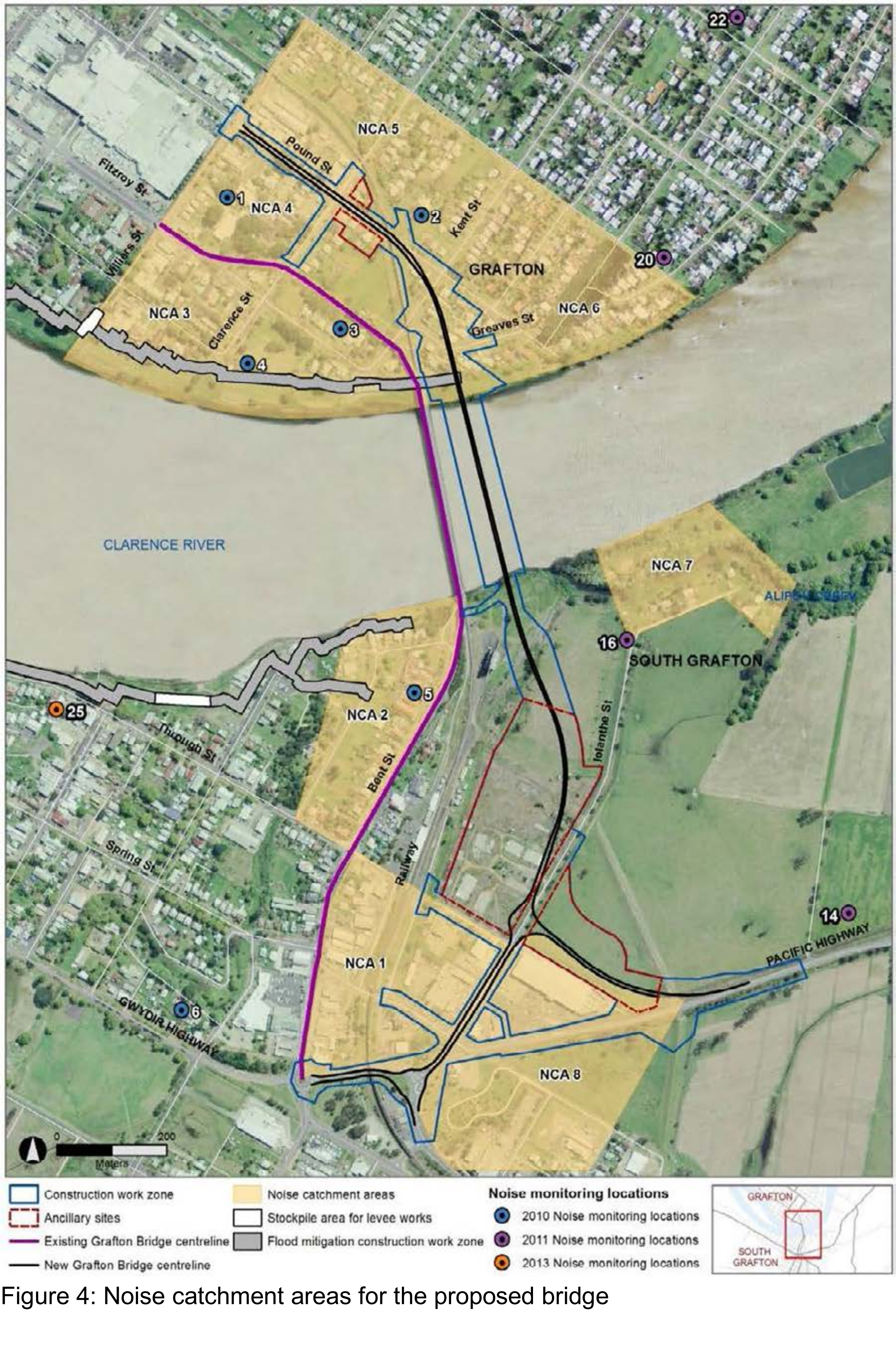


Figure 4: Noise catchment areas for the proposed bridge

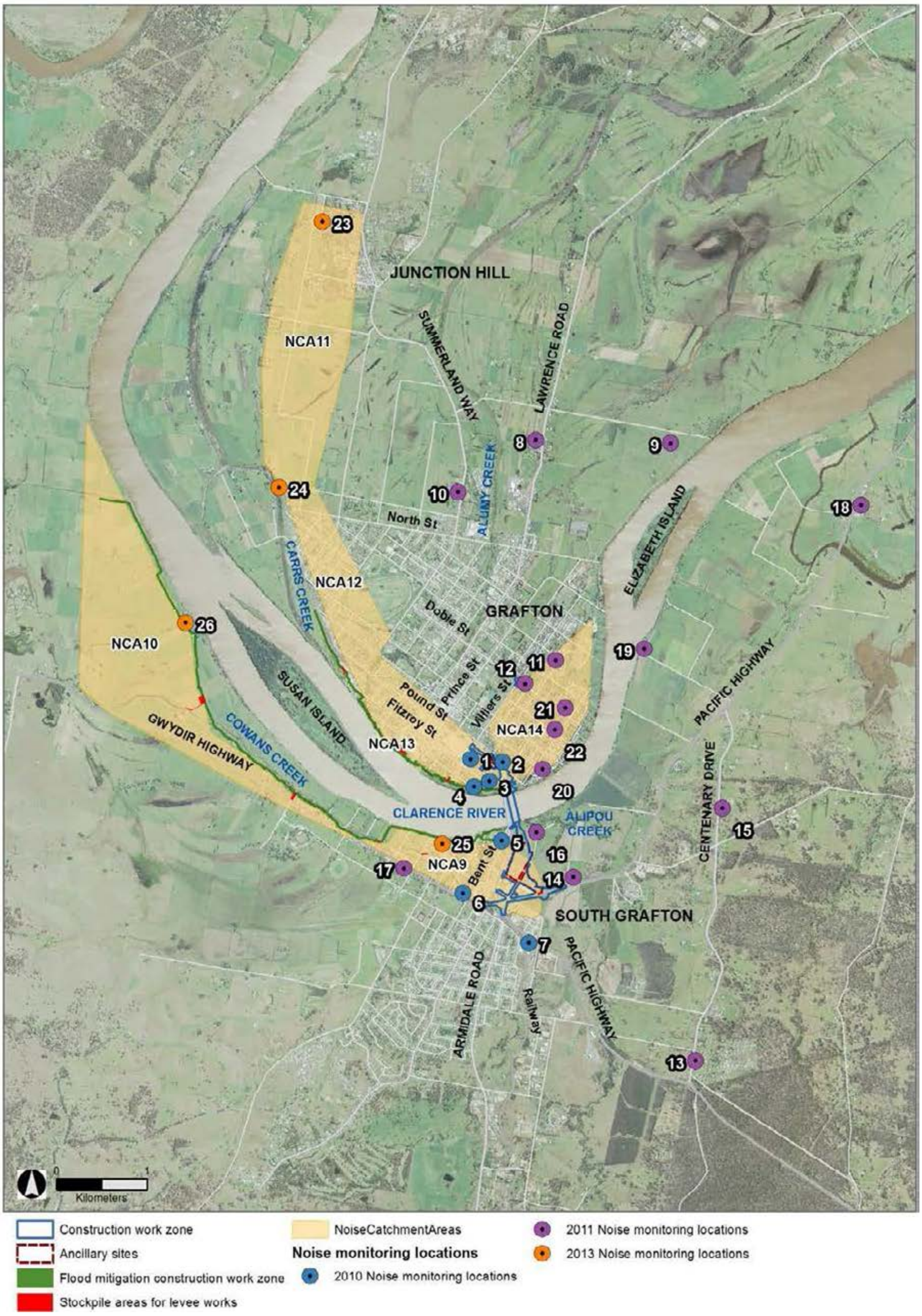


Figure 5: Noise catchment areas for the flood mitigation works

5.2 Project construction overview

5.2.1 Construction delivery

Roads and Maritime would consider and select the most suitable procurement method for project construction delivery. The preferred procurement method would be selected and implemented in compliance with the project EIS and the conditions of approval for the project.

Roads and Maritime would be responsible for overseeing the construction, including inspections, monitoring and auditing work performed by the construction contractor(s).

5.2.2 Construction timing

A construction program for the project has not yet been determined. However, it is expected that construction would take about three years. The NSW Government has nominated the end of 2019 as the desired completion date for the project. The actual timing of construction, opening to traffic and completion would depend on the availability of construction funding.

The construction program in Figure 6 is indicative only and may change based on further work during detailed design. The timing and duration of construction activities may also be influenced by:

- Wet weather periods
- Changes to construction methods and/or materials.

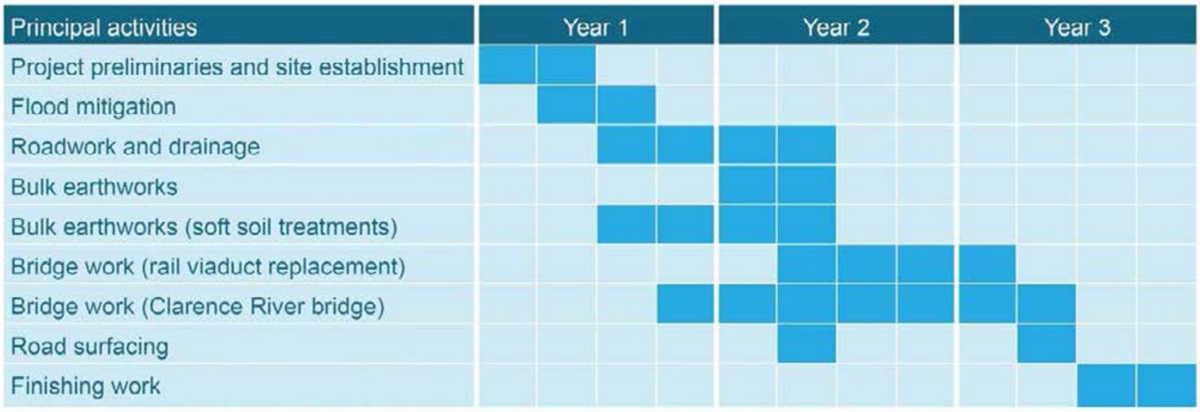


Figure 6: Proposed Grafton Bridge project – indicative construction timeline

5.2.3 Construction activities

The project would be built using conventional methods used on most major road and bridge construction projects. These methods may be modified to address site-specific environmental or engineering constraints. The typical construction sequence and activities shown in Table 18 are based on standard construction practices and are informed by the concept design for the proposed project.

The activities and typical construction plant and equipment listed in Table 18 provide sufficient detail to allow an assessment of the likely nature and extent of environmental impacts during construction. It is not a full list of works, activities, plant and equipment, and it is possible that activities would not occur in the precise order listed.

The construction contractor would refine construction methods during detailed design in view of the site constraints and in accordance with any conditions of approval.

Table 19 Typical construction activities and plant

Component	Typical activities	Typical plant and equipment
Preliminary activities and site establishment	Property acquisition and adjustments, including property access changes Detailed geotechnical investigations and survey Dilapidation surveys General site clearance, site establishment work, fencing and signage Establishment of temporary construction facilities and compound sites including the site office Temporary traffic management arrangements Progressive installation of environmental controls including temporary or permanent fencing, and erosion and sediment control measures Construction of temporary drainage controls Clearing and removal of vegetation Diversion of utilities	Trucks Generators Light vehicles Excavators Chainsaws Mulchers Water carts Cranes Drilling rigs
Flood mitigation works	Clearing of vegetation (where required) Stripping of topsoil Placement and compaction of earthwork Reinstatement of topsoil and planting / grass seeding to establish vegetation Upgrade of flood mitigation structures Adjustments to minor structures within built areas Adjustment of control gates and regulatory devices	Excavators Dump trucks Compactors Graders Loaders Water carts Profilers Bulldozers Vibratory rollers

Component	Typical activities	Typical plant and equipment
Roadwork and road surfacing	Stripping of topsoil, removal of trees and other vegetation Construction of temporary local traffic management diversions Placement and compaction of earthwork Road widening, including construction of box cuts and road surfaces Staged construction on local roads Installation of traffic signals, roadside furniture and lighting Installation of road markings Construction of any retaining walls and subsurface drainage Construction of road surface Construction of pedestrian and cycle path Progressive landscaping and tree planting	Chainsaw Graders Backhoes Trucks Water carts Vibratory compactors Bitumen sprayers Vibratory rollers Rubber tyred rollers
Drainage	Construction of drainage, including kerb and gutter (where required) Major drainage work – eg cross-drainage structures and Pound Street drainage, including the pump station Installation of cross-drainage, including culverts and inlet and outlet work, such as channel diversions and scour protection Installation of longitudinal and vertical drainage in cuttings and embankments Construction of diversion and catch drains along the formation and sedimentation control basins or swales (where required)	Trucks Bulldozers Excavators Concrete pumps Concrete trucks
Bulk earthwork	Stripping topsoil and stockpiling it for reuse in landscaping Materials haulage Soft soils treatment Construction of embankments Stockpiling	Trucks Bulldozers Excavators
Bridge work	Establishment of batching plant Preparation of bridge work areas including temporary piling pads, access platforms Installation of bridge foundations (driven or bored piles, pile caps and footings) Construction of new bridge superstructure and piers Replacement of ARTC rail viaduct at Pound Street Construction of bridge superstructure including deck and pavement work (cast in-situ or pre-cast bridge elements) Construction of noise barrier	Batching plant Piling rigs Concrete pumps Concrete trucks Cranes Barge(s) Excavators Trucks Small equipment

Component	Typical activities	Typical plant and equipment
Finishing work	Remove temporary work Restoration and landscaping of temporary sites General site clean-up Restoration of topsoil and revegetation of batters Removal of temporary environmental controls Site clean-up and demobilisation, including restoration of ancillary sites and construction access roads (where required)	Trucks Generators Light vehicles Cranes

5.2.4 Ancillary facilities

A range of construction related facilities would be required to build the project. These ancillary facilities would include some or all of the following:

- Site compounds
- Concrete batching plant
- Stockpile areas
- Precast facilities
- Flood mitigation stockpile sites.

These ancillary facilities are described below and potential locations are shown on Figure 7. The work zones and stockpile areas for the flood mitigation works are shown in Figure 8a–f.

Initial site work in these areas would involve site clearing, installing appropriate environmental controls and providing hardstand areas for storage, parking and access roads. The actual locations and layout of ancillary facilities would be determined by the construction contractor.

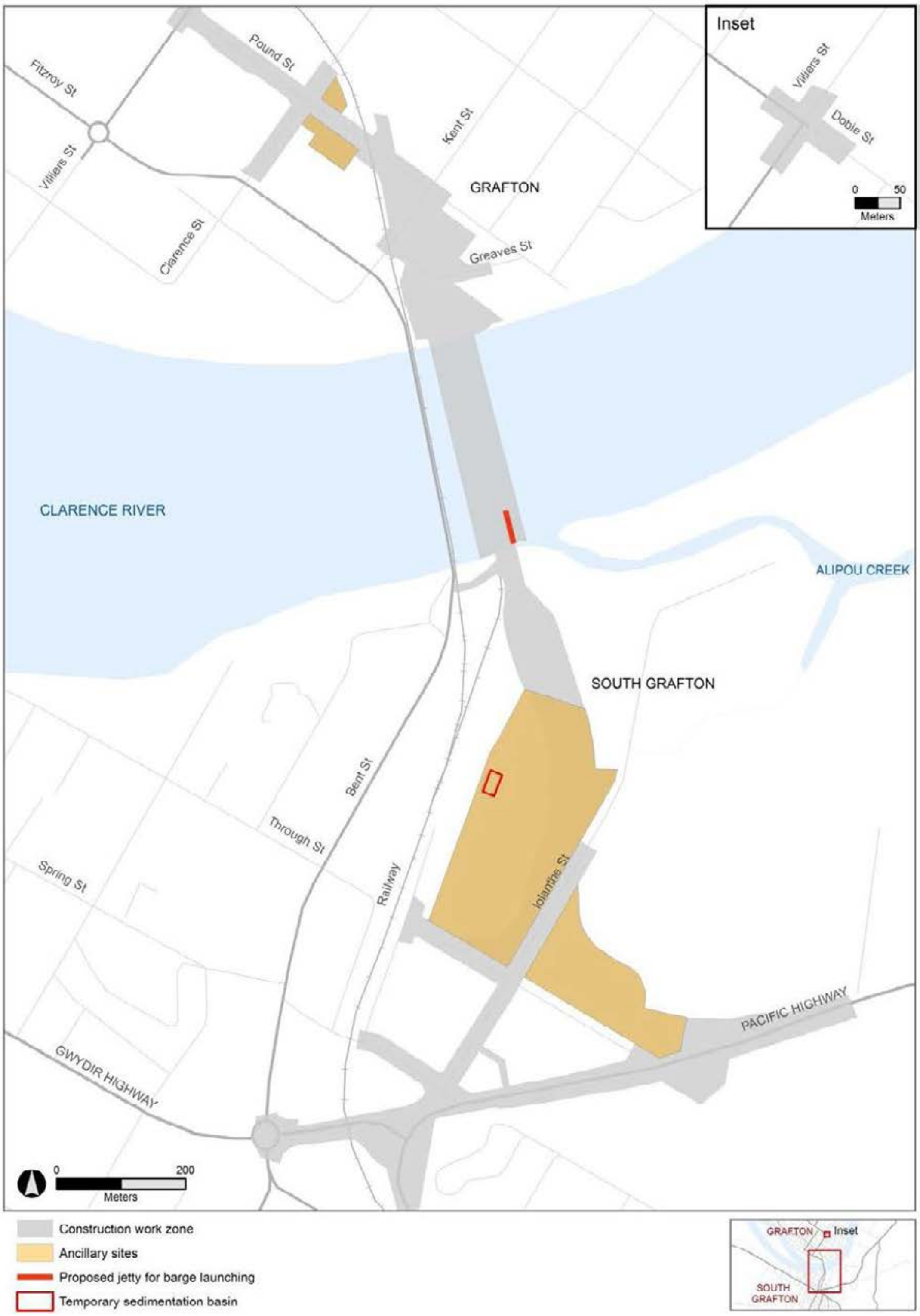


Figure 7 Indicative locations of ancillary facilities

Figure 8a: Levee construction work zones and stockpile areas

Figure 6b: Levee construction work zones and stockpile areas

Figure 6c: Levee construction work zones and stockpile areas

Figure 6d: Levee construction work zones and stockpile areas

Figure 6e: Levee construction work zones and stockpile areas

Figure 6f: Levee construction work zones and stockpile areas

5.2.4.1 Site compounds

Site compounds are located within ancillary sites (refer to Figure 7) and include offices, workforce facilities (such as parking, lunchrooms and toilets), workshops and storage areas for plant and construction materials. A main ancillary site is likely to be located in South Grafton (about 90,000 square metres in size) and a smaller compound is likely to be required in Grafton for the construction of the northern abutment, the Pound Street railway viaduct replacement and road upgrades in Grafton (about 4,500 square metres in size).

These site compounds may be co-located with batch plants and are likely to be sited near major construction activities to minimise construction traffic. All site compounds would be fenced for security and safety purposes

These site compounds may be co-located with batch plants and are likely to be sited near major construction activities to minimise construction traffic. All site compounds would be fenced for security and safety purposes.

5.2.4.2 Concrete batching plant

It is possible that a concrete batching plant would be required to build the bridge.

The plant would be installed as required by the construction contractor and where external sources are unable to meet the production rates required for the project, or where on-site production would be more cost effective than importing from external sources.

The construction contractor would determine the location of the batching plant. It is likely that the plant would be co-located with the South Grafton ancillary site.

5.2.4.3 Stockpile areas

Stockpile areas (refer to Figure 8a–f) would be required to temporarily store:

- General fill material. Imported fill would be required for the project. The fill stockpile areas would likely be within the construction footprint and the need for stockpiling would depend on the sequence of construction
- Spoil. The excavation of existing ground and road surfaces would create excess spoil material that may need to be stockpiled. Some of it would be re-used as general fill for other parts of the project; the rest would be unsuitable spoil material and would be appropriately disposed (unsuitable spoil material may consist of soil, sand, clay, and asphalt). The spoil stockpile areas would be located within the ancillary facilities, as well as other areas within the construction footprint (including along sections of the flood levee that need to be raised for the project)

- Mulch. Minor stockpiles of mulch are likely to result from the removal of top layers of soil from the ground surface and from the slashed vegetation from clearing.

5.2.4.4 Precast facilities

Precast facilities may be required to build the bridge across the Clarence River. These facilities would be used to build the bridge deck segments and Super T girders ready for assembly.

A precast facility would require an area of about 400 by 100 metres, and would likely be located in South Grafton within the ancillary facilities shown in Figure 7. The need for precast facilities would be determined by the construction contractor and would depend on the bridge construction method adopted, value for money and the availability and proximity of alternative precast facilities.

5.2.5 Construction work hours

The proposed working hours for the project are the standard approved working hours for construction projects, namely:

- Weekdays: 7am to 6pm
- Saturdays: 8am to 1pm
- Sundays and public holidays: no work.

The majority of construction activities would be carried out during the proposed working hours. There would be certain activities that would need to be carried out outside of these standard working hours. These ‘out of hours’ periods would be needed to reduce impacts on adjoining properties and reduce disruption for the travelling public and rail operations.

The reasons for out of hours work are presented below.

5.2.5.1 Out of hours work

The *Interim Construction Noise Guidelines* (DECC, 2009) have been developed by a number of State Government agencies to provide guidance on managing noise from construction work in NSW. Section 2.3 of the guidelines provides details on the five categories of work that might be done outside the recommended standard hours. These categories are:

- The delivery of oversized plant or structures that police or other authorities determine require special arrangements to transport along public roads
- Emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- Maintenance and repair of public infrastructure where disruption to essential services and/or considerations of worker safety do not allow work within standard hours

- Public infrastructure works that shorten the length of the project and are supported by the affected community
- Works where a proponent demonstrates and justifies a need to operate outside the recommended standard hours.

In addition, the guidelines state that, public infrastructure works are one of the five categories of works that might be undertaken outside the recommended standard hours. This need is typically based on a requirement to sustain the operational integrity of public infrastructure, as work to restore operation of the infrastructure provides a benefit to the greater community (that is, more than just local residents).

Construction activities on the proposed project that may require out of hours and fall under the above categories include:

- Delivering materials (such as oversize elements of plant and large construction equipment) required outside these hours by the Police or other authorities for the safety of road users and the public
- Delivering materials to reduce traffic volumes across the Clarence River, the Pacific Highway, Gwydir Highway and Summerland Way
- Upgrading local roads in Grafton and South Grafton to minimise impacts on road users, local businesses and the TAFE
- Building the new bridge (eg the lifting and setting of bridge elements)
- Replacing the Pound Street viaduct. This is an operating rail line that would need to be closed while the viaduct is being replaced. Work would need to be carried out 24 hours per day to minimise the time that the rail line is closed
- Tying in the project with the existing Pacific Highway (tie-in work would need to maintain the safety of the travelling public)
- Managing traffic and traffic switches to reduce inconvenience to road users, avoid traffic delays during daytime or peak traffic periods, and provide safety for construction workers working on the existing highway
- Relocating utilities near existing roads to avoid and minimise disruptions for utility customers
- Construction compound operations to support any activities that may be undertaken out of hours
- Refuelling (this would be done out of hours to maximise the plant and machinery operations during the recommended standard hours)
- Work required in an emergency to avoid the loss of lives, property and/or to prevent harm
- Short-term major traffic diversions, including full or partial road closures
- Work that would not cause construction noise disturbance at any sensitive receivers
- Work as agreed between Roads and Maritime and potentially affected sensitive receivers
- Deliveries to the ancillary facilities

- Concrete paving, concrete saw-cutting, and concrete batch plant activities.

With the exception of emergencies, construction activities would not take place outside standard hours without prior notification to local residents, businesses and Clarence Valley Council in accordance with the Roads and Maritime *Noise Management Manual Practice Note VII*.

Specific activities requiring special circumstances are described below.

Concrete paving

- Roads and Maritime has specifications for concrete paving that relate to temperature and rainfall. For jointed concrete base, the specifications prohibit the placement of concrete during rain or when the ambient air temperatures are below five degrees or above 32 degrees. As hot weather affects the quality of the concrete pavement, paving in the early evening and into the night is preferred as it takes advantage of cool night-time temperatures
- It is likely that concrete paving would need to be carried out during summer. Due to climatic conditions experienced in the region during summer, where daytime temperatures often exceed the maximum temperature threshold of 32 degrees, concrete paving would need to occur during the day, evening and night-time period

Concrete saw-cutting

- In some places, the project would use plain concrete pavement, which is an unreinforced pavement. To manage cracking associated with drying and shrinkage, saw cutters are used to cut the pavement. The timing of concrete cutting is governed by the hydration rate of the concrete and may require cutting at anytime within four and 24 hours after paving, with a 'cutting window' as short as 30 minutes. As the timing of the cutting is critical to the quality of the pavement and acceptability of the finished product, concrete saw-cutting may be needed at any time including outside standard construction hours. Concrete saw-cutting is a construction activity that is transient in nature, and each saw cut would be of a short duration.

Concrete batch plants

- In addition to normal daytime operation for concrete structures, the concrete batch plants would need to operate in conjunction with paving work during the evening and night-time. There may also be a need to cast some elements in situ, which could require the plant to operate continuously for up to 24 hours. To keep up with the materials demand during these peak periods of concrete production, the batch plant would also require material deliveries outside normal working hours. Due to the regional location of the project, the timing of deliverables may be determined by the pattern of supplier fleet movements (at night).

5.3 Construction noise assessment

The following sections provide a broad assessment of the likely noise impacts generated during construction of the project. As noted previously the precise locations and types of equipment used to construct the bridge and the associated roadwork is not known in detail at this stage. Furthermore, the typical construction plant and equipment described in Table 18 will not normally all operate at the same time, but may be used sequentially across each part of the construction area.

On that basis, this assessment provides a broad assessment of the key construction activities that have the potential to adversely impact the local community based on typical sound power levels for construction plant of various types, and the proximity of the sensitive receivers to the construction zones.

5.3.1 General construction works

Construction works described in Section 5.2 will require the use of heavy construction equipment such as earthmoving equipment, piling rigs and trucks.

General construction noise source sound power levels can been determined from published construction equipment noise levels from AS2436[9], BS5228.1[10] and the DEFRA construction noise database[11]. The following table provides the typical source sound power levels for equipment expected to be used for the construction of the crossing.

Table 20: Expected construction sound power level for construction plant and equipment

Plant	Sound Power Level, dB(A) re 10^{-12} W
Trucks	115
Generators	102
Excavators	114
Water carts	106
Cranes	98
Drilling rigs	114
Drilling rigs	102
Dump trucks	115
Compactors	106
Graders	114

[9] Australian Standard AS 2436 Guide to noise and vibration control on construction, demolition and maintenance sites (2010)

[10] British Standard BS5228.1 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise (2009)

[11] Department for Environment Food and Rural Affairs (United Kingdom), Update of noise database for prediction of noise on construction and open sites (2006)

Plant	Sound Power Level, dB(A) re 10^{-12} W
Loaders	110
Bulldozers	113
Vibratory rollers	101
Backhoes	97
Vibratory compactors	106
Rubber tyred rollers	102
Concrete pumps	108
Concrete trucks	107
Pilling Rig	117
Batching Plant (If required. South Grafton ancillary site)	106

Based on a typical average-maximum construction site sound power level of around 113–115 dBL_{Amax} (re 1pW), and allowing for distance losses and typical atmospheric and environmental noise attenuation, typical construction noise levels are predicted to be around 70–75 dB_{LAmax} at a distance of 50 m from construction work zones, and 45–55 dBL_{Amax} at a distance of 150 m. This would apply equally to bulk earthworks, roadwork, road surfacing and flood mitigation construction activities. These noise levels are representative of the ‘highly noise affected level’ and ‘noise affected level’ respectively for noise catchments identified in Table 4.

The predicted construction noise levels at the most affected receiver in each of the noise catchment areas has been calculated based on the broad construction activities and typical plant and equipment shown in Table 18. The predicted construction noise levels at the most affected receiver within each of the noise catchment areas (shown in Figure 4 and Figure 5) are provided in Table 20 below.

For the purposes of the sleep disturbance assessment, maximum allowable noise levels for construction equipment from the Transport for New South Wales (TfNSW) Construction Noise Strategy[12] have been used. These levels are summarised in Table 22.

[12] Transport for New South Wales- *Construction Noise Strategy* (April, 2012)

Table 21: Summary of predicted noise levels for construction activities

Noise Catchment Area	Noise Limits (dBA)				Predicted noise level for construction stage (dBA)															
	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance (L_{Amax})	Project preliminaries and site establishment		Flood mitigation		Roadwork and road surfacing		Drainage		Bulk earthwork		Bridge work		Piling		Finishing work	
					L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}
1	Day (standard hours)	55	75	-	62	67	-	-	61	67	66	67	62	67	61	67	51	80	58	67
	Day (outside hours)	50	55	-																
	Evening	44	49	-																
	Night	37	42	47																
2	Day (standard hours)	69	75	-	62	67	-	-	61	67	66	67	62	67	61	67	65	80	58	67
	Day (outside hours)	64	69	-																
	Evening	51	56	-																
	Night	41	46	51																
3	Day (standard hours)	63	75	-	73	77	-	-	72	77	76	77	72	77	72	77	71	90	68	77
	Day (outside hours)	58	63	-																
	Evening	46	51	-																

Noise Catchment Area	Noise Limits (dBA)				Predicted noise level for construction stage (dBA)															
	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance (L_{Amax})	Project preliminaries and site establishment		Flood mitigation		Roadwork and road surfacing		Drainage		Bulk earthwork		Bridge work		Piling		Finishing work	
					L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}
	Night	36	41	46																
4	Day (standard hours)	58	75	-	82	87	-	-	81	87	86	87	82	87	81	87	61	100	78	87
	Day (outside hours)	53	58	-																
	Evening	47	52	-																
	Night	40	45	50																
5	Day (standard hours)	54	75	-	82	87	-	-	81	87	86	87	82	87	81	87	63	100	78	87
	Day (outside hours)	49	54	-																
	Evening	44	49	-																
	Night	40	45	50																
6	Day (standard hours)	54	75	-	82	87	-	-	81	87	86	87	82	87	81	87	75	100	78	87
	Day (outside hours)	49	54	-																
	Evening	44	49	-																

Noise Catchment Area	Noise Limits (dBA)				Predicted noise level for construction stage (dBA)															
	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance (L_{Amax})	Project preliminaries and site establishment		Flood mitigation		Roadwork and road surfacing		Drainage		Bulk earthwork		Bridge work		Piling		Finishing work	
					L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}
	Night	40	45	50																
7	Day (standard hours)	49	75	-	62	67	-	-	61	67	66	67	62	67	61	67	64	80	58	67
	Day (outside hours)	44	49	-																
	Evening	47	52	-																
	Night	42	47	52																
8	Day (standard hours)	59	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Day (outside hours)	54	59	-																
	Evening	53	58	-																
	Night	46	51	56																
9	Day (standard hours)	69	75	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Day (outside hours)	64	69	-																
	Evening	51	56	-																

Noise Catchment Area	Noise Limits (dBA)				Predicted noise level for construction stage (dBA)															
	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance (L_{Amax})	Project preliminaries and site establishment		Flood mitigation		Roadwork and road surfacing		Drainage		Bulk earthwork		Bridge work		Piling		Finishing work	
					L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}
	Night	41	46	51																
10	Day (standard hours)	40	75	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Day (outside hours)	35	40	-																
	Evening	46	51	-																
	Night	42	47	52																
11	Day (standard hours)	39	75	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Day (outside hours)	34	39	-																
	Evening	41	46	-																
	Night	40	45	50																
12	Day (standard hours)	39	75	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Day (outside hours)	34	39	-																
	Evening	41	46	-																

Noise Catchment Area	Noise Limits (dBA)				Predicted noise level for construction stage (dBA)															
	Time Period	Noise Affected Level	Highly Noise Affected Level	Sleep Disturbance (L_{Amax})	Project preliminaries and site establishment		Flood mitigation		Roadwork and road surfacing		Drainage		Bulk earthwork		Bridge work		Piling		Finishing work	
					L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}
	Night	40	45	50																
13	Day (standard hours)	63	75	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Day (outside hours)	58	63	-																
	Evening	46	51	-																
	Night	36	41	46																
14	Day (standard hours)	54	75	-	-	-	84	90	-	-	-	-	-	-	-	-	-	-	-	-
	Day (outside hours)	49	54	-																
	Evening	44	49	-																
	Night	40	45	50																

The construction noise levels at the most affected residences are likely to exceed the noise affected levels in many of the catchment areas, due to the close proximity of existing residences to the construction works zones.

There is therefore potential for noise impacts during the construction process where sensitive receivers are in close proximity to construction works, particularly at residences within Grafton nearest to the roadworks at properties in Greaves Street, Pound Street, Clarence Street, Kent Street and Bromley Street.

In South Grafton, there are fewer sensitive receivers near to the construction area, with sensitive receivers in Butters Lane most likely to be impacted by general construction noise. Properties on Bent Street and Riverside drive are less likely to be impacted by construction noise, since they are already subject to relatively high levels of existing road traffic noise.

Where the noise levels exceed the noise affected level for any works outside the recommended standard hours, there is a risk of sleep disturbance, and alternative scheduling of the work or work methods used should be considered.

5.4 Ancillary sites

Ancillary sites are described in Section 5.2.4 and shown in Figure 1. A main ancillary site is likely to be located in South Grafton, where there are fewer sensitive receivers, with a smaller ancillary site likely to be required in Grafton. Depending on the specific needs of the construction contractor and the sequencing of construction, there may potentially be additional ancillary sites required.

Noise associated with each of the ancillary sites would primarily be generated from vehicle movements, although, as noted above, the South Grafton ancillary site may also incorporate batching plant and equipment. Noise from these construction compounds would likely be generated for the entire construction period.

Properties within between 100 to 150 m from the ancillary sites and stockpile areas may be subject to construction noise at levels exceeding the criteria established in Table 4. The noise from ancillary sites would therefore be most likely to affect several sensitive receivers in Clarence and Pound Streets in Grafton. However, the South Grafton site is not expected to have a major noise impact on sensitive receivers.

5.5 Stockpile areas

Stockpile areas would be required for storage of fill material, mulch and spoil. A total of eight stockpile areas have been identified for the flood mitigation works (Refer to Figure 8a–f for the location of these stockpile areas). The approximate distance between the stockpile areas and the nearest sensitive receiver is presented in Table 21.

Table 22: Distance between stockpile areas and the nearest sensitive receiver

Stockpile	Approximate distance to nearest sensitive receiver (metres)
South Grafton	
1	75
2	Immediately adjacent to residential receivers
3	35
4	15
5	17
Grafton	
6	Immediately adjacent to a non-residential receiver (Sisters of Mercy Grafton Congregation)
7	17
8	135

The location of the stockpile areas may be refined to respond to the specific needs of the construction contractor. Noise associated with the stockpile areas would primarily be generated by earthmoving equipment and heavy haulage vehicles loading and unloading.

5.6 Concrete batching plant

It is possible that a concrete batching plant would be required to build the bridge should the construction contractor opt for casting the bridge pile caps in the South Grafton ancillary site. The plant would be installed in the South Grafton ancillary site as required by the construction contractor and where external sources are unable to meet the production rates required for the project, or where on-site production would be more cost effective than importing from external sources.

Noise associated with this plant would primarily be generated from associated vehicle movements and use of plant and equipment. Noise from the plant also has the potential to impact sensitive receivers within the vicinity of the plant location. An indicative radius of 100 to 150 m has been identified as an area where construction noise criteria may be exceeded at times. As noted in Section 5.4, the South Grafton ancillary site is not expected to have a major noise impact on sensitive receivers.

5.7 Construction traffic

Construction traffic will generate noise over a relatively wide area and beyond the construction site itself. It would be expected that traffic noise would be greatest where there is a concentration of vehicle movements, such as at ancillary sites, batching plant locations and where construction is occurring at a given time.

Indicative access routes to ancillary facilities are presented in Figure 9.

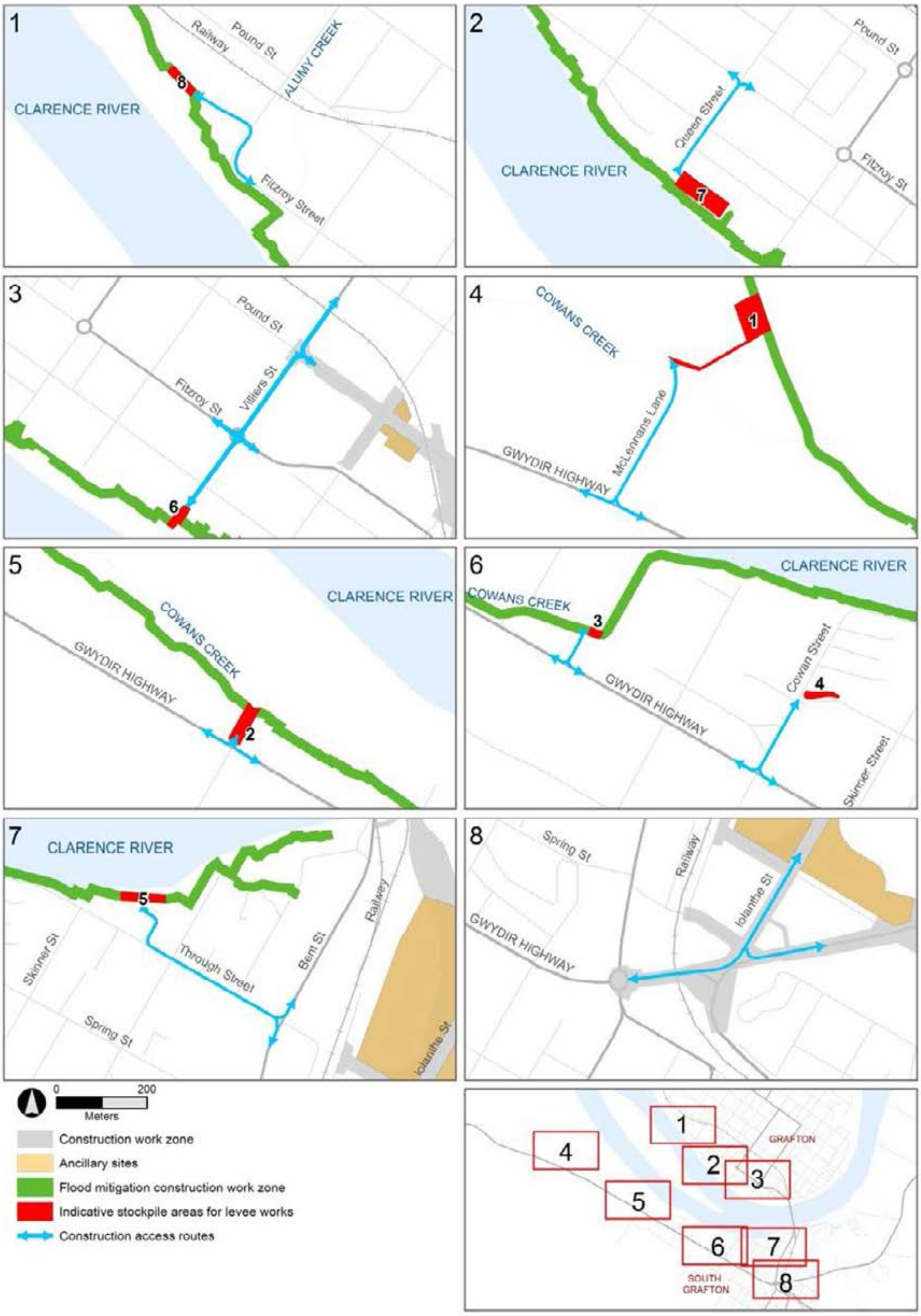


Figure 9: Indicative access routes to ancillary facilities

Indicative access routes are subject to refinement during detailed design and construction stages. At this stage of the project, indicative routes for construction traffic have been determined and are used for the construction traffic noise assessment.

About 18,700 haulage truck trips are estimated throughout the entire construction stage of the project. This implies a total average generation of around 40 trips per day, throughout the three year construction period.

The daily increase in road traffic due to the project's construction would be relatively low when compared with daily traffic demand on the existing road network (refer Section 2.2 of Appendix D, Technical Paper: Traffic and Transport). Hence, the associated change in road traffic noise during construction would be negligible. For example in order to increase traffic noise levels by 2 dB the traffic volume would need to roughly double.

Although the average impact over the three year construction period will be negligible, it is possible that the construction schedule may require higher truck traffic volumes to certain ancillary facilities for short periods. This could result in significant, noticeable noise impacts for short periods. At this stage, there is no information that can be used to quantitatively assess these impacts. Any significant noise impacts would need to be addressed in the construction noise and vibration management plan, once a detailed plan of truck trips has been prepared by the construction contractor.

5.8 Piling

Construction of the new bridge will require piling for the installation of bridge foundations on the river bed and river banks. Depending on the piling method used, this activity has the potential to cause significant noise impacts.

Hydraulic impact piling generates the highest levels of construction noise.

Based on the sound power level of typical impact piling (see Section 5.3.1) noise from piling work could be over 75 $dBL_{Aeq,15min}$ at the closest effected receivers in Greaves Street. The piling noise is likely to remain higher than the noise affected limit up to several hundred meters from the piling works, affecting sensitive receivers in Pound Street, Breimba Street, Bromley Street and Kent Street in Grafton, and Butters Lane, Bent Street and Riverside Drive in South Grafton.

Depending on the particular geotechnical properties of the ground, impact piling may be able to be undertaken at lower energies or quieter vibratory or bored piling may also be used, in some locations.

5.9 Construction vibration

The main sources of construction vibration will be as follows

- Piling in the river bed and banks
- Excavation
- Grading of existing roadways
- Demolition of houses and other structures
- Vibratory compacting of new road surfaces

Analysis of the potential vibration impacts from each of the identified construction activities is provided in the following sections. This analysis has been done for both the road works and flood mitigation works and assessed to the nearest non-aboriginal heritage and residential receiver locations.

5.9.1 Heritage listed structures

The nearest potentially affected heritage listed structures to the proposed construction works are depicted in Figure 10. These receiver locations represent the structures potentially most sensitive to vibration impacts for the project.

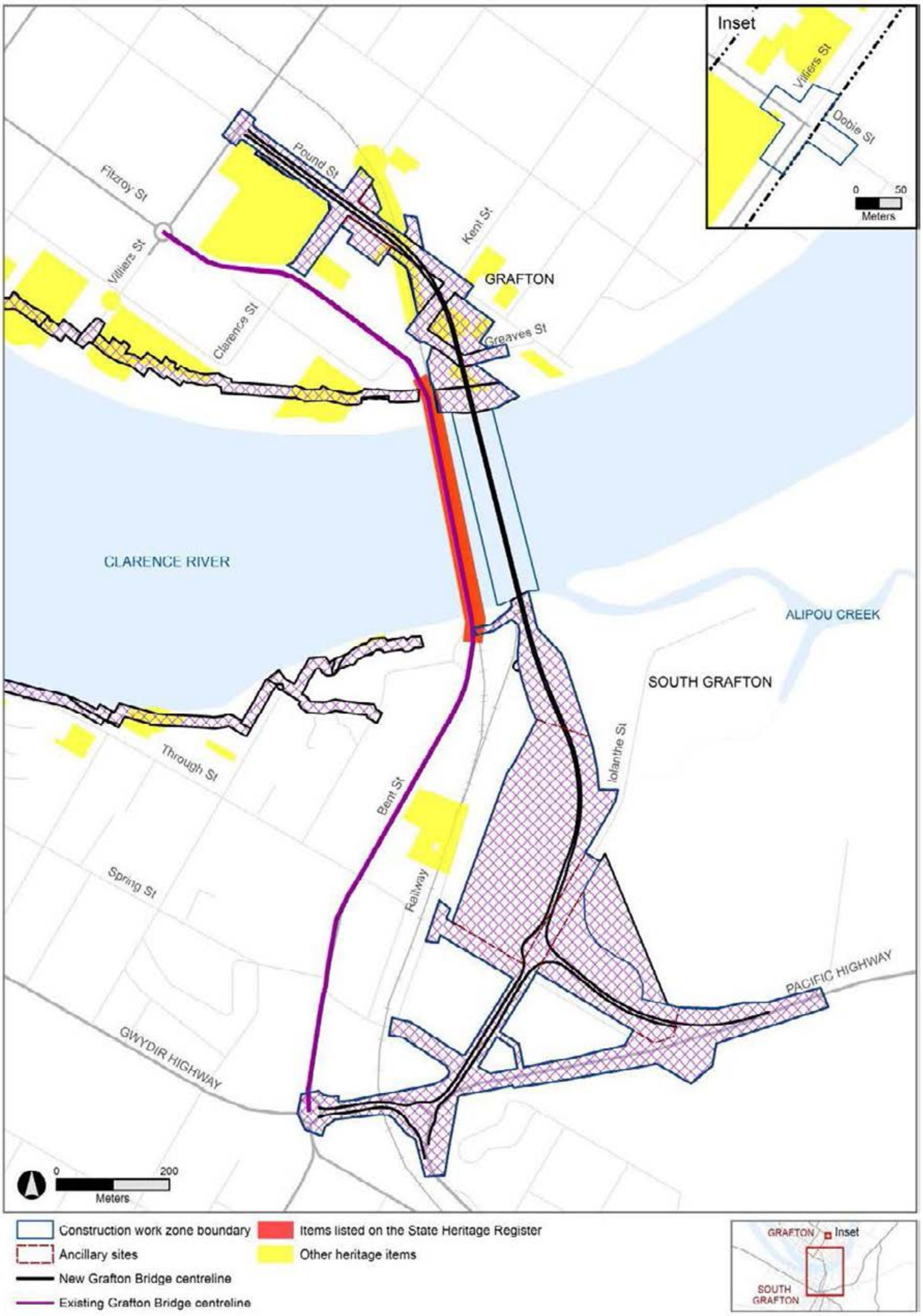


Figure 10: Map of non-aboriginal heritage items in Grafton

The nearest potentially affected State listed non-aboriginal heritage structure to the proposed new river crossing is the existing bridge, around 50 m away. At that distance, vibration from piling works, in particular will be well below the most conservative limits developed in Section 4.2.2. While vibration impacts on the bridge may still require management, it is acknowledged that the existing bridge is likely to be more structurally robust than most heritage buildings for which the criteria were derived.

5.10 Construction noise and vibration mitigation

Noise mitigation measures for each major construction activity are discussed in the following sections. These mitigation measures are considered to represent all 'feasible and reasonable' mitigation measures suitable for implementation during construction of the project.

5.10.1 General

In general, practices to reduce construction noise impacts will be required, and may include;

- Adherence to the standard approved working hours for construction projects where possible as outlined in Section 5.2.5
- Manage noise from construction work that might be undertaken outside the recommended standard hours following Section 2.3 of the Interim Construction Noise Guidelines (DECC, 2009)
- The location of stationary plant (air-compressors, generators, etc.) as far away as possible from sensitive receivers
- Using natural screening by topography wherever possible to reduce noise impacts
- Using site sheds and other temporary structures or screens to limit noise exposure where possible
- Installing operational noise barriers as early as possible to provide ongoing screening from construction activities, where possible
- The appropriate choice of low-noise construction equipment and/or methods
- Modifications to construction equipment or the construction methodology or programme. This may entail programming activities to occur concurrently where a noisy activity will mask a less noisy activity, or, at different times where more than one noisy activity will significantly increase the noise. The programming should also consider the location of the activities due to occur concurrently.
- The Draft Community Consultation Strategy prepared for the project outline methods for consultation with the community during construction including, but not limited to; advance notification of planned activities and expected disruption/effects, construction noise complaints handling procedures and effective monitoring of noise levels in and around potentially affected dwellings.

The above represents the best practical means of control. While the contractor will be able to achieve moderate reductions in noise and vibration, some impact is expected. A Construction Noise and Vibration Management Plan would be adopted for construction stages incorporating a programme of noise monitoring at sensitive receivers, a community information programme and a complaints hotline.

5.10.2 Construction noise and vibration management plan

For all construction works, the appointed contractor will be required to prepare a detailed Construction Noise and Vibration Management Plan (CNVMP). This plan should include but not be limited to the following:

- Roles and responsibilities
- Noise sensitive receiver locations
- Predicted impacts
- Mitigation strategy
- Monitoring methodology
- Community engagement strategy.

Specific engineering methods for controlling construction noise and vibration impacts relevant to this study are discussed in the following sections.

5.10.3 Universal work practices

The following noise mitigation work practices are recommended to be adopted at all times on site:

- Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise.
- Site managers to periodically check the site and nearby residences for noise problems so that solutions can be quickly applied.
- Avoid the use of radios or stereos outdoors.
- Avoid the overuse of public address systems.
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.
- Turn off all plant and equipment when not in use.

5.10.4 Maximum equipment noise levels

The Transport for New South Wales (TfNSW) Construction Noise Strategy[13] provides a framework for applying standard and additional mitigation measures for transport infrastructure construction projects. Table 22 summarises the maximum allowable noise levels for construction equipment as defined in the TfNSW Construction Noise Strategy, which could form an appropriate basis for screening machinery adopted for use on site by the construction contractor.

[13] Transport for New South Wales- *Construction Noise Strategy* (April, 2012)

Table 23: TfNSW maximum allowable noise levels for construction equipment

Equipment	Maximum Allowable Noise Level (dBA) – L_{Amax} [1,2,3]	
	Sound Power Level	Sound Pressure Level at 7 m
Excavator Hammer	122	97
Excavator (approx. 3 tonne)	90	65
Excavator (approx. 6 tonne)	95	70
Excavator (approx. 10 tonne)	100	75
Excavator (approx. 20 tonne)	105	80
Excavator (approx. 30 tonne)	110	85
Excavator (approx. 40 tonne)	115	90
Skidsteer Loaders (approx. 1/2 tonne)	107	82
Skidsteer Loaders (approx. 1 tonne)	110	85
Dozer (equiv. CAT D8)	118	93
Dozer (equiv. CAT D9)	120	95
Dozer (equiv. CAT D10)	121	96
Backhoe/FE Loader	111	86
Dump Truck (approx. 15 tonne)	108	83
Concrete Truck	112	87
Concrete Pump	109	84
Concrete Vibrator	105	80
Bored Piling Rig	110	85
Scraper	110	85
Grader	110	85
Vibratory Roller (approx. 10 tonne)	114	89
Vibratory Pile Driver	121	96
Impact Piling Rig	134	109
Compressor (approx. 600 CFM)	100	75
Compressor (approx. 1500 CFM)	105	80
Concrete Saw	118	93
Jackhammer	113	88
Generator	104	79
Lighting Tower	80	55
Flood Lights	90	65
Cherry Picker	102	77
Mobile Crane	110	85

Notes:

1. The Sound Power Level (SWL) represents the total noise output of the plant of equipment. The SWL is normally used in computer noise models to predict the Sound Pressure Levels (SPLs) at nearby receivers. When undertaking site compliance measurements, it is normally the SPL that is measured at a specified distance (typically 7m) from the plant or equipment.
2. The SWLs presented in the above table have been compiled from a selection of field measurements conducted by Heggies Pty Ltd between 2004 and 2006 of plant and equipment operating on construction projects throughout NSW and are therefore considered to be representative of plant and equipment SWLs which are readily achieved by current plant and equipment normally used in the construction industry.
3. Plant and equipment with SWLs higher than those presented in the table would be deemed to be emitting an excessive level of noise and should not be permitted to operate on construction sites.

5.10.5 Piling

To reduce the effect on residents of piling noise, nearby residents should be consulted regarding the intended activities associated with the piling process.

Mitigation measures to reduce the impact of percussive piling activities include:

- Using a resilient pad (dolly) between pile and hammer head
- Enclosing the hammer head in a temporary acoustic shroud.

Alternatively, rotary bored or vibro-piling may be used where consistent with the type of pile used and restrictions on soil disturbance.

Piling, in particular, should not be undertaken outside of the standard working hours.

5.10.6 Noise level reductions from mitigation

Indicative noise reduction for different noise mitigation measures relevant to construction activities for the project have been obtained from the guidance of AS2436 and BS5228.1, as summarised below in Table 23.

Table 24: Indicative noise reduction provided by noise mitigation measures

Construction Equipment	Noise Mitigation Measure	Indicative Noise Reduction	Source
Jackhammer	Muffler and screen	20 dBA	Table C2 AS2436:2010
Compressor Cement mixers Hand-held tools	Screening	5 dBA	Table C3 AS2436:2010

Construction Equipment	Noise Mitigation Measure	Indicative Noise Reduction	Source
Excavators/loaders Trucks Mobile cranes Asphalt paver Bulldozers Road graders Rollers/compactors	Residential-grade silencer	10 dBA	Table C2 AS2436:2010 Table B1 BS5228.1:2009
Excavator with hammer attachment	Residential-grade silencer Screening of hammer attachment	15 dBA	Table C2 AS2436:2010
Piling impact	Resilient pad (dolly) between pile and hammerhead	10 dBA	Table C2 AS2436:2010 Table B1 BS5228.1:2009

5.10.7 Vibration

The TfNSW guidance also provides recommended safe working distances for vibration intensive plant. These are based on international standards and guidance and reproduced in Table 24 below for reference.

Table 25: TfNSW recommended safe working distances for vibration intensive plant

Plant Item	Rating / Description	Safe Working Distance	
		Cosmetic Damage (BS 7385)	Human Response (OH&E Vibration Guideline)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Note: More stringent conditions may apply to heritage or other sensitive structures

Mitigation will therefore need to be considered where sensitive receivers are located closer to the construction work zone than these 'safe working distances'.

6 Operational road traffic noise assessment

6.1 Noise catchment areas

This assessment has considered noise catchment areas in Grafton and South Grafton. The broad noise catchment areas considered in this assessment are shown in Figure 4.

6.2 Traffic modelling parameters

Traffic modelling parameters and figures are discussed in detail in the traffic and transport assessment prepared for the project's EIS (Arup, 2014). All indices and parameters used in the acoustic study are based on the existing traffic model prepared for the project.

6.2.1 Main river crossing alignments

In order to assess the future road traffic noise impacts for the project, projected traffic flow data for both the 'no-build' (also known as 'Future Existing') and 'build' options have been used. For both scenarios, modelling has been undertaken for the assumed year of opening (i.e. 2019) and ten years after operation (i.e. 2029).

The extents of road traffic noise modelling were agreed with Roads and Maritime and are depicted in Figure 4. This generally constitutes the main alignment of both the existing and additional river crossings from Villiers Street through to the Gwydir / Pacific Highway.

A summary of the annual average flows used in the noise model for both the existing and additional river crossing is presented in Table 25 for reference.

Table 26: Projected traffic flows used in noise model

Road Section Name	Direction	No Build Day of opening 2019				No Build 2029				Build Day of opening 2019				Build year 2029			
		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)	
		Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles
Bent St - south ramp to Through St	N	1193	94	119	18	1623	128	163	24	533	43	54	8	724	57	72	11
Bent St - south ramp to Through St	S	813	65	82	12	1086	86	109	16	204	17	21	3	229	18	23	4
Bent St - Spring St to Gwydir Highway	N	903	69	59	9	1207	93	79	12	329	26	21	4	442	34	29	5
Bent St - Spring St to Gwydir Highway	S	622	48	40	7	832	64	54	9	3	1	1	0	11	1	0	1
Bent St - Through St to Spring St	N	1008	78	66	10	1456	112	94	15	335	26	22	4	467	36	30	5
Bent St - Through St to Spring St	S	722	56	46	8	1037	80	67	11	123	10	8	2	26	2	1	1
Craig St	N	1204	95	121	18	1379	109	139	20	539	43	54	8	727	58	73	11
Craig St	S	444	35	44	7	519	41	52	8	375	30	37	6	426	34	42	7
Existing Bridge	N	1193	94	119	18	1623	128	163	24	533	43	54	8	724	57	72	11

Road Section Name	Direction	No Build Day of opening 2019				No Build 2029				Build Day of opening 2019				Build year 2029			
		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)	
		Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles
Existing Bridge	S	813	65	82	12	1086	86	109	16	204	17	21	3	229	18	23	4
Existing bridge - north ramp	N	1193	94	119	18	1623	128	163	24	533	43	54	8	724	57	72	11
Existing bridge - north ramp	S	813	65	82	12	1086	86	109	16	204	17	21	3	229	18	23	4
Existing bridge - south ramp	N	1193	94	119	18	1623	128	163	24	533	43	54	8	724	57	72	11
Existing bridge - south ramp	S	813	65	82	12	1086	86	109	16	204	17	21	3	229	18	23	4
Gwydir Highway - Bent St to Pacific Highway	E	-	-	-	-	-	-	-	-	558	43	36	6	894	69	58	9
Gwydir Highway - Bent St to Pacific Highway	W	-	-	-	-	-	-	-	-	614	47	39	7	800	62	52	8
Option C - Bridge	N	-	-	-	-	-	-	-	-	659	52	66	10	900	71	91	13

Road Section Name	Direction	No Build Day of opening 2019				No Build 2029				Build Day of opening 2019				Build year 2029			
		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)	
		Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles
Option C - Bridge	S	-	-	-	-	-	-	-	-	609	48	61	9	858	68	86	13
Option C - Iolanthe St	N	-	-	-	-	-	-	-	-	659	52	66	10	900	71	91	13
Option C - Iolanthe St	S	-	-	-	-	-	-	-	-	609	48	61	9	858	68	86	13
Option C - Pacific Highway	N	-	-	-	-	-	-	-	-	842	67	84	13	1080	85	108	16
Option C - Pacific Highway	S	-	-	-	-	-	-	-	-	923	73	92	14	1213	96	122	18
Option C - Pound St	N	-	-	-	-	-	-	-	-	771	61	77	12	1026	81	103	15
Option C - Pound St	S	-	-	-	-	-	-	-	-	610	49	61	9	855	68	86	13
Pacific Highway - North of Option C	N	-	-	-	-	-	-	-	-	247	30	29	11	375	45	44	17
Pacific Highway - North of Option C	S	-	-	-	-	-	-	-	-	390	47	46	18	568	69	68	25

Road Section Name	Direction	No Build Day of opening 2019				No Build 2029				Build Day of opening 2019				Build year 2029			
		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)		day 15hr (hourly average)		night 9hr (hourly average)	
		Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles	Cars	Heavy Vehicles
Pacific Highway - South of Gwydir Highway	N	-	-	-	-	-	-	-	-	564	44	37	6	693	53	45	7
Pacific Highway - South of Gwydir Highway	S	-	-	-	-	-	-	-	-	572	44	37	6	758	58	49	8

6.3 Modelling methodology

The noise model is based upon the Concept Design alignment for the proposed bridge and road system, and may be updated and refined during the detailed design process.

Acoustic modelling has been undertaken in accordance with Roads and Maritime guidelines[1] as well as international best practice[14]. Predictions have been made using the Calculation of Road Traffic Noise[15] (CoRTN) model within the SoundPLAN 7.3 software suite. Guidance on acoustic modelling best practice has been obtained from the WG-AEN[14] position paper as appropriate.

CoRTN predicts an L_{A10} single number value (either $L_{A10,\ 1\ hour}$ or $L_{A10,\ 18\ hour}$) at a distance of 10 m from the edge of the road. For continuous traffic flows, based on past project experience and baseline measurements conducted for this study, L_{A10} has been found to be approximately 3 dB(A) higher than L_{Aeq}, and therefore the predicted L_{A10} values have been corrected to L_{Aeq} values using this correlation.

Single point receiver calculations have been made at a height of 1.5 m above the worst affected storey on the most exposed facade of the receiver. Noise levels have been predicted at 1 m from the receiver façade and a +2.5 dB façade correction has been applied to take account of reflections of sound from the façade.

In accordance with Road and Maritime guidelines, the modelling procedure has segregated source height and components for the exhaust and engine of heavy vehicles. The road source was modelled using source heights of 0.5 m, 1.5 m and 3.6 m above ground level. The source height of 0.5 m corresponds to the noise sources from light vehicles. The heavy vehicle noise source is split into 1.5 m and 3.6 m source heights. The 3.6 m source, which represents heavy vehicle exhaust noise sources, is 8 dB(A) below the 1.5 m source. The total of the 1.5 m and 3.6 m sources is equal to the total heavy vehicle source level as defined in CoRTN.

A summary of the modelling parameters is included below in Table 26.

Table 27: SoundPLAN input parameters

Input	Detail
Traffic speed	Design Speed (Posted): New bridge 60 km/hr All existing roads 50 km/hr
Source height (above ground level)	Cars 0.5 m Truck Engine and Transmission 1.5 m Truck Exhaust 3.6 m
Road surface	Dense Graded Asphalt – no road surface correction applied

[14] WG-AEN Position Paper – *Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure* (January, 2006).
[15] UK Department of Transport – *Calculation of Road Traffic Noise* (1988).

Input	Detail
Methodology	Department of Transport, Welsh Office, Calculation of Road Traffic Noise, 1988
CoRTN calibration for Australian conditions[16]	-1.7 dB, 1 m in front of building façade -0.7 dB, free field locations
Façade correction	+2.5 dB
Terrain data	1 m contours
Building heights	As per WG-AEN position paper.
Building footprints	Buildings from aerial photography and surveys on site
Noise receiver height	4.5 m above ground level to assess 2nd storey (i.e. worst affected) facades
Traffic Volumes	Traffic volumes for 2019 (year of opening) and 2029 (design year) summarised in Section 6.2

6.4 Modelling validation

The measured noise data presented in Table 2 has been used to validate the current SoundPLAN model for the project. Road traffic noise level calculations were performed based on the hourly traffic count data measured concurrently with the noise logging at each respective noise logger location.

Noise logging locations where the dominant noise source was road traffic from the existing river crossing and approaches were used for validation purposes in order to accurately validate the road traffic noise levels. Validation of the noise logging location at Pound Street included traffic flows measured on Pound Street as well as the main alignments.

On the basis of the validation, a +2.5 dB correction was applied to the model to account for local conditions.

The validation results are presented below in Table 27.

Table 28: Comparison of predicted and existing noise levels

Reference Location	Address	Daytime Road Traffic Noise Level (dB $L_{Aeq, 15hour}$)		Change dB(A)	Night time Road Traffic Noise Level (dB $L_{Aeq, 9hour}$)		Change dB(A)
		Measured	Modelled		Measured	Modelled	
1	Villiers Street, near TAFE, Grafton	66	65.8	-0.2	58	58.7	+1.7
3	8 Fitzroy Street, Grafton	59	61.0	+2.0	53	51.6	-1.4

[16] Saunders et al, *An evaluation of the U.K DoE Traffic Noise Prediction Method*, Australian Road Research Board Research Report, 1983

Reference Location	Address	Daytime Road Traffic Noise Level (dB $L_{Aeq, 15hour}$)		Change dB(A)	Night time Road Traffic Noise Level (dB $L_{Aeq, 9hour}$)		Change dB(A)
		Measured	Modelled		Measured	Modelled	
5	12 Bent Street, Grafton Aged Care Home, South Grafton	68	66.1	-1.9	59	59.8	+0.8

On the basis of the good correlation between modelled and measured levels for both the daytime and night time periods for noise impacts from the existing alignment, the SoundPLAN model created is considered robust in accordance with Roads and Maritime guidelines[1].

6.5 Traffic noise level assessment

Noise levels have been predicted at individual residential receivers and other sensitive land uses along the existing and proposed alignment. The noise level predictions were made both for daytime (7am - 10pm, 15hr) and night-time (10pm - 7am, 9hr) for two future scenarios; without the project (termed the 'no-build' scenario), and with the project (termed the 'build' scenario). The road traffic noise levels for both the 'no-build' and the 'build' scenario have been predicted for two future periods.

- Year of opening ie 2019
- 10 years after opening ie 2029.

The *base case* assumes a dense graded asphalt (DGA) wearing surface with a pavement noise level correction of +0 dB.

Noise contour plots for these prediction scenarios are shown in noise contour maps in Appendix E.

Table 29: Traffic noise level contour plots, shown in Appendix E

Day/Night	Year	Description
Day	2019	'no build'
Night	2019	'build'
Day	2029	'no build'
Night	2029	'build'

The results for individual receivers are shown in Appendix F. The applicable noise criteria have been determined for each property individually based on the requirements of Practice Note I of the ENMM.

Generally, the need for noise mitigation is required to be assessed if:

- The predicted noise level in the year of opening or 10 years after opening is above the absolute day or night-time noise limits provided in the RNP (ie 55 $dBL_{Aeq,15hr}$ or 50 $dBL_{Aeq,9hr}$ respectively for residential receivers),

OR

- The predicted change in noise level from the 'no-build' to the 'build' scenario at either 2019 or 2029 is greater than 12 dB

OR

- The noise level is 'Acute', (ie > 65 $dBL_{Aeq,15hr}$ daytime, > 60 $dBL_{Aeq,9hr}$ night-time).

Based on the EIS Concept Design for the scenarios described above, 93 properties have been identified which exceed these noise trigger levels in the RNP, or exceed the ENMM 'acute' noise levels (see Appendix F).

Of these affected properties, 47 (from which 34 are residential properties in Grafton, three are residential properties in South Grafton, nine are buildings within the TAFE and one is the Gummyaney Aboriginal Preschool) have been determined to qualify for mitigation. Maps showing indicative locations that would qualify for mitigation are shown in Appendix G.

Note that these figures are based on the EIS Concept Design. In accordance with the ENMM, RMS will undertake further noise modelling during detailed design to determine the extent of affected properties based on the final design. The final design results will be used to determine appropriate levels of mitigation provided for affected properties in accordance with the ENMM.

6.6 Operational Vibration Assessment

Operational vibration from road traffic movements is low because the vehicles are generally well isolated from the ground by pneumatic tyres and vehicle suspension systems. Operational vibration due to the project is therefore not expected to be above perceptible levels at any of the sensitive receivers.

6.7 Analysis of 'feasible and reasonable' noise mitigation

Practice Note IV of the RTA ENMM provides a detailed procedure for *'selecting and designing "feasible and reasonable" treatment options for road traffic noise'* that is aimed at providing a consistent approach to the evaluation, selection and design of appropriate noise control options. In particular, Practice Note IV Part (a) provides a detailed cost/benefit analysis of noise barrier options, including the level of noise reduction achieved, the number of residences protected and the typical installed cost of noise barriers.

This section of the report provides the analysis of road traffic noise mitigation options for the concept design alignment, in strict accordance with Practice Note IV. RMS will undertake further noise modelling and analysis during detailed design to determine the extent of noise mitigation provided for affected properties.

In accordance with Practice Note IV, noise barriers are not considered feasible and reasonable where affected residences are grouped in numbers of three or less. This is the situation for many of the properties on this route, for example those properties located on Clarence Street and Villiers Street. Therefore, architectural treatment should be considered for the majority of affected residences.

As noted in Table 26, the road surface used as the basis of the analysis is dense graded asphalt. At this stage, low-noise road surfaces (such as stone mastic asphalt) have not been considered for mitigation, since these provide relatively small benefits at the typical road traffic speeds being considered in this assessment.

For the cluster of receivers within the noise catchment area around Pound Street, Kent Street and Greaves Street in Grafton which exceed noise trigger levels in the RNP, or exceed the ENMM 'acute' noise levels, the provision of a noise barrier on the bridge and embankment has also been evaluated. The indicative location of a noise barrier for this catchment is shown in Appendix H.

The predicted effectiveness of this noise barrier, for varying heights, has been analysed. The *target*[17] *barrier* option has been calculated in accordance with Practice Note IV(a) *Noise barrier heights*.

The target noise level of 50 dB(A) cannot be met with a barrier less than or equal to 8 m high. According to the ENMM it is therefore not feasible or reasonable to provide a noise barrier as it will not achieve the necessary noise reduction.

However, as a noise reduction of up to 3 dB can be achieved with a 310 m long barrier for the most affected property the *assessed barrier*[18] could still be considered. As shown in Figure 11 and Figure 12, the assessed barrier in this situation is approximately 3.0 m high above the road surface. With this barrier the highest marginal benefit value can be achieved. The noise reduction with this barrier will be 2 dB at the most affected property.

[17] The target barrier is the noise barrier having the height required to meet the RNP target noise levels.

[18] The assessed barrier is the noise barrier having the height that provides the greatest marginal noise reduction benefit and the greatest benefit per unit of barrier area.

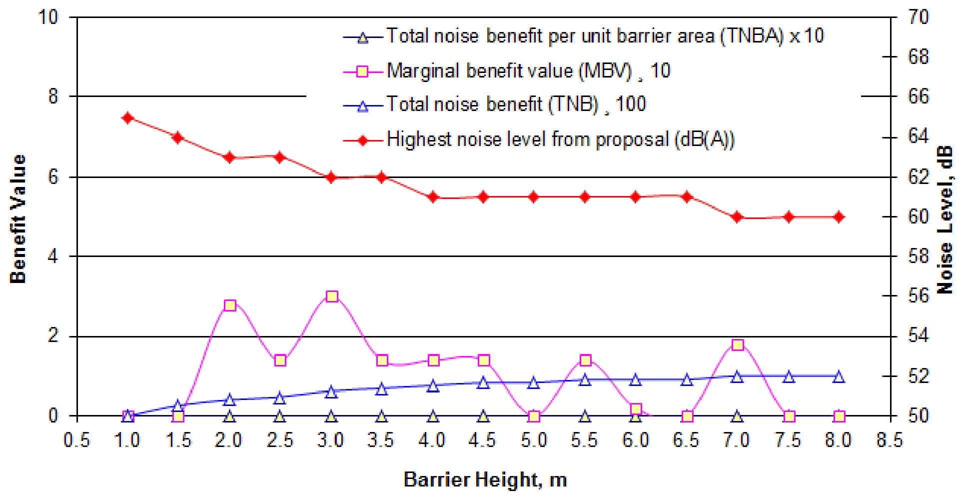


Figure 11: Practice Note IV day time barrier assessment

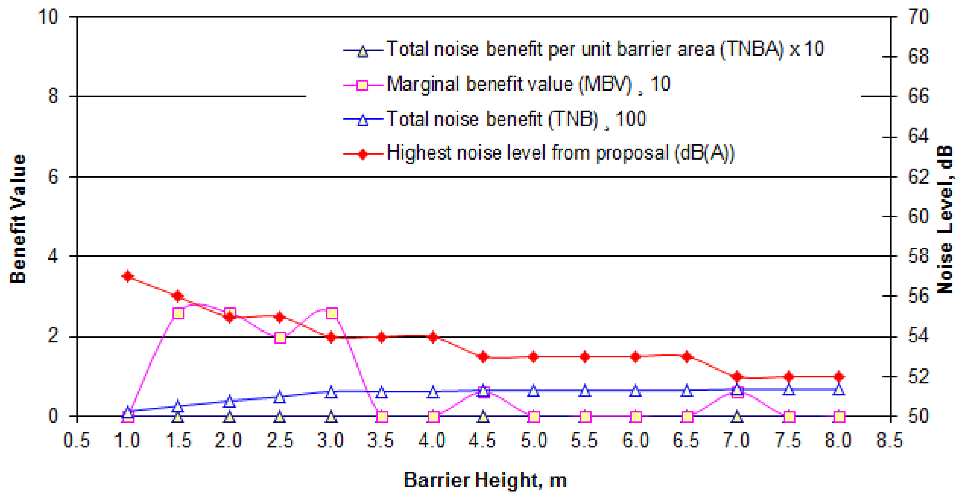


Figure 12: Practice Note IV night time barrier assessment

An analysis of the cost-effectiveness of the proposed barrier *in conjunction* with architectural treatments suggests that architectural treatment is also considered to be cost effective for these properties.

6.7.1 Summary of road traffic noise mitigation options

The operational traffic noise assessment found that architectural treatment will be required at approximately 47 properties (see Appendix G for locations) which exceed noise trigger levels in the RNP, or exceed the ENMM 'acute' noise levels. The number of properties requiring architectural treatment will be refined and confirmed after project approval and once the project detailed design is developed.

The form of the architectural treatment to be implemented on each property is to be agreed with the individual property owners, and will be undertaken in accordance with the ENMM. Architectural noise treatments on heritage listed properties will need to be undertaken in a sympathetic manner to minimise impact upon the significance of the heritage item.

Architectural noise treatments may include one or a combination of the following:

- Upgraded glazing
- Doors and window seals
- Provision of fresh air ventilation/air-conditioning.

The reduction in noise level that will be achieved by these treatments will depend on the structure type and condition of the existing building, but the treatments could achieve an improvement of between 10 and 15 dB(A) indoors.

A noise barrier is proposed for the noise catchment area around Pound Street, Kent Street and Greaves Street in Grafton. The noise assessment indicates that the target noise levels cannot be met even with an 8 m high barrier, and as such, the barrier was not considered feasible in strict accordance with Practice Note IV (for a barrier greater than 5 m high to be considered reasonable and feasible, it must provide at least 10 dB(A) attenuation). Nevertheless, the *assessed* barrier was calculated to be 3.0 m high and does provide some level of noise reduction. The extent, height and type of noise barrier will be refined after project approval and once the project detailed design is developed.

It is also recommended that architectural treatment be provided in conjunction with the noise barrier for properties that exceed noise trigger levels in the RNP, or exceed the ENMM ‘acute’ noise levels.

7 Maximum noise level assessment

Maximum noise levels were assessed in accordance with Practice Note III of the RTA Environmental Noise Management Manual.

One of the major causes of maximum noise level events is the use of engine brakes on heavy vehicles. Engine compression braking (ECB), also known as exhaust braking or the use of ‘jake brakes’, is a secondary braking system which is present on most heavy vehicles. Engine compression brakes dissipate the vehicle’s kinetic energy by opening the exhaust valves near the top of the compression stroke, releasing stored energy in the cylinder, which causes the characteristic sound. Engine compression brakes are used to reduce the strain placed on the vehicle’s conventional braking system, and is commonly used when descending steep grades. Reduced usage of the conventional braking system also lowers maintenance costs through reduced brake wear. The fitting of ECB systems to heavy vehicles leads to higher vehicle efficiency, productivity and safety.

However, engine brake noise is a significant source of community complaint regarding the heavy vehicle industry. This is due to the low-frequency nature of the noise, which has relatively low attenuation with propagation distance, and also the characteristic sound.

In 2006, Arup undertook an investigation into compression braking noise levels on behalf of Roads and Maritime (then RTA). The aim of the study was to quantify the incidence of engine braking events and loudness on roads of varying gradient.

A brief summary of mean measured maximum noise levels for all downhill events is provided in Figure 13 below for reference.

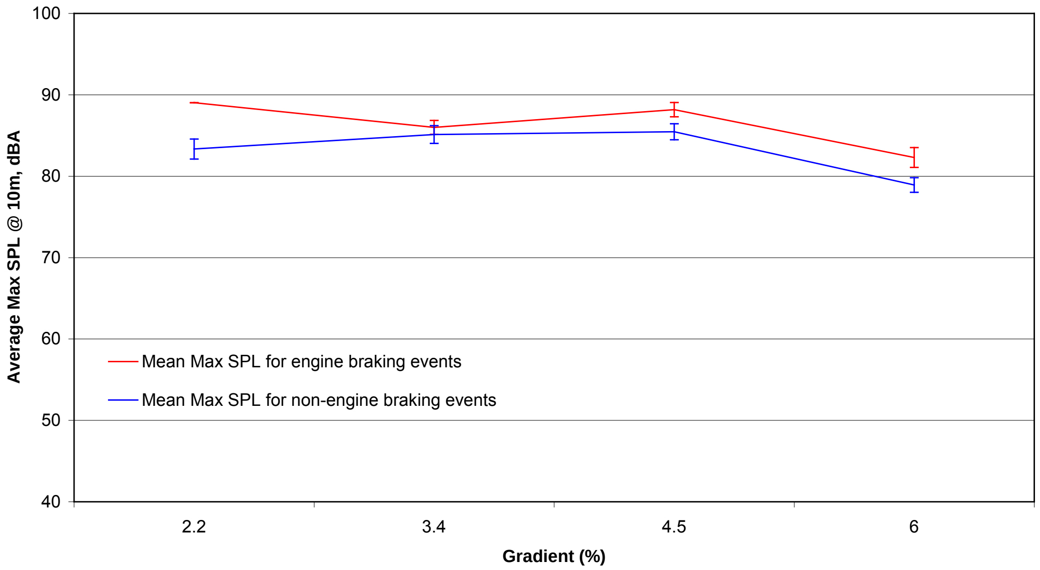


Figure 13: Mean max SPL for all downhill events

Figure 13 shows that there is typically, little difference (around 1–3 dB) between noise levels from engine braking events and non-engine braking events. This shows good correlation with a study which was carried out by the Environmental and Resource Management Group of HDR in Minneapolis, USA, which concluded that peak noise levels due to engine compression braking were 2 dB higher than typical heavy vehicle pass-by noise levels[19]. Further, there is no obvious correlation between increased gradients and higher maximum noise levels.

Based on the data obtained during the study, an average maximum noise level of 88 dB(A) at 10 m has been used to assess potential maximum noise level impacts from ECB.

On the basis that maximum *internal* noise levels below 50–55 dB(A) are unlikely to cause awakening reactions, external noise levels of 65 dB(A) or less are likely to be acceptable. This maximum noise level would be experienced by unshielded properties up to approximately 150 m from the road alignment.

On the basis of the predicted heavy vehicles movements shown in Table 25, above, the typical number of maximum noise level events from heavy vehicle movements, and the event noise level (L_{Amax}) at the most effected receiver in each of the noise catchment areas is shown in Table 30.

Table 30: Typical number of night-time noise events at sensitive receivers in the noise catchment areas for the no build and build scenarios

Noise Catchment Area	No Build		Build			
	Existing Bridge		Existing Bridge		New Bridge	
	Number of events (night)	Event noise level (L_{Amax})	Number of events (night)	Event noise level (L_{Amax})	Number of events (night)	Event noise level (L_{Amax})
1	352	84	124	84	229	62
2		84		84		66
3		86		86		70
4		86		86		78
5		65		65		80
6		68		68		76
7		60		60		63

Overall, the number of maximum noise events is not expected to increase due to the construction of the new bridge. However, the number of maximum noise level events at locations near to the existing bridge is expected to reduce following construction due to the expected shift in heavy vehicle movements to the new bridge. Catchments 5, 6 and 7 will experience and increase in maximum noise levels due to the closer proximity of the new bridge.

[19] Environmental Noise Analysis for the Reconstruction of I-35 in Duluth, Minn., by Beth Regan, C.I.H., Timothy Casey, Q.E.P., and Mike Parsons

8 Rail noise assessment

In order to provide sufficient vertical clearance on Pound Street beneath the railway line, the existing railway viaduct overpass at Pound Street will require replacement. It is proposed to replace the existing section of viaduct with a steel-concrete composite bridge. This will incorporate rail tracks on sleepers and ballast laid on the concrete deck slabs, supported by steel cross beams, and steel trusses.

This type of bridge structure has the potential to result in marginally increased noise emission from the railway, compared to noise from trains using the existing concrete bridge structure. A discussion of potential acoustic impacts associated with the redeveloped bridge is provided below.

8.1 Elevated railway structures

When a train passes over an elevated railway structure there is an increase in noise due to the transmission of vibration into the structure which results in Structure Radiated Noise (SRN) from the bridge that will not be present when a train passes over track at grade.

Additional structure radiated noise from bridges is dependent on two factors:

- The type of bridge structure (i.e. concrete, steel or composite structures)
- The dynamic stiffness of the rail fastening system (i.e. resilient, non-resilient, ballasted track)

The UK Calculation of Railway Noise[20] (CRN) methodology recommends SRN corrections for bridges and these are reproduced in Table 30 below.

Table 31: Corrections for Structure Radiated Noise Included in the CRN Methodology

Type/Description	Correction Factor dB(A)
Concrete bridges and viaducts	+1
Steel bridges	+4
Box girder with rails fitted directly to girder + orthotropic slab. Rail bearer + cross girder +lattice girder	+9

Although steel-concrete composite viaducts have been found to result in increases in structure radiated noise, experience of noise from viaducts would suggest that corrections of +4 dB(A) and +9 dB(A) are excessive for the type of viaduct that is proposed.

It is expected that the correction for the proposed steel-concrete composite viaduct, if fitted with resilient track-fixings, would fall within the range of 1 to 4 dB, somewhere between the correction for an all-concrete viaduct and an all-steel bridge.

[20] UK Department of Transport: *Calculation of Railway Noise* (1995)

8.2 Rail noise predictions

A preliminary assessment of rail noise has been undertaken in order to assess the potential increase in noise level at the nearest residential receiver due to the upgrade. This assessment has been made based on the following assumptions:

- Parapets on the new bridge will be comparable to those on the existing viaduct structure. Attenuation of airborne noise impacts from wheel-rail interface will therefore remain similar.
- The overall A-weighted noise (structure noise and rolling noise) from the proposed steel bridge is likely to be between 1 and 4 dB higher than the existing concrete bridge (depending on the track fixing used on the proposed bridge). +4 dBA has been used as a conservative estimate.

Based on the above assumptions, calculations have been made of the potential increase in overall noise level at the nearest residential receiver due to the replacement of the viaduct section over Pound Street. This increase is predicted to be approximately 1.8 dBA. This is within the maximum allowable increase as stipulated in RING (refer Section 4.4.1).

Reradiated groundborne noise and vibration is expected to remain the same or improve on existing levels with the upgrade.

Notwithstanding the above predictions, care should be taken during detailed design to ensure that the redeveloped section of rail is equal or better than the existing construction and that no additional impact noise is introduced into the system via expansion joints or similar.

9 Industrial noise assessment

The proposed stormwater management system on Pound Street has been designed to allow flood-free access to the new bridge in a 20-year average recurrence interval flood event and includes a pump station to extract water from a detention basin and convey it to the Clarence River.

While the operation of the pump station is only expected in the event of an emergency, it will be necessary to carry out maintenance testing of associated plant and equipment (i.e. industrial pumps).

The current proposed location of the pump house is depicted in Figure 14, and is approximately 50 m from the nearest properties on Greaves Street.

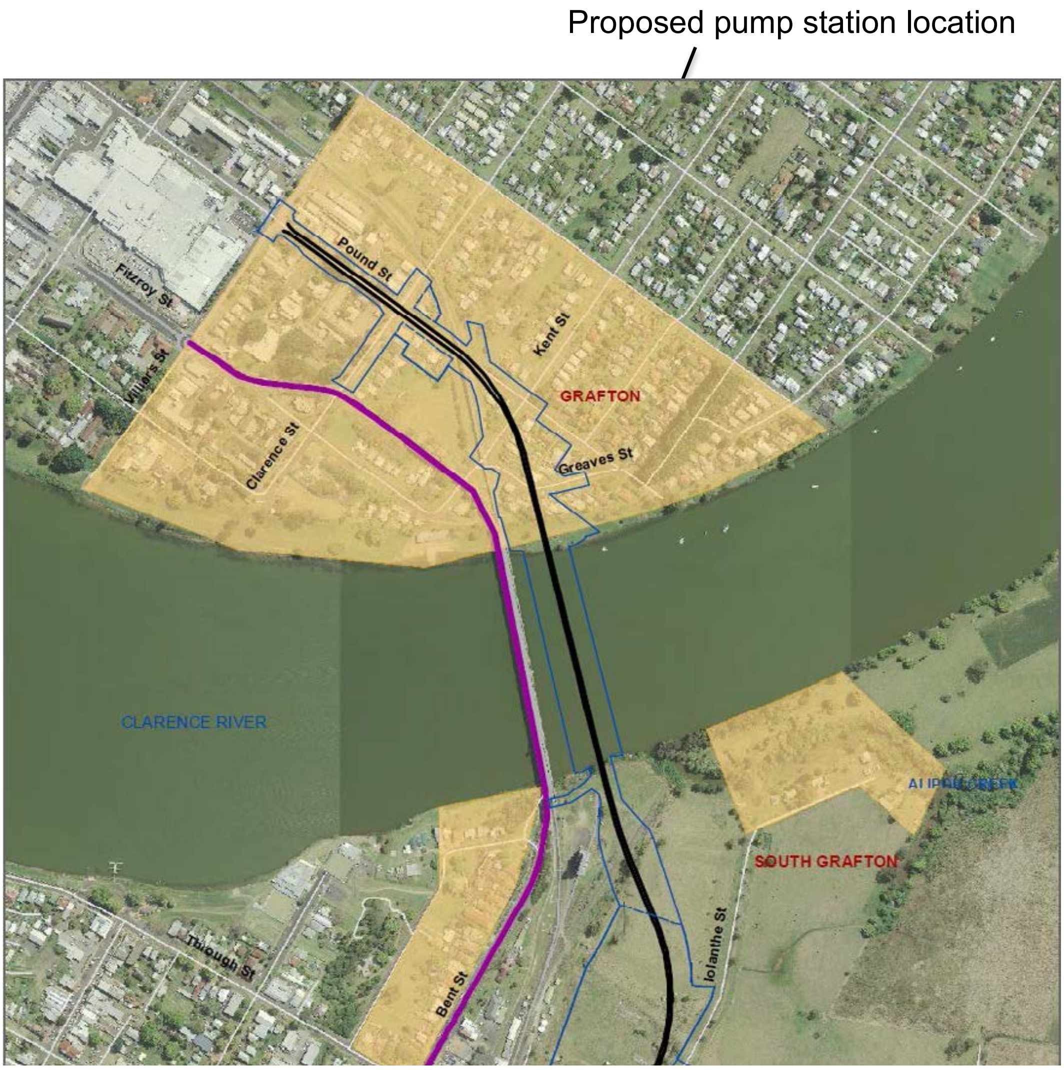


Figure 14: Proposed pump station location

At this stage of the project, specific details as to the construction of the pump station enclosure and necessary pumps and mechanical plant required to extract the floodwater are not available. However, it is likely that the pumps will be installed underground and run from mains electricity, with a backup generator available for emergency use.

It will be necessary during detailed design to ensure that the design of the pump station is sufficient to maintain the industrial noise criteria defined in Section 4.5.5 of this technical paper.

9.1 Pump station noise mitigation measures

Given the nature of the pumping station equipment, and the fact that it will usually only run during flooding events, significant noise impacts from its operation are not expected. Nevertheless, the pump station building may require some noise mitigation to ensure that noise emissions during regular maintenance and testing comply with the Industrial Noise Policy.

This would likely include careful selection of the equipment, including acoustic enclosures, if appropriate, and acoustic treatment for the pump station building and ventilation systems.

10 Conclusion

Noise and vibration from the construction and operation of the proposed additional crossing of the Clarence River at Grafton has been assessed in accordance with the Director General's Requirements.

The construction noise and vibration assessment indicates that noise from the general construction works may impact on sensitive receivers that are close to the construction works zone and the ancillary site in Grafton. The works zone and ancillary site in South Grafton are likely to have much less impact, since there are few sensitive receivers in close proximity.

If impact piling is required, it is likely to have the highest noise impact, and consideration should be given to using piling methodologies that result in lower noise emissions, such as bored piling, if geotechnical conditions permit.

To limit potential noise impacts on sensitive receivers, construction work should only be undertaken outside of normal working hours in special circumstances.

Vibration from the construction work, and particularly from impact piling works for the bridge foundation are not likely to adversely impact on sensitive receivers.

The noise modelling indicates that up to 93 receivers will exceed the noise trigger levels in the RNP, or exceed the ENMM 'acute' noise levels as a result of the project operation. Of those affected properties, 47 would be considered for noise mitigation.

An analysis of 'feasible and reasonable' noise mitigation options, in accordance with Practice Note IV of the ENMM, indicates that 3.0 m high barrier on the bridge ramp, in conjunction with architectural treatment, is an option to mitigate noise impacts.

Appendix A

Acoustic Terminology

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 L_{A90} 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.

dB(A)

dB(A) 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 dB(A).

Some typical dB(A) levels are shown below.

Noise Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside nightclub
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

L_1

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 dB(A) or higher for 1% of the 15 minute measurement period.

L_{10}

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 dB(A) or higher for 10% of the 18 hour measurement period.

L_{90}

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 dB(A) or higher for 90% of the 15 minute measurement period.

L_{eq}

The 'equivalent continuous sound level', L_{eq}, is used to describe the level of a time-varying sound or vibration measurement.

L_{eq} 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 dB(A) weighting is applied, the level is denoted dB $L_{Aeq.}$ Often the measurement duration is quoted, thus $L_{Aeq,15\ min}$ represents the dB(A) weighted energy-average level of a 15 minute measurement.

L_{max}

The L_{max} statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time.

Mathematically, L_{max} is the highest value recorded during the measurement period. As an example, 94 dB L_{Amax} is a highest value of 94 dB(A) during the measurement period.

Since L_{max} is often caused by an instantaneous event, L_{max} 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".

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 criteria, and is often interpreted as a PPV based on the L_{max} or $L_{max,spec}$ index.

Sound Exposure Level (SEL)

The Sound Exposure Level or Single Event Noise Exposure Level, denoted SEL or L_{AE}, is a measure of the total amount of acoustic energy contained in an acoustic event. The SEL is the constant sound pressure level that would produce in a period of one second the same amount of acoustic energy contained in the acoustic event. SEL is commonly used to quantify the total acoustic energy contained in transient events such as a vehicle pass-by.

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.

Structureborne Noise

The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structureborne noise is controlled by structural discontinuities, i.e. expansion joints and floating floors.

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/s²) or else using a decibel scale.

Appendix B

Noise Monitoring Locations

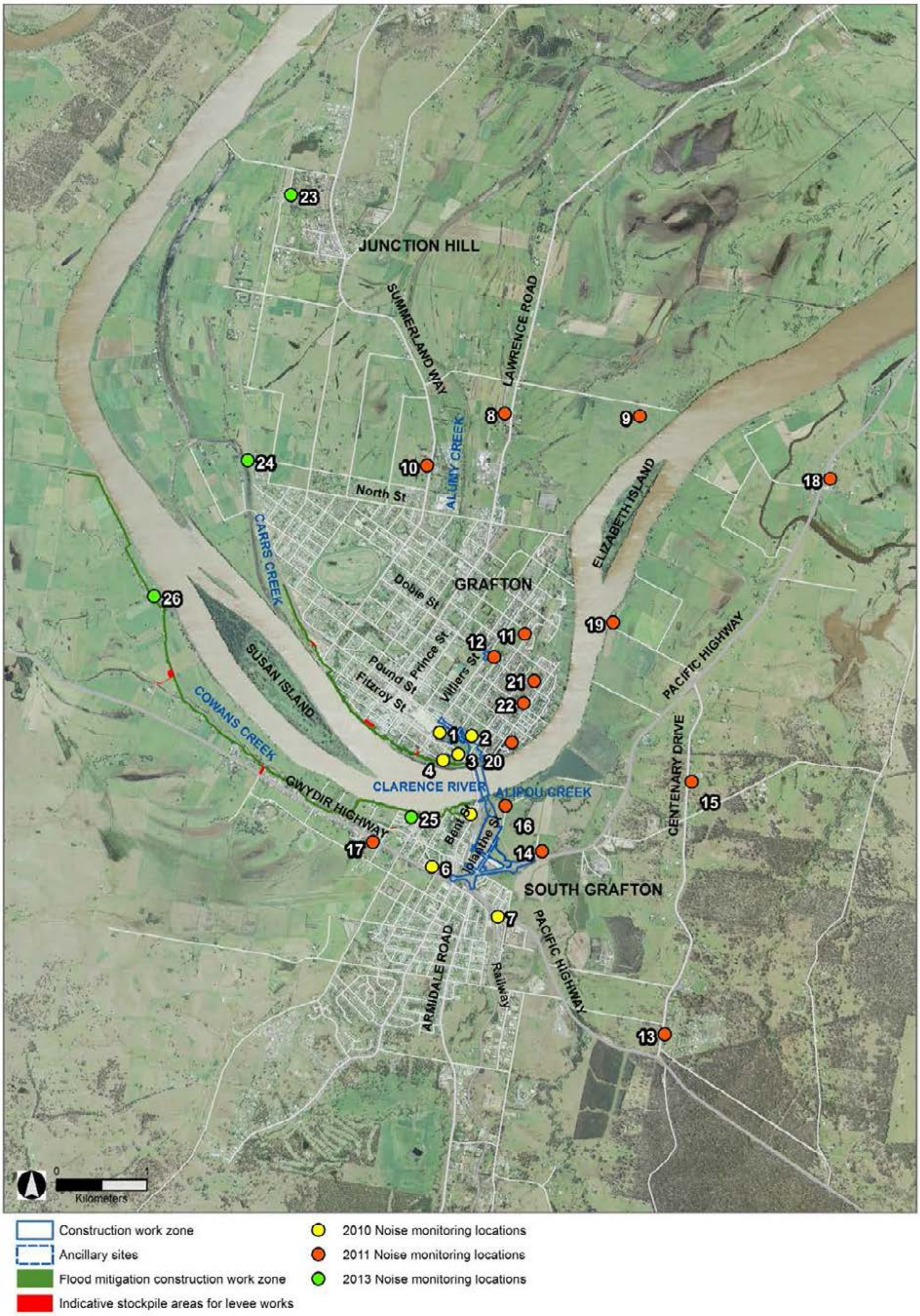


Figure 15 - Noise monitoring locations

Table 32: Description and photo of noise monitoring locations

Reference Location	Address	Notes	Site Photo
1	29 Villiers Street, in front of TAFE College, Grafton	Single-storey residence with floor raised approximately 1m on brick columns with TAFE college at back fence by tree. Residential facade approximately 15m back from kerbside. Main noise contribution from traffic on Villiers Street that includes some through traffic and traffic using the shopping mall directly opposite.	
2	Gummyaney Pre School, 30 Pound Street, Grafton	Noise logger set up on school boundary with school building approximately 25m back from logger and logger approximately 15m back from Pound Street. The school is located in a residential area with an elevated train line running across Pound Street within 50-60m of the School facade. The noise environment is generally quiet except for occasional residential car traffic and trains.	

Reference Location	Address	Notes	Site Photo
3	8 Fitzroy Street, Grafton	Two storey residence at rear and one at the front. Rear of residence faces elevated section of Bent Street. The elevated road has an approximately 1.5-2m solid concrete barrier along both sides. The roofs of some passing traffic, particularly trucks can be seen from the receiver and logging location. The elevated rail line is also in direct line of sight of the rear of the receiver. The dominant noise source is from traffic on the elevated Bent Street. Freight trains are also audible when passing.	
4	St. Mary's Church, Clarence Street, Grafton	Receiver located close to edge of the river and in the corner of a park adjacent to a 90 degree bend on Clarence Street/Victoria Street. The noise environment is generally dominated by the heavy traffic on Bent Street as it crosses the river for the south and eastern facades (approximately 320m), and at the end of Clarence Street for the north facade (approximately 150m). There is some additional noise from traffic on the less busy local Fitzroy and Clarence Streets.	

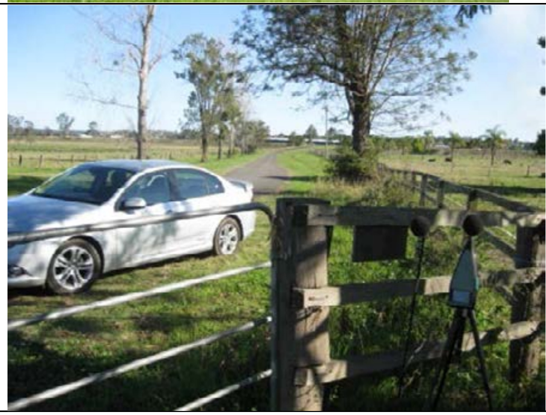
Reference Location	Address	Notes	Site Photo
5	12 Bent Street, Grafton Aged Care Home, South Grafton	Elevated single storey brick building located approximately 20-30m from nearside carriageway. The land rises by approximately 1-2m from the carriageway level and looks directly onto it. Both car and commercial traffic noise from Bent Street dominates the noise environment.	
6	8 Beatson Street, South Grafton	Noise logger placed on second storey balcony at the rear of a two storey house set back approximately 50m back from Ryan Street/Gwydir Highway. It was not possible to set up the noise logger at houses directly overlooking the road. The dominant noise source was from a mix of traffic including cars and commercial traffic using Ryan Street/Gwydir Highway. Beatson Street is a local street with a low volume of traffic use.	

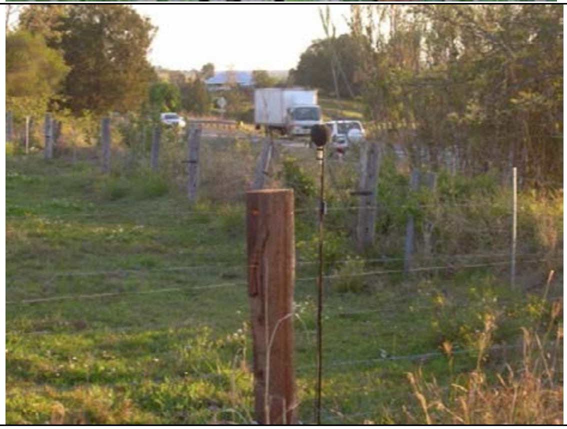
Reference Location	Address	Notes	Site Photo
7	España Hotel, Schwinghammer Street, South Grafton	This receiver is a single storey brick building located adjacent the Pacific Highway/Schwinghammer Street in South Grafton. The noise logger was set up a few meters from the facade in a free-field position and the facade is approximately 30m back from the kerb side of the road. Car traffic and particularly commercial traffic at night are the dominant noise sources at this location.	
8	245 Lawrence Road, Great Marlow	Single-storey residence with receiver at building facade, approximately 16.2 m to the edge of Lawrence Rd. House located on large acreage and surrounded by farmland. Main contribution from Lawrence Road. Some local agriculture during day-time period.	

Reference Location	Address	Notes	Site Photo
9	86 Great Marlow Road, Great Marlow	Receiver located along paddock fence line on rural road serving 15 semi-rural residences along the Clarence River. Noise environment generally governed by farm machinery, road traffic on Great Marlow Road and livestock/wildlife. Receiver is positioned approximately 16.3m from roadside.	
10	591 Summerland Way, Carrs Creek	Single-storey residence with receiver placed in tree line at front of property, approximately 4.6 m from facade due to access restrictions. Approximately 12.2m to the edge of Summerland Way, separated by a wide grassed verge. Road traffic along Summerland Way noted as the dominant noise source.	

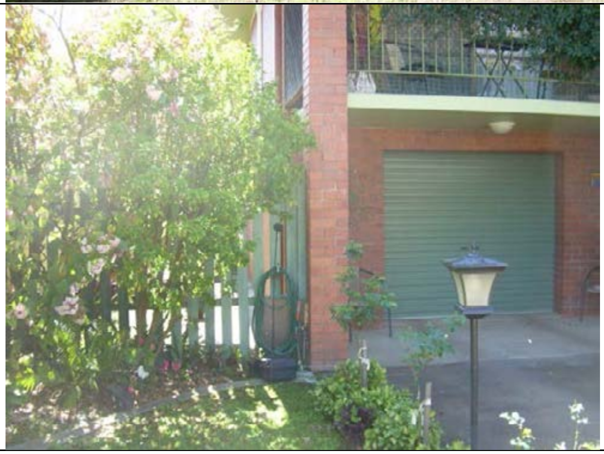
Reference Location	Address	Notes	Site Photo
11	Cnr Hoof and Clarence Streets, Grafton	Receiver located along fence line in an uninhabited paddock surrounded by single and double storey residences. Located approximately 11.3m from the roadside. The relative level of the property was noted as being slightly below the level of the road surface. Local traffic flows and community noise governs ambient noise environment.	
12	94 Dobie Street, Grafton	Single-storey residence with receiver placed at building facade, approximately 16.8m from Dobie Street roadside. Road traffic noise, including some heavy vehicles from further north along Dobie Street, noted as dominant noise source.	

Reference Location	Address	Notes	Site Photo
13	81 Edward Ogilvie Drive, Clarenza	Receiver placed in large front garden of single storey residence in semi-rural suburb approximately 10.7m from Centenary Drive roadside. Grass verge and light shrubbery separates receiver from road. Centenary Drive receives significant use by both cars and heavy vehicles.	
14	Pacific Highway near Alipou Creek	Receiver positioned directly adjacent to Pacific Highway northbound approximately 6.6m to guard to roadside. The noise environment at this location is significantly dominated by road traffic flows including high percentage of heavy vehicles.	

Reference Location	Address	Notes	Site Photo
15	326 Centenary Drive, Clarenza	Single storey semi-rural residence with receiver positioned approximately 67.7m from Centenary Drive and a further 2m from the facade outside front porch canopy. Receiver separated from Centenary Drive by considerable grassed expanse. Predominantly affected by road traffic along Centenary Drive and local farm industry.	
16	Cnr Iolanthe Street & Butters Lane, South Grafton	Semi-rural property located relatively close to South Grafton urban area, existing Grafton Bridge and Clarence Riverbank. Receiver positioned in empty paddock surrounded by livestock and semi-rural residences. Butters lane is a no thoroughfare road that services 3 residences that is fed by Iolanthe Street. Primary noise sources in the area include livestock, local residential activity, rail movements along the nearby Northern Line and road traffic noise predominantly along the existing Grafton Bridge.	

Reference Location	Address	Notes	Site Photo
17	146-148 Ryan Street, South Grafton	Receiver located along fence line within a community garden owned by Clarence Valley Council. Receiver is located approximately 10.2m from Ryan St roadside. Acoustic environment governed by significant road traffic flows along Ryan Street during the day-time period.	
18	5 School Drive, Swan Creek	Receiver located adjacent to community hall within roadside overgrowth approximately 21.1m from the Pacific Highway and 18.7m to School Drive. Receiver is positioned approximately 2.5m above road level. Primary source of noise is heavy vehicle flow along the Pacific Highway. Compression braking noted during attended noise surveys, especially during night-time period.	

Reference Location	Address	Notes	Site Photo
19	Riverbank at end of Meona Lane, off Pacific Highway.	Receiver located in rural paddock occupied by livestock along the bank of the Clarence River and approximately 660m from the Pacific Highway. Due to the gradient of the riverbank the receiver was partially acoustically shielded from road traffic noise although the Pacific Highway was still identified as being the primary noise source.	
20*	4 Bacon Street, Grafton	Receiver located in front of garage door at building façade, approximately 11.3m to Bacon Street roadside. Intermittent local traffic flows along Bacon Street. Distant Highways faintly audible. Some construction noise nearby noted during attended measurements.	

Reference Location	Address	Notes	Site Photo
21*	40 Dobie Street, Grafton	Receiver located at property boundary approximately 12 m to Dobie Street roadside. Logger elevated to approximately 3.5m. Low ambient noise environment. Intermittent local traffic flows along Dobie and nearby intersections.	
22*	22 Fry Street, Grafton	Receiver located against front fence of property approximately 10.2m from Fry Street roadside. Ambient noise environment governed by intermittent traffic flows along Fry Street and distant Highway noise.	

Reference Location	Address	Notes	Site Photo
23	320 Back Lane, Junction Hill	Receiver located in front garden of property, approximately 5m from Back Lane roadside. Ambient noise environment governed by intermittent traffic flows on Back Lane and insect and bird noise. Occasional rail passby's on rail line approximately 125m from noise logger location. During the night periods, distant heavy vehicle noise on Highway audible.	
24	235 Carr Street, Grafton	Receiver located on front fence of property, approximately 30m from rail line. Ambient noise characteristic of a semi-rural environment, with dominant noise sources being domestic noise from nearby residences, bird and insect noise, and occasional rail passby's on rail line running next to property.	

Reference Location	Address	Notes	Site Photo
25	98 Through Street, South Grafton	Receiver located in front garden of medical practice, set back 4m from the Through Street roadside. Ambient noise environment characteristic of a quiet urban location, with additional noise impacts during opening hours of the medical practice and nearby TAB/Bottle shop. Some distant air-conditioning units audible.	

Reference Location	Address	Notes	Site Photo
26	Maclennan's Lane, Waterview	Receiver located in rural paddock occupied by livestock, 100m from the bank of the Clarence River. Ambient noise environment characteristic of a quiet rural environment. Occasional rail passby's audible from rail line on other side of Clarence River.	

*4 of the noise loggers were omitted from the noise study due to either of the following:

- Noise Logger failure (i.e. no data being recorded); or
- Significant amounts of spurious data being recorded across the entire measurement period

Appendix C

Unattended Noise Logger Graphs

C1 Noise Logger Location 1 – Villiers Street, near TAFE, Grafton

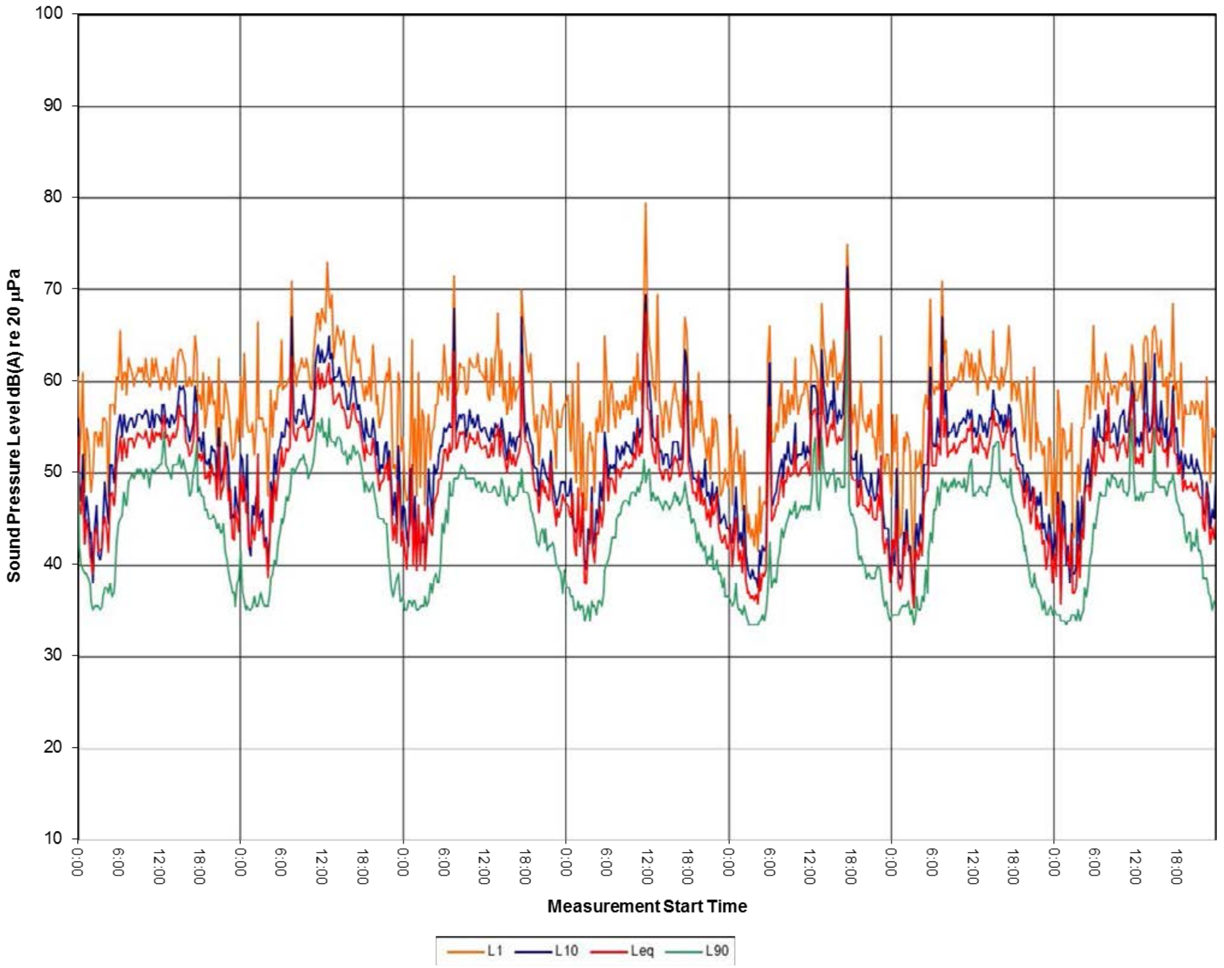


Figure 16: Measured Noise Levels – Logger Location 1 – Wednesday 11 August to Tuesday 17 August 2010, dB re 20 µPa

C2 Noise Logger Location 2 – Gummyaney Pre-School, 30 Pound Street, Grafton

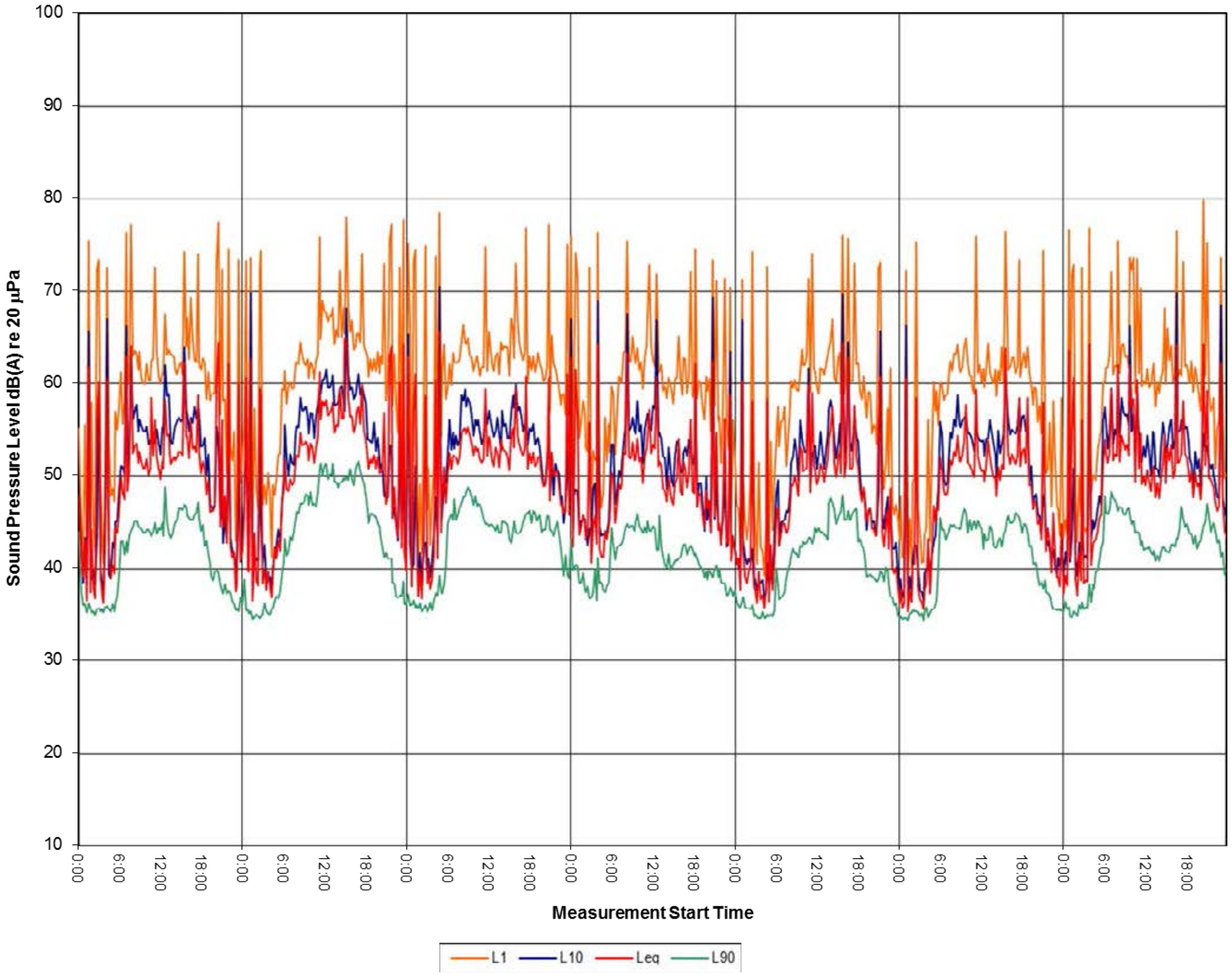


Figure 17: Measured Noise Levels – Logger Location 2 – Wednesday 11 August to Tuesday 17 August 2010, dB re 20 µPa

C3 Noise Logger Location 3 – 8 Fitzroy Street, Grafton

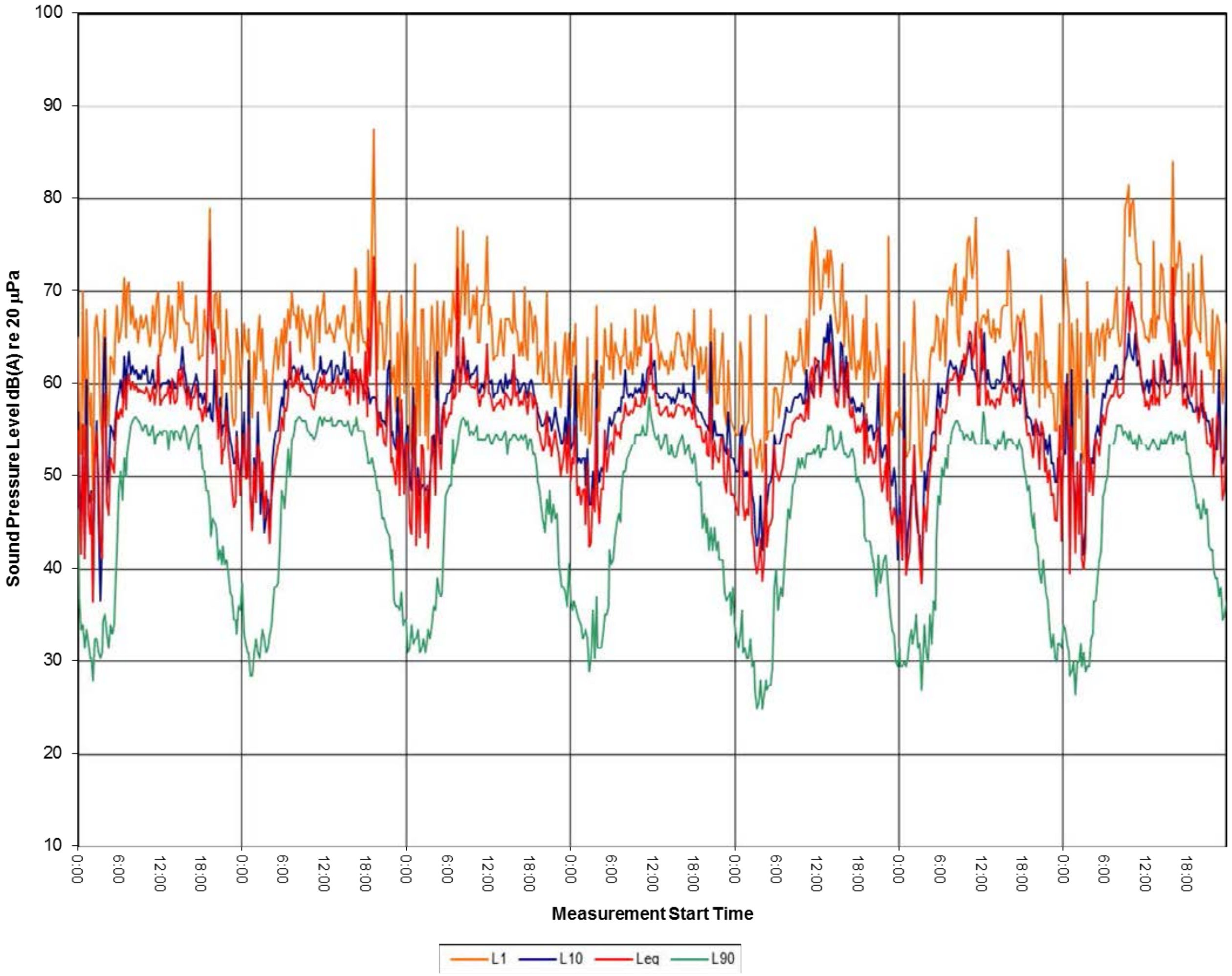


Figure 18: Measured Noise Levels – Logger Location 3 – Wednesday 11 August to Tuesday 17 August 2010, dB re 20 µPa

C4 Noise Logger Location 4 – St. Mary’s Church, Clarence Street

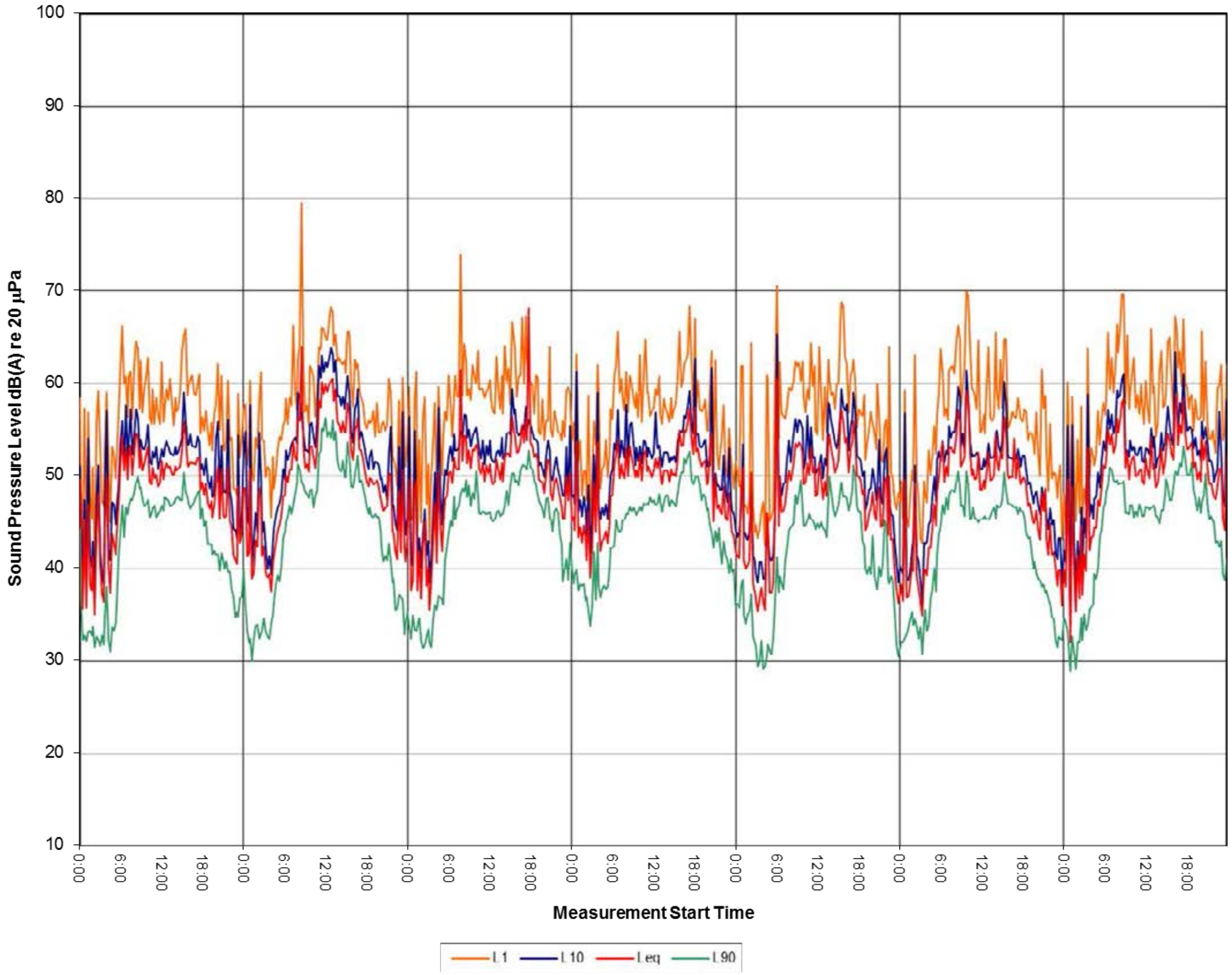


Figure 19: Measured Noise Levels – Logger Location 4 – Wednesday 11 August to Tuesday 17 August 2010, dB re 20 µPa

C5 Noise Logger Location 5 – 12 Bent Street, Grafton Aged Care Home, South Grafton

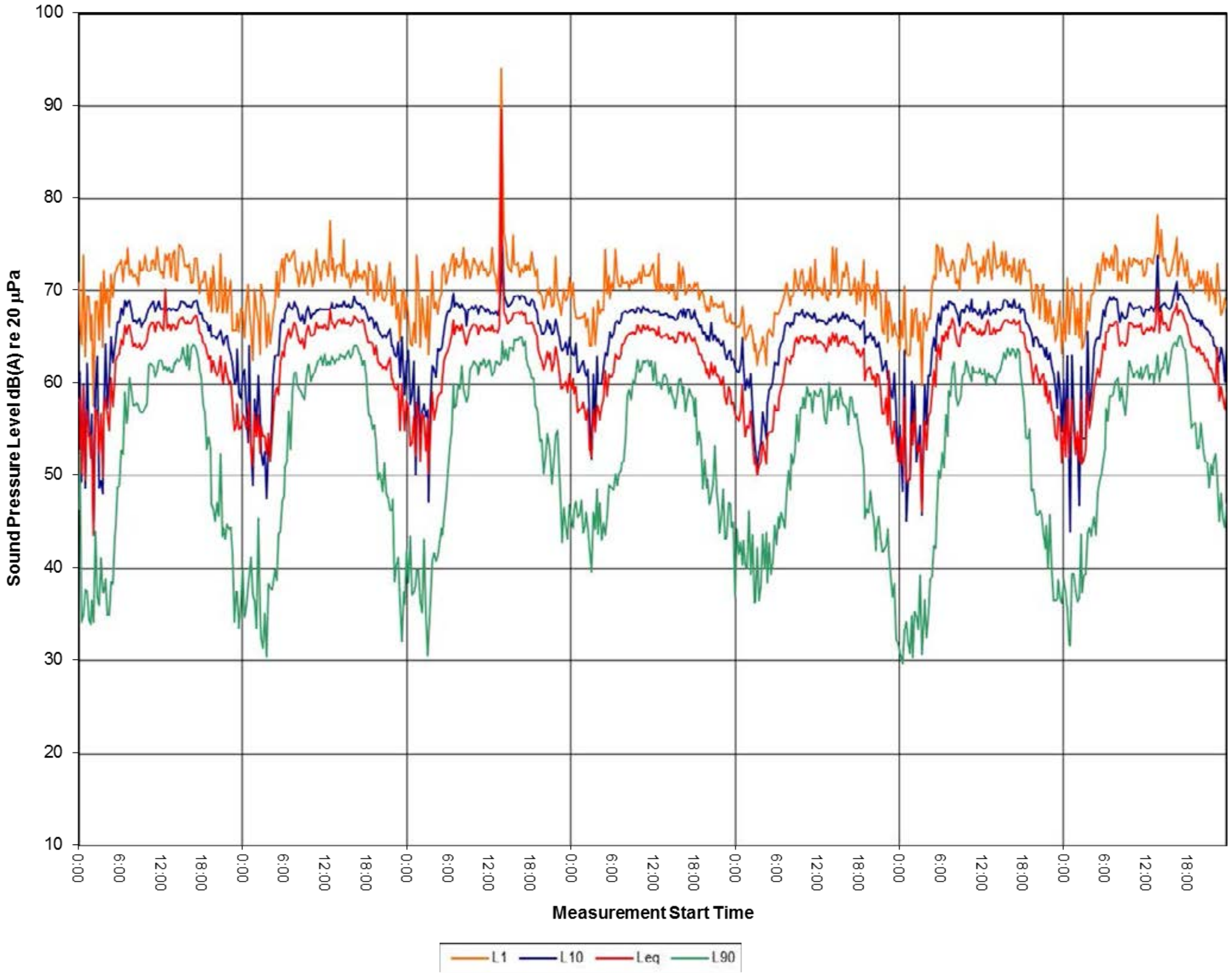


Figure 20: Measured Noise Levels – Logger Location 5 – Wednesday 11 August to Tuesday 17 August 2010, dB re 20 µPa

C6 Noise Logger Location 6 – 8 Beatson Street, South Grafton

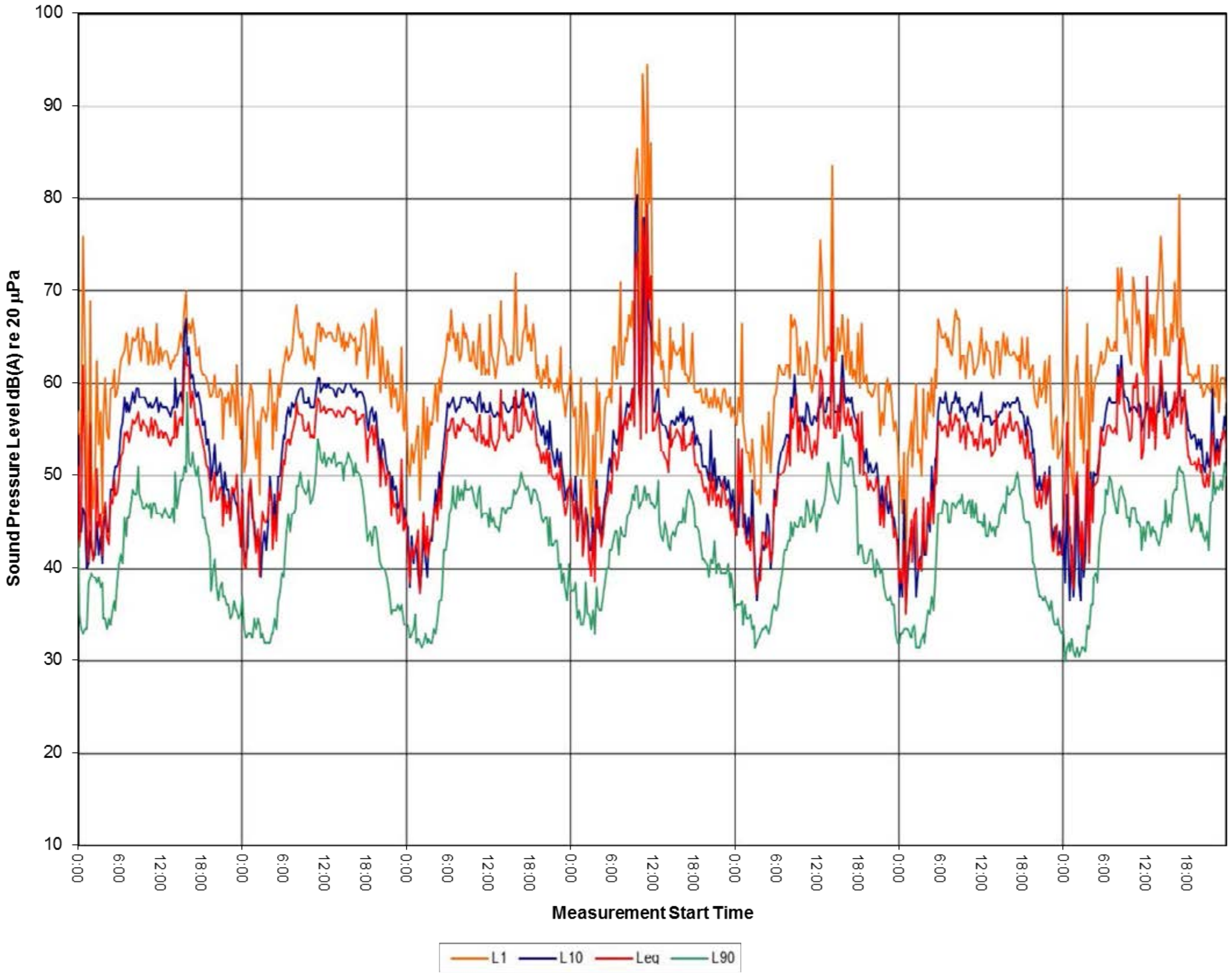


Figure 21: Measured Noise Levels – Logger Location 6 – Wednesday 11 August to Tuesday 17 August 2010, dB re 20 µPa

C7 Noise Logger Location 7 – España Hotel, Schwinghammer Street, South Grafton

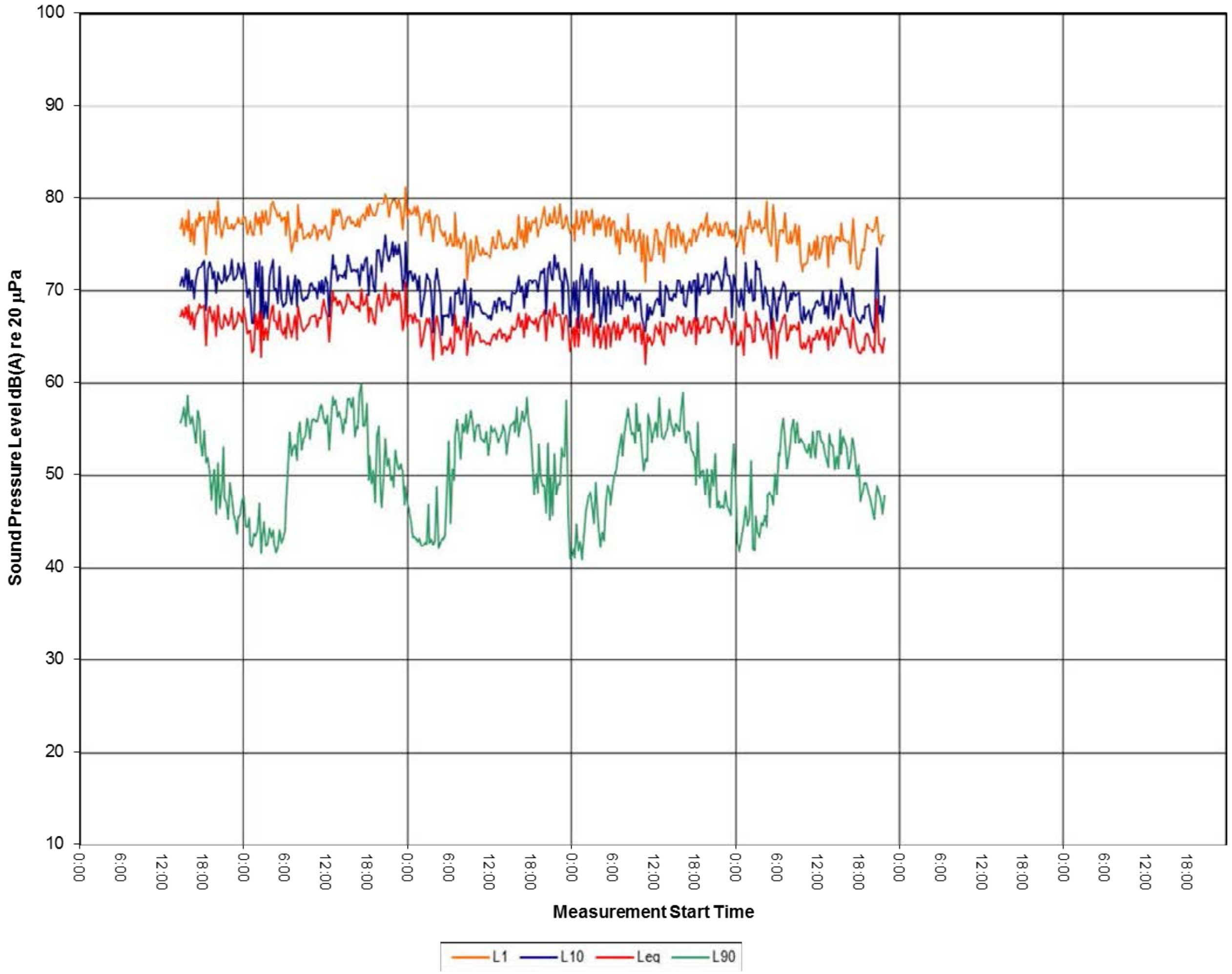


Figure 22: Measured Noise Levels – Logger Location 7 – Wednesday 11 August to Tuesday 17 August 2010, dB re 20 µPa

C8 Noise Logger Location 8 – 245 Lawrence Road, Great Marlow

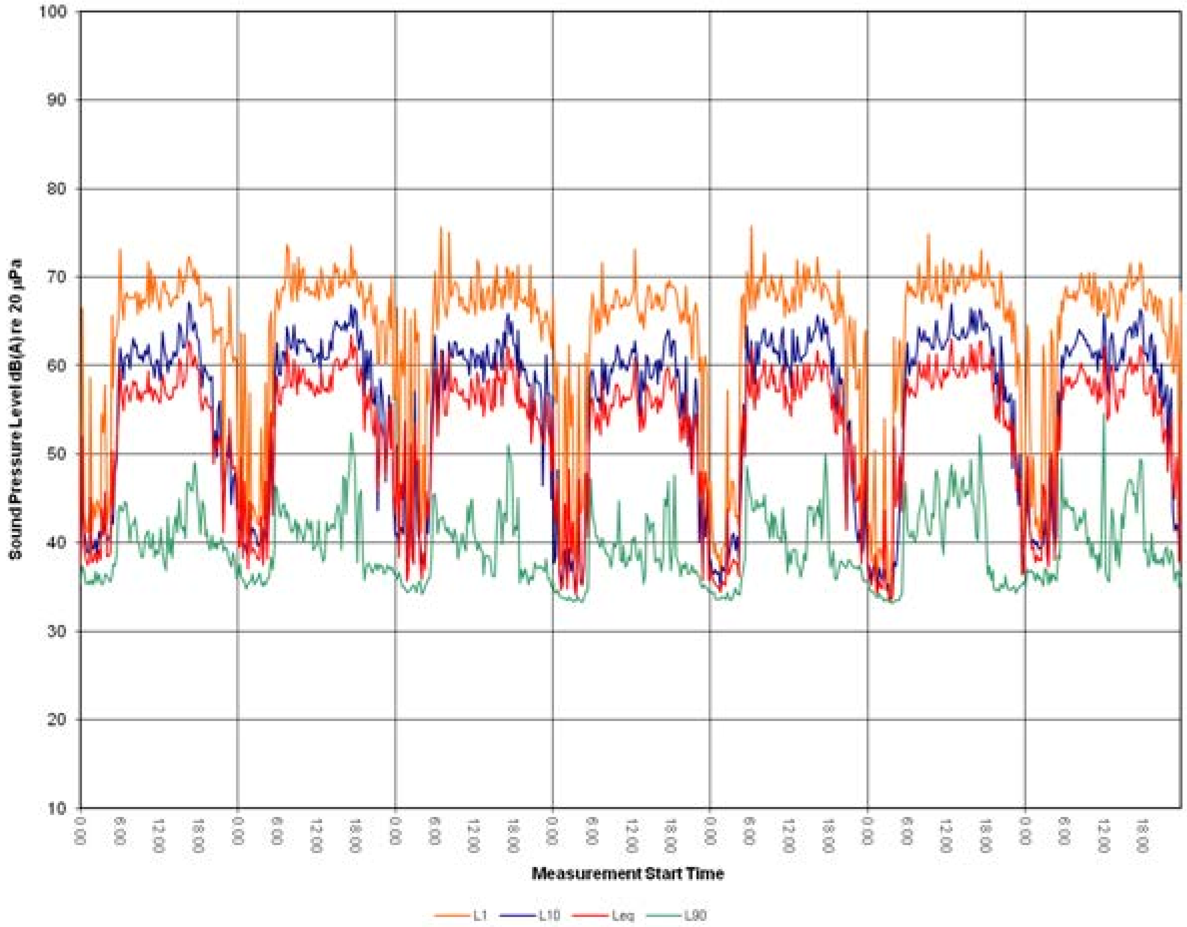


Figure 23: Measured Noise Levels – Logger Location 8 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C9 Noise Logger Location 9 – 86 Great Marlow Road, Great Marlow

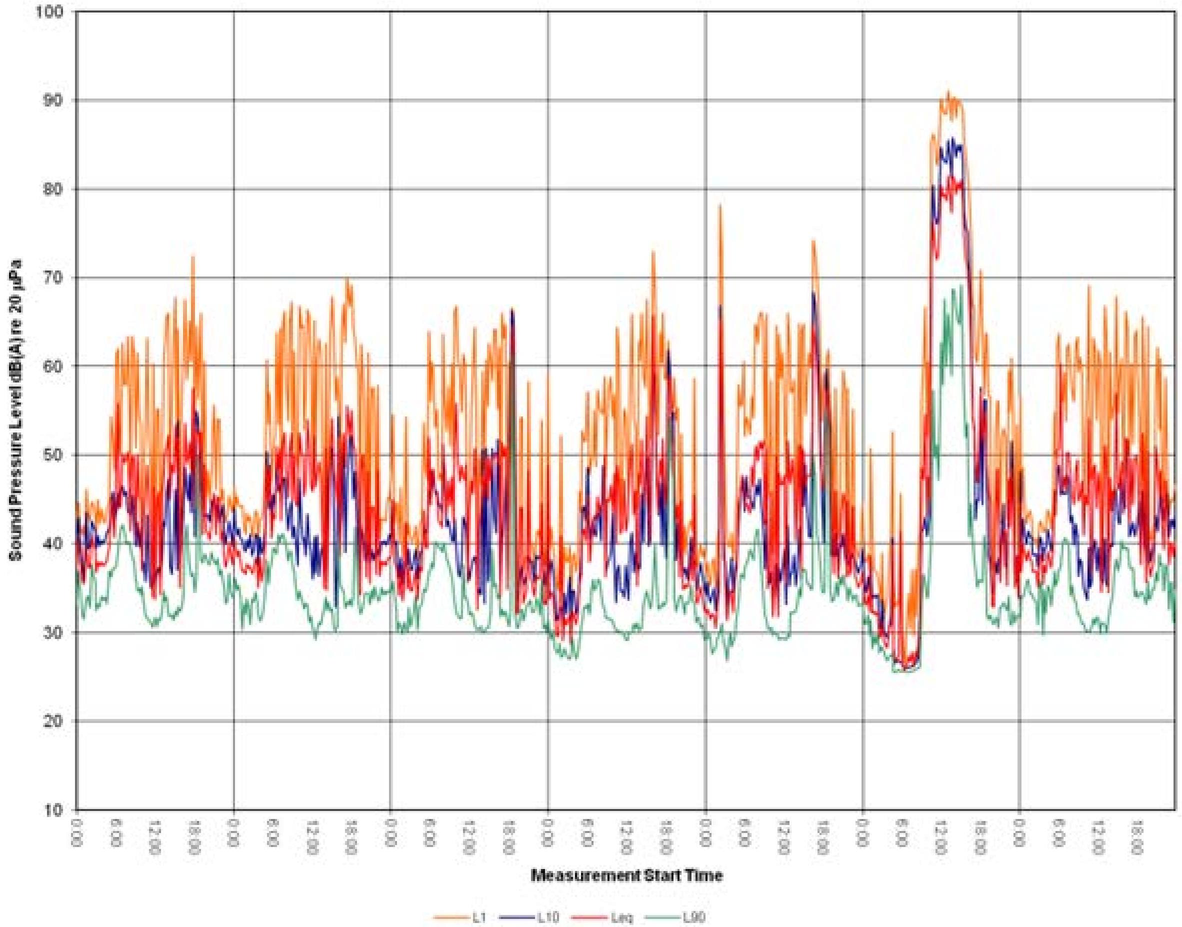


Figure 24: Measured Noise Levels – Logger Location 9 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C10 Noise Logger Location 10 – 591 Summerland Way, Carrs Creek

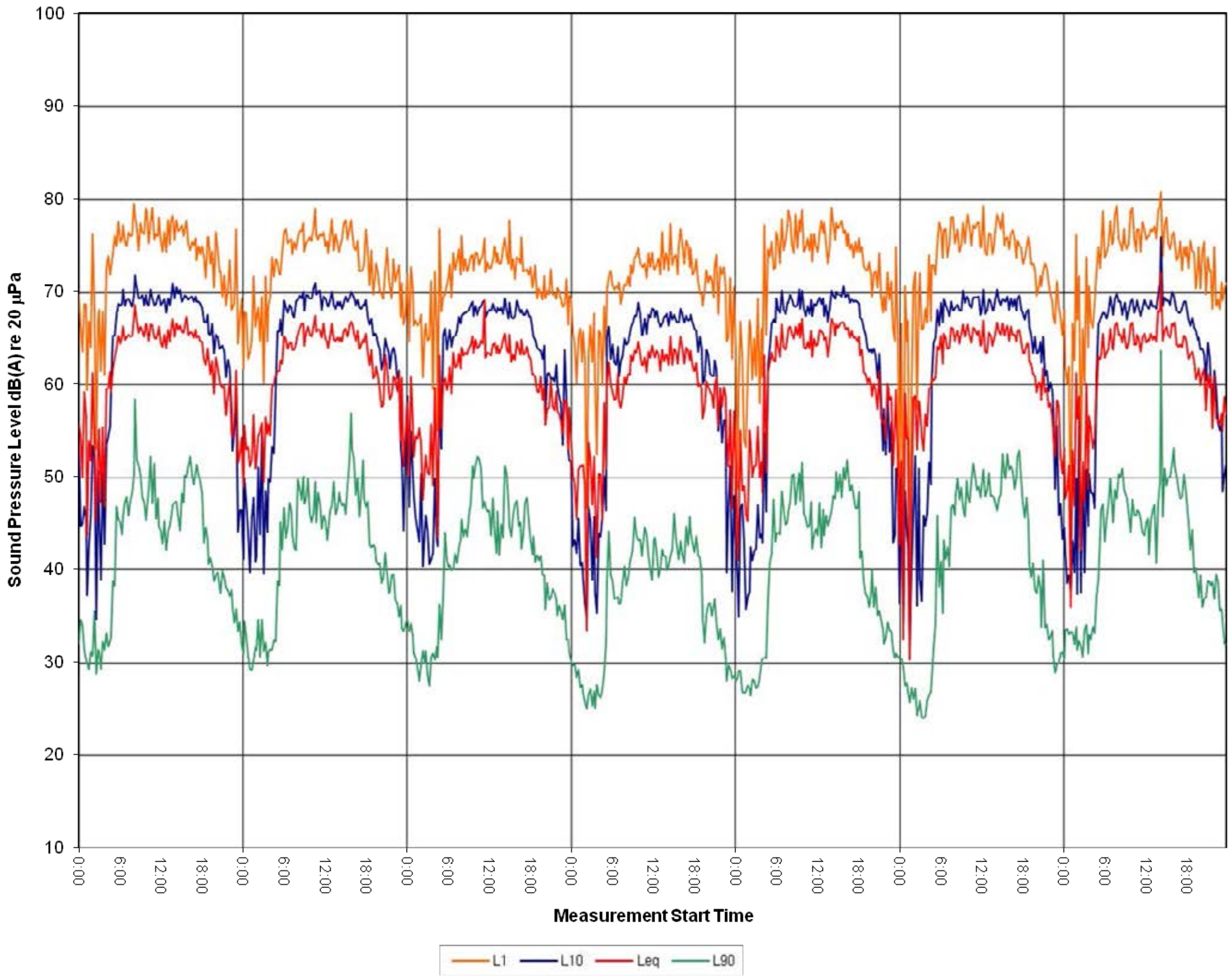


Figure 25: Measured Noise Levels – Logger Location 10 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C11 Noise Logger Location 11 – Cnr Hoof & Clarence St, Grafton

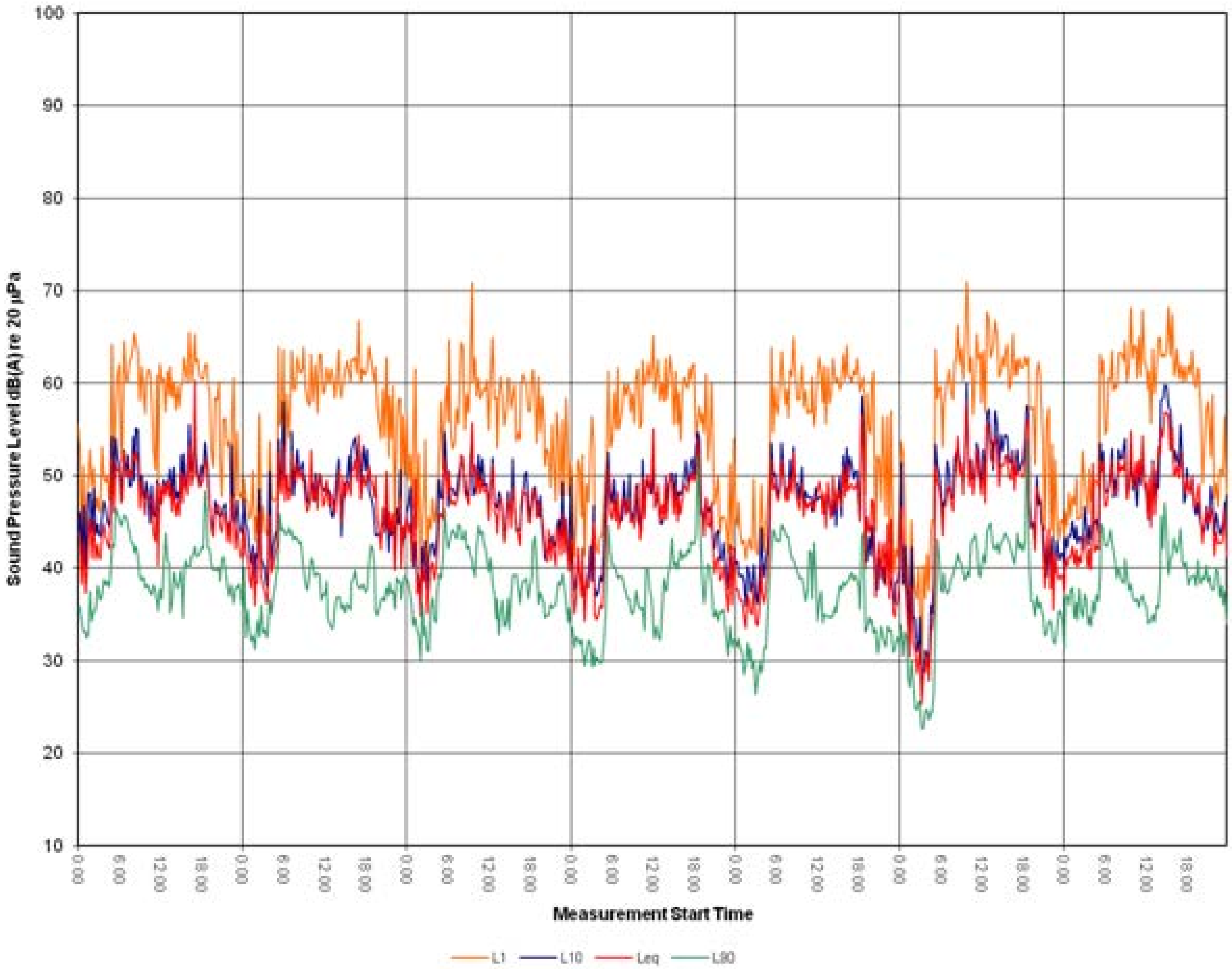


Figure 26: Measured Noise Levels – Logger Location 11 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C12 Noise Logger Location 12 – 94 Dobie Street, Grafton

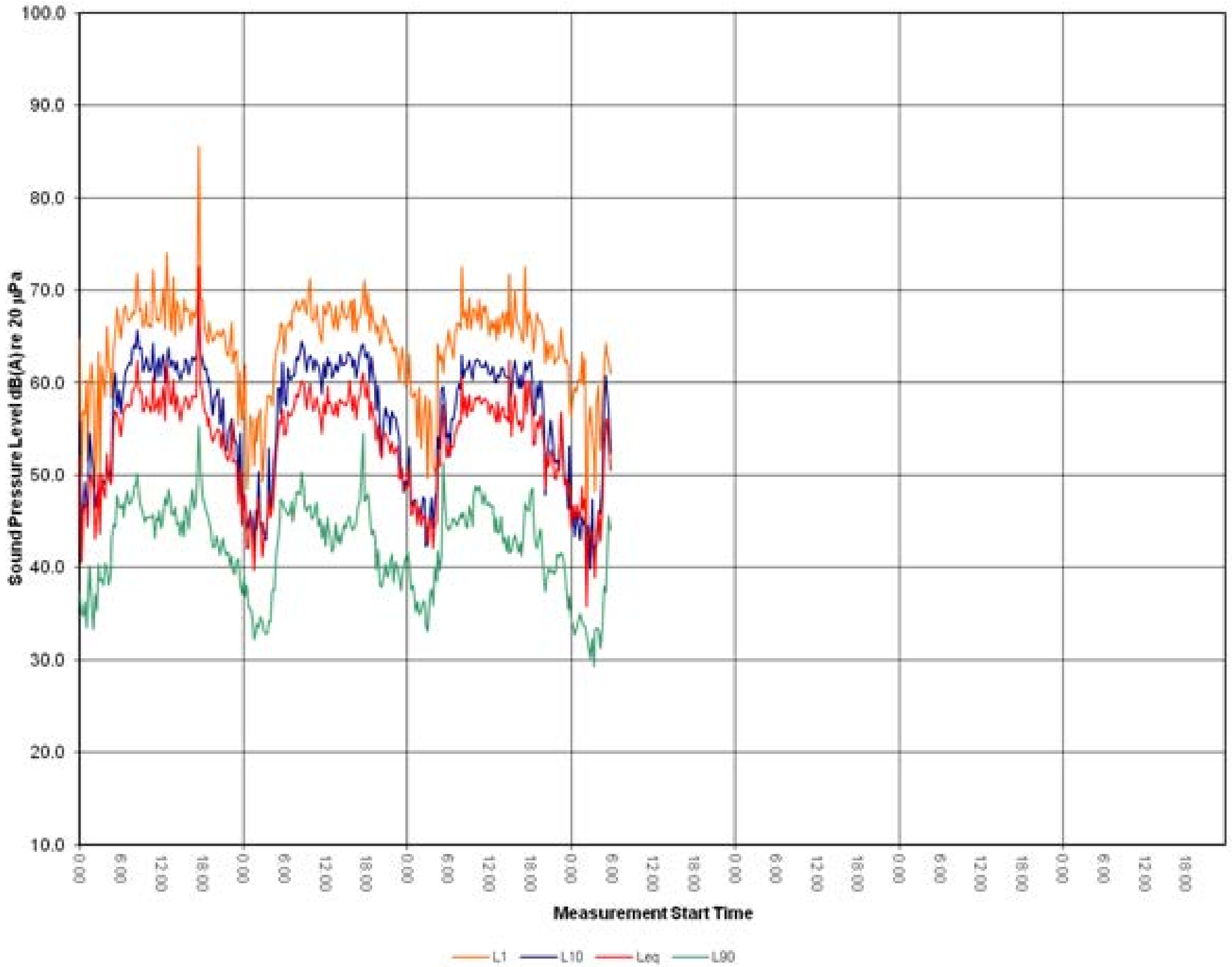


Figure 27: Measured Noise Levels – Logger Location 12 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C13 Noise Logger Location 13 – 81 Edward Ogilvie Drive, Grafton

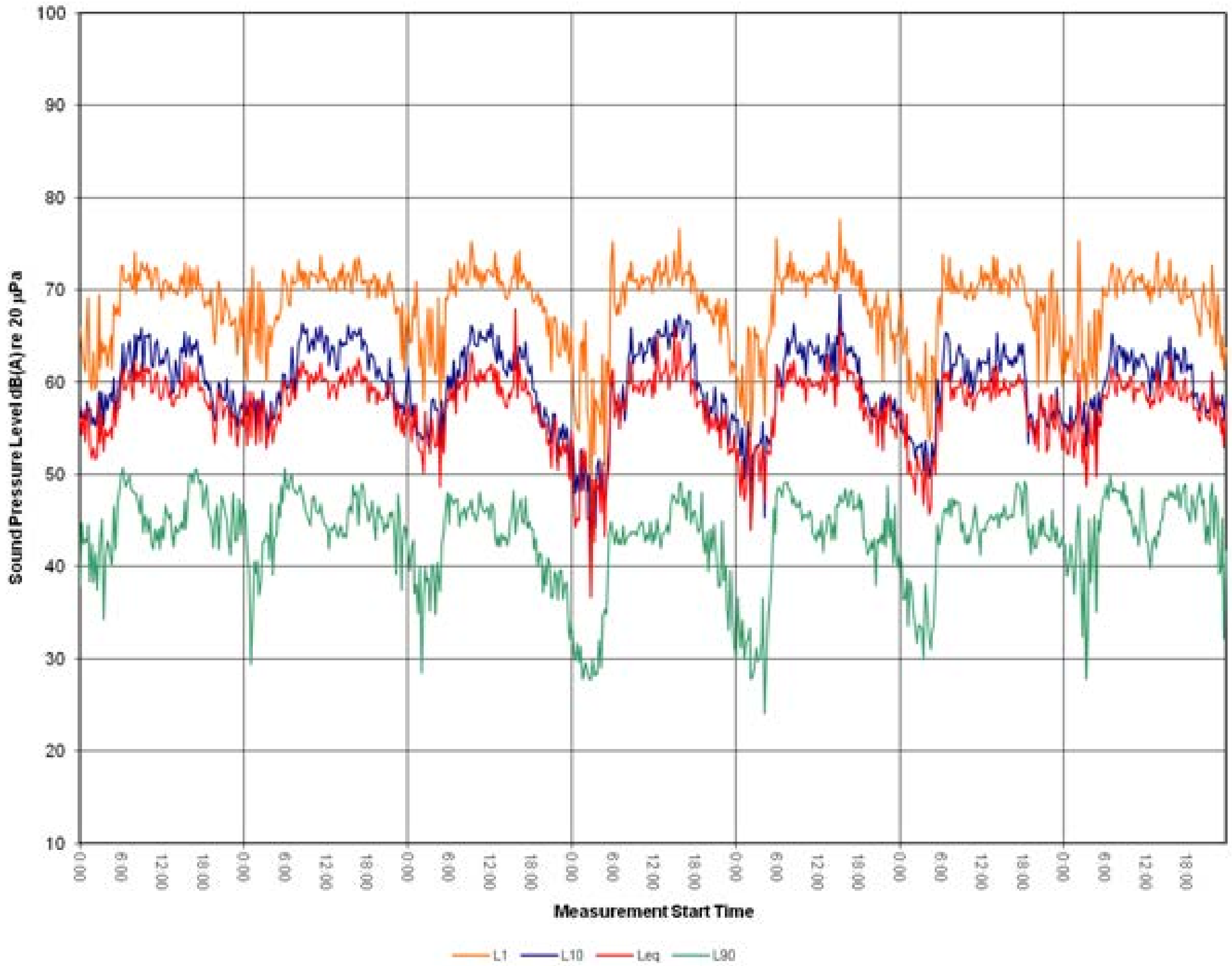


Figure 28: Measured Noise Levels – Logger Location 13 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C14 Noise Logger Location 14 – Pacific Highway, Grafton

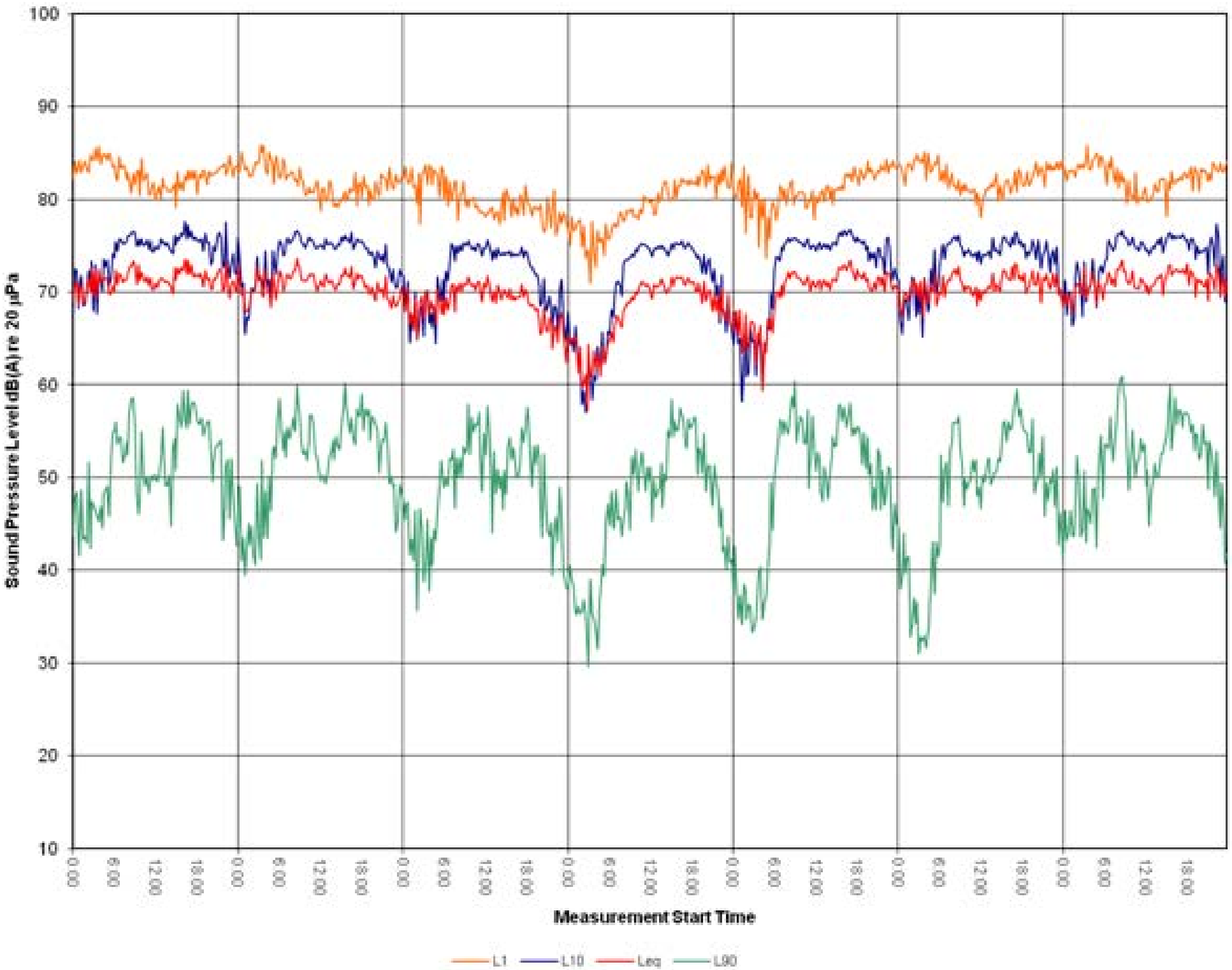


Figure 29: Measured Noise Levels – Logger Location 14 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C15 Noise Logger Location 15 – 326 Centenary Drive, Clarenza

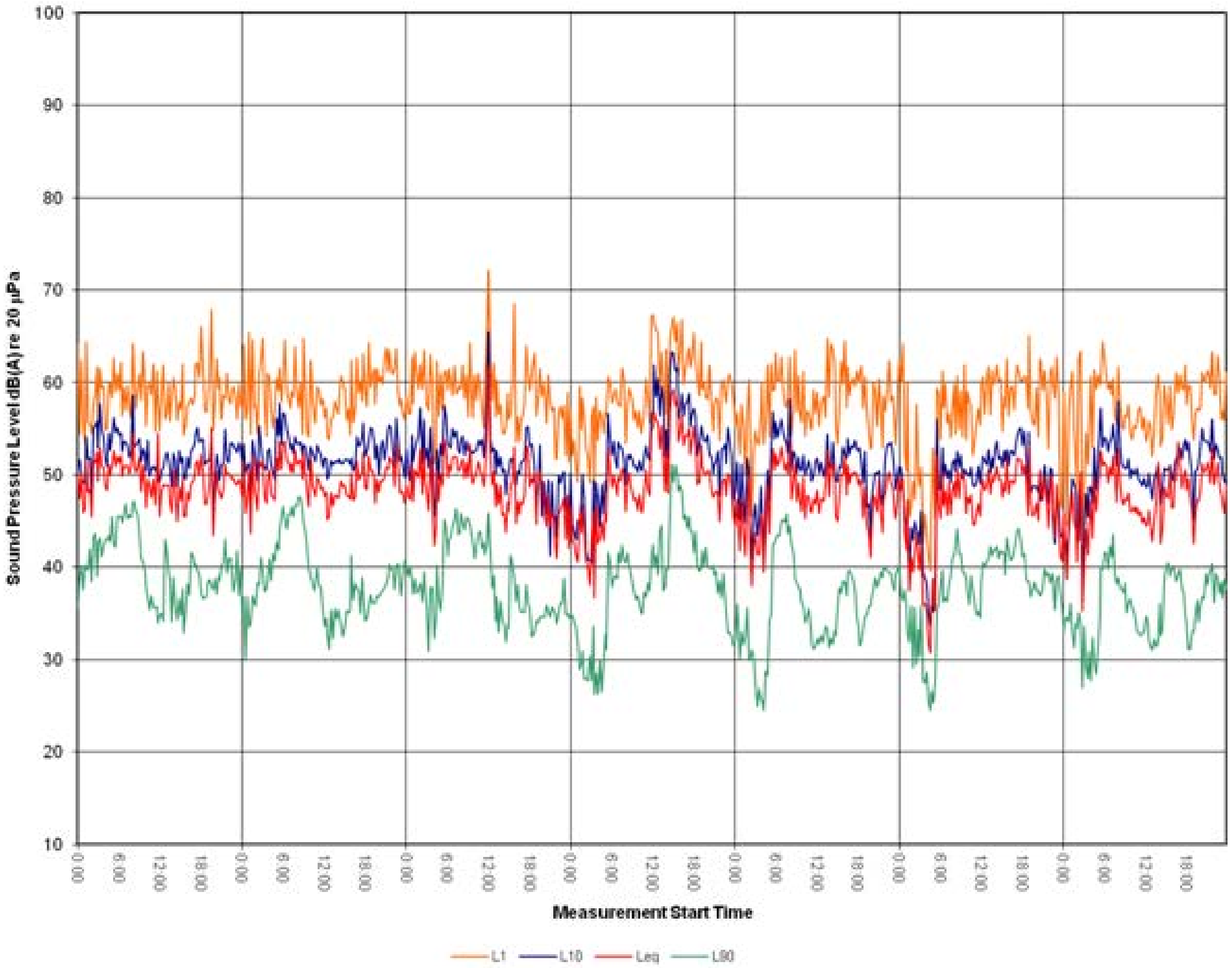


Figure 30: Measured Noise Levels – Logger Location 15 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C16 Noise Logger Location 16 – Cnr Iolanthe St & Butters Lane, Grafton

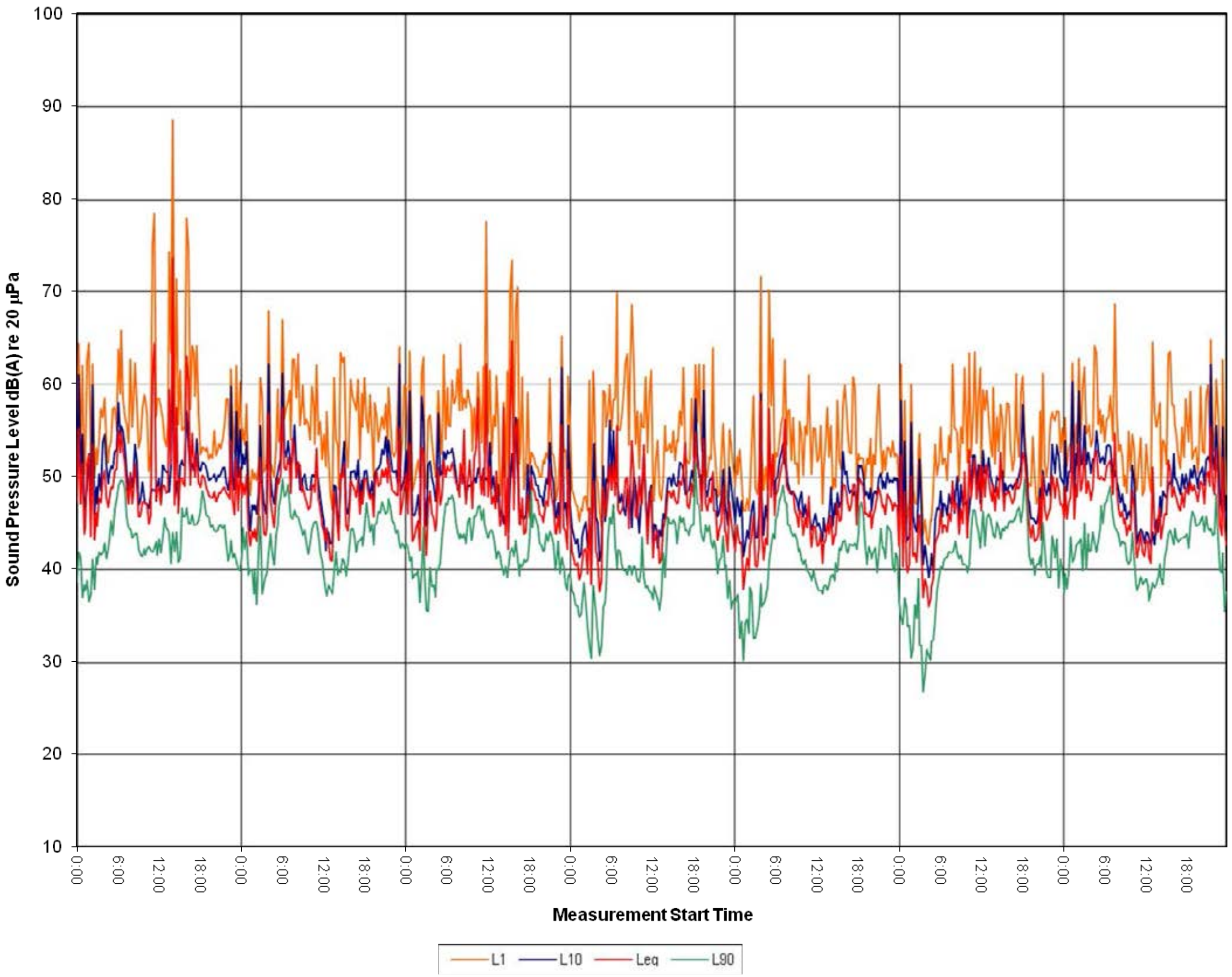


Figure 31: Measured Noise Levels – Logger Location 16 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C17 Noise Logger Location 17 – 146-148 Ryan St, Grafton

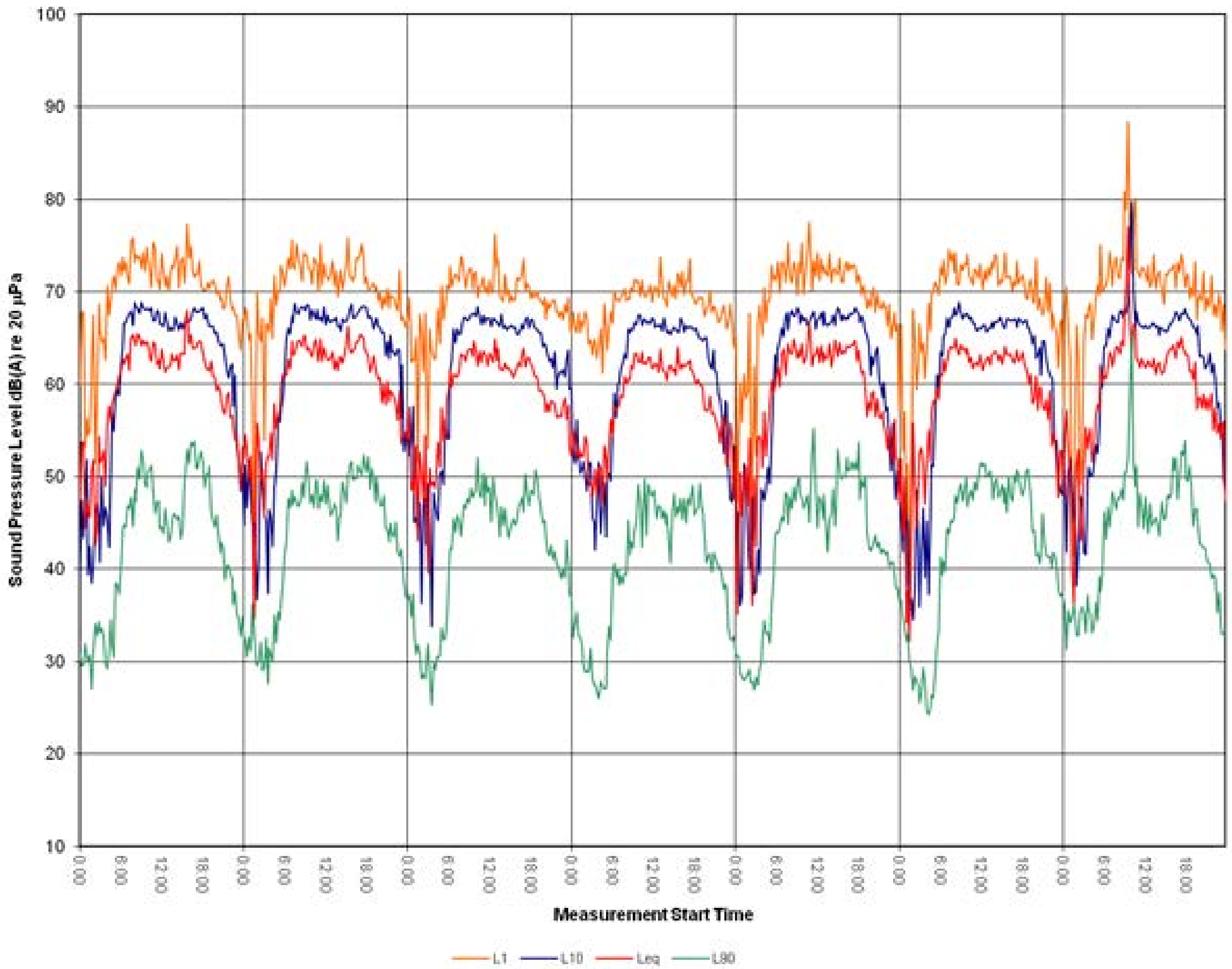


Figure 32: Measured Noise Levels – Logger Location 17 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C18 Noise Logger Location 18 – 5 School Drive, Grafton

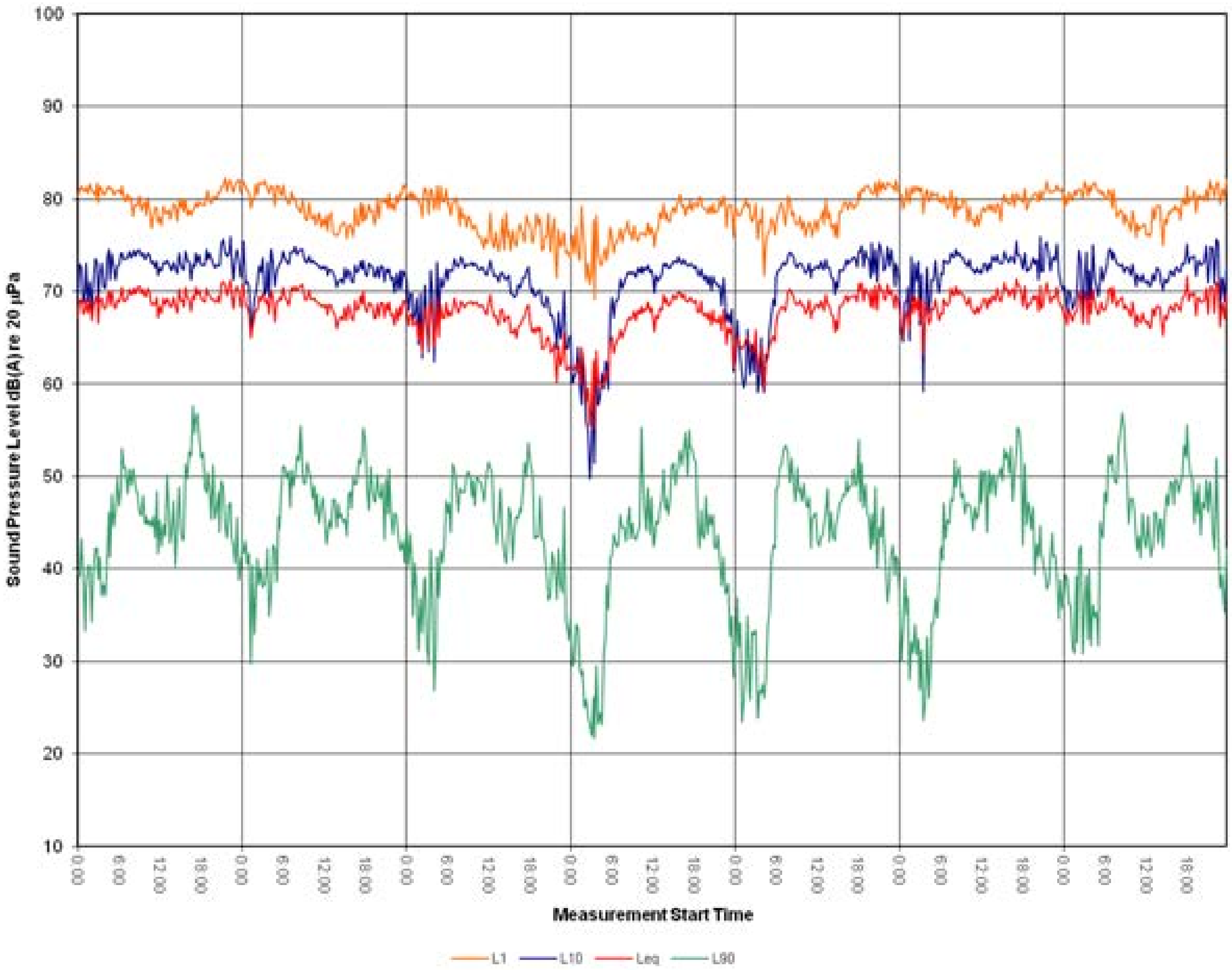


Figure 33: Measured Noise Levels – Logger Location 18 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C19 Noise Logger Location 19 – Riverbank at end of Meona Lane, Grafton

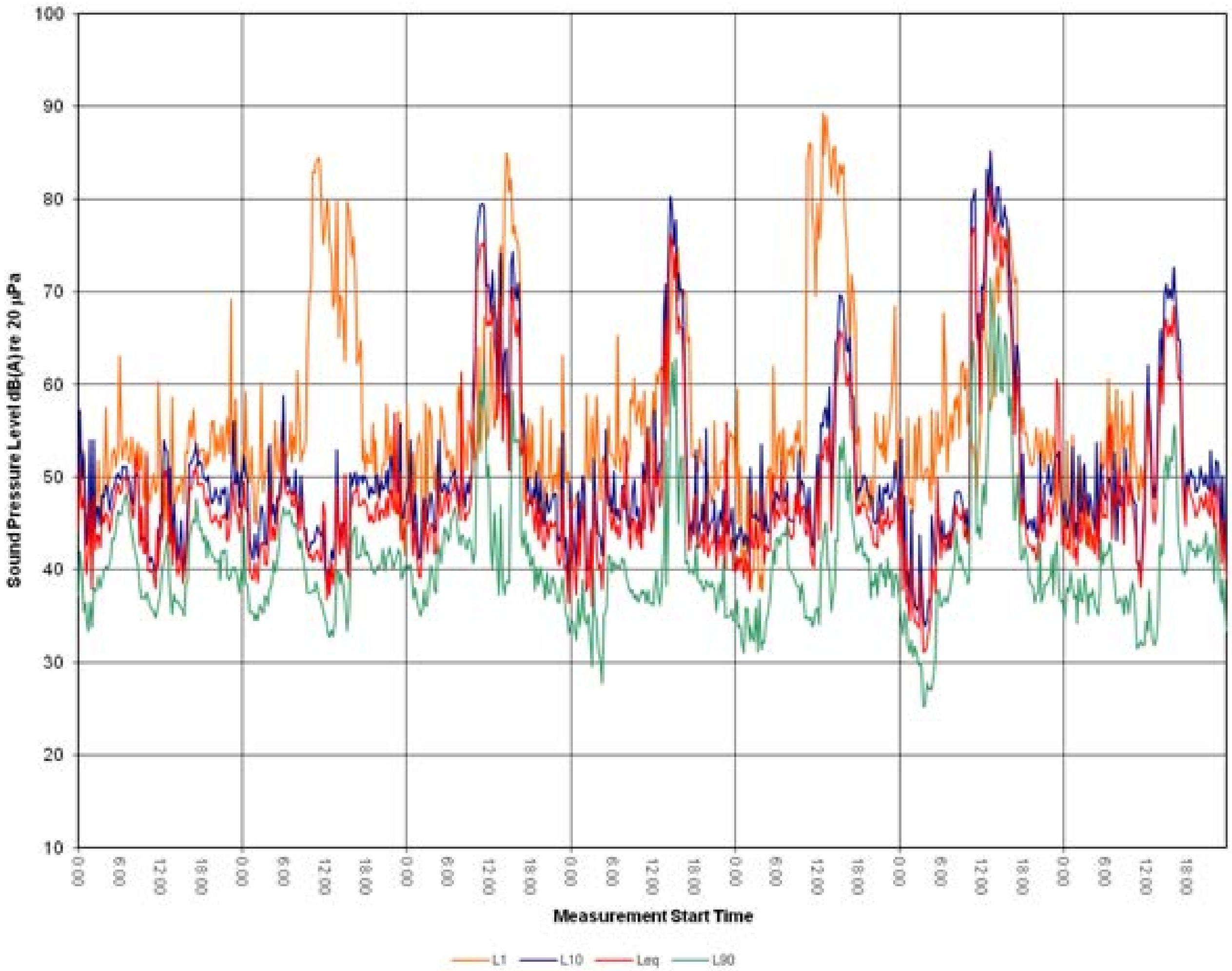


Figure 34: Measured Noise Levels – Logger Location 19 – Thursday 15 September to Wednesday 21 September 2011, dB re 20 µPa

C20 Noise Logger Location 23 – 320 Back Lane, Junction Hill

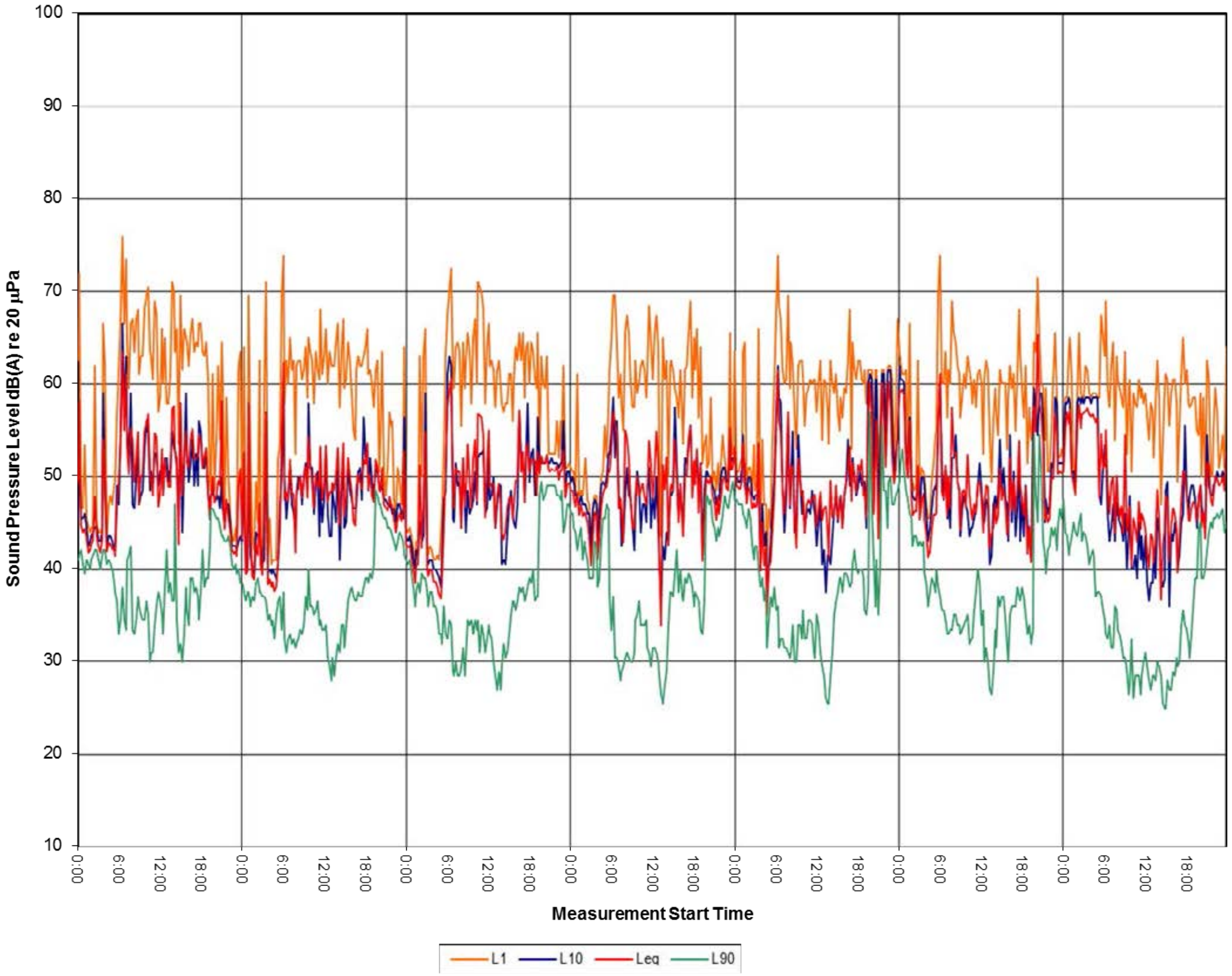


Figure 35: Measured Noise Levels – Logger Location 23 – Friday 18 October to Thursday 24 October 2013, dB re 20 µPa

C21 Noise Logger Location 25 – 98 Through Street, South Grafton

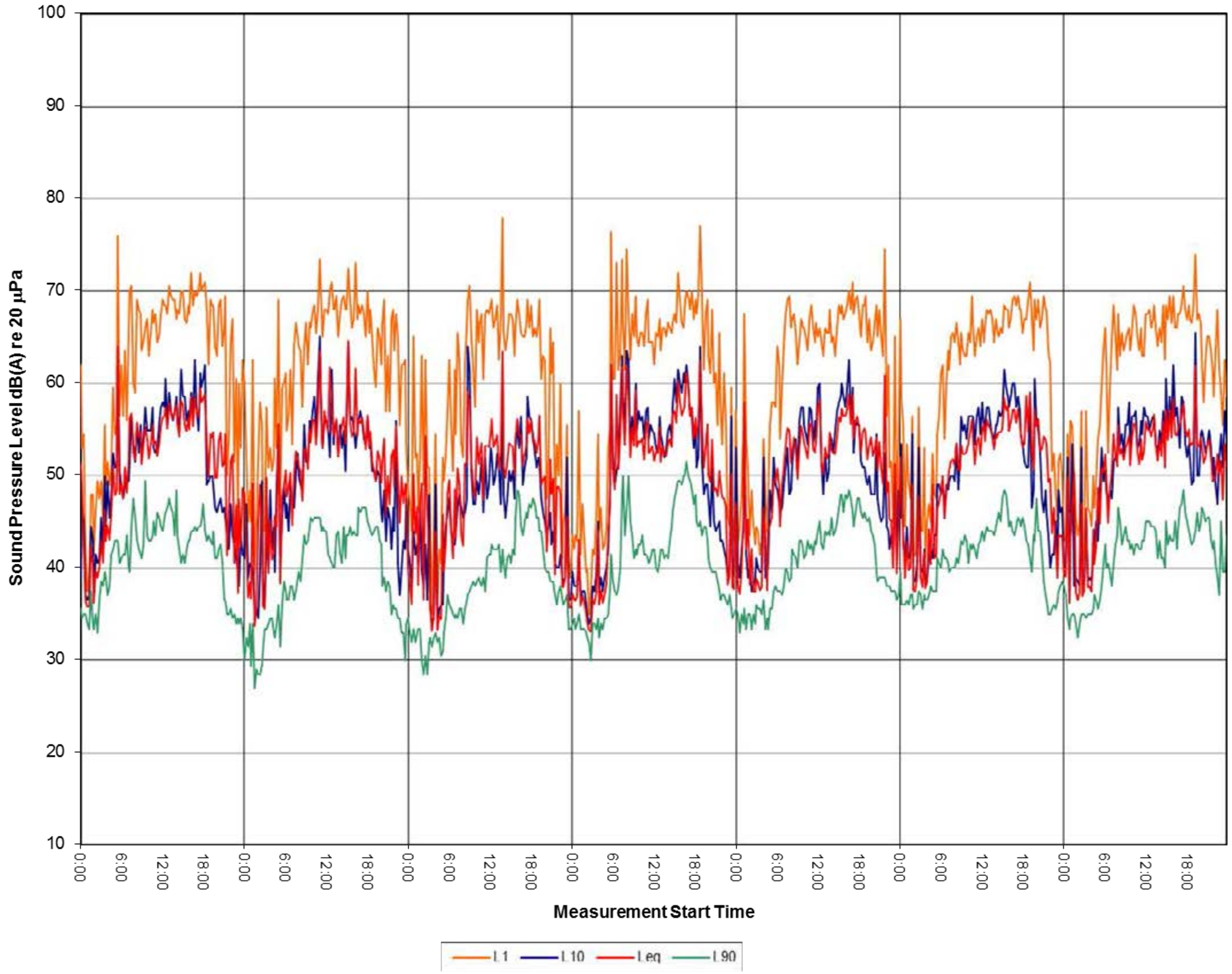


Figure 36: Measured Noise Levels – Logger Location 25 – Friday 18 October to Thursday 24 October 2013, dB re 20 µPa

C22 Noise Logger Location 26 – Maclennan's Lane, Waterview

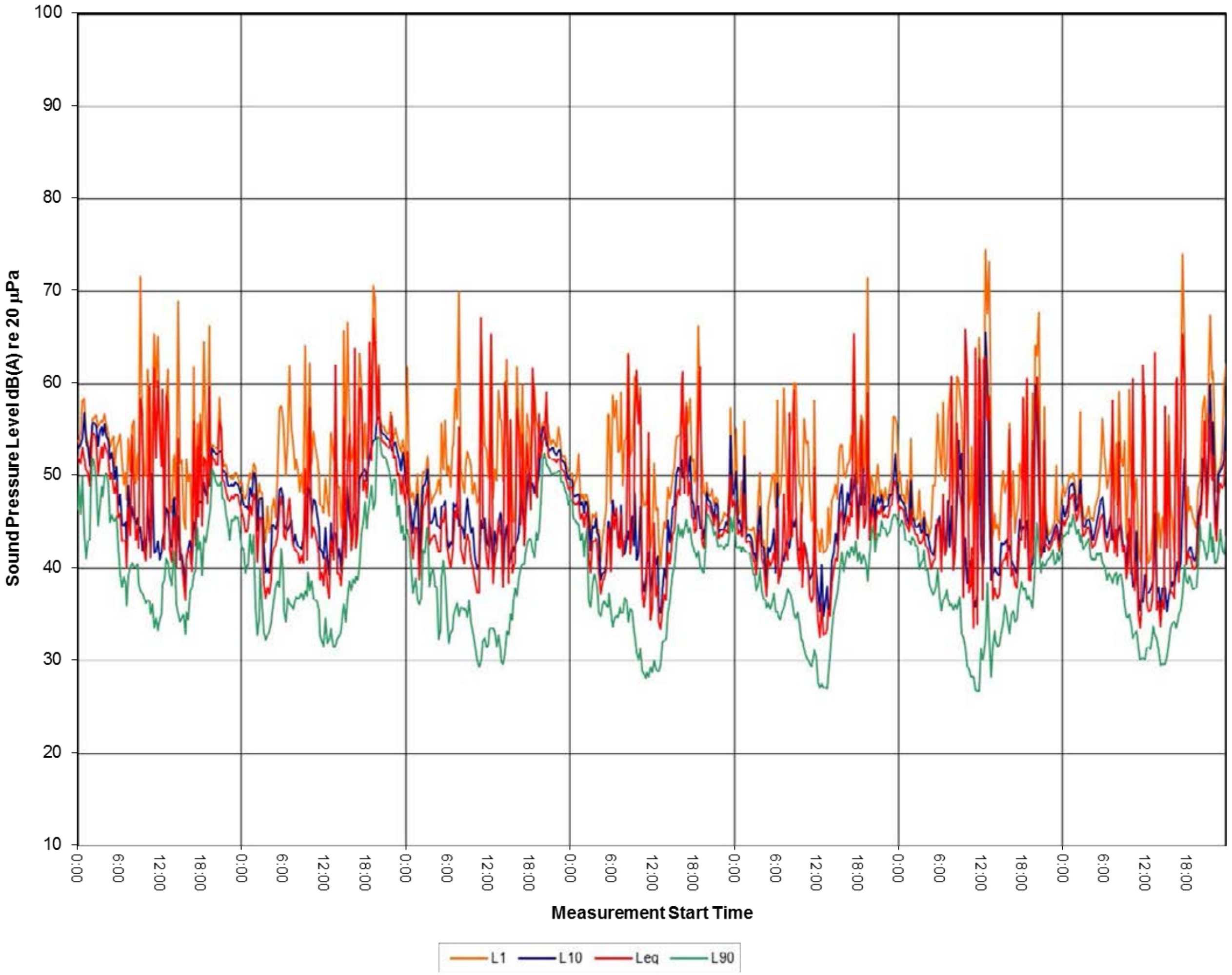


Figure 37: Measured Noise Levels – Logger Location 26 – Friday 18 October to Thursday 24 October 2013, dB re 20 µPa

Appendix D

Attended Noise Monitoring Spectra

Table 33: Attended noise monitoring results, dB re 20 µPa

Reference Location	Address	Period	Octave Band Centre Frequency, $_{LAeq(15minute)}$ dB re 20 µPa									
			31.5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
1	29 Villiers Street, in front of TAFE College, Grafton	Day	66	74	71	64	62	62	59	52	47	66
		Night	54	66	63	56	54	53	51	45	43	58
2	Gummyaney Pre School, 30 Pound Street, Grafton	Day	56	62	57	49	47	48	45	42	32	53
		Night	67	72	70	59	60	56	55	52	48	63
3	8 Fitzroy Street, Grafton	Day	65	70	64	59	56	53	50	49	39	59
		Night	54	61	49	46	44	42	38	29	37	47
4	St. Mary's Church, Clarence Street, Grafton	Day	59	64	59	47	43	46	48	52	42	56
		Night	60	64	59	48	45	43	39	33	24	49
5	12 Bent Street, Grafton Aged Care Home, South Grafton	Day	64	73	68	61	59	63	60	49	40	66
		Night	56	62	62	60	57	58	54	46	39	62
6	8 Beatson Street, South Grafton	Day	69	71	68	62	62	61	57	51	46	65
		Night	60	69	64	60	57	56	53	48	47	61
7	España Hotel, Schwinghammer Street, South Grafton	Day	67	78	73	69	65	64	59	53	47	69
		Night	69	82	75	70	68	67	62	57	53	71
8	245 Lawrence Rd, Great Marlow	Day	68	68	67	65	65	66	60	51	44	69
		Night	46	49	45	31	32	30	26	31	15	37
9	86 Great Marlow Rd, Great Marlow	Day	74	70	63	55	43	31	26	23	18	51
		Night	55	61	60	47	48	50	39	42	41	53
10	591 Summerland Way, Carrs Creek	Day	68	72	68	63	62	63	60	52	45	67
		Night	84	64	58	56	52	57	55	44	32	60
11	Cnr Hoof & Clarence St, Grafton	Day	66	69	59	54	53	54	47	41	32	57
		Night	68	54	50	40	36	38	32	21	15	42

Reference Location	Address	Period	Octave Band Centre Frequency, $_{LAeq(15minute)}$ dB re 20 μPa									
			31.5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
12	94 Dobie St, Grafton	Day	71	73	67	63	60	61	57	52	45	65
		Night	68	57	55	47	45	45	42	32	19	49
13	81 Edward Ogilvie Drive, Clarenza	Day	83	63	58	49	40	44	40	34	24	50
		Night	83	70	61	53	54	55	48	38	24	58
14	Pacific Hwy nr Alipou Creek	Day	86	74	68	57	45	38	34	34	27	55
		Night	102	76	73	71	67	65	57	47	37	70
15	326 Centenary Drive, Clarenza	Day	83	75	73	74	75	77	68	60	51	79
		Night	70	61	54	47	50	49	40	29	17	52
16	Cnr Iolanthe Street & Butter Lane, South Grafton	Day	77	63	53	42	38	41	39	35	27	47
		Night	64	60	54	49	51	48	38	22	13	52
17	146-148 Ryan Street, South Grafton	Day	78	70	69	64	63	65	60	51	42	68
		Night	68	61	59	57	54	59	54	44	35	62
18	5 School Drive, Swan Creek	Day	85	69	64	61	60	64	58	51	43	66
		Night	84	76	75	67	69	71	66	57	48	74
19	Riverbank at end of Meona Lane, Grafton	Day	88	73	66	55	44	40	32	28	20	54
		Day*	102	76	73	71	67	65	57	47	37	70
		Night	67	61	49	45	49	46	35	21	13	50
20	4 Bacon St, Grafton	Day	64	59	53	48	47	45	38	38	29	50
		Night	74	51	49	46	44	40	28	14	14	45
21	40 Dobie St, Grafton	Day	64	62	57	56	57	58	51	45	38	60
		Night	73	55	51	44	41	38	30	20	14	44
22	22 Fry Street, Grafton	Day	76	60	50	44	39	40	42	44	34	49
		Night	43	50	47	38	38	33	21	14	14	39

Reference Location	Address	Period	Octave Band Centre Frequency, $_{LAeq(15minute)}$ dB re 20 µPa									
			31.5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
23	320 Back Lane, Junction Hill	Day	44	45	41	39	37	44	41	52	42	54
		Night	44	37	30	26	28	26	23	38	22	39
24	235 Carr Street, Grafton	Day	53	53	44	36	34	36	38	37	29	43
		Night	65	55	55	50	49	48	48	47	41	54
25	98 Through Street, South Grafton	Day	56	57	54	50	45	45	40	34	27	49
		Night	56	60	47	40	36	32	27	28	23	40
26	Maclennan's Lane, Waterview	Day**	-	-	-	-	-	-	-	-	-	-
		Night	48	41	32	24	26	25	23	41	22	43

* Second day measurement taken on top of river bank with line of sight to Pacific Highway

** Measurement data corrupted

Appendix E

Noise Level Contour Plots

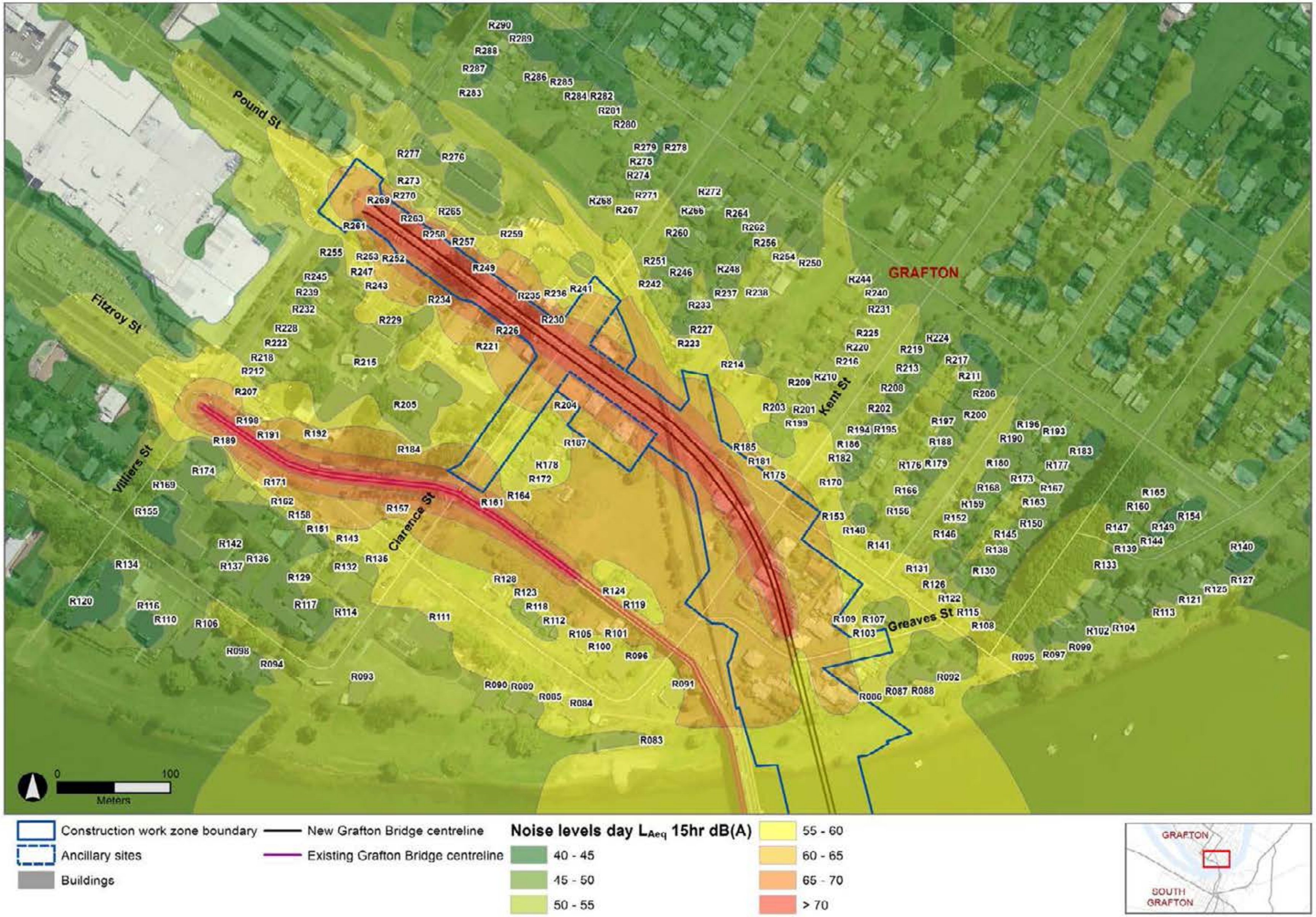


Figure 38 – Grafton traffic noise contour for day time, 2029 (7am to 10pm)

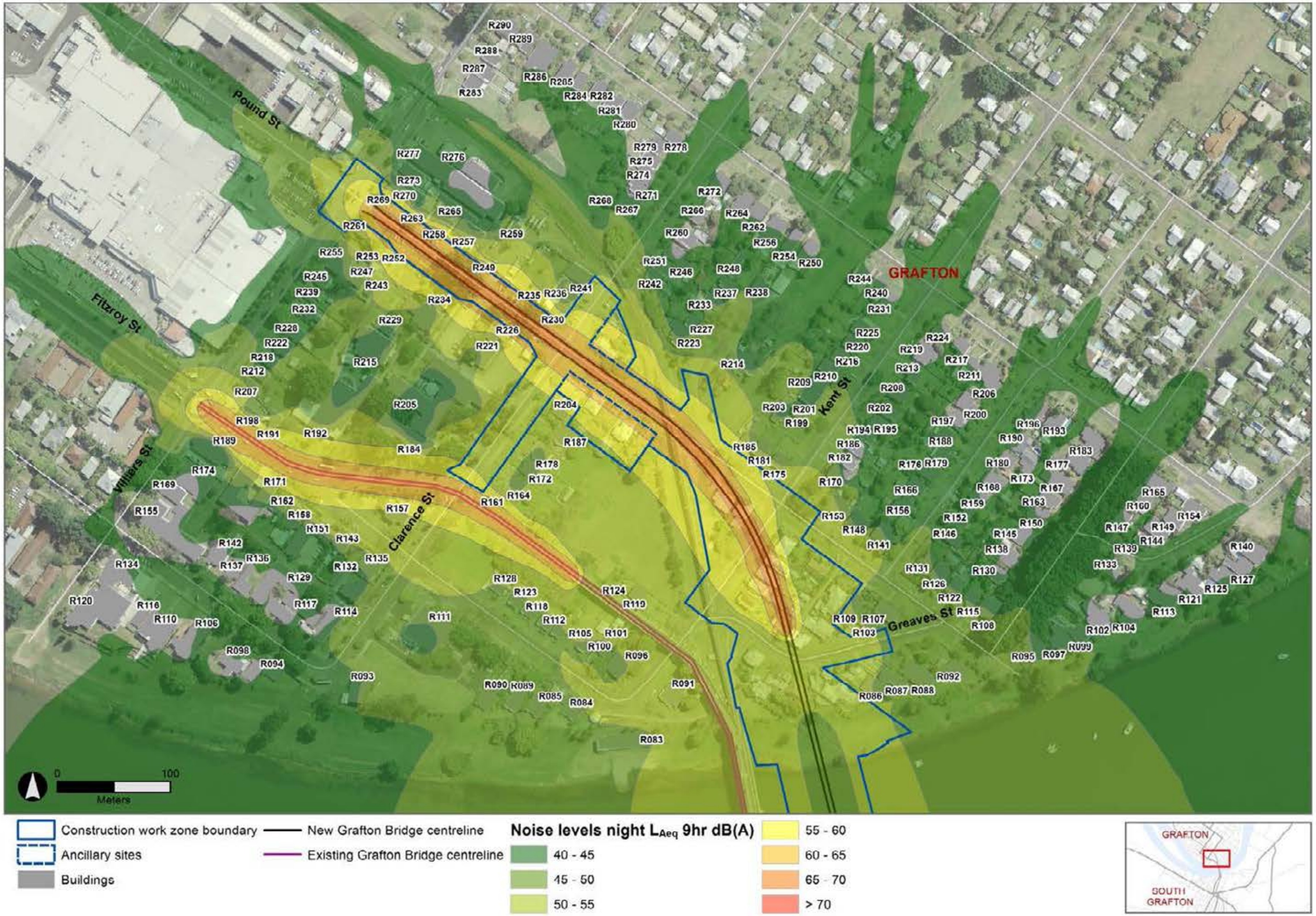


Figure 39 – Grafton traffic noise contour for night time, 2029 (10pm to 7am)

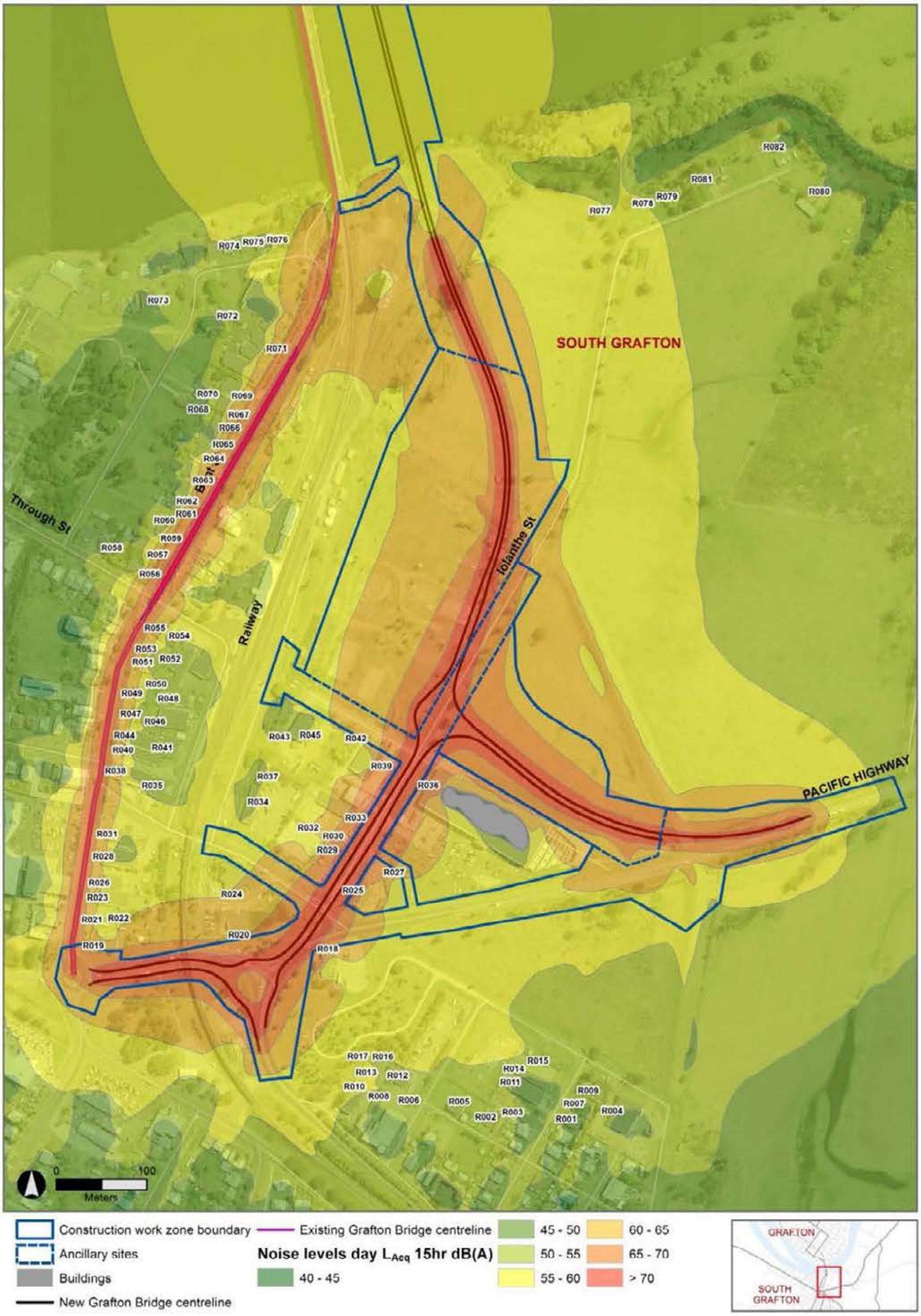


Figure 40 – South Grafton traffic noise contour for day time (7am to 10pm)

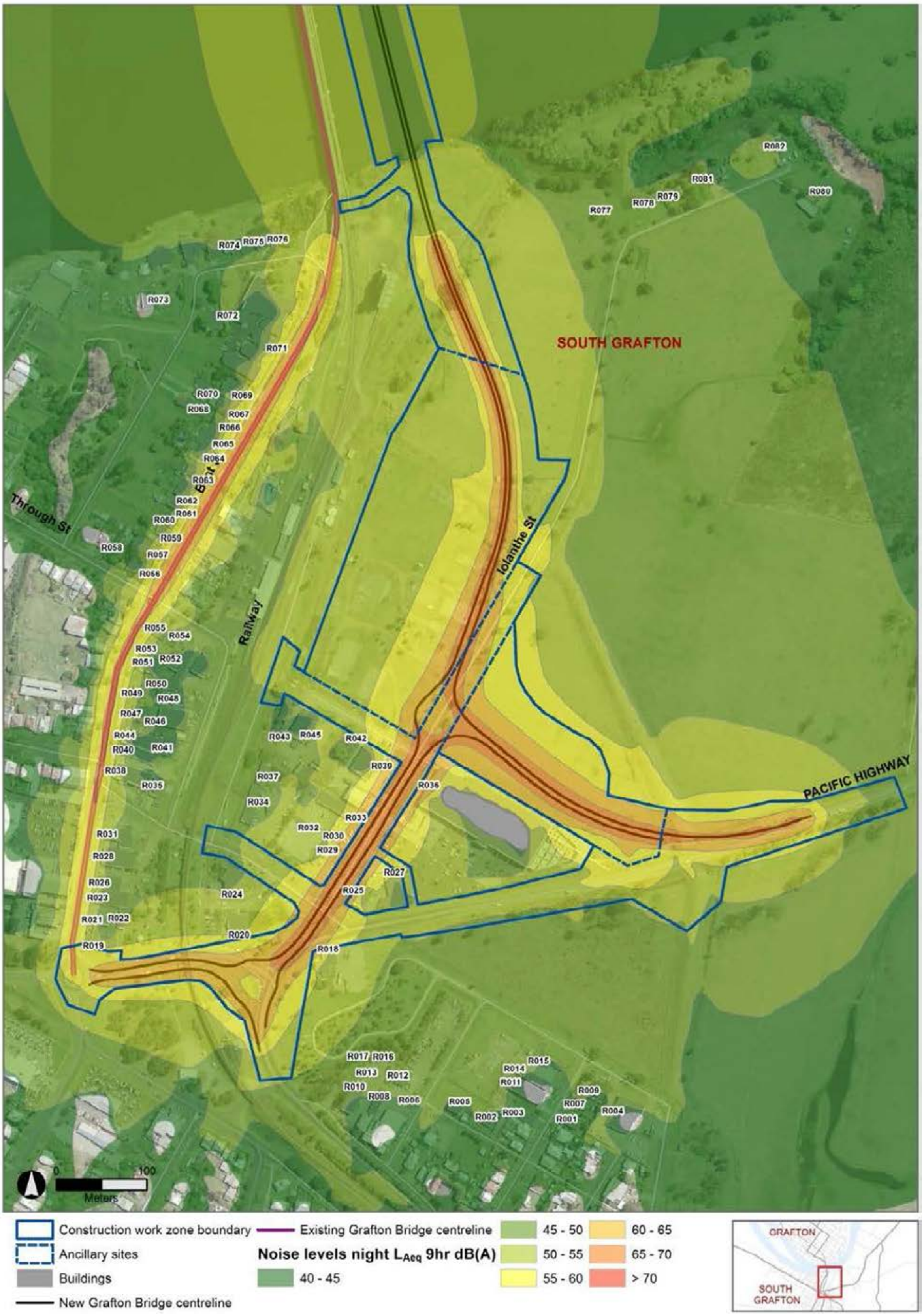


Figure 41 – South Grafton traffic noise contour for night time (10pm to 7am)

Appendix F

Individual receiver noise level results

Legend
Level exceeds RNP absolute criteria
Level exceeds RNP relative criteria
Level exceeds ENMM acute criteria
Residential property qualifies for mitigation according to ENMM
Non-residential property qualifies for mitigation according to ENMM

Usage	Key
Aged care	AC
Place of worship	CH
Clubs and recreation	CR
DA building	DA
Education	EDU
Emergency services	ES
Health	HEA
Hotel	HOT
Residential	RES

Receiver No.	Usage	No Build Option				Criteria Period		Criteria						Build Option				Reason noise affected	Qualify for mitigation		Qualifies?
		Future Existing 2019		Future Existing 2029				Absolute		Relative		Acute		Option C 2019		Option C 2029			Option C 2029 - Future Existing 2019		
		$L_{eq, 15hr}$	$L_{eq, 9hr}$	$L_{eq, 15hr}$	$L_{eq, 9hr}$	hr	hr	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$				
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night		Day	Night	
R001	RES	45.8	37.4	47.1	38.7	15	9	55	50	59.1	50.7	65	60	51.3	43.9	52.7	45.3		6.9	7.9	
R002	RES	46.6	38.4	47.9	39.6	15	9	55	50	59.9	51.6	65	60	52.1	44.5	53.4	45.9		6.8	7.5	
R003	RES	46.6	38.4	47.9	39.6	15	9	55	50	59.9	51.6	65	60	50.9	42.8	52.1	44.0		5.5	5.6	
R005	RES	46.9	38.7	48.1	39.9	15	9	55	50	60.1	51.9	65	60	52.5	45.1	53.8	46.5		6.9	7.8	
R007	RES	44.8	36.4	46.1	37.6	15	9	55	50	58.1	49.6	65	60	51.8	44.8	53.2	46.3		8.4	9.9	
R009	RES	46.0	37.8	47.3	39.0	15	9	55	50	59.3	51.0	65	60	52.0	45.1	53.4	46.5		7.4	8.7	
R047	RES	68.1	58.8	69.6	60.2	15	9	55	50	81.6	72.2	65	60	62.8	54.1	63.2	54.3	RNP-Absolute	-4.9	-4.5	
R049	RES	68.4	59.0	69.8	60.5	15	9	55	50	81.8	72.5	65	60	63.0	54.3	63.3	54.4	RNP-Absolute	-5.1	-4.6	
R051	RES	68.1	58.8	69.6	60.3	15	9	55	50	81.6	72.3	65	60	62.9	54.2	63.0	54.2	RNP-Absolute	-5.1	-4.6	
R053	RES	69.2	60.0	70.7	61.5	15	9	55	50	82.7	73.5	65	60	64.0	55.4	64.2	55.5	RNP-Absolute	-5.0	-4.5	
R056	RES	70.1	61.9	71.3	63.2	15	9	55	50	83.3	75.2	65	60	**66.1**	58.1	**67.0**	59.1	RNP-Absolute ENMM Acute	-3.1	-2.8	
R057	RES	68.9	60.9	70.2	62.1	15	9	55	50	82.2	74.1	65	60	**65.1**	57.1	**66.0**	58.2	RNP-Absolute ENMM Acute	-2.9	-2.7	
R058	RES	52.2	43.7	53.5	45.0	15	9	55	50	65.5	57.0	65	60	49.0	40.9	50.0	41.8		-2.2	-1.9	
R059	RES	70.4	62.4	71.6	63.6	15	9	55	50	83.6	75.6	65	60	**66.6**	58.7	**67.6**	59.9	RNP-Absolute ENMM Acute	-2.8	-2.5	
R060	RES	69.6	61.7	70.9	62.9	15	9	55	50	82.9	74.9	65	60	**65.9**	58.0	**66.9**	59.1	RNP-Absolute ENMM Acute	-2.7	-2.6	
R061	RES	69.3	61.4	70.6	62.6	15	9	55	50	82.6	74.6	65	60	**65.6**	57.7	**66.6**	58.9	RNP-Absolute ENMM Acute	-2.7	-2.5	
R062	RES	70.3	62.4	71.5	63.6	15	9	55	50	83.5	75.6	65	60	**66.5**	58.6	**67.5**	59.8	RNP-Absolute ENMM Acute	-2.8	-2.6	
R063	RES	69.4	61.5	70.6	62.7	15	9	55	50	82.6	74.7	65	60	**65.7**	57.8	**66.7**	58.9	RNP-Absolute ENMM Acute	-2.7	-2.6	
R064	RES	69.1	61.2	70.3	62.4	15	9	55	50	82.3	74.4	65	60	**65.4**	57.5	**66.4**	58.7	RNP-Absolute ENMM Acute	-2.7	-2.5	
R065	RES	69.4	61.6	70.7	62.8	15	9	55	50	82.7	74.8	65	60	**65.7**	57.8	**66.8**	59.0	RNP-Absolute ENMM Acute	-2.6	-2.6	
R066	RES	68.7	60.8	69.9	62.0	15	9	55	50	81.9	74.0	65	60	65.0	57.1	**66.1**	58.3	RNP-Absolute ENMM Acute	-2.6	-2.5	
R067	RES	69.2	61.4	70.5	62.6	15	9	55	50	82.5	74.6	65	60	**65.6**	57.6	**66.6**	58.8	RNP-Absolute ENMM Acute	-2.6	-2.6	
R068	DA	50.9	43.0	52.2	44.2	1	1	55	50	64.2	56.2	65	60	50.0	44.2	51.1	45.3		-0.9	-0.8	
R069	RES	66.8	58.9	68.0	60.1	15	9	55	50	80.0	72.1	65	60	63.2	55.3	64.3	56.5	RNP-Absolute	-2.5	-2.4	
R070	RES	50.7	42.8	51.9	44.0	15	9	55	50	63.9	56.0	65	60	48.6	40.7	49.7	41.9		-1.0	-0.9	

Receiver No.	Usage	No Build Option				Criteria								Build Option					Qualify for mitigation		Qualifies?
		Future Existing 2019		Future Existing 2029		Criteria Period		Absolute		Relative		Acute		Option C 2019		Option C 2029		Reason noise affected	Option C 2029 - Future Existing 2019		
		$L_{eq, 15hr}$	$L_{eq, 9hr}$	$L_{eq, 15hr}$	$L_{eq, 9hr}$	hr	hr	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$				
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night		Day	Night	
R071	AC	69.2	61.4	70.5	62.6	15	9	55	50	82.5	74.6	65	60	**65.7**	57.8	**66.7**	59.0	RNP-Absolute ENMM Acute	-2.5	-2.4	
R072	RES	55.5	47.8	56.7	48.9	15	9	55	50	68.7	60.9	65	60	54.0	46.2	55.1	47.4	RNP-Absolute	-0.4	-0.4	
R074	RES	51.7	44.0	52.9	45.2	15	9	55	50	64.9	57.2	65	60	50.2	42.3	51.3	43.6		-0.4	-0.4	
R075	RES	56.3	48.7	57.5	49.9	15	9	55	50	69.5	61.9	65	60	54.5	46.9	55.7	48.1	RNP-Absolute	-0.6	-0.6	
R076	RES	61.8	54.2	63.0	55.4	15	9	55	50	75.0	67.4	65	60	59.6	52.0	60.7	53.2	RNP-Absolute	-1.1	-1.0	
R078	RES	53.3	45.5	54.6	46.7	15	9	55	50	66.6	58.7	65	60	56.0	48.3	57.2	49.6	RNP-Absolute	3.9	4.1	YES
R079	RES	51.0	43.1	52.2	44.3	15	9	55	50	64.2	56.3	65	60	53.9	46.3	55.2	47.6	RNP-Absolute	4.2	4.5	YES
R080	RES	50.5	42.5	51.7	43.6	15	9	55	50	63.7	55.6	65	60	52.8	45.2	54.1	46.5		3.6	4.0	
R081	RES	51.9	44.1	53.1	45.3	15	9	55	50	65.1	57.3	65	60	54.2	46.6	55.5	47.9	RNP-Absolute	3.6	3.8	YES
R082	RES	51.3	43.5	52.5	44.7	15	9	55	50	64.5	56.7	65	60	53.3	45.7	54.5	47.0		3.2	3.5	
R083	CR	60.1	52.7	61.3	53.9	15	1	60	-	-	-	-	-	58.4	53.1	59.5	54.3		-0.6	-0.5	
R084	RES	60.4	52.9	61.6	54.1	15	9	55	50	73.6	66.1	65	60	58.5	50.8	59.6	52.1	RNP-Absolute	-0.8	-0.8	
R085	RES	59.1	51.6	60.2	52.7	15	9	55	50	72.2	64.7	65	60	56.8	49.1	57.9	50.3	RNP-Absolute	-1.2	-1.3	
R086	RES	57.3	49.7	58.5	50.9	15	9	55	50	70.5	62.9	65	60	59.5	51.9	60.8	53.3	RNP-Absolute	3.5	3.6	YES
R087	RES	56.4	48.8	57.6	49.9	15	9	55	50	69.6	61.9	65	60	57.3	49.7	58.6	51.0	RNP-Absolute	2.2	2.2	YES
R088	RES	56.3	48.7	57.5	49.8	15	9	55	50	69.5	61.8	65	60	57.2	49.6	58.4	50.9	RNP-Absolute	2.1	2.2	YES
R089	RES	58.9	51.3	60.1	52.4	15	9	55	50	72.1	64.4	65	60	56.7	48.9	57.7	50.1	RNP-Absolute	-1.2	-1.2	
R090	RES	58.4	50.7	59.5	51.8	15	9	55	50	71.5	63.8	65	60	55.8	48.0	56.9	49.3	RNP-Absolute	-1.5	-1.4	
R091	RES	59.9	52.6	61.1	53.7	15	9	55	50	73.1	65.7	65	60	60.9	53.3	62.1	54.5	RNP-Absolute	2.2	1.9	YES
R092	RES	54.8	47.1	56.0	48.3	15	9	55	50	68.0	60.3	65	60	56.0	48.3	57.3	49.6	RNP-Absolute	2.5	2.5	YES
R093	CH	55.1	47.3	56.1	48.4	1	1	50	50	-	-	-	-	54.7	48.7	55.8	49.9		-0.5	-0.4	
R094	CH	53.1	45.4	54.2	46.4	1	1	50	50	-	-	-	-	53.1	47.2	54.3	48.4		0.0	0.0	
R095	RES	54.7	47.0	55.9	48.2	15	9	55	50	67.9	60.2	65	60	56.7	49.0	58.0	50.3	RNP-Absolute	3.3	3.3	YES
R096	RES	61.7	54.4	62.9	55.6	15	9	55	50	74.9	67.6	65	60	60.6	53.1	61.8	54.3	RNP-Absolute	0.1	-0.1	
R097	RES	53.2	45.5	54.4	46.7	15	9	55	50	66.4	58.7	65	60	54.1	46.4	55.3	47.7	RNP-Absolute	2.1	2.2	YES
R098	CH	51.2	43.5	52.2	44.5	1	1	50	50	-	-	-	-	51.6	45.6	52.7	46.8		0.3	0.3	
R099	RES	52.6	44.9	53.8	46.1	15	9	55	50	65.8	58.1	65	60	53.3	45.6	54.6	46.9		2.0	2.0	
R100	RES	63.8	56.5	65.1	57.6	15	9	55	50	77.1	69.6	65	60	61.0	53.4	62.0	54.7	RNP-Absolute	-1.8	-1.8	

Receiver No.	Usage	No Build Option				Criteria Period		Criteria						Build Option					Qualify for mitigation		
		Future Existing 2019		Future Existing 2029				Absolute		Relative		Acute		Option C 2019		Option C 2029		Reason noise affected	Option C 2029 - Future Existing 2019		Qualifies?
		$L_{eq, 15hr}$	$L_{eq, 9hr}$	$L_{eq, 15hr}$	$L_{eq, 9hr}$	hr	hr	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$				
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night		Day	Night	
R101	RES	63.5	56.2	64.7	57.4	15	9	55	50	76.7	69.4	65	60	61.5	54.0	62.6	55.3	RNP-Absolute	-0.9	-0.9	
R102	RES	51.5	43.8	52.7	45.0	15	9	55	50	64.7	57.0	65	60	52.3	44.6	53.6	45.9		2.1	2.1	
R103	RES	55.5	47.8	56.7	49.0	15	9	55	50	68.7	61.0	65	60	59.1	51.6	60.4	52.9	RNP-Absolute	4.9	5.1	YES
R104	RES	52.0	44.3	53.2	45.5	15	9	55	50	65.2	57.5	65	60	52.9	45.2	54.1	46.4		2.1	2.1	
R105	RES	64.1	56.7	65.3	57.8	15	9	55	50	77.3	69.8	65	60	61.1	53.5	62.1	54.7	RNP-Absolute	-2.0	-2.0	
R106	CH	51.7	43.9	52.7	44.9	1	1	50	50	-	-	-	-	52.0	46.1	53.2	47.3		0.3	0.3	
R107	RES	49.7	41.8	50.9	43.0	15	9	55	50	62.9	55.0	65	60	53.1	45.3	54.3	46.6		4.6	4.8	
R108	RES	52.3	44.5	53.5	45.7	15	9	55	50	65.5	57.7	65	60	56.0	48.3	57.3	49.6	RNP-Absolute	5.0	5.1	YES
R109	RES	54.7	47.0	55.9	48.2	15	9	55	50	67.9	60.2	65	60	60.8	53.3	62.1	54.6	RNP-Absolute	7.4	7.6	YES
R110	EDU	49.0	41.3	50.0	42.2	1	1	50	-	-	-	-	-	49.7	43.8	50.8	44.9		0.6	0.5	
R111	HEA	60.2	52.5	61.3	53.5	1	1	45	45	-	-	-	-	58.8	52.8	59.8	53.9		-1.6	-1.5	
R112	RES	64.2	56.8	65.4	57.9	15	9	55	50	77.4	69.9	65	60	61.1	53.5	62.1	54.7	RNP-Absolute	-2.1	-2.1	
R113	RES	51.1	43.3	52.3	44.5	15	9	55	50	64.3	56.5	65	60	52.3	44.5	53.5	45.8		2.4	2.5	
R114	RES	56.2	48.4	57.4	49.6	15	9	55	50	69.4	61.6	65	60	54.1	46.3	55.2	47.5	RNP-Absolute	-1.0	-0.9	
R115	RES	52.6	44.8	53.8	46.0	15	9	55	50	65.8	58.0	65	60	56.2	48.5	57.5	49.8	RNP-Absolute	4.9	5.0	YES
R116	EDU	49.4	41.7	50.5	42.7	1	1	50	-	-	-	-	-	50.0	44.1	51.1	45.2		0.6	0.5	
R117	EDU	51.4	43.6	52.3	44.5	1	1	50	-	-	-	-	-	51.8	46.0	52.9	47.1		0.3	0.2	
R118	RES	64.4	56.9	65.6	58.1	15	9	55	50	77.6	70.1	65	60	61.1	53.5	62.1	54.7	RNP-Absolute	-2.3	-2.2	
R119	RES	60.3	52.7	61.4	53.9	15	9	55	50	73.4	65.9	65	60	57.4	49.7	58.3	50.9	RNP-Absolute	-2.0	-1.8	
R120	EDU	42.0	34.2	42.7	34.9	1	1	50	-	-	-	-	-	42.6	36.6	43.6	37.7		0.2	0.2	
R121	RES	50.4	42.7	51.6	43.9	15	9	55	50	63.6	55.9	65	60	51.4	43.7	52.7	45.0		2.3	2.3	
R122	RES	52.5	44.7	53.7	45.9	15	9	55	50	65.7	57.9	65	60	56.4	48.7	57.7	50.0	RNP-Absolute	5.2	5.3	YES
R123	RES	64.8	57.3	66.0	58.5	15	9	55	50	78.0	70.5	65	60	61.4	53.8	62.4	55.0	RNP-Absolute	-2.4	-2.3	
R125	RES	50.2	42.5	51.4	43.7	15	9	55	50	63.4	55.7	65	60	51.3	43.6	52.5	44.8		2.3	2.3	
R126	RES	52.2	44.5	53.4	45.7	15	9	55	50	65.4	57.7	65	60	56.7	49.0	57.9	50.2	RNP-Absolute	5.7	5.7	YES
R127	RES	49.3	41.7	50.5	42.9	15	9	55	50	62.5	54.9	65	60	50.5	42.7	51.7	44.0		2.4	2.3	
R128	RES	65.3	57.7	66.5	58.9	15	9	55	50	78.5	70.9	65	60	61.8	54.1	62.8	55.3	RNP-Absolute	-2.5	-2.4	
R129	EDU	53.1	45.3	54.1	46.2	1	1	50	-	-	-	-	-	53.0	47.1	54.1	48.2		-0.3	-0.3	

Receiver No.	Usage	No Build Option				Criteria Period		Criteria						Build Option				Reason noise affected	Qualify for mitigation		
		Future Existing 2019		Future Existing 2029				Absolute		Relative		Acute		Option C 2019		Option C 2029			Option C 2029 - Future Existing 2019		Qualifies?
		$L_{eq,\ 15hr}$	$L_{eq,\ 9hr}$	$L_{eq,\ 15hr}$	$L_{eq,\ 9hr}$	hr	hr	$L_{eq,\ period}$	$L_{eq,\ period}$	$L_{eq,\ period}$	$L_{eq,\ period}$	$L_{eq,\ period}$	$L_{eq,\ period}$	$L_{eq,\ period}$	$L_{eq,\ period}$	$L_{eq,\ period}$	$L_{eq,\ period}$				
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night		Day	Night	
R130	RES	47.8	39.9	49.0	41.1	15	9	55	50	61.0	53.1	65	60	49.7	41.8	51.0	43.1		3.2	3.2	
R131	RES	52.0	44.3	53.2	45.5	15	9	55	50	65.2	57.5	65	60	56.5	48.8	57.8	50.1	RNP-Absolute	5.8	5.8	YES
R133	RES	50.2	42.4	51.4	43.6	15	9	55	50	63.4	55.6	65	60	50.9	43.1	52.1	44.3		1.9	1.9	
R134	EDU	49.3	41.5	50.4	42.5	1	1	50	-	-	-	-	-	49.8	43.9	50.9	45.1		0.5	0.5	
R135	RES	61.7	53.9	62.6	54.7	15	9	55	50	74.6	66.7	65	60	59.4	51.5	60.4	52.7	RNP-Absolute	-1.3	-1.2	
R136	EDU	51.5	43.7	52.3	44.5	1	1	50	-	-	-	-	-	51.7	45.8	52.8	46.9		0.0	0.0	
R138	RES	48.9	41.1	50.1	42.3	15	9	55	50	62.1	54.3	65	60	50.5	42.7	51.8	43.9		2.9	2.8	
R139	RES	47.6	39.9	48.8	41.0	15	9	55	50	60.8	53.0	65	60	49.0	41.1	50.3	42.4		2.7	2.5	
R140	RES	46.3	38.5	47.5	39.7	15	9	55	50	59.5	51.7	65	60	47.5	39.5	48.6	40.8		2.3	2.3	
R141	RES	52.6	44.9	53.8	46.0	15	9	55	50	65.8	58.0	65	60	58.6	50.9	59.8	52.2	RNP-Absolute	7.2	7.3	YES
R143	RES	62.6	54.8	63.3	55.4	15	9	55	50	75.3	67.4	65	60	60.3	52.4	61.3	53.5	RNP-Absolute	-1.3	-1.3	
R144	RES	41.8	33.9	42.9	35.0	15	9	55	50	54.9	47.0	65	60	44.4	36.4	45.6	37.6		3.8	3.7	
R145	RES	49.0	41.2	50.2	42.4	15	9	55	50	62.2	54.4	65	60	50.4	42.5	51.6	43.7		2.6	2.5	
R146	RES	50.6	42.9	51.8	44.1	15	9	55	50	63.8	56.1	65	60	52.9	45.2	54.1	46.5		3.5	3.6	
R147	RES	50.1	42.3	51.3	43.5	15	9	55	50	63.3	55.5	65	60	50.7	42.9	51.9	44.2		1.8	1.9	
R148	RES	52.8	45.1	54.0	46.3	15	9	55	50	66.0	58.3	65	60	58.6	51.0	59.9	52.4	RNP-Absolute	7.1	7.3	YES
R149	RES	40.6	32.7	41.8	33.8	15	9	55	50	53.8	45.8	65	60	42.9	34.9	44.2	36.2		3.6	3.5	
R150	RES	45.5	37.8	46.7	38.9	15	9	55	50	58.7	50.9	65	60	48.0	40.0	49.2	41.3		3.7	3.5	
R151	HOT	63.8	56.0	64.4	56.6	15	9	55	50	76.4	68.6	65	60	61.5	53.7	62.5	54.7	RNP-Absolute	-1.3	-1.3	
R152	RES	50.4	42.7	51.6	43.8	15	9	55	50	63.6	55.8	65	60	52.3	44.5	53.6	45.8		3.2	3.1	
R153	RES	52.5	44.9	53.7	46.1	15	9	55	50	65.7	58.1	65	60	60.3	52.7	61.6	54.0	RNP-Absolute	9.1	9.1	YES
R154	RES	43.8	35.9	45.0	37.1	15	9	55	50	57.0	49.1	65	60	45.8	37.9	47.1	39.2		3.3	3.3	
R156	RES	47.0	39.3	48.2	40.5	15	9	55	50	60.2	52.5	65	60	51.4	43.5	52.7	44.8		5.7	5.5	
R158	HOT	65.0	57.2	65.6	57.7	15	9	55	50	77.6	69.7	65	60	62.7	54.9	63.7	55.9	RNP-Absolute	-1.3	-1.3	
R159	RES	45.7	37.9	46.8	39.0	15	9	55	50	58.8	51.0	65	60	48.4	40.4	49.6	41.7		3.9	3.8	
R160	RES	45.9	38.2	47.1	39.3	15	9	55	50	59.1	51.3	65	60	47.8	39.9	49.0	41.1		3.1	2.9	
R161	RES	72.5	64.7	73.7	65.8	15	9	55	50	85.7	77.8	65	60	**68.4**	**60.5**	**69.2**	**61.6**	RNP-Absolute ENMM Acute	-3.3	-3.1	
R162	RES	64.2	56.4	64.8	56.9	15	9	55	50	76.8	68.9	65	60	61.9	54.1	62.9	55.1	RNP-Absolute	-1.3	-1.3	

Receiver No.	Usage	No Build Option				Criteria Period		Criteria						Build Option				Reason noise affected	Qualify for mitigation		Qualifies?
		Future Existing 2019		Future Existing 2029				Absolute		Relative		Acute		Option C 2019		Option C 2029			Option C 2029 - Future Existing 2019		
		$L_{eq, 15hr}$	$L_{eq, 9hr}$	$L_{eq, 15hr}$	$L_{eq, 9hr}$	hr	hr	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$				
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night		Day	Night	
R163	RES	49.3	41.5	50.5	42.7	15	9	55	50	62.5	54.7	65	60	50.4	42.6	51.7	43.8		2.4	2.3	
R164	RES	65.8	58.1	67.0	59.3	15	9	55	50	79.0	71.3	65	60	61.8	54.0	62.7	55.2	RNP-Absolute	-3.1	-2.9	
R165	RES	40.6	32.7	41.8	33.9	15	9	55	50	53.8	45.9	65	60	43.0	35.0	44.2	36.2		3.6	3.5	
R166	RES	48.1	40.4	49.3	41.5	15	9	55	50	61.3	53.5	65	60	51.1	43.3	52.4	44.6		4.3	4.2	
R167	RES	44.1	36.3	45.3	37.4	15	9	55	50	57.3	49.4	65	60	46.6	38.6	47.8	39.9		3.7	3.6	
R168	RES	44.2	36.3	45.4	37.5	15	9	55	50	57.4	49.5	65	60	47.1	39.1	48.3	40.4		4.1	4.1	
R169	RES	50.2	42.4	50.8	42.9	15	9	55	50	62.8	54.9	65	60	48.4	40.6	49.3	41.6		-0.9	-0.8	
R170	RES	52.9	45.3	54.1	46.4	15	9	55	50	66.1	58.4	65	60	58.0	50.5	59.3	51.8	RNP-Absolute	6.4	6.5	YES
R171	HOT	68.5	60.7	69.1	61.2	15	9	55	50	81.1	73.2	65	60	**66.1**	58.3	**67.1**	59.3	RNP-Absolute ENMM Acute	-1.4	-1.4	
R172	RES	61.8	54.1	63.0	55.3	15	9	55	50	75.0	67.3	65	60	60.4	52.6	61.5	53.8	RNP-Absolute	-0.3	-0.3	
R173	RES	49.5	41.6	50.7	42.8	15	9	55	50	62.7	54.8	65	60	50.7	42.9	51.9	44.1		2.4	2.5	
R174	EDU	51.3	43.5	51.9	44.1	1	1	50	-	-	-	-	-	51.4	45.4	52.5	46.4		-0.2	-0.2	
R175	RES	54.4	46.8	55.6	47.9	15	9	55	50	67.6	59.9	65	60	62.3	54.7	63.7	56.1	RNP-Absolute	9.3	9.3	YES
R176	RES	49.3	41.6	50.5	42.8	15	9	55	50	62.5	54.8	65	60	51.5	43.7	52.7	44.9		3.4	3.3	
R177	RES	44.5	36.7	45.7	37.8	15	9	55	50	57.7	49.8	65	60	47.0	39.1	48.2	40.3		3.7	3.6	
R178	RES	59.7	52.0	60.9	53.2	15	9	55	50	72.9	65.2	65	60	59.8	51.9	61.0	53.2	RNP-Absolute	1.3	1.2	
R179	RES	43.2	35.3	44.4	36.5	15	9	55	50	56.4	48.5	65	60	46.4	38.4	47.6	39.7		4.4	4.4	
R180	RES	48.1	40.4	49.2	41.5	15	9	55	50	61.2	53.5	65	60	49.6	41.8	50.8	43.0		2.7	2.6	
R181	RES	55.5	47.9	56.7	49.1	15	9	55	50	68.7	61.1	65	60	64.1	56.4	**65.4**	57.8	RNP-Absolute ENMM Acute	9.9	9.9	YES
R182	RES	50.0	42.5	51.2	43.6	15	9	55	50	63.2	55.6	65	60	54.9	47.3	56.2	48.6	RNP-Absolute	6.2	6.1	YES
R183	RES	43.2	35.4	44.3	36.4	15	9	55	50	56.3	48.4	65	60	45.8	37.9	47.1	39.2		3.9	3.8	
R184	EDU	65.9	58.1	66.6	58.7	1	1	50	-	-	-	-	-	64.8	58.7	65.7	59.7		-1.6	-1.5	
R185	RES	54.3	46.7	55.5	47.9	15	9	55	50	67.5	59.9	65	60	63.7	56.1	65.0	57.4	RNP-Absolute	10.7	10.7	YES
R186	RES	49.5	41.9	50.7	43.1	15	9	55	50	62.7	55.1	65	60	54.3	46.6	55.6	48.0	RNP-Absolute	6.1	6.1	YES
R187	RES	58.7	51.0	59.9	52.2	15	9	55	50	71.9	64.2	65	60	61.5	53.6	62.8	54.9	RNP-Absolute	4.1	3.9	YES
R188	RES	48.7	41.0	49.9	42.2	15	9	55	50	61.9	54.2	65	60	50.5	42.6	51.7	43.9		3.0	2.9	
R190	RES	49.3	41.6	50.5	42.8	15	9	55	50	62.5	54.8	65	60	50.6	42.7	51.8	44.0		2.5	2.4	

Receiver No.	Usage	No Build Option				Criteria Period		Criteria						Build Option				Reason noise affected	Qualify for mitigation		Qualifies?
		Future Existing 2019		Future Existing 2029				Absolute		Relative		Acute		Option C 2019		Option C 2029			Option C 2029 - Future Existing 2019		
		$L_{eq, 15hr}$	$L_{eq, 9hr}$	$L_{eq, 15hr}$	$L_{eq, 9hr}$	hr	hr	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$				
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night		Day	Night	
R192	EDU	64.9	57.1	65.5	57.6	1	1	50	-	-	-	-	-	64.1	58.0	65.1	59.0		-1.3	-1.3	
R193	RES	47.5	39.6	48.6	40.8	15	9	55	50	60.6	52.8	65	60	49.1	41.2	50.4	42.5		2.9	2.9	
R194	RES	49.0	41.4	50.1	42.6	15	9	55	50	62.1	54.6	65	60	53.3	45.6	54.6	46.9		5.6	5.5	
R195	RES	48.0	40.1	49.2	41.3	15	9	55	50	61.2	53.3	65	60	50.2	42.2	51.3	43.4		3.3	3.3	
R196	RES	46.9	39.2	48.0	40.3	15	9	55	50	60.0	52.3	65	60	48.4	40.5	49.6	41.8		2.7	2.6	
R197	RES	49.8	42.1	51.0	43.3	15	9	55	50	63.0	55.3	65	60	51.2	43.3	52.4	44.6		2.6	2.5	
R199	RES	49.7	42.0	50.9	43.2	15	9	55	50	62.9	55.2	65	60	54.9	47.3	56.1	48.6	RNP-Absolute	6.4	6.6	YES
R200	RES	48.3	40.5	49.5	41.6	15	9	55	50	61.5	53.6	65	60	49.4	41.6	50.6	42.8		2.3	2.3	
R201	RES	51.0	43.3	52.2	44.5	15	9	55	50	64.2	56.5	65	60	54.9	47.3	56.1	48.6	RNP-Absolute	5.1	5.3	YES
R202	RES	48.5	40.9	49.6	42.0	15	9	55	50	61.6	54.0	65	60	51.5	43.7	52.7	45.0		4.2	4.1	
R203	RES	50.8	43.0	51.9	44.1	15	9	55	50	63.9	56.1	65	60	56.3	48.4	57.5	49.7	RNP-Absolute	6.7	6.7	YES
R204	RES	45.8	37.9	46.8	38.9	15	9	55	50	58.8	50.9	65	60	64.4	56.5	**65.7**	57.7	RNP-Absolute RNP-Relative ENMM Acute	19.9	19.8	YES
R205	EDU	52.5	44.7	53.2	45.4	1	1	50	-	-	-	-	-	52.6	46.6	53.7	47.7		-0.2	-0.2	
R206	RES	47.0	39.2	48.2	40.3	15	9	55	50	60.2	52.3	65	60	48.9	41.0	50.1	42.3		3.1	3.1	
R207	RES	61.9	54.1	62.6	54.7	15	9	55	50	74.6	66.7	65	60	59.8	51.9	60.7	52.9	RNP-Absolute	-1.2	-1.2	
R208	RES	48.3	40.7	49.4	41.8	15	9	55	50	61.4	53.8	65	60	51.1	43.3	52.3	44.6		4.0	3.9	
R209	RES	48.7	40.9	49.9	42.0	15	9	55	50	61.9	54.0	65	60	53.3	45.4	54.6	46.7		5.9	5.8	
R210	RES	43.1	35.3	44.3	36.4	15	9	55	50	56.3	48.4	65	60	46.9	38.9	48.1	40.1		5.0	4.8	
R211	RES	48.8	41.2	50.0	42.3	15	9	55	50	62.0	54.3	65	60	50.1	42.3	51.3	43.5		2.5	2.3	
R212	RES	56.2	48.3	56.8	48.9	15	9	55	50	68.8	60.9	65	60	54.1	46.3	55.1	47.3	RNP-Absolute	-1.1	-1.0	
R213	RES	48.4	40.8	49.6	41.9	15	9	55	50	61.6	53.9	65	60	50.6	42.9	51.9	44.1		3.5	3.3	
R214	EDU	52.7	45.1	53.9	46.3	1	1	50	-	-	-	-	-	58.7	52.7	59.9	54.0	RNP Absolute	6.2	6.1	YES
R215	EDU	51.6	43.8	52.4	44.5	1	1	50	-	-	-	-	-	52.1	46.1	53.1	47.2		0.2	0.1	
R216	RES	49.9	42.2	51.1	43.4	15	9	55	50	63.1	55.4	65	60	52.0	44.3	53.2	45.6		3.3	3.4	
R217	RES	49.9	42.2	51.0	43.3	15	9	55	50	63.0	55.3	65	60	50.9	43.1	52.1	44.4		2.2	2.2	
R218	RES	54.0	46.2	54.6	46.7	15	9	55	50	66.6	58.7	65	60	52.2	44.3	53.2	45.4		-0.8	-0.8	
R219	RES	48.2	40.7	49.4	41.8	15	9	55	50	61.4	53.8	65	60	50.3	42.6	51.6	43.9		3.4	3.2	

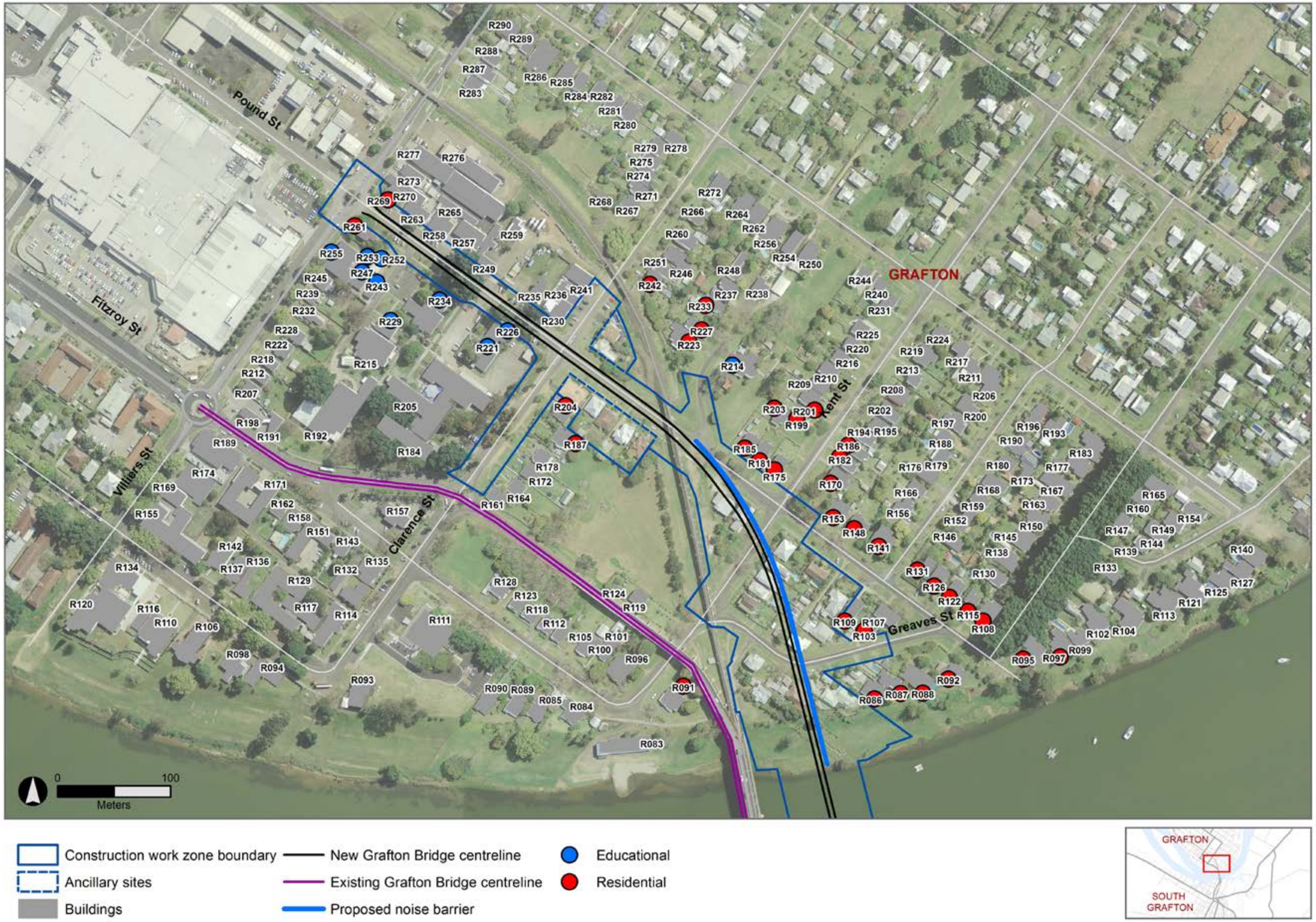
Receiver No.	Usage	No Build Option				Criteria Period		Criteria						Build Option					Qualify for mitigation		Qualifies?
		Future Existing 2019		Future Existing 2029				Absolute		Relative		Acute		Option C 2019		Option C 2029		Reason noise affected	Option C 2029 - Future Existing 2019		
		$L_{eq, 15hr}$	$L_{eq, 9hr}$	$L_{eq, 15hr}$	$L_{eq, 9hr}$	hr	hr	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$				
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night		Day	Night	
R220	RES	49.5	41.9	50.7	43.0	15	9	55	50	62.7	55.0	65	60	51.4	43.7	52.6	45.0		3.1	3.1	
R221	EDU	44.5	36.6	45.5	37.6	1	1	50	-	-	-	-	-	61.2	55.3	62.4	56.5	RNP Absolute	16.6	16.5	YES
R222	RES	50.6	42.8	51.2	43.3	15	9	55	50	63.2	55.3	65	60	49.4	41.5	50.4	42.5		-0.2	-0.3	
R223	RES	51.7	44.2	52.9	45.4	15	9	55	50	64.9	57.4	65	60	57.3	49.6	58.6	51.0	RNP-Absolute	6.9	6.8	YES
R224	RES	44.9	37.1	46.0	38.1	15	9	55	50	58.0	50.1	65	60	47.6	39.7	48.8	40.9		3.9	3.8	
R225	RES	49.1	41.4	50.3	42.6	15	9	55	50	62.3	54.6	65	60	50.9	43.2	52.2	44.5		3.1	3.1	
R226	EDU	41.0	33.1	42.0	34.1	1	1	50	-	-	-	-	-	72.7	66.8	73.9	68.0	RNP Absolute	31.4	31.2	YES
R227	RES	51.9	44.4	53.1	45.6	15	9	55	50	65.1	57.6	65	60	56.4	48.8	57.7	50.1	RNP-Absolute	5.8	5.7	YES
R228	RES	50.4	42.5	51.0	43.1	15	9	55	50	63.0	55.1	65	60	49.4	41.5	50.5	42.6		0.1	0.1	
R229	EDU	44.7	36.7	45.5	37.6	1	1	50	-	-	-	-	-	59.2	53.2	60.4	54.4	RNP Absolute	14.2	14.2	YES
R231	RES	49.3	41.6	50.5	42.7	15	9	55	50	62.5	54.7	65	60	51.0	43.2	52.2	44.5		2.9	2.9	
R232	RES	48.4	40.6	49.1	41.2	15	9	55	50	61.1	53.2	65	60	48.4	40.5	49.5	41.6		1.1	1.0	
R233	RES	50.6	43.1	51.8	44.2	15	9	55	50	63.8	56.2	65	60	55.3	47.6	56.6	48.9	RNP-Absolute	6.0	5.8	YES
R234	EDU	44.2	36.3	45.1	37.1	1	1	50	-	-	-	-	-	68.0	62.0	69.3	63.3	RNP Absolute	23.5	23.4	YES
R237	RES	48.8	41.2	50.0	42.4	15	9	55	50	62.0	54.4	65	60	50.8	43.1	52.0	44.3		3.2	3.1	
R238	RES	51.2	43.6	52.4	44.7	15	9	55	50	64.4	56.7	65	60	53.3	45.4	54.5	46.7		3.3	3.1	
R239	RES	48.8	40.9	49.4	41.5	15	9	55	50	61.4	53.5	65	60	49.0	41.1	50.1	42.2		1.3	1.3	
R240	RES	49.3	41.5	50.4	42.7	15	9	55	50	62.4	54.7	65	60	51.0	43.1	52.2	44.4		2.9	2.9	
R242	RES	48.9	41.2	50.0	42.3	15	9	55	50	62.0	54.3	65	60	54.3	46.5	55.5	47.7	RNP-Absolute	6.6	6.5	YES
R243	EDU	45.2	37.6	46.4	38.5	1	1	50	-	-	-	-	-	63.0	57.0	64.2	58.2	RNP Absolute	17.5	17.1	YES
R244	RES	49.5	41.9	50.7	43.0	15	9	55	50	62.7	55.0	65	60	50.9	43.1	52.1	44.3		2.6	2.4	
R245	RES	47.8	40.0	48.4	40.5	15	9	55	50	60.4	52.5	65	60	48.4	40.4	49.5	41.6		1.7	1.6	
R246	RES	47.1	39.3	48.2	40.4	15	9	55	50	60.2	52.4	65	60	49.8	41.9	51.0	43.1		3.9	3.8	
R247	EDU	44.0	36.1	44.9	37.0	1	1	50	-	-	-	-	-	59.7	53.7	61.0	55.0	RNP Absolute	15.4	15.3	YES
R248	RES	45.1	37.2	46.1	38.2	15	9	55	50	58.1	50.2	65	60	48.5	40.5	49.7	41.8		4.6	4.6	
R250	RES	51.2	43.6	52.4	44.8	15	9	55	50	64.4	56.8	65	60	52.6	44.9	53.9	46.2		2.7	2.6	
R251	RES	46.8	38.9	47.6	39.7	15	9	55	50	59.6	51.7	65	60	52.4	44.5	53.6	45.7		6.8	6.8	
R252	EDU	42.9	35.0	43.8	35.8	1	1	50	-	-	-	-	-	67.4	61.5	68.7	62.7	RNP Absolute	24.2	24.2	YES

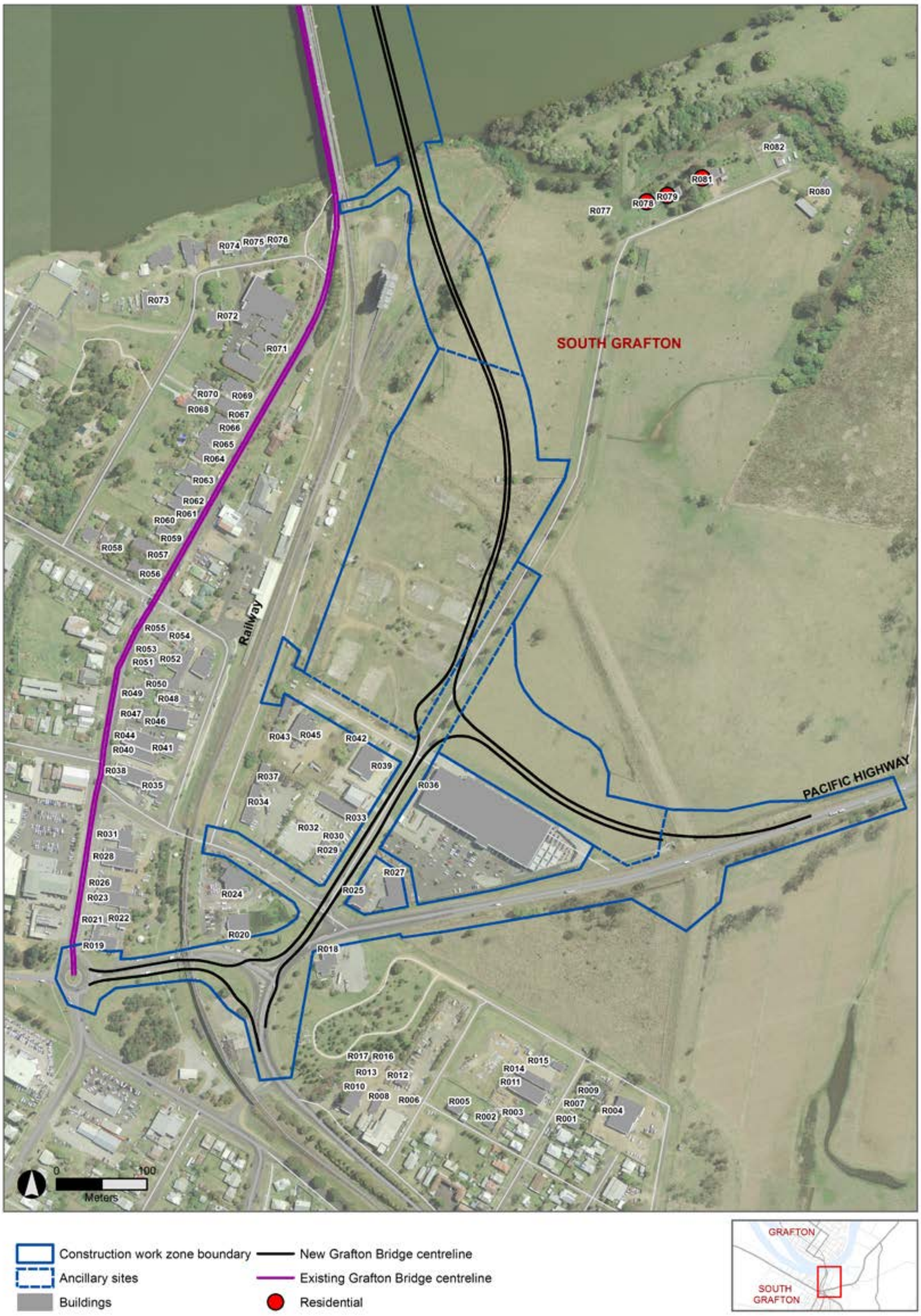
Receiver No.	Usage	No Build Option				Criteria								Build Option					Qualify for mitigation		
		Future Existing 2019		Future Existing 2029		Criteria Period		Absolute		Relative		Acute		Option C 2019		Option C 2029		Reason noise affected	Option C 2029 - Future Existing 2019		Qualifies?
		$L_{eq, 15hr}$	$L_{eq, 9hr}$	$L_{eq, 15hr}$	$L_{eq, 9hr}$	hr	hr	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$				
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night		Day	Night	
R253	EDU	44.7	36.8	45.4	37.5	1	1	50	-	-	-	-	-	59.8	53.8	61.1	55.1	RNP Absolute	14.8	14.7	YES
R254	RES	50.8	43.1	51.9	44.2	15	9	55	50	63.9	56.2	65	60	52.4	44.7	53.7	46.0		2.9	2.9	
R255	EDU	46.6	38.7	47.2	39.3	1	1	50	-	-	-	-	-	51.3	45.3	52.5	46.5	RNP Absolute	4.4	4.3	YES
R256	RES	48.2	40.5	49.3	41.7	15	9	55	50	61.3	53.7	65	60	51.7	43.9	53.0	45.1		4.8	4.6	
R260	RES	45.8	38.0	46.6	38.8	15	9	55	50	58.6	50.8	65	60	50.8	42.9	52.0	44.1		6.2	6.1	
R261	RES	41.5	33.6	42.2	34.3	15	9	55	50	54.2	46.3	65	60	59.4	51.4	60.6	52.6	RNP-Absolute RNP-Relative	19.1	19.0	YES
R262	RES	48.9	41.2	50.0	42.3	15	9	55	50	62.0	54.3	65	60	50.4	42.6	51.6	43.8		2.7	2.6	
R264	RES	46.9	39.2	48.1	40.3	15	9	55	50	60.1	52.3	65	60	48.8	40.9	50.0	42.1		3.1	2.9	
R266	RES	45.2	37.4	46.0	38.1	15	9	55	50	58.0	50.1	65	60	49.8	41.9	51.1	43.1		5.9	5.7	
R267	RES	48.2	40.5	49.3	41.6	15	9	55	50	61.3	53.6	65	60	52.5	44.6	53.7	45.8		5.5	5.3	
R268	RES	47.7	40.0	48.9	41.2	15	9	55	50	60.9	53.2	65	60	52.8	45.0	54.1	46.2		6.4	6.2	
R269	RES	50.1	42.4	51.2	43.4	15	9	55	50	63.2	55.4	65	60	**69.3**	**61.3**	**70.6**	**62.6**	RNP-Absolute RNP-Relative ENMM Acute	20.5	20.2	YES
R271	RES	46.7	38.9	47.8	40.1	15	9	55	50	59.8	52.1	65	60	51.2	43.3	52.4	44.5		5.7	5.6	
R272	RES	46.1	38.3	47.0	39.2	15	9	55	50	59.0	51.2	65	60	49.5	41.7	50.7	42.8		4.6	4.5	
R274	RES	42.5	34.7	43.3	35.4	15	9	55	50	55.3	47.4	65	60	46.8	38.9	48.0	40.1		5.5	5.4	
R275	RES	43.3	35.4	44.1	36.2	15	9	55	50	56.1	48.2	65	60	47.1	39.2	48.3	40.3		5.0	4.9	
R278	RES	46.1	38.3	47.2	39.4	15	9	55	50	59.2	51.4	65	60	49.6	41.6	50.8	42.9		4.7	4.6	
R279	RES	43.4	35.6	44.3	36.4	15	9	55	50	56.3	48.4	65	60	47.1	39.2	48.3	40.4		4.9	4.8	
R280	RES	45.4	37.6	46.4	38.6	15	9	55	50	58.4	50.6	65	60	48.3	40.5	49.5	41.7		4.1	4.1	
R281	RES	45.7	38.0	46.8	39.1	15	9	55	50	58.8	51.1	65	60	48.5	40.6	49.7	41.8		4.0	3.8	
R282	RES	46.3	38.6	47.3	39.6	15	9	55	50	59.3	51.6	65	60	48.2	40.3	49.3	41.5		3.0	2.9	
R283	RES	43.6	35.7	44.5	36.6	15	9	55	50	56.5	48.6	65	60	47.6	39.7	48.8	40.9		5.2	5.2	
R284	RES	45.5	37.8	46.5	38.8	15	9	55	50	58.5	50.8	65	60	49.2	41.5	50.4	42.7		4.9	4.9	
R285	RES	45.6	37.8	46.6	38.9	15	9	55	50	58.6	50.9	65	60	48.4	40.5	49.6	41.7		4.0	3.9	
R286	RES	45.9	38.2	46.9	39.2	15	9	55	50	58.9	51.2	65	60	49.7	41.8	50.9	43.1		5.0	4.9	
R287	RES	39.4	31.5	40.2	32.2	15	9	55	50	52.2	44.2	65	60	43.4	35.4	44.5	36.6		5.1	5.1	
R288	RES	39.9	32.0	40.7	32.8	15	9	55	50	52.7	44.8	65	60	43.5	35.5	44.7	36.7		4.8	4.7	

Receiver No.	Usage	No Build Option				Criteria Period		Criteria						Build Option				Reason noise affected	Qualify for mitigation		
		Future Existing 2019		Future Existing 2029				Absolute		Relative		Acute		Option C 2019		Option C 2029			Option C 2029 - Future Existing 2019		Qualifies?
		$L_{eq, 15hr}$	$L_{eq, 9hr}$	$L_{eq, 15hr}$	$L_{eq, 9hr}$	hr	hr	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$	$L_{eq, period}$				
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night		Day	Night	
R289	RES	40.8	32.9	41.6	33.7	15	9	55	50	53.6	45.7	65	60	44.1	36.2	45.3	37.3		4.5	4.4	
R290	RES	38.3	30.5	39.1	31.2	15	9	55	50	51.1	43.2	65	60	41.3	33.3	42.4	34.5		4.1	4.0	

Appendix G

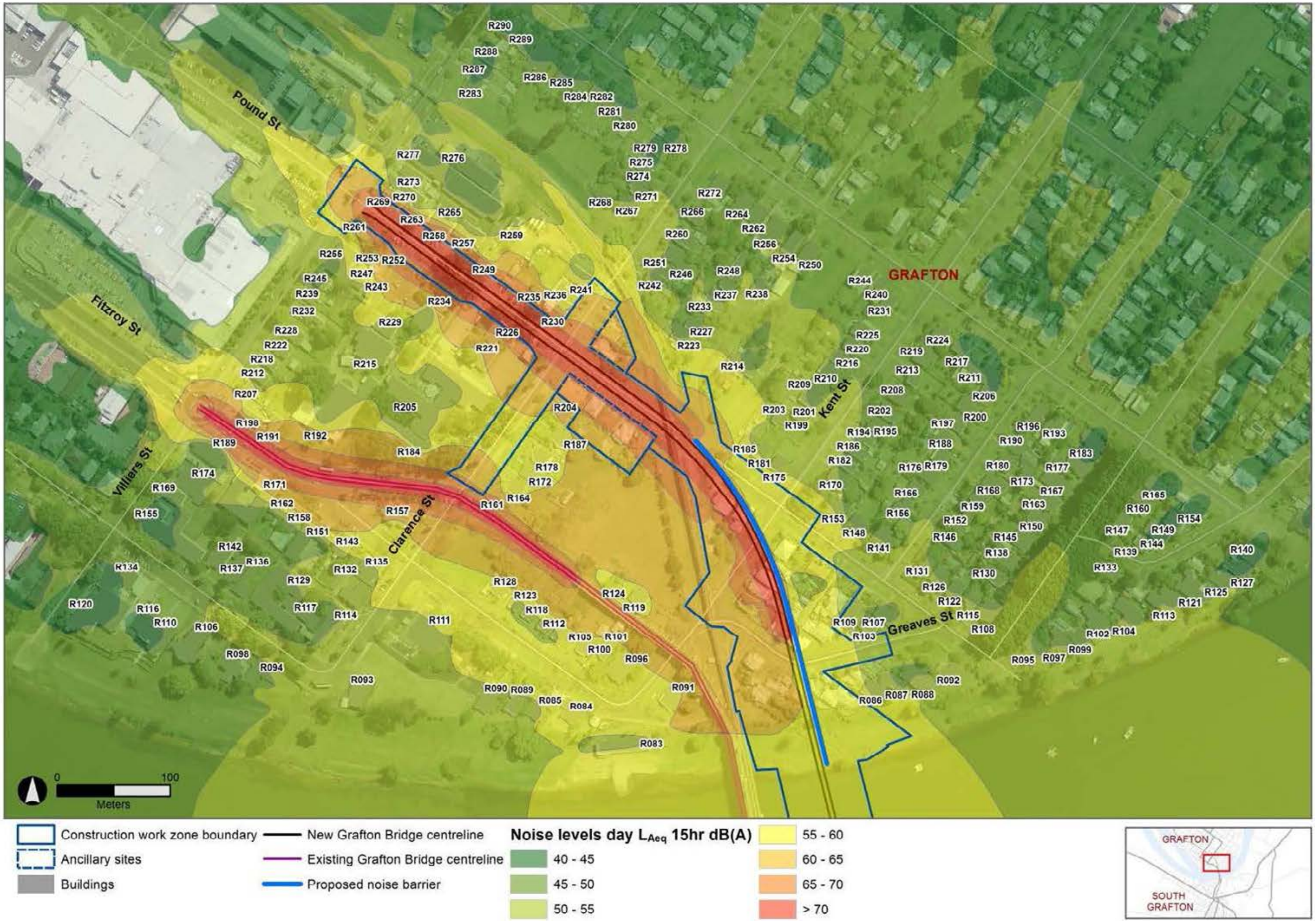
Properties potentially considered for noise mitigation


GRAFTON
Pound St
Fitzroy St
Villiers St
Clarence St
Kent St
Greaves St
0
100
Meters
Construction work zone boundary
Ancillary sites
Buildings
New Grafton Bridge centreline
Existing Grafton Bridge centreline
Proposed noise barrier
Educational
Residential
GRAFTON
SOUTH GRAFTON

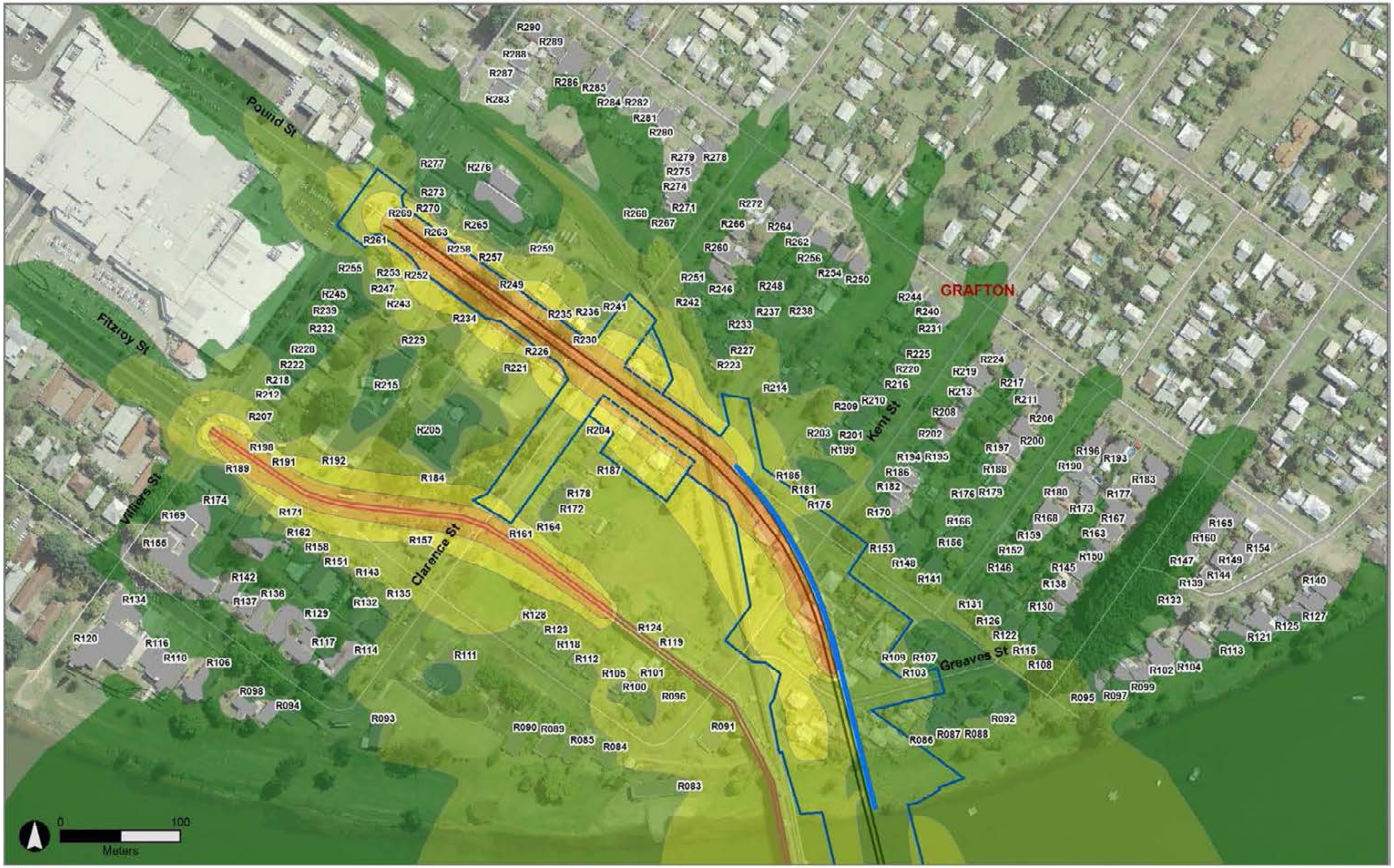

SOUTH GRAFTON
Railway
PACIFIC HIGHWAY
R082
R081
R080
R079
R078
R077
R074 R075 R076
R073
R072
R071
R070 R069
R068
R067
R066
R065
R064
R063
R062
R061
R060
R059
R058
R057
R056
R055
R054
R053
R052
R051
R050
R049
R048
R047
R046
R044
R041
R040
R043 R045
R042
R039
R038
R037
R035
R036
R034
R033
R032
R031
R030
R029
R028
R027
R026
R025
R024
R023
R021 R022
R020
R019
R018
R017 R016
R015
R014
R013
R012
R011
R010
R009
R008
R007
R006
R005
R004
R003
R002
R001
0
100
Meters
Construction work zone boundary
Ancillary sites
Buildings
New Grafton Bridge centreline
Existing Grafton Bridge centreline
Residential
GRAFTON
SOUTH GRAFTON

Appendix H

Mitigated noise level contour plots



Pound St
Fitzroy St
Villiers St
Clarence St
Kent St
Greaves St
GRAFTON
0
100
Meters
Construction work zone boundary
Ancillary sites
Buildings
New Grafton Bridge centreline
Existing Grafton Bridge centreline
Proposed noise barrier
Noise levels day LAeq 15hr dB(A)
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
> 70
GRAFTON
SOUTH GRAFTON



Construction work zone boundary
Ancillary sites
Buildings
New Grafton Bridge centreline
Existing Grafton Bridge centreline
Proposed noise barrier

Noise levels night LAeq 9hr dB(A)

40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
> 70