REPORT 20-1605R3

Airport Link
Environmental Impact Statement
Construction Noise and Vibration

PREPARED FOR

SKM Connell Wagner Joint Venture

JULY 2006

General

This analysis of noise and vibration impacts associated with the Airport Link project has been prepared based on a number of design parameters as supplied by the SKM Connell Wagner Joint Venture. The analysis is intended to provide a practical and specific understanding of the potential impacts, and the mitigation measures that may be necessary to mitigate any impacts during the construction phase.

It is anticipated that the construction methodology will evolve and be refined as detailed construction plans are developed for the project, with consequential implications for the design of mitigation strategies. It is therefore recommended that a detailed Construction Noise and Vibration Management Plan (or sub-plans) be prepared for the project as the detailed construction plans are developed.

Recommended Noise and Vibration Targets for Mitigation Design

The objective for the management of construction noise and vibration is to maintain a reasonable noise and vibration environment within sensitive properties for the duration of the project.

Definitions of 'reasonable' construction noise and vibration are recommended for the purpose of guiding the development of detailed design of mitigation strategies for this project and to provide guidance for establishing a compliance framework for licensing purposes have been developed.

Preparation and Operation of Worksites

The project involves the establishment and operation of worksites in three distinct area of the project through which tunnel spoil will be removed over a period of nearly three years. For each of these worksites there are significant potential noise impacts at nearby or adjoining residential locations that would require careful design and development of mitigation measures.

The most significant potentially intrusive noise scenarios at worksites are extensive initial daytime earthworks. The night-time tunnelling activities are conducted from within proposed acoustic enclosures over the portals and spoil stockpiles. At the most affected residences near worksites, maximum levels of noise from these scenarios has the potential to interfere with normal indoor living (eg interference with passive listening, resting and conversation) over an extended period of time if not properly mitigated.

The following noise control measures are recommended for noise mitigation at these worksites:

- Provide advance notification of the time and duration of earthworks.
- Install (temporary) noise screens to reduce earthmoving noise during "Site Preparation" at property boundaries of residences south of Federation St. These screens need to be on property boundaries beyond the worksite to be effective and a minimum of 5 m in height as the adjacent buildings are all double storeys. As an alternative, consideration could be given to upgrading the façade windows, and provision of airconditioning to the affected residents, where it proves cost effective and acceptable to the community.
- Use localised noise screens for particularly noisy operations such as rockdrilling and rockbreaking.
- Select plant and processes which minimise source noise levels
- Construction of a 'high' performance acoustic enclosure over the portal and stockpile area for the Southern and Gympie Road West worksites, with indicative acoustic performance as shown in **Table 28** (subject to detailed design).
- Construction of noise screens along worksite boundaries to reduce earthmoving (along the property boundary common with the Gympie Road West works) noise at adjoining residences.
    - Noise screens would need to be a minimum of 5 m in height as most residential dwellings in the area are double storeys;

  - At the southern end of the Gympie Rd (West) worksite, it is noted that there are 4 residential buildings that are 3 storeys, and hence a relatively high noise barrier would be required. A solution to providing noise mitigation may be to provide architectural treatment to the upper levels, as it may prove more cost effective, provided it is consistent with current policy and favoured by the residents.

- Construction of a 'medium' performance acoustic enclosure over the portal and stockpile area for the Gympie Road East and Sandgate worksites, with indicative acoustic performance as shown in **Table 28** (subject to detailed design).
- Undertake a further examination of Kedron High School and the office building adjacent to the southern side of the Gympie Rd West worksite, to confirm whether the windows are normally open (as assumed) or if the buildings are air conditioned, and hence the windows are normally closed.
- Design of continuously operating ventilation plant and any other plant that operates at night to meet 'reasonable' night-time noise objectives.
- For residences nearest and facing the Southern, Gympie Rd and Sandgate Rd worksites, assist owners of properties to temporarily upgrade the acoustical insulation and ventilation of rooms facing the worksite to mitigate construction noise during site preparation.
- Monitor noise levels from variable noise sources (e.g. rock-drill noise at the tunnel entrance which will diminish as tunnelling progresses) to ensure that such activities meet the 'reasonable' levels as defined in **Section 2.2.2.**

Surface Construction of Roadways

Particularly noisy construction activities are anticipated during the surface construction of the roadways

Southern Connections

The daytime construction of the elevated structures adjacent to the Mews Apartments is predicted to result in significant exceedances of the design goal and the noise level likely to be intrusive for the building occupants. This level of intrusion could interfere with normal indoor living (eg interference with passive listening, resting and conversation). Consequently, the following noise mitigation is recommended for further consideration:

- Advance notification of the time and duration of construction.
- Plant selection to consider noise emissions;
- Location of plant items to maximise distance to residences

There are no predicted exceedances of the noise goals for the night-time widening of the ICB underpass due primarily to the large offset distance and the higher building façade nominated for the Mews Apartments.

Gympie Road Connections

The construction works associated with the elevated structures and cut and cover tunnelling works for residences directly adjacent to Gympie Rd and Lutwyche Rd are likely to be found intrusive. This level of intrusion could interfere with normal indoor living (eg interference with passive listening, resting and conversation).

The following mitigation measures are recommended for further consideration guided by the 'reasonable' noise objectives for construction noise:-

- Construction of noise screens along the eastern boundary of the construction site north of Kedron Brook, where direct access to Gympie Rd is not required, to reduce construction noise on the eastern side of Gympie Rd due to elevated structure construction.

- Construction of noise screens along the western boundary of the construction site south of Kedron Brook, where direct access to Lutwyche Rd is not required, to reduce construction noise on the western side of Lutwyche Rd due to cut and cover construction
- Advance notification of the time and duration of earthworks.
- If required, assist owners of properties along Gympie Rd and Lutwyche Rd to temporarily upgrade the acoustical insulation and ventilation of rooms facing the worksite to address noise during both road widening/regrading and trough excavation.
- Advance notification of night roadworks.

Sandgate Rd Connections

The highest potential for impacts at residential locations occurs during the construction of the open trough and cut and cover construction, where the construction noise levels are predicted to significantly exceed the noise goals

The following noise control measures are recommended for mitigation of noise and vibration around roadworks for the Sandgate Rd connections, guided by the 'reasonable' noise objectives:

- Advance notification of the time and duration of works, especially any night works.
- Select construction processes and plant to minimise construction noise
- Assist owners of properties nearest the construction site to temporarily upgrade the acoustical insulation and ventilation of rooms facing the construction area.
- Construction of noise screens along the southern and western boundaries of the construction site west of Sandgate Rd.
- Early construction of the operational noise barrier south of the East-west Arterial to protect residences in Wongara St during the construction period.

Vibration

In addition, to minimise vibration impacts it is globally recommended:

- Specific advance notification of any impact piling activities or night-time road construction activities.
- Monitoring of vibration on structures due to vibratory rolling that occurs within a nominal distance of 25 m.

Underground Tunnelling Between Portals

Roadheading

Anticipated vibration levels generated by roadheading are sufficiently low to be imperceptible in buildings along the whole tunnel alignment. No on-going vibration mitigation measures or impact response management procedures are anticipated to be necessary for this type of tunnelling.

However, noise and vibration monitoring should be undertaken at the commencement of road header tunnelling to confirm that the source data utilised for this assessment is applicable to this project.

Blasting

Only daytime blasting is envisaged for the project. Blasting generally results in short, strongly noticeable vibrations lasting one to two seconds. The normal mitigation method in relation to human impacts is to give clear and concise pre-notification to all persons in the affected area.

The most problematic receptors in terms of human comfort during blasting is Amarina Nursing Home; and Rosemount Hospital, both of which provide palliative and dementia care. It is common that such patients are easily distressed by unexpected events such as fireworks. A regular schedule of blasting times and pre-warning of tunnelling vibration or noise will assist to allay unnecessary fears or anxieties. It is suggested that design vibration levels for this receptor location should be no more than 4 mm/s vertical peak particle velocity, based on daytime transient vibration criteria for "low probability of reaction" derived from AS2670:1990.

Earth Pressure Balance Tunnel Boring

It is anticipated that Earth Pressure Balance TBM vibrations and regenerated noise will generally not be noticeable in buildings along the tunnel path where the building foundations are at ground level. Some exceedences of the noise (45 dBA) and vibration (0.5 mm/s) goals may occur around the eastern portal (between Park Ave and Jackson St) due to the shallower tunnel depths and where pile footings have been placed under buildings. Exceedences of the vibration goal (0.5 mm/s) may occur around the western portal (between Gorman St and Roseleigh St) again due to the shallower tunnel depths and only where piled footings have been utilised.

It is not expected that exceedences of either the (noise or vibration) goal would occur between Roseleigh St and Park Ave - even if piles have been utilised - due to the increased tunnel depth.

Noise and vibration monitoring should be undertaken at the commencement of EPB tunnelling to confirm that the source data utilised for this assessment is applicable to this project.

Sensitive Building Contents

For this project, a Building Sensitivity Study is recommended for the Rosemount Hospital. The Building Sensitivity Study should be conducted prior to construction activities to establish the sensitivity of the building and contents in greater detail.

Recommended Mitigation for Tunnelling Vibration and Regenerated Noise

The following impact management and mitigation strategies are recommended to minimise the effects of tunnelling vibration and regenerated noise:

- Comprehensive advance notice of intended tunnelling activities in the localities near the tunnel alignment.
- Noise and vibration monitoring should be undertaken at the commencement of both road header and EPB tunnelling to confirm that the source data utilised for this assessment is applicable to this project
- If blasting is required in the vicinity of Amarina Nursing Home or Rosemount Hospital, consideration should be given to the adoption of a lower 'reasonable' blast vibration limit of 4 mm/s.
- Conduct building-specific vibration sensitivity investigations for the Rosemount Hospital to establish 'reasonable' vibration levels for these facilities prior to finalisation of a management plan for construction vibration.
- Conduct pre- and post-blasting Building Condition Surveys in accordance with Brisbane City Council requirements where it is considered there may be potential for cosmetic (superficial) building damage from drill-and-blast methods.

Construction Traffic

Spoil traffic would generally not increase average 18-hour (day and evening) traffic noise levels on spoil routes by more than about 0.5 dBA along major road corridors except for O'Connel Tce and Montpellier Rd where increases would be below 2 dBA. Neither of these increases would represent a significant impact.

Night-time spoil traffic would generally not increase traffic noise levels in the quietest hour (2 am to 3 am) on spoil routes by more than about 2 dBA along major road corridors except for O'Connell Tce and Montpeleir Rd where the increases would be around 5 and 3 dBA respectively. However, there are only a few residential locations along this section of the haul route and these residences are located in predominantly in commercial/industrial areas. It is recommended that noise mitigation measures be negotiated with the individual property owners on a case by case basis.

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1 INTRODUCTION

1.1 Background

Heggies Australia Pty Ltd (Heggies) has been commissioned by the SKM Connell Wagner Joint Venture to prepare an assessment of the construction noise and vibration aspects associated with the Airport Link project, for inclusion into the Environmental Impact Statement (EIS).

1.2 Terms of Reference

The specific requirements of the Terms of Reference[1] in relation to the construction noise and vibration impacts associated with the project are reproduced below.

> ***5.5 Noise and Vibration***
>
> ***5.5.1 Description of Existing Environment***
>
> *The existing noise environment should be assessed by;*
>
> - *Reviewing available data from any ambient noise monitoring in the study corridor; and*
> - *Conducting additional baseline noise monitoring at selected locations, primarily at sensitive locations in the vicinity of tunnel portals, associated roadways and ventilation infrastructure.*
>
> ***5.5.2 Potential Impacts and Mitigation Measures - Construction***
>
> *To assess construction impacts the following should be undertaken:*
>
> - *Identification and assessment of significant noise and vibration impacts which may arise from the construction of the Project, including noise and vibration generated by tunnelling works and surface construction sites, particularly in regard to sensitive sites;*
> - *Identification and assessment of significant noise impacts associated with potential spoil haulage routes; and*
> - *Identification of mitigation measures to address construction noise and vibration impacts.*
>
> *This assessment is to be inclusive of noise and vibration impacts to or on critical areas (eg health care facilities) and ground vibration effects on equipment within health care facilities.*

1.3 Objectives

The objectives of this report in relation to the project description are to:-

- Address the acoustical requirements detailed in the project's Terms of Reference in relation to the construction phase of the project;
- Evaluate the construction noise and vibration impacts at sensitive locations in terms of planning levels identified in the EPP[Noise] and other Guidelines;
- Define noise and vibration criteria by which construction noise and vibration impacts at sensitive locations may be evaluated;
- Evaluate the extent of resulting impacts and the scope for the reduction of these impacts through reasonable and feasible mitigation strategies; and
- Recommend appropriate mitigation measures.

[1] *Queensland Government's Department of State Development and Innovation,* Airport Link Project – Terms of Reference for an Environmental Impact Statement.

2 IMPACT ASSESSMENT CRITERIA

2.1 Community Values Relating to Noise and Vibration

The Queensland Environmental Protection (Noise) Policy 1997 defines the values to be protected as the qualities of the acoustic environment that are conducive to:

a. The wellbeing of the community or a part of the community, including its social and economic amenity; or

b. The wellbeing of an individual, including the individual's opportunity to have sleep, relaxation and conversation without unreasonable interference from intrusive noise.

Sleep

A person's ability to sleep is perhaps the most important value that can be impacted by noise and/or vibration. Noise and vibration effects on sleep are generally referred to as sleep disturbance.

Recreation

Recreation is an important aspect of a healthy lifestyle. Recreation may include time spent both indoors and outdoors. In terms of acoustic function, recreation may involve communication with others in verbal conversation or simple enjoyment of an outdoor or indoor soundscape.

Education and Work

The needs for education and work in relation to the acoustic environment relate to the need to be able to communicate effectively either face-to-face or by telephone, and the ability to think or focus on auditory information without undue intrusion from other sources of noise.

Evaluating Impacts

The impact of a project on community values relating to noise and vibration and is normally evaluated using statutory regulations and policies which describe acceptable levels of noise and vibration from various sources.

For types of noise for which specific levels are not listed in statutory regulations or policies, it is common to refer to relevant Australian or internationally recognised standards that define acceptable levels of noise and vibration in various human and structural contexts. Such standards can serve an advisory function to regulatory organisations and may be adopted by statutory authorities for the purpose of defining regulatory levels.

2.2 Noise Impact Assessment Criteria

2.2.1 Standard Statutory Construction Noise Regulations

The Environmental Protection Amendment (No 2) Regulation 1999 (EPAR) requires that a builder or building contractor not to carry out building work on a building site in a way that makes or causes audible noise to be made from the building work:

a. On a Sunday or public holiday, at any time; or

b. On a Saturday or business day, before 6.30 am or after 6.30 pm.

When the activity is an Environmentally Relevant Activity (ERA) or has had an EIS prepared, the penalties as defined in the Regulation, including the time restrictions above, do not automatically apply. Environmental safeguards for such activities are determined on a project specific basis and are detailed in the project's Approval Conditions.

Thus, construction activity between the hours of 6.30 am to 6.30 pm Monday to Saturday, excluding public holidays is not normally subject to numerical noise limits, providing the machinery being used is in good working condition. This regulation is summarised in **Table 1**.

Table 1 Standard Noise Regulations for Construction Activity

Day	Operating Constraint
Monday to Saturday	6.30 am – 6.30 pm – no numerical noise limits
Sunday, Public Holidays and all other times	Construction must be inaudible at noise sensitive locations

This project would involve some instances where construction activity would be required to be undertaken on a 24 hour basis and that would likely be audible outside of the regulated construction hours. Accordingly, the project would require approval to operate outside of the regulated hours[2].

2.2.2 Assessment Philosophy for Extended Construction Works

It is anticipated that the project would involve the operation of certain noise sources on worksites (eg temporary ventilation and spoil extraction to surface from tunnelling) on a 24 hour per day basis, 5.5 days per week over a nominal period of three years. Thus, these construction noise sources would begin to resemble a permanent rather than temporary feature of the noise environment at neighbouring noise sensitive locations. Based on experience from other similar projects, it is also unlikely that these sources could be made completely inaudible at night.

There are no established noise criteria in Queensland for the assessment of impacts associated with long-term construction noise sources, especially at night. It is suggested that assessment criteria for long-term construction noise sources should reflect the noise environment that is considered acceptable for normal functioning of adjoining developments (eg residential and educational uses).

Thus, the potential impacts of long-term construction noise sources have been assessed by comparison with the following criteria:

1. Sleep disturbance criteria contained in statutory guidelines and policies;
2. Recommended internal noise levels for various building uses specified in AS/NZS 2107: 2000 *Acoustics – Recommended design sound levels and reverberation times for building interiors,* and
3. Comparison with the existing noise environment.

These criteria are generally similar to those expressed in the Brisbane City Council's *Noise Impact Assessment Planning Scheme Policy* (NIAPSP), except that the above criteria do not make any reference to 'background noise creep'. Background noise creep requires consideration where a locality is subject to various (continuous) noise sources from on-going development. However in this instance, as the proposed construction works are not permanent, it would be unreasonable to apply a 'background creep' criterion to this project.

It must be emphasised that the purpose of these criteria is to enable an assessment of impacts to be made. This is distinctly different from the function of criteria in the normal application of NIAPSP, which is for setting design limits.

The specific criteria for sleep disturbance, recommended noise levels for various building functions and comparison with existing noise levels are discussed in the following sections.

[2] *A function of this report is therefore to define the possible impacts associated with operation outside regulated hours to support the application for this permission.*

Sleep Preservation

Both the Brisbane City Council's *Noise Impact Assessment Planning Scheme Policy* (NIAPSP) and the Queensland Environmental Protection Agency's Ecoaccess Guideline *Planning for Noise Control* recommend maximum internal noise levels in sleeping areas to avoid sleep disturbance. The recommended maximum levels from these two policies are summarised in **Table 2.**

Table 2 Regulatory Guidelines for Avoidance of Noise-induced Sleep Disturbance

Guideline	Recommended Maximum Internal L_{Amax}	Recommended Maximum Number of Occurrences per Night
BCC NIAPSP[1]		
AS1055.1 Appendix A R1-R3 Categories	45 dBA	"must not regularly exceed"
AS1055.1 Appendix A R4-R6 Categories	50 dBA	"must not regularly exceed"
EPA Ecoaccess	"Approximately 45 dBA"	"no more than 10 to 15"

Note 1: Contained in the NIAPSP Draft Guideline 2001.

The "R-category" descriptions in AS1055.1 are somewhat subjective. R3 is described as "Areas with medium density transportation or some commerce or industry" and is tabulated with an average night-time (10.00 pm to 7.00 am) background noise level of 40 dBA (L_{A90}). R4 is described as "Areas with dense transportation or with some commerce or industry" with an average night-time (10.00 pm to 7.00 am) background noise level of 45 dBA (L_{A90}).

The NIAPSP approach to assessing sleep disturbance is preferred as it includes some recognition that sleep disturbance is a function of the background noise level in addition to the level of the intrusive sound.

Acceptable levels of steady or near-steady ("quasi-steady") noise for sleeping environments are recommended in Australian Standard AS2107 *Acoustics – Recommended Noise Levels and Reverberation Times for Building Interiors.* These are detailed below:

Functional Noise Levels for Various Building Uses

The maximum recommended internal noise levels specified in AS/NZS 2107: 2000 *Acoustics – Recommended design sound levels and reverberation times for building interiors* are shown in Table 3 for a selection of building uses that may be relevant to building uses near construction sites.

Table 3 Example Noise Design Levels from AS/NZS 2107:2000

Type of Building Occupancy	**Maximum Design Level $L_{Aeq(60second)}$ (dBA)**
Residential buildings (sleeping areas)	40 (near major roads) 35 (near minor roads)
Residential buildings (living areas)	45 (near major roads) 40 (near minor roads)
Hospitals	40 (wards) 45 (operating theatres, nurses stations consulting rooms and the like)
Place of Worship	40 (with speech amplification)
School music rooms	45
School teaching area	45
School library	50
School Gymnasium	55
Commercial buildings – office space	45
Commercial Buildings – retail space	50

The stated scope of AS/NZS 2107 applies to noise that is steady or quasi-steady in nature. In practice the design levels from AS/NZS 2107 are widely used by Councils (eg Brisbane City Council NIAPSP) and the Department of Main Roads[3] as design goals in relation to daytime and night-time traffic noise which demonstrates some fluctuations in noise level. Brisbane City Council also uses AS/NZS 2107 for the assessment of mechanical plant noise intrusion into new residential developments. A measurement period of between 15 minutes and 1 hour is normally used to evaluate the L_{Aeq} parameter. Thus the proposed use of AS/NZS 2107 levels for the assessment of relatively steady plant noise emanating from construction sites has some similarities to the utilisation of AS/NZS 2107 in contemporary assessments of traffic noise and of mechanical plant noise intrusion into dwellings.

Because the AS/NZS 2107 design levels are expressed in terms of the L_{Aeq} parameter, some variability in a noise source is implicitly included when the average level meets the design level. For residential receptors, the implicit variability permitted by the L_{Aeq} parameter can be problematic at night. For this reason, night-time noise sources need to be assessed against sleep disturbance criteria for the L_{Amax} parameter in addition to the AS/NZS 2107 L_{Aeq} levels.

Comparison with Existing Noise Levels

The use of existing noise levels for the assessment of noise impacts is a common impact assessment practice. The Brisbane City Council NIAPSP refers to this type of assessment as “Comparison of like parameters or descriptors”.

Adjustments are normally made to the source levels as per AS1055.1-1997 in order to account for the increased subjective loudness associated with noises that are particularly tonal or impulsive.

2.3 Vibration Impact Assessment Criteria

2.3.1 General

Given a sufficiently high vibration level the potential adverse effects of vibration in buildings generated by construction activities are threefold:

- Occupants or users of the building may be inconvenienced or possibly disturbed;
- The building contents may be disturbed or affected; and
- Cosmetic or structural building damage may be induced.

3 *Queensland Department of Main Roads* “Road Traffic Noise Management - Code of Practice”.

Vibration criteria which are relevant to the disturbance of building contents are more stringent than criteria relating to cosmetic building damage. However, vibration criteria relating to human comfort are the most stringent. This is because people are able to "feel" vibration at levels much lower than those required to cause even superficial damage to the most susceptible classes of building.

Vibration criteria are also differentiated between short transient vibrations, such as those induced by blasting (of the order of one to two seconds), and more sustained vibrations such as those associated with tunnel boring, roadheading or rockhammering. The risk of human discomfort is generally lower for short duration vibrations. The risk of cosmetic building damage is also lower for short duration vibrations compared to continuous vibrations of the same magnitude. This is because short duration vibrations will be less likely to fully 'excite' resonant vibration responses in a building structure.

2.3.2 Property Impacts

Review of Design Standards

Most commonly specified "safe" structural vibration levels are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have the potential to cause damage to the main structure. Examples of threshold or cosmetic cracking include minor non-structural effects such as superficial cracking in cement render or plaster.

In terms of the relevant vibration damage criteria, British Standard 7385:Part 2-1993 *Evaluation and Measurement for Vibration in Buildings* is a definitive standard against which the likelihood of cosmetic building damage from ground vibration can be assessed. Sources of vibration which are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

BS 7385 sets guide values for building vibration based on the lowest vibration levels above which cosmetic damage has been credibly demonstrated. These levels are judged to give a minimal risk of vibration-induced cosmetic damage, where 'minimal risk' for a named effect is usually taken as a 95% probability of no effect. In this standard, the guide values for transient vibration judged to give minimal risk of cosmetic damage to residential buildings are 3.7 mm/s at 1 Hz, rising to 15 mm/s at a frequency of 4 Hz, increasing to 20 mm/s at a frequency of 15 Hz, then to 50 mm/s at a frequency of 40 Hz and above. Where the dynamic loading of a building caused by continuous vibration of foundations is such as to give rise to dynamic magnification of vibration between the foundations and other parts of the building due to resonance, especially at the lower frequencies where lower guide values apply, BS 7385 advises that guide values may need to be reduced by up to 50%.

An earlier reference than BS 7385, German Standard DIN 4150:Part 3-1986 (reissued in 1999 without substantive changes) also provides commonly referenced guidelines for evaluating the effects of vibration on structures. For vibration frequencies of less than 10 Hz, the DIN Standard give "safe levels" up to which no cosmetic damage due to vibration effects has been observed, ie 100% confidence. These levels for peak vibrations are 5 mm/s for dwellings and 3 mm/s for historic buildings (with preservation orders or the like).

In relation to historic buildings, BS 7385 notes that "*Important buildings which are difficult to repair may require special consideration on a case-by-case basis. A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*." A classification of buildings is given in Annexure A of BS 7385: Part 1: 1990 with an indication of the relative resistance to vibration. In contrast, DIN 4150 automatically applies the lowest possible criterion to historic buildings without justification, based on the actual building sensitivity.

As opposed to the "minimal risk of cosmetic damage" approach adopted in BS 7385, the "safe levels" given in DIN 4150 are the vibration levels up to which no cosmetic damage due to vibration effects has been observed. However, BS 7385 states that, *"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK*."

The DIN 4150 levels are more conservative than BS 7385 (generally twice as stringent) to avoid a small risk of cosmetic cracking. In practical terms, this could mean half the rate of tunnelling advance in sensitive areas and therefore twice the duration of exposure of a given receiver. A perceived advantage of the use of the DIN 4150 criteria is that full compliance with the recommended vibration levels should avoid any vibration-induced cosmetic building damage.

Regulatory Requirements

The Queensland Environmental Protection (Noise) Policy 1997, (EPP (Noise)) defines acceptable vibration limits for blasting with 80% compliance in stating that:

"*The noise from blasting is reasonable if, measured outside the most exposed part of an affected noise sensitive place*

c. the air-blast overpressure is not more than 115 dB(Lin Peak) for 4 out of any 5 consecutive blasts; and

d. the ground vibration is

a. for vibrations of more than 35 Hz - not more than 25 mm/s ground vibration, peak particle velocity; or

b. for vibrations of not more than 35 Hz - not more than 10 mm/s ground vibration, peak particle velocity."

Part 6 of the Brisbane City Council Local Law 5 - *Permits and Licences* specifies vibration limits for blasting. The key environmental management requirements of this are:

- Provision of formal notification of intention to blast 24 hours in advance.
- Performance of pre- and post-construction building condition surveys for all buildings where the anticipated ground vibration level will be 10 mm/s peak particle velocity or greater.
- Compliance with the ground vibration limits shown in **Table 4.**

Table 4 Council Ground Vibration Limits – Part 6 of Local Law 5

Type of Building or Structure	Ground Vibration Limit (peak particle velocity)
Historical buildings, monuments or ruin	2 mm/s
Visibly damaged or cracked buildings or structures	10 mm/s
Structurally sound buildings or structures	20 mm/s
Reinforced concrete or steel buildings or structures	50 mm/s

The Council vibration limits are not related to the frequency of the ground vibrations. As can be seen from the graphical comparison of all limits and recommended values illustrated in Figure 1, the simplification in the expression of the Council limits results in increased conservatism at high frequencies, but greater leniency at low frequencies where the potential for resonance-related building damage may be greater.

Comparison of Vibration Standards and Regulations

The vibration guide values and limits expressed in the standards and regulations discussed above are expressed graphically in Figure 1 for transient or blast vibrations and in

Figure 2 for continuous vibration.

Figure 1 Comparison of Standards and Regulations – Transient Vibration

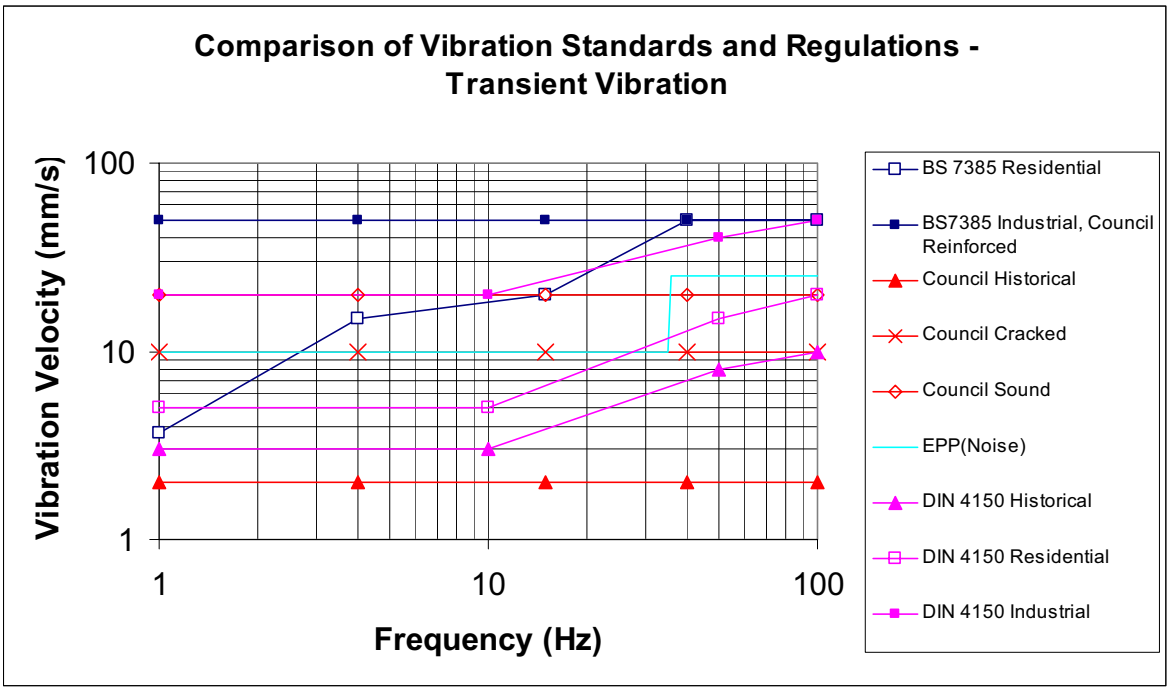
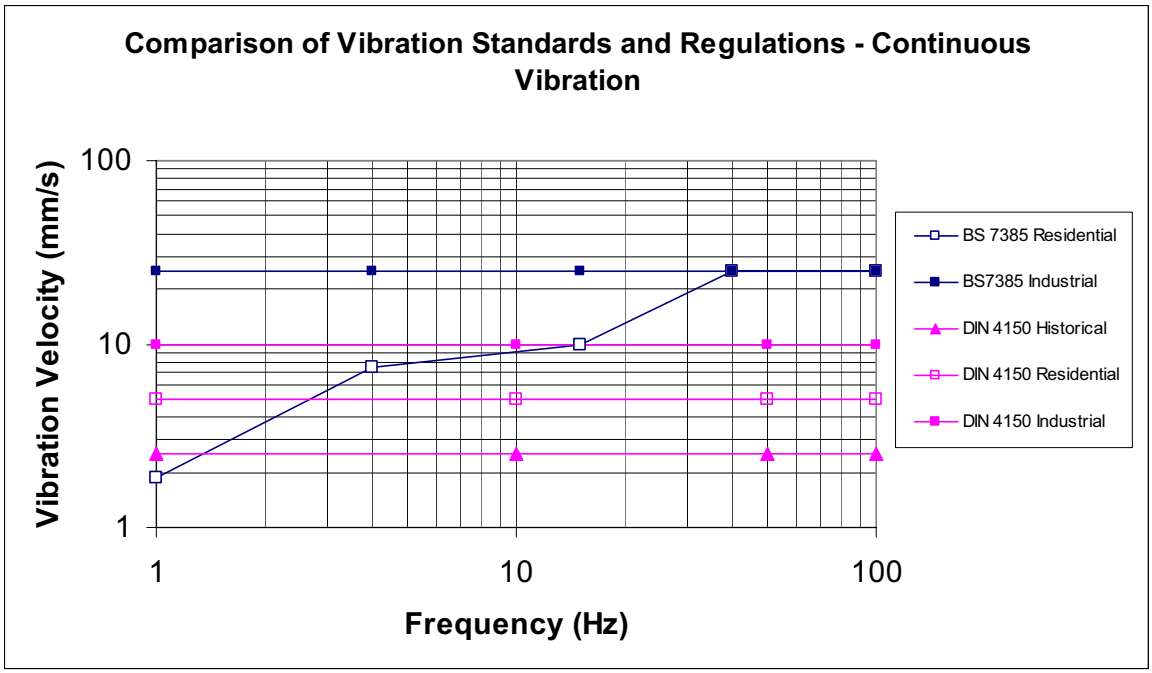


Figure 2 Comparison of Standards – Continuous Vibration



Levels for Assessment of Cosmetic Damage Potential

For impact assessment purposes, the EPP (Noise) limits for blasting (transient vibration) have been utilised for residential and other sensitive buildings. A 50% reduction of the guide values has been utilised to assess continuous vibration in line with the recommendation of BS 7385. The Council limit of 2 mm/s has been utilised for evaluating vibration levels at historical buildings. Guide values specific to reinforced structures have not been specifically referenced in this assessment of vibration as specific construction details of buildings are not known for all buildings along the corridor.

The assessment guide values for transient and continuous vibration in order to ensure a minimal risk of cosmetic damage to residential and other sensitive buildings are presented numerically in **Table 5**. It should be understood that these guide values are conservative, as the actual degree of tolerance of any building depends in a complex way on both the structural characteristics of the building and the frequency spectrum of the exciting vibration. At this stage of assessment, neither of these items of information are known in detail however, such information will likely act to increase the values in **Table 5**.

Table 5 Vibration Assessment Guide Values – Minimal Risk of Cosmetic Damage

Vibration Type	**Peak Particle Velocity (mm/s)**		
	Heritage Listed	**Residential**	**Sensitive Commercial**
Transient Vibration (eg blasting)	2	10	10
Continuous Vibration (eg TBM, roadheading, rockhammering)	2	5	5

2.3.3 Building Contents

Over the frequency range typical of vibration in buildings from excavation and construction equipment (approximately 8 Hz to possibly 100 Hz), the threshold for visible movement of susceptible building contents (eg plants, hanging pictures, blinds, etc.) is approximately 0.5 mm/s. Audible rattling of loose objects (eg crockery) generally does not occur until levels of about 1 mm/s are reached.

In any premises, day-to-day activities (eg footfalls, closing of doors, etc) will cause levels of vibration in floors and walls that exceed 1 mm/s (sometimes by quite considerable margins), therefore visible movement and rattling are often observed. In most instances however, such movement is considered normal and vibration levels of even much greater magnitude do not result in damage to the objects or building contents.

Potentially vibration-susceptible building contents include sensitive instrumentation, computers and other electronic equipment, although such items are not usually kept in residences (apart from personal computers which are considerably more robust). Typical floor vibration levels for satisfactory operation of such sensitive items are presented in **Table 6**.

Table 6 Typical Satisfactory Vibration Levels for Sensitive Building Contents

Equipment Type	**Maximum Vibration Levels**
Precision balances	0.5 mm/s to 2 mm/s
Some optical microscopes	0.5 mm/s
Large computer disk drives Sensitive electronic instrumentation	1 mm/s to 5 mm/s

Short-duration vibration events such as blasting may be permitted to cause somewhat higher vibration levels, depending on the vibration frequency content and on the specific susceptibility of particular items and their location.

Where particularly sensitive building contents have been identified, it is normal to undertake preliminary tests to establish the threshold of sensitivity before construction works proceed.

2.3.4 Human Comfort

In the previous section considering cosmetic building damage, the frequency of vibration excitation was important, as it related to the natural vibration frequencies of buildings and therefore the potential for building movement. In relation to human perception, it is the duration and time of day when the vibration occurs that is more important. Thus, human comfort vibration guidelines are expressed in terms of time of day and duration, rather than frequency.

Human Subjective Response to Vibration

Human tactile perception of vibration, as distinct from human comfort considerations, is summarised in German Standard DIN 4150 Part 2-1975. The degrees of perception for humans are suggested by the continuous vibration level categories given in **Table 7**.

Table 7 Vibration Levels and Human Perception of Motion

Approximate Vibration Level	Degree of Perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1.0 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hz to 80 Hz.

Table 7 suggests that people will just be able to feel continuous floor vibration at levels of about 0.15 mm/s and that the motion becomes “noticeable” at a level of approximately 1 mm/s.

Human Comfort Criteria for Continuous Vibration

Australian Standard AS 2670.2-1990 provides “human comfort” criteria for building use categories, including the following (in order of increasing sensitivity):

- Workshops;
- Office;
- Residential - day;
- Residential - night; and
- Critical working areas – for example hospital operating theatres, precision laboratories etc).

The standard primarily defines vibrations guidelines in RMS (Root Mean Square). The units for velocity and acceleration are mm/s and mm/s^2 respectively.

Satisfactory vibration levels are established with respect to human response as shown in **Table 8**.

Table 8 Vibration Criteria (RMS) – Human Comfort (from AS 2670:1990) – 8 Hz to 80 Hz

Type of Space Occupancy	Time of Day	RMS Vibration Levels in mm/s corresponding to a Low Probability of Reaction			
		Continuous Vibration (16 h Day, 8 h Night)		Transient Vibration Excitation with several Occurrences per Day	
		Vertical	Horizontal	Vertical	Horizontal
Critical working areas (eg some hospital operating theatres, some precision laboratories, etc)	Day Night	0.1 0.1	0.3 0.3	0.1 0.1	0.3 0.3
Residential	Day Night	0.2 to 0.4 0.14	0.6 to 1.1 0.40	3 to 9 0.14 to 2	9 to 26 0.4 to 6
Offices	Day Night	0.4 0.4	1.2 1.2	6 to 13 6 to 13	17 to 37 17 to 37
Workshops	Day Night	0.8 0.8	2.3 2.3	9 to 13 9 to 13	26 to 37 26 to 37

The standard indicates that people (standing or sitting) in buildings are significantly less susceptible to horizontal vibration than to vertical vibration.

The standard also indicates that people are more sensitive to continuous vibration than to transient vibration.

The satisfactory vibration levels presented in **Table 8** are based on the RMS or “root mean squared” vibration levels. The RMS is a vibration level averaged within a defined time period.

In order to determine corresponding allowable peak vibration levels that can be readily monitored during various construction activities, the RMS vibration levels need to be multiplied by an appropriate “crest” factor (ie ratio of the peak level to RMS level) to obtain a “peak” vibration level. Crest factors will vary from 1.4 for construction activities of a sinusoidal nature (eg continuous vibratory rolling and rotating plant) up to 4 or more for intermittent activities such as rockbreaking and blasting.

Table 9 presents the recommended “peak” vibration levels to achieve “low probability of adverse comment” for continuous vibration sources based on a conservative crest factor of 1.4.

Table 9 Vibration Criteria (Peak, cf=1.4) – Human Comfort (adapted from AS 2670:1990) 8 Hz to 80 Hz

Type of Space Occupancy	Time of Day	Peak Vibration Levels in mm/s corresponding to a Low Probability of Reaction			
		Continuous Vibration (16h Day, 8h Night)		Transient Vibration Excitation with several Occurrences per day	
		Vertical	Horizontal	Vertical	Horizontal
Critical working areas (eg some hospital operating theatres, some precision laboratories, etc)	Day or Night	0.14	0.4	0.14	0.4
Residential	Day Night	0.3 to 0.6 0.2	0.8 to 1.5 0.6	4 to 13 0.2 to 3	13 to 36 0.6 to 8.4
Offices	Day or Night	0.6	1.7	8 to 18	24 to 52

As can be seen from the last two columns of **Table 9** situations can exist where vibration magnitudes above those generally corresponding to a low probability of reaction, particularly for temporary disturbances and infrequent and intermittent events, such as those associated with blasting. With close cooperation and liaison with the occupants of the potentially affected properties, significantly higher levels of short-term vibration could be tolerated by many people for construction projects. In many instances there is a trade-off between the magnitude and duration of construction related vibration (eg rockbreaking versus blasting).

Sleep Preservation

It is difficult to define the level of vibration that would disturb sleep at night, as there is not a significant body of research that specifically investigates this issue. In practice, vibration in buildings that is considered to be disturbing is often perceived as structure-borne regenerated noise, noise generated by rattling objects, or through visual cues such as movement of wall hangings, rather than through tactile perception only. Often it is these effects that may make falling asleep difficult rather than actually disturbing a person out of a sleep state.

Nevertheless it is important to make an estimate of the threshold of vibration levels that may produce effects that disturb sleep, to identify geographical areas where specific attention may need to be directed in respect of night-time vibration.

For this purpose a vibration guide level of 0.5 mm/s (peak) has been estimated. This estimate is based on consideration of vibration levels commonly associated with the on-set of movement and rattling of building contents, vibration guide values based on human perception nominated in AS2670-1990, and the qualitative perception scale for continuous vibration outlined in German Standard DIN 4150 Part 2-1975.

The actual night-time response of individuals to vibration is difficult to predict and is usually altered by their level of understanding of the causes of vibration and the likely (or unlikely) effects, and their awareness of the project construction methods and timeframe. Some people may be comfortable with much higher levels of night vibration than the 0.5 mm/s estimate.

It is important therefore that public consultation and education is conducted before and during tunnelling, combined with early vibration monitoring, to confirm actual vibration levels that are likely to avoid night-time sleep disturbance associated with tunnelling vibration.

2.3.5 Air-blast

Building Damage

Based largely on work carried out by the US Bureau of Mines, the US Office of Surface Mining has presented the following regulatory levels for airblast from blasting (depending on the low frequency limit of the measuring system):

Low Frequency Limit	Peak Airblast Level Limit
2 Hz or lower	132 dB Linear
6 Hz or lower	130 dB Linear

These levels are generally consistent with the level of 133 dB Linear nominated in AS 2187.2-1993.

The US criteria are based on relationships between the level of airblast and the probability of window breakage, and include a significant safety margin. It has been well documented that windows are the elements of residential buildings most at risk to damage from airblast from blasting.

While cracked plaster is the type of damage most frequently monitored in airblast complaints, research has shown that window panes fail before any other structural damage occurs (USBM, RI 8485-1980). The probabilities of damage to windows exposed to a single airblast event are as shown in **Table 10.**

Table 10 Probability of Window Damage from Airblast

Airblast dB Linear	Level kPa	Probability of Damage	Effects and Comments
140	0.2	0.01%	"No damage" - windows rattle
150	0.6	0.5%	Very occasional failure
160	2.0	20%	Substantial failures
180	20.0	95%	Almost all fail

Human Comfort

The EPP (Noise) specifies a human comfort requirement of 115 dB (Linear Peak) for airblast.

3 IDENTIFICATION OF SPECIAL NOISE/VIBRATION SENSITIVE BUILDINGS

Apart from the residential dwellings that are in the vicinity of the Airport Link portals and route alignment, there are a number of other noise/vibration sensitive locations that have been identified which have been considered in this report when assessing the potential for impacts arising from airborne or regenerated noise and vibration.

Relevant properties have been identified from a variety of sources including the *Social Environment Report* (Elliott Whiteing Pty Ltd, December 2005) report, general project information, site visits and a review of the latest UBD.

In the southern section of the project, the following noise sensitive properties have been identified. It is noted that some properties have been included, even though they may be considered to be some distance from the actual works.

Table 11 Special Noise/Vibration Sensitive Properties – Southern Section

Type	Facility	Location
Aged Care	Amarina Nursing Home	26 Palmer Street, Windsor
Child care	Windsor Neighbourhood Child Care Centre	17 Bonython Street, Windsor
	YMCA Child Care Centre	387 Lutwyche Road, Windsor
	Holy Rosary Primary School	9 Roblane Street, Windsor
Education	Windsor Primary School	270 Lutwyche Road, Windsor
	Windsor School of Arts	407 Lutwyche Rd, Windsor
Hospitals	Rosemount Hospital	189 Lutwyche Road, Windsor
	Royal Brisbane Hospital	30 Bowen Bridge Road, Herston

Other places not specifically identified, such as community facilities, would be treated in the same manner as the surrounding residential properties.

In the northern area around the Gympie Road portal, the potentially noise sensitive properties are identified in **Table 12**.

Table 12 Noise Sensitive Properties – Northern Section

Type	Facility	Location
Childcare	Lutwyche Windsor Kindergarten	Lucas Street, Lutwyche
	Kedron Park Childcare Centre	84 Kedron Park Road
	Hutchison's Early Learning Centre	7 Ninth Avenue
	Kedron Heights Kindergarten	107 Kitchener Road
Education	Kedron Secondary School	34 Park Road
	Woodwin Primary School	663 Lutwyche Road
Nursing Homes	Wooloowin Nursing Home	99 Kedron Park Road
	Eveleigh Retirement Village	35 Eveleigh St Wooloowin

There is only one special noise sensitive properties close to the alignment in the section between the Gympie Road Portal and Sandgate Road Portal - Clifford House Aged Care facility (44 Jimbour Street).

4 EXISTING NOISE AND VIBRATION ENVIRONMENT

4.1 Introduction

A record of existing noise levels provides a baseline for assessment of potential noise emissions associated with construction and operational phases of the tunnel.

The aspects of the tunnel infrastructure that are of particular interest in respect of the existing noise environment are those areas in the vicinity of:-

- Construction sites,
- Ventilation Outlets, and
- Tunnel portals and entry/exit roadways.

The existing noise environment will be utilised to assist in the development of criteria for the assessment of noise impacts associated with the project, and be used to determine the reasonableness of providing noise control measures, where the base noise objectives are exceeded.

Existing ambient vibration levels at residences and other sensitive buildings are not normally significant. On maintained roads, ambient vibration levels on building foundations are generally below or near the minimum measurement threshold of regular vibration measurement instrumentation, and below the threshold of perception. A limited amount of ambient vibration measurements were conducted to verify the validity of this generalisation on this project.

The Terms of Reference required the existing noise levels to be described from available ambient noise records and additional noise measurements specifically targeted at assessing the noise environment around surface development associated with the project. In this regard available ambient noise records were found to be too site specific to relate to areas surrounding proposed surface developments. For this reason noise monitoring has been conducted at locations specific to surface developments associated with the project.

Information about the existing noise environment has been obtained from the following sources:-

- Site inspection during peak traffic periods and during quiet late-night periods;
- Unattended continuous measurement of sound pressure levels at eleven locations over a 7 day period

4.2 Noise Descriptors

The noise level descriptors that have been utilised for measurements are graphically illustrated in **Figure 3**, which presents a hypothetical noise profile in a suburban area.

L_{Amax} The maximum A-weighted noise level associated with a noise sampling period.

L_{A1} The noise level exceeded for 1% of a given measurement period. This parameter is often used to represent the typical maximum noise level in a given period.

L_{A10} The A-weighted sound pressure level exceeded 10% of a given measurement period and is utilised normally to characterise average maximum noise levels.

L_{Aeq} The average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound over the same measurement period.

L_{A90} The A-weighted sound pressure level exceeded 90% of a given measurement period and is representative of the average minimum background sound level (in the absence of the source under consideration), or simply the "background" level.

Figure 3 Graphical Display of Typical Noise Indices

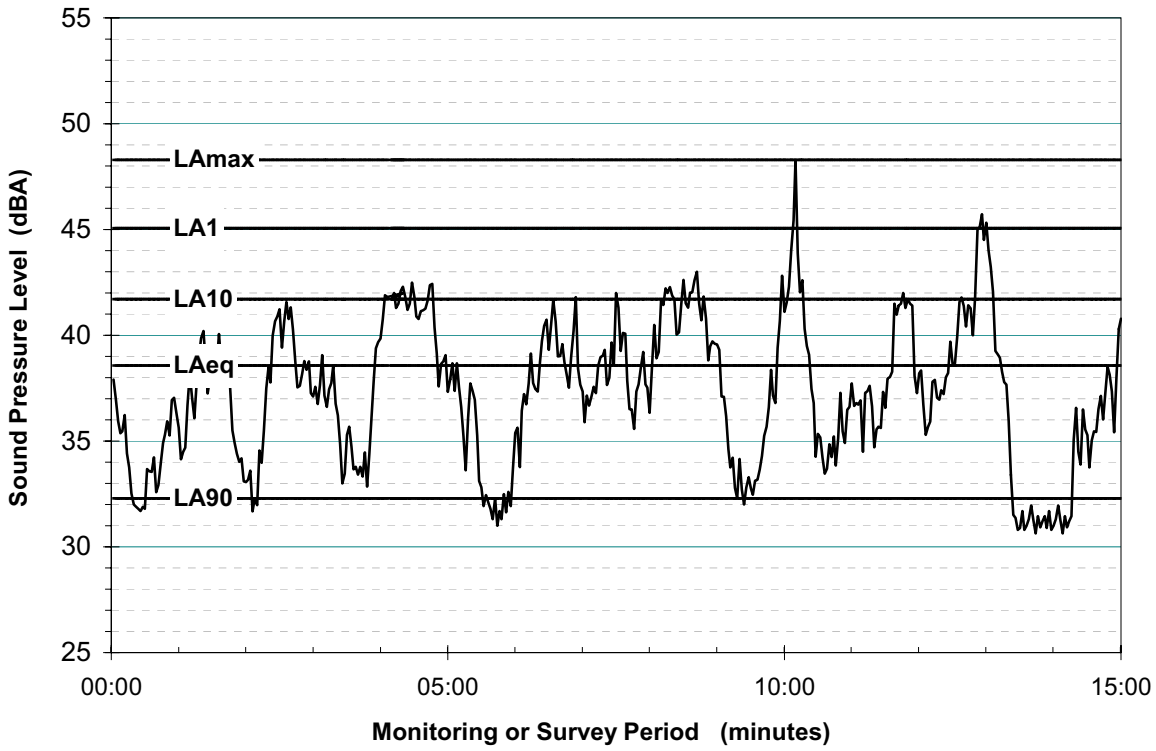


Table 13 presents examples of typical noise levels together with a subjective evaluation of the loudness.

Table 13 Typical Noise Levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130 120 110	Threshold of pain Heavy rock concert Grinding on steel	Intolerable Extremely noisy
100 90	Loud car horn at 3 m Construction site with pneumatic hammering	Very noisy
80 70	Kerb side of busy street Loud radio or television	Loud
60 50	Department store General Office	Moderate to Quiet
40 30	Inside private office Inside bedroom	Quiet to Very quiet
20	Unoccupied recording studio	Almost silent

The overall level of a sound is usually expressed in terms of dBA, which is measured using the "A-weighting" filter incorporated in sound level meters. These filters have a frequency response corresponding approximately to that of human hearing. People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz) and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally as loud, although the perceived loudness can also be affected by the character of the sound (eg the loudness of human speech and a distant motorbike may be perceived differently, although they are of the same dBA level).

A change of up to 3 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

4.3 Noise Monitoring Sites

Noise monitoring sites have been selected to be representative of residential development that may be potentially affected by the Airport Link project.

Only the general location of tunnel portals and vent stacks was known at the time of the noise logging. Noise logging sites were therefore selected where the existing noise environment would be similar to that of the most-affected residential areas.

The details of the selected noise monitoring sites, are summarised in **Table 14**.

Figure 4 to **Figure 7** (inclusive) shows location maps illustrating the noise monitoring locations. Photographs showing the noise logger position of each monitoring site are presented in **Appendix A.**

Table 14 Noise Monitoring Locations

Address / Description	Location in Appendix A	Locality Reference
30 Wongara Street, Clayfield	Location 1	Figure 7
86 Alma Road, Clayfield	Location 2	Figure 7
27 Parkland Street, Nundah	Location 3	Figure 7
72 Kalinga Street, Clayfield	Location 4	Figure 7
34 Park Road, Kedron (Kedron State High School)	Location 5	Figure 6
20 Perry Street, Lutwyche	Location 6	Figure 6
30 Colton Avenue, Lutwyche	Location 7	Figure 6
12 Park Terrace, Kedron	Location 8	Figure 6
17 Roblane Street, Windsor	Location 9	Figure 5
7 Roblane Street, Windsor	Location 10	Figure 6
46 Gallway Street, Windsor	Location 11	Figure 4
49 Earle Street, Windsor	Location 12	Figure 4
Royal Women's Hospital	Location 13	Figure 4
62 Victoria Street, Windsor	Location 14	Figure 4
42 Hooker Street, Windsor	Location 15	Figure 4
Nursing Home, 26 Palmer Street, Windsor	Location 16	Figure 5
7 Lamington Avenue, Lutwyche	Location 17	Figure 6
16 East Street, Lutwyche	Location 18	Figure 6

Figure 4 Monitoring Locations – Southern Section of the Project.

Figure 5 Monitoring Locations between Southern Section and Gympie Portal

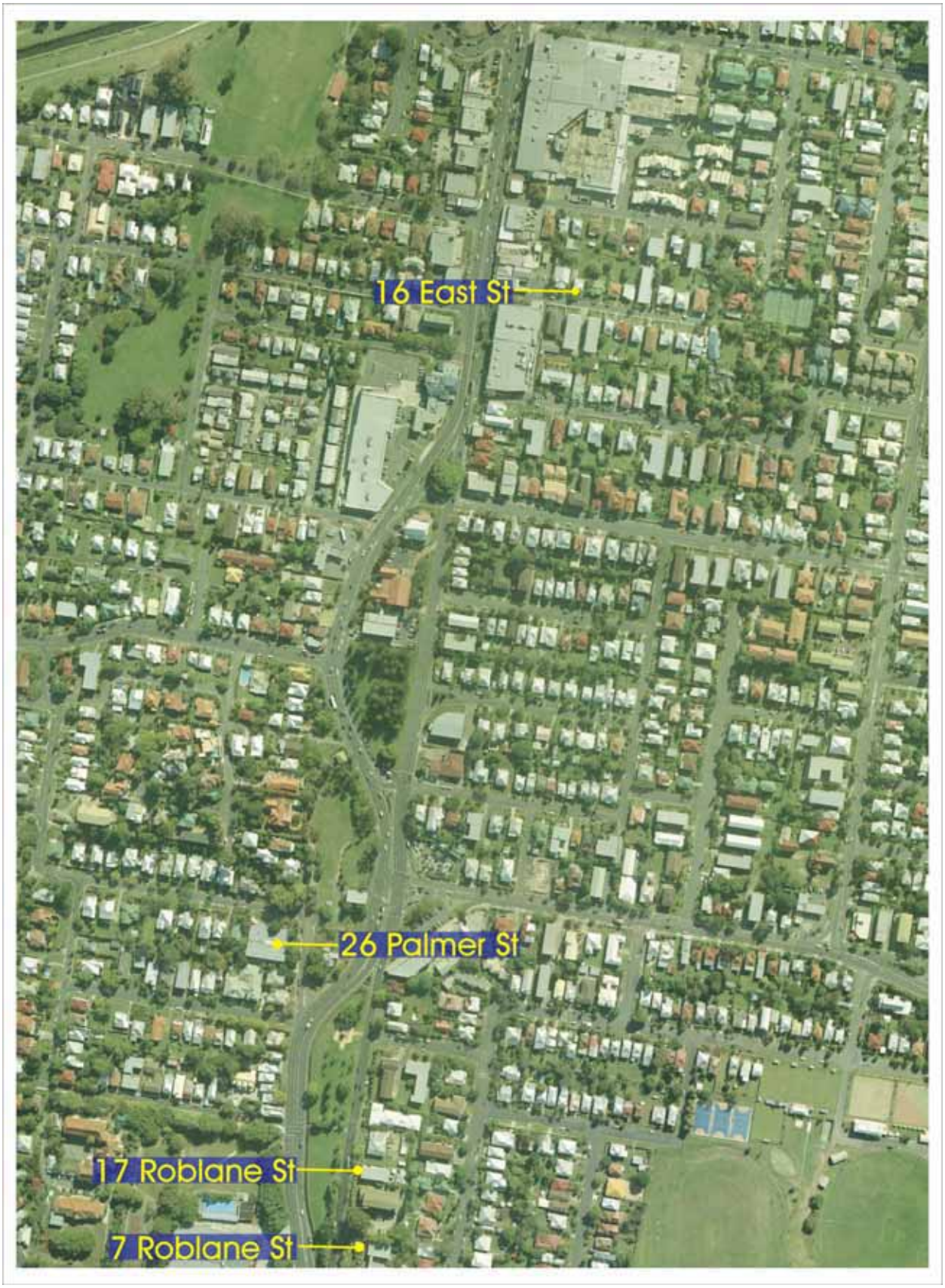


Figure 6 Monitoring Locations Northern Section of the Project

Figure 7 Monitoring Locations Sandgate Portal Area

4.4 Noise Measurement Methods and Instrumentation

Noise monitoring was conducted generally in accordance with Australian Standard AS1055-1997 *Acoustics – Description and Measurement of Environmental Noise* and the Queensland Environmental Protection Agency's *Noise Measurement Manual* 2000.

A measurement interval of 15 minutes has been utilised for both attended and unattended noise monitoring. For the unattended noise monitoring, the prevailing noise environment was measured in consecutive 15 minute periods for a total survey period of 7 days in accordance with the definition of 'long-term background' levels contained in the *Environmental Protection (Noise) Policy 1997*.

4.5 Instrumentation

The instrumentation that was used for the long-term noise monitoring is listed in **Table 15**. The calibration of all instruments was checked before and after monitoring and was found to be within 0.8 dBA of the appropriate calibration level in all instances.

All instruments were programmed to continuously record A-weighted fast-response noise levels over 15 minute sampling intervals.

Table 15 Noise Monitoring Instrumentation

Measurement Location	**Instrumentation**
All locations	Calibrator, Bruel &Kjaer Type 4230, S/N 1274 986
1	Acoustic Research Laboratories Environmental Noise Logger EL 215, SN 194447
2	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 19-299-425
3	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-301-471
4	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194528
5	Larson Davis Environmental Noise Logger LD720, SN B0939
6	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 15-299-419
7	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194581
8	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 15-299-423
9	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 15-299-422
10	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-505
11	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194444
12	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 1944410
13	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-508
14	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194660
15	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194629
16	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 15-299-452
17	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194442
18	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194555

The limitation as to how low a noise level that can be measured is governed by the combined microphone and electronic noise floor specification. For the instruments utilised, the noise floor is shown below and is well removed from the prevailing noise levels:

- ARL 215 26 dBA
- ARL 315/316 22 dBA
- Rion NA27 15 dBA
- Larson Davis 26 dBA

4.6 Results of Noise Surveys

4.6.1 Noise

The noise environment in the tunnel study area is typical of many inner urban areas, in that it is largely determined by road traffic noise, however at some locations rail noise and/or mechanical plant noise also contributed to the prevailing noise environment.

Monitoring sites were inspected during the morning or afternoon peak traffic times and also during the late night/early morning period when the background noise is typically low. The prevailing audible sounds at each location are summarised in **Table 16**. As can be seen in **Table 16,** traffic noise from nearby major roadways was a dominant source of noise at all times of the day.

Noise logger measurements were undertaken between Thursday 24 November and Thursday 15 December 2005. Weather conditions during this period were typically fine and warm to hot however there were some periods of significant rainfall. Winds were generally light to moderate with typically calm conditions, or light winds, occurring at night.

Results of the noise logger measurements are summarised in **Table 17** to **Table 20** with the full graphical output (including the prevailing weather conditions) presented in **Appendix B**. The results in **Table 17** to **Table 20** exclude noise monitoring results obtained during periods of rain (greater than 0.5 mm per 15 minute interval) or high wind speeds (greater than 5 m/s) as recommended in AS 1055.1.

Table 16 Prevailing (Observed) Noise Sources

ef	Description	ominant Daytime Noise ources	Dominant Noise Sources Late at Night
1	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes a facade reflection, facing East-West Arterial Road (behind noise barriers)	East West Arterial Road Traffic	East West Arterial Road Traffic
2	Rear yard, detached dwelling at 86 Alma Road, Clayfield	Sandgate Road Traffic, North Coast Line and Air Train rail traffic	Sandgate Road Traffic, North Coast Line and Air Train rail traffic, insects
3	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	Sandgate Road Traffic, North Coast Line and Air Train rail traffic, Construction Work	Sandgate Road Traffic, North Coast Line and Air Train rail traffic
4	Rear yard, eastern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	Sandgate Road Traffic, North Coast Line and Air Train rail traffic	Sandgate Road Traffic, North Coast Line and Air Train rail traffic, insects
5	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	Lutwyche Road / Gympie Road Traffic	Lutwyche Road / Gympie Road Traffic, Mechanical Plant from Dept of Emergency Services
6	Front yard, includes a facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	Lutwyche Road / Gympie Road Traffic	Lutwyche Road / Gympie Road Traffic
7	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	Lutwyche Road / Gympie Road Traffic, Pool Filter	Lutwyche Road / Gympie Road Traffic
8	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	Gympie Road Traffic, adjacent commercial activities (car yard), Mechanical Plant	Gympie Road Traffic, distant mechanical plant
9	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	Lutwyche Road / Roblane Street Traffic, Ferny Grove Line rail traffic	Lutwyche Road / Roblane Street Traffic
10	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	Lutwyche Road / Roblane Street Traffic, Ferny Grove Line rail traffic	Lutwyche Road / Roblane Street Traffic
11	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	Ferny Grove Rail Line and rail noise from Mayne Yards, dogs barking, localised road traffic noise	Rail noise from Mayne Yards, dogs barking
12	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	Lutwyche Road/Inner City Bypass Traffic, localised (Earle Street) traffic, rail noise from Mayne yards	Lutwyche Road/Inner City Bypass Traffic, Rail noise from Mayne Yards, distant mechanical plant
13	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	Bowen Bridge Road and Campbell Street Traffic, mechanical plant, Helicopter landing on Level 11 of Hospital (intermittent)	Bowen Bridge Road and Campbell Street Traffic, mechanical plant
14	Front yard, detached dwelling at 62 Victoria Street, Windsor	Lutwyche Road Traffic, Localised (Victoria Street) Traffic, noise from commercial activities across road	Lutwyche Road Traffic, Localised (Victoria Street) Traffic
15	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	Lutwyche Road Traffic, Localised traffic (Hooker Street), rail movements on Ferny Grove Line	Lutwyche Road Traffic, Rail movements on Ferny Grove Line
16	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	Lutwyche Road Traffic, Localised traffic (Palmer Street, Palmer Street)	Lutwyche Road Traffic
17	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	Lutwyche Road Traffic, Localised traffic (Lamington Avenue, Bradshaw Road, Norman Street)	Lutwyche Road Traffic
18	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	Lutwyche Road Traffic, Localised traffic (East Street, Lowerson Street) distant Mechanical Plant noise from Lutwyche Shopping Centre	Lutwyche Road Traffic, Mechanical Plant from Lutwyche Shopping Centre

Table 17 Existing Noise Levels - LAmax Parameter

Locations	Description	LAmax Levels + (standard deviation)

			Day	Evening	Night
			6am – 6pm	6pm – 10pm	10pm – 6am
1	30 Wongara Street, Clayfield	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes a facade reflection, facing East-West Arterial Road (behind noise barriers)	76 (5.3)	71 (5.0)	64 (6.1)
2	86 Alma Road, Clayfield	Rear yard, detached dwelling at 86 Alma Road, Clayfield	70 (3.4)	69 (3.2)	66 (4.5)
3	27 Parkland Street, Nundah	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	79 (3.8)	81 (4.2)	65 (9.5)
4	72 Kalinga Street, Clayfield	Rear yard, northern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	72 (3.9)	70 (4.7)	62 (7.7)
5	34 Park Road, Kedron	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	74 (5.1)	63 (7.8)	52 (8.6)
6	20 Perry Street, Lutwyche	Front yard, includes a facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	81 (4.3)	80 (4.3)	76 (3.5)
7	30 Colton Avenue, Lutwyche	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	68 (4.9)	62 (5.5)	58 (6.0)
8	12 Park Terrace, Kedron	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	70 (4.2)	67 (4.8)	62 (5.0)
9	17 Roblane Street, Windsor	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	83 (3.5)	79 (3.2)	79 (4.0)
10	7 Roblane Street, Windsor	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	77 (3.9)	74 (3.7)	74 (3.8)
11	46 Gallway Street, Windsor	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	75 (5.6)	72 (6.6)	63 (7.2)
12	49 Earle Street, Windsor	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	72 (4.2)	68 (5.0)	62 (5.5)
13	Royal Women's Hospital	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	78 (4.4)	77 (3.6)	75 (4.2)
14	62 Victoria Street, Windsor	Front yard, detached dwelling at 62 Victoria Street, Windsor	75 (4.9)	70 (4.5)	64 (7.2)
15	42 Hooker Street, Windsor	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	75 (5.3)	75 (6.3)	65 (10.0)
16	Nursing Home, 26 Palmer St, Windsor	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	76 (3.7)	73 (3.7)	71 (4.2)
17	7 Lamington Avenue, Lutwyche	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	68 (4.8)	69 (5.0)	62 (6.3)
18	16 East Street, Lutwyche	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	68 (5.9)	66 (5.3)	57 (6.7)

Table 18 Existing Noise Levels - LA10 Parameter

Locations		Description	LA10 Levels + (standard deviation)		
			Day	Evening	Night
			6am – 6pm	6pm – 10pm	10pm – 6am
1	30 Wongara Street, Clayfield	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes a facade reflection, facing East-West Arterial Road (behind noise barriers)	60 (3.4)	59 (58.5)	49 (3.0)
2	86 Alma Road, Clayfield[1]	Rear yard, detached dwelling at 86 Alma Road, Clayfield	61 (3.2)	61 (61.2)	59 (1.8)
3	27 Parkland Street, Nundah	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	63 (2.6)	61 (4.5)	50 (4.5)
4	72 Kalinga Street, Clayfield	Rear yard, northern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	55 (3.0)	57 (6.7)	48 (3.5)
5	34 Park Road, Kedron	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	56 (4.6)	50 (4.7)	38 (2.3)
6	20 Perry Street, Lutwyche	Front yard, includes a facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	68 (0.9)	67 (1.0)	63 (3.0)
7	30 Colton Avenue, Lutwyche	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	55 (2.7)	51 (3.8)	46 (3.3)
8	12 Park Terrace, Kedron	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	61 (4.3)	55 (4.7)	50 (3.6)
9	17 Roblane Street, Windsor	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	68 (0.8)	67 (1.0)	63 (3.4)
10	7 Roblane Street, Windsor	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	64 (0.9)	62 (1.0)	59 (3.1)
11	46 Gallway Street, Windsor	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	55 (2.9)	54 (2.7)	47 (2.9)
12	49 Earle Street, Windsor	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	56 (2.0)	53 (3.2)	48 (2.2)
13	Royal Women's Hospital	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	69 (0.7)	68 (0.6)	66 (2.1)
14	62 Victoria Street, Windsor	Front yard, detached dwelling at 62 Victoria Street, Windsor	59 (2.0)	53 (3.2)	47 (4.5)
15	42 Hooker Street, Windsor	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	59 (3.0)	55 (5.2)	46 (4.9)
16	Nursing Home, 26 Palmer St, Windsor	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	65 (1.6)	63 (2.8)	58 (3.1)
17	7 Lamington Avenue, Lutwyche	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	53 (1.9)	52 (2.2)	45 (3.7)
18	16 East Street, Lutwyche	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	54 (3.4)	51 (5.4)	43 (3.5)

[1] Evening and night-time noise level influenced by air conditioner or other similar plant item

Table 19 Existing Noise Levels - LAeq Parameter

Locations		Description	LAeq Levels + (standard deviation)		
			Day	Evening	Night
			6am – 6pm	6pm – 10pm	10pm – 6am
1	30 Wongara Street, Clayfield	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes a facade reflection, facing East-West Arterial Road (behind noise barriers)	59 (2.7)	61 (59.8)	48 (3.3)
2	86 Alma Road, Clayfield[1]	Rear yard, detached dwelling at 86 Alma Road, Clayfield	59 (2.9)	60 (60.4)	58 (1.6)
3	27 Parkland Street, Nundah	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	62 (2.3)	62 (62.1)	52 (5.9)
4	72 Kalinga Street, Clayfield	Rear yard, northern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	54 (2.5)	59 (5.6)	49 (3.8)
5	34 Park Road, Kedron	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	56 (3.8)	51 (4.8)	38 (2.7)
6	20 Perry Street, Lutwyche	Front yard, includes a facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	65 (1.1)	64 (1.3)	61 (3.0)
7	30 Colton Avenue, Lutwyche	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	53 (2.2)	51 (3.3)	45 (3.6)
8	12 Park Terrace, Kedron	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	60 (3.5)	57 (4.8)	51 (3.3)
9	17 Roblane Street, Windsor	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	66 (1.0)	64 (1.3)	61 (3.1)
10	7 Roblane Street, Windsor	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	62 (1.1)	60 (1.2)	57 (2.9)
11	46 Gallway Street, Windsor	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	54 (2.5)	54 (2.9)	47 (3.2)
12	49 Earle Street, Windsor	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	54 (2.1)	52 (2.8)	47 (2.1)
13	Royal Women's Hospital[2]	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	67 (0.7)	66 (0.9)	64 (1.6)
14	62 Victoria Street, Windsor	Front yard, detached dwelling at 62 Victoria Street, Windsor	56 (2.1)	52 (2.8)	48 (4.4)
15	42 Hooker Street, Windsor	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	59 (3.0)	58 (4.8)	52 (7.0)
16	Nursing Home, 26 Palmer St, Windsor	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	63 (1.5)	62 (2.5)	57 (3.5)
17	7 Lamington Avenue, Lutwyche	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	52 (2.3)	52 (3.6)	45 (3.6)
18	16 East Street, Lutwyche	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	53 (3.3)	53 (4.9)	44 (3.9)

[1] Evening and night-time noise level influenced by air conditioner or other similar plant item.
[2] Noise levels influenced by hospital air conditioning plant.

Table 20 Existing Noise Levels - LA90 Parameter

Locations		Description	LA90 Background Levels + (standard deviation)		
			Day	Evening	Night
			6am – 6pm	6pm – 10pm	10pm – 6am
1	30 Wongara Street, Clayfield	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes a facade reflection, facing East-	49 (2.2)	50 (4.0)	40 (2.8)

		West Arterial Road (behind noise barriers)			
2	86 Alma Road, Clayfield[1]	Rear yard, detached dwelling at 86 Alma Road, Clayfield	47 (4.5)	55 (2.4)	55 (3.2)
3	27 Parkland Street, Nundah	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	53 (3.1)	50 (4.8)	42 (3.0)
4	72 Kalinga Street, Clayfield	Rear yard, northern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	45 (2.5)	48 (5.0)	41 (2.3)
5	34 Park Road, Kedron	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	45 (2.5)	43 (4.7)	34 (1.4)
6	20 Perry Street, Lutwyche	Front yard, includes a facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	58 (1.5)	55 (3.0)	47 (4.1)
7	30 Colton Avenue, Lutwyche	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	48 (1.8)	45 (2.2)	39 (3.1)
8	12 Park Terrace, Kedron	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	50 (2.4)	48 (2.7)	40 (3.8)
9	17 Roblane Street, Windsor	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	57 (1.9)	56 (1.0)	48 (4.8)
10	7 Roblane Street, Windsor	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	55 (2.1)	53 (2.1)	45 (3.2)
11	46 Gallway Street, Windsor	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	47 (2.0)	48 (3.0)	41 (1.6)
12	49 Earle Street, Windsor	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	47 (1.4)	46 (2.7)	42 (1.9)
13	Royal Women's Hospital[2]	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	62 (0.5)	61 (0.6)	60 (0.5)
14	62 Victoria Street, Windsor	Front yard, detached dwelling at 62 Victoria Street, Windsor	48 (1.8)	45 (2.6)	39 (2.6)
15	42 Hooker Street, Windsor	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	50 (3.6)	47 (5.7)	37 (4.8)
16	Nursing Home, 26 Palmer St, Windsor	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	56 (1.2)	52 (3.0)	46 (4.8)
17	7 Lamington Avenue, Lutwyche	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	45 (2.1)	44 (2.8)	37 (2.4)
18	16 East Street, Lutwyche	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	44 (2.4)	45 (3.5)	37 (2.2)

[1] Evening and night-time noise level influenced by air conditioner or other similar plant item.
[2] Noise levels influenced by hospital air conditioning plant.

Short-term operator attended surveys were conducted at five (5) of the long-term monitoring locations to assist in qualifying the prevailing noise environment at each location. The results of these surveys are presented in **Table 21**. These surveys are sampled over a short-duration (ie 15 minute), thus the results would be expected to differ from the longer-term noise surveys previously presented.

Table 21 Summary of Short-term Noise Measurements

Measurement Location	Date - Time	Period	L10 (dBA)	Leq (dBA)	L90 (dBA)	Discernible Sources
7 Roblane Street, Windsor	06/12/05 - 23:25	Night	57	53	39	Traffic on Roblane Street (southbound) and Lutwyche Rd (northbound), Ferny Grove Railway Line and Insects
	12/12/05 - 12:40	Day	67	64	58	Traffic on Roblane Street (southbound) and Lutwyche Rd (northbound), Ferny Grove Railway Line and Insects
49 Earle Street, Windsor	12/12/05 - 13:05	Day	52	52	45	Traffic on Lutwyche Road, Birds, Mayne Rail Yard.
	06/12/05 - 00:15	Night	45	43	41	Traffic on Lutwyche Road, Mayne Rail Yard, distant mechanical plant.
17 Roblane Street, Windsor	09/12/05 - 18:05	Evening	66	63	54	Traffic on Roblane Street, Birds and Insects
72 Kalinga Street, Clayfield	12/12/05 - 12:19	Day	58	55	44	Traffic on Sandgate Road, Train Passby, Birds and Insects
	12/12/05 - 01:32	Night	43	41	38	Traffic on Sandgate Road, Train Passby, Insects
20 Perry Street, Lutwyche	09/12/05 - 17:35	Day	65	64	58	Traffic on Gympie Road, Birds and Insects
	09/12/05 - 23:00	Night	65	62	51	Traffic on Gympie Road, Birds and Insects

4.6.2 Analysis of Baseline Noise Levels

The existing noise levels at the reference locations have been examined in relation to the EPP[Noise] planning levels for road traffic noise. This examination is summarised in **Table 22** for the $L_{A10(18hour)}$ planning levels of 68 dBA for State-controlled roads and 63 dBA for other roads. The planning levels for this parameter can be understood as providing a control on the average maximum level of traffic noise during the day-evening period.

The analysis in **Table 23** compares the maximum night-time $L_{Aeq(1hour)}$ values with the 60 dBA $L_{Aeq(1hour)}$ planning level. This planning level can be understood as an attempt to limit the average level of night-time traffic noise.

The analysis in **Table 24** compares the average maximum night-time L_{Amax} values with the 80 dBA L_{Amax} planning level. This planning level can be understood as an attempt to limit the sleep disturbance effects of single-vehicle drive-by events at night.

As roads are regarded under the EPP[Noise] as Beneficial Assets, the Planning Noise Levels for road traffic noise represent a compromise between the need for protection of the public utility of roadways, and the need for protection of the acoustic environment of people in residential places.

Table 22 Analysis of Baseline $L_{A10(18hour)}$ Noise Levels

Ref	Location Description	Assessment of Average Day Evening Traffic Noise $L_{A10(18hour)}$ (dBA)		
		Measured	Planning Level	Excess
1	30 Wongara Street, Clayfield	58	68	-
2	86 Alma Road, Clayfield	61	68	-
3	27 Parkland Street, Nundah	62	68	-
4	72 Kalinga Street, Clayfield	54	68	-
5	34 Park Road, Kedron	52	68	-
6	20 Perry Street, Lutwyche	67	68	-
7	30 Colton Avenue, Lutwyche	53	68	-
8	12 Park Terrace, Kedron	58	68	-
9	17 Roblane Street, Windsor	67	68	-
10	7 Roblane Street, Windsor	63	68	-
11	46 Gallway Street, Windsor	54	68	-
12	49 Earle Street, Windsor	54	68	-
13	Royal Women's Hospital	69	68	1
14	62 Victoria Street, Windsor	56	68	-
15	42 Hooker Street, Windsor	56	68	-
16	Nursing Home, 26 Palmer St, Windsor	64	68	-
17	7 Lamington Avenue, Lutwyche	52	68	-
18	16 East Street, Lutwyche	52	68	-

Table 23 Analysis of Night-time Equivalent Average Noise Levels

Ref	Location Description	Assessment of Maximum $L_{Aeq,1hour}$ (dBA) between 10 pm and 6 am		
		Measured	Planning Level	Excess
1	30 Wongara Street, Clayfield	52	60	-
2	86 Alma Road, Clayfield	58	60	-
3	27 Parkland Street, Nundah	57	60	-
4	72 Kalinga Street, Clayfield	49	60	-
5	34 Park Road, Kedron	40	60	-
6	20 Perry Street, Lutwyche	63	60	**3**
7	30 Colton Avenue, Lutwyche	48	60	-
8	12 Park Terrace, Kedron	52	60	-
9	17 Roblane Street, Windsor	63	60	**3**
10	7 Roblane Street, Windsor	59	60	-
11	46 Gallway Street, Windsor	49	60	-
12	49 Earle Street, Windsor	49	60	-
13	Royal Women's Hospital	65	60	**5**
14	62 Victoria Street, Windsor	51	60	-
15	42 Hooker Street, Windsor	55	60	-
16	Nursing Home, 26 Palmer St, Windsor	59	60	-
17	7 Lamington Avenue, Lutwyche	47	60	-
18	16 East Street, Lutwyche	46	60	-

It can be seen in **Table 23** that the maximum night-time $L_{Aeq(1hour)}$ planning level of 60 dBA is equalled or exceeded at all but three of the measurement locations.

It can be inferred from **Table 24** and an inspection of the ambient noise monitoring records in **Appendix B** that from time to time, most of the residential location fronting any major roadway experiences maximum pass-by noise events in excess of 80 dBA L_{Amax}. It is therefore concluded that this is not a very useful impact assessment parameter as it does not appear to be achievable in practice even at relatively quiet measurement locations.

Table 24 Analysis of Baseline Maximum Levels

Measurement Position	Description	Average Levels + (standard deviation) $L_{Amax,15min}$ (dBA)			Planning Level
		Day	Evening	Night	L_{Amax} (dBA)
		6 am – 6 pm	6 pm – 10 pm	10 pm – 6 am	
1	30 Wongara Street, Clayfield	76 (5.3)	71 (5.0)	64 (6.1)	80 dBA
2	86 Alma Road, Clayfield	70 (3.4)	69 (3.2)	66 (4.5)	80 dBA
3	27 Parkland Street, Nundah	79 (3.8)	81 (4.2)	65 (9.5)	80 dBA
4	72 Kalinga Street, Clayfield	72 (3.9)	70 (4.7)	62 (7.7)	80 dBA
5	34 Park Road, Kedron	74 (5.1)	63 (7.8)	52 (8.6)	80 dBA
6	20 Perry Street, Lutwyche	81 (4.3)	80 (4.3)	76 (3.5)	80 dBA
7	30 Colton Avenue, Lutwyche	68 (4.9)	62 (5.5)	58 (6.0)	80 dBA
8	12 Park Terrace, Kedron	70 (4.2)	67 (4.8)	62 (5.0)	80 dBA
9	17 Roblane Street, Windsor	83 (3.5)	79 (3.2)	79 (4.0)	80 dBA
10	7 Roblane Street, Windsor	77 (3.9)	74 (3.7)	74 (3.8)	80 dBA
11	46 Gallway Street, Windsor	75 (5.6)	72 (6.6)	63 (7.2)	80 dBA
12	49 Earle Street, Windsor	72 (4.2)	68 (5.0)	62 (5.5)	80 dBA
13	Royal Women's Hospital	78 (4.4)	77 (3.6)	75 (4.2)	80 dBA
14	62 Victoria Street, Windsor	75 (4.9)	70 (4.5)	64 (7.2)	80 dBA
15	42 Hooker Street, Windsor	75 (5.3)	75 (6.3)	65 (10.0)	80 dBA
16	Nursing Home, 26 Palmer St, Windsor	76 (3.7)	73 (3.7)	71 (4.2)	80 dBA
17	7 Lamington Avenue, Lutwyche	68 (4.8)	69 (5.0)	62 (6.3)	80 dBA
18	16 East Street, Lutwyche	68 (5.9)	66 (5.3)	57 (6.7)	80 dBA

4.6.3 Vibration

Vibration measures were carried out at a small number of locations to determine existing vibration levels prior to the start of construction using an Instantel MiniMate Vibration Logger. All measurements were taken in the ground outside the respective residence. The summarised results of the measurements are documented in **Table 25**.

Table 25 Summarised Vibration Measurements

Location	Date - Time	Dominant Frequency	Max PPV mm/s
49 Earle Street, Windsor	16/12/05 – 15:04	>100 Hz	0.08 mm/s
17 Roblane Street, Windsor	16/12/05 – 14:50	>100 Hz	0.08 mm/s
72 Kalinga Street, Clayfield	16/12/05 – 14:17	>100 Hz	0.08 mm/s
20 Perry Street, Lutwyche	16/12/05 – 14:33	>100 Hz	0.08 mm/s

These measurements show that existing vibration levels are at or below the floor of the measurement equipment (~0.08 mm/s) and therefore below the threshold of human perception (~ 0.15 mm/s).

Should the study reveal highly sensitive scientific instrumentation in any buildings in the vicinity of the works, additional baseline measurements would fall within the scope of specialist investigations that would be conducted as part of an *Environmental Management Plan*, at the conclusion of the EIS.

5 REFERENCE NOISE AND VIBRATION DATA

5.1 Machinery Noise

A wide range of mechanical plant items are anticipated for the construction phase of the project. The specific sizes and selections of these plant items are not yet known, however typical items of plant have been nominated based on observations of similar tunnelling activities at existing worksites in the Sydney region[4] and on indicative sizing of materials handling equipment that would be required to transport the spoil at the anticipated rates of tunnel excavation. Indicative source sound power levels have been obtained from AS 2436-1981[5].

A summary of these plant items, their function, likely location of use on the project and indicative sound power level are summarised in **Table 26.**

Sound power refers to the total rate of sound generation of a given item of plant. This quantity is independent of the distance from the plant item (analogous to the wattage power of a light-bulb) and allows direct comparison of the relative acoustic 'size' of different plant items. From this data, the sound pressure level (or noise level) at any offset distance from the plant can be calculated (analogous to the light intensity from a light-bulb – the greater the distance, the less intense).

It is proposed to enclose night-time noise sources within large enclosures to allow spoil accumulation on a 24 hour basis. In general, any enclosure is more effective at containing high-pitched noises (eg hisses, scrapes, whines) than low-pitched noises (eg thuds, deep exhaust notes). Therefore, to understand how effectively an enclosure will contain machinery noise, estimates are needed of both the frequency spectrum (or pitch) of noise sources and the frequency-dependent (or pitch-dependent) sound transmission characteristics of the enclosure.

Typical spectral shape data for representative types of noise sources that may be used within worksite enclosures are summarised in **Table 27**.

4 *Cross-City Tunnel William Street worksite, Lane Cove Tunnel Mowbray Road and Marden Street worksites, Epping-Chatswood Rail Link Tunnel M2 worksite.*

5 *Australian Standard 2436-1981 – Guide to Noise Control on Construction, Maintenance and Demolition Sites.*

Table 26 Source Sound Power Level Estimates for Mechanical Plant

Description of Plant	Sound Power Level (L_{Amax} dBA)	Plant Function	Possible Locations of Use
25 t Articulated off-road Dump Truck	114	Underground spoil haulage from tunnel face	All areas of tunnel excavation
On-road Truck and Dog	103	Off-site spoil transport	All earthworks areas
20 t, 100 kW Excavator	112	Spoil loading	Initial excavations of cut and cover areas
35 t, 200 kW Excavator	114	Surface excavation; rubble removal	Initial excavations of cut and cover areas
200 kW Grader	116	Road grading	All surface connections
25 t, 200 kW Front-end Loader	116	Spoil loading	All worksite enclosures
38 t, 250 kW Dozer	118	Ripping	Initial excavations of cut and cover areas
600 kW Electric Conveyor Drive	106	Transport of spoil along tunnel to surface	Transport of spoil between EPM and spoil enclosures
Pneumatic Rock Drill	120	Pre-drilling for rock-bolting, drilling for explosives	All excavations in loose rock, all drill and blast operations
Large Air Compressor	103	Supply to rock drill	All drilling operations
Hydraulic Rockbreaker	120	Loosening rocky ground, trimming rock faces	All excavations in loose rock and all drill
20 t Mobile Crane	105	Enclosure erection, loading/unloading	All worksites
Pile Boring	118	Excavation for poured concrete piles	Edge of excavations in loose material and retaining walls
24 t Concrete Truck	112	Concrete delivery	All foundations, pouring of bored piles and shotcreting
Concrete Pump	107	Concrete delivery	All foundations, pouring of bored piles and shotcreting
Asphalt Paver	114	Road surfacing	All surface connections
Roller	104	Compacting and surfacing	All surface connections
100 Tonne Hydraulic Crane	110	Heavy lifting of elevated structure components?	Southern?
Water Truck	105	Dust suppression	Northern and Southern
Compressor 285 L/s	100	Power pneumatic tools	All worksites
Semi trailer	114	Delivery of construction equipment	All worksites
Bobcat	112	Spoil mucking	All worksites

Ventilation plant will also be a major item of plant that would operate at all worksites on a 24 hour basis. Sound power levels have not been listed for this plant since no indicative selections of construction ventilation plant have yet been determined. Further, the acoustic specification for this plant would normally be determined by site-specific acoustic constraints in accordance with the standard EPA's licensing requirements for fixed stationary noise sources. For this reason, a general indicative sound power level is not listed.

Table 27 Indicative Spectral Sound Power Distribution for Plant Located within Enclosures

Plant Type	Octave A-weighted Sound Power Levels Relative to Overall A-weighted Power Level (dB)							
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Air Compressor	-27	-10	-6	-6	-9	-9	-14	-20
Diesel Powered Mobile Plant	-27	-20	-9	-7	-5	-6	-14	-24
Electric Conveyor Drive	-35	-22	-13	-9	-2	-12	-16	-32
Rock Drill	-23	-18	-15	-8	-6	-5	-7	-14

5.2 Acoustic Properties of Enclosure Materials

The amount by which acoustic energy is reduced as it passes through a material is known as the transmission-loss of the material. As discussed in the previous section, the transmission-loss is generally greater for high-pitched sounds than for low-pitched sounds.

Transmission-loss spectra for examples of possible enclosure construction materials are detailed in **Table 28**.

Table 28 Indicative Transmission Loss Spectra for Representative Enclosure Constructions

Material Description		Transmission Loss in Octave Bands (dB)							
		63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
1.	Low Performance Option 0.62 mm metal decking	3	8	14	20	23	26	27	35
2.	Medium Performance Option 0.62 mm metal decking lined with 50 mm fibreglass[6]	5 (est)	10	15	22	32	37	43	43
3.	High performance Option 0.62 mm metal decking, 110 mm airspace, 50 mm fibreglass blanket in airspace, internal lining of 18 kg/m^2 porous-faced fibre-board[7]	15 (est)	20	29	43	46	57	63	63

The effectiveness of the possible enclosure materials listed in **Table 28** in reducing the types of internal noise sources shown in **Table 27** has been calculated. The results of these calculations are presented in **Table 30**.

Factors that maximise the effectiveness of an enclosure include the minimisation or avoidance of gaps or holes, effective mechanical isolation of the enclosure from pieces of machinery inside, and most importantly, the inclusion of sound absorption on internal surfaces of the enclosure.

An enclosure that has hard (non-absorptive) internal surfaces will cause what is described as reverberant build-up within the enclosure. This is noise that is reflected within the enclosure rather than being dissipated in acoustically absorptive materials (such as glass-fibre of poly-fibre linings - loose spoil also exhibits acoustical absorption). The more reverberant build-up of noise within the enclosure, the less effective the enclosure is in controlling noise because the inside noise level effectively increases.

The actual degree of absorption within the proposed enclosures is difficult to predict without an enclosure design and without information relating to the absorptivity of spoil.

6 *Report No. 3668/159/4517B-5-83 in accordance with AS1276-1979 – Louis A. Challis & Associates Pty Ltd*

7 *Report No. 3798-1-82 – Louis A. Challis & Associates Pty Ltd*

For indicative purposes the reverberant corrections described by Bies and Hansen[8] have been utilised. These corrections are reproduced in **Table 29.**

Table 29 Correction Factors for Internal Acoustic Conditions

Enclosure Internal Acoustic Conditions	Reverberant Corrections in Octave Bands (dB)							
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Live (bare metal)	18	16	15	14	12	13	15	16
Average (absorptive lining of enclosure)	13	11	9	7	5	4	3	3
Dead (absorptive lining of all surfaces)	11	9	6	5	3	2	1	1

'Live' internal conditions would occur if all internal surfaces were hard, such as bare metal. This would occur for the Option 1 enclosure construction in **Table 24.**

'Average' internal conditions would occur if all internal surfaces of the enclosure were faced with a sound-absorptive material. Enclosure construction Options 2 and 3 in **Table 28** would achieve this**.** It is considered unlikely that acoustically 'dead' conditions would be achievable.

The effective noise reductions that would be achieved by alternative enclosure designs are summarised in **Table 30**. These estimates account for the spectral characteristics of sources (refer **Table 27**), enclosure constructions (refer **Table 28)**, and associated internal reverberant characteristics (refer **Table 29**).

Table 30 Effective Noise Reductions Achieved by Enclosure

Plant Type	Effective Noise Reduction (dBA)		
	1. Low Performance enclosure	2. Medium Performance enclosure	3. High Performance enclosure
Air compressor	0	7	18
Diesel powered mobile plant	4	12	24
Electric conveyor drive	7	16	28
Rock drill	4	12	23

It can be seen in **Table 30** that a simple metal inclosure would achieve no overall noise level reduction for a noise source such as a compressor that has a noise emission dominated by low-frequency components. Overall, a bare metal enclosure should not be regarded as an effective noise control.

Substantial improvements in the effectiveness of an acoustic enclosure can be achieved by adding an acoustically absorptive internal lining (refer Option 2). A further substantial improvement can be achieved by effectively creating a double layer construction for walls and ceiling elements (refer Option 3).

It can also be seen from **Table 30** that the effective noise reduction can vary as much as 17 dBA depending on the frequency content of the plant item. Plant emissions that are dominated by high frequency noises, such as rockbreaking, will benefit most from an acoustic enclosure.

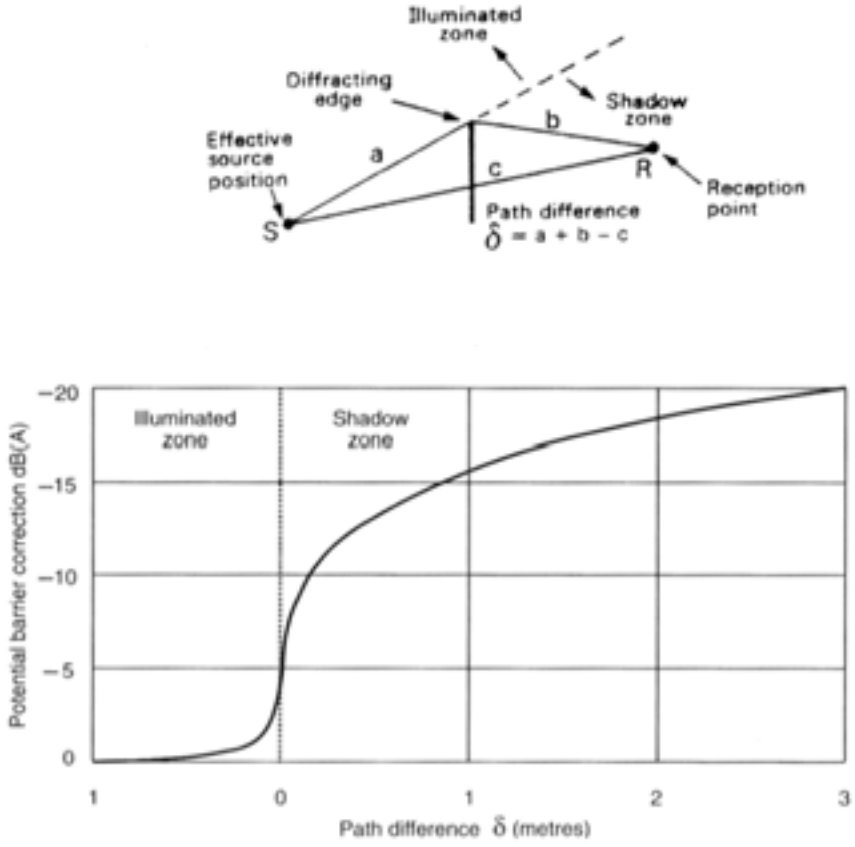
5.3 Indicative Effectiveness of Noise Barriers

The effectiveness of noise barriers typically ranges from 5 dBA if line-of-sight between the noise source and receiver location is just obscured, up to around 15 dBA where the barrier provides optimal blocking of the sound transmission path.

8 *Engineering Noise Control – D.A. Bies & C.H. Hansen (1988)*

The actual degree of attenuation will depend on the frequency spectrum of the noise and the length of the diffracted noise path compared with the direct noise path. For a noise spectrum dominated by sound in the range of 300 to 500 Hz, the relationship between the barrier attenuation and geometrical parameters is illustrated on **Figure 8**.

Figure 8 Geometric Dependency of Barrier Attenuation



For this project it is very difficult to generalise about the degree of barrier shielding that would likely result from the erection of noise barriers near construction sites. Construction site barriers are typically in the range of 2.4m to 3.0m high. In general, the dwellings near construction areas for this project are either highset or multi-level unit buildings. This gives a nominal receptor height of 4.2m or higher.

The effective height of noise sources will vary depending on the type of machinery in use and the exhaust height. For a pile-boring rig as an example, this height may be around 3 to 4m. For a front-end loader or excavator, the effective source height may be in the range of 2 to 3m.

Thus it can be seen that for many construction noise sources typical barriers in the range of 2.4m to 3.0m high would not obscure line-of-sight and would therefore not produce significant attenuation. The height of temporary barriers may therefore need to be 5 to 6m high in many instances to provide optimal noise reductions.

5.4 Indicative Effectiveness of Upgrading Building Facades

The following analysis of potential construction noise impacts in residential buildings is based on the assumption that the noise level difference outside a dwelling to inside a habitable room is a nominal 10 dBA for older type dwellings that rely predominantly on natural ventilation through windows, and 20 dBA for modern residential apartments with close-fitting sliding windows that would normally be equipped with air conditioning.

For older dwellings it would be possible to increase the inside/outside noise level difference by 10 to 20 dBA.

This type of improvement would require a combination of the following physical changes to windows facing construction sites:-

- Retrofitting or replacing window seals
- Closing windows
- Fitting a secondary sliding window system, or alternatively replacing the existing window system

Fitment of ceiling fans and/or an air-conditioner system (window-mounted or split-type) and/or silenced fresh air ventilators may be appropriate to compensate for the loss of thermal comfort and natural ventilation that may occur if windows were kept closed.

For modern residential units, inside/outside noise level differences of up to 10 dBA higher than the nominal assumed value of 20 dBA may already be achieved if facades have already been design for control of traffic noise.

To give an exact prediction of possible gains in inside/outside noise level differences requires specific knowledge about the construction of individual dwellings. This could be achieved within the context of a detailed noise management plan.

5.5 Vibration

5.5.1 General Considerations

Different excavation methods generate different patterns of vibration. Conventional blasting can produce one very short period group of vibrations associated with a blast each shift. This could mean one blast each 12 hours during blasting operations. Blasting would normally be complimented by rockbreaking to trim the excavation envelope.

The milder form of blasting known as Penetrating Cone Fracture or PCF blasting (also referred to as Gas Blasting) does not require the same degree of evacuation as conventional blasting. In theory, PCF blasting could achieve be undertaken to carry out smaller, more frequent blasts.

Rockbreaking normally involves periods of operation interrupted by manoeuvring and clearing by an excavator. Earth pressure balance machines and roadheaders, on the other hand, generate relatively constant vibration levels during sustained periods of operation.

The vibration levels generated at the surface of the ground during surface or tunnel excavation is a function of many variables, including the excavation method, advance rate, depth below surface, ground (rock) hardness and the structure of surface strata. With limited strata information available before construction, it is difficult to predict exactly what vibration levels may be experienced. In this circumstance, it is usual to collate the highest vibration levels recorded for a range of extraction methods in similar circumstances. A consequence of this approach is that actual vibration levels may be lower than the predicted levels.

5.5.2 Reference Vibration Levels

Drill and Blast

Vibration levels from blasting do not represent a constant vibration source. To a greater degree than mechanical excavation methods, the design of a blast can be controlled to ensure that vibration levels remain within specified bounds. The extraction rate of advance is therefore dependent on the size and design of blasts.

Indicative blast vibration levels associated with tunnelling have been sourced from measurements carried out during the trial blasting for Brisbane Rail Tunnel Duplication[9]. These trials were conducted at the Creek Street tunnel portals that were excavated in hard rock. Vibration transducers were located on the foundations of nearby buildings, including the Incholm Building on Wickham Terrace and All-Saints Anglican Church on Anne Street. Thus, the circumstances of these trial blasts are comparable to the rock conditions and sensitivity of high-interest structures such as St Mary's Anglican Church, Woolloongabba Post Office and 'Leckhampton' in the vicinity of the Shafston tunnel ramps. The correlation obtained from this study is:

Vibration, V (mm/s) = $14655 \times \{Q^{0.5}/R\}^{2.27}$ (RHA Q02-R1)

Where R = distance (m) and Q = maximum instantaneous charge (kg).

A second estimate of blast vibration levels has been obtained from the ICI Explosives Blasting Guide[10] for tunnel blasts. The prediction formula from this guide would suggest lower vibration levels than the data from the Brisbane Rail Tunnel Duplication project. This relationship, for 80 percentile peak vibration levels, is:-

V (mm/s) = $608 \times \{Q^{0.5}/R\}^{1.6}$ (ICI Tunnelling).

Table 31 shows the indicative permissible blast sizes that could result in a ground vibration velocity level of 2 mm/s at the building foundations. A limit of 2 mm/s is specified by the Brisbane City Council local laws for blasting near heritage-listed buildings.

Table 32 shows the indicative permissible blast sizes that could result in a ground vibration velocity level of 5 mm/s at the building foundations. A level of 5 mm/s would typically relate to commercial buildings containing sensitive equipment. Based on the normal frequency spectra associated with blasting, vibrations are likely to contain dominant frequencies above 3 Hz.

Table 31 Indicative Permissible Maximum Instantaneous Charge (MIC) to Achieve 2 mm/s PPV Near Heritage Structures – Conventional Blasting

Data Source	Indicative Permissible Charge weight (kg) Versus Distance					
	Exceedance	5 m	10 m	20 m	30 m	40 m
General ICI Tunnelling formula	20%	0.02	0.08	0.03	0.07	1.3
QR Rail Tunnel trial blasts	20%	0.01	0.04	0.15	0.35	0.6

Table 32 Indicative Permissible Maximum Instantaneous Charge (MIC) to Achieve 5 mm/s PPV Near Buildings with Sensitive Equipment – Conventional Blasting

Data Source		Indicative Permissible Charge weight (kg) Versus Distance				
	Exceedance	5 m	10 m	20 m	30 m	40 m
General ICI Tunnelling formula	20%	0.06	0.25	1.0	2.2	4.0
QR Rail Tunnel trial blasts	20%	0.02	0.09	0.35	0.8	1.4

Table 33 shows indicative permissible blast sizes that could result in a ground vibration velocity level of 10 mm/s PPV. This level would relate to residential dwellings and other buildings not containing highly sensitive equipment.

A 20% exceedance level has been reported for consistency with the blasting criteria in the EPP (Noise).

9 *Richard Heggie Associates Pty Ltd Report Q02-R1, 1 June 1990 "Trail Blast Monitoring and Site Law Development – Duplication of Brisbane Inner City Rail Tunnels" Prepared for Connell Wagner (Qld) Pty Ltd*

10 *ICI Explosives Blasting Guide – Technical Services, ICI Explosives, October 1995.*

Table 33 Indicative Permissible Maximum Instantaneous Charge (MIC) to achieve 10 mm/s PPV Near Residential Dwellings and other Buildings – Conventional Blasting

Data Source	Indicative Permissible Charge weight (kg) Versus Distance					
	Exceedance	5 m	10 m	20 m	30 m	40 m
General ICI Tunnelling formula	20%	0.15	0.6	2.3	5.3	9.4
QR Rail Tunnel trial blasts	20%	0.04	0.16	0.65	1.4	2.6

In recent years, Penetrating Cone Fracture (PCF) blasting technology has been developed for rock excavation where vibration (and/or airblast) constraints are critical. In suitable rock formations the more efficient fracture mechanism employed by PCF allows vibration levels to be approximately half that of conventional explosives for the same volume of broken rock (or alternatively double the extraction for comparable vibration levels).

The PCF technique also dramatically reduces flyrock issues and airblast. PCF may therefore have advantages where blasting is required close to the surface (eg excavation of tunnelling access shafts at worksites) as well as for tunnel blasting beneath sensitive areas.

Charge sizes per blasthole for PCF technology typically range from 10 grams to 300 grams. Minimum charge sizes for conventional blasting are upwards of 120 grams per blasthole.

Earth Pressure Balance type Tunnel Boring Machines[11] (TBMs)-

The proposed TBMs are approximately 12 m in diameter. Likely ground vibration levels for the Airport Link TBMs are shown in **Table 34.** These levels have been inferred from the following tunnelling projects:

- Canning Town, UK (Rail))[12];
- Durand's Wharf (Rail) [12]
- Sutton (Sewer line); [12]
- Los Angeles MTA Red Line (Metro)[13].

The data was measured in strata having a similar geology to the sediments and alluvium that prevail in the east-west tunnel

Roadheaders and Rockbreaking

The typical maximum levels of ground vibration from heavy roadheading and rockbreaking operations are also listed in **Table 30.** The frequency content of the ground vibration associated with roadheaders and rockbreaking is normally concentrated between 10 Hz and 50 Hz. These vibration levels have been determined from field vibration measurements collated by Heggies.

A summary of vibration levels anticipated from mechanical tunnel excavation methods are shown in **Table 30.** Vibration levels associated with example conventional blast charge sizes are also included for comparison purposes.

From **Table 30** it can be seen that vibration level associated with earth pressure balance machines and roadheaders are very low in comparison to other excavation methods, particularly blasting.

11 The term TBM used in this report, specifically refers to Earth Pressure Balance type Tunnel Boring Machines

12 Hiller DM, Crabb GI, 2000. Groundborne vibration caused by mechanised construction works. TRL Report 429, Transport Research Laboratory, Berkshire, England.

13 Saurenman, Hugh. 1993. Vibration from Metro Rail Tunnelling Operations. Harris Miller Miller & Hanson Inc.

Table 34 Indicative Maximum Ground Vibration Levels for Mechanical Tunnel Excavation Methods

Operation	Peak Vibration Levels (mm/s) Versus Distance					
	5 m	10 m	20 m	30 m	40 m	50 m
12m Dia. Earth Pressure Balance Machine	0.98	0.53	0.29	0.20	0.16	0.13
Heavy Rockbreaking	4.5	1.3	0.4	0.2	0.14	0.1
Heavy Roadheading	0.5	0.13	0.04	0.02	0.01	0.01
Blasting - ICI tunnelling formula						
5 kg Maximum Instantaneous Charge	168	55	18	10	6	4
1 kg Maximum Instantaneous Charge	46	15	5	2.6	1.7	1.2
0.2 kg Maximum Instantaneous Charge	13	4.2	1.4	0.7	0.5	0.3

5.6 Regenerated Noise

Regenerated noise refers to noise that is first transmitted to the ground by machinery as a vibration which then travels to a sensitive location (such as a house) through the ground and foundations, where the walls, floor and ceiling then radiate this vibration as audible noise.

Regenerated noise levels are more difficult to predict than noise that is transmitted through the air only. This is because the transmission of regenerated noise depends on the ground strata on the structure and internal acoustical characteristics of buildings in which regenerated noise is being considered.

An indicative summary of vibration levels anticipated from mechanical tunnel excavation methods is presented in **Table 35** based on a -30 x $\log_{10}$(distance) relationship[14] between distance and regenerated noise level.

Table 35 Indicative Regenerated Noise Levels for Mechanical Tunnel Excavation Methods

Operation	Regenerated Noise Levels (dBA) Versus Distance					
	5 m	10 m	20 m	30 m	40 m	50 m
12 m Dia. Earth Pressure Balance Machine *15 16*	47	42	36	33	31	29
Roadheading (Wilkinson Murray 38dBA @ 20m)	56-62	47-53	38-44	32-38	29-35	26-32
Rockbreaking (RHA 60 dBA @ 10m)	69-75	60-66	51-57	47-53	42-48	39-45
Rockdrilling (RHA 38dBA @ 23m)	58-64	49-54	40-46	36-42	31-37	29-35

Regenerated noise levels associated with blasting are not normally considered due to the short duration of blast events and the low levels of regenerated noise in the audible frequency range.

14 Sound pressure is related to vibration velocity as 20 x $\log_{10}$(V), in the ground, vibration velocity varies with distance$^{-1.5}$ as an approximation across a range of rock conditions. (The exponent can typically vary from -0.5 to -2.5) depending on the particular rock conditions.) Combining these, the sound pressure is related to distance as -30 x $\log_{10}$(distance).

15 *Goto, J., Thompson, S., Squire, S., Mizuno, S., 2004. Dublin Port Tunnel Project Office, Nishimatsu Construction Co. Ltd "Dublin Port Tunnel – Excavation of an 11.8m diameter urban motorway tunnel" - Proceedings of 30th International Tunnelling Association Congress, Singapore, 22-27 May 2004.*

16 *Hiller DM, Crabb GI, 2000. Groundborne vibration caused by mechanised construction works. TRL Report 429, Transport Research Laboratory, Berkshire, England.*

6 ASSESSMENT OF PREPARATION AND OPERATION OF WORK SITES

6.1 Modelling Methodology

This assessment provides an assessment of the acoustical impacts from the site preparation and construction works associated with the project. At this stage of the project, there has been no detailed assessment of the construction methodology however, it is still possible to provide a good estimate of the noise emissions based on reference sound power levels for typical items of plant and the anticipated location of plant on the worksite.

For this project, worksites are relatively confined, preventing a large number of plant items from operating simultaneously. In general it is considered that one plant item will dominate at any given time since processes such as excavation and loading will generally occur sequentially.

Indicative noise emissions from worksites have been assessed by following the following analysis sequence:

1. Establish typical daytime and night-time operating scenarios in consultation with the JV.
2. Identify representative receptor locations around worksites.
3. Calculate external noise goals at receptor locations based on internal noise assessment goals specific to the nature of the receptor.
4. Calculate maximum external noise levels at receptor locations from individual plant items, taking into account effects of distance (hemispherical spreading assumed) and where relevant, the effective noise reduction provided by an acoustic enclosure. For simplicity, no attenuation has been allowed for from site hoardings or other structures that may provide barrier shielding[17]. Meteorological effects are not included as they are not relevant in the near-field zones upon which this assessment focuses.
5. The predicted maximum noise levels are converted to an L_{Aeq} index by the subtraction of 8 dBA.
6. Compare the predicted L_{Aeq} levels with the external noise goals to determine significance of potential impacts.
7. Specific mitigation strategies have been developed after analysis of noise emissions for the day and night operating scenarios. In this way mitigation strategies have been based on the most critical operating scenario.

The noise emissions from each worksite have been assessed for three scenarios:- site preparation, daytime tunnelling and night-time tunnelling. Of these scenarios, site preparation will take the least amount of time but frequently results in the highest noise emissions at adjoining locations. An assessment of noise levels from earthworks would not normally be undertaken for a building construction site during daytime operations. However, in this instance the initial earthworks are only the beginning of a much longer construction operation, and have therefore been assessed in the same way as day and night-time tunnelling operations.

The ambient noise records that have been collected for this project are considered to be representative of the range of ambient noise situations relative to major and minor roads. However, it has not been possible to measure ambient noise levels at all potentially affected locations. Where ambient levels have not been measured for a location of interest, ambient noise levels have been inferred from other measurement locations where it is believed the relative proximity to the major source of ambient noise (ie road traffic) is similar. Where ambient levels have been inferred in this manner, the similar location has been specifically identified in the analysis for reference purposes.

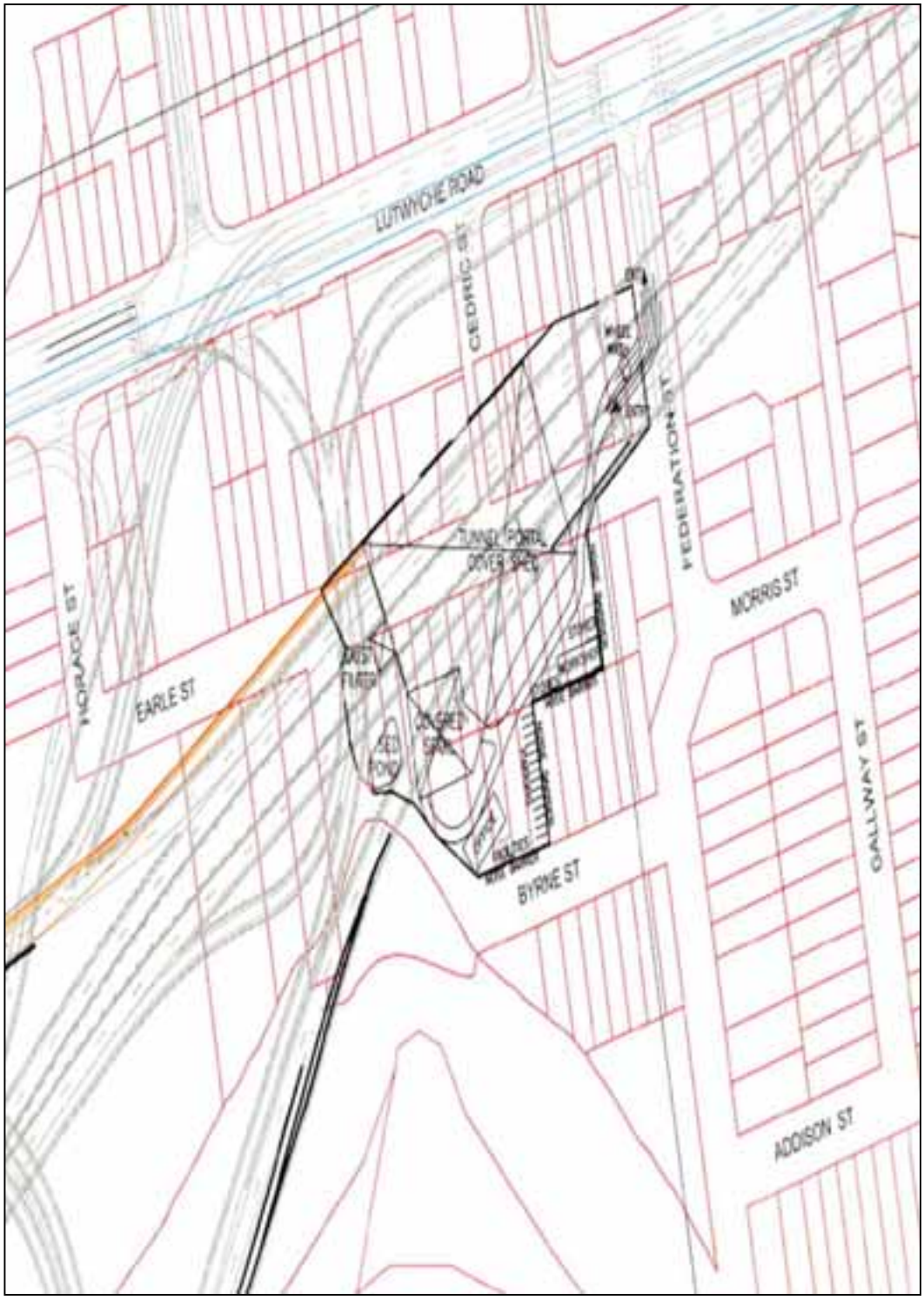
17 *The barrier shielding that would be afforded by perimeter hoardings is highly dependent on the relative height of the receiver, the ground level at the barrier and the source noise height.*

6.2 Southern Worksite

6.2.1 Proposed Activities

The schematic layout diagram for the northern worksite is illustrated in **Figure 9**.

Figure 9 Southern Worksite Layout



The primary noise-generating activities anticipated during the preparation and operation of the southern worksite are summarised in **Table 36**.

Table 36 Southern Worksite Surface Works Noise Sources

Construction Phase and Approx. Duration	Enclosed/Underground Day and Night-time Noise Sources	Additional Daytime Noise Sources
Removal of Buildings (2 weeks)	Nil	Excavators, hydraulic rockbreakers, bulldozers, dump trucks, manual trades, compressors, generators
Earthworks (12 months)	Nil	Excavators, bulldozers, graders, loaders, bobcats, compaction equipment, dump trucks, water trucks, manual trades
Enclosure Construction (4 weeks)	Nil	Mobile cranes, concrete trucks, concrete pump, delivery trucks, manual trades, excavator, structural steelwork
Roadheader Tunnelling (38 months)	Dump truck removal of roadheader spoil, supply of temporary support material, ventilation plant, concrete lining of tunnel	Removal of spoil and delivery of materials

6.2.2 Noise Impacts

Site Preparation

Site preparation would involve removal of existing buildings, initial earthworks and enclosure construction. These works would be carried out during the daytime only. It is anticipated that the most noticeable source of noise during site preparation would be heavy earthmoving and rockbreaking machinery during bulk material excavation. In terms of the whole project duration, the site preparation phase is relatively brief.

Noise levels that could be received at representative surrounding buildings during site preparation earthworks are compared with functional internal noise goals for surrounding building uses in **Table 37**.

Table 37 Noise Assessment – Southern Worksite - Site Preparation

		Representative Receptors	
		Residences south of Federation St	**Residences north of Federation St**
Minimum Separation from Earthworks (indicative only)		15 m	80 m
AS/NZS 2107 Maximum Internal Noise Goal (L_{Aeq} - dBA)		45 (living area, near minor roads)	45 (living area, near minor roads)
Nominal Facade Reduction (dBA)		10	10
External Noise Goal (L_{Aeq} dBA)		**55**	**55**
Existing Daytime Levels			
Representative measurement location (external)		(12)	(11)
average $L_{Aeq,15minute}$ - dBA		54	54
average $L_{Amax,15minute}$ - dBA		72	75
Typical Plant Items	**Plant Sound Power Levels (L_{Amax} dBA)**	**Indicative External Plant Noise Level at Receptor (L_{Aeq} dBA)**	
Bobcat	112	72	58
38 t, 250 kW Dozer	118	78	64
Hydraulic Rockbreaker	120	80	66
35 t, 200 kW Excavator	114	74	60
200 kW Grader	116	76	62
Roller	104	64	50
Compressor 285 L/s	100	60	46
Water Truck	105	65	51
25 t, 200 kW Front-end Loader	116	76	62
25 t Articulated off-road Dump Truck	114	74	60
20 t Mobile Crane	105	65	51
External Noise Goal (L_{Aeq} dBA)		**55**	**55**

The following conclusions regarding noise impacts associated with site preparation are drawn from the assessment summary in **Table 37:**

Residents South of Federation Street

- At the closest residences to the south of Federation St, the highest noise levels arise due to the operation of the rockbreaker. Based on "typical" emissions, exceedances of 25 dBA are predicted whilst it is in use. This represents a very significant exceedance of the design objective and by comparison with the prevailing ambient levels would likely represent a high acoustical impact. The impacts particularly apply to those rooms which are orientated towards the construction site and highly likely to result in acoustic impacts (eg interference with passive listening, resting and conversation).
- The noise from other plant items will exceed the design goal by 10-20 dBA. Given the exceedance above the prevailing traffic noise levels, the construction noise is likely to result in significant impacts.
- The consideration of noise mitigation should be examined for residents at this location (as detailed in **Section 6.2.3**), so as to maintain a reasonable noise environment.

Residents North of Federation Street

- At the closest residences in the north of Federation St, the highest noise levels arise due to the operation of the rockbreaker. Based on "typical" emission levels, exceedances of 11 dBA are predicted whilst it is in use. Given the exceedance above the prevailing traffic noise levels, significant impacts would be expected. Levels of this magnitude would be audible within dwellings and likely to result in some degree of acoustic impacts.

- The noise from other plant items will exceed both the design goal and the prevailing traffic noise levels by up to (typically) 7 dBA to 8 dBA. This represents a noticeable exceedance of the design goals however this level is unlikely to significantly interfere with internal activities.
- Noise mitigation to reduce the emissions from the rock-hammer and general plant emissions should be considered (as detailed in **Section 6.2.3**).

Daytime Tunnelling

During daytime tunnelling operations, the dominant noise sources will be loading of spoil within the enclosure and trucking of the spoil off-site by truck and dog.

Indicative L_{Aeq} noise levels that could be received at representative surrounding buildings during the roadheader tunnelling phase are compared with noise goals in **Table 38**.

For assessment purposes it has been assumed that a high performance acoustic enclosure would be utilised as described in Table 30

Table 38 Noise Assessment – Southern Worksite - Daytime Tunnelling

		Representative Receptors	
		Residences south of Federation St	**Residences north of Federation St**
Minimum Separation from Earthworks (indicative only)		15 m	80 m
AS/NZS 2107 Maximum Internal Noise Goal (L_{Aeq} - dBA)		45 (living area, near minor roads)	45 (living area, near minor roads)
Nominal Facade Reduction (dBA)		10	10
External Noise Goal (L_{Aeq} dBA)		**55**	**55**
Existing Daytime Levels			
Representative measurement location (external)		(12)	(11)
average $L_{Aeq,15minute}$ - dBA		54	54
average $L_{Amax,15minute}$ - dBA		72	75
Typical Plant Items	**Effective Sound Power Level (L_{Amax} dBA)**	**Indicative External Plant Noise Level at Receptor (L_{Aeq} dBA)[2]**	
Concrete Pump	107-24=83[1]	43 - 48	29 - 34
Semi Trailer	117-24=90[1]	50 - 55	36 - 41
On-road Truck and Dog	103-24=79[1]	39 - 44	25 - 30
25 t, 200 kW Front-end Loader	116-24=92[1]	52 - 57	38 - 43
600 kW Electric Conveyor Drive	106-28=78[1]	38 - 43	24 – 29
External Noise Goal (L_{Aeq} dBA)		**55**	**55**

1 Indicates that the effective sound power level has been adjusted for a high performance acoustic enclosure as per corrections in Table 30.

2 Lower value – shed closed; Upper value – shed open at nominal entry and exit doors shown in Figure 8 where a nominal 5dBA reduction in the performance of the acoustic shed has been adopted.

Residents South of Federation Street

- The noise from the plant items are not expected to exceed the design goal (to any adjacent resident) when the doors on the acoustic enclosure are closed.
- With the doors open there is predicted to be a minor exceedance of the noise goal due to noise from the front end loader at residents adjacent to the worksite. This exceedance is minor (2 dBA) and therefore it is anticipated that noise impacts will be negligible.
- Apart from the detailed design of the enclosure, the provision of additional noise mitigation is not recommended for residents at this location.

Residents North of Federation Street

- The noise from plant items is not expected to exceed the design goal. As a result, no significant acoustical impacts would be expected.
- The further examination of other specific noise mitigation measures is not warranted.

Night-time Tunnelling

During night-time tunnelling operations, all surface noise sources would be confined within the enclosure extending over the tunnel portals. Spoil haul-out and stockpiling would be achieved by dump trucks from within the enclosure, with the doors kept closed while loading operations are being conducted. Significant noise sources would include intermittent dump-truck noise and continuous noise from the temporary tunnel ventilation system.

Indicative L_{Aeq} noise levels that could be received at night during the roadheader tunnelling phases are compared with noise goals in **Table 39.**

Table 39 Noise Assessment - Southern Worksite - Night-time Tunnelling

		Representative Receptors			
		Residences south of Federation St		**Residences north of Federation St**	
Minimum Separation from Earthworks (indicative only)		15 m		80 m	
AS/NZS 2107 Maximum Internal Noise Goal (L_{Aeq} - dBA)		40 (sleeping areas, near major roads)		40 (sleeping areas, near major roads)	
Internal Sleep Disturbance Noise Goal (L_{Amax} - dBA)		50		50	
Nominal Facade Reduction (dBA)		10		10	
External Noise Goal (L_{Aeq} dBA)		**50**		**50**	
External Noise Goal (L_{Amax} dBA)		**60**		**60**	
Existing Night-Time Levels					
Representative measurement location (external)		(12)		(11)	
average L_{A90}, 15minute – dBA		42		41	
average $L_{Aeq,15minute}$ - dBA		47		47	
average $L_{Amax,15minute}$ - dBA		62		63	
Typical Plant Items	**Effective Sound Power Level (L_{Amax} dBA)**	**Indicative External Plant Noise Level at Receptor - (dBA)**			
		L_{Aeq}	**L_{Amax}**	**L_{Aeq}**	**L_{Amax}**
Concrete Pump	107-24=83[1]	43	51	29	37
On-road Truck and Dog	103-24=79[1]	39	47	25	33
25 t, 200 kW Front-end Loader	116-24=92[1]	52	60	38	46
600 kW Electric Conveyor Drive	106-28=78[1]	38	46	24	32
Ventilation	Design to meet Background L_{A90}+3 dB at residences	45		44	
External Noise Goal (L_{Aeq} dBA)		**50**		**50**	
External Noise Goal (L_{Amax} dBA)			**60**		**60**

1 Indicates that the effective sound power level has been adjusted for a high performance acoustic enclosure as per corrections in Table 30.

Residents North and South of Federation Street

- The noise from plant items is not expected to exceed the L_{Aeq} (apart from a negligible 2 dBA exceedance for the front end loader) or L_{Amax} design goal. As a result, no significant acoustical impacts would be expected.

- Apart from the detailed design of the enclosure, the provision of additional noise mitigation should not be considered for residents at this location.

6.2.3 Noise Mitigation

The following noise control measures are recommended for noise mitigation at the southern worksite:-

- Provide advance notification of the time and duration of earthworks;
- Install (temporary) noise screens to reduce earthmoving noise during “Site Preparation” at property boundaries of residences south of Federation St. These screens need to be on property boundaries beyond the worksite to be effective and a minimum of 5 m in height as the adjacent buildings are all double storeys. As an alternative, consideration cold be given to upgrading the façade windows, and provision of airconditioning to the affected residents, where it proves cost effective and acceptable to the community.
- Use localised noise screens for particularly noisy operations such as rockdrilling and rockbreaking.
- Ensure the construction of ‘high’ performance acoustic enclosure over the portal and stockpile is optimised, to ensure there are no ‘leakage paths’ which would degrade the overall performance of the enclosure.
- Design of continuously operating ventilation plant and any other plant that operates at night to meet ‘reasonable’ night-time noise objectives as defined in **Section** Error! Reference source not found.

6.2.4 Vibration Impacts

Due to the significant separation distances between the bulk earthworks on the worksite and the surrounding sensitive uses, significant vibration impacts are not anticipated from site preparation and surface activities. Vibration levels associated with the commencement of tunnelling at this worksite are discussed in **Section** 8.

6.3 Gympie Rd Worksite

6.3.1 Proposed Activities

The schematic layout diagram for the Gympie Rd Worksite is illustrated in **Figure 10**.

Figure 10 Schematic Gympie Rd Worksite at Norman Ave Layout

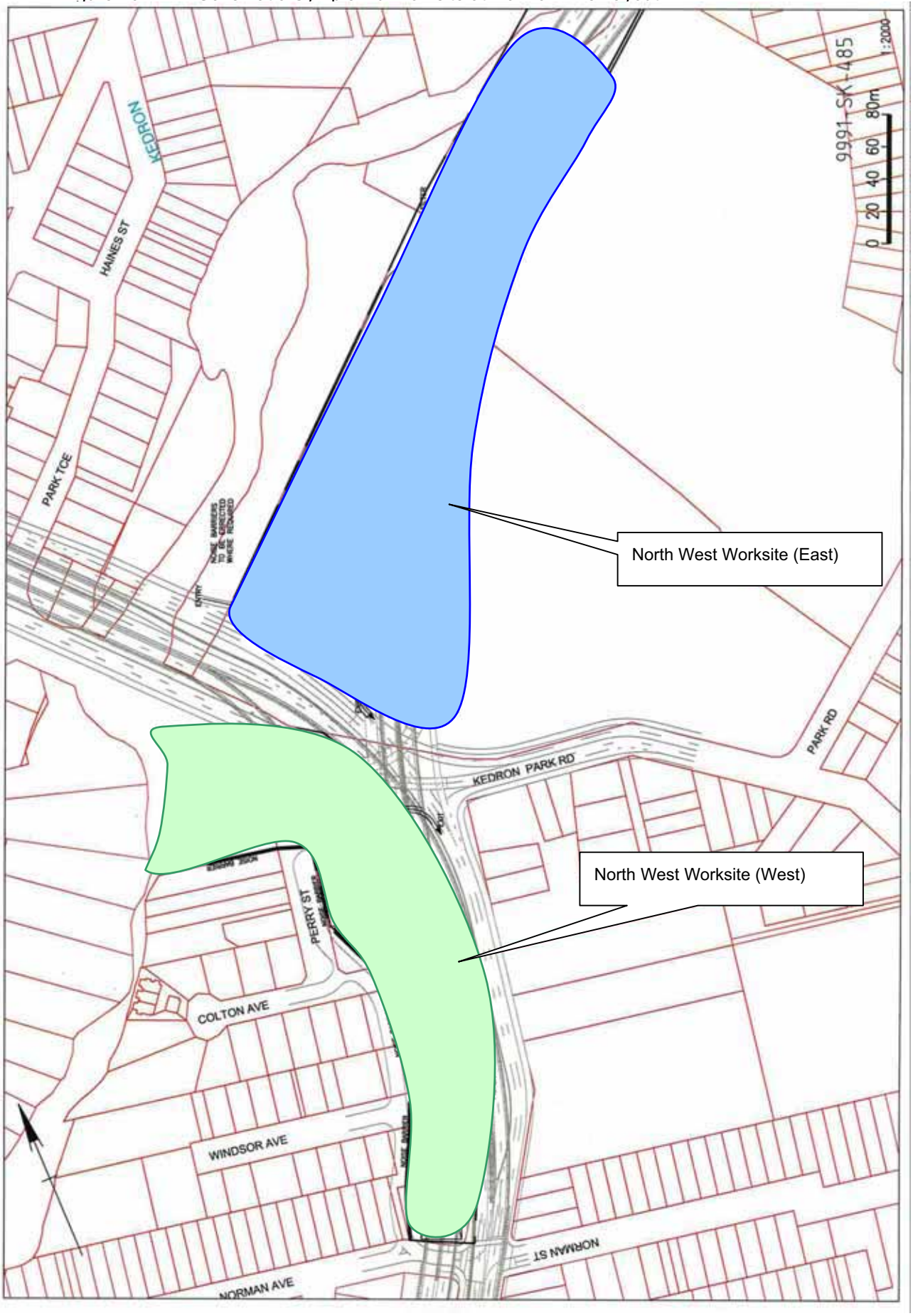


Figure 10 shows that the Gympie Rd Worksite is divided into two distinct sections; one east of Gympie Rd, and one west of Gympie Rd. As Gympie Rd is the most dominant existing noise source in the immediate area and acoustically divides the worksite into two sections, the following construction noise analysis for the Gympie Rd Worksite will take each section (ie east and west) into account individually.

The primary noise-generating activities anticipated during the preparation and operation of the Gympie Rd Worksite (East) and (West) are summarised in

Table 41.

Table 40 Gympie Rd Worksite (East) Noise Sources

Construction Phase and Approx. Duration	Enclosed/Underground Day and Night-time Noise Sources	Additional Daytime Noise Sources
Initial Site Earthworks (18 weeks)	Nil	Excavators, bulldozers, graders, loaders, bobcats, compaction equipment, dump trucks, water trucks, manual trades
Enclosure Construction (4 weeks)	Nil	Mobile cranes, concrete trucks, concrete pump, delivery trucks, manual trades, excavator, structural steelwork
EPB Machine Tunnelling (23 months)	Delivery of spoil to enclosure by conveyor, supply of segments to machine, supply all other consumables to machine, grout plant at enclosure	Removal of spoil and delivery of materials to inside enclosure

Table 41 Gympie Rd Worksite (West) Noise Sources

Construction Phase and Approx. Duration	Enclosed/Underground Day and Night-time Noise Sources	Additional Daytime Noise Sources
Removal of Buildings (2 weeks)	Nil	Excavators, bulldozers, dump trucks, manual trades
Initial Site Earthworks (18 weeks)	Nil	Excavators, bulldozers, graders, loaders, bobcats, compaction equipment, dump trucks, water trucks, manual trades
Enclosure Construction (4 weeks)	Nil	Mobile cranes, concrete trucks, concrete pump, delivery trucks, manual trades, excavator, structural steelwork
Roadheader Tunnelling (34 months)	Dump truck removal of roadheader spoil, supply of temporary support materials, ventilation, supply of concrete for tunnel lining	Removal of spoil and delivery of materials to inside enclosure

6.3.2 Noise Impacts

Site Preparation - East

Site preparation would involve initial earthworks and enclosure construction. These works would be carried out during the daytime only. It is anticipated that the most noticeable source of noise during site preparation would be heavy earthmoving machinery during bulk material excavation before the enclosure is constructed.

Indicative L_{Aeq} noise levels that could be received at representative surrounding buildings during site preparation at the Gympie Rd Worksite (East) are compared with noise goals in **Table 42**.

Table 42 Noise Impacts – Gympie Rd Worksite (East) - Site Preparation

		Representative Receptors		
		Park Tce Residences	**Kedron High School**	**Gorman St Residences**
Minimum Separation from Earthworks (indicative only)		100 m	160 m	150 m
AS/NZS 2107 Maximum Internal Noise Goal (LAeq - dBA)		45 (living areas, near major roads)	45 (school teaching area)	40 (living areas, near minor roads)
Nominal Facade Reduction (dBA)		10	10	10
External Noise Goal (LAeq dBA)		**55**	**55**	**50**
Existing Daytime Levels				
Representative measurement location (external)		(8)	(5)	(5)
average LAeq,15minute - dBA		60	56	56
average LAmax,15minute - dBA		70	74	74
Typical Plant Items	**Plant Sound Power Levels (LAmax dBA)**	**Indicative External Plant Noise Level at Receptor (LAeq dBA)**		
Bobcat	112	56	52	52
38 t, 250 kW Dozer	118	62	58	58
Hydraulic Rockbreaker	120	64	60	60
35 t, 200 kW Excavator	114	58	54	54
200 kW Grader	116	60	56	56
Compressor 285 L/s	100	44	40	40
Water Truck	105	49	45	45
25 t, 200 kW Front-end Loader	116	60	56	56
25 t Articulated off-road Dump Truck	114	58	54	54
20 t Mobile Crane	105	49	45	45
External Noise Goal (LAeq dBA)		**55**	**55**	**50**

The following conclusions regarding noise impacts associated with site preparation are drawn from the assessment summary in **Table 42:**

Park Tce and Gorman Street Residences

- The residents in Park Tce and Gorman Street are located approximately 100 to 150 m from the site works;
- At these locations the highest noise levels arise due to rockbreaker. Based on the sound power level for the rock-breaker, exceedances of 9 dBA are predicted whilst it is in use.
- The noise from other plant items will generally exceed the design goal by typically up to 5 to 7 dBA, however are similar to the prevailing levels of traffic noise. Consequently, it is unlikely that the construction noise levels will result in any significant acoustical impacts.
- No additional noise controls are recommended.

Kedron High School

- Kedron High School is located approximately 160 m form the construction works;
- At this location the highest noise levels arise due to rockbreaker. Based on the sound power level for the rock-breaker, exceedances of 5 dBA are predicted whilst it is in use. Levels of this magnitude would be audible within classrooms, however this level is unlikely to significantly interfere with internal activities.

- The noise from other plant items will exceed the design goal by up to a marginal 3 dBA. Exceedances of this magnitude are unlikely to result in any significant noise impact, given the construction noise is at similar noise levels to the prevailing levels of road traffic noise.
- No additional noise controls are recommended.
- During development of the Construction Environmental Management Plan (CEMP) it is recommended that further investigation of the attenuation through the façade of the school buildings closest to the construction works be undertaken to confirm this assessment.

Site Preparation - West

It is anticipated that the most noticeable source of noise during site preparation would be heavy earthmoving machinery during bulk material excavation before the enclosure is constructed.

Table 43 shows the indicative L_{Aeq} noise levels that are predicted to be received at representative surrounding buildings during site preparation at the Gympie Rd Worksite (West) compared with the noise goals.

Table 43 Noise Impacts – Gympie Rd Worksite (West) - Site Preparation

		Representative Receptors		
		Residences adjacent to site on western side	**Offices adjacent to site at southern end**	**School on eastern side of Lutwyche Rd**
Minimum Separation from Earthworks (indicative only)		15 m	25 m	50 m
AS/NZS 2107 Maximum Internal Noise Goal (LAeq - dBA)		40 (living areas, near minor roads)	45 (commercial building - office space)	45 (school teaching area)
Nominal Façade Reduction (dBA)		10	20	20
External Noise Goal (LAeq dBA)		**50**	**65**	**65**
Existing Daytime Levels				
Representative measurement location (external)		(7)	(6)	(6)
average LAeq,15minute - dBA		45	66	66
average LAmax,15minute - dBA		58	81	81
Typical Plant Items	**Plant Sound Power Levels (LAmax dBA)**	**Indicative External Plant Noise Level at Receptor (LAeq dBA)**		
Bobcat	112	72	68	62
38 t, 250 kW Dozer	118	78	74	68
Hydraulic Rockbreaker	120	80	76	70
35 t, 200 kW Excavator	114	74	70	64
200 kW Grader	116	76	72	66
Roller	104	64	60	54
Compressor 285 L/s	100	60	56	50
Water Truck	105	65	61	55
25 t, 200 kW Front-end Loader	116	76	72	66
25 t Articulated off-road Dump Truck	114	74	70	64
20 t Mobile Crane	105	65	61	55
External Noise Goal (LAeq dBA)		**50**	**65**	**65**

The following conclusions regarding noise impacts associated with site preparation are drawn from the assessment summary in **Table 43:**

Resident to the West of the Site

- The residents to the east of the site works are located approx 25 m away;
- At these locations the highest noise levels arise due to rockbreaker. Based on the sound power level for the rock-breaker exceedances of 30 dBA are predicted whilst it is in use. Comparison of the emission levels with the prevailing traffic noise indicates that the construction levels would be clearly audible within dwellings and likely to result in very significant acoustic impacts (eg interference with passive listening, resting, conversation, watching TV etc).
- The noise from other plant items will exceed the design goal by (typically) 26 dBA. Exceedances of this magnitude are also likely to result in significant acoustical impacts (eg interference with passive listening, resting and conversation) given the construction noise levels are noticeably above the prevailing levels of road traffic noise.
- The provision of noise mitigation should be considered for residents at this location, so as to maintain a reasonable noise environment, as detailed in **Section 6.3.3**.

Offices adjacent to site at southern end

- The offices adjacent to the southern of the site works are located approx 25 m away;
- At these locations the highest noise levels arise due to rockbreaker. Based on the sound power level for the rock-breaker exceedances of 11 dBA are predicted, whilst it is in use. Levels of this magnitude would be audible within offices and likely to result in some degree of acoustic impacts.
- The noise from other plant items will exceed the design goal by typically up to 7 dBA. Levels of this magnitude would be audible within offices, however this level is unlikely to significantly interfere with internal activities, depending on the nature of the operations being undertaken.
- The provision of noise mitigation should be considered for the offices at this location, after a more comprehensive study has been undertaken, having consideration of the use of the internal spaces and following confirmation of the attenuation provided by the building facades.

School on eastern side of Lutwyche Rd

- The school buildings facing Lutwyche Rd are approximately 50 m from the worksite boundary.
- At these locations the highest noise levels arise due to rockbreaker. Based on the sound power level for the rock-breaker exceedances of 5 dBA are predicted, whilst it is in use. Levels of this magnitude are unlikely to cause acoustic impact at the school
- Similar to the recommendations made for offices adjacent to the worksite, a more comprehensive study is required taking into consideration the attenuation provided by the building facades.

Daytime Tunnelling

During daytime tunnelling works at both worksite sections, the dominant noise sources will be excavation processes, loading of spoil within the enclosure and trucking of the spoil off-site by truck and dog. Indicative L_{Aeq} noise levels that could be received at representative surrounding buildings during daytime tunnelling at the Gympie Rd (East) Worksite are compared with noise goals in **Table 44**.

Table 44 Noise Impacts – Gympie Rd Worksite (East) - Daytime Tunnelling

		Representative Receptors		
		Park Tce Residences	**Kedron High School**	**Gorman St Residences**
Minimum Separation from Earthworks (indicative only)		120 m	160 m	150 m
AS/NZS 2107 Maximum Internal Noise Goal (LAeq - dBA)		45 (living areas, near major roads)	45 (school teaching area)	40 (living areas, near minor roads)
Nominal Facade Reduction (dBA)		10	10	10
External Noise Goal (LAeq dBA)		**55**	**55**	**50**
Existing Daytime Levels				
Representative measurement location (external)		(8)	(5)	(5)
average LAeq,15minute - dBA		60	56	56
average LAmax,15minute - dBA		70	74	74
Typical Plant Items	**Effective Plant Sound Power Levels (LAmax dBA)**	**Indicative External Plant Noise Level at Receptor[2] (LAeq dBA)**		
Concrete Pump	107-12=95[1]	37 - 42	35 - 40	35 - 40
Semi Trailer	114-12=102[1]	44 - 49	42 - 47	42 - 47
On-road Truck and Dog	103-12=91[1]	33 - 38	31 - 36	31 - 36
CAT 966 Loader	116-12=104[1]	46 - 51	44 - 49	44 - 49
600 kW Electric Conveyor Drive	106-16=90[1]	32 - 37	30 - 35	30 – 35
External Noise Goal (LAeq dBA)		**55**	**55**	**50**

1 Indicates that the effective sound power level has been adjusted for a medium performance acoustic enclosure as per corrections in Table 30

2 Lower value – shed closed; Upper value – shed open at nominal entry and exit doors shown in Figure 8 where a nominal 5dBA reduction in the performance of the acoustic shed has been adopted.

No exceedances of the noise goals have been predicted for daytime tunnelling works at the Gympie Rd Worksite - east. No additional noise mitigation is likely to be required for this activity.

Table 45 shows the indicative LAeq noise levels that could be received at representative surrounding buildings during site preparation at the Gympie Rd Worksite (West) compared with the noise goals.

Table 45 Noise Impacts – Gympie Rd Worksite (West) - Daytime Tunnelling

		Representative Receptors		
		Residences adjacent to site on eastern side	**Offices adjacent to site at southern end**	**School on eastern side of Lutwyche Rd**
Minimum Separation from Earthworks (indicative only)		15 m	25 m	50 m
AS/NZS 2107 Maximum Internal Noise Goal (LAeq - dBA)		40 (living areas, near minor roads)	45 (commercial building - office space)	45 (school teaching area)
Nominal Facade Reduction (dBA)		10	20	20
External Noise Goal (LAeq dBA)		**50**	**65**	**65**
Existing Daytime Levels				
Representative measurement location (external)		(7)	(6)	(6)
average LAeq,15minute - dBA		45	66	66
average LAmax,15minute - dBA		58	81	81
Typical Plant Items	**Effective Sound Power Level (L_{Amax} dBA)**	**Indicative External Plant Noise Level at Receptor (L_{Aeq} dBA)[2]**		
Concrete Pump	107-24=83[1]	43 - 48	39 - 44	33 - 38
Semi Trailer	117-24=90[1]	50 - 55	46 - 51	40 - 45
On-road Truck and Dog	103-24=79[1]	39 - 44	35 - 40	29 - 34
25 t, 200 kW Front-end Loader	116-24=92[1]	52 - 57	48 - 53	42 - 47
600 kW Electric Conveyor Drive	106-28=78[1]	38 - 43	34 - 39	28 – 33
External Noise Goal (LAeq dBA)		**50**	**65**	**65**

1 Indicates that the effective sound power level has been adjusted for a high performance acoustic enclosure as per corrections in Table 30.

2 Lower value – shed closed; Upper value – shed open at nominal entry and exit doors shown in Figure 8 where a nominal 5dBA reduction in the performance of the acoustic shed has been adopted.

The following conclusions regarding noise impacts associated with site preparation are drawn from the assessment summary in **Table 45**:

Residences adjacent to site on eastern side

- Residences are located approximately 15 m from the work site.
- With the doors closed, the predicted noise levels are a marginal 2 dBA greater than the desired L_{Aeq} noise criteria, increasing to 7 dBA with the doors open. Consideration of further noise mitigation should be undertaken for this site.

Offices adjacent to site at southern end

- Offices are located approximately 25 m from work site
- No exceedances of the noise goals are predicted for this location, therefore no noise mitigation is recommended for these locations.

School on eastern side of Lutwyche Rd

- The nearest school buildings to the worksite are located approximately 50 m from the work site
- No exceedances of the noise goals are predicted for this location, therefore no noise mitigation is recommended for these locations.

Night-time Tunnelling

During night-time tunnelling operations at both sections of the worksite, all surface noise sources would be confined within the tunnel portal enclosures. Spoil haul-out and stockpiling would be achieved by conveyor system at the Gympie Rd Worksite (East) and by loaders and trucks at the Gympie Rd Worksite (West) within the enclosure.

Indicative L_{Aeq} noise levels that could be received at night during night-time tunnelling for Gympie Rd worksite (east) are compared with noise goals in **Table 46**.

Table 46 Noise Impacts – Gympie Rd Worksite (East) - Night-time Tunnelling

		Representative Receptors			
		Park Tce Residences		**Gorman St Residences**	
Minimum Separation from Earthworks (indicative only)		100 m		150 m	
AS/NZS 2107 Maximum Internal Noise Goal (LAeq - dBA)		40 (sleeping areas, near major roads)		35 (sleeping areas, near minor roads)	
Internal Sleep Disturbance Noise Goal (L_{Amax} - dBA)		50		45	
Nominal Facade Reduction (dBA)		10		10	
External Noise Goal (LAeq dBA)		**50**		**45**	
External Noise Goal (LAmax dBA)		**60**		**55**	
Existing Night-Time Levels					
Representative measurement location (external)		(8)		(5)	
average LAeq,15minute - dBA		51		38	
average LAmax,15minute - dBA		62		52	
Typical Plant Items	**Effective Plant Sound Power Levels (LAmax dBA)**	**Indicative External Plant Noise Level at Receptor - (dBA)**			
		LAeq	**LAmax**	**LAeq**	**LAmax**
Concrete Pump	107-12=95[1]	37	45	35	43
Truck and Superdog	103-12=91[1]	33	41	31	39
25 t, 200 kW Front-end Loader	116-12=104[1]	46	54	44	52
600 kW Electric Conveyor Drive	106-16=90[1]	32	40	30	38
Ventilation	Design to meet Background L_{A90}+3 dB at residences	43		37	
External Noise Goal (LAeq dBA)		**50**		**45**	
External Noise Goal (LAmax dBA)			**60**		**55**

1 Indicates that the effective sound power level has been adjusted for a medium performance acoustic enclosure as per corrections in Table 30.

Night-time tunnelling activities are not likely to be greater than the desired L_{Aeq} criteria, nor are the sleep disturbance criteria exceeded. Therefore additional mitigation at this location is not recommended.

Table 47 shows the indicative L_{Aeq} noise levels that could be received at representative surrounding buildings during site preparation at the Gympie Rd Worksite (West) compared with the noise goals.

Table 47 Noise Impacts - Gympie Rd Worksite (West) – Night-time Tunnelling

		Representative Receptors	
		Residences adjacent to site on eastern side	
Minimum Separation from Earthworks (indicative only)		15 m	
AS/NZS 2107 Maximum Internal Noise Goal (LAeq - dBA)		35 (sleeping areas, near minor roads)	
Internal Sleep Disturbance Noise Goal (LAmax - dBA)		45	
Nominal Facade Reduction (dBA)		10	
External Noise Goal (LAeq dBA)		**45**	
External Noise Goal (LAmax dBA)		**55**	
Existing Night-time Levels			
Representative measurement location (external)		(7)	
average LA90, 15minute - dBA		39	
average LAeq,15minute - dBA		45	
average LAmax,15minute - dBA		58	
Typical Plant Items	**Effective Sound Power Level (LAmax dBA)**	**Indicative External Plant Noise Level at Receptor - dBA**	
		LAeq	LAmax
Concrete Pump	107-24=83[1]	43	51
On-road Truck and Dog	103-24=79[1]	39	47
25 t, 200 kW Front-end Loader	116-24=92[1]	52	60
600 kW Electric Conveyor Drive	106-28=78[1]	38	46
Ventilation	Design to meet Background LA90+3 dB at residences	42	
External Noise Goal (LAeq dBA)		**45**	
External Noise Goal (LAmax dBA)			**55**

1 Indicates that the effective sound power level has been adjusted for a high performance acoustic enclosure as per corrections in Table 30.

For residences adjacent to the site on the eastern side, the predicted LAeq and LAmax construction noise levels exceed the criteria by a 7 dBA and 5 dBA respectively. Given the duration of the activities, some further consideration of noise mitigation should be undertaken.

6.3.3 Noise Mitigation

The following noise control measures may be suitable for noise mitigation at the Gympie Rd worksite:

- Construction of noise screens along worksite boundaries to reduce earthmoving (site preparation) noise at adjoining residences.
    - Noise screens would need to be a minimum of 5 m in height as most residential dwellings in the area are double storeys;
    - At the southern end of the Gympie Rd (West) worksite, it is noted that there are 4 residential buildings that are 3 storeys, and hence a relatively high noise barrier would be required. A solution to providing noise mitigation may be to provide architectural treatment to the upper levels, as it may prove more cost effective, provided it is consistent with current policy and favoured by the residents.
- Advance notification of the time and duration of earthworks.

- Construction of a high performance acoustic enclosure over the portal and stockpile area with indicative acoustic performance as shown in **Table 28** (subject to detailed design) for the Gympie Rd (west) worksite. A 'medium' performance acoustic enclosure should be sufficient for the Gympie Rd (east) worksite.
- Further assess and consulate with property owners immediately adjoining the site as to the best form of noise mitigation, ie noise barriers or the provision of architectural treatment (and ventilation) to impacted rooms facing the worksite to address noise during site preparation and/or rock-drilling at or near the access shaft.
- Use localised noise screens for particularly noisy operations such as rockdrilling and rockbreaking.
- Undertake a further examination of Kedron High School and the office building adjacent to the southern side of the Gympie Rd Work site, to confirm whether the windows are normally open (as assumed) or if the buildings are air conditioned, and hence the windows are normally closed.
- Design of continuously operating ventilation plant and any other plant that operates at night to meet 'reasonable' night-time noise objectives as defined in **Section 2.2.2**.
- Monitor noise levels from variable noise sources (e.g. rock-drill noise at the tunnel entrance which will diminish as tunnelling progresses) to ensure that such activities are only carried out at night once noise levels meet 'reasonable' levels as defined in **Section 2.2.2**

6.3.4 Vibration Impacts

Due to the significant separation distances between the bulk earthworks on the worksite and the surrounding sensitive uses, significant vibration impacts are not anticipated from site preparation and surface activities. Vibration levels associated with the commencement of tunnelling at this worksite are discussed in **Section** 8.

6.3.5 Proposed Activities

The schematic layout diagram for the Sandgate Rd Worksite is illustrated in **Figure 11**.

Figure 11 Schematic Sandgate Road Worksite Layout

The primary noise-generating activities anticipated during the preparation and operation of the Sandgate Road Worksite are summarised in **Table 48**.

Table 48 Sandgate Rd Worksite Noise Sources

Construction Phase and Approx. Duration	**Enclosed/Underground Day and Night-time Noise Sources**	**Additional Daytime Noise Sources**
Removal of Buildings (2 weeks)	Nil	Excavators, hydraulic rockbreakers, bulldozers, dump trucks, manual trades, compressors, generators
Earthworks (24 months)	Nil	Bored piling rig, excavators, shotcrete equipment, rock bolting equipment, compressors, cranage for precast items, concrete pump, ventilation equipment
Enclosure construction (4 weeks)	Nil	Mobile cranes, concrete trucks, concrete pump, delivery trucks, manual trades, excavator, structural steelwork
EPB Machine Turnaround (2 months)	No acoustically significant noise sources	Nil

6.3.6 Noise Impacts

Site Preparation

Site preparation would involve removal of existing buildings, initial earthworks and enclosure construction. These works would be carried out during the daytime only. It is anticipated that the most noticeable source of noise during site preparation would be heavy earthmoving and rockbreaking machinery during bulk material excavation before the enclosure is constructed.

Indicative L_{Aeq} noise levels that could be received at representative surrounding buildings during site preparation are compared with noise goals in **Table 49**.

Table 49 Noise Impacts – Sandgate Rd Worksite - Site Preparation

		Representative Receptors		
		Kalinga St Residences	**Parkland St Residences**	**Residences immediately south of worksite**
Minimum Separation from Earthworks (indicative only)		30 m	160 m	15 m
AS/NZS 2107 Maximum Internal Noise Goal (L_{Aeq} - dBA)		40 (living areas, near minor roads)	45 (living areas, near major roads)	40 (living areas, near minor roads)
Nominal Facade Reduction (dBA)		10	10	10
External Noise Goal (L_{Aeq} dBA)		**50**	**55**	**50**
Existing Daytime Levels				
Representative measurement location (external)		(4)	(3)	(2)
average $L_{Aeq,15minute}$ - dBA		54	62	59
average $L_{Amax,15minute}$ - dBA		72	79	70
Typical Plant Items	**Plant Sound Power Levels (L_{Amax} dBA)**	**Indicative External Plant Noise Level at Receptor (L_{Aeq} dBA)**		
Bobcat	112	66	52	72
38 t, 250 kW Dozer	118	72	58	78
Hydraulic Rockbreaker	120	74	60	80
35 t, 200 kW Excavator	114	68	54	74
200 kW Grader	116	70	56	76
Compressor 285 L/s	100	54	40	60
Water Truck	105	59	45	65
25 t, 200 kW Front-end Loader	116	70	56	76
25 t Articulated off-road Dump Truck	114	68	54	74
20 t Mobile Crane	105	59	45	65
External Noise Goal (L_{Aeq} dBA)		**50**	**55**	**50**

The following conclusions regarding noise impacts associated with site preparation are drawn from the assessment summary in **Table 49**:-

Kalinga St and Residents Immediately South of the Worksite

- These residents are located 15 m to 30 m from the worksite;
- At this location the highest noise levels arise due to rockbreaker. Based on the sound power level for the rock-breaker exceedances of 24 dBA to 30 dBA are predicted, whilst it is in use. The predicted levels would be clearly audible within dwellings and likely to result in acoustic impacts (eg interference with passive listening, resting, conversation and watching TV).
- Typically, the noise from other plant items will exceed the design goal by 20 dBA to 26 dBA. Exceedances of this magnitude are likely to result in acoustical impacts, given the construction noise is noticeably higher than the prevailing levels of road traffic noise.
- The provision of noise mitigation should be considered for residents at this location, so as to maintain a reasonable noise environment, as detailed in **Section 6.3.7**.

Parkland Street Residence

- These residents are located 160 m from the worksite;
- At this location the highest noise levels arise due to rockbreaker. Based on the sound power level for the rock-breaker exceedances of 5 dBA are predicted whilst it is in use. Levels of this magnitude would be audible within dwellings and not likely to result in any significant acoustic impacts.
- The noise from other plant items will not significantly exceed the design goal. It is unlikely that the construction works would result in any significant acoustical impacts, given the emissions are significantly lower than the prevailing levels of road traffic noise.
- No noise mitigation is considered reasonable for residents at this location.

Daytime Tunnelling

Tunnelling operations between the Gympie Rd and the Sandgate Rd worksites will be undertaken using one EPB Machine. Tunnelling will commence from the Gympie Rd worksite and work towards the Sandgate Rd worksite. Once the EPB Machine reaches the Sandgate Rd worksite, the machine is turned around in the acoustic enclosure and redirected back towards the Gympie Rd worksite.

Indicative L_{Aeq} noise levels that could be received at representative surrounding buildings during the night-time tunnelling are compared with noise goals in

Table 50. The predictions assume the adoption of a medium performance acoustic enclosure as described in **Table 30**.

Table 50 Noise Impacts - Sandgate Rd Worksite - Daytime Tunnelling

		Representative Receptors		
		Kalinga St Residences	**Parkland St Residences**	**Residences immediately south of worksite**
Minimum Separation from Earthworks (indicative only)		30 m	160 m	15 m
AS/NZS 2107 Maximum Internal Noise Goal (L_{Aeq} - dBA)		40 (living areas, near minor roads)	45 (living areas, near major roads)	45 (living areas, near major roads)
Nominal Facade Reduction (dBA)		10	10	10
External Noise Goal (L_{Aeq} dBA)		**50**	**55**	**55**
Existing Daytime Levels				
Representative measurement location (external)		(4)	(3)	(2)
average $L_{Aeq,15minute}$ - dBA		54	62	59
average $L_{Amax,15minute}$ - dBA		72	79	70
Typical Plant Items	**Effective Plant Sound Power Levels (L_{Amax} dBA)**	**Indicative External Plant Noise Level at Receptor (dBA)**		
600 kW Electric Conveyor Drive	106-16=90[1]	44	30	50
Ventilation	Design to meet Background L_{A90}+3 dB at residences	43	45	58
External Noise Goal (L_{Aeq} dBA)		**50**	**55**	**55**

1 Indicates that the effective sound power level has been adjusted for a medium performance acoustic enclosure as per corrections in Table 30

Noise predictions for the daytime tunnelling operations for the Sandgate Rd worksite show that noise emissions will be less that the noise goal. No further noise mitigation is required for this construction activity.

Night-Time Tunnelling

Indicative L_{Aeq} noise levels that could be received at representative surrounding buildings during the night-time tunnelling are compared with noise goals in **Table 51**. The predictions assume the adoption of a medium performance acoustic enclosure as described in **Table 30**.

Table 51 Noise Impacts - Sandgate Rd Worksite – Night-Time Tunnelling

		Representative Receptors					
		Kalinga St Residences		**Parkland St Residences**		**Residences immediately south of worksite**	
Minimum Separation from Earthworks (indicative only)		30 m		160 m		15 m	
AS/NZS 2107 Maximum Internal Noise Goal (LAeq - dBA)		35 (sleeping areas, near minor roads)		40 (sleeping areas, near major roads)		35 (sleeping areas, near minor roads)	
Internal Sleep Disturbance Noise Goal (LAmax - dBA)		45		50		45	
Nominal Facade Reduction (dBA)		10		10		10	
External Noise Goal (LAeq dBA)		**45**		**50**		**45**	
External Noise Goal (LAmax dBA)		**55**		**60**		**55**	
Existing Night-Time Levels							
Representative measurement location (external)		(4)		(3)		(2)	
average LA90, 15minute - dBA		41		42		55	
average LAeq,15minute - dBA		49		52		58	
average LAmax,15minute - dBA		62		65		66	
Typical Plant Items	**Effective Plant Sound Power Levels (LAmax dBA)**	**Indicative External Plant Noise Level at Receptor (dBA)**					
		LAeq	**LAmax**	**LAeq**	**LAmax**	**LAeq**	**LAmax**
600 kW Electric Conveyor Drive	106-16=90[1]	44	46	30	32	50	52
Ventilation	Design to meet Background LA90+3 dB at residences	43		45		58	
External Noise Goal (LAeq dBA)		**45**		**50**		**45**	
External Noise Goal (LAmax dBA)			**55**		**60**		**55**

1 Indicates that the effective sound power level has been adjusted for a medium performance acoustic enclosure as per corrections in Table 30

Table 51 shows residences in Kalinga and Parkland St compliant with the noise goals. For those residences south of the construction site, the predicted LAeq construction noise levels exceed the goal by a marginal 5 dBA. However, the predicted Leq noise levels are below the prevailing levels of road traffic noise. It is therefore unlikely that night-time noise levels will result in acoustic impacts at these residences, given the installation of a medium performance noise enclosure. The maximum noise levels south of the construction site are compliant with the maximum noise goal.

6.3.7 Noise Mitigation

The following noise control measures are recommended for noise mitigation at the Sandgate Rd worksite:

- Construction of noise screens along the southern and western worksite boundary to reduce earthmoving noise at adjoining residences.

- Minimum of 5 m screen height to account for double storey buildings.
- There is a 3 storey unit complex on Alma Rd. It is recommended to examine the feasibility and cost effectiveness of architecturally treating the uppermost storey so that the internal noise criteria are met.

- Advance notification of the time and duration of earthworks.
- Construction of a medium performance acoustic enclosure over the portal with indicative acoustic performance as shown in Table 28 (subject to detailed design). However, if the conveyer drives are tonal, additional noise control measured may be required. This may be in the form of local enclosures around the drives or the upgrading of the entire worksite enclosure.
- Use localised noise screens for particularly noisy operations such as rockdrilling and rockbreaking.
- Design of continuously operating ventilation plant and any other plant that operates at night to meet 'reasonable' night-time noise objectives as defined in **Section 2.2.2**.

6.3.8 Vibration Impacts

Due to the significant separation distances between the earthworks on the worksite and the surrounding sensitive uses, significant vibration impacts are not anticipated from site preparation and surface activities. Vibration levels associated with the tunnelling at this worksite are discussed in **Section 8.**

7 SURFACE CONSTRUCTION OF ROADWAYS

7.1 Southern Connections

7.1.1 Proposed Activities

The primary noise-generating activities anticipated during the construction of the southern surface connection roads, interfacing with Lutwyche Rd, the ICB and the proposed NSBT, are summarised in **Table 52**.

Table 52 Southern Surface Road Connections - Construction Noise Sources

Construction Phase (and Approx Duration)	**Night-time Noise Sources**	**Additional Daytime Noise Sources**
Removal of Buildings (6 weeks)	Nil	Excavators, hydraulic rockbreakers, bulldozers, dump trucks, manual trades, compressors, generators
Earthworks (12 months)	Nil	Excavators bulldozers, graders, loaders, bobcats, compaction equipment, dump trucks, water trucks, manual trades
Cut and Cover Construction (11 months)	Nil	Bored piling rig (if necessary), hydraulic rockbreakers, rock ripping equipment, pneumatic jack hammer, excavators, shotcrete equipment, rock bolting equipment, compressors, cranes, concrete pump
Widen Underpass Below ICB (6 months)	Bored piling rig, excavators, steel fixing, cranage for precast items, concreting equipment, road surfacing	Excavators, soil nailing equipment, shotcreting equipment, compaction equipment, dump trucks, water carts, road paving equipment
Elevated Structure Beside the Mews (7 months)	Nil	Bored piling rigs, excavators, steel fixing, compressors, cranes, concrete pump
Other bridges (20 months)	Nil	Bored piling rigs, excavators, steel fixing, compressors, cranes, concrete pump
Road Surfacing (1 month)	As for daytime but limited to areas of interface with existing road infrastructure (NSBT)	Delivery trucks, paving machine, compaction equipment, line marking

7.1.2 Noise Impacts

Construction of surface road connections would generally be confined to daytime hours. It is anticipated that the highest daytime noise levels at residential locations due to Airport Link construction would typically result from the construction of elevated structure beside The Mews apartments at 141 Campbell St, Bowen Hills. The highest night-time noise levels are likely to be from construction activities at the ICB underpass widening. The following sections predict the likely noise levels at the Mews apartments due to these two operations.

Daytime Elevated Structure Construction

Indicative noise levels that could be received at the eastern facing apartments at The Mews apartments during daytime elevated structure construction are compared with noise goals in **Table 53**.

Table 53 Noise Impacts – Southern Surface Road Construction - Elevated Structure

		Representative Receptors
		Residences within Mews Apartments
Minimum Separation from Earthworks (indicative only)		50 m
AS/NZS 2107 Maximum Internal Noise Goal (L_{Aeq} - dBA)		45 (A/C living areas, near major roads)
Nominal Facade Reduction (dBA)		20
External Noise Goal (L_{Aeq} dBA)		**65**
Existing Daytime Levels		
Representative measurement location (external)		(13)
average $L_{Aeq,15minute}$ - dBA		67
average $L_{Amax,15minute}$ - dBA		78
Typical Plant Items	**Plant Sound Power Levels (L_{Amax} dBA)**	**Indicative External Plant Noise Level at Receptor (L_{Aeq} dBA)**
24 t Concrete Truck	112	82
Concrete Pump	107	77
100 Tonne Hydraulic Crane	110	80
35 t, 200 kW Excavator	114	84
Compressor 285 L/s	100	70
External Noise Goal (L_{Aeq} dBA)		**65**

It can be seen from **Table 53** that noise from construction of elevated structure is significantly higher (12-17 dBA) than the desired noise levels. This level of intrusion would likely result in acoustical impacts (eg interference with passive listening, resting and conversation). Noise mitigation should be investigated, where it is possible so as to maintain a reasonable noise environment at the Mews apartments.

Night-Time ICB Underpass Widening

Indicative noise levels that could be received at the eastern facing apartments at The Mews apartments during the night-time ICB underpass widening are compared with noise goals in **Table 54**.

Table 54 Noise Impacts - Southern Surface Road Construction - ICB Underpass Widening

		Representative Receptors	
		Residences within Mews Apartments	
Minimum Separation from Underpass (indicative only)		120 m	
AS/NZS 2107 Maximum Internal Noise Goal (L_{Aeq} - dBA)		40 (A/C sleeping area, near major roads)	
Internal Sleep Disturbance Noise Goal (L_{Amax} - dBA)		50	
Nominal Facade Reduction (dBA)		20	
External Noise Goal (L_{Aeq} dBA)		**60**	
External Noise Goal (L_{Amax} dBA)		**70**	
Existing Night-Time Levels			
Representative measurement locations (external)		(13)	
average LA90, 15minute - dBA		60	
average $L_{Aeq,15minute}$ - dBA		64	
average $L_{Amax,15minute}$ - dBA		75	
Typical Plant Items	**Plant Sound Power Levels (L_{Amax} dBA)**	**Indicative External Plant Noise Level at Receptor - dBA**	
		L_{Aeq}	**L_{Amax}**
Pile Boring	118	60	68
35 t, 200 kW Excavator	114	56	64
100 Tonne Hydraulic Crane	110	52	60
Asphalt Paver	114	56	64
24 t Concrete Truck	112	54	62
Concrete Pump	107	49	57
External Noise Goal (L_{Aeq} dBA)		**60**	
External Noise Goal (L_{Amax} dBA)			**70**

Table 54 shows that there are no exceedances of the noise goals for the night-time widening of the ICB underpass due primarily to the large offset distance and the higher building façade nominated for the Mews Apartments.

Daytime Cut and Cover Tunnelling

Indicative noise levels that could be received at representative surrounding buildings during daytime cut and cover tunnelling are compared with noise goals in **Table 55**.

Table 55 Noise Impacts – Southern Surface Road Construction - Cut and Cover Construction

		Representative Receptors	
		Residences south of Federation St	**Residences north of Federation St**
Minimum Separation from Earthworks (indicative only)		50 m	80 m
AS/NZS 2107 Maximum Internal Noise Goal (L_{Aeq} - dBA)		45 (living area, near minor roads)	45 (living area, near minor roads)
Nominal Facade Reduction (dBA)		10	10
External Noise Goal (L_{Aeq} dBA)		**55**	**55**
Existing Daytime Levels			
Representative measurement location (external)		(12)	(11)
average $L_{Aeq,15minute}$ - dBA		54	54
average $L_{Amax,15minute}$ - dBA		72	75
Typical Plant Items	**Effective Sound Power Level (L_{Amax} dBA)**	**Indicative External Plant Noise Level at Receptor (L_{Aeq} dBA)[2]**	
Pile Boring	118	68	64
Hydraulic Rockbreaker	120	70	66
35 t, 200 kW Excavator	114	64	60
24 t Concrete Truck	112	62	58
Concrete Pump	107	57	53
Compressor 285 L/s	100	50	46
100 Tonne Hydraulic Crane	110	60	56
External Noise Goal (L_{Aeq} dBA)		**55**	**55**

At the closest residences to the south of Federation St, the highest noise levels arise due to the operation of the rockbreaker. Based on "typical" emissions, exceedances of 15 dBA are predicted whilst it is in use. This represents a significant exceedance of the design objective and by comparison with the prevailing ambient levels would likely represent a significant acoustical impact. The impacts particularly apply to those rooms which are orientated towards the construction site and likely to result in acoustic impacts (eg interference with passive listening, resting and conversation).

At the closest residences to the north of Federation St, the highest noise levels also arise due to the operation of the rockbreaker. Based on "typical" emissions, exceedances of 11 dBA are predicted whilst it is in use. This represents a significant exceedance of the design objective and by comparison with the prevailing ambient levels would likely represent a significant acoustical impact. The impacts particularly apply to those rooms which are orientated towards the construction site and likely to result in acoustic impacts (eg interference with passive listening, resting and conversation).

7.1.3 Noise Mitigation

The following noise control measures are recommended for noise mitigation during construction of the elevated structure for the northern tunnel connections:

- Advance notification of the time and duration of construction.
- Plant selection to consider noise emissions;
- Location of plant items to maximise distance to residences

7.1.4 Vibration Impacts

The anticipated sources of vibration during the construction of the southern surface connection roads are vibratory rolling during earthworks and underpass widening, and rockbreaking during cut and cover construction.

Vibration levels from rockbreaking would not be significant due to the substantial separation distance (at least 50 m) from buildings.

In general it is not anticipated that vibration levels associated with vibratory rolling will be significant. However it is normal environmental monitoring practice to monitor vibration on structures from vibratory rolling that occurs within a nominal distance of 25 m. This may be relevant for buildings near roadworks along Tufton St.

7.2 Gympie Rd Connections

7.2.1 Proposed Activities

The primary noise-generating activities anticipated during the construction of the Gympie Rd surface connections are summarised in **Table 48**.

Table 56 Gympie Rd Surface Connections - Construction Noise Sources

Construction Phase and Approx. Duration	**Night-time Noise Sources**	**Daytime Noise Sources**
Removal of buildings (6 week)	Nil	Excavators, hydraulic breakers, bulldozers, dump trucks, manual trades, compressors, generators
Earthworks (18 months)	Nil	Excavators, bulldozers, graders, loaders, bobcats, compaction equipment, dump trucks, water trucks, manual trades
Cut and Cover Construction Near or Under Lutwyche Rd (18 months)	Bored piling rig, excavators, steel fixing, cranage for precast items, concreting equipment, road surfacing	Bored piling rig, excavators, shotcrete equipment, rock bolting equipment, compressors, cranage for precast items, concrete pump, ventilation equipment
Cut and Cover Construction Across Oval (24 months)	Nil	Bored piling rig, excavators, shotcrete equipment, rock bolting equipment, compressors, cranage for precast items, concrete pump, ventilation equipment
Elevated structures (20 months)	As for daytime but limited to areas of interface with existing road infrastructure particularly where bridge crosses existing road at Lutwyche Rd just south of Kedron Brook and at Stafford Rd	Bored piling rig, excavators, steel fixing, compressors, crane, concrete pump
Road surfacing for 1st stage traffic diversion (1 month)	As for daytime but limited to areas of interface with existing road infrastructure (Lutwyche and Gympie Rd)	Delivery trucks, paving machine, compaction equipment, line marking
Road surfacing for final traffic arrangement (1 month)	As for daytime but limited to areas of interface with existing road infrastructure (Lutwyche and Gympie Rd)	Delivery trucks, paving machine, compaction equipment, line marking

7.2.2 Noise Impacts

Construction of surface road connections would generally be confined to daytime hours. **Table 56** shows that some night-time construction works is required. This is primarily due to the need to redirect traffic on Lutwyche and Gympie Roads during periods of minimal traffic to allow construction within the existing road corridor to occur.

It is anticipated that the highest daytime noise levels at residential locations due to AirportLink construction would typically result from construction of the elevated structures on around Gympie Rd and Lutwyche Rd. The nearest noise sensitive locations would be residences immediately adjacent to Gympie Rd and Lutwyche Rd.

The highest anticipated night-time noise levels would be due to cut and cover construction across Lutwyche Rd. As the equipment list for the elevated structure and cut and cover construction are very similar, the predicted noise levels due to each activity will be very similar. Therefore, these activities have been combined into a day and night-time assessment of the likely noise impacts.

Daytime Construction of Elevated Structures and Cut and Cover Tunnelling

Indicative noise levels that could be received at the most exposed surrounding buildings during daytime elevated structure and cut and cover construction are compared with noise goals in **Table 57**.

Table 57 Noise Impacts - Daytime Construction - Elevated Structure and Cut and Cover Construction

		Residential Receptors		
		North of Kedron Brook directly adjacent to Gympie Rd	**South of Kedron Brook directly adjacent to Lutwyche Rd**	**South of Kedron Brook west and shielded from Lutwyche Rd**
Minimum Separation from Earthworks (indicative only)		25 m	15 m	80 m
AS/NZS 2107 Maximum Internal Noise Goal (LAeq - dBA)		45 (living areas, near major roads)	45 (living areas, near major roads)	40 (living areas, near minor roads)
Nominal Facade Reduction (dBA)		10	10	10
External Noise Goal (LAeq dBA)		**55**	**55**	**50**
Existing Daytime Levels				
Representative measurement location (external)		(8)	(6)	(7)
average LAeq,15minute - dBA		60	65	53
average $L_{Amax,15minute}$ - dBA		70	81	68
Typical Plant Items	**Plant Sound Power Levels (LAmax dBA)**	**Indicative Maximum External Plant Noise Level at Receptor (LAeq dBA)**		
Pile Boring	118	74	78	64
35 t, 200 kW Excavator	114	70	74	60
Concrete Pump	107	63	67	53
100 Tonne Hydraulic Crane	110	66	70	56
Compressor 285 L/s	100	56	60	46
External Noise Goal (LAeq dBA)		**55**	**55**	**50**

Table 57 shows that the predicted noise levels for residences directly adjacent to Gympie Rd and Lutwyche Rd would likely be found intrusive (19-23 dBA above the noise goals). This level of intrusion could interfere with normal indoor living (eg interference with passive listening, resting and conversation). The predicted noise levels for residences west and shielded from Lutwyche Rd would also likely be found intrusive (10-14 dBA above the noise goals). Consequently, noise mitigation should be examined so as to maintain a reasonable noise environment at these residences.

Night-time Construction of Elevated Structures and Cut and Cover Tunnelling

Indicative noise levels that could be received at representative surrounding buildings during night-time elevated structure and cut and cover construction are compared with noise goals in

Table 58.

Table 58 Noise Impacts – Night-Time Construction - Elevated Structure and Cut and Cover Construction

		Representative Receptors					
		North of Kedron Brook directly adjacent to Gympie Rd		South of Kedron Brook directly adjacent to Lutwyche Rd		South of Kedron Brook west and shielded from Lutwyche Rd	
Minimum Separation from Earthworks (indicative only)		25 m		15 m		80 m	
AS/NZS 2107 Maximum Internal Noise Goal (LAeq - dBA)		40 (sleeping areas, near major roads)		40 (sleeping areas, near major roads)		35 (sleeping areas, near minor roads)	
Internal Sleep Disturbance Noise Goal (LAmax - dBA)		50		50		45	
Nominal Facade Reduction (dBA)		10		10		10	
External Noise Goal (LAeq dBA)		**50**		**50**		**45**	
External Noise Goal (LAmax dBA)		**60**		**60**		**55**	
Existing Daytime Levels							
Representative measurement location (external)		(8)		(6)		(7)	
average LA90,15minute - dBA		40		47		39	
average LAeq,15minute - dBA		51		61		45	
average LAmax,15minute - dBA		62		76		58	
Typical Plant Items	**Plant Sound Power Levels (LAmax dBA)**	**Indicative Maximum External Plant Noise Level at Receptor - dBA**					
		LAeq	**LAmax**	**LAeq**	**LAmax**	**LAeq**	**LAmax**
Pile Boring	118	74	82	78	86	64	72
35 t, 200 kW Excavator	114	70	78	74	82	60	68
Concrete Pump	107	63	71	67	75	53	61
100 Tonne Hydraulic Crane	110	66	74	70	78	56	64
Compressor 285 L/s	100	56	58	60	62	46	48
External Noise Goal (LAeq dBA)		**50**		**50**		**45**	
External Noise Goal (LAmax dBA)			**60**		**60**		**60**

Table 58 shows that the predicted noise levels for residences directly adjacent to Gympie Rd and Lutwyche Rd would likely be found intrusive (24-26 dBA above the L_{Aeq} noise goals). Additionally, exceedances of 22-24 dBA above the L_{Amax} noise goal are predicted. This level of intrusion would interfere with normal indoor living (eg interference with passive listening, resting and conversation) and could cause sleep disturbance. Consequently, it is strongly recommended that noise mitigation should be examined so as to maintain a reasonable noise environment at these residences.

7.2.3 Noise Mitigation

The following noise control measures are recommended for mitigation of noise around the Gympie Rd surface connection works, guided by the 'reasonable' noise objectives for construction noise as defined in **Section 2.2.2**.

- Construction of noise screens along the eastern boundary of the construction site north of Kedron Brook, where direct access to Gympie Rd is not required, to reduce construction noise on the eastern side of Gympie Rd due to elevated structure construction.
- Construction of noise screens along the western boundary of the construction site south of Kedron Brook, where direct access to Lutwyche Rd is not required, to reduce construction noise on the western side of Lutwyche Rd due to cut and cover construction
- Advance notification of the time and duration of earthworks.
- If required, assist owners of properties along Gympie Rd and Lutwyche Rd to temporarily upgrade the acoustical insulation and ventilation of rooms facing the worksite to address noise during both road widening/regrading and trough excavation.
- Advance notification of night roadworks.

7.2.4 Vibration Impacts

It is not anticipated that vibration levels associated with vibratory rolling during road widening/regrading will be significant. However it is normal environmental monitoring practice to monitor vibration on structures during vibratory rolling that occurs within a nominal distance of 25 m. This may be relevant for properties on Lutwyche and Gympie Roads.

7.3 Sandgate Rd Connections

7.3.1 Proposed Activities

The primary noise-generating activities anticipated during the construction of the southern surface connections are summarised in **Table 59**.

Table 59 North East Surface Connections - Construction Noise Sources

Construction Phase and Approx Duration	Night-time Noise Sources	Daytime Noise Sources
Removal of Buildings (2 weeks)	Nil	Excavators, hydraulic breakers, bulldozers, dump trucks, manual trades, compressors, generators
Cut and Cover Construction in Park Area (24 months)	Nil	Bored piling rig, excavators, shotcrete equipment, rock bolting equipment, compressors, cranage for precast items, concrete pump, ventilation equipment
Open Trough Construction East of Sandgate Rd (6 months)	Nil	Bored piling rig, excavators, shotcrete equipment, rock bolting equipment, compressors, cranage for precast items, concrete pump, ventilation equipment
Elevated Structure (7 months)	As for daytime but limited to areas of interface with existing Sandgate Rd	Bored piling rig, excavators, steel fixing, compressors, crane, concrete pump
Road surfacing (1 month)	As for daytime but limited to areas of interface with existing road infrastructure (Sandgate Rd and East West Arterial)	Delivery trucks, paving machine, compaction equipment, line marking

7.3.2 Noise Impacts

All construction noise levels will be limited to daytime construction except areas interfacing with the existing road infrastructure at Sandgate Rd and the East-west Arterial. It is anticipated that highest noise levels would typically result from open trough construction east of Sandgate Rd and the cut and cover tunnelling west of Sandgate Rd.

Indicative noise levels that could be received at the most exposed residences during open trough construction for the East-west Arterial and cut and cover tunnelling in Kalinga Park are compared with noise goals in **Table 60**.

Table 60 Noise Impacts – Sandgate Rd Construction - Open Trough and Cut and Cover Construction

		Representative Receptors			
		West of Kalinga Park (Cut & Cover)	South of Kalinga Park (Cut & Cover)	North of Kalinga Park (Cut & Cover)	South of East-west Arterial (Open Trough)
Minimum Separation from Earthworks (indicative only)		30 m	15 m	160 m	20 m
AS/NZS 2107 Maximum Internal Noise Goal (LAeq - dBA)		40 (living areas, near minor roads)	40 (living areas, near minor roads)	45 (living areas, near major roads)	45 (living areas, near major roads)
Nominal Facade Reduction (dBA)		10	10	10	10
External Noise Goal (LAeq dBA)		**50**	**50**	**55**	**60[1]**
Existing Daytime Levels					
Representative measurement location (external)		(4)	(2)	(3)	(1)
average LAeq,15minute - dBA		54	59	62	59
average LAmax,15minute - dBA		72	70	79	76
Typical Plant Items	**Plant Sound Power Levels (LAmax dBA)**	**Indicative External Plant Noise Level at Receptor (LAeq dBA)**			
Pile Boring	118	72	78	58	76
35 t, 200 kW Excavator	114	68	74	54	72
24 t Concrete Truck	112	66	72	52	70
Concrete Pump	107	61	67	47	65
Compressor 285 L/s	100	54	60	40	58
100 Tonne Hydraulic Crane	110	64	70	50	68
External Noise Goal (LAeq dBA)		**50**	**50**	**55**	**60[1]**

Note 1: A 5 dBA reduction has been assumed for these residences due to the existing noise barrier to the south of the East-west Arterial.

At residential locations around the cut and cover construction, the construction noise levels are predicted to significantly exceed the noise goals by up to 28 dBA. This level of construction noise would likely be found to be intrusive and result in an acoustic impact on the residences (eg interference with passive listening, resting and conversation). Noise mitigation should be further examined to assist in maintaining a reasonable noise environment at nearby residential locations.

For residential locations south of the open trough construction west of Sandgate Rd, predicted noise levels are up to 16 dBA greater than the noise goals. This may be found to be intrusive and this level of intrusion could also result in an acoustic impact on the residences. Noise mitigation should be further examined to assist in maintaining a reasonable noise environment at these residential locations.

Night-time Works

Night-time construction would be limited to specific tasks of limited duration where daytime construction would be precluded by existing traffic flows. Likely night works include final capping and paving of the interface between Sandgate Rd and the East-west Arterial and the construction of elevated structures north of the East-west Arterial.

Indicative noise levels that could be received at the most exposed residences during the construction of elevated structures north of the East-west Arterial are compared with noise goals in **Table 61**.

Table 61 Noise Impacts – Sandgate Rd Construction - Night-time Elevated Structure Construction

		Representative Receptors	
		Wongara St Residences	
Minimum Separation from Construction (indicative only)		45 m	
AS/NZS 2107 Maximum Internal Noise Goal (L_{Aeq} - dBA)		40 (sleeping areas, near major roads)	
Internal Sleep Disturbance Noise Goal (L_{Amax} - dBA)		50	
Nominal Facade Reduction (dBA)		10	
External Noise Goal (L_{Aeq} dBA)		**55**[1]	
External Noise Goal (LAmax dBA)		**65**[1]	
Existing Night-Time Levels			
Representative measurement location (external)		(1)	
average LA90, 15minute - dBA		40	
average $L_{Aeq,15minute}$ - dBA		48	
average $L_{Amax,15minute}$ - dBA		64	
Typical Plant Items	**Plant Sound Power Levels (L_{Amax} dBA)**	**Indicative External Plant Noise Level at Receptor - dBA**	
		L_{Aeq}	**L_{Amax}**
Pile Boring	118	69	77
35 t, 200 kW Excavator	114	65	73
24 t Concrete Truck	112	63	71
Concrete Pump	107	58	66
Compressor 285 L/s	100	51	59
100 Tonne Hydraulic Crane	110	61	69
External Noise Goal (L_{Aeq} dBA)		**55**[1]	
External Noise Goal (LAmax dBA)			**65**[1]

Note 1: A 5 dBA reduction has been assumed for these residences due to the existing noise barrier to the south of the East-West Arterial

For residential locations south of the elevated structure construction, the predicted L_{Aeq} noise levels are 14 dBA higher than the desired noise goals. This would likely be found to be intrusive and this level of intrusion would result in an acoustic impact on the residences.

The L_{Amax} noise goal is predicted to be exceeded by 12 dBA. This could result in sleep disturbance at the residences and noise mitigation should be further examined to assist in maintaining a reasonable noise environment at nearby residential locations.

7.3.3 Noise Mitigation

The following noise control measures are recommended for mitigation of noise and vibration around roadworks for the Sandgate Rd connections, guided by the 'reasonable' noise objectives for daytime construction noise as defined in **Section 2.2.2**.

- Advance notification of the time and duration of works, especially any night works.
- Select construction processes and plant to minimise construction noise
- Assist owners of properties nearest the construction site to temporarily upgrade the acoustical insulation and ventilation of rooms facing the construction area.
- Construction of noise screens along the southern and western boundaries of the construction site west of Sandgate Rd.
- Early construction of the operational noise barrier south of the East-west Arterial to protect residences in Wongara St during the construction period.

7.3.4 Vibration Impacts

It is not anticipated that vibration levels associated with vibratory rolling during road surfacing of the East-west Arterial will be significant. However it is normal environmental monitoring practice to monitor vibration on structures during vibratory rolling that occurs within a nominal distance of 25 m. This may be relevant for properties in Wongara St that would be nearest to works for the road surfacing of the East-west Arterial as well as residences south of the construction area west of Sandgate Rd.

8 TUNNELLING BETWEEN PORTALS

8.1 Introduction

It is proposed that a road-header will be used to excavate the tunnel section between the Southern and Gympie Road portals where the rock strata are relatively hard. An Earth Pressure Balance Tunnel Boring Machine[18] (TBM) will be used to excavate the tunnel section between Gympie Road Portal and Sandgate Portals, where the ground condition is relatively soft. Limited drill-and-blast excavation may be required to create the cross passages in hard rock for the north/south tunnel - subject to environmental constraints and community consultation.

Vibration issues have been considered in relation to residential properties, hospitals, aged-care facilities and known buildings of particular heritage value.

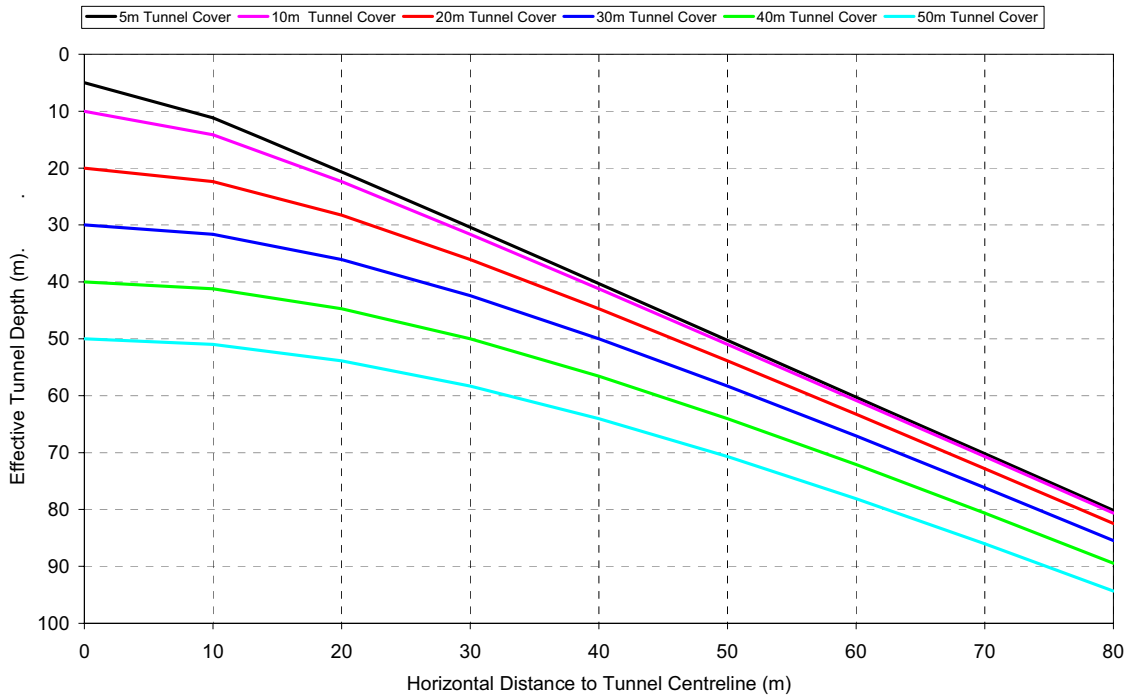
8.2 Tunnel Slant Distance to Sensitive Properties

The crown of the tunnel is nominally 8 m above a control line at the lateral centre-line of the tunnel at the finished road pavement. The actual height of the excavated crown relative to the control line will vary depending on the number of traffic lanes, method of construction (road-header versus TBM) and localised tunnel enlargements for accommodation of services.

The “slant distance” from the crown of the tunnel to nearby building footings is a primary variable controlling the reduction of ground vibration transmitted into buildings from tunnelling.

The relationship between the vertical distance from tunnel crown to ground level, the side-line distance to a building and the slant distance is presented in **Figure 12**.

Figure 12 Determination of Slant Distance from Tunnel to a Building



Cross-street locations have been referenced in the vibration emission prediction tables (rather than specific chainage distances) to enhance interpretation of the data.

[18] *Throughout this report, the term TBM specifically refers to an Earth Pressure Balance Tunnel Boring Machine*

The relative level of building footings near the tunnel alignment has been assumed to be the same as the natural ground level immediately above the tunnel. Slant distances have been calculated on this basis.

A sensitivity analysis has also been undertaken to determine the effects that piled footings (under the building floor slabs) could have on the predicted levels of vibration and regenerated noise from the EPB machine when driving the tunnel between the Gympie Rd and Sandgate Rd portals.

The JV advised that piled footings up to 15 m in depth may have been placed below homes in this area due to the soft ground, but no detailed investigations have been undertaken to confirm this assumption.

8.3 Community Consultation with Significant Facilities

Consultation meetings were held with management from a number of healthcare facilities in the vicinity of the tunnel alignment. The consultation was designed to identify any particularly sensitive health care environments or potentially vibration-sensitive building contents (eg communications equipment, computing equipment, instrumentation and processes). While such equipment is generally not very sensitive to vibration (considering that significant vibration occurs during its normal transportation and use), it is important to address any perceptions to the contrary.

Consultation was conducted with representatives of the following facilities:

- Amarina Nursing Home; and
- Rosemount Hospital.

Neither facility had equipment that is considered vibration sensitive, though both facilities provides palliative and dementia care. It is common that such patients are easily distressed by unexpected events such as fireworks. A regular schedule of blasting times and pre-warning of tunnelling vibration or noise will assist to allay unnecessary fears or anxieties.

8.4 Vibration Impacts

8.4.1 Overview

Specific vibration levels have been predicted using the indicative ground vibration levels (based on the measurement results for tunnelling methods in **Table 34**) and the slant distances to the receivers.

The potential impacts of vibration on buildings have been assessed by comparing the predicted vibration levels using the guide values for *minimising the risk of cosmetic (superficial) building damage* summarised in **Table 5** - and/or also statutory requirements - as appropriate. The potential impacts of vibration on people have been assessed using the guideline values for subjective human disturbance response given in **Table 7**.

Summaries of the key parameters describing the impacts on buildings and residents along the route are presented in **Table 63**, **Table 64** and **Table 69**. A summary of the indicative extent of possible human perception resulting from the tunnelling operations (ie road header or TBM) and from blast vibration is shown in **Table 67**.

In order to address community concerns regarding potential vibration impacts in a pro-active manner, a range of response management measures will be implemented prior to and/or during tunnelling operations. The specific management response measures are dependent on the predicted levels of possible impacts on buildings and their occupants - and are described in **Table 62.**

Table 62 Potential Vibration Impact Response Management Measures

Predicted Effect of Tunnelling Vibration Emissions	Pre Notification to Building Occupants	Building Condition Survey	Building Sensitivity Study (Refer Note 1)	Vibration Monitoring
Not felt	-	-	-	-
Threshold of perception	-	-	-	
Barely noticeable	✓		✓	
Sleep disturbance Note 2	✓		✓	✓
Noticeable	✓		✓	✓
Easily noticeable	✓	✓	✓	✓
Strongly noticeable	✓	✓	✓	✓
Very strongly noticeable	✓	✓	✓	✓

Note 1: This only applies for specific noise sensitive buildings identified in **Section 3** of this report
Note 2: This category is not within Table 7, and is defined to be 0.5 mm/s. Refer **Section 8.4.5**

For blasting, the Maximum Instantaneous Charge (MIC) of explosive used in the design of the blast and the distance to a receiver dictate the likely received levels of vibration. Explosive MICs will be selected to ensure that predicted vibration levels do not exceed permissible limits. The representative blast MIC was determined based on previous trial blasts in Brisbane - and is a first approximation.

Wherever blasting is undertaken, building condition surveys, building sensitivity studies and vibration monitoring is recommended. The results of these surveys will feed back into the blast design process over time (according to **Table 5**) to provide greater confidence with the blast design and implementation processes (which will commence with trial blasting designed to achieve conservatively low predicted vibration emission levels).

Table 63 Tunnelling Vibration Summary – Cedric Street to Felix Street for properties on the Eastern Side of the Tunnel

Tunnel Section	**Type of Building**	**RL of Tunnel Crown**	**Excavation Method**	**Indicative max. Vibration Level, or Indicative max. Blast MIC**	**Guide Value (G) or Statutory Limit (L) for cosmetic damage**	**Possible Impact** NF - Not felt TP - Threshold of perception BN - Barely noticeable SD – Sleep Disturbance N - Noticeable EN - Easily noticeable SN - Strongly noticeable VSN - Very strongly noticeable CC = cosmetic cracking	**Mitigation** P = pre notification BCS = building condition survey BSS = building sensitive study M = monitoring
Cedric St to Bryden St	Residential Commercial Hospital	1.3m – 10.8m	Roadheader	0.024 to 0.067 mm/s	5 mm/s (G)	NF	
			Blasting	0.7 Kg	10 mm/s (L)	SN, CC	P, BCS, M
Bryden St to Cartwright St	Commercial	10.8m – 15.8m	Roadheader	0.015 to 0.024mm/s	5 mm/s (G)	NF	
			Blasting	1.5 kg	10 mm/s (L)	SN, CC	P, BCS, M
Cartwright St to Somerset St	Residential Commercial	15.8m – 26.3m	Roadheader	0.012 to 0.016mm/s	5 mm/s (G)	NF	
			Blasting	2.2 kg	10 mm/s (L)	SN, CC	P, BCS, M
Somerset St to Hadfield St	Residential Commercial	26.3m – 35.0m	Roadheader	0.006 to 0.019mm/s	5 mm/s (G)	NF	
			Blasting	3.6 kg	10 mm/s (L)	SN, CC	P, BCS, M
Hadfield St to Ada St	Residential Commercial School	28.3m - 35.0m	Roadheader	0.006 to 0.009mm/s	5 mm/s (G)	NF	
			Blasting	4.7 kg	10 mm/s (L)	SN, CC	P, BCS, M
Ada St to Lowerson St	Residential Commercial Religious	21.0m – 28.3m	Roadheader	0.006 to 0.009mm/s	5 mm/s (G)	NF	
			Blasting	4.5 kg	10 mm/s (L)	SN, CC	P, BCS, M
Lowerson St to Felix St	Residential Commercial	5.7m – 21.0m	Roadheader	0.009 to 0.017mm/s	5 mm/s (G)	NF	
			Blasting	2.6 kg	10 mm/s (L)	SN, CC	P, BCS, M

Table 64 Tunnelling Vibration Summary – Cedric Street to Felix Street for properties on the Western Side of the Tunnel

Tunnel Section	Type of Building	RL of Tunnel Crown	Excavation Method	Indicative max. Vibration Level	Guide Value (G) or Statutory Limit (L) for cosmetic damage	Possible Impact NF - Not felt TP - Threshold of perception BN - Barely noticeable SD – Sleep Disturbance N - Noticeable EN - Easily noticeable SN - Strongly noticeable VSN - Very strongly noticeable	Mitigation P = pre notification BCS = building condition survey BSS = building sensitive study M = monitoring
Cedric St to Bryden St	Commercial	1.2m – 10.6m	Roadheader	0.028 to 0.079mm/s	5 mm/s (G)	NF	
			Blasting	0.6 kg	10 mm/s (L)	SN, CC	P, BCS, M
Bryden St to Cartwright St	Residential Commercial	10.6m – 15.4m	Roadheader	0.016 to 0.028mm/s	5 mm/s (G)	NF	
			Blasting	1.4 kg	10 mm/s (L)	SN, CC	P, BCS, M
Cartwright St to Somerset St	Commercial	15.4m – 25.7m	Roadheader	0.012 to 0.016mm/s	5 mm/s (G)	NF	
			Blasting	2.3 kg	10 mm/s (L)	SN, CC	P, BCS, M
Somerset St to Hadfield St	Residential	25.7m – 35.9m	Roadheader	0.007 to 0.018mm/s	5 mm/s (G)	NF	
			Blasting	3.1 kg	10 mm/s (L)	SN, CC	P, BCS, M
Hadfield St to Ada St	Residential Commercial	28.2m - 35.9m	Roadheader	0.006 to 0.008mm/s	5 mm/s (G)	NF	
			Blasting	5.0 kg	10 mm/s (L)	SN, CC	P, BCS, M
Ada St to Lowerson St	Residential Commercial	21.3m – 28.2m	Roadheader	0.006 to 0.008mm/s	5 mm/s (G)	NF	
			Blasting	4.6 kg	10 mm/s (L)	SN, CC	P, BCS, M
Lowerson St to Felix St	Commercial	6.5m – 21.3m	Roadheader	0.008 to 0.017mm/s	5 mm/s (G)	NF	
			Blasting	2.7 kg	10 mm/s (L)	SN, CC	P, BCS, M

Table 65 Tunnelling Vibration Summary – Gorman Street to Jackson for properties on the Northern Side of the Tunnel

Tunnel Section	Type of Building	RL of Tunnel Crown	Excavation Method	Indicative max. Vibration Level	Guide Value (G) or Statutory Limit (L) for cosmetic damage	Possible Impact NF - Not felt TP - Threshold of perception BN - Barely noticeable SD – Sleep Disturbance N - Noticeable EN - Easily noticeable SN - Strongly noticeable VSN - Very strongly noticeable	Mitigation P = pre notification BCS = building condition survey BSS = building sensitive study M = monitoring
Gorman St to Roseleigh St	Residential	13.5m – 26.5m	EPB	0.16 to 0.26mm/s	5 mm/s (G)	TP	
Roseleigh St to Dawson St	Residential	25.3m - 26.5m	EPB	0.16 to 0.17mm/s	5 mm/s (G)	TP	
Dawson St to Park Ave	Residential	21.8m – 25.3m	EPB	0.17 to 0.19mm/s	5 mm/s (G)	TP	
Park Ave to Jackson St	Residential	16.0m – 21.8m	EPB	0.19 to 0.31mm/s	5 mm/s (G)	TP (approaching BN)	

Table 66 Tunnelling Vibration Summary – Gorman Street to Jackson Street for properties on the Southern Side of the Tunnel

Tunnel Section	Type of Building	RL of Tunnel Crown	Excavation Method	Indicative max. Vibration Level	Guide Value (G) or Statutory Limit (L) for cosmetic damage	Possible Impact NF - Not felt TP - Threshold of perception BN - Barely noticeable N - Noticeable EN - Easily noticeable SN - Strongly noticeable VSN - Very strongly noticeable	Mitigation P = pre notification BCS = building condition survey BSS = building sensitive study M = monitoring
Gorman St to Roseleigh St	Residential	16.6m – 27.1m	EPB	0.16 to 0.20mm/s	5 mm/s (G)	TP	
Roseleigh St to Dawson St	Residential	26.4m - 27.1m	EPB	0.17 to 0.18mm/s	5 mm/s (G)	TP	
Dawson St to Park Ave	Residential	21.1m – 26.4m	EPB	0.18 to 0.20mm/s	5 mm/s (G)	TP	
Park Ave to Jackson St	Residential	14.0m – 21.1m	EPB	0.20 to 0.33mm/s	5 mm/s (G)	TP (approaching BN)	

Table 67 Indicative Radius of Perceptible TBM and Blasting Vibration

Tunnelling Method	Tunnel Cover	Indicative Radius of Vibration Note 1 (0.2 mm/s threshold)	Indicative Radius of Possible Sleep Disturbance (0.5 mm/s threshold)
Earth Pressure Balance TBM	10 m	29 m	4 m
	20 m	23 m	Below threshold
	30 m	2.5 m	Below threshold
Blasting	**Maximum Instantaneous Charge**	**Indicative Radius of Perceptible Vibration (0.2 mm/s threshold)**	**Sleep Disturbance Not Applicable to Daytime Blasting**
	5 kg	350 m	Below threshold
	1 kg	150 m	Below threshold
	0.2 kg	70 m	Below threshold

Note:1 – Correlates to low probability of reaction

8.4.2 General Discussion

It can be seen from a comparison of the criteria and guideline levels in **Table 5** and **Table 9** that the threshold vibration levels below which cosmetic building damage from transient vibrations (eg blasting) do not occur, are comparable to vibration levels readily accepted as being normal by people in buildings during the daytime. Thus, in general terms, the objective of protecting buildings from excessive blast vibrations generally results in vibration levels that people will accept, provided there is an effective community consultation process in place to ensure that people are well-informed of the works and the nature of their vibration emissions.

During night-time, it could be expected that blasting would result in significant adverse comment. Blasting will therefore normally be avoided during this time of day.

8.4.3 Roadheading

Anticipated vibration levels generated by roadheading are sufficiently low to be imperceptible in buildings along the whole tunnel alignment. No on-going vibration mitigation measures or impact response management procedures are anticipated to be necessary for this type of tunnelling. It is recommended however that indicative vibration measurements/monitoring be conducted during the start of the tunnelling works to confirm the predictions (based on the actual plant item being used) and to allay any concerns that the community may express.

8.4.4 Blasting

Depending on the number of blastholes and the millisecond delays used between successive detonations, tunnel face blasting typically results in a series of short vibration “events” lasting several seconds. Apart from limiting the size of the charge, the normal mitigation method in relation to human comfort impacts is to give clear and concise pre-notification to all persons in the area. People will “hear” the blast, although vibration (and noise) levels are usually relatively low. It is imperative that the community be properly advised so that ill-informed perceptions do not cause unnecessary concern.

It is often the case with projects where blasting is carried out that a regular schedule is established whereby people come to anticipate blast vibrations at a set time with minimal “startle effects” or other concerns.

Potentially the most sensitive receptor in terms of human disturbance effects from blasting operations are:

- Amarina Nursing Home; and

- Rosemount Hospital.

Both facilities provides palliative and dementia care. It is common that in such facilities, patients are easily distressed by unexpected events such as fireworks. A regular schedule of blasting times and pre-warning of tunnelling vibration or noise will assist to allay unnecessary fears or anxieties.

If drill and blast methods are required, the following guidelines will be considered by the project team:

- Appropriate attention to blast design, with a low MIC. It is suggested that design vibration levels for this receptor location should be no more than 4 mm/s vertical peak particle velocity, based on daytime transient vibration criteria for "low probability of reaction" derived from AS2670:1990;
- Effective pre-warnings and coordination of the timing of the blast activities to minimise impacts on specific healthcare operations via the community consultation team;
- Monitoring of the blast emissions and correlation of the readings with consultation with the staff members; and

In general, minimisation of impacts on buildings and their occupants is achieved by appropriate blast design. This usually involves commencing with a small, controlled blast design with low emission levels and then progressively increasing charge weights to establish prudent blast design parameters. It is a requirement of Brisbane City Council to conduct pre- and post-blasting Building Condition Surveys where it is considered there may be potential for cosmetic (superficial) building damage.

8.4.5 Earth Pressure Balancing Type Tunnel Boring Machine

It is proposed to operate the Earth Pressure Balancing TBM on a near continuous basis. Sleep disturbance may result if the vibration levels from continuous vibration levels are higher than 0.5 mm/s.

It should be noted that the subjective responses of individual people to vibration in their dwellings is variable. Tolerances and susceptibility to vibration vary markedly. The 0.5 mm/s night-time guideline vibration level for this project is conservatively low and some people may be comfortable with higher levels.

Sensitive Building Contents

For this project, it is recommended that a Building Sensitivity Studies be conducted at Rosemount Hospital prior to any blasting to establish the sensitivity of the building and its contents in greater detail. Blasting in this vicinity can then be designed (ie lower explosive charge weights per blast delay) to achieve the necessary vibration limits.

8.5 Regenerated Noise Impacts

Possible regenerated noise impacts and mitigation options along the tunnel alignments are summarised in **Table 69**, **Table 70**, **Table 71** and **Table 72.**

A summary of the indicative extent of possible human perception of Roadheader and TBM regenerated noise, and possible sleep disturbance from regenerated noise, is shown in **Table 73**.

Regenerated noise impacts have been assessed by comparing the indicative regenerated noise levels associated with the proposed tunnelling methods with the slant distance, Type of Building and tunnelling method data in **Table 69**, **Table 70**, **Table 71** and **Table 72**.

Possible impacts of regenerated noise have been assessed using the guideline values for acceptable noise levels inside building in AS/NZS 2107, summarised in **Table 3 -** although this standard refers to noise from a prevailing ambient noise such as road traffic - and not to a short term source such as tunnel construction. Regenerated noise from tunnelling can usually only be perceived in rooms that are well insulated from outside air-borne traffic noise. It is therefore reasonable to use the AS/NZS 2107 guideline values for living areas and bedrooms in dwellings near 'minor roads' for the assessment. For the most exposed rooms within many of the homes along the Bowen Bridge Rd/Lutwyche Rd corridor, this assumption will be conservative as it is likely that existing internal levels of road traffic noise could assist to mask regenerated noise from tunnelling whilst traffic is passing by.

In order to assist in quantifying the impacts on residents, the flowing descriptors were used:

- Very Low – more than 5 dBA below the appropriate criteria;
- Low – where the levels of regenerated noise are above "very low" but lower than the criteria;
- Moderate – where the criteria is exceeded by up to 5dBA;
- High - where the levels of regenerated noise are more than 5 dBA above the criteria. This category corresponds to the potential on-set of sleep disturbance in a residential area (refer **Table 2**).

In order to address community concerns regarding potential regenerated-noise impacts in a pro-active manner, a range of response management measures will be implemented prior to and/or during tunnelling operations. The specific management response measures are dependent on the predicted levels of possible impacts on building occupants - and are described in **Table 63**.

Table 68 Potential Regenerated Noise Impact Response Management Measures

Level of Regenerated Noise	**Pre Notification**	**Monitoring**
Very Low	-	-
Low	✓	✓ (depending upon community sensitivity)
Moderate	✓	✓
High	✓	✓

Tunnel blasting can generate regenerated noise, although the primary community concern is vibration. Impacts from blasting operations are therefore usually managed by regulated the vibration emission levels.

The potential regenerated noise levels of rockdrills has not been specifically calculated at all receptor locations. As a guide, the levels of regenerated rockdrill noise are usually lower than regenerated noise levels from roadheader operations.

Table 69 Tunnelling Regenerated Noise Summary – Cedric Street to Felix Street for properties on the Eastern Side of the Tunnel

Tunnel Section	Type of Building	RL of Tunnel Crown	Excavation Method	Indicative max. Regenerated Noise Level (dBA)	AS/NZS 2107 Max. Guide Value - Internal Noise Levels (dBA)	Possible Impact[1] Very Low: > 5 dBA below criteria Low: Criteria to criteria – 5dBA Moderate: Low to criteria + 5dBA High: > criteria + 5dBA equates to sleep disturbance for residential properties	Mitigation P = pre-notification M = monitoring
Cedric St to Bryden St	Residential Commercial Hospital	1.3m – 10.8m	Roadheader	37 – 44	40 day 35 night 45 dBA to 50 dBA 40 dBA	Moderate High Low Moderate	P, M P, M - P, M
Bryden St to Cartwright St	Commercial	10.8m – 15.8m	Roadheader	34 – 37	45 dBA to 50 dBA	Very Low	P, M
Cartwright St to Somerset St	Residential Commercial	15.8m – 26.3m	Roadheader	32 – 34	40 day 35 night 45 dBA to 50 dBA	Very Low Low Very Low	- P, M -
Somerset St to Hadfield St	Residential Commercial	26.3m – 35.0m	Roadheader	26 – 35	40 day 35 night 45 dBA to 50 dBA	Very Low Moderate Very Low	- P, M -
Hadfield St to Ada St	Residential Commercial School	28.3m - 35.0m	Roadheader	27 – 29	40 day 35 night 45 dBA to 50 dBA 45 dBA	Very Low Very Low Very Low Very Low	- - - -
Ada St to Lowerson St	Residential Commercial	21.0m – 28.3m	Roadheader	27 – 30	40 day 35 night 45 dBA to 50 dBA	Very Low Very Low Very Low	- - -
Lowerson St to Felix St	Residential Commercial	5.7m – 21.0m	Roadheader	30 - 35	40 day 35 night 45 dBA to 50 dBA	Very Low Moderate Very Low	- P, M -

[1] For the most exposed rooms in many of the homes along the Bowen Bridge Rd/Lutwhcye Rd corridor, this possible impact may be conservative as some masking of regenerated noise from tunnelling is likely due to internal road traffic noise levels attributable to this major road corridor.

Table 70 Tunnelling Regenerated Noise Summary – Cedric Street to Felix Street for properties on the Western Side of the Tunnel

Tunnel Section	**Type of Building**	**RL of Tunnel Crown**	**Excavation Method**	**Indicative max. Regenerated Noise Level (dBA)**	**AS/NZS 2107 Max. Guide Value - Internal Noise Levels (dBA)**	**Possible Impact** [1] Very Low: > 5 dBA below criteria Low: Criteria to criteria – 5dBA Moderate: Low to criteria + 5dBA High: > criteria + 5dBA equates to sleep disturbance for residential properties	**Mitigation** P = pre-notification M = monitoring
Cedric St to Bryden St	Commercial	1.2m – 10.6m	Roadheader	38 – 46	45 dBA to 50 dBA	Very low to moderate	-
Bryden St to Cartwright St	Residential Commercial	10.6m – 15.4m	Roadheader	34 - 38	40 day 35 night 45 dBA to 50 dBA	Low Moderate Low	P, M P, M -
Cartwright St to Somerset St	Commercial	15.4m – 25.7m	Roadheader	32 – 34	45 dBA to 50 dBA	Very Low	-
Somerset St to Hadfield St	Residential	25.7m – 35.9m	Roadheader	27 – 35	40 day 35 night	Very Low Moderate	- P, M
Hadfield St to Ada St	Residential Commercial	28.2m - 35.9m	Roadheader	27 – 28	40 day 35 night 45 dBA to 50 dBA	Very Low Very Low Very Low	- - -
Ada St to Lowerson St	Residential Commercial	21.3m – 28.2m	Roadheader	27 – 29	40 day 35 night 45 dBA to 50 dBA	Very Low Very Low Very Low	- - -
Lowerson St to Felix St	Commercial	6.5m – 21.3m	Roadheader	29 – 34	45 dBA to 50 dBA	Very Low	-

[1] For the most exposed rooms in many of the homes along the Bowen Bridge Rd/Lutwhcye Rd corridor, this possible impact may be conservative as some masking of regenerated noise from tunnelling is likely due to internal road traffic noise levels attributable to this major road corridor

Table 71 Tunnelling Regenerated Noise Summary – Gorman Street to Jackson Street for properties on the Northern Side of the Tunnel

Tunnel Section	**Type of Building**	**RL of Tunnel Crown**	**Excavation Method**	**Indicative max. Regenerated Noise Level (dBA)**	**AS/NZS 2107 Max. Guide Value (dBA)**	**Possible Impact** Very Low: > 5 dBA below criteria Low: Criteria to criteria – 5dBA Moderate: Low to criteria + 5dBA High: > criteria + 5dBA equates - to sleep disturbance for residential properties	**Mitigation** P = pre-notification M = monitoring
Gorman St to Roseleigh St	Residential	13.5m – 26.5m	EPB	32 – 36	40 day and 35 night	Low Moderate	P, M P, M
Roseleigh St to Dawson St	Residential	25.3m - 26.5m	EPB	32 – 33	40 day and 35 night	Very Low Low	- P, M
Dawson St to Park Ave	Residential	21.8m – 25.3m	EPB	33 – 34	40 day and 35 night	Very Low Low	- P, M
Park Ave to Jackson St	Residential	16.0m – 21.8m	EPB	34 - 38	40 day and 35 night	Low Moderate	P, M P, M

Table 72 Tunnelling Regenerated Noise Summary – Gorman Street to Jackson Street for properties on the Southern Side of the Tunnel

Tunnel Section	**Type of Building**	**RL of Tunnel Crown**	**Excavation Method**	**Indicative max. Regenerated Noise Level (dBA)**	**AS/NZS 2107 Max. Guide Value (dBA)**	**Possible Impact** Very Low: > 5 dBA below criteria Low: Criteria to criteria – 5dBA Moderate: Low to criteria + 5dBA High: > criteria + 5dBA equates to sleep disturbance for residential properties	**Mitigation** P = pre-notification M = monitoring
Gorman St to Roseleigh St	Residential	16.6m – 27.1m	EPB	32 – 34	40 day and 35 night	Very Low Low	- P, M
Roseleigh St to Dawson St	Residential	26.4m - 27.1m	EPB	32 – 33	40 day and 35 night	Very Low Low	- P, M
Dawson St to Park Ave	Residential	21.1m – 26.4m	EPB	33 – 34	40 day and 35 night	Very Low Low	- P, M
Park Ave to Jackson St	Residential	14.0m – 21.1m	EPB	34 - 38	40 day and 35 night	Low Moderate	- P, M

Table 73 Radius of Perceptible TBM Regenerated Noise versus Tunnel Cover

Tunnelling Method	Tunnel Cover	Indicative Radius to achieve a level of 40 dBA Regenerated Noise	Indicative Radius of Possible Sleep Disturbance (45 dBA threshold)
Roadheader	10 m	22 m	15 m
	20 m	10 m	2 m
	30 m	Below threshold	Below threshold
	40 m	Below threshold	Below threshold
	50 m	Below threshold	Below threshold
Earth Pressure Balancing Machine TBM	10 m	9 m	Below threshold
	20 m	Below threshold	Below threshold
	30 m	Below threshold	Below threshold
	40 m	Below threshold	Below threshold
	50 m	Below threshold	Below threshold

Roadheading

Predicted worst-case regenerated noise levels from roadheading are not expected to be exceed the sleep disturbance criterion at any location.

Earth Pressure Balancing Tunnel Boring Machine

By comparing the possible zone of influence of Earth Pressure Balancing TBM regenerated noise in **Table 73** with the possible zone of influence of TBM vibration in **Table 67**, it can be seen that the predicted extent of potential impacts of TBM regenerated noise and vibration are similar.

Worst-case predictions indicate that it is possible that regenerated noise may be noticeable in buildings nearest to the TBM alignment.

Table 73 presents an indication of the distances from the tunnel where there is potential for sleep disturbance effects from various mechanical tunnelling plant. Regenerated noise levels (as a result of vibration from the TBM) exceeding sleep disturbance criteria are not expected to occur at any point along the project.

Tolerances to noise vary markedly. Some people may be comfortable with much higher levels at night noise than the nominated 45 dBA sleep disturbance value, depending on many factors, including how the sleeping areas are currently affected by traffic noise.

Sensitivity of EPB Machine Predictions to Piled Footings

Preliminary calculations indicate that exceedences of the 0.5 mm/s sleep disturbance vibration goal noise goal may occur at some locations near the tunnel portals (between Gorman St and Roseleigh St to the west and Park Ave to Jackson St to the east), due to the shallower tunnel depth. Some exceedences of the 45 dBA sleep disturbance regenerated noise goal may occur around the eastern portal (between Park Ave and Jackson St) only. It is not expected that exceedences of either (noise or vibration) goal would occur be between Roseleigh St and Park Ave due to the increased tunnel depth.

Further investigations will be required during design development and detailed construction design to determine more confidently where piles have been constructed so that more detailed predictions can be undertaken.

Mitigation of Vibration and Regenerated Noise from Tunnelling

The following impact management and mitigation strategies are recommended to minimise the effects of tunnelling vibration and regenerated noise:

- Comprehensive advance notice of intended tunnelling activities in the localities near the tunnel alignment.
- Conduct night-time tunnelling subject to compliance with 'reasonable' night-time vibration and regenerated noise levels as defined in **Section 2.2.2**.
- Noise and vibration monitoring should be undertaken at the commencement of road header tunnelling to confirm that the source data utilised for this assessment is applicable to this project.
- If blasting is required in the vicinity of Amarina Nursing Home or Rosemount Hospital, consideration should be given to the adoption of a lower 'reasonable' blast vibration limit of 4 mm/s.
- Conduct building-specific vibration sensitivity investigations for the Rosemount Hospital to establish 'reasonable' vibration levels for these facilities prior to finalisation of a management plan for construction vibration.
- Conduct pre- and post-blasting Building Condition Surveys in accordance with Brisbane City Council requirements where it is considered there may be potential for cosmetic (superficial) building damage from drill-and-blast methods.

9 CONSTRUCTION TRAFFIC

9.1 Proposed Activities

9.1.1 Spoil Removal

Spoil movement would be achieved by trucks with dog trailers (truck and dog). The local access arrangements, anticipated peak frequencies and total duration of spoil removal operations are summarised in **Table 7474**.

Table 74 Summary of Truck and Dog Spoil Movements

Worksite	**Southern**	**Gympie Rd**	**Sandgate Rd**
Local Access Rd	Inner City Bypass	Lutwyche Rd and Gympie Rd	East-west Arterial
Hours of Spoil Removal	24 hours Monday to Friday, 6.30 am to 6.30 pm Saturday, no spoil removal Sunday or Public Holidays		
Peak Daily Spoil Truck Movements	140	300	80
Peak Hourly Night-Time Spoil Truck Movements	4	10	0
Duration of Spoil Removal	32 months	30 months	16 months

Note: One-way volumes - total truck movements are double these values due to return trip.

9.1.2 Material and Machinery Supplies

Truck deliveries of materials and machinery would utilise the same local site access arrangements as for the spoil removal. These movements would occur during daytime working hours only, except where over-size regulations require transit at other times.

Precast concrete segments for lining of the EPB Machine tunnels would be delivered and installed through the Gympie Road worksite. It is estimated that up to 15 trucks per day will be necessary at peak tunnelling rates to supply these segments (based on NSBT truck numbers).

Specific numbers of trucks associated with other deliveries are not available as this relates to detailed construction methods. However, for the purpose of this analysis it has been estimated that the total number of truck deliveries for machinery and material supplies may be around 10% of the number of spoil loads. Thus, for the northern worksite there would be an estimated 6 deliveries (10% of 58), The remainder of the deliveries would relate to wet concrete, materials and plant for tunnel services, initial supply and off-site maintenance of construction machinery and general refuse removal.

9.1.3 Employee Transport

All employee access to worksites is directly from major roads.

Proposed tunnelling shifts would run from 9.00 pm to 7.00 am and from 7.00 am to 5.00 pm, therefore local traffic movements associated with employees arriving and departing worksites would not occur during the most sensitive night-time period.

9.2 Identification of Residential Areas along Spoil Routes

Residential areas along spoil routes are summarised in **Table 75**.

Table 75 Residential Areas along Spoil Routes

Spoil Source	Residential Street Frontages along Route
Southern Worksite	Bowen Bridge Rd, O'Connell Tce[1], Montpelier Rd Breakfast Creek Rd, Kingsford Smith Drv
Gympie Rd Worksite	Lutwyche Rd, Bowen Bridge Rd, O'Connell Tce[1], Montpelier Rd Breakfast Creek Rd, Kingsford Smith Drv
Sandgate Rd Worksite	East-west Arterial

[1] No residential properties directly front onto O'Connell Tce, however a new residential high-rise in Tufton Street is positioned one house block away from O'Connell Tce.

It should be noted that there are only a small number of residential locations adjacent to Bowen Bridge, O'Connell Tce, Montpelier Rd and Breakfast Creek Rd and that the residences are located in predominantly commercial/industrial areas with high ambient noise levels.

It has been assumed that existing traffic volumes on the Gateway Motorway are such that any spoil trucks will not significantly increase the road traffic noise from the Gateway Motorway.

9.3 Noise Impacts

The effect of construction-related truck traffic on the noise emission from roadways has been assessed by calculating how the additional truck traffic would alter the $L_{A10(18hour)}$ level of noise emission from roadways using the CoRTN prediction algorithms. For the purpose of this analysis, the $L_{A10(18hour)}$ is the average L_{A10} traffic noise level between the hours of 6am and midnight. An assessment has also been undertaken to determine the change in the $L_{A10(1hour)}$ noise level between 2am and 3 am which has been identified as the quietest hour during the night-time period.

On a given roadway, the essential modelling inputs that the additional truck traffic will alter are the percentage of heavy vehicles and total vehicle numbers utilising that roadway. For the assessment of typical construction truck volumes, the peak daily and night-time hourly spoil truck frequencies have been adopted as being representative of total truck movements. This assessment is summarised in **Table 76 and Table 77.**

For this analysis the existing AADT road traffic predictions an all roads has been obtained from traffic information supplied by the BCC. The existing traffic counts for the quietest night-time hour (2 am to 3 am) has been obtained from the following information supplied by the JV:

2 am to 3 am Traffic Counts as a Percentage of AADT

- Lutwyche Rd/Bowen Bridge Rd - 0.60%
- O'Connell Tce/Montpelier Rd - 0/59%
- Breakfast Creek Rd - 0.44%
- Kingsford Smith Drive - 0.36%
- East West Arterial - 0.30%

2 am to 3 am Heavy Vehicle Traffic Counts as a Percentage of Heavy Vehicle AADT

- Lutwyche Rd - 0.71%
- Kingsford Smith Drive - 0.63%
- All other roads have assumed 0.7%

It should be noted that this analysis takes into account the anticipated heavy vehicle traffic due to construction spoil haulage for the NSBT in the "existing" scenario. Any incremental noise impacts from construction spoil haulage associated with the Airport Link Project are then determined by calculating the change that the additional Airport Link traffic would cause to the "existing" noise levels (existing traffic plus NSBT spoil haulage traffic).

Table 76 Effect of Construction Truck Movements on Traffic Noise Levels along Spoil Routes - $L_{A10(18hour)}$

Roadway	Road Section	Change in $L_{A10(18hour)}$ Traffic Noise Level (dBA)
Lutwyche Rd	Norman St - Kedron Park Rd	+ 0.3
Bowen Bridge Rd	Site - O'Connell Tce	+ 0.3
O'Connell Tce	Bowen Bridge Rd - Hamilton Rd	+ 1.2
Montpelier Rd	Abbotsford Rd - Breakfast Creek Rd	+ 0.9
Breakfast Creek Rd	Montpelier Rd - ICB	+ 0.4
Kingsford Smith Drv	ICB - Crescent Rd	+ 0.3
	Crescent Rd - Riverview Tce	+ 0.3
	Racecourse Rd – Nudgee Rd	+ 0.3
	Nudgee Rd - Woonah Ave	+ 0.3
	Woonah Ave - Gateway Mwy	+ 0.3
East-west Arterial	Sandgate Rd - Widdop Rd	+ 0.1
	Widdop Rd - Gateway Mwy	+ 0.1

Table 76 demonstrates that spoil traffic would generally not increase average traffic noise levels on spoil routes by more than 0.5 dBA for relevent road corridors excluding O'Connell Tce and Montpelier Rd where the predicted increases are 1.2 and 0.9 dBA respectively. Changes in noise levels of 2 dBA or less are undetectable to the human ear and such changes are therefore usually considered to represent negligible additional impact.

Table 77 Effect of Construction Truck Movements on Traffic Noise Levels along Spoil Routes - $L_{A10(1hour)}$ (2am – 3am)

Roadway	Road Section	Change in $L_{A10(1hour)}$ Traffic Noise Level (dBA)
Lutwyche Rd	Norman St - Kedron Park Rd	+ 1.4
Bowen Bridge Rd	Site - O'Connell Tce	+ 1.2
O'Connell Tce	Bowen Bridge Rd - Hamilton Rd	+ 2.2
Montpelier Rd	Abbotsford Rd - Breakfast Creek Rd	+ 1.7
Breakfast Creek Rd	Montpelier Rd - ICB	+ 1.3
Kingsford Smith Drv	ICB - Crescent Rd	+ 1.3
	Crescent Rd - Riverview Tce	+ 1.3
	Racecourse Rd – Nudgee Rd	+ 1.0
	Nudgee Rd - Woonah Ave	+ 1.2
	Woonah Ave - Gateway Mwy	+ 1.4
East-west Arterial	Sandgate Rd - Widdop Rd	+ 0.0
	Widdop Rd - Gateway Mwy	+ 0.0

Table 77 demonstrates that spoil traffic would generally not increase average traffic noise levels during the quietest period of the night (2 am to 3 am) on spoil routes by more than 1.5 dBA for relevent road corridors excluding O'Connell Tce and Montpelier Rd where the predicted increases are 2.2 and 1.7 dBA respectively. Changes in noise levels of 2 dBA or less are undetectable to the human ear and such changes are therefore usually considered to represent negligible additional impact.

The changes in noise level documented in **Tables 76** and **77** are in addition to the changes in noise levels attributable to the NSBT Project and would therefore have a cumulative effect for residences when compared to the traffic currently using these roads (prior to either project).

The absolute maximum noise levels associated with vehicle pass-bys would not be altered by spoil removal, however, the frequency of such events would increase.

It is concluded that spoil traffic associated with the Airport Link project would not significantly change noise impacts on the noise environment of residential locations along the spoil routes that have been evaluated. Best practice noise management should be incorporated into management of spoil removal as required by the General Environmental Duty under the Environmental Protection Act 1994. These measures are discussed in the following section.

Mitigation

Recommended mitigation measures include:

- Best practice management over engine noise emissions by procurement and maintenance of a fleet that conforms to Australian Design Rule 28/01 for engine noise emissions, tested in accordance with the National Road Transport Commission document *Stationary Exhaust Noise Test Procedures for In-Service Motor Vehicles*.
- Adoption of airbag suspension throughout the fleet to minimise noise associated with empty trucks travelling over road irregularities.
- Satellite tracking and management of the position of the truck fleet to ensure that waiting queues are appropriate to space constraints, minimising noise from idling trucks.
- Negotiation with residents to discuss noise mitigation measures available such as property treatments (eg window and/or door upgrades and ventilation/air-conditioning) if determined to be required during detailed design or development of the Construction Noise and Vibration Management Plan.

9.4 Vibration Impacts

Fully loaded trucks travelling on properly maintained public roadways would not generate significant levels of ground vibration at buildings adjacent to spoil routes.

10 CONCLUSIONS

10.1 General

This analysis of noise and vibration impacts associated with the Airport Link project has been prepared based on a number of design parameters as supplied by the SKM Connell Wagner Joint Venture. The analysis is intended to provide a practical and specific understanding of the potential impacts, and the mitigation measures that may be necessary to mitigate any impacts during the construction phase.

It is anticipated that the construction methodology will evolve and be refined as detailed construction plans are developed for the project, with consequential implications for the design of mitigation strategies. It is therefore recommended that a detailed Construction Noise and Vibration Management Plan (or sub-plans) be prepared for the project as the detailed construction plans are developed.

10.2 Recommended Noise and Vibration Targets for Mitigation Design

The objective for the management of construction noise and vibration is to maintain a reasonable noise and vibration environment within sensitive properties for the duration of the project.

The following definitions of 'reasonable' construction noise and vibration are recommended for the purpose of guiding the development of detailed design of mitigation strategies for this project and to provide guidance for establishing a compliance framework for licensing purposes.

10.2.1 'Reasonable' Construction Noise

The recommended definition of 'reasonable' construction noise for the purpose of detailed development of mitigation strategies for this project is as follows:-

- For the daytime, adoption of "maximum" internal design levels advised in AS/NZS 2107:2000 as non-binding noise targets for steady and quasi-steady sources of construction noise assessed by a $L_{Aeq(15minute)}$ parameter (e.g. rock-drill, excavator, bulldozer), with a tolerance of 10 dB above these levels for the $L_{A10(15minute)}$ parameter to control non-steady sources of construction noise (e.g. rock-hammer, pile-driver).
- For long-term evening and night-time noise sources (e.g. ventilation plant, and 24 hour spoil handling systems), 'reasonable' noise levels would be:-
  - For transient noises, the recommended internal sleep disturbance criteria for L_{Amax} levels of 45dBA/50dBA as advised in NIAPSP (refer to **Section 2.2.1**);
  - for steady noises, "satisfactory"[19] internal design levels advised in AS/NZS 2107:2000, or imission levels not greater than the external background noise level (L_{A90}), whichever is lower, with imission assessed using an $L_{Aeq,adj}$[20] $_{(15minute)}$ parameter; and
  - These targets should be treated as binding.
- For temporary evening and night-time noise sources (e.g. regenerated noise during the underground pass-by of tunnelling machinery), 'reasonable' noise levels would be:-
  - For transient noises, the recommended internal sleep disturbance criteria for L_{Amax} levels of 45dBA/50dBA as advised in NIAPSP, and
  - For steady noises, "maximum" internal design levels advised in AS/NZS 2107:2000 assessed by an $L_{Aeq(15minute)}$ parameter; and
  - These targets should also be treated as binding.

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19 *"satisfactory" noise level recommendations in AS2107 are generally 10 dBA lower, or more stringent, than "maximum" recommendations.*

20 *Adjusted for intrusive tonal or impulsive characteristics in accordance with AS1055 Part 1.*

10.2.2 'Reasonable' Construction Vibration

The definition of 'reasonable' construction vibration for the purpose of detailed development of vibration mitigation strategies for this project is as follows:-

- For the daytime, statutory vibration limits for blasting, and the recommended vibration guide values for other extraction methods as summarised in **Table 5**, and a blasting limit of 4 mm/s vertical peak particle velocity at Amarina Nursing Home and Rosemount Hospital based on daytime transient vibration criteria for "low probability of reaction" derived from AS2670:1990.
- For night-time human comfort, recommended 'reasonable' vibration levels would be up to 0.5mm/s (peak).

10.3 Preparation and Operation of Worksites

Southern Worksite

The most significant potential noise issues at the southern worksite are initial daytime earthworks, and night-time tunnelling activities within the proposed acoustic enclosure, at the commencement of tunnelling. The highest impacts are expected at the residents south to the Federation Street, where maximum levels of noise from the works could result in some degree of interfere with normal indoor living (eg interference with passive listening, resting, and conversation) over several months. Noise mitigation should be further considered to maintain a reasonable noise environment at these residences.

Gympie Road East Worksite

Whilst noise from the site preparation may exceed the design goals, the prevailing level of traffic noise will provide a mask to the construction noise minimising any impacts. Noise from the tunnelling operations is expected to be below the design objectives and therefore not result in any significant impact.

Gympie Road West Worksite

The most significant potential noise issues at the Gympie Road West worksite are daytime earthworks and to a much lesser extent, the night-time spoil removal inside of the proposed acoustic enclosure. At the adjoining residences adjacent to the site (on the western side), the noise from rockbreakers and other plant items will significantly exceed the design goal and is likely to result in significant acoustical impacts (eg interference with passive listening, resting and conversation) given the construction noise levels are noticeably above the prevailing levels of road traffic noise. Noise mitigation should be further examined to maintain a reasonable noise environment at these residential locations.

Sandgate Road Worksite

The most significant potential noise issues at the Sandgate Road worksite is the daytime earthworks. At the adjoining residences in Kalinga St and residents immediately south of the worksite, the noise from rockbreakers and other plant items will significantly exceed the design goal and is likely to result in significant acoustical impacts (eg interference with passive listening, resting and conversation) given the construction noise levels are noticeably above the prevailing levels of road traffic noise. Noise mitigation should be further examined to maintain a reasonable noise environment at these residential locations.

Noise Mitigation for Worksites

The following noise control measures are recommended for noise mitigation at worksites:-

- Provide advance notification of the time and duration of earthworks.

- Install (temporary) noise screens to reduce earthmoving noise during “Site Preparation” at property boundaries of residences south of Federation St. These screens need to be on property boundaries beyond the worksite to be effective and a minimum of 5 m in height as the adjacent buildings are all double storeys. As an alternative, consideration could be given to upgrading the façade windows, and provision of airconditioning to the affected residents, where it proves cost effective and acceptable to the community.
- Use localised noise screens for particularly noisy operations such as rockdrilling and rockbreaking.
- Select plant and processes which minimise source noise levels
- Construction of a ‘high’ performance acoustic enclosure over the portal and stockpile area for the Southern and Gympie Road West worksites, with indicative acoustic performance as shown in **Table 28** (subject to detailed design).
- Construction of noise screens along worksite boundaries to reduce earthmoving (along the property boundary common with the Gympie Road West works) noise at adjoining residences.
    - Noise screens would need to be a minimum of 5 m in height as most residential dwellings in the area are double storeys;
    - At the southern end of the Gympie Rd (West) worksite, it is noted that there are 4 residential buildings that are 3 storeys, and hence a relatively high noise barrier would be required. A solution to providing noise mitigation may be to provide architectural treatment to the upper levels, as it may prove more cost effective, provided it is consistent with current policy and favoured by the residents.
- Construction of a ‘medium’ performance acoustic enclosure over the portal and stockpile area for the Gympie Road East and Sandgate worksites, with indicative acoustic performance as shown in **Table 28** (subject to detailed design).
- Undertake a further examination of Kedron High School and the office building adjacent to the southern side of the Gympie Rd West worksite, to confirm whether the windows are normally open (as assumed) or if the buildings are air conditioned, and hence the windows are normally closed.
- Design of continuously operating ventilation plant and any other plant that operates at night to meet ‘reasonable’ night-time noise objectives as defined in **Section 2.2.2**.
- For residences nearest and facing the Southern, Gympie Rd and Sandgate Rd worksites, assist owners of properties to temporarily upgrade the acoustical insulation and ventilation of rooms facing the worksite to mitigate construction noise during site preparation.
- Monitor noise levels from variable noise sources (e.g. rock-drill noise at the tunnel entrance which will diminish as tunnelling progresses) to ensure that such activities meet the ‘reasonable’ levels as defined in **Section 2.2.2.**

10.4 Surface Construction of Roadways

Southern Connections

The daytime construction of the elevated structures adjacent to the Mews Apartments is predicted to result in significant exceedances of the design goal and the noise level likely to be intrusive for the building occupants. This level of intrusion could interfere with normal indoor living (eg interference with passive listening, resting and conversation). Consequently, the following noise mitigation is recommended for further consideration:

- Advance notification of the time and duration of construction.
- Plant selection to consider noise emissions;
- Location of plant items to maximise distance to residences.

There are no predicted exceedances of the noise goals for the night-time widening of the ICB underpass due primarily to the large offset distance and the higher building façade nominated for the Mews Apartments.

Gympie Road Connections

The daytime construction of the elevated structures and cut and cover tunnelling works for residences directly adjacent to Gympie Rd and Lutwyche Rd are likely to be found intrusive (19-23 dBA above the noise goals). This level of intrusion could interfere with normal indoor living (eg interference with passive listening, resting and conversation). Consequently, noise mitigation should be examined so as to maintain a reasonable noise environment at these residences.

The night-time construction of the elevated structures and cut and cover tunnelling works for residences directly adjacent to Gympie Rd and Lutwyche Rd would likely be found to be intrusive (24-26 dBA above the L_{Aeq} noise goals). This level of intrusion would interfere with normal indoor living (eg interference with passive listening, resting and conversation) and could cause sleep disturbance. Consequently, it is strongly recommended that noise mitigation should be examined so as to maintain a reasonable noise environment at these residences.

The following mitigation measures are recommended for further consideration guided by the 'reasonable' noise objectives for construction noise:-

- Construction of noise screens along the eastern boundary of the construction site north of Kedron Brook, where direct access to Gympie Rd is not required, to reduce construction noise on the eastern side of Gympie Rd due to elevated structure construction.
- Construction of noise screens along the western boundary of the construction site south of Kedron Brook, where direct access to Lutwyche Rd is not required, to reduce construction noise on the western side of Lutwyche Rd due to cut and cover construction
- Advance notification of the time and duration of earthworks.
- If required, assist owners of properties along Gympie Rd and Lutwyche Rd to temporarily upgrade the acoustical insulation and ventilation of rooms facing the worksite to address noise during both road widening/regrading and trough excavation.
- Advance notification of night roadworks.

Sandgate Rd Connections

The highest potential for impacts at residential locations occurs during the construction of the open trough and cut and cover construction, where the construction noise levels are predicted to significantly exceed the noise goals by up to 28 dBA. This level of construction noise would likely be found to be intrusive and result in an acoustic impact on the residences (eg interference with passive listening, resting and conversation).

The following noise control measures are recommended for mitigation of noise and vibration around roadworks for the Sandgate Rd connections, guided by the 'reasonable' noise objectives:

- Advance notification of the time and duration of works, especially any night works.
- Select construction processes and plant to minimise construction noise
- Assist owners of properties nearest the construction site to temporarily upgrade the acoustical insulation and ventilation of rooms facing the construction area.
- Construction of noise screens along the southern and western boundaries of the construction site west of Sandgate Rd.
- Early construction of the operational noise barrier south of the East-west Arterial to protect residences in Wongara St during the construction period.

Vibration

To minimise vibration impacts for all worksites, it is recommended:

- Specific advance notification of any impact piling activities or night-time road construction activities.
- Monitoring of vibration on structures due to vibratory rolling that occurs within a nominal distance of 25 m.

10.5 Underground Tunnelling Between Portals

Roadheading

Anticipated vibration levels generated by roadheading are sufficiently low to be imperceptible in buildings along the whole tunnel alignment. No on-going vibration mitigation measures or impact response management procedures are anticipated to be necessary for this type of tunnelling. However, noise and vibration monitoring should be undertaken at the commencement of road header tunnelling to confirm that the source data utilised for this assessment is applicable to this project.

Blasting

Only daytime blasting is envisaged for the project. Blasting generally results in short, strongly noticeable vibrations lasting one to two seconds. The normal mitigation method in relation to human impacts is to give clear and concise pre-notification to all persons in the affected area.

The most sensitive receptors in terms of human comfort during blasting is Rosemount Hospital and Amarina Nursing Home, both of which provide palliative and dementia care. The mitigation options at these locations are careful notification, choice of time of day, and blast design to control vibration levels. It is suggested that design vibration levels for this receptor location should be no more than 4 mm/s vertical peak particle velocity, based on daytime transient vibration criteria for “low probability of reaction” derived from AS2670:1990.

Careful blast design is recommended to mitigate against building impacts, and if necessary, using gradually increasing trial blasts to establish safe design parameters. It is a requirement of Brisbane City Council to conduct pre- and post-blasting Building Condition Surveys where it is considered there may be potential for cosmetic building damage.

Earth Pressure Balancing type Tunnel Boring

It is anticipated that Earth Pressure Balancing type TBM vibrations and regenerated noise will generally not be noticeable in buildings along the tunnel path where the building foundations are at ground level. However, exceedences of the noise (45 dBA) and vibration (0.5 mm/s) goals may occur around the eastern portal (between Park Ave and Jackson St) due to the shallower tunnel depths where piles have been placed under building foundations. Exceedences of the vibration goal (0.5 mm/s) may occur around the western portal (between Gorman St and Roseleigh St) again due to the shallower tunnel depths and only where piles have been utilised.

It is not expected that exceedences of either (noise or vibration) goal would occur between Roseleigh St and Park Ave even if piles have been utilised due to the increase tunnel depth.

Noise and vibration monitoring should be undertaken at the commencement of EPB tunnelling to confirm that the source data utilised for this assessment is applicable to this project.

Sensitive Building Contents

For this project, a Building Sensitivity Study is recommended for the Rosemount Hospital. The Building Sensitivity Study should be conducted prior to construction activities to establish the sensitivity of the building and contents in greater detail.

Recommended Mitigation for Tunnelling Vibration and Regenerated Noise

The following impact management and mitigation strategies are recommended to minimise the effects of tunnelling vibration and regenerated noise:

- Comprehensive advance notice of intended tunnelling activities in the localities near the tunnel alignment.
- Noise and vibration monitoring should be undertaken at the commencement of both road header and EPB tunnelling to confirm that the source data utilised for this assessment is applicable to this project
- Conduct night-time tunnelling subject to compliance with 'reasonable' night-time vibration and regenerated noise levels as defined in **Section** Error! Reference source not found..
- If blasting is required in the vicinity of Amarina Nursing Home or Rosemount Hospital, consideration should be given to the adoption of a lower 'reasonable' blast vibration limit of 4 mm/s.
- Conduct building-specific vibration sensitivity investigations for the Rosemount Hospital to establish 'reasonable' vibration levels for these facilities prior to finalisation of a management plan for construction vibration.
- Conduct pre- and post-blasting Building Condition Surveys in accordance with Brisbane City Council requirements where it is considered there may be potential for cosmetic (superficial) building damage from drill-and-blast methods.

10.6 Construction Traffic

Spoil traffic would generally not increase average 18-hour (day and evening) traffic noise levels on spoil routes by more than about 0.5 dBA along major road corridors except for O'Connel Tce and Montpellier Rd where increases would be below 2 dBA. Neither of these increases would represent a significant impact.

Night-time spoil traffic would generally not increase traffic noise levels in the quietest hour (2 am to 3 am) on spoil routes by more than about 2 dBA along major road corridors except for O'Connell Tce and Montpeleir Rd where the increases would be around 5 and 3 dBA respectively. However, there are only a few residential locations along this section of the haul route and these residences are located in predominantly in commercial/industrial areas. It is recommended that noise mitigation measures be negotiated with the individual property owners on a case by case basis.

Recommended mitigation measures include:

- Best practice management over engine noise emissions by procurement and maintenance of a fleet that conforms to Australian Design Rule 28/01 for engine noise emissions, tested in accordance with the National Road Transport Commission document *Stationary Exhaust Noise Test Procedures for In-Service Motor Vehicles*.
- Adoption of airbag suspension throughout the fleet to minimise noise associated with empty trucks travelling over road irregularities.
- Satellite tracking and management of the position of the truck fleet to ensure that waiting queues are appropriate to space constraints, minimising noise from idling trucks.

- Negotiation with residents along O'Connell Tce and Montpelier Rd to discuss noise mitigation measures available. Property treatments could include window and/or door upgrades and ventilation/airconditioning.

Location	Address	Description	Photographs
1	30 Wongara Street, Clayfield	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes facade reflection facing East-West Arterial Road (behind noise barriers)	
2	86 Alma St, Clayfield	Rear yard, detached dwelling at 86 Alma Road, Clayfield	
3	27 Parkland Street, Nundah	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	
4	72 Kalinga Street, Clayfield	Rear yard, northern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	

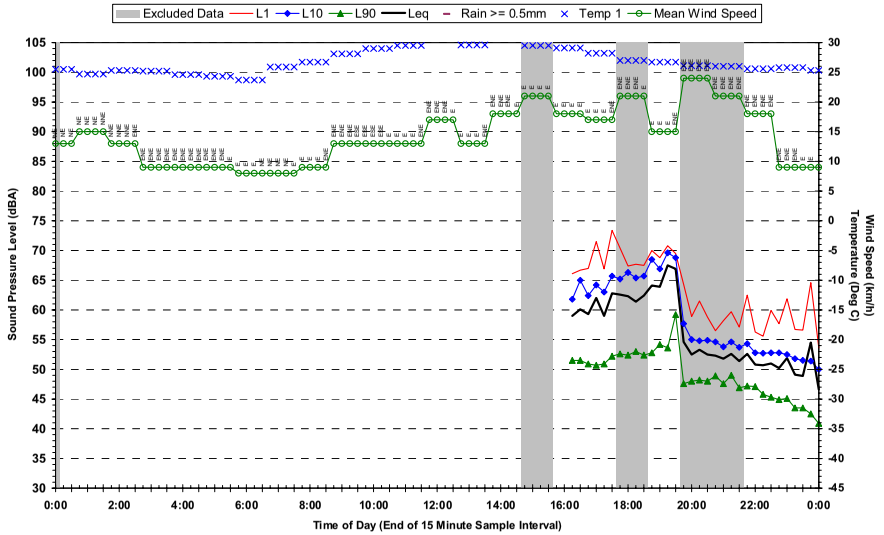
Location	Address	Description	Photographs
5	34 Park Road, Kedron Kedron State High School	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	
6	20 Perry Street, Lutwyche	Front yard, includes facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	
7	30 Colton Avenue, Lutwyche	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	
8	12 Park Terrace, Kedron	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	

Locations	Address	Description	Photographs
9	17 Roblane Street, Windsor	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	
10	7 Roblane Street, Windsor	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	
11	46 Gallway Street, Windsor	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	
12	49 Earle Street, Windsor	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	

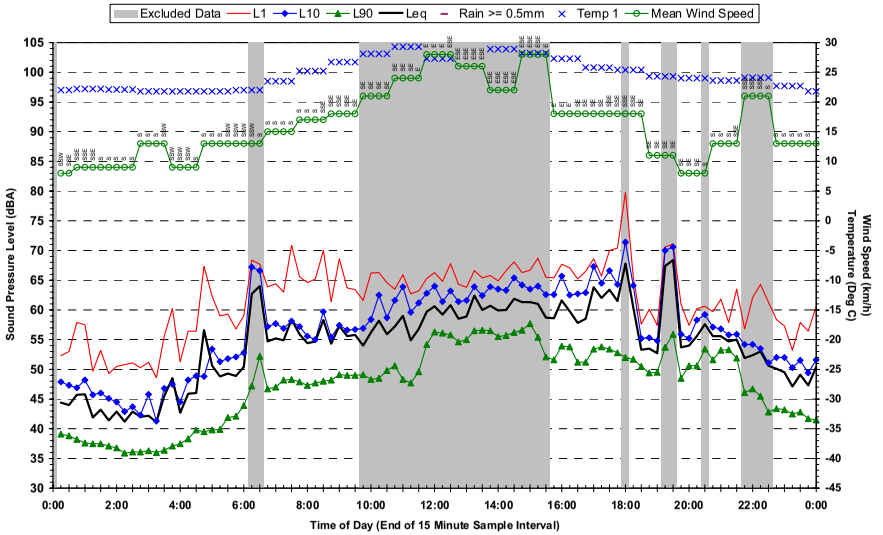
Locations	Address	Description	Photographs
13	Royal Women's Hospital	Level 5 rooftop, James Demacy Building,, Royal Brisbane Hospital, facing Bowen Bridge Road	
14	62 Victoria Street, Windsor	Front yard, detached dwelling at 62 Victoria Street, Windsor	
15	42 Hooker Street, Windsor	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	
16	Nursing Home, 26 Palmer Street, Windsor	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	

17	7 Lamington Avenue, Lutwyche	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	
18	16 East Street, Lutwyche	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	

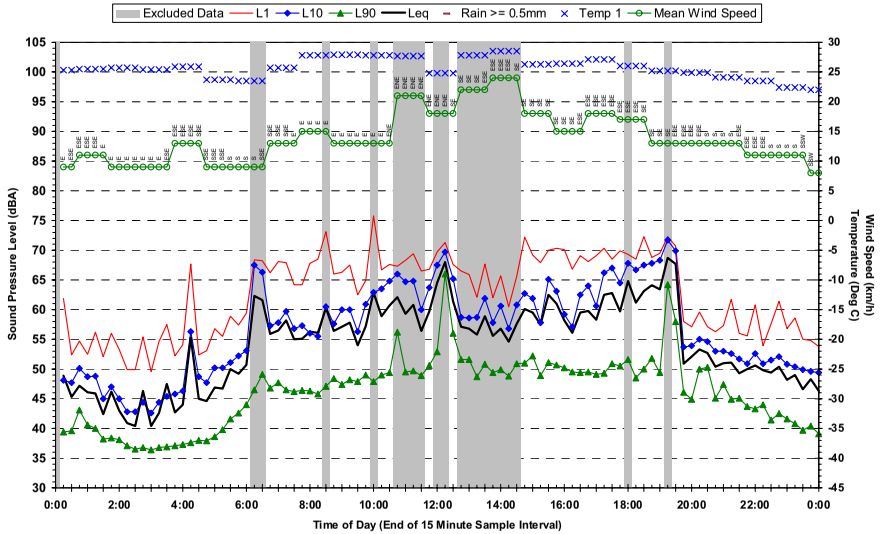
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Monday 20 February 2006



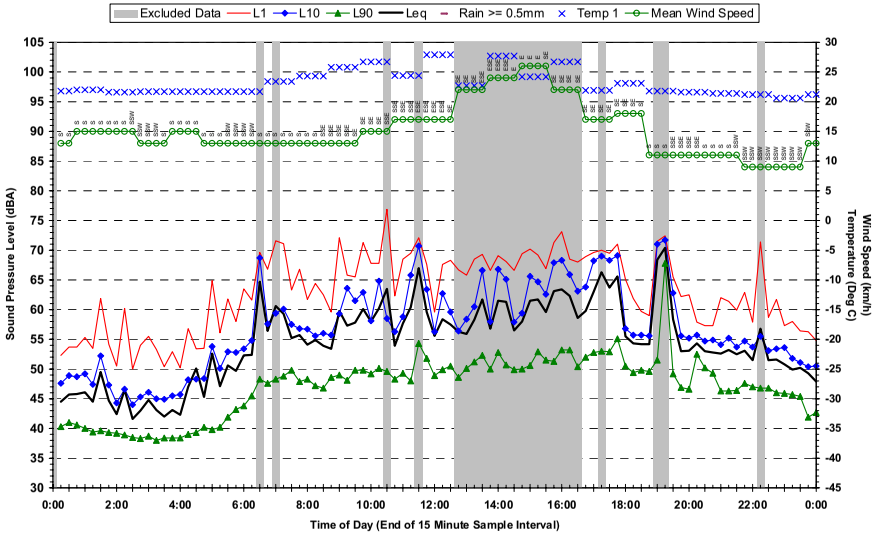
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Wednesday 22 February 2006



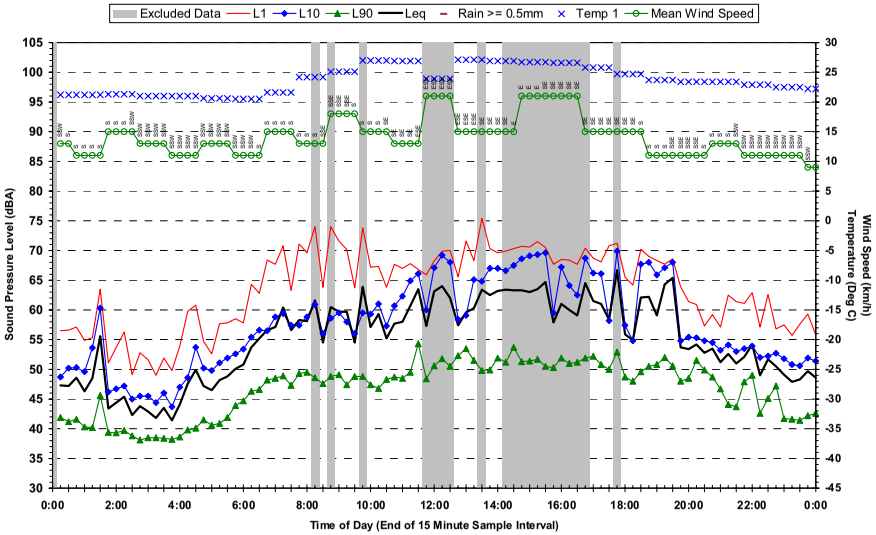
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Tuesday 21 February 2006



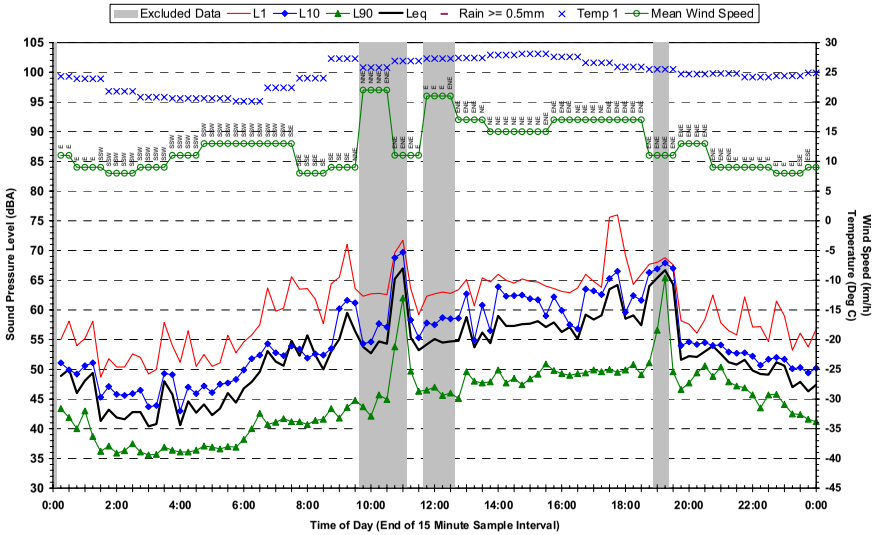
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Thursday 23 February 2006



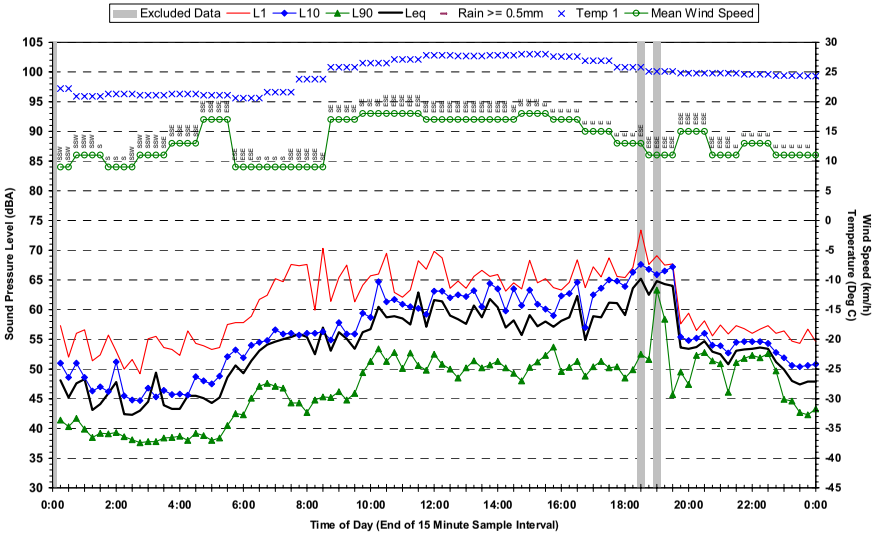
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Friday 24 February 2006



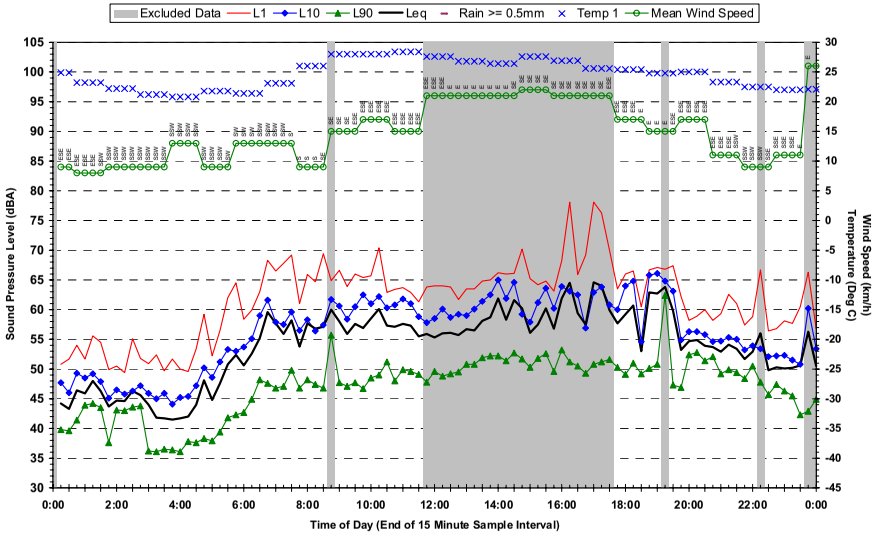
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Sunday 26 February 2006

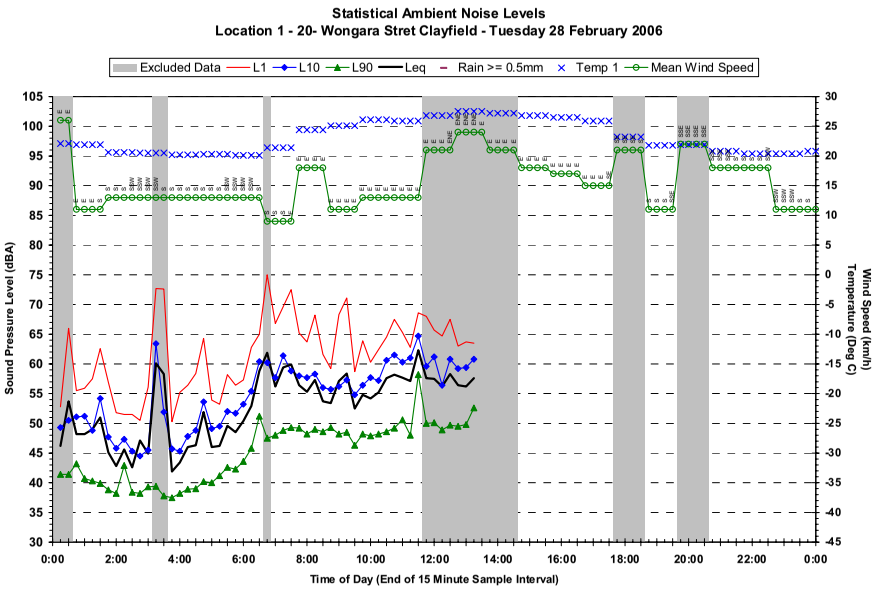


Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Saturday 25 February 2006

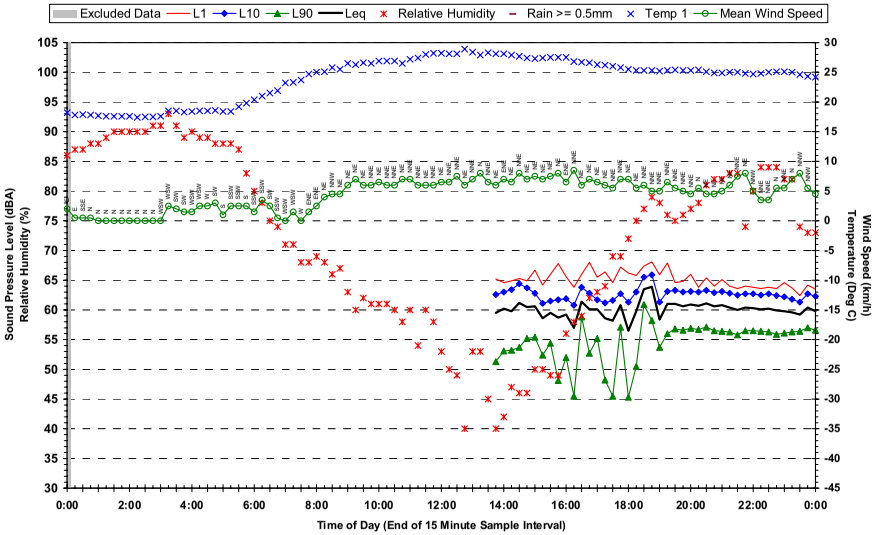


Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Monday 27 February 2006

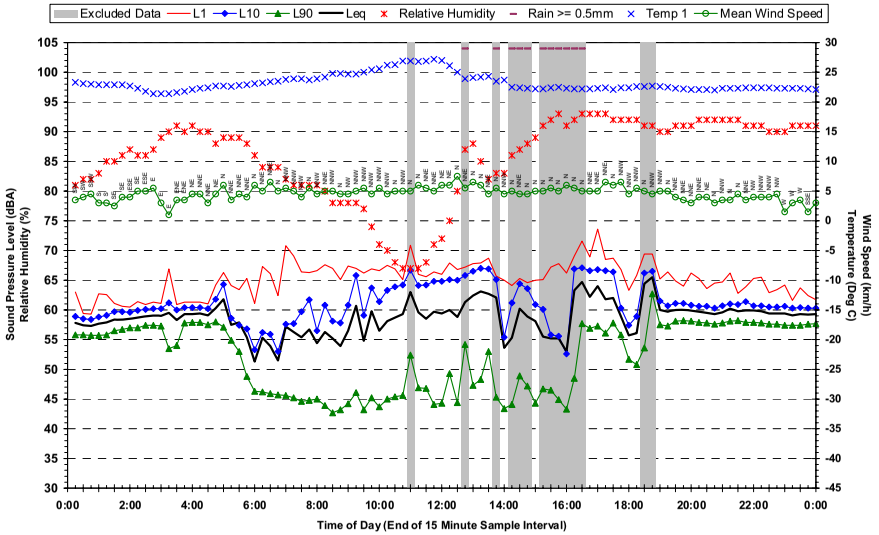



Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Tuesday 28 February 2006
Excluded Data
L1
L10
L90
Leq
Rain >= 0.5mm
Temp 1
Mean Wind Speed
Sound Pressure Level (dBA)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

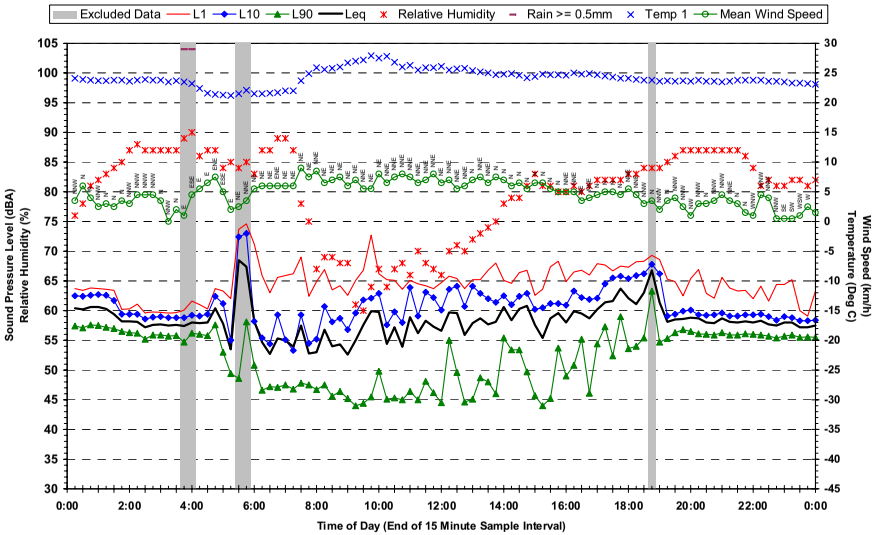
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Wednesday 30 November 2005



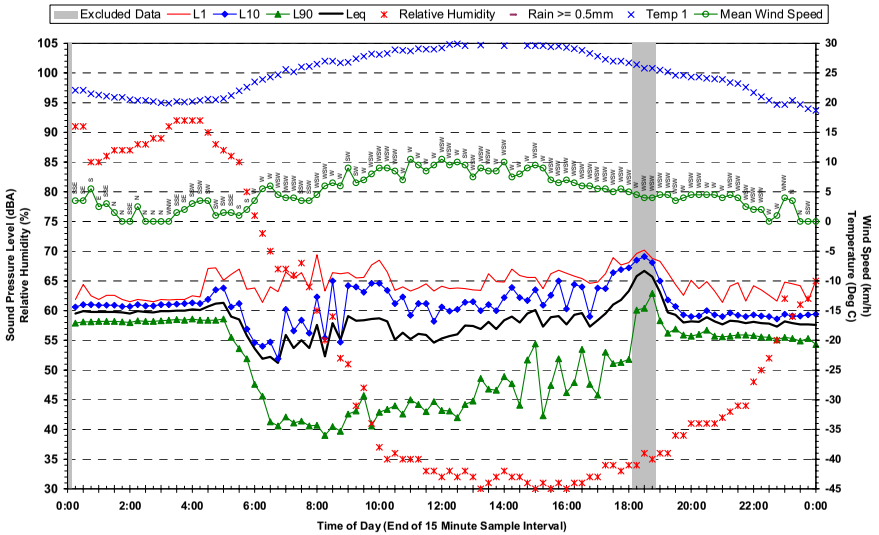
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Friday 2 December 2005



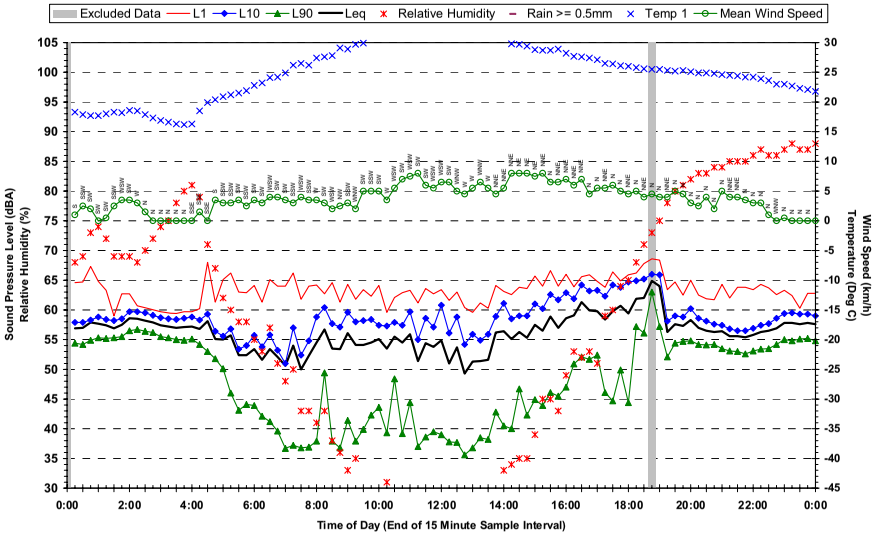
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Thursday 1 December 2005



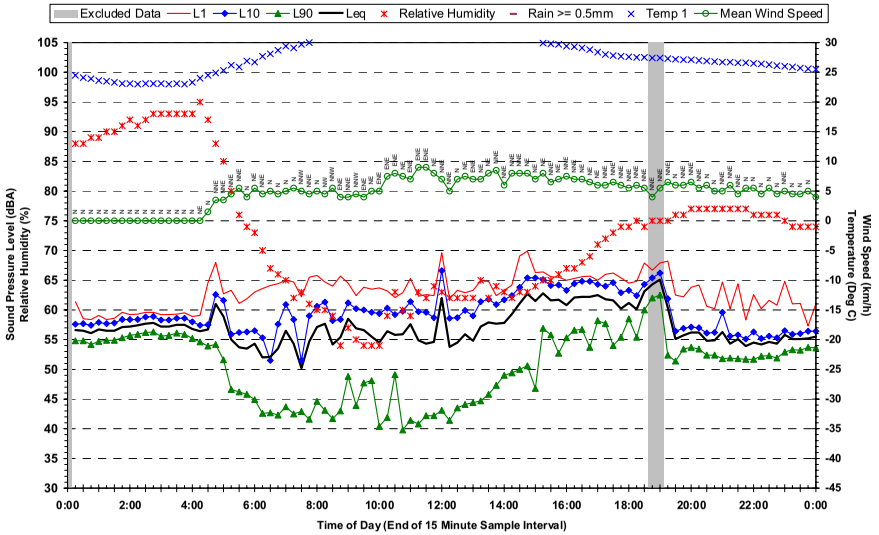
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Saturday 3 December 2005



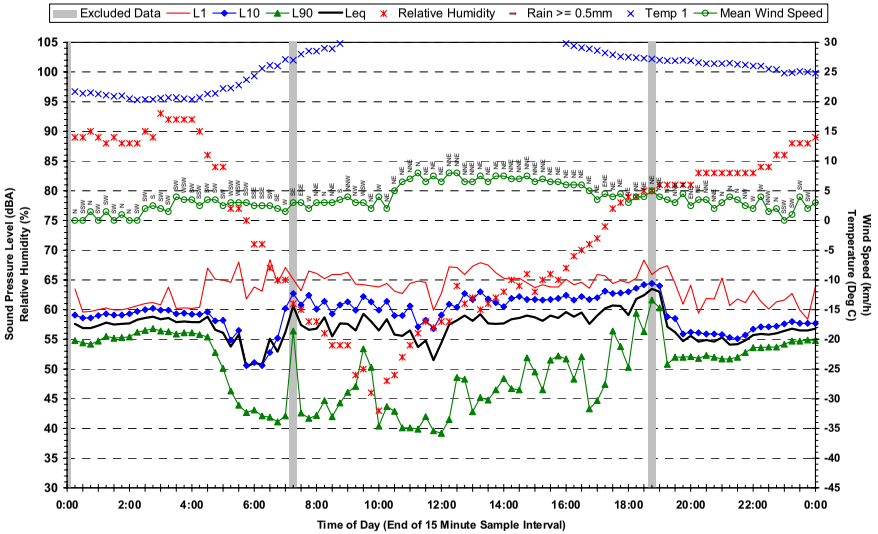
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Sunday 4 December 2005



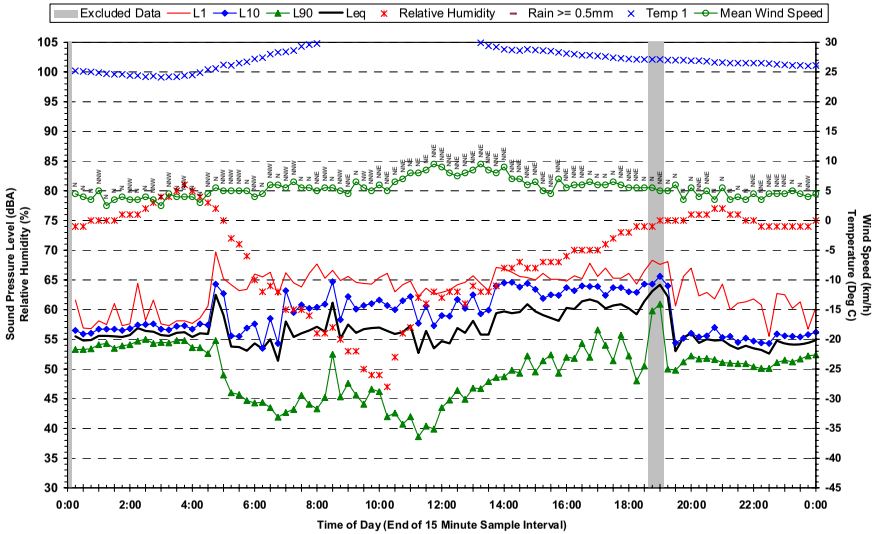
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Tuesday 6 December 2005



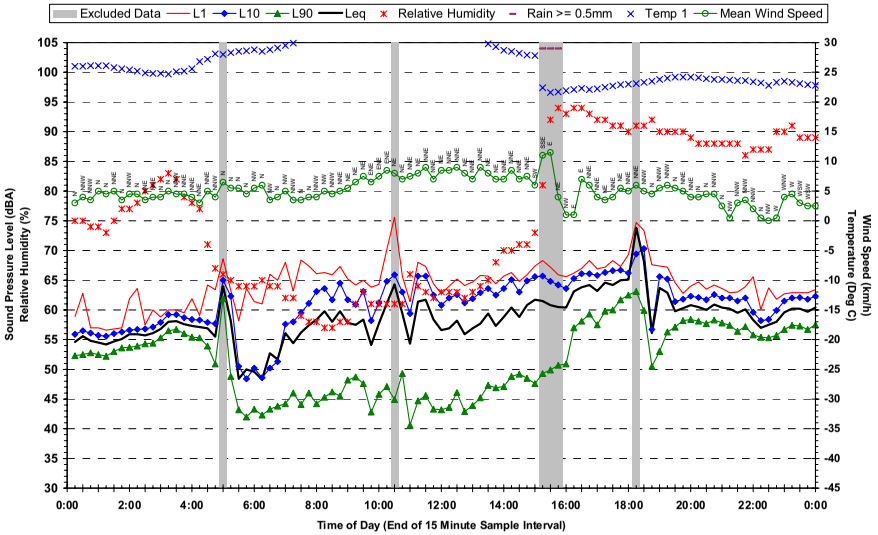
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Monday 5 December 2005



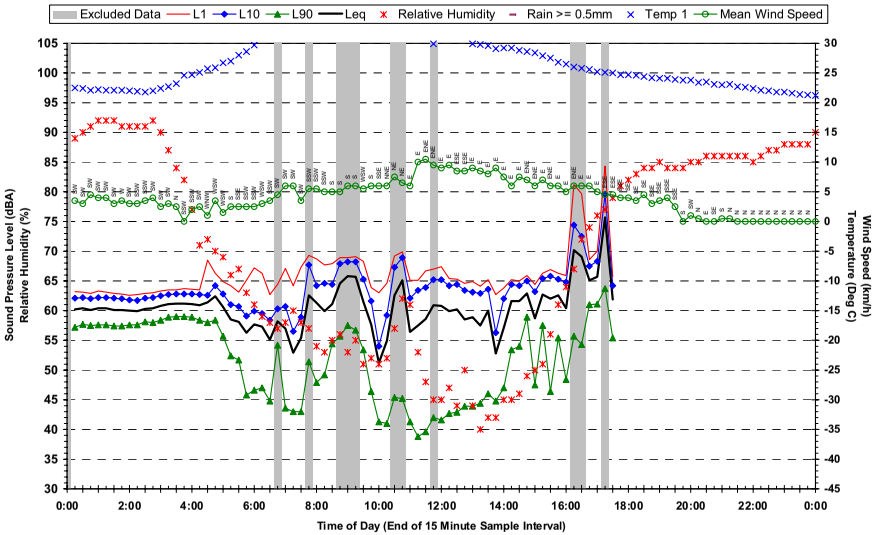
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Wednesday 7 December 2005



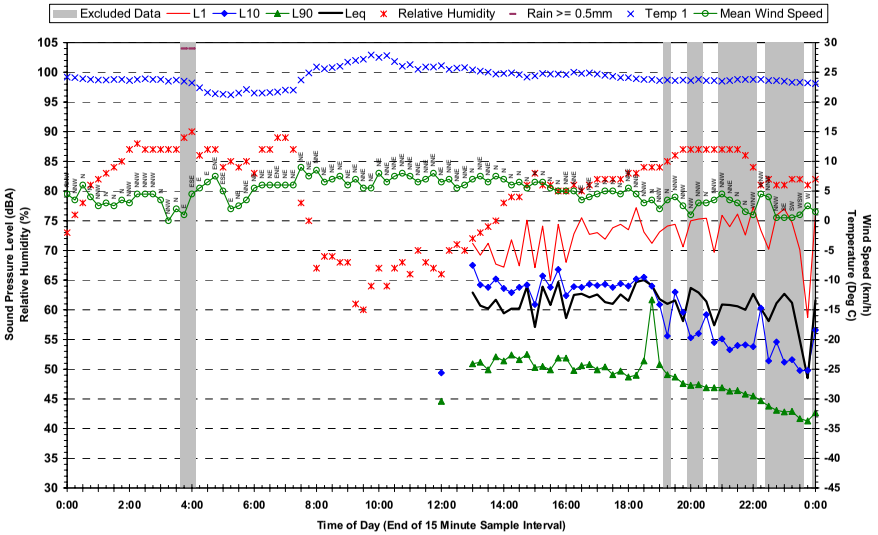
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Thursday 8 December 2005



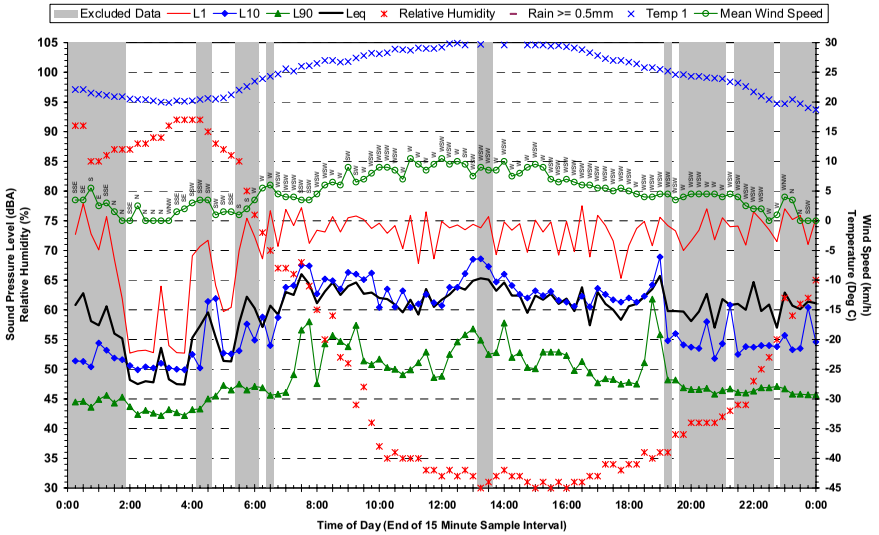
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Friday 9 December 2005



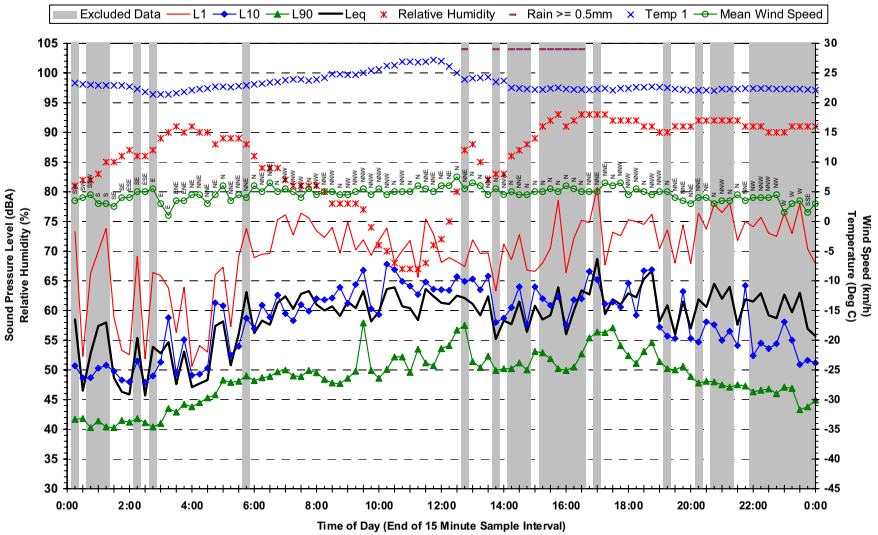
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Thursday 1 December 2005



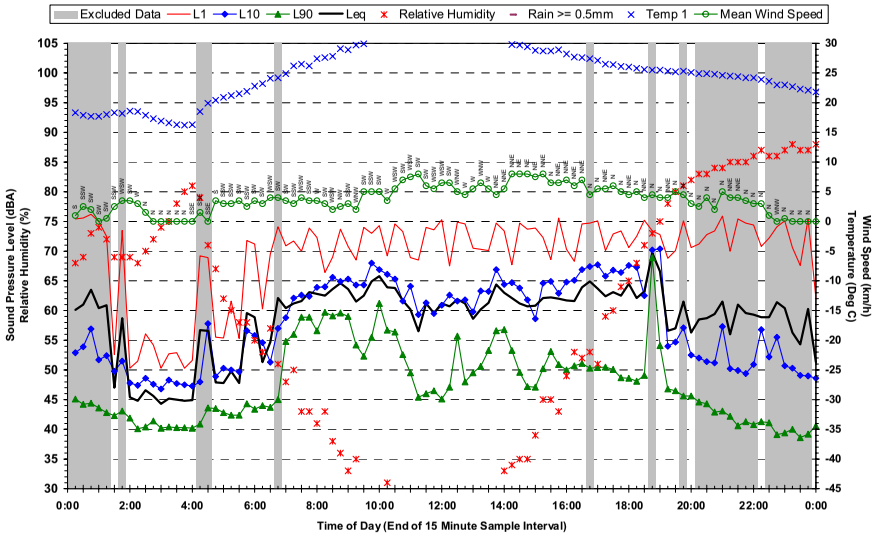
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Saturday 3 December 2005



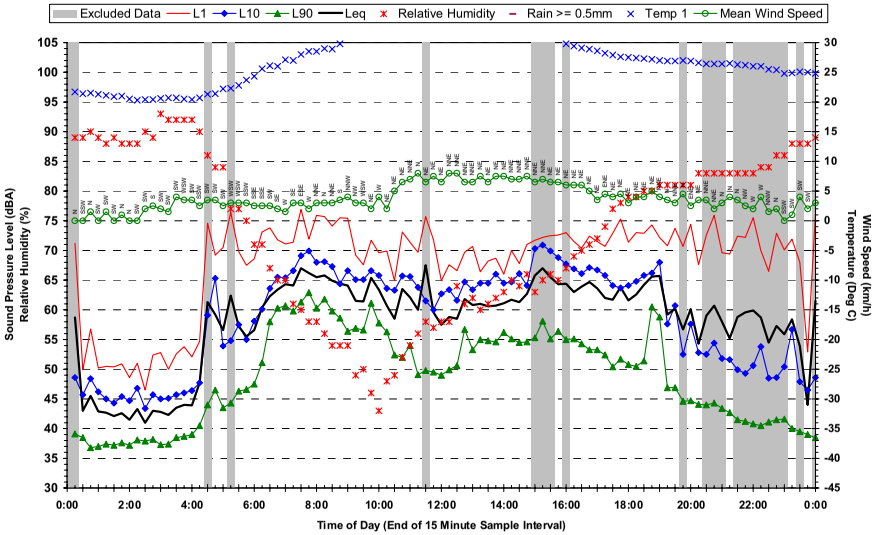
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Friday 2 December 2005



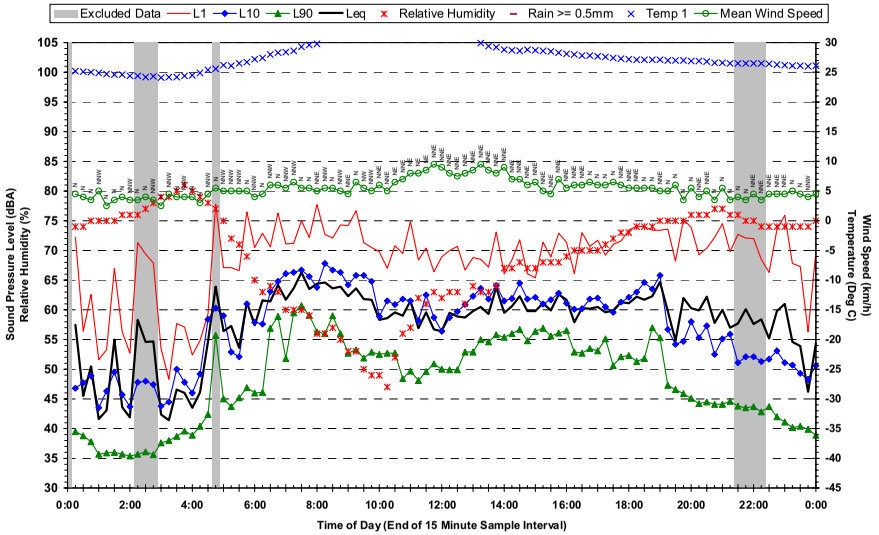
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Sunday 4 December 2005



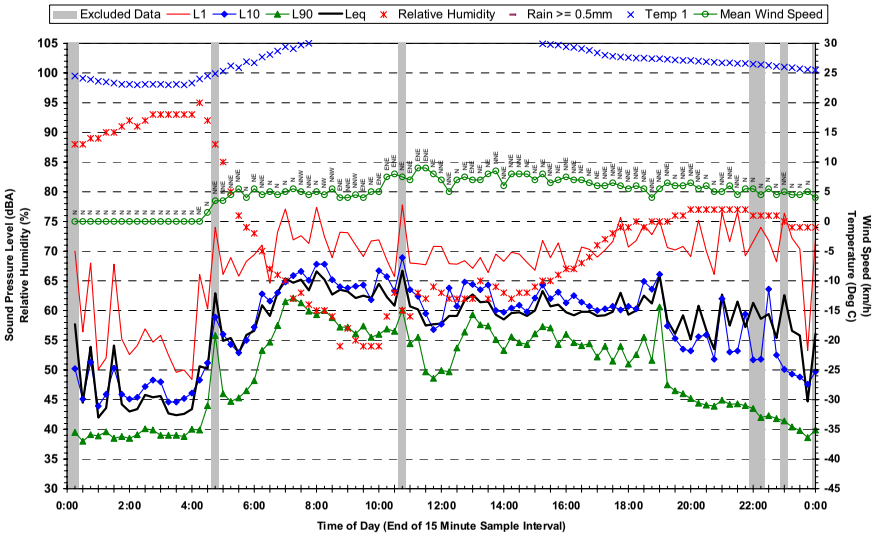
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Monday 5 December 2005



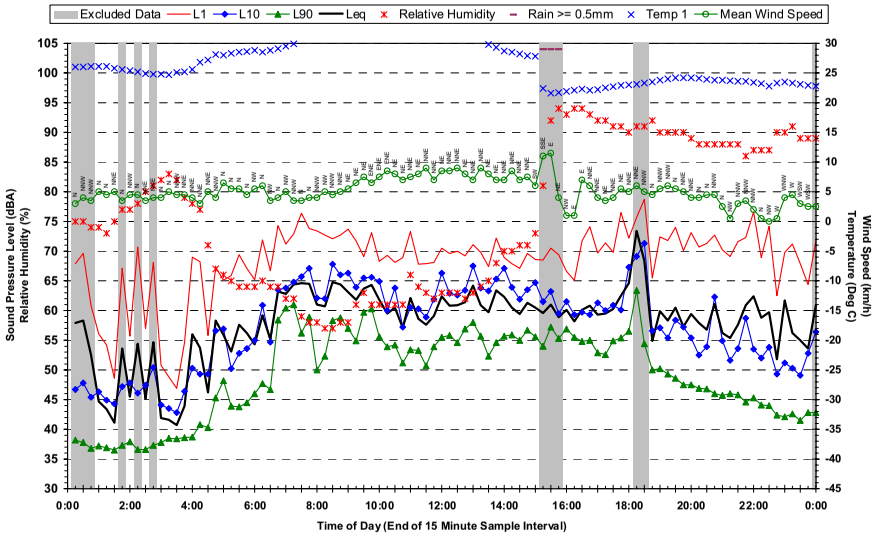
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Wednesday 7 December 2005

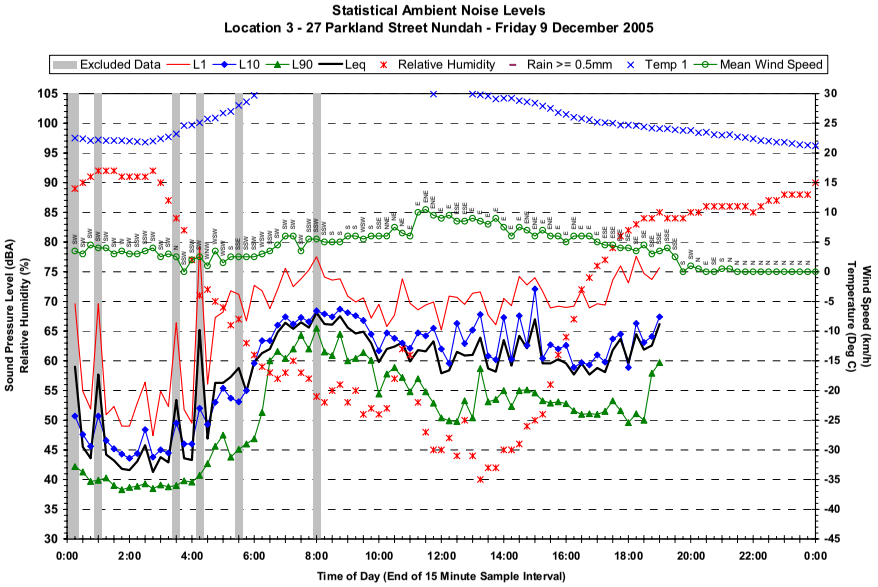


Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Tuesday 6 December 2005

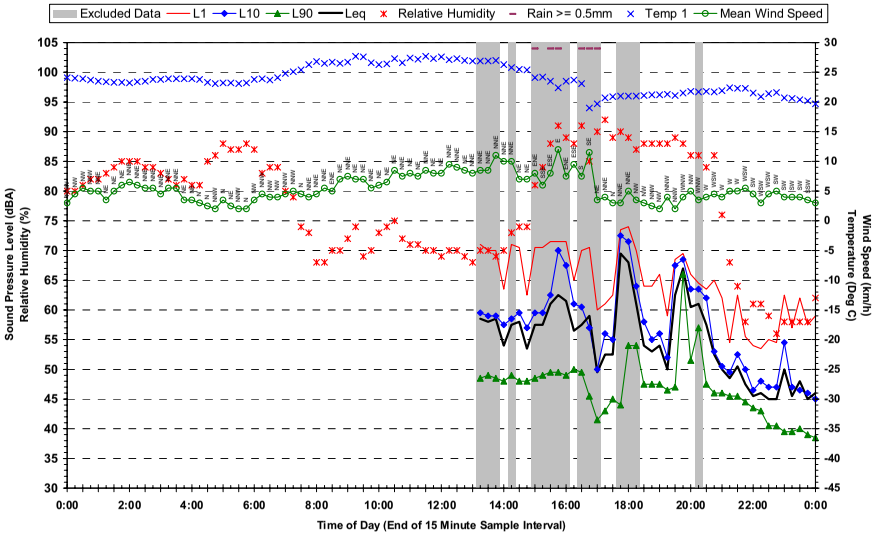


Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Thursday 8 December 2005

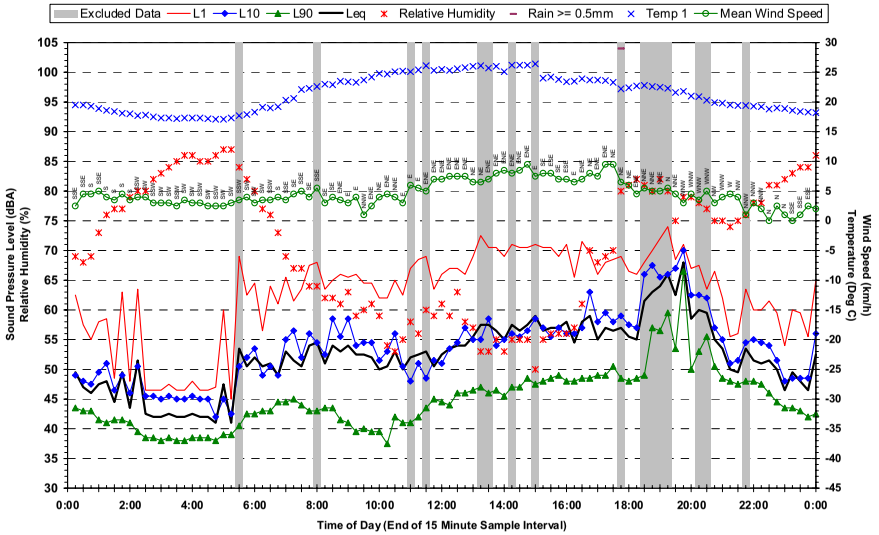



Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Friday 9 December 2005
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.5mm
Temp 1
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

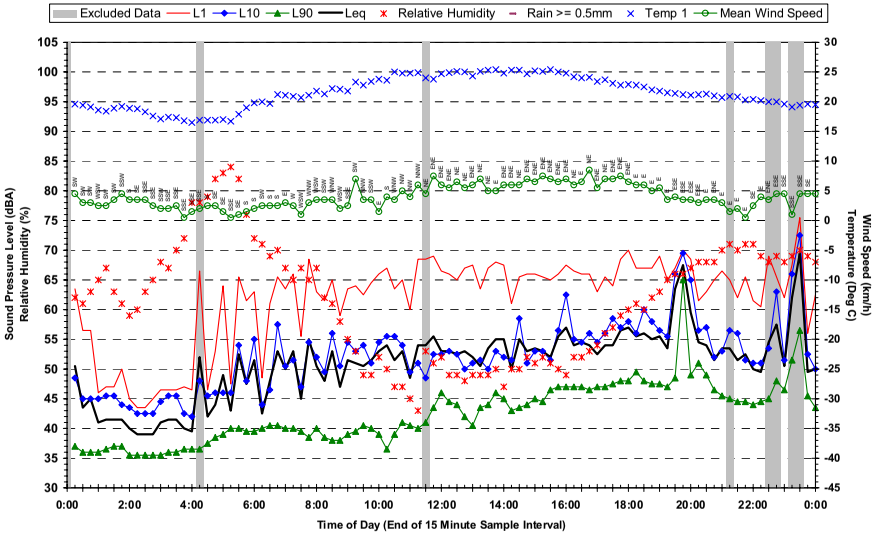
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Sunday 27 November 2005



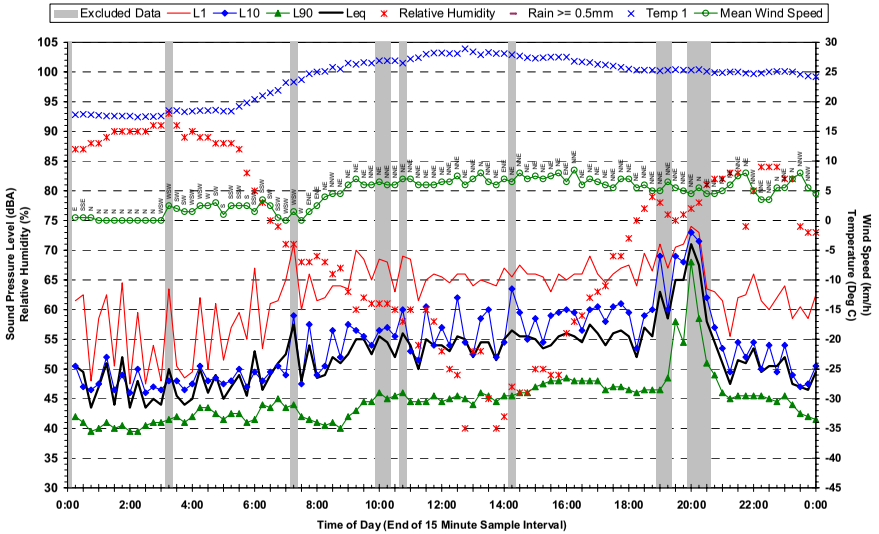
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Tuesday 29 November 2005



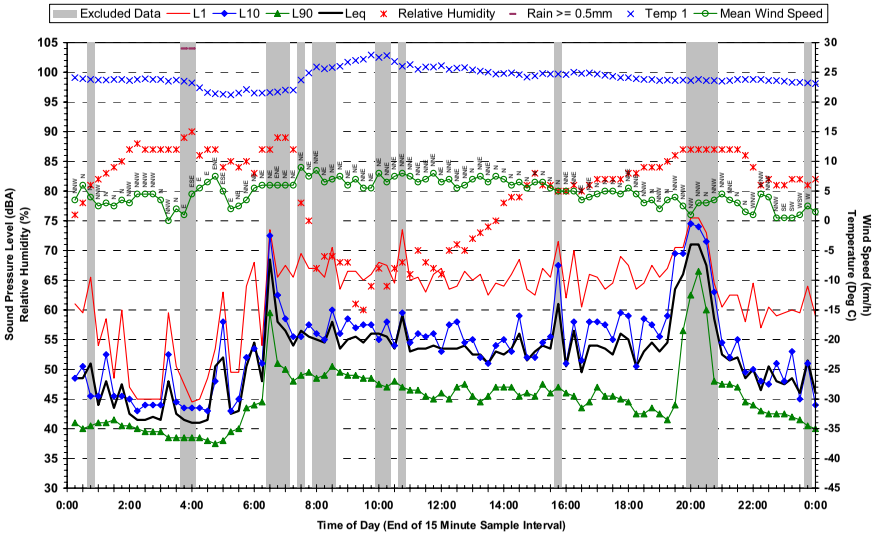
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Monday 28 November 2005



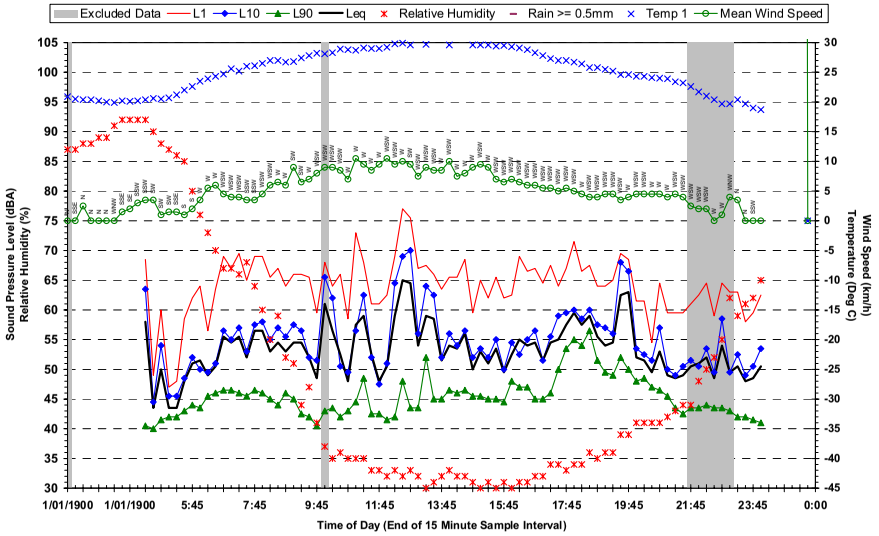
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Wednesday 30 November 2005



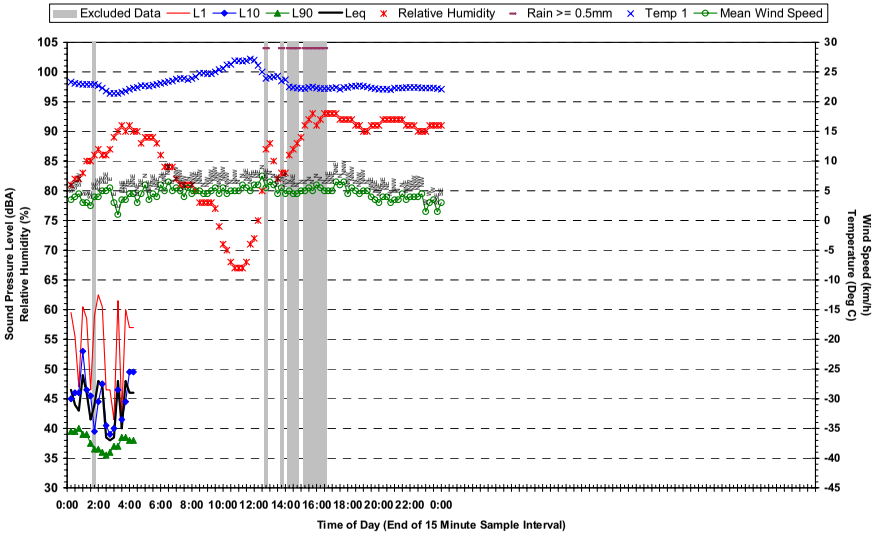
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Thursday 1 December 2005



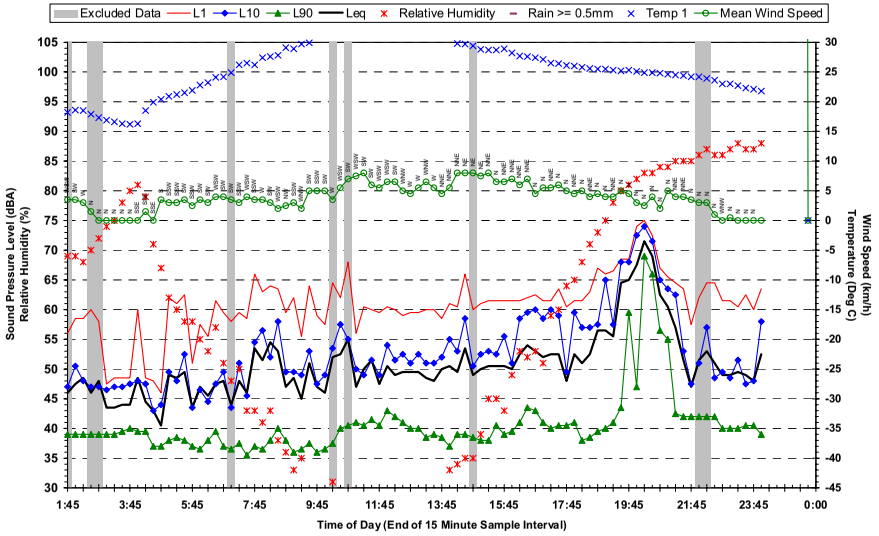
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Saturday 3 December 2005



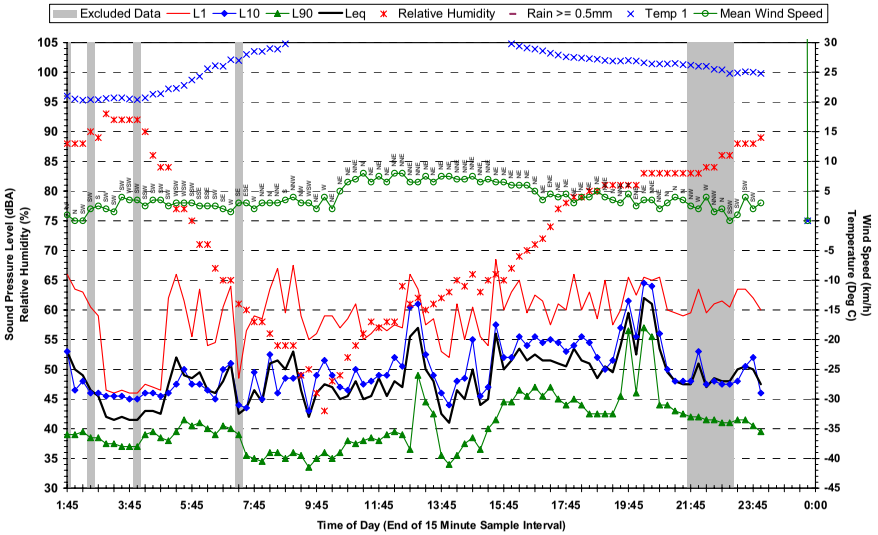
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Friday 2 December 2005



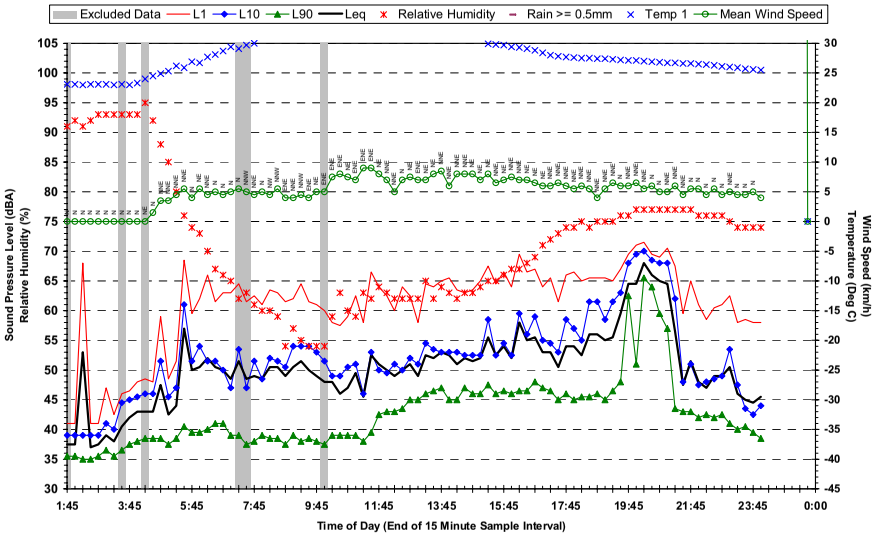
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Sunday 4 December 2005



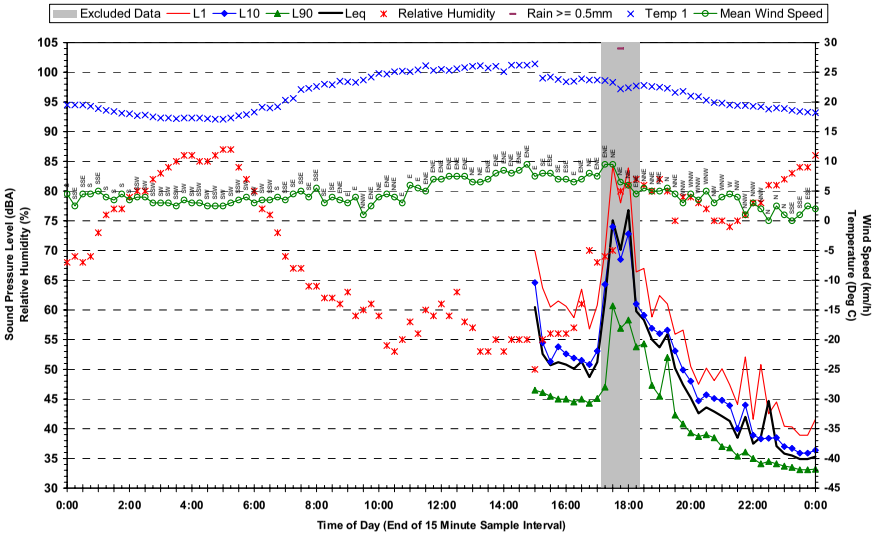
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Monday 5 December 2005



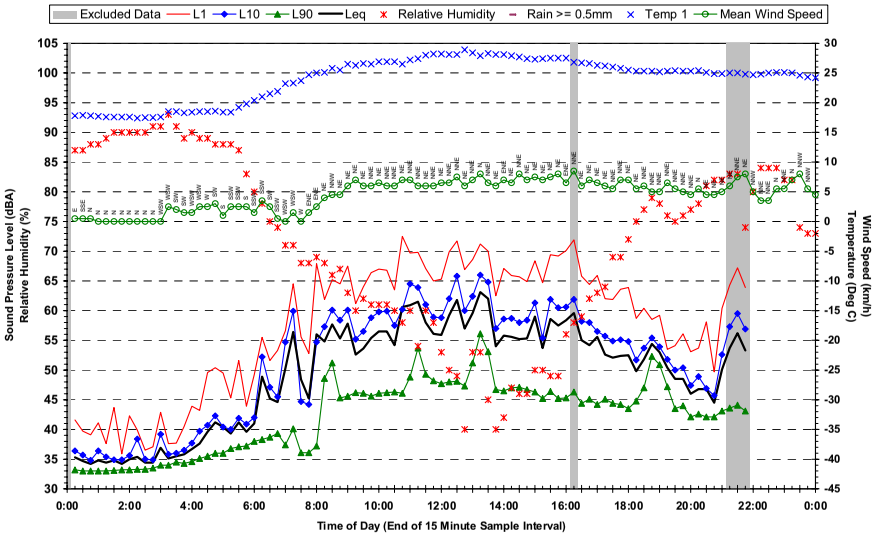
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Tuesday 6 December 2005



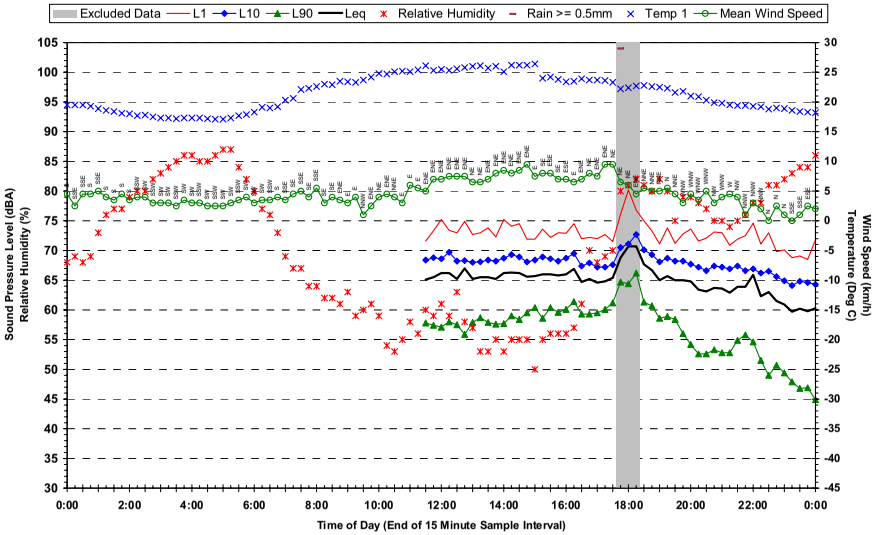
Statistical Ambient Noise Levels
Location 5 - Kedron State High School - Tuesday 29 November 2005



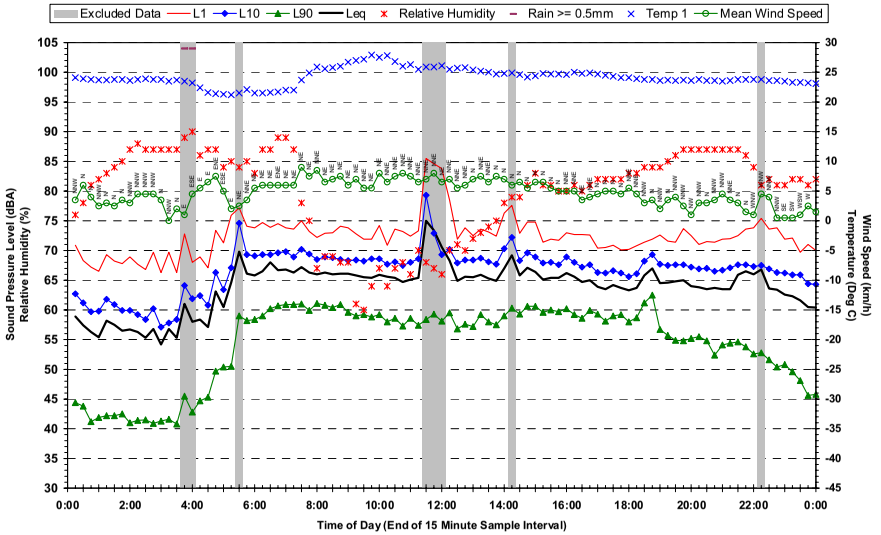
Statistical Ambient Noise Levels
Location 5 - Kedron State High School - Wednesday 30 November 2005



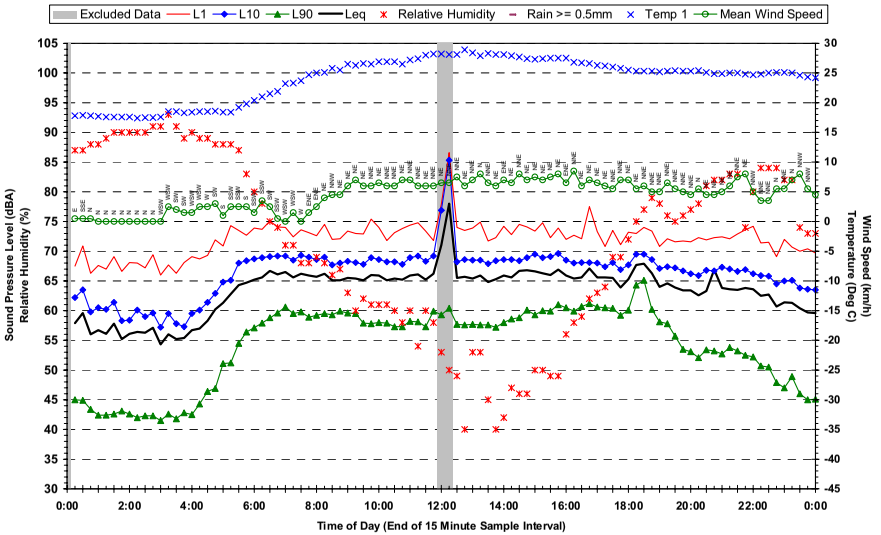
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Tuesday 29 November 2005



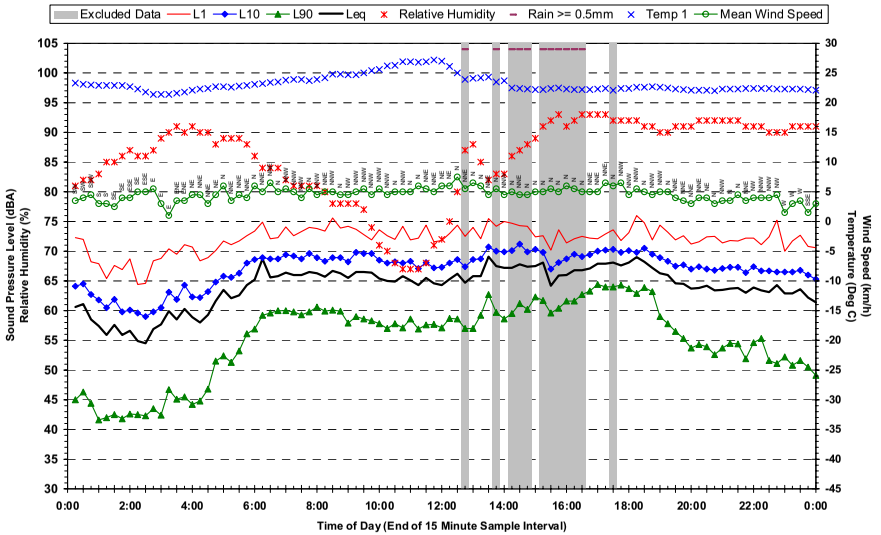
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Thursday 1 December 2005



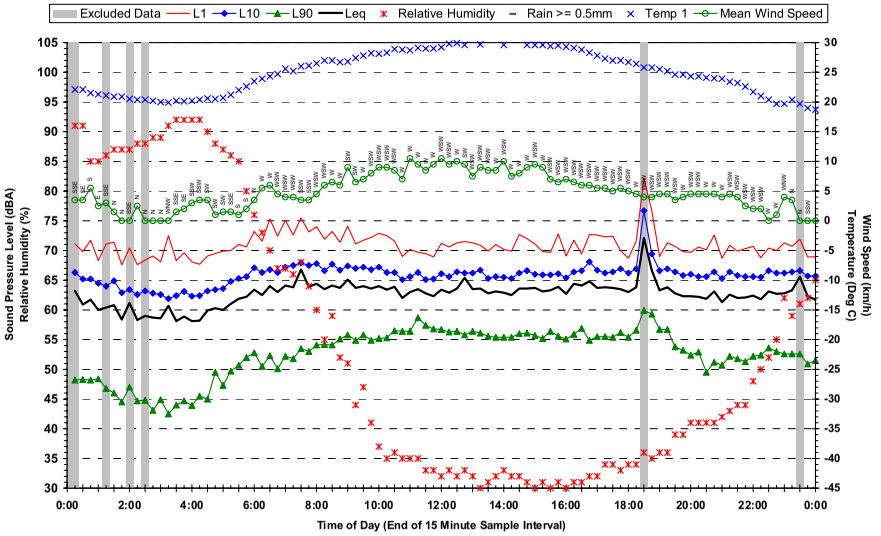
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Wednesday 30 November 2005



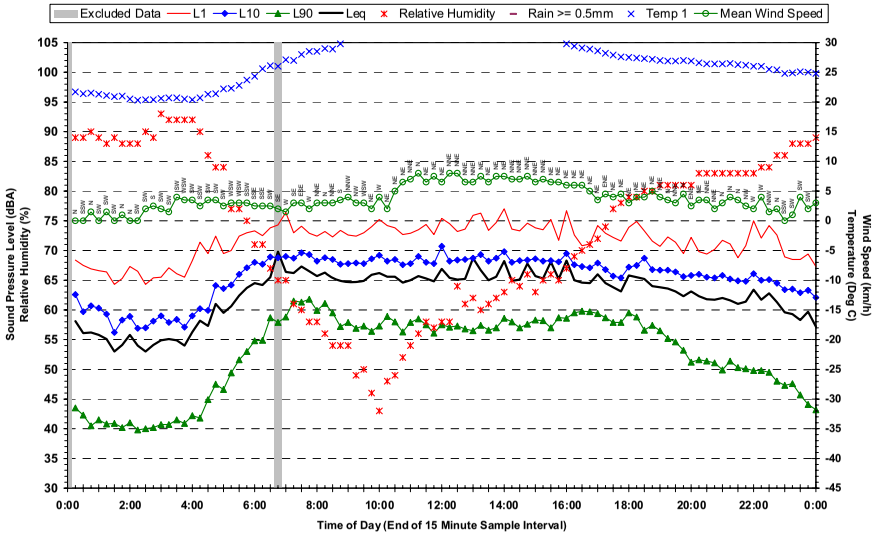
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Friday 2 December 2005



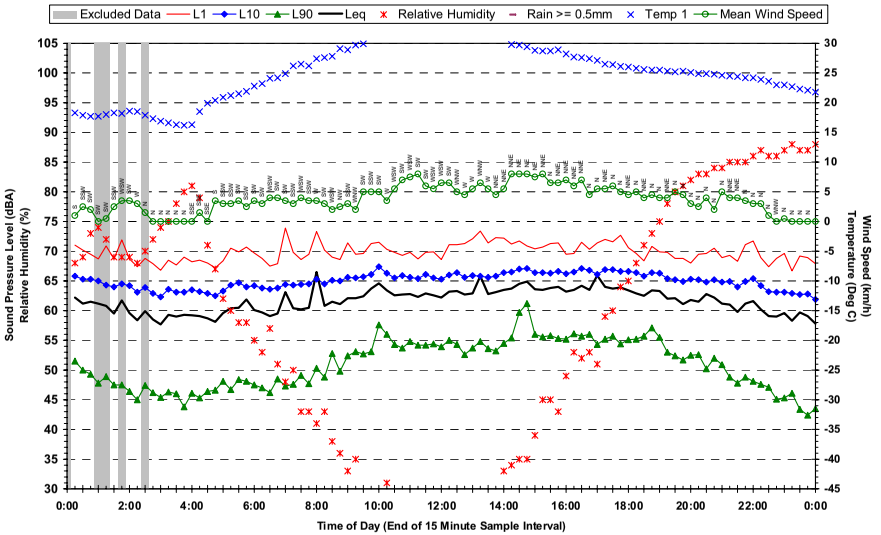
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Saturday 3 December 2005



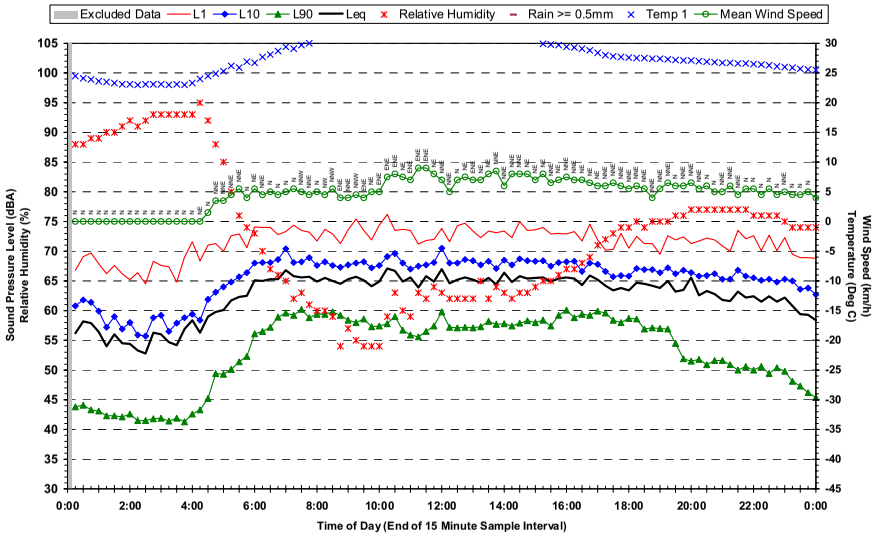
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Monday 5 December 2005



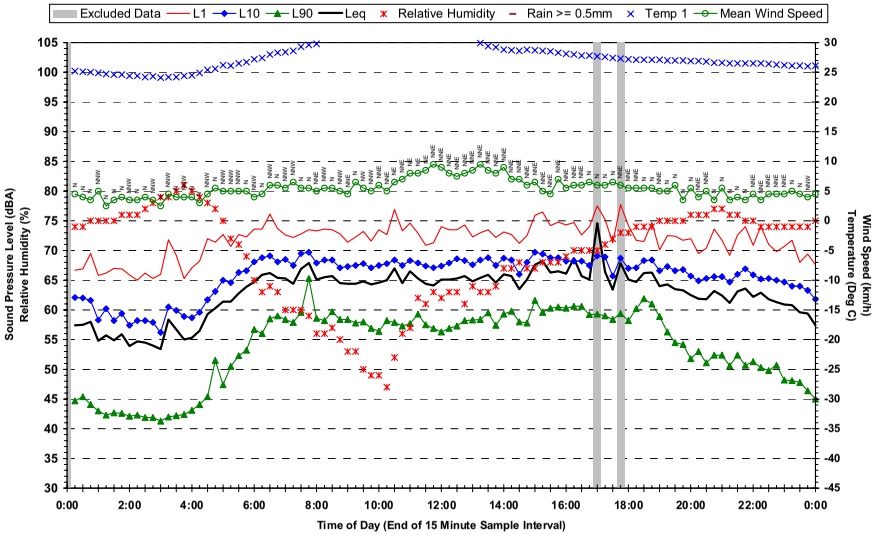
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Sunday 4 December 2005



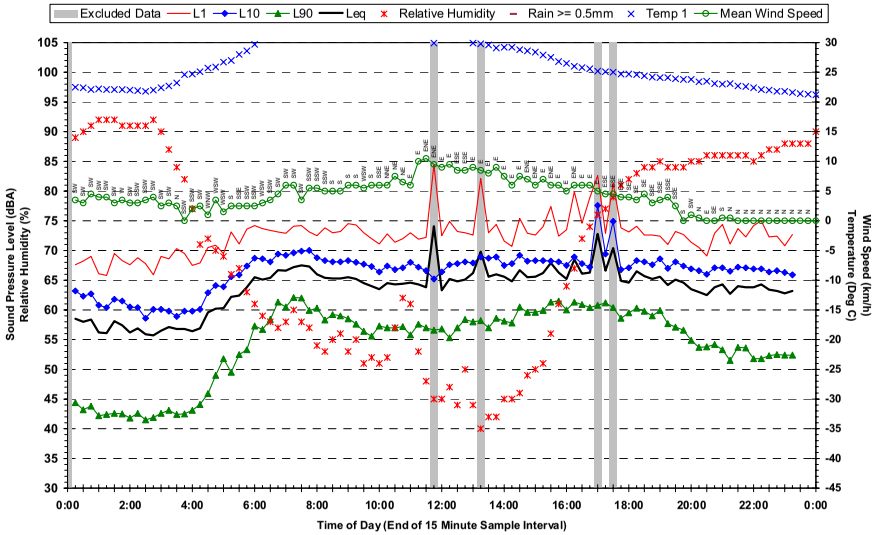
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Tuesday 6 December 2005



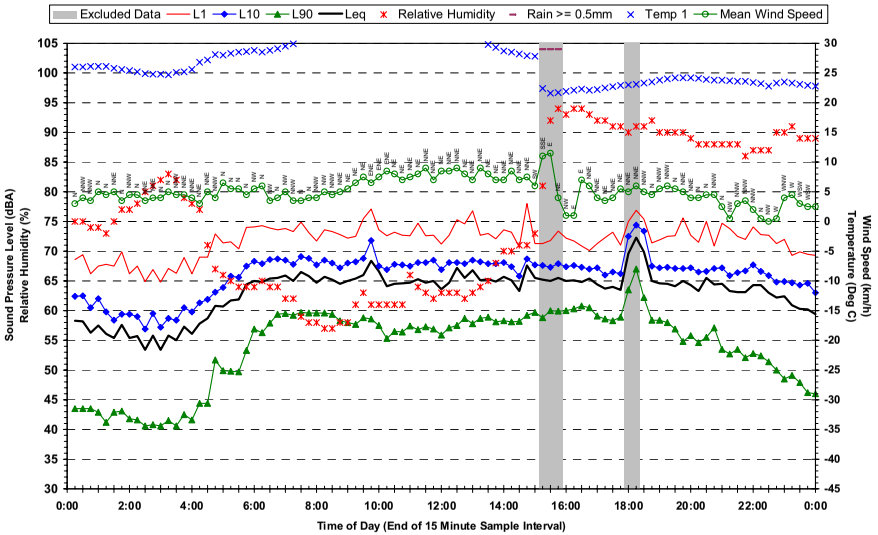
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Wednesday 7 December 2005



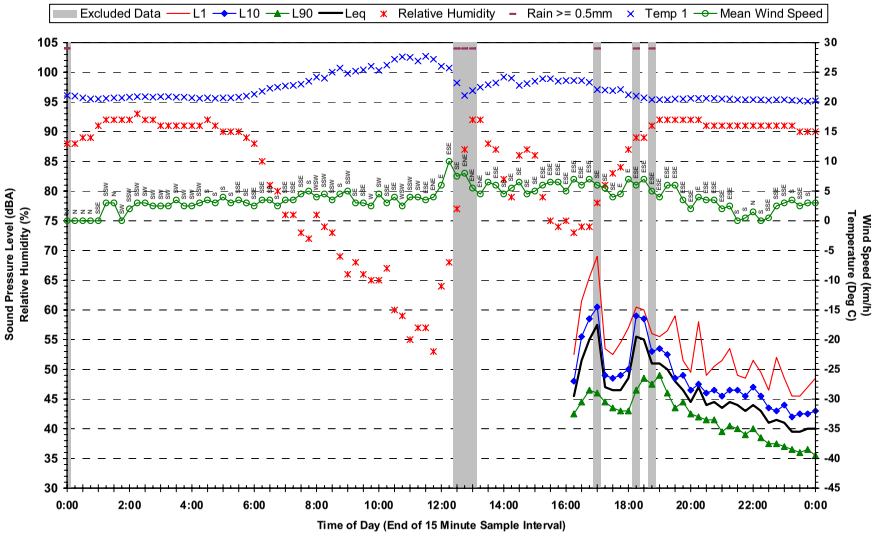
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Friday 9 December 2005



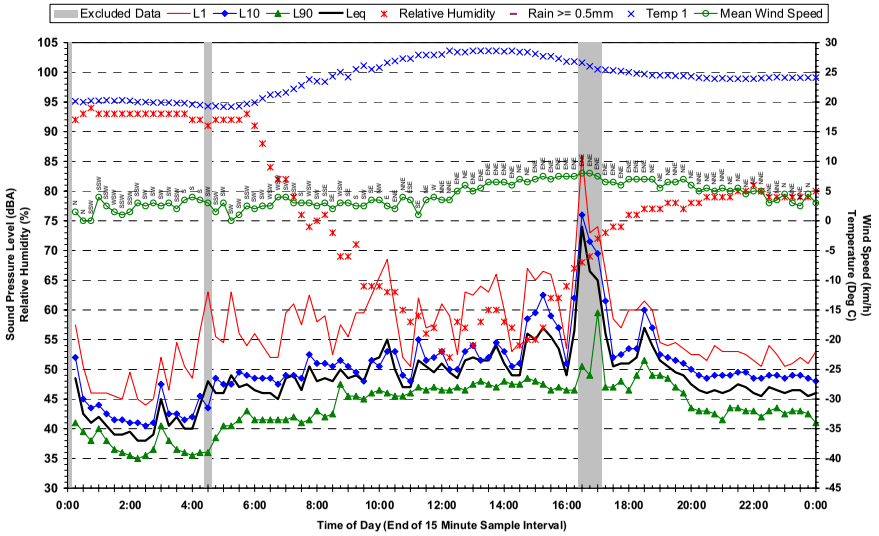
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Thursday 8 December 2005



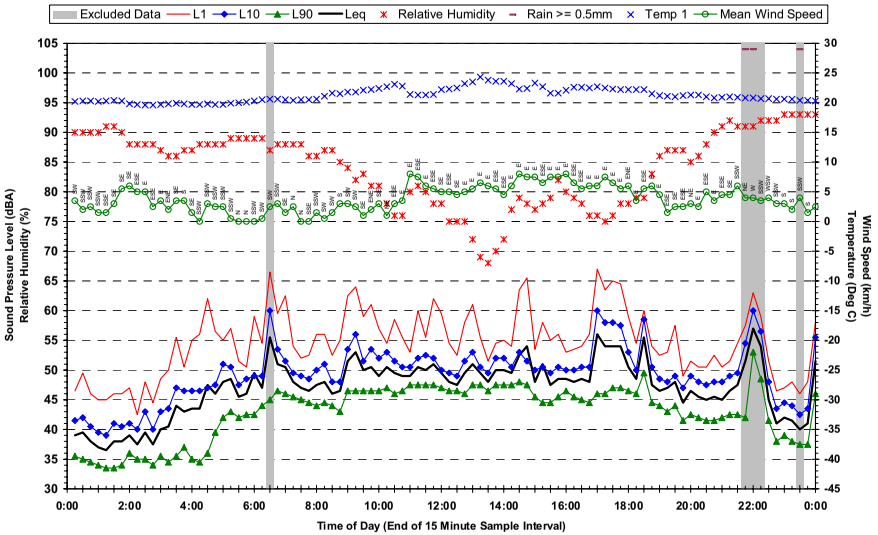
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Thursday 24 November 2005



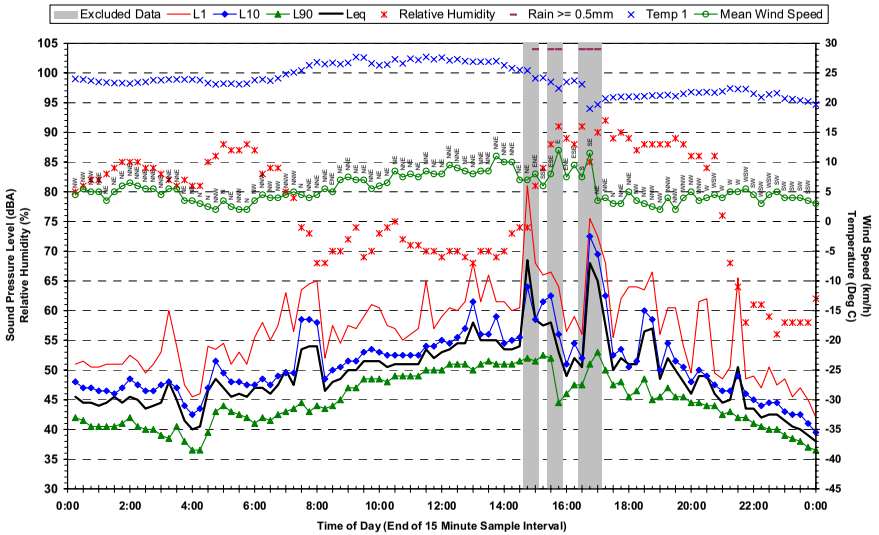
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Saturday 26 November 2005



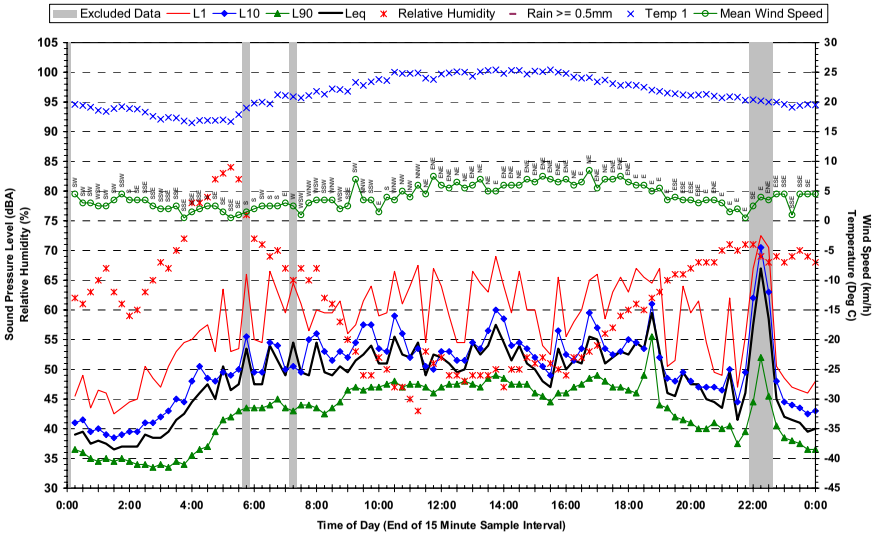
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Friday 25 November 2005



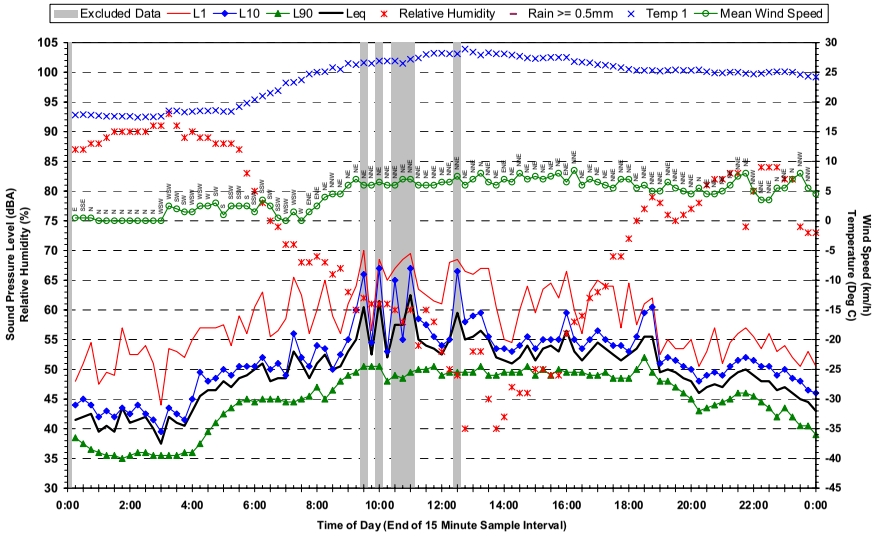
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Sunday 27 November 2005



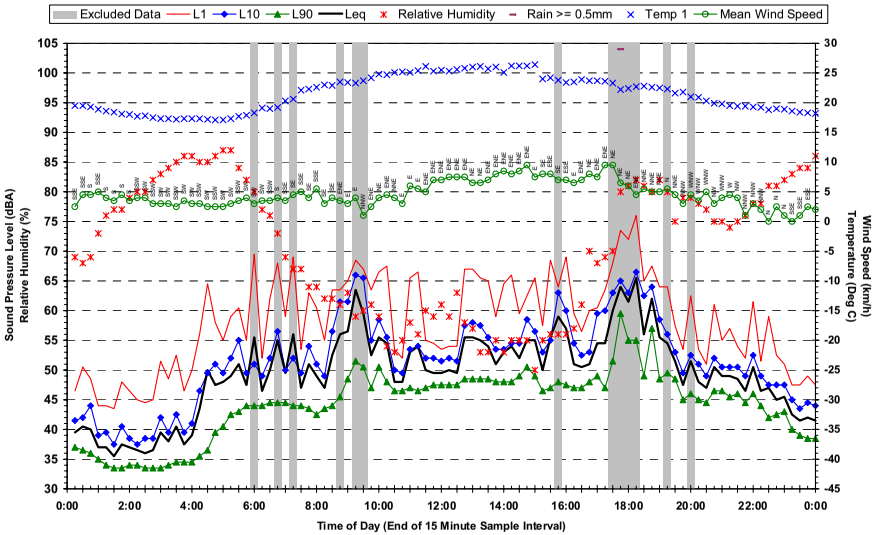
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Monday 28 November 2005



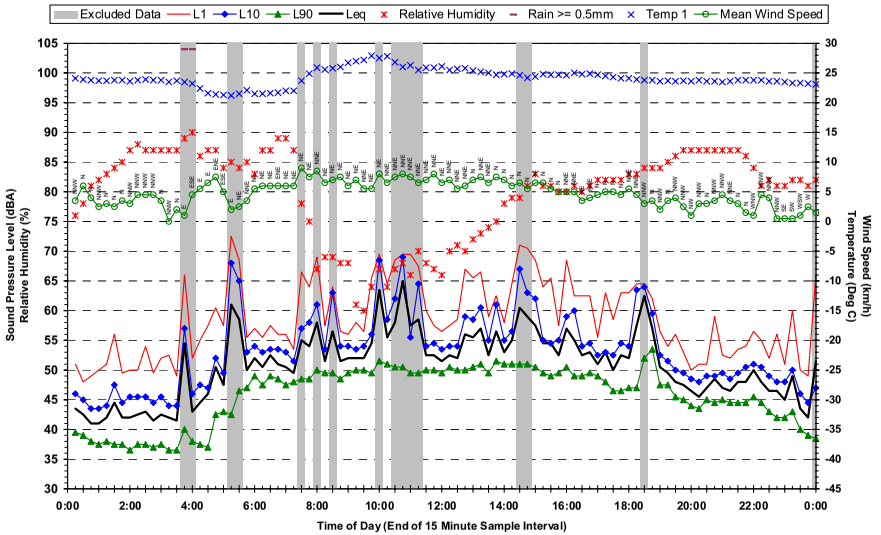
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Wednesday 30 November 2005



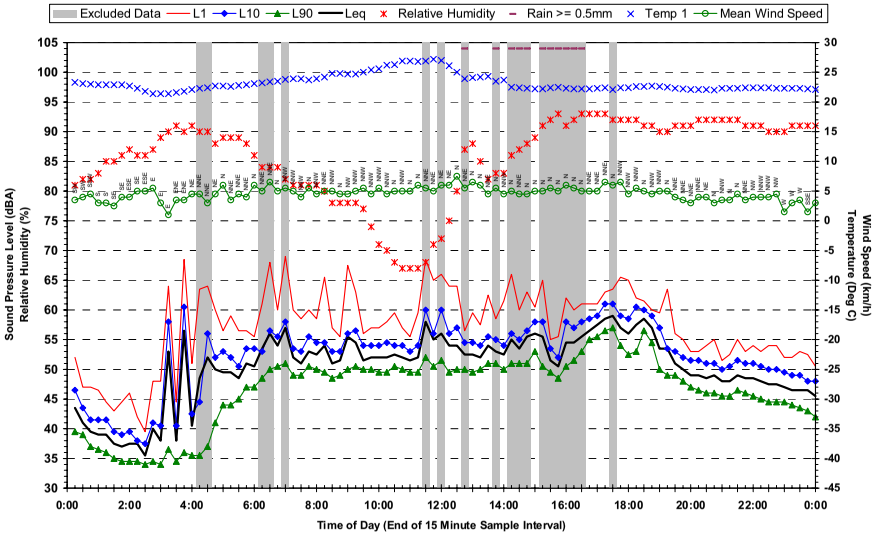
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Tuesday 29 November 2005



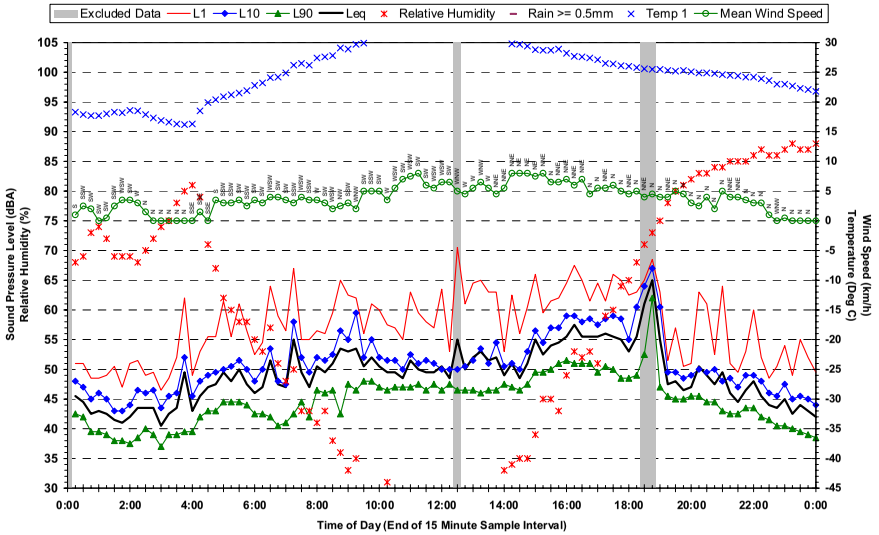
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Thursday 1 December 2005



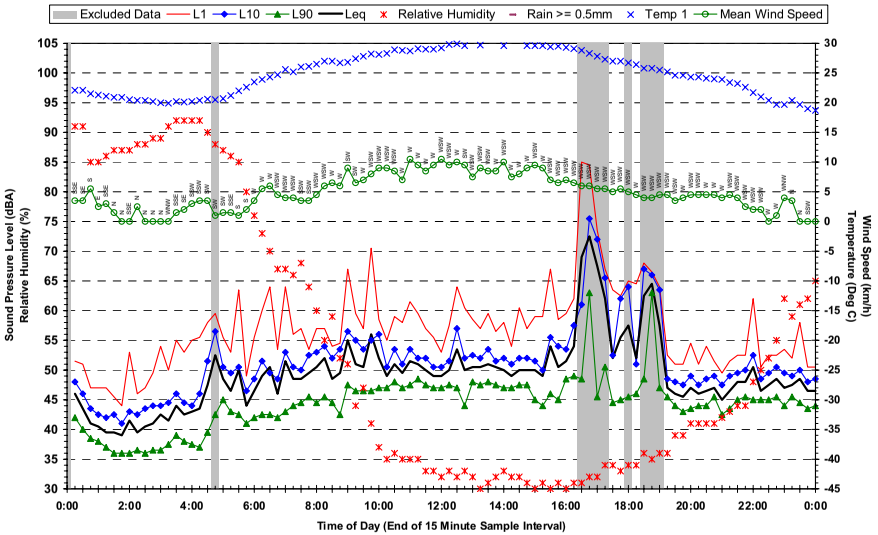
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Friday 2 December 2005



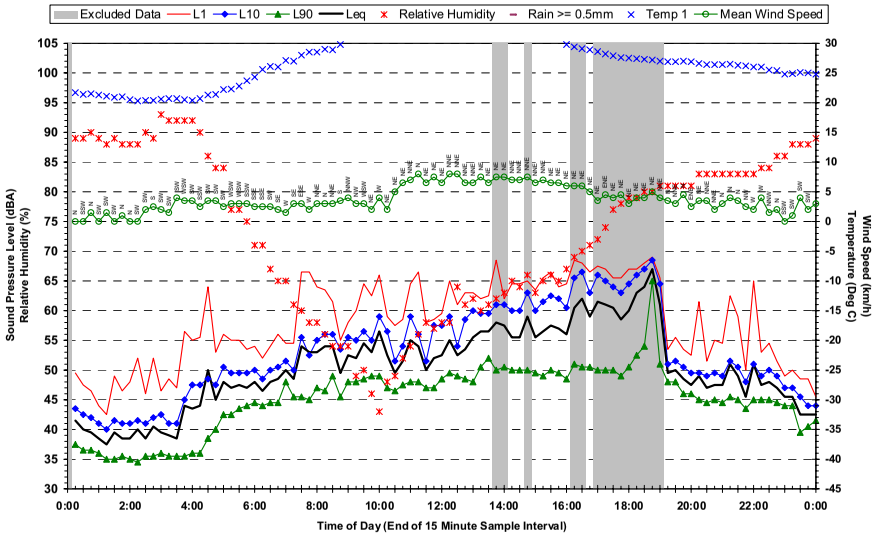
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Sunday 4 December 2005



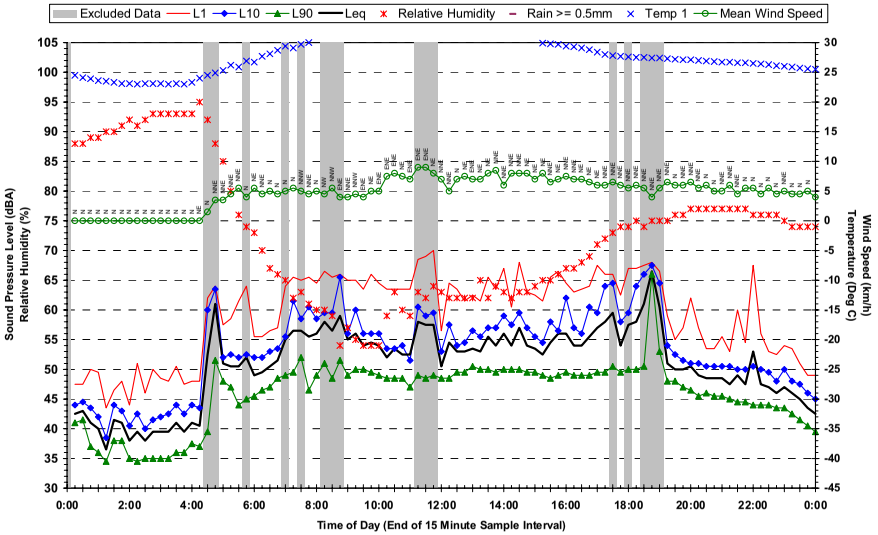
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Saturday 3 December 2005



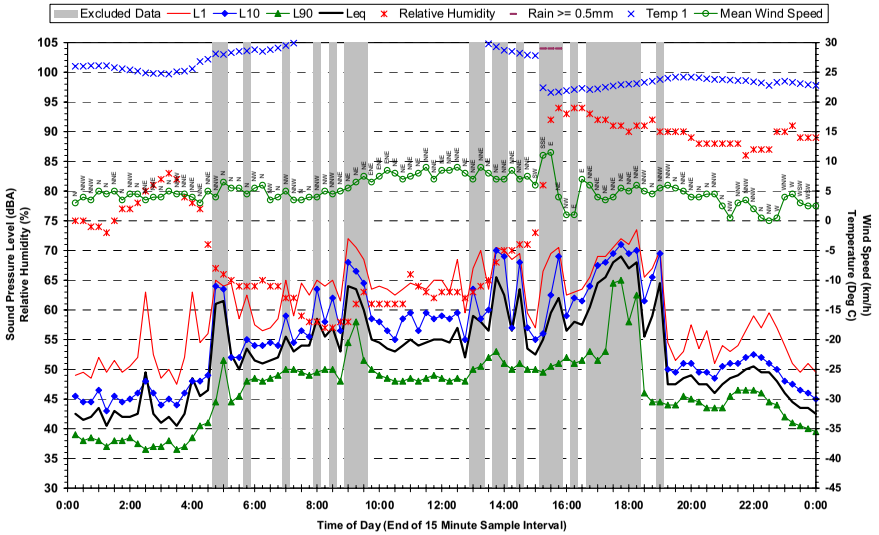
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Monday 5 December 2005



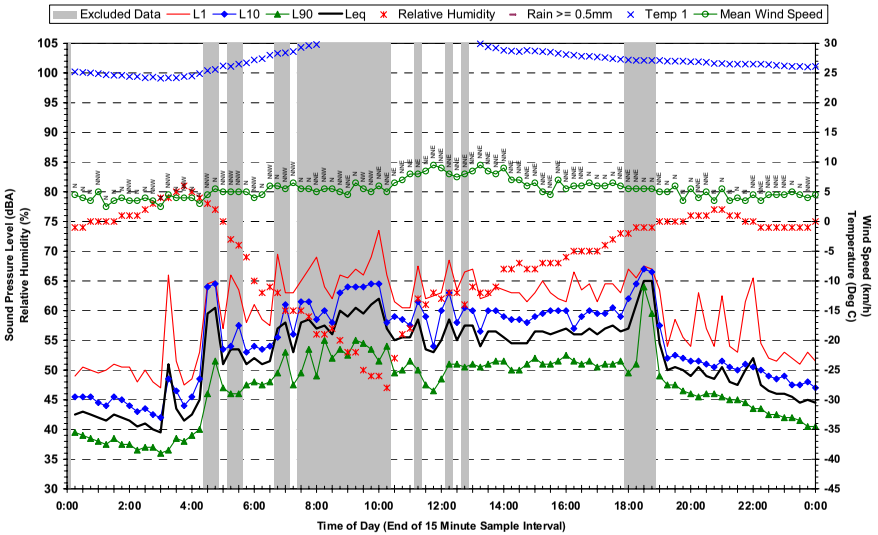
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Tuesday 6 December 2005



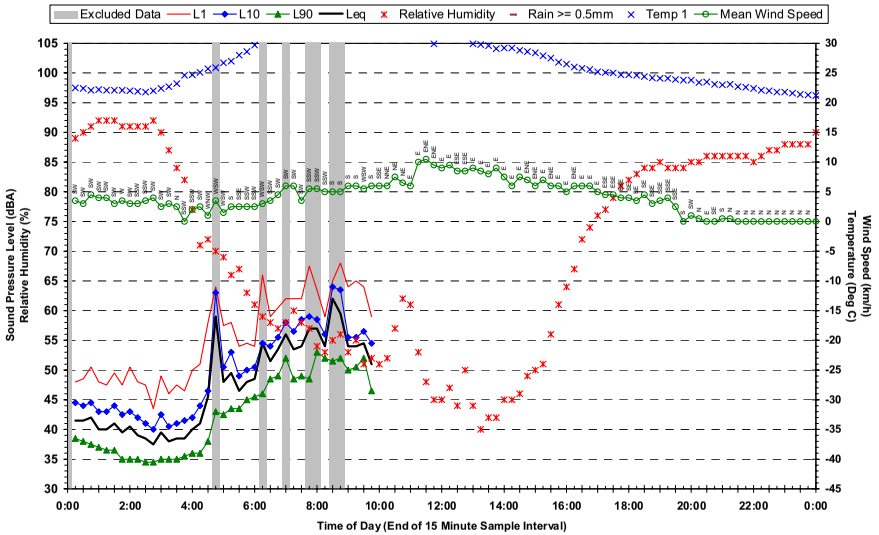
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Thursday 8 December 2005



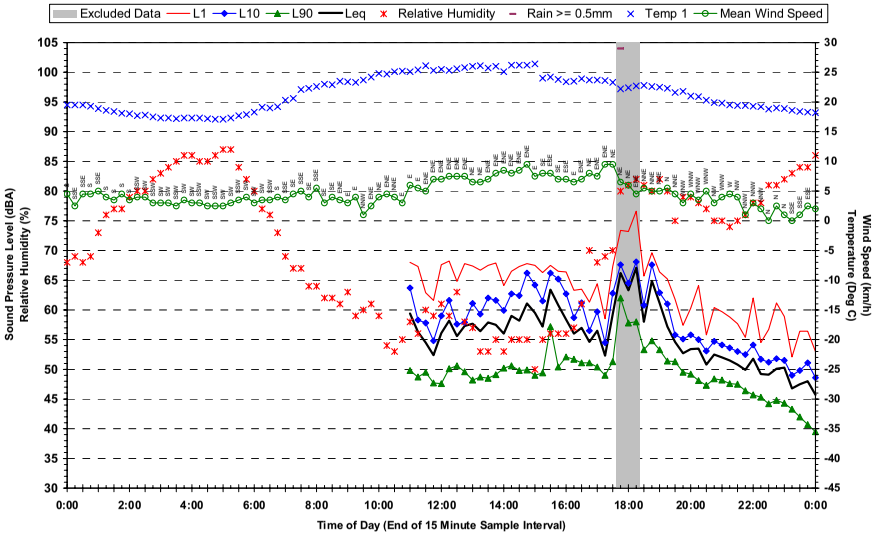
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Wednesday 7 December 2005



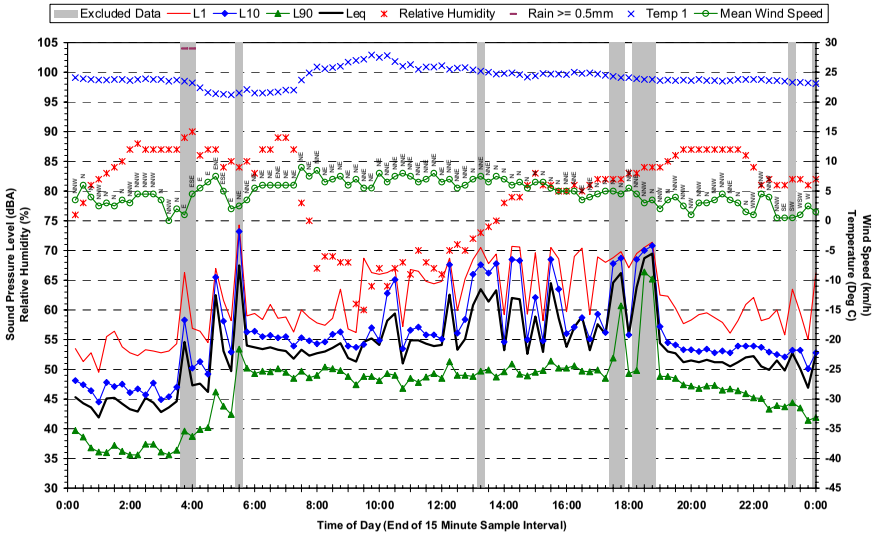
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Friday 9 December 2005



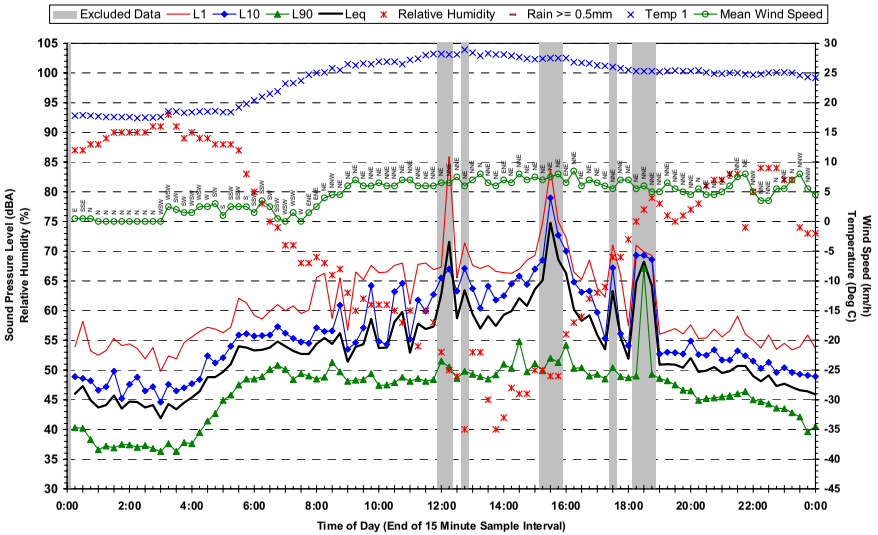
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Tuesday 29 November 2005



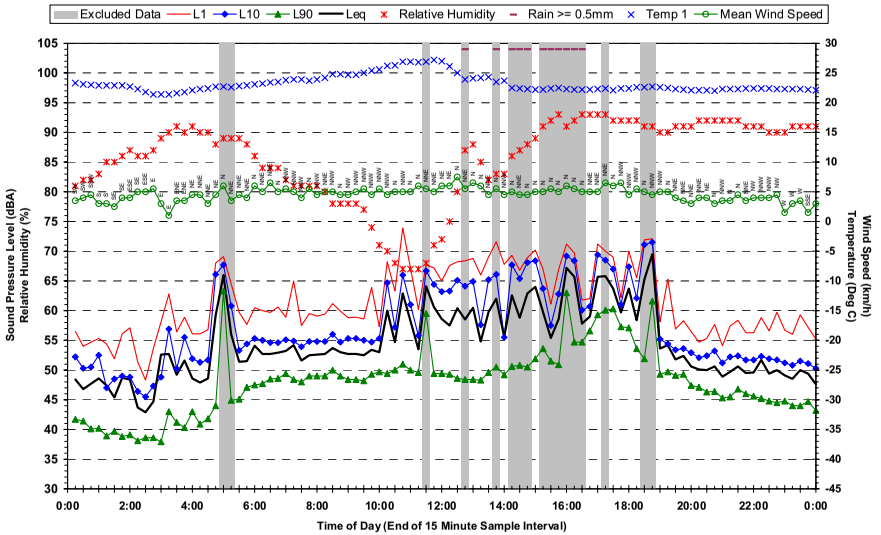
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Thursday 1 December 2005



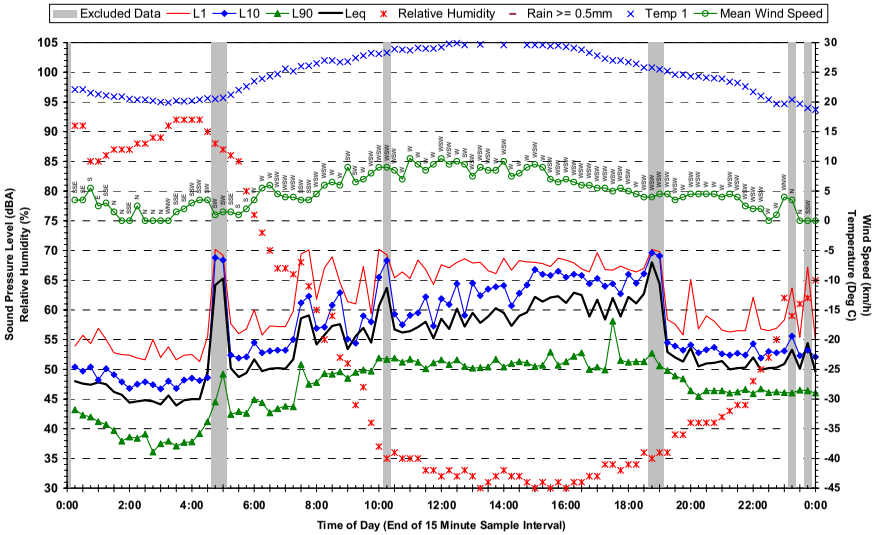
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Wednesday 30 November 2005



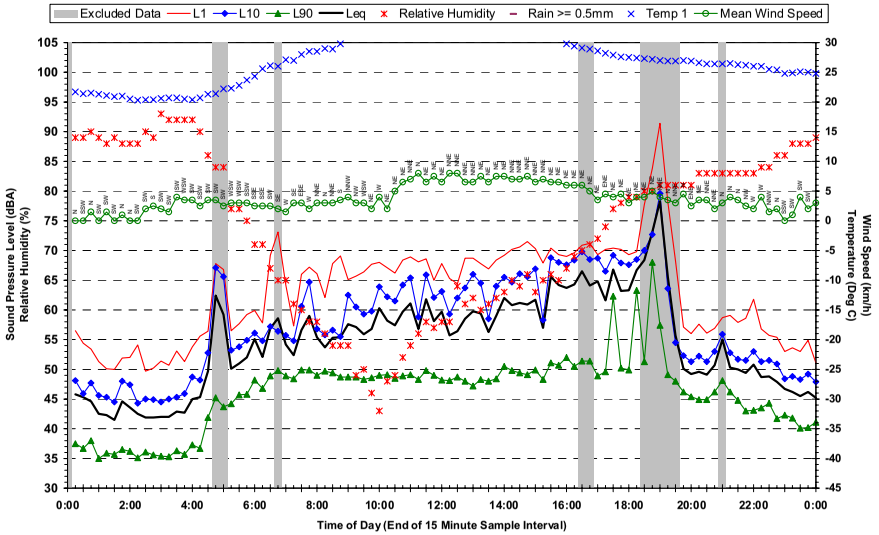
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Friday 2 December 2005



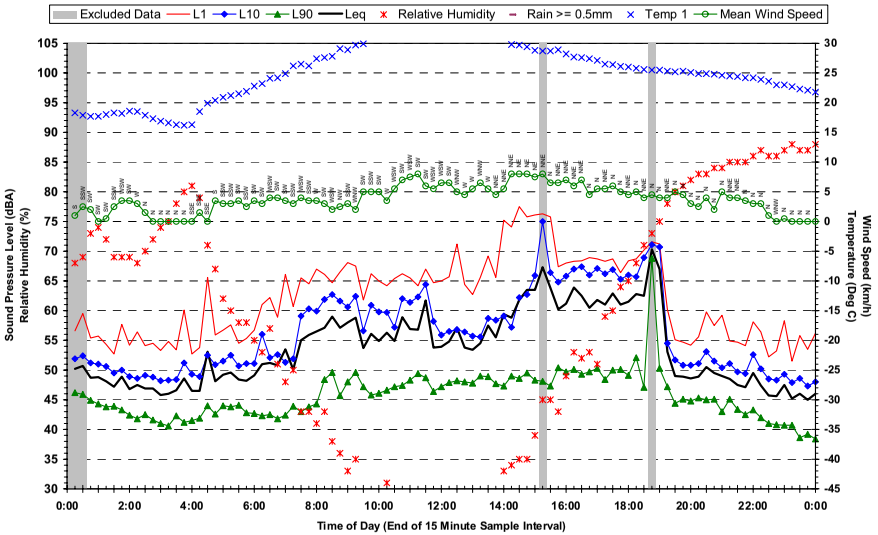
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Saturday 3 December 2005



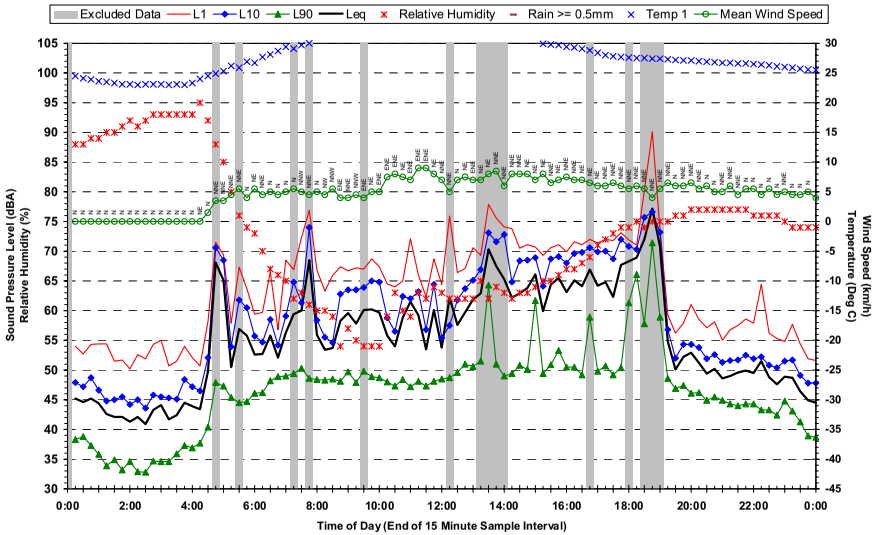
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Monday 5 December 2005



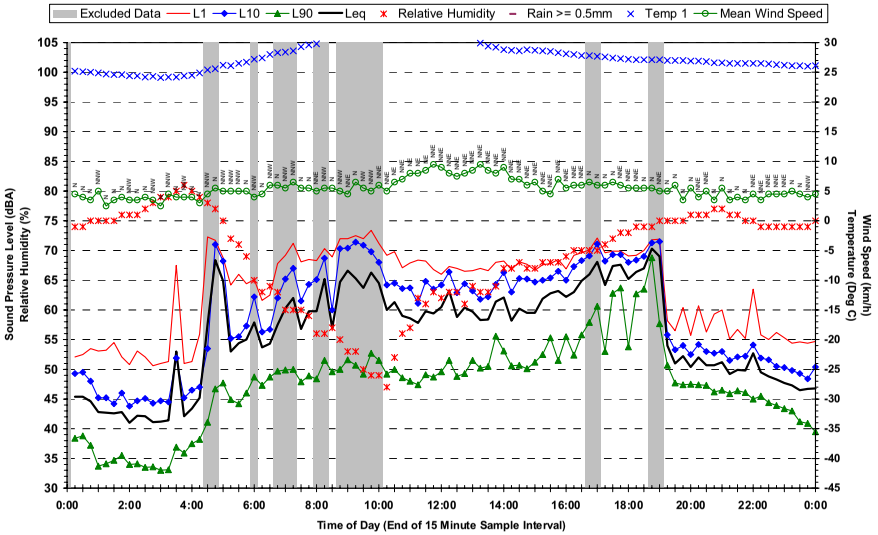
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Sunday 4 December 2005



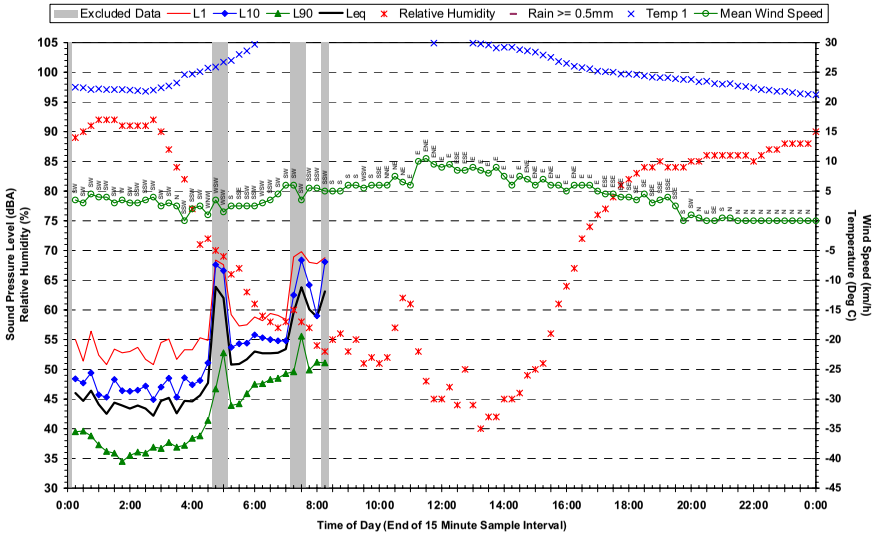
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Tuesday 6 December 2005



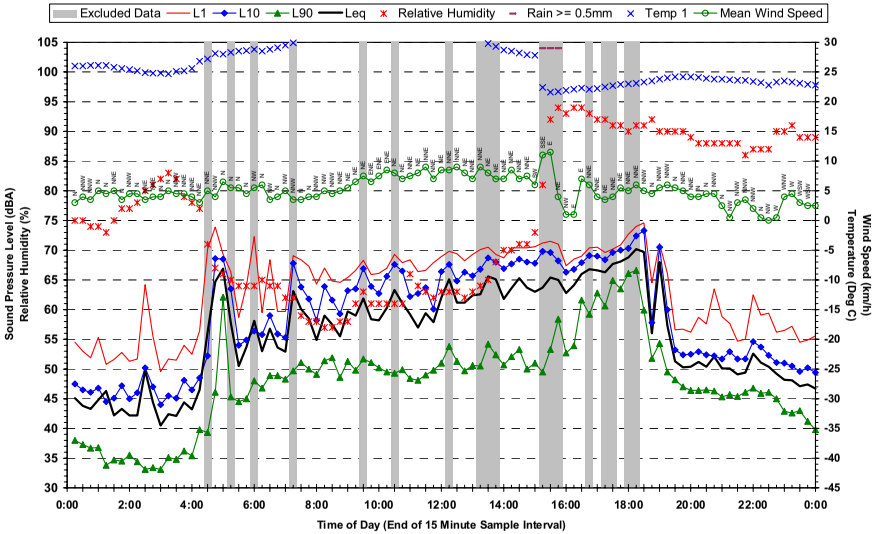
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Wednesday 7 December 2005



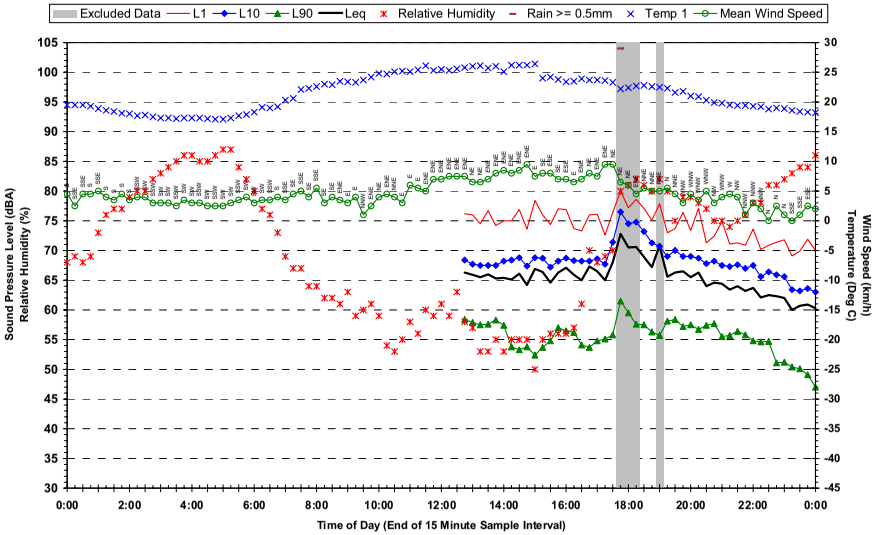
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Friday 9 December 2005



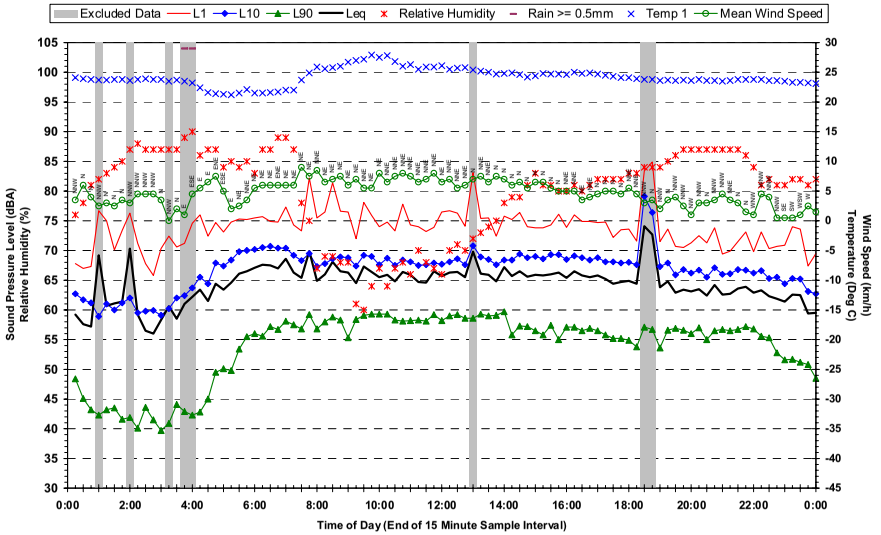
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Thursday 8 December 2005



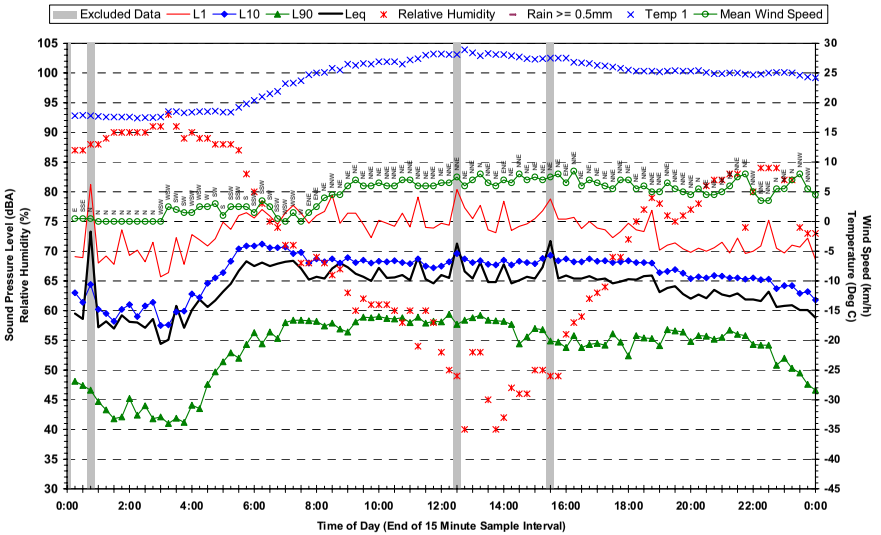
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Tuesday 29 November 2005



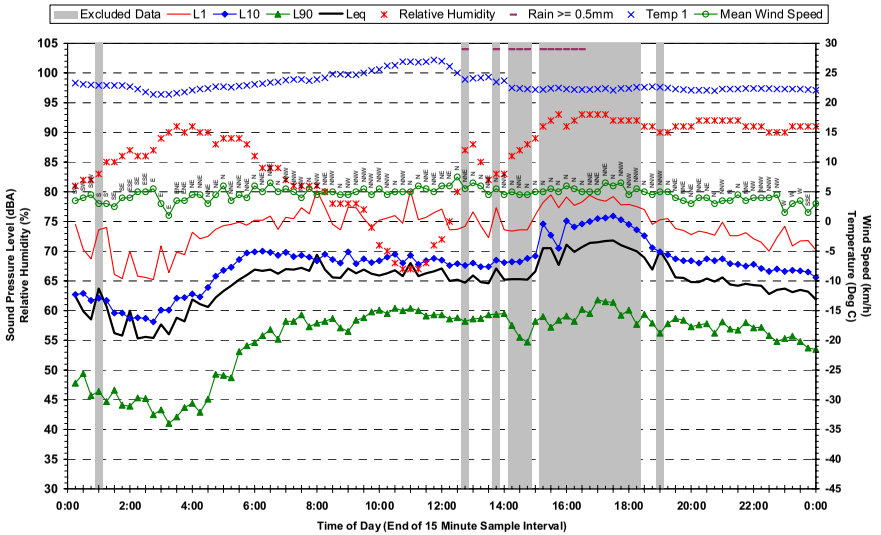
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Thursday 1 December 2005



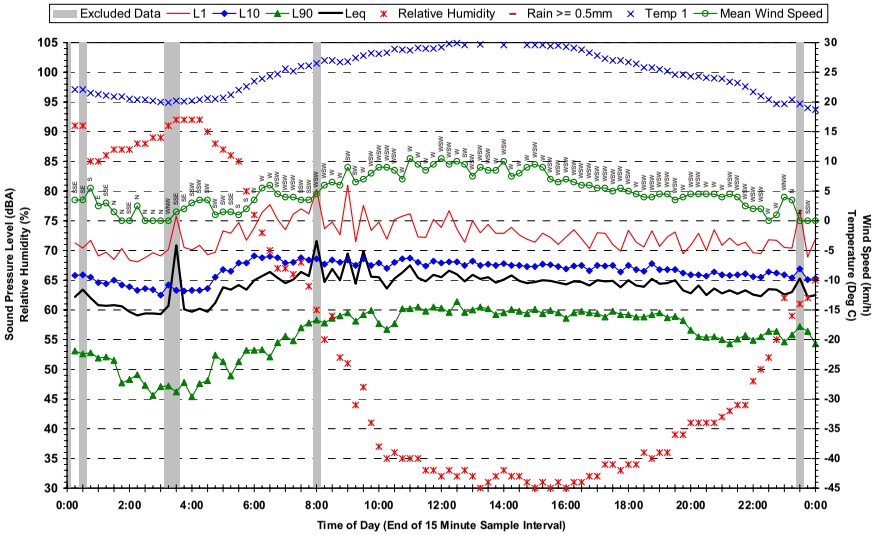
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Wednesday 30 November 2005



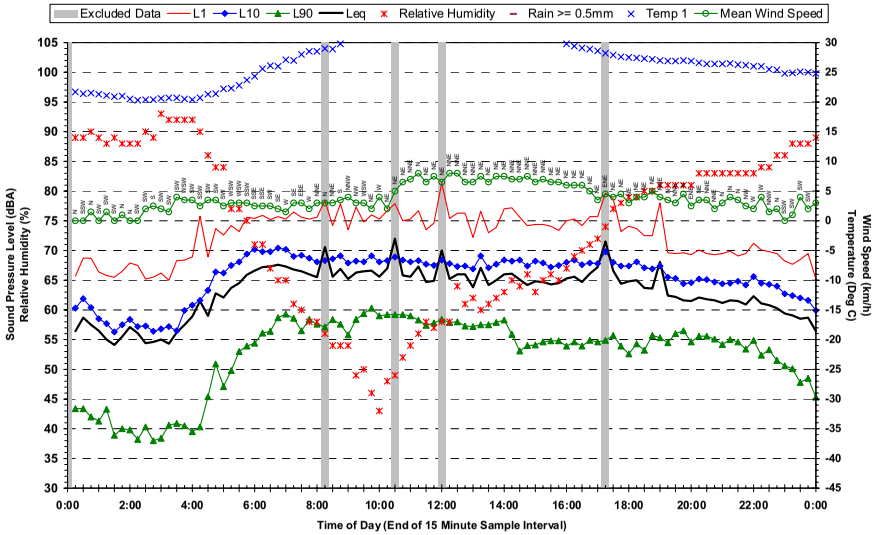
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Friday 2 December 2005



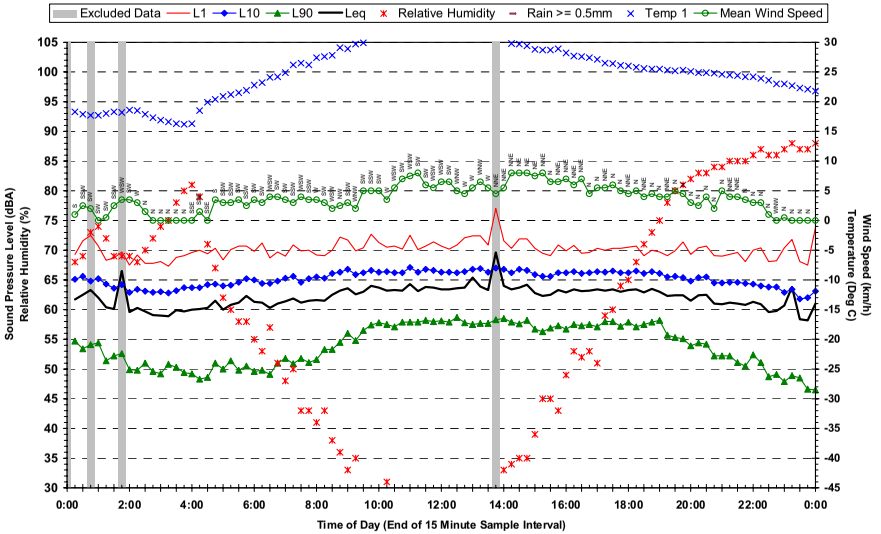
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Saturday 3 December 2005



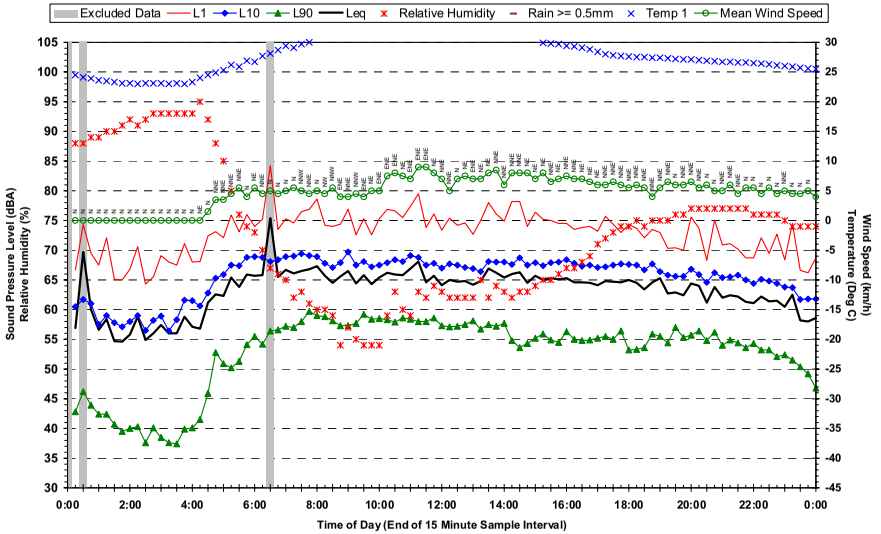
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Monday 5 December 2005



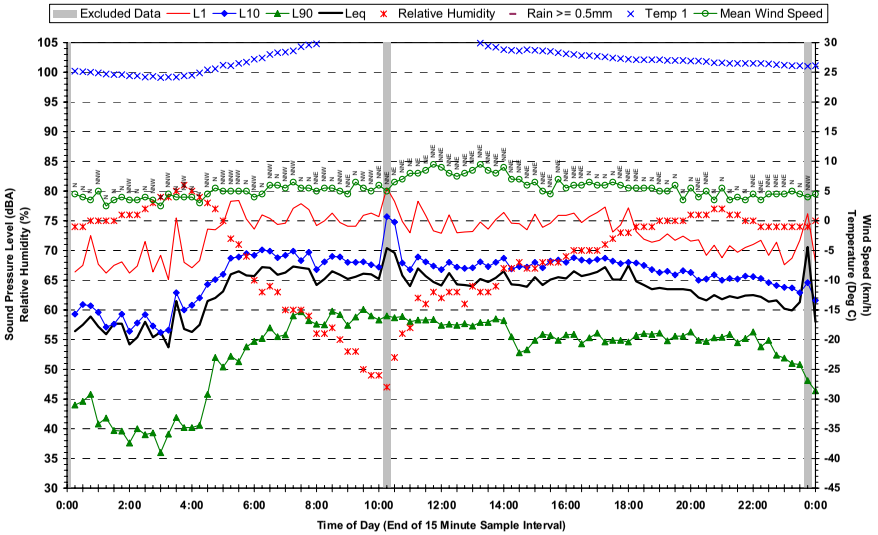
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Sunday 4 December 2005



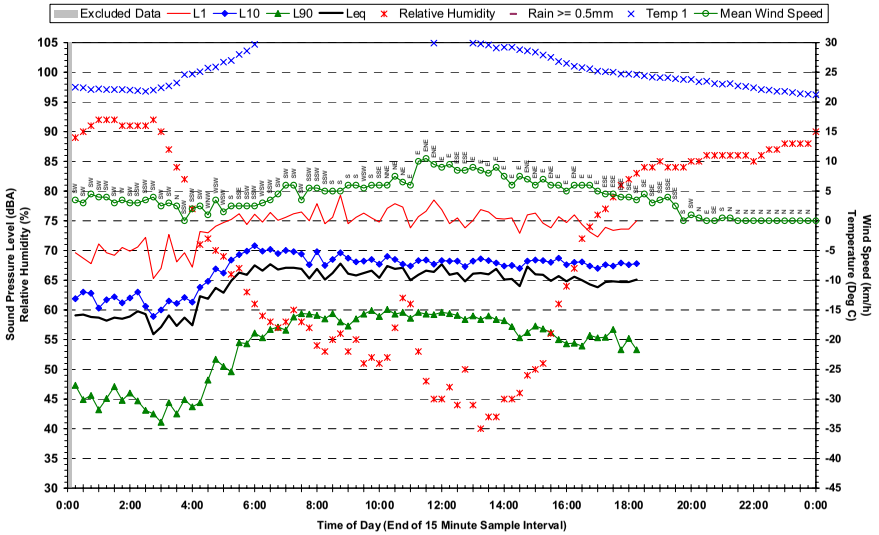
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Tuesday 6 December 2005



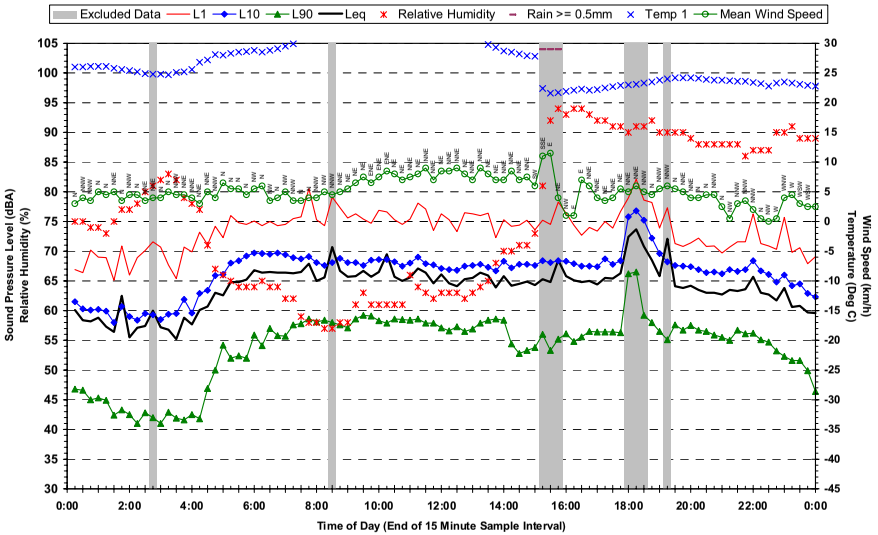
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Wednesday 7 December 2005



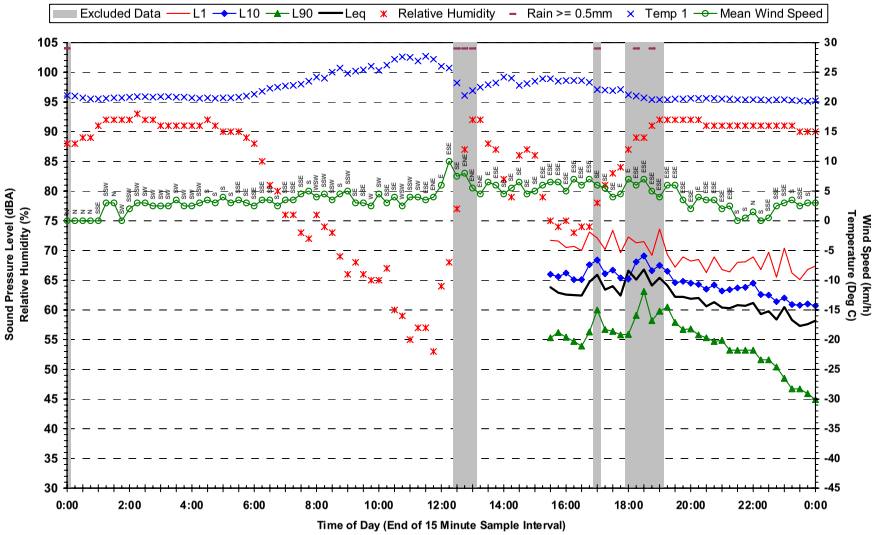
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Friday 9 December 2005



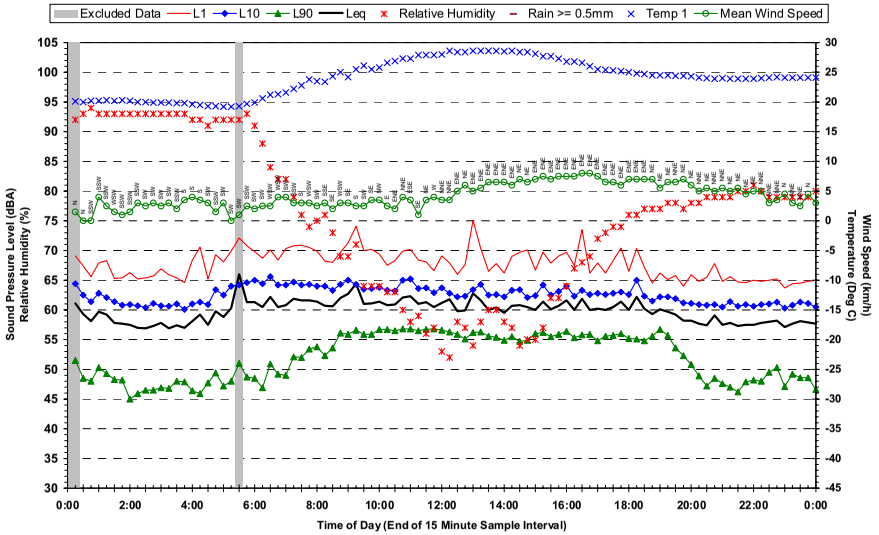
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Thursday 8 December 2005



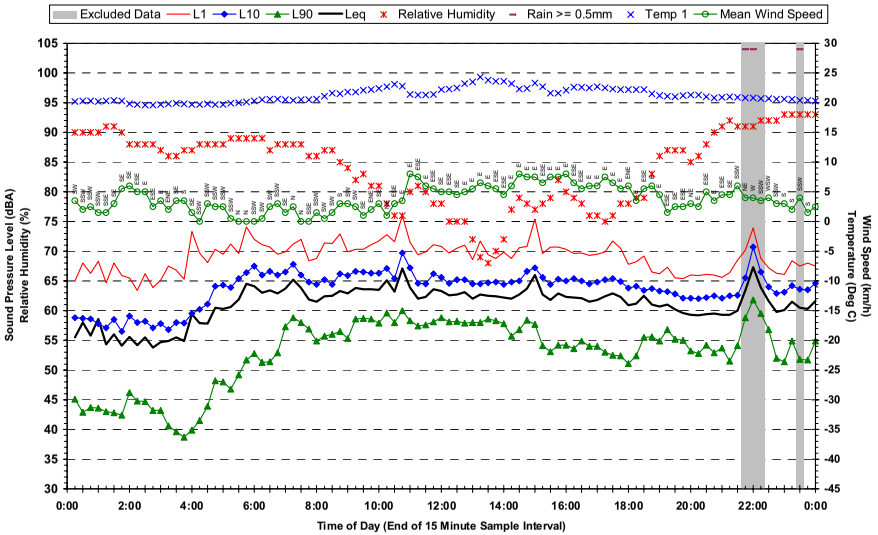
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Thursday 24 November 2005



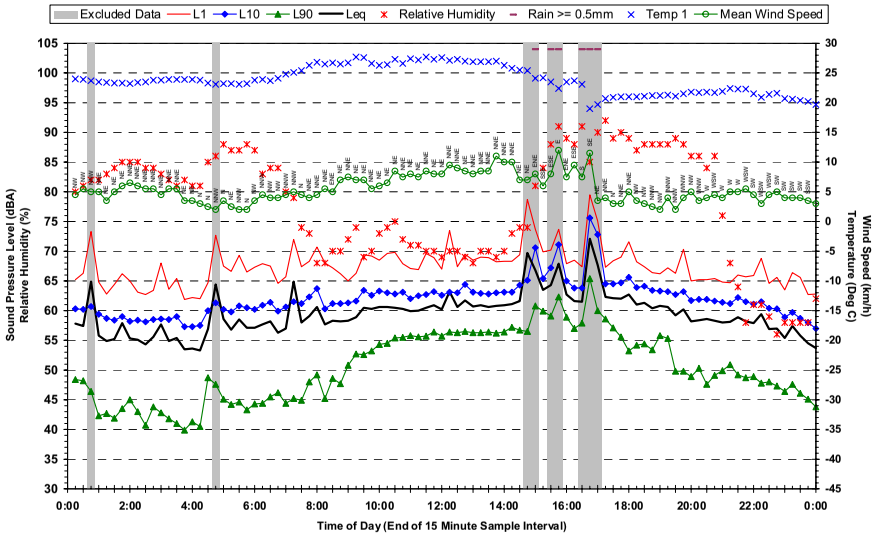
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Saturday 26 November 2005



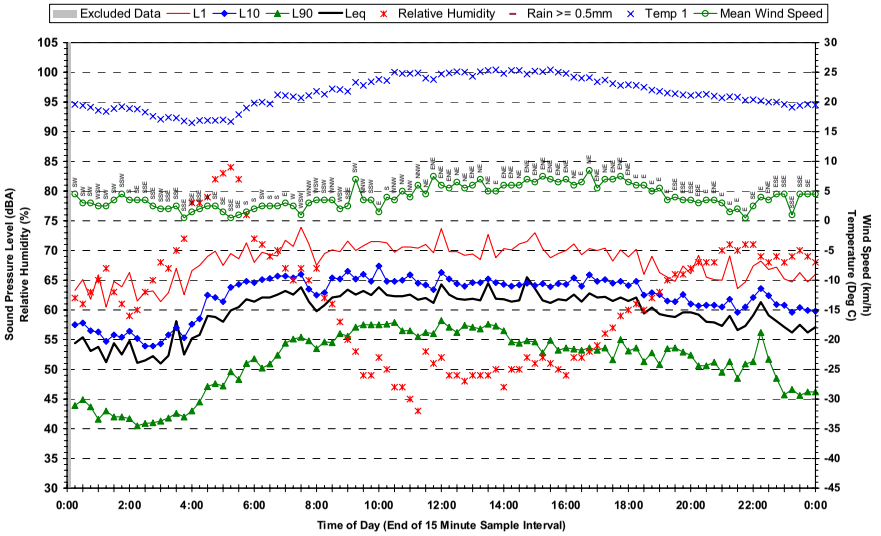
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Friday 25 November 2005



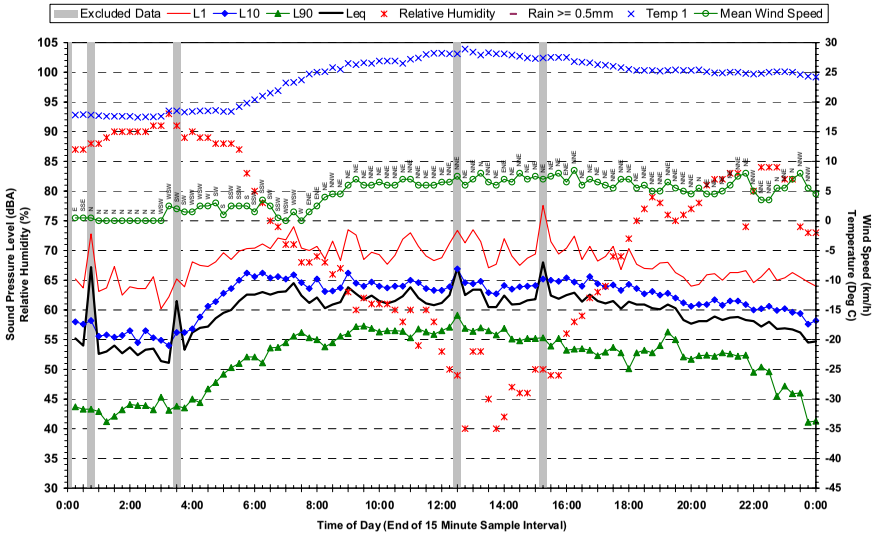
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Sunday 27 November 2005



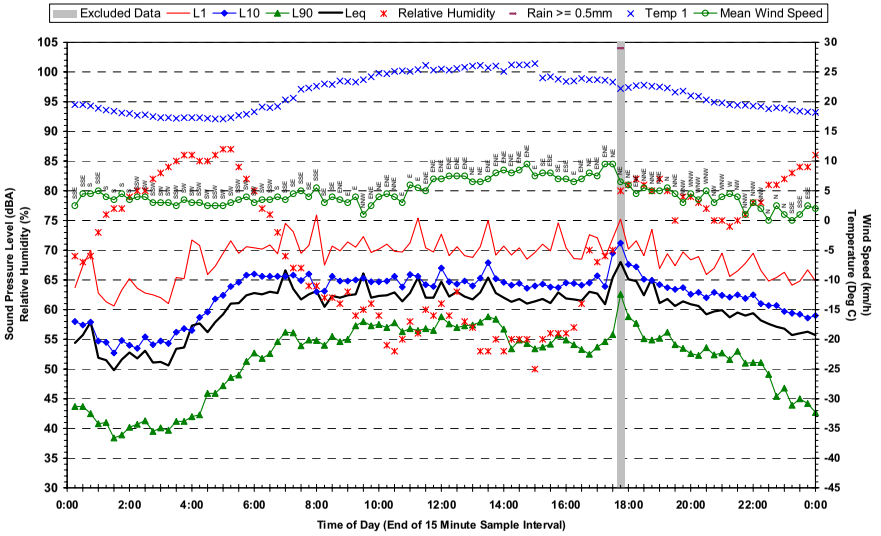
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Monday 28 November 2005



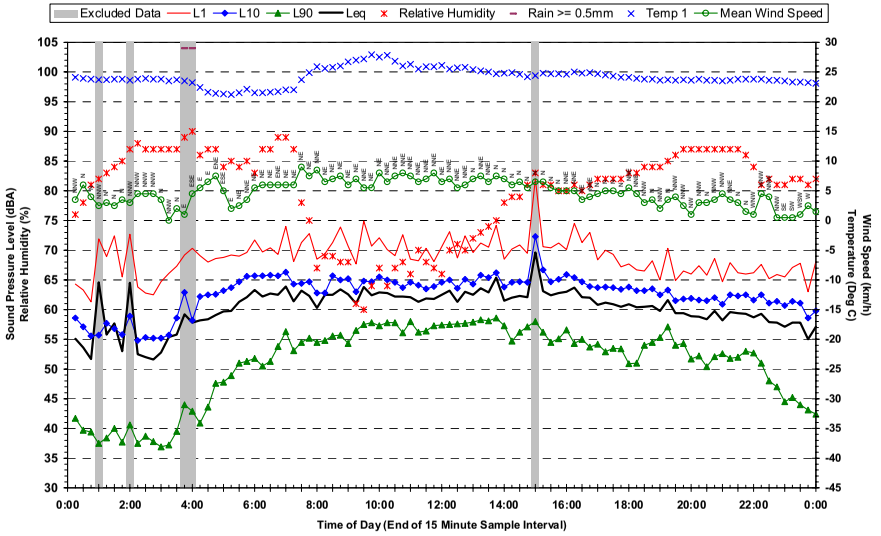
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Wednesday 30 November 2005



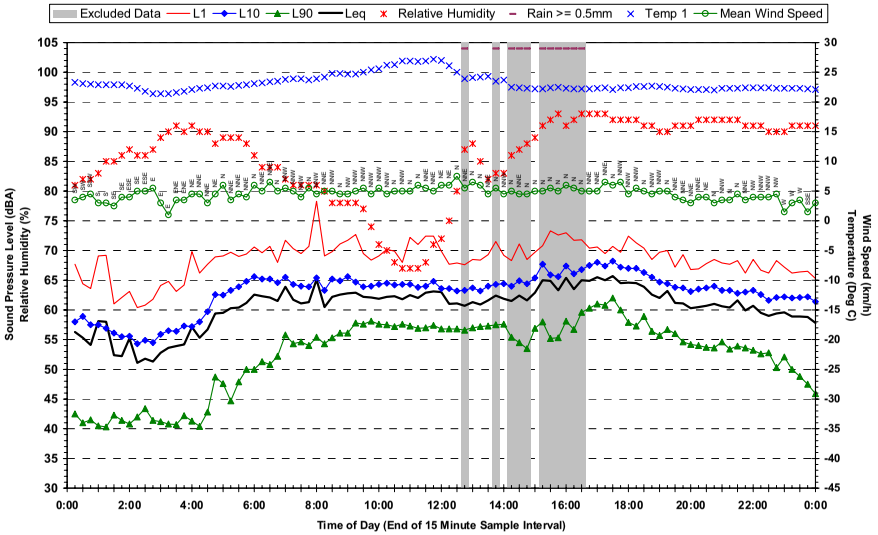
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Tuesday 29 November 2005



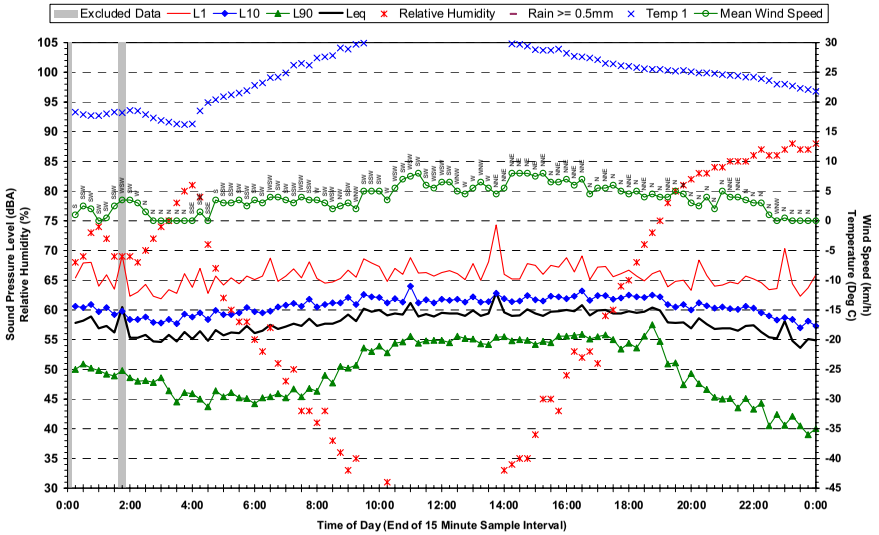
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Thursday 1 December 2005



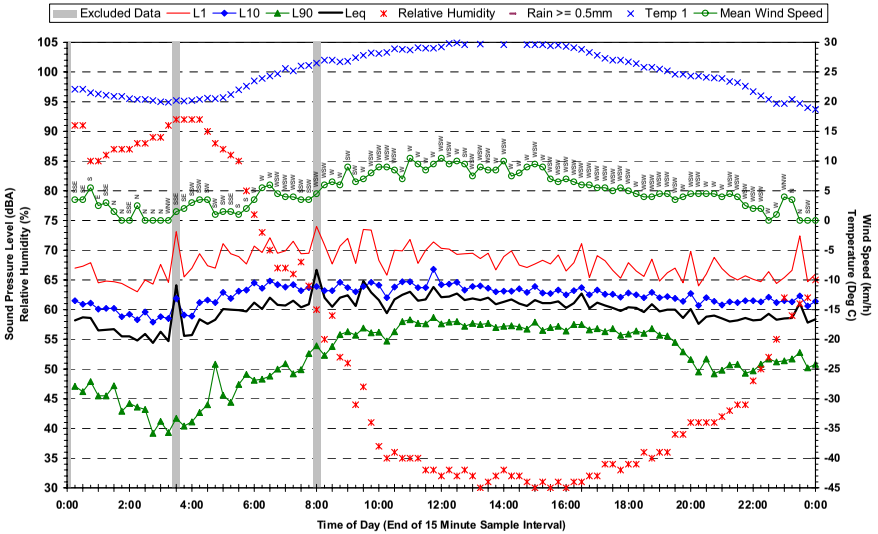
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Friday 2 December 2005



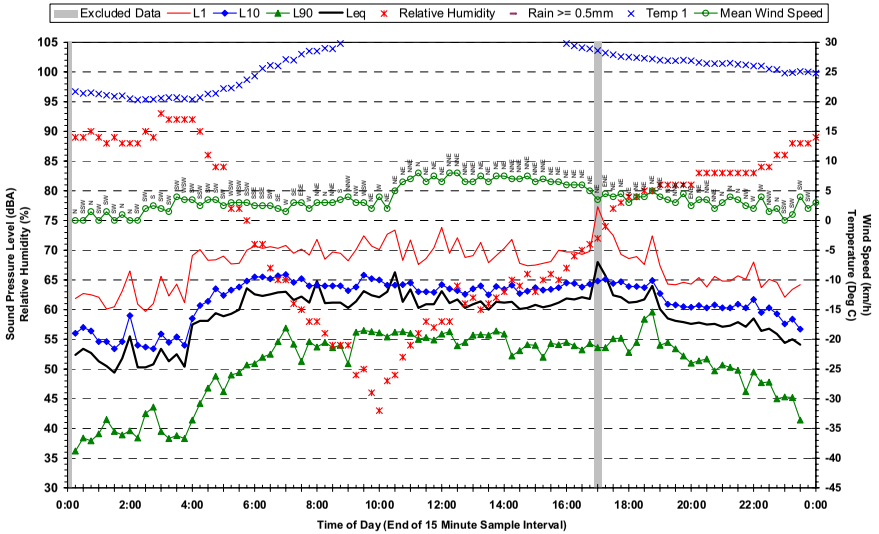
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Sunday 4 December 2005



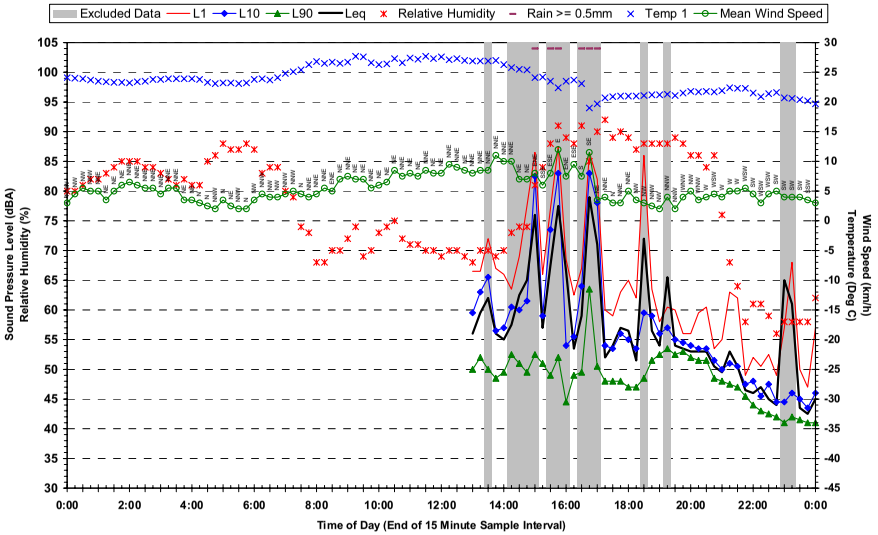
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Saturday 3 December 2005



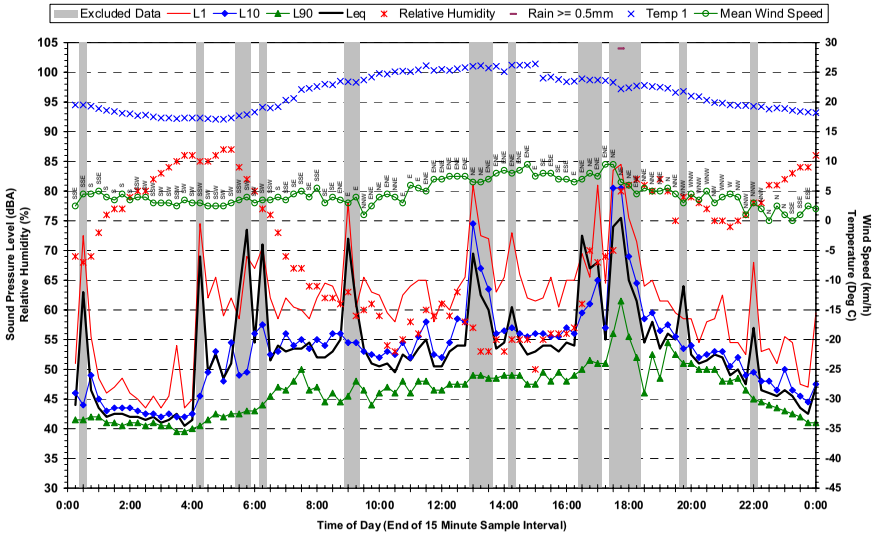
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Monday 5 December 2005



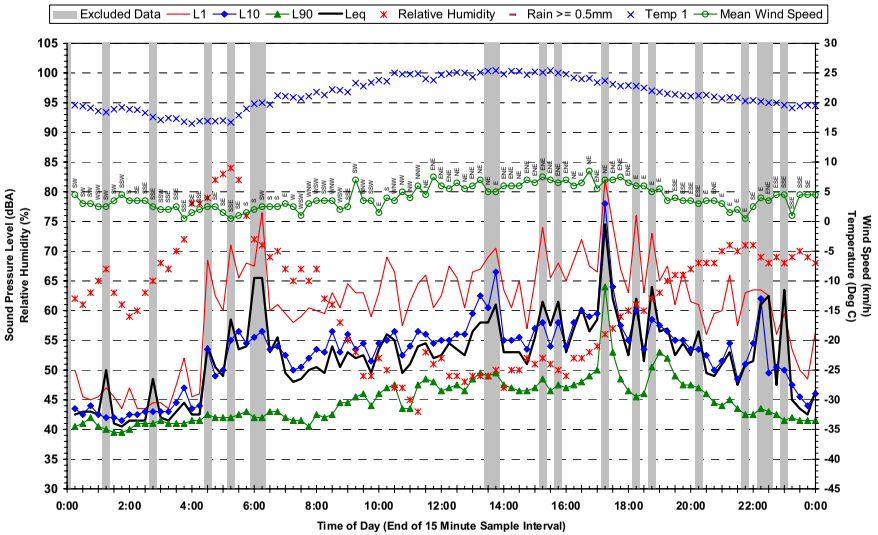
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Sunday 27 November 2005



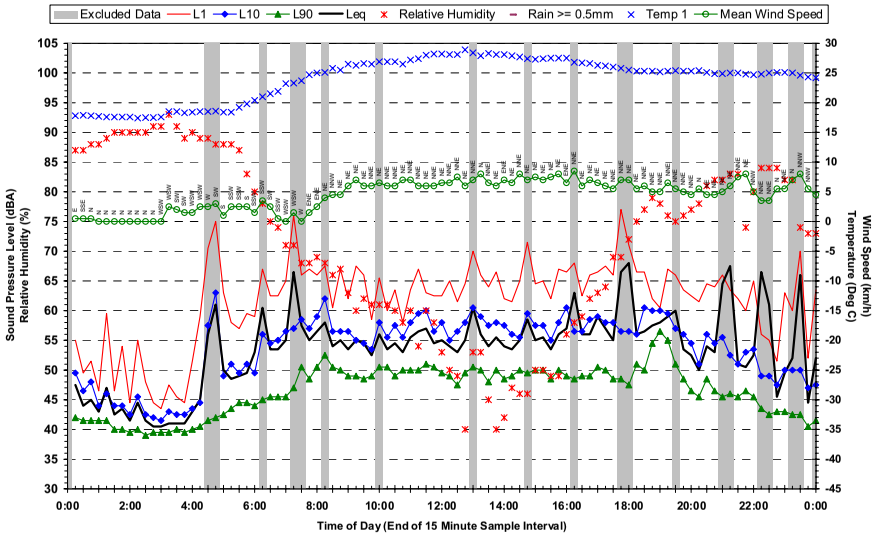
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Tuesday 29 November 2005



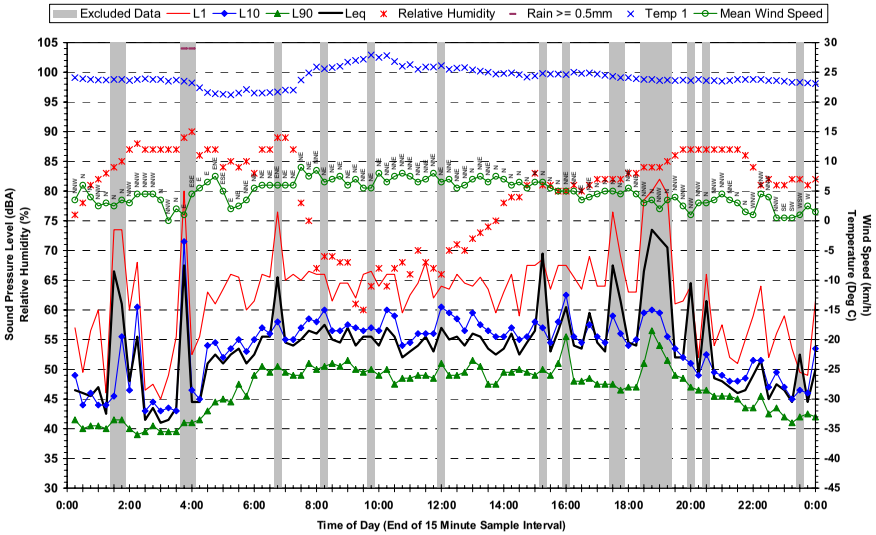
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Monday 28 November 2005



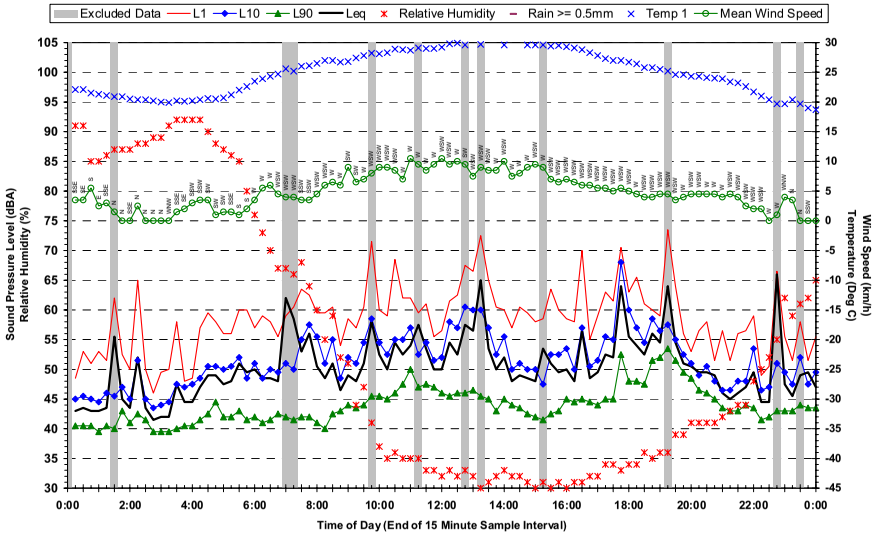
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Wednesday 30 November 2005



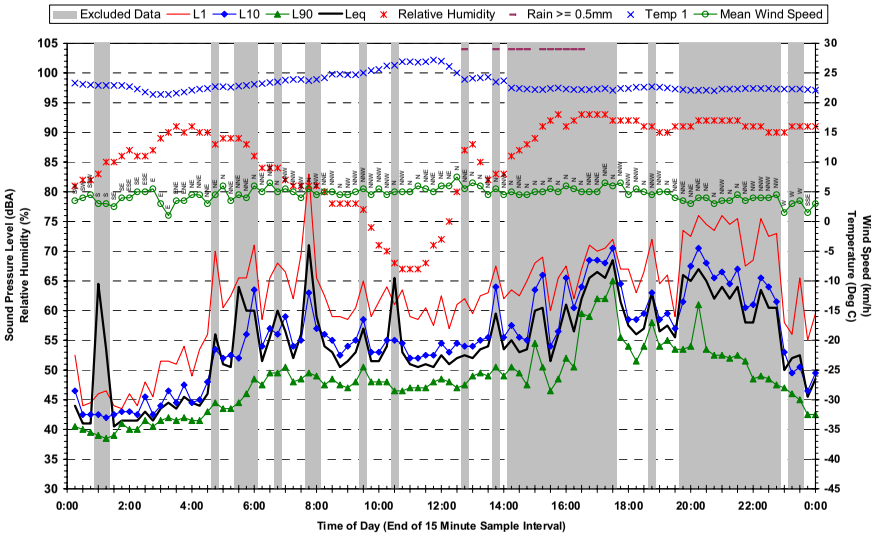
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Thursday 1 December 2005



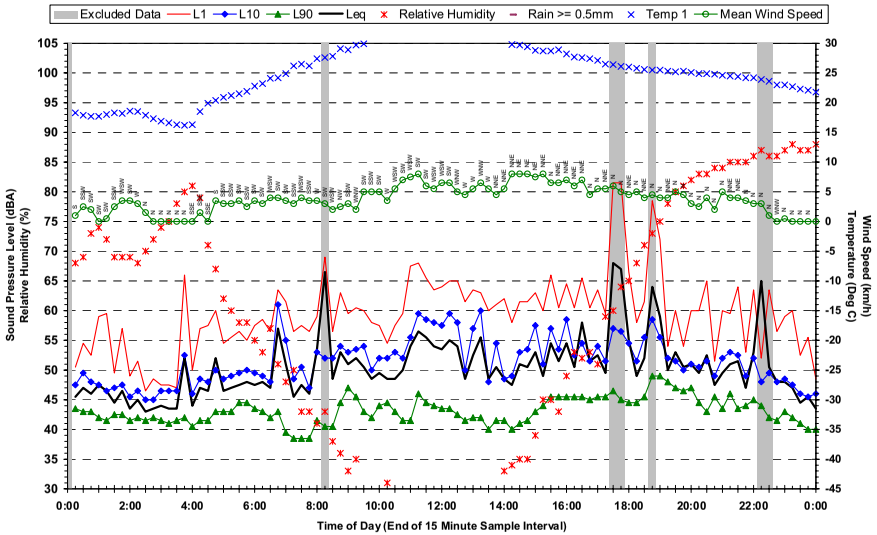
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Saturday 3 December 2005



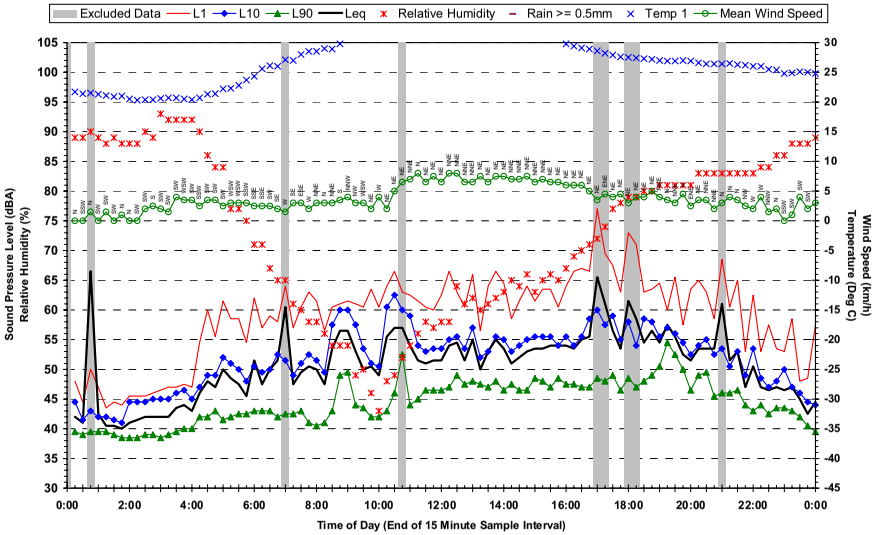
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Friday 2 December 2005



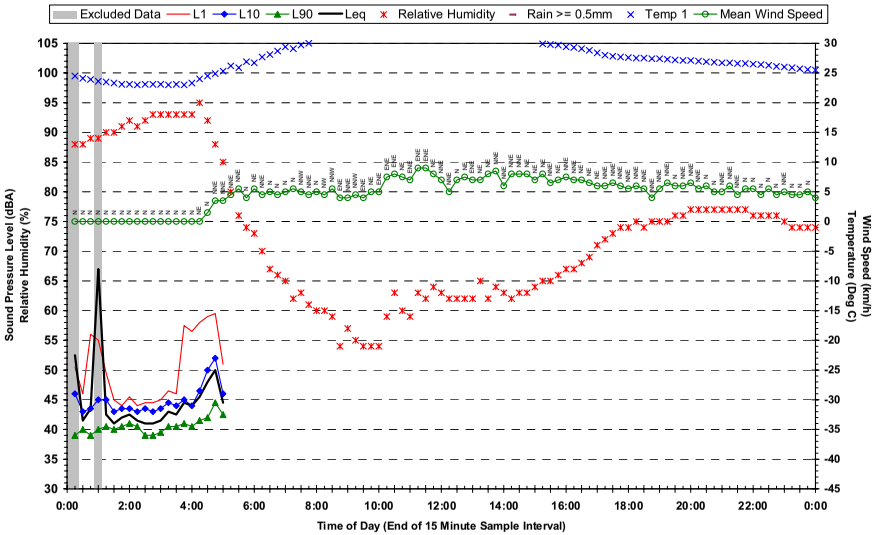
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Sunday 4 December 2005



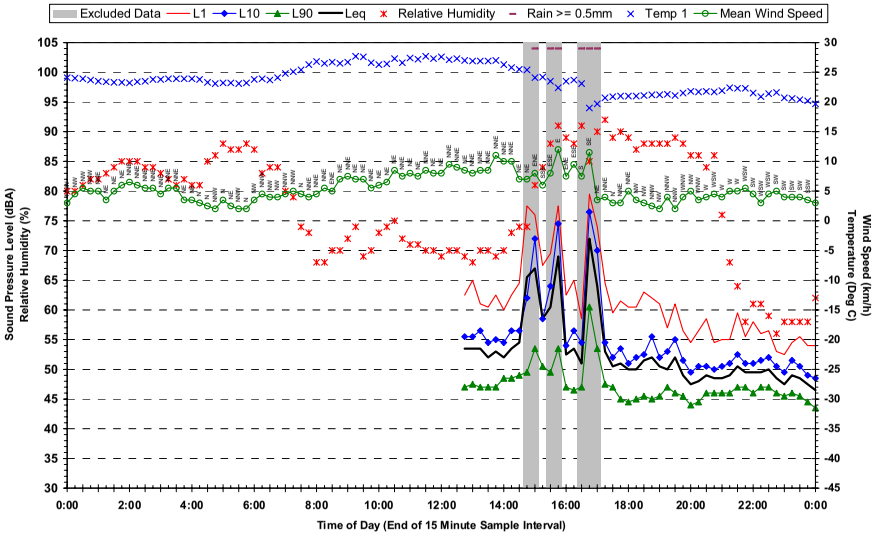
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Monday 5 December 2005



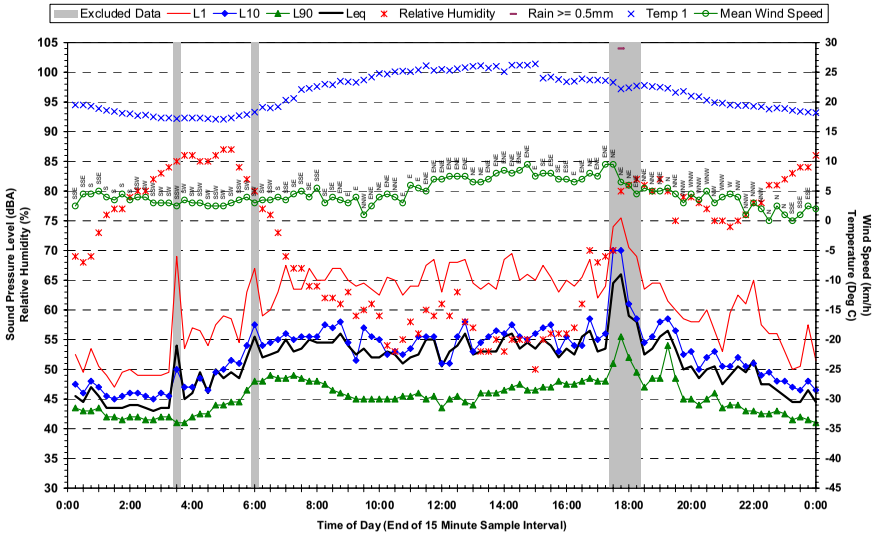
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Tuesday 6 December 2005



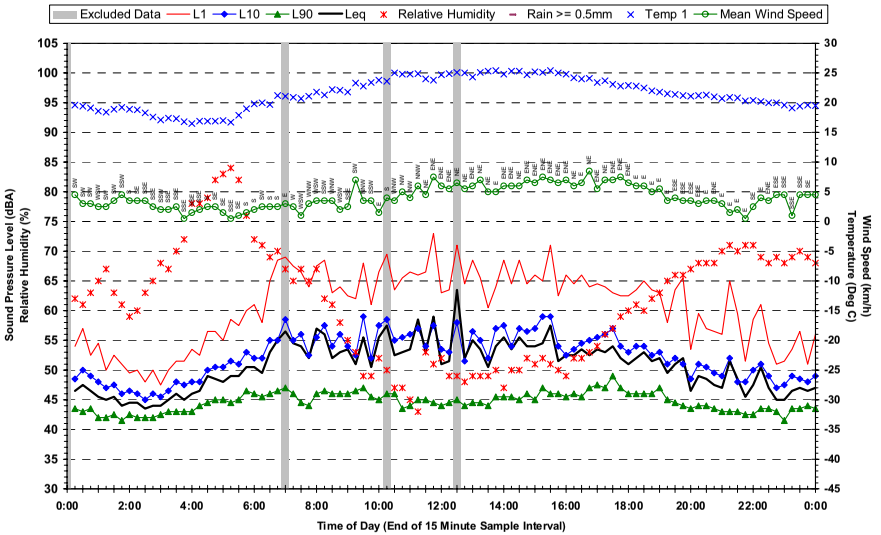
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Sunday 27 November 2005



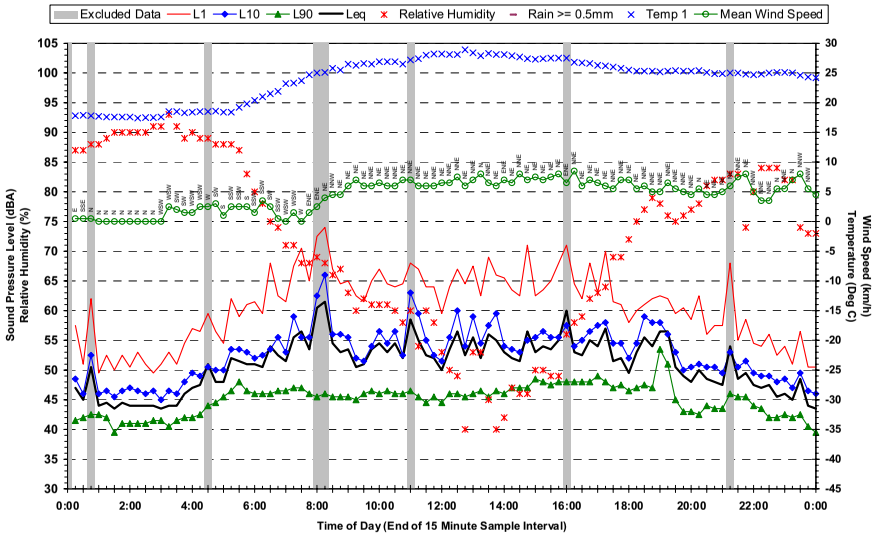
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Tuesday 29 November 2005



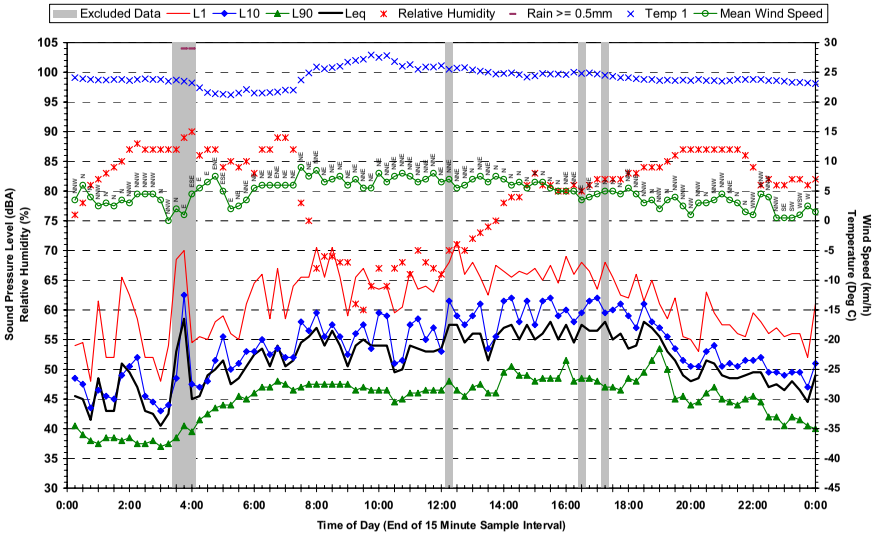
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Monday 28 November 2005



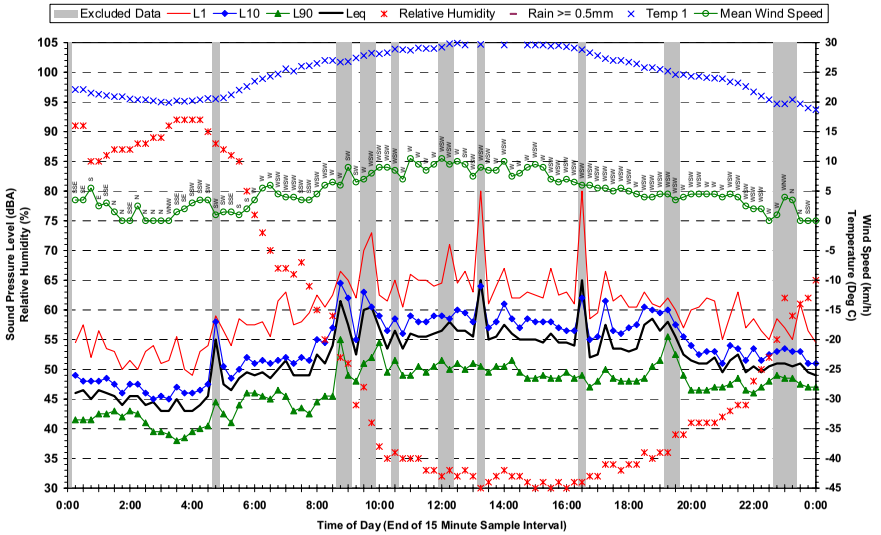
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Wednesday 30 November 2005



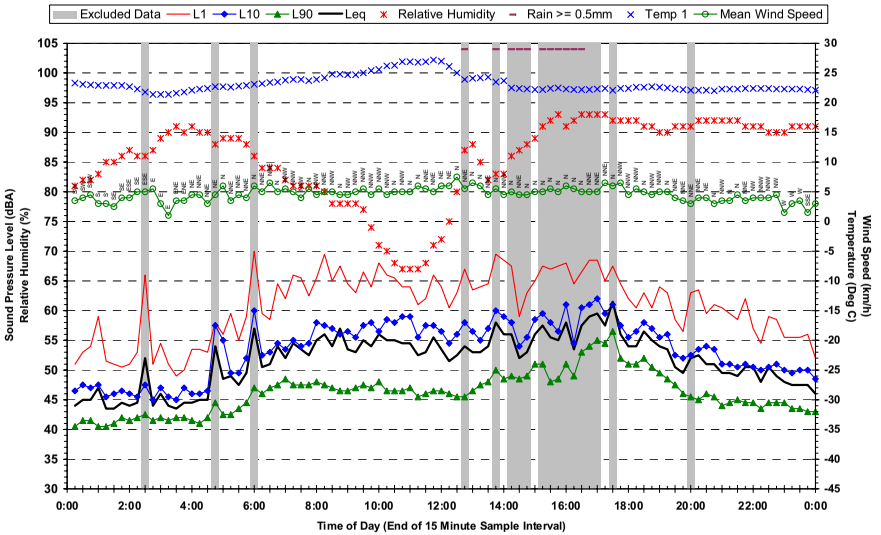
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Thursday 1 December 2005



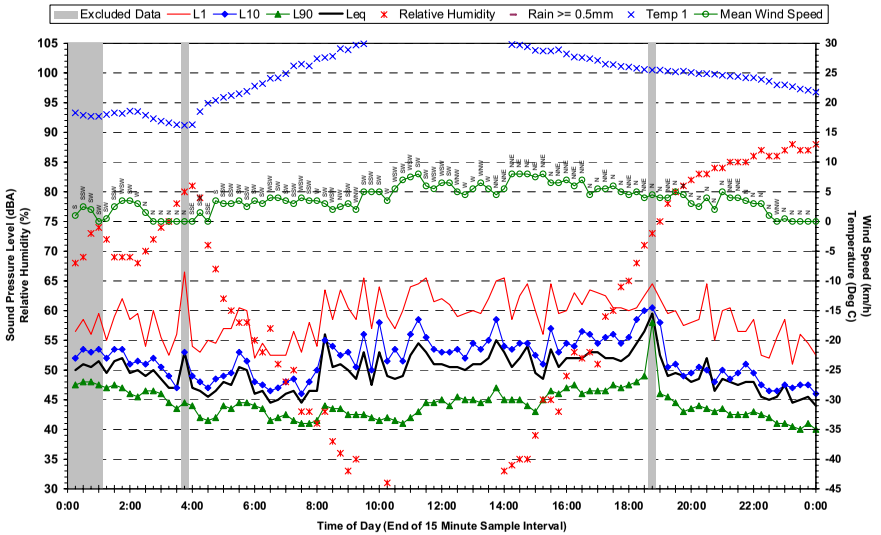
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Saturday 3 December 2005

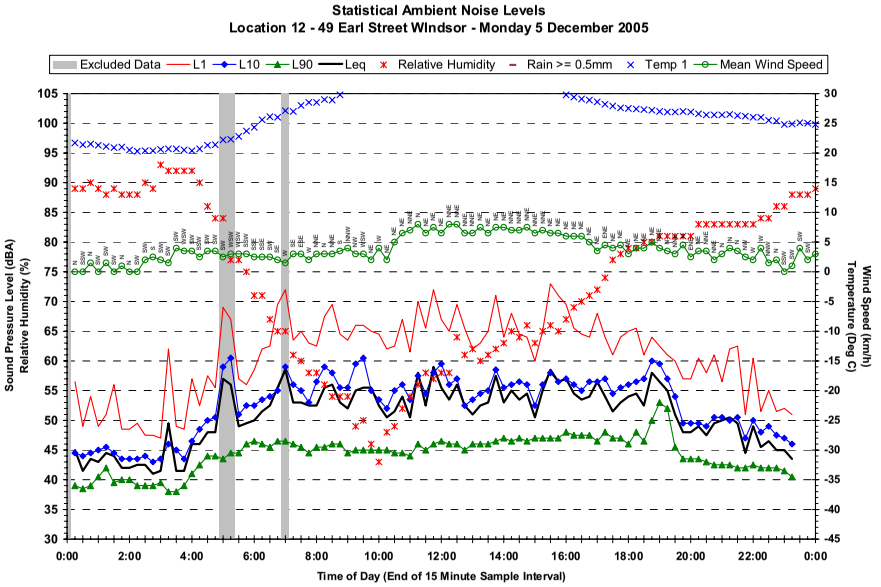


Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Friday 2 December 2005

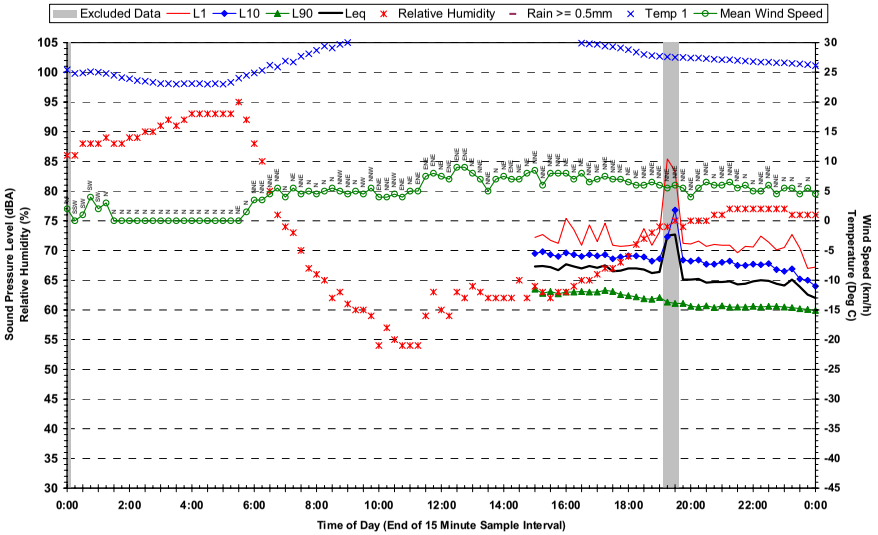


Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Sunday 4 December 2005

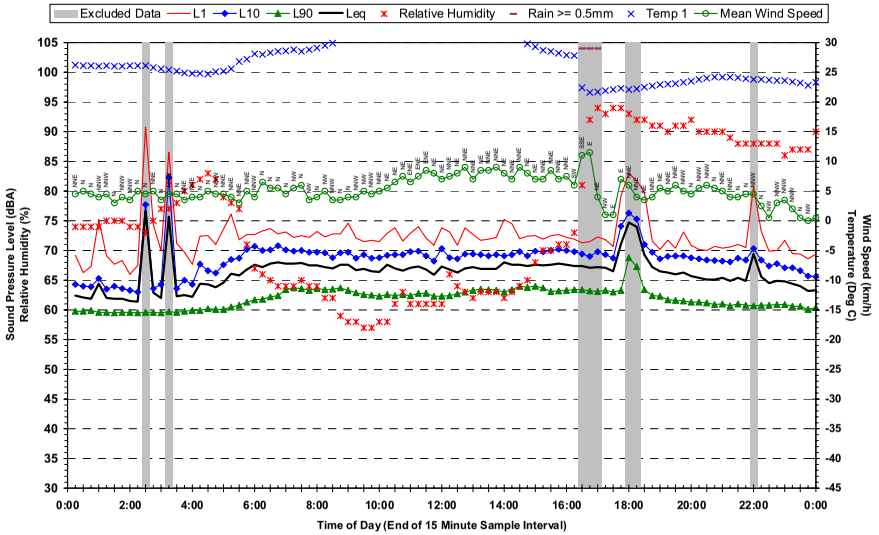



Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Monday 5 December 2005
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.5mm
Temp 1
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

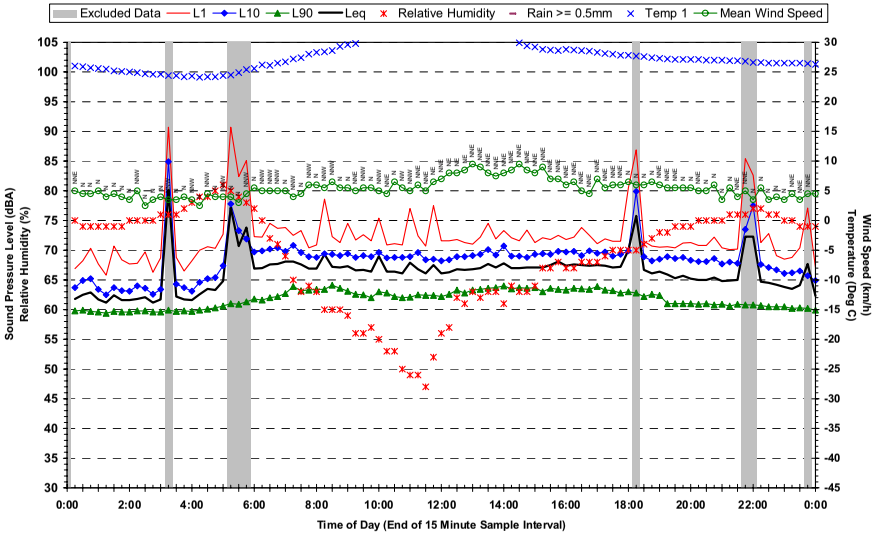
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Tuesday 6 December 2005



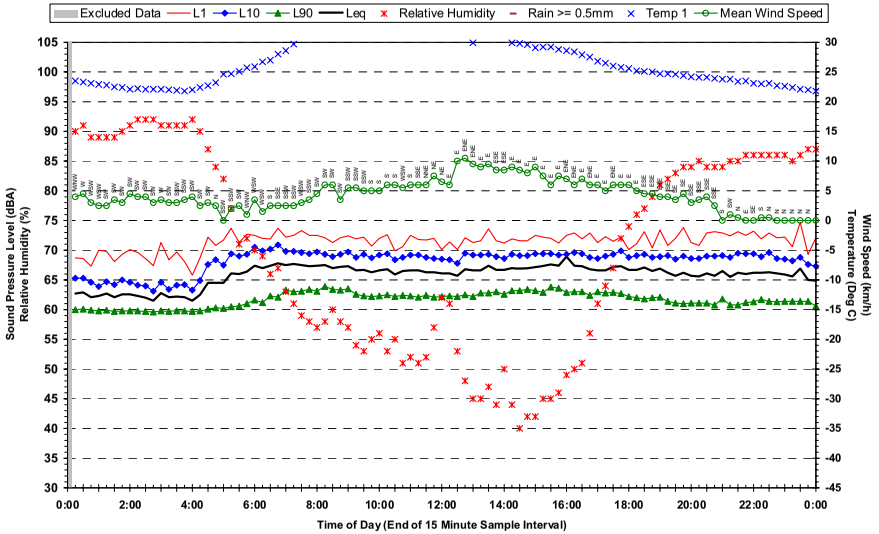
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Thursday 8 December 2005



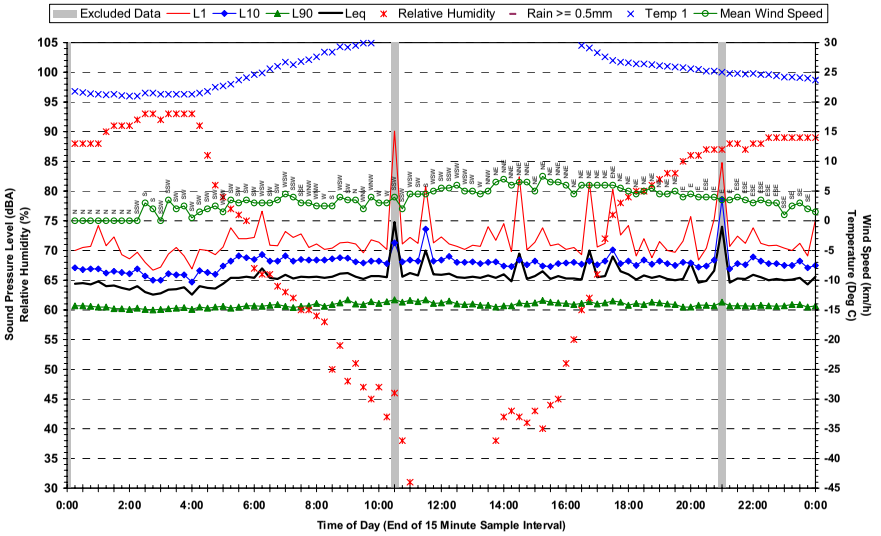
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Wednesday 7 December 2005



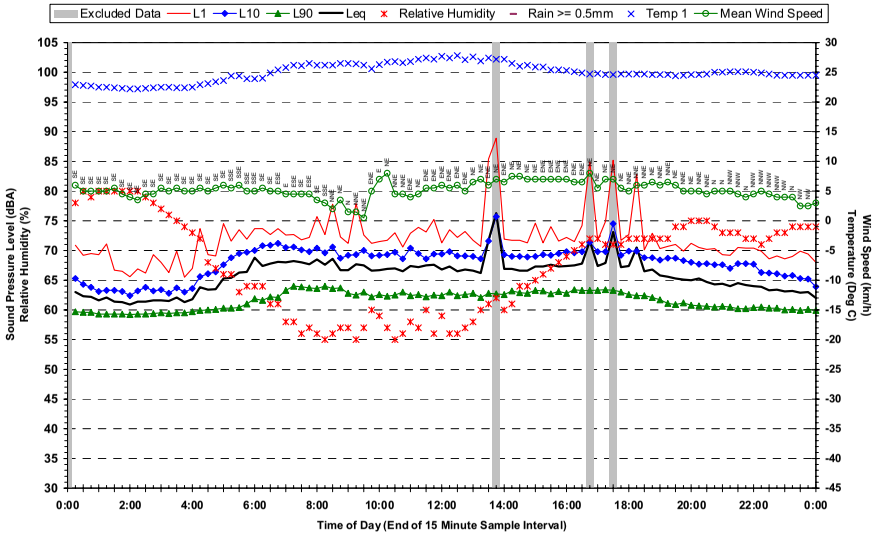
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Friday 9 December 2005



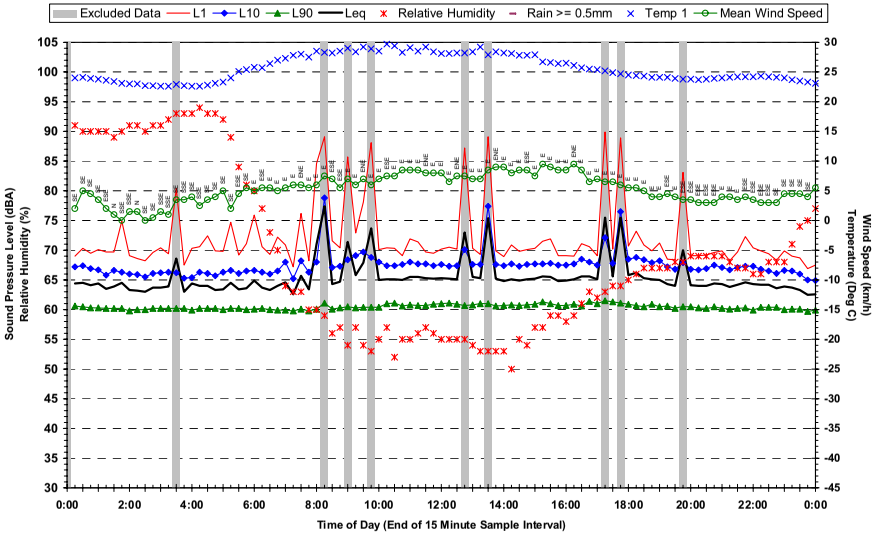
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Saturday 10 December 2005



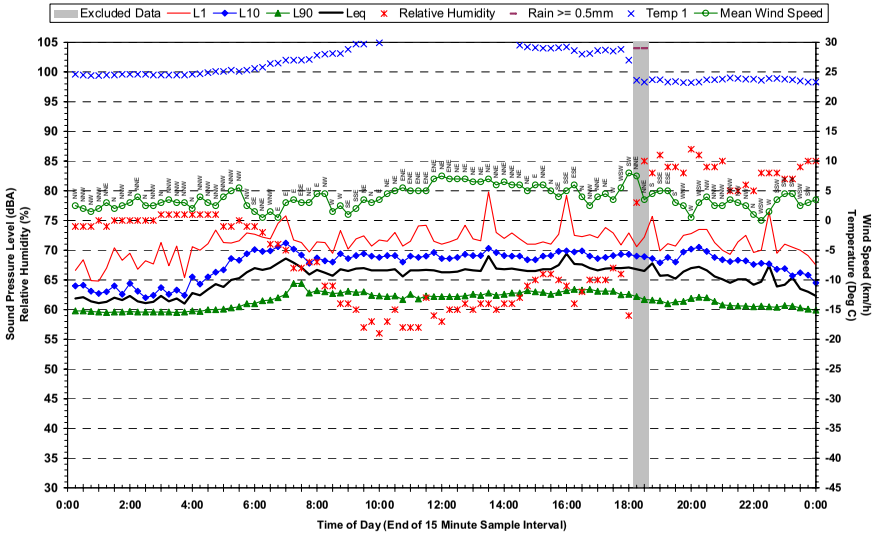
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Monday 12 December 2005



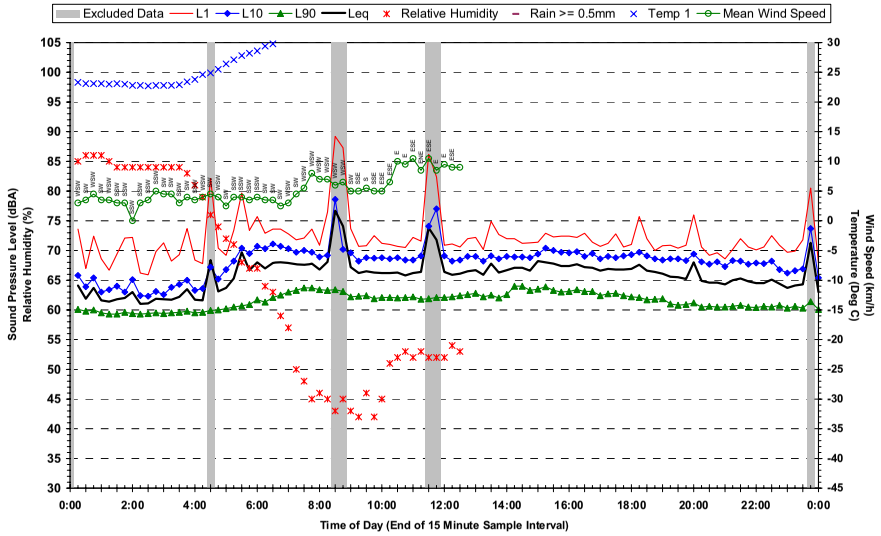
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Sunday 11 December 2005



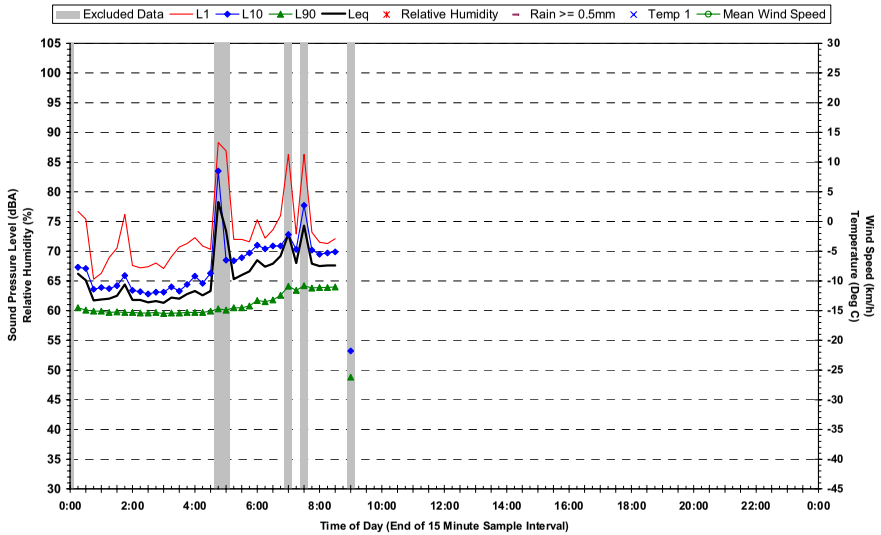
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Tuesday 13 December 2005



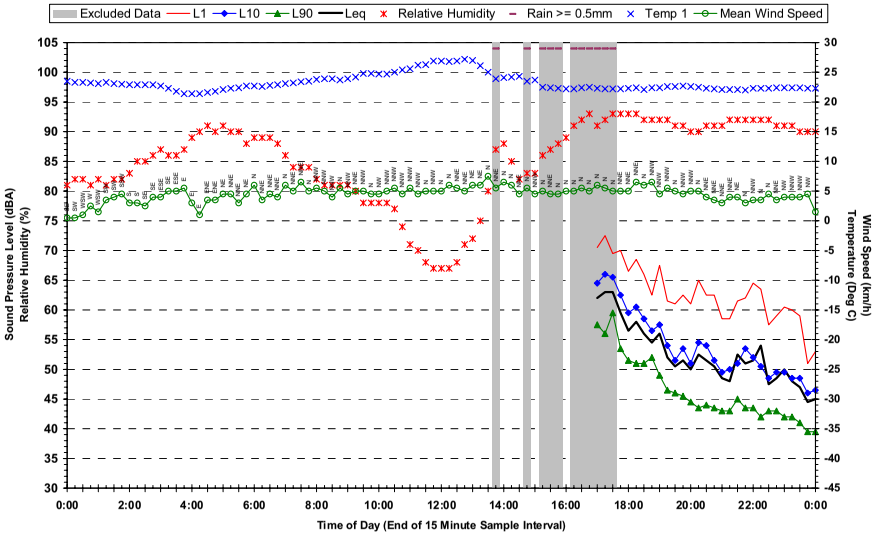
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Wednesday 14 December 2005



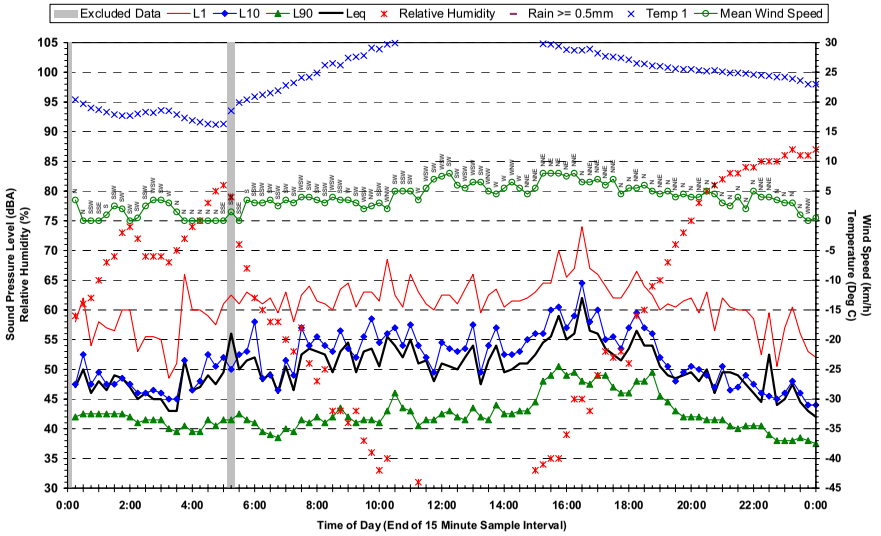
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Thursday 15 December 2005



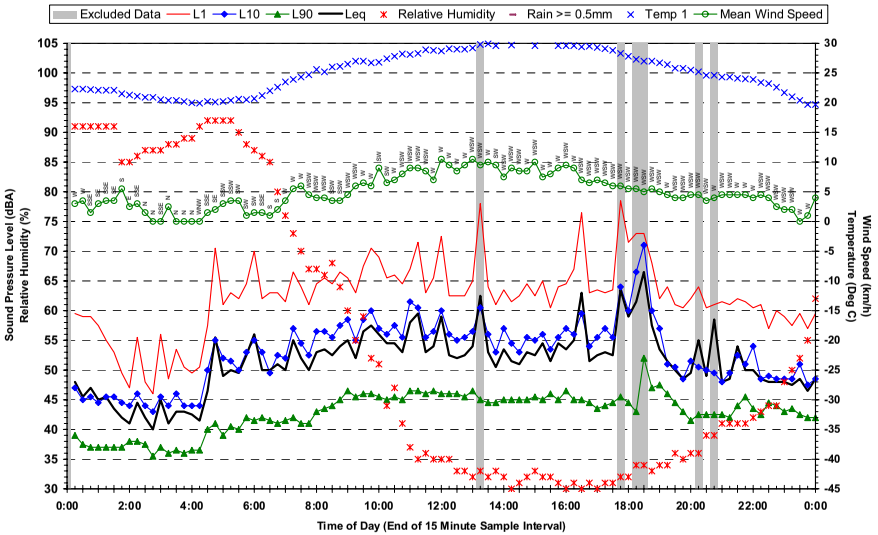
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Friday 2 December 2005



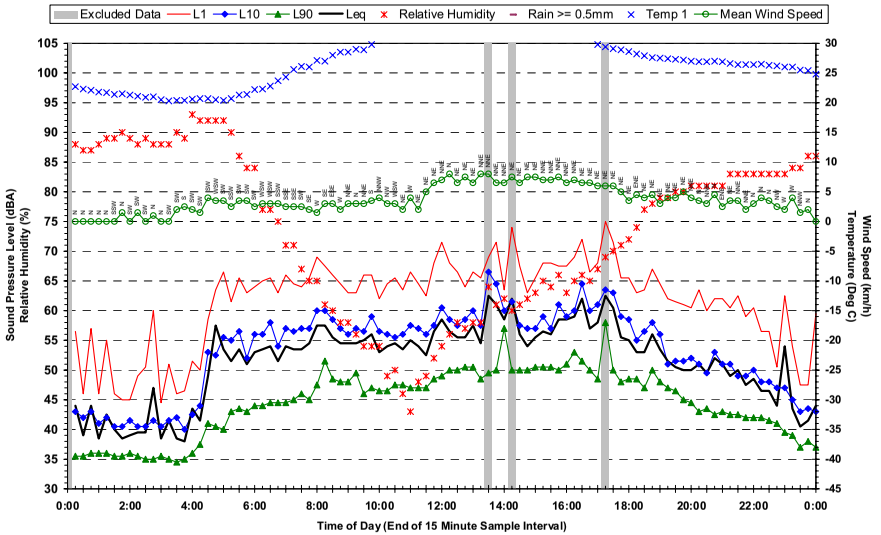
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Sunday 4 December 2005



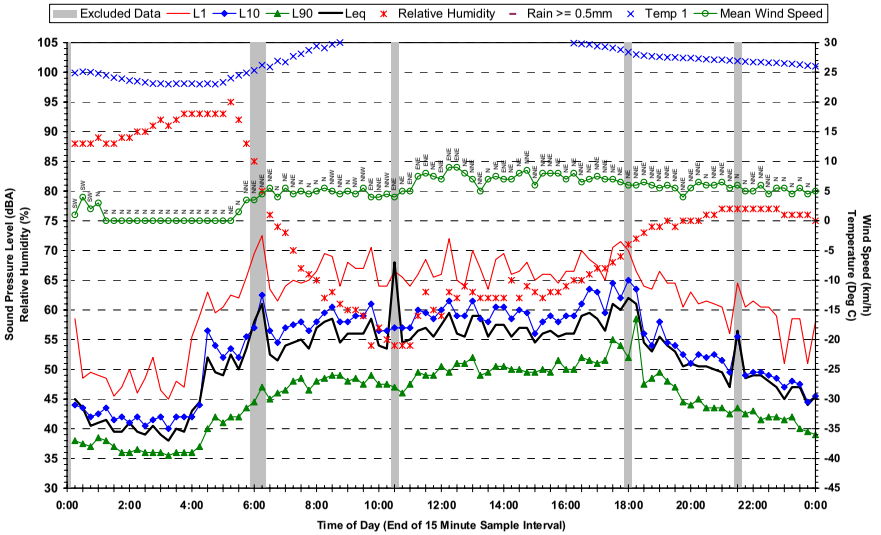
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Saturday 3 December 2005



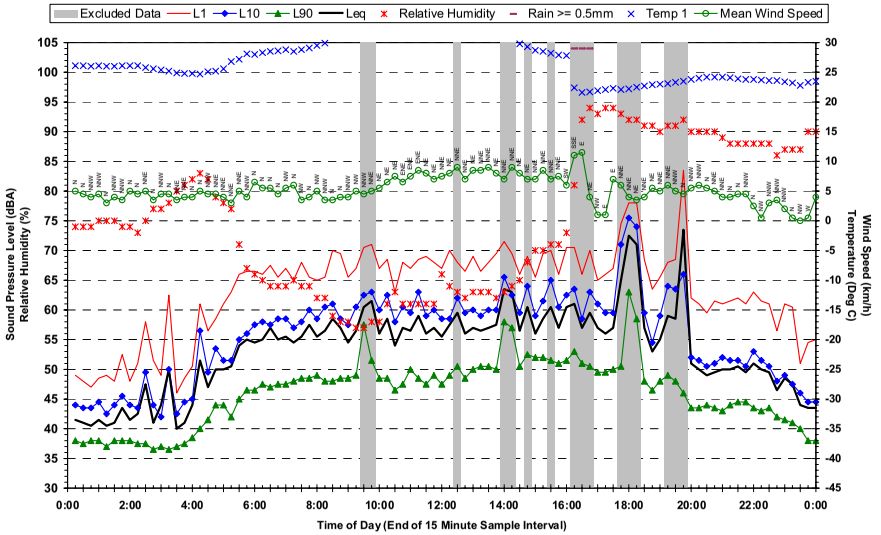
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Monday 5 December 2005



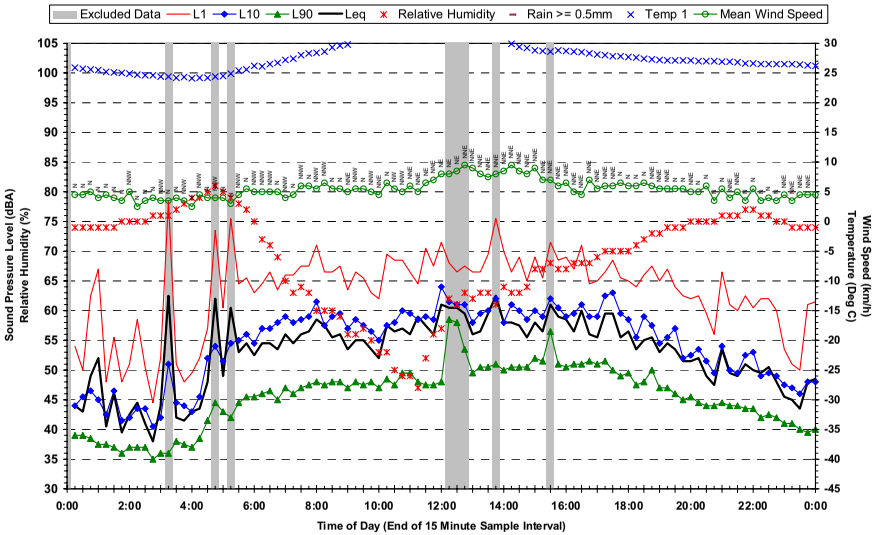
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Tuesday 6 December 2005



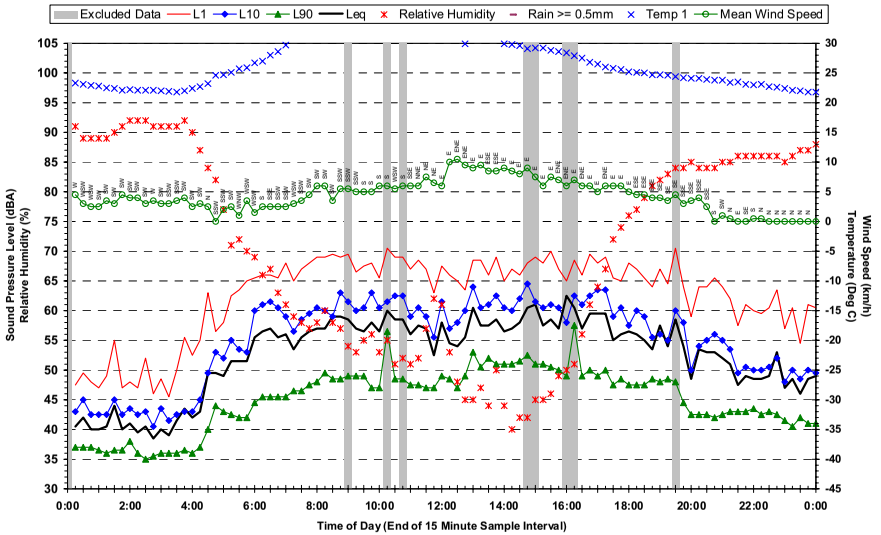
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Thursday 8 December 2005

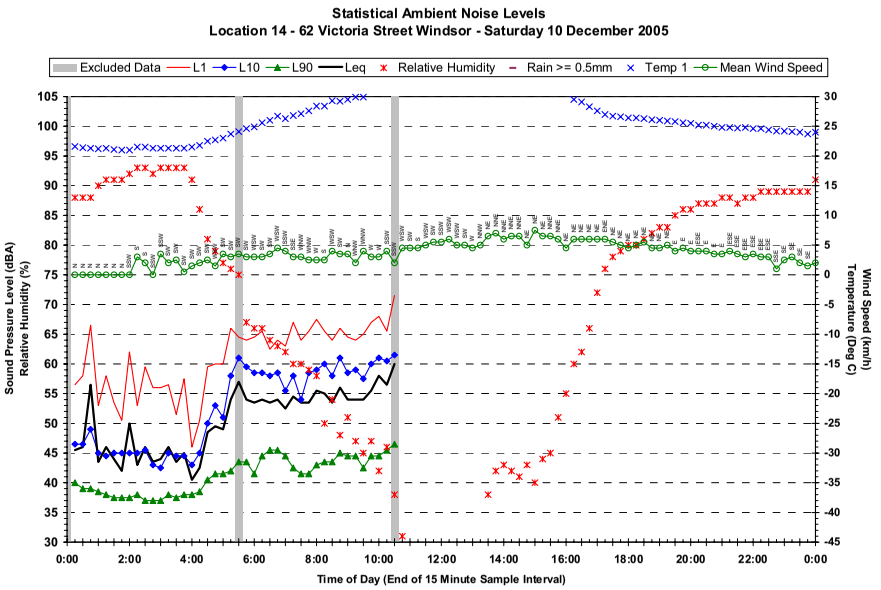


Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Wednesday 7 December 2005

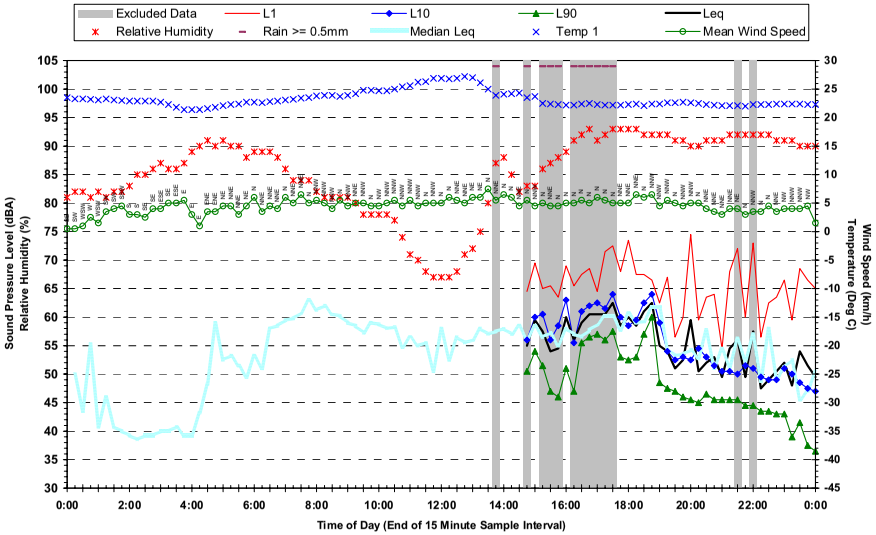


Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Friday 9 December 2005

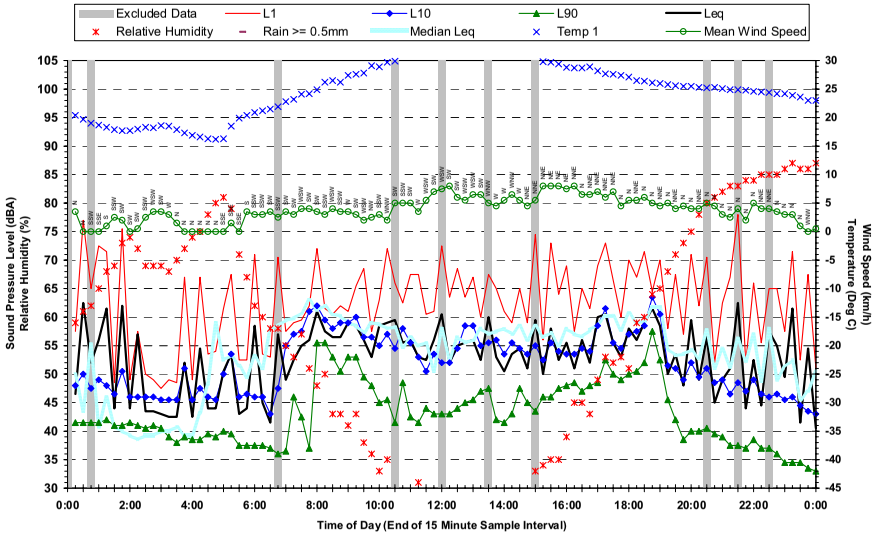



Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Saturday 10 December 2005
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.5mm
Temp 1
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
Location 15 - 42 Hooker Street Windsor - Friday 2 December 2005



Statistical Ambient Noise Levels
Location 15 - 42 Hooker Street Windsor - Sunday 4 December 2005



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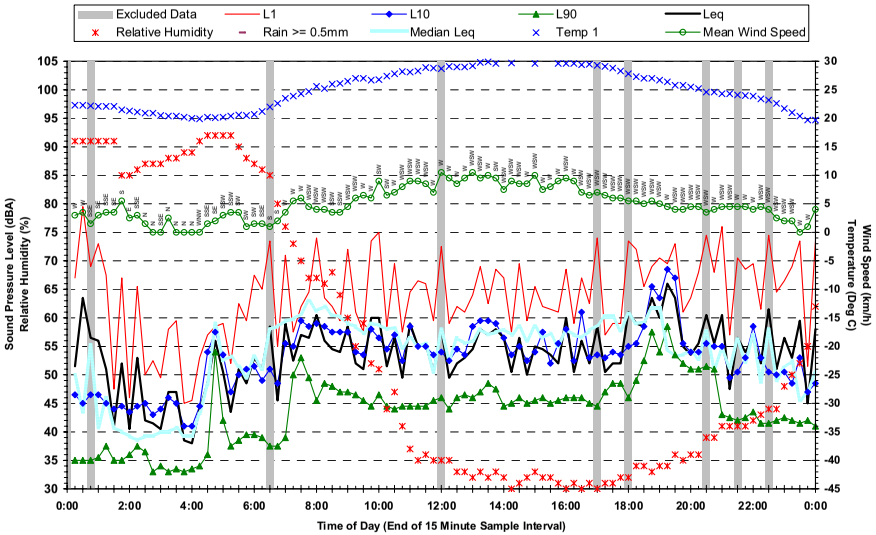

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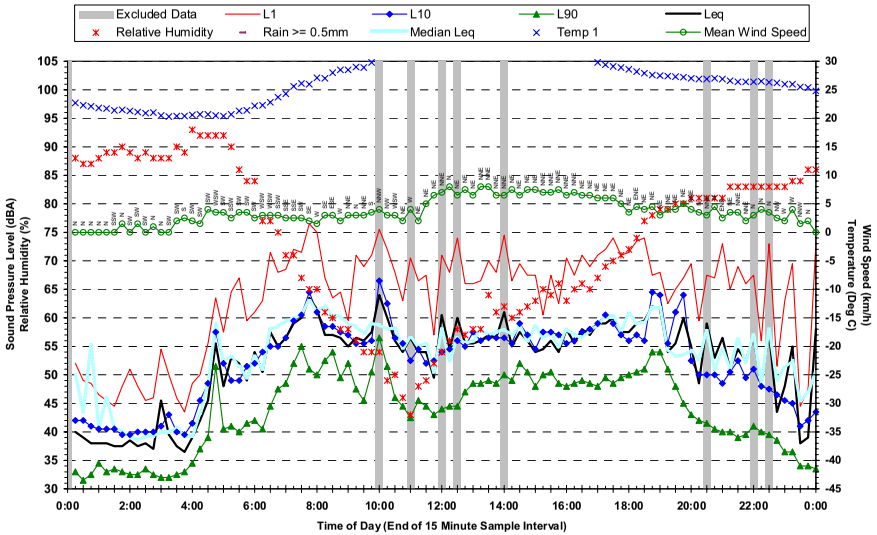

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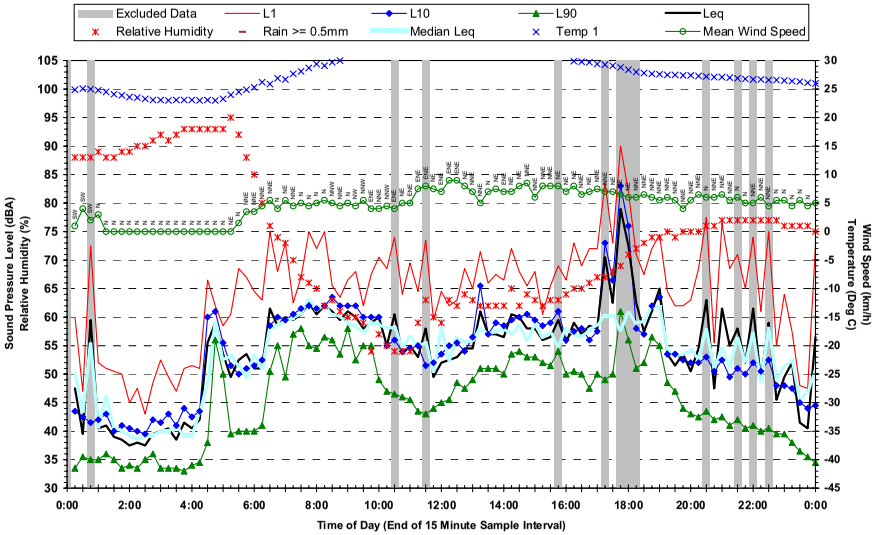

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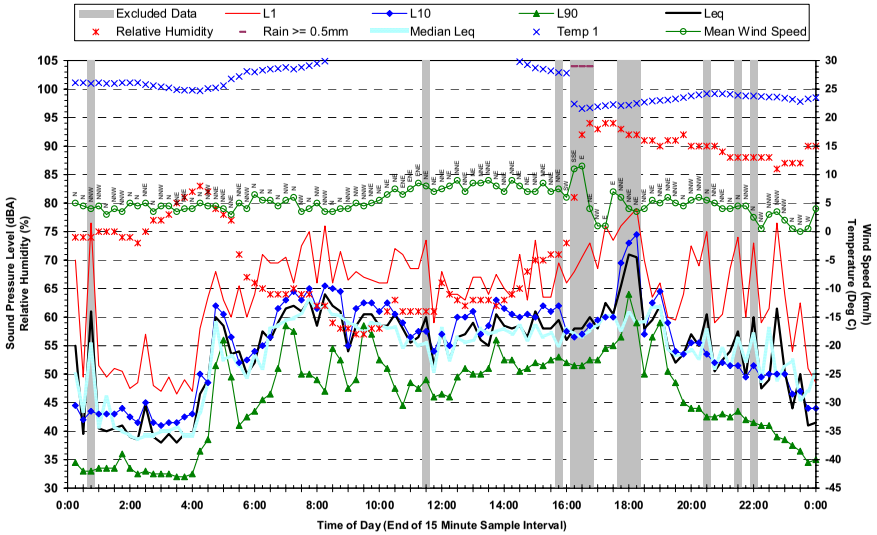

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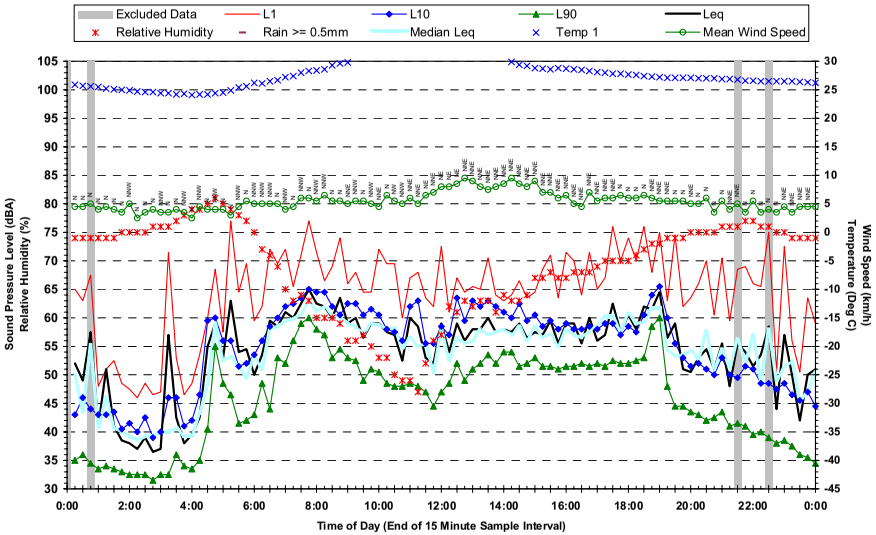

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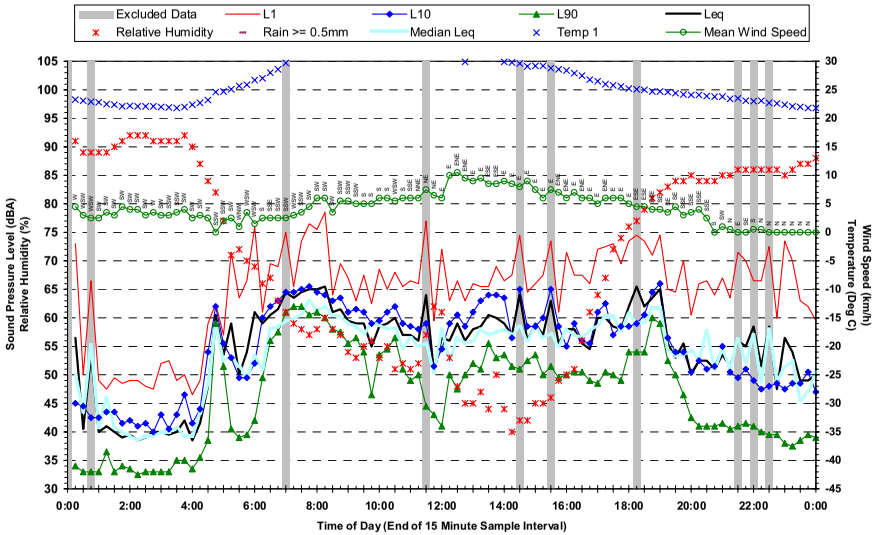

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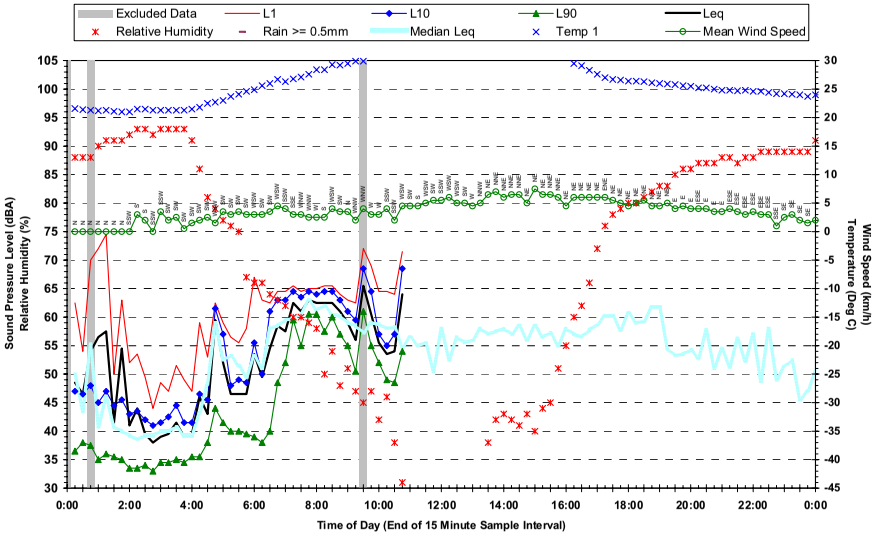

Statistical Ambient Noise Levels
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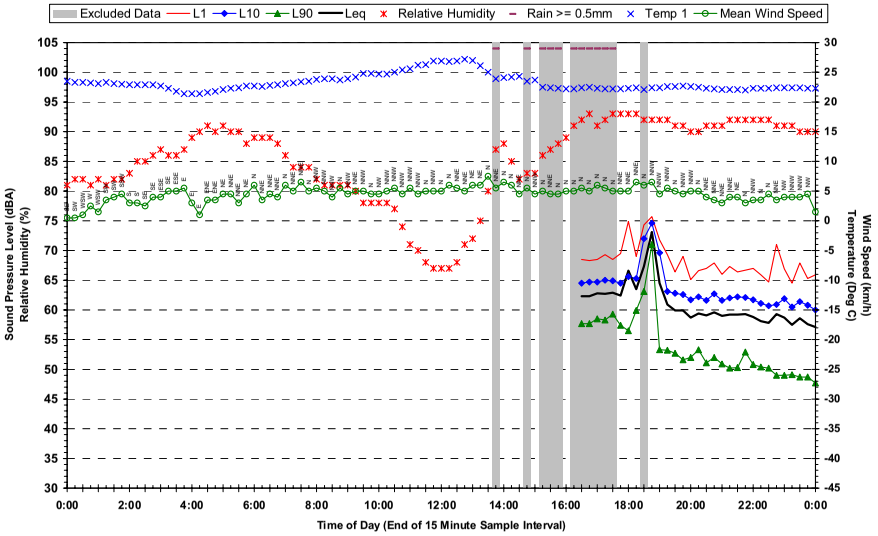

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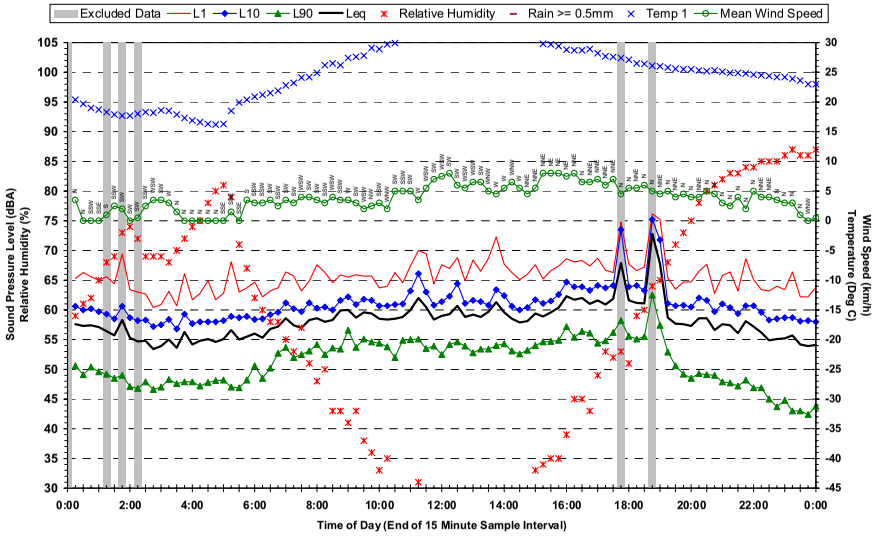

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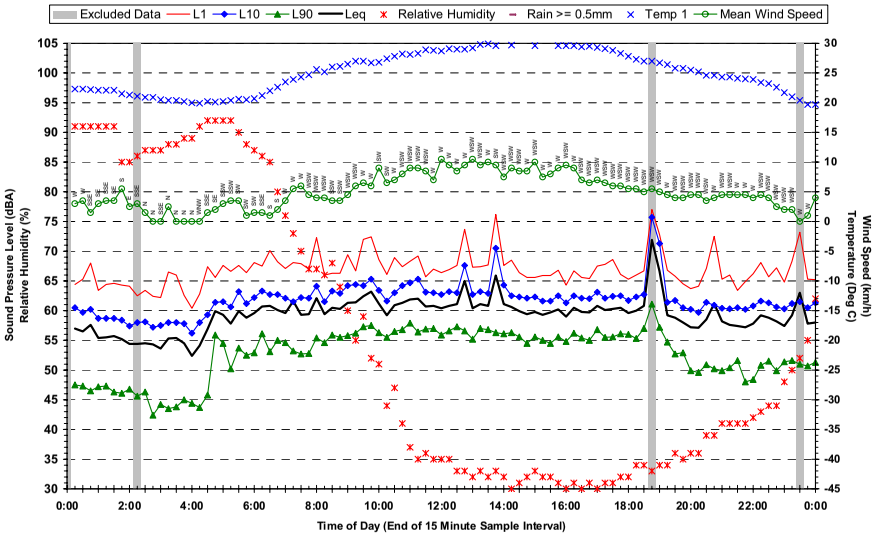

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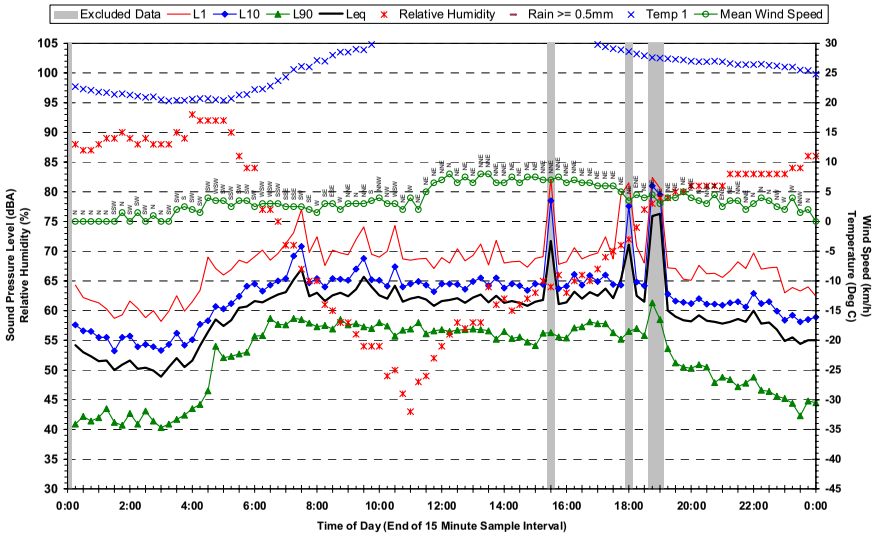

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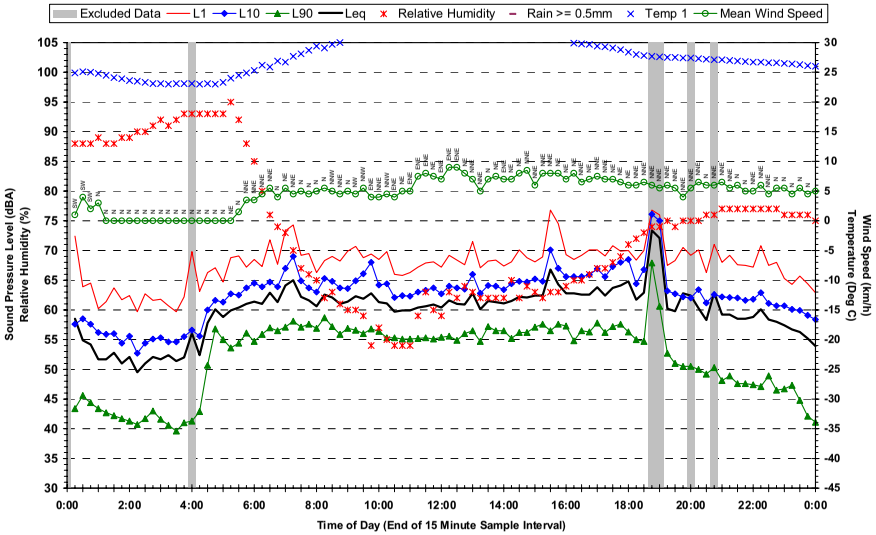
Location 16 - Nursing Home, 26 Palmer Street Windsor - Tuesday 6 December 2005



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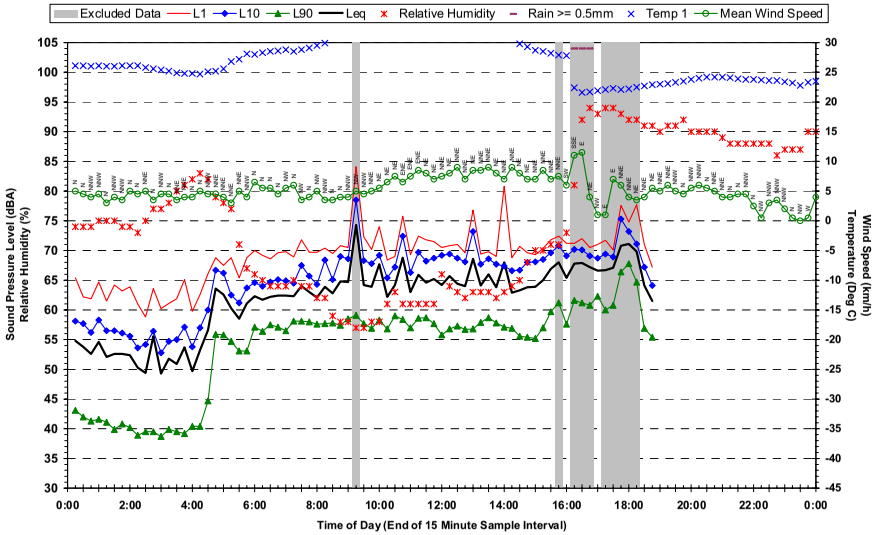

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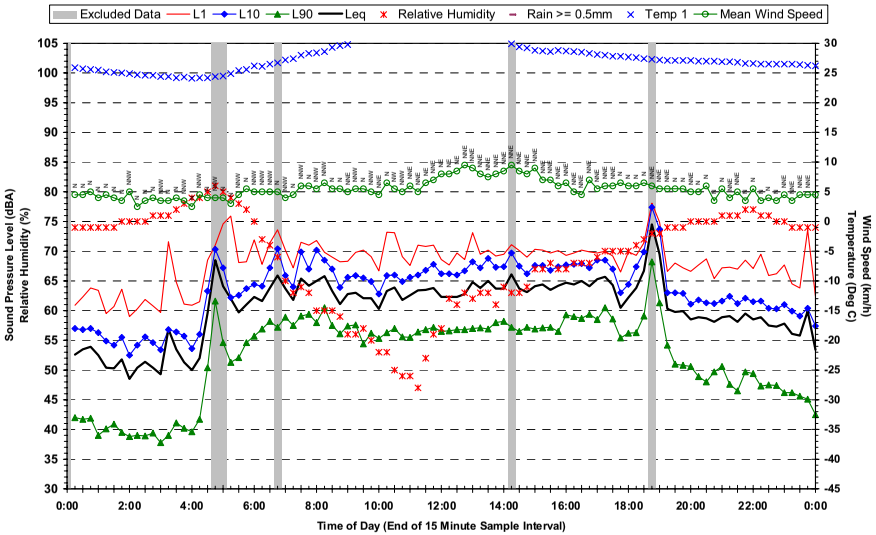
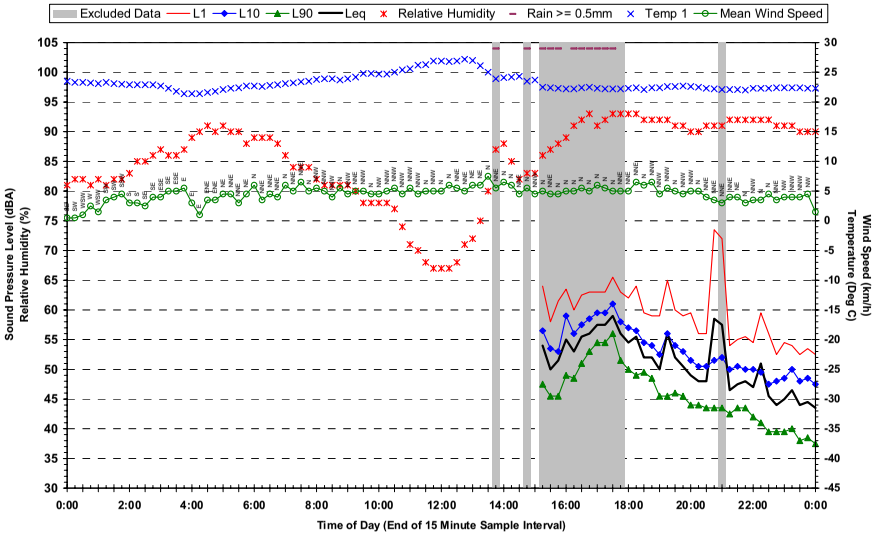


Statistical Ambient Noise Levels
Location 17 - 7 Lamington Avenue Lutwyche - Friday 2 December 2005



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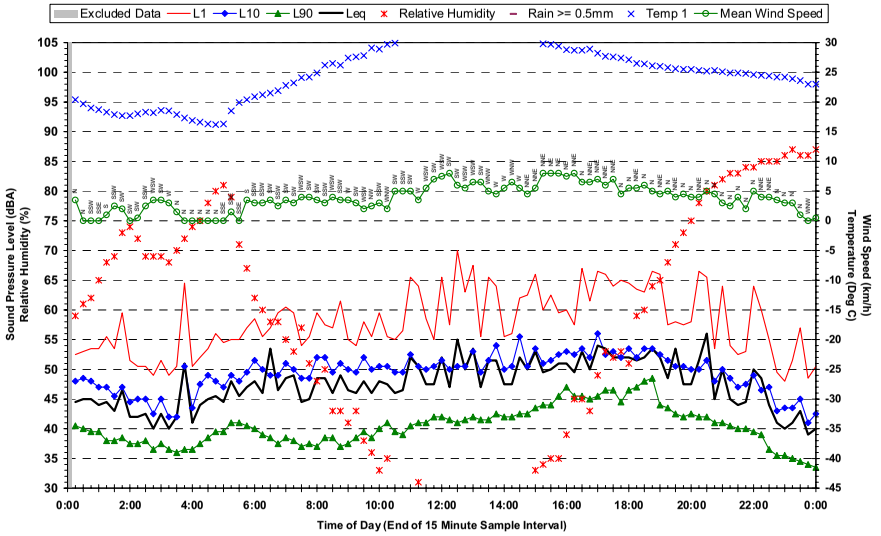

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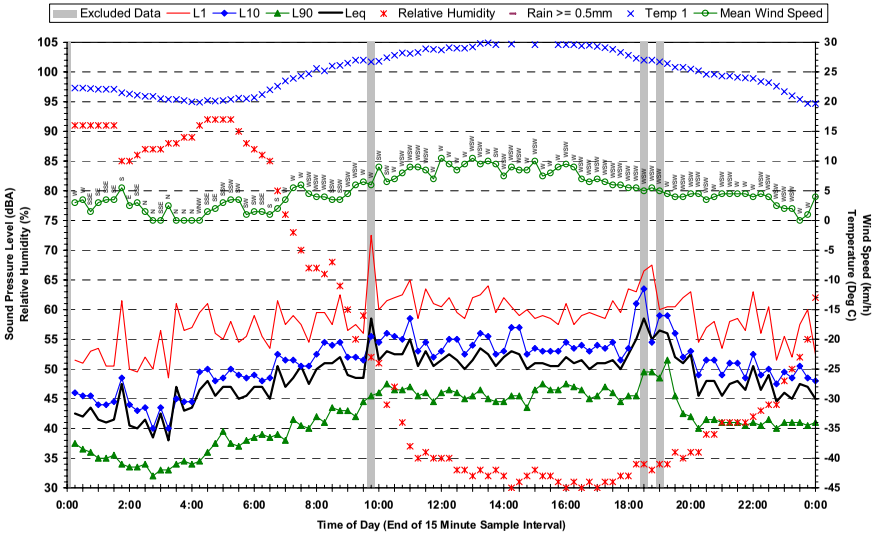

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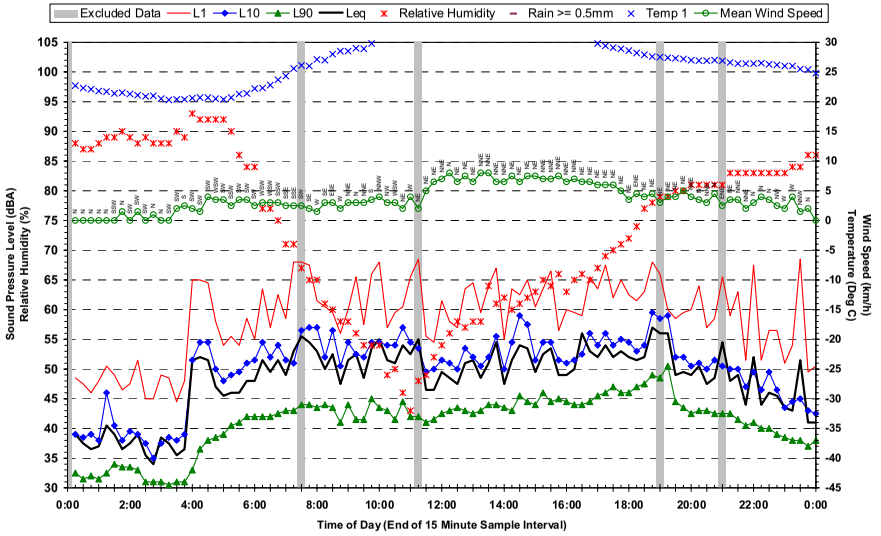
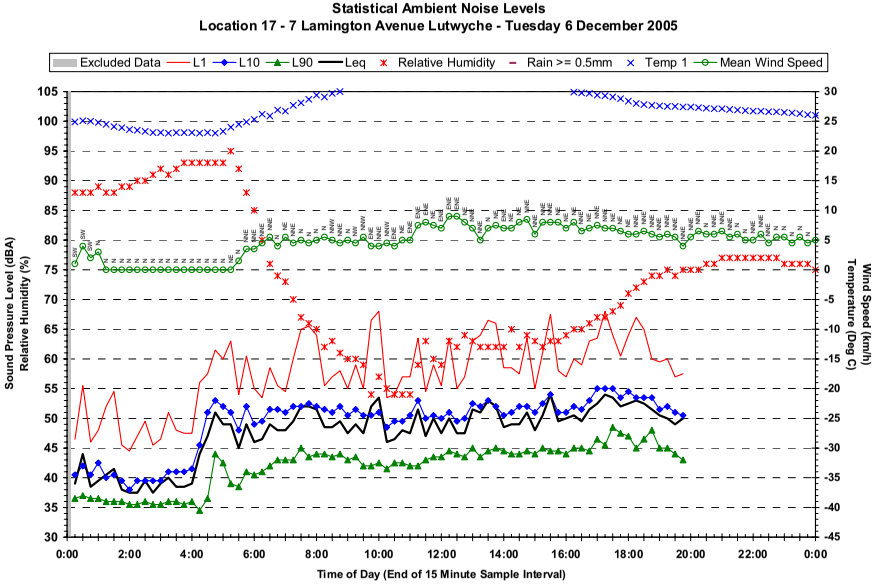
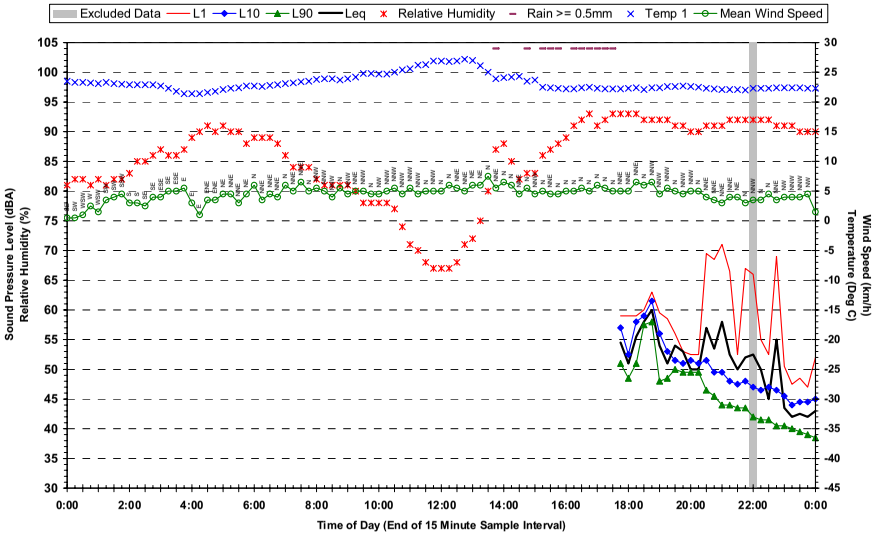



Statistical Ambient Noise Levels
Location 17 - 7 Lamington Avenue Lutwyche - Tuesday 6 December 2005
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.5mm
Temp 1
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
Location 18 - 16 East Street Lutwyche - Friday 2 December 2005



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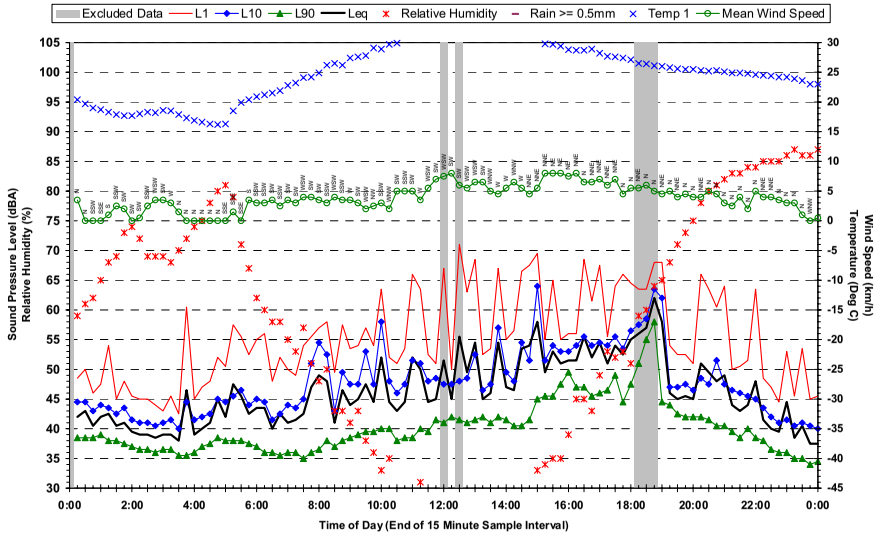

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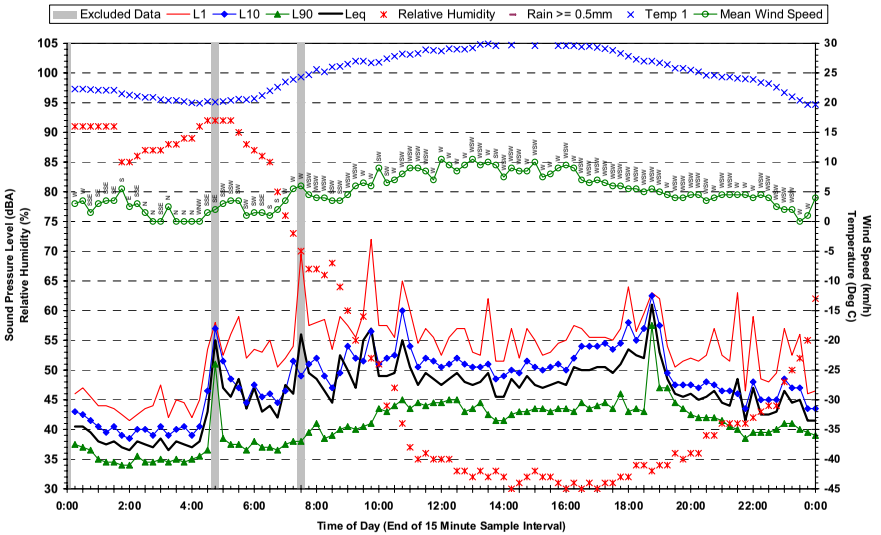

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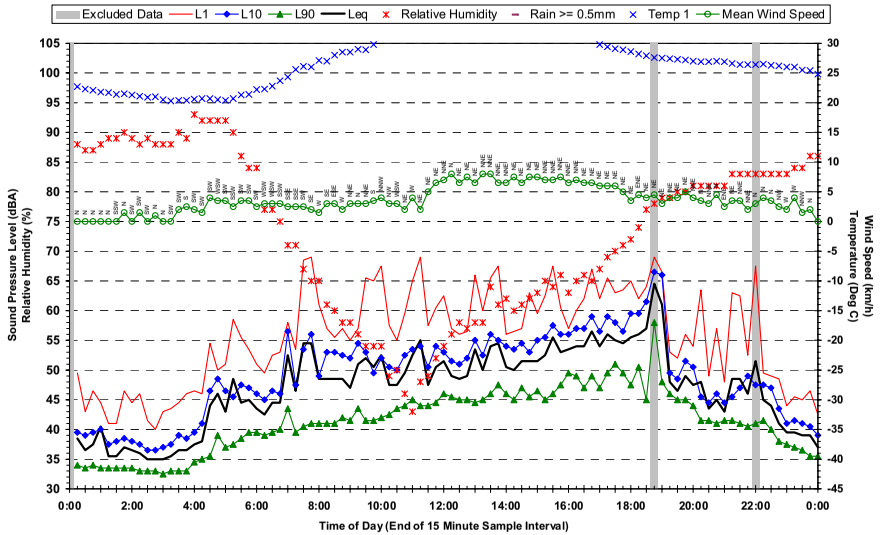

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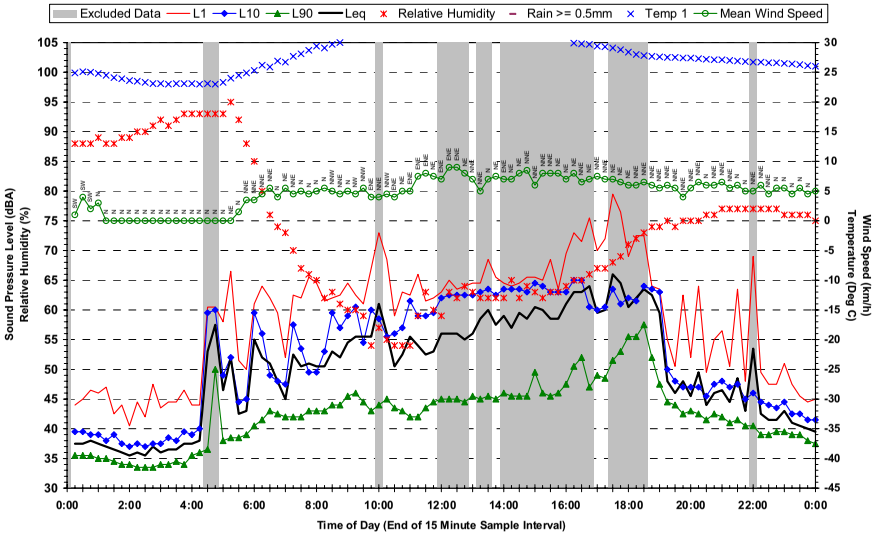
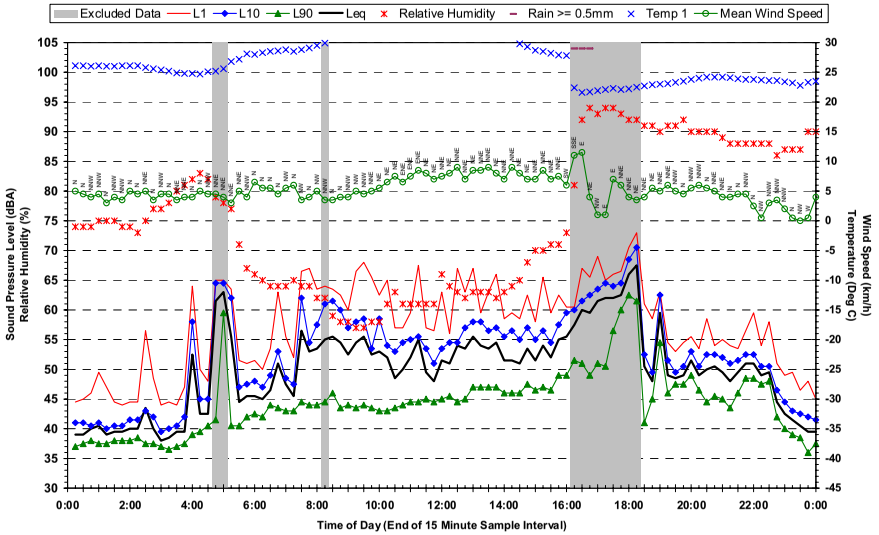


Statistical Ambient Noise Levels
Location 18 - 16 East Street Lutwyche - Thursday 8 December 2005



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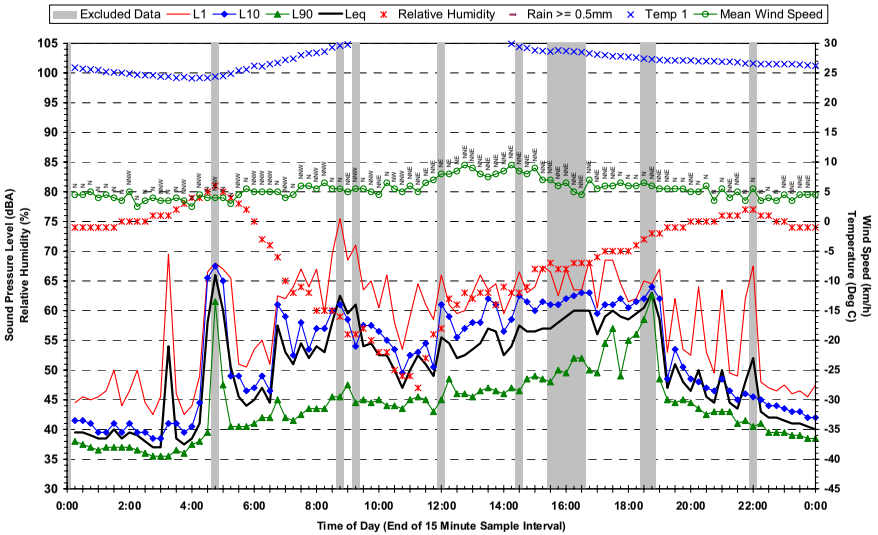

Statistical Ambient Noise Levels
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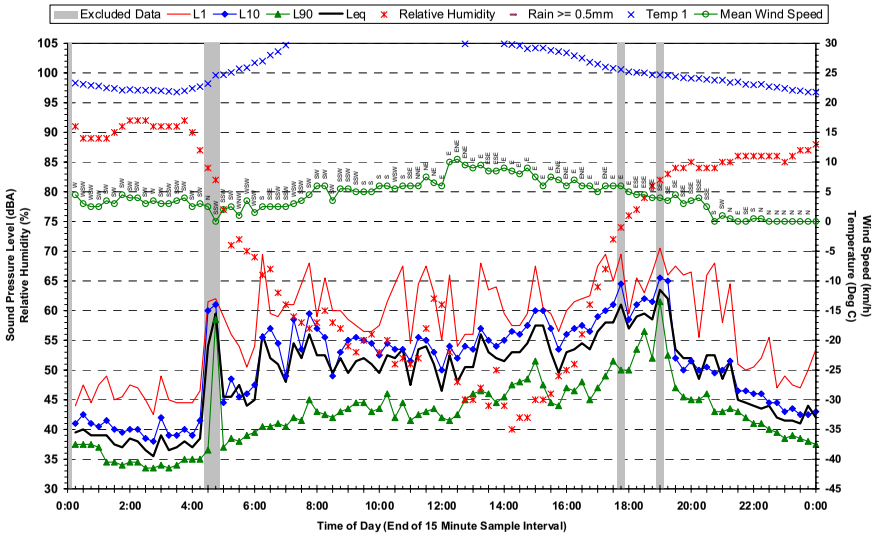

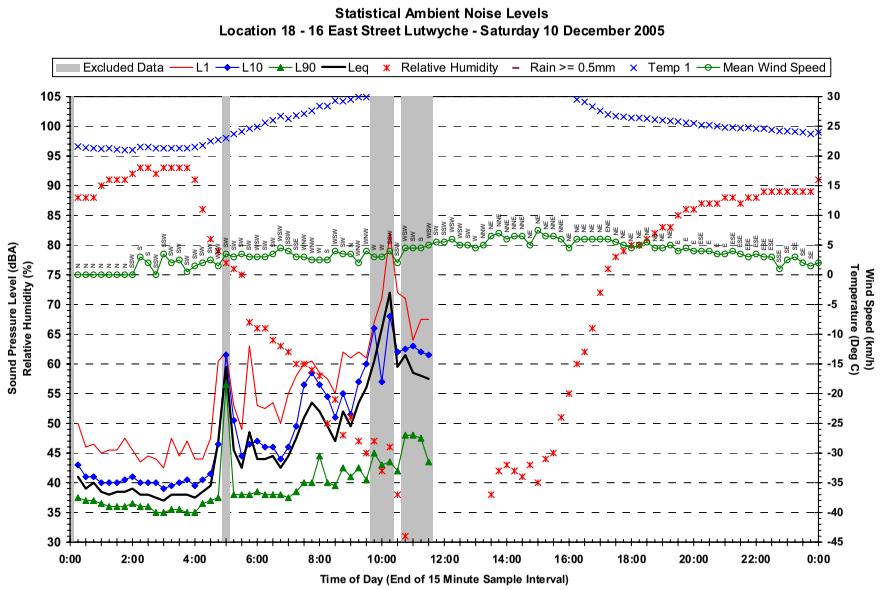
Statistical Ambient Noise Levels
Location 18 - 16 East Street Lutwyche - Saturday 10 December 2005
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.5mm
Temp 1
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

REPORT 20-1605R4D2

Airport Link

Environmental Impact Statement

Operational Noise & Vibration

PREPARED FOR

SKM Connell Wagner Joint Venture

10 JULY 2006

EXECUTIVE SUMMARY

General

This analysis of noise and vibration impacts associated with the operational phase of the Airport Link project has been prepared based on a number of design parameters supplied by the SKM Connell Wagner Joint Venture. The analysis is intended to provide a practical and specific understanding of the potential impacts, and the range of mitigation measures that may be necessary to address any impacts.

Criteria

For noise from activities described as "beneficial assets" (particularly roads, railways and airports), the EPP[Noise] specifies "planning levels" for noise sensitive locations (eg residences, educational and health care facilities) which "may be used as a guide'' when assessing the noise levels from an activity.

The planning levels for a Public Road are:

1. For a State-controlled road - 68 dBA $L_{A10(18hour)}$;
2. For all other public roads - 63 dBA $L_{A10(18hour)}$;
3. 60 dBA, assessed as the highest 1 hour equivalent continuous A-weighted sound pressure level between 10 pm and 6 am (60 dBA $L_{Aeq(1hour)}$); and
4. 80 dBA assessed as a single event maximum sound pressure level (80 dBA L_{Amax}).

The Main Roads document *Road Traffic Noise Management: Code of Practice,* provides details for the assessment of road traffic noise for Declared Roads (ie to State-controlled roads). Different criteria and priorities apply dependent on the road type (new or existing access/non-access controlled roads) and to receiver/land usage type (residential, educational and health, or parks and other recreational facilities).

For this project, surface works on Gympie Rd (north of Kedron Brook) and the East West Arterial (east of Sandgate Rd) associated with the tunnel are in state controlled road corridors and would be regarded as upgrading of the existing road network (in accordance with the Code of Practice).

Noise Environment

A record of existing noise levels provides a baseline for assessment of potential noise emissions associated with construction and operational phases of the tunnel.

The aspects of the tunnel infrastructure that are of particular interest in respect of the existing noise environment are those areas in the vicinity of:-

- Construction sites,
- Ventilation Outlets, and
- Tunnel portals and entry/exit roadways.

The existing noise environment will be utilised to assist in the development of criteria for the assessment of noise impacts associated with the project, and be used to determine the reasonableness of providing noise control measures, where the base noise objectives are exceeded.

Road Traffic Noise Local to Tunnel Portals

The EPP[Noise] identifies Planning Levels for traffic noise emissions from roadways, but does not specify what actions should be carried out in response to road developments that may result in exceedances of Planning Levels.

For this project, the Planning Levels from the EPP[Noise] are generally already equalled or substantially exceeded at residential facades facing the major roads that connect to the tunnel.

EXECUTIVE SUMMARY

The Interim Northern Busway, a Queensland Transport project also utilising the Bowen Bridge Rd /Lutwyche Rd corridor, is expected to be completed in 2022, thus for this report, the following situations have been modelled in accordance with the ToR:

- **Do minimum (2022)**: The predictions include all future (ie 2022) traffic utilising the existing road corridor, excluding the Airport Link and the Northern Busway projects. This scenario represents the future traffic that would have arisen in the absence of these major transport initiatives, and represents the baseline noise projections against which some of the other scenarios are compared;
- **Airport Link without Interim Northern Busway (2022)** - traffic flows including Airport Link, but excluding the Interim Northern Busway project. This scenario represents the change in traffic noise, attributable directly to the Airport Link project; and
- **Airport Link with Interim Northern Busway (2022)** - traffic flows including Airport Link and the Interim Northern Busway projects.

The Ultimate Northern busway design, (where the bus lanes are mostly in a tunnel along Bowen Bridge Rd and Lutwyche Rd) is expected to be completed in 2026. In accordance with usual practice, the acoustic design year would consequently be 2036. Heggies has been informed that traffic modelling is not reliable for a 30 year design. Thus, for the Ultimate Northern Busway scenarios, the assessment has been undertaken for the year of opening (ie 2026). As the Ultimate Northern Busway project develops in coming years, further environmental assessments will need to be undertaken to confirm the levels of impact (either positive or negative) presented in this report. At this time it may be more reasonable and feasible to assess the predicted traffic noise levels in 2036 (10 years after opening). Thus, for the assessment involving the Ultimate Northern Busway, the scenarios identified above are replicated using 2026 traffic data.

Two noise barrier designs have been undertaken for the Airport Link scenarios, with and without Interim/Ultimate Northern Busway, as outlined below.

"Status Quo" Noise Barrier Option

The objective used to develop the "status quo" barrier option for the 2 design years (2022 and 2026) is to develop road-side noise barriers, where practical and feasible, to achieve traffic noise levels comparable to the "Do Minimum" option.

"Planning Level" Noise Barrier Option

The objective used to develop the "planning level" barrier option for the 2 design years (2022 and 2026) is to develop road-side noise barriers, where practical and feasible, to limit traffic noise levels to the 63 dBA or 68 dBA (as applicable) $L_{A10(18hr)}$ planning levels wherever possible.

The purpose of this option is to illustrate the scale of noise controls that would be necessary to achieve the "planning" traffic noise levels in accordance with the EPP[Noise] and Code of Practice. In many areas this would require noise controls to account for gradual increases in traffic noise over time that are not attributable to the tunnel.

In general, noise mitigation should be designed for compliance with the relevant planning levels (ie $L_{A10(18hour)}$ levels of 63/68 dBA) . Where this cannot be achieved, the barrier design should then examine the feasibility and reasonableness of maintaining the "status-quo".

In all areas it is considered that the recommended noise control options in this report represent a starting point for discussions between key stake-holders.

Southern Connection

Noise mitigation to achieve the "63 dBA criterion" where reasonable and feasible is shown in **Appendix J4, J7, J11** and **J14** (for the Airport Link without Interim Northern Busway (2022), Airport Link with Interim Busway (2022), Airport Link without Ultimate Busway (2026) and Airport Link with Ultimate Busway (2026). It should be noted that south of Enoggera Creek, compliance with the 63 dBA criterion was not always feasible, particularly at the Mews Apartments, Tufton Street apartments and Wren Street properties, due to the impractical height the barriers would need to be to achieve the "planning" level. Consequently, at these locations, the barrier design aims to achieve the status quo levels, rather than the 63 dBA "planning" criterion.

All of the barriers presented are considered to be of a feasible scale but will need to be reviewed in the context of urban renewal concepts along this corridor. Safety issues associated with sight lines would also need to be considered. In theory, long continuous commercial or residential building structures could provide noise screening in lieu of barriers, where space permits. The cost effectiveness of the alternative option of upgrading building envelopes could also be investigated as an alternative to barriers. An advantage of barriers (as opposed to building upgrades) is that barriers would also control traffic noise increases in outdoor areas.

Gympie Road Connection

Noise mitigation to achieve the "63/68 dBA criterion" where reasonable and feasible is shown in **Appendix K4, K7, K11** and **K14** (for the Airport Link without Interim Northern Busway (2022), Airport Link with Interim Busway (2022), Airport Link without Ultimate Busway (2026) and Airport Link with Ultimate Busway (2026).

All of the barriers presented are considered to be of a feasible scale but will need to be reviewed in the context of urban renewal concepts along this corridor. Safety issues associated with sight lines would also need to be considered. In theory, long continuous commercial or residential building structures could provide noise screening in lieu of barriers, where space permits. The cost effectiveness of the alternative option of upgrading building envelopes could also be investigated as an alternative to barriers. An advantage of barriers (as opposed to building upgrades) is that barriers would also control traffic noise increases in outdoor areas.

Sandgate Road Connections

Noise mitigation to achieve the "63/68 dBA criterion" where reasonable and feasible is shown in **Appendix L4, L7, L11** and **L14** (for the Airport Link without Interim Northern Busway (2022), Airport Link with Interim Busway (2022), Airport Link without Ultimate Busway (2026) and Airport Link with Ultimate Busway (2026).

Given the significant distance between the Sandgate Rd Portal and the Interim or Ultimate Northern Busway infrastrucure, this (Busway) project has minimal impacts on the resulting levels of road traffic noise in this area due simply to changes in traffic volumes and compositions.

All of the barriers presented are considered to be of a feasible scale but will need to be reviewed in the context of urban renewal concepts along this corridor. Safety issues associated with sight lines would also need to be considered. In theory, long continuous commercial or residential building structures could provide noise screening in lieu of barriers, where space permits. The cost effectiveness of the alternative option of upgrading building envelopes could also be investigated as an alternative to barriers. An advantage of barriers (as opposed to building upgrades) is that barriers also control traffic noise increases in outdoor areas.

Road Traffic Noise Remote from Tunnel Portals

For the Years 2022 and 2026, the introduction of the Airport Link is predicted to result in a small change in the levels of road traffic noise on the wider road network (ie well removed from the portal areas). Generally noise levels decrease, but at a number of locations the noise levels are predicted to increase.

The expected changes in the traffic noise as a result of the introduction of the Airport Link and Busway projects are generally within 2 dBA. Such changes are considered to be minor and not to be generally noticeable.

For roads beyond the immediate tunnel infrastructure, the following options could be explored to mitigate increases in traffic noise as attributable to the tunnel:-

- Open-graded or stone mastic asphaltic road surfacing; and
- Building insulation upgrade programmes.

Road-side barriers are generally not a feasible option along local streets due to the requirement for property access from the street frontage.

Regenerated Noise

Regenerated noise from roadways in shallow tunnel areas is not considered to be an issue at any of the tunnel portals.

Ventilation System Noise

Preliminary calculations of ventilation outlet noise emissions indicate that it would be feasible for noise emissions to comply with the BCC's Noise Impact Assessment Planning Scheme Polices and traditional EPA licensing.

Providing that immissions at residential locations are free of distinct tonal characteristics, and do not exceed background noise levels, the normal licensing requirements would allow the ventilation outlets to be developed with negligible noticeable noise impact to residents.

Some additional noise reduction is required to be incorporated into the ventilation system, though the requirements are not considered excessive or restrictive.

Vibration and regenerated noise issues may need to be addressed if the ventilation outlets are to be integrated into a residential or commercial building. This issue would be manageable through appropriate mechanical and structural design.

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1 INTRODUCTION

1.1 Background

Heggies Australia Pty Ltd (Heggies) has been commissioned by the SKM Connell Wagner Joint Venture to prepare the construction noise and vibration aspects of the Airport Link project for inclusion into the Environmental Impact Statement (EIS).

1.2 Terms of Reference

The specific requirements of the Terms of Reference[1] in relation to operational noise and vibration impacts associated with the project are reproduced below.

5.5 Noise and Vibration

5.5.1 Description of Existing Environment

The existing noise environment should be assessed by;

- *Reviewing available data from any ambient noise monitoring in the study corridor;*
- *Conducting additional baseline noise monitoring at selected locations, primarily at sensitive locations in the vicinity of tunnel portals, associated roadways and ventilation infrastructure.*

5.5.3 Potential Impacts and Mitigation Measures – Operational

To assess operation impacts the following should be undertaken:

- *Assess the direct noise impacts associated with the tunnel by preparing a 3-D noise contour model of air-borne noise transmission from critical areas such as portals, new surface roadways and ventilation outlets;*
- *Carry out calculations to assess operational phase vibration and regenerated noise impacts in critical shallow tunnel areas;*
- *Analyse and identify significant changes in traffic noise generation on the road network remote from the tunnel;*
- *Assess and document the noise predictions against relevant guidelines and legislation;*
- *Comparison of predicted noise levels with planning noise levels stated in the Environmental Protection (Noise) Policy 1997; and*
- *Develop likely operational noise and vibration management measures. These measures are to include measures to limit vibration impacts to health care facilities' equipment if required.*

1.3 Objectives

The objectives of this report in relation to the project description are to:-

- Address the acoustical requirements detailed in the project's Terms of Reference in relation to the operational phase of the project;
- Evaluate the operational noise and vibration impacts at sensitive locations in terms of planning levels identified in the EPP[Noise] and other Guidelines;
- Evaluate the extent of resulting impacts and the scope for the reduction of these impacts through reasonable and feasible mitigation strategies; and
- Recommend appropriate mitigation measures.

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[1] *Queensland Government State Development and Innovation,* Airport Link Project – Terms of Reference for an Environmental Impact Statement (March 2006)

2 IMPACT ASSESSMENT CRITERIA

2.1 Community Values Relating to Noise

The *Queensland Environmental Protection (Noise) Policy 1997* defines the values to be protected as the qualities of the acoustic environment that are conducive to:-

1. The wellbeing of the community or a part of the community, including its social and economic amenity; or
2. The wellbeing of an individual, including the individual's opportunity to have sleep, relaxation and conversation without unreasonable interference from intrusive noise.

Sleep

A person's ability to sleep is perhaps the most important value that can be impacted by noise and/or vibration. Noise and vibration effects on sleep are generally referred to as sleep disturbance.

Recreation

Recreation is an important aspect of a healthy lifestyle. Recreation may include time spent both indoors and outdoors. In terms of acoustic function, recreation may involve communication with others in verbal conversation or simple enjoyment of an outdoor or indoor soundscape.

Education and Work

The needs of education and work in relation to the acoustic environment relate to the need to be able to communicate effectively either face-to-face or by telephone, and the ability to think or focus on auditory information without undue intrusion from external sources of noise.

Evaluating Impacts

The impact of a project on community values relating to noise and vibration is normally evaluated using statutory regulations and policies which describe acceptable levels of noise and vibration from various sources.

For some types of noise (or vibration) for which specific levels are not listed in statutory regulations or policies, it is common to refer to relevant Australian or internationally recognised standards that define acceptable levels in various human contexts. Such standards can serve an advisory function to regulatory organisations and may be adopted by statutory authorities for the purposes of defining regulatory levels.

2.2 Noise Impact Assessment Criteria

In the operational phase of the tunnel, potential noise impacts may be associated with traffic at tunnel portals and connecting ramps, toll plazas, traffic changes on surface roads between and beyond tunnel portals, and noise from tunnel ventilation plant.

Regenerated noise from heavy vehicles, particularly those travelling under buildings in shallow tunnel areas is also a potential operational noise issue.

2.2.1 Traffic Noise

Traffic noise criteria applicable to the project are contained in two documents, Queensland's *Environmental Protection (Noise) Policy 1997*[2] and *Road Traffic Noise Management: Code of Practice (Queensland Main Roads, January 2000*).[3]

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2 *Referred to within this report as EPP[Noise*

The EPP[Noise] is applicable to all public roads whilst the Code of Practice is only applicable to the State-controlled road network. The sections of road within the study area that are State-controlled are:

- Gympie Rd - North of Kedron Brook
- East West Arterial - East of Sandgate Rd

Unless it is specifically stated, it may be assumed that all traffic noise levels quoted in this report apply to a position one metre in front of the most exposed facade of a noise sensitive building and therefore include the appropriate façade correction.

Environmental Protection (Noise) Policy 1997

For noise from activities described as "beneficial assets" (particularly roads, railways and airports), the EPP[Noise] specifies "planning levels" for noise sensitive locations (eg residences, educational and health care facilities) which "may be used as a guide'' when assessing the noise levels from an activity.

The planning levels for a Public Road are:

3. For a State-controlled road - 68 dBA $L_{A10(18hour)}$;
4. For all other public roads - 63 dBA $L_{A10(18hour)}$;
5. 60 dBA, assessed as the highest 1 hour equivalent continuous A-weighted sound pressure level between 10 pm and 6 am (60 dBA $L_{Aeq(1hour)}$); and
6. 80 dBA assessed as a single event maximum sound pressure level (80 dBA L_{Amax}).

Main Roads – Road Traffic Noise Management: Code of Practice

The Main Roads document *Road Traffic Noise Management: Code of Practice,* provides details for the assessment of road traffic noise for Declared Roads (ie to State-controlled roads). Different criteria and priorities apply dependent on the road type (new or existing access/non-access controlled roads) and to receiver/land usage type (residential, educational and health, or parks and other recreational facilities).

For this project, surface works on Gympie Rd (north of Kedron Brook) and the East West Arterial (east of Sandgate Rd) associated with the tunnel would be regarded as upgrading of the existing road network.

For existing residential sites adjacent to "Upgraded Existing Roads", the Code of Practice noise objective is 68 dBA $L_{A10(18hour)}$ within a 10 year post-construction period.

2.2.2 Educational and Health Buildings

The EPP[Noise] does not make any distinction between residences and educational or healthcare facilities - the 63 dBA $L_{A10(18hour)}$ planning level is applied to all these noise sensitive locations. Consistent with the ToR, guidance for the assessment of educational and health care facilities was sought from Main Roads' *Code of Practice*, where noise mitigation for an "Upgraded Existing Road" is considered on a case-by-case basis for those properties where the following criteria are exceeded:

- $L_{A10(1hour)}$ noise level is greater than 55 dBA (internal); and
- An increase of at least 3 dBA above the pre-construction level.

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[3] *Referred to within this report as Code of Practice*

The 55 dBA $L_{A10(1hour)}$ noise level (internal) for the worst hour is essentially equivalent to the 63 dBA $L_{A10(18hour)}$ external noise goal nominated in the EPP[Noise] given the below analysis:

1. Main Roads' Code of Practice nominates an internal 55 dBA LA10(1hr) (worst hour) criterion for educational and health care facilities adjacent existing roads.
2. Assuming a 10 dBA façade noise reduction, with windows open, this equates to an external (façade corrected) criterion of 65 dBA $L_{A10(1hr)}$ for the worst or "loudest" hour.
3. It is typically understood (through historical measurement data) that the worst hour of traffic noise is (approximately) 2 to 3 dBA louder than the 18 hour noise level, therefore the equivalent 18 hour noise level is 62 to 63 dBA $L_{A10(18hr)}$.
4. This is potentially up to 1 dBA lower than the 63 dBA $L_{A10(18hr)}$ criterion however a 1 dBA difference in environmental acoustics is considered negligible (given that humans are unable to distinguish changes in noise levels of 2 dBA or less and given the accuracy of environmental noise modelling and measurement) and therefore is justified for this impact assessment.

Therefore, for simplicity, educational and health care facilities have been assessed against the 63 dBA $L_{A10(18hr)}$ external noise goal, as for residences adjacent non-stated controlled roads.

It will be important that during the detailed design phase of this project, specific internal $L_{A10(1hr)}$ (worst hour) noise level predictions be undertaken based on actual building façade noise reductions and internal noise monitoring in the most exposed rooms/spaces used for educational and health care purposes within each facility.

2.2.3 Tunnel Ventilation Plant

The applicable statutory requirement for noise emissions associated with fixed mechanical plant is the *Queensland Environmental Protection (Noise) Policy 1997*.

The EPP[Noise] nominates qualitative characteristics of the noise environment that are to be protected, but does not specify any numerical limits that are applicable to stationary mechanical plant.

It is generally found that for noise sources which are continuous, like ventilation plant noise, the consideration of 'background creep' will tend to be the controlling issue in the setting of noise goals.

The Brisbane City Council's Noise Impact Assessment Planning Scheme Policy (NIAPSP) aims to control 'background creep' by recommending that "*Outside noise levels must not exceed the levels detailed in the table below:*"

Noise area category Appendix A AS1055.2[a]	Permissable level of exceedance of $L_{A90,T}$ for the appropriate time of day		
	Where there is residential development	Where there is no residential development	Where background levels already exceed stated levels in AS1055.2 (i.e. without the proposed development
R1	by 5dB(A)	N/A	The development's noise contribution must still comply with the stated levels in *AS1055.2*
R2	by 5dB(A)	N/A	
R3	by 0dB(A)	by 10dB(A)	
R4			
R5			
R6			

(a) Refer to Appendix A in AS1055.2 for $L_{A90,T}$ levels for the noise area categories

The traditional license conditions used by the EPA throughout Queensland, which are less stringent than the NIAPSP criteria, are summarised in **Table 1**.

Table 1 Traditional EPA License Requirements for Stationary Plant

Time Period	**Level at Receptor Location - $L_{Amax,adj,T}$**	
	Residential	**Commercial**
Day (7 am to 6 pm) Mon to Sat 8 am to 6 pm Sun. & Public Hols.	Background + 5 dBA	Background + 10 dBA
Evening (6 am to 10 pm)	Background + 5 dBA	Background + 10 dBA
Night (10 pm to 7 am/8 am)	Background + 3 dBA	Background + 8 dBA

Noise from large ventilation fans can be tonal. It is common practice in Queensland (as evidenced by the abbreviated adjustment term "adj" in the above EPA conditions) and throughout Australia to penalise noise emissions containing "detectable" tonal characteristics (eg whine, hiss, screech, hum etc). Adjustments consistent with the corrections for tonality described in Clause 6.6 of AS1055.1 *Acoustics - Description and measurement of environmental noise Part 1: General procedures (1997)* should be applied.

The NIAPSP requirements for the avoidance of 'background creep' are recommended for use on this project on the basis that these limits avoid significant perceptible noise impacts and are consistent with traditional EPA licensing practice. The AS1055 corrections for tonality and impulsiveness will be applied, where necessary.

2.2.4 Regenerated Noise

Vibration generated by heavy vehicles on a roadway can sometimes be heard in nearby buildings as a low frequency "rumbling" sound. The potential for this to occur may be enhanced where the tunnel is situated directly beneath a building.

The "satisfactory" noise levels listed in AS/NZS 2107 are recommended as guidance for the purpose of assessing regenerated noise levels within buildings during the operational phase of the project. An extract from AS/NZ 2107, for some common areas is presented in **Table 2.**

Table 2 Example Noise Design Levels from AS/NZS 2107:2000

Type of Building Occupancy	**Maximum Design Level $L_{Aeq(60second)}$ (dBA)**
Residential buildings (sleeping areas)	40 (near major roads) or 35 (near minor roads)
Residential buildings (living areas)	45 (near major roads) or 40 (near minor roads)
Place of Worship	40 (with speech amplification)
School music rooms	45
School teaching area	45
School library	50
School Gymnasium	55
Commercial buildings – office space	45
Commercial Buildings – retail space	50

3 IDENTIFICATION OF NOISE SENSITIVE BUILDINGS

Apart from the residential dwellings that are in the vicinity of the Airport Link portals and route alignment, there are a number of other noise sensitive dwellings that have been identified when assessing the potential for impacts arising from airborne or regenerated noise.

Relevant properties have been identified from a variety of sources including Chapter 16 of the *Concept Design Impact Management Plan* (CDIMP), the *Social Environment Report* (Elliott Whiteing Pty Ltd, December 2005) report, general project information, site visits and a review of the latest UBD.

In the southern section of the project, the following noise sensitive properties have been identified, it is noted that some properties have been included, even though they may be considered to be some distance from the actual works.

Table 3 Noise Sensitive Properties – Southern Section

Type	Facility	Location
Aged Care	Amarina Nursing Home	26 Palmer Street, Windsor
	Marooma Nursing Home	12 Federation Street, Windsor
Child care	Windsor Neighbourhood Child Care Centre	17 Bonython Street, Windsor
	YMCA Child Care Centre	387 Lutwyche Road, Windsor
	Holy Rosary Primary School	9 Roblane Street, Windsor
Education	Windsor Primary School	270 Lutwyche Road, Windsor
	Windsor School of Arts	407 Lutwyche Rd, Windsor
Hospitals	Rosemount Hospital	189 Lutwyche Road, Windsor
	Royal Brisbane Hospital	30 Bowen Bridge Road, Herston

Other places not specifically identified, such as community facilities, would be treated in the same manner as the surrounding residential properties.

In the wider area around the Gympie Road portal, the potentially noise sensitive properties are identified in **Table 4**.

Table 4 Noise Sensitive Properties – Northern Section

Type	Facility	Location
Childcare	Lutwyche Windsor Kindergarten	Lucas Street, Lutwyche
	Kedron Park Childcare Centre	84 Kedron Park Road
	Hutchison's Early Learning Centre	7 Ninth Avenue
	Kedron Heights Kindergarten	107 Kitchener Road
Education	Kedron Secondary School	34 Park Road
	Wooloowin Primary School	663 Lutwyche Road
Nursing Homes	Wooloowin Nursing Home	99 Kedron Park Road

There are no noise sensitive properties close to the alignment in the section between the Gympie Road Portal and Sandgate Road Portal. The only nursing home is Clifford House Aged Care facility (44 Jimbour Street), though this is some distance from the alignment.

4 EXISTING NOISE AND VIBRATION ENVIRONMENT

4.1 Introduction

A record of existing noise levels provides a baseline for assessment of potential noise emissions associated with construction and operational phases of the tunnel.

The aspects of the tunnel infrastructure that are of particular interest in respect of the existing noise environment are those areas in the vicinity of:-

- Construction sites,
- Ventilation Outlets, and
- Tunnel portals and entry/exit roadways.

The existing noise environment will be utilised to assist in the development of criteria for the assessment of noise impacts associated with the project, and be used to determine the reasonableness of providing noise control measures, where the base noise objectives are exceeded.

Existing ambient vibration levels at residences and other sensitive buildings are not normally significant. On maintained roads, ambient vibration levels on building foundations are generally below or near the minimum measurement threshold of regular vibration measurement instrumentation, and below the threshold of perception. A limited amount of ambient vibration measurements were conducted to verify the validity of this generalisation on this project.

The Terms of Reference required the existing noise levels to be described from available ambient noise records and additional noise measurements specifically targeted at assessing the noise environment around surface development associated with the project. In this regard available ambient noise records were found to be too site specific to relate to areas surrounding proposed surface developments. For this reason noise monitoring has been conducted at locations specific to surface developments associated with the project.

Information about the existing noise environment has been obtained from the following sources:-

- Site inspection during peak traffic periods and during quiet late-night periods;
- Unattended continuous measurement of sound pressure levels at eleven locations over a 7 day period

4.2 Noise Descriptors

The noise level descriptors that have been utilised for measurements are graphically illustrated in **Figure 1**, which presents a hypothetical noise profile in a suburban area.

L_{Amax} The maximum A-weighted noise level associated with a noise sampling period.

L_{A1} The noise level exceeded for 1% of a given measurement period. This parameter is often used to represent the typical maximum noise level in a given period.

L_{A10} The A-weighted sound pressure level exceeded 10% of a given measurement period and is utilised normally to characterise average maximum noise levels.

L_{Aeq} The average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound over the same measurement period.

L_{A90} The A-weighted sound pressure level exceeded 90% of a given measurement period and is representative of the average minimum background sound level (in the absence of the source under consideration), or simply the "background" level.

Figure 1 Graphical Display of Typical Noise Indices

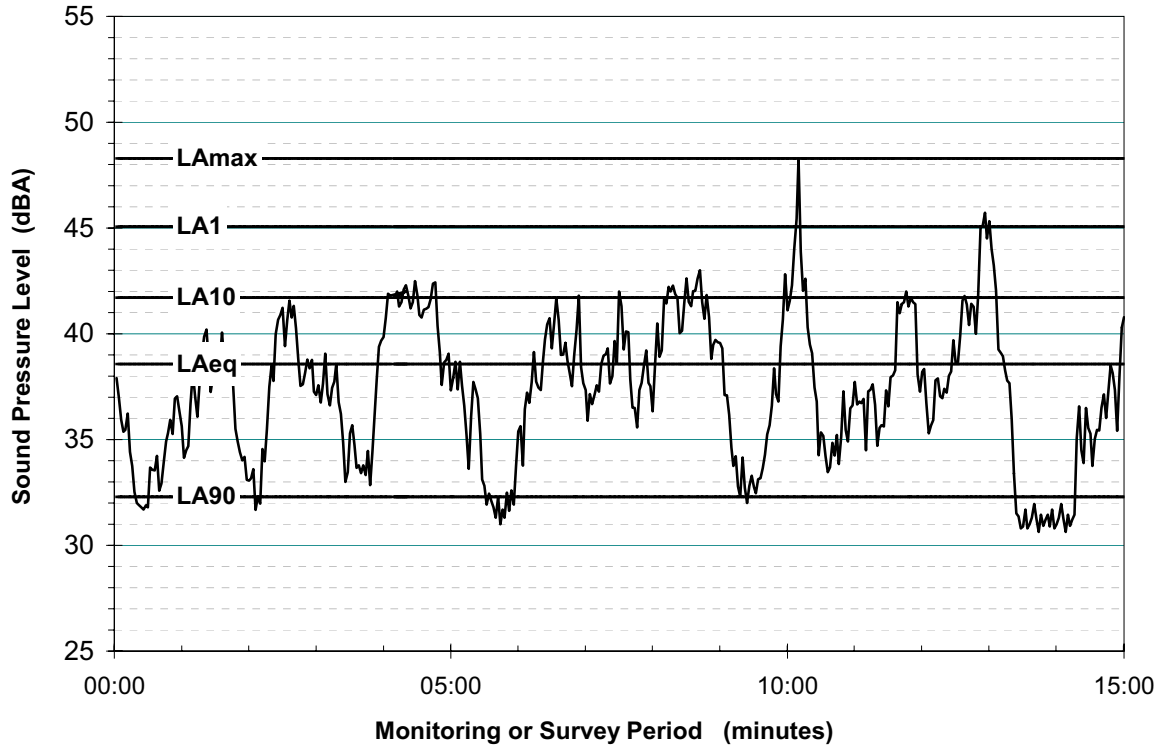


Table 5 presents examples of typical noise levels together with a subjective evaluation of the loudness.

Table 5 Typical Noise Levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130 120 110	Threshold of pain Heavy rock concert Grinding on steel	Intolerable Extremely noisy
100 90	Loud car horn at 3 m Construction site with pneumatic hammering	Very noisy
80 70	Kerb side of busy street Loud radio or television	Loud
60 50	Department store General Office	Moderate to Quiet
40 30	Inside private office Inside bedroom	Quiet to Very quiet
20	Unoccupied recording studio	Almost silent

The overall level of a sound is usually expressed in terms of dBA, which is measured using the "A-weighting" filter incorporated in sound level meters. These filters have a frequency response corresponding approximately to that of human hearing. People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz) and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally as loud, although the perceived loudness can also be affected by the character of the sound (eg the loudness of human speech and a distant motorbike may be perceived differently, although they are of the same dBA level).

A change of up to 3 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

4.3 Noise Monitoring Sites

Noise monitoring sites have been selected to be representative of residential development that may be potentially affected by the Airport Link project.

Only the general location of tunnel portals and vent stacks was known at the time of the noise logging. Noise logging sites were therefore selected where the existing noise environment would be similar to that of the most-affected residential areas.

The details of the selected noise monitoring sites, are summarised in **Table 6**.

Figure 2 to **Figure 5** (inclusive) shows location maps illustrating the noise monitoring locations. Photographs showing the noise logger position of each monitoring site are presented in **Appendix A.**

Table 6 Noise Monitoring Locations

Address / Description	Location in Appendix A	Locality Reference
30 Wongara Street, Clayfield	Location 1	Figure 5
86 Alma Road, Clayfield	Location 2	Figure 5
27 Parkland Street, Nundah	Location 3	Figure 5
72 Kalinga Street, Clayfield	Location 4	Figure 5
34 Park Road, Kedron (Kedron State High School)	Location 5	Figure 4
20 Perry Street, Lutwyche	Location 6	Figure 4
30 Colton Avenue, Lutwyche	Location 7	Figure 4
12 Park Terrace, Kedron	Location 8	Figure 4
17 Roblane Street, Windsor	Location 9	Figure 3
7 Roblane Street, Windsor	Location 10	Figure 4
46 Gallway Street, Windsor	Location 11	Figure 2
49 Earle Street, Windsor	Location 12	Figure 2
Royal Women's Hospital	Location 13	Figure 2
62 Victoria Street, Windsor	Location 14	Figure 2
42 Hooker Street, Windsor	Location 15	Figure 2
Nursing Home, 26 Palmer Street, Windsor	Location 16	Figure 3
7 Lamington Avenue, Lutwyche	Location 17	Figure 4
16 East Street, Lutwyche	Location 18	Figure 4

Figure 2 Monitoring Locations – Southern Section of the Project.

Figure 3 Monitoring Locations between Southern Section and Gympie Portal

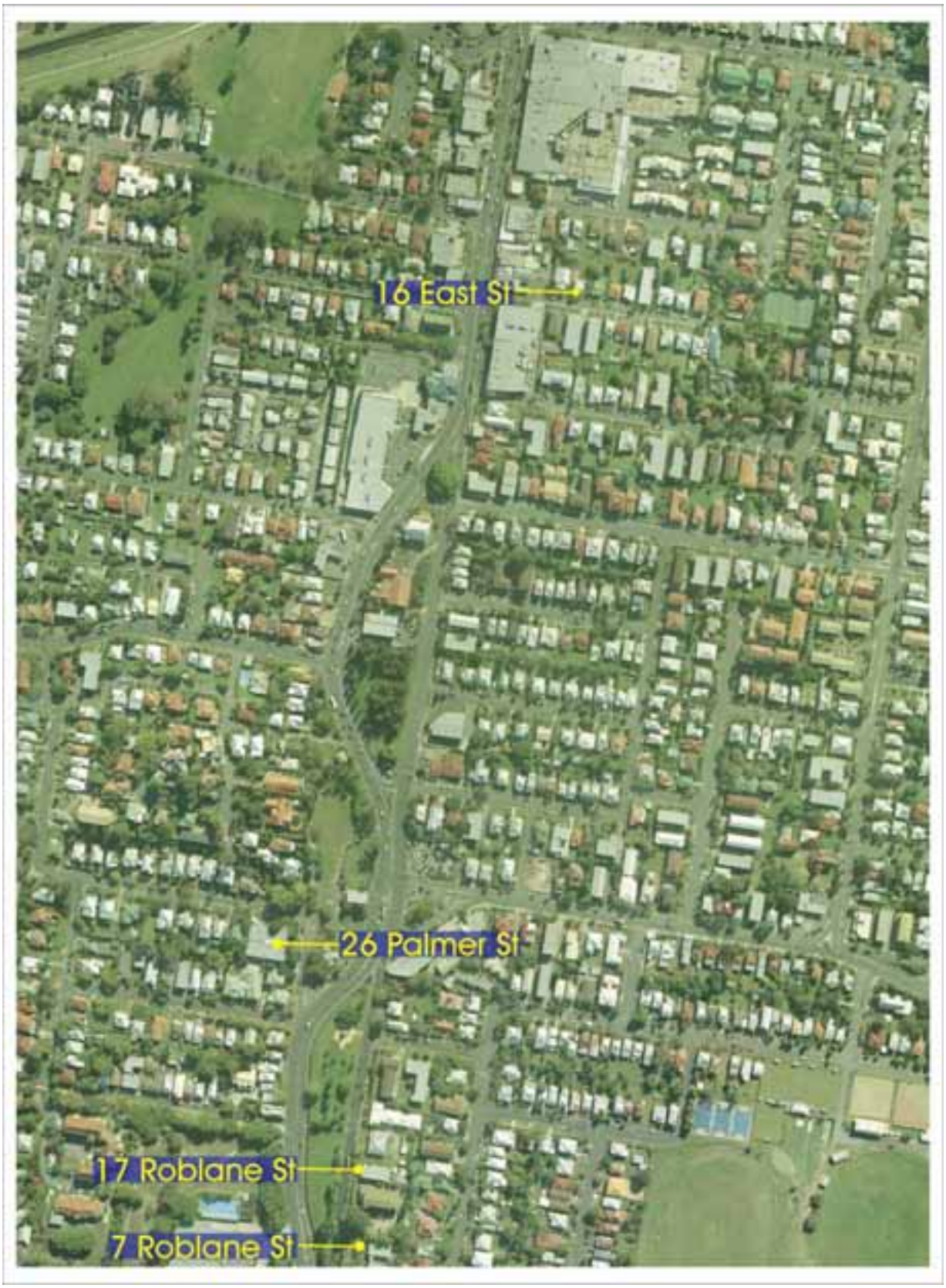


Figure 4 Monitoring Locations Northern Section of the Project

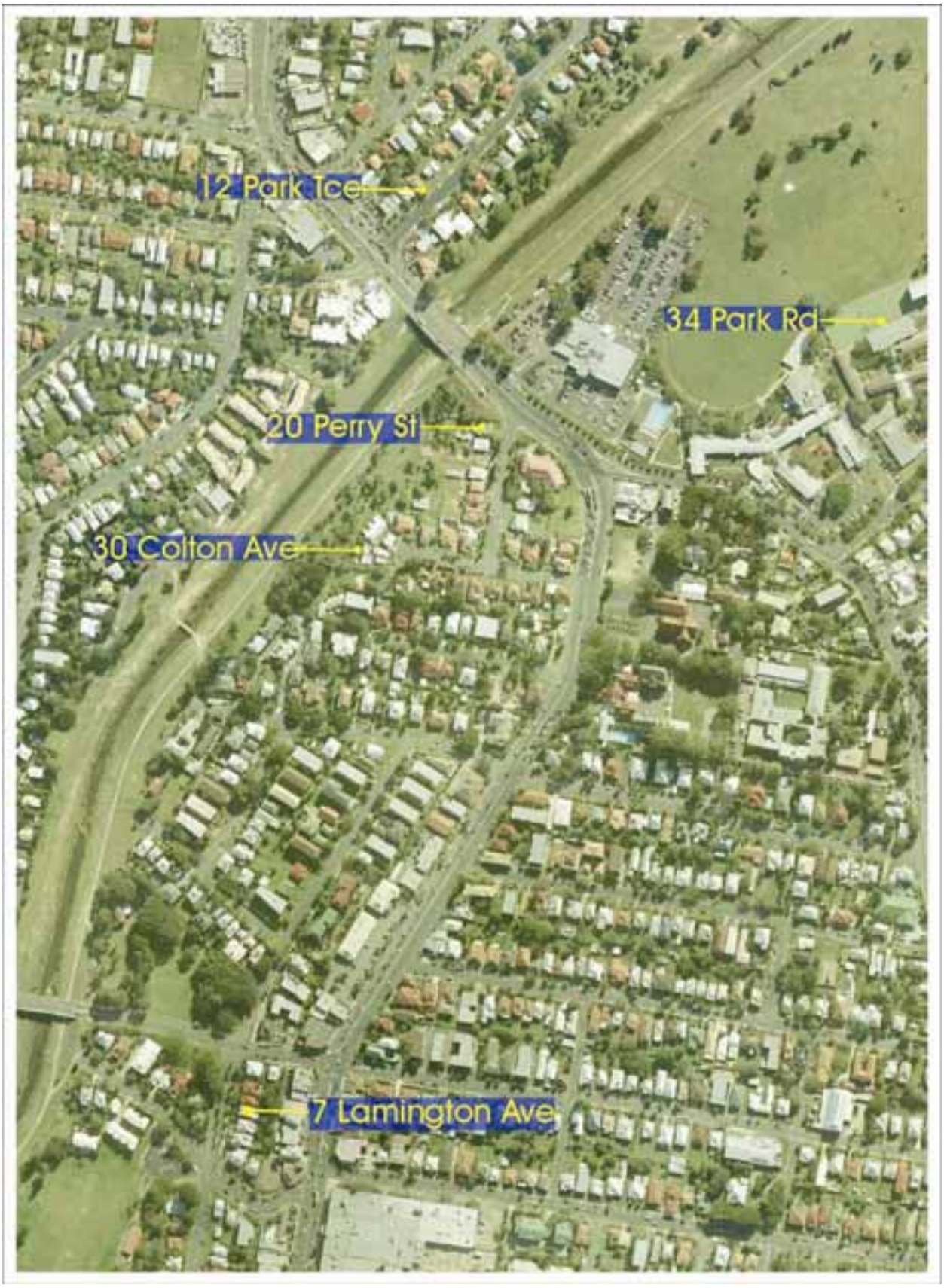


Figure 5 Monitoring Locations Sandgate Portal Area

4.4 Noise Measurement Methods and Instrumentation

Noise monitoring was conducted generally in accordance with Australian Standard AS1055-1997 *Acoustics – Description and Measurement of Environmental Noise* and the Queensland Environmental Protection Agency's *Noise Measurement Manual* 2000.

A measurement interval of 15 minutes has been utilised for both attended and unattended noise monitoring. For the unattended noise monitoring, the prevailing noise environment was measured in consecutive 15 minute periods for a total survey period of 7 days in accordance with the definition of 'long-term background' levels contained in the *Environmental Protection (Noise) Policy 1997*.

4.5 Instrumentation

The instrumentation that was used for the long-term noise monitoring is listed in **Table 7**. The calibration of all instruments was checked before and after monitoring and was found to be within 0.8 dBA of the appropriate calibration level in all instances.

All instruments were programmed to continuously record A-weighted fast-response noise levels over 15 minute sampling intervals.

Table 7 Noise Monitoring Instrumentation

Measurement Location	**Instrumentation**
All locations	Calibrator, Bruel &Kjaer Type 4230, S/N 1274 986
1	Acoustic Research Laboratories Environmental Noise Logger EL 215, SN 194447
2	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 19-299-425
3	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-301-471
4	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194528
5	Larson Davis Environmental Noise Logger LD720, SN B0939
6	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 15-299-419
7	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194581
8	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 15-299-423
9	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 15-299-422
10	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-505
11	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194444
12	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 1944410
13	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-508
14	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194660
15	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194629
16	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 15-299-452
17	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194442
18	Acoustic Research Laboratories Environmental Noise Logger EL215, SN 194555

The limitation as to how low a noise level that can be measured is governed by the combined microphone and electronic noise floor specification. For the instruments utilised, the noise floor is shown below and is well removed from the prevailing noise levels:

- ARL 215 26 dBA
- ARL 315/316 22 dBA
- Rion NA27 15 dBA
- Larson Davis 26 dBA

4.6 Results of Noise Surveys

4.6.1 Noise

The noise environment in the tunnel study area is typical of many inner urban areas, in that it is largely determined by road traffic noise, however at some locations rail noise and/or mechanical plant noise also contributed to the prevailing noise environment.

Monitoring sites were inspected during the morning or afternoon peak traffic times and also during the late night/early morning period when the background noise is typically low. The prevailing audible sounds at each location are summarised in **Table 8**. As can be seen in **Table 8,** traffic noise from nearby major roadways was a dominant source of noise at all times of the day.

Noise logger measurements were undertaken between Thursday 24 November and Thursday 15 December 2005. Weather conditions during this period were typically fine and warm to hot however there were some periods of significant rainfall. Winds were generally light to moderate with typically calm conditions, or light winds, occurring at night.

Results of the noise logger measurements are summarised in

Table 9 to **Table 12** with the full graphical output (including the prevailing weather conditions) presented in **Appendix B**. The results exclude noise monitoring results obtained during periods of rain (greater than 0.5 mm per 15 minute interval) or high wind speeds (greater than 5 m/s) as recommended in AS 1055.1.

Table 8 Prevailing (Observed) Noise Sources

ef	Description	ominant Daytime Noise ources	Dominant Noise Sources Late at Night
1	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes a facade reflection, facing East-West Arterial Road (behind noise barriers)	East West Arterial Road Traffic	East West Arterial Road Traffic
2	Rear yard, detached dwelling at 86 Alma Road, Clayfield	Sandgate Road Traffic, North Coast Line and Air Train rail traffic	Sandgate Road Traffic, North Coast Line and Air Train rail traffic, insects
3	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	Sandgate Road Traffic, North Coast Line and Air Train rail traffic, Construction Work	Sandgate Road Traffic, North Coast Line and Air Train rail traffic
4	Rear yard, eastern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	Sandgate Road Traffic, North Coast Line and Air Train rail traffic	Sandgate Road Traffic, North Coast Line and Air Train rail traffic, insects
5	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	Lutwyche Road / Gympie Road Traffic	Lutwyche Road / Gympie Road Traffic, Mechanical Plant from Dept of Emergency Services
6	Front yard, includes a facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	Lutwyche Road / Gympie Road Traffic	Lutwyche Road / Gympie Road Traffic
7	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	Lutwyche Road / Gympie Road Traffic, Pool Filter	Lutwyche Road / Gympie Road Traffic
8	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	Gympie Road Traffic, adjacent commercial activities (car yard), Mechanical Plant	Gympie Road Traffic, distant mechanical plant
9	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	Lutwyche Road / Roblane Street Traffic, Ferny Grove Line rail traffic	Lutwyche Road / Roblane Street Traffic
10	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	Lutwyche Road / Roblane Street Traffic, Ferny Grove Line rail traffic	Lutwyche Road / Roblane Street Traffic
11	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	Ferny Grove Rail Line and rail noise from Mayne Yards, dogs barking, localised road traffic noise	Rail noise from Mayne Yards, dogs barking
12	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	Lutwyche Road/Inner City Bypass Traffic, localised (Earle Street) traffic, rail noise from Mayne yards	Lutwyche Road/Inner City Bypass Traffic, Rail noise from Mayne Yards, distant mechanical plant
13	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	Bowen Bridge Road and Campbell Street Traffic, mechanical plant, Helicopter landing on Level 11 of Hospital (intermittent)	Bowen Bridge Road and Campbell Street Traffic, mechanical plant
14	Front yard, detached dwelling at 62 Victoria Street, Windsor	Lutwyche Road Traffic, Localised (Victoria Street) Traffic, noise from commercial activities across road	Lutwyche Road Traffic, Localised (Victoria Street) Traffic
15	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	Lutwyche Road Traffic, Localised traffic (Hooker Street), rail movements on Ferny Grove Line	Lutwyche Road Traffic, Rail movements on Ferny Grove Line
16	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	Lutwyche Road Traffic, Localised traffic (Palmer Street, Palmer Street)	Lutwyche Road Traffic
17	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	Lutwyche Road Traffic, Localised traffic (Lamington Avenue, Bradshaw Road, Norman Street)	Lutwyche Road Traffic
18	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	Lutwyche Road Traffic, Localised traffic (East Street, Lowerson Street) distant Mechanical Plant noise from Lutwyche Shopping Centre	Lutwyche Road Traffic, Mechanical Plant from Lutwyche Shopping Centre

Table 9 Existing Noise Levels - LAmax Parameter

Locations		Description	LAmax Levels + (standard deviation)		
			Day	Evening	Night
			6am – 6pm	6pm – 10pm	10pm – 6am
1	30 Wongara Street, Clayfield	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes a facade reflection, facing East-West Arterial Road (behind noise barriers)	76 (5.3)	71 (5.0)	64 (6.1)
2	86 Alma Road, Clayfield	Rear yard, detached dwelling at 86 Alma Road, Clayfield	70 (3.4)	69 (3.2)	66 (4.5)
3	27 Parkland Street, Nundah	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	79 (3.8)	81 (4.2)	65 (9.5)
4	72 Kalinga Street, Clayfield	Rear yard, northern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	72 (3.9)	70 (4.7)	62 (7.7)
5	34 Park Road, Kedron	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	74 (5.1)	63 (7.8)	52 (8.6)
6	20 Perry Street, Lutwyche	Front yard, includes a facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	81 (4.3)	80 (4.3)	76 (3.5)
7	30 Colton Avenue, Lutwyche	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	68 (4.9)	62 (5.5)	58 (6.0)
8	12 Park Terrace, Kedron	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	70 (4.2)	67 (4.8)	62 (5.0)
9	17 Roblane Street, Windsor	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	83 (3.5)	79 (3.2)	79 (4.0)
10	7 Roblane Street, Windsor	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	77 (3.9)	74 (3.7)	74 (3.8)
11	46 Gallway Street, Windsor	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	75 (5.6)	72 (6.6)	63 (7.2)
12	49 Earle Street, Windsor	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	72 (4.2)	68 (5.0)	62 (5.5)
13	Royal Women's Hospital	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	78 (4.4)	77 (3.6)	75 (4.2)
14	62 Victoria Street, Windsor	Front yard, detached dwelling at 62 Victoria Street, Windsor	75 (4.9)	70 (4.5)	64 (7.2)
15	42 Hooker Street, Windsor	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	75 (5.3)	75 (6.3)	65 (10.0)
16	Nursing Home, 26 Palmer St, Windsor	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	76 (3.7)	73 (3.7)	71 (4.2)
17	7 Lamington Avenue, Lutwyche	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	68 (4.8)	69 (5.0)	62 (6.3)
18	16 East Street, Lutwyche	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	68 (5.9)	66 (5.3)	57 (6.7)

Table 10 Existing Noise Levels - LA10 Parameter

Locations		Description	LA10 Levels + (standard deviation)		
			Day	Evening	Night
			6am – 6pm	6pm – 10pm	10pm – 6am
1	30 Wongara Street, Clayfield	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes a facade reflection, facing East-West Arterial Road (behind noise barriers)	60 (3.4)	59 (58.5)	49 (3.0)
2	86 Alma Road, Clayfield	Rear yard, detached dwelling at 86 Alma Road, Clayfield	61 (3.2)	61 (61.2)	59 (1.8)
3	27 Parkland Street, Nundah	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	63 (2.6)	61 (4.5)	50 (4.5)
4	72 Kalinga Street, Clayfield	Rear yard, northern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	55 (3.0)	57 (6.7)	48 (3.5)
5	34 Park Road, Kedron	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	56 (4.6)	50 (4.7)	38 (2.3)
6	20 Perry Street, Lutwyche	Front yard, includes a facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	68 (0.9)	67 (1.0)	63 (3.0)
7	30 Colton Avenue, Lutwyche	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	55 (2.7)	51 (3.8)	46 (3.3)
8	12 Park Terrace, Kedron	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	61 (4.3)	55 (4.7)	50 (3.6)
9	17 Roblane Street, Windsor	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	68 (0.8)	67 (1.0)	63 (3.4)
10	7 Roblane Street, Windsor	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	64 (0.9)	62 (1.0)	59 (3.1)
11	46 Gallway Street, Windsor	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	55 (2.9)	54 (2.7)	47 (2.9)
12	49 Earle Street, Windsor	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	56 (2.0)	53 (3.2)	48 (2.2)
13	Royal Women's Hospital	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	69 (0.7)	68 (0.6)	66 (2.1)
14	62 Victoria Street, Windsor	Front yard, detached dwelling at 62 Victoria Street, Windsor	59 (2.0)	53 (3.2)	47 (4.5)
15	42 Hooker Street, Windsor	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	59 (3.0)	55 (5.2)	46 (4.9)
16	Nursing Home, 26 Palmer St, Windsor	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	65 (1.6)	63 (2.8)	58 (3.1)
17	7 Lamington Avenue, Lutwyche	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	53 (1.9)	52 (2.2)	45 (3.7)
18	16 East Street, Lutwyche	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	54 (3.4)	51 (5.4)	43 (3.5)

Table 11 Existing Noise Levels - LAeq Parameter

Locations		Description	LAeq Levels + (standard deviation)		
			Day	Evening	Night
			6am – 6pm	6pm – 10pm	10pm – 6am
1	30 Wongara Street, Clayfield	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes a facade reflection, facing East-West Arterial Road (behind noise barriers)	59 (2.7)	61 (59.8)	48 (3.3)
2	86 Alma Road, Clayfield	Rear yard, detached dwelling at 86 Alma Road, Clayfield	59 (2.9)	60 (60.4)	58 [1] (1.6)
3	27 Parkland Street, Nundah	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	62 (2.3)	62 (62.1)	52 (5.9)
4	72 Kalinga Street, Clayfield	Rear yard, northern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	54 (2.5)	59 (5.6)	49 (3.8)
5	34 Park Road, Kedron	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	56 (3.8)	51 (4.8)	38 (2.7)
6	20 Perry Street, Lutwyche	Front yard, includes a facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	65 (1.1)	64 (1.3)	61 (3.0)
7	30 Colton Avenue, Lutwyche	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	53 (2.2)	51 (3.3)	45 (3.6)
8	12 Park Terrace, Kedron	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	60 (3.5)	57 (4.8)	51 (3.3)
9	17 Roblane Street, Windsor	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	66 (1.0)	64 (1.3)	61 (3.1)
10	7 Roblane Street, Windsor	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	62 (1.1)	60 (1.2)	57 (2.9)
11	46 Gallway Street, Windsor	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	54 (2.5)	54 (2.9)	47 (3.2)
12	49 Earle Street, Windsor	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	54 (2.1)	52 (2.8)	47 (2.1)
13	Royal Women's Hospital	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	67 (0.7)	66 (0.9)	64 (1.6)
14	62 Victoria Street, Windsor	Front yard, detached dwelling at 62 Victoria Street, Windsor	56 (2.1)	52 (2.8)	48 (4.4)
15	42 Hooker Street, Windsor	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	59 (3.0)	58 (4.8)	52 (7.0)
16	Nursing Home, 26 Palmer St, Windsor	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	63 (1.5)	62 (2.5)	57 (3.5)
17	7 Lamington Avenue, Lutwyche	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	52 (2.3)	52 (3.6)	45 (3.6)
18	16 East Street, Lutwyche	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	53 (3.3)	53 (4.9)	44 (3.9)

Note 1: Night-time noise level influenced by airconditioned or other similar plant item

Table 12 Existing Noise Levels - LA90 Parameter

Locations		Description	LA90 Background Levels + (standard deviation)		
			Day	Evening	Night
			6am – 6pm	6pm – 10pm	10pm – 6am
1	30 Wongara Street, Clayfield	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes a facade reflection, facing East-West Arterial Road (behind noise barriers)	49 (2.2)	50 (4.0)	40 (2.8)
2	86 Alma Road, Clayfield	Rear yard, detached dwelling at 86 Alma Road, Clayfield	47 (4.5)	55[1] (2.4)	55[1] (3.2)
3	27 Parkland Street, Nundah	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	53 (3.1)	50 (4.8)	42 (3.0)
4	72 Kalinga Street, Clayfield	Rear yard, northern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	45 (2.5)	48 (5.0)	41 (2.3)
5	34 Park Road, Kedron	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	45 (2.5)	43 (4.7)	34 (1.4)
6	20 Perry Street, Lutwyche	Front yard, includes a facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	58 (1.5)	55 (3.0)	47 (4.1)
7	30 Colton Avenue, Lutwyche	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	48 (1.8)	45 (2.2)	39 (3.1)
8	12 Park Terrace, Kedron	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	50 (2.4)	48 (2.7)	40 (3.8)
9	17 Roblane Street, Windsor	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	57 (1.9)	56 (1.0)	48 (4.8)
10	7 Roblane Street, Windsor	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	55 (2.1)	53 (2.1)	45 (3.2)
11	46 Gallway Street, Windsor	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	47 (2.0)	48 (3.0)	41 (1.6)
12	49 Earle Street, Windsor	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	47 (1.4)	46 (2.7)	42 (1.9)
13	Royal Women's Hospital	Level 5 rooftop, James Demacy Building, Royal Brisbane Hospital, facing Bowen Bridge Road	62 (0.5)	61 (0.6)	60 (0.5)
14	62 Victoria Street, Windsor	Front yard, detached dwelling at 62 Victoria Street, Windsor	48 (1.8)	45 (2.6)	39 (2.6)
15	42 Hooker Street, Windsor	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	50 (3.6)	47 (5.7)	37 (4.8)
16	Nursing Home, 26 Palmer St, Windsor	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	56 (1.2)	52 (3.0)	46 (4.8)
17	7 Lamington Avenue, Lutwyche	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	45 (2.1)	44 (2.8)	37 (2.4)
18	16 East Street, Lutwyche	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	44 (2.4)	45 (3.5)	37 (2.2)

Note 1: Night-time noise level influenced by airconditioned or other similar plant item

Short-term operator attended surveys were conducted at five (5) of the long-term monitoring locations to assist in qualifying the prevailing noise environment at each location. The results of these surveys are presented in **Table 13**. These surveys are sampled over a short-duration (ie 15 minute), thus the results would be expected to differ from the longer-term noise surveys previously presented.

Table 13 Summary of Short-term Noise Measurements

Measurement Location	Date - Time	Period	L_{10} (dBA)	L_{eq} (dBA)	L_{90} (dBA)	Discernible Sources
7 Roblane Street, Windsor	06/12/05 - 23:25	Night	57	53	39	Traffic on Roblane Street (southbound) and Lutwyche Rd (northbound), Ferny Grove Railway Line and Insects
	12/12/05 - 12:40	Day	67	64	58	Traffic on Roblane Street (southbound) and Lutwyche Rd (northbound), Ferny Grove Railway Line and Insects
49 Earle Street, Windsor	12/12/05 - 13:05	Day	52	52	45	Traffic on Lutwyche Road, Birds, Mayne Rail Yard.
	06/12/05 - 00:15	Night	45	43	41	Traffic on Lutwyche Road, Mayne Rail Yard, distant mechanical plant.
17 Roblane Street, Windsor	09/12/05 - 18:05	Evening	66	63	54	Traffic on Roblane Street, Birds and Insects
72 Kalinga Street, Clayfield	12/12/05 - 12:19	Day	58	55	44	Traffic on Sandgate Road, Train Passby, Birds and Insects
	12/12/05 - 01:32	Night	43	41	38	Traffic on Sandgate Road, Train Passby, Insects
20 Perry Street, Lutwyche	09/12/05 - 17:35	Day	65	64	58	Traffic on Gympie Road, Birds and Insects
	09/12/05 - 23:00	Night	65	62	51	Traffic on Gympie Road, Birds and Insects

4.6.2 Analysis of Baseline Noise Levels

The existing noise levels at the reference locations have been examined in relation to the EPP[Noise] planning levels for road traffic noise. This examination is summarised in **Table 14** for the $L_{A10(18hour)}$ planning levels of 68 dBA for State-controlled roads and 63 dBA for other roads. The planning levels for this parameter can be understood as providing a control on the average maximum level of traffic noise during the day-evening period.

It can be seen in **Table 15** that the maximum night-time $L_{Aeq(1hour)}$ planning level of 60 dBA is exceeded on those properties fronting major roadways. The monitoring positions were selected to represent those properties on the major transport corridors and those set back in the quieter areas, co that construction impacts could be assessed

The analysis in **Table 16** compares the average maximum night-time L_{Amax} values with the 80 dBA L_{Amax} planning level. This planning level can be understood as an attempt to limit the sleep disturbance effects of single-vehicle drive-by events at night.

It can be inferred from **Table 16** and an inspection of the ambient noise monitoring records in **Appendix B** that from time to time, most of the residential location fronting any major roadway experiences maximum pass-by noise events in excess of 80 dBA L_{Amax}. It is therefore concluded that this is not a very useful impact assessment parameter as it does not appear to be achievable in practice even at relatively quiet measurement locations.

As roads are regarded under the EPP[Noise] as Beneficial Assets, the Planning Noise Levels for road traffic noise represent a compromise between the need for protection of the public utility of roadways, and the need for protection of the acoustic environment of people in residential places.

Table 14 Analysis of Baseline $L_{A10(18hour)}$ Noise Levels

Ref	Location Description	Assessment of Average Day Evening Traffic Noise $L_{A10(18hour)}$ (dBA)		
		Measured	Planning Level	Excess
1	30 Wongara Street, Clayfield	58	68	-
2	86 Alma Road, Clayfield	61	63	-
3	27 Parkland Street, Nundah	62	63	-
4	72 Kalinga Street, Clayfield	54	63	-
5	34 Park Road, Kedron	52	63	-
6	20 Perry Street, Lutwyche	67	63	4
7	30 Colton Avenue, Lutwyche	53	63	-
8	12 Park Terrace, Kedron	58	63	-
9	17 Roblane Street, Windsor	67	63	4
10	7 Roblane Street, Windsor	63	68	-
11	46 Gallway Street, Windsor	54	63	-
12	49 Earle Street, Windsor	54	63	-
13	Royal Women's Hospital	69	63	6
14	62 Victoria Street, Windsor	56	63	-
15	42 Hooker Street, Windsor	56	63	-
16	Nursing Home, 26 Palmer St, Windsor	64	63	1
17	7 Lamington Avenue, Lutwyche	52	63	-
18	16 East Street, Lutwyche	52	63	-

It can be inferred from **Table 16** and an inspection of the ambient noise monitoring records in **Appendix B** that from time to time, most of the residential location fronting any major roadway experiences maximum pass-by noise events in excess of 80 dBA L_{Amax}. It is therefore concluded that this is not a very useful impact assessment parameter as it does not appear to be achievable in practice even at relatively quiet measurement locations.

Table 15 Analysis of Night-time Equivalent Average Noise Levels

Ref	Location Description	Assessment of Maximum $L_{Aeq,1hour}$ (dBA) between 10 pm and 6 am		
		Measured	**Planning Level**	**Excess**
1	30 Wongara Street, Clayfield	52	60	**-**
2	86 Alma Road, Clayfield	58	60	**-**
3	27 Parkland Street, Nundah	57	60	**-**
4	72 Kalinga Street, Clayfield	49	60	**-**
5	34 Park Road, Kedron	40	60	**-**
6	20 Perry Street, Lutwyche	63	60	**3**
7	30 Colton Avenue, Lutwyche	48	60	**-**
8	12 Park Terrace, Kedron	52	60	**-**
9	17 Roblane Street, Windsor	63	60	**3**
10	7 Roblane Street, Windsor	59	60	**-**
11	46 Gallway Street, Windsor	49	60	**-**
12	49 Earle Street, Windsor	49	60	**-**
13	Royal Women's Hospital	65	60	**5**
14	62 Victoria Street, Windsor	51	60	**-**
15	42 Hooker Street, Windsor	55	60	**-**
16	Nursing Home, 26 Palmer St, Windsor	59	60	**-**
17	7 Lamington Avenue, Lutwyche	47	60	**-**
18	16 East Street, Lutwyche	46	60	**-**

Table 16 Analysis of Baseline Maximum Levels

Measurement Position	Description	Average Levels + (standard deviation) $L_{Amax,15min}$ (dBA)			Planning Level L_{Amax} (dBA)
		Day 6 am – 6 pm	Evening 6 pm – 10 pm	Night 10 pm – 6 am	
1	30 Wongara Street, Clayfield	76 (5.3)	71 (5.0)	64 (6.1)	80 dBA
2	86 Alma Road, Clayfield	70 (3.4)	69 (3.2)	66 (4.5)	80 dBA
3	27 Parkland Street, Nundah	79 (3.8)	81 (4.2)	65 (9.5)	80 dBA
4	72 Kalinga Street, Clayfield	72 (3.9)	70 (4.7)	62 (7.7)	80 dBA
5	34 Park Road, Kedron	74 (5.1)	63 (7.8)	52 (8.6)	80 dBA
6	20 Perry Street, Lutwyche	81 (4.3)	80 (4.3)	76 (3.5)	80 dBA
7	30 Colton Avenue, Lutwyche	68 (4.9)	62 (5.5)	58 (6.0)	80 dBA
8	12 Park Terrace, Kedron	70 (4.2)	67 (4.8)	62 (5.0)	80 dBA
9	17 Roblane Street, Windsor	83 (3.5)	79 (3.2)	79 (4.0)	80 dBA
10	7 Roblane Street, Windsor	77 (3.9)	74 (3.7)	74 (3.8)	80 dBA
11	46 Gallway Street, Windsor	75 (5.6)	72 (6.6)	63 (7.2)	80 dBA
12	49 Earle Street, Windsor	72 (4.2)	68 (5.0)	62 (5.5)	80 dBA
13	Royal Women's Hospital	78 (4.4)	77 (3.6)	75 (4.2)	80 dBA
14	62 Victoria Street, Windsor	75 (4.9)	70 (4.5)	64 (7.2)	80 dBA
15	42 Hooker Street, Windsor	75 (5.3)	75 (6.3)	65 (10.0)	80 dBA
16	Nursing Home, 26 Palmer St, Windsor	76 (3.7)	73 (3.7)	71 (4.2)	80 dBA
17	7 Lamington Avenue, Lutwyche	68 (4.8)	69 (5.0)	62 (6.3)	80 dBA
18	16 East Street, Lutwyche	68 (5.9)	66 (5.3)	57 (6.7)	80 dBA

4.6.3 Vibration

Vibration measures were carried out at a small number of locations to determine existing vibration levels prior to the start of construction using an Instantel MiniMate Vibration Logger. All measurements were taken in the ground outside the respective residence. The summarised results of the measurements are documented in **Table 17**.

Table 17 Summarised Vibration Measurements

Location	Date - Time	Dominant Frequency	Max PPV mm/s
49 Earle Street, Windsor	16/12/05 – 15:04	>100 Hz	0.08 mm/s
17 Roblane Street, Windsor	16/12/05 – 14:50	>100 Hz	0.08 mm/s
72 Kalinga Street, Clayfield	16/12/05 – 14:17	>100 Hz	0.08 mm/s
20 Perry Street, Lutwyche	16/12/05 – 14:33	>100 Hz	0.08 mm/s

These measurements show that existing vibration levels are at or below the floor of the measurement equipment (~0.08 mm/s) and therefore below the threshold of human perception (~ 0.15 mm/s).

Should the study reveal highly sensitive scientific instrumentation in any buildings in the vicinity of the works, additional baseline measurements would fall within the scope of specialist investigations that would be conducted as part of an *Environmental Management Plan*, at the conclusion of the EIS.

5 TRAFFIC NOISE PREDICTIONS AND IMPACT ASSESSMENT

5.1 Modelling Methodology

The CoRTN (Calculation of Road Traffic Noise) 1988 traffic noise prediction procedure was utilised within SoundPLAN suite of noise prediction software to calculate the traffic noise emissions. SoundPLAN is a software package which enables compilation of a computer model comprising a 3-D ground map containing ground contours, the final 3-D road design and building locations, traffic volumes, heavy vehicle composition and speed, road pavement characteristics and noise barriers. CoRTN is a recommended road prediction technique in Main Roads' *Code of Practice* and has been the primary validated road traffic noise model used in within Australia for many years.

Receivers were placed at 1.5m above the ground for single story properties and 4.2 m above the ground for two story dwellings. For multistorey buildings the receptor(s) were positioned at the most exposed building level.

Noise barriers, where they have been designed, are based on the results of single-point calculations at defined building facade locations.

All predictions include the Australian Road Research Board recommendations, which apply a correction for Australian road conditions of -1.7 dBA to CoRTN predictions at facades, and -0.7 dBA to CoRTN predictions at free-field locations.

Treatment of Noise Emissions from Portals

Emissions of traffic noise from portal openings have been modelled as area sources in the vertical plane of the portal opening. The source sound power for this area source and distribution of sound power over the portal area has been modelled as described by S. Olafsen's Inter-Noise 96 paper titled *"Noise from Road Tunnel Openings – An Engineering Approach"*. The propagation of the portal noise emissions has been modelled using the Industrial Noise Model within the SoundPLAN modelling suite. The noise predictions from the portal noise model has then been added logarithmically to the noise predictions for the standard CoRTN traffic noise predictions, to generate overall noise levels for the combination of portals and roadways.

Traffic Noise Composition Assumption

Inherent in the modelling methodology is the assumption that the loudness of the vehicle fleet as a whole would remain static over the period to the Years 2022 and 2026. On higher speed roads, where tyre noise is a large component of overall vehicle noise, this may be a reasonable assumption. However on other roads with sign-posted speeds of around 60 km per hour, the significance of engine and transmission noise is much greater. It can be anticipated that on these roads, engine and transmission noise will reduce to some extent over time as the overall fleet modernises. It is difficult to predict what the reduction would be, other than to say the assumption of static fleet noise emissions is conservative.

5.2 Choice of Assessment Parameter

The EPP[Noise] Planning Levels are expressed in terms of the $L_{A10(18hour)}$, maximum night-time LAeq(1hour), and the LAmax measurement parameters.

The L_{Amax} measurement parameter has previously been shown to be a poor indicator of the level of noise impact at residential locations, being both difficult to predict and widely exceeded across the range of ambient monitoring locations utilised in this study.

As long term projections of night-time traffic are not available, it is not feasible to directly calculate future traffic noise impacts in terms of the maximum night-time $L_{Aeq(1hour)}$ parameter. However, predictions of the $L_{Aeq(1hour)}$ parameter could be determined based on the typical 3 dBA offset between the typical maximum night-time $L_{Aeq(1hour)}$ and the $L_{A10(18hour)}$ level, observable from traffic noise records at the reference locations. Analysis of the data for this project indicates the average difference between the $L_{A10(18hour)}$ planning level and the maximum night-time $L_{Aeq(1hour)}$ planning level is 4 dBA, meaning that predictions based on the $L_{A10(18hour)}$ index would also be a slightly conservative indication of the $L_{Aeq(1hour)}$ index. A specific assessment of $L_{Aeq(1hour)}$ predictions would therefore only produce redundant information.

The assessment undertaken in this report has therefore been presented in terms of the $L_{A10(18hour)}$ parameter only.

5.3 Model Scenarios

The EPP[Noise] identifies Planning Levels for traffic noise emissions from roadways, but does not specify what actions should be carried out in response to road developments that may result in exceedances of Planning Levels.

Traffic noise predictions have been undertaken for the future predicted levels of road traffic noise with and without the Airport Link project proceeding.

The Interim Northern Busway, a Queensland Transport project also utilising the Bowen Bridge Rd /Lutwyche Rd corridor, is expected to be completed in 2022, thus for this report, the following situations have been modelled in accordance with the ToR:

- **Do minimum (2022)**: The predictions include all future (ie 2022) traffic utilising the existing road corridor, excluding the Airport Link and the Northern Busway projects. This scenario represents the future traffic that would have arisen in the absence of these major transport initiatives, and represents the baseline noise projections against which some of the other scenarios are compared;
- **Airport Link without Interim Northern Busway (2022)** - traffic flows including Airport Link, but excluding the Interim Northern Busway project. This scenario represents the change in traffic noise, attributable directly to the Airport Link project; and
- **Airport Link with Interim Northern Busway (2022)** - traffic flows including Airport Link and the Interim Northern Busway projects.

The Ultimate Northern busway design, (where the bus lanes are mostly in a tunnel along Bowen Bridge Rd and Lutwyche Rd) is expected to be completed in 2026. In accordance with usual practice, the acoustic design year would consequently be 2036. Traffic forecasts of 30 years are not typically undertaken due to the difficulty in estimating the capacity of and demands on the wider transport infrastructure network 30 years in the future, as well as local infrastructure that may exist in communities around the road corridor, both of which have a significant impact on the modelling predictions. Thus, for the Ultimate Northern Busway scenarios, the assessment has been undertaken for the year of opening (ie 2026). As the Ultimate Northern Busway project develops in coming years, further environmental assessments will need to be undertaken to confirm the levels of impact (either positive or negative) presented in this report. At this time it may be more reasonable and feasible to assess the predicted traffic noise levels in 2036 (10 years after opening).

Therefore the following situations are modelled for the Ultimate Northern Busway scenarios:

- **Do minimum (2026)**: The predictions include all future (ie 2026) traffic utilising the existing road corridor, excluding the Airport Link and the Northern Busway projects. This scenario represents the future traffic that would have arisen in the absence of these major transport initiatives, and represents the baseline noise projections against which some of the other scenarios are compared.

- **Airport Link without Ultimate Northern Busway (2026)** - traffic flows including Airport Link, but excluding the Ultimate Northern Busway project. This scenario represents the change in traffic noise, attributable directly to the Airport Link project; and
- **Airport Link with Ultimate Northern Busway (2026)** - traffic flows including Airport Link and the Ultimate Northern Busway projects.

In addition to the modelling scenarios described above, a model was developed to simulate the existing 2005 traffic flows and existing road network for verification of the noise prediction model.

All the traffic data (including the heavy vehicle content) for these scenarios was supplied by the Joint Venture (JV) and is presented in **Appendix C** to **Appendix F** (inclusive).

5.4 Model Verification

Table 18 compares the measured $L_{A10(18hour)}$ noise levels against the predicted noise levels utilising the (existing) 2005 SoundPLAN model. The traffic data used within the model is based on the provided 2004 traffic flows plus 2%.

The Australian Road Research Board corrections for Australian road conditions of -1.7 dBA to CoRTN predictions at facades, and -0.7 dBA to CoRTN predictions at free-field locations have been applied. No road surface correction has been applied, as all existing road surfaces are dense graded asphalt.

Table 18 Comparison of Measured and Predicted Noise Levels in 2005

Location	Dominant Source of Traffic Noise	$L_{A10(18hour)}$ Noise Level (dBA)		
		Measured	Predicted	Difference
30 Wongara Street	East-West Arterial	57	58	-1
27 Parklands Street	Sandgate Road	61	63	-2
20 Perry Street	Gympie Road	70	68	+2
Kedron State High	Gympie Road	51	52	-2
17 Roblane Street	Roblane Street / Lutwyche Road	70	68	+2
Royal Woman's Hospital	Lutwyche Road	71	69	+2
Mews Apartments	ICB	67	67	0

Differences between measured and predicted levels of 2 dBA are considered readily acceptable for the purpose of model verification. All the predicted $L_{A10(18hour)}$ noise levels for locations directly adjacent existing roads are within 2 dBA of the measured results therefore the model is considered to be verified.

5.5 Barrier Design

Where required, the heights of roadside barriers have been determined to achieve the appropriate criterion. A cap on the height of any barrier is set to 8 m, due to consideration of "practicality and feasibility" of construction, aesthetics and other urban design issues such as overshadowing.

Two noise barrier designs have been undertaken for the Airport Link scenarios, with and without Interim/Ultimate Northern Busway, as outlined below.

"Status Quo" Noise Barrier Option

The objective used to develop the "status quo" barrier option for the 2 design years (2022 and 2026) is to develop road-side noise barriers, where practical and feasible, to achieve traffic noise levels comparable to the "Do Minimum" option.

"Planning Level" Noise Barrier Option

The objective used to develop the "planning level" barrier option for the 2 design years (2022 and 2026) is to develop road-side noise barriers, where practical and feasible, to limit traffic noise levels to the 63 dBA or 68 dBA (as applicable) $L_{A10(18hr)}$ planning levels wherever possible.

The purpose of this option is to illustrate the scale of noise controls that would be necessary to achieve the "planning" traffic noise levels in accordance with the EPP[Noise] and Code of Practice. In many areas this would require noise controls to account for gradual increases in traffic noise over time that are not attributable to the tunnel.

5.6 Modelling Output

Summary tables documenting the report appendices containing the various colour noise contour plots (for all the modelling scenarios outlined in **Section 5**) are presented in **Table 19** to **Table 21**.

The noise contours provide a representation of the noise level in a particular area of interest. They are provided for information only and are generated for a receiver height 4.2 m above ground level. This height best represents the height of residences in the study area. At any particular residence, the appropriate design height may be higher or lower than this 'typical' height. The detailed design of barriers is conducted based on the noise levels at particular residences, where the actual properties of the building are used (ie single story on slab, single story (elevated above the ground), double story etc).

Discussions on the impacts and effects of noise mitigation are presented in **Section 5.7**, **Section 5.8** and **Section 5.8** for the Southern, Gympie Road and Sandgate Road Portal areas respectively.

Table 19 Summary of Noise Maps for Southern Portal Area

Prediction Scenario	No Mitigation Measures	Barrier Design to maintain Status Quo	Barrier Design to achieve 63/68 dBA $L_{A10(18hr)}$
2022			
Do Minimum	Appendix J1	n/a	n/a
Airport Link without NB	Appendix J2	Appendix J3	Appendix J4
Airport Link with Interim NB	Appendix J5	Appendix J6	Appendix J7
2026			
Do Minimum	Appendix J8	n/a	n/a
Airport Link without NB	Appendix J9	Appendix J10	Appendix J11
Airport Link with Ultimate NB	Appendix J12	Appendix J13	Appendix J14

Table 20 Summary of Noise Maps for Gympie Road Portal Area

Prediction Scenario	No Mitigation Measures	Barrier Design to maintain Status Quo	Barrier Design to achieve 63/68 dBA $L_{A10(18hr)}$
2022			
Do Minimum	Appendix K1	n/a	n/a
Airport Link without Interim NB	Appendix K2	Appendix K3	Appendix K4
Airport Link with Interim NB	Appendix K5	Appendix K6	Appendix K7
2026			
Do Minimum	Appendix K8	n/a	n/a
Airport Link without NB	Appendix K9	Appendix K10	Appendix K11
Airport Link with Ultimate NB	Appendix K12	Appendix K13	Appendix K14

Table 21 Summary of Noise Maps for Sandgate Road Portal

Prediction Scenario	No Mitigation Measures	Barrier Design to maintain Status Quo	Barrier Design to achieve 63/68 dBA $L_{A10(18hr)}$
2022			
Do Minimum	Appendix L1	n/a	n/a
Airport Link without Interim NB	Appendix L2	Appendix L3	Appendix L4
Airport Link with Interim NB	Appendix L5	Appendix L6	Appendix L7
2026			
Do Minimum	Appendix L8	n/a	n/a
Airport Link without NB	Appendix L9	Appendix L10	Appendix L11
Airport Link with Ultimate NB	Appendix L12	Appendix L13	Appendix L14

5.7 Discussion of Results – Southern Portal Area

The appropriate planning level for traffic noise in the Southern portal area is 63 dBA $L_{A10(18hour)}$ for all residential locations. The noise contours produced for this area are detailed in **Appendix J,** and have been generated 4.2 m above ground level. This height is generally representative of residences in the area.

Receptor locations below the planning level of 63 dBA $L_{A10(18hour)}$ are in a green colour band.

5.7.1 2022 “Do Minimum” Results

Appendix J1 presents the noise contours for 2022, assuming no Airport Link or Northern Busway Projects, which is referred to as the “Do Minimum” option.

For the “Do Minimum” option, the 2022 traffic noise levels include the proposed NSBT design barriers at various locations as detailed in **Appendix J1**.

South of the Enoggera Creek, there are a number of noise sensitive properties, the Royal Brisbane Hospital, the Mews Apartments and residences in Tufton Street and Wren Street.

At the Royal Brisbane Hospital, the resultant noise levels are around 71 dBA, whilst, at the Mews Apartments, the noise level is in the range 71 dBA to 74 dBA.

North of Enoggera Creek, the dwellings on the eastern side of Lutwyche Road are predicted to experience noise levels of around 66 dBA to 68 dBA behind the proposed NSBT barriers. To the north of these barriers, the noise levels increase to 77 dBA to 80 dBA or more on the eastern and western sides of Bowen Bridge road.

There is a logical suggestion, that as the tunnel removes traffic from the surface roads, that dwellings in this area that are away from the immediate portal would be expected to receive a benefit from the project.

5.7.2 2022 "Airport Link with No Interim Northern Busway" Results

No Mitigation Measures (2022)

Appendix J2 presents the noise contours for 2022, without any mitigation in place, assuming the Airport Link has been constructed but without the Interim Northern Busway Project.

At the Royal Brisbane Hospital, the introduction of the airport link will result in a marginal (nominal 1 dBA) reduction in noise along the Bowan Bridge Road façade. The Mews apartments are expected to experience increased noise levels of up to 3 dBA on the north-eastern facades.

Residents in Tufton Street are expected to experience increased noise levels of around 3 dBA (on the Campbell Street facades).

Residents in Wren Street are expected to experience decreased noise levels of around 1 dBA.

Residences north of Enoggera Creek on Lutwyche Road are predicted to experience a very marginal decrease in the predicted noise levels. Away from Lutwyche Road to the east, residents in the vicinity of Byrne Street and Federation Street are expected to receive increases of around 6 dBA, as a result of the new road works and the loss of barrier effects from the intervening dwellings that were acquired and demolished as part of the project.

Barriers to Maintain 'Status Quo' Noise Levels (2022)

For the Airport Link without the Interim Northern Busway option, the noise barriers required to maintain the "status quo" (ie to have an acoustic environment no worse off than would have otherwise occurred due to natural traffic increases) are presented in **Appendix J3**.

The barriers are concentrated near:

- Campbell Street – near Tufton Street;
- the ramps east of the Mews Apartments; and
- immediately to the north of the tunnel portals, near Earle Street and Byrne Street, Bowen Hill.

Even with the nominated barriers, the "status quo" cannot be fully achieved for residences and consideration should be given to the laying of Open Graded Asphaltic Concrete for a distance of 270 m from the APL portal on the 'APL southbound to ICB' (eastern most road). This is subject to further evaluation of safety (ie use of OGAC in tunnels is not normally permitted for safety reasons), cost (higher initial and on-going maintenance costs) and wear (given the heavy vehicle content).

To achieve compliance with the "status quo" noise levels at the Mews Apartments, the NSBT "ICB to Lutwyche Road" elevated structure, east of the Mews, needs to be fully enclosed on the western side up to the underside of the Airport Link "O'Connell Tce southbound on-ramp" elevated structure. Provided this acoustic solution for the Mews Apartments is acceptable to all other disciplines (eg civil engineering) then compliance with the "status quo" noise levels is predicted at the most exposed faces of the Mews Apartments. This mitigation technique is recommended for all the noise barrier designs (both "status quo" and "planning" levels) contained in **Section 5.7** of the report and has been approximated for all of the barrier lengths and barrier areas as a 6 m high barrier.

For the 2002 'status quo' design, there is a total of 1,846 linear meters or 8,098 m^2 of noise barrier required along this section of the project, including the upgrading of some NSBT barriers. These barrier quantities include the wall joining the two elevated structures (discussed above) adjacent to the Mews Apartments.

Barriers to Achieve 63 dBA $L_{A10(18hour)}$ Design Objective (2022)

The barrier design required to achieve the appropriate 63 dBA $L_{A10(18hour)}$ criterion at noise sensitive properties adjacent to the roadworks is presented in **Appendix J4**.

It has to be noted that it is not practical to achieve the $L_{A10(18hour)}$ criterion at high rise Mews apartments, Tufton Street apartments and Wren Street properties, due to the impractical height they would need to be to achieve compliance. Consequently, at these locations, the barrier design aims to achieve the "status quo" levels, rather than the 63 dBA criterion.

This design incorporates a total of 1,846 linear meters (or 7,486 m^2) of barrier to achieve the 63 dBA design target at residential properties north of Enoggera Creek and "status quo" levels South of Enoggera Creek.

5.7.3 2022 "Airport Link with Interim Northern Busway" Results

No Mitigation Measures

Appendix J5 presents the noise contours for 2022, without any mitigation in place, assuming both the Airport Link and Interim Northern Busway Projects have been constructed.

For the properties south of Enoggera Creek in the vicinity of Campbell, Wren and Tufton Streets, there is no noticeable change as a result of the Interim Busway phase of the project. For properties along Lutwyche Road, the introduction of the Interim Northern Busway results in a decrease in the noise environment of less than 1 dBA on either side of the roadway. Such decreases are of marginal impact, though the absolute noise levels are considerable higher that the 63 dBA $L_{A10(18hour)}$ planning level.

Barriers to Maintain 'Status Quo' Noise Levels (2022)

For the Airport Link with Interim Northern Busway option, the noise barriers required to maintain the 'status quo' (ie to have an acoustic environment, no worse off than would have otherwise occurred due to natural traffic increases) are presented in **Appendix J6**.

The resulting noise levels are quite similar at the most affected properties to the Airport Link with no interim busway, thus the barrier design closely resembles the barrier design presented in **Appendix J3**.

This design incorporates a total of 1,846 linear meters or 8,098 m^2 of barrier to maintain the status quo at residential properties.

Barriers to Achieve 63 dBA $L_{A10(18hour)}$ Design Objective (2022)

The barrier design required to achieve the appropriate 63 dBA $L_{A10(18hour)}$ criterion at residential properties adjacent to the roadworks is presented in **Appendix J7**.

The resulting noise levels are quite similar at the most affected properties to the Airport Link with no interim busway, thus the barrier design closely resembles the barrier design presented in **Appendix J4**.

It has to be noted that it is not practical to achieve the $L_{A10(18hour)}$ criterion at high rise apartments in the Mews, Tufton Street apartments and Wren Street properties, due the impractical height they would need to be to achieve compliance. Consequently, at these locations, the barrier design aims to achieve the status quo levels, rather than the 63 dBA criterion.

This design incorporates a total of 1,846 linear meters (or 7,486 m^2) of barrier to achieve the 63 dBA design target at most residential properties.

5.7.4 2026 "Do Minimum" Results

Appendix J8 presents the noise contours for 2026, assuming no Airport Link or Northern Busway Projects, which is referred to as the "Do Minimum" option.

The "Do Minimum" for 2026 appears to be almost identical to the 2022 "Do Minimum" predictions that are presented in **Appendix J1**. Given the difference between these two scenarios is the natural increase in traffic, unrelated to either the Airport Link or Northern Busway projects, it would be expected that the two sets of results are very similar.

5.7.5 2026 "Airport Link with No Ultimate Northern Busway" Results

No Mitigation Measures

Appendix J9 presents the noise contours for 2026, without any mitigation in place, assuming the Airport Link has been constructed but without the Ultimate Northern Busway Project.

Similar to the "Do Minimum" scenario, the road traffic noise emissions predicted from this scenario are very similar to the results in **Appendix J2**.

Barriers to Maintain 'Status Quo' Noise Levels (2026)

For the Airport Link without the Northern Busway option, the noise barriers required to maintain the 'status quo' noise levels (ie to have an acoustic environment, no worse off than would have otherwise occurred due to natural network increases) are presented in **Appendix J10**.

The very marginal impact from the busway and the small change in traffic growth between 2022 and 2026, results in the barrier quantities for the "status quo" for 2022 not changing.

This design incorporates a total of 1,846 linear meters or 8,098 m^2 of barrier to maintain the status quo at residential properties.

Barriers to Achieve 63 dBA $L_{A10(18hour)}$ Design Objective (2026)

Appendix J11 presents the noise contours for 2026, assuming the Airport Link without the Northern Busway Project which incorporate the noise barriers required to achieve the relevant 63 dBA $L_{A10(18hour)}$ planning level.

The very marginal impact from the busway and the small change in traffic growth between 2022 and 2026, results in the barrier quantities needed for compliance with the 63 dBA design for 2022 not changing.

This design incorporates a total of 1,846 linear meters (or 7,486 m^2) of barrier to achieve the 63 dBA design target at most residential properties.

5.7.6 2026 "Airport Link with Ultimate Northern Busway" Results

No Mitigation Measures

Appendix J12 presents the noise contours for 2026, without any mitigation in place, assuming the ultimate Airport Link and Northern Busway Projects have been constructed.

Comparison of these levels with the "Do Minimum" predictions (**Appendix J8**) indicates that:

- The properties in Tufton Street (near Campbell Street) will experience increases in noise levels of up to 3 dBA;
- The Campbell Street façade of the Wren Street apartments will experience a marginal decrease in noise;
- The north-eastern facade of the Mews apartments will experience increases of up to 3 dBA;
- Residences on the eastern and western side of Lutwyche Road (north of Taylor Street and Federation Street respectively), will experience noise levels decreases of up to 3 dBA,
- Properties in Earle and Byrne Streets will experience increases in the level of noise between (typically) 3 dBA to 7 dBA, due to the introduction of the busway and the demolition of dwellings, which would have acted as a partial noise barrier.

Barriers to Maintain 'Status Quo' Noise Levels (2026)

For the Airport Link with the Ultimate Northern Busway option, the noise barriers required to maintain the 'status quo' noise levels (ie to have an acoustic environment, no worse off than would have otherwise occurred due to natural network increases) are presented in **Appendix J13**.

Even with the nominated barriers, the "status quo" cannot be fully achieved and consideration should be given to the laying of Open Graded Asphaltic Concrete for a distance of 270 m from the portal on the 'APL southbound to ICB' (eastern most road). This is subject to further evaluation of safety (ie use of OGAC in tunnels is not normally permitted for safety reasons), cost (higher initial and on-going maintenance costs) and wear (given the heavy vehicle content).

Regarding the existing NSBT barriers north of Federation Street, it is assumed that these will be in place as part of the NSBT project. All barriers adjacent Lutwyche Road, south of Federation St, are assumed to be demolished as the busway lanes coincides with their location.

This design incorporates a total of 1,725 linear meters (or 7,603 m^2) of barrier to maintain the 'status quo' noise levels at residential properties.

Barriers to Achieve 63 dBA $L_{A10(18hour)}$ Design Objective (2026)

Appendix J14 presents the noise contours for 2026, assuming the Airport Link with the Ultimate Northern Busway Project, which incorporate the noise barriers required to achieve the relevant 63 dBA $L_{A10(18hour)}$ planning level.

Regarding the existing NSBT barriers north of Federation Street, it is assumed that these will be in place as part of the NSBT project. All barriers adjacent Lutwyche Road, south of Federation St, are assumed to be demolished as the busway lanes coincides with their location.

It has to be noted that it is not practical to achieve the $L_{A10(18hour)}$ criterion at high rise apartments in the Mews, Tufton Street apartments and Wren Street properties, due the impractical height they would need to be to achieve compliance. Consequently, at these locations, the barrier design aims to achieve the "status quo" levels, rather than the 63 dBA criterion.

This design incorporates a total of 1,725 linear meters (or 7,603m^2) of barrier to achieve the 63 dBA $L_{A10(18hour)}$ planning level at most residential properties.

5.8 Discussion of Results – Gympie Road Portal Area

The appropriate planning level for traffic noise in the Gympie Rd portal area is 63 dBA $L_{A10(18hour)}$ for any residential locations south of Kedron Brook and 68 dBA $L_{A10(18hour)}$ for residences north of Kedron Brook.

The noise contours produced for the Gympie Rd area, contained in **Appendix K,** have been generated 4.2 m above ground level. This height is generally representative of residences in the area.

Receptor locations below the planning level of 63 dBA $L_{A10(18hour)}$ are in a green colour band. Receptor locations within the light to darker red colour bands exceed the planning level of 68 dBA $L_{A10(18hour)}$.

5.8.1 2022 "Do Minimum" Results

Appendix K1 presents the noise contours for 2022, assuming no Airport Link or Northern Busway Projects, which is referred to as the "Do Minimum" option.

For the "Do Minimum" option, the 2022 traffic noise levels at the first row of residences on the eastern side and western side of Lutwyche Road and Gympie Road would typically be in the range 74 dBA $L_{A10(18hour)}$ to more than 77 dBA $L_{A10(18hour)}$, significantly above the 63 dBA $L_{A10(18hour)}$ Planning Level for Lutwyche Road (south of Kedron Brook) and 68 dBA $L_{A10(18hour)}$ for Gympie Road (north of Kedron Brook).

There is a logical suggestion, that as the tunnel removes traffic from the surface roads, that dwellings in this area would be expected to receive a benefit from the project.

5.8.2 2022 "Airport Link with No Interim Northern Busway" Results

No Mitigation Measures (2022)

Appendix K2 presents the noise contours for 2022, without any mitigation in place, assuming the Airport Link has been constructed but without the Interim Northern Busway Project.

On the east and west side of Lutwyche Rd (south of Isedale Street) it is predicted that there will be a 3 dBA reduction in overall levels of road traffic noise with respect to the "Do Minimum" case.

Along the eastern side of Gympie Rd, directly north of Kedron Brook, there are a number of buildings that require acquisition and demolition. These buildings provided acoustic shielding to the subsequent rows and as a consequence of their removal, noise levels at the newly exposed residences increases by typically 3 dBA to 6 dBA. Such increases are clearly noticeable and likely to result in some impacts.

The noise environment to the east of Lutwyche Road, south of the Kedron Park Rd (ie around Wooloowin Primary School and the Anglican Church will experience a marginal decrease in the overall level of road traffic noise.

Barriers to Maintain 'Status Quo' Noise Levels (2022)

For the Airport Link without the Interim Northern Busway Option, the noise barriers required to maintain the status quo (ie to have an acoustic environment no worse off than would have otherwise occurred due to natural traffic increases) are presented in **Appendix K3**.

The barriers are concentrated near the new overpasses and near areas where properties have been acquired and demolished, exposing new dwellings to increased traffic noise levels.

West of Lutwyche Road, where noise levels at residences increased due to the acquisition of the first row of properties, 4 m to 8 m high barriers will generally be required. Similarly, there are a number of properties acquired and demolished on the northern side of Gympie Road, which will also require barriers of between 2 m and 6 m high.

In those areas where houses have been demolished, it may be preferable (from an urban design perspective) to construct new buildings at locations where space exists, that would achieve comparable barrier shielding benefits to these indicative barrier designs.

No barriers have been adopted at Wooloowin Primary School due to access requirements and the possible implication for children's security (being out of sight from teachers, parents and school supervisors). Some further consultation will be required with the school and the barrier design in this area may need to be revised at some future date.

For the 2022 'status quo' design, there is a total of 1,706 linear meters or 8,114 m^2 of noise barrier required along this section of the project.

Barriers to Achieve 63/68 dBA $L_{A10(18hour)}$ Design Objective (2022)

The barrier design required to achieve the appropriate 63/68 dBA $L_{A10(18hour)}$ criterion at noise sensitive properties adjacent to the roadworks is presented in **Appendix K4**.

The barrier design is broadly similar along Lutwyche Road (south of Kedron Brook) to the Status Quo design. However fewer barriers are recommended along Gympie Road (north of Kedron Brook) due to the higher 68 dBA $L_{A10(18hour)}$ criterion.

This barrier design not only mitigates the increases in road traffic noise levels arising from the project, but also the gradual build up of traffic over the intervening time period.

This design incorporates a total of 1,177 linear meters (or 5,486 m^2) of barrier to achieve the 63/68 dBA design target at residential properties.

5.8.3 2022 "Airport Link with Interim Northern Busway" Results

No Mitigation Measures

Appendix K5 presents the noise contours for 2022, without any mitigation in place, assuming both the Airport Link and Interim Northern Busway Projects have been constructed.

For properties along Lutwyche Road, south of Kedron Park Road, the introduction of the Interim Northern Busway results in only a marginal change in the noise environment of 2 dBA on either side of the roadway. Such increases are of marginal impacts, though the absolute noise levels are considerable higher that the 63 dBA $L_{A10(18hour)}$ planning level.

Comparison of **Appendix K5** with **Appendix K2**, the Interim Northern Busway does not result in any significant change in the overall levels of traffic noise for the residential properties along Gympie Road, south of Somerset Street. Whilst the Interim Northern Busway does not increase the levels, they remain significantly above the 68 dBA $L_{A10(18hour)}$ planning level, with many properties experiencing levels of 77 dBA $L_{A10(18hour)}$ or more.

Barriers to Maintain 'Status Quo' Noise Levels (2022)

For the Airport Link with Interim Northern Busway Option, the noise barriers required to maintain the 'status quo' (ie to have an acoustic environment, no worse off than would have otherwise occurred due to natural traffic increases) are presented in **Appendix K6**.

No barriers have been adopted at Wooloowin Primary School due to access requirements and the possible implication for children's security (being out of sight from teachers, parents and school supervisors). Some further consultation will be required with the school and the barrier design in this area may need to be revised at some future date.

This design incorporates a total of 1,910 linear meters (or 9,123 m^2) of barrier to maintain the status quo at residential properties.

Barriers to Achieve 63/68 dBA $L_{A10(18hour)}$ Design Objective (2022)

The barrier design required to achieve the appropriate 63/68 dBA $L_{A10(18hour)}$ criterion at residential properties adjacent to the roadworks is presented in **Appendix K7**.

The barrier design is somewhat similar to the barrier design presented in **Appendix K4** and **Appendix K7**, though local conditions have acted to change the heights of the barriers in some areas.

This barrier design not only mitigates the increases in road traffic noise levels arising from the project, but also the gradual build up of traffic over the intervening time period.

This design incorporates a total of 1,218 linear meters (or 5,041 m^2) of barrier to achieve the 63/68 dBA $L_{A10(18hour)}$ planning level at residential properties.

5.8.4 2026 “Do Minimum” Results

Appendix K8 presents the noise contours for 2026, assuming no Airport Link or Northern Busway Projects, which is referred to as the “Do Minimum” option.

The “Do Minimum” for 2026 appears to be almost identical to the 2022 “Do Minimum” predictions that are presented in **Appendix K1**. Given the difference between these two scenarios is the natural increase in traffic, unrelated to either the Airport Link or Northern Busway projects, it would be expected that the two sets of results are quite similar.

5.8.5 2026 “Airport Link with No Ultimate Northern Busway” Results

No Mitigation Measures

Appendix K9 presents the noise contours for 2026, without any mitigation in place, assuming the Airport Link has been constructed but without the Ultimate Northern Busway Project.

Comparison of these levels with the “Do Minimum” predictions (**Appendix K8**) indicates that where the properties in Lutwyche Road (south of Kedron Brook) are being acquired and demolished, increases of between 5 dBA to 10 dBA are predicted in the newly exposed properties. This represents a significant increase in the level of road traffic noise and would definitely warrant further consideration of noise mitigation.

Residents adjacent Lutwyche Road and Gympie Road, around the wider portal area, are predicted to experience marginal increases in noise levels of around 3 dBA due to increased traffic and the new road design.

Similar to the “Do Minimum” scenario, the road traffic noise emissions predicted from this scenario are very similar to the results in **Appendix K2**.

Barriers to Maintain ‘Status Quo’ Noise Levels (2026)

For the Airport Link without the Northern Busway Option, the noise barriers required to maintain the ‘status quo’ noise levels (ie to have an acoustic environment, no worse off than would have otherwise occurred due to natural network increases) are presented in **Appendix K10**.

No barriers have been adopted at Wooloowin Primary School due to access requirements and the possible implication for children's security (being out of sight from teachers, parents and school supervisors). Some further consultation will be required with the school and the barrier design in this area may need to be revised at some future date.

This design incorporates a total of 1,706 linear meters (or 8,244 m^2) of barriers to maintain the 'status quo' at residential properties.

Barriers to Achieve 63/68 dBA $L_{A10(18hour)}$ Design Objective (2026)

Appendix K11 presents the noise contours for 2026, assuming the Airport Link without the Northern Busway Project which incorporate the noise barriers required to achieve the relevant 63/68 dBA $L_{A10(18hour)}$ planning level.

No barriers have been adopted at Wooloowin Primary School due to access requirements and the possible implication for children's security (being out of sight from teachers, parents and school supervisors). Some further consultation will be required with the school and the barrier design in this area may need to be revised at some future date.

The barrier design not only mitigates the increases in road traffic noise levels arising from the project, but also the gradual build up of traffic over the intervening time period.

This design incorporates a total of 1,177 linear meters (or 5,486m^2) of barrier to achieve the 63/68 dBA $L_{A10(18hour)}$ planning level at residential properties.

5.8.6 2026 "Airport Link with Ultimate Northern Busway" Results

No Mitigation Measures

Appendix K12 presents the noise contours for 2026, without any mitigation in place, assuming the Airport Link and Northern Busway Projects have been constructed.

Comparison of these levels with the "Do Minimum" predictions (**Appendix K8**) indicates that where the properties in Lutwyche Road (south of Kedron Brook) are being acquired and demolished, increases of between 5 dBA to 10 dBA are predicted in the newly exposed properties. This represents a significant increase in the level of road traffic noise and would definitely warrant further consideration of noise mitigation.

Residents adjacent Lutwyche Road and Gympie Road, around the wider portal area, are predicted to experience marginal increases in noise levels of around 3 dBA due to increased traffic and the new road design.

Barriers to Maintain 'Status Quo' Noise Levels (2026)

For the Airport Link with the Ultimate Northern Busway Option, the noise barriers required to maintain the 'status quo' noise levels (ie to have an acoustic environment, no worse off than would have otherwise occurred due to natural network increases) are presented in **Appendix K13**.

No barriers have been adopted at Wooloowin Primary School due to access requirements and the possible implication for children's security (being out of sight from teachers, parents and school supervisors). Some further consultation will be required with the school and the barrier design in this area may need to be revised at some future date.

This design incorporates a total of 1,901linear meters (or 9,123 m^2) of barrier to maintain the 'status quo' noise levels at residential properties.

Barriers to Achieve 63/68 dBA $L_{A10(18hour)}$ Design Objective (2026)

Appendix K14 presents the noise contours for 2026, assuming the Airport Link with the Ultimate Northern Busway Project, which incorporate the noise barriers required to achieve the relevant 63/68 dBA $L_{A10(18hour)}$ planning level.

No barriers have been adopted at Wooloowin Primary School due to access requirements and the possible implication for children's security (being out of sight from teachers, parents and school supervisors). Some further consultation will be required with the school and the barrier design in this area may need to be revised at some future date.

This barrier design not only mitigates the increases in road traffic noise levels arising from the project, but also the gradual build up of traffic over the intervening time period.

This design incorporates a total of 1,218 linear meters (or 5,041 m^2) of barrier to achieve the 63/68 dBA $L_{A10(18hour)}$ planning level at residential properties.

5.9 Discussion of Results – Sandgate Road Portal Area

The appropriate planning level for traffic noise in the Sandgate Road portal area is 63 dBA $L_{A10(18hour)}$ for residents in locations west of Sandgate Road and 68 dBA $L_{A10(18hour)}$ for residents east of Sandgate Road.

The noise contours produced for the Sandgate Road portal area, contained in **Appendix L,** have been generated 4.2 m above ground level. This height is generally representative of residences in the area.

Receptor locations below the planning level of 63 dBA $L_{A10(18hour)}$ are in a green colour band. Receptor locations within the light to darker red colour bands exceed the planning level of 68 dBA $L_{A10(18hour)}$.

5.9.1 2022 “Do Minimum” Results

Appendix L1 presents the noise contours for 2022, assuming no Airport Link or Northern Busway Projects, which is referred to as the “Do Minimum” option. There are existing 2 m to 4 m high roadside noise barriers along the residential property boundary common with the East-West Arterial Freeway. These have been incorporated into the “Do Minimum” model.

For the “Do Minimum” option, the predicted 2022 traffic noise levels at the first row of residences on the southern side of the East-West Arterial Road are typically in the range 63 dBA $L_{A10(18hour)}$ to 68 dBA $L_{A10(18hour)}$ which complies (with only a few exceptions) with the applicable 68 dBA $L_{A10(18hour)}$ criterion.

Residences to the west of Sandgate Road experience a wide range of noise levels. Those on Sandgate Road currently experience levels of 77 dBA $L_{A10(18hour)}$ or more, whilst those residents in Alma Street and further to the west experience levels of 65 dBA $L_{A10(18hour)}$ or lower, marginally exceeding the 63 dBA $L_{A10(18hour)}$ Planning Level.

5.9.2 2022 “Airport Link with No Interim Northern Busway” Results

No Mitigation Measures (2022)

Appendix L2 presents the noise contours for 2022, without any mitigation in place, assuming the Airport Link has been constructed but without the Interim Northern Busway Project.

At the eastern end of the East-West Arterial (towards Widdop Street and around the Hendra Secondary College), the introduction of the Airport Link does not have any significant impacts to the prevailing levels of traffic noise.

The western end (near Sandgate Road) of the existing noise barrier south of the East West Arterial will need to be demolished for road widening associated with Airport Link. For the purposes of this modelling, that section of the existing 4 m high noise barrier (that will be demolished) has been replaced with a 1.2 m high concrete safety barrier only. This has been done to examine the impacts associated with this scenario and should **not** be interpreted as a recommended mitigation measure. In practice, the minimum mitigation should be to relocate the existing wall closer to the residents. The demolished noise barrier results in increases of 6 dBA or more to adjacent residents.

Residents along the northern sections of Alma Rd, Stuckley Rd and Elliott St are expected to experience increases in traffic noise from the new roadway, and from the acquisition and demolition of a number of intervening dwellings. Without any mitigation measures, the most affected property is predicted to experience absolute noise levels of 69 dBA $L_{A10(18hour)}$ and a corresponding increase of approximately 13 dBA.

Barriers to Maintain 'Status Quo' Noise Levels (2022)

For the Airport Link without the Interim Northern Busway Option,, the noise barriers required to maintain the 'status quo' (ie to have an acoustic environment, no worse off than would have otherwise occurred due to natural network increases) are presented in **Appendix L3**.

For the section of the new roadway between Sandgate Road and the portal entrance, barriers are required to be constructed on the southern side of the roadway that range between 3 m and 8 m high. Along the East-West Arterial, a new barrier is required for the section that was demolished, of height 2 m to 5 m.

For the 2022 'status quo' design, there is a total of 484 linear meters or 2,963 m^2 of barrier required along this section of the project.

Barriers to Achieve 63/68 dBA $L_{A10(18hour)}$ Design Objective (2022)

The barrier design required to achieve the appropriate 63/68 dBA $L_{A10(18hour)}$ criterion at residential properties adjacent to the roadworks is presented in **Appendix L4**.

The barrier design is broadly similar to the status quo design, except that the existing noise barrier (south of the East West Arterial) needs to be extended east between Widdop Street and The Promenade, to provide mitigation to Hendra Secondary College and the residences in The Promenade. The barrier needed to be extended past the end of the roadworks, to ensure all of the properties received an adequate level of noise mitigation.

This barrier design not only mitigates the increased in the levels of road traffic arising from the project, but also the gradual build up of traffic over many successive years.

This design incorporates a total of 1,099 linear meters (or 4,410 m^2) of barrier to achieve the 63/68 dBA $L_{A10(18hour)}$ planning levels at residential and educational properties.

5.9.3 2022 "Airport Link with Interim Northern Busway" Results

The introduction of the Interim Northern Busway has a very negligible influence (less that 0.1 dBA difference) on the road traffic noise levels in the section of the project due to changes in the traffic volumes. Therefore, the noise barrier designs for the Status Quo and 63/68 dBA $L_{A10(18hour)}$ scenarios without the Busway are also applicable (without any adjustments) for the Airport Link with Interim Northern Busway scenario.

5.9.4 2026 "Do Minimum" Results

Appendix L8 presents the noise contours for 2022, assuming no Airport Link or Northern Busway Projects, which is referred to as the "Do Minimum" option.

The "Do Minimum" for 2026 appears to be almost identical to the 2022 "Do Minimum" predictions that are presented in **Appendix L1**. Given the difference between these two scenarios is the natural increase in traffic, unrelated to either the Airport Link or Northern Busway projects, it would be expected that the two sets of results are quite similar.

5.9.5 2026 "Airport Link with No Ultimate Northern Busway" Results

No Mitigation Measures

Appendix L9 presents the noise contours for 2026, without any mitigation in place, assuming the Airport Link has been constructed but without the Ultimate Northern Busway Project.

The predicted levels of road traffic noise emissions from this scenario are very similar to the results of **Appendix L2**, reflecting the close comparison between the 2022 and 2026 traffic flows.

Barriers to Maintain 'Status Quo' Noise Levels (2026)

For the Airport Link without the Northern Busway Option, the noise barriers required to maintain the 'status quo' noise levels (ie to have an acoustic environment, no worse off than would have otherwise occurred due to natural network increases) are presented in **Appendix L10**.

This design incorporates a total of 484 linear meters (or 2,963 m^2) of barriers to maintain the 'status quo' at residential properties.

Barriers to Achieve 63/68 dBA $L_{A10(18hour)}$ Design Objective (2026)

Appendix L11 presents the noise contours for 2026, assuming the Airport Link without the Northern Busway Project which incorporate the noise barriers required to achieve the relevant 63/68 dBA $L_{A10(18hour)}$ planning level.

This barrier design not only mitigates the increases in the levels of road traffic arising from the project, but also the gradual build up of traffic over many successive years.

This design incorporates a total of 1,099 linear meters (or 4,410m^2) of barrier to achieve the 63/68 dBA $L_{A10(18hour)}$ planning level at residential and educational properties.

5.9.6 2026 "Airport Link with Ultimate Northern Busway" Results

The introduction of the Ultimate Northern Busway has a very negligible influence (less that 0.2 dBA difference) on the road traffic noise levels in this section of the project due to changes in the traffic volumes. Therefore, the noise barrier designs for the status quo and 63/68 dBA $L_{A10(18hour)}$ scenarios without the Ultimate Northern Busway are also applicable (without any adjustments) for the Airport Link with Ultimate Northern Busway scenario.

5.10 Recommended Mitigation Measures

In general, noise mitigation should be designed for compliance with the relevant planning levels (ie $L_{A10(18hour)}$ levels of 63/68 dBA) . Where this cannot be achieved, the barrier design should then examine the feasibility and reasonableness of maintaining the "status-quo".

5.11 Alternative Mitigation Strategies to Reduce Road Traffic Noise Impacts

During the detailed design phase of the works, consideration should be given to the following options as alternative means of noise control, where noise barriers prove to be unreasonable or feasible:

Road Surface Treatments: The prevailing road surface directly influences the noise emissions from the roadway. The use of Open Graded Asphaltic Concrete (OGAC), for example, would result in noise levels that are 3dBA lower than Dense Graded Asphaltic Concrete (DGAC) which is the road surface that has been modelled for all roads in this study. Other similar surfaces include Stone Mastic Asphalt (SMA), where noise reductions of 1 - 2 dBA are reported (compared to DGA), depending on the stone size.

This option has some limitations:

- It is relatively costly to lay;
- It needs to be periodically replaced due to wear
- In tunnels, OGAC cannot be used as it is a potential fire hazard. In the case of a petrol or other flammable liquid spill the roadway encourages the absorption of the volatile liquid rather than letting it stay on the surface.

Architectural acoustic treatment of existing dwellings: As an alternative to noise barriers, it may be possible to provide upgrading to the façade windows and doors in some circumstances.

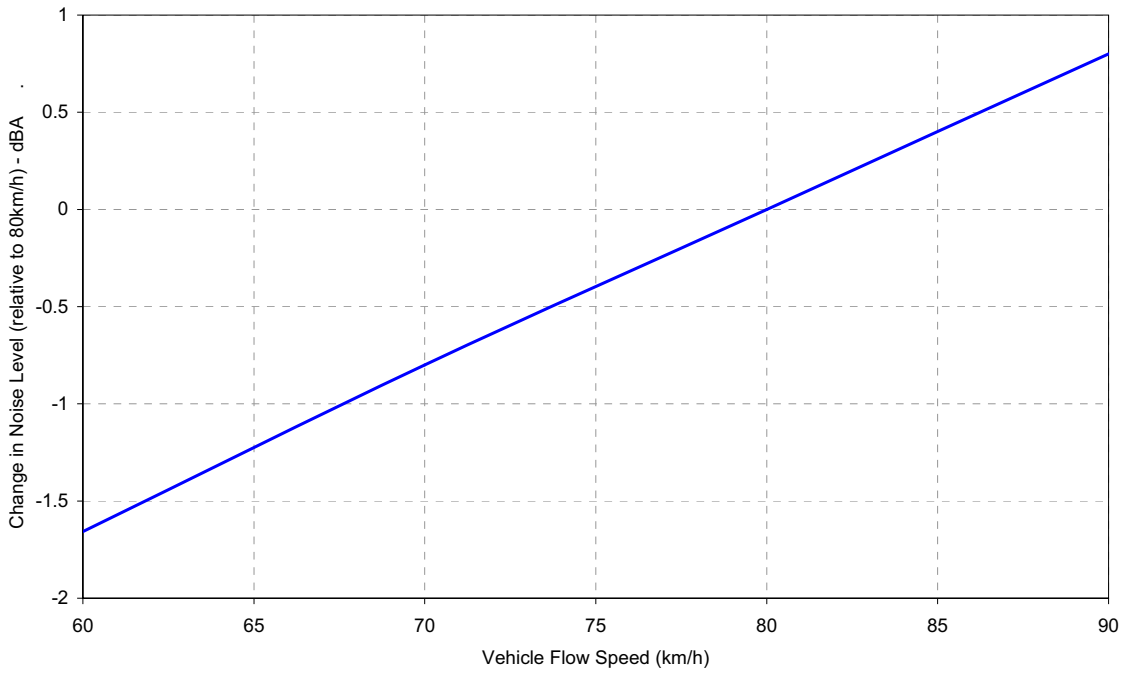
Depending on the extent of impacts, consideration should be given to the supply of fresh air and/or air-conditioning into habitable rooms (allowing the windows to remain closed for noise control purposes) and to the upgrading of facade windows and doors (subject to qualifications).

Resumptions: In consultation with the property owners, Council could consider the purchasing of properties severely impacted by a project.

Urban Renewal: Councils and other authorities can consider an urban renewal program for areas or buildings that are adversely impacted by road traffic noise, replacing noise sensitive buildings (eg homes) with non-noise sensitive buildings (e.g. commercial).

Vehicular Speed: The overall traffic noise could be reduced by the lowering of the vehicular flow speed. At the higher speeds, noise is emitted from the interaction of the tyres and the roadway, whilst at lower speeds, the noise tends to arise from the engine and exhaust. **Figure 6** presents the relationship between noise level and speed, relative to 80 km/h.

Figure 6 Noise Levels and Vehicular Speed



Reducing road speed is generally not considered a viable form of noise mitigation due to the relatively small changes involved, and it opposes one of the primary functions of road infrastructure projects which is to decrease travel times between destinations.

Reductions in Vehicle Noise Emissions: Noise emissions for new vehicles are defined within the Australian Design Rule 28/01, within the *Motor Vehicles Standard ACT*. Over time, changes to the standards would result in lower noise levels in the community.

5.12 Vibration and Regenerated Noise

On roadways that are well maintained, regenerated noise and vibration from individual vehicle movements is not considered to result in significant acoustical disruption to residents.

There are no shallow tunnel areas beneath sensitive buildings where it is anticipated that vibration or regenerated noise from truck movements on the carriageways would be a significant issue.

6 TRAFFIC NOISE ON ROAD NETWORK REMOTE FROM THE PORTAL AREAS

6.1 Assessment Methodology

The effect of tunnel-related traffic on the noise emission from roadways remote from the tunnel connection areas has been assessed. This assessment has been performed by calculating how traffic changes attributable to the tunnel would alter the $L_{A10(18hour)}$ level of noise emission from roadways using the CoRTN[4] prediction algorithms. The $L_{A10(18hour)}$ parameter is the average of the hourly L_{A10} traffic noise level between the hours of 6 am and midnight.

6.2 Assessment Criteria

Assuming that the proportion of heavy vehicles, traffic speed and road surface remain constant, the relationship between increases in traffic volume on a roadway and the resulting increase in $L_{A10(18hour)}$ traffic noise emission is summarised in **Table 22.**

Table 22 Relationship Between Traffic Volume Changes and $L_{A10(18hour)}$ Noise Emission

Increase/Decrease in AADT Traffic	**Resultant Change in $L_{A10(18hour)}$ Noise Emission**
10%	0.4 dBA
25%	1.0 dBA
50%	1.8 dBA
75%	2.4 dBA
100%	3.0 dBA

It can be seen from **Table 22** that a doubling of traffic on a given roadway will result in a 3 dBA increase in the $L_{A10(18hour)}$ emission from this roadway. A change of up to 3 dBA in the level of a dynamic noise, such as passing vehicles is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

It is acknowledged that people will probably notice increased traffic based on visual clues and perception of vehicle pass-by frequency before they will objectively notice an increase in the average noise level.

For assessment purposes it is common to set the threshold of significance in relation to changes to the emission level from roads at 2 dBA. This threshold is adopted in this study.

6.3 Traffic Noise Projections

For this analysis the traffic speed and road pavement surfaces have all been assumed to remain constant throughout the various scenarios

Traffic projections, supplied by the JV, have been analysed for the design years (ie 2022 and 2026) and for the Do Minimum, Airport Link without the Busway and Airport Link with Busway scenarios, for major representative surface roads in the wider vicinity of the portals.

4 Calculation of Road Traffic Noise - U.K. Department of Transport, Welsh Office.

Table 23 2022 Traffic Noise on Road Network Remote from the Portal Areas

Location	Do Minimum		With Airport Link Only		With Airport Link & Interim Busway		Change in LA10(18hour) Due to Airport Link Only	Change in LA10(18hour) Due to Airport Link & Interim Busway
	18hr Traffic Count	%CV	18hr Traffic Count	%CV	18hr Traffic Count	%CV		
Roads in Vicinity of Southern Portal								
Bradfield Hwy	89310	5.6	89740	5.4	90530	5.2	0.0	-0.1
Herston Rd	19280	15.5	18700	15.2	18820	3.1	-0.2	-2.7
Brunswick St	33210	8.4	31760	8.5	30110	8.4	-0.2	-0.4
Bowen Bridge Rd	71130	7.1	53780	6.6	50410	6.7	-1.3	-1.6
Inner City Bypass	73130	10.4	55730	10.9	55640	11.1	-1.1	-1.1
Breakfast Creek Rd	39220	9.7	40030	10.2	40510	9.8	0.2	0.2
Kingsford Smith Rd	69130	11.0	66410	11.5	66150	11.5	-0.1	-0.1
Roads in Vicinity of Gympie Rd Portal								
Stafford Rd	25310	5.1	37650	5.2	37770	5.2	1.7	1.8
Webster Rd	26880	5.0	22580	4.3	23530	4.2	-0.9	-0.8
Gympie Rd (North of Stafford Rd)	73300	5.3	93830	5.3	92010	5.6	1.1	1.0
Leckie Rd	6370	7.1	5650	7.0	5470	7.4	-0.5	-0.6
Rode Rd (W of Gympie Rd)	28980	3.8	28890	5.6	28860	5.6	0.4	0.4
Rode Rd (E of Gympie Rd)	29090	3.3	25500	5.6	25400	5.6	0.0	0.0
Roads in Vicinity of Sandgate Rd Portal								
Sandgate Rd (North of East/West Arterial Rd)	59930	5.6	50660	5.8	51210	5.8	-0.7	-0.6
Melton Rd	18600	6.9	15140	6.0	15280	5.8	-1.1	-1.1
East-West Arterial Rd	64580	7.1	75040	6.8	75020	6.9	0.6	0.6
Nudgee Rd (North of East/West Arterial Rd)	21430	4.8	18750	3.8	18530	4.0	-0.8	-0.9
Nudgee Rd (South of East/West Arterial Rd)	10310	11.6	12860	12.2	13020	12.2	1.1	1.1
Zillman Rd	6320	5.3	4440	6.1	4440	6.0	-1.4	-1.4
Roads between Portals								
Lutwyche Rd	63500	2.7	47850	2.4	40000	2.2	-1.4	-2.2
Junction Rd / Rose St	28460	5.6	21740	2.8	21730	2.7	-1.9	-1.9
Park Rd	24590	5.7	18360	2.5	18200	2.6	-2.1	-2.2
Sandgate Rd (South of East/West Arterial Rd - North of Junction Rd)	61240	5.3	44380	2.4	45040	2.3	-2.2	-2.2
Sandgate Rd (South of Junction Rd)	53040	5.2	37050	4.0	37490	1.6	-1.9	-2.5
Albion Rd/Albion Bypass	23360	5.5	21680	5.3	19450	5.9	-0.4	-0.7
Northey St	8570	9.2	6830	8.9	7730	8.4	-1.1	-0.6
Newmarket Rd	41440	4.0	32170	3.3	32440	3.3	-1.3	-1.2
Maygar St	8910	6.7	8340	6.1	8320	5.8	-0.4	-0.5

Table 24 2026 Traffic Noise on Road Network Remote from the Portal Areas

Location	Do Minimum		With Airport Link Only		With Airport Link & Ultimate Busway		Change in LA10(18hour) Due to Airport Link Only	Change in LA10(18hour) Due to Airport Link & Interim Busway
	18hr Traffic Count	%CV	18hr Traffic Count	%CV	18hr Traffic Count	%CV		
Roads in Vicinity of Southern Portal								
Bradfield Hwy	91570	5.0	92170	5.0	91850	5.1	0.0	0.0
Herston Rd	20010	15.2	19620	15.0	19640	15.2	-0.1	-0.1
Brunswick St	33270	8.2	32350	8.1	30670	8.5	-0.1	-0.3
Bowen Bridge Rd	74430	7.3	56690	6.5	53640	6.2	-1.4	-1.7
Inner City Bypass	72220	11.6	57110	11.4	57580	11.2	-1.0	-1.1
Breakfast Creek Rd	42890	8.3	42760	8.7	42570	8.8	0.1	0.1
Kingsford Smith Rd	55800	11.0	68050	11.2	68100	11.1	0.9	0.9
Roads in Vicinity of Gympie Rd Portal								
Stafford Rd	25270	4.7	38810	4.9	38820	5.0	1.9	1.9
Webster Rd	29310	4.9	23530	4.2	24560	4.1	-1.2	-1.0
Gympie Rd (N of Stafford))	74890	13.9	95880	5.6	94430	5.7	-0.6	-0.6
Leckie Rd	6940	8.2	5710	9.8	5610	8.4	-0.5	-0.9
Rode Rd (W of Gympie Rd	29820	5.7	29100	5.1	29230	5.6	-0.2	-0.1
Rode Rd (E of Gympie Rd)	29200	5.3	26250	6.2	24920	5.3	-0.2	-0.7
Roads in Vicinity of Sandgate Rd Portal								
Sandgate Rd (North of East/West Arterial Rd)	61010	5.1	52700	5.4	53080	5.4	-0.6	-0.5
Melton Rd	19170	7.2	16040	5.6	16040	5.6	-1.1	-1.2
East-West Arterial Rd	66880	6.3	76080	6.5	76180	6.6	0.6	0.6
Nudgee Rd (North of East/West Arterial Rd)	23010	4.5	18550	3.5	19070	3.4	-1.2	-1.1
Nudgee Rd (South of East/West Arterial Rd)	11480	11.0	13750	11.9	13870	11.9	1.0	1.0
Zillman Rd	6950	5.7	4940	6.0	4860	6.1	-1.4	-1.4
Roads between Portals								
Lutwyche Rd	64160	5.9	48620	2.3	40840	1.9	-2.2	-3.1
Junction Rd and Rose St	29140	5.0	22690	2.3	22740	2.3	-1.8	-1.8
Park Rd	24270	5.0	18510	2.0	18460	1.8	-2.0	-2.1
Sandgate Rd (South of East/West Arterial Rd, North of Junction Rd)	62430	5.0	47770	2.5	47960	2.2	-1.9	-1.9
Sandgate Rd (South of Junction Rd)	54280	5.3	40070	3.8	40180	3.8	-1.7	-1.7
Albion Rd/Albion Bypass	24680	6.1	23020	5.1	20560	5.8	-0.5	-0.9
Northey St	8790	9.0	7090	8.3	7750	8.3	-1.1	-0.7
Newmarket Rd	43880	4.2	34170	3.2	34090	3.3	-1.4	-1.4
Maygar St	9470	6.6	8920	6.1	8770	5.8	-0.4	-0.5

6.4 Assessment of Traffic Noise Impacts

Table 23 and **Table 24**, presents the changes in traffic noise levels for the Airport Link (without Busways) and Airport Link (with Busways) scenarios, relative to the Do Minimum option.

For the Years 2022 and 2026, the introduction of the Airport Link is predicted to result in a small change in the levels of road traffic noise on the wider road network. Generally noise levels decrease, but at a number of locations the noise levels are predicted to increase. **Table 25** presents a summary of the highest and lowest changes across the wider road network.

Table 25 Summary of Changes

	Comparison of Do Minimum to Airport Link - No Busway		**Comparison of Do Minimum to Airport Link - with Busway**	
	Highest Increase	**Highest Decrease**	**Highest Increase**	**Highest Decrease**
2022	+1.7	-2.2	1.8	-2.7
2026	+1.9	-2.0	1.9	-2.1

The expected changes in the traffic noise as a result of the introduction of the Airport Link and Busway projects are considered to be minor and not be generally noticeable.

6.5 Mitigation Options

For roads beyond the immediate tunnel infrastructure, the following options could be explored to mitigate increases in traffic noise as attributable to the tunnel:-

a. Open-graded or stone mastic asphaltic road surfacing; and

b. Building insulation upgrade programmes.

Road-side barriers are not a feasible option along many roads due to the requirement for property access from the street frontage.

7 VENTILATION NOISE FROM VENTILLATION STATIONS

7.1 Introduction

The purpose of this chapter is to assess the noise impact of the tunnel ventilation system during normal tunnel operation. In this context 'normal' tunnel operation refers to tunnel ventilation induced by any of the three ventilation sites, and excludes emergency in-tunnel fire/smoke scenarios that would trigger the operation of auxiliary in-tunnel jet-fans.

At this stage, the proposed mechanical plant selections and associated noise control equipment for the tunnel ventilation system have not undergone detailed design or specification, thus there is no specific acoustic emission data from the facilities. Therefore, it is not possible to make an exact determination of the noise impact from any of the proposed ventilation systems. In practice the design process begins with agreed noise emission performance requirements which ensure noise impacts are deemed to be acceptable.

This EIS chapter proposes to address whether it is *feasible* for the ventilation systems to meet normally accepted noise emission performance requirements, based on best practice noise control equipment, and if so, what types of noise control measures would be required.

7.2 Description of Ventilation System

It is proposed that there are three ventilation stations. The final locations of any of the stations has not been finalised, but the current preferred sites are presented in **Figure 7**, **Figure 8** and **Figure 9**. It is noted that for the Sandgate Portal, two options for the location of the ventilation station are still being considered.

Figure 7 Preferred Ventilation Station Location – Southern Portal

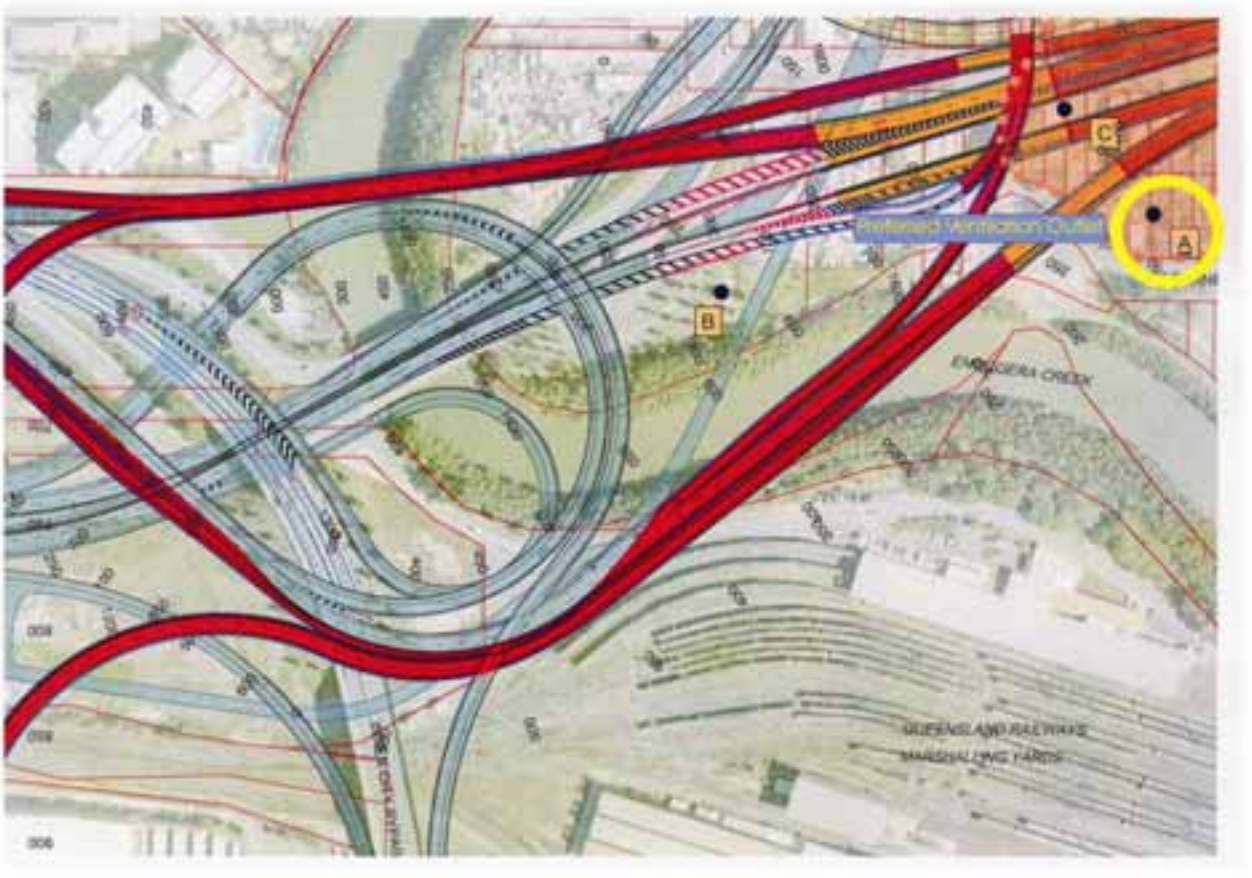


Figure 8 Preferred Ventilation Station Location – Gympie Road Portal

Figure 9 Preferred Ventilation Station Locations – Sandgate Portal

Whilst the design of the mechanical ventilation system is somewhat preliminary, the following summarises the key design factors that relate to noise.

Table 26 Ventilation Design Factors

	Southern Ventilation Station	**Gympie Road Station**	**Northern Ventilation Station**
Total extracted air flow (m^3/s)	700	1150	450
No. of fans (excluding standby)	7	10	5
Motor size (kW) (per fan)	400	400	400
Cross sectional area of duct (m^2/s)	50	80	30

The ventilation systems are designed to operate under peak hour conditions. At other times, the demand for air flow is lower and the number of fans required to operate is reduced. **Table 27** presents a generalised fan utilisation schedule for various times throughout the day.

Table 27 Utilisation of Ventilation Capacity at Different of Day

Time of Day	Ventilation Capacity Utilised
Morning /evening traffic peaks	100%
Day	80%
Evening	66%
Night	50%

The heights of the discharge stacks will be determined based on wind dispersion modelling, which will be undertaken during the detailed design phase of the works. However, for the purposed of this assessment, a height of 30 m has been adopted.

7.3 Receptor Locations

Southern Ventilation Outlet

The nominated location for the southern ventilation outlet is shown as "A" in **Figure 7** and is adjacent to a predominantly residential area towards the east. The nearest existing residential receptors dwellings are Byrne Street and Federation Street.

Gympie Road Ventilation Outlet

The nominated area for the southern ventilation outlet is shown as "A" in **Figure 8.** The proposed ventilation station is near Gympie Road, south of Kedron Brook. It is adjacent to parkland, with Kedron State High School to the south-east and the closest residential dwellings to the north in Park Tce and Haines St.

Sandgate Road Ventilation Outlet

A preferred site has not yet been determined for this portal hence two options will be assessed, shown in **Figure 9**.

Option A, is built within the building structure of Toombul Shopping Centre, whilst Option B is located between the eastbound and westbound lanes of the new Airport Link Roadway, immediately to the west of Sandgate Road.

The nearest residential receptors to the Option A location are located in Masefield St, Melton Rd, Wongara St and Parklands St. The nearest residential receptors to the Option B location are located south of the station (eg Alma Road) and in Kalinga St, Wongara St and Parklands St.

7.4 Target Emission Levels

In order to minimise the acoustical impacts from the continuous ventilation system, the design criteria for noise emissions from the ventilation stations is set to a level equal to the existing background noise levels, as discussed in **Section 2.2.3**. The nearest assessment locations and design criteria are presented in **Table 28**.

Table 28 Assessment Locations and Design Criteria for Ventilation Stations

Portal	Nearest Assessment Point	Representative Noise Monitoring Location	Existing Night-time Background Noise Level (dBA)	Design Criteria (dBA - L_{90})
Southern Portal	Byrne Street	49 Earle St	43	43
	Gallway St	46 Gallway St	42	42
Gympie Road Portal	Kedron High School	34 Park Road	34	34
	Park Tce	12 Park Terrace	40	40
	Haines St	12 Park Terrace	40	40
Sandgate Road Portal	Alma Road	86 Alma Road	40	40
	Kalinga St	72 Kalinga St	41	41
	Parklands St	27 Parklands St	42	42
	Wongara St	30 Wongara St	40	40
	Masefield St	30 Wongara St	40	40
	Melton Rd	30 Wongara St	40	40

7.5 Noise Level Predictions and Assessment

Calculations of indicative ventilation outlet noise have been carried out for the nearest known residential areas in each of the three portal areas. These calculations include the effect of a 3 m long industrial silencer on the intake and discharge sides of ventilation fans, hemispherical spreading, the directivity of the discharge and typical worst-case meteorological conditions. Calculations have not taken into account any attenuation from dampers, straight sections of duct or duct bends, and are therefore considered to be conservative.

The generic source data is summarised in **Table 29,** from which the Sound Power Levels was adjusted to reflect the number of fans for each location.

Table 29 Source Data for Ventilation Noise Predictions

Data and Source	Parameter	Weighting	63	125	250	500	1 k	2 k	4 k	8 k
5 off Axial Fan, 110m^3/s @ 1500 Pa (Source: fan supplier)	Sound Power (dB)	Linear	129	128	123	119	122	120	115	109
Insertion loss, 3m 50% channel area industrial silencer (source: silencer supplier)	Insertion loss (dB)	Linear	-12	-19	-36	-43	-47	-28	-18	-16

For the purpose of this assessment, it has been assumed that the fans would be operational during the night (ie 50% capacity).

The sound power level associated with each fan has been obtained by comparing estimated sound power spectra from potential fan suppliers.

Table 30 Additional Attenuation Required (preliminary)

Portal	Predicted Emission Levels	Additional Attenuation Required	Comments
Southern	39	Nil	It would be desirable to incorporate some additional attenuation in the low and high frequencies (ie 63 Hz and 2 KHz).
Gympie Road	50	16 dBA (overall)	Exceedances in the low and high frequencies (ie 125 Hz and 2 KHz). In between frequencies do not exhibit any exceedances.
Sandgate Road – Option A	43	3 dBA (overall)	Exceedances in the low and high frequencies (ie 63 Hz and 2 KHz). In between frequencies do not exhibit any exceedances.
Sandgate Road – Option B	50	10 dBA (overall)	Exceedances in the low and high frequencies (ie 125 Hz and 2 KHz). In between frequencies do not exhibit any exceedances.

The amount of additional attenuation that has been identified is not considered to represent any significant design issue, as the predictions have not accounted for:

- End reflection[5]. - which provides substantial low frequency attenuation;
- Any internal attenuation along the internal duct length, which is particularly effective in reducing high frequency noise.

Once fan and the system design has progressed, the noise predictions should be reviewed and refined. At this stage it is not possible to provide any specific recommendations, but the levels of attenuation required do not appear to highlight any design problem. Extra attenuation in the system will be required, and would likely be in the form of an additional splitter silencer(s), internal insulation on the duct walls etc.

Given the immissions at residential locations are free of distinct tonal characteristics, and are equal to the (night-time) Rating Background Level, it is concluded that it would be feasible for the ventilation outlets to be developed with negligible noticeable noise impact to residents, and in compliance with both the traditional EPA requirements and NIAPSP requirements.

Vibration and regenerated noise issues would need to be further considered for the Sandgate Road Ventilation Station - Option A as the ventilation outlet may be integrated into an existing commercial building. The design may require mechanical isolation of the major mechanical and structural components. This issue is however, avoidable at the detailed design stage through appropriate design. Vibration or regenerated noise would not be an issue for Option B.

5 *End reflection is where a component of the low frequency noise in a ventilation system, is reflected back into the duct*

8 CONCLUSIONS

Road Traffic Noise Local to Tunnel Portals

General

The EPP[Noise] identifies Planning Levels for traffic noise emissions from roadways, but does not specify what actions should be carried out in response to road developments that may result in exceedances of Planning Levels.

For this project, the Planning Levels from the EPP[Noise] are generally already equalled or substantially exceeded at residential facades facing the major roads that connect to the tunnel.

Main Roads' Code of Practice is also applicable to this study as it outlines Main Roads' strategy to control road traffic noise from State-controlled roads. The sections of road within the study area that are State-controlled are:

- Gympie Rd - North of Kedron Brook
- East West Arterial - East of Sandgate Rd

The Interim Northern Busway, a Queensland Transport project also utilising the Bowen Bridge Rd /Lutwyche Rd corridor, is expected to be completed in 2022, thus for this report, the following situations have been modelled in accordance with the ToR:

- **Do minimum (2022)**: The predictions include all future (ie 2022) traffic utilising the existing road corridor, excluding the Airport Link and the Northern Busway projects. This scenario represents the future traffic that would have arisen in the absence of these major transport initiatives, and represents the baseline noise projections against which some of the other scenarios are compared;
- **Airport Link without Interim Northern Busway (2022)** - traffic flows including Airport Link, but excluding the Interim Northern Busway project. This scenario represents the change in traffic noise, attributable directly to the Airport Link project; and
- **Airport Link with Interim Northern Busway (2022)** - traffic flows including Airport Link and the Interim Northern Busway projects.

The Ultimate Northern busway design, (where the bus lanes are mostly in a tunnel along Bowen Bridge Rd and Lutwyche Rd) is expected to be completed in 2026. In accordance with usual practice, the acoustic design year would consequently be 2036. Heggies has been informed that traffic modelling is not reliable for a 30 year design. Thus, for the Ultimate Northern Busway scenarios, the assessment has been undertaken for the year of opening (ie 2026). As the Ultimate Northern Busway project develops in coming years, further environmental assessments will need to be undertaken to confirm the levels of impact (either positive or negative) presented in this report. At this time it may be more reasonable and feasible to assess the predicted traffic noise levels in 2036 (10 years after opening). Thus, for the assessment involving the Ultimate Northern Busway, the scenarios identified above are replicated using 2026 traffic data.

Two noise barrier designs have been undertaken for the Airport Link scenarios, with and without Interim/Ultimate Northern Busway, as outlined below.

"Status Quo" Noise Barrier Option

The objective used to develop the "status quo" barrier option for the 2 design years (2022 and 2026) is to develop road-side noise barriers, where practical and feasible, to acheive traffic noise levels comparable to the "Do Minimum" option.

"Planning Level" Noise Barrier Option

The objective used to develop the "planning level" barrier option for the 2 design years (2022 and 2026) is to develop road-side noise barriers, where practical and feasible, to limit traffic noise levels to the 63 dBA or 68 dBA (as applicable) $L_{A10(18hr)}$ planning levels wherever possible.

The purpose of this option is to illustrate the scale of noise controls that would be necessary to achieve the "planning" traffic noise levels in accordance with the EPP[Noise] and Code of Practice. In many areas this would require noise controls to account for gradual increases in traffic noise over time that are not attributable to the tunnel.

In general, the recommendation of this assessment is that noise mitigation should be designed for compliance with the relevant planning levels (ie $L_{A10(18hour)}$ levels of 63/68 dBA) . Where this cannot be achieved, the barrier design should then examine the feasibility and reasonableness of maintaining the "status-quo".

In all areas it is considered that the recommended noise control options in this report represent a starting point for discussions between key stake-holders.

Southern Connection

Noise mitigation to achieve the "63 dBA criterion" where reasonable and feasible is shown in **Appendix J4, J7, J11** and **J14** (for the Airport Link without Interim Northern Busway (2022), Airport Link with Interim Busway (2022), Airport Link without Ultimate Busway (2026) and Airport Link with Ultimate Busway (2026). It should be noted that south of Enoggera Creek, compliance with the 63 dBA criterion was not always feasible, particularly at the Mews Apartments, Tufton Street apartments and Wren Street properties, due to the impractical height the barriers would need to be to achieve the "planning" level. Consequently, at these locations, the barrier design aims to achieve the status quo levels, rather than the 63 dBA "planning" criterion.

All of the barriers presented are considered to be of a feasible scale but will need to be reviewed in the context of urban renewal concepts along this corridor. Safety issues associated with sight lines would also need to be considered. In theory, long continuous commercial or residential building structures could provide noise screening in lieu of barriers, where space permits. The cost effectiveness of the alternative option of upgrading building envelopes could also be investigated as an alternative to barriers. An advantage of barriers (as opposed to building upgrades) is that barriers would also control traffic noise increases in outdoor areas.

Gympie Road Connection

Noise mitigation to achieve the "63/68 dBA criterion" where reasonable and feasible is shown in **Appendix K4, K7, K11** and **K14** (for the Airport Link without Interim Northern Busway (2022), Airport Link with Interim Busway (2022), Airport Link without Ultimate Busway (2026) and Airport Link with Ultimate Busway (2026).

All of the barriers presented are considered to be of a feasible scale but will need to be reviewed in the context of urban renewal concepts along this corridor. Safety issues associated with sight lines would also need to be considered. In theory, long continuous commercial or residential building structures could provide noise screening in lieu of barriers, where space permits. The cost effectiveness of the alternative option of upgrading building envelopes could also be investigated as an alternative to barriers. An advantage of barriers (as opposed to building upgrades) is that barriers would also control traffic noise increases in outdoor areas.

Sandgate Road Connections

Noise mitigation to achieve the "63/68 dBA criterion" where reasonable and feasible is shown in **Appendix L4, L7, L11** and **L14** (for the Airport Link without Interim Northern Busway (2022), Airport Link with Interim Busway (2022), Airport Link without Ultimate Busway (2026) and Airport Link with Ultimate Busway (2026).

Given the significant distance between the Sandgate Rd Portal and the Interim or Ultimate Northern Busway infrastructure, this (Busway) project has minimal impacts on the resulting levels of road traffic noise in this area due simply to changes in traffic volumes and compositions.

All of the barriers presented are considered to be of a feasible scale but will need to be reviewed in the context of urban renewal concepts along this corridor. Safety issues associated with sight lines would also need to be considered. In theory, long continuous commercial or residential building structures could provide noise screening in lieu of barriers, where space permits. The cost effectiveness of the alternative option of upgrading building envelopes could also be investigated as an alternative to barriers. An advantage of barriers (as opposed to building upgrades) is that barriers also control traffic noise increases in outdoor areas.

Road Traffic Noise Remote from Tunnel Portals

For the Years 2022 and 2026, the introduction of the Airport Link is predicted to result in a small change in the levels of road traffic noise on the wider road network (ie well removed from the portal areas). Generally noise levels decrease, but at a number of locations the noise levels are predicted to increase.

The expected changes in the traffic noise as a result of the introduction of the Airport Link and Busway projects are generally within 2 dBA. Such changes are considered to be minor and not to be generally noticeable.

For roads beyond the immediate tunnel infrastructure, the following options could be explored to mitigate increases in traffic noise as attributable to the tunnel:-

- Open-graded or stone mastic asphaltic road surfacing; and
- Building insulation upgrade programmes.

Road-side barriers are generally not a feasible option along local streets due to the requirement for property access from the street frontage.

Regenerated Noise

Regenerated noise from roadways in shallow tunnel areas is not considered to be an issue at any of the tunnel portals.

Ventilation System Noise

Preliminary calculations of ventilation outlet noise emissions indicate that it would be feasible for noise emissions to comply with the BCC's Noise Impact Assessment Planning Scheme Polices and traditional EPA licensing.

Providing that immissions at residential locations are free of distinct tonal characteristics, and do not exceed background noise levels, the normal licensing requirements would allow the ventilation outlets to be developed with negligible noticeable noise impact to residents.

Some additional noise reduction is required to be incorporated into the ventilation system, though the requirements are not considered excessive or restrictive.

Vibration and regenerated noise issues may need to be addressed if the ventilation outlets are to be integrated into a residential or commercial building. This issue would be manageable through appropriate mechanical and structural design.

Appendix A

Noise Monitoring Locations
Result of Noise Monitoring
Report 20-1605R4

1 APPENDICIES

Location	Address	Description	Photographs
1	30 Wongara Street, Clayfield	Rear landing, detached dwelling at 30 Wongara Street, Clayfield, logger located on upper (2nd) storey, includes facade reflection facing East-West Arterial Road (behind noise barriers)	
2	86 Alma St, Clayfield	Rear yard, detached dwelling at 86 Alma Road, Clayfield	
3	27 Parkland Street, Nundah	Southern property boundary facing parkland, detached dwelling at 27 Parkland Street, Nundah	
4	72 Kalinga Street, Clayfield	Rear yard, northern property boundary, detached dwelling at 72 Kalinga Street, Clayfield	

Location	Address	Description	Photographs
5	34 Park Road, Kedron Kedron State High School	On top of awning adjacent to canteen block, facing towards Kedron Brook and Gympie Road, at Kedron State High School, Park Road Kedron	
6	20 Perry Street, Lutwyche	Front yard, includes facade reflection, 2 metres above ground, facing Gympie Road, detached dwelling at 20 Perry Street, Lutwyche	
7	30 Colton Avenue, Lutwyche	Rear yard, detached dwelling at 30 Colton Avenue, Lutwyche	
8	12 Park Terrace, Kedron	Rear yard western property boundary, detached dwelling at 12 Park Terrace, Kedron	

Locations	Address	Description	Photographs
9	17 Roblane Street, Windsor	Front landing, ground floor level, facing Roblane Street, detached dwelling at 17 Roblane Street, Windsor	
10	7 Roblane Street, Windsor	Southern boundary adjoining 5 Roblane Street, adjacent to most exposed facade fronting Roblane Street, Holy Rosary School, 7 Roblane Street, Windsor	
11	46 Gallway Street, Windsor	Rear verandah north west corner, detached dwelling at 46 Gallway Street, Windsor	
12	49 Earle Street, Windsor	Front yard near southern boundary, detached dwelling at 49 Earle Street, Windsor	

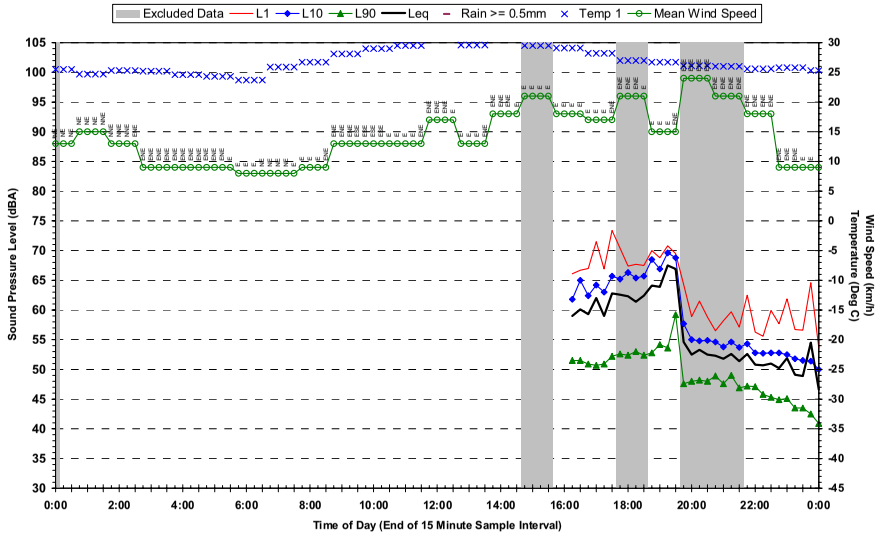
Locations	Address	Description	Photographs
13	Royal Womens Hospital	Level 5 rooftop, James Demacy Building,, Royal Brisbane Hospital, facing Bowen Bridge Road	
14	62 Victoria Street, Windsor	Front yard, detached dwelling at 62 Victoria Street, Windsor	
15	42 Hooker Street, Windsor	Front yard, western property boundary, detached dwelling at 42 Hooker Street, Windsor	

16	Nursing Home, 26 Palmer Street, Windsor	Front garden facing Lutwyche Road, Amarina Aged Care Facility, 26 Palmer Street, Nursing Home	
17	7 Lamington Avenue, Lutwyche	Front yard, facing Lamington Avenue, detached dwelling at 7 Lamington Avenue, Lutwyche	
18	16 East Street, Lutwyche	Rear yard, 2m from western boundary, detached dwelling at 16 East Street, Lutwyche	

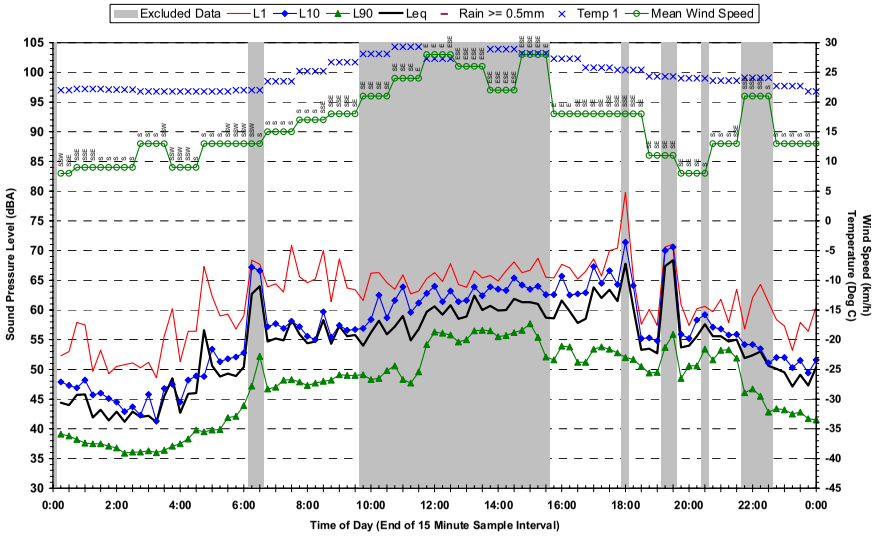
Appendix B

Results of Noise Monitoring
Report 20-1605R4

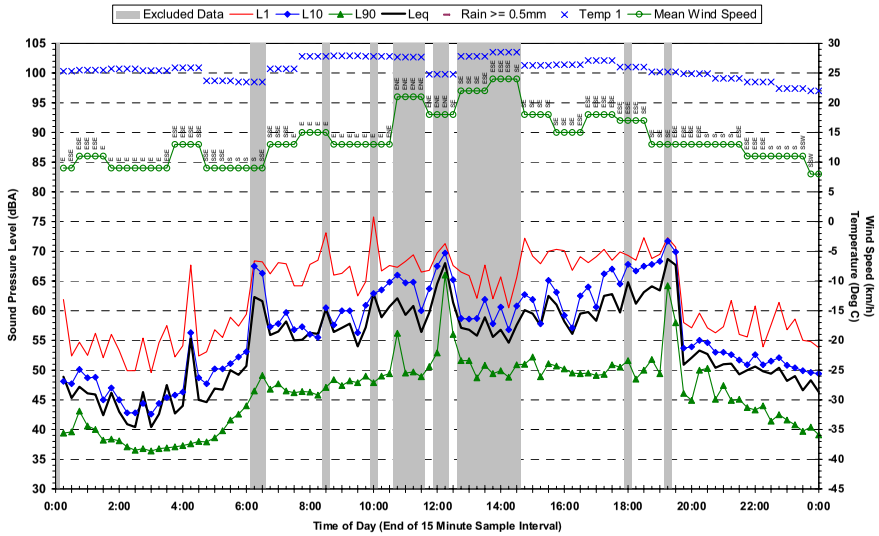
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Monday 20 February 2006



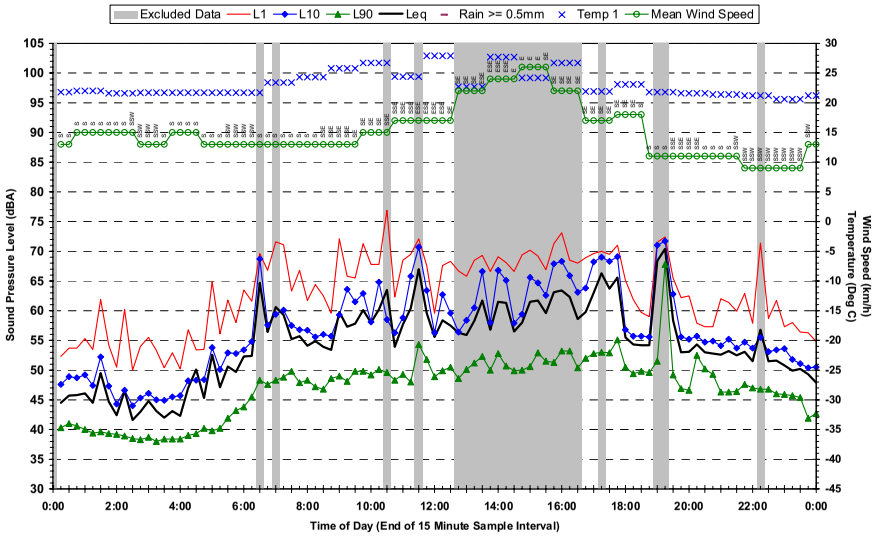
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Wednesday 22 February 2006



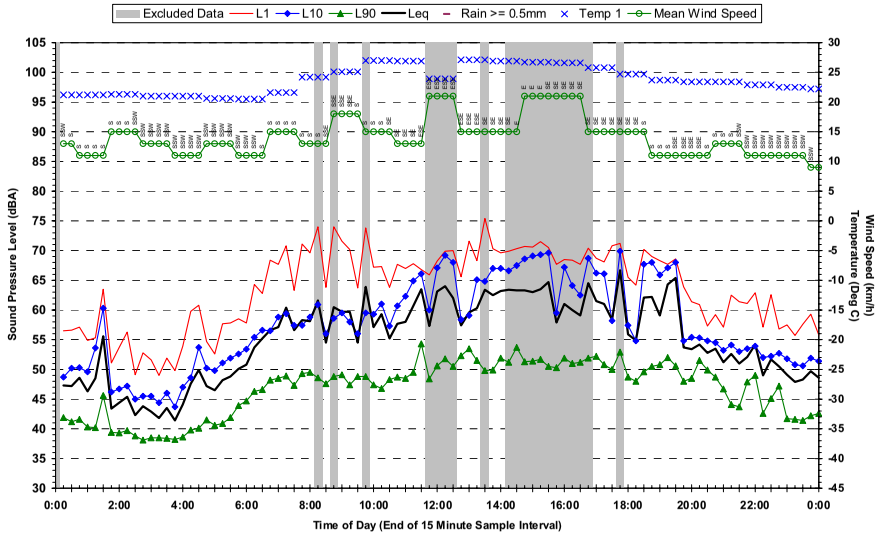
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Tuesday 21 February 2006



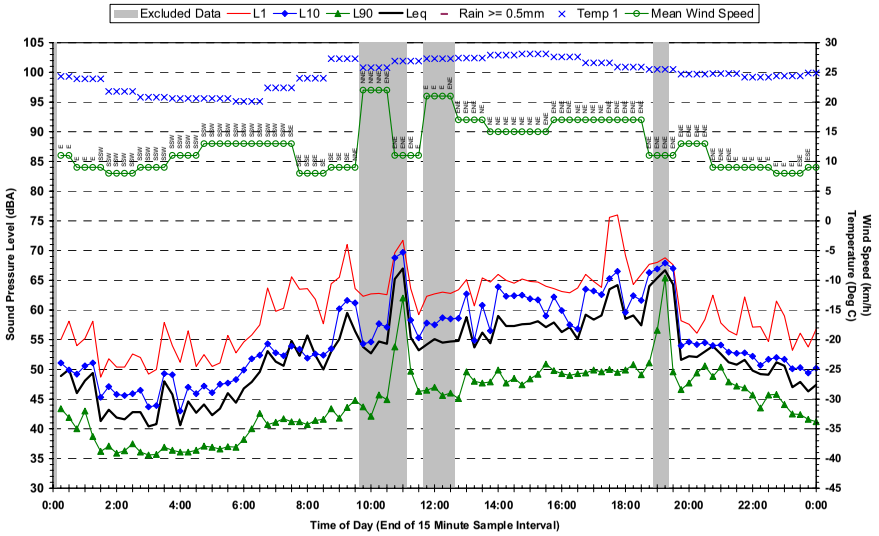
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Thursday 23 February 2006



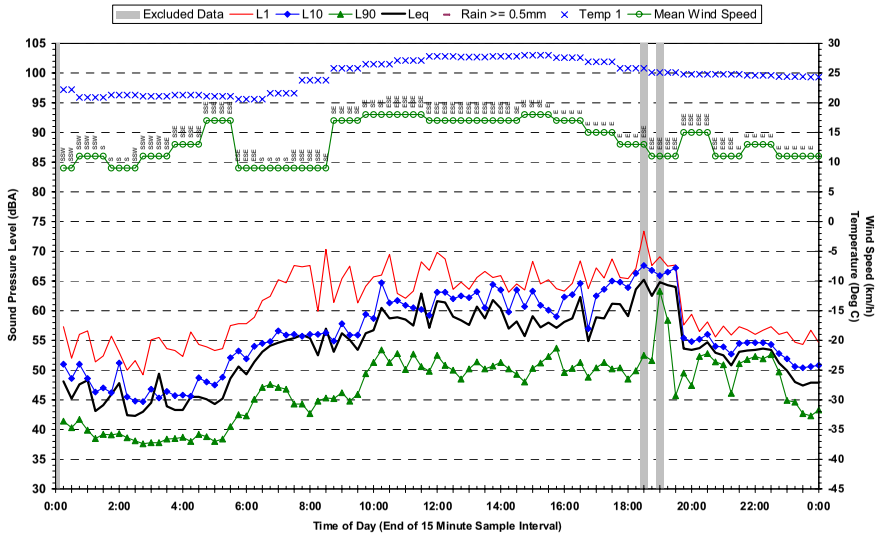
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Friday 24 February 2006



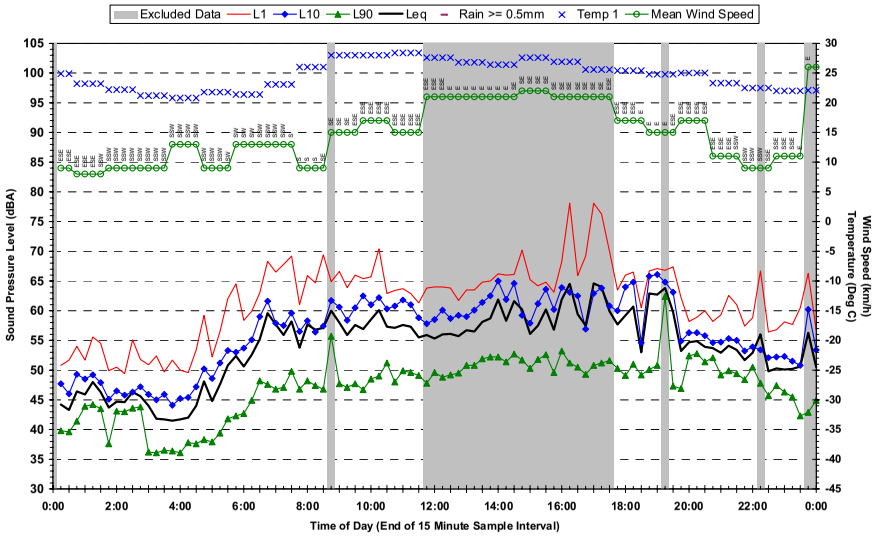
Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Sunday 26 February 2006

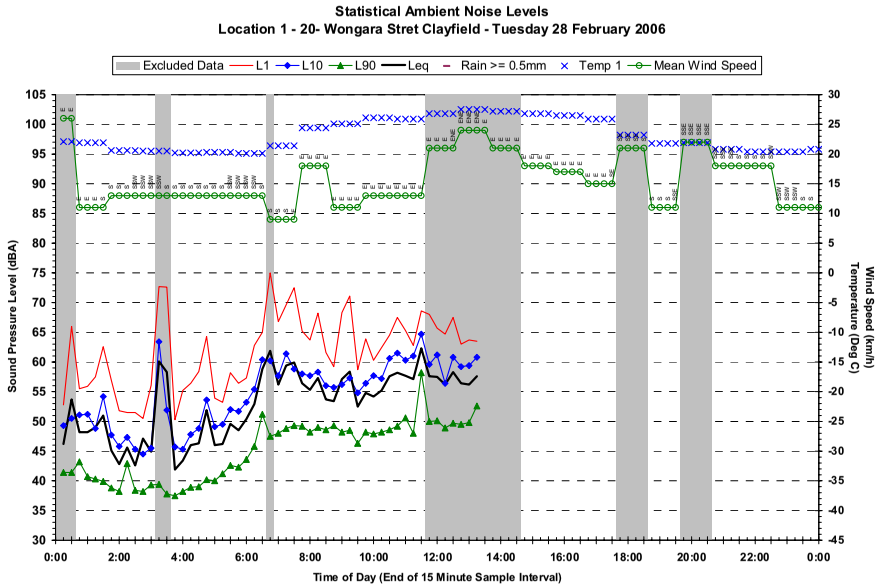


Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Saturday 25 February 2006

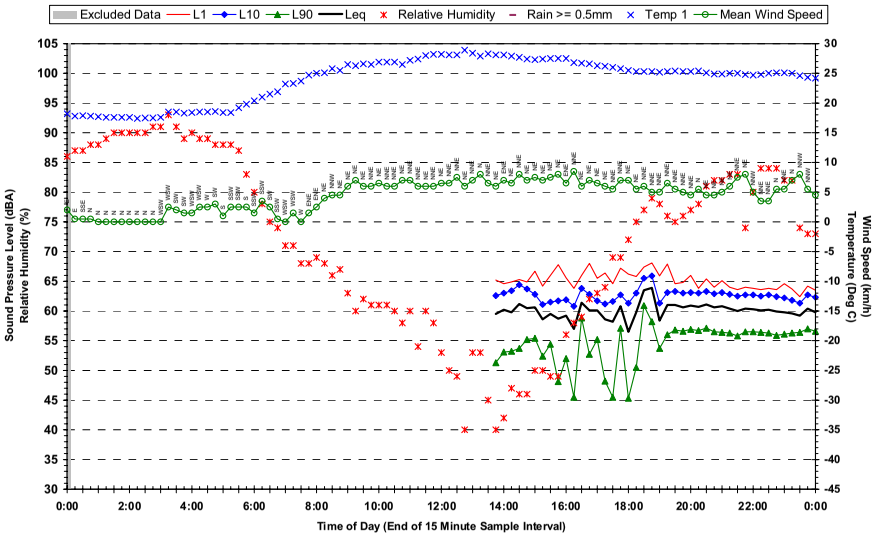


Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Monday 27 February 2006




Statistical Ambient Noise Levels
Location 1 - 20- Wongara Stret Clayfield - Tuesday 28 February 2006
Excluded Data
L1
L10
L90
Leq
Rain >= 0.5mm
Temp 1
Mean Wind Speed
Sound Pressure Level (dBA)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Wednesday 30 November 2005



Statistical Ambient Noise Levels
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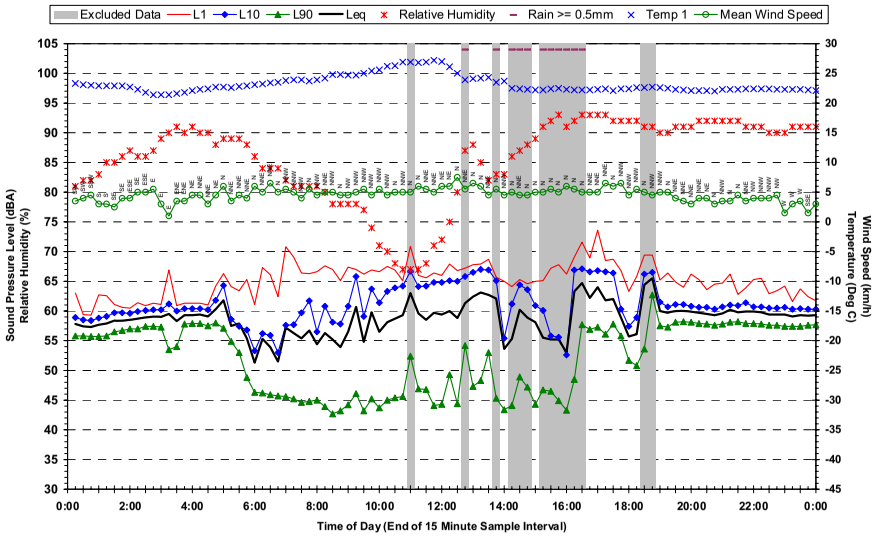

Statistical Ambient Noise Levels
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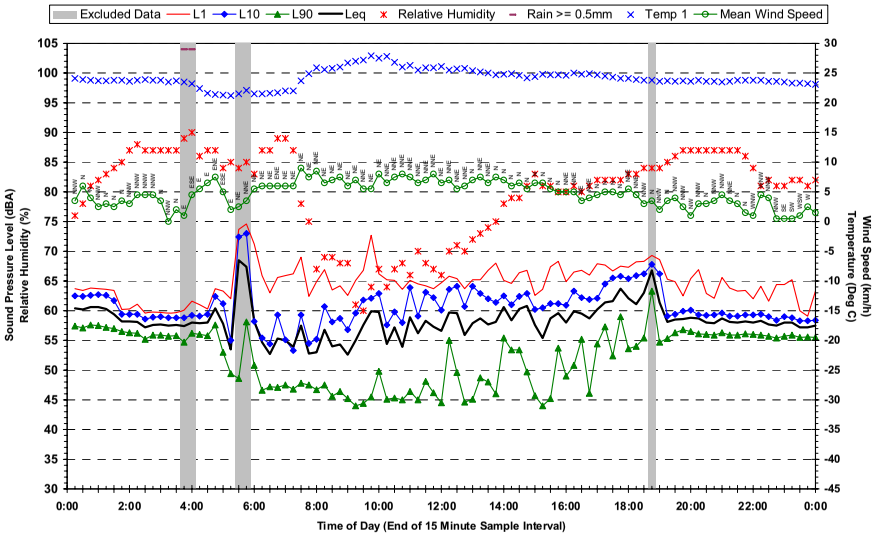

Statistical Ambient Noise Levels
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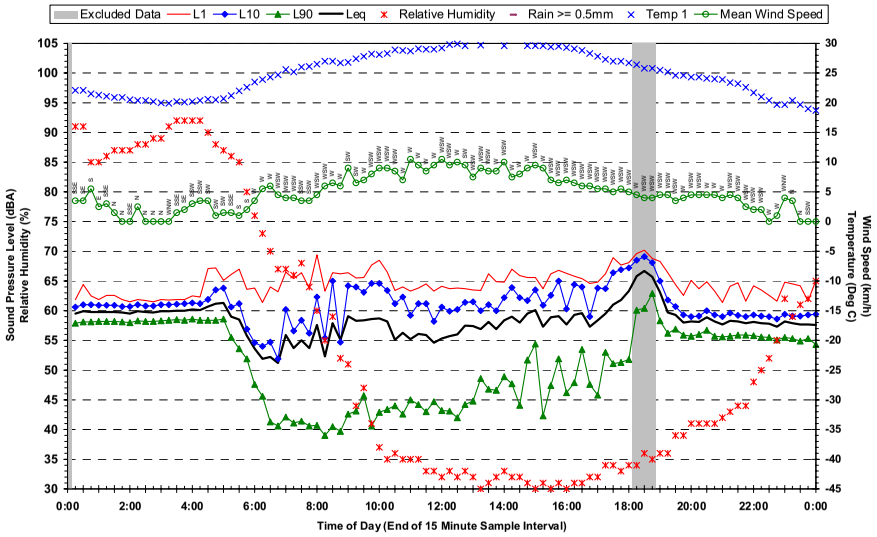
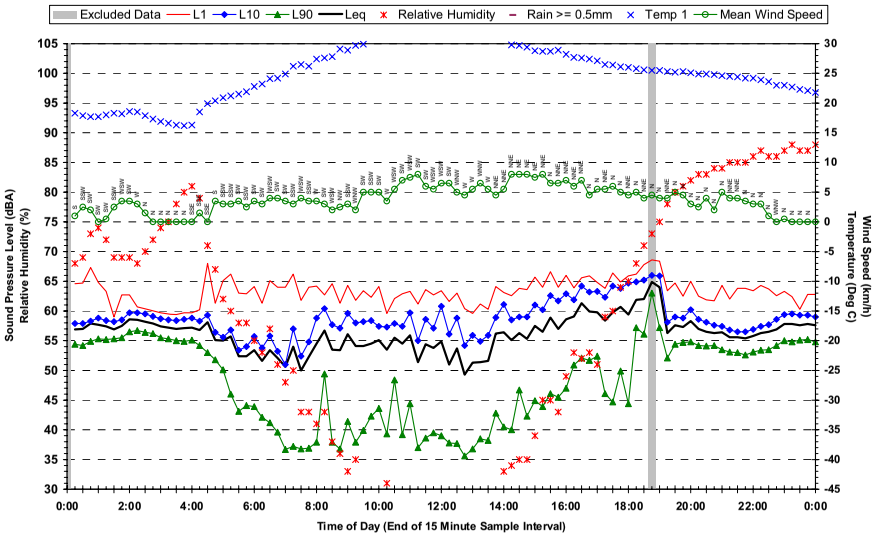
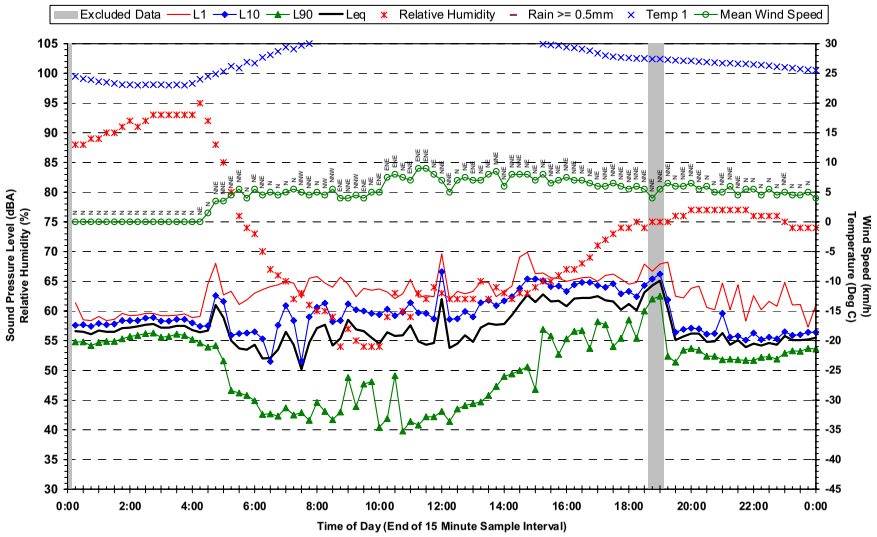


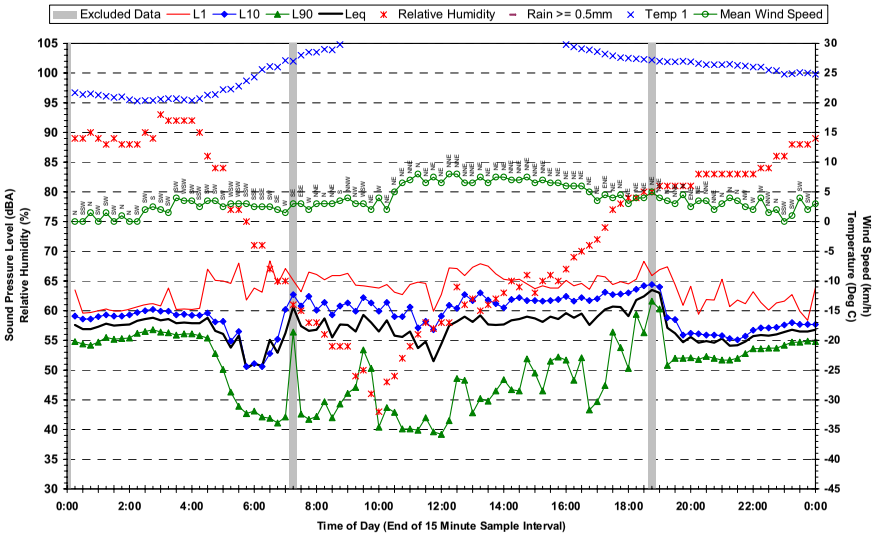
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Sunday 4 December 2005



Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Tuesday 6 December 2005



Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Monday 5 December 2005



Statistical Ambient Noise Levels
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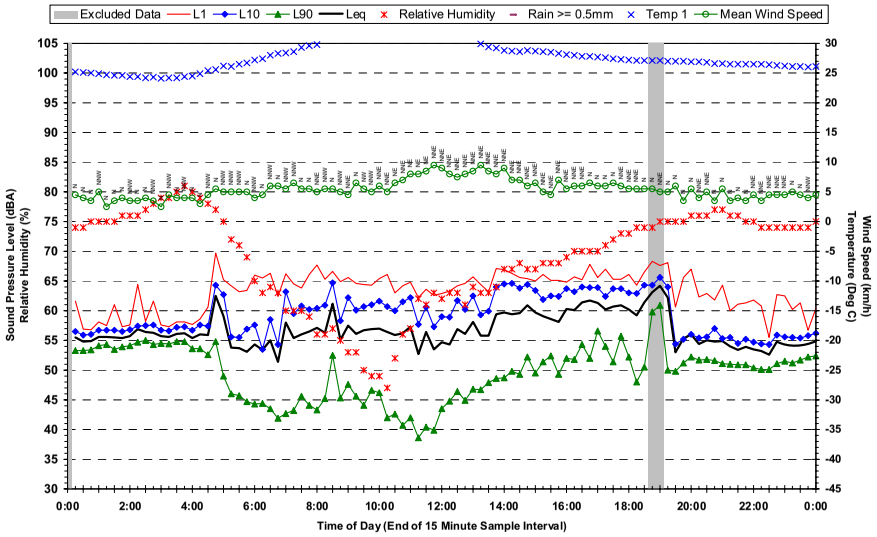

Statistical Ambient Noise Levels
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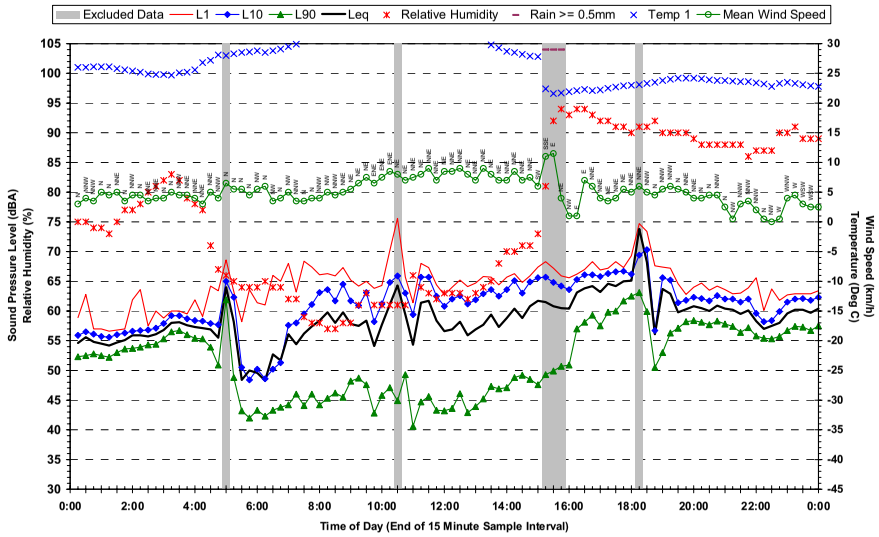
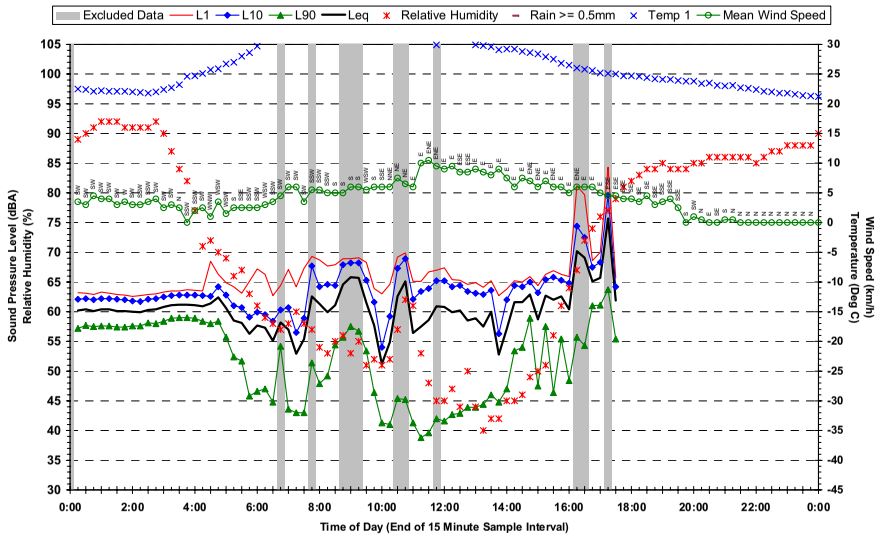
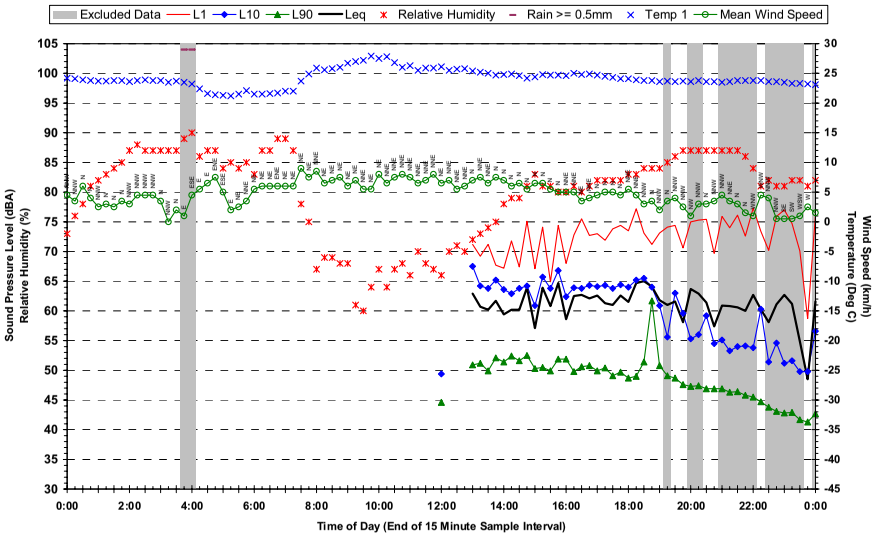


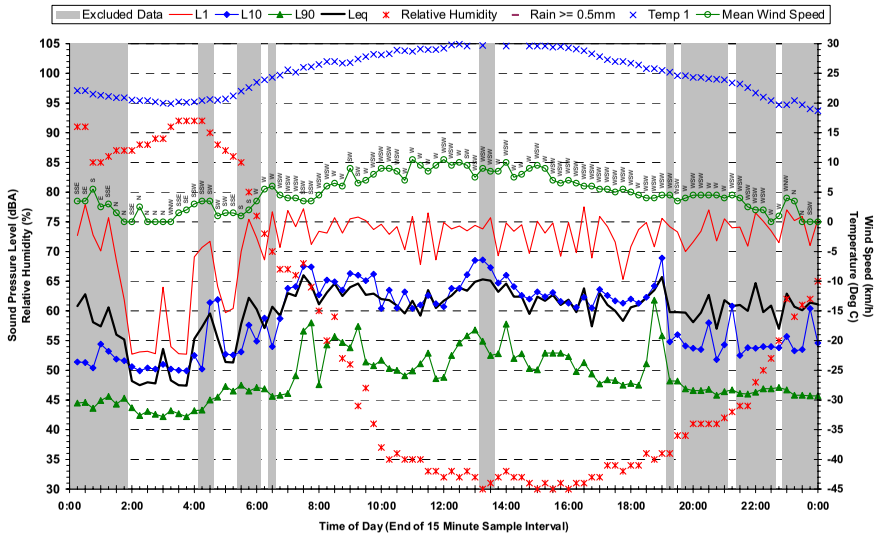
Statistical Ambient Noise Levels
Location 2 - 86 Alma Road Clayfield - Friday 9 December 2005



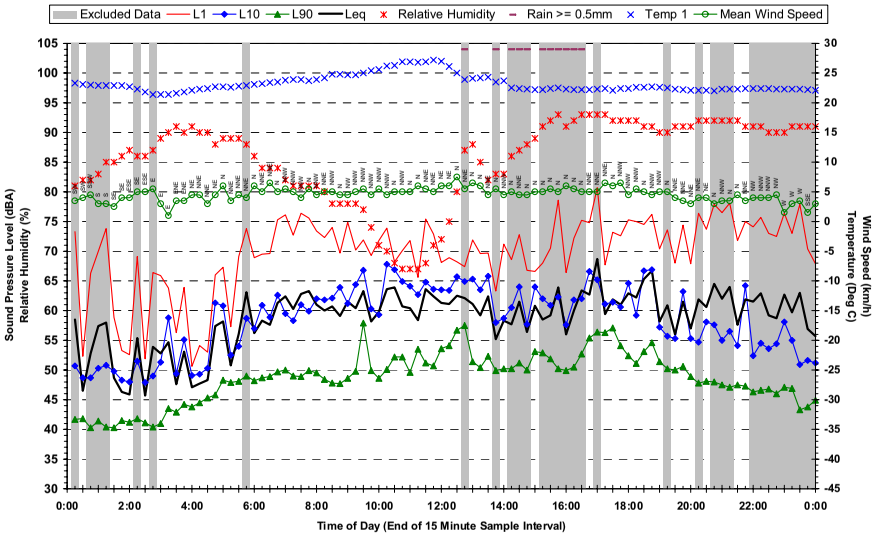
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Thursday 1 December 2005



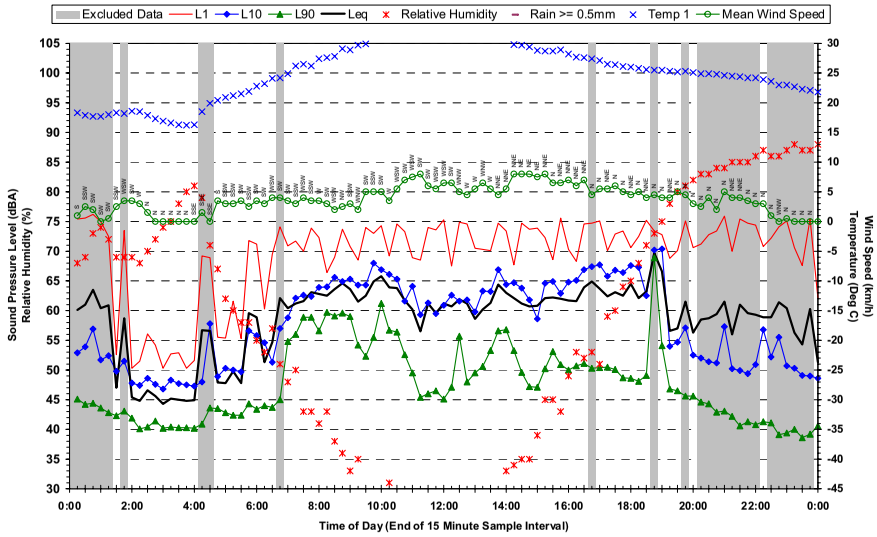
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Saturday 3 December 2005



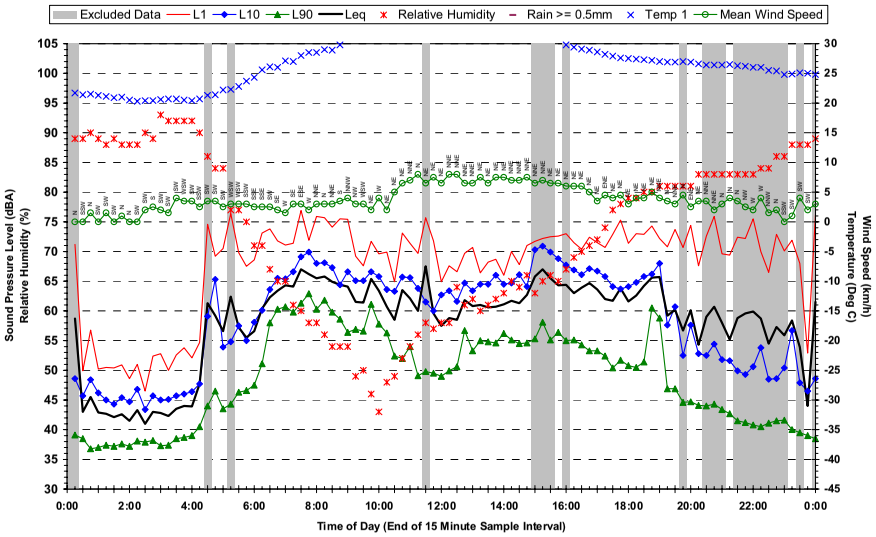
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Friday 2 December 2005



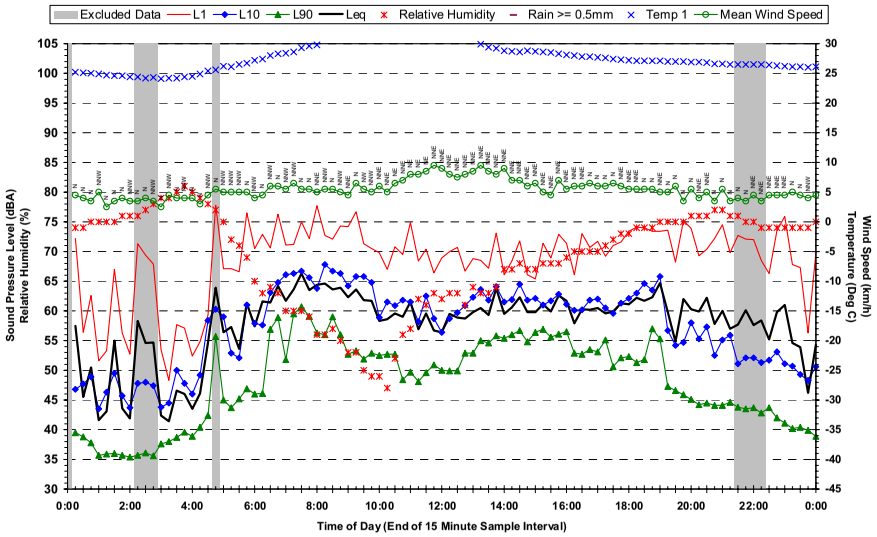
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Sunday 4 December 2005



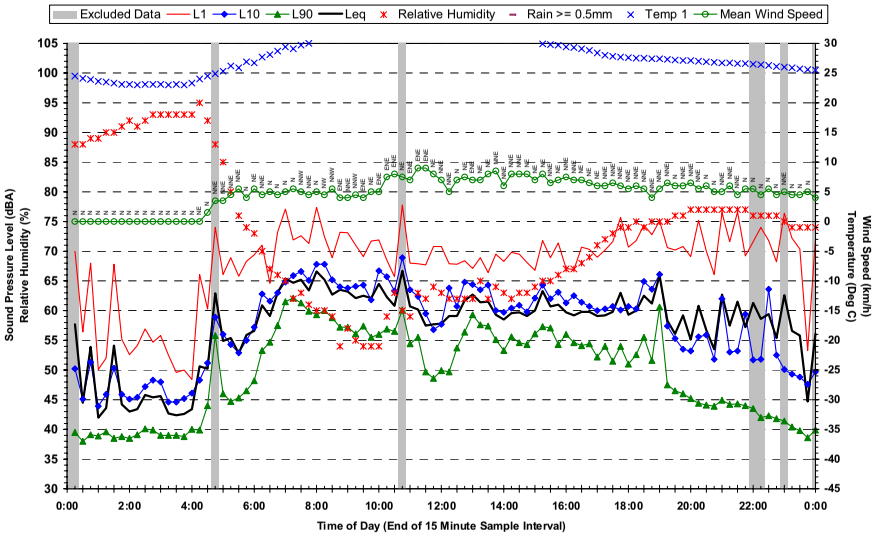
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Monday 5 December 2005



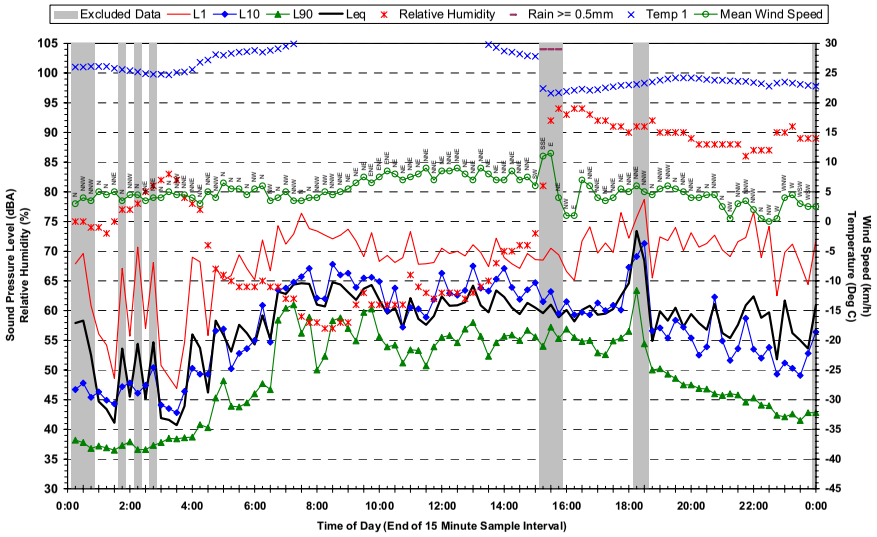
Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Wednesday 7 December 2005

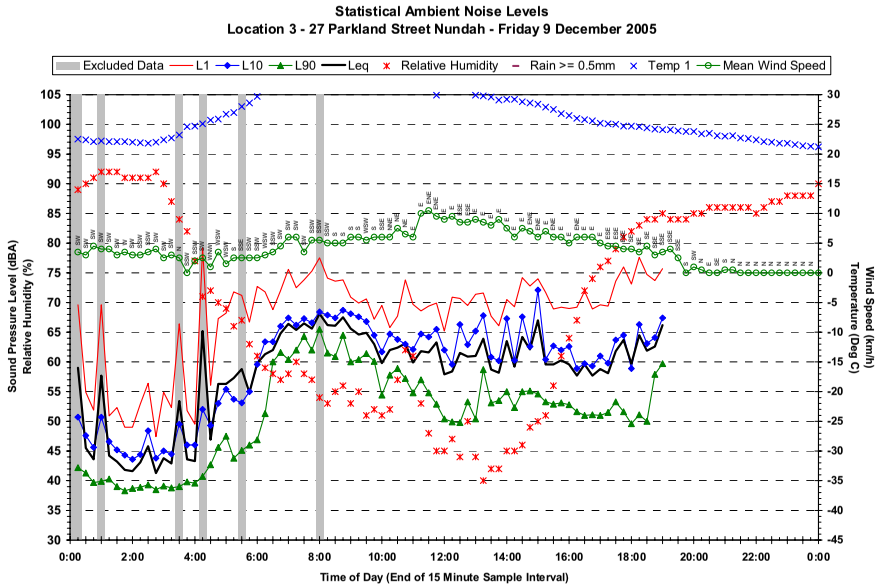


Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Tuesday 6 December 2005

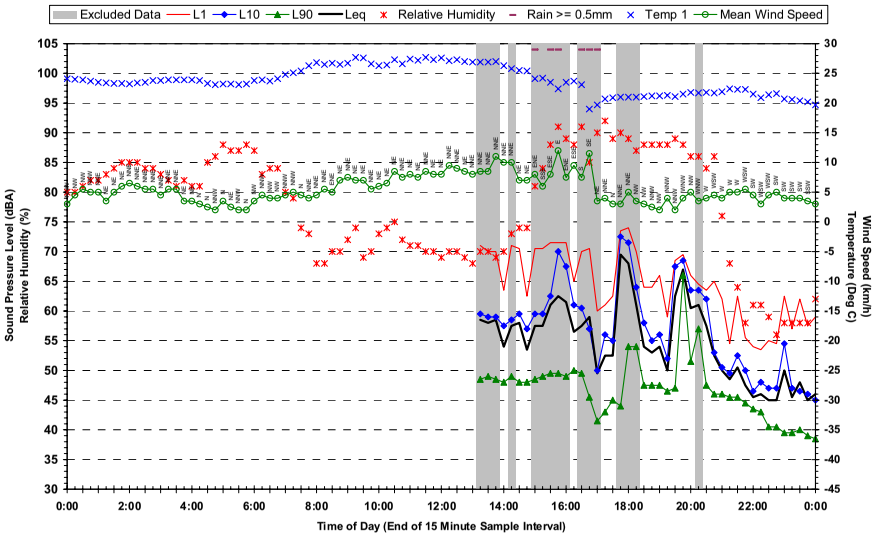


Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Thursday 8 December 2005

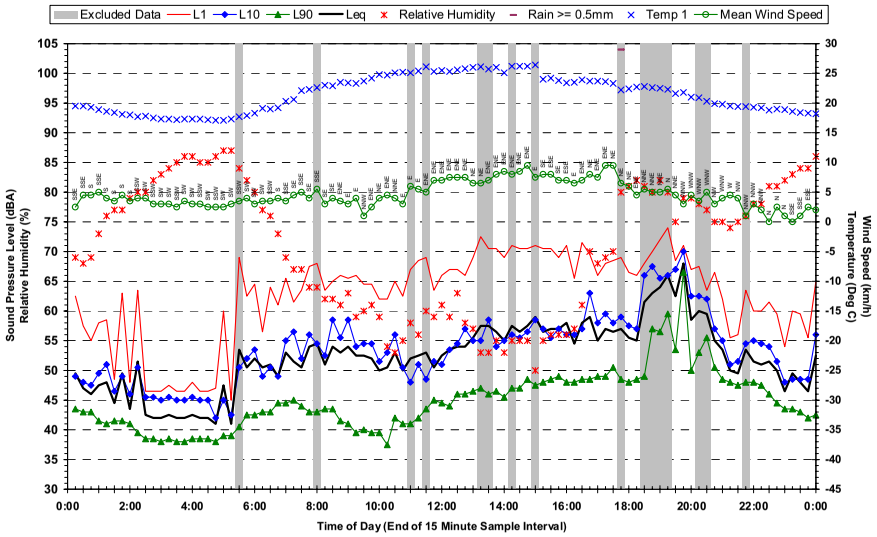



Statistical Ambient Noise Levels
Location 3 - 27 Parkland Street Nundah - Friday 9 December 2005
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.5mm
Temp 1
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

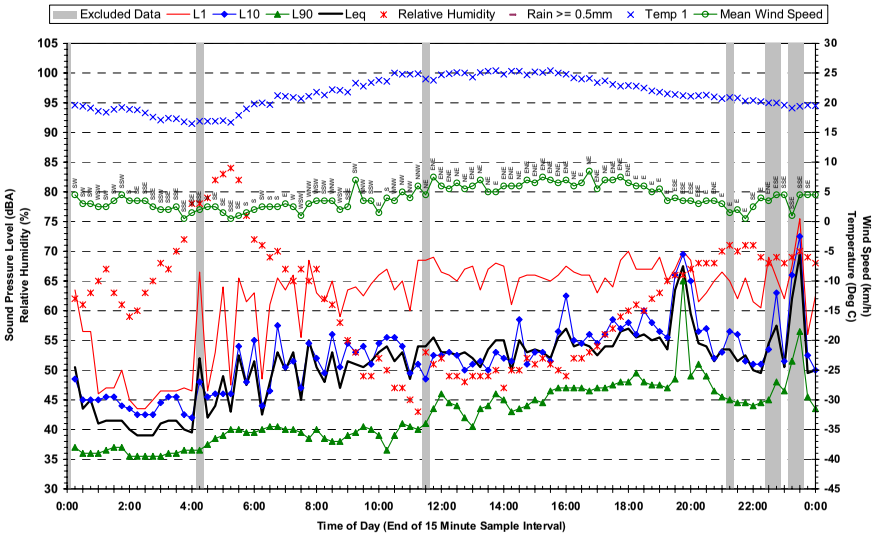
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Sunday 27 November 2005



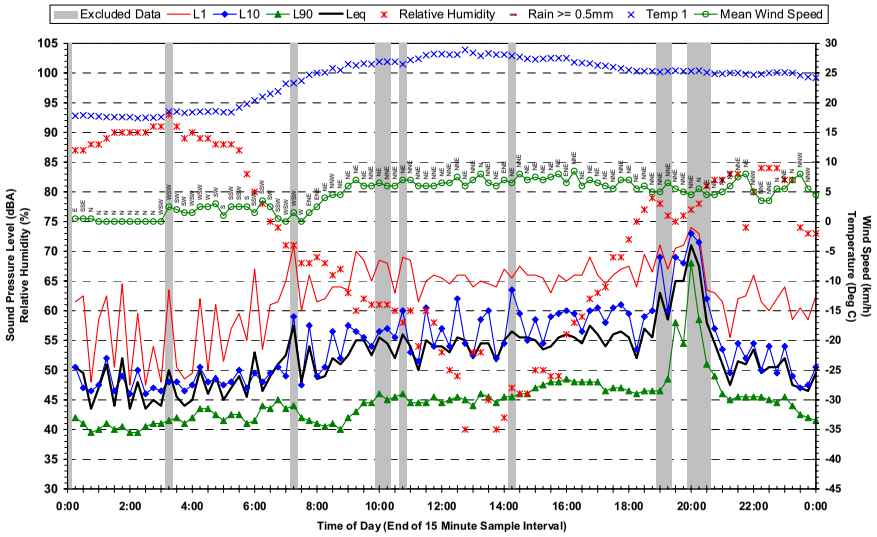
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Tuesday 29 November 2005



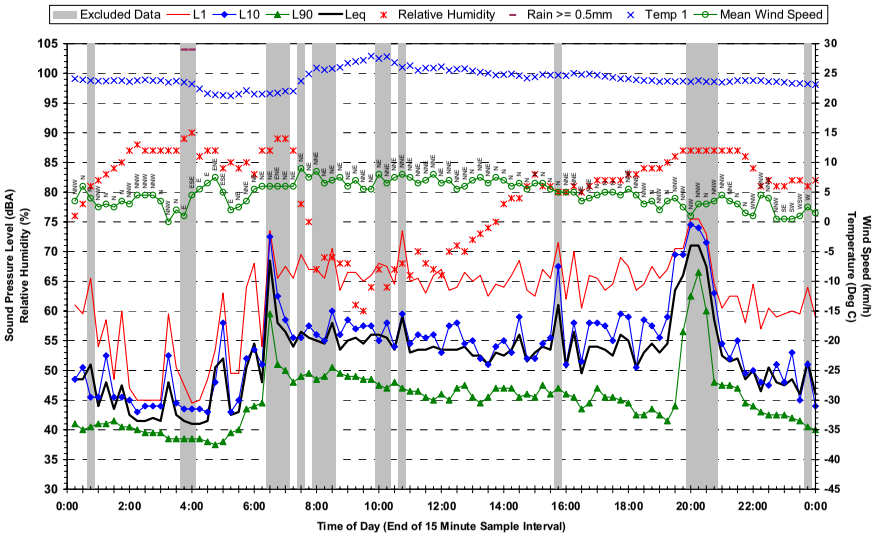
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Monday 28 November 2005



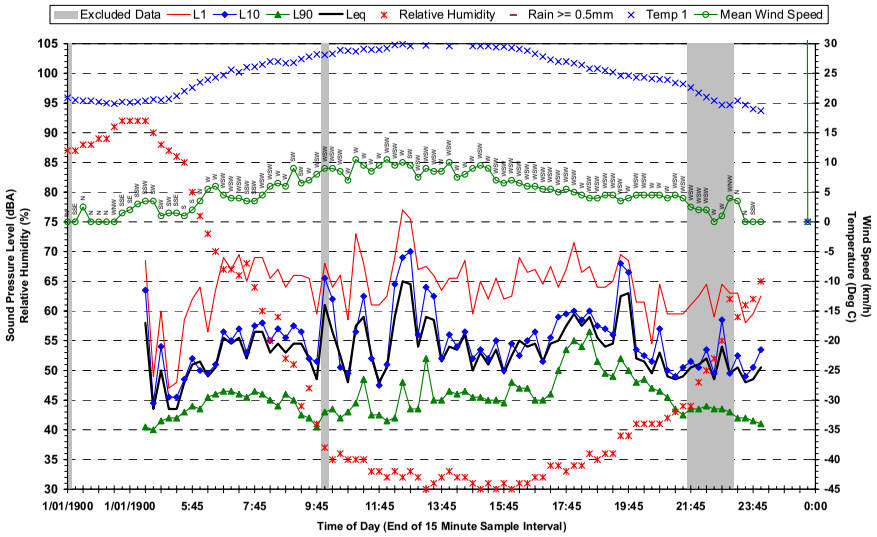
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Wednesday 30 November 2005



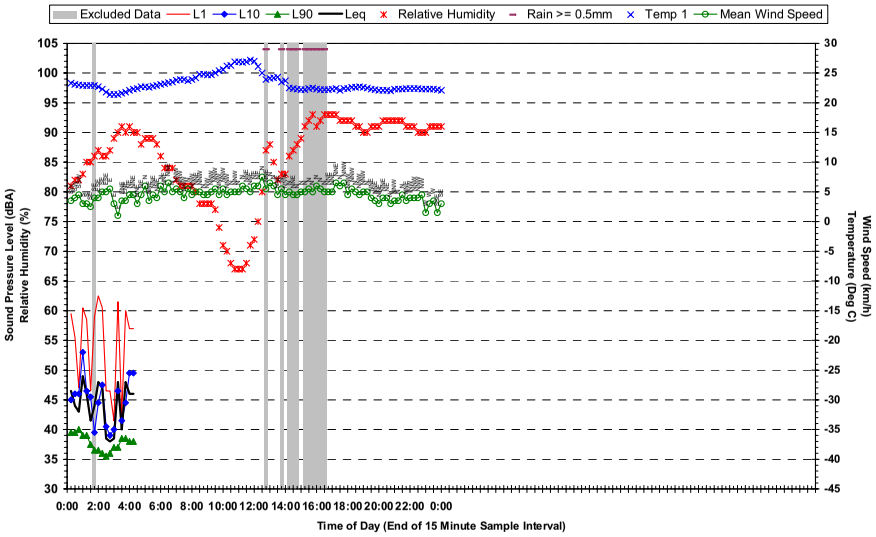
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Thursday 1 December 2005



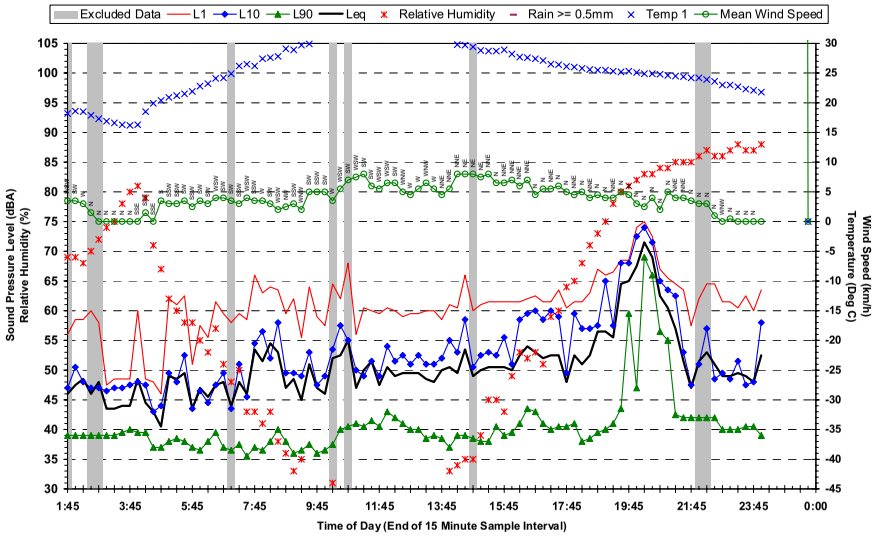
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Saturday 3 December 2005



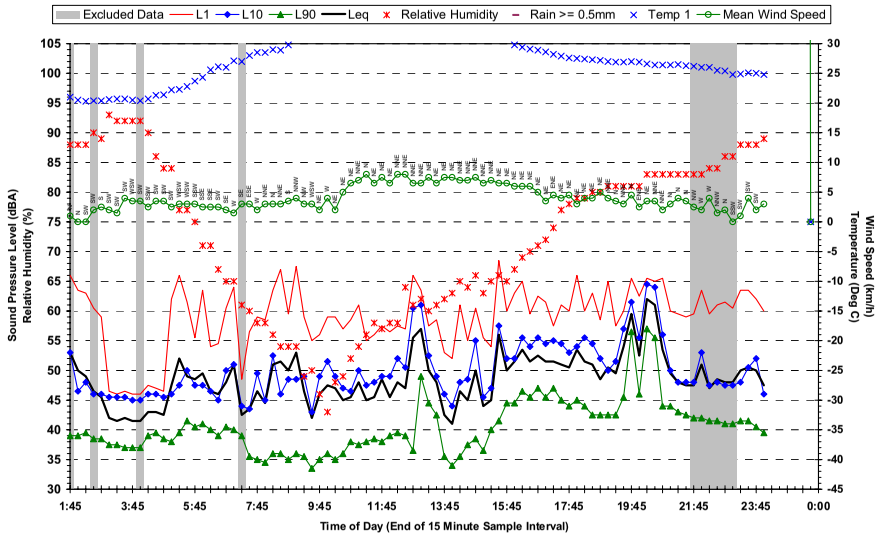
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Friday 2 December 2005



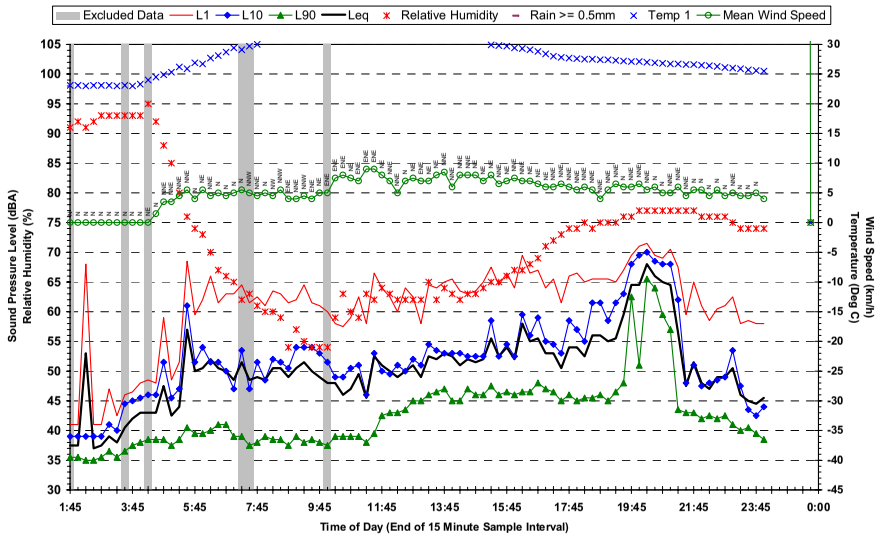
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Sunday 4 December 2005



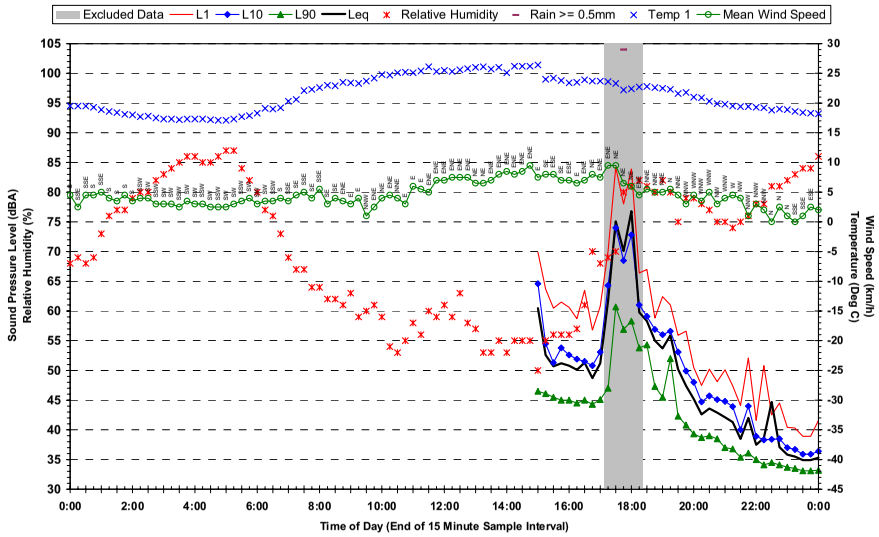
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Monday 5 December 2005



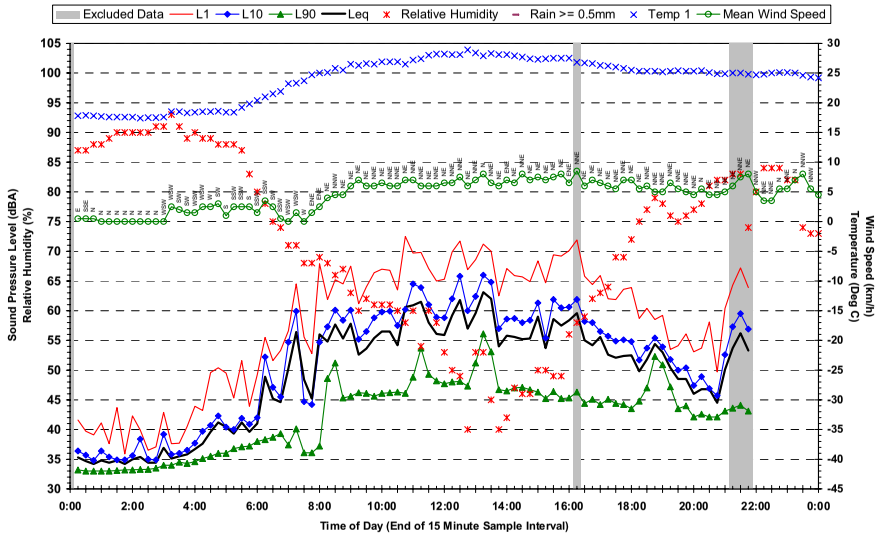
Statistical Ambient Noise Levels
Location 4 - 72 Kalinga Street Clayfield - Tuesday 6 December 2005



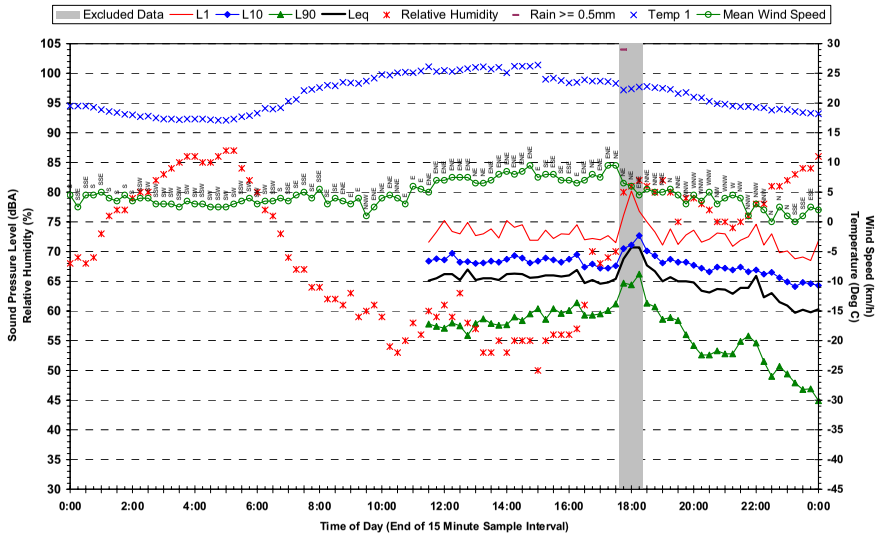
Statistical Ambient Noise Levels
Location 5 - Kedron State High School - Tuesday 29 November 2005



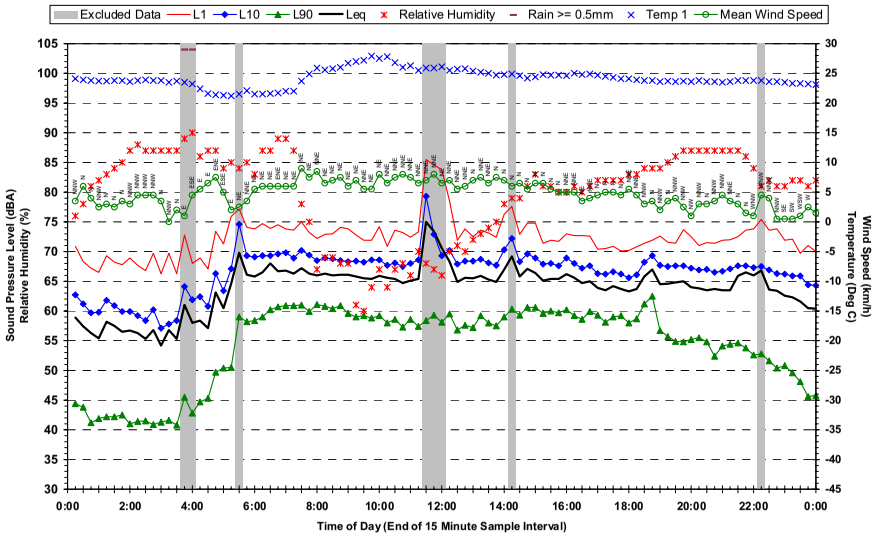
Statistical Ambient Noise Levels
Location 5 - Kedron State High School - Wednesday 30 November 2005



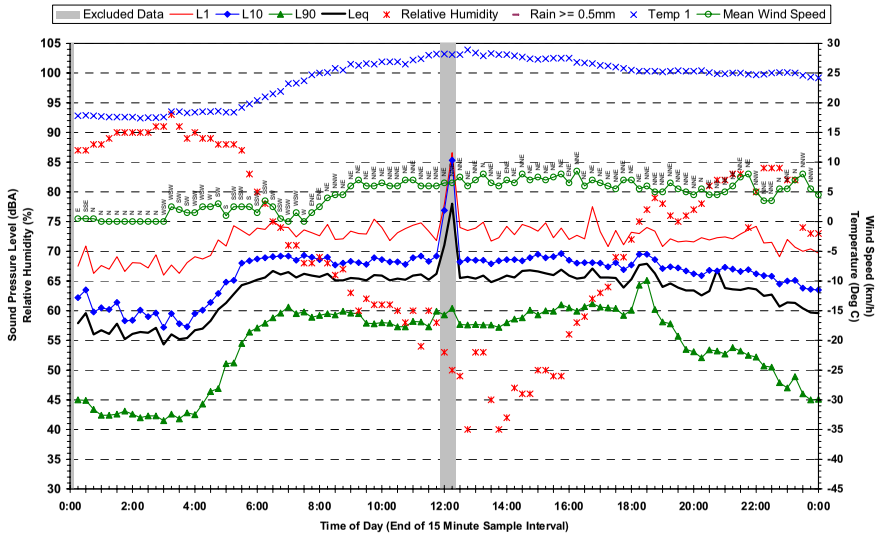
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Tuesday 29 November 2005



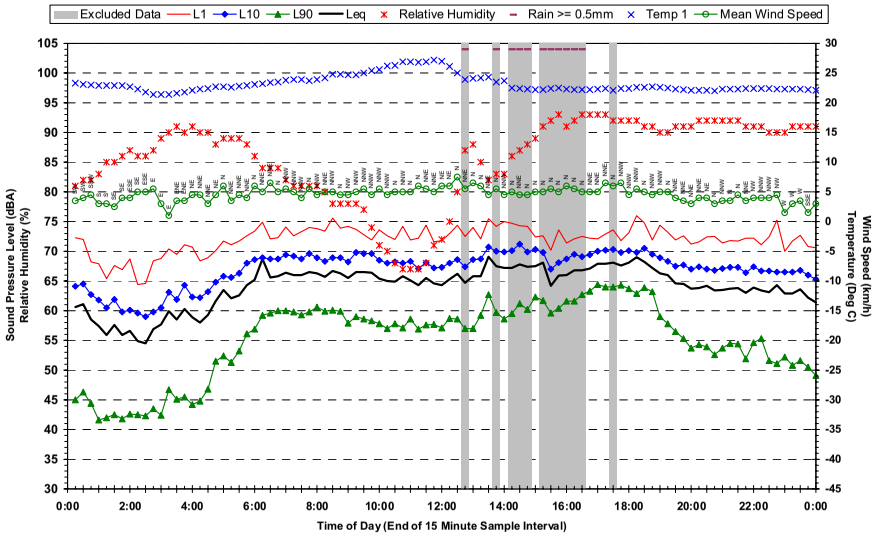
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Thursday 1 December 2005



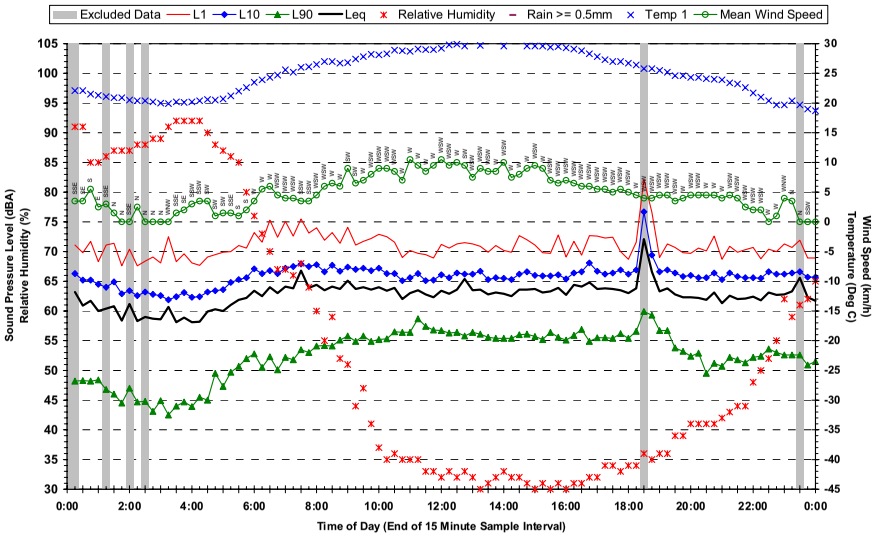
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Wednesday 30 November 2005



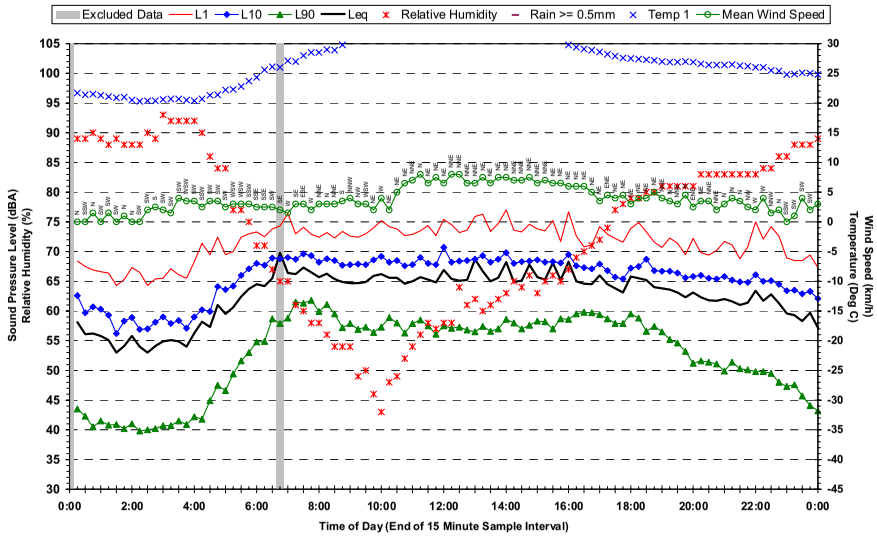
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Friday 2 December 2005



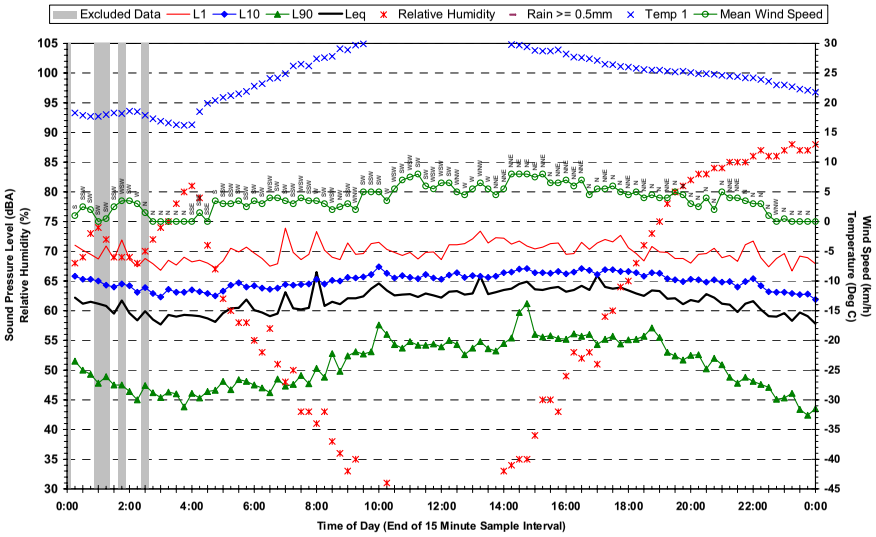
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Saturday 3 December 2005



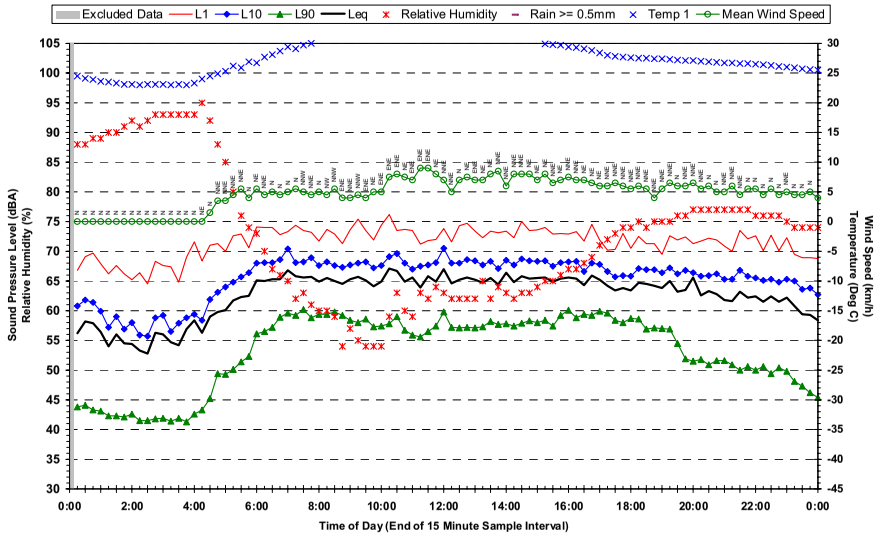
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Monday 5 December 2005



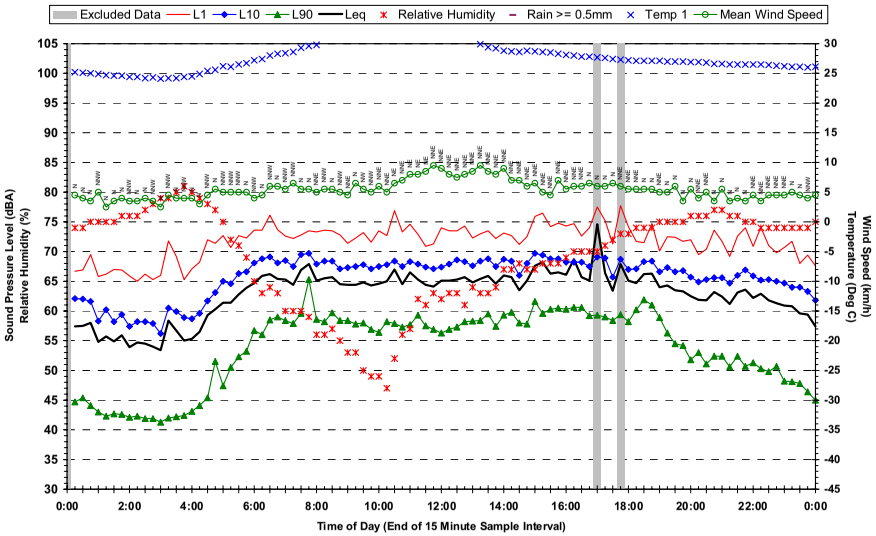
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Sunday 4 December 2005



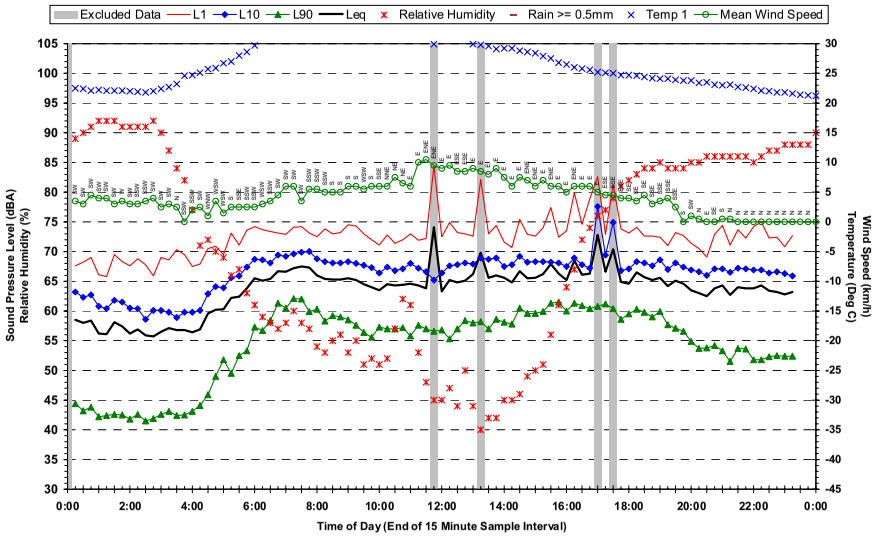
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Tuesday 6 December 2005



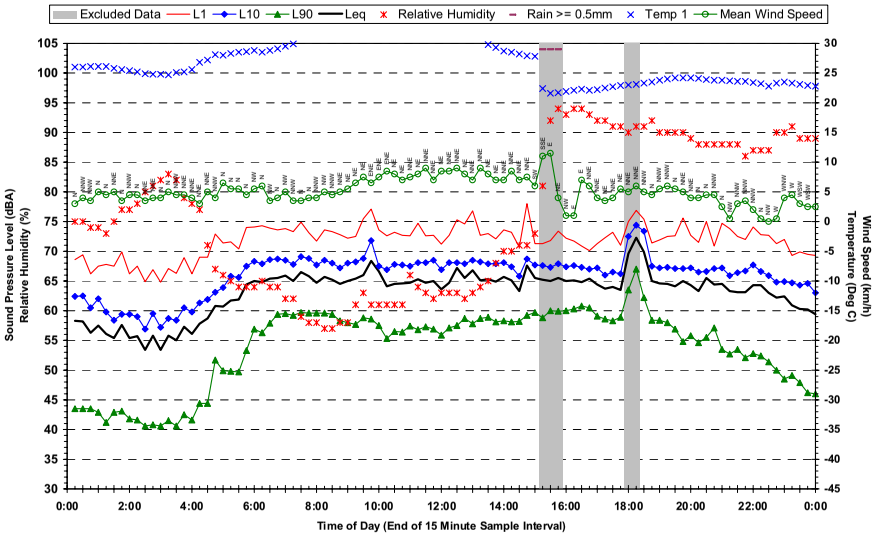
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Wednesday 7 December 2005



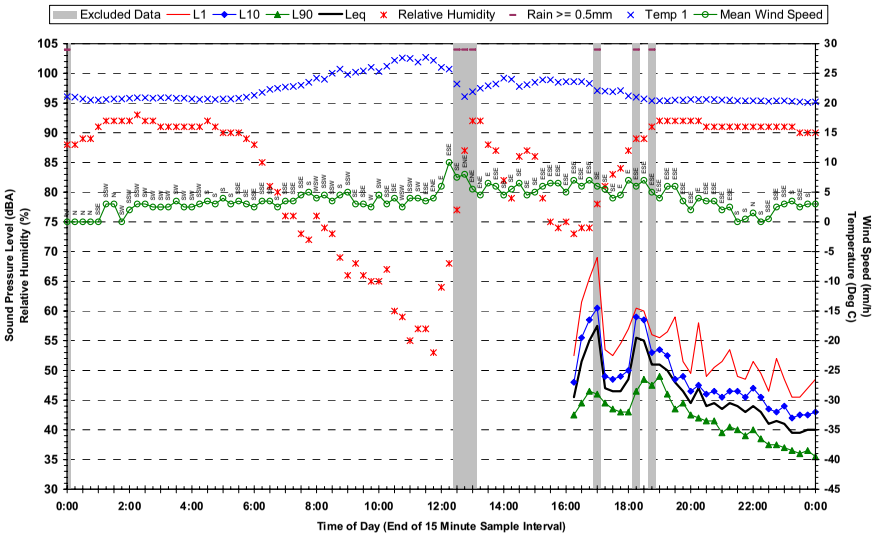
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Friday 9 December 2005



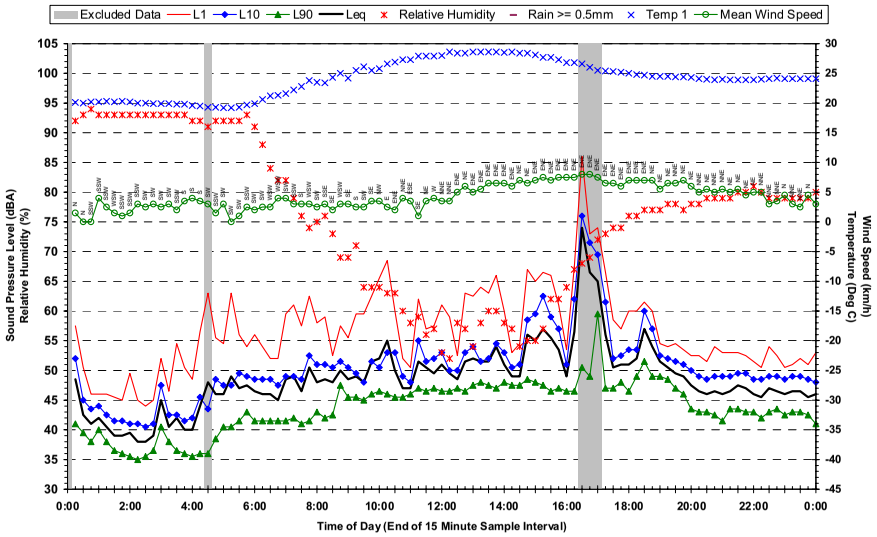
Statistical Ambient Noise Levels
Location 6 - 20 Perry Street Lutwyche - Thursday 8 December 2005



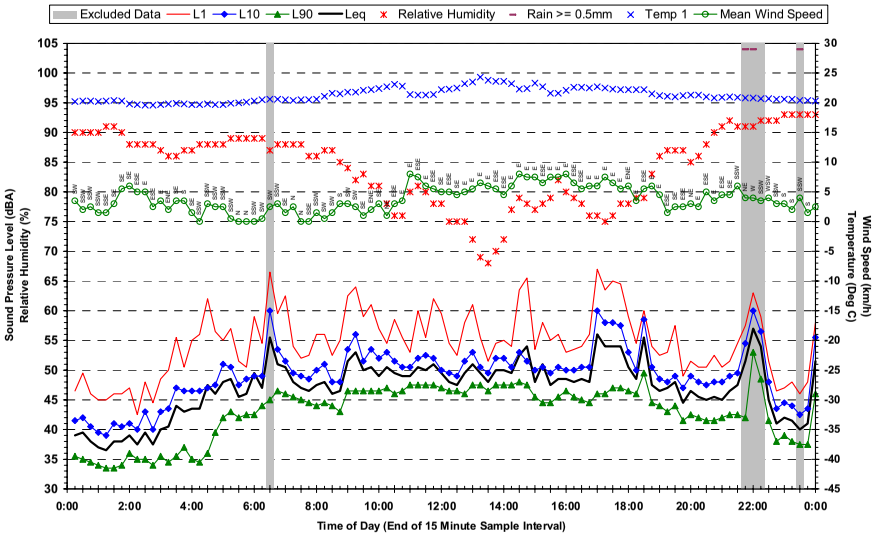
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Thursday 24 November 2005



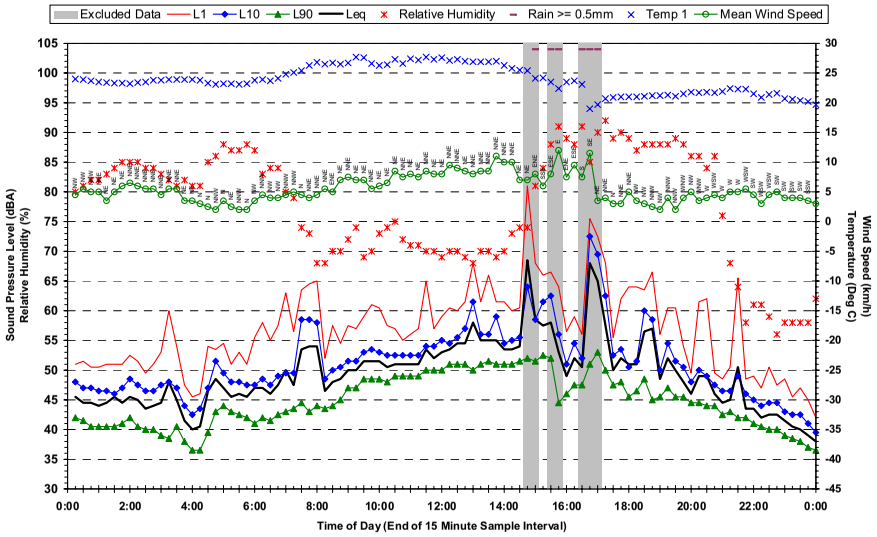
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Saturday 26 November 2005



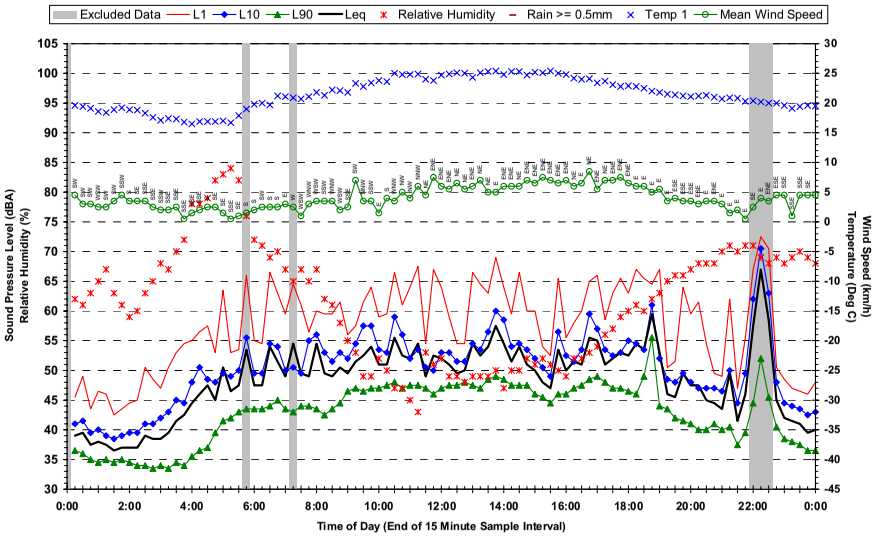
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Friday 25 November 2005



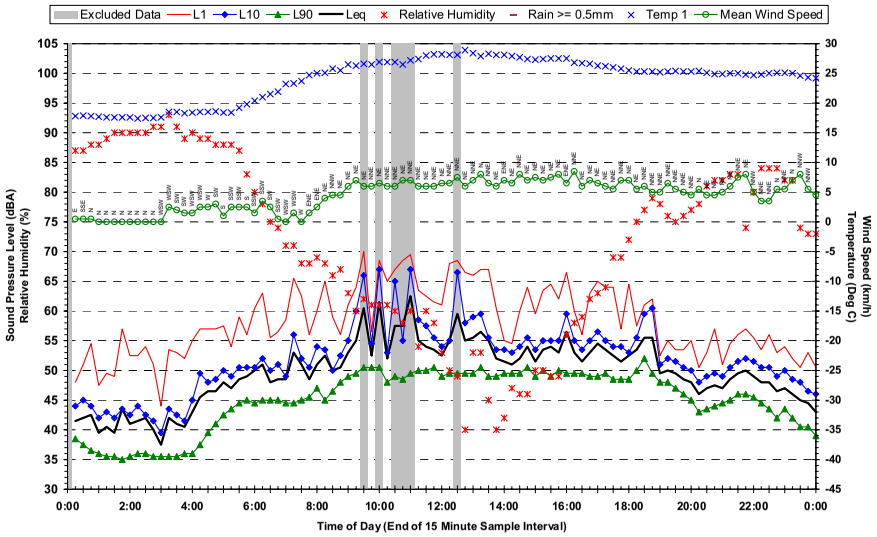
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Sunday 27 November 2005



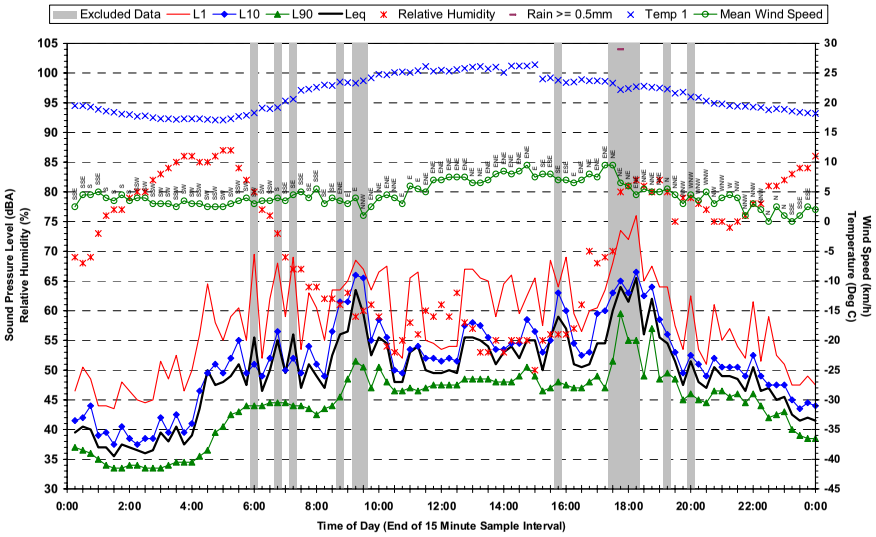
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Monday 28 November 2005



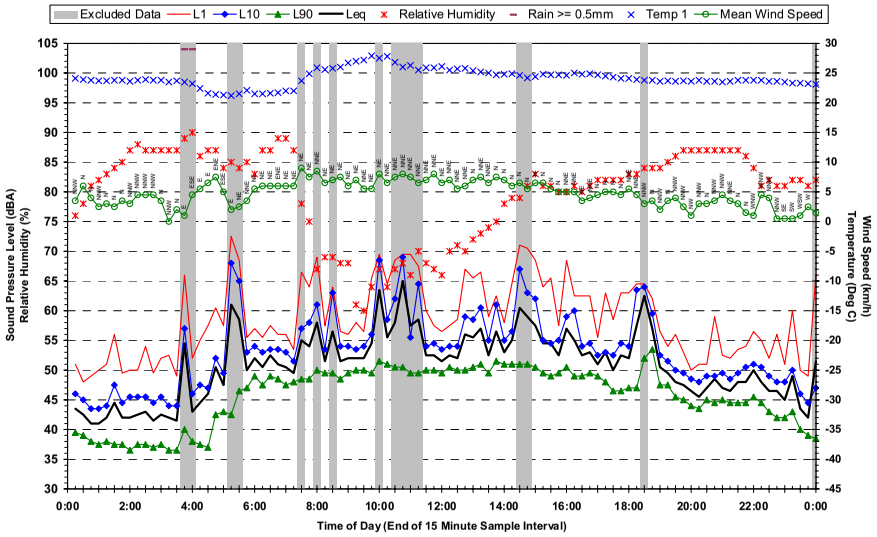
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Wednesday 30 November 2005



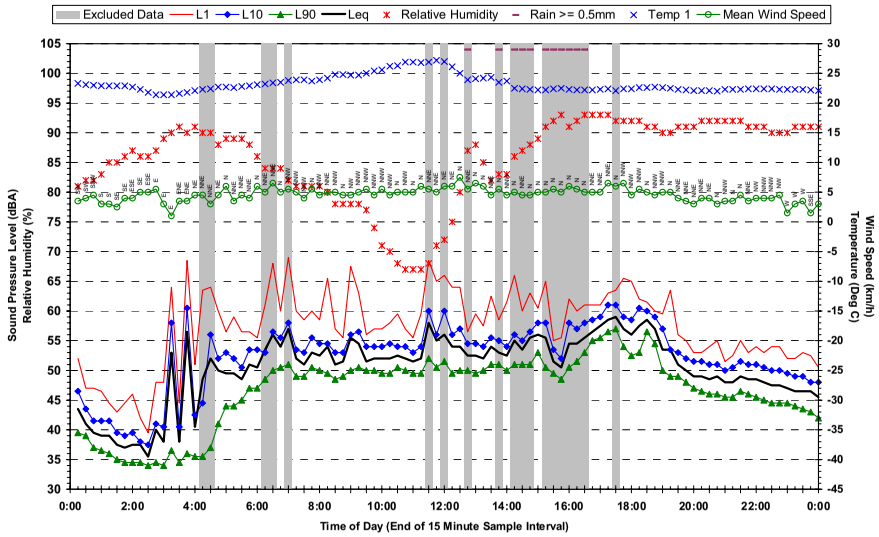
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Tuesday 29 November 2005



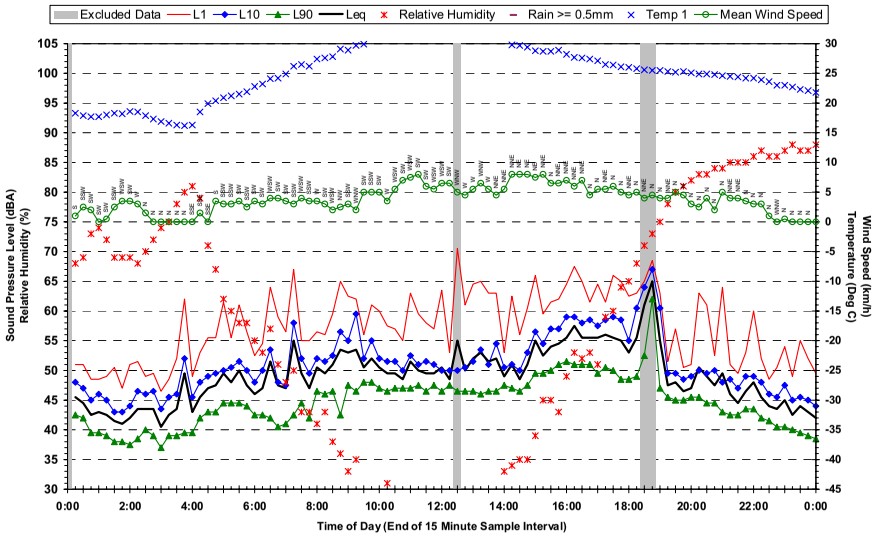
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Thursday 1 December 2005



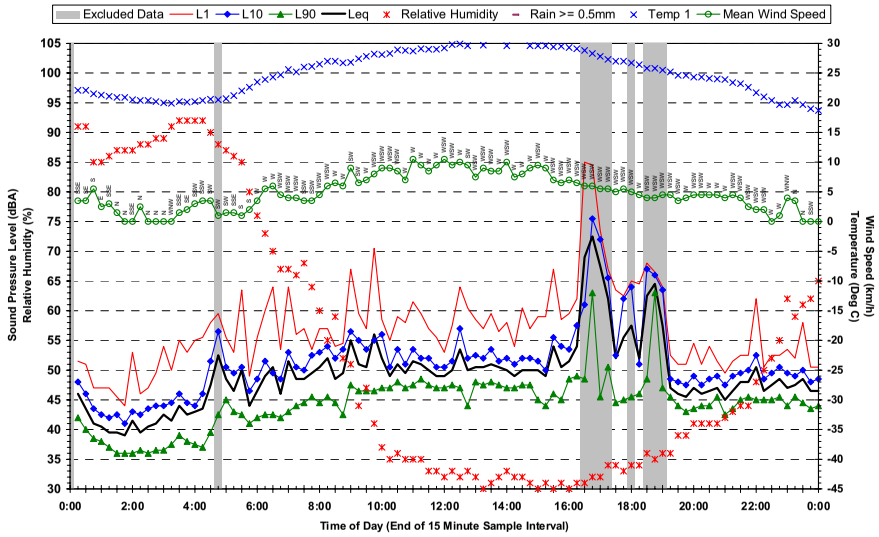
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Friday 2 December 2005



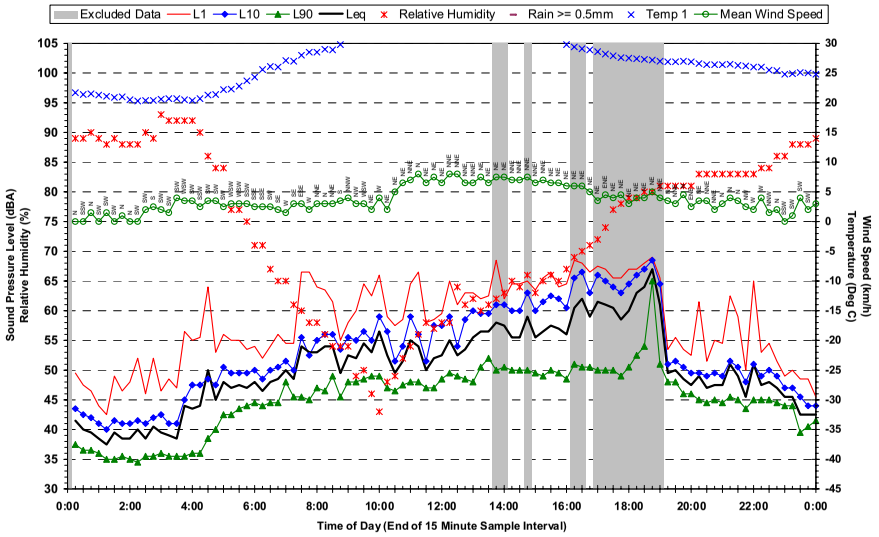
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Sunday 4 December 2005



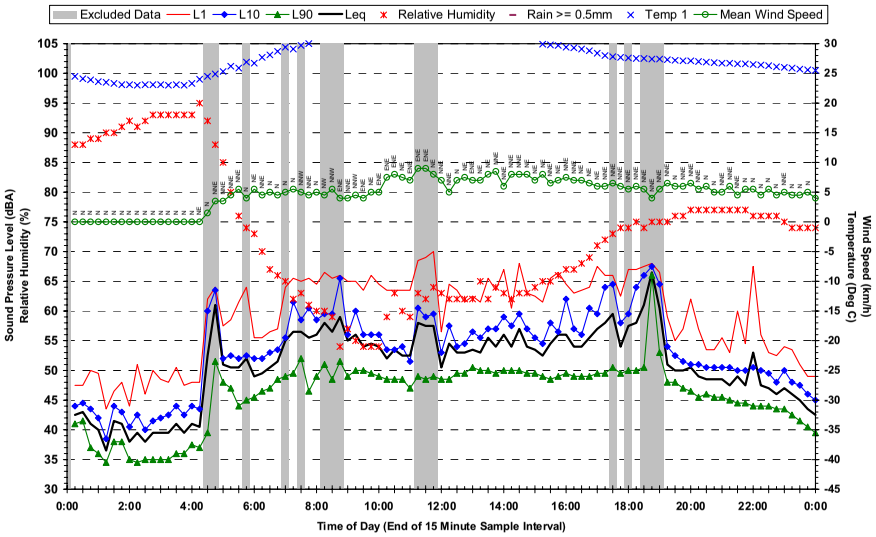
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Saturday 3 December 2005



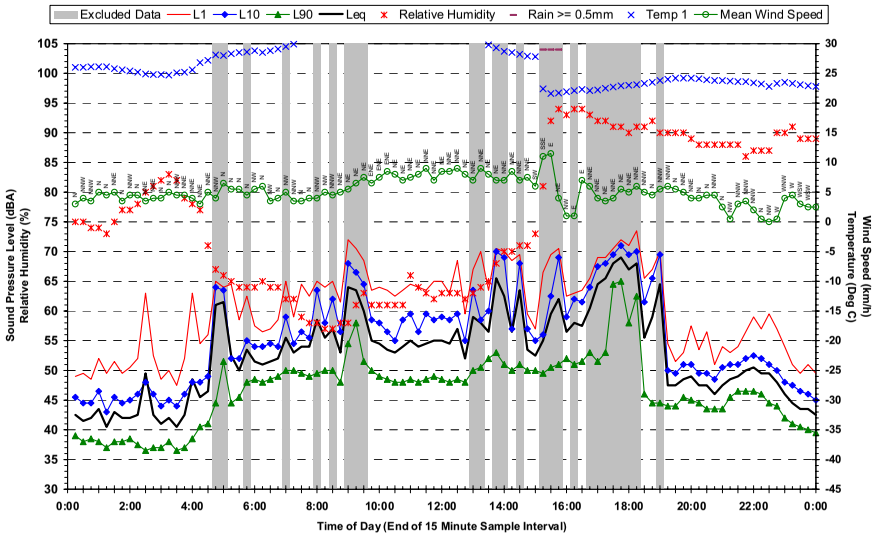
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Monday 5 December 2005



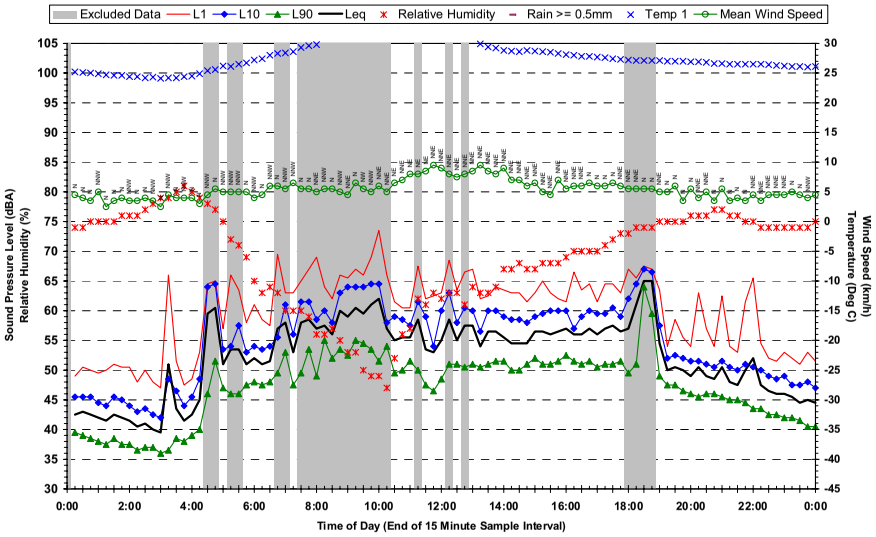
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Tuesday 6 December 2005



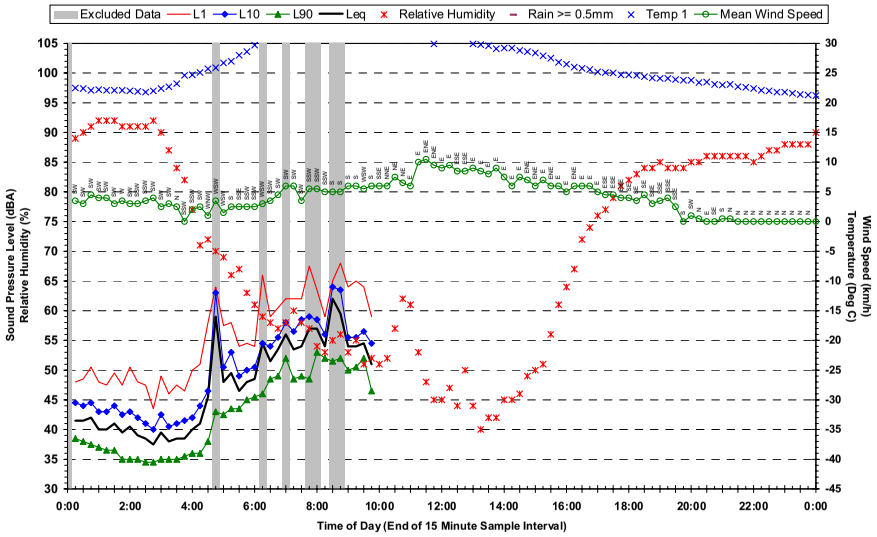
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Thursday 8 December 2005



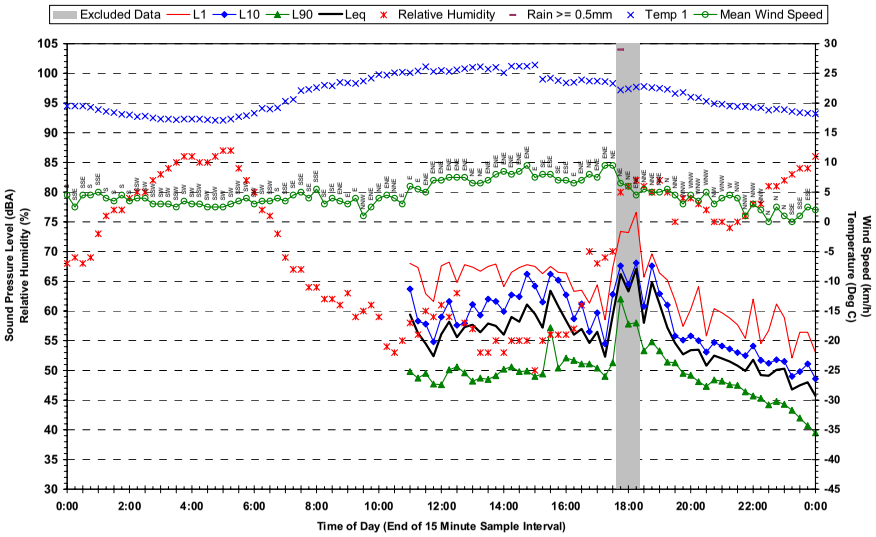
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Wednesday 7 December 2005



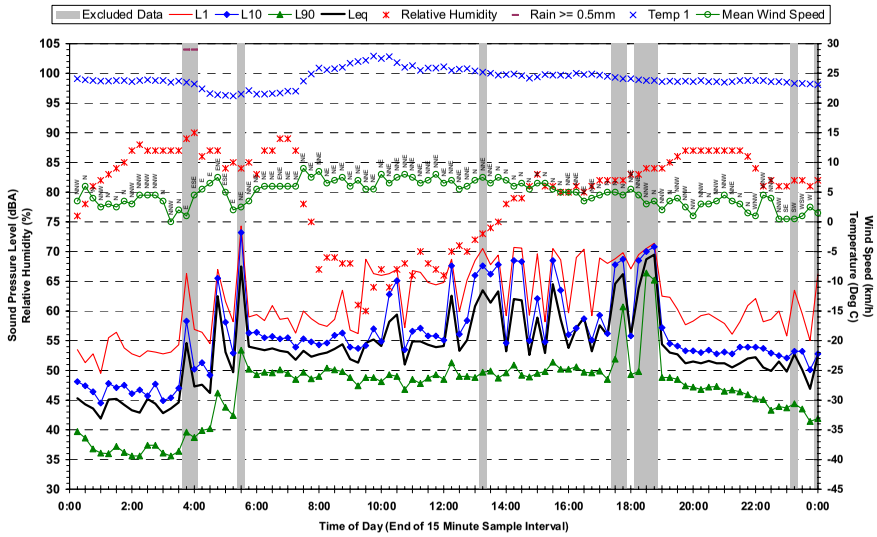
Statistical Ambient Noise Levels
Location 7 - 30 Coulton Avenue Lutwyche - Friday 9 December 2005



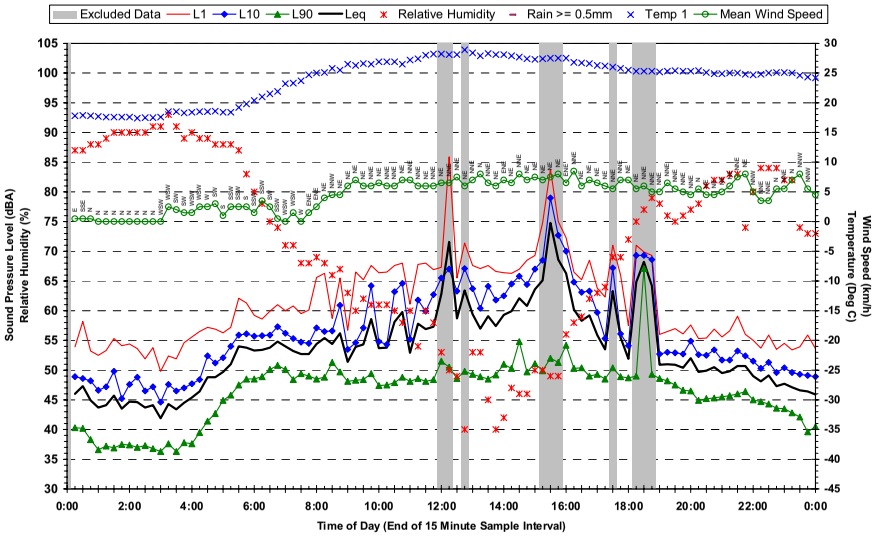
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Tuesday 29 November 2005



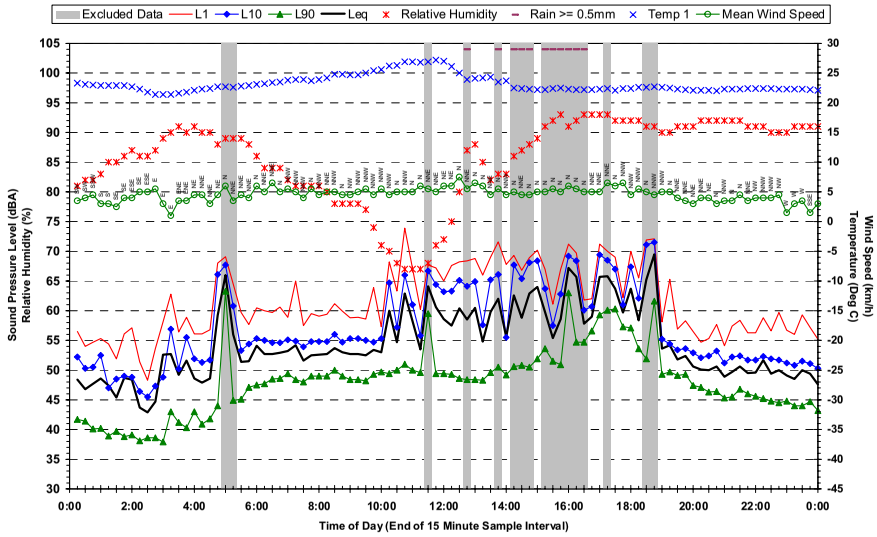
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Thursday 1 December 2005



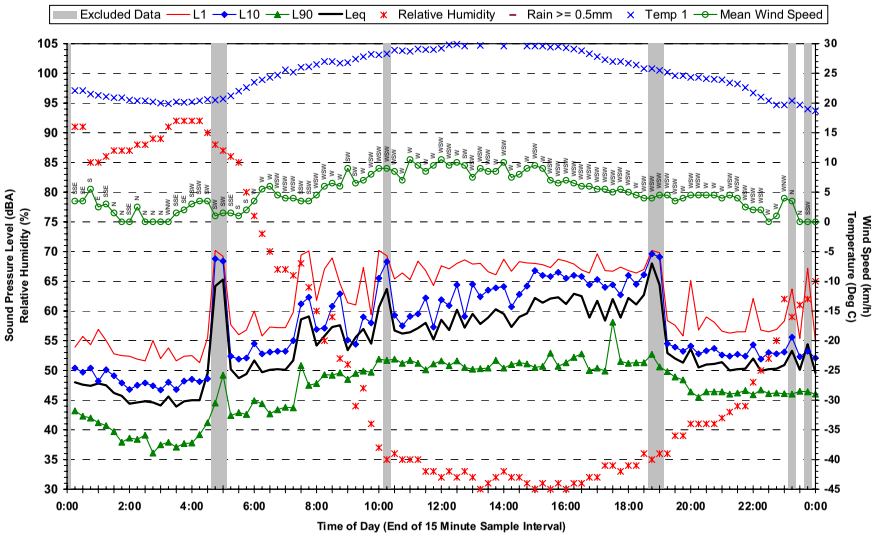
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Wednesday 30 November 2005



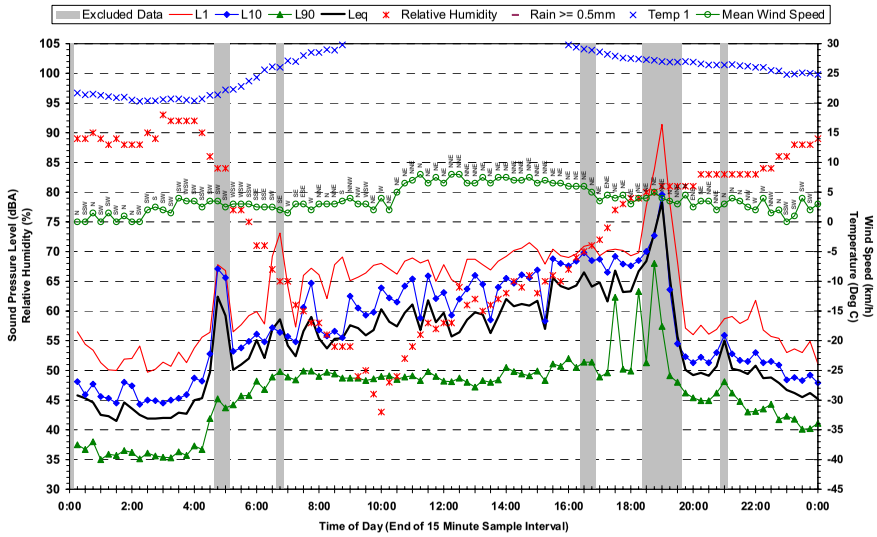
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Friday 2 December 2005



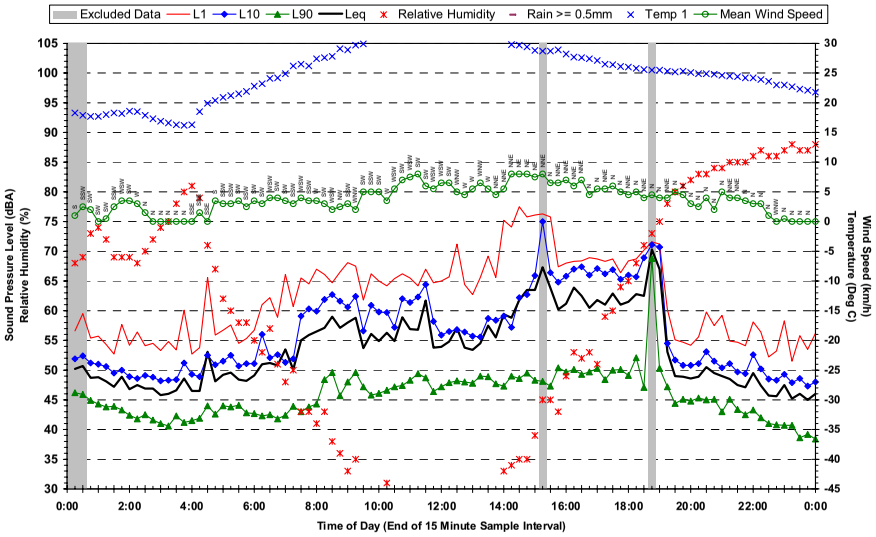
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Saturday 3 December 2005



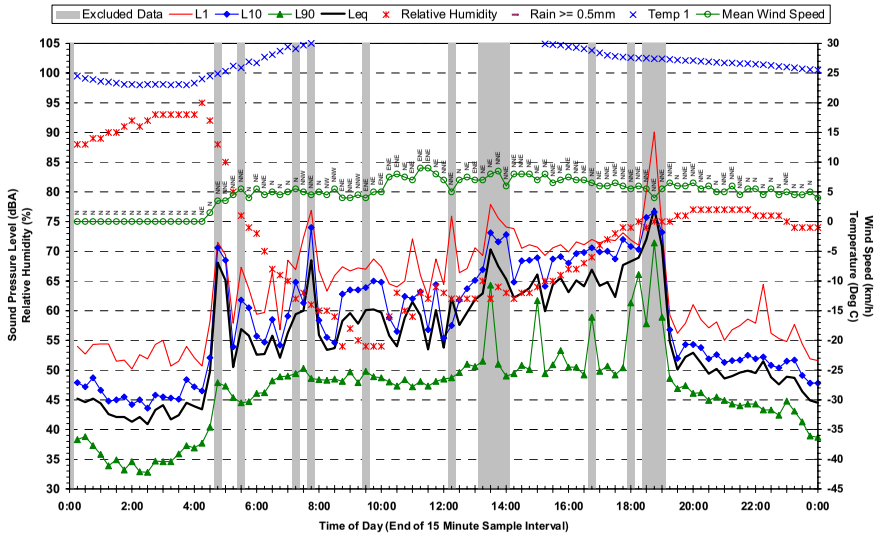
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Monday 5 December 2005



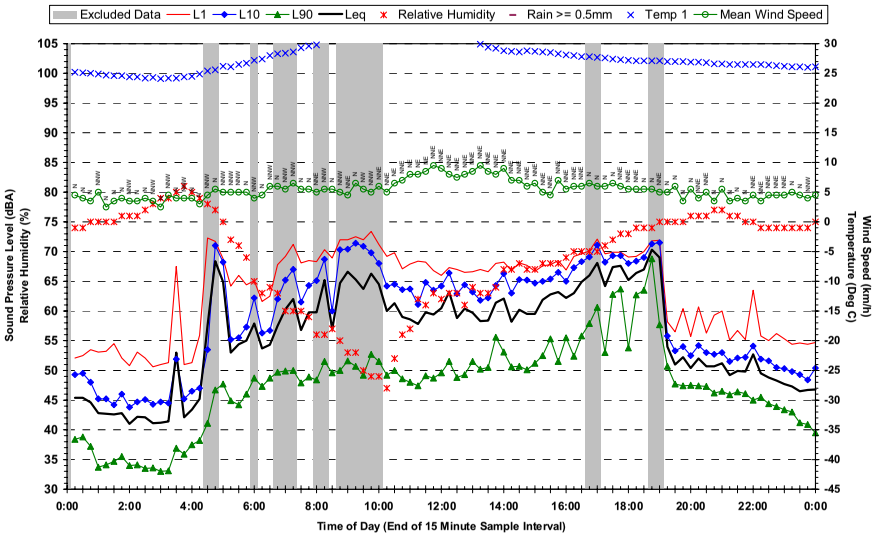
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Sunday 4 December 2005



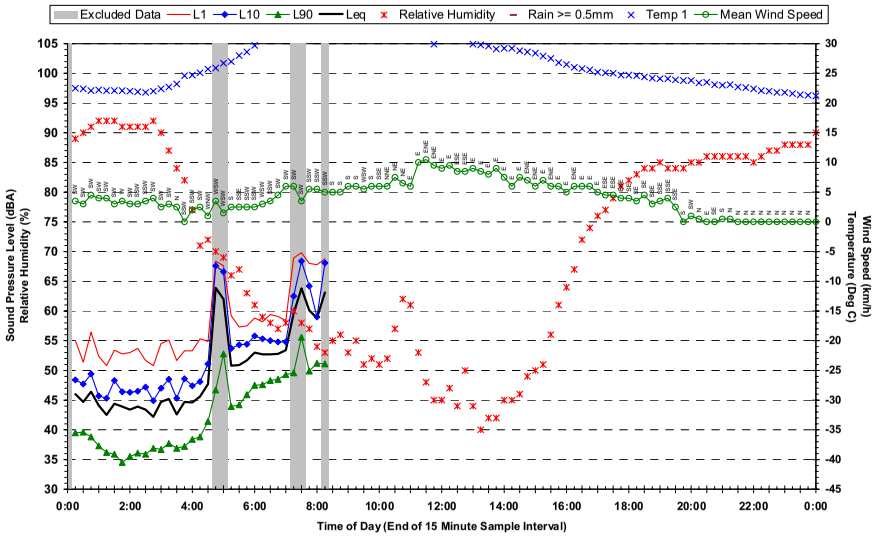
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Tuesday 6 December 2005



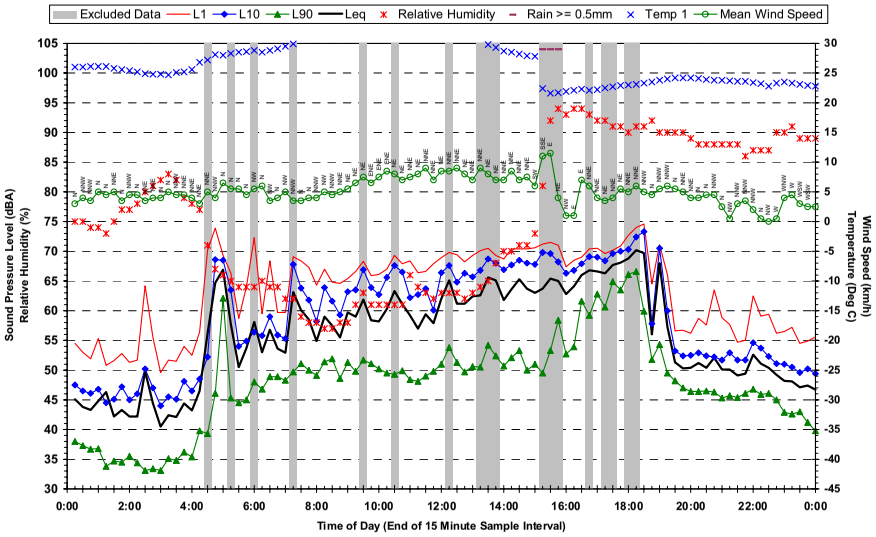
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Wednesday 7 December 2005



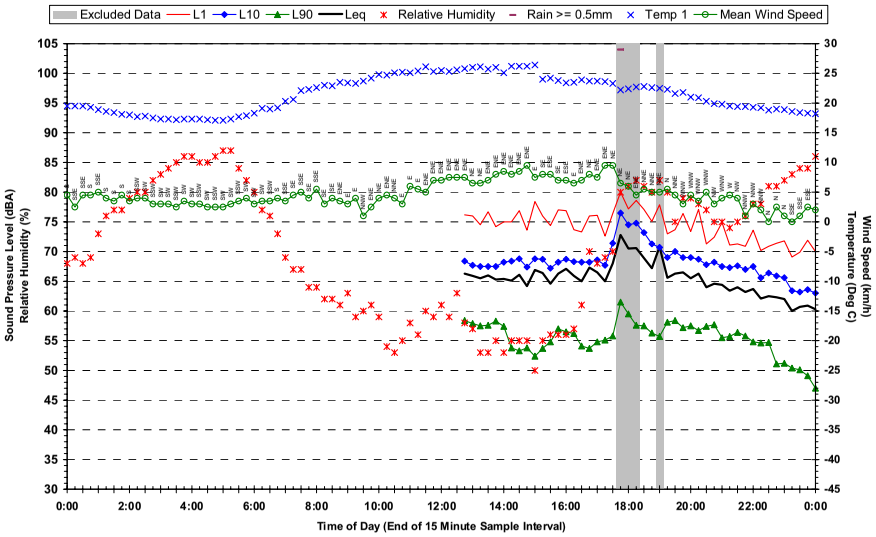
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Friday 9 December 2005



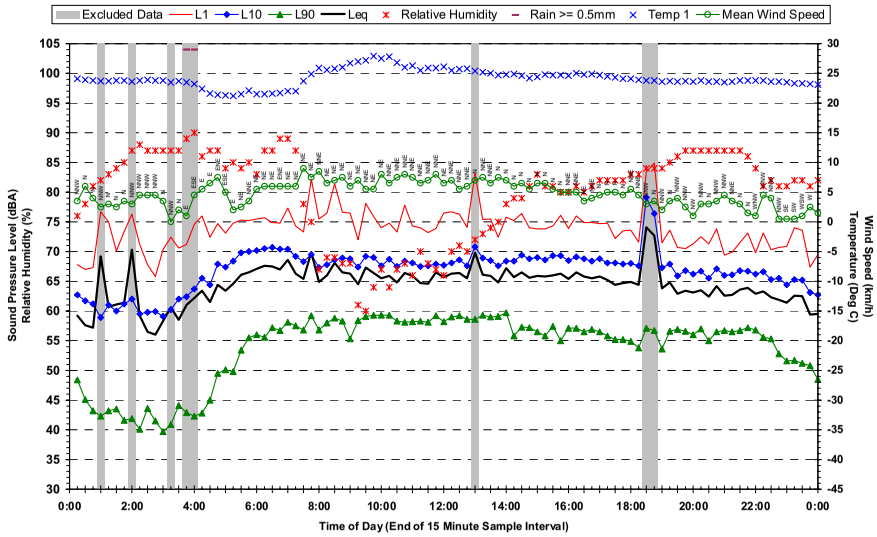
Statistical Ambient Noise Levels
Location 8 - 12 Park Terrace Kedron - Thursday 8 December 2005



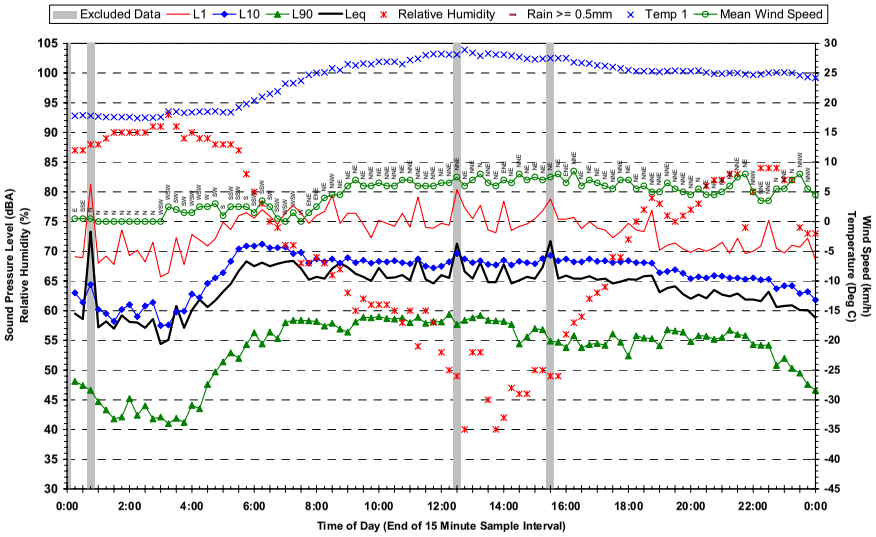
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Tuesday 29 November 2005



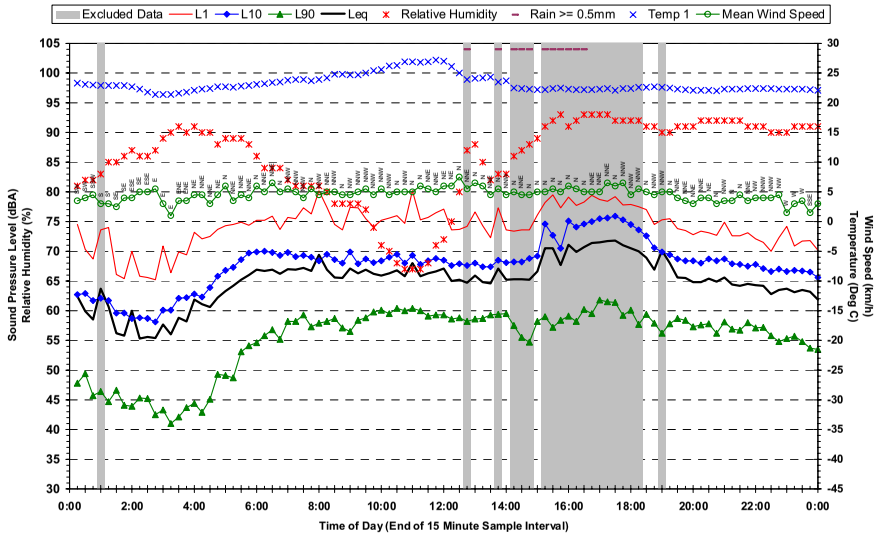
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Thursday 1 December 2005



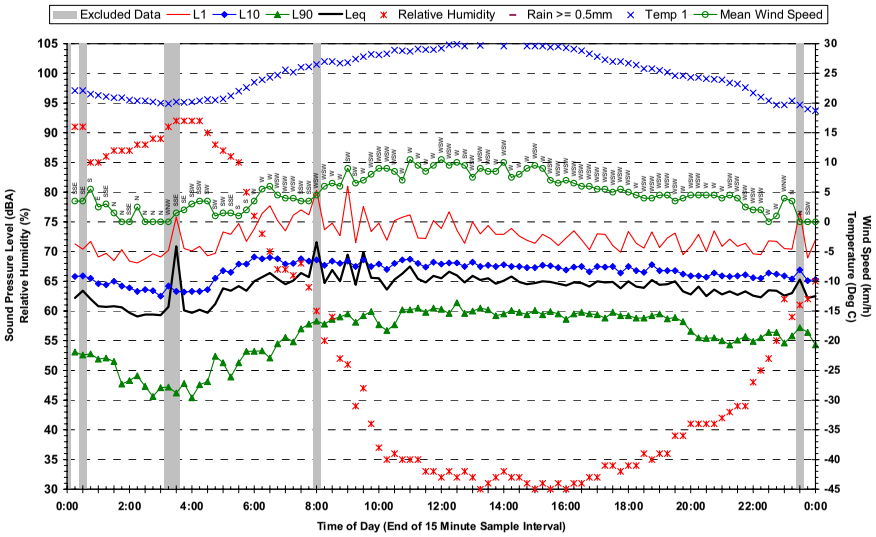
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Wednesday 30 November 2005



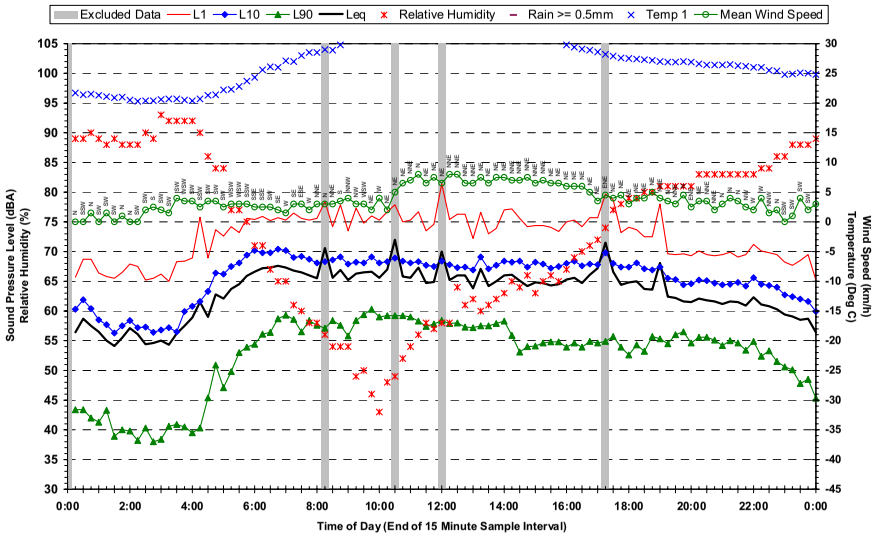
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Friday 2 December 2005



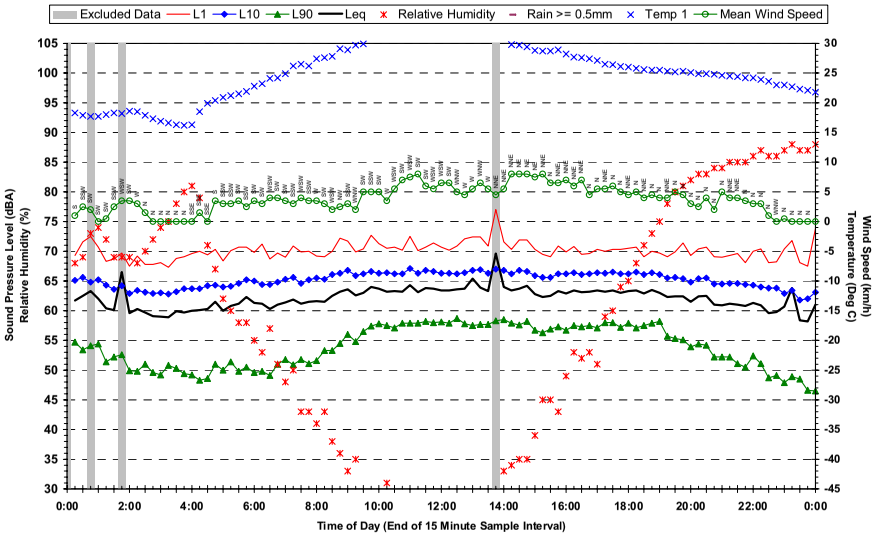
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Saturday 3 December 2005



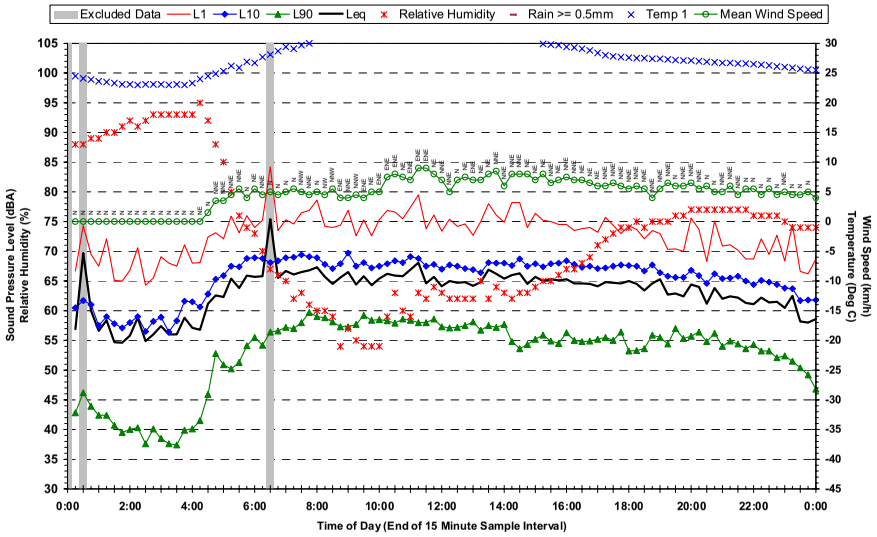
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Monday 5 December 2005



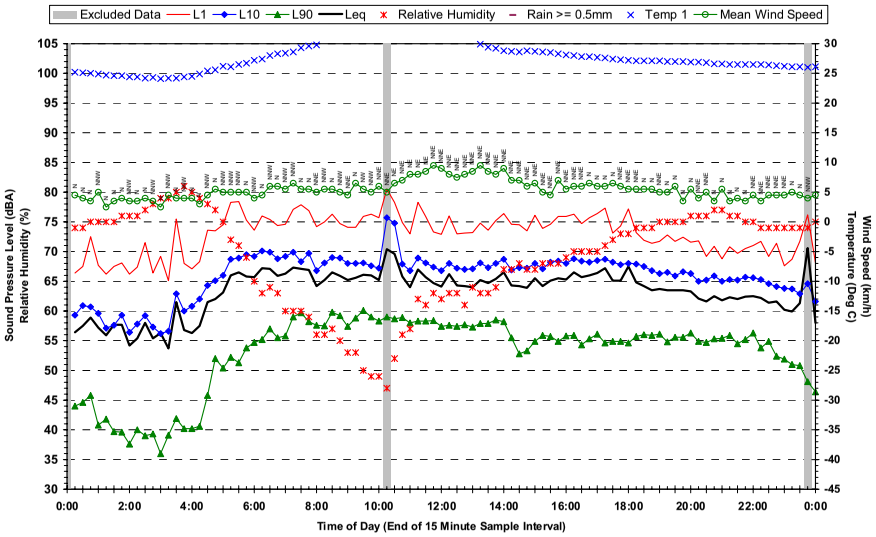
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Sunday 4 December 2005



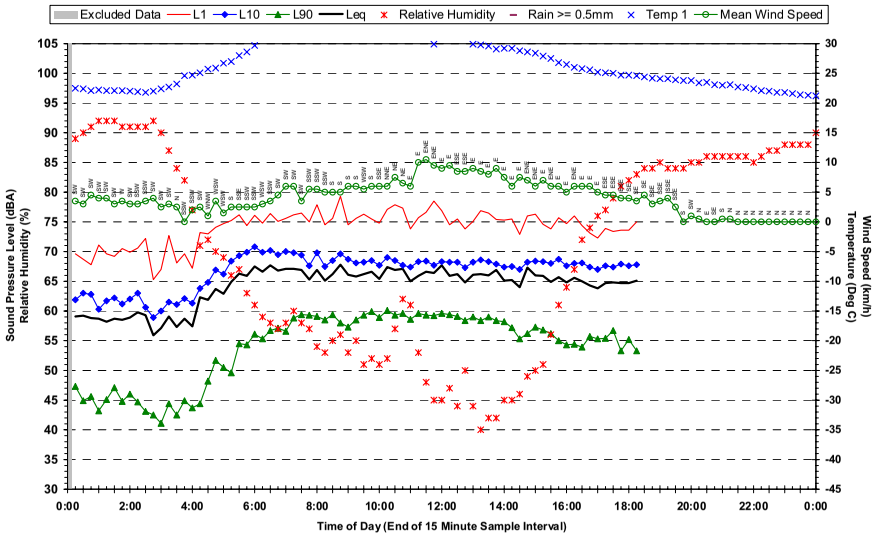
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Tuesday 6 December 2005



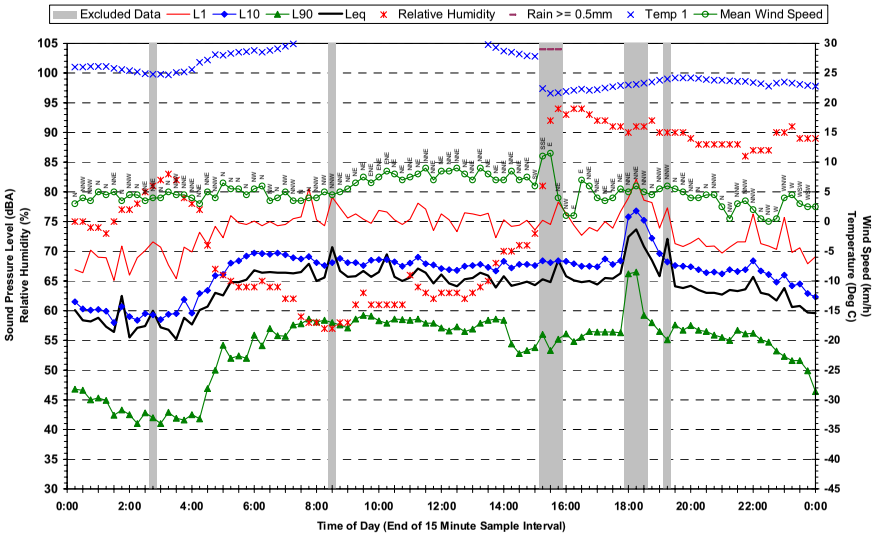
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Wednesday 7 December 2005



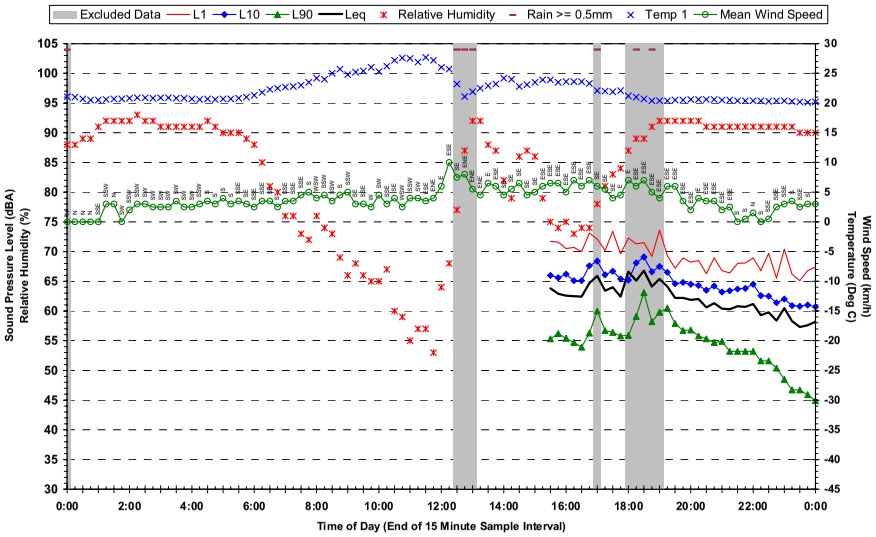
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Friday 9 December 2005



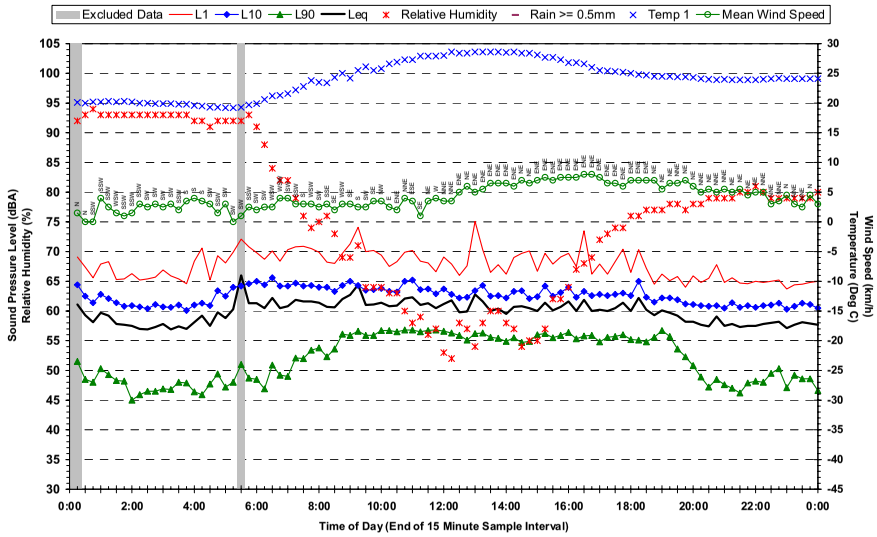
Statistical Ambient Noise Levels
Location 9 - 17 Roblane Street Windsor - Thursday 8 December 2005



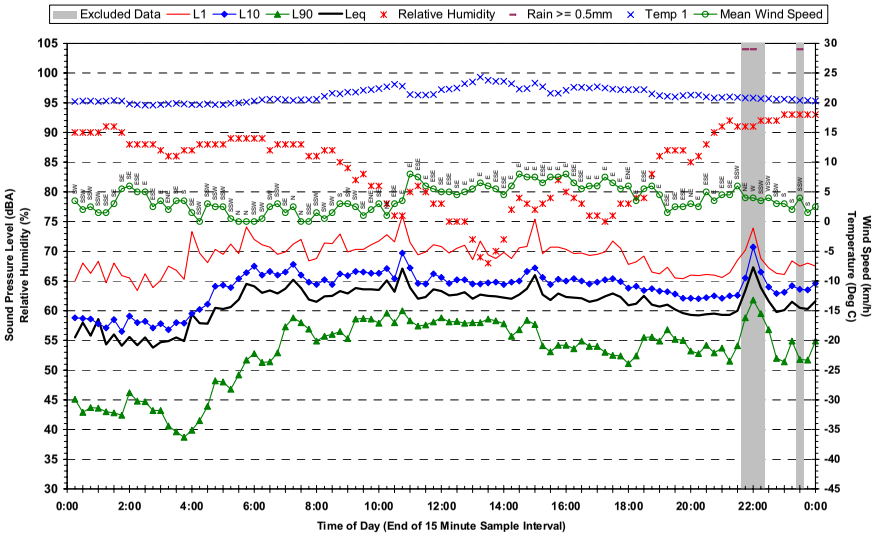
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Thursday 24 November 2005



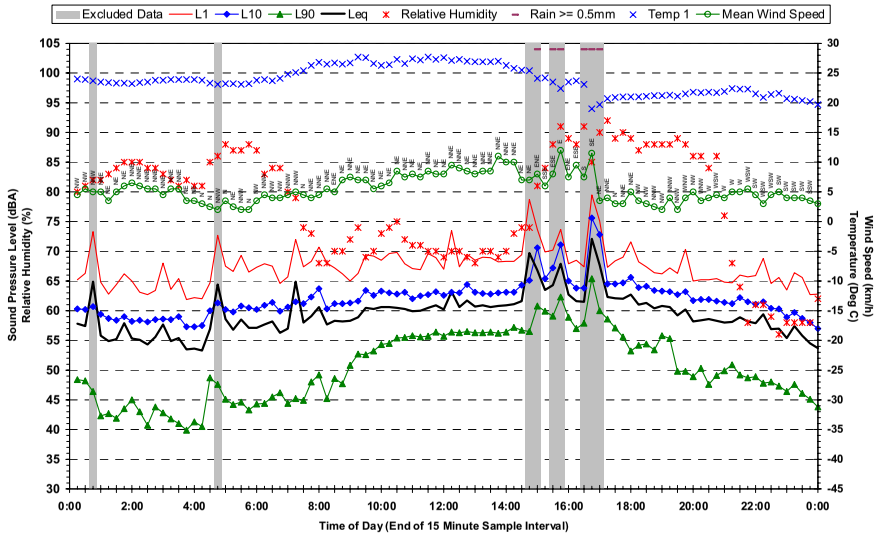
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Saturday 26 November 2005



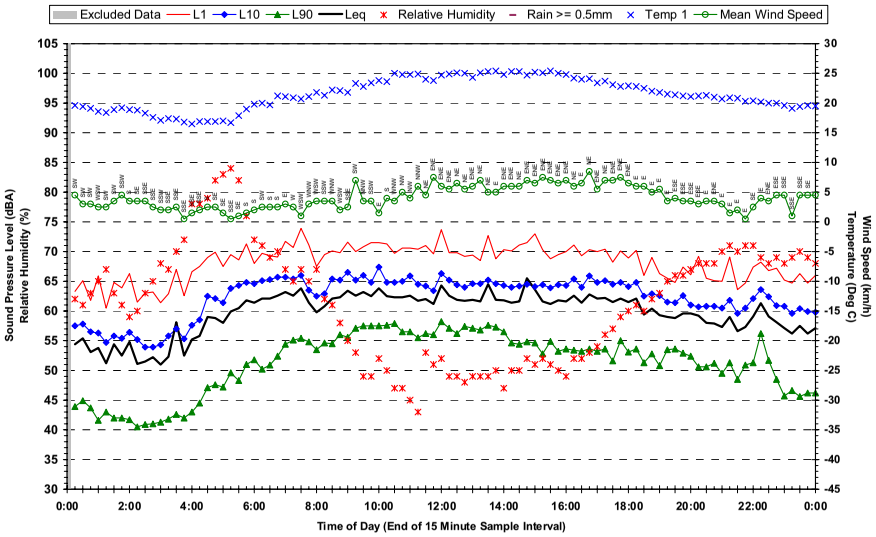
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Friday 25 November 2005



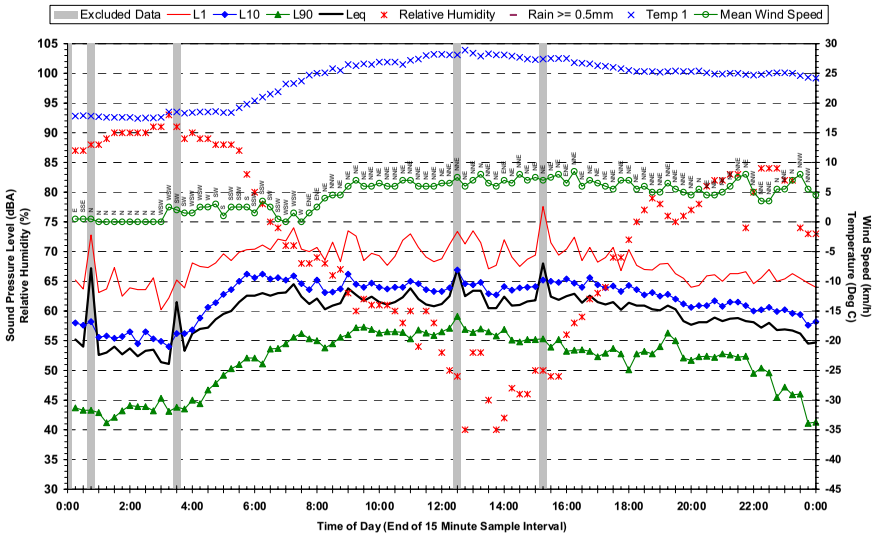
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Sunday 27 November 2005



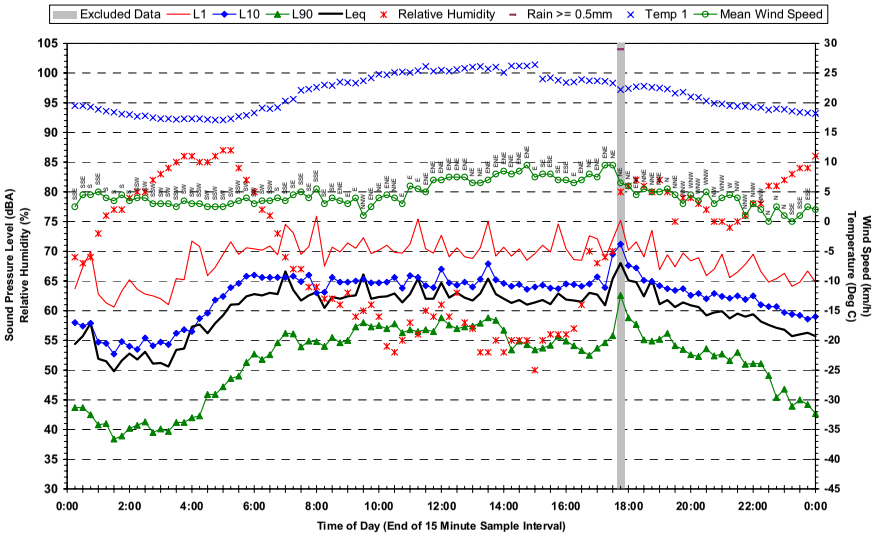
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Monday 28 November 2005



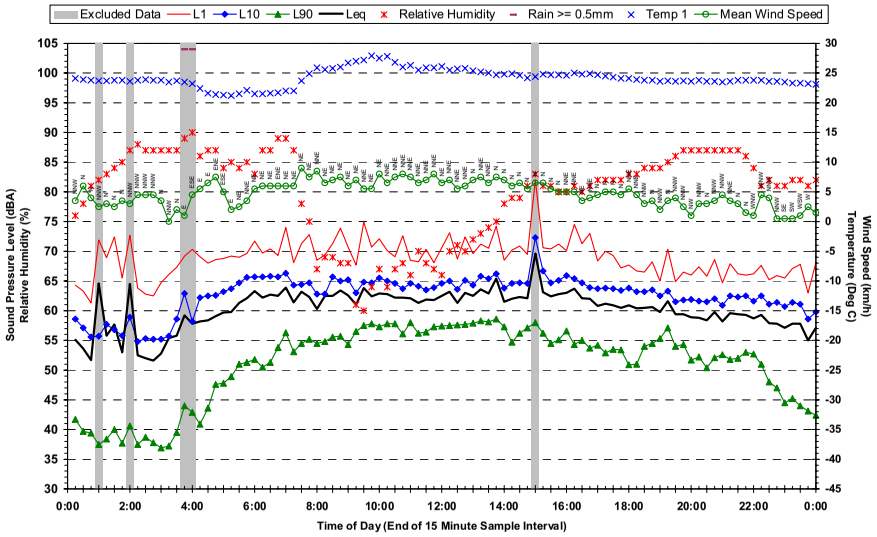
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Wednesday 30 November 2005



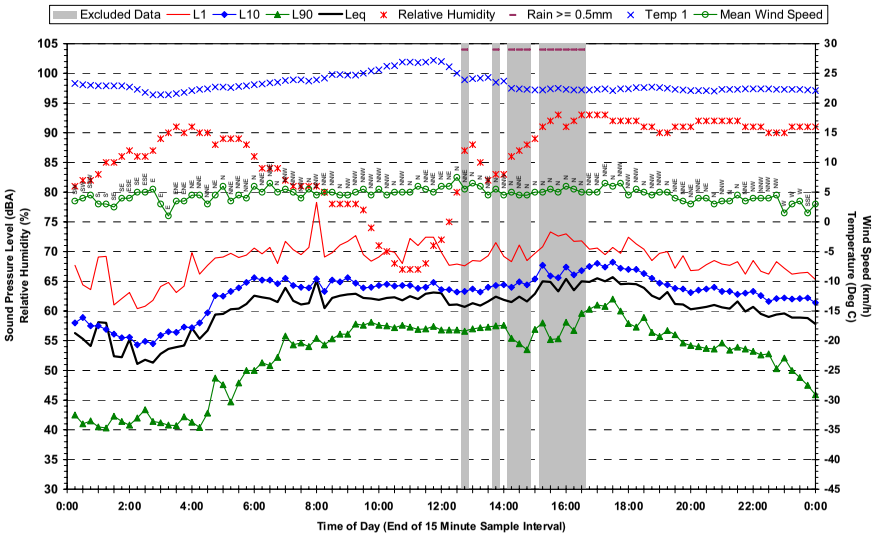
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Tuesday 29 November 2005



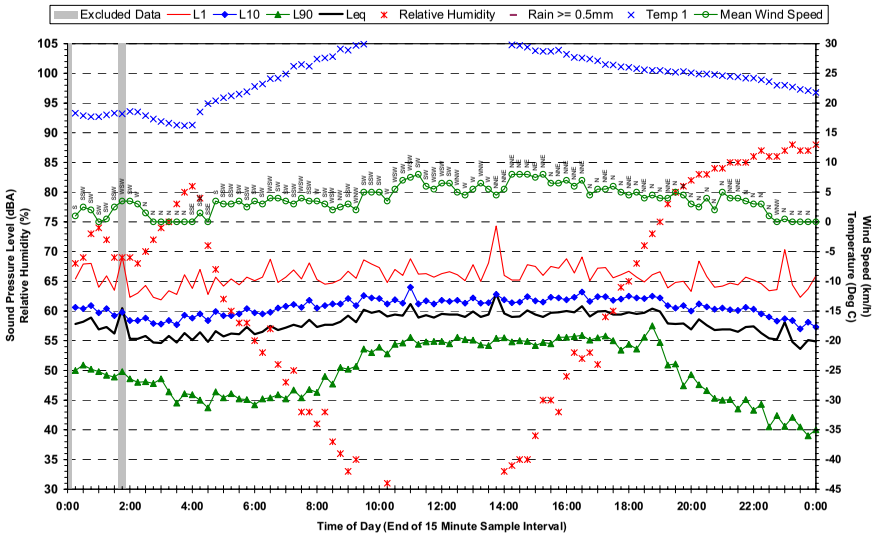
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Thursday 1 December 2005



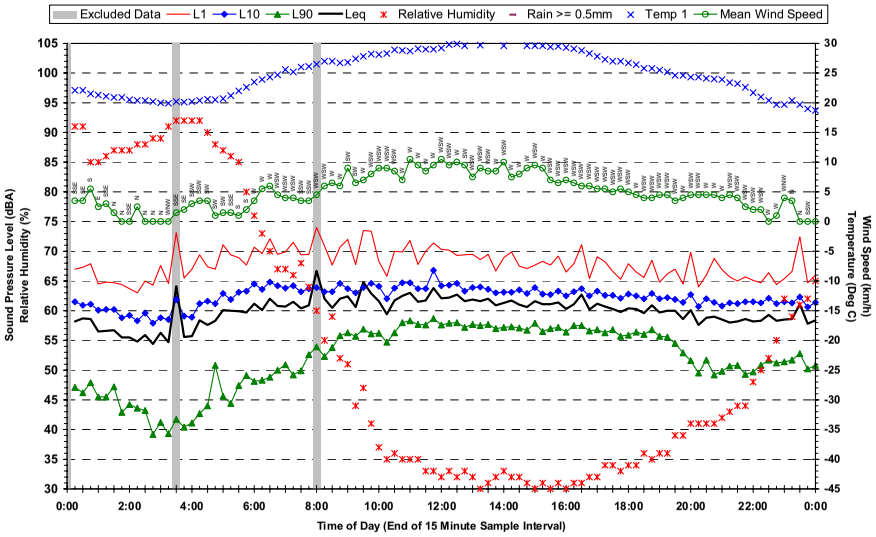
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Friday 2 December 2005



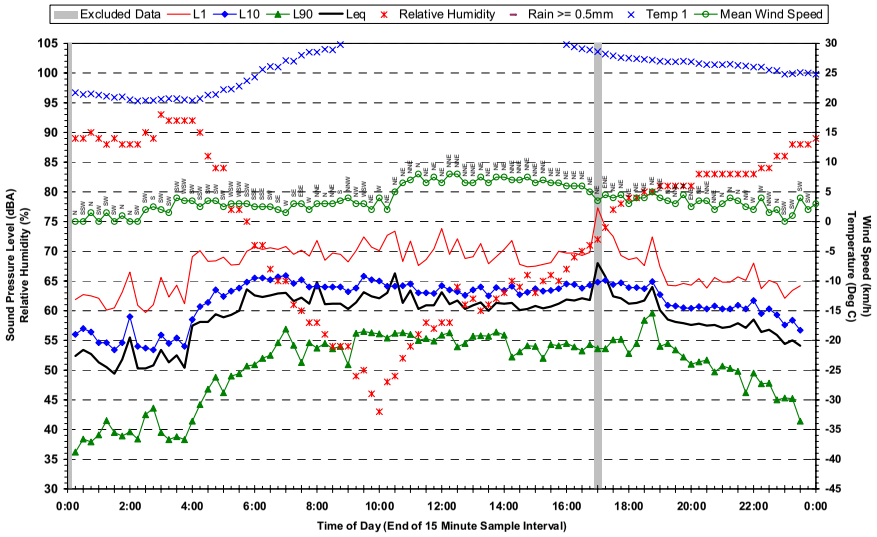
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Sunday 4 December 2005



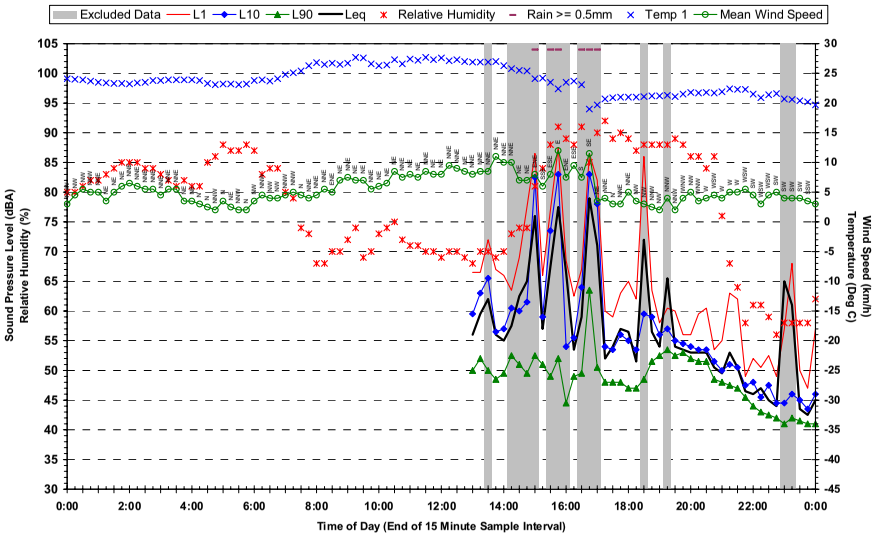
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Saturday 3 December 2005



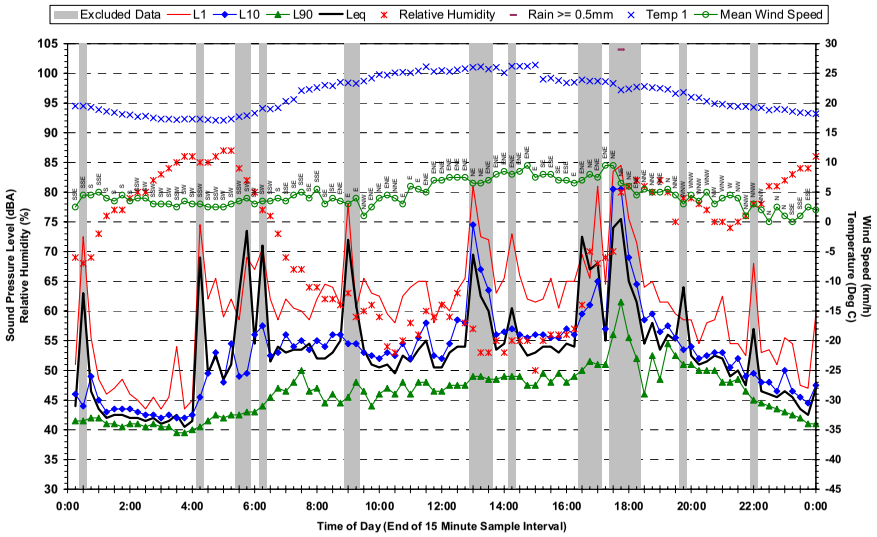
Statistical Ambient Noise Levels
Location 10 - 7 Robane Street Windsor - Monday 5 December 2005



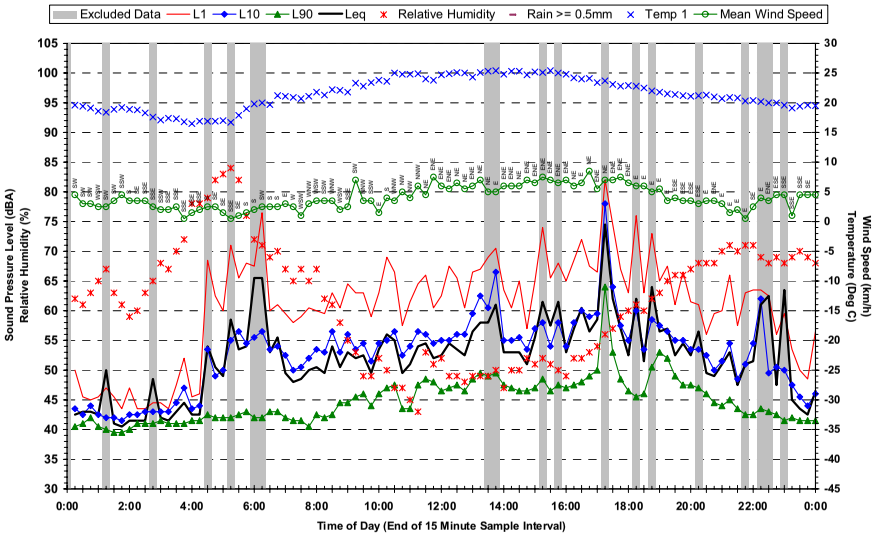
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Sunday 27 November 2005



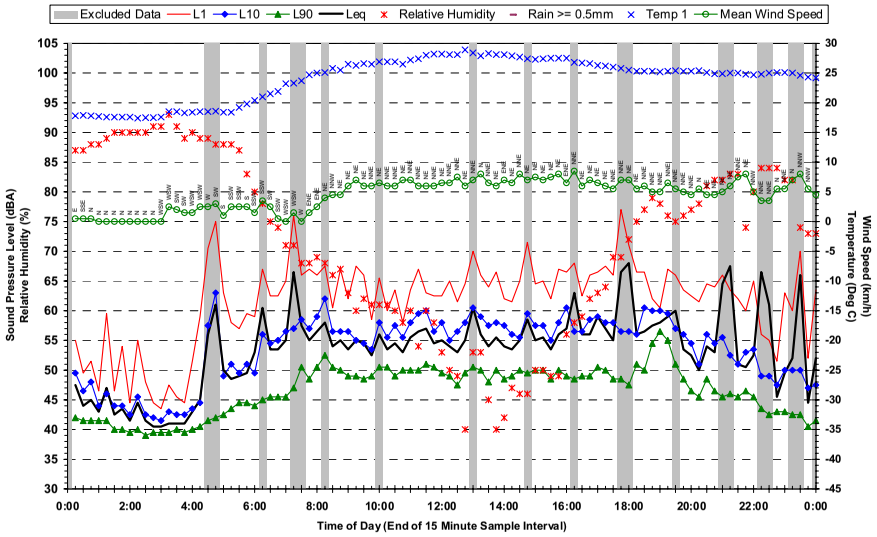
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Tuesday 29 November 2005



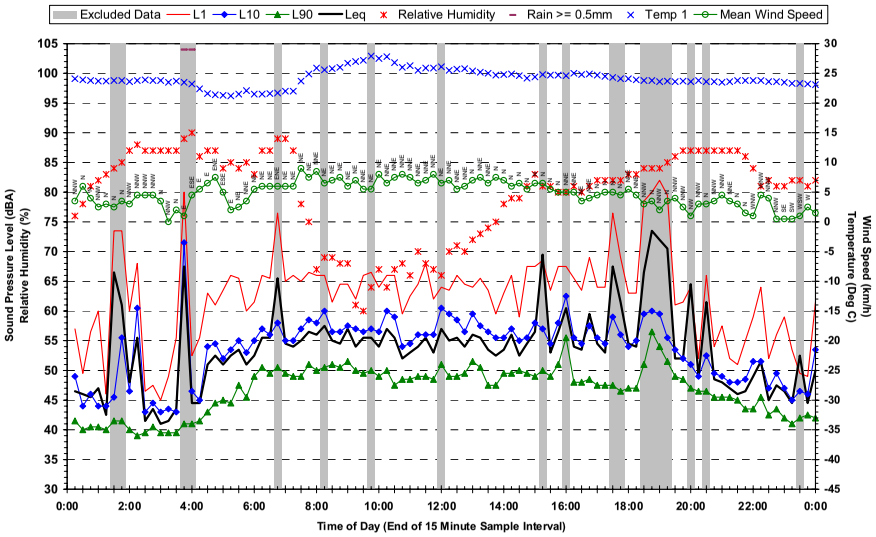
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Monday 28 November 2005



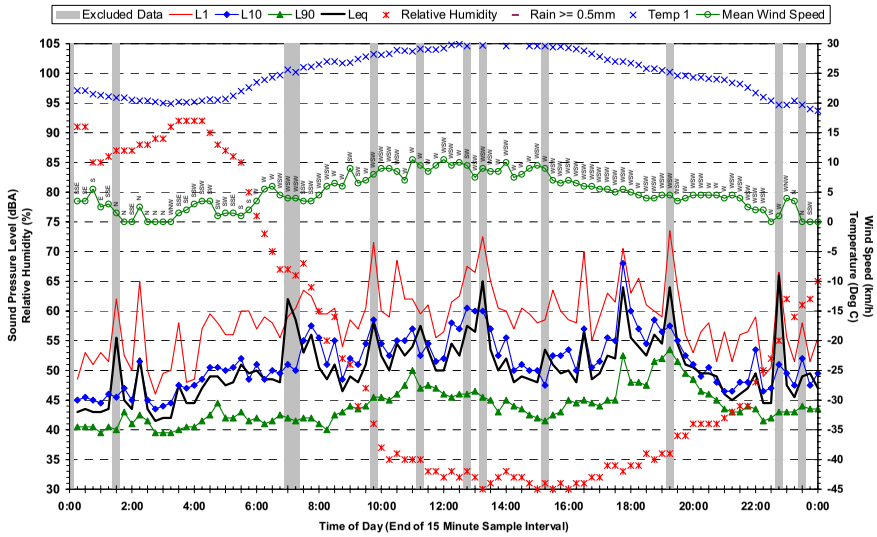
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Wednesday 30 November 2005



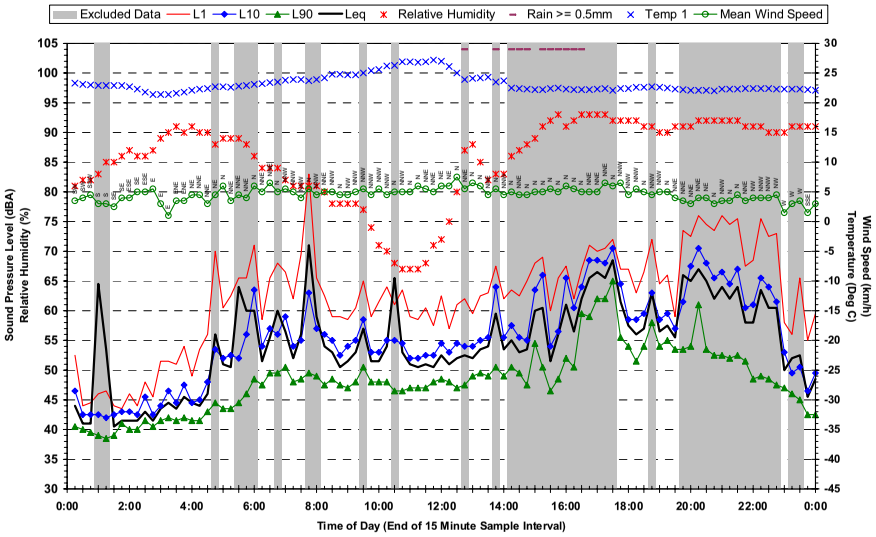
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Thursday 1 December 2005



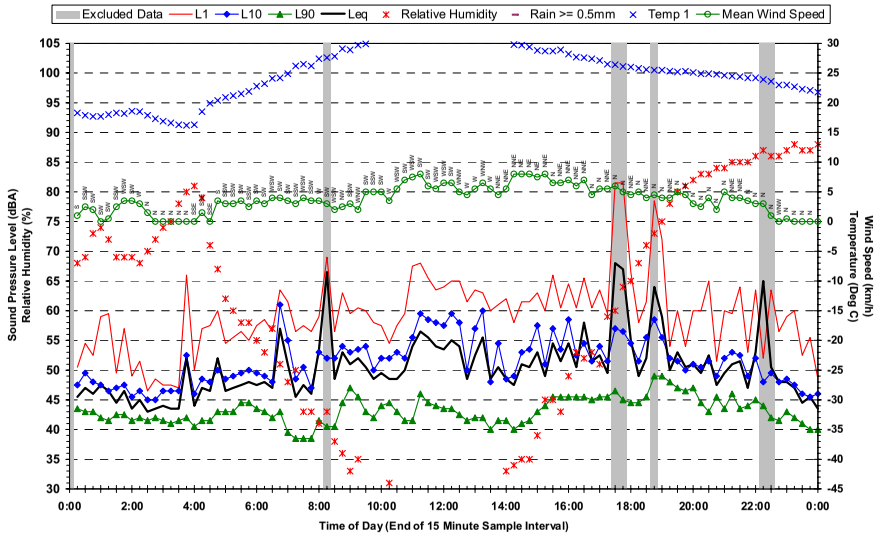
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Saturday 3 December 2005



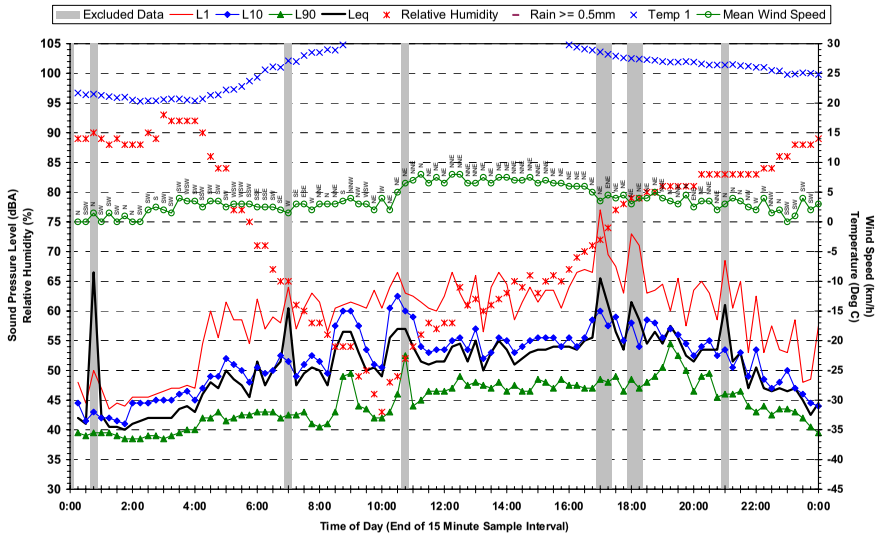
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Friday 2 December 2005



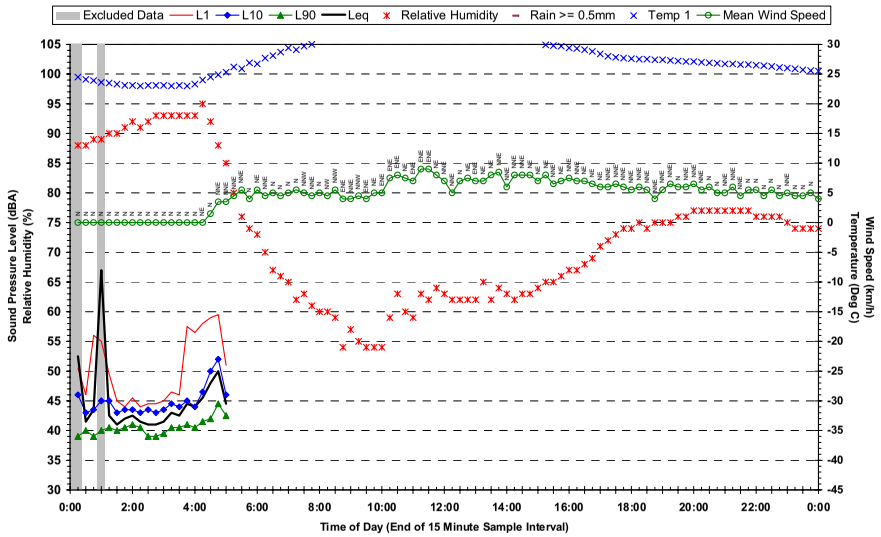
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Sunday 4 December 2005



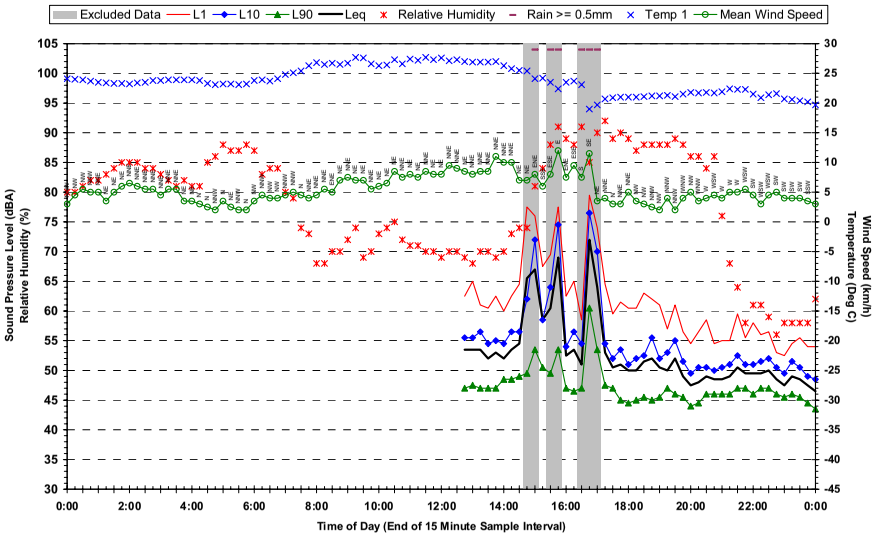
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Monday 5 December 2005



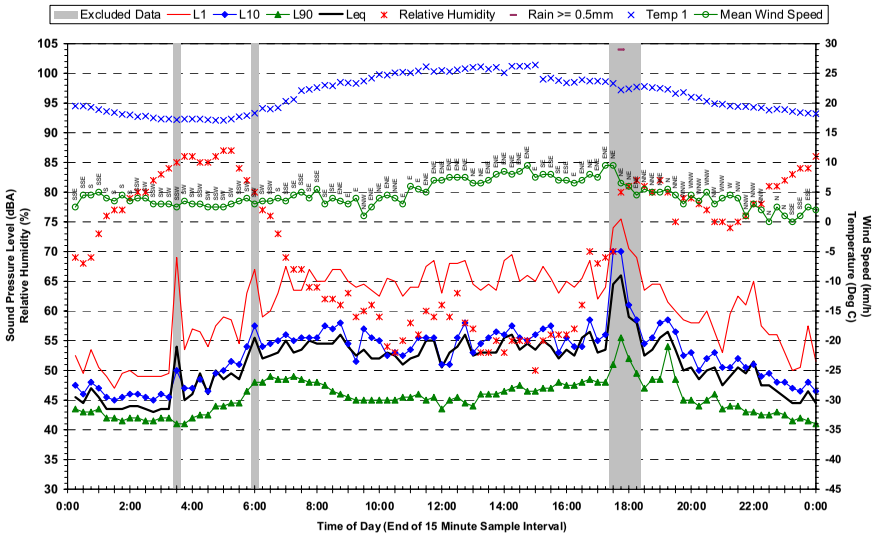
Statistical Ambient Noise Levels
Location 11 - 46 Gallway Street Windsor - Tuesday 6 December 2005



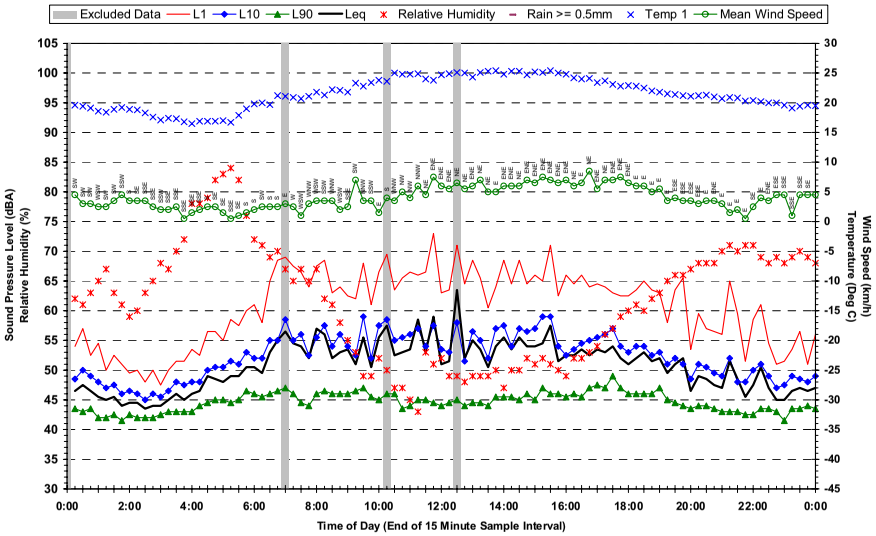
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Sunday 27 November 2005



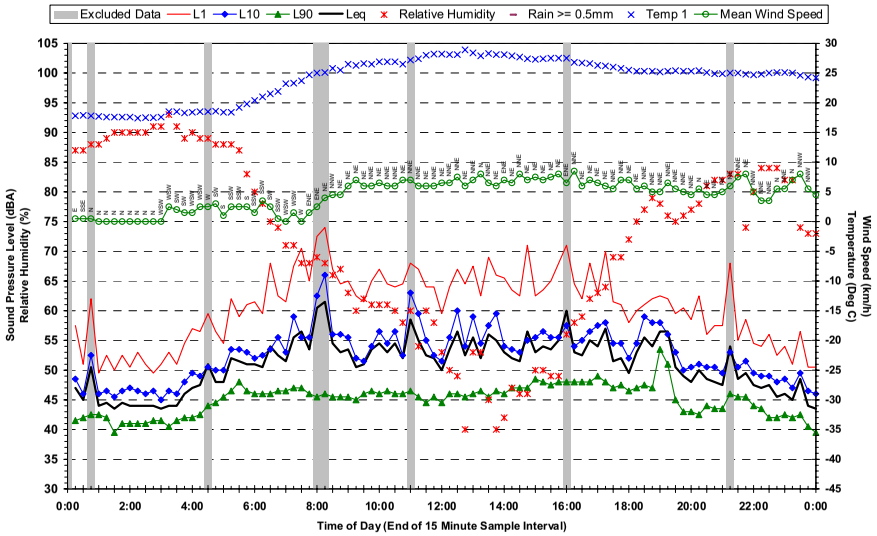
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Tuesday 29 November 2005



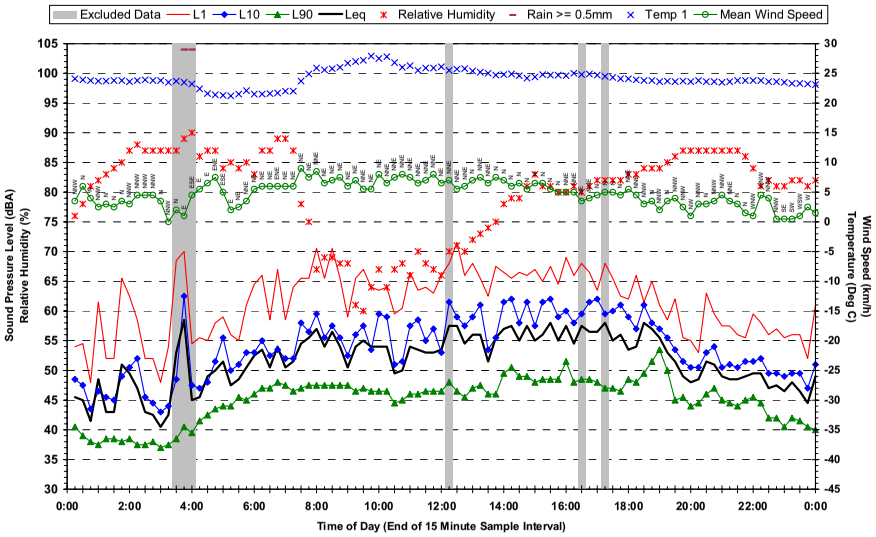
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Monday 28 November 2005



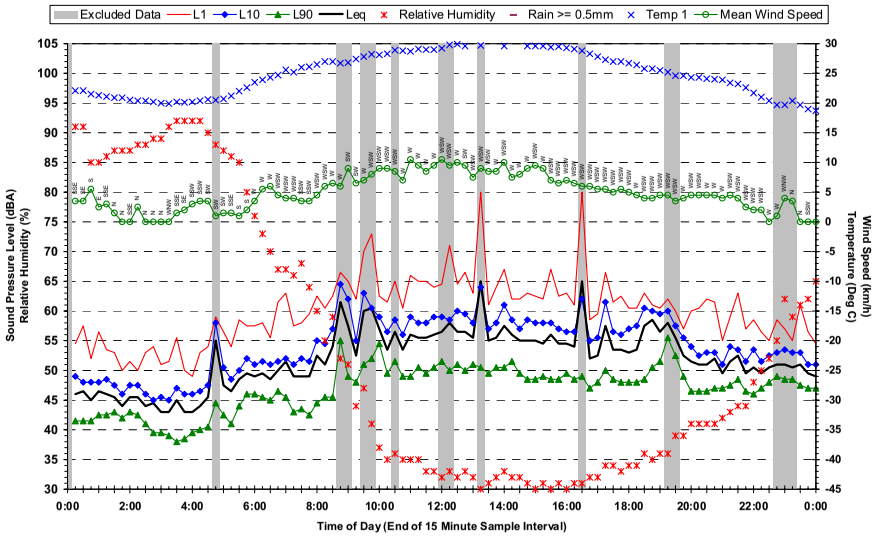
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Wednesday 30 November 2005



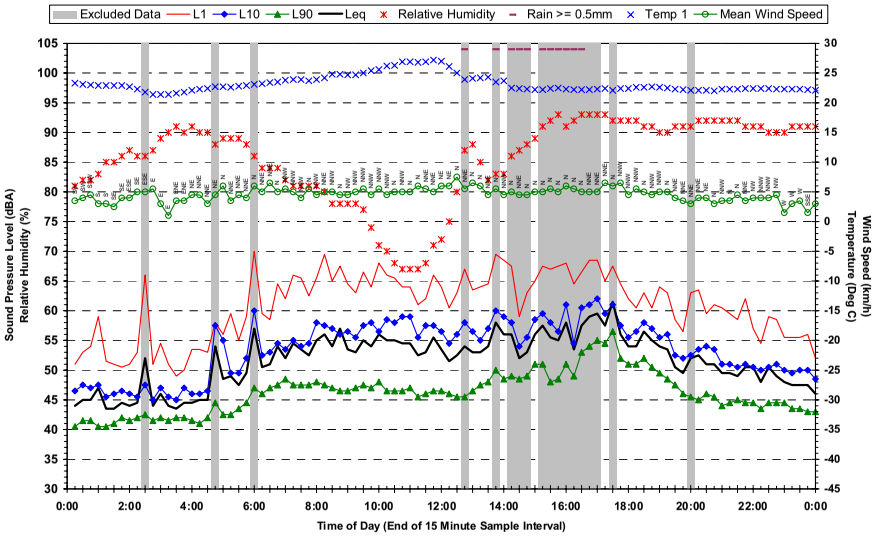
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Thursday 1 December 2005



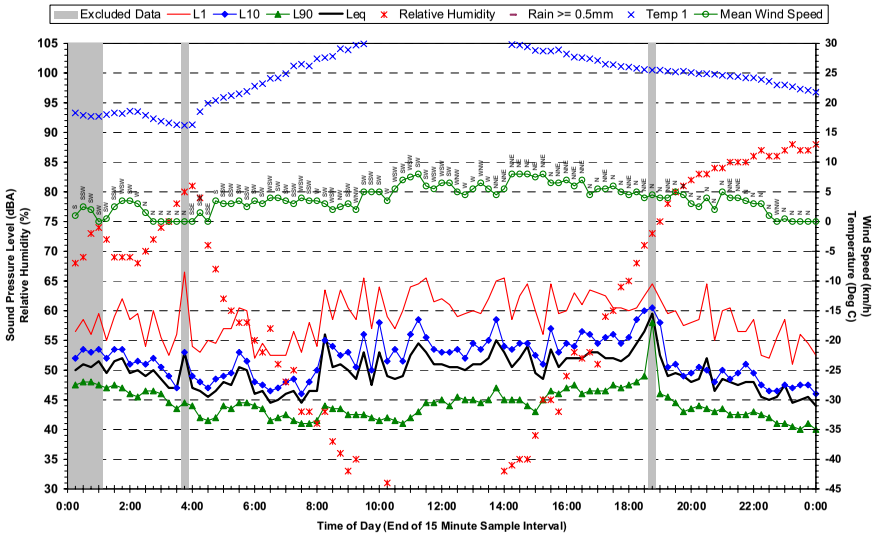
Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Saturday 3 December 2005

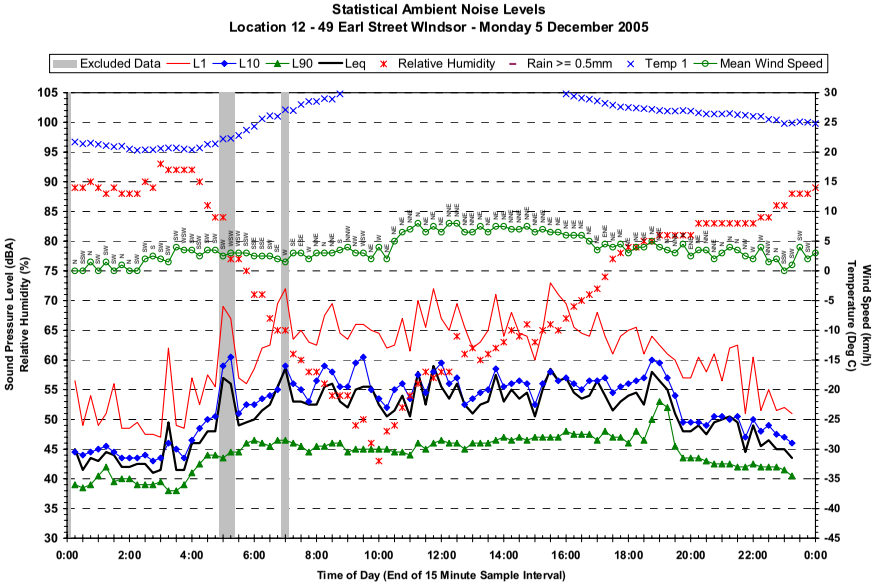


Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Friday 2 December 2005

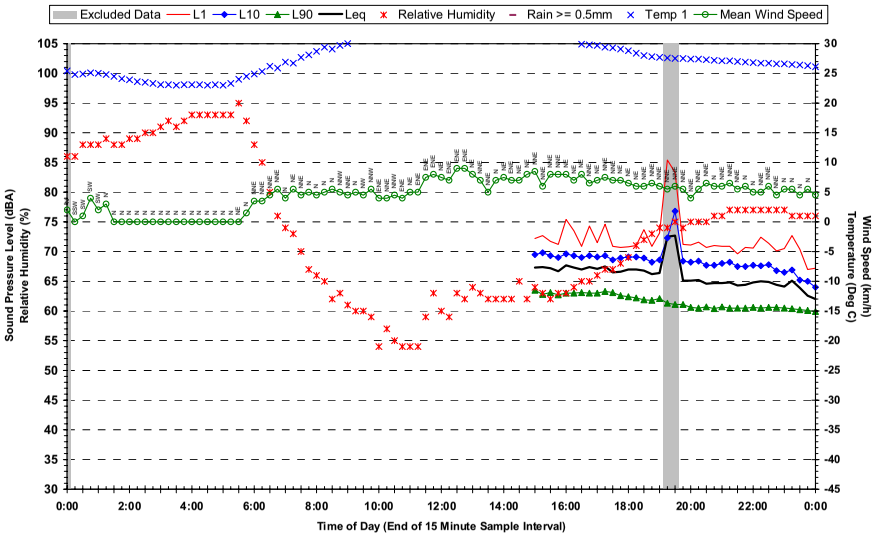


Statistical Ambient Noise Levels
Location 12 - 49 Earl Street WIndsor - Sunday 4 December 2005

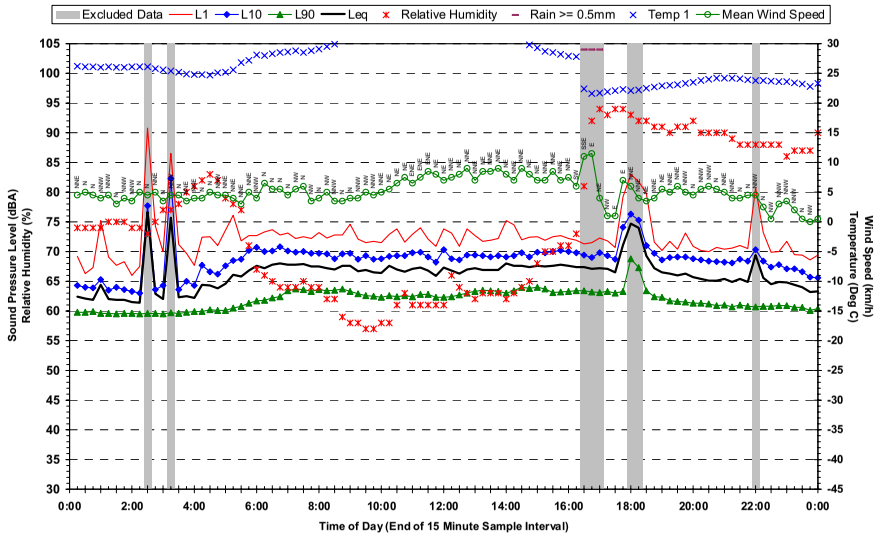



Statistical Ambient Noise Levels
Location 12 - 49 Earl Street Windsor - Monday 5 December 2005
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.5mm
Temp 1
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

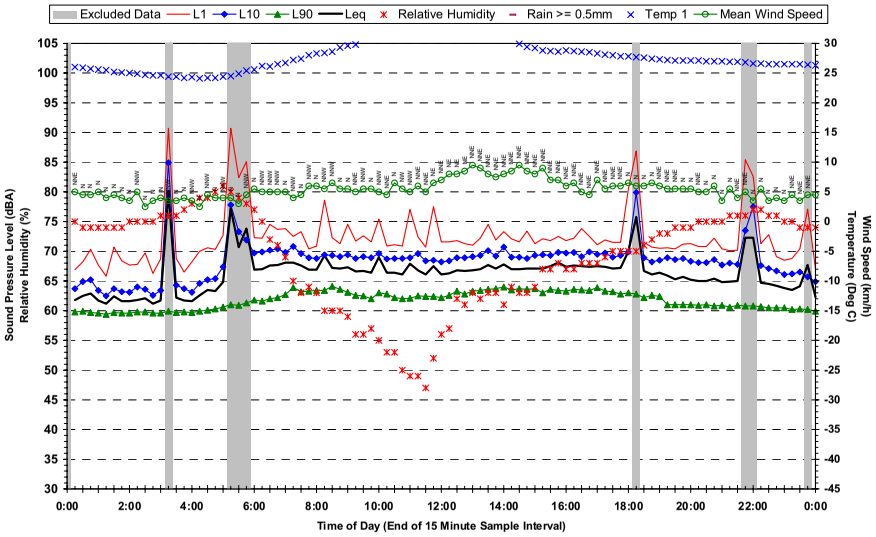
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Tuesday 6 December 2005



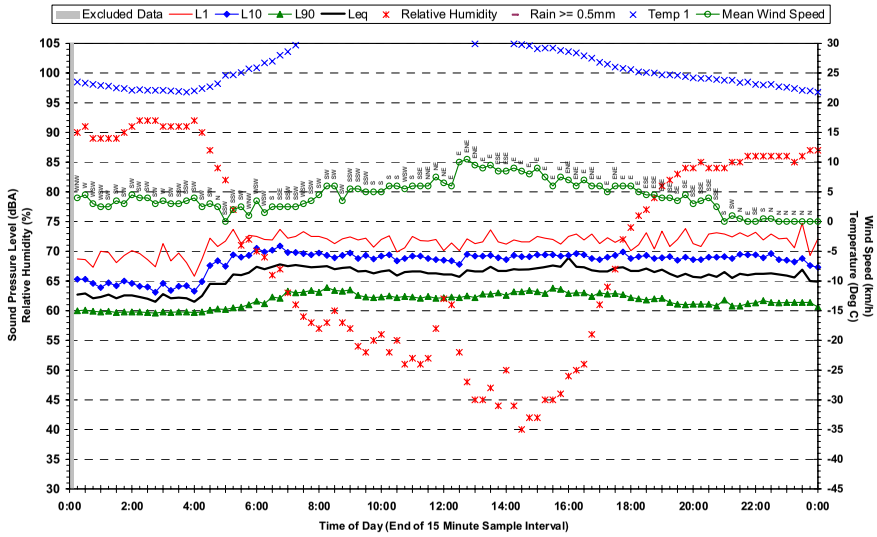
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Thursday 8 December 2005



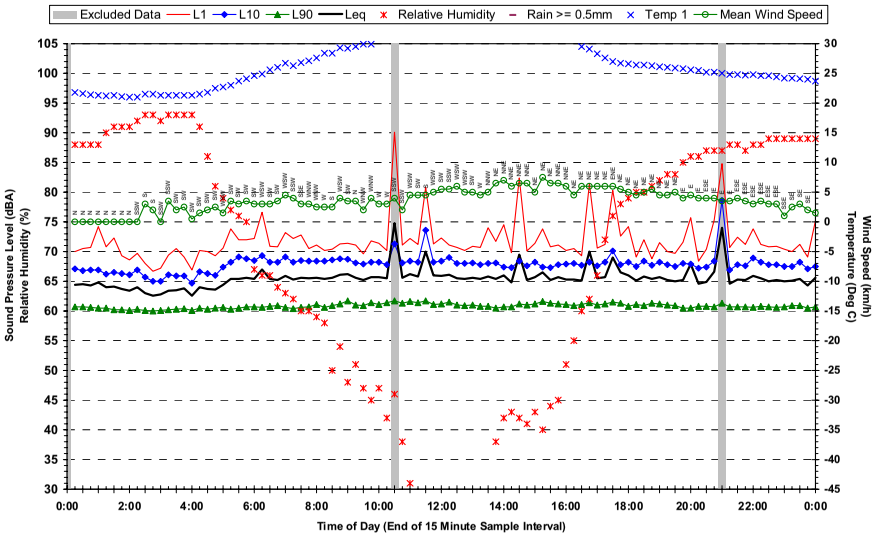
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Wednesday 7 December 2005



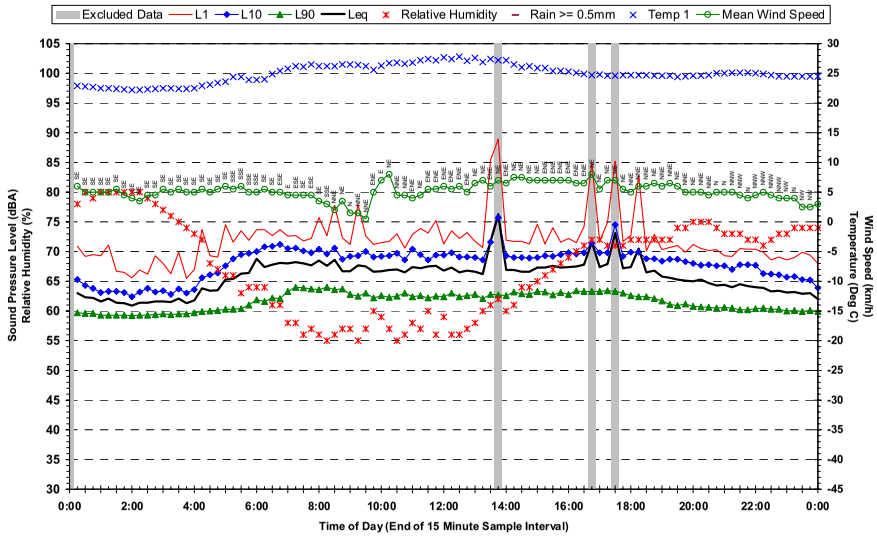
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Friday 9 December 2005



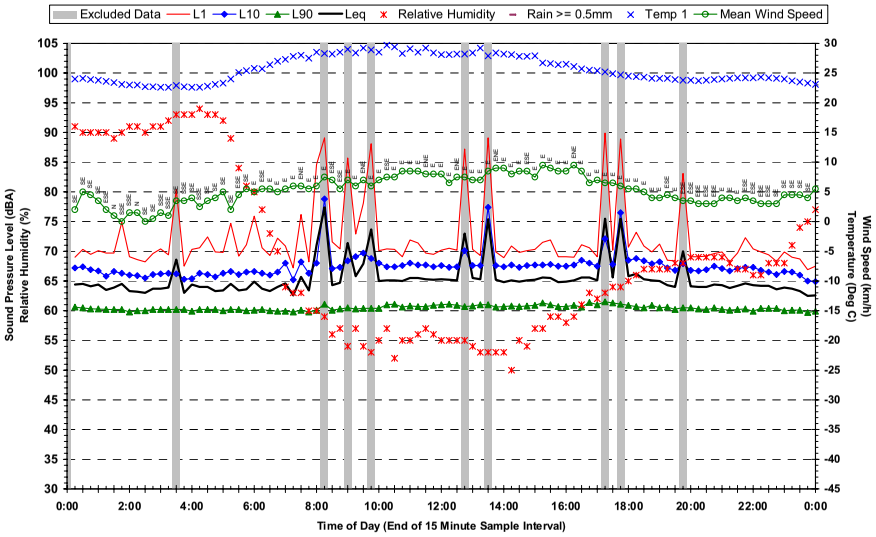
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Saturday 10 December 2005



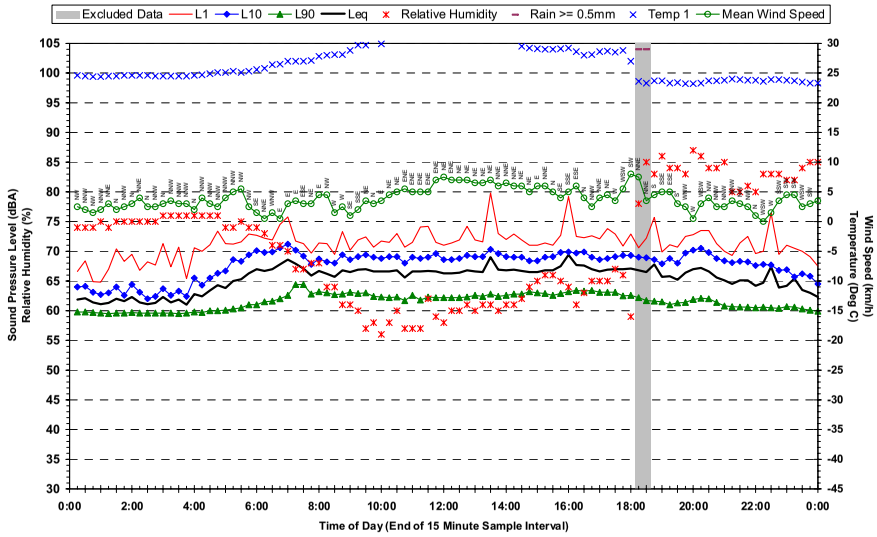
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Monday 12 December 2005



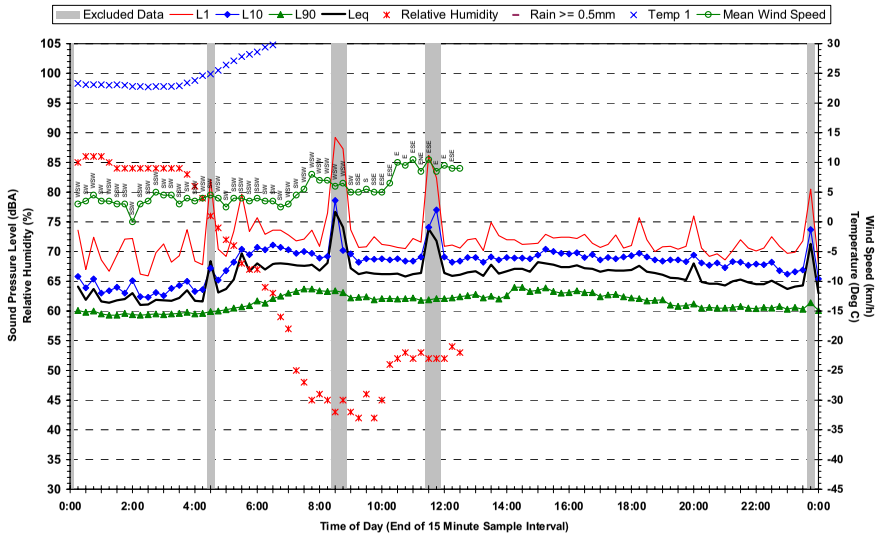
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Sunday 11 December 2005



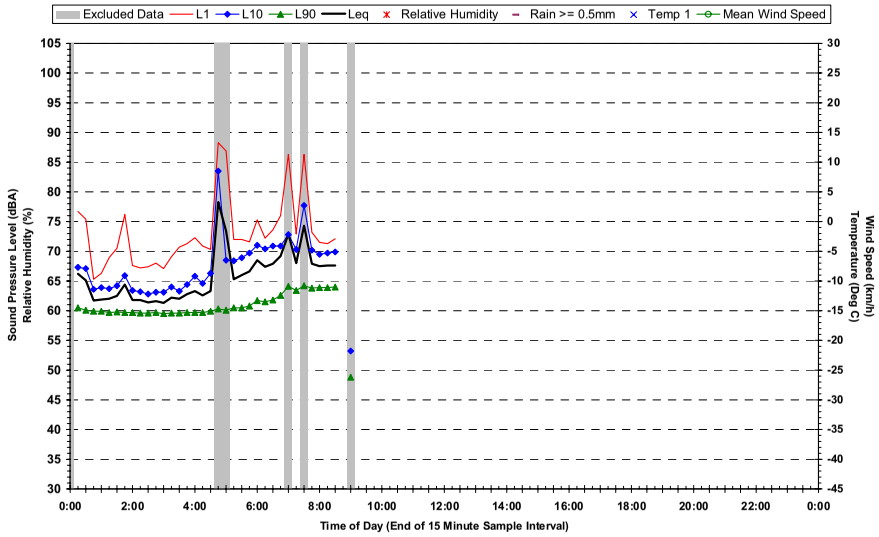
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Tuesday 13 December 2005



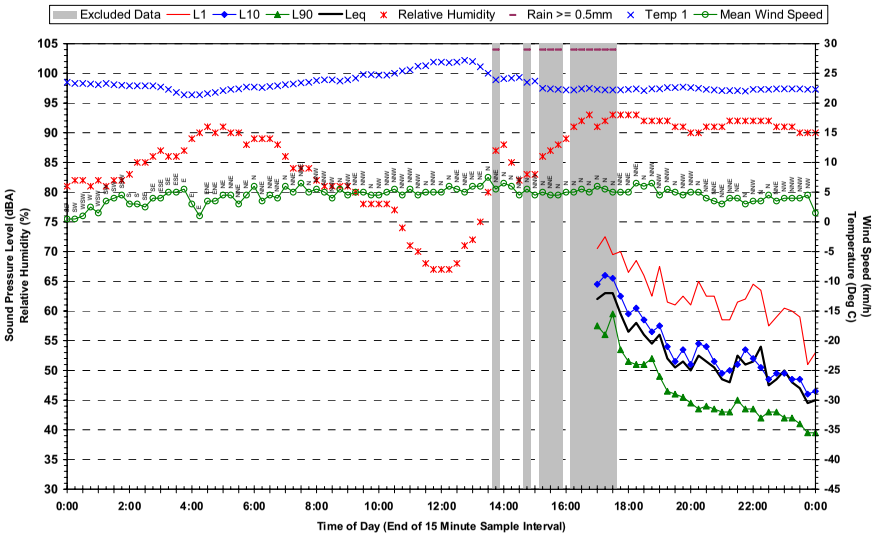
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Wednesday 14 December 2005



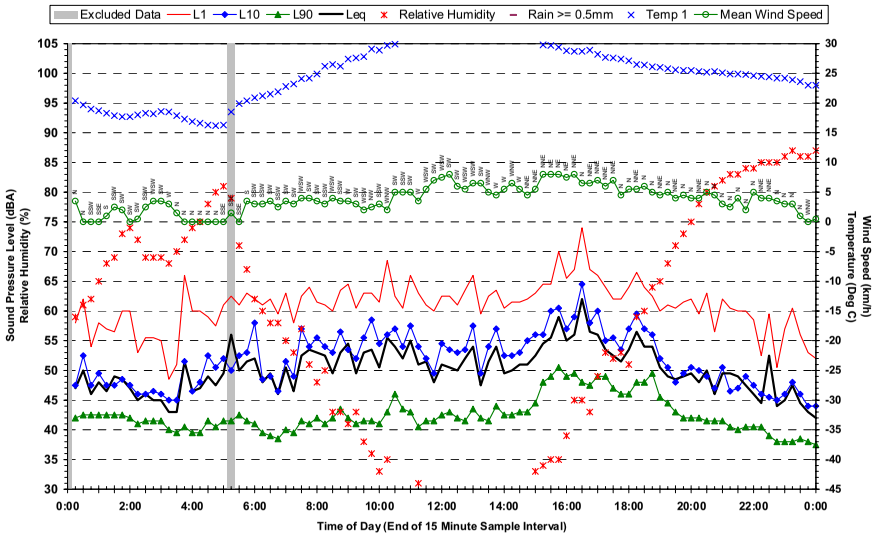
Statistical Ambient Noise Levels
Location 13 - Royal Brisbane Hospital - Thursday 15 December 2005



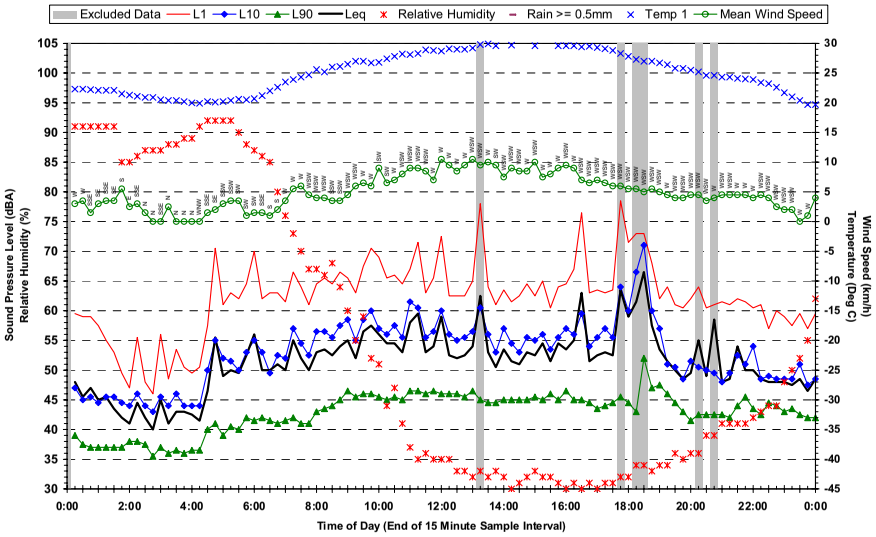
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Friday 2 December 2005



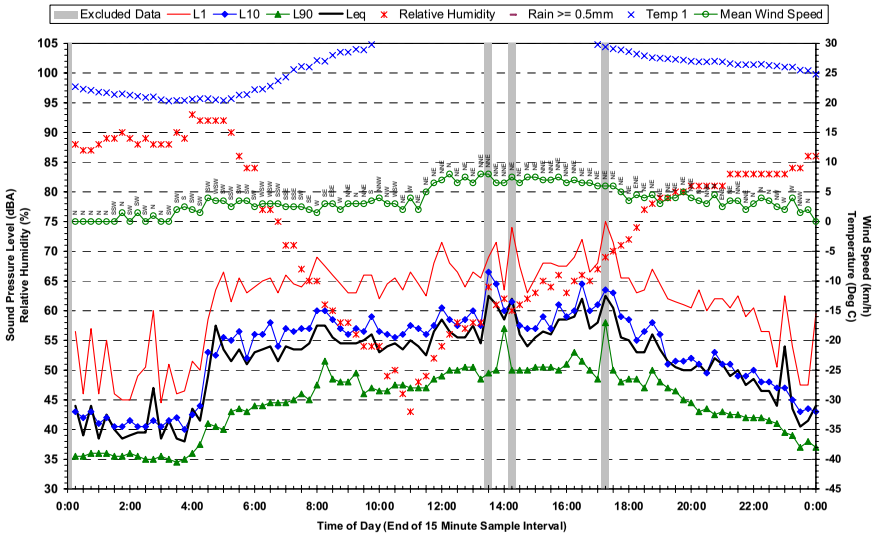
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Sunday 4 December 2005



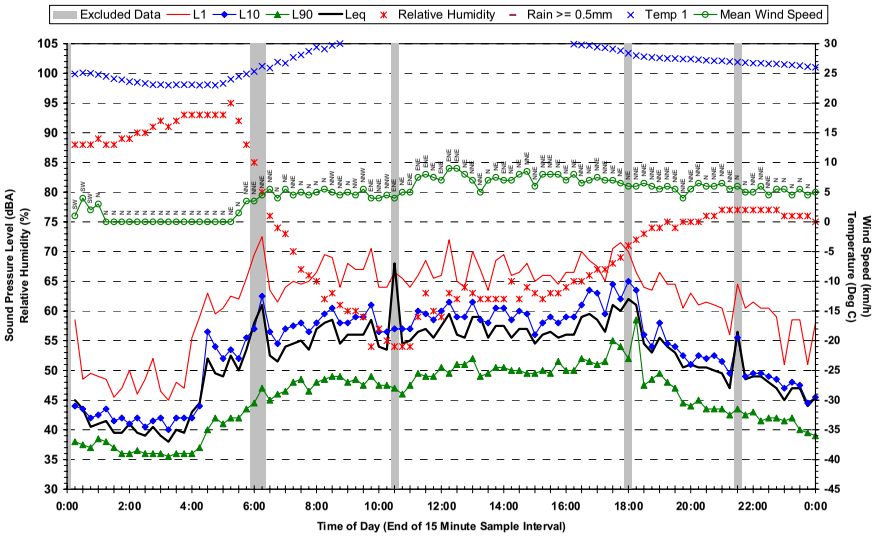
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Saturday 3 December 2005



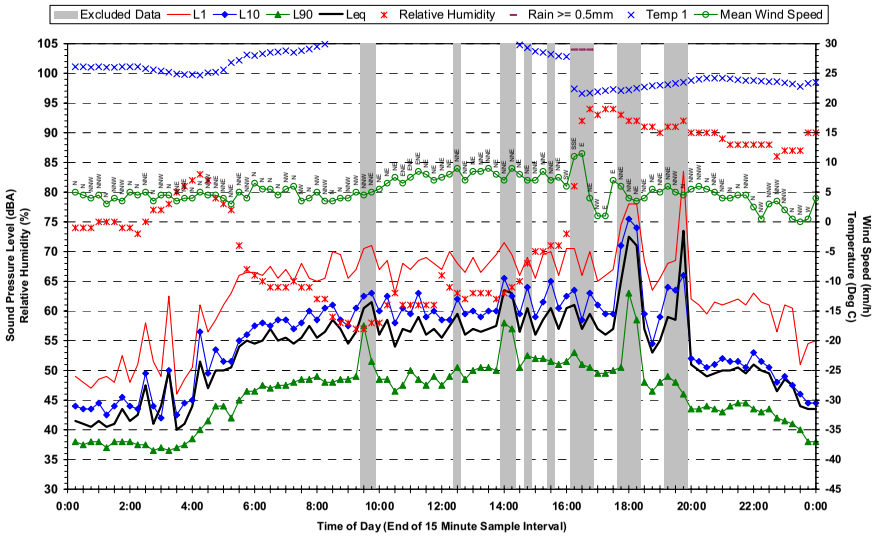
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Monday 5 December 2005



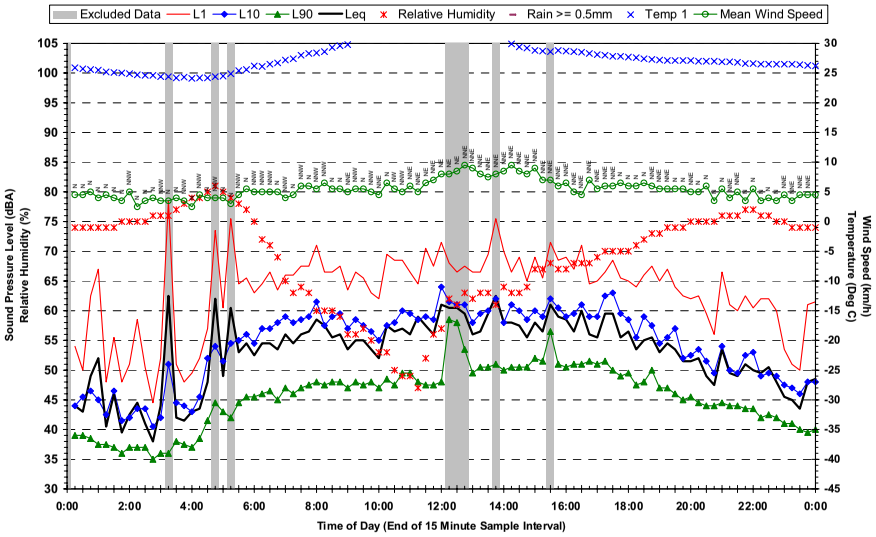
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Tuesday 6 December 2005



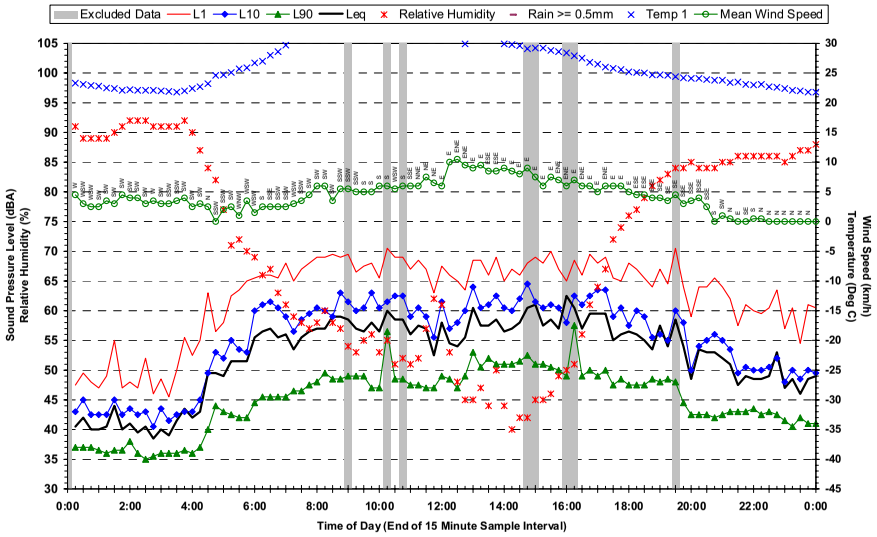
Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Thursday 8 December 2005

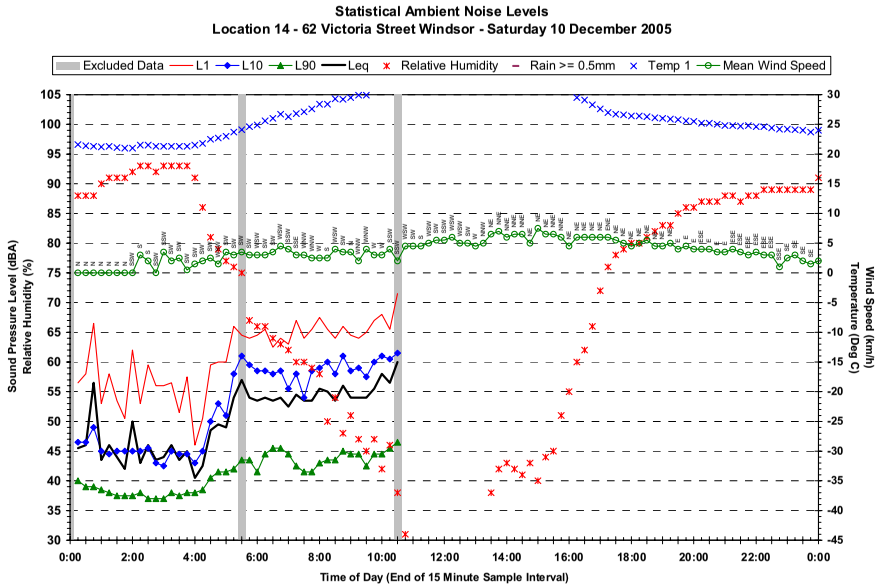


Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Wednesday 7 December 2005

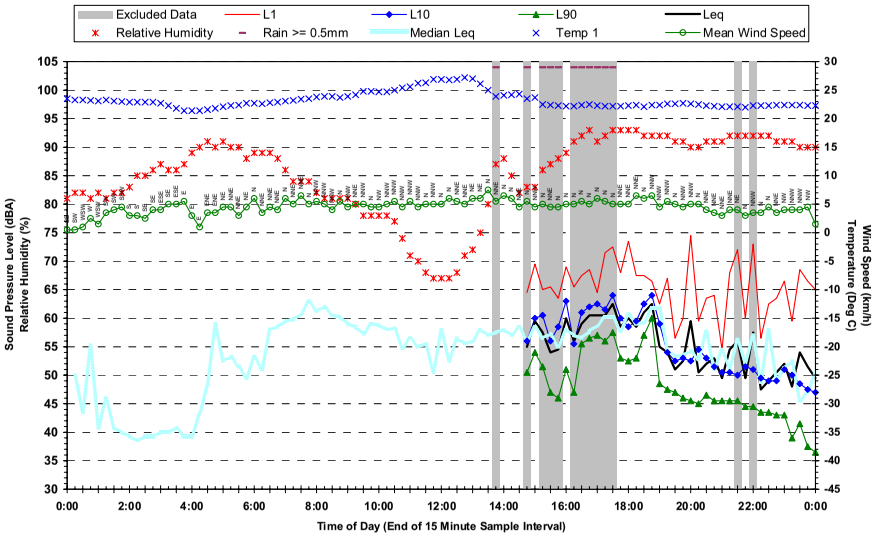


Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Friday 9 December 2005

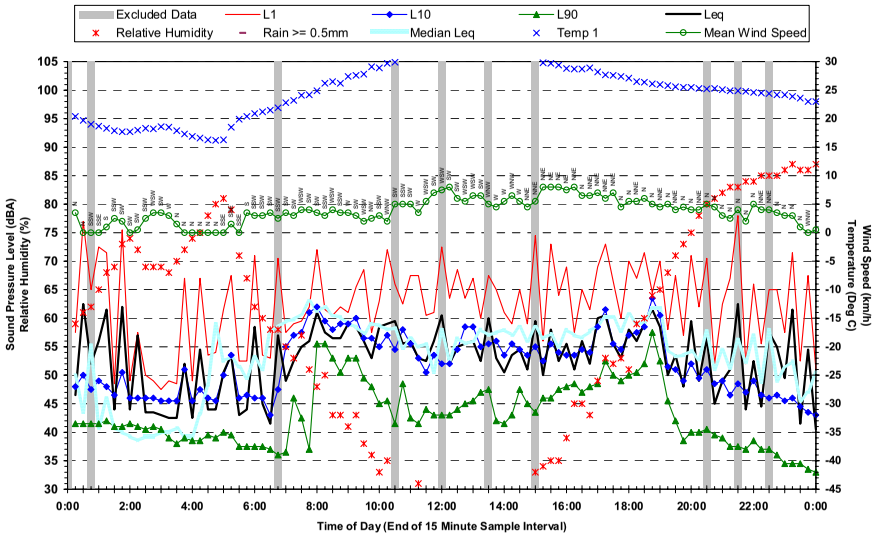



Statistical Ambient Noise Levels
Location 14 - 62 Victoria Street Windsor - Saturday 10 December 2005
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.5mm
Temp 1
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

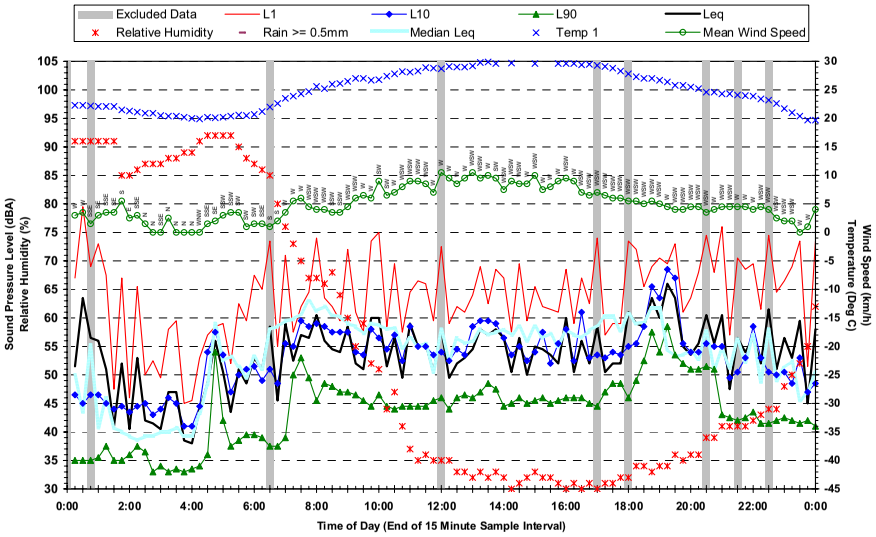
Statistical Ambient Noise Levels
Location 15 - 42 Hooker Street Windsor - Friday 2 December 2005



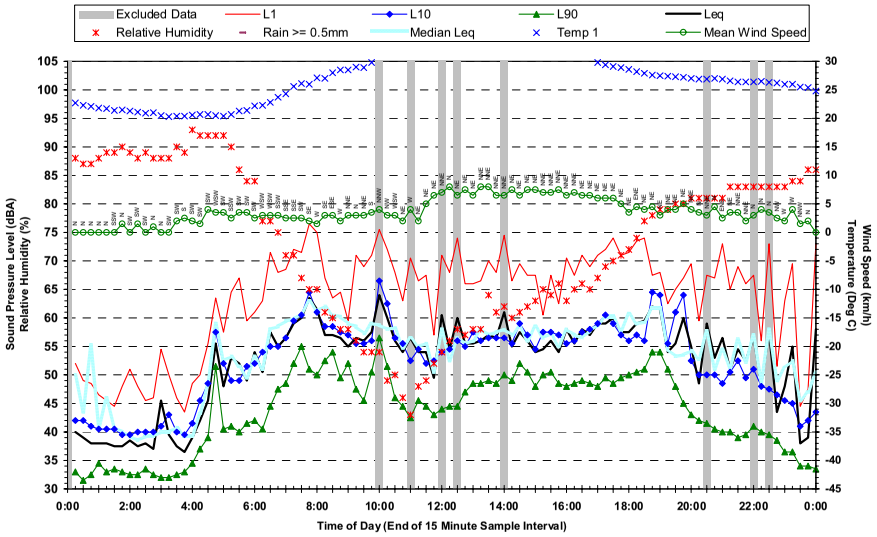
Statistical Ambient Noise Levels
Location 15 - 42 Hooker Street Windsor - Sunday 4 December 2005



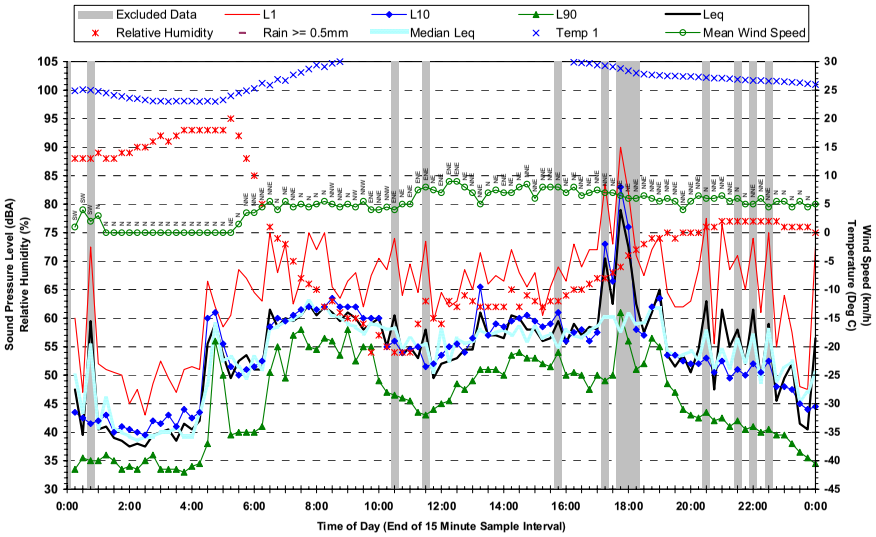
Statistical Ambient Noise Levels
Location 15 - 42 Hooker Street Windsor - Saturday 3 December 2005



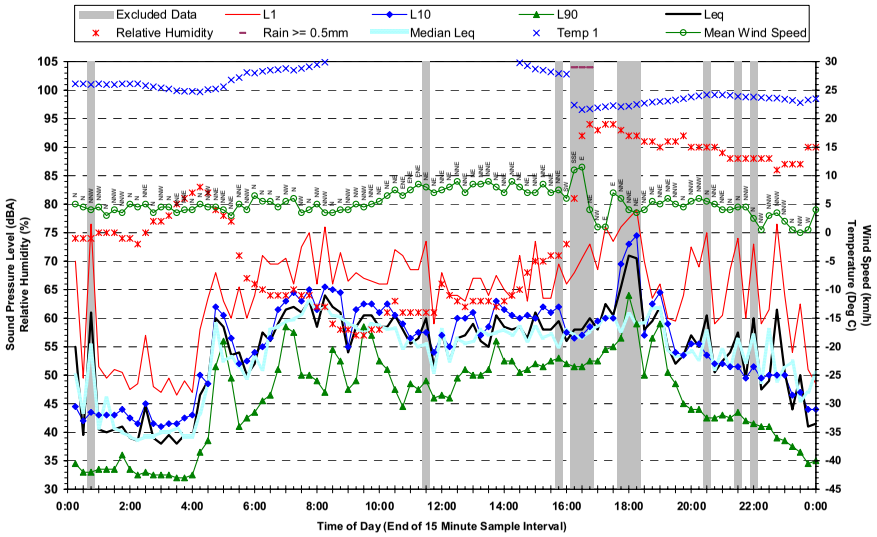
Statistical Ambient Noise Levels
Location 15 - 42 Hooker Street Windsor - Monday 5 December 2005



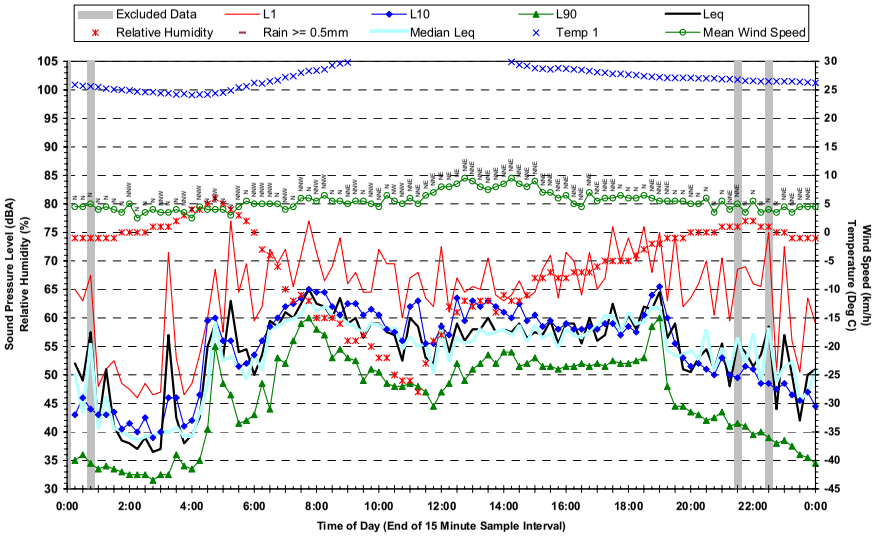
Statistical Ambient Noise Levels
Location 15 - 42 Hooker Street Windsor - Tuesday 6 December 2005



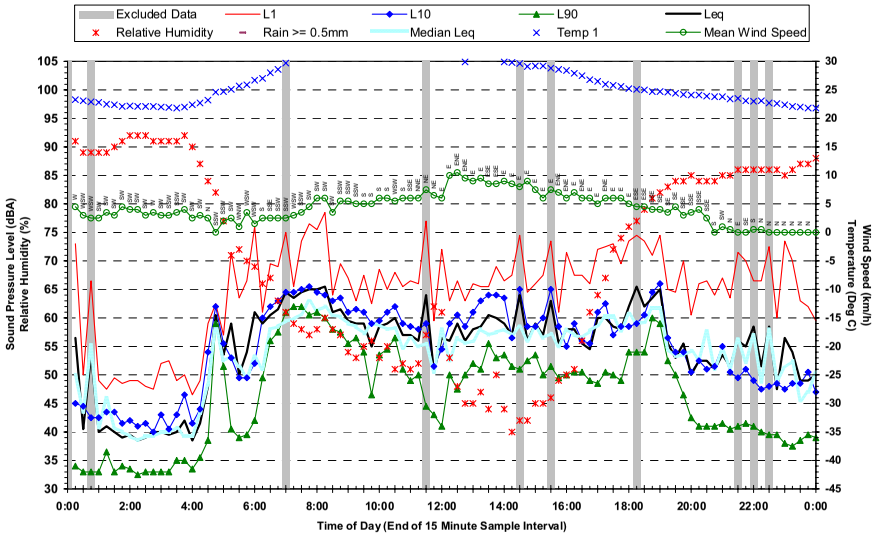
Statistical Ambient Noise Levels
Location 15 - 42 Hooker Street Windsor - Thursday 8 December 2005

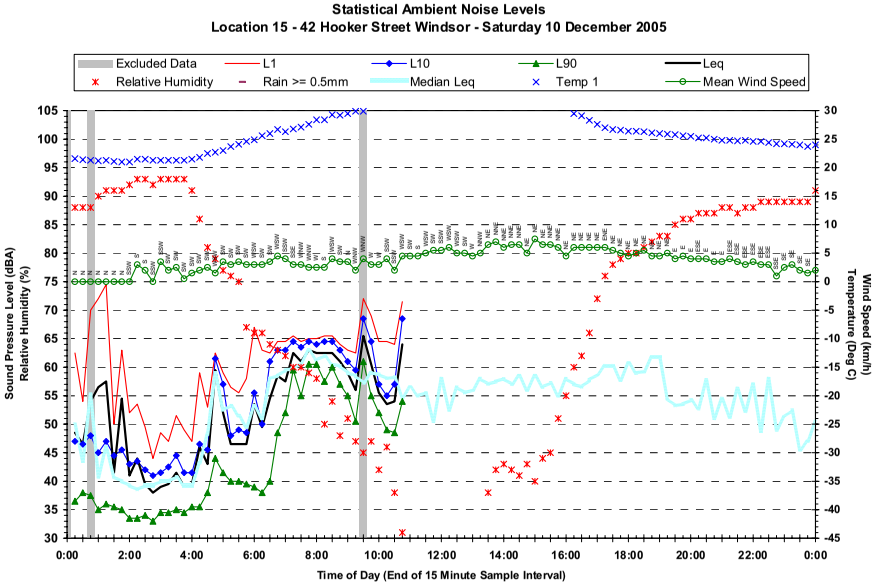


Statistical Ambient Noise Levels
Location 15 - 42 Hooker Street Windsor - Wednesday 7 December 2005

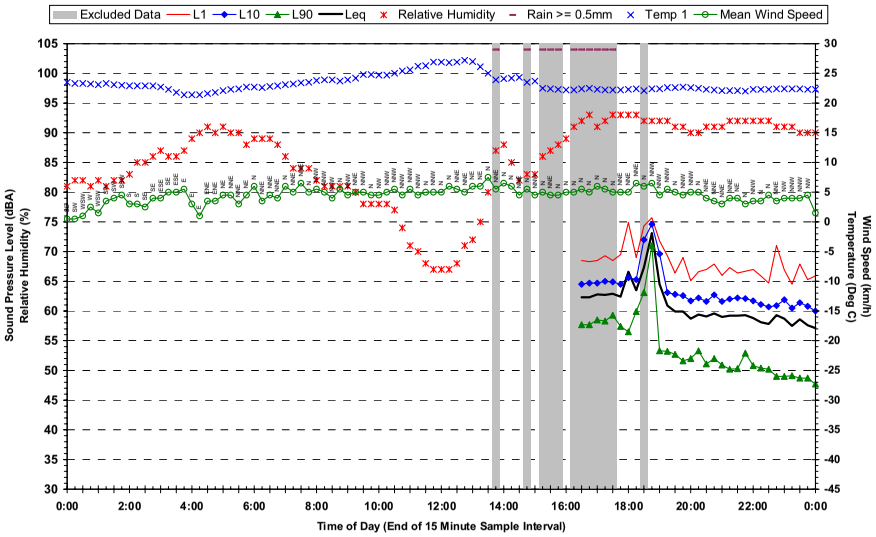


Statistical Ambient Noise Levels
Location 15 - 42 Hooker Street Windsor - Friday 9 December 2005

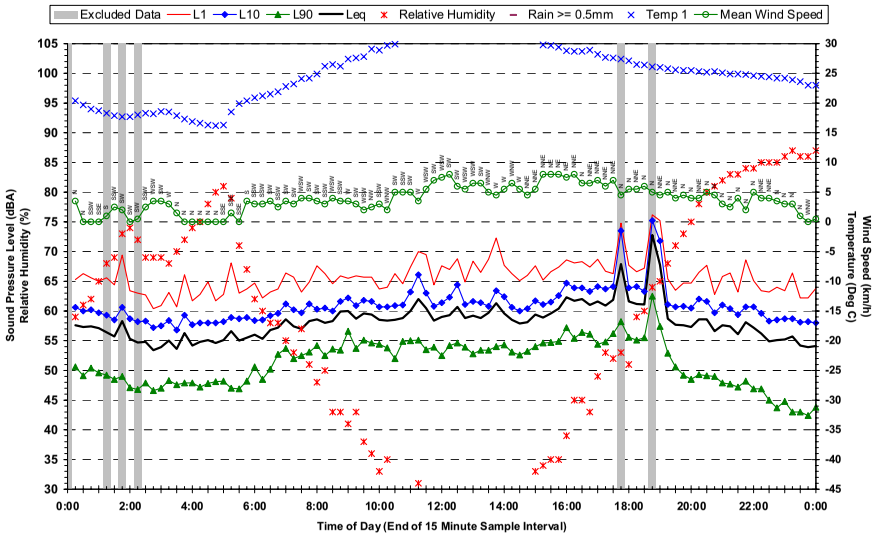



Statistical Ambient Noise Levels
Location 15 - 42 Hooker Street Windsor - Saturday 10 December 2005
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.5mm
Median Leq
Temp 1
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

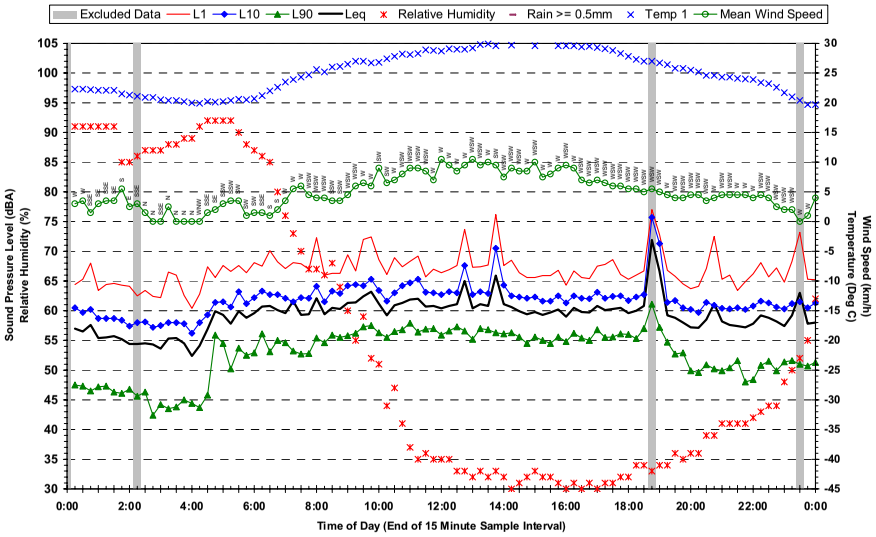
Statistical Ambient Noise Levels
Location 16 - Nursing Home, 26 Palmer Street Windsor - Friday 2 December 2005



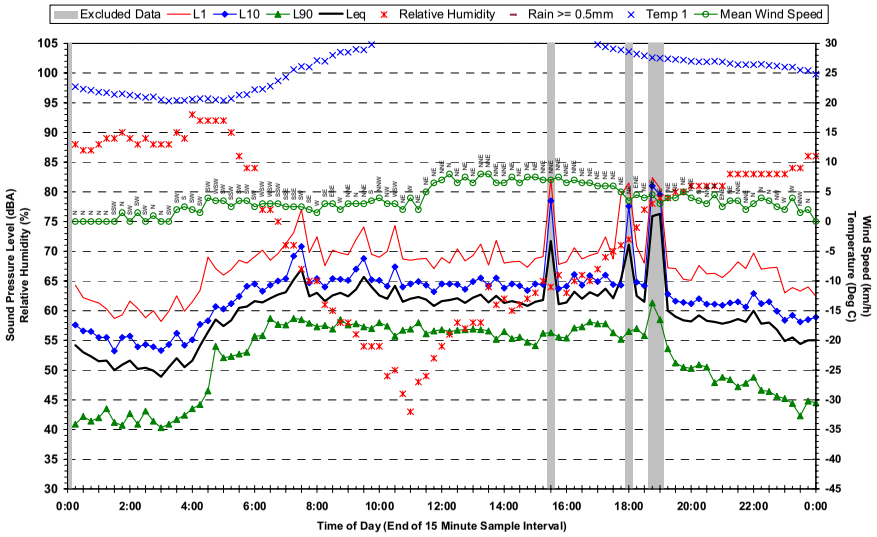
Statistical Ambient Noise Levels
Location 16 - Nursing Home, 26 Palmer Street Windsor - Sunday 4 December 2005



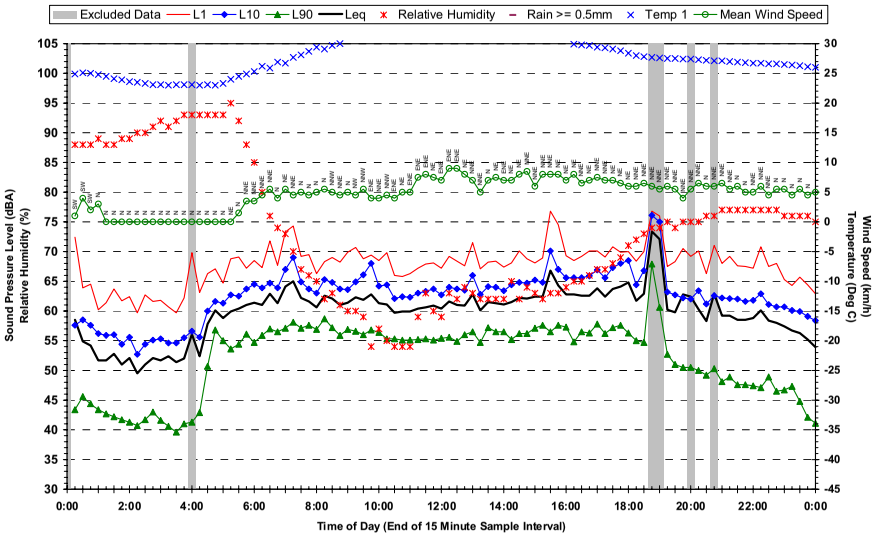
Statistical Ambient Noise Levels
Location 16 - Nursing Home, 26 Palmer Street Windsor - Saturday 3 December 2005



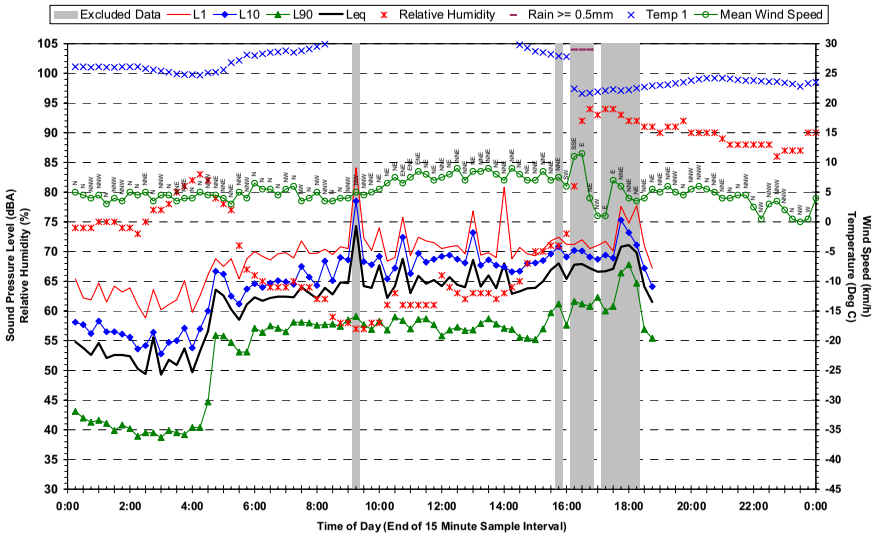
Statistical Ambient Noise Levels
Location 16 - Nursing Home, 26 Palmer Street Windsor - Monday 5 December 2005



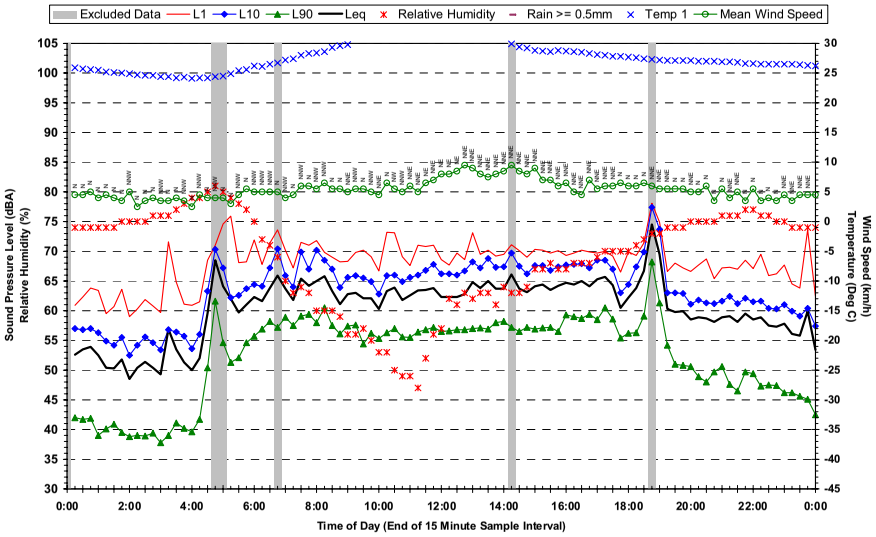
Statistical Ambient Noise Levels
Location 16 - Nursing Home, 26 Palmer Street Windsor - Tuesday 6 December 2005



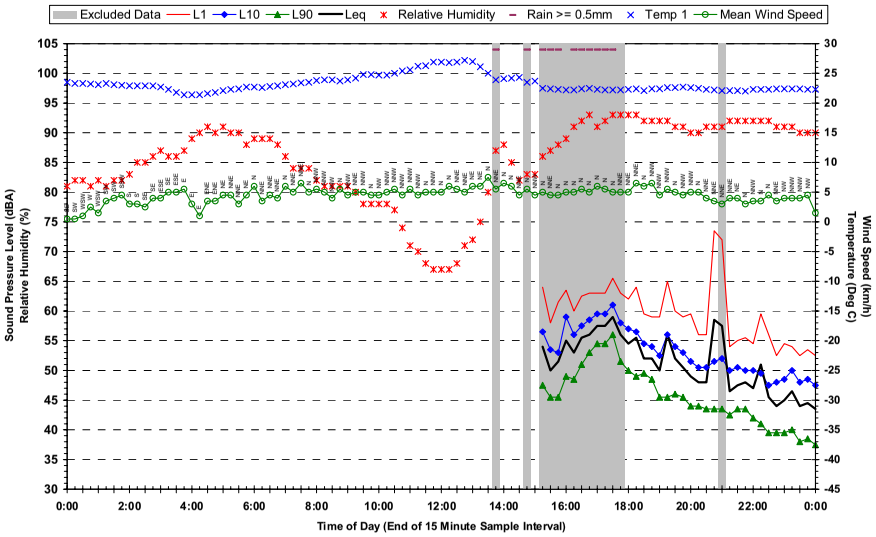
Statistical Ambient Noise Levels
Location 16 - Nursing Home, 26 Palmer Street Windsor - Thursday 8 December 2005



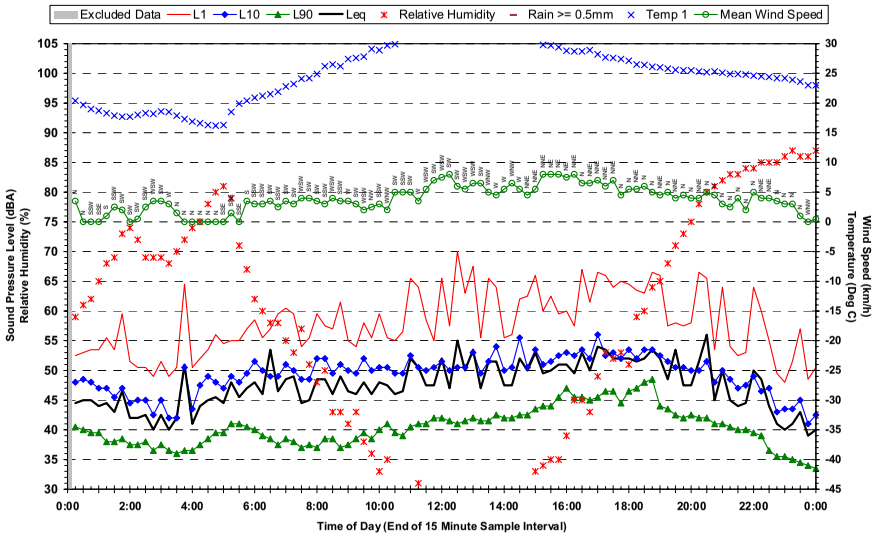
Statistical Ambient Noise Levels
Location 16 - Nursing Home, 26 Palmer Street Windsor - Wednesday 7 December 2005



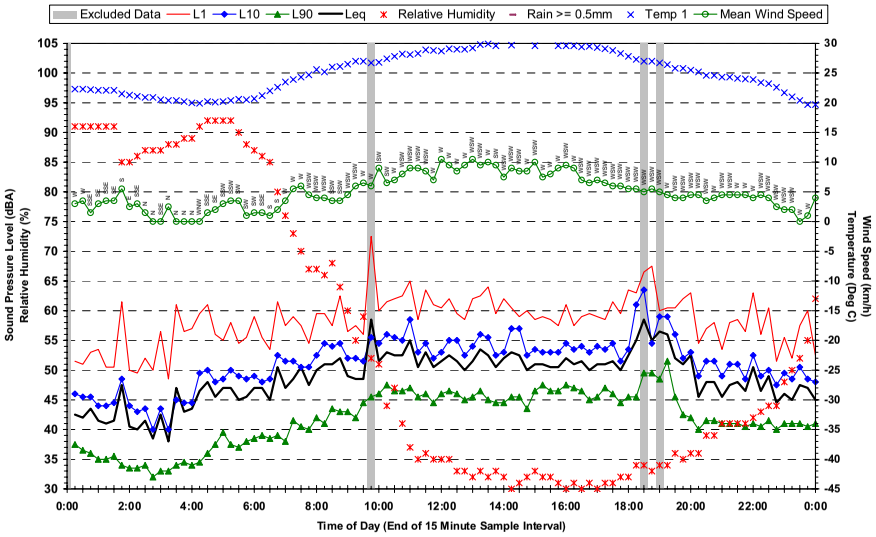
Statistical Ambient Noise Levels
Location 17 - 7 Lamington Avenue Lutwyche - Friday 2 December 2005



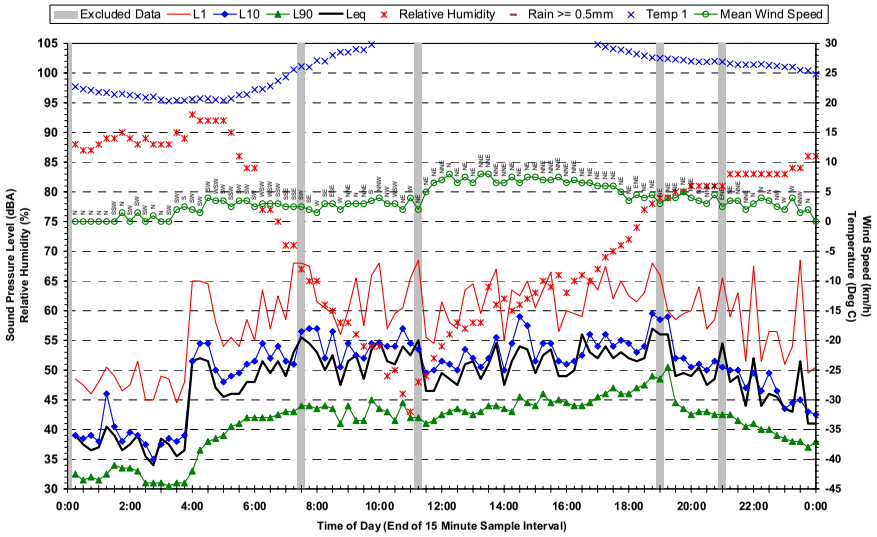
Statistical Ambient Noise Levels
Location 17 - 7 Lamington Avenue Lutwyche - Sunday 4 December 2005



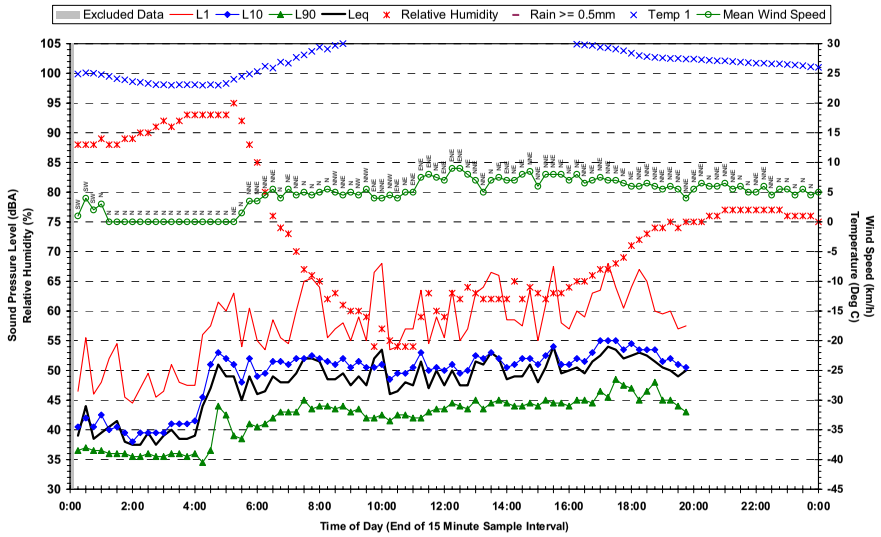
Statistical Ambient Noise Levels
Location 17 - 7 Lamington Avenue Lutwyche - Saturday 3 December 2005



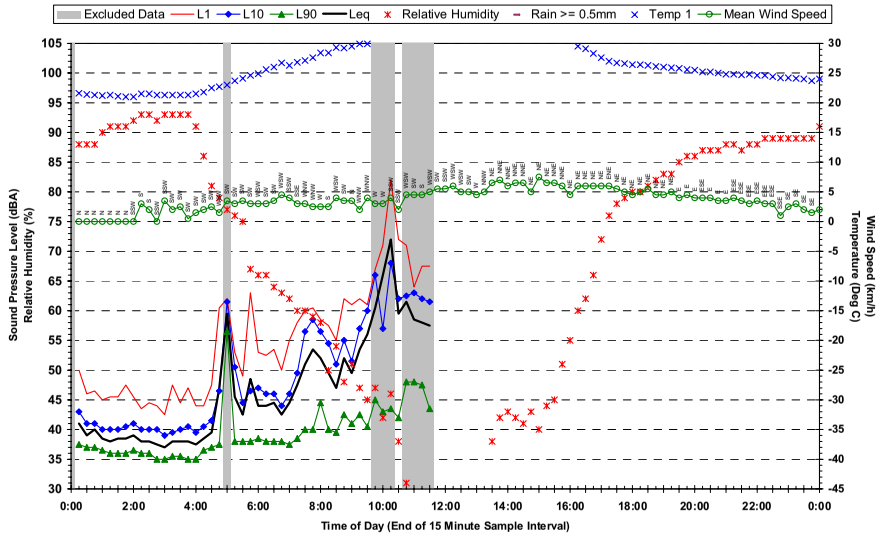
Statistical Ambient Noise Levels
Location 17 - 7 Lamington Avenue Lutwyche - Monday 5 December 2005



Statistical Ambient Noise Levels
Location 17 - 7 Lamington Avenue Lutwyche - Tuesday 6 December 2005



Statistical Ambient Noise Levels
Location 18 - 16 East Street Lutwyche - Saturday 10 December 2005



Appendix C

2005 18hrTraffic Data – Validation Model
Report 20-1605R4

Table 1 2005 18hr Traffic Flows for Model Validation (North-South Flows)

		Northbound		Southbound	
Region	**Road**	**2005**	**% Heavy Vehicle**	**2005**	**% Heavy Vehicle**
Gympie	Gympie Rd, North End	24612	5.8%	24306	6.1%
Gympie	Gympie Rd	33270	6.3%	31353	6.2%
Gympie / central	Lutwych Rd, North End	23510	6.1%	22052	6.5%
Central	Lutwych Rd, Just B4 Roblane	3011	6.4%	22052	6.8%
Central	Lutwych Rd, Parallel To Roblane	3011	6.4%	22052	6.8%
Central	Roblane	22685	6.8%		
Central	Truro ST	22685	6.8%		
Central / south	Lutwyche Rd, North Of Northey	22685	6.8%	22052	6.8%
Sandgate	Sandgate Rd, South Of Eliza	23107	7.4%	22235	7.3%
Sandgate	Sandgate Rd, B/W Eliza And E-W Arterial	23107	7.4%	22235	7.3%
Sandgate	Sandgate Rd, North Of E-W Arterial	23107	7.4%	22235	7.3%
Sandgate	Widdop St, North Of E-W Arterial	5302	7.1%	5714	7.0%
Sandgate	Widdop St, South Of E-W Arterial	5302	7.1%	5714	7.0%
South	Lutwyche Rd, South Of Northey	24488	8.1%	27479	8.1%

Table 2 2005 18hr Traffic Flows for Model Validation (East-West Flows)

		Eastbound		Westbound	
Region	**Road**	**2005**	**% Heavy Vehicle**	**2005**	**% Heavy Vehicle**
Gympie	Park Rd	8447	7.2%	7527	6.0%
Gympie	Stafford Rd	9540	5.9%	7584	5.3%
Gympie	Leckie Rd	2282	6.7%	2205	7.0%
Sandgate	E-W Arterial, Sandgate To Widdop	15581	10.9%	14583	10.8%
	E-W Arterial, East Of Widdop	15581	10.9%	15561	10.0%
South	Northey St	2570	6.3%	6318	6.5%
	Horace St	8524	5.8%	9214	5.2%
	ICB	21688	10.6%	25955	11.2%
	Campbell St	4401	11.8%	3701	6.0%
Central	Albion Rd	8159	7.1%	5571	5.3%

Appendix D

2022 18hr Traffic Data – Do Minimum
Report 20-1605R4

Table 3 **2022** 18hr **Traffic Flows for Do Minimum (North-South Flows**

Region	Road	Southbound		Northbound	
		2022	**% Heavy Vehicle**	**2022**	**% Heavy Vehicle**
Gympie	Gympie Rd, North of Leckie	36890	4.9%	36260	5.7%
Gympie	Gympie Rd, Leckie to Stafford	39560	4.6%	37470	5.5%
Gympie	Gympie Rd, Stafford to Park	48840	5.5%	46080	5.9%
Gympie	Lutwych Rd, Norman to Park	32610	5.3%	30890	6.2%
Gympie	Lutwych Rd, Bradshaw to Norman	32690	5.3%	30220	6.3%
Central	Lutwych Rd, Stonleigh to Bradshaw	35740	5.6%	33490	6.3%
Central	Lutwych Rd, Fuller to Stonleigh	2130	2.3%	34540	6.1%
Central	Lutwych Rd, Maygar to Fuller	1440	3.3%	34060	6.2%
Central	Lutwych Rd, Albion to Maygar	2520	1.9%	36360	5.8%
Central	Lutwych Rd, Constitution to Albion	8390	7.1%	39550	6%
Central	Truro St	35210	5.2%		
Central	Roblane	30020	6.1%		
Central	Lutwych Rd, Newmarket to Constitution	40840	5.9%	40050	6.7%
Central	Lutwych Rd, Northey to Newmarket	53540	4.5%	50650	5.3%
Central	Lutwych Rd, Butterfield to Northey	34010	7%	37120	7.2%
Sandgate	Sandgate Rd, South of Eliza	30560	4.9%	31530	4.9%
Sandgate	Sandgate Rd, b/w Eliza and E-W Arterial	30070	5.0%	31170	5.0%
Sandgate	Sandgate Rd, north of E-W Arterial	33050	6.0%	31220	5.8%
Sandgate	Widdop St, North of E-W Arterial	9270	6.7%	9330	6.8%
Sandgate	Widdop St, Eliza to E-W Arterial	9270	6.7%	7960	7.9%

Table 4 **2022** 18hr **Traffic Flows for Do Minimum (East-West Flows)**

Region	Road	Eastbound		Westbound	
		2022	**% Heavy Vehicle**	**2022**	**% Heavy Vehicle**
Gympie	Park	17760	4.1%	16950	4.0%
Gympie	Stafford Rd	12460	5.7%	12050	5.3%
Gympie	Leckie Rd	1480	8.4%	2930	8.2%
Sandgate	E-W Arterial, Sandgate to Widdop	33070	6.9%	30150	7.0%
Sandgate	E-W Arterial, east of Widdop	33070	6.9%	31510	7.0%
Central	Albion Rd	11880	6.4%	8810	5.7%

Table 5 2022 18hr Traffic Data- Airport Link without Northern Busway (North South Flows)

Region	Road	Southbound		Northbound	
		2022	% Heavy Vehicle	2022	% Heavy Vehicle
Gympie	Gympie Rd, North of Leckie	48010	5.0%	46920	5.3%
Gympie	Gympie Rd, Leckie to Stafford	27510	6.0%	27730	7.2%
Gympie	Gympie Rd, Stafford to Park	41210	7.0%	41650	7.0%
Gympie	Lutwych Rd, Norman to Park	26770	3.4%	21080	1.5%
Gympie	Lutwych Rd, Bradshaw to Norman	26500	4.0%	19830	2.2%
Central	Lutwych Rd, Stonleigh to Bradshaw	29180	3.6%	21940	2.1%
Central	Lutwych Rd, Fuller to Stonleigh	2530	2.2%	22350	2.0%
Central	Lutwych Rd, Maygar to Fuller	1800	3.1%	22230	2.0%
Central	Lutwych Rd, Albion to Maygar	2300	2.5%	23900	1.9%
Central	Lutwych Rd, Constitution to Albion	3690	1.5%	26080	1.7%
Central	Truro St	27200	4.5%		
Central	Roblane	25390	4.8%		
Central	Lutwych Rd, Newmarket to Constitution	30880	4.8%	26000	2.0%
Southern	Lutwych Rd, Northey to Newmarket	40200	5.1%	34010	4.3%
Southern	Lutwych Rd, Butterfield to Northey	28160	5.0%	27810	4.3%
Gympie	Gympie Rd to APL tunnel SB	24860	7.6%	23720	9.4%
Gympie	APL - north of Stafford	20490	8.1%	19190	10.4%
Gympie	Gympie to APL tunnel NB	12470	7.2%	10990	6.3%
Gympie	APL north of Park	27680	6.8%	27430	7.1%
Sandgate	Sandgate Rd, South of Eliza	21160	3.1%	23380	1.7%
Sandgate	Sandgate Rd, Eliza and E-W Arterial	21610	3.1%	23430	1.6%
Sandgate	Sandgate Rd, north of E-W Arterial	28520	6.3%	29090	5.7%
Sandgate	Widdop St, North of E-W Arterial	7510	5.9%	7770	5.7%
Sandgate	Widdop St, Eliza to E-W Arterial	7510	5.9%	6550	6.7%

Table 6 2022 18hr Traffic Data- Airport Link without Northern Busway (East West Flows)

Region	Road	Eastbound		Westbound	
		2022	% Heavy Vehicle	2022	% Heavy Vehicle
Gympie	Park	2.4%	10370	1.3%	15010
Gympie	Stafford Rd	0.9%	21180	1.1%	17040
Gympie	Leckie Rd	4.1%	920	4.0%	930
Sandgate	E-W Arterial, Sandgate to Widdop	6.4%	37440	6.9%	36360
Sandgate	E-W Arterial, east of Widdop	6.4%	37440	6.9%	36360
Sandgate	Airport Link	7.0%	18400	7.7%	18980
Sandgate	Sandgate Rd to Airport Link - EB	5.9%	19030		
Sandgate	Sandgate Rd to Airport Link – WB			4.8%	8340
Sandgate	Airport Link WB to Sandgate Rd			6.0%	17370
Sandgate	Airport Link EB to Sandgate Rd	7.5%	8750		

Appendix F

2022 18hr Traffic Data – Airport Link with Interim Busway
Report 20-1605R4

Table 7 2022 18hr Traffic Data- Airport Link with Interim Busway (North South Flows)

Region	Road	Southbound		Northbound	
		2022	% Heavy Vehicle	2022	% Heavy Vehicle
Gympie	Gympie Rd, North of Leckie	47410	5.3%	45740	5.4%
Gympie	Gympie Rd, Leckie to Stafford	26050	7.9%	26280	7.3%
Gympie	Gympie Rd, Stafford to Park	39690	7.9%	40100	7.3%
Gympie	Lutwych Rd, Norman to Park	21900	3.0%	18100	1.5%
Gympie	Lutwych Rd, Bradshaw to Norman	21600	3.1%	16850	1.6%
Central	Lutwych Rd, Stonleigh to Bradshaw	23320	3.5%	18790	2.2%
Central	Lutwych Rd, Fuller to Stonleigh	22240	3.5%	18360	2.2%
Central	Lutwych Rd, Maygar to Fuller	21420	3.5%	18460	2.2%
Central	Lutwych Rd, Albion to Maygar	21410	3.5%	18780	2.2%
Central	Lutwych Rd, Constitution to Albion	25260	3.5%	21830	2.2%
Central	Truro St				
Central	Roblane				
Central	Lutwych Rd, Newmarket to Constitution	27580	4.1%	21840	4.1%
Southern	Lutwych Rd, Northey to Newmarket	37490	5.4%	30060	4.8%
Southern	Lutwych Rd, Butterfield to Northey	26650	6.7%	27160	5.5%
Gympie	Gympie Rd to APL tunnel SB	25610	8.3%	24250	9.3%
Gympie	APL - north of Stafford	21360	9.0%	19460	10.6%
Gympie	Gympie to APL tunnel NB	12530	7.1%	10910	6.5%
Gympie	APL north of Park	27330	7.1%	27160	7.3%
Sandgate	Sandgate Rd, South of Eliza	21160	3.0%	23380	1.7%
Sandgate	Sandgate Rd, b/w Eliza and E-W Arterial	21610	3.1%	23430	1.6%
Sandgate	Sandgate Rd, north of E-W Arterial	28520	6.3%	29090	5.8%
Sandgate	Widdop St, North of E-W Arterial	7510	5.9%	7770	5.6%
Sandgate	Widdop St, Eliza to E-W Arterial	7510	5.9%	6550	6.6%

Table 8 2022 18hr Traffic Data- Airport Link with Interim Busway (East West Flows)

Region	Road	Eastbound		Westbound	
		2022	% Heavy Vehicle	2022	% Heavy Vehicle
Gympie	Park	13360	1.8%	15950	1.2%
Gympie	Stafford rd	21040	4.3%	21780	4.7%
Gympie	Leckie rd	920	4.1%	930	4.0%
Sandgate	E-w arterial, Sandgate to Widdop	37440	6.5%	36360	7.0%
Sandgate	E-w arterial, east of Widdop	37440	6.5%	36360	7.2%
Sandgate	Airport link	18400	7.1%	18980	7.9%
Sandgate	Sandgate rd to airport link - eastbound	19030	5.8%		
Sandgate	Sandgate rd to airport link- westbound			8340	5.3%
Sandgate	Airport link westbound to Sandgate Rd			17370	6.1%
Sandgate	Airport link eastbound to Sandgate Rd	8750	7.7%		

Appendix G

2026 18hr Traffic Data – Do Minimum
Report 20-1605R4

Table 9 2026 18hr Traffic Data- Do Minimum Scenario (North South Flows)

Region	Road	Southbound		Northbound	
		2026	% Heavy Vehicle	2026	% Heavy Vehicle
Gympie	Gympie Rd, North of Leckie	37660	4.9%	37000	5.7%
Gympie	Gympie Rd, Leckie to Stafford	40630	4.6%	38430	5.5%
Gympie	Gympie Rd, Stafford to Park	49560	5.5%	46880	5.9%
Gympie	Lutwych Rd, Norman to Park	32970	5.3%	31190	6.2%
Gympie	Lutwych Rd, Bradshaw to Norman	33140	5.3%	30380	6.3%
Central	Lutwych Rd, Stonleigh to Bradshaw	36070	5.6%	33600	6.3%
Central	Lutwych Rd, Fuller to Stonleigh	2020	2.3%	34560	6.1%
Central	Lutwych Rd, Maygar to Fuller	1390	3.3%	34060	6.2%
Central	Lutwych Rd, Albion to Maygar	2700	1.9%	36750	5.8%
Central	Lutwych Rd, Constitution to Albion	9110	7.1%	40030	6%
Central	Truro St	35690	5.2%		
Central	Roblane	30340	6.1%		
Central	Lutwych Rd, Newmarket to Constitution	41750	5.9%	40440	6.7%
Central	Lutwych Rd, Northey to Newmarket	55400	4.5%	51600	5.3%
Central	Lutwych Rd, Butterfield to Northey	35890	7%	38630	7.2%
Sandgate	Sandgate Rd, South of Eliza	31190	4.9%	32330	4.9%
Sandgate	Sandgate Rd, b/w Eliza and E-W Arterial	30470	5.0%	31960	5.0%
Sandgate	Sandgate Rd, north of E-W Arterial	33660	6.0%	31520	5.8%
Sandgate	Widdop St, North of E-W Arterial	9580	6.7%	9590	6.8%
Sandgate	Widdop St, Eliza to E-W Arterial	9580	6.7%	8110	7.9%

Table 10 2026 18hr Traffic Data- Do Minimum Scenario (East West Flows)

Region	Road	Eastbound		Westbound	
		2026	% Heavy Vehicle	2026	% Heavy Vehicle
Gympie	Park	18370	4.1%	17460	4.0%
Gympie	Stafford Rd	12530	5.7%	12080	5.3%
Gympie	Leckie Rd	1710	8.4%	3240	8.2%
Sandgate	E-W Arterial, Sandgate to Widdop	34520	6.9%	30890	7.0%
Sandgate	E-W Arterial, east of Widdop	34520	6.9%	30890	7.0%
Central	Albion Rd	12080	6.4%	9190	5.7%

Appendix H

2026 18hr Traffic Data – Airport Link without Northern Busway
Report 20-1605R4

Table 11 2026 18hr Traffic Data- Airport Link without Busway (North South Flows)

Region	Road	Southbound		Northbound	
		2026	% Heavy Vehicle	2026	% Heavy Vehicle
Gympie	Gympie Rd, North of Leckie	48480	5.0%	48360	5.3%
Gympie	Gympie Rd, Leckie to Stafford	27440	6.0%	28080	7.2%
Gympie	Gympie Rd, Stafford to Park	41590	7.0%	42370	7.0%
Gympie	Lutwych Rd, Norman to Park	27630	3.4%	20990	1.5%
Gympie	Lutwych Rd, Bradshaw to Norman	27310	4.0%	19510	2.2%
Central	Lutwych Rd, Stonleigh to Bradshaw	30080	3.6%	21770	2.1%
Central	Lutwych Rd, Fuller to Stonleigh	2440	2.2%	22250	2.0%
Central	Lutwych Rd, Maygar to Fuller	1770	3.1%	22100	2.0%
Central	Lutwych Rd, Albion to Maygar	2560	2.5%	24010	1.9%
Central	Lutwych Rd, Constitution to Albion	3830	1.5%	26400	1.7%
Central	Truro St	28000	4.5%		
Central	Roblane	26910	4.8%		
Central	Lutwych Rd, Newmarket to Constitution	32310	4.8%	26220	2.0%
Southern	Lutwych Rd, Northey to Newmarket	41810	5.1%	34570	4.3%
Southern	Lutwych Rd, Butterfield to Northey	30820	5.0%	28840	4.3%
Gympie	Gympie Rd to APL tunnel SB	25390	7.6%	25200	9.4%
Gympie	APL - north of Stafford	21040	8.1%	20280	10.4%
Gympie	Gympie to APL tunnel NB	12750	7.2%	10360	6.3%
Gympie	APL north of Park	29660	6.8%	26420	7.1%
Sandgate	Sandgate Rd, South of Eliza	22170	3.1%	25310	1.7%
Sandgate	Sandgate Rd, b/w Eliza and E-W Arterial	22360	3.2%	25410	1.7%

Table 12 2026 18hr Traffic Data- Airport Link without Busway (East West Flows)

Region	Road	Eastbound		Westbound	
		2026	% Heavy Vehicle	2026	% Heavy Vehicle
Gympie	Park	10370	2.4%	15010	1.3%
Gympie	Stafford Rd	21180	4.3%	17040	6.0%
Gympie	Leckie Rd	920	4.1%	930	4.0%
Sandgate	E-W Arterial, Sandgate to Widdop	37420	6.4%	36430	6.9%
Sandgate	E-W Arterial, east of Widdop	37420	6.4%	36430	6.9%
Sandgate	Airport Link	18760	6.9%	19230	7.6%
Sandgate	Sandgate Rd to Airport Link - EB	18660	6.0%		
Sandgate	Sandgate Rd to Airport Link - WB			8450	4.8%

Table 13 2026 18hr Traffic Data- Airport Link with Ultimate Busway (North South Flows)

Region	Road	Southbound		Northbound	
		2026	% Heavy Vehicle	2026	% Heavy Vehicle
Gympie	Gympie Rd, north of Leckie	48070	5.4%	47390	5.8%
Gympie	Gympie Rd, Leckie to StaffoRd	25880	8.1%	26770	8.5%
Gympie	Gympie Rd, StaffoRd to park	39870	8.1%	41100	8.5%
Gympie	Lutwych Rd, Norman to park	22670	2.7%	18170	1.5%
Gympie	Lutwych Rd, Bradshaw to Norman	22350	2.7%	16700	1.6%
Central	Lutwych Rd, Stonleigh To Bradshaw	24000	3.2%	18490	2.3%
Central	Lutwych Rd, Fuller to Stonleigh	22800	3.2%	18600	2.3%
Central	Lutwych Rd, Maygar to Fuller	22060	3.2%	18680	2.3%
Central	Lutwych Rd, Albion to Maygar	22210	3.2%	19080	2.3%
Central	Lutwych Rd, Constitution to Albion	23680	3.2%	22380	2.3%
Central	Truro St				
Central	Roblane	3050	4.1%		
Central	Lutwych Rd, Newmarket to Constitution	28780	4.1%	22360	4.0%
Southern	Lutwych Rd, Northey to Newmarket	38910	5.0%	30880	4.7%
Southern	Lutwych Rd, Butterfield To Northey	29500	6.0%	28030	5.4%
Gympie	Gympie Rd To Apl Tunnel SB	26760	8.7%	25640	9.7%
Gympie	Apl - North of Staffo Rd	22190	9.5%	20620	11.0%
Gympie	Gympie To Apl Tunnel NB	12980	7.0%	10270	6.9%
Gympie	Apl North of Park	29690	7.0%	27130	7.9%
Sandgate	Sandgate Rd, South of Eliza	22410	2.9%	25230	1.5%
Sandgate	Sandgate Rd, B/W Eliza and E-W Arteria	22670	2.9%	25290	1.4%
Sandgate	Sandgate Rd, North Of E-W Arterial	30300	6.0%	29180	5.6%
Sandgate	Widdop St, North Of E-W Arterial	8190	5.7%	7850	5.1%
Sandgate	Widdop St, Eliza to E-W Arterial	8190	5.7%	6640	6.1%

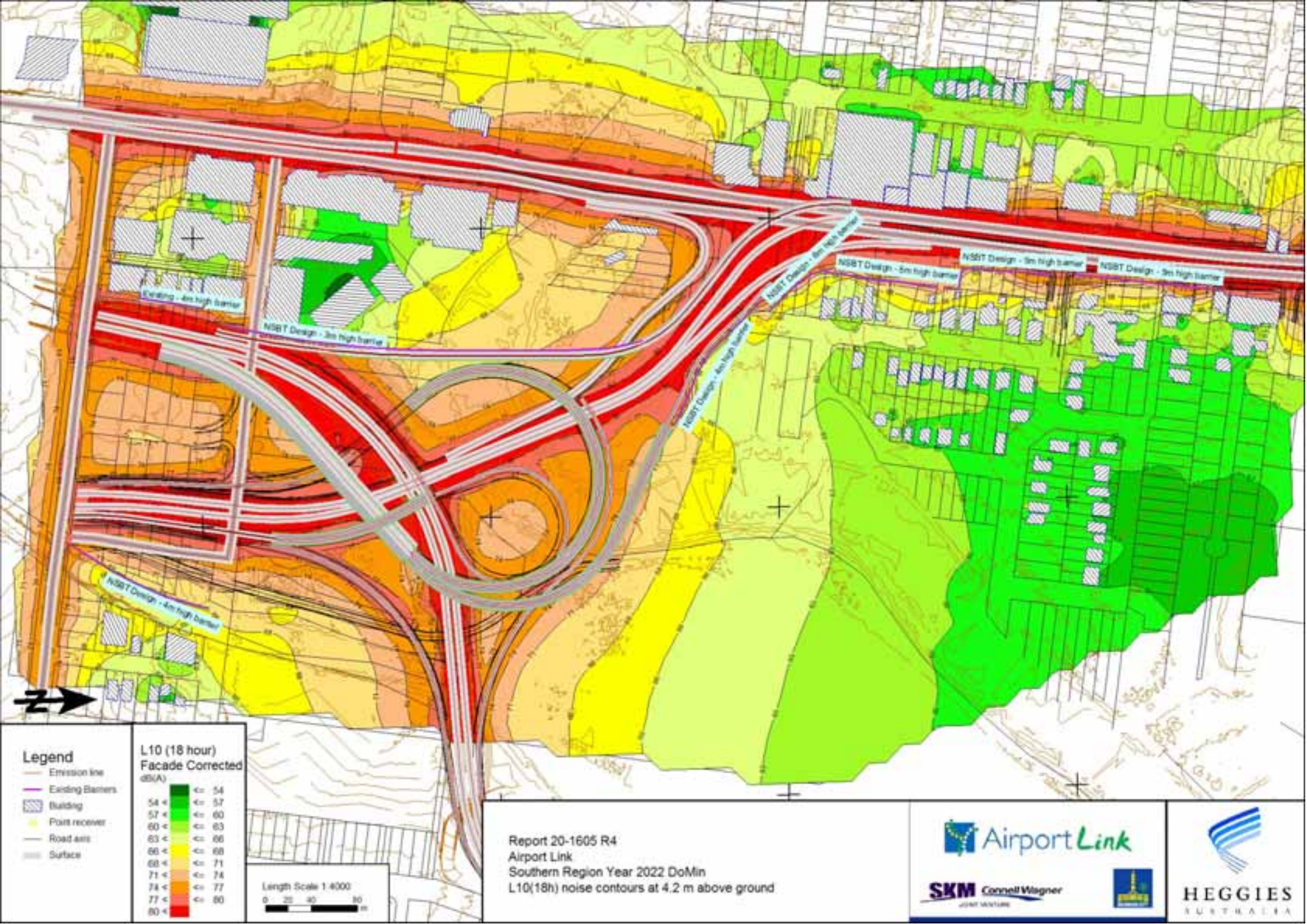
Table 14 2026 18hr Traffic Data- Airport Link with Ultimate Busway (East West Flows)

Region	Road	Eastbound		Westbound	
		2026	% Heavy Vehicle	2026	% Heavy Vehicle
Gympie	Park	13610	1.0%	16640	1.2%
Gympie	Stafford Rd	21840	4.1%	22630	4.4%
Gympie	Leckie Rd	910	4.1%	900	4.2%
Sandgate	E-W Arterial, Sandgate to Widdop	38080	6.2%	36890	6.7%
Sandgate	E-W Arterial, east of Widdop	38080	6.2%	36890	6.9%
Sandgate	Airport Link	17730	7.8%	19980	7.9%
Sandgate	Sandgate Rd to Airport Link - EB	20350	4.9%		
Sandgate	Sandgate Rd to Airport Link – WB			9710	5.4%
Sandgate	Airport Link WB to Sandgate Rd			16910	5.3%
Sandgate	Airport Link EB to Sandgate Rd	9400	8.0%		

Appendix J

Noise Contour Maps - Southern Portal

Report 20-1605R4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NSBT Design - 4m high barrier
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Legend
Emission line
Existing Barriers
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
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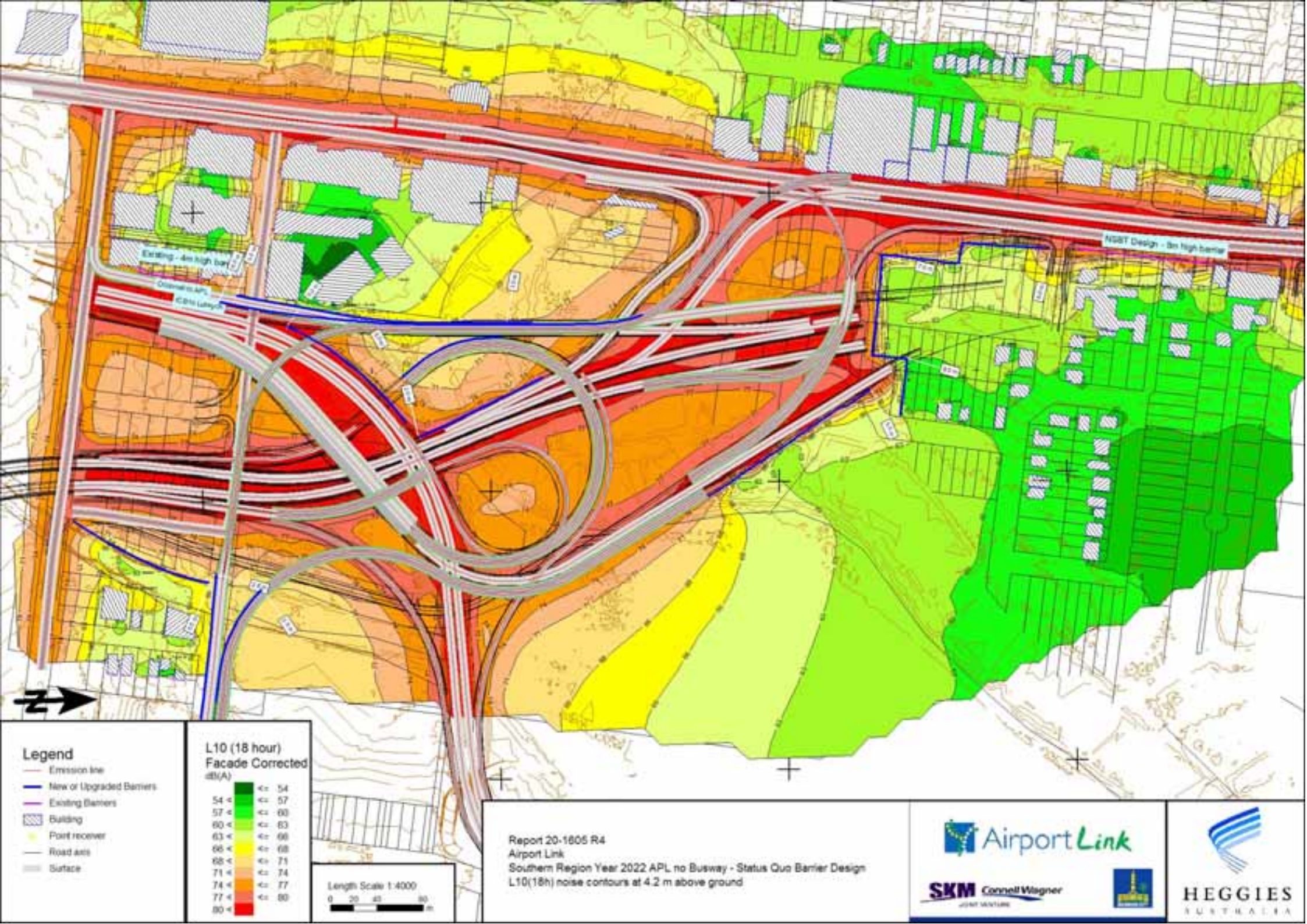
Report 20-1605 R4
Airport Link
Southern Region Year 2022 DoMin
L10(18h) noise contours at 4.2 m above ground
Airport Link
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA

Report 20-1605 R4
Airport Link
Southern Region Year 2022 APL no Busway
L10(18h) noise contours at 4.2 m above ground

Airport Link

SKM Connell Wagner
JOINT VENTURE

HEGGIES
AUSTRALIA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NSBT Design - 8m high barrier
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Emission line
New or Upgraded Barriers
Existing Barriers
Building
Point receiver
Road axis
Surface
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Facade Corrected
dB(A)
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57 < <= 60
60 < <= 63
63 < <= 66
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77 < <= 80
80 <
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Report 20-1605 R4
Airport Link
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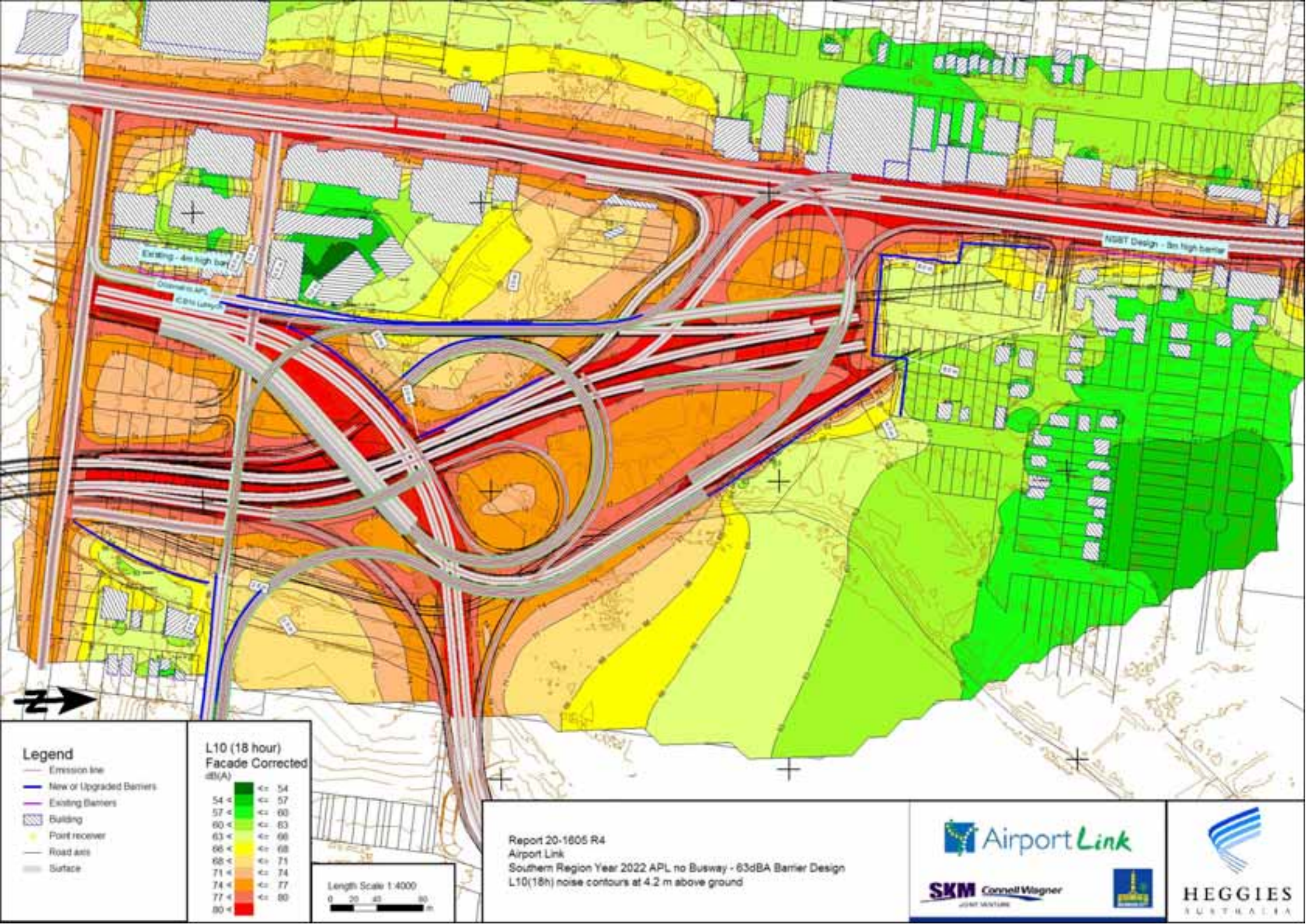
L10(18h) noise contours at 4.2 m above ground
Airport Link
SKM Connell Wagner
HEGGIES AUSTRALIA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Emission line
New or Upgraded Barriers
Existing Barriers
Building
Point receiver
Road axis
Surface
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Facade Corrected
dB(A)
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Report 20-1605 R4
Airport Link
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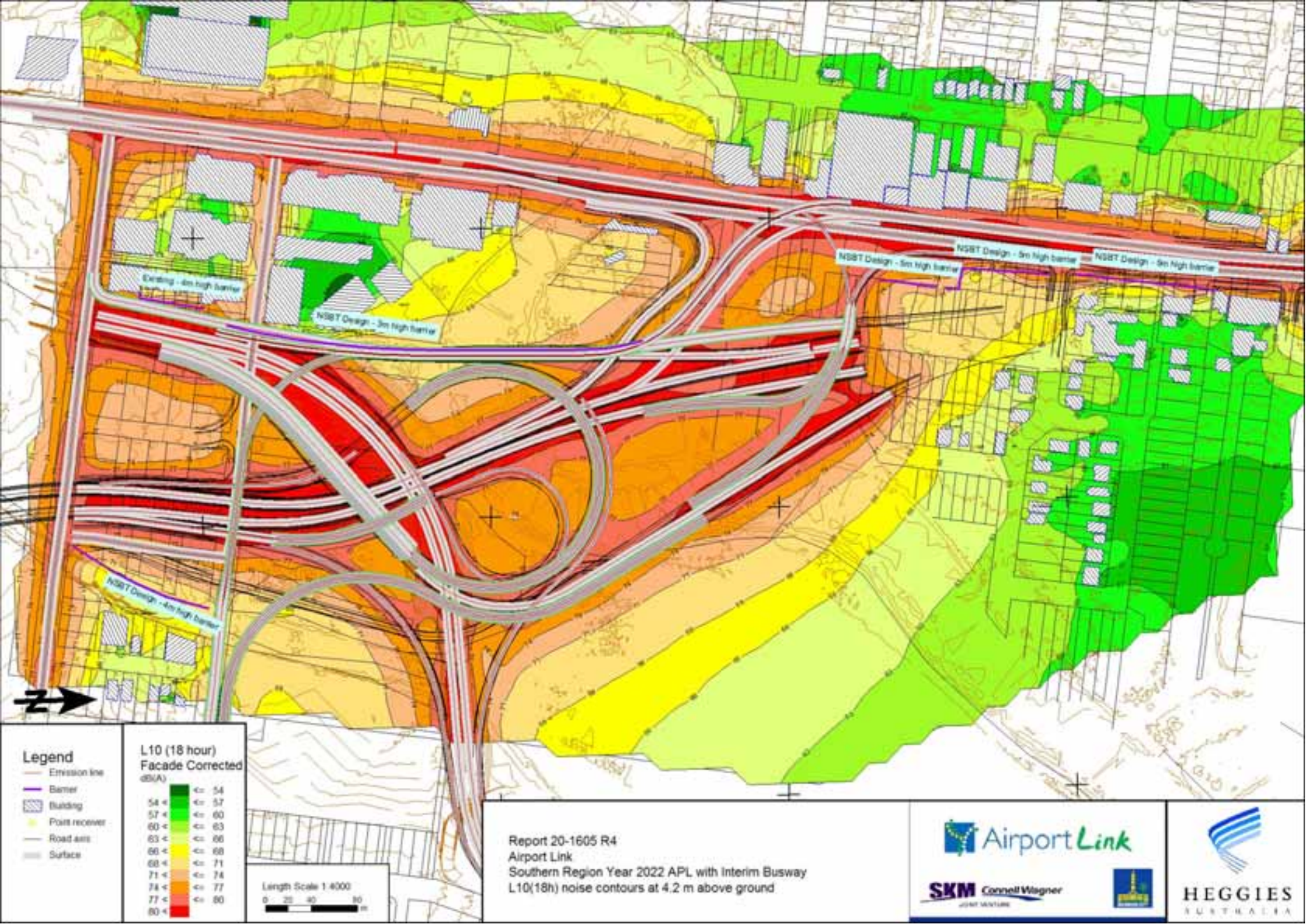
L10(18h) noise contours at 4.2 m above ground
Airport Link
SKM Connell Wagner
HEGGIES AUSTRALIA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Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
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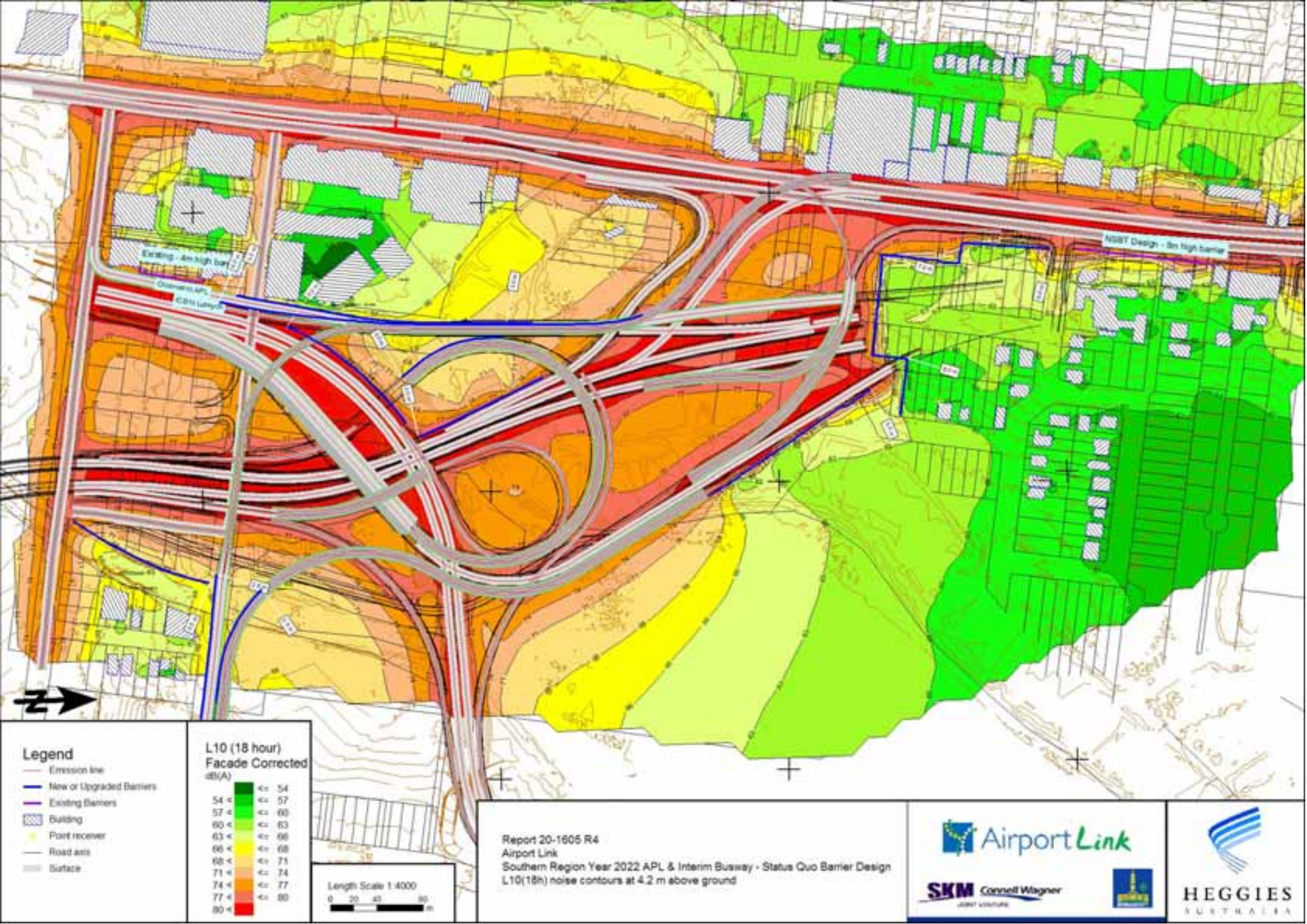
Report 20-1605 R4
Airport Link
Southern Region Year 2022 APL with Interim Busway
L10(18h) noise contours at 4.2 m above ground
Airport Link
SKM Connell Wagner
HEGGIES AUSTRALIA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NSBT Design - 8m high barrier
Legend
Emission line
New or Upgraded Barriers
Existing Barriers
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
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74 < <= 77
77 < <= 80
80 <
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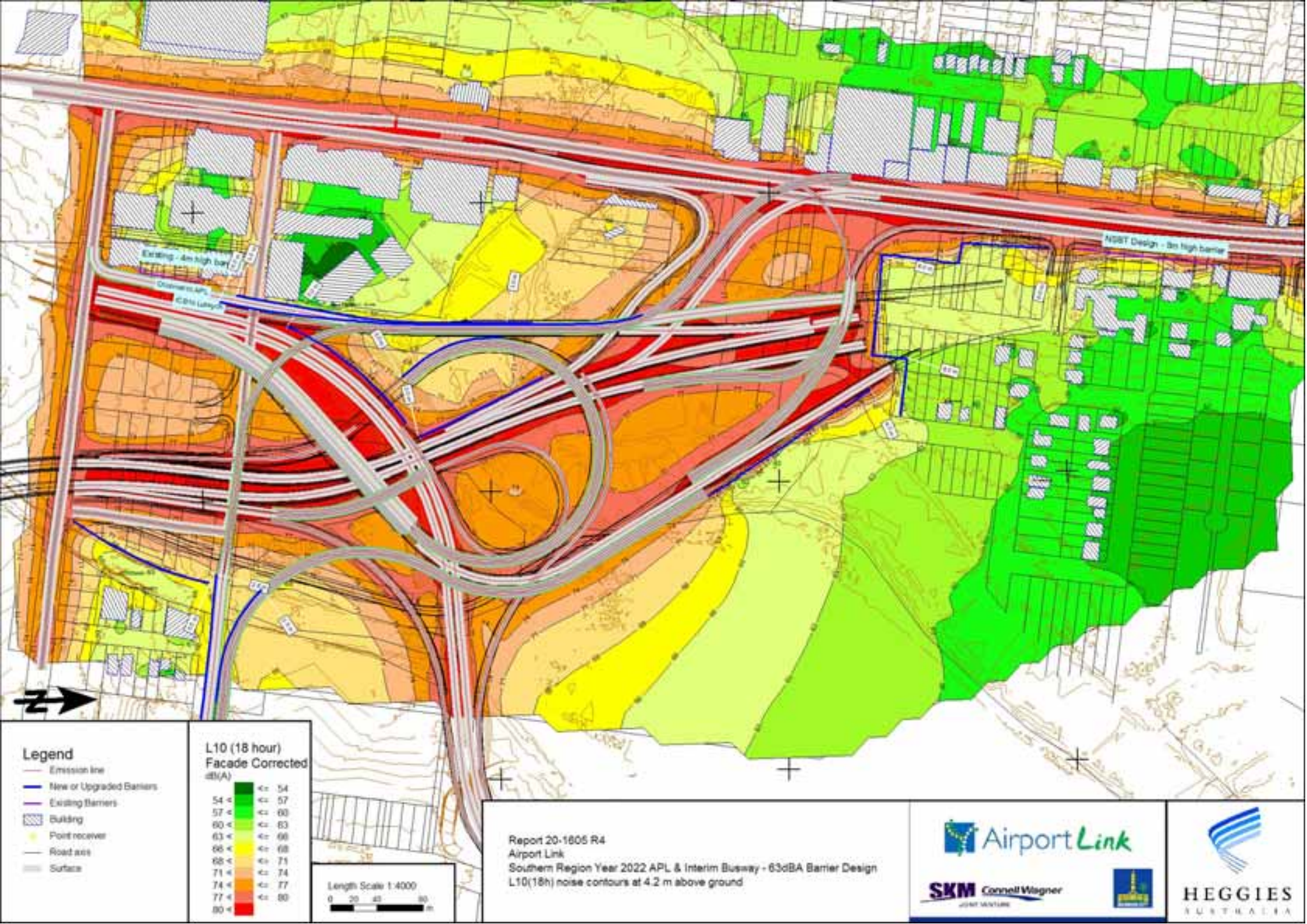
Report 20-1605 R4
Airport Link
Southern Region Year 2022 APL & Interim Busway - Status Quo Barrier Design
L10(18h) noise contours at 4.2 m above ground
AirportLink
SKM Connell Wagner
HEGGIES AUSTRALIA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NSBT Design - 8m high barrier
Legend
Emission line
New or Upgraded Barriers
Existing Barriers
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
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60 < <= 63
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66 < <= 68
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74 < <= 77
77 < <= 80
80 <
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m
Report 20-1605 R4
Airport Link
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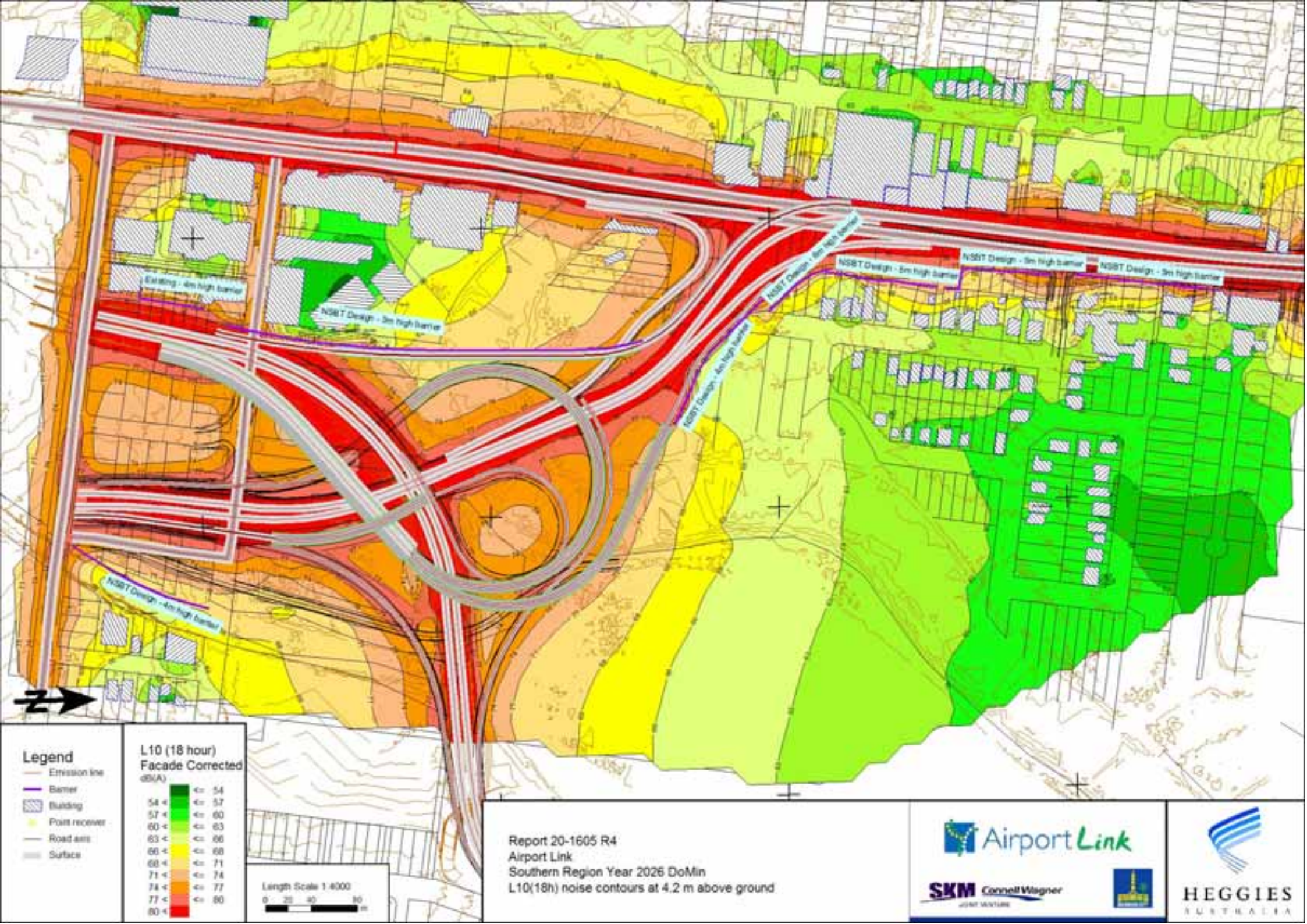
L10(18h) noise contours at 4.2 m above ground
Airport Link
SKM Connell Wagner
HEGGIES AUSTRALIA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NSBT Design - 3m high barrier
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NSBT Design - 3m high barrier
NSBT Design - 3m high barrier
NSBT Design - 4m high barrier
N
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
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74 < <= 77
77 < <= 80
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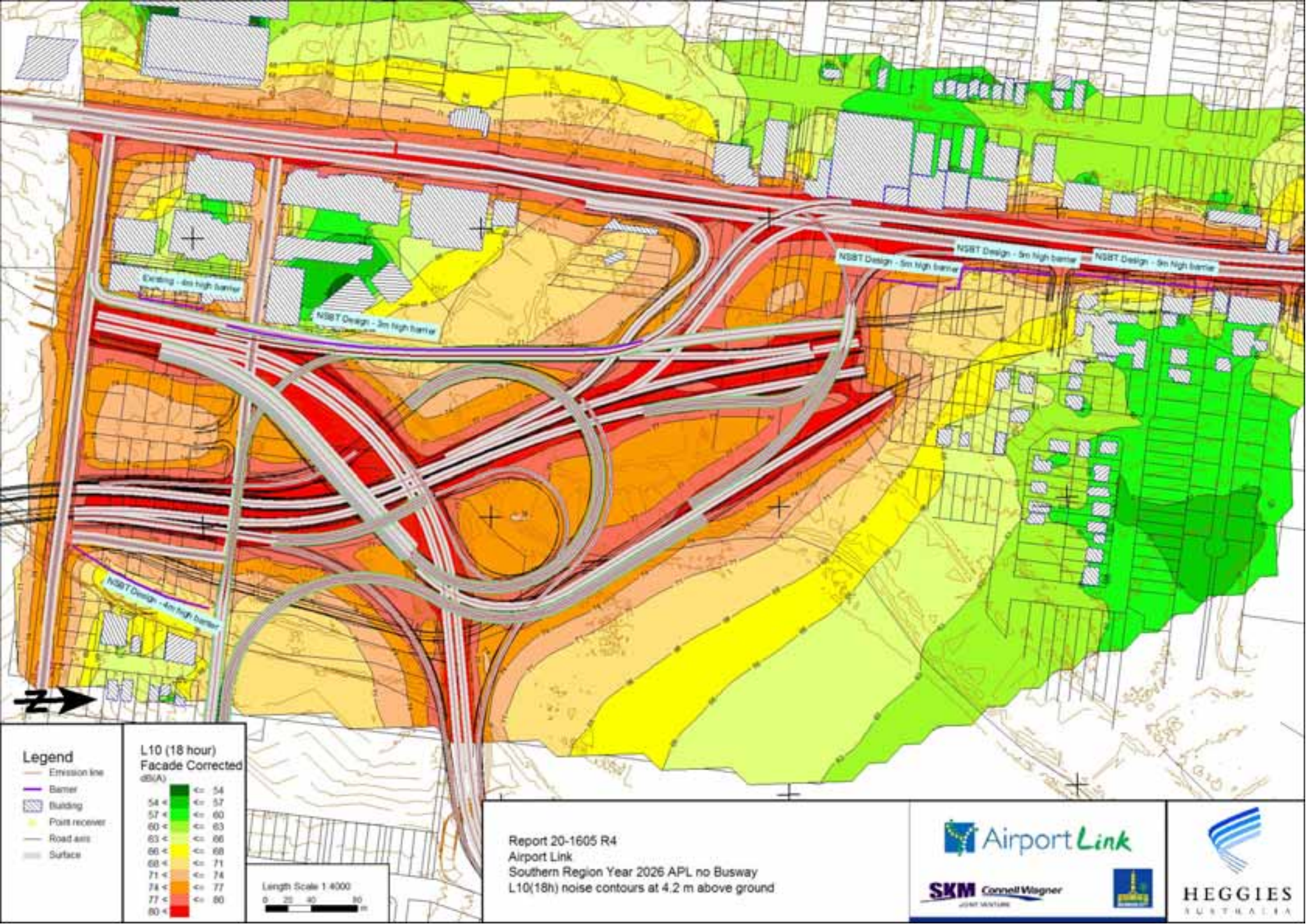
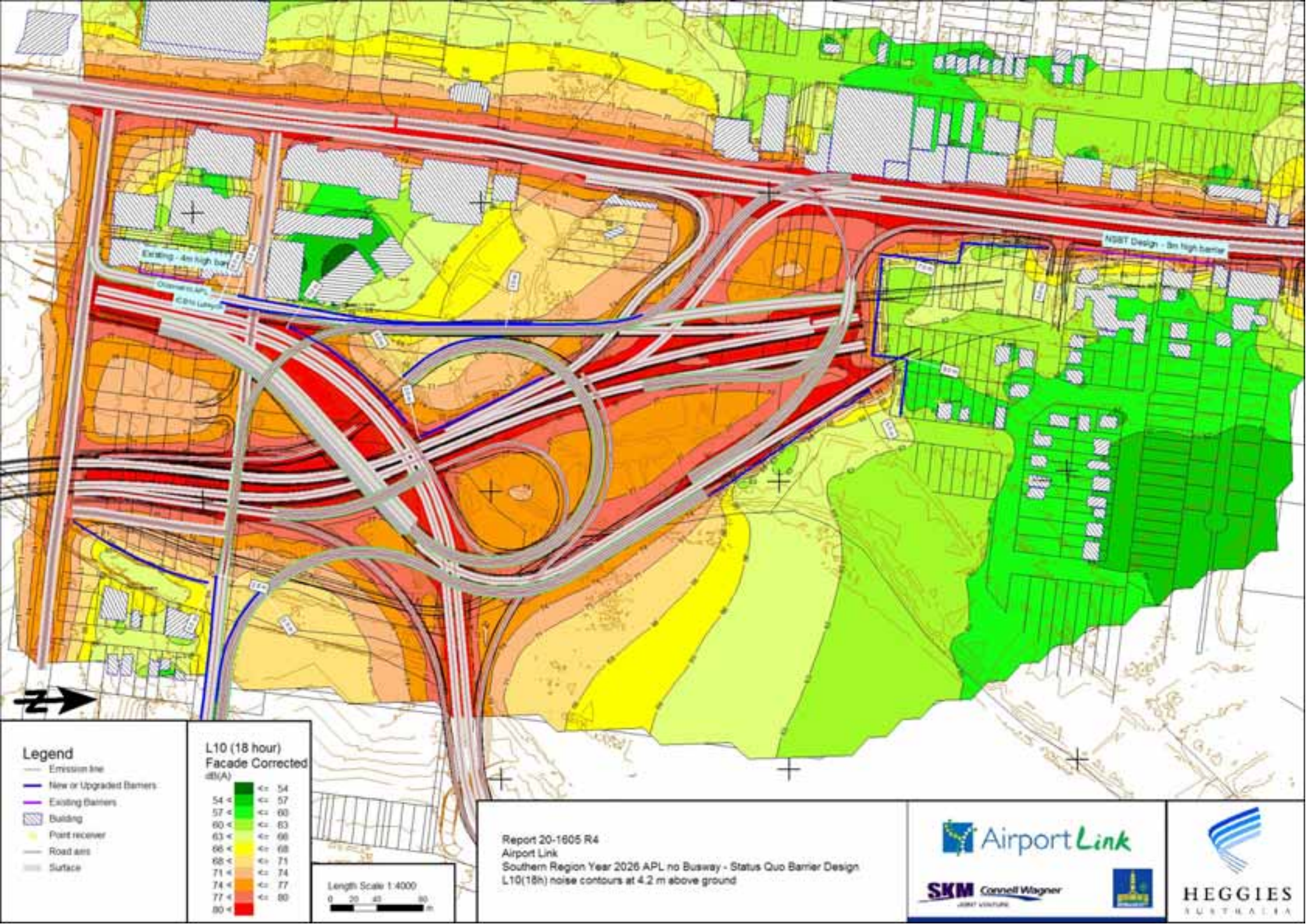
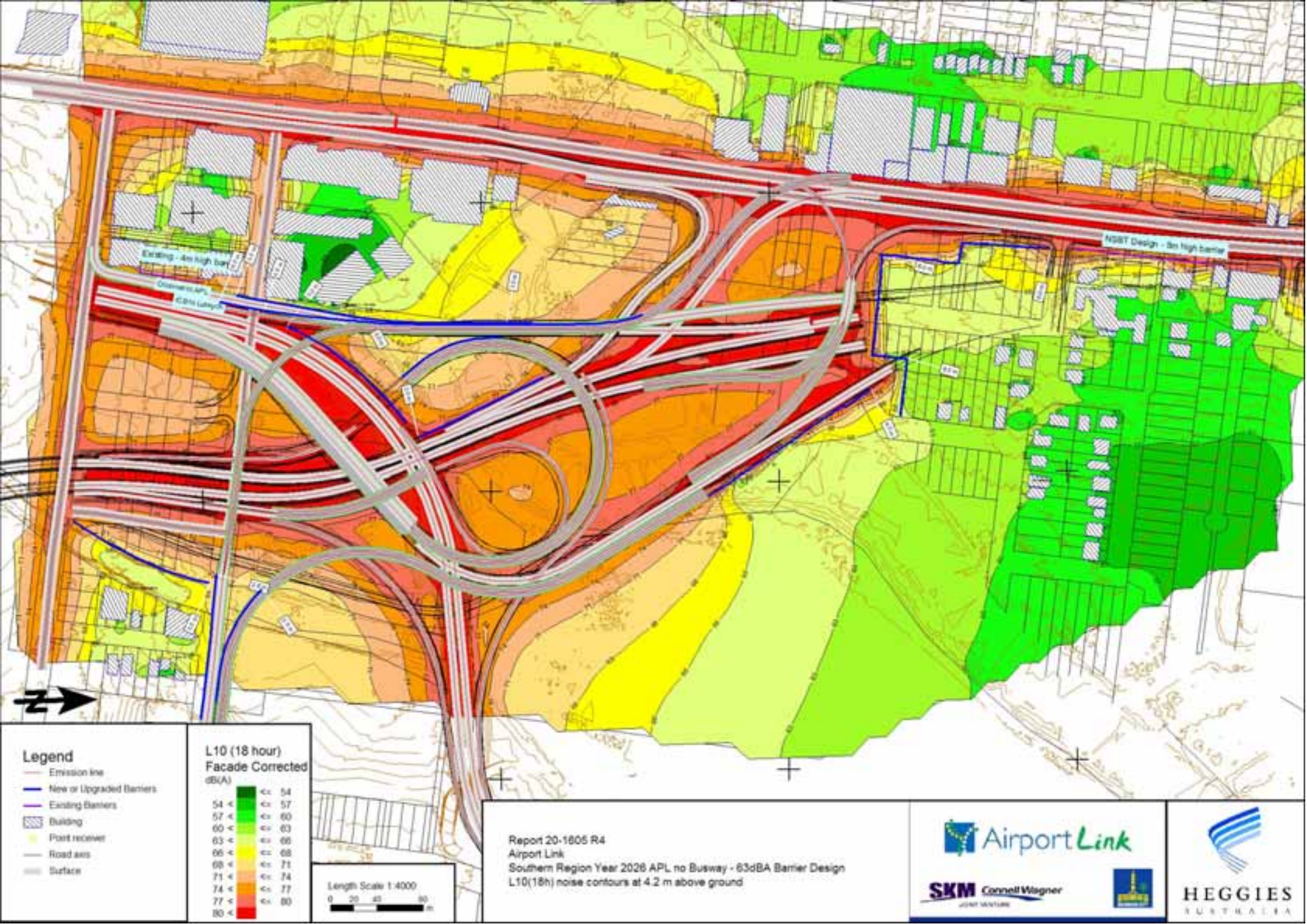
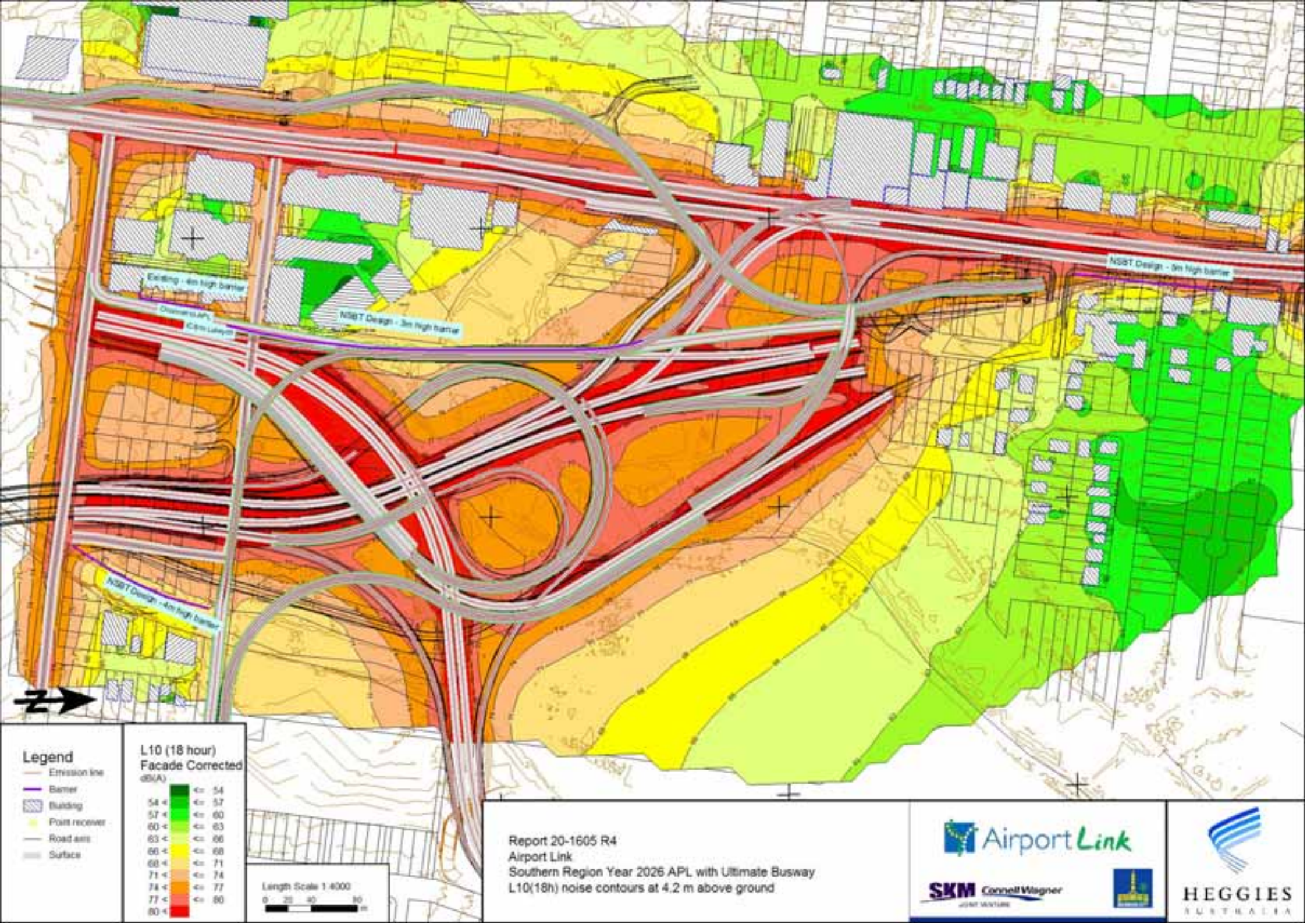
Length Scale 1:4000
0 20 40 80
m
Report 20-1605 R4
Airport Link
Southern Region Year 2026 DoMin
L10(18h) noise contours at 4.2 m above ground
Airport Link
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA


Existing - 4m high barrier
NSBT Design - 3m high barrier
NSBT Design - 5m high barrier
NSBT Design - 5m high barrier
NSBT Design - 5m high barrier
NSBT Design - 4m high barrier
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:4000
0 20 40 80
m
Report 20-1605 R4
Airport Link
Southern Region Year 2026 APL no Busway
L10(18h) noise contours at 4.2 m above ground
Airport Link
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA


Existing - 4m high barrier
NSBT Design - 8m high barrier
Legend
Emission line
New or Upgraded Barriers
Existing Barriers
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:4000
0 20 40 80
m
Report 20-1605 R4
Airport Link
Southern Region Year 2026 APL no Busway - Status Quo Barrier Design
L10(18h) noise contours at 4.2 m above ground
AirportLink
SKM Connell Wagner
HEGGIES
AUSTRALIA


Existing - 4m high barrier
NSBT Design - 8m high barrier
Legend
Emission line
New or Upgraded Barriers
Existing Barriers
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:4000
0 20 40 80 m
Report 20-1605 R4
Airport Link
Southern Region Year 2026 APL no Busway - 63dBA Barrier Design
L10(18h) noise contours at 4.2 m above ground
Airport Link
SKM Connell Wagner
HEGGIES AUSTRALIA



Report 20-1605 R4
Airport Link
Southern Region Year 2026 APL with Ultimate Busway
L10(18h) noise contours at 4.2 m above ground

Airport Link

SKM Connell Wagner
JOINT VENTURE

HEGGIES
AUSTRALIA

Legend

- Emission line
- Main building
- New or Upgraded Barriers
- Existing Barriers
- Elevation line
- Point receiver

L10 (18 hour) Facade Corrected dB(A)

54 <	<= 57
57 <	<= 60
60 <	<= 63
63 <	<= 66
66 <	<= 68
68 <	<= 71
71 <	<= 74
74 <	<= 77
77 <	<= 80

Length Scale 1:4000

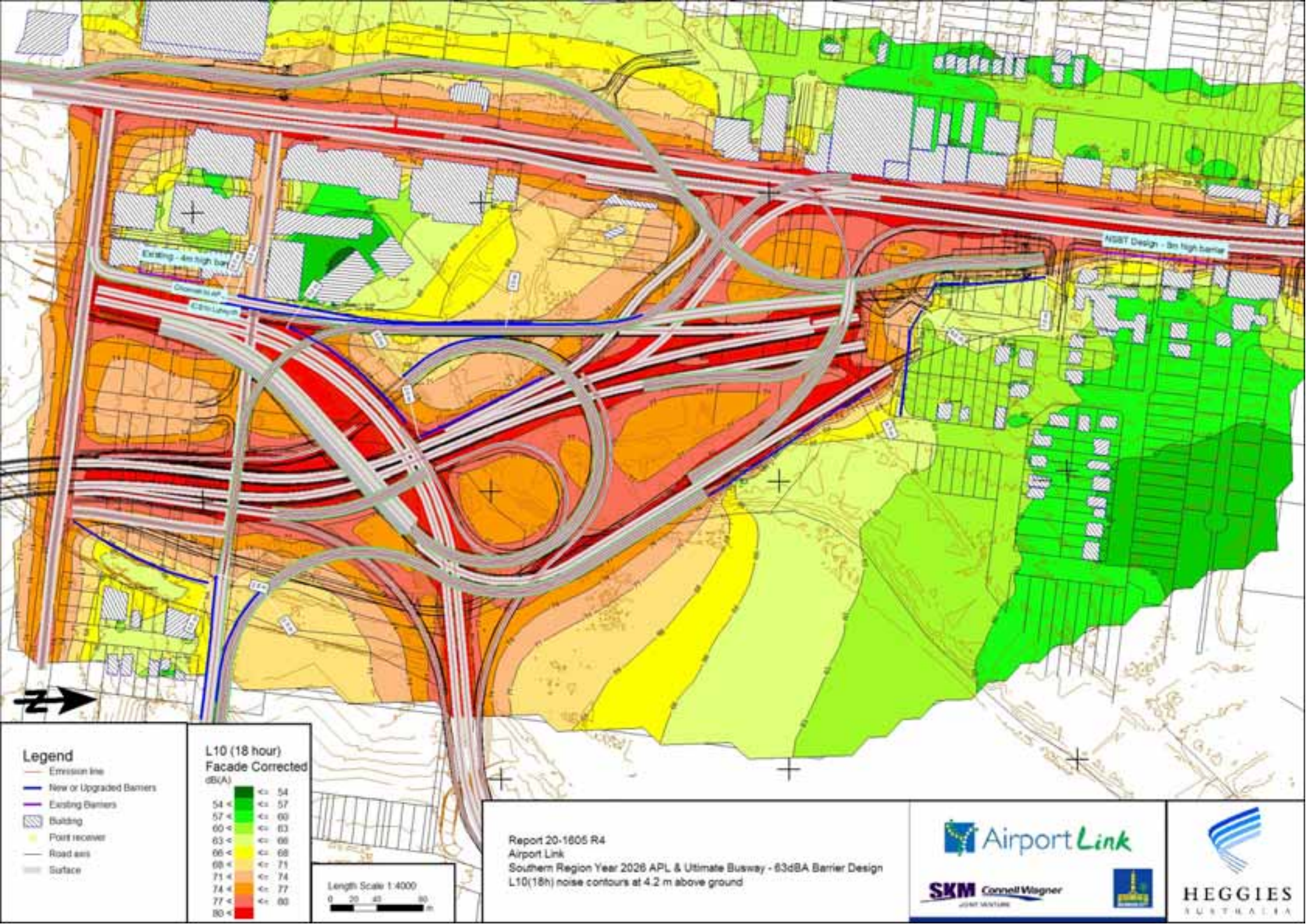
0 20 40 80 m

Report 20-1605 R4
Airport Link
Southern Region Year 2026 APL & Ultimate Busway - Status Quo Barrier Design
L10(18h) noise contours at 4.2 m above ground

Airport Link

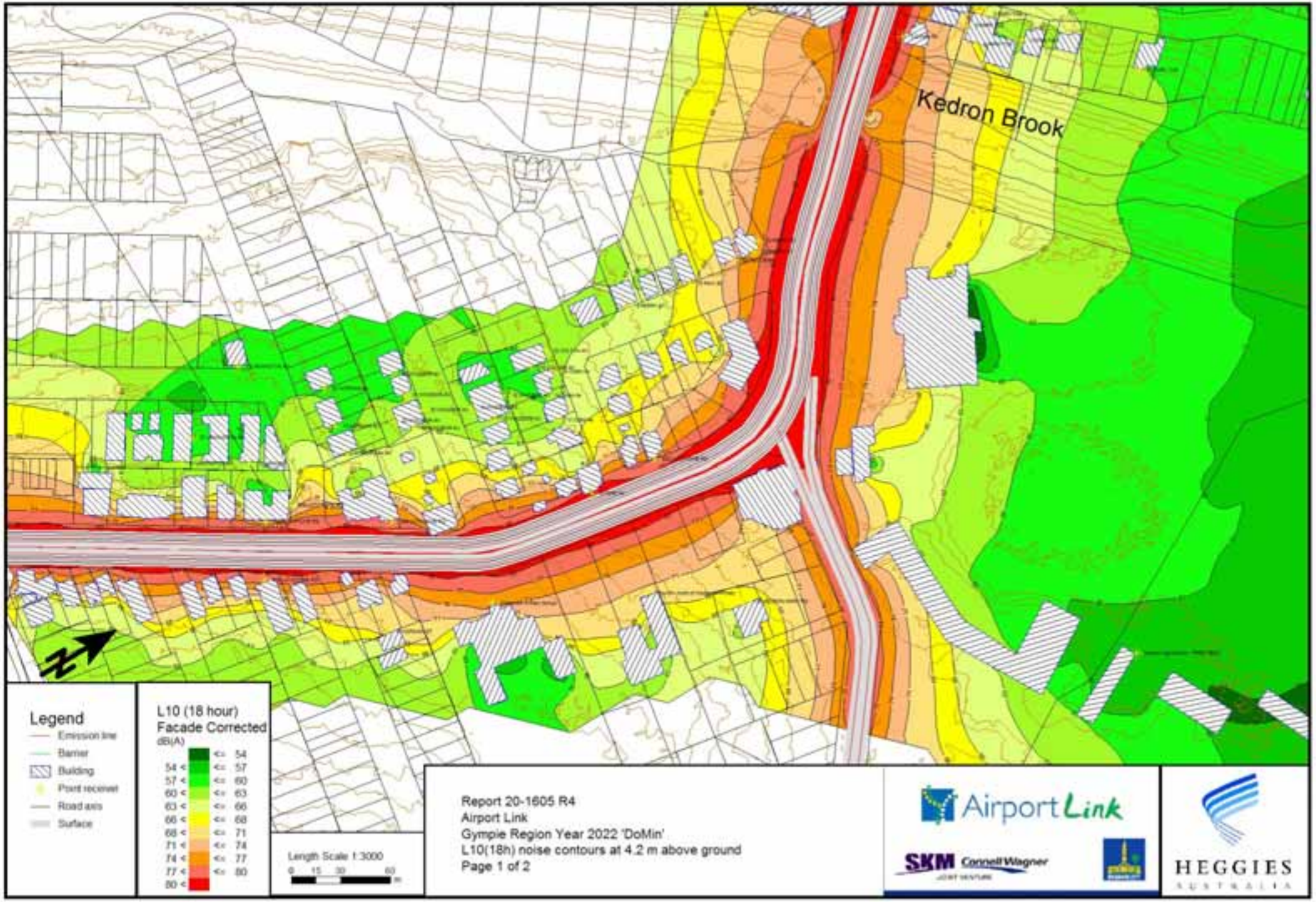
SKM Connell Wagner

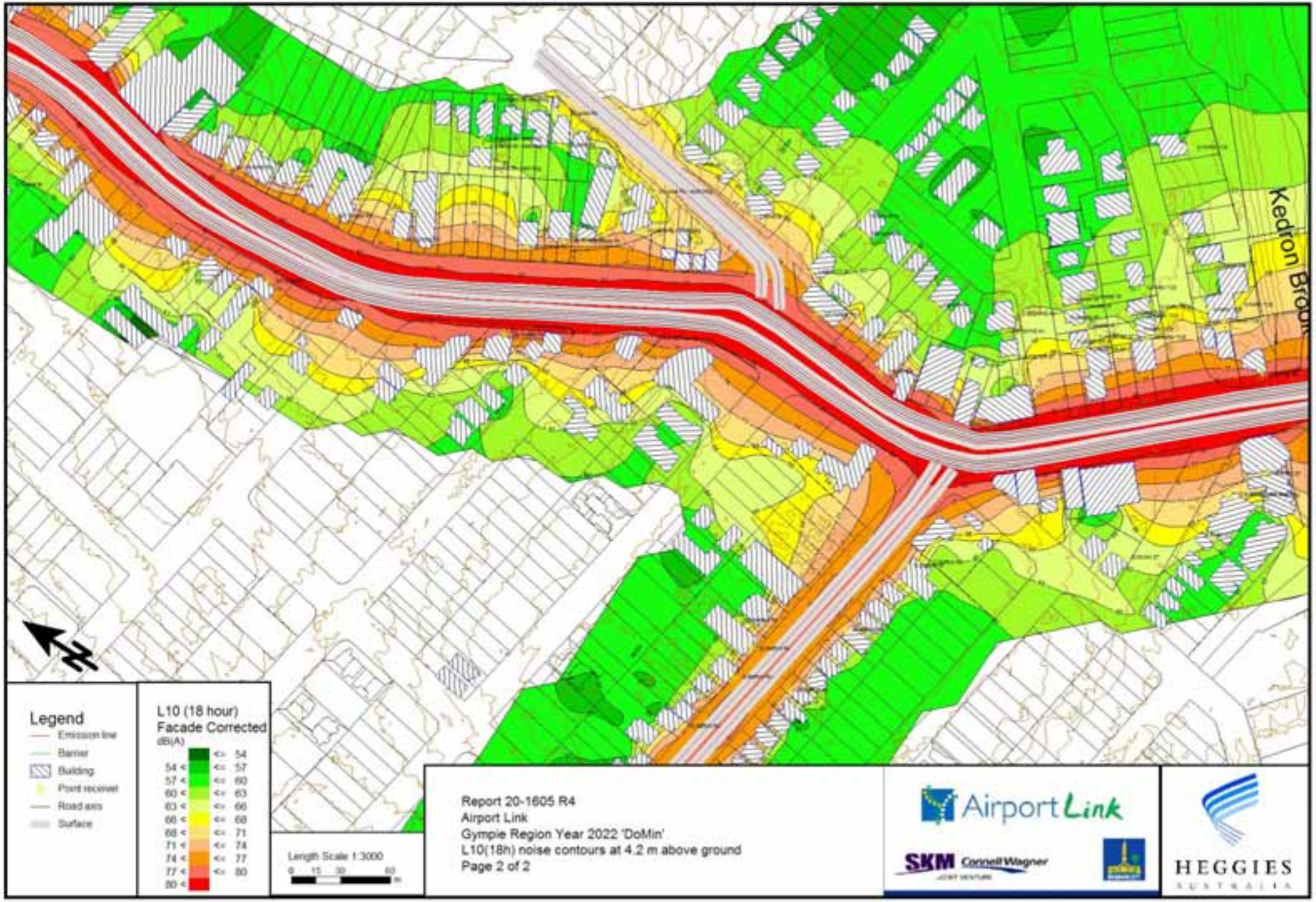
HEGGIES AUSTRALIA


Existing - 4m high barrier
NSBT Design - 8m high barrier
Legend
Emission line
New or Upgraded Barriers
Existing Barriers
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:4000
0 20 40 80
m
Report 20-1605 R4
Airport Link
Southern Region Year 2026 APL & Ultimate Busway - 63dBA Barrier Design
L10(18h) noise contours at 4.2 m above ground
Airport Link
SKM Connell Wagner
HEGGIES AUSTRALIA

Appendix K

Noise Contour Maps – Gympie Road Portal
Report 20-1605R4


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 'DoMin'
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2
Airport Link
SKM Connell Wagner
HEGGIES
AUSTRALIA


Kedron Brook
N
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
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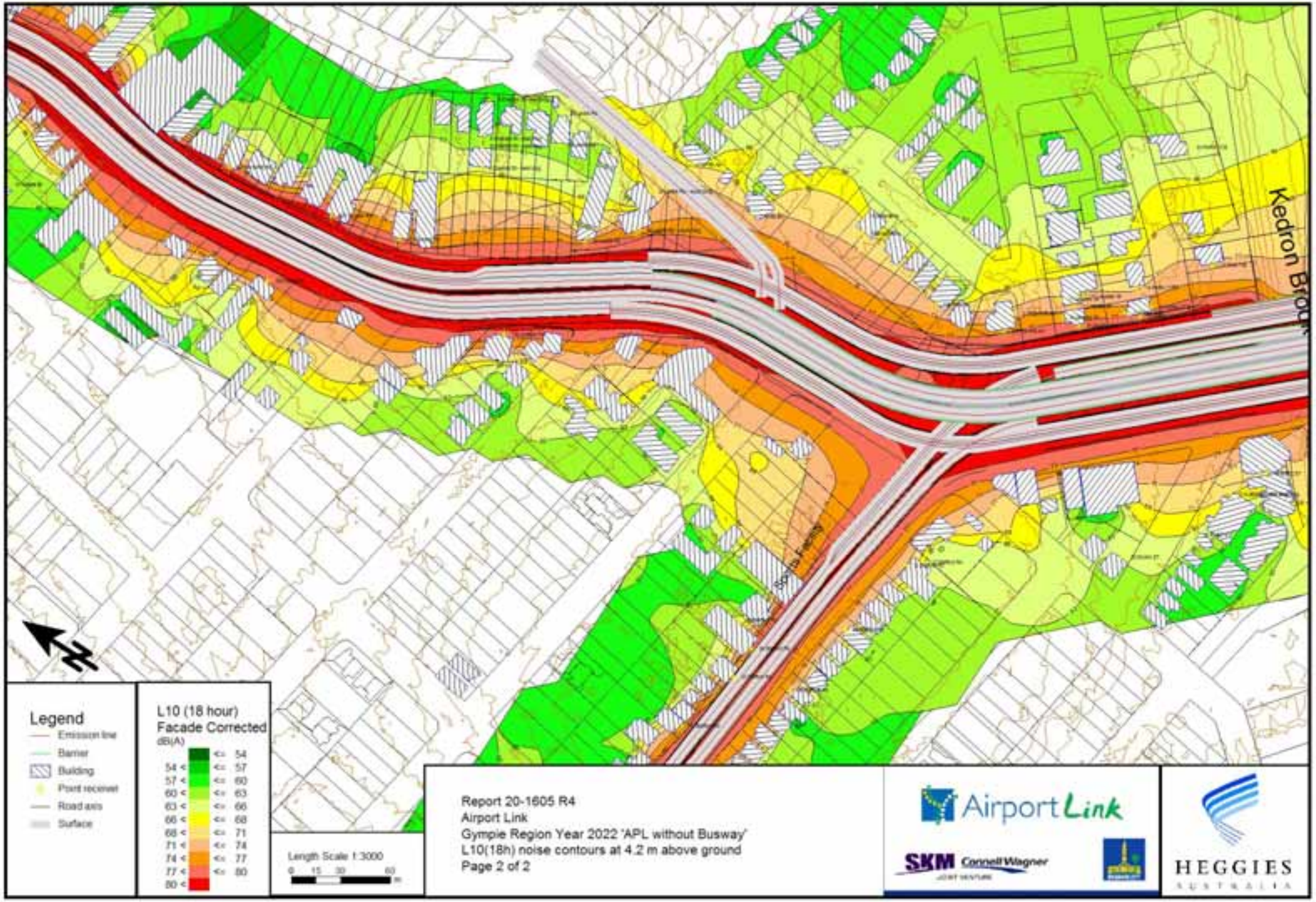
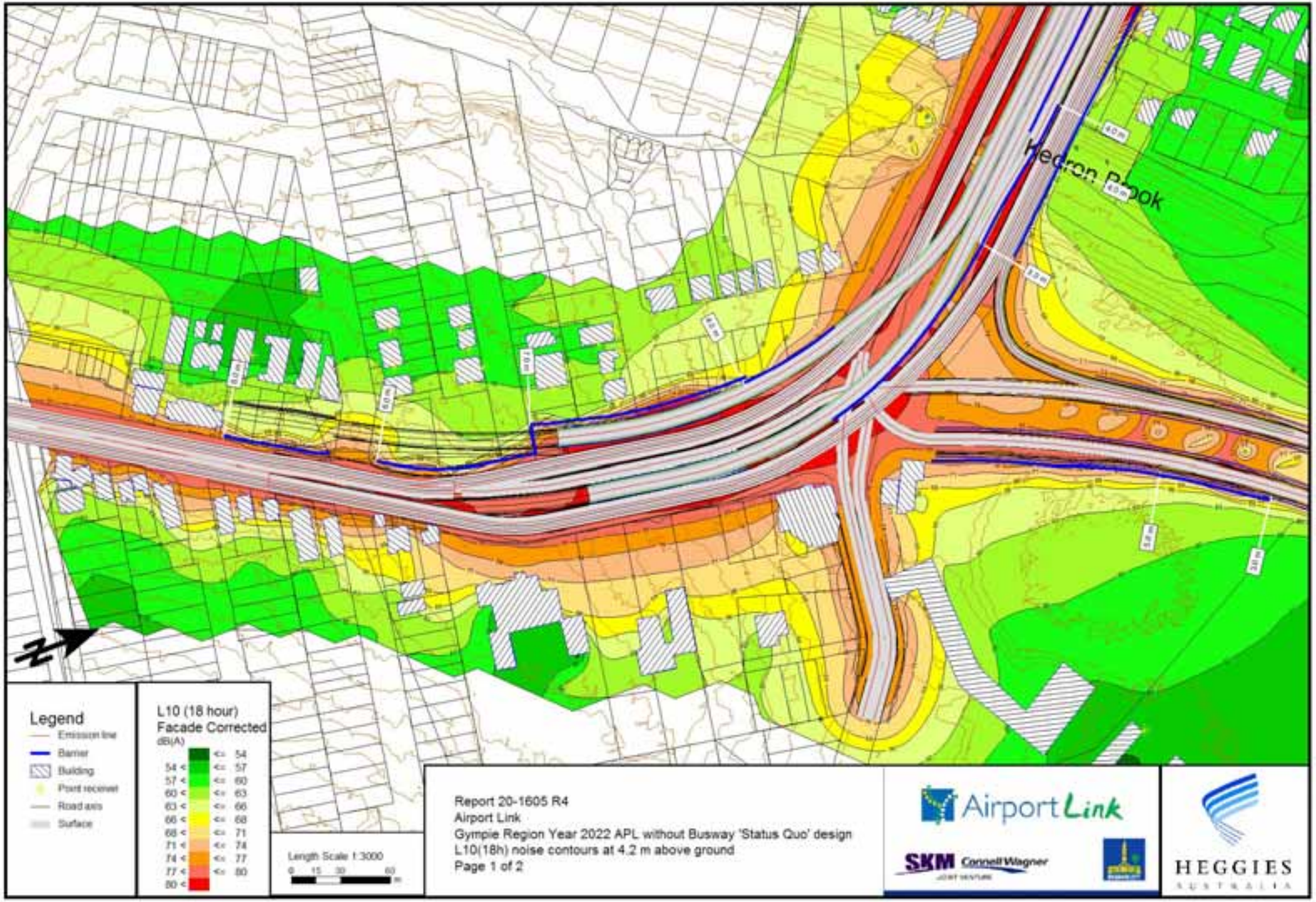
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 'DoMin'
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA

Kedron Brook
N
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
<= 54
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60
m
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 'APL without Busway'
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 'APL without Busway'
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA

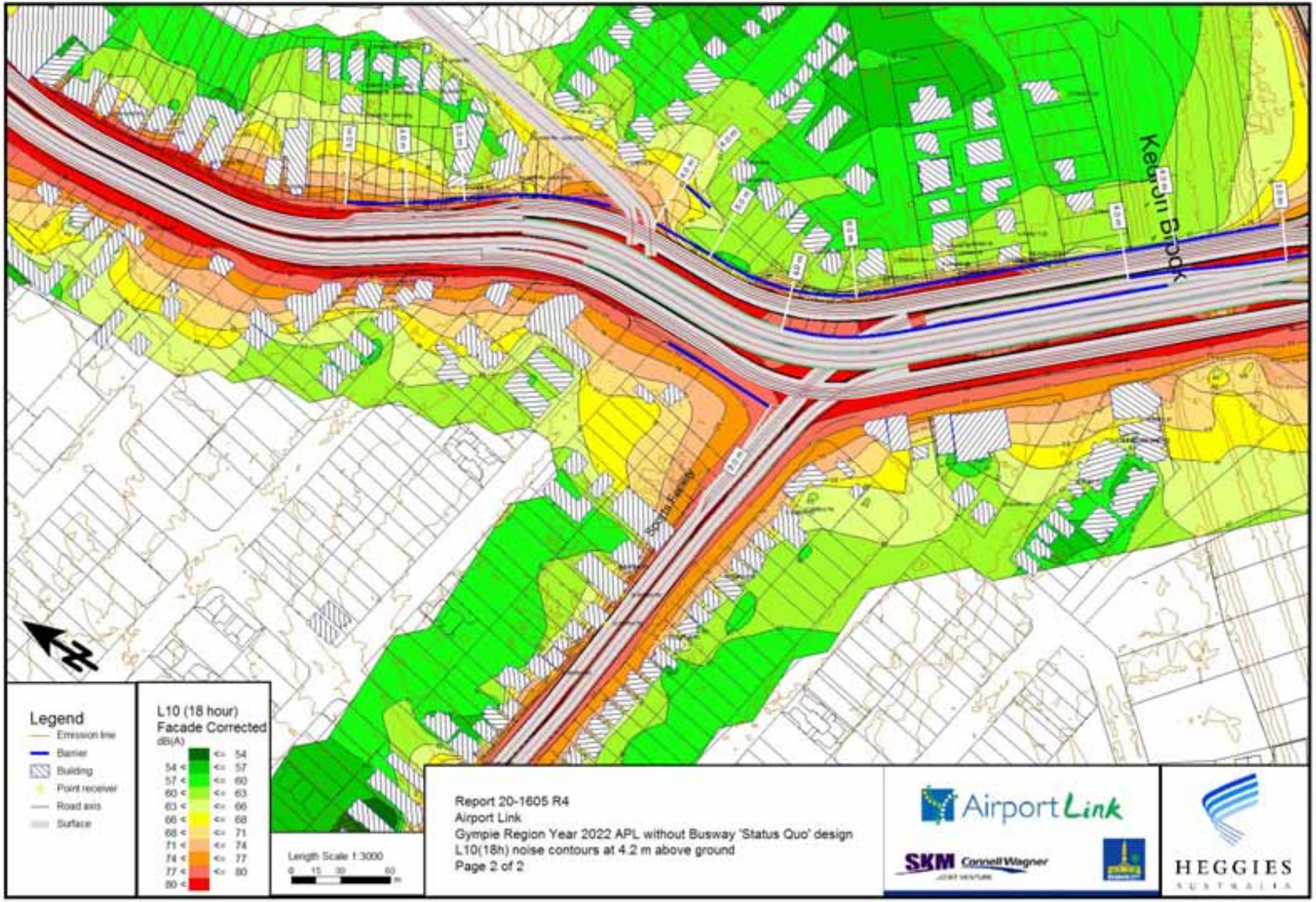


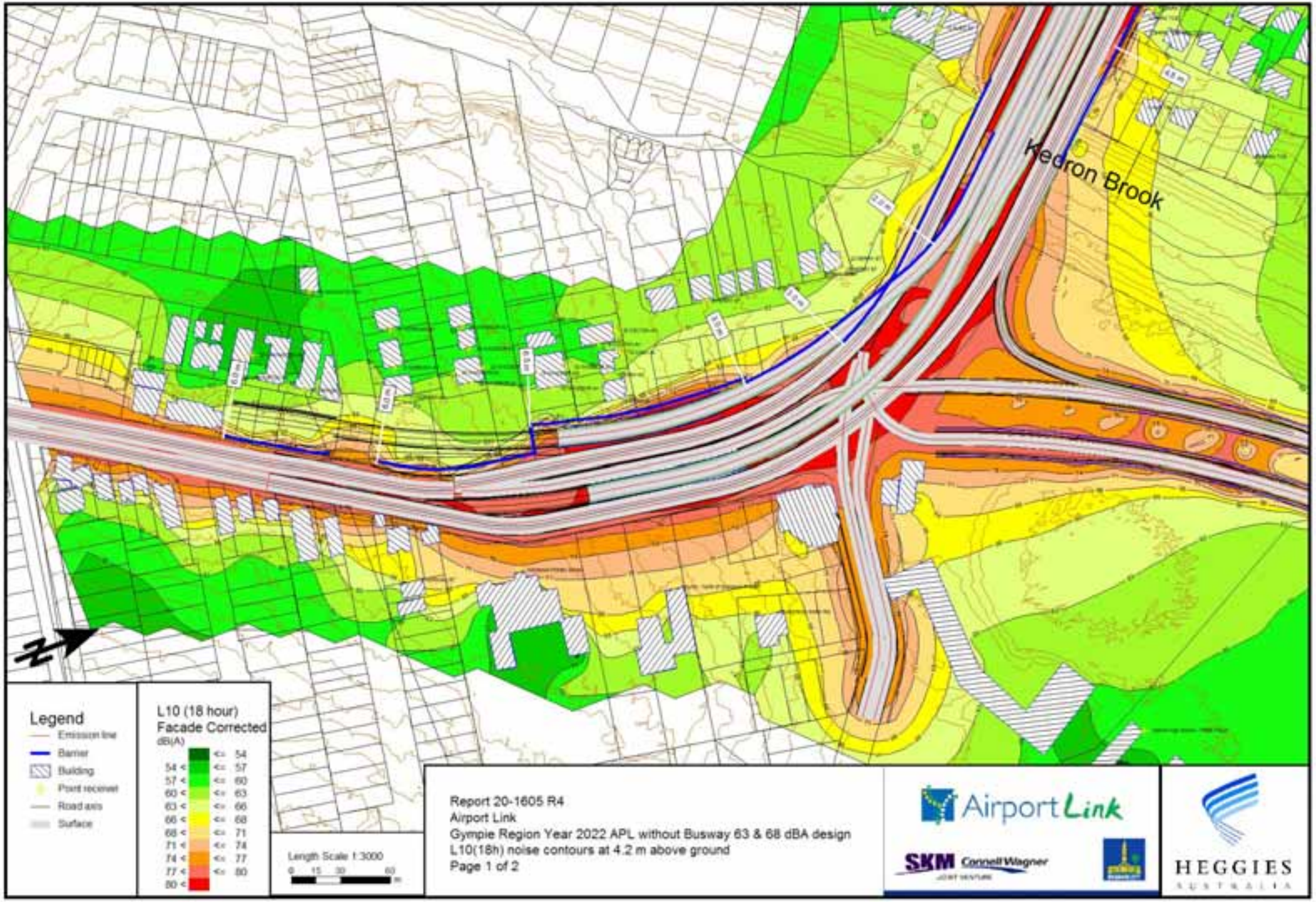
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 APL without Busway 'Status Quo' design
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2

Airport Link

SKM Connell Wagner JOINT VENTURE

HEGGIES AUSTRALIA


Kedron Brook
North Facing
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
<= 54
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 APL without Busway 'Status Quo' design
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
Airport Link
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA

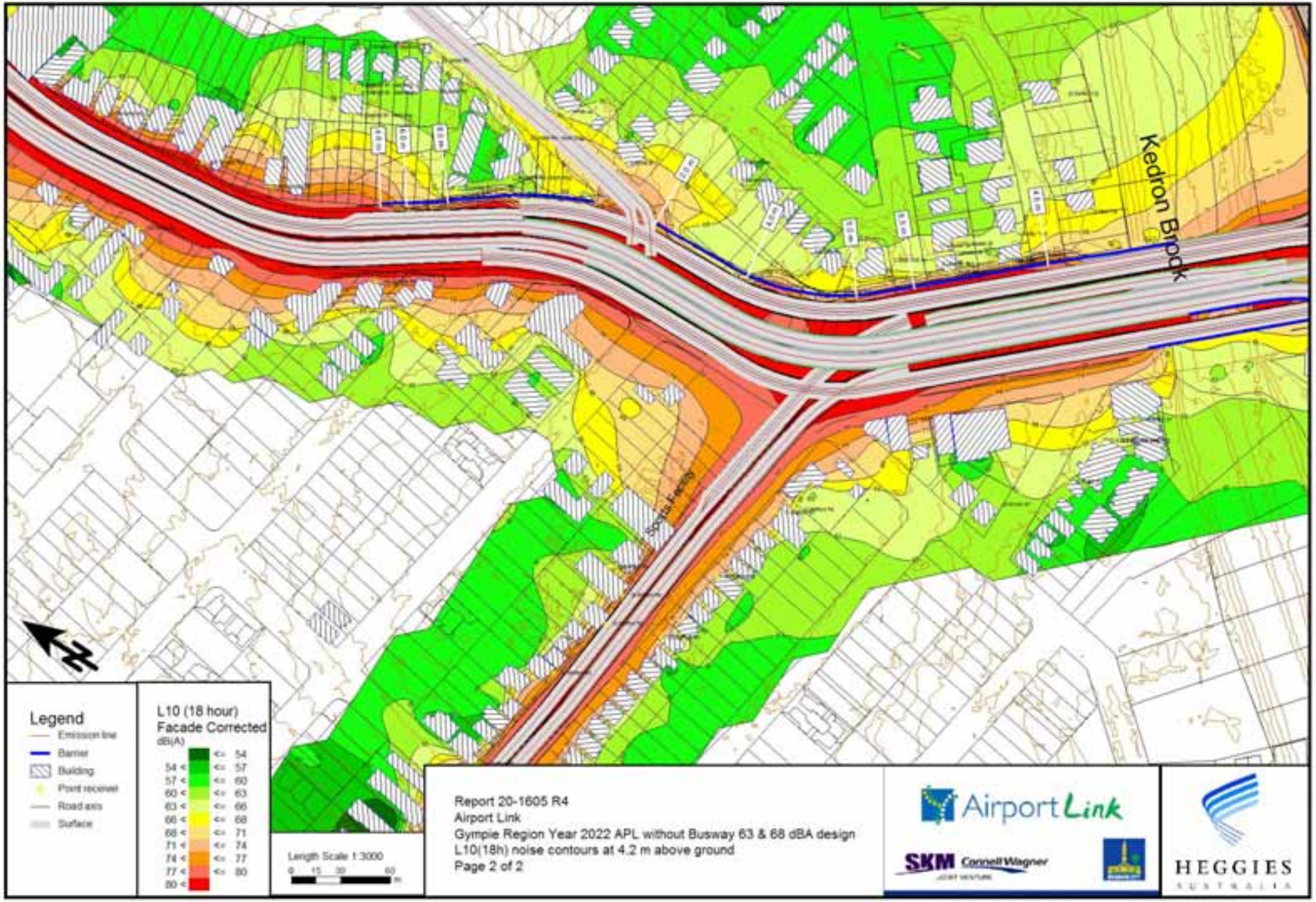


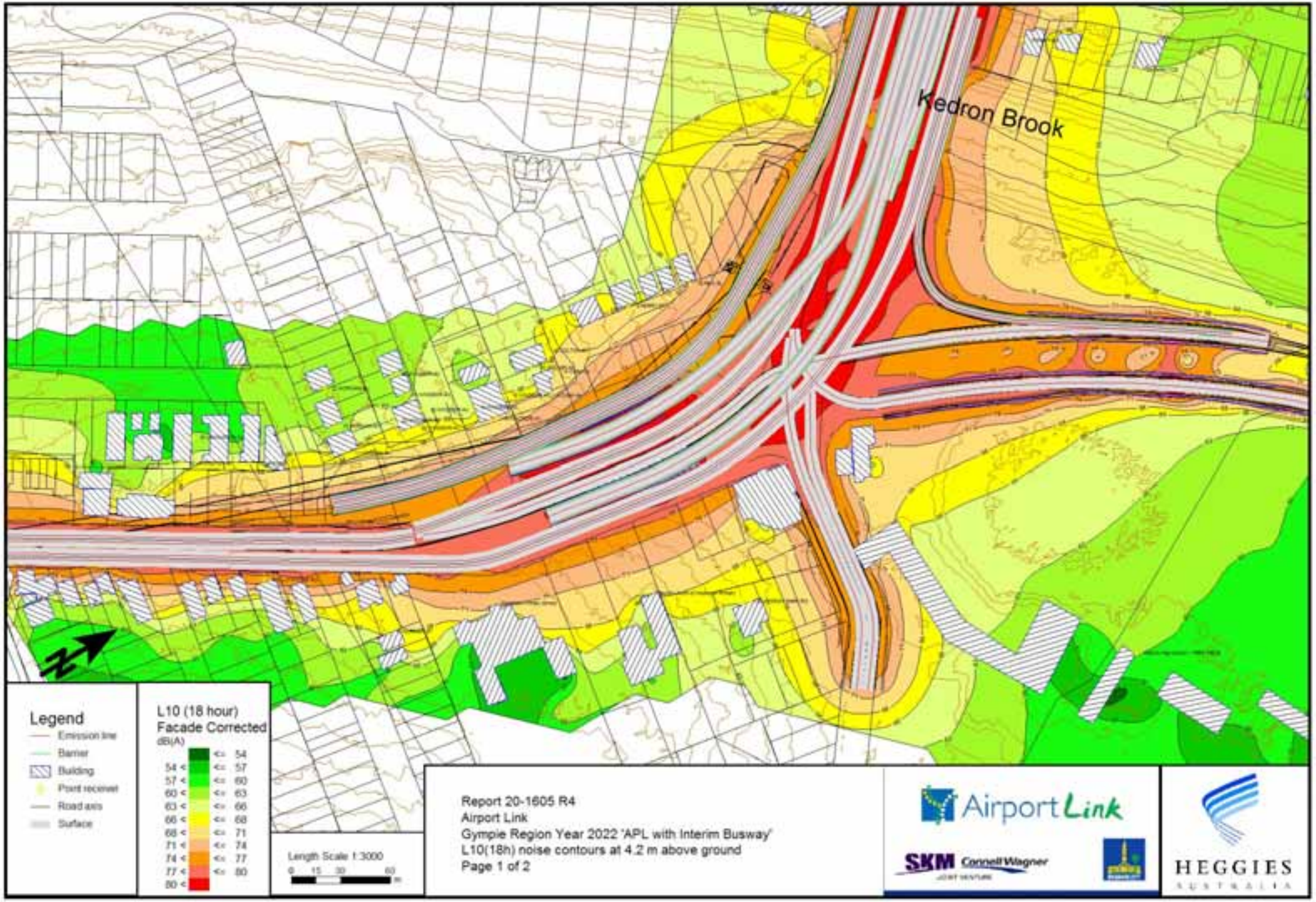
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 APL without Busway 63 & 68 dBA design
L10(18h) noise contours at 4.2 m above ground

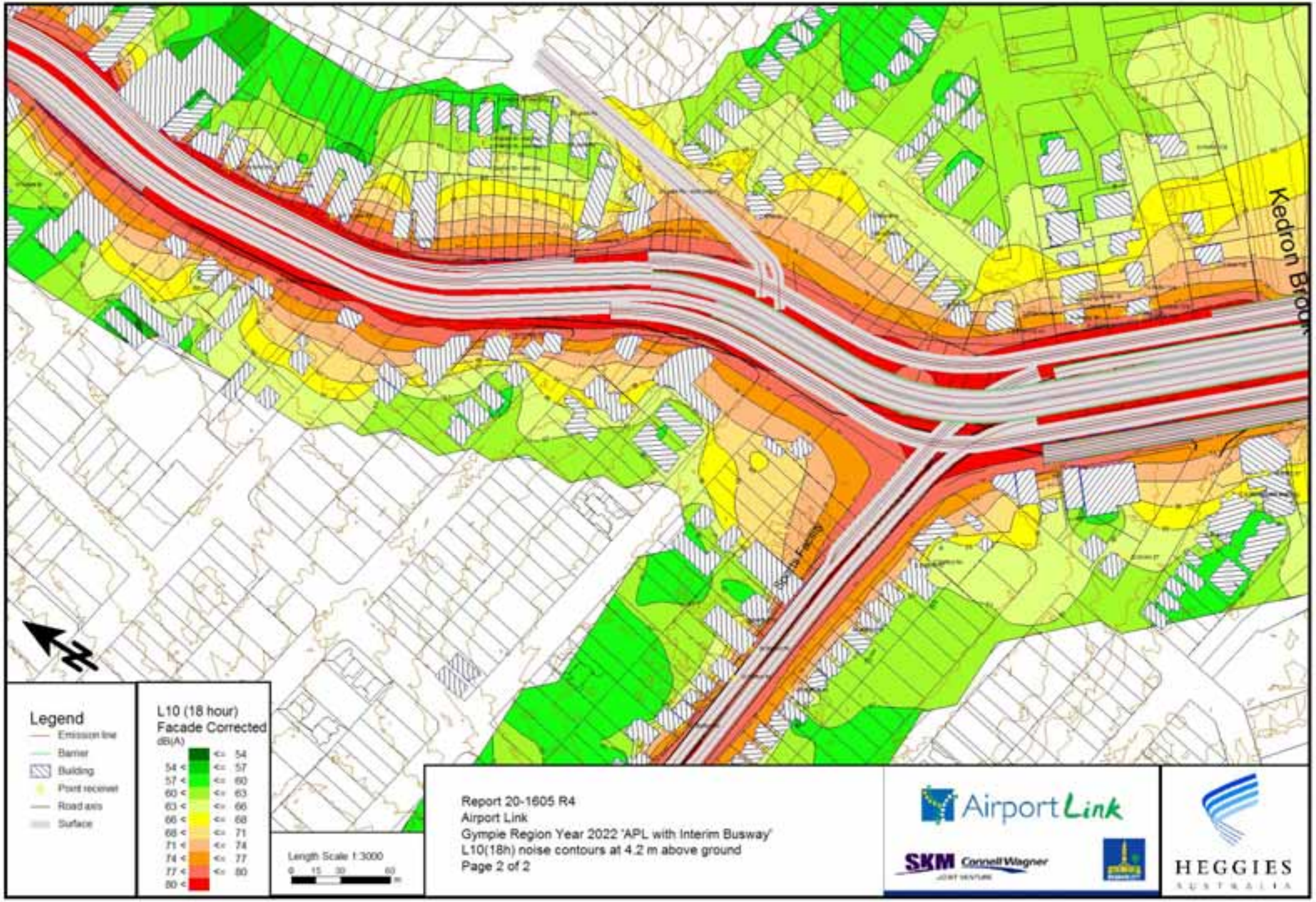
Airport Link

SKM Connell Wagner
JOINT VENTURE

HEGGIES
AUSTRALIA


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60
m
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 APL without Busway 63 & 68 dBA design
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA


Kedron Brook
N
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
<= 54
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60
m
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 'APL with Interim Busway'
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
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60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
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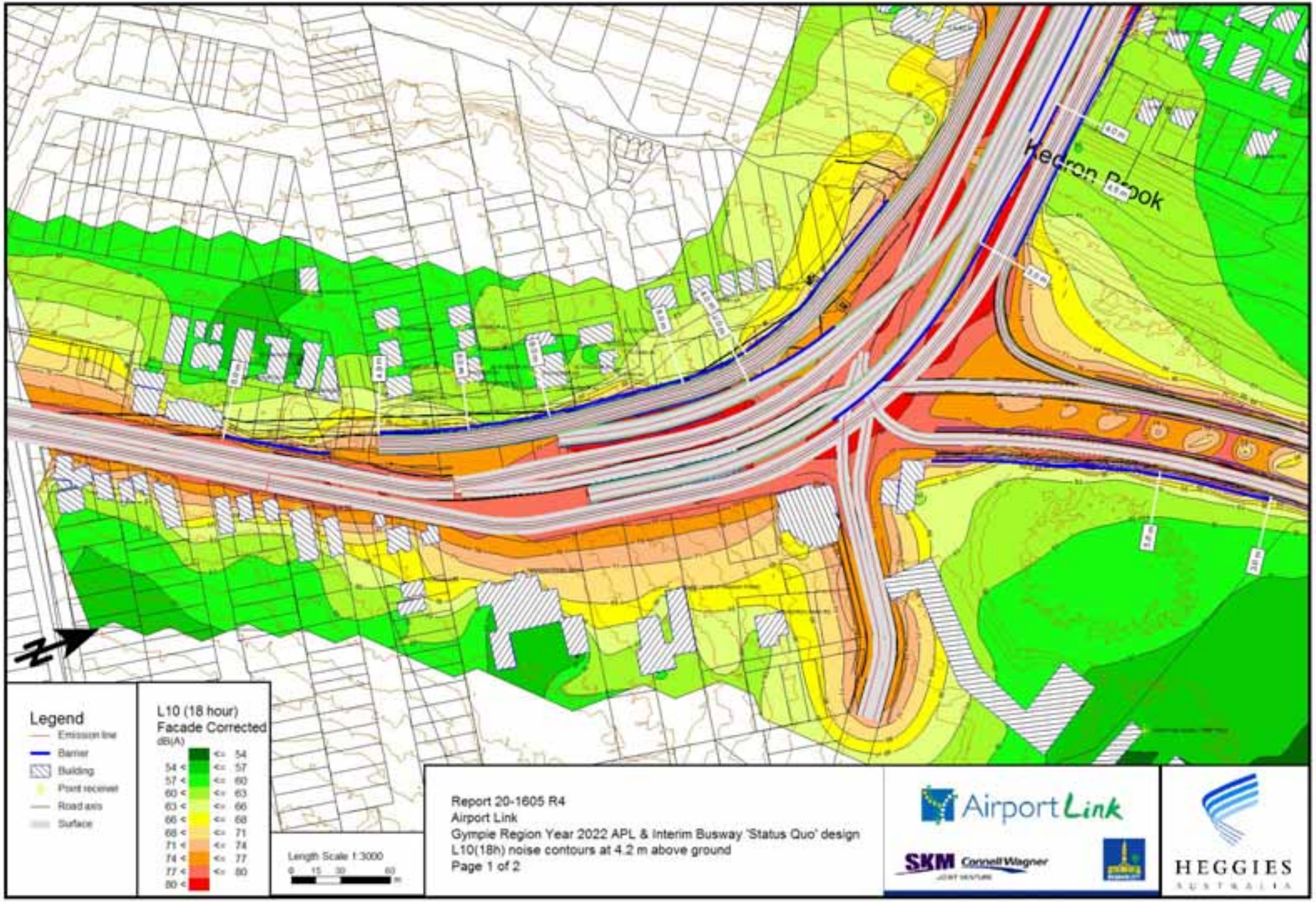
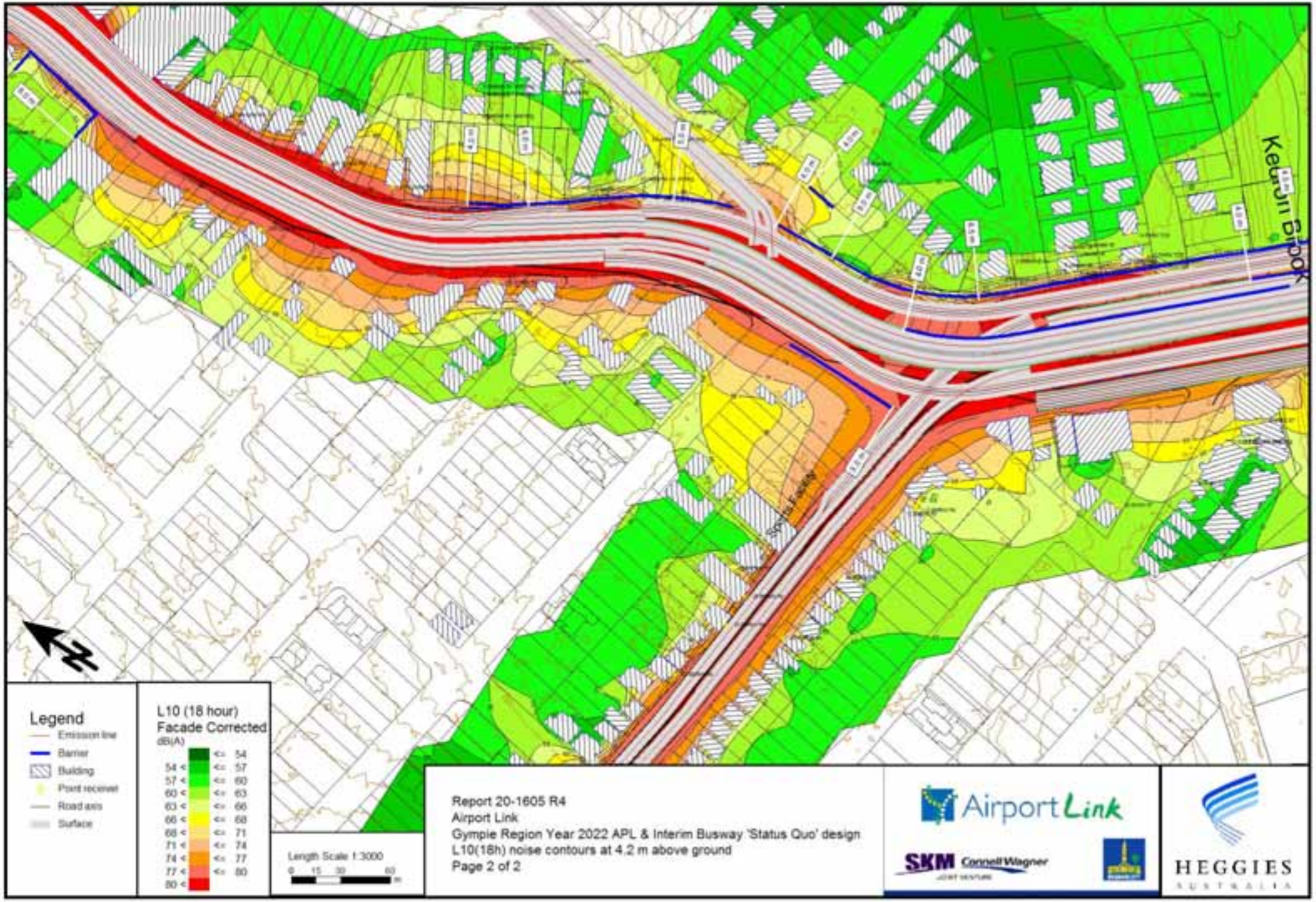
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 'APL with Interim Busway'
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA



Report 20-1605 R4
Airport Link
Gympie Region Year 2022 APL & Interim Busway 'Status Quo' design
L10(18h) noise contours at 4.2 m above ground

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
<= 54
54 < <= 57
57 < <= 60
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63 < <= 66
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74 < <= 77
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Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 APL & Interim Busway 'Status Quo' design
L10(18h) noise contours at 4.2 m above ground
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AirportLink
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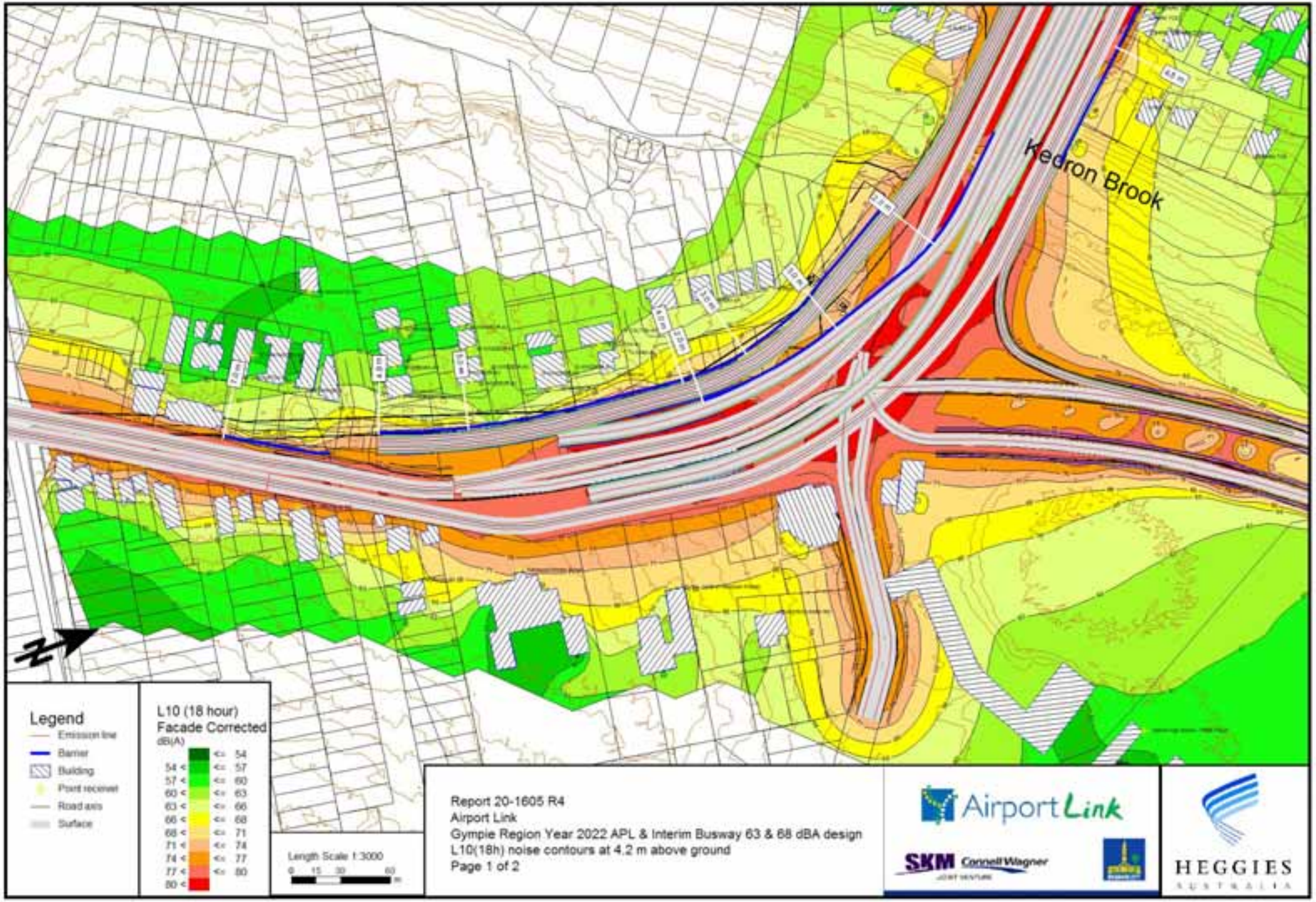
HEGGIES
AUSTRALIA

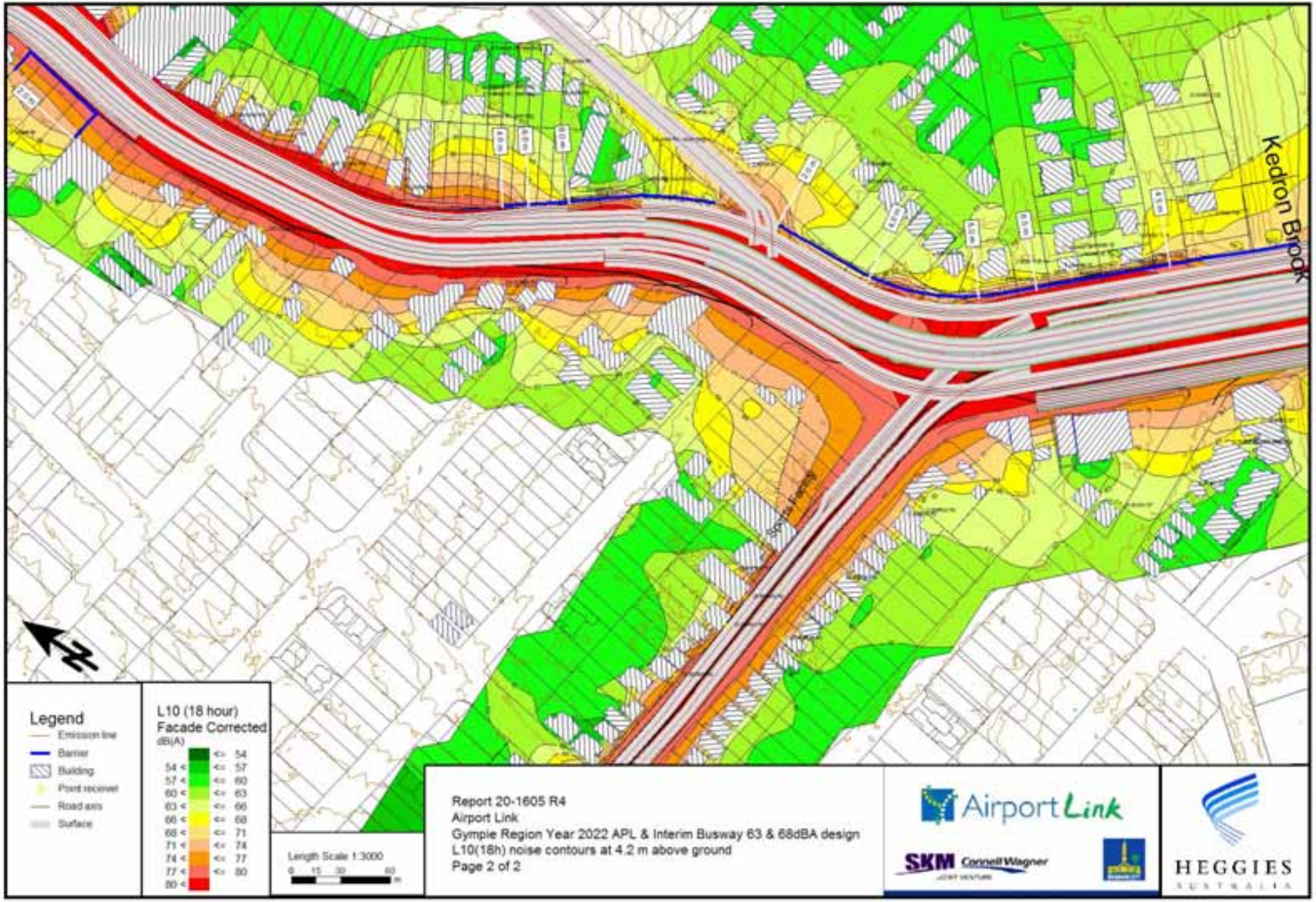


Report 20-1605 R4
Airport Link
Gympie Region Year 2022 APL & Interim Busway 63 & 68 dBA design
L10(18h) noise contours at 4.2 m above ground

Airport Link

SKM Connell Wagner JOINT VENTURE

HEGGIES AUSTRALIA


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
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74 < <= 77
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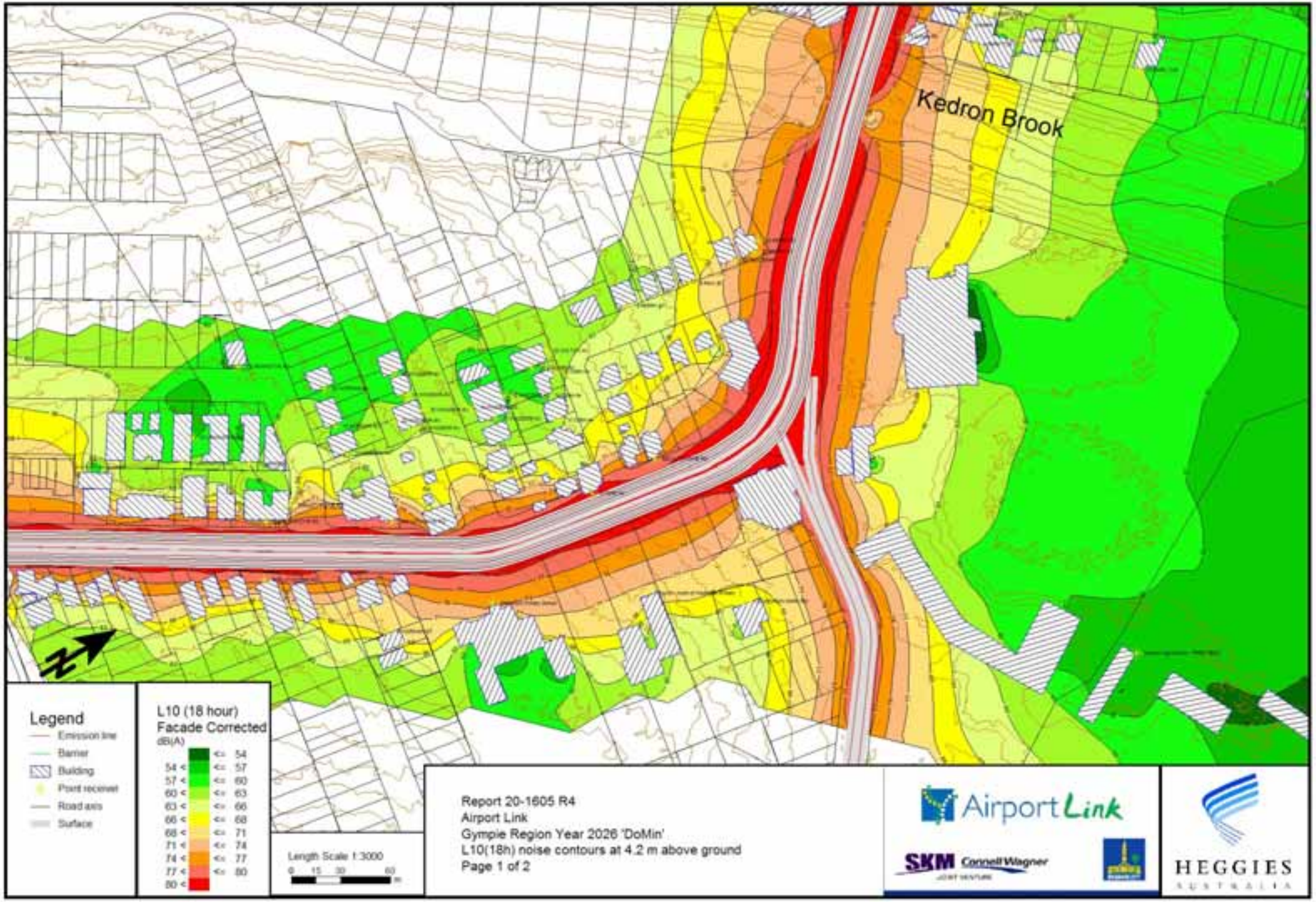
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2022 APL & Interim Busway 63 & 68dBA design
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
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74 < <= 77
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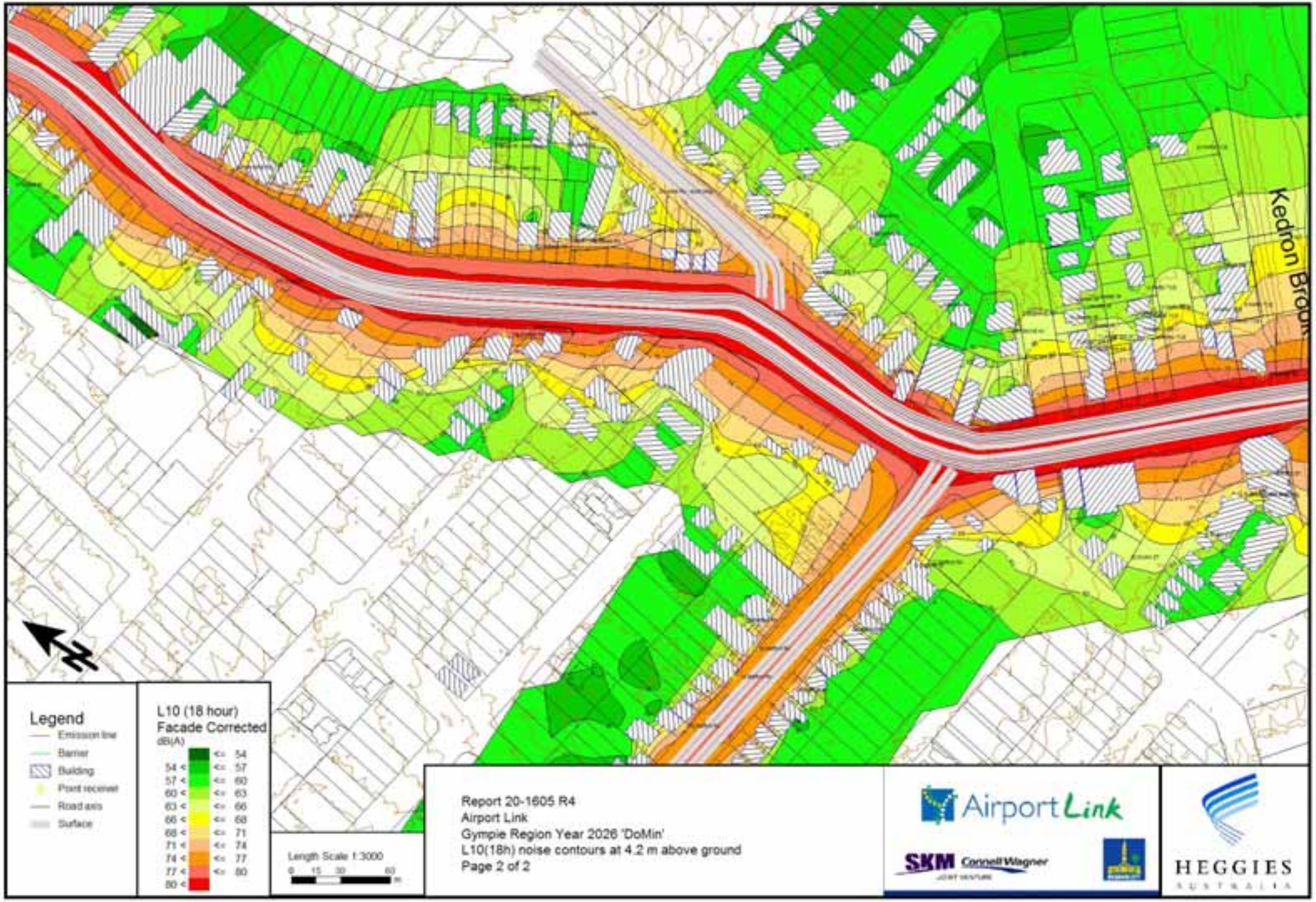
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2026 'DoMin'
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA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Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
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54 < <= 57
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80 <
Length Scale 1:3000
0 15 30 60
m
Report 20-1605 R4
Airport Link
Gympie Region Year 2026 'DoMin'
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA

Kedron Brook
N
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
<= 54
54 < <= 57
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68 < <= 71
71 < <= 74
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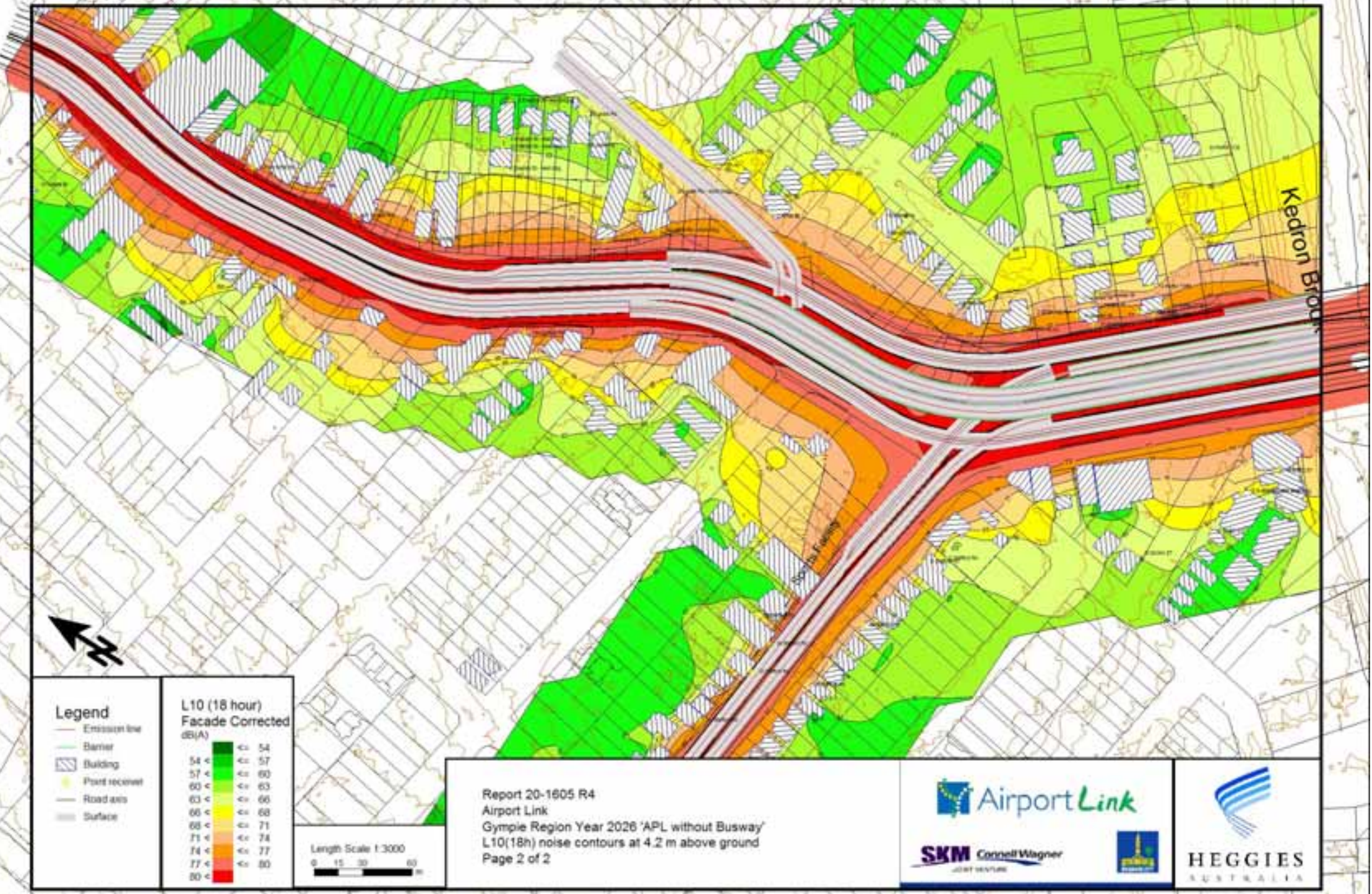
Length Scale 1:3000
0 15 30 60
m
Report 20-1605 R4
Airport Link
Gympie Region Year 2026 'APL without Busway'
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA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Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
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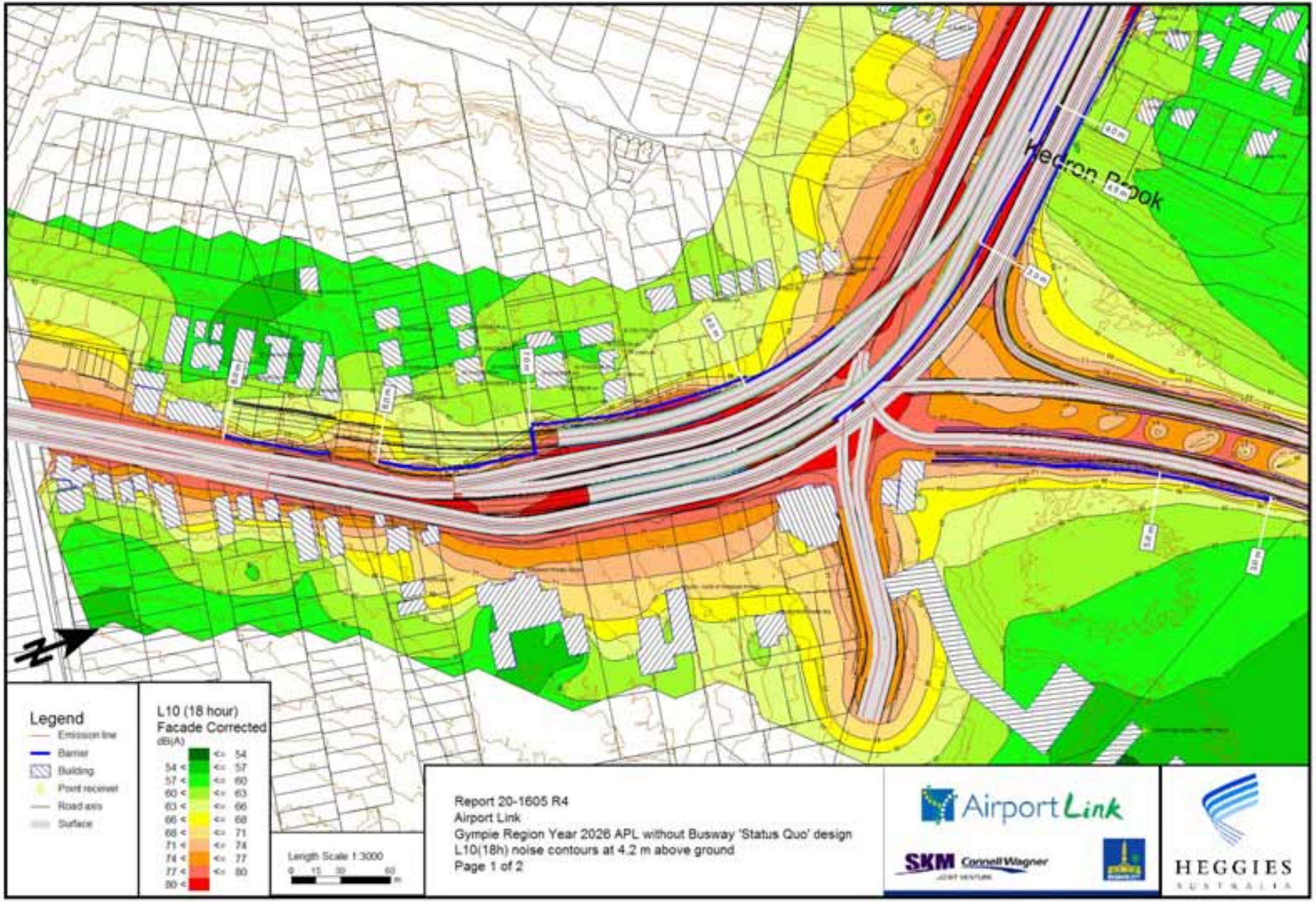
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2026 'APL without Busway'
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA



Report 20-1605 R4
Airport Link
Gympie Region Year 2026 APL without Busway 'Status Quo' design
L10(18h) noise contours at 4.2 m above ground
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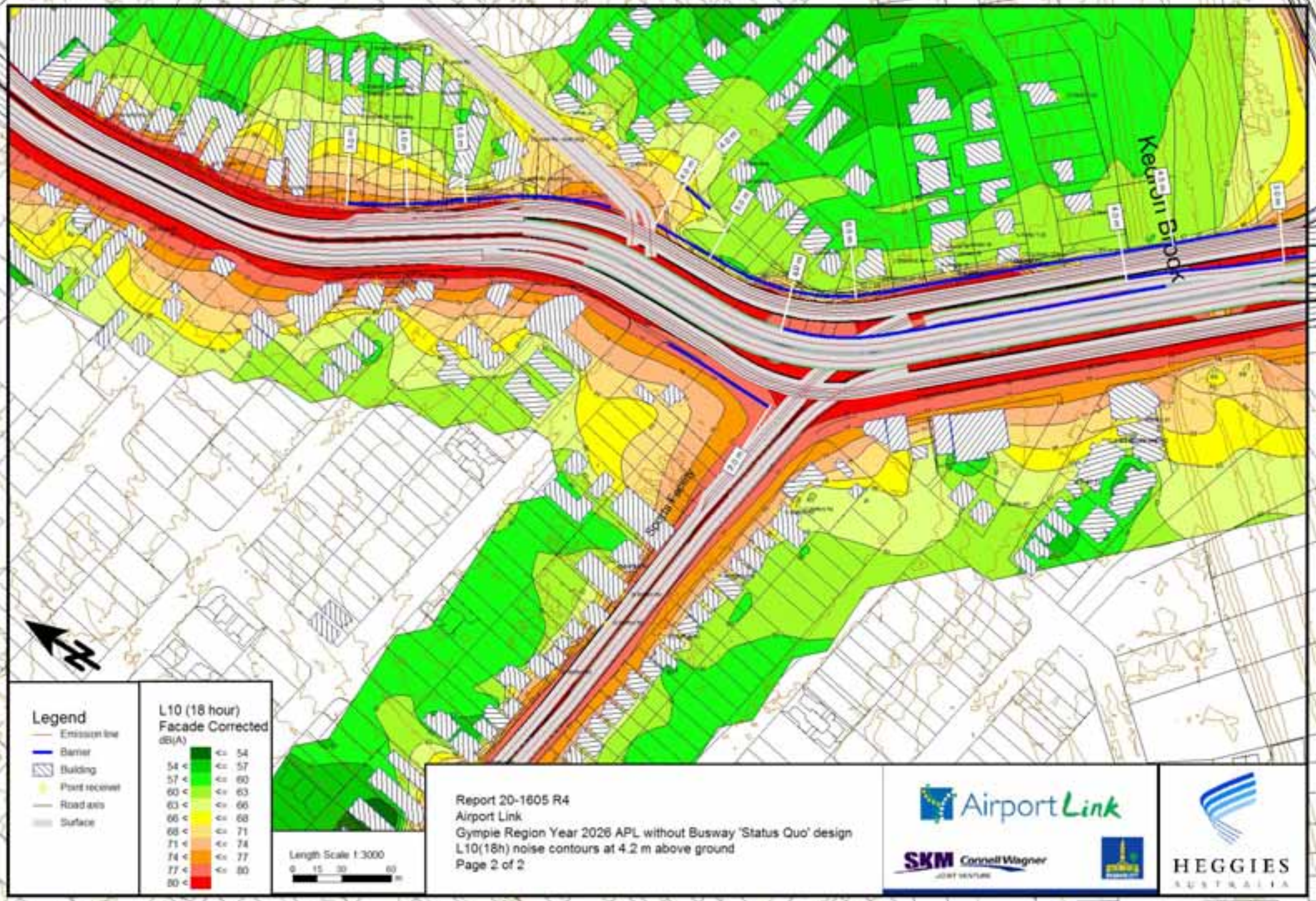
Airport Link

SKM Connell Wagner JOINT VENTURE

HEGGIES AUSTRALIA


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
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60 < <= 63
63 < <= 66
66 < <= 68
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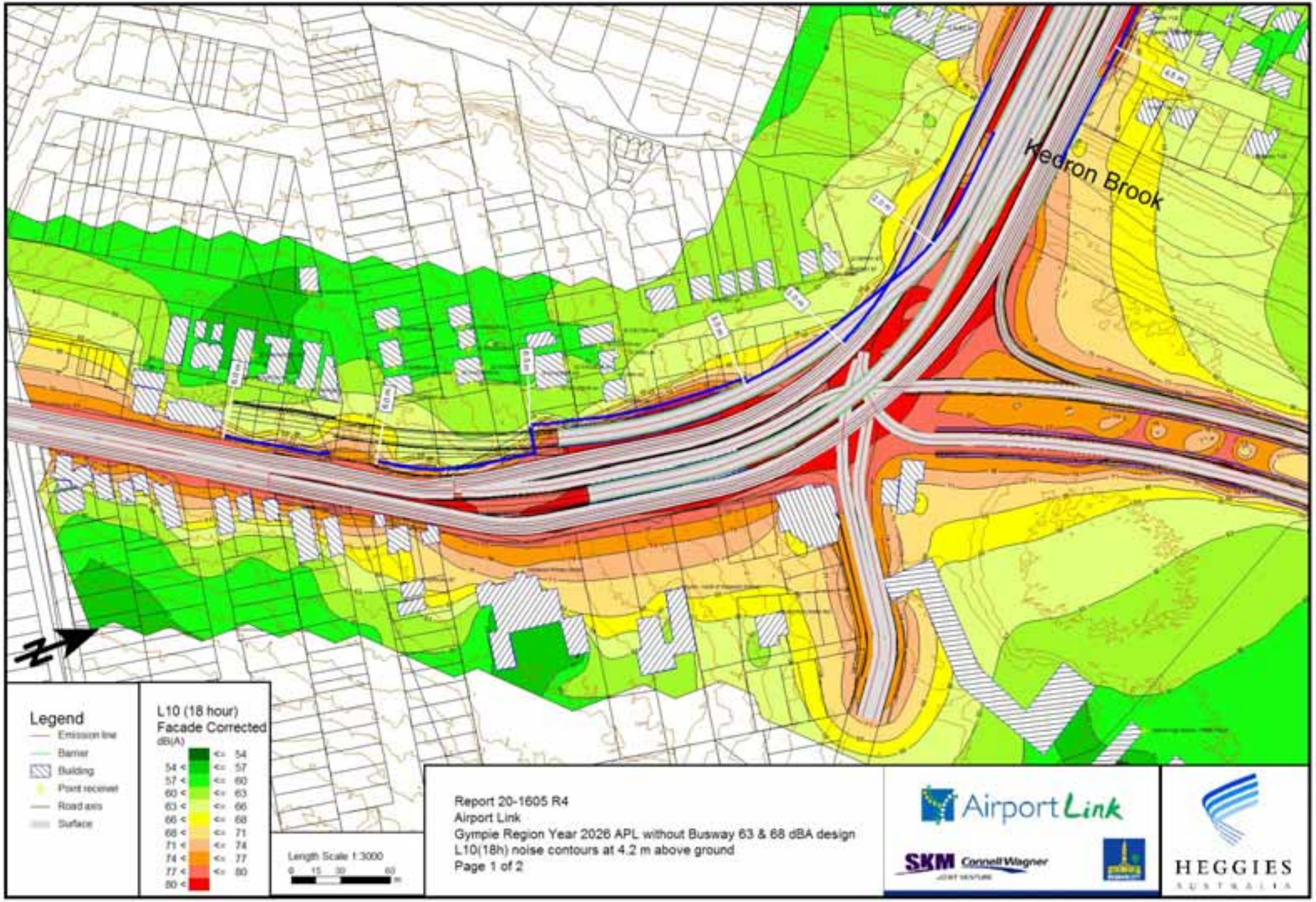
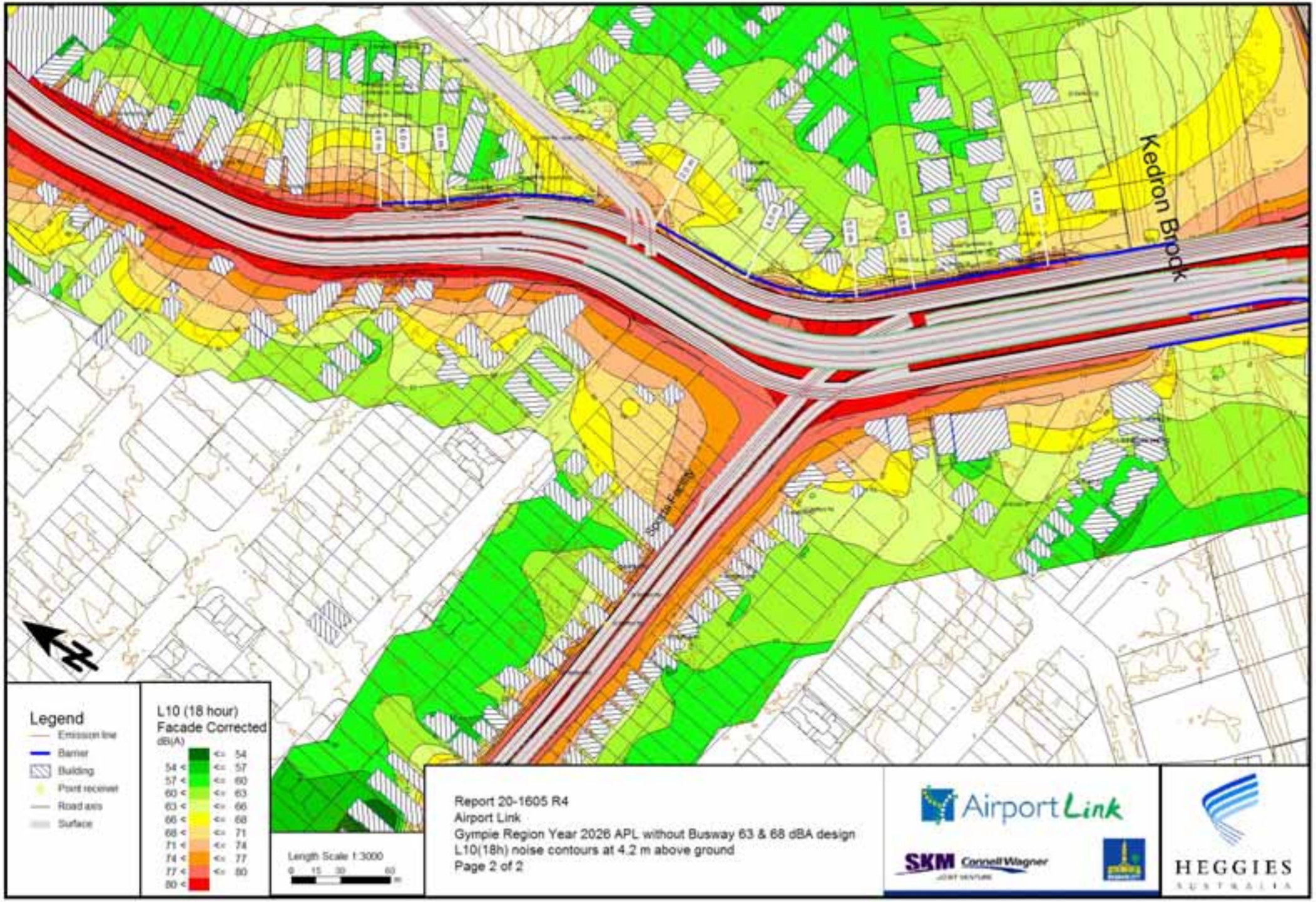
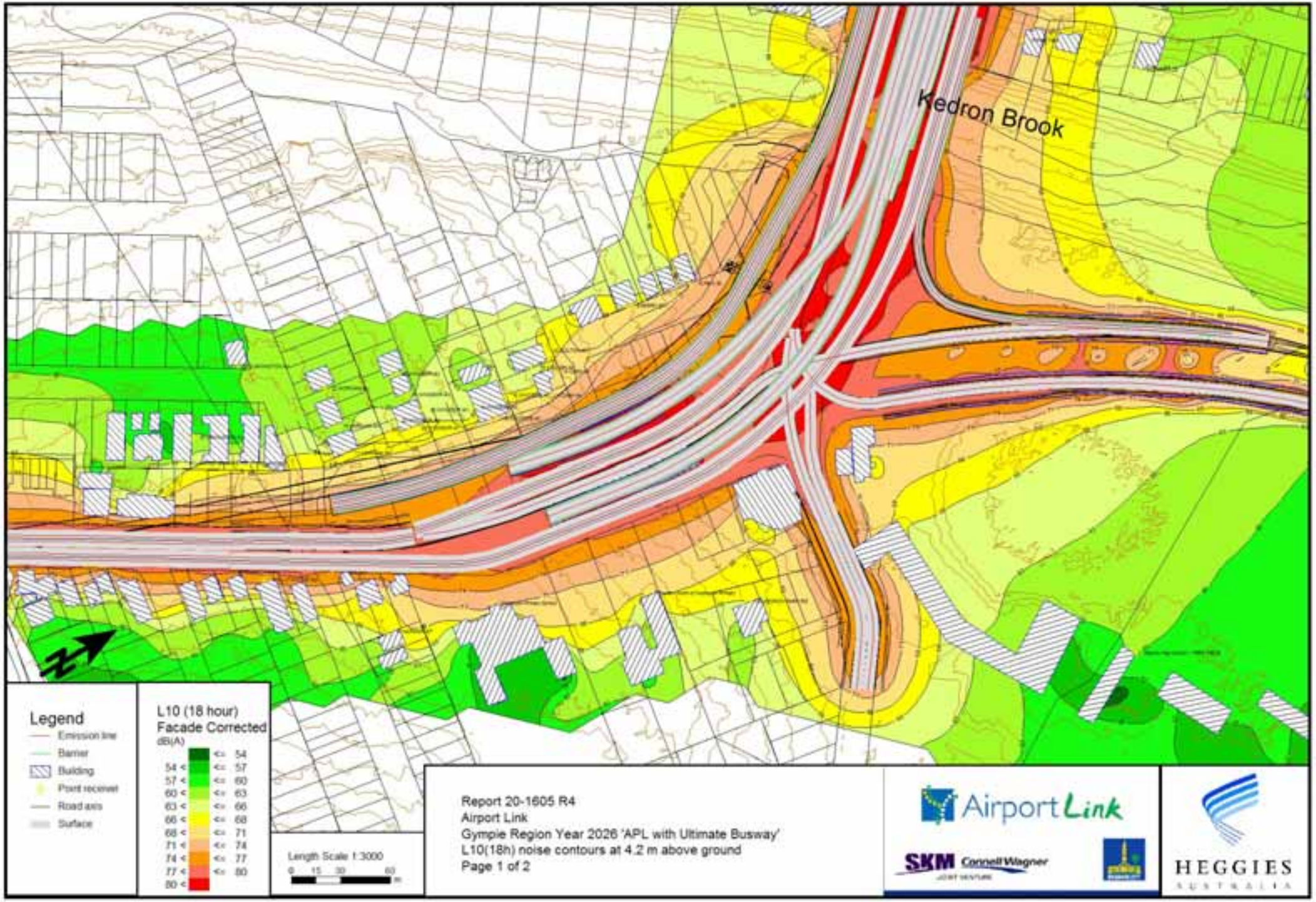
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2026 APL without Busway 'Status Quo' design
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA



Report 20-1605 R4
Airport Link
Gympie Region Year 2026 APL without Busway 63 & 68 dBA design
L10(18h) noise contours at 4.2 m above ground

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA


Kedron Brook
North Pine River
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
<= 54
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2026 APL without Busway 63 & 68 dBA design
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
<= 54
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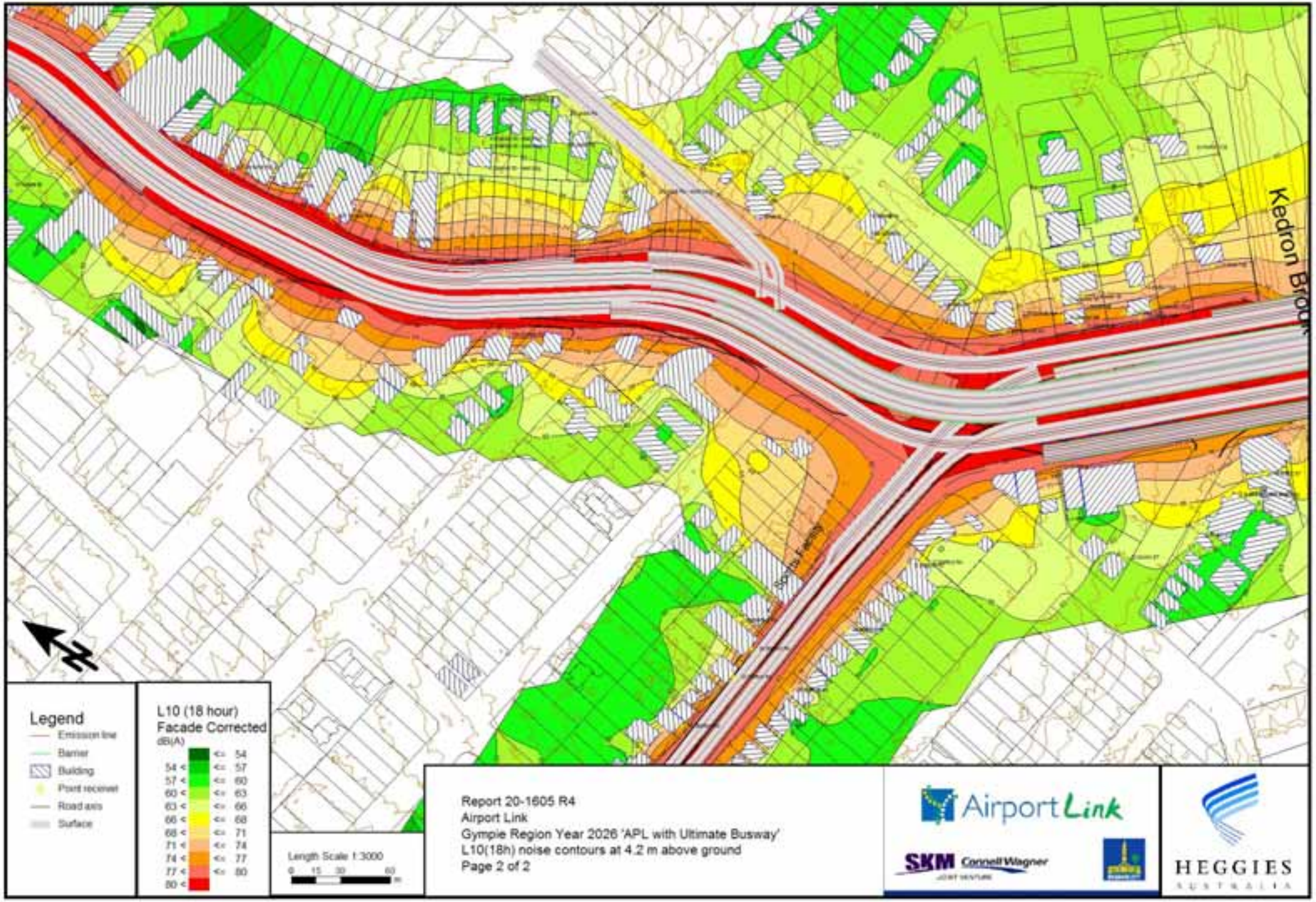
66 < <= 68
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60
m
Report 20-1605 R4
Airport Link
Gympie Region Year 2026 'APL with Ultimate Busway'
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2
Airport Link
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
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77 < <= 80
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Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2026 'APL with Ultimate Busway'
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA

Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
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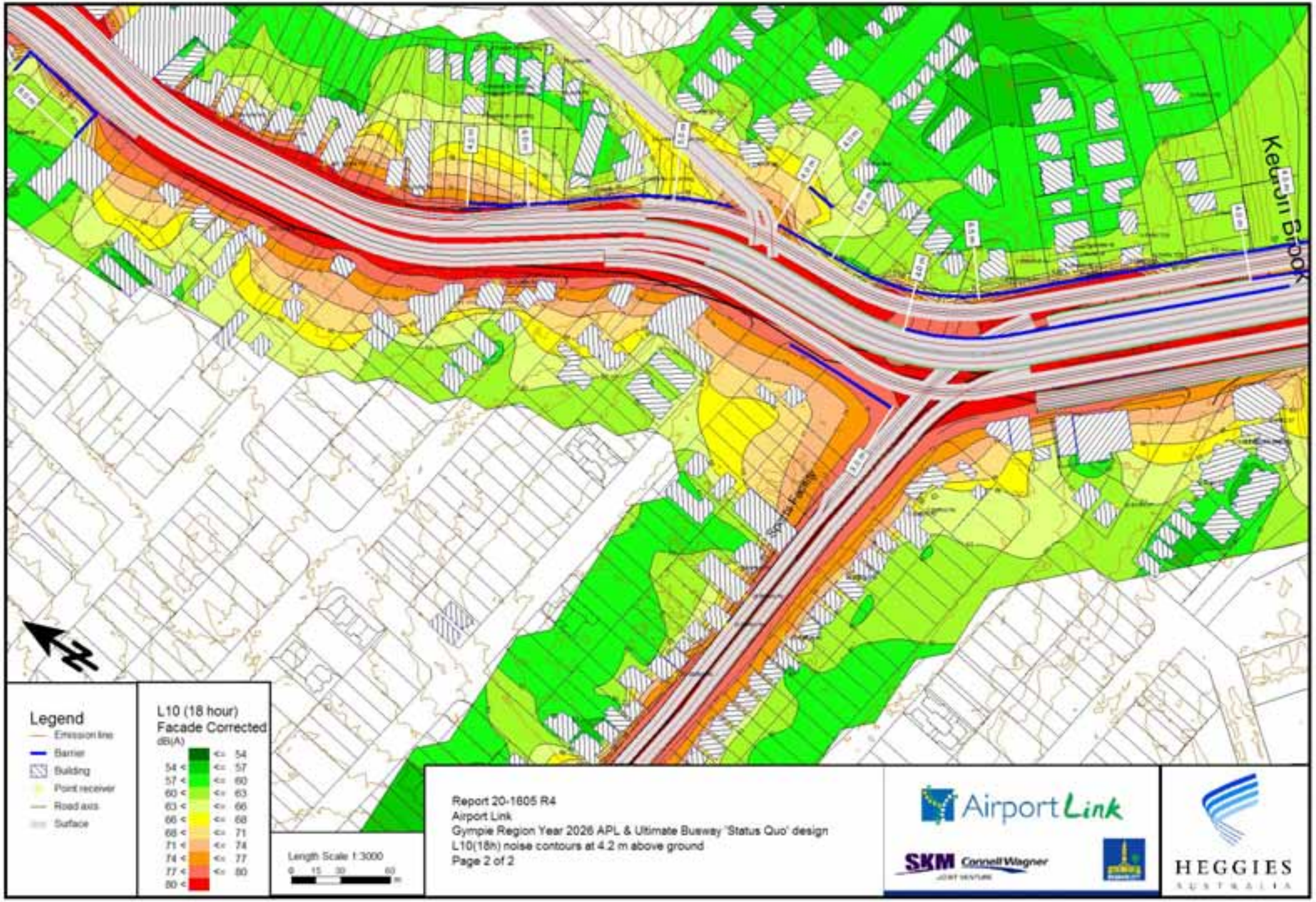
68 < <= 71
71 < <= 74
74 < <= 77
77 < <= 80
80 <
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2026 APL & Ultimate Busway 'Status Quo' design
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
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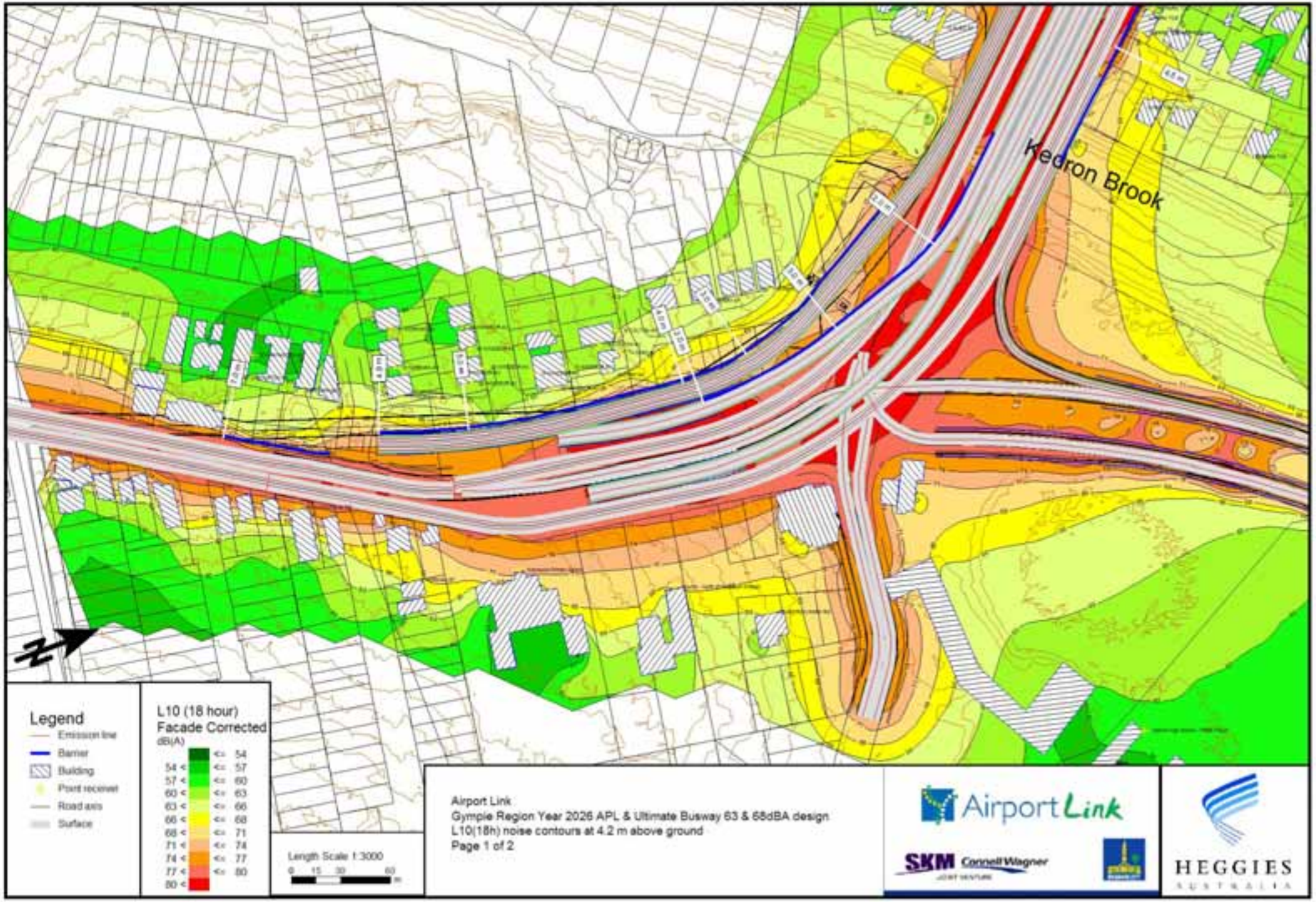
Length Scale 1:3000
0 15 30 60 m
Report 20-1605 R4
Airport Link
Gympie Region Year 2026 APL & Ultimate Busway 'Status Quo' design
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA


Kedron Brook
Legend
Emission line
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
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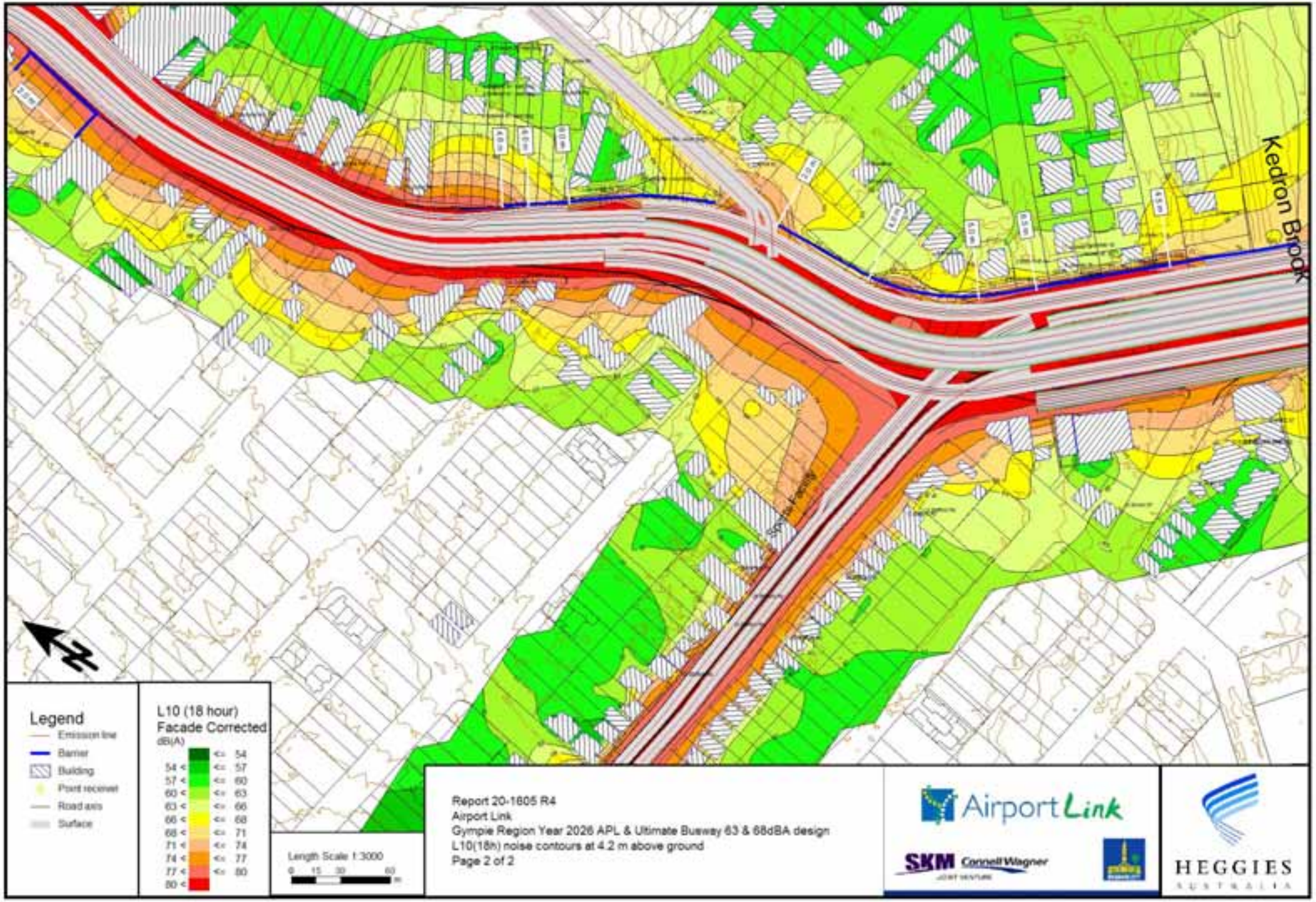
80 <
Length Scale 1:3000
0 15 30 60
m
Airport Link
Gympie Region Year 2026 APL & Ultimate Busway 63 & 68dBA design
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2
AirportLink
SKM Connell Wagner
JOINT VENTURE
HEGGIES
AUSTRALIA



Report 20-1605 R4
Airport Link
Gympie Region Year 2026 APL & Ultimate Busway 63 & 68dBA design
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2

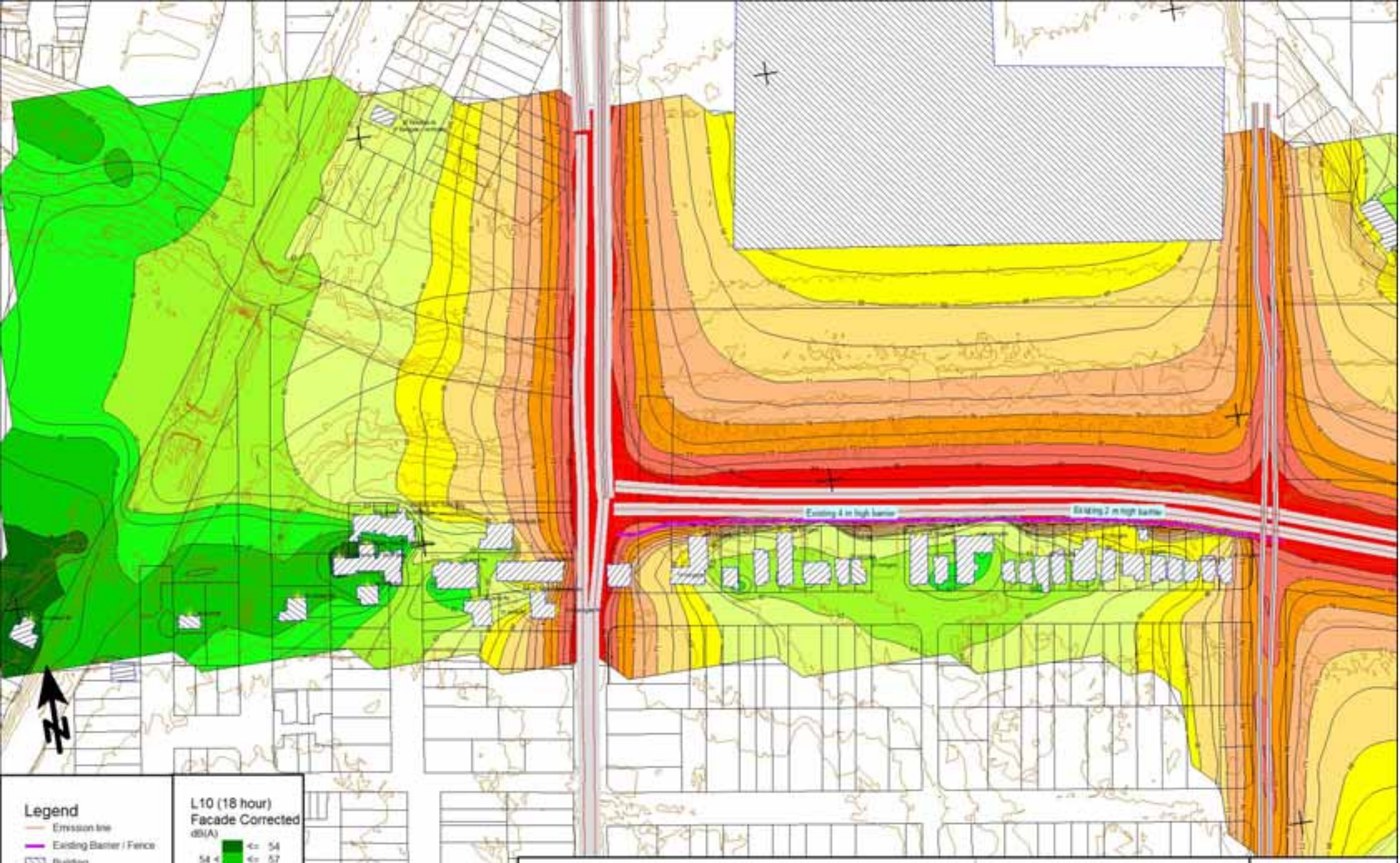
Airport Link

SKM Connell Wagner JOINT VENTURE

HEGGIES AUSTRALIA

Appendix L

Noise Contours Sandgate Road Portal
Report 20-1605R4



Legend

- Emission line
- Existing Barrier / Fence
- Building
- Point receiver
- Road axis
- Surface

L10 (18 hour)
Facade Corrected
dB(A)

	<= 54
54 <	<= 57
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60 <	<= 63
63 <	<= 66
66 <	<= 68
68 <	<= 71
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74 <	<= 77
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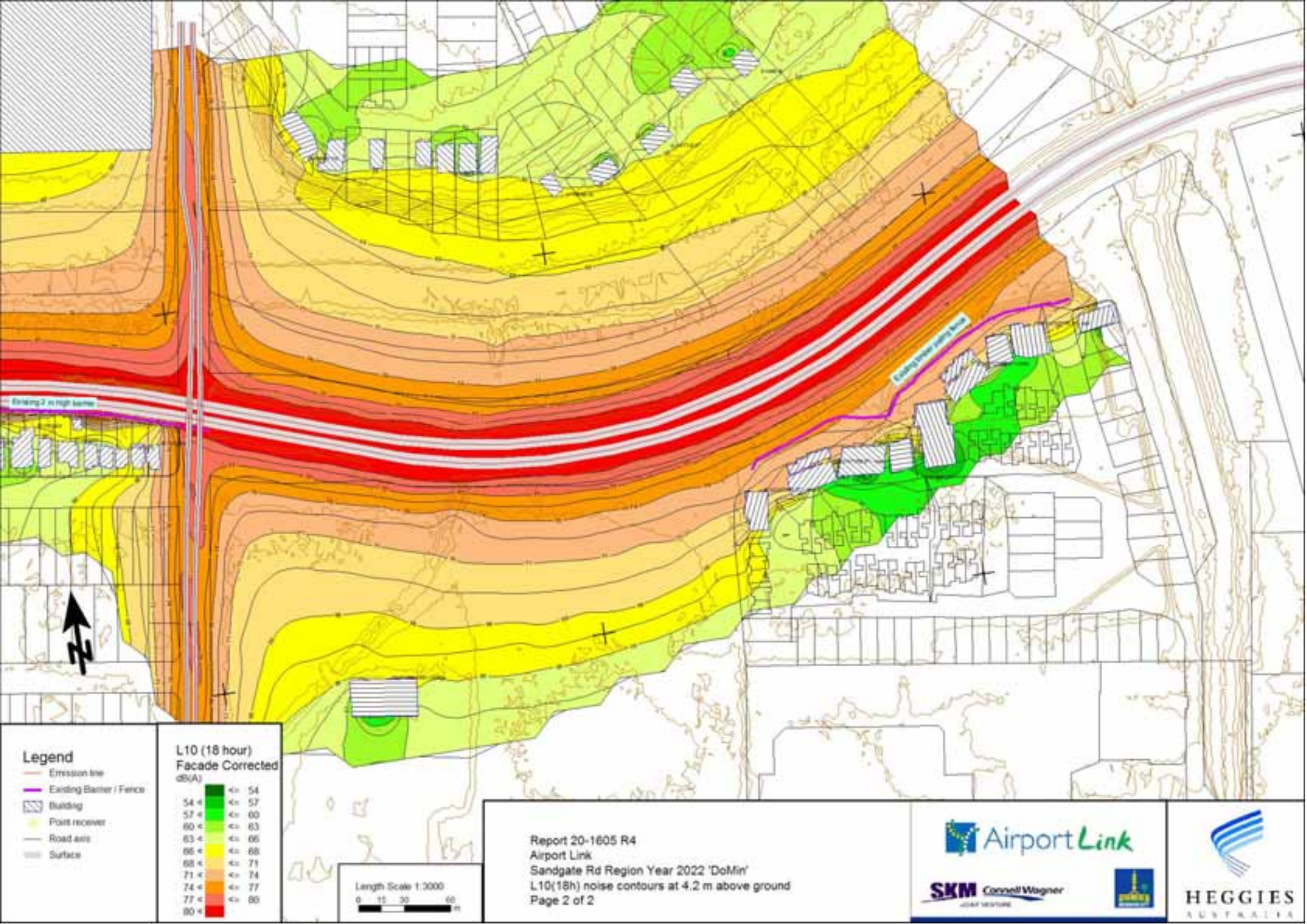
80 <	

Length Scale 1:3000
0 15 30 60 m

Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2022 'DoMin'
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2

Airport Link
SKM Connell Wagner
HEGGIES AUSTRALIA



Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2022 'DoMin'
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2

Airport Link

SKM Connell Wagner

HEGGIES AUSTRALIA

Legend
- Emission line
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- Surface

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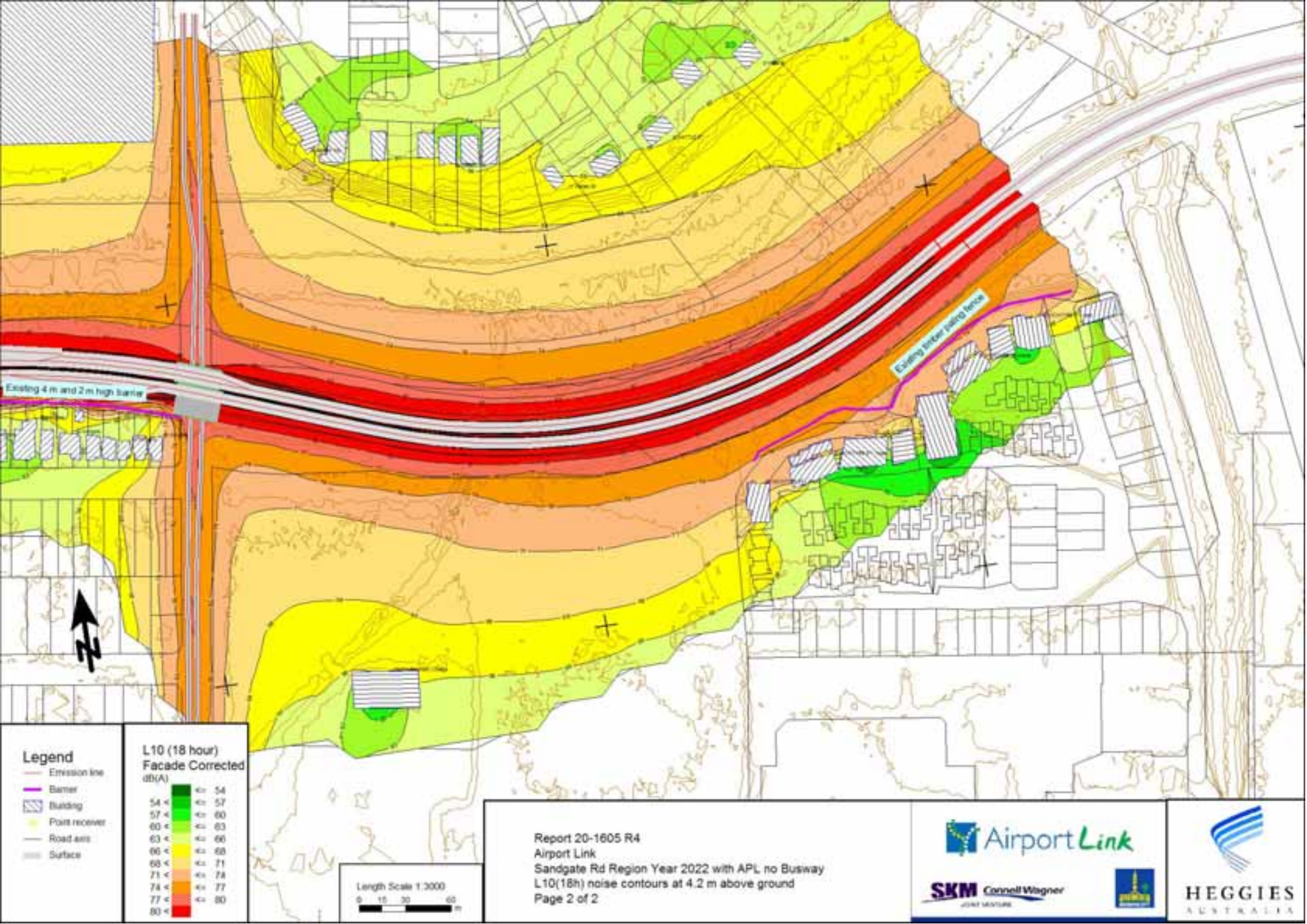
Length Scale 1:3000
0 15 30 60 m

Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2022 with APL no Busway
L10(18h) noise contours at 4.2 m above ground

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA



Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2022 with APL no Busway
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2

Airport Link

SKM Connell Wagner
JOINT VENTURE

HEGGIES
AUSTRALIA

Legend
- Emission line
- New or Upgraded Barriers
- Existing Barriers
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L10 (18 hour)
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Length Scale 1:3000
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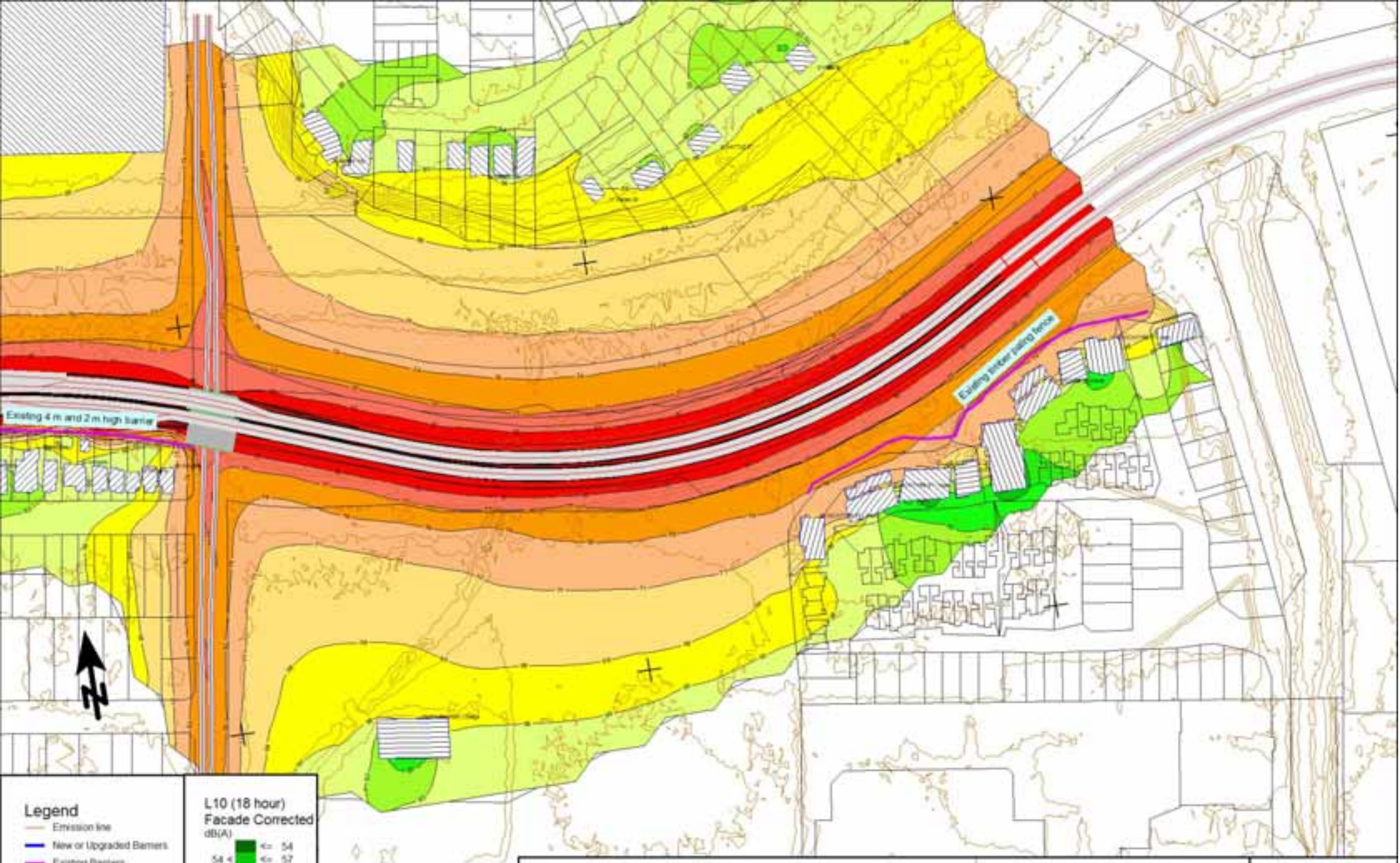
Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2022 with APL no Busway 'Status Quo' Design
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA



Legend
- Emission line
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- Existing Barriers
- Building
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Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2022 with APL no Busway 'Status Quo' Design
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA

Legend
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Length Scale 1:3000
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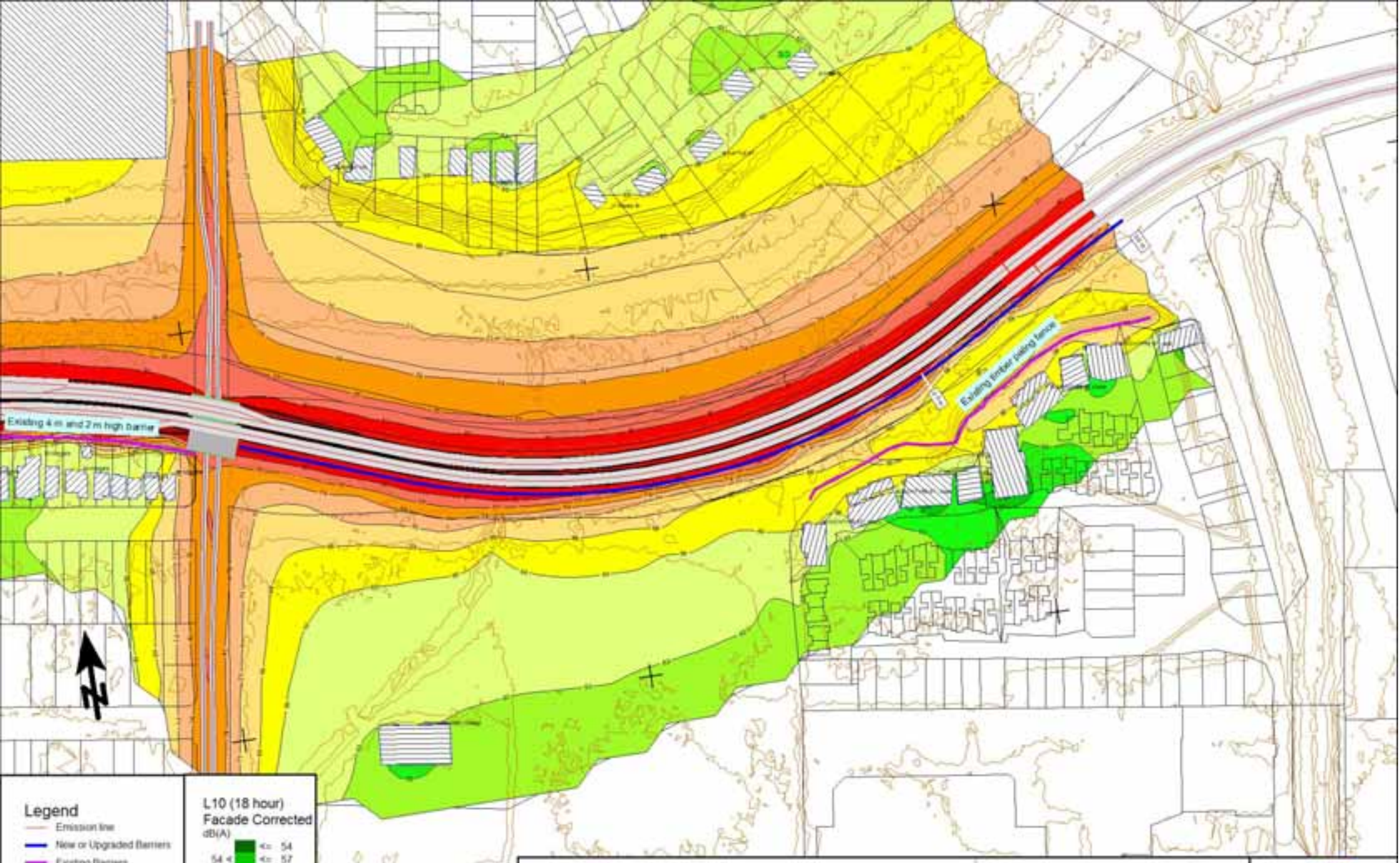
Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2022 with APL no Busway 63 & 68dBA Design
L10(16h) noise contours at 4.2 m above ground
Page 1 of 2

Airport Link
SKM Connell Wagner
HEGGIES AUSTRALIA



Legend

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Length Scale 1:3000

0 15 30 60 m

Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2022 with APL no Busway 63 & 68dBA Design
L10(16h) noise contours at 4.2 m above ground
Page 2 of 2

Airport Link

SKM Connell Wagner

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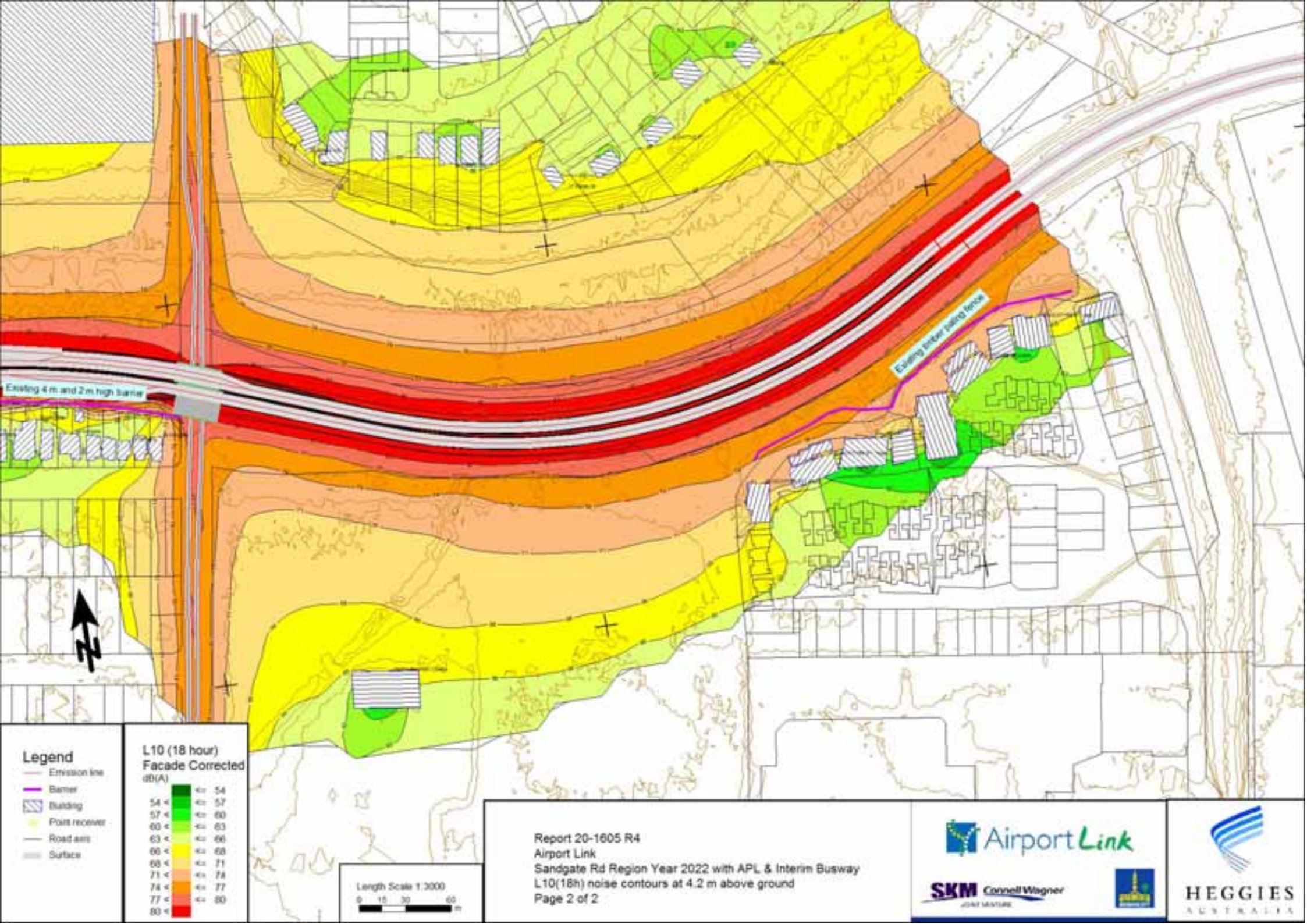
Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2022 with APL & Interim Busway
L10(18h) noise contours at 4.2 m above ground

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALASIA



Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2022 with APL & Interim Busway
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2

Airport Link

SKM Connell Wagner
JOINT VENTURE

HEGGIES
AUSTRALIA

Legend
- Emission line
- New or Upgraded Barriers
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- Building
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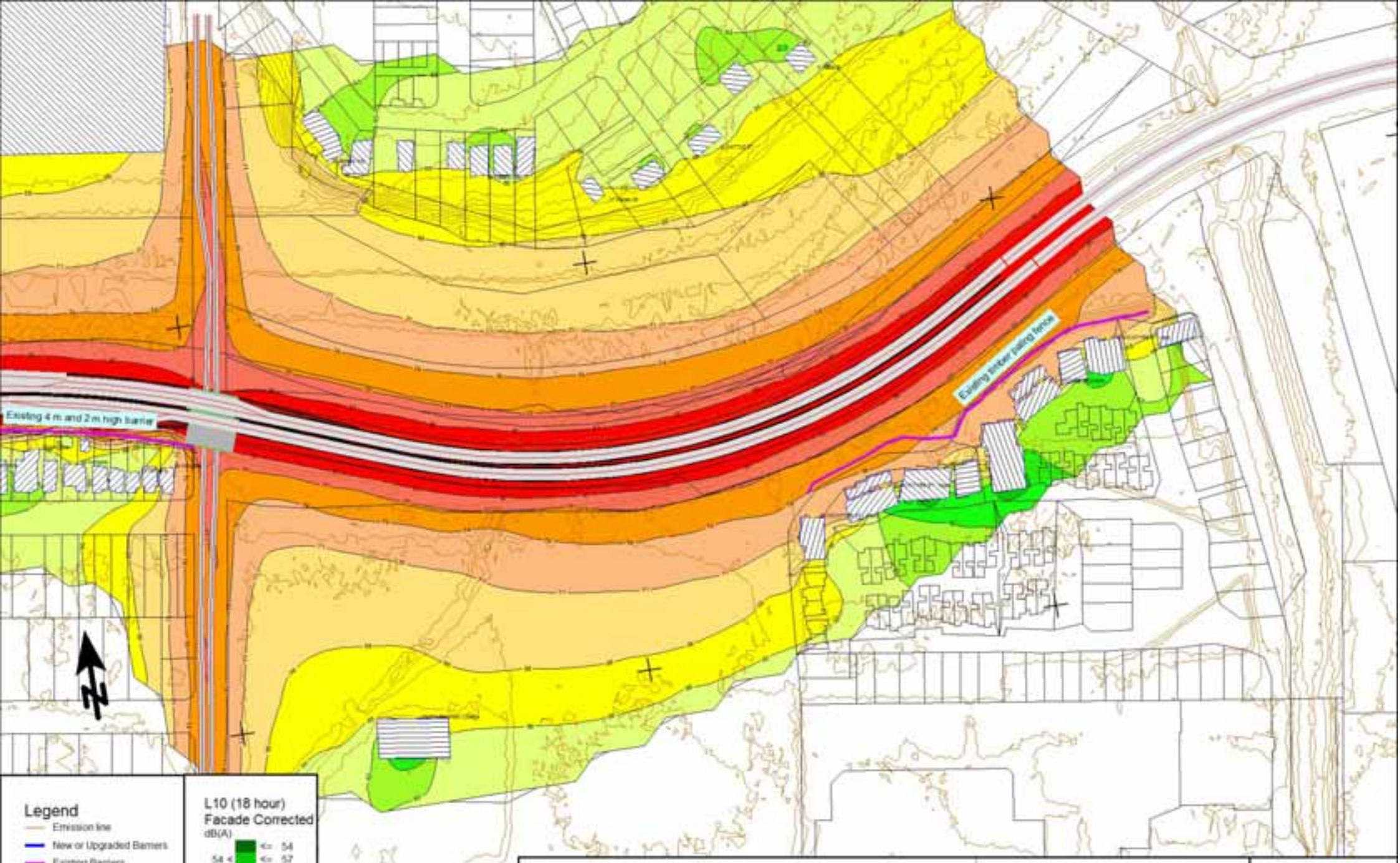
Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2022 with APL & Interim Busway 'Status Quo' Design
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2

AirportLink
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA



Legend
- Emission line
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Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2022 with APL & Interim Busway 'Status Quo' Design
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA

Legend
- Emission line
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Length Scale 1:3000
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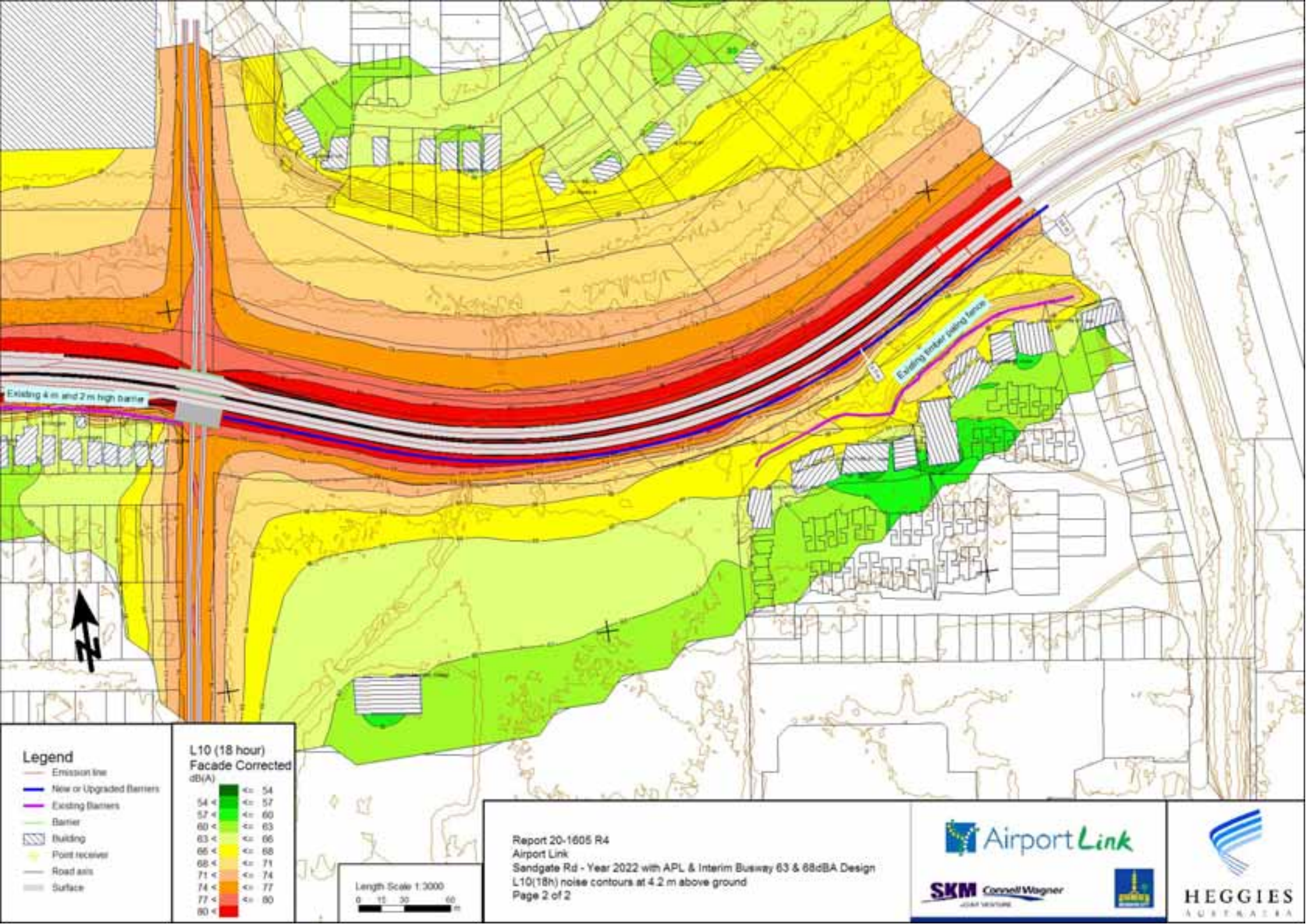
Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2022 with APL & Interim Busway 63 & 68dBA Design
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2

Airport Link
SKM Connell Wagner
HEGGIES AUSTRALIA



Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2022 with APL & Interim Busway 63 & 68dBA Design
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2

Airport Link

SKM Connell Wagner

HEGGIES AUSTRALIA

Legend

- Emission line
- Existing Barrier / Fence
- Building
- Point receiver
- Road axis
- Surface

L10 (18 hour)
Facade Corrected
dB(A)

	<=	54
54 <	<=	57
57 <	<=	60
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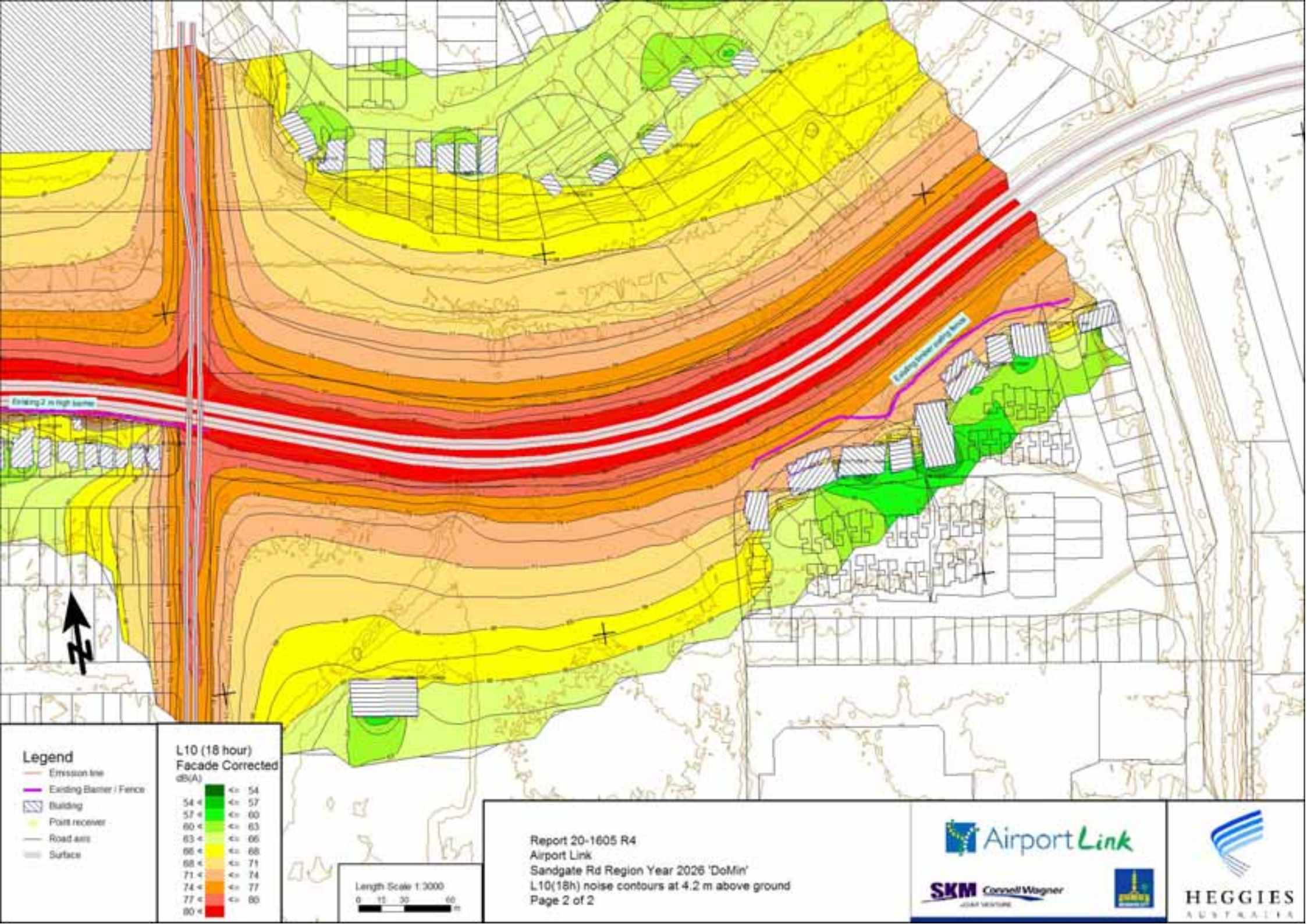
77 <	<=	80
80 <		

Length Scale 1:3000
0 15 30 60 m

Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2026 'DoMin'
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2

Airport Link
SKM Connell Wagner
HEGGIES AUSTRALIA

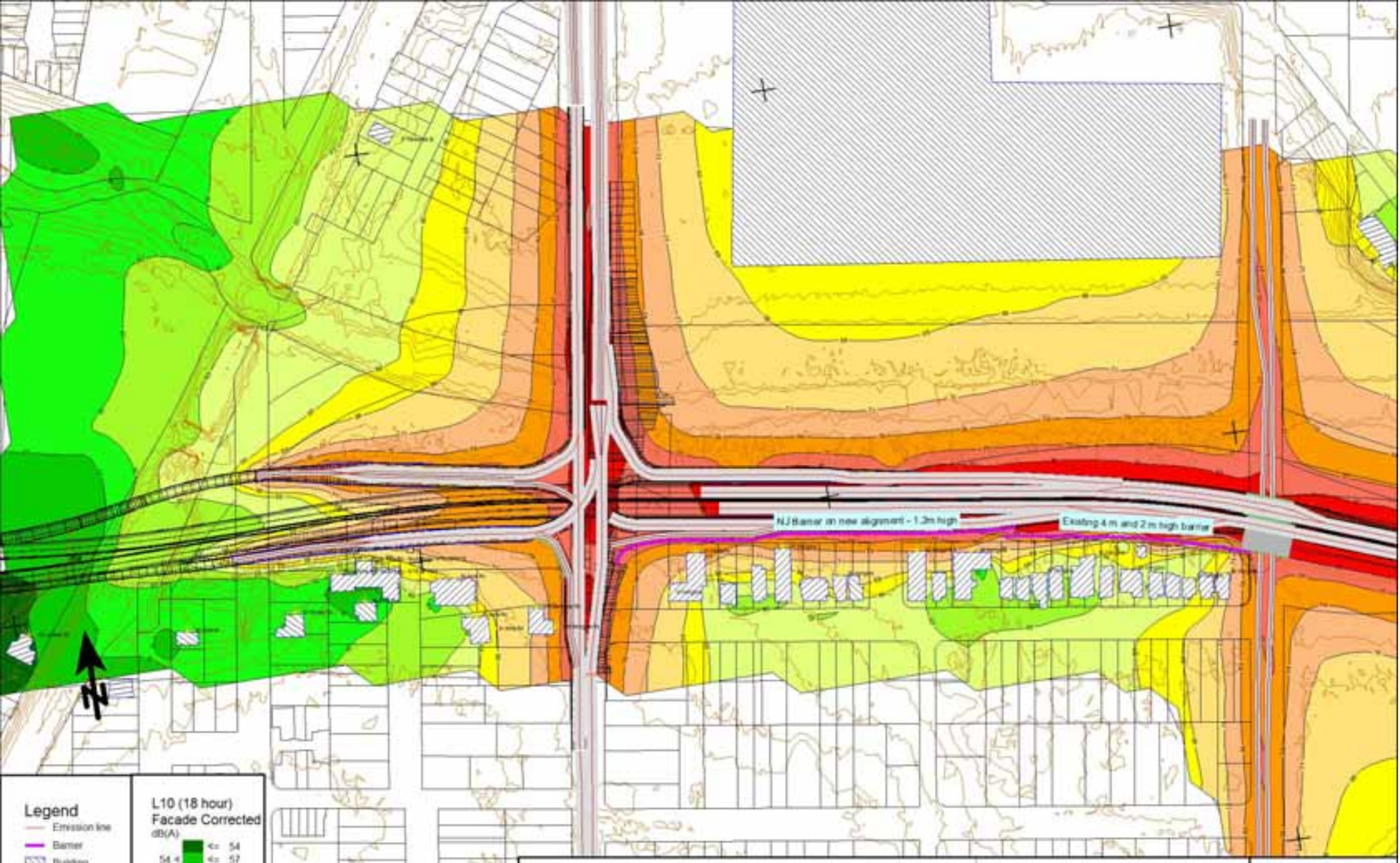


Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2026 'DoMin'
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2

Airport Link

SKM Connell Wagner
JOINT VENTURE

HEGGIES
AUSTRALIA



Legend

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- Building
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- Surface

L10 (18 hour)
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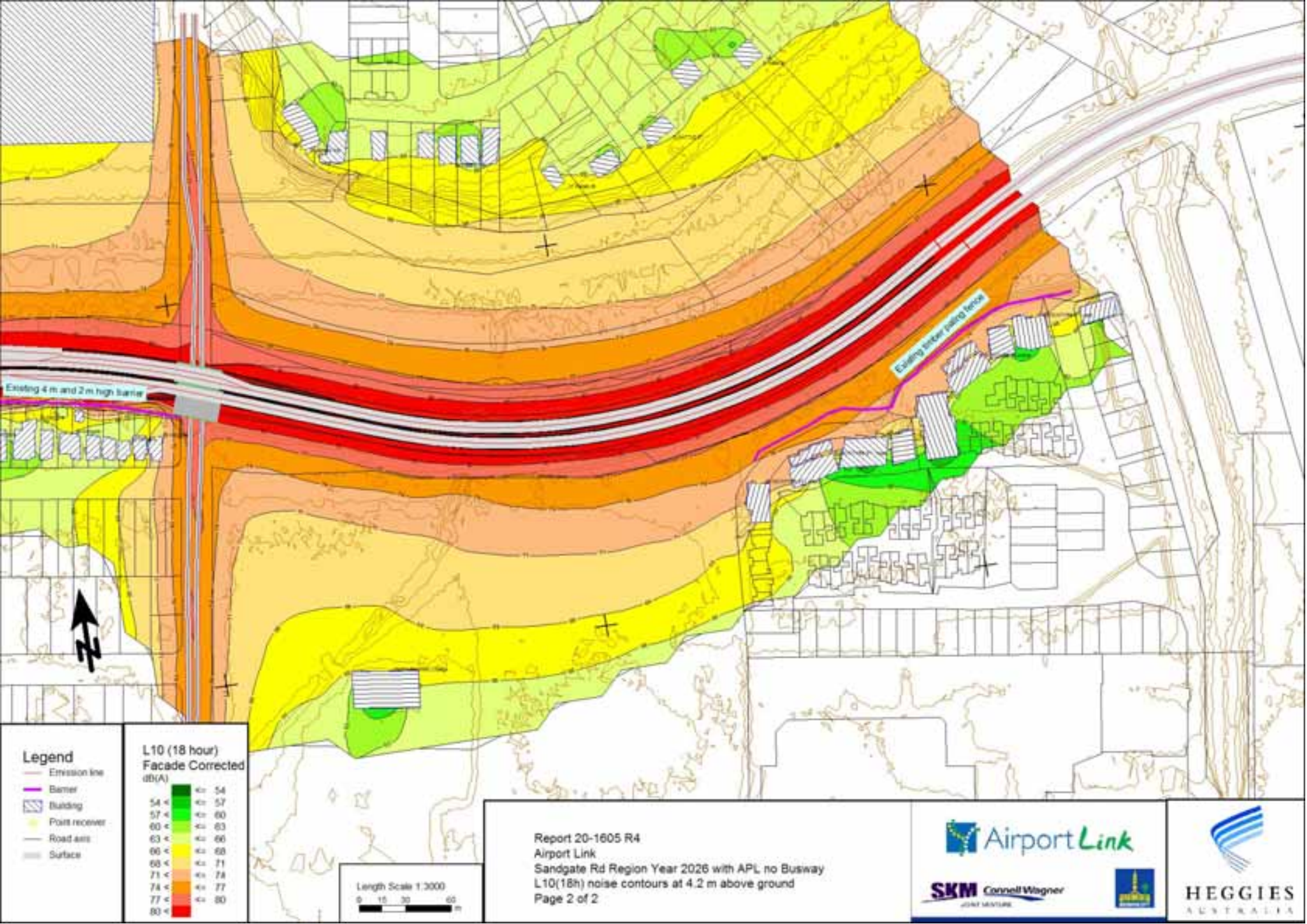
Length Scale 1:3000
0 15 30 60 m

Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2026 with APL no Busway
L10(18h) noise contours at 4.2 m above ground

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA



Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2026 with APL no Busway
L10(18h) noise contours at 4.2 m above ground
Page 2 of 2

Airport Link

SKM Connell Wagner
JOINT VENTURE

HEGGIES
AUSTRALIA

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- New or Upgraded Barriers
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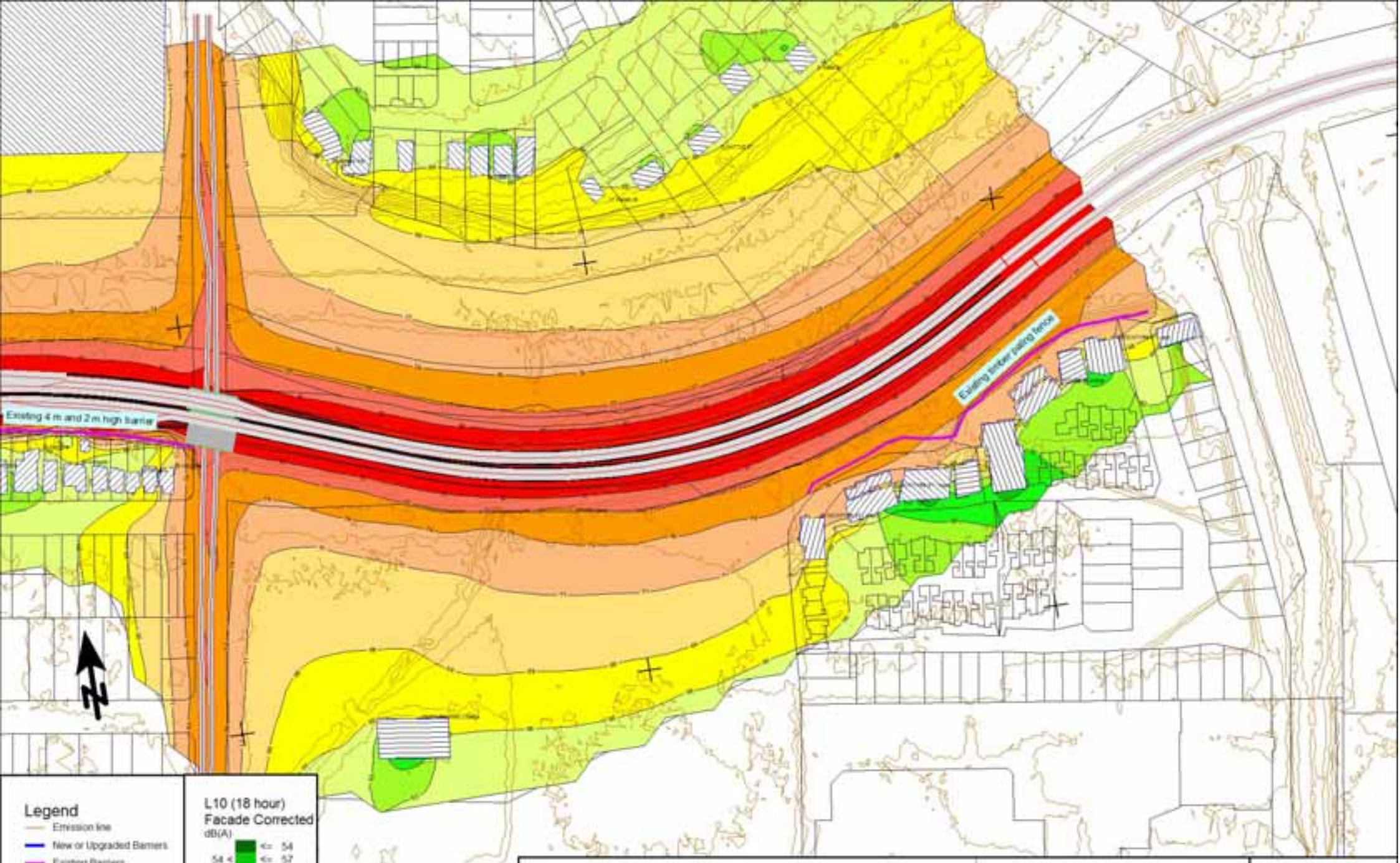
Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2026 with APL no Busway 'Status Quo' Design
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA



Legend
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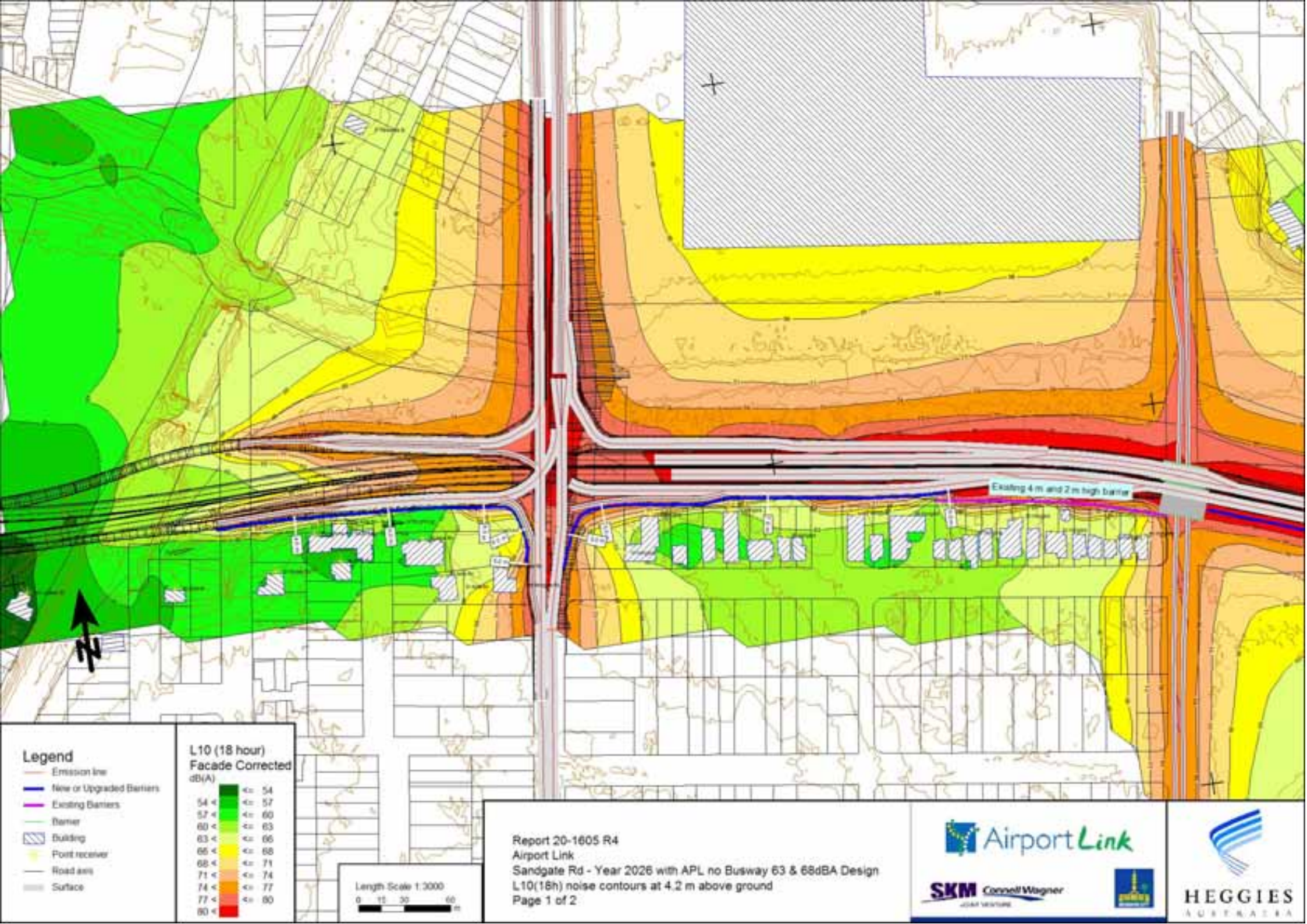
Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2026 with APL no Busway 'Status Quo' Design
L10(18h) noise contours at 4.2 m above ground

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA


Existing 4 m and 2 m high barrier
N
Legend
Emission line
New or Upgraded Barriers
Existing Barriers
Barrier
Building
Point receiver
Road axis
Surface
L10 (18 hour)
Facade Corrected
dB(A)
54 < <= 57
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Length Scale 1:3000
0 15 30 60
m
Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2026 with APL no Busway 63 & 68dBA Design
L10(16h) noise contours at 4.2 m above ground
Page 1 of 2
Airport Link
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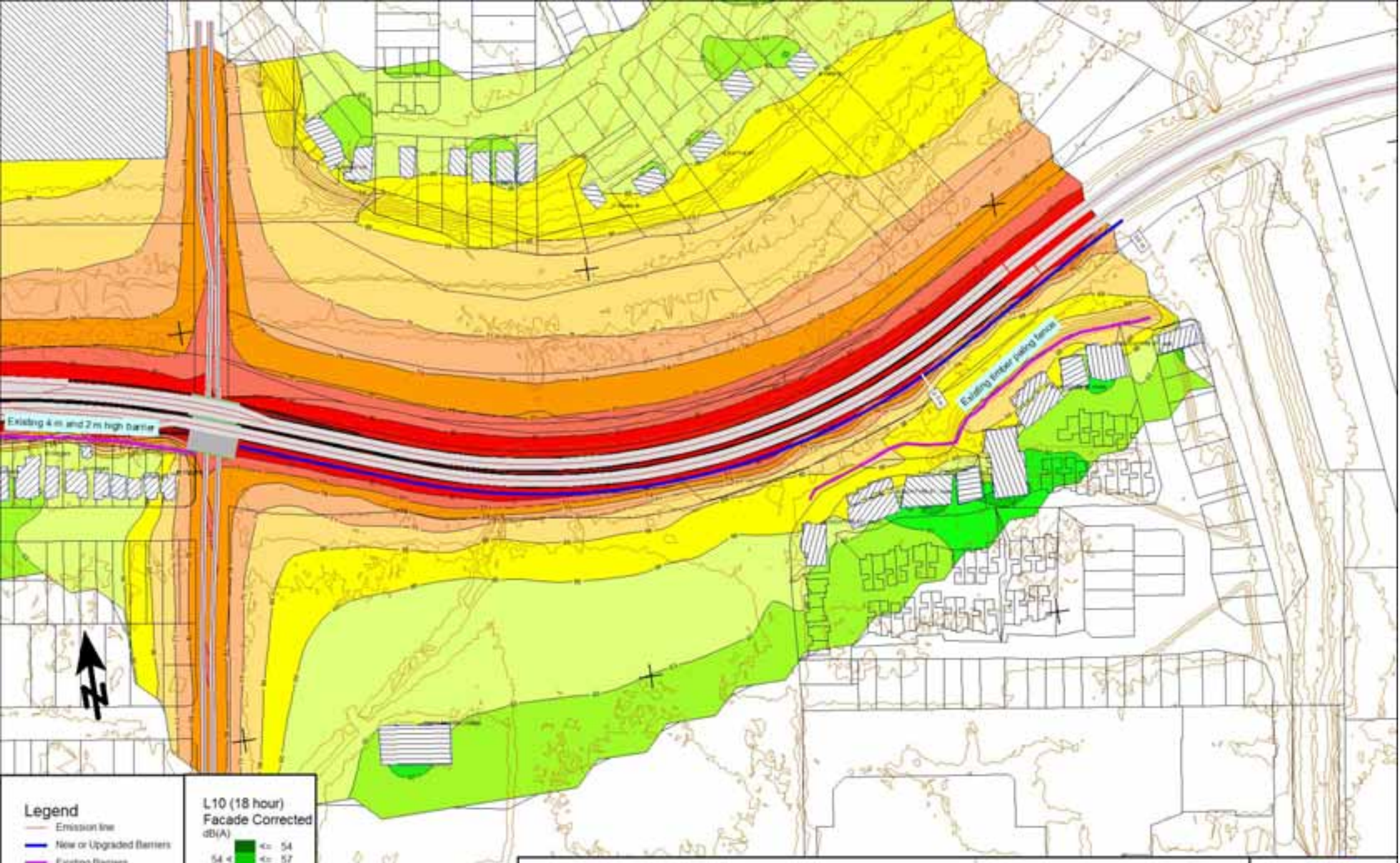

Legend

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66 <	<= 68
68 <	<= 71
71 <	<= 74
74 <	<= 77
77 <	<= 80
80 <	

Length Scale 1:3000

0 15 30 60 m

Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2026 with APL no Busway 63 & 68dBA Design
L10(16h) noise contours at 4.2 m above ground
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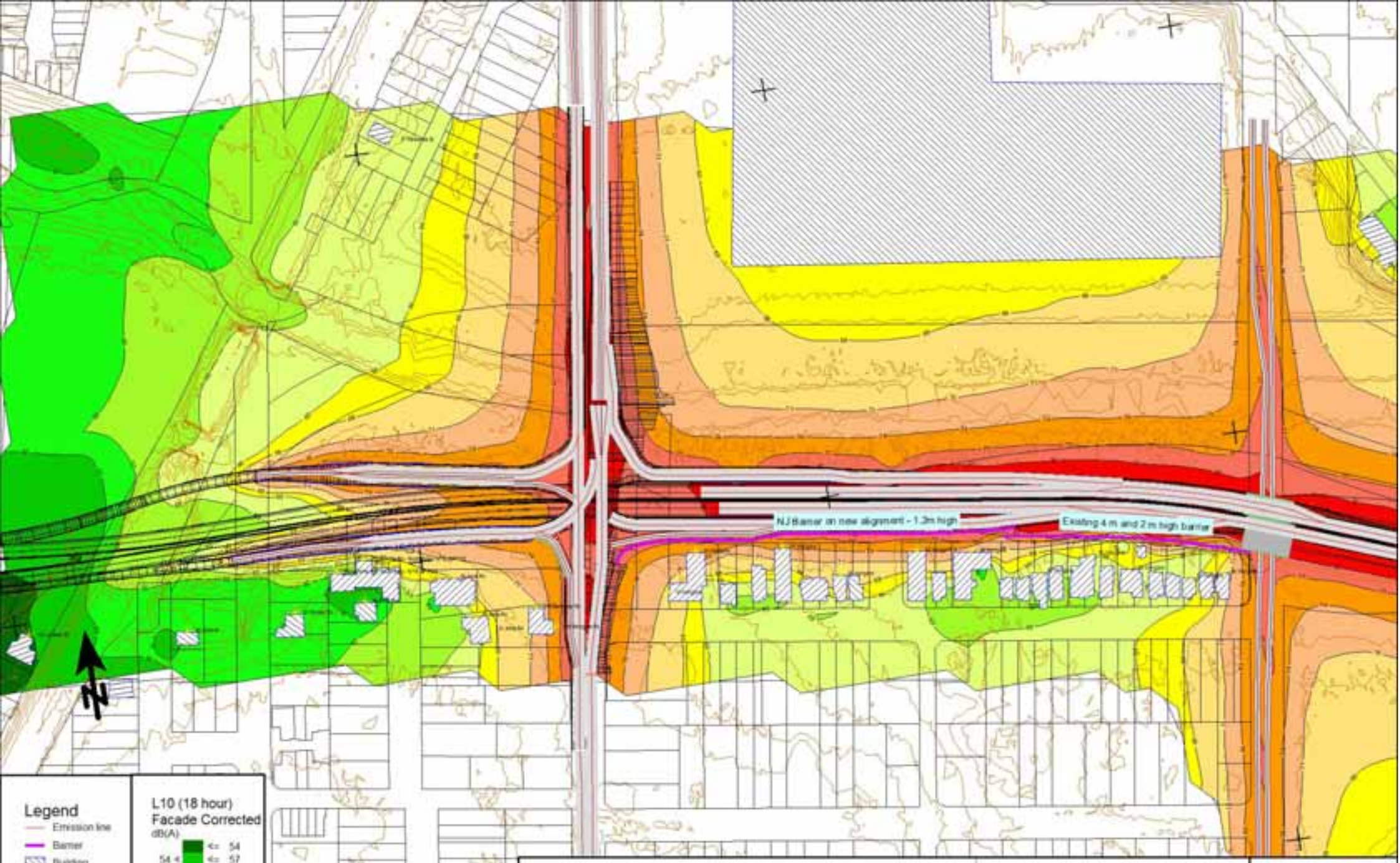
Airport Link

SKM Connell Wagner

HEGGIES AUSTRALIA



Legend
- Emission line
- Barrier
- Building
- Point receiver
- Road axis
- Surface

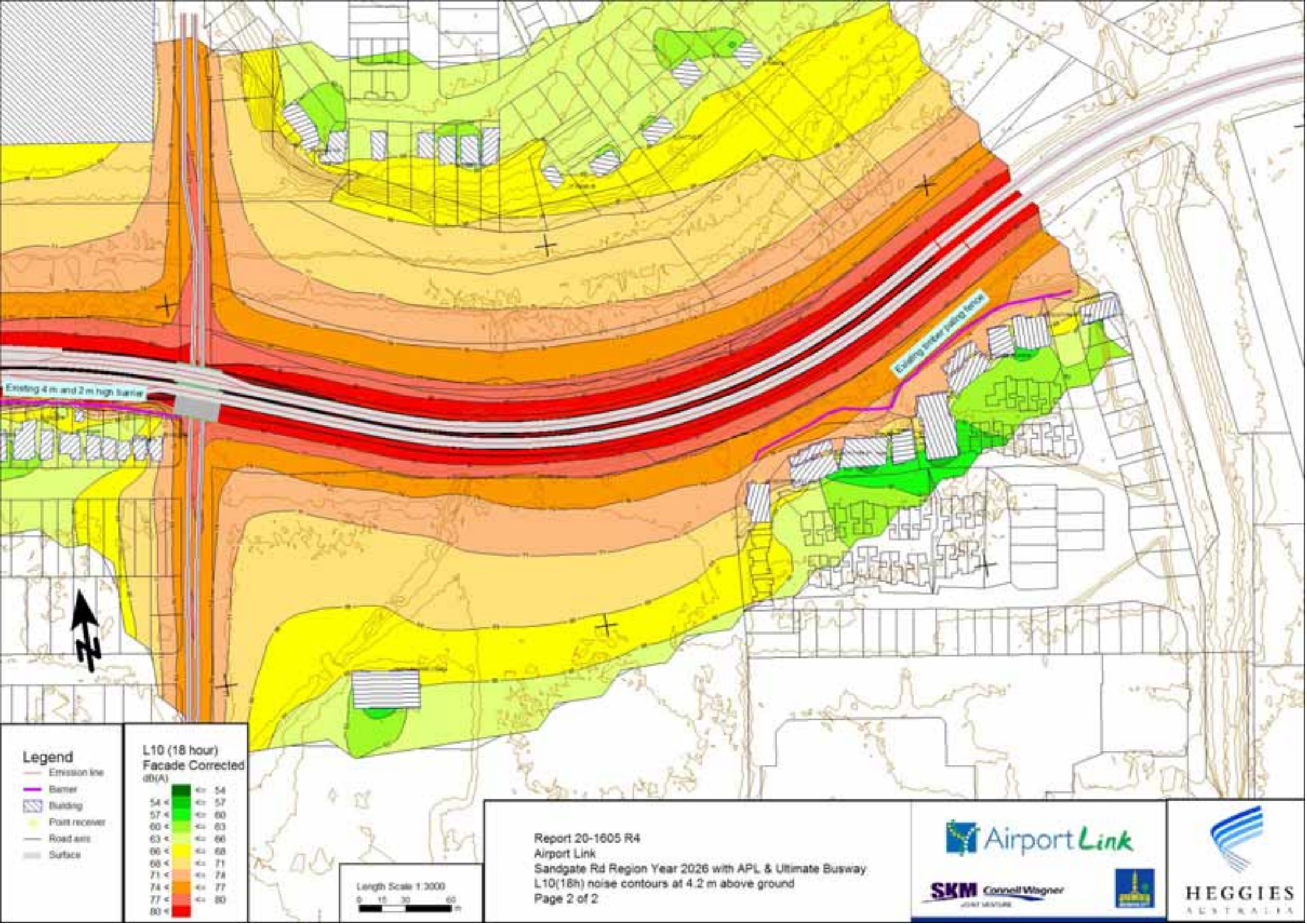
L10 (18 hour)
Facade Corrected
dB(A)

	<= 54
54 <	<= 57
57 <	<= 60
60 <	<= 63
63 <	<= 66
66 <	<= 68
68 <	<= 71
71 <	<= 74
74 <	<= 77
77 <	<= 80
80 <	

Length Scale 1:3000
0 15 30 60 m

Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2026 with APL & Ultimate Busway
L10(18h) noise contours at 4.2 m above ground
Page 1 of 2

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA



Report 20-1605 R4
Airport Link
Sandgate Rd Region Year 2026 with APL & Ultimate Busway
L10(18h) noise contours at 4.2 m above ground
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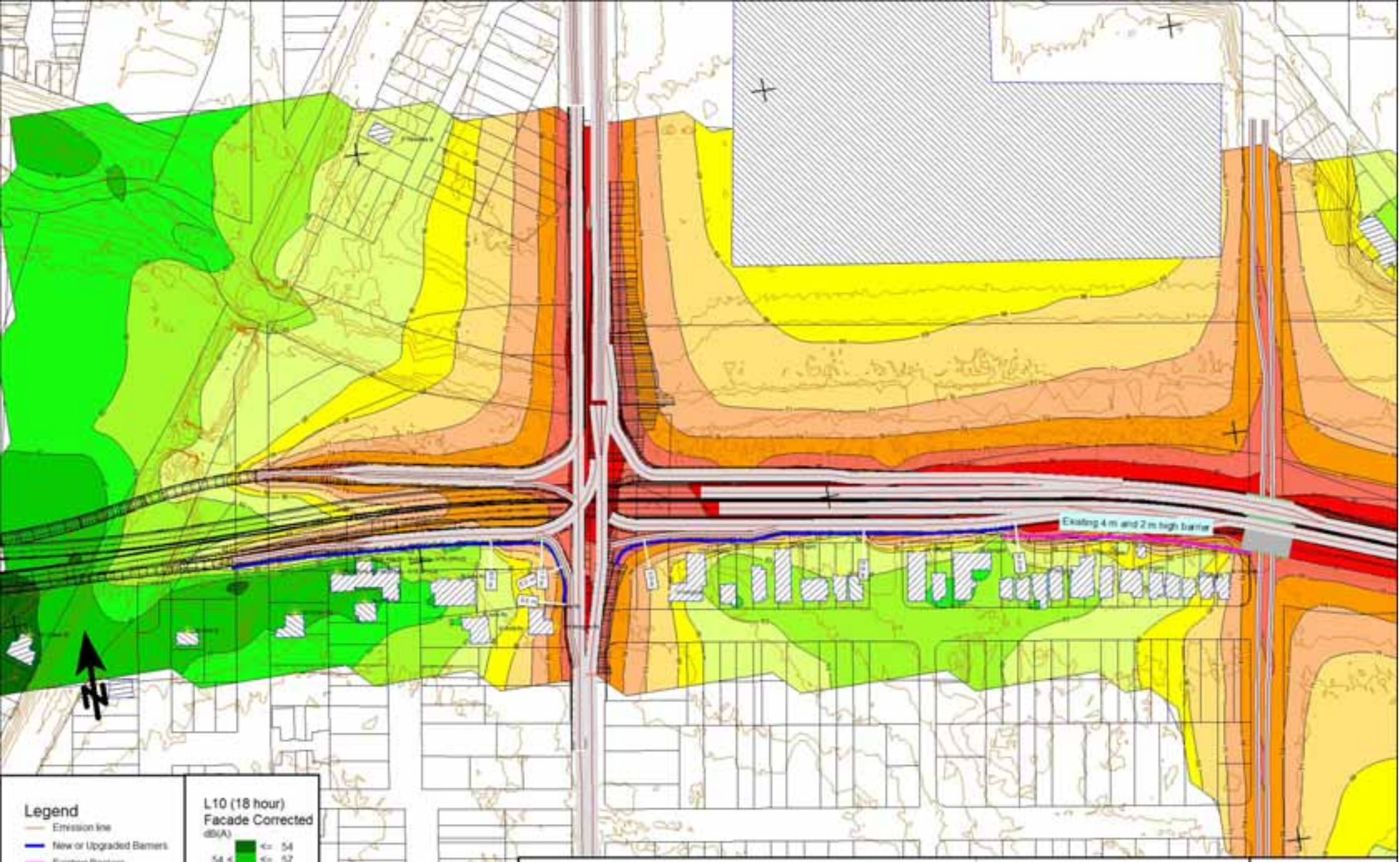
Airport Link

SKM Connell Wagner JOINT VENTURE

HEGGIES AUSTRALIA



Legend
- Emission line
- New or Upgraded Barriers
- Existing Barriers
- Building
- Point receiver
- Road axis
- Surface

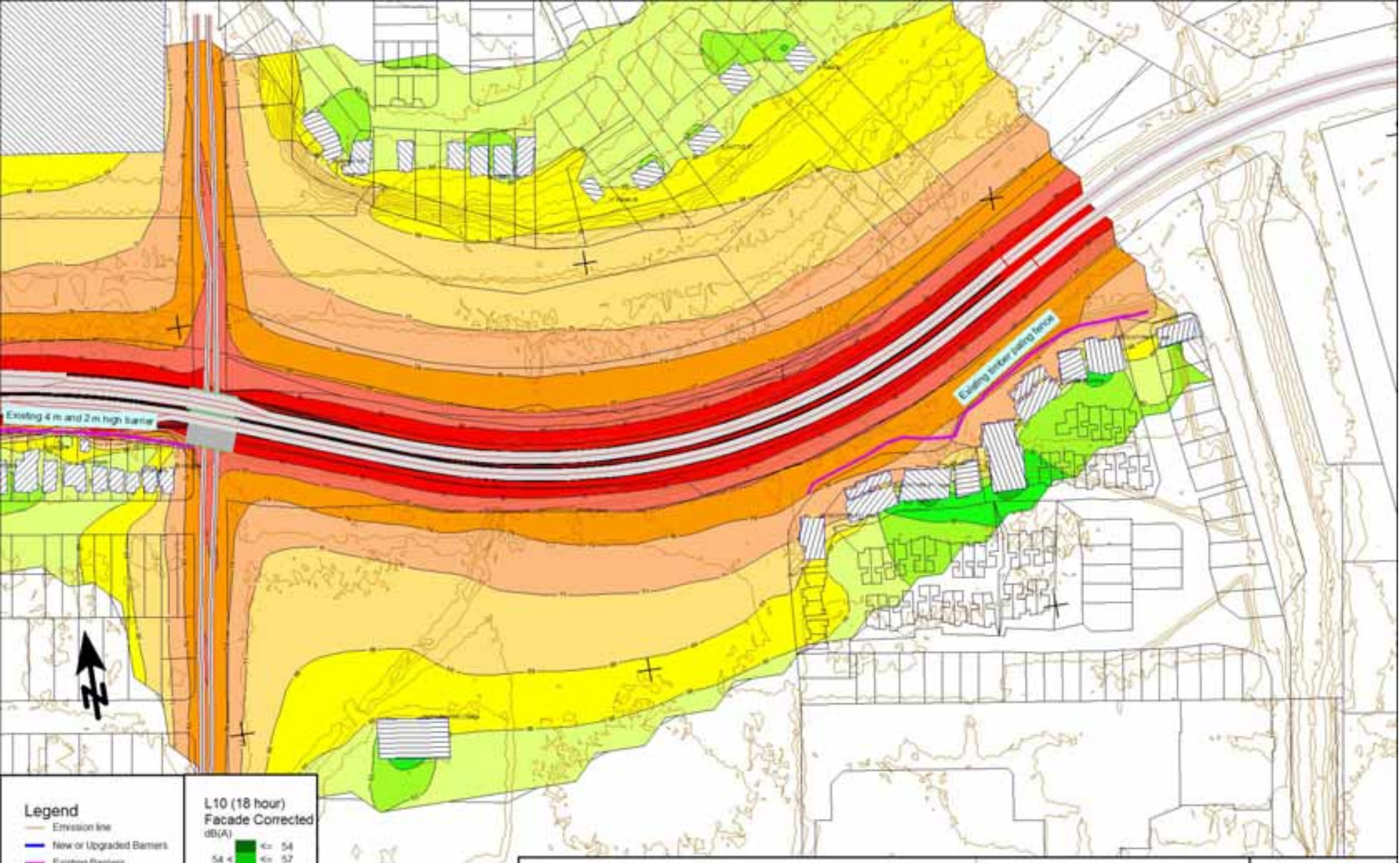
L10 (18 hour) Facade Corrected dB(A)

54 <	<= 54
57 <	<= 57
60 <	<= 60
63 <	<= 63
66 <	<= 66
68 <	<= 68
71 <	<= 71
74 <	<= 74
77 <	<= 77
80 <	<= 80

Length Scale 1:3000
0 15 30 60 m

Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2026 with APL & Ultimate Busway 'Status Quo' Design
L10(18h) noise contours at 4.2 m above ground

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA



Legend
- Emission line
- New or Upgraded Barriers
- Existing Barriers
- Building
- Point receiver
- Road axis
- Surface

L10 (18 hour)
Facade Corrected
dB(A)

	<= 54
54 <	<= 57
57 <	<= 60
60 <	<= 63
63 <	<= 66
66 <	<= 68
68 <	<= 71
71 <	<= 74
74 <	<= 77
77 <	<= 80
80 <	

Length Scale 1:3000
0 15 30 60 m

Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2026 with APL & Ultimate Busway 'Status Quo' Design
L10(18h) noise contours at 4.2 m above ground
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Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA

Legend
- Emission line
- New or Upgraded Barriers
- Existing Barriers
- Barrier
- Building
- Point receiver
- Road axis
- Surface

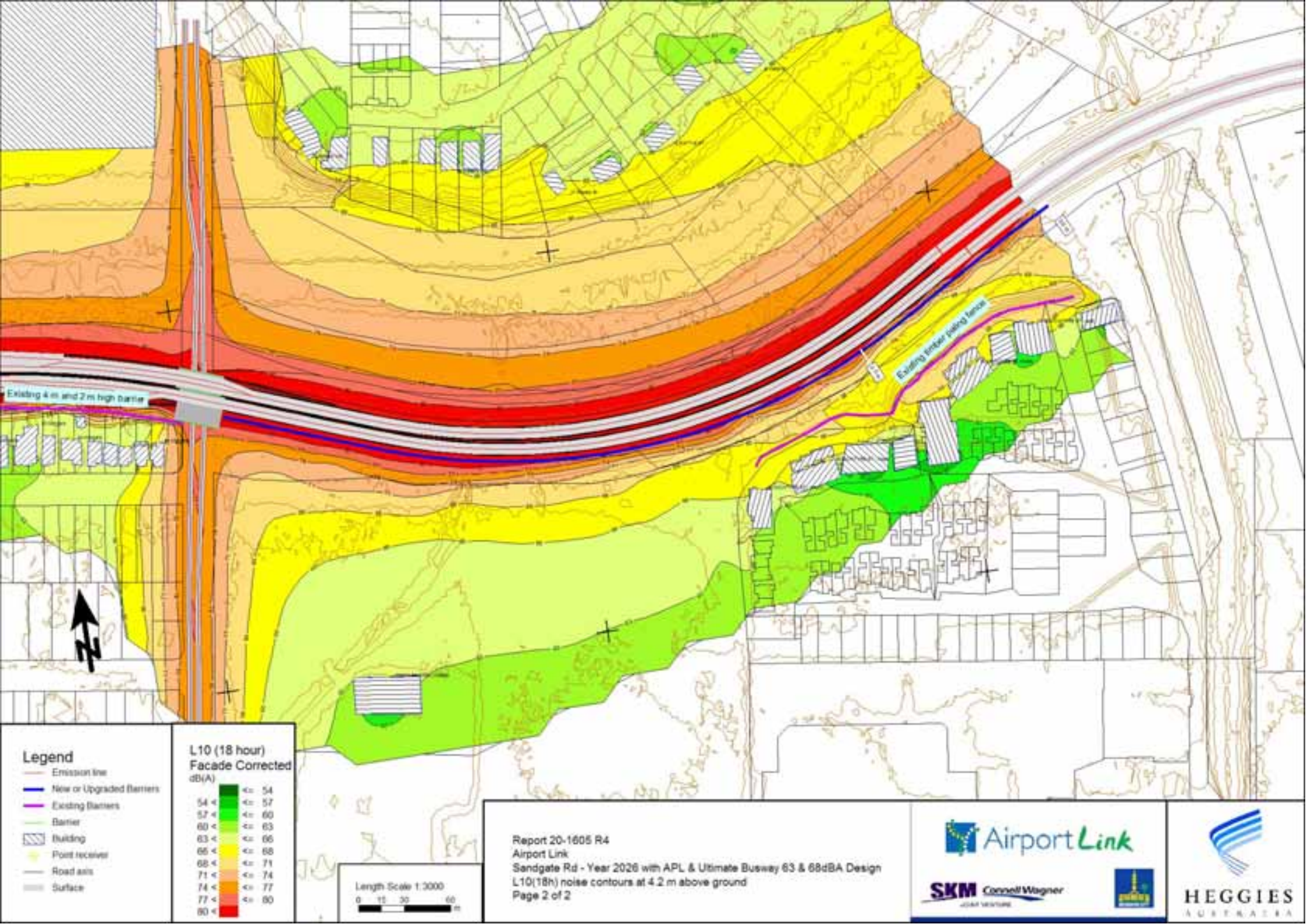
L10 (18 hour)
Facade Corrected
dB(A)

	<= 54
54 <	<= 57
57 <	<= 60
60 <	<= 63
63 <	<= 66
66 <	<= 68
68 <	<= 71
71 <	<= 74
74 <	<= 77
77 <	<= 80
80 <	

Length Scale 1:3000
0 15 30 60 m

Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2026 with APL & Ultimate Busway 63 & 68dBA Design
L10(18h) noise contours at 4.2 m above ground

Airport Link
SKM Connell Wagner JOINT VENTURE
HEGGIES AUSTRALIA



Report 20-1605 R4
Airport Link
Sandgate Rd - Year 2026 with APL & Ultimate Busway 63 & 68dBA Design
L10(18h) noise contours at 4.2 m above ground
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