Lloyd George Acoustics
PO Box 717
Hillarys WA 6923
T: 9401 7770 F:9300 4199
E: terry@lgacoustics.com.au W: www.lgacoustics.com.au

THE LAKES REVITALISATION STRATEGY

Acoustic Analysis

Reference: 15083290-01.docx

Prepared for:
City of Cockburn

Member Firm of Association of Australian Acoustical Consultants

Report: 15083290-01.docx

Lloyd George Acoustics Pty Ltd

ABN: 79 125 812 544

PO Box 717
Hillarys WA 6923

T: 9300 4188 / 9401 7770
F: 9300 4199

Contacts	Daniel Lloyd	Terry George	Mike Cake	Matt Moyle	Olivier Mallié
E:	daniel@lgacoustics.com.au	terry@lgacoustics.com.au	mike@lgacoustics.com.au	matt@lgacoustics.com.au	olivier@lgacoustics.com.au
M:	0439 032 844	0400 414 197	0438 201 071	0412 611 330	0439 987 455

Prepared By:	Terry George 
Position:	Project Director
Date:	8 July 2016

Table of Contents

List of Tables

List of Figures

Appendices

A Noise Contour Plots – R20 Single Storey Scenario

B Noise Contour Plots – R30 Single Storey Scenario

C Noise Contour Plots – R30/R60 Double Storey Scenario

D Noise Contour Plots – R60 Three Storey Scenario

E Noise Contour Plots – R100 Four Storey Scenario

F SPP 5.4 Acceptable Treatment Packages

G FLC Architectural Treatment Packages

H Terminology

1 INTRODUCTION

The City of Cockburn is undertaking a 'Revitalisation Strategy" for the suburbs of North Lake, Bibra Lake and South Lake – refer *Figure 1-1*. The Strategy will guide the form of future development and will identify opportunities for redevelopment through establishing residential density changes. Each of the suburbs adjoins a major transport corridor and as such, part of the planning consideration is to take into account noise impacts.

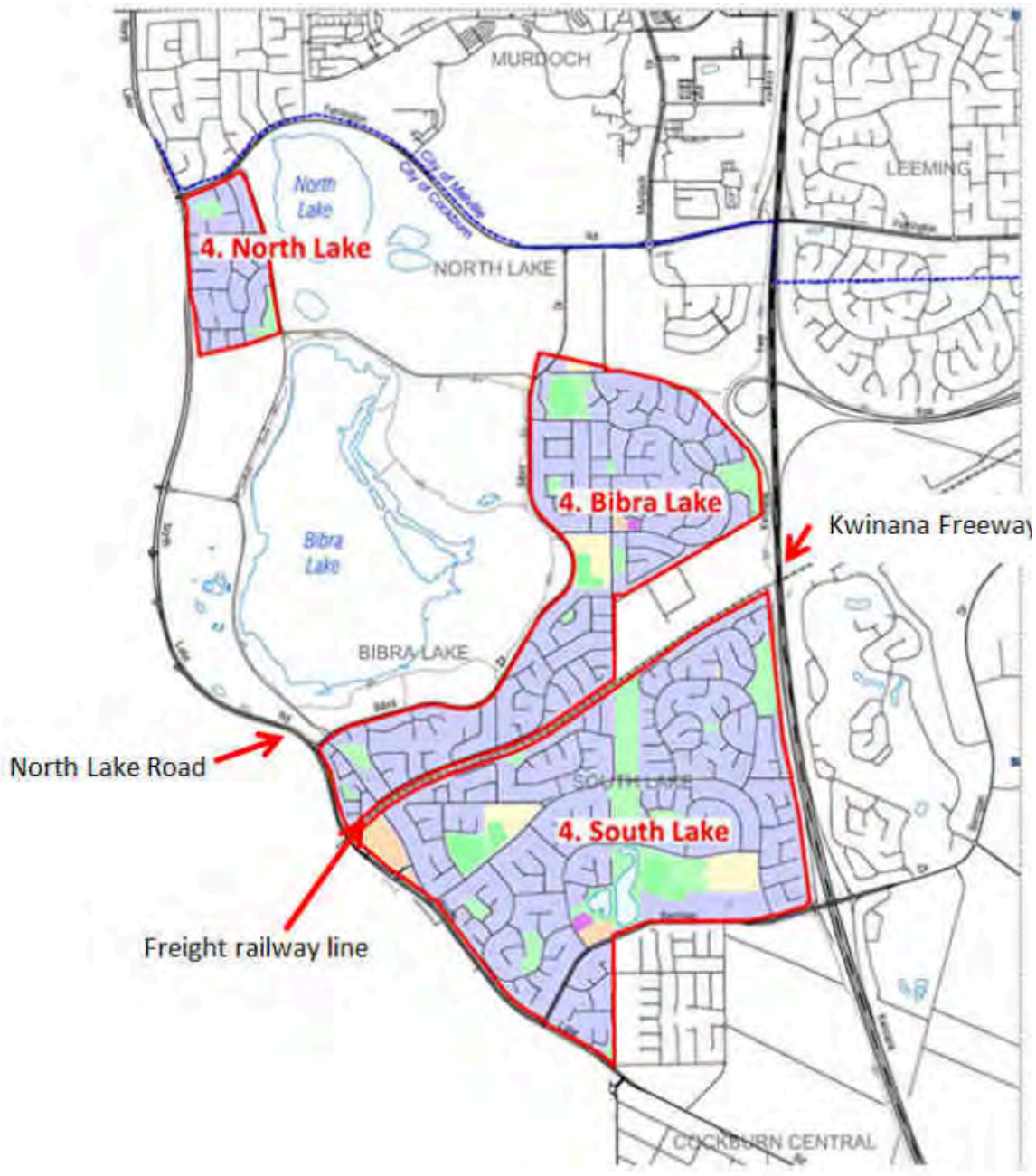


Figure 1-1 Study Area

The transport corridors of interest are:

- North Lake Road;
- Farrington Road;
- Roe Highway;
- Kwinana Freeway; and
- Freight Railway Line.

The noise from each of these transport corridors is modelled to various assumed adjoining developments ranging from single storey dwellings, townhouses, two storey apartments and three and four storey apartments. The results from each transport corridor to each style of development are then assessed in terms of their acoustic impacts.

Appendix H contains a description of some of the terminology used throughout this report.

2 CRITERIA

2.1 SPP Noise Criteria

The criteria relevant to this assessment is the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (hereafter referred to as the Policy) produced by the Western Australian Planning Commission (WAPC). The objectives in the Policy are to:

- Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;
- Protect major transport corridors and freight operations from incompatible urban encroachment;
- Encourage best practice design and construction standards for new development proposals and new or redevelopment transport infrastructure proposals;
- Facilitate the development and operation of an efficient freight network; and
- Facilitate the strategic co-location of freight handling facilities.

The Policy's outdoor noise criteria are shown below in *Table 2-1*. These criteria applying at any point 1-metre from a habitable façade of a noise sensitive premises and in one outdoor living area.

Table 2-1 SPP 5.4 Outdoor Noise Criteria

Period	Target	Limit
Day (6am to 10pm)	55 dB $L_{Aeq(Day)}$	60 dB $L_{Aeq(Day)}$
Night (10pm to 6am)	50 dB $L_{Aeq(Night)}$	55 dB $L_{Aeq(Night)}$

Note: The 5 dB difference between the target and limit is referred to as the margin.

In the application of these outdoor noise criteria to new noise sensitive developments, the objectives of this Policy is to achieve -

- acceptable indoor noise levels in noise-sensitive areas (e.g. bedrooms and living rooms of houses); and
- a 'reasonable' degree of acoustic amenity in at least one outdoor living area on each residential lot.

If a noise sensitive development takes place in an area where outdoor noise levels will meet the *target*, no further measures are required under this policy.

In areas where the *target* is exceeded, customised noise mitigation measures should be implemented with a view to achieving the *target* in at least one outdoor living area on each residential lot, or if this is not practicable, within the *margin*. It should be noted that where the development is apartment style with balconies overlooking the transport corridor, achieving the *limit* may not be practicable. In these circumstances, shared communal outdoor spaces should be provided where noise levels are no more than the *limit*.

Where indoor spaces are planned to be facing outdoor areas that are above the *target*, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces. Acceptable indoor noise levels are defined as 35 dB $L_{Aeq(Night)}$ for bedrooms and 40 dB $L_{Aeq(Day)}$ for living areas.

The Guidelines to the Policy provide deemed to comply architectural treatment packages based on external noise levels as follows:

- Package A – Applied where external noise levels are 55-60 dB $L_{Aeq(Day)}$ or 50-55 dB $L_{Aeq(Night)}$;
- Package B – Applied where external noise levels are 60-63 dB $L_{Aeq(Day)}$ or 55-58 dB $L_{Aeq(Night)}$;
- Package C – Applied where external noise levels are 63-65 dB $L_{Aeq(Day)}$ or 58-60 dB $L_{Aeq(Night)}$.

These packages are provided in *Appendix F* for information.

2.2 FLC Noise Criteria

The gazetted SPP (refer *Section 2.1*) uses the L_{Aeq} parameter to assess the noise impacts, which is a logarithmic average of noise levels over time. For road traffic noise, this parameter is considered to adequately capture the potential noise impacts. Freight trains on the other hand are discrete events throughout the day and therefore if these events are infrequent, the L_{Aeq} can be relatively low.

Early drafts of the SPP contemplated the inclusion of a maximum noise level criteria (L_{Amax}) for freight trains, however this was removed during stakeholder consultation. In an attempt to account for the potential L_{Amax} impacts from freight trains as well as not compromising long-term utilisation of a freight rail line, the Guidelines to SPP 5.4 require a minimum of 1 train movement per hour to be assumed, irrespective of whether this will occur in the future or not.

Lloyd George Acoustics undertook a study for the Freight Logistics Council (FLC) to assess whether or not the Guideline 1 train movement per hour was adequate in assessing the potential L_{Amax} impacts. The approach in the study was to adopt the same L_{Amax} criteria put forward in the SPP early drafts and this is shown in *Table 2-2*.

Table 2-2 L_{Amax} Proposed Outdoor Noise Criteria

Period	Target	Limit
Any	75 dB L_{Amax}	80 dB L_{Amax}

Based on the above criteria, the findings of the FLC study were that in most instances, the L_{Amax} criteria was more stringent than the L_{Aeq} criteria, even under the assumption of 1 train movement per hour.

It should be noted that the L_{Amax} parameter is primarily used to assess sleep disturbance and therefore the L_{Amax} criteria may only be applicable during the night (10pm to 6am) and/or only to bedrooms. As the early SPP 5.4 drafts did not contemplate this, this distinction has also not been made in this report.

The outcome of the FLC study was that a new set of acceptable treatment packages were put forward for developments adjoining freight rail lines as follows:

- Package AF – Applied where external noise levels from freight trains are 75-80 dB L_{Amax};
- Package BF – Applied where external noise levels from freight trains are 80-88 dB L_{Amax}; and
- Package CF – Applied where external noise levels from freight trains are 88-92 dB L_{Amax}.

These packages are provided in *Appendix G* for information. One of the main changes in the freight packages is to require the use of clay roof tiles. This was required in order to economically attenuate low frequency noise associated with the locomotives, transferring through the roof/ceiling noise path.

The L_{Amax} criteria and the packages have formed part of the FLC's Bulletin No.7, October 2015. The Bulletin and the Lloyd George Acoustics study have been released by FLC and are publicly available on their website. It is the Council's intention that these documents will help influence and inform Government policy and practice, in relation to freight noise and the protection of freight rail corridors.

2.3 Vibration Criteria

Exposure limits for vibration are normally defined in terms of a multiplying factor that is applied to the base curves defined in AS 2670.2:1990. The base curve is the point at which adverse comment is considered rare. It also states that at levels above the base curve, vibration may or may not give rise to adverse comment depending on circumstances. The measure of human annoyance is a velocity (mm/s) root mean squared (rms). The multiplying factors are given in Appendix A of AS 2670.2-1990 as follows for a residential premises:

- Night-time continuous or intermittent vibration – Curve 1.4;
- Daytime continuous or intermittent vibration – Curve 2 to Curve 4;
- Night-time transient vibration with several occurrences per day – Curve 1.4 to Curve 20;
- Daytime transient vibration with several occurrences per day – Curve 30 to 90

It is noted that within residential areas there are wide variations in vibration tolerance. Specific values are dependent upon social and cultural factors, psychological attitudes and expected interference with privacy.

Previous projects within the City of Cockburn have adopted the use of Curve 2. The Curve 2 vibration level varies with direction (radial, transverse, vertical) and frequency. For the vertical direction, the vibration level is consistent at 0.199mm/s from 8 to 80Hz.

There are no Australian Standards that provide criteria in relation to structural damage to buildings. Structural damage measurements are normally undertaken as peak component particle velocity (PCPV). For instance, for road construction projects Main Roads Western Australia generally adopts a limit of 5mm/s PCPV for structurally sound dwellings. The Curves of AS2670.2 are not relevant for structural damage.

It should be noted that structural damage occurs at significantly higher vibration levels than human perception, so a person will perceive vibration (and be annoyed by it) well before any structural damage is likely to occur.

3 METHODOLOGY

Noise and vibration measurements have been undertaken in relation to the freight railway and this is discussed in *Section 3.1*. No noise or vibration measurements have been undertaken in relation to road traffic. Modelling has been undertaken for both road and rail and this is discussed in *Section 3.2*.

3.1 Site Measurements

Noise monitoring was undertaken within the study area alongside the Freight Rail Line at a distance of 20 metres from the nearest track, in order to:

- Quantify existing noise levels;
- Identify train pass-bys; and
- Calibrate the noise model for existing conditions.

The instrument used was an Ngara noise data logger (refer *Figure 3-1*), with the microphone 1.4 metres above ground level. The logger was programmed to record 1-minute L_{AFmax} and L_{Aeq} levels. The logger was field calibrated before and after the measurement session and found to be accurate to within +/- 1 dB. Lloyd George Acoustics also holds a current laboratory calibration certificate for the logger.

Vibration monitoring was undertaken at 20, 40 and 80 metres from the nearest track. Vibration levels were logged at 1-minute intervals using a Texcel GTM Vibration Logger connected to a tri-axial geophone (refer *Figure 3-1*). The logger was set to record the worst-case frequency, peak component particle velocity (PCPV) and the component root-mean-square (rms).

Figure 3-1 Noise & Vibration Data Loggers on Subject Site

Figure 3-2 Location of Noise and Vibration Monitoring

3.2 Noise Modelling

To model the noise emissions from the freight railway and roads, the computer programme *SoundPLAN 7.4* was utilised.

For rail traffic, a modified version of the Nordic Rail Prediction Method (Kilde Rep. 130) algorithms were used. The Nordic Rail Prediction Method (Kilde Rep. 130) algorithm is for generic train types in Europe and requires modification to align with measured noise levels of locomotives and wagons used in the Perth region. In addition, to accurately predict the effect of barriers (hills, buildings or walls), the noise source height of the locomotive was raised from the model standard of 0.5 metres to 4.0 metres above the railhead.

Road traffic incorporated the *Calculation of Road Traffic Noise* (CoRTN) algorithms, modified to reflect Australian conditions. The modifications included the following:

- Vehicles were separated into heavy (Austroads Class 3 upwards) and non-heavy (Austroads Classes 1 & 2) with non-heavy vehicles having a source height of 0.5 metres above road level and heavy vehicles having two sources, at heights of 1.5 metres and 3.6 metres above road level, to represent the engine and exhaust respectively. By splitting the noise source into three, allows for less barrier attenuation for high level sources where barriers are to be considered. Note that corrections are applied to the exhaust of –8.0 dB (based on Transportation Noise Reference Book, Paul Nelson, 1987) and to the engine source of –0.8 dB, so as to provide consistent results with the CoRTN algorithms for the no barrier scenario; and

- An adjustment of –1.7 dB has been applied to the predicted levels based on the findings of An Evaluation of the U.K. DoE Traffic Noise Prediction; Australian Road Research Board, Report 122 ARRB – NAASRA Planning Group 1982.

Predictions are made at heights of 1.4 metres above ground floor level and at 1.0 metre from a building façade (resulting in a + 2.5 dB correction due to reflected noise).

Various input data are included in the modelling such as ground topography, road design, traffic volumes etc. These model inputs are discussed below.

3.2.1 Ground Topography

In all scenarios, the ground is assumed to be flat.

Where the topography is not flat, the following changes may occur:

- Road/Rail Elevated:
    - The distance from the track to the receiver, will be slightly longer than the horizontal distance, which may result in a minor reduction in vibration levels depending on the elevation. The elevated ground may also be 'softer' (sandy type soil conditions) and this could also reduce vibration levels;

- Noise to the first row of houses is unlikely to be significantly different to the flat scenario, however the barrier effect provided by the first row of houses may be less than the flat ground scenario so the noise may spread further. The spread of noise would be more significant for locomotives and trucks than it would be for a wagons and cars.

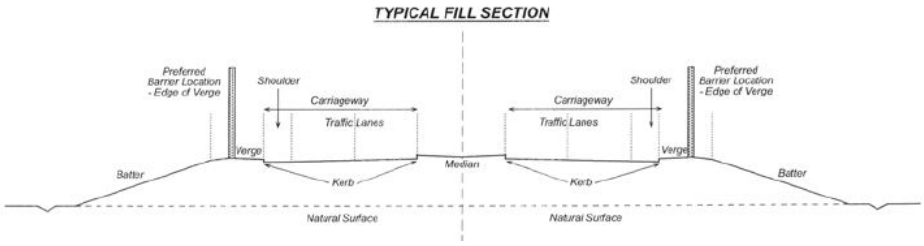


Figure 3-3 Road/Rail Elevated

- Road/Rail in Cut

  - The distance from the track to the receiver, will be slightly longer than the horizontal distance, which may result in a minor reduction in vibration levels depending on the depth. The lower level ground may be 'harder' (limestone) and this could increase vibration levels;
  - Noise to the first row of houses is unlikely to be significantly different to the flat scenario, however the barrier effect provided by the first row of houses may be more than the flat ground scenario so that the noise may not spread as far. This increased barrier effect would be more for the cars and wagons than trucks and locomotives.

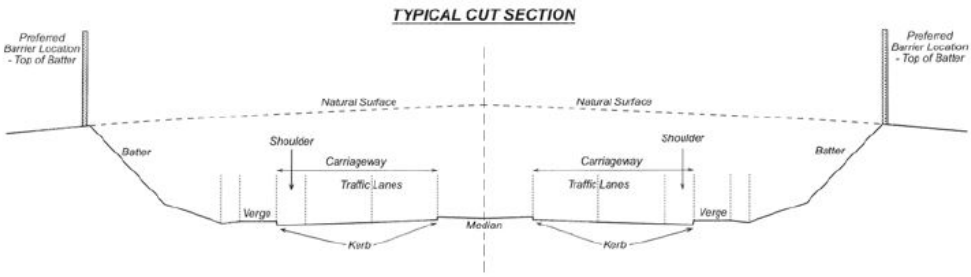


Figure 3-4 Road/Rail in Cut

For the most part, existing houses appear to back onto the roads or rail of concern. For the purpose of this study, a 1.8m high boundary wall has been included. In new developments, it is likely that a higher wall would be required, however such walls are mostly only of benefit to the first row of houses and therefore won't affect the outcomes of this study.

Table 3-1 provides the assumed distances from the houses to the noise sources and road layout. These are considered to represent 'typical' distances.

Table 3-1 Rail and Road Geometry Details Used in Modelling

Road/Rail	Median Width	No. Of Lanes	Distance to Houses (m)
North Lake Road	2m	4 Lanes Total 2 Lanes Each Way	15m to Nearest Lane Edge
Farrington Road	1m	2 Lanes Total 1 Lane Each Way	15m to Nearest Lane Edge
Roe Highway	18m	4 Lanes Total 2 Lanes Each Way	40m to Nearest Lane Edge
Kwinana Freeway	30m	6 Lanes Total 3 Lanes Each Way	35m to Nearest Lane Edge
Freight Railway	5m Between Tracks	2 Tracks Total 1 Track Each Way	25m to Nearest Track

A grid of different dwellings have been constructed spanning 1000m parallel to the road or rail and 300m away from the rail in 100m blocks. The various scenarios are described below.

Standard Dwellings (Nominally R20 Zoning)

In this scenario, each block is assumed to be approximately 17 metres wide and 30 metres deep. The house plan used and the 2D and 3D images of a 100m x 100m (1 hectare) block is shown in *Figure 3-5*. All houses are single storey with a modelled height of 3.5 metres. The first row of houses is assumed to back onto the transport corridor and is then separated from the next two rows of houses by a 10-metre wide road reserve.

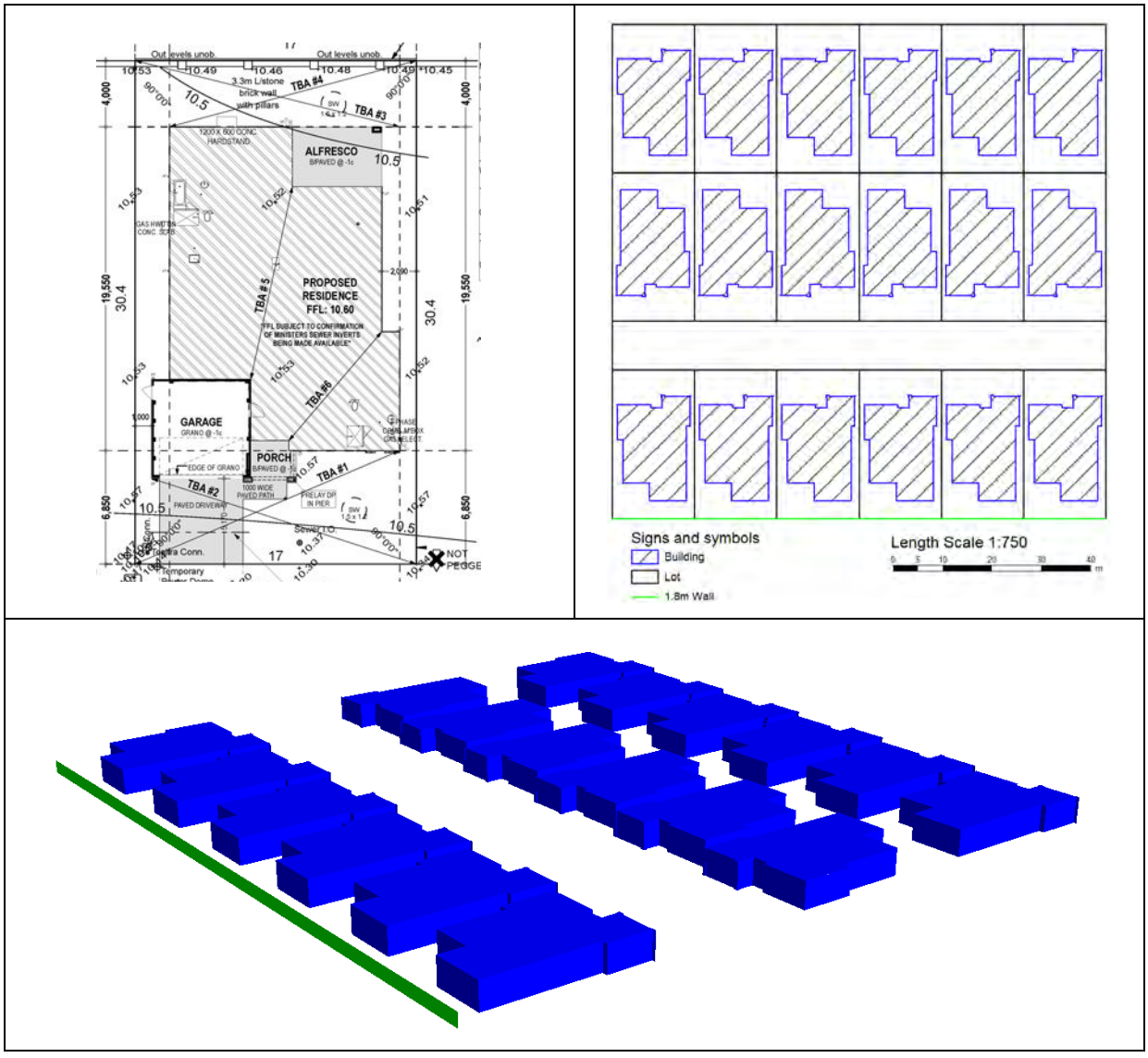


Figure 3-5 Standard Dwellings (Nominally R20 Zoning)

Based on 3.5 persons per dwelling, the above relates to 63 people per hectare.

Boundary-to-Boundary Dwellings (Nominally R30 Zoning)

In this scenario, each block is assumed to be approximately 10 metres wide and 30 metres deep. The house plan used and the 2D and 3D images of a 100m x 100m (1 hectare) block is shown in *Figure 3-6*. All houses are single storey with a modelled height of 3.5 metres. The first row of houses is assumed to back onto the transport corridor and is then separated from the next two rows of houses by a 10-metre wide road reserve.

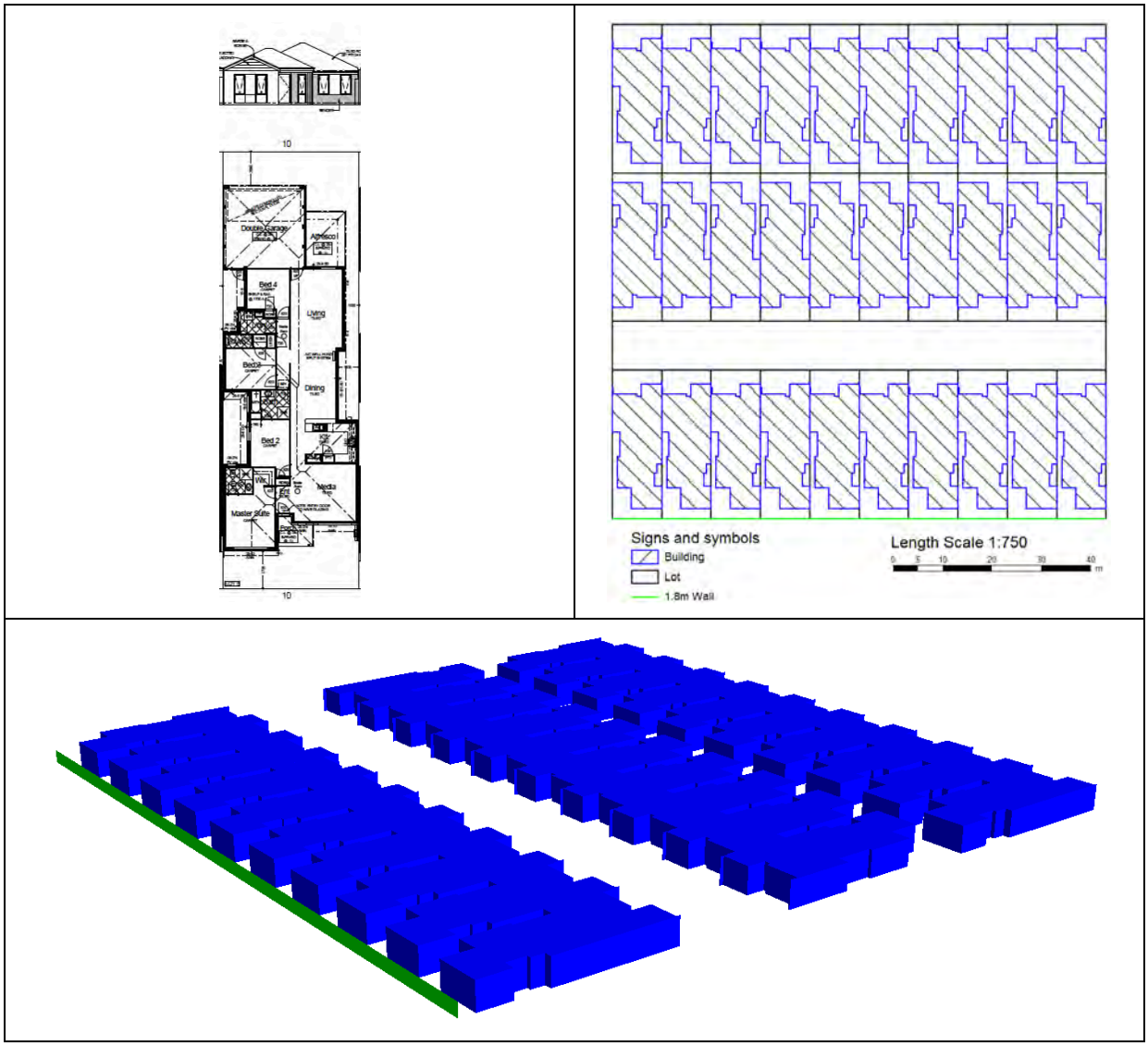


Figure 3-6 Boundary-to-Boundary Dwellings (Nominally R30 Zoning)

Based on 2.5 persons per dwelling, the above relates to 75 people per hectare.

Boundary-to-Boundary Two-Storey Dwellings (Nominally R30/R60 Zoning)

This scenario is identical to that described previously, except houses are double storey. This could represent either two storey houses (townhouses) or separate sole-occupancy units above and below each other (nominally R60 zoning). The house plan used and the 2D and 3D images of a 100m x 100m (1 hectare) block is shown in *Figure 3-7*. All buildings are double storey with a modelled height of 7.0 metres. The first row of houses is assumed to back onto the transport corridor and is then separated from the next two rows of houses by a 10-metre wide road reserve.

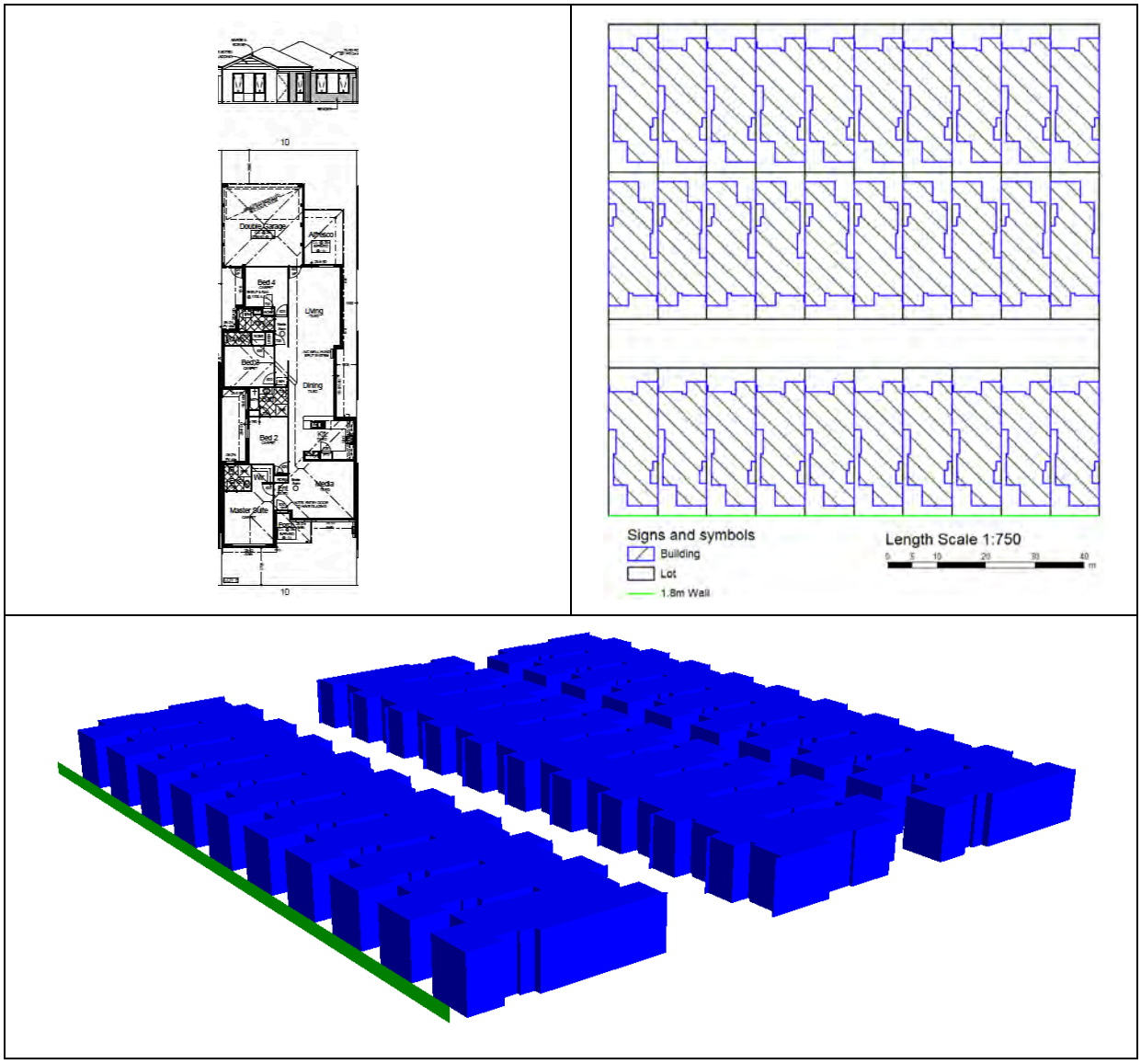


Figure 3-7 Boundary-to-Boundary Two-Storey Dwellings (R30/R60 Zoning)

On the assumption of these being townhouses, an average of 3 persons per dwelling are expected, being a total of 90 people per hectare. If the site were more of an apartment type development, an average of 2 persons per unit would be expected (4 per individual building with 1 unit on ground and 1 on first floor), relating to 120 people per hectare.

Three-Storey Apartments (Nominally R60 Zoning)

In this scenario, each block is assumed to be approximately 33 metres wide and 35 metres deep. Each lot consists of 4 apartments on each floor (12 total) with open-air car parking at the rear. The plan used and the 2D and 3D images of a 100m x 100m (1 hectare) block is shown in *Figure 3-8*. The total building height is 10 metres. Again, the rows of lots are separated by a 10-metre wide road reserve.

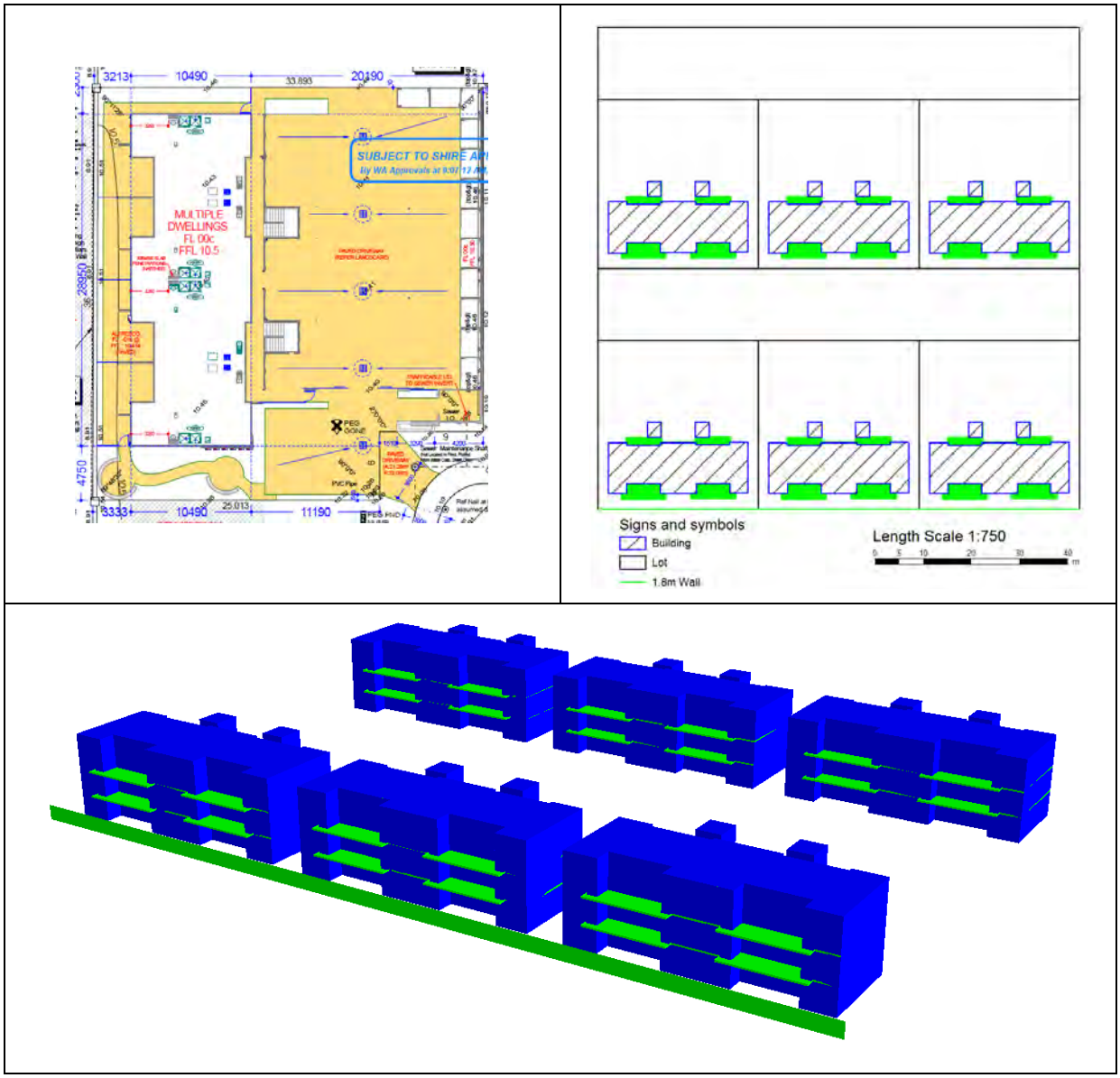


Figure 3-8 Three Storey Apartments (R60 Zoning)

Based on 2.5 persons per unit, so 30 persons per building, the above relates to 180 people per hectare.

Four-Storey Apartments (Nominally R100 Zoning)

In this scenario, each block is assumed to be approximately 33 metres wide and 28 metres deep. The ground floor of this development is used for car parking with three levels of apartments above, having a total building height of 13 metres. Each floor consists of 7 apartments, yielding 21 total. The plan used and the 2D and 3D images of a 100m x 100m (1 hectare) block is shown in *Figure 3-9*. Each row of lots are separated by a 5-metre wide laneway type road.

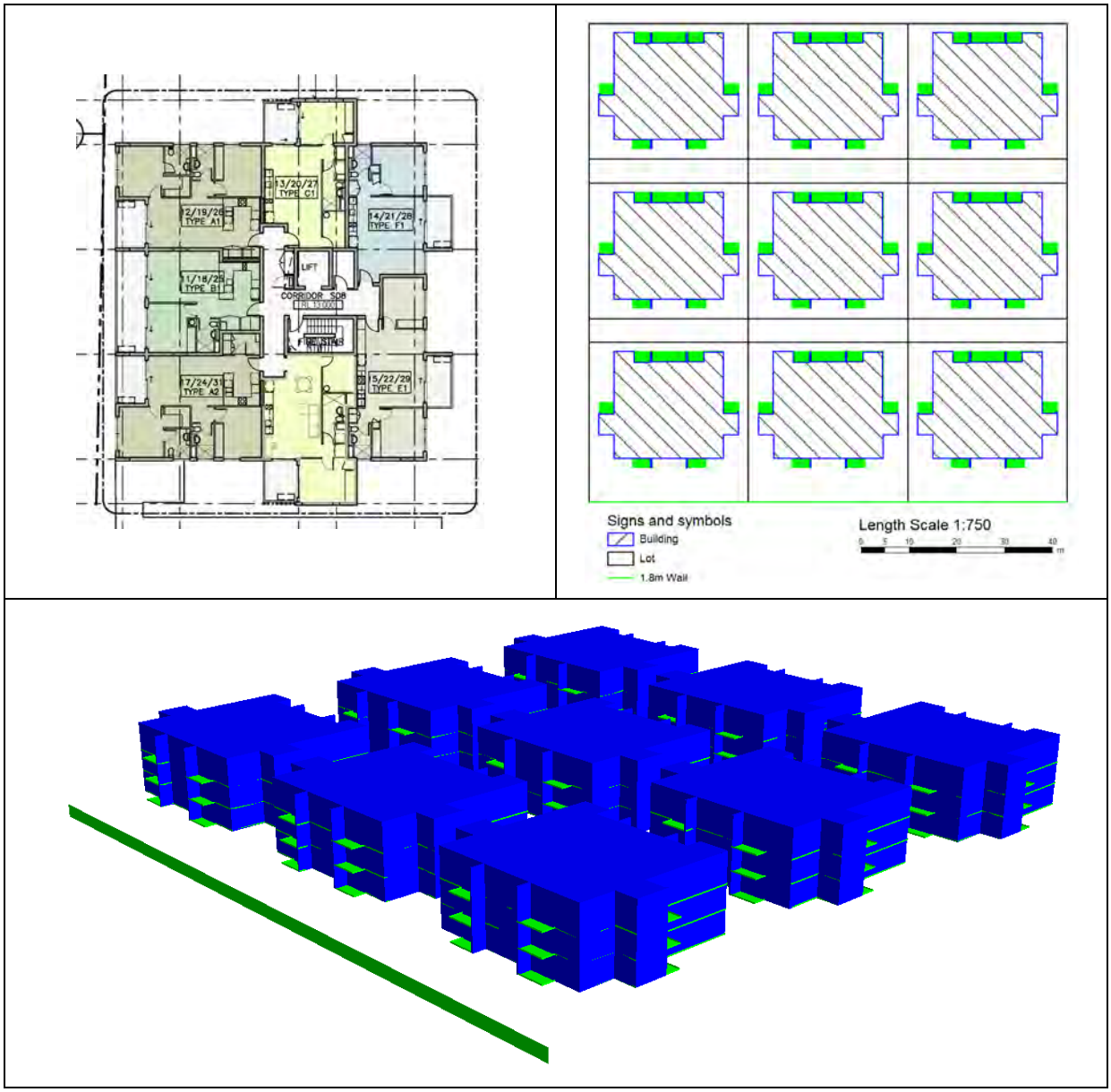


Figure 3-9 Four Storey Apartments (R100 Zoning)

Based on 2 persons per unit, so 42 persons per building, the above relates to 378 people per hectare.

3.2.2 Traffic Data

The assumed road traffic data used in the modelling is provided in *Table 3-2*. For North Lake Road, Farrington Road and Roe Highway, these are forecast 2031 traffic volumes obtained from Lloyd George Acoustics involvement in the Perth Freight Link project. The Kwinana Freeway volumes are also for the year 2031, obtained from work undertaken in the southbound widening projects between Roe Highway and Russell Road.

Table 3-2 Road Traffic Data Used in Modelling

Parameter	Road			
	North Lake Road	Farrington Road	Roe Highway	Kwinana Freeway
Posted Speed	70km/hr	70km/hr	100km/hr	100km/hr
Road Surface	DGA	DGA	OGA	OGA
Volumes				
Eastbound/Northbound	10,700	5,800	38,300	81,600
Westbound/Southbound	10,300	5,700	38,700	88,800
Percentage Heavy Vehicles				
Eastbound/Northbound	8%	3%	10%	8%
Westbound/Southbound	8%	3%	10%	10%

Table 3-3 provides the acoustic relationship between different road surfaces.

Table 3-3 Noise Relationship Between Different Road Surfaces

Chip Seal			Asphalt			
14mm	10mm	5mm	Dense Graded	Novachip	Stone Mastic	Open Graded
+3.5 dB	+2.5 dB	+1.5 dB	0.0 dB	-0.2 dB	-1.0 dB	-2.5 dB

Trains were identified from the vibration data and audio files recorded by the noise logger. It was found that there is less than 1 movement per hour and as such, the train volumes assumed in the study have been increased to 1 per hour in line with the SPP 5.4 Guidelines.

3.2.3 Ground Attenuation

The ground attenuation has been assumed to be 0.0 (0%) for the road and rail itself and 0.5 (50%) throughout the subdivision. Note 0.0 represents hard reflective surfaces such as water and 1.00 represents absorptive surfaces such as grass.

3.2.4 Parameter Conversion

The freight rail noise has been calibrated against the measured $L_{Aeq(Night)}$ and L_{Amax} values. For rail, $L_{Aeq(Night)}$ has been used instead of L_{Aeq}(day), as this will be more critical in terms of complying with the *Section 2.1* criteria.

For road traffic, the CoRTN algorithms used in the *SoundPlan* modelling package were originally developed to calculate the $L_{A10,18hour}$ noise level. The WAPC Policy however uses $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$. The relationship between the parameters varies depending on the composition of traffic on the road (volumes in each period and percentage heavy vehicles). *Table 3-5* shows the conversions have been used for each road.

Table 3-4 Parameter Conversions for Road Noise Modelling

Parameter	Road			
	North Lake Drive	Farrington Road	Roe Highway	Kwinana Freeway
$L_{A10,18hour} - L_{Aeq(Day)}$	2.2	2.2	2.0	1.6
$L_{Aeq(Day)} - L_{Aeq(Night)}$	7.0	7.0	5.0	5.0

In all road traffic cases, the $L_{Aeq(Night)}$ is expected to be at least 5 dB less than the $L_{Aeq(Day)}$. As such, only the $L_{Aeq(Day)}$ parameter is provided within this report.

4 RESULTS

4.1 Noise Monitoring

Table 4-1 provides the results of the noise level measurements recorded by the automatic noise data logger in free-field conditions. Note that noise measurements were taken at a distance of 20 metres from the closest line of the track. The noise monitoring results are also shown graphically by *Figure 4-1*, with train movements characterised by sharp spikes in the measured noise levels.

Table 4-1 Noise Levels of Train Events at 20m from Nearest Track

Date	Time	Train Noise Level	
		dB $L_{Aeq, 1min}$	dB L_{AFmax}
20 October 2015	14:53:00	77.0	87.1
	15:36:00	77.6	92.0
	15:54:00	76.7	90.1
	17:42:00	76.2	88.2
	18:56:00	80.6	93.0

Date	Time	Train Noise Level	
		dB $L_{Aeq, 1min}$	dB L_{AFmax}
21 October 2015	00:27:00	71.9	81.4
	00:41:00	72.9	82.5
	04:12:00	80.6	91.5
	06:48:00	81.1	92.8
	16:15:00	76.1	87.2
	18:10:00	74.9	85.9
	18:58:00	81.0	92.1
22 October 2015	01:07:00	74.5	87.1
	04:49:00	74.7	88.9
	04:56:00	78.2	92.9
	07:23:00	68.9	77.3
	09:05:00	79.3	91.4
	11:04:00	N/A	N/A
	13:58:00	69.8	75.8
	16:24:00	75.0	87.5
	16:33:00	74.5	85.6
	17:40:00	70.9	74.0
	18:40:00	74.7	86.4
	18:50:00	69.0	77.6
	19:01:00	75.9	87.6

Date	Time	Train Noise Level	
		dB $L_{Aeq, 1min}$	dB L_{AFmax}
23 October 2015	00:24:00	65.9	80.0
	00:27:00	71.7	80.2
	01:01:00	77.7	88.5
	02:45:00	70.0	75.5
	04:57:00	71.7	79.3
	05:03:00	76.2	89.8
	06:05:00	71.0	72.2
	06:30:00	70.0	77.0
	07:15:00	77.7	91.3
	07:26:00	67.1	75.1
	09:29:00	70.0	80.6
	09:46:00	80.7	90.8
	12:04:00	68.8	74.5
	14:32:00	75.9	84.5
Mean		74.4	84.6
Standard Deviation (SD)		4.2	6.4
Mean + SD		78.6	91.0

The average noise level of a passing train is 74.4 dB $L_{Aeq,1min}$ and 84.6 dB L_{Amax}. Using the arithmetic average is not considered appropriate for the L_{Amax} as this means that half of the trains will be noisier. As such, the mean +1SD has been used in this assessment of 91.0 dB L_{Amax}.

For the L_{Aeq} value, it would be normal practice to calculate the $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ value of each day, and then determine the arithmetic average of these. In this case however, the number of movements each day were highly variable. The numbers presented are the L_{Aeq} for a 1-minute duration. In some cases, the train movement may take longer than 1-minute or the train movement may not fall exactly within a 1-minute period. As such, for consistency with the L_{Amax} approach, the $L_{Aeq,1min}$ value used was also the mean+1SD of 78.6 dB. This value is to be extrapolated to an $L_{Aeq(Night)}$ value on the assumption of 1 movement per hour which equates to 60.8 dB $L_{Aeq(Night)}$.

Where noise is assessed at a residence, it is measured at 1 metre from a façade, which results in an increase of 2.5 dB from reflected noise. As such, the noise levels are adjusted to 63.3 dB $L_{Aeq(Night)}$ and 93.5 dB L_{Amax}. Comparing these directly with the *target* criteria of *Section 2*, means that the $L_{Aeq(Night)}$ exceeds by 13 dB and the L_{Amax} by 18 dB.

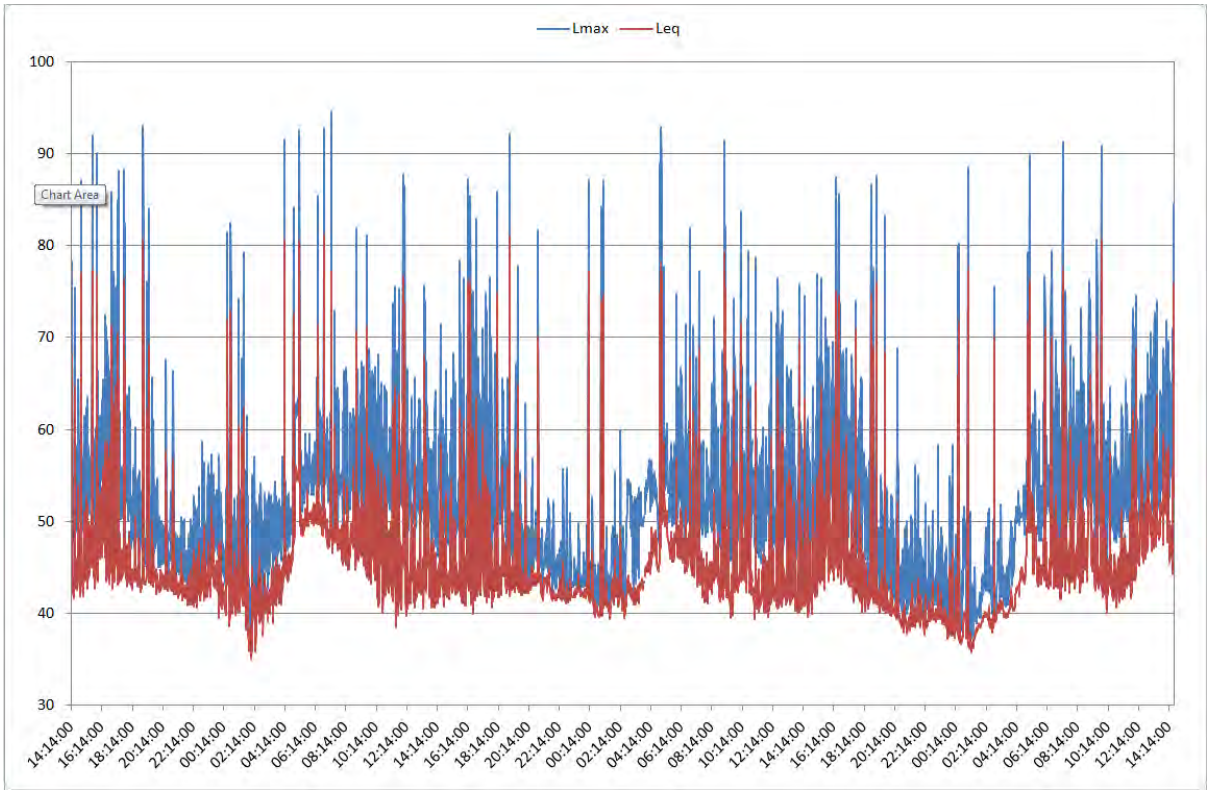


Figure 4-1 Freight Rail Noise Monitoring Results

4.2 Vibration Monitoring

The results of the monitoring are provided on *Figures 4-2(a) to (c) to 4-4(a) to (c)*, being 20m, 40m and 80m from the track, with each location having a radial, transverse and vertical result respectively.

The graphs show that for this measurement location, the most critical direction is the vertical. Note that this may be different if the track is on a bend, incline or decline. At 20 metres from the track, there are a number of occurrences at or above Curve 4. At 40 metres from the track, there are no events above Curve 4, but a number within the Curve 2 to Curve 4 range. At 80 metres from the track, there are no events above Curve 2, with only 3 between Curves 1.4 and Curve 2.

It should be noted that the vibration logger located at 80 metres from the track was tampered with part way through the measurement period and therefore some data was ignored.

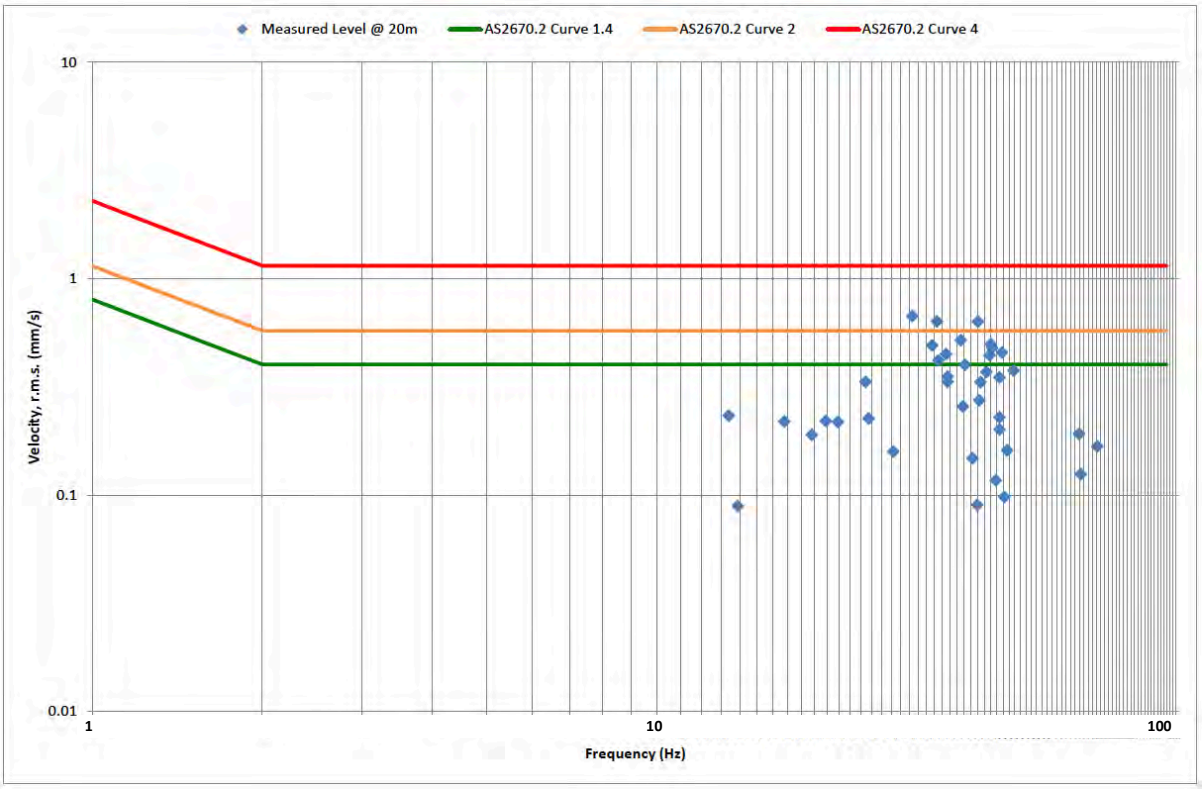


Figure 4-2(a) Vibration Monitoring at 20 metres from Track: Radial Velocity

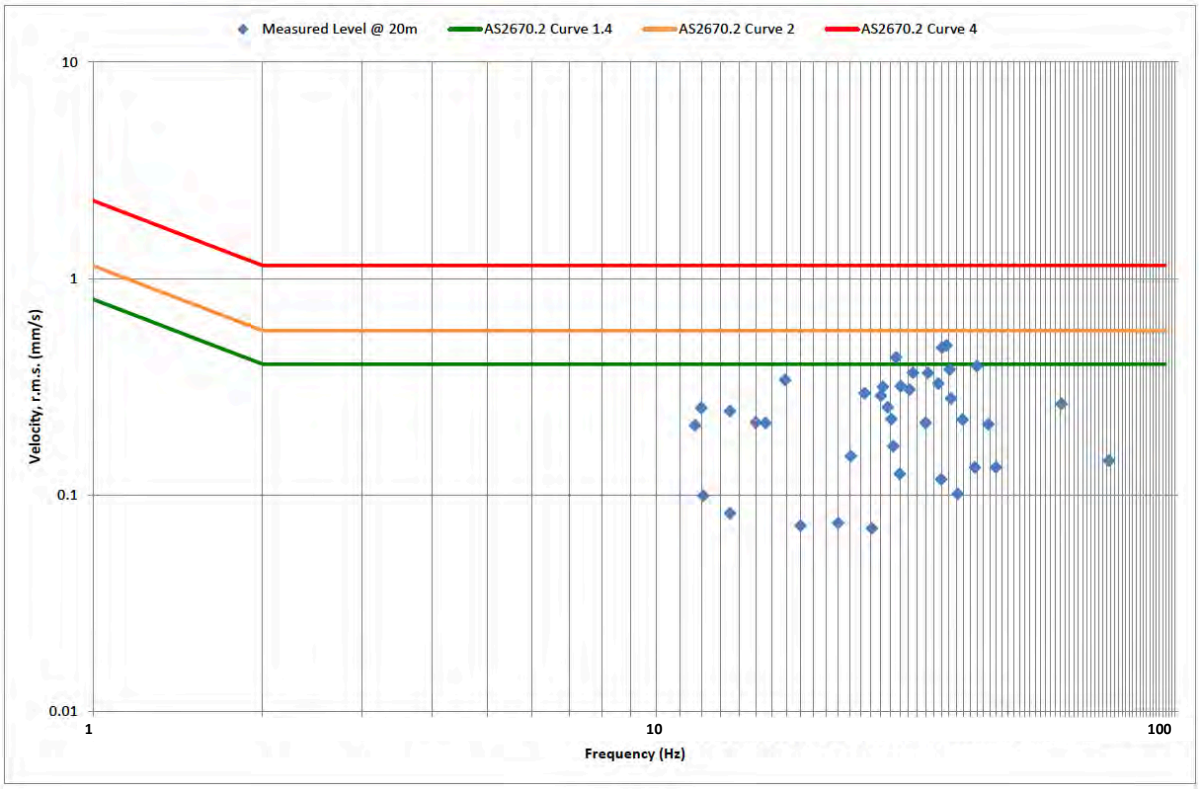


Figure 4-2(b) Vibration Monitoring at 20 metres from Track: Transverse Velocity

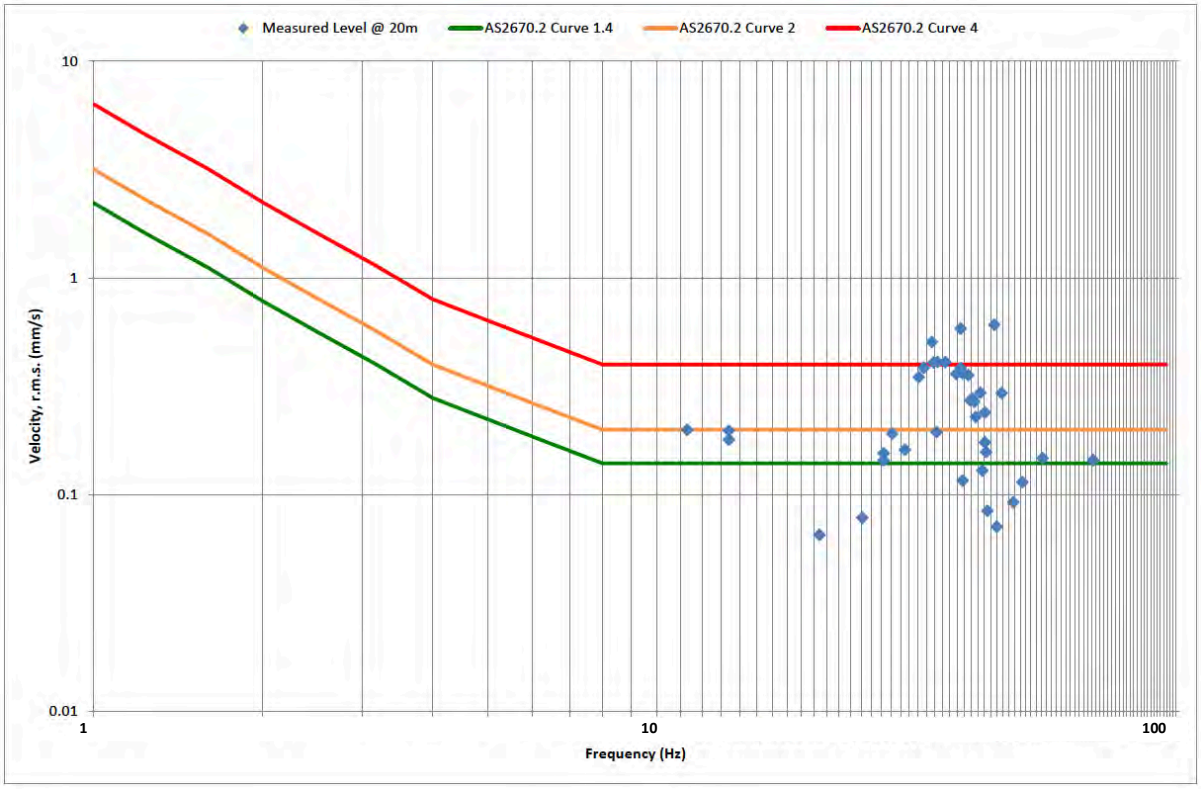


Figure 4-2(c) Vibration Monitoring at 20 metres from Track: Vertical Velocity

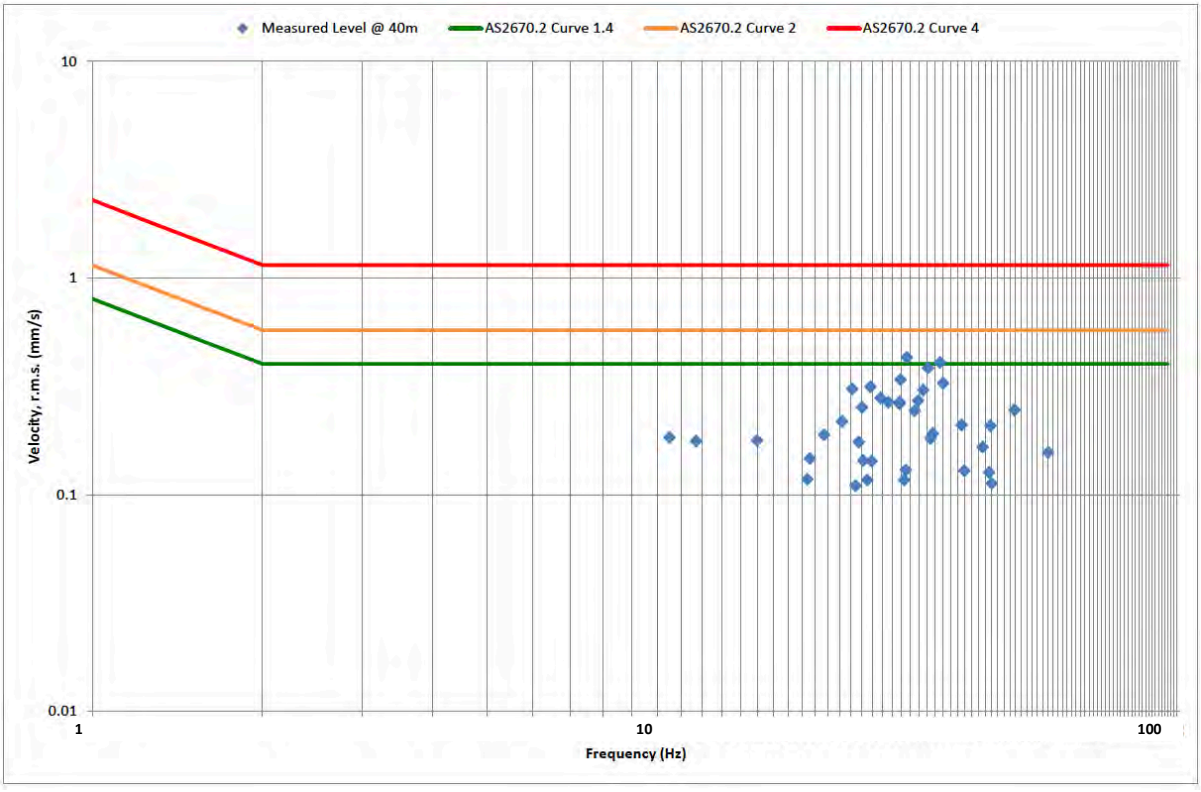


Figure 4-3(a) Vibration Monitoring at 40 metres from Track: Radial Velocity

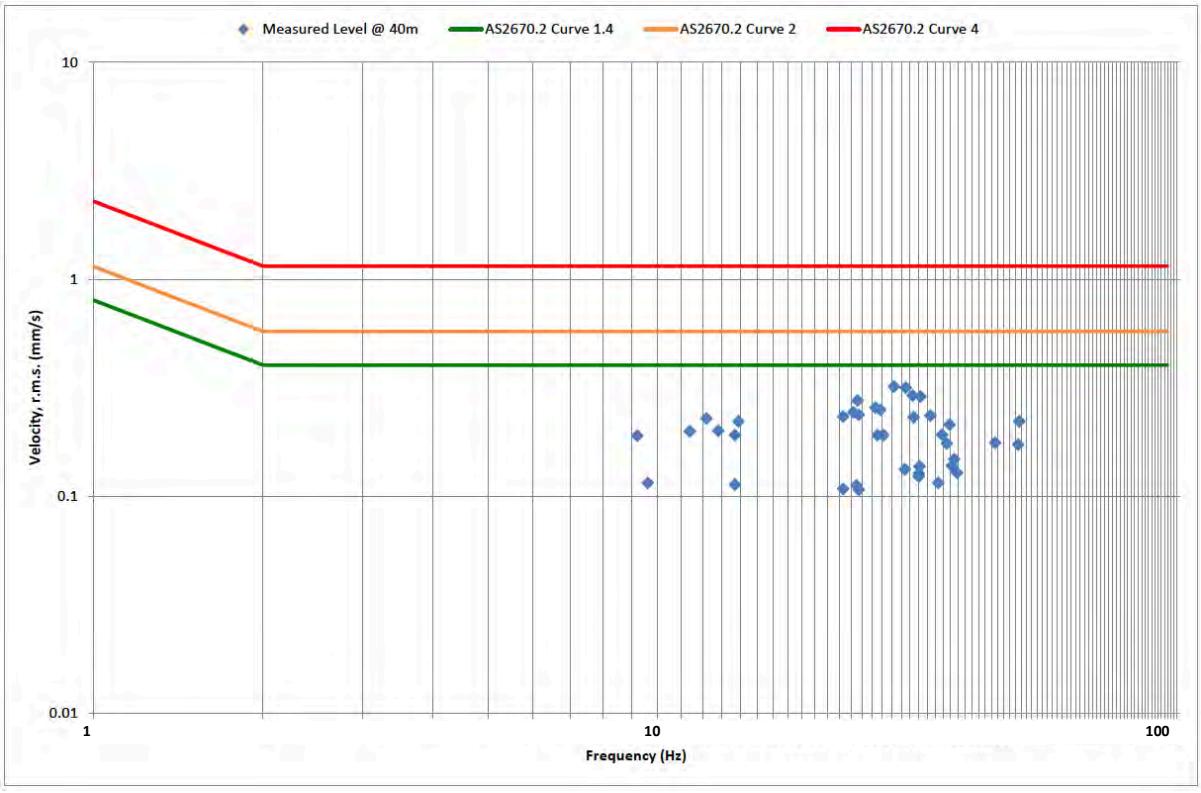


Figure 4-3(b) Vibration Monitoring at 40 metres from Track: Transverse Velocity

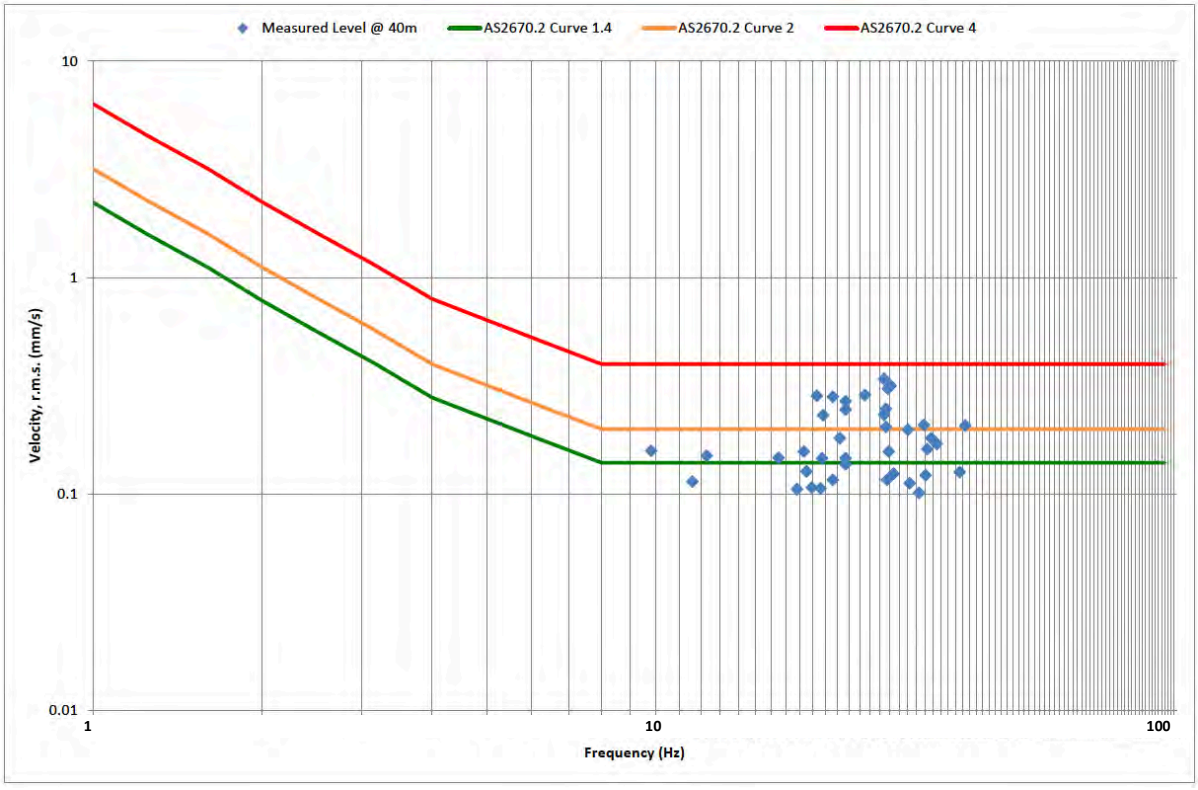


Figure 4-3(c) Vibration Monitoring at 40 metres from Track: Vertical Velocity

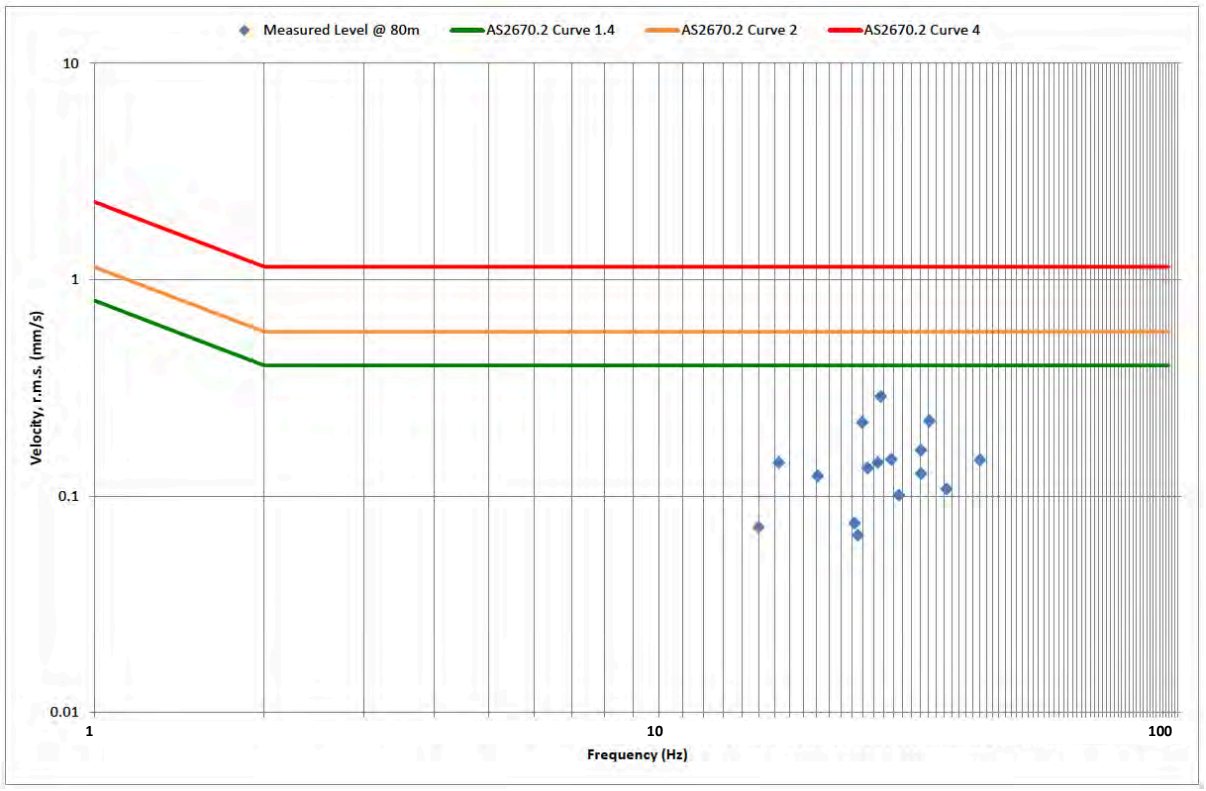


Figure 4-4(a) Vibration Monitoring at 80 metres from Track: Radial Velocity

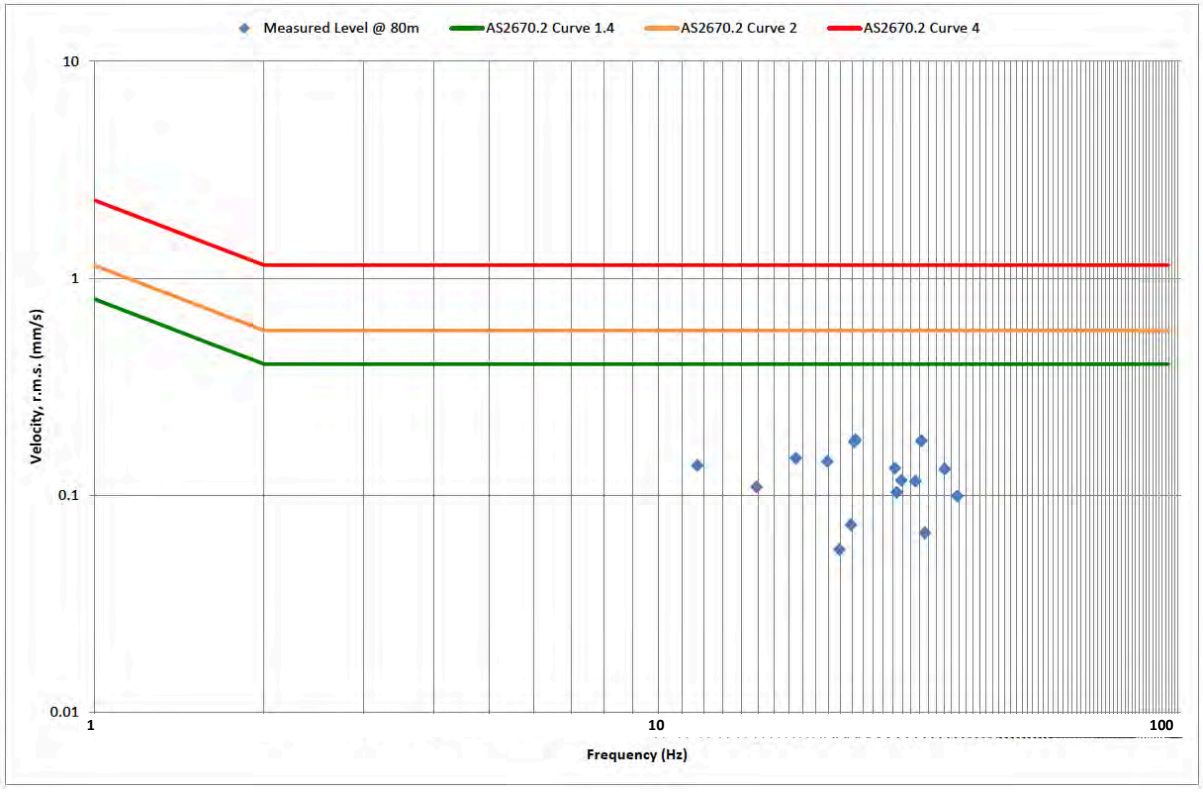


Figure 4-4(b) Vibration Monitoring at 80 metres from Track: Transverse Velocity

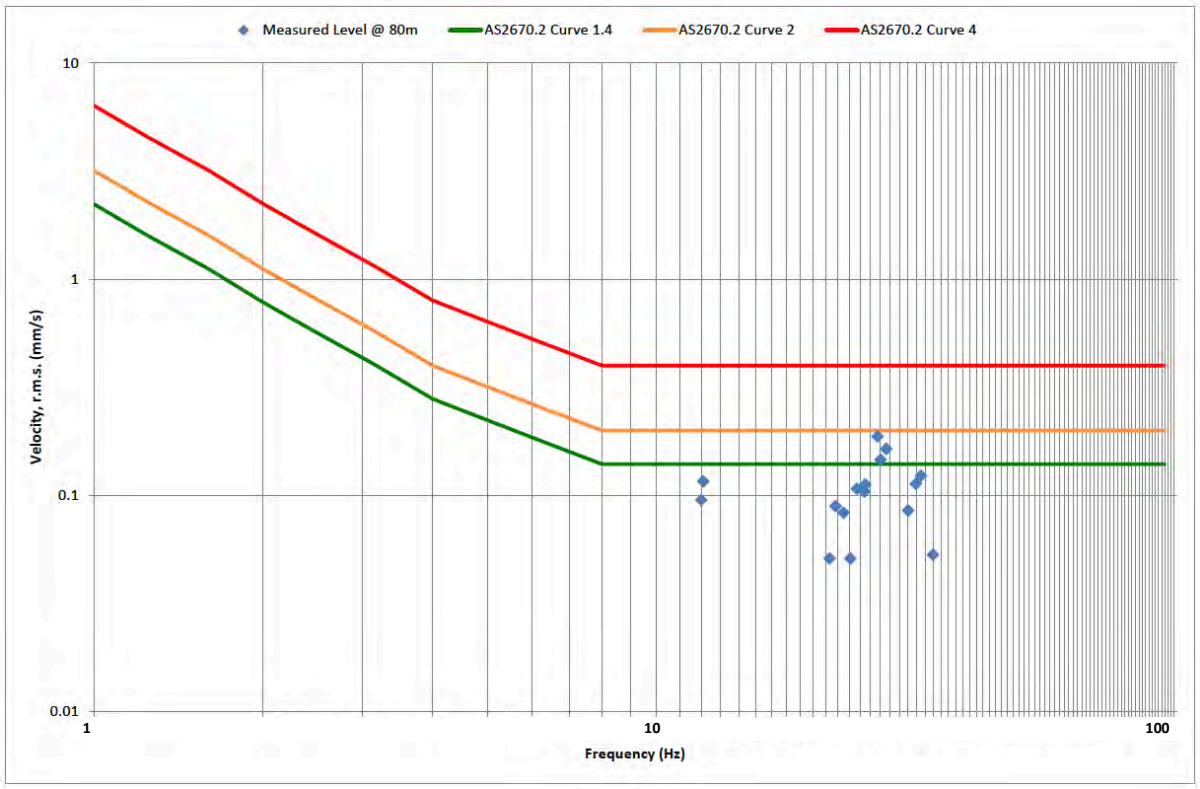


Figure 4-4(c) Vibration Monitoring at 80 metres from Track: Vertical Velocity

To further explore the vibration relationship with distance, *Figures 4-5 to 4-7* provide the radial, transverse and vertical data incorporating a line of best fit.

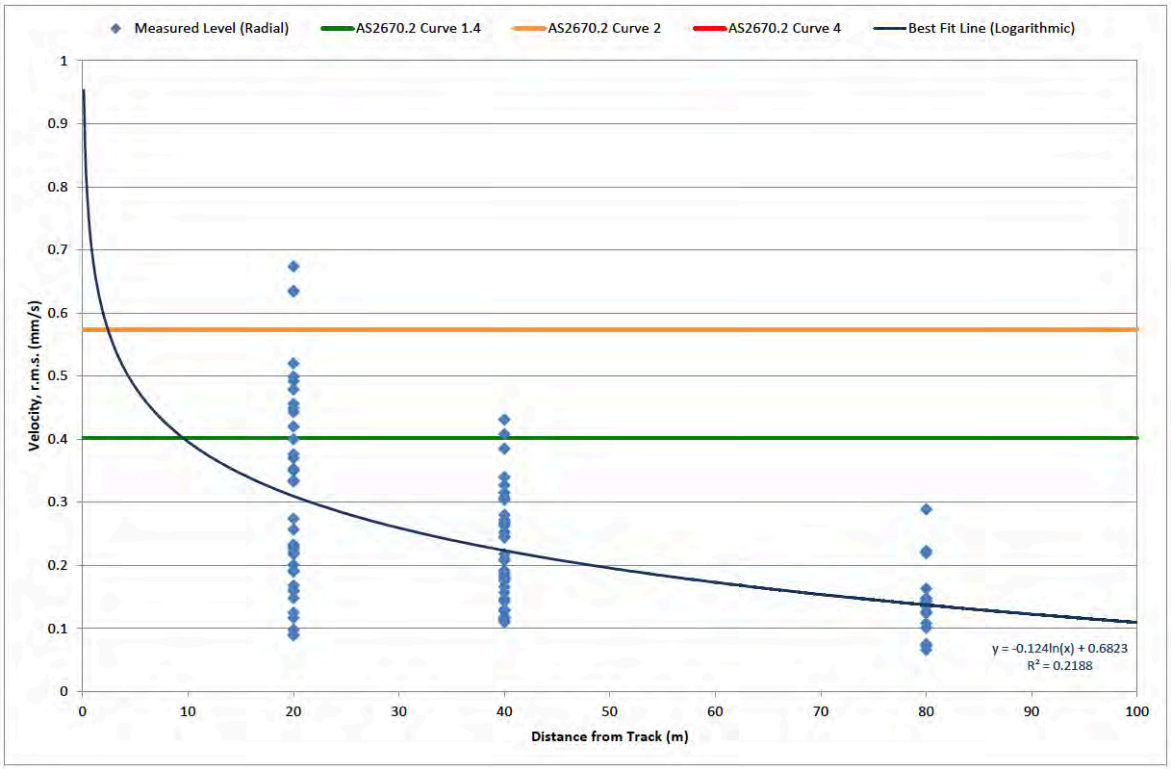


Figure 4-5 Radial Velocity Vibration Monitoring Summary

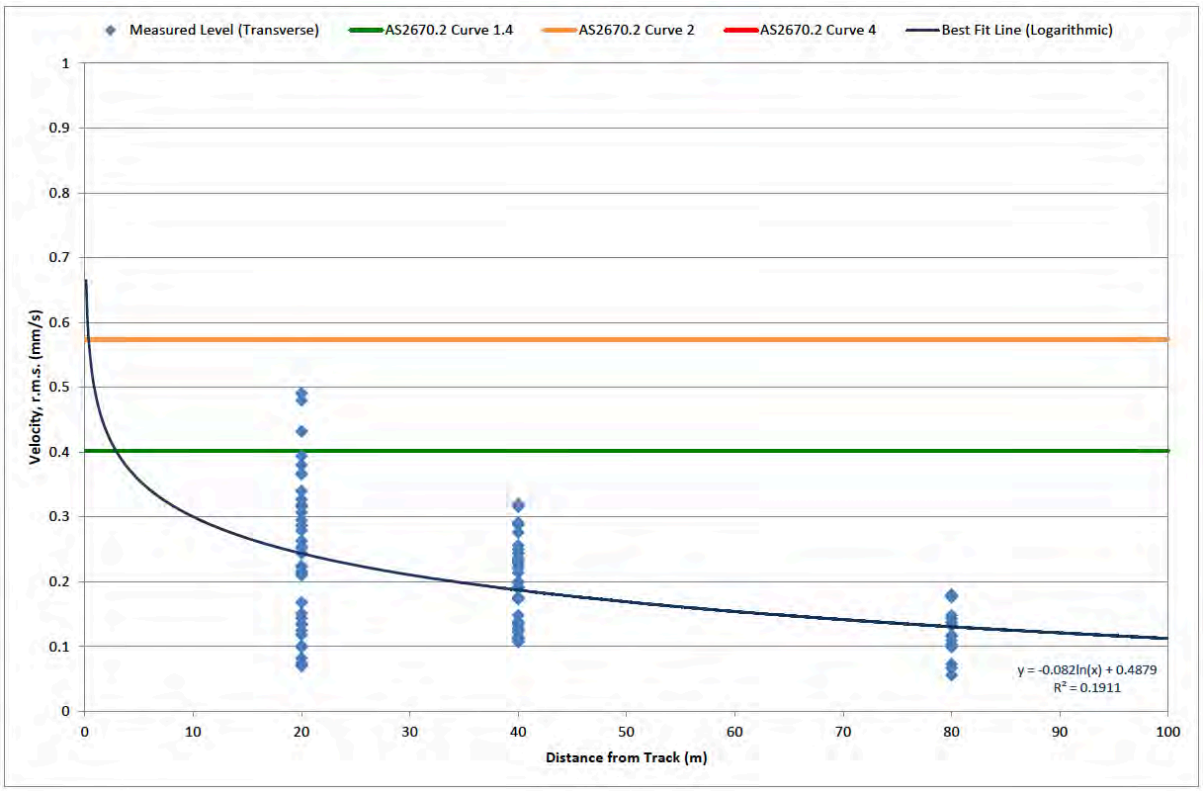


Figure 4-6 Transverse Velocity Vibration Monitoring Summary

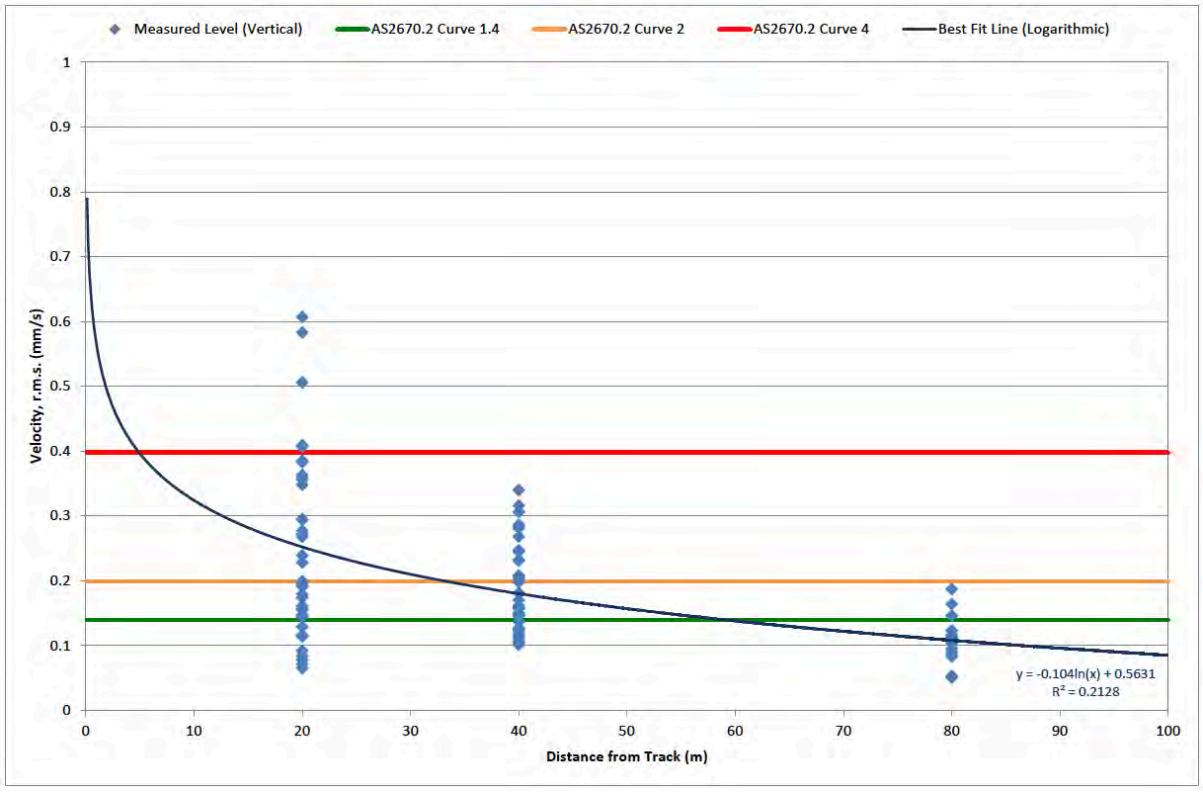


Figure 4-7 Vertical Velocity Vibration Monitoring Summary

Using the line of best fit, the radial and transverse vibration velocities satisfy Curve 2 at distances of 3 metres and 1 metre respectively. The most critical is the vertical vibration velocity, which does not satisfy Curve 2 (based on the line of best fit) until a distance of around 35 metres. At this distance, there may still be half the train movements with vertical vibration velocity between Curves 2 and 4. Again from the line of best fit, the Curve 1.4 is satisfied at a distance of around 60 metres.

An occupant inside a building may be standing or lying down. The vibration measurements to date assume a person is standing and there is no change in vibration level from inside to outside. For lightweight floors, the vibration levels may be higher and for concrete floors, the vibration levels may be less, depending on the coupling loss. The most conservative approach is to use the radial/transverse measurements but assess these against the z-axis criteria as shown in *Figure 4-8*. This essentially assumes a there is no change in vibration level from outside to a person laying down inside.

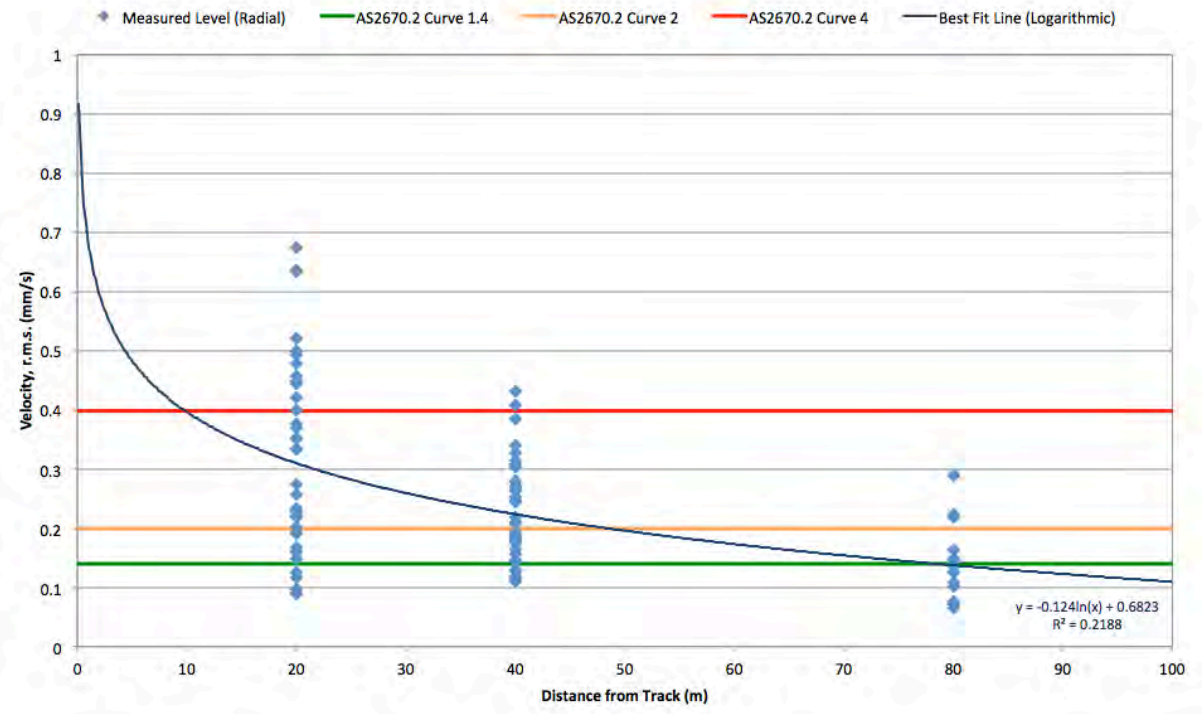


Figure 4-8 Radial Velocity Vibration Assessed Against Vertical Criteria

From *Figure 4-8*, the distances for the radial measurement to achieve Curves 2 and 1.4 of the z-axis, based on the line of best fit, are 50 metres and 80 metres respectively.

4.3 Noise Modelling

Due to the number of scenarios considered, a large number of noise contour plots have been generated and are provided in the appendices as follows:

- *Appendix A* – Noise contours associated with standard dwelling type development, nominally R20 zoning.
- *Appendix B* – Noise contours associated with boundary-to-boundary single storey dwellings, nominally R30 zoning.
- *Appendix C* – Noise contours associated with boundary-to-boundary double storey developments. These could represent townhouses (nominally R30 zoning) or two floors of unit type developments (nominally R60 zoning).
- *Appendix D* – Noise contours associated with three level apartment developments, nominally R60 zoning.
- *Appendix E* – Noise contours associated with four level apartment developments, nominally R100 zoning. Note that the ground floor of this particular example was carparking only.

For each scenario, the length of the road and development was 1000 metres. However for the analysis, a 100-metre width of development has been considered in order to determine the number of houses affected and subsequently the number of persons affected.

The contour data has been summarised in *Table 4-3*, noting that the distance provided is from the edge of the road, as opposed to the edge of the transport corridor. The data within *Table 4-3* has then been presented graphically in *Figures 4-8 to 4-12*.

Note that this analysis assumes that, for each development scenario, the same zoning and building type will continue for subsequent rows of houses behind. Although this is adequate for drawing broad conclusions, a preferred planning strategy may be to mix the zonings so that, for example, higher density was permitted closer to the transport corridor, with lower densities further back (or vice versa). From an acoustic perspective this could result in an optimal mix of development that could deliver strategic acoustic provide benefits. Such possibilities are discussed further in *Section 5 - Summary of Findings*.

Table 4-2 Summary of Noise Modelling

Scenario	Transportation Corridor				
	North Lake Road	Farrington Road	Roe Highway	Kwinana Fwy	Freight Railway[5] L_{Aeq}/L_{Amax}
Freefield					
Distance to *Limit*	78m	33m	214m	200m	100m / 87m
Distance to *Target*	183m	100m	433m	447m	248m / 151m
Standard Dwelling (~ R20)					
Distance to *Limit*	20m	15m	50m	46m	44m / 72m
Distance to *Target*	28m	22m	157m	153m	141m / 124m
Number of Houses Within *Limit*	6	0	6	6	12
Number of Affected Persons within *Limit*	21	0	21	21	42
Number of Houses Within *Margin*	0	6	18	18	6
Number of Affected Persons within *Margin*	0	21	63	63	21
Boundary to Boundary Single Storey (~ R30)					
Distance to *Limit*	17	16	46	46	44m / 44m
Distance to *Target*	22	19	155	155	141m / 77m
Number of Houses Above *Limit*	10	0	10	10	10
Number of Affected Persons Above *Limit*	25	0	25	25	25
Number of Houses Within *Margin*	0	10	20	20	30
Number of Affected Persons within *Margin*	0	25	50	50	75
Boundary to Boundary Double Storey (R30/R60)[1,2]					
Distance to *Limit*	21	20	49	50	38m / 42m
Distance to *Target*	26	24	84	84	73m / 77m
Number of Houses / Apartments Above *Limit*	10 / 20	0 / 10	10 / 20	10 / 20	10 / 20
Number of Affected Persons Above *Limit*	30 / 40	0 / 20	30 /40	30 / 40	30 / 40
Number of Houses / Apartments Within *Margin*	0 / 0	10 / 10	10 / 10	10 / 10	10 / 10
Number of Affected Persons within *Margin*	0 / 0	30 / 20	30 / 20	30 / 20	30 / 20

Scenario	Transportation Corridor				
	North Lake Road	Farrington Road	Roe Highway	Kwinana Fwy	Freight Railway[5] L_{Aeq}/L_{Amax}
Three Level Apartments (R60)[1,3]					
Distance to *Limit*	26	23	58	59	45m / 82m
Distance to *Target*	38	29	95	96	83m / 104m
Number of Apartments Above *Limit*	36	24	36	36	36
Number of Affected Persons Above *Limit*	90	60	90	90	90
Number of Apartments Within *Margin*	0	12	12	12	36
Number of Affected Persons within *Margin*	0	30	30	30	90
Four Level Apartments (R100)[1,4]					
Distance to *Limit*	34	30	66	77	111m / 120m
Distance to *Target*	44	38	94	108	251m / 216m
Number of Apartments Above *Limit*	63	63	84	84	105
Number of Affected Persons Above *Limit*	126	126	168	168	210
Number of Apartments Within *Margin*	0	0	63	63	105
Number of Affected Persons within *Margin*	0	0	126	126	210

Notes:

1. Distances shown are for the worst-case floor level.
2. Two values are shown for number of houses with the first relating to townhouse style development and the second relating to a unit type development, with upper and lower floor being different occupants.
3. Number of apartments relates to total number, in this case, 12 apartments per building with 4 per floor.
4. Number of apartments relates to total number, in this case, 21 apartments per building with 7 per floor. Ground floor has no apartments with this space used for car parking.
5. Freight train values for distances present both the L_{eq} and L_{max} whilst the number of houses and people use the worst case.

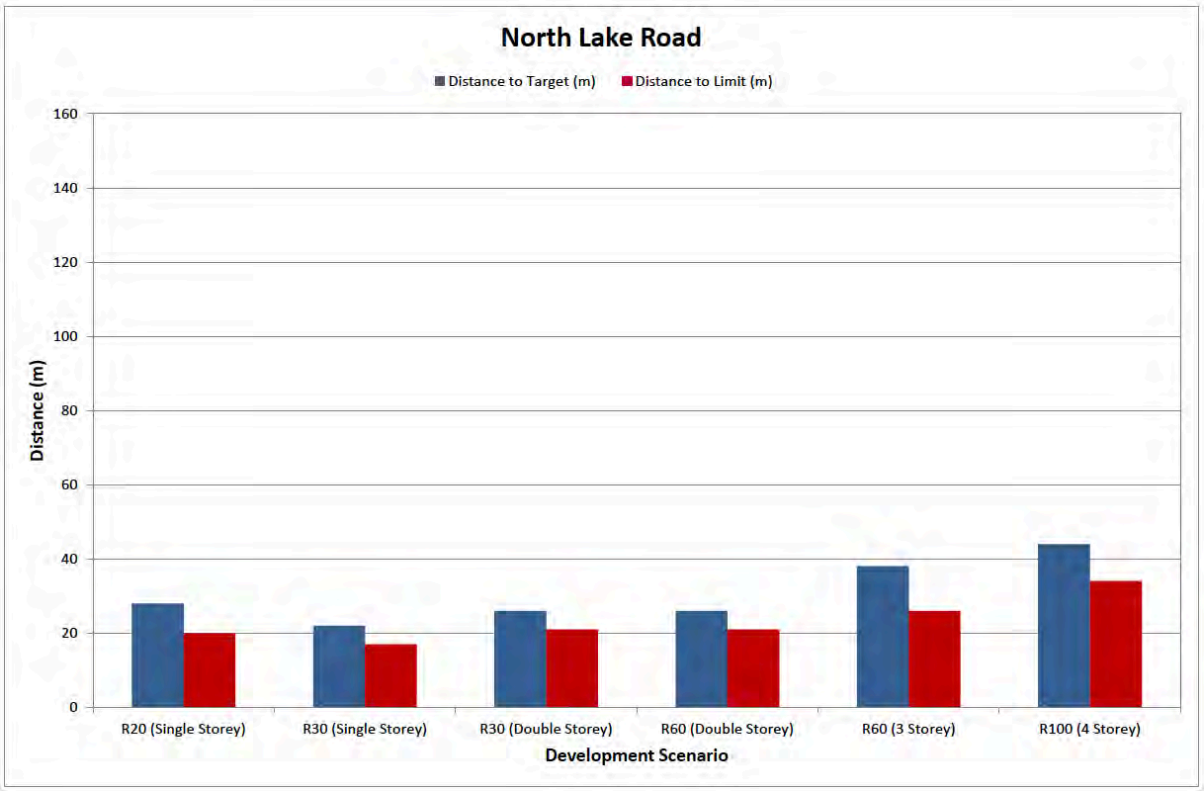


Figure 4-8(a) Distance to Limit and Target: North Lake Road

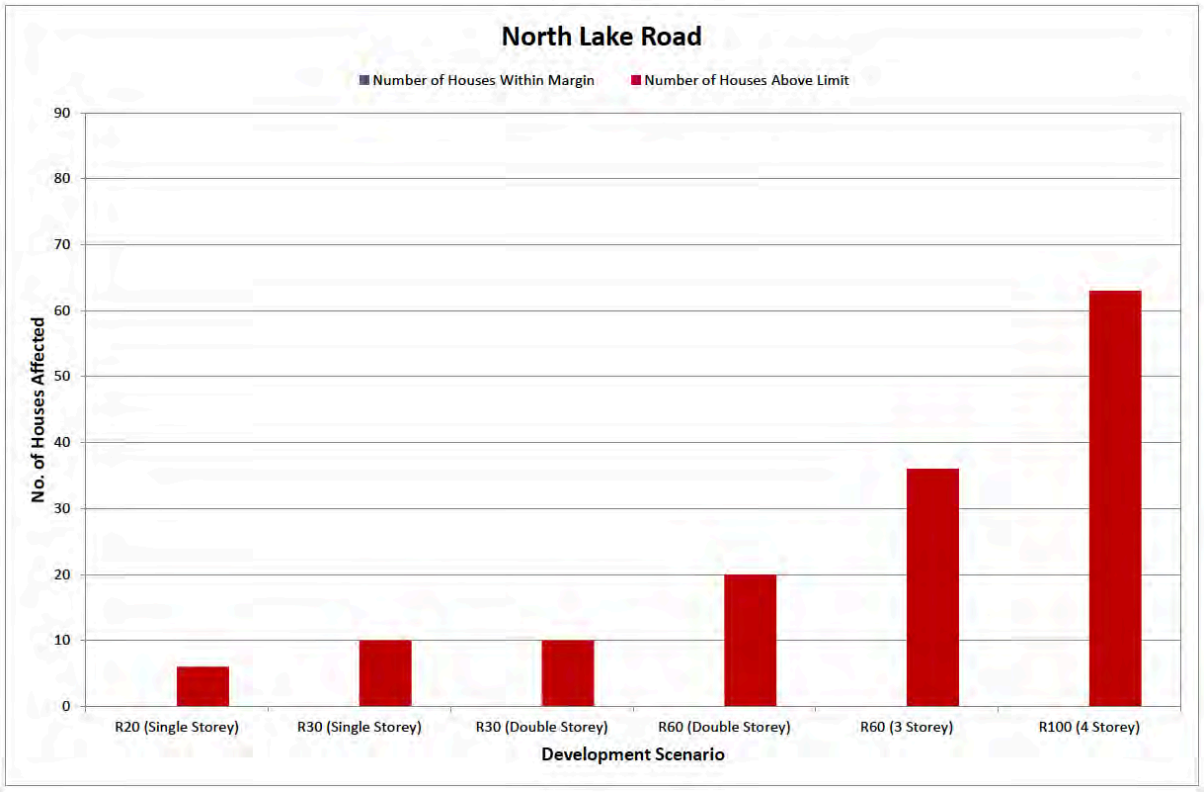


Figure 4-8(b) Number of Affected Houses: North Lake Road

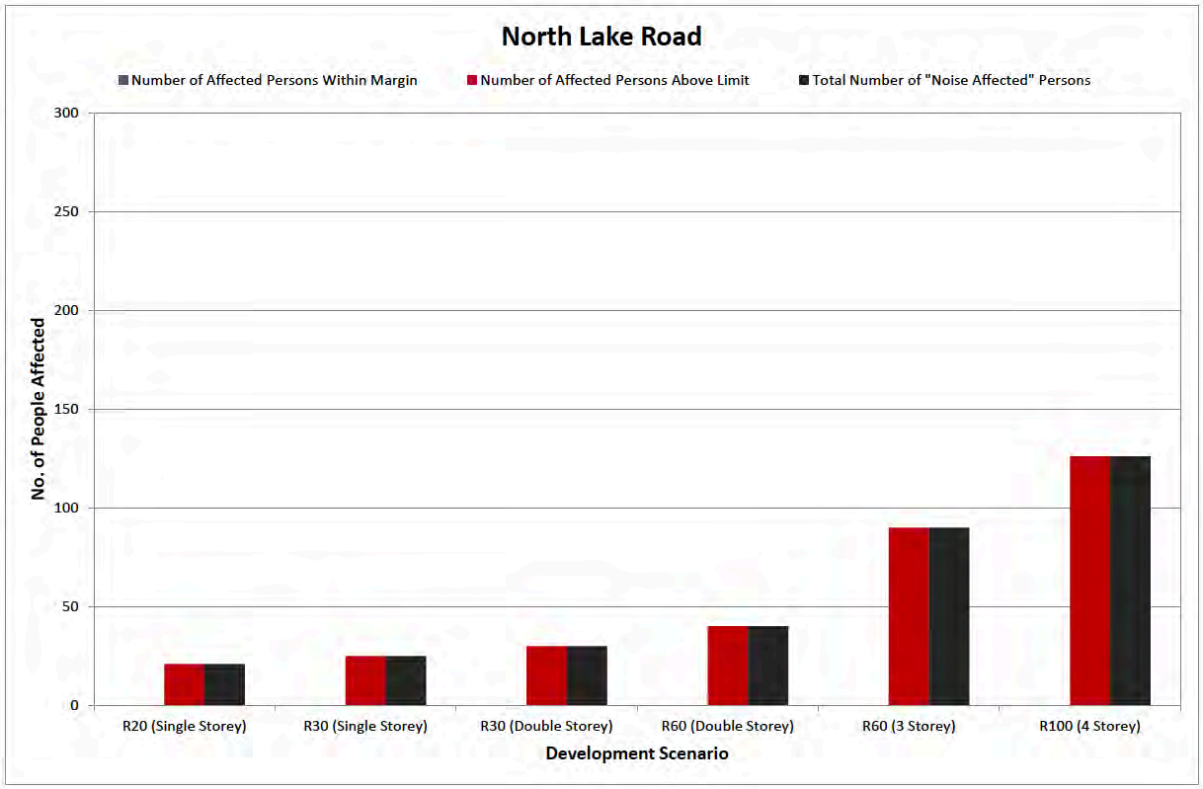


Figure 4-8(c) Number of Affected Persons: North Lake Road

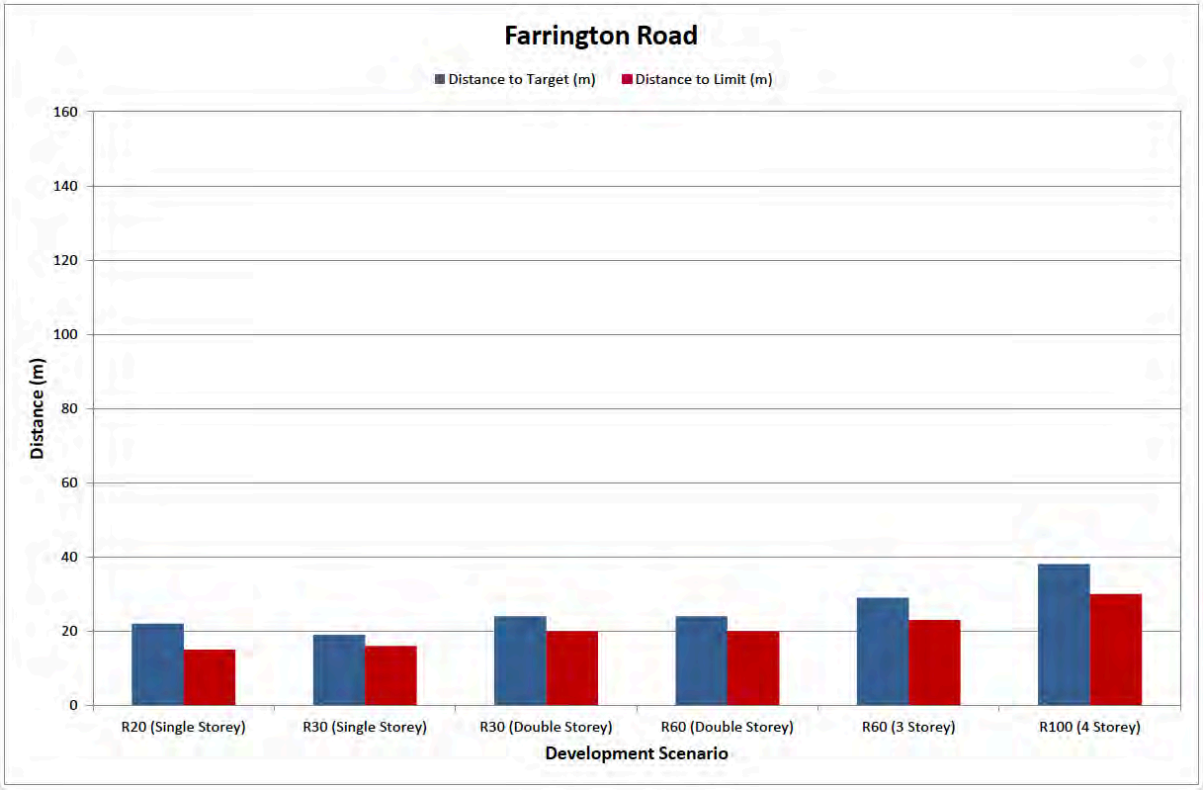


Figure 4-9(a) Distance to Limit and Target: Farrington Road

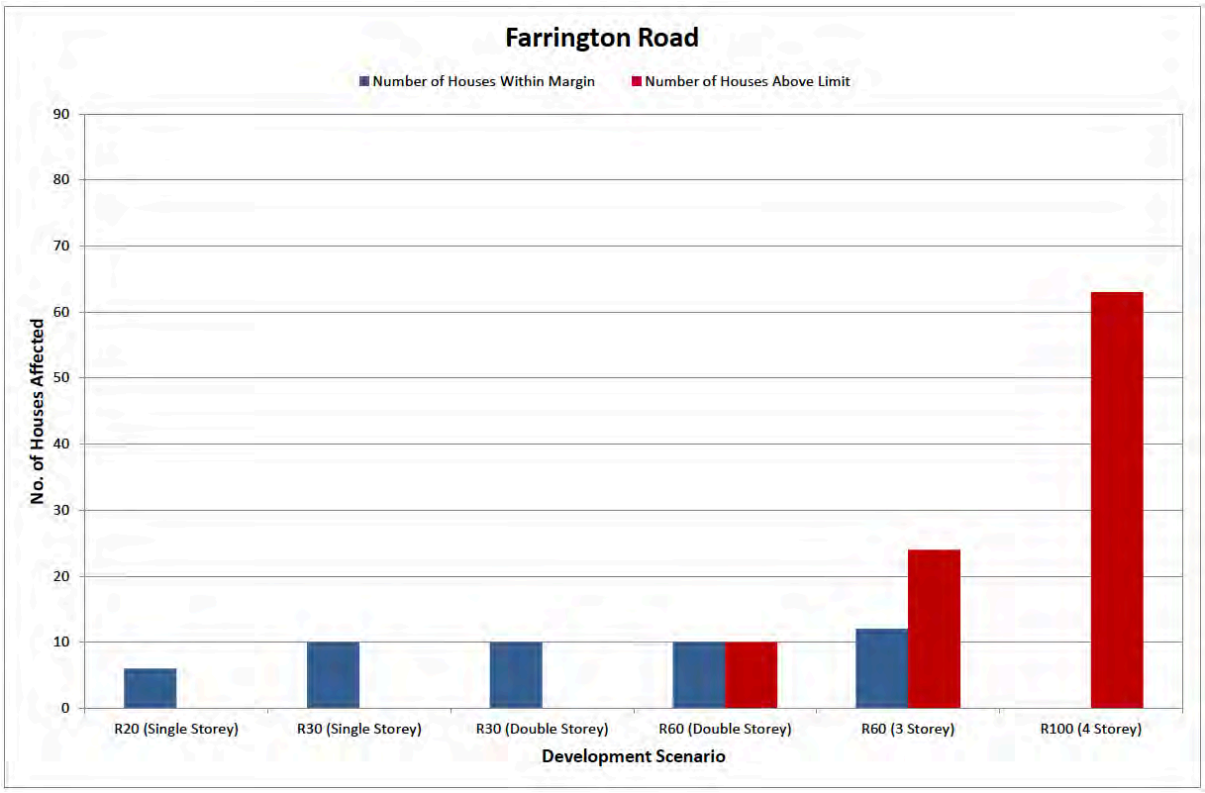


Figure 4-9(b) Number of Affected Houses: Farrington Road

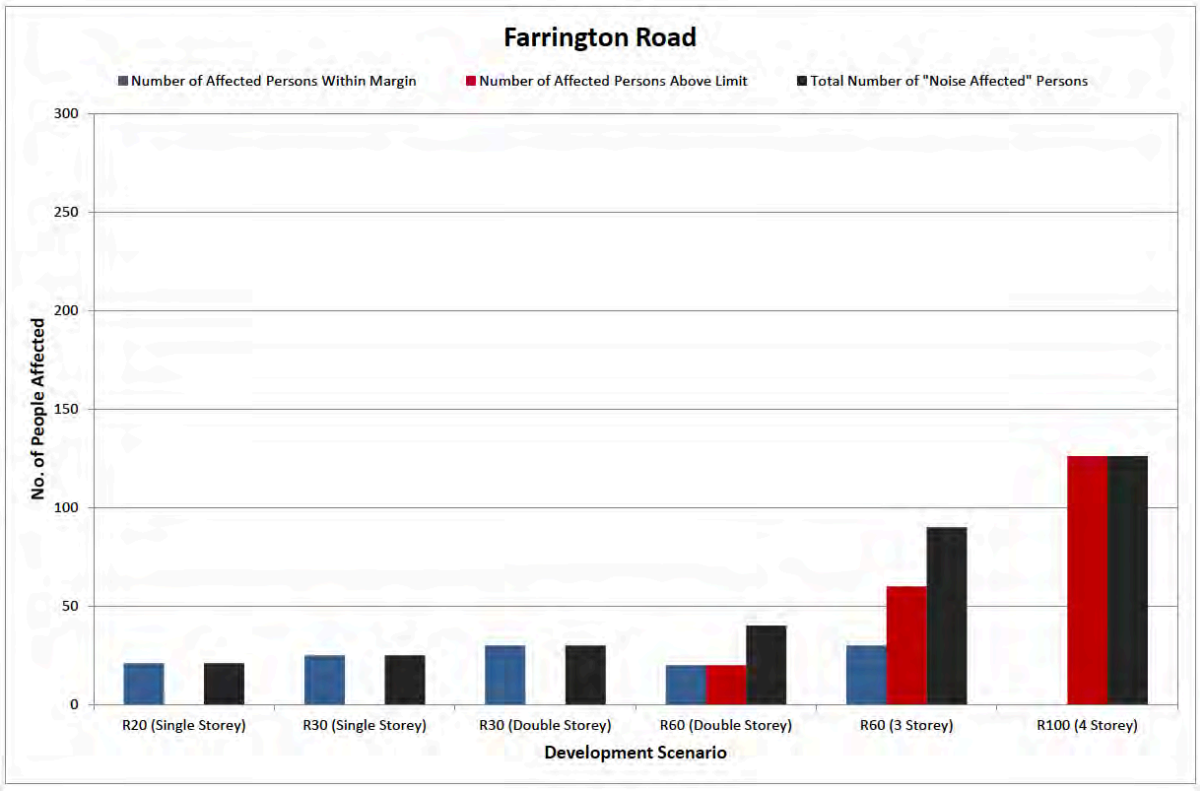


Figure 4-9(c) Number of Affected Persons: Farrington Road

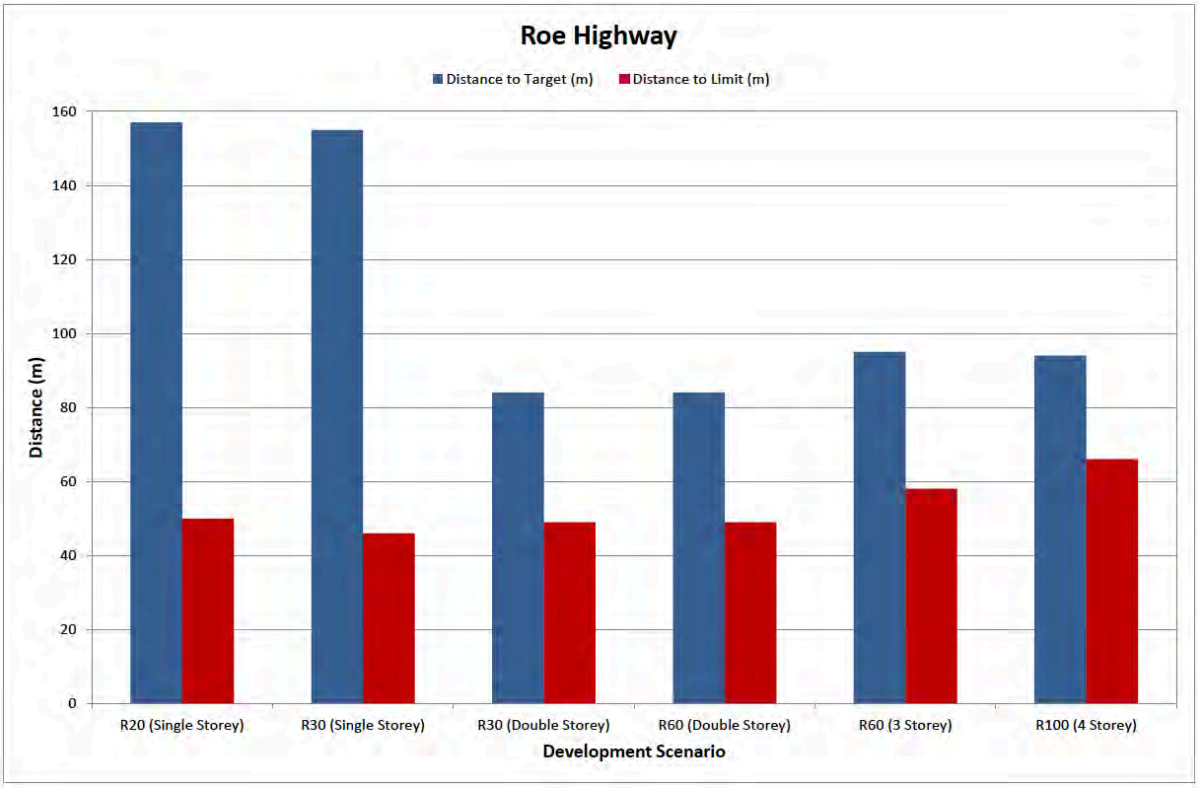


Figure 4-10(a) Distance to Limit and Target: Roe Highway

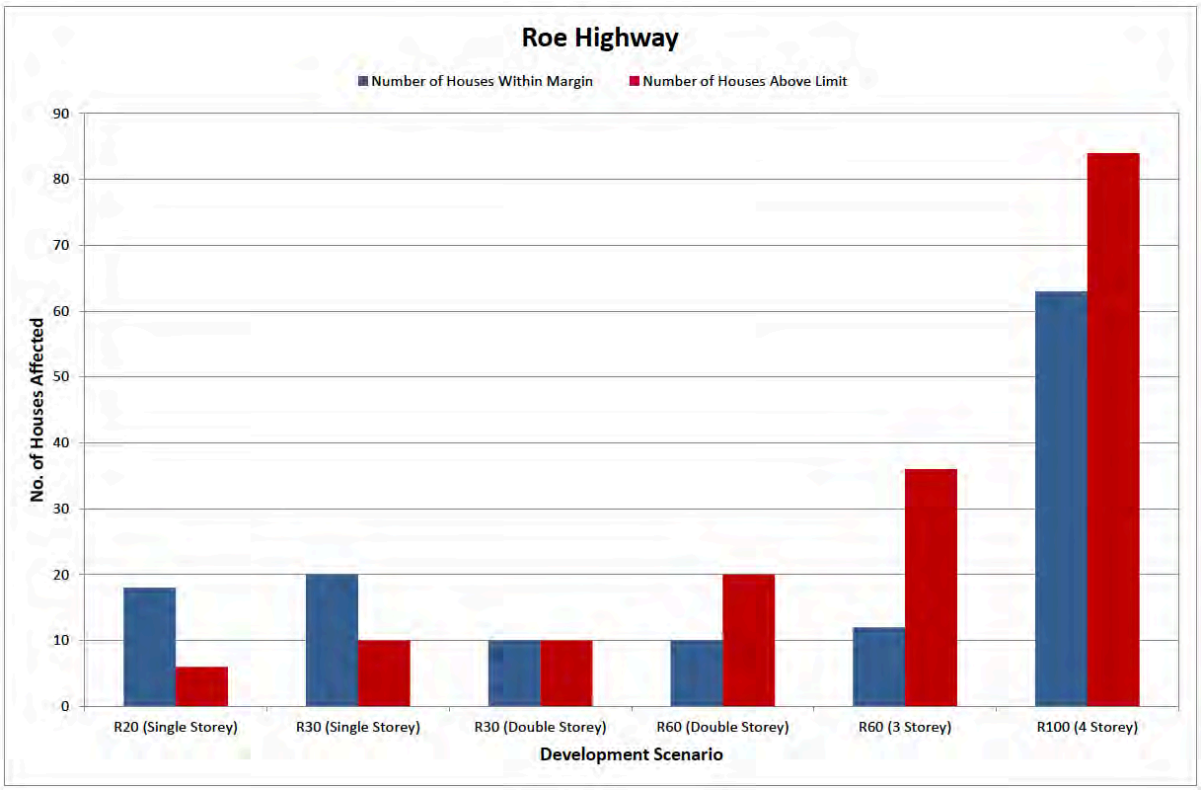


Figure 4-10(b) Number of Affected Houses: Roe Highway

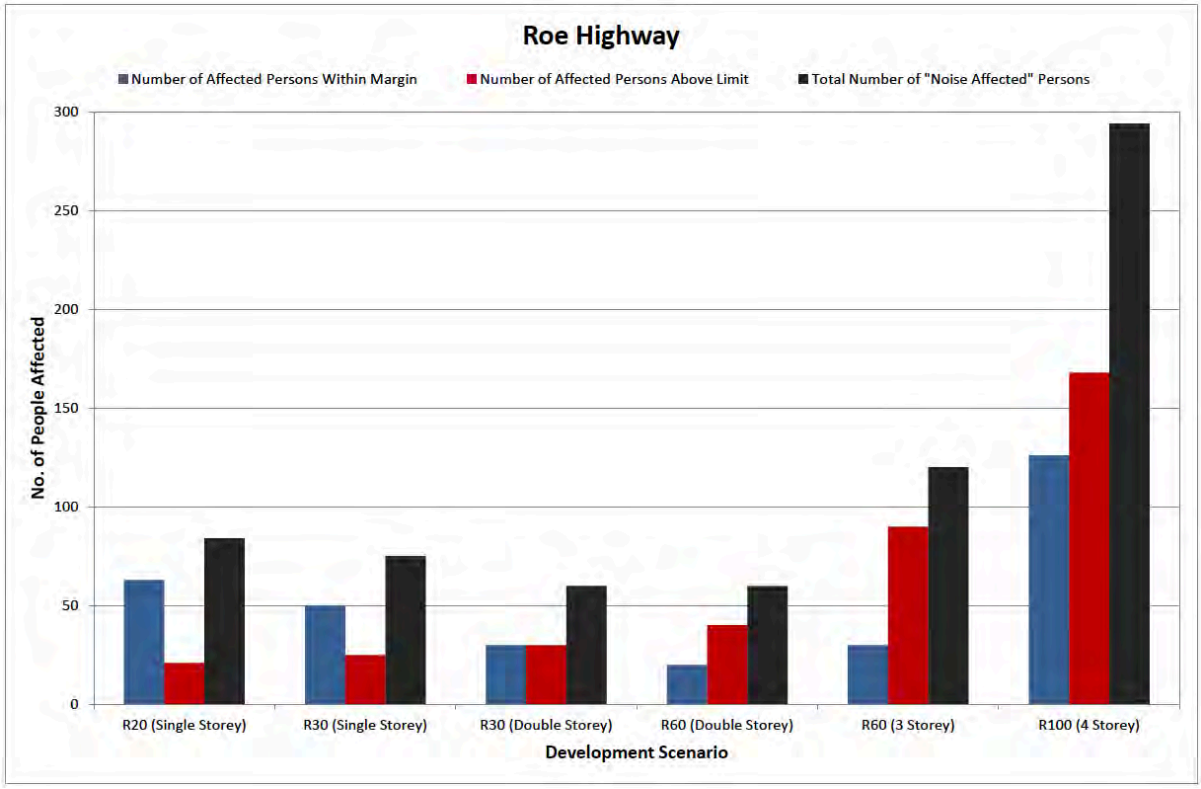


Figure 4-10(c) Number of Affected Persons: Roe Highway

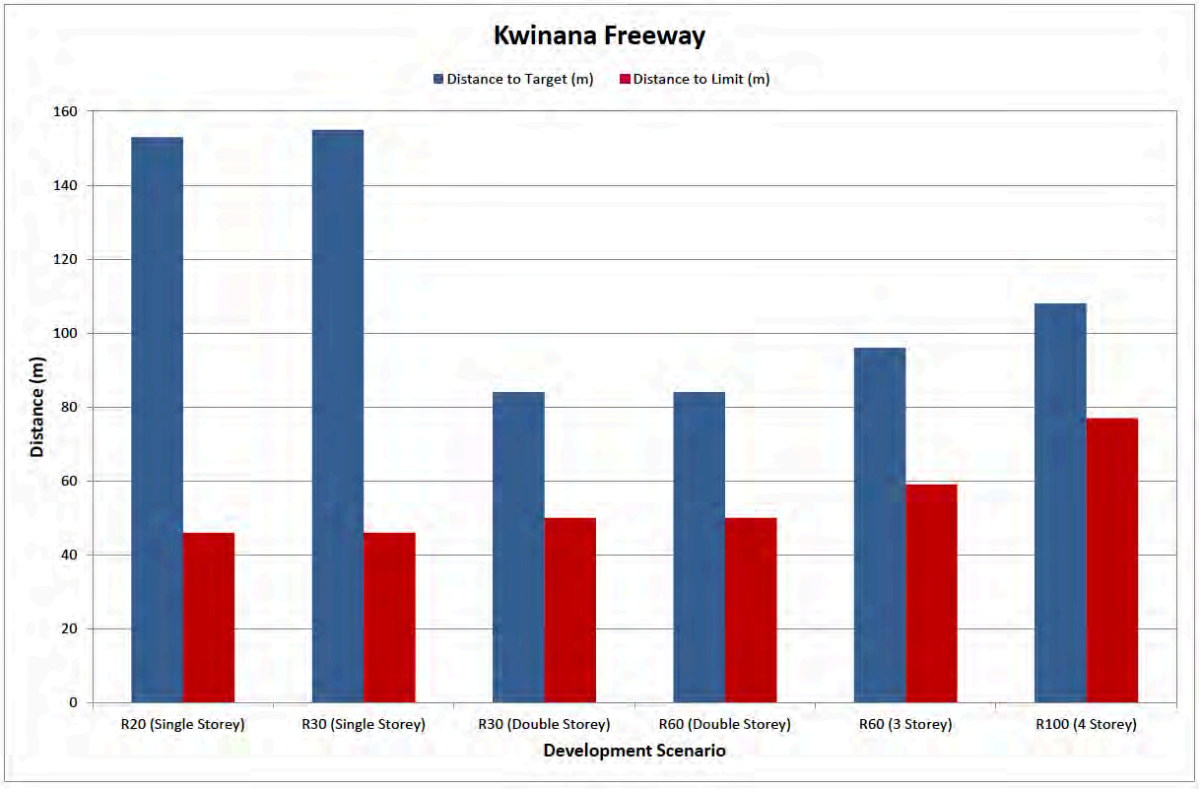


Figure 4-11(a) Distance to Limit and Target: Kwinana Freeway

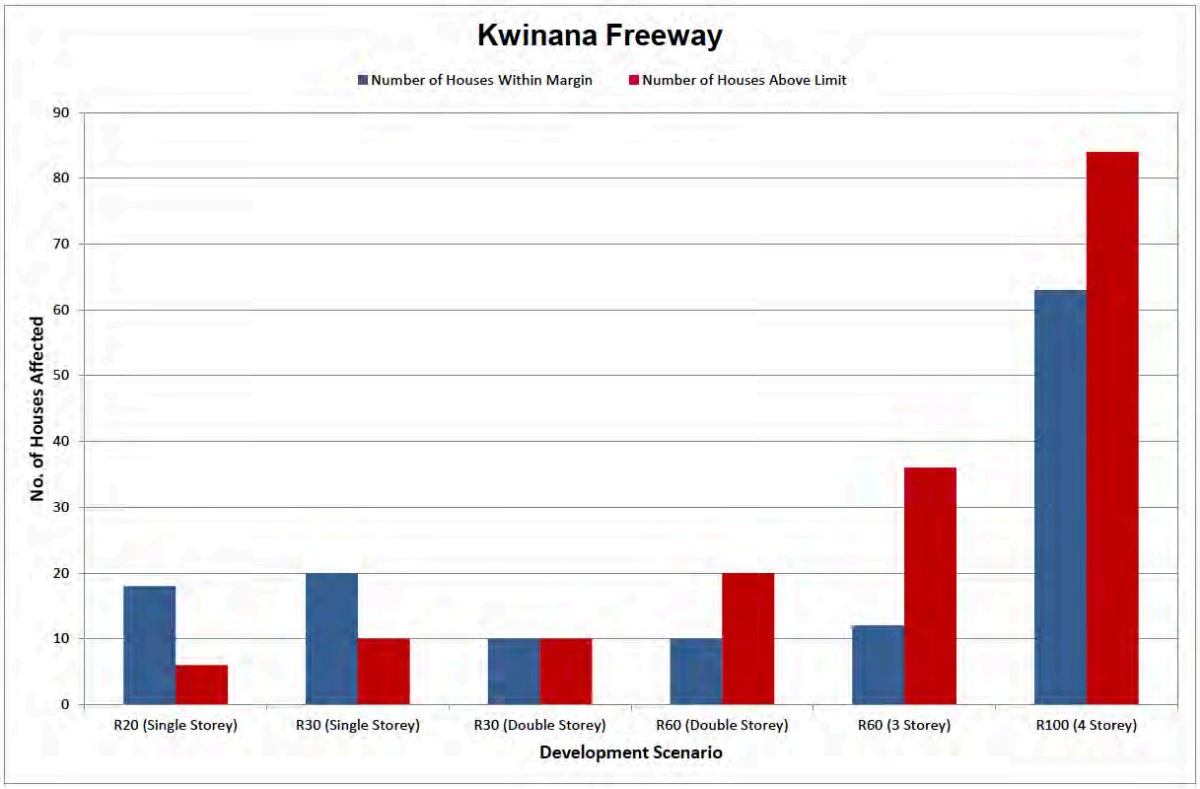


Figure 4-11(b) Number of Affected Houses: Kwinana Freeway

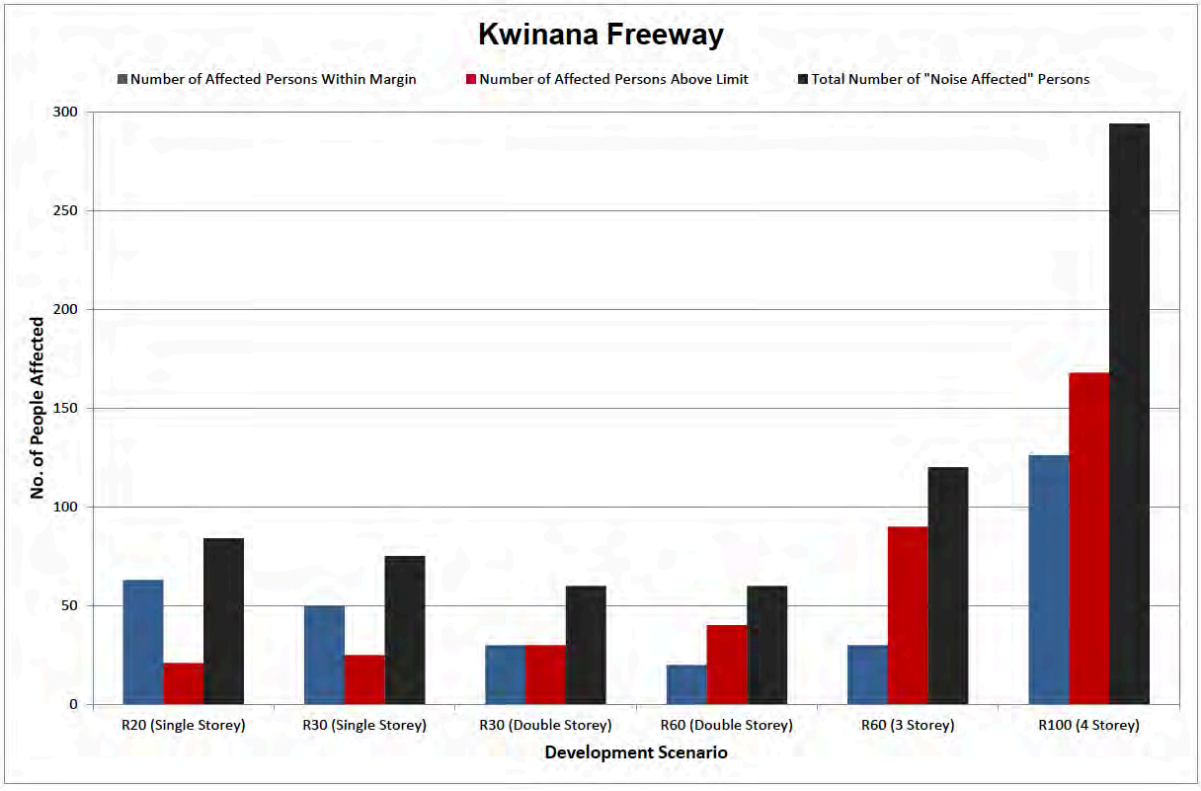


Figure 4-11(c) Number of Affected Persons: Kwinana Freeway

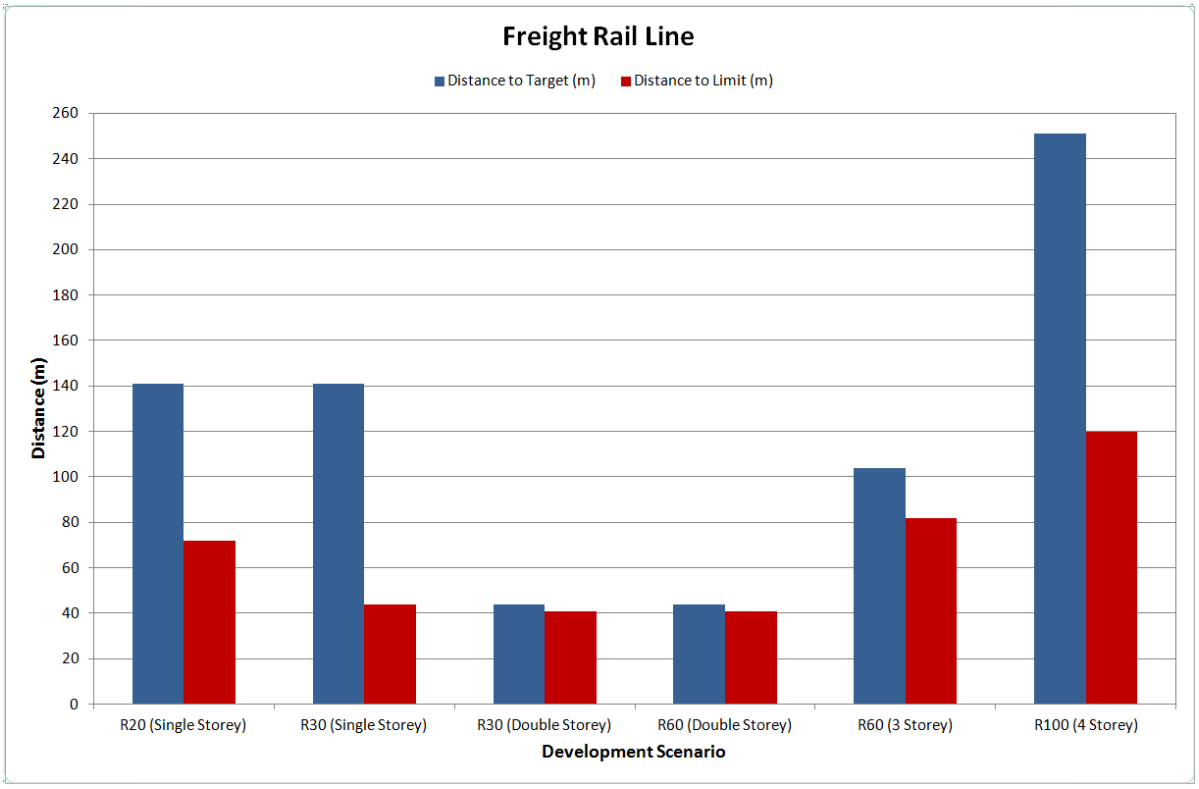


Figure 4-12(a) Distance to Limit and Target: Freight Rail Line

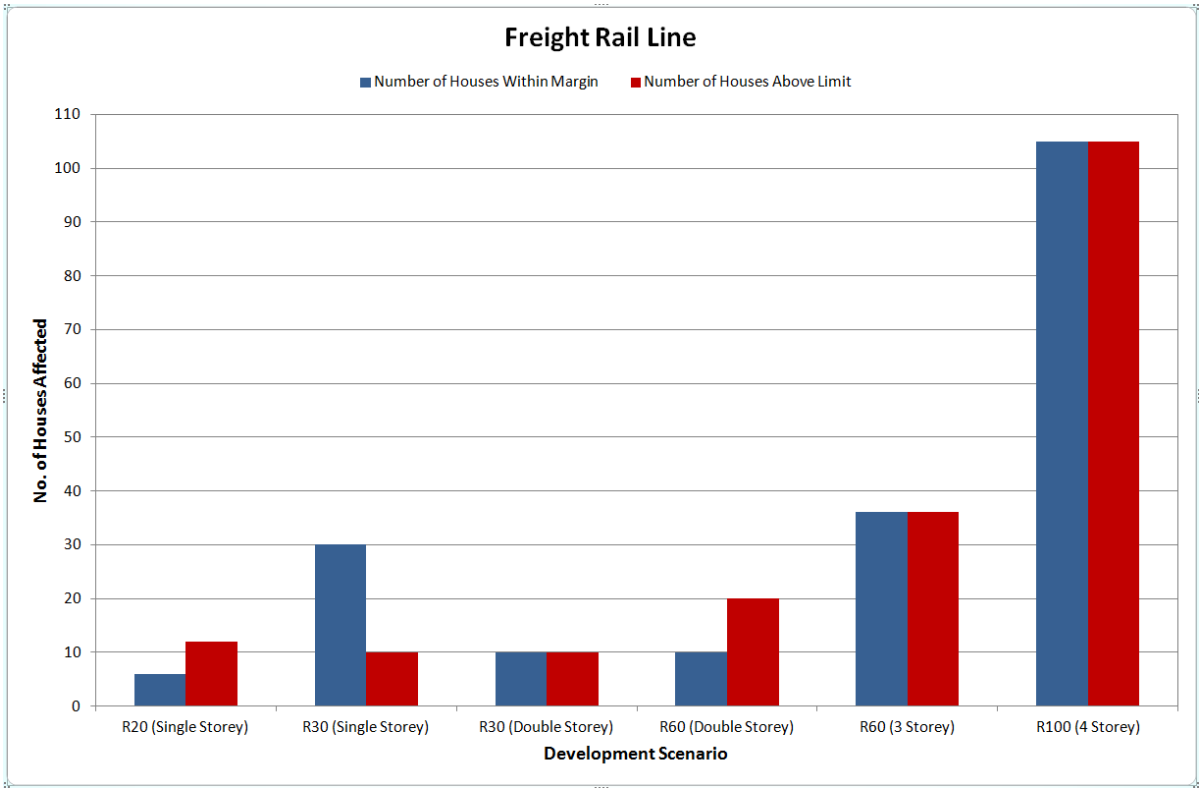


Figure 4-12(b) Number of Affected Houses: Freight Rail Line

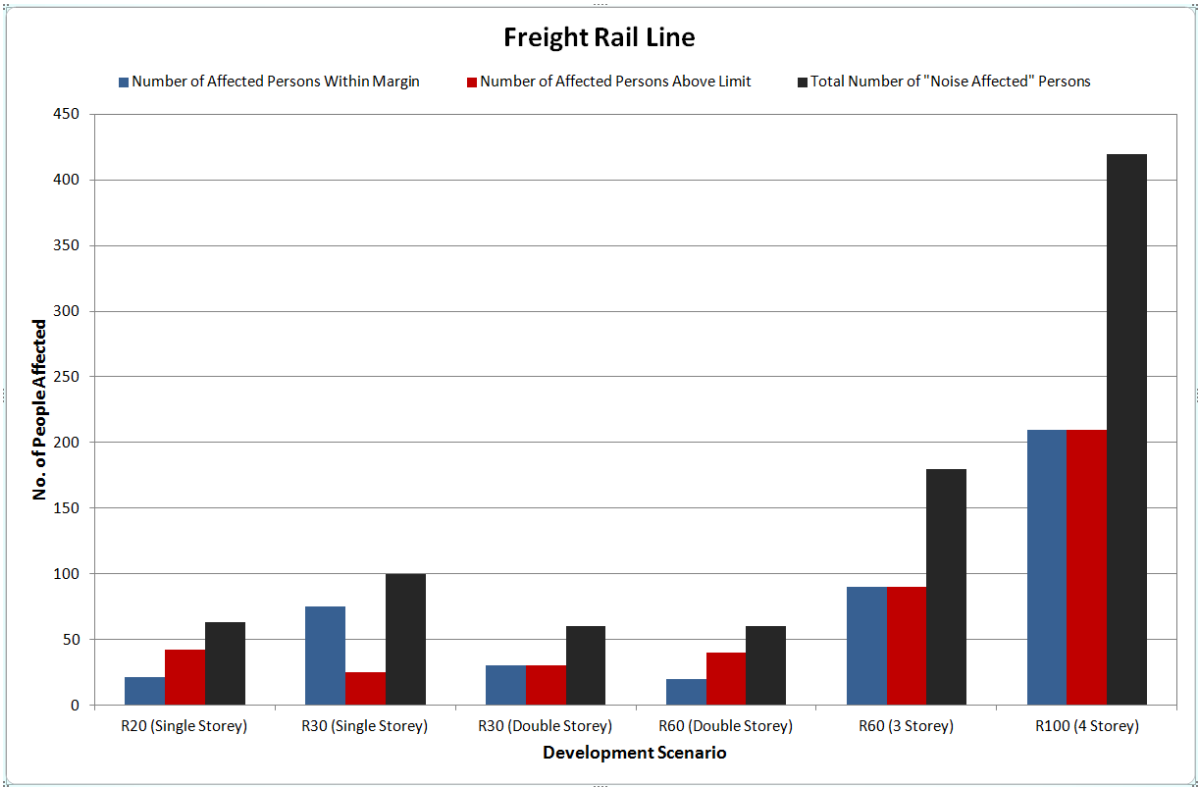


Figure 4-12(c) Number of Affected Persons: Freight Rail Line

5 SUMMARY OF FINDINGS

A summary of the key findings of this study is as follows:

General Planning

- The incorporation of buildings significantly reduces the extent of the noise impact in terms of distance from the corridor. This is evident from the free-field noise modelling. Essentially this means that whilst locating public open space alongside these major transport corridors might provide a noise buffer to residential development behind, it may not lead to an optimum use of space for development purposes.
- For transport corridors where the noise impact is not as significant (e.g. North Lake Road and Farrington Road), encouraging large buildings / high density development adjacent to the corridor will not reduce the extent of the noise affected area. Increasing the density in these areas will, therefore, only serve to increase the number of persons affected by noise.
- For transport corridors where the noise impacts are significant (e.g. Roe Highway, Kwinana Freeway and Freight Rail Line), supporting large buildings / high density development adjacent to the corridor can be beneficial in reducing the extent of the noise affected area. In these cases, to limit the number of persons affected, the first row could be high density with the rows behind being lesser density.
- There is negligible acoustic difference between R20 and R30 single storey development.

The findings are discussed in more detail for each transport corridor.

North Lake Road

For development alongside North Lake Road:

- The first row of buildings maybe be marginally above the *limit*, however this could be reduced at ground level to below the *limit* by increasing the boundary wall height.
- Where development behind the first row is only single storey, this will not be noise affected.
- Where the first row is single storey:
    - double storey development could commence in the third row (70m) and not be noise affected.
    - Three and four storey development could commence in the fourth row (110m) and not be noise affected.
- Where the first row is double storey (or more), this is adequate to provide a buffer to any development behind.
- Whilst increasing the density of the first row of houses minimises the extent of noise impacts behind, the number of persons affected in the front row increases.

Conclusion for North Lake Road is:

- There is an acoustic benefit in preferring lower density development alongside North Lake Road, as this will minimise the number of houses and the number of people affected by noise.
- Where single storey development is preferred, this same density should remain for potentially 3 rows of houses before increasing the density.
- Where higher density multiple storey development is preferred, this should be limited to double storey R30 only in order to limit the number of affected persons. Higher density can then occur in the rows behind.
- These findings could vary if Roe Highway does not proceed, as significantly higher traffic volumes would then be expected on North Lake Road.

Farrington Road

For development alongside Farrington Road:

- The first row of buildings may be marginally above the *target*.
- Where development behind the first row is single or double storey, this will not be noise affected.
- Where the first row is single storey:
    - double storey development could commence in the second row and not be noise affected.
    - Three and four storey development could commence in the third row (70m) and not be noise affected.

- Where the first row is double storey (or more), this is adequate to provide a buffer to any development behind.
- Whilst increasing the density of the first row of houses minimises the extent of noise impacts behind, the number of persons affected in the front row increases.

Conclusion for Farrington Road is:

- There is an acoustic benefit in preferring lower density development alongside Farrington Road, as this will minimise the number of houses and the number of people affected by noise.
- Where single storey development is preferred, this same density should remain for potentially 2 rows of houses before increasing the density.
- Where higher density multiple storey development is preferred, this should be limited to double storey R30 only in order to limit the number of affected persons. Higher density can then occur in the rows behind.
- These findings could vary if Roe Highway does not proceed, as significantly higher traffic volumes would then be expected on Farrington Road.

Roe Highway and Kwinana Freeway

For development alongside Roe Highway and Kwinana Freeway:

- The first row of buildings will be above the *limit*. However a wall could be constructed so that the ground level is below the *limit*, but it would need to be significant in height.
- Where the first row is single storey:
    - More single storey development behind will still be noise affected approximately 4 rows from the road (110m).
    - Double storey development could commence in the eighth row (250m) and not be noise affected.
    - Three and four storey development could commence in the tenth row (320m) and not be noise affected.
- Where the first row is double storey:
    - The second row remains noise affected.
    - Double storey development is noise affected to the fourth row.
    - Three storey development could commence five rows away (140m) and not be noise affected.
    - Four storey development could commence six rows away and not be noise affected.
- Where the first row is three storey development:
    - Single and double storey development behind will not be noise affected.
    - Three storey development can occur in the third row (100m) and not be noise affected.

- Where the first row is four storey development:
    - Any development style behind the first row may still be noise affected due to the assumed ground level carpark to this style of development. Alternative design models for apartments 4 storeys (or higher) may help to provide additional screening to houses behind and could be incorporated into design guidelines.
- Due to the high noise impact of these roads, reducing the extent of the noise affected area may be beneficial from a planning and land development perspective, so higher density zonings may be preferred.
    - Whilst increasing the density of the first row of houses minimises the extent of noise impacts behind (assuming a ground floor building), the number of persons affected in the front row increases.

Conclusion for Roe Highway and Kwinana Freeway is:

- There is an acoustic benefit in preferring higher density development alongside Roe Highway and Kwinana Freeway, as this will shield houses behind and will reduce the extent of the noise affected area. Potentially this could also increase the development yield without significantly increasing the number of houses and people affected by noise.
- Preference should be given to at least double storey development and preferably three storey development in the first row.
- Where four storey development is constructed with ground level carpark, this style should also occur in the second row. Behind the second row can be any style of development.
- Development guidelines that encourages ground level occupation and/or screening at ground level should be considered for multi-story development (four storeys or more).

Freight Rail

In respect to noise, for development alongside the Freight Rail Line:

- An L_{Amax} assessment is likely to be critical in protecting the amenity of residents at close distances to the rail line.
- Where the first row is single storey:
    - More single storey development behind will still be noise affected approximately 4 rows from the road (110m).
    - Double storey development could commence in the sixth row (180m) and not be noise affected.
    - Three and four storey development could commence in the seventh row (210m) and not be noise affected.

- Where the first row is double storey:
    - Single storey development could occur in the second row and not be noise affected.
    - Double storey development is noise affected in the second row.
    - Three storey development could commence three rows away (70m) and not be noise affected.
    - Four storey development could commence four rows away (110m) and not be noise affected.
- Where the first row is three storey development:
    - Any development in the second row will still be noise affected.
    - Any development can occur in the third row and not be noise affected.
- Where the first row is four storey development:
    - Any development style behind the first row may still be noise affected due to the assumed ground level carpark to this style of development. Alternative design models for apartments 4 storeys (or higher) may help to provide additional screening to houses behind and could be incorporated into design guidelines.
- Due to the high noise impact of the Freight Rail Line, reducing the extent of the noise affected area may be beneficial from a planning and land development perspective, so higher density zonings may be preferred.
    - Whilst increasing the density of the first row of houses minimises the extent of noise impacts behind (assuming a ground floor building), the number of persons affected in the front row increases.

In respect to vibration, for development alongside the Freight Rail Line:

- Average vibration levels are expected to comply with the most stringent vibration criteria (Curve 1.4) at a distance of 60 metres from the track.
- Taking a more conservative assessment approach by comparing radial vibration with the z-axis criteria would result in a recommended buffer distance of 80 metres from the track, which would then result in greater protection from vibration for residents.
- If less stringent vibration criteria were chosen (Curve 2), as per previous projects, then the recommended buffer distance would reduce to 35 metres for the mean vibration value or 50 metres for the more conservative approach.
- Any development that is within the buffer distances adopted should be subject to a site specific assessment.

Conclusion for the Freight Rail Line is:

- There is an acoustic benefit in preferring higher density development alongside the Freight Rail Line, as this will shield houses behind and will reduce the extent of the noise affected area. Potentially this could also increase the development yield without significantly increasing the number of houses and people affected by noise.
- Preference should be given to at least double storey development and preferably three-storey development in first row.

- Where four-storey development is constructed, any ground level carpark shall incorporate walls to provide screening to the development behind.
- A development guideline that encourages ground level occupation and/or screening at ground level should be considered for multi-story development (four storeys or more).
- An appropriate vibration criteria will need to be selected in consultation with the Department of Environment Regulation. It is recommended that for any new development within 80 metres of the track a site specific vibration assessment be required.
- Policy guidelines should be developed for assessing the acceptability of L_{Amax} noise and vibration levels and for determining noise and vibration control treatments to buildings alongside the Freight Rail Line. These policies should clearly define the measurement method to be employed for any such assessment and prescribe relevant criteria. With respect to L_{Amax}, the FLC's Bulletin No. 7 may provide a reasonable starting point.

6 CONCLUSIONS & FURTHER WORK

The analysis in this report is considered suitable for a broad policy type study to assist in guiding preferred rezoning from an acoustic perspective only. In reality, other town planning considerations will also shape the rezoning process.

Assuming the rezoning occurs, the change is expected to be slow. That is, if the existing zoning is R20 and then changes to R60, it will only be sporadic lots that make this change. As such, the analysis for the free-field and R20 scenarios are considered most appropriate to be used as an initial guide. It is worth re-iterating that no noise measurements were undertaken for the road calculations and therefore these are un-calibrated. Also, the topography is assumed to be flat with houses of identical shape and set-backs. Furthermore, the noise and vibration measurements undertaken for the freight rail were only in one section of the track, so variations can be expected in other areas (for instance, locomotives are likely to use higher notch settings if travelling up an incline and therefore generate more noise). Ignoring the limitations of the study, the following can be used as a guide:

- Development near North Lake Road:
    - Where the site is within 20 metres of the edge of the nearest carriageway, a site specific noise assessment is to be undertaken by a suitably qualified[1] acoustical consultant;
    - Any single storey development between 20 metres and 30 metres from the edge of the nearest carriageway, is to incorporate Package A architectural treatments or alternatively, undertake a site specific assessment by a suitably qualified acoustical consultant;
    - Any multiple storey development within 180 metres is to undertake a site specific assessment by a suitably qualified acoustical consultant.

[1] Suitably qualified is a firm that is a member of the Association of Australian Acoustical Consultants.

- Development near Farrington Road:
    - Where the site is within 15 metres of the edge of the nearest carriageway, a site specific noise assessment is to be undertaken by a suitably qualified acoustical consultant;
    - Any single storey development between 15 metres and 25 metres from the edge of the nearest carriageway, is to incorporate Package A architectural treatments or alternatively, undertake a site specific assessment by a suitably qualified acoustical consultant;
    - Any multiple storey development within 100 metres is to undertake a site specific assessment by a suitably qualified acoustical consultant.
- Development near Roe Highway/Kwinana Freeway:
    - Where the site is within 50 metres of the edge of the nearest carriageway, a site specific noise assessment is to be undertaken by a suitably qualified acoustical consultant;
    - Any single storey development between 50 metres and 150 metres from the edge of the nearest carriageway, is to incorporate Package A architectural treatments or alternatively, undertake a site specific assessment by a suitably qualified acoustical consultant;
    - Any multiple storey development within 400 metres is to undertake a site specific assessment by a suitably qualified acoustical consultant.
- Development near the freight rail:
    - Where the site is within 80 metres of the freight rail:
        - Vibration levels are to be measured and assessed by a suitably qualified acoustical consultant.
            - Where vibration levels are found to be below Curve 1.4, no further work is required.
            - Where vibration levels are found to be between Curves 1.4 and 2, notifications are required on the lot title(s).
            - Where vibration levels are between Curves 2 and 4, notifications are required on lot title(s) and vibration control considered.
            - Where vibration levels are above Curve 4, notifications are required on lot title(s) and vibration control mandatory;
        - Noise levels are to be measured and assessed by a suitably qualified acoustical consultant.
            - Consideration is to be given to the L_{Aeq} parameter as defined in SPP 5.4;
            - Consideration is to be given to the L_{Amax} parameter, in particular, achieving 60 dB L_{Amax} internally and incorporating the freight packages or suitable equivalent;

- Any single storey development between 80 metres and 140 metres of the track is to incorporate Package A architectural treatment or alternatively, undertake a site specific assessment by a suitably qualified acoustical consultant;
- Any multiple storey development within 250 metres is to undertake a site specific assessment.

The preference would be to rather than rely on the above findings, develop these further by undertaking more detailed assessments of each transport corridor (essentially noise mapping). The work required for each would comprise of:

- Setting up noise data loggers to quantify existing noise levels;
- Setting up vibration data loggers along the freight line;
- Set-up and run noise model of existing conditions, calibrating against measured levels;
- Rerun model for future traffic conditions. Some roads may need to consider a with and without Roe Highway scenario;
- Produce contours for various vibration zones;
- Produce noise contours over existing house heights, predicting noise levels at ground, first and second floors.

The advantage of the above is that it can provide a more accurate picture of the noise and vibration impacts. Ideally, when a proposed development is submitted, its potential noise and/or vibration impacts can already be known. As well as providing Council with a useful tool, it may also limit the extent of potentially requiring acoustic assessments, although this option would still be open to the developer. Depending on the number of vibration measurements undertaken will depend on whether site specific vibration assessments can be avoided. The reason for this is that vibration is likely to vary significantly along the track and it may take a significant number of measurements to have sufficient confidence in the results without undertaking a site specific assessment.

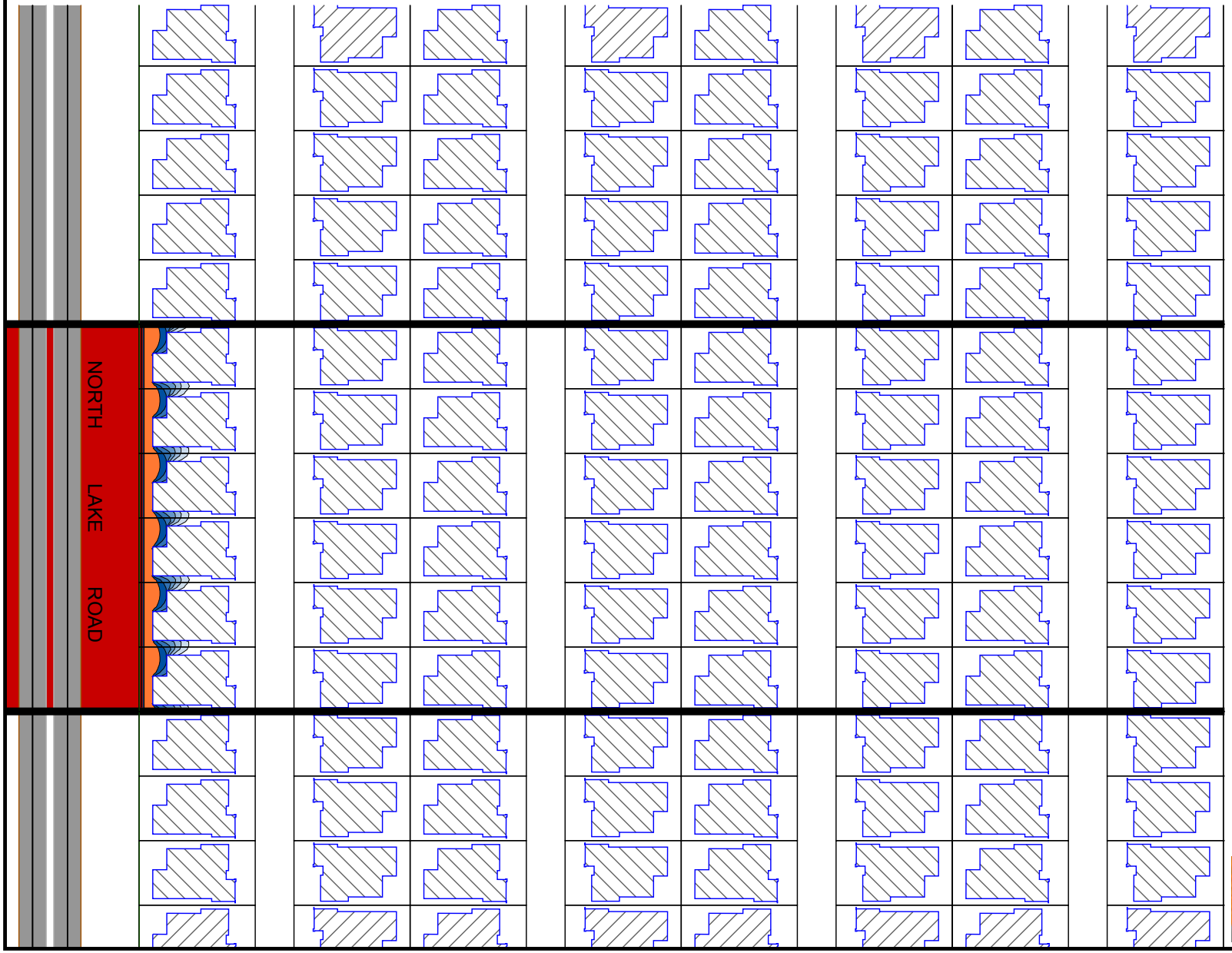
Appendix A

Noise Contour Plots – Single Storey R20 Scenario

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - North Lake Road: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure A1



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

15 October 2015

Length Scale 1:1500

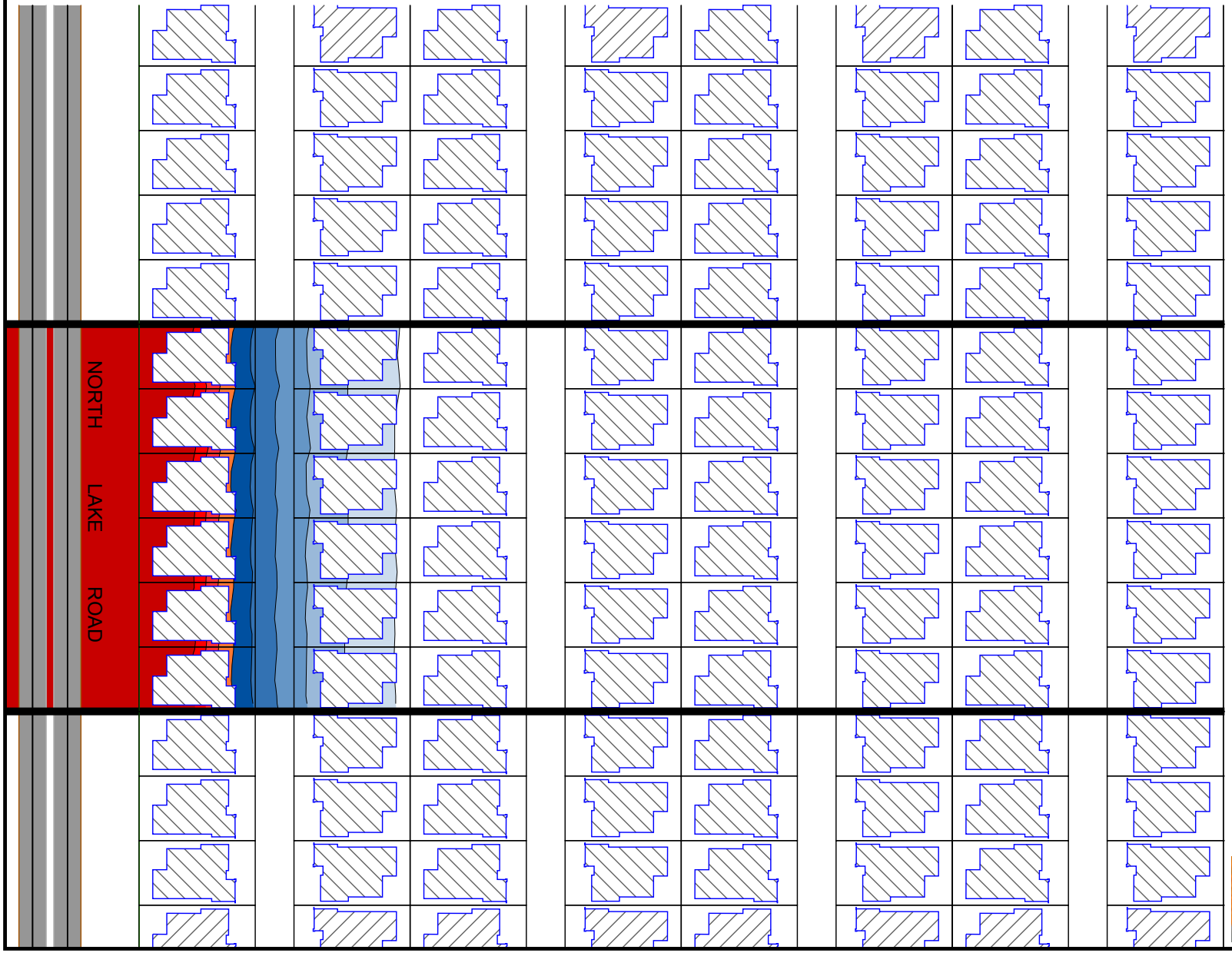
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - North Lake Road: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure A1a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

15 October 2015

Length Scale 1:1500

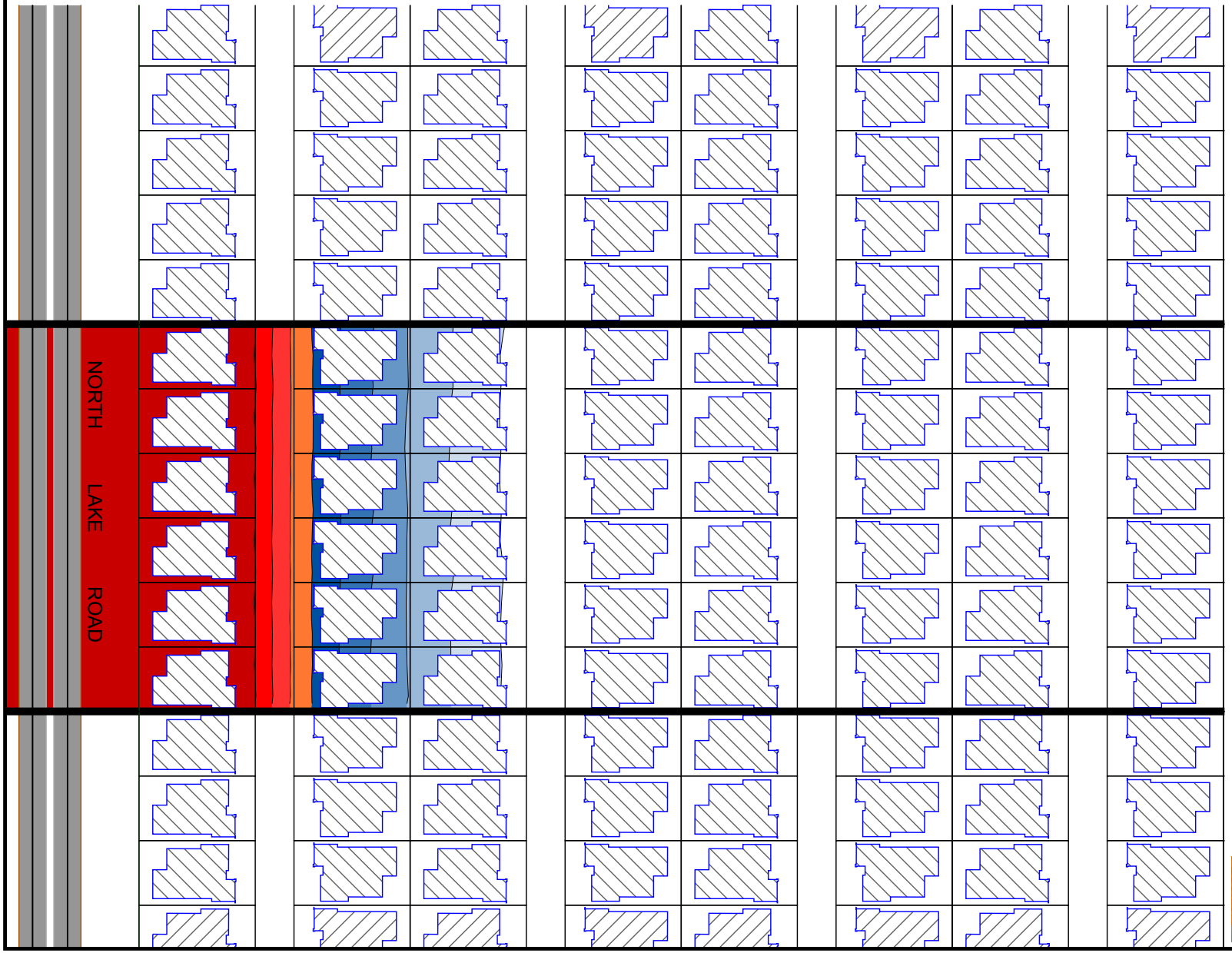
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - North Lake Road: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure A1b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

15 October 2015

Length Scale 1:1500

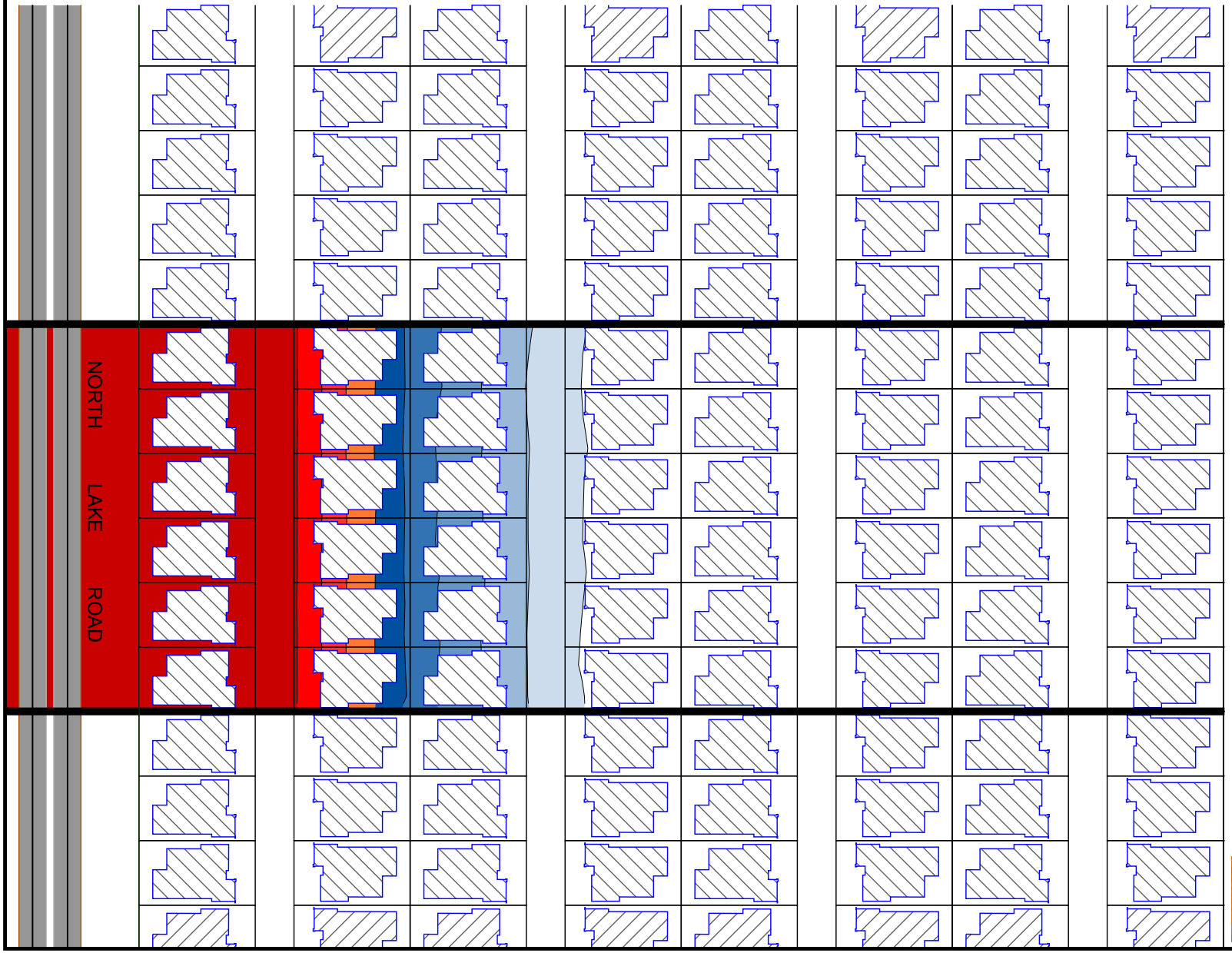
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - North Lake Road: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure A1c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

15 October 2015

Length Scale 1:1500

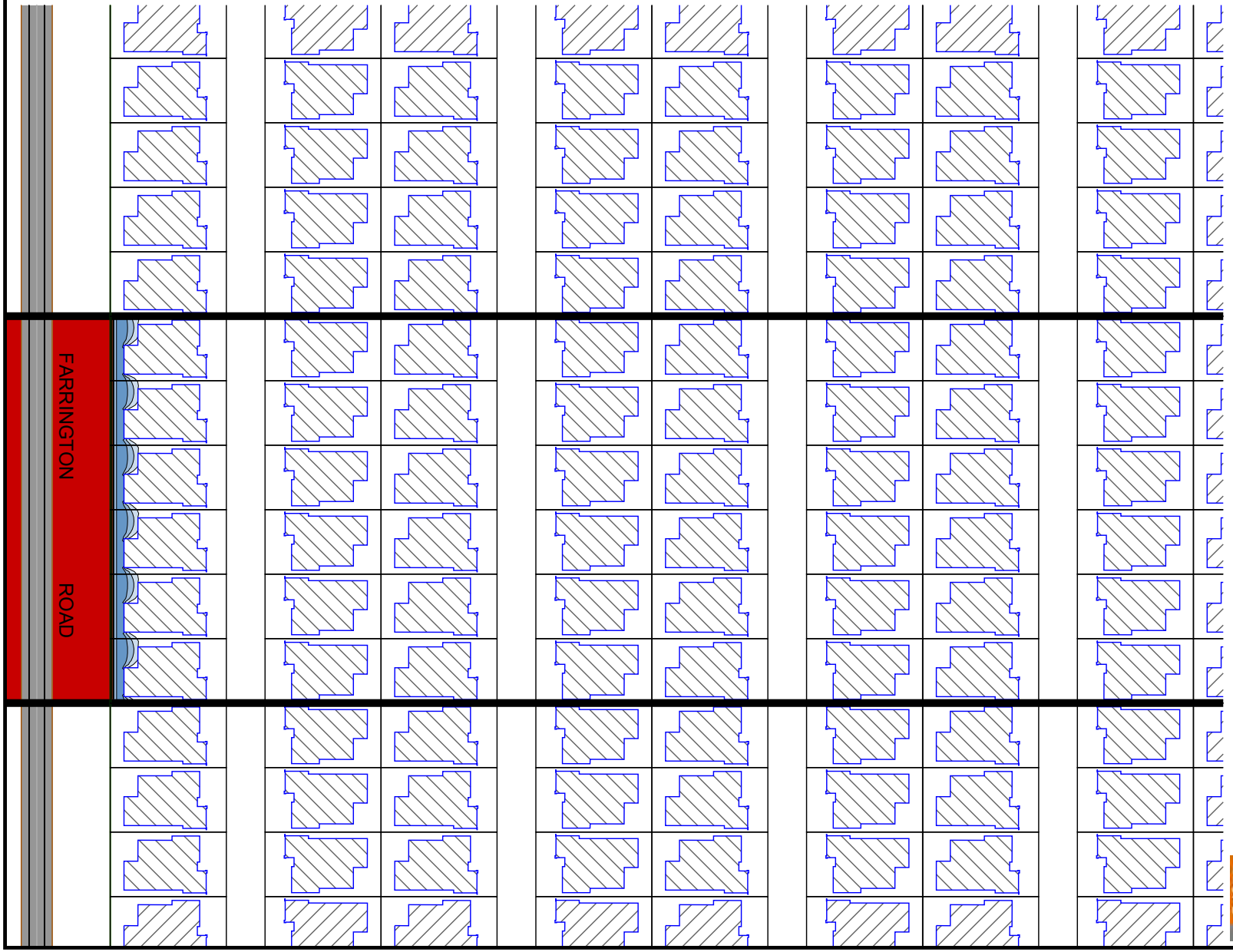
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Farrington Road: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure A2



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

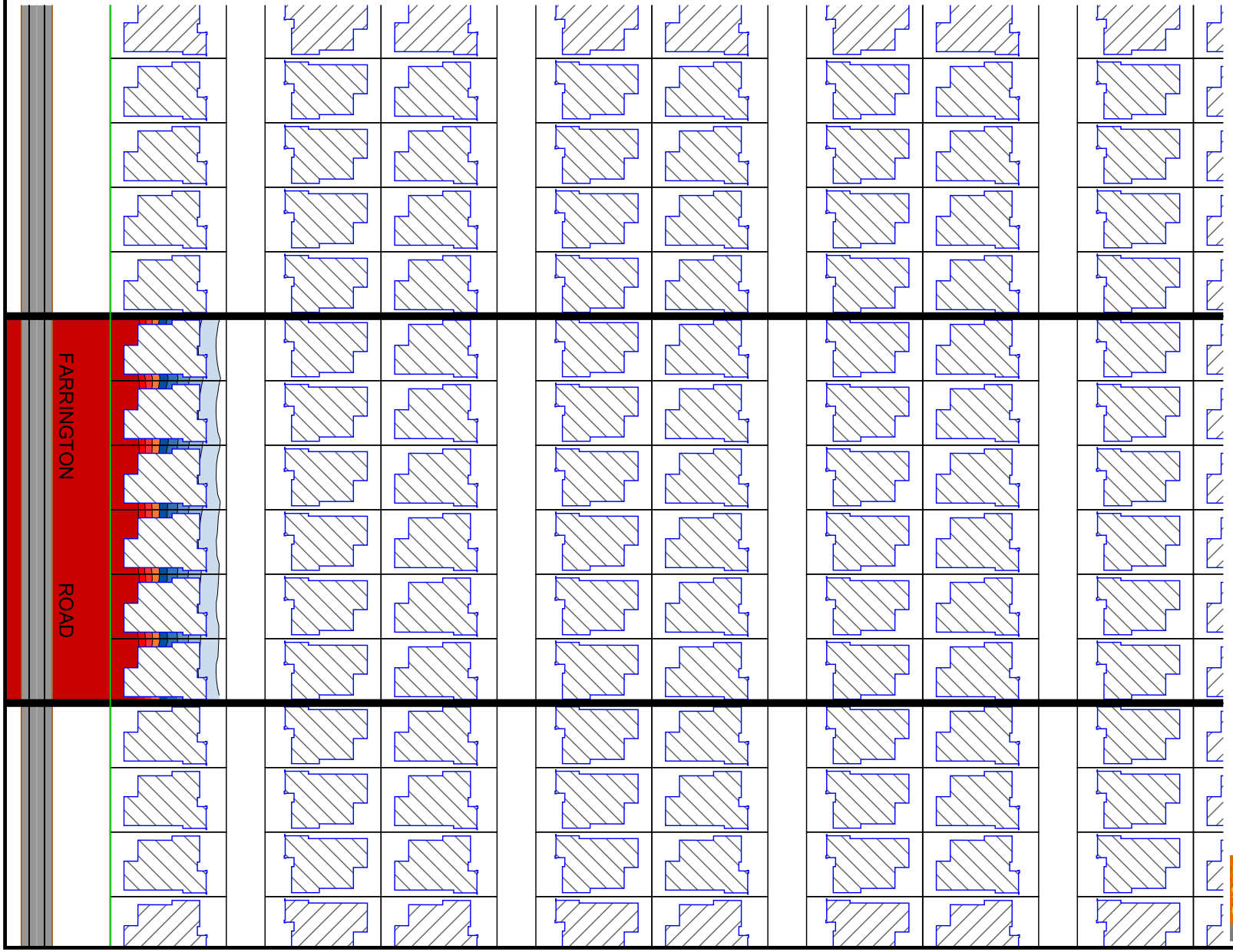
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Farrington Road: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure A2a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

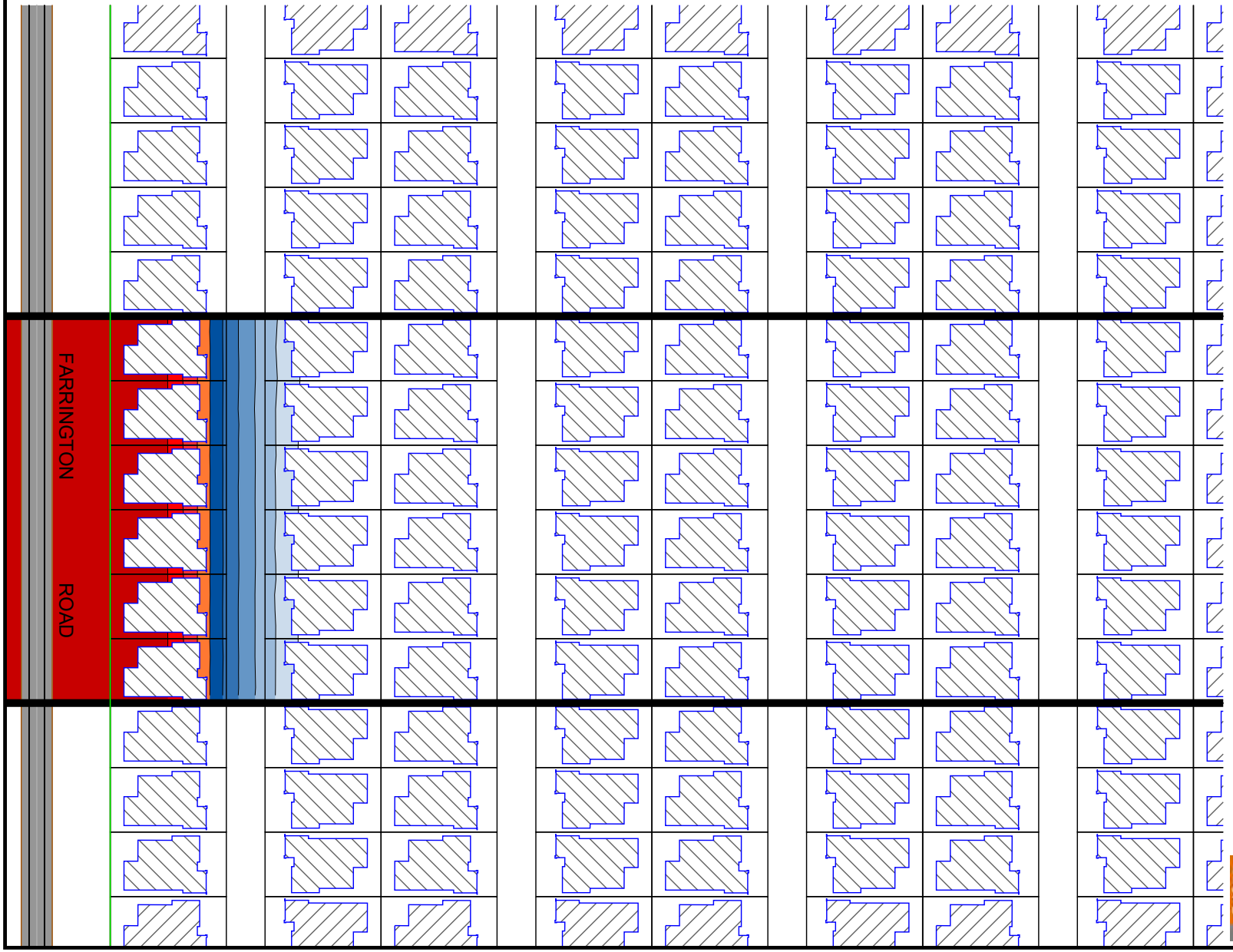
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Farrington Road: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure A2b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

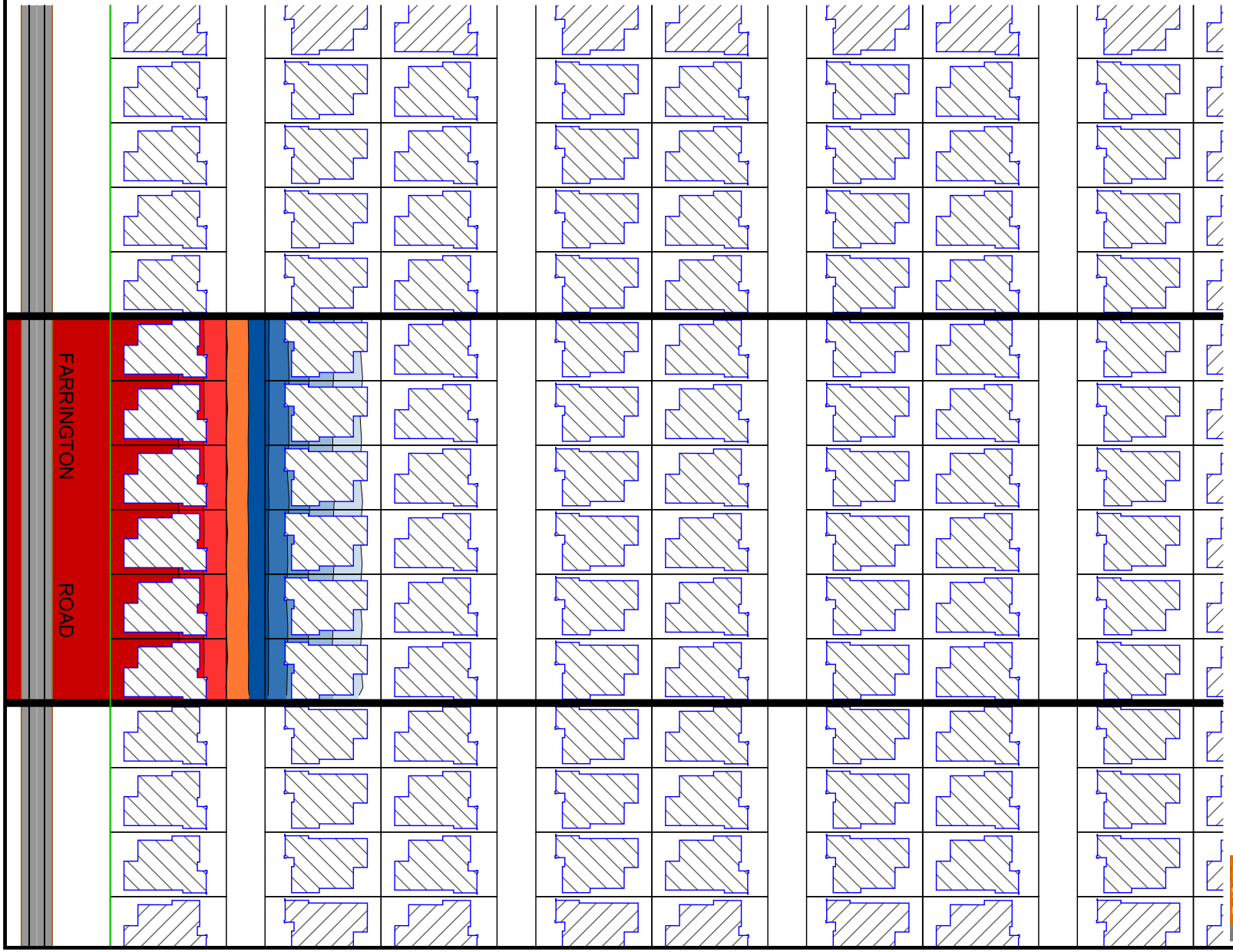
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Farrington Road: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure A2c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

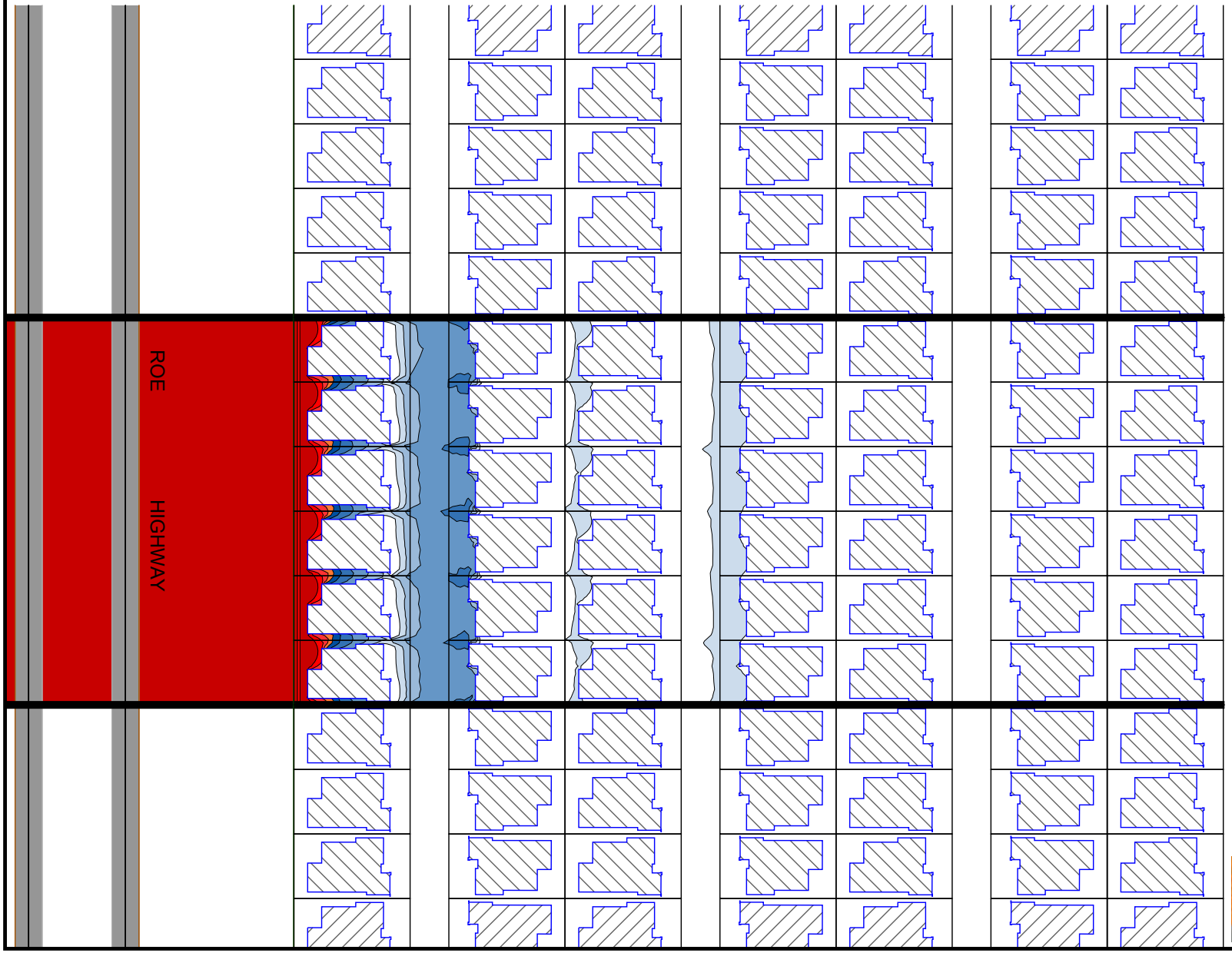
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure A3



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

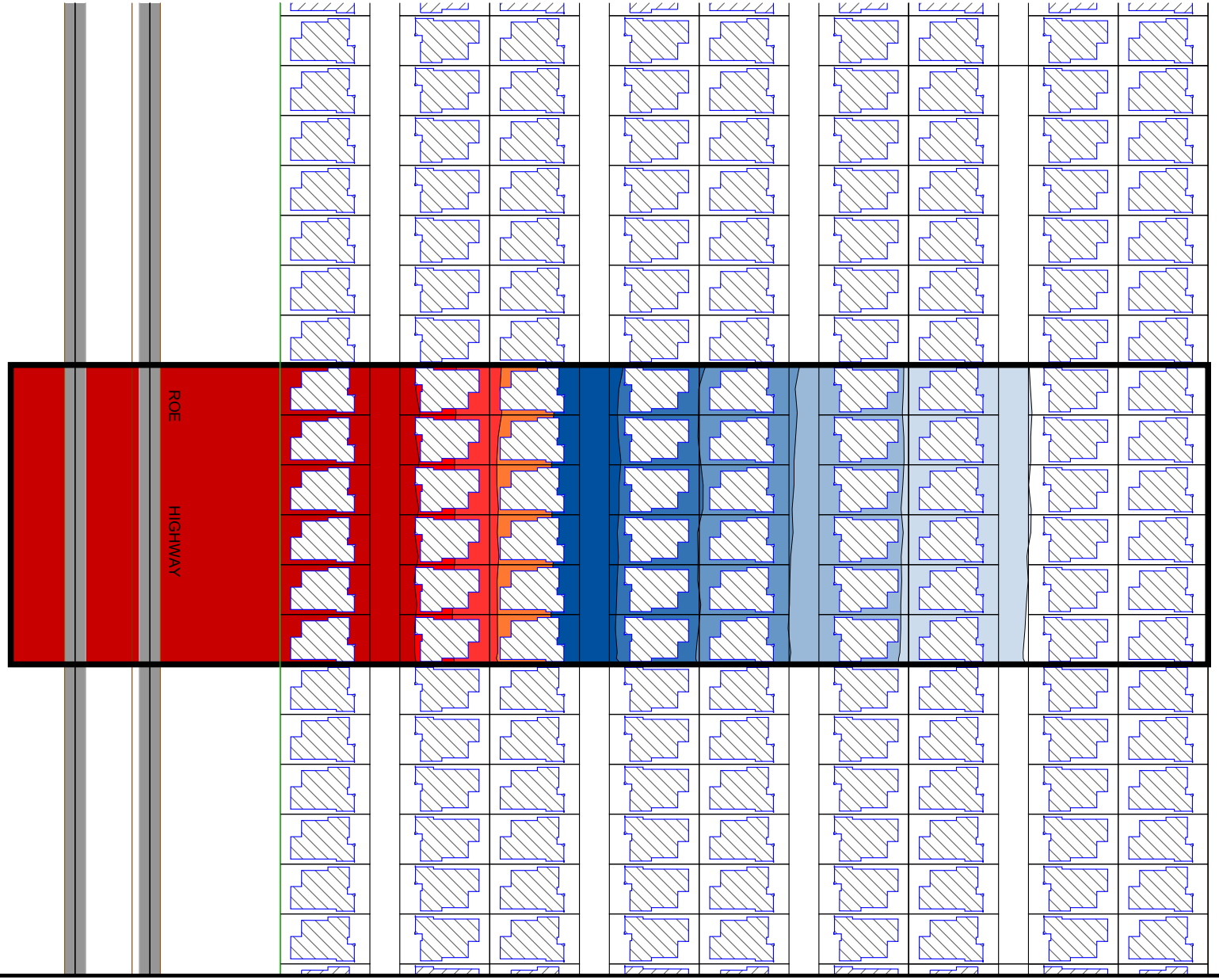
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure A3a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:2000

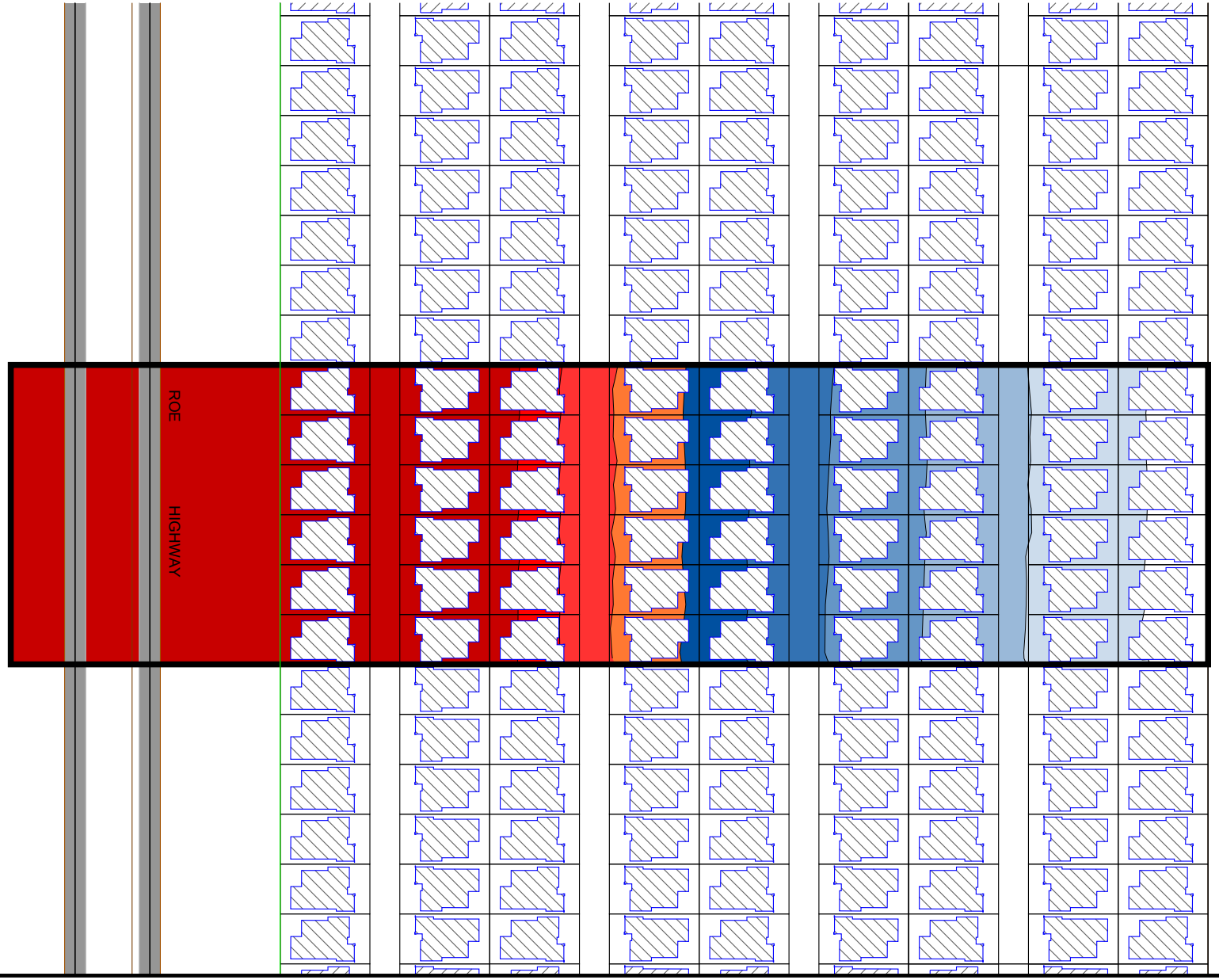
0 15 30 60 90 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure A3b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:2000

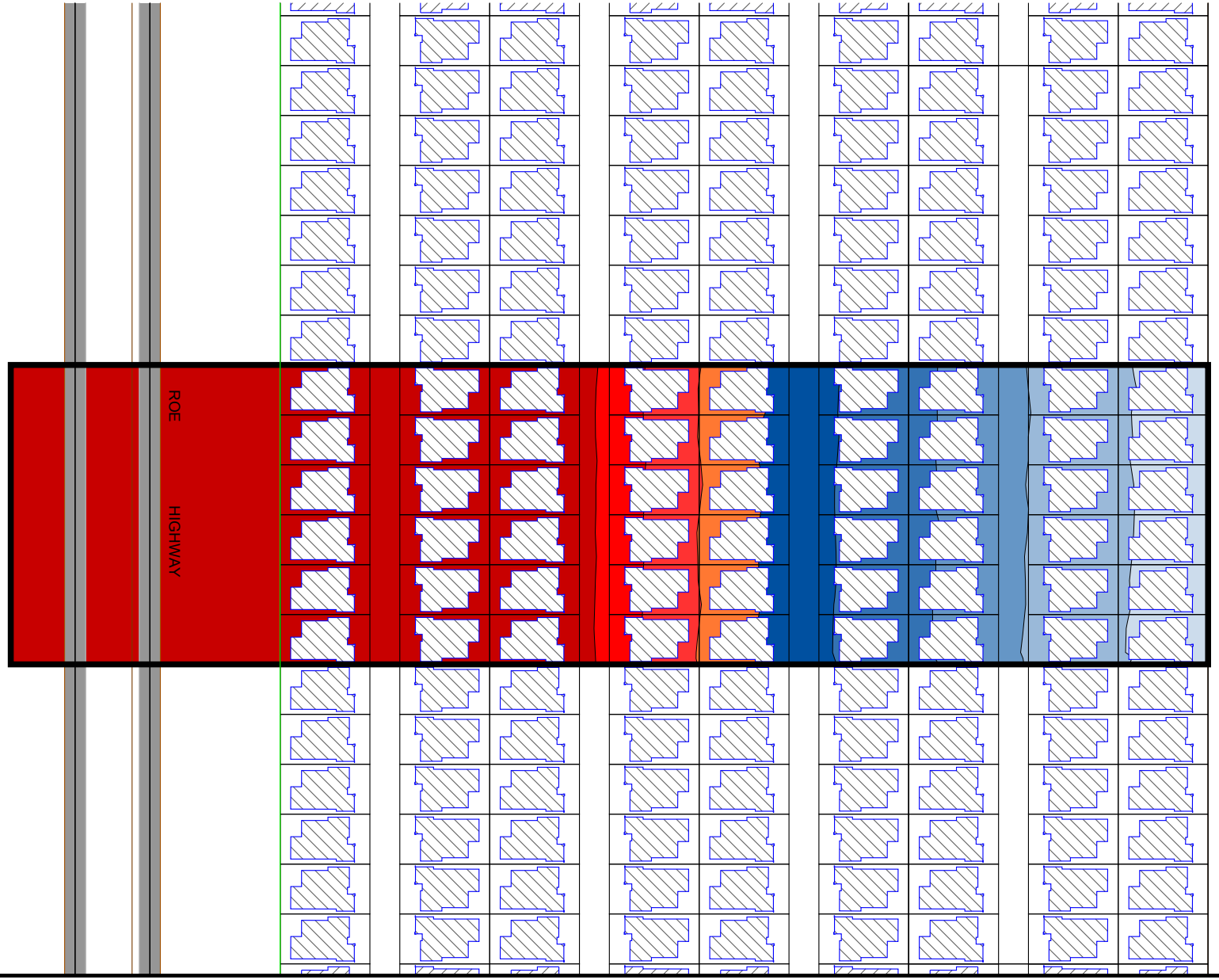
0 15 30 60 90 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure A3c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:2000

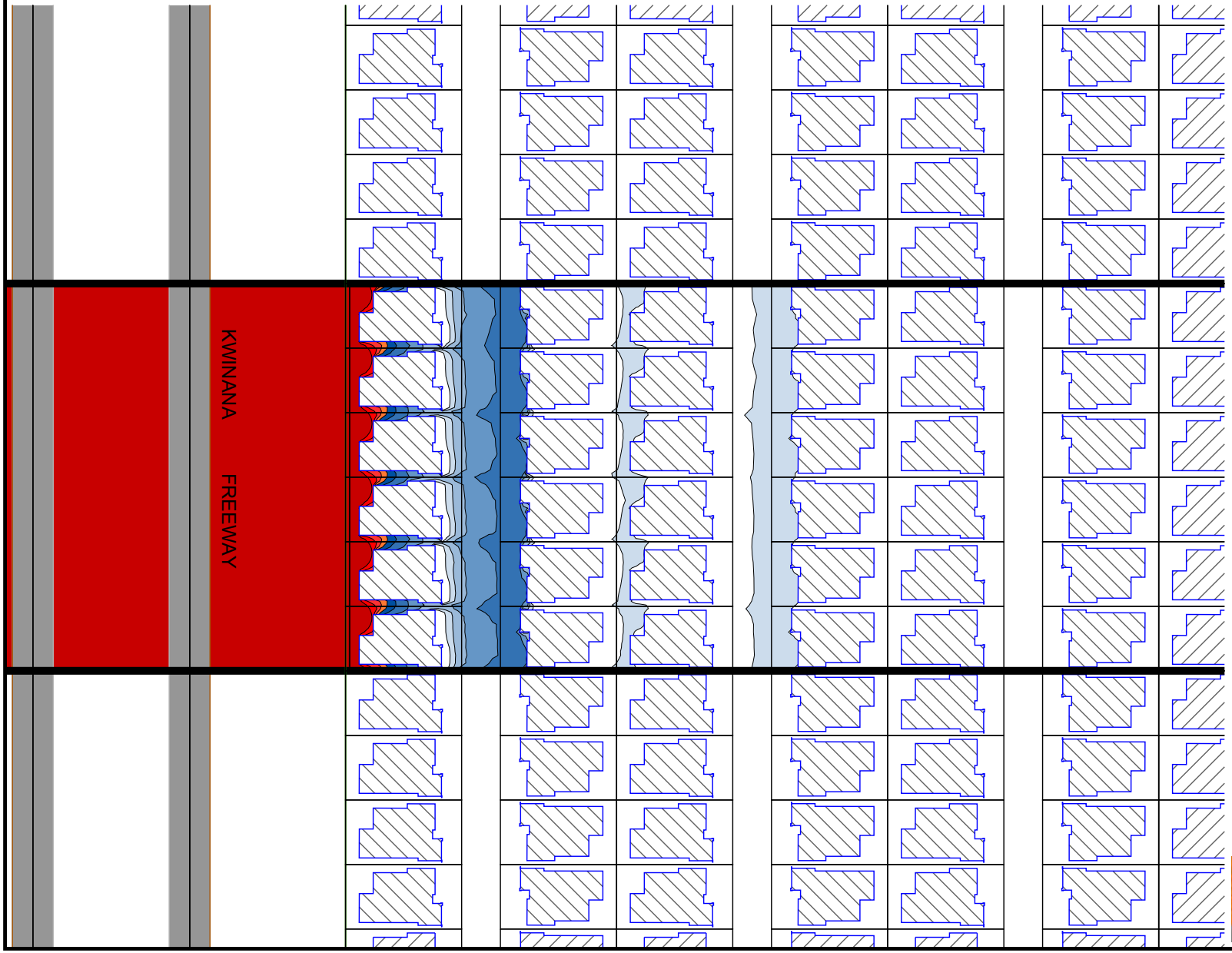
0 15 30 60 90 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure A4



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

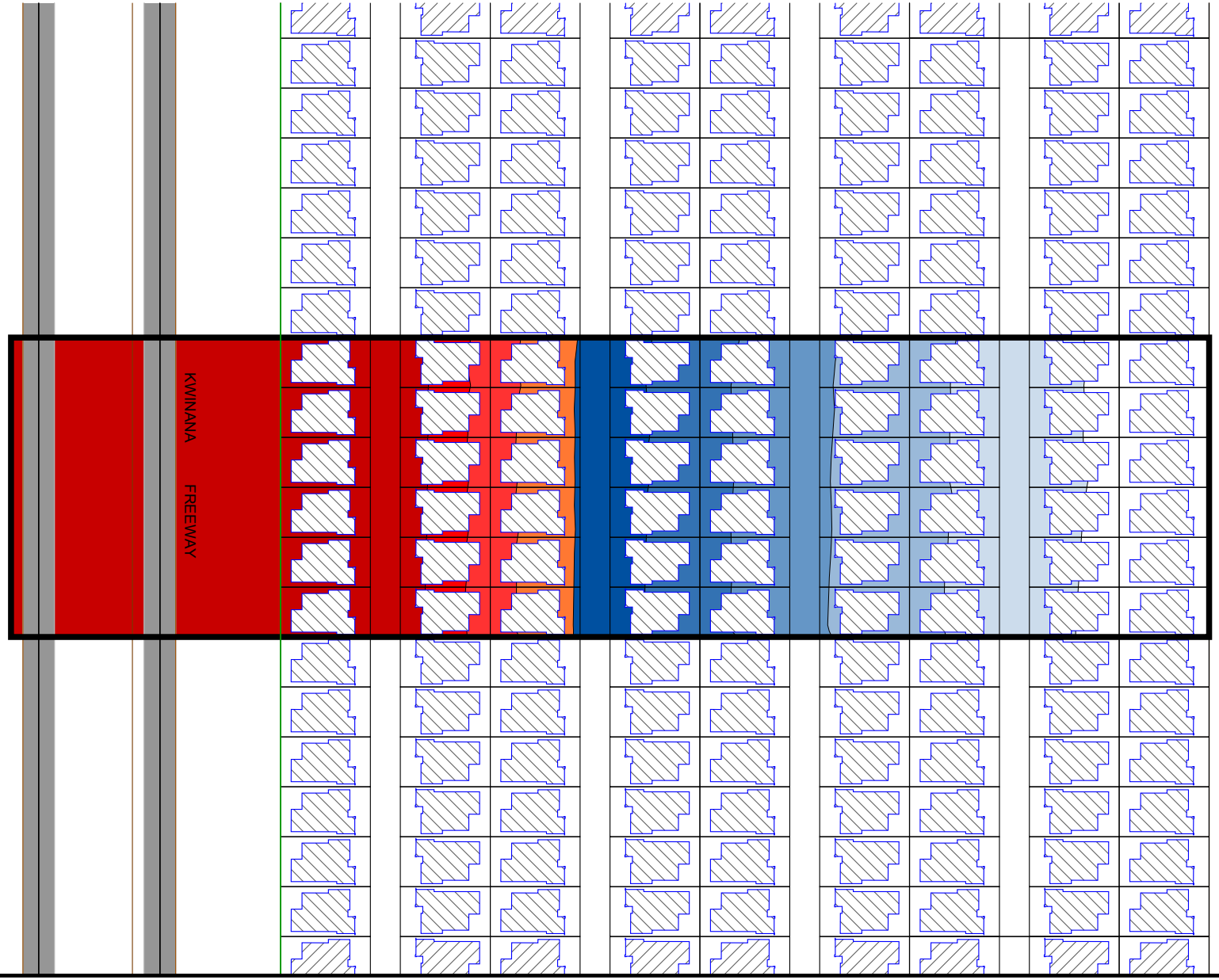
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure A4a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:2000

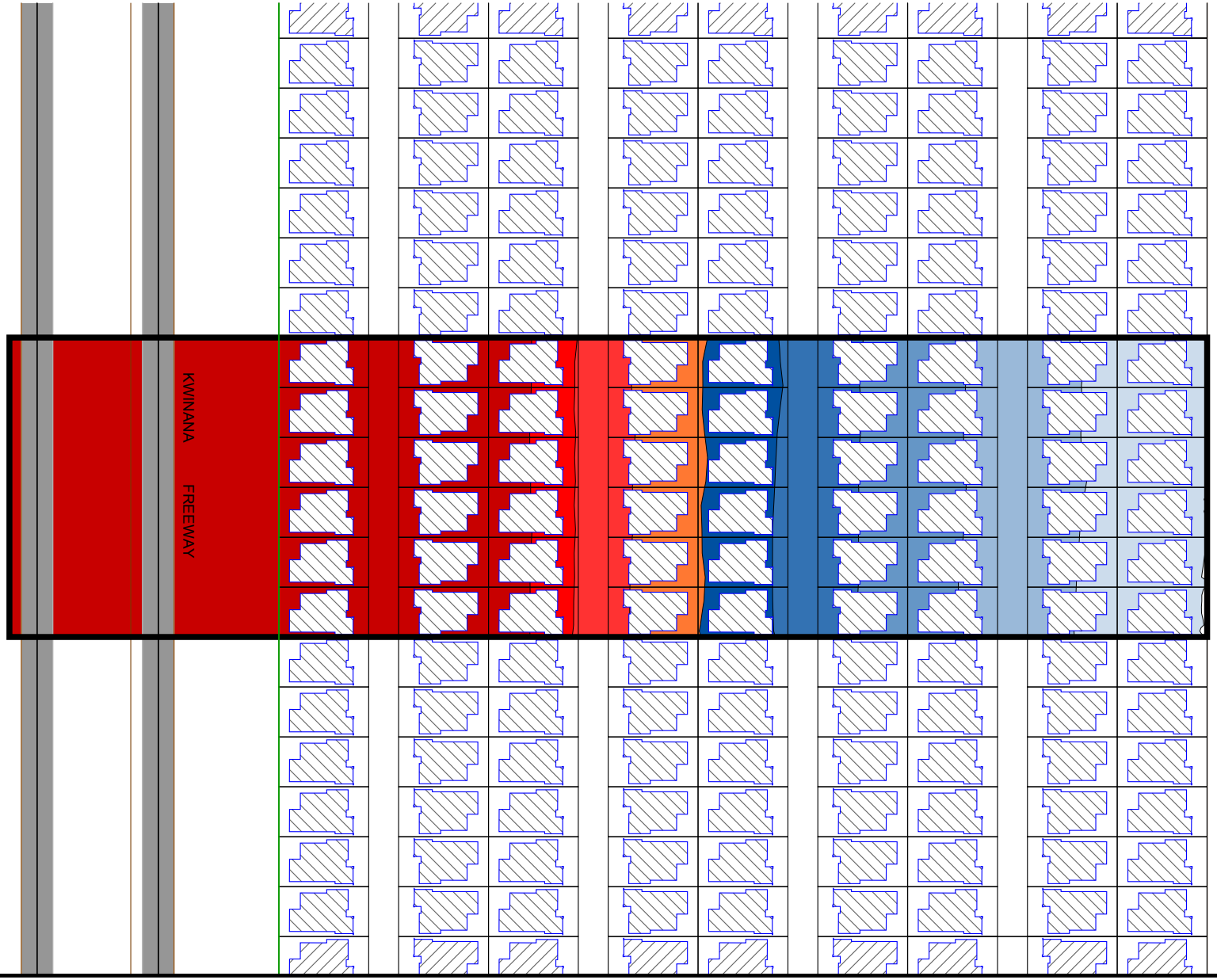
0 15 30 60 90

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure A4b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:2000

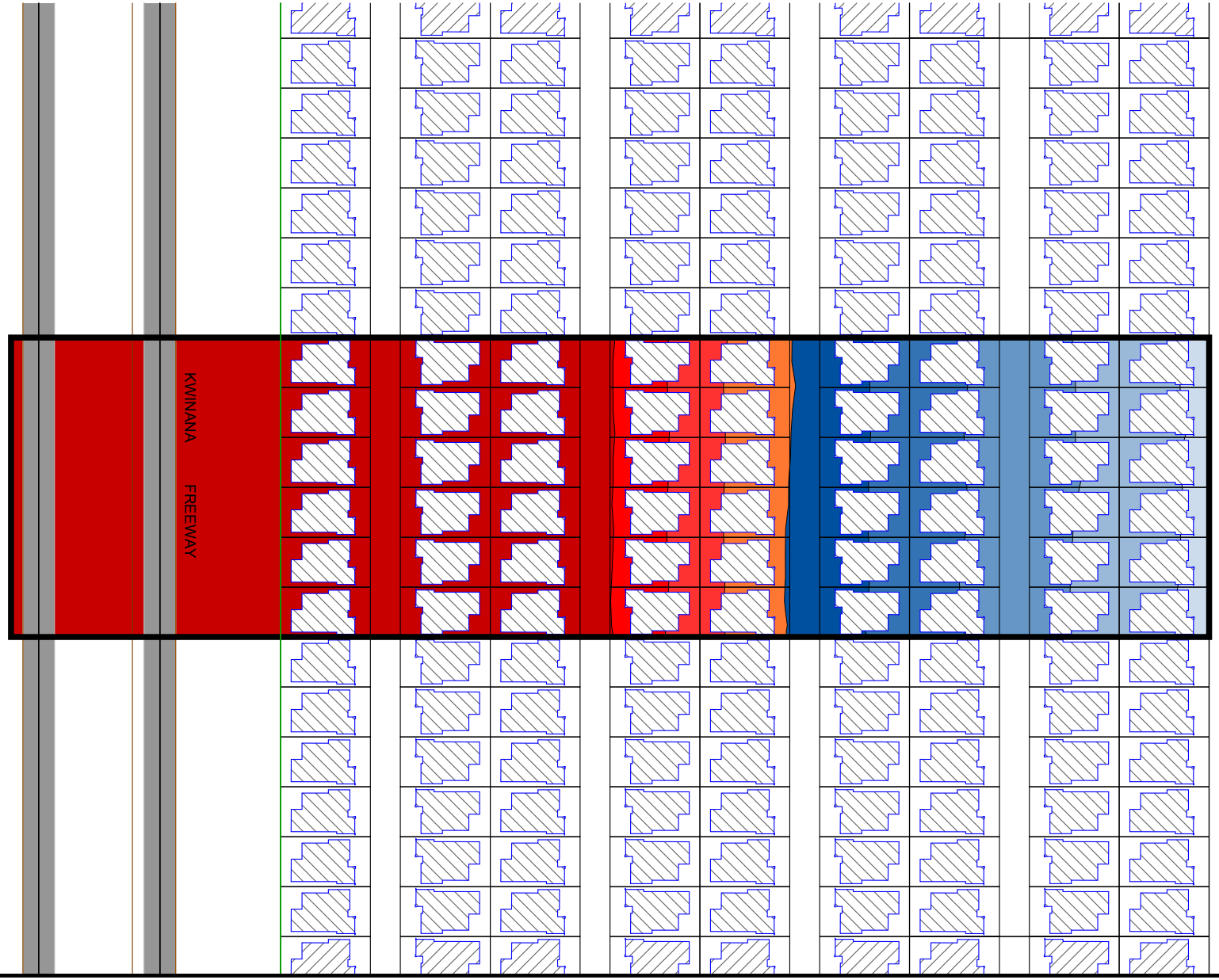
0 15 30 60 90

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure A4c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:2000

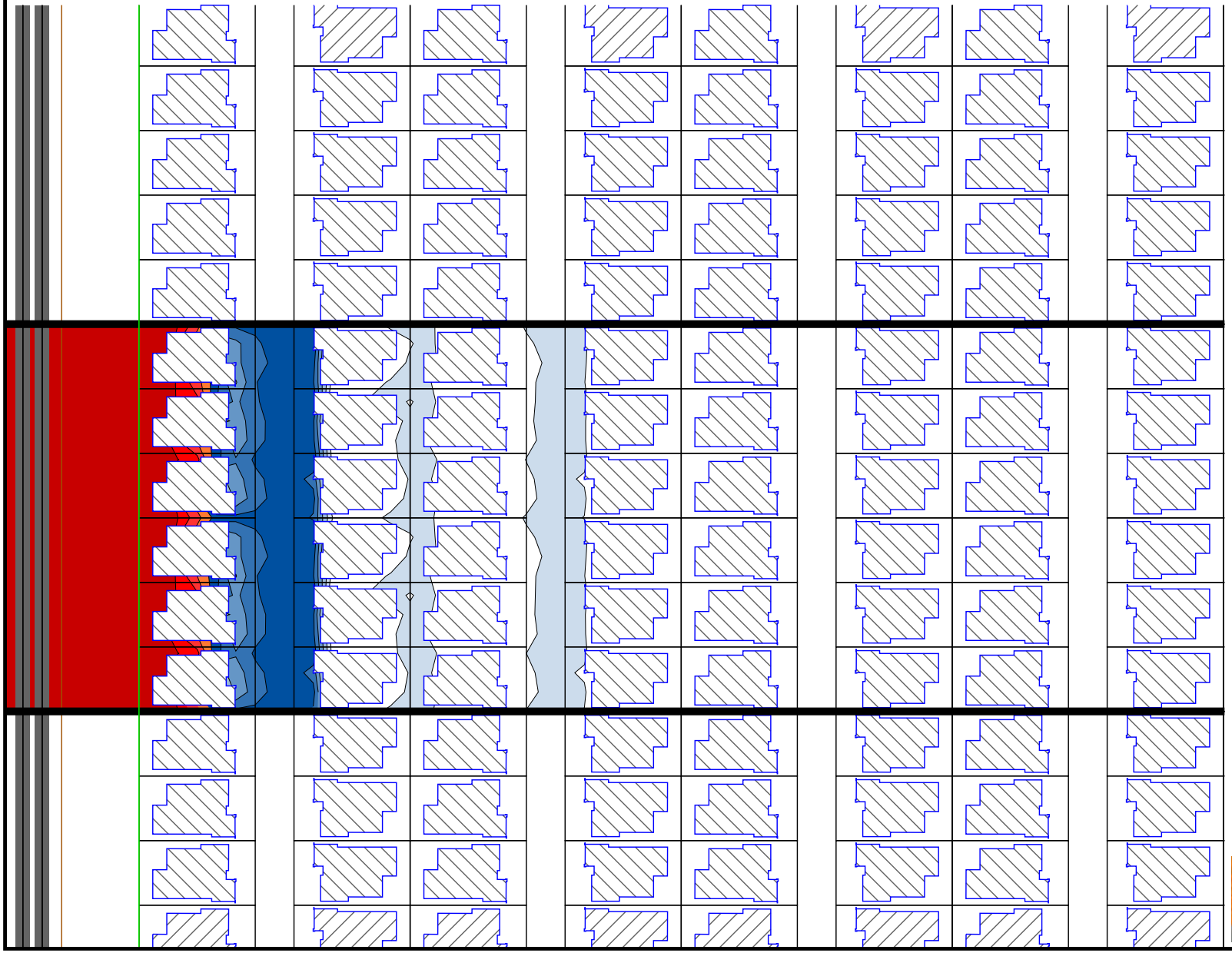
0 15 30 60 90

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure A5



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

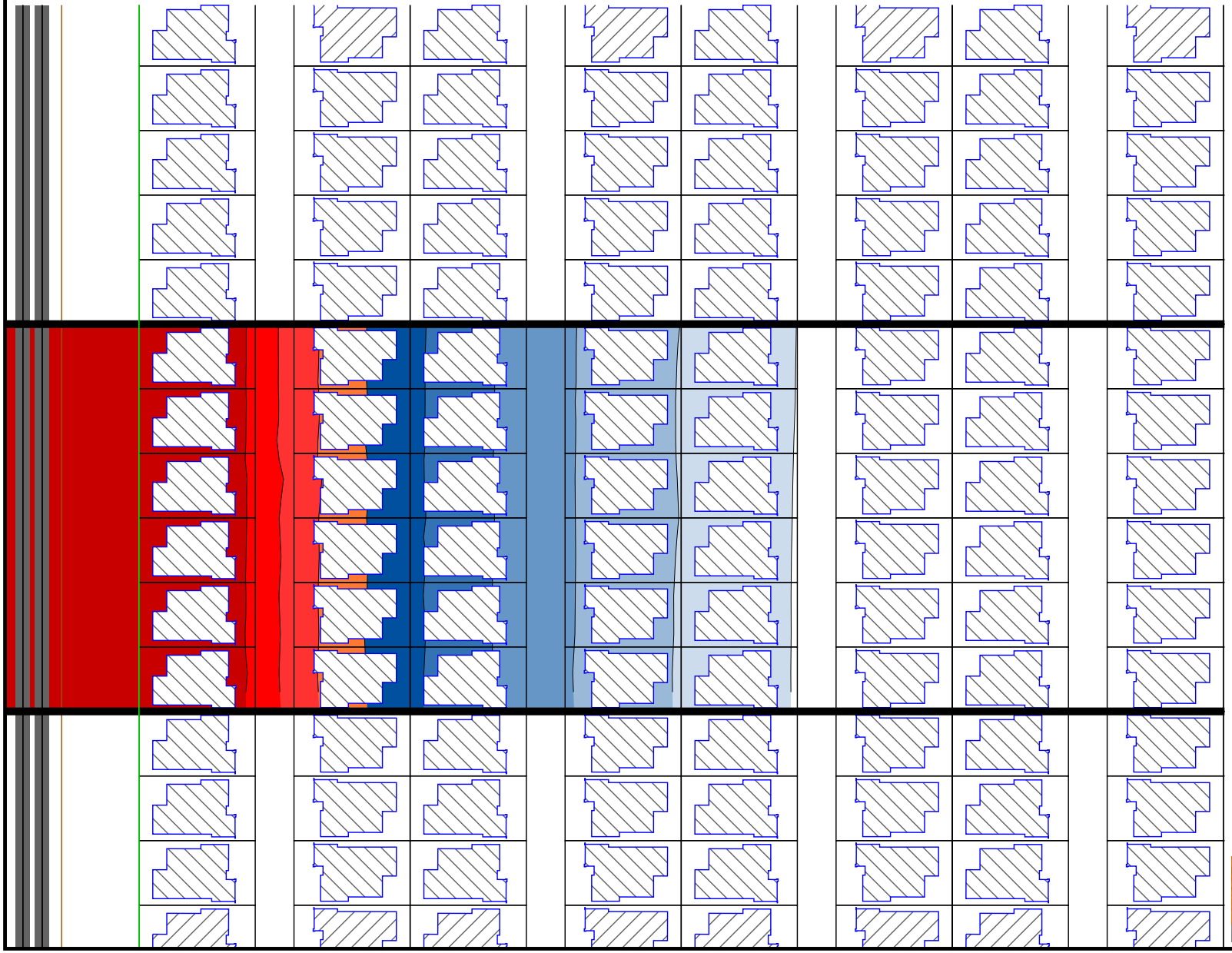
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure A5a



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

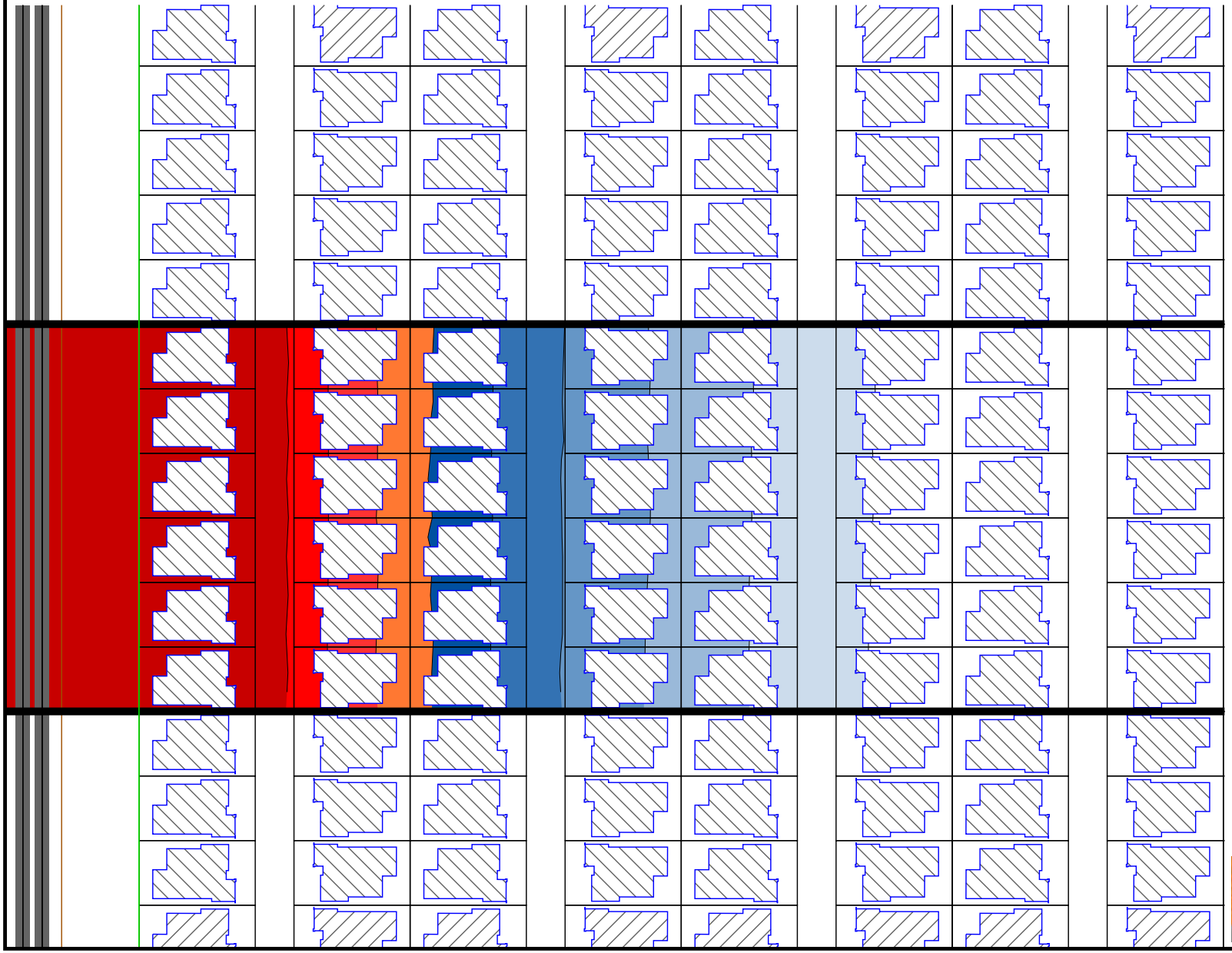
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure A5b



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

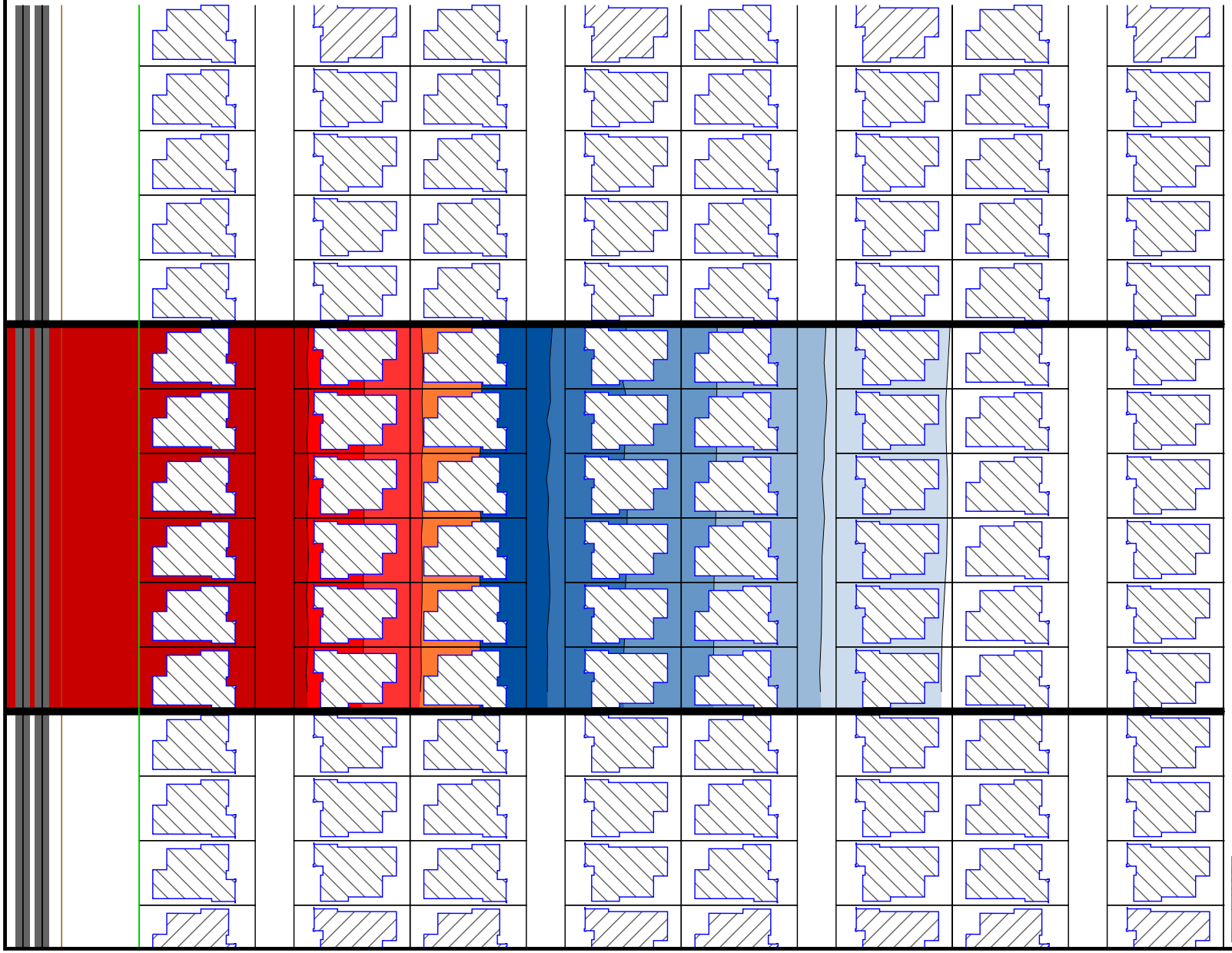
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure A5c



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

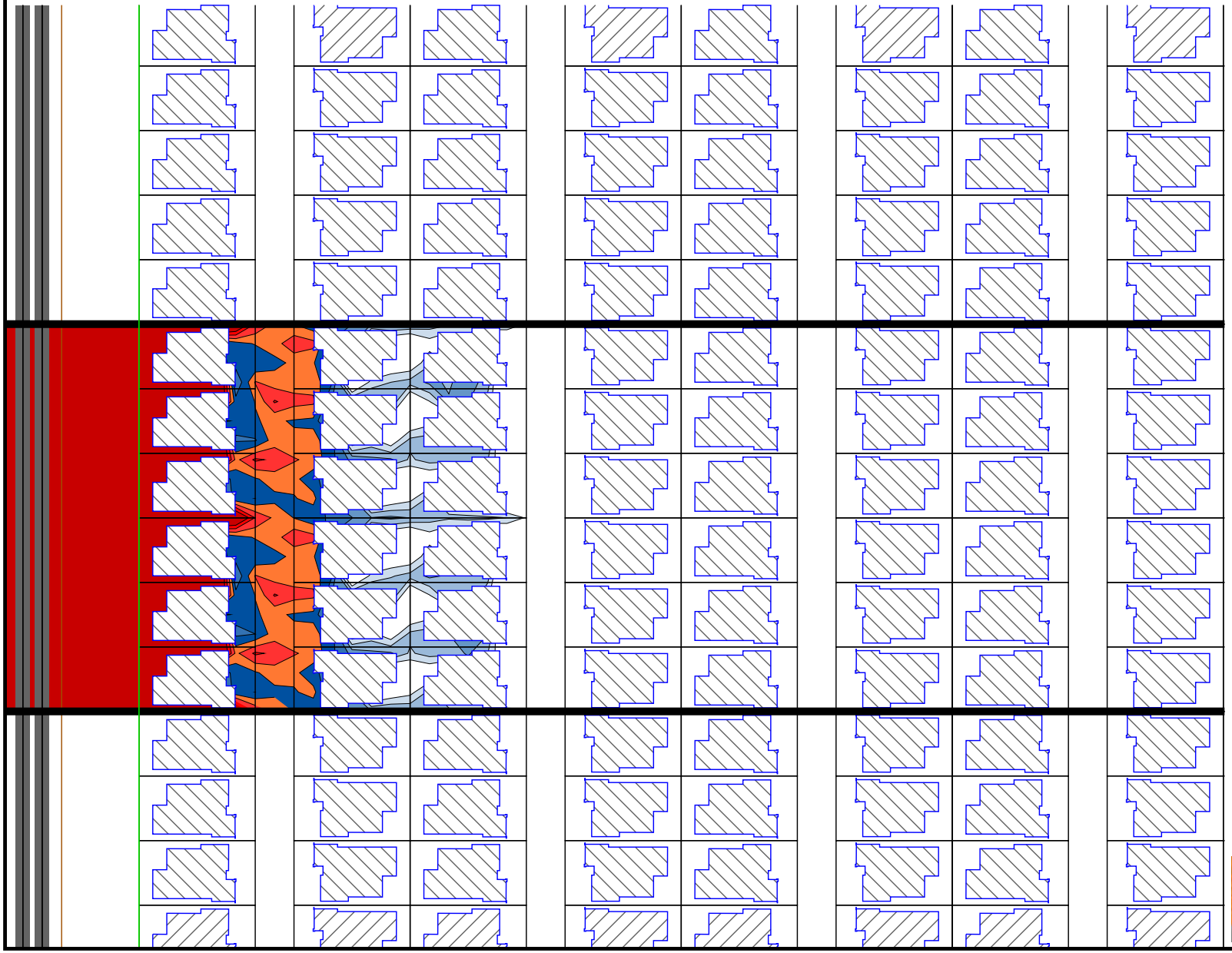
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure A6



Noise levels
LAmax dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

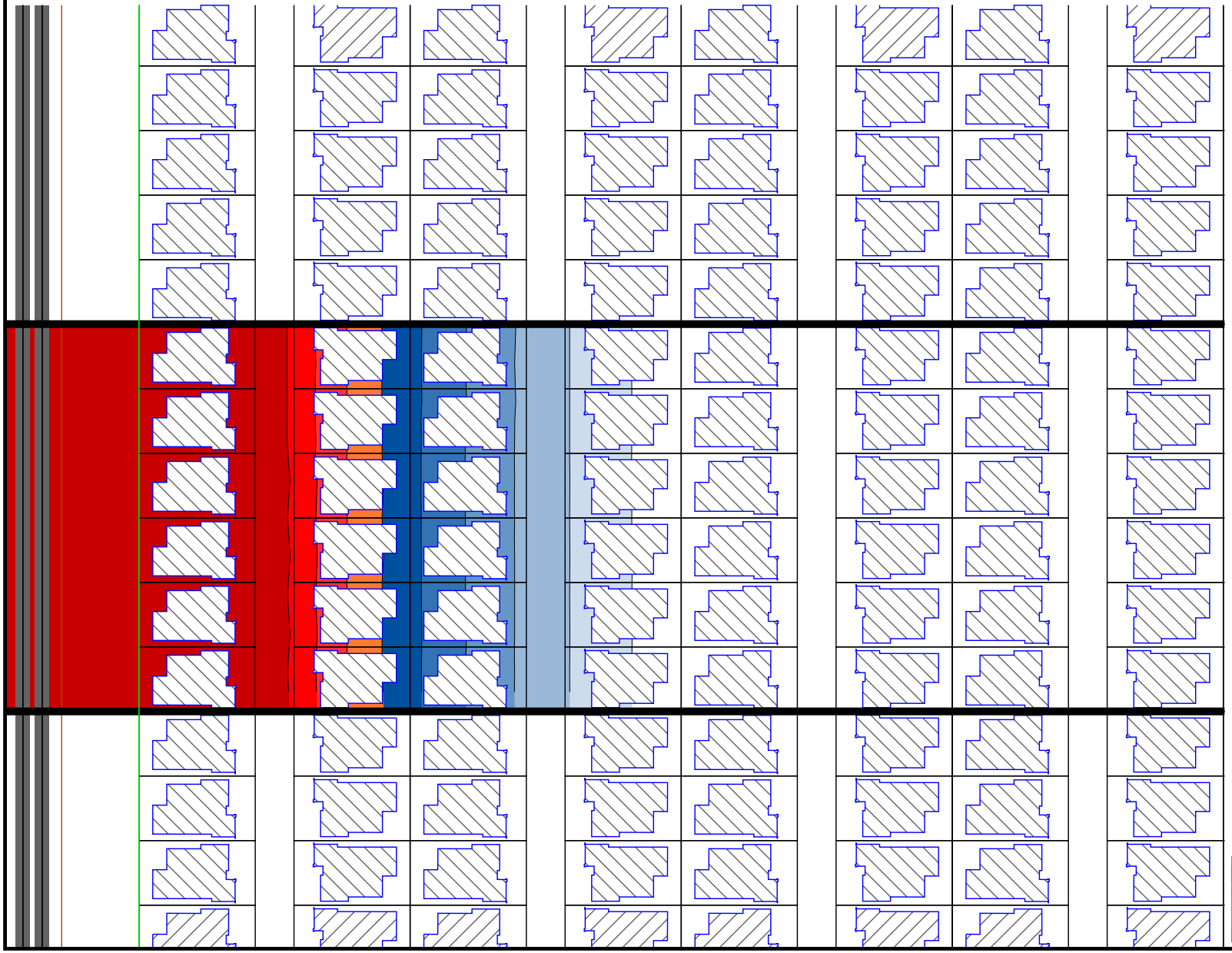
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure A6a



Noise levels
LAmax dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

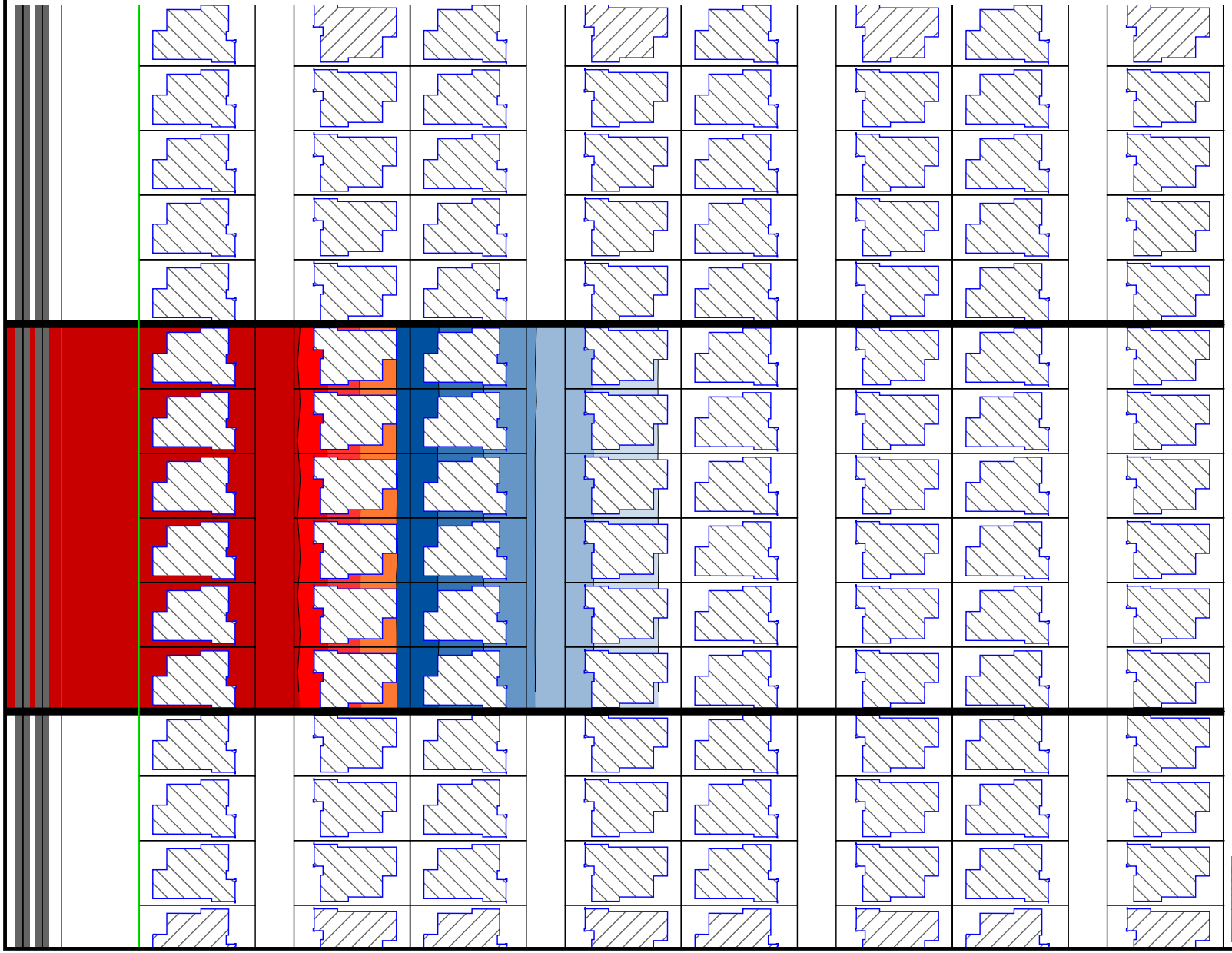
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure A6b



Noise levels
LAmax dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

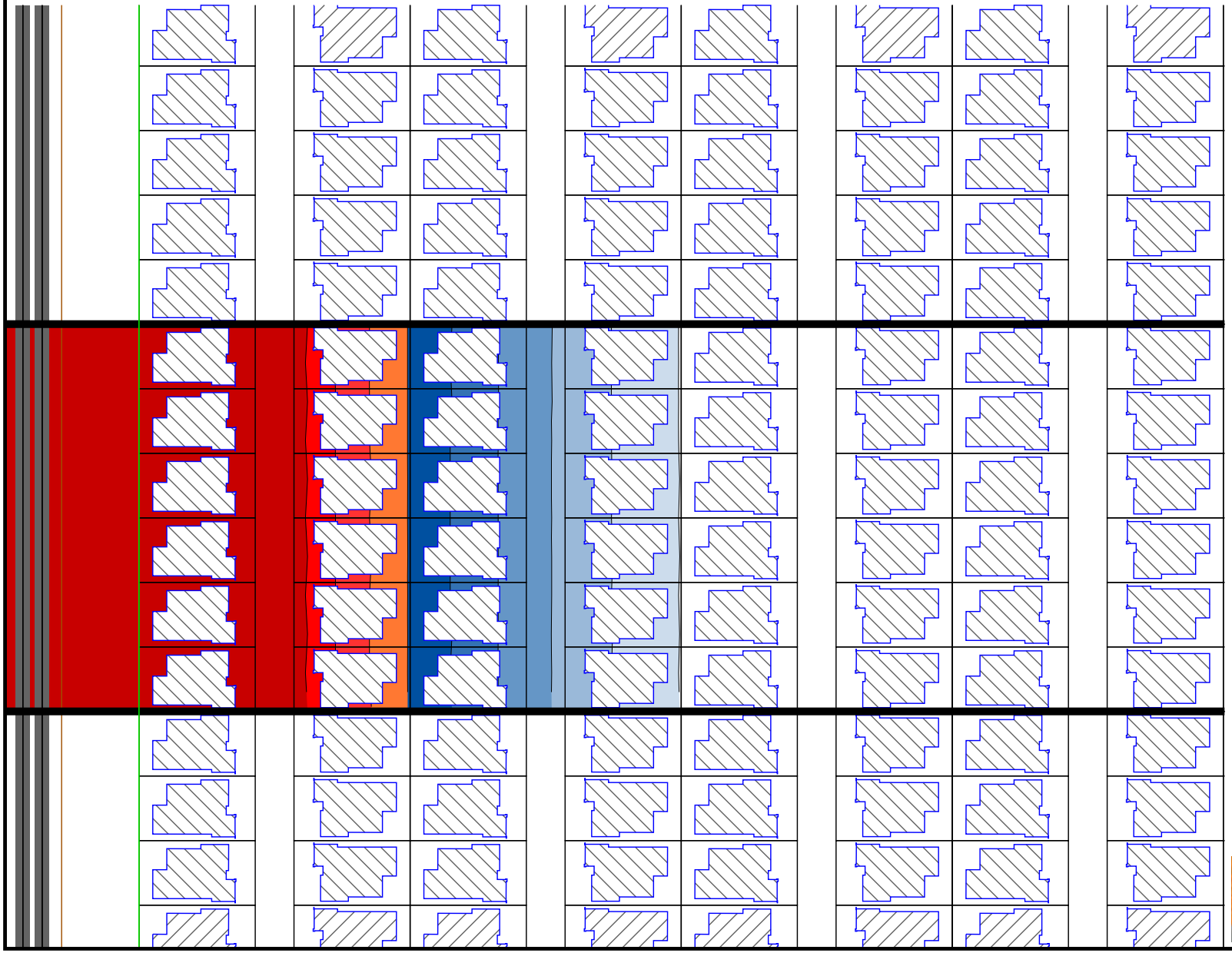
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Standard Single Storey Dwelling (Nominally R20 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure A6c



Noise levels
LAmax dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

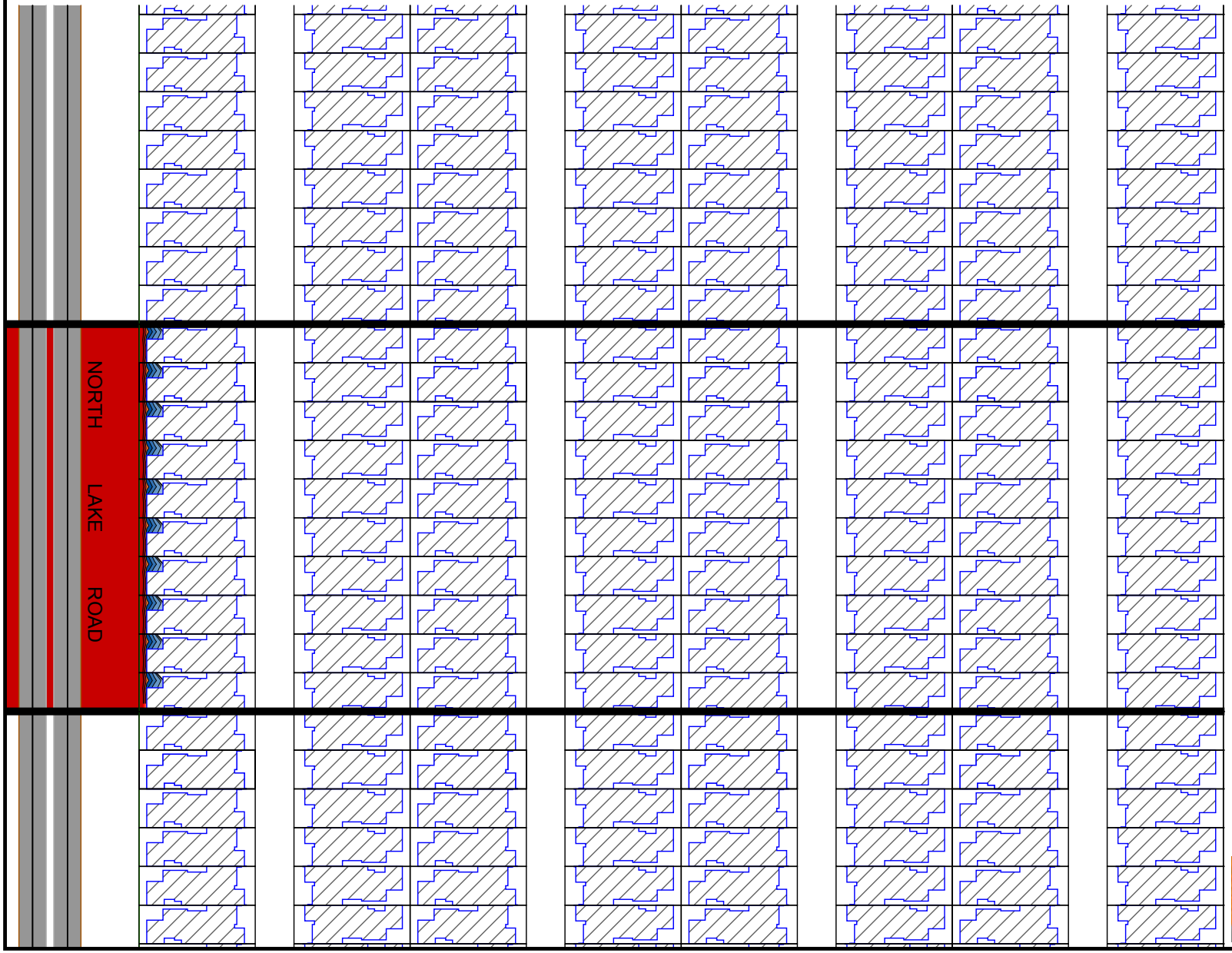
Appendix B

Noise Contour Plots – Single Storey R30 Scenario

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Boundary to Boundary Single Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure B1



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

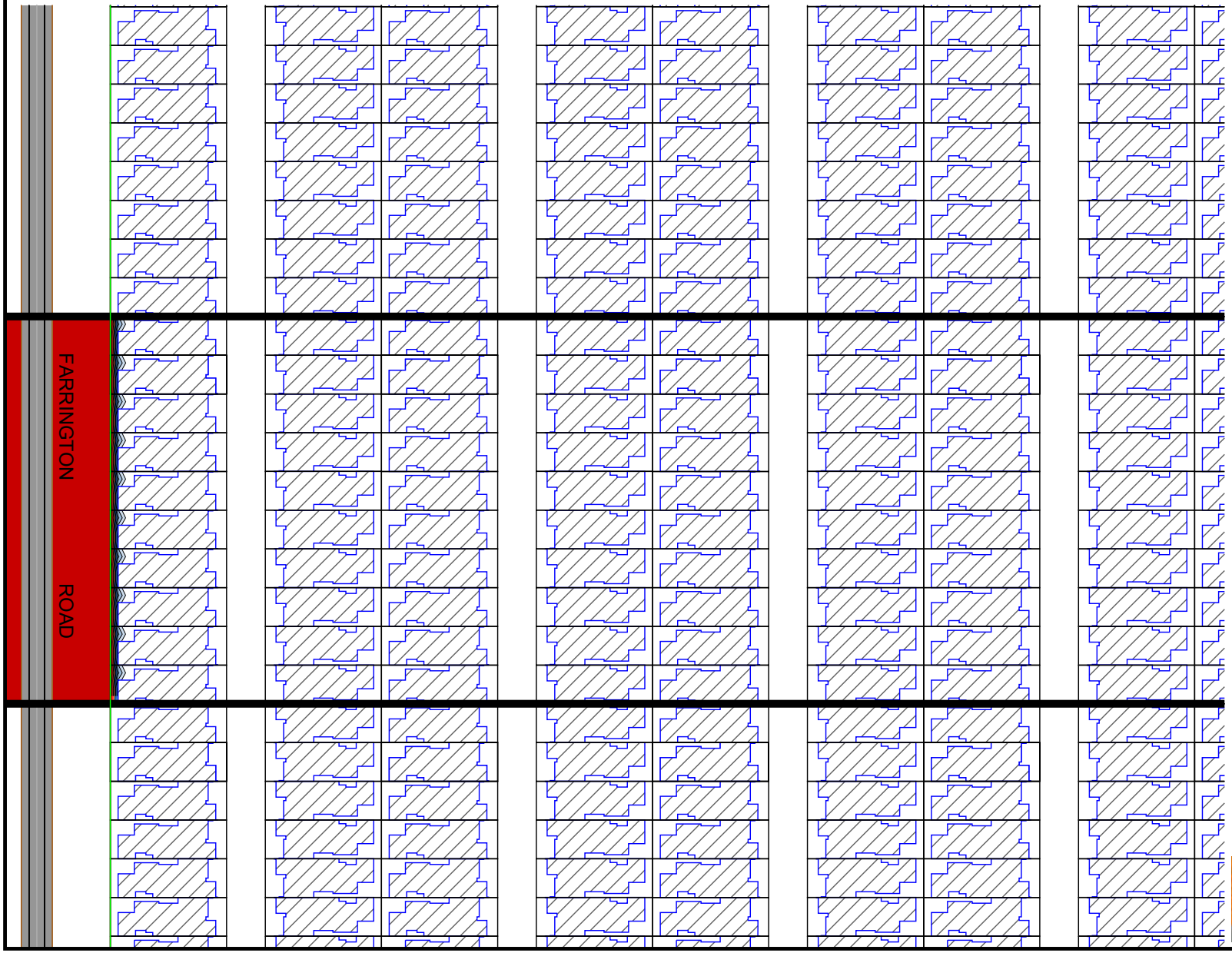
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Farrington Road: Boundary to Boundary Single Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure B2



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

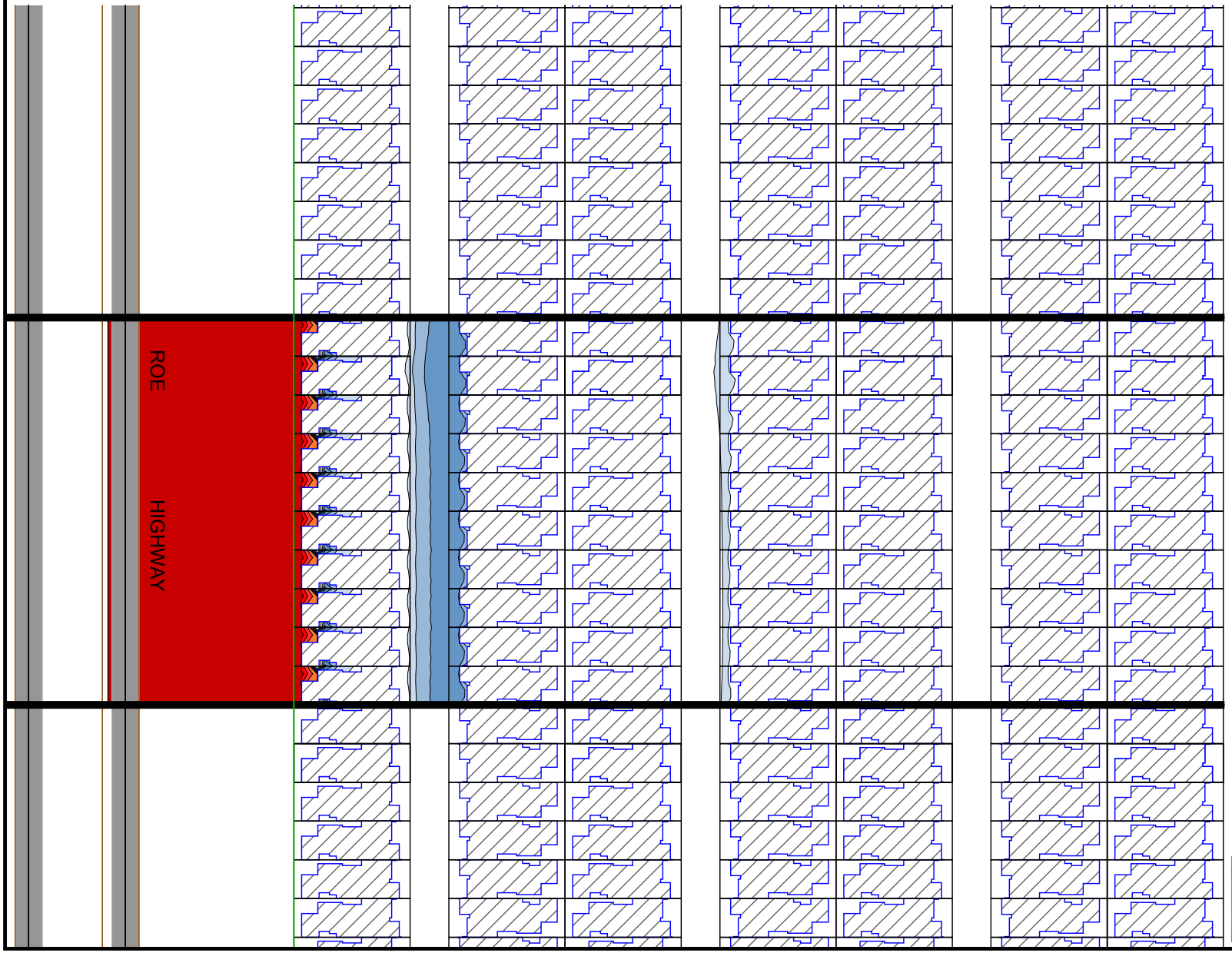
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Boundary to Boundary Single Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure B3



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

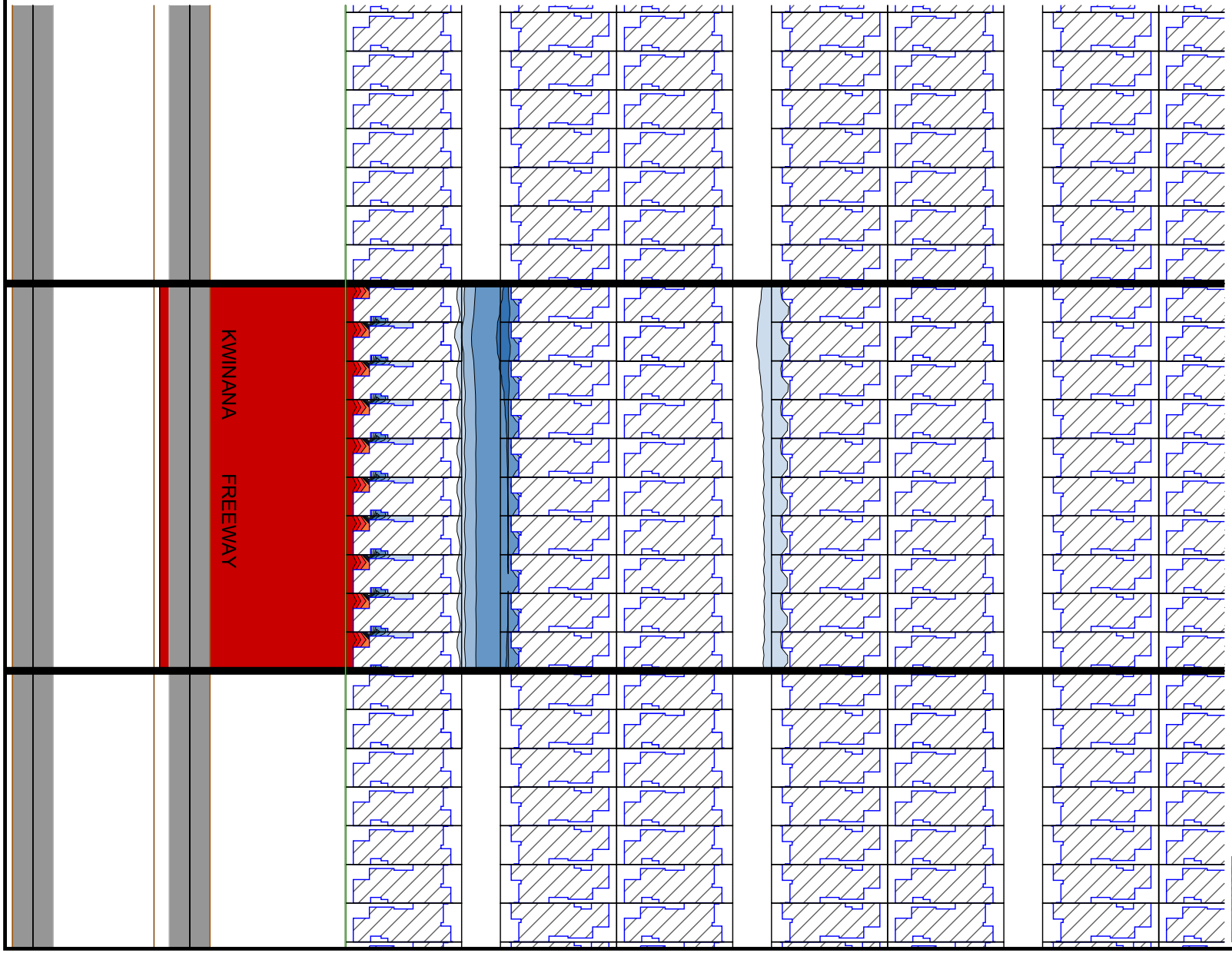
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Boundary to Boundary Single Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure B4



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

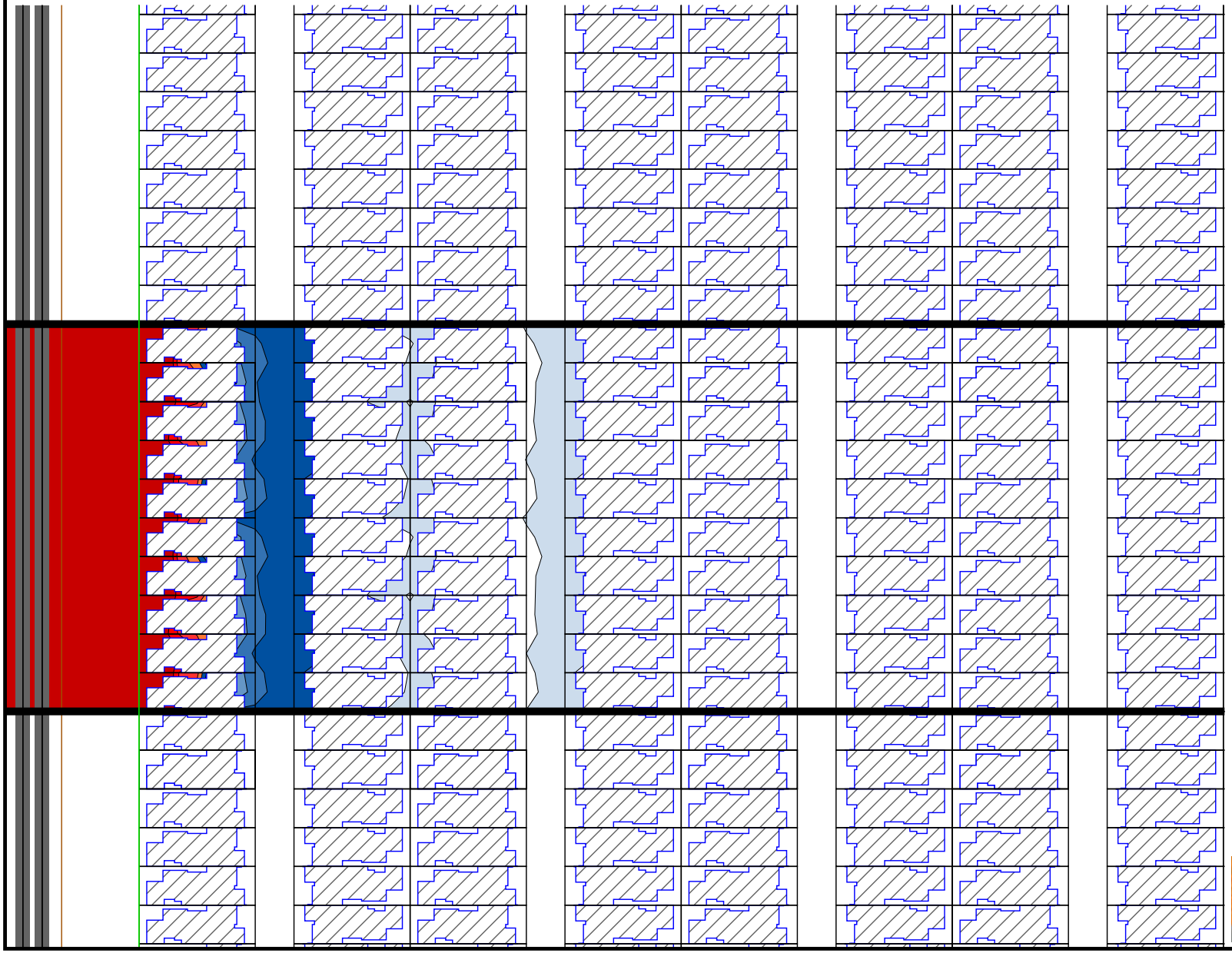
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Boundary to Boundary Single Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure B5



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

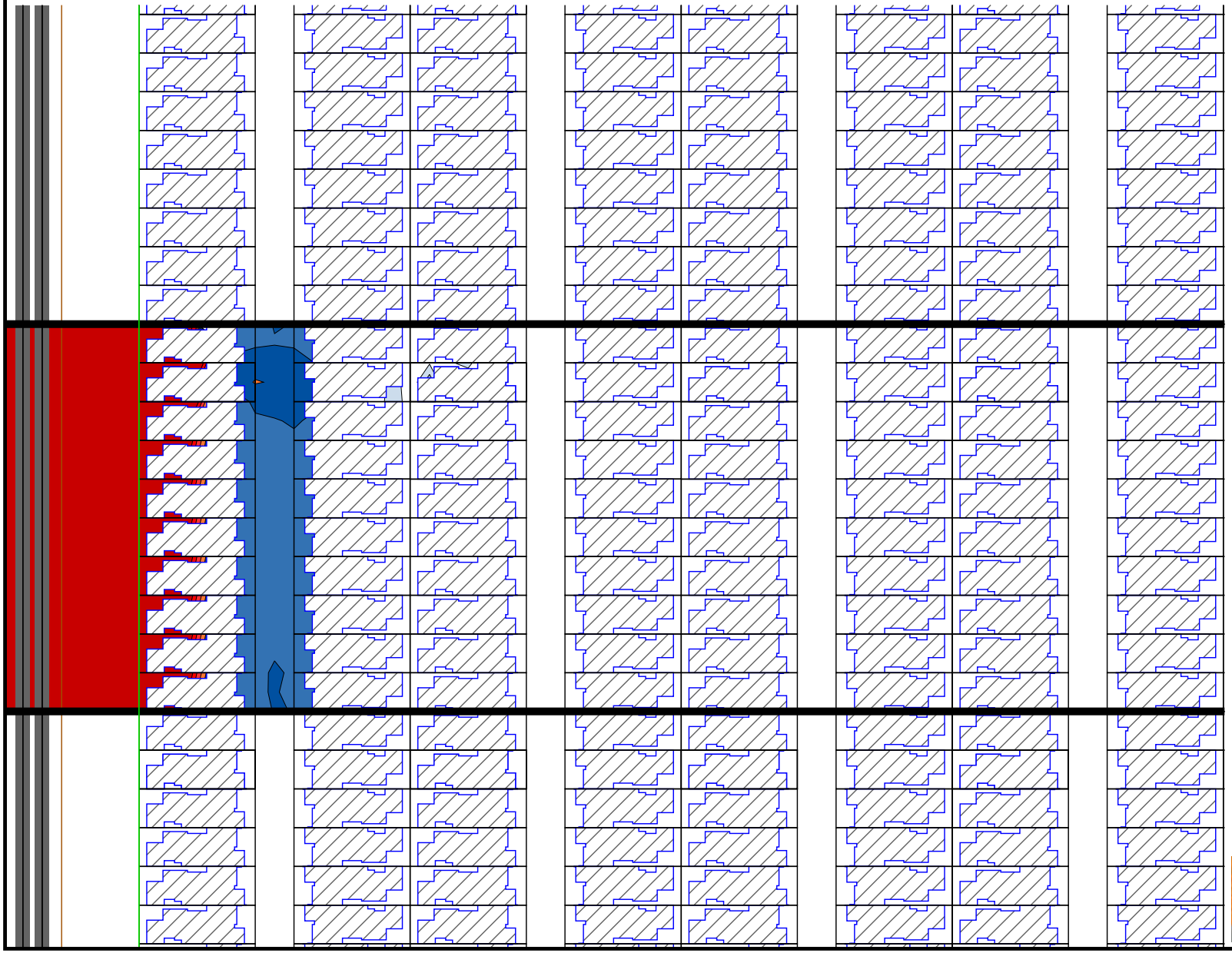
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Boundary to Boundary Single Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure B6



Noise levels
LAmax dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

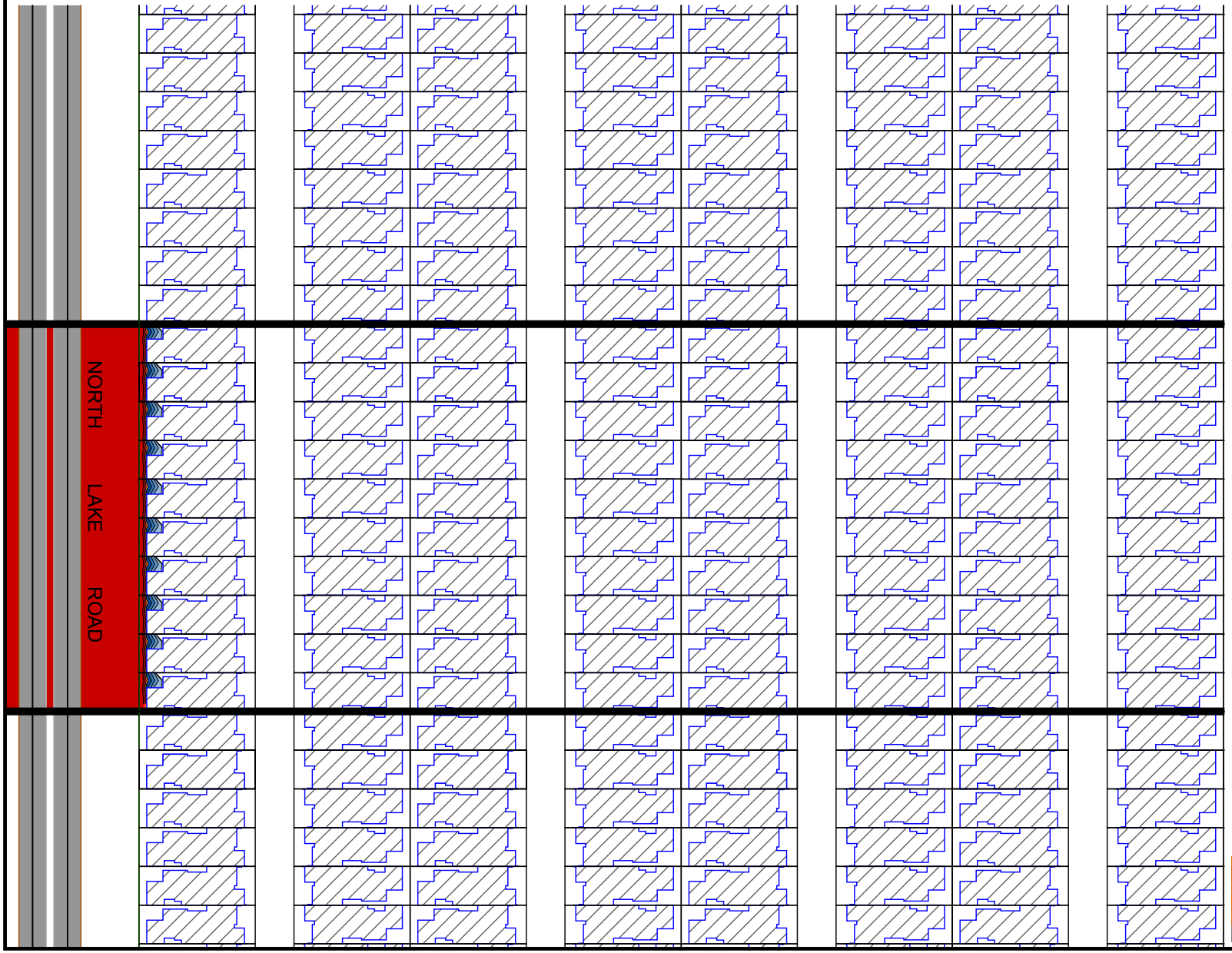
Appendix C

Noise Contour Plots – Double Storey R30 Scenario

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Boundary to Boundary Double Storey Dwelling (Nominally R30/R60 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure C1



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

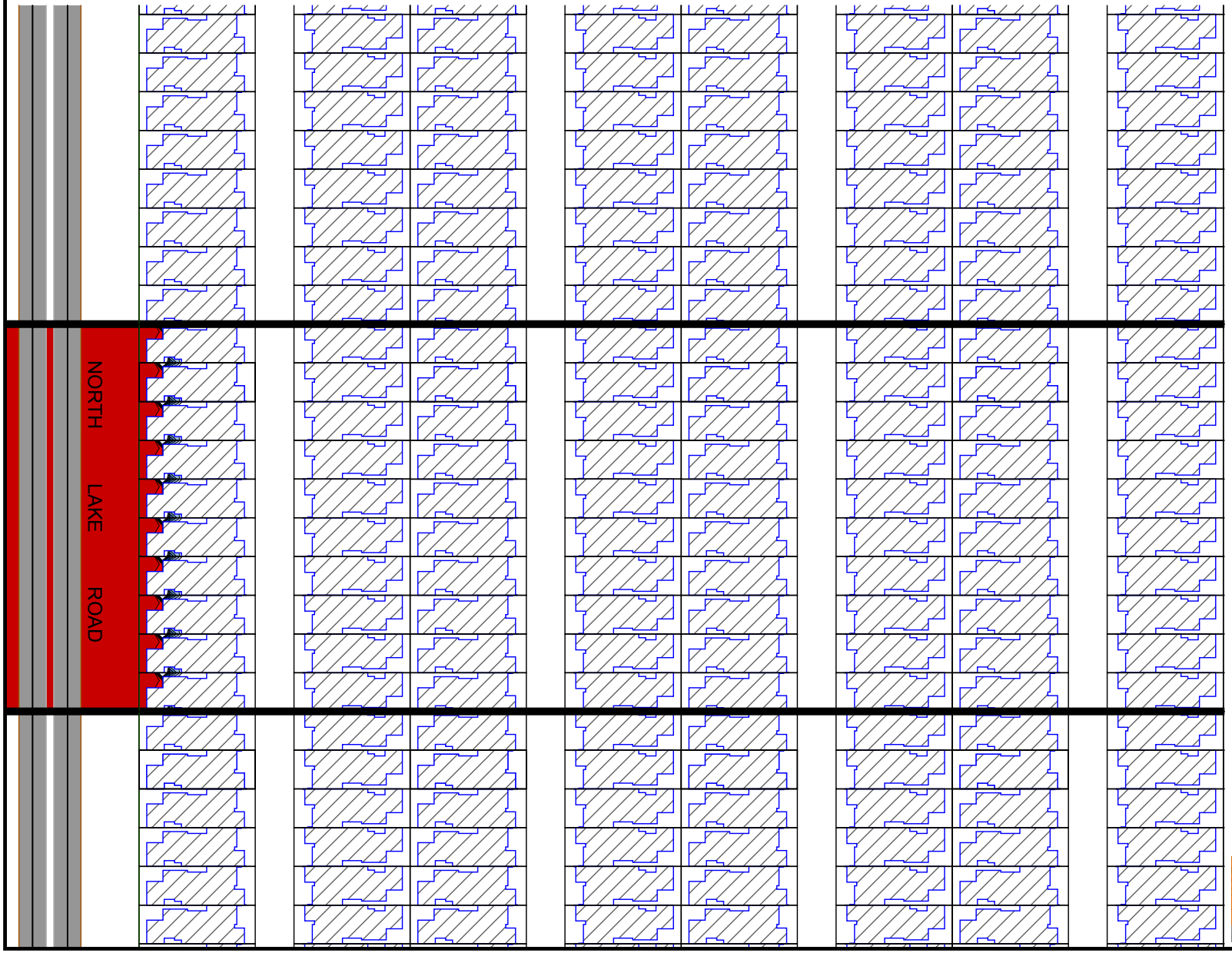
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Boundary to Boundary Double Storey Dwelling (Nominally R30/R60 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure C1a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

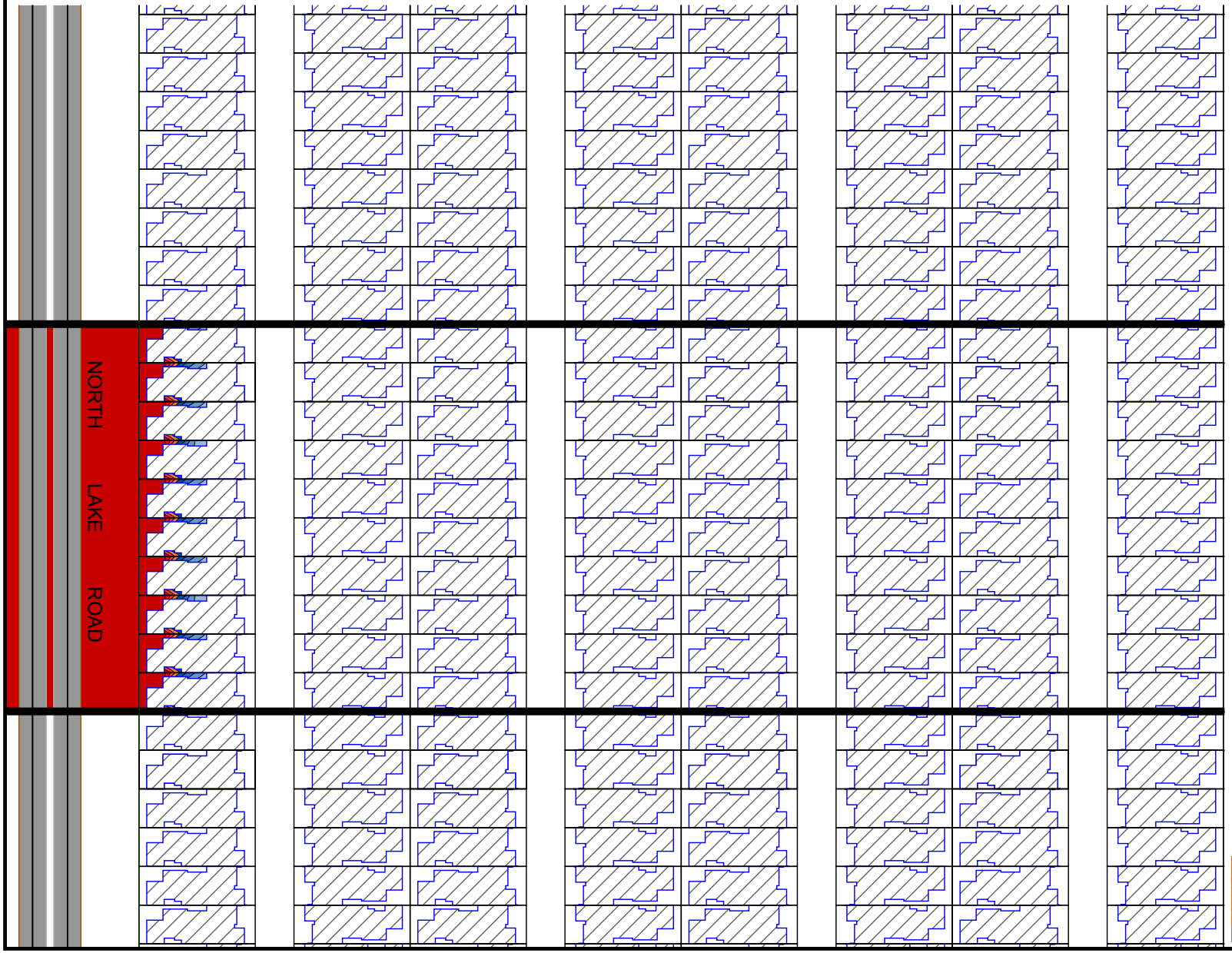
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Boundary to Boundary Double Storey Dwelling (Nominally R30/R60 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure C1b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

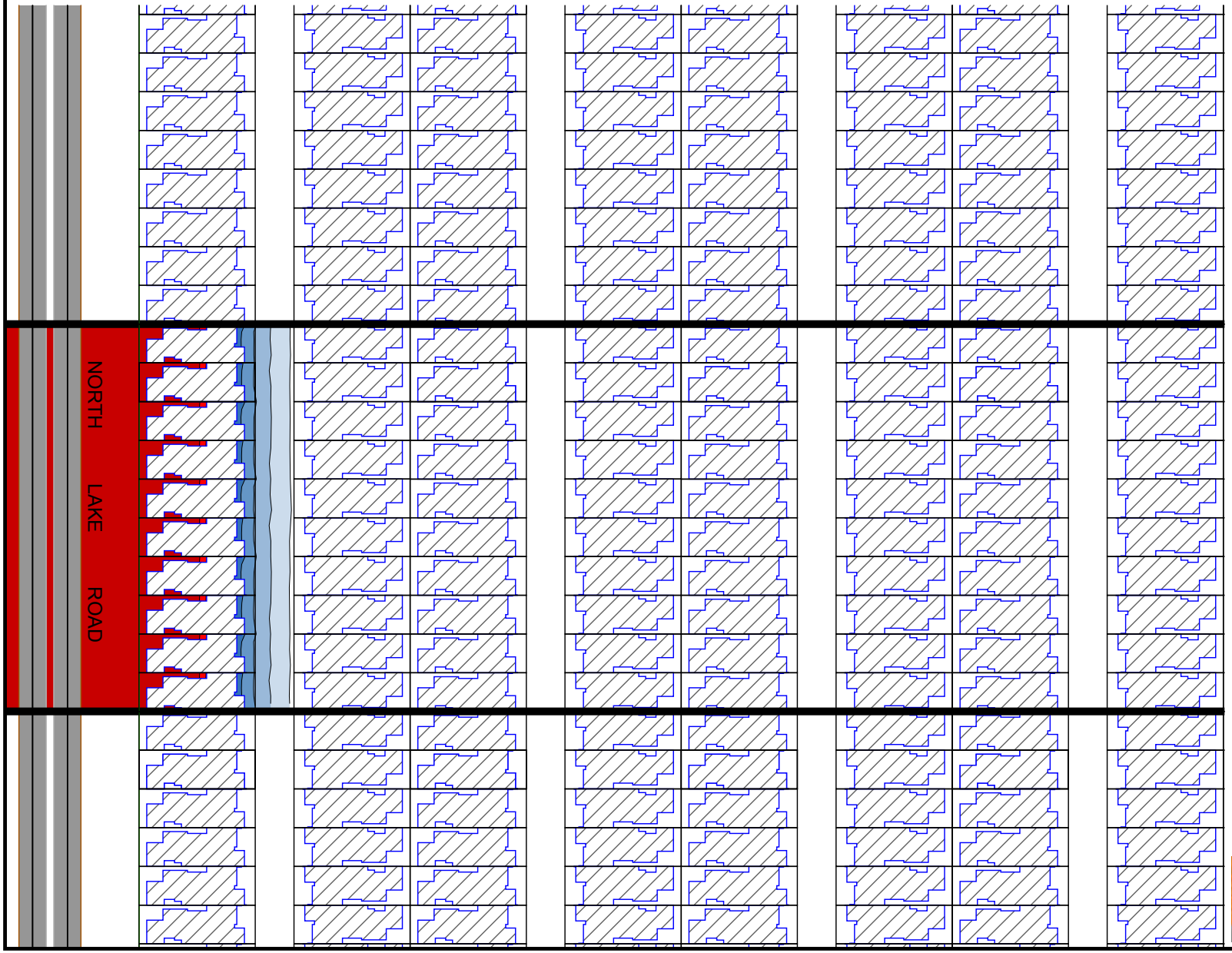
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Boundary to Boundary Double Storey Dwelling (Nominally R30/R60 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure C1c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

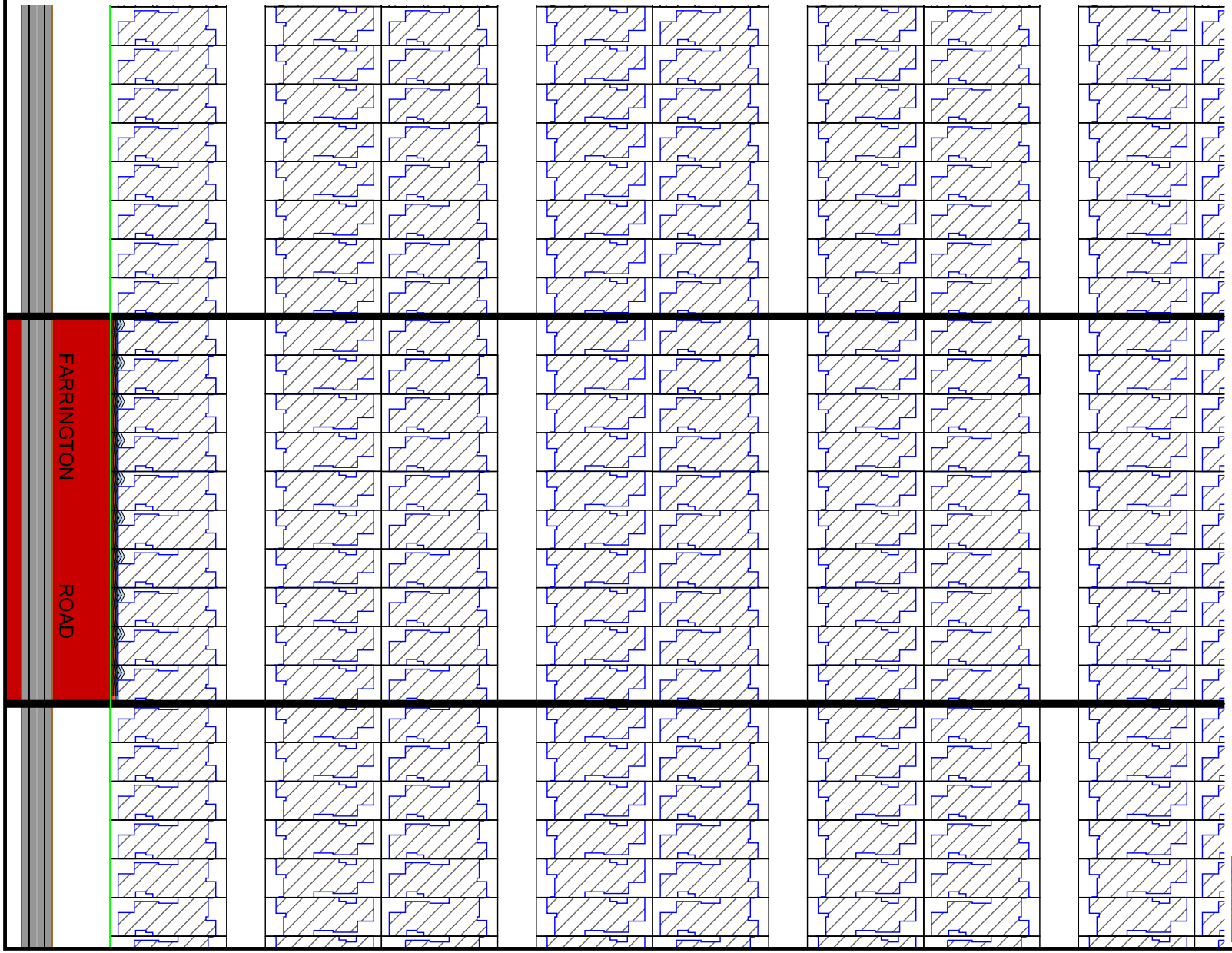
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Farrington Road: Boundary to Boundary Double Storey Dwelling (R30/R60 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure C2



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

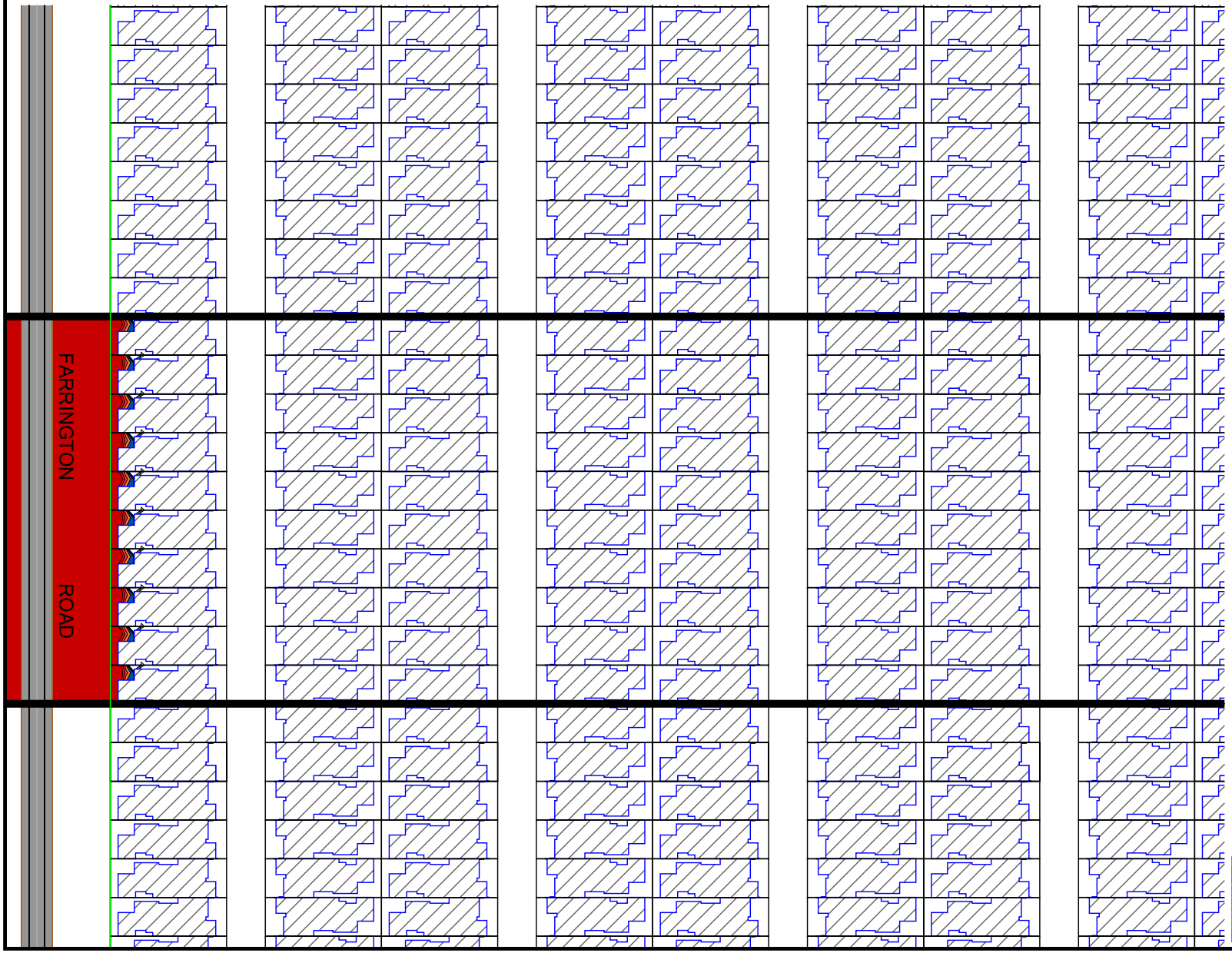
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Farrington Road: Boundary to Boundary Double Storey Dwelling (R30/R60 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure C2a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

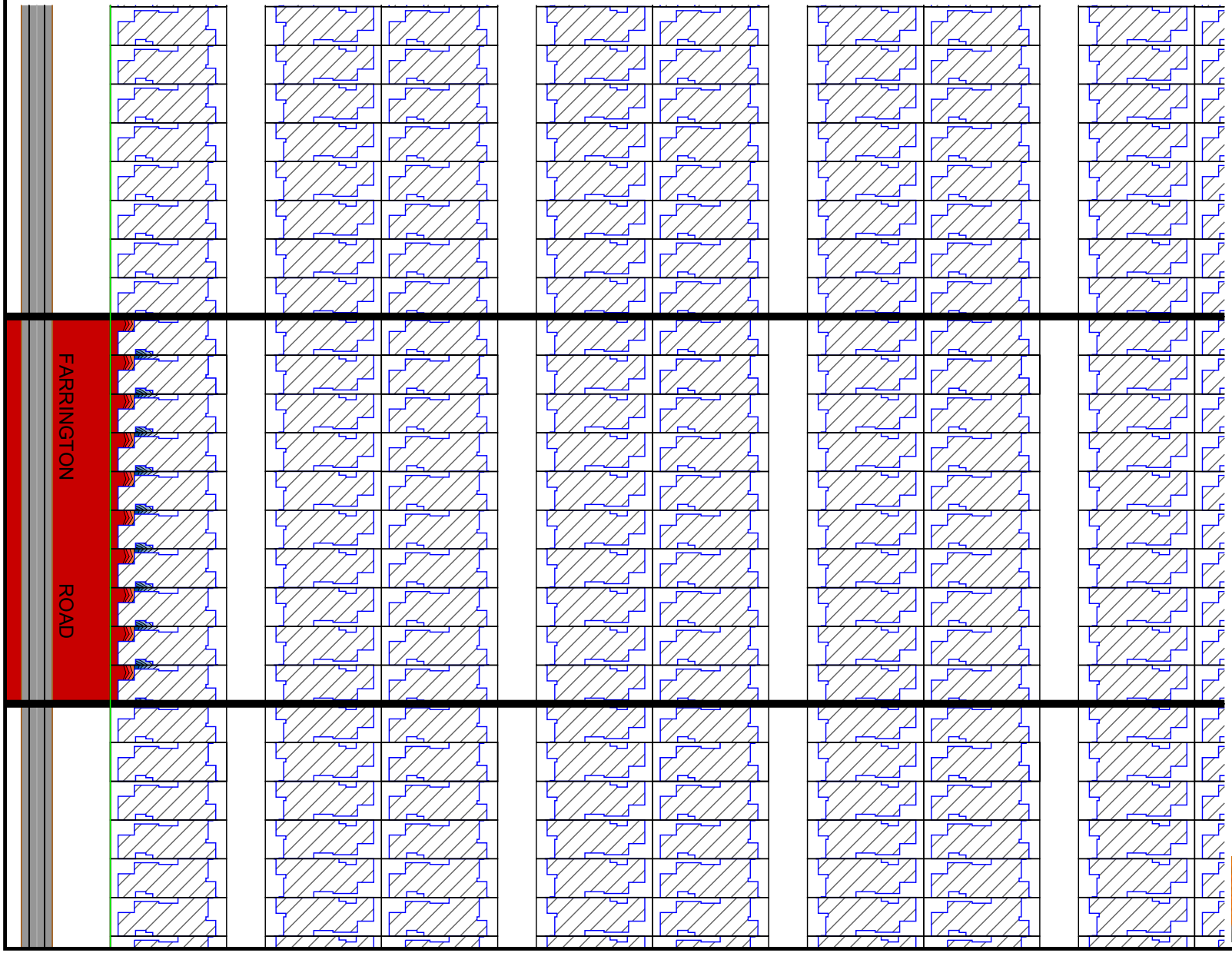
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Farrington Road: Boundary to Boundary Double Storey Dwelling (R30/R60 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure C2b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

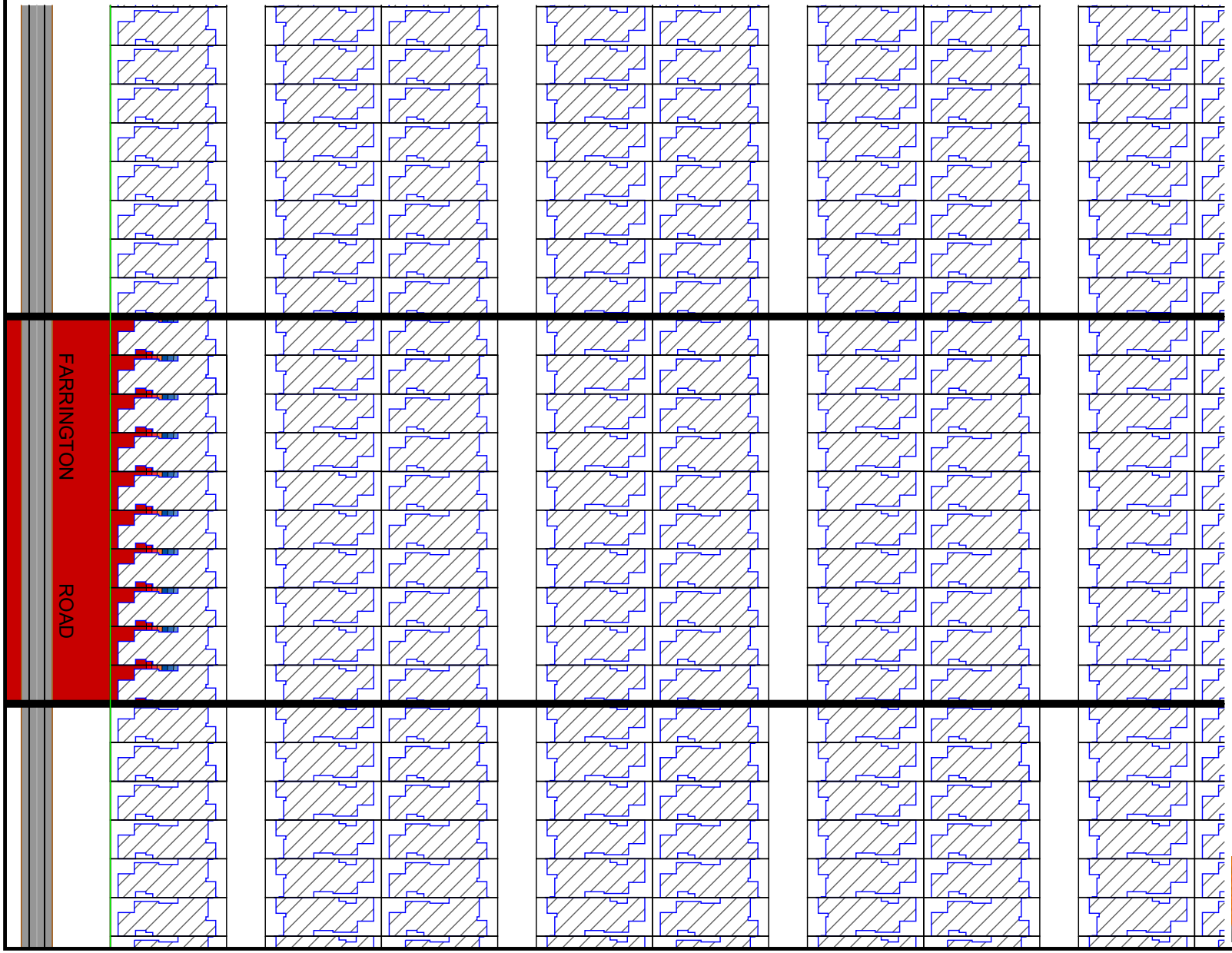
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Farrington Road: Boundary to Boundary Double Storey Dwelling (R30/R60 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure C2c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

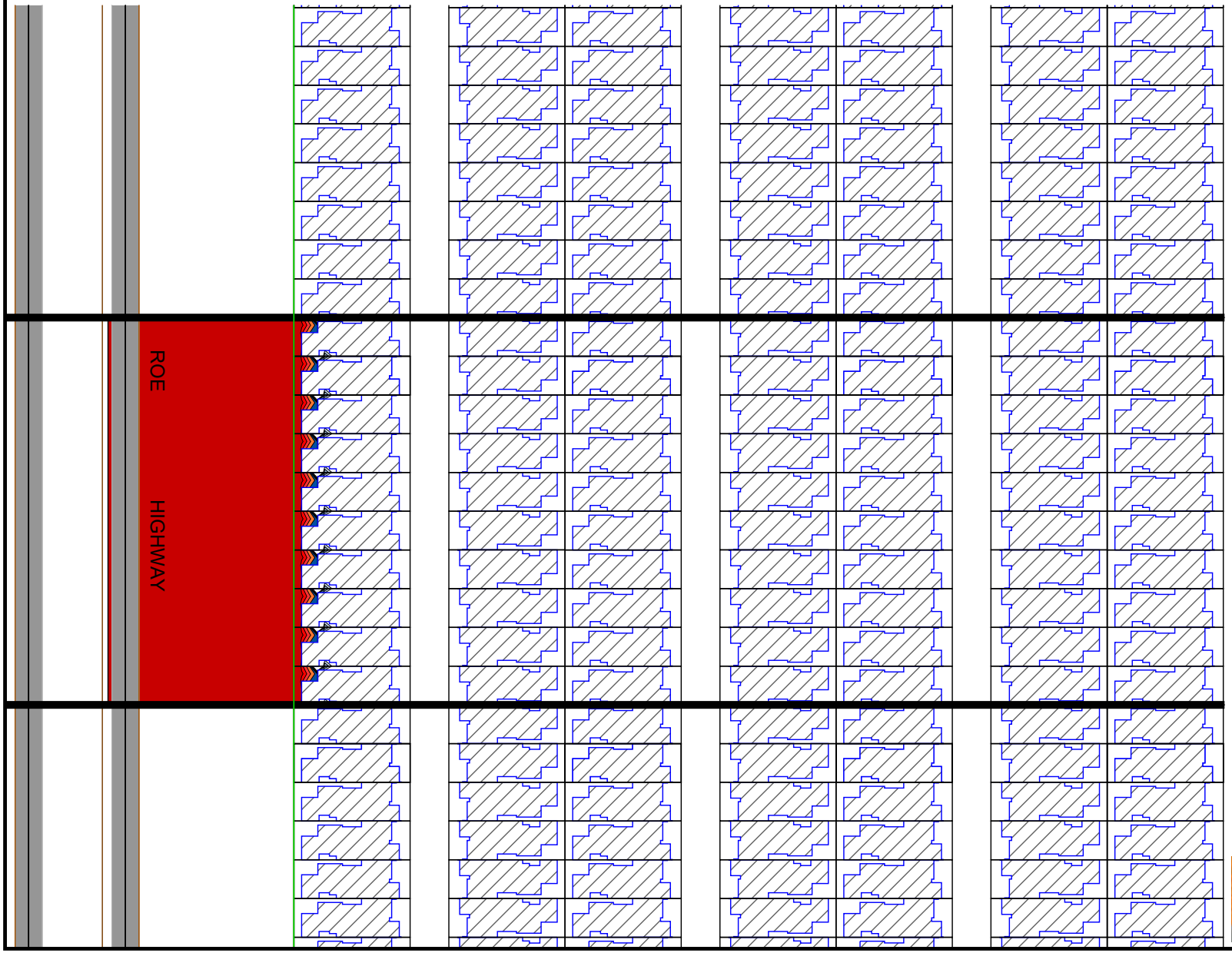
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure C3



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

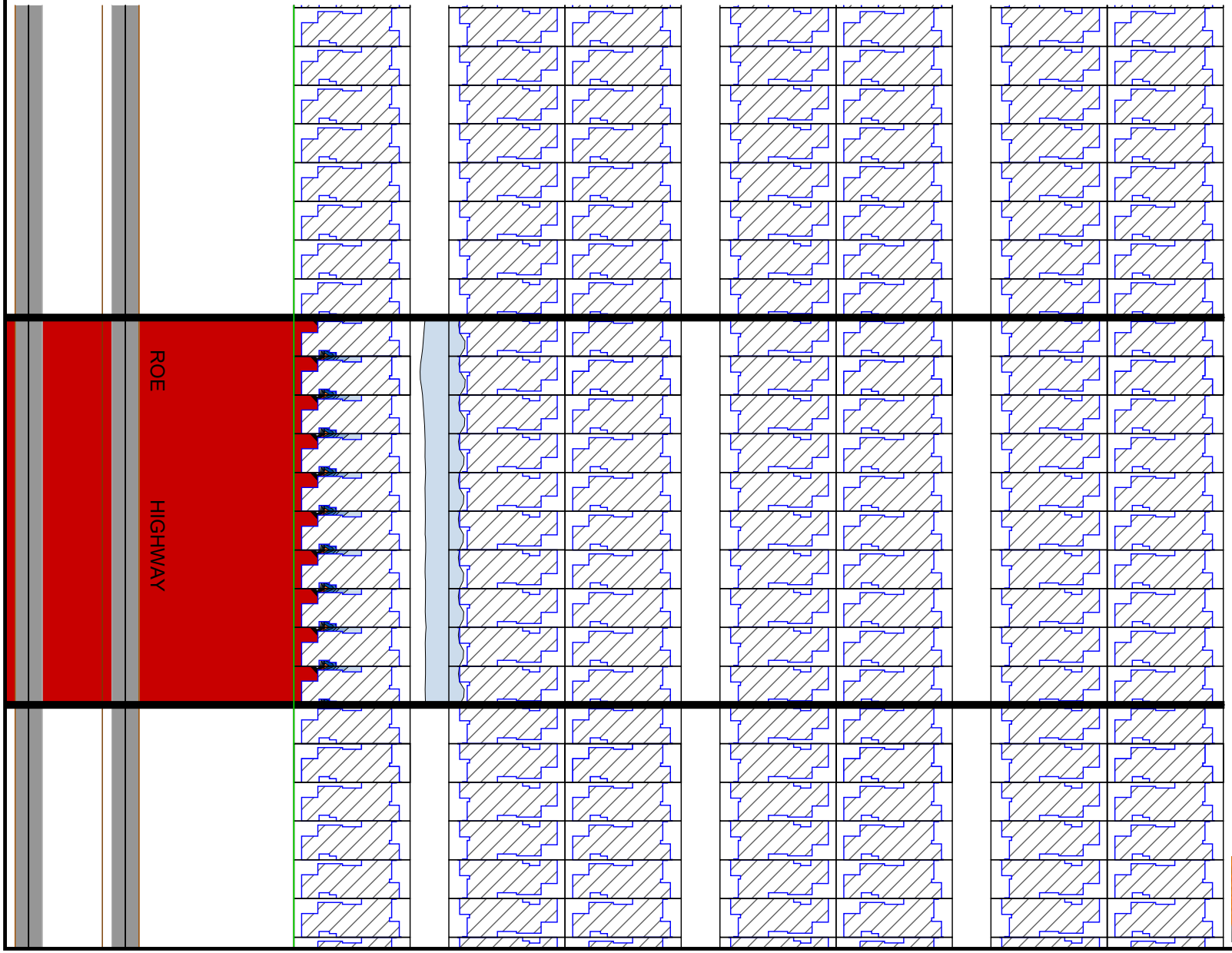
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure C3a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

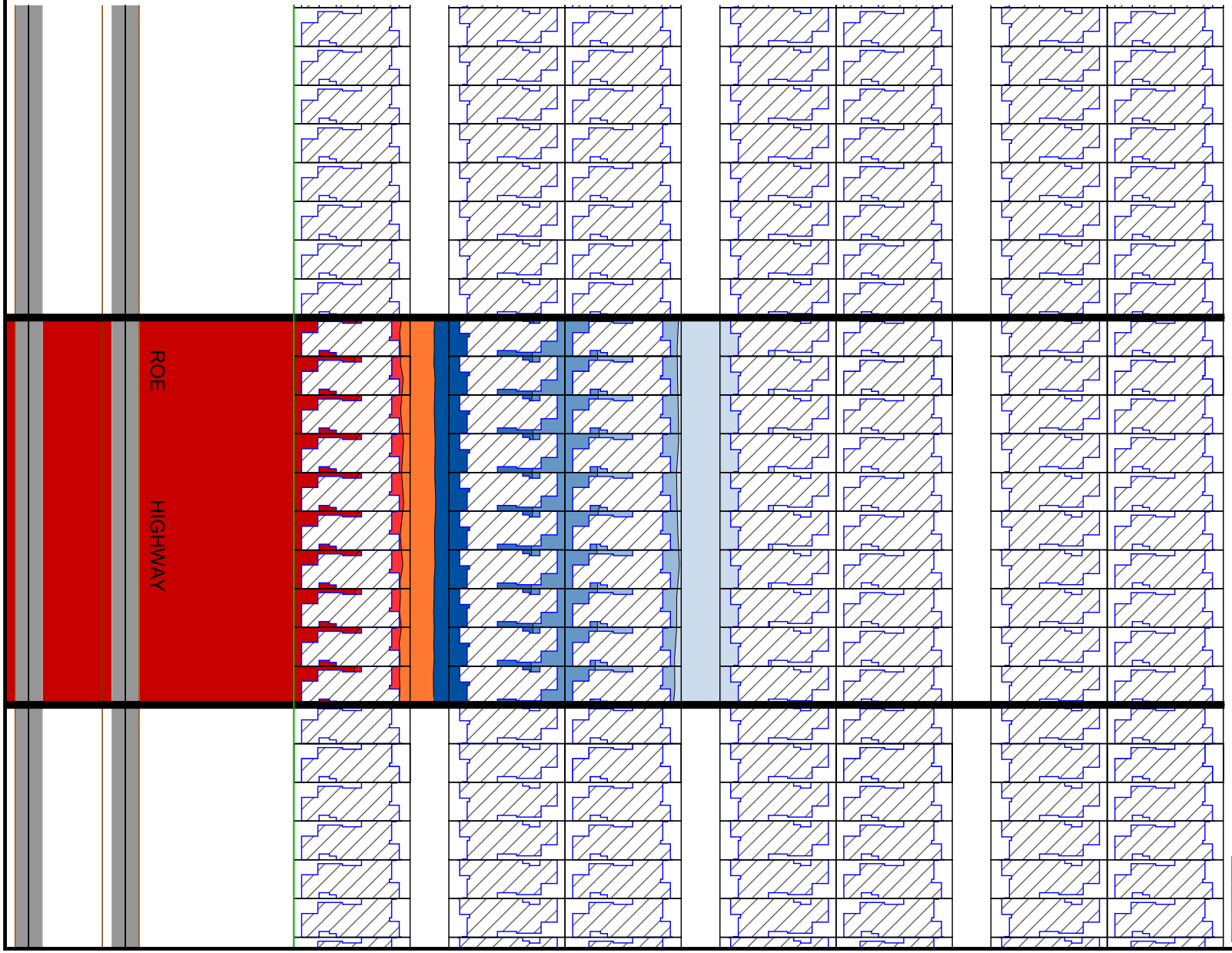
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure C3b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

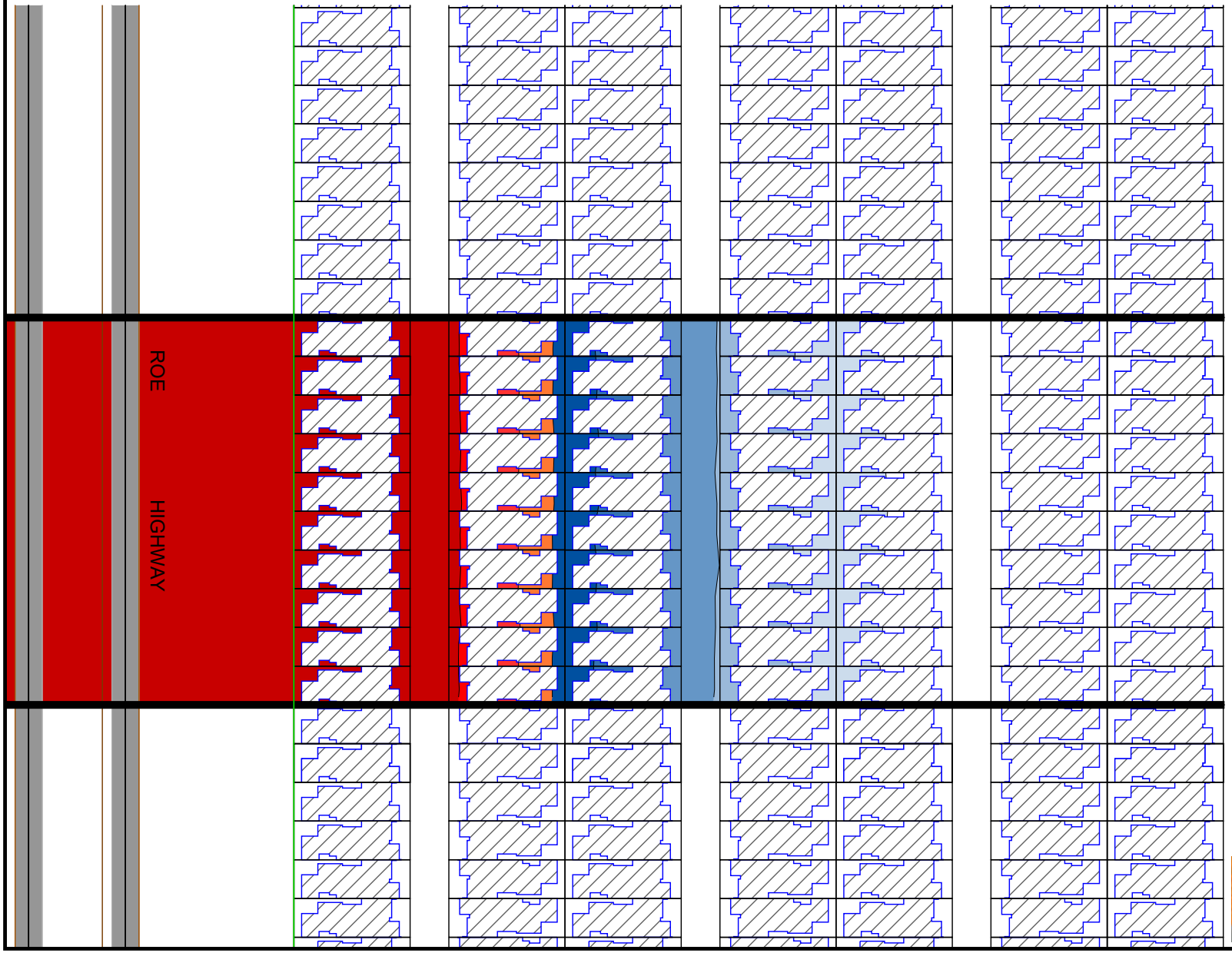
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure C3c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

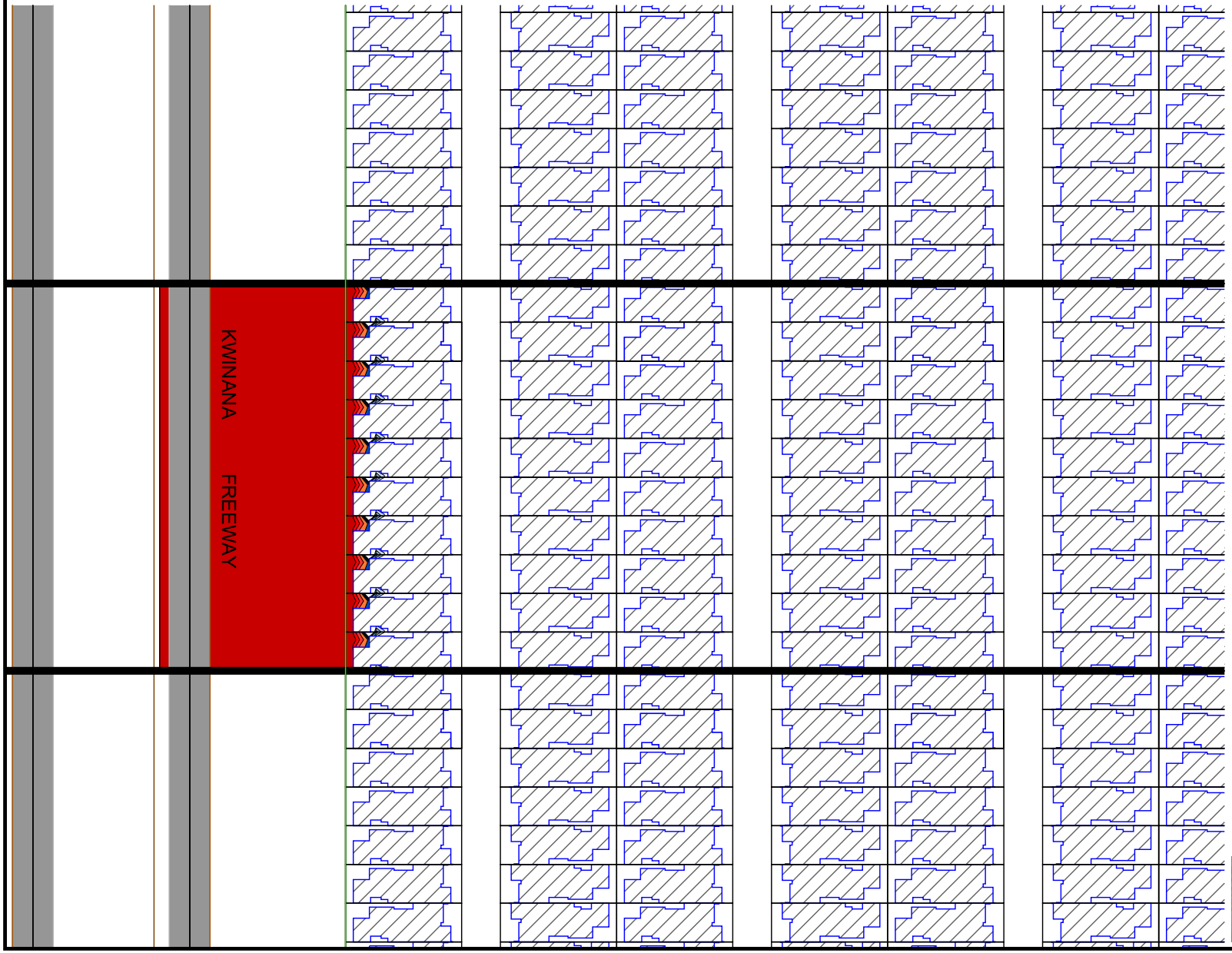
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure C4



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area
- Area
- Road axis
- Elevation line
  16 October 2015
- Base line
- Ground absorption

Length Scale 1:1500

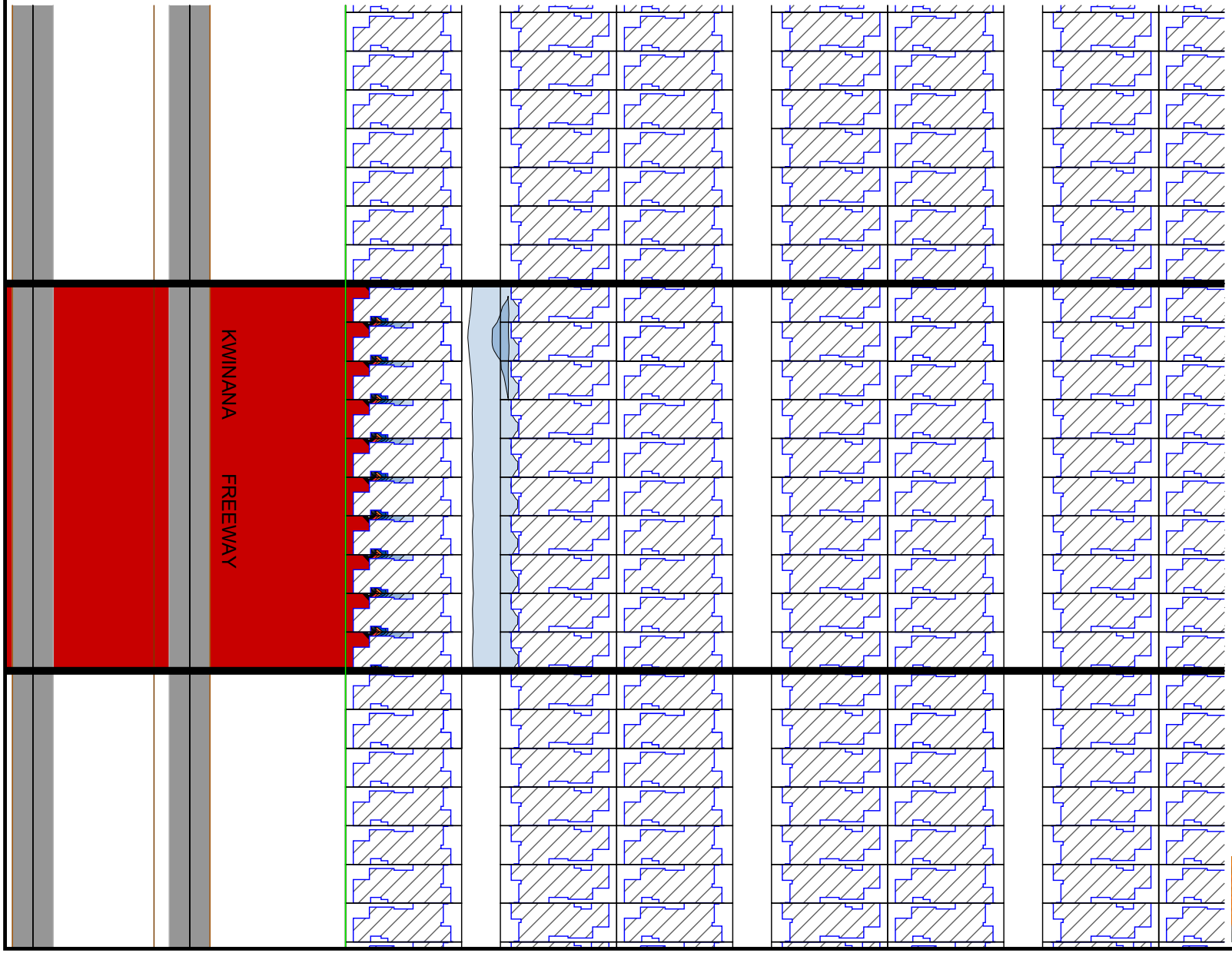
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure C4a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

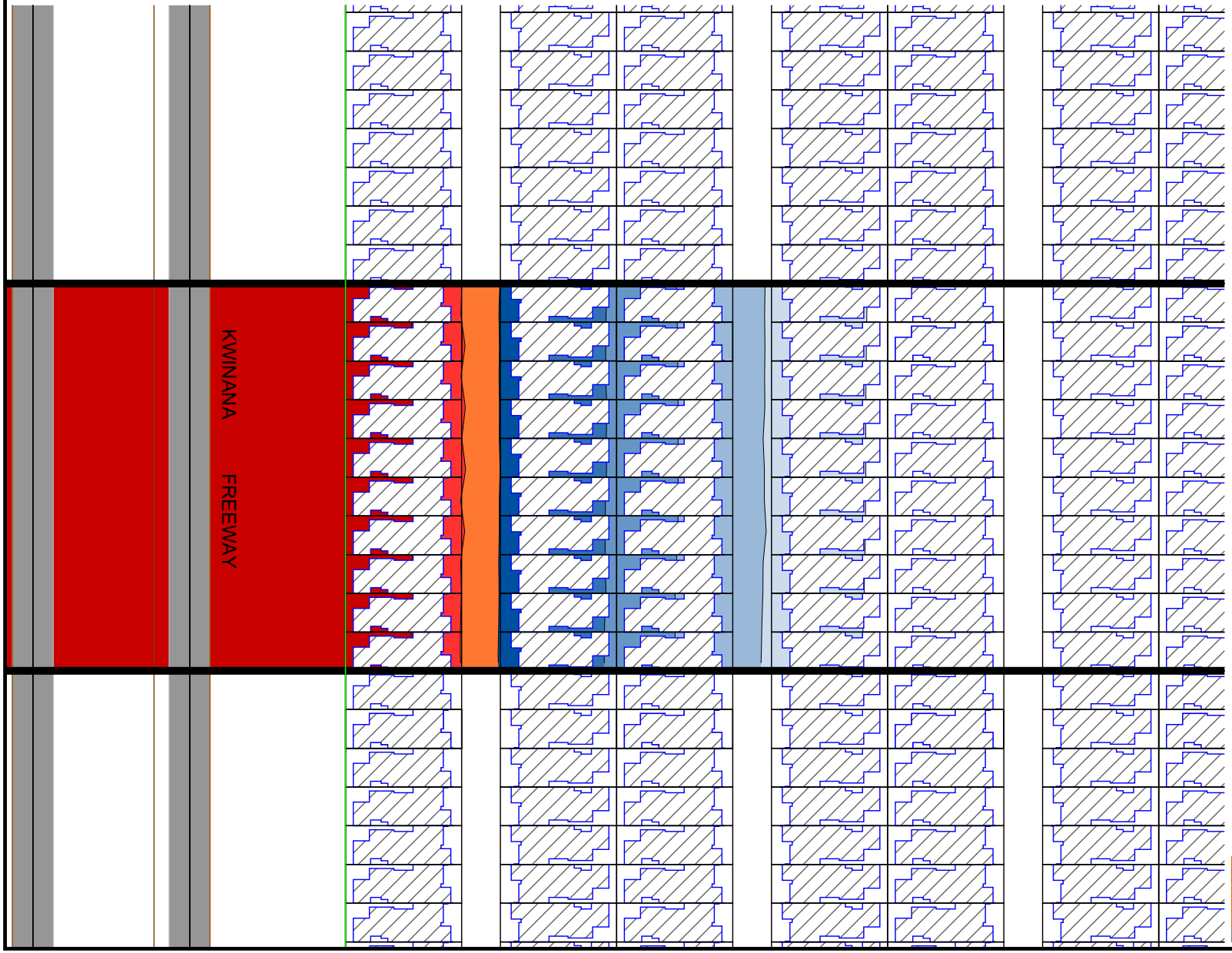
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure C4b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

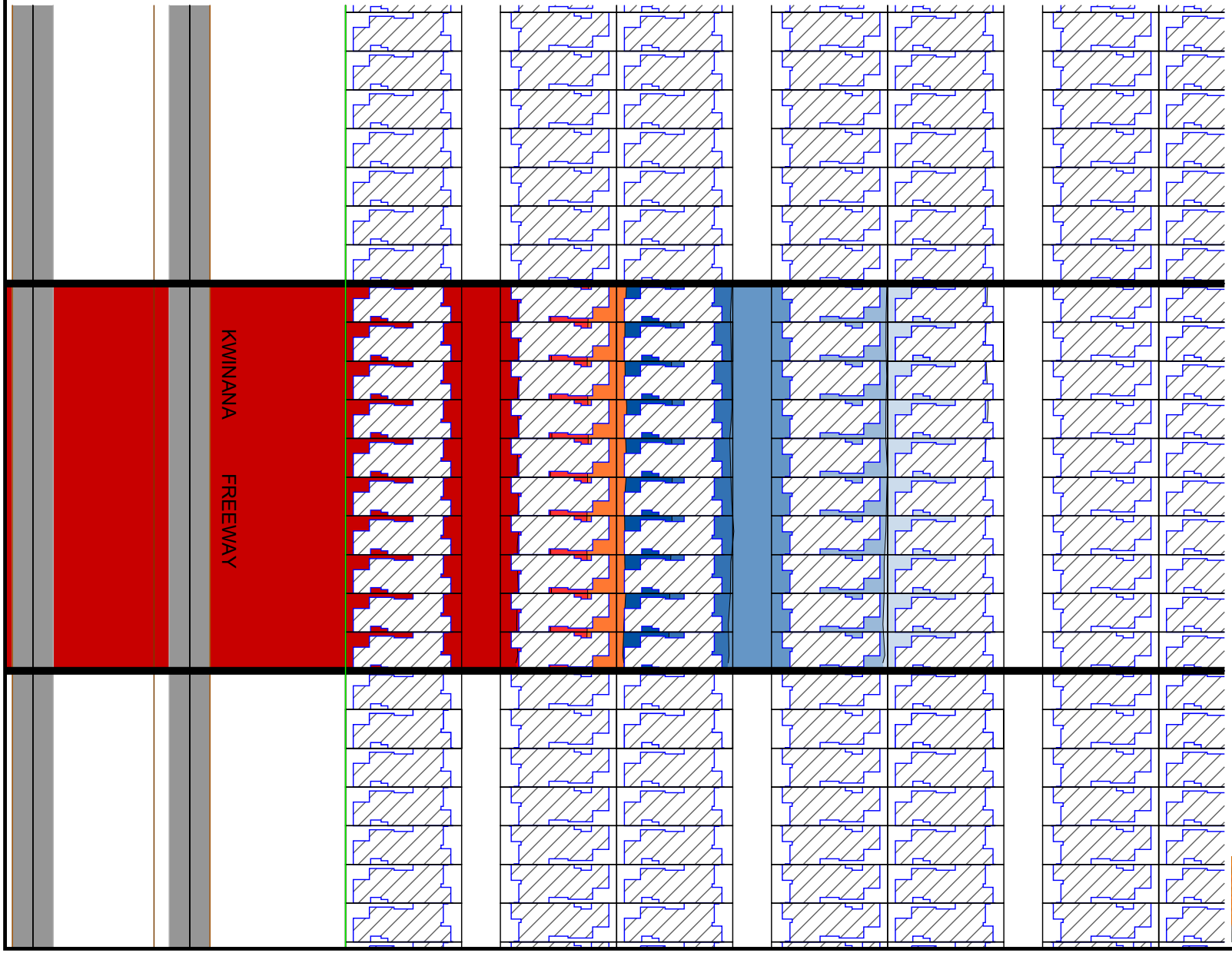
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure C4c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

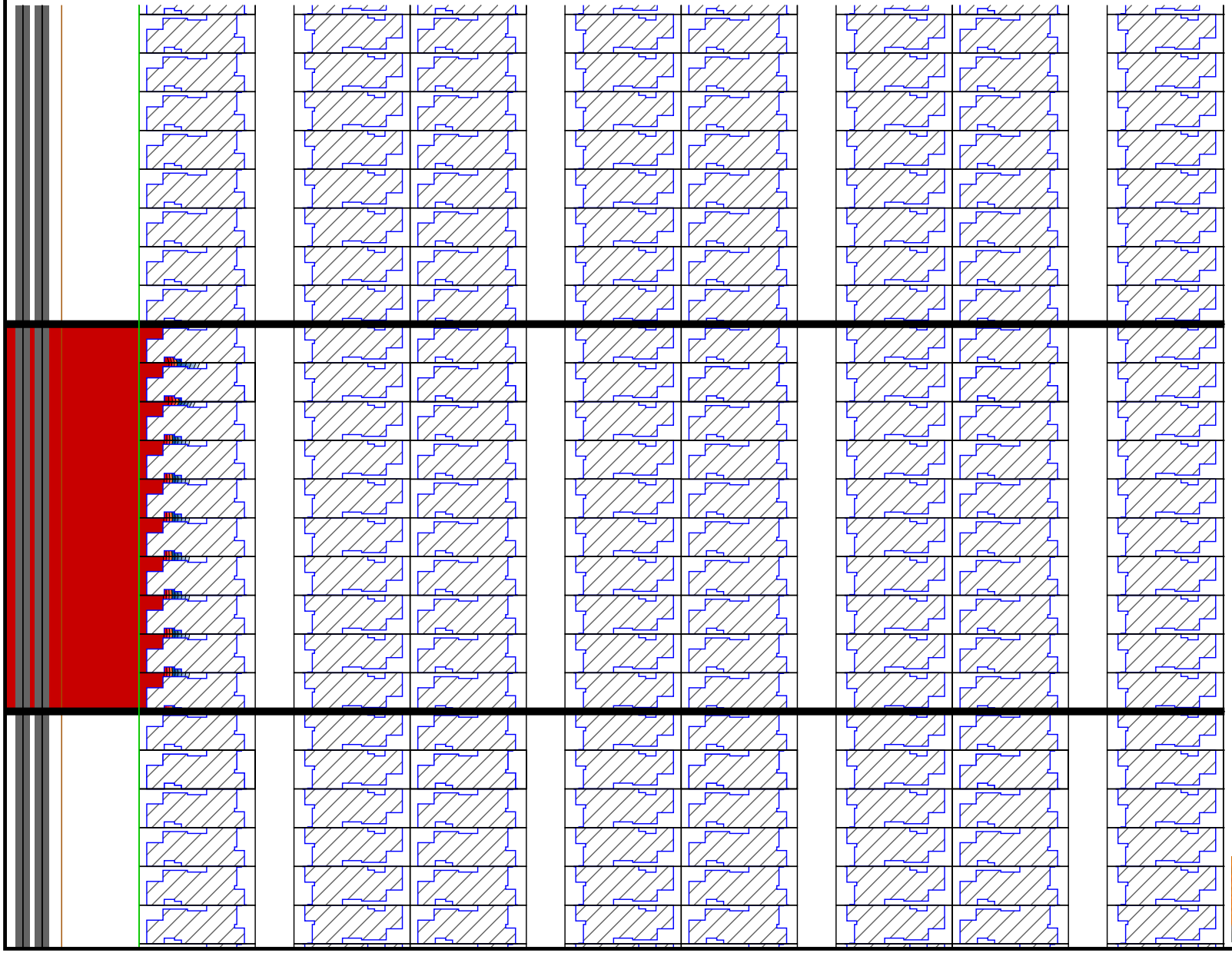
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure C5



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

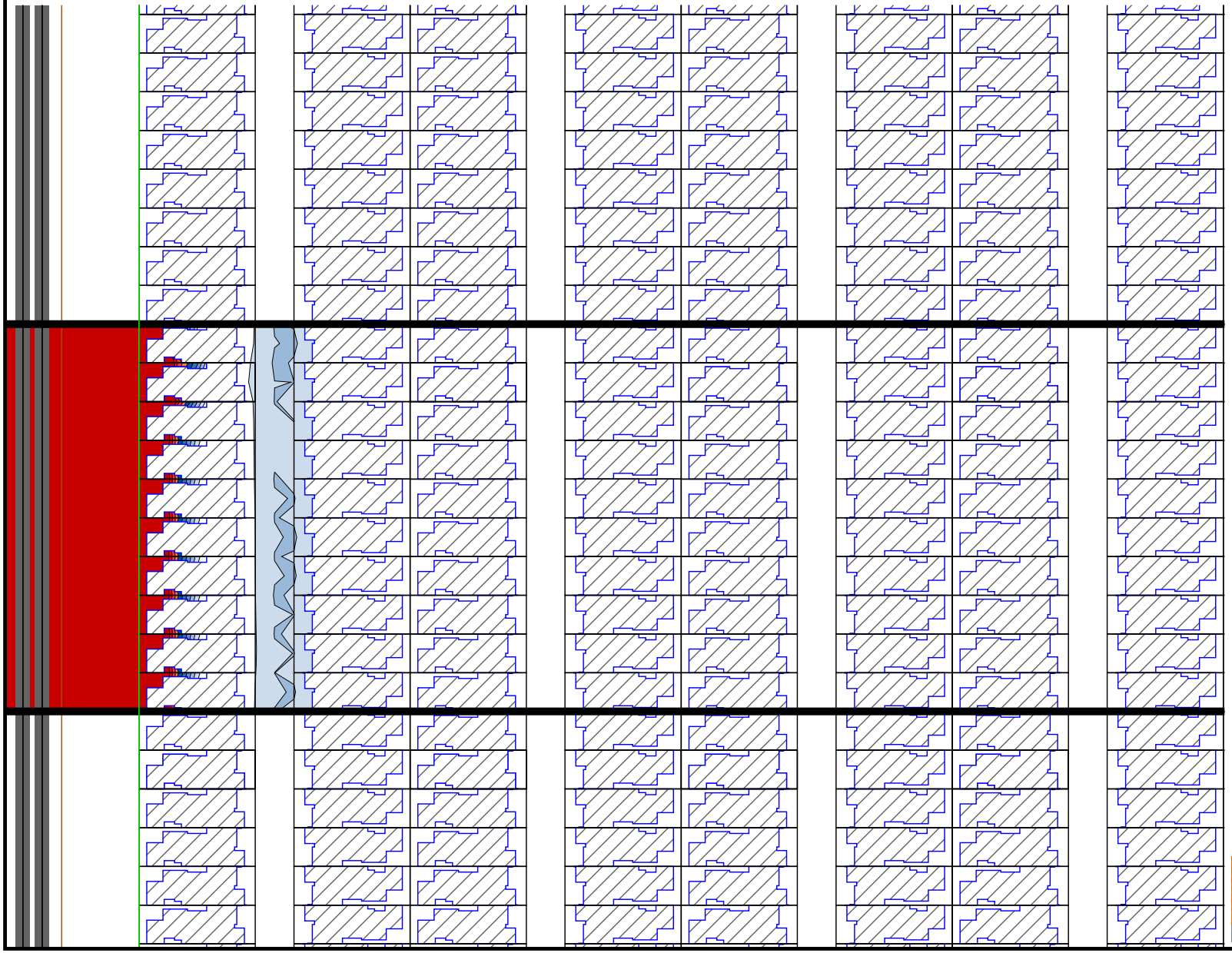
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure C5a



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

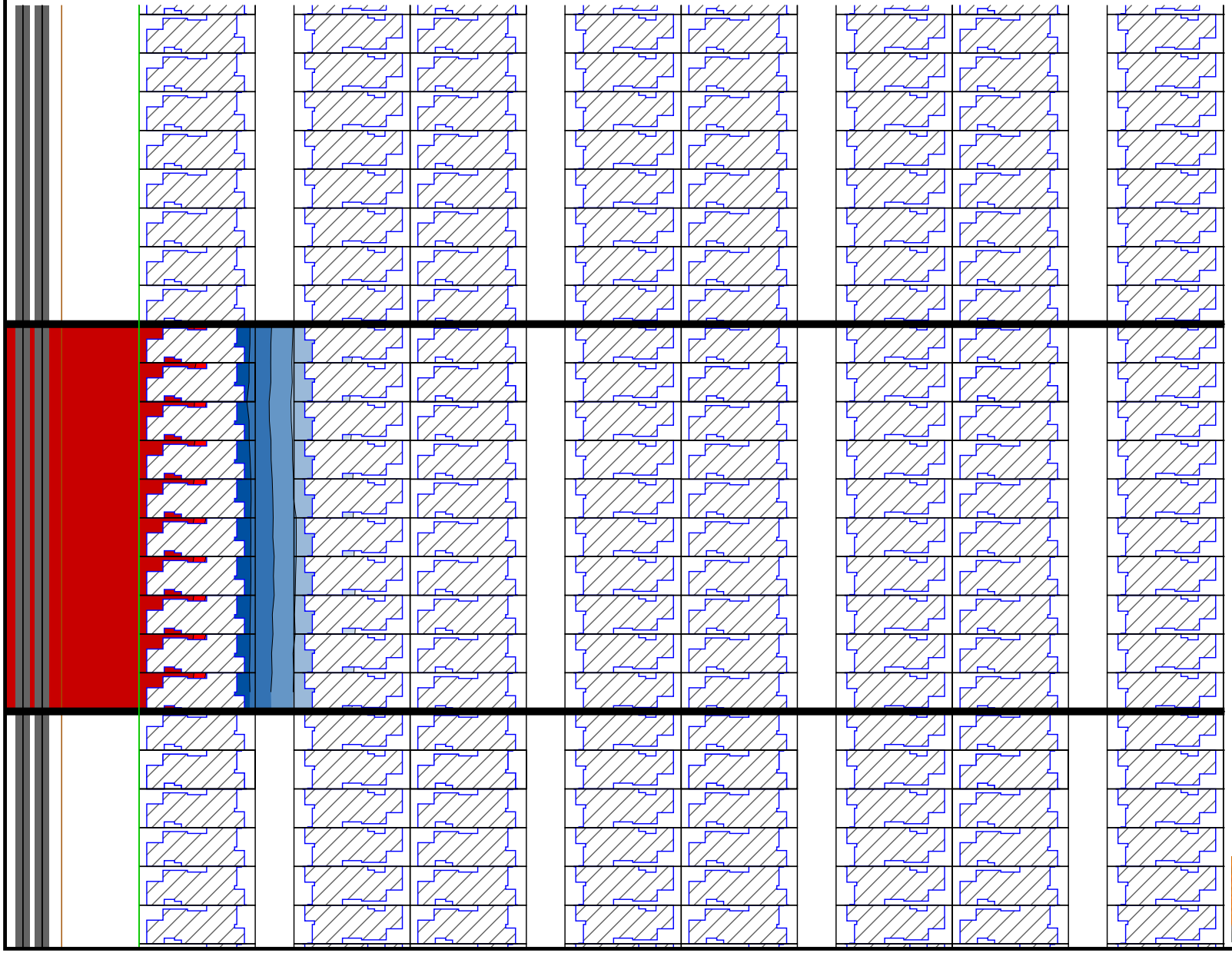
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure C5b



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

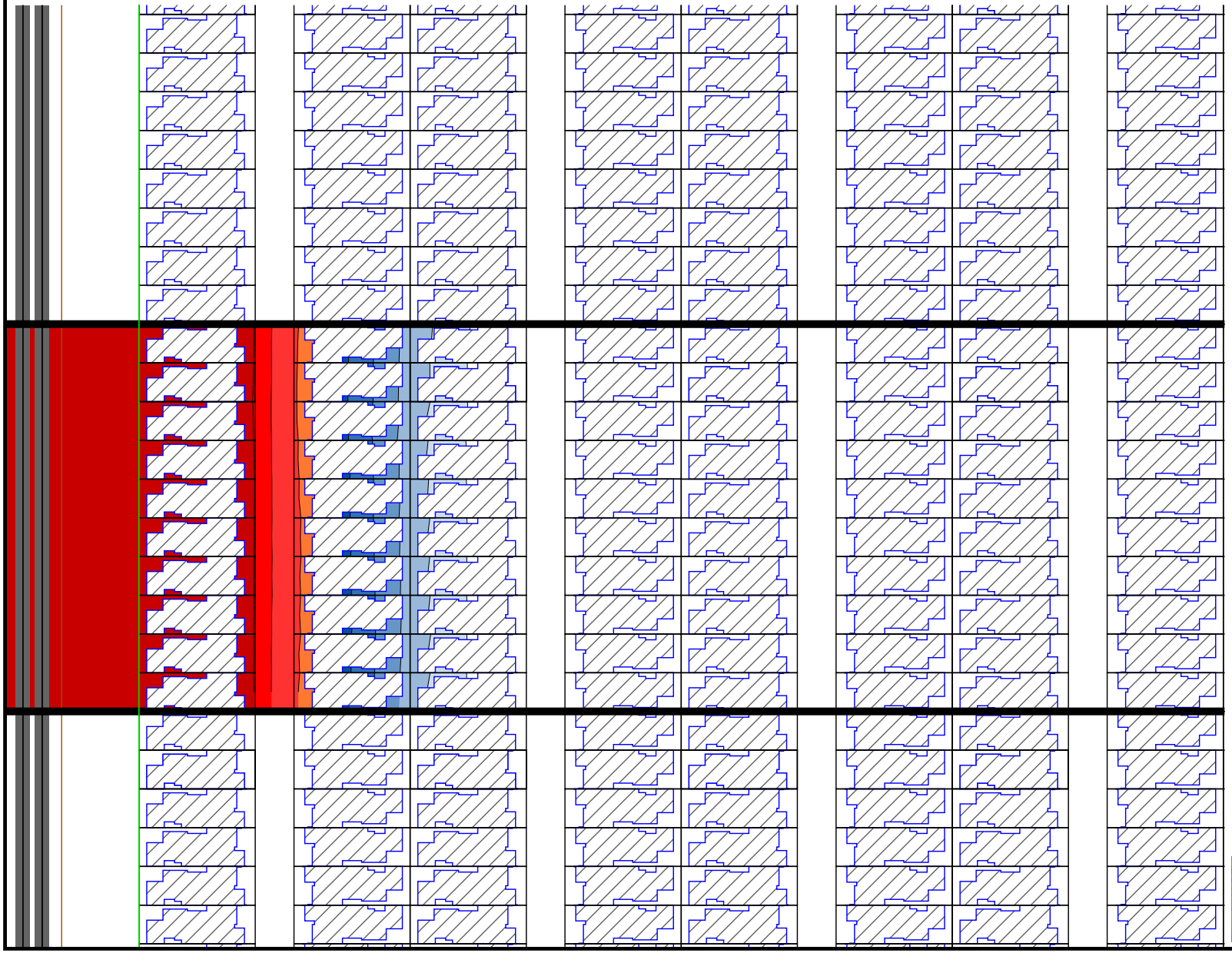
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure C5c



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

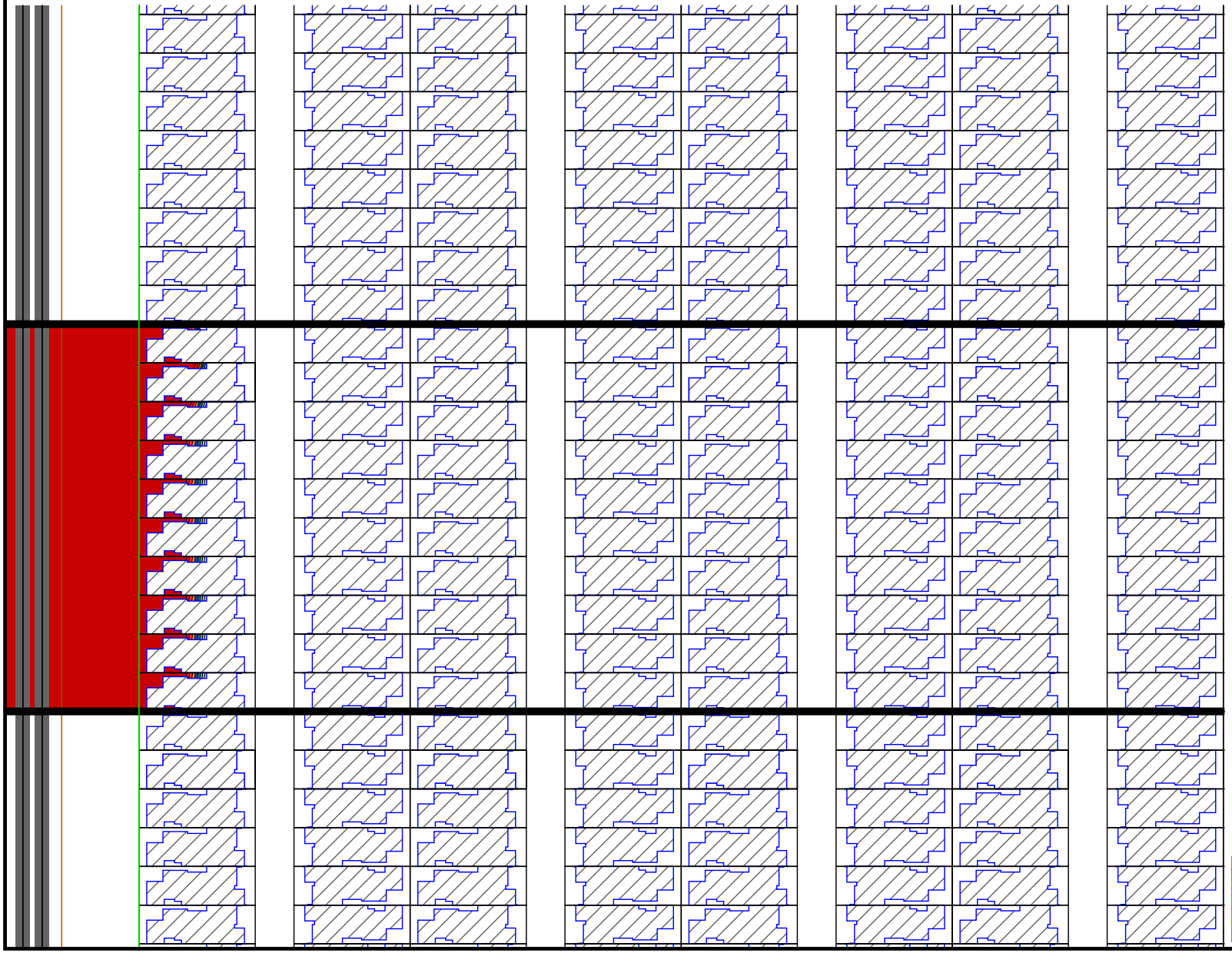
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure C6



Noise levels
LAmax dB

75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

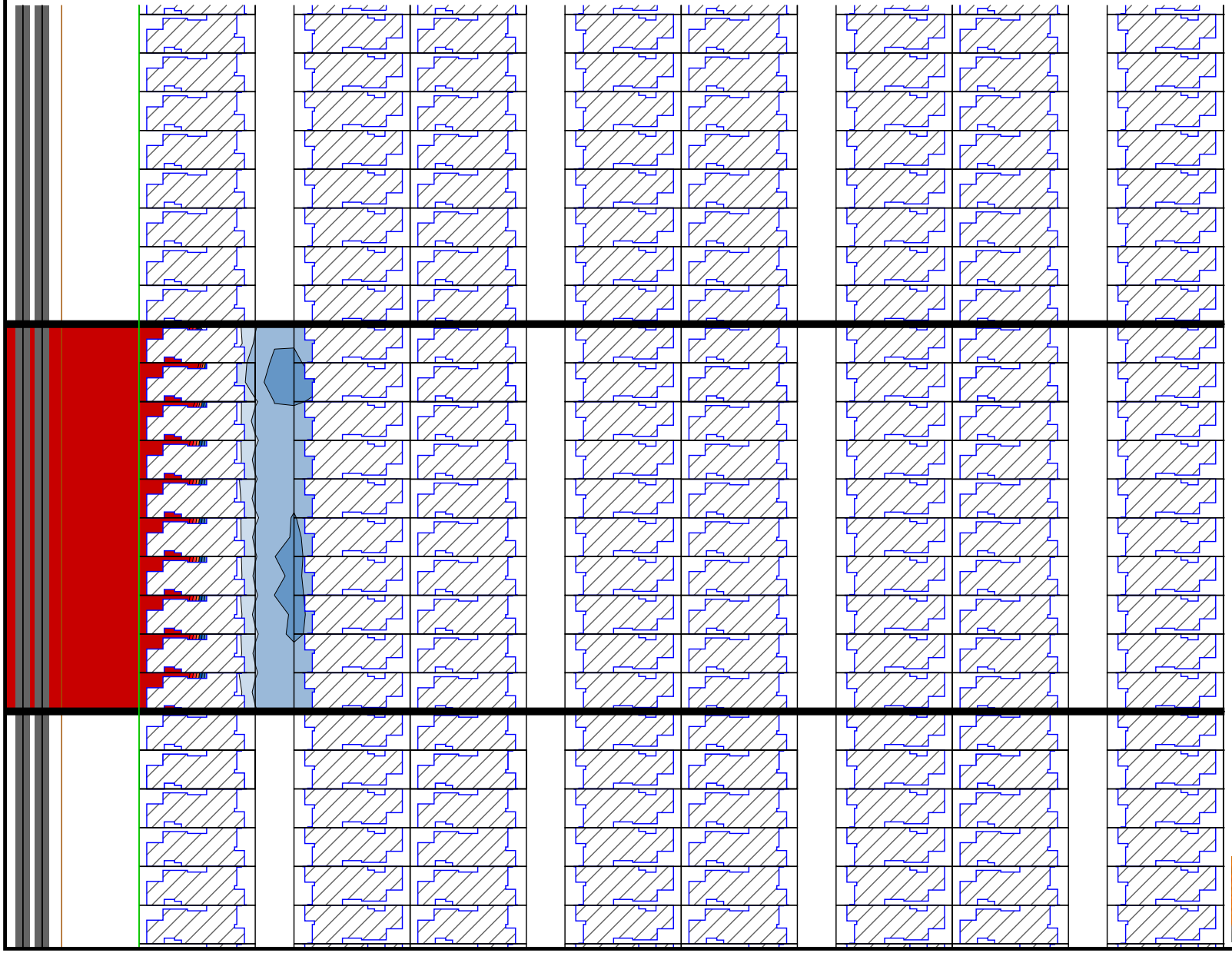
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure C6a



Noise levels
LAmax dB

75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

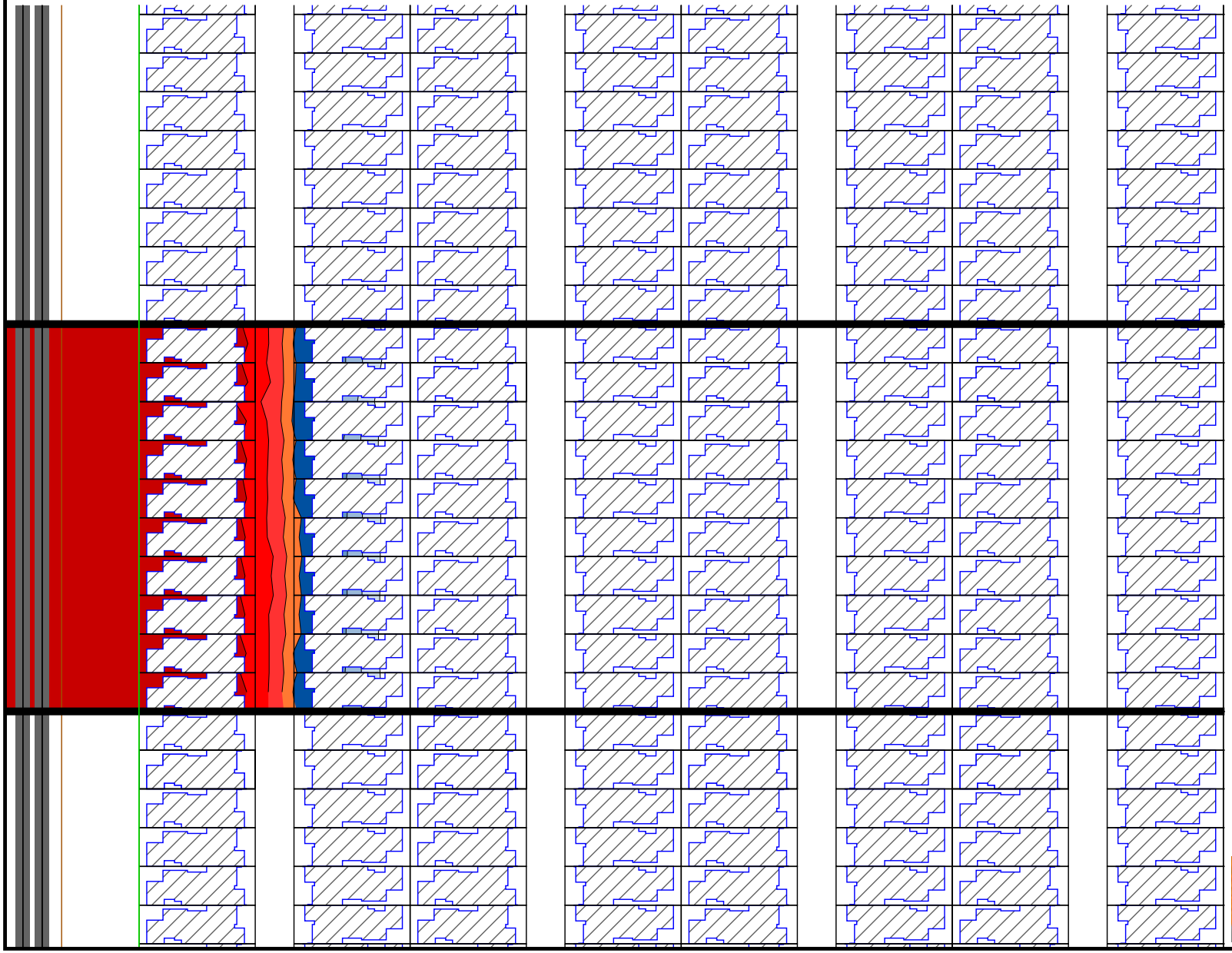
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure C6b



Noise levels
LAmax dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols

- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

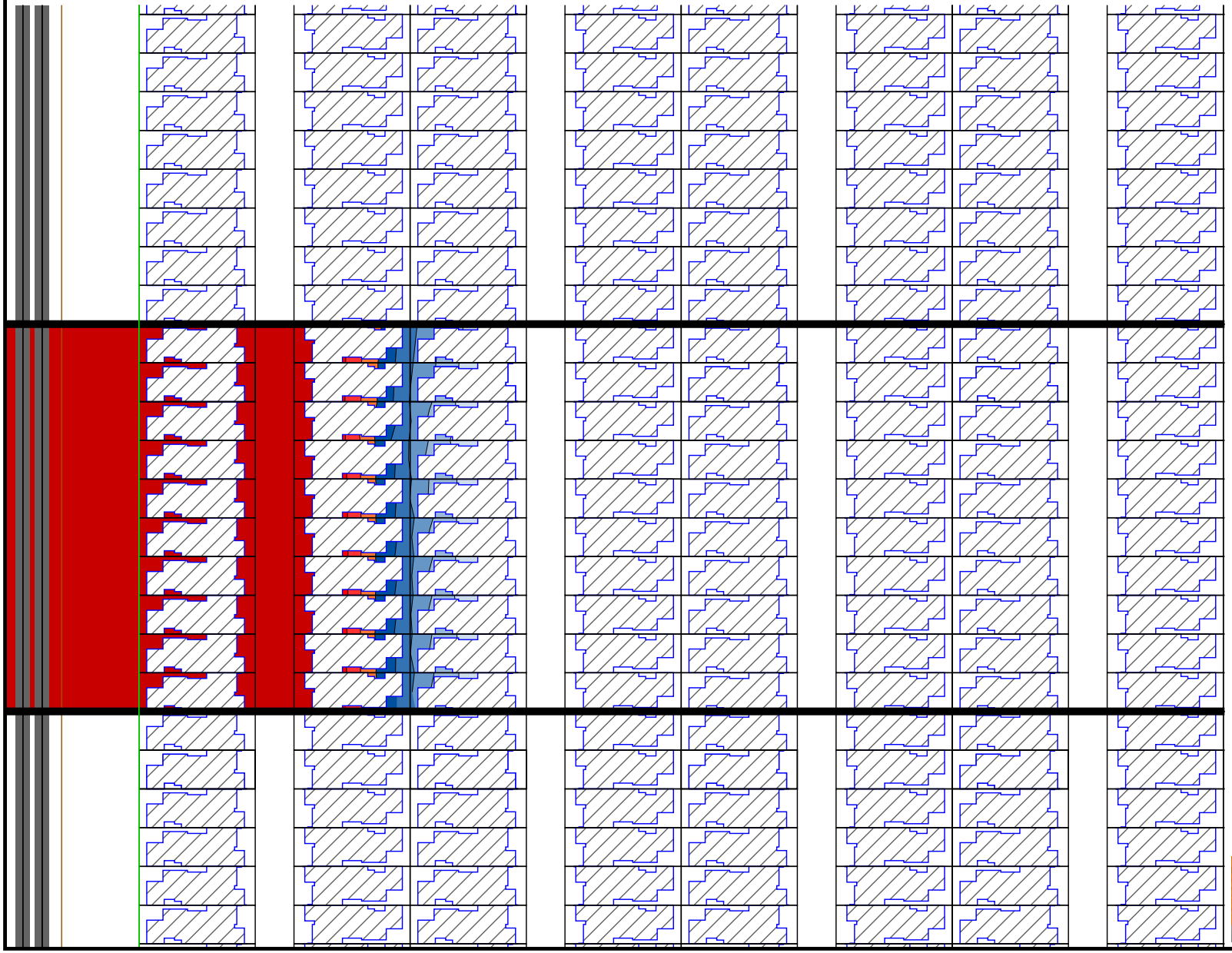
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Boundary to Boundary Double Storey Dwelling (Nominally R30 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure C6c



Noise levels
LAmax dB

75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

Appendix D

Noise Contour Plots – Three Storey R60 Scenario

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure D1

Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

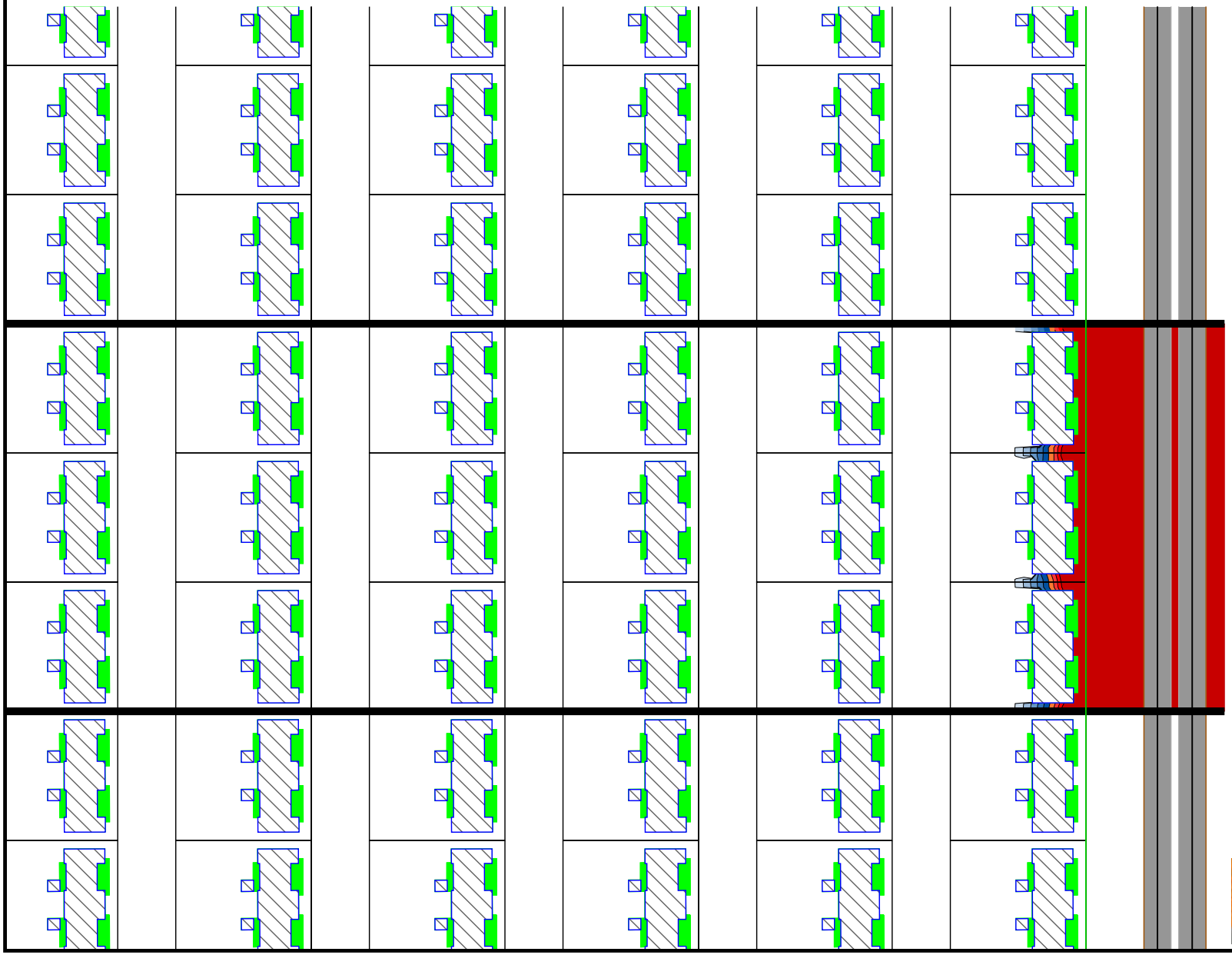
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure D1a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

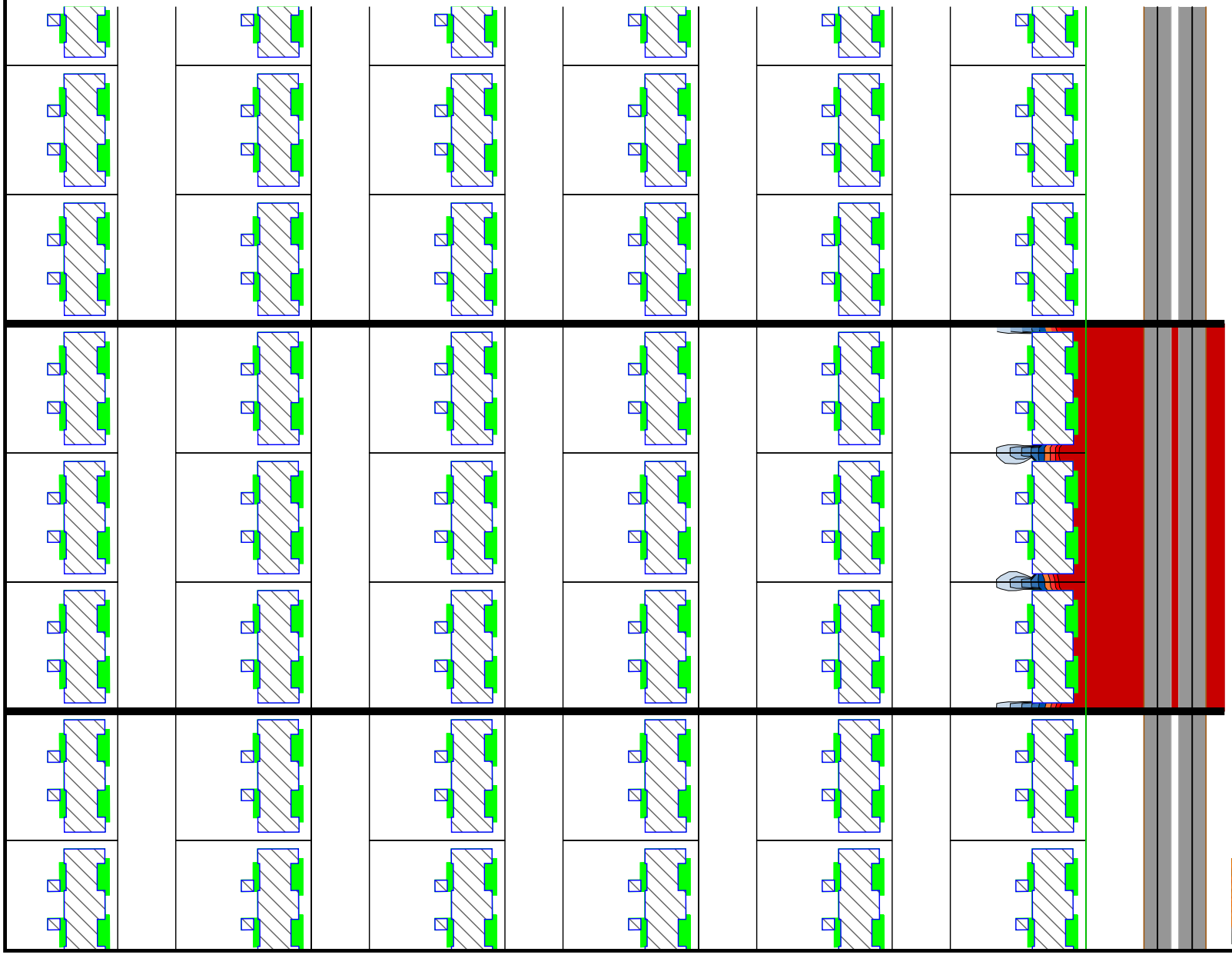
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure D1b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

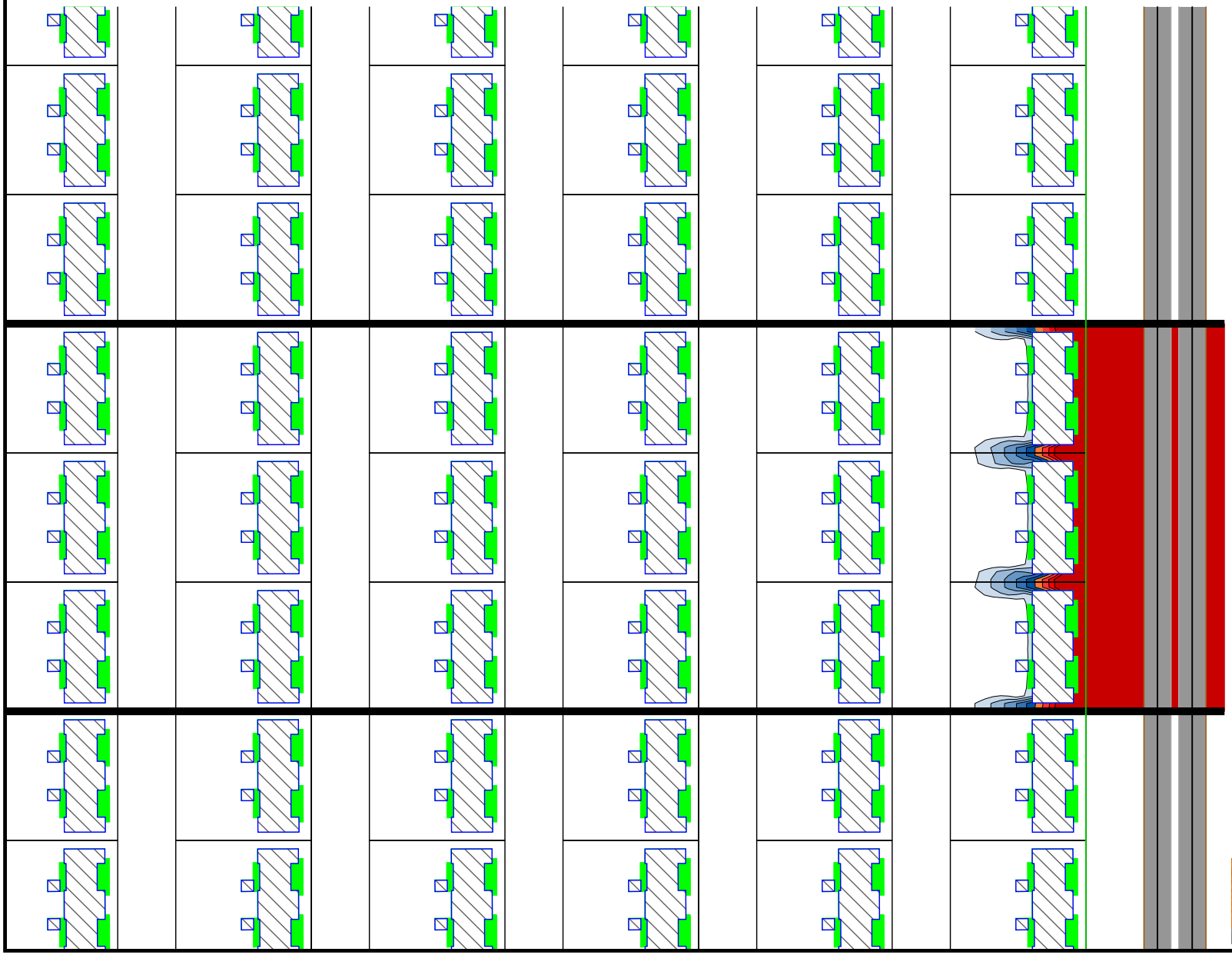
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure D1c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

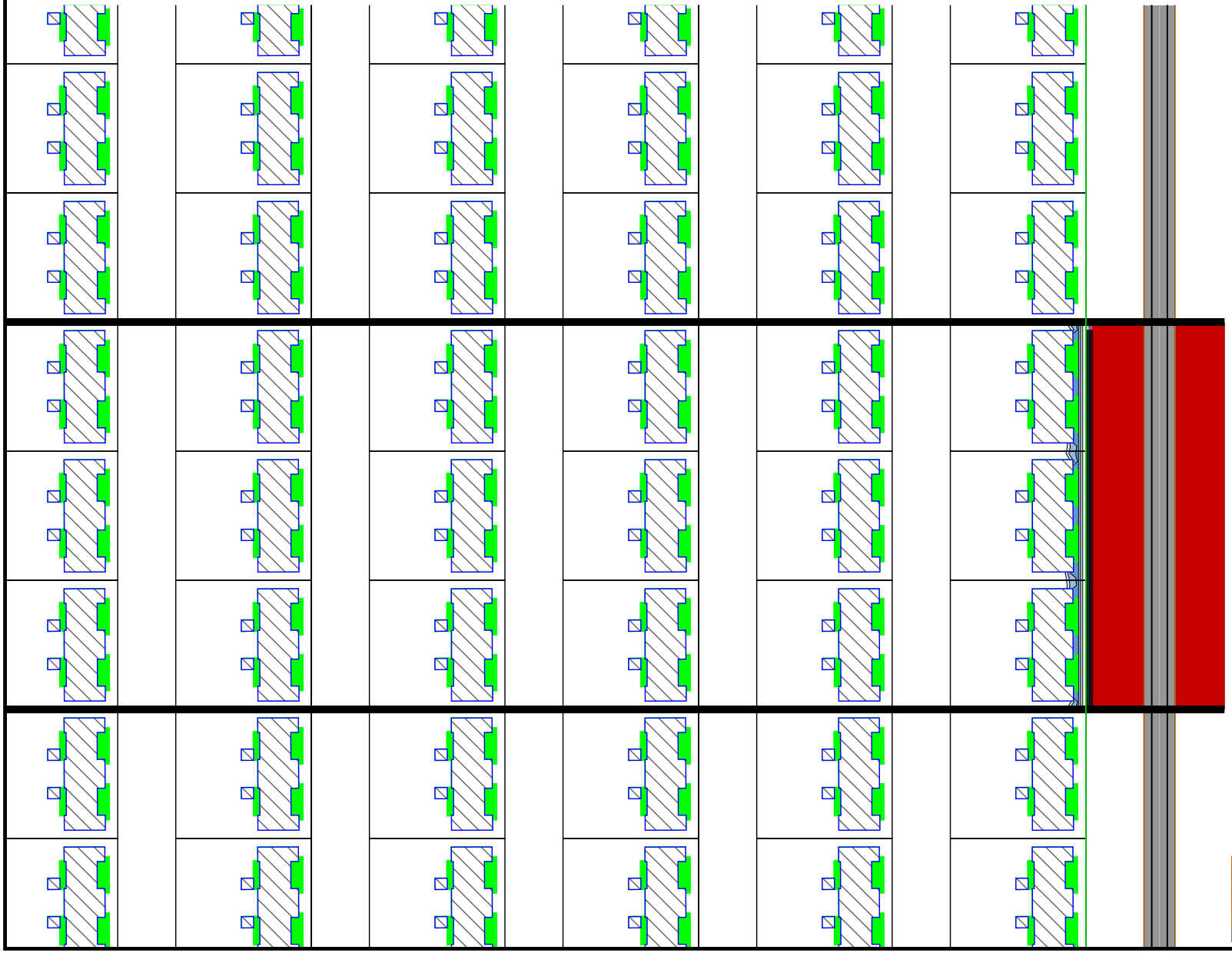
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Farrington: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure D2



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

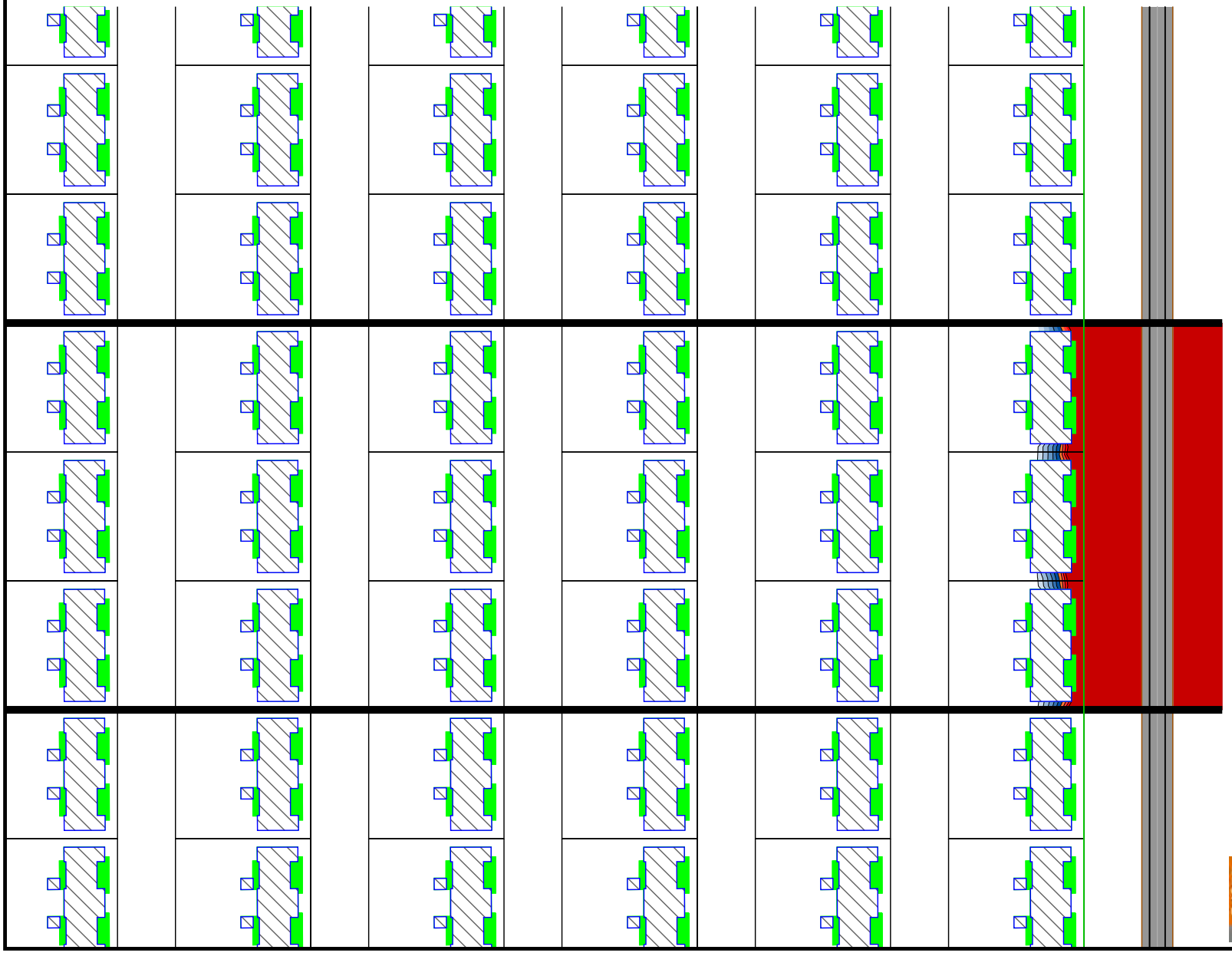
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Farrington: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure D2a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

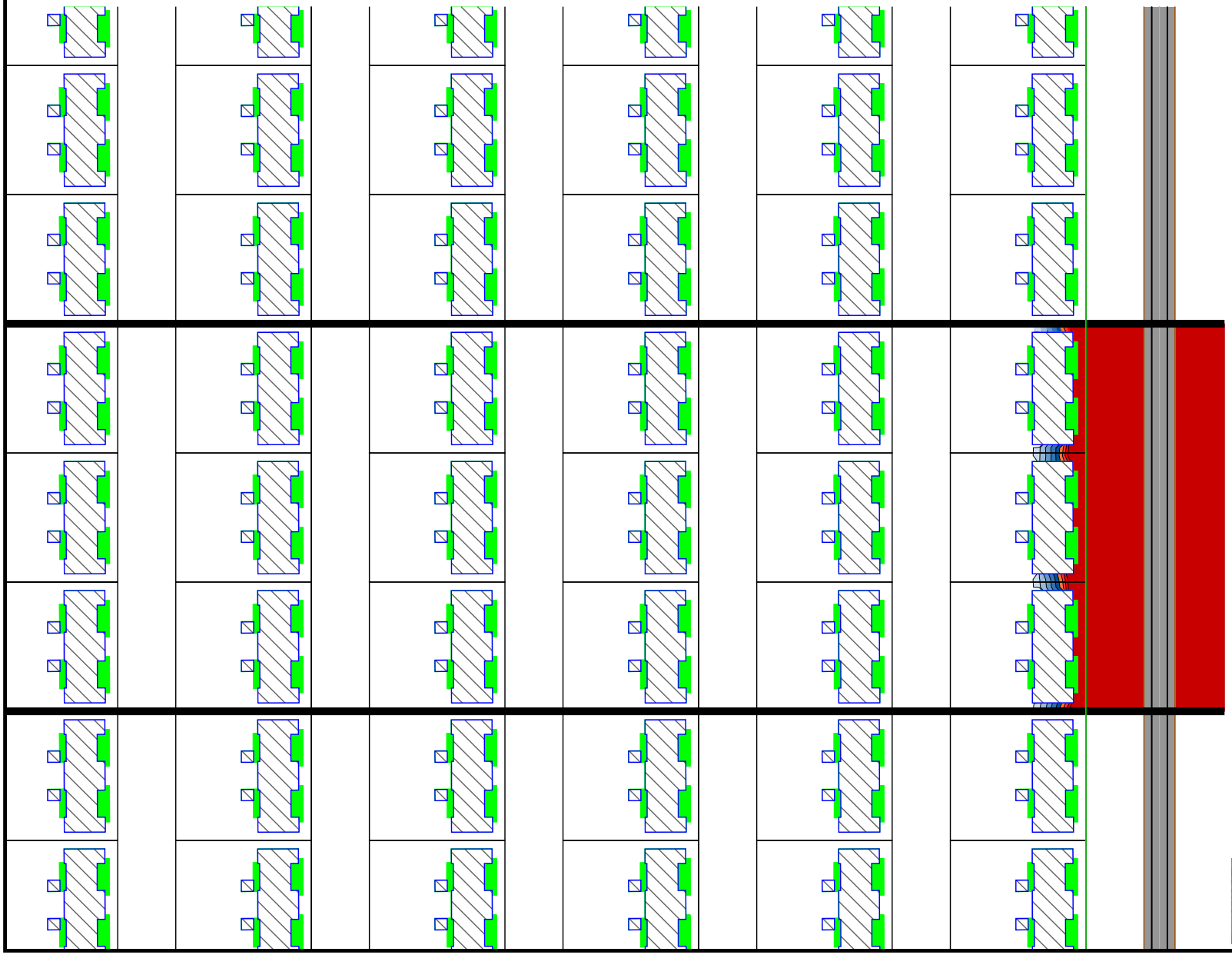
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Farrington: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure D2b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

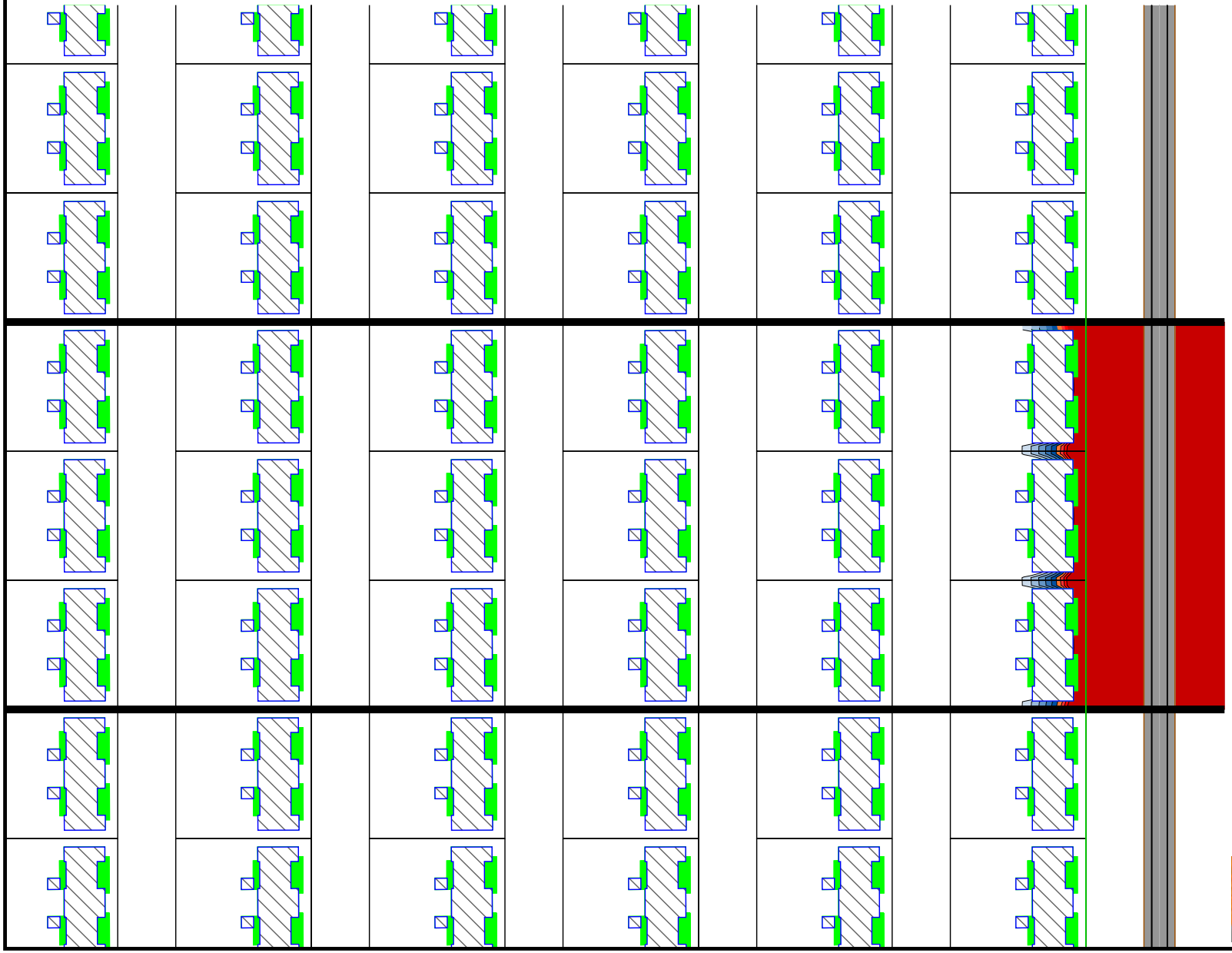
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Farrington: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure D2c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

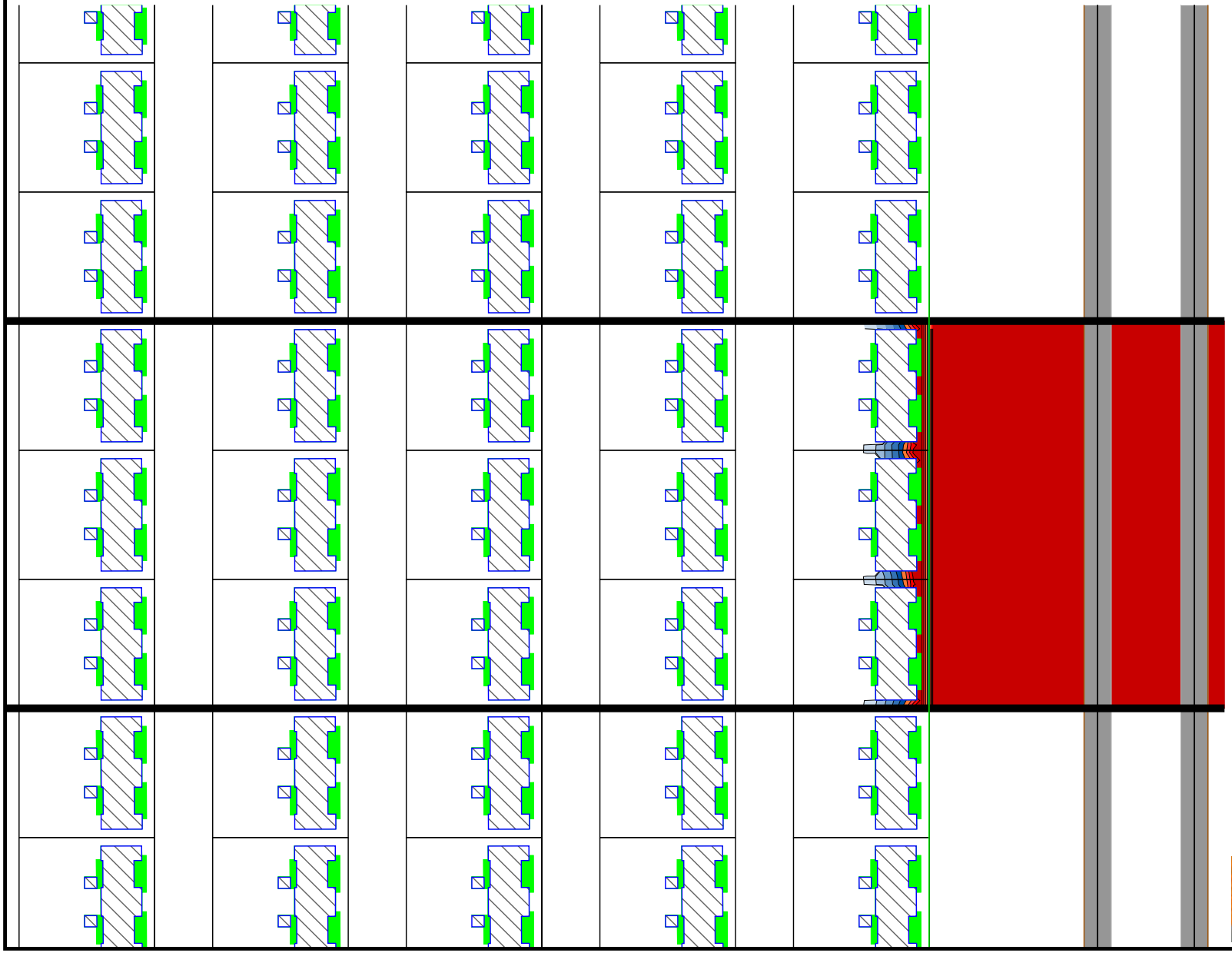
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure D3



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

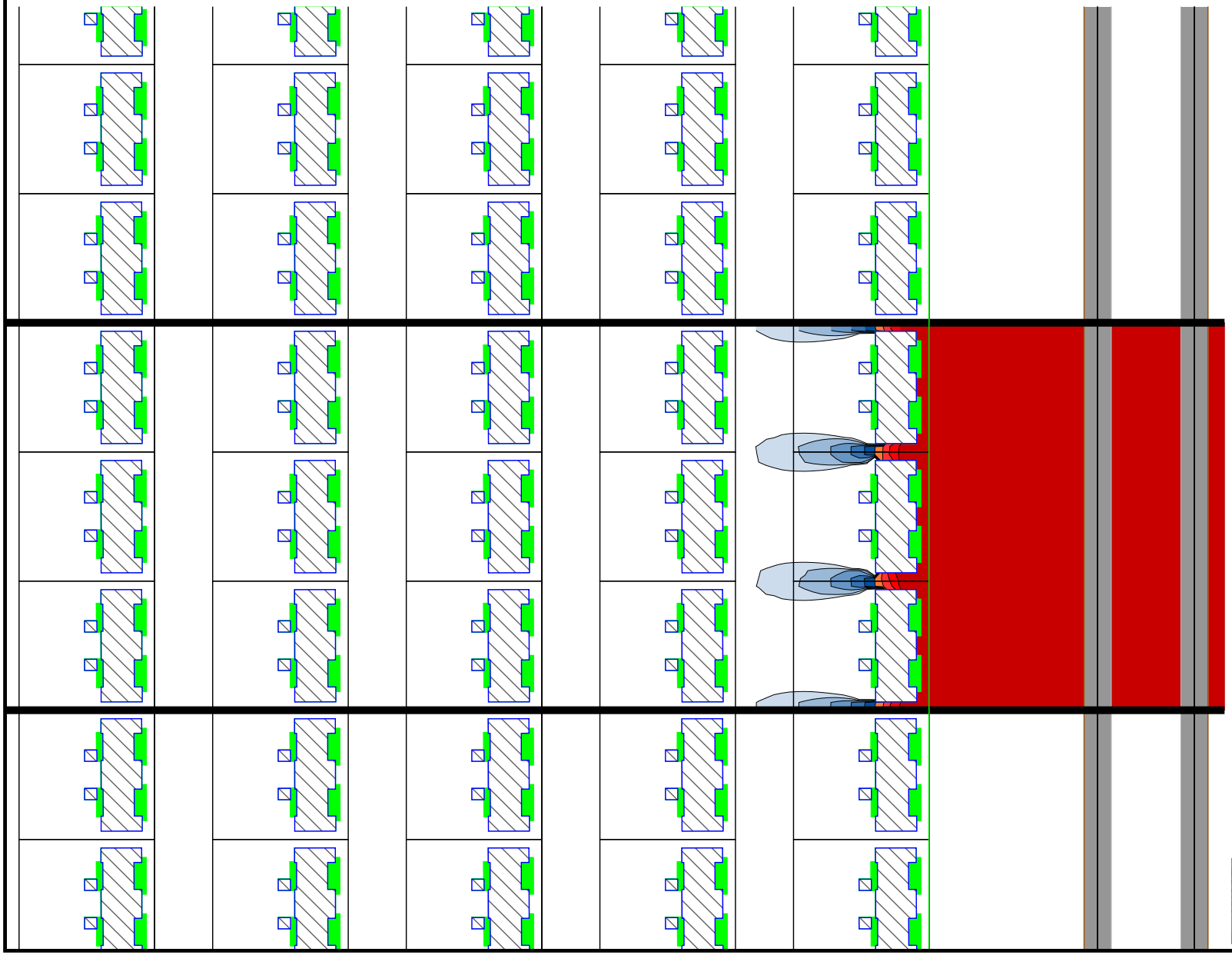
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure D3a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

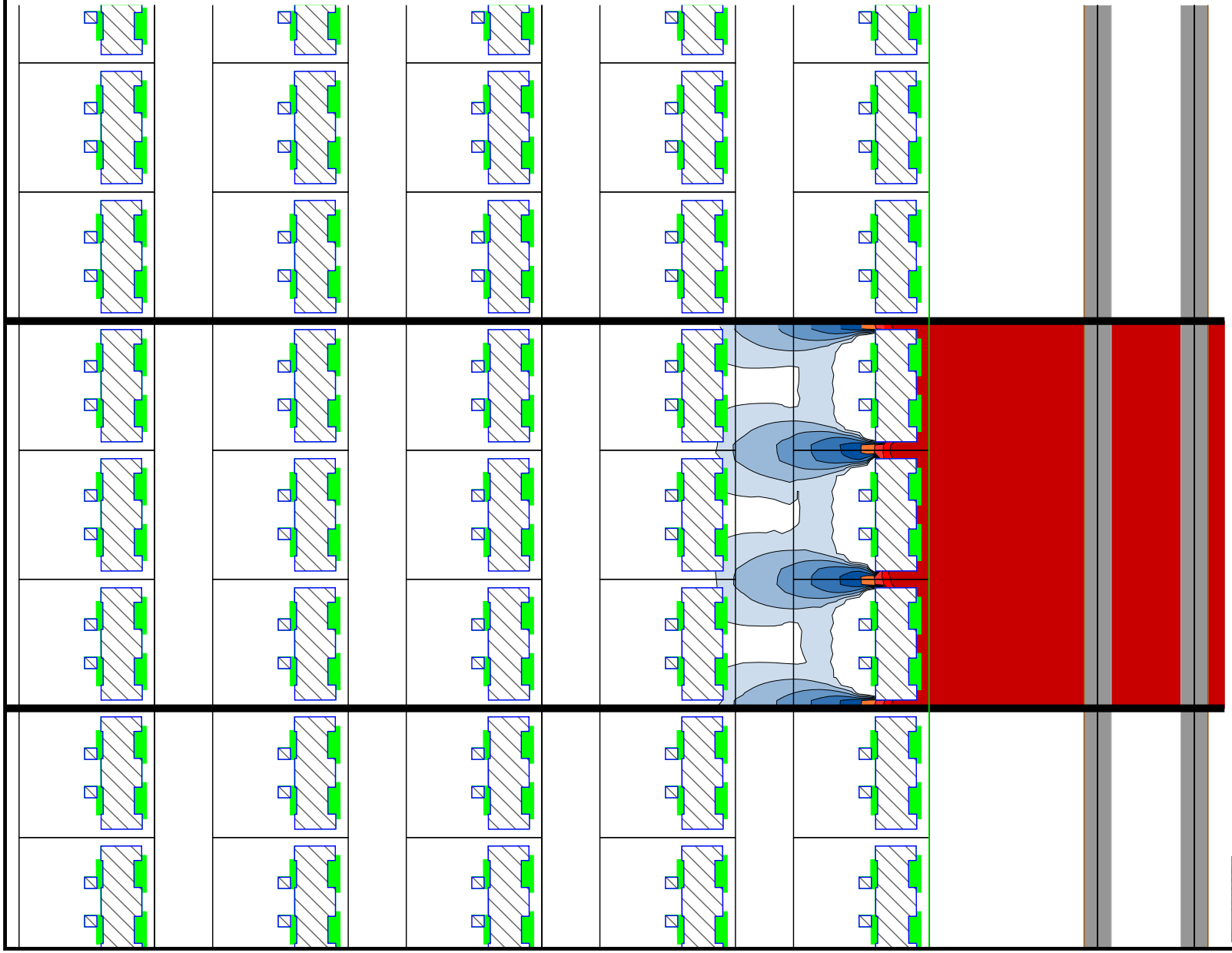
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure D3b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

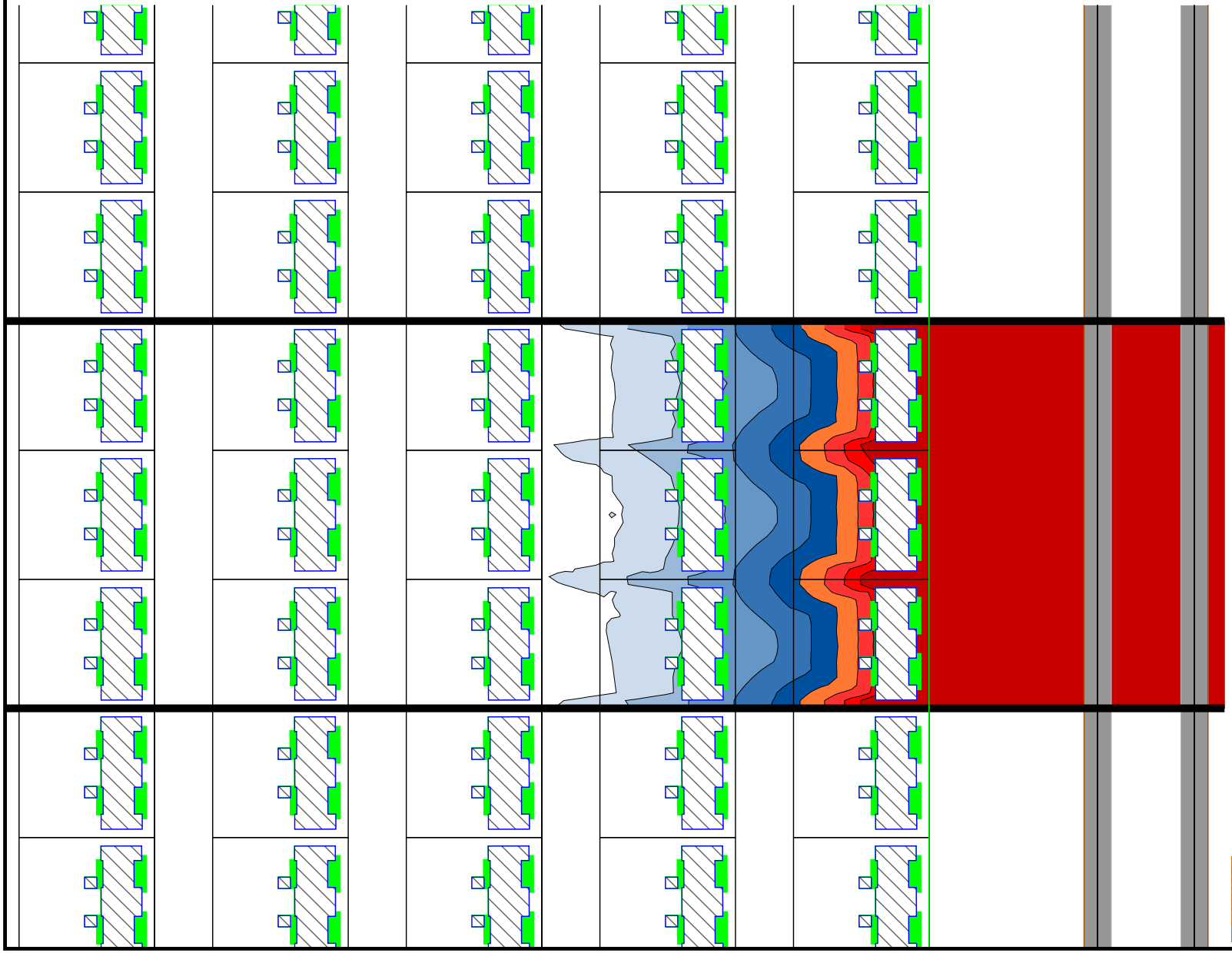
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Roe Highway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure D3c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

0 10 20 40 60 m

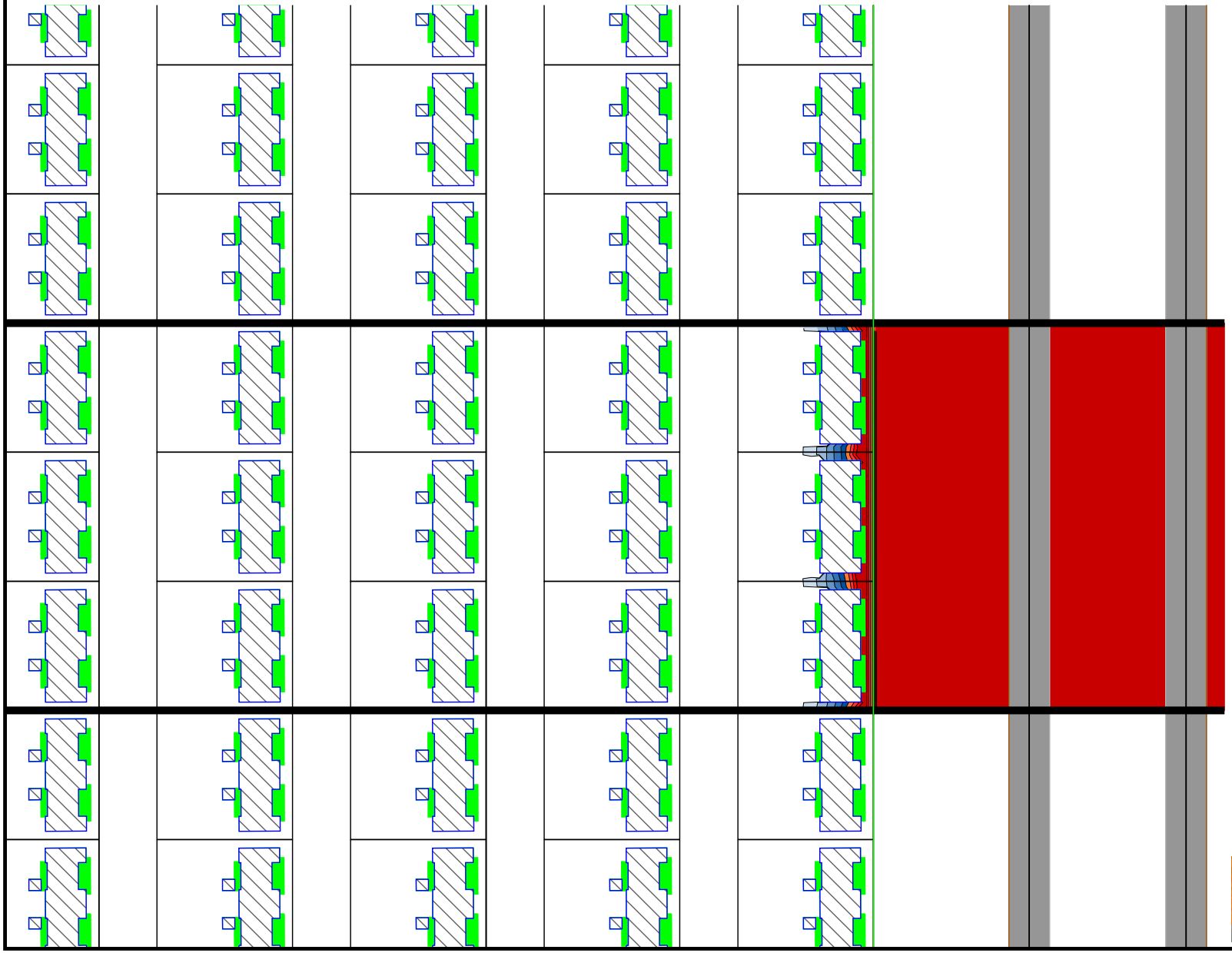
Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

Figure D4

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Three Storey Apartments (Nominally R60 Zoning)

Predicted Noise Levels at 1.4m Above Ground Level



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

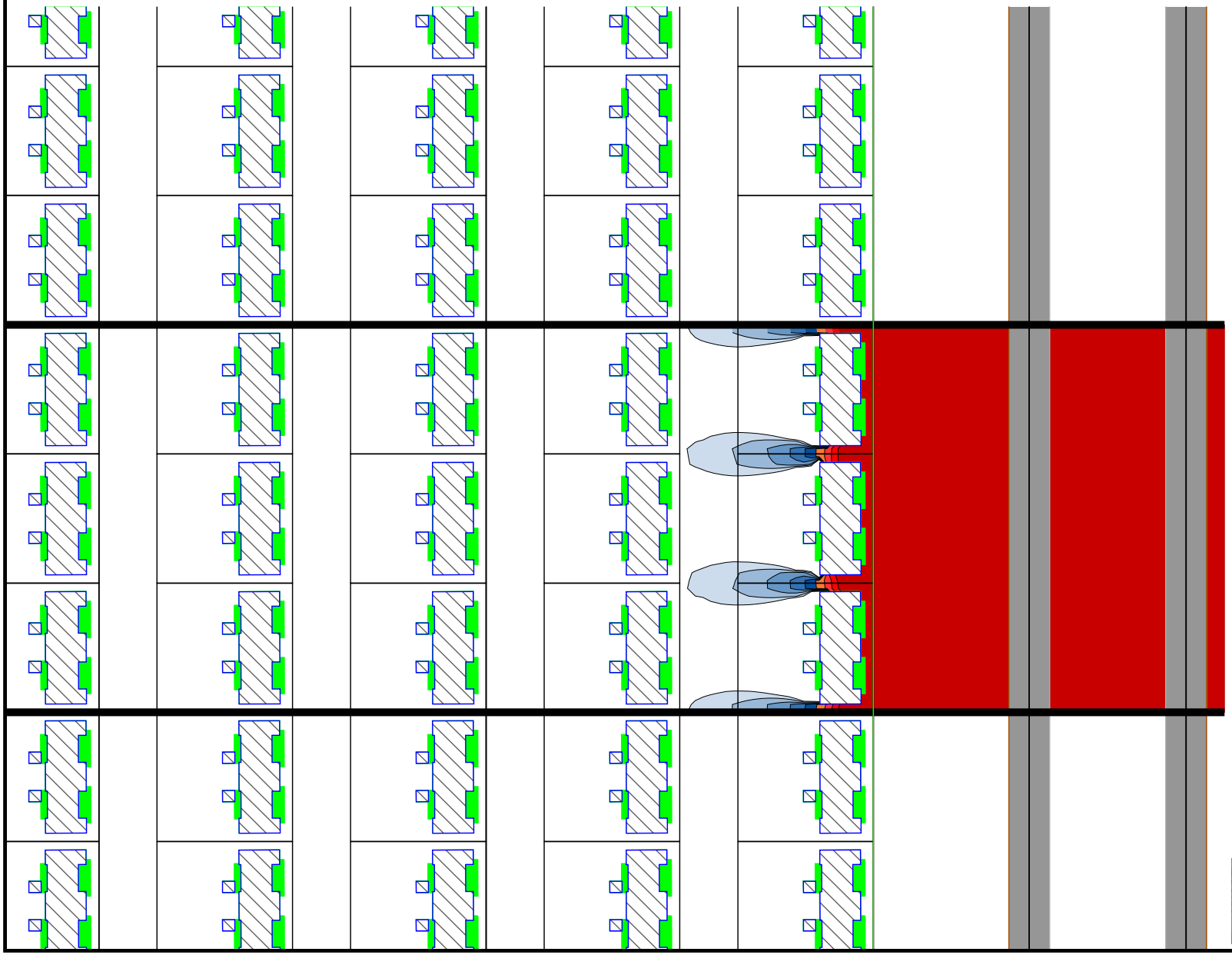
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure D4a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

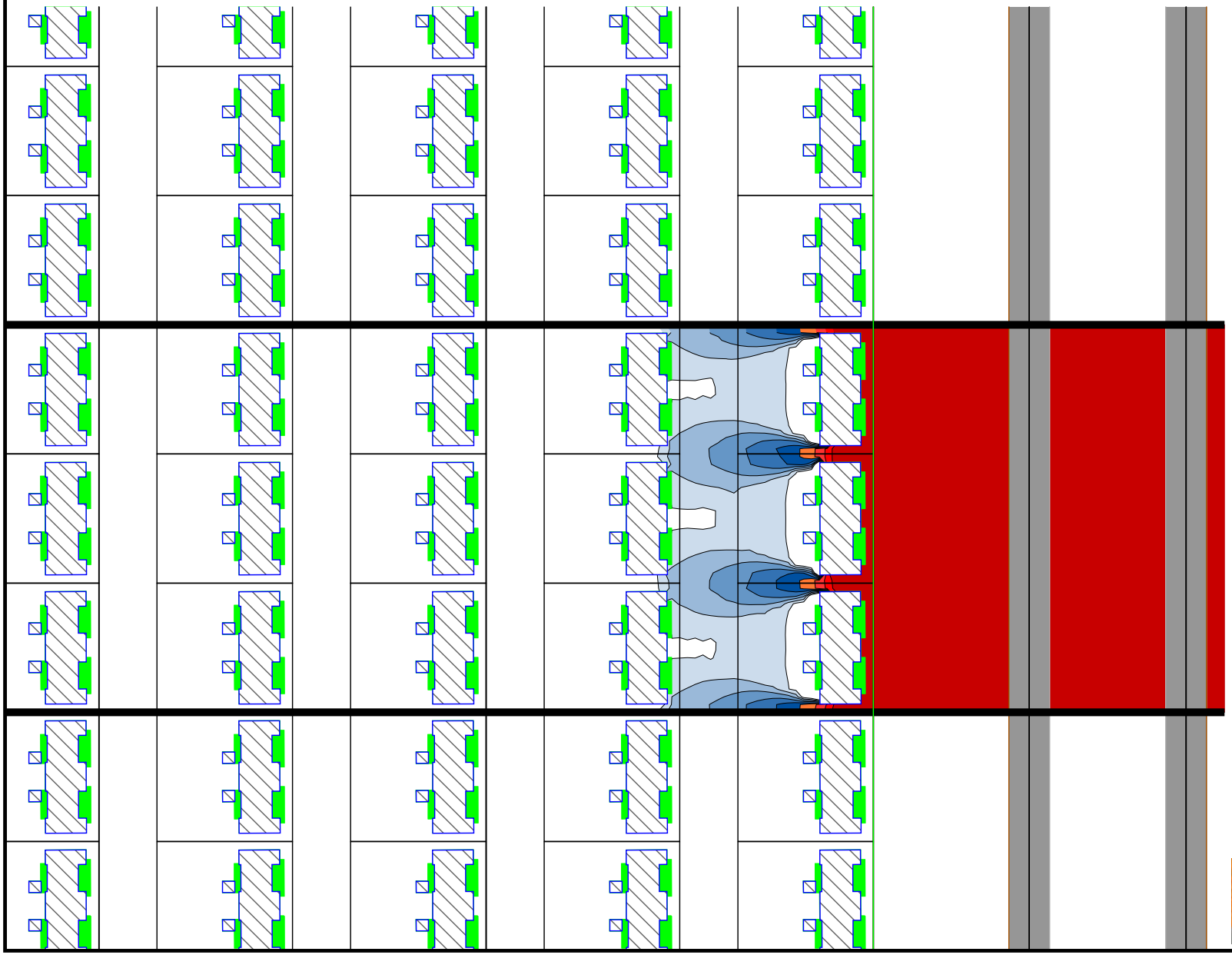
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure D4b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

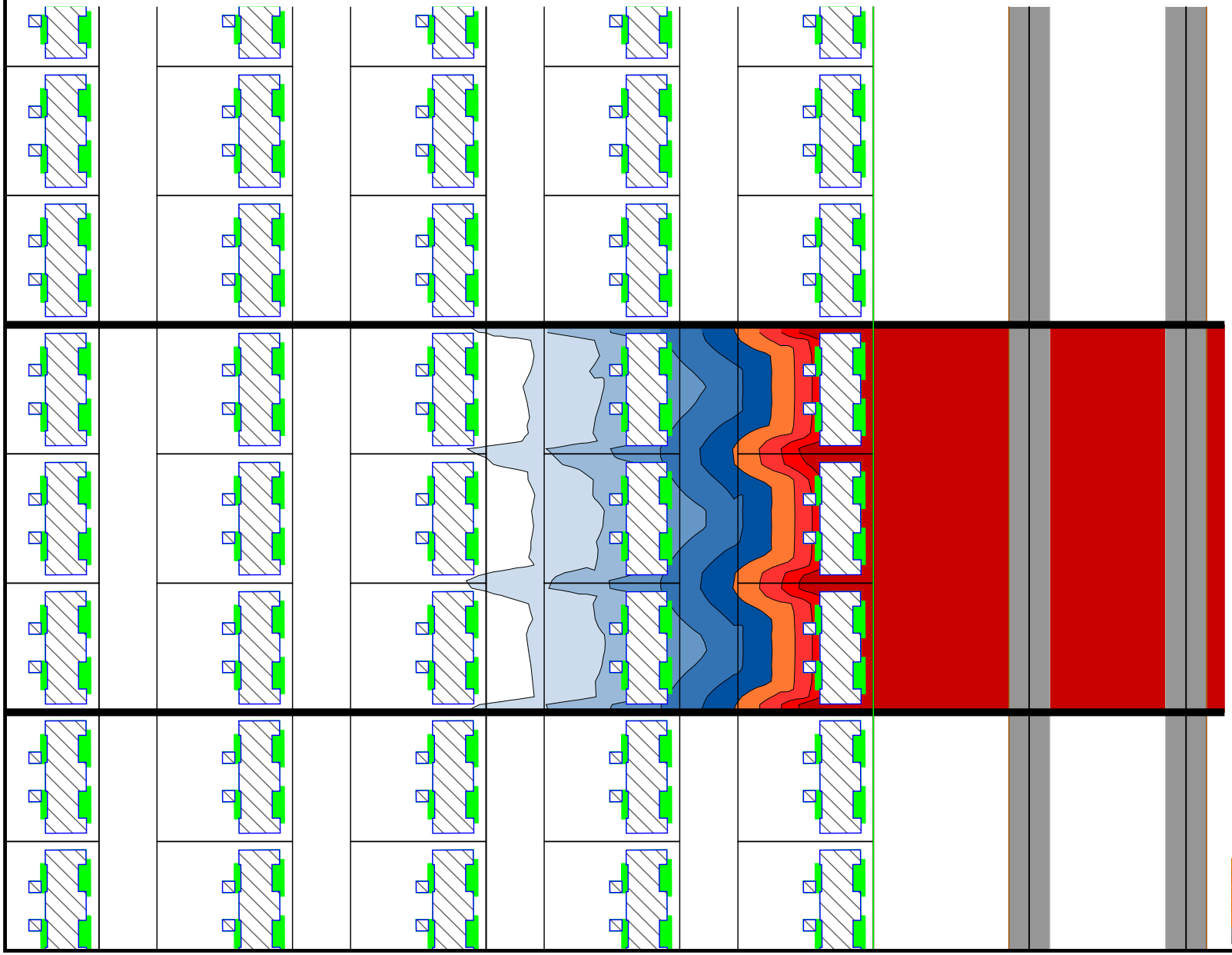
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours - Kwinana Freeway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure D4c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

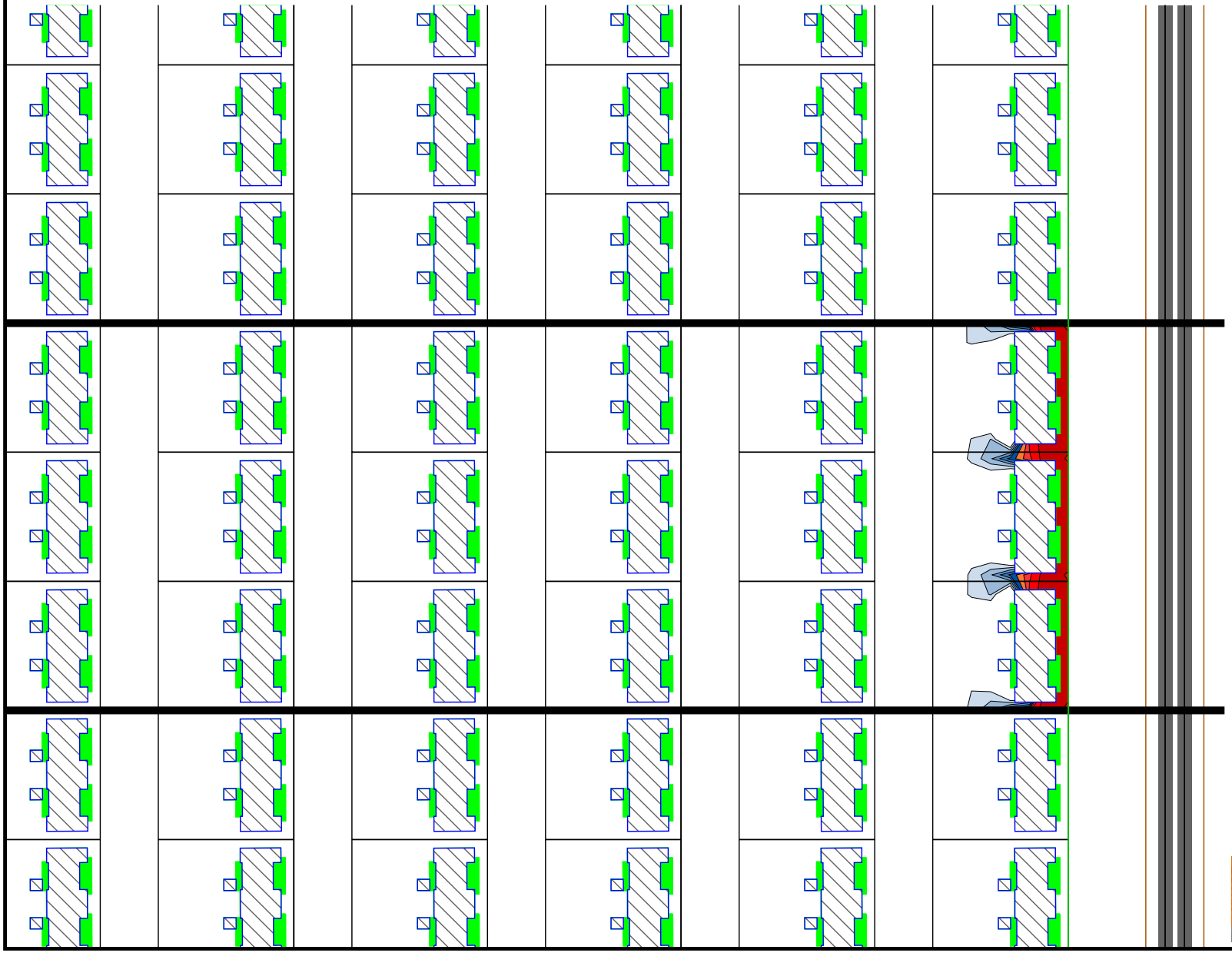
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure D5



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

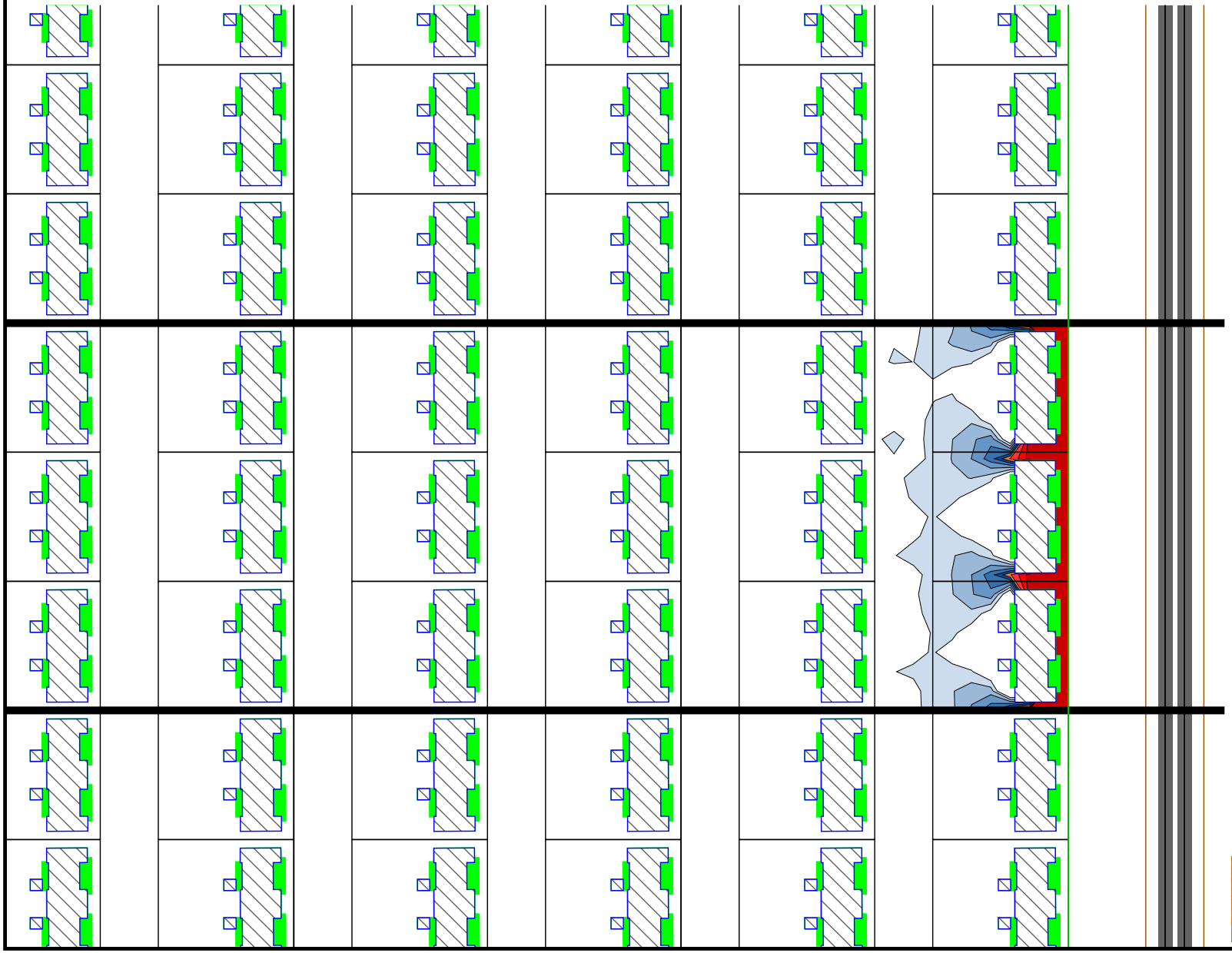
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure D5a



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

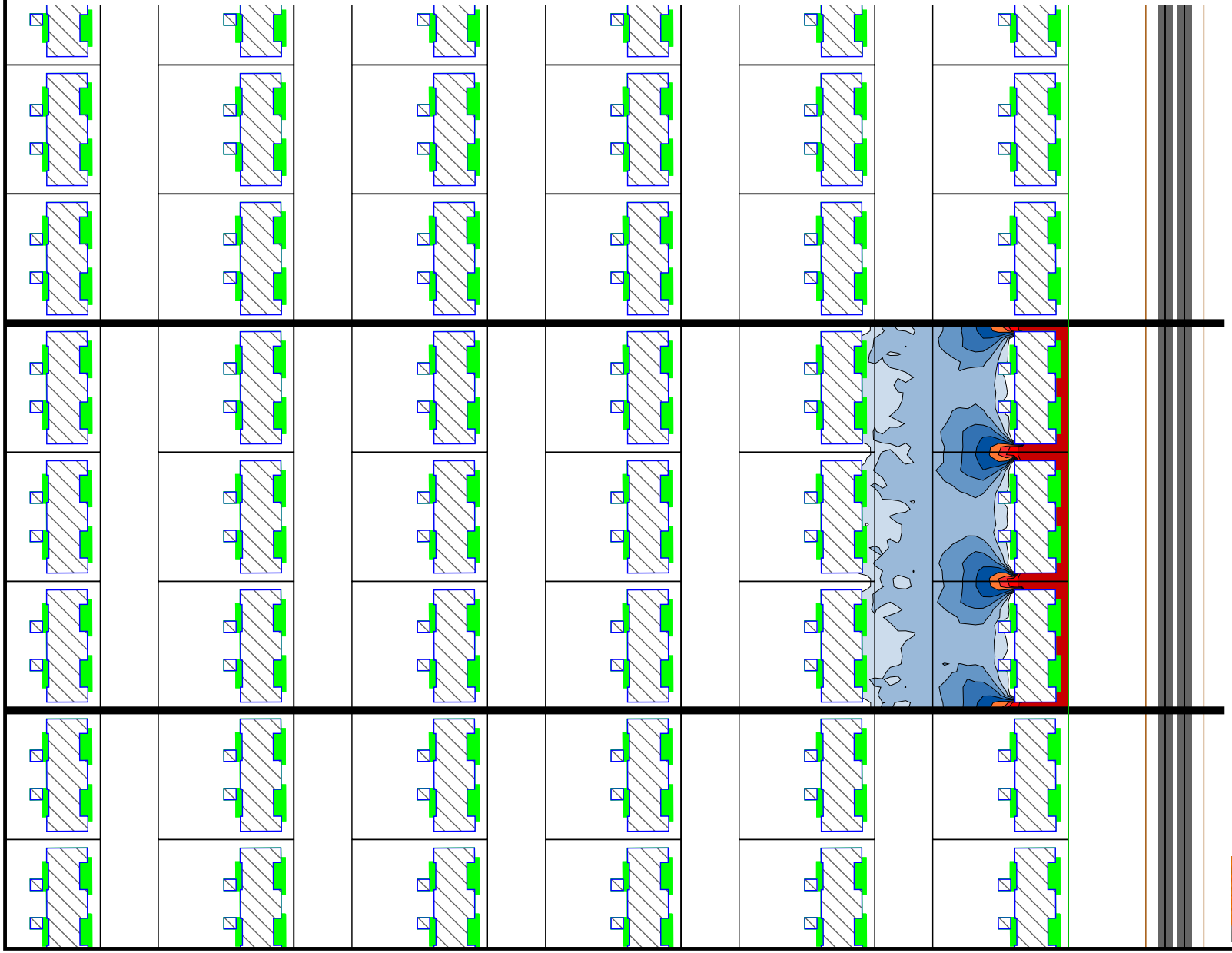
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure D5b



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

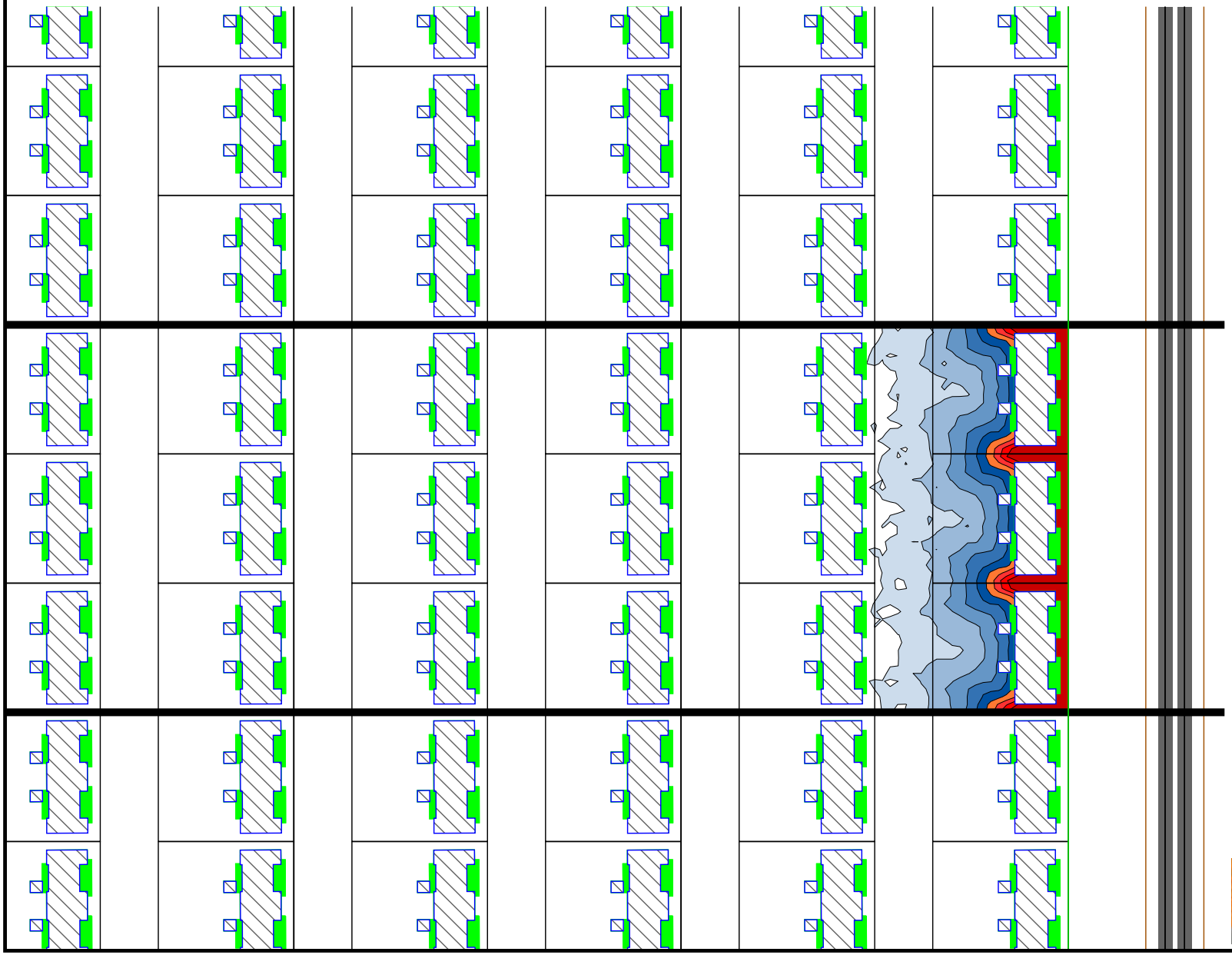
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure D5c



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

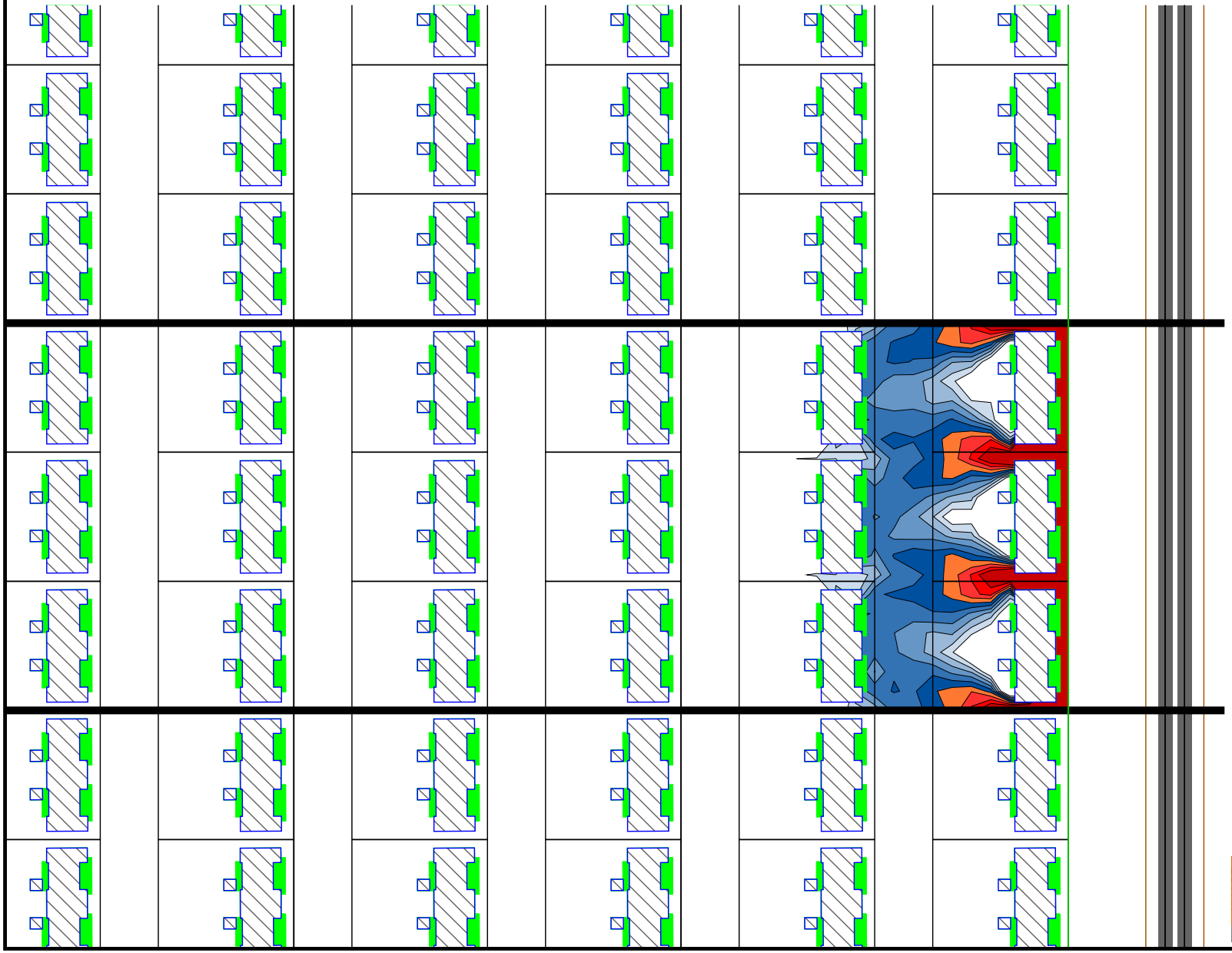
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 1.4m Above Ground Level

Figure D6



Noise levels
LAmax,Night dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

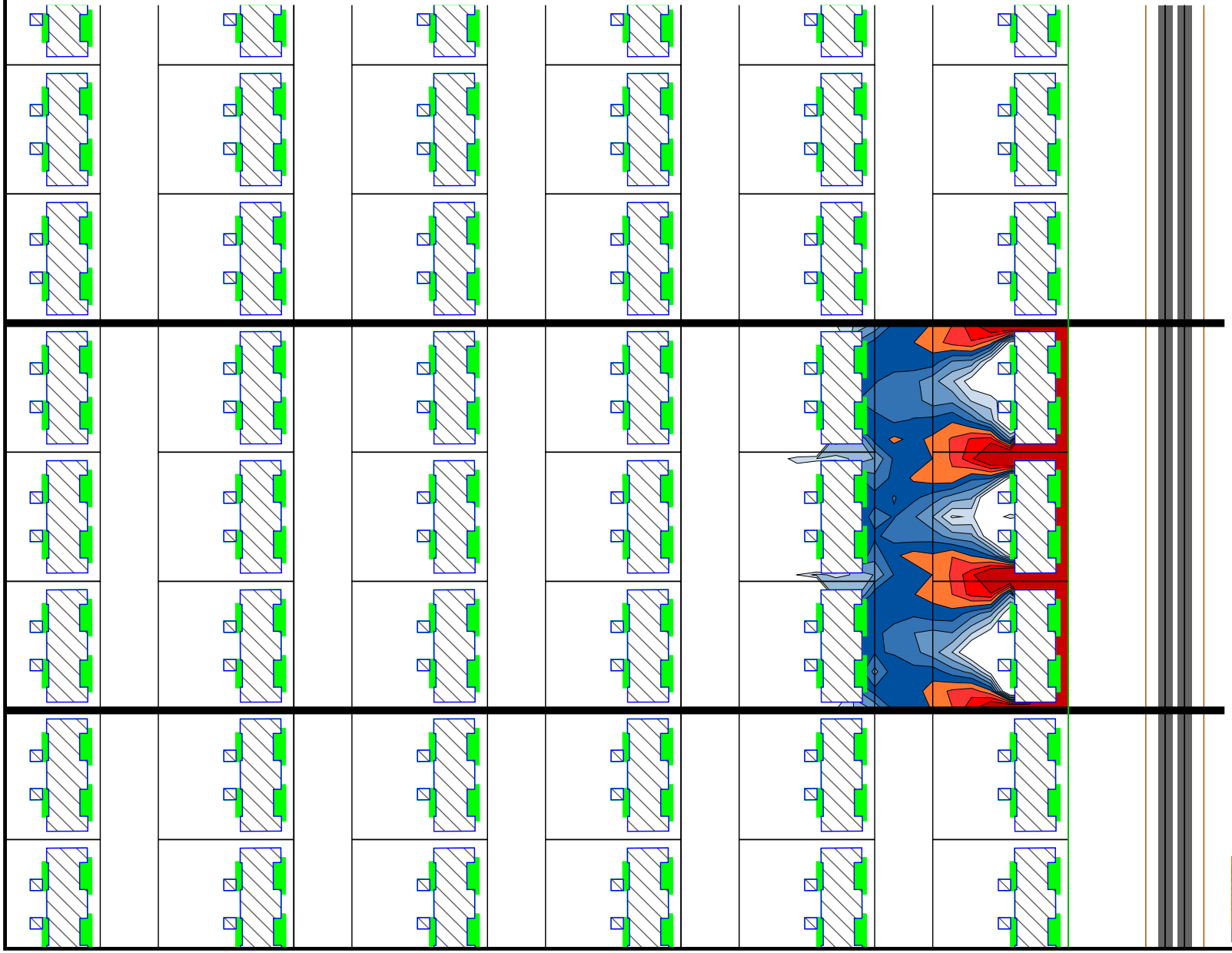
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure D6a



Noise levels
LAmax,Night dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

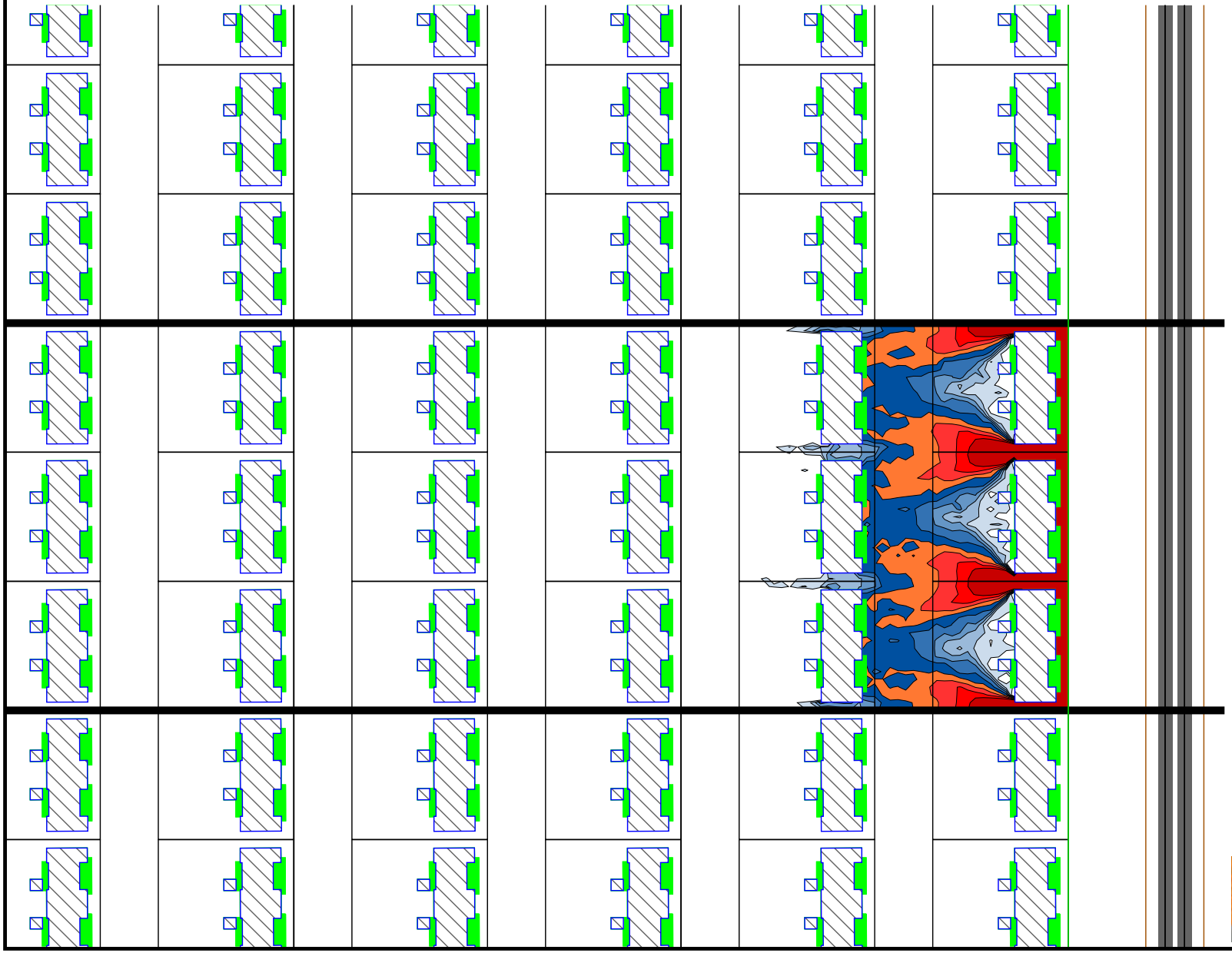
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure D6b



Noise levels
LAmax,Night dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

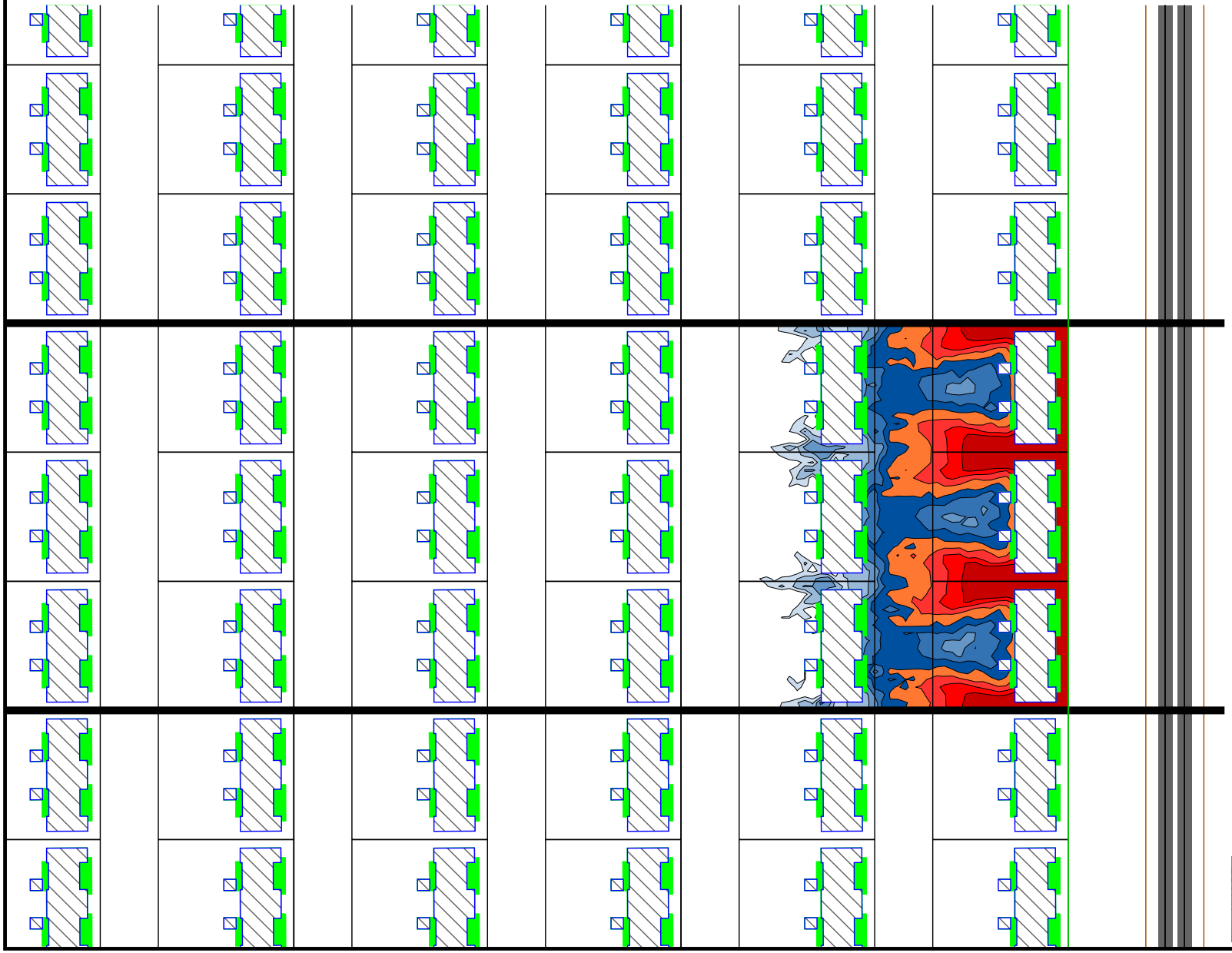
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Three Storey Apartments (Nominally R60 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure D6c



Noise levels
LAmax,Night dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

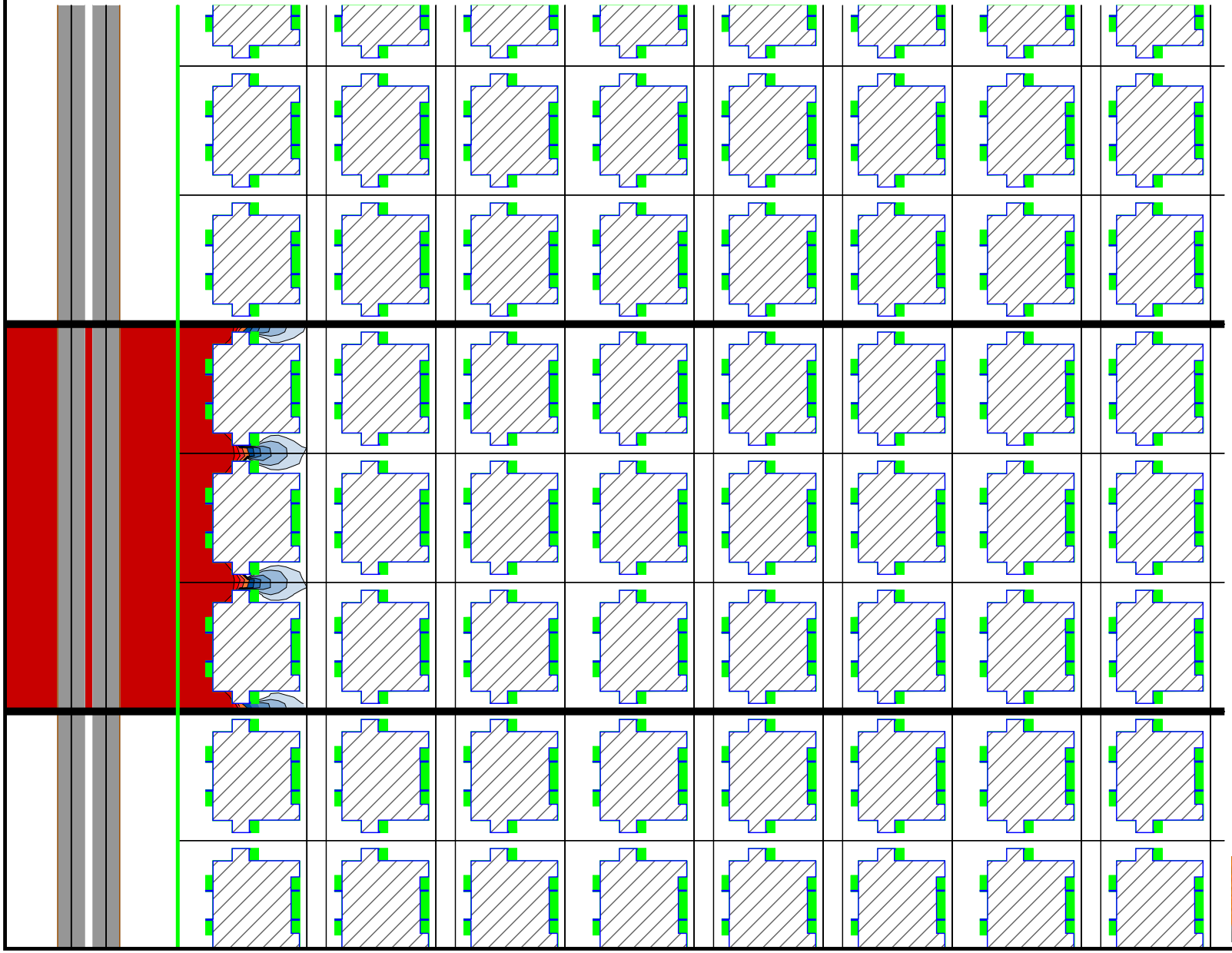
Appendix E

Noise Contour Plots – Four Storey R100 Scenario

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure E1a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

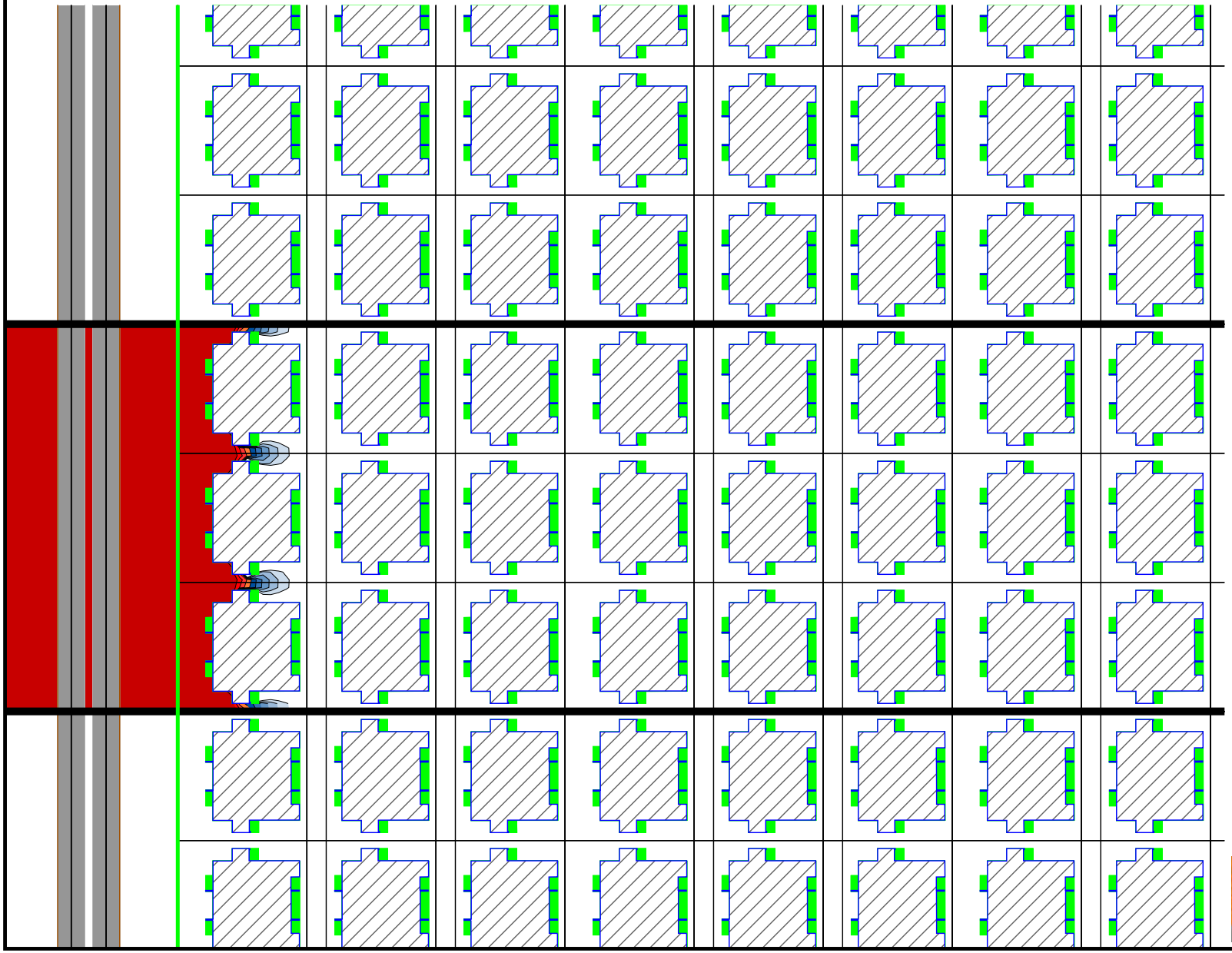
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure E1b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

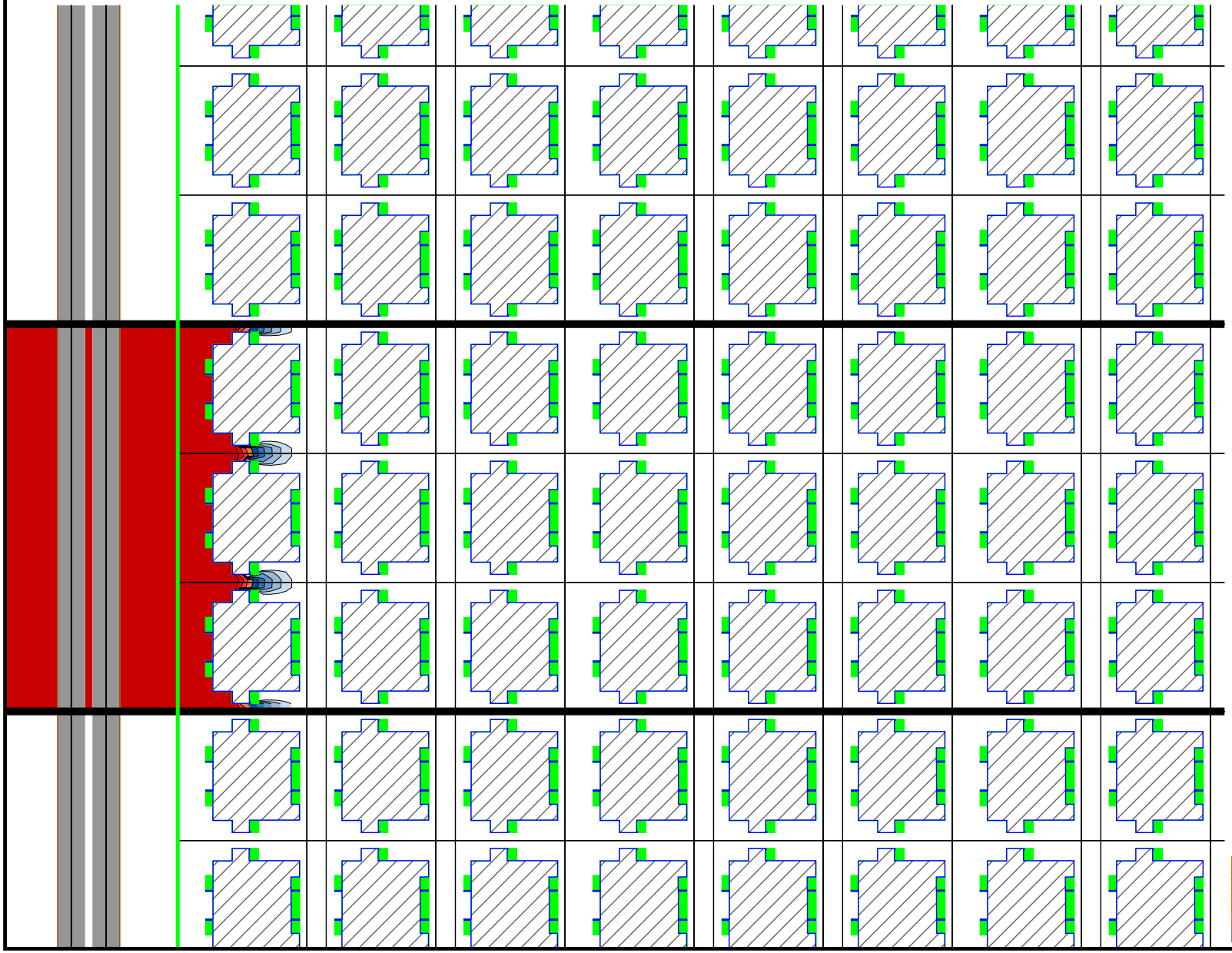
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -North Lake Road: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure E1c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

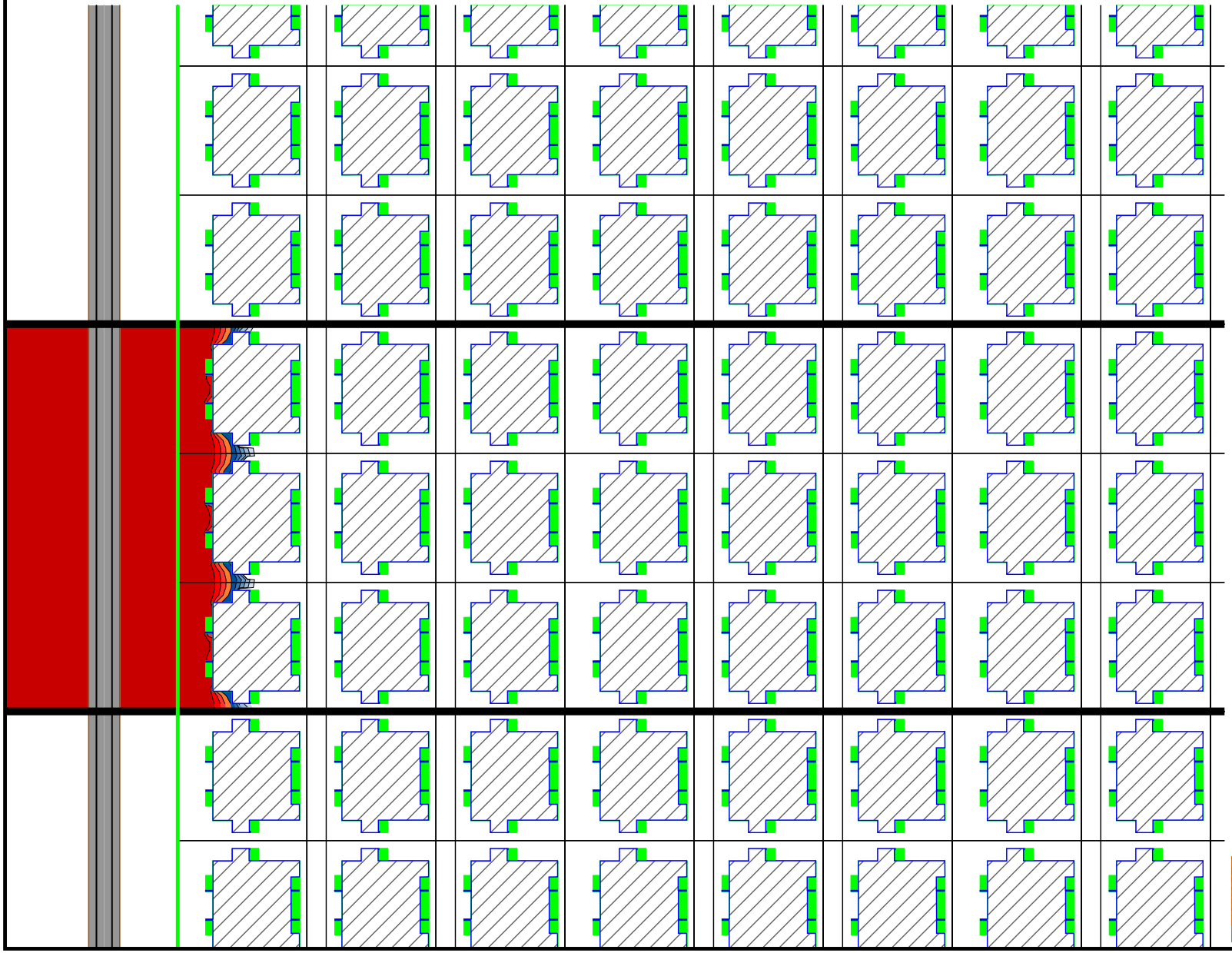
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Farrington Road: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure E2a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

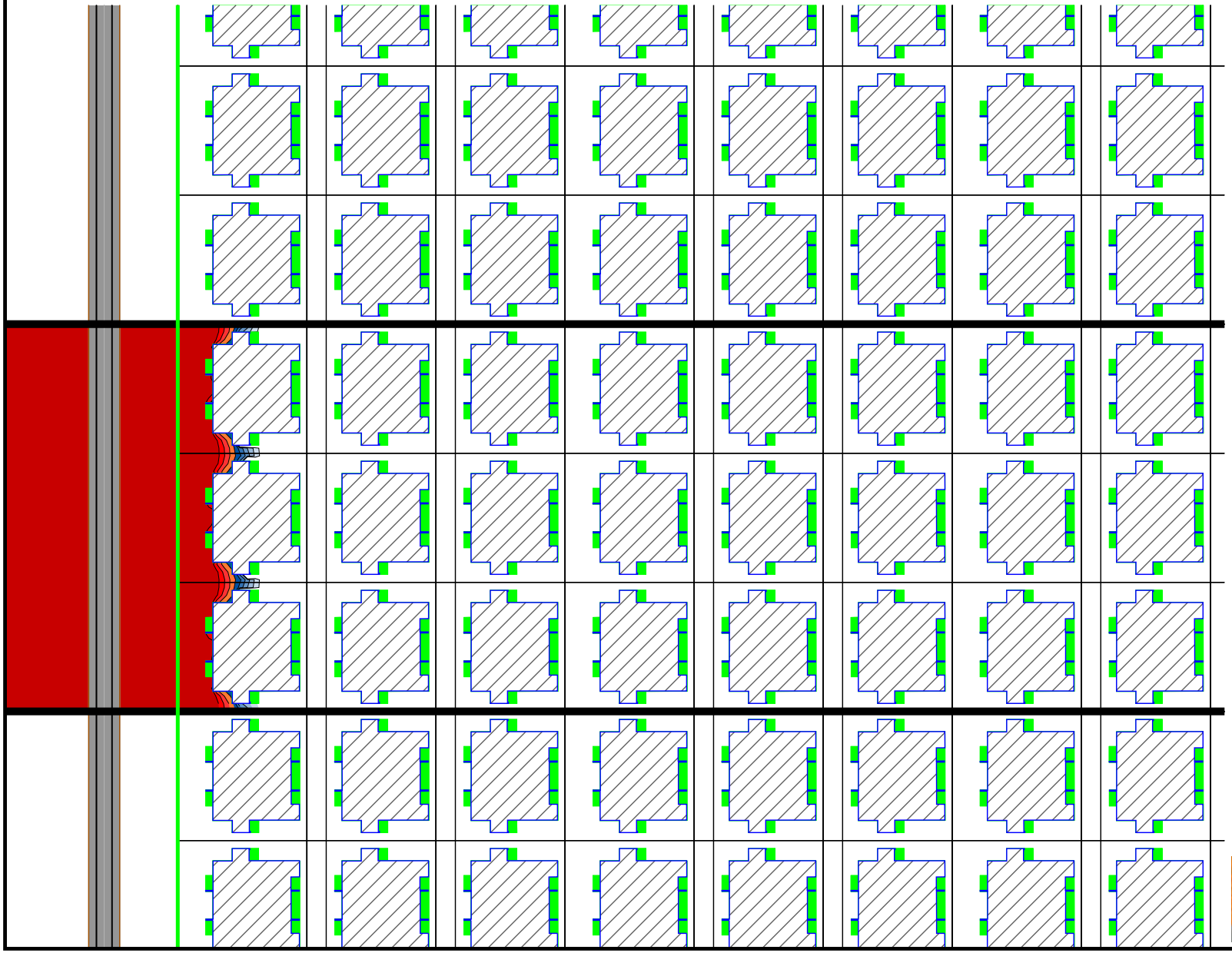
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Farrington Road: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure E2b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

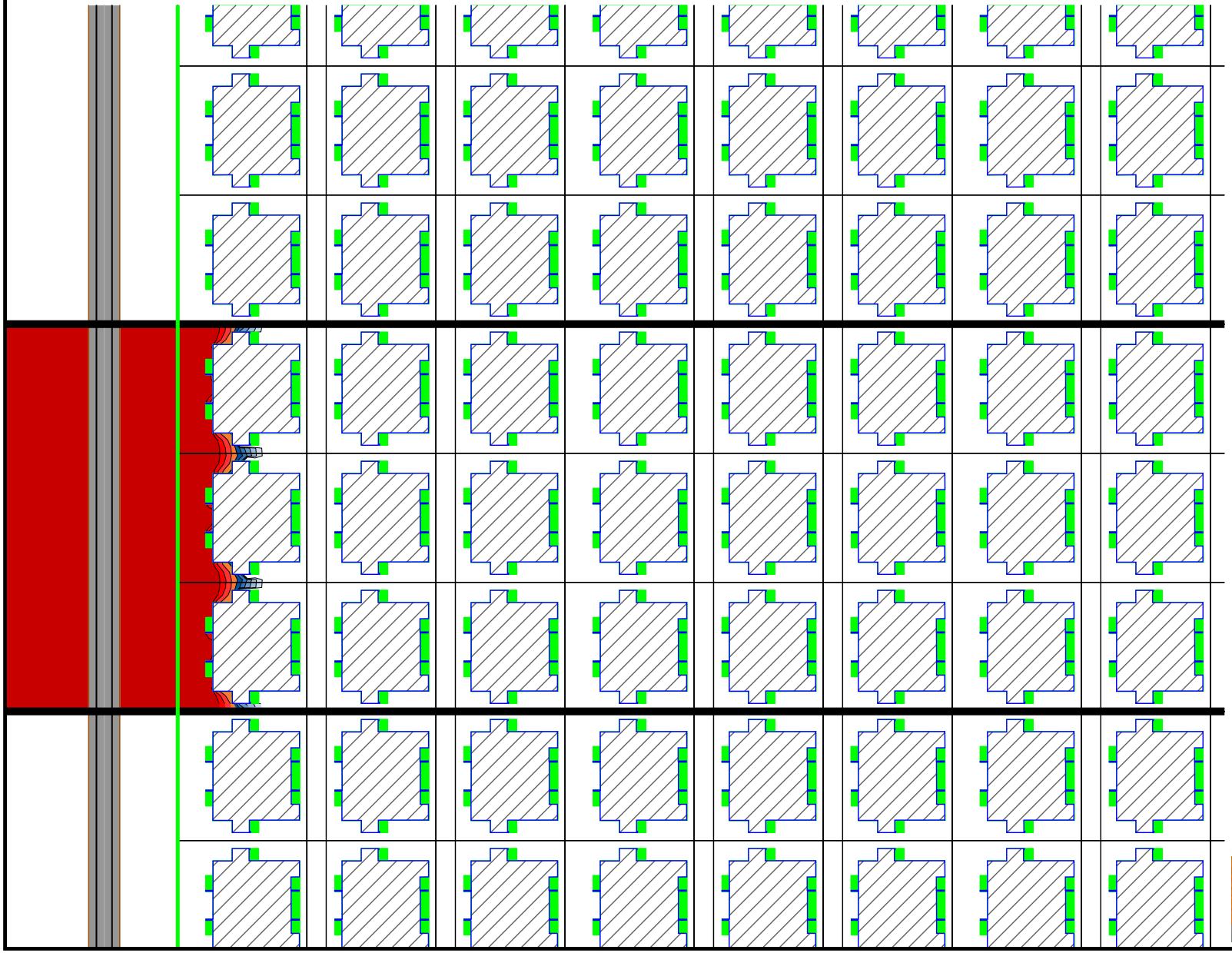
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Farrington Road: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure E2c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

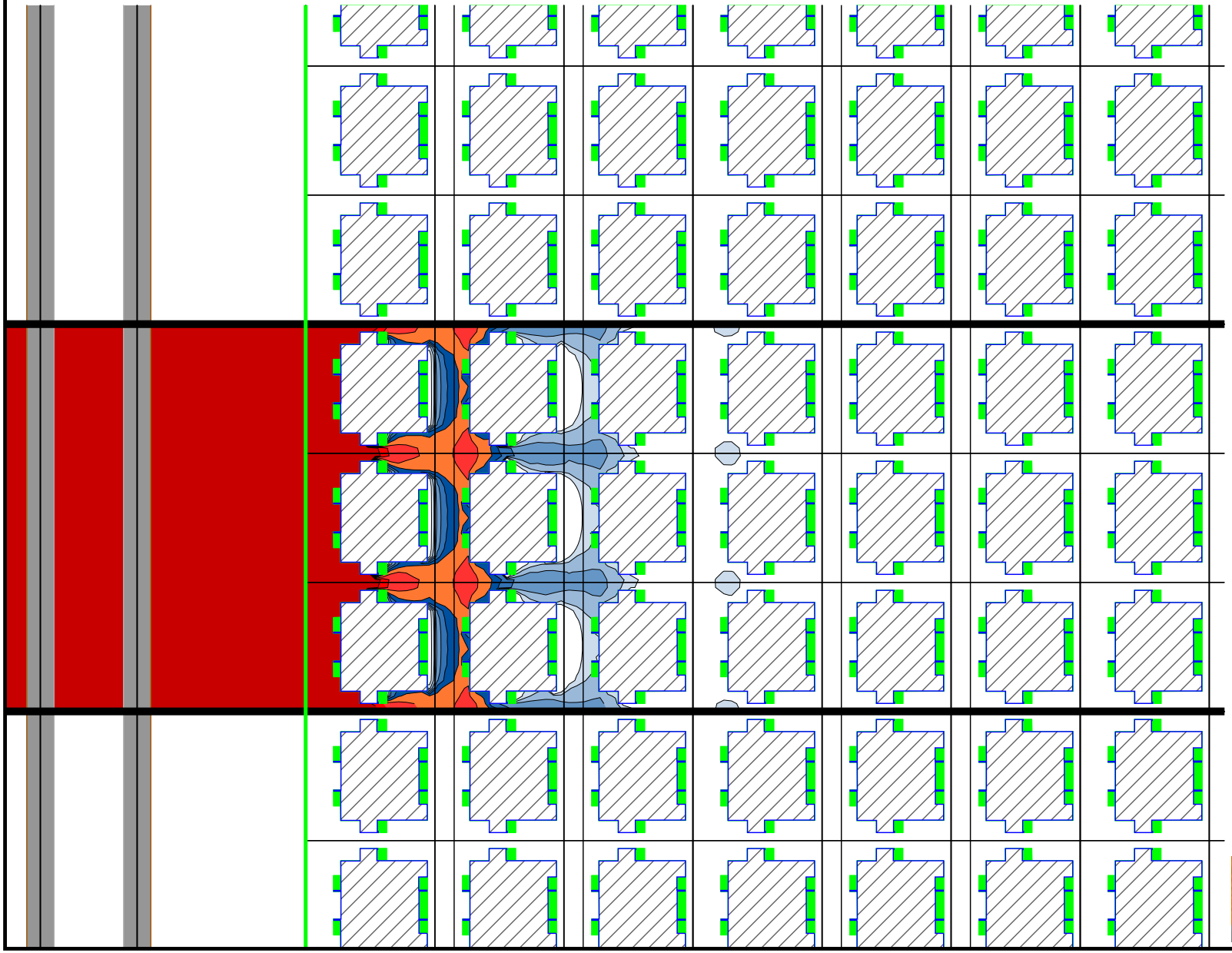
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Roe Highway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure E3a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

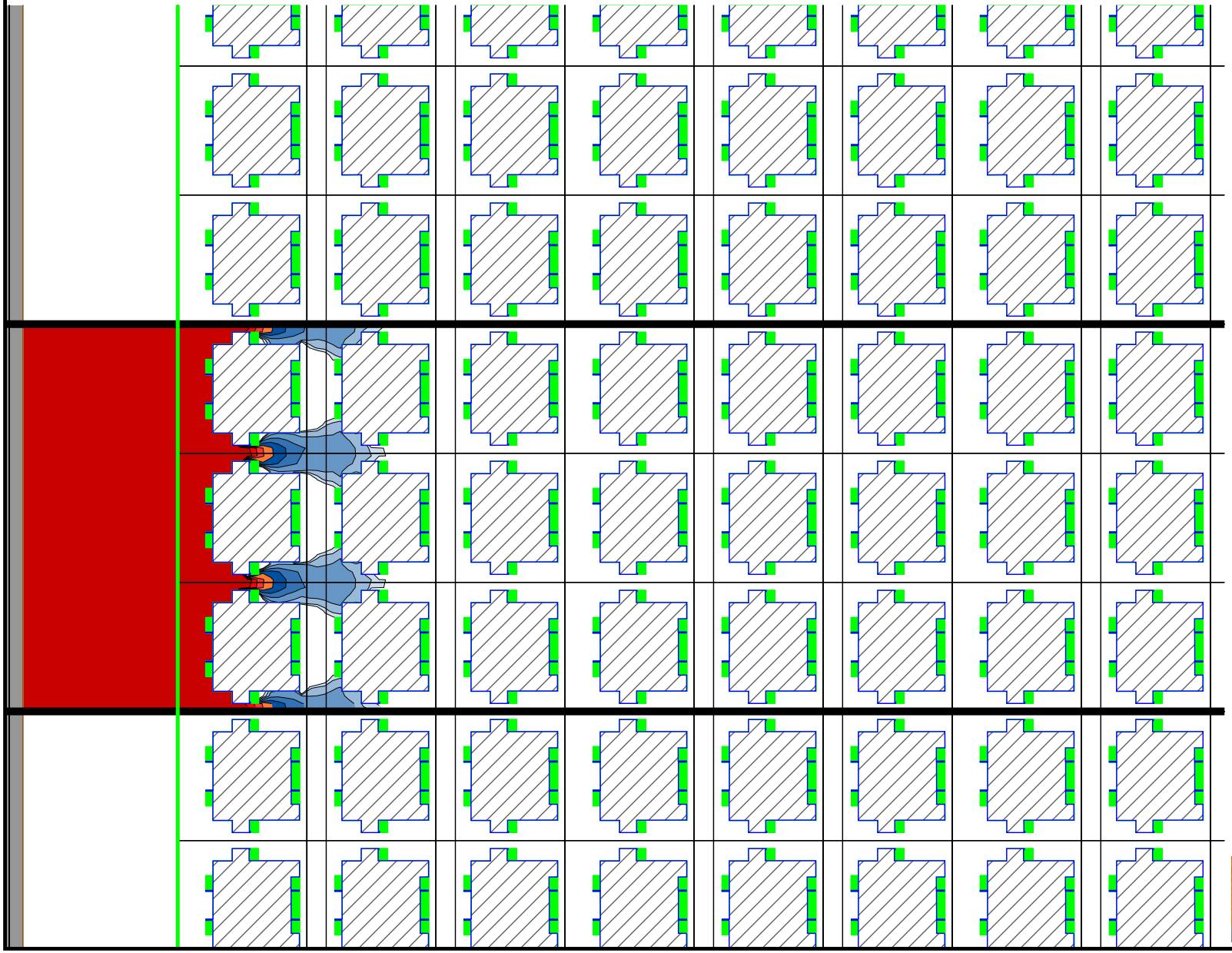
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Roe Highway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure E3b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

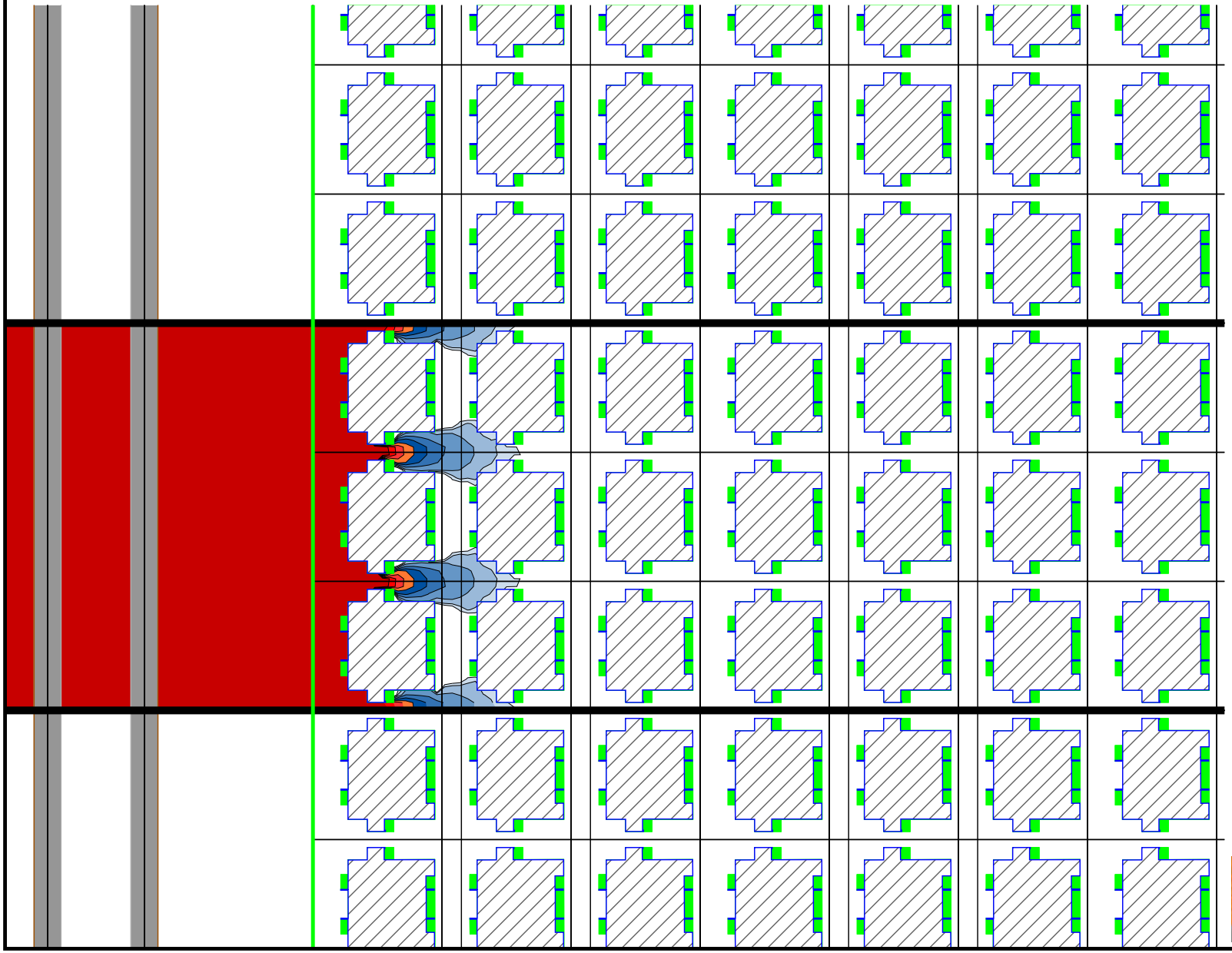
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Roe Highway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure E3c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

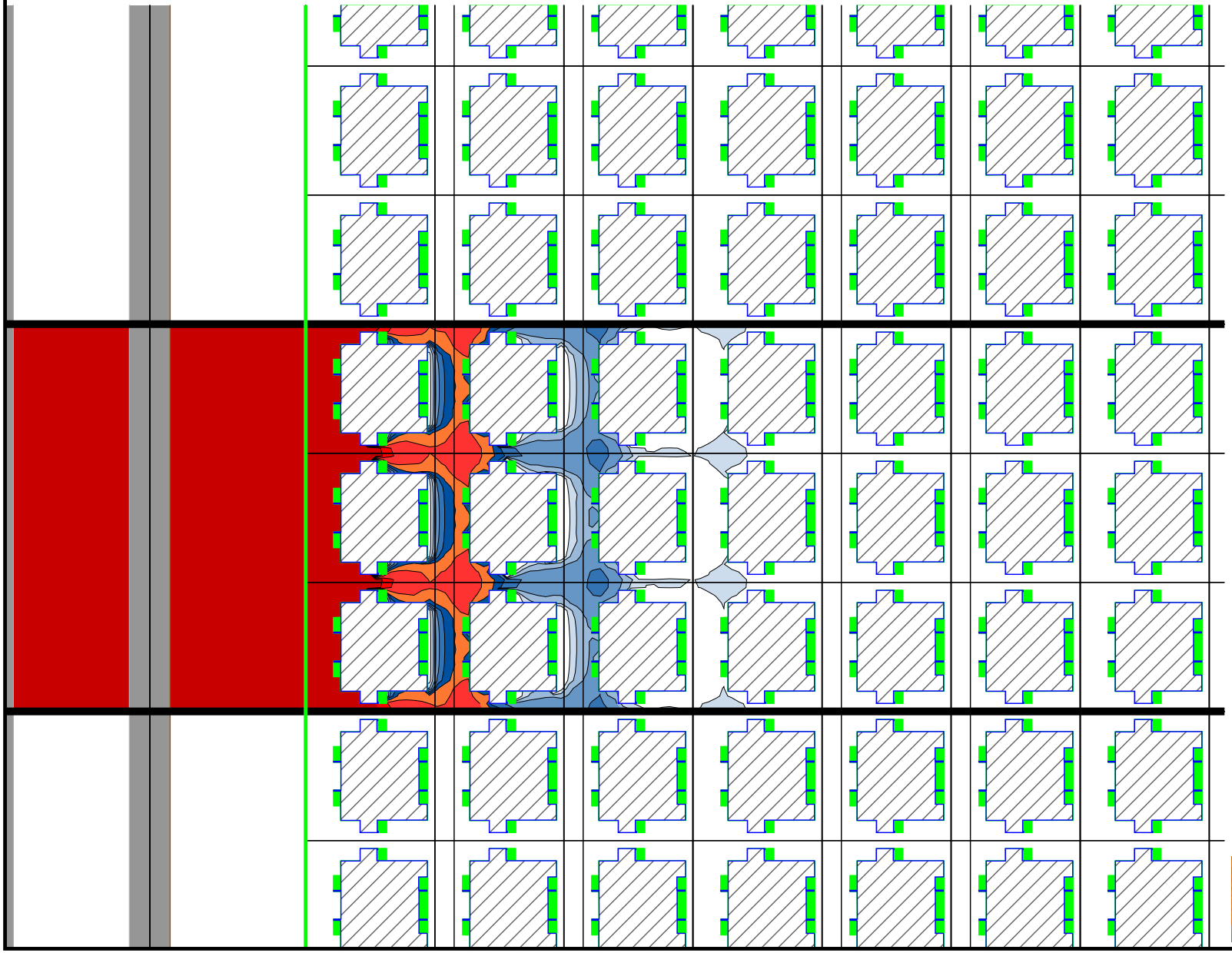
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Kwinana Freeway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure E4a



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

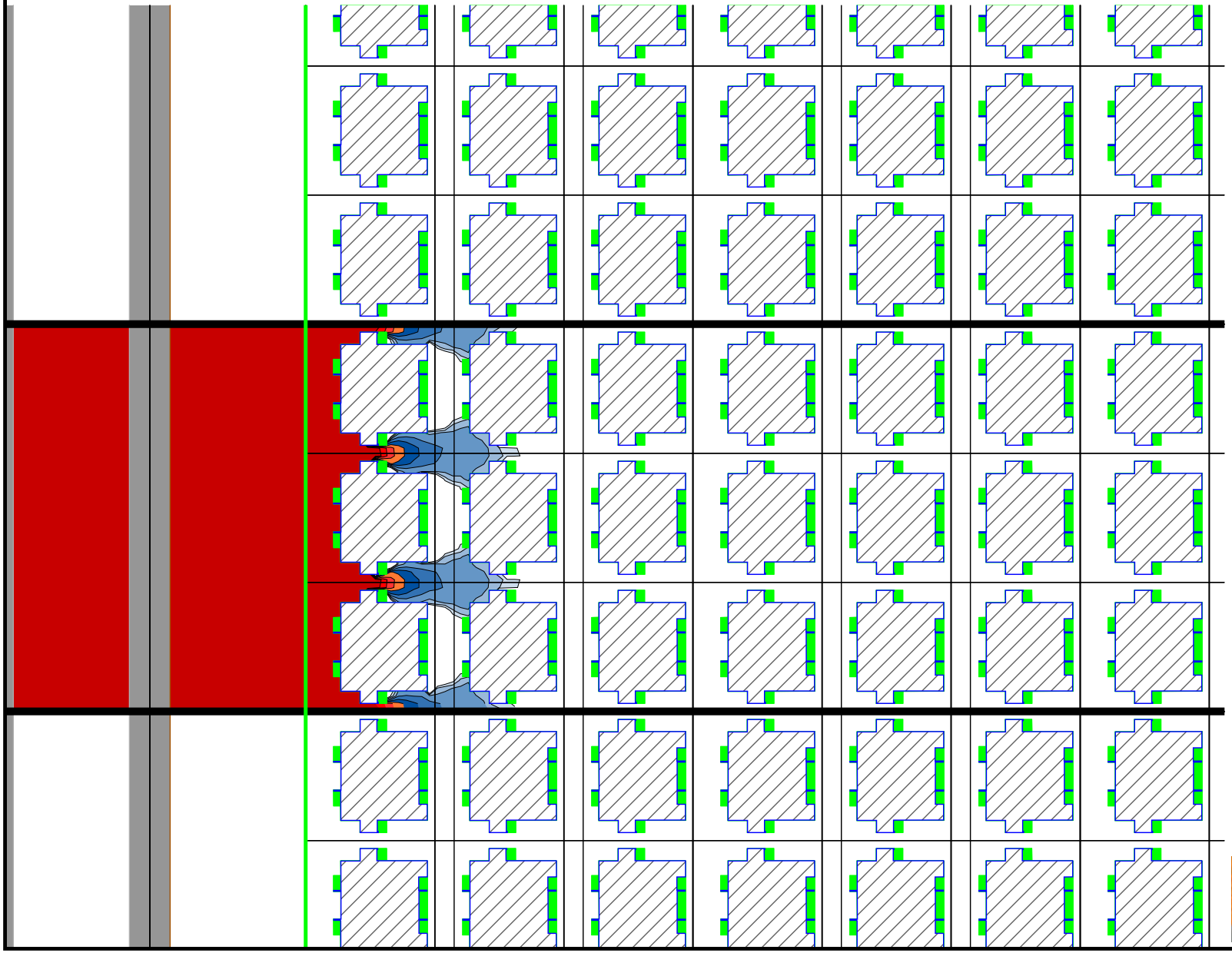
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Kwinana Freeway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure E4b



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

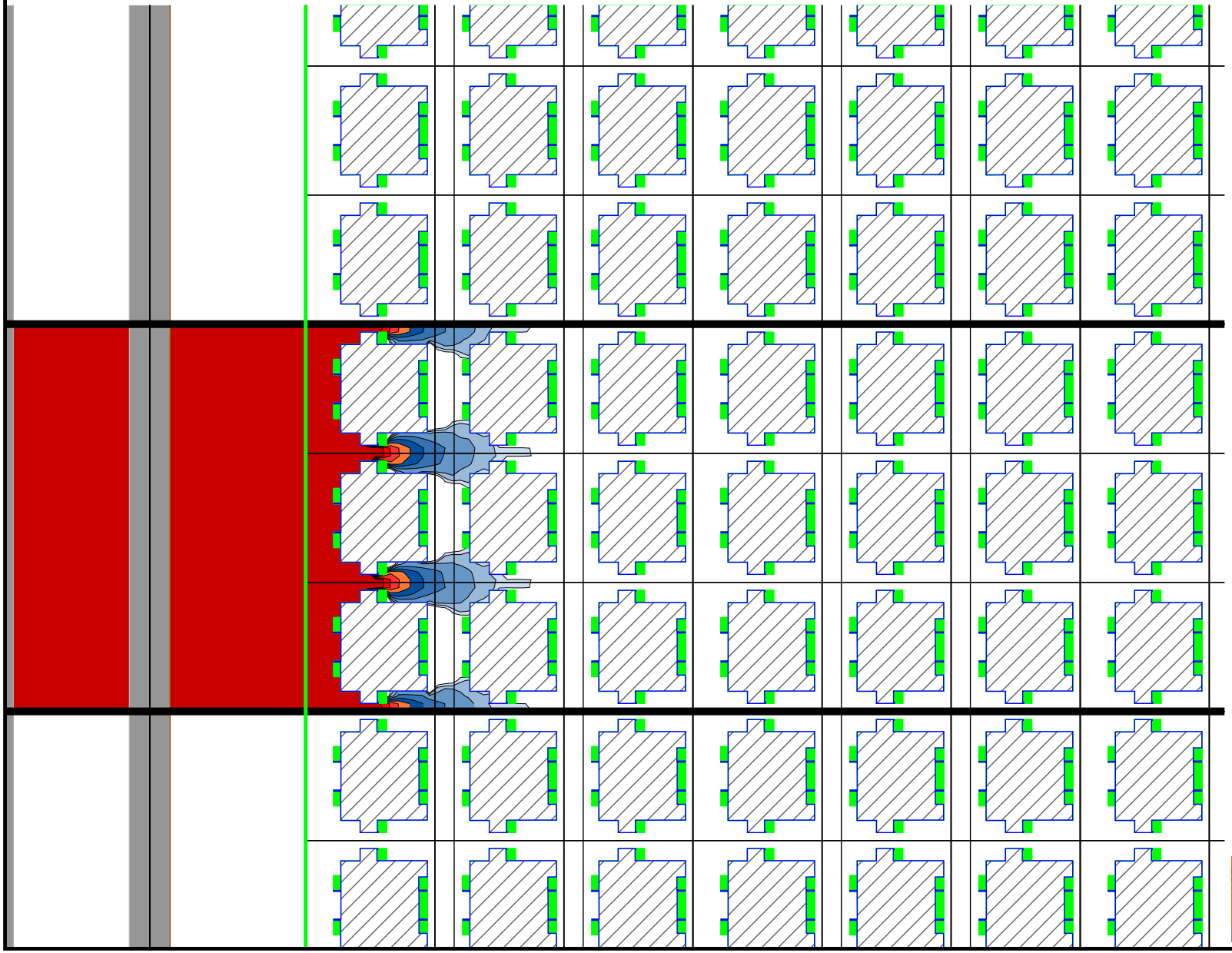
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Day) Noise Level Contours -Kwinana Freeway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure E4c



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols
- Road Surface
- Building
- Wall
- Noise calculation area

16 October 2015

Length Scale 1:1500

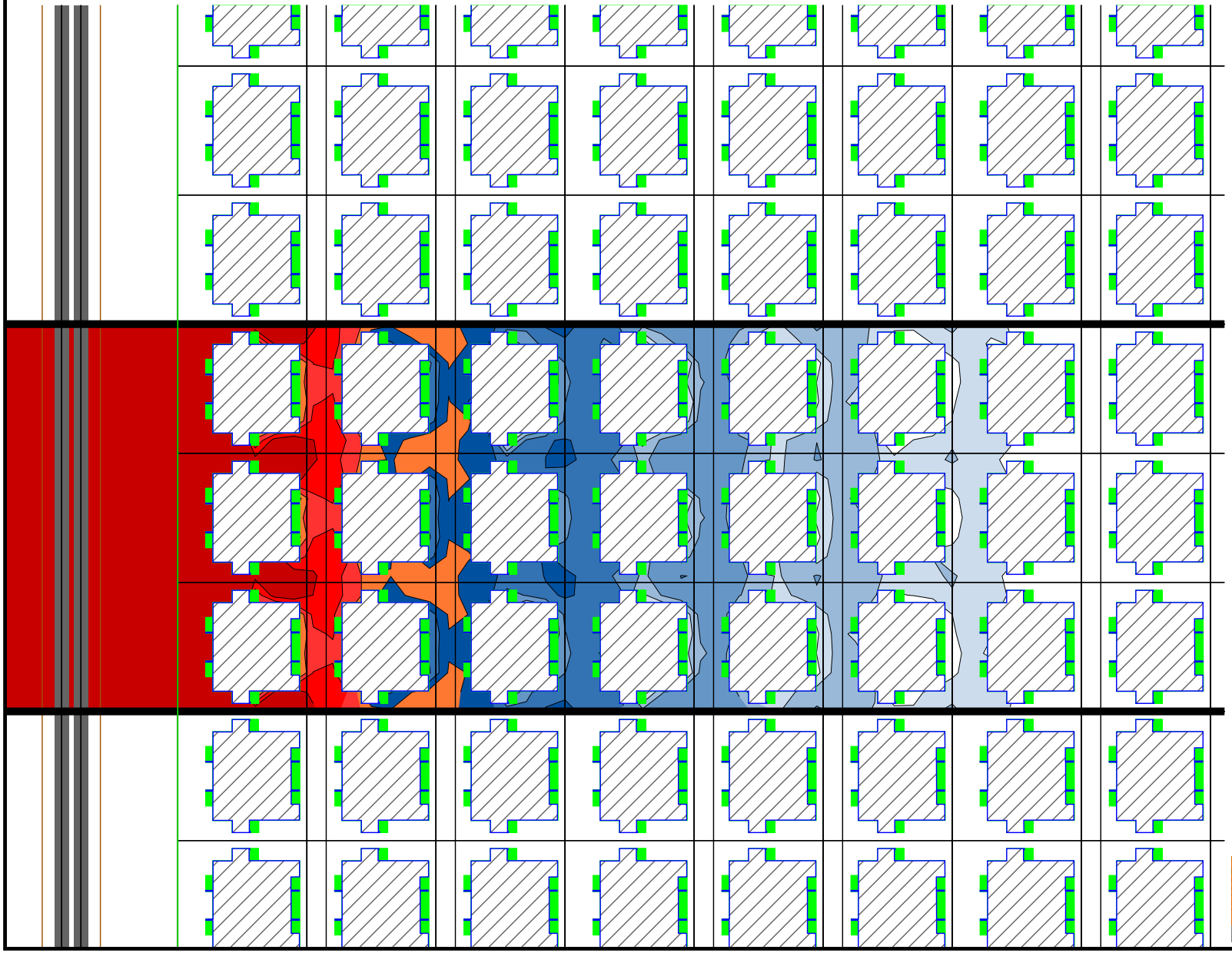
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure E5a



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

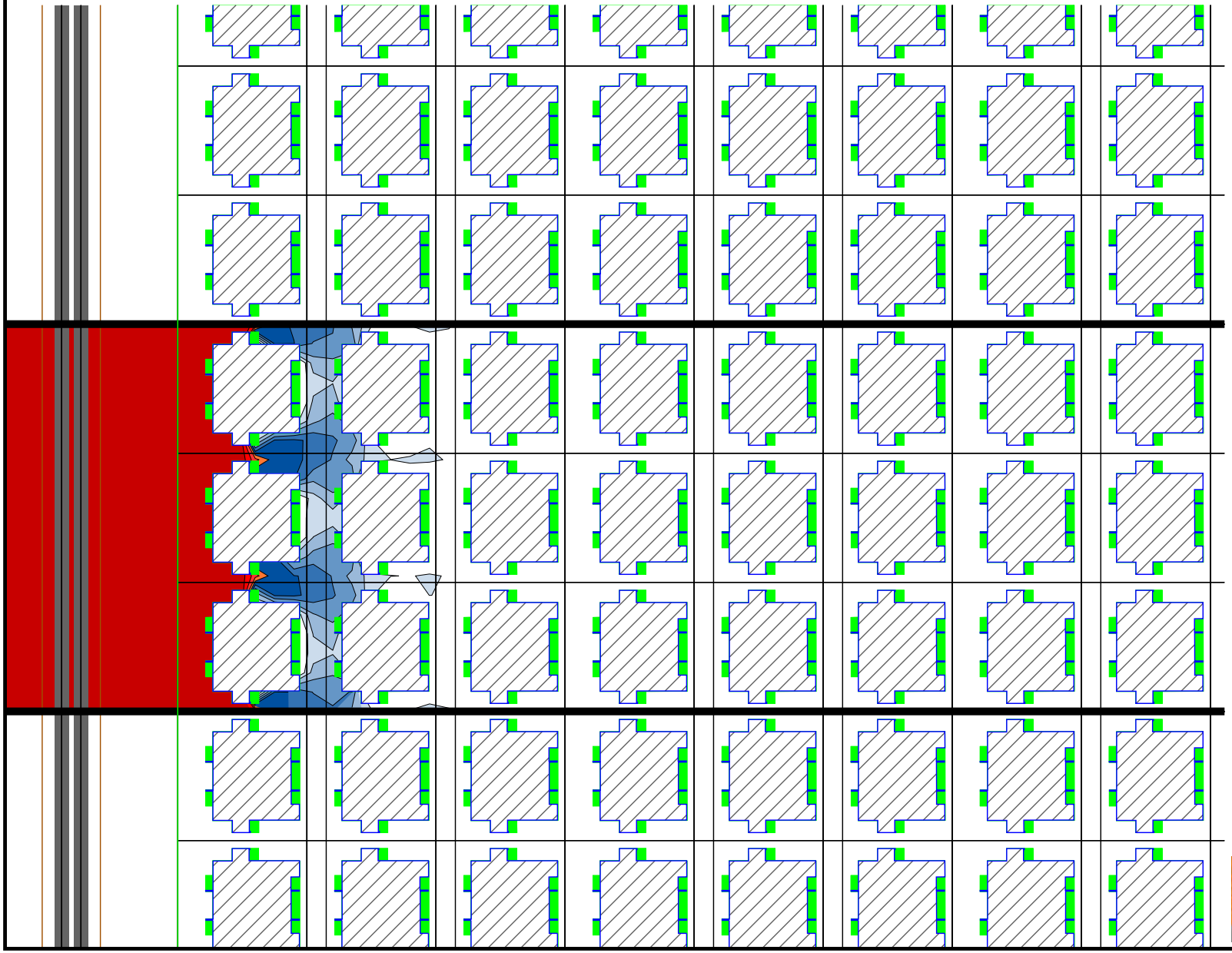
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure E5b



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

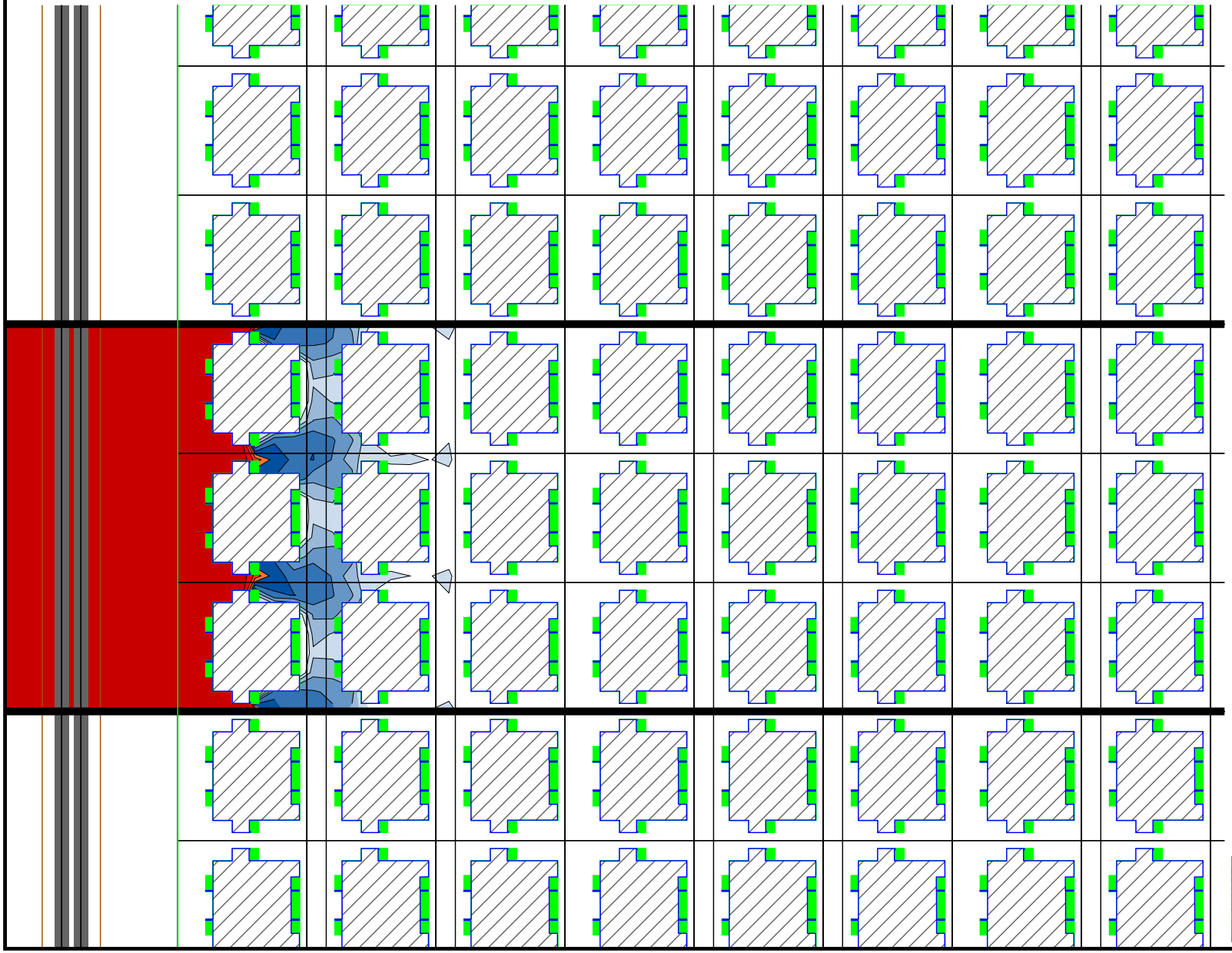
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAeq(Night) Noise Level Contours - Freight Railway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure E5c



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

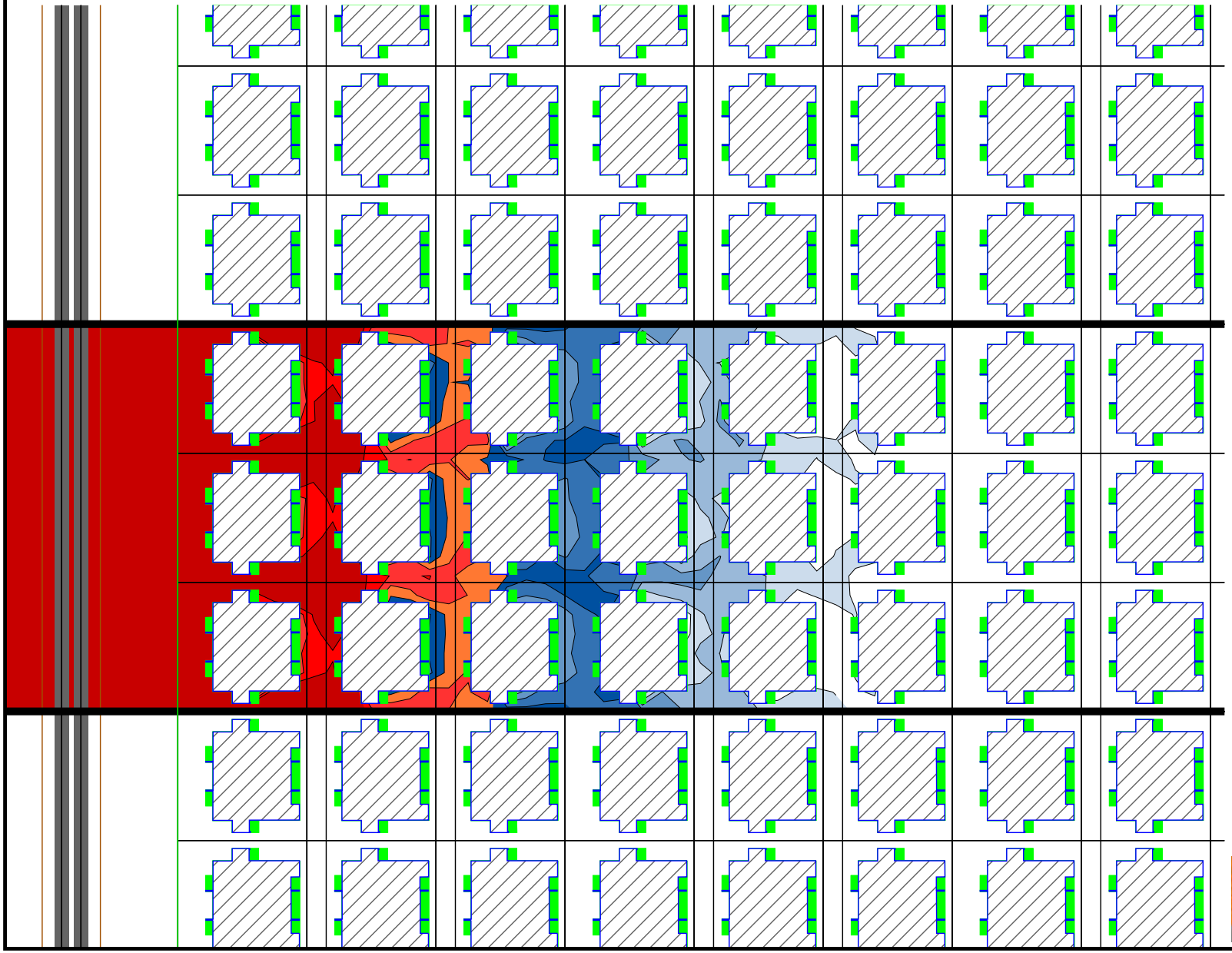
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 4.4m Above Ground Level

Figure E6a



Noise levels
LAmax dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

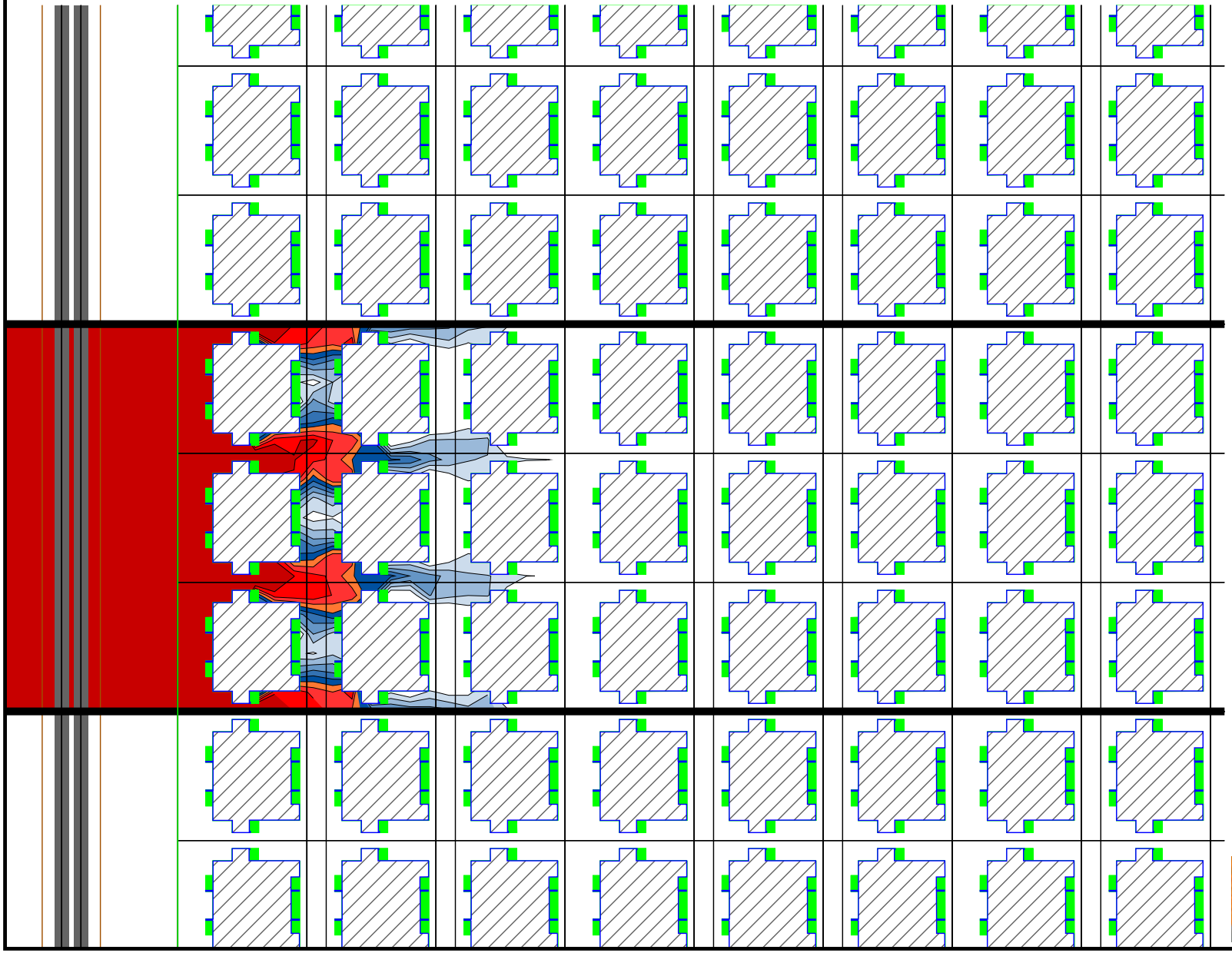
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 7.4m Above Ground Level

Figure E6b



Noise levels
LAmax dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

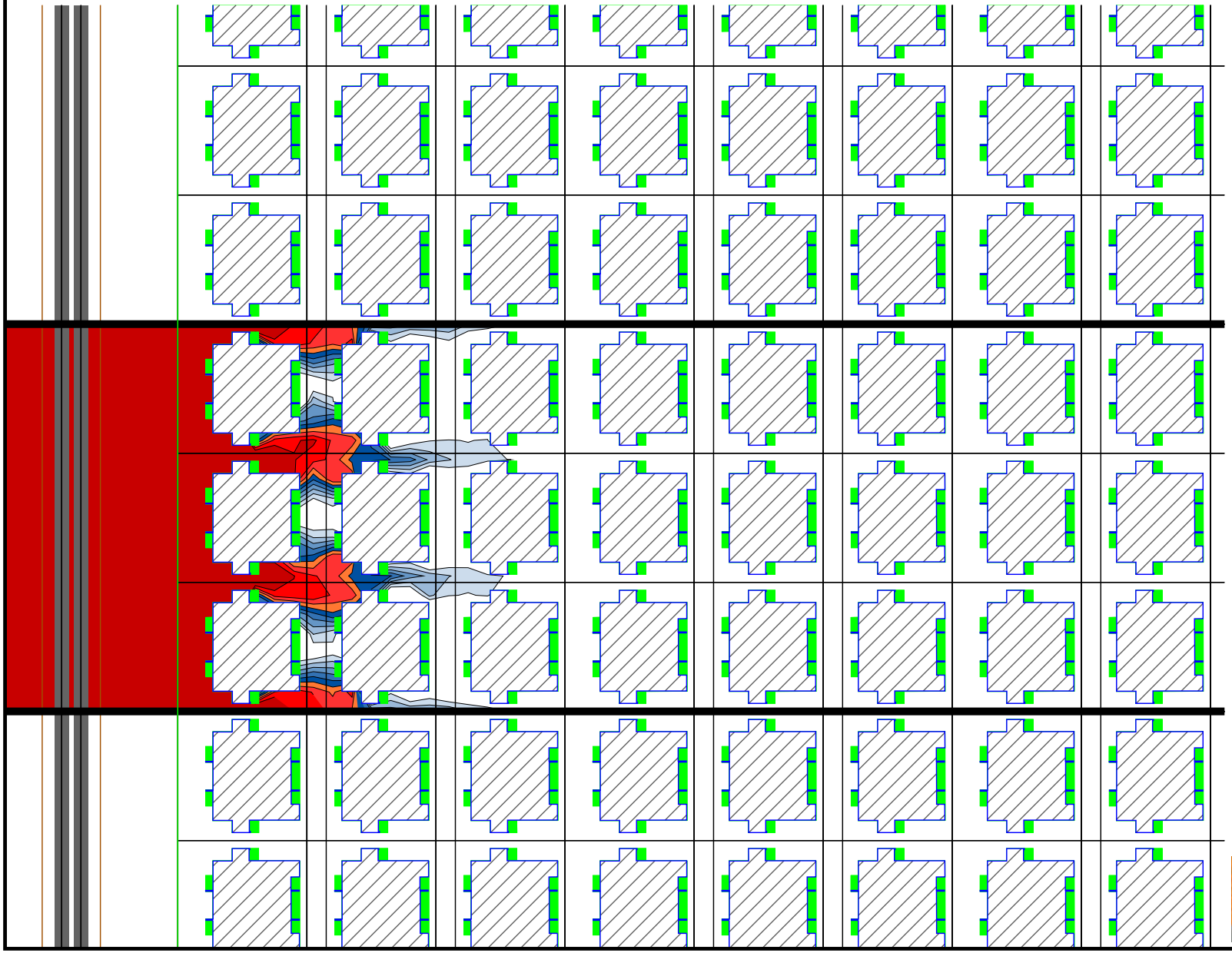
0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

City of Cockburn Recoding Study

LAmax Noise Level Contours - Freight Railway: Four Storey Apartment Development (Nominally R100 Zoning)
Predicted Noise Levels at 10.4m Above Ground Level

Figure E6c



Noise levels
LAmax dB

	< 75
75 <=	< 76
76 <=	< 77
77 <=	< 78
78 <=	< 79
79 <=	< 80
80 <=	< 81
81 <=	< 82
82 <=	< 83
83 <=	

Signs and symbols
- Building
- Wall
- Noise calculation area
- Railway

17 November 2015

Length Scale 1:1500

0 10 20 40 60 m

Lloyd George Acoustics
by Terry George
terry@lgacoustics.com.au
(08) 9401 7770

Appendix F

SPP 5.4 Packages

The packages and information provided on the following pages are taken from *Implementation Guidelines for State Planning Policy 5.4 Road and Rail Transport Noise and freight Considerations in Land Use Planning*; December 2014.

Where outdoor noise levels are above the ***target*** level, excluding the effect of any boundary fences, the Guidelines propose acceptable treatment packages that may be implemented without requiring detailed review. The packages are also intended for residential development only. At higher noise levels or for other building usages, specialist acoustic advice will be needed.

The acceptable treatment packages are intended to simplify compliance with the noise criteria, and the relevant package should be required as a condition of development in lieu of a detailed assessment.

Transition between each package should be made on the basis of the highest incident $L_{Aeq(Day)}$ or $L_{Aeq(Night)}$ value to the nearest whole number determined for the building development under assessment.

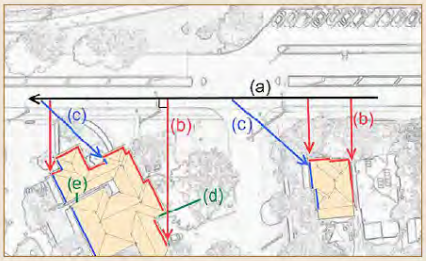
Any departures from the acceptable treatment specifications need to be supported by professional advice from a competent person that the proposal will achieve the requirements of the Policy.

With regards to the packages, the following definitions are provided:

- **Facing** the transport corridor: Any part of a building façade is 'facing' the transport corridor if any straight line drawn perpendicular to its nearest road lane or railway line intersects that part of the façade without obstruction (ignoring any fence).
- **Side-on** to transport corridor: Any part of a building façade that is not 'facing' is 'side-on' to the transport corridor if any straight line can be drawn from it to intersect the nearest road lane or railway line without obstruction (ignoring any fence).
- **Opposite** to transport corridor: Neither 'side on' nor 'facing', as defined above.

Determining building face orientation

The following sketch shows two residences in proximity to a road.



'Facing' façades are identified by drawing straight lines (b) perpendicular (at a 90 degree angle) to the road (a). Where these lines intersect a façade – without obstruction – the façades are shown in red as 'facing' the road.

Façades shown in blue are not 'facing' but have clear lines (c) that intersect the road at any angle, and are therefore classed as 'side on' to the road.

The remaining façades are 'opposite' to the road.

Package A

Area	Orientation to Road or Rail Corridor	Package A (up to 60 dB $L_{Aeq(Day)}$ and 55 dB $L_{Aeq(Night)}$)
Bedrooms	Facing	• Windows systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
	Side	• Windows systems: As above.
	Opposite	No requirements
Other Habitable Rooms Including Kitchens	Facing	• Windows and external door systems: Glazing up to 60% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Doors to be either 35mm thick solid timber core door with full perimeter acoustic seals. Glazed inserts to match the above. Sliding glass doors to be same performance including brush seals.
	Side	• Windows and external door systems: As above.
	Opposite	No requirements
General	Any	• Walls (minimum $R_w + C_{tr}$ 45) – Two leaves of 90mm thick brick with minimum 50mm cavity • Roof and ceiling (minimum $R_w + C_{tr}$ 35) – Standard roof construction with 10mm plasterboard ceiling and minimum R2.5 insulation between ceiling joists. • Eaves to be closed using 4mm compressed fibre cement sheet. • Mechanical ventilation – Refer following pages.
Outdoor Living Area		• Boundary wall to be minimum 2m high; or • Locate on the side of the building that is opposite to the corridor; or • Locate within alcove area so that the house shields it from corridor.

Note: Any penetrations in a part of the building envelope must be acoustically treated so as to not downgrade the performance of the building elements affected. Most penetrations in external walls such as pipes, cables or ducts can be sealed through caulking gaps with non-hardening mastic or suitable mortar.

Package B

Area	Orientation to Road or Rail Corridor	Package B (up to 63 dB $L_{Aeq(Day)}$ and 58 dB $L_{Aeq(Night)}$)
Bedrooms	Facing	• Windows systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 31) – 10mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
	Side	• Windows systems: As above.
	Opposite	• Windows systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 25) – 4mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Alternatively, 6mm thick glass (monolithic, toughened or laminated) in sliding frame.
Other Habitable Rooms Including Kitchens	Facing	• Windows and external door systems: Glazing up to 60% of floor area (minimum $R_w + C_{tr}$ 31) – 10mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Doors to be either 35mm thick solid timber core door with full perimeter acoustic seals. Glazed inserts to match the above. Sliding glass doors to have laboratory certificate confirming $R_w + C_{tr}$ 31 performance. Alternative, change to hinged door with perimeter acoustic seals and 10mm thick glass.
	Side	• Windows and external door systems: Glazing up to 60% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Doors to be either 35mm thick solid timber core door with full perimeter acoustic seals. Glazed inserts to match the above. Glass doors to be same performance ($R_w + C_{tr}$ 28) including brush seals.
	Opposite	No requirements
General	Any	• Walls (minimum $R_w + C_{tr}$ 50) – Two leaves of 90mm thick brick with minimum 50mm cavity. Cavity to include 25mm thick, 24kg/m^3 insulation and where wall ties are required, these are to be anti-vibration/resilient type. • Roof and ceiling (minimum $R_w + C_{tr}$ 35) – Standard roof construction with 10mm plasterboard ceiling and minimum R2.5 insulation between ceiling joists. • Eaves to be closed using 4mm thick compressed fibre cement sheet. • Mechanical ventilation – Refer following pages.
Outdoor Living Area		• Boundary wall to be minimum 2.4m high; or • Locate on the side of the building that is opposite to the corridor; or • Locate within alcove area so that the house shields it from corridor.

Note: Any penetrations in a part of the building envelope must be acoustically treated so as to not downgrade the performance of the building elements affected. Most penetrations in external walls such as pipes, cables or ducts can be sealed through caulking gaps with non-hardening mastic or suitable mortar.

Package C

Area	Orientation to Road or Rail Corridor	Package C (up to 65 dB $L_{Aeq(Day)}$ and 60 dB $L_{Aeq(Night)}$)
Bedrooms	Facing	• Windows systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 34) – 10.5mm thick VLam Hush glass in fixed sash, awning or casement opening with seals to openings.
	Side	• Windows systems: • Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 31) – 10mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
	Opposite	• Windows systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
Other Habitable Rooms Including Kitchens	Facing	• Windows and external door systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 31) – 10mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Doors to be either 40mm thick solid timber core door with full perimeter acoustic seals. Glazed inserts to match the above. Sliding glass doors to have laboratory certificate confirming $R_w + C_{tr}$ 31 performance. Alternatively, change to fully glazed hinged door with perimeter acoustic seals and 10mm thick glass.
	Side	• Windows and external door systems: Glazing up to 60% of floor area (minimum $R_w + C_{tr}$ 31) – 10mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Doors to be either 35mm thick solid timber core door with full perimeter acoustic seals certified to R_w 30. Glazed inserts to match the above. Sliding glass doors to have laboratory certificate confirming $R_w + C_{tr}$ 31 performance. Alternatively, change to hinged door with perimeter acoustic seals and 10mm thick glass.
	Opposite	• Windows systems: Glazing up to 60% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
General	Any	• Walls (minimum $R_w + C_{tr}$ 50) – Two leaves of 90mm thick brick with minimum 50mm cavity. Cavity to include 25mm thick, 24kg/m^3 insulation and where wall ties are required, these are to be anti-vibration/resilient type. • Roof and ceiling (minimum $R_w + C_{tr}$ 40) – Standard roof construction with 2 x 10mm plasterboard ceiling and minimum R3.0 insulation between ceiling joists. • Eaves to be closed using 6mm thick compressed fibre cement sheet. • Mechanical ventilation – Refer following pages.
Outdoor Living Area		• Locate on the side of the building that is opposite to the corridor; or • Locate within alcove area so that the house shields it from corridor.

Note: Any penetrations in a part of the building envelope must be acoustically treated so as to not downgrade the performance of the building elements affected. Most penetrations in external walls such as pipes, cables or ducts can be sealed through caulking gaps with non-hardening mastic or suitable mortar.

Mechanical Ventilation requirements

It is noted that natural ventilation must be provided in accordance with F4.6 and F4.7 of Volume One and 3.8.5.2 of Volume Two of the National Construction Code. Where the noise *limit* is likely to be exceeded, a mechanical ventilation system is usually required. Mechanical ventilation systems will need to comply with AS 1668.2 – *The use of mechanical ventilation and air-conditioning in buildings*.

In implementing the acceptable treatment packages, the following must be observed:

- Evaporative air conditioning systems will meet the requirements for Packages A and B provided attenuated air vents are provided in the ceiling space and designed so that windows do not need to be opened.
- Refrigerant based air conditioning systems need to be designed to achieve fresh air ventilation requirements.
- External openings (e.g. air inlets, vents) need to be positioned facing away from the transport corridor where practicable.
- Ductwork needs to be provided with adequate silencing to prevent noise intrusion.

Notification

Notifications on certificates of title and advice to prospective purchasers warning of the potential for noise impacts from major transport corridors help with managing expectations.

The area of land for which notification is required should be identified in the noise management plan and contain a description of major noise sources nearby (e.g. 24-hour freight rail).

Notification should be provided to prospective purchasers, and required as a condition of subdivision (including strata subdivision) for the purposes of noise sensitive development or planning approval involving noise sensitive development, where external noise levels are forecast or estimated to exceed the 'target' criteria as defined by the Policy.

In the case of subdivision and development, conditions of approval should include a requirement for registration of a notice on title, which is provided for under Section 165 of the Planning and Development Act 2005 and Section 70A of the Transfer of Land Act 1893. An example of a suitable notice is:

Notice: This lot is situated in the vicinity of a transport corridor and is currently affected, or may in the future be affected, by transport noise. Transportation noise controls and Quiet House design strategies at potential cost to the owner may be required to achieve an acceptable level of noise reduction. Further information is available on request from the relevant local government offices.

Appendix G

FLC Packages

Area	Orientation to Road or Rail Corridor	Freight Rail Package CF (up to 92 dB L_{Amax})	Freight Rail Package BF (up to 88 dB L_{Amax})	Freight Rail Package AF (up to 80 dB L_{Amax})
All Habitable Rooms (Including Kitchens)	Facing	• Walls: 2 x 110mm double brick wall with 50mm cavity and 50mm fibreglass insulation within the cavity. • Window: 10.5mm VLam Hush awning windows (up to 40% of room floor area). • External Doors: 10mm fully glazed hinged door (up to 20% of room floor area). • External doors to bedrooms are not recommended. • Roof and ceiling: Clay roof tiles with sarking and 10mm plasterboard ceiling, or, Colorbond roof sheeting with sarking, 4mm fibre cement sheeting fixed to the roof purlins and 2 x 10mm plasterboard ceiling. • Mechanical ventilation.	• Walls: 2 x 90mm double brick wall with 20mm cavity. • Windows: 6mm awning windows (up to 40% of room floor area); or, 10mm awning windows (up to 60% of room floor area). • External Doors: 10mm sliding glass doors (up to 20% of room floor area). • External doors to bedrooms are not recommended. • Roof and ceiling: Clay roof tiles with sarking and 10mm plasterboard ceiling, or, Colorbond roof sheeting with sarking, 4mm fibre cement sheeting fixed to the roof purlins and 2 x 10mm plasterboard ceiling. • Mechanical ventilation.	• Walls: 2 x 90mm double brick wall with 20mm cavity. • Windows: 6mm awning or 10mm sliding windows (up to 40% of room floor area); or, 6mm awning windows (up to 60% of room floor area). • External Doors: 6mm sliding glass doors (up to 20% of room floor area). • Roof and ceiling: Colorbond roof sheeting with 10mm plasterboard ceiling. • Mechanical ventilation.
	Side	• As above.	• As above.	• As above.
	Opposite	• As above, except - • Windows: 6mm awning windows (up to 40% of room floor area); or, 10mm awning windows (up to 60% of room floor area). • External Doors: 6mm fully glazed hinged door (up to 20% of room floor area).	• As above, except - • Windows: 6mm awning or 10mm sliding windows (up to 40% of room floor area); or, 6mm awning windows (up to 60% of room floor area). • External Doors: 6mm sliding glass doors (up to 20% of room floor area).	• As above, except - • Windows: 4mm awning or 6mm sliding windows (up to 40% of room floor area); or, 6mm awning or 10mm sliding windows (up to 60% of room floor area).
Outdoor Living Area		• Where practicable, locate an outdoor living area on the opposite side of the rail corridor or in an alcove on the side of the house.	• Where practicable, locate an outdoor living area on the opposite side of the rail corridor or in an alcove on the side of the house.	• Where practicable, locate an outdoor living area on the opposite side of the rail corridor or in an alcove on the side of the house.

Appendix H

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)

The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

A-Weighting

An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

L_1

An L_1 level is the noise level which is exceeded for 1 per cent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{10}

An L_{10} level is the noise level which is exceeded for 10 per cent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{90}

An L_{90} level is the noise level which is exceeded for 90 per cent of the measurement period and is considered to represent the "*background*" noise level.

L_{eq}

The L_{eq} level represents the average noise energy during a measurement period.

$L_{A10,18hour}$

The $L_{A10,18\ hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight. The *CoRTN* algorithms were developed to calculate this parameter.

$L_{Aeq,24hour}$

The $L_{Aeq,24\ hour}$ level is the logarithmic average of the hourly L_{Aeq} levels for a full day (from midnight to midnight).

$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$

The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$

The $L_{Aeq\ (Day)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is typically 1-3 dB less than the $L_{A10,18hour}$.

R_w

This is the weighted sound reduction index and is similar to the previously used STC (Sound Transmission Class) value. It is a single number rating determined by moving a grading curve in integral steps against the laboratory measured transmission loss until the sum of the deficiencies at each one-third-octave band, between 100 Hz and 3.15 kHz, does not exceed 32 dB. The higher the R_w value, the better the acoustic performance.

C_{tr}

This is a spectrum adaptation term for airborne noise and provides a correction to the R_w value to suit source sounds with significant low frequency content such as road traffic or home theatre systems. A wall that provides a relatively high level of low frequency attenuation (i.e. masonry) may have a value in the order of –4 dB, whilst a wall with relatively poor attenuation at low frequencies (i.e. stud wall) may have a value in the order of -14 dB.

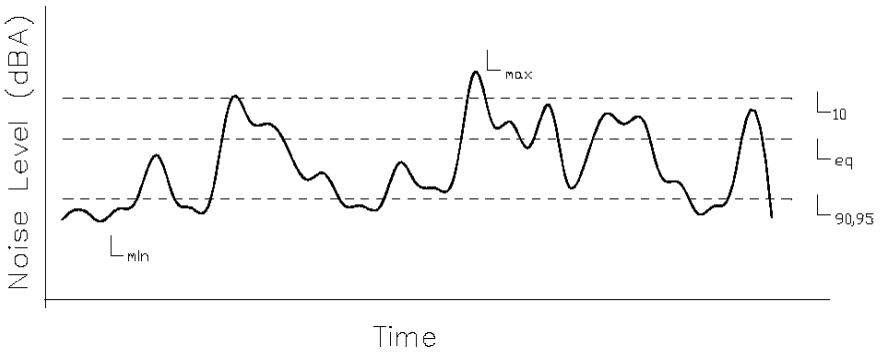
Satisfactory Design Sound Level

The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.

Maximum Design Sound Level

The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.

Chart of Noise Level Descriptors



Austroads Vehicle Class

AUSTROADS Vehicle Classification System

Level 1 Length (indicative) Type	Level 2 Axles and Axle Groups Axles	Groups	Level 3 Vehicle Type Typical Description	AUSTROADS Classification Class	Parameters	Typical Configuration
			LIGHT VEHICLES			
Short up to 5.5m		1 or 2	**Short** Sedan, Wagon, 4WD, Utility, Light Van, Bicycle, Motorcycle, etc	1	d(1) ≤ 3.2m and axles = 2	
	3, 4 or 5	3	**Short – Towing** Trailer, Caravan, Boat, etc	2	groups = 3 d(1) ≥ 2.1m, d(1) ≤ 3.2m, d(2) ≥ 2.1m and axles = 3, 4 or 5	
			HEAVY VEHICLES			
Medium 5.5m to 14.5m	2	2	**Two Axle Truck or Bus**	3	d(1) > 3.2m and axles = 2	
	3	2	**Three Axle Truck or Bus**	4	axles = 3 and groups = 2	
	> 3	2	**Four Axle Truck**	5	axles > 3 and groups = 2	
Long 11.5m to 19.0m	3	3	**Three Axle Articulated** Three axle articulated vehicle, or Rigid vehicle and trailer	6	d(1) > 3.2m, axles = 3 and groups = 3	
	4	> 2	**Four Axle Articulated** Four axle articulated vehicle, or Rigid vehicle and trailer	7	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 4 and groups > 2	
	5	> 2	**Five Axle Articulated** Five axle articulated vehicle, or Rigid vehicle and trailer	8	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 5 and groups > 2	
	≥ 6	> 2	**Six Axle Articulated** Six axle articulated vehicle, or Rigid vehicle and trailer	9	axles = 6 and groups > 2 or axles = 6 and groups = 3	
Medium Combination 17.5m to 36.5m	> 6	4	**B Double** B Double, or Heavy truck and trailer	10	groups = 4 and axles > 6	
	> 6	5 or 6	**Double Road Train** Double road train, or Medium articulated vehicle and one dog trailer (M.A.D.)	11	groups = 5 or 6 and axles > 6	
Large Combination Over 33.0m	> 6	> 6	**Triple Road Train** Triple road train, or Heavy truck and three trailers	12	groups > 6 and axles > 6	

Definitions: Group: Axle group, where adjacent axles are less than 2.1m apart. Groups: Number of axle groups. Axles: Number of axles (maximum axle spacing of 10.0m). d(1): Distance between first and second axle. d(2): Distance between second and third axle.

Typical Noise Levels