RYDE HOSPITAL REDEVELOPMENT

Noise and Vibration Impact Assessment for Concept and Stage 1 Early Works State Significant Development (SSD) Application

Issued

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Appendices	As listed in the Table of Contents

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Glossary & Abbreviations

Term	Definition
dB	Decibel is the unit used for expressing sound pressure level (SPL) or power level (SWL).
dB(A)	Decibel expressed as an 'A – weighted' sound pressure level, based on the frequency response of the human ear and has been found to correlate well with human subjective reactions to various sounds. It is noted that an increase or decrease of approximately 10 dB corresponds to a subjective doubling or halving of the loudness of a noise, and a change of 2 to 3 dB is subjectively barely perceptible.
EIS	Environmental Impact Statement
Frequency	The rate of repetition of a sound wave. Frequency is measured Hertz (Hz), or cycles per second. Human hearing ranges approximately from 20 Hz to 20 kHz (2000 Hz).
Ground-borne noise	The transmission of noise energy as vibration of the ground. The energy may then be re-radiated as airborne noise.
ICNG	Interim Construction Noise Guideline
$L_{1(period)}$	The sound pressure level that is exceeded for 1% of a measurement period. This is commonly accepted as the maximum noise level.
$L_{10(period)}$	The sound pressure level that is exceeded for 10% of a measurement period. This is commonly accepted as the maximum noise levels.
$L_{90(period)}$	The sound pressure level that is exceeded for 90% of a measurement period. This is commonly accepted as the background noise level.
$L_{Aeq(period)}$	The equivalent continuous sound pressure level. The level of noise equivalent to the energy average of noise levels occurring over a measurement period.
L_{Amax}	The highest sound pressure level recorded over a measurement period.
Octave Band Centre Frequency	The most commonly used frequency bands are octave bands, in which the centre frequency of each band is twice that of the band below it.
Rating Background Level (RBL)	Rating background level is the overall single-figure background level representing each assessment period (day/evening/night) over a measurement period.
Sound Power Level (SWL)	Expressed in dB, it is the total acoustic energy radiated by a plant or equipment to the environment
Sound Pressure Level (SPL)	Expressed in dB, it is the level of noise measured by a standard sound level meter and requires a description of where the noise was measured relative to the source
SSD	State Significant Development
Vibration	Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity and acceleration are most commonly used when assessing structure-borne noise or human comfort issues respectively.

1 Executive Summary

NSW Health Infrastructure (HI) proposes the redevelopment of Ryde Hospital. This acoustic report includes a noise and vibration assessment that has been undertaken to to support the Concept Proposal and Stage 1 Early Works State Significant Development (SSD) Application. The acoustic assessment is detailed in this report.

The existing noise environment has been established based on long-term and short-term monitoring data. Appropriate criteria for both noise and vibration have been discussed and set according to established guidelines and standards including:

- NSW Environmental Protection Authority (EPA) Noise Policy for Industry (NSW NPI) 2017.
- NSW EPA Interim Construction Noise Guideline 2009.
- NSW EPA Assessing Vibration: A Technical Guideline 2006.

A summary of the outcomes and recommendations of this noise and vibration assessment are as follows:

SEARs

The following outline the SEARs requirements for Noise and Vibration, and the relevant sections where requirements are addressed within this report.

Item	SEARS Requirement	Relevant Section In Report
Issue and Assessment Requirements - Concept Proposal		
11	**Noise and Vibration**	
	Provide a noise and vibration assessment prepared in accordance with the relevant NSW Environment Protect Authority (EPA) guidelines. The assessment must detail construction and operational noise and vibration impacts on nearby sensitive receivers and structures and outline the proposed management and mitigation measures that would be implemented.	Section 7
Issue and Assessment Requirements - Stage 1		
2	**Noise and Vibration**	
	Provide a noise and vibration assessment prepared in accordance with the relevant NSW Environment Protect Authority (EPA) guidelines. The assessment must detail construction and operational noise and vibration impacts on nearby sensitive receivers and structures and outline the proposed management and mitigation measures that would be implemented.	Section **8**

Concept Proposal

The concept design has incorporated acoustic planning principles and considerations to provide optimal design and coordination with the architectural and services strategy to support the proposed hospital buildings as part of the Ryde Hospital Redevelopment Project. This includes:

- Noise mitigation and management strategies to inform the design.
- Strategies to avoid or reduce impact of noise on users of the site.
- Planning and locating of noise generating areas to limit and avoid impacts on noise sensitive receivers.
- Strategies to limit traffic noise generation and impact to surrounding receivers

Further detail is provided in Section 7.

The detailed design, construction (also referred to as main works) and operation of new hospital buildings will be subject to a separate Stage 2 SSD application and is not included in this assessment.

Stage 1 Early Works

Construction Noise

Proposed construction hours for the Stage 1 Early Works are as follows:

- Monday to Friday - 7:00am to 6:00pm.
- Saturday - 8:00am to 1:00pm.
- Sunday and Public Holidays – No works.

Construction works noise impacts will be greatest at on Campus noise receivers including the existing Graithwaite Rehabilitation Centre and Ryde Medical Centre Buildings. Noise from various plant and equipment operating individually are generally predicted to be above the NMLs due to the proximity to the nearest affected receivers. The worst-case noise impacts are for excavators with hammers with noise levels predicted to be above the NMLs by up to 21 dB.

Noise levels from operations of various plant and equipment are predicted to be up to 12 dB lower when location of activities within the site boundary are further away from a particular receiver, and in some cases, within the NMLs depending on the distance to the receiver.

Construction noise impacts at residential receivers are the highest to the West of the Ryde Hospital Campus across Ryedale Road. The worst-case noise impacts are for excavators with hammers which are 22 dB above the NMLs, however they are within Highly Affected Noise Levels (75 dB(A)).

Where NMLs are exceeded, mitigation measures to be considered and incorporated where reasonable and feasible would include:

- Schedule noisy activities to less sensitive times of the day for each nominated receiver (i.e. daytime hours).
- Including Respite Periods where activities are found to exceed the 75 dB(A) Highly Affected Noise Level at receivers, such as 3 hours on and 1 hour off.

The predictions for noise levels above NMLs is not unusual given the heavy plant and equipment that must be used, such as excavators and hammers, and the proximity to on campus sensitive receivers (some of which are within 20m).

Construction traffic along the roads surrounding the site will meet applicable road noise targets on nearby receivers during the day-time period.

Implementation of all reasonable and feasible mitigation measures for all works will ensure that any adverse noise impacts to surrounding residential, commercial and

recreational receivers are minimised when NMLs cannot be met due to safety or space constraints.

Construction Vibration

Based on the scope of works and typical equipment required, some human perception vibration impacts are expected and there is a potential for minor cosmetic impacts to some structures which must be reviewed as works processes are planned in more detail – particularly from the use of excavators with hammers near the existing Ryde Hospital buildings. In addition, there is potential for vibration impacts on sensitive equipment. A comprehensive Construction Noise and Vibration Management Plan (CNVMP) will be prepared by the engaged Contractor. The CNVMP will consider proposed plant, equipment and construction methodology, prior to the commencement of any Stage 1 Early Works.

It is recommended that, prior to the commencement of the Stage 1 Early Works, vibration surveys be carried out of each key vibration-generating-activity / equipment.

In addition to the assessment of structural and human perception vibration, the CNVMP prepared by the Contractor must ensure, at the relevant on campus buildings (including but not limited to the existing Graithwaite Rehabilitation Centre, Ryde Medical Centre) and other hospital campus areas where sensitive equipment is operated or heritage structures exist, that the equipment-specific and structure-specific vibration criteria are set and managed accordingly.

The Contractor shall carry out a vibration assessment at the commencement of operations for each vibration generating activity to determine whether the existence of significant vibration levels justifies a more detailed investigation. Site law tests will help determine allowable working distances from structures to manage vibration.

If the assessment indicates that vibration levels might exceed the relevant criteria then vibration mitigation measures will need to be put in place to ensure vibration impacts are minimised using all reasonable and feasible measures.

A method of monitoring vibration levels must then be put in place. Additionally, vibration monitors must also be put in place to manage sensitive areas. Vibration mitigation measures and vibration criteria will then need to be reviewed.

All practical means are to be used to minimise impacts on the affected buildings and occupants from activities generating significant levels of vibration on site.

The following considerations shall be taken into account:

- Modifications to construction equipment used.
- Modifications to methods of construction.
- Rescheduling of activities to less sensitive times.

2 Introduction

Acoustic Studio has been engaged by NSW Health Infrastructure to assess the potential noise and vibration impacts of the proposed Ryde Hospital Redevelopment (Concept and Stage 1).

The Ryde Hospital site is located at 1 Denistone Road, Denistone and comprises Lots 10-11 DP 1183279 and Lots A-B DP 323458. It has an area of approximately 7.69Ha and currently accommodates the existing Ryde Hospital Campus.

This report accompanies a State Significant Development Application that seeks approval for the establishment of a maximum building envelope and gross floor area for the future new hospital buildings, and physical Stage 1 Early Works to prepare the site for the future development. For a detailed project description refer to the Environmental Impact Statement prepared by Ethos Urban.

The Stage 1 Early works comprise the following:

- Establishing access to the Project site and general establishment;
- Site preparation including environmental clearing;
- Bulk earthworks, including, cut and fill, associated with stage 1 footprint and proposed stage 1 internal roads
- Shoring associated with bulk earthworks
- Establishment of construction access roads;
- Relocation and upgrades of in-ground building services works and utility adjustments to facilitate bulk earthworks

The assessment has been carried out by:

- Establishing the appropriate noise and vibration criteria in accordance with the relevant standards and guidelines.
- Quantifying the existing ambient and background noise levels at noise sensitive receivers on and surrounding the site.
- Identifying the main noise and vibration generating sources.
- Assessing whether the relevant criteria can be achieved and, where applicable, recommending measures to minimise and mitigate potential impacts.

The assessment considers noise and vibration impacts for community and land uses surrounding the site.

2.1 Concept Proposal and Stage 1 Early Works

This component seeks approval for a Concept proposal and Stage 1 Early Works for the Ryde Hospital Project.

The concept proposal application includes approval for the establishment of a maximum building envelope maximum gross floor area to facilitate the development of a new hospital services development, car-park and refurbishment works.

The Stage 1 Early Works application will include the following relevant to the Enabling works construction zone as shown on the architectural drawings:

- Establishing access to the Project site and general establishment;
- Site preparation including environmental clearing;
- Bulk earthworks, including, cut and fill, associated with stage 1 footprint and proposed stage 1 internal roads;
- Shoring associated with bulk earthworks;
- Establishment of construction access roads;
- Relocation and upgrades of in-ground building services works and utility adjustments to facilitate bulk earthworks;
- Partial removal of Lantana undergrowth to proposed APZ

2.1.1 Stage 2 SSDA

Stage 2 (which will be subject to a separate application following the Concept Proposal and Stage 1 Early Works), will seek approval for:

- the detailed design, construction and operation of the new Hospital building
- connections to the existing Hospital
- public domain improvements
- refurbishment of existing hospital facilities
- Multi-deck and on-grade car-park.

3 Surrounding Land Uses

3.1 Ryde Hospital Site

The site is located within a suburban environment in Denistone, characterised by medium levels of activity throughout the day / evening and low noise levels in the night.

The following land-uses surround the project site:

- R2 - Low density residential
- E2 – Environmental conservation
- RE1 – Public Recreation
- SP2 – Infrastructure.

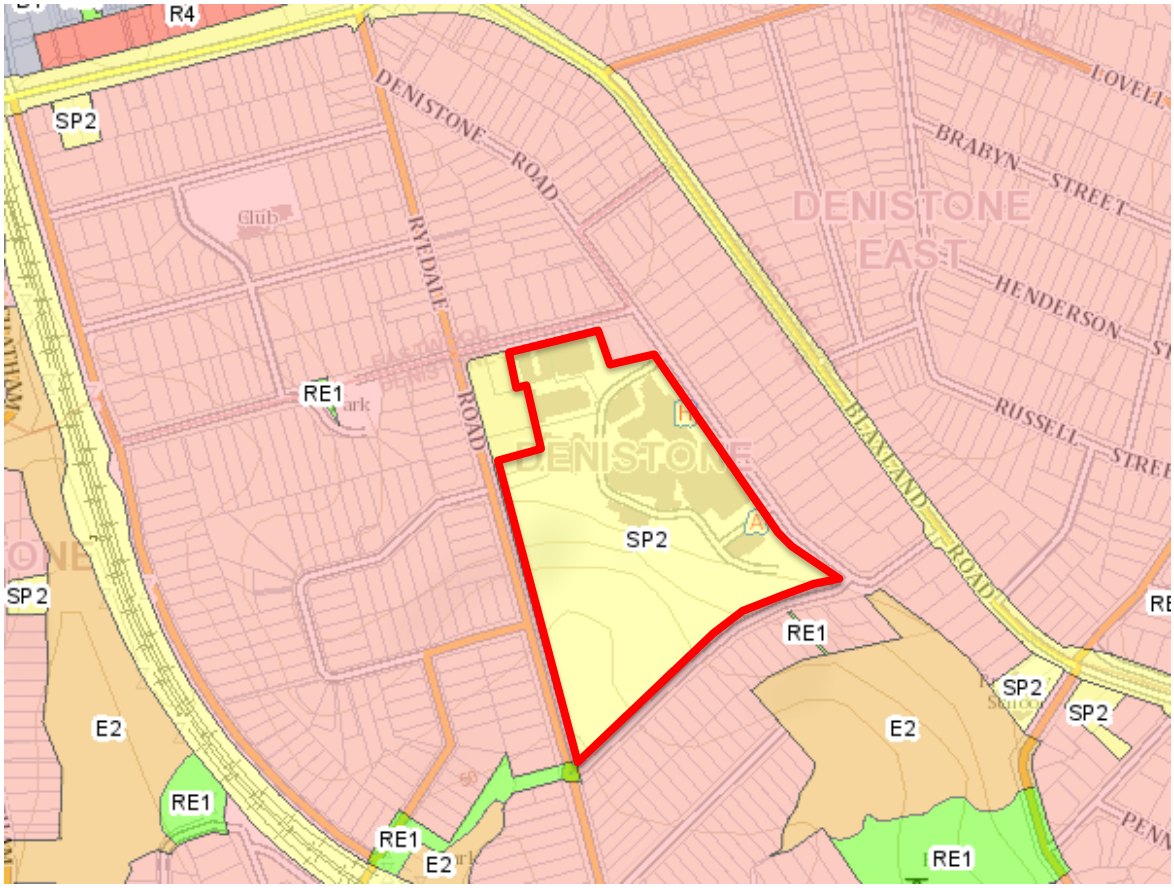


Figure 1: Ryde Hospital Site (red outline) and surrounding land uses

The following potentially noise sensitive receivers surround the existing the project boundaries:

- Residential receivers
    - Zone 1 - Across Fourth Avenue to the north.
    - Zone 2 - Across Denistone road to the east.
    - Zone 3 - Across Ryedale Road to the west.
    - Zone 4 - Across Florence Street to the south.
- On campus receivers to the north and west including Ryde Medial Centre, PRP Radiology and Graithwaite Rehabilitation Centre.

Figure 2 presents the project site in context of the surrounding land uses, and displays long-term noise monitoring locations plus off-site, short term monitoring locations.

Figure 2: Aerial View showing Ryde Hospital Site in relation to noise-sensitive receivers

4 The Key Acoustic Issues

The SEARS for the SSDA states the following in regards to Noise and Vibration for both the Concept and Stage 1 assessment.

"Provide a noise and vibration assessment prepared in accordance with the relevant NSW Environment Protect Authority (EPA) guidelines. The assessment must detail construction and operational noise and vibration impacts on nearby sensitive receivers and structures and outline the proposed management and mitigation measures that would be implemented."

The following acoustic issues are to be addressed as part of the assessment:

Concept design considerations – Including consideration of potential operational noise and vibration impacts on nearby sensitive receivers.

Noise and Vibration Emissions from Stage 1 Early Works - The impact of noise and vibration generated during the Stage 1 Early Works of the Project on surrounding noise and vibration sensitive premises.

The development will contribute to an increase in noise and vibration to the surrounding environment during Stage 1 Early Works of the Project. Typically, this will result from a combination of intermittent and continuous noise from construction and excavation equipment, construction traffic and plant commonly used on construction sites.

Design noise and vibration limits have been set for the Project and construction noise impacts have been anticipated from standard construction procedures.

The Stage 1 Early Works noise and vibration targets and expected impacts are reported in Section 6 and Section 8 of this report. Where the noise and vibration impacts are predicted to be above the Noise Management Levels, then all reasonable and feasible noise and vibration mitigation measures must be considered as detailed in Section 8.5.

The engaged Contractor would be required to prepare a comprehensive Construction Noise and Vibration Management Plan (CNVMP) based on their proposed plant, equipment and construction methodology, prior to the commencement of any works.

The comprehensive CNVMP is to provide the following:

- A quantitative construction noise and vibration assessment, which includes:
    - Identifying noise and vibration sensitive receivers potentially affected by the proposed works.
    - Reporting noise surveys which determine the existing ambient and background noise and vibration levels at the nearest sensitive receivers that surround the proposed development site.

    - Establishing the appropriate construction noise and vibration criteria based on the measurement results from the surveys.
    - Identifying noise and vibration sources associated with the proposed works.
    - Providing an assessment of noise and vibration generated by the proposed works against the relevant criteria.
    - Determining the likely need for noise and vibration mitigation and management measures.
- A control strategy for construction noise and vibration mitigation to best minimise potential impacts through implementation of reasonable and feasible measures.
- Noise and vibration monitoring as required, using monitors equipped with alert/notification systems to ensure works are carried out within established criteria.

5 Existing Noise Environment

5.1 General Survey Information

A survey of the existing noise environment at and around the site was conducted through unattended noise monitoring to continuously record the noise levels on the site. Unattended long-term noise monitoring was carried out for the following periods:

- Monday 31st January 2022 to 16th February 2022

Unattended long-term noise monitoring was carried out with the following noise loggers:

- Logger 1: Ngara (Serial Number 878079)
- Logger 2: Ngara (Serial Number 87809E)
- Logger 3: Ngara (Serial Number 878012)
- Logger 4: Ngara (Serial Number 878000)

The noise loggers recorded L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters at 15-minute intervals continuously for the measurement period. The calibration of the loggers was checked before and after use and no variations were noted.

The unattended long-term noise monitoring locations are shown in Figure 2.

The detailed results of the unattended long-term noise monitoring at the four (4) logger locations are shown in Appendix B.

These locations were chosen as they:

- Were secure places to leave the noise loggers unattended, and
- Were judged to provide representative of background and ambient noise levels at the nearest noise sensitive receivers.

Operator attended, short-term monitoring was also carried out as follows:

- Monday 31st January 2022
- Wednesday 9th February 2022
- Wednesday 16th February 2022

The short-term monitoring was conducted in order to supplement the long-term outdoor data across the site and at key surrounding receivers, and to obtain spectral noise data for traffic noise at the proposed site. These short-term measurements included measurements at the property boundaries of the closest residential properties, which were used to confirm that the long-term monitoring at each location (on the opposite side of the street) is

representative of the background and ambient noise levels at the nearest noise sensitive receivers.

Attended short-term measurements were made with two Brüel & Kjær Hand-held Analysers Type 2250 (Serial Numbers 2832406 and 3010373). The calibrations of the analysers were checked before and after the surveys and no variation in levels occurred.

Windshields were used to protect the microphones of all the loggers and analysers. Weather conditions were calm and dry during the attended noise surveys.

Isaac Bradbury and Anthony Cano of Acoustic Studio Pty Ltd carried out the surveys.

The unattended long-term noise monitoring plus locations attended, short-term noise monitoring locations are shown in Figure 2.

5.2 Unattended Long-term Monitoring Results

The loggers were located at the proposed site at the following locations:

- Location 1 – Residential – 56 Ryedale Road.
- Location 2 – Residential – 6 Florence Avenue.
- Location 3 – Residential – 56 Denistone Road.
- Location 4 – Ryde Hospital Campus – adjacent to existing CARes Building and Building 17.

The unattended long-term noise monitoring locations are shown in Figure 3.

The detailed results of the unattended long-term noise monitoring at the four (4) logger locations are shown in Appendix B.

5.2.1 Background and Ambient Noise

The logged data shows the background and ambient noise levels representative of the area. The recorded background noise levels have been used to establish limiting criteria for noise emitted from the construction and operation of the new building.

The background sound level is defined as the sound level exceeded 90% of the time, and is designated as the L_{90}. The ambient noise level impacting on the buildings is referred to as the equivalent continuous sound level (L_{eq}). This parameter is commonly used to describe a time varying noise such as traffic noise.

The background sound levels have been established in general accordance with the methodology described in the NSW Noise Policy for Industry (NPI), i.e. the 10^{th} percentile background sound level for each period for each day of the ambient noise survey. The median of these levels is then presented as the background sound level for each assessment

period. These background noise levels are shown in Table 1 below, together with the L_{Aeq} ambient noise levels measured for each period.

In accordance with the NSW NPI, any data likely to be affected by rain, wind or other extraneous noise have been excluded from the calculations.

Location	Background Noise Levels (RBL), dB(A)			Leq Ambient Noise Levels, dB(A)		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
Logger Location 1	41	40	34	55	54	49
Logger Location 2	43	38	30	58	58	49
Logger Location 3	41	40	35	56	54	47
Logger Location 4	44	40	38	55	51	50

Table 1: Long-term background and ambient noise levels

Based on our observations during the site inspections, both ambient and background noise levels around the Project Site are generally dominated by traffic noise and general urban hum around the site at all four locations.

5.3 Short-term Monitoring Results

Nine short-term noise monitoring locations were chosen as representative of the site and surrounds as follows:

- **Location A** – Fifth Avenue.
- **Location B and C** – Ryedale Avenue.
- **Location D** – Florence Avenue.
- **Location E** – Denistone Road.
- **Location F** – Ryde Hospital – CARes Building.
- **Location G** – Ryde Hospital – Graithwaite Building
- **Location H** – Ryde Hospital – ED Building
- **Location I** – Fourth Avenue.

The attended short-term monitoring locations are shown in Figure 3.

Figure 3: Measurement Locations (Logger – Yellow, Attended – Magenta)

A summary of the measured values of the short-term background and ambient noise monitoring around the existing site is provided in Table 2.

Location	Time	Descriptor	Measured sound level, dB re 20 µPa								
			Overall dB(A)	Octave band centre frequency[1], Hz							
				31.5	63	125	250	500	1k	2k	4k	8k
A	Between 3-4pm, 31st Jan 2022	Leq	57	73	67	64	59	51	49	48	45	44
		L90	40	53	52	47	43	35	33	29	27	26
B	Between 3-4pm, 31st Jan 2022	Leq	47	55	57	51	46	41	43	39	36	34
		L90	36	48	47	40	35	32	31	27	26	25
C	Between 3-4pm, 31st Jan 2022	Leq	61	56	61	59	58	57	59	52	47	42
		L90	43	51	50	45	41	38	37	35	33	33
D	Between 1.30-2.30pm, 31st Jan 2022	Leq	54	52	55	50	46	43	46	45	49	47
		L90	43	46	44	38	35	32	32	34	36	40
E	Between 1.30-2.30pm, 31st Jan 2022	Leq	56	61	61	57	55	53	49	49	46	40
		L90	44	54	53	49	45	43	38	34	29	25
F	Between 3-4pm, 9th Feb 2022	Leq	43	58	59	52	49	50	45	45	44	43
		L90	45	52	54	48	45	45	37	35	32	29
G	Between 3-4pm, 9th Feb 2022	Leq	49	58	58	54	48	45	44	43	35	30
		L90	47	56	55	52	47	44	42	38	32	23
H	Between 3-4pm, 9th Feb 2022	Leq	53	64	62	59	52	51	47	42	40	33
		L90	51	58	60	58	51	50	46	41	37	29
I	Between 4-5pm, 31st Jan 2022	Leq	55	62	62	59	53	50	50	46	41	43
		L90	45	53	54	50	47	43	39	36	32	27

Table 2: Summary of short-term traffic, background and ambient noise levels

5.4 Traffic Noise

From the attended measurements in Table 2, the Day and Night traffic periods are summarised in Table 3 below. Traffic noise levels have also been calculated based on attended measurements and traffic data along roads surrounding the Hospital road from Roads and Maritime Services Traffic Volume Viewer.

Location	Traffic Noise Levels[1], dB(A)			
	1 Hour Period		Period[2]	
	Day $L_{eq, (1\ hr)}$	Night $L_{eq, (1\ hr)}$	Day $L_{eq, (15\ hr)}$	Night $L_{eq, (9\ hr)}$
Ryedale	60	53	59	53
Denistone	57	49	56	48

Table 3: Summary of measured traffic noise levels

[1] Levels at 7m distance from centre of the closest lane

6 Project Noise and Vibration Criteria

6.1 Relevant Standards and Guidelines

The following acoustic standards and guidelines have been considered in establishing noise and vibration criteria and assessment for this project.

- City of Ryde Development Control Plans (DCP) and Local Environment Plan (LEP),
- NSW EPA Noise Policy for Industry (NSW NPI) 2017.
- NSW EPA Road Noise Policy (RNP) 2011.
- NSW Department of Environment and Climate Change (DECC) "Interim Construction Noise Guideline" (ICNG) 2009.
- NSW Department of Environment and Conservation (DEC) "Assessing Vibration: A Technical Guideline" (AVTG) 2006.
- NSW Department of Planning "Development Near Rail Corridors and Busy Roads – Interim Guideline" 2008.
- NSW Protection of the Environmental Operations (POEO) Act 1997.
- Australian Standard AS 2107:2000 "Acoustics – Recommended design sound levels and reverberation times for building interiors".
- Australian Standard AS 2021:2000 "Acoustics – Aircraft noise intrusion - building siting and construction".
- Australian Standard "AS 2436 : Guide to Noise and Vibration Control on Construction, Demolition & Maintenance Sites" 2010.
- Australian Standard "AS 1055 : Acoustics – Description and Measurement of Environment Noise" 1997.
- Australian Standard "AS 2670.2 : Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)" 1990.
- British Standards Institution "BS 6472 – Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)" 1992.
- German Standard DIN 4150-3:1999 "Structural vibration Part 3: Effects of vibration on structures".
- British Standard BS7385: Part 2: 1993 "Evaluation and measurement for vibration in buildings. Guide to damage levels from ground borne vibration".

- NSW Health Infrastructure "Engineering Services Guidelines (ESG)", August 2016. We note that Section 13 (Acoustics) of these guidelines has been updated. The updated guideline performance requirements for acoustics are provided in "Design Guidance Note No.33", (RevA 19 July 2017).
- *"Australasian Health Facility Guidelines"* December 2012 Revision v.4.0.

6.2 Construction Noise and Vibration

6.2.1 Noise Management Levels

The relevant guideline applied for the assessment of construction noise is the ICNG. This guideline provides construction Noise Management Levels for Residential, Commercial and Industrial noise receivers as follows.

Residential Receivers

Section 4 of the ICNG provides recommendations for standard hours of work and suggests construction Noise Management Levels that aim to minimise the likelihood of annoyance caused to noise sensitive receivers. These consider both airborne and ground borne noise level impacts.

Table 4 outlines the methodology for determining construction Noise Management Levels at nearby residential receivers surrounding the development site based on existing background noise levels.

Time of Day	Management level $L_{Aeq\ (15\ min)}$	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours:	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2.

Table 4: Residential construction Noise Management Levels for airborne noise as outlined in the ICNG

The project-specific construction Noise Management Levels are shown in Table 5 based on the measured background noise levels at the site (in Section 5 – also refer to Appendix B).

Location	Period		Rating Background Level RBL, dB(A)	Noise Management Level $L_{eq\ (15\ min)}$ dB(A)	
Residential (Zone 1 - North, Zone 2 - East, Zone 3 - West)	Recommended Standard Hours	Monday to Friday 7am to 6pm	41	RBL + 10	51
		Saturday 8am to 1pm	41		51
	Outside Recommended Standard Hours[3]	Saturday 1pm to 6pm	40	RBL + 5	50
Residential (Zone 4 - South)	Recommended Standard Hours	Monday to Friday 7am to 6pm	43	RBL + 10	53
		Saturday 8am to 1pm	43		53
	Outside Recommended Standard Hours	Saturday 1pm to 6pm	43	RBL + 5	43

Table 5: Project Specific residential construction Noise Management Levels for **airborne** noise

The ICNG also recommends *ground-borne* Noise Management Levels at residences affected by nearby construction activities. Ground-borne noise is noise generated by vibration transmitted through the ground into a structure and can be more noticeable than airborne noise.

The ground-borne noise levels presented below are for evening and night-time periods only, as the objective is to protect the amenity and sleep of occupants during the more sensitive time periods.

Time of Day	Noise Management level L_{Aeq} (15 min)
Evening (6pm to 10pm)	40 dB(A) - Internal
Night (10pm to 7am)	35 dB(A) - Internal

Table 6: Residential construction Noise Management Levels for **ground-borne** noise

[3] For "Outside Recommended Standard Hours" the relevant RBL has been established based on the NSW NPI period (Day, Evening, Night) that the proposed outside hours works fall within. Shoulder periods are applied where the outside hours' works are proposed within one hour of "Recommended Standard Hours".

Non-Residential Receivers: Commercial, Industrial and Educational Receivers

The ICNG also provides recommended construction Noise Management Levels for commercial, industrial and educational facilities surrounding a construction site, which are as follows:

Occupancy	Management level L_{Aeq} (15 min)
Offices, retail outlets	70 dB(A) - External
Hospital wards and operating theatres	45 dB(A) - Internal / 65 dB(A) - External[4]
Classrooms at schools and other educational institutions	45 dB(A) - Internal / 65 dB(A) - External[5]

Table 7: Industrial, commercial, educational and hospital construction Noise Management Levels for airborne noise

Construction Noise Impacts on the Existing Hospital Campus

On Campus receivers have been included in the assessment to assist with managing construction noise impacts on Campus.

The ICNG does not provide specific guidance for hospitals other than recommending a NML of 45 dB(A) for wards or operating theatres, above which the proponent is to consult with the health authority to determine ways to manage noise impacts.

For assessment of Ryde Hospital buildings, reference is made to the Non-Residential Receiver NMLs in Table 7 above.

Construction Traffic Noise on Public Roads

The RNP provides criteria for traffic noise from new roads or additional traffic generated on roads from land use development. The criterion applies to additional traffic generated on public roads from construction vehicles / traffic.

Table 8 below provides the RNP criteria for additional traffic generated on local roads from land use development in relation to the applicable receiver types surrounding the site.

[4] Minimum 20 dB loss from a closed façade typical of commercial or hospital ward.

[5] Where internal noise levels are specified, the NSW NPI assessment methodology states that in cases where the gaining of internal access for monitoring is difficult, then external noise levels 10 dB above internal noise levels apply assuming a window opened sufficiently to provide ventilation.

Receiver	Assessment Criteria (external[6])	
	Day (7am to 10pm) $L_{Aeq\ (period)}$	Night (10pm to 7am) $L_{Aeq\ (period)}$
Residential	60 (15 hour)	55 (9 hour)
Hospital Wards	55 (1 hour)	55 (1 hour)
School classrooms (Educational)	60 (1 hour)	-
	55 (1 hours) – Sleeping Rooms	-
Childcare Centres	60 (1 hours) – Indoor Play	-
	55 (1 hour) Outdoor Play	-

Table 8: RNP assessment criteria for additional traffic on local roads generated by land use development including construction vehicles / traffic

When considering land use redevelopment and the impact on sensitive land uses (residential / schools / hospitals / recreational) the RNP guideline states that *"In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB"... (in relation to existing noise levels).. "represents a minor impact that is considered barely perceptible to the average person".*

[6] Non-residential external noise criteria are derived from internal noise criteria, assuming a transmission loss of 10dBA if windows are opened to provide natural ventilation (worst-case) and 20dBA if the windows are closed or external façade is glazing. This methodology is supported by the NPI.

6.2.2 Vibration Criteria

Construction vibration is to be assessed in terms of:

- Human comfort
- Disruption to sensitive equipment
- Structural damage

Relevant criteria for each of these are detailed in the sections that follow.

Human Comfort

The DEC AVTG provides suitable criteria that can be applied to the assessment of vibration and human comfort. The guideline makes reference to the British Standard BS 6472: 1992, which shares many similarities to the Australian Standards AS 2670.2: 1990. This guideline presents preferred and maximum vibration values for use in assessing human responses to vibration plus limits for critical areas in hospital and educational buildings, and provides recommendations for measurement and evaluation techniques.

Vibration in buildings can be caused by many different external sources, including industrial, construction and transportation activities. The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time). Vibration in buildings may also occur from internal sources (within a building structure), such as building services and plant.

Vibration and its associated effects are usually classified as continuous, impulsive or intermittent:

- **Continuous vibration** continues uninterrupted for a defined period (usually throughout daytime and/or night-time) including machinery or steady road traffic. This type of vibration is assessed on the basis of weighted rms acceleration values.
- **Impulsive vibration** is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds (e.g. occasional dropping of heavy equipment, occasional loading and unloading).
- **Intermittent vibration** can be defined as interrupted periods of continuous (e.g. a drill) or repeated periods of impulsive vibration (e.g. a pile driver), or continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g. pile drivers and forging presses) or repetitive sources (e.g. pavement breakers), or sources which operate intermittently, but which would produce continuous vibration if operated continuously (for example, intermittent machinery,

railway trains and traffic passing by). This type of vibration is assessed on the basis of vibration dose values.

The criterion also considers the type of vibration being assessed, namely continuous, impulsive and intermittent vibration.

The relevant criteria for human exposure to continuous and impulsive vibration are detailed in Table 9. Vibration levels are assessed through the consideration of the summation of effects for vibration levels at frequencies from 1 to 80 Hz for all axes.

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous vibration					
Critical areas	Day or night time	0.10	0.072	0.20	0.14
Residences	Day time	0.20	0.14	0.40	0.28
	Night time	0.14	0.10	0.28	0.2
Offices, schools, educational institutions and places of worship	Day or night time	0.40	0.28	0.80	0.56
Workshops	Day or night time	0.80	0.58	1.6	1.16
Impulsive vibration					
Critical areas	Day or night time	0.10	0.072	0.20	0.14
Residences	Day time	6.0	4.2	12.0	8.4
	Night time	2.0	1.4	4.0	2.8
Offices, schools, educational institutions and places of worship	Day or night time	13.0	9.2	26.0	18.4
Workshops	Day or night time	13.0	9.2	26.0	18.4

Table 9: Preferred and maximum weighted rms values for continuous and impulsive vibration velocity (mm/s) 1-80 Hz

Human exposure to intermittent vibration is assessed using the Vibration Dose Value (VDV). The VDV accumulates the vibration energy experienced over an extended period (daytime and night-time periods) from intermittent events. Table 10 sets out the acceptable VDV values for intermittent vibration.

Location	Daytime		Night-time	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Table 10: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Sensitive Equipment

Areas with sensitive equipment are likely to require a higher degree of vibration isolation than the values in Table 9 & Table 10.

Vibration Criterion (VC) curves are used to provide the basis for the design and protection of highly vibration sensitive equipment. Table 11 details the VC curves applicable to a range of highly sensitive equipment that is to be referred to and considered in conjunction with manufacturer guidelines specific to each type of equipment.

Curve	Max Value 8-80Hz	Detail Size	Equipment Types / Requirements
	Microns / sec, rms	Microns	
VC-A	50	8	Bench Microscopes < 400 x Magnification, optical and other precision balances, coordinate measuring machines and optical comparators
VC-B	25	3	Bench Microscopes > 400 x Magnification, microsurgery and neurosurgery
VC-C	12.5	1	Electron Microscopes < 30,000 x magnification, magnetic resonance imagers and microelectronics manufacturing equipment
VC-D	6	0.3	Electron Microscopes > 30,000 x magnification, mass spectrometers and cell impact equipment
VC-E	3	0.1	Un Isolated laser and optical research systems

Table 11: VC Curves for Highly Sensitive Equipment

Figure 4 shows the relationship between criteria for highly sensitive equipment and human exposure criteria shown in Table 9.

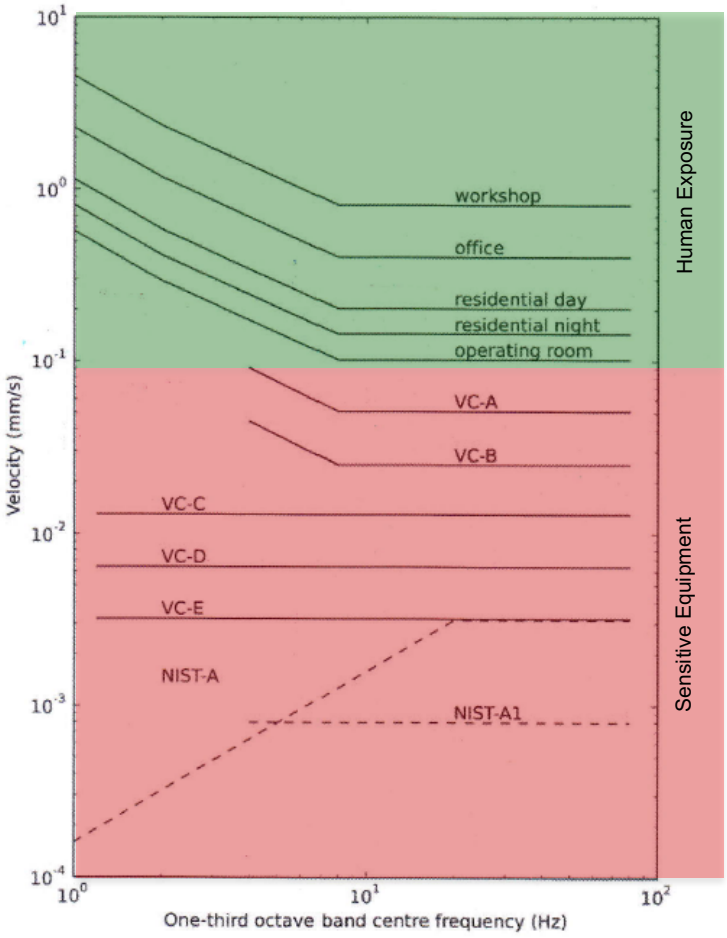


Figure 4: VC Curves - Source: ANC Guidelines – Measurement and Assessment of Ground-borne Noise & Vibration, Association of Noise Consultants (2012)

Structural Damage

Vibration-induced damage of buildings and structures is a common concern, but it is actually rare in practice. This explains why there is limited reliable data on the threshold of vibration-induced damage in buildings and there is no directly relevant Australian Standard. There are guidelines available in a number of international standards, although these vary significantly.

German Standard

The relevant German standard is *DIN 4150-3 Structural vibration Part 3: Effects of vibration on structures" (Feb 1999)*. This standard gives guidelines for short-term and steady state structural vibration.

The short-term vibration limits as follows:

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

Table 12: Guideline Values of Vibration Velocity, v_i, for Evaluating the Effects of Short-term Vibration

The guidelines note that: "*provided the values given in* Table 12 *are observed, damage due to vibration, in terms of a reduction in utility value, is unlikely to occur. If the values of* Table 12 *are exceeded, it does not necessarily follow that damage will occur. Should these values be significantly exceeded, further investigation is necessary.*"

British Standard

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

The Standard proposes the following limits on the foundations of the buildings:

Structural type	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15Hz and above
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s @ 4Hz increasing to 20mm/s @ 15Hz	20mm/s @ 15Hz increasing to 50mm/s @ 40Hz and above

Table 13: Transient Vibration Guide Values for Cosmetic Damage

The standard states in Annex A, that ... *"the age and existing condition of a building are factors to consider in assessing the tolerance to vibration. If a building is in a very unstable state, then it will tend to be more vulnerable to the possibility of damage arising from vibration or any other ground-borne disturbance". It is recommended that buildings*

of importance be considered on a case-by-case basis with detailed engineering analysis being carried out if necessary.
Annex B of the Standard gives a breakdown of data that would be recorded. Included in this are details of the building structure, such as general condition of the structure, list of defects, photographs, details of all major extensions, repairs and renovations. A crack exposure report would be prepared both pre and post exposure, both internally and externally.

Australian Standard

There is no specific Australian Standard referring to structural vibration in buildings. There is however AS 2187.2 - 2006, which, in Appendix J, recommends maximum peak particle velocities, measured at the ground surface due to blasting. The lower recommended peak particle velocity is 10 mm/s. The standard states however, that structures that may be particularly susceptible to ground-borne vibration would be examined on an individual basis. It is suggested that in the absence of a particular site-specific study then a maximum peak particle velocity of 5 mm/s is used.

Summary

Table 14 gives a summary of vibration limits recommended in relevant standards and guidelines for minimising the risk of vibration-induced damage to buildings.

Standard	Type of building	Recommended vibration limit	Comments
DIN 4150	Structures of particular sensitivity or worthy of protection	3 mm/s to 20 mm/s @ < 10 Hz 3-40 mm/s @ 10-50 Hz 8-50 mm/s @ 50 Hz+ Also measurement at the top floor with limit of 8 mm/s to 40 mm/s across frequency range	Limit is for peak particle velocity in x,y, and z directions. Measurement on the top floor in x and y directions only
BS 7385	Un-reinforced or light framed	15 mm/s @ 4 Hz rising to 20 mm/s @ 15 Hz then rising to 50 mm/s @ 40 Hz and above[1]	Limit is for peak particle velocity in x, y, and z directions
AS 2187	Houses and low-rise residential, commercial buildings not of reinforced or steel construction	5 mm/s[1]	For buildings particularly susceptible to vibration. Limit is for peak *resultant* particle velocity, measured on the ground adjacent to the structure
SN 640 312	Structures of particular sensitivity	3 mm/s to 12 mm/s @ 10-30 Hz 3 mm/s to 18 mm/s @ 30-60 Hz	Limit is for peak particle velocity in x, y, and z directions

Table 14: Summary of vibration limits

Recommendations

It is clear from the above that relevant standards provide a wide range of suggested vibration limit values for structural damage, but the actual risk of vibration-induced damage is relatively low.

It is recommended that a precautionary approach for managing vibration-induced damage be taken for this project, whereby conservative vibration criteria are adopted in the first instance. It would be possible to relax these criteria if required, subject to review of specific buildings by a structural engineer and a regime of vibration monitoring.

The recommended precautionary criteria are:

- 3 mm/s (130 dB re 10^{-6} mm/s) for buildings surrounding the Project identified as "sensitive". At this stage no structures at or surrounding the site have been identified as particularly sensitive to vibration-induced damage.
- 5 mm/s (134 dB re 10^{-6} mm/s) for residential dwellings.
- 20 mm/s (146 dB re 10^{-6} mm/s) for classrooms, non-precision laboratories and commercial premises.

These limits apply across the full frequency range of relevance (i.e. typically 1 Hz – 100Hz encountered in building construction).

Additional Criteria

The following includes (but is not limited to) areas that we understand to have sensitivity to vibration due to the occupancy / use or due to vibration-sensitive equipment:

- Medical Imaging - PRP Diagnostic Imaging (245 Ryedale Road – west of campus)
- Operating Theatres

Detailed review of all potentially vibration sensitive receivers on campus will be carried out and objective requirements will be established including further consultation with the relevant stakeholders prior to works commencing on site and incorporated within the CNVMP prepared by the contractor.

6.3 Operational Noise Emissions

6.3.1 General Noise

NSW Noise Policy for Industry

The NSW NPI provides guidance on methodology for determining limiting noise criteria for external noise emissions from plant associated with a development.

The criteria have two components:

- Intrusiveness Noise Level – controlling intrusive noise impacts in the short term for residences.
- Amenity Noise Level (ANL) – maintaining noise level amenity for particular land uses for residences and other land uses.

Applying the more stringent of the two criteria provides the Project Noise Trigger Level (PNTL).

The NSW NPI considers the following when establishing the criteria:

- The existing Ambient (L_{eq}) and Background noise levels (L_{90}) that surround the site.
- The time of day that the noise generating development will be in operation, defined by the following:
    - Day (7am to 6pm).
    - Evening (6pm to 10pm).
    - Night (10pm to 7am).
- The type of receivers.
- The type of area that the development site and its nearest receivers are located. The NSW NPI provides recommended noise levels for specific receiver types and the type of area they are located within.
- The type of noise source and its characteristics. The NSW NPI provides modifying factors for noise sources with certain characteristics that may potentially cause greater annoyance than other noise sources of the same level.

Further guidance on establishing the criteria can be found in the NSW NPI.

Based on the measured noise levels detailed in Section 5 and in accordance with the methodology outlined in the NSW NPI (further described in Appendix C), Table 15 details the corresponding limits of allowable noise emission from external plant and equipment at the nearest receiver boundaries from the Hospital.

Receiver (External)	Period	Project Noise Trigger Level (PNTL)[7] $dBL_{Aeq(15min)}$ dB(A)
Residential (Zone 1 - North, Zone 2 - East, Zone 3 - West)	Day	46
	Evening	43
	Night	38
Residential (Zone 4 - South)	Day	48
	Evening	43
	Night	35
Hospital Ward	When in use	43
Commercial Premises	When in use	58

Table 15: NSW NPI Project Noise Trigger Levels for external noise emissions from proposed development

Noise Impacts on the Existing Hospital Campus

Redevelopment of any site must consider all neighbouring receivers. When the redevelopment site is an extension of an existing campus, neighbouring receivers will include existing "on-campus" buildings. However, compliance with the NPI PTNL in Table 15 is discretionary.

A target noise level of 50 to 55 dB(A) is recommended at external occupied and trafficable areas surrounding existing hospital buildings. This is based on observations of pre-existing conditions made by Acoustic Studio during site inspections and noise surveys at the Ryde Hospital Campus. This target also applies to external areas for the new building.

[7] Project Noise Trigger Level is based on the more stringent of the Project Amenity and Intrusiveness Noise Levels.

6.3.2 Sleep Disturbance (Residential Receivers)

Noise sources with the potential for sleep disturbance are likely to occur during night-time (10pm to 7am) operational and construction works activities.

The NSW NPI provides guidance on the assessment of sleep disturbance based on the predicted event $L_{Aeq,15min}$ and/or L_{AFmax} noise levels at the receiver that are considered applicable to the SSDA. It suggests Sleep Disturbance Screening Criteria of:

- Event $L_{Aeq,15min}$ 40 dB(A) or Night Time RBL+ 5 dB, whichever is the greater, and/or
- Event L_{AFmax} 52 dB(A) or Night Time RBL + 15 dB, whichever is the greater.

If the $L_{Aeq,15min}$ noise level above background is less than 5 dB and/or maximum noise emergence above background is less than 15 dB, then the noise is considered unlikely to cause sleep disturbance. If the screening test level is exceeded, then further assessment of sleep disturbance effects is warranted.

The Sleep Disturbance Screening Criteria are presented in Table 16.

Residential Receiver Location	Period	Sleep Disturbance Screening Criteria	
		$L_{Aeq,15min}$ dBA	L_{AFmax}, dBA
All	Night (10pm to 7am)	40	52

Table 16: Sleep Disturbance Screening Criteria

The Sleep Disturbance Screening Criteria $L_{Aeq,15min}$ and L_{AFmax} not exceeding the $L_{A90,\ (15\ minute)}$ by more than 5 dB(A) and 15 dB(A) respectively are screening criteria for the purpose of assessing potential impacts from a project. It applies outside bedroom windows during the night-time period.

If the Sleep Disturbance Screening Criteria is exceeded, the detailed analysis is to cover the extent to which the noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the RNP.

Other factors that may be important in assessing the extent of impacts on sleep include:

- How often high noise events will occur;
- Time of day (normally between 10pm and 7am);
- Whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).

A further consideration for sleep awakening is whether the environmental noise has changed. Section 5.3 "Response to a Change in Noise Level" of the RNP states:

"While people may express a certain tolerance for their existing noise environment, they may feel strongly about increases in noise. […] The difference in reported awakenings from sleep was equivalent to a difference of 7 dB(A) in maximum noise levels."

Section 5.4 of the RNP, "Sleep Disturbance", states that:

"From the research on sleep disturbance to date it can be concluded that:

- *Maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep;*
- *One or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly."*

The internal noise levels provided in the RNP are related to potential sleep awakening.

Typically noise impact assessments consider the worst-case scenario, including when residential receivers have windows open sufficiently to provide natural ventilation. This would result in approximately 10 dB(A) attenuation from outside to inside through the open window. This situation is considered likely during warmer seasons. When windows are closed, the likely sound attenuation through standard windows with poor seals (common in older houses) is approximately 20 dB(A).

Based on a minimum attenuation of 10 dB(A) with windows open, the first conclusion of the RNP suggests (extract from RNP Section 5.4 above) that short term external noises of 60 to 65 dB(A) are unlikely to cause awakening reactions. In addition, external levels of 75 to 80 dB(A) are unlikely to affect health and wellbeing significantly, provided that these events occur no more than twice in one night.

Residential Receiver Location	Period	Sleep Awakening Level
		L_{AFmax}, dB(A)
All	Night (10pm to 7am)	60 to 65

Table 17: Sleep Awakening Level

6.3.3 Traffic Noise

NSW Road Noise Policy

The RNP provides criteria for traffic noise from new roads or additional traffic generated on roads from land use development. The relevant criteria is as per construction traffic noise criteria outlined in Section 6.2.1.

CONCEPT PROPOSAL

7 SEARS Requirements for Concept Proposal

The SEARS sets the following requirement related to the Concept Proposal Assessment:

"...

Concept Proposal

11. Noise and Vibration

Provide a noise and vibration assessment prepared in accordance with the relevant NSW Environment Protect Authority (EPA) guidelines. The assessment must detail construction and operational noise and vibration impacts on nearby sensitive receivers and structures and outline the proposed management and mitigation measures that would be implemented.

..."

We make the following comments with regard to the concept design.

Concept Proposal Layouts and Noise Mitigation and Management Strategies

The Concept Proposal layout in Figure 5 provides current the general strategy for the hospital layout.

Figure 5: Concept Layout – Proposed Site Plan

The Concept layout and design to minimise noise impact include:

- Car parking will be provided on both sides of the campus with access via Ryedale and Denistone Roads.
- Ambulance bays, ED / public drop off and loading docks will be strategically located and distributed to avoid traffic congestion and incorporate shielding and separation from noise sensitive from surrounding noise sensitive receivers as best practical.
- Strategies for control of noise emission from plant and equipment include:
    - Selecting plant and equipment without any annoying characteristics such as low frequency or tonality (which can often be associated with pumps and chillers).
    - Locating of plant strategically (basement, interstitial and on roof) to ensure that the cumulative noise contribution at the receiver boundary is achieved. Where practical, plant will be located facing away from the nearest noise sensitive receivers or controls will be provided as required to reduce noise impact.

- Noise mitigation / control measures that are allowed for in the design (generally for plant and equipment) will include:
    - Noise enclosures or barriers / screening as required.
    - Acoustic louvres as required.
    - In-duct attenuation.
    - Sound absorptive panels.

A detailed assessment of the completed project and main works will be undertaken as part of the future detailed design and associated SSDA 2 submission.

STAGE 1 EARLY WORKS

8 Construction Noise and Vibration

8.1 Proposed Hours

Proposed construction hours for the Stage 1 Early Works are as follows, in line with the ICNG Standard Construction Hours:

- Monday to Friday - 7:00am to 6:00pm.
- Saturday - 8:00am to 1:00pm.
- Sunday and Public Holidays – No works.

8.2 Description of Proposed Works

The Stage 1 Early Works application will include the following relevant to the Enabling works construction zone as shown on the architectural drawings:

- Establishing access to the Project site and general establishment;
- Site preparation including environmental clearing;
- Minor earthworks for site preparation, including, cut and fill, associated with stage 1 footprint and proposed stage 1 internal roads;
- Shoring associated with bulk earthworks;
- Establishment of access roads;
- Relocation and upgrades of in-ground building services works and utility adjustments to facilitate bulk earthworks;

Stage of Work (Period)	Main Tasks	Typical Plant
Stage 1 Early Works (Q1 2023 to Q4 2023)	Construction Compound	Hand Tools / Grinder / Circular Saws / Drills / Delivery Trucks / Mobile crane
	Site preparation and Environmental Clearing	Chain saw / Wood Chipper / Excavator / Bobcat
	Bulk Earthworks	Excavators / Backhoe / Bobcats / Skip Trucks / Rock Breaker
	Construction of access roads	Vibratory Roller / Compactor / Grader / Excavators / Bobcats / Skip Trucks
	Services Diversion	Jackhammer / Excavator / Grinder / Saws / Drills

Table 18: Stage 1 Early Works

The Early Work Zone is outlined in Figure 6

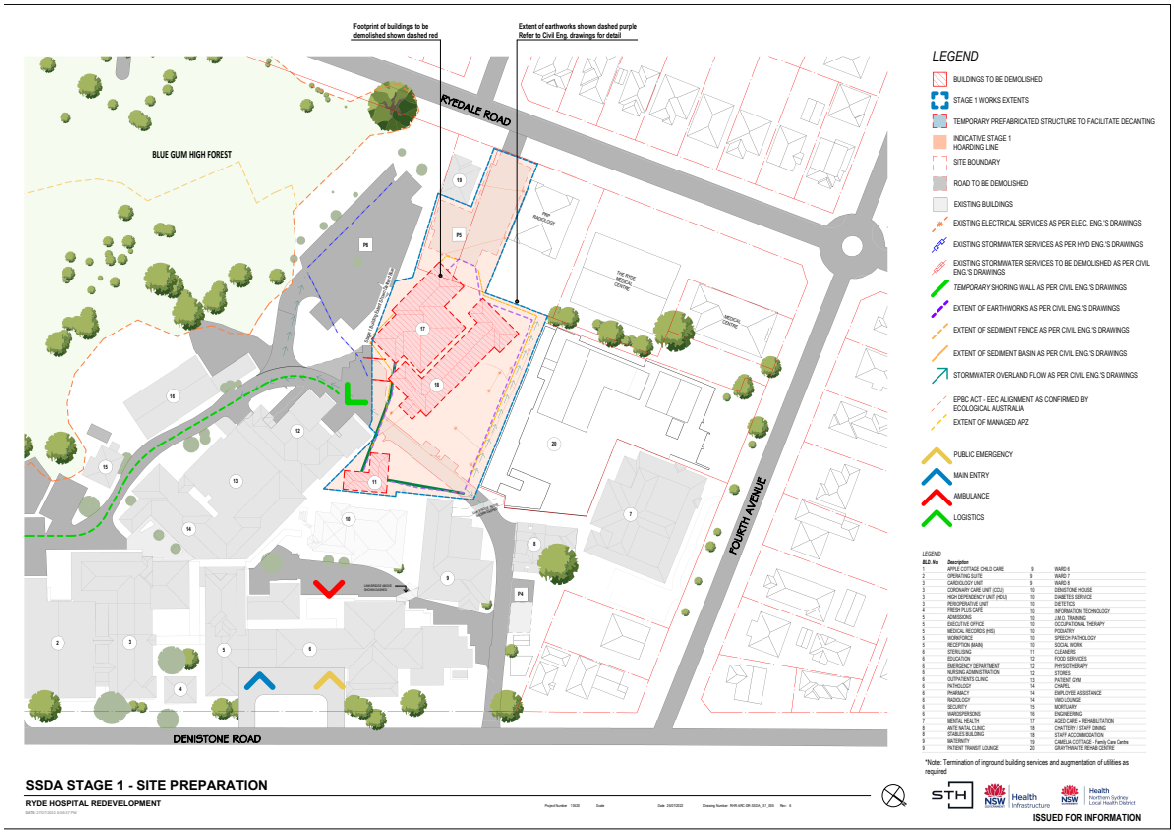


Figure 6: Early Works Zones – Site Preparation Plan

8.3 Construction Noise

The following sections outline the preliminary assessment carried out for construction noise emissions.

8.3.1 Noise Sources

The key noise sources for the activities occurring during construction works and the associated equipment sound power levels are listed in Table 19. These values are based on Acoustic Studio's database and the relevant Australian and International Standards including AS2436:2010 and BS5228-1:2009.

Equipment Type	Item	Typical Noise Level $dBL_{Aeq,15min}$ SWL
Heavy Vehicles	Concrete Mixer trucks	109
	Hiab Truck	111
	Dump Truck (20 Tonne 35-50 Tonne)	107
	Dump Truck (Tipping Material)	117
	Delivery trucks (semi-trailers, rigid trucks)	105
	Tipper / Skip Truck	111
Site Machinery	Mobile Crane	111
	Bulldozer	113
	Bobcat	110
	Excavator (w/bucket) / Backhoe / Front Loader	113
	Excavator (with rock breaker / rock saw – up to 40 tonne)	119
	Wood Chipper	117
	Compactor	110
	Grader	107
	Vibratory Roller	107
	Forklift	104
	Rock Crusher / Mulcher	119
	Piling / Drill Rig	113
	Concrete pump	110
	Concrete Vibrator	101

Equipment Type	Item	Typical Noise Level $dBL_{Aeq,15min}$ SWL
Hand Held Tools	Angle Grinder	101
	Drill	91
	Hammer Drill	104
	Jackhammer	110
	Hand Tools (Electric)	99
	Circular saw	112
	Chain Saw	114

Table 19: Anticipated airborne noise levels for equipment / plant during construction works

Potential sources of vibration and ground-borne noise during the Project works include:

- Excavation and rock breaking.
- Shoring / rotary piling.
- Vibratory Rollers.

Vibration and ground-borne noise impacts are likely to be highest during the excavation stages of the Project, when equipment such as rock breakers and jackhammers are used.

8.3.2 Sensitive receivers

Nearest sensitive receivers to the Project Site that will be potentially affected by noise and vibration are as presented in Section 3.

Table 20 outlines the most critical receivers surrounding the site for each type of impact.

Receiver	Impact	Location	Typical Worst-Case Distance from construction site (m)
Residential	Airborne	North	110
	Airborne	South	240
	Airborne	East	100
	Airborne	West	40
Graithwaite Rehabilitation Centre	Airborne + Vibration	North	10
Existing Hospital Buildings	Airborne + Vibration	South	10
Commercial	Airborne	West	5
	Airborne	East	100

Table 20: Noise sensitive receivers and approximate distance to Project construction works site

8.3.3 Construction Noise Assessment Methodology

A preliminary assessment of the likely noise impacts of the proposed works on the most-affected receivers surrounding the site has been carried out.

The assessment has considered the following:

- Typical activities considered in the noise impact assessment are as detailed in Section 8.2.
- Project specific Noise Management Levels at each sensitive receiver location as outlined in Section 6.2.
- Noise level predictions are calculated using the noise data provided in Table 19.
- Noise level predictions consider:
    - Distance attenuation
    - Shielding
    - Ground and building reflections
- The noise level predictions are based on assumptions that represent the worst-case scenario.
- L_{Aeq} noise levels are predicted for the operations of the nearest works area on the site to each of the nearest sensitive receiver location.
- Predictions consider the typical worst-case distances in Table 20.
- The predictions consider individual tasks and associated equipment with a range from the nearest construction site boundary (for receivers on campus that are adjacent to the site) and the centre of construction site.
- The predictions assume continuous operation of equipment / plant over the 15-minute assessment period to provide a worst-case assessment, unless otherwise stated.

8.3.4 Assessment Results

Construction Noise

Table 21 presents the results for the construction noise assessment at surrounding receivers based on typical plant and equipment outlined in Section 8.3.1 operating within the boundary of the construction works site.

Location	Residential				Hospital	Commercial
	West	South	East	North		
NML	**51**	**53**	**51**	**51**	**65**	**70**
Construction						
Trucks	71	55	63	62	77 - 83	77 -89
Concrete Mixer Truck	69	53	61	60	75 – 81	75 – 87
Mobile Crane	71	55	63	62	77 – 83	77 – 89
Compactor	70	54	62	61	76 – 82	76 – 88
Grader / Roller	67	51	59	58	73 – 79	73 – 85
Excavator with Hammer	73	57	65	64	79 – 85	79 – 91
Excavator with bucket / Backhoe / Front loader	67	51	59	58	73 -79	73 – 85
Bobcat	70	54	62	61	79 – 82	76 -88
Concrete Pump	70	54	62	61	79 – 82	76 -88
Jackhammer	70	54	62	61	79 – 82	76 -88
Drilling / Piling Rig	73	57	65	64	79 – 85	79 – 91
Concrete Vibrator	61	45	53	52	67 – 73	67 – 79
Grinder	61	45	53	52	67 – 73	67 – 79
Hand Tools / Drills	59	43	51	50	65 – 71	65 - 77
Chain / Circular Saw	72	56	64	63	78 - 84	78 - 90
Wood Chipper	77	61	69	68	83 – 89	83 – 95

Location	Residential				Hospital	Commercial
	West	South	East	North		
NML	**51**	**53**	**51**	**51**	**65**	**70**
Construction						
Forklift	64	48	56	55	70 -76	70 - 82

Table 21: Predicted equipment/plant noise levels at the nearest surrounding community receiver locations – Levels predicted to exceed the NMLs during "Recommended Standard Hours" are in **red** .

Construction Traffic Noise

As described in Section 6.2.1 and as per the RNP, an increase in the traffic noise level of up to + 2dB in relation to the existing traffic noise level is considered to be a minor impact and barely perceptible to the average person.

Road	Existing Traffic Volume (DATE)		Limit of Increase in Traffic Volume	
	Peak Hour			
	am	pm	am	pm
Ryedale Road	210	205	122	119
Denistone	200	222	116	129
Florence	150	170	87	99
Fourth	143	157	83	91

Table 22: Indicative limit of increase in traffic volume due to addition of construction traffic, in order to maintain an increase in traffic noise level of less than 2 dB(A).

Based on information provided by the Traffic Consultant, we understand the following with regard to construction workers and parking:

- Some construction parking is to be provided on site within the construction area.
- Construction workers will be permitted to park on street, however only minimal overflow is expected given low number of peak workers, parking on site and sustainable transport methods to be encouraged.
- Given the site's proximity to a range of high frequency public transport services, workers will be encouraged to use public transport to access the site. Appropriate arrangements will be made for any equipment/ tool storage and drop-off requirements.

- Recommendations will be made for construction workers to operate a "car pool" to / from the local train stations to encourage uptake of sustainable travel modes
- Light vehicle traffic generation would be largely generated by construction worker traffic movements to and from the site. Some parking will be provided on-site, with workers to be encouraged to use public transport to access the site. As such, light vehicle traffic generation associated with construction workers will be minor. Further to this, any construction worker traffic movements will generally be outside of peak periods.

Based on information from the Project Manager, anticipated construction traffic movements are as follows:

- Heavy Vehicles – up to 20 heavy vehicles per day for a peak period of three months during Early Works.
- Light Vehicles – traffic will largely be generated by construction worker movements to and from site. The project is expected to generate up to 35 construction jobs. Workers would be encouraged to car pool and utilise public transport to access site.

Volumes of construction traffic are expected to be well below the allowable target of increase in traffic volumes outlined in Table 22.

Further to the above, once the Contractor is engaged on this project, a detailed understanding of construction traffic vehicle generation plus noise mitigation strategies will be confirmed and included in the CNVMP. This will also include strategies and advice to heavy vehicle drivers to limit noise generation by avoiding heavy acceleration (entry to site avoiding access via the southern end of Ryedale Road), plus limiting idling, engine braking and use of horns.

Cumulative Noise Impact

The Contractor will also need to consider cumulative noise impact as part of the CNVMP and collaboration will be required with other proponents and Contractors for other construction sites / activities in the vicinity are carried out at the same time.

The program and CNVMP prepared by the Contractor will need to consider the staging and other concurrent works on campus as part of the Project in order to minimise cumulative noise impacts on surrounding receivers.

8.3.5 Summary of Noise Assessment Findings and Discussion of Noise Controls During Construction

Based on the results from the high-level assessment of the indicative works, we make the following comments:

- Construction works noise impacts will be greatest at on Campus noise receivers including the existing Graithwaite Rehabilitation Centre and Ryde Medical Centre Buildings. Noise from various plant and equipment operating individually are generally predicted to be above the NMLs due to the proximity to the nearest affected receivers. The worst-case noise impacts are for excavators with hammers with noise levels predicted to be above the NMLs by up to 21 dB.
- Noise levels from operations of various plant and equipment are predicted to be up to 12 dB lower when location of activities within the site boundary are further away from a particular receiver, and in some cases, within the NMLs depending on the distance to the receiver.
- Construction noise impacts at residential receivers are the highest to the West of the Ryde Hospital Campus across Ryedale Road. The worst-case noise impacts are for excavators with hammers which are 22 dB above the NMLs, however they are within Highly Affected Noise Levels (75 dB(A)).
- Where NMLs are exceeded, mitigation measures to be considered and incorporated where reasonable and feasible would include:
- Schedule noisy activities to less sensitive times of the day for each nominated receiver (i.e. daytime hours).
- Including Respite Periods where activities are found to exceed the 75 dB(A) Highly Affected Noise Level at receivers, such as 3 hours on and 1 hour off.
- The predictions for noise levels above NMLs is not unusual given the heavy plant and equipment that must be used, such as excavators and hammers, and the proximity to on campus sensitive receivers (some of which are within 20m).
- Construction traffic along the roads surrounding the site will meet applicable road noise targets on nearby receivers during the day-time period.
- Implementation of all reasonable and feasible mitigation measures for all works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when NMLs cannot be met due to safety or space constraints.

It is important to recognise that the actual noise levels generated during the construction works are likely to vary considerably depending on many factors including:

- Number of items of plant and equipment operating simultaneously.
- Location of equipment on the site – relative to the noise-sensitive receivers.
- Shielding of noise provided by structures and hoardings on and around the site.
- Reflections provided by existing structures on and around the site.
- Meteorological conditions.

When construction and excavation works are likely to exceed stated criteria at nearest sensitive receivers, particularly when works occur in the areas closer to the nominated receiver, all feasible and reasonable noise control measures are to be considered.

If, during construction works, an item of equipment exceeds either the noise criteria at any location or the equipment noise level limits, the following noise control measures, together with construction best practices presented in Section 8.5 shall be considered to minimise the noise impacts on the neighbourhood:

- Schedule noisy activities to occur outside of the most sensitive times of the day for each nominated receiver. For example, avoiding works during "outside standard hours" at nearby residential receivers.
- Consider implementing equipment-specific temporary screening for noisy equipment, or other noise control measures recommended in Appendix E of AS2436. This is most likely to apply to noisier items such as jackhammers.
- For large work areas, solid screening or hoarding as part of the worksite perimeters would be beneficial.
- Locate specific activities such as carpentry areas (use of circular saws etc) to internal spaces or where shielding is provided by existing structures or temporary screening.
- Limit the number of trucks and heavy vehicles on site at any given time (through scheduling deliveries at different times).
- Unnecessary idling of vehicles and equipment is to be avoided.
- Traffic routes are to be prepared to minimise the noise impact on the community.
- When loading and unloading trucks, adopt best practice noise management strategies to avoid materials being dropped from a height.
- Adopt quieter methodologies. For example, where possible, use concrete sawing and removal of sections as opposed to jackhammering.

- Ensure that any miscellaneous equipment (extraction fans, hand tools, etc), not specifically identified in this assessment, incorporates silencing/shielding equipment as required to meet the noise criteria.

Implementation of all reasonable and feasible mitigation measures for all works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when Noise Management Levels cannot be met due to safety or space constraints.

It is recommended that a comprehensive Stage 1 Early Works CNVMP is prepared further to this assessment. The engaged Contractor would be required to prepare a comprehensive CNVMP based on their proposed plant, equipment and construction methodology, prior to the commencement of any works.

8.4 Construction Vibration

When considering the vibration impact associated with construction works, the following is to be taken into account.

- The type of vibration generating equipment.
- Geotechnical characteristics of the site.
- The layout of the site, including the location of static sources of vibration.
- Techniques used in construction to minimise generated vibration levels.
- Hours of work with regard to the nature of operations in the affected buildings and the duration of the works.

8.4.1 Summary of Vibration Assessment and Discussion of Vibration Controls During Construction

A detailed vibration assessment has not been carried out at this stage, as actual vibration levels experienced will be dependent upon

- Site and strata characteristics.
- Specific construction equipment used.
- Vibration requirements of sensitive equipment.

Activities that have the potential to generate ground-borne vibration during the construction works include:

- Excavator hammer
- Vibratory roller
- Jackhammer

Based on the scope of works and typical equipment required, some structural and human perception vibration impacts are expected – particularly from the use of excavators with hammers near the existing Ryde Hospital buildings. In addition, there is potential for vibration impacts on sensitive equipment. The significance of these impacts will need to be determined as part of the CNVMP prepared by the Contractor.

Final details of the vibration management controls required for the works would be determined when the Stage 1 Early Works CNVMP is prepared by the Contractor.

It is recommended that, prior to the commencement of the Stage 1 Early Works, vibration surveys be carried out of each key vibration-generating-activity / equipment.

In addition to the assessment of structural and human perception vibration, the CNVMP prepared by the Contractor must ensure, at the relevant on campus buildings (including but not limited to the existing Ryde Hospital buildings) and other Hospital campus areas where sensitive equipment is operated, that the equipment-specific vibration criteria are set and managed accordingly.

The Contractor shall carry out a vibration assessment at the commencement of operations for each vibration generating activity to determine whether the existence of significant vibration levels justifies a more detailed investigation. Site law tests will help determine allowable working distances from structures to manage vibration.

If the assessment indicates that vibration levels might exceed the relevant criteria, then vibration mitigation measures will need to be put in place to ensure vibration impacts are minimised using all reasonable and feasible measures.

On campus buildings present the most stringent vibration criteria, particularly given their proximity to the Project Site. Controlling vibration at these receivers will also ensure that vibration criteria at all other receivers will also be satisfied.

The Contractor would be required to prepare a final CNVMP based on their proposed plant, equipment and construction methodology.

8.5 Control elements

8.5.1 Noise

As a general rule, prevention is to be applied as universal work practice at any time of day, but especially for the occasional construction works to be undertaken at critical times outside normal daytime/weekday periods.

It is noted that the reduction of noise at the source and the control of the transmission path between the construction site and the receiver(s) are the preferred options for noise mitigation/minimisation. Providing treatments at the affected residences or other sensitive land uses is to be only considered as a last resort. Construction noise shall be managed by implementing the strategies listed below:

- Plant and equipment
  - Use quieter methods.
  - Use quieter equipment.
  - Operate plant in a quiet and effective manner.
  - Where appropriate, limit the operating noise of equipment.
  - Maintain equipment regularly.
  - Where appropriate, obtain acoustic test certificates for equipment.
- On-site noise management
  - Strategically locate equipment and plant.
  - Avoid the use of reversing alarms or provide for alternative systems.
  - Maximise shielding in the form of existing structures or temporary barriers.
  - Schedule the construction of barriers and structures so they can be used as early as possible.
  - Brief Project staff and workers on the noise sensitivity of the neighbours to the site, particularly the residents nearby. The staff and workers need to be mindful of the noise from their discussions and colour of the language, particularly in sensitive periods, for example, during the pre-start times or "toolbox talk" as they gather to commence for work in the morning.
- Consultation, notification and complaints handling
  - Provide information to neighbours before and during construction.
  - Maintain good communication between the community and Project staff.
  - Have a documented complaints process and keep register of any complaints.
  - Give complaints a fair hearing and provide for a quick response.
  - Implement all feasible and reasonable measures to address the source of complaint.
- Work scheduling

- Schedule activities to minimise noise impacts.
- Ensure periods of respite are provided in the case of unavoidable maximum noise levels events.
- Keep truck drivers informed of designated routes, parking locations and delivery hours.

8.5.2 Vibration

At this stage, we anticipate that construction works will result in some structural and human perception vibration impacts at surrounding receivers – particularly from the use of excavators with hammers near the existing Ryde Hospital Campus buildings.

Vibration management controls required for the works would be determined when the Stage 1 Early Works CNVMP is prepared by the Contractor.

The Contractor shall carry out a vibration assessment at the commencement of operations for each vibration-generating-activity / equipment to determine whether the existence of significant vibration levels justifies a more detailed investigation.

A more detailed investigation will involve methods of constraining activities generating high vibration levels. A method of monitoring vibration levels will then need to be put in place. An additional review of vibration mitigation measures and vibration criteria may then be necessary.

All practical means are to be used to minimise impacts on the affected buildings and occupants from activities generating significant levels of vibration on-site.

The following considerations shall be taken into account:

- Modifications to excavation and construction equipment used.
- Modifications to methods of excavation and construction.
- Rescheduling of activities to less sensitive times.

If the measures given above cannot be implemented or have no effect on vibration levels or impact generated, a review of the vibration criteria is to be undertaken and the vibration management strategy amended.

8.5.3 Vibration surveys

Since the actual vibration levels experienced will be dependent upon the site characteristics and the specific equipment being used, early vibration level checks are to be carried out on site at the outset of each key vibration generating activity (if vibration is considered to be an issue).

Shortly before the commencement of each activity, the background vibration level is to be measured and again once the activity has begun. If the survey indicates levels of vibration exceeding those expected, the vibration management strategy for that process is to be re-assessed.

8.5.4 Additional Noise and Vibration Control Measures

All practical means should be used to minimise impacts on the affected buildings and occupants from activities generating significant levels of vibration on site.

If, during construction, an item of equipment exceeds ether the noise criteria at any location or the equipment noise level limits, the following noise control measures, together with construction best practices presented in Section 8.5.1, shall be considered to minimise the noise impacts on the neighbourhood.

- Modifications to construction equipment used:
    - Avoid the use of large excavators – use the smallest size practicable;
    - Avoid the use of vibratory rollers – switch off vibration mode, or use the smallest size practicable if vibration must be employed;
    - Avoid the use of tracked vehicles on site, where practicable, particularly large tracked excavators and cranes – use vehicles with tyres.
- Modifications to methods of construction:
    - Saw cutting can be considered for rock removal rather than conventional rock hammering techniques to limit vibration when closed to vibration sensitive locations.
- Schedule noisy activities to occur outside of the most sensitive times of the day for each nominated receiver. For example, residential receivers are likely to be more sensitive to noise before 9 am than the other receivers.
- Consider implementing equipment-specific screening or other noise control measures recommended in Appendix E of AS2436.
- Limit the number of trucks on site at the commencement of site activities to the minimum required by the loading facilities on site.
- When loading trucks, adopt best practice noise management strategies to avoid materials being dropped from height into dump trucks.
- Avoid unnecessary idling of trucks and equipment.
- Ensure that any miscellaneous equipment (extraction fans, hand tools, etc) not specifically identified in this assessment incorporates silencing/shielding equipment as required to meet the noise criteria.

- Minimise noise from workers as discussed in Section 8.5.1.

Implementation of all reasonable and feasible mitigation measures for all construction works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when noise goals cannot be met due to safety or space constraints.

8.6 Noise and vibration monitoring

8.6.1 Noise monitoring

The Contractor is to consider implementing environmental noise monitoring at the locations described below.

- West Boundary Residential receivers along Rydedale Road.
- On campus Ryde Hospital Campus Receivers.

An allowance of 1.5 days per week, at least, is to be dedicated to monitoring of noise and vibration for the first four weeks of construction works. Further monitoring is to be reviewed after this time or sooner should it be deemed necessary by the acoustic consultant and the Project Manager. This is to take place mainly at the above locations although other locations and plant and equipment monitoring are to take place as and when necessary. If results indicate vibration levels exceeding allowable limits appropriate action is to be taken.

8.6.2 Vibration monitoring

A vibration monitoring system is to be implemented if required. This system would monitor vibration levels when there is potential for them to change. This could happen in various situations, such as, changes in equipment and activities or changes to work procedures that might affect existing vibration control measures. The monitoring procedure would be carried out with appropriate equipment so that results obtained are readily comparable with results obtained earlier. If results indicate vibration levels exceeding allowable limits appropriate action is to be taken.

8.6.3 Reporting

The Contractor is to prepare a noise monitoring report each month for review by the Project Manager. The reports are to summarise and interpret the results of the noise and vibration monitoring carried out during the past month.

Communication and complaints

The Contractor is to establish a communication register for recording incoming complaints. The registration of a particular item will remain open until the complaint has been appropriately dealt with.

In addition, the following procedures are an example of the procedures that are to be specifically adopted for complaints relating to noise.

Upon receipt of a complaint the Contractor is to:

- Try to ascertain from the complaint which appliance is causing the problem i.e. inside or outside the site and in what position.
- Establish from the monitoring equipment if the allowable noise levels have been complied with.
- Establish if the appliance positioning has previously been highlighted as a problem area. If not and the noise levels are above the allowable limit, then the equipment and its position shall be noted.
- Move machinery if the allowable levels have been exceeded or take other acoustic remedial action.

If the activity is occurring outside normal working hours, the activity is to be immediately stopped. Where stopping the activity would create a safety issue the activity may be permitted to continue only as long as is necessary to make the area safe. The activity is to then cease.

Any activity that is directed to cease due to excessive noise is not to recommence until the Project Manager is satisfied that the noise and vibration limits requirements can be met and has given permission to recommence the activity.

The Site Supervisor is to ensure that a report of any incident is provided to the Project Manager.

The Project Manager is to provide a report on the incident to the relevant stakeholders.

The Contractor is to provide a 24-hour telephone contact number and this number is to be prominently displayed on the site.

8.7 Non-compliances

Non-compliance reports can be used as appropriate to deal with failures to meet the construction noise and vibration management and control requirements.

9 Discussion and Recommendations

A noise and vibration assessment has been carried out to consider the potential noise and vibration impacts from the Ryde Hospital Redevelopment Concept and Stage 1 Early Works.

The existing noise environment has been established through long-term and short-term noise monitoring data.

Appropriate criteria for both noise and vibration have been established based on relevant guidelines and standards. A summary of outcomes and recommendations of this noise and vibration assessment are as follows:

Concept Proposal

The concept design has incorporated acoustic planning principles and considerations to provide optimal design and coordination with the architectural and services strategy to support the proposed hospital buildings as part of the Ryde Hospital Redevelopment Project. This includes:

- Noise mitigation and management strategies to inform the design.
- Strategies to avoid or reduce impact of noise on users of the site.
- Planning and locating of noise generating areas to limit and avoid impacts on noise sensitive receivers.
- Strategies to limit traffic noise generation and impact to surrounding receivers

Further detail is provided in Section 7.

The detailed design, construction (also referred to as main works) and operation of new hospital buildings will be subject to a separate Stage 2 SSD Application and is not included in this assessment.

Stage 1 Early Works

Construction Noise

- Proposed construction hours for the Stage 1 Early Works are as follows:
    - Monday to Friday - 7:00am to 6:00pm.
    - Saturday - 8:00am to 1:00pm.
    - Sunday and Public Holidays – No works.
- Construction works noise impacts will be greatest at on Campus noise receivers including the existing Graithwaite Rehabilitation Centre and Ryde Medical Centre Buildings. Noise from various plant and equipment operating individually are generally predicted to be above the NMLs due to the proximity to the nearest affected receivers. The worst-case noise impacts are for excavators with hammers with noise levels predicted to be above the NMLs by up to 21 dB.
- Noise levels from operations of various plant and equipment are predicted to be up to 12 dB lower when location of activities within the site boundary are further away from a particular receiver, and in some cases, within the NMLs depending on the distance to the receiver.
- Construction noise impacts at residential receivers are the highest to the West of the Ryde Hospital Campus across Ryedale Road. The worst-case noise impacts are for excavators with hammers which are 22 dB above the NMLs, however they are within Highly Affected Noise Levels (75 dB(A)).
- Where NMLs are exceeded, mitigation measures to be considered and incorporated where reasonable and feasible would include:
- Schedule noisy activities to less sensitive times of the day for each nominated receiver (i.e. daytime hours).
- Including Respite Periods where activities are found to exceed the 75 dB(A) Highly Affected Noise Level at receivers, such as 3 hours on and 1 hour off.
- The predictions for noise levels above NMLs is not unusual given the heavy plant and equipment that must be used, such as excavators and hammers, and the proximity to on campus sensitive receivers (some of which are within 20m).
- Construction traffic along the roads surrounding the site will meet applicable road noise targets on nearby receivers during the day-time period.
- Implementation of all reasonable and feasible mitigation measures for all works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when NMLs cannot be met due to safety or space constraints.

Construction Vibration

- Based on the scope of works and typical equipment required, some human perception vibration impacts are expected and there is a potential for minor cosmetic impacts to some structures which must be reviewed as works processes are planned in more detail – particularly from the use of excavators with hammers near the existing Ryde Hospital buildings. In addition, there is potential for vibration impacts on sensitive equipment. A comprehensive Construction Noise and Vibration Management Plan (CNVMP) will be prepared by the engaged Contractor. The CNVMP will consider proposed plant, equipment and construction methodology, prior to the commencement of any Stage 1 Early Works.

It is recommended that, prior to the commencement of the Stage 1 Early Works, vibration surveys be carried out of each key vibration-generating-activity / equipment.

In addition to the assessment of structural and human perception vibration, the CNVMP prepared by the Contractor must ensure, at the relevant on campus buildings (including but not limited to the existing Graithwaite Rehabilitation Centre, Ryde Medical Centre) and other hospital campus areas where sensitive equipment is operated or heritage structures exist, that the equipment-specific and structure-specific vibration criteria are set and managed accordingly.

The Contractor shall carry out a vibration assessment at the commencement of operations for each vibration generating activity to determine whether the existence of significant vibration levels justifies a more detailed investigation. Site law tests will help determine allowable working distances from structures to manage vibration.

If the assessment indicates that vibration levels might exceed the relevant criteria then vibration mitigation measures will need to be put in place to ensure vibration impacts are minimised using all reasonable and feasible measures.

A method of monitoring vibration levels must then be put in place. Additionally, vibration monitors must also be put in place to manage sensitive areas. Vibration mitigation measures and vibration criteria will then need to be reviewed.

All practical means are to be used to minimise impacts on the affected buildings and occupants from activities generating significant levels of vibration on site.

The following considerations shall be taken into account:

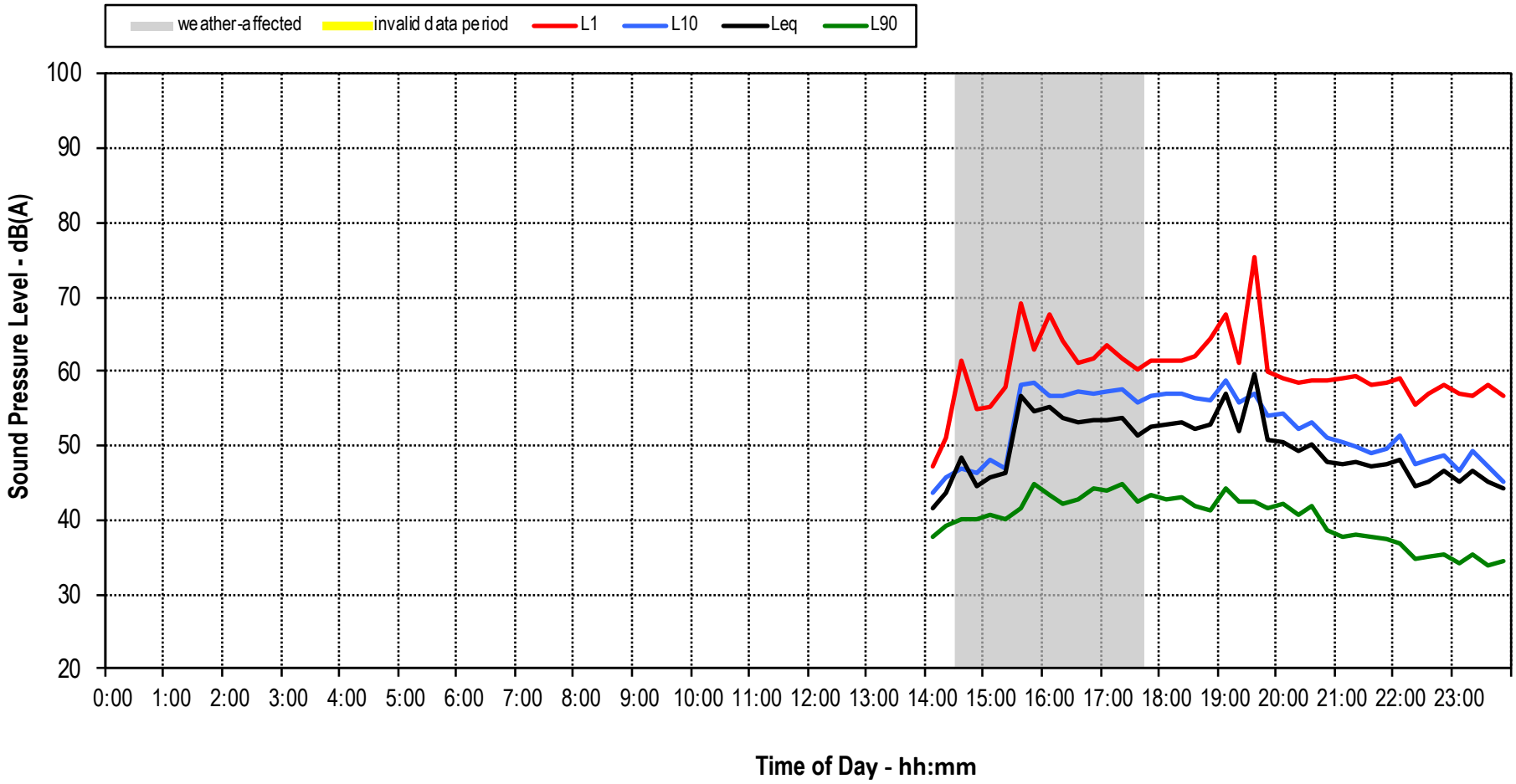
- Modifications to construction equipment used.
- Modifications to methods of construction.

Rescheduling of activities to less sensitive times

Appendix A – Ambient Noise Monitoring Data

Location 1 – Ryedale Road

Location 1 - 56 Ryedale Road - Monday 31 January 2022



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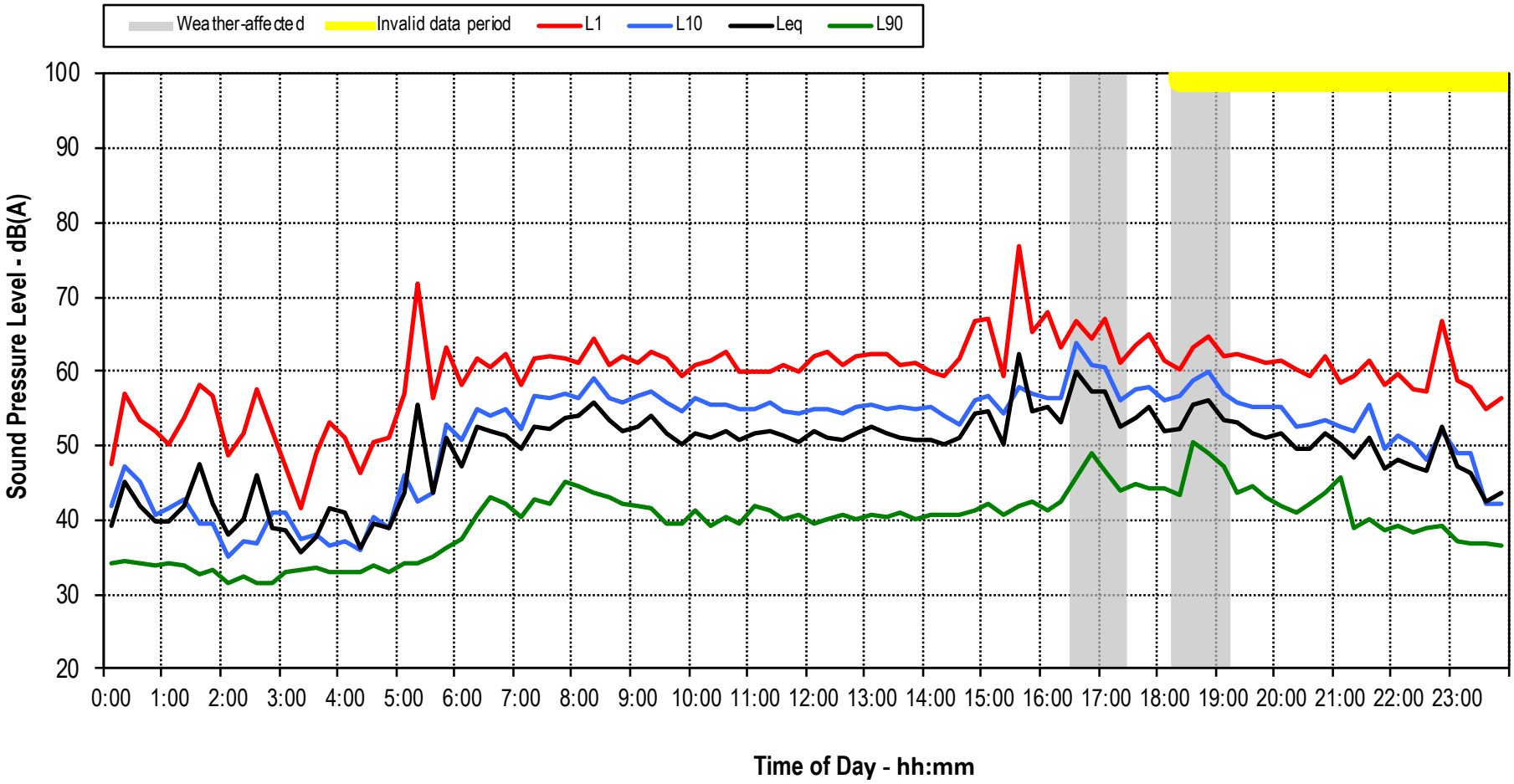

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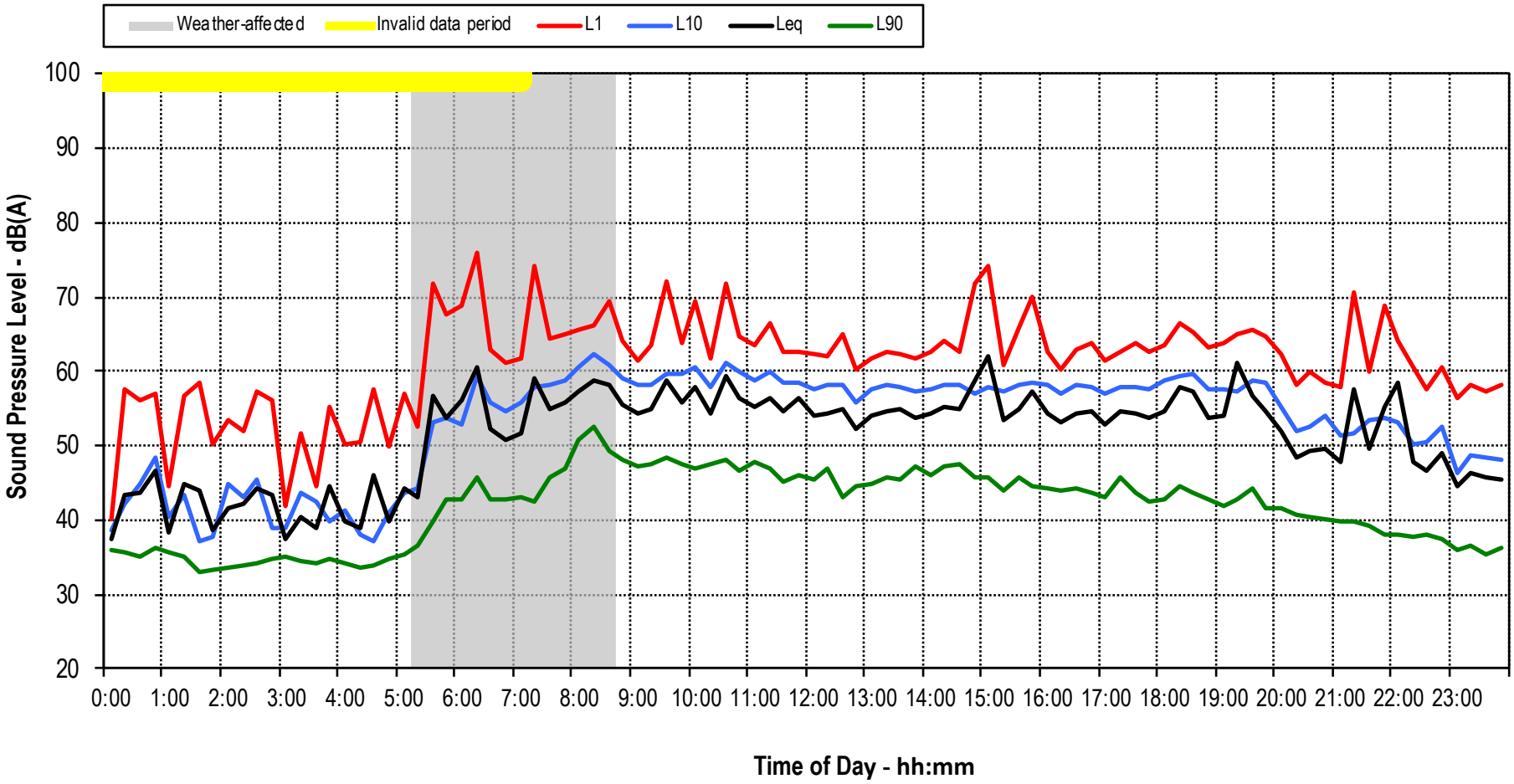

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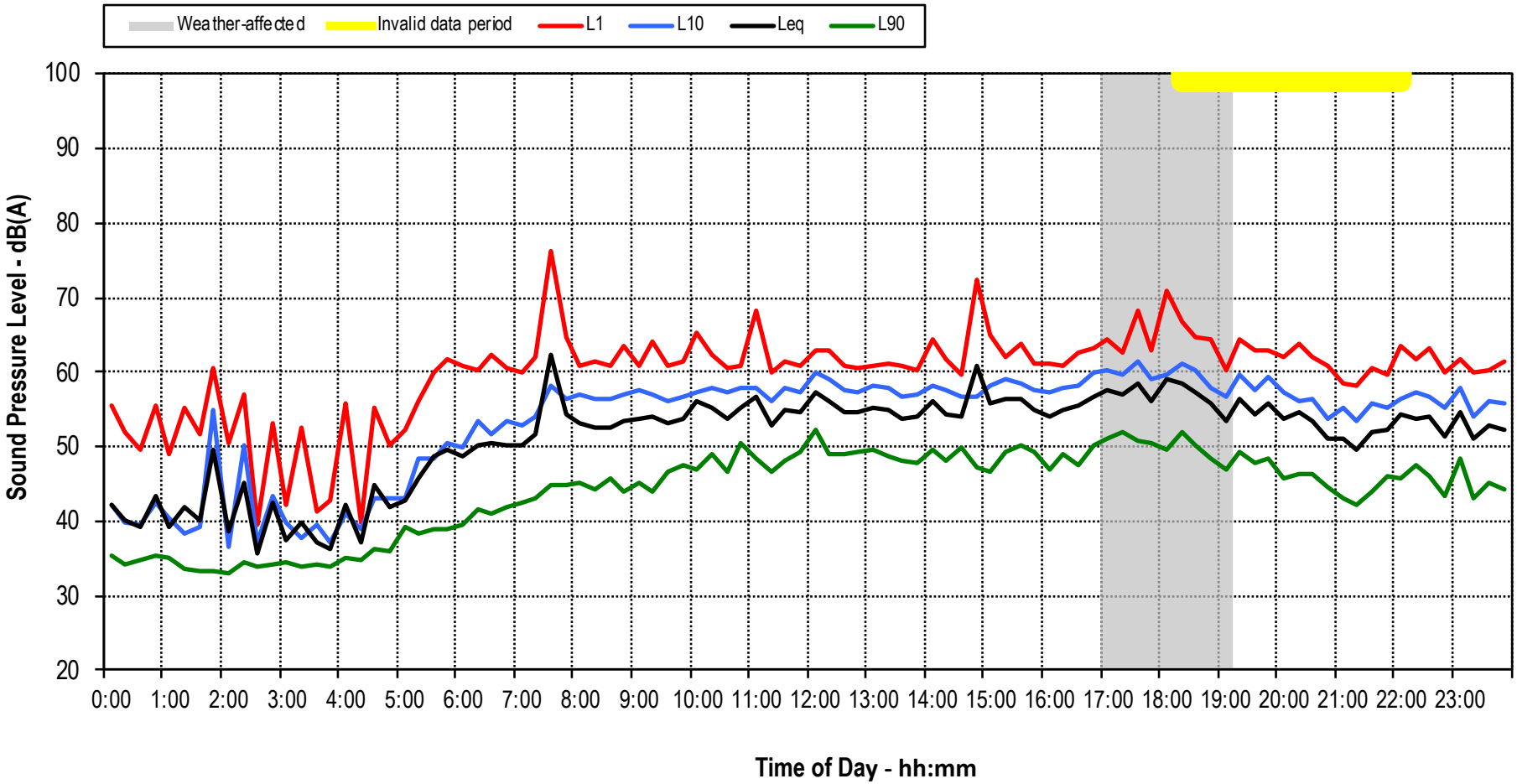

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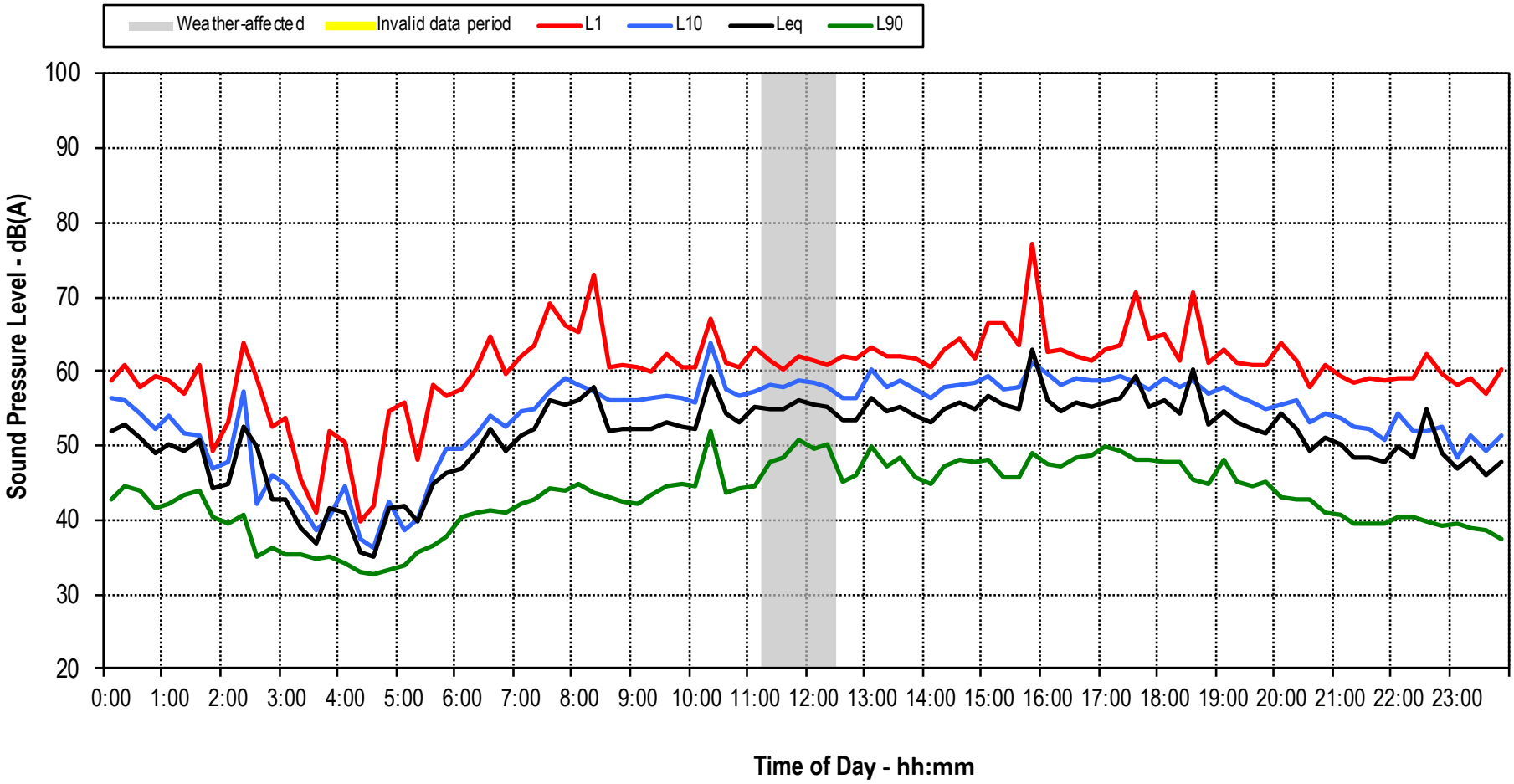

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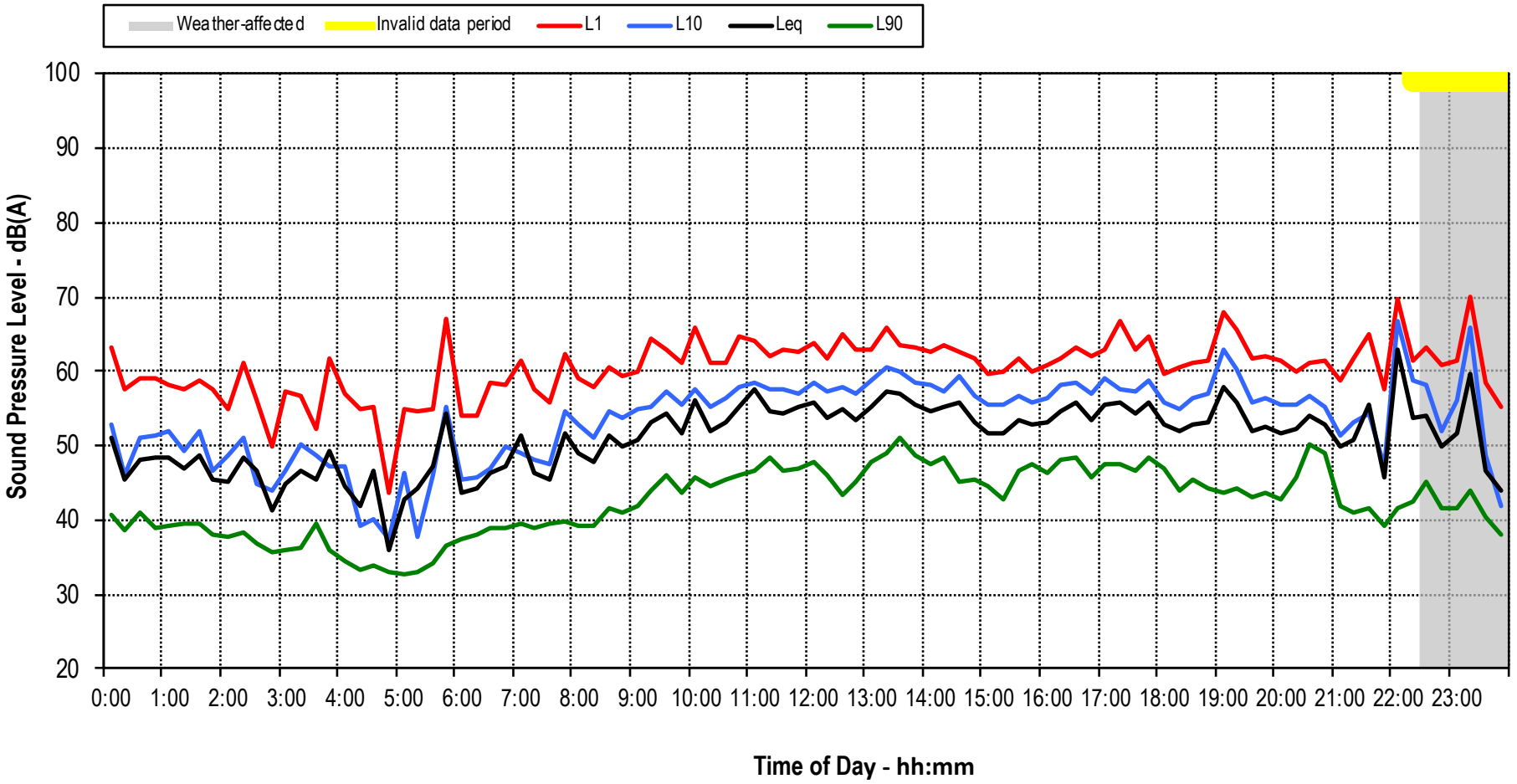

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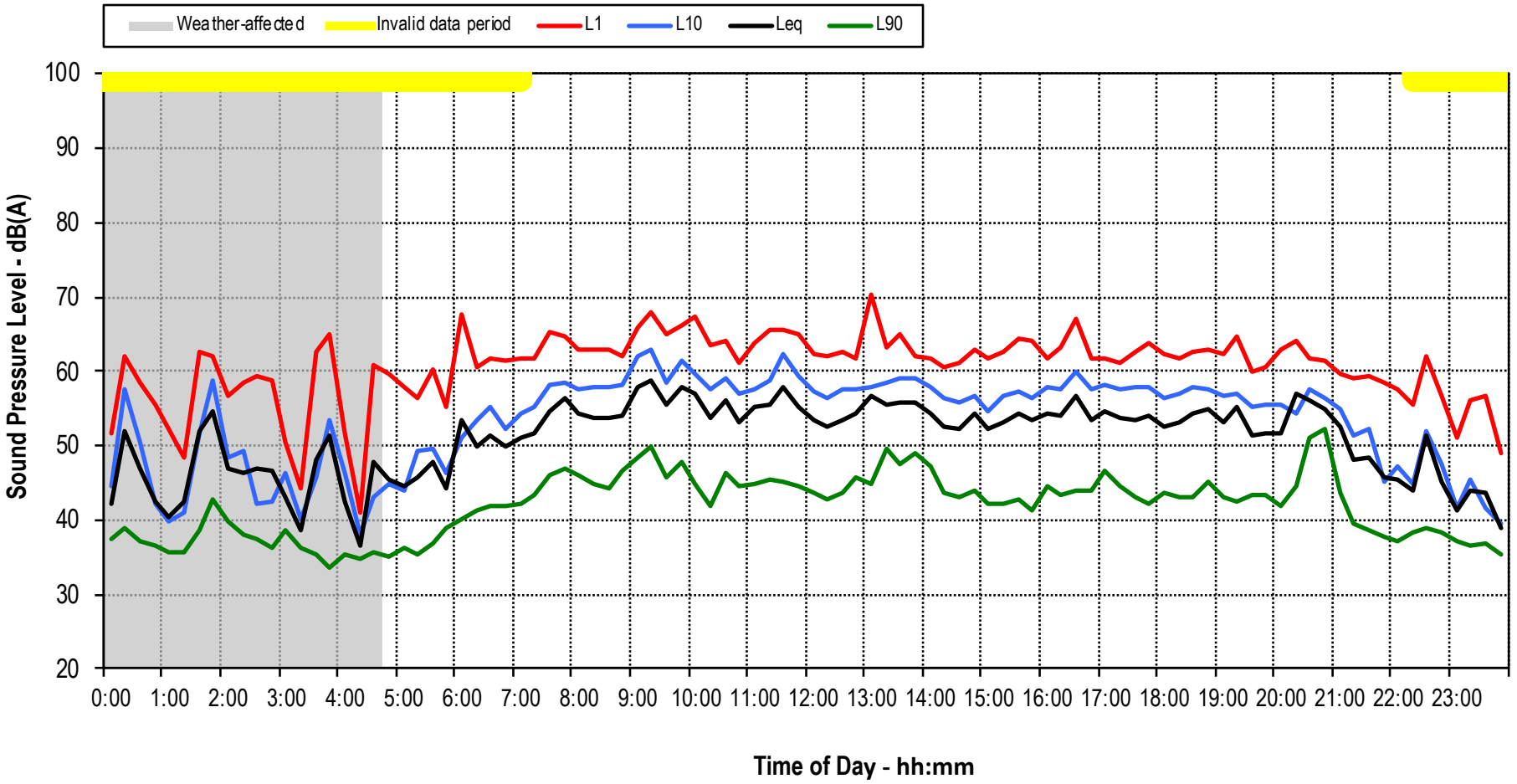

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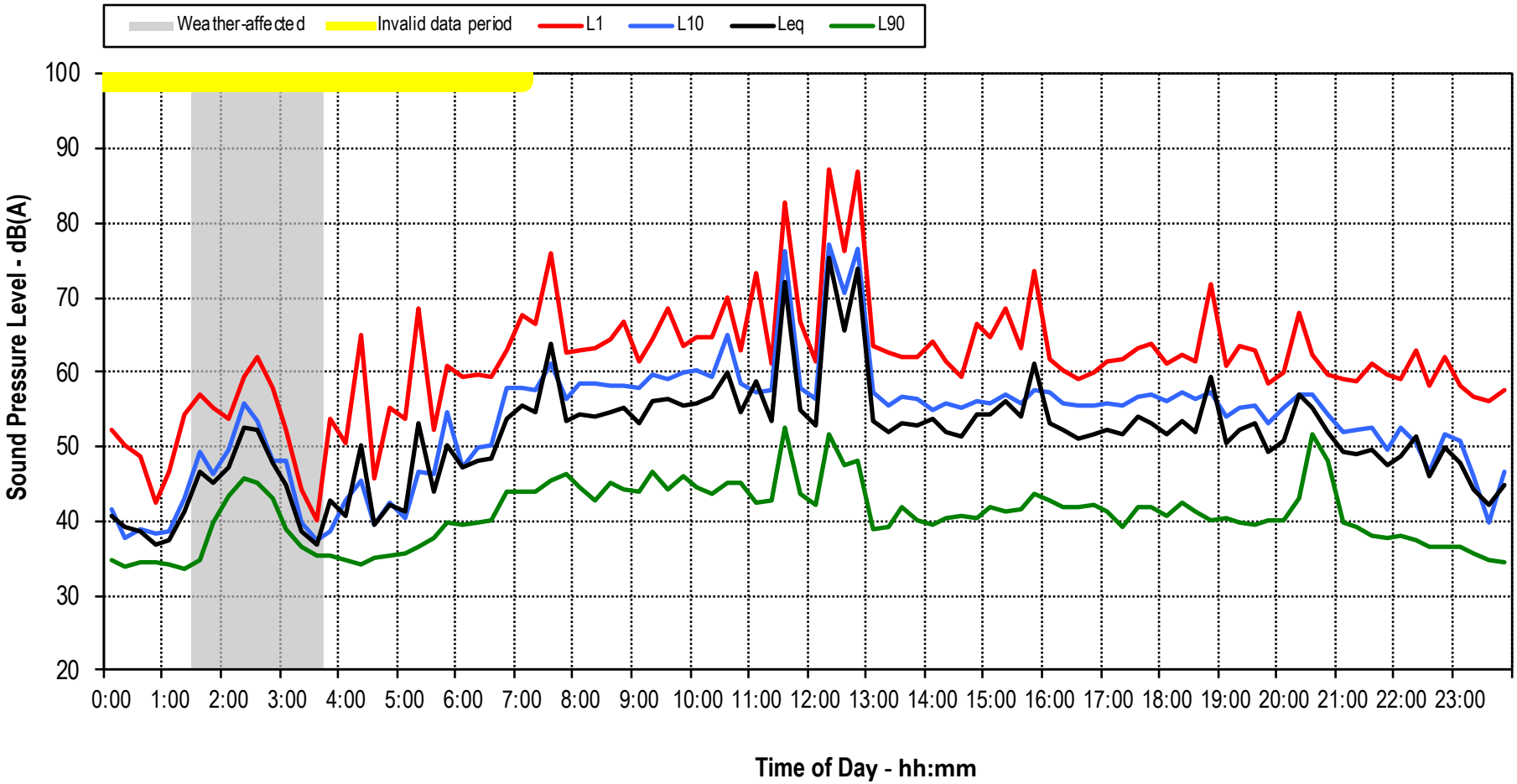

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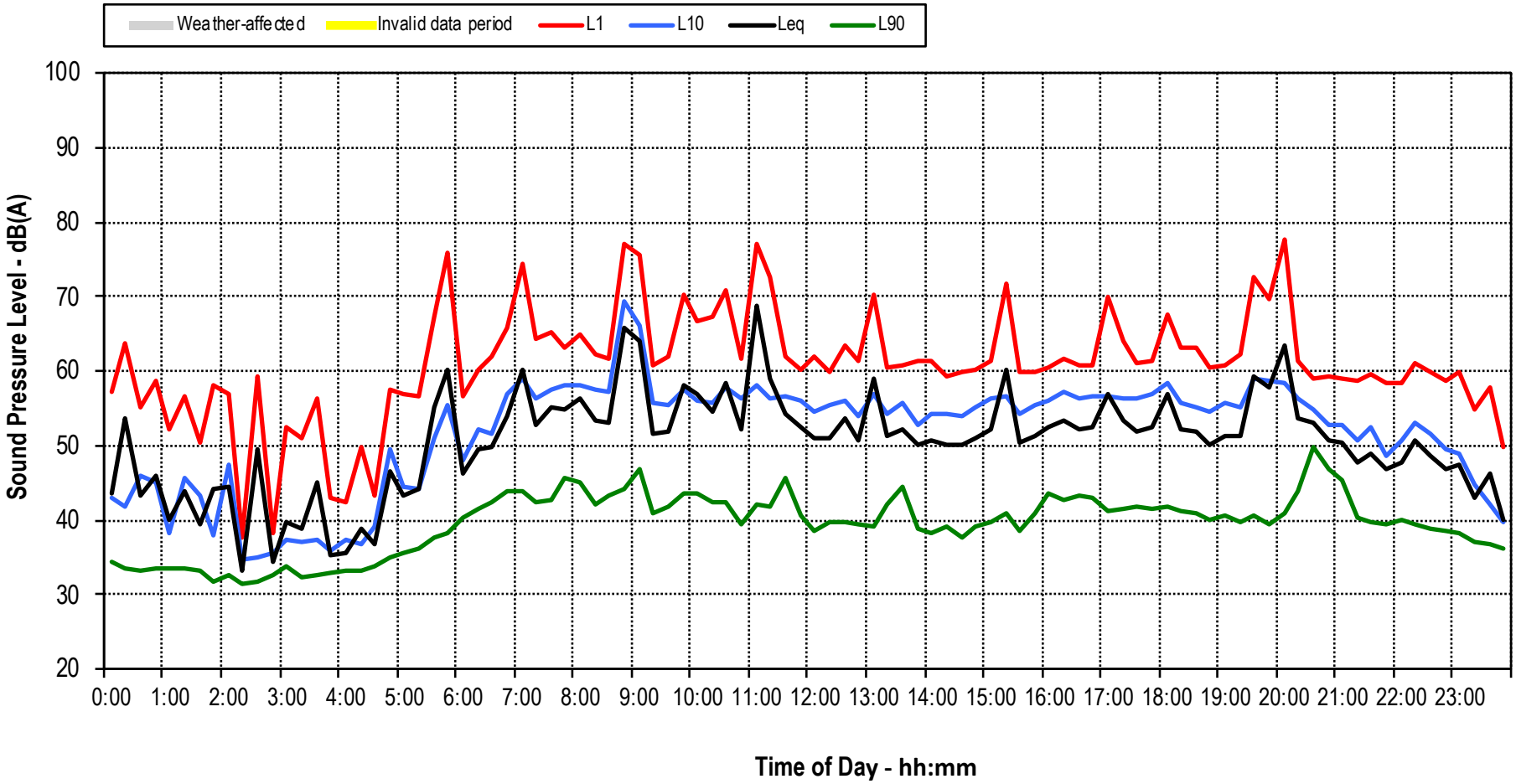

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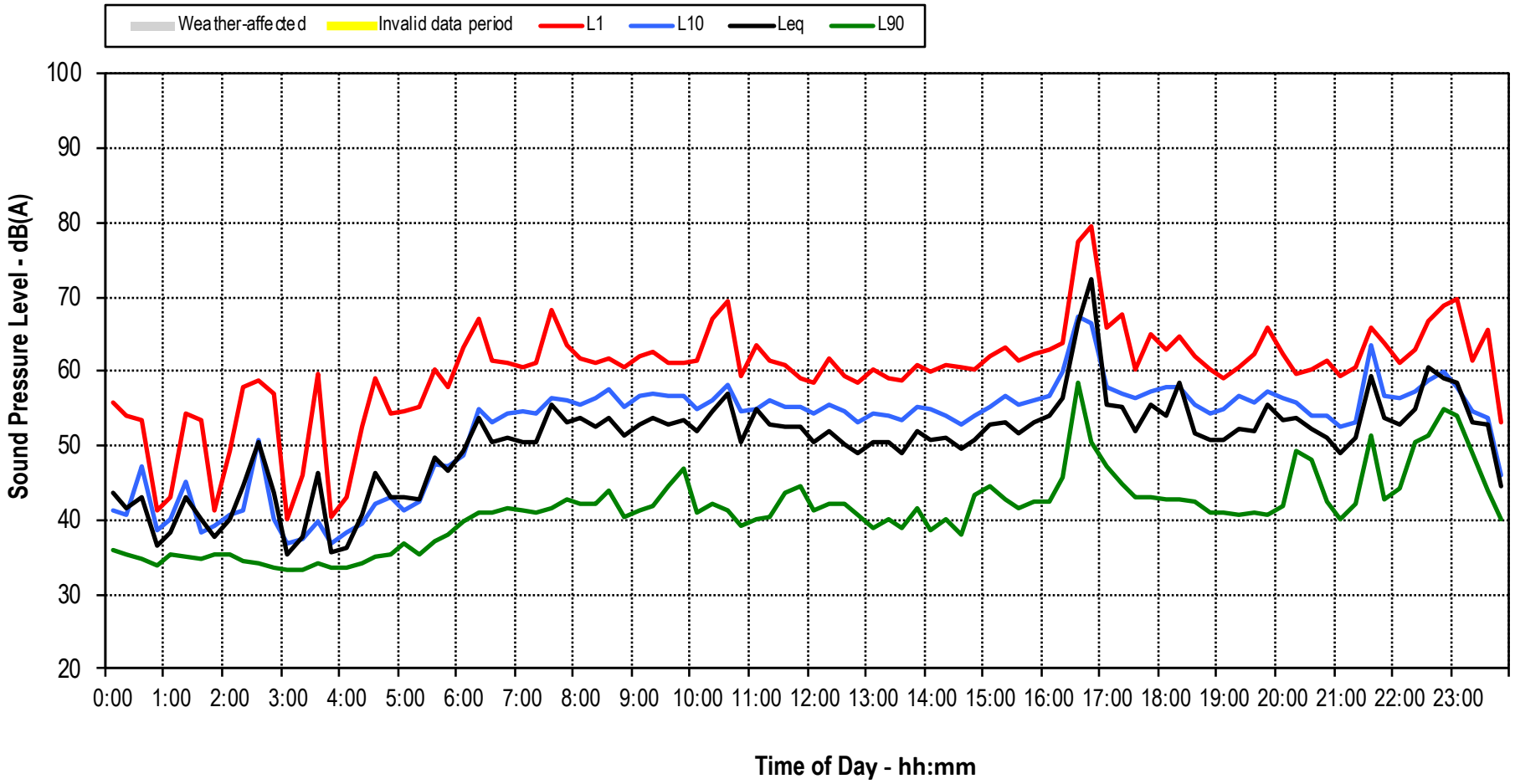

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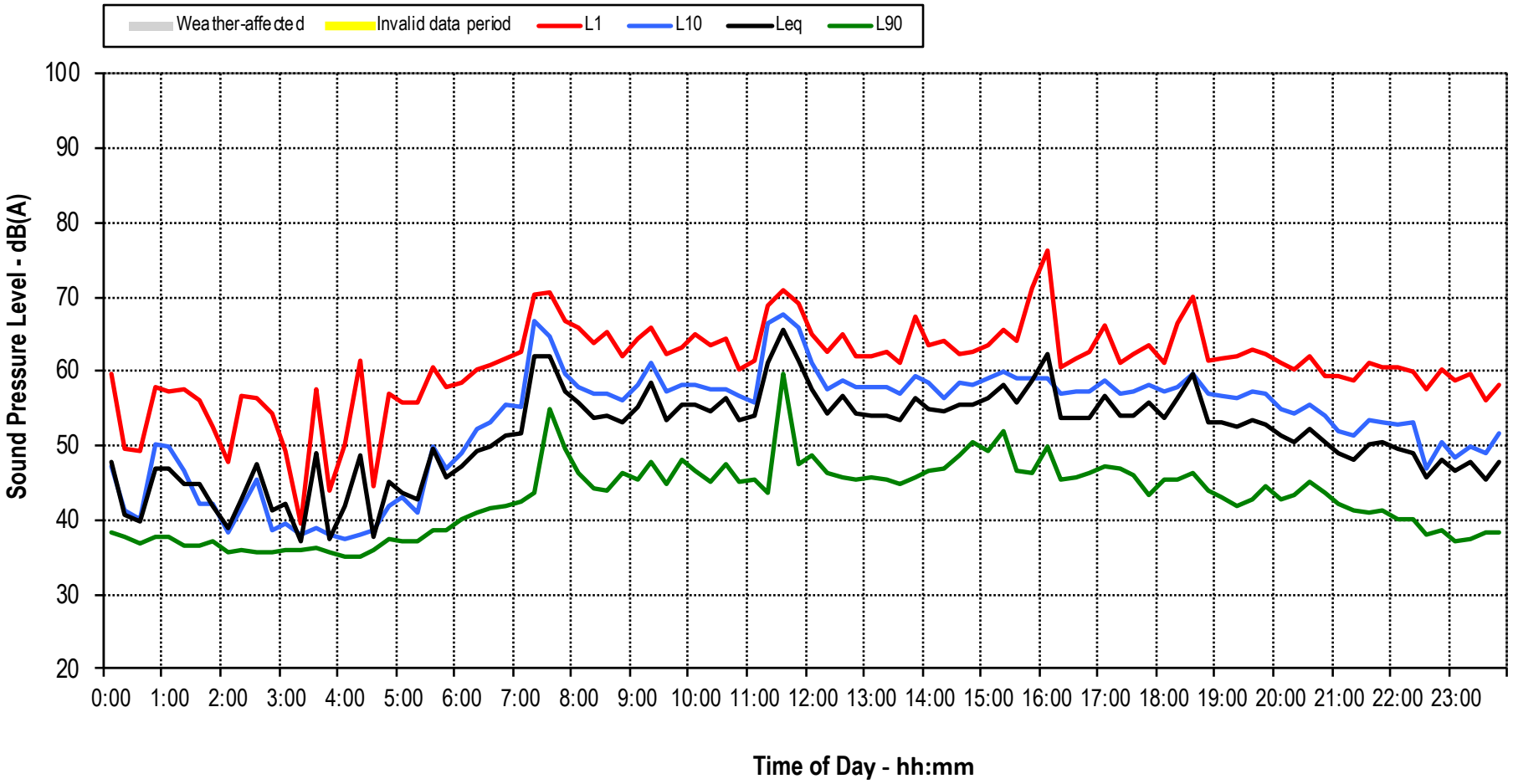

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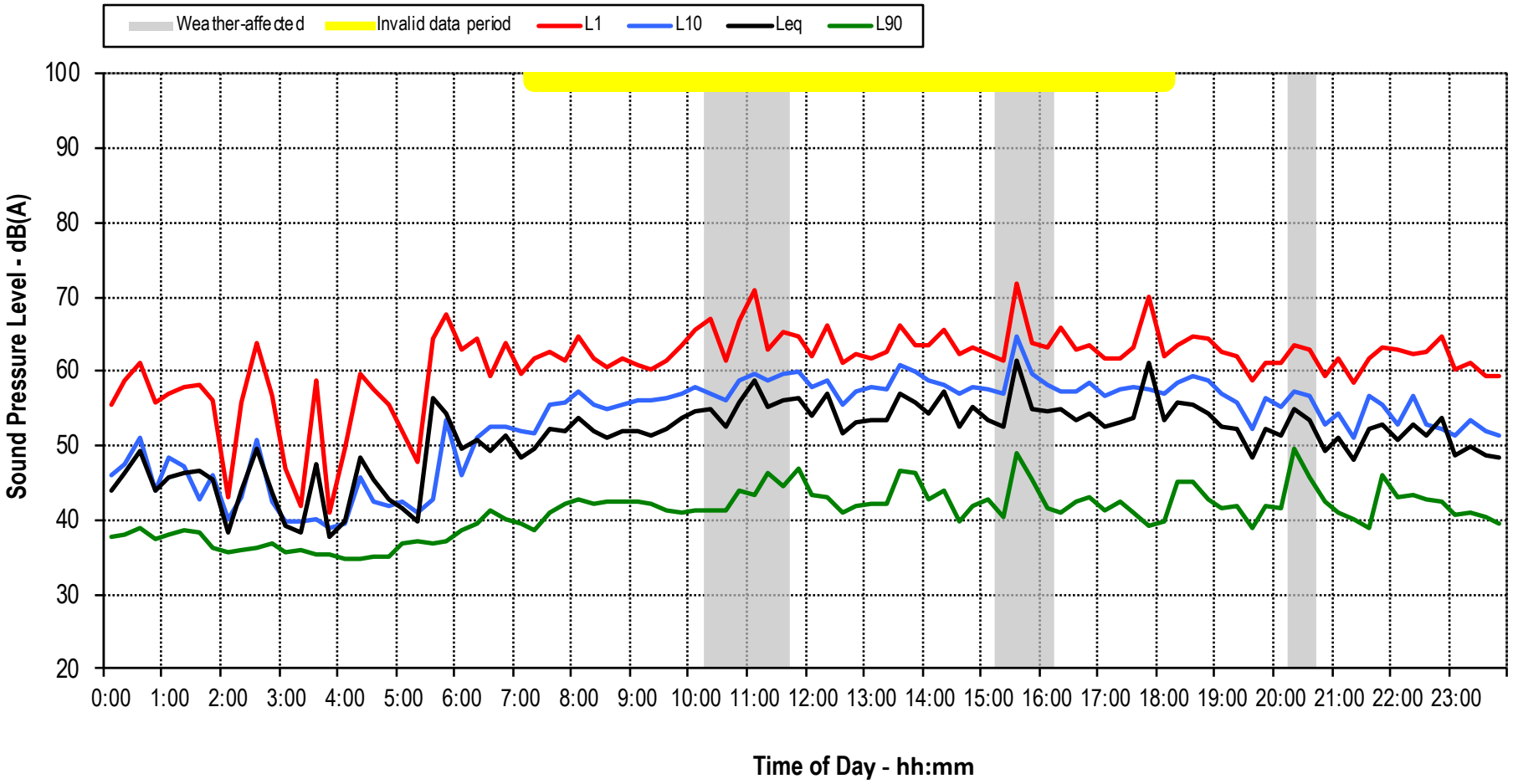

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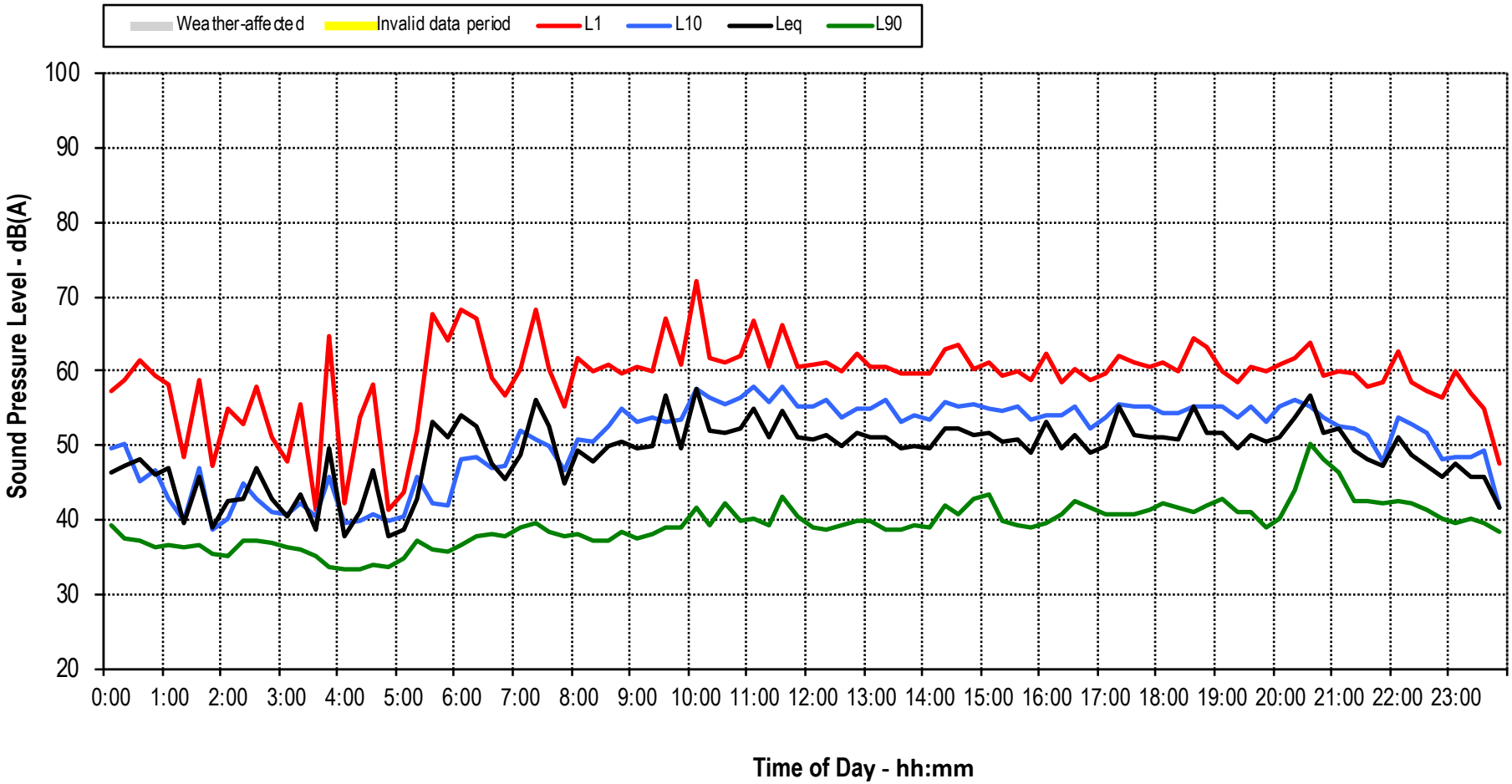

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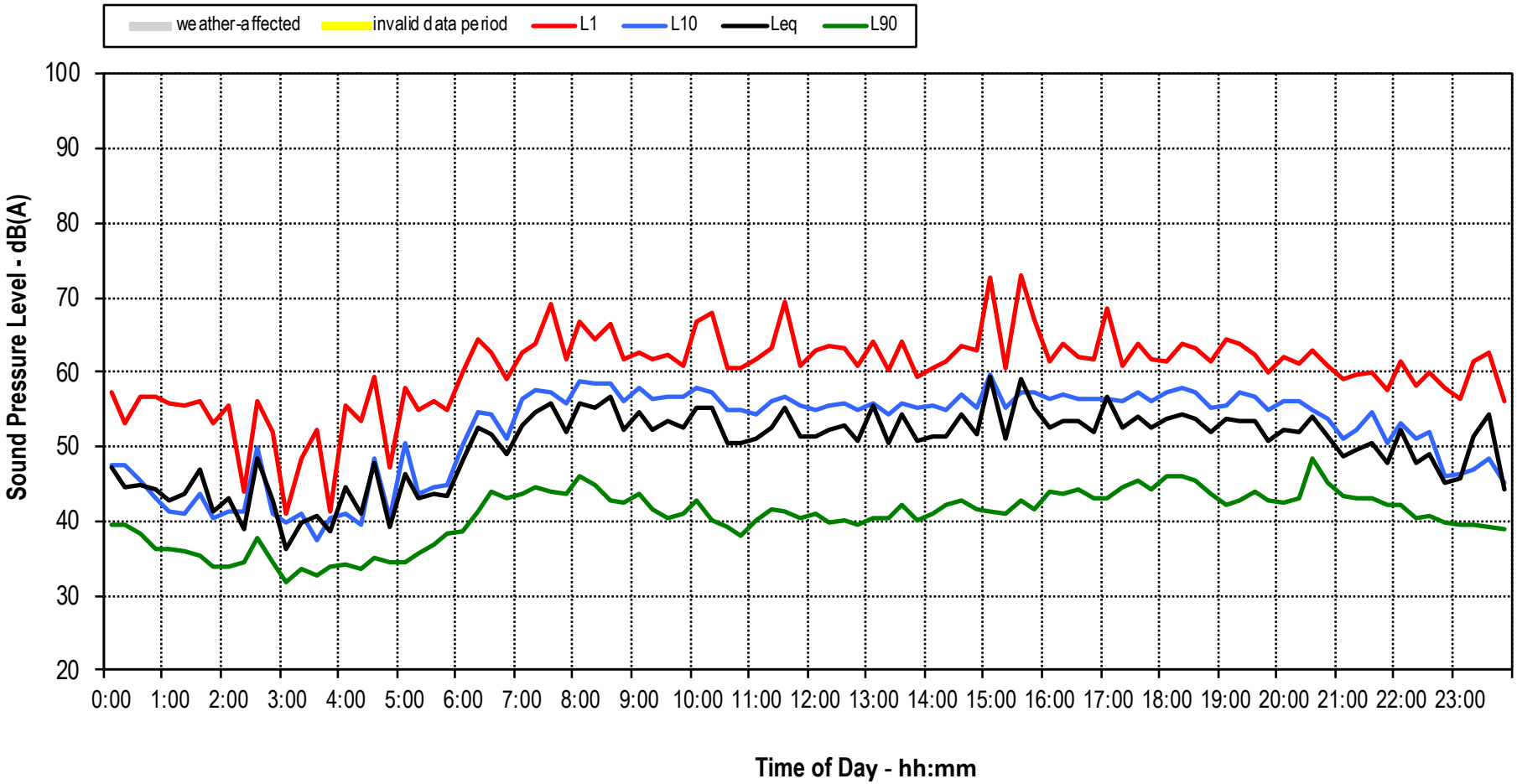

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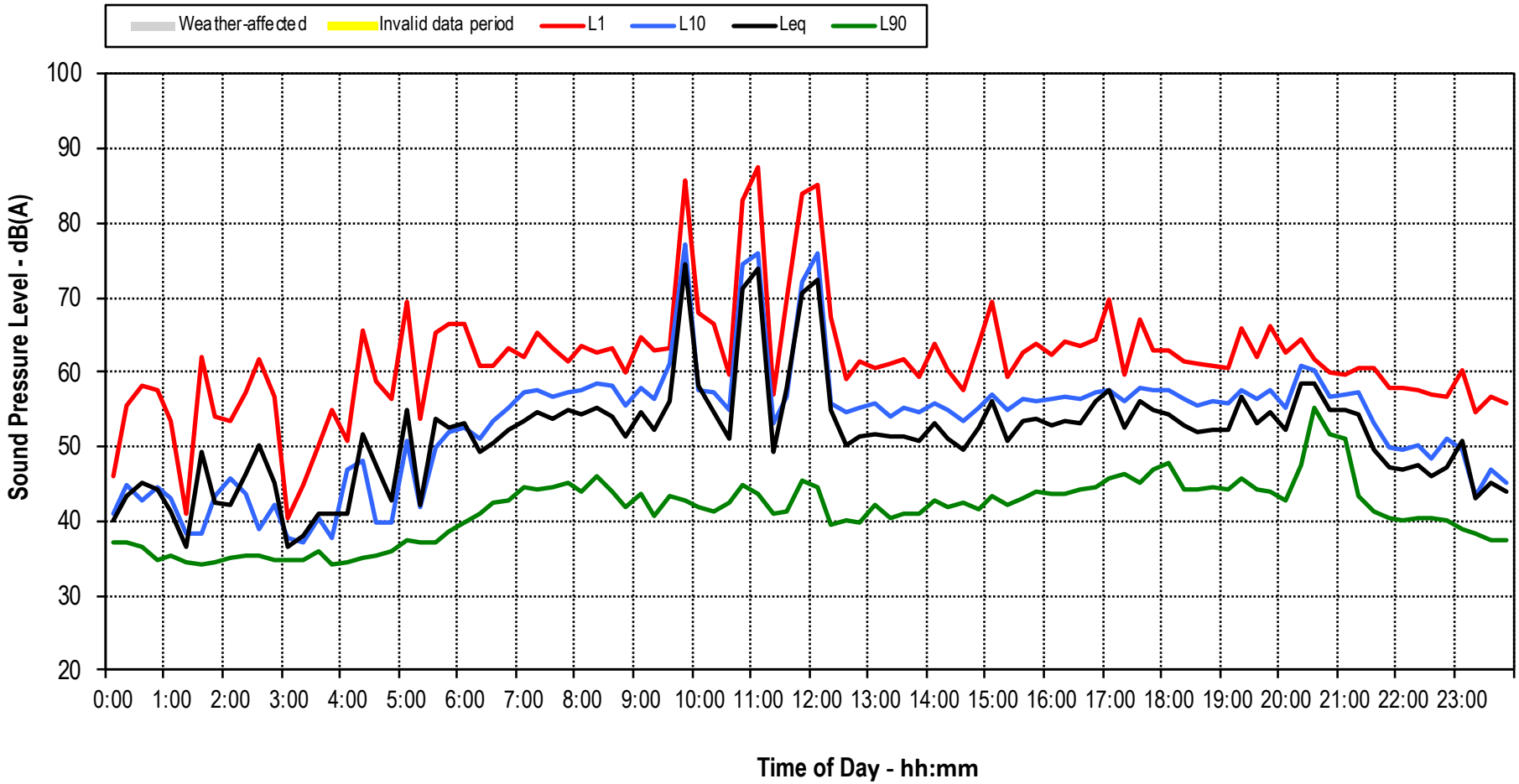
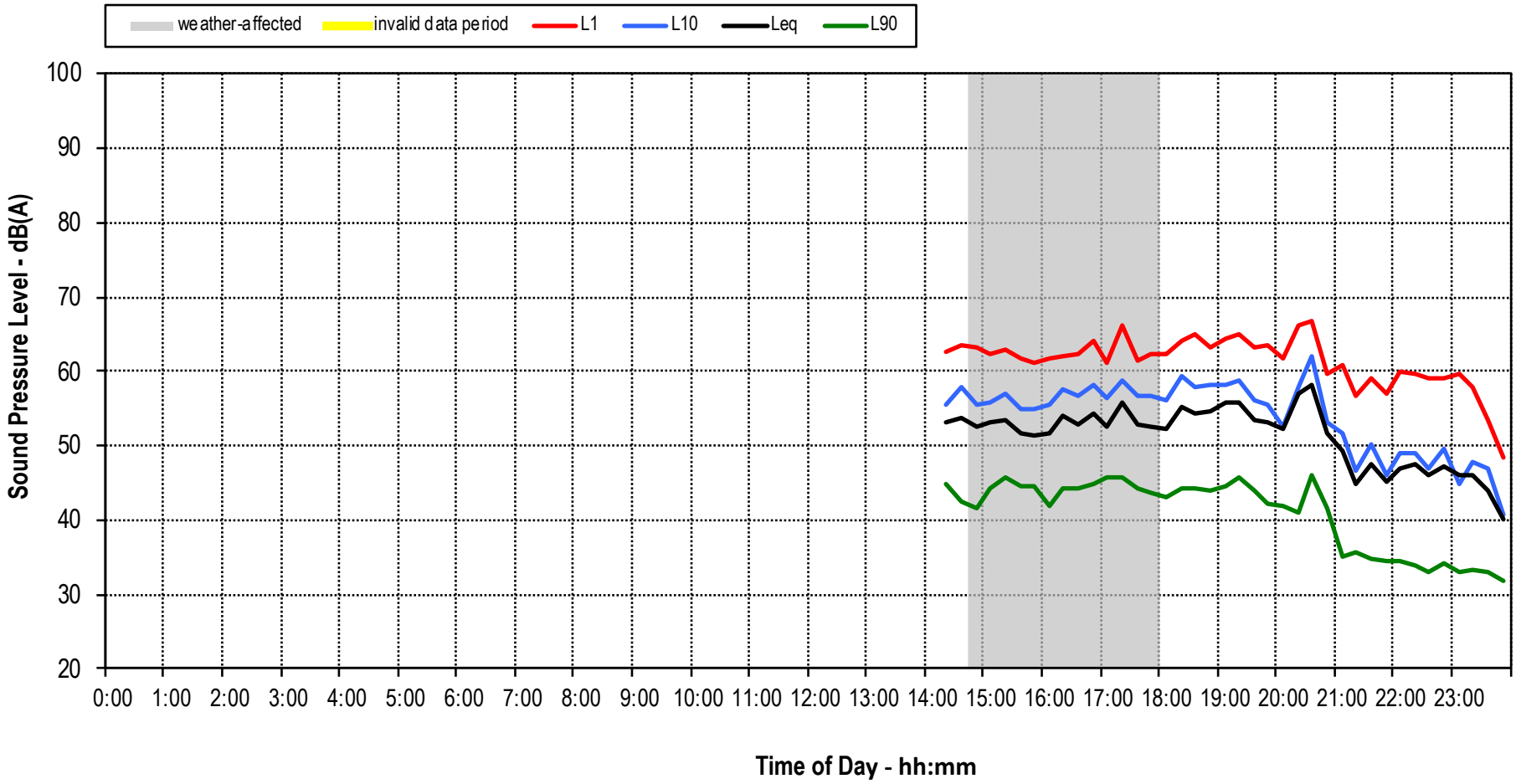
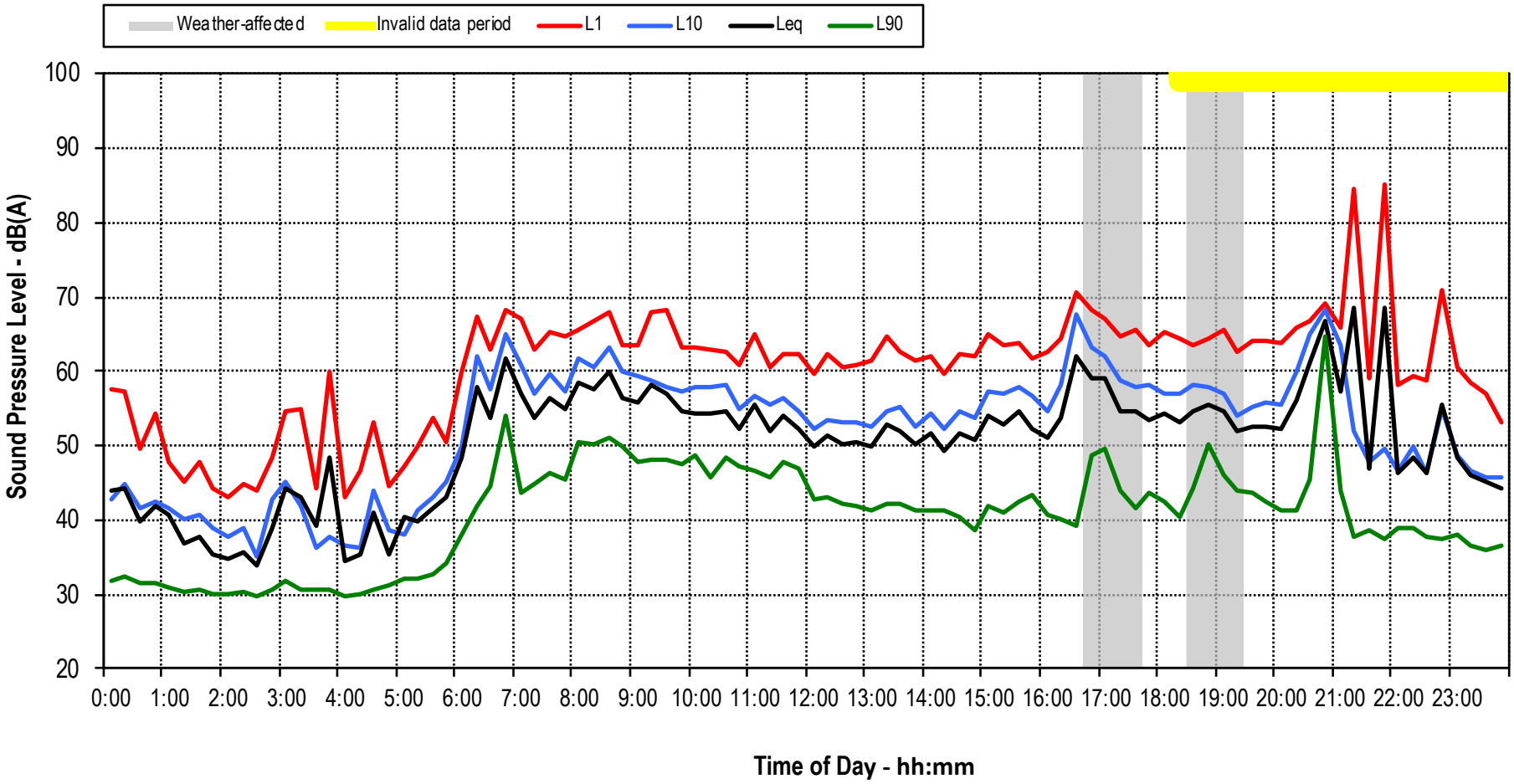


Location 2 – Florence Avenue

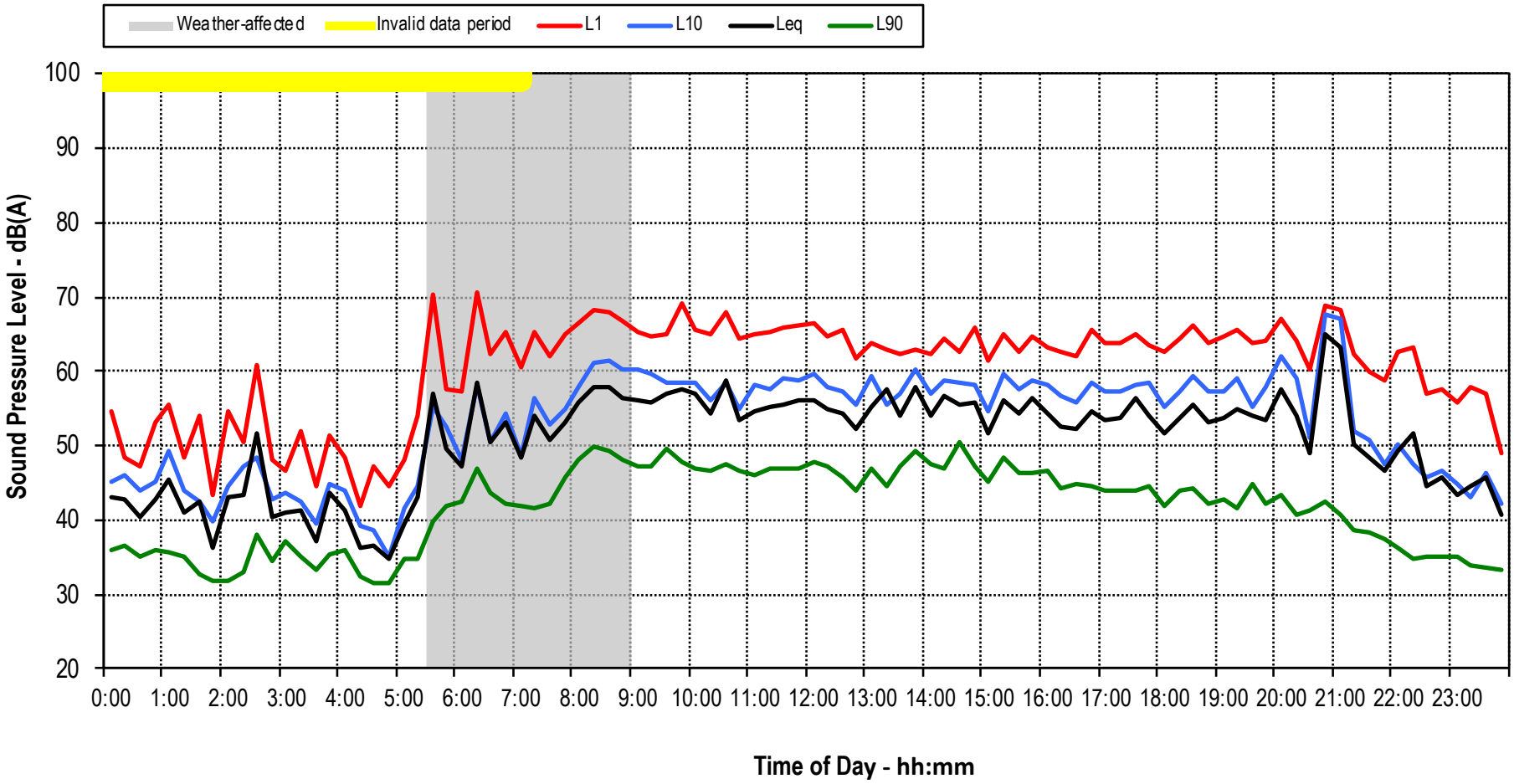
Location 2 - 6 Florence Avenue - Monday 31 January 2022



Location 2 - 6 Florence Avenue - Tuesday 01 February 2022



Location 2 - 6 Florence Avenue - Wednesday 02 February 2022



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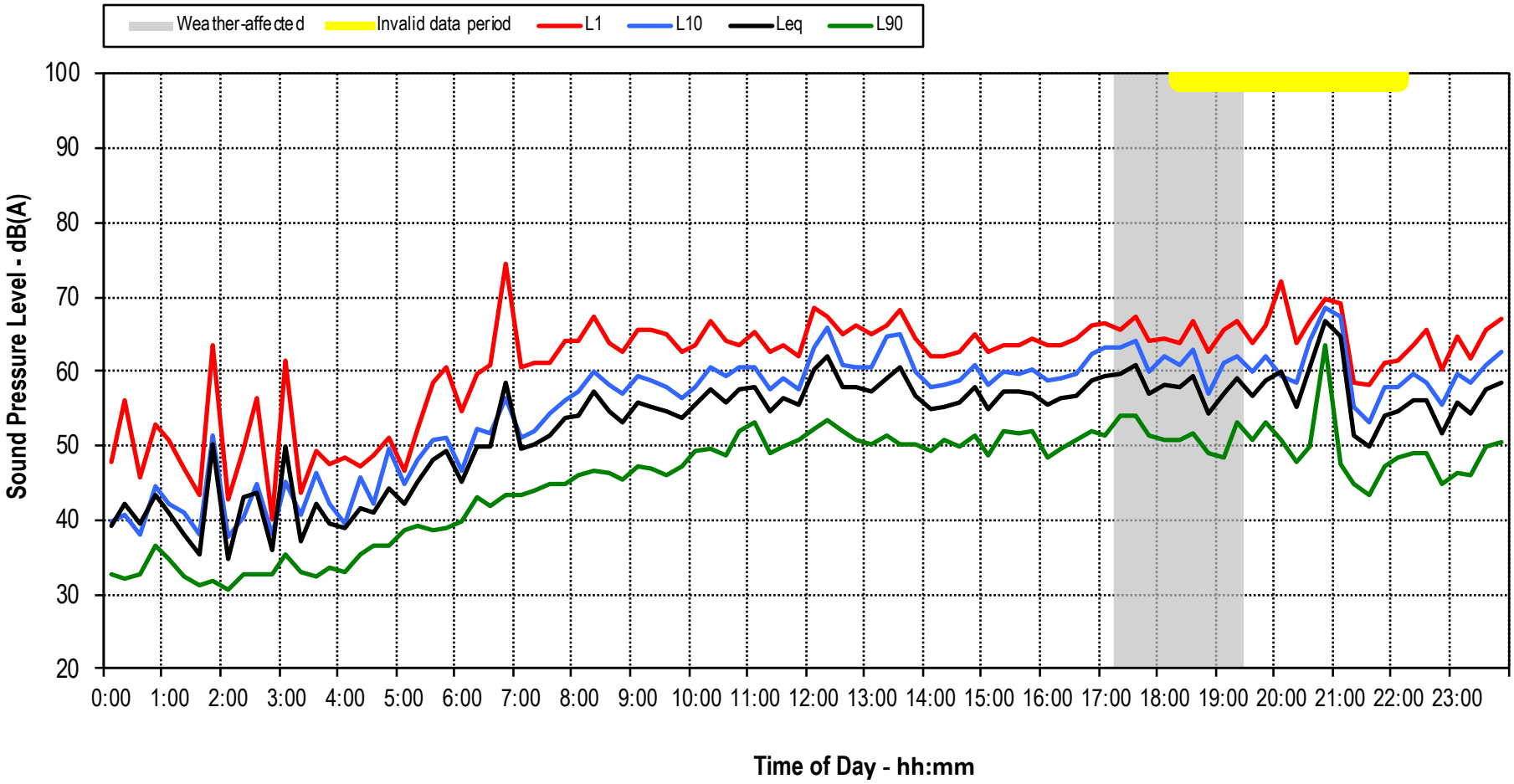

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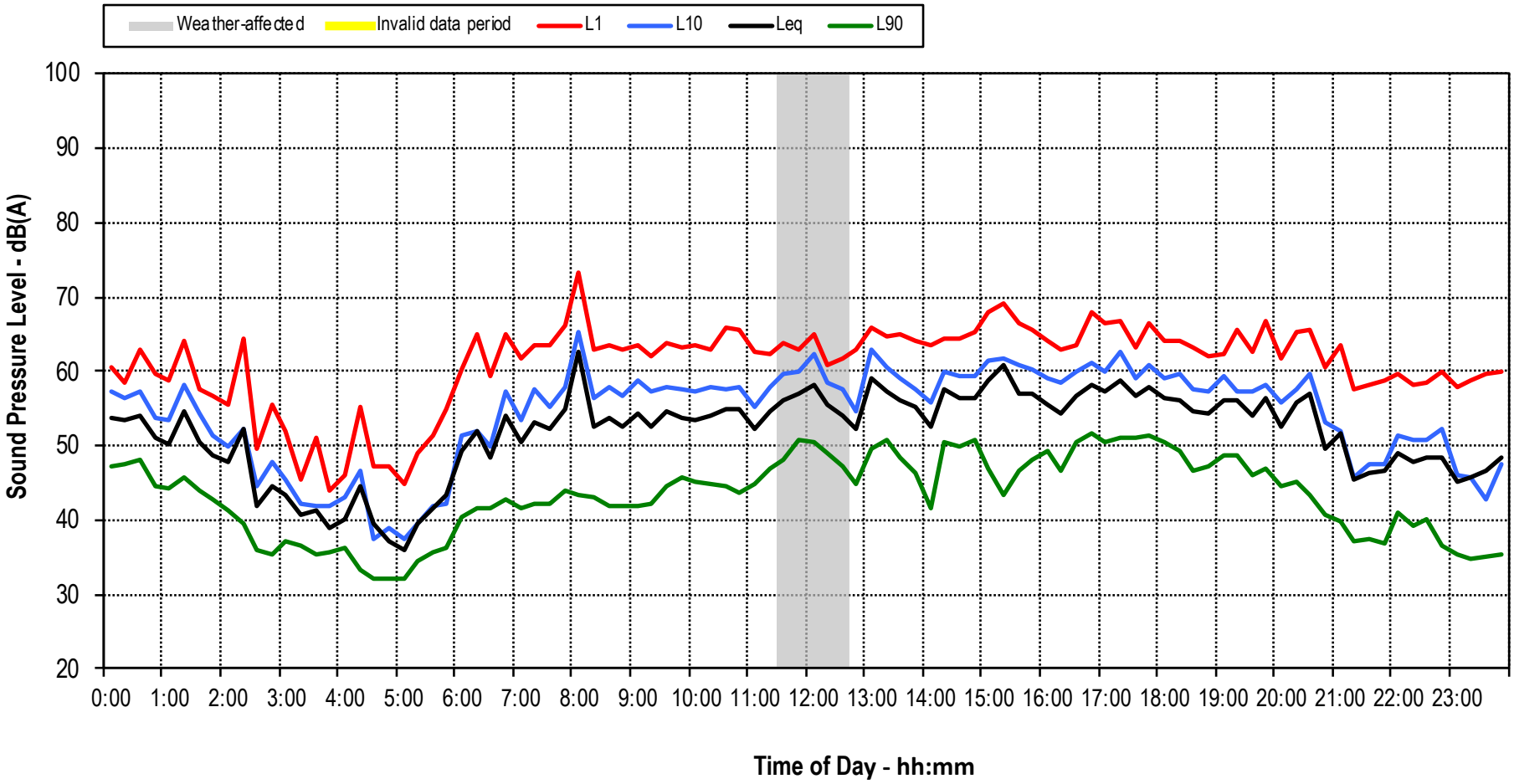

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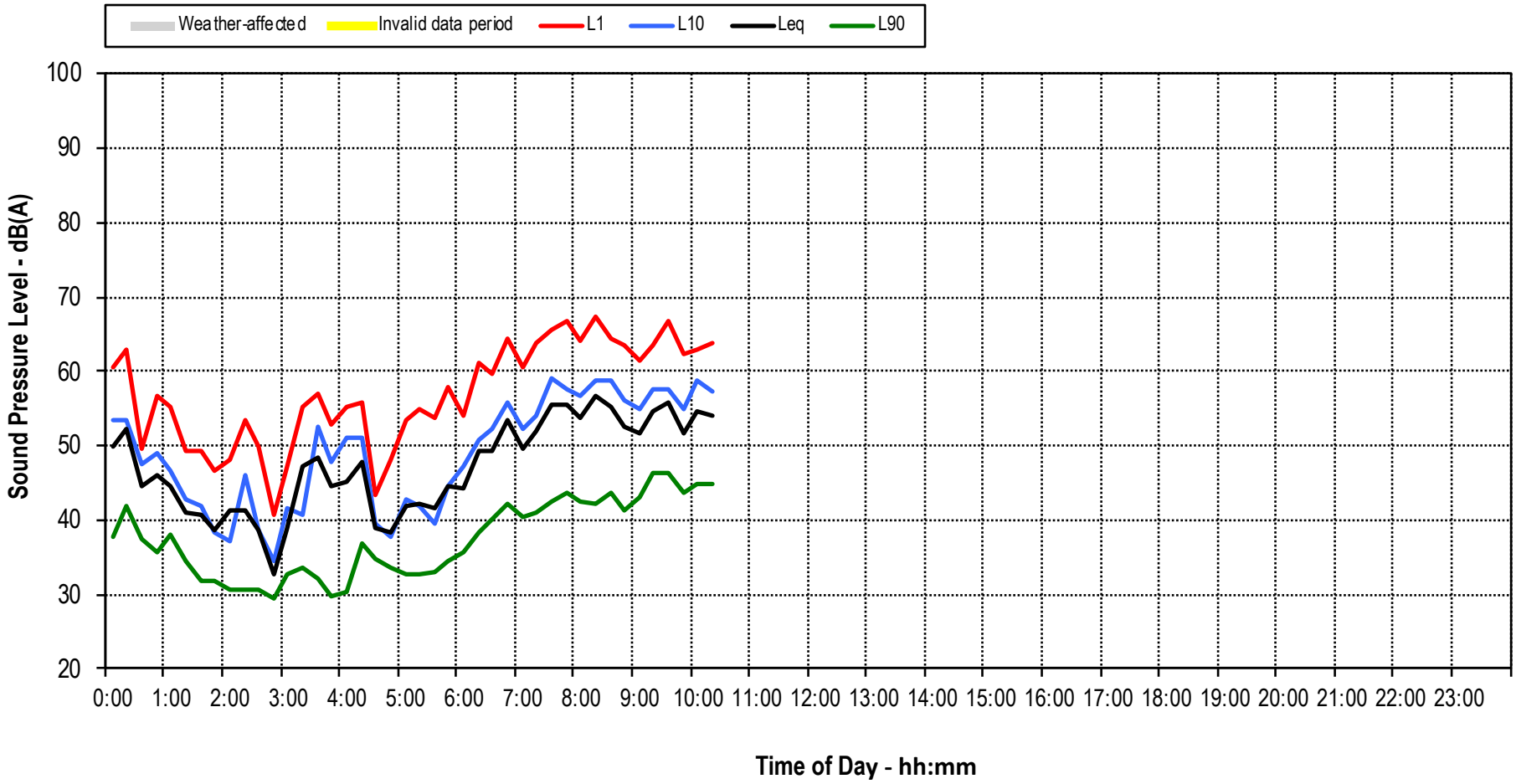

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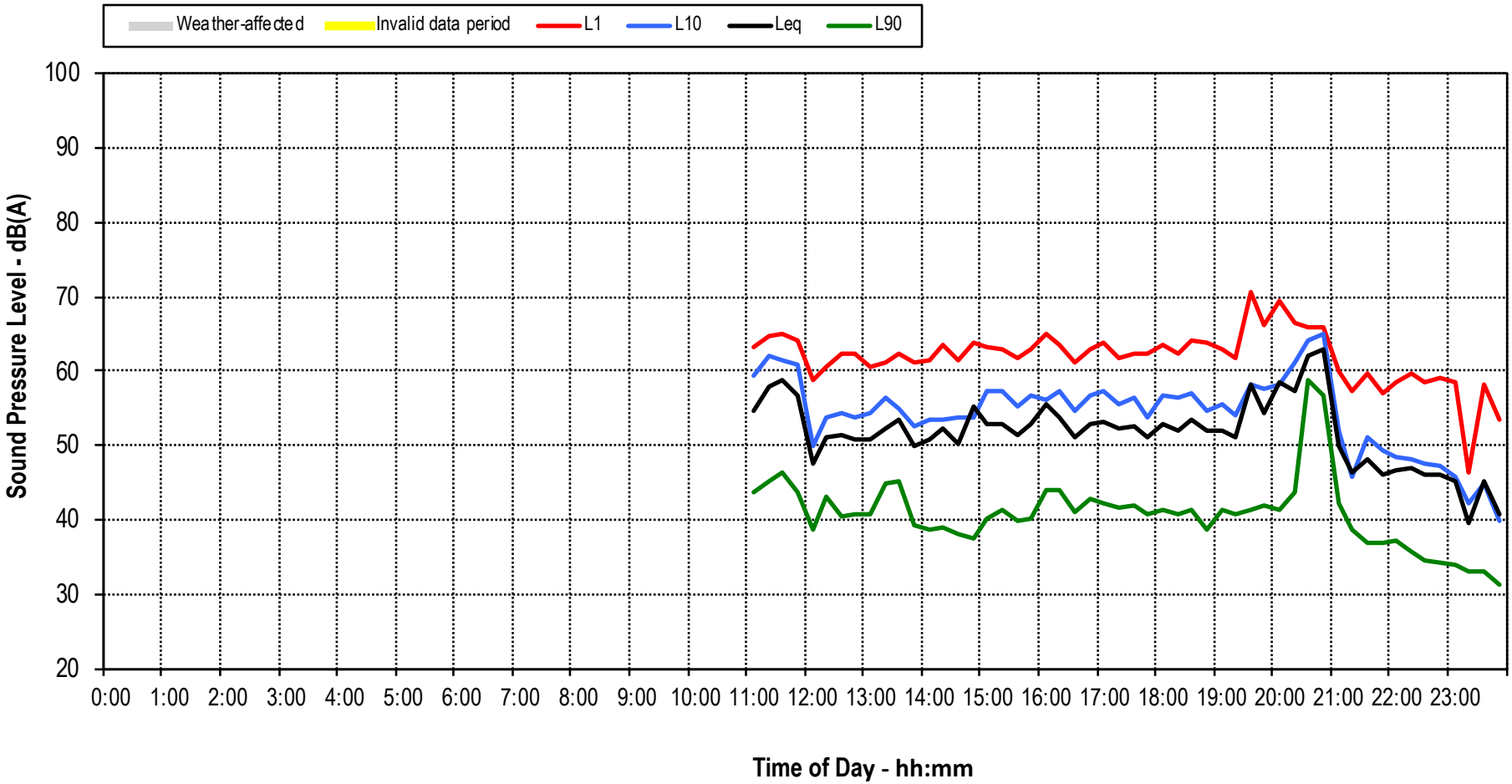

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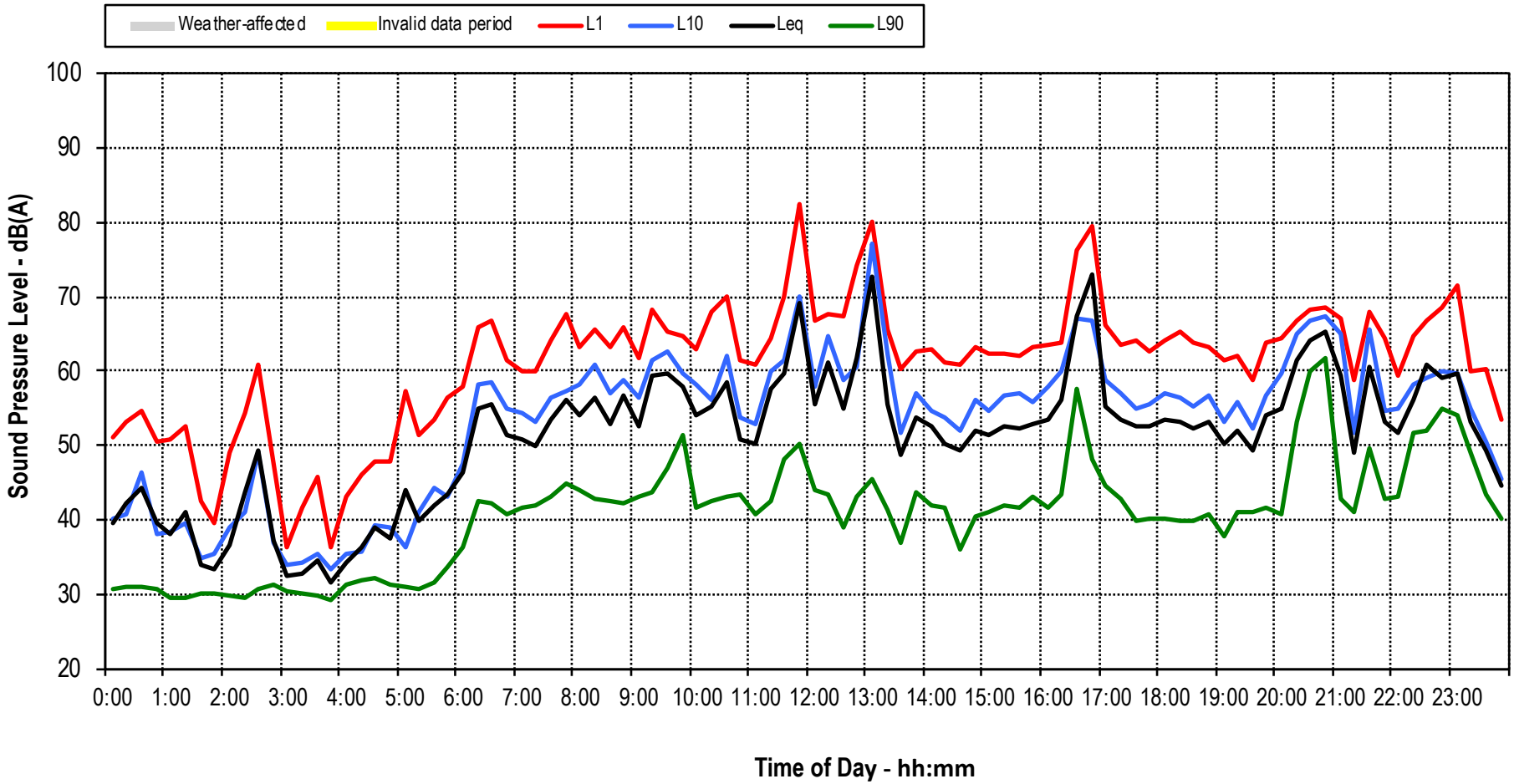

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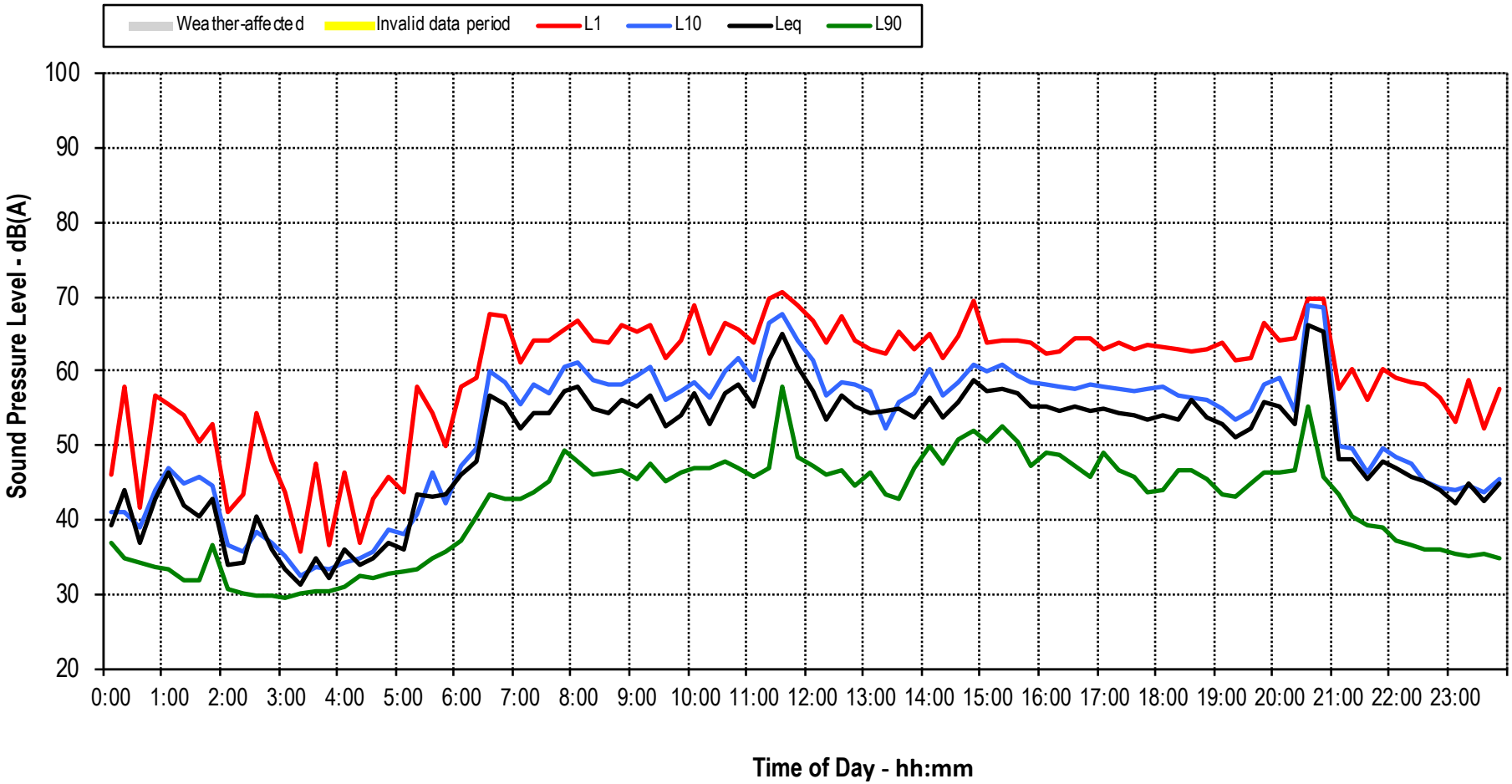

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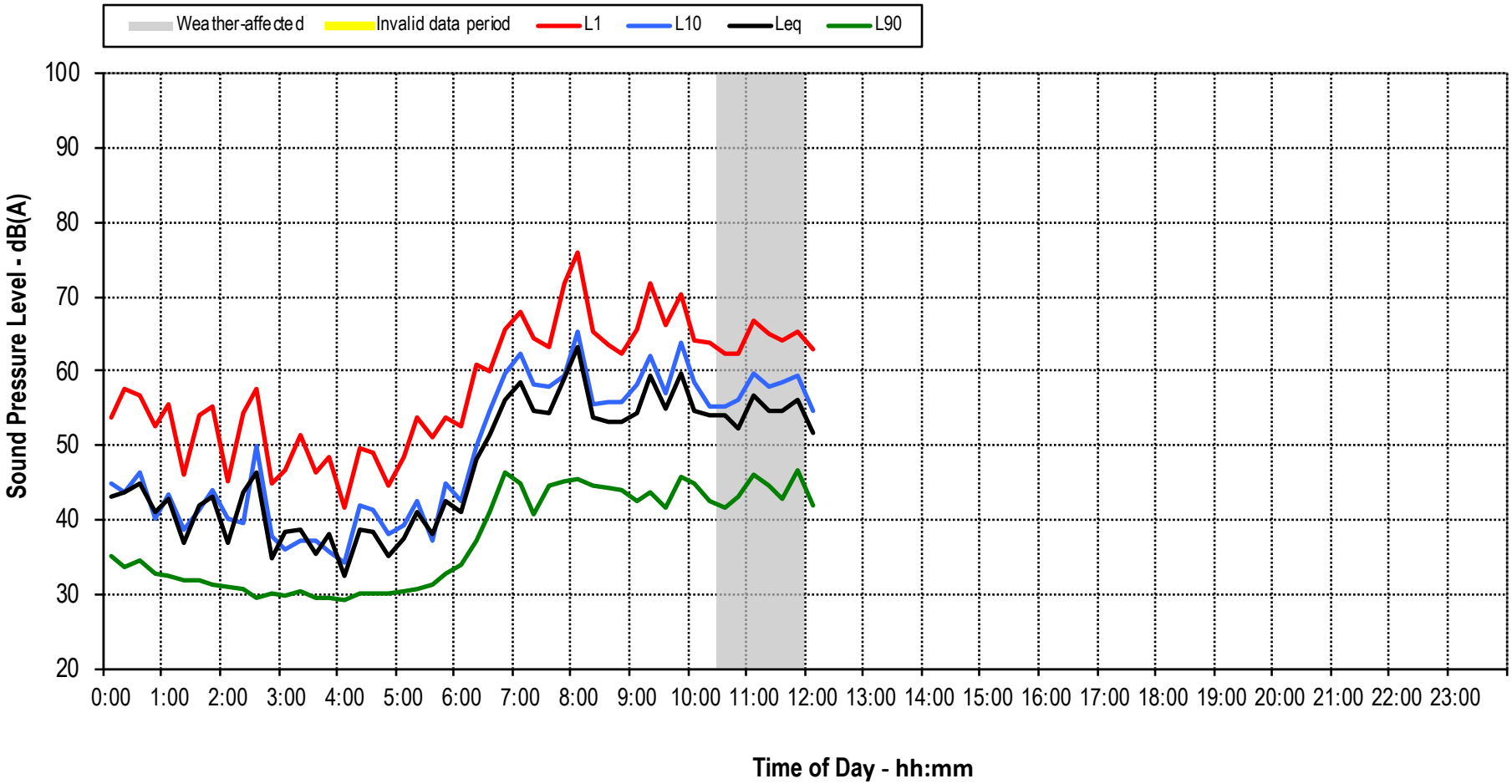
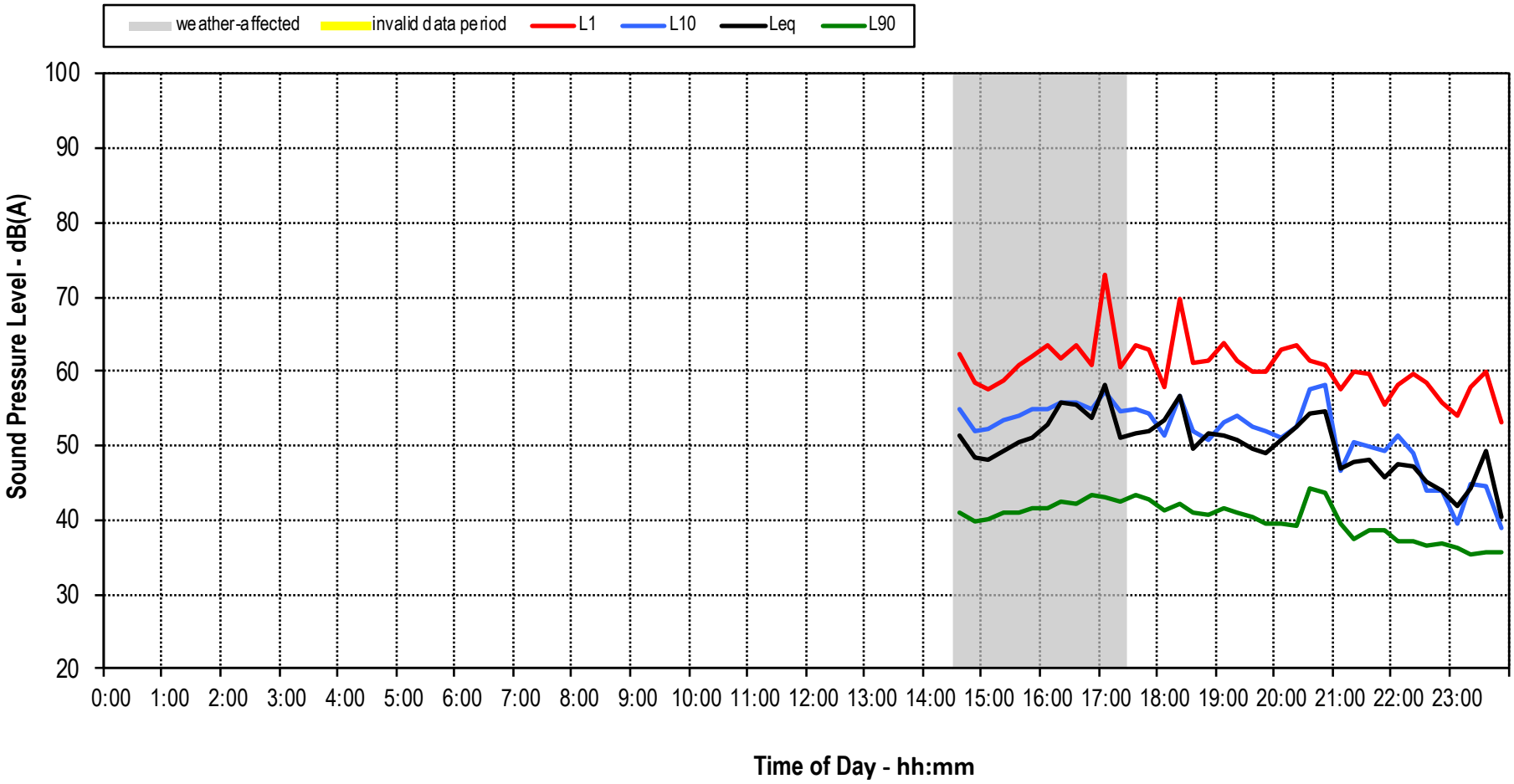


Location 3 – Denistone Road

Location 3 - 56 Denistone Road - Monday 31 January 2022



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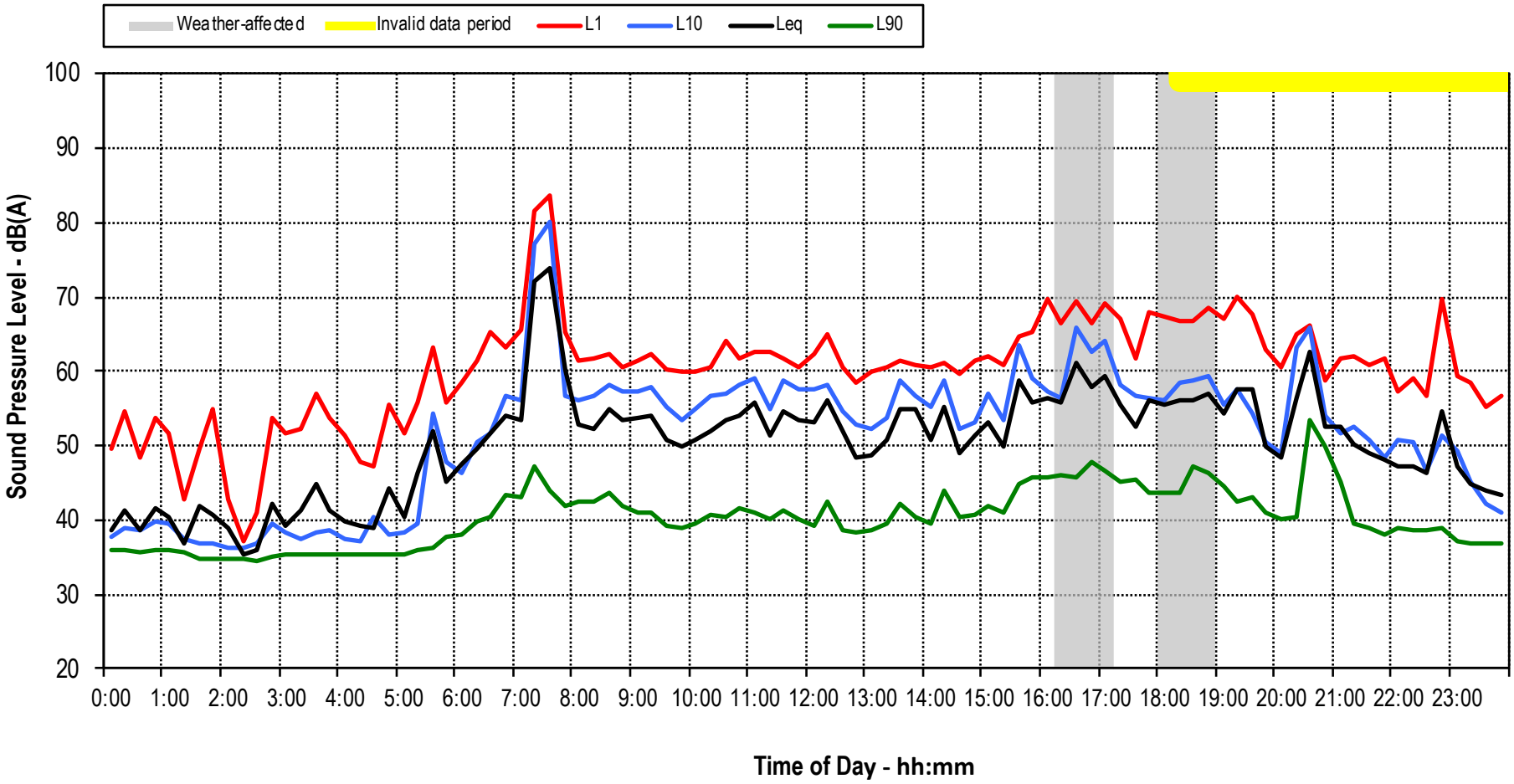
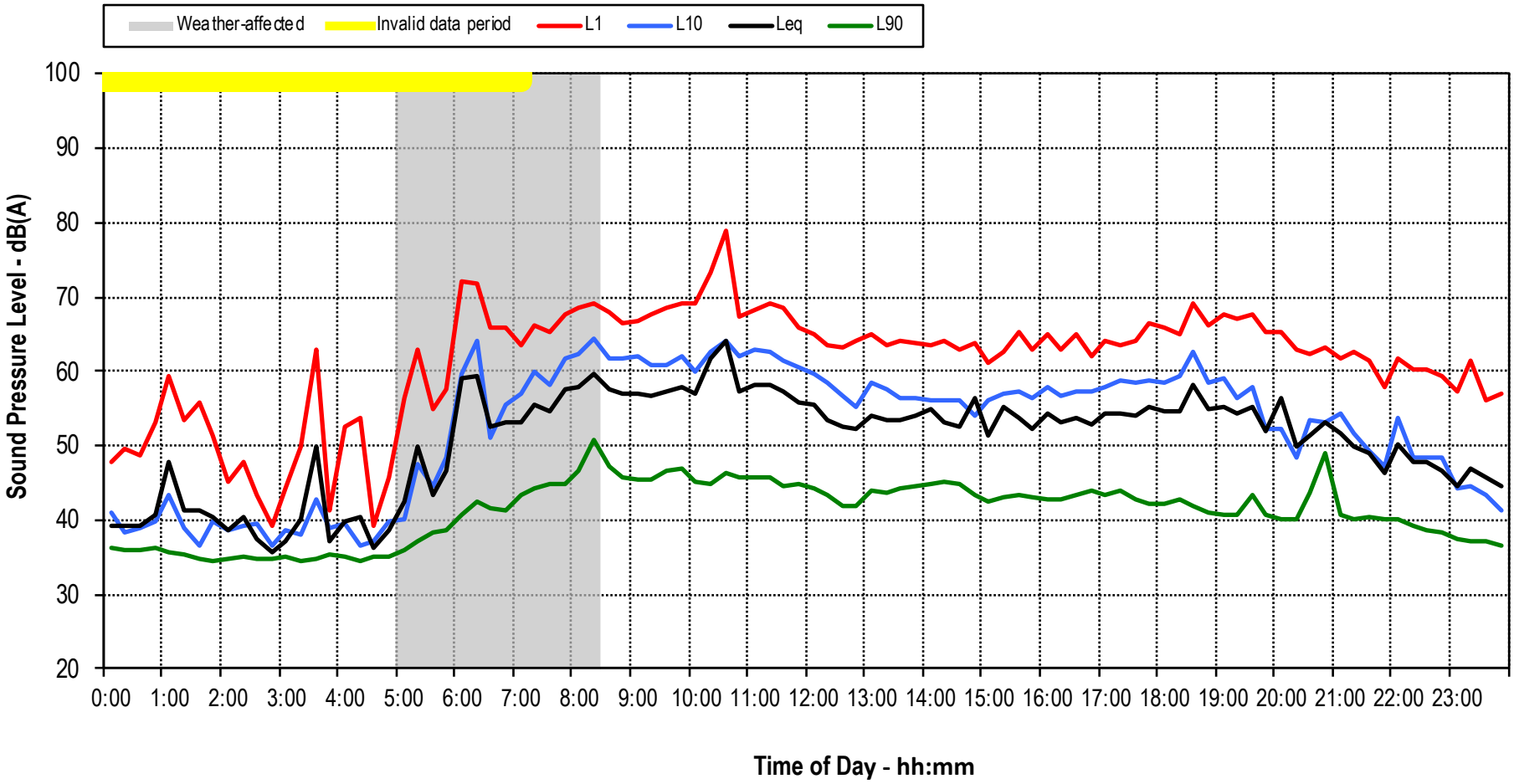
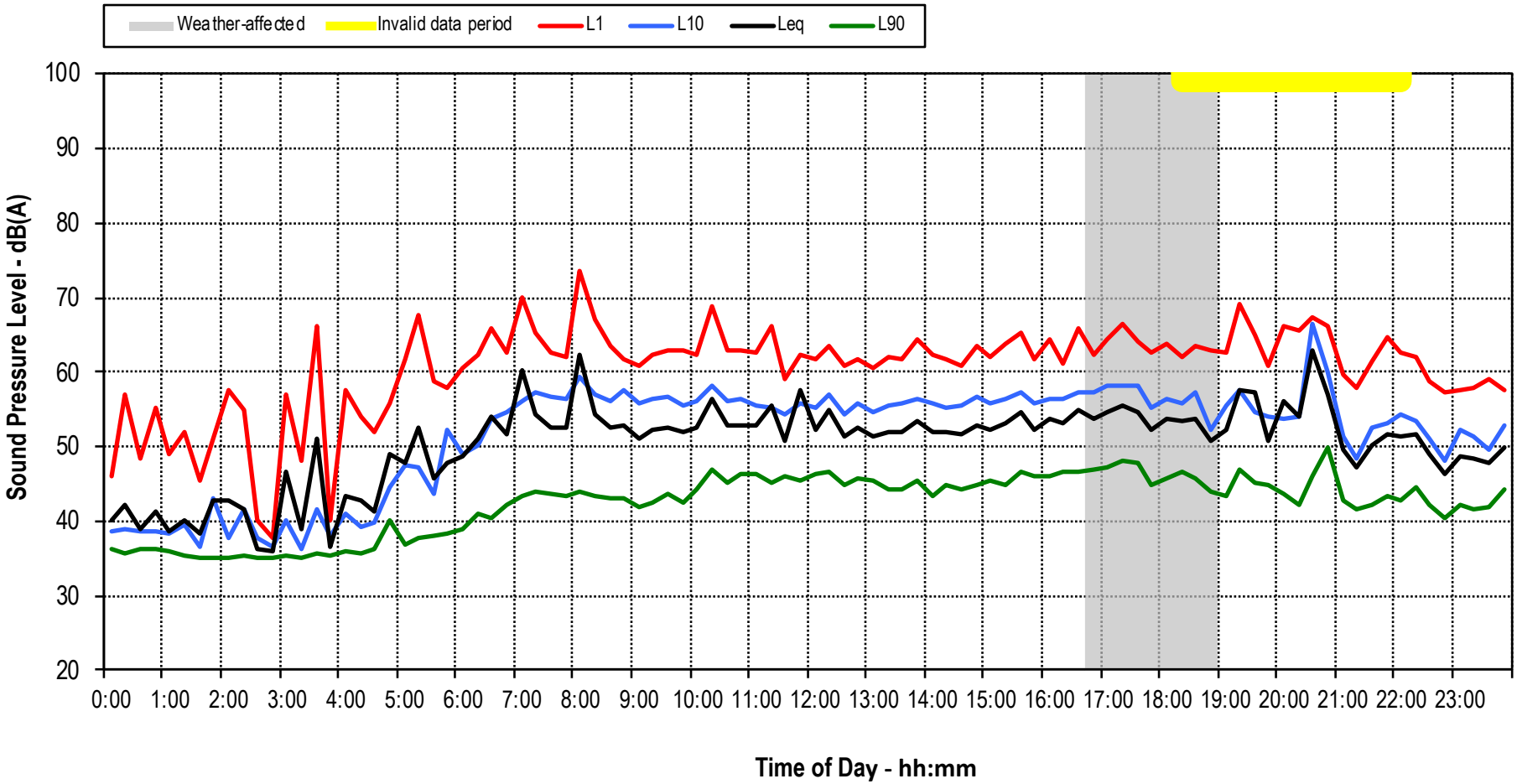


Location 3 - 56 Denistone Road - Wednesday 02 February 2022



Location 3 - 56 Denistone Road - Thursday 03 February 2022



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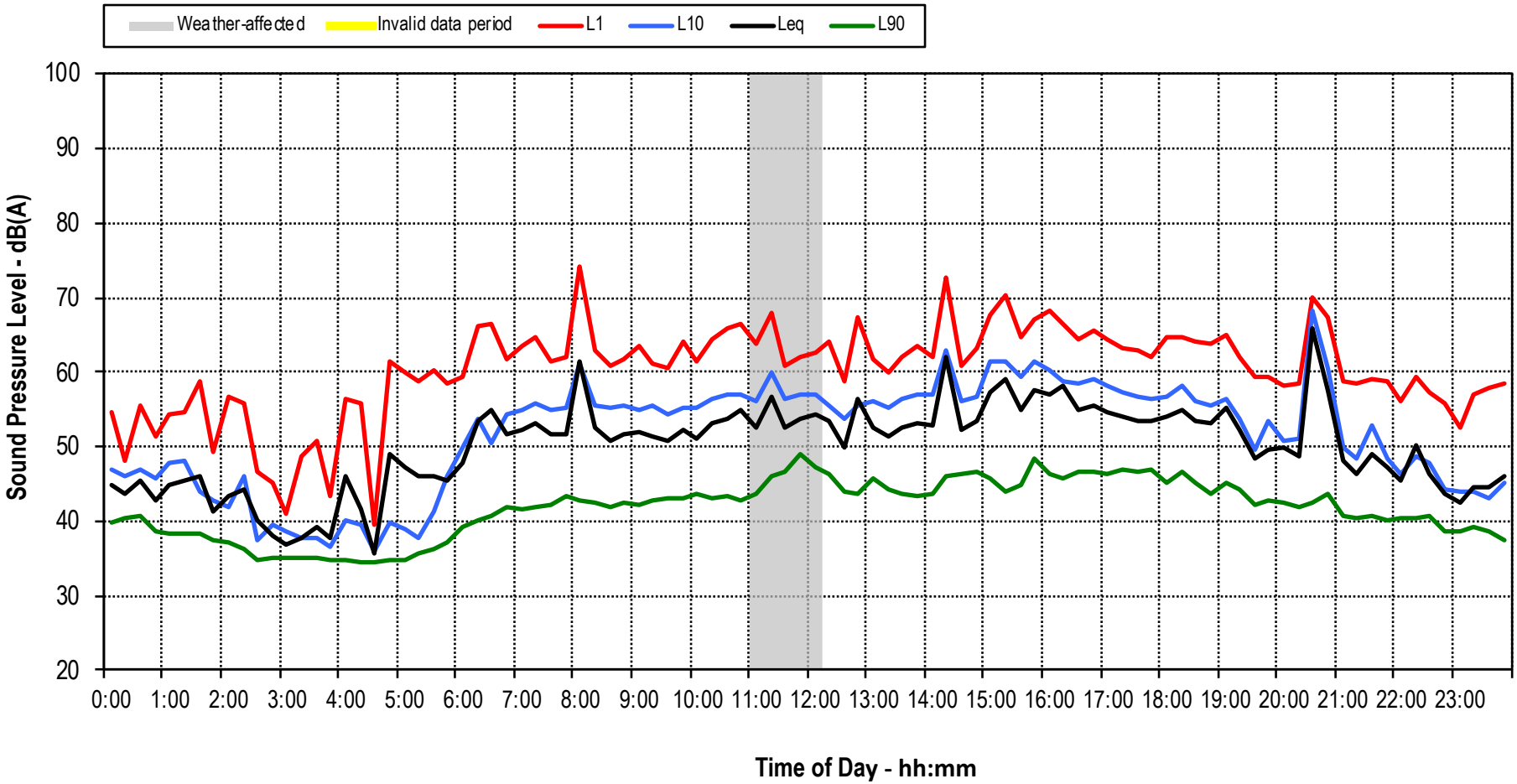

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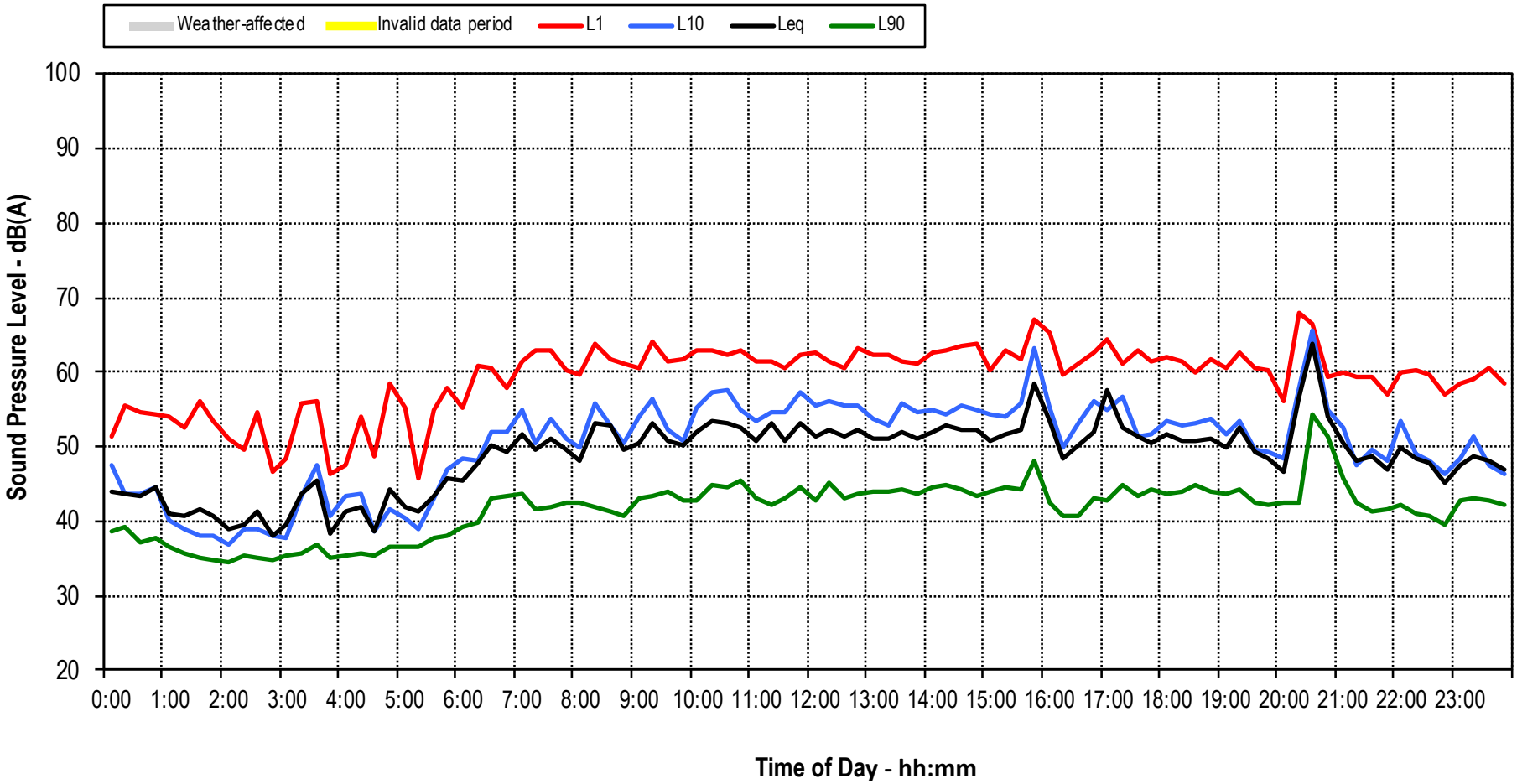

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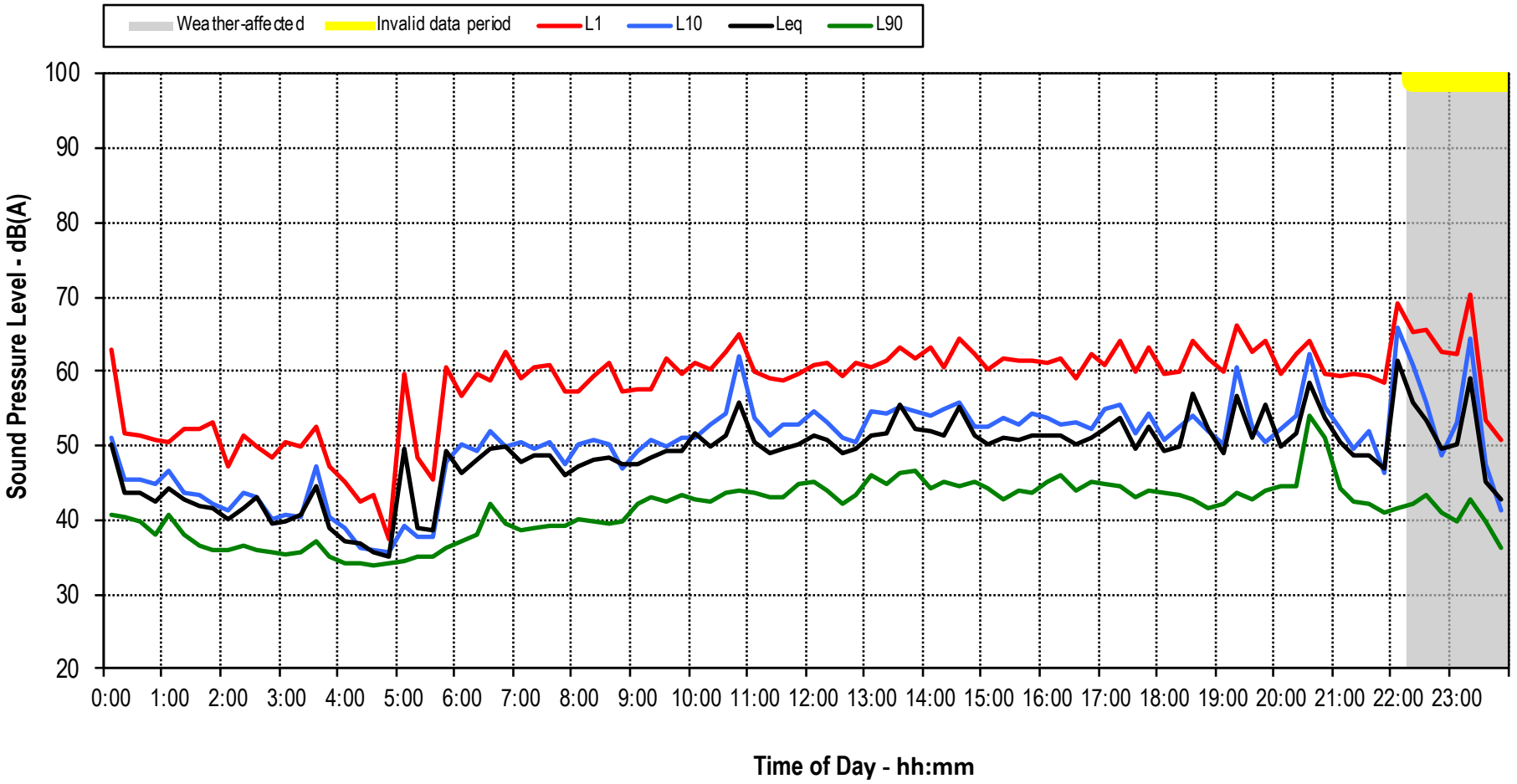

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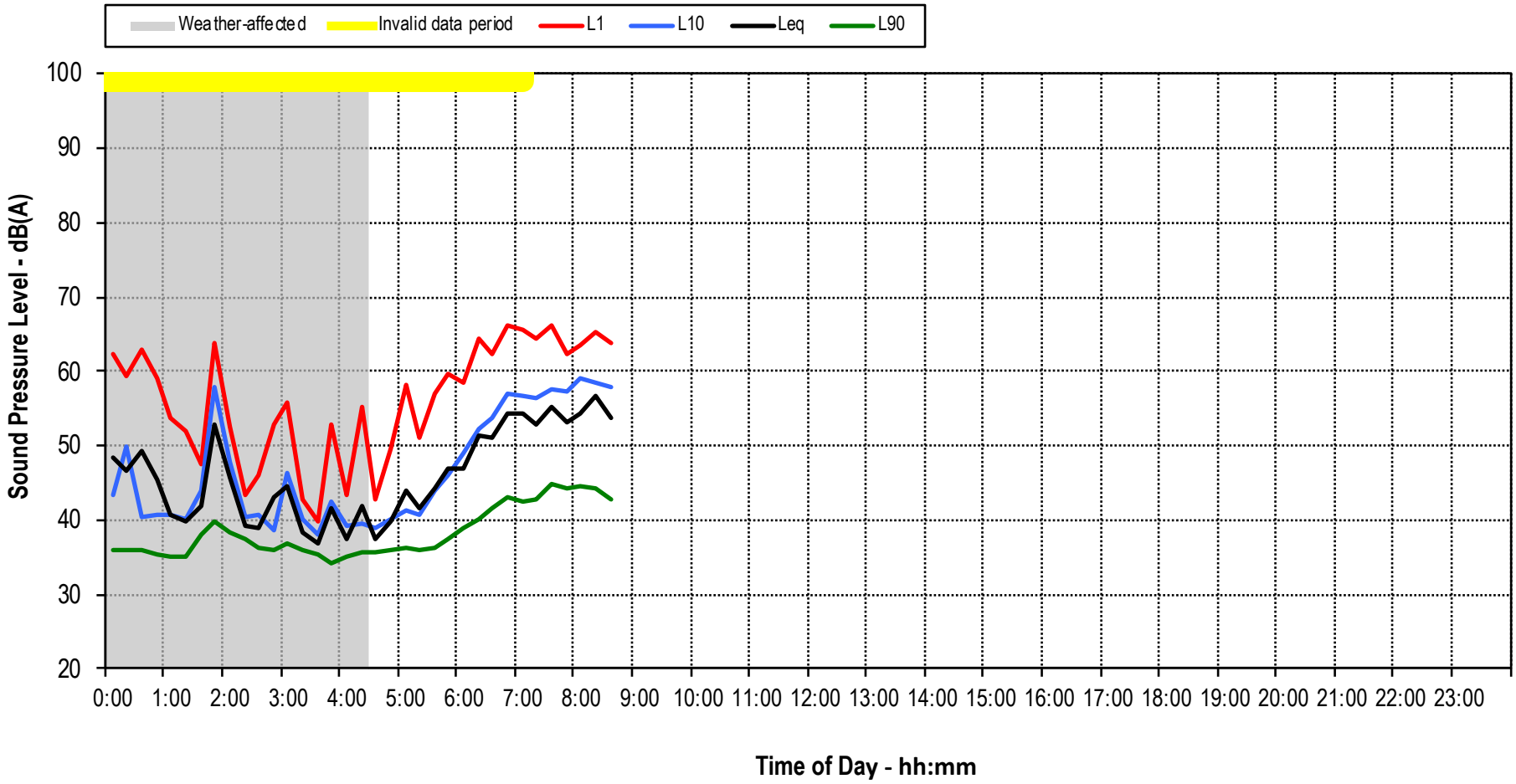

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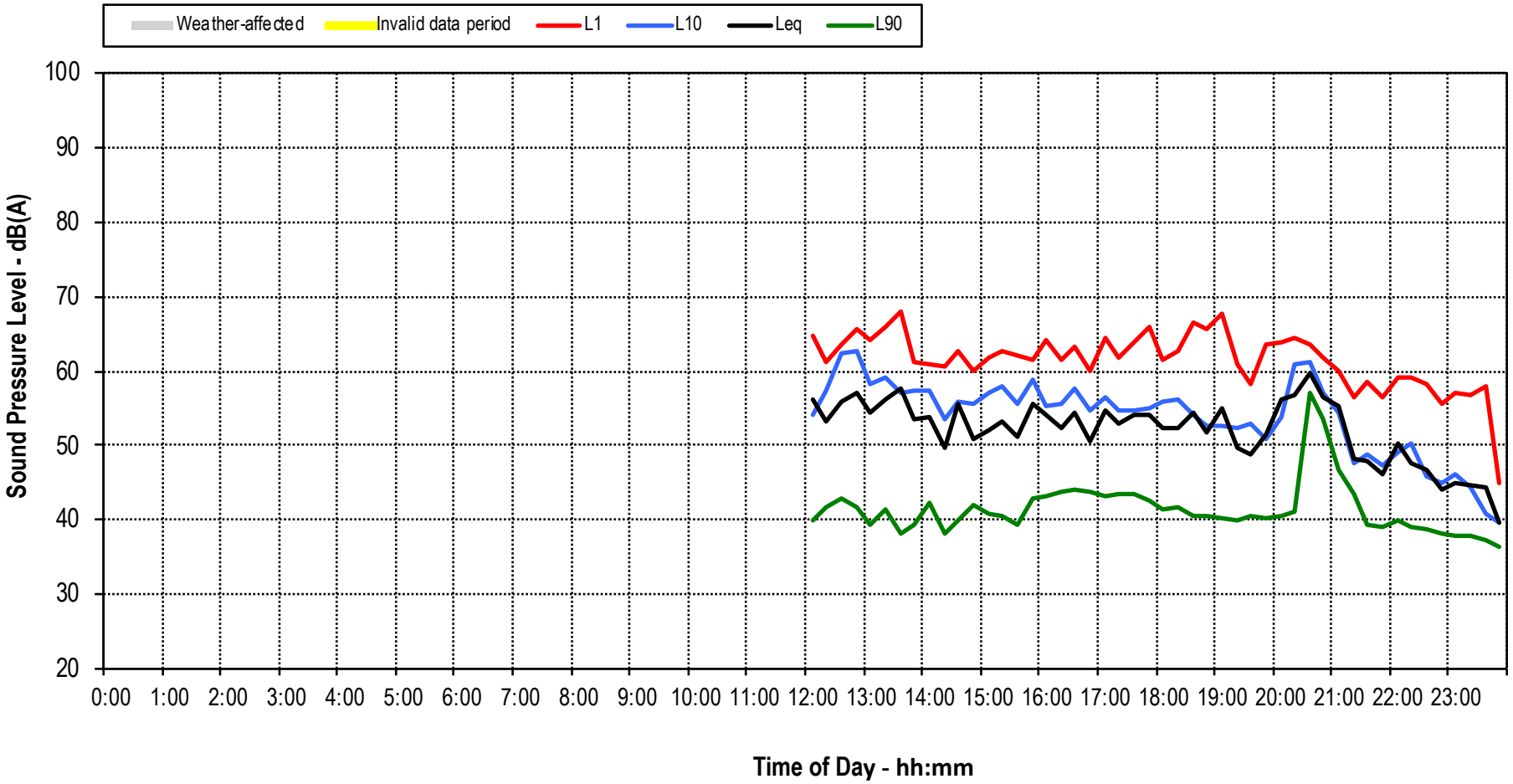

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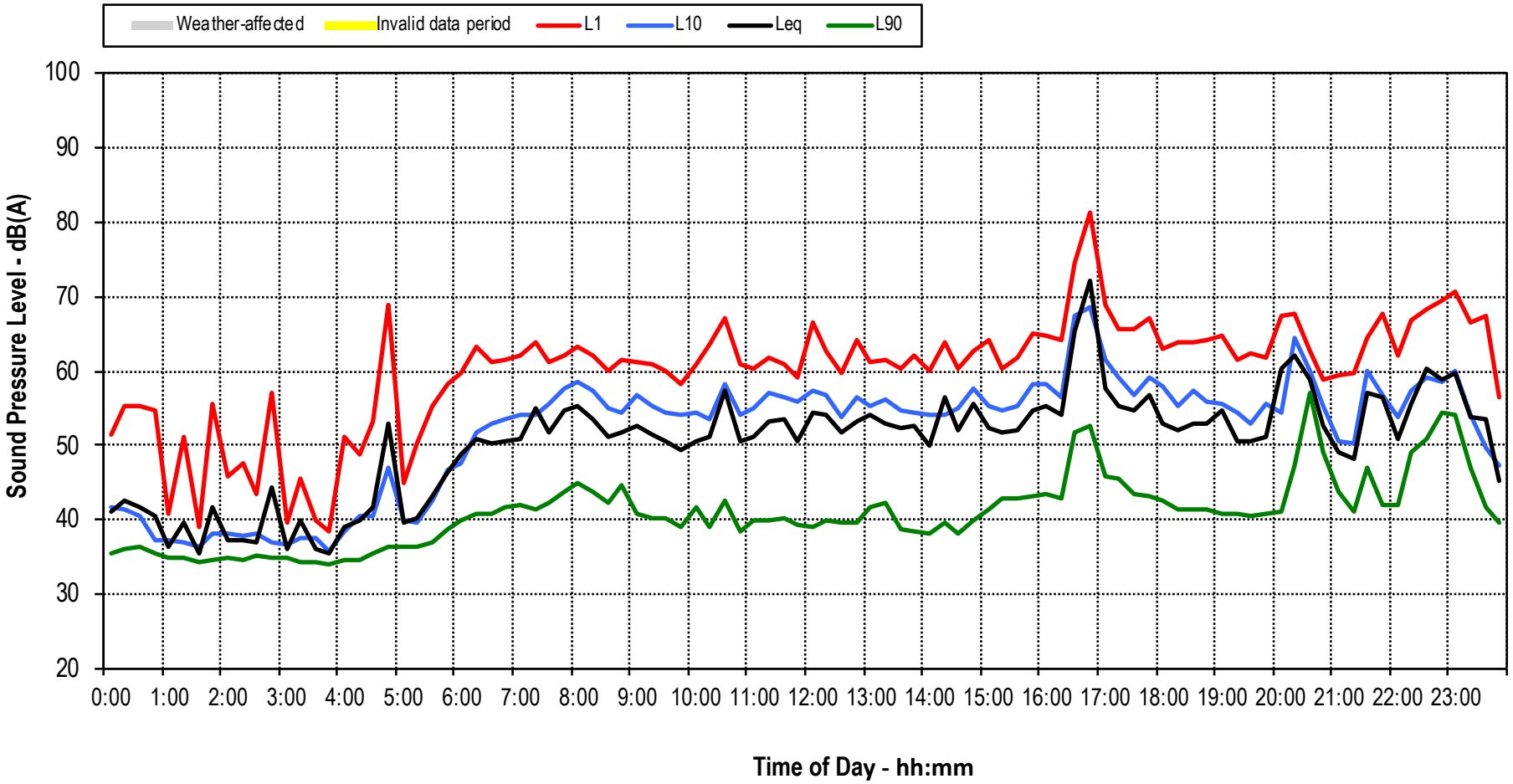

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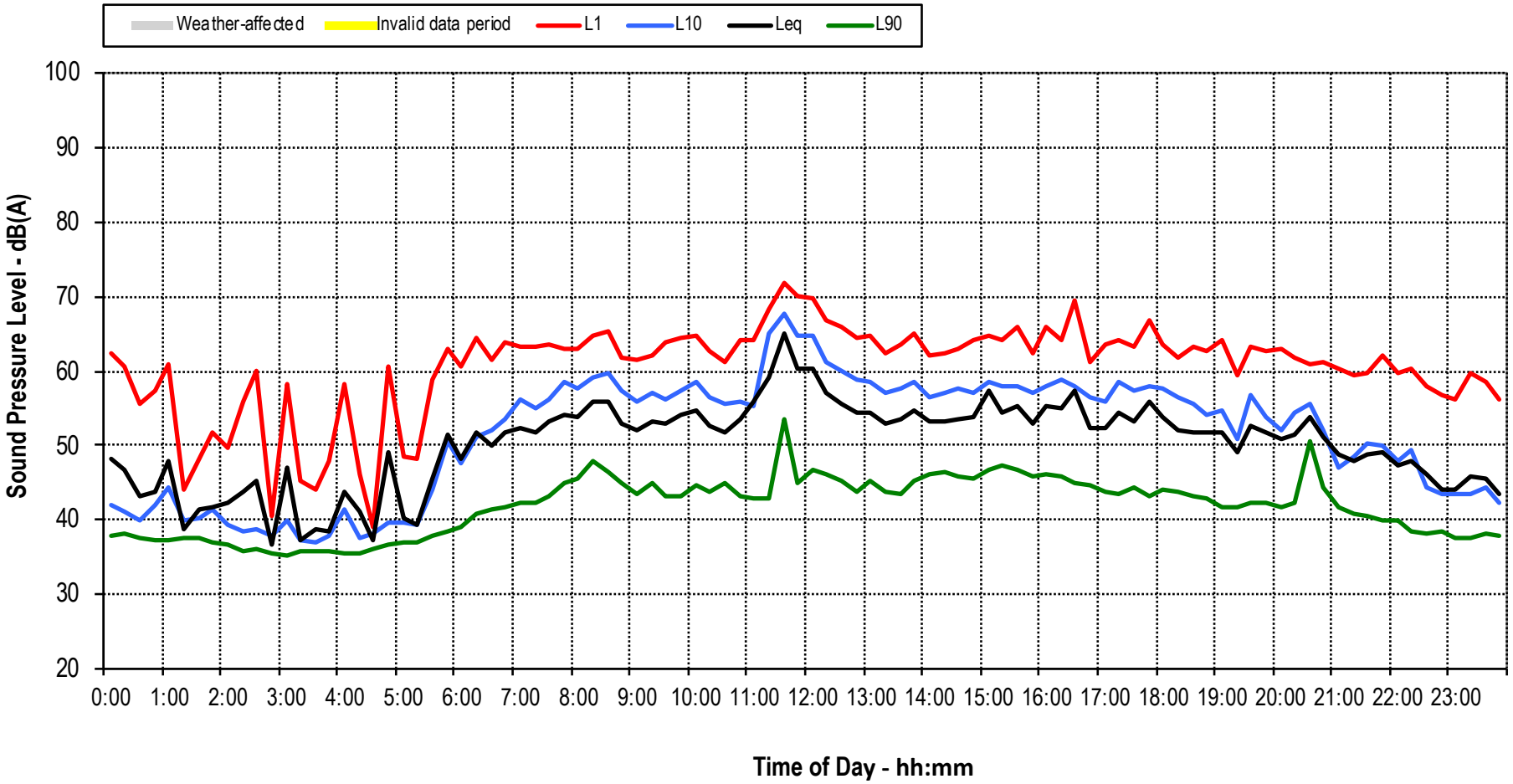

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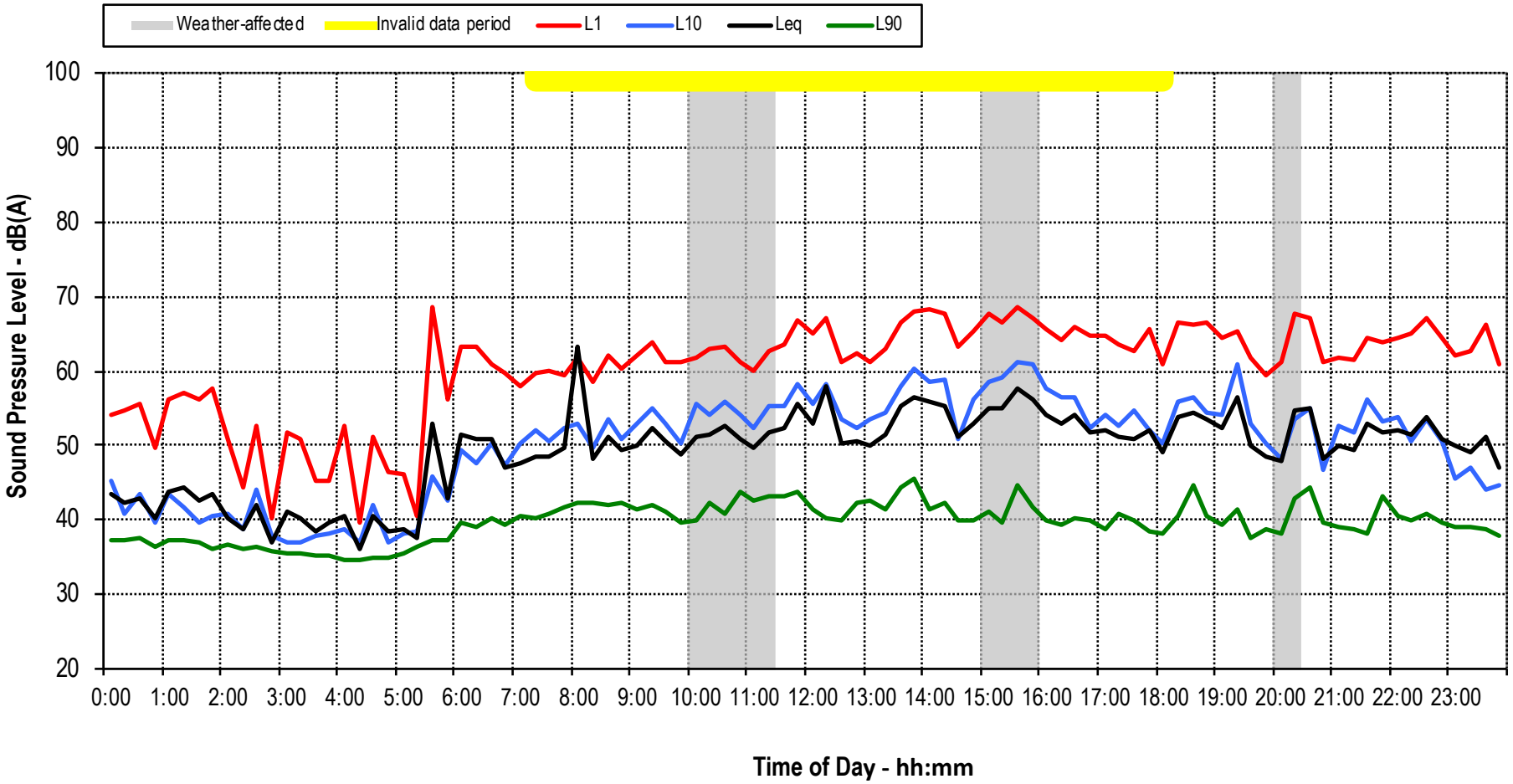

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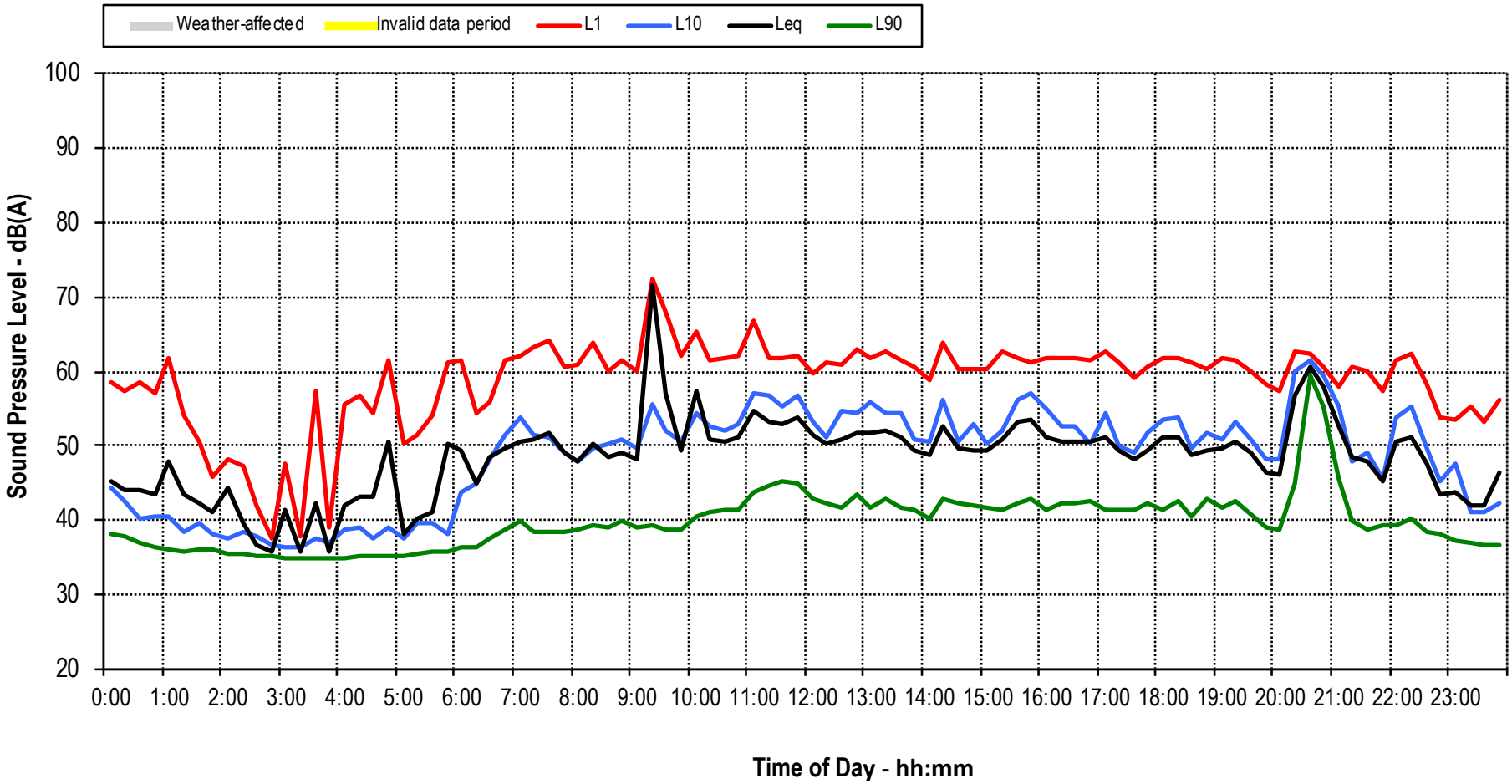

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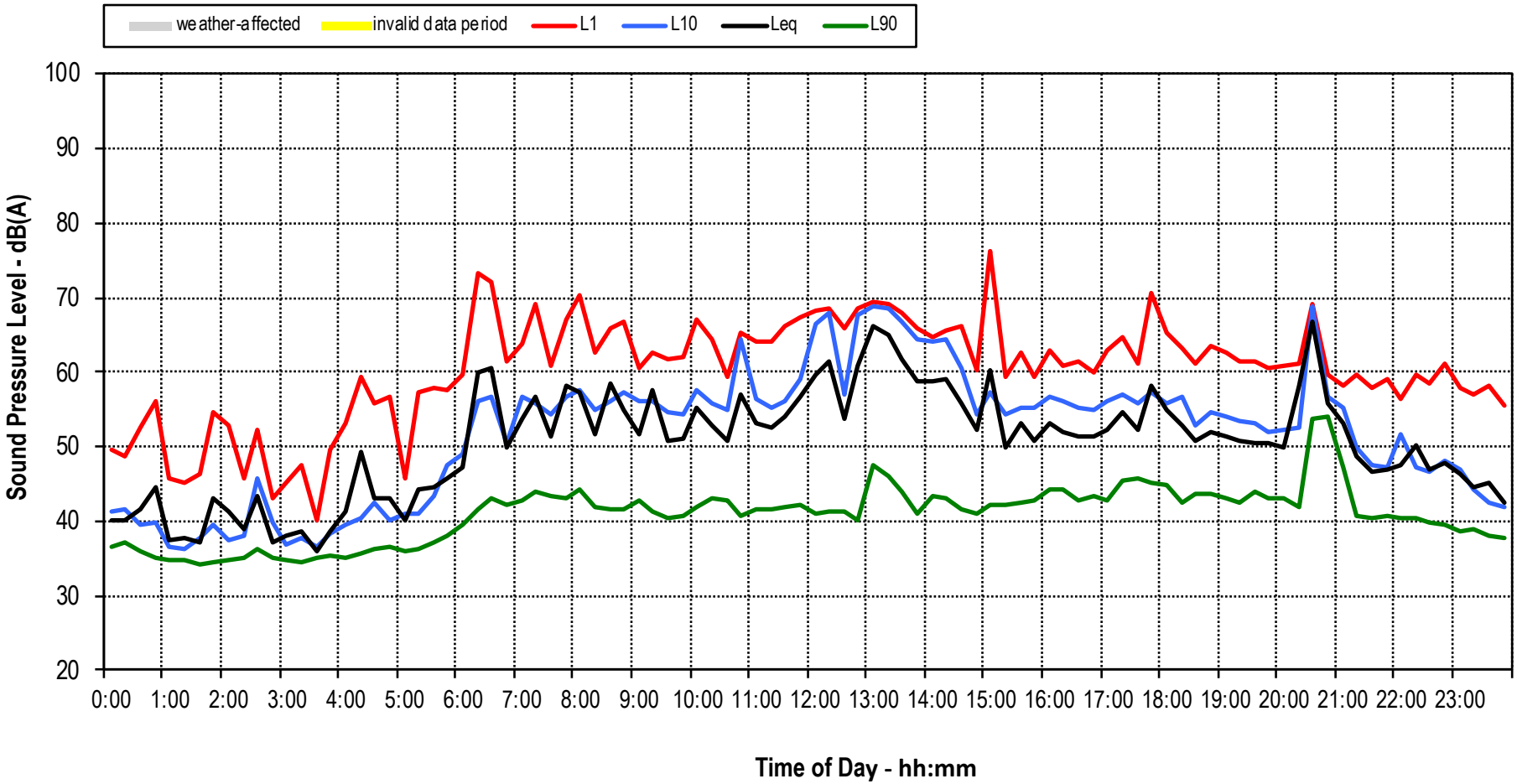

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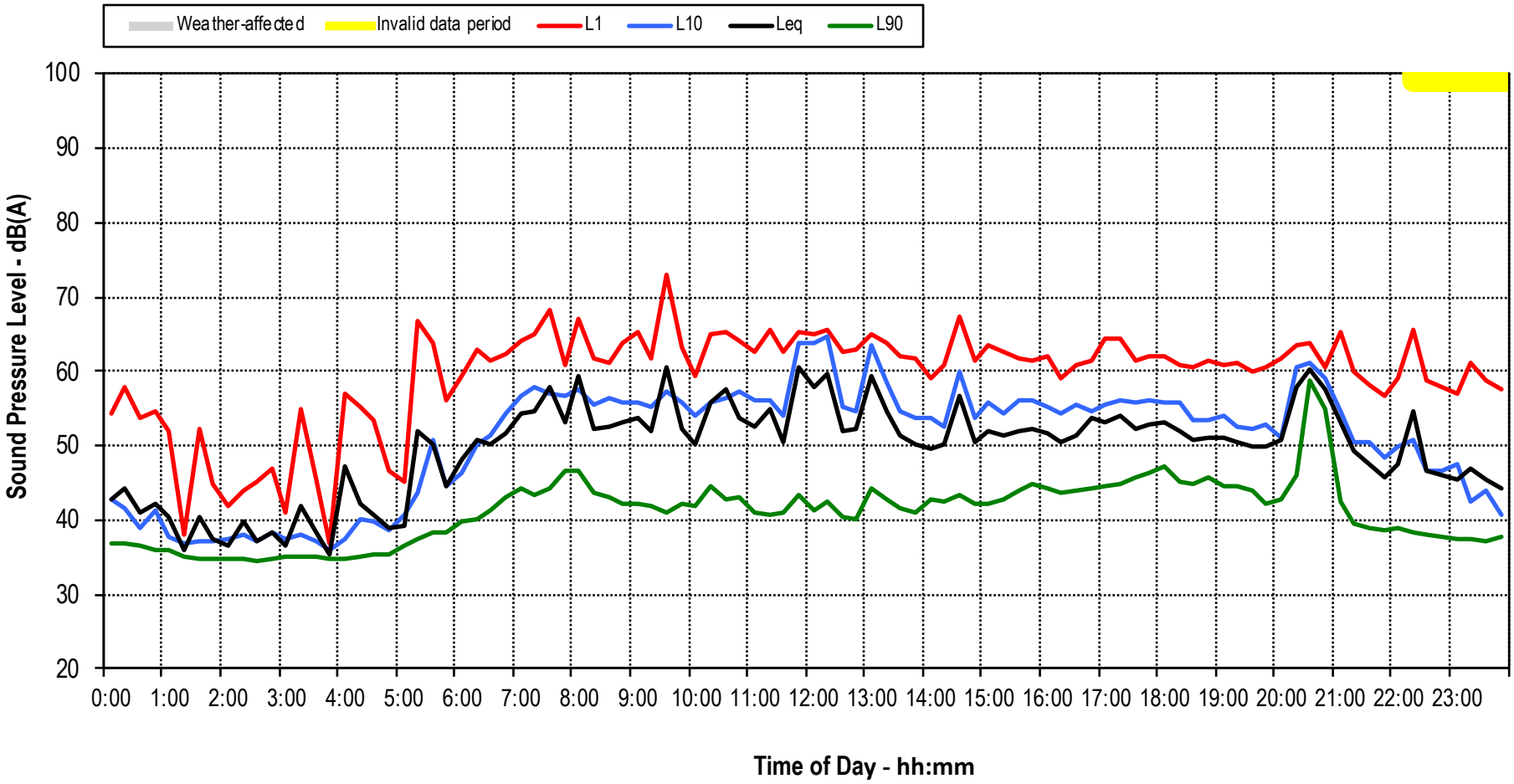
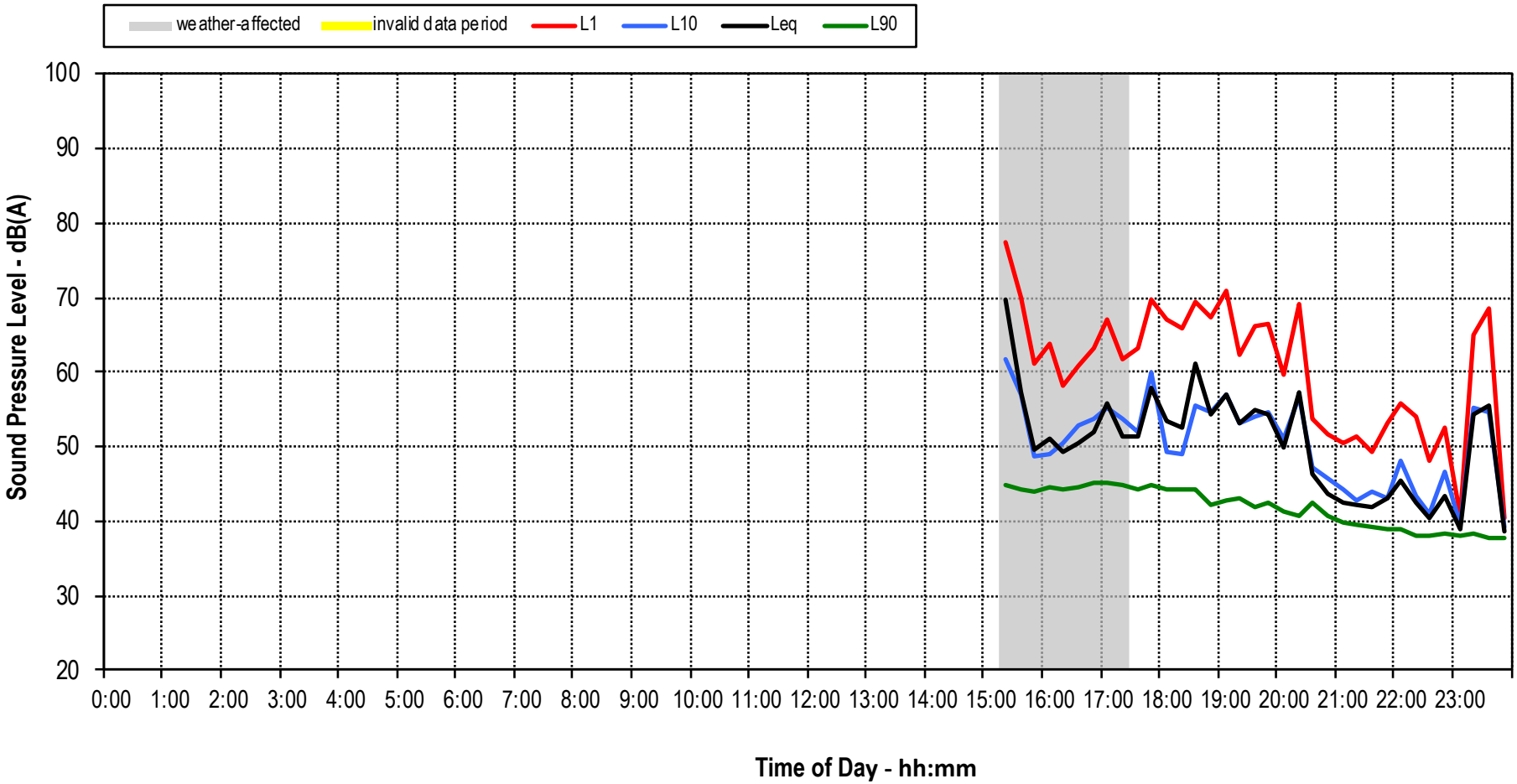
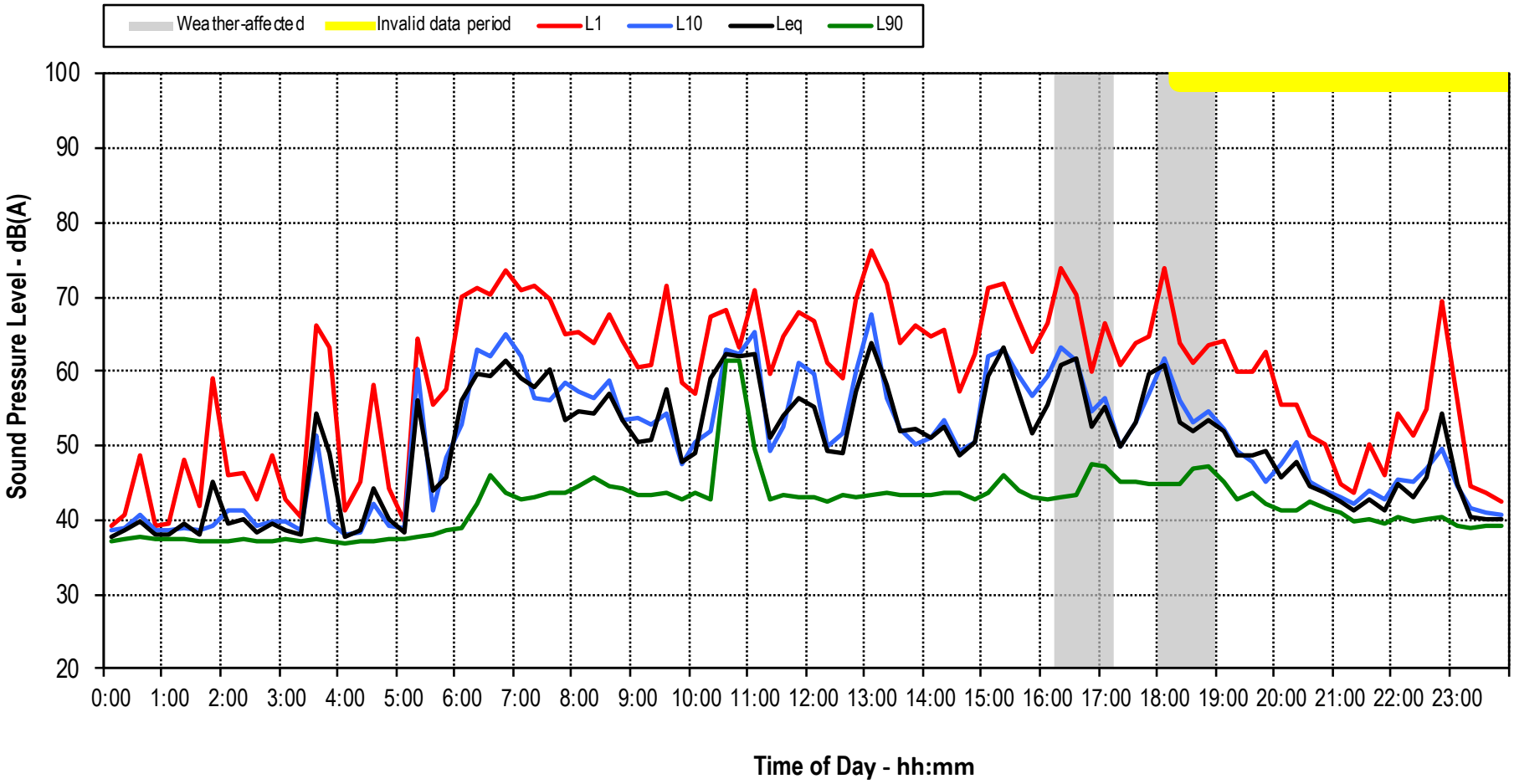


Location 4 – Ryde Hospital Campus

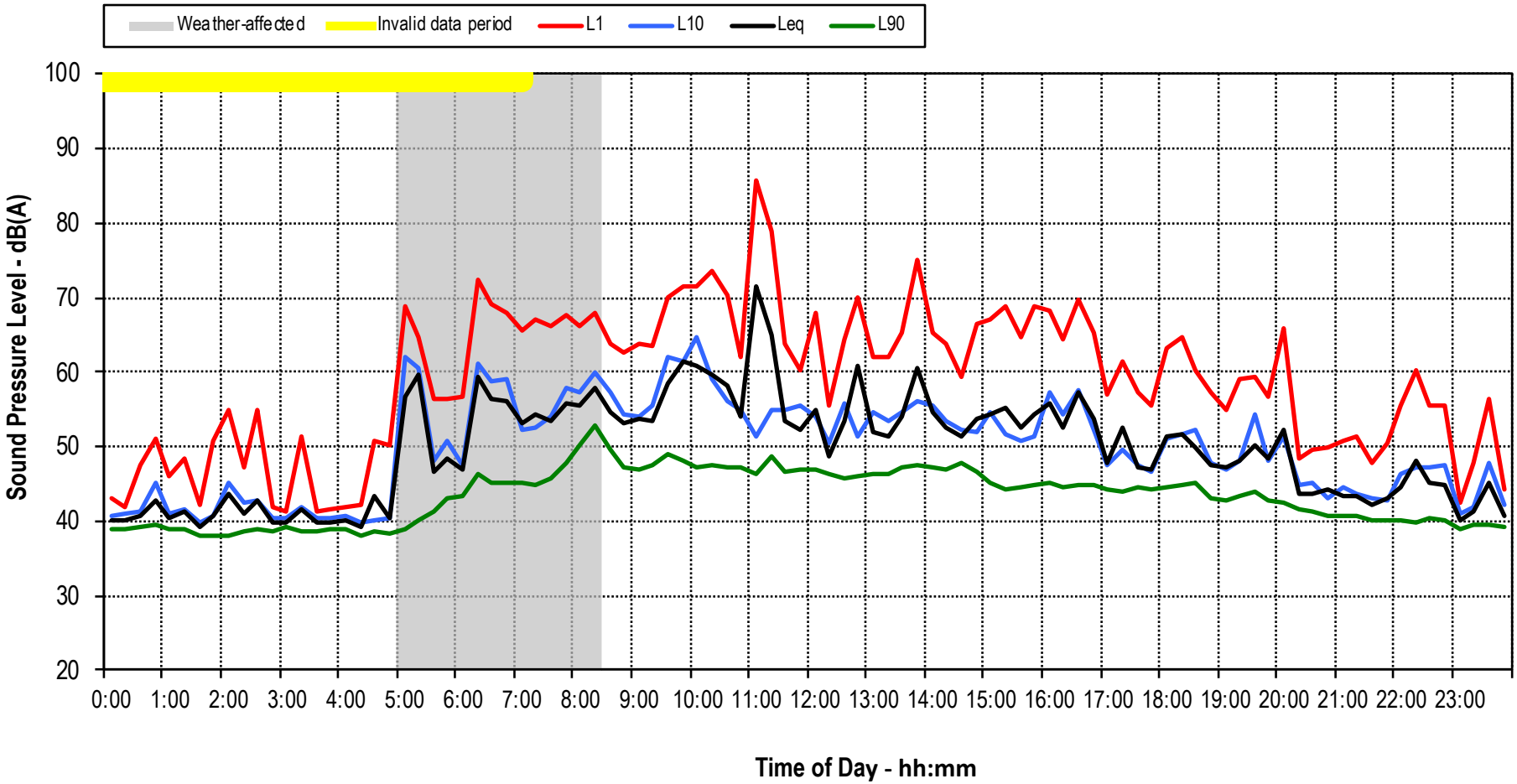
Location 4 - Ryde Hospital Campus - Monday 31 January 2022



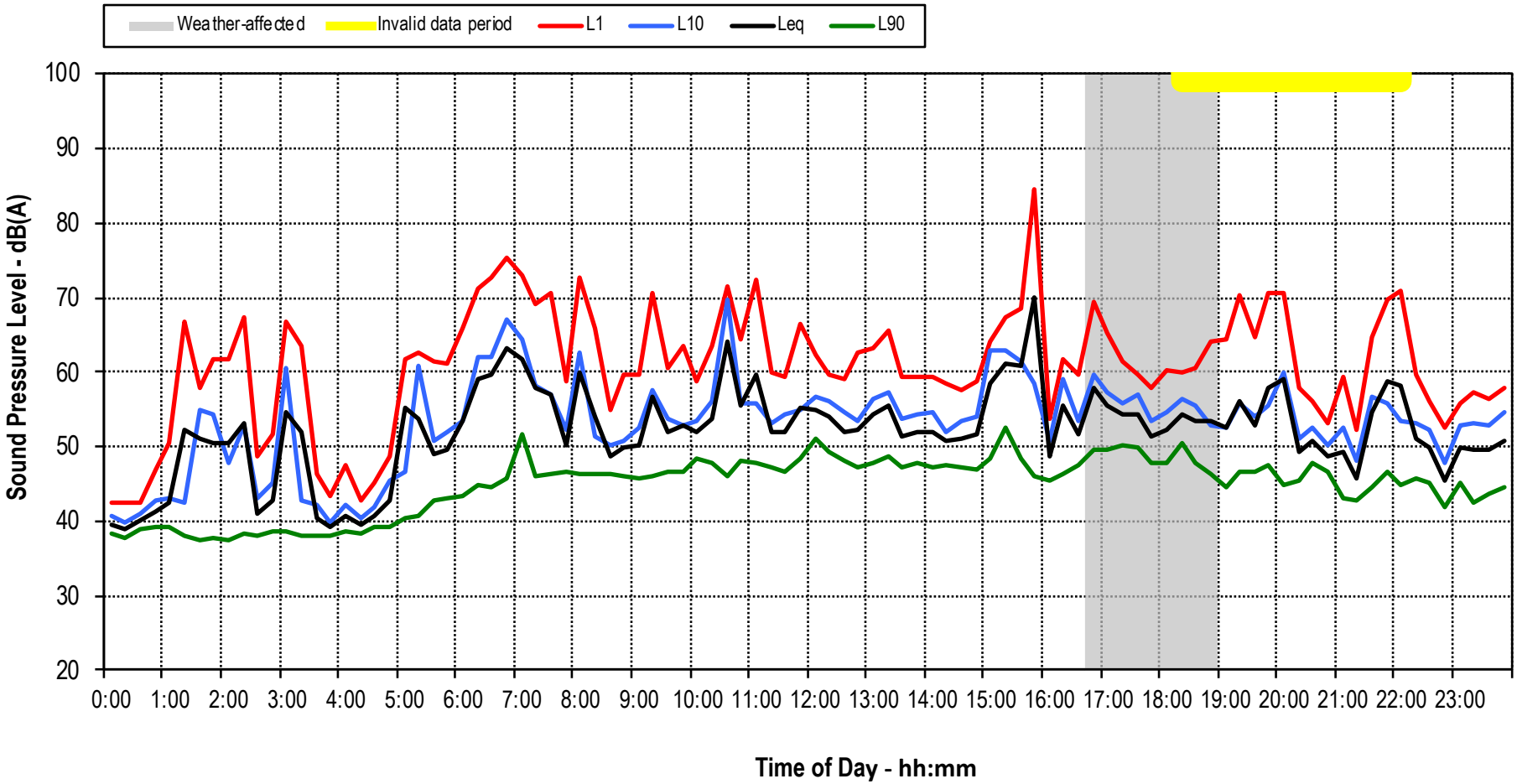
Location 4 - Ryde Hospital Campus - Tuesday 01 February 2022



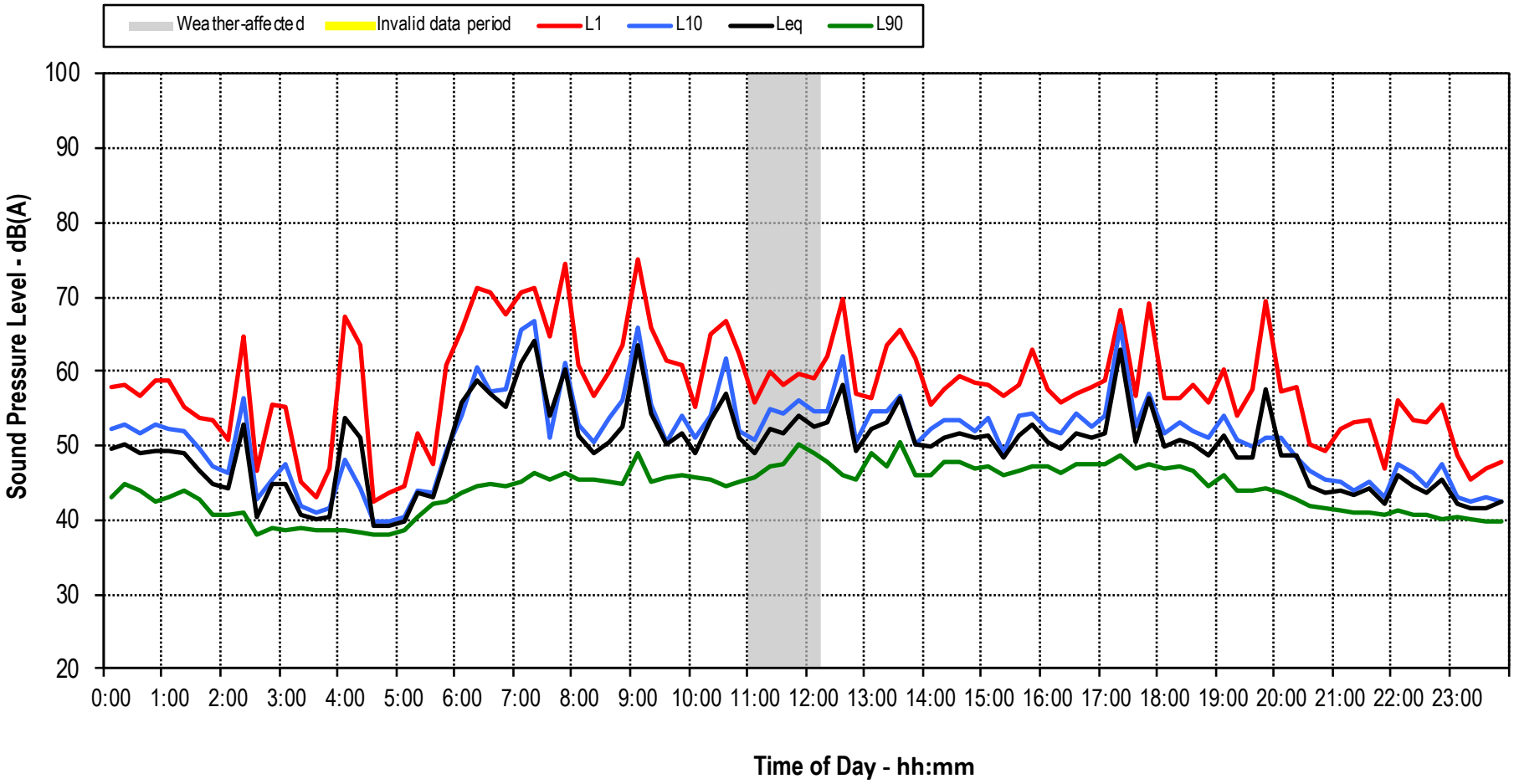
Location 4 - Ryde Hospital Campus - Wednesday 02 February 2022



Location 4 - Ryde Hospital Campus - Thursday 03 February 2022



Location 4 - Ryde Hospital Campus - Friday 04 February 2022



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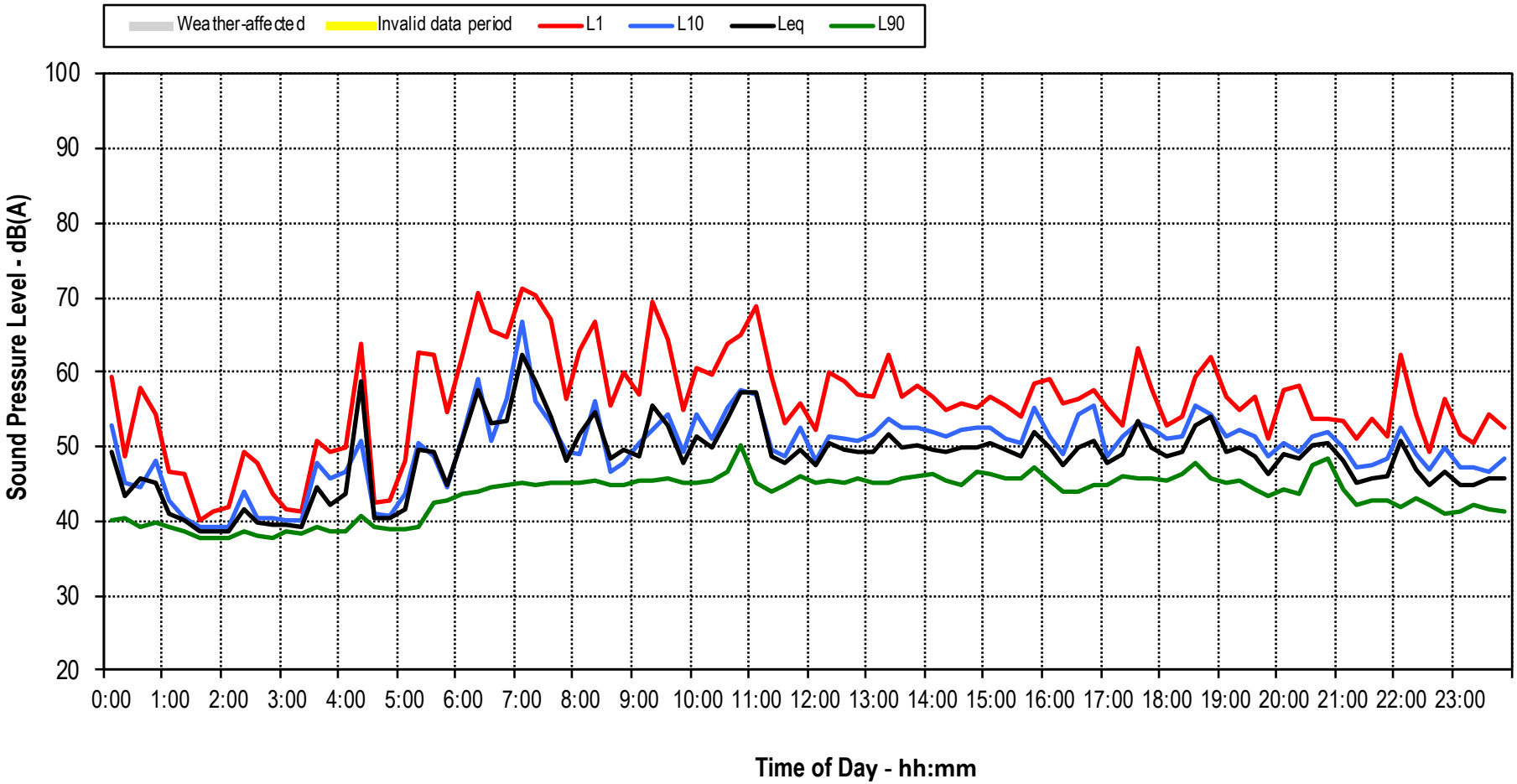

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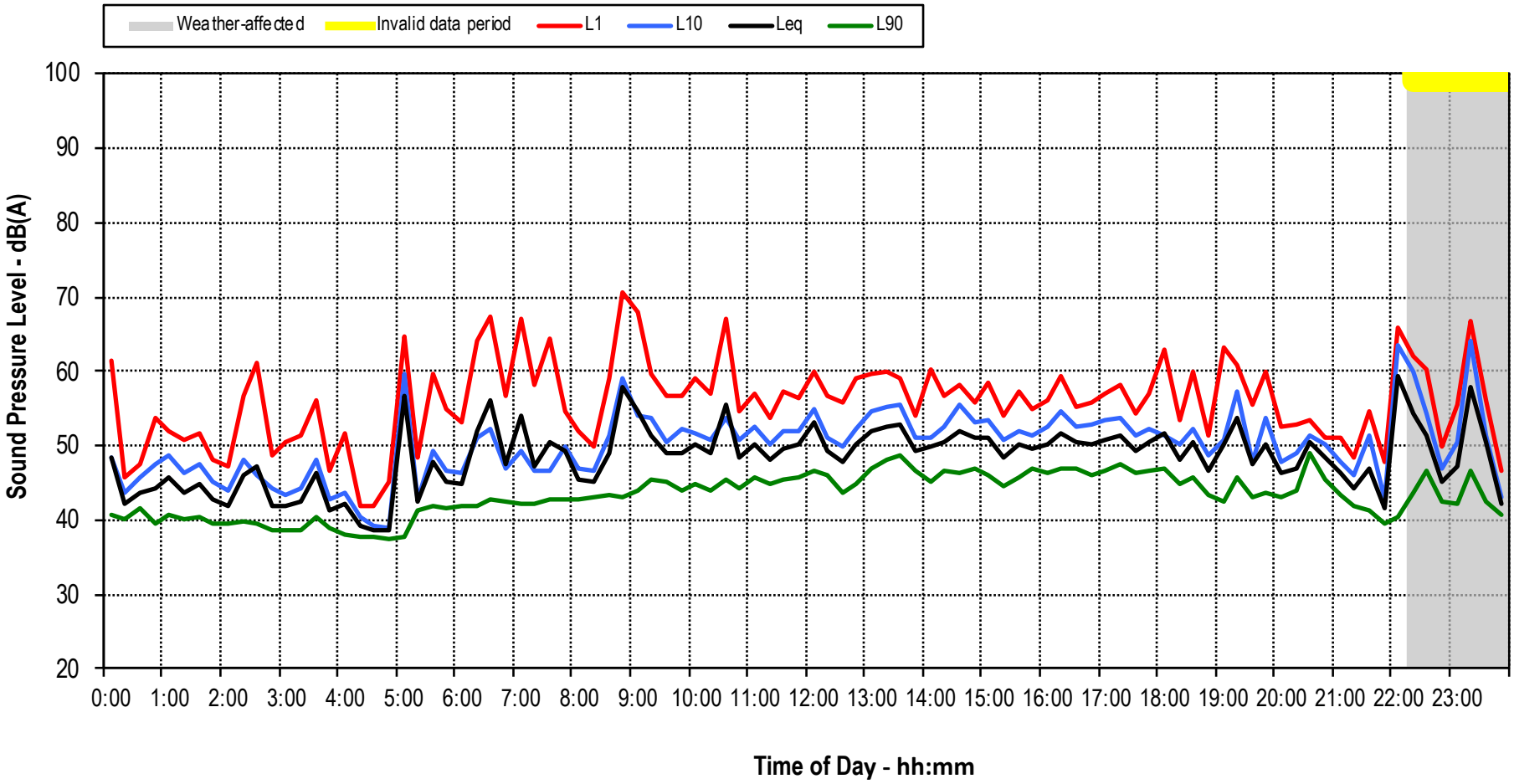
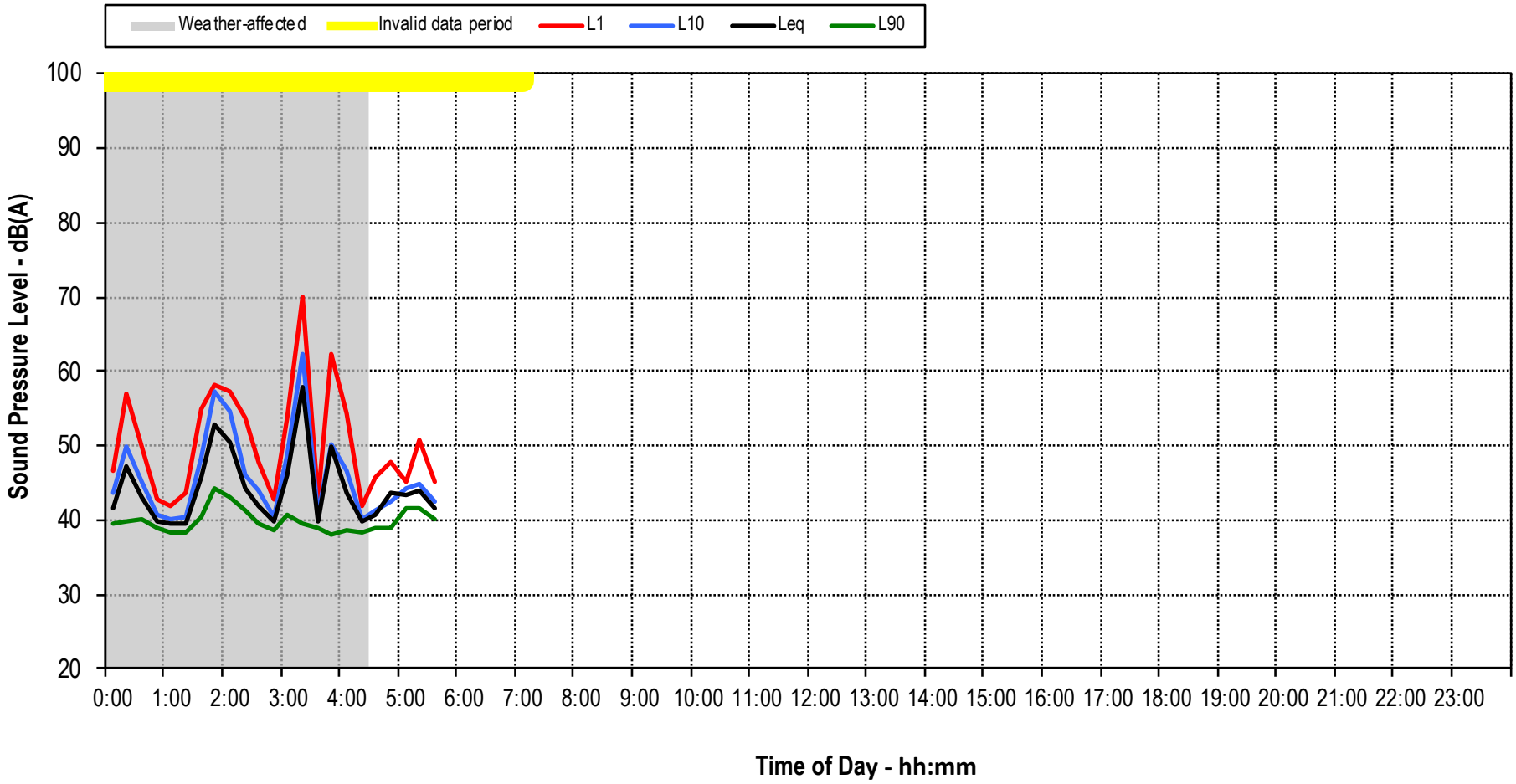
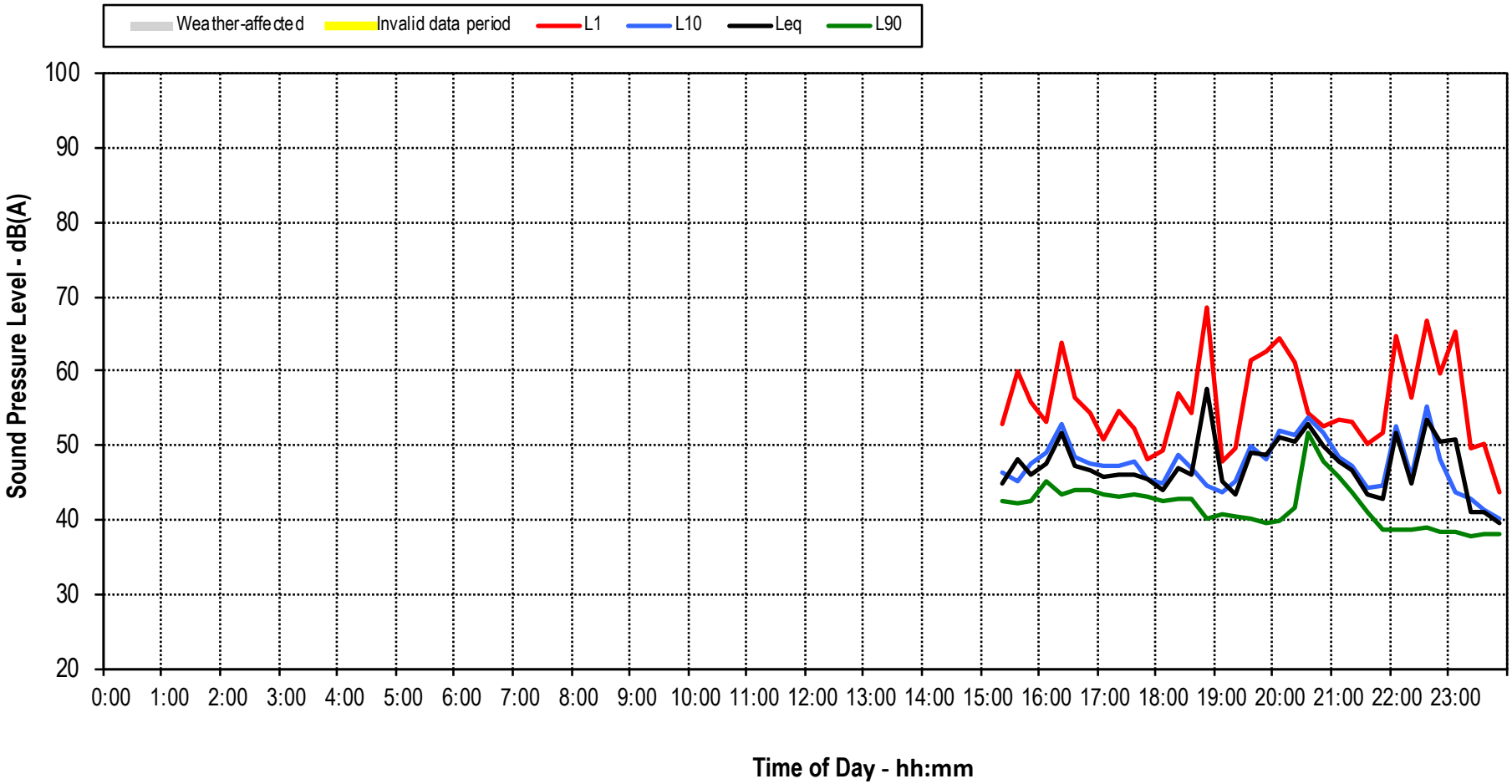


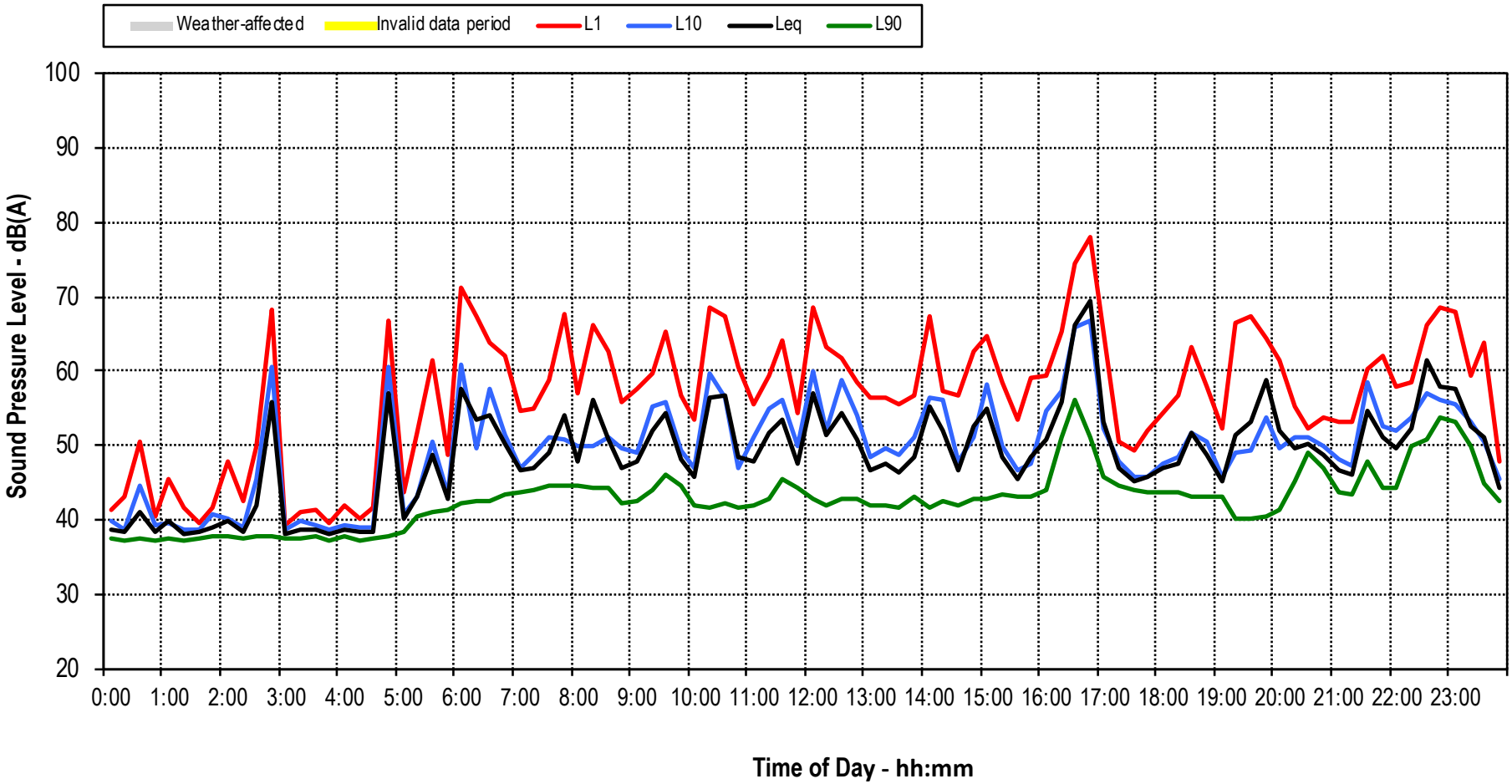
Location 4 - Ryde Hospital Campus - Monday 07 February 2022



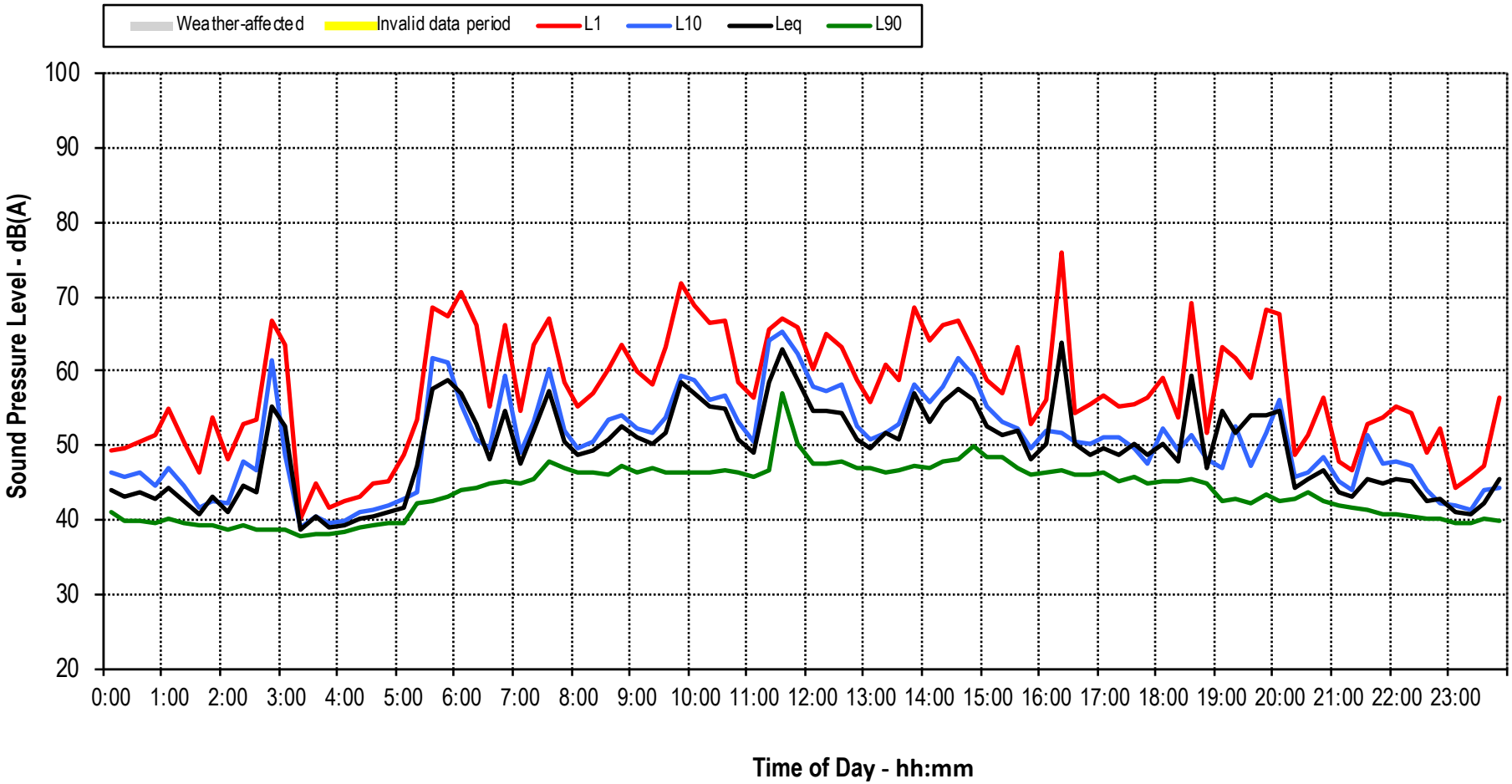
Location 4 - Ryde Hospital Campus - Wednesday 09 February 2022



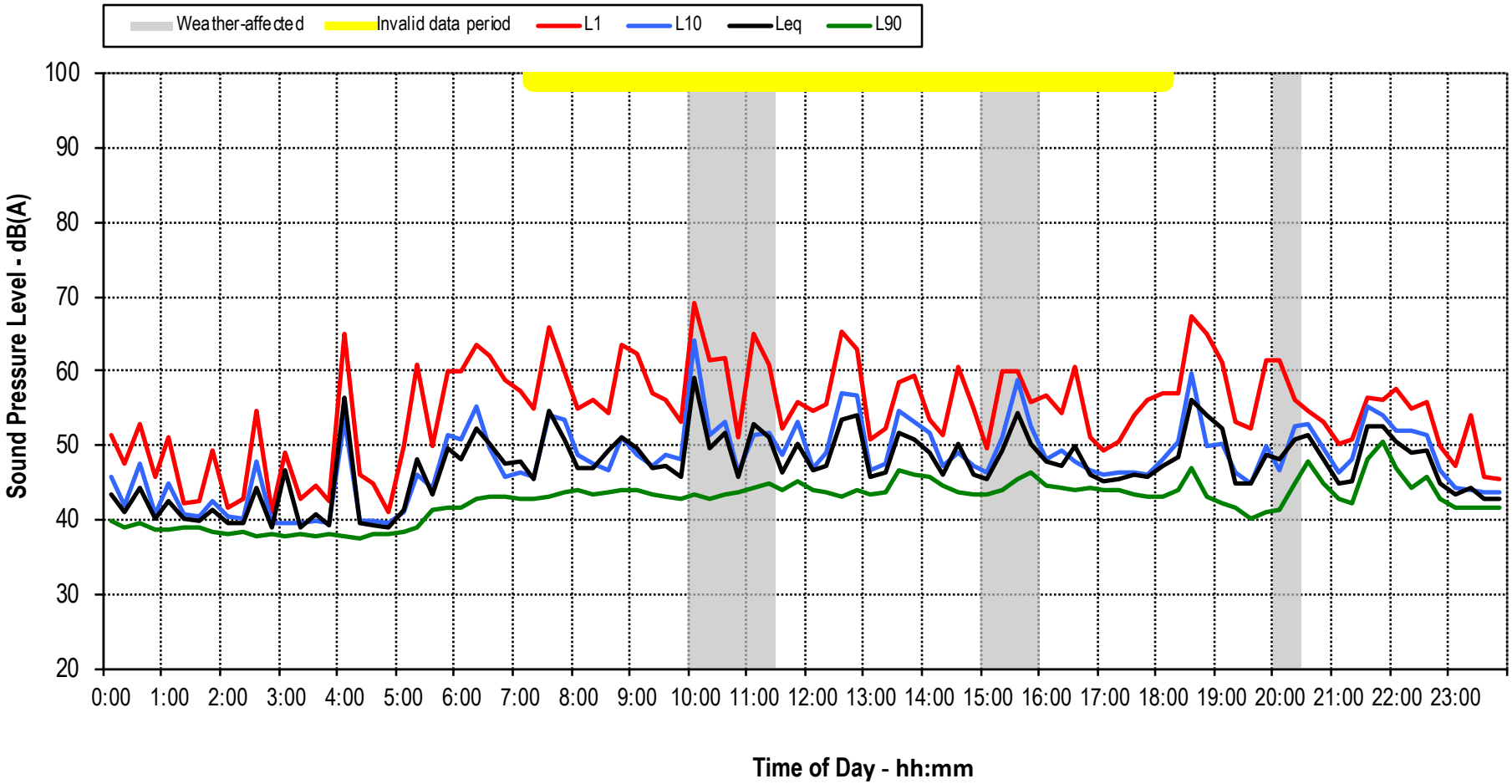
Location 4 - Ryde Hospital Campus - Thursday 10 February 2022



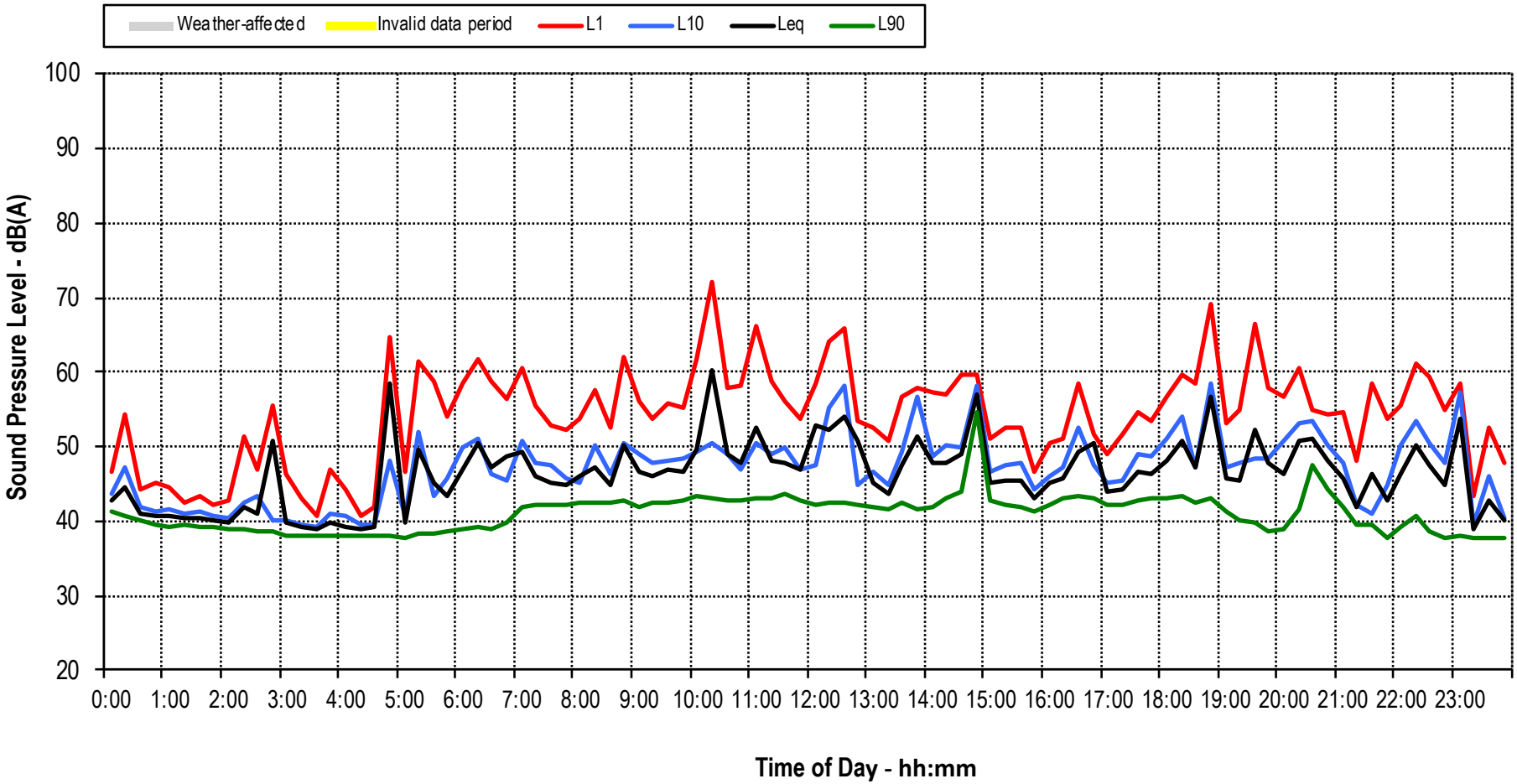
Location 4 - Ryde Hospital Campus - Friday 11 February 2022



Location 4 - Ryde Hospital Campus - Saturday 12 February 2022



Location 4 - Ryde Hospital Campus - Sunday 13 February 2022



Appendix B – Establishing NSW NPI Criteria

The main source of noise break-out from the proposed development to the environment will be activities noise from the premises and noise from the mechanical plant.

The environmental noise impact of the site has been assessed in accordance with the NSW EPA Noise Policy for Industry 2017 (NSW NPI).

The NSW NPI sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. Both are used to derive the Project Noise Trigger Level (PNTL).

Assessing intrusiveness

The intrusiveness criterion essentially means that the equivalent continuous noise level of the source is not to be more than 5 dB above the measured existing background noise level.

Assessing amenity

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria only relate to industrial-type noise, including plant. The existing noise level from industry (or plant) is measured – if it approaches the criterion value, then the noise levels from new plant need to be designed so that the cumulative effect does not produce noise levels that would significantly exceed the criterion.

The cumulative effect of noise from all industrial or plant sources is considered in assessing impact.

Project noise trigger level

For the new plant in ASB premises, the more stringent of the intrusive and the amenity criteria sets the PNTL.

The derivation of the PNTL is provided below.

B.1 Existing Background and Ambient Noise Levels

The Rating Background Level (RBL) has been determined from $L_{A90,15min}$ measured during the long-term noise survey in accordance with the methodology prescribed in NSW NPI.

Three time periods are considered (consistent with the operating times and the time of day classifications in the NSW NPI):

- Day - 7am to 6pm
- Evening - 6pm to 10pm
- Night - 10pm to 7am

The estimated RBL's and ambient noise levels are shown below in Table B1.

Location	L_{90} RBL Background Noise Levels, dB(A)			L_{eq} Ambient Noise Levels, dB(A)		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
Logger Location 1	41	40	34	55	54	49
Logger Location 2	43	38	30	58	58	49
Logger Location 3	41	40	35	56	54	47
Logger Location 4	44	40	38	55	51	50

Table B1 : Long-term background and ambient noise levels based on NSW NPI around the site

We make the following comments with regard to the summary above:

- Review of the data and weather observations during the monitoring period confirmed that there were times of high winds during the monitoring period. Where data was affected by adverse weather conditions, these were excluded.
- There were instance of extraneous noise that was removed from the data. This only affects the ambient noise level summary which does not affect the amenity criteria established for the project.
- With consideration of the above it was noted that 90% of the data captured was consistent daily and the data collected is considered representative of the existing conditions at site (i.e. additional monitoring will not change the long term background summary).
- Based on the unattended and attended noise monitoring, the data from the follow loggers is representative of the following locations and used to establish the respective criteria:
    - Logger 1 – Pre-existing ambient and background noise levels at residential receivers to the west of the hospital.
    - Logger 2 – Pre-existing ambient and background noise levels at residential receivers to the south of the hospital.
    - Logger 3 – Pre-existing ambient and background noise levels at residential receivers to the east and north of the hospital campus
    - Logger 4 – Pre-existing ambient and background levels typical of the Ryde Hospital Campus.

B.2 Determination of project intrusiveness noise level

The intrusiveness noise level is defined as:

$$L_{Aeq,15minute} = \text{RBL plus 5 dB(A)} \quad \text{(Equation 1)}$$

The intrusiveness noise level has been determined from the RBL's presented below for each period.

Zone 1 to 3 (based on Logger Location 1)

- Day Intrusiveness criterion of - 41 + 5 = **46 dB(A)**
- Evening Intrusiveness criterion of - 40 + 5 = **45 dB(A)**
- Night Intrusiveness criterion of - 34 + 5 = **39 dB(A)**

Zone 4 (based on Logger Location 2)

- Day Intrusiveness criterion of - 43 + 5 = **48 dB(A)**
- Evening Intrusiveness criterion of - 38 + 5 = **43 dB(A)**
- Night Intrusiveness criterion of - 30 + 5 = **35 dB(A)**

The Intrusiveness noise levels are only applied to residential receivers.

B.3 Determination of project amenity noise levels

To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined is to remain below the recommended Amenity Noise Levels (ANL) specified in Table 2.2 of the NSW NPI where feasible and reasonable. The recommended amenity noise levels will protect against noise impacts such as speech interference, community annoyance and some sleep disturbance.

The recommended ANL represents the objective for total industrial noise at a receiver location, whereas the project ANL represents the objective for noise from a single industrial development at a receiver location.

To ensure that industrial noise levels (existing plus new) remain within the recommended ANL for an area, a project ANL applies for each new source of industrial noise from an industrial development as follows:

Project ANL = Recommended ANL minus 5 dB(A) (Equation 2)

The nearest residential receivers to the project are considered to be – as per NSW NPI Table 2.3 – in a Noise Amenity Area characterised by the NSW NPI as urban.

The recommended ANLs relevant to this project are specified in Table B3.

Receiver[8]	*Time of Day*	L_{Aeq}, *dB(A)*
		Recommended ANL
Residential (Suburban)	Day	55
	Evening	45
	Night	40
Hospital Ward - External	When in Use	50
Commercial	When in use	65

Table B3 : Recommended L_{Aeq} noise levels from industrial noise sources at residential and non-residential receivers

[8] The NSW NPI states, "Where internal noise levels are specified, they refer to the noise level at the centre of the habitable room that is most exposed to the noise and are to apply with the windows opened sufficiently to provide adequate ventilation, except where means of ventilation complying with the Building Code of Australia are provided. In cases where gaining internal access for monitoring is difficult, then external noise levels 10 dB(A) above internal levels apply".

The following exceptions to the above method to derive the project ANL apply:

- **Exception A – In areas with high traffic noise levels**

  The level of transport noise, road traffic noise in particular, may be high enough to make noise from an industrial source effectively inaudible, even though the LAeq noise level from that industrial noise source may exceed the project amenity noise level. In such cases the project amenity noise level may be derived from the $L_{Aeq,\ period(traffic)}$ minus 15 dB(A).

  This high traffic project amenity noise level may be applied only if all the following apply:

  - traffic noise is identified as the dominant noise source at the site,
  - the existing traffic noise level (determined using the procedure outlined in Section A2, Fact Sheet A of NSW NPI, measuring traffic instead of industrial noise) is 10 dB or more above the recommended ANL for the area, and
  - it is highly unlikely traffic noise levels will decrease in the future,

  for each assessment period where these traffic noise provisions apply, the High Traffic Project ANL is to be used for industrial development, derived from the $L_{Aeq,period(traffic)}$ as:

  High Traffic Project ANL = $L_{Aeq,period(traffic)}$ minus 15 dB(A) (Equation 3)

- **Exception B – In proposed developments in major industrial clusters**

  The recommended amenity noise level from Table B3 represents the total industrial noise level from all sources (new and proposed) that is sought to be achieved using feasible and reasonable controls.

  The approach of deriving the project amenity noise level resulting from a new development on the basis of the recommended amenity noise level minus 5 dB is based on a receiver not being impacted by more than three to four individual industrial noise sources.

Where an existing cluster of industry, for example, an industrial estate or port area, is undergoing redevelopment and/or expansion and the development constitutes a single premises addition or expansion, with no other redevelopment planned in the foreseeable future, the project amenity noise level approach procedure in Section B.3 can be applied.

However, where a greenfield or redevelopment of an existing cluster of industry consisting of multiple new noise-generating premises is proposed, the approach for determining the project amenity noise level in Section B.3 is not applicable and the approach below is to be applied.

For the new multiple premises or redevelopment of existing clusters of industry, for each individual premise,

$$\text{Individual Project ANL} = 10\text{Log}_{10}(10^{(L - 5\ dB/10)}/N)\ dB(A) \quad \text{(Equation 4)}$$

where L is the relevant recommended ANL from Table B3 and N is the number of proposed additional premises.

Where a greenfield development is proposed and it can be demonstrated that existing L_{Aeq} industrial noise levels are more than 5 dB lower than the relevant recommended ANL, the above equation can be modified to reflect "L" in lieu of "L – 5 dB".

- **Exception C**

  Where the resultant project ANL is 10 dB or more lower than the existing industrial noise level. In this case the project ANL can be set at 10 dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time.

- **Exception D**

  Where cumulative industrial noise is not a necessary consideration because no other industries are present in the area, or likely to be introduced into the area in the future. In such cases the relevant ANL is assigned as the project ANL for the development.

Where the project ANL applies and it can be met, no additional consideration of cumulative industrial noise is required. However, in circumstances where this level cannot be feasibly and reasonably met, an assessment of existing industrial noise, and the combined resulting noise level from existing and the proposed industries, is required so the impact of the residual noise levels can be determined in accordance with Section 4.2 of the NSW NPI.

Receiver - External	*Time of Day*	*Recommended ANL*	*Adjustment*	*Project ANL*[9]
Residential	Day	55	Equation 2	53
	Evening	45	Equation 2	43
	Night	40	Equation 2	38
Hospital Ward	When in use	50	Equation 2	48
Commercial Premises	When in use	65	Equation 2	63

Table B4: Determination of Project Amenity Noise Levels for residential and commercial receivers

[9] The L_{Aeq} is determined over a 15-minute period for the project intrusiveness noise level and over an assessment period (day, evening and night) for the Project ANL. This leads to the situation where, because of the different averaging periods, the same numerical value does not necessarily represent the same amount of noise heard by a person for different time periods. To standardize the time periods for the intrusiveness and amenity noise levels, the Policy assumes that the $L_{Aeq,15min}$ will be taken to be equal to the $L_{Aeq,period}$ + 3dB(A).

B.4 Project noise trigger level

The PNTL is defined as the lower of the project intrusiveness and amenity noise levels. On this basis, the PNTL are shown in Table C5 below (PNTLs shown shaded).

Receiver - External	*Period*	*Project Intrusiveness Noise Level*	*Project Amenity Noise Level*
Residential (Zone 1 - North, Zone 2 - East, Zone 3 - West)	Day	46	53
	Evening	45	43
	Night	39	38
Residential (Zone 4 - South)	Day	48	53
	Evening	43	43
	Night	35	38
Hospital Ward	When in use	-	48
Commercial Premises	When in use	-	63

Table B5 : Determination of Project Noise Trigger Levels for the si