Omahu Development

Proposed New Apartments

Omahu Road, Remuera, Auckland

PRELIMINARY ASSESSMENT & RECOMMENDATIONS NOISE AND VIBRATIONS

For Coordination

Date: 16th April 2021
Prepared for: Urban Resort
Prepared by: Earcon Acoustics Limited
Reference: J004371

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Document Control

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Contact	Issue	Date	Rev
Alex Jacob s 9(2)(a) s 9(2)(a)	For Internal Review	16/04/2021	C
Fadia Sami s 9(2)(a) s 9(2)(a)	For Client Review	16/04/2021	C

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Executive Summary - Acoustics

The subject site is adjacent two high noise routes; State Highway 1 and Great South Road, in addition to a high noise and vibrations source being the railway track at the eastern boundary. To achieve compliance with the regulatory and guideline requirements pertaining to acoustics; a number of considerations and mitigation measures may need to be taken into account. Based on an initial preliminary assessment of the development plans, we would recommend consideration of the following recommendations:

Site Plan

- Building footprints offset from the eastern boundary such that the closest point of any building is at least 10m from the edge of the closest railway line
- Buildings at the western boundary are located at least 7m away from the driveable edge of Great South Road in consideration of heavy traffic along Great South Road.
- As many bedrooms as possible face towards the central area of the development, away from the roads.

Construction

- Assessment by Geotech engineers required to confirm amount of rock breaking required and foundation methodology.
- Recommend offsetting basement cut away from adjacent receivers where possible.
- Where piling is required for foundations or retention, we strongly recommend use of bored cast in-situ concrete piles.
- If casing is required for bores, we would recommend use of Continuous Flight Augers (CFA)
- Equipment restrictions likely needed close to adjacent neighbours (e.g. excavators no larger than 23T and compactors limited to non-vibro)
- Perimeter shielding required close to neighbours.
- Special considerations required for:
    - Audiology facility at 232 Great South Road. Sensitive to noise and vibrations, and likely to require additional coordination and mitigation measures.
    - Elevated (2-3 storey) residential buildings at 234 Great South Road may require additional shielding during earthworks.

Building Envelope - Facade

- Facades with line of sight to SH1 should have heavy-weight cladding such as Concrete, Bricks or Block
- Facades facing the interior of the development, and with no line of sight to SH1 or Great South Road, may include Weatherboard
- Facades facing Great South Road can include Weatherboard or Fibre Cement, but would require high density 13mm plasterboard lining, e.g. Noiseline or similar.

Building Envelope - Roof

- Long run steel roofing requires the addition of 2 layers of 13mm high density plasterboard linings to the ceilings of habitable areas at the top floor.
- Asphalt Shingle Roofing systems require either 1x13mm high density Plasterboard; or 2x13mm Standard Plasterboard

Building Envelope - Glazing

- Glazing for the facades of buildings facing the roads or with line of sight to them: 23.4mm Laminated IGU (6.38mm / 12mm AS / 5mm)
- Recommend against the use of sliding glass doors facing either of the roads. Recommend hinged doors instead.

Intertenancy

- Intertenancy walls and floors are designed at an STC rating of at least 60 (note that 55 would be strictly sufficient for compliance)
- Intertenancy floors are designed at an IIC rating of at least 60 (note that 55 would be strictly sufficient for compliance)

Mechanical Ventilation

- Mechanical ventilation and/or air-conditioning will be required in all habitable spaces of the subject apartments to meet the Auckland Unitary plan ventilation requirements

Mechanical Plant

- Mechanical services should be selected, located and shielded to control noise emissions to neighbouring sites to within AUP compliance levels.

Commercial Facilities

- Noise management plans or mitigation measures required for noise generating commercial facilities, including receivers within the proposed development itself (e.g. apartments above a café)

1 Introduction

This report has been prepared as a preliminary assessment of acoustic considerations for the proposed development at the subject site adjacent Omahu Road and Great South Road in Remuera, Auckland.

The site for the proposed development is across seven lots along the eastern side of Great South Road and the northern side of Omahu Road in Remuera. The subject site is generally flat and in proximity to dual railway tracks at the eastern boundary. State Highway 1 further to the East, and as such, the site is exposed to noise from traffic and train movements.

It is our understanding that the proposed development comprises seven blocks of multi-storey apartment buildings and commercial activities, in addition to basement level car parking.

This report:

- Identifies the surrounding environment in terms of regulatory zoning, geological stratigraphy, underlying services and any relevant heritage protections.
- Describes the acoustic environment associated with the subject site, including traffic, rail, and zone noise and vibration levels.
- Details relevant regulatory criteria and recommended guidelines pertaining to both compliance and amenity of the facility, both in context of construction and operations.
- Proposes strategies and potential mitigation measures associated with effects on surrounding receivers, and effects within the proposed apartments.

This report is based on information provided by Warren and Mahoney drawings dated 14th April 2021.

2 Site

2.1 Identification

The proposed development site is located in a mixed use neighbourhood on the Eastern side of Great South Road in Remuera, Auckland. The area of development is proposed across seven lots comprising the subject site.

For ease of reference in this report, directional boundary references are noted in the figure below. The site is approximately 160m on its longest North-South axis and 120m on its longest East-West Axis.

Figure 1 - Site Location

2.2 Zoning

In accordance with the Auckland Unitary Plan – Operative Version, the subject site and adjacent sites are zoned *Residential – Terrace Housing and Apartment Building Zone.*

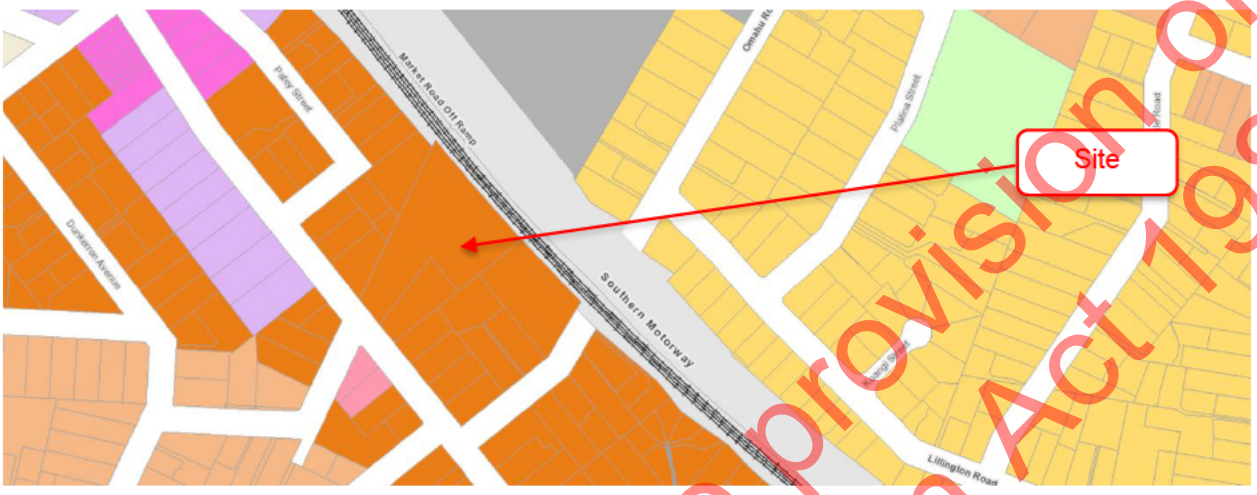

Figure 2 - Site Zoning

2.3 Services

Consideration must be given to vibratory work in proximity to underground services, due to their potential to transmit vibrations well beyond the range of ground propagation levels. As per the figure Auckland Council GeoMap below, the site is underlain by local network wastewater pipeline running across the site from the northwest to the southeast, in addition to stormwater pipes running through the centre of the site.

Figure 3 - Services Underlying Area (Auckland Council GeoMaps)

2.4 Heritage Sites

Pertaining to structures highly sensitive to vibrations, we note that the subject site is not in proximity to any special character or heritage sites.

2.5 Vicinity

The neighbouring areas to the subject site are predominantly residential, commercial and medical facilities. The site is between two high noise routes; Great South Road and SH1, in addition to the dual railway track on the Eastern boundary.

In context of proximity to sensitive receivers, especially pertaining to construction noise, the buildings at the southern corner intersection of Omahu Road and Great South Road include:

- Education facility (Sen Art Academy) at 236 Great South Road
- Three storey Residential buildings at 234 A, B, C and D Great South Road.
- Audiology facility (Applied Hearing Ltd) at 232 Great South Road

Figure 4 – Site Vicinity – facing North

2.6 Stratigraphy

With reference to the GNS Science, New Zealand Geology Web Maps at 1:250k Geology. Based on the published geology, the majority of the site is understood to generally have the following stratigraphy:

- Auckland Basalt Tuff of the Auckland Volcanic Field comprising comminuted pre-volcanic materials with basaltic fragments and unconsolidated ash and lapilli deposits.

The GNS indication of fragmented basalt likely means that most solid materials could be extracted by picking or bucket excavation. Notwithstanding that, and pending detailed geotechnical assessment, it is reasonable to conservatively assume that some rock breaking may be required.

We note the above is indicative only for purposes of assessing noise and vibration generation. Any conclusions pertaining to excavation and foundation methodologies require detailed, specialised, Geotechnical analysis.

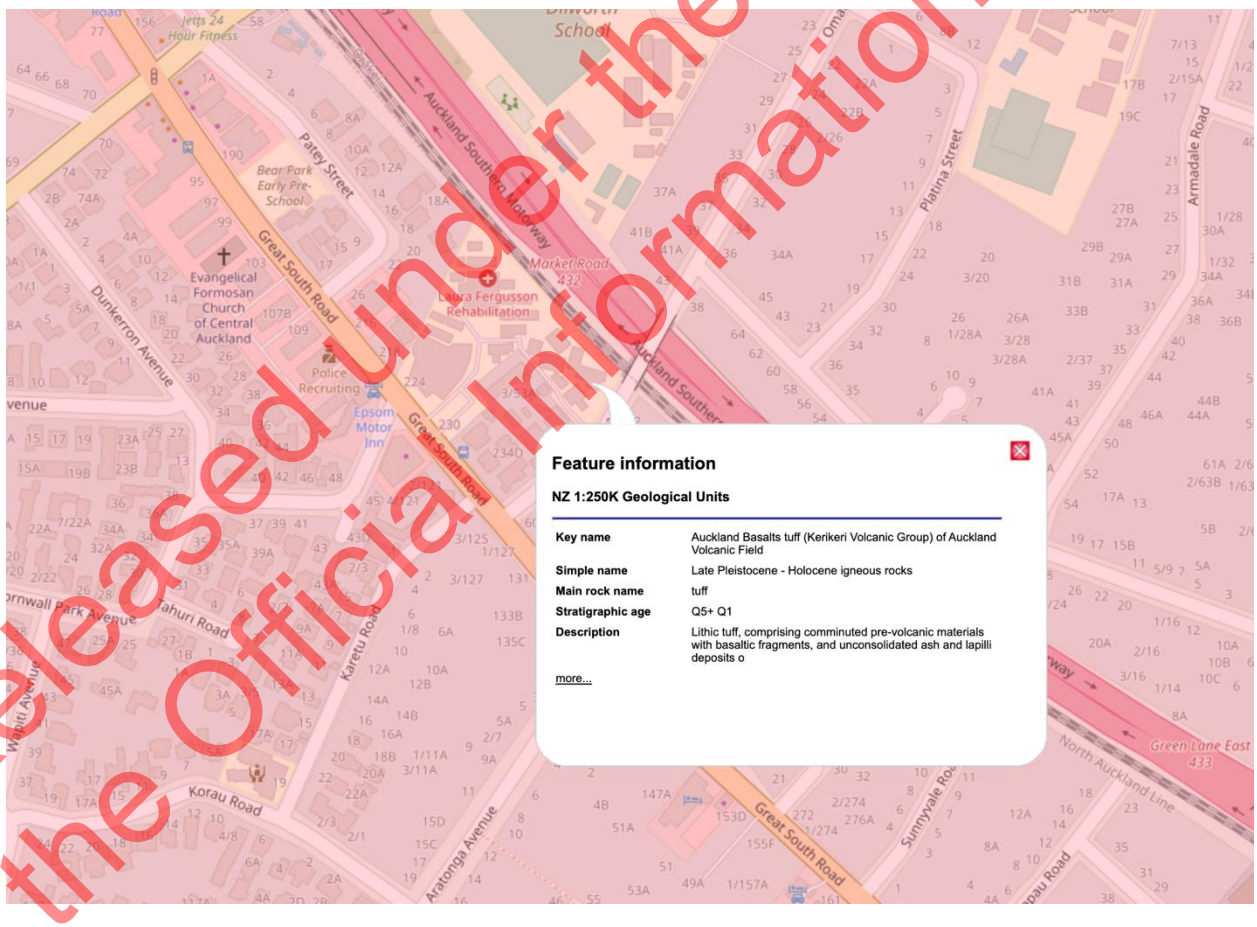

Figure 5 - Site Stratigraphy - GNS Science NZ Geology Web Map

3 Proposed Development

3.1 Proposed Building

The proposed buildings will span throughout the site, with buildings along the eastern boundary aligned along the east-west axis of the site. The development also includes basement level car parks and podium level parking at the centre of the eastern boundary. The following is an indicative preliminary site plan

Figure 6 - Site Plan – Indicative Only – [Warren and Mahoney – 14/04/2021]

Figure 7 - Overview – [Warren and Mahoney – 14/04/2021]

4 Construction Noise and Vibration Regulations

This section details the regulatory and standards-based criteria for noise and vibrations for the demolition and construction activities on the subject site. The next section summarises the assessment criteria used in this report based on the standards in this section.

4.1 Construction Noise

The following rules apply to the site and to surrounding sites:

E25.6.27. Construction noise levels in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone

Time of week	Time Period	Maximum noise level (dBA)	
		Leq	Lmax
Weekdays	6:30am – 7:30am	60	75
	7:30am – 6:00pm	75	90
	6:00pm – 8:00pm	70	85
	8:00pm – 6:30am	45	75
Saturdays	6:30am – 7:30am	45	75
	7:30am – 6:00pm	75	90
	6:00pm – 8:00pm	45	75
	8:00pm – 6:30am	45	75
Sundays and public holidays	6:30am – 7:30am	45	75
	7:30am – 6:00pm	55	85
	6:00pm – 8:00pm	45	75
	8:00pm – 6:30am	45	75

Table 1 - Referencing Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone

(4) For a project involving a total duration of construction work that is more than 20 weeks the noise limits in Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone and Table E25.6.27.2 Construction noise levels for noise effecting any other activity above pay be decreased by 5dB in all cases..

4.2 Construction Vibrations

The effects of Vibrations should be assessed against their effects on both humans and buildings. The following sections reference the criteria pertaining to each, in context of regulatory requirements and international standards. In accordance with the Auckland Unitary Plan, pertaining to construction vibrations:

E25.6.30 Vibration

(1) Construction and demolition activities must be controlled to ensure any resulting vibration does not exceed:

- ***a) the limits set out in German Industrial Standard DIN 4150-3 (1999): Structural vibration – Part 3 Effects of vibration on structures when measured in accordance with that Standard on any structure not on the same site; and***
- ***b) the limits in Table E25.6.30.1 Vibration limits in buildings in any axis when measured in the corner of the floor of the storey of interest for multi-storey buildings, or within 500mm of ground level at the foundation of a single storey building.***

Receiver	*Period*	*Peak Particle Velocity Limit*
Occupied activity sensitive to noise	*Night – time 10pm to 7am*	*0.3 mm/s*
	Daytime 7 am to 10pm	*2 mm/s*
Other occupied buildings	*At all times*	*2 mm/s*

Table 2 - Referencing Table E25.6.30.1 of the AUP

In accordance with the *DIN 4150-3:1999 "Structural Vibration – Part 3: Effects of Vibration on Structures"* standard additional factors apply to limit the effects of vibrations at different frequencies on different types of buildings. The DIN 4150-3:1999 guidelines are summarised in the table below:

Structure Type	Peak Particle Velocity - PPV (mm/s) at the foundation at a frequency of		
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100Hz*
Industrial	20	20-40	40-50
Residential	5	5-15	15-20
Sensitive Structures	3	3-8	8-10
**At Frequencies above 100Hz, the values in this column can be used as minimum values*			

Table 3 - DIN4150-3:1999 - Guideline values of vibration velocity, for evaluating the effects of short-term vibrations

5 Operational Regulations

5.1 Operational Noise Regulations

5.1.1 Noise Levels within Residential Zone – AUP

In accordance with the Auckland Unitary Plan (AUP) – E25.6.8, Noise levels from activities within residential zones as applies to the subject site and the most sensitive and closest neighbouring sites are as follows. These apply when measured within the boundary of any adjacent site.

Time	Noise Level
Monday to Saturday 7:00am to 10:00pm	50dB LA_{eq}
Sunday 9:00am to 6:00pm	50dB LAeq
All other times	40dB LA_{eq} 75dB LAF_{max}

Table 4 - Noise Levels in Residential Zones

5.1.2 Waka Kotahi Conditions

1. *Any dwelling on the site must be designed, constructed and maintained to achieve a design noise level of 40 dB LAeq(24h) inside all habitable spaces.*
2. *If windows are required to be closed to achieve the design noise level in condition 1, a ventilation system must be designed, constructed and maintained. For habitable spaces the system must achieve the following:*
    a. *Ventilation must be provided to meet Clause G4 of the New Zealand Building Code. At the same time, the sound of the system shall not exceed 30 dB LAeq(30s) when measured 1 m away from any grille or diffuser*
    b. *The occupant must be able to control the ventilation rate in increments up to a high air flow setting that provides at least 6 air changes per hour. At the same time the sound of the system must not exceed 35 dB LAeq(30s) when measured 1m away from any grille or diffuser.*
    c. *The system must provide cooling that is controllable by the occupant and can maintain the temperature at no greater than 250C. At the same time, the sound of the system must not exceed 35 dB LAeq(30s) when measured 1m away from any grille or diffuser.*
3. *A design report prepared by an acoustics specialist must be submitted to Auckland Council demonstrating compliance with conditions 1 and 2, prior to construction or alteration of any dwelling. The design shall take into account future permitted use of the state highway; for existing roads by the addition of 3 dB to existing measured or predicted levels.*

5.1.3 Airborne and Impact Sound Insulation – NZ Building Code

STC (Sound Transmission Class) 55 and IIC (Impact Insulation Class) 55 ratings are required between the inter-tenancy floors and walls to prevent undue noise transmission from other occupancies or common spaces to the habitable spaces of the household units. The STC and IIC ratings are required for common walls and floors of different tenancies. The code allows 5dB for field situation; i.e., FSTC 50 and FIIC 50 in situ.

- FSTC is the field measurement based single number derived from measured values of transmission loss in accordance with classification ASTM E 413. The STC rating is given by the value of the contour at 500 Hz.
- FIIC is the field measurement based single number derived from measured values of transmission loss in accordance with classification ASTM E989-89. The STC rating is given by the value of the contour at 500 Hz.

Based on the above and to allow for in-situ field performance, the minimum design levels required for insulation are STC 55 and IIC 55.

The following table is a summary of the generally accepted subjective relationship between FSTC performance and privacy based only on human occupancy activities.

FSTC	Receiver Condition	Privacy Level
~55	Presence of occupants in adjacent rooms barely distinguishable	Private
52-55	Activity sounds in adjacent rooms occasionally heard. Conversations muffled.	Sense of Privacy
50-52	Awareness of occupancy in adjacent rooms. Conversations in adjacent rooms hard to understand.	Minimal Privacy

Table 5 - Subjective privacy levels for FSTC levels.

Based on the above, and taking into account in-situ field situations, the guidelines imply the requirement of IIC and STC design levels of 60 to achieve acceptable privacy levels.

5.2 Operational Vibrations Regulations

5.2.1 Railway - KiwiRail Reverse Sensitivity

In accordance with the requirements of KiwiRail reverse sensitivity provisions:

Indoor railway vibration

3. Any new buildings or alterations to existing buildings containing an activity sensitive to noise, closer than 60 metres from the boundary of a railway network:

a) is designed, constructed and maintained to achieve rail vibration levels not exceeding 0.3 mm/s vw,95 or

b) is a single-storey framed residential building with:

i. a constant level floor slab on a full surface vibration isolation bearing with natural frequency not exceeding 10 Hz, installed in accordance with the supplier's instructions and recommendations; and

ii. vibration isolation separating the sides of the floor slab from the ground; and

iii. no rigid connections between the building and the ground.

5.2.2 Waka Kotahi Conditions

New buildings or alterations to existing buildings containing noise sensitive activities, within 40m of the State Highway must be designed, constructed and maintained to achieve internal vibration levels complying with class C of NS 8176E:2005.

5.2.3 NS8176.E:2005

The limits in this standard are selected as guidelines based on statistical studies of population reactions to vibrations, and depend on the classification of the buildings in question. The guidance classes, and the statistical designation for each class are:

- Class A: Very good vibration conditions where people will not notice vibrations
- Class B: Relatively good vibration conditions where people can notice vibrations.
- Class C: New residential buildings where 15% can be disturbed by vibrations
- Class D: Existing residential buildings where 25% can be disturbed by vibrations

Type of vibration value	Class A	Class B	Class C	Class D
Statistical maximum value for weighted velocity $v_{w,95}$ (mm/s)	0.1	0.15	0.3	0.6
Statistical maximum value for weighted acceleration $a_{w,95}$ (mm/s^2)	3.6	5.4	11	21

Table 6 - Reference Table B.1 of NS8176 - Upper limits for statistical maximum vibration levels

Where:

- **$v_{w,95}$ (mm/s)** is the 95% statistical maximum vibration velocity measured as the root mean square (r.m.s.) and weighted by NS8176 frequency weighting filter
- **$a_{w,95}$ (mm/s^2)** is the 95% statistical maximum vibration acceleration measured as the root mean square (r.m.s.) and weighted by NS8176 frequency weighting filter

For comparative purposes, in accordance with Standard BS5228.2, Annex B.2, the threshold of human perception of vibrations is in the range of 0.14mm/s to 0.3mm/s. Vibrations above 0.3mm/s are noted to be perceptible. As per guidelines of BS5228.2, the following are vibration levels and the associated human response:

Vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

Table 7 - Reference Table B.1 of BS5528.2 Guidance on effects of vibration levels

6 Noise Assessment

6.1 Construction Noise

6.1.1 Rock Breaking

A key activity expected to generate notable noise levels would be rock breaking, if required. Unmitigated, an average sized rock breaker can generate approximately to 87-90dBA at 10m from the where the breaking occurs.

If required, additional mitigation measures are likely to be needed for rock breaking. This may include time restrictions for breaking in addition to shielding key receivers with boundary fencing. Some localised shielding may also be required, albeit it may not be practicable to maintain noise levels within strict compliance for upper storey (high elevation) receivers.

We note for reference that the level and nature of rock breaking can vary significantly between fractured fragmented rocks that can be picked and extracted, versus basalt boulders which require significant energy (breaking or cracking) to fragment and extract. Reference should be made to a specialist geotechnical assessment of the site to identify the excavation methodology and the extent of rock breaking required, if any.

6.1.2 Foundations and Retention

Considering the scale of the proposed structures, and the underlying strata, it is likely that piling for foundations and retention is required. We note this is indicative only, and reference should be made to a detailed geotechnical assessment for foundation and retention recommendations.

If piling is required, we would strongly recommend consideration of bored cast in-situ concrete piles. Cast in-situ piles represent the best practicable option to minimise effects on adjacent neighbours.

The use of driven piles (vibratory sheet piles, or impact driven steel piles) would generate excessive noise and vibration levels in proximity to sensitive receivers. Due to the elevation of noise from driven piling, it is usually not practicable to mitigate it. As such, bored cast in-situ concrete piles are recommended.

If any high noise or vibrations generating activities are required (e.g. drilling, anchoring) then additional mitigation measures may be required

6.1.3 Other construction activities

Equipment sizes and operations are likely to require controls near sensitive receiver or underlain services. This may include limiting excavator sizes, and controlling compacting (e.g. either hand-held, or driven with vibratory functions off).

Some limitations may be required for tools used on the building structures especially for steel components. As an example, for steel structures, the use of stud shots or rattling guns can generate excessive levels of noise, and alternative methodologies or façade shielding may be needed.

The submission and implementation of a Construction Noise and Vibration Management Plan (CNVMP) is likely to be a condition of consent for the works due to proximity to receivers.

6.2 Operational Noise

6.2.1 Traffic

A predictive model was established based on the latest traffic volume counts for State Highway 1 and Great South Road in proximity to the subject site. Calculation included the speed limits on each road and assumed 5% of traffic comprising Heavy Vehicles. For the purposes of modelling and assessment against the criteria, a design year of 2035 requires the increase of traffic volumes by 5% every year, resulting in doubling of traffic volumes above in approximately 15 years. Assessment will be based on all traffic in each direction being on the lane closest to the development as conservative measure.

To predict noise propagation at the subject site from the proposed works, an environmental model was constructed for the extension using the CadnaA version 2019 computer modelling program. As per the predicted noise levels based on the traffic volumes for the design year 2035, accumulative traffic noise and railway noise from State Highway 1 shall be based on

- 80 dB $LA_{eq\ (24\ hour)}$ at the eastern boundary facing SH1.

As per the predicted noise levels based on the traffic volumes for the design year 2035, traffic noise from Great South Road shall be based on

- 73 dB $LA_{eq\ (24\ hour)}$ at the western boundary facing Great South Road.

The image on the following page shows the noise level contours based on Cadna 2019 predictive modelling, for the highest noise sources associated with State Highway 1, Railway Tracks and Great South Road.

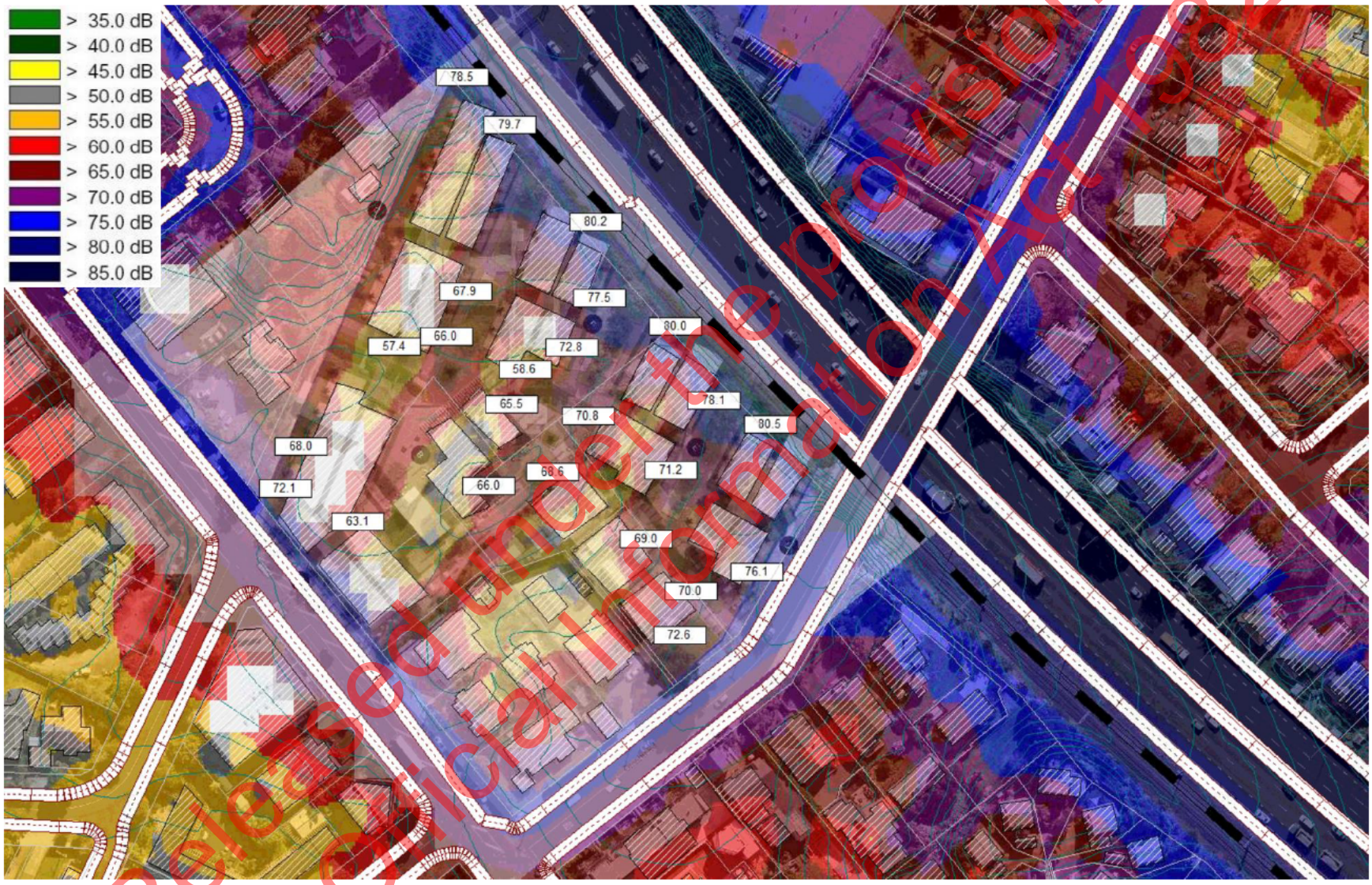

Figure 8 – Preliminary Noise Propagation predictive Model

7 Vibration Level Assessment

7.1 Construction Vibrations

The key activities expected to generate high levels of vibrations are Rock Breaking (if required,) augering for piles, and compacting. The activities involved in rock breaking, if well managed and monitored, generate vibrations of up to 1.5mm/s at 10m for pneumatic breakers attached to 12T-20T tracked Excavators and up to 1 mm/s at 10m for pneumatic breakers were attached to 6T-8T tracked Excavators. Compacting has the potential to produce vibrations at 2mm/s at 10m, as per measurements conducted on similar, well managed sites for driven vibratory compactors.

If casing of augered bores is required, we would recommend the use of continuous flight augers (CFA) to avoid the noise and vibration effects associated with vibratory casing insertion and extraction. We note that the strata as per GNS, generally indicates that casing of bores is unlikely to be required. This would however need to be ascertained by Geotechnical engineers.

Based on the above, some mitigation measures may be required during construction to control vibration levels (e.g. limiting size of equipment near boundaries with receivers)

Provided vibrations are monitored during test runs and provided all mitigation procedures (e.g. intensity management or alternate methodologies) are implemented, it is expected that vibration levels can be maintained within the criteria limits at all receivers.

7.2 Operational Vibrations

The main sources of operational vibrations affecting the development are the railway tracks and associated train movements adjacent the eastern boundary.

The subject site has significant ground irregularities between the source and receiver including a steep bank 1-2m in height. This would be expected to attenuate the propagation of vibrations between the source and the receiver.

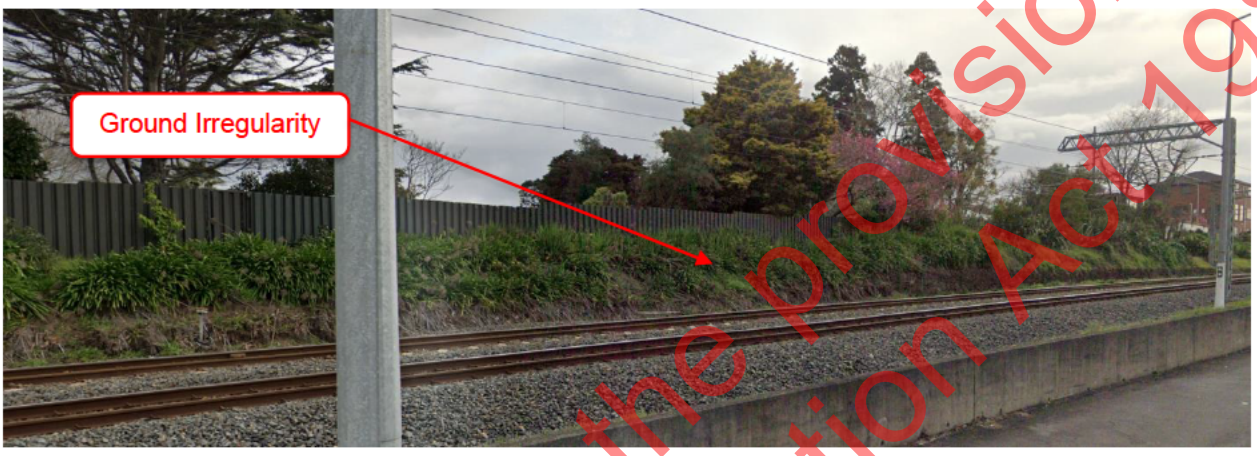

Figure 9 - Ground Irregularity at the eastern boundary

We regularly conduct vibration monitoring in proximity to railway tracks for design purposes and for compliance purposes. From our library of measurements, a representative monitored site was selected, where tracks are also straight with minimal discernible curves. As a conservative measure the representative measurements do not involve irregular ground as is present at the subject site. The highest PPV vibration levels measured at different distances during train traversals at the were:

- At 5m from track: 0.295 mm/s PPV
- At 9m from track: 0.132 mm/s PPV
- At 12m from track: 0.098 mm/s PPV
- At 15m from track: 0.052 mm/s PPV
- At 20m from track: 0.043 mm/s PPV

The dominant frequencies of vibrations were between 70Hz and 100Hz. Traversals of freight trains generated the highest vibrations, where at 20m a passenger train generated a maximum of 0.039mm/s PPV when compared with 0.043mm/s PPV for a freight train. The following video is representative of the highest vibrations measured at 5m from the closest railway tracks:

- https://www.dropbox.com/s/bsprqxga5ybizif/IMG_4552.MOV?dl=0

8 Preliminary Recommendations

We note for reference that the following **recommendations are preliminary** in nature, and are likely to change based on more detailed plans, specialist assessments, and construction material selections. These recommendations should only be used as **initial guidelines** pertaining to noise and vibrations.

8.1 Site Plan

8.1.1 Building Locations

It is recommended that building footprints are offset from the eastern boundary such that the closest point of any building is at least 10m from the edge of the closest railway line. This is to allow for the natural ground attenuation of railway vibrations over sufficient distance.

We would also recommend that buildings at the western boundary are located at a sufficient distance away from the driveable edge of Great South Road. The necessary mitigation measures will be included as necessary to achieve the internal noise and vibration levels. This is in consideration of the 5% of traffic being heavy, as per the latest Auckland transport traffic counts.

8.1.2 Living Space Orientations

It is recommended that as many bedrooms as possible face away from the roads. Where there are living areas less sensitive to noise, these can be positioned (where practical) towards the roads in lieu of the bedrooms.

8.1.3 Commercial / Entertainment Premises

We would recommend more detailed assessment of commercial premises proposed within the site, and the locations and types of mechanical plant required for these commercial facilities.

It is highly likely that noise management plans or mitigation measures will be included as conditions of consent for any noise generating commercial facilities in proximity to sensitive receivers, including receivers within the proposed development itself (e.g. apartments above a café)

8.2 Building Envelope

8.2.1 Façade

Assuming the proposed glazing takes no more than 30% of the façade surface area, and assessing against the frequency distribution of traffic noise, the following cladding options yield the internal noise levels in a representatively modelled bedroom with Internal Lining of 1x13mm Plasterboard:

- Brick Cladding: 34dBA
- Block Work Cladding: 34dBA
- Weatherboard: 40dBA
- Fibre Cement Cladding: 40dBA

Worth noting here that the single measures of attenuation (e.g. R_w) are insufficient in this case to predict internal levels due to the low frequency content of noise from Traffic (as per ISO 717.) Brick and Blocks are more effective at attenuating noise at or below 250Hz, when compared with Weatherboard and Fibre Cement which are noted to yield internal noise levels approximately 6dBA higher than Bricks for example.

In accordance with the guideline criteria, Internal Noise levels within bedrooms should be circa LA_{eq} 35dB-40dBA and in other habitable areas must not exceed LA_{eq} 45dB. Assessment against the criteria yields the following:

- Brick Cladding and Block Work cladding would result in compliance with the internal noise guidelines to within a margin of 1-2dBA.
- Weatherboard and Fibre Cement would result in exceedance of the internal noise limits for bedrooms by approximately 5dBA.

As such, and based on preliminary models, it is recommended that the following is considered:

- All facades with line of sight to SH1 should have heavy weight cladding such as Concrete, Bricks or Block work in order to comply with internal noise limits
- Facades facing the interior of the development, and with no line of sight to SH1 or Great South Road, may include Weatherboard as long as the external wall construction is as noted above.
- Facades facing Great South Road can include weatherboard or Fibre Cement, but would require high density 13mm plasterboard lining.

8.2.2 Roof

Assessing against the frequency distribution of traffic noise, the cladding following options yield internal noise levels in a representatively modelled bedroom with 180mm Autex Greenstuff R3.2 Insulation:

- 0.6mm Longrun Steel Roofing, with internal ceiling lining of 2x13mm Noiseline Plasterboard: 40dBA
- 3mm Asphalt Shingles with internal ceiling lining of 1x13mm Noiseline Plasterboard: 40dBA
- 3mm Asphalt Shingles with internal ceiling lining of 2x13mm Plasterboard: 36dBA

In accordance with the guideline criteria, Internal Noise levels within bedrooms should be LA_{eq} 35dB-40dBA and in other habitable areas within LA_{eq} 45dB. Assessment against the criteria yields the following:

- The use of long run steel roofing requires the addition of 2 layers of 13mm Noiseline plasterboard linings to the ceilings of habitable areas to achieve compliance.
- An alternative would be the use of Asphalt Shingle Roofing systems with either:
    - 1x13mm Noiseline (high density) Plasterboard; or
    - 2x13mm Plasterboard

Worth noting here that the use of Asphalt with 2x13mm Plasterboard would yield internal noise levels comfortably below the compliance levels. The other alternatives modelled would be just at compliance levels and have the associated risk of in-situ performance degradation from design levels.

It is required that penetrations for light fittings in the ceilings of habitable areas at the top floor are to be restricted to 1x130mm diameter recessed light in the ceiling per $2m^2$ in order for sound insulation not to be adversely affected. The acoustic criterion also requires all penetrations to be acoustically sealed.

8.2.3 Glazing

Taking into account high noise levels incident on the facades of the apartments facing the roads and build-ability constraints for the light weight timber framing of the structure, the following glazing is proposed for the facades of buildings facing the roads or with line of sight to them (SH1 and Great South Road):

- 23.4mm Laminated IGU (6.38mm / 12mm AS / 5mm) or equivalent.

The window suites / frames are required to match the STC ratings noted above, complete with compressible weather seals. This glazing has the manufacturer attenuation parameters of: R_w: 38 and PSR (Perceived Sound Reduction): 55%

In order to meet the internal noise levels, windows in all the habitable spaces need to be closed and hence mechanical ventilation is required. We would like to clarify that the windows are openable, i.e. those are not fixed windows.

Mechanical ventilation will be required in all habitable spaces of the subject apartments to meet ventilation requirements. There is no minimum requirement for glazing in non-habitable spaces such as garages and bathrooms.

For the units along the Eastern boundary (facing motorway), we recommend against the use of sliding glass doors. Instead, we recommend hinged doors with compression seals. Sliding glass doors do not usually achieve high levels of noise attenuation, and may become a source of noise breakout into the space.

8.3 Intertenancy

8.3.1 Walls and Floors - Airborne

It is recommended that all intertenancy walls and floors are designed at an STC rating of at least 60 to ensure that even with in-situ degradation, noise insulation would still be at FSTC 55 whereby privacy between units is maintained.

8.3.2 Floors – Impact

Similarly, if units have intertenancy floors, it is recommended that all intertenancy floors are designed at an IIC rating of at least 60 to ensure that even with in-situ degradation, noise insulation would still be at FIIC 55 whereby privacy between units is maintained.

To achieve this, it is recommended that all intertenancy non-carpeted areas (i.e. tiles or timber flooring) include the use of appropriate vibration isolation underlay, to be confirmed as part of the design, in addition to best practice design measures for intertenancy floor impact.

8.4 Ventilation

It is recommended that all habitable spaces in all units are provided with mechanical ventilation and/or a cooling system in accordance with the Waka Kotahi Conditions applicable to new dwellings in proximity to motorways, as per Section 5 above.

8.5 Operational Vibration Mitigation

In context of vibrations, the main source of concern is the railway at the Eastern boundary of the site, and Great South Road at the Western boundary. Based on generic preliminary vibration propagation models, we would recommend consideration of the following:

- Location of building footprints to be no less than 10m from the closest railway tracks,
- Location of building footprints to be no less than 7m from the driveable edge of Great South Road.
- Positioning of sleeping areas as far offset as possible from the East or West boundaries.

8.6 Mechanical Plant Selection, Location and Shielding

Mechanical services should be selected, located and shielded to control noise emissions to neighbouring sites to within AUP compliance levels.

8.7 Operation of Commercial Premises (e.g. Cafes)

Commercial premises within, and in proximity to, residential areas require consideration of noise emissions, including:

- People Noise, especially for entertainment facilities.
- Amplified music location and volume.
- Outdoor service (e.g. Cafes)
- Mechanical Services (e.g. extraction fans)
- Internal noise insulation to residential occupancies within same buildings.
- Operating hours, and associated traffic noise on internal roads.

8.8 Construction Methodology

8.8.1 Perimeter Shielding

It is likely that temporary perimeter shielding will be required (using plywood panels or acoustic blankets affixed to chain-link fences):

- 2.4m high along the northern boundary, and
- 2.4m-3.4m high at the boundary with the adjacent receivers at the southern corner

8.8.2 Excavation

The audiology facility at 232 Great South Road may require strict noise and vibration limits due to the likely presence of sensitive medical equipment. While this can be managed for limited excavations, it may become impractical if deep cuts or rock breaking are required close to the building footprint.

With the caveat that this requires input from Geotechnical engineers, we would recommend assessment of the proximity of basement cuts to adjacent sensitive receivers.

It is likely that excavators operating close to the adjacent building at the southern corner would be limit to no larger than 23Tonnes. Furthermore, compactors operating within 15m of a neighbouring buildings would need to either be small (hand held rolling or plate) or for driven compactors, operated with vibratory functions OFF.

The three storey residential dwellings at 234 Great South Road may require additional shielding (e.g. acoustic blankets on scaffolding) to control noise to within the limits.

8.8.3 Foundation and Retention Methodology

Geotechnical advice is required to assess foundation methodologies.

If piling is required for either foundations or basement retention, we would strongly recommend consideration of bored cast in-situ concrete piles. Cast in-situ piles represent the best practicable option to minimise effects on adjacent neighbours. The use of driven piles (vibratory sheet piles, or impact driven piles) would generate excessive noise and vibration levels.

If casing of augered bores is required, we would recommend the use of continuous flight augers (CFA) to avoid the noise and vibration effects associated with vibratory casing insertion and extraction.

8.8.4 Building Structure

The use of rattle guns or stud shots on steel structures can generate high and tonal noise levels especially when occurring at elevation. If required, we would recommend consideration of the shear snap off bolts or use of hydraulic torque wrenches in lieu of rattle guns. Use of screw fixing is recommended over stud shots.

9 Auckland Council/Transport Consultation

The following is a summary of queries and comments received pertaining to noise and vibration assessments, with associated responses:

Query

There is a disconnect between the acoustic report recommendations and the architectural package proposed that needs to be addressed. Page 19 of the architectural package includes the sentence: "Operable windows will be located on east and west elevations to avoid noise penetration and face the parks to take advantage of the passive ventilation" This is contrary to the Earcon report and is unlikely to be practicable given the very high noise exposures and there only being slight reduction for reduced angle of view on the east and west façades (see Earcon figure 9). The architectural package also appears to be referencing a larger glazed area facing the motorway than recommended by Earcon.

Response

We would like to clarify for the avoidance of doubt that habitable spaces with line of sight to the motorway would not meet internal criteria levels with windows open. As noted in Section 9.2.3, this does not mean the windows must be shut during noisy periods. Provided these spaces have mechanical ventilation, and if equipped with operable windows, opening windows would be a personal choice. While it would be easier to achieve the required attenuation with fixed glazing, it can, in many cases, also be achieved with openable glazing. As this report is preliminary, a more detailed assessment at the appropriate stage, may require changes to glazing to achieve internal levels.

Query

He also commented that in terms of rail noise and vibration the Earcon report relies on vibration measurements from another site, which is not adequate given that this cannot be addressed/mitigated retrospectively. A site vibration survey is required before the site layout can be confirmed.

Response

We note that the preliminary predictions and assessment made are based on measurements at multiple sites similar to the subject site in terms of stratigraphy and general topography. While levels are likely to differ at the subject site, for a preliminary assessment, the differences would likely be within the tolerances and safety margins taken into account. Notwithstanding the above, we agree that in-situ monitoring and measurements of noise and vibrations from rail activities are required to empirically confirm levels, offsets, and exclusion zones prior to the finalisation of the site layout.

Query

It is also recommended that standard Waka Kotahi noise limit (40 dB LAeq(24h) inside habitable spaces) and standard ventilation requirements should be specified in conditions.

Response

Acknowledged and confirmed. This updated report includes the Waka Kotahi conditions as compliance regulations in Section 5.

We note for reference that the assessment undertaken already incorporated the noise and vibration requirements (e.g. NC8176E:2005 Class C) albeit in context of guidelines. These have now been included as conditions.

Appendix I – Standards

Regulatory

Auckland Unitary Plan – Operative

The Auckland Unitary Plan provides, inter alia, a regulatory framework defining the noise and vibration limits on construction sites within the jurisdiction of the Auckland City Council. These limits are references in this report and assessed against for compliance analysis.

Noise

NZS 6801: 2008 – Acoustics – Measurement of Environmental Sound

This standard defines the parameters, quantities and metrics to describe noise in community environments, in addition to the procedures and methodologies of measuring and acquiring these quantities.

NZS 6802: 2008 – Acoustics – Environmental Noise

This standard defines procedures for the assessment of noise against compliance criteria.

NZS 6803:1999 - Acoustics – Construction Noise

This standard covers the specifics of measurement and assessment of noise from construction, maintenance and demolition. This standard also provides, for the purposes of noise level predictions, guideline noise levels expected from different machinery associated with construction and demolition activities. NZS 6803:1999 includes reproduced annexes from the British Standard BS 5228: Part 1: 1997. These are cited in this report as "pertaining to BS5228 as referenced in NZS6803".

ISO717:1 1996 Acoustics – Rating of sound insulation in building and of building elements – Airborne Sound Insulation

This standard defines measures for airborne sound insulation in buildings and of building elements such as walls, floors, doors and windows and takes into consideration the different sound level spectra of various noise sources such as noise sources inside a building and traffic outside a building.

NZS6806:2010 – Acoustics – Road Traffic Noise – New and Altered Roads

This standard pertains to the management and assessment of noise for new or altered roads, and includes recommendations of noise criteria to be applied at assessment positions of protected premises and facilities.

Vibrations

BS 5228-2:2009 - Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration

This standard provides guideline vibration levels for different construction activities, and recommended methods for vibration control on construction and open sites where operations are expected to generate significant vibration levels.

AS 2670.1: 2001 - Evaluation of human exposure to whole-body vibration - General

This standard provides methods for the measurement and assessment of vibrations as they pertain to human health, comfort and perception.

DIN 4150-3:1999-02 – Structural Vibrations – Part 3: Effects of Vibration on Structures

This standard provides methodology for measuring and assessing the effects of vibrations on buildings and structures designed for static loading.

KiwiRail – Reverse Sensitivity Noise and Vibrations

This standard provides noise and vibrations requirements for the use of land likely to be susceptible to noise and vibrations pertaining to rail operations.

AS 2670.1: 2001 - Evaluation of human exposure to whole-body vibration - General

This standard provides methods for the measurement and assessment of vibrations as they pertain to human health, comfort and perception.

NS8176.E:2005 – Vibration and shock – Measurement of vibration in buildings from land based transport and guidance to evaluation of its effects on human beings

This standard is commonly used for assessment of transport generated vibrations, and has been applied in a number of projects in New Zealand. This standard is focused on the human response to building vibrations from transport sources.

BS 7385-2:1993 – Evaluation and measurement for vibration in buildings. Guide to damage levels from ground borne vibration

This standard gives guidance on the level of vibrations above which building structures could be damaged, and identifies the factors which affect the vibration response on buildings. This standard is focused on the effects of vibrations on buildings.

Glossary of Terms- Acoustics

Ambient Noise: the total noise, at a given place, a composite of sounds from many sources near and far.

Asymmetric: a waveform not identical on both sides of the mean or zero line, lacks symmetry.

Average: in acoustics where dB levels are extensively used, average may not mean adding up the values and then dividing by the number of samples.

Octave: a range of frequencies whose upper frequency limit is twice that of its lower frequency limit. For example, the 1000 Hertz octave band contains noise energy at all frequencies from 707 to 1414 Hertz.

In acoustical measurements, Sound Pressure Level is often measured in octave bands, and the centre frequencies of these bands are defined by ISO - 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, 16 kHz to divide the audio spectrum into 10 equal parts.

The sound pressure level of sound that has been passed through an octave band pass filter is termed the octave band sound pressure level.

One-third Octave Bands, there are three similar bands in each octave band.

1/1, 1/3, 1/6, 1/12, and 1/24 octaves are all used in acoustics.

Background Noise: the noise at a given location and time, measured in the absence of any alleged noise nuisance sources, also known as Residual Noise.

Broadband Noise: also called wideband noise - noise whose energy is distributed over a wide section of the audible range as opposed to Narrowband Noise.

Class 1: precision grade sound level meters for laboratory and field use - also known as Type 1.

Continuous Spectrum: sound spectrum whose components are continuously distributed over a given frequency range.

Frequency Weighted Sound Levels: Frequency weightings correlate objective sound measurements with the subjective human response. The human ear is frequency selective; between 500 Hz and 6 kHz our ears are very sensitive compared with lower and higher frequencies.

A-weighting: the A-weighting filter covers the full audio range - 20 Hz to 20 kHz and the shape is similar to the response of the human ear at the lower levels

C-weighting: a standard frequency weighting for sound level meters, commonly used for higher level measurements and Peak - Sound Pressure Levels.

Z-weighting: Z for 'Zero' frequency weighting, which implies no frequency weighting. In reality the range is 10 Hz to 20 kHz ±1.5 dB.

dB Level: is the Logarithm of the ratio of a given acoustic quantity to a reference quantity of the same kind. The base of the logarithm, the reference quantity, and the kind of level must be indicated.

decibel: dB : a relative unit of measurement widely used in acoustics, electronics and communications. The dB is a Logarithmic unit used to describe a ratio between the measured level and a reference or threshold level of 0dB. The ratio may be Sound Power, Sound Pressure, voltage or Sound Intensity, etc.

Deltatron ®: trade name for IEPE - Integrated Electronics Piezoelectric.

FFT: Fast Fourier Transform : a digital signal processing technique that converts a time record into a narrow band constant bandwidth filtered spectrum. Measurements are defined by specifying the frequency span and a number of lines (or filters).

Frequency: f : the number of times that a Periodic function or vibration occurs or repeats itself in a specified time, often 1 second - cycles per second. It is usually measured in Hertz (Hz).

Frequency Analysis: analysing an overall broadband noise to identify the different contributions in different parts of the audio spectrum. Typically the analysis in made using 1/1-Octave, 1/3-Octave or narrow band (FFT) Analysis.

Frequency Band: a continuous range of frequencies between two limiting frequencies.

Hertz: Hz : the unit of Frequency or Pitch of a sound. One hertz equals one cycle per second.

Impact Sound: the sound produced by the collision of two solid objects. Typical sources are footsteps, dropped objects, etc., on an interior surface (wall, floor, or ceiling) of a building.

Infrasound: sound whose frequency is below the low-frequency limit of audible sound (about 16 Hz).

Integrating (of an instrument): indicating the mean value or total sum of a measured quantity.

kHz: kilohertz : 1 kHz = 1000 Hz = 1000 Hertz.

LA: A-weighted, Sound Level.

LA10: is the noise level just exceeded for 10% of the measurement period, A-weighted and calculated by Statistical Analysis.

LA90: is the noise level exceeded for 90% of the measurement period, A-weighted and calculated by Statistical Analysis.

LAn: noise level exceeded for n% of the measurement period with A-weighted , calculated by Statistical Analysis - where n is between 0.01% and 99.99%.

LAeq: A-weighted, equivalent sound level. A widely used noise parameter describing a sound level with the same Energy content as the varying acoustic signal measured - also written as dBA Leq

LAF: A-weighted, Fast, Sound Level.

LAFmax: A-weighted, Fast, Maximum, Sound Level.

LAFmin: A-weighted, Fast, Minimum, Sound Level.

LAIeq: A-weighted, Impulse, Leq, Sound Level.

LAmax: A-weighted, Maximum, Sound Level

LAS: A-weighted, Slow, Sound Level.

LASmax: A-weighted, Slow, Maximum, Sound Level.

LASmin: A-weighted, Slow, Minimum, Sound Level.

LC: C-weighted, Sound Level.

LCE: C-weighted, Sound Exposure Level

LCeq: C-weighted, Leq, Sound Level

LCF: C-weighted, Fast, Sound Level.

LCFmax: C-weighted, Fast, Maximum, Sound Level.

LCpeak: C-weighted, Peak, Sound Level.

Leq: Equivalent Sound Level

Lpeak: Peak Sound Level

LZ: Z weighted, Sound Level.

LZE: Z-weighted, Sound Exposure Level

LZeq: Z-weighted, Leq, Sound Level.

LZF: Z-weighted, Fast, Sound Level.

LZFmax: Z-weighted, Fast, Maximum, Sound Level.

LZFmin: Z-weighted, Fast, Minimum, Sound Level.

Multi-spectrum: a one or two-dimensional array of spectra, consisting of two or more spectra that were recorded during the same measurement

Narrowband Noise: noise which has its energy distributed over a relatively small section of the audible range.

Natural Frequency: the frequency at which a resiliently mounted mass will vibrate when set into free vibration. The frequency of oscillation of the free vibration of a system if no Damping were present.

Noise: any sound that is undesired by the recipient. Any sound not occurring in the natural environment, such as sounds emanating from aircraft, highways, industrial, commercial and residential sources. Interference of an electrical or acoustical nature.

Octave: a range of frequencies whose upper frequency limit is twice that of its lower frequency limit. For example, the 1000 Hertz octave band contains noise energy at all frequencies from 707 to 1414 Hertz.

Octave Band analyser: an instrument that measures Sound Levels in octave bands.

Peak-to-Peak: the amplitude difference between the most positive and most negative value in a time waveform, that is, the total Amplitude.

Piezoelectric: PE : any material which provides a conversion between mechanical and electrical energy. Piezo is a Greek term which means 'to squeeze'. If mechanical stresses are applied to a piezoelectric crystal, then an electrical charge results. Conversely, when an electrical voltage is applied across a piezoelectric material, the material deforms.

Pitch: is a subjective auditory sensation and depends on the frequency, the harmonic content, and to a lesser extent on the loudness of a sound.

Spectrum: the description of a sound wave's resolution into its components of frequency and amplitude.

Third Octave Band: Octave bands sub-divided into three parts, equal to 23% of the centre frequency. Used when octave analysis is not discrete enough. Divides the audio spectrum into 33 or more equal parts with Constant Percentage Bandwidth filter.

Tone: sound or noise recognisable by its regularity. A simple or Pure Tone has one frequency. Complex tones have two or more simple tones, the lowest tone frequency is called the Fundamental, the others are Overtones.

Vibration: mechanical oscillations occur about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random.